SEL-710

Motor Protection Relay

Instruction Manual

20241014

SCHWEITZER ENGINEERING LABORATORIES

Part Number: PM710-01

Table of Contents

Section 5: Metering and Monitoring

Section 6: Settings

Section 7: Communications

Section 8: Front-Panel Operations

Section 9: Analyzing Events

Section 10: Testing and Troubleshooting

Appendix A: Firmware, ICD, and Manual Versions

Appendix B: Firmware Upgrade Instructions

Appendix C: SEL Communications Processors

Appendix D: Modbus Communications

Appendix E: IEC 61850 Communications

Appendix F: DeviceNet Communications

Appendix G: MIRRORED BITS Communications

Appendix H: Motor Thermal Element

Appendix I: Relay Word Bits

Appendix J: Analog Quantities

Glossary

Index

SEL-710 Command Summary

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List of Tables

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List of Figures

Preface

Manual Overview

The SEL-710 Motor Protection Relay Instruction Manual describes common aspects of motor relay application and use. It includes the necessary information to install, set, test, and operate the relay.

An overview of each manual section and topics follows:

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

Section 1: Introduction and Specifications. Describes the basic features and functions of the SEL-710; lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-710; illustrates wiring connections for various applications.

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

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

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

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

Section 7: Communications. Describes how to connect the SEL-710 to a PC for communication; shows serial port pinouts; lists and defines serial port commands. Describes the communications port interfaces and protocols supported by the relay for serial and Ethernet ports.

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

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

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

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

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

Appendix C: SEL Communications Processors. Provides examples of how to use the SEL-710 with SEL communications processors for total substation automation solutions.

Appendix D: Modbus Communications. Describes the Modbus protocol support provided by the SEL-710.

Appendix E: IEC 61850 Communications. Describes IEC 61850 implementation in the SEL-710.

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

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

Appendix H: Motor Thermal Element. Contains a fundamental description of the SEL-710 thermal element. Describes interpretation of percent thermal capacity and thermal capacity used to start quantities.

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

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

SEL-710 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:

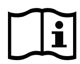
⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

⚠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 2 environment.	Pour utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature shall not exceed 50°C (122°F).	La température de l'air ambiant ne doit pas dépasser 50°C (122°F).
For use on a flat surface of a Type 1 enclosure.	Pour 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 Terminal Block: 0.9–1.4 Nm (8–12 in-lb) Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lb) Compression Plug Mounting Ear Screw: 0.18–0.25 Nm (1.6–2.2 in-lb)	Spécifications des bornes Type de filage Utiliser seulement des conducteurs en cuivre spécifiés à 75°C (167°F). Couple de serrage Bornes : 0,9–1,4 Nm (8–12 livres-pouce) Fiche à compression : 0,5–1,0 Nm (4,4–8,8 livres-pouce) Vis à oreille de montage de la fiche à compression : 0,18–0,25 Nm (1,6–2,2 livres-pouce)

Hazardous Locations Safety Marks

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

Hazardous Locations Approvals

The SEL-710 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 T3C in the maximum surrounding air temperature of 50°C. The SEL-710 shall be installed in an indoor or outdoor (extended) locked enclosure that provides a degree of protection to personnel against access to hazardous parts. In either environment, the relay shall be protected from direct sunlight, precipitation, and full wind pressure.

To comply with the requirements of the European ATEX standard for hazardous locations, the SEL-710 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 60079-7. The enclosure shall be limited to the surrounding air temperature range of –20°C ≤ Ta ≤ +50°C. The enclosure should be certified to these requirements, or be tested for compliance as part of the complete assembly. The enclosure must be marked “WARNING—Do not open when an explosive atmosphere is present.”

Other Safety Marks (Sheet 1 of 2)

⚠DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	⚠DANGER Débrancher tous les raccordements externes avant d’ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l’appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠DANGER Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠DANGER Tout contact avec les bornes de l’appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠DANGER Synchronous Motor Voltage Divider Module terminals carry high ac/dc voltage signals. Disconnect the device from the synchronous motor before working on the device. Contact with live wires can cause electrical shock resulting in injury or death.	⚠DANGER Les bornes de raccordement du circuit diviseur de tension du motor synchrone sont alimentées par une haute tension ca/cc. Débrancher le module du moteur synchrone avant de le manipuler. Tout contact avec les fils sous tension peut être la cause d’ 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.

Other Safety Marks (Sheet 2 of 2)

⚠WARNING Before working on a CT circuit, first apply a short to the secondary winding of the CT.	⚠AVERTISSEMENT Avant de travailler sur un circuit TC, placez d'abord un court-circuit sur l'enroulement secondaire du TC.
⚠WARNING Do not perform any procedures or adjustments that this instruction manual does not describe.	⚠AVERTISSEMENT Ne pas appliquer une procédure ou un ajustement qui n'est pas décrit explicitement dans ce manuel d'instruction.
⚠WARNING During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.	⚠AVERTISSEMENT Durant l'installation, la maintenance ou le test des ports optiques, utilisez exclusivement des équipements de test homologués comme produits de type laser de Classe 1.
⚠WARNING Overtightening the mounting nuts may permanently damage the relay chassis.	⚠AVERTISSEMENT Une pression excessive sur les écroux de montage peut endommager de façon permanente le chassis du relais.
⚠WARNING This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.	⚠AVERTISSEMENT Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accès non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.
⚠WARNING To install an option card, the relay must be de-energized and then re-energized. When re-energized, the relay will reboot. Therefore, de-energize the protected motor before installing the option card to prevent damage to the motor.	⚠AVERTISSEMENT Pour installer une carte à option, le relais doit être éteint et ensuite rallumé. Quand il est rallumé, le relais redémarrera. Donc, il faut éteindre le moteur protégé avant d'installer la carte à option pour empêcher des dégats au moteur.
⚠WARNING Do not attempt to synchronize the brush-type synchronous motor without the external voltage divider board. Severe damage to the relay can result if the external voltage divider board is improperly connected.	⚠AVERTISSEMENT Ne pas essayer de synchroniser le moteur synchrone à balai sans le circuit de diviseur de tension externe. Des dégâts importants pourraient survenir au relais si le diviseur de tension externe était mal connecté.
⚠CAUTION Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	⚠ATTENTION Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.	⚠ATTENTION Regarder vers les connecteurs optiques, les extrémités des fibres oules connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.
⚠CAUTION Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.	⚠ATTENTION L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.
⚠CAUTION Do not connect power to the relay until you have completed these procedures and receive instruction to apply power. Equipment damage can result otherwise.	⚠ATTENTION Ne pas mettre le relais sous tension avant d'avoir complété ces procédures et d'avoir reçu l'instruction de brancher l'alimentation. Des dommages à l'équipement pourraient survenir autrement.

General Information

Typographic Conventions

There are three ways to communicate with the SEL-710:

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

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

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

Trademarks

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

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

ACSELERATOR Architect®	SEL-2407®
ACSELERATOR QuickSet®	SELOGIC®
ACSELERATOR Report Server®	SYNCHROWAVE®
MIRRORED BITS®	

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-710. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the current version of your SEL-710.

LED Emitter

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

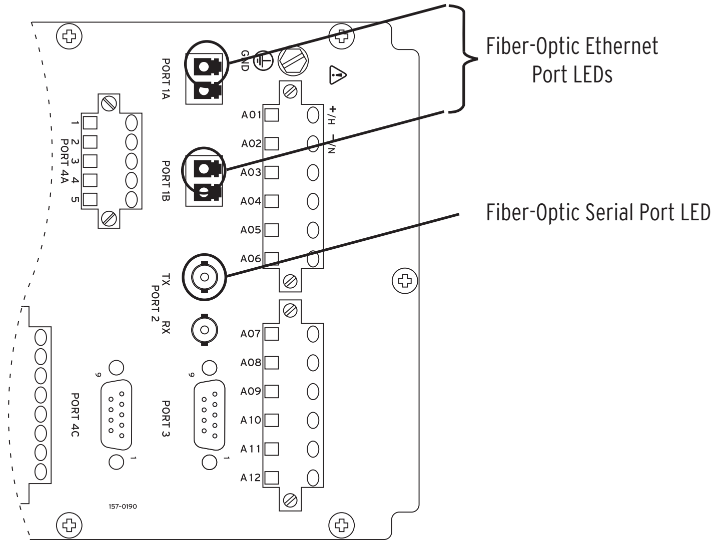
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

The following table shows LED information specific to the SEL-710 (see *Figure 2.9* for the location of fiber-optic Ethernet PORT 1 [or 1A, 1B] and PORT 2, the ports using these LEDs, on the relay).

SEL-710 LED Information

Item	Fiber-Optic Ethernet Port 1 (1A, 1B)	Port 2
Mode	Multimode	Multimode
Wavelength	1300 nm	820 nm
Source	LED	LED
Connector type	LC	ST
Typical output power	–15.7 dBm	–16 dBm

The following figure shows the LED location specific to the SEL-710 (see *Figure 2.9* for the complete rear-panel drawing).



SEL-710 LED Locations

LED Safety Warnings and Precautions

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

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

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

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

Wire Sizes and Insulation

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

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

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

[a] See Table 2.16 for typical maximum RTD lead length.

Instructions for Cleaning and Decontamination

Use a mild soap or detergent solution and a damp cloth to carefully clean the SEL-710 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 use 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

Section 1

Introduction and Specifications

Overview

The SEL-710 Motor Protection 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 needed to install, set, test, operate, and maintain any SEL-710. You need not review the entire manual to perform specific tasks.

Features

Standard Protection Features

- Thermal Overload (Thermal Model) (49)
- Undercurrent (Load Loss) (37)
- Current Balance and Phase Loss (46)
- Overcurrent (Load Jam)
- Short Circuit (50P)
- Ground Fault—Residual Overcurrent (50G)
- Ground Fault—Neutral Overcurrent (50N)
- Negative-Sequence Overcurrent (50Q)
- Phase Time Overcurrent (51P)
- Ground (Residual) Time Overcurrent (51G)
- Negative-Sequence Time Overcurrent (51Q)
- Phase Reversal (47), current based
- Motor Starting/Running
  - 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)
- Breaker/Contactor Failure Protection

Optional Protection Features

- Differential Overcurrent (87M)
- PTC Overtemperature (Positive Temperature Coefficient Switching Thermistor) (49)
- Voltage-Based Protection
  - Undervoltage (27)
  - Overvoltage (59)
  - Underpower (37)
  - Reactive Power
  - Phase Reversal (47)
  - Power Factor (55)
- RTD-Based Protection: As many as ten (10) RTDs may be monitored when an internal RTD card is used, or as many as twelve (12) when an external SEL-2600 RTD Module with the ST option is used. There are separate Trip and Warn settings for each RTD.

Monitoring Features

- Event summaries that contain relay ID, date and time, trip cause, and current/voltage magnitudes
- Event reports including filtered and raw analog data
- Sequential Events Record (SER)
- Motor operating statistics since the last reset:
  - Running and stopped times
  - Number of starts and emergency starts
  - Average and peak metering values during start and run periods
  - Load profiling
  - Number of various alarms and trips
- Motor Start Reports, for as long as 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, single or dual, copper or fiber-optic Ethernet port(s), and fiber-optic rear-panel EIA-232 port
- IRIG-B time-code input
- Modbus RTU slave, Modbus TCP/IP, Ethernet FTP, Telnet, SNTP, MIRRORED BITS, IEC 61850, and DeviceNet
- SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, and Fast SER
- Programmable Boolean and math operators, logic functions, and analog compare

Models, Options, and Accessories

Models

Complete ordering information is not provided in this instruction manual. See the latest SEL-710 Model Option Table at selinc.com, under SEL Literature, Ordering Information (Model Option Tables). Options and accessories are listed below.

Options

- Voltage Option: four-wire wye, open-delta, or single phase connected VTs; Voltage Option plus three differential current inputs.
- Input/Output (I/O) Option:
  - Additional digital I/O
  - Additional analog I/O
  - 10 RTD inputs
- Communications Options (Protocol/Ports):
  - EIA-485/EIA-232/Ethernet ports
  - Multimode (ST) fiber-optic serial port
  - Modbus RTU, Modbus TCP/IP protocol
  - DeviceNet (**Note:** This option has been discontinued and is no longer available as of September 25, 2017.)
  - IEC 61850 Communications
  - Simple Network Time Protocol (SNTP)
- Choice of IRIG-B time-code input or PTC (thermistor) input.

Accessories

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

- External RTD protection:
  - SEL-2600 RTD Modules (ST option only)
  - A simplex 62.5/125 µm fiber-optic cable with an ST connector for connecting the external RTD module to the SEL-710
- SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to relay fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the relay
- SEL-710 Configurable Labels
- Rack-Mounting Kits:
  - For one relay
  - For two relays
  - For one relay and a test switch
- Wall-Mounting Kits
- Bezels for Retrofit
- Replacement Rear Connector Kit

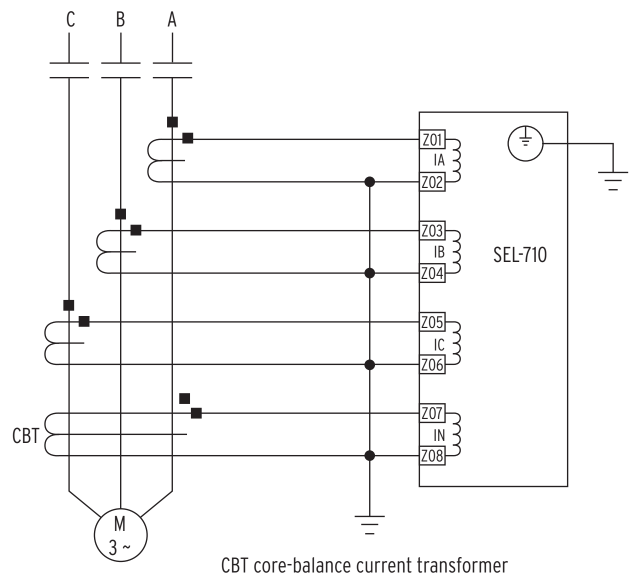
For all SEL-710 mounting accessories for competitor products, including adapter plates, visit selinc.com/applications/mountingselector/.

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

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



CBT core-balance current transformer

The current transformers and the SEL-710 chassis must be grounded in the relay cabinet.

Figure 1.1 AC Connections—Across-the-Line Starting

Getting Started

Understanding basic relay operation principles and methods will help you use the SEL-710 effectively. This section presents the fundamental knowledge you need to operate the SEL-710, organized by task. These tasks help you become familiar with the relay and include the following:

- ➤ *Powering the Relay*
- ➤ *Establishing Communication*
- ➤ *Checking the Relay Status*
- ➤ *Setting the Date and Time*

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

Powering the Relay

Power the SEL-710 with 110–240 Vac, 110–250 Vdc or 24/48 Vdc, depending on the part number.

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

Establishing Communication

The SEL-710 has two EIA-232 serial communications ports. The following steps require PC terminal emulation software and an SEL-C662 Cable (or equivalent) to connect the SEL-710 to the PC. See *Section 6: Settings* for further information on serial communications connections and the required cable pinout.

Step 1. Connect the PC to the SEL-710 with the serial communications cable.

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

Step 3. Start the PC terminal emulation program.

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

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

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

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

Table 1.1 SEL-710 Serial Port Settings

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

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

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

```
=>QUIT <Enter>
Motor 1                        Date: 12/10/2003   Time: 10:31:43
Station 1                      Time Source: Internal
```

Figure 1.2 Response Header

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.9* for factory-default passwords) to go to Access Level 1.

Checking the Relay Status

Use the **STA** serial port command to view the SEL-710 operational status. Note that offsets are shown only when the relay is online and tracking frequency. If the dc offset exceeds a warning threshold, the analog value has a “w” next to it. Analog channel dc offset and monitored component status are listed in the status report depicted in *Figure 1.3*.

```
=>>STA <Enter>

SEL-710                                    Date: 05/16/2011   Time: 14:53:46.555
MOTOR RELAY                                Time Source: Internal

Serial Num = 2007226319     FID = SEL-710-X429-V0-Z006004-D20110506
CID = CBFD                  PART NUM = 071001B0X6X7286000X

SELF TESTS (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  +0.9V  +1.2V  +1.5V
  OK    OK    OK    OK    OK    OK      OK       OK     0.90   1.20   1.51

  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.80   2.50   3.33   3.75    4.95   -1.26   -4.97   2.97

Option Cards
  CARD_C  CARD_D  CARD_E  CURRENT
  OK      OK      OK      OK

Offsets
   IA    IB    IC    IN    VA    VB    VC
  1     1     1     1     0     0     0

  Relay Enabled

=>>
```

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

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

```
=>>STA <Enter>

SEL-710                                    Date: 05/16/2011   Time: 14:53:46.555
MOTOR RELAY                                Time Source: Internal

Serial Num = 2007226319     FID = SEL-710-X429-V0-Z006004-D20110506
CID = CBFD                  PART NUM = 071001BA36X7286000X

SELF TESTS (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  +0.9V  +1.2V  +1.5V
  OK    OK    OK    OK    OK    OK      OK       OK     0.90   1.20   1.51

  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.80   2.50   3.33   3.75    4.95   -1.26   -4.97   2.97

Option Cards
  CARD_C  CARD_D  CARD_E  CURRENT
  OK      OK      OK      OK

DeviceNet
  DN_MAC_ID    ASA       DN_RATE  DN_STATUS
  3         1a0d c1e9h   500kbps  0000 0001

Offsets
   IA    IB    IC    IN    VA    VB    VC   IA87  IB87  IC87
  0     0     1     1     12    11    11   -11   -11    -1

  Relay Enabled

=>>
```

Figure 1.4 STA Command Response—Communications Card/DeviceNet Protocol

Table 7.44 provides the definition of each status report designator and *Table 10.8* shows all the self-tests performed by the relay. The beginning of the status report printout (see *Figure 1.3*) contains the relay serial number, firmware identification string (FID), and checksum string (CID). These strings uniquely identify the relay and the version of the operating firmware.

Setting the Date and Time

DAT (Date Command)

Viewing the Date

Type **DAT <Enter>** at the prompt to view the date stored in the SEL-710. 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-710. 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 E212775, NRGU, NRGU7)

CE Mark

RCM Mark

UKCA Mark

Hazardous locations

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

EU

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

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

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

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

General

AC Current Input

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

I_{NOM} = 2.5 mA

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	21 mA peak (14.8 mA rms symmetrical)
1-Second Thermal:	100 A
Burden (per phase):	<0.1 mVA @ 2.5 mA
Measurement Category:	II

Differential Currents

I_{NOM} = 1 A/5 A Universal

Continuous Rating:	15 A
Saturation Current Rating:	Linear to 8 A symmetrical
1-Second Thermal:	500 A
Burden (per phase):	<0.01 VA @ 5 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	0.003 VA @ 120 Vac	5 MΩ	10 MΩ

Power Supply

Relay Start-up Time	Approximately 5–10 seconds (after power is applied until **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:	<50 VA (ac) <25 W (dc)
Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

Low-Voltage Supply

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range (Design Range):	19.2–60 Vdc
Power Consumption:	<25 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Fuse Ratings

LV 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

HV 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

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

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
Thermal:	50 A for 1 s
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
Thermal:	50 A for 1 s
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, 115 J

Fast Hybrid Output Contacts

(High-Speed, High-Current Interrupting)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
1 s Rating:	50 A
Open State Leakage Current:	<500 µA
MOV Protection (maximum voltage):	250 Vac/330 Vdc
Pickup Time:	<50 µs, resistive load
Dropout Time:	≤8 ms, resistive load

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

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

Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation) per IEC 60255-0-20:1974:

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

AC Output Ratings

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

Optoisolated Control Inputs

When Used With DC Control Signals

250 V:	ON for 200.0–312.5 Vdc OFF below 150 Vdc
220 V:	ON for 176–275 Vdc OFF below 132 Vdc
125 V:	ON for 100.0–156.2 Vdc OFF below 75 Vdc
110 V:	ON for 88.0–137.5 Vdc OFF below 66 Vdc
48 V:	ON for 38.4–60.0 Vdc OFF below 28.8 Vdc
24 V:	ON for 15–30 Vdc OFF below 5 Vdc

When Used With AC Control Signals

250 V:	ON for 200.0–312.5 Vac OFF below 106 Vac
220 V:	ON for 180–275 Vac OFF below 93.3 Vac
125 V:	ON for 95.0–156.2 Vac OFF below 53 Vac
110 V:	ON for 90.0–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 37.5–60.0 Vac OFF below 20.3 Vac
24 V:	ON for 14–30 Vac OFF below 5 Vac
Current Draw at Nominal DC Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Impulse Withstand Voltage (U_{imp}):	4000 V
Maximum Pickup Time:	Approx. 1 cycle
Maximum Dropout Time:	Approx. 2 cycles

Analog Output (Optional)

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

Analog Inputs (Optional)

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

Frequency and Phase Rotation

System Frequency:	50, 60 Hz
Phase Rotation:	ABC, ACB
Frequency Tracking:	20–70 Hz

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ

Synchronization Accuracy

Internal Clock:	±1 µs
All Reports:	±5 ms

Simple Network Time Protocol (SNTP) Accuracy

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

Communications Ports

Standard EIA-232 (2 Ports)

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

EIA-485 Port (Optional)

Location:	Rear Panel
Data Speed:	300–19200 bps

Ethernet Port (Optional)

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

Standard Multimode Fiber-Optic Port

Location:	Rear Panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

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

Port 2 Serial

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

Optional Communications Cards

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

Communications Protocols

SEL, Modbus, FTP, TCP/IP, Telnet, SNTP, IEC 61850, MIRRORED BITS Communications, and DeviceNet. See *Table 7.5* for details.

Operating Temperature

IEC Performance Rating (per IEC/EN 60068-2-1 and 60068-2-2):	–40° to +85°C (–40° to +185°F) Not applicable to UL applications

Note: LCD contrast is impaired for temperatures below –20°C and above +70°C.

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

Operating Environment

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

Dimensions

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

Weight

2.7 kg (6.0 lb)

Relay Mounting 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 Tightening Torque

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 IP50-rated for terminals enclosed in the dust-protection assembly (protection against solid foreign objects only) (SEL P/N 915900170). The 10°C temperature derating applies to the temperature specifications of the relay. IP10 for terminals and the relay rear panel
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: 2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3: 1993 IEC 60255-27: 2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1: 2007 IEC 60255-27: 2013, Section 10.6.1.2 IEC 60255-27: 2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2: 2007 IEC 60255-27: 2013, Section 10.6.1.1 IEC 60255-27: 2013, Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013, Section 10.6.1.6 25°–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 1.0 kVac on analog outputs, Ethernet ports 2.0 kVac on analog inputs, IRIG, PTC 2.5 kVac on contact I/O 3.6 kVdc on power supply, current and voltage inputs
Impulse:	IEC 60255-27:2013, Section 10.6.4.2 Severity Level: 0.5 J, 5 kV on power supply, contact I/O, ac current and voltage inputs 0.5 J, 530 V on analog outputs, PTC IEEE C37.90:2005 Severity Level: 0.5 J, 5 kV 0.5 J, 530 V on analog outputs, PTC

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 61000-4-4:2012 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 61000-4-18:2010 IEC 60255-26:2013, Section 7.2.6 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2002 2.5 kV oscillatory 4 kV fast transient
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 60225-26:2013, 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 CAN ICES-001(A) / NMB-001(A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A
Radiated Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.109 Class A CAN ICES-001(A) / NMB-001(A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	16 samples per power system cycle
Frequency Tracking Range:	20–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is four times per power system cycle (except for math variables and analog quantities [see *Appendix J: Analog Quantities*] which are processed every 100 ms).

Oscillography

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

Sequential Events Recorder

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

Relay Elements

Thermal Overload (49)

Full-Load Current (FLA) Limits:	0.2–5000.0 A primary (limited to 20–160% of CT rating)
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% plus ±25 ms at multiples of FLA > 2 (cold curve method)

FLA is a setting (see the *Group Settings (SET Command)* in the *SEL-710 Settings Sheets* for setting ranges).

PTC Overtemperature (49)

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

Undercurrent (Load Loss) (37)

Setting Range:	Off, 0.10–1.00 • FLA
Accuracy:	±5% of setting plus ±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 rms secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0–240 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 rms secondary
Maximum Pickup Dropout Time:	1.5 cycles
Time Delay:	0–120 s, 0.1 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 plus ±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, 0.10–20.00 • FLA
Accuracy:	±5% of setting plus ±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 (50N)

Setting Range:	Off, 0.01–650 A or 0.01–25 A primary
Accuracy	
1 A, 5 A models:	±5% of setting plus ±0.01 • I_{NOM} A secondary
2.5 mA models:	±5% of setting plus ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time	
1 A, 5 A models:	1.5 cycles/1.5 cycles
2.5 mA models:	30 ms + 1.5 cycles/1.5 cycles (for the 2.5 mA models, a fixed delay of 30 ms is added to the entered delay setting for the 50N element (50N*x*D))
Time Delay:	0.0–5.0 s, 0.01 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Negative-Sequence Overcurrent (50Q)

Setting Range:	Off, 0.10–20.00 • FLA
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary

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

Pickup Setting Range, A Secondary:	
5 A models:	Off, 0.50–10.00 A, 0.01 A steps
1 A models:	Off, 0.10–2.00 A, 0.01 A steps
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (within the linear current range of the CT specified)
Time Dial:	
US:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Accuracy:	±1.5 cycles plus ±4% between 2 and 30 multiples of pickup (as high as the continuous rating of the current input)

Differential Protection (87M)

Setting Range:	Off, 0.05–8.00 A secondary
Accuracy:	±5% of setting plus ±0.02 A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–60.0 s, 0.01 s increment
Accuracy:	±0.5% of setting or ±1/4 cycle

Undervoltage (27)

Vnm = [VNOM/PT Ratio] if DELTA_Y := DELTA;
Vnm = [VNOM/(1.732 • PT Ratio)] if DELTA_Y := WYE

Setting Range:	Off, 0.02–1.00 • Vnm
Accuracy:	±5% of setting plus ±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 or ±1/4 cycle

VNOM is a setting (see the *Group Settings (SET Command)* in the *SEL-710 Settings Sheets* for setting ranges).

Overvoltage (59)

Vnm = [VNOM/PT Ratio] if DELTA_Y := DELTA;
Vnm = [VNOM/(1.732 • PT Ratio)] if DELTA_Y := WYE

Setting Range:	Off, 0.02–1.20 • Vnm
Accuracy:	±5% of setting plus ±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 or ±1/4 cycle

Underpower (37)

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

Reactive Power (VAR)

Setting Range:	Off, 1–25000 kVAR primary
Accuracy:	±5% of setting plus ±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 or ±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 or ±1/4 cycle

Frequency (81)

Setting Range:	Off, 20.0–70.0 Hz
Accuracy:	±0.1 Hz
Maximum Pickup/Dropout Time:	5 cycles
Time Delay:	0.0–240.0 s, 0.1 s increment
Accuracy:	±0.5% of setting or ±1/4 cycle

Timers

Setting Range:	See *SEL-710 Settings Sheets*
Accuracy:	±0.5% of setting plus ±1/4 cycle

RTD Protection

Setting Range:	Off, 1–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	1.4 Vac (peak) at 50 Hz or greater frequency
RTD Fault, Trip, and Alarm Time Delay:	Approximately 12 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 plus ±1.5% of I_{NOM}, ±2°
Three-Phase Average Motor Current:	±2% of reading plus ±1.5% of I_{NOM}
Three-Phase Average Motor Load (%FLA):	±2% of reading plus ±1.5% of I_{NOM}
Current Unbalance (%):	±2% of reading plus ±1.5% of I_{NOM}
IG (Residual Current):	±3% of reading plus ±1.5% of I_{NOM}, ±2°
IN (Neutral Current):	±2% of reading plus ±1.5% of I_{NOM}, ±2°
3I2 Negative-Sequence Current:	±3% of reading
System Frequency:	±0.1 Hz of reading for frequencies within 20–70 Hz
Thermal Capacity:	±1% TCU Time to trip ±1 second
Slip:	±5% slip for 100% > speed ≥ 40% ±10% slip for 40% > speed > 0%
Line-to-Line Voltages:	±2% of reading, ±1° for voltages within 24–264 V
Three-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
Three-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:	±3% of reading for voltages within 24–264 V
Real Three-Phase Power (kW):	±5% of reading for 0.10 < pf < 1.00
Reactive Three-Phase Power (kVAR):	±5% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Power (kVA):	±5% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C
Real Three-Phase Energy (out of bus) (MWh3P):	±5% of reading for 0.10 < pf < 1.00
Negative Reactive Three-Phase Energy-IN (into bus) (MVARh3P):	±5% of reading for 0.00 < pf < 0.90
Positive Reactive Three-Phase Energy- OUT (out of bus) (MVARh3P):	±5% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Energy (out of bus) (MVAh3P):	±2% of reading

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

Section 2
Installation

Overview

The first steps in applying the SEL-710 Motor Protection Relay are installing and connecting the relay. This section describes common installation features and requirements.

To install and connect the relay safely and effectively, you must be familiar with relay configuration features and options. You should carefully plan relay placement, cable connections, and relay communication.

This section contains drawings of typical ac and dc connections to the SEL-710. Use these drawings as a starting point for planning your particular relay application.

The instructions for using the versatile front-panel custom label option are available on the SEL-710 product page on the SEL website. This allows you to use SELOGIC control equations and slide-in configurable front-panel labels to change the function and identification of target LEDs.

Relay Placement

Proper placement of the SEL-710 helps to ensure years of trouble-free motor protection. Use the following guidelines for proper physical installation of the SEL-710.

Physical Location

The SEL-710 is EN 61010-1 certified at Installation/Overvoltage Category II and Pollution Degree 2. This allows mounting of the relay in weather-protected locations that are not temperature controlled but do not exceed the temperature and humidity ratings for the relay. The SEL-710 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 1.10*.) For EN 61010-1 certification, the SEL-710 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-710 shall be installed in an ATEX-certified enclosure with a tool-removable door or cover that provides a degree of protection not less than IP54, in accordance with EN 60079-0. The enclosure shall be limited to the surrounding air temperature range of –20°C ≤ Ta ≤ +50°C. The enclosure should be certified to these requirements or be tested for compliance as part of the complete assembly. The enclosure must be marked “WARNING—Do not open when an explosive atmosphere is present.” In North America, the relay is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T3C with a maximum surrounding air temperature of 50°C.

Relay Mounting

To flush mount the SEL-710 in a panel, cut a rectangular hole with the dimensions shown in *Figure 2.1*. Use the supplied front-panel gasket for protection against dust and water ingress into the panel (IP65).

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

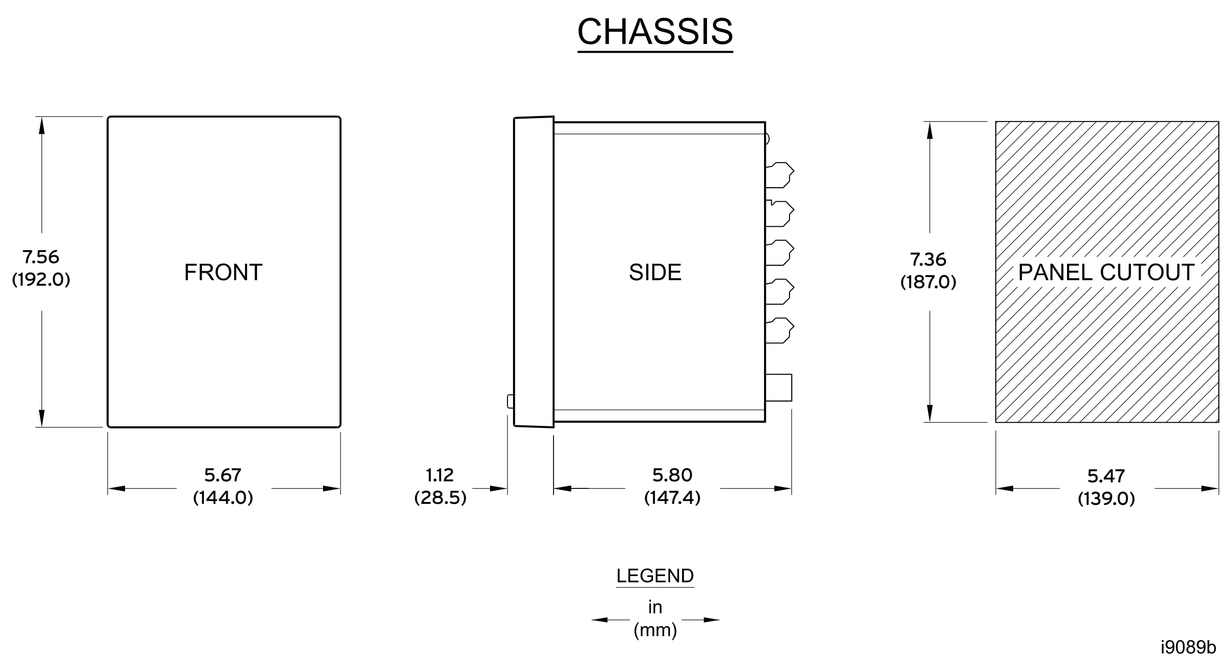


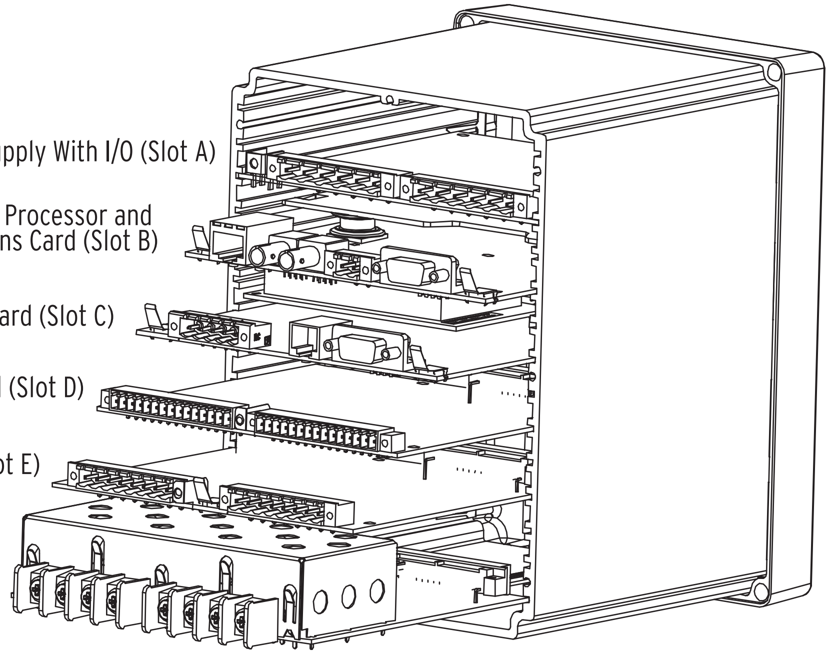
Figure 2.1 Relay Panel-Mount Dimensions

Refer to *Section 1: Introduction and Specifications*, *Models, Options, and Accessories on page 1.3* for information on mounting accessories.

I/O Configuration

Your SEL-710 offers flexibility in tailoring I/O to your specific application. In total, the SEL-710 has six rear-panel slots, labeled as Slots **A**, **B**, **C**, **D**, **E**, and **Z**. Slots **A**, **B**, and **Z** are base unit slots, each associated with a specific function. Optional digital/analog I/O, communications, RTD, and voltage cards are available for the SEL-710. *Figure 2.2* shows the slot allocations for the cards.

Because installations differ substantially, the SEL-710 offers a variety of card configurations to provide options for the many diverse applications. Choose the combination of option cards most suited for your application from the following selection.



	Rear-Panel Slot					
	A	B	C	D	E	Z
Software Reference	1 (e.g., OUT101)		3 (e.g., IN301)	4 (e.g., OUT401)	5 (e.g., AI501)	
Description	Power supply and I/O card[a]	CPU/comm. card[b]	Comm. or input/ output[c] card	Input/output[c] or RTD card	Input/output[c] or voltage card	Current card
Card Type						
SELECT EIA-232/485			●			
SELECT DeviceNet			●			
SELECT 3 DI/4 DO/1 AO (one card per relay)			●	●	●	
SELECT 4 DI/4 DO[d]			●	●	●	
SELECT 4 DI/3 DO (2 Form C, 1 Form B)[e]			●	●	●	
SELECT 8 DI[d]			●	●	●	
SELECT 8 AI			●	●	●	
SELECT 4 AI/4 AO (one card per relay)			●	●	●	
SELECT 10 RTD				●		
SELECT 3 AVI					●	
SELECT 3 ACI/3 AVI[f]					●	
SELECT 4 ACI						●

[a] Power supply, two inputs, and three outputs.
[b] IRIG-B/PTC, EIA-232/485, fiber-optic serial and/or Ethernet ports (The IRIG-B/PTC input option is available on terminals B01, B02 for all models except models with a fiber-optic Ethernet port (P1) and a dual-copper Ethernet port (P1) that have Port 3 as an EIA-232 serial port and can input IRIG-B via the EIA-232 port and an SEL communications processor). IRIG-B is also supported by Port 2 in relays with firmware R304 and higher.
[c] Digital or analog.
[d] The fast, high-current interrupting output option and the 8 DI card option require R300 or higher firmware revisions.
[e] Requires R402 or higher or R306 or higher firmware revisions.
[f] Requires R201 or higher firmware revisions.

Figure 2.2 Slot Allocations for Different Cards

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

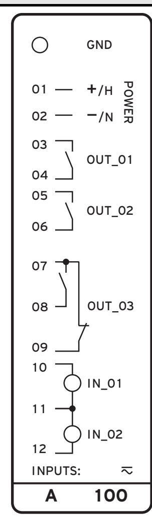
Select appropriate power supply option for the application:

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

Select the appropriate digital input voltage option: 125 Vdc/Vac, 24 Vdc/Vac, 48 Vdc/Vac, 110 Vdc/Vac, 220 Vdc/Vac, or 250 Vdc/Vac.

This card is supported in Slot A of the SEL-710 Relay. It has two digital inputs and three digital outputs (two normally open Form A contact outputs and one Form C output). *Table 2.1* shows the terminal designation for the PSIO/2 DI/3 DO card.

Table 2.1 Power Supply Inputs (PSIO/2 DI/3 DO) Card Terminal Designations



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

Communications Ports (Slot B)

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

Table 2.2 Communications Ports

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

Port F supports the following protocols:

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

Port 1 (Ethernet) supports the following protocols:

- Modbus TCP/IP
- IEC 61850
- FTP
- Telnet

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

- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Settings File Transfer
- SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTA, MBTB)

Communications Card (Slot C)

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

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

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

Select either EIA-232 or EIA-485 functionality 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 all of the following protocols:

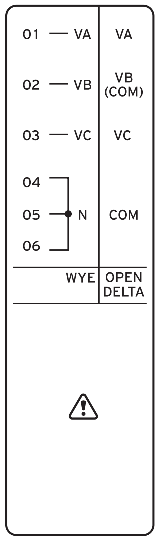
- Modbus RTU Slave
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Settings File Transfer
- SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTB, MBTA)

Voltage/Differential Current Card (3 AVI or 3 ACI/3 AVI)

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

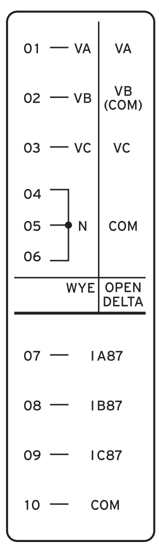
Supported in Slot E only, order this card when you have either single or three-phase (wye or delta) PTs. With a voltage card installed, the SEL-710 samples the voltages at 16 times a cycle—see *Processing Specifications and Oscillography on page 1.12* for more information. Optionally, this card also includes differential current inputs.

Table 2.4 Voltage Inputs (3 AVI) Card Terminal Designations



Side-Panel Connections Label	Terminal Number	Description
(see diagram above)	E01	VA, Phase A voltage input
	E02	VB, Phase B voltage input
	E03	VC, Phase C voltage input
	E04 E05 E06	N, Common connection for VA, VB, VC

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



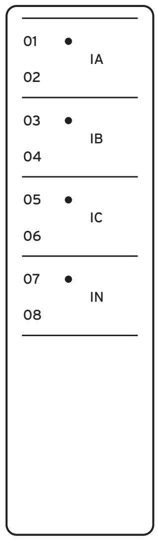
Side-Panel Connections Label	Terminal Number	Description
(see diagram above)	E01	VA, Phase A voltage input
	E02	VB, Phase B voltage input
	E03	VC, Phase C voltage input
	E04	N, Common connection for VA, VB, VC
	E05	N, Common connection for VA, VB, VC
	E06	N, Common connection for VA, VB, VC
	E07	IA87, Phase A differential current input
	E08	IB87, Phase B differential current input
	E09	IC87, Phase C differential current input
	E10	IN87, differential current neutral return

Current Card (4 ACI)

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

Supported in Slot **Z** only, this card provides current inputs for three-phase CTs and one neutral CT. Secondary phase current ratings are either all 1 A or all 5 A; you cannot order a combination of 1 A and 5 A phase CTs on one card. However, the phase CTs and the neutral CT can be of different current rating. You can order one of three neutral CT ratings, 1 A, 5 A, or 2.5 mA (high sensitivity). With a current card installed, the SEL-710 samples the currents at 16 times a cycle—see *Processing Specifications and Oscillography on page 1.12* for more information.

Table 2.6 Current Inputs (4 ACI) Card Terminal Designations

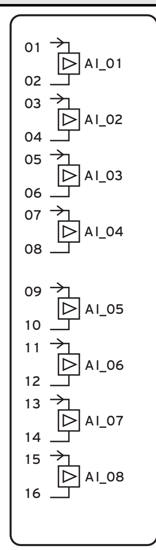


Side-Panel Connections Label	Terminal Number	Description
	Z01, Z02	IA, Phase A current input
	Z03, Z04	IB, Phase B current input
	Z05, Z06	IC, Phase C current input
	Z07, Z08	IN, neutral current input

Analog Inputs Card (8 AI)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has eight analog inputs. *Table 2.7* shows the terminal designations.

Table 2.7 Eight Analog Inputs (8 AI) Card Terminal Designations



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

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

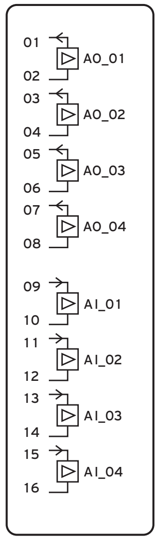
Analog Inputs/Outputs Card (4 AI/4 AO)

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

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

Supported in only one of the nonbase unit slots (Slot C through Slot E), this card has four analog inputs and four analog outputs (AO). *Table 2.8* shows the terminal designations.

Table 2.8 Four Analog Inputs/Four Analog Outputs (4 AI/4 AO) Card Terminal Designations

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

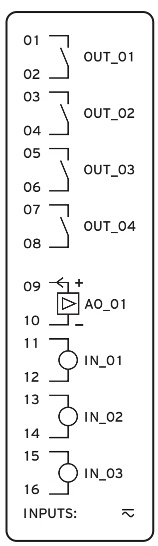
[a] x = 3, 4, or 5 if the card is installed in Slot C, D, or E, respectively.

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

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

Supported in one nonbase unit slot (Slot C, D, or E), this card has three digital inputs, four digital outputs, and one analog output. *Table 2.9* shows the terminal designations.

Table 2.9 Three Digital Inputs/Four Digital Outputs/One Analog Output (3 DI/4 DO/1 AO) Card Terminal Designations

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

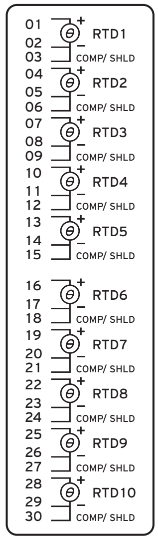
[a] x = 3, 4, or 5 if the card is installed in Slot C, D, or E, respectively.

RTD Card (10 RTD)

Supported in Slot **D** only, this card has 10 3-wire RTD inputs. *Table 2.10* shows the terminal designations.

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

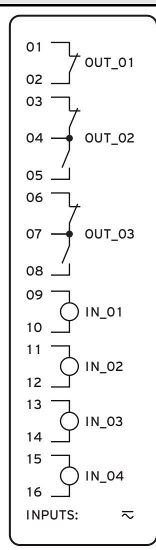
Table 2.10 RTD (10 RTD) Card Terminal Designations

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

I/O Card (4 DI/3 DO)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has four digital inputs, one Form B digital output (normally closed contact output), and two Form C digital output contacts. *Table 2.11* shows the terminal designations.

Table 2.11 Four Digital Inputs, One Form B Digital Output, Two Form C Digital Outputs (4 DI/3 DO) Card Terminal Designations

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

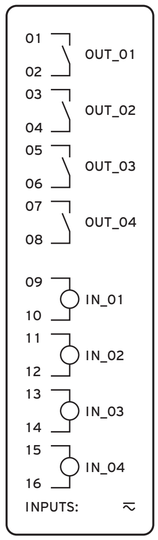
[a] x = 3, 4, or 5 if the card is installed in Slot C, D, or E, respectively.

I/O Card (4 DI/4 DO)

Supported in any nonbase unit slot (Slot **C** through Slot **E**), this card has four digital inputs and four outputs. The four outputs are normally open contact outputs. Optional fast hybrid (high-speed, high-current interrupting) outputs are supported in Slot **C** through Slot **E**. *Table 2.12* shows the terminal designations.

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

Table 2.12 Four Digital Inputs/Four Digital Outputs (4 DI/4 DO) Card Terminal Designations

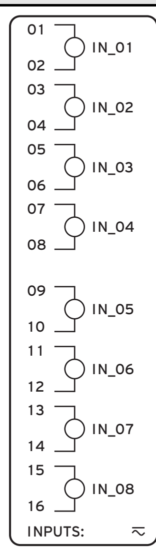
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC equation
	03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC equation
	05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC equation
	07, 08	OUT*x*04, driven by OUT*x*04 SELOGIC equation
	09, 10	IN*x*01, drives IN*x*01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

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

I/O Card (8 DI)

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

Table 2.13 Eight Digital Inputs (8 DI) Card Terminal Designations

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

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

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-710 offers flexibility in tailoring I/O for your specific application. The SEL-710 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-710 in Slots **C**, **D**, and **E**. Optional communications cards are available only for Slot **C**, an RTD card is available only for Slot **D**, ac voltages or ac voltages and differential currents cards are available only on Slot **E**, and current cards are available for Slot **Z**. *Figure 2.2* shows the slot allocations for the cards. Because installations differ substantially, the SEL-710 offers a variety of card configurations that provide options for an array of applications. Choose the combination of cards most suited for your application.

Swapping Optional I/O Boards

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

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

The SEL-710 Relay can be upgraded by adding as many as three cards.

Installation

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

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

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

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

Step 3. Disconnect all the connection plugs.

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

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

Step 6. Insert the option card in the correct slot.

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

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

Step 8. Carefully reattach the rear cover.

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

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

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

```
STATUS FAIL
X Card Failure
```

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

If you *do* see this message, proceed to *Step 12*.

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

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

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

The front panel displays the following:

```
STATUS
Relay Status
```

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

The front panel displays the following:

```
Serial Num
000000000000000000000000
```

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

The front panel displays the following:

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

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

The front panel displays the following:

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

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

The front panel displays the following:

```
Config Accepted
Enter to Reboot
```

Step 19. Press the **ENT** pushbutton.

Step 20. Use the **PARTNO** command from Access Level C to enter the exact part number of the relay after the relay restarts and the **ENABLED** LED turns on to indicate the option card is installed correctly.

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

```
PART NUM = 071001B5X1X7X86020X
```

Step 21. Update the side-panel drawing with the drawing sticker provided in the option card kit. If necessary, replace the rear panel with the one applicable to the option card and attach the terminal-marking label provided with the card to the rear-panel cover. Also, contact SEL for an updated product serial label with the updated part number.

Step 22. Reconnect all of the connection plugs and add any additional wiring/connectors required by the new option card.

Slot B CPU Card Replacement

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

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

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

Step 1. Turn off the power to the relay.

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

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

Step 4. Remove the rear panel.

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

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

Step 7. Apply new side stickers to the relay.

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

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

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

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

The default password for Access Level C is CLARKE.

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

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

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

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

Slot A Power Supply Card

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

Analog Input Card Voltage/Current Jumper Selection

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

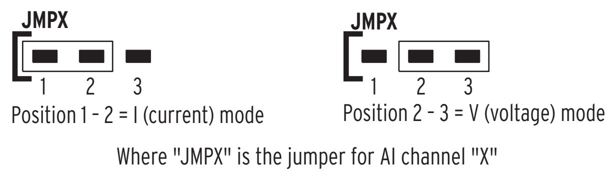


Figure 2.3 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (4 AI/AO Card) Configuration Jumper

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

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

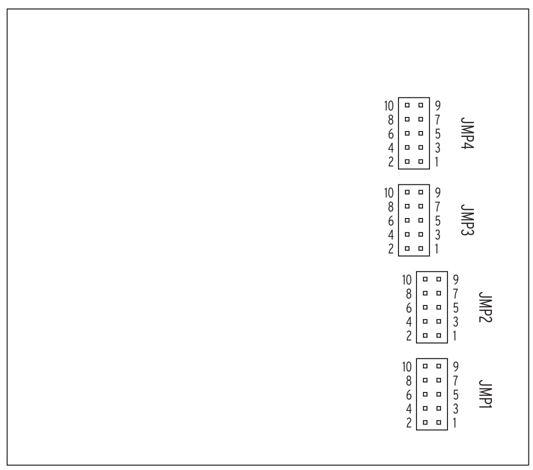
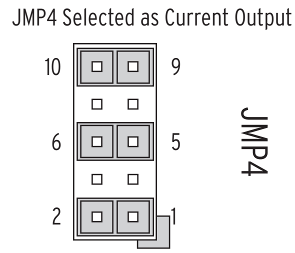


Figure 2.4 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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

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



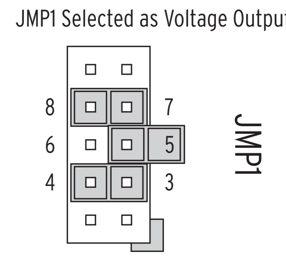


Figure 2.5 Current Output Jumpers **Figure 2.6 Voltage Output Jumpers**

Password and SELBOOT Jumper Selection

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

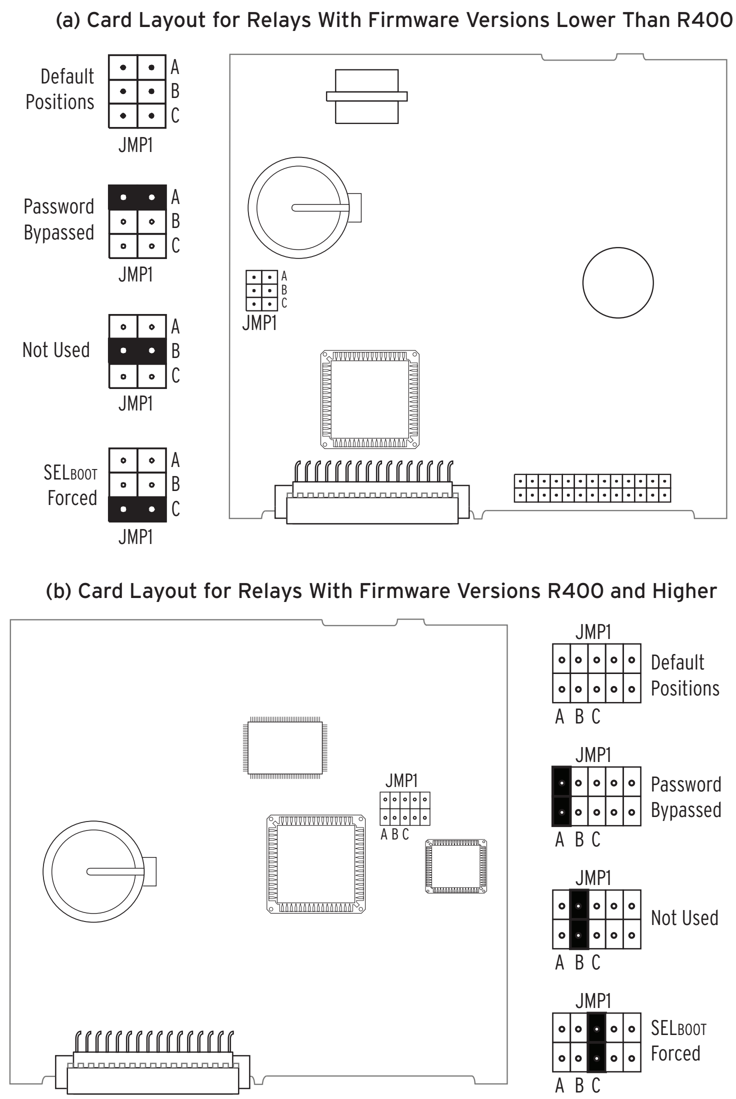


Figure 2.7 Pins for Password Jumper and SELBOOT Jumper

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-710 experiences an internal failure, communication with the relay may be compromised. Forcing the relay to SELBOOT provides you with a way to download new firmware. To force the relay to SELBOOT, place the jumper in position C, as shown in *Figure 2.7* (SELBOOT forced). After the relay is forced to SELBOOT, you can only communicate with it via the front-panel port.

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

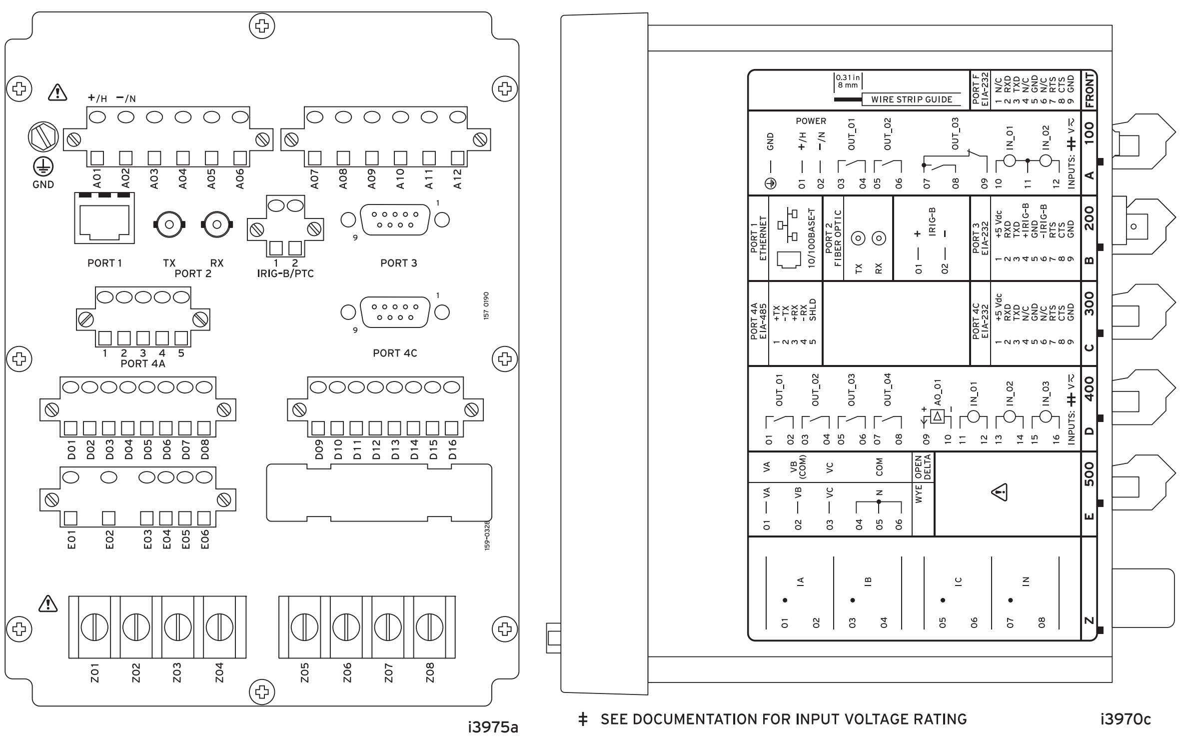
Table 2.14 Jumper Functions and Default Positions

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

Relay Connections

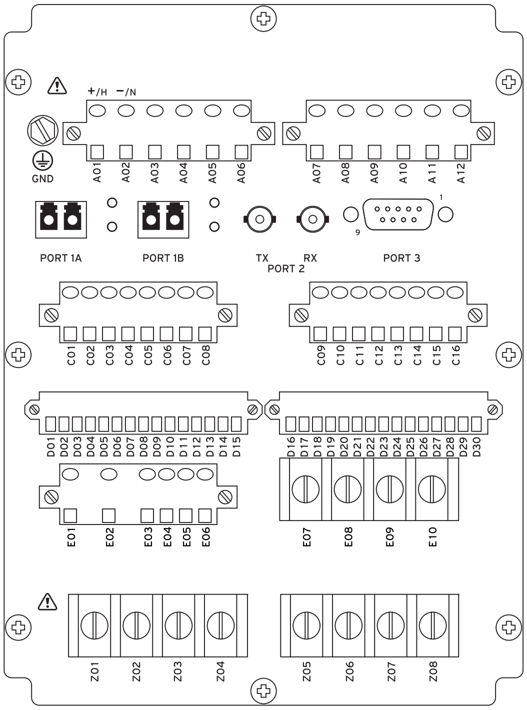
Rear-Panel and Side-Panel Diagrams

The physical layout of the connectors on the rear-panel and side-panel diagrams of three sample configurations of the SEL-710 are shown in *Figure 2.8* through *Figure 2.10*.



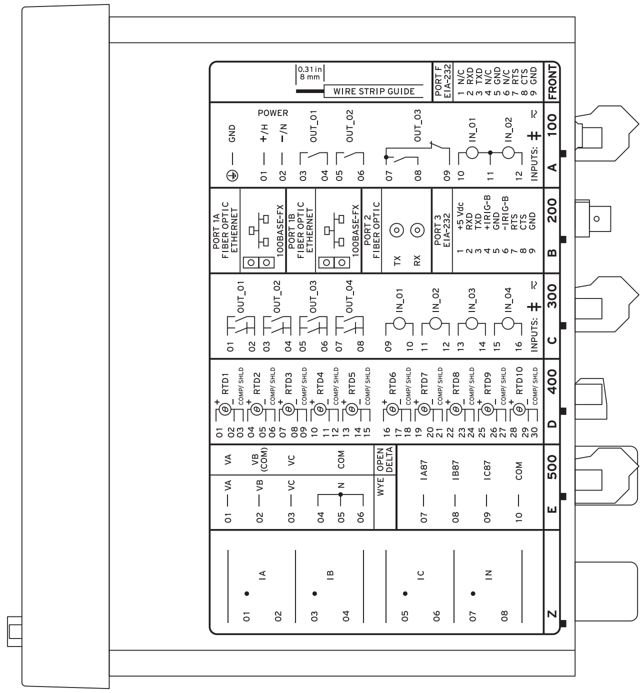
(A) Rear-Panel Layout (B) Side-Panel Input and Output Designations

Figure 2.8 IRIG-B, Ethernet, EIA-232 Communication, 3 DI/4 DO/1 AO, and Voltage Option



i6325a

(A) Rear-Panel Layout

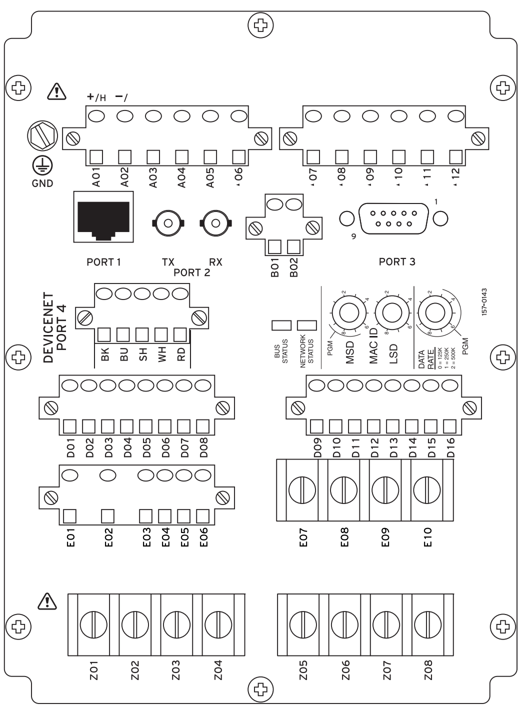


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

i6324a

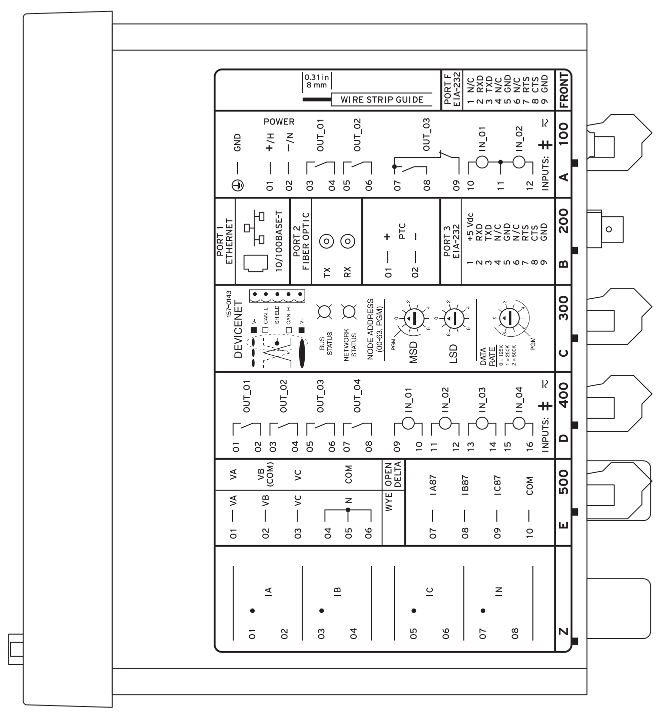
(B) Side-Panel Input and Output Designations

Figure 2.9 Dual Fiber-Optic Ethernet, Fiber-Optic Serial, Fast Hybrid 4 DI/4 DO, RTD, and Voltage/Differential Option



i4136c

(A) Rear-Panel Layout



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

i4137d

(B) Side-Panel Input and Output Designations

Figure 2.10 PTC, DeviceNet, 4 DI/4 DO, and Voltage/Differential Option

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

For compliance with IEC 60947-1 and IEC 60947-3, place a suitable external switch or circuit breaker in the power leads for the SEL-710; 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 2.30* for details. Be sure to use fuses that comply with IEC 60127-2.

Grounding (Earthing) Connections

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

Serial Ports

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

The serial port EIA-485 plug-in connector accepts wire size AWG 26 through AWG 14. Strip the wires 8 mm (0.31 in) and install with a small slotted-tip 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 SEL-2812 compatible ST fiber-optic port. The SEL-2800 family of transceivers provides fiber-optic links between devices for electrical isolation and long-distance signal transmission. Contact SEL for further information on these products.

IRIG-B Time-Code Input

The SEL-710 accepts a demodulated IRIG-B time signal to synchronize the internal clock with an external source. Three options for IRIG-B signal input are given, but only one should be used at a time. You can use the IRIG-B (**B01** and **B02**) inputs, an SEL communications processor via EIA-232 serial **PORT 3**, or fiber-optic serial **PORT 2**. The available communications processors are the SEL-2032, SEL-2030, SEL-2020, and the SEL-2100 Logic Processor. You can also use the SEL-3530 Real-Time Automation Controller (RTAC) to provide IRIG-B input.

The models with fiber-optic Ethernet and dual copper Ethernet do not have the terminals **B01** and **B02** for IRIG-B but have IRIG-B input via EIA-232 **PORT 3**. The third option for IRIG-B is via fiber-optic serial **PORT 2**. Use an SEL-2812MT Transceiver to connect to the SEL-2030 or SEL-2032 and bring the IRIG-B signal with the EIA-232 input. Use a fiber-optic cable pair with ST connectors (C805 or C807) to connect to **PORT 2** on the SEL-710. Refer to *Section 7: Communications* for IRIG-B connection examples and for details about using an SEL-2401/2407/2488 as a time source.

Ethernet Port

The SEL-710 can be ordered with an optional single/dual 10/100BASE-T or 100BASE-FX Ethernet port. Connect to **Port 1** of the device using a standard RJ45 connector for the copper port and an LC connector for the fiber-optic port.

Fiber-Optic Port

The SEL-710 includes a fiber-optic port, which is compatible with the SEL-2812 (with IRIG-B), the SEL-2814 Fiber-Optic Transceivers, and the SEL-2600 RTD Module.

I/O Diagram

A more functional representation of two of the control (I/O) connections is shown in *Figure 2.11* and *Figure 2.12*.

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

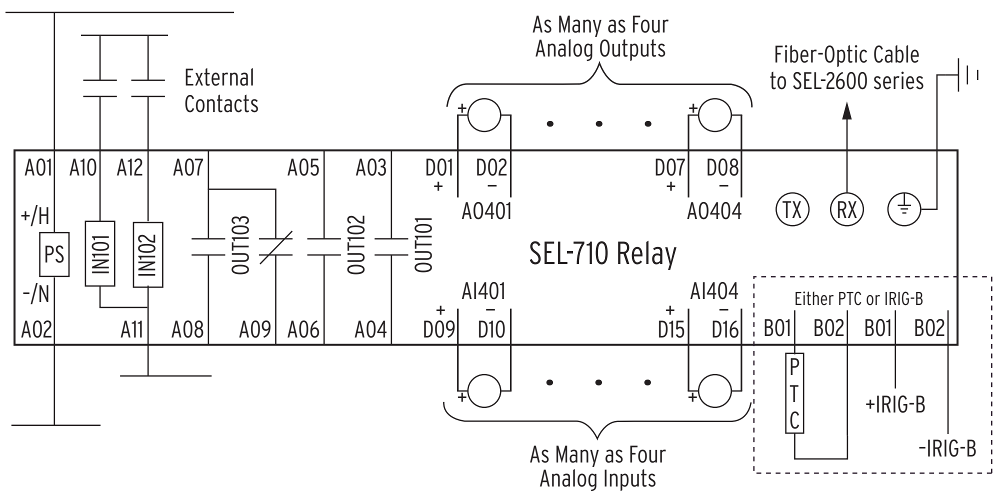


Figure 2.11 Control I/O Connections—4AI/4AO Option in Slot D

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

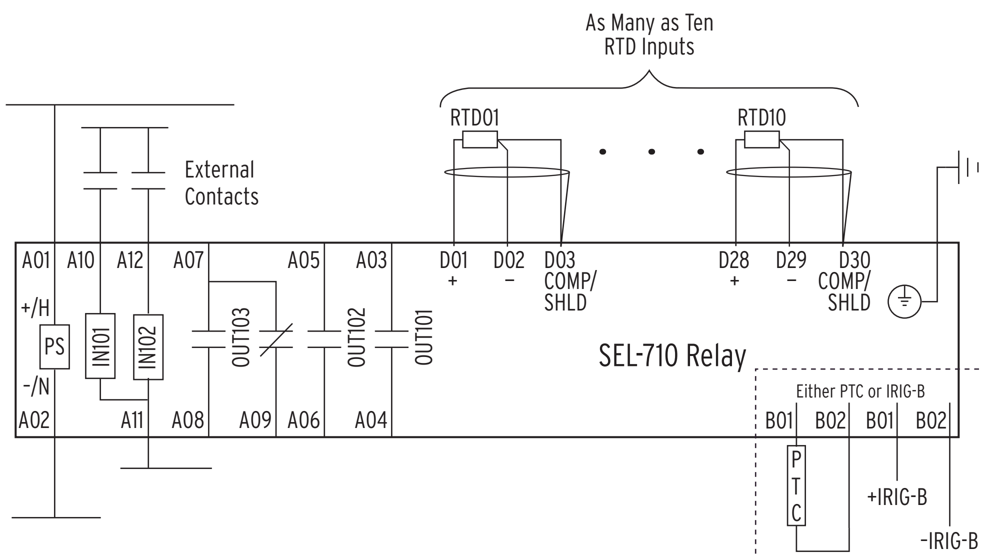


Figure 2.12 Control I/O Connections—Internal RTD Option

- Power supply rating (110–240 Vac, 110–250 Vdc or 24–48 Vdc) depends on relay part number.
- Optoisolated inputs **IN101** and **IN102** are standard and located on the card in Slot **A**.
- All optoisolated inputs are single-rated: 24, 48, 110, 125, 220, or 250 Vac/Vdc. Standard inputs **IN101**/**102** may have a different rating than the optional **IN401**/**402**/**403/404** (not shown).

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-710 model number. As many as six thermistors may be connected in a series. Refer to Table 2.15 for PTC external cable length restrictions. Note that **B01–B02**-based IRIG or PTC input is not available in SEL-710 models with fiber-optic or dual copper Ethernet port.

- Output contacts **OUT101**, **OUT102**, and **OUT103** are standard and located on the card in Slot **A**.
- The Analog (transducer) Outputs shown are located on the optional I/O Expansion card in Slot **D**.
- The fiber-optic 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-710 with an SEL-2600 RTD Module. This fiber-optic cable should be 1000 meters or shorter.
- The chassis ground connector located on the rear-panel card Slot **A** must always be connected to the local ground mat.

PTC Wiring

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

Table 2.15 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

RTD Wiring

Table 2.16 shows the maximum cable lengths for the RTD connections that satisfy the 25-ohm limit required for connecting to SEL devices.

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

Table 2.16 Typical Maximum RTD Lead Length

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

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

RTD wiring recommendations:

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

Use relay wire termination kits—see SEL application note *Wiring SEL-2400, SEL-2200, and SEL-700 Series Devices* (AN2014-08)—and avoid fitting multiple wires into a single terminal, the bird-caging effect of stranded wires, and bulky wire bundles.

Analog Output Wiring

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

Connect the two terminals of the analog output as shown in *Figure 2.13*. 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.

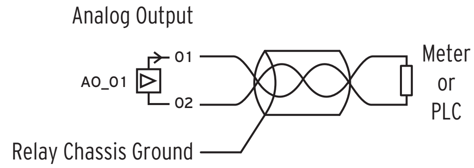


Figure 2.13 Analog Output Wiring Example

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 2.14 shows the output **OUT103** relay coil and Form C contact. When the relay coil de-energizes, the contact between **A07** and **A08** opens while the contact between **A07** and **A09** closes.

NOTE: Fast hybrid contacts are designed for fast closing (50 µs) only. Fail-safe mode operating time (time to open the contacts) for fast-hybrid contacts is <8 ms (the same time as for a normal output contact).

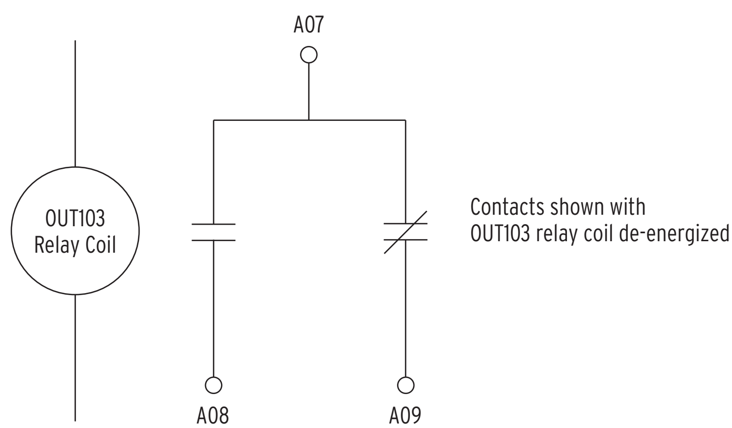


Figure 2.14 Output OUT103 Relay Output Contact Configuration

The SEL-710 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-710 is powered and operational.
- ➤ When the SEL-710 generates a trip signal, the relay coil is de-energized.
- ➤ The relay coil is also de-energized if the SEL-710 power supply voltage is removed or if the SEL-710 fails (self-test status is FAIL).

Figure 2.15 shows fail-safe and nonfail-safe wiring methods to control breakers and contactors.

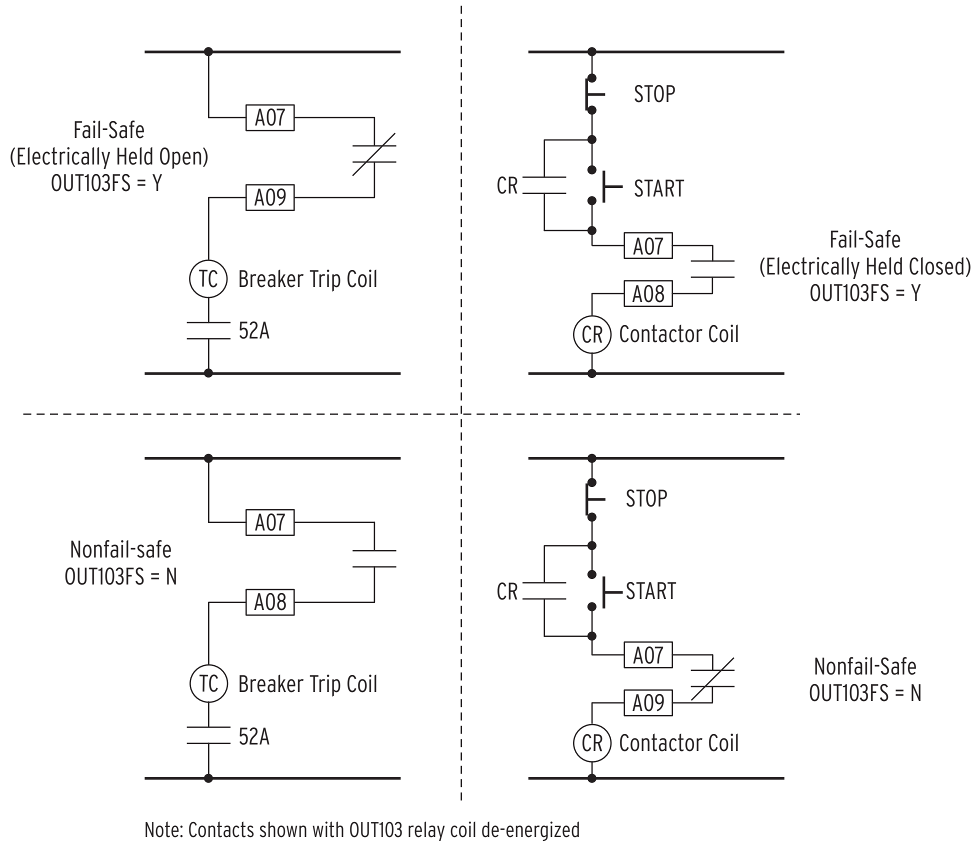


Figure 2.15 Breaker Trip Coil and Contactor Connections With OUT103FS := Y and OUT103FS := N

Figure 2.16 shows a typical contactor application using the factory-default settings for output OUT102 and output OUT103. Note that the START Relay Word bit is used to start the motor in addition to the manual start pushbutton. This allows internal relay logic to start the motor. *Figure 4.27* shows the logic the relay uses to initiate motor starts.

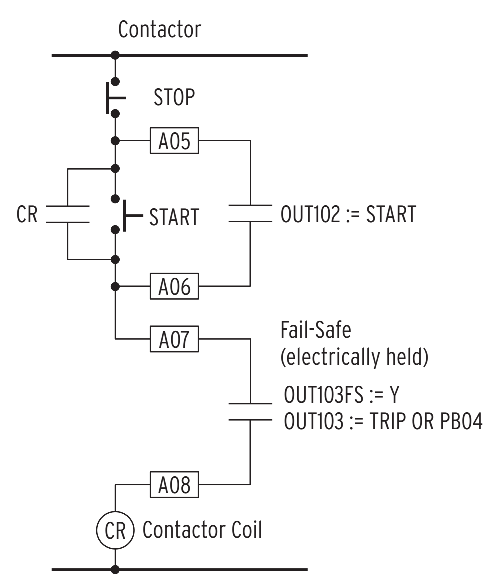


Figure 2.16 Contactor Application Using Factory-Default Settings

High-Speed, High-Current Interrupting DC Tripping Outputs

High-speed outputs are optimized for direct tripping of power circuit breakers. They operate in less than 50 µs, work with dc trip coil circuits, are polarity insensitive and capable of making 30 A, and can interrupt 10 A with an 8 ms dropout time. High-speed outputs are implemented as hybrid circuits, each of which consists of the parallel combination of a high-current, solid-state switch and an electromechanical bypass relay.

Avoid using high-speed outputs to drive highly sensitive, high-input-resistance electronic inputs (e.g., <2 mA electronic circuits) unless such inputs are connected in parallel with a low-resistance load (e.g., a breaker trip coil). Avoid connecting multiple high-speed outputs in parallel when driving highly sensitive electronic inputs. Keep wiring short, and use fiber-based MIRRORED BITS communications to bridge longer distances.

Voltage Connections

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

With the voltage inputs option, the AC voltages may be directly connected, wye-wye VT connected, open-delta VT connected, or a single-phase VT can be used. *Figure 2.17* and *Figure 2.18* show the methods of connecting single-phase and three-phase voltages.

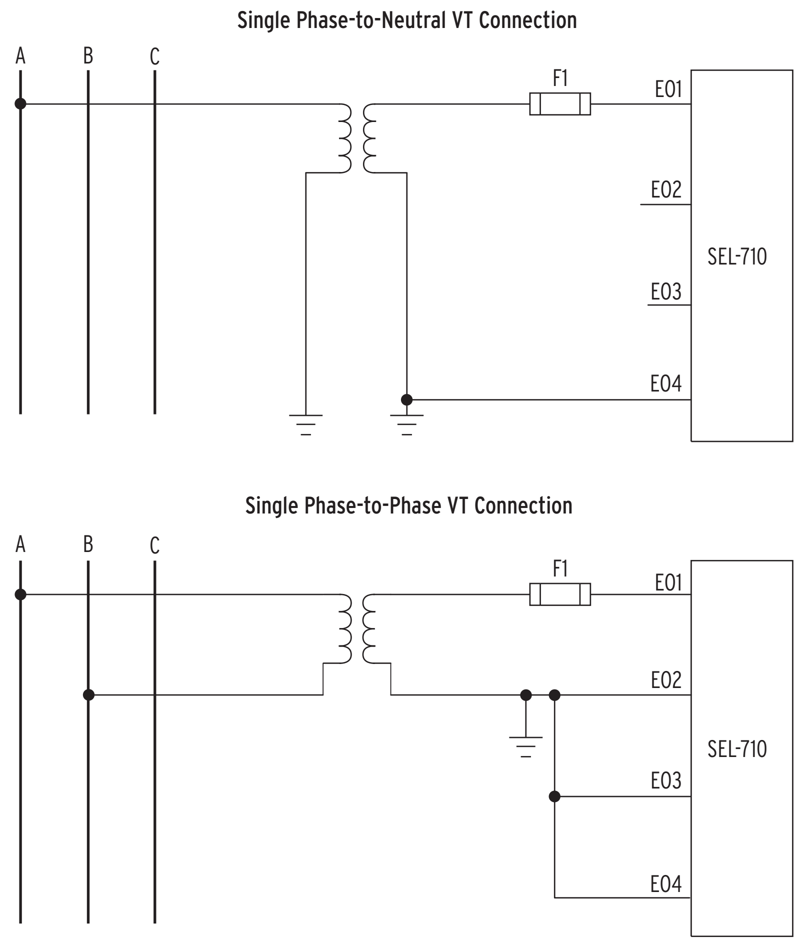
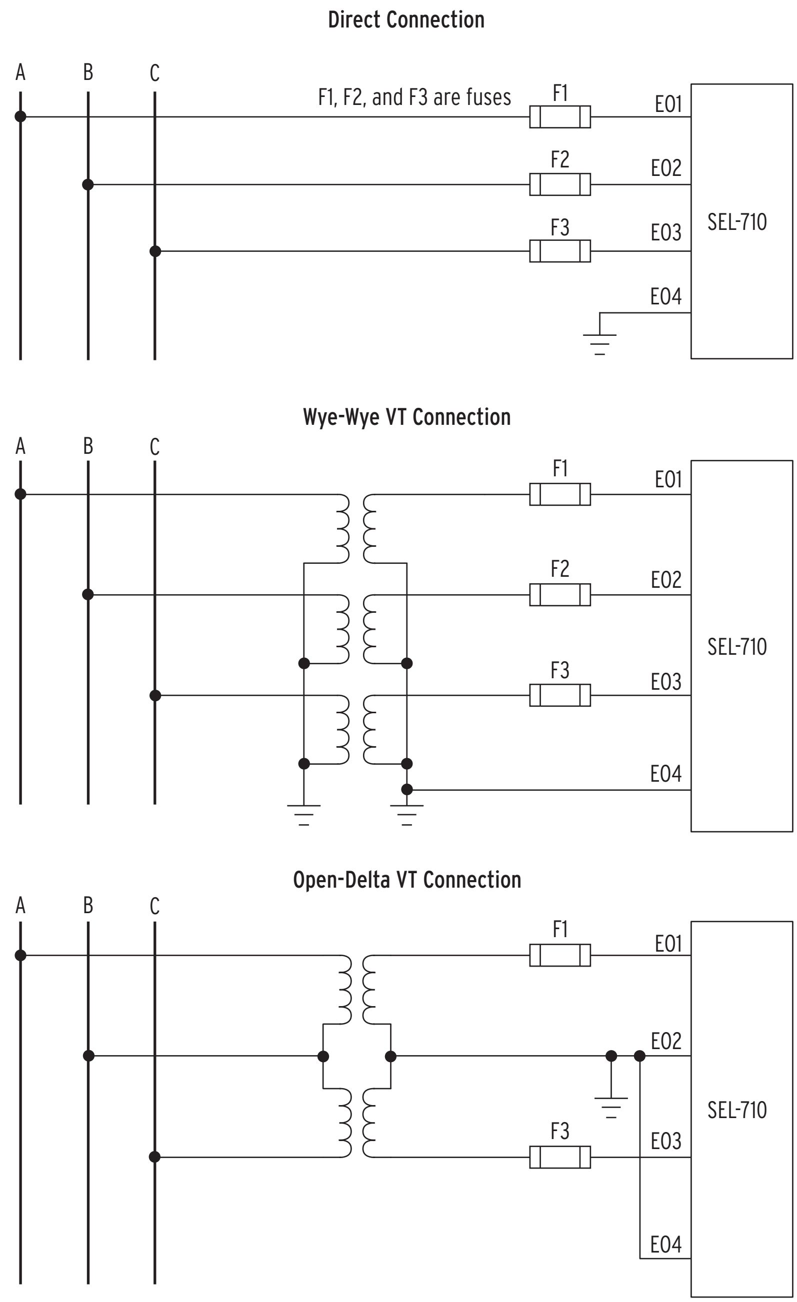


Figure 2.17 Single-Phase Voltage Connections

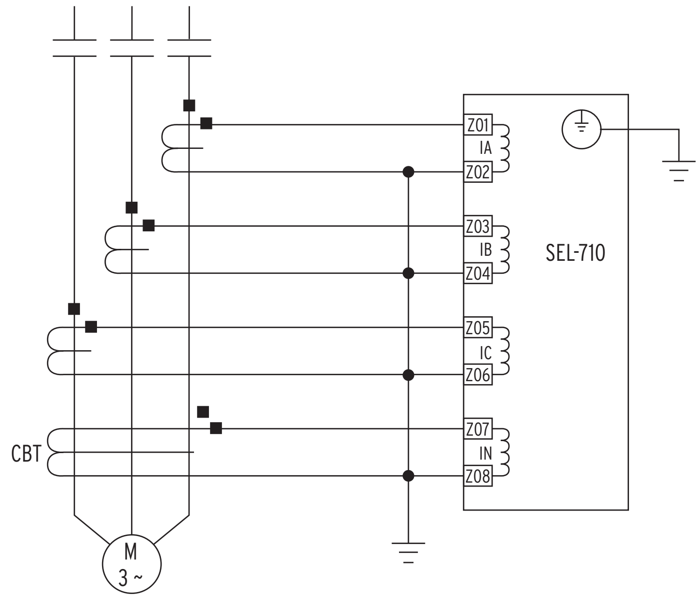


The VT secondary circuit should be grounded in the relay cabinet.

For open-delta VT connections, the figure shows grounding Phase B (E02). You can choose to ground Phase A or Phase C instead of Phase B; however, keep the jumper between terminals E02 and E04 as is.

Figure 2.18 Voltage Connections

Across-the-Line Starting



CBT (core-balance current transformer)

The current transformers and the SEL-710 chassis should be grounded in the relay cabinet.

Figure 2.19 AC Connections With Core-Balance Neutral CT

Figure 2.20 and *Figure 2.21* show current circuit connections for the differential elements.

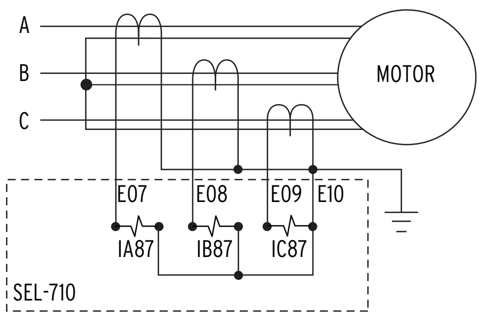


Figure 2.20 AC Connections With Core-Balance Differential CTs

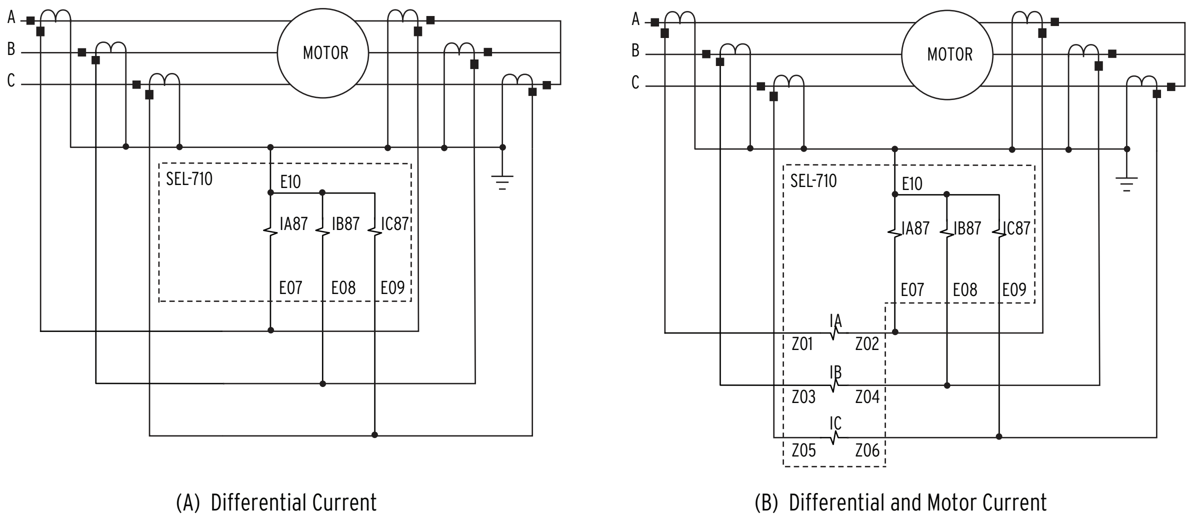


Figure 2.21 AC Connections With Source- and Neutral-Side CTs

The implementation in *Figure 2.22* requires the following settings:

OUT101 := SALARM OR HALARM
OUT103 := TRIP OR PB04
OUT103FS := Y

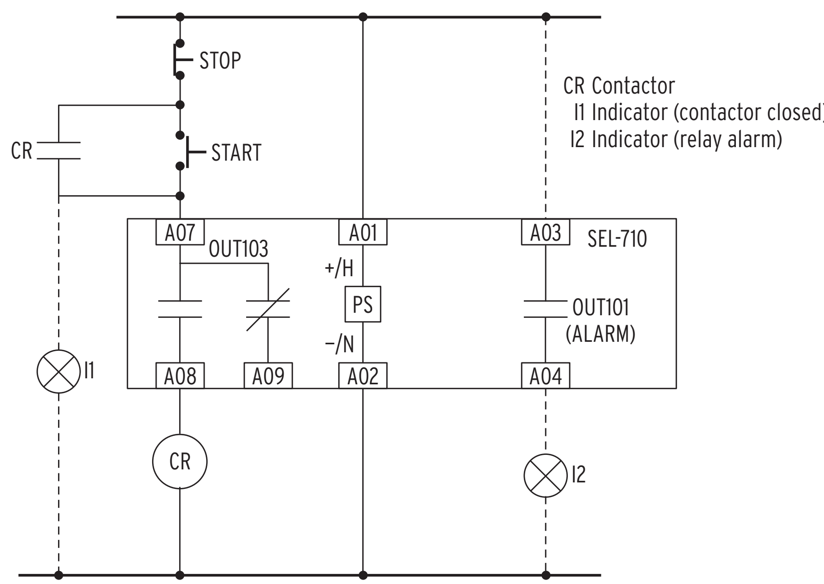


Figure 2.22 Control Connections for Fail-Safe Tripping

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 2.23* and *Figure 2.24* requires the following settings.

OUT101 := SALARM OR HALARM
OUT103 := TRIP OR PB04
OUT103FS := Y
OUT401 := DELTA
OUT402 := STAR

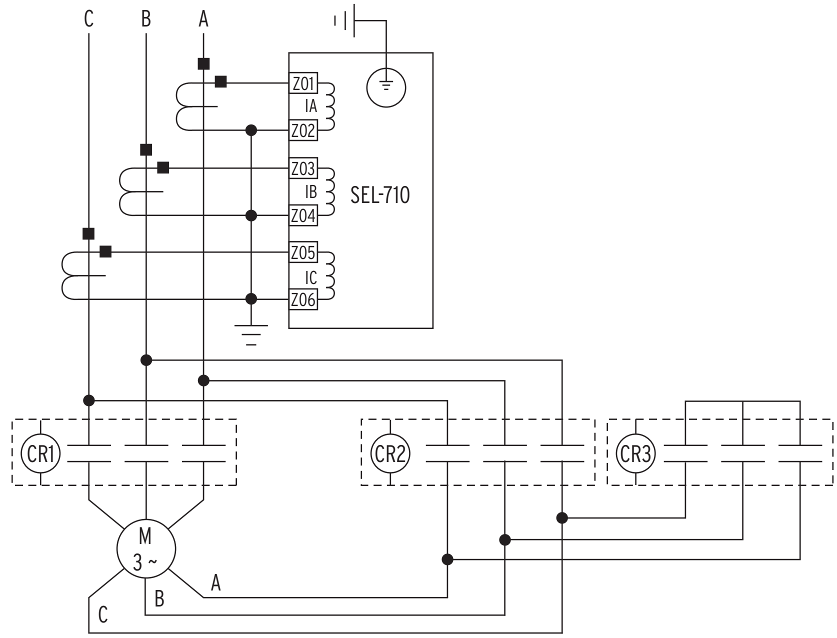


Figure 2.23 AC Connections for Star-Delta Starting

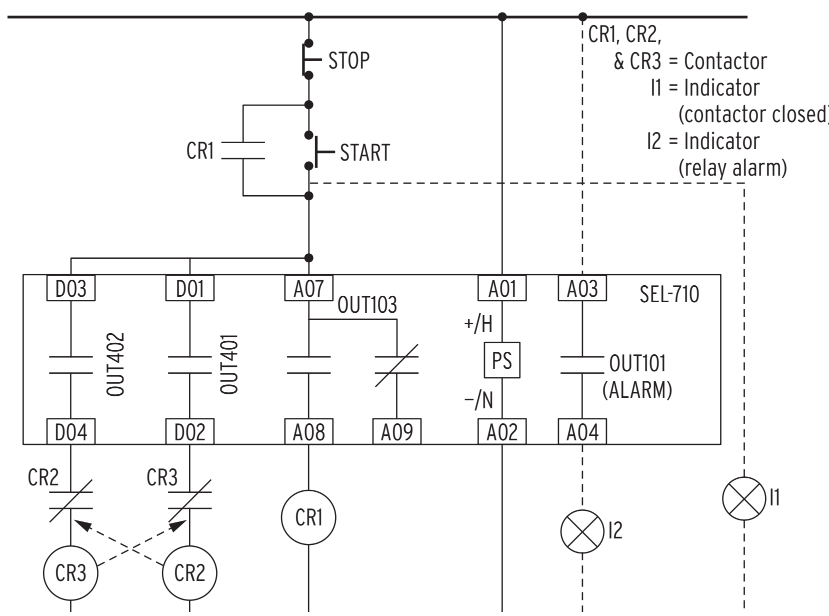


Figure 2.24 Control Connections for Star-Delta Starting

Two-Speed Motor

In *Figure 2.25*, 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

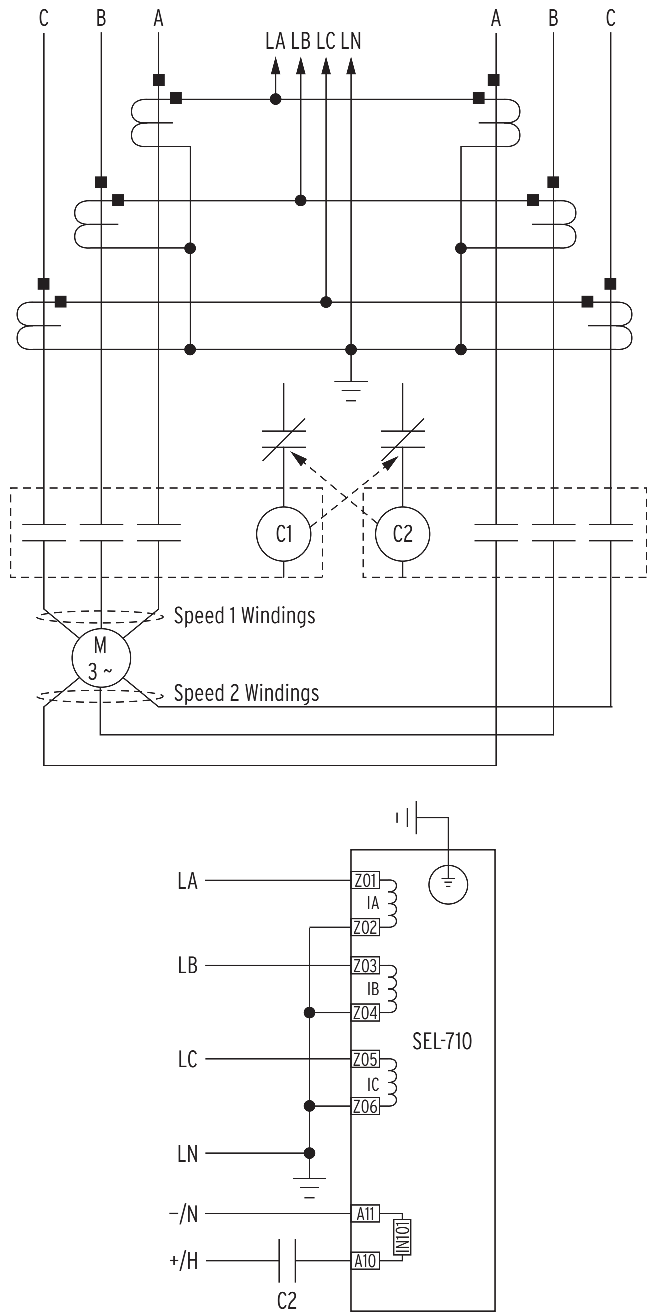


Figure 2.25 AC Connections for a Two-Speed Motor—Paralleled CTs

Full-Voltage Reversing Starter

Set FVR Phasing (FVR-PH) to identify the phase that is not affected by the Reverse contactor. For example, the FVR starter shown in *Figure 2.26* requires the following settings.

E2SPEED := Y FVR_PH := A SPEED2 := IN101

When phase CTs are located on the bus side of the contactor, set FVR_PH := NONE or set.

E2SPEED := N SPEED2 := 0

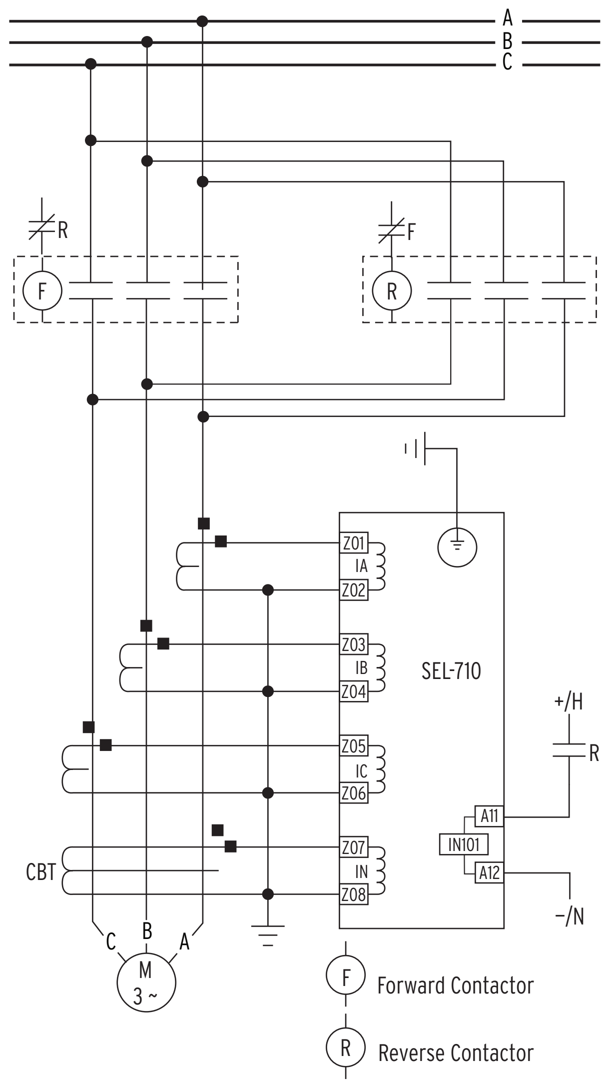


Figure 2.26 AC Connections for Full-Voltage Reversing (FVR) Starter

Field Serviceability

The SEL-710 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 may 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.

⚠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 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 BUSS S505 3.15A (ceramic), Schurter T 3.15A H 250V, or equivalent.

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

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

Real-Time Clock Battery Replacement

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with 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

SEL provides many PC software solutions (applications) to support the SEL-710 Motor Protection Relay as well as other SEL devices. *Table 3.1* lists the SEL-710 software solutions.

Table 3.1 SEL Software Solutions

Part Number	Product Name	Description
SEL-5030	ACSELERATOR QuickSet SEL-5030 Software	See *Table 3.2*.
SEL-5032	ACSELERATOR Architect SEL-5032 Software	Configures IEC 61850 communications.
SEL-5040	ACSELERATOR Report Server SEL-5040 Software	Automatically retrieves, files, and summarizes reports.
SEL-5601-2	SEL-5601-2 SYNCHROWAVE Event Software	Plots COMTRADE and SEL ASCII format event report oscillography; performs custom calculations on analog, digital, and complex quantities; and analyzes the Impedance Plane for distance element (mho) operation, the Alpha Plane for differential element (78L) operation, and the Bewley Lattice for traveling-wave data.
SEL-5801	SEL-5801 Cable Selector Software	Selects the proper SEL cables for your application.

This section describes how to get started with the SEL-710 and QuickSet. QuickSet is a powerful setting, event analysis, and measurement tool that aids in setting, applying, and using the SEL-710. *Table 3.2* shows the suite of QuickSet applications provided for the SEL-710.

Table 3.2 QuickSet Applications (Sheet 1 of 2)

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 relays in a database.
HMI	Provides a summary view of device operation. Use this feature to simplify commissioning.
Design Templates[a]	Allows you to customize relay settings to particular applications and store those settings in Design Templates. You can lock settings to match your standards or lock and hide settings that are not used.
Event Analysis	Provides oscillography and other event analysis tools.
Setting Database Management	QuickSet uses a database to manage the settings of multiple devices.

Table 3.2 QuickSet Applications (Sheet 2 of 2)

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-710 for use. Perform the following steps to initiate communications:

Step 1. Connect the appropriate communications cable between the SEL-710 and the PC.

Step 2. Apply power to the SEL-710.

Step 3. Start QuickSet.

Communications

QuickSet uses relay communications **Port 1** through **Port 4**, or **Port F** (front panel) to communicate with the SEL-710. Perform the following steps to configure QuickSet to communicate effectively with the relay.

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

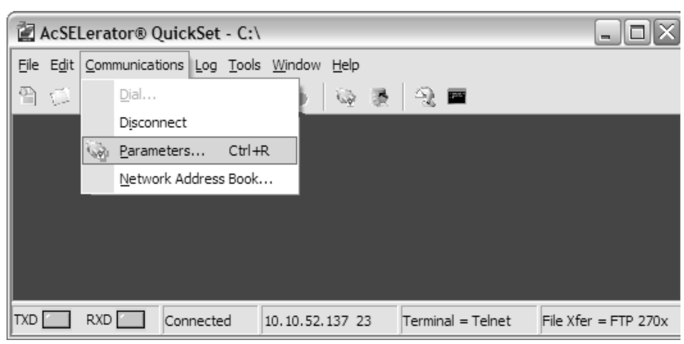


Figure 3.1 Serial Port Communications Dialog Box

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

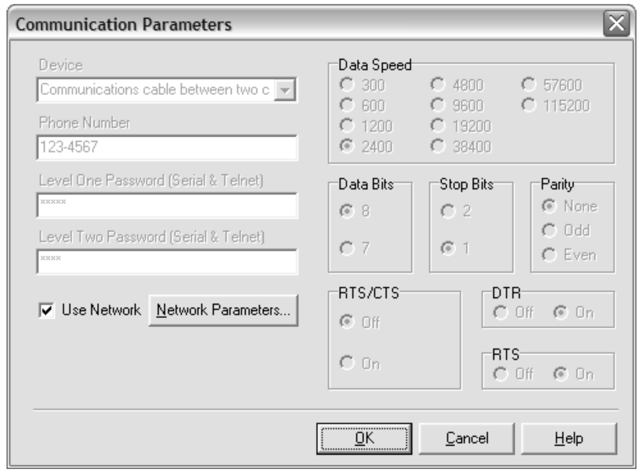


Figure 3.2 Serial Port Communications Parameters Dialog Box

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

Step 4. Configure QuickSet to match the SEL-710 default settings by entering Access Level 1 and Access Level 2 passwords in the respective text boxes.

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

Step 6. For network communications, check the **Use Network** check box and enter the network parameters as shown in *Figure 3.3*.

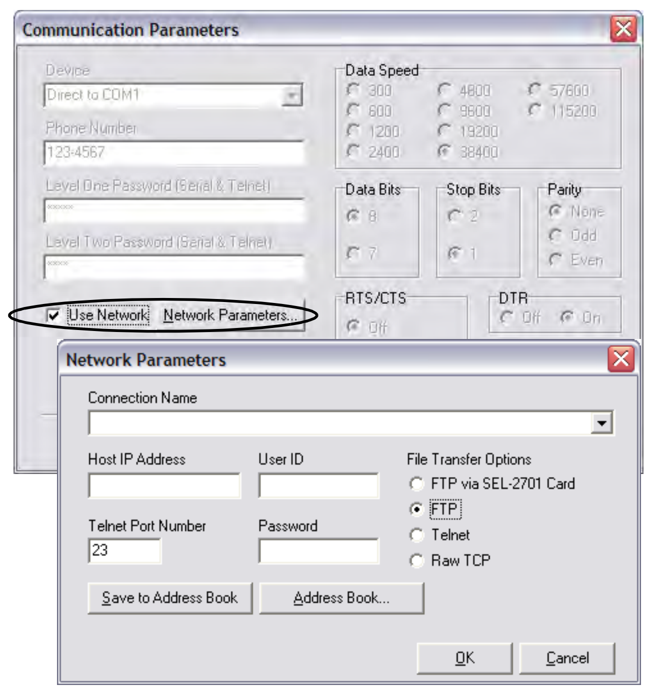


Figure 3.3 Network Communications Parameters Dialog Box

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

Terminal

Terminal Window

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

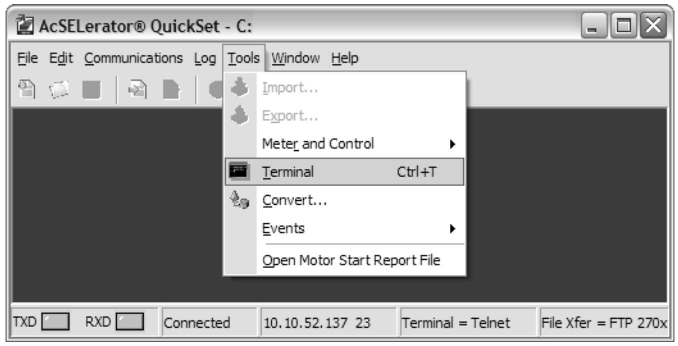


Figure 3.4 Tools Menu

The terminal window is an ASCII interface with the relay. This is a basic terminal emulation. Many third-party terminal emulation programs are available with file transfer encoding schemes. Open the terminal window by either clicking **Tools > 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 **Log** menu, and specify a file at the prompt. QuickSet records communications events and errors in this file. Click **Log > Connect Log** to view the log. Clear the log by selecting **Log > Clear Connection Log**.

Drivers and Part Number

After clicking **Tools > 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-710-X202-V0-Z002002-D20070507,08A6
BFID=BOOTLDR-R303-V0-Z000000-D20060612,0949
CID=0252,0246
DEVID=SEL-710,03C2
DEVCODE=66,0313
PARTNO=071001B0X6X7285121X,06C4
CONFIG=11111201,03EB
iedName =TEMPLATE,05DC
type =SEL_710,046A
configVersion =ICD-710-R101-V0-Z001001-D20070307,0D2F
=>
```

Figure 3.5 Device Response to the ID Command

Locate and record the Z number (Z001001) in the FID string. The first portion of the Z number (Z001…) determines the QuickSet relay settings driver version when you are creating or editing relay settings files. The use of the Device Editor driver version will be discussed in more detail later in this section—see *Settings Editor (Editor Mode) on page 3.8*. Compare the part number (PARTNO=0710XXXXXXXXXXXXXX) with the Model Option Table (MOT) to ensure the correct relay configuration.

Settings Database Management and Drivers

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

Database Manager

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

Settings Database

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

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

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

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

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

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

Copy/Move Settings Between Databases

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

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

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

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

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

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

Create a New Database, Copy an Existing Database

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

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

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

Step 3. Click **OK**.

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

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

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

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

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

Settings

QuickSet offers the capability of creating settings for one or more SEL-710 Relays. Store existing relay settings downloaded from SEL-710 Relays with QuickSet, creating a library of relay settings, then modify and upload these settings from the settings library to an SEL-710. QuickSet makes setting the relay easy and efficient. However, you do not have to use QuickSet to configure the SEL-710; you can use an ASCII terminal or a computer running terminal emulation software. QuickSet provides the advantages of rules-based settings checks, SELOGIC control equation Expression Builder, operator control and metering HMI, event analysis, and help.

Settings Editor

The Settings Editor shows the relay settings in easy-to-understand categories. The SEL-710 settings structure makes setting the relay easy and efficient. Settings are grouped logically, and relay elements that are not used in the selected protection scheme are not accessible. For example, if there is only one analog card installed in the relay, you can access settings for this one card only. Settings for the other slots are dimmed (grayed) in the QuickSet menus. QuickSet shows all of the settings categories in the settings tree view. The settings tree view remains constant whether settings categories are enabled or disabled. However, any disabled settings are dimmed when accessed by clicking an item in the tree view.

Settings Menu

QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own record of settings. Use the **File** menu to **Open** an existing record, create and open a **New** record, or **Read** relay settings from a connected SEL-710 and then create and open a new record. Use **Tools** menu to **Convert** and open an existing record. The record will be opened in the **Setting Editor** as a **Setting Form** (template) or in **Editor Mode**.

Table 3.3 File/Tools Menus

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

File > New

Selecting the **New** menu item creates new settings files. QuickSet makes the new settings files from the driver that you specify in the **Settings Editor Selection** dialog box. QuickSet uses the Z number in the FID string to create a particular version of settings. To get started making SEL-710 settings with the **Settings Editor** in the **Editor Mode**, select **File > New** from the main menu bar, and SEL-710 and **001** from the **Settings Editor Selection** window as shown in *Figure 3.6*.

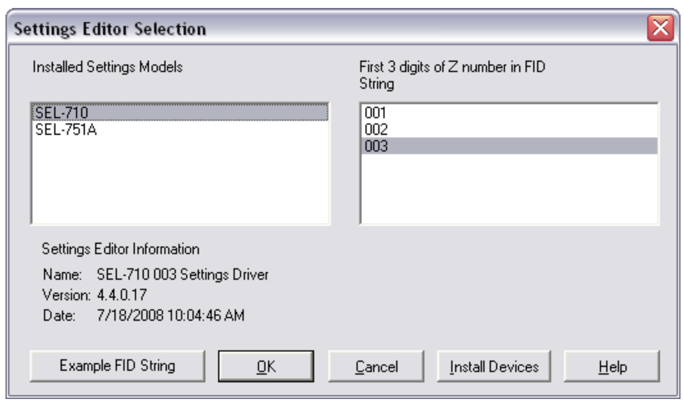


Figure 3.6 Driver Selection

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

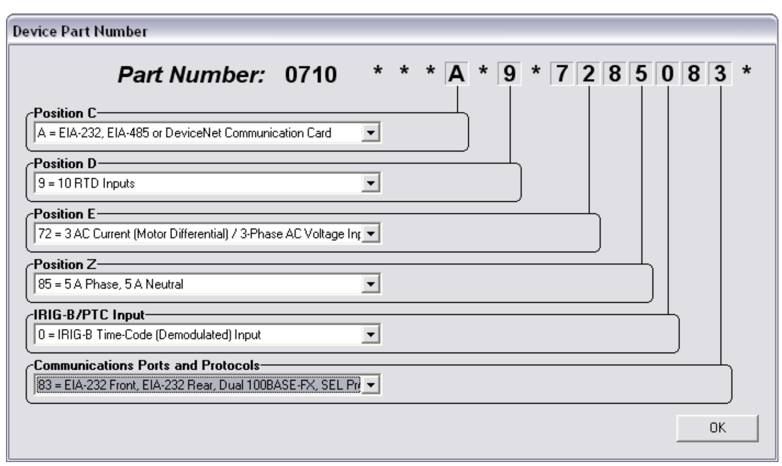


Figure 3.7 Update Part Number

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

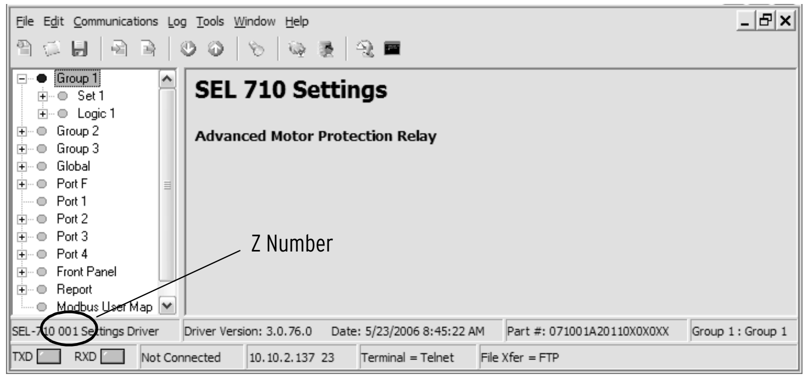


Figure 3.8 New Setting Screen

File > Open

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

File > Read

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

Tools > Convert

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

Settings Editor (Editor Mode)

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

Entering Settings

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

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

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

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

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

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

Expression Builder

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

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

Access the Expression Builder

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

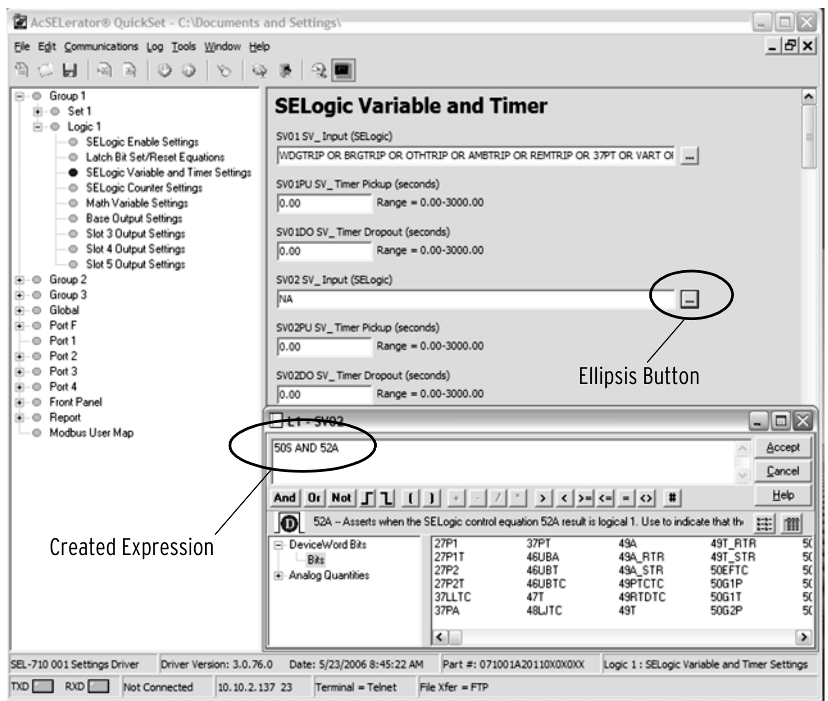


Figure 3.9 Expression Created With Expression Builder

Expression Builder Organization

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

Using the Expression Builder

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

File > Save

Select the **Save** menu item from the **File** menu item of the **Settings Editor** once settings are entered into QuickSet. This will help ensure the settings are not lost.

File > Send

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

Edit > Part Number

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

Text Files

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

Event Analysis

QuickSet has integrated analysis tools that help you retrieve information about relay operations quickly and easily. Use the event information that the SEL-710 stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.10* shows the event retrieval screen.

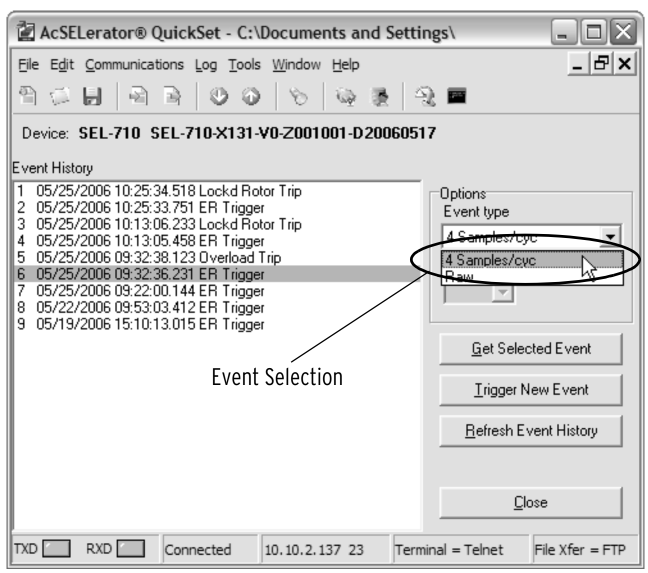


Figure 3.10 Retrieve Events Screen

Event Waveforms

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

View Event History

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

Get Event

Highlight the event you want to view (e.g., Event 3 in *Figure 3.10*), select the event type with the Options Event type function (4 samples or 16 samples), and click the **Get Selected Event** button. QuickSet then queries where to save the file on your computer, as shown in *Figure 3.11*.

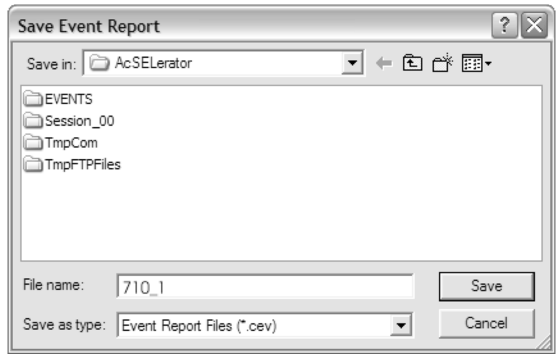


Figure 3.11 Save the Retrieved Event

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

View Event Files

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

Meter and Control

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

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

Device Overview

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

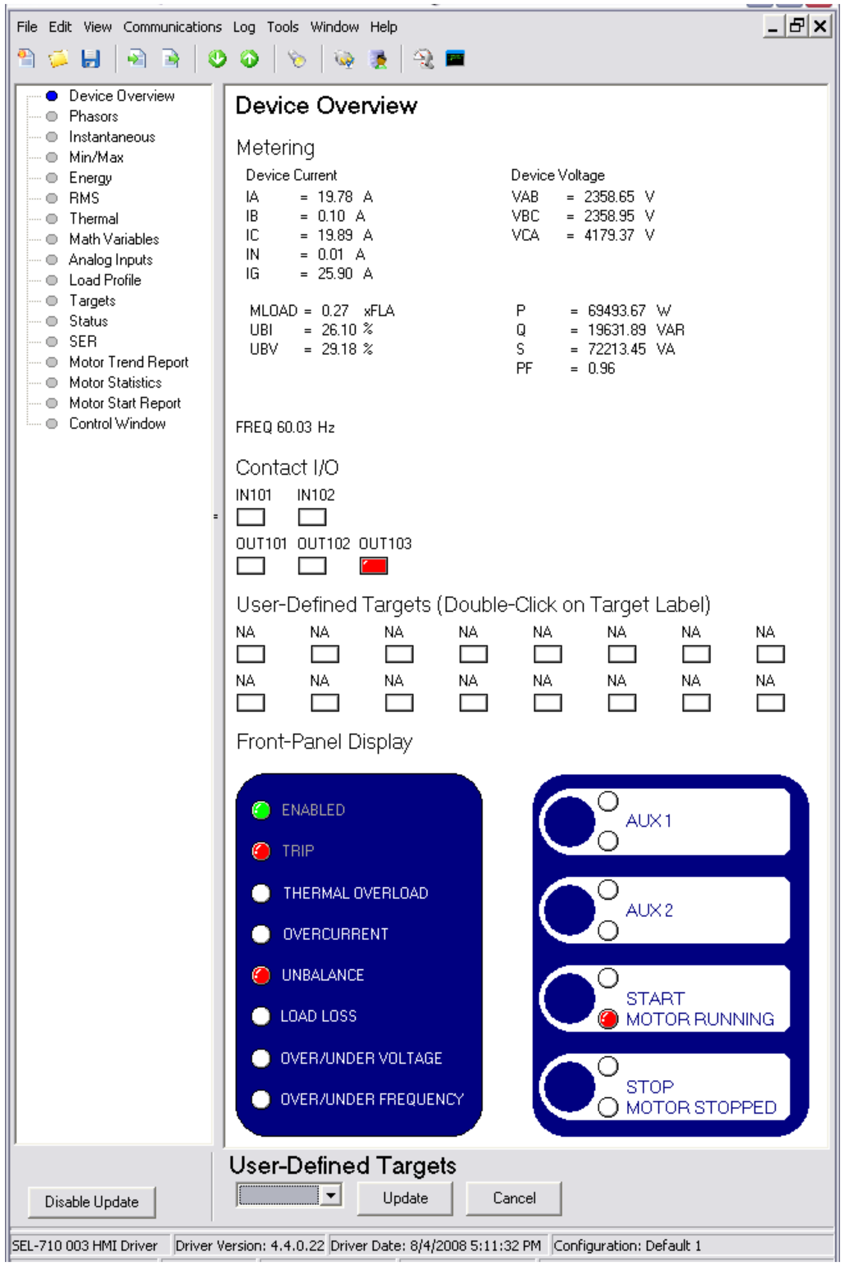


Figure 3.12 Device Overview Screen

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

The front-panel LEDs display the status of the 16 front-panel LEDs. Use the front-panel settings to change the front-panel LED assignment. The Phasors, Instantaneous, Min/Max, etc., screens display the corresponding values.

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

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

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*.

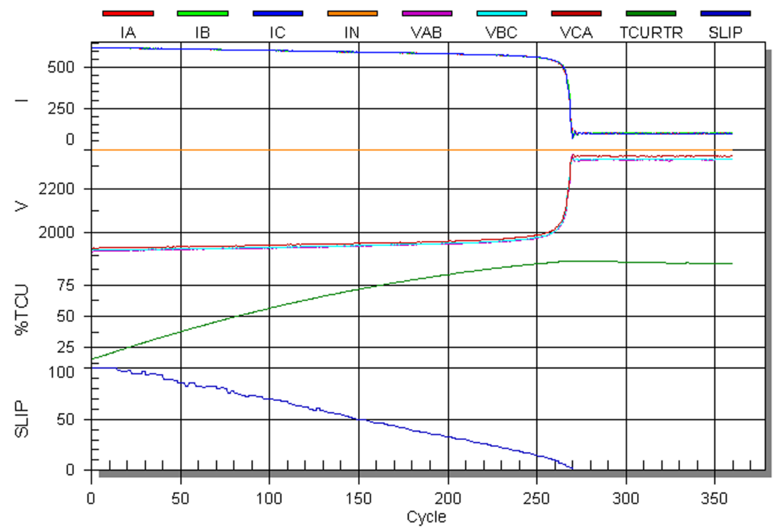


Figure 3.13 Graphical Display of Motor Start Report

Figure 3.14 shows the control screen. From here you can clear the Event History, MIRRORED BITS report, SER, trigger events, and reset metering data. You can also reset the targets, synchronize with IRIG, and set the time and date.

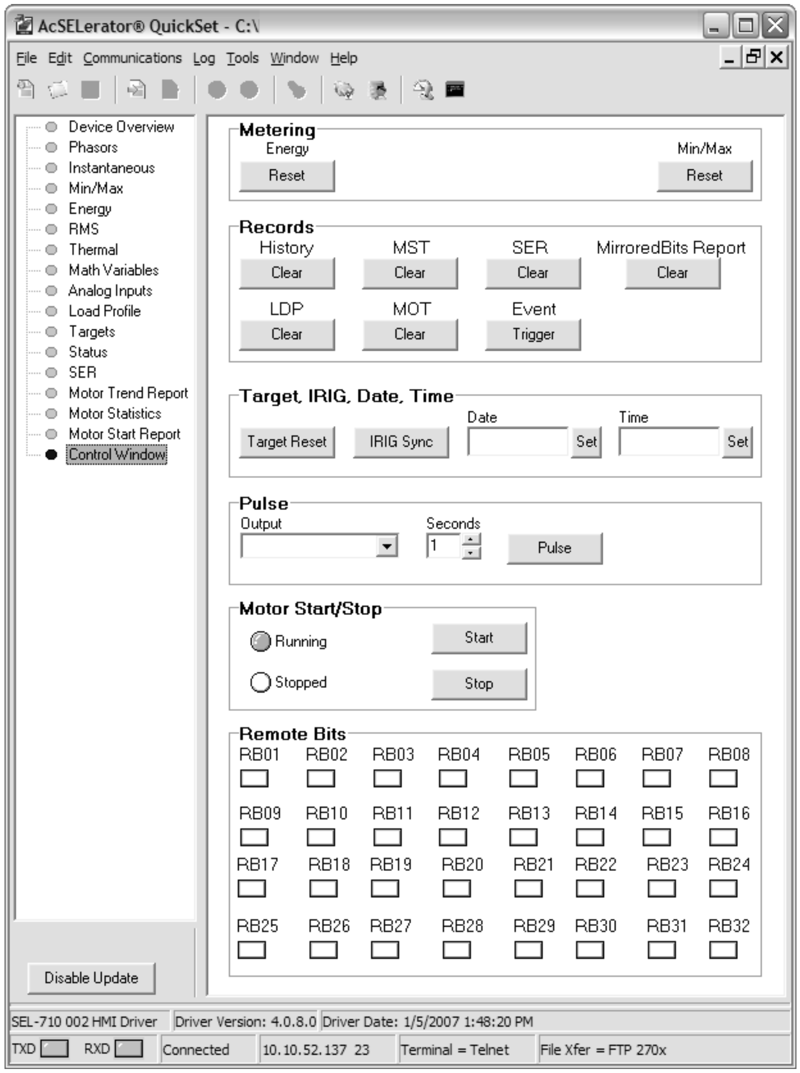


Figure 3.14 Control Screen

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

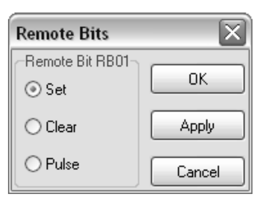


Figure 3.15 Remote Operation Selection

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

Help	Description
General QuickSet	Select **Help** from the main menu bar.
Relay Settings	Select **Help** > **Settings Help** from the main menu bar.

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Section 4
Protection and Logic Functions

Overview

NOTE: Each SEL-710 is shipped with default factory settings. Calculate the settings for your motor to ensure secure and dependable protection. Document and enter the settings (see Section 6: Settings).

This section describes the SEL-710 Motor Protection 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.

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.

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

Basic Motor Protection. Lists settings for protection elements included in all models of the SEL-710, 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. 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-710 with enhanced and/or expanded performance when optional voltage inputs are used.

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

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

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

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

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

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

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

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-710 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 F.1).

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

Application Data

It is faster and easier for you to calculate settings for the SEL-710 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
  - Full-load slip, per unit
  - Locked rotor torque, per unit
- 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 devices (RTDs), if used
- Expected fault current magnitudes for motor or cable ground and three-phase faults

Group Settings (SET Command)

ID Settings

All models of the SEL-710 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-710
UNIT ID LINE 2	16 Characters	TID := MOTOR RELAY

The SEL-710 prints the Relay and Terminal Identifier strings at the top of the responses to serial port commands to identify messages from individual relays.

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

Configuration Settings

NOTE: FLA setting is limited to 20-160% of CT primary rating. Refer to Table 6.6 for the allowable FLA/CTR ranges.

NOTE: The SEL-710 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 4.41).

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]
FVR PHASING	NONE, A, B, C	FVR_PH := NONE
NEUTRAL CT RATIO	1–2000	CTRN := 100

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

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.

The FLA settings are in primary amperes, see *Example 4.3* for sample calculations of Motor FLA. Always use the full-load current at rated voltage for the FLA setting, for example, when star-delta (see *Table 4.24*) or reduced voltage starting is used.

See the full-voltage reversing starter in *Full-Voltage Reversing Starter on page 2.29* for a description of the setting FVR_PH. *Table 4.3* shows the voltage settings for relay models with the optional voltage inputs.

Table 4.3 Voltage Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE PT RATIO	1.00–250.00	PTR := 35.00
LINE VOLTAGE[a]	100–30000 V	VNOM := 4160
XFMR CONNECTION	WYE, DELTA	DELTA_Y := DELTA
SINGLE V INPUT	Y, N	SINGLEV := N

[a] The line voltage setting is 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.

In applications where only a single voltage is available, set SINGLEV equal to Y. As shown in *Figure 2.17*, the single voltage must be connected to the A-phase input, but it may be an A-N or an A-B voltage. Be sure to set DELTA_Y equal to WYE for an A-N input or DELTA_Y equal to DELTA for an A-B input voltage.

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

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

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

VNOM/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 the 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 ungrounded phases by a factor of 1.732.

Basic Motor Protection

Thermal Overload Element

The SEL-710 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-710. 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, which is typical for a rotor limited motor. For a stator limited motor, see the discussions later in this section.

Rating Thermal Method (SETMETH := Rating or Rating_1). When this method is 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. When the optional settings full-load slip and locked rotor torque are set, the relay uses a slip-dependent thermal model during the motor start.

Curve Thermal Method (SETMETH := Curve). When selected, the relay offers 45 standard motor thermal limit curves, or you can construct a custom curve.

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 for stator and for rotor. When either % Thermal Capacity reaches 100 percent, the relay trips. You can see the present % Thermal Capacity values by using the relay front-panel `Meter > Thermal` function or the serial port **METER T** command. See *Appendix H: Motor Thermal Element* for more detail on the thermal model.

The SEL-710 uses setting SF as the overload pickup threshold. For IEC and NEMA motors with a service factor of 1.0, set SF between 1.05 and 1.2.

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 Capacities as 0, as noted in *Section 5: Metering and Monitoring*.

NOTE: For induction motors, set SLIPSRC := R1 and for synchronous motors, set SLIPSRC := STAT.

Table 4.4 Overload (Thermal Model) Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
OVERLOAD ENABLE	Y, N	E49MOTOR := Y
FULL LOAD SLIP	OFF, 0.0010–0.1000 pu	FLS := OFF
SLIP SOURCE	STAT, R1	SLIPSRC := R1
LOCKD RTR TORQUE	0.30–2.00 pu	LRQ := 0.80
THERMAL METHOD[a]	Rating, Rating_1, Curve	SETMETH := RATING
OL RESET LEVEL	10–99 %TCU	49RSTP := 75
SERVICE FACTOR	1.01–1.50	SF := 1.15
MOTOR LRA	2.5–12.0 xFLA	LRA1 := 6.0
LOCKD RTR TIME 1	1.0–600.0 s	LRTHOT1 := 10.0
ACCEL FACTOR	0.10–1.50	TD1 :=1.00
STATOR TC	Auto, 1–2000 min	RTC1 := AUTO

Table 4.4 Overload (Thermal Model) Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
MOTOR LRA–2nd	2.5–12.0 xFLA2	LRA2 := 6.0
LOCKD RTR TIME 2	1.0–600.0 s	LRTHOT2 := 10.0
ACCEL FACT–2nd	0.10–1.50	TD2 :=1.00
STATOR TC–2nd	Auto, 1–2000 min	RTC2 := AUTO
THERM OL CURVE1	1–46	CURVE1 := 5
THERM OL CURVE2	1–45	CURVE2 := 7

[a] The Curve Method is available for the SETMETH setting only when the FLS setting is OFF.

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. Full load slip (FLS) and locked rotor torque (LRQ) are optional. The relay automatically enhances the thermal model by using slip-dependent rotor resistance when FLS and LRQ are known (see *Appendix H: Motor Thermal Element* for details).

For high-inertia motor applications, consider the slip-dependent thermal model when FLS and LRQ data are available from the motor manufacturer. The speed switch element (see *Table 4.27*) provides additional locked rotor protection that is particularly useful in high-inertia motor applications when FLS/LRQ cannot be used (e.g., there are no voltage inputs). For synchronous motors, the FLS and LRQ are generally unavailable.

Rating Thermal Method

NOTE: When SETMETH := Rating, the relay automatically raises the initial heat estimate in the rotor model at Starting (motor current > 2.5 per unit of FLA) to a full-load operating level. You may observe a sudden rise in % Thermal Capacity value when you start the motor. This is normal operation for the SEL-710.

The SEL-710 runs rotor and stator models simultaneously. The rotor thermal model trips in locked rotor time at locked rotor current. Set SETMETH := Rating if you like the rotor model to trip in hot locked rotor time even when the rotor is at lower than normal operating temperatures. This is a conservative approach suitable for most applications where motor acceleration time is significantly less than hot locked rotor time. Set the SETMETH := Rating_1 if the acceleration time is close to hot locked rotor time. The stator model provides overload protection by limiting the stator heat energy estimate to a value represented by the overload settings.

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

The Relay Word bit 50S asserts when the motor current > 2.5 times FLA and deasserts when the current < 2.4 times FLA.

NOTE: The SEL-710 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 4.41).

EXAMPLE 4.3 Thermal Element Setting

A 4000 V, 600 HP motor is protected by the SEL-710 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 seconds
Hot = 15 seconds
Service Factor = 1.2

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

NOTE: When RTC is set to AUTO, the relay rounds the calculated value of RTC down if the decimal value is less than 5. The relay rounds the RTC value up if the decimal is equal to a value of 5 or higher.

Phase current transformers with 100:5 A rating are selected for the application. The SEL-710 settings for the application are calculated as shown below:

Current Transformer Ratio: CTR1 := 100/5 := 20 (see Group Settings (SET Command))

Full-Load Amps (FLA): FLA1 := 80 A primary (see Group 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

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

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

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

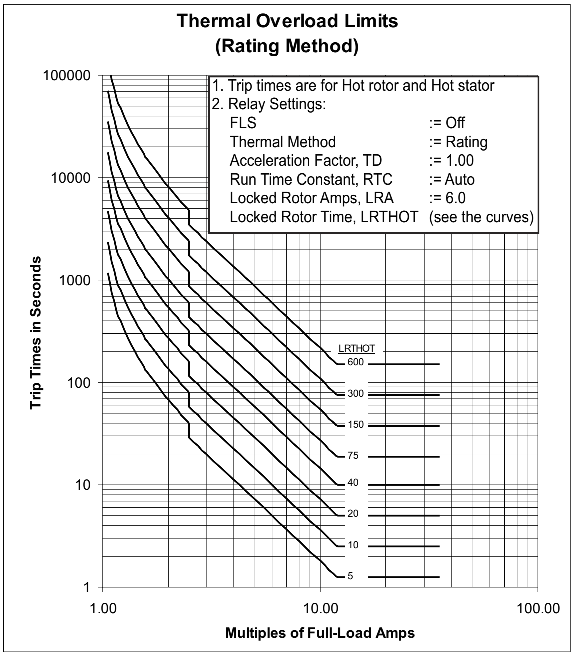
$$\mathrm{COOLTIME} > 3 \bullet \mathrm{RTC1} = 3 \bullet 39 + 1 = 118 \text{ minutes}$$

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

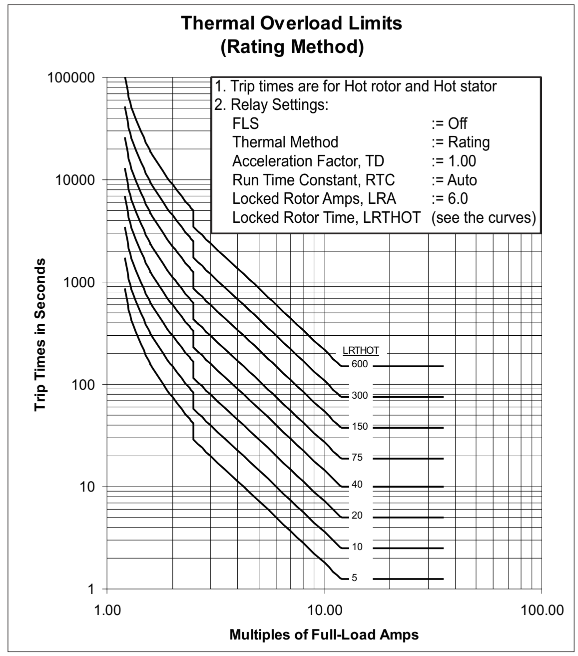
$$\mathrm{RTC} = \frac{\mathrm{LRTHOT}}{60 \bullet \ln\left[\frac{\mathrm{LRA}^2 - 0.4^2}{\mathrm{LRA}^2 - \mathrm{SF}^2}\right]} \text{ minutes}$$

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

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 4.27*) to provide locked rotor protection. See *Figure 4.1* for the thermal overload limits for selected settings. *Thermal Element Trip-Time Equations on page H.9* shows the equations for these and additional curves as well as definitions for hot stator and hot rotor.



(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.

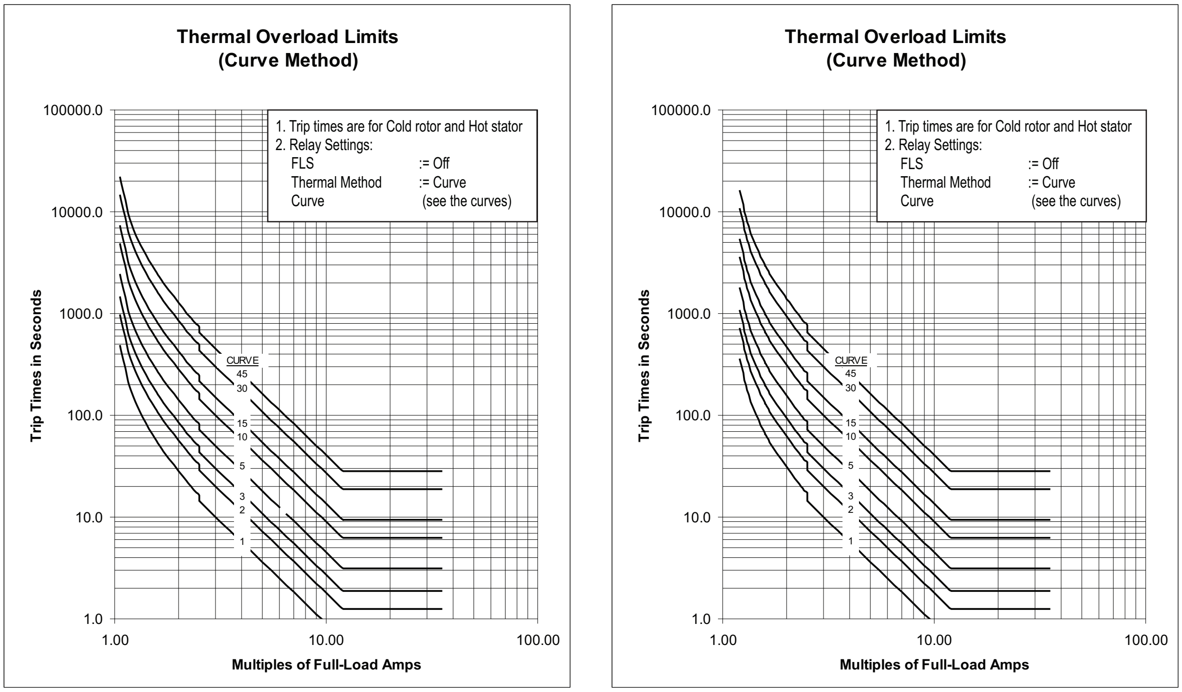
Setting the TD1 equal to 0.75 causes the relay to trip in 7.5 seconds under locked rotor conditions. This setting allows ample time for the motor to start, but does not subject the motor to the full 10 seconds of locked rotor current if a locked rotor start attempt takes place.

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, or set Curve := 46 to configure a custom curve, then, set the motor-rated Full-Load Amps and Service Factor. Based on the curve number, the relay automatically determines and hides LRA, LRTHOT, TD, and RTC settings.
- ➤ The relay does not raise the initial heat estimate at starting (motor current > 2.5 per unit of FLA). 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). The Relay Word bit 50S asserts if the thermal element is in the rotor model (motor current > 2.5 times FLA) and deasserts if in the stator model (motor current < 2.5 times FLA).

Figure 4.2 shows several of the available curves. *Thermal Element Trip-Time Equations on page H.9* shows the equations 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 the full-load current. For a cold rotor, the curve 10 trip time at six times the full-load current is 25 seconds. *Table 4.5* shows the thermal limit time versus current for several curves.



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

Figure 4.2 Thermal Overload Limits (Curve Method)

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 the full-load current.

Table 4.5 Thermal Limit Tripping Times in Seconds vs. Multiples of Full-Load Amps (Service Factor = 1.01)[a] (Sheet 1 of 2)

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	Stator 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	

Table 4.5 Thermal Limit Tripping Times in Seconds vs. Multiples of Full-Load Amps (Service Factor = 1.01)[a] (Sheet 2 of 2)

Multiples of FLA	Curve 1	Curve 2	Curve 3	Curve 5	Curve 10	Curve 15	Curve 30	Curve 45	Remarks
2.50	14.40	28.80	43.20	72.00	144	216	432	648.0	Rotor 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).

EXAMPLE 4.5 Thermal Element Curve Method Setting

A 4160 V, 800 HP motor is to be protected through use of the SEL-710 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 the full-load current. Therefore, we can select the maximum curve number by using the following equation:

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

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

Phase current transformers having 150:5 ratios are selected for the application. Following are the SEL-710 settings for the application.

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, and LRTHOT=Curve# • 2.08.]
RTC = 81 minutes
COOLTIME = 3 • 81 + 1 = 244 minutes

NOTE: Refer to AG2018-23: Testing Curve 46 in SEL Motor Protection Relays for more details on testing user-defined thermal curve 46 in SEL motor protection relays.

When the thermal element setting method is set to CURVE1 := 46, the relay allows you to construct a custom motor protection curve using as few as 5 or as many as 28 thermal limit points. The relay requires:

- The Full-Load Amps and Service Factor ratings for the motor.
- Time to Trip settings at 2.00 and 2.50 times Full-Load Amps for overload protection (hot stator trip-times).
- Time to Trip settings at 5.50, 6.00, and 6.50 times Full-Load Amps for locked rotor protection (cold rotor trip-times).

If you wish to emulate a manufacturer's specified thermal limit curve, you must enter additional time points along the curve. If you do not enter a time for a point, enter AUTO. The relay automatically uses a calculated thermal limit time between the entered time points.

You may use this method if the motor thermal limit curve includes a discontinuity between the stator limit curve and the locked rotor limit curve, as shown in *Figure 4.3*. See *Table 4.6* for the available settings to construct a custom curve.

NOTE: Trip times for FL values up to 2.5 FL are Hot Stator trip times. Trip times for FL values greater than 2.5 FL are Cold Rotor trip times.

Table 4.6 Thermal Element Configuration Settings, Setting Method Curve and Curve1 := 46 (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name = Example Setting
Trip Time @ 1.05 FL	1.0–6000.0 s, Auto	TTT105 := AUTO
Trip Time @ 1.10 FL	1.0–6000.0 s, Auto	TTT110 := AUTO
Trip Time @ 1.20 FL	1.0–6000.0 s, Auto	TTT120 := AUTO
Trip Time @ 1.30 FL	1.0–6000.0 s, Auto	TTT130 := AUTO
Trip Time @ 1.40 FL	1.0–6000.0 s, Auto	TTT140 := AUTO
Trip Time @ 1.50 FL	1.0–6000.0 s, Auto	TTT150 := AUTO
Trip Time @ 1.75 FL	1.0–6000.0 s, Auto	TTT175 := 625.0
Trip Time @ 2.00 FL	1.0–6000.0 s	TTT200 := 400.0
Trip Time @ 2.25 FL	1.0–6000.0 s, Auto	TTT225 := AUTO
Trip Time @ 2.50 FL	1.0–6000.0 s	TTT250 := 225.0
Trip Time @ 2.75 FL	1.0–6000.0 s, Auto	TTT275 := AUTO
Trip Time @ 3.00 FL	1.0–6000.0 s, Auto	TTT300 := AUTO
Trip Time @ 3.50 FL	1.0–6000.0 s, Auto	TTT350 := AUTO
Trip Time @ 4.00 FL	1.0–6000.0 s, Auto	TTT400 := 72.0
Trip Time @ 4.50 FL	1.0–6000.0 s, Auto	TTT450 := 58.0
Trip Time @ 5.00 FL	1.0–600.0 s, Auto	TTT500 := 30.0
Trip Time @ 5.50 FL	1.0–600.0 s	TTT550 := 25.0
Trip Time @ 6.00 FL	1.0–600.0 s	TTT600 := 18.1
Trip Time @ 6.50 FL	1.0–600.0 s	TTT650 := 15.2
Trip Time @ 7.00 FL	1.0–600.0 s, Auto	TTT700 := 13.2
Trip Time @ 7.50 FL	1.0–600.0 s, Auto	TTT750 := AUTO
Trip Time @ 8.00 FL	1.0–600.0 s, Auto	TTT800 := AUTO
Trip Time @ 8.50 FL	1.0–600.0 s, Auto	TTT850 := AUTO
Trip Time @ 9.00 FL	1.0–600.0 s, Auto	TTT900 := AUTO

Table 4.6 Thermal Element Configuration Settings, Setting Method Curve and Curve1 := 46 (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name = Example Setting
Trip Time @ 9.50 FL	1.0–600.0 s, Auto	TTT950 := AUTO
Trip Time @10.0 FL	1.0–600.0 s, Auto	TTT1000 := AUTO
Trip Time @ 11.0 FL	1.0–600.0 s, Auto	TTT1100 := AUTO
Trip Time @ 12.0 FL	1.0–600.0 s, Auto	TTT1200 := AUTO

EXAMPLE 4.6 Thermal Element Curve Method, Curve := 46

A 4000 V, 3000 HP motor is to be protected using the SEL-710 Relay Thermal Element Curve Method. The motor data sheet includes the following information:

Rated Horsepower (HP) = 3000 HP
Rated Voltage (V) = 4000 V
Rated Full-Load Current (A) = 366 A
Rated Locked Rotor Amps (A) = 2380 A
Safe Stall Time at 100% Volts
Cold = 16 seconds
Hot = 12 seconds
Service Factor = 1.25

The motor data sheet also includes the Thermal Limit Curve shown in Figure 4.3.

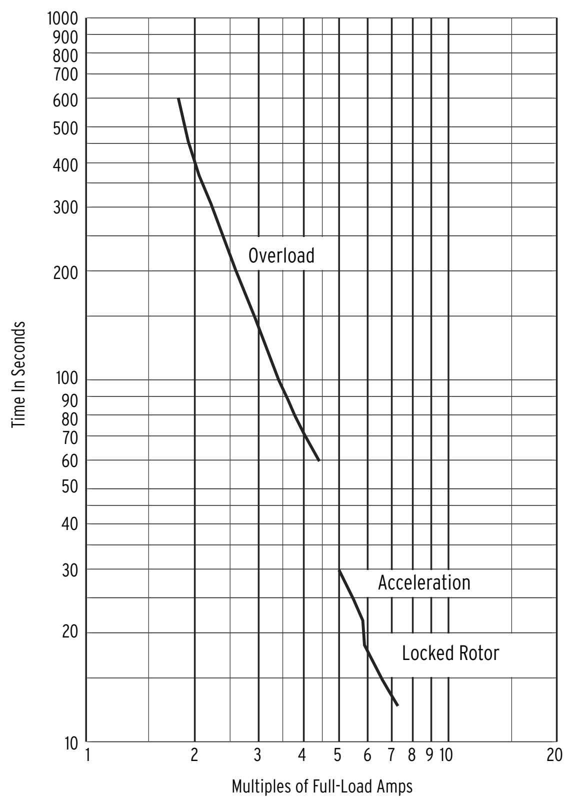


Figure 4.3 3000 HP Example Motor Thermal Limit Curve

The discontinuities in the thermal limit curve between the Overload, Acceleration, and Locked Rotor curve sections make this motor ideal for protection using a purpose-built thermal limit curve. The Curve setting method provides the facility to protect this motor.

By examining the curve, we can find the thermal limit times at various multiples of Full-Load Current, as listed in *Table 4.7*. These times map directly to the relay settings shown.

Table 4.7 3000 HP Motor Thermal Limit Times

Multiples of Full-Load Current	Thermal Limit Time (Seconds)
1.75	625
2.00	400
2.50	225
4.00	72
4.50	58
5.00	30
5.50	25
6.00	18.1
6.50	15.2
7.00	13.2

Phase current transformers having 500:5 ratios are selected for the application. The SEL-710 settings for the application are calculated as follows.

Current Transformer Ratio (CTR) = 500/5 = 100
Full-Load Amps (FLA) = 366 A primary
Service Factor (SF) = 1.25
Time to Trip at 1.30 x FLA (TTT130) = AUTO
Time to Trip at 1.40 x FLA (TTT140) = AUTO
Time to Trip at 1.50 x FLA (TTT150) = AUTO
Time to Trip at 1.75 x FLA (TTT175) = 625.0 seconds
Time to Trip at 2.00 x FLA (TTT200) = 400.0 seconds
Time to Trip at 2.25 x FLA (TTT225) = AUTO
Time to Trip at 2.50 x FLA (TTT250) = 225.0 seconds
Time to Trip at 2.75 x FLA (TTT275) = AUTO
Time to Trip at 3.00 x FLA (TTT300) = AUTO
Time to Trip at 3.50 x FLA (TTT350) = AUTO
Time to Trip at 4.00 x FLA (TTT400) = 72.0 seconds
Time to Trip at 4.50 x FLA (TTT450) = 58.0 seconds
Time to Trip at 5.00 x FLA (TTT500) = 30.0 seconds
Time to Trip at 5.50 x FLA (TTT550) = 25.0 seconds
Time to Trip at 6.00 x FLA (TTT600) = 18.1 seconds
Time to Trip at 6.50 x FLA (TTT650) = 15.2 seconds
Time to Trip at 7.00 x FLA (TTT700) = 13.2 seconds
Time to Trip at 7.50 x FLA (TTT750) = AUTO
Time to Trip at 8.00 x FLA (TTT800) = AUTO
Time to Trip at 8.50 x FLA (TTT850) = AUTO
Time to Trip at 9.00 x FLA (TTT900) = AUTO
Time to Trip at 9.50 x FLA (TTT950) = AUTO
Time to Trip at 10.0 x FLA (TTT1000) = AUTO
Time to Trip at 11.0 x FLA (TTT1100) = AUTO
Time to Trip at 12.0 x FLA (TTT1200) = AUTO

The relay neither requests settings for thermal limit times less than the service factor nor does it require that all settings have a time entered. You can enter AUTO for some points and the relay automatically builds the thermal limit curve between the nearest two specified points. For instance, a relay thermal limit characteristic between 2.5 and 4.0 times Full-load Amps forms a continuous curve between 225 seconds and 72 seconds.

When SETMETH := CURVE and CURVE := 46, then the relay uses the following equation to calculate TD and RTC1 values:

$$\mathrm{TD} = \frac{\mathrm{TTT600}}{\mathrm{Ta}} \text{ where } \mathrm{Ta} = \frac{(\mathrm{TTT550} + \mathrm{TTT600} + \mathrm{TTT650})}{3}$$

and

$$\mathrm{RTC1} = \frac{\mathrm{LRTHOT1} \bullet (\mathrm{TD} + 0.2)}{60 \bullet \ln\left(\dfrac{36 - (0.9 \bullet \mathrm{SF})^2}{36 - (\mathrm{SF})^2}\right)} \text{ minutes}$$

Equation 4.1

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

Additional Thermal Overload Settings

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

Table 4.8 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
LEARN TCSTART?	Y, N	TCL9RNEN := Y
STOP COOL TIME	1–6000 min	COOLTIME := 84
STOP COAST TIME	1–3600 sec	COASTIME := 5
LEARN COOLTIME?	Y, N	COOLEN := N
OL RTD BIASING	Y, N	ETHMBIAS := N

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

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

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

Equation 4.2

The motor tripping and starting functions include supervision to help prevent a thermal trip on a normal start. The relay prevents motor starting until the thermal element has enough available rotor thermal capacity to allow a motor start without tripping. Set the start inhibit level TCSTART greater than the rotor thermal capacity required to start (Start TCU) the motor. Refer to *Figure 4.41*, which shows the TCSTART usage for the thermal lockout logic. This feature can be disabled by setting TCSTART equal to OFF.

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

Equation 4.3

NOTE: A 5–10% margin is suggested for Equation 4.2, Equation 4.3, and Equation 4.4.

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

$$49RSTP < \frac{100}{SF^2}$$

Equation 4.4

When you use the Use Learned Starting Thermal Capacity function (TCLRNEN := Y and TCSTART ≠ Off), the relay records the thermal capacity used during the past five starts and uses it in the thermal model in place of the TCSTART setting. The learned TCSTART is 115 percent of the largest of the last five starting thermal capacities. The relay records the thermal capacity and uses it in the thermal model in place of the TCSTART setting. The relay requires that the rotor thermal model cool enough to permit that start.

EXAMPLE 4.7 Learned Starting Thermal Capacity Calculation

Over the past five starts, a motor has used 24%, 27%, 22%, 25%, and 26% of thermal capacity. The largest thermal capacity to start is 27%. The relay requires that the present thermal capacity drop below 69% (100%–31%) before a new start is allowed.

You can view the present learned thermal capacity to start (Start TC) using the serial port **MOTOR** command or the front-panel `Monitor\Display Mot Data\Learn Parameters` (see *Figure 8.6*).

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

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 4.5*:

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

Equation 4.5

where:

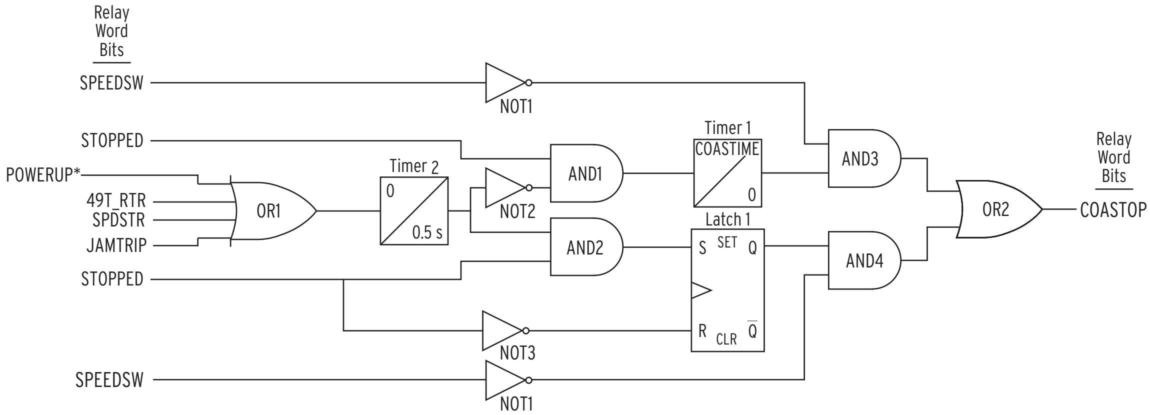
RTC= RTC1 or RTC2 (whichever is higher)

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

NOTE: Normal motor starts are inhibited until the COASTOP Relay Word bit asserts; however, the emergency start is not. See Start Inhibit Function on page 4.38.

Set COASTIME to 90–95% of the time the motor coasts before the rotor stops on a normal stop. The relay automatically delays the use of the slower cooling rate (based on COOLTIME) by this setting, which can significantly reduce the wait time before the next start may be allowed by thermal lockout. *Figure 4.4* shows the coast-stop logic diagram. If the normal motor coast time is not available or if it is not necessary to minimize the wait time before the next start, you can safely leave the COASTIME setting at the default value of 5 seconds.



* POWERUP is an internal bit; it asserts for 1/4 cycle every time the relay turns on.

Figure 4.4 Coast-Stop Logic Diagram

When the relay monitors one or more RTDs in the motor windings and an ambient temperature RTD, the relay learns the stator cooling time by monitoring the winding temperature when the motor is stopped. If you set Use Learned Cooling Time (COOLEN) equal to Y, the relay learns the cooling time over five stops and uses it in the thermal model in place of the Motor Stopped Cooling Time setting. However, when no ambient RTD is selected in the settings or if the ambient RTD/winding RTD has failed open or short, and COOLEN is set to Y, the relay does not learn the stator cooling time over five stops and continues to use the COOLTIME setting. *Figure 4.5* shows the **MOT** command response for this case.

```
=>>MOT <Enter>

SEL-710                                 Date: 05/23/2017   Time: 06:57:48.679
MOTOR RELAY                             Time Source: Internal

Operating History (elapsed time in ddd:hh:mm)
Last Reset Date    03/04/2016
Last Reset Time      21:34:53
Running Time          3:18:01
Stopped Time       >  315:22:00
Time Running (%)          1.2
Total MWhr (MWhr)         0.3
Number of Starts           55
Emergency Starts            1

Avg/Peak Data
                 AVERAGE     PEAK
Start Time (s)      64.4   1598.4
Max Start I (A)    865.9   1907.0
Min Start V (V)     54.7      0.0
Start %TCU         175.1   6553.5
Running %TCU         0.1     48.3
RTD %TCU             0.0     31.0
Running Cur (A)     63.3   1901.7
Running kW           2.3   1997.2
Running kVARin       0.0      7.0
Running kVARout      0.0     14.5
Running kVA          2.3   1997.2
Max WDG RTD (C)       71       72
Max BRG RTD (C)      119      120
Ambient RTD (C)      121      200
Max OTH RTD (C)  NA       NA
```

Figure 4.5 MOTOR Command Response

```
Learn Parameters
CoolTime (s)  Insufficient Data
Start TC (%)  Insufficient Data

Trip/Alarm Data
                ALARMS  TRIPS
Overload            0      0
Locked Rotor       18     17
Undercurrent        0      0
Jam                 0      0
Current Imbal       0      1
Overcurrent         0      8
Ground Fault        0      0
Speed Switch        0      0
Undervoltage        2      0
Overvoltage         0      0
Underpower          0      0
Power Factor        0      0
Reactive Power      0      0
RTD                12      4
Phase Reversal             2
87M Phase Diff             0
Underfrequency             3
Overfrequency              0
Start Timer                0
Remote Trip                0
Other Trips                0
Total              32     35

=>>
```

Figure 4.5 MOTOR Command Response (Continued)

The Learned Cooling Time function can revise the Cool Time only if the learned value is greater than the COOLTIME setting.

When you apply the user-defined curve Thermal Element Setting Method Curve1 := 46, the rotor and stator cooling time constants for the motor can differ significantly. Therefore, in this case, disable Use Learned Cooling Time (COOLEN = N) unless the motor manufacturer recommends a cooling time or time constant.

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 4.29 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:

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

$T_{VRTDn} = TRTMP_n - K_{RTD}$ 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

Calculate 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

Calculate the ambient bias factor K_{TH} using the following equations. Use the factor K_{TH} in the thermal model to calculate start and run state trip values (TVS and TVR).

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

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

where

0 = <= K_{TH} <=1

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

Slip-Dependent Thermal Model for Synchronous Motors

Slip-dependent thermal models enable longer motor start times, which are often needed on high inertia applications. The SEL-710 slip-dependent thermal model uses the locked rotor torque (LRQ) in per unit of the full load torque of the motor, the locked rotor current (LRA) in per unit of FLA, and the full load slip of the motor (FLS). These numbers are readily available for most induction motors.

For synchronous motors, however, these numbers are generally unavailable. To compute the LRQ setting, both the locked rotor torque and the full load torque of the machine operating as an induction motor must be available; but, the full load torque of synchronous motors operating as induction machines is seldom available.

Similarly, to compute the LRA setting, the locked rotor current, and the full load current of the machine operating as induction in primary amps must be available; but again, the full load current of synchronous motors operating as induction machines is unavailable. Finally, the full load slip of synchronous motors operating as induction machines is unavailable to set the FLS setting.

This section details the procedure to set the SEL-710 thermal model to adequately protect synchronous motors connected to high inertia loads.

Rotor Thermal Model

The slip-independent rotor thermal model integrates the motor starting current over time to estimate the rotor temperature. On each processing interval the relay uses the following calculation in computing the rotor TCU:

$$\mathrm{TCU}[k] = \mathrm{TCU}[k-1] + 100 \bullet \frac{\Delta t I^2[k]}{\mathrm{LRA}^2 \cdot \mathrm{LRT}}$$

Note that if the current remains at the locked rotor value (LRA) for the locked rotor time (LRT) the TCU reaches 100 percent as defined by the locked rotor time and current.

Multiplying and dividing the TCU equation by the rotor resistance, you obtain the following:

$$\mathrm{TCU}[k] = \mathrm{TCU}[k-1] + 100 \bullet \frac{\Delta t I^2[k] \cdot R_r}{\mathrm{LRA}^2 \cdot \mathrm{LRT} \cdot R_r}$$

where ($\mathrm{LRA}^2 \bullet \mathrm{LRT} \bullet R_r$) is the energy that the rotor absorbs before reaching a damaging temperature. The numerator is the amount of energy added to the rotor by time k. The slip-dependent thermal model recognizes that the rotor resistance is a function of the slip. To include the rotor resistance dependence on the slip, rewrite the TCU equation as follows:

$$\mathrm{TCU}[k] = \mathrm{TCU}[k-1] + 100 \bullet \frac{\Delta t}{\mathrm{LRA}^2 \bullet \mathrm{LRT}} \bullet \frac{I^2[k] \bullet R_r(S[k])}{R_r(1)}$$

where the rotor resistance as a function of the slip $R_r(S)$ is given by:

$R_r(S) = R_1 S + R_0(1-S)$ with $R_1 \geq R_0$ and $S[k] \in [0, 1]$. Substituting for R_r in the latest TCU expression, you obtain the following:

$$\mathrm{TCU}[k] = \mathrm{TCU}[k-1] + 100 \bullet \frac{\Delta t}{\mathrm{LRA}^2 \bullet \mathrm{LRT}} \bullet \frac{I^2[k] \bullet (R_1 S[k] + R_0(1 - S[k]))}{R_1}$$

The ratio of $R_1 S[k] + R_0(1-S[k])$ to R_1 is between 1, when the slip is one and $0 < R0/R1 \leq 1$ when the slip is zero, making the TCU increments smaller than in the slip-independent thermal model. The smaller TCU increments lead to longer start times. *Figure 4.6* shows a comparison of the slip-independent thermal model to the slip-dependent thermal model where $R_0/R_1 = 2/3$. Note that as the slip approaches zero the slope of the slip-dependent TCU goes down allowing for two additional seconds of start time.

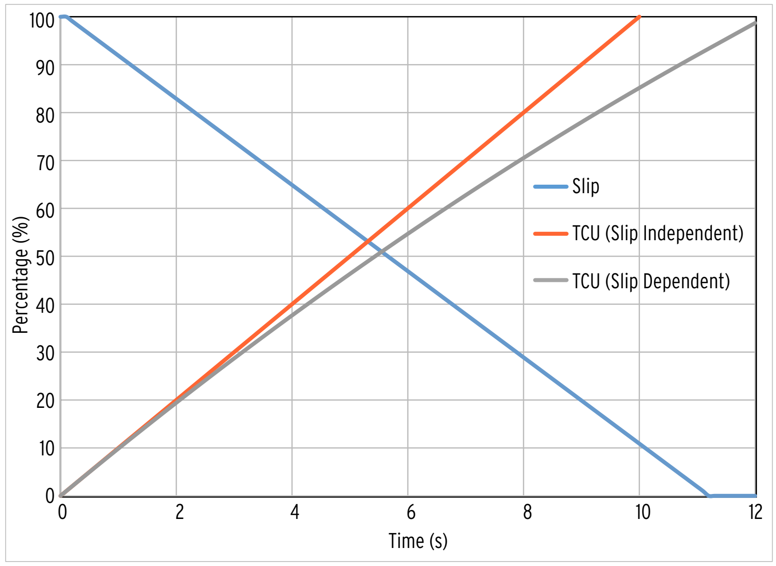


Figure 4.6 Slip-Dependent and Slip-Independent Thermal Models

For induction motors, the R_0/R_1 ratio is generally between 1/3 and 1/9. For synchronous motors, the ratio is generally between 1/3 and 1/6. The following guidelines lead to $R_0/R_1 = 1/3$.

Settings Guidelines

These settings guidelines pertain specifically to synchronous motors that are connected to high-inertia loads, which require start times longer than the locked rotor time. To enable the slip-dependent thermal model, set FLS and LRQ to:

$$\mathrm{FLS} := \frac{1}{3 \cdot \mathrm{LRA}^2}$$

$$\mathrm{LRQ} := 1.0$$

where LRA is the locked rotor current in per unit FLA. Internally, the relay sets R_0 = FLS and $R_1 = \mathrm{LRQ}/\mathrm{LRA}^2$.

The SLIPSRC setting specifies the source for the motor slip used in the thermal model. Two options are available: STAT and R1. Select the SLIPSRC setting based on the following guidelines.

NOTE: Use the SMSLIP2 analog quantity in the CEV report to view the synchronous motor slip when SLIPSRC := STAT.

STAT: The relay computes the motor slip based on the stator measurements as described in U.S. Patent Application Publication No. 2015/0088444, "Monitoring *Synchronization of a Motor Using Stator Current Measurements.*" Use this method for brushless synchronous motors or when the field measurements are unavailable to the relay.

R1: The relay computes the motor slip based on the positive-sequence resistance measured during motor start up. This method is not recommended for synchronous motors. If this method is necessary for your application, contact SEL.

Overcurrent Elements

Table 4.9 Phase Overcurrent Settings

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 s	50P1D := 0.00
PH OC WARN LVL	OFF, 0.10–20.00 xFLA	50P2P := OFF
PH OC WARN DLAY	0.00–5.00 s	50P2D := 0.50

If the SEL-710 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 the desired value with an 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 4.7*) 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.

NOTE: The setting ranges for 50N1P and 50N2P are dependent on the neutral CT ratio, CTRN. Refer to Table 6.6 for the settings interdependency.

Table 4.10 Neutral Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEUT OC TRIP LVL	OFF, 0.01–25.00 A[a]	50N1P := OFF
NEUT OC TRIP LVL	OFF, 0.01–650.00 A	50N1P := OFF
NEU OC TRIP DLAY	0.00–5.00 s	50N1D := 0.50
NEUT OC WARN LVL	OFF, 0.01–25.00 A[a]	50N2P := OFF
NEUT OC WARN LVL	OFF, 0.01–650.00 A	50N2P := OFF
NEU OC WARN DLAY	0.0–120.0 s	50N2D := 10.0

[a] A 0.01–25 A range applies to high sensitivity 2.5 mA neutral input models.

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 4.7*).

When a core-balance CT is connected to the relay IN input, as in *Figure 2.19*, 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.

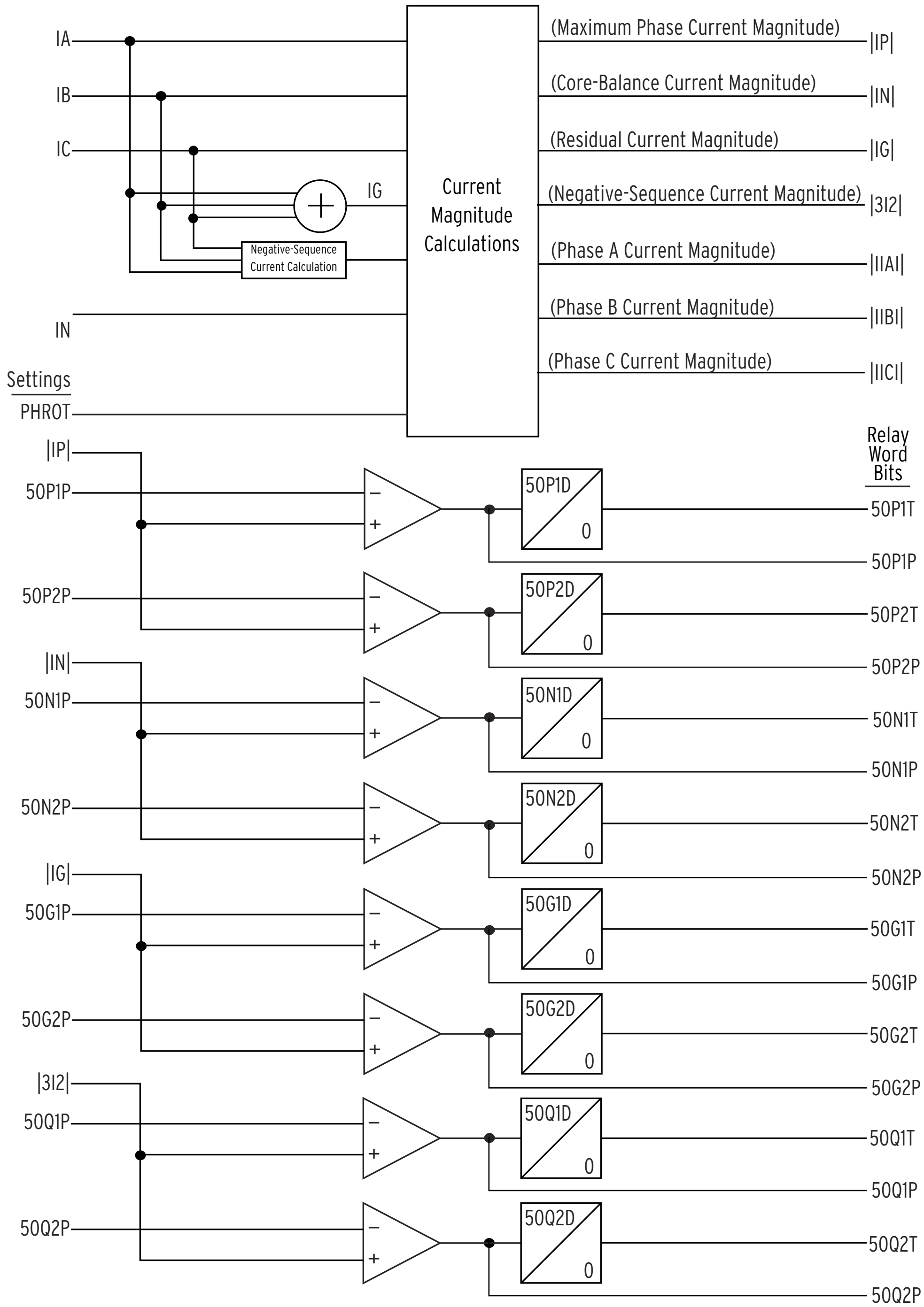


Figure 4.7 Overcurrent Element Logic

EXAMPLE 4.8 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-710 **IN** current input (terminals Z07, Z08), as shown in Figure 4.8. Setting the Neutral OC CT Ratio (CTRN—see Group Settings (SET Command) on page 4.3) equal to 10 and Neutral Trip Lvl (50N1P) equal to 5 A with a 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.

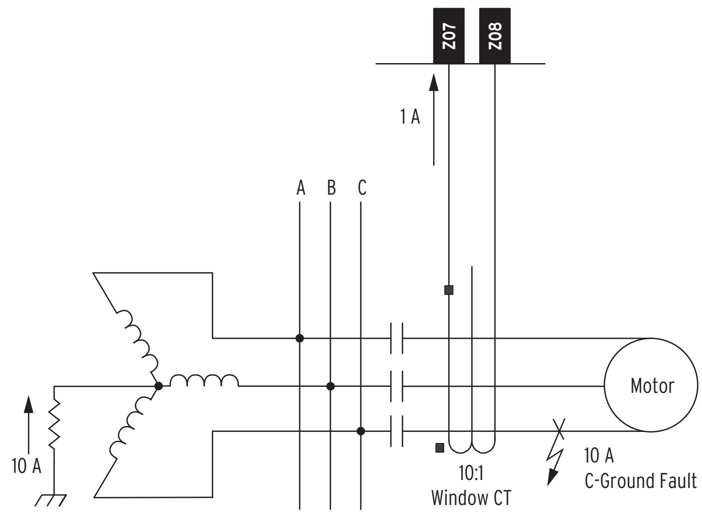


Figure 4.8 Ground Fault Protection Using Core-Balance CT

Table 4.11 Residual Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RES OC TRIP LVL	OFF, 0.10–20.00 xFLA	50G1P := OFF
RES OC TRIP DLAY	0.00–5.00 s	50G1D := 0.50
RES OC WARN LVL	OFF, 0.10–20.00 xFLA	50G2P := OFF
RES OC WARN DLAY	0.0–120.0 s	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 the residual overcurrent element is used 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 be caused by phase CT saturation during motor starting.

Table 4.12 Negative-Sequence Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NSEQ OC TRIP LVL	OFF, 0.10–20.00 xFLA	50Q1P := 3.00
NSEQ OC TRIP DLY	0.1–120.0 s	50Q1D := 0.1
NSEQ OC WARN LVL	OFF, 0.10–20.00 xFLA	50Q2P := 0.30
NSEQ OC WARN DLY	0.1–120.0 s	50Q2D := 0.2

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

Time-Overcurrent Elements

One level of inverse time element is available for phase A, B, C, and negative-sequence overcurrent. Also, two levels of inverse time elements are available for maximum phase and residual overcurrent. See *Table 4.13* through *Table 4.16* for available settings.

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

You can select from five U.S. and five IEC inverse characteristics. *Table 4.17* and *Table 4.18* show equations for the curves and *Figure 4.13* through *Figure 4.22* show the curves. The curves and equations shown do not account for constant time adder and minimum response time (settings 51_CT and 51_MR respectively, each assumed equal to zero). Use the 51_CT if you want to raise the curves by a constant time. Also, you can use the 51_MR if you want to ensure the curve times no faster than a minimum response time.

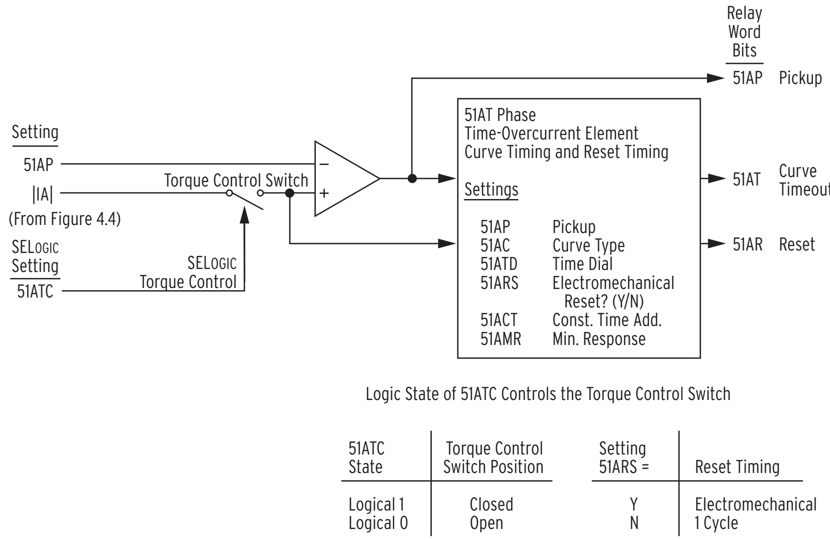
Each element can be torque controlled using appropriate SELOGIC control equations (e.g., when 51P1TC := IN401, the 51P1 element will be operational only if IN401 is asserted).

Table 4.13 Phase A, B, and C Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51AP := OFF 51AP := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51AC := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.00[d]	51ATD := 3.00
EM RESET DELAY	Y, N	51ARS := N
CONST TIME ADDER	0.00–1.00 s	51ACT := 0.00
MIN RESPONSE TIM	0.00–1.00	51AMR := 0.00
TOC TRQ CONTROL	SELOGIC	51ATC := 1
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51BP := OFF 51BP := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51BC := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.00[d]	51BTD := 3.00
EM RESET DELAY	Y, N	51BRS := N
CONST TIME ADDER	0.00–1.00 s	51BCT := 0.00
MIN RESPONSE TIM	0.00–1.00	51BMR := 0.00
TOC TRQ CONTROL	SELOGIC	51BTC := 1
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51CP := OFF 51CP := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51CC := U3
TOC TIME DIAL51_C	0.50–15.00[c], 0.05–1.00[d]	51CTD := 3.00
EM RESET DELAY	Y, N	51CRS := N
CONST TIME ADDER	0.00–1.00 s	51CCT := 0.00
MIN RESPONSE TIM	0.00–1.00	51CMR := 0.00
TOC TRQ CONTROL	SELOGIC	51CTC := 1

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

The phase time-overcurrent elements, 51AT, 51BT, and 51CT, respond to A, B, and C phase currents, respectively, as shown *Figure 4.9*.



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

Figure 4.9 Phase Time-Overcurrent Elements 51AT, 51BT, and 51CT

Table 4.14 Maximum Phase Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51P1P := OFF 51P1P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51P1C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.00[d]	51P1TD := 3.00
EM RESET DELAY	Y, N	51P1RS := N
CONST TIME ADDER	0.00–1.00 s	51P1CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51P1MR := 0.00
TOC TRQ CONTROL	SELOGIC	51P1TC := 1
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51P2P := OFF 51P2P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51P2C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.00[d]	51P2TD := 3.00
EM RESET DELAY	Y, N	51P2RS := N
CONST TIME ADDER	0.00–1.00 s	51P2CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51P2MR := 0.00
TOC TRQ CONTROL	SELOGIC	51P2TC := 1

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

The maximum phase time-overcurrent elements, 51P1T and 51P2T, respond to the highest of A-, B-, and C-phase currents as shown *Figure 4.10*.

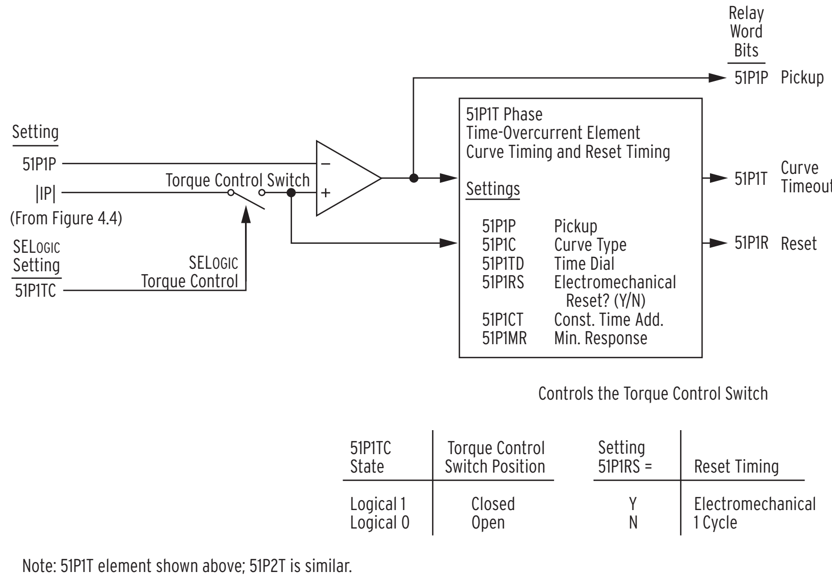


Figure 4.10 Maximum Phase Time-Overcurrent Elements 51P1T and 51P2T

Table 4.15 Negative-Sequence Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51QP := OFF 51QP := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51QC := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.00[d]	51QTD := 3.00
EM RESET DELAY	Y, N	51QRS := N
CONST TIME ADDER	0.00–1.00 s	51QCT := 0.00
MIN RESPONSE TIM	0.00–1.00	51QMR := 0.00
TOC TRQ CONTROL	SELOGIC	51QTC := 1

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

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

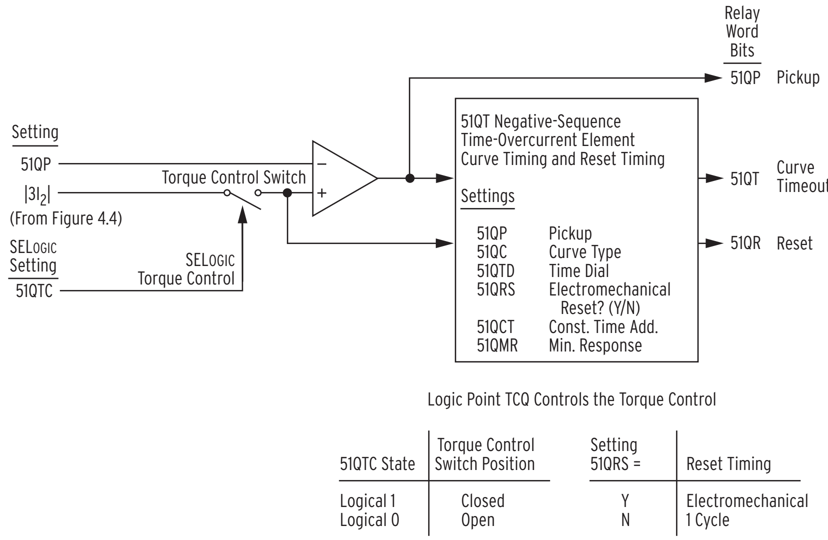


Figure 4.11 Negative-Sequence Time-Overcurrent Element 51QT

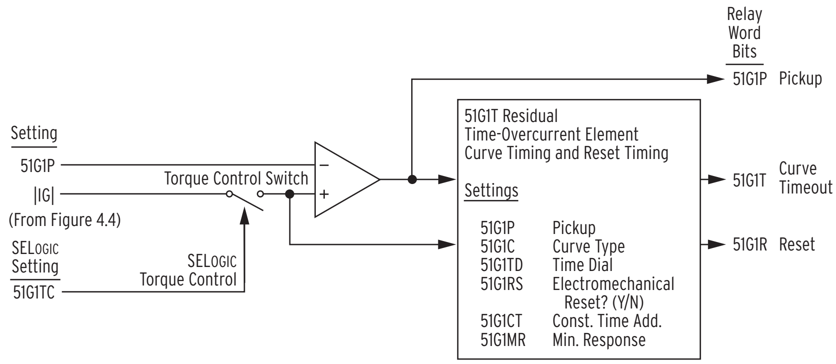
False negative-sequence current can transiently appear when a circuit breaker is closed and balanced load current suddenly appears. To avoid tripping for this transient condition, do not use a time-dial setting that results in curve times below three cycles.

Table 4.16 Residual Time-Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51G1P := OFF 51G1P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51G1C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.00[d]	51G1TD := 1.50
EM RESET DELAY	Y, N	51G1RS := N
CONST TIME ADDER	0.00–1.00 s	51G1CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51G1MR := 0.00
TOC TRQ CONTROL	SELOGIC	51G1TC := 1
TOC TRIP LVL	OFF, 0.50–10.00 A[a], 0.10–2.00 A[b]	51G2P := OFF 51G2P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51G2C := U3
TOC TIME DIAL	0.50–15.00[c], 0.05–1.00[d]	51G2TD := 1.50
EM RESET DELAY	Y, N	51G2RS := N
CONST TIME ADDER	0.00–1.00 s	51G2CT := 0.00
MIN RESPONSE TIM	0.00–1.00	51G2MR := 0.00
TOC TRQ CONTROL	SELOGIC	51G2TC := 1

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

The residual time-overcurrent elements, 51G1T and 51G2T, respond to residual current IG as shown *Figure 4.12*.



Controls the Torque Control Switch

51G1TC State	Torque Control Switch Position
Logical 1	Closed
Logical 0	Open

Setting 51G1RS =	Reset Timing
Y	Electromechanical
N	1 Cycle

Note: 51G1T element shown above; 51G2T is similar.

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

Time-Overcurrent Curves

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements (see *Figure 4.9* through *Figure 4.12*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.13* through *Figure 4.22*. Curves U1, U2, and U3 (*Figure 4.13* through *Figure 4.15*) conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Relay Word Bit ORED51T

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

Table 4.17 Equations Associated With U.S. Curves

Curve Type	Operating Time	Reset Time	Figure
U1 (Moderately Inverse)	$t_p = TD \bullet \left(0.0226 + \frac{0.0104}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{1.08}{1 - M^2}\right)$	*Figure 4.13*
U2 (Inverse)	$t_p = TD \bullet \left(0.180 + \frac{5.95}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{5.95}{1 - M^2}\right)$	*Figure 4.14*
U3 (Very Inverse)	$t_p = TD \bullet \left(0.0963 + \frac{3.88}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{3.88}{1 - M^2}\right)$	*Figure 4.15*
U4 (Extremely Inverse)	$t_p = TD \bullet \left(0.0352 + \frac{5.67}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{5.67}{1 - M^2}\right)$	*Figure 4.16*
U5 (Short-Time Inverse)	$t_p = TD \bullet \left(0.00262 + \frac{0.00342}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{0.323}{1 - M^2}\right)$	*Figure 4.17*

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

Table 4.18 Equations Associated With IEC Curves

Curve Type	Operating Time	Reset Time	Figure
C1 (Standard Inverse)	$t_p = TD \bullet \left(\frac{0.14}{M^{0.02} - 1}\right)$	$t_r = TD \bullet \left(\frac{13.5}{1 - M^2}\right)$	*Figure 4.18*
C2 (Very Inverse)	$t_p = TD \bullet \left(\frac{13.5}{M - 1}\right)$	$t_r = TD \bullet \left(\frac{47.3}{1 - M^2}\right)$	*Figure 4.19*
C3 (Extremely Inverse)	$t_p = TD \bullet \left(\frac{80}{M^2 - 1}\right)$	$t_r = TD \bullet \left(\frac{80}{1 - M^2}\right)$	*Figure 4.20*
C4 (Long-Time Inverse)	$t_p = TD \bullet \left(\frac{120}{M - 1}\right)$	$t_r = TD \bullet \left(\frac{120}{1 - M}\right)$	*Figure 4.21*
C5 (Short-Time Inverse)	$t_p = TD \bullet \left(\frac{0.05}{M^{0.04} - 1}\right)$	$t_r = TD \bullet \left(\frac{4.85}{1 - M^2}\right)$	*Figure 4.22*

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

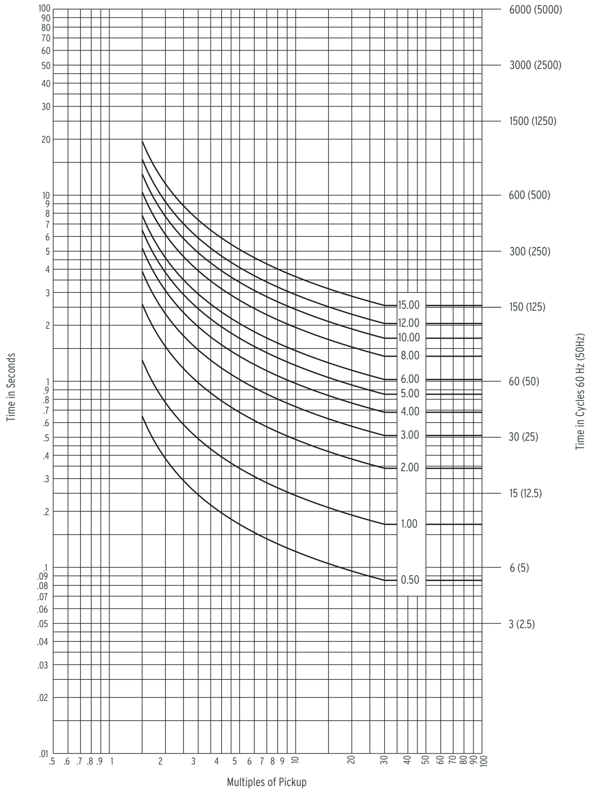


Figure 4.13 U.S. Moderately Inverse Curve: U1

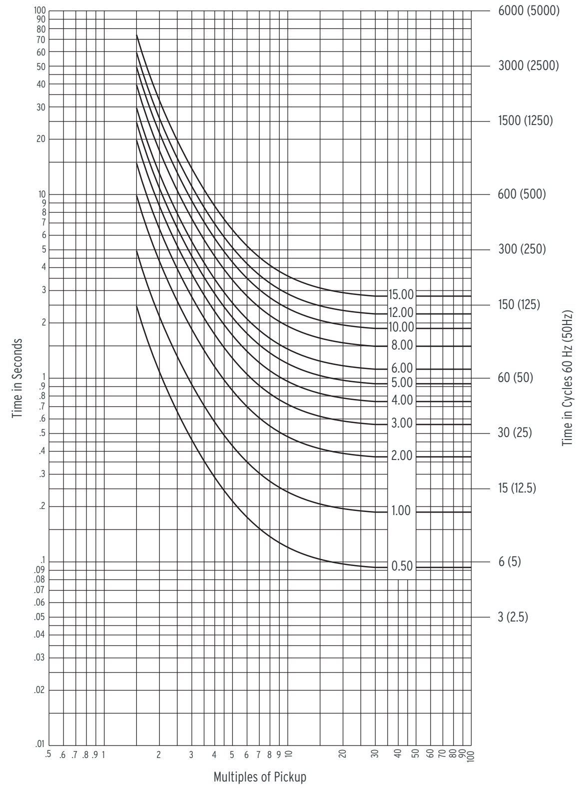


Figure 4.14 U.S. Inverse Curve: U2

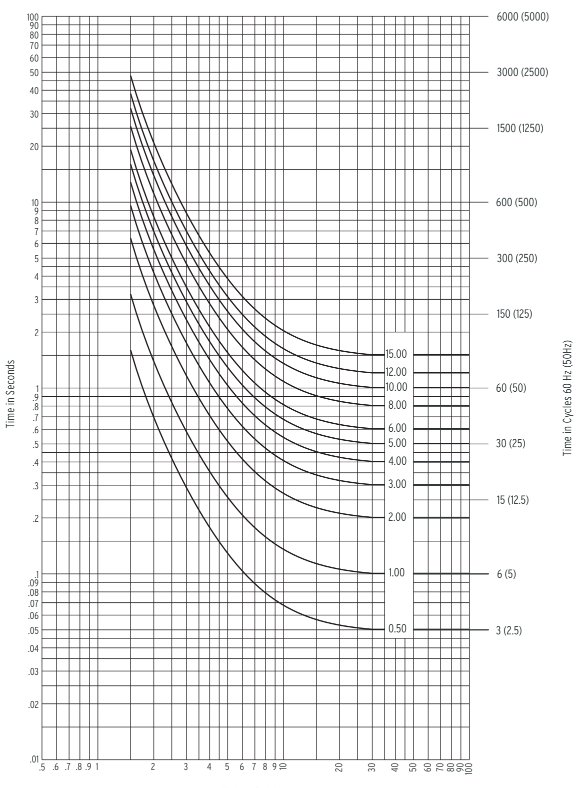


Figure 4.15 U.S. Very Inverse Curve: U3

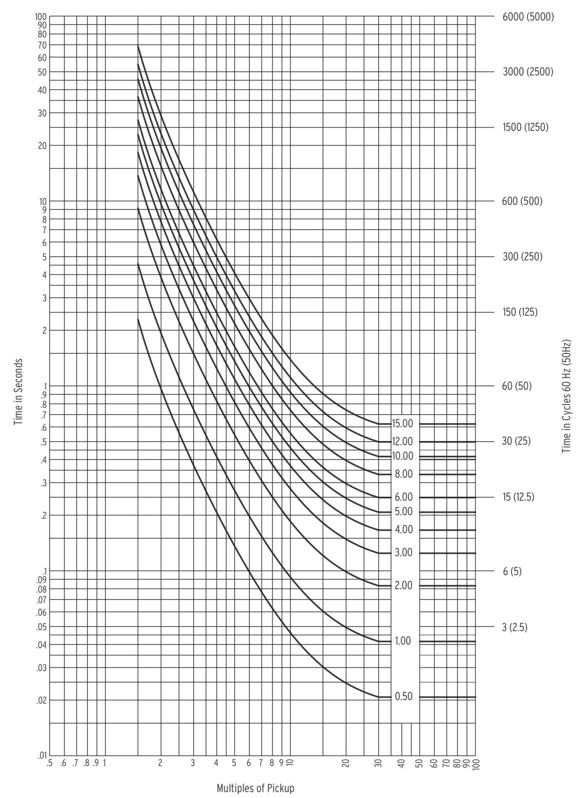


Figure 4.16 U.S. Extremely Inverse Curve: U4

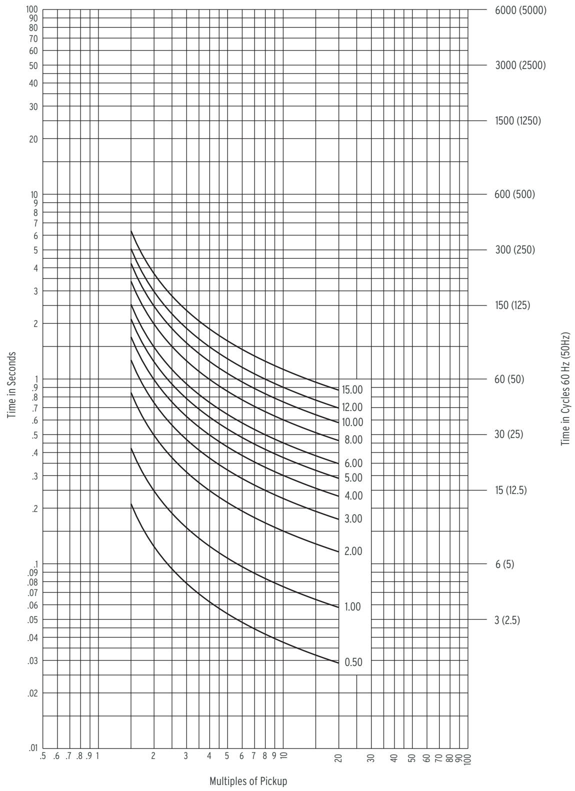


Figure 4.17 U.S. Short-Time Inverse Curve: U5

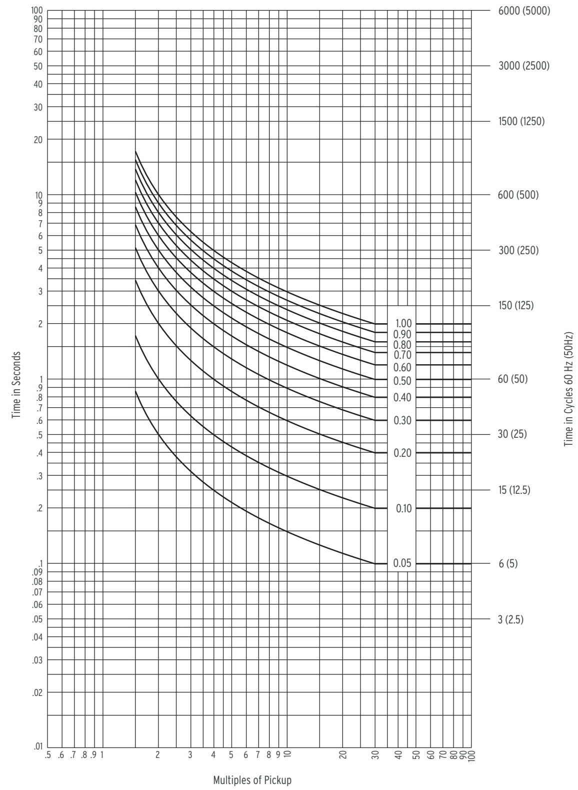


Figure 4.18 IEC Class A Curve (Standard Inverse): C1

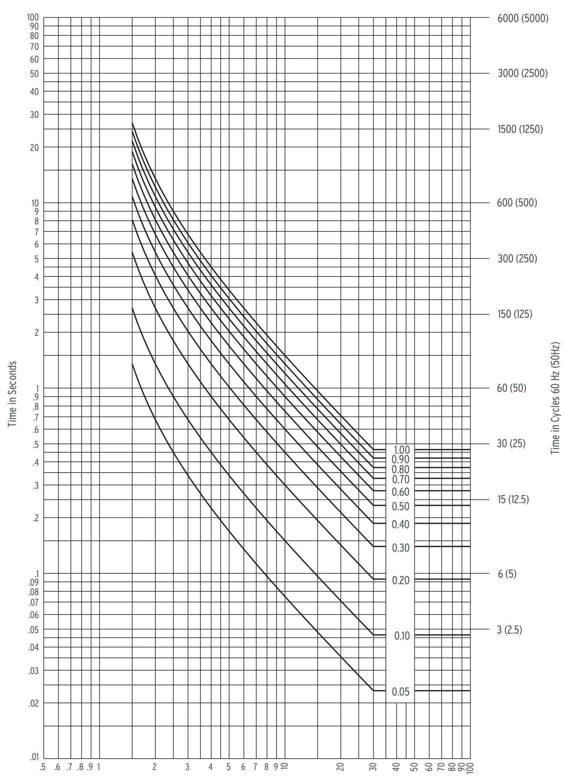


Figure 4.19 IEC Class B Curve (Very Inverse): C2

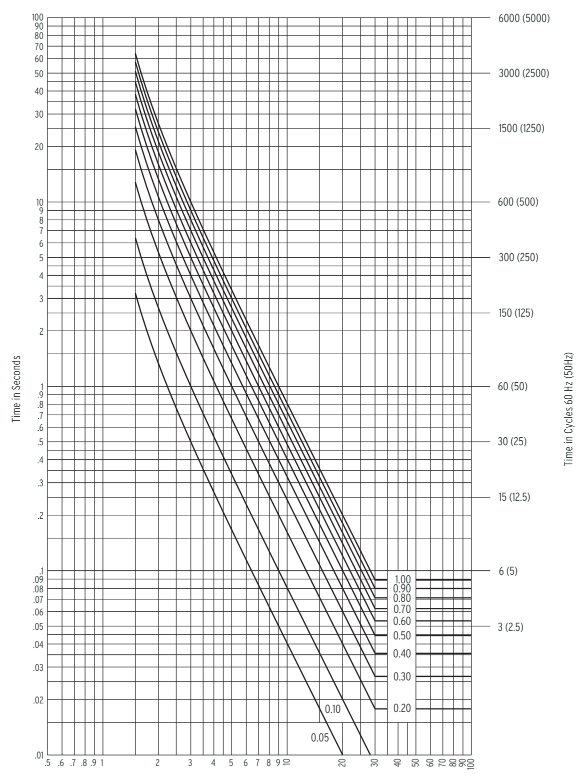


Figure 4.20 IEC Class C Curve (Extremely Inverse): C3

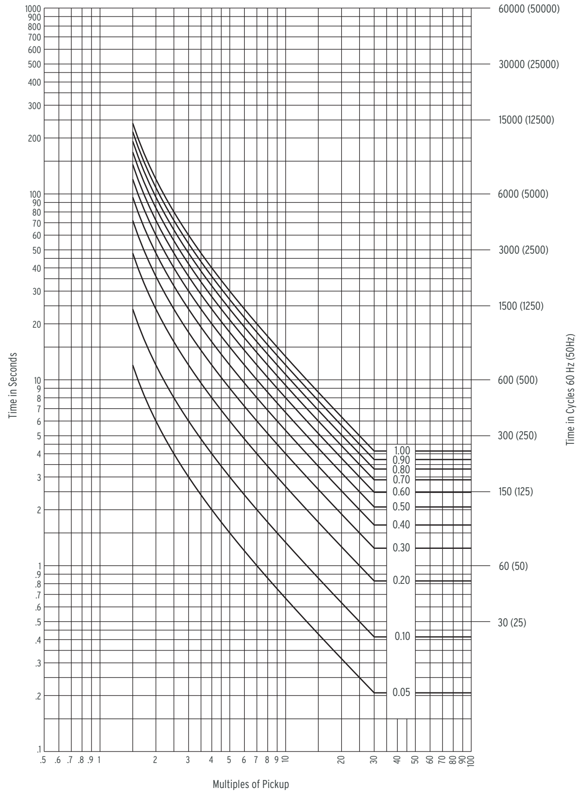


Figure 4.21 IEC Long-Time Inverse Curve: C4

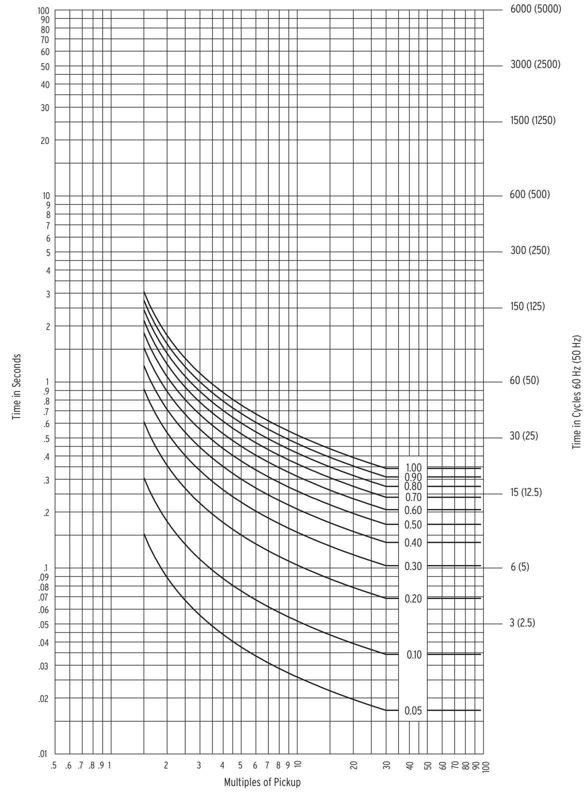


Figure 4.22 IEC Short-Time Inverse Curve: C5

Differential Elements

Table 4.19 Motor Differential Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DIFF ENABLE	Y, N	E87M := N
DIFF CT RATIO	1–5000	CTR87M := 100
DIFF 1 TRIP LVL	OFF, 0.05–8.00 A s	87M1P := OFF
DIFF 1 TRIP DLY	0.00–60.00 s	87M1TD := 0.10
DIFF 1 TRQ CON	SELOGIC	87M1TC := 50S
DIFF 2 TRIP LVL	OFF, 0.05–8.00 A s	87M2P := OFF
DIFF 2 TRIP DLY	0.00–60.00 s	87M2TD := 0.10
DIFF 2 TRQ CON	SELOGIC	87M2TC := NOT 50S

NOTE: If the SEL-710 is connected to a motor protected by a fused contactor, disable the differential elements by setting the 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 differential faults.

The SEL-710 optionally provides two definite-time delayed differential overcurrent elements. See *Figure 4.23* for the element logic diagrams. The relay can be used either with core-balance differential CTs (see *Figure 2.20*) or with separate CTs on the source and neutral sides of the motor (see *Figure 2.21*).

A dedicated CT ratio setting (CTR87M) is provided for the differential elements. This is particularly useful when core-balance differential CTs are used.

Each differential element can be set independently with operate level (pickup), delay, and torque control equations to provide flexibility. For example, the factory-default torque control equations allow you to set higher level 1 pickup during motor starting for better security and lower level 2 pickup during the rest of the times for more sensitive protection. Note that false differential current is more likely during motor starting because of large inrush currents.

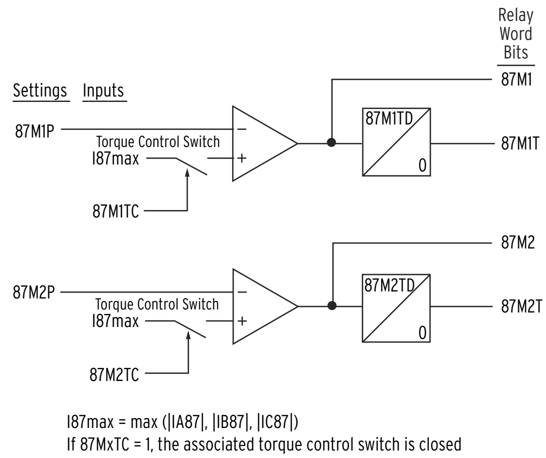


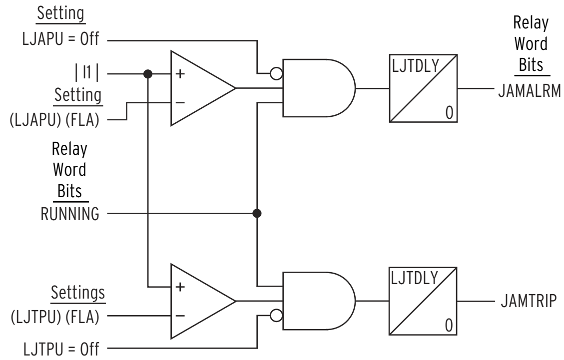
Figure 4.23 Differential Element Logic

Load-Jam Elements

Table 4.20 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 s	LJTDLY := 0.5
JAM WARN LEVEL	OFF, 1.00–6.00 xFLA	LJAPU := OFF
JAM WARN DELAY	0.0–120.0 s	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 4.24*). Set the jam trip level greater than the expected normal load current but less than the rated locked rotor current. This setting is entered in per unit of the Full-Load Amps (FLA) setting.



LJAPU, LJTPU = Load-Jam Alarm and Trip Pickup
I1 = Positive-Sequence Current Magnitude
RUNNING = Motor is Running
LJADLY, LJTDLY = Load-Jam Alarm and Trip Delay
JAMALRM, JAMTRIP = Load-Jam Alarm and Trip
FLA = Full-Load Amps Setting

Note: When LJAPU or LJTPU = OFF is satisfied, a Logical 1 input is generated.

Figure 4.24 Load-Jam Element Logic

Undercurrent (Load Loss) Elements

Table 4.21 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 s	LLTDLY := 5.0
UC WARN LEVEL	OFF, 0.10–1.00 xFLA	LLAPU := OFF
UC WARN DELAY	0.4–120.0 s	LLADLY := 10.0
UC START DELAY	0–5000 s	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 4.25*). Set this delay to allow pumps or compressors to reach normal load. Once armed, this function issues a warning or trip if phase current drops below warn or trip level for the specified time delay. You can block these elements using SELOGIC (see *Table 4.38*).

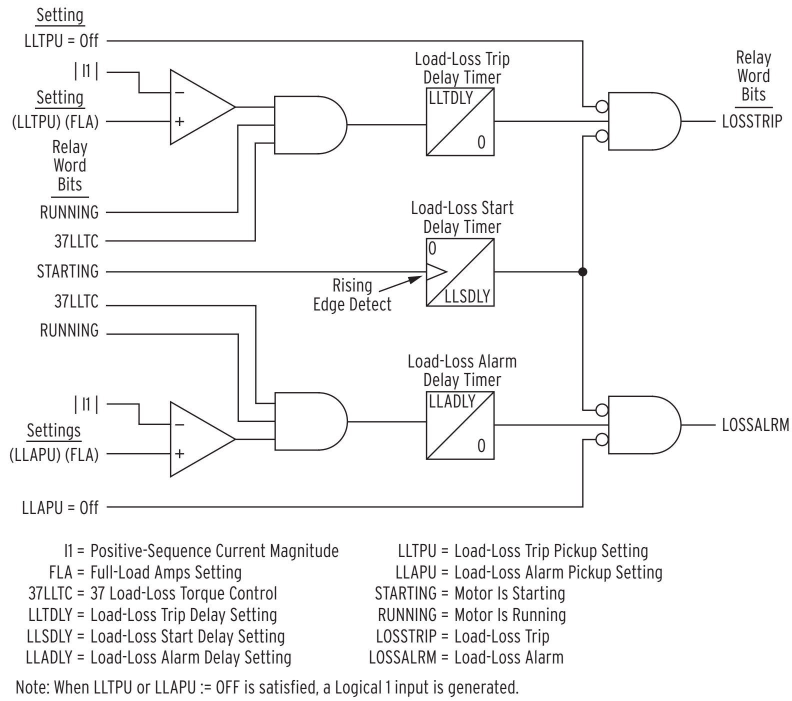


Figure 4.25 Undercurrent (Load-Loss) Logic

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 4.22 Current Unbalance Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
CI TRIP LEVEL	OFF, 5%–80%	46UBT := 20
CI TRIP DELAY	0–240 s	46UBTD := 5
CI WARN LEVEL	OFF, 5%–80%	46UBA := 10
CI WARN DELAY	0–240 s	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-710 motor thermal element models the heating effect of the negative-sequence current, you may want the additional unbalanced and single-phasing protection offered by the current unbalance element.

The SEL-710 calculates percent unbalance current in one of two ways, depending on the magnitude of the average current. When the average current, Iav, is greater than the motor-rated full-load current, the relay calculates the percent unbalance:

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

Equation 4.6

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

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

where

$$\mathrm{UB\%} = \text{Current unbalance percentage}$$
$$\mathrm{Im} = \max\{|\mathrm{Imax} - \mathrm{Iav}|, |\mathrm{Imin} - \mathrm{Iav}|\}$$

where

$$\mathrm{Imax} = \max\{|\mathrm{Ia}|, |\mathrm{Ib}|, |\mathrm{Ic}|\}$$
$$\mathrm{Imin} = \min\{|\mathrm{Ia}|, |\mathrm{Ib}|, |\mathrm{Ic}|\}$$
$$\mathrm{Iav} = (|\mathrm{Ia}| + |\mathrm{Ib}| + |\mathrm{Ic}|)/3$$
$$\mathrm{FLA} = \text{Motor-rated full-load current}$$

Equation 4.7

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 4.26*).

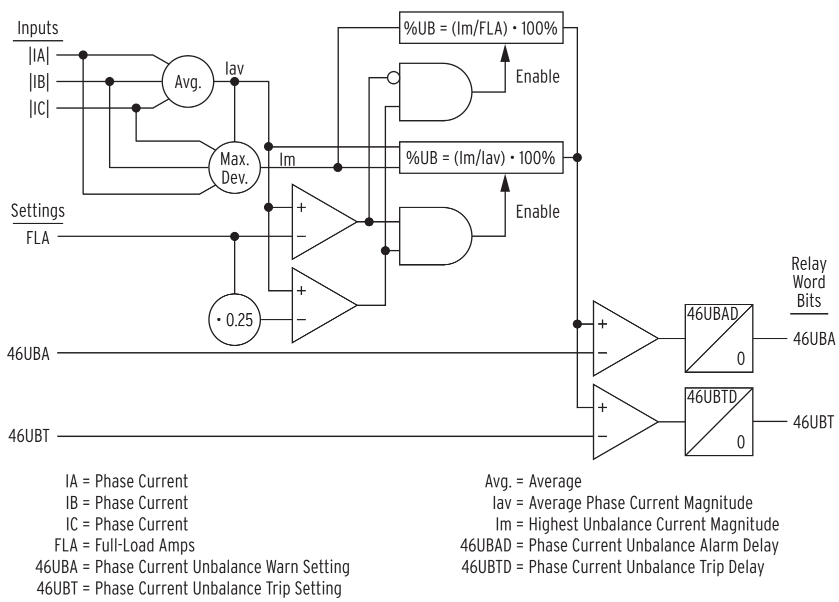


Figure 4.26 Current Unbalance Element Logic

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

Start Monitoring

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

Table 4.23 Start Monitor Settings

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

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 4.27* shows the typical current during motor start and the START_T time setting.

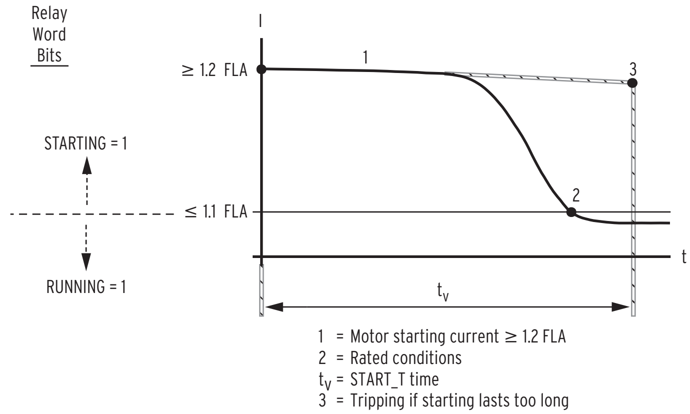


Figure 4.27 Monitoring Starting Time

Star-Delta (Wye-Delta) Starting

NOTE: In addition to enabling the Star-Delta, you must assign Star and Delta to auxiliary output relays (one each); see Figure 2.23 for a typical connection diagram.

Table 4.24 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 s	STAR_MAX := OFF

The SEL-710 issues the command to switch from Star to Delta (Wye to Delta) as soon as the starting current drops to near rated value in Star (Wye). The relay will make the change to Delta within the STAR_MAX setting (if used), regardless of the magnitude of the starting current.

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

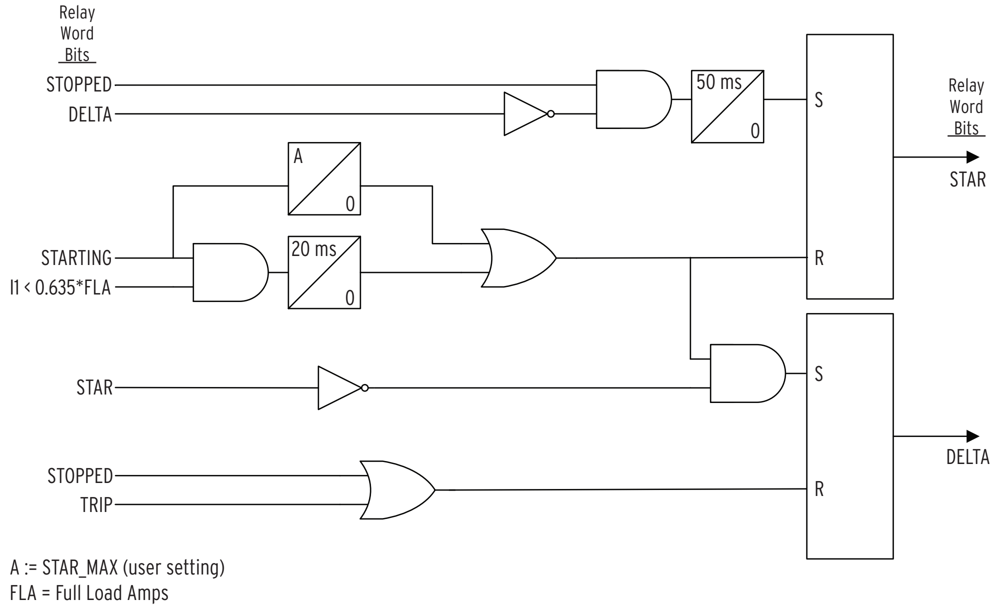


Figure 4.28 Star-Delta Starting

Start Inhibit Function

NOTE: See Figure 4.40 and Figure 4.43 for the stop/trip and start logic diagrams.

Table 4.25 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, 1–1500 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 4.26 Phase Reversal Setting

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

The SEL-710 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 4.29*).

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.

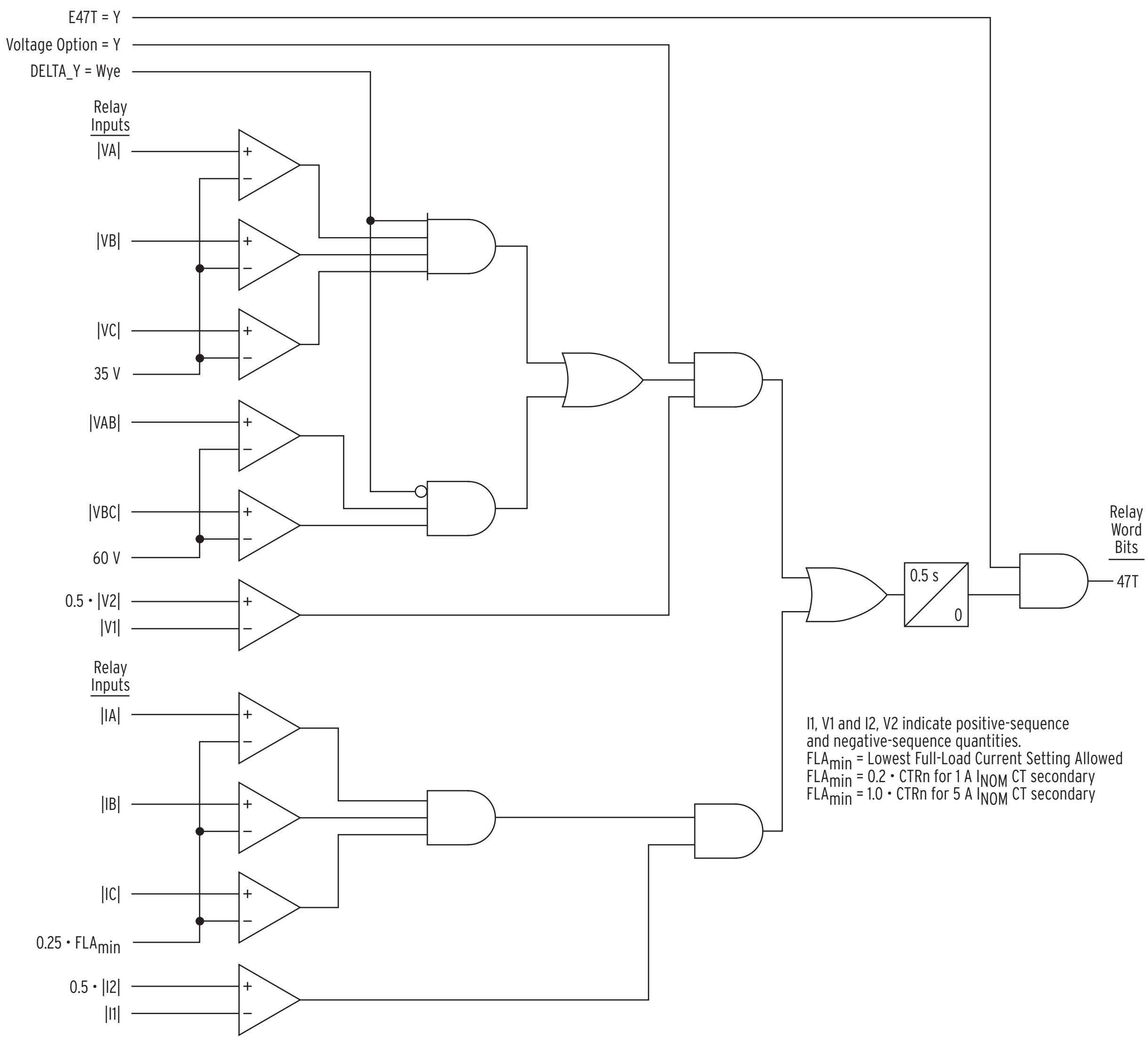


Figure 4.29 Phase Reversal Element Logic

Speed Switch (Stalling During Start) Function

Table 4.27 Speed Switch Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SS TRIP DELAY	OFF, 1–240 s	SPDSDLYT := OFF
SS WARN DELAY	OFF, 1–240 s	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 4.41 and Figure 2.11 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 4.30* shows typical currents during motor start (normal and stall during start) and the SS TRIP DELAY time setting. *Figure 4.31* shows the speed switch logic.

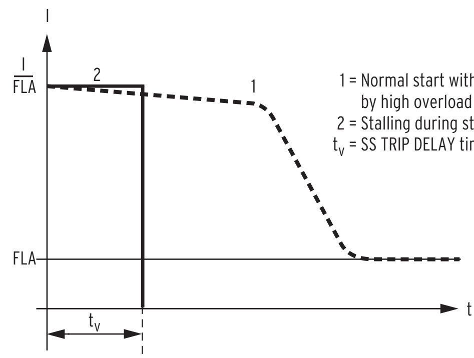


Figure 4.30 Stalling During Starting

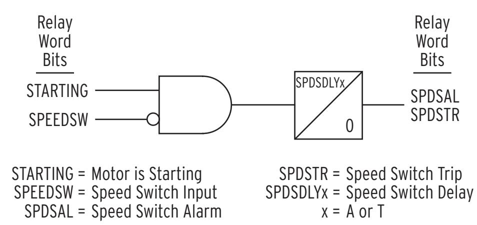


Figure 4.31 Speed Switch Logic

PTC/RTD-Based Protection

Thermistor (PTC) Input Function

Table 4.28 PTC Settings

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

NOTE: The PTC element is disabled by the Relay Word bit BLKPROT if the setting BLK49PTC := Y (see Table 4.38 for details).

NOTE: In addition to enabling the PTC function, you must also connect at least one thermistor to the relay (see Figure 2.12 for a connection diagram).

You can connect as many as six thermistor detectors (PTC) to the SEL-710 with PTC option. The detectors are typically embedded in the stator winding of the motor, and they monitor the actual temperature of the winding. This function is independent of the thermal model and accounts for conditions such as ambient temperature, obstructed cooling, etc.

The sensors have a low resistance below the rated response temperature and increase their resistance (exponentially) in the range of the rated response temperature. The rated response temperature is defined by the PTC sensor.

Motors with different thermal insulation classes (Class F or H) are equipped with different PTC sensors, each of which has its own response temperature, such as 120°, 130°, and 140°C.

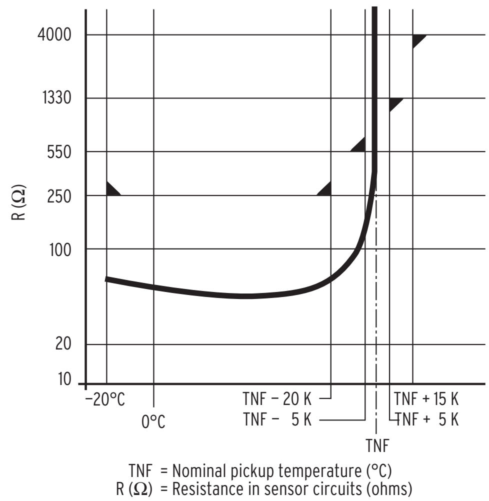


Figure 4.32 Characteristic of PTC Sensors as per IEC 34-11-2

RTD Input Function

When you connect an SEL-2600 RTD Module (set E49RTD := EXT) or order the internal RTD card (set E49RTD := INT) option, the SEL-710 offers several protection and monitoring functions, settings for which are described in *Table 4.29*. See *Figure 2.11* for the RTD module fiber-optic cable connections. If the relay does not have internal or external RTD inputs, set E49RTD := NONE.

NOTE: The SEL-710 can monitor as many as 10 RTDs connected to an internal RTD card or as many as 12 RTDs connected to an external SEL-2600 RTD Module. Table 4.29 shows Location, Type, and Trip/Warn Level settings only for RTD1; settings for RTD2–RTD12 are similar.

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

Table 4.29 RTD Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RTD ENABLE	INT, EXT, NONE	E49RTD := NONE
RTD1 LOCATION	OFF, WDG, BRG, AMB, OTH	RTD1LOC := OFF
RTD1 TYPE	PT100, NI100, NI120, CU10	RTD1TY := PT100
RTD1 TRIP LEVEL	OFF, 1–250°C	TRTMP1 := OFF
RTD1 WARN LEVEL	OFF, 1–250°C	ALTMP1 := OFF
• • •	• • •	• • •
WIND TRIP VOTING	Y, N	EWDGV := N
BEAR TRIP VOTING	Y, N	EBRGV := N
TMP RTD BIASING?	Y, N	ERTDBIAS := N

RTD Location

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

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

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

- ➤ For RTDs embedded in motor stator windings, set the RTD location equal to WDG.
- ➤ For inputs connected to RTDs measuring bearing race temperature, set the RTD location equal to BRG.
- ➤ For the input connected to an RTD measuring ambient motor cooling air temperature, set the RTD location equal to AMB. Only one ambient temperature RTD is allowed.
- ➤ For inputs connected to monitor temperatures of another apparatus, set the RTD location equal to OTH.

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

RTD Type

The four available RTD types are:

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

RTD Trip/Warning Levels

The SEL-710 provides temperature warnings and trips through use of the RTD temperature measurements and the warning and trip temperature settings in *Table 4.29*.

NOTE: An open condition for an RTD is detected if the temperature is greater than 250°C and a short condition is detected if the temperature is less then –50°C.

NOTE: To improve security, RTD FAULT, ALARM, and TRIP are delayed by approximately 12 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 4.8*).

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 4.8* to calculate RTD % Thermal Capacity.

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

Equation 4.8

As ambient temperature rises, the ability of a motor to shed heat to the surroundings is reduced and internal temperatures rise. To preserve insulation life, NEMA standards suggest a 1°C reduction in RTD trip temperature for each 1°C rise in ambient temperature over 40°C.

When you enable RTD biasing, the SEL-710 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.

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 percent 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. Additionally, the relay also biases the thermal model by lowering the stator and rotor model trip thresholds by a factor of K_{TH} calculated as shown in *Additional Thermal Overload Settings*.

For all the RTD thermal capacity and bias calculations previously described, the relay uses the winding RTD with the measured temperature closest to the winding trip value. *Table 4.30* lists the RTD resistance versus temperature for the four supported RTD types.

Table 4.30 RTD Resistance Versus Temperature (Sheet 1 of 2)

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
–58	–50.00	80.31	86.17	74.30	7.10
–40	–40.00	84.27	92.76	79.10	7.49
–22	–30.00	88.22	99.41	84.20	7.88
–4	–20.00	92.16	106.15	89.30	8.26
14	–10.00	96.09	113.00	94.60	8.65
32	0.00	100.00	120.00	100.00	9.04
50	10.00	103.90	127.17	105.60	9.42
68	20.00	107.79	134.52	111.20	9.81
86	30.00	111.67	142.06	117.10	10.19
104	40.00	115.54	149.79	123.00	10.58

Table 4.30 RTD Resistance Versus Temperature (Sheet 2 of 2)

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
122	50.00	119.39	157.74	129.10	10.97
140	60.00	123.24	165.90	135.30	11.35
158	70.00	127.07	174.25	141.70	11.74
176	80.00	130.89	182.84	148.30	12.12
194	90.00	134.70	191.64	154.90	12.51
212	100.00	138.50	200.64	161.80	12.90
230	110.00	142.29	209.85	168.80	13.28
248	120.00	146.06	219.29	176.00	13.67
266	130.00	149.83	228.96	183.30	14.06
284	140.00	153.58	238.85	190.90	14.44
302	150.00	157.32	248.95	198.70	14.83
320	160.00	161.05	259.30	206.60	15.22
338	170.00	164.77	269.91	214.80	15.61
356	180.00	168.47	280.77	223.20	16.00
374	190.00	172.17	291.96	231.80	16.39
392	200.00	175.85	303.46	240.70	16.78
410	210.00	179.15	315.31	249.80	17.17
428	220.00	183.17	327.54	259.20	17.56
446	230.00	186.82	340.14	268.90	17.95
464	240.00	190.45	353.14	278.90	18.34
482	250.00	194.08	366.53	289.10	18.73

Voltage-Based Protection

The following information applies to relay models with voltage inputs.

Undervoltage Function

Table 4.31 Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UV TRIP LEVEL	OFF, 0.02–1.00 xVnm	27P1P := OFF
UV TRIP DELAY	0.0–120.0 s	27P1D := 0.5
UV WARN LEVEL	OFF, 0.02–1.00 xVnm	27P2P := OFF
UV WARN DELAY	0.0–120.0 s	27P2D := 5.0

Overvoltage Function

Table 4.32 Overvoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OV TRIP LEVEL	OFF, 0.02–1.20 xVnm	59P1P := 1.10
OV TRIP DELAY	0.0–120.0 s	59P1D := 0.5
OV WARN LEVEL	OFF, 0.02–1.20 xVnm	59P2P := OFF
OV WARN DELAY	0.0–120.0 s	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/PT Ratio] if DELTA_Y := DELTA; Vnm = [VNOM/(1.732 • PT Ratio)] if DELTA_Y := WYE.

When you connect the SEL-710 voltage inputs to phase-to-phase connected VTs, as in *Figure 2.17* or *Figure 2.18*, the relay provides two levels of phase-to-phase overvoltage and undervoltage elements.

When you connect the SEL-710 voltage inputs to phase-to-neutral connected VTs, as in *Figure 2.17* or *Figure 2.18*, 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 4.33* and *Figure 4.34* show the logic diagram for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

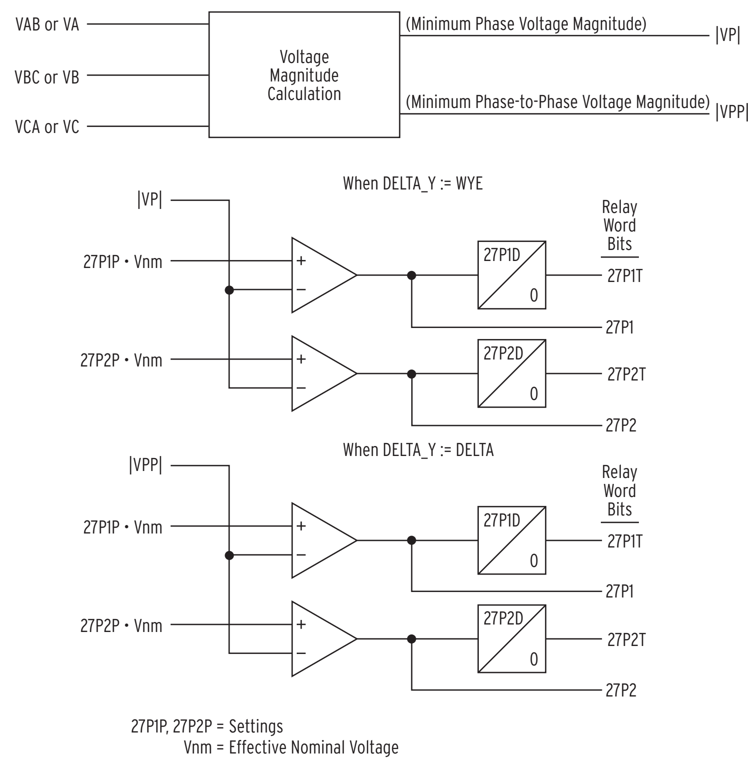


Figure 4.33 Undervoltage Element Logic

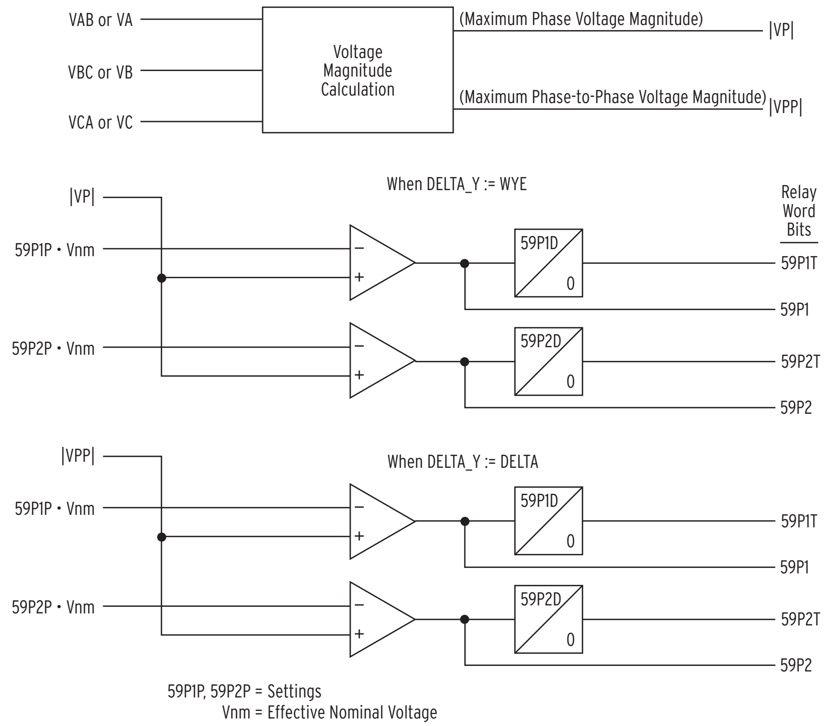


Figure 4.34 Overvoltage Element Logic

VAR Function

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

Table 4.33 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 DELAY	1–240 s	VARTD := 1
NEG VAR WARN LEV	OFF, 1–25000 kVAR	NVARAP := OFF
POS VAR WARN LEV	OFF, 1–25000 kVAR	PVARAP := OFF
VAR WARN DELAY	1–240 s	VARAD := 1
VAR ARMING DELAY	0–5000 s	VARDLY := 0

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 4.35* 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.

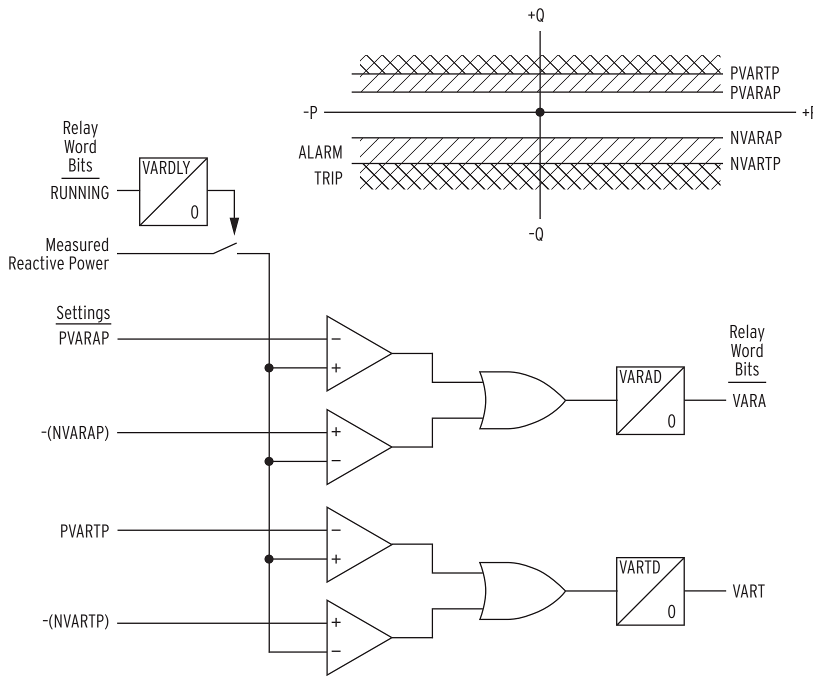


Figure 4.35 Reactive Power (VAR) Element Logic

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 4.34 Underpower Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
UP TRIP LEVEL	OFF, 1–25000 kW	37PTP := OFF
UP TRIP DELAY	1–240 s	37PTD := 1
UP WARN LEVEL	OFF, 1–25000 kW	37PAP := OFF
UP WARN DELAY	1–240 s	37PAD := 1
UP ARMING DELAY	0–5000 s	37DLY := 0

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 4.36* 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.

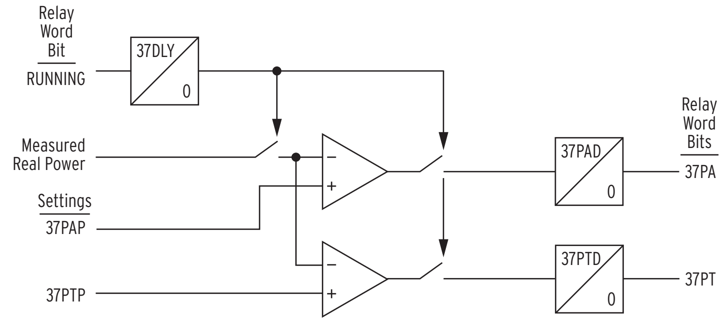


Figure 4.36 Underpower Element Logic

Power Factor Elements

Table 4.35 Power Factor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PF LAG TRIP LEVL	OFF, 0.05–0.99	55LGTP := OFF
PF LD TRIP LEVEL	OFF, 0.05–0.99	55LDTP := OFF
PF TRIP DELAY	1–240 s	55TD := 1
PF LAG WARN LEVL	OFF, 0.05–0.99	55LGAP := OFF
PF LD WARN LEVEL	OFF, 0.05–0.99	55LDAP := OFF
PF WARN DELAY	1–240 s	55AD := 1
PF ARMING DELAY	0–5000	55DLY := 0

If the absolute value of 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 4.37* 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.

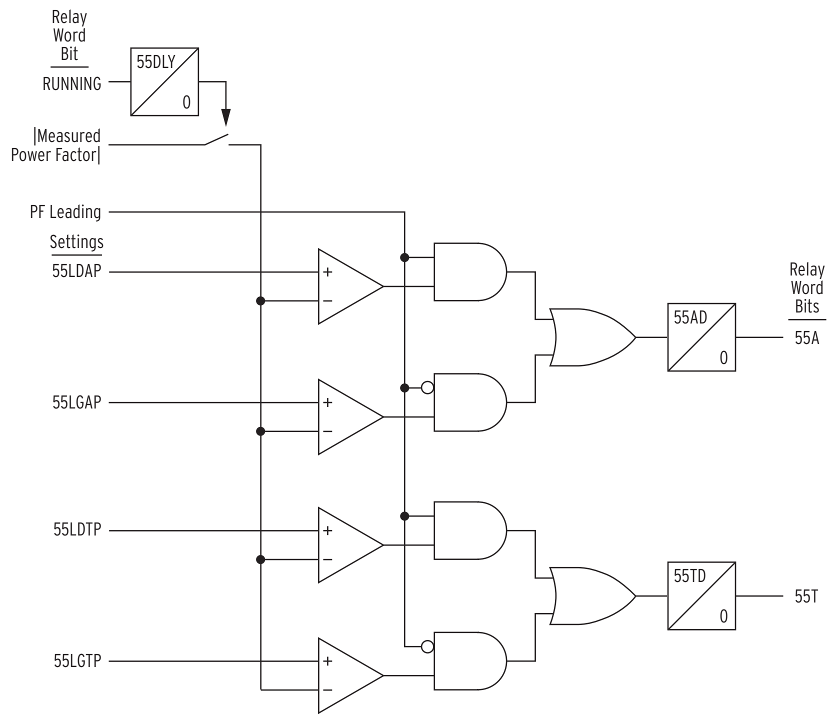


Figure 4.37 Power Factor Elements Logic

Loss-of-Potential (LOP) Protection

The SEL-710 sets Relay Word bit LOP (loss-of-potential) upon detecting a loss of relay ac voltage input such as that caused by blown potential fuses or by the operation of molded-case circuit breakers. Because accurate relaying potentials are required by certain protection elements (undervoltage 27 elements, for example), you can use the LOP function to supervise these protection elements.

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

If this condition persists for 60 cycles, then the relay latches the LOP Relay Word bit at logical 1. The relay resets LOP when the positive-sequence voltage (V1) returns to a level greater than 0.43 • VNOM/PTR 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 LOP function has no settings and is always active. You must incorporate the LOP function in a SELOGIC control equation to supervise relay protection elements (see *Example 4.9*).

LOP Impact on Other Protection Elements

Undervoltage and directional power elements require accurate relaying potentials for correct operation. It is critical that the relay detects an LOP condition and prevents operation of these elements. For example, if a wrench drops on the phase-voltage input fuse holders, the relay LOP logic accurately determines that this loss of input voltages is an LOP condition and does not trip (if the LOP Relay Word bit supervises selected tripping elements, see

Example 4.9). 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 4.9 Supervising Voltage-Element Tripping With LOP

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

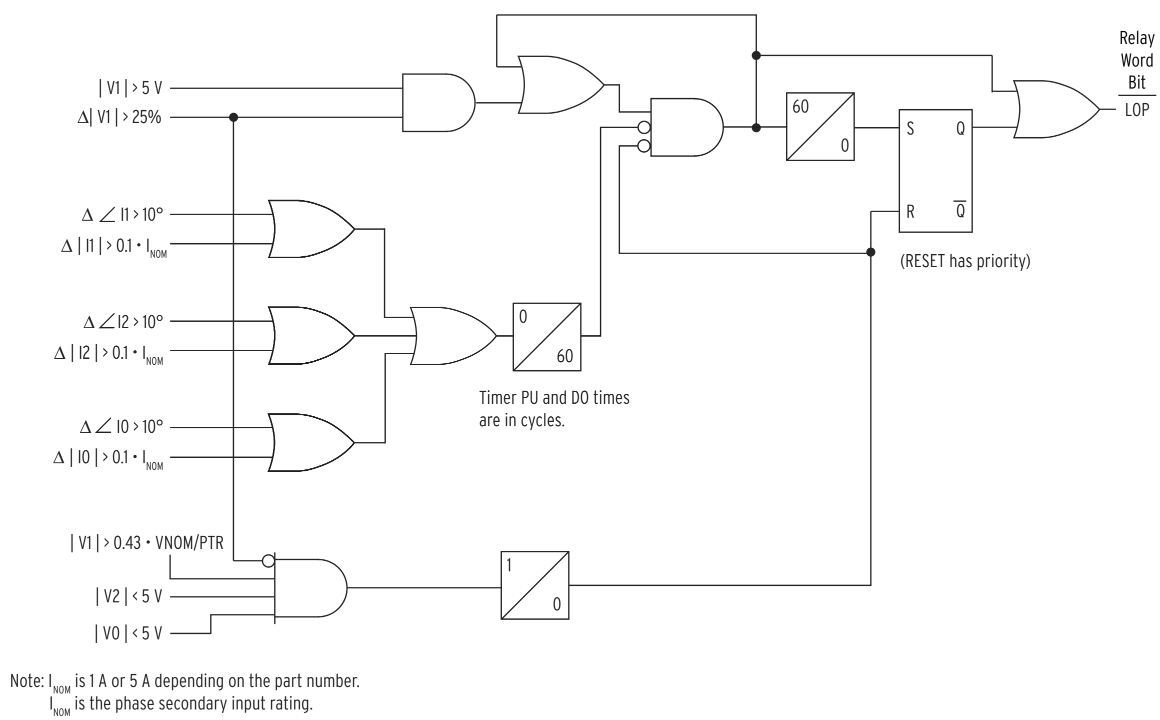


Figure 4.38 Loss-of-Potential (LOP) Logic

Frequency and Load Control Settings

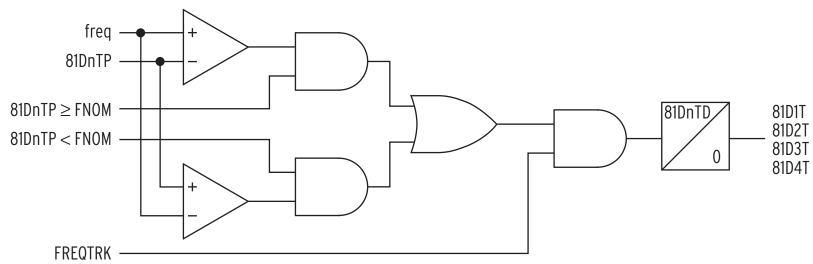
Frequency Elements

Table 4.36 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FREQ1 TRIP LEVEL	OFF, 20.0–70.0 Hz	81D1TP := OFF
FREQ1 TRIP DELAY	0.0–240.0 s	81D1TD := 1.0
FREQ2 TRIP LEVEL	OFF, 20.0–70.0 Hz	81D2TP := OFF
FREQ2 TRIP DELAY	0.0–240.0 s	81D2TD := 1.0
FREQ3 TRIP LEVEL	OFF, 20.0–70.0 Hz	81D3TP := OFF
FREQ3 TRIP DELAY	0.0–240.0 s	81D3TD := 1.0
FREQ4 TRIP LEVEL	OFF, 20.0–70.0 Hz	81D4TP := OFF
FREQ4 TRIP DELAY	0.0–240.0 s	81D4TD := 1.0

NOTE: The relay measures system frequency for these elements with the positive-sequence voltage if the voltage input option is present and the applied positive-sequence voltage is greater than 10 volts for at least three cycles. Otherwise, the relay uses positive-sequence current as long as the minimum magnitude is 0.1 • (nominal CT rating). The measured frequency is set to nominal frequency setting (FNOM) if the signal is below the minimum level.

The SEL-710 provides four 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 4.39* shows the logic diagram for the frequency elements.



n = Frequency Elements 1–4
freq = Measured Frequency
81DnTP = Frequency Pickup Setting
FNOM = Nominal Frequency Setting
81DnTD = Over- and Underfrequency Element Pickup Time Delay
81DnT = Definite-Time Delayed Over- and Underfrequency Element Relay Word Bit
FREQTRK = Relay Is Tracking Frequency

Figure 4.39 Over- and Underfrequency Element Logic

Load Control Function

Table 4.37 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: Prompts of the settings LOADUPP and LOADLOWP are dependent on the LOAD setting. All possible prompts are shown in Table 4.37. The relay will show only the appropriate prompts based on the LOAD setting.

NOTE: In addition to setting the load control levels, you must assign LOADUP and LOADLOW to auxiliary output relays (one each); see Table 4.50, and Figure 2.10 for the connection diagrams.

The SEL-710 provides an ability to control external devices based on the parameter load control selection. You can select current, power, or stator thermal capacity utilized to operate auxiliary outputs. Load control is active only when the motor is in the running state.

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

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

Trip Logic and Motor Control

Trip Inhibit (Block) Function

Table 4.38 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 4.38* can be inhibited when the BLKPROT control input asserts. Using the SELOGIC control equation BLKPROT, you can achieve torque control for the protective functions shown in *Table 4.38*. The SELOGIC control equations in *Table 4.39* are internal and not available for setting. You can monitor the status of the torque control of the protective functions using the Relay Word bits shown.

Table 4.39 Torque Control Status (Sheet 1 of 2)

SELOGIC Control Equations	
46UBTC := 1	if setting BLK46 := NO
46UBTC := !BLKPROT	if setting BLK46 := YES
48LJTC := 1	if setting BLK48 := NO
48LJTC := !BLKPROT	if setting BLK48 := YES
50EFTC := 1	if setting BLK50EF := NO
50EFTC := !BLKPROT	if setting BLK50EF := YES
50PTC := 1	if setting BLK50P:= NO
50PTC := !BLKPROT	if setting BLK50P := YES

Table 4.39 Torque Control Status (Sheet 2 of 2)

SELogic Control Equations	
37LLTC := 1	if setting BLK37 := NO
37LLTC := !BLKPROT	if setting BLK37 := YES
66JOGTC := 1	if setting BLK66 := NO
66JOGTC := !BLKPROT	if setting BLK66 := YES
49PTCTC := 1	if setting BLK49PTC := NO
49PTCTC := !BLKPROT	if setting BLK49PTC := YES
49RTDTC := 1	if setting BLK49RTD := NO
49RTDTC := !BLKPROT	if setting BLK49RTD := YES

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 example, during starting of a motor there can be an inrush current; you can block ground fault protection and short circuit protection elements by assigning BLKPROT := STARTING and BLK50EF := Y, BLK50P := Y. Once the motor is in running state, the blocking condition no longer exists and the protection elements are enabled.

When a block protection scheme is active, you could have no warning or trip or reset. Tripping delays begin to run or are active once the blocking function deasserts. Some of the instances where you could use trip inhibit function are as follows:

- 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)

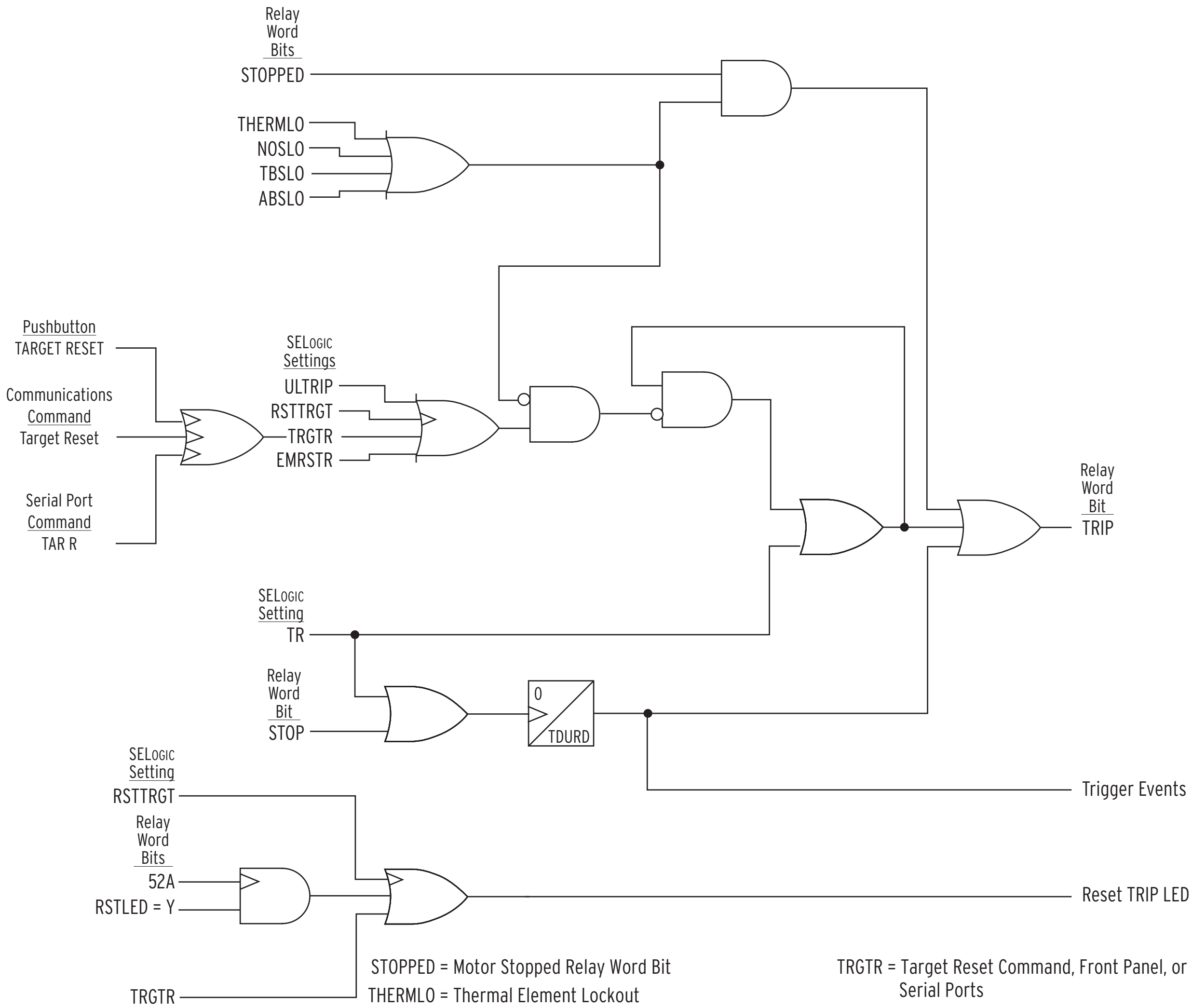
Trip/Close Logic

Table 4.40 Trip and Close Logic Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MIN TRIP TIME	0.0–400.0 s	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 (27P1T AND NOT LOP) OR SV01T
REMOTE TRIP EQN	SV	REMTRIP := 0
UNLATCH TRIP EQN	SV	ULTRIP := 0
CONTACTOR STATUS	SV	52A := 0

NOTE: The factory-default assignment of the Relay Word bit TRIP is the output **OUT103**. See Table 4.50 for the output contacts settings.

The SEL-710 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 4.40* illustrates the tripping logic.



STOPPED = Motor Stopped Relay Word Bit
THERMLO = Thermal Element Lockout
NOSLO = Starts-Per-Hour Lockout
TBSLO = Minimum Time Between Starts Lockout
ABSLO = Antibackspin Lockout
ULTRIP = Unlatch Trip SELOGIC Control Equation
RSTTRGT = Target Reset SELOGIC Control Equation
TRGTR = Target Reset Command, Front Panel, or Serial Ports
EMRSTR = Emergency Start Command, Front Panel, or Modbus/DeviceNet Command
TR = Trip SELOGIC Control Equation
STOP = Motor Stop Command, Front Panel, or Serial Ports
TDURD = Minimum Trip Time Setting

Figure 4.40 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

NOTE: The outputs in the SEL-710 are not designed to interrupt the trip coil current. An auxiliary contact with adequate current interrupting capacity must clear the trip coil current before the output of the SEL-710 opens. Failure to observe this safeguard could result in damage to the SEL-710 output contacts. Avoid programming Relay Word bit TR in the output equation to directly trip the breaker. Instead use Relay Word bit TRIP, which stays asserted for at least the duration of the TDURD setting or until TRIP is unlatched, whichever is longer.

The SEL-710 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 *Fail-Safe/Nonfail-Safe Tripping on page 2.21*).

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: The factory-default setting of ULTRIP provides a manual reset of the protection trips. You can make the reset automatic by setting ULTRIP := 1.

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 **TARGET 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 value is too high to permit a normal motor start without tripping. The trip signal is maintained until the % Thermal Capacity decreases to a level where a start can safely take place (see the following logic diagram for details).

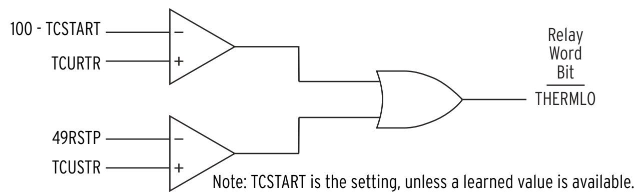


Figure 4.41 Thermal Element Lockout Logic

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 reset when all the lockouts are cleared.

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 4.42). This is particularly important if the motor has low operational idling current (less than 10 percent FLA).

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 no auxiliary contact connection (52A := 0).

If you connect the breaker auxiliary contact to a digital input, you must change the factory-default logic equation 52A. For example, set 52A := IN101 if you connect the 52a contact to input IN101.

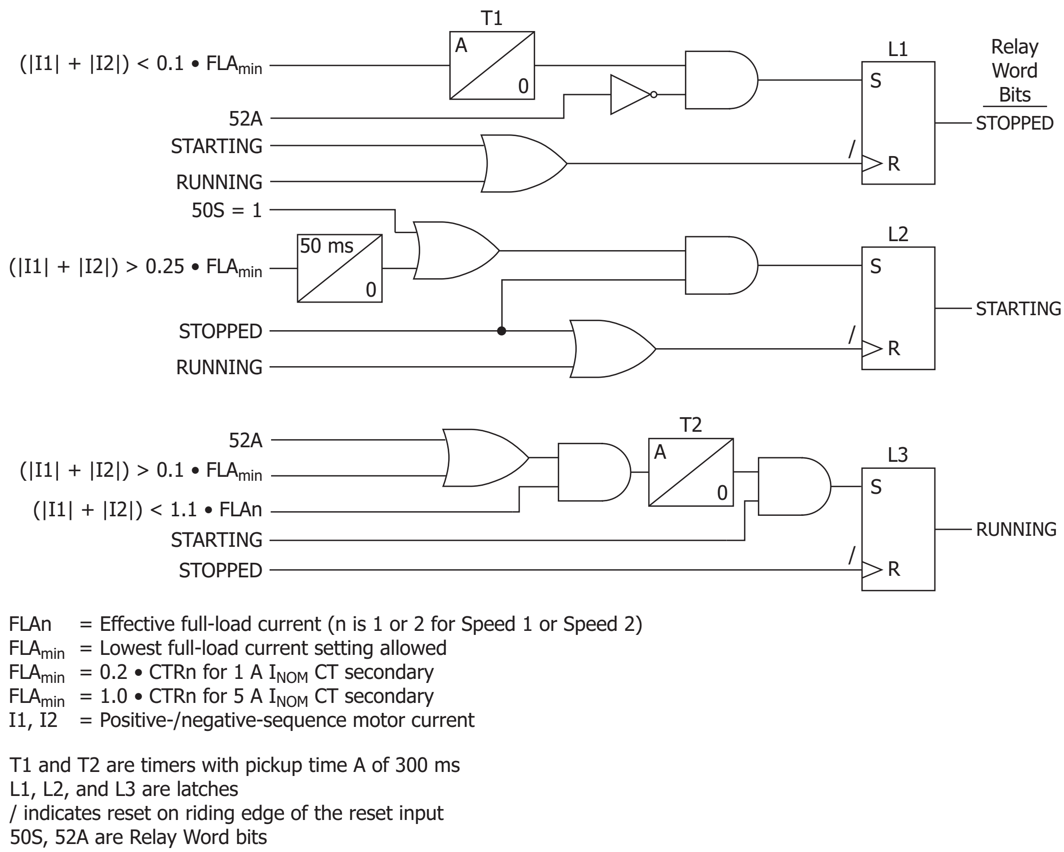


Figure 4.42 Motor State Logic

Motor Control

The Motor Control settings interface the SEL-710 for external start control and motor speed control. *Table 4.41* lists these SELOGIC control equation settings.

Table 4.41 Motor Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
START EQUATION	SELOGIC	STREQ := PB03
EMERGENCY START	SELOGIC	EMRSTR := 0
SPEED2	SELOGIC	SPEED2 := 0
SPEED SWITCH	SELOGIC	SPEEDSW := 0

Start Controls

Figure 4.43 shows the logic the relay uses to initiate motor starts.

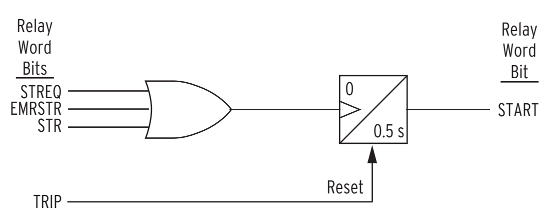


Figure 4.43 Start Logic

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 is received from SELOGIC control equation STREQ
- Emergency restart signal is 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 4.40*). 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 4.43*.

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 the SEL-710 selects second values for the settings shown in *Table 4.42*. 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. Refer to *Table 4.27* for more detail.

Table 4.42 Settings Selected by SPEED2 Input (Sheet 1 of 2)

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 LRA (LRA1)	MOTOR LRA–2nd (LRA2)
Hot-Locked Rotor Time	LOCKD RTR TIME 1 (LRTHOT1)	LOCKD RTR TIME 2 (LRTHOT2)

Table 4.42 Settings Selected by SPEED2 Input (Sheet 2 of 2)

Setting Description	Normal Setting Prompt (Normal Setting Name)	Second Setting Prompt (Second Setting Name)
Acceleration Factor	ACCEL FACTOR (TD1)	ACCEL FACT–2nd (TD2)
Run State Time Constant	STATOR TC (RTC1)	STATOR TC–2nd (RTC2)
Overload Curve Number	THERM OL CURVE1 (CURVE1)	THERM OL CURVE2 (CURVE2)

Logic Settings (SET L Command)

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

SELogic Enables

The following table shows the enable settings for latch bits (ELAT), SELogic control equations (including timers) (ESV), Counters (ESC), and math variable equations (EMV). This helps limit the number of settings that you need to make. For example, if you need six timers, only enable six timers.

Table 4.43 Enable Settings

Setting Prompt	Setting Range	Default Setting
SELogic Latches	N, 1–32	ELAT := N
SV/Timers	N, 1–32	ESV := 1
SELogic Counters	N, 1–32	ESC := N
Math Variables[a]	N, 1–32	EMV := N

[a] If a math variable is set equal to NA (e.g., MV01 := NA), it is treated as 0.

Latch Bits

Latch control switches (latch bits are the outputs of these switches) replace traditional latching devices. Traditional latching devices maintain output contact state. The SEL-710 latch control switch also retains state even when power to the device is lost. If the latch control switch is set to a programmable output contact and power to the device is lost, the state of the latch control switch is stored in nonvolatile memory, but the device de-energizes the output contact. When power to the device is restored, the programmable output contact will go back to the state of the latch control switch after device initialization. Traditional latching device output contact states are changed by pulsing the latching device inputs (see *Figure 4.44*). Pulse the set input to close (set) the latching device output contact. Pulse the reset input to open (reset) the latching device output contact. The external contacts wired to the latching device inputs are often from remote control equipment (e.g., SCADA, RTU).

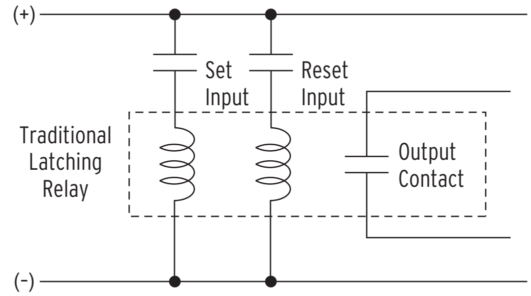


Figure 4.44 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-710 provide latching device functionality. *Figure 4.45* shows the logic diagram of a latch switch. The output of the latch control switch is a Relay Word bit LT*n* (*n* = 01–32), called a latch bit.

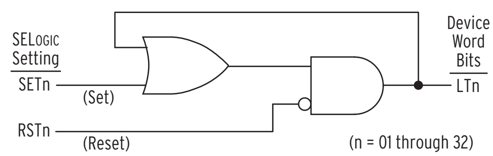


Figure 4.45 Logic Diagram of a Latch Switch

If setting SET*n* asserts to logical 1, latch bit LT*n* asserts to logical 1. If setting RST*n* asserts to logical 1, latch bit LT*n* deasserts to logical 0. If both settings SET*n* and RST*n* assert to logical 1, setting RST*n* has priority and latch bit LT*n* deasserts to logical 0. You can use these latch bits in SELOGIC control equations to create custom logic for your application.

The SEL-710 includes 32 latches. *Table 4.44* shows the **SET** and **RESET** default settings for Latch 1. The remaining latches have the same settings.

Table 4.44 Latch Bits Equation Settings

Settings Prompt	Setting Range	Setting Name := Factory Default
SET01	SELOGIC	SET01 := NA
RST01	SELOGIC	RST01 := NA
•	•	•
•	•	•
•	•	•
SET32	SELOGIC	SET32 := NA
RST32	SELOGIC	RST32 := NA

Latch Bits: Nonvolatile State

Power Loss

The states of the latch bits (LT01–LT32) are retained if power to the device is lost and then restored. If a latch bit is asserted (e.g., LT02 := logical 1) when power is lost, it is asserted (LT02 := logical 1) when power is restored. If a latch bit is deasserted (e.g., LT03 := logical 0) when power is lost, it is deasserted (LT03 := logical 0) when power is restored.

Settings Change

If individual settings are changed, the states of the latch bits (Relay Word bits LT01 through LT32) are retained, as in the preceding *Power Loss on page 4.60* explanation. If the individual settings change causes a change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1 through 32), the retained states of the latch bits can be changed, subject to the newly enabled settings SET*n* or RST*n*.

Make Latch Control Switch Settings With Care

The latch bit states are stored in nonvolatile memory so they can be retained during power loss or settings change. The nonvolatile memory is rated for a finite number of writes for all cumulative latch bit state changes. Exceeding the limit can result in a flash self-test failure. *An average of 70 cumulative latch bit state changes per day can be made for a 25-year device service life.*

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

SELOGIC Control Equation Variables/Timers

Enable the number of SELOGIC control equations necessary for your application. Only the enabled SELOGIC control equations appear for settings. Each SELOGIC control equation variable/timer has a SELOGIC control equation setting input and variable/timer outputs as shown in *Figure 4.46*. Timers SV01T through SV32T in *Figure 4.46* have a setting range of 0.00–3000.00 seconds. This timer setting range applies to both pickup and dropout times (SV*n*PU and SV*n*DO, *n* = 1 through 32).

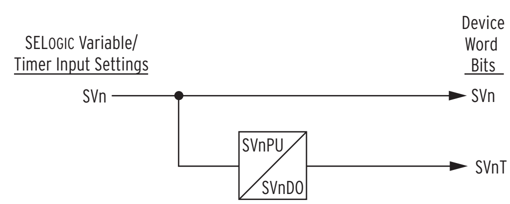


Figure 4.46 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

You can enter as many as 15 elements per SELOGIC equation, including a total of 14 elements in parentheses (see *Table 4.45* for more information).

SELOGIC Control Equation Operators

Use the Boolean operators to combine values with a resulting Boolean value. Edge trigger operators provide a pulse output. Combine the operators and operands to form statements that evaluate complex logic. SELOGIC control equations are either Boolean type or math type. Because the equals sign (=) is already used as an equality comparison, both Boolean type and math type of SELOGIC control equation settings begin with an “assignment” operator (:=) instead of with an equals sign.

Boolean SELOGIC control equation settings use logic similar to Boolean algebra logic, combining Relay Word bits together with one or more of the Boolean operators listed in *Table 4.45*. Math SELOGIC control equation settings operate on numerical values, using one or more of the Mathematical operators listed in *Table 4.45*. These numerical values can be mathematical variables or actual real numbers.

The relay converts variables from decimal to integer before performing math operations, i.e., scales it by multiplying by 128 followed by rounding. After the math operations, the relay converts the result back from integer to decimal by scaling the value down by 128 before reporting the results. This effectively means that math calculations are rounded. See *Example 4.10* for an explanation on improving the accuracy of the math operations by managing the processing order.

EXAMPLE 4.10 Improving the Accuracy of Math Operations

If MV01 := (60/4160) • 100,000, the relay performs the 60/4160 calculation and scales it by 128, then rounds this up to a 2. The relay then multiplies it by 100,000 and stores it as 200,000. When the number is reported it divides out the scale factor (128) and reports 1562.5.

Alternatively, if MV01 := (60 • 100,000)/4160, the relay multiplies (60 • 100,000) and then scales by 128 and then divides by 4160. This result is then rounded and stored as 184,615. The relay then divides 184,615 by 128 and reports 1442.3.

Example 4.10 illustrates how important it is to avoid calculations where a small number is divided by a large number followed by multiplication. It will amplify the error significantly.

The executed result of a math SELOGIC control equation is stored in a math variable. The smallest and largest values a math variable can represent are –16777215.99 and +16777215.99, respectively. If the executed result exceeds these limits, it will be clipped at the limit value. For example, when the MV01:= executed result is –16777219.00, MV01 will be –16777215.99. Similarly, when the MV02 := executed result is +16777238.00, MV02 will be +16777215.99.

Comments can be added to both Boolean and math SELOGIC control equations by inserting a # symbol. Everything following the # symbol in a SELOGIC control equation is treated as a comment. See *Table 4.46* for this and other Boolean and math operators and values.

Operator Precedence

When you combine several operators and operands within a single expression, the SEL-710 evaluates the operators from left to right, starting with the highest precedence operators and working down to the lowest precedence. This means that if you write an equation with three AND operators, for example SV01 AND SV02 AND SV03, each AND will be evaluated from the left to the right. If you substitute NOT SV04 for SV03 to make SV01 AND SV02 AND NOT SV04, the device evaluates the NOT operation of SV04 first and uses the result in subsequent evaluation of the expression.

Table 4.45 SELOGIC Control Equation Operators (Listed in Operator Precedence)

Operator	Function	Function Type (Boolean and/or Mathematical)
( )	parentheses	Boolean and Mathematical (highest precedence)
–	negation	Mathematical
NOT	NOT	Boolean
R_TRIG	rising-edge trigger/detect	Boolean
F_TRIG	falling-edge trigger/detect	Boolean

Table 4.45 SELOGIC Control Equation Operators (Listed in Operator Precedence)

Operator	Function	Function Type (Boolean and/or Mathematical)
* /	multiply divide	Mathematical
+ -	add subtract	Mathematical
<, >, <=, >=	comparison	Boolean
= <>	equality inequality	Boolean
AND	AND	Boolean
OR	OR	Boolean (lowest precedence)

Parentheses Operator ( )

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

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

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

Math Negation Operator (–)

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

MV01 := **RB01**

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

MV01 := **-1 * RB01**

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

Boolean NOT Operator (NOT)

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

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

SV01 := **NOT RB01**

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

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

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

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

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

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

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

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

Boolean Rising-Edge Operator (R_TRIG)

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

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

ER := **R_TRIG IN101 OR R_TRIG IN102**

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

Boolean Falling-Edge Operator (F_TRIG)

Apply the falling-edge operator, F_TRIG, to individual Relay Word bits only; you cannot apply F_TRIG to groups of elements within parentheses. The falling-edge operator, F_TRIG, operates similarly to the rising-edge operator, but operates on Relay Word bit deassertion (elements going from logical 1 to logical 0) instead of Relay Word bit assertion. When the Relay Word bit deasserts, F_TRIG interprets this logical 1 to logical 0 transition as a “falling edge” and asserts to logical 1 for one processing interval, as shown in *Figure 4.47*.

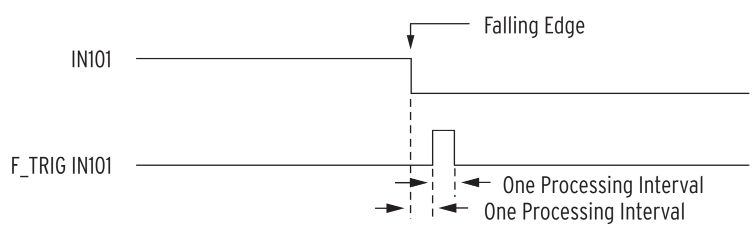


Figure 4.47 Result of Falling-Edge Operator on a Deasserting Input

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

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

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

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

Comparisons are mathematical operations that compare two numerical values, with the result being a logical 0 (if the comparison is not true) or logical 1 (if the comparison is true). Thus, what starts out as a mathematical comparison ends up as a Boolean resultant.

For example, if the output of a math variable is above a certain value, an output contact is asserted:

OUT103 := **MV01 > 8**

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

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

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

OUT102 := **MV01 <> 45**

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

Table 4.46 Other SELOGIC Control Equation Operators/Values

Operator/ Value	Function	Function Type (Boolean and/or Mathematical)
0	Set SELOGIC control equation directly to logical 0 (XXX := 0)	Boolean
1	Set SELOGIC control equation directly to logical 1 (XXX := 1)	Boolean
#	Characters entered after the # operator are not processed and deemed as comments	Boolean and Mathematical
\	Indicates that the preceding logic should be continued on the next line ("\" is entered only at the end of a line)	Boolean and Mathematical

Timers Reset When Power Lost or Settings Changed

If the device loses power or settings change, the SELOGIC control equation variables/timers reset. Relay Word bits SV*n* and SV*n*T (*n* = 01–32) reset to logical 0 after power restoration or a settings change. *Figure 4.48* 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)**

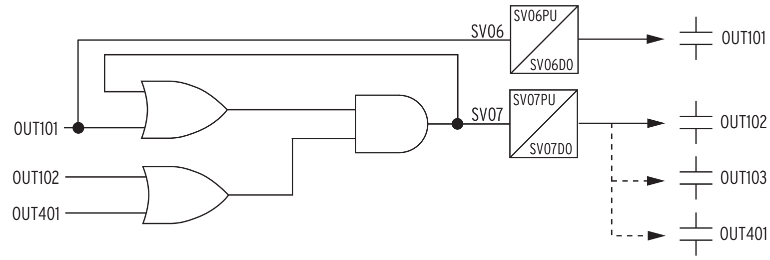


Figure 4.48 Example Use of SELogic Variables/Timers

SV/Timers Settings

The SEL-710 includes 32 SELogic variables. *Table 4.47* shows the pickup, dropout, and equation settings for SV01 and SV02. The remaining SELogic variables have the same default settings as SV02.

Table 4.47 SELogic Variable Settings

Setting Prompt	Setting Range	Default Settings
SV TIMER PICKUP	0.00–3000.00	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00	SV01DO := 0.00
SV INPUT	SELogic	SV01 := WDGTRIP OR BRGTRIP OR OTHTRIP OR AMBTRIP OR REMTRIP OR 37PT OR VART OR PTCTRIP OR 81D1T OR 81D2T OR 81D3T OR 81D4T OR 50Q1T OR 87M1T OR 87M2T
SV TIMER PICKUP	0.00–3000.00	SV02PU := 0.000
SV TIMER DROPOUT	0.00–3000.00	SV02DO := 0.000
SV INPUT	SELogic	SV02 := NA
• • •		

Counter Variables

NOTE: These counter elements conform to the standard counter function block #3 in IEC 1131-3 First Edition 1993-03 International Standard for Programmable controllers—Part 3: Programming languages.

NOTE: For device configurations that include either current or voltage cards, the SEL-710 tracks the frequency. When tracking the frequency, the processing interval varies with the frequency.

NOTE: If setting SCnnCD is set to NA, the entire counter nn is disabled).

NOTE: SELogic counters are reset to zero if the relay loses power because the counters are stored in volatile memory.

SELogic counters are up- or down-counting elements, updated every processing interval.

Each counter element consists of one count setting, four control inputs, two digital outputs, and one analog output. *Figure 4.49* shows Counter 01, the first of 32 counters available in the device.

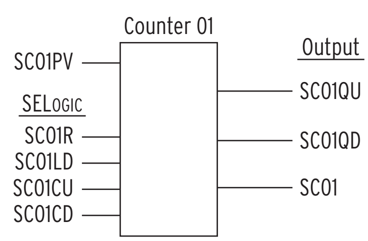


Figure 4.49 Counter 01

Digital output SC01QD asserts when the counter is at position zero, and Digital output SC01QU asserts when the counter reaches the programmable count value. Use the reset input (SC01R) to force the count to zero, and the analog output (SC*nn*) with analog comparison operators. *Table 4.48* describes the counter inputs and outputs, and *Table 4.49* shows the order of precedence of the control inputs.

Table 4.48 Counter Input/Output Description

Name	Type	Description
SC*nn*LD	Active High Input	Load counter with the preset value to assert the output (SC*n*QU) (follows SELOGIC setting).
SC*nn*PV	Input Value	This Preset Value is loaded when SC*n*LD pulsed. This Preset Value is the number of counts before the output (SC*n*QU) asserts (follows SELOGIC setting).
SC*nn*CU	Rising-Edge Input	Count Up increments the counter (follows SELOGIC setting).
SC*nn*CD	Rising-Edge Input	Count Down decrements the counter (follows SELOGIC setting).
SC*nn*R	Active High Input	Reset counter to zero (follows SELOGIC setting)
SC*nn*QU	Active High Output	This Q Up output asserts when the Preset Value (maximum count) is reached (SC*n* = SC*n*PV, *n* = 01 to 32).
SC*nn*QD	Active High Output	This Q Down output asserts when the counter is equal to zero (SC*n* = 0, *n* = 01 to 32).
SC*nn*	Output Value	This counter output is an analog value that may be used with analog comparison operators in a SELOGIC control equation and viewed using the **COU** command.

Table 4.49 Order of Precedence of the Control Inputs

Order	Input
1	SC*nn*R
2	SC*nn*LD
3	SC*nn*CU
4	SC*nn*CD

Figure 4.50 shows an example of the effects of the input precedence, with SC01PV set to 7. The vertical dashed line indicates the relationship between SC01CU first being seen as a rising edge and the resultant outputs. This indicates that there is no intentional lag between the control input asserting and the count value changing. Most of the pulses in the diagram are on every second processing interval. The “one processing interval” valley is an example where the CD and CU pulses are only separated by one processing interval.

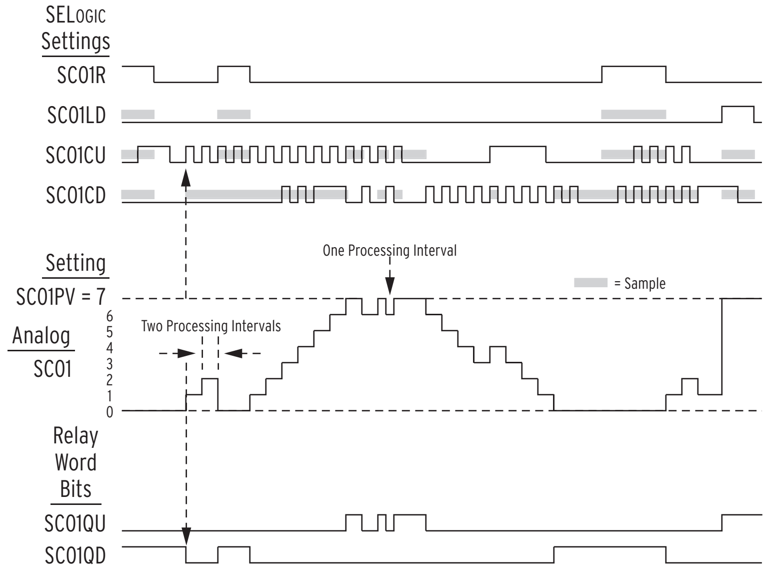


Figure 4.50 Example of the Effects of the Input Precedence

The shaded areas illustrate the precedence of the inputs:

- ➤ When SC01R is asserted, the SC01LD input is ignored.
- ➤ When SC01R or SC01LD is asserted, rising edges on the SC01CU or SC01CD inputs are ignored.
- ➤ When input SC01CU has a rising edge, a rising edge on SC01CD is ignored (unless SC01 is already at the maximum value SC01PV (= 7), in which case SC01CU is ignored, and the SC01CD is processed). An example of this exception appears in *Figure 4.50*, just before the “one processing interval” notation.

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

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

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

Output Contacts

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

NOTE: Four digital outputs for Slot **C** are shown. The outputs for Slot **D** (OUT401–OUT404) and Slot **E** (OUT501–OUT504) have similar settings.

Table 4.50 Control Output Equations and Contact Behavior Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT101 FAIL-SAFE	Y, N	OUT101FS := Y
OUT101	SELOGIC	OUT101 := HALARM OR SALARM
OUT102 FAIL-SAFE	Y, N	OUT102FS := N
OUT102	SELOGIC	OUT102 := START
OUT103 FAIL-SAFE	Y, N	OUT103FS := Y
OUT103	SELOGIC	OUT103 := TRIP or PB04
OUT301 FAIL-SAFE	Y, N	OUT301FS := N

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 4.50 Control Output Equations and Contact Behavior Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT301	SELOGIC	OUT301 := 0
OUT302 FAIL-SAFE	Y, N	OUT302FS := N
OUT302	SELOGIC	OUT302 := 0
OUT303 FAIL-SAFE	Y, N	OUT303FS := N
OUT303	SELOGIC	OUT303 := 0
OUT304 FAIL-SAFE	Y, N	OUT304FS := N
OUT304	SELOGIC	OUT304 := 0

You can use SELOGIC control equations to map protection (trip and warning) and general-purpose control elements to the outputs with the SEL-710. In addition, you can enable fail-safe output contact operation for relay contacts on an individual basis.

If the contact fail-safe is enabled, the relay output is held in its energized position when relay control power is applied. The output falls to its de-energized position when control power is removed. Contact positions with de-energized output relays are indicated on the relay chassis and in *Figure 2.11* and *Figure 2.12*.

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

MIRRORED BITS Transmit SELOGIC Control Equations

See *Appendix G: MIRRORED BITS Communications* and *SEL-710 Settings Sheets* for details.

Global Settings (SET G Command)

General Settings

Table 4.51 General Global Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
APPLICATION	FULL, NAMEPLATE	APP := FULL
PHASE ROTATION	ABC, ACB	PHROT := ABC
RATED FREQ.	50, 60 Hz	FNOM := 60
DATE FORMAT	MDY, YMD, DMY	DATE_F := MDY
FAULT CONDITION	SELOGIC	FAULT := STARTING OR 50S OR 50G1P OR 50N1P OR TRIP

The APP setting is intended to set the SEL-710 to provide basic motor protection as quickly as possible. When you set APP := NAMEPLATE, the SEL-710 does the following:

- ➤ Forces all Group 1, Logic 1, and Global settings to the factory-default values, except those shown in the following table.

Setting Name (Prompt)	Forced Value
COOLTIME (STOP COOL TIME)	4 * RTC1
50P1P (PH OC TRIP LVL)	K * LRA1[a]
APP (APPLICATION)	NA[b]
PHROT (PHASE ROTATION)	NA[b]
FNOM (RATED FREQ)	NA[b]
DATE_F (DATE FORMAT)	NA[b]

[a] SEL-710 uses K=2.0 in most cases, but it will automatically use a lower number (1.5 < K < 2.0) to satisfy setting interdependencies, if any.
[b] Not applicable, existing setting is retained.

- ➤ Hides all Group, Logic, and Global settings except those shown in the following table. These are the only settings you must set for your application.

Setting Name (Prompt)	Range
Global Settings	
APP (APPLICATION)	FULL, NAMEPLATE
PHROT (PHASE ROTATION)	ABC, ACB
FNOM (RATED FREQ)	50, 60 Hz
DATE_F (DATE FORMAT)	MDY, YMD, DMY
Group Settings	
RID (UNIT ID LINE 1)	16 characters
TID (UNIT ID LINE 2)	16 characters
CTR1 (PHASE CT RATIO)	1–5000
FLA1 (MOTOR FLA)	0.2–5000.0 A
CTRN (NEUTRAL CT RATIO)	1–2000
PTR (PHASE PT RATIO)	1.00–250.00
VNOM (LINE VOLTAGE)	100–30000 V
DELTA_Y (XFMR CONNECTION)	Delta, Wye
SINGLEV (SINGLE V INPUT)	Y, N
SF (SERVICE FACTOR)	1.01–1.50
LRA1 (MOTOR LRA)	2.5–12.0 xFLA
LRTHOT1 (LOCKED ROTOR TIME)	1.0–600.0 s
50N1P (NEUT OC TRIP LVL)	OFF, 0.01–25.00 A
50N1D (NEU OC TRIP DLAY)	0.00–5.00 s
50G1P (RES OC TRIP LVL)	OFF, 0.10–20.00 xFLA
50G1D (RES OC TRIP DLAY)	0.00–5.00 s

Setting Name (Prompt)	Range
Logic Setting	
OUT103FS (OUT103 FAIL-SAFE)	Y, N

When you change the APP setting from FULL to NAMEPLATE, the following protection is provided by the SEL-710 based on the settings listed in the previous table and the hidden settings (all other protections and warning functions are disabled).

- Thermal stator and rotor protection based on motor ratings
- Current unbalance protection (20 percent unbalance, 5-second delay)
- Instantaneous phase overcurrent trip level set based on IEEE C37.96 recommendation for phase overcurrent protection
- Ground overcurrent protection
- Phase overvoltage protection (1.1 • VNOM, 0.5-second delay)
- Phase reversal protection
- Breaker failure protection

When you change the APP setting from FULL to NAMEPLATE, the SEL-710 automatically simplifies control functions as described below:

- No star-delta starting
- No load control
- Input/output functions via Analog Input/Output cards disabled
- SELOGIC control equations for emergency start and data reset (Target, Energy, and Max/Min) disabled and hidden (You can use the front-panel menu for these functions.)
- SELOGIC control equations for selecting setting groups 2 and 3 disabled and hidden

When global setting APPLICATION is set to FULL, all group, global, and logic settings are available for complete motor protection and control.

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

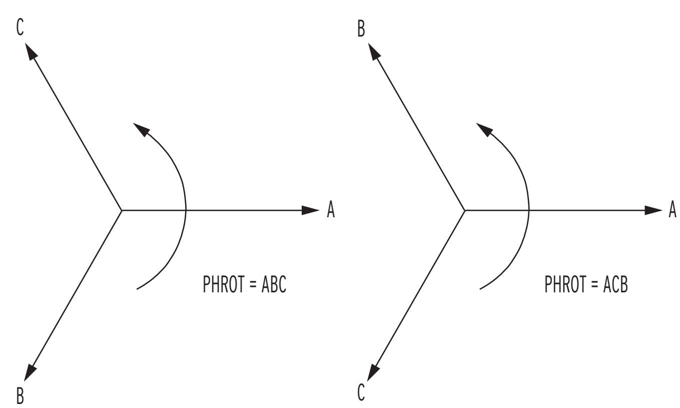


Figure 4.51 Phase Rotation Setting

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

Set the SELOGIC equation FAULT to temporarily block *Maximum and Minimum Metering on page 5.5*.

Multiple Settings Groups

SEL-710 Relays have three independent settings groups. Each settings group has complete relay settings and protection SELOGIC settings. The active settings group can be:

- ➤ Viewed on the front-panel LCD using the **MAIN** > **Set/Show** > **Active Group** menus, as shown in *Figure 8.23*.
- ➤ Viewed using the SEL ASCII serial port **GROUP** command, as described in *Table 7.19*.
- ➤ Selected using the SEL ASCII serial port **GROUP *n*** command described in *Table 7.19*.
- ➤ Selected using SELOGIC control equation settings SS1 through SS3, as shown in *Table 4.52*.

If SELOGIC control equations SS1–SS3 are defined and evaluate to logical 1, they have priority over the **GROUP *n*** command to select the active settings group. If the SELOGIC control equations are defined but evaluate to logical 0, or if they are not defined, the **GROUP *n*** command can be used to select the active settings group.

Active Settings Group Indication

Only one settings group can be active at a time. Relay Word bits SG1 through SG3 indicate the active settings group. For example, if settings Group 3 is the active settings group, Relay Word bit SG3 is asserted to logical 1 and Relay Word bits SG1 and SG2 are deasserted to logical 0.

Active Settings Group Selection Via SELOGIC Control Equations

The Global settings class contains the SELOGIC control equation settings SS1 through SS3, as shown in *Table 4.52*.

Table 4.52 Setting Group Selection

Setting Prompt	Setting Range	Setting Name := Factory Default
GRP CHG DELAY	0–400 s	TGR := 3
SELECT GROUP1	SELOGIC	SS1 := 1
SELECT GROUP2	SELOGIC	SS2 := 0
SELECT GROUP3	SELOGIC	SS3 := 0

As an example of how these settings operate, assume that the active settings group is settings Group 3. The corresponding Relay Word bit, SG3, is asserted to logical 1 to indicate that settings Group 3 is the active settings group.

When settings Group 3 is the active settings group, setting SS3 has priority. If setting SS3 is asserted to logical 1, settings Group 3 remains the active settings group, regardless of the activity of settings SS1 and SS2. If settings SS2 and SS3 all deassert to logical 0, settings Group 3 remains the active settings group.

If the active setting Group 3 SELOGIC control equation SS3 deasserts to logical 0 and one of the other settings (e.g., SS1) asserts to logical 1, the relay switches the active settings group from settings Group 3 to one of the other settings groups (e.g., settings Group 1) after the qualifying time setting TGR (Global setting).

In this example, if multiple SS*n* assert after SS3 deasserts to logical 0, the order of switching follows the first SS*n* that is set in a priority order of 1 through 3.

Active Settings Group Changes

The relay is disabled for less than one second while it processes the active settings group change. Relay elements, timers, and logic are reset, unless otherwise indicated in the specific logic description. For example, local bit (LB01–LB32), remote bit (RB01–RB32), and latch bit (LT01–LT32) states are retained during an active settings group change. The output contacts do not change state until the relay enables in the new settings group and the SELOGIC control equations are processed to determine the output contact status for the new group. After a group change, an automatic message is shown on the front panel and sent to any serial port that has setting AUTO := Y.

Active Setting: Nonvolatile State

Power Loss

The active settings group is retained if power to the relay is lost and then restored. If a settings group is active when power is lost, the same settings group is active when power is restored.

Settings Change

If individual settings are changed for the active settings group or one of the other settings groups, the active settings group is retained. If individual settings are changed for a settings group other than the active settings group, there is no interruption of the active settings group, so the relay is not momentarily disabled. If the individual settings change causes a change in one or more SELOGIC control equation settings SS1–SS3, the active settings group can be changed, subject to the newly enabled SS1–SS3 settings.

Time and Date Management Settings

The SEL-710 supports several methods of updating the relay time and date. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.13*.

Table 4.53 shows the time and date management settings that are available in the Global settings.

Table 4.53 Time and Date Management Settings (Sheet 1 of 2)

Setting Description	Setting Range	Setting Name := Factory Default
IRIG-B Control Bits Definition	NONE, C37.118	IRIGC := NONE
Offset From UTC	–24.00 to 24.00 hours, rounds up to nearest 0.25 hour	UTC_OFF := 0.00
Month To begin DST	OFF, 1–12	DST_BEGM := OFF
Week Of The Month To Begin DST	1–3, L	DST_BEGW := 2
Day Of The Week To Begin DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_BEGD := SUN

Table 4.53 Time and Date Management Settings (Sheet 2 of 2)

Setting Description	Setting Range	Setting Name := Factory Default
Local Hour To Begin DST	0–23	DST_BEGH := 2
Month To End DST	1–12	DST_ENDM := 11
Week Of The Month To End DST	1–3, L	DST_ENDW := 1
Day Of The Week To End DST	SUN, MON, TUE, WED, THU, FRI, SAT, SUN	DST_ENDD := SUN
Local Hour To End DST	0–23	DST_ENDH := 2

Simple Network Time Protocol (SNTP)

The SEL-710 Port 1 (Ethernet Port) supports the SNTP Client protocol. See *Section 7: Communications*, *Simple Network Time Protocol (SNTP) on page 7.13* for a description and *Table 7.6* for the settings.

Breaker Failure Settings

Table 4.54 Breaker Failure Settings

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

The SEL-710 provides flexible breaker failure logic (see *Figure 4.52*). In the default breaker failure logic, assertion of Relay Word bit TRIP starts the BFD timer if the average motor current is above 0.1 • FLA_{min}. If the current remains above the threshold for BFD delay setting, Relay Word bit BFT will assert. Use the BFT to operate an output relay to trip appropriate backup breakers.

Changing the BFI and/or 52ABF settings can modify the default breaker failure logic.

- ➤ Set BFI = R_TRIG TRIP AND NOT IN102 if input IN102 is manual trip only and breaker failure initiation is not wanted when the tripping is caused by this input.
- ➤ Set 52ABF = Y if you want the breaker failure logic to detect failure of breaker/contactor auxiliary contact to operate during the trip operation as defined by the BFI setting.

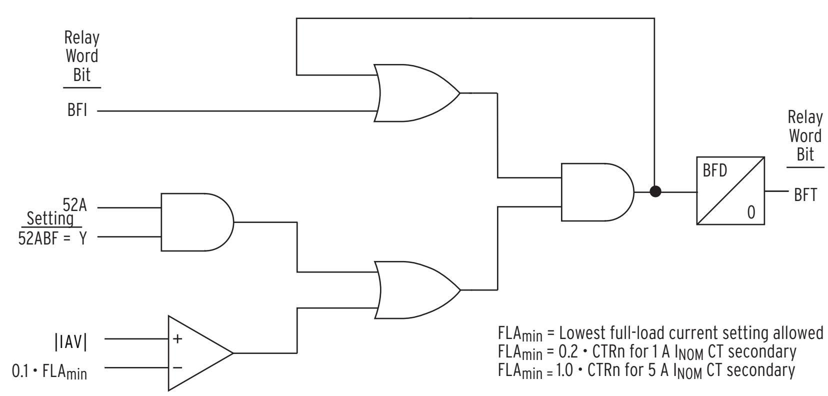


Figure 4.52 Breaker Failure Logic

Analog Inputs

The SEL-710 tracks the power system frequency and samples the analog inputs four times per power system cycle. For analog inputs, set the following parameters for each input:

- Analog type
- High and low input levels
- Engineering units

Because of the flexibility to install different cards in the rear-panel slots on the device, the setting prompt adapts to the *x* and *y* variables shown in *Figure 4.53*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4 or 8).

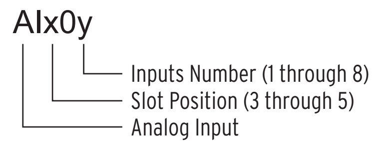


Figure 4.53 Analog Input Card Adaptive Name

Analog Input Calibration Process

In the analog input circuit, the dominant error is signal offset. To minimize the signal offset, we adjust each of the device analog input channels by a compensation factor. These compensation factors correct the signal offset errors to within ±1 µA or ±1 mV.

Signal offset compensation factor calculation procedure:

1. Turn the SEL-710 on and allow it to warm up for a few minutes.
2. Set the analog inputs for each analog channel to the desired range using the AI*xxx*TYP, AI*xxx*L, AI*xxx*H, AI*xxx*EL, and AI*xxx*EH settings (for example, ±1 mA).
3. Short each analog input in turn at the device terminals using short, low resistance leads with solid connections.
4. Issue the command **MET AI 10** to obtain 10 measurements for each channel.
5. Record these 10 measurements, then calculate the average of the 10 measurements by adding the 10 values algebraically, and dividing the sum by 10. This is the average offset error in engineering units at zero input (for example, –0.014 mA).
6. Negate this value (flip the sign) and add the result to each of the AI*xxx*EL and AI*xxx*EH quantities. For this example, the new AI*xxx*EL and AI*xxx*EH values are –0.986 mA and 1.014 mA.

Analog Input Setting Example

Assume we installed an analog card in Slot **3**. On Input 1 of this analog card, we connect a 4–20 mA transducer driven from a device that measures temperature on a transformer load tap changer mechanism. For this temperature transducer, 4 mA corresponds to –50°C, and 20 mA corresponds to 150°C. You have already installed the correct hardware jumper (see *Figure 2.3* for more information) for Input 1 to operate as a current input. At power up, allow approximately five seconds for the SEL-710 to boot up, perform self-diagnostics, and detect installed cards.

Table 4.55 summarizes the steps and describes the settings we will carry out in this example.

Table 4.55 Summary of Steps

	Step	Activity	Terse Description
General	1	SET G AI301NAM	Access settings for INPUT 1
	2	TX_TEMP	Enter a Tag name
	3	I	Select type of analog input; “I” for current
Transducer High/Low Output	4	4	Enter transducer low output (LOW IN VAL)
	5	20	Enter transducer high output (HI IN VAL)
Level	6	Degrees C	Enter Engineering unit
	7	–50	Enter Engineering unit value LOW
	8	150	Enter Engineering unit value HIGH
Low Warning/ Alarm	9	OFF	Enter LOW WARNING 1 value
	10	OFF	Enter LOW WARNING 2 value
	11	OFF	Enter LOW ALARM value
High Warning/ Alarm	12	65	Enter HIGH WARNING 1 value
	13	95	Enter HIGH WARNING 1 value
	14	105	Enter HIGH ALARM value

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

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

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

Use the Instrument Tag Name to give the analog quantity a more descriptive name. This tag name appears in reports (EVENT, METER, and SUMMARY) instead of the default name of AI301. SELOGIC control equations, Signal Profiles, and Fast Message Read use the default names. Use as many as eight valid tag name characters to name the analog quantity. Valid tag names characters are: 0–9, A–Z, and the underscore (_). For this example, we assign TX_TEMP as the tag name.

Because this is a 4–20 mA transducer, enter **I <Enter>** (for current driven device) at AI301TYP, the next prompt (enter **V** if this is a voltage-driven device). The next two settings define the lower level (AI301L) and the upper level (AI301H) of the transducer. In this example, the low level is 4 mA and the high level is 20 mA.

```
AI301 TYPE  (I,V)               AI301TYP:= I  ?
```

NOTE: Because the SEL-710 accepts current values ranging from -20.48 to 20.48 mA, be sure to enter the correct range values.

The next three settings define the applicable engineering unit (AI301EU), the lower level in engineering units (AI301EL) and the upper level in engineering units (AI301EH). Engineering units refer to actual measured quantities, i.e., temperature, pressure, etc. Use the 16 available characters to assign descriptive names for engineering units. Because we measure temperature in this example, enter “degrees C” (without quotation marks) as engineering units. Enter **–50 <Enter>** for the lower level and **150 <Enter>** for the upper level.

With the levels defined, the next six settings provide two warning settings and one alarm setting for low temperature values, as well as two warning settings and one alarm setting for high temperature values. State the values in engineering units, not the setting range of the transducer. Note the difference between low warnings and alarm functions and high warnings and alarm functions: low warnings and alarm functions assert when the measured value falls below the setting; high warnings and alarm functions assert when the measured values rise above the setting.

In this example, we measure the oil temperature of a power transformer, and we want the following three actions to take place at three different temperature values:

- At 65°C, start the cooling fans
- At 95°C, send an alarm
- At 105°C, trip the transformer

Because we are only interested in cases when the temperature values exceed their respective temperature settings (high warnings and alarm functions), we do not use the low warnings and alarm functions. Therefore, set the lower values (AI301LW1, AI301LW2, AI301LAL) to OFF, and the three higher values as shown in *Figure 4.54*. Set inputs connected to voltage driven transducers in a similar way.

```
=>>SET G AI301NAM TERSE <Enter>

Global
AI 301 Settings
AI301 TAG NAME (8 characters)
AI301NAM:= AI301
? TX_TEMP <Enter>
AI301 TYPE (I,V)                              AI301TYP:= I        ? <Enter>
AI301 LOW IN VAL (-20.480 to 20.480 mA)       AI301L  := 4.000    ? <Enter>
AI301 HI IN VAL (-20.480 to 20.480 mA)        AI301H  := 20.000   ? <Enter>
AI301 ENG UNITS (16 characters)
AI301EU := mA
? degrees C <Enter>
AI301 EU LOW (-99999.000 to 99999.000)        AI301EL := 4.000    ? -50 <Enter>
AI301 EU HI (-99999.000 to 99999.000)         AI301EH := 20.000   ? 150 <Enter>
AI301 LO WARN L1 (OFF,-99999.000 to 99999.000) AI301LW1:= OFF     ? <Enter>
AI301 LO WARN L2 (OFF,-99999.000 to 99999.000) AI301LW2:= OFF     ? <Enter>
AI301 LO ALARM (OFF,-99999.000 to 99999.000)  AI301LAL:= OFF      ? <Enter>
AI301 HI WARN L1 (OFF,-99999.000 to 99999.000) AI301HW1:= OFF     ? 65 <Enter>
AI301 HI WARN L2 (OFF,-99999.000 to 99999.000) AI301HW2:= OFF     ? 95 <Enter>
AI301 HI ALARM (OFF,-99999.000 to 99999.000)  AI301HAL:= OFF      ? 115 <Enter>
AI 302 Settings
AI302 TAG NAME (8 characters)
AI302NAM:= AI302
? END  <Enter>

Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.54 Settings to Configure Input 1 as a 4–20 mA Transducer Measuring Temperatures Between –50°C and 150°C

Analog (DC Transducer) Input Board

Table 4.56 shows the setting prompt, setting range, and factory-default settings for an analog input card in Slot **3**. For the name setting (AI301NAM, for example), enter only alphanumeric and underscore characters. Characters are not case sensitive, but the device converts all lowercase characters to uppercase. Although the device accepts alphanumeric characters, the name AI301NAM setting must begin with an alpha character (A–Z) and not a number.

Table 4.56 Analog Input Card in Slot 3

Setting Prompt	Setting Range	Setting Name := Factory Default
AI301 TAG NAME	8 characters 0–9, A–Z, _	AI301NAM := AI301
AI301 TYPE	I, V	AI301TYP := I
AI301 LOW IN VAL	–20.480 to +20.480 mA	AI301L := 4.000
AI301 HI IN VAL	–20.480 to +20.480 mA	AI301H := 20.000
AI301 LOW IN VAL	–10.240 to +10.240 V	AI301L := 0.000[a]
AI301 HI IN VAL	–10.240 to +10.240 V	AI301H := 10.000[a]
AI301 ENG UNITS	16 characters	AI301EU := mA
AI301 EU LOW	–99999.000 to +99999.000	AI301EL := 4.000
AI301 EU HI	–99999.000 to +99999.000	AI301EH := 20.000
AI301 LO WARN 1	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO WARN 2	OFF, –99999.000 to +99999.000	AI301LW1 := OFF
AI301 LO ALARM	OFF, –99999.000 to +99999.000	AI301LAL := OFF
AI301 HI WARN 1	OFF, –99999.000 to +99999.000	AI301HW1 := OFF
AI301 HI WARN 2	OFF, –99999.000 to +99999.000	AI301HW2 := OFF
AI301 HI ALARM	OFF, –99999.000 to +99999.000	AI301HAL := OFF

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

Analog Outputs

If an SEL-710 configuration includes the four analog inputs and four analog outputs (4 AI/4 AO) card, the analog outputs are allocated to output numbers 1–4. *Figure 4.55* shows the *x* and *y* variable allocation for the analog output card.

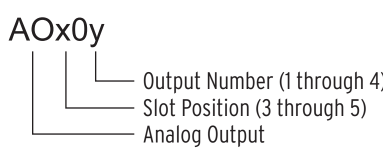


Figure 4.55 Analog Output Number Allocation

For an analog input/output card in Slot **3**, setting AO301AQ identifies the analog quantity we assign to Analog Output 1 (when set to OFF, the device hides all associated AO*x*0*y* settings and no value appears on the output). You can assign any of the analog quantities listed in *Appendix J: Analog Quantities*. *Table 4.57* shows the setting prompt, setting range, and factory-default settings for an analog card in Slot **3.**

NOTE: The SEL-710 hides the following settings with default values when you use a 3 DI/4 DO/1 AO card:
AOxx1TYP := I
AOxx1L := 4.000
AOxx1H := 20.000

Table 4.57 Output Setting for a Card in Slot 3 (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AO301 ANALOG QTY	Off, 1 analog quantity	AO301AQ := OFF
AO301 TYPE	I, V	AO301TYP := I
AO301 AQTY LO	–2147483647.000 to +2147483647.000	AO301AQL := 4.000
AO301 AQTY HI	–2147483647.000 to +2147483647.000	AO301AQH := 20.000
AO301 LO OUT VAL	–20.480 to +20.480 mA	AO301L := 4.000
AO301 HI OUT VAL	–20.480 to +20.480 mA	AO301H := 20.000

Table 4.57 Output Setting for a Card in Slot 3 (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AO301 LO OUT VAL	–10.240 to +10.240 V	AO301L := 0.000[a]
AO301 HI OUT VAL	–10.240 to +10.240 V	AO301H := 10.000[a]

[a] Voltage setting range for a voltage transducer, i.e., when AO301TYP := V.

In this example, assume we want to display, in the control room, the analog quantity (refer to *Appendix J: Analog Quantities*) IA_MAG, Phase A current magnitude in primary amperes (0 to 3000 Amps range) using a –20 to +20 mA analog output channel. We install an analog input/output card in Slot C (SELECT 4 AI/ 4 AO) and set the card channel AO301 as shown in *Figure 4.56*. Note that the AO301 channel has to be configured as a "current analog output" channel (refer to *Figure 2.4* to *Figure 2.6*).

The display instrument expects –20 mA when the IA_MAG current is 0 amperes primary and +20 mA when it is 3000 amperes primary.

```
=>>SET G AO301AQ TERSE <Enter>

Global
AO 301 Settings
AO301 ANALOG QTY (OFF, 1 analog quantity)
AO301AQ := OFF
? AI301 <Enter>
AO301 TYPE (I,V)                              AO301TYP:= I          ? <Enter>
AO301 AQTY LO (-2147483647.000 to 2147483647.000)
                                              AO301AQL:= 4.000      ? 0 <Enter>
AO301 AQTY HI (-2147483647.000 to 2147483647.000)
                                              AO301AQH:= 20.000     ? 3000 <Enter>
AO301 LO OUT VAL (-20.480 to 20.480 mA)       AO301L  := 4.000      ? –20 <Enter>
AO301 HI OUT VAL (-20.480 to 20.480 mA)       AO301H  := 20.000     ? 20 <Enter>
AO 302 Settings
AO302 ANALOG QTY (OFF, 1 analog quantity)
AO302AQ := OFF

? END <Enter>

Save changes (Y,N)? Y <Enter>

Settings Saved

=>>
```

Figure 4.56 Analog Output Settings

Breaker Monitor

The breaker monitor in the SEL-710 helps in scheduling circuit breaker maintenance. Refer to *Breaker Monitor on page 5.11* for a detailed description and *Table 5.7* for the settings.

Data Reset

Table 4.58 Data Reset Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
RESET TARGETS	SELOGIC	RSTTRGT := 0
RESET ENERGY	SELOGIC	RSTENRGY := 0
RESET MAX/MIN	SELOGIC	RSTMXMN := 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 4.40* for more details. The RSTENRGY and RSTMXMN settings reset the Energy and Max/Min Metering values respectively. You should assign a contact input (for example, RSTTRGT := IN401) to each of these settings if you want remote reset.

Access Control

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

The DSABLSET setting defines conditions for disabling all setting changes from the front-panel interface. To disable setting changes from the front-panel interface, assign, for example, a contact input (e.g., DSABLSET := IN402) to the DSABLSET setting. When Relay Word bit DSABLSET asserts, you can view the device settings from the front-panel interface, but you can only change settings using serial port commands. *Table 4.59* shows the settings prompt, setting range, and factory-default settings.

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.

Table 4.59 Setting Change Disable Settings

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

Time Synchronization Source

The SEL-710 accepts a demodulated IRIG-B time signal. *Table 4.60* shows the setting to identify the input for the signal. Set TIME_SRC := IRIG1 when you use relay terminals B01/B02 or EIA-232 serial Port 3 for the time signal input. When you use fiber-optic Port 2 for the signal, set the TIME_SRC := IRIG2. Refer to *IRIG-B Time-Code Input on page 2.18* and *IRIG-B on page 7.5* for additional information.

Table 4.60 Time Synchronization Source Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
IRIG TIME SOURCE	IRIG1, IRIG2	TIME_SRC := IRIG1

Port Settings (SET P Command)

The SEL-710 provides settings that allow you to configure the parameters for the communications ports. See *Section 2: Installation* for a detailed description of port connections. On the base unit: **Port F** (front panel) is an EIA-232 port; **Port 1** is optional Ethernet port or ports; **Port 2** is a fiber-optic EIA-232 port; and **Port 3** (rear) is optionally an EIA-232 or EIA-485 port. On the optional communications card, you can select **Port 4** as either EIA-485 or EIA-232 (not both) with the COMMINF setting. See *Table 4.61* through *Table 4.66* for the port settings. See the appropriate appendix for additional information on communication protocols (Modbus, IEC 61850, DeviceNet, MIRRORED BITS).

The EPORT setting provides you with access control for the corresponding port. Setting EPORT := N disables a port and hides the remaining port settings.

PORT F

Table 4.61 Front-Panel Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
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
HDWR HANDSHAKING	Y, N	RTSCTS := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 1

IMPORTANT: Upon relay initial power up or Port 1 setting changes or Logic setting changes, the user may have to wait as long as two minutes before an additional setting change can occur. Note that the relay is functional with protection enabled, as soon as the ENABLED LED comes ON (about 5–10 seconds from power up).

Table 4.62 Ethernet Port Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
IP ADDRESS	zzz.yyy.xxx.www	IPADDR := 192.168.1.2
SUBNET MASK	15 characters	SUBNETM := 255.255.255.0
DEFAULT ROUTER	15 characters	DEFRTR := 192.168.1.1
Enable TCP Keep-Alive	Y, N	ETCPKA := Y
TCP Keep-Alive Idle Range	1–20 s	KAIDLE := 10
TCP Keep-Alive Interval Range	1–20 s	KAINTV := 1
TCP Keep-Alive Count Range	1–20 s	KACNT := 6
FAST OP MESSAGES	Y, N	FASTOP := N
OPERATING MODE	FIXED FAILOVER SWITCHED	NETMODE := FAILOVER
FAILOVER TIMEOUT	0.10–65.00 s	FTIME := 1.00
PRIMARY NETPORT	A, B	NETPORT := A
NETWRK PORTA SPD	AUTO, 10, 100 Mbps	NETASPD := AUTO
NETWRK PORTB SPD	AUTO, 10, 100 Mbps	NETBSPD := AUTO
ENABLE TELNET	Y, N	ETELNET := Y
TELNET PORT	23, 1025–65534	TPORT := 23
TELNET TIME OUT	1–30 min	TIDLE := 15
ENABLE FTP	Y, N	EFTPSERV := Y
FTP USER NAME	20 characters	FTPUSER := FTPUSER
ENABLE IEC 61850 PROTOCOL	Y, N	E61850 := N
ENABLE IEC 61850 GSE	Y, N	EGSE := N
ENABLE MODBUS SESSIONS	0–2	EMOD := 0
MODBUS TCP PORT 1	1–65534	MODNUM1 := 502

Table 4.62 Ethernet Port Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
MODBUS TCP PORT 2	1–65534	MODNUM2 := 502
MODBUS TIMEOUT 1	15–900 s	MTIME01 := 15
MODBUS TIMEOUT 2	15–900 s	MTIME02 := 15

The SEL-710 Port 1 (Ethernet Port) supports SNTP Client protocol. See *Section 7: Communications*, *Simple Network Time Protocol (SNTP) on page 7.13* for the description and *Table 7.6* for the settings.

Port Number Settings Must be Unique

When making the SEL-710 Port 1 settings, port number settings cannot be used for more than one protocol. The relay checks all of the settings shown in *Table 4.63* before saving changes. If a port number is used more than once, or if it matches any of the fixed port numbers (20, 21, 23, 102, 502), the relay displays an error message and returns to the first setting that is in error or contains a duplicate value.

Table 4.63 Port Number Settings That Must be Unique

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1[a]	Modbus TCP Port 1	EMOD > 0
MODNUM2[a]	Modbus TCP Port 2	EMOD > 1
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF

[a] MODNUM1 and MODNUM2 can have the same port number. The relay displays an error message if this number matches with the port numbers of the other protocols.

PORT 2

Table 4.64 Fiber-Optic Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIME-OUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

NOTE: For additional settings when PROTO := MBxx, see Table G.5 as well as MIRRORED BITS Transmit SELOGIC Equations on page SET.24.

PORT 3

Table 4.65 Rear-Panel Serial Port (EIA-232) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

NOTE: For additional settings when PROTO := MBxx, see Table G.5 as well as MIRRORED BITS Transmit SELOGIC Equations on page SET.24.

PORT 4

Table 4.66 Rear-Panel Serial Port (EIA-232/EIA-485) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, DNET, MBA, MBB, MB8A, MB8B, MBTA, MBTB	PROTO := SEL
COMM INTERFACE	232, 485	COMMINF := 232
SPEED	300–38400 bps	SPEED := 9600
DATA BITS	7, 8 bits	BITS := 8
PARITY	O, E, N	PARITY := N
STOP BITS	1, 2 bits	STOP := 1
PORT TIMEOUT	0–30 min	T_OUT := 5
SEND AUTOMESSAGE	Y, N	AUTO := N
HDWR HANDSHAKING	Y, N	RTSCTS := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

NOTE: For additional settings when PROTO := MBxx, see Table G.5 as well as MIRRORED BITS Transmit SELOGIC Equations on page SET.24.

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

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

Set PROTO := SEL (standard SEL ASCII protocol), MOD (Modbus RTU protocol), or one of the MIRRORED BITS protocols, as needed for your application. For detailed information, refer to *Appendix C: SEL Communications Processors*, *Appendix D: Modbus Communications*, and *Appendix G: MIRRORED BITS Communications*.

Use the MBT option for the Pulsar MBT 9600 bps modem (see *Appendix G: MIRRORED BITS Communications* for more information). With this option set, the relay transmits a message every second processing interval and the device deasserts the RTS signal on the EIA-232 connector. Also, the device monitors the CTS signal on the EIA-232 connector, which the modem deasserts if the channel has too many errors. The modem uses the device RTS signal to determine whether the MB or MB8 MIRRORED BITS protocol is in use.

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

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

Set FASTOP := Y to enable binary Fast Operate messages at the serial port. Set FASTOP := N to block binary Fast Operate messages. Refer to *Appendix C: SEL Communications Processors* for the description of the SEL-710 Fast Operate commands.

Set PROTO := DNET to establish communications when the DeviceNet card is used. *Table 4.67* shows the additional settings, which can be set only at the rear on the DeviceNet card. Once the relay detects the DeviceNet card, all **Port 4** settings are hidden. Refer to *Appendix F: DeviceNet Communications* for details on DeviceNet.

Table 4.67 Rear-Panel DeviceNet Port Settings

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

Front-Panel Settings (SET F Command)

General Settings

Local bits provide control from the front panel (local bits), and display points display selected information on the LCD display. However, you need to first enable the appropriate number of local bits and display points necessary for your application. When your SEL-710 arrives, four display points are already enabled, but no local bits are enabled. If more display points are necessary for your application, use the EDP setting to enable as many as 32 display points. Use the ELB setting to enable as many as 32 local bits.

Table 4.68 Display Point and Local Bit Default Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DISPLAY PTS ENABL	N, 1–32	EDP := 4
LOCAL BITS ENABL	N, 1–32	ELB := N

To optimize the time you spend on setting the device, only the number of enabled display points and enabled local bits become available for use. Use the front-panel LCD time-out setting (FP_TO) as a security measure. If the display is within an Access Level 2 function when a time-out occurs, such as the device setting entry, the function is automatically terminated (without saving changes) after inactivity for this length of time. After terminating the function, the front-panel display returns to the default display.

If you prefer to disable the front-panel time-out function during device testing, set the LCD time-out equal to OFF. Use the front-panel LCD contrast setting (FP_CONT) to adjust the contrast of the liquid crystal display. Use the front-panel automessage setting FP_AUTO to define displaying of Trip or Warning message. Set FP_AUTO either to Override or add to the Rotating display when the relay triggers a Trip or Warning message. Set RSTLED := Y to reset the latched LEDs automatically when the breaker, or contactor, closes.

Table 4.69 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
FP AUTOMESSAGES	OVERRIDE, ROTATING	FP_AUTO := OVERRIDE
CLOSE RESET LEDS	Y, N	RSTLED := Y

Display Points

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

Use display points to view either the state of internal relay elements (Boolean information) or analog information on the LCD display. Although the LCD screen displays a maximum of 16 characters at a time, you can enter as many as 60 valid characters. Valid characters are 0–9, A–Z, -, /, ", {, }, space. For text exceeding 16 characters, the LCD displays the first 16 characters, then scrolls through the remaining text not initially displayed on the screen.

Boolean Display Point Entry Composition

Boolean information is the status of Relay Word bits (see *Appendix I: Relay Word Bits*). In general, the legal syntax for Boolean display points consists of the following four fields or strings, separated by commas:

Relay Word Bit Name, “Alias”, “Set String”, “Clear String”.

where:

Name = Relay Word bit name (IN101, for example). All binary quantities occupy one line on the front-panel display (all analog quantities occupy two lines).

Alias = A more descriptive name for the Relay Word bit (such as TRANSFORMER 3), or the analog quantity (such as TEMPERATURE).

Set String = State that should be displayed on the LCD when the Relay Word bit is asserted (CLOSED, for example)

Clear String = State that should be displayed on the LCD when the Relay Word bit is deasserted (OPEN, for example)

Any or all of Alias, Set String, or Clear String can be empty. Although the relay accepts an empty setting Name as valid, a display point with an empty Name setting is always hidden (see below). Commas are significant in identifying and separating the four strings. Use quotation marks only if the text you enter for Alias, Set String, or Clear String contains commas or spaces. For example, DP01 = Name,Text is valid, but Name, Alias 3 is not valid (contains a space). Correct the Alias name by using the quotation marks: Name, “Text 3”. You can customize the data display format by entering data in selected strings only. *Table 4.70* shows the various display appearances resulting from entering data in selected strings.

Hidden (No Display)

A display point is hidden when settings are entered (DP*n* = XX, where *n* = 01 through 32 and XX = any valid setting), but nothing shows on the front-panel display. *Table 4.70* shows examples of settings that always, never, or conditionally hide a display point.

Table 4.70 Settings That Always, Never, or Conditionally Hide a Display Point

Programmable Automation Controller Setting	Name	Alias	Set String	Clear String	Comment
DP01 := IN101,TRFR1,CLOSED,OPEN	IN101	TRFR1	CLOSED	OPEN	Never hidden
DP01 := IN101,TRFR1	IN101	TRFR1	—	—	Never hidden
DP01 := NA	—	—	—	—	Always hidden
DP01 := IN101,,,	IN101	—	—	—	Always hidden
DP01 := IN101,TRFR1,,	IN101	TRFR1	—	—	Always hidden
DP01 := IN101,TRFR1,CLOSED,	IN101	TRFR1	CLOSED	—	Hidden when IN101 is deasserted
DP01 := IN101,”TRFR 1”,,OPEN	IN101	TRFR 1	—	OPEN	Hidden when IN101 is asserted
DP01 := 1, {}	1	{}	—	—	Displays empty line
DP01 := 1, “Fixed Text”	1	Fixed Text	—	—	Displays the fixed text
DP01 := 0	0	—	—	—	Hides the display point

Following are examples of selected display point settings, showing the resulting front-panel displays. For example, at a certain station we want to display the status of both HV and LV circuit breakers of Transformer 1. When the HV circuit breaker is open, we want the LCD display to show: `TRFR 1 HV BRKR: OPEN`, and when the HV circuit breaker is closed, we want the display to show: `TRFR 1 HV BRKR: CLOSED`. We also want similar displays for the LV breaker.

After connecting a Form A (normally open) auxiliary contact from the HV circuit breaker to Input **IN101** and a similar contact from the LV circuit breaker to Input **IN102** of the SEL-710, we are ready to program the display points, using the following information for the HV breaker (LV breaker similar):

- Relay Word bit—IN101
- Alias—TRFR 1 HV BRKR
- Set String—CLOSED (the Form A [normally open] contact asserts or sets Relay Word bit IN101 when the circuit breaker is closed)
- Clear String—OPEN (the Form A [normally open] contact deasserts or clears Relay Word bit IN101 when the circuit breaker is open)

Name, Alias, Set String, and Clear String

When all four strings have entries, the relay reports all states.

Table 4.71 Entries for the Four Strings

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

Figure 4.57 shows the settings for the example, using the **SET F** command. Use the **>** character to move to the next settings category.

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                         EDP     := 4        ? > <Enter>
Target LED Set
TRIP LATCH T_LED (Y,N)                            T01LEDL := Y        ? > <Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := RID,"{16}"
? IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP02 (60 characters)
DP02    := TID,"{16}"
? IN102,"TRFR 1 LV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "I MOTOR {6} A"
? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.57 Display Point Settings

Figure 4.58 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.59* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

```
TRFR 1 HV BRKR:=OPEN
TRFR 1 LV BRKR:=OPEN
```

Figure 4.58 Front-Panel Display—Both HV and LV Breakers Open

```
TRFR 1 HV BRKR:=CLOSED
TRFR 1 LV BRKR:=OPEN
```

Figure 4.59 Front-Panel Display—HV Breaker Closed, LV Breaker Open

Name String, Alias String, and Either Set String or Clear String Only

The following discusses omission of the Clear String; omission of the Set String gives similar results. Omitting the Clear String causes the relay to only show display points in the set state, using the **SET F** command as follows:

```
DP01    := RID, "{16}"
 ? IN101,"TRFR 1 HV BRKR:",CLOSED <Enter>
```

When the Relay Word bit IN101 deasserts, the relay removes the complete line with the omitted Clear String (TRFR 1 HV BRKR). When both breakers are closed, the relay has the set state information for both HV and LV breakers, and the relay displays the information as shown in *Figure 4.60*. When the HV breaker opens (LV breaker is still closed), the relay removes the line containing the HV breaker information because the Clear String information was omitted. Because the line containing the HV breaker information is removed, the relay now displays the LV breaker information on the top line, as shown in *Figure 4.61*.

```
TRFR 1 HV BRKR:=CLOSED
TRFR 1 LV BRKR:=CLOSED
```

Figure 4.60 Front-Panel Display—Both HV and LV Breakers Closed

Figure 4.61 Front-Panel Display—HV Breaker Open, LV Breaker Closed

If you want the relay to display a blank state when IN101 deasserts instead of removing the line altogether, use the curly brackets {} for the Clear String, as follows:

```
DP01    := RID, "{16}"
 ? IN101,"TRFR 1 HV BRKR:",CLOSED,{} <Enter>
```

When Input IN101 now deasserts, the relay still displays the line with the HV breaker information, but the state is left blank, as shown in *Figure 4.62*.

Figure 4.62 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.72 shows an entry in the Name String only (leaving the Alias string, Set String, and Clear String void), using the **SET F** command as follows:

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

Table 4.72 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.63 shows the front-panel display for the entry in *Table 4.72*. Input IN101 is deasserted in this display (IN101=0), but changes to IN101=1 when Input IN101 asserts.

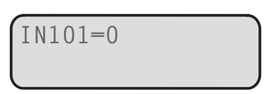


Figure 4.63 Front-Panel Display for a Binary Entry in the Name String Only

Analog Display Point Entry Composition

In general, the legal syntax for analog display points consists of the following two fields or strings:

Name, "User Text and Formatting."

where:

Name = Analog quantity name (AI301 for example). All analog quantities occupy two lines on the front-panel display (all binary quantities occupy one line on the display).

User text and numerical formatting = Display the user text, replacing the numerical formatting {width.dec,scale} with the value of Name, scaled by "scale", formatted with total width "width" and "dec" decimal places. Name can be either an analog quantity or a Relay Word bit. The width value includes the decimal point and sign character, if applicable. The "scale" value is optional; if omitted, the scale factor is 1. If the numeric value is smaller than the string size requested, the string is padded with spaces to the left of the number. If the numeric value does not fit within the string width given, the string grows (to the left of the decimal point) to accommodate the number.

Unlike binary quantities, the relay displays analog quantities on both display lines. *Table 4.73* shows an entry in the Name string only (leaving the User Text and Formatting string void) with the following syntax:

Table 4.73 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.64 shows the front-panel display for the entry in *Table 4.73*, using the **SET F** command as follows:

```
P01    := RID, "{16}"
? AI301 <Enter>
```

Figure 4.64 Front-Panel Display for an Analog Entry in the Name String Only

Name and Alias

For a more descriptive name of the Relay Word bit, enter the Relay Word bit in the Name String, and an alias name in User Text and Formatting String. *Table 4.74* shows a Boolean entry in the Name and Alias Strings (DP01) and an entry in the Name and User Text and Formatting Strings (DP02), using the **SET F** command as follows:

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

Table 4.74 Entry in the Name String and the Alias Strings

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

Figure 4.65 shows the front-panel display for the entry in *Table 4.74*. Input IN101 is deasserted in this display (0), and the display changes to `INPUT IN101=1` when Input IN101 asserts.

Figure 4.65 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name and User Text and Formatting Strings

If the engineering units are set, then the front-panel display shows the engineering units. For example, in the Group setting example, we set AI301EU to degrees C. With this setting, the front-panel display looks as shown in *Figure 4.66*.

Figure 4.66 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name, User Text and Formatting Strings, and Engineering Units

For fixed text, enter a 1 in the Name String, then enter the fixed text as the alias text. For example, to display the word DEFAULT and SETTINGS on two different lines, use a display point for each word, i.e., DP01 = 1,“DEFAULT” and DP02 = 1,“SETTINGS.” The following table shows other options and front-panel displays for the User Text and Formatting settings.

Table 4.75 Example Settings and Displays

Example Display Point Setting Value	Example Display
AI301,"TEMP {4}deg C"	TEMP 1234 deg C
AI301,"TEMP = {4.1}"	TEMP = 1234.0
AI301,"TEMP={4.2,0.001} C"	TEMP = 1.23 C
AI301,"TEMP HV HS1={4,1000}"	TEMP HV HS1 = 12340000
1,{}	Empty line
1,"Fixed Text"	Fixed text
0	Hides the display point

Following is an example of an application of analog settings. Assume we also want to know the hot-spot temperature, oil temperature, and winding temperature of the transformer at a certain installation. To measure these temperatures, we have installed an analog card in relay Slot **C**, and connected 4–20 mA transducers inputs to analog inputs AI301 (hot-spot temperature), AI302 (oil temperature), and AI303 (winding temperature).

First enable enough display points for the analog measurements (e.g. EDP = 5). *Figure 4.67* shows the settings to add the three transducer measurements. (Use the **>** character to move to the next settings category).

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                         EDP     := 4         ? 5 <Enter>
LOCAL BITS ENABL (N,1-32)                         ELB     := 1         ? > <Enter>
Target LED Set
TRIP LATCH T_LED (Y,N)                            T01LEDL := Y         ?> <Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN
? <Enter>
DISPLAY POINT DP02 (60 characters)
DP02    := IN102,"TRFR 1 LV BRKR:",CLOSED,OPEN
? <Enter>
DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "I MOTOR {6} A"
? AI301,"HOT SPOT TEMP" <Enter>
DISPLAY POINT DP04 (60 characters)
DP04    := TCUSTR, "Stator TCU {3} %"
? AI302,"OIL TEMPERATURE" <Enter>
DISPLAY POINT DP05 (60 characters)
DP05    := IA_MAG, "IA {7.1} A pri"
? AI303,"WINDING TEMP" <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.67 Adding Temperature Measurement Display Points

Rotating Display

With more than two display points enabled, the relay scrolls through all enabled display points, thereby forming a rotating display, as shown in *Figure 4.68*.

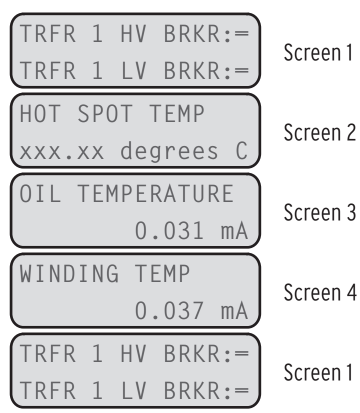


Figure 4.68 Rotating Display

To change the temperature units to more descriptive engineering units, enter the desired units with the AI*xxx*EU (e.g., AI302EU) setting.

Local Bits

Local bits are variables (LB*nn*, where *nn* means 01 through 32) that are controlled from front-panel pushbuttons. Use local bits to replace traditional panel switches. The state of the local bits are stored in nonvolatile memory every second. When power to the device is restored, the local bits will go back to their states after the device initialization. Each local bit requires three of the following four settings, using a maximum of 14 valid characters for the NLB*nn* setting, and a maximum seven valid characters (0–9, A–Z, -, /, ., space) for the remainder:

- NLB*nn*: Name the switch (normally the function that the switch performs, such as SUPERV SW) that will appear on the LCD display.

- ➤ CLB*nn*: Clear local bit. Enter the text that describes the intended operation of the switch (this text appears on the display) when LB*nn* deasserts (OPEN, for example).
- ➤ SLB*nn*: Set local bit. Enter the text that describes the intended operation of the switch (this text appears on the display) when LB*nn* asserts (CLOSE, for example).
- ➤ PLB*nn*: Pulse local bit. When selecting the pulse operation, LB*nn* asserts for only one processing interval before deasserting again. Enter the text that describes the intended operation when LB*nn* asserts (START, for example).
- ➤ Omit either SLB*nn* or PLB*nn* (never CLB*nn*) by setting the omitted setting to NA.

For the transformer in our example, configure two local bits: one to replace a supervisory switch, and the other to start a fan motor. Local bit 1 replaces a supervisory switch (SUPERV SW) and we use the clear/set combination. Local bit 2 starts a fan motor (START) that only needs a short pulse to seal itself in, and we use the clear/pulse combination. *Figure 4.69* shows the settings to program the two local bits.

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                    EDP     := 5        ? <Enter>
LOCAL BITS ENABL (N,1-32)                    ELB     := N        ? 2 <Enter>
LCD TIMEOUT (OFF,1-30 min)                   FP_TO   := 15       ? > <Enter>
Target LED Set
TRIP LATCH T_LED (Y,N)                       T01LEDL := Y        ? > <Enter>
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN
? > <Enter>
Local Bits Labels:
LB_ NAME (14 characters; Enter NA to null)
NLB01   :=
? SPERV SW <Enter>
CLEAR LB_ LABEL (7 characters; Enter NA to null)
CLB01   :=
? OPEN <Enter>
SET LB_ LABEL (7 characters; Enter NA to null)
SLB01   :=
? CLOSE <Enter>
PULSE LB_ LABEL (7 characters; Enter NA to null)
PLB01   :=
? NA <Enter>
LB_ NAME (14 characters; Enter NA to null)
NLB02   :=
? FAN START <Enter>
CLEAR LB_ LABEL (7 characters; Enter NA to null)
CLB02   :=
? OFF <Enter>
SET LB_ LABEL (7 characters; Enter NA to null)
SLB02   :=
? NA <Enter>

PULSE LB_ LABEL (7 characters; Enter NA to null)
PLB02   :=
? START <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.69 Adding Two Local Bits

Target LED Settings

The SEL-710 offers the following two types of LEDs. See *Figure 8.1* and *Figure 8.28* for the programmable LED locations:

- ➤ Six Target LEDs
- ➤ Eight Pushbutton LEDs

You can program all 14 LEDs using SELOGIC control equations, the only difference being that the target LEDs also include a latch function.

Target LEDs

NOTE: If the LED latch setting (TnLEDL) is set to Y, and TRIP asserts, the LED latches to the state at TRIP assertion. The latched LED targets can be reset using TARGET RESET if the target conditions are absent.

Settings T*n*LEDL (*n* = 01 through 06) and T*n*_LED (*n* = 01 through 06) control the six front-panel LEDs. With T*n*LEDL set to Y, the LEDs latch the LED state only if a TRIP condition occurs and the T*n*_LED equation asserts at the time of the trip. To reset these latched LEDs, the TRIP condition should no longer exist and one of the following must occur:

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

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

Enter any of the Relay Word bits (or combinations of Relay Word bits) as conditions in the T*n*_LED SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts.

Table 4.76 Target LED Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
TRIP LATCH T_LED	Y, N	T01LEDL := Y
LED1 EQUATION	SELOGIC	T01_LED := 49T OR AMBTRIP OR BRGTRIP OR OTHTRIP OR WDGTRIP
TRIP LATCH T_LED	Y, N	T02LEDL := Y
LED2 EQUATION	SELOGIC	T02_LED := 50P1T OR 50N1T OR 50G1T
TRIP LATCH T_LED	Y, N	T03LEDL := Y
LED3 EQUATION	SELOGIC	T03_LED := 46UBT OR 47T
TRIP LATCH T_LED	Y, N	T04LEDL := Y
LED4 EQUATION	SELOGIC	T04_LED := LOSSTRIP OR 37PT
TRIP LATCH T_LED	Y, N	T05LEDL := Y
LED5 EQUATION	SELOGIC	T05_LED := (NOT STOPPED AND 27P1T) OR 59P1T
TRIP LATCH T_LED	Y, N	T06LEDL := Y
LED6 EQUATION	SELOGIC	T06_LED := 87M1T OR 87M2T

Pushbutton LEDs

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

Table 4.77 Pushbutton LED Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PB1A_LED EQUATION	SELOGIC	PB1A_LED := PB01
PB1B_LED EQUATION	SELOGIC	PB1B_LED := 0
PB2A_LED EQUATION	SELOGIC	PB2A_LED := PB02
PB2B_LED EQUATION	SELOGIC	PB2B_LED := 0
PB3A_LED EQUATION	SELOGIC	PB3A_LED := PB03
PB3B_LED EQUATION	SELOGIC	PB3B_LED := STARTING OR RUNNING
PB4A_LED EQUATION	SELOGIC	PB4A_LED := PB04
PB4B_LED EQUATION	SELOGIC	PB4B_LED := STOPPED

Report Settings (SET R Command)

The report settings use Relay Word bits for the SER and event report trigger as shown in *Table 4.78* and *Table 4.79*. See *Appendix I: Relay Word Bits* for detail. Refer to *Section 9: Analyzing Events* for additional information about SER and event reports.

SER Trigger Lists

Table 4.78 SER[a] Trigger Settings

Setting Prompt	Setting Name := Factory Default
SER1	SER1 := IN101 IN102 PB01 PB02 PB03 PB04 ABSLO TBSLO NOSLO THERMLO
SER2	SER2 := 49T 49T_STR 49T_RTR LOSSTRIP JAMTRIP 46UBT 50P1T RTDT PTCTRIP 50G1T VART 37PT 27P1T 59P1T 47T 55T SPDSTR 50N1T SMTRIP 81D1T 81D2T OTHTRIP 87M1T 87M2T
SER3	SER3 := AMBTRIP PTCFLT RTDFLT COMMIDLE COMMLOSS REMTRIP RSTTRGT 49A LOSSALRM JAMALRM 46UBA RTDA 55A 50N2T 50G2T VARA 37PA 27P2T 59P2T 50P2T 50Q1T 50Q2T
SER4	SER4 := SPDSAL 81D3T 81D4T 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.

Relay Word Bit Aliases

Table 4.79 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable ALIAS Settings (N, 1–20)	N, 1–20	EALIAS = 15

To simplify your review of the information displayed in the SER record, the relay provides the Alias setting function. Using the Alias settings, you can change the way the relay elements listed in the previous SER settings are displayed in the SER report. In addition, the Alias settings allow you to change the text displayed when a particular element is asserted and deasserted. The relay permits as many as 20 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. Factory-default alias settings are shown in *Table 4.80*.

Define the enabled alias settings by entering the Relay Word bit name, a space, the desired alias, a space, the text to display when the condition asserts, a space, and the text to display when the condition deasserts.

```
ALIAS1 = STARTING MOTOR_STARTING BEGINS ENDS
```

See *Table I.1* for the complete list of Relay Word bits. Use as many as 15 characters to define the alias, asserted text, and deasserted text strings. You can use capital letters (A–Z), numbers (0–9), and the underscore character (_) within each string. Do not attempt to use a space within a string because the relay will interpret a space as the break between two strings. If you wish to clear a string, simply type **NA**.

Table 4.80 SET R SER Alias Settings

Setting Prompt	Relay Word Bit	Alias	Asserted Text	Deasserted Text
ALIAS1 :=	STARTING	MOTOR_STARTING	BEGINS	ENDS
ALIAS2 :=	RUNNING	MOTOR_RUNNING	BEGINS	ENDS
ALIAS3 :=	STOPPED	MOTOR_STOPPED	BEGINS	ENDS
ALIAS4 :=	JAMTRIP	LOAD_JAM_TRIP	PICKUP	DROPOUT
ALIAS5 :=	LOSSTRIP	LOAD_LOSS_TRIP	PICKUP	DROPOUT
ALIAS6 :=	LOSSALRM	LOAD_LOSS_ALARM	PICKUP	DROPOUT
ALIAS7 :=	46UBA	UNBALNC_I_ALARM	PICKUP	DROPOUT
ALIAS8 :=	46UBT	UNBALNC_I_TRIP	PICKUP	DROPOUT
ALIAS9 :=	49A	THERMAL_ALARM	PICKUP	DROPOUT
ALIAS10 :=	49T	THERMAL_TRIP	PICKUP	DROPOUT
ALIAS11 :=	47T	PHS_REVRSL_TRIP	PICKUP	DROPOUT
ALIAS12 :=	PB01	FP_AUX1	PICKUP	DROPOUT
ALIAS13 :=	PB02	FP_AUX2	PICKUP	DROPOUT
ALIAS14 :=	PB03	fp_start	PICKUP	DROPOUT
ALIAS15 :=	PB04	fp_stop	PICKUP	DROPOUT
ALIAS16 –ALIAS20	NA			

Event Report Settings

Table 4.81 Event Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EVENT TRIGGER	SELOGIC	ER := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 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 typically hold as many as 100 15-cycle event reports or 23 64-cycle event reports.

Start Report Setting

Table 4.82 Motor Start Report Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
MSR RESOLUTION	0.25, 0.5, 1, 2, 5, 20 cyc	MSRR := 5
MSR TRIGGER[a]	SELOGIC	MSRTRG := 0

[a] Do not use SELOGIC control equation MSRTRG to capture starting conditions. Starting conditions are automatically captured for each start.

The setting MSRR defines the resolution of the motor start report. The report is always triggered by each motor start; to trigger for additional conditions, use the SELOGIC control equation MSRTRG. For more information on the motor start report, go to *Section 5: Metering and Monitoring*.

Load Profile Settings

Use the LDLIST setting to declare the analog quantities you want included in the Load Profile Report. Enter as many as 17 analog quantities, separated by spaces or commas, into LDLIST setting. See *Appendix J: Analog Quantities* for a list of the available analog quantities. Also set the LDAR to the desired acquisition rate for the report.

IMPORTANT: All stored load data are lost when changing the LDLIST.

Table 4.83 Load Profile Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LDP LIST	0, as many as 17 analog quantities	LDLIST := 0
LDP ACQ RATE	5, 10, 15, 30, 60 min	LDAR := 15

Modbus Map Settings (SET M Command)

Modbus User Map

Table 4.84 shows the available settings. See *Appendix D: Modbus Communications* for additional details.

Table 4.84 User Map Register Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
USER REG#1	NA, 1 Modbus Register Label	MOD_001 :=
•	•	•
•	•	•
•	•	•
USER REG#125	NA, 1 Modbus Register Label	MOD_125 :=

[a] See Appendix D: Modbus Communications for Modbus Register Labels and factory-default settings.

Section 5
Metering and Monitoring

Overview

The SEL-710 Motor Protection Relay includes metering functions to display the present values of current, voltage (if included), analog inputs (if included), and RTD measurements (with the external SEL-2600 RTD Module or an internal RTD card). The relay provides the following methods to read the present meter values:

- ➤ Front-panel rotating display
- ➤ Front-panel menu
- ➤ EIA-232 serial ports (using SEL ASCII text commands or ACSELERATOR QuickSet SEL-5030 Software)
- ➤ Telnet via Ethernet port
- ➤ Modbus via EIA-485 port or EIA-232 port
- ➤ Modbus TCP via Ethernet port
- ➤ DeviceNet port
- ➤ Analog outputs
- ➤ IEC 61850 via Ethernet port

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

For monitoring and preventive maintenance purposes, the SEL-710 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-710 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-710 meter data fall into the following categories:

- Fundamental metering
- Thermal metering
  - Thermal model metering
  - RTD metering (with the external SEL-2600 RTD Module or an internal RTD option)
- Energy metering
- Maximum and minimum metering
- Math variable metering
- RMS metering
- Analog transducer input metering

Fundamental Metering

Table 5.1 details each of the fundamental meter data types in the SEL-710. *Section 8: Front-Panel Operations* and *Section 7: Communications* describe how to access the various types of meter data using the relay front panel and communications ports.

Table 5.1 Measured Fundamental Meter Values

Relay Option	Meter Values
All Models	Line Currents IA, IB, IC and IN (Core-Balance Ground Fault Current) magnitudes (A) and phase angles (deg)
	IG (Residual Ground Fault Current) magnitude (A) and phase angle (deg)
	IAV (Average Current Magnitude) Average Motor Load (xFLA) Negative-Sequence Current (3I2) Current Unbalance %[a] System Frequency (Hz)
With Voltage/Differential Option	VAB, VBC, VCA (DELTA-connected PTs) or VAN, VBN, VCN, VG (wye-connected PTs) magnitudes (V) and phase angles (deg)
	Average Voltage (L-L or L-N) Negative-Sequence (3V2) Voltage Unbalance %[a]
	Real Power (kW) Reactive Power (kVAR)
	Apparent Power (kVA) Power Factor
	Differential currents IA87, IB87, IC87

[a] Current Unbalance % = 0 when IAV ≤ 0.25 • INOM. Voltage Unbalance = 0 when VAV ≤ 0.25 • Vnm, where Vnm = VNOM/1.732 when wye, VNOM when delta.

All angles are displayed between –180 and +180 degrees. The angles are referenced to VAB or VAN (for delta- or wye-connected PT, respectively) or IA. If the voltage channels are not supported, or if VAB < 13 V (for delta-connected PT) or VAN < 13 V (for wye-connected PT), the angles are referenced to IA current. *Figure 5.1* shows an example of the **METER** command report.

```
=>>MET <Enter>

SEL-710                                   Date: 12/07/2013   Time: 16:52:48
MOTOR RELAY                                   Time Source: Internal
                              IA       IB       IC       IN       IG
Current Magnitude (A pri.)    196.6    198.8    196.6      0.00     3.7
Current Angle (deg)           -21.8   -141.4     98.8   -136.7   -133.6
Ave Curr Mag    (A pri.)      197.3
Mot Load (xFLA1)                0.81
Neg-Seq Curr 3I2 (A pri.)       0.8
Current Imb (%)                 0.6

                               IA87     IB87     IC87
Diff Phase Curr     (A pri.)      0.0      0.0      0.0

                               VA         VB         VC         VG
Voltage Magnitude (V pri.)     3251       3245       3246         33
Voltage Angle (deg)               0.0     -119.6      120.7     -104.8
Avg Phase (V pri.)            3247
Neg-Seq Volt 3V2 (V pri.)       38.9
Voltage Imb (%)                 0.1

Real Power (kW)              1784
Reactive Power (kVAR)         715
Apparent Power (kVA)         1922
Power Factor (LAG)              0.93
Frequency (Hz)   60.0
=>>
```

Figure 5.1 METER Command Report With Voltage and Differential Option

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

Thermal Metering

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* shows the thermal meter values.

Table 5.2 Thermal Meter Values

Relay Option	Thermal Values
All Models	Motor Load (xFLA) Stator Thermal Capacity Used % Rotor Thermal Capacity Used % Time to Trip (s) Time to Reset (min) Starts Available
With External SEL-2600 RTD Module or Internal RTD Option	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 and their meanings.

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.

NOTE: If the overload protection is disabled by setting E49MOTOR := N, the relay always reports %Thermal Capacity = 0 and Calculated Time to Thermal Trip (s) = 9999.

Table 5.3 RTD Input Status Messages

Message	Status
Open	RTD leads open
Short	RTD leads shorted
Comm Fail	Fiber-optic communications to SEL-2600 RTD Module have failed
Stat Fail	SEL-2600 RTD Module self-test status failure

Figure 5.2 provides an example of the **METER T** command report.

NOTE: The maximum time to thermal trip is 3600 seconds (values greater than this are displayed as 9999 seconds).

```
=>MET T <Enter>

SEL-710                                    Date: 04/17/2006   Time: 09:51:21
MOTOR RELAY                                Time Source: Internal

Max Winding RTD  Fail
Max Bearing RTD  NA
Ambient RTD      Fail
Max Other RTD    NA

 RTD 1 WDG   Comm Fail
 RTD 2 AMB   Comm Fail

Motor Load (xFLA1)       0.0
Stator TCU (%)           0
Rotor TCU (%)            0
RTD TCU (%)              0
Thermal Trip In (sec)  9999

Time to Reset (min)      0

=>
```

Figure 5.2 METER T Command Report With RTDs

Power Measurement Conventions

The SEL-710 uses the IEEE convention for power measurement assuming motor action. The implications of this convention are depicted in *Figure 5.3*. In the SEL-710, reported positive real power is always into the motor.

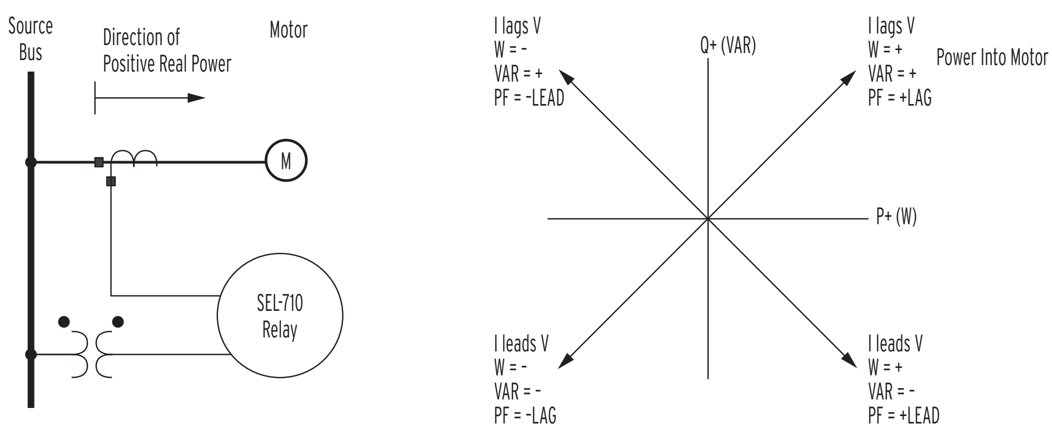


Figure 5.3 Complex Power Measurement Conventions—Motor Action

Energy Metering

The SEL-710 with the voltage option includes energy metering. Use this form of metering to quantify how much real, reactive, and apparent energy your motor is using. You can also determine if your motor is giving reactive power back to the power system. Below are the energy meter values.

- MWh3P—Real three-phase energy (out of bus)
- NEGATIVE MVARh3P_IN—Reactive three-phase energy (into bus)
- POSITIVE MVARh3P_OUT—Reactive three-phase energy (out of bus)
- MVAh3P—Apparent three-phase energy (out of bus)
- Last date and time of energy meter quantities being reset

NOTE: Energy values roll over after 99,999.999 MVAh and reset to 0.

Figure 5.4 shows the device response to the **METER E** command.

```
=>MET E <Enter>
SEL-710                                   Date: 07/17/2008   Time: 13:27:39
MOTOR RELAY                               Time Source: Internal

Energy
MWh3P (MWh)                    1.302
NEG MVARh3P-IN (MVArh)         0.000
POS MVARh3P-OUT (MVArh)        0.817
MVAh3P (MVAh)                  1.538

LAST RESET = 07/17/2008 13:24:59
=>
```

Figure 5.4 Device Response to the METER E Command

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

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

Figure 5.5 Device Response to the METER RE Command

Maximum and Minimum Metering

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

Table 5.4 Maximum/Minimum Meter Values

Relay Option	Max/Min Meter Values
Base Model	Maximum and minimum line currents IA, IB, IC, and IN (core-balance ground fault current) magnitudes (A) Maximum and minimum IG (residual ground fault current) magnitude (A) Maximum and minimum system frequency (Hz)
With Voltage Option	VAB, VBC, VCA or VAN, VBN, and VCN magnitudes (V) Maximum and minimum real, reactive and apparent three-phase power (kW, kVAR, kVA)
With RTD option or SEL-2600 RTD Module	Maximum and minimum RTD temperatures (°C)
With analog input option	Maximum and minimum analog input values (engineering units)

All maximum and minimum metering values will have the date and time that they occurred. The analog quantities from *Table 5.4* are checked approximately every 0.5 seconds and, if a new maximum or minimum value occurs, this value is saved along with the date and time that the maximum or minimum value occurred. Maximum and minimum values are only checked if relay element FAULT is deasserted (no fault condition exists) and the motor is in the running state (relay element RUNNING asserted).

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

```
=>MET M <Enter>

SEL-710                                   Date: 11/29/2005   Time: 11:13:47
MOTOR RELAY                               Time Source: Internal
                  MAX        DATE       TIME       MIN        DATE       TIME
IA (A)             99.8  11/29/2005  11:12:49       49.4  11/29/2005  11:13:06
IB (A)            102.9  11/29/2005  11:12:53       49.7  11/29/2005  11:13:11
IC (A)            100.4  11/29/2005  11:12:35       49.5  11/29/2005  11:13:46
IN (A)            104.2  11/29/2005  11:12:54       52.1  11/29/2005  11:13:16
IG (A)              4.9  11/29/2005  11:12:50        0.6  11/29/2005  11:13:24
VAB (V)          2464.8  11/29/2005  11:12:45     2445.9  11/29/2005  11:13:06
VBC (V)          2465.1  11/29/2005  11:12:28     2445.2  11/29/2005  11:13:41
VCA (V)          4290.3  11/29/2005  11:13:01     4256.9  11/29/2005  11:13:20
kW3P (kW)         430.0  11/29/2005  11:12:55      211.3  11/29/2005  11:13:36
kVAR3P (kVAR)     249.2  11/29/2005  11:12:32      118.8  11/29/2005  11:13:23
kVA3P (kVA)       496.4  11/29/2005  11:12:45      243.4  11/29/2005  11:13:22
FREQ (Hz)          60.0  11/29/2005  11:13:02       60.0  11/29/2005  09:54:30
AI301 (mA)         -0.0  11/29/2005  10:20:33       -0.0  11/29/2005  09:54:54
AI302 (mA)         -0.0  11/29/2005  10:04:07       -0.0  11/29/2005  09:54:43
AI303 (mA)         -0.0  11/29/2005  10:57:45       -0.0  11/29/2005  09:55:45
AI304 (mA)         -0.0  11/29/2005  11:12:18       -0.0  11/29/2005  09:55:31
AI305 (mA)         -0.0  11/29/2005  10:56:10       -0.0  11/29/2005  09:54:46
AI306 (mA)         -0.0  11/29/2005  10:37:13       -0.0  11/29/2005  09:58:04
AI307 (mA)         -0.0  11/29/2005  11:11:09       -0.0  11/29/2005  09:55:33
AI308 (mA)         -0.0  11/29/2005  10:32:45       -0.0  11/29/2005  09:55:00
LAST RESET = 11/29/2005 09:54:26
=>
```

Figure 5.6 Device Response to the METER M Command

To reset maximum/minimum meter values, issue the **MET RM** command as shown in *Figure 5.7*. The max/min meter values can be reset from the serial port, Modbus, the front panel, or assertion of the RSTMXMN relay element. The date and time of the reset are preserved and shown in the max/min meter report.

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

Figure 5.7 Device Response to the METER RM Command

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

Math Variable Metering

The SEL-710 includes 32 math variables. When you receive your SEL-710, no math variables are enabled. To use math variables, enable the number of math variables (between 1 and 32) you require, using the EMV setting in the Logic setting category. *Figure 5.8* shows the device response to the **METER MV M**(ath) **V**(ariable) command with 8 of the 32 math variables enabled.

```
=>>MET MV <Enter>
SEL-710                                   Date: 04/17/2006   Time: 12:32:10
MOTOR RELAY                               Time Source: Internal

MV01       1.00
MV02  -32767.00
MV03      -1.00
MV04       0.00
MV05    1000.59
MV06   -1000.61
MV07    2411.01
MV08    2410.99
=>>
```

Figure 5.8 Device Response to the MET MV Command

RMS Metering

The SEL-710 includes root-mean-square (rms) metering. Use rms metering to measure the entire signal (including harmonics) at which the motor is running. You can measure the rms quantities shown in *Table 5.5*.

Table 5.5 RMS Meter Values

Relay Option	RMS Meter Values
Base Model	RMS current IA, IB, IC, and IN magnitudes (A)
With Voltage Option	VAB, VBC, VCA or VAN, VBN, and VCN magnitudes (V)

RMS quantities contain the total signal energy including harmonics. This differs from the fundamental meter (**METER** command) in that the fundamental meter quantities only contain the fundamental frequency (60 Hz for a 60-Hz system).

Figure 5.9 shows the **METER RMS** command.

```
=>MET RMS <Enter>
SEL-710                                     Date: 03/09/2006   Time: 10:46:00
MOTOR RELAY                                 Time Source: Internal
                IA       IB       IC       IN
RMS (A pri.)     99.3    102.8    102.0      0.2
                VAB      VBC      VCA
RMS (V pri.)     2463     4246     4289
=>
```

Figure 5.9 Device Response to the METER RMS Command

Analog Input Metering

The SEL-710 can monitor analog (transducer) quantities that it is measuring if equipped with optional analog inputs. Analog input metering shows transducer values from standard voltage and current transducers. These values can then be used for automation and control applications within an industrial plant or application.

Through the global settings, you can set each type of analog input to the type of transducer that drives that analog input. You also set the range of the transducer output. Analog inputs can accept both current and voltage transducer outputs. Ranges for the current transducers are ±20 mA and ranges for the voltage transducers are ±10 V. You also set the corresponding output of the analog inputs in engineering units. See *Section 4: Protection and Logic Functions* for an explanation of how to set up analog inputs for reading transducers. *Figure 5.10* shows an example of analog input metering.

```
=>MET AI <Enter>
SEL-710                                     Date: 11/28/2005   Time: 16:22:22
MOTOR RELAY                                 Time Source: Internal
Input Card 4
AI401 (psi)         99.97
AI402 (mA)           2.013
AI403 (Volts)       -0.0027
AI404 (ft-lbs)     993
AI405 (HP)        1423
AI406 (mA)           9.013
AI407 (mA)          -3.014
AI408 (mA)          -0.013
=>
```

Figure 5.10 Device Response to the METER AI Command

Small Signal Cutoff for Metering

The relay applies a threshold to the voltage and current magnitude metering quantities to force a reading to zero when the measurement is near zero. The threshold for current values is 0.01• INOM and for voltage values is 0.1 V.

Load Profiling

The SEL-710 includes a load profiling function. The relay automatically records selected quantities into nonvolatile memory every 5, 10, 15, 30, or 60 minutes, depending on the LDAR load profile report setting (see *Load Profile Settings on page 4.96*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix J: Analog Quantities*. Set these quantities into the LDLIST load profile list report setting.

The relay memory can hold data for 6500 time-stamped entries. For example, if you chose to monitor 10 values at a rate of every 15 minutes, you could store 66 days worth of data.

Download the load rate profile data using the serial port **LDP** command described in *LDP Command (Load Profile Report) on page 7.31*. *Figure 5.11* shows an example **LDP** serial port command response.

```
=>LDP <Enter>

SEL-710                                 Date: 04/27/2006   Time: 15:39:24
MOTOR RELAY                             Time Source: Internal

#     DATE          TIME          IAV        UBI       VAVE        UBV       FREQ      TCURTR      MLOAD
5  04/27/2006  15:18:39.997     39.900      3.100   2455.000      2.300     60.000     17.000      0.300
4  04/27/2006  15:23:41.043     40.002      3.110   2456.020      2.299     60.004     15.873      0.321
3  04/27/2006  15:28:40.176     40.101      3.089   2453.129      2.391     59.997     15.231      0.308
2  04/27/2006  15:33:40.233     40.375      3.102   2458.391      2.107     60.010     14.827      0.319
1  04/27/2006  15:38:41.082     40.079      3.114   2454.294      2.292     60.002     13.298      0.326
. . .
=>
```

Figure 5.11 LDP Command Response

Motor Operating Statistics

NOTE: While the relay power is off, the elapsed timers do not advance. If relay power is off for a significant amount of time, the elapsed calendar time will not match the elapsed time recorded by the relay.

The SEL-710 retains useful machine operating statistics information for the protected motor. 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. Items included in the report are shown in *Figure 5.12*.

```
=>>MOT <Enter>

SEL-710                                 Date: 04/25/2006   Time: 08:43:08
MOTOR RELAY                             Time Source: Internal

Operating History (elapsed time in ddd:hh:mm)
Last Reset Date    04/25/2006
Last Reset Time      08:09:22
Running Time       >  0:00:26
Stopped Time          0:00:06
Time Running (%)         79.9
Total MWhr (MWhr)         0.9
Number of Starts            6
Emergency Starts            0
Avg/Peak Data
```

Figure 5.12 MOTOR Command Example

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.

```
                    AVERAGE     PEAK
Start Time (s)          5.0      5.3
Max Start I (A)      1503.2   1504.0
Min Start V (V)      4016.5   4013.0
Start %TCU             63.6     71.0
Running %TCU           63.9    100.7
RTD %TCU                0.0      0.0
Running Cur (A)       252.1    253.0
Running kW           1760.0   1766.5
Running kVARin         63.6     70.5
Running kVARout         0.0      0.0
Running kVA          1761.2   1767.6
Max WDG RTD (C)  Fail     Fail
Max BRG RTD (C)  NA       NA
Ambient RTD (C)  Fail     Fail
Max OTH RTD (C)  NA       NA
Learn Parameters
CoolTime (s)  Insufficient Data
Start TC (%)        47
Trip/Alarm Data
                ALARMS  TRIPS
Overload            0      0
Locked Rotor        2      1
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
RTD                 0      0
Phase Reversal             0
87M Phase Diff             0
Underfrequency             0
Overfrequency              0
Start Timer                0
Remote Trip                0
Other Trips                0
Total               2      1

=>>
```

Figure 5.12 MOTOR Command Example (Continued)

Motor Start Report

The SEL-710 records motor start data for each motor start. The relay stores the five latest motor start reports in nonvolatile memory. View any of the five latest motor start reports using the serial port **MSR *n*** command, where $n = 1–5$, and $n = 1$ is the most recent report. Each report consists of two parts.

- A summary
- The start data

Summary Data

The summary shows the following information:

NOTE: The relay reports %TCU values during starting based upon the starting model trip value, thus providing the appropriate %TCU magnitude scaling.

- Date and time of the motor start
- Number of starts since last reset
- Motor start time
- Start % Rotor Thermal Capacity Used (%RotorTCU)
- Maximum Start Current
- Minimum Start Voltage, if Voltage Inputs card option installed

The relay calculates motor start time from the time the starting current is detected until the running state is declared (see *Figure 5.12*). The %RotorTCU value is the rotor thermal element capacity used at the end of the start, expressed in percent of the trip value.

Start Data

The motor start data are taken periodically after the starting current is detected. The relay stores 720 sets of the data with the period determined by the setting MSRR (motor start report resolution).

The following data are stored:

- Magnitude of A-, B-, and C-phase currents
- Magnitude of neutral current, IN
- % Rotor Thermal Capacity Used (%RotorTCU)
- Magnitude of AB, BC, and CA phase-to-phase voltages, if included
- Calculated % Slip for the motor

Figure 5.13 shows data from an example Motor Start Report.

```
=>>MSR 3 <Enter>

SEL-710                                 Date: 04/21/2006   Time: 12:35:16
MOTOR RELAY                             Time Source: Internal
FID  SEL-710-R100-V0-Z001001-D20060626
Start Date  04/17/2006
Start Time  12:07:00.478
# Starts               3
Start Time (s)      18.2
Start TCU  (%)        80
MaxCurrent (A)       618
MinVoltage (V)      1903
 CYCLE     IA     IB     IC     IN     VAB    VBC    VCA    TCURTR  SLIP
           (A)    (A)    (A)    (A)    (V)    (V)    (V)     (%)     (%)
    5.00   614    615    616      0   1905   1909   1917    16.8   100.0
   10.00   614    614    616      0   1907   1910   1918    17.3   100.0
   15.00   614    615    615      0   1908   1912   1919    17.8   100.0
   20.00   614    614    616      0   1910   1913   1920    18.2    88.0
   25.00   615    615    616      0   1912   1914   1921    18.7    88.0
   .
   .
   .
 1070.00   305    305    295      0   2224   2224   2231    80.8     2.1
 1075.00   162    158    154      0   2292   2294   2310    80.9     0.8
 1080.00   108    107    106      0   2308   2313   2330    80.9     0.5
 1085.00    99     99     98      0   2318   2319   2333    80.9     0.5
 1090.00    98     98     97      0   2316   2318   2332    80.9     0.5
   .
   .
   .
 3595.00     0      0      0      0      0      1      1    76.9   100.0
 3600.00     0      0      0      0      0      0      0    76.9   100.0

=>>
```

Figure 5.13 Motor Start Report Example

Motor Start Trending

NOTE: All the trend data collected each day are added to nonvolatile memory at midnight. If the relay power is removed, the information collected between midnight and power removal is lost.

NOTE: While the relay power is off, the elapsed timers do not advance. If relay power is off for a significant amount of time, the elapsed calendar time will not match the elapsed time recorded by the relay.

For each motor start, the relay stores a motor start report and adds these data (described in *Summary Data on page 5.9*) to the motor start trending buffer. Motor start trending tracks motor start data for the past eighteen 30-day periods. For each 30-day interval, the relay records the following information:

- the date the interval began
- the total number of starts in the interval
- the averages of the following quantities:
  - Motor Start Time
  - Start % Rotor Thermal Capacity Used
  - Maximum Start Current
  - Minimum Start Voltage, if Voltage Inputs card option is installed

View the motor start trending data using the serial port **MST** command. *Figure 5.14* shows data from an example Motor Start Trend Report.

```
=>MST <Enter>

SEL-710                                   Date: 11/29/2005   Time: 16:35:37
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     11/29/2005      4      14.4         18         913      2578
   2        ---         ---      ---        ---         ---       ---
   3        ---         ---      ---        ---         ---       ---
   4        ---         ---      ---        ---         ---       ---
   5        ---         ---      ---        ---         ---       ---
   6        ---         ---      ---        ---         ---       ---
   7        ---         ---      ---        ---         ---       ---
   8        ---         ---      ---        ---         ---       ---
   9        ---         ---      ---        ---         ---       ---
  10        ---         ---      ---        ---         ---       ---
  11        ---         ---      ---        ---         ---       ---
  12        ---         ---      ---        ---         ---       ---
  13        ---         ---      ---        ---         ---       ---
  14        ---         ---      ---        ---         ---       ---
  15        ---         ---      ---        ---         ---       ---
  16        ---         ---      ---        ---         ---       ---
  17        ---         ---      ---        ---         ---       ---
  18        ---         ---      ---        ---         ---       ---
=>
```

Figure 5.14 Motor Start Trending Report Example

Breaker Monitor

The breaker monitor in the SEL-710 helps in scheduling circuit breaker maintenance. The breaker monitor is enabled with the enable setting:

EBMON = **Y**

The breaker monitor settings in *Table 5.7* are available via the **SET G** commands (see *Table 6.3*). Also refer to *BRE Command (Breaker Monitor Data) on page 7.22* and *BRE n Command (Preload/Reset Breaker Wear) on page 7.22*.

The breaker monitor is set with breaker maintenance information provided by circuit breaker manufacturers. This breaker maintenance information lists the number of close/open operations that are permitted for a given current interruption level. The following is an example of breaker maintenance information for a 25 kV circuit breaker. The breaker maintenance information in *Table 5.6* is plotted in *Figure 5.15*.

Table 5.6 Breaker Maintenance Information for a 25 kV Circuit Breaker

Current Interruption Level (kA)	Permissible Number of Close/Open Operations[a]
0.00–1.20	10,000
2.00	3,700
3.00	1,500
5.00	400
8.00	150
10.00	85
20.00	12

[a] The action of a circuit breaker closing and then later opening is counted as **one** close/open operation.

Connect the plotted points in *Figure 5.15* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-710 breaker monitor, three set points are entered:

Set Point 1 COSP1 — **maximum** number of close/open operations with corresponding current interruption level.

Set Point 2 COSP2 — number of close/open operations that correspond to some **midpoint** current interruption level.

Set Point 3 COSP3 — number of close/open operations that correspond to the **maximum** current interruption level.

These three points are entered with the settings in *Table 5.7*.

Table 5.7 Breaker Monitor Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Breaker Monitor	(Y,N)	EBMON := Y
CL/OPN OPS SETPT 1	(0–65000)	COSP1 := 10000[a]
CL/OPN OPS SETPT 2	(0–65000)	COSP2 := 150[b c]
CL/OPN OPS SETPT 3	(0–65000)	COSP2 := 12
kA PRI INTERRPTD 1	(0.10–999.00 kA)	KASP1 := 1.20[d]
kA PRI INTERRPTD 2	(0.10–999.00 kA)	KASP2 := 8.00
kA PRI INTERRPTD 3	(0.10–999.00 kA)	KASP3 := 20.00[e]
BRKR MON CONTROL	SELOGIC	BKMON := TRIP

[a] COSP1 must be set greater than COSP2.
[b] COSP2 must be set greater than or equal to COSP3.
[c] If COSP2 is set the same as COSP3, then KASP2 must be set the same as KASP3.
[d] KASP1 must be set less than KASP2.
[e] KASP3 must be set at least five times (but no more than 100 times) the KASP1 setting value.

The following settings are made from the breaker maintenance information in *Table 5.6* and *Figure 5.15*. *Figure 5.16* shows the resultant breaker maintenance curve.

COSP1 = **10000**	KASP1 = **1.20**
COSP2 = **150**	KASP2 = **8.00**
COSP3 = **12**	KASP3 = **20.00**

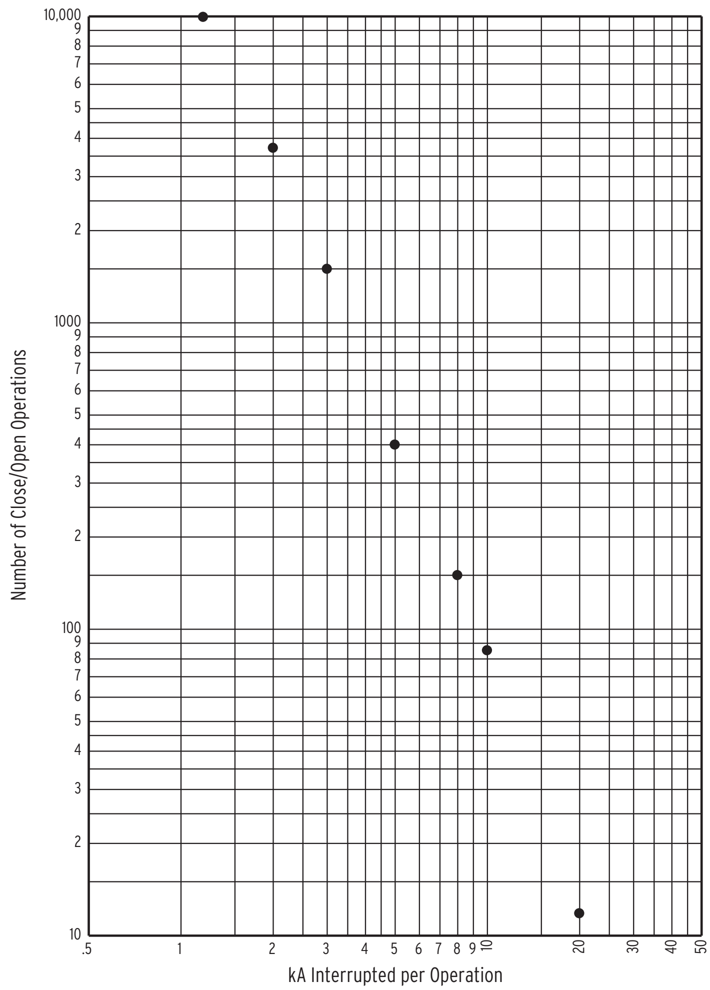


Figure 5.15 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

Breaker Maintenance Curve Details

In *Figure 5.16*, note that set points KASP1, COSP1 and KASP3, COSP3 are set with breaker maintenance information from the two extremes in *Table 5.6* and *Figure 5.15*.

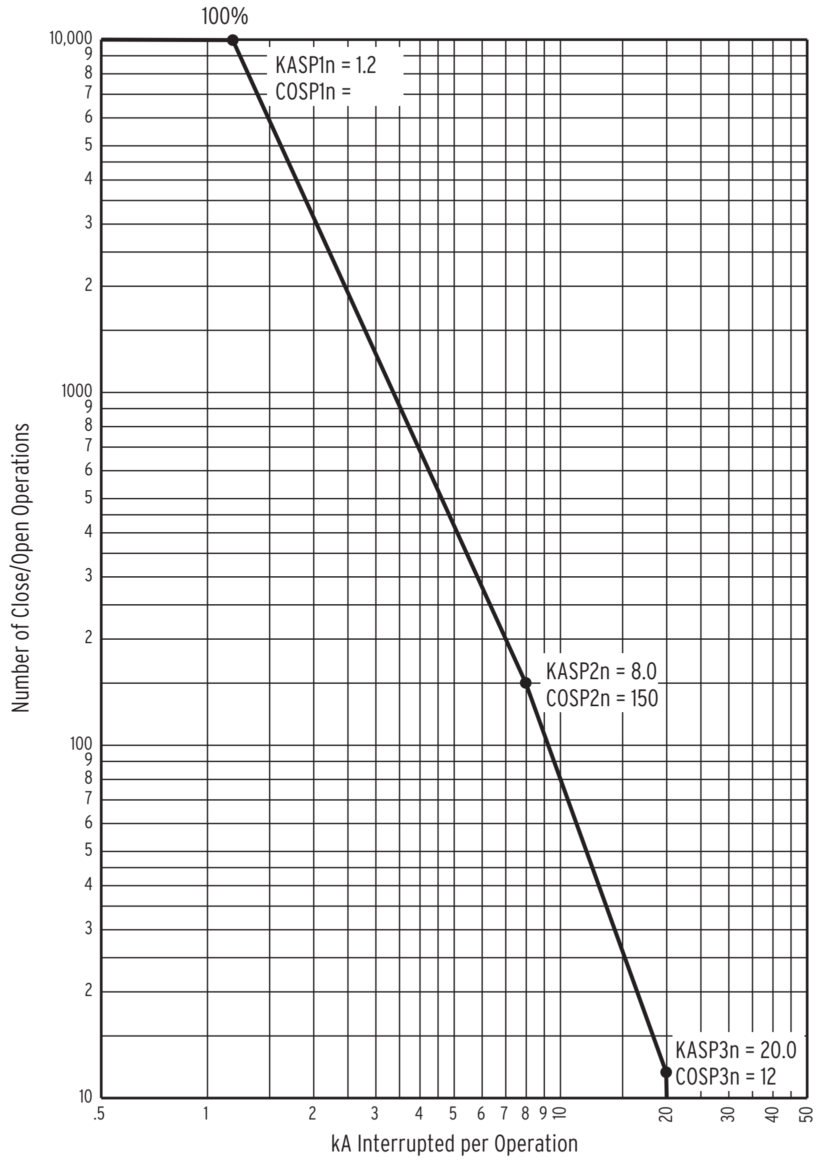


Figure 5.16 SEL-710 Breaker Maintenance Curve for a 25 kV Circuit Breaker

In this example, set point KASP2, COSP2 happens to be from an in-between breaker maintenance point in the breaker maintenance information in *Table 5.6* and *Figure 5.15*, but it does not have to be. Set point KASP2, COSP2 should be set to provide the best "curve-fit" with the plotted breaker maintenance points in *Figure 5.15*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 5.16*), because the separate circuit breaker interrupting contacts for phases A, B, and C do not necessarily interrupt the same magnitude current (depending on fault type and loading).

In *Figure 5.16*, note that the breaker maintenance curve levels off horizontally above set point KASP1, COSP1. This is the close/open operation limit of the circuit breaker (COSP1 = 10000), regardless of interrupted current value.

Also, note that the breaker maintenance curve falls vertically below set point KASP3, COSP3. This is the maximum interrupted current limit of the circuit breaker (KASP3 = 20.0 kA). If the interrupted current is greater than setting KASP3, the interrupted current is accumulated as a current value equal to setting KASP3.

Operation of SELogic Control Equation Breaker Monitor Initiation Setting BKMON

The SELogic control equation breaker monitor initiation setting BKMON in *Table 5.7* determines when the breaker monitor reads in current values (Phases A, B, and C) for the breaker maintenance curve (see *Figure 5.16*) and the breaker monitor accumulated currents/trips (see *BRE Command (Breaker Monitor Data) on page 7.22*).

The BKMON setting looks for a rising edge (logical 0 to logical 1 transition) as the indication to read in current values. The acquired current values are then applied to the breaker maintenance curve and the breaker monitor accumulated currents/trips (see references in previous paragraph).
In the factory-default settings, the SELogic control equation breaker monitor initiation setting is set:

BKMON = **TRIP** (TRIP is the logic output of *Figure 4.33*)

Refer to *Figure 5.17*. When BKMON asserts (Relay Word bit TRIP goes from logical 0 to logical 1), the breaker monitor reads in the current values and applies them to the breaker monitor maintenance curve and the breaker monitor accumulated currents/trips.

As detailed in *Figure 5.17*, the breaker monitor actually reads in the current values 1.5 cycles after the assertion of BKMON. This helps especially if an instantaneous trip occurs. The instantaneous element trips when the fault current reaches its pickup setting level. The fault current may still be "climbing" to its full value, at which it levels off. The 1.5-cycle delay on reading in the current values allows time for the fault current to level off.

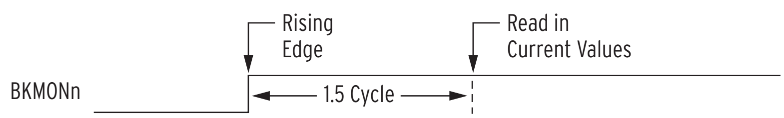


Figure 5.17 Operation of SELogic Control Equation Breaker Monitor Initiation Setting

See *Figure 5.22* and accompanying text for more information on setting BKMON. The operation of the breaker monitor maintenance curve, when new current values are read in, is explained in the following example.

Breaker Monitor Operation Example

As stated earlier, each phase (A, B, and C) has its own breaker maintenance curve. For this example, presume that the interrupted current values occur on a single phase in *Figure 5.18–Figure 5.21*. Also, presume that the circuit breaker interrupting contacts have no wear at first (brand new or recent maintenance performed).

Note in the following four figures (*Figure 5.18–Figure 5.21*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 5.19*, 2.5 kA is interrupted 290 times). This is not realistic, but helps in demonstrating the operation of the breaker maintenance curve and how it integrates for varying current levels.

0 Percent to 10 Percent Breaker Wear

Refer to *Figure 5.18*. 7.0 kA is interrupted 20 times (20 close/open operations = 20 – 0), pushing the breaker maintenance curve from the 0 percent wear level to the 10 percent wear level.

Compare the 100 percent and 10 percent curves and note that for a given current value, the 10 percent curve has only 1/10 of the close/open operations of the 100 percent curve.

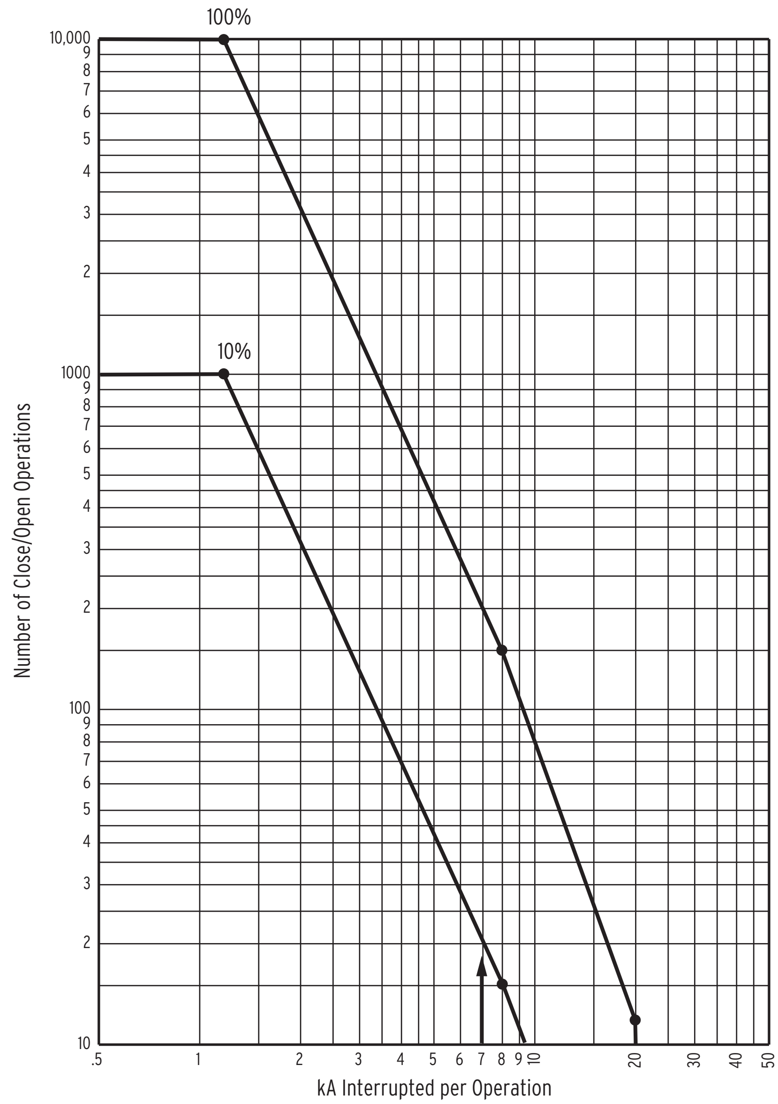


Figure 5.18 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.19*. The current value changes from 7.0 kA to 2.5 kA. 2.5 kA is interrupted 290 times (290 close/open operations = 480 – 190), pushing the breaker maintenance curve from the 10 percent wear level to the 25 percent wear level.

Compare the 100 percent and 25 percent curves and note that for a given current value, the 25 percent curve has only 1/4 of the close/open operations of the 100 percent curve.

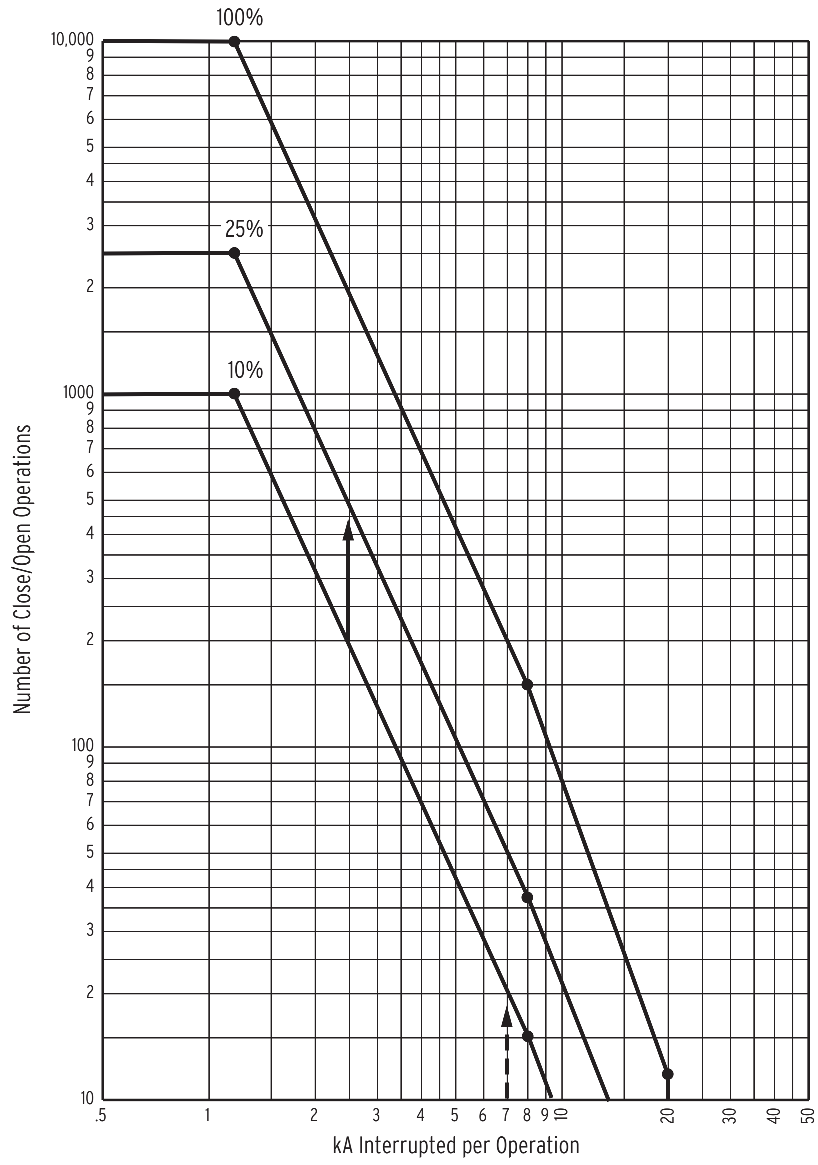


Figure 5.19 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.20*. The current value changes from 2.5 kA to 12.0 kA. 12.0 kA is interrupted 11 times (11 close/open operations = 24 – 13), pushing the breaker maintenance curve from the 25 percent wear level to the 50 percent wear level.

Compare the 100 percent and 50 percent curves and note that for a given current value, the 50 percent curve has only 1/2 of the close/open operations of the 100 percent curve.

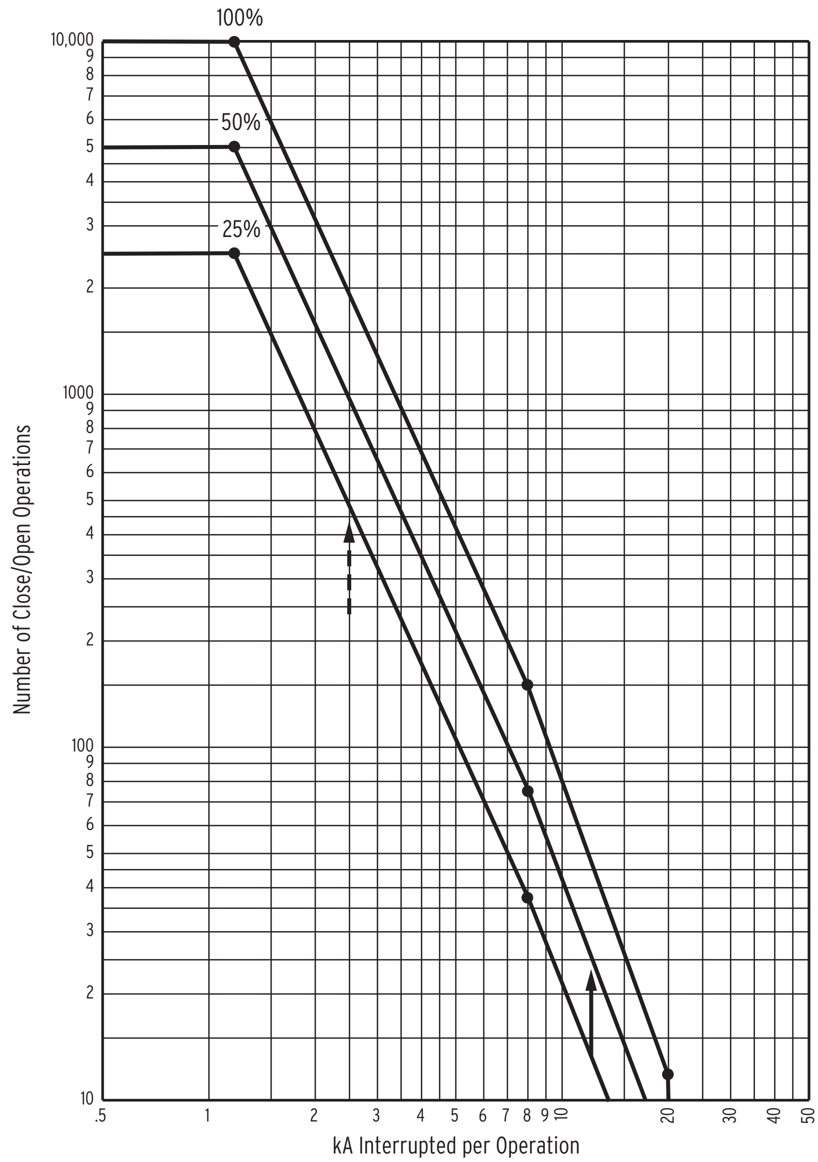


Figure 5.20 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.21*. The current value changes from 12.0 kA to 1.5 kA. 1.5 kA is interrupted 3000 times (3000 close/open operations = 6000 – 3000), pushing the breaker maintenance curve from the 50 percent wear level to the 100 percent wear level.

When the breaker maintenance curve reaches 100 percent for a particular phase, the percentage wear remains at 100 percent (even if additional current is interrupted), until reset by the **BRE R** command (see *View or Reset Breaker Monitor Information on page 5.20*). But the current and trip counts continue to be accumulated, until reset by the **BRE R** command.

Additionally, logic outputs assert for alarm or other control applications—see the following discussion.

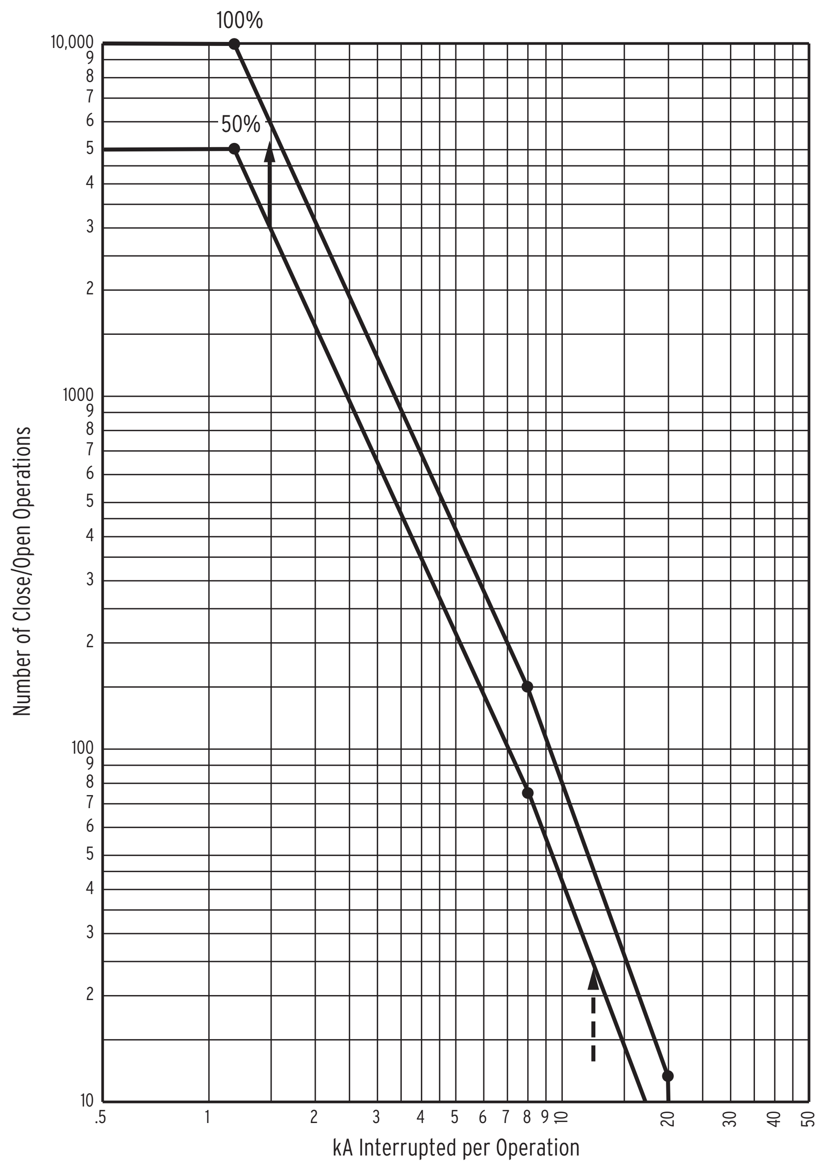


Figure 5.21 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 5.21*), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Table 5.8 Relay Word Bits Setting

Relay Word Bits	Definition
BCWA	Phase A breaker contact wear has reached the 100 percent wear level
BCWB	Phase B breaker contact wear has reached the 100 percent wear level
BCWC	Phase C breaker contact wear has reached the 100 percent wear level
BCW	BCWA or BCWB or BCWC

EXAMPLE 5.1 Example Applications

These logic outputs can be used to alarm:

OUT*xxx* = **BCW**

or drive the relay to lockout the next time the relay trips:

79DTL = **TRIP AND BCW**

View or Reset Breaker Monitor Information

Accumulated breaker wear/operations data are retained if the relay loses power or the breaker monitor is disabled (setting EBMON = N). The accumulated data can only be reset if the **BRE R** command is executed (see the following discussion on the **BRE R** command).

Via Serial Port

See *Section 7: Communications*. The **BRE** command displays the following information:

- Accumulated number of relay initiated trips
- Accumulated interrupted current from relay initiated trips
- Accumulated number of externally initiated trips
- Accumulated interrupted current from externally initiated trips
- Percent circuit breaker contact wear for each phase
- Date when the preceding items were last reset (via the **BRE R** command)

See *Section 7: Communications*. The **BRE W** command allows the trip counters, accumulated values, and percent breaker wear to be preloaded for each individual phase.

The **BRE R** command resets the accumulated values and the percent wear for all three phases. For example, if breaker contact wear has reached the 100 percent wear level for A-phase, the corresponding Relay Word bit BCWA asserts (BCWA = logical 1). Execution of the **BRE R** command resets the wear levels for all three phases back to 0 percent and consequently causes Relay Word bit BCWA to deassert (BCWA = logical 0).

Via Front Panel

The information and reset functions available via the previously discussed serial port commands **BRE** and **BRE R** are also available via the front panel. See *Section 8: Front-Panel Operations* for details.

Determination of Relay Initiated Trips and Externally Initiated Trips

See *Section 7: Communications*. Note in the **BRE** command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: that generated by **relay initiated trips** (Rly Trips) and that generated by **externally initiated trips** (Ext Trips). The categorization of these data is determined by the status of the TRIP Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON operates.

Refer to *Figure 5.17* and accompanying explanation. If BKMON newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now the decision has to be made: where is this current and trip count information accumulated? Under **relay initiated trips or externally initiated trips**?

To make this determination, the status of the TRIP Relay Word bit is checked at the instant BKMON newly asserts (TRIP is the logic output of *Figure 4.33*). If TRIP is asserted (TRIP = logical 1), the current and trip count information is accumulated under **relay initiated trips** (Rly Trips). If TRIP is deasserted (TRIP = logical 0), the current and trip count information is accumulated under **externally initiated trips** (Ext Trips).

Regardless of whether the current and trip count information is accumulated under relay initiated trips or externally initiated trips, this same information is routed to the breaker maintenance curve for continued breaker wear integration (see *Figure 5.17–Figure 5.21*).

Relay initiated trips (Rly Trips) are also referred to as **internally initiated trips** (Int Trips) in the course of this manual; the terms are interchangeable.

EXAMPLE 5.2 Factory-Default Setting Example

As discussed previously, the SELOGIC control equation breaker monitor initiation factory-default setting is:

BKMON = **TRIP**

Thus, any new assertion of BKMON will be deemed a relay trip, and the current and trip count information is accumulated under relay initiated trips (Rly Trips).

EXAMPLE 5.3 Additional Example

Refer to Figure 5.22. Output contact **OUT103** is set to provide tripping:

OUT103 = **TRIP**

Note that optoisolated input **INxxx** monitors the trip bus. If the trip bus is energized by output contact **OUT103**, an external control switch, or some other external trip, then **INxxx** is asserted.

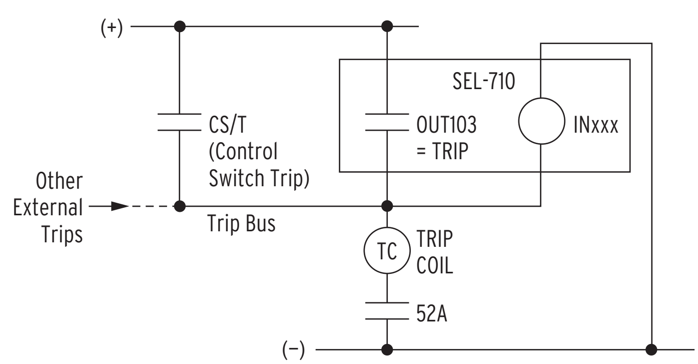


Figure 5.22 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = **INxxx**

then the SEL-710 breaker monitor sees all trips.

If output contact **OUT103** asserts, energizing the trip bus, the breaker monitor will deem it a relay initiated trip. This is because when BKMON is newly asserted (input **INxxx** energized), the TRIP Relay Word bit is asserted. Thus, the current and trip count information is accumulated under relay initiated trips (Rly Trips).

If the control switch trip (or some other external trip) asserts, energizing the trip bus, the breaker monitor will deem it an externally initiated trip. This is because when BKMON is newly asserted (input **INxxx** energized), the TRIP Relay Word bit is deasserted. Thus, the current and trip count information is accumulated under externally initiated trips (Ext Trips).

Section 6
Settings

Overview

The SEL-710 Motor Protection Relay stores the settings you enter in nonvolatile memory. Settings are divided into the following seven setting classes:

1. Relay Group *n* (*n* = 1, 2, or 3)
2. Logic Group *n* (*n* = 1, 2, or 3)
3. Global
4. Port *p* (where *p* = F, 1 [Ethernet], 2, 3, or 4)
5. Front Panel
6. Report
7. Modbus

Some setting classes have multiple instances. In the previous list, there are five port setting instances, one for each port. Settings may be viewed or set in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings

	Serial Port Commands[a]	Front-Panel HMI Set/Show Menu[b]	ACSELERATOR QuickSet SEL-5030 Software[c]
Display Settings	All settings (**SHO** command)	Global, Group, and Port settings	All settings
Change Settings	All settings (**SET** command)	Global, Group, and Port settings	All settings

[a] Refer to Section 7: Communications for detailed information on set-up and use of the serial communications port and Ethernet port.
[b] Refer to Section 8: Front-Panel Operations for detailed information on the front-panel layout, menus and screens, and operator control pushbuttons.
[c] Refer to Section 3: PC Software for detailed information.

Setting entry error messages, together with corrective actions, are also presented in this section to assist in correct settings entry.

The *SEL-710 Settings Sheets* at the end of this section list all SEL-710 settings, the setting definitions, and input ranges. Refer to *Section 4: Protection and Logic Functions* for detailed information on individual elements and settings.

View/Change Settings With Front Panel

You can use the pushbuttons on the front panel to view/change settings. *Section 8: Front-Panel Operations* presents the operating details of the front panel.

Enter the front-panel menu by pushing the **ESC** pushbutton. It will display the following message:

```
MAIN
Meter
```

Scroll down the menu by using the **Down Arrow** pushbutton until the display shows the following message:

```
Control
Set/Show
```

The cursor (underline) should be on the Set/Show command. Enter the Set/Show command by pushing the **ENT** pushbutton. The display shows the following message:

```
Global
Group
```

Enter the underlined RELAY message with the **ENT** pushbutton, and the relay will present you with the RELAY settings as listed in the *SEL-710 Settings Sheets*. Use the **Up Arrow**, **Down Arrow**, **Left Arrow**, and **Right Arrow** pushbuttons to scroll through the relay settings. View and change the settings according to your needs by selecting and editing them. After viewing or changing the RELAY settings, press the **ESC** pushbutton until the following message appears:

```
Save Changes?
Yes   No
```

NOTE: Each SEL-710 is shipped with default factory settings. Calculate the settings for your motor to ensure secure and dependable protection. Document the settings on the **SEL-710 Settings Sheets** at the end of this section before entering new settings in the relay.

Select and enter the appropriate command by pushing the **ENT** pushbutton. Select Yes to save the settings changes and No to discard the changes.

Figure 6.1 shows a front-panel menu navigation example for the relay to enter the MOTOR FLA, FLA1 setting.

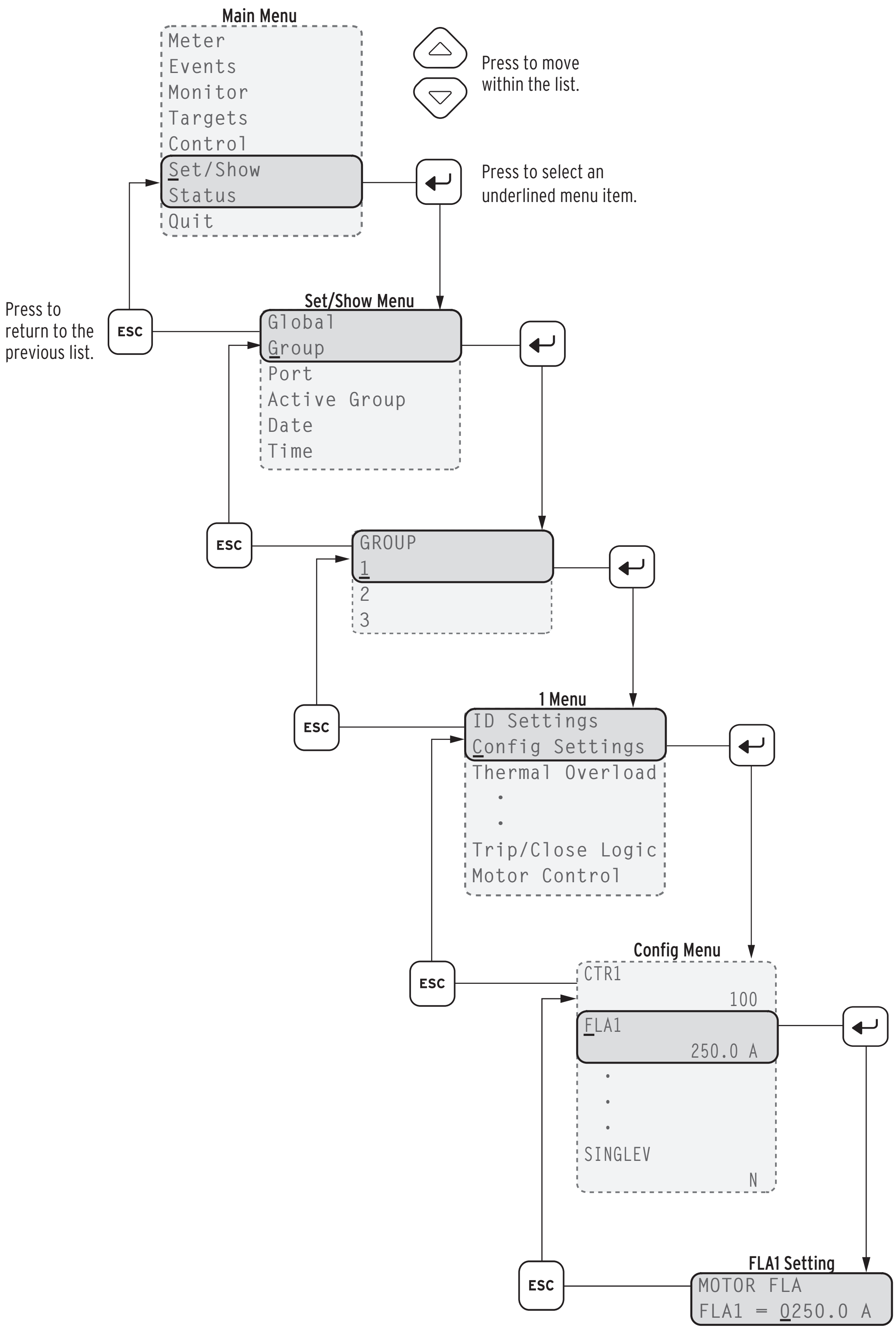


Figure 6.1 Front-Panel Setting Entry Example

View/Change Settings Over Communications Port

Refer to *Section 7: Communications* for information on how to set up and access the relay serial or Ethernet port with a personal computer and how to use ASCII commands to communicate with the relay.

View Settings

Use the **SHOW** command to view relay settings. The **SHOW** command is available from Access Level 1 and Access Level 2. *Table 6.2* lists the **SHOW** command options.

Table 6.2 SHOW Command Options

Command	Description
SHOW *n*	Show relay group settings: *n* specifies the settings group (1, 2, or 3); *n* defaults to active settings group if not listed.
SHO L *n*	Show logic settings: *n* specifies the settings group (1, 2, or 3); *n* defaults to active settings group if not listed.
SHO G	Show global configuration settings
SHO P *n*	Show serial port settings for PORT *n* (*n* = F, 1, 2, 3, or 4)
SHO F	Show front-panel display and LED settings
SHO R	Show Sequential Event Report (SER) and Event Report settings
SHO M	Show Modbus settings

You may append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 50P1P** displays the relay settings starting with setting **50P1P**). The default is the first setting. The **SHOW** command displays only the enabled settings.

Enter Settings

The **SET** command (available from Access Level 2) allows you to view or change settings. *Table 6.3* lists the **SET** command options.

NOTE: The **SET** command is not available as long as 90 seconds after the relay is powered up and as long as 40 seconds after a setting change. If you issue a **SET** command during this period, the relay responds with the following message:

```
Command Unavailable;
Relay Configuration in
Progress, Try Again.
```

Table 6.3 SET Command Options

Command	Settings Type	Description
SET *n*	Group	Protection elements, timers, etc., for settings group *n* (1, 2, or 3)
SET L *n*	Logic	SELOGIC control equations for settings group *n* (1, 2, or 3)
SET G	Global	Global configuration settings
SET P *n*	Port	Serial port settings for serial port *n* (1, 2, 3, 4, or F)
SET F	Front Panel	Front-panel display and LED settings
SET R	Reports	SER and Event Report settings
SET M	Modbus	Modbus user map

You may append a setting name to each of the commands to specify the first setting to display (e.g., **SET 50P1P** displays the relay settings starting with setting 50P1P). The default is the first setting.

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are listed in *Table 6.4*.

Table 6.4 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

The relay checks each entry to ensure that the entry is within the setting range. If it is not in range, an `Out of Range` message is generated, and the relay prompts you for the setting again.

When all the settings are entered, the relay displays the new settings and prompts you for approval to enable them. Press **Y <Enter>** to enable the new settings. The relay is disabled for as long as five seconds while it saves the new settings. The ALARM Relay Word bit is set momentarily, and the **ENABLED** LED extinguishes while the relay is disabled.

To change a specific setting, enter the command shown in *Table 6.5*.

Table 6.5 SET Command Format

SET n m s TERSE	
where:	
n	is left blank or is G, L, F, R, M, or P to identify the class of settings.
m	is left blank or is F, 1, 2, 3, or 4 when *n* = P.
m	is left blank or is 1, 2, or 3 when *n* = G or L for group or logic settings.
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 (*m* = 1 or 2, *n* = 1 or 2)	Phase Overcurrent and Main Settings	For phase input current rating of 5 A nominal, modify the 50P*m*P (or FLA*n*/CTR*n*) to satisfy 50P*m*P • (FLA*n*/CTR*n*) ≥ 0.5
50P*m*P • FLA*n*/CTR*n* must be greater than or equal to 0.10 Amp (*m* = 1 or 2, *n* = 1 or 2)	Phase Overcurrent and Main Settings	For phase input current rating of 1 A nominal, modify the 50P*m*P (or FLA*n*/CTR*n*) to satisfy 50P*m*P • (FLA*n*/CTR*n*) ≥ 0.1
50N*n*P must be within (0.050 • CTRN) xx.xx and (10.0 • CTRN) yy.yy (*n* = 1 or 2)	Neutral Overcurrent	For phase input current rating of 5 A nominal, modify the 50N*n*P (or CTR*n*) 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	For phase input current rating of 1 A, modify the 50N*n*P (or CTR*n*) setting to satisfy the requirement shown in the error message.
50N*n*P must be within (0.000125 • CTRN) xx.xx and (0.0125 • CTRN) yy.yy (*n* = 1 or 2)	Neutral Overcurrent	For phase input current rating of 2.5 mA nominal, modify the 50N*n*P (or CTR*n*) 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-710 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.

- ➤ 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.

Group Settings (SET Command)

Identifier

UNIT ID LINE 1 (16 Characters)	**RID**	:= ________________
UNIT ID LINE 2 (16 Characters)	**TID**	:= ________________

Configuration

PHASE CT RATIO (1–5000)	**CTR1**	:= ________________
MOTOR FLA (0.2–5000.0 A)	**FLA1**	:= ________________
TWO SPEED ENABLE (Y, N)	**E2SPEED**	:= ________________
CT RATIO-2nd (1–5000) *(Hidden if E2SPEED := N)*	**CTR2**	:= ________________
MOTOR FLA-2nd (0.2–5000.0 A) *(Hidden if E2SPEED := N)*	**FLA2**	:= ________________
FVR PHASING (None, A, B, C) *(Hidden if E2SPEED :=N)*	**FVR_PH**	:= ________________
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 (WYE, DELTA) *(Hidden if voltages not included)*	**DELTA_Y**	:= ________________
SINGLE V INPUT (Y, N) *(Hidden if voltages not included)*	**SINGLEV**	:= ________________

Thermal Overload

OVERLOAD ENABLE (Y, N) *(All of the following overload settings are hidden if E49MOTOR := N)*	**E49MOTOR**	:= ________________
FULL LOAD SLIP (OFF, 0.0010–0.1000 pu) *(Hidden and set to OFF if E2SPEED := Y, ESTAR_D := Y, or voltages not included)*	**FLS**	:= ________________
SLIP SOURCE (STAT, R1) *(Hidden if FLS := OFF; hidden and set to R1 if E2SPEED := Y or ESTAR_D := Y)*	**SLIPSRC**	:= ________________
LOCKD RTR TORQUE (0.30–2.00 pu) (*Hidden if FLS := OFF)*	**LRQ**	:= ________________

THERMAL METHOD (Rating, Rating_1, Curve) (*Hide Curve if 0.001*[*FLS*[*0.10)*	**SETMETH**	:= ______________
OL RESET LEVEL (10–99%TCU)	**49RSTP**	:= ______________
SERVICE FACTOR (1.01–1.50)	**SF**	:= ______________
MOTOR LRA (2.5–12.0 xFLA) (*Hidden and set to 6.0 if SETMETH := CURVE)*	**LRA1**	:= ______________
LOCKD RTR TIME 1 (1.0–600.0 s) (*Hidden if SETMETH := CURVE)*	**LRTHOT1**	:= ______________
ACCEL FACTOR (0.10–1.50) *(Hidden if SETMETH := CURVE or if 0.001* [*FLS* [*0.10)*	**TD1**	:= ______________
STATOR TC (Auto, 1–2000 min) *(Hidden if SETMETH := CURVE)*	**RTC1**	:= ______________
MOTOR LRA – 2nd (2.5–12.0 xFLA) *(Hidden and set to 6.0 if E2SPEED := N, or SETMETH := CURVE)*	**LRA2**	:= ______________
LOCKD RTR TIME 2 (1.0–600.0 s) *(Hidden if E2SPEED := N, or SETMETH := CURVE)*	**LRTHOT2**	:= ______________
ACCEL FACT – 2nd (0.10–1.50) (*Hidden if E2SPEED := N, or hidden and set to 1.00 if SETMETH := CURVE)*	**TD2**	:= ______________
STATOR TC – 2nd (Auto, 1–2000 min) (*Hidden if E2SPEED :=* N, or *SETMETH := CURVE.)*	**RTC2**	:= ______________
THERM OL CURVE1(1–46) *(Hidden if SETMETH := Rating or Rating_1)*	**CURVE1**	:= ______________
TRIP TIME@1.05FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45, SETMETH := Rating or Rating_1, or SF≥1.05)*	**TTT105**	:= ______________
TRIP TIME@1.10FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45, SETMETH := Rating or Rating_1, or SF≥1.10)*	**TTT110**	:= ______________
TRIP TIME@1.20FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45, SETMETH := Rating or Rating_1, or SF≥1.20)*	**TTT120**	:= ______________
TRIP TIME@1.30FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45, SETMETH := Rating or Rating_1, or SF≥1.30)*	**TTT130**	:= ______________
TRIP TIME@1.40FL (1.0–6000.0, AUTO) *Hidden if CURVE1 := 1–45, SETMETH := Rating or Rating_1, or SF≥1.40)*	**TTT140**	:= ______________
TRIP TIME@1.50FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45, SETMETH := Rating or Rating_1, or SF := 1.50)*	**TTT150**	:= ______________
TRIP TIME@1.75FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT175**	:= ______________
TRIP TIME@2.00FL (1.0–6000.0) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT200**	:= ______________
TRIP TIME@2.25FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT225**	:= ______________
TRIP TIME@2.50FL (1.0–6000.0) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT250**	:= ______________
TRIP TIME@2.75FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT275**	:= ______________
TRIP TIME@3.00FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT300**	:= ______________

TRIP TIME@3.50FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT350**	**:=** ________
TRIP TIME@4.00FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT400**	**:=** ________
TRIP TIME@4.50FL (1.0–6000.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT450**	**:=** ________
TRIP TIME@5.00FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT500**	**:=** ________
TRIP TIME@5.50FL (1.0–600.0) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT550**	**:=** ________
TRIP TIME@6.00FL (1.0–600.0) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT600**	**:=** ________
TRIP TIME@6.50FL (1.0–600.0) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT650**	**:=** ________
TRIP TIME@7.00FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT700**	**:=** ________
TRIP TIME@7.50FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT750**	**:=** ________
TRIP TIME@8.00FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT800**	**:=** ________
TRIP TIME@8.50FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT850**	**:=** ________
TRIP TIME@9.00FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT900**	**:=** ________
TRIP TIME@9.50FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT950**	**:=** ________
TRIP TIME@10.0FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT1000**	**:=** ________
TRIP TIME@11.0FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT1100**	**:=** ________
TRIP TIME@12.0FL (1.0–600.0, AUTO) *(Hidden if CURVE1 := 1–45 or SETMETH := Rating or Rating_1)*	**TTT1200**	**:=** ________
THERM OL CURVE2 (1–45) *(Hidden if SETMETH := Rating or Rating_1 or E2SPEED := N)*	**CURVE2**	**:=** ________
OL WARN LEVEL (OFF, 50–99%TCU)	**TCAPU**	**:=** ________
START INH. LEVEL (OFF, 1–99%TCU)	**TCSTART**	**:=** ________
LEARN TCSTART? (Y, N)	**TCLRNEN**	**:=** ________
STOP COOL TIME (1–6000 min)	**COOLTIME**	**:=** ________
STOP COAST TIME (1–3600 sec)	**COASTIME**	**:=** ________
LEARN COOLTIME? (Y, N) *(Hidden if E49RTD := NONE)*	**COOLEN**	**:=** ________
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 s) *(Hidden if 50P1P := OFF)*	**50P1D**	:= ____________
PH OC WARN LVL (OFF, 0.10–20.00 xFLA)	**50P2P**	:= ____________
PH OC WARN DLAY (0.00–5.00 s) *(Hidden if 50P2P := OFF)*	**50P2D**	:= ____________

Neutral Overcurrent

(Refer to *Table 6.6* for setting interdependency checks. Pickup settings below are in primary amperes.)

NEUT OC TRIP LVL (OFF, 0.01–25.00 A) *(Hidden if 1 or 5 Amp neutral input detected)*	**50N1P**	:= ____________
NEUT OC TRIP LVL (OFF, 0.01–650.00 A) *(Hidden if high sensitive 2.5 mA neutral input detected)*	**50N1P**	:= ____________
NEU OC TRIP DLAY (0.00–5.00 s) *(Hidden if 50N1P := OFF)*	**50N1D**	:= ____________
NEUT OC WARN LVL (OFF, 0.01–25.00 A) (*Hidden if 1 or 5 Amp neutral input detected)*	**50N2P**	:= ____________
NEUT OC WARN LVL (OFF, 0.01–650.00 A) *(Hidden if high sensitive 2.5 mA neutral input detected)*	**50N2P**	:= ____________
NEU OC WARN DLAY (0.0–120.0 s) *(Hidden if 50N2P := OFF)*	**50N2D**	:= ____________

Residual Overcurrent

RES OC TRIP LVL (OFF, 0.10–20.00 xFLA)	**50G1P**	:= ____________
RES OC TRIP DLAY (0.00–5.00 s) *(Hidden if 50G1P := OFF)*	**50G1D**	:= ____________
RES OC WARN LVL (OFF, 0.10–20.00 xFLA)	**50G2P**	:= ____________
RES OC WARN DLAY (0.0–120.0 s) *(Hidden if 50G2P := OFF)*	**50G2D**	:= ____________

Negative-Sequence Overcurrent

NSEQ OC TRIP LVL (OFF, 0.10–20.00 xFLA)	**50Q1P**	:= ____________
NSEQ OC TRIP DLY (0.1–120.0 s) *(Hidden if 50Q1P := OFF)*	**50Q1D**	:= ____________
NSEQ OC WARN LVL (OFF, 0.10–20.00 xFLA)	**50Q2P**	:= ____________
NSEQ OC WARN DLY (0.1–120.0 s) *(Hidden if 50Q2P := OFF)*	**50Q2D**	:= ____________

Phase Time Overcurrent

TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51AP**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51AP := OFF)*	**51AC**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51AP := OFF)*	**51ATD**	:= ____________
EM RESET DELAY (Y, N) *(Hidden if 51AP := OFF)*	**51ARS**	:= ____________

CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51AP := OFF)*	**51ACT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51AP := OFF)*	**51AMR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51AP := OFF)*	**51ATC**	:= ____________
TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51BP**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51BP := OFF)*	**51BC**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51BP := OFF)*	**51BTD**	:= ____________
EM RESET DELAY (Y, N) *(Hidden if 51BP := OFF)*	**51BRS**	:= ____________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51BP := OFF)*	**51BCT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51BP := OFF)*	**51BMR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51BP := OFF)*	**51BTC**	:= ____________
TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51CP**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51CP := OFF)*	**51CC**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51CP := OFF)*	**51CTD**	:= ____________
EM RESET DELAY (Y, N) *(Hidden if 51CP := OFF)*	**51CRS**	:= ____________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51CP := OFF)*	**51CCT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51CP := OFF)*	**51CMR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51CP := OFF)*	**51CTC**	:= ____________

Maximum Phase Time Overcurrent

TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51P1P**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51P1P := OFF)*	**51P1C**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51P1P := OFF)*	**51P1TD**	:= ____________
EM RESET DELAY (Y, N) *(Hidden if 51P1P := OFF)*	**51P1RS**	:= ____________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51P1P := OFF)*	**51P1CT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51P1P := OFF)*	**51P1MR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51P1P := OFF)*	**51P1TC**	:= ____________
TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51P2P**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51P2P := OFF)*	**51P2C**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51P2P := OFF)*	**51P2TD**	:= ____________

EM RESET DELAY (Y, N) *(Hidden if 51P2P := OFF)*	**51P2RS**	:= ____________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51P2P := OFF)*	**51P2CT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51P2P := OFF)*	**51P2MR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51P2P := OFF)*	**51P2TC**	:= ____________

Negative-Sequence Time Overcurrent

TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51QP**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51QP := OFF)*	**51QC**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51QP := OFF)*	**51QTD**	:= ____________
EM RESET DELAY (Y, N) *(Hidden if 51QP := OFF)*	**51QRS**	:= ____________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51QP := OFF)*	**51QCT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51QP := OFF)*	**51QMR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51QP := OFF)*	**51QTC**	:= ____________

Residual Time Overcurrent

TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51G1P**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51G1P := OFF)*	**51G1C**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51G1P := OFF)*	**51G1TD**	:= ____________
EM RESET DELAY (Y, N) *(Hidden if 51G1P := OFF)*	**51G1RS**	:= ____________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51G1P := OFF)*	**51G1CT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51G1P := OFF)*	**51G1MR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51G1P := OFF)*	**51G1TC**	:= ____________
TOC TRIP LVL (OFF, 0.50–10.00 A {5 A nom.}, 0.10–2.00 A {1 A nom.})	**51G2P**	:= ____________
TOC CURVE SEL (U1, U2, U3, U4, U5, C1, C2, C3, C4, C5) *(Hidden if 51G2P := OFF)*	**51G2C**	:= ____________
TOC TIME DIAL (0.50–15.00 {if 51_C := U_}, 0.05–1.00 {if 51_C := C_}) *(Hidden if 51G2P := OFF)*	**51G2TD**	:= ____________
EM RESET DELAY (Y, N) *(Hidden if 51G2P := OFF)*	**51G2RS**	:= ____________
CONST TIME ADDER (0.00–1.00 s) *(Hidden if 51G2P := OFF)*	**51G2CT**	:= ____________
MIN RESPONSE TIM (0.00–1.00 s) *(Hidden if 51G2P := OFF)*	**51G2MR**	:= ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden if 51G2P := OFF)*	**51G2TC**	:= ____________

Motor Differential Overcurrent

DIFF ENABLE (Y, N)	**E87M**	:=
DIFF CT RATIO (1–5000) (*Hidden if E87M := N*)	**CTR87M**	:=
DIFF 1 TRIP LVL (OFF, 0.05–8.00 A s) (*Hidden if E87M := N*)	**87M1P**	:=
DIFF 1 TRIP DLY (0.00–60.00 s) (*Hidden if 87M1P := Off*)	**87M1TD**	:=
DIFF 1 TRQ CON (SELOGIC) (*Hidden if 87M1P := Off*)	**87M1TC**	:=
DIFF 2 TRIP LVL (OFF, 0.05–8.00 A s) (*Hidden if E87M := N*)	**87M2P**	:=
DIFF 2 TRIP DLY (0.00–60.00 s) (*Hidden if 87M2P := Off*)	**87M2TD**	:=
DIFF 2 TRQ CON (SELOGIC) (*Hidden if 87M2P := Off*)	**87M2TC**	:=

Jam

JAM TRIP LEVEL (OFF, 1.00–6.00 xFLA)	**LJTPU**	**:=**
JAM TRIP DELAY (0.0–120.0 s) *(Hidden if LJTPU := OFF)*	**LJTDLY**	**:=**
JAM WARN LEVEL (OFF, 1.00–6.00 xFLA)	**LJAPU**	**:=**
JAM WARN DELAY (0.0–120.0 s) *(Hidden if LJAPU := OFF)*	**LJADLY**	**:=**

Undercurrent

UC TRIP LEVEL (OFF, 0.10–1.00 xFLA)	**LLTPU**	**:=**
UC TRIP DELAY (0.4–120.0 s) *(Hidden if LLTPU := OFF)*	**LLTDLY**	**:=**
UC WARN LEVEL (OFF, 0.10–1.00 xFLA)	**LLAPU**	**:=**
UC WARN DELAY (0.4–120.0 s) *(Hidden if LLAPU := OFF)*	**LLADLY**	**:=**
UC START DELAY (0–5000 s) *(Hidden if both LLTPU and LLAPU := OFF)*	**LLSDLY**	**:=**

Current Unbalance

CI TRIP LEVEL (OFF, 5–80%)	**46UBT**	**:=**
CI TRIP DELAY (0–240 s) *(Hidden if 46UBT := OFF)*	**46UBTD**	**:=**
CI WARN LEVEL (OFF, 5–80%)	**46UBA**	**:=**
CI WARN DELAY (0–240 s) *(Hidden if 46UBA := OFF)*	**46UBAD**	**:=**

Start Monitoring

START MOTOR TIME (OFF, 1–240 s)	**START_T**	**:=**

Star-Delta

STAR-DELTA ENABL (Y, N)	**ESTAR_D**	**:=**
MAX STAR TIME (OFF, 1–600 s) *(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, 1–1500 min)	**ABSDLY**	:= ____________

Phase Reversal

PH REV. ENABLE (Y, N)	**E47T**	:= ____________

Speed Switch

SS TRIP DELAY (OFF, 1–240 s)	**SPDSDLYT**	:= ____________
SS WARN DELAY (OFF, 1–240 s)	**SPDSDLYA**	:= ____________

PTC

PTC ENABLE (Y, N) *(Hidden if PTC option not included)*	**EPTC**	:= ____________

RTD

RTD ENABLE (INT, EXT, NONE) *(All RTD settings below hidden if E49RTD := NONE)*	**E49RTD**	:= ____________
RTD1 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD1LOC**	:= ____________
RTD1 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD1LOC := OFF)*	**RTD1TY**	:= ____________
RTD1 TRIP LEVEL (OFF,1–250°C) *(Hidden if RTD1LOC := OFF)*	**TRTMP1**	:= ____________
RTD1 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD1LOC := OFF)*	**ALTMP1**	:= ____________
RTD2 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD2LOC**	:= ____________
RTD2 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD2LOC := OFF)*	**RTD2TY**	:= ____________
RTD2 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD2LOC := OFF)*	**TRTMP2**	:= ____________
RTD2 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD2LOC := OFF)*	**ALTMP2**	:= ____________
RTD3 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD3LOC**	:= ____________
RTD3 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD3LOC := OFF)*	**RTD3TY**	:= ____________
RTD3 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD3LOC := OFF)*	**TRTMP3**	:= ____________
RTD3 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD3LOC := OFF)*	**ALTMP3**	:= ____________
RTD4 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD4LOC**	:= ____________

RTD4 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD4LOC := OFF)*	**RTD4TY**	:= ______________
RTD4 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD4LOC := OFF)*	**TRTMP4**	:= ______________
RTD4 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD4LOC := OFF)*	**ALTMP4**	:= ______________
RTD5 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD5LOC**	:= ______________
RTD5 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD5LOC := OFF)*	**RTD5TY**	:= ______________
RTD5 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD5LOC := OFF)*	**TRTMP5**	:= ______________
RTD5 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD5LOC := OFF)*	**ALTMP5**	:= ______________
RTD6 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD6LOC**	:= ______________
RTD6 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD6LOC := OFF)*	**RTD6TY**	:= ______________
RTD6 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD6LOC := OFF)*	**TRTMP6**	:= ______________
RTD6 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD6LOC := OFF)*	**ALTMP6**	:= ______________
RTD7 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD7LOC**	:= ______________
RTD7 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD7LOC := OFF)*	**RTD7TY**	:= ______________
RTD7 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD7LOC := OFF)*	**TRTMP7**	:= ______________
RTD7 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD7LOC := OFF)*	**ALTMP7**	:= ______________
RTD8 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD8LOC**	:= ______________
RTD8 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD8LOC := OFF)*	**RTD8TY**	:= ______________
RTD8 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD8LOC := OFF)*	**TRTMP8**	:= ______________
RTD8 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD8LOC := OFF)*	**ALTMP8**	:= ______________
RTD9 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD9LOC**	:= ______________
RTD9 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD9LOC := OFF)*	**RTD9TY**	:= ______________
RTD9 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD9LOC := OFF)*	**TRTMP9**	:= ______________
RTD9 WARN LEVEL (OFF, 1–250°C) (*Hidden if RTD9LOC := OFF)*	**ALTMP9**	:= ______________
RTD10 LOCATION (OFF, WDG, BRG, AMB, OTH)	**RTD10LOC**	:= ______________
RTD10 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD10LOC := OFF)*	**RTD10TY**	:= ______________

RTD10 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD10LOC := OFF)*	**TRTMP10**	:= ______
RTD10 WARN LEVEL (OFF, 1–250°C) (*Hidden if RTD10LOC := OFF)*	**ALTMP10**	:= ______
RTD11 LOCATION (OFF, WDG, BRG, AMB, OTH) *(Hidden if E49RTD := INT)*	**RTD11LOC**	:= ______
RTD11 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD11LOC := OFF or E49RTD := INT)*	**RTD11TY**	:= ______
RTD11 TRIP LEVE (OFF, 1–250°C) *(Hidden if RTD11LOC := OFF or E49RTD := INT)*	**TRTMP11**	:= ______
RTD11 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD11LOC := OFF or E49RTD := INT)*	**ALTMP11**	:= ______
RTD12 LOCATION (OFF, WDG, BRG, AMB, OTH) *(Hidden if E49RTD := INT)*	**RTD12LOC**	:= ______
RTD12 TYPE (PT100, NI100, NI120, CU10) *(Hidden if RTD12LOC := OFF or E49RTD := INT)*	**RTD12TY**	:= ______
RTD12 TRIP LEVEL (OFF, 1–250°C) *(Hidden if RTD12LOC := OFF or E49RTD := INT)*	**TRTMP12**	:= ______
RTD12 WARN LEVEL (OFF, 1–250°C) *(Hidden if RTD12LOC := OFF or E49RTD := INT)*	**ALTMP12**	:= ______
WIND TRIP VOTING (Y, N) *(Hidden if less than 2 locations are WDG)*	**EWDGV**	:= ______
BEAR TRIP VOTING (Y, N) *(Hidden if less than 2 locations are BRG)*	**EBRGV**	:= ______
TMP RTD BIASING? (Y, N) *(Hidden if no RTDnLOC := AMB or if all winding RTD trip temperatures are OFF)*	**ERTDBIAS**	:= ______

Undervoltage

UV TRIP LEVEL (OFF, 0.02–1.00 xVnm)	**27P1P**	:= ______
UV TRIP DELAY (0.0–120.0 s) *(Hidden if 27P1P := OFF)*	**27P1D**	:= ______
UV WARN LEVEL (OFF, 0.02–1.00 xVnm)	**27P2P**	:= ______
UV WARN DELAY (0.0–120.0 s) *(Hidden if 27P2P := OFF)*	**27P2D**	:= ______

Overvoltage

OV TRIP LEVEL (OFF, 0.02–1.20 xVnm)	**59P1P**	:= ______
OV TRIP DELAY (0.0–120.0 s) *(Hidden if 59P1P := OFF)*	**59P1D**	:= ______
OV WARN LEVEL (OFF, 0.02–1.20 xVnm)	**59P2P**	:= ______
OV WARN DELAY (0.0–120.0 s) *(Hidden if 59P2P := OFF)*	**59P2D**	:= ______

VAR

NEG VAR TRIP LEV (OFF, 1–25000 kVAR)	**NVARTP**	:= ______
POS VAR TRIP LEV (OFF, 1–25000 kVAR)	**PVARTP**	:= ______

VAR TRIP DELAY (1–240 s) *(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 (1–240 s) *(Hidden if both NVARAP and PVARAP := OFF)*	**VARAD**	:=
VAR ARMING DELAY (0–5000 s) *(Hidden if all NVARTP, PVARTP, NVARAP, and PVARAP := OFF)*	**VARDLY**	:=

Underpower

UP TRIP LEVEL (OFF, 1–25000 kW)	**37PTP**	:=
UP TRIP DELAY (1–240 s) *(Hidden if 37PTP := OFF)*	**37PTD**	:=
UP WARN LEVEL (OFF, 1–25000 kW)	**37PAP**	:=
UP WARN DELAY (1–240 s) *(Hidden if 37PAP := OFF)*	**37PAD**	:=
UP ARMING DELAY (0–5000 s) *(Hidden if both 37PTP and 37PAP are := OFF)*	**37DLY**	:=

Power Factor

PF LAG TRIP LEVL (OFF, 0.05–0.99)	**55LGTP**	:=
PF LD TRIP LEVEL (OFF, 0.05–0.99)	**55LDTP**	:=
PF TRIP DELAY (1–240 s) *(Hidden if both 55LDTP and 55LGTP := OFF)*	**55TD**	:=
PF LAG WARN LEVL (OFF, 0.05–0.99)	**55LGAP**	:=
PF LD WARN LEVEL (OFF, 0.05–0.99)	**55LDAP**	:=
PF WARN DELAY (1–240 s) *(Hidden if both 55LDAP and 55LGAP := OFF)*	**55AD**	:=
PF ARMING DELAY (0–5000 s) *(Hidden if all 55LGTP, 55LDTP, 55LGAP, and 55LDAP := OFF)*	**55DLY**	:=

Frequency

FREQ1 TRIP LEVEL (OFF, 20.0–70.0 Hz)	**81D1TP**	:=
FREQ1 TRIP DELAY (0.0–240.0 s) *(Hidden if 81D1TP := OFF)*	**81D1TD**	:=
FREQ2 TRIP LEVEL (OFF, 20.0–70.0 Hz)	**81D2TP**	:=
FREQ2 TRIP DELAY (0.0–240.0 s) *(Hidden if 81D2TP := OFF)*	**81D2TD**	:=
FREQ3 TRIP LEVEL (OFF, 20.0–70.0 Hz)	**81D3TP**	:=
FREQ3 TRIP DELAY (0.0–240.0 s) *(Hidden if 81D3TP := OFF)*	**81D3TD**	:=
FREQ4 TRIP LEVEL (OFF, 20.0–70.0 Hz)	**81D4TP**	:=
FREQ4 TRIP DELAY (0.0–240.0 s) (*Hidden if 81D4TP := OFF)*	**81D4TD**	:=

Load Control

LOAD CONTROL SEL (OFF, CURRENT, POWER, TCU) *(If LOAD is OFF, hide the rest of the settings)*	**LOAD**	:=
LD CTL CUR UPPER (OFF, 0.20–2.00 xFLA) *(If LOAD := CURRENT, otherwise hidden)*	**LOADUPP**	:=
LD CTL CUR LOWER (OFF, 0.20–2.00 xFLA) *(If LOAD := CURRENT, otherwise hidden)*	**LOADLOWP**	:=
LD CTL PWR UPPER (OFF, 1–25000 kW) *(If LOAD := POWER, otherwise hidden)*	**LOADUPP**	:=
LD CTL PWR LOWER (OFF, 1–25000 kW) *(If LOAD := POWER, otherwise hidden)*	**LOADLOWP**	:=
LD CTL TCU UPPER (OFF, 1–99%TCU) *(If LOAD := TCU, otherwise hidden)*	**LOADUPP**	:=
LD CTL TCU LOWER (OFF, 1–99%TCU) *(If LOAD := TCU, otherwise hidden)*	**LOADLOWP**	:=

Trip Inhibit

BLOCK PROTECTION (SELOGIC)

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 s)	**TDURD**	:=

TRIP EQUATION (SELOGIC)

TR :=

REMOTE TRIP EQN (SELOGIC)	**REMTRIP**	:=
UNLATCH TRIP EQN (SELOGIC)	**ULTRIP**	:=
CONTACTOR STATUS (SELOGIC)	**52A**	:=

Motor Control

START EQUATION (SELOGIC)	**STREQ**	:=
EMERGENCY START (SELOGIC)	**EMRSTR**	:=

SPEED 2 (SELOGIC)	**SPEED2**	:= ________________
SPEED SWITCH (SELOGIC)	**SPEEDSW**	:= ________________

Logic Settings (SET L Command)

SELOGIC Enables

SELOGIC LATCHES (N, 1–32)	**ELAT**	:= ________________
SV/TIMERS (N, 1–32)	**ESV**	:= ________________
SELOGIC COUNTERS (N, 1–32)	**ESC**	:= ________________
MATH VARIABLES (N, 1–32)	**EMV**	:= ________________

Latch Bits Equations

SET01	:= ________________
RST01	:= ________________
SET02	:= ________________
RST02	:= ________________
SET03	:= ________________
RST03	:= ________________
SET04	:= ________________
RST04	:= ________________
SET05	:= ________________
RST05	:= ________________
SET06	:= ________________
RST06	:= ________________
SET07	:= ________________
RST07	:= ________________
SET08	:= ________________
RST08	:= ________________
SET09	:= ________________
RST09	:= ________________
SET10	:= ________________
RST10	:= ________________
SET11	:= ________________
RST11	:= ________________
SET12	:= ________________
RST12	:= ________________
SET13	:= ________________
RST13	:= ________________

SET14 := ____________________
RST14 := ____________________
SET15 := ____________________
RST15 := ____________________
SET16 := ____________________
RST16 := ____________________
SET17 := ____________________
RST17 := ____________________
SET18 := ____________________
RST18 := ____________________
SET19 := ____________________
RST19 := ____________________
SET20 := ____________________
RST20 := ____________________
SET21 := ____________________
RST21 := ____________________
SET22 := ____________________
RST22 := ____________________
SET23 := ____________________
RST23 := ____________________
SET24 := ____________________
RST24 := ____________________
SET25 := ____________________
RST25 := ____________________
SET26 := ____________________
RST26 := ____________________
SET27 := ____________________
RST27 := ____________________
SET28 := ____________________
RST28 := ____________________
SET29 := ____________________
RST29 := ____________________
SET30 := ____________________
RST30 := ____________________
SET31 := ____________________
RST31 := ____________________
SET32 := ____________________
RST32 := ____________________

SELogic Variable Timers

SV TIMER PICKUP (0.00–3000.00 s)	**SV01PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV01DO**	:= ______________
SV INPUT (SELogic)	**SV01**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV02PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV02DO**	:= ______________
SV INPUT (SELogic)	**SV02**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV03PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV03DO**	:= ______________
SV INPUT (SELogic)	**SV03**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV04PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV04DO**	:= ______________
SV INPUT (SELogic)	**SV04**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV05PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV05DO**	:= ______________
SV INPUT (SELogic)	**SV05**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV06PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV06DO**	:= ______________
SV INPUT (SELogic)	**SV06**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV07PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV07DO**	:= ______________
SV INPUT (SELogic)	**SV07**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV08PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV08DO**	:= ______________
SV INPUT (SELogic)	**SV08**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV09PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV09DO**	:= ______________
SV INPUT (SELogic)	**SV09**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV10PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV10DO**	:= ______________
SV INPUT (SELogic)	**SV10**	:= ______________
SV TIMER PICKUP (0.00–3000.00 s)	**SV11PU**	:= ______________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV11DO**	:= ______________
SV INPUT (SELogic)	**SV11**	:= ______________

SV TIMER PICKUP (0.00–3000.00 s)	**SV12PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV12DO**	:= ________________
SV INPUT (SELOGIC)	**SV12**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV13PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV13DO**	:= ________________
SV INPUT (SELOGIC)	**SV13**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV14PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV14DO**	:= ________________
SV INPUT (SELOGIC)	**SV14**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV15PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV15DO**	:= ________________
SV INPUT (SELOGIC)	**SV15**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV16PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV16DO**	:= ________________
SV INPUT (SELOGIC)	**SV16**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV17PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV17DO**	:= ________________
SV INPUT (SELOGIC)	**SV17**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV18PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV18DO**	:= ________________
SV INPUT (SELOGIC)	**SV18**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV19PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV19DO**	:= ________________
SV INPUT (SELOGIC)	**SV19**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV20PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV20DO**	:= ________________
SV INPUT (SELOGIC)	**SV20**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV21PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV21DO**	:= ________________
SV INPUT (SELOGIC)	**SV21**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV22PU**	:= ________________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV22DO**	:= ________________
SV INPUT (SELOGIC)	**SV22**	:= ________________
SV TIMER PICKUP (0.00–3000.00 s)	**SV23PU**	:= ________________

SV TIMER DROPOUT (0.00–3000.00 s)	**SV23DO**	:= ________
SV INPUT (SELOGIC)	**SV23**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV24PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV24DO**	:= ________
SV INPUT (SELOGIC)	**SV24**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV25PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV25DO**	:= ________
SV INPUT (SELOGIC)	**SV25**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV26PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV26DO**	:= ________
SV INPUT (SELOGIC)	**SV26**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV27PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV27DO**	:= ________
SV INPUT (SELOGIC)	**SV27**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV28PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV28DO**	:= ________
SV INPUT (SELOGIC)	**SV28**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV29PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV29DO**	:= ________
SV INPUT (SELOGIC)	**SV29**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV30PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV30DO**	:= ________
SV INPUT (SELOGIC)	**SV30**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV31PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV31DO**	:= ________
SV INPU (SELOGIC)	**SV31**	:= ________
SV TIMER PICKUP (0.00–3000.00 s)	**SV32PU**	:= ________
SV TIMER DROPOUT (0.00–3000.00 s)	**SV32DO**	:= ________
SV INPUT (SELOGIC)	**SV32**	:= ________

Counters

SC PRESET VALUE (1–65000)	**SC01PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC01R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC01LD**	:= ________

SC CNT UP INPUT (SELOGIC)	**SC01CU**	:= ______
SC CNT DN INPUT (SELOGIC)	**SC01CD**	:= ______
SC PRESET VALUE (1–65000)	**SC02PV**	:= ______
SC RESET INPUT (SELOGIC)	**SC02R**	:= ______
SC LOAD PV INPUT (SELOGIC)	**SC02LD**	:= ______
SC CNT UP INPUT (SELOGIC)	**SC02CU**	:= ______
SC CNT DN INPUT (SELOGIC)	**SC02CD**	:= ______
SC PRESET VALUE (1–65000)	**SC03PV**	:= ______
SC RESET INPUT (SELOGIC)	**SC03R**	:= ______
SC LOAD PV INPUT (SELOGIC)	**SC03LD**	:= ______
SC CNT UP INPUT (SELOGIC)	**SC03CU**	:= ______
SC CNT DN INPUT (SELOGIC)	**SC03CD**	:= ______
SC PRESET VALUE (1–65000)	**SC04PV**	:= ______
SC RESET INPUT (SELOGIC)	**SC04R**	:= ______
SC LOAD PV INPUT (SELOGIC)	**SC04LD**	:= ______
SC CNT UP INPUT (SELOGIC)	**SC04CU**	:= ______
SC CNT DN INPUT (SELOGIC)	**SC04CD**	:= ______
SC PRESET VALUE (1–65000)	**SC05PV**	:= ______
SC RESET INPUT (SELOGIC)	**SC05R**	:= ______
SC LOAD PV INPUT (SELOGIC)	**SC05LD**	:= ______
SC CNT UP INPUT (SELOGIC)	**SC05CU**	:= ______
SC CNT DN INPUT (SELOGIC)	**SC05CD**	:= ______
SC PRESET VALUE (1–65000)	**SC06PV**	:= ______
SC RESET INPUT (SELOGIC)	**SC06R**	:= ______
SC LOAD PV INPUT (SELOGIC)	**SC06LD**	:= ______
SC CNT UP INPUT (SELOGIC)	**SC06CU**	:= ______
SC CNT DN INPUT (SELOGIC)	**SC06CD**	:= ______
SC PRESET VALUE (1–65000)	**SC07PV**	:= ______
SC RESET INPUT (SELOGIC)	**SC07R**	:= ______
SC LOAD PV INPUT (SELOGIC)	**SC07LD**	:= ______
SC CNT UP INPUT (SELOGIC)	**SC07CU**	:= ______
SC CNT DN INPUT (SELOGIC)	**SC07CD**	:= ______
SC PRESET VALUE (1–65000)	**SC08PV**	:= ______
SC RESET INPUT (SELOGIC)	**SC08R**	:= ______

SC LOAD PV INPUT (SELOGIC)	**SC08LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC08CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC08CD**	:= ________
SC PRESET VALUE (1–65000)	**SC09PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC09R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC09LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC09CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC09CD**	:= ________
SC PRESET VALUE (1–65000)	**SC10PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC10R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC10LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC10CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC10CD**	:= ________
SC PRESET VALUE (1–65000)	**SC11PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC11R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC11LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC11CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC11CD**	:= ________
SC PRESET VALUE (1–65000)	**SC12PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC12R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC12LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC12CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC12CD**	:= ________
SC PRESET VALUE (1–65000)	**SC13PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC13R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC13LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC13CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC13CD**	:= ________
SC PRESET VALUE (1–65000)	**SC14PV**	:= ________
SC RESET INPUT (SELOGIC)	**SC14R**	:= ________
SC LOAD PV INPUT (SELOGIC)	**SC14LD**	:= ________
SC CNT UP INPUT (SELOGIC)	**SC14CU**	:= ________
SC CNT DN INPUT (SELOGIC)	**SC14CD**	:= ________
SC PRESET VALUE (1–65000)	**SC15PV**	:= ________

SC RESET INPUT (SELOGIC)	**SC15R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC15LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC15CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC15CD**	:=
SC PRESET VALUE (1–65000)	**SC16PV**	:=
SC RESET INPUT (SELOGIC)	**SC16R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC16LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC16CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC16CD**	:=
SC PRESET VALUE (1–65000)	**SC17PV**	:=
SC RESET INPUT (SELOGIC)	**SC17R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC17LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC17CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC17CD**	:=
SC PRESET VALUE (1–65000)	**SC18PV**	:=
SC RESET INPUT (SELOGIC)	**SC18R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC18LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC18CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC18CD**	:=
SC PRESET VALUE (1–65000)	**SC19PV**	:=
SC RESET INPUT (SELOGIC)	**SC19R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC19LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC19CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC19CD**	:=
SC PRESET VALUE (1–65000)	**SC20PV**	:=
SC RESET INPUT (SELOGIC)	**SC20R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC20LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC20CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC20CD**	:=
SC PRESET VALUE (1–65000)	**SC21PV**	:=
SC RESET INPUT (SELOGIC)	**SC21R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC21LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC21CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC21CD**	:=

SC PRESET VALUE (1–65000)	**SC22PV**	:=
SC RESET INPUT (SELOGIC)	**SC22R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC22LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC22CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC22CD**	:=
SC PRESET VALUE (1–65000)	**SC23PV**	:=
SC RESET INPUT (SELOGIC)	**SC23R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC23LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC23CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC23CD**	:=
SC PRESET VALUE (1–65000)	**SC24PV**	:=
SC RESET INPUT (SELOGIC)	**SC24R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC24LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC24CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC24CD**	:=
SC PRESET VALUE (1–65000)	**SC25PV**	:=
SC RESET INPUT (SELOGIC)	**SC25R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC25LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC25CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC25CD**	:=
SC PRESET VALUE (1–65000)	**SC26PV**	:=
SC RESET INPUT (SELOGIC)	**SC26R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC26LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC26CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC26CD**	:=
SC PRESET VALUE (1–65000)	**SC27PV**	:=
SC RESET INPUT (SELOGIC)	**SC27R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC27LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC27CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC27CD**	:=
SC PRESET VALUE (1–65000)	**SC28PV**	:=
SC RESET INPUT (SELOGIC)	**SC28R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC28LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC28CU**	:=

SC CNT DN INPUT (SELOGIC)	**SC28CD**	:=
SC PRESET VALUE (1–65000)	**SC29PV**	:=
SC RESET INPUT (SELOGIC)	**SC29R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC29LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC29CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC29CD**	:=
SC PRESET VALUE (1–65000)	**SC30PV**	:=
SC RESET INPUT (SELOGIC)	**SC30R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC30LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC30CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC30CD**	:=
SC PRESET VALUE (1–65000)	**SC31PV**	:=
SC RESET INPUT (SELOGIC)	**SC31R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC31LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC31CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC31CD**	:=
SC PRESET VALUE (1–65000)	**SC32PV**	:=
SC RESET INPUT (SELOGIC)	**SC32R**	:=
SC LOAD PV INPUT (SELOGIC)	**SC32LD**	:=
SC CNT UP INPUT (SELOGIC)	**SC32CU**	:=
SC CNT DN INPUT (SELOGIC)	**SC32CD**	:=

Math Variables

MV01	:=
MV02	:=
MV03	:=
MV04	:=
MV05	:=
MV06	:=
MV07	:=
MV08	:=
MV09	:=
MV10	:=
MV11	:=
MV12	:=
MV13	:=

MV14 := ____________________

MV15 := ____________________

MV16 := ____________________

MV17 := ____________________

MV18 := ____________________

MV19 := ____________________

MV20 := ____________________

MV21 := ____________________

MV22 := ____________________

MV23 := ____________________

MV24 := ____________________

MV25 := ____________________

MV26 := ____________________

MV27 := ____________________

MV28 := ____________________

MV29 := ____________________

MV30 := ____________________

MV31 := ____________________

MV32 := ____________________

Base Output

OUT101 FAIL-SAFE (Y, N) **OUT101FS** := ____________

OUT101 := ____________________

OUT102 FAIL-SAFE (Y, N) **OUT102FS** := ____________

OUT102 := ____________________

OUT103 FAIL-SAFE (Y, N) **OUT103FS** := ____________

OUT103 := ____________________

Slot C Output

OUT301 FAIL-SAFE (Y, N) **OUT301FS** := ____________

OUT301 := ____________________

OUT302 FAIL-SAFE (Y, N) **OUT302FS** := ____________

OUT302 := ____________________

OUT303 FAIL-SAFE (Y, N) **OUT303FS** := ____________

OUT303 := ____________________

OUT303 FAIL-SAFE (Y, N) **OUT304FS** := ____________

OUT304 := ____________________

Slot D Output

OUT401 FAIL-SAFE (Y, N) **OUT401FS** := ____________

OUT401 := ____________

OUT402 FAIL-SAFE (Y, N) **OUT402FS** := ____________

OUT402 := ____________

OUT403 FAIL-SAFE (Y, N) **OUT403FS** := ____________

OUT403 := ____________

OUT404 FAIL-SAFE (Y, N) **OUT404FS** := ____________

OUT404 := ____________

Slot E Output

OUT501 FAIL-SAFE (Y, N) **OUT501FS** := ____________

OUT501 := ____________

OUT502 FAIL-SAFE (Y, N) **OUT502FS** := ____________

OUT502 := ____________

OUT503 FAIL-SAFE (Y, N) **OUT503FS** := ____________

OUT503 := ____________

OUT505 FAIL-SAFE (Y, N) **OUT504FS** := ____________

OUT504 := ____________

MIRRORED BITS Transmit SELOGIC Equations

(Hidden if PROTO is not MBxx on any of the communications ports)

TMB1A := ____________

TMB2A := ____________

TMB3A := ____________

TMB4A := ____________

TMB5A := ____________

TMB6A := ____________

TMB7A := ____________

TMB8A := ____________

TMB1B := ____________

TMB2B := ____________

TMB3B := ____________

TMB4B := ____________

TMB5B := ____________

TMB6B := ____________

TMB7B := ____________

TMB8B := ____________

Global Settings (SET G Command)

General

APPLICATION (FULL, NAMEPLATE)	**APP** := ______________
PHASE ROTATION (ABC, ACB)	**PHROT** := ______________
RATED FREQ. (50, 60 Hz)	**FNOM** := ______________
DATE FORMAT (MDY, YMD, DMY)	**DATE_F** := ______________
FAULT CONDITION (SELOGIC)	**FAULT** := ______________

Group Selection

GRP CHG DELAY (0–400 s)	**TGR** := ______________
SELECT GROUP1 (SELOGIC)	**SS1** := ______________
SELECT GROUP2 (SELOGIC)	**SS2** := ______________
SELECT GROUP3 (SELOGIC)	**SS3** := ______________

Time and Date Management

CTRL BITS DEFN (NONE, C37.118) (*Hidden if relay has the PTC option*)	**IRIGC** := ______________
OFFSET FROM UTC (–24.00 to 24.00) rounded up to quarter	**UTC_OFF** := ______________
MONTH TO BEGIN DST (OFF, 1–12)	**DST_BEGM** := ______________
WEEK OF THE MONTH TO BEGIN DST (1–3, L) L = Last week of the month (*Hidden if DST_BEGM := OFF*)	**DST_BEGW** := ______________
DAY OF THE WEEK TO BEGIN DST (SUN, MON, TUE, WED, THU, FRI, SAT) (*Hidden if DST_BEGM := OFF*)	**DST_BEGD** := ______________
LOCAL HOUR TO BEGIN DST (0–23) (*Hidden if DST_BEGM := OFF*)	**DST_BEGH** := ______________
MONTH TO END DST (1–12) (*Hidden if DST_BEGM := OFF*)	**DST_ENDM** := ______________
WEEK OF THE MONTH TO END DST (1–3, L) L = Last week of the month (*Hidden if DST_BEGM := OFF*)	**DST_ENDW** := ______________
DAY OF THE WEEK TO END DST (SUN, MON, TUE, WED, THU, FRI, SAT) (*Hidden if DST_BEGM := OFF*)	**DST_ENDD** := ______________
LOCAL HOUR TO END DST (0–23) (*Hidden if DST_BEGM := OFF*)	**DST_ENDH** := ______________

Breaker Failure

52A INTERLOCK (Y, N)	**52ABF** := ______________
BK FAILURE DELAY (0.00–2.00 s)	**BFD** := ______________
BK FAIL INITIATE (SELOGIC)	**BFI** := ______________

For the following settings, *x* is the card position (3, 4, or 5 in Slot C, D, and E, respectively).

AI*x*01

AI*x*01 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*01NAM**	:= __________
AI*x*01 TYPE (I, V)	**AI*x*01TYP**	:= __________
If AI*x*01TYP = I		
AI*x*01 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*01L**	:= __________
AI*x*01 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*01H**	:= __________
If AI*x*01TYP = V		
AI*x*01 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*01L**	:= __________
AI*x*01 HI IN VAL (–10.240 to +10.240 V)	**AI*x*01H**	:= __________

Note: Set Warn and Alarm to a value between Engr Low and Engr High settings.

AI*x*01 ENG UNITS (16 characters)	**AI*x*01EU**	:= __________
AI*x*01 EU LOW (–99999.000 to +99999.000)	**AI*x*01EL**	:= __________
AI*x*01 EU HI (–99999.000 to +99999.000)	**AI*x*01EH**	:= __________
AI*x*01 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01LW1**	:= __________
AI*x*01 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*01LW2**	:= __________
AI*x*01 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01LAL**	:= __________
AI*x*01 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*01HW1**	:= __________
AI*x*01 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*01HW2**	:= __________
AI*x*01 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*01HAL**	:= __________

AI*x*02

AI*x*02 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*02NAM**	:= __________
AI*x*02 TYPE (I, V)	**AIx02TYP**	:= __________
If AI*x*02TYP = I		
AI*x*02 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*02L**	:= __________
AI*x*02 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*02H**	:= __________
If AI*x*02TYP = V		
AI*x*02 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*02L**	:= __________
AI*x*02 HI IN VAL (–10.240 to +10.240 V)	**AI*x*02H**	:= __________
AI*x*02 ENG UNITS (16 characters)	**AI*x*02EU**	:= __________
AI*x*02 EU LOW (–99999.000 to +99999.000)	**AI*x*02EL**	:= __________
AI*x*02 EU HI (–99999.000 to +99999.000)	**AI*x*02EH**	:= __________
AI*x*02 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*02LW1**	:= __________
AI*x*02 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*02LW2**	:= __________

AI*x*02 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*02LAL**	:= ______________
AI*x*02 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*02HW1**	:= ______________
AI*x*02 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*02HW2**	:= ______________
AI*x*02 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*02HAL**	:= ______________

AI*x*03

AI*x*03 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*03NAM**	:= ______________
AI*x*03 TYPE (I, V)	**AIx03TYP**	:= ______________
If AI*x*03TYP = I		
AI*x*03 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*03L**	:= ______________
AI*x*03 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*03H**	:= ______________
If AI*x*03TYP = V		
AI*x*03 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*03L**	:= ______________
AI*x*03 HI IN VAL (–10.240 to +10.240 V)	**AI*x*03H**	:= ______________
AI*x*03 ENG UNITS (16 characters)	**AI*x*03EU**	:= ______________
AI*x*03 EU LOW (–99999.000 to +99999.000)	**AI*x*03EL**	:= ______________
AI*x*03 EU HI (–99999.000 to +99999.000)	**AI*x*03EH**	:= ______________
AI*x*03 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*03LW1**	:= ______________
AI*x*03 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*03LW2**	:= ______________
AI*x*03 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*03LAL**	:= ______________
AI*x*03 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*03HW1**	:= ______________
AI*x*03 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*03HW2**	:= ______________
AI*x*03 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*03HAL**	:= ______________

AI*x*04

AI*x*04 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*04NAM**	:= ______________
AI*x*04 TYPE (I, V)	**AIx04TYP**	:= ______________
If AI*x*04TYP = I		
AI*x*04 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*04L**	:= ______________
AI*x*04 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*04H**	:= ______________
If AI*x*04TYP = V		
AI*x*04 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*04L**	:= ______________
AI*x*04 HI IN VAL (–10.240 to +10.240 V)	**AI*x*04H**	:= ______________
AI*x*04 ENG UNITS (16 characters)	**AI*x*04EU**	:= ______________
AI*x*04 EU LOW (–99999.000 to +99999.000)	**AI*x*04EL**	:= ______________
AI*x*04 EU HI (–99999.000 to +99999.000)	**AI*x*04EH**	:= ______________

AI*x*04 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*04LW1**	:=
AI*x*04 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*04LW2**	:=
AI*x*04 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04LAL**	:=
AI*x*04 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*04HW1**	:=
AI*x*04 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*04HW2**	:=
AI*x*04 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*04HAL**	:=

AI*x*05

AI*x*05 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*05NAM**	:=
AI*x*05 TYPE (I, V)	**AIx05TYP**	:=
If AI*x*05TYP = I		
AI*x*05 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*05L**	:=
AI**x**05 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*05H**	:=
If AI*x*05TYP = V		
AI*x*05 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*05L**	:=
AI*x*05 HI IN VAL (–10.240 to +10.240 V)	**AI*x*05H**	:=
AI*x*05 ENG UNITS (16 characters)	**AI*x*05EU**	:=
AI*x*05 EU LOW (–99999.000 to +99999.000)	**AI*x*05EL**	:=
AI*x*05 EU HI (–99999.000 to +99999.000)	**AI*x*05EH**	:=
AI*x*05 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*05LW1**	:=
AI*x*05 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*05LW2**	:=
AI*x*05 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*05LAL**	:=
AI*x*05 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*05HW1**	:=
AI*x*05 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*05HW2**	:=
AI*x*05 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*05HAL**	:=

AI*x*06

AI*x*06 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*06NAM**	:=
AI*x*06 TYPE (I, V)	**AIx06TYP**	:=
If AI*x*06TYP = I		
AI*x*06 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*06L**	:=
AI*x*06 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*06H**	:=
If AI*x*06TYP = V		
AI*x*06 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*06L**	:=
AI*x*06 HI IN VAL (–10.240 to +10.240 V)	**AI*x*06H**	:=
AI*x*06 ENG UNITS (16 characters)	**AI*x*06EU**	:=

AI*x*06 EU LOW (–99999.000 to +99999.000)	**AI*x*06EL**	:= ______________
AI*x*06 EU HI (–99999.000 to +99999.000)	**AI*x*06EH**	:= ______________
AI*x*06 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*06LW1**	:= ______________
AI*x*06 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*06LW2**	:= ______________
AI*x*06 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*06LAL**	:= ______________
AI*x*06 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*06HW1**	:= ______________
AI*x*06 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*06HW2**	:= ______________
AI*x*06 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*06HAL**	:= ______________

AI*x*07

AI*x*07 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*07NAM**	:= ______________
AI*x*07 TYPE (I, V)	**AIx07TYP**	:= ______________
If AI*x*07TYP = I		
AI*x*07 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*07L**	:= ______________
AI*x*07 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*07H**	:= ______________
If AI*x*07TYP = V		
AI*x*07 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*07L**	:= ______________
AI*x*07 HI IN VAL (–10.240 to +10.240 V)	**AI*x*07H**	:= ______________
AI*x*07 ENG UNITS (16 characters)	**AI*x*07EU**	:= ______________
AI*x*07 EU LOW (–99999.000 to +99999.000)	**AI*x*07EL**	:= ______________
AI*x*07 EU HI (–99999.000 to +99999.000)	**AI*x*07EH**	:= ______________
AI*x*07 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*07LW1**	:= ______________
AI*x*07 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*07LW2**	:= ______________
AI*x*07 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*07LAL**	:= ______________
AI*x*07 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*07HW1**	:= ______________
AI*x*07 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*07HW2**	:= ______________
AI*x*07 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*07HAL**	:= ______________

AI*x*08

AI*x*08 TAG NAME (8 characters 0–9, A–Z, _)	**AI*x*08NAM**	:= ______________
AI*x*08 TYPE (I, V)	**AIx08TYP**	:= ______________
If AI*x*08TYP = I		
AI*x*08 LOW IN VAL (–20.480 to +20.480; mA)	**AI*x*08L**	:= ______________
AI*x*08 HI IN VAL (–20.480 to +20.480; mA)	**AI*x*08H**	:= ______________

If AI*x*08TYP = V		
AI*x*08 LOW IN VAL (–10.240 to +10.240 V)	**AI*x*08L**	:=
AI*x*08 HI IN VAL (–10.240 to +10.240 V)	**AI*x*08H**	:=
AI*x*08 ENG UNITS (16 characters)	**AI*x*08EU**	:=
AI*x*08 EU LOW (–99999.000 to +99999.000)	**AI*x*08EL**	:=
AI*x*08 EU HI (–99999.000 to +99999.000)	**AI*x*08EH**	:=
AI*x*08 LO WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*08LW1**	:=
AI*x*08 LO WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*08LW2**	:=
AI*x*08 LO ALARM (OFF, –99999.000 to +99999.000)	**AI*x*08LAL**	:=
AI*x*08 HI WARN L1 (OFF, –99999.000 to +99999.000)	**AI*x*08HW1**	:=
AI*x*08 HI WARN L2 (OFF, –99999.000 to +99999.000)	**AI*x*08HW2**	:=
AI*x*08 HI ALARM (OFF, –99999.000 to +99999.000)	**AI*x*08HAL**	:=

AO*x*01

AO*x*01 ANALOG QTY (Off, 1 analog quantity)	**AO*x*01AQ**	:=
AO*x*01 TYPE (I, V)	**AO*x*01TYP**	:=
AO*x*01 AQTY LOW (–2147483647 to +2147483647)	**AO*x*01AQL**	:=
AO*x*01 AQTY HI (–2147483647 to +2147483647)	**AO*x*01AQH**	:=
If AO*x*01TYP = I		
AO*x*01 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*01L**	:=
AO*x*01 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*01H**	:=
If AO*x*01TYP = V		
AO*x*01 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*01L**	:=
AO*x*01 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*01H**	:=

AO*x*02

AO*x*02 ANALOG QTY (Off, 1 analog quantity)	**AO*x*02AQ**	:=
AO*x*02 TYPE (I, V)	**AO*x*02TYP**	:=
AO*x*02 AQTY LOW (–2147483647 to +2147483647)	**AO*x*02AQL**	:=
AO*x*02 AQTY HI (–2147483647 to +2147483647)	**AO*x*02AQH**	:=
If AO*x*02TYP = I		
AO*x*02 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*02L**	:=
AO*x*02 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*02H**	:=
If AO*x*02TYP = V		
AO*x*02 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*02L**	:=
AO*x*02 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*02H**	:=

AO*x*03

AO*x*03 ANALOG QTY (Off, 1 analog quantity)	**AO*x*03AQ** := ________
AO*x*03 TYPE (I, V)	**AO*x*03TYP** := ________
AO*x*03 AQTY LOW (–2147483647 to +2147483647)	**AO*x*03AQL** := ________
AO*x*03 AQTY HI (–2147483647 to +2147483647)	**AO*x*03AQH** := ________
If AO*x*03TYP = I	
AO*x*03 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*03L** := ________
AO*x*03 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*03H** := ________
If AO*x*03TYP = V	
AO*x*03 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*03L** := ________
AO*x*03 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*03H** := ________

AO*x*04

AO*x*04 ANALOG QTY (Off, 1 analog quantity)	**AO*x*04AQ** := ________
AO*x*04 TYPE (I, V)	**AO*x*04TYP** := ________
AO*x*04 AQTY LOW (–2147483647 to +2147483647)	**AO*x*04AQL** := ________
AO*x*04 AQTY HI (–2147483647 to +2147483647)	**AO*x*04AQH** := ________
If AO*x*04TYP = I	
AO*x*04 LO OUT VAL (–20.480 to +20.480 mA)	**AO*x*04L** := ________
AO*x*04 HI OUT VAL (–20.480 to +20.480 mA)	**AO*x*04H** := ________
If AO*x*04TYP = V	
AO*x*04 LO OUT VAL (–10.240 to +10.240 V)	**AO*x*04L** := ________
AO*x*04 HI OUT VAL (–10.240 to +10.240 V)	**AO*x*04H** := ________

Breaker Monitor Settings

BREAKER MONITOR (Y, N) (*All subsequent settings hidden if EBMON := N*)	**EBMON** := ________
CL/OPN OPS SETPT 1 (0–65000)	**COSP1** := ________
CL/OPN OPS SETPT 2 (0–65000)	**COSP2** := ________
CL/OPN OPS SETPT 3 (0–65000)	**COSP3** := ________
kA PRI INTERRPTD 1 (0.10–999.00)	**KASP1** := ________
kA PRI INTERRPTD 2 (0.10–999.00)	**KASP2** := ________
kA PRI INTERRPTD 3 (0.10–999.00)	**KASP3** := ________

Control Breaker Monitor (SELOGIC)

BKMON := ____

Data Reset

RESET TARGETS (SELOGIC)

RSTTRGT := ______________________________

RESET ENERGY (SELOGIC)

RSTENRGY := ______________________________

RESET MAX/MIN (SELOGIC)

RSTMXMN := ______________________________

Access Control

DISABLE SETTINGS (SELOGIC)

DSABLSET := ______________________________

BLOCK MODBUS SET (NONE, R_S, ALL) **BLKMBSET :=** ____________

Time-Synchronization Source

IRIG TIME SOURCE (IRIG1, IRIG2) (*Hidden if relay has the PTC option*) **TIME_SRC :=** ____________

SET PORT p (p = F, 1, 2, 3, or 4) Command

PORT F

All serial port settings are hidden if EPORT := N.

ENABLE PORT (Y, N) **EPORT :=** ____________

Protocol Select

PROTOCOL (SEL, MOD) **PROTO :=** ____________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 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

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL)* **SLAVEID :=** ____________

PORT 1 (Ethernet Port in Slot B)

All Ethernet settings are hidden if the Ethernet option is not available or if EPORT := N. IP addresses are entered using zzz = 1–126, 128–223; yyy = 0–255; xxx = 0–255; www = 0–255.

ENABLE PORT (Y, N)	**EPORT**	:= ______
IP ADDRESS (zzz.yyy.xxx.www)	**IPADDR**	:= ______
SUBNET MASK(zzz.yyy.xxx.www)	**SUBNETM**	:= ______
DEFAULT ROUTER (zzz.yyy.xxx.www)	**DEFRTR**	:= ______
Enable TCP Keep-Alive (Y, N)	**ETCPKA**	:= ______
TCP Keep-Alive Idle Range (1–20 s) (*Hidden if ETCPKA := N*)	**KAIDLE**	:= ______
TCP Keep-Alive Interval Range (1–20 s) (*Hidden if ETCPKA := N*)	**KAINTV**	:= ______
TCP Keep-Alive Count Range (1–20 s) (*Hidden if ETCPKA := N*)	**KACNT**	:= ______
FAST OP MESSAGES (Y, N)	**FASTOP**	:= ______
OPERATING MODE (FIXED, FAILOVER, SWITCHED) *(Hidden if not dual redundant Ethernet Port option)*	**NETMODE**	:= ______
FAILOVER TIMEOUT (0.10–65.00 s) *(Hidden if not dual redundant Ethernet Port option or if NETMODE is not set to FAILOVER)*	**FTIME**	:= ______
PRIMARY NETPORT (A, B) *(Hidden if not dual redundant Ethernet Port option)*	**NETPORT**	:= ______
NETWRK PORTA SPD (AUTO,10,100 Mbps) *(Hidden if not dual redundant Ethernet Port option)*	**NETASPD**	:= ______
NETWRK PORTB SPD (AUTO,10,100 Mbps) *(Hidden if not dual redundant Ethernet Port option)*	**NETBSPD**	:= ______
ENABLE TELNET (Y, N)	**ETELNET**	:= ______
TELNET PORT (23,1025–65534)	**TPORT**	:= ______
TELNET TIME-OUT (1–30 min)	**TIDLE**	:= ______
ENABLE FTP (Y, N)	**EFTPSERV**	:= ______
FTP USER NAME (20 characters)	**FTPUSER**	:= ______
Enable IEC 61850 Protocol (Y, N) (*Hidden if IEC 61850 is not supported*)	**E61850**	:= ______
Enable IEC 61850 GSE (Y, N) (*Hidden if E61850 := N*)	**EGSE**	:= ______
Enable Modbus Sessions (0–2)	**EMOD**	:= ______
Modbus TCP Port1 (1–65534) *(*Hidden if EMOD := 0*)	**MODNUM1**	:= ______
Modbus TCP Port2 (1–65534) *(*Hidden if EMOD := 0 or 1*)	**MODNUM2**	:= ______
Modbus Timeout 1 (15–900 s) (*Hidden if EMOD := 0*)	**MTIMEO1**	:= ______
Modbus Timeout 2 (15–900 s) (*Hidden if EMOD := 0 or 1*)	**MTIMEO2**	:= ______

*Exclude the following port numbers: 20 (FTP Data), 21 (FTP Control), 102 (IEC 61850), 23 (Telnet), SNTPPORT, and TPORT setting.

SNTP Client Protocol Settings

Enable SNTP Client (OFF, UNICAST, MANYCAST, BROADCAST) **ESNTP** := ____________________

Make the following settings when ESNTP ≠ OFF.

Primary Server IP Address (zzz.yyy.xxx.www)

NOTE: To accept updates from any server when ESNTP = BROADCAST, set SNTPPSIP to 0.0.0.0. **SNTPPSIP** := ____________________

Make the following setting when ESNTP = UNICAST.

Backup Server IP Address (zzz.yyy.xxx.www) **SNTPBSIP** := ____________________

SNTP IP (Local) Port Number (1–65534)

NOTE: SNTPPORT cannot be set to 20, 21, 102, 502, 23, or TPORT **SNTPPORT** := ____________________

SNTP Update Rate (15–3600 sec) **SNTPRATE** := ____________________

Make the following setting when ESNTP = UNICAST or MANYCAST.

SNTP Timeout (5–20 sec) **SNTPTO** := ____________________

Note: SNTPTO must be less than setting SNTPRATE.

Port Number Settings Must be Unique

When making the SEL-710 Port 1 settings, port number settings cannot be used for more than one protocol. The relay checks all of the settings shown in *Table SET.1* before saving the changes. If a port number is used more than once, or if it matches any of the fixed port numbers (20, 21, 23, 102, 502), the relay displays an error message and returns to the first setting that is in error or that contains a duplicate value.

Table SET.1 Port Number Settings That Must be Unique

Setting	Name	Setting Required When
TPORT	Telnet Port	Always
MODNUM1[a]	Modbus TCP Port 1	EMOD > 0
MODNUM2[a]	Modbus TCP Port 2	EMOD > 1
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF

[a] MODNUM1 and MODNUM2 settings can have the same port number. The relay displays an error message if this number matches the port numbers of the other protocols.

PORT 2 (Fiber-Optic Port in Slot B) (Hidden if E49RTD := EXT)

All port settings are hidden if EPORT := N.

ENABLE PORT (Y, N) **EPORT** := ____________________

Protocol Select

PROTOCOL (SEL, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB) **PROTO** := ____________________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	**:=** ________
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD or MB_)*	**BITS**	**:=** ________
PARITY (O, E, N) (*Hidden if E49RTD := EXT or PROTO :=MB_)*	**PARITY**	**:=** ________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD or MB_)*	**STOP**	**:=** ________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD or MB_)*	**T_OUT**	**:=** ________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD or MB_)*	**AUTO**	**:=** ________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD or MB_)*	**FASTOP**	**:=** ________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL or MB_)*	**SLAVEID**	**:=** ________

MIRRORED BITS Protocol **(Hidden if PROTO := SEL or MOD)**

MB Transmit Identifier (1–4)	**TXID**	:= ________
MB Receive Identifier (1–4)	**RXID**	:= ________
MB RX Bad Pickup Time (0–10000 sec)	**RBADPU**	:= ________
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU**	:= ________
MB Receive Default State (8 characters)	**RXDFLT**	:= ________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU**	:= ________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO**	:= ________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU**	:= ________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO**	:= ________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU**	:= ________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO**	:= ________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU**	:= ________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO**	:= ________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU**	:= ________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO**	:= ________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU**	:= ________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO**	:= ________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU**	:= ________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO**	:= ________
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU**	:= ________

RMB8 Dropout Debounce Messages (1–8)	**RMB8DO**	:= ________

PORT 3 (EIA-232/485 Port in Slot B)

All port settings are hidden if EPORT := N.

ENABLE PORT (Y, N)	**EPORT**	:= ________

Protocol Select

PROTOCOL (SEL, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB)	**PROTO**	:= ________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED**	:= ________
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD, or MB_)*	**BITS**	:= ________
PARITY (O, E, N) *(Hidden if PROTO := MB_)*	**PARITY**	:= ________
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, or MB_)*	**STOP**	:= ________
PORT TIME-OUT (0–30 min) *(Hidden if PROTO := MOD, or MB_)*	**T_OUT**	:= ________
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO := MOD, or MB_)*	**AUTO**	:= ________
HDWR HANDSHAKING (Y, N) *(Hidden if COMMINF :=485 or PROTO := MOD, or MB_)*	**RTSCTS**	:= ________
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, or MB_)*	**FASTOP**	:= ________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL or MB_)*	**SLAVEID**	:= ________

MIRRORED BITS Protocol (Hidden if PROTO := SEL or MOD)

MB Transmit Identifier (1–4)	**TXID**	:= ________
MB Receive Identifier (1–4)	**RXID**	:= ________
MB RX Bad Pickup Time (0–10000 sec)	**RBADPU**	:= ________
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU**	:= ________
MB Receive Default State (8 characters)	**RXDFLT**	:= ________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU**	:= ________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO**	:= ________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU**	:= ________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO**	:= ________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU**	:= ________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO**	:= ________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU**	:= ________

RMB4 Dropout Debounce Messages (1–8)	**RMB4DO**	:= ______
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU**	:= ______
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO**	:= ______
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU**	:= ______
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO**	:= ______
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU**	:= ______
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO**	:= ______
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU**	:= ______
RMB8 Dropout Debounce Messages (1–8)	**RMB8DO**	:= ______

PORT 4 (EIA-232/485 Port or DeviceNet Port in Slot C)

All port settings are hidden if EPORT := N.

ENABLE PORT (Y, N)	**EPORT**	:= ______

Protocol Select

PROTOCOL (SEL, MOD, DNET, MBA, MBB, MB8A, MB8B, MBTA, MBTB)	**PROTO**	:= ______

Interface Select (Hidden if PROTO := DNET)

COMM INTERFACE (232, 485)	**COMMINF**	:= ______

Communications

SPEED (300–38400 bps) *(Hidden if PROTO := DNET)*	**SPEED**	:= ______
DATA BITS (7, 8 bits) *(Hidden if PROTO := MOD, MB_, or DNET)*	**BITS**	:= ______
PARITY (O, E, N) *(Hidden if PROTO := MB_)*	**PARITY**	:= ______
STOP BITS (1, 2 bits) *(Hidden if PROTO := MOD, MB_, or DNET)*	**STOP**	:= ______
PORT TIME-OUT (0–30 min) *(Hidden if PROTO:=MOD, MB_, or DNET)*	**T_OUT**	:= ______
SEND AUTOMESSAGE (Y, N) *(Hidden if PROTO:=MOD, MB_, or DNET)*	**AUTO**	:= ______
HDWR HANDSHAKING (Y, N) *(Hidden if COMMINF :=485 or PROTO := MOD, MB_, or DNET)*	**RTSCTS**	:= ______
FAST OP MESSAGES (Y, N) *(Hidden if PROTO := MOD, MB_, or DNET)*	**FASTOP**	:= ______

Modbus

MODBUS SLAVE ID (1–247) *(Hidden if PROTO := SEL, MB_, or DNET)*	**SLAVEID**	:= ______

MIRRORED BITS Protocol (Hidden if PROTO := SEL or MOD)

MB Transmit Identifier (1–4)	**TXID**	:= ____________
MB Receive Identifier (1–4)	**RXID**	:= ____________
MB RX Bad Pickup Time (0–10000 sec)	**RBADPU**	:= ____________
MB Channel Bad Pickup (1–10000 ppm)	**CBADPU**	:= ____________
MB Receive Default State (8 characters)	**RXDFLT**	:= ____________
RMB1 Pickup Debounce Messages (1–8)	**RMB1PU**	:= ____________
RMB1 Dropout Debounce Messages (1–8)	**RMB1DO**	:= ____________
RMB2 Pickup Debounce Messages (1–8)	**RMB2PU**	:= ____________
RMB2 Dropout Debounce Messages (1–8)	**RMB2DO**	:= ____________
RMB3 Pickup Debounce Messages (1–8)	**RMB3PU**	:= ____________
RMB3 Dropout Debounce Messages (1–8)	**RMB3DO**	:= ____________
RMB4 Pickup Debounce Messages (1–8)	**RMB4PU**	:= ____________
RMB4 Dropout Debounce Messages (1–8)	**RMB4DO**	:= ____________
RMB5 Pickup Debounce Messages (1–8)	**RMB5PU**	:= ____________
RMB5 Dropout Debounce Messages (1–8)	**RMB5DO**	:= ____________
RMB6 Pickup Debounce Messages (1–8)	**RMB6PU**	:= ____________
RMB6 Dropout Debounce Messages (1–8)	**RMB6DO**	:= ____________
RMB7 Pickup Debounce Messages (1–8)	**RMB7PU**	:= ____________
RMB7 Dropout Debounce Messages (1–8)	**RMB7DO**	:= ____________
RMB8 Pickup Debounce Messages (1–8)	**RMB8PU**	:= ____________
RMB8 Dropout Debounce Messages (1–8)	**RMB8DO**	:= ____________

Front-Panel Settings (SET F Command)

General

DISPLY PTS ENABL (N,1–32)	**EDP**	:= ________
LOCAL BITS ENABL (N,1–32)	**ELB**	:= ________
LCD TIMEOUT (OFF,1–30 min)	**FP_TO**	:= ________
LCD CONTRAST (1–8)	**FP_CONT**	:= ________
FP AUTOMESSAGES (OVERRIDE, ROTATING)	**FP_AUTO**	:= ________
CLOSE RESET LEDS (Y, N)	**RSTLED**	:= ________

Target LED

TRIP LATCH T_LED (Y, N)	**T01LEDL**	:= ________
LED1 EQUATION (SELOGIC)	**T01_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T02LEDL**	:= ________
LED2 EQUATION (SELOGIC)	**T02_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T03LEDL**	:= ________
LED3 EQUATION (SELOGIC)	**T03_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T04LEDL**	:= ________
LED4 EQUATION (SELOGIC)	**T04_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T05LEDL**	:= ________
LED5 EQUATION (SELOGIC)	**T05_LED**	:= ________
TRIP LATCH T_LED (Y, N)	**T06LEDL**	:= ________
LED6 EQUATION (SELOGIC)	**T06_LED**	:= ________
PB1A_LED EQUATION (SELOGIC)	**PB1A_LED**	:= ________
PB1B_LED EQUATION (SELOGIC)	**PB1B_LED**	:= ________
PB2A_LED EQUATION (SELOGIC)	**PB2A_LED**	:= ________
PB2B_LED EQUATION (SELOGIC)	**PB2B_LED**	:= ________
PB3A_LED EQUATION (SELOGIC)	**PB3A_LED**	:= ________
PB3B_LED EQUATION (SELOGIC)	**PB3B_LED**	:= ________
PB4A_LED EQUATION (SELOGIC)	**PB4A_LED**	:= ________
PB4B_LED EQUATION (SELOGIC)	**PB4B_LED**	:= ________

Display Point

Display Point Settings (maximum 60 characters):

- ➤ (Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
- ➤ (Analog): Analog Quantity Name, "User Text and Formatting"

DISPLAY POINT DP01 (60 characters)	**DP01**	:= ____________
DISPLAY POINT DP02 (60 characters)	**DP02**	:= ____________
DISPLAY POINT DP03 (60 characters)	**DP03**	:= ____________
DISPLAY POINT DP04 (60 characters)	**DP04**	:= ____________
DISPLAY POINT DP05 (60 characters)	**DP05**	:= ____________
DISPLAY POINT DP06 (60 characters)	**DP06**	:= ____________
DISPLAY POINT DP07 (60 characters)	**DP07**	:= ____________
DISPLAY POINT DP08 (60 characters)	**DP08**	:= ____________
DISPLAY POINT DP09 (60 characters)	**DP09**	:= ____________
DISPLAY POINT DP10 (60 characters)	**DP10**	:= ____________
DISPLAY POINT DP11 (60 characters)	**DP11**	:= ____________
DISPLAY POINT DP12 (60 characters)	**DP12**	:= ____________
DISPLAY POINT DP13 (60 characters)	**DP13**	:= ____________
DISPLAY POINT DP14 (60 characters)	**DP14**	:= ____________
DISPLAY POINT DP15 (60 characters)	**DP15**	:= ____________
DISPLAY POINT DP16 (60 characters)	**DP16**	:= ____________
DISPLAY POINT DP17 (60 characters)	**DP17**	:= ____________
DISPLAY POINT DP18 (60 characters)	**DP18**	:= ____________
DISPLAY POINT DP19 (60 characters)	**DP19**	:= ____________
DISPLAY POINT DP20 (60 characters)	**DP20**	:= ____________
DISPLAY POINT DP21 (60 characters)	**DP21**	:= ____________
DISPLAY POINT DP22 (60 characters)	**DP22**	:= ____________
DISPLAY POINT DP23 (60 characters)	**DP23**	:= ____________
DISPLAY POINT DP24 (60 characters)	**DP24**	:= ____________
DISPLAY POINT DP25 (60 characters)	**DP25**	:= ____________
DISPLAY POINT DP26 (60 characters)	**DP26**	:= ____________
DISPLAY POINT DP27 (60 characters)	**DP27**	:= ____________
DISPLAY POINT DP28 (60 characters)	**DP28**	:= ____________
DISPLAY POINT DP29 (60 characters)	**DP29**	:= ____________
DISPLAY POINT DP30 (60 characters)	**DP30**	:= ____________

DISPLAY POINT DP31 (60 characters)	**DP31**	:= ______________
DISPLAY POINT DP32 (60 characters)	**DP32**	:= ______________

Local Bits Labels

LB_NAME (14 characters)	**NLB01**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB01**	:= ______________
SET LB_ LABEL (7 characters)	**SLB01**	:= ______________
PULSE LB_ LABEL (7 characters)	**PLB01**	:= ______________
LB_NAME (14 characters)	**NLB02**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB02**	:= ______________
SET LB_ LABEL (7 characters)	**SLB02**	:= ______________
PULSE LB_ LABEL (7 characters)	**PLB02**	:= ______________
LB_NAME (14 characters)	**NLB03**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB03**	:= ______________
SET LB_ LABEL (7 characters)	**SLB03**	:= ______________
PULSE LB_ LABEL (7 characters)	**PLB03**	:= ______________
LB_NAME (14 characters)	**NLB04**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB04**	:= ______________
SET LB_ LABEL (7 characters)	**SLB04**	:= ______________
PULSE LB_ LABEL (7 characters)	**PLB04**	:= ______________
LB_NAME (14 characters)	**NLB05**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB05**	:= ______________
SET LB_ LABEL (7 characters)	**SLB05**	:= ______________
PULSE LB_ LABEL (7 characters)	**PLB05**	:= ______________
LB_NAME (14 characters)	**NLB06**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB06**	:= ______________
SET LB_ LABEL (7 characters)	**SLB06**	:= ______________
PULSE LB_ LABEL (7 characters)	**PLB06**	:= ______________
LB_NAME (14 characters)	**NLB07**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB07**	:= ______________
SET LB_ LABEL (7 characters)	**SLB07**	:= ______________
PULSE LB_ LABEL (7 characters)	**PLB07**	:= ______________
LB_NAME (14 characters)	**NLB08**	:= ______________
CLEAR LB_ LABEL (7 characters)	**CLB08**	:= ______________

SET LB_ LABEL (7 characters)	**SLB08**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB08**	:= ________
LB_NAME (14 characters)	**NLB09**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB09**	:= ________
SET LB_ LABEL (7 characters)	**SLB09**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB09**	:= ________
LB_NAME (14 characters)	**NLB10**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB10**	:= ________
SET LB_ LABEL (7 characters)	**SLB10**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB10**	:= ________
LB_NAME (14 characters)	**NLB11**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB11**	:= ________
SET LB_ LABEL (7 characters)	**SLB11**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB11**	:= ________
LB_NAME (14 characters)	**NLB12**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB12**	:= ________
SET LB_ LABEL (7 characters)	**SLB12**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB12**	:= ________
LB_NAME (14 characters)	**NLB13**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB13**	:= ________
SET LB_ LABEL (7 characters)	**SLB13**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB13**	:= ________
LB_NAME (14 characters)	**NLB14**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB14**	:= ________
SET LB_ LABEL (7 characters)	**SLB14**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB14**	:= ________
LB_NAME (14 characters)	**NLB15**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB15**	:= ________
SET LB_ LABEL (7 characters)	**SLB15**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB15**	:= ________
LB_NAME (14 characters)	**NLB16**	:= ________
CLEAR LB_ LABEL (7 characters)	**CLB16**	:= ________
SET LB_ LABEL (7 characters)	**SLB16**	:= ________
PULSE LB_ LABEL (7 characters)	**PLB16**	:= ________

LB_NAME (14 characters)	**NLB17**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB17**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB17**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB17**	**:=** ____________
LB_NAME (14 characters)	**NLB18**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB18**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB18**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB18**	**:=** ____________
LB_NAME (14 characters)	**NLB19**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB19**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB19**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB19**	**:=** ____________
LB_NAME (14 characters)	**NLB20**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB20**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB20**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB20**	**:=** ____________
LB_NAME (14 characters)	**NLB21**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB21**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB21**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB21**	**:=** ____________
LB_NAME (14 characters)	**NLB22**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB22**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB22**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB22**	**:=** ____________
LB_NAME (14 characters)	**NLB23**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB23**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB23**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB23**	**:=** ____________
LB_NAME (14 characters)	**NLB24**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB24**	**:=** ____________
SET LB_ LABEL (7 characters)	**SLB24**	**:=** ____________
PULSE LB_ LABEL (7 characters)	**PLB24**	**:=** ____________
LB_NAME (14 characters)	**NLB25**	**:=** ____________
CLEAR LB_ LABEL (7 characters)	**CLB25**	**:=** ____________

SET LB_ LABEL (7 characters)	**SLB25**	:=
PULSE LB_ LABEL (7 characters)	**PLB25**	:=
LB_NAME (14 characters)	**NLB26**	:=
CLEAR LB_ LABEL (7 characters)	**CLB26**	:=
SET LB_ LABEL (7 characters)	**SLB26**	:=
PULSE LB_ LABEL (7 characters)	**PLB26**	:=
LB_NAME (14 characters)	**NLB27**	:=
CLEAR LB_ LABEL (7 characters)	**CLB27**	:=
SET LB_ LABEL (7 characters)	**SLB27**	:=
PULSE LB_ LABEL (7 characters)	**PLB27**	:=
LB_NAME (14 characters)	**NLB28**	:=
CLEAR LB_ LABEL (7 characters)	**CLB28**	:=
SET LB_ LABEL (7 characters)	**SLB28**	:=
PULSE LB_ LABEL (7 characters)	**PLB28**	:=
LB_NAME (14 characters)	**NLB29**	:=
CLEAR LB_ LABEL (7 characters)	**CLB29**	:=
SET LB_ LABEL (7 characters)	**SLB29**	:=
PULSE LB_ LABEL (7 characters)	**PLB29**	:=
LB_NAME (14 characters)	**NLB30**	:=
CLEAR LB_ LABEL (7 characters)	**CLB30**	:=
SET LB_ LABEL (7 characters)	**SLB30**	:=
PULSE LB_ LABEL (7 characters)	**PLB30**	:=
LB_NAME (14 characters)	**NLB31**	:=
CLEAR LB_ LABEL (7 characters)	**CLB31**	:=
SET LB_ LABEL (7 characters)	**SLB31**	:=
PULSE LB_ LABEL (7 characters)	**PLB311**	:=
LB_NAME (14 characters)	**NLB32**	:=
CLEAR LB_ LABEL (7 characters)	**B32**	:=
SET LB_ LABEL (7 characters)	**SLB32**	:=
PULSE LB_ LABEL (7 characters)	**PLB32**	:=

Report Settings (SET R Command)

SER Trigger Lists

SERn = As many as 24 Relay-Word elements separated by spaces or commas. Use NA to disable setting.

SER1 := ______________________

SER2 := ______________________

SER3 := ______________________

SER4 := ______________________

Relay Word Bit Aliases

ALIASn= 'RW Bit'(space)'Alias'(space)'Asserted Text'(space)'Deasserted Text'. Alias, Asserted, and Deasserted text strings can be as many as 15 characters long. Use NA to disable setting.

Enable ALIAS (N, 1–20)	**EALIAS**	:= ________
ALIAS 1	**ALIAS1**	:= ________
ALIAS 2	**ALIAS2**	:= ________
ALIAS 3	**ALIAS3**	:= ________
ALIAS 4	**ALIAS4**	:= ________
ALIAS 5	**ALIAS5**	:= ________
ALIAS 6	**ALIAS6**	:= ________
ALIAS 7	**ALIAS7**	:= ________
ALIAS 8	**ALIAS8**	:= ________
ALIAS 9	**ALIAS9**	:= ________
ALIAS 10	**ALIAS10**	:= ________
ALIAS 11	**ALIAS11**	:= ________
ALIAS 12	**ALIAS12**	:= ________
ALIAS 13	**ALIAS13**	:= ________
ALIAS 14	**ALIAS14**	:= ________
ALIAS 15	**ALIAS15**	:= ________
ALIAS 16	**ALIAS16**	:= ________
ALIAS 17	**ALIAS17**	:= ________
ALIAS 18	**ALIAS18**	:= ________
ALIAS 19	**ALIAS19**	:= ________
ALIAS 20	**ALIAS20**	:= ________

Event Report

EVENT TRIGGER (SELOGIC)	**ER**	:= ______________
EVENT LENGTH (15, 64 cyc)	**LER**	:= ______________
PREFAULT LENGTH (1–59 cyc)	**PRE**	:= ______________

Start Report

MSR RESOLUTION (0.25, 0.5, 1, 2, 5, 20 cyc)	**MSRR**	:= ______________
MSR TRIGGER (SELOGIC)	**MSRTRG**	:= ______________

Load Profile

LDP LIST (NA, as many as 17 analog quantities)	**LDLIST**	:= ______________
LDP ACQ RATE (5, 10, 15, 30, 60 min)	**LDAR**	:= ______________

Modbus Map Settings (SET M Command)

Modbus User Map

(See Appendix D: Modbus Communications for additional details)

User Map Register Label Name (8 characters)	**MOD_001**	:= ______________
User Map Register Label Name (8 characters)	**MOD_002**	:= ______________
User Map Register Label Name (8 characters)	**MOD_003**	:= ______________
User Map Register Label Name (8 characters)	**MOD_004**	:= ______________
User Map Register Label Name (8 characters)	**MOD_005**	:= ______________
User Map Register Label Name (8 characters)	**MOD_006**	:= ______________
User Map Register Label Name (8 characters)	**MOD_007**	:= ______________
User Map Register Label Name (8 characters)	**MOD_008**	:= ______________
User Map Register Label Name (8 characters)	**MOD_009**	:= ______________
User Map Register Label Name (8 characters)	**MOD_010**	:= ______________
User Map Register Label Name (8 characters)	**MOD_011**	:= ______________
User Map Register Label Name (8 characters)	**MOD_012**	:= ______________
User Map Register Label Name (8 characters)	**MOD_013**	:= ______________
User Map Register Label Name (8 characters)	**MOD_014**	:= ______________
User Map Register Label Name (8 characters)	**MOD_015**	:= ______________
User Map Register Label Name (8 characters)	**MOD_016**	:= ______________
User Map Register Label Name (8 characters)	**MOD_017**	:= ______________
User Map Register Label Name (8 characters)	**MOD_018**	:= ______________

User Map Register Label Name (8 characters)	**MOD_019**	:= ______________
User Map Register Label Name (8 characters)	**MOD_020**	:= ______________
User Map Register Label Name (8 characters)	**MOD_021**	:= ______________
User Map Register Label Name (8 characters)	**MOD_022**	:= ______________
User Map Register Label Name (8 characters)	**MOD_023**	:= ______________
User Map Register Label Name (8 characters)	**MOD_024**	:= ______________
User Map Register Label Name (8 characters)	**MOD_025**	:= ______________
User Map Register Label Name (8 characters)	**MOD_026**	:= ______________
User Map Register Label Name (8 characters)	**MOD_027**	:= ______________
User Map Register Label Name (8 characters)	**MOD_028**	:= ______________
User Map Register Label Name (8 characters)	**MOD_029**	:= ______________
User Map Register Label Name (8 characters)	**MOD_030**	:= ______________
User Map Register Label Name (8 characters)	**MOD_031**	:= ______________
User Map Register Label Name (8 characters)	**MOD_032**	:= ______________
User Map Register Label Name (8 characters)	**MOD_033**	:= ______________
User Map Register Label Name (8 characters)	**MOD_034**	:= ______________
User Map Register Label Name (8 characters)	**MOD_035**	:= ______________
User Map Register Label Name (8 characters)	**MOD_036**	:= ______________
User Map Register Label Name (8 characters)	**MOD_037**	:= ______________
User Map Register Label Name (8 characters)	**MOD_038**	:= ______________
User Map Register Label Name (8 characters)	**MOD_039**	:= ______________
User Map Register Label Name (8 characters)	**MOD_040**	:= ______________
User Map Register Label Name (8 characters)	**MOD_041**	:= ______________
User Map Register Label Name (8 characters)	**MOD_042**	:= ______________
User Map Register Label Name (8 characters)	**MOD_043**	:= ______________
User Map Register Label Name (8 characters)	**MOD_044**	:= ______________
User Map Register Label Name (8 characters)	**MOD_045**	:= ______________
User Map Register Label Name (8 characters)	**MOD_046**	:= ______________
User Map Register Label Name (8 characters)	**MOD_047**	:= ______________
User Map Register Label Name (8 characters)	**MOD_048**	:= ______________
User Map Register Label Name (8 characters)	**MOD_049**	:= ______________
User Map Register Label Name (8 characters)	**MOD_050**	:= ______________
User Map Register Label Name (8 characters)	**MOD_051**	:= ______________
User Map Register Label Name (8 characters)	**MOD_052**	:= ______________

User Map Register Label Name (8 characters)	**MOD_053**	:= ____________
User Map Register Label Name (8 characters)	**MOD_054**	:= ____________
User Map Register Label Name (8 characters)	**MOD_055**	:= ____________
User Map Register Label Name (8 characters)	**MOD_056**	:= ____________
User Map Register Label Name (8 characters)	**MOD_057**	:= ____________
User Map Register Label Name (8 characters)	**MOD_058**	:= ____________
User Map Register Label Name (8 characters)	**MOD_059**	:= ____________
User Map Register Label Name (8 characters)	**MOD_060**	:= ____________
User Map Register Label Name (8 characters)	**MOD_061**	:= ____________
User Map Register Label Name (8 characters)	**MOD_062**	:= ____________
User Map Register Label Name (8 characters)	**MOD_063**	:= ____________
User Map Register Label Name (8 characters)	**MOD_064**	:= ____________
User Map Register Label Name (8 characters)	**MOD_065**	:= ____________
User Map Register Label Name (8 characters)	**MOD_066**	:= ____________
User Map Register Label Name (8 characters)	**MOD_067**	:= ____________
User Map Register Label Name (8 characters)	**MOD_068**	:= ____________
User Map Register Label Name (8 characters)	**MOD_069**	:= ____________
User Map Register Label Name (8 characters)	**MOD_070**	:= ____________
User Map Register Label Name (8 characters)	**MOD_071**	:= ____________
User Map Register Label Name (8 characters)	**MOD_072**	:= ____________
User Map Register Label Name (8 characters)	**MOD_073**	:= ____________
User Map Register Label Name (8 characters)	**MOD_074**	:= ____________
User Map Register Label Name (8 characters)	**MOD_075**	:= ____________
User Map Register Label Name (8 characters)	**MOD_076**	:= ____________
User Map Register Label Name (8 characters)	**MOD_077**	:= ____________
User Map Register Label Name (8 characters)	**MOD_078**	:= ____________
User Map Register Label Name (8 characters)	**MOD_079**	:= ____________
User Map Register Label Name (8 characters)	**MOD_080**	:= ____________
User Map Register Label Name (8 characters)	**MOD_081**	:= ____________
User Map Register Label Name (8 characters)	**MOD_082**	:= ____________
User Map Register Label Name (8 characters)	**MOD_083**	:= ____________
User Map Register Label Name (8 characters)	**MOD_084**	:= ____________
User Map Register Label Name (8 characters)	**MOD_085**	:= ____________
User Map Register Label Name (8 characters)	**MOD_086**	:= ____________

User Map Register Label Name (8 characters)	**MOD_087**	:= ______________
User Map Register Label Name (8 characters)	**MOD_088**	:= ______________
User Map Register Label Name (8 characters)	**MOD_089**	:= ______________
User Map Register Label Name (8 characters)	**MOD_090**	:= ______________
User MapRegister Label Name (8 characters)	**MOD_091**	:= ______________
User Map Register Label Name (8 characters)	**MOD_092**	:= ______________
User Map Register Label Name (8 characters)	**MOD_093**	:= ______________
User Map Register Label Name (8 characters)	**MOD_094**	:= ______________
User Map Register Label Name (8 characters)	**MOD_095**	:= ______________
User Map Register Label Name (8 characters)	**MOD_096**	:= ______________
User Map Register Label Name (8 characters)	**MOD_097**	:= ______________
User Map Register Label Name (8 characters)	**MOD_098**	:= ______________
User Map Register Label Name (8 characters)	**MOD_099**	:= ______________
User Map Register Label Name (8 characters)	**MOD_100**	:= ______________
User Map Register Label Name (8 characters)	**MOD_101**	:= ______________
User Map Register Label Name (8 characters)	**MOD_102**	:= ______________
User Map Register Label Name (8 characters)	**MOD_103**	:= ______________
User Map Register Label Name (8 characters)	**MOD_104**	:= ______________
User Map Register Label Name (8 characters)	**MOD_105**	:= ______________
User Map Register Label Name (8 characters)	**MOD_106**	:= ______________
User Map Register Label Name (8 characters)	**MOD_107**	:= ______________
User Map Register Label Name (8 characters)	**MOD_108**	:= ______________
User Map Register Label Name (8 characters)	**MOD_109**	:= ______________
User Map Register Label Name (8 characters)	**MOD_110**	:= ______________
User Map Register Label Name (8 characters)	**MOD_111**	:= ______________
User Map Register Label Name (8 characters)	**MOD_112**	:= ______________
User Map Register Label Name (8 characters)	**MOD_113**	:= ______________
User Map Register Label Name (8 characters)	**MOD_114**	:= ______________
User Map Register Label Name (8 characters)	**MOD_115**	:= ______________
User Map Register Label Name (8 characters)	**MOD_116**	:= ______________
User Map Register Label Name (8 characters)	**MOD_117**	:= ______________
User Map Register Label Name (8 characters)	**MOD_118**	:= ______________
User Map Register Label Name (8 characters)	**MOD_119**	:= ______________
User Map Register Label Name (8 characters)	**MOD_120**	:= ______________

User Map Register Label Name (8 characters)	**MOD_121**	**:=** ____________________
User Map Register Label Name (8 characters)	**MOD_122**	**:=** ____________________
User Map Register Label Name (8 characters)	**MOD_123**	**:=** ____________________
User Map Register Label Name (8 characters)	**MOD_124**	**:=** ____________________
User Map Register Label Name (8 characters)	**MOD_125**	**:=** ____________________

Section 7
Communications

Overview

A communications interface and protocol are required for communicating with the SEL-710 Motor Protection Relay. A communications interface is the physical connection on a device. Once you have established a physical connection, you must use a communications protocol to interact with the relay.

The first part of this section describes communications interfaces and protocols available with the relay, including communications interface connections. The remainder of the section describes the ASCII commands you can use to communicate with the relay to obtain information, reports, data, or perform control functions.

Communications Interfaces

The SEL-710 physical interfaces are shown in *Table 7.1*. Several optional SEL devices are available to provide alternative physical interfaces, including EIA-485, EIA-232 fiber-optic serial port, copper or fiber-optic Ethernet port, single- or dual-redundant.

Table 7.1 SEL-710 Communications Port Interfaces

Port	Communications Port Interface	Location	Feature
PORT F	EIA-232	Front	Standard
PORT 1	Option 1: 10/100BASE-T Ethernet (RJ45 connector) Option 2: Dual, redundant 10/100BASE-T Ethernet (Port 1A, Port 1B) Option 3: 100BASE-FX Ethernet (LC connector) Option 4: Dual, redundant 100BASE-FX Ethernet (Port 1A, Port 1B)	Rear	Ordering Option
PORT 2 [a]	Multimode Fiber-Optic	Rear	Standard
PORT 3	Option 1: EIA-232 Option 2: EIA-485	Rear	Ordering Option
PORT 4	Option 1: EIA-232 or EIA-485 Serial Communications Card Option 2: DeviceNet Communications Card [b]	Rear	Ordering Option

[a] This port can receive the RTD measurement information from the optional external SEL-2600 RTD Module. Refer to the applicable SEL-2600 RTD Module Instruction Manual for information on the fiber-optic interface.
[b] Refer to Appendix F: DeviceNet Communications for information on the DeviceNet communications card.

Be sure to evaluate the installation and communications necessary to integrate with existing devices before ordering your SEL-710. For example, consider the fiber-optic interface in noisy installations or for large communications distances. General information on possible applications of the different interfaces follows.

Serial (EIA-232 and EIA-485) Port

Use the EIA-232 port for communications distances as long as 15 m (49 ft) in low noise environments. Use the optional EIA-485 port for communications distances as long as 1200 m (3937 ft) maximum distance (to achieve this performance, ensure proper line termination at the receiver).

To connect a PC serial port to the relay front-panel serial port and enter relay commands, you 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-710 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 series fiber-optic transceivers
- ➤ SEL-2890 Ethernet Transceiver
- ➤ SEL-2505 Remote I/O Module (with SEL-2812 compatible ST fiber-optic port) for connection to relay fiber-optic serial Port 2, or use SEL-2505 with EIA-232 (DB-9) serial port to connect to EIA-232 Port 3 on the relay

A variety of terminal emulation programs on personal computers can communicate with the relay. For the best display, use VT-100 terminal emulation or the closest variation.

The default settings for all EIA-232 serial ports are listed below:

Data Rate = 9600
Data Bits = 8
Parity = N
Stop Bits = 1

To change the port settings, use the **SET P** command (see *Section 6: Settings*) or the front panel. *Section 8: Front-Panel Operations* provides details on making settings with the front panel.

Hardware Flow Control

All EIA-232 serial ports support RTS/CTS hardware handshaking (hardware flow control). To enable hardware handshaking, use the **SET P** command or front-panel PORT submenu to set RTSCTS := Y. Disable hardware handshaking by setting RTSCTS := N.

- ➤ If RTSCTS := N, the relay permanently asserts the RTS line.
- ➤ If RTSCTS := Y, the relay deasserts RTS when it is unable to receive characters.
- ➤ If RTSCTS := Y, the relay does not send characters until the CTS input is asserted.

Fiber-Optic Serial Port

Use the fiber-optic port (Port 2) for safety and communications distances as far as 1 km. Communications distances as far as 4 km can be achieved by using an SEL-2812 fiber-optic transceiver on Port 3. While Port 2 and the SEL-2812 are compatible, Port 2 is less sensitive than the SEL-2812, which limits the distance to 1 km. This port can receive the RTD measurement information from the optional external SEL-2600 RTD Module.

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. SEL-710 Ethernet port choices include single or dual copper or fiber-optic configurations. With dual Ethernet ports the unit has an unmanaged Ethernet switch. Redundant configurations support automatic failover switching from primary to backup network if a failure in the primary network is detected. In addition to failover mode, the unit can operate in a "fixed connection (to netport) mode" or in a "switched mode" (as an unmanaged switch).

Figure 7.1 shows an example of a Simple Ethernet Network Configuration, *Figure 7.2* shows an example of an Ethernet Network Configuration with Dual Redundant Connections, and *Figure 7.3* shows an example of an Ethernet Network Configuration with Ring Structure.

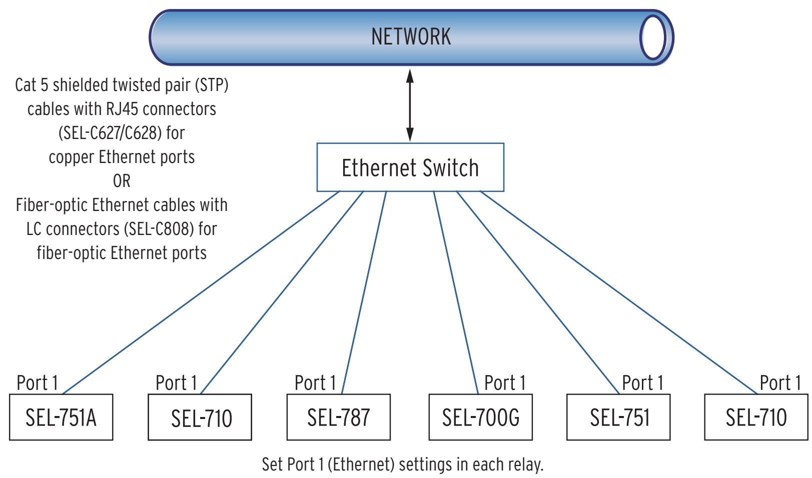


Figure 7.1 Simple Ethernet Network Configuration

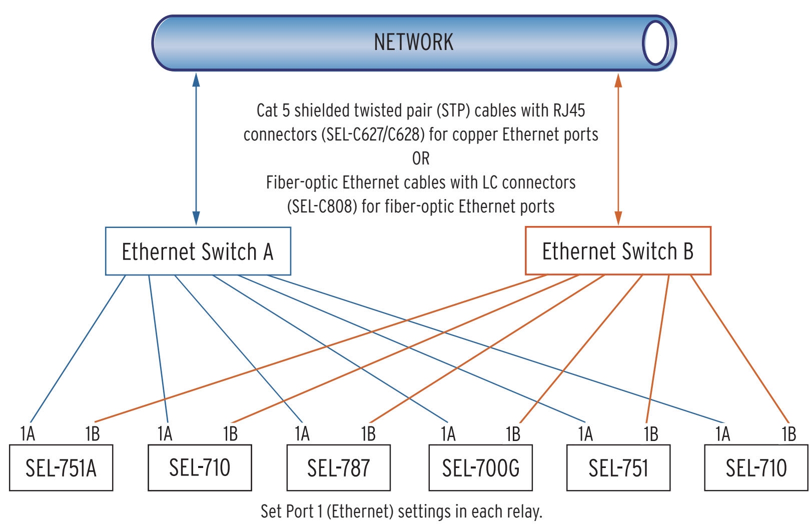


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

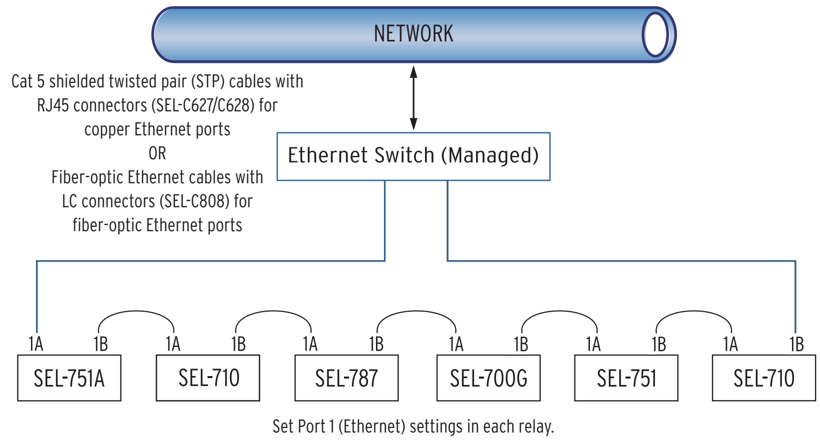


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-710 dual Ethernet port option has two network ports. Network port failover mode enables the dual Ethernet port to operate as a single network adapter with a primary and standby physical interface. You can connect the two network ports to the same network or to different networks depending on your specific Ethernet network architecture.

Failover Mode

In the failover mode operation, the relay determines the active port. To use failover mode, proceed with the following steps.

NOTE: If you change settings for the host port in the relay and the standby network port is active, the relay resets and returns to operation on the primary port.

Step 1. Set NETMODE to FAILOVER.

Step 2. Set FTIME to the desired network port failover time.

Step 3. Set NETPORT to the preferred network interface.

On startup the relay communicates via NETPORT (primary port) selected. If the SEL-710 detects a link failure on the primary port, it activates the standby port after the failover time, FTIME, elapses. If the link status on the primary link returns to normal before the failover time expires, the failover timer resets and uninterrupted operation continues on the primary network port.

After failover, while communicating via standby port, the SEL-710 checks the primary link periodically and continues checking until it detects a normal link status. The relay continues to communicate via the standby port even after the primary port returns to normal. The port of choice for communications is reevaluated on change of settings or failure of the standby port or on reboot. The relay returns to operation on the primary link under those conditions if it detects a normal link status. When the active and backup links both fail, the relay alternates checking for the link status of the primary and standby ports.

Unmanaged Switch Mode

If you have a network configuration where you want to use the relay as an unmanaged switch, set NETMODE to SWITCHED. In this mode, both links are enabled. The relay will respond to the messages received on either port. All the messages received on one network port that are not addressed to the relay will be transmitted out of the other port without any modifications. In this mode NETPORT setting is ignored.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates and the other port is disabled.

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports are capable of autonegotiating to determine the link speed and duplex mode. This is accomplished by setting the NETASPD and NETBSPD (network speed) to AUTO. Single or dual copper ports can also be set to a specific speed to be able to apply them in networks with older switch devices. However, the speed setting is ignored for fiber Ethernet ports. The single and dual fiber Ethernet ports are fixed by the hardware to work at 100 Mbps and full duplex mode.

NETPORT Selection

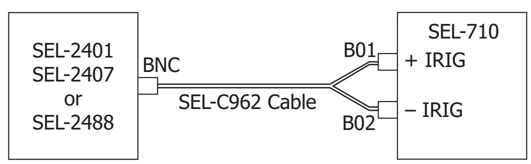
The NETPORT setting gives the user the option to select the primary port of communication in failover or fixed communication modes.

IRIG-B

The SEL-710 has three different physical interfaces, depending on the model options, to provide demodulated IRIG-B time-code input for time synchronization. If the relay has multiple options for IRIG-B input, only one input can be used at a time. Connection diagrams for IRIG-B and settings selection are in *Figure 7.4* through *Figure 7.8* in this section.

Option 1: Terminals B01 and B02

This input is available on all models except models with dual Ethernet Port or Fiber-Optic Ethernet port. Refer to *Figure 7.4* for a connection diagram.



B01–B02 IRIG-B input is available on all models except those with fiber-optic Ethernet or dual-copper Ethernet.

Cannot bring IRIG-B via Port 2 or 3 if **B01–B02** input is used.

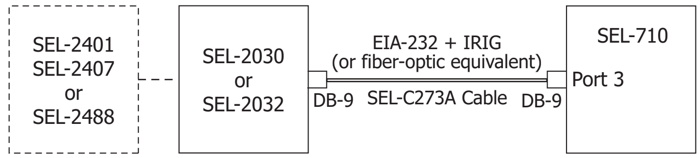
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.4 IRIG-B Input (Relay Terminals B01–B02)

Option 2: Port 3 (EIA-232 Option Only)

Connect to an SEL communications processor with SEL-C273A Cable to bring IRIG-B input with the EIA-232 Port. Refer to *Figure 7.5* for a connection diagram.

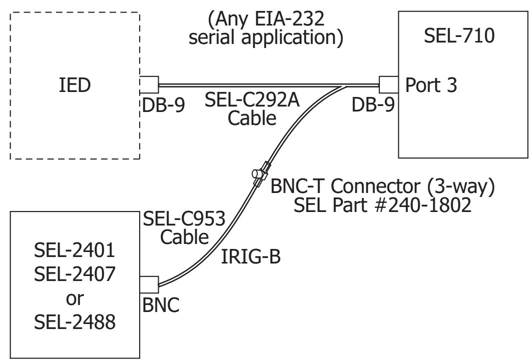
Refer to *Figure 7.6* on how to connect a SEL Time Source (SEL-2401, SEL-2407, SEL-2488) for IRIG-B Input to Port 3.



Cannot use **B01–B02** input or Port 2 if Port 3 is used.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.5 IRIG-B Input Via EIA-232 Port 3 (SEL Communications Processor as Source)



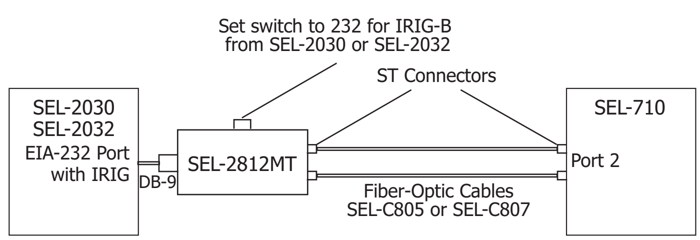
Cannot use **B01–B02** input or Port 2 if Port 3 is used.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.6 IRIG-B Input Via EIA-232 Port 3 (SEL-2401/2407/2488 Time Source)

Option 3: Port 2 (Fiber-Optic Serial Port)

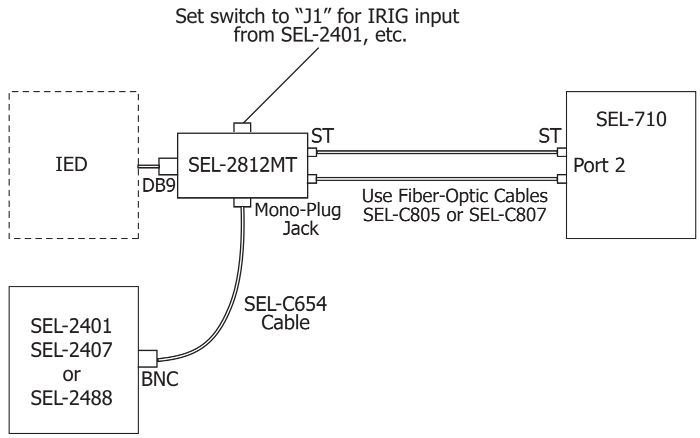
Fiber-Optic Serial Port 2 can be used to bring IRIG-B Input to the relay as shown in *Figure 7.7* and *Figure 7.8*.



Cannot use **B01–B02** input or Port 3 input if Port 2 is used for IRIG-B input.

Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG2.

Figure 7.7 IRIG-B Input Via Fiber-Optic EIA-232 Port 2 (SEL-2030/2032 Time Source)



Cannot use **B01–B02** input or Port 3 input if Port 2 is used for IRIG-B input.
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG2.

Figure 7.8 IRIG-B Input Via Fiber-Optic EIA-232 Port 2 (SEL-2401/2407/2488 Time Source)

Time Quality of the IRIG Source

The time synchronization Relay Word bits in *Table 7.2* indicate the present status of the timekeeping function of the SEL-710.

Table 7.2 Time Synchronization Relay Word Bits

Name	Description
IRIGOK	Asserts while relay time is based on IRIG-B time source.
TSOK	Time synchronization OK. Asserts while time is based on an IRIG-B time source of sufficient accuracy.

The SEL-710 determines the suitability of the IRIG-B signal for normal accuracy by applying several tests:

- Seconds, minutes, and day fields are in range.
- Time from two consecutive messages differs by one second, except for leap second or daylight-saving time transitions.
- When IRIGC := C37.118, the signal contains the correct parity bit.

NOTE: The jitter measurement for the IRIG signal could take as long as 15 seconds to determine. During this time, TSOK is not asserted.

NOTE: The SEL-710 does not support synchrophasors, and the TSOK bit will always be 0.

The SEL-710 determines the suitability of the IRIG-B signal for high-accuracy timekeeping by applying two additional tests:

- The jitter between positive transitions (rising edges) of the clock signal is less than 500 ns.
- The time-error information contained in the IRIG-B control field indicates a time error of less than 10^{-6} seconds (1 µs).

The time error information in the IRIG-B control field is mapped to the TQUAL bits in the relay. *Table 7.3* lists the TQUAL bits and how they translate to time quality. The values 0 (Locked) and 4 (1 µs) indicate that the relay is receiving high-accuracy IRIG. When the IRIG signal is lost, IRIGOK deasserts.

Table 7.3 TQUAL Bits Translation to Time Quality

TQUAL8	TQUAL4	TQUAL2	TQUAL1	Value	Time Quality
0	0	0	0	0	Locked
0	0	0	1	1	1 nanosecond
0	0	1	0	2	10 nanoseconds
0	0	1	1	3	100 nanoseconds
0	1	0	0	4	1 microsecond
0	1	0	1	5	10 microseconds
0	1	1	0	6	100 microseconds
0	1	1	1	7	1 millisecond
1	0	0	0	8	10 milliseconds
1	0	0	1	9	100 milliseconds
1	0	1	0	10	1 second
1	0	1	1	11	10 seconds
1	1	0	0	12	100 seconds
1	1	0	1	13	1000 seconds
1	1	1	0	14	10000 seconds
1	1	1	1	15	Fault

+5 Vdc Power Supply

Serial port power can provide as much as 0.25 A total from all of the +5 Vdc pins. Some SEL communications devices require the +5 Vdc power supply. This +5 Vdc is available only on Pin 1 of the DB-9 connector for the EIA-232 ports.

Connect Your PC to the Relay

The front port of the SEL-710 is a standard female 9-pin connector with pin numbering shown in *Figure 7.9*. The pinout assignments for this port are shown in *Table 7.4*. You can connect to a standard 9-pin computer port with an SEL-C662 Cable; wiring for this cable is shown in *Figure 7.10*. The SEL-C662 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 at selinc.com.

For best performance, the SEL-C662 cable should not be more than 15 m (49 ft) long. For long-distance communications and for electrical isolation of communications ports, use the SEL family of fiber-optic transceivers. Contact SEL for more details on these devices.

Port Connector and Communications Cables

Figure 7.9 shows the front-panel EIA-232 serial port (PORT F) DB-9 connector pinout for the SEL-710.

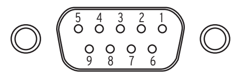


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

Table 7.4 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.4 EIA-232/EIA-485 Serial Port Pin Functions

Pin[a]	PORT 3 EIA-232[b]	PORT 3 EIA-485[a]	PORT 4C EIA-232	PORT 4A EIA-485[a]	PORT F EIA-232
1	+5 Vdc	+TX	+5 Vdc	+TX	N/C
2	RXD	–TX	RXD	–TX	RXD
3	TXD	+RX	TXD	+RX	TXD
4	IRIG+	–RX	N/C	–RX	N/C
5	GND	Shield	GND	Shield	GND
6	IRIG–		N/C		N/C
7	RTS		RTS		RTS
8	CTS		CTS		CTS
9	GND		GND		GND

[a] For EIA-485, the pin numbers represent relay terminals _01 through _05.
[b] For relays with the PTC option, this port does not support IRIG-B.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-710 to other devices. These and other cables are available from SEL. Contact the factory for more information.

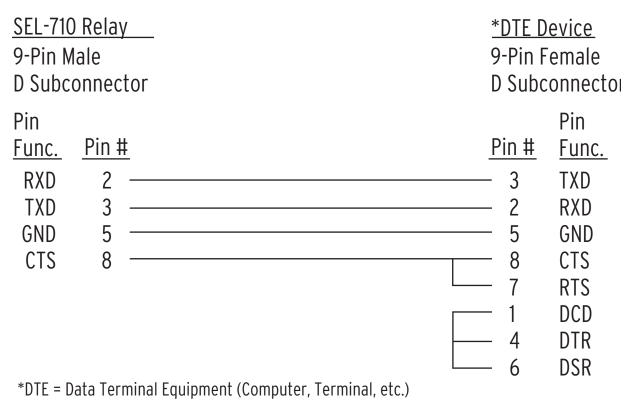


Figure 7.10 SEL-C662 Cable—SEL-710 to DTE Device

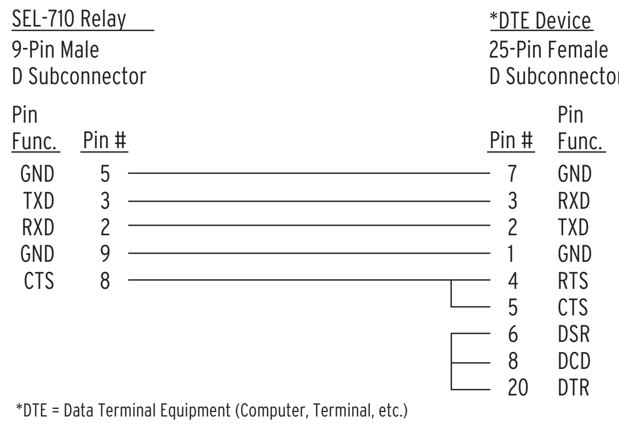


Figure 7.11 SEL-C227A Cable—SEL-710 to DTE Device

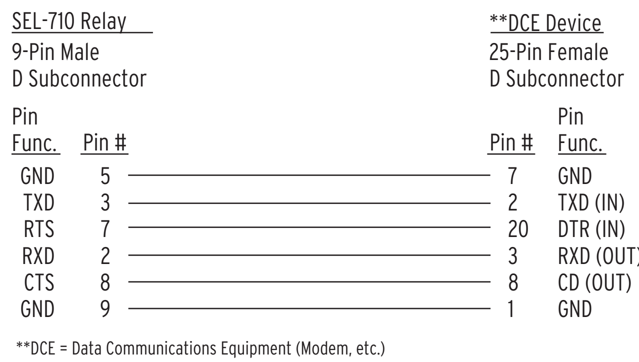


Figure 7.12 SEL-C222 Cable—SEL-710 to Modem

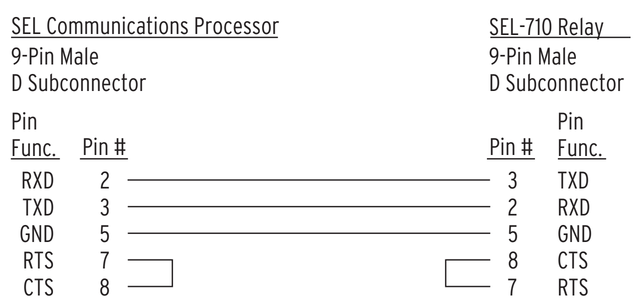


Figure 7.13 SEL-C272A Cable—SEL-710 to SEL Communications Processor (Without IRIG-B Signal)

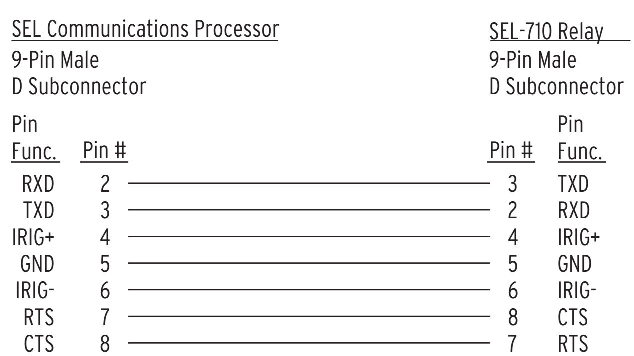


Figure 7.14 SEL-C273A Cable—SEL-710 to SEL Communications Processor (With IRIG-B Signal)

Communications Protocols

Protocols

Although the SEL-710 supports a wide range of protocols, not all protocols are available on all ports. In addition, not all hardware options support all protocols.

Be sure to select the correct hardware to support a particular protocol. For example, if Modbus TCP is necessary for your application, be sure to order the Ethernet option for **Port 1**. *Table 7.5* shows the ports and the protocols available on each port.

NOTE: FTP, Modbus, and DeviceNet protocols ignore the hide rules of the settings.

Table 7.5 Protocols Supported on the Various Ports

PORT	Supported Protocol
PORT F	SEL ASCII and Compressed ASCII Protocols, SELBOOT, File Transfer Protocol, and Modbus RTU Slave
PORT 1[a]	Modbus TCP/IP, FTP, TCP/IP, IEC 61850, SNTP, and Telnet TCP/IP (SEL ASCII, Compressed ASCII, SEL Fast Meter, Fast Operate, and Fast SER)
PORT 2	All the protocols supported by **PORT 3**
PORT 3	SEL ASCII and Compressed ASCII Protocols; SEL Fast Meter, Fast Operate, Fast SER, Settings File Transfer, and MIRRORED BITS; and Modbus RTU Slave
PORT 4	All the protocols supported by **PORT 3** and DeviceNet

[a] PORT 1 concurrently supports two Modbus, two FTP, two Telnet, one SNTP, and six IEC 61850 sessions.

SEL Communications Protocols

SEL ASCII. This protocol is described in *SEL ASCII Protocol and Commands on page 7.15*.

SEL Compressed ASCII. This protocol provides compressed versions of some of the ASCII commands. The compressed commands are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Meter. This protocol supports binary messages to transfer metering and digital element messages. Compressed ASCII commands that support Fast Meter are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Operate. This protocol supports binary messages to transfer operation messages. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast SER. This protocol is used to receive binary Sequential Events Record unsolicited responses. The protocol is described in *Appendix C: SEL Communications Processors*.

MIRRORED BITS Protocol

The SEL-710 supports two MIRRORED BITS communications channels, designated A and B. Within each MIRRORED BITS communications message for a given channel (A or B), there are eight logical data channels (1–8). You can, for example, set MBA on **Port 3** of the base unit and MBB on **Port 4A** of the optional communications card. Attempting to set the PROTO setting to MBA, MB8A, or MBTA when channel A is already assigned to another port (or MBB, MB8B, or MBTB when channel B is already assigned on another port) results in the following error message: `This Mirrored Bits channel is assigned to another port`. After displaying the error message, the device returns to the PROTO setting for reentry.

Modbus RTU Protocol

The SEL-710 provides Modbus RTU support. Modbus is a protocol described in *Appendix D: Modbus Communications*.

DeviceNet

The SEL-710 provides DeviceNet Support. DeviceNet is an optional protocol described in *Appendix F: DeviceNet Communications*.

Ethernet Protocols

As with other communications interfaces, you must choose a data exchange protocol that operates over the Ethernet network link to exchange data. The relay supports FTP, Telnet, Ping, Modbus/TCP, and IEC 61850 protocols.

You should carefully design your Ethernet network to maximize reliability, minimize system administration effort, and provide adequate security. Work with a networking professional to design your substation Ethernet network.

FTP Server

Use the single FTP (File Transfer Protocol) session to access the following files:

CFG.XML	Configuration read-only file in XML format
CFG.TXT	Configuration read-only file in TXT format
ERR.TXT	Error read-only file in text format
SET_61850.CID	IEC 61850 CID read-write file
SET_xx.TXT	Setting files in TXT format

FTP is a standard TCP/IP protocol for exchanging files. A free FTP application is included with most web browser software. You can also obtain a free or inexpensive FTP application from the Internet. When you connect to the relay Ethernet port, you will find files stored in the root (top-level) directory.

Telnet Server

Use the Telnet session (TPORT default setting is Port 23) to connect to the relay to use the protocols, which are described in more detail below:

- SEL ASCII
- Compressed ASCII
- Fast Meter
- Fast Operate

NOTE: Use the **QUIT** command prior to closing the Telnet-to-Host session to set the relay to Access Level 0. Otherwise the relay will remain at an elevated access level until TIDLE expires.

Telnet is a terminal connection across a TCP/IP network that operates in a manner very similar to a direct serial port connection to one of the relay ports. As with FTP, Telnet is a part of TCP/IP. A free Telnet application is included with most computer operating systems, or you can obtain low-cost or free Telnet applications on the Internet.

Ping Server

Use a Ping client with the relay Ping server to verify that your network configuration is correct.

Ping is an application based on ICMP over an IP network. A free Ping application is included with most computer operating systems.

IEC 61850

Use as many as six sessions of MMS over a TCP network to exchange data with the relay. Use GOOSE to do real-time data exchange with as many as 16 incoming messages and 8 outgoing messages. For more details on the IEC 61850 protocol, see *Appendix E: IEC 61850 Communications*.

Simple Network Time Protocol (SNTP)

When Port 1 (Ethernet port) setting ESNTP is not OFF, the internal clock of the relay conditionally synchronizes to the time of day served by a Network Time Protocol (NTP) server. The relay uses a simplified version of NTP called the Simple Network Time Protocol (SNTP). SNTP is not as accurate as IRIG-B. The relay can use SNTP as a less accurate primary time source, or as a backup to the higher accuracy IRIG-B time source.

SNTP as Primary or Backup Time Source

If an IRIG-B time source is connected and either Relay Word bit TSOK or Relay Word bit IRIGOK asserts, then the relay synchronizes the internal time-of-day clock to the incoming IRIB-G time code signal, even if SNTP is configured in the relay and an NTP server is available. If the IRIG-B source is disconnected (if both TSOK and IRIGOK deassert) then the relay synchronizes the internal time-of-day clock to the NTP server, if available. In this way, an NTP server acts either as the primary time source or as a backup time source to the more accurate IRIG-B time source.

Creating an NTP Server

Three SEL application notes, available from the SEL website, describe how to create an NTP server.

- *AN2009-10: Using an SEL-2401, SEL-2404, or SEL-2407 to Serve NTP Via the SEL-3530 RTAC*
- *AN2009-38: Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3354 to Output NTP*
- *AN2010-03: Using an SEL-2401, SEL-2404, or SEL-2407 to Create a Stratum 1 Linux NTP Server*

Configuring SNTP Client in the Relay

To enable SNTP in the relay, make Port 1 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 7.6* shows each setting associated with SNTP.

Table 7.6 Settings Associated With SNTP

Setting	Range	Description
ESNTP	UNICAST, MANYCAST, BROADCAST	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes on page 7.14*.
SNTPPSIP	Valid IP Address	Selects primary NTP server when ESNTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
SNTPPSIB	Valid IP Address	Selects backup NTP server when ESNTP = UNICAST.
SNTPPORT	1–65534	Ethernet port used by SNTP. Leave at default value unless otherwise required.
SNTPRATE	15–3600 seconds	Determines the rate at which the relay asks for updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the time the relay will wait for an NTP broadcast when ESNTP = BROADCAST.
SNTPTO	5–20 seconds	Determines the time the relay will wait for the NTP master to respond when ESNTP = UNICAST or MANYCAST.

SNTP Operation Modes

The following sections explain the setting associated with each SNTP operation mode (UNICAST, MANYCAST, and BROADCAST).

ESNTP = UNICAST

In unicast mode of operation, the SNTP client in the relay requests time updates from the primary (IP address setting SNTPPSIP) or backup (IP address setting SNTPBSIP) NTP server at a rate defined by setting SNTPRATE. If the NTP server does not respond with the period defined by setting SNTPTO, then the relay tries the other SNTP server. When the relay successfully synchronizes to the primary NTP time server, Relay Word bit TSNTPP asserts. When the relay successfully synchronizes to the backup NTP time server, Relay Word bit TSNTPB asserts.

ESNTP = MANYCAST

In the manycast mode of operation, the relay initially sends an NTP request to the broadcast address contained in setting SNTPPSIP. The relay continues to broadcast requests at a rate defined by setting SNTPRATE. When a server replies, the relay considers that server to be the primary NTP server, and switches to UNICAST mode, asserts Relay Word bit TSNTPP, and thereafter requests updates from the primary server. If the NTP server stops responding for time SNTPTO, the relay deasserts TSNTPP and begins to broadcast requests again until the original or another server responds.

ESNTP = BROADCAST

If setting SNTPPSIP = 0.0.0.0 while setting ESNTP = BROADCAST, the relay will listen for and synchronize to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the relay will listen for and synchronize to only NTP server broadcasts from that address. When synchronized, the relay asserts Relay Word bit TSNTPP. Relay Word bit TNSTPP deasserts if the relay does not receive a valid broadcast within five seconds after the period defined by setting SNTPRATE.

SNTP Accuracy Considerations

SNTP time-synchronization accuracy is limited by the accuracy of the SNTP Server and by the networking environment. The highest degree of SNTP time synchronization can be achieved by minimizing the number of switches and routers between the SNTP Server and the SEL-710. Network monitoring software can also be used to ensure that average and worst-case network bandwidth use is moderate.

When installed on a network configured with one Ethernet switch between the SEL-710 and the SNTP Server, and when using ESNTP = UNICAST or MANYCAST, the relay time-synchronization error with the SNTP server is typically less than ±1 millisecond.

SEL ASCII Protocol and Commands

Message Format

SEL ASCII protocol is designed for manual and automatic communication. All commands the relay receives must be of the following form:

```
<command><CR>  or  <command><CRLF>
```

NOTE: The **<Enter>** key on most keyboards is configured to send the ASCII character 13 (**<Ctrl+M>**) for a carriage return. This manual instructs you to press the **<Enter>** key after commands to send the proper ASCII code to the SEL-710.

A command transmitted to the relay consists of the command followed by either a CR (carriage return) or a CRLF (carriage return and line feed). You can truncate commands to the first three characters. For example, **EVENT 1 <Enter>** becomes **EVE 1 <Enter>**. Use upper- and lowercase characters without distinction, except in passwords.

The relay transmits all messages in the following format:

```
<STX><MESSAGE LINE 1><CRLF>
<MESSAGE LINE 2><CRLF>
.
.
.
<LAST MESSAGE LINE><CRLF><ETX>
```

Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

Software Flow Control

The relay implements XON/XOFF flow control. You can use the XON/XOFF protocol to control the relay during data transmission. When the relay receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the relay receives XOFF, it blocks transmission of any message presented to the relay input buffer. Messages will be accepted after the relay receives XON.

The relay transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking is enabled) when the relay input buffer drops below 25 percent full.

The relay transmits XOFF (ASCII hex 13) when the buffer is more than 75 percent full. If hardware handshaking is enabled, the relay deasserts the RTS output when the buffer is approximately 95 percent full. Automatic transmission sources should monitor for the XOFF character to avoid overwriting the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and can resume when the relay sends XON.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful for terminating an unwanted transmission. You can send control characters from most keyboards with the following keystrokes:

- XOFF**: <Ctrl+S>** (hold down the **<Ctrl>** key and press **S**)
- XON: **<Ctrl+Q>** (hold down the **<Ctrl>** key and press **Q**)
- CAN: **<Ctrl+X>** (hold down the **<Ctrl>** key and press **X**)

Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. *Table 7.7* lists these messages.

Table 7.7 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-710 sends a status report each time a self-test warning or failure condition is detected. See *STATUS Command (Relay Self-Test Status) on page 7.41*.

Access Levels

Commands can be issued to the SEL-710 via the serial port or Telnet session to view metering values, change relay settings, etc. The available serial port commands are listed in the *SEL-710 Command Summary* at the end of this manual. These commands can be accessed only from the corresponding access level, as shown in the *SEL-710 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-710, 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-710 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-710 to Access Level 1. See *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.19* for more detail.

Access Level 1

When the SEL-710 is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-710 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-710 sends the prompt:

```
=>>
```

See the *SEL-710 Command Summary* at the end of this manual for the commands available from Access Level 2.

Any of the Access Level 1 commands are also available in Access Level 2.

Access Level C

The CAL access level is used exclusively by the SEL factory and SEL field service personnel to diagnose troublesome installations. 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-710 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-710 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 7.8 lists the header items and their definitions.

Table 7.8 Command Response Header Definitions

Item	Definition
`[RID Setting]`:	This is the RID (Relay Identifier) setting. The relay ships with the default setting `RID = 710`; see *ID Settings on page 4.3*.
`[TID Setting]`:	This is the TID (Terminal Identifier) setting. The relay ships with the default setting `TID = MOTOR RELAY`; see *ID Settings on page 4.3*.
`Date`:	This is the date when the command response was given, except for relay response to the **EVE** command (Event), when it is the date the event occurred. You can modify the date display format (Month/Day/Year, Year/Month/Day, or Day/Month/Year) by changing the DATE_F relay setting.
`Time`:	This is the time when the command response was given, except for relay response to the **EVE** command, when it is the time the event occurred.
`Time Source`:	This is internal if no time-code input is attached and external if an input is attached.

Command Explanations

This section lists ASCII commands alphabetically. Commands, command options, and command variables to enter are shown in bold. Lowercase italic letters and words in a command represent command variables that are determined based on the application. For example, time ***t*** = 1 to 30 seconds, remote bit number ***n*** = 01 to 32, and ***level***.

Command options appear with brief explanations about the command function. Refer to the references listed with the commands for more information on the control function corresponding to the command or examples of the control response to the command.

You can simplify the task of entering commands by shortening any ASCII command to the first three characters; for example, **ACCESS** becomes **ACC**. Always send a carriage return **<CR>** character or a carriage return character followed by a line feed character **<CR><LF>** to command the control to process the ASCII command. Usually, most terminals and terminal programs interpret the Enter key as a **<CR>**. For example, to send the **ACCESS** command, type **ACC <Enter>**.

Tables in this section show the access level(s) where the command or command option is active. Access levels in this device are Access Level 0, Access Level 1, and Access Level 2.

Access Commands (ACCESS, 2ACCESS, and CAL)

The **ACC**, **2AC**, and **CAL** commands (see *Table 7.9*) provide entry to the multiple access levels. Different commands are available at the different access levels, as shown in the *SEL-710 Command Summary* at the end of this manual. Commands **ACC** and **2AC** are explained together because they operate similarly. See *Access Levels on page 7.16* for a discussion of placing the relay in an access level.

Table 7.9 ACCESS Commands

Command	Description	Access Level
ACC	Moves from Access Level 0 to Access Level 1.	0
2AC	Moves from Access Level 1 to Access Level 2.	1
CAL	Moves from Access Level 2 to Access Level C.	2

Password Requirements

Passwords are required unless they are disabled. See *PASSWORD Command (Change Passwords) on page 7.34* for the list of default passwords and for more information on changing and disabling passwords.

Access Level Attempt (Password Required). Assume the following conditions:

- Access Level 1 password is not disabled.
- Access Level is 0.

At the Access Level 0 prompt, enter the **ACC** command:

```
=ACC <Enter>
```

Because the password is not disabled, the relay prompts you for the Access Level 1 password:

```
Password: ?
```

The relay is shipped with the default Access Level 1 password shown in *PASSWORD Command (Change Passwords) on page 7.34*. At the prompt, enter the default password and press the **<Enter>** key. The relay responds with the following:

```
[RID Setting]                              Date: mm/dd/yyyy  Time: hh:mm:ss
[TID Setting]                              Time Source: external

Level 1
=>
```

The => prompt indicates 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 **ANA** command to test an analog output by temporarily assigning a value to an analog output channel (see *Table 7.10* for the command description and the format). After entering the **ANA** command, the device suspends normal operation of the analog output channel and scales the output to a percentage of full scale. After assigning the specified value for the specified time, the device returns to normal operation. Entering any character (including pressing the space key) ends the command before reaching the specified interval completion. You can test the analog output in one of the following two modes:

- ➤ Fixed percentage: Outputs a fixed percentage of the signal for a specified duration
- ➤ Ramp: Ramps the output from minimum to maximum of full scale over the time specified

Table 7.10 ANALOG Command

Command	Description	Access Level
ANA *c p t*	Temporarily assigns a value to an analog output channel.	2
Parameters		
c	The analog channel (either the channel name, e.g., A0301, or the channel number, e.g., 301)	
p	A percentage of full scale, or either the letter "R" or "r" to indicate ramp mode	
t	The duration (in decimal minutes) of the test	

NOTE: 0% = low span, 100% = high span. For a scaled output from 4–20 mA, 0 percent is 4 mA and 100 percent is 20 mA.

When parameter *p* is a percentage, the relay displays the following message during the test:

```
Outputting xx.xx [units] to Analog Output Port for y.y minutes. Press any key to end
    test
```

where:

`xx.xx` is the calculation of percent of full scale
`[units]` is either mA or V, depending on the channel type setting
`y.y` is the time in minutes

When parameter *p* is a ramp function, the device displays the following message during the test:

```
Ramping Analog Output at xx.xx [units]/min; full scale in y.y minutes. Press any key
    to end test
```

where:

`xx.xx` is the calculation based upon range/time *t*
`[units]` is either mA or V, depending on the channel type setting
`y.y` is the time in minutes

For either mode of operation (percentage or ramp), when the time expires, or upon pressing a key, the analog output port returns to normal operation and the device displays the following message:

```
Analog Output Port Test Complete
```

Example 1

The following is an example of the device response to the **ANA** command in the percentage mode. For this example, we assume the analog output signal type is 4–20 mA, and we want to test the analog output at 75 percent of rating for 5.5 minutes. To check the device output, calculate the expected mA output as follows:

$$\text{Output} = \left[(20.00\text{ mA} - 4.00\text{ mA}) \bullet \frac{75}{100}\right] + 4.00\text{ mA} = 16.00\text{ mA}$$

To start the test, enter **ANA AO301 75 5.5** at the Access Level 2 prompt:

```
=>>ANA AO301 75 5.5 <Enter>
Outputting 16.00 mA to Analog Output Port for 5.5 minutes.
Press any key to end test
```

Example 2

The following is an example of the ramp mode when the analog output signal type is 4–20 mA for a 9.0 minute test.

To check the device output, calculate the current/time (mA/min) output as follows:

$$\text{Output} = \left[\frac{20.00\text{ mA} - 4.00\text{ mA}}{9.0\text{ min}}\right] = 1.78\text{ mA/min}$$

To start the test, enter **ANA AO301 R 9.0** at the Access Level 2 prompt:

```
=>>ANA AO301 R 9.0 <Enter>
Ramping Analog Output at 1.78 mA/min; full scale in 9.0 minutes.
Press any key to end test
```

BRE Command (Breaker Monitor Data)

Use the **BRE** command (Access Level 1) to view the breaker monitor report. See *Breaker Monitor on page 5.11* for further details on the breaker monitor.

```
=>BRE <Enter>

SEL-710                                    Date: 12/04/2009   Time: 14:26:57
MOTOR PROTECTION RELAY                     Time Source: External

Trip Counters

Rly Trips (counts)      32
Ext Trips (counts)       0

Cumulative Interrupted Currents

                 IA     IB     IC
Rly Trips (kA)  538.1  483.6  485.5
Ext Trips (kA)    0.0    0.0    0.0

Breaker Contact Wear

           A    B    C
Wear (%)   48   37   36

LAST RESET  11/25/2009 11:16:21

=>
```

See *Breaker Monitor on page 5.11* for further details on the breaker monitor.

BRE n Command (Preload/Reset Breaker Wear)

The **BRE W** command (Access Level 2) only saves new settings after the `Save Changes (Y/N)?` message. If a data entry error is made using the **BRE W** command, the values echoed after the `Invalid format, changes not saved` message are the previous **BRE** values, unchanged by the aborted **BRE W** attempt.

```
=>>BRE W <Enter>

Breaker Wear Percent Preload

Relay (or Internal) Trip Counter (0-65000)    =     0     ? 14  <Enter>

Internal Current (0.0-999999 kA)      IA      = 0.0      ? 32.4  <Enter>

                                      IB      = 0.0      ? 18.6  <Enter>

                                      IC      = 0.0      ? 22.6  <Enter>
```

```
External Trip Counter (0-65000)               =     0     ? 2  <Enter>

External Current (0.0-999999 kA)      IA      = 0.0      ? 0.8  <Enter>

                                      IB      = 0.0      ? 0.6  <Enter>

                                      IC      = 0.0      ? 0.7  <Enter>

Percent Wear (0-100%)                 A-phase =   0       ? 22  <Enter>

                                      B-phase =   0       ? 28  <Enter>

                                      C-phase =   0       ? 25  <Enter>


Last Reset                            Date    = 12/04/2009 ? 12/04/2009  <Enter>

                                      Time    = 14:27:10  ? 17:50:12  <Enter>

Save changes (Y,N)? Y <Enter>

=>>
```

Use the **BRE R** command to reset the breaker monitor:

```
=>>BRE R <Enter>

Reset Breaker Wear (Y,N)? Y <Enter>
Clearing Complete

=>>LAST RESET 02/03/10 05:41:07
```

See *Breaker Monitor on page 5.11* for further details on the breaker monitor.

CEV Command

The SEL-710 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and SEL-5601-2 SYNCHROWAVE Event Software take advantage of the Compressed ASCII format. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** (**CEV**) command to display Compressed ASCII event reports. See *Table C.2* for further information. Compressed ASCII Event Reports contain all of the Relay Word bits. The **CEV R** command gives the raw Compressed ASCII event report.

COMMUNICATIONS Command

The **COM *x*** command (see *Table 7.11*) displays communications statistics for the MIRRORED BITS communications channels. For more information on MIRRORED BITS communications, see *Appendix G: MIRRORED BITS Communications*. The summary report includes information on the failure of ROKA or ROKB. The Last Error field displays the reason for the most recent channel error, even if the channel was already failed. We define failure reasons as one of the following error types:

- Device disabled
- Framing error
- Parity error
- Overrun
- Re-sync
- Data error
- Loopback
- Underrun

Table 7.11 COM Command

Command	Description	Access Level
COM S A or **COM S B**	Return a summary report of the last 255 records in the communications buffer for either MIRRORED BITS communications Channel A or Channel B when only one channel is enabled.	1
COM A	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Return a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.	1
COM C	Clears all communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.	1
COM C A	Clears all communications records for Channel A.	1
COM C B	Clears all communications records for Channel B.	1

CONTROL Command (Control Remote Bit)

Use the **CON** command (see *Table 7.12*) to control remote bits (Relay Word bits RB01–RB32). You can use the **CON** function from the front panel (`Control > Outputs`) to pulse the outputs. Remote bits are device variables that you set via serial port communication only; you cannot navigate Remote Bits via the front-panel HMI. You can select the control operation from three states: set, clear, or pulse, as described in *Table 7.12*.

Table 7.12 CONTROL Command

Command	Description	Access Level
CON RB*nn k*	Set a remote bit to set, clear, or pulse.	2
Subcommand		
S	Set remote bit (ON position)	2
C	Clear remote bit (OFF position)	2
P	Pulse remote bit for 1/4 cycle (MOMENTARY position)	2
Parameters		
nn	A number from 01 to 32, representing RB01 through RB32	
k	S, C, or P	

For example, use the following command to set Remote bit RB05:

```
=>>CON RB05 S <Enter>
```

COPY Command

Use the **COPY *m n*** command (see *Table 7.13*) to copy the settings of settings Group *m* to the settings of settings Group *n*. The settings of settings Group *m* effectively overwrite the settings of settings Group *n*. Parameters *m* and *n* can be any available settings group number 1 through 3.

Table 7.13 COPY Command

Command	Description	Access Level
COPY *m n*	Copy settings values from Group *m* to Group *n*.	2
Parameters		
m	1, 2, or 3	
n	1, 2, or 3	

For example, when you enter the **COPY 1 3** command, the relay responds, `Are you sure (Y/N)?` Answer **Y <Enter>** (for yes) to complete copying. The resultant settings in Group 3 are overwritten by the settings in Group 1.

COUNTER Command (Counter Values)

The device generates the values of the 32 counters in response to the **COU** command (see *Table 7.14*).

Table 7.14 COUNTER Command

Command	Description	Access Level
COU *n*	Display current state of device counters *n* times, with a 1/2-second delay between each display.	1

DATE Command (View/Change Date)

Use the **DATE** command (see *Table 7.15*) to view and set the relay date.

Table 7.15 DATE Command

Command	Description	Access Level
DATE	Display the internal clock date.	1
DATE *mm/dd/yyyy*, ***yyyy/mm/dd***, or ***dd/mm/yyyy***	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.

ETH Command

The **ETH** command (Access Level 1) may be used to display the Ethernet port (Port 1) status as shown in *Figure 7.15* for the redundant fiber-optic (FX) Ethernet **Port 1A** and **Port 1B** configuration. Copper Ethernet port is labeled as TX. The nonredundant port response is similar, as shown in *Figure 7.16*.

```
=>>ETH <Enter>

SEL-710                                 Date: 06/05/2008   Time: 10:41:37
MOTOR PROTECTION RELAY                  Time Source: Internal

 MAC: 00-30-A7-00-75-6A
 IP ADDRESS: 192.168.1.2
 SUBNET MASK: 255.255.255.0
 DEFAULT GATEWAY: 192.168.1.1

 PRIMARY PORT:  PORT 1A
 ACTIVE PORT:   PORT 1B

             LINK   SPEED  DUPLEX   MEDIA
PORT 1A      Up    100M     Full    FX
PORT 1B      Down   --       --     FX

=>>
```

Figure 7.15 Ethernet Port (PORT 1) Status Report

```
=>>ETH <Enter>

SEL-710                                 Date: 06/05/2008   Time: 10:41:44
MOTOR PROTECTION RELAY                  Time Source: Internal

 MAC: 00-30-A7-00-75-6A
 IP ADDRESS: 192.168.1.2
 SUBNET MASK: 255.255.255.0
 DEFAULT GATEWAY: 192.168.1.1


             LINK   SPEED  DUPLEX   MEDIA
PORT 1A      Up     100M    Full      TX

=>>
```

Figure 7.16 Nonredundant Port Response

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.16*) to view event reports. See *Section 9: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.30* for details on clearing event reports.

Table 7.16 EVENT Command (Event Reports)

Command	Description	Access Level
EVE [DIF] *n*	Return the *n* event report (standard or differential) with 4-samples/cycle data.	1
EVE [DIF] R	Return the *n* event report (standard or differential) with raw (unfiltered) 16 samples/cycle analog data and 4 samples/cycle digital data.	1
Parameters		
DIF	Specifies a differential event report. If DIF is not specified, the relay will display a standard event report.	
n	Specifies the event report number to be returned. Use the **HIS** command to determine the event report number of the event you want to display. If *n* is not specified, the relay will display event report 1 by default.	

FILE Command

The **FIL** command (see *Table 7.17*) is intended to be a safe and efficient means of transferring files between intelligent electronic devices (IEDs) and external support software (ESS). The **FIL** command ignores the hide rules and transfers visible as well as hidden settings, except the settings hidden by a part number. The **FIL** command is not supported if you connect over the Ethernet using Telnet. Use FTP over Ethernet to transfer files.

Table 7.17 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

GOOSE Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging information, which can be used for troubleshooting. The **GOOSE** command variants and options are shown in *Table 7.18*.

Table 7.18 GOOSE Command Variants

Command	Description	Access Level
GOOSE	Display GOOSE information.	1
GOOSE *count*	Display GOOSE information *count* times.	1

The information displayed for each GOOSE IED is described in the following table.

IED	Description
`Transmit GOOSE Control Reference`	This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_710_1CFG/LLN0GOGooseDSet13).
`Receive GOOSE Control Reference`	This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_710_1CFG/LLN0GOGooseDSet13).
`MultiCastAddr` (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
`Ptag`	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
`Vlan`	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
`StNum` (State Number)	This hexadecimal field represents the state number that increments with each state change.
`SqNum` (Sequence Number)	This hexadecimal field represents the sequence number that increments with each GOOSE message sent.

IED	Description
TTL (Time to Live)	This field contains the time (in ms) before the next message is expected.
Code	This text field contains warning or error condition text when appropriate that is abbreviated as follows: **Code Abbreviation** — **Explanation** OUT OF SEQUENC — Out of sequence error CONF REV MISMA — Configuration Revision mismatch NEED COMMISSIO — Needs Commissioning TEST MODE — Test Mode MSG CORRUPTED — Message Corrupted TTL EXPIRED — Time to live expired
Transmit Data Set Reference	This field represents the DataSetReference (Data Set Reference) that includes the IED name, LN0 lnClass (Logical Node Class), and GSEControl datSet (Data Set Name) (e.g., SEL_710_1/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_710_1CFG/LLN0$DSet13).

An example response to the **GOOSE** commands is shown in *Figure 7.17*.

```
#>GOOSE <Enter>

GOOSE Transmit Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_710_2CFG/LLN0$GO$GooseDSet13
   01-0C-CD-01-00-04  4:1     2          20376      50
   Data Set: SEL_710_2CFG/LLN0$DSet13

GOOSE Receive Status

   MultiCastAddr   Ptag:Vlan  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_710_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-05  4:0     1          100425     160
   Data Set: SEL_710_1CFG/LLN0$DSet10

SEL_710_1CFG/LLN0$GO$NewGOOSEMessage3
   01-0C-CD-01-00-03  4:0     1          98531      120
   Data Set: SEL_710_1CFG/LLN0$DSet05

SEL_710_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          97486      200
   Data Set: SEL_710_1CFG/LLN0$DSet04

SEL_710_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          96412      190
   Data Set: SEL_710_1CFG/LLN0$DSet03
```

Figure 7.17 GOOSE Command Response

```
SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage5
   01-0C-CD-01-00-06  4:0     1          116156     140
   Data Set: SEL_387E_1CFG/LLN0$DSet10

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage4
   01-0C-CD-01-00-05  4:0     1          116041     130
   Data Set: SEL_387E_1CFG/LLN0$DSet06

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage2
   01-0C-CD-01-00-02  4:0     1          115848     120
   Data Set: SEL_387E_1CFG/LLN0$DSet04

SEL_387E_1CFG/LLN0$GO$NewGOOSEMessage1
   01-0C-CD-01-00-01  4:0     1          115798     150
   Data Set: SEL_387E_1CFG/LLN0$DSet03

=>
```

Figure 7.17 GOOSE Command Response (Continued)

GROUP Command

Use the **GROUP** command (see *Table 7.19*) to display the active settings group or try to force an active settings group change.

Table 7.19 GROUP Command

Command	Description	Access Level
GROUP	Display the active settings group.	1
GROUP *n*	Change the active Group *n*.	2
Parameter		
n	Indicates group numbers 1–3	

When you change the active group, the relay responds with a confirmation prompt: `Are you sure (Y/N)?` Answer **Y <Enter>** to change the active group. The relay asserts the Relay Word bit SALARM for one second when you change the active group.

If any of the SELOGIC control equations SS1–SS3 are set when you issue the **GROUP *n*** command, the group change will fail. The relay responds: `Command Unavailable: Active setting group SELOGIC equations have priority over the GROUP command`.

HELP Command

The **HELP** command (see *Table 7.20*) gives a list of commands available at the present access level. You can also get a description of any particular command; type **HELP** followed by the name of the command for help on each command.

Table 7.20 HELP Command

Command	Description	Access Level
HELP	Display a list of each command available at the present access level with a one-line description.	1
HELP *command*	Display information on the command *command*.	1

HISTORY Command

Use the **HIS** command (see *Table 7.21*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory.

Table 7.21 HISTORY Command

Command	Description	Access Level
HIS	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS *n*	Return event histories with the oldest at the bottom of the list and the most recent at the top of the list, beginning at Event *n*.	1
HIS C or **R**	Clear/reset the event history and all corresponding event reports from nonvolatile memory.	1

For more information on event reports, see *Section 9: Analyzing Events*.

IDENTIFICATION Command

Use the **ID** command (see *Table 7.22*) to extract device identification codes.

Table 7.22 IDENTIFICATION Command

Command	Description	Access Level
ID	Return a list of device identification codes.	0

IRIG Command

Use the **IRIG** command to direct the relay to read the demodulated IRIG-B time code at the serial port or IRIG-B input (see *Table 7.23*).

Table 7.23 IRIG Command

Command	Description	Access Level
IRIG	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:

```
=>IRIG <Enter>
```

If the relay successfully synchronizes to IRIG-B, it sends the following header and access-level prompt:

```
SEL-710                   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 with `IRIG-B DATA ERROR`.

If an IRIG-B signal is present, the relay synchronizes its internal clock with IRIG-B. It is not necessary to issue the **IRIG** command to synchronize the relay clock with IRIG-B. Use the **IRIG** command to determine if the relay is properly reading the IRIG-B signal.

L_D Command (Load Firmware)

Use the **L_D** command (see *Table 7.24*) to load firmware. See *Appendix A: Firmware, ICD, and Manual Versions* for information on changes to the firmware and instruction manual. See *Appendix B: Firmware Upgrade Instructions* for further details on downloading firmware.

Table 7.24 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Loads new firmware.	2

Only download firmware to the front port.

LDP Command (Load Profile Report)

Use the **LDP** commands (see *Table 7.25*) to view and manage the Load Profile report (see *Figure 5.11*). If there is no stored data and an **LDP** command is issued, the relay responds with `No data available`.

Table 7.25 LDP Commands

Command	Description	Access Level
LDP *row1 row2* LDP *date1 date2*	Use the **LDP** command to display a numeric progression of all load profile report rows. Use the **LDP** command with parameters to display a numeric or reverse numeric subset of the load profile rows.	1
LDP C	Use this command to clear the load profile report from nonvolatile memory.	1
Parameters		
row1 row2	Append *row1* to return a chronological progression of the first *row1* rows. Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows.	
date1 date2	Append *date1* to return all rows with this date. Append *date1* and *date2* to return all rows between *date1* and date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F.	

LOOPBACK Command

The **LOO** command (see *Table 7.26*) is used for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix G: MIRRORED BITS Communications*. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing will be wrong and ROK will be deasserted. The **LOO** command tells the MIRRORED BITS software to temporarily expect to see its own data looped back as its input. In this mode, LBOK will assert if error-free data are received. The **LOO** command with just the channel specifier, enables looped back mode on that channel for five minutes, while the inputs are forced to the default values.

Table 7.26 LOO Command

Command	Description	Access Level
LOO	Enable loopback testing of MIRRORED BITS channels.	2
LOO A	Enable loopback on MIRRORED BITS Channel A for the next 5 minutes.	2
LOO B	Enable loopback on MIRRORED BITS Channel B for the next 5 minutes.	2

```
=>>LOO A <Enter>
Loopback will be enabled on Mirrored Bits channel A for the next 5 minutes.
The RMB values will be forced to default values while loopback is enabled.
Are you sure (Y/N)?
=>>
```

If only one MIRRORED BITS port is enabled, the channel specifier (A or B) may be omitted. To enable loopback mode for other than the 5-minute default, enter the desired number of minutes (1–5000) as a command parameter. To allow the loopback data to modify the RMB values, include the DATA parameter.

```
=>>LOO 10 DATA <Enter>
Loopback will be enabled on Mirrored Bits channel A for the next 10 minutes.
The RMB values will be allowed to change while loopback is enabled.
Are you sure (Y/N)? N <Enter>
Canceled.
=>>
```

To disable loopback mode before the selected number of minutes, re-issue the **LOO** command with the R parameter. The R parameter returns the device to normal operation. If both MIRRORED BITS channels are enabled, omitting the channel specifier in the disable command will cause both channels to be disabled.

```
=>>LOO R <Enter>
Loopback is disabled on both channels.
=>>
```

MAC Command

Use the **MAC** command to display the MAC addresses of **PORT 1**, as shown below.

```
=>>MAC <Enter>
Port 1 MAC Address:  00-30-A7-00-00-00
=>>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.27* and *Table 7.28*) provides access to the relay metering data.

Table 7.27 Meter Command

Command	Description	Access Level
MET *c n*	Display metering data.	1
MET *c* R	Reset metering data.	2
Parameters		
c	Parameter for identifying meter class.	
n	Parameter used to specify number of times (1–32767) to repeat the meter response.	

Table 7.28 Meter Class

c	Meter Class
F	Fundamental Metering
E[a]	Energy Metering
M[a]	Maximum/Minimum Metering
RMS	RMS Metering
T	Thermal and RTD Metering
AI	Analog Input (transducer) Metering
MV	SELOGIC Math Variable Metering

[a] Reset metering available.

For more information on metering and example responses for each meter class, see *Section 5: Metering and Monitoring*.

On issuing the **MET *c* R** command for resetting metering quantities in class *c*, the relay responds: `Reset Metering Quantities (Y,N)?` Upon confirming (pressing **Y**), the metering quantities will be reset and the relay responds with `Reset Complete`.

MOTOR Command

The **MOT** command (see *Table 7.29*) 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 7.29 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 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 or CMSR Command

Use the **MSR** (Motor Start Report) command (see *Table 7.30*) to view motor start reports. The relay records a 720-data point report each time the motor starts. Use the **CMSR** *n* command for compressed motor start reports. ACSELERATOR QuickSet SEL-5030 Software supports viewing of the compressed motor start reports (*.cmsr).

Table 7.30 MSR (Motor Start Report) Command

Command	Description	Access Level
MSR *n*	Return the *n* motor start report where *n* is event number. The *n* defaults to 1, where 1 is the most recent event.	1

See *Section 5: Metering and Monitoring* for information on the contents of motor start reports. Motor Start Report data are cleared when the **MOT R** or **MOT C** command is executed.

MST Command

Use the **MST** (Motor Start Trend) command (see *Table 7.31*) to review the motor start trend data. The relay records the number of starts and average information for each of the past eighteen 30-day periods. See *Section 5: Metering and Monitoring* for information on the contents of the motor start trend data.

Table 7.31 MST (Motor Start Trend) Command

Command	Description	Access Level
MST	Return the motor start trend data	1
MST R or **C**	Reset or clear the data stored in the motor start trend buffers.	2

PASSWORD Command (Change Passwords)

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Use the **PAS** command (see *Table 7.32*) to change existing passwords.

Table 7.32 PASSWORD Command

Command	Description	Access Level
PAS *level new-password*	Set a password *new-password* for Access Level *level*.	2, C
Parameters		
level	Parameter *level* represents the relay Access Levels 1, 2, or C	
new-password	New password	

The factory-default passwords are as shown in *Table 7.33*.

Table 7.33 Factory-Default Passwords for Access Levels 1, 2, and C

Access Level	Factory-Default Password
1	OTTER
2	TAIL
C	CLARKE

To change the password for Access Level 1 to #Ot3579!ijd7, enter the following command sequence:

```
=>>PAS 1  <Enter>
New PW: ?#0t3579!ijd7 <Enter>
Confirm PW: ?#0t3579!ijd7 <Enter>
Password Changed
=>>
```

Similarly, use **PAS 2** to change Level 2 passwords and **PAS C** to change Level C passwords.

Table 7.34 Valid Password Characters

<table>
<tr><td>Alpha</td><td>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z</td></tr>
<tr><td>Numeric</td><td>0 1 2 3 4 5 6 7 8 9</td></tr>
<tr><td>Special</td><td>! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~</td></tr>
</table>

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are shown below:

- #0t3579!ijd7
- $A24.68&,mvj
- (Ih2dcs)36dn
- *4u-Iwg+?lf-

PING Command

When you are setting up or testing substation networks, it is helpful to determine if the network is connected properly and if the other devices are powered up and configured properly. The **PING** command (Access Level 2) allows you to determine if a host is reachable across an IP network and/or if the Ethernet port (Port 1) is functioning and configured correctly. A typical **PING** command response is shown in *Figure 7.18*.

The command structure is:

PING *x.x.x.x t*

where:

x.x.x.x is the Host IP address and

t is the PING interval in seconds, with a 2 to 255 second range.

The default PING interval is one second when *t* is not specified. The relay sends ping messages to the remote node until you stop the PING test by pressing the **Q** key.

```
=>>PING 10.201.7.52 <Enter>

Press the Q key to end the ping test.

Pinging 10.201.7.52 every 1 second(s):

Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Reply from 10.201.7.52
Ping test stopped.

Ping Statistics for 10.201.7.52
   Packets: Sent = 7, Received = 6, Lost = 1
   Duplicated = 0

=>>
```

Figure 7.18 PING Command Response

PULSE Command

Use the **PULSE** command (see *Table 7.35*) to pulse any of the relay control outputs for a specified time. This function aids you in relay testing and commissioning. When a **PUL** command is issued, the selected contact will close or open depending on the output contact type (a or b). The **PUL** command energizes the coil and does not have any effect if the coil is already energized. The control outputs are OUT*nnn*, where *nnn* represents 101–103 (standard), 301–304 (optional), 401–404 (optional), and 501–504 (optional).

Table 7.35 PUL OUTnnn Command

Command	Description	Access Level
PUL OUT*nnn*	Pulse output OUT*nnn* for 1 second.	2
PUL OUT*nnn s*	Pulse output OUT*nnn* for *s* seconds.	2
Parameters		
nnn	A control output number	
s	Time in seconds, with a range of 1–30	

QUIT Command

Use the **QUIT** command (see *Table 7.36*) to revert to Access Level 0.

Table 7.36 QUIT Command

Command	Description	Access Level
QUIT	Go to Access Level 0.	0

Access Level 0 is the lowest access level; the SEL-710 performs no password check to descend to this level (or to remain at this level).

R_S Command (Restore Factory Defaults)

Use the **R_S** command (see *Table 7.37*) to restore factory-default settings.

Table 7.37 R_S Command (Restore Factory Defaults)

Command	Description	Access Level
R_S	Restore the factory-default settings and passwords and reboot the system.[a]	2

[a] Only available after a settings or critical RAM failure.

RLP Command

Use the **RLP** command (see *Table 7.38*) to reset learned motor parameters.

Table 7.38 RLP Command

Command	Description	Access Level
RLP	Reset learned motor parameters	2

In response to the **RLP** command, the device responds with the following prompt: `Reset Cooltime (Y/N)?` If the user confirms the prompt, the device resets the learned cooling time and responds: `Learned Cooling Time Reset`. Otherwise, the device aborts the request and responds: `Command Canceled`. The device will then respond: `Reset Start TC (Y/N)?` If the user confirms the prompt, the device shall reset the Learned Starting Thermal Capacity and responds: `Learned Starting TC Reset`. Otherwise, the device aborts the request and responds with `Command Canceled`.

SER Command (Sequential Events Recorder Report)

Use the **SER** commands (see *Table 7.39*) to view and manage the Sequential Events Recorder report. If there is no SER report row stored, the relay responds with `No data available`. See *Section 9: Analyzing Events* for further details on SER reports.

Table 7.39 SER Command (Sequential Events Recorder Report)

Command	Description	Access Level
SER	Use the **SER** command to display a chronological progression of all available SER rows (as many as 1024 rows). Row 1 is the most recently triggered row and row 1024 is the oldest.	1
SER C or **R**	Use this command to clear/reset the SER records.	1
Parameters		
row1	Append *row1* to return a chronological progression of the first *row1* rows. For example, use **SER 5** to return the first five rows.	
row1 row2	Append *row1* and *row2* to return all rows between *row1* and *row2*, beginning with *row1* and ending with *row2*. Enter the smaller number first to display a numeric progression of rows through the report. Enter the larger number first to display a reverse numeric progression of rows. For example, use **SER 1 10** to return the first 10 rows in numeric order or **SER 10 1** to return these same items in reverse numeric order.	
date1	Append *date1* to return all rows with this date. For example, use **SER 1/1/2003** to return all records for January 1, 2003.	
date1 date2	Append *date1* and *date2* to return all rows between *date1* and *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.	

SET Command (Change Settings)

The **SET** command is for viewing or changing the relay settings (see *Table 7.40*).

Table 7.40 SET Command (Change Settings)

Command	Description	Access Level
SET *n s* TERSE	Set the Relay settings, beginning at the first setting for Group *n* (*n* = 1, 2, or 3).	2
SET L *n s* TERSE	Set general logic settings for Group *n* (*n* = 1, 2, or 3).	2
SET G *s* TERSE	Set global settings.	2
SET P *n s* TERSE	Set serial port settings. *n* specifies the **PORT** (**1**, **2**, **3**, **4**, or **F**); *n* defaults to the active port if not listed.	2
SET R *s* TERSE	Set report settings such as Sequential Events Recorder (SER) and event report (ER) settings.	2
SET F *s* TERSE	Set front-panel settings.	2
SET M *s* TERSE	Set Modbus user map settings.	2
Parameters		
s	Append *s*, the name of the specific setting you want to view and jumps to this setting. If *s* is not entered, the relay starts at the first setting.	
TERSE	Append TERSE to skip the settings display after the last setting. Use this parameter to speed up the **SET** command. If you want to review the settings before saving, do not use the TERSE option.	

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are shown in *Table 7.41*.

Table 7.41 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

The relay checks each setting to ensure that it is within the allowed range. If the setting is not within the allowed range, the relay generates an `Out of Range` message and prompts you for the setting again.

When all the settings are entered, the relay displays the new settings and prompts you for approval to enable them. Answer **Y <Enter>** to enable the new settings. The relay is disabled for as long as one second while it saves the new settings. The SALARM Relay Word bit is set momentarily, and the **ENABLED** LED extinguishes while the relay is disabled.

SHOW Command (Show/View Settings)

When showing settings, the relay displays the settings label and the present value from nonvolatile memory for each setting class. See *Table 7.42* for the **SHOW** command settings and format.

Table 7.42 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO *n s*	Show relay settings for Group *n*.	1
SHO L *n s*	Show general logic settings for Group *n*.	1
SHO G *s*	Show global settings.	1
SHO P *k s*	Show serial port settings. *k* specifies the port; *k* defaults to the active port if not listed.	1
SHO R *s*	Show report settings such as Sequential Events Recorder (SER) and event report (ER) settings.	1
SHO F *s*	Show front-panel settings.	1
SHO M *s*	Show Modbus user map settings.	1
Parameter		
k	1, 2, 3, 4, or F.	
n	1, 2, or 3.	
s	Append *s*, the name of the specific setting you want to view, and jump to this setting. If *s* is not entered, the relay starts at the first setting.	

```
=>>SHO <Enter>

Group 1
Relay Settings

ID Settings
RID      := SEL-710
TID      := MOTOR RELAY

Config Settings
CTR1     := 100            FLA1     := 250.0         E2SPEED  := N
CTRN     := 100            PTR      := 35.00         VNOM     := 4160
DELTA_Y  := DELTA          SINGLEV  := N

Thermal Overload
E49MOTOR := Y              FLS      := OFF           SETMETH  := RATING
49RSTP   := 75             SF       := 1.15          LRA1     := 6.0
LRTHOT1  := 10.0           TD1      := 1.00          RTC1     := AUTO
TCAPU    := 85             TCSTART  := OFF           TCLRNEN  := Y
COOLTIME := 84

Phase Overcurr
50P1P    := 10.00          50P1D    := 0.00          50P2P    := OFF

Neutral Overcurr
50N1P    := OFF            50N2P    := OFF

Residual Overcur
50G1P    := OFF            50G2P    := OFF

Neq Seq Overcur
50Q1P    := 3.00           50Q1D    := 0.10          50Q2P    := 0.30
50Q2D    := 0.2

Motor Diff OC
E87M     := N

Jam Settings
LJTPU    := OFF            LJAPU    := OFF

Undercurrent Set
LLTPU    := OFF            LLAPU    := OFF

Current Imb Set
46UBT    := 20             46UBTD   := 5             46UBA    := 10
46UBAD   := 10

Start Monitoring
START_T  := OFF

Star-Delta Set
ESTAR_D  := N

Start Inhibt Set
MAXSTART := OFF            TBSDLY   := OFF           ABSDLY   := OFF

Phase Rev Set
E47T     := Y

Speed Sw Set
SPDSDLYT := OFF            SPDSDLYA := OFF

RTD Settings
E49RTD   := NONE

Undervoltage Set
27P1P    := OFF            27P2P    := OFF

Overvoltage Set
59P1P    := 1.10           59P1D    := 0.5           59P2P    := OFF

VAR Settings
NVARTP   := OFF            PVARTP   := OFF           NVARAP   := OFF
PVARAP   := OFF

Underpower Set
37PTP    := OFF            37PAP    := OFF

Power Factor Set
55LGTP   := OFF            55LDTP   := OFF           55LGAP   := OFF
55LDAP   := OFF
```

Figure 7.19 SHOW Command Example

```
Freq Settings
81D1TP   := OFF            81D2TP   := OFF            81D3TP   := OFF
81D4TP   := OFF

Load Control Set
LOAD     := OFF

Trip Inhibit
BLKPROT  := 0
BLK46    := N              BLK48    := N              BLK50EF  := N
BLK50P   := N              BLK37    := N              BLK66    := N
BLK49RTD := N

Trip/Close Logic
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 ( 27P1T AND NOT LOP ) OR
            SV01T
REMTRIP  := 0
ULTRIP   := 0
52A      := 0

Motor Control
STREQ    := PB03
EMRSTR   := 0
SPEED2   := 0
SPEEDSW  := 0

=>>
```

Figure 7.19 SHOW Command Example (Continued)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.43*) displays the status report. See *Figure 7.20* for an example of a status report.

Table 7.43 STATUS Command (Relay Self-Test Status)

Command	Description	Access Level
STA *n*	Display the relay self-test information *n* times (*n* = 1–32767). Defaults to 1 if *n* is not specified.	1
STA S	Display the memory and execution utilization for the SELOGIC control equations.	1
STA C or **R**	Reboot the relay and clear self-test warning and failure status results.	2

Refer to *Section 10: Testing and Troubleshooting* for self-test thresholds and corrective actions, as well as hardware configuration conflict resolution. *Table 7.44* shows the status report definitions and message formats for each test. Refer to *Figure 1.3* and *Figure 1.4* for examples of the **STATUS** command response.

Table 7.44 STATUS Command Report and Definitions (Sheet 1 of 2)

STATUS Report Designator	Definition	Message Format
Serial Num	Serial number	Text Data
FID	Firmware identifier string	Text Data
CID	Firmware checksum identifier	Hex
PART NUM	Part number	Text Data
Current Offset (IA, IB, IC, IN)	DC offset in hardware circuits of current channels	Measurement of dc offset/WARN

Table 7.44 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	Measurement of dc offset/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 FPGA programming unsuccessful, or Front-Panel FPGA failed	OK/WARN
RAM	Volatile memory integrity	OK/FAIL
ROM	Firmware integrity	OK/FAIL
CR_RAM	Integrity of settings in RAM and code that runs in RAM	OK/FAIL
Non_Vol	Integrity of data stored in nonvolatile memory	OK/FAIL
BATT	Clock battery voltage	Voltage/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
CARD_C	Integrity of Card C	OK/FAIL
CARD_D	Integrity of Card D	OK/FAIL
CARD_E	Integrity of Card E	OK/FAIL
DN_MAC_ID	Specific DeviceNet card identification	Text Data
ASA	Manufacturers identifier for DeviceNet	Text Data
DN_Rate	DeviceNet card network communications data rate ___kbps	Text Data
DN_Status	DeviceNet connection and fault status 000b bbbb	Text Data
CID_FILE	Configured IED description file	OK/FAIL

Figure 7.20 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

NOTE: The STA S report gives the available SELOGIC capacity of the relay. For example, in Figure 7.20, Execution 90% means 90% of the execution capacity is still available.

```
=>STA S <Enter>
SEL-710                                     Date: 05/09/2006   Time: 15:44:46
MOTOR RELAY                                 Time Source: Internal
Part Number  071001BX9X7186020X
Global (%)    76
FP (%)        77
Report (%)    62
               GROUP 1  GROUP 2  GROUP 3
Execution (%)   90       90       90
Group (%)       85       85       85
Logic (%)       89       89       89

=>
```

Figure 7.20 Typical Relay Output for STATUS S Command

STOP Command

The **STOP** command (see *Table 7.45*) causes the relay to trip, opening the motor contactor or circuit breaker and stopping the motor. For further details refer to *Figure 4.40*.

Table 7.45 STOP Command

Command	Description	Access Level
STOP	Initiates user operation of an output to stop the motor.	2

STR Command

The **STR** command (see *Table 7.46*) uses internal relay logic to initiate a motor start. For further details refer to *Section 4: Protection and Logic Functions*.

Table 7.46 STR Command

Command	Description	Access Level
STR	Initiates user operation of an output to start and run the motor.	2

SUMMARY Command

The **SUM** command (see *Table 7.47*) displays an event summary in human readable format.

Table 7.47 SUMMARY Command

Command	Description	Access Level
SUM *n*	The command without arguments displays the latest event summary. Use *n* to display particular event summary.	1
SUM R or **C**	Use this command to clear the archive.	1

Each event summary report shows the date, time, current magnitudes (primary values), frequency, and, if the relay has the voltage option, voltage magnitudes (primary values). The relay reports the voltage and current when the largest current occurs during the event. The event summary report also shows the event type (e.g., OVERLOAD TRIP).

TARGET Command (Display Relay Word Bit Status)

The **TAR** command (see *Table 7.48*) 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 7.48 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR ***name k*** **TAR** ***n*** **TAR** ***n k***	Use **TAR** without parameters to display Relay Word Row 0 or last displayed target row.	1
TAR R	Clears front-panel tripping targets. Unlatches the trip logic for testing purposes (see *Figure 8.1*). Shows Relay Word Row 0.	1
Parameter		
name	Displays the Relay Word row with Relay Word bit name	
n	Shows Relay Word row number *n*	
k	Repeats *k* times (1–32767)	

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first four rows, representing the front-panel operation and target LEDs, correspond to *Table 7.49*. All Relay Word rows are described in *Table I.1* and *Table I.2*. Relay Word bits are used in SELOGIC control equations. See *Appendix I: Relay Word Bits*.

The **TAR** command does not remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.49 Front-Panel LEDs and the TAR 0 Command

LEDs	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.50*) returns information about the SEL-710 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 7.50 TIME Command (View/Change Time)

Command	Description	Access Level
TIME	Display the present internal clock time.	1
TIME ***hh***	Set the internal clock to *hh*.	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***, **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-710 responds with `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command (see *Table 7.51*) to trigger the SEL-710 to record data for high-resolution oscillographs and event reports.

Table 7.51 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Trigger event report data capture.	1

When you issue the **TRI** command, the SEL-710 responds with `Triggered`. If the event did not trigger within one second, the relay responds with `Did not trigger`. See *Section 9: Analyzing Events* for further details on event reports.

VEC Command (Show Diagnostic Information)

Issue the **VEC** command 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 7.52 VEC Command

Command	Description	Access Level
VEC D	Displays the standard vector report.	2
VEC E	Displays the extended vector report.	2

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Section 8
Front-Panel Operations

Overview

The SEL-710 Motor Protection 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-710 features a straightforward menu-driven control structure presented on the front-panel liquid crystal display (LCD). Front-panel targets and other LEDs give a clear indication of the SEL-710 operation status. The features that help you operate the relay from the front panel include the following:

- Reading metering
- Inspecting targets
- Accessing settings
- Controlling relay operations
- Viewing diagnostics

Front-Panel Layout

Figure 8.1 shows the following regions:

- HMI
- **TARGET RESET** and navigation pushbuttons
- Operation and target LEDs
- Operator control pushbuttons and pushbutton LEDs
- EIA-232 Serial Port (**PORT F**). See *Section 7: Communications* for details on the serial port.

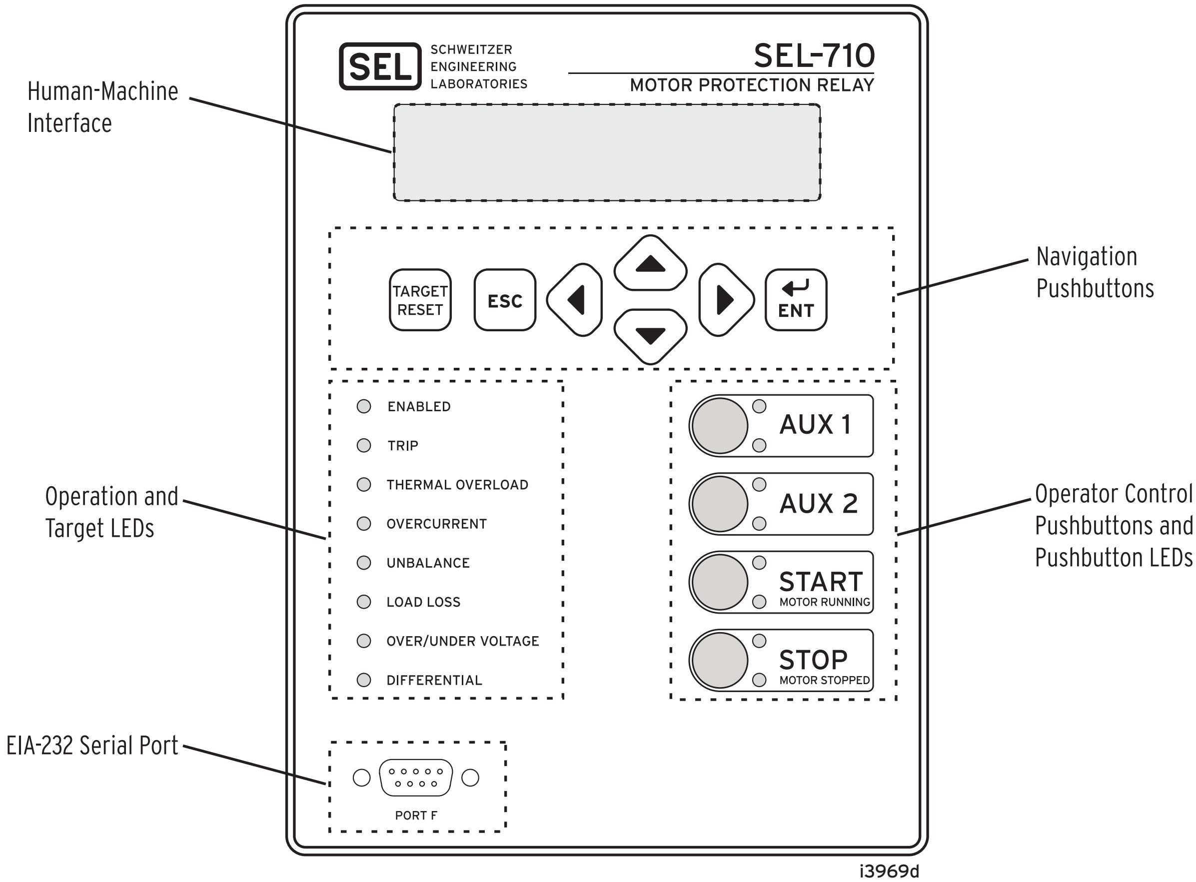

Figure 8.1 Front-Panel Overview

This versatile front panel supports the following features so you can customize it for your needs:

- ➤ Rotating display on the HMI
- ➤ Programmable target LEDs
- ➤ Programmable pushbutton LEDs
- ➤ Slide-in configurable front-panel labels to change the identification of target LEDs, pushbuttons, pushbutton LEDs and their operation.

Human-Machine Interface

Contrast

NOTE: See the Preface for an explanation of typographic conventions used to describe menus, the front-panel display, and the front-panel pushbuttons.

You can adjust the LCD screen contrast to suit your viewing angle and lighting conditions. To change screen contrast, press and hold the **ESC** pushbutton for two seconds. The SEL-710 displays a contrast adjustment box. Pressing the **Right Arrow** pushbutton increases the contrast. Pressing the **Left Arrow** pushbutton decreases the screen contrast. When you are finished adjusting the screen contrast, press the **ENT** pushbutton; this process is a shortcut for changing the LCD contrast setting FP_CONT in the front-panel settings.

Front-Panel Automatic Messages

The relay displays automatic messages, overriding the rotating display, under the conditions described in *Table 8.1*, with the relay failure having the highest priority, followed by trip and alarm when the front-panel setting FP_AUTO := OVERRIDE. If the front-panel setting FP_AUTO := ROTATING, then the rotating display messages continue and any TRIP or ALARM message is added to the rotation. Relay failure will still override the rotating display.

Table 8.1 Front-Panel Automatic Messages

Condition	Front-Panel Message
Relay detecting any failure	Displays the type of latest failure (see *Section 10: Testing and Troubleshooting*).
Relay trip has occurred	Displays the type or cause of the trip. Refer to *Table 9.1* for a list of trip display messages.
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.
Relay has lockout because of the number of starts, time between starts, antibackspin, or thermal lockout	Displays the type of lockout condition, lockout time remaining, and TRIP* at the end of the lockout. Use **TARGET RESET** to clear TRIP*.
Motor in starting state	Displays Rotor TCU%
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-710 front panel typically operates at Access Level 1 and provides viewing of relay measurements and settings. Some activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 passwords.

In the figures that follow, restricted activities are indicated by the padlock symbol.

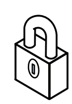

Figure 8.2 Access Level Security Padlock Symbol

Before you can perform a front-panel menu activity that is marked with the padlock symbol, you must enter the correct Access Level 2 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 (Change Passwords) on page 7.34* for the list of default passwords and for more information on changing passwords.

Front-Panel Time-Out

To help prevent unauthorized access to password-protected functions, the SEL-710 provides a front-panel time out, setting FP_TO. A timer is reset every time a front-panel pushbutton is pressed. Once the time-out period has expired, the access level is reset to Access Level 1. Manually reset the access level by selecting `Quit` from the `MAIN` menu.

Front-Panel Menus and Screens

Navigating the Menus

The SEL-710 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.

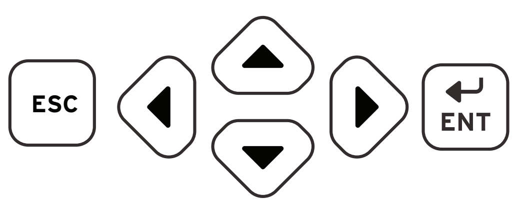

Figure 8.4 Front-Panel Pushbuttons

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 two seconds to display contrast adjustment screen.
ENT	Move from the rotating display to the `MAIN` menu. Select the menu item at the cursor. Select the displayed setting to edit that setting.

The SEL-710 automatically scrolls information that requires more space than provided by a 16-character LCD line. Use the **Left Arrow** and **Right Arrow** pushbuttons to suspend automatic scrolling and enable manual scrolling of this information.

MAIN Menu

Figure 8.5 shows the `MAIN` menu screen. Using the **Up Arrow** or **Down Arrow** and **ENT** pushbuttons, you can navigate to specific menu item in the `MAIN` menu. Each menu item is explained in detail in the following paragraphs.

```
MAIN
Meter
Events
Monitor
Targets
Control
Set/Show
Status
```

Figure 8.5 Main Menu

Meter Menu

Select the `Meter` menu item from the `MAIN` menu as shown in *Figure 8.6* to view metering data. The `Meter` menu has menu items for viewing different types of metering data like Fundamental, rms, Thermal, etc. Select the type of metering and view the data using the **Up Arrow** or **Down Arrow** pushbuttons. See *Metering on page 5.2* for a description of the available data fields.

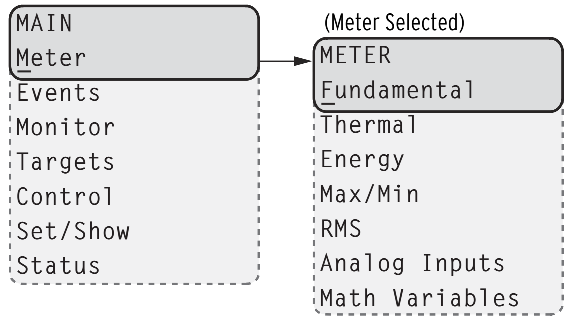

Figure 8.6 MAIN Menu and METER Submenu

For viewing Energy (or Max/Min) metering data, select the `Energy` (or `Max/Min`) menu item from the `METER` menu and select the `Display` menu item as shown in *Figure 8.7*.

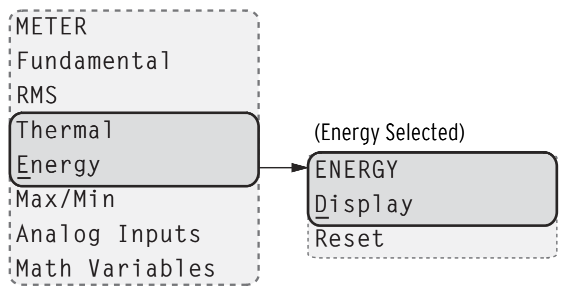

Figure 8.7 METER Menu and ENERGY Submenu

Energy (or Max/Min) metering data can be reset from the front-panel HMI by selecting the `Reset` menu item in the `Energy` (or `Max/Min`) menu. After selecting `Reset` and confirming the reset, the relay displays as shown in *Figure 8.8*.

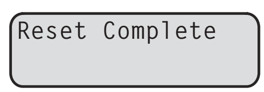

Figure 8.8 Relay Response When Energy (or Max/Min) Metering Is Reset

Assume the relay configuration contains no analog input cards. In response to a request for analog data (selecting `Analog Inputs`), the device displays the message as shown in *Figure 8.9*.

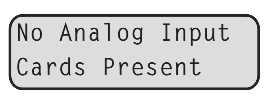

Figure 8.9 Relay Response When No Analog Cards Are Installed

Assume the math variables are not enabled. In response to a request for math variable data (selecting `Math Variables`), the device displays the message as shown in *Figure 8.10*.

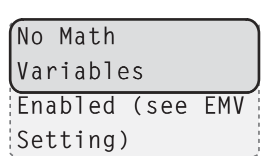

Figure 8.10 Relay Response When No Math Variables Enabled

Events Menu

Select the `Events` menu item from the `MAIN` menu as shown in *Figure 8.11*. `EVENTS` menu has `Display` and `Clear` as menu items. Select `Display` to view events and `Clear` to delete all the events data.

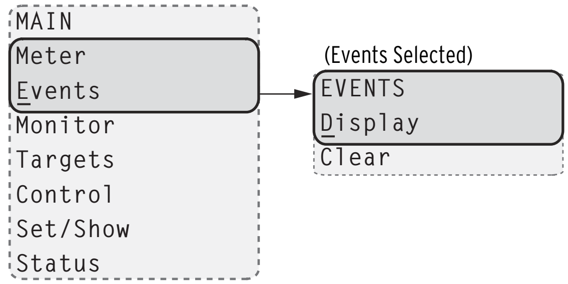

Figure 8.11 MAIN Menu and EVENTS Submenu

Figure 8.12 shows the `DISPLAY` menu when `Display` is selected from the `EVENTS` menu with events in the order of occurrence starting with the most recent. You can select an event from the `DISPLAY` menu and navigate through the event data.

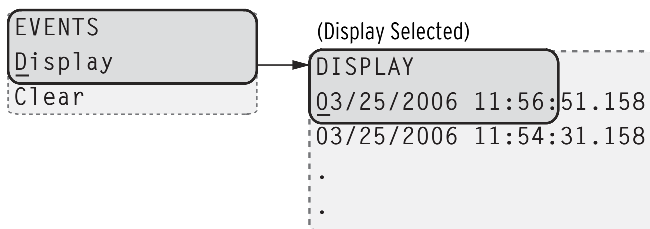

Figure 8.12 EVENTS Menu and DISPLAY Submenu

When `Display` is selected and no event data are available, the relay displays as shown in *Figure 8.13*.

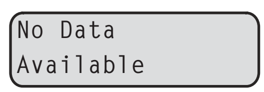

Figure 8.13 Relay Response When No Event Data Available

When `Clear` is selected from the `EVENTS` menu and confirming the selection, the relay displays as shown in *Figure 8.14* after clearing the events data.

Figure 8.14 Relay Response When Events Are Cleared

Monitor Menu

NOTE: Reset Learn Data are available only when TCLRNEN=Y or COOLEN=Y.

Select the `Monitor` menu item on the `MAIN` menu as shown in *Figure 8.15*. The `Monitor` menu has `Display Mot Data`, `Clear Motor Data` and `Reset Learn Data` as menu items.

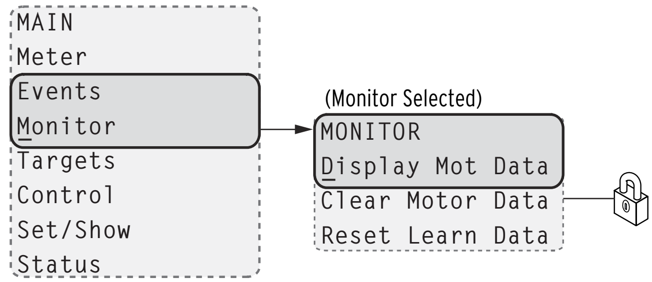

Figure 8.15 MAIN Menu and MONITOR Submenu

Select `Display Mot Data` from the `MONITOR` menu as shown in *Figure 8.16* to view motor operating statistics. See *Motor Operating Statistics on page 5.8* for a description of the data available.

NOTE: Learn Parameters is available only when TCLRNEN = Y or COOLEN = Y.

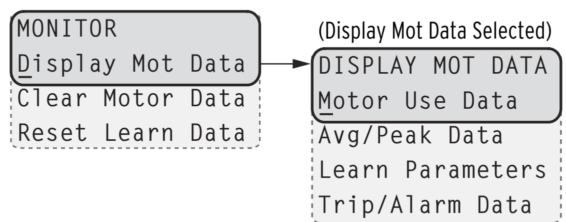

Figure 8.16 MONITOR Menu and DISPLAY MOT DATA Submenu

Motor operating statistics can be cleared from the front-panel HMI by selecting `Clear Mot Data` menu item in the `MONITOR` menu. You need a Level 2 access to clear motor operating statistics.

Select `Reset Learn Data` from `MONITOR` menu as shown in *Figure 8.17* to reset learn data. You need a Level 2 access to reset learn data.

NOTE: Reset Cooltime is available only when COOLEN = Y. `Reset Start TC` is available only when TCLRNEN = Y.

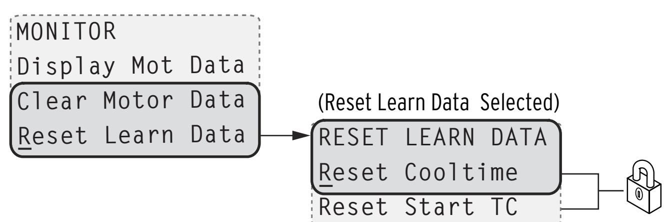

Figure 8.17 MONITOR Menu and RESET LEARN DATA Submenu

Targets Menu

Select the `Targets` menu item on the `MAIN` menu as shown in *Figure 8.18* to view the binary state of the target rows. Each target row has eight Relay Word bits as shown in *Table I.1*.

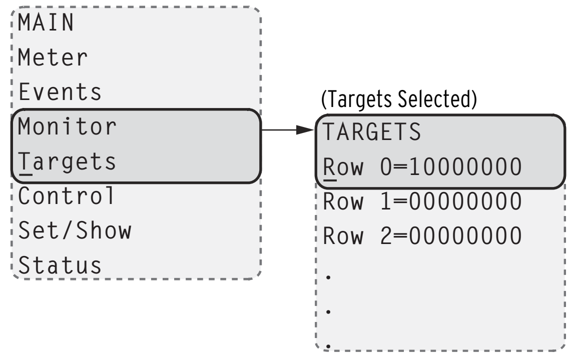

Figure 8.18 MAIN Menu and TARGETS Submenu

Select the target row to display two consecutive Relay Word bits with name and binary state as shown in *Figure 8.19*.

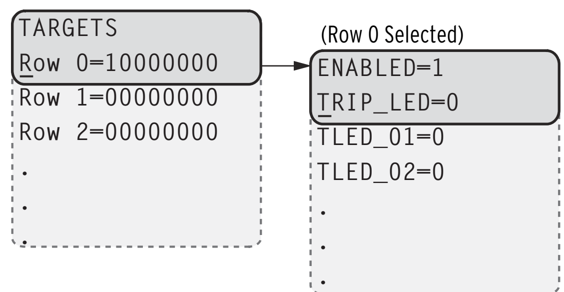

Figure 8.19 TARGETS Menu Navigation

Control Menu

Select the `Control` menu item on the `MAIN` menu as shown in *Figure 8.20* to go to the `CONTROL` menu.

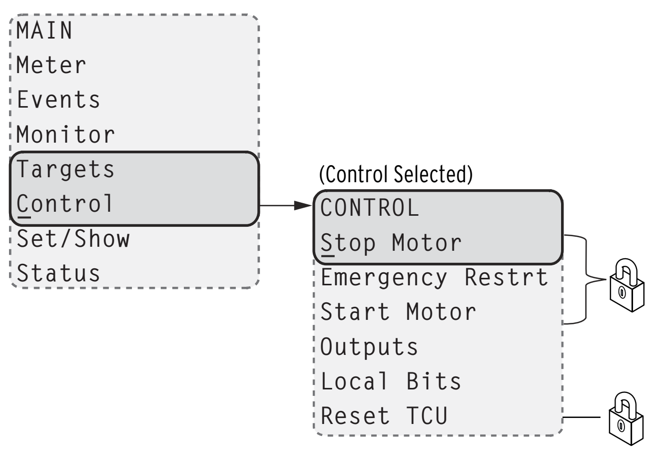

Figure 8.20 MAIN Menu and CONTROL Submenu

The `CONTROL` menu has `Stop Motor`, `Emergency Restrt`, `Start Motor`, `Outputs`, `Local Bits`, and `Reset TCU` as menu items.

Select the `Stop Motor` menu item to assert Relay Word bit STOP that stops the motor (see *Figure 8.21*). Note that this requires Level 2 access.

NOTE: The emergency restart feature is available only through front-panel HMI.

Select the `Emergency Restrt` menu item to assert Relay Word bit EMRSTR that initiates an emergency start (see *Figure 4.42*). Note that this requires Level 2 access.

Select the `Start Motor` menu item to assert Relay Word bit STR that initiates a motor start (see *Figure 4.42*). Note that this requires Level 2 access.

Select the `Outputs` menu item from the `CONTROL` menu as shown in *Figure 8.21* to test (pulse) SEL-710 output contacts and associated circuits. Choose the output contact by navigating through the `OUTPUT` menu and test it by pressing the **ENT** pushbutton. Note that testing the output contact requires Level 2 access and reconfirmation.

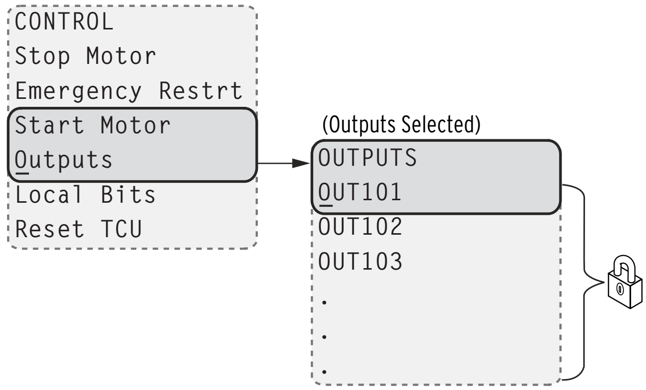

Figure 8.21 CONTROL Menu and OUTPUTS Submenu

Select the `Local Bits` menu item from the `CONTROL` menu for local control action. Local bits take the place of traditional panel switches, and perform isolation, open, close, or pulse operations.

With the settings as per the example in *Section 4* (see *Local Bits on page 4.91* for more information), local bit 1 replaces a supervisory switch. *Figure 8.22* shows the screens in closing the supervisory switch. In this operation, local bit LB01 is deasserted (SUPER SW = OPEN), and changes to asserted (SUPER SW = CLOSE) as shown in the final screen of *Figure 8.22*.

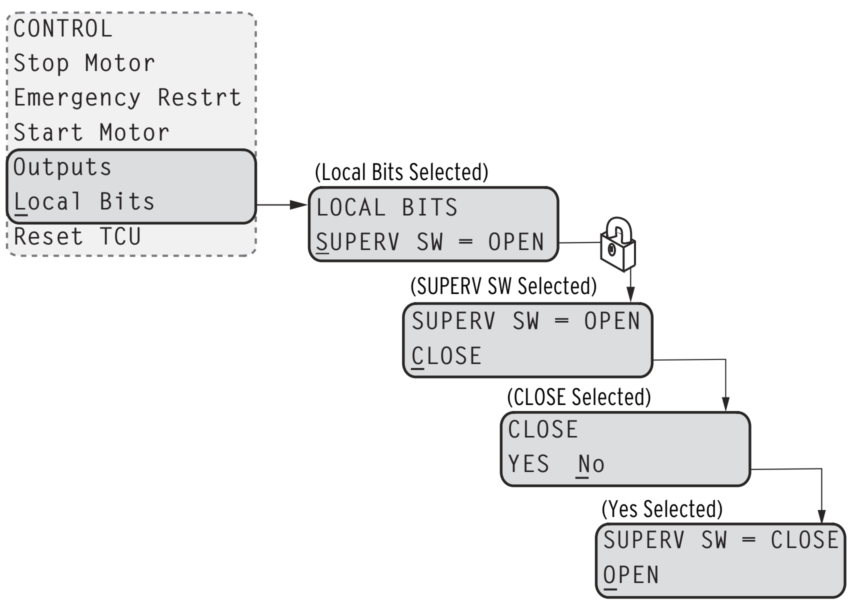

Figure 8.22 CONTROL Menu and LOCAL BITS Submenu

Select the `Reset TCU` menu item to reset the thermal capacity used (see *Thermal Overload Element on page 4.5* for description). Note that this requires Level 2 access.

Set/Show Menu

Select the `Set/Show` menu item on the `MAIN` menu. The `Set/Show` menu is used to view or modify the settings (`Global`, `Group`, and `Port`), `Active Group`, `Date`, and `Time`. Note that modifying the settings requires Level 2 access.

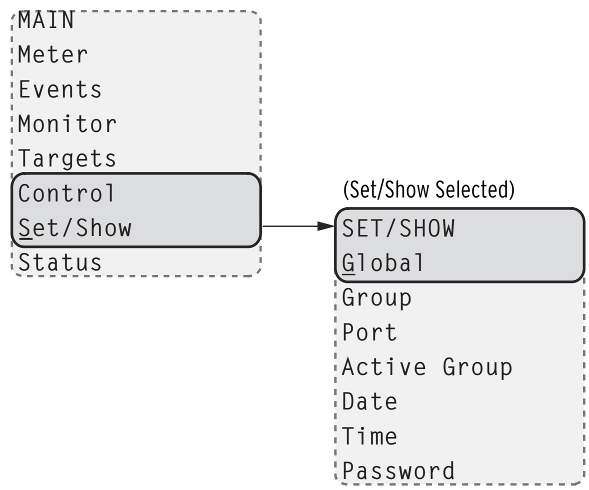

Figure 8.23 MAIN Menu and SET/SHOW Submenu

Each settings class (`Global`, `Group`, and `Port`) includes headings that create subgroups of associated settings as shown in the following illustration. Select the heading that contains the setting of interest, and then navigate to the particular setting. View or edit the setting by pressing the **ENT** pushbutton. For text settings, use the four navigation pushbuttons to scroll through the available alphanumeric and special character settings matrix. For numeric settings, use the **Left Arrow** and **Right Arrow** pushbuttons to select the digit to change and the **Up Arrow** and **Down Arrow** pushbuttons to change the value. Press the **ENT** pushbutton to enter the new setting.

Setting changes can also be made using ACSELERATOR QuickSet SEL-5030 Software or ASCII **SET** commands via a communications port.

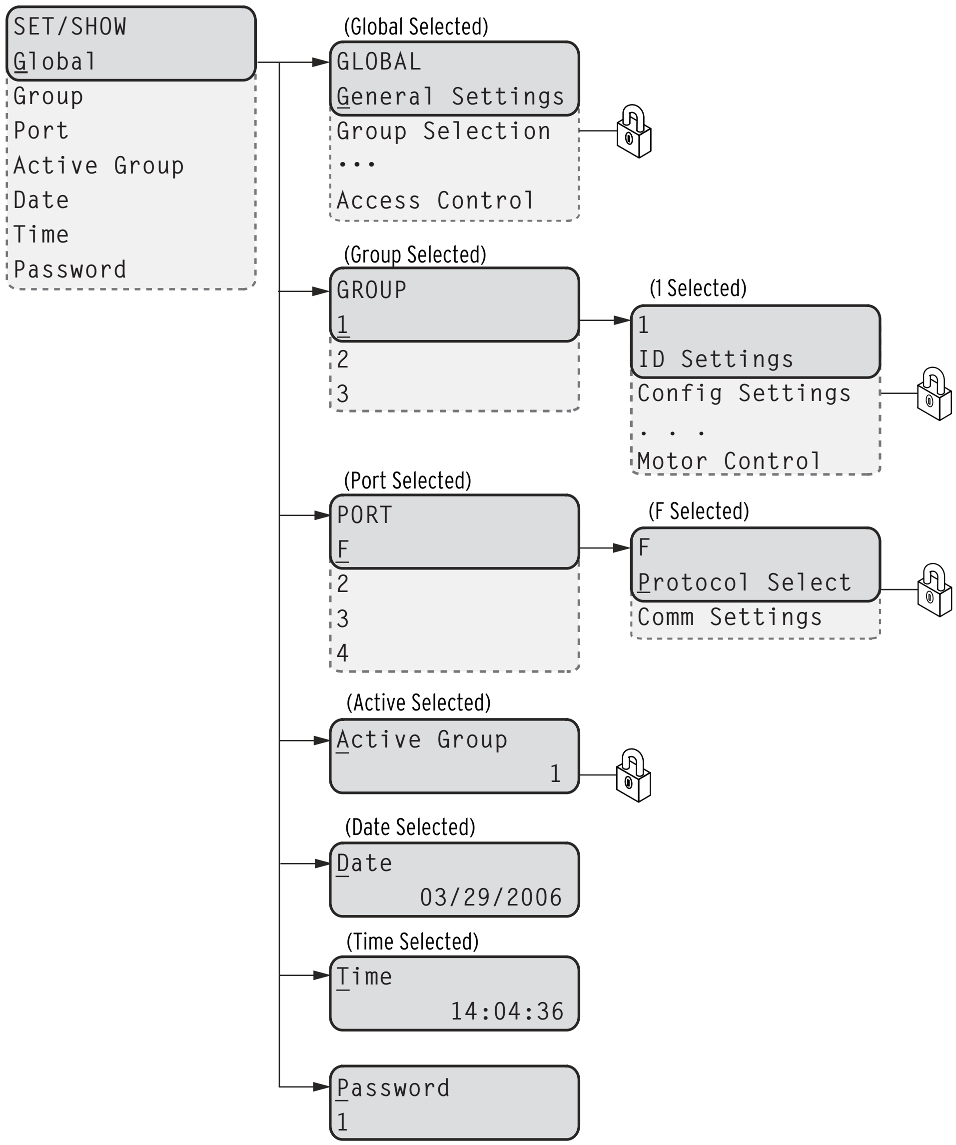

Figure 8.24 SET/SHOW Menu

Status Menu

Select the `Status` menu item on the `MAIN` menu as shown in *Figure 8.25* to access `Relay Status` data and `Reboot Relay`. See *STATUS Command (Relay Self-Test Status) on page 7.41* for the **STATUS** data field description.

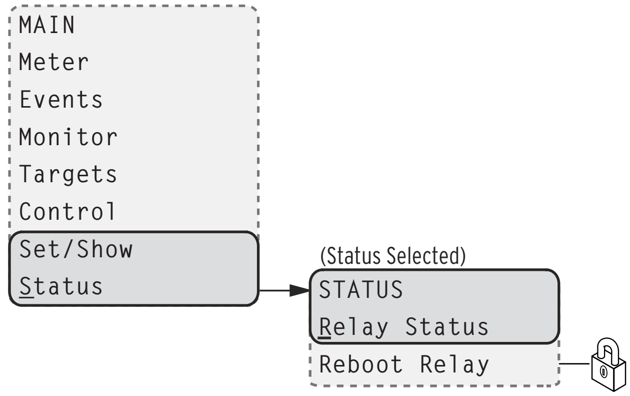

Figure 8.25 MAIN Menu and Status Submenu

Operation and Target LEDs

Programmable LEDs

The SEL-710 provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.26* shows this region with factory-default text on the front-panel configurable labels. See *Target LED Settings on page 4.92* for the SELOGIC control equations.

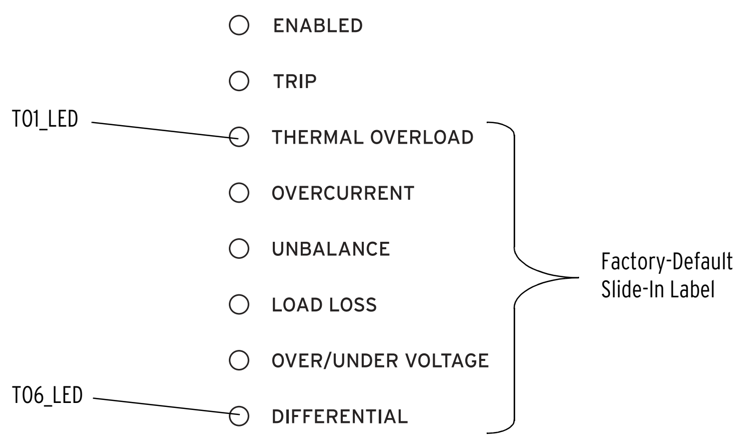

Figure 8.26 Factory-Default Front-Panel LEDs

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.

T0*n*_LED settings are SELOGIC control equations that work with the corresponding T0*n*LEDL latch settings to illuminate the LEDs shown in *Figure 8.26*. Parameter *n* is a number from 1 through 6 that indicates each LED. If the latch setting (T0*n*LEDL) for a certain LED is set to N, then the LED will follow the status of the corresponding control equation (T0*n*_LED). When the equation asserts, the LED will illuminate, and when the equation deasserts, the LED will extinguish. If the latch setting is set to Y, the LED will only assert if a trip condition occurs and the T0*n*_LED equation is asserted at the time of the trip. At this point, the LED will latch in and can be reset using the **TARGET RESET** pushbutton or the **TAR R** command as long as the target conditions are absent. For a concise listing of the default programming on the front-panel LEDs, see *Table 4.76*.

The SEL-710 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. Word processor templates for printing slide-in labels are available at selinc.com.

The ENABLED LED indicates that the relay is powered correctly, is functional, and has no self-test failures. Trip events illuminate the TRIP LED. The prominent location of the TRIP LED in the top target area aids in recognizing trip events quickly.

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 I: Relay Word Bits*.

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 OR 50Q2T
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

For a trip event, the SEL-710 latches the trip-involved target LEDs except for the ENABLED LED. Press the TARGET RESET pushbutton to reset the latched target LEDs. When a new trip event occurs and the previously latched trip targets have not been reset, the relay clears the latched targets and displays the new trip targets. Pressing and holding the TARGET RESET pushbutton illuminates all the LEDs. Upon release of the TARGET RESET pushbutton, two possible trip situations can exist: the conditions that caused the relay to trip have cleared, or the trip conditions remain present at the relay inputs. If the trip conditions have cleared, the latched target LEDs turn off. If the trip event conditions remain, the relay re-illuminates the corresponding target LEDs. The TARGET RESET pushbutton also removes the trip automatic message displayed on the LCD menu screens if the trip conditions have cleared.

Figure 8.27 TARGET RESET Pushbutton

Lamp Test

The TARGET RESET pushbutton also provides a front-panel lamp test. Pressing and holding TARGET RESET illuminates all the front-panel LEDs, and these LEDs remain illuminated for as long as TARGET RESET is pressed. The target LEDs return to a normal operational state after release of the TARGET RESET pushbutton.

Other Target Reset Options

Use the ASCII command **TAR R** to reset the target LEDs; see *Table 7.48* for more information. Programming specific conditions in the SELOGIC control equation RSTTRGT is another method for resetting target LEDs. Access RSTTRGT in *Global Settings (SET G Command)*, *Data Reset on page 4.79* for further information.

Front-Panel Operator Control Pushbuttons

The SEL-710 features four operator-controlled pushbuttons, each with two programmable pushbutton LEDs, for local control as shown in *Figure 8.28*.

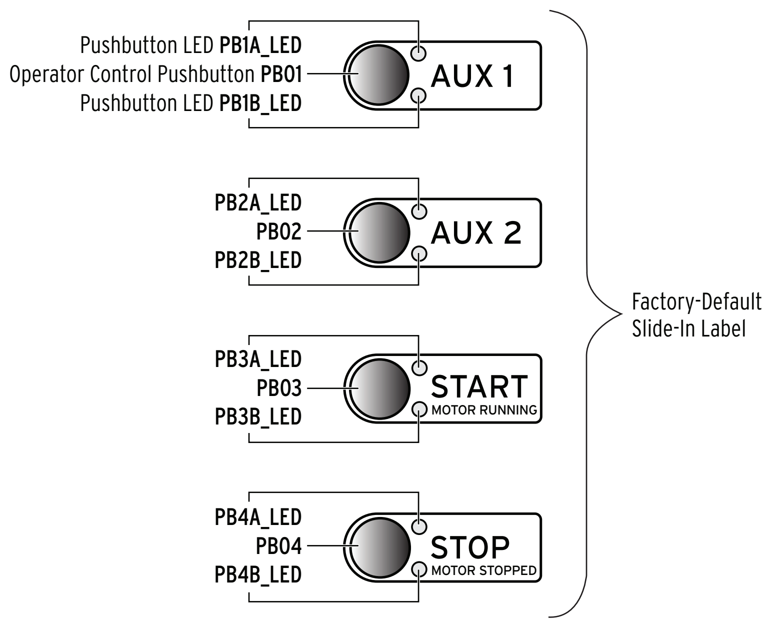

Figure 8.28 Operator Control Pushbuttons and LEDs

Pressing any one of these four pushbuttons asserts the corresponding PB*n* (*n* = 01 through 04) Relay Word bit, and the corresponding PB*n*_PUL Relay Word bit. The PB*n* Relay Word bit remains asserted as long as the pushbutton is pressed, but the PB*n*_PUL Relay Word bit asserts only for the initial processing interval, even if the button is still being pressed. Releasing the pushbutton, and then pressing the pushbutton again asserts the corresponding PB*n*_PUL Relay Word bit for another processing interval. The pushbutton LEDs are independent of the pushbutton.

Pushbutton LEDs are programmable using front-panel settings PB*nm*_LED (where *n* = 1 through 4 and *m* = A or B). PB*nm*_LED settings are SELOGIC control equations that, when asserted, illuminate the corresponding LED for as long as the input is asserted. When the input deasserts, the LED also deasserts without latching.

Initially the SEL-710 comes with factory defaults for the pushbutton LEDs. Using SELOGIC control equations, you can readily change the default LED functions. Use the slide-in label to mark the pushbuttons and pushbutton LEDs with custom names to reflect any programming changes that you make. Word processor templates for printing slide-in labels are available at selinc.com. See the instructions included in the Configurable Label kit for more information on changing the slide-in labels.

Section 9
Analyzing Events

Overview

The SEL-710 Motor Protection Relay provides several tools (listed below) to analyze the cause of relay operations. Use these tools to help diagnose the cause of the relay operation and more quickly restore the protected 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-710 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 I.1*)
- Event summary, including the front-panel target states at the time of tripping and fault type
- Group, Logic, Global, and Report settings that were in service when the event was retrieved

The SEL-710 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and 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 *Table C.2* for further information.

Compressed ASCII Event Reports contain *all* of the Relay Word bits.

Sequential Events Recorder (SER)

The SER report captures digital element state changes over time. Settings allow as many as 96 Relay Word bits to be monitored, in addition to the automatically generated triggers for relay power up, settings changes, and active setting group changes. State changes are time-tagged to the nearest millisecond. SER information is stored when state changes occur.

SER report data are useful in commissioning tests and during operation for system monitoring and control.

Event Reporting

Length

IMPORTANT: Changing the LER setting will clear all events in memory. Be sure to save critical event data prior to changing the LER setting.

The SEL-710 provides selectable event report length (LER) and prefault length (PRE). Event report length is either 15 or 64 cycles. Prefault length is 1–10 cycles for LER = 15 and 1–59 cycles for LER = 64. Prefault length is the first part of the total event report length and precedes the event report triggering point. Changing the PRE setting has no effect on the stored reports. The relay stores as many as 23 of the most recent 64-cycle or as many as 100 of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.38* and *Report Settings (SET R Command) on page SET.45*.

Triggering

The SEL-710 triggers (generates) an event report when any of the following occur:

- Relay Word bit TR asserts
- Programmable SELOGIC control equation setting ER asserts (in Report settings)
- **TRI** (Trigger Event Reports) serial port command executes
- Front panel or serial port (including Modbus and DeviceNet) **STOP** command

Relay Word Bit TR

Refer to *Figure 4.40*. If Relay Word bit TR asserts to logical 1, an event report is automatically generated. Thus, any Relay Word bit that causes a trip does *not* have to be entered in SELOGIC control equation setting ER.

Programmable SELOGIC Control Equation Setting ER

The programmable SELOGIC control equation event report trigger setting ER is set to trigger event reports for conditions other than trip conditions (see **SET R** in *SET Command (Change Settings) on page 7.38*). When setting ER detects a logical 0 to logical 1 transition, it generates an event report (if the SEL-710 is not already generating a report that encompasses the new transition). The factory setting is shown in *Event Report Settings on page 4.95*.

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 7.45* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

IMPORTANT: Clearing the HISTORY report with the **HIS C** command also clears all event data within the SEL-710 event memory.

For every triggered event, the relay generates and stores an event summary. The relay stores as many as 100 of the most recent event summaries (if LER := 15) or as many as 23 of the most recent event summaries (if LER := 64). When the relay stores a new event summary, it discards the oldest event and event summary if the event memory is full. Event summaries contain the following information:

- Relay and Terminal Identification (RID and TID)
- Event number, date, time, event type, and frequency (see *Table 9.1*)
- The primary magnitudes of line, neutral and residual currents
- The primary magnitudes of the line to neutral voltage (if DELTA_Y := WYE) or phase-to-phase voltages (if DELTA_Y := DELTA), optional Voltage Inputs card required
- The primary magnitudes of differential currents, optional Differential Input card required
- Hottest RTD temperatures, SEL-2600 RTD Module or internal RTD card option required

The relay includes the event summary in the event report. The identifiers, date, and time information are at the top of the event report, and the remaining information follows at the end (see *Figure 9.3*). The example event summary in *Figure 9.1* corresponds to the standard 15-cycle event report in *Figure 9.3*.

```
=>>SUM <Enter>
SEL-710                                  Date: 12/21/2006   Time: 15:55:17.664
FW X140
Serial No = 000000000000000
FID = SEL-710-R200-V0-Z002002-D20061109                CID = 6BE5
EVENT LOGS =  6

Event:     Lockd Rotor Trip
Targets    11100000
Freq (Hz)  60.1

Current Mag
        IA            IB            IC            IN       IG
(A)    1487.1        1495.4        1491.9         0.06    26.47

Voltage Mag
       VAN    VBN    VCN    VG
(V)    2331   2328   2328     23

Differential Current Mag
       IA87     IB87     IC87
(A)      0.16     0.00     0.26
```

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 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 OR 50Q1T) AND TRIP
`Overcurrent Trip`	50P1T AND TRIP
`Ground Flt Trip`	(50N1T OR 50G1T) AND TRIP
`Phase A 51 Trip`	51AT AND TRIP
`Phase B 51 Trip`	51BT AND TRIP
`Phase C 51 Trip`	51CT AND TRIP
`Phase 51 Trip`	(51P1T OR 51P2T) AND TRIP
`GND 51 Trip`	(51G1T OR 51G2T) AND TRIP
`NEG SEQ 51 Trip`	(51QT) 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
`87M Diff Trip`	(87M1T OR 87M2T) 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
`ER Trigger`	ER Equation assertion
`Trip`	TRIP (trip from any undefined, unlisted cause)

Currents, Voltages, and RTD Temperatures

The relay determines the maximum phase current during an event. The instant the maximum phase current occurs is marked by an asterisk (*) in the event report (see *Figure 9.3*). This row of data corresponds to the analogs shown in the summary report for the event.

The `Current Mag` fields display the primary current magnitudes at the instant when the maximum 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`
- Differential Currents (`IA87`, `IB87`, `IC87`)

NOTE: Frequency measurement is available in CEV reports only.

The `Voltage Mag` fields 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`)

If the RTDs are connected, the hottest RTD (°C) fields display the hottest RTD reading in each RTD group. The hottest RTD temperatures in degrees centigrade (°C) are listed below:

- Winding
- Bearing
- Ambient
- Other

Event History

The event history report gives you a quick look at recent relay activity. The relay labels each new event in reverse chronological order with `1` as the most recent event. See *Figure 9.2* for a sample event history. Use this report to view the events that are presently stored in the SEL-710.

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
- Frequency
- Target LED status

```
=>>HIS <Enter>

SEL-710              Date: 12/10/2003  Time: 22:24:11.418
MOTOR RELAY             Time Source: internal

#  DATE        TIME           EVENT                CURR   FREQ    TARGETS

1  12/03/2005   22:24:00.101   Overcurrent Trip   1049.2   60      11010000
2  12/03/2005   22:15:20.714   Overload Trip      1493.0   60      11100000
3  12/03/2005   15:21:10.663   Trigger               4.7   60      11000000
4  12/03/2005   15:21:07.512   PTC Trip              7.8   60      11000000
5  12/03/2005   10:49:34.103   Trigger               6.4   60      11000000
6  12/03/2005   10:49:30.040   PTC Trip              7.7   60      11000000
7  12/02/2005   20:50:54.846   Lockd Rotor Trip      1.2   60      11100000
8  12/02/2005   20:44:58.448   Lockd Rotor Trip   1494.4   60      11100010
9  12/02/2005   16:38:04.829   Trigger               1.4   60      10000000
```

Event Number · Event Type · Maximum Current · Frequency · User-Defined Target LEDs

Figure 9.2 Sample Event History

Viewing the Event History

Access the history report from the communications ports, using the **HIS** command or the analysis menu within ACSELERATOR QuickSet SEL-5030 Software. View and download history reports from Access Level 1 and higher.

Use the **HIS** command from a terminal to obtain the event history. You can specify the number of the most recent events that the relay returns. See *HISTORY Command on page 7.30* for information on the **HIS** command.

Use the front-panel `MAIN > Events > Display Events` menu to display event history data on the SEL-710 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:

- ➤ Analog values of current and voltage
- ➤ Digital states of the protection and control elements, including overcurrent, and voltage elements, plus status of digital output and input states
- ➤ Event Summary
- ➤ Settings in service at the time of event trigger, 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.

Differential Event Report

Use the **EVE DIF** command to retrieve a differential event report, which includes motor currents, differential currents, and differential Relay Word bits.

Filtered and Unfiltered Event Reports

The SEL-710 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

Raw event reports display one extra cycle of data at the beginning of the report.

Event Report Column Definitions

Refer to the example event report in *Figure 9.3* to view event report columns. This example event report displays rows of information each 1/4 cycle. Retrieve this report with the **EVE** command.

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 7.43*) to retrieve event summary reports.

Table 9.2 summarizes the event summary report current and voltage columns. *Table 9.3* summarizes the event summary report output, input, protection, and control element columns.

Table 9.2 Event Report Current and Voltage Columns

Column Heading	Description
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
IG	Residual current (IA + IB + IC, primary A)
IN	Current measured by channel IN (primary A)
IA87	Differential current measured by channel IA87 (primary A)
IB87	Differential current measured by channel IB87 (primary A)
IC87	Differential current measured by channel IC87 (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

`87MTC`	`1`
	`2`
	`b`
		87M1TC AND NOT 87M2TC
		87M2TC AND NOT 87M1TC
		87M1TC AND 87M2TC

`87M`	`1`
	`2`
	`b`
		87M1T AND NOT 87M2T
		87M2T AND NOT 87M1T
		87M1T AND 87M2T

`RTD Wdg` (SEL-2600 RTD Module or RTD card required)	`w` `W`	WDGALRM AND NOT WDGTRIP WDGTRIP
`RTD Brg` (SEL-2600 RTD Module or RTD card required)	`b` `B`	BRGALRM AND NOT BRGTRIP BRGTRIP
`RTD Oth` (SEL-2600 RTD Module or RTD card required)	`o` `O`	OTHALRM AND NOT OTHTRIP OTHTRIP
`RTD Amb` (SEL-2600 RTD Module or RTD card 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

`Out 12`	`1`
	`2`
	`b`
		OUT101 AND NOT OUT102
		NOT OUT101 AND OUT102
		OUT101 AND OUT102

`Out 3`	`3`	OUT103

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*.

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.

```
=>>EVE <Enter>
                                                                             Date and Time of Event
SEL-710                                 Date: 01/19/2007 Time: 09:22:44.530
MOTOR RELAY
Serial No = 000000000000000
FID=SEL-710-R200-V0-Z002002-D20070119 CID=1483

                                                     M L    O/C   O
                                                     o o        I u
                                                     t a444 555 n t
       Currents (A Pri)          Voltages (V Pri) o d679 000 1 13
    IA     IB     IC     IN     IG   VAB   VBC   VCA  r      PGN 2 2
[1]                                                                  Optional Voltage Card Required
  126.7   71.3 -194.7    0.0    3.3   683  3225 -3908 R .... ... . ..
 -153.3  184.0  -30.3   -0.0    0.3 -4100  2647  1452 R .... ... . ..
 -128.0  -72.3  193.3   -0.0   -7.0  -679 -3227  3906 R .... ... . ..
  153.0 -183.3   29.0    0.0   -1.3  4100 -2644 -1456 R .... ... . ..
[2]
  125.7   72.0 -196.7    0.0    1.0   672  3231 -3904 R .... ... . ..
 -156.0  183.0  -29.3    0.0   -2.3 -4101  2642  1460 R .... ... . ..   One Cycle of Data
 -126.0  -74.3  195.3    0.0   -5.0  -668 -3232  3900 R .... ... . ..
  154.0 -185.0   28.0   -0.0   -3.0  4101 -2636 -1465 R .... ... . ..
[3]
  125.7   74.0 -196.7   -0.0    3.0   663  3237 -3900 R .... ... . ..
 -156.0  184.0  -30.3   -0.0   -2.3 -4103  2633  1470 R .... ... . ..
 -127.0  -75.3  195.3    0.0   -7.0  -660 -3240  3899 R .... ... . ..
  157.7 -186.0   30.0    0.0    1.7  4104 -2627 -1476 R .... ... . ..
[4]
  124.7   74.0 -197.3    0.0    1.3   654  3244 -3898 R .... ... . ..
 -158.0  184.7  -30.3   -0.0   -3.7 -4106  2624  1482 R .... ... . ..
 -126.0  -75.3  195.3   -0.0   -6.0  -650 -3247  3897 R .... ... . ..
  262.0 -396.3  129.3    0.0   -5.0  3668 -2195 -1474 R .... ... . ..
[5]
  375.3   92.0 -468.0    0.0   -0.7   328  2844 -3172 R .... ... . ..
 -654.7  865.7 -210.7   -0.0    0.3 -2481  1436  1045 R .... ... . ..
 -689.3 -275.3  963.7   -0.0   -1.0  -138 -1907  2045 R .... ... . ..
  937.0-1125.0  186.0    0.0   -2.0  1729 -1099  -630>R .... 1.. . ..
[6]
  754.0  435.3-1190.3    0.0   -1.0   265  1374 -1639 R .... 1.. . .3
 -940.3 1122.7 -185.3   -0.0   -3.0 -1730  1099   631 R .... 1.. . .3
 -755.3 -440.7 1187.3   -0.0   -8.7  -265 -1374  1639 R .... 1.. . .3
  940.0-1122.3  182.0    0.0   -0.3  1729 -1096  -633 R .... 1.. . .3
```

Figure 9.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution

```
[7]
  752.0  441.0-1188.7    0.0    4.3   261  1376 -1638 R .... 1.. . .3
 -941.0 1119.0 -181.3   -0.0   -3.3 -1730  1094   636 R .... 1.. . .3
 -750.3 -440.7 1189.3   -0.1   -1.7  -260 -1375  1635 R .... 1.. . .3
  940.7-1121.3  178.3   -0.0   -2.3  1730 -1093  -636 R .... 1.. . .3

[8]
  748.3  440.3-1191.3    0.0   -2.7   258  1379 -1637 R .... 1.. . .3
 -942.0 1119.0 -177.7   -0.0   -0.7 -1733  1094   638 R .... 1.. . .3
 -749.7 -444.3 1189.3    0.0   -4.7  -256 -1380  1636 R .... 1.. . .3
  942.7-1120.3  176.3    0.0   -1.3  1733 -1091  -642 R .... 1.. . .3
[9]
  746.3  444.0-1190.3    0.0    0.0   253  1381 -1635 R .... 1.. . .3
 -945.0 1119.0 -176.0   -0.0   -2.0 -1734  1089   645 R .... 1.. . .3
 -746.7 -446.0 1189.3   -0.1   -3.3  -252 -1380  1633 R .... 1.. . .3
  943.7-1121.3  172.7    0.0   -5.0  1732 -1085  -646 R .... 1.. . .3
[10]
  747.3  447.7-1191.3    0.0    3.7   249  1384 -1633 R .... 1.. . .3
 -947.7 1119.0 -174.0   -0.0   -2.7 -1732  1085   647 R .... 1.. . .3
 -746.7 -451.0 1190.0   -0.0   -7.7  -250 -1383  1633 R .... 1.. . .3
  946.3-1118.3  170.7    0.0   -1.3  1733 -1083  -649 R .... 1.. . .3
[11]
  742.7  449.7-1191.3    0.0    1.0   247  1386 -1633 R .... 1.. . .3
 -948.7 1116.3 -169.3    0.0   -1.7 -1733  1083   650 R .... 1.. . .3
 -743.0 -452.7 1188.3   -0.0   -7.3  -245 -1386  1631 R .... 1.. . .3
  947.3-1115.7  168.0    0.0   -0.3  1733 -1079  -653 R .... 1.. . .3
[12]
  741.7  453.3-1189.7    0.0    5.3   243  1387 -1630 R .... 1.. . .3
 -948.7 1113.3 -169.3   -0.1   -4.7 -1736  1080   656 R .... 1.. . .3
 -740.3 -457.3 1191.0   -0.0   -6.7  -241 -1387  1628 R .... 1.. . .3
  948.3-1116.7  165.3    0.0   -3.0  1735 -1077  -659 R .... 1.. . .3
[13]
  738.0  457.0-1191.3    0.0    3.7   237  1391 -1628 R .... 1.. . .3
 -950.7 1117.0 -163.7   -0.0    2.7 -1736  1076   660 R .... 1.. . .3
 -738.3 -458.3 1189.3   -0.0   -7.3  -236 -1391  1627 R .... 1.. . .3
  950.3-1117.3  161.3    0.0   -5.7  1735 -1072  -663*R .... 1.. . .3
```

See Figure 9.4 and Figure 9.5

```
[14]
  735.0  457.0-1192.3    0.0   -0.3   233  1393 -1626 R .... 1.. . .3
 -951.3 1115.3 -161.7   -0.0    2.3 -1736  1071   665 R .... 1.. . .3
 -735.3 -459.3 1191.0   -0.0   -3.7  -231 -1393  1624 R .... 1.. . .3
  953.0-1114.7  159.7    0.0   -2.0  1735 -1069  -666 R .... 1.. . .3
[15]
  732.3  459.0-1190.3    0.0    1.0   227  1397 -1624 R .... 1.. . .3
 -955.3 1113.3 -159.0   -0.0   -1.0 -1736  1069   667 R .... 1.. . .3
 -732.7 -462.0 1190.0   -0.1   -4.7  -226 -1398  1624 R .... 1.. . .3
  953.0-1114.7  155.7    0.0   -6.0  1736 -1066  -670 R .... 1.. . .3
```

Firmware Identifier
Firmware Checksum Identifier

```
FID = SEL-710-R200-V0-Z002002-D20070119 CID = 1483
EVENT LOGS =  2

EVENT      Overcurrent Trip
TARGETS    11010000
FREQ (Hz)  60.0

Current Mag
        IA            IB            IC            IN        IG
(A)    1203.4        1207.7        1200.2          0.05      9.27

Voltage Mag
       VAB    VBC    VCA
(V)    1751   1756   1757

Differential Current Mag
        IA87          IB87          IC87
(A)       0.08          0.00          0.11
Global Settings

General Settings
APP     := FULL    PHROT   := ABC     FNOM    := 60      DATE_F  := MDY
FAULT   := STARTING OR 50S OR 50G1P OR 50N1P OR TRIP

Group Selection
TGR     := 3       SS1     := 1
SS2     := 0
SS3     := 0

52ABF   := N       BFD     := 0.50    BFI     := R_TRIG TRIP

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0

DSABLSET:= 0
```

Figure 9.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
RID     := SEL-710
TID     := MOTOR RELAY
CTR1    := 100     FLA1    := 250.0   E2SPEED := N       CTRN    := 100
PTR     := 35.00   VNOM    := 4160    DELTA_Y := DELTA   SINGLEV := N

E49MOTOR:= Y       FLS     := OFF     SETMETH := RATING  49RSTP  := 75
SF      := 1.15    LRA1    := 6.0     LRTHOT1 := 10.0    TD1     := 1.00
RTC1    := AUTO    TCAPU   := 85      TCSTART := OFF     TCLRNEN := Y
COOLTIME:= 42
50P1P   := 4.00    50P1D   := 0.00    50P2P   := OFF     50N1P   := OFF
50N2P   := OFF     50G1P   := OFF     50G2P   := OFF     50Q1P   := 3.00
50Q2P   := 0.30
E87M    := N
LJTPU   := OFF     LJAPU   := OFF

LLTPU   := OFF     LLAPU   := OFF

46UBT   := 32      46UBTD  := 5       46UBA   := 10      46UBAD  := 10
START_T := OFF

ESTAR_D := N

MAXSTART:= OFF     TBSDLY  := OFF     ABSDLY  := OFF

E47T    := Y
SPDSDLYT:= OFF     SPDSDLYA:= OFF

E49RTD  := NONE
27P1P   := OFF     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     81D2TP  := OFF
81D3TP  := OFF
81D4TP  := OFF

LOAD    := OFF

BLKPROT := 0

BLK46   := N       BLK48   := N       BLK50EF := N       BLK50P  := N
BLK37   := N       BLK66   := 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 (27P1T AND NOT LOP) OR SV01T
REMTRIP := 0
ULTRIP  := 0
52A     := 0

STREQ   := 0
EMRSTR  := 0
SPEED2  := 0
Report Settings

SER1    := IN101 IN102 IN401 IN402 IN403 IN404 ABSLO TBSLO NOSLO THERMLO
SER2    := 49T 49T_STR 49T_RTR 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 50P2T FAULT
SER4    := SPDSAL 81D3T 81D4T OTHALRM AMBALRM SALARM WARNING LOADUP LOADLOW 50P2T STOPPED
RUNNING STARTING STAR DELTA START SPEED2

EALIAS  := 12

ALIAS1  :=STARTING MOTOR_STARTING BEGINS ENDS
ALIAS2  :=RUNNING MOTOR_RUNNING BEGINS ENDS

ALIAS3  :=STOPPED MOTOR_STOPPED BEGINS ENDS

ALIAS4  :=JAMTRIP LOAD_JAM_TRIP PICKUP DROPOUT

ALIAS5  :=LOSSTRIP LOAD_LOSS_TRIP PICKUP DROPOUT

ALIAS6  :=LOSSALRM LOAD_LOSS_ALARM PICKUP DROPOUT

ALIAS7  :=46UBA UNBALNC_I_ALARM PICKUP DROPOUT

ALIAS8  :=46UBT UNBALNC_I_TRIP PICKUP DROPOUT

ALIAS9  :=49A THERMAL_ALARM PICKUP DROPOUT

ALIAS10 :=49T THERMAL_TRIP PICKUP DROPOUT
```

Figure 9.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
ALIAS11 :=47T PHS_REVRSL_TRIP PICKUP DROPOUT

ALIAS12 :=IN101 MOTOR_BREAKER OPEN CLOSED

ER      := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 37PA ORR_TRIG 55A OR R_TRIG VARA
LER     := 15      PRE     := 5
MSRR    := 5       MSRTRG  := 0

Load Profile Settings:

LDLIST  := 0

LDAR    := 15

Logic Settings

ELAT    := N       ESV     := 1       ESC     := N       EMV     := N

SV01PU  := 0.00    SV01DO  := 0.00
SV01    := WDGTRIP OR BRGTRIP OR OTHTRIP OR AMBTRIP OR REMTRIP OR 37PT OR VARTOR PTCTRIP OR 81D1T OR 81D2T OR 81D3T OR 81D4T
    OR 50QIT

OUT101FS:= Y       OUT101  := HALARM OR SALARM
OUT102FS:= N       OUT102  := START
OUT103FS:= Y       OUT103  := TRIP OR PB04
```

Figure 9.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

Figure 9.4 and *Figure 9.5* look in detail at one cycle of A-phase current (channel IA) identified in *Figure 9.3*. *Figure 9.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 9.5* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

In *Figure 9.4*, note that 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.

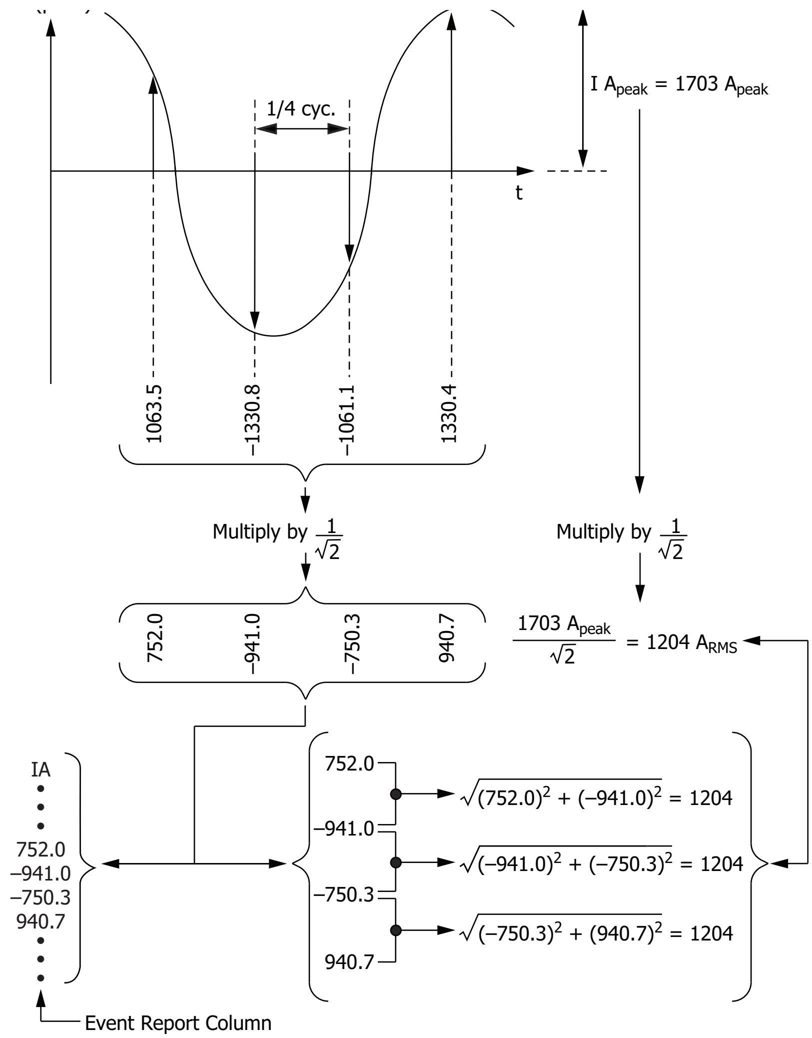

Figure 9.4 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

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:

$$IA = 1204\ A\ \angle{-38.6°} \quad \textbf{Equation 9.1}$$

The present sample (IA = 940.7 A) is a real rms current value that relates to the phasor rms current value:

$$1204\ A \bullet \cos(-38.6°) = 940.7\ A \quad \textbf{Equation 9.2}$$

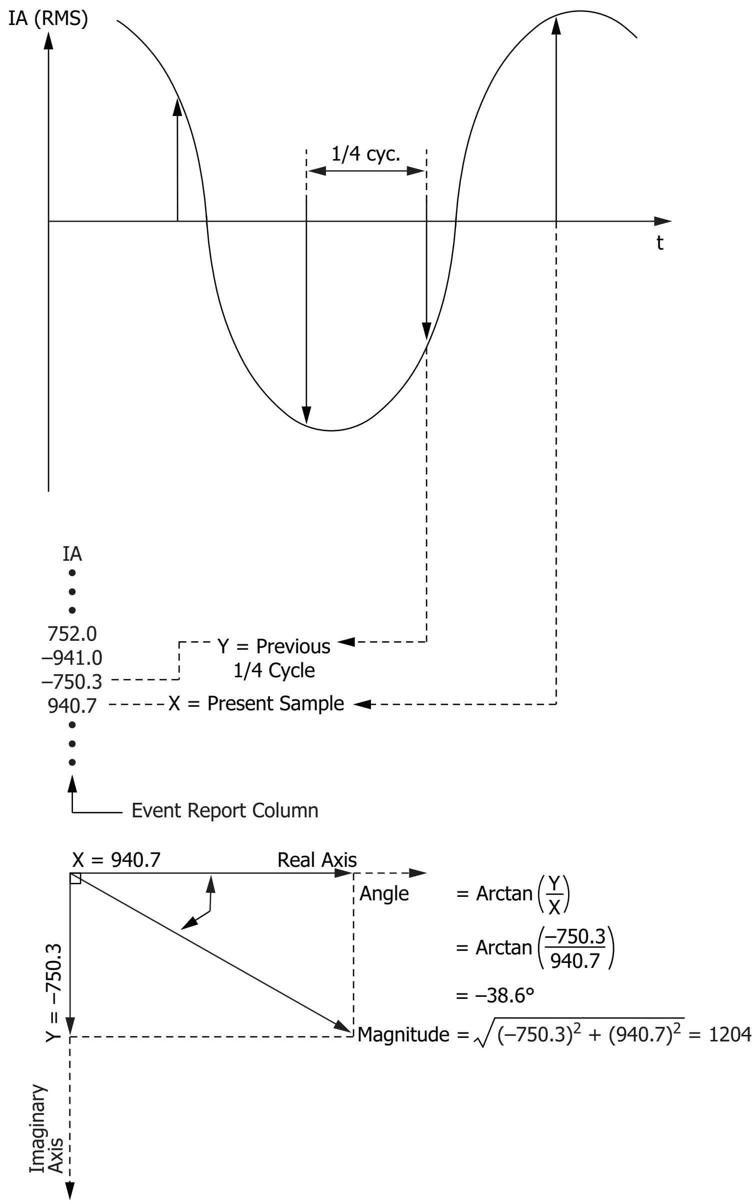

Figure 9.5 Derivation of Phasor RMS Current Values From Event Report Current Values

NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that the angle that your calculator reports is correct.

Sequential Events Recorder (SER) Report

The SER report captures relay element state changes over an extended period.

SER report data are useful in commissioning tests and root-cause analysis studies. SER information is stored when state changes occur. The report records the most recent 1024 state changes if a relay element is listed in the SER trigger equations.

SER Triggering

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.

SER Aliases

You may rename as many as 20 of the SER trigger conditions using the ALIAS settings. For instance, the factory-default alias setting 1 renames Relay Word bit STARTING for reporting in the SER:

```
ALIAS1:= STARTING MOTOR_STARTING BEGINS ENDS
```

When Relay Word bit STARTING is asserted, the SER report will show the date and time of MOTOR_STARTING BEGINS. When Relay Word bit STARTING is deasserted, the SER report will show the date and time of MOTOR_STARTING ENDS. With this and other alias assignments, the SER record is easier for the operator to review. See *Relay Word Bit Aliases on page 4.94* for additional details.

Retrieving and Clearing SER Reports

See *SER Command (Sequential Events Recorder Report) on page 7.37* 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 5 <Enter>
SEL-710                                    Date: 05/04/2006   Time: 04:28:53
MOTOR RELAY                                Time Source: Internal
FID=SEL-710-R100-V0-Z001001-D20060626 CID = 6CFF
#     DATE         TIME         ELEMENT                              STATE
5  11/16/2005  04:24:05.785   RUNNING                               Asserted
4  11/16/2005  04:24:07.497   50P1T                                 Asserted
3  11/16/2005  04:24:09.486   50P1T                                 Deasserted
2  11/16/2005  04:24:09.807   RUNNING                               Deasserted
1  11/16/2005  04:24:09.807   STOPPED                               Asserted
```

Figure 9.6 Example Sequential Events Recorder (SER) Event Report

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Section 10
Testing and Troubleshooting

Overview

Relay testing is typically divided into two categories:

- Tests performed at the time the relay is installed or commissioned
- Tests performed periodically once the relay is in service

This section provides information on both types of testing for the SEL-710 Motor Protection Relay. Because the SEL-710 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 10.15* provides a guide to isolating and correcting the problem.

Testing Tools

Serial Port Commands

The following serial port commands assist you during relay testing.

The **METER** command shows the ac currents and voltages (magnitude and phase angle) presented to the relay in primary values. In addition, the command shows power system frequency. Compare these quantities against other devices of known accuracy. The **METER** command is available at the serial ports and front-panel display. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

The relay generates a 15- or 64-cycle event report in response to faults or disturbances. Each report contains current and voltage information, relay element states, and input/output contact information. If you question the relay response or your test method, use the event report for more information. The **EVENT** command is available at the serial ports. See *Section 9: Analyzing Events*.

The relay provides a Sequential Events Recorder (SER) event report that time-tags changes in relay element and input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the relay. The **SER** command is available at the serial ports. See *Section 9: Analyzing Events*.

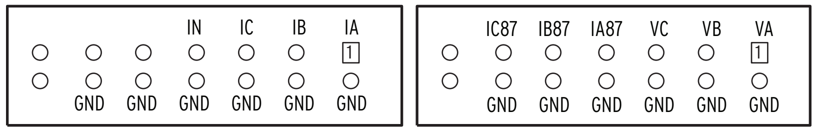
Use the **TARGET** command to view the state of relay control inputs, relay outputs, and relay elements individually during a test. The **TARGET** command is available at the serial ports and the front panel. See *Section 7: Communications* and *Section 8: Front-Panel Operations*.

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-710 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.

The SEL-RTS Low-Level Relay Test System can be used to provide signals to test the relay. *Figure 10.1* shows the Test Interface connectors.



(A) Connector J2 on Current Input Board (B) Connector J3 on Voltage Input Board

Figure 10.1 Low-Level Test Interface (J2 and J3)

Table 10.1 shows the signal scale factor information used by the SEL-5401 program for the calibrated inputs. SEL-5401 scale factors must be greater than one. For the IN channel with a scale factor of 0.02311, set the SEL-5401 scale factor to 23.11. This requires that the magnitude of current applied to the IN channel be 1000 times the desired value. To simulate 1.0 milliamp, set the SEL-5401 IN current magnitude to 1.0 ampere.

Table 10.1 Resultant Scale Factors for Inputs

Channel Label	Circuit Board & Connector	SEL-5401 Channel No.	Nominal Input	Scale Factor (A/V or V/V)
IA	CT Board / J2	1	1 A	34.7
IB	CT Board / J2	2	1 A	34.7
IC	CT Board / J2	3	1 A	34.7
IA	CT Board / J2	1	5 A	173.7
IB	CT Board / J2	2	5 A	173.7
IC	CT Board / J2	3	5 A	173.7
IN	CT Board / J2	4	5 A (Low)	18.2
IN	CT Board / J2	4	1 A (Medium)	3.64
IN	CT Board / J2	4	High	0.02311
VA	Voltage / J3	7	250 V	358.1
VB	Voltage / J3	8	250 V	358.1
VC	Voltage / J3	9	250 V	358.1
IA87	Voltage with Diff. / J3	10	1–5 A	14.48
IB87	Voltage with Diff. / J3	11	1–5 A	14.48
IC87	Voltage with Diff. / J3	12	1–5 A	14.48

⚠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.

Access the low-level test interface connectors by using the following procedure.

Step 1. Loosen the mounting screws and the ground screw 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 J3 and connect low-level signal connector (e.g., ribbon cable connector of SEL-RTS Test System).

NOTE: You can use the 14-pin connectors of the SEL-RTS ribbon cable C750A. The connectors are not keyed; make sure Pin 1 is connected to the IA/VA channel on the CT and voltage board, respectively.

Step 8. Insert the voltage board back into Slot **E**.

Refer to the SEL-*RTS Instruction Manual* for additional detail.

When simulating a delta PT connection, DELTA_Y := DELTA, with the low-level test interface referenced in *Figure 10.1*, apply the following signals:

- Apply low-level test signal VAB to Pin VA.
- Apply low-level test signal –VBC (equivalent to VCB) to Pin VC.
- Do not apply any signal to pin VB.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-710 before it is shipped. This helps to ensure that you receive a relay that operates correctly and accurately. Commissioning tests confirm that the relay is properly connected to the motor and all auxiliary equipment, and they verify control signal inputs and outputs.

The following connection tests help you enter settings into the SEL-710 and verify that the relay is properly connected. Brief functional tests ensure that the relay settings are correct. It is unnecessary to test every element, timer, and function in these tests. Modify the procedure as necessary to conform to your standard practices. Use the procedure at initial relay installation; you should not need to repeat it unless major changes are made to the relay electrical connections.

Required Equipment

- The SEL-710, installed and connected according to your protection design
- A PC with serial port, terminal emulation software, and serial communications cable
- *SEL-710 Settings Sheets* with settings appropriate to your application and protection design
- The ac and dc elementary schematics and wiring diagrams for this relay installation
- A continuity tester
- A protective relay ac test source; three-phase voltage and current with phase angle control

Connection Tests

Step 1. Remove control voltage and ac signals from the SEL-710 by opening the appropriate breaker(s) or removing fuses.

Step 2. Isolate the relay contact assigned to be the **TRIP** output.

Step 3. Verify correct ac and dc connections by performing point-to-point continuity checks on the associated circuits.

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

Step 4. Apply ac or dc control voltage to the relay.

After the relay is energized, the front-panel green ENABLED LED should illuminate.

Step 5. Use the appropriate serial cable (SEL-C662 or equivalent) to connect a PC to the relay.

Step 6. Start the PC terminal emulation software and establish communication with the relay.

Refer to *Section 7: Communications* for more information on serial port communications.

Step 7. Set the correct relay time and date by using either the front-panel or serial port commands.

Step 8. Using the **SET**, **SET P**, **SET G**, **SET L**, and **SET R** serial port commands, enter the relay settings from the settings sheets for your application.

Step 9. If you are connecting an external SEL-2600 RTD Module, follow the substeps below; otherwise continue with the next step.

a. Connect the fiber-optic cable to the RTD Module fiber-optic output.

b. Plug the relay end of the fiber-optic cable into the relay fiber-optic input.

Step 10. Verify the relay ac connections.

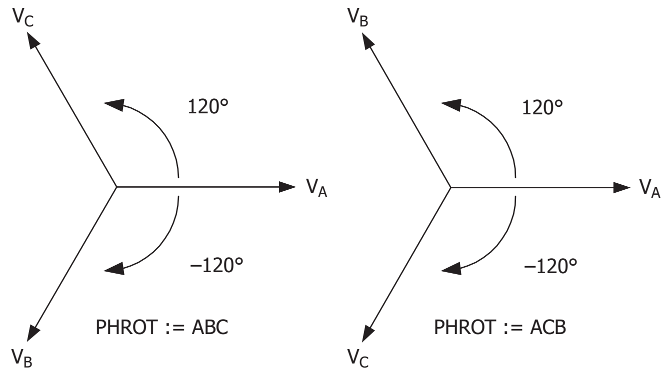
Step 11. Connect the ac test source current or voltage to the appropriate relay terminals.

NOTE: Make sure the current transformer secondary windings are shorted before they are disconnected from the relay.

a. Disconnect the current transformer and voltage transformer (if present) secondaries from the relay prior to applying test source quantities.

b. If you set the relay to accept phase-to-ground voltages (DELTA_Y := WYE), set the current and/or voltage phase angles as shown in *Figure 10.2*.

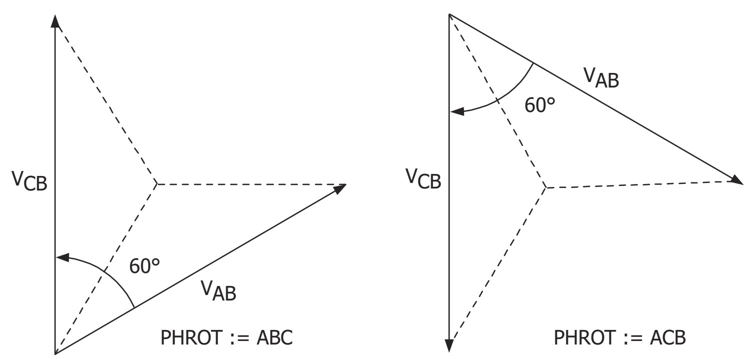
c. If you set the relay to accept delta voltages (DELTA_Y := DELTA), set the current and/or voltage phase angles as shown in *Figure 10.3*.



When setting PHROT := ABC, set angle V_A = angle I_A = 0°
set angle V_B = angle I_B = –120°
set angle V_C = angle I_C = 120°

When setting PHROT := ACB, set angle V_A = angle I_A = 0°
set angle V_B = angle I_B = 120°
set angle V_C = angle I_C = –120°

Figure 10.2 Three-Phase Wye AC Connections



When setting PHROT := ABC, set angle I_A = 0°
set angle I_B = –120°
set angle I_C = 120°
set angle V_{AB} = 30°
set angle V_{CB} = 90°

When setting PHROT := ACB, set angle I_A = 0°
set angle I_B = 120°
set angle I_C = –120°
set angle V_{AB} = –30°
set angle V_{CB} = –90°

Figure 10.3 Three-Phase Open-Delta AC Connections

Step 12. Apply rated current (1 A or 5 A).

Step 13. If the relay is equipped with voltage inputs, apply rated voltage for your application.

Step 14. Use the front-panel `METER > Fundamental` function or serial port **METER** command to verify that the relay is measuring the magnitude and phase angle of both voltage and current correctly, taking into account the relay PTR and 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 to the **IN** terminals. Do not apply voltage.

Step 16. Verify that the relay is measuring the magnitude and phase angle correctly.

The expected magnitude is (applied current) • (CTRN). The expected phase angle is zero (0).

Step 17. Verify control input connections. Using the front-panel `MAIN > Targets > Row 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).

Step 18. Verify output contact operation:

a. For each output contact, set the input to logical 1. This causes the output contact to close. For example, setting OUT101 = 1 causes the output **OUT101** contact to close.

b. Repeat the process for all contact outputs.

Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Step 19. Perform any desired protection element tests. Perform only enough tests to prove that the relay operates as intended; exhaustive element performance testing is not necessary for commissioning.

Step 20. Connect the relay for tripping duty.

Step 21. Verify that any settings changed during the tests performed in *Step 18* and *Step 19* are changed back to the correct values for your application.

Step 22. Use the serial port commands in *Table 10.2* to clear the relay data buffers and prepare the relay for operation.

This prevents data generated during commissioning testing from being confused with operational data collected later.

Table 10.2 Serial Port Commands That Clear Relay Data Buffers

Serial Port Command	Task Performed
LDP C	Clears Load Profile Data
MOT R	Clears Motor Statistics buffers
MST R	Resets Start Trend Data
SER R	Resets Sequential Events Record buffer
SUM R	Resets Event Report and Summary Command buffers

Step 23. When it is safe to do so, start the motor.

Step 24. Verify the following ac quantities by using the front-panel `METER > Fundamental` or serial port **METER** command.

- ➢ Phase current magnitudes should be nearly equal.
- ➢ Phase current angles should be balanced, have proper phase rotation, and have the appropriate phase relationship to the phase voltages.

Step 25. If your relay is equipped with voltage inputs, check the following:

- ➢ Phase voltage magnitudes should be nearly equal.
- ➢ Phase voltage phase angles should be balanced and have proper phase rotation.

The SEL-710 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*. (For differential current accuracy tests, use the appropriate relay terminals for IA87, IB87, and IC87, per *Figure 2.10*, Slot E.)

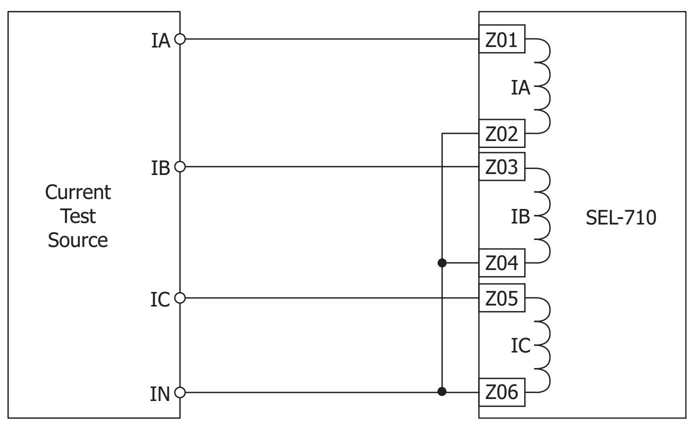


Figure 10.4 Current Source Connections

Step 2. Using the front-panel `SET/SHOW` or the serial port **SHO** 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*.

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 **SHO** 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.

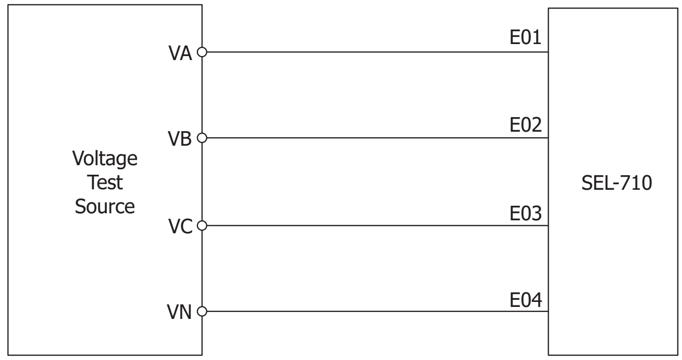


Figure 10.5 Wye Voltage Source Connections

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 ∠–26 Ib = 2.5 ∠–146 Ic = 2.5 ∠+94	**Expected:** P = 0.4523 • CTR1 • PTR	**Expected:** Q = 0.2211 • CTR1 • PTR	**Expected:** pf = 0.90 lag
Va = 67 ∠0 Vb = 67 ∠–120 Vc = 67 ∠+120	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 ∠–26 Ib = 2.5 ∠+94 Ic = 2.5 ∠–146	**Expected:** P = 0.4523 • CTR1 • PTR	**Expected:** Q = 0.2211 • CTR1 • PTR	**Expected:** pf = 0.90 lag
Va = 67 ∠0 Vb = 67 ∠+120 Vc = 67 ∠–120	**Measured:**	**Measured:**	**Measured:**

Delta-Connected Voltages

Perform the following steps to test delta-connected voltages:

Step 1. Connect the current source to the relay, as shown in *Figure 10.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 10.6*. Make sure that DELTA_Y := DELTA.

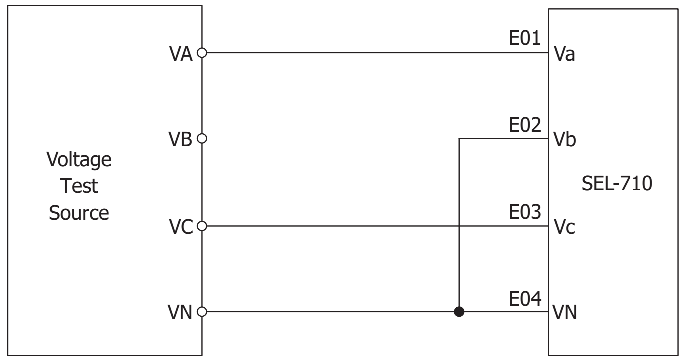


Figure 10.6 Delta Voltage Source Connections

Step 3. Using the front-panel SET/SHOW or the serial port **SHOW** command, record the 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
VA (Vab) = 120 ∠+30 VC (Vcb) = 120 ∠+90	**Measured:**	**Measured:**	**Measured:**
PHROT := ACB Ia = 2.5 ∠–26 Ib = 2.5 ∠+94 Ic = 2.5 ∠–146	**Expected:** P = 0.4677 • CTR1 • PTR	**Expected:** Q = 0.2286 • CTR1 • PTR	**Expected:** pf = 0.90 lag
VA (Vab) = 120 ∠–30 VC (Vcb) = 120 ∠–90	**Measured:**	**Measured:**	**Measured:**

Periodic Tests (Routine Maintenance)

Because the SEL-710 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-710 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

The SEL-710 runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 10.8*):

➤ Protection Disabled: The relay disables protection and control elements and trip/close logic. All output contacts are de-energized. The **ENABLED** front-panel LED is extinguished.

NOTE: Refer to Access Commands (ACCESS, 2ACCESS, and CAL) for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

➤ ALARM Output: Two Relay Word bits, HALARM and SALARM, signal self-test problems. SALARM is pulsed for software programmed conditions, such as settings changes, access-level changes, unsuccessful password entry attempts, active group changes, copy commands, or password changes. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures. A diagnostic alarm may be configured as explained in *Section 4: Protection and Logic Functions*. In the Alarm Status column of *Table 10.8*, Latched indicates that HALARM is continuously asserted, Not Latched indicates that HALARM is pulsed for five seconds, and NA indicates that HALARM is not asserted.

- The relay generates automatic STATUS reports at the serial port for warnings and failures (ports with setting AUTO = Y).
- The relay displays failure messages on the relay LCD display for failures.
- For certain failures, the relay will automatically restart as many as three times. In many instances, this will correct the failure. The failure message might not be fully displayed before automatic restart occurs. Indication that the relay restarted will be recorded in the Sequential Events Recorder (SER).

Use the serial port **STATUS** command or the front-panel to view the relay self-test status. Based on the self-test type, issue the **STA C** command as directed in the Corrective Actions column. Contact SEL if this does not correct the problem.

Table 10.8 Relay Self-Tests (Sheet 1 of 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front-Panel Message on Failure	Corrective Action
Watchdog Timer Periodic Resetting (1/32 cycle)			Yes	De-energized	No	No	
Main Board FPGA (power up)	Fail if the main board field programmable gate array does not accept a program or the version number is incorrect		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
Main Board FPGA (run time)	Fail on lack of data acquisition interrupts or on detection of a CRC error in the FPGA code		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
GPSB (back-plane) Communications	Fail if GPSB is busy on entry to processing interval		Yes	Latched	Yes	Status Fail GPSB Failure	Automatic restart. Contact SEL if failure returns.
Front-Panel HMI (power up)	Fail if ID registers do not match expected or if FPGA programming is unsuccessful		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External RAM (power up)	Performs a read/write test on system RAM		Yes	Latched	No	No	
External RAM (run time)	Performs a read/write test on system RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Internal RAM (power up)	Performs a read/write test on system CPU RAM		Yes	Latched	No	No	
Internal RAM (run time)	Performs a read/write test on system CPU RAM		Yes	Latched	Yes	Status Fail RAM Failure	Automatic restart. Contact SEL if failure returns.
Code Flash (power up)	SELBOOT qualifies code with a checksum		NA	NA	NA	NA	

Table 10.8 Relay Self-Tests (Sheet 2 of 3)

Self Test	Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front-Panel Message on Failure	Corrective Action
Data Flash (power up)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Data Flash (run time)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	
Critical RAM (settings)	Performs a checksum test on the active copy of settings		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
Critical RAM (run time)	Verify instruction matches FLASH image		Yes	Latched	Yes	Status Fail CR_RAM Failure	Automatic restart. Contact SEL if failure returns.
I/O Board Failure	Check if ID register matches part number		Yes	Latched	Yes	Status Fail Card [C|D|E] Failure	
DeviceNet Board Failure	DeviceNet card does not respond in three consecutive 300 ms time out periods		NA	NA	NA	COMMFLT Warning	
CT Board (power up)	Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail CT Card Fail	
CT Board A/D Offset Warn	Measure dc offset at each input channel	–50 mV to +50 mV	No	Not Latched	No	NA	STA C, 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	Yes	Status Fail Card E Fail	
VT Board A/D Offset Warn	Measure dc offset at each input channel	–50 to +50 mV	No	Not Latched	No	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
+0.9 V Fail	Monitor +0.9 V power supply	0.855 to 0.945 V	Yes	Latched	Yes	Status Fail +0.9 V Failure	
+1.2 V Fail	Monitor +1.2 V power supply	1.152 to 1.248 V	Yes	Latched	Yes	Status Fail +1.2 V Failure	
+1.5 V Fail	Monitor +1.5 V power supply	1.35 to 1.65 V	Yes	Latched	Yes	Status Fail +1.5 V Failure	
+1.8 V Fail	Monitor +1.8 V power supply	1.71 to 1.89 V	Yes	Latched	Yes	Status Fail +1.8 V Failure	
+3.3 V Fail	Monitor +3.3 V power supply	3.07 to 3.53 V	Yes	Latched	Yes	Status Fail +3.3 V Failure	
+5 V Fail	Monitor +5 V power supply	4.65 to 5.35 V	Yes	Latched	Yes	Status Fail +5 V Failure	

Table 10.8 Relay Self-Tests (Sheet 3 of 3)

Self Test / Description	Normal Range	Protection Disabled on Failure	Alarm Status	Auto Message on Failure	Front-Panel Message on Failure	Corrective Action
+2.5 V Fail Monitor +2.5 V power supply	2.32 to 2.68 V	Yes	Latched	Yes	Status Fail +2.5 V Failure	
+3.75 V Fail Monitor +3.75 V power supply	3.48 to 4.02 V	Yes	Latched	Yes	Status Fail +3.75 V Failure	
–1.25 V Fail Monitor –1.25 V power supply	–1.16 to –1.34 V	Yes	Latched	Yes	Status Fail –1.25 V Failure	
–5 V Fail Monitor –5 V power supply	–4.65 to –5.35 V	Yes	Latched	Yes	Status Fail –5 V Failure	
Clock Battery Monitor clock battery	2.3 to 3.5 V	No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip RAM Clock chip static RAM fails		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Internal/External RTD Fails if the internal RTD card or the external RTD reports that at least one enabled RTD input is open or shorted, if there is no communication, or if there is a power supply failure for the external RTD module		NA	NA	No	RTD Failure	STA C, to clear the warning in the status report. Contact SEL if failure returns.
CID (configured IED description) File (access) Failure to access/read CID file		No	NA	No	Status Fail CID File Failure	
Exception Vector CPU error		Yes	Latched	NA	Vector *nn* Relay Disabled	Automatic restart. Contact SEL if failure returns.

Troubleshooting

Table 10.9 Troubleshooting

Symptom/Possible Cause	Diagnosis/Solution
The relay ENABLED front-panel LED is dark.	
Input power is not present or a fuse is blown.	Verify that input power is present. Check fuse continuity.
Self-test failure	View the self-test failure message on the front-panel display.
The relay front-panel display does not show characters.	
The relay front panel has timed out.	Press the **ESC** pushbutton to activate the display.
The relay is de-energized.	Verify input power and fuse continuity.
The relay does not accurately measure voltages or currents.	
Wiring error	Verify input wiring.
Incorrect 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.
The relay does not respond to commands from a device connected to the serial port.	
Cable is not connected.	Verify the cable connections.
Cable is not the correct type.	Verify the cable pinout.
The relay or device is at an incorrect data rate or has another parameter mismatch.	Verify device software setup.
The relay serial port has received an XOFF, halting communications.	Type **<Ctrl+Q>** to send the relay XON and restart communications.
The relay does not respond to faults.	
The relay is improperly set.	Verify the relay settings.
Improper test source settings	Verify the test source settings.
Current or voltage input wiring error	Verify input wiring.
Failed relay self-test	Use the front-panel RELAY STATUS function to view self-test results.

Technical Support

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

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Appendix A
Firmware, ICD, and Manual Versions

Firmware

Determining the Firmware Version

To determine the firmware version, view the status report by using the serial port **STATUS** command or the front panel. The status report displays the firmware identification (FID) string.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device FID string.

Existing firmware:

FID=SEL-710-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-710-**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-710-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-710-R100-**V1**-Z001001-D*xxxxxxxx*

The date code is after the D. For example, the following is firmware revision number R100, date code June 26, 2006.

FID=SEL-710-R100-V0-Z001001-**D20060626**

Revision History

Table A.1 lists the firmware versions for the R400 series firmware, a description of modifications, and the instruction manual date code that corresponds to firmware versions (see *Table A.2* for R300 series firmware, *Table A.3* for R200 series firmware, and *Table A.4* for R100 series firmware). The most recent firmware version is listed first.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with “[Cybersecurity]”. Other improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with “[Cybersecurity Enhancement]”.

Table A.1 R400 Series Firmware Revision History (Sheet 1 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-R412-V2-Z008004-D20241014	Includes all the functions of SEL-710-R412-V1-Z008004-D20220114 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component to remove low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ Resolved an issue with the rms voltage analog quantities not being reported according to the DELTA_Y setting. ➤ Resolved an issue where entering a special character for a settings value during an SEL ASCII session could cause the relay to interpret the setting as 0. ➤ Resolved an issue where the relay could experience a NON VOL failure under certain conditions. ➤ Improved dependability of the slip calculation for rare corner cases.	20241014
SEL-710-R412-V1-Z008004-D20220114	Includes all the functions of SEL-710-R412-V0-Z008004-D20190508 with the following additions: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part. ➤ Resolved a rare issue in which the calibration settings could cause the relay to disable. ➤ Resolved an issue that caused the relay to occasionally reject the autocalculated COOLTIME setting sent via QuickSet software when using the curve thermal method. ➤ Resolved an issue with the analog output on the 3 DI/4 DO/1 AO card. The analog output was resetting to zero for approximately one second when any relay setting change was made. ➤ Resolved an issue in which the MOT command response reported the total number of trips incorrectly.	20220114
SEL-710-R412-V0-Z008004-D20190508	➤ Added the enable port setting EPORT to each communications port to enhance port security. ➤ Resolved an issue that could cause the relay to disable if exactly four IEC 61850 buffered reports were enabled. ➤ Improved the security of the resistance temperature detector (RTD) FAULT, ALARM, and TRIP indicators by adding an approximately 12-second delay to filter RTD measurements distorted by electrical noise. ➤ Resolved an issue in which the RTD measurements were not updated when the setting BLK49RTD was set equal to Y and Relay Word bit BLKPROT was asserted. ➤ Modified the General Purpose Serial Bus (GPSB) diagnostics logic to show a failure only if the GPSB diagnostics fail three consecutive times within a 24-hour period. ➤ Resolved an issue in which the starts-per-hour lockout Relay Word bit NOSLO asserted for 1 second when the setting BLKPROT was set equal to STARTING and the setting BLK66 was set equal to Y. ➤ Resolved an issue in which the power factor element did not correctly operate when real power was negative. ➤ Resolved an issue in which the emergency restart did not reset the stator Thermal Capacity Used (TCU) to 0 if the motor was in Speed 2.	20190508

Table A.1 R400 Series Firmware Revision History (Sheet 2 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue in which the frequency analog quantity (FREQ) was reset to 0 following a settings change. ➤ Resolved an issue in which the relay continued to send Fast Sequential Events Recorder (SER) data to the real-time automation controller (RTAC) after the relay acknowledged an RTAC disable command. ➤ Addressed an issue with event type mismatch between the CHI and CEV commands that resulted in RTACs being unable to collect events with event type strings longer than 14 characters. ➤ Addressed an issue with the validation of IP addresses and port numbers of enabled protocols.	
SEL-710-R411-V3-Z007004-D20241014	Includes all the functions of SEL-710-R411-V2-Z007004-D20220114 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ [Cybersecurity] Resolved a rare, low-risk issue where deliberately crafted Ethernet traffic could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Updated a third-party networking software component to remove low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ Resolved an issue with the rms voltage analog quantities not being reported according to the DELTA_Y setting. ➤ Resolved an issue where entering a special character for a settings value during an SEL ASCII session could cause the relay to interpret the setting as 0. ➤ Resolved an issue where the relay could experience a NON VOL failure under certain conditions. ➤ Improved dependability of the slip calculation for rare corner cases.	20241014
SEL-710-R411-V2-Z007004-D20220114	Includes all the functions of SEL-710-R411-V1-Z007004-D20190508 with the following additions: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part. ➤ Resolved a rare issue in which the calibration settings could cause the relay to disable. ➤ Resolved an issue that caused the relay to occasionally reject the autocalculated COOLTIME setting sent via QuickSet software when using the curve thermal method. ➤ Resolved an issue with the analog output on the 3 DI/4 DO/1 AO card. The analog output was resetting to zero for approximately one second when any relay setting change was made. ➤ Resolved an issue in which the MOT command response reported the total number of trips incorrectly.	20220114
SEL-710-R411-V1-Z007004-D20190508	Includes all the functions of SEL-710-R411-V0-Z007004-D20170623 with the following additions: ➤ Resolved an issue that could cause the relay to disable if exactly four IEC 61850 buffered reports were enabled.	20190508
SEL-710-R411-V0-Z007004-D20170623	➤ Enhanced the motor thermal model by allowing for a fast cooling rate during coasting to a stop. Based on the new COASTIME setting, the relay automatically delays the use of the slower cooling rate (based on COOLTIME), which significantly reduces the wait time before the next start is allowed by thermal lockout.	20170623

Table A.1 R400 Series Firmware Revision History (Sheet 3 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Enhanced the thermal model for synchronous motor applications by adding a new slip derived from stator measurements (SMSLIP2). Added slip source setting SLIPSRC to select the source for the motor slip used in the thermal model calculated from the stator quantities (STAT) or the R1 signal. Enhanced the MSR and CMSR reports to show the slip calculated from the stator quantities or the R1 signal when the slip source setting SLIPSRC is set to STAT or R1, respectively, and also added SMSLIP2 to the CEV report. ➤ Resolved an issue in R408–R410 firmware versions by removing option D from the NETPORT setting. The relay became unresponsive on power up if the setting NETPORT was set to D in dual Ethernet models with the setting NETMODE set to FIXED or FAILOVER. ➤ Resolved an issue with RTD biasing that, in certain cases, caused the relay to trip on 49T even when currents were not applied. ➤ Resolved an issue with changing phase angles even though the magnitude/angles of the analog channels were squelched. ➤ Resolved an issue with the load loss element where the 37LLTC bit was blocking the function when the STARTING Relay Word bit was asserted. ➤ Added a feature in Modbus to always show the latest event data unless another event is selected.	
SEL-710-R410-V0-Z006004-D20140303	➤ Added logical nodes to the IEC 61850 ICD file. ➤ Enhanced the firmware for the breaker failure logic to use IAV (average current) instead of I1 (positive-sequence current). This improves the operation when the current is purely negative sequence. ➤ Resolved an issue that can cause small jumps in the angle calculations for analog quantities. ➤ Resolved an issue with dc offset on analog channels when the relay was turned on. ➤ Resolved an issue where port settings were not accepted when the relay settings were downloaded with ACSELERATOR QuickSet SEL-5030 Software. QuickSet reported with a message that settings files were not received. ➤ Changed storage of latch and local bits from volatile to non-volatile memory. ➤ Improved the security of RTD ALARM and TRIP by adding an approximately 6-second delay to qualify the event. ➤ Resolved an issue where the front panel showed a blank page after resetting a TRIP message. ➤ Added Y-MODEM over Telnet to support file transfer. ➤ Resolved an issue with the data type "Units_0" in the IEC 61850 ICD file by changing the unit data type name to SIUnit. ➤ Resolved an issue with the start delay timer for the Load-Loss function. ➤ Resolved an issue with port timeout when accessing SEL Fast protocol data over Telnet. In all previous firmware revisions that support Telnet, it was necessary to send ASCII characters regularly to keep the connection alive. ➤ Modified the firmware to make the MATHERR Relay Word bit visible. ➤ Implemented a firmware enhancement to preserve any existing IEC 61850 CID file while upgrading from a previous firmware version.	20140303

Table A.1 R400 Series Firmware Revision History (Sheet 4 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added Flash File System support to make settings and other miscellaneous nonvolatile data storage more robust and avoid the display of NON-VOL FAIL messages. ➤ Enhanced the average motor load (xFLA) resolution in the Fundamental Meter Report to have two digits after the decimal point. ➤ Enhanced the neutral current IN channel resolution in the Fundamental Meter Report to have two digits after the decimal point. ➤ Revised the firmware to support the HMI hardware revisions. Firmware R410 is supported by previous hardware. Hardware shipped with R410 and later does not support firmware R408 and earlier. ➤ Updated the firmware to resolve the DeviceNet EDS file scaling issue with Parameter Numbers 829 (STATOR %TCU) and 830 (ROTOR %TCU). Firmware version R410 is for upgrading relays with R400–R408 firmware.	
SEL-710-R409	➤ R409 was not production released. R410 follows R408.	NA
SEL-710-R408-V0-Z006004-D20130726	➤ Corrected an Ethernet Failover Switching issue for dual-Ethernet models. ➤ Corrected an issue with the initial Gratuitous ARP request not being sent for as long as five minutes after startup. ➤ Updated error messages for setting interdependency checks to match the global setting AOx0yH. ➤ Corrected an issue where INx04 was shown in targets for the 3 DI/4 DO card, which has only three inputs. ➤ Modified the Real Time Clock (RTC) diagnostics logic to show failure only if the RTC diagnostics fail three consecutive times. ➤ Changed the processing of the RSTTRGT input to the Trip Logic to rising edge of RSTTRGT. ➤ Corrected the response to the **STA C** command such that the relay responds with REBOOT RELAY instead of STATUS RESET. ➤ Corrected a front-panel trip message display issue where it does not update the previous trip type message for a trip on lockout condition. ➤ Corrected an issue where old packets were returned on new connections when polling Modbus at high speed. Firmware version R408 is for upgrading relays with R400–R407 firmware.	20130726
SEL-710-R407-V0-Z006004-D20111123	➤ Corrected an issue with the rms meter values, where in some cases the values would spike for a short time. ➤ Revised the units for MIRRORED BITS protocol setting CBADPU to ppm (parts per million). ➤ Corrected an issue with the MMS error message in response to an IEC 61850 control operation failure. ➤ Corrected an issue of missing SER records upon warm start. ➤ Fixed an issue with the ENABLED LED that did not turn off when the relay was disabled.	20111123
SEL-710-R406-V0-Z006004-D20110620	➤ Added support for Simple Network Time Protocol (SNTP) to Ethernet. ➤ Corrected an issue with inverse-time overcurrent elements (did not accumulate time correctly at off-nominal frequency for FNOM = 50 Hz nominal frequency).	20110620

Table A.1 R400 Series Firmware Revision History (Sheet 5 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added new settings for time and date management (including daylight-saving time) under Global Settings. ➤ Added a squelch threshold for very low-level secondary voltages (below 0.3 V) and currents (below 3% of INOM) in the rms metering quantities command response. ➤ Corrected IEC 61850 KEMA compliance issue. ➤ Corrected issue with reading Modbus Communications Counter registers (Registers 1789–1798) using the user map. ➤ Corrected the issue of SALARM not asserting for a settings group change.	
SEL-710-R405-V0-Z005004-D20101101	➤ Corrected an **LDP** command issue (relay lockup if data exceeds a threshold) in R400–403 firmware. ➤ Corrected an issue in R403 firmware with off-nominal frequency timing calculation for Time-Overcurrent element (51).	20101101
SEL-710-R403-V0-Z005004-D20100913	➤ Corrected a data issue with **MET E** and **LDP** command responses. ➤ Added a squelch threshold for very low-level voltages (below 0.1 V) and currents (below 1% of INOM) in the metering quantities command response. ➤ Added calculated phase-to-phase voltages for wye-connected PTs to the analog quantities to allow selection for display points. ➤ Implemented improved diagnostics and actions in the relay self-tests including soft error detection and automatic restarts. ➤ Corrected an issue with inverse-time overcurrent elements (did not accumulate time correctly at off-nominal frequency). ➤ Enhanced the firmware to make the serial number visible to the IEC 61850 protocol and also revised the ICD file to add serial and part number information to PhyNam DO.	20100913
SEL-710-R402-V0-Z005004-D20100611	➤ Added the Rating_1 choice to the Thermal Method setting. The Rating_1 Method is exactly the same as the Rating Method, except that it does not raise the initial heat estimate at start like the Rating Method. ➤ For the Thermal Overload element, expanded the range of the LRQ (Locked Rotor Torque) setting from 0.50–2.00 to 0.30–2.00 pu. ➤ Added two time-out settings for the Modbus TCP sessions on Ethernet port. ➤ Added Frequency to the CEV event report. ➤ Expanded the settings range at the low end to 0.02 xVnm for all under- and overvoltage elements. ➤ Added Select Before Operate control (SBO) to IEC 61850 protocol. ➤ Added Access Control setting BLOCK MODBUS SET (BLKMBSET) to be able to block settings changes from a remote Modbus or DeviceNet master. ➤ Added new I/O card (4 DI/3 DO), which has one Form-B and two Form-C outputs. ➤ Added breaker monitor function and associated settings and commands to allow tracking breaker activity and help in scheduling breaker maintenance. ➤ Corrected relay status reporting via Modbus when relay is disabled. ➤ Updated Ethernet port settings IPADDR, SUBNETM, and DEFRTR validation to allow addresses in the private address space.	20100611

Table A.1 R400 Series Firmware Revision History (Sheet 6 of 6)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-R401-V0-Z004003-D20100118	➤ Corrected an occasional IEC 61850 communications defect where the firmware incorrectly reads an opcode from Flash memory and results in a vector.	20100118
SEL-710-R400-V0-Z004003-D20090924	➤ Revised firmware for processor update. Previous versions cannot be upgraded to R400. ➤ Improved stator thermal capacity calculation accuracy.	20090924

Table A.2 R300 Series Firmware Revision History (Sheet 1 of 3)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-R311-V1-Z005004-D20190508	Includes all the functions of SEL-710-R311-V0-Z005004-D20130726 with the following additions: ➤ Resolved an issue that could cause the relay to disable if exactly four IEC 61850 buffered reports were enabled. ➤ Resolved an issue in which the RTD measurements were not updated when the setting BLK49RTD was set equal to Y and Relay Word bit BLKPROT was asserted. ➤ Improved the security of RTD ALARM and TRIP by adding an approximately six second delay to qualify the event. ➤ Resolved an issue with RTD biasing that, in certain cases, caused the relay to TRIP on 49T even when currents were not applied. ➤ Resolved an issue where SALARM did not assert for settings group changes.	20190508
SEL-710-R311-V0-Z005004-D20130726	➤ Corrected an issue where INx04 was shown in targets for the 3 DI/4 DO card, which has only three inputs. ➤ Updated error messages for setting interdependency checks to match the global setting AOx0yH. ➤ Changed the processing of RSTTRGT input to the Trip Logic to rising edge of RSTTRGT. ➤ Corrected the response to the **STA C** command such that the relay responds with REBOOT RELAY instead of STATUS RESET. ➤ Corrected a front-panel trip message display issue where it does not update the previous trip type message for a trip on lockout condition. ➤ Corrected an issue where old packets were returned on new connections when polling Modbus at high speed. ➤ Corrected an Ethernet Failover Switching issue for dual-Ethernet models. ➤ Corrected an issue with the initial Gratuitous ARP request not being sent for as long as five minutes after startup.	20130726
SEL-710-R310-V0-Z005004-D20111123	➤ Corrected an issue with the rms meter values, where in some cases the values would spike for a short time. ➤ Fixed an issue with the ENABLED LED that did not turn off when the relay was disabled. ➤ Corrected an issue of missing SER records upon warm start.	20111123
SEL-710-R309-V0-Z005004-D20110620	➤ Corrected an issue with inverse-time overcurrent elements (did not accumulate time correctly for off-nominal frequency for FNOM = 50 Hz nominal frequency).	20110620
SEL-710-R308-V0-Z005004-D20101101	➤ Corrected an issue in R307 firmware with off-nominal frequency timing calculation for Time-Overcurrent element (51).	20101101

Table A.2 R300 Series Firmware Revision History (Sheet 2 of 3)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-R307-V0-Z005004-D20100913	➤ Added a squelch threshold for very low-level voltages (below 0.1 V) and currents (below 1% of INOM) in the metering quantities command response. ➤ Added calculated phase-to-phase voltages for wye-connected PTs to the analog quantities to allow selection for display points. ➤ Enhanced the firmware to make the serial number visible to the IEC 61850 protocol and also revised the ICD file to add the serial and part number information to PhyNam DO.	20100913
SEL-710-R306-V0-Z005004-D20100611	➤ Added Ratings_1 choice to the Thermal Method setting. The Rating_1 Method is exactly the same as the Rating Method except that it does not raise the initial heat estimate at start like the Rating Method. ➤ For the Thermal Overload element, expanded the range of the LRQ (Locked Rotor Torque) setting from 0.50–2.00 to 0.30–2.00 pu. ➤ Added two time-out settings for the Modbus TCP sessions on Ethernet port. ➤ Added Frequency to the CEV event report. ➤ Expanded the settings range at the low end to 0.02 xVnm for all under- and overvoltage elements. ➤ Added Select Before Operate control (SBO) to IEC 61850 protocol. ➤ Added Access Control setting BLOCK MODBUS SET (BLKMBSET) to be able to block settings changes from a remote Modbus or DeviceNet master. ➤ Added new I/O card (4 DI/3 DO), which has one Form-B and two Form-C outputs. ➤ Added breaker monitor function and associated settings and commands to allow tracking breaker activity and help in scheduling breaker maintenance. ➤ Corrected relay status reporting via Modbus when relay is disabled. ➤ Updated Ethernet port settings IPADDR, SUBNETM, and DEFRTR validation to allow addresses in the private address space.	20100611
SEL-710-R305-V0-Z004003-D20091026	➤ Improved stator thermal capacity calculation accuracy.	20091026
SEL-710-R304-V0-Z004003-D20090327	➤ Added new inverse-timed overcurrent elements 51P, 51Q and 51G, related settings, and Relay Word bits. ➤ Added IRIG-B support to fiber-optic serial Port 2. ➤ Added new Global setting for time-synchronization source selection TIME_SRC. ➤ Added fast operate messages setting FASTOP to ETHERNET PORT 1. ➤ Improved slip-dependent thermal model. ➤ Added front-panel setting FP_AUTO to allow choice between OVERRIDE and ROTATING display messages. ➤ Resolved an issue with the 87M motor differential element where the element remained operational even when the enable setting E87M was set to N. This issue was introduced in firmware R201.	20090327
SEL-710-R303-V0-Z003003-D20081124	➤ Corrected a firmware upgrade issue in firmware revision R302 when upgrading relays with previous firmware version R301.	20081124
SEL-710-R302-V0-Z003003-D20081022	➤ Updated IEC 61850 firmware to streamline MMS processing and improve TCP/IP connections. ➤ Improved security (see selinc.com/privacy.htm for details).	20081022
SEL-710-R301-V0-Z003003-D20080808	➤ Added new option of 8 DI card. ➤ Added new option of 4 DI/4 DO card with fast, high current interrupting hybrid outputs.	20080808

Table A.2 R300 Series Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added new Ethernet port options including dual redundant copper Ethernet and single and dual redundant fiber-optic Ethernet. ➤ Added capability to support two independent Modbus TCP sessions. ➤ Added Virtual Bits (VB1 to VB128) for GOOSE messaging in IEC 61850 protocol. ➤ Added ASCII commands **ETHERNET** and **PING** to support Ethernet communications. ➤ Added Motor Running Time to the Analog Quantities (Appendix J) to facilitate Motor Running Time display on the front panel using Display Points. ➤ Improved Energy Metering resolution to 1 KWh in METER E report and Modbus communications. ➤ Corrected Thermal element slip calculation in relays with 1 A phase current inputs.	

Table A.3 R200 Series Firmware Revision History (Sheet 1 of 2)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-R205-V0-Z002002-D20081022	➤ Updated IEC 61850 firmware to streamline MMS processing and improve TCP/IP connections. ➤ Improved security (see selinc.com/support/security-notifications/ for details).	20081022
SEL-710-R204-V0-Z002002-D20080325	➤ Enhanced IEC 61850 functionality with KEMA certification updates. ➤ Corrected reporting of digital inputs (INXXX) during relay power MMS for IEC 61850 protocol.	20080325
SEL-710-R203-V0-Z002002-D20071114	➤ Corrected thermal model operation for two-speed motor applications.	20071114
SEL-710-R202-V0-Z002002-D20070514	➤ Changed ID command response to include IEC 61850 information when it is used. ➤ Changed STA (STATUS) command response to include display of IA87, IB87, and IC87 offset status when differential current option is used. ➤ Revised Modbus Map to include IA87, IB87, and IC87 Offset Status and CIDFILE Status. ➤ Fixed EIA-485 port communications issue found in R201 firmware.	20070514
SEL-710-R201-V0-Z002002-D20070314	➤ Added motor differential protection option (87 element). This element requires the AVI/ACI input card in slot E. New settings are required. ➤ Added MIRRORED BITS communications protocol and settings. ➤ Added IEC 61850 communications protocol and settings. ➤ Increased firmware code space (Flash), SDRAM space and added new hardware self-tests (revised design CPU/Comm card in slot B). For this reason R100 firmware relay cannot be upgraded to R200 firmware. R100 relay can be converted to R200 relay by returning the relay to SEL for the conversion. ➤ Added new Modbus registers and revised Modbus Map significantly from R100 firmware release. Rearranged Modbus map and kept the relay elements table at the end of the map. ➤ Added hysteresis in the Thermal Warning (49A) logic to prevent occasional nuisance chatter.	20070314

Table A.3 R200 Series Firmware Revision History (Sheet 2 of 2)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ In the Motor Thermal Model redefined “Hot” motor criteria from 0.9 pu load to 0.9 times the SF pu load where SF is the motor service factor to better represent “Hot” motor condition. ➤ Expanded the setting range of setting LRQ (Locked Rotor Torque) to 0.50–2.00 from 0.50–1.50.	

Table A.4 R100 Series Firmware Revision History

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-R102-V1-Z001001-D20150918	Includes all the functions of SEL-710-R102-V0-Z001001-D20071114 with the following addition: ➤ Resolved an issue that causes SELOGIC timers to momentarily deassert after a temporary deassertion of that 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 dropout time setting. If the input deassertion time is longer than the dropout time setting, then the timer operates correctly. Firmware version R102-V1 is for upgrading relays with R100–R102-V0 firmware.	20150918
SEL-710-R102-V0-Z001001-D20071114	➤ Corrected thermal model operation for two-speed motor applications.	20071114
SEL-710-R101-V0-Z001001-D20070314	➤ Corrected Modbus User Register Mapping to Trip/Warn data registers.	20070314
SEL-710-R100-V0-Z001001-D20060626	➤ Initial version.	20060626

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions, as listed in *Table A.5*. The version number of this firmware is only accessible via the DeviceNet interface.

Table A.5 DeviceNet Card Versions

DeviceNet Card Software Version	Revisions	Release Date
Major Rev: 1, Minor Rev: 5 (Rev 1.005)	Reads product code, DeviceNet card parameter descriptions, etc., from the relay.	20080407
Major Rev: 1, Minor Rev: 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-710 are zipped together (SEL-*xxx*R*xxx*.EXE) and can be downloaded at selinc.com. *Table A.6* lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.6 EDS File Compatibility (Sheet 1 of 2)

EDS File	Firmware Revisions Supported	Release Date
SEL-710R605.EDS	R411, R412 (with DeviceNet version 1.005)	20170623
SEL-710R604.EDS	R410 (with DeviceNet version 1.005)	20140303
SEL-710R603.EDS	R406, R407, R408 (with DeviceNet version 1.005)	20110620
SEL-710R306R402.EDS	R306, R307, R308, R309, R310, R311, R402, R403, R405 (with DeviceNet version 1.005)	20100614
SEL-710R304.EDS	R304, R305, R400, R401 (with DeviceNet version 1.005)	20090331

Table A.6 EDS File Compatibility (Sheet 2 of 2)

EDS File	Firmware Revisions Supported	Release Date
SEL-710R300.EDS	R300, R301, R302, R303 (with DeviceNet version 1.005)	20080801
SEL-710R203.EDS	R203, R204, R205 (with DeviceNet version 1.001)	20071113
SEL-710R202.EDS	R202 (with DeviceNet version 1.001)	20070521
SEL-710R200.EDS	R200, R201 (with DeviceNet version 1.001)	20070209
SEL-710R100.EDS	R100, R101, R102 (with DeviceNet version 1.001)	20060628

ICD File

Determining the ICD File Version

To find the ICD revision number in your relay, view the configVersion using the ID command. The configVersion is the last item displayed in the information returned from the ID command.

configVersion=ICD-710-R302-V0-Z410004-D20140301

The ICD revision number is after the R (e.g., 100) and the release date is after the D. This revision number is not related to the relay firmware revision number. The configVersion revision displays the ICD file version used to create the CID file that is loaded in the relay.

NOTE: The Z number representation is implemented with ICD File Revision R302. Previous ICD File Revisions do not provide an informative Z number.

The configVersion contains other useful information. The Z number consists of six digits. The first three digits following the Z represent the minimum IED firmware required to be used with the ICD (e.g., 410). The second three digits represent the ICD ClassFileVersion (e.g., 004). The ClassFileVersion increments when there is a major addition or change to the IEC 61850 implementation of the relay.

Table A.7 lists the ICD file versions, a description of modifications, and the instruction manual date code that corresponds to the versions. The most recent version is listed first.

Table A.7 SEL-710 ICD File Revision History (Sheet 1 of 2)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect		Manual Date Code
				File Description	Software Version	
ICD-710-R302-V0-Z410004-D20140301	➤ Modified default MMS Report and Dataset names. ➤ Updated all Report Control attributes. ➤ Corrected Report Control rptID attributes to display report name instead of dataset name. ➤ Updated orCat control instances to proprietary node. ➤ Made corrections per KEMA recommendations.	R410 or higher	004[a]	710 R410 and above	1.1.145.0 or higher	20140303

Table A.7 SEL-710 ICD File Revision History (Sheet 2 of 2)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	ACSELERATOR Architect Software Version	Manual Date Code
	➤ Added new P1TPTOC3, P2TPTOC4, G1TPTOC5, G2TPTOC6, Q1TPTOC7, ATPTOC8, BTPTOC9, CTPTOC10, RMSMMXU2, DIFFMMXU3, BWASCBR1, BWBSCBR2, BWCSCBR3, LBGGIO24, MBOKGGIO25, MOTGGIO26, TRIPGGIO27, PROGGIO28, and MISCGGIO29 Logical Nodes and attributes. ➤ Updated configVersion for new format.					
ICD-710-R301-V0-Z000000-D20111014	➤ Improved IEC 61850 conformance ➤ Added Serial and Model Number attributes to PhyNam DO.	R406 and higher	004[a]	710 R406 and above	1.1.145.0 or higher	20110620
ICD-710-R200-V0-Z000000-D20100611	➤ Added select before operate (SBO) and enhanced security SBO modes to IEC 61850 MMS	R306 and higher R402 and higher	003[b]	Enhanced Controls R306/R402 and above	1.1.92.0 or higher	20100611
ICD-710-R105-V0-Z002001-D20080618	➤ Added Virtual Bits ➤ Added additional attributes for 8 Digital Inputs to INCGGIO13, INDGGIO15, and INEGGIO17 LNs.	R301–R305 R400–R401	002	R300 or greater	1.1.75.0 or higher	20080808
ICD-710-R104-V0-Z002001-D20080508	➤ Made corrections per KEMA recommendations.	R204–R205	002	Short LN Prefixes	1.1.73.0 or higher	20081022
ICD-710-R103-V0-Z002001-D20080324	➤ Modifications for Conformance testing. ➤ Modified default GOOSE data set GooseDSet13 and MSTA LN.	R204–R205	002[c]	N/A	N/A	20080325
ICD-710-R102-V0-Z001001-D20070712	➤ Corrected bufTime attribute of all un-buffered reports to 250 ms.	R201–R203	001[c]	N/A	N/A	20070514
ICD-710-R101-V0-Z001001-D20070307	➤ Corrections to the MTHR Logical Node Extension to conform to standard.	R201–R203	001[c]	N/A	N/A	20070314
ICD-710-R100-V0-Z001001-D20070119	➤ Initial ICD File Release.	R201–R203	001[c]	N/A	N/A	20070314

[a] ICD files with ClassFileVersion 004 require R4xx series firmware and do not work with R3xx firmware.
[b] ICD files with ClassFileVersion 003 can be used with R4xx series firmware with IEC 61850 device library 004 also. Architect will convert the ICD file to ClassFileVersion 004 and send to the relay.
[c] These ICD files are no longer supported and not included with Architect Software.

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.8* lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.8 Instruction Manual Revision History (Sheet 1 of 11)

Date Code	Summary of Revisions
20241014	Preface ➤ Added a note regarding terminal block wire sizes to *Wire Sizes and Insulation*. Section 1 ➤ Updated *Specifications*. Section 2 ➤ Updated *Physical Location* in *Relay Placement*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions* to remove SEL-5010 Relay Assistant Software. Section 4 ➤ Added a note on setting RTC to AUTO to *Rating Thermal Model*. ➤ Updated *Figure 4.42: Motor State Logic* and *Table 4.75: Example Settings and Displays*. ➤ Updated *Target LEDs*. Section 7 ➤ Updated *Figure 7.4: IRIG-B Input (Relay Terminals B01–B02)*, *Figure 7.5: IRIG-B Input Via EIA-232 Port 3 (SEL Communications Processor as Source)*, *Figure 7.6: IRIG-B Input Via EIA-232 Port 3 (SEL-2401/2407/2488 Time Source)*, and *Figure 7.8: IRIG-B Input Via Fiber-Optic EIA-232 Port 2 (SEL-2401/2407/2488 Time Source)* for the SEL-2488. ➤ Added a note on synchrophasors and the TSOK Relay Word bit to *Time Quality of the IRIG Source*. Appendix A ➤ [Cybersecurity] Updated for firmware revisions R412-V2 and R411-V3. ➤ Updated *Determining the Firmware Version*.
20220114	Appendix A ➤ Updated *Table A.1: R400 Series Firmware Revision History* for revisions R412-V1 and R411-V2.
20211015	Section 1 ➤ Updated *RFI and Interference Tests* conducted and radiated emissions. Section 4 ➤ Updated *Figure 4.40: Stop/Trip Logic*.
20200715	Preface ➤ Updated the product compliance label. Section 1 ➤ Updated *Compliance* in *Specifications*.
20190508	Preface ➤ Updated *General Safety Marks* and *Hazardous Locations Safety Marks*. ➤ Updated *Hazardous Locations Approvals*, including the product compliance label. ➤ Updated *Typographic Conventions*, *Trademarks*, *Product Labels*, *LED Safety Warning and Precautions*, *Wire Sizes and Insulation*, and *Technical Support*. Section 1 ➤ Updated *Options* for a note on the discontinuation of the DeviceNet option. ➤ Updated *Specifications*, *Compliance*, *General*, *Relay Elements*, and *Type Tests*. ➤ Added *Product Standards* to *Specifications*.

Table A.8 Instruction Manual Revision History (Sheet 2 of 11)

Date Code	Summary of Revisions
	Section 2 ➤ Updated *Physical Location*. ➤ Updated *I/O Card (4 DI/4 DO)* for slot availability. ➤ Updated *Card Configuration Procedure*. ➤ Updated a note for *Figure 2.12: Control I/O Connections–Internal RTD Option* for the power supply rating. ➤ Updated *Table 2.16: Typical Maximum RTD Lead Length* and added RTD wiring recommendations. ➤ Added a note to *Fail-Safe/Nonfail-Safe Tripping* for fast hybrid contacts. ➤ Updated *Figure 2.15: Breaker Trip Coil and Contactor Connections With OUT103FS := Y and OUT103FS := N*, *Figure 2.17: Single-Phase Voltage Connections*, *Figure 2.25: AC Connections for a Two-Speed Motor–Paralleled CTs*, and *Figure 2.26: AC Connections for Full-Voltage Reversing (FVR) Starter*. ➤ Added *High-Speed, High-Current Interrupting DC Tripping Outputs*.
	Section 3 ➤ Updated *Table 3.1: SEL Software Solutions* and *Table 3.2: ACSELERATOR QuickSet SEL-5030 Software*.
	Section 4 ➤ Updated *Figure 4.25: Undercurrent (Load-Loss) Logic* and *Figure 4.29: Phase Reversal Element Logic*. ➤ Updated *Thermistor (PTC) Input Function*, including *Figure 4.32: Characteristic of PTC Sensors as per IEC 34-11-2*, and added a note for the PTC element and BLKPROT Relay Word bit. ➤ Added a note on short/open RTD detection to *RTD Input Function*. ➤ Added a note for trip coil current interruption and updated *Figure 4.40: Stop/Trip Logic* for *Trip/Close Logic*. ➤ Updated *Lockout After Stop*, including *Figure 4.42: Motor State Logic*. ➤ Updated *Table 4.43: Enable Settings* for a note regarding math variables set to NA. ➤ Added a note to *Counter Variables* regarding counter reset on power loss. ➤ Updated *Table 4.50: Control Output Equations and Contact Behavior Settings*. ➤ Updated *Figure 4.52: Breaker Failure Logic*. ➤ Updated *Table 4.75: Example Settings and Displays*. ➤ Updated *Target LED Settings*.
	Section 7 ➤ Updated *Serial (EIA-232 and EIA-485) Port*. ➤ Updated *Creating an NTP Server*. ➤ Updated *BRE Command (Breaker Monitor Data)* and *BRE n Command (Preload/Reset Breaker Wear)* for access levels. ➤ Updated *COPY Command*, *DATE Command (View/Change Date)*, *L_D Command*, *PING Command*, *SHOW Command (Show/View Settings)*, *TIME Command (View/Change Time)*. ➤ Updated *Table 7.44: STATUS Command Report and Definitions* for current and voltage offset message formats.
	Section 10 ➤ Added a note to *Connection Tests* regarding working on CT circuits. ➤ Updated *Self-Test* for a note on access commands and SALARM. ➤ Updated *Table 10.8: Relay Self-Tests*.
	Appendix A ➤ Updated *Table A.1: R400 Series Firmware Revision History* for revision R412 and *Table A.2: R300 Series Firmware Revision History* for revision R311-V1. ➤ Updated *Table A.2: R300 Series Firmware Revision History* for an 87M motor different element issue that was resolved in SEL-710-R304-V0-Z004003-D20090327. ➤ Updated *Table A.6: EDS File Compatibility* for revision R412.
	Appendix B ➤ Updated *Upgrade Firmware Using QuickSet* for a note regarding firmware loader availability over Ethernet.
	Appendix C ➤ Updated *Table C.3: SEL Communications Processors Protocol Interfaces*.
	Appendix D ➤ Updated *User-Defined Modbus Data Region* and *SET M Command*. ➤ Added a note for Modbus registers 820–861 regarding DELTA_Y being set to either DELTA or WYE in *Table D.33: Modbus Register Labels for Use With SET M Command*. ➤ Updated *Reading History Data Using Modbus*. ➤ Updated *Modbus Register Map* for the concatenation note and *Table D.34: Modbus Register Map*.

Table A.8 Instruction Manual Revision History (Sheet 3 of 11)

Date Code	Summary of Revisions
	Appendix E ➤ Updated *GOOSE Processing*. Appendix F ➤ Updated *DeviceNet Card* for a note on the discontinuation of the DeviceNet option. Appendix I ➤ Updated *Table I.2: Relay Word Bit Definitions for the SEL-710* for Relay Word bit RELAY_EN. Appendix J ➤ Updated *Table J.1: Analog Quantities* for a note on assigning RTD analog quantities to SELOGIC or math variables. Command Summary ➤ Updated ACC, 2AC, PING *x.x.x.x t*, and COPY *m n*. ➤ Added TIME *hh*, TIME *hh:mm*, R_S, VEC D, and VEC E.
20170623	Preface ➤ Updated the *Safety Information*. ➤ Updated *Safety Marks*, including the *General Safety Marks* table. ➤ Updated *Hazardous Locations Approvals*. ➤ Added *Trademarks*, *Product Labels*, *Wire Sizes and Insulation*, and *Technical Assistance*. Section 1 ➤ Updated *Accessories*. ➤ Updated *Checking Relay Status*, including *Figure 1.3: STA Command Response–No Communications Card or EIA-232/EIA-485 Communications Card* and *Figure 1.4: STA Command Response–Communications Card/ DeviceNet Protocol*. ➤ Updated *Specifications*, including *Compliance*, *General*, *Type Tests*, *Relay Elements*, and *Metering*. Section 2 ➤ Updated *Card Installation for Slots C, D, E, and Z* and *Slot B CPU Card Replacement*. Section 4 ➤ Added a note for the setting SLIPSRC. ➤ Updated *Table 4.4: Overload (Thermal Model) Settings* for SLIP SOURCE. ➤ Updated *Additional Thermal Overload Settings*, including *Table 4.8: Overload Settings (Alarm, Start Inhibit, Cooling, and RTD Bias)* for the STOP COAST TIME setting. Also added coast stop information, including *Figure 4.4: Coast-Stop Logic Diagram*, as well as information for the setting COOLEN, including *Figure 4.5: MOTOR Command Response*. ➤ Added *Slip-Dependent Thermal Model for Synchronous Motors*. ➤ Updated *Figure 4.25: Undercurrent (Load-Loss) Logic* and *Figure 4.27: Monitoring Starting Time*. ➤ Updated *RTD Biasing*. ➤ Updated *VAR Function*, including *Table 4.33: VAR Settings* and *Underpower Function*, including *Table 4.34: Underpower Settings*. ➤ Updated *Table 4.39: Torque Control Status*. ➤ Updated *Figure 4.40: Stop/Trip Logic*. ➤ Updated the note for the ULTRIP factory-default setting in *ULTRIP Unlatch Trip Conditions SELOGIC Control Equation*. ➤ Updated *SELOGIC Control Equation Operators* and added *Example 4.10: Improving the Accuracy of Math Operations*. ➤ Updated *PORT F*. ➤ Added *Port Numbers Must be Unique* and *Table 4.63: Port Number Settings That Must be Unique*. ➤ Updated *Table 4.70: Settings That Always, Never, or Conditionally Hide a Display Point*, *Table 4.78: SER Trigger Settings*, and *Table 4.82: Motor Start Report Settings*. Section 6 ➤ Updated *Table 6.3: SET Command Options*. Settings Sheets ➤ Added the SLIP SOURCE and STOP COAST TIME settings. ➤ Added *Port Numbers Must be Unique* and *Table SET.1: Port Number Settings That Must be Unique*.

Table A.8 Instruction Manual Revision History (Sheet 4 of 11)

Date Code	Summary of Revisions
	Section 7 ➤ Added *Time Quality of the IRIG Source*. ➤ Updated *Table 7.4: EIA-232/EIA-485 Serial Port Pin Functions*. ➤ Added a note regarding serial communication and cables for the MIRRORED BITS protocol. ➤ Updated *Figure 7.20: Typical Relay Output for STATUS S Command* and added a note for the STA S report for execution capacity % in *STATUS Command (Relay Self-Test Status)*. Section 8 ➤ Updated *Figure 8.28: Operator Control Pushbuttons and LEDs* in *Front-Panel Operator Control Pushbuttons*. Section 9 ➤ Updated *Triggering*, including *Relay Word Bit TR*. Section 10 ➤ Updated *Figure 10.6: Delta Voltage Source Connections* and *Table 10.6: Power Quantity Accuracy—Delta Voltages*. ➤ Updated *Technical Assistance*. Appendix A ➤ Updated for firmware version R411. Appendix B ➤ Updated *Technical Assistance*. Appendix D ➤ Updated *Table D.34: Modbus Register Map*. Appendix G ➤ Updated *Message Transmission*. Appendix I ➤ Updated *Table I.1: SEL-710 Relay Word Bits* and *Table I.2: Relay Word Bit Definitions for the SEL-710*.
20150918	Preface ➤ Updated the *General Safety Marks* and *Other Safety Marks* tables. ➤ Updated *Hazardous Locations Approvals*. ➤ Updated the *Wire Sizes and Insulation* table for RTD connections. Section 2 ➤ Updated *Table 2.16: Typical Maximum RTD Lead Length*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions*. Appendix A ➤ Updated for firmware version R102-V1. Appendix B ➤ Updated *Overview* for standard and point release firmware identification. Appendix J ➤ Added information on analog quantities for rms data.
20150130	Preface ➤ Added *Safety Information* and *General Information*. ➤ Updated the product labels and compliance label. Section 1 ➤ Changed the *Certifications* section title to *Compliance* and relocated the section to the beginning of the *Specifications*. ➤ Added the applied current at which the burden is measured for I_{NOM} = 1 A, 5 A, and 2.5 mA in the *Specifications*. ➤ Updated the *Type Test* compliance specifications in the *Specifications* section. ➤ Updated the *Specifications* for element accuracy.

Table A.8 Instruction Manual Revision History (Sheet 5 of 11)

Date Code	Summary of Revisions
	Section 2 ➤ Updated the *Card Configuration Procedure* section. ➤ Added a note on CT circuits to applicable current card descriptions. ➤ Added a note stating that the fail-safe option should not be used for fast hybrid output contacts in fail-safe/ nonfail-safe tripping. Section 3 ➤ Updated the *Settings Database Management and Drivers* section. Section 4 ➤ Added *Figure 4.25: Star-Delta Starting*. Section 5 ➤ Updated the number of time-stamp entries that the relay memory can hold for load profiling. ➤ Updated *Figure 5.3: Complex Power Measurement Conventions–Motor Action*. Section 7 ➤ Added the *VEC Command (Show Diagnostic Information)* section. Section 9 ➤ Updated the event type for the differential trip to 87M Diff Trip in *Table 9.1: Event Types*. Section 10 ➤ Added a note on CT circuits. Appendix A ➤ Added *ICD File* section. Appendix B ➤ Added a note to save the calibration settings before the upgrade in *Upgrade Firmware Using a Terminal Emulator*. Appendix E ➤ Added a note for GOOSE and ACSELERATOR Architect regarding GOOSE subscriptions when loading a new CID file. Appendix G ➤ Updated the RBADPU setting prompt description in *Table G.5: Mirrored Bits Protocol Settings*. Appendix H ➤ Added rating and curve method equations for cold stator. Appendix I ➤ Updated the definition for the 49T Relay Word bit. Appendix J ➤ Added a note to *Table J.1: Analog Quantities* for RTDWDGMX, RTDBRGMX, RTDAMB, and RTDOTHMX analog quantities.
20140303	Section 1 ➤ Updated the ac current inputs under *AC Current Inputs* and the input voltage range under *Power Supply* in the *Specifications*. ➤ Added Trip thresholds for PTC input. ➤ Added the *RTD Trip/Alarm Time Delay* to the *RTD Protection* category of the *Specifications.* Section 2 ➤ Updated *Figure 2.9: Dual Fiber-Optic Ethernet, Fiber-Optic Serial, Fast Hybrid 4 DI/4 DO, RTD and Voltage/ Differential Option*. Section 4 ➤ Added a note to the *RTD Trip/Warning Levels* section. ➤ Added a note for Thermal Metering ➤ Added a note for *Figure 4.21: Load- Jam Element Logic* and *Figure 4.22: Undercurrent (Load-Loss) Element Logic*. ➤ Updated *Figure 4.34: Loss-of-Potential (LOP) Logic*. ➤ Clarified *Trip Inhibit (Block) Function*. ➤ Added *Table 4.39: Torque Control*. ➤ Revised *Figure 4.48: Breaker Failure Logic* to show IAV instead of I1.

Table A.8 Instruction Manual Revision History (Sheet 6 of 11)

Date Code	Summary of Revisions
	Section 5 ➤ Updated *Figure 5.1: METER Command Report With Voltage and Differential Option.* Section 6 ➤ Updated *Table 6.6: Setting Interdependency Error Messages* to show the nominal currents at which the interdependency error messages apply. Section 7 ➤ Updated the *Fiber-Optic Serial Port* section. ➤ Updated the *+5 Vdc Power Supply* section. Section 10 ➤ Updated the SALARM conditions in the ALARM Output paragraph of *Self-Test*. Appendix A ➤ Updated for firmware revisions R410. Appendix E ➤ Updated *Figure E.1 SEL-710 Predefined Reports* and *Figure E.2 SEL-710 Dataset.* ➤ Updated *Table E.7: New Logical Node Extension, Table E.8: Thermal Metering Data Logical Node Class Definition*, *Table E.9: Demand Metering Statistics Logical Node Class Definition*, *Table E.10: Motor Measurement Data Logical Node Class Definition*, *Table E.11: Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition*. ➤ Added *Table E.12: Compatible Logical Nodes With Extension*, *Table E.13: Metering Statistics Logical Node Class Definition*, *Table E.14: Circuit Breaker Logical Node Class Definition*. ➤ Updated *Table E.15: Logical Device: PRO (Protection)*, *Table E.16: Logical Device: MET (Metering)*, *Table E.17: Logical Device: CON (Remote Control)*, *Table E.18: Logical Device: ANN (Annunciation)*. ➤ Added *Table E.19: Logical Device: CFG (Configuration)*. Appendix I ➤ Updated the definition for the SALARM Relay Word bit. ➤ Added Relay Word bit MATHERR in *Table I.1: SEL-710 Relay Word Bits* and *Table I.2: Relay Word Bit Definitions for the SEL-710*.
20130726	Preface ➤ Updated product label examples in *Product Labels*. Section 1 ➤ Updated *Specifications*. Section 2 ➤ Added a note on delta voltage connections to *Figure 2.17: Voltage Connections*. Section 4 ➤ Added a note to *Figure 4.37: Thermal Element Lockout Logic*. ➤ Added a note to the *Display Points* paragraph on update rate. Section 8 ➤ Updated *Table 8.1: Front-Panel Automatic Messages* for the thermal lockout condition. Appendix A ➤ Updated for firmware revisions R408 and R311. Appendix B ➤ Added instructions for upgrading firmware using QuickSet. Appendix D ➤ Added BLOCK MODBUS SET setting paragraph. Appendix F ➤ Added BLOCK MODBUS SET setting paragraph. Appendix J ➤ Added a note to *Table J.1: Analog Quantities* on RTD OPEN/SHORT values.

Table A.8 Instruction Manual Revision History (Sheet 7 of 11)

Date Code	Summary of Revisions
20120903	Preface ➤ Updated product label examples in *Product Labels*. Section 1 ➤ Updated *Specifications*.
20111123	Section 1 ➤ Added *Compression Plug Mounting Ear Screw Tightening Torque* specifications. Section 4 ➤ Revised the note for *Table 4.2: CT Configuration and Full-Load Current Settings* to cross-reference *Table 6.6: Setting Interdependency Error Messages*. Section 5 ➤ Added a note regarding maximum time to trip for *Figure 5.2: METER T Command Report With RTDs*. Section 6 ➤ Revised MIRRORED BITS setting CBADPU units to ppm (parts per million). Appendix A ➤ Updated for firmware versions R310 and R407. Appendix D ➤ Corrected Modbus Register Map scaling issue for Rotor and Stator %TCU.
20110620	Section 1 ➤ Added SNTP accuracy specification to *Time-Code Input*. ➤ Revised voltage ratings for *Optoisolated Control Inputs*. ➤ Added *Oscillography* and *SER* specifications. Section 2 ➤ Added *Power Supply Card PSIO/2DI/3DO (Slot A)* description and terminal designations. Section 4 ➤ Added *Time and Date Management Settings* section. ➤ Added *Simple Network Time Protocol (SNTP)* reference to *Section 7: Communications*. Section 6 ➤ Updated *Settings Sheets* to include *Time and Date Management* and *SNTP Client Protocol Settings*. Section 7 ➤ Added *Simple Network Time Protocol (SNTP)* section. Appendix A ➤ Updated for firmware versions R309 and R406. Appendix D ➤ Updated *Table D.32: Modbus Register Map* with new settings. Appendix I ➤ Updated *Table I.1: Relay Word Bits* and *Table I.2: Relay Word Bit Definitions* with new Relay Word bits for SNTP and Time and Date Management.
20101217	Section 1 ➤ Revised Analog Output (1AO) accuracy specification to <±1%, full scale, at 25°C in *Specifications*. ➤ Updated Dielectric (HiPot) type tests in *Specifications*.
20101101	Section 4 ➤ Added custom curve (46) TD and RTC1 equations. Appendix A ➤ Updated for firmware versions R308 and R405. ➤ Added *DeviceNet and Firmware Versions*.
20100913	Preface ➤ Updated product compliance label. Section 1 ➤ Updated *Specifications* for UL508 certification.

Table A.8 Instruction Manual Revision History (Sheet 8 of 11)

Date Code	Summary of Revisions
	Section 4 ➤ Added a note in *Differential Elements* cautioning against tripping if a contactor is used. ➤ Updated *Example* for the *Analog Outputs* application. Section 5 ➤ Added a note to *Figure 5.1: METER Command Report*. ➤ Added subsection, *Small Signal Cutoff for Metering*. Section 8 ➤ Updated *Table 8.3: Possible Warning Conditions (Flashing TRIP LED)* to include warning messages. ➤ Revised paragraph describing settings T0n_LED and T0nLEDL. Section 10 ➤ Added watchdog timer to *Table 10.8: Relay Self-Tests*. Appendix A ➤ Updated for firmware versions R403 and R307.
20100611	Section 1 ➤ Updated Analog Inputs and Current Metering accuracy specifications and Type Tests descriptive data. Section 2 ➤ Added SELECT 4DI/3 DO (2 Form C, 1 Form B) card information. Added note that digital inputs and outputs are polarity neutral. Section 4 ➤ Added 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. Revised LRQ setting range to 0.30–2.00 pu. ➤ Added a description of the new Access Control setting BLOCK MODBUS SET (BLKMBSET), which blocks settings changes from remote Modbus or DeviceNet masters. ➤ Revised over- and undervoltage setting range low end value to 0.02 xVnm. ➤ Revised *Figure 4.34: Loss-of- Potential (LOP) Logic*. ➤ Added Modbus time-out settings for the Ethernet port. Section 5 ➤ Added breaker monitor description. ➤ Added note for the energy meter rollover value. Section 6 ➤ Updated for new settings. Section 7 ➤ Added CAL level access and password information. Section 8 ➤ Updated *Figure 8.28: Operator Control Pushbuttons and LEDs* and added note for the target LEDs latching with trip. Section 9 ➤ Added note that says frequency is available in CEV reports only. Appendix A ➤ Updated for firmware versions R402 and R306. Appendix E ➤ Updated for Select Before Operate (SBO) changes. Appendix H ➤ Updated for Rating_1 Thermal Method addition. Appendix I ➤ Added new Relay Word bits for the breaker monitor function. Appendix J ➤ Reformatted *Table J.1: Analog Quantities* to make it user friendly. Command Summary ➤ Added Breaker Monitor commands and CAL level commands.

Table A.8 Instruction Manual Revision History (Sheet 9 of 11)

Date Code	Summary of Revisions
20100118	Appendix A ➤ Updated for firmware version R401.
20091026	Appendix A ➤ Updated for firmware version R305.
20090924	Section 1 ➤ Updated CT ratings. Updated *Figure 1.3: STA Command Response—No Communications Card or EIA-232/EIA-485 Communications Card* and *Figure 1.4: STA Command Response—Communications Card/DeviceNet Protocol*. Section 2 ➤ Updated *Figure 2.7: Pins for Password Jumper and SELBOOT Jumper* to show jumper locations on updated processor card. Section 4 ➤ Updated number of event reports that can be stored. ➤ Revised *Figure 4.34: Loss-of- Potential (LOP) Logic*. Section 10 ➤ Updated *Table 10.8: Relay Self-Tests* to show additional voltage checks on updated processor card. Appendix A ➤ Updated for firmware version R400.
20090327	Preface Updated product labels. Section 1 ➤ Added specifications to include 51 elements and optical port specifications. Section 2 ➤ Added notes for analog I/O card. Section 4 ➤ Updated thermal element, added 51 element, added TIME_SRC, and FASTOP for Port 1 settings. Section 6 Settings Sheets ➤ Added new settings for 51 elements, time source, and fast operate in Port 1. Section 7 ➤ Added Ethernet application diagrams. ➤ Added IRIG-B connection diagrams. Section 8 ➤ Revised front-panel LED operation description. Appendix A ➤ Updated for firmware version R304. Appendix D ➤ Revised Modbus map for new settings and Relay Word bit additions. Appendix H ➤ Added thermal element trip-time equations. Appendix I ➤ Added new Relay Word bits for the 51 elements.
20081124	Appendix A ➤ Updated for firmware version R303.
20081022	Appendix A ➤ Updated for firmware versions R205 and R302.
20080808	Preface ➤ Updated LED information to include the added feature of fiber-optic Ethernet port. Section 1 ➤ Added specifications for the Hybrid outputs, Ethernet ports and Energy Metering.

Table A.8 Instruction Manual Revision History (Sheet 10 of 11)

Date Code	Summary of Revisions
	Section 2 ➤ Added descriptions and connection details for the new 8 DI card and Ethernet options. Replaced *Table 2.1: Slot Allocations for Different Cards* with *Figure 2.2: Slot Allocations for Different Cards* to show card options for the relay. Section 3 ➤ Updated screen captures to show the new functions and options. Section 4 ➤ Updated and added the new Ethernet option settings. Section 5 ➤ Updated **MET E** response in *Figure 5.4: Device Response to the METER E Command* to show the improved resolution of 1 kWh. Section 6 and Settings Sheets ➤ Added new settings for the Ethernet options. Section 7 ➤ Added Ethernet functional description, **ETH** command, **PING** command. Appendix A ➤ Updated for firmware version R300. Appendix C ➤ Updated *Table C.9: Communications Processor TARGET Region*. Appendix D ➤ Updated *Table D.31:Modbus Register Labels for Use With SET M Command* and *Table D.32: Modbus Register Map* for the additions. Appendix E ➤ Updated *Table E.11: Logical Device: PROT (Protection)*, *Table E.12: Logical Device: MET (Metering)*, *Table E.13: Logical Device: CON (Control)*, and *Table E.14: Logical Device: ANN (Annunciation)*. Appendix I ➤ Added Relay Word Bits rows 89 to 108. Appendix J ➤ Added analog quantity MRT (motor run time). Index ➤ Added Index references for the new functions.
20080325	Appendix A ➤ Updated for firmware version R204. ➤ Added *Table A.2: ACSELERATOR Architect CID File Compatibility*. Appendix B ➤ Added IEC 61850 verification testing. Appendix E ➤ Added table to document new ICD file versions supported by ACSELERATOR Architect revision R.1.1.69.0. ➤ Added *Table E.7: ICD Logical Nodes Summary*. ➤ Updated Tables: *E.10: Logical Device: PRO (Protection)*; *E.11: Logical Device: MET (Metering)*; *E.12: Logical Device: CON (Control)*; and *E.13: Logical Device ANN (Annunciation)*.
20071128	Updated to correct printing error.
20071114	Preface ➤ Updated Hazardous Locations Approvals. ➤ Updated for firmware versions R203 and R102.
20070514	Section 1 ➤ Updated specifications. Section 2 ➤ Updated for the Class 1, Division 2 installation.

Table A.8 Instruction Manual Revision History (Sheet 11 of 11)

Date Code	Summary of Revisions
	Section 3 ➤ Revised screen capture for ID Command. Section 6 and Settings Sheets ➤ Updated Settings Sheets. Section 7 ➤ Revised PASSWORD command description and STATUS command. Section 8 ➤ Updated front-panel operations. Appendix A ➤ Updated for firmware version R202. Appendix D ➤ Revised Modbus Register Labels table. ➤ Revised Modbus Register Map table.
20070314	Section 1 ➤ Updated specifications. Section 2 ➤ Updated for the new differential current protection option. Section 3 ➤ Revised screen captures. Section 4 ➤ Added differential current element and settings. Section 5 ➤ Updated meter report to show differential currents. Section 6 and Settings Sheets ➤ Added new settings for the 87 element, MIRRORED BITS, IEC 61850, and revised the LRQ range. Section 7 ➤ Added MIRRORED BITS and IEC 61850 protocol-related changes. Section 9 ➤ Added EVE DIF (Differential element) event report. Section 10 ➤ Updated self-tests. Appendix A ➤ Updated for firmware versions R101 and R201. Appendix D ➤ Revised Modbus Register Labels table. ➤ Revised Modbus Register Map table. Appendix E ➤ Added new appendix IEC 61850 Communications (and following appendixes renumbered). Appendix G ➤ Added new appendix MIRRORED BITS Communications (and following appendixes renumbered). Appendix I ➤ Revised Relay Word Bits table. Appendix J ➤ Added Differential Currents.
20060626	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

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-710-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-710-**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-710-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-710-R100-**V1**-Z001001-D*xxxxxxxx*

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-710 stores firmware in flash memory, changing physical components is not necessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the front-panel serial port via ACSELERATOR QuickSet SEL-5030 Software or terminal emulator as outlined in the following sections. For relays with IEC 61850 option, verify IEC 61850 protocol after the upgrade (see *Protocol Verification for Relays With IEC 61850 Option*).

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- ➤ Personal computer (PC)
- ➤ Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- ➤ Serial communications cable (SEL-C662 Cable or equivalent, or a null-modem cable)

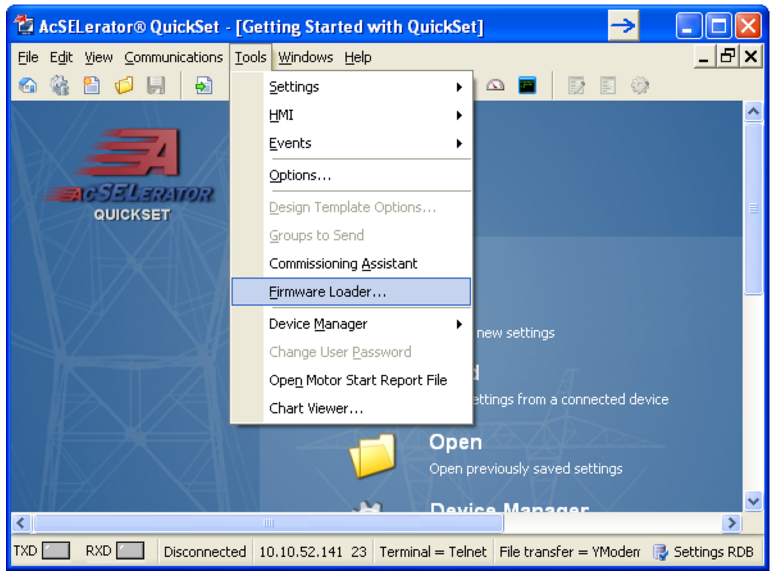
NOTE: Firmware releases are also available as zip files (.z19). Use the zip file for faster download.

➤ Firmware upgrade file (e.g., r1017*xx*.s19 or r1017*xx*.z19)

➤ QuickSet Software

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.



NOTE: The firmware loader is not supported on Ethernet port connections.

Firmware Loader will not start if:

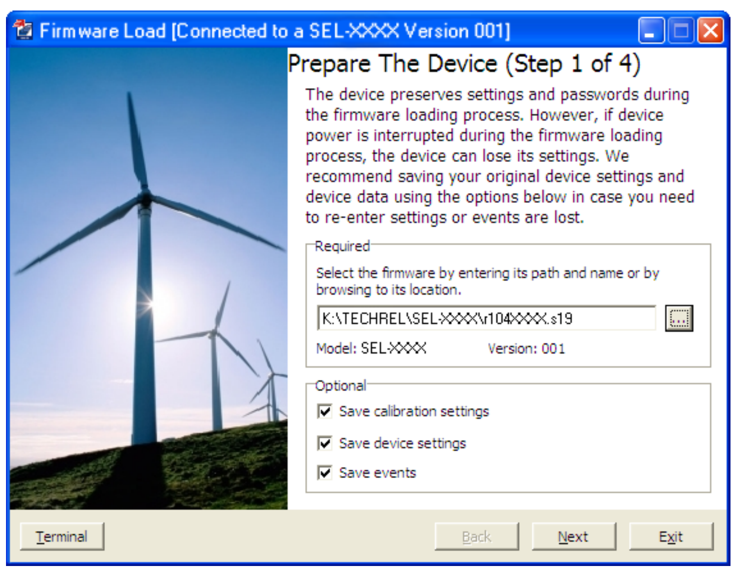
➤ The device is unsupported by QuickSet.

➤ The device is not connected to the computer with a communications cable.

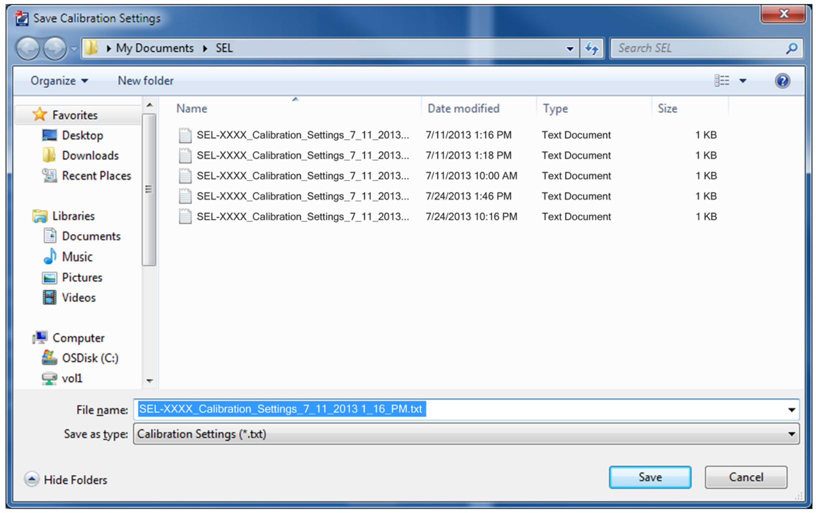
➤ The device is disabled.

Step 1. Prepare the device.

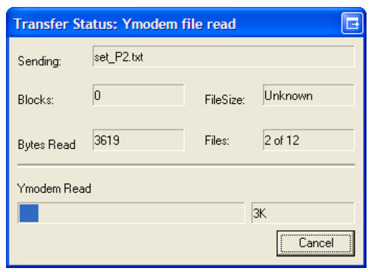
a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

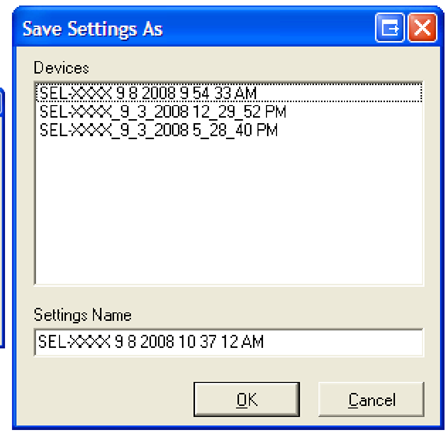


b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



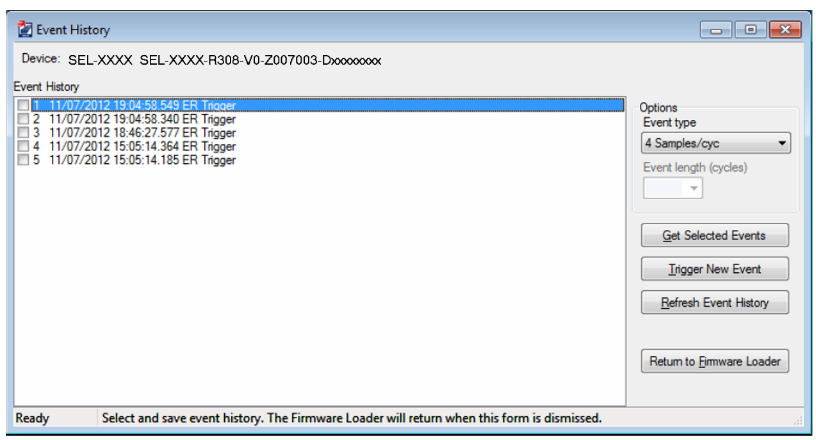
c. The **Transfer Status: Ymodem file read** window shows the transfer progress of the settings file. Clicking **Cancel** will stop the transfer.
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown.





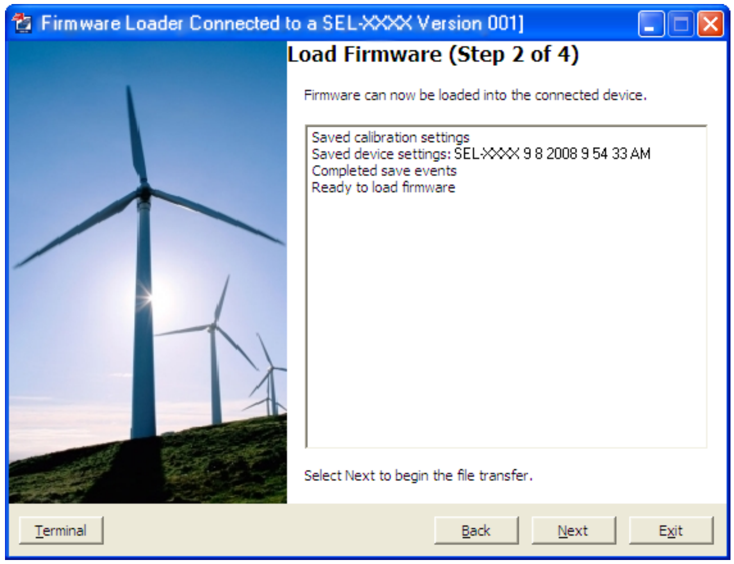
d. Click **Return to Firmware Loader** if this product does not have any event reports.

If there are any event reports to be saved, click the **Get Selected Event** button after selecting the events. After saving them, click the **Return to Firmware Loader** button.



Step 2. Transfer firmware.

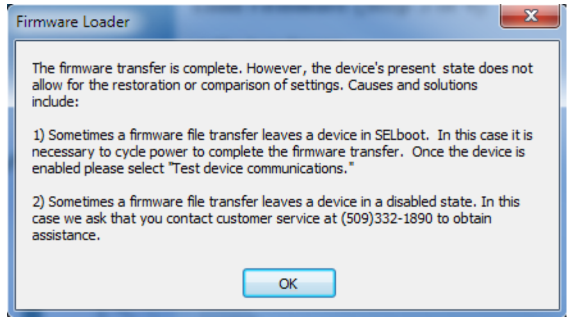
Click **Next** to begin the firmware transfer.



Step 3. Load firmware.

During this step, the device is put in SELBOOT mode. 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 Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Click on the Terminal button on the Firmware Load screen of QuickSet.

b. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

c. Enter Access Level 2 by issuing the **2AC** command.

d. Issue the **R_S** command to restore the factory-default settings.

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the **STATUS** report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**. This will save the relay calibration settings. The relay responds:

`Config Accepted`

The relay reboots and comes up enabled.

Step 4. Verify device settings.

Select from four verification options, which perform as follows.

Test Device Communications. If the device cannot be restarted, then turn power off and back on to restart it. Once the device is enabled, this option reconnects and reinitializes the device.

Compare Device Settings. This option verifies settings by reading them from the device and comparing them with settings saved to the database.

Restore Device Settings. This option restores settings by writing settings 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 (for example, send and receive binary files).

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (described in *Section 3: PC Software*) to save and restore settings easily. Otherwise, use the following steps.

a. Issue the following commands at the ASCII prompt:
SHO, **SHO L**, **SHO G**, **SHO P**, **SHO F**, **SHO R**, **SHO C**, etc.

b. Record all the settings for possible re-entry after the firmware upgrade.

c. We recommend that you save all stored data in the relay, including EVENTS, before the upgrade.

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.

NOTE: Change the data rate of the relay serial port to 9600 before issuing the **L_D** command to start the upgrade process.

NOTE: If you have difficulty at 115200 bps, choose a slower data transfer rate (e.g., 38400 bps or 57600 bps). Be sure to match the relay and PC data rates.

Step 4. Start upgrading the firmware.

a. Issue the **L_D** command to the relay.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay will send the `!>` prompt.

Step 5. Change the data rate, if necessary.

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.

Use the Xmodem protocol and send the file that contains the new firmware (e.g., r101*xxx*.s19 or r101*xxx*.z19).

The file transfer typically takes less than 15 minutes at 115200 bps, depending on the product. After the transfer is complete, the relay reboots and returns to Access Level 0.

Figure B.1 shows the entire process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=BOOTLDR-R500-V0-Z000000-D20090925
!>BAU 115200 <Enter>
!>REC <Enter>
This command uploads new firmware.
When new firmware is uploaded successfully, IED will erase old firmware,
load new firmware and reboot.

Are you sure you want to erase the existing firmware (Y,N)? Y <Enter>
Press any key to begin transfer and then start transfer at the terminal.<Enter>
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.
```

Figure B.1 Firmware File Transfer Process

Step 10. The relay illuminates the **ENABLED** front-panel LED if the relay settings were retained through the download.

If the **ENABLED** LED is illuminated, proceed to *Step 11*.

If the **ENABLED** LED is not illuminated or the front panel displays `STATUS FAIL Non_Vol Failure`, use the following procedure to restore the factory-default settings:

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory-default settings.

The relay then reboots with the factory-default settings.

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the relay is **ENABLED**, go to *Step f*.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

`Confirm Hardware Config`

`Accept & Reboot (Y/N)?`

Enter **Y**. This will save the relay calibration settings.

The relay will respond:

`Config Accepted`

The relay reboots and comes up enabled.

f. Restore relay settings back to the settings saved in *Step 3*.

Step 11. Change the data rate of the PC to match that of the relay prior to *Step 5*, and enter Access Level 2.

Step 12. Issue the **STATUS** command; verify all relay self-test results are OK.

Step 13. Apply current and voltage signals to the relay.

Step 14. Issue the **METER** command; verify that the current and voltage signals are correct.

Step 15. Autoconfigure the SEL communications processor port if you have a communications processor connected.

This step re-establishes automatic data collection between the SEL communications processor and the SEL relay. Failure to perform this step can result in automatic data collection failure when cycling communications processor power.

Protocol Verification for Relays With IEC 61850 Option

NOTE: A relay with optional IEC 61850 protocol requires the presence of one valid CID file to enable the protocol. You should only transfer a CID file to the relay if you want to implement a change in the IEC 61850 configuration or if new relay firmware does not support the current CID file version. If you transfer an invalid CID file, the relay will disable the IEC 61850 protocol, because it no longer has a valid configuration. To restart IEC 61850 protocol operation, you must transfer a valid CID file to the relay.

Perform the following steps to verify that the IEC 61850 protocol is still operational after a relay firmware upgrade and if not, re-enable it. This procedure assumes that IEC 61850 was operational with a valid CID file immediately before initiating the relay firmware upgrade.

Step 1. Establish an FTP connection to the relay Ethernet port.

Step 2. Open the ERR.TXT file.

If the ERR.TXT file is empty, the relay found no errors during CID file processing and IEC 61850 should be enabled. Go to *Step 3* if ERR.TXT is empty.

If the ERR.TXT file contains error messages relating to CID file parsing, the relay has disabled the IEC 61850 protocol. Use ACSELERATOR Architect SEL-5032 Software to convert the existing CID file and make it compatible again.

a. Install the Architect software upgrade that supports your required CID file version.

b. Run Architect and open the project that contains the existing CID file for the relay.

c. Download the CID file to the relay.

Step 3. Upon connecting to the relay, Architect detects the upgraded relay firmware and prompts you to allow it to convert the existing CID file to a supported version. Once converted, downloaded, and processed, the valid CID file allows the relay to re-enable the IEC 61850 protocol.

Step 4. In the Telnet session, type **GOO <Enter>**.

Step 5. View the GOOSE status and verify that the transmitted and received messages are as expected.

The relay is now ready for your commissioning procedure.

Technical Support

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

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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Appendix C
SEL Communications Processors

SEL Communications Protocols

The SEL-710 Motor Protection Relay supports SEL protocols and command sets shown in *Table C.1*.

Table C.1 Supported Serial Command Sets

Command Set	Description
SEL ASCII	Use this protocol to send ASCII commands and receive ASCII responses that are human readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Use this protocol to send ASCII commands and receive Compressed ASCII responses that are comma-delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Meter	Use this protocol to send binary commands and receive binary meter and target responses.
SEL Fast Operate	Use this protocol to receive binary control commands.
SEL Fast SER	Use this protocol to receive binary Sequential Events Recorder unsolicited responses.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor needed to interpret nondelimited messages. The relay calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports because the compressed reports reduce blanks, tabs, and other white space between data fields to a single comma.

Table C.2 lists the Compressed ASCII commands and contents of the command responses.

Table C.2 Compressed ASCII Commands

Command	Response	Access Level
BNAME	ASCII names of Fast Meter status bits	0
CASCII	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEVENT	Event report	1
CHISTORY	List of events	1
CLDP	Load Profile Data	1
CMETER	Metering data, including fundamental, thermal, energy, max/min, rms, analog inputs, and math variables	1
CMSR	Motor Start Data	1
CSE	Sequence Of Events Data	1
CSTATUS	Relay status	1
CSUMMARY	Summary of an event report	1
DNAME	ASCII names of digital I/O reported in Fast Meter	0
ID	Relay identification	0
SNS	ASCII names for SER data reported in Fast Meter	0

Interleaved ASCII and Binary Messages

SEL relays have two separate data streams that share the same physical serial port. Human data communications with the relay consist of ASCII character commands and reports that you view through use of a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information; the ASCII data stream continues after the interruption. This mechanism uses a single communications channel for ASCII communication (transmission of an event report, for example) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. However, you do not need a device to interleave data streams to use the binary or ASCII commands. Note that XON, XOFF, and CAN operations operate on only the ASCII data stream.

An example of using these interleaved data streams is when the SEL-710 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-710 and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, and Fast SER

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically. If the relay is connected to an

SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

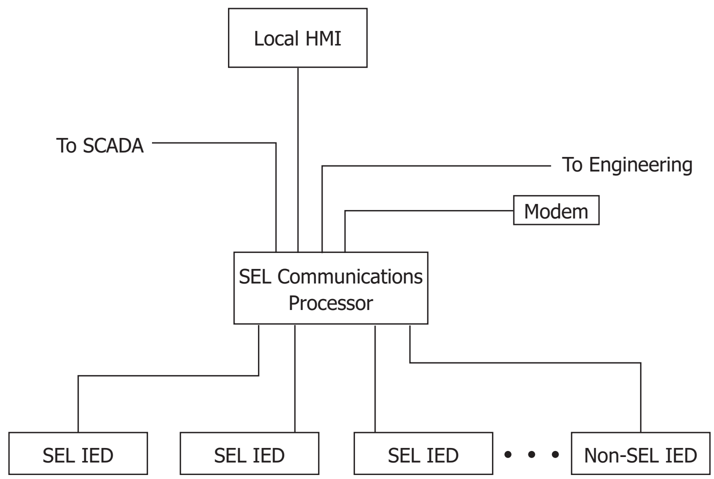


Figure C.1 SEL Communications Processor Star Integration Network

In the star topology network in *Figure C.1* the SEL communications processor offers the following substation integration functions:

- Collection of real-time data from SEL and non-SEL IEDs
- Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- Distribution of IRIG-B time-synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- Automated dial-out on alarms

The SEL communications processors have 16 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*. In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and substation IEDs.

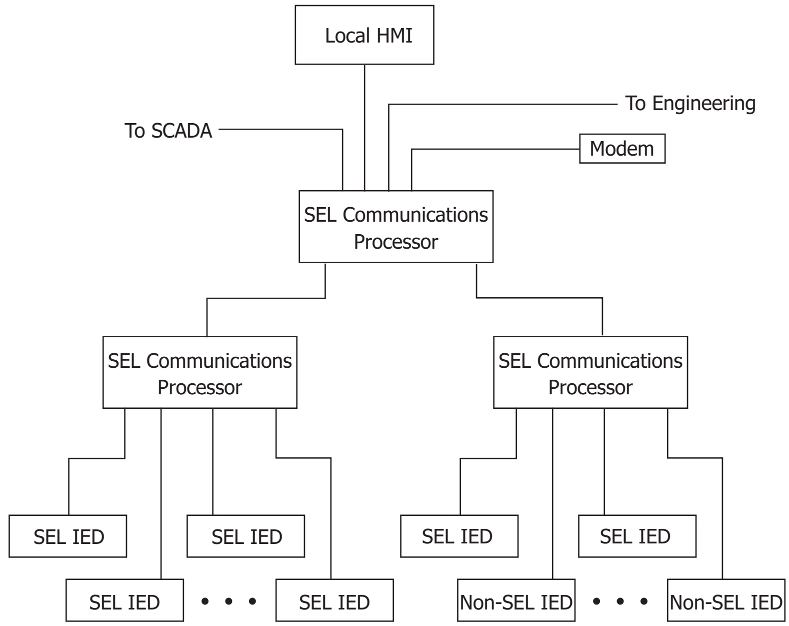


Figure C.2 Multitiered SEL Communications Processor Architecture

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL relays. In terms of MTBF (mean time between failures), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor is different from other general-purpose integration platforms. You can configure SEL communications processors with a system of communication-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.3*.

Table C.3 SEL Communications Processors Protocol Interfaces

Protocol	Connect to
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-710 and an SEL communications processor is shown in *Figure C.1*. In this architecture, the SEL communications processor collects data from the SEL-710 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 communications processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective relays and other station IEDs. This insulation of the protective devices from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, and protection.

SEL communications processors equipped with an SEL-2701 Ethernet Processor can provide a UCA2 interface to SEL-710 Relays and other serial IEDs. The SEL-710 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.

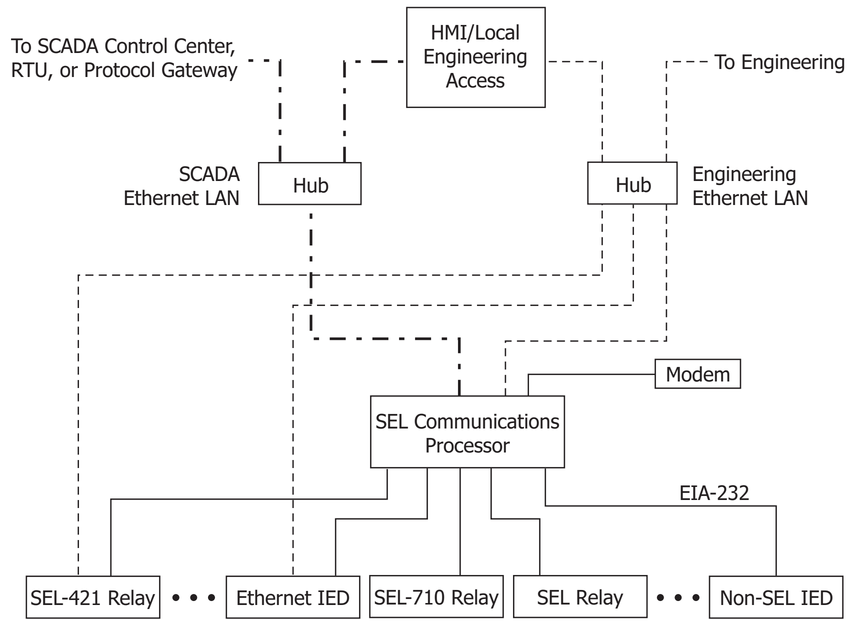


Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

In this example, the SEL communications processor provides the following enhancements when compared to a system that employs only the multidrop network:

- Ethernet access for IEDs with serial ports
- Backup engineering access through the dial-in modem
- IRIG-B time signal distribution to all station IEDs
- Integration of IEDs without Ethernet
- Single point of access for real-time data for SCADA, HMI, and other uses
- Significant cost savings by use of existing IEDs with serial ports

SEL Communications Processor Example

This example demonstrates the data and control points available in the SEL communications processor when you connect an SEL-710. The physical configuration used in this example is shown in *Figure C.4*.

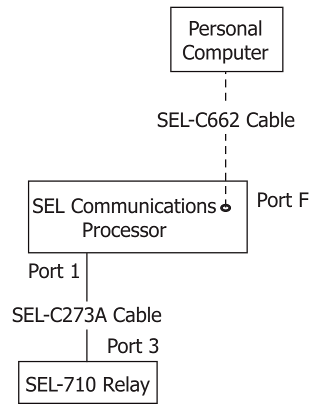


Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

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 time-out that terminates transparent connections of 30 seconds

[a] Automatically collected by the SEL communications processor during autoconfiguration.

Data Collection

The SEL communications processor is configured to collect data from the SEL-710, 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-710. 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 Communications Processor METER Region Map (Sheet 1 of 2)

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
	2011h	float
IN	2013h	float
IG	2015h	float
MLOAD	2017h	float
UBI	2019h	float
	201Bh	float
VAB	201Dh	float
VBC	201Fh	float
VCA	2021h	float
*	2023h	float
UBV	2025h	float
	2027h	float
P	2029h	float

Table C.8 Communications Processor METER Region Map (Sheet 2 of 2)

Item	Starting Address	Type
Q	202Bh	float
S	202Dh	float
PF	202Fh	float
FREQ		
WDG	2031h	float
BRG	2033h	float
AMB	2035h	float
OTH	2037h	float
TCUSTR	2039h	float
TCURTR	203Bh	float

Relay Word Bits Information

Table C.9 lists the Relay Word bit data available in the SEL communications processor TARGET region.

Table C.9 Communications Processor TARGET Region

Address	Relay Word Bits (in Bits 7–0)							
	7	6	5	4	3	2	1	0
2804h	*	*	*	STSET	*	*	*	*
2805h	See *Table I.1*, Row 0							
2806h	See *Table I.1*, Row 1							
2807h	See *Table I.1*, Row 2							
2808h	See *Table I.1*, Row 3							
2809h	See *Table I.1*, Row 4							
280Ah	See *Table I.1*, Row 5							
280Bh	See *Table I.1*, Row 6							
280Ch	See *Table I.1*, Row 7							
280Dh	See *Table I.1*, Row 8							
280Eh	See *Table I.1*, Row 9							
280Fh	See *Table I.1*, Row 10							
2810h	See *Table I.1*, Row 11							
2811h	See *Table I.1*, Row 12							
• • •	• • •							
2871h	See *Table I.1*, Row 108							

Control Points

The SEL communications processor can pass control messages, called Fast Operate messages, to the SEL-710 automatically. You must enable Fast Operate messages by using the FASTOP setting in the SEL-710 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-RB32 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-710.

Breaker bit BR1 operates differently than remote bits. There are no breaker bits in the SEL-710. For Circuit Breaker 1, when you set BR1, the SEL communications processor sends a message to the SEL-710 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-710 that asserts the motor start bit STR for one processing interval. STOP will stop the motor and STR will start the motor. See *Figure 4.40* and *Figure 4.43* for the motor stop and start logic diagrams, respectively.

Appendix D
Modbus Communications

Overview

This appendix describes Modbus RTU communications features supported by the SEL-710 Motor Protection Relay. Complete specifications for the Modbus protocol are available from the Modbus user's group website at www.modbus.org.

Modbus TCP is automatically available with the optional Ethernet port. Modbus TCP uses the device IP address as the Modbus identifier and accesses the data in the relay using the same function codes and data maps as Modbus RTU. The TCP Port for Modbus TCP is 502.

Enable Modbus RTU protocol with the serial port settings. When Modbus RTU protocol is enabled, the relay switches the port to Modbus RTU protocol and deactivates the ASCII protocol.

Modbus RTU is a binary protocol that permits communication between a single master device and multiple slave devices. The communication is half duplex—only one device transmits at a time. The master transmits a binary command that includes the address of the desired slave device. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-710 Modbus communication allows a Modbus master device to do the following:

- ➤ Acquire metering, monitoring, and event data from the relay.
- ➤ Control SEL-710 output contacts.
- ➤ Read the SEL-710 self-test status and learn the present condition of all the relay protection elements.
- ➤ Read most of the relay settings and modify the relay settings.

NOTE: Be aware of the following setting in the relay: Under Global settings =====>> Access Control, there is a setting called BLOCK MODBUS SET.

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

You are strongly advised to change the BLKMBSET (BLOCK MODBUS SET) := ALL if you do not want the PLC (Programmable Logic Controller) or DCS (Distributed Control System) to send the settings to the SEL-710 Relay. There is a strong possibility that under special conditions like a reboot, the

PLC/DCS will send default settings to the relay, overwriting the existing settings. To protect the existing settings under these conditions it is highly recommended to set the setting to ALL.

Communications Protocol

Modbus Queries

Modbus RTU master devices initiate all exchanges by sending a query. The query consists of the fields shown in *Table 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-710 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 an error is detected, the relay discards the packet.

Modbus Responses

The slave device sends a response message after it performs the action the query specifies. If the slave cannot execute the query command for any reason, it sends an error response. Otherwise, the slave device response is formatted similarly to the query and includes the slave address, function code, data (if applicable), and a cyclical redundancy check value.

Supported Modbus Function Codes

The SEL-710 supports the Modbus function codes shown in *Table D.2*.

Table D.2 SEL-710 Modbus Function Codes

Codes	Description
01h	Read Discrete Output Coil Status
02h	Read Discrete Input Status
03h	Read Holding Registers
04h	Read Input Registers
05h	Force Single Coil
06h	Preset Single Register
08h	Diagnostic Command
10h	Preset Multiple Registers
60h	Read Parameter Information
61h	Read Parameter Text
62h	Read Enumeration Text
7Dh	Encapsulate Modbus Packet With Control
7Eh	NOP (can only be used with the 7Dh function)

Modbus Exception Responses

The SEL-710 sends an exception code under the conditions described in *Table D.3*.

Table D.3 SEL-710 Modbus Exception Codes

Exception Code	Error Type	Description
1	Illegal Function Code	The received function code is either undefined or unsupported.
2	Illegal Data Address	The received command contains an unsupported address in the data field (i.e., cannot write to a read-only register, cannot write as settings are locked, etc.).
3	Illegal Data Value	The received command contains a value that is out of range.
4	Device Error	The SEL-710 is in the wrong state for the function a query specifies. This also stands for Service Failure for DeviceNet interface applications. The relay is unable to perform the action specified by a query (i.e., cannot write to a read-only register, cannot write as settings are locked, etc.).
6	Busy	The device is unable to process the command at this time because of a busy resource.

In the event that any of the errors listed in *Table 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-710 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-710, the master device uses the data received. If there is no match, the check fails and the message is ignored. The devices use a similar process when the master sends queries.

01h Read Discrete Output Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils) (see the Modbus Register Map shown in *Table D.34*). You can read the status of as many as 2000 bits per query, using the fields shown in *Table D.4*. Note that the SEL-710 coil addresses start at 0 (e.g., Coil 1 is located at address zero). The coil status is packed one coil per bit of the data field. The Least Significant Bit (LSB) of the first data byte contains the starting coil address in the query. The other coils follow towards the high order end of this byte and from low order to high order in subsequent bytes.

Table D.4 01h Read Discrete Output Coil Status Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the first bit
2 bytes	Number of bits to read
2 bytes	CRC-16

Table D.4 01h Read Discrete Output Coil Status 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 (01h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the SEL-710 calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros to make an even byte. *Table D.14* includes the coil number and lists all possible coils (identified as Outputs and Remote bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

The relay responses to errors in the query are shown in *Table D.5*.

Table D.5 Responses to 01h Read Discrete Output Coil Query Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

02 Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table D.6*. You can read the status of as many as 2000 bits per query. Note that input addresses start at 0 (e.g., Input 1 is located at address zero). The input status is packed one input per bit of the data field. The LSB of the first data byte contains the starting input address in the query. The other inputs follow towards the high order end of this byte, and from low order to high order in subsequent bytes.

Table D.6 02h Read Input Status Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
2 bytes	Address of the first bit
2 bytes	Number of bits to read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data (*n*)
n bytes	Data
2 bytes	CRC-16

To build the response, the device calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros to make an even byte.

In each row, the input numbers are assigned from the right-most input to the left-most input (i.e., Input 1 is TLED_06 and Input 8 is ENABLED). Input addresses start at 0000 (i.e., Input 1 is located at Input Address 0000). *Table D.7* includes the coil address in decimal and lists all possible inputs (Relay Word bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

Table D.7 02h SEL-710 Inputs (Sheet 1 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
0–7	2	Relay Element Status Row 0
8–15	2	Relay Element Status Row 1
16–23	2	Relay Element Status Row 2
24–31	2	Relay Element Status Row 3
32–39	2	Relay Element Status Row 4
40–47	2	Relay Element Status Row 5
48–55	2	Relay Element Status Row 6
56–63	2	Relay Element Status Row 7
64–71	2	Relay Element Status Row 8
72–79	2	Relay Element Status Row 9
80–87	2	Relay Element Status Row 10
88–95	2	Relay Element Status Row 11
96–103	2	Relay Element Status Row 12
104–111	2	Relay Element Status Row 13
112–119	2	Relay Element Status Row 14
120–127	2	Relay Element Status Row 15
128–135	2	Relay Element Status Row 16
136–143	2	Relay Element Status Row 17
144–151	2	Relay Element Status Row 18
152–159	2	Relay Element Status Row 19
160–167	2	Relay Element Status Row 20
168–175	2	Relay Element Status Row 21
176–183	2	Relay Element Status Row 22
184–191	2	Relay Element Status Row 23
192–199	2	Relay Element Status Row 24
200–207	2	Relay Element Status Row 25
208–215	2	Relay Element Status Row 26
216–223	2	Relay Element Status Row 27
224–231	2	Relay Element Status Row 28

Table D.7 02h SEL-710 Inputs (Sheet 2 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
232–239	2	Relay Element Status Row 29
240–247	2	Relay Element Status Row 30
248–255	2	Relay Element Status Row 31
256–263	2	Relay Element Status Row 32
264–271	2	Relay Element Status Row 33
272–279	2	Relay Element Status Row 34
280–287	2	Relay Element Status Row 35
288–295	2	Relay Element Status Row 36
296–303	2	Relay Element Status Row 37
304–311	2	Relay Element Status Row 38
312–319	2	Relay Element Status Row 39
320–327	2	Relay Element Status Row 40
328–335	2	Relay Element Status Row 41
336–343	2	Relay Element Status Row 42
344–351	2	Relay Element Status Row 43
352–359	2	Relay Element Status Row 44
360–367	2	Relay Element Status Row 45
368–375	2	Relay Element Status Row 46
376–383	2	Relay Element Status Row 47
384–391	2	Relay Element Status Row 48
392–399	2	Relay Element Status Row 49
400–407	2	Relay Element Status Row 50
408–415	2	Relay Element Status Row 51
416–423	2	Relay Element Status Row 52
424–431	2	Relay Element Status Row 53
432–439	2	Relay Element Status Row 54
440–447	2	Relay Element Status Row 55
448–455	2	Relay Element Status Row 56
456–463	2	Relay Element Status Row 57
464–471	2	Relay Element Status Row 58
472–479	2	Relay Element Status Row 59
480–487	2	Relay Element Status Row 60
488–495	2	Relay Element Status Row 61
496–503	2	Relay Element Status Row 62
504–511	2	Relay Element Status Row 63
512–519	2	Relay Element Status Row 64
520–527	2	Relay Element Status Row 65
528–535	2	Relay Element Status Row 66

Table D.7 02h SEL-710 Inputs (Sheet 3 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
536–543	2	Relay Element Status Row 67
544–551	2	Relay Element Status Row 68
552–559	2	Relay Element Status Row 69
560–567	2	Relay Element Status Row 70
568–575	2	Relay Element Status Row 71
576–583	2	Relay Element Status Row 72
584–591	2	Relay Element Status Row 73
592–599	2	Relay Element Status Row 74
600–607	2	Relay Element Status Row 75
608–615	2	Relay Element Status Row 76
616–623	2	Relay Element Status Row 77
624–631	2	Relay Element Status Row 78
632–639	2	Relay Element Status Row 79
640–647	2	Relay Element Status Row 80
648–655	2	Relay Element Status Row 81
656–663	2	Relay Element Status Row 82
664–671	2	Relay Element Status Row 83
672–679	2	Relay Element Status Row 84
680–687	2	Relay Element Status Row 85
688–695	2	Relay Element Status Row 86
696–703	2	Relay Element Status Row 87
704–711	2	Relay Element Status Row 88
712–719	2	Relay Element Status Row 89
720–727	2	Relay Element Status Row 90
728–735	2	Relay Element Status Row 91
736–743	2	Relay Element Status Row 92
744–751	2	Relay Element Status Row 93
752–759	2	Relay Element Status Row 94
760–767	2	Relay Element Status Row 95
768–775	2	Relay Element Status Row 96
776–783	2	Relay Element Status Row 97
784–791	2	Relay Element Status Row 98
792–799	2	Relay Element Status Row 99
800–807	2	Relay Element Status Row 100
808–815	2	Relay Element Status Row 101
816–823	2	Relay Element Status Row 102
824–831	2	Relay Element Status Row 103
832–839	2	Relay Element Status Row 104
840–847	2	Relay Element Status Row 105

Table D.7 02h SEL-710 Inputs (Sheet 4 of 4)

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
848–855	2	Relay Element Status Row 106
856–863	2	Relay Element Status Row 107
864–871	2	Relay Element Status Row 108
872-879	2	Relay Element Status Row 109
880–887	2	Relay Element Status Row 110
888–895	2	Relay Element Status Row 111
896–903	2	Relay Element Status Row 112

[a] The input numbers are assigned from the right-most input to the left-most input in the Relay row as show in the following example.
Address 7 = ENABLED
Address 6 = TRIP
Address 5 = T01_LED
Address 4 = T02_LED
Address 3 = T03_LED
Address 2 = T04_LED
Address 1 = T05_LED
Address 0 = T06_LED

The relay responses to errors in the query are shown in *Table D.8*.

Table D.8 Responses to 02h Read Input Query Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table D.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table D.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table D.10*.

Table D.10 Responses to 03h Read Holding Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table D.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

Table D.11 04h Read Input Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table D.12*.

Table D.12 Responses to 04h Read Input Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil. In *Table D.13*, the command response is identical to the command request.

Table D.13 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

Table D.14 lists the coil numbers supported by the SEL-710. The physical coils (coils 0–26) are self-resetting. Pulsing a Set remote bit (decimal address 59 through 90) causes the remote bit to be cleared at the end of the pulse.

Table D.14 01h, 05h SEL-710 Output (Sheet 1 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
0	01, 05	Pulse OUT101 1 second
1	01, 05	Pulse OUT102 1 second
2	01, 05	Pulse OUT103 1 second
3	01, 05	Pulse OUT301 1 second
4	01, 05	Pulse OUT302 1 second
5	01, 05	Pulse OUT303 1 second
6	01, 05	Pulse OUT304 1 second
7	01, 05	Reserved
8	01, 05	Reserved
9	01, 05	Reserved
10	01, 05	Reserved
11	01, 05	Pulse OUT401 1 second
12	01, 05	Pulse OUT402 1 second
13	01, 05	Pulse OUT403 1 second
14	01, 05	Pulse OUT404 1 second
15	01, 05	Reserved
16	01, 05	Reserved
17	01, 05	Reserved
18	01, 05	Reserved
19	01, 05	Pulse OUT501 1 second
20	01, 05	Pulse OUT502 1 second
21	01, 05	Pulse OUT503 1 second
22	01, 05	Pulse OUT504 1 second
23	01, 05	Reserved
24	01, 05	Reserved

Table D.14 01h, 05h SEL-710 Output (Sheet 2 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
25	01, 05	Reserved
26	01, 05	Reserved
27	01, 05	RB01
28	01, 05	RB02
29	01, 05	RB03
30	01, 05	RB04
31	01, 05	RB05
32	01, 05	RB06
33	01, 05	RB07
34	01, 05	RB08
35	01, 05	RB09
36	01, 05	RB10
37	01, 05	RB11
38	01, 05	RB12
39	01, 05	RB13
40	01, 05	RB14
41	01, 05	RB15
42	01, 05	RB16
43	01, 05	RB17
44	01, 05	RB18
45	01, 05	RB19
46	01, 05	RB20
47	01, 05	RB21
48	01, 05	RB22
49	01, 05	RB23
50	01, 05	RB24
51	01, 05	RB25
52	01, 05	RB26
53	01, 05	RB27
54	01, 05	RB28
55	01, 05	RB29
56	01, 05	RB30
57	01, 05	RB31
58	01, 05	RB32
59	01, 05	Pulse RB01[a]
60	01, 05	Pulse RB02[a]
61	01, 05	Pulse RB03[a]
62	01, 05	Pulse RB04[a]
63	01, 05	Pulse RB05[a]
64	01, 05	Pulse RB06[a]

Table D.14 01h, 05h SEL-710 Output (Sheet 3 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
65	01, 05	Pulse RB07[a]
66	01, 05	Pulse RB08[a]
67	01, 05	Pulse RB09[a]
68	01, 05	Pulse RB10[a]
69	01, 05	Pulse RB11[a]
70	01, 05	Pulse RB12[a]
71	01, 05	Pulse RB1[a]3
72	01, 05	Pulse RB14[a]
73	01, 05	Pulse RB15[a]
74	01, 05	Pulse RB16[a]
75	01, 05	Pulse RB17[a]
76	01, 05	Pulse RB18[a]
77	01, 05	Pulse RB19[a]
78	01, 05	Pulse RB20[a]
79	01, 05	Pulse RB21[a]
80	01, 05	Pulse RB22[a]
81	01, 05	Pulse RB23[a]
82	01, 05	Pulse RB24[a]
83	01, 05	Pulse RB25[a]
84	01, 05	Pulse RB26[a]
85	01, 05	Pulse RB27[a]
86	01, 05	Pulse RB28[a]
87	01, 05	Pulse RB29[a]
88	01, 05	Pulse RB30[a]
89	01, 05	Pulse RB31[a]
90	01, 05	Pulse RB32[a]

[a] Pulsing a Set remote bit will cause the remote bit to be cleared at the end of the pulse (1 SELogic Processing Interval).

Coil addresses start at 0000 (i.e., Coil 1 is located at Coil address 0000). If the device is disabled, it will respond with error code 4 (Device Error). In addition to Error Code 4, the device responses to errors in the query are shown in *Table D.15*.

Table D.15 Responses to 05h Force Single Coil Query Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-710 uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Register Map in *Table D.34* 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.16*, the command response is identical to the command required by the master.

Table D.16 06h Preset Single Register Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table D.20*.

Table D.17 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-710 uses this function to allow a Modbus master to perform a diagnostic test on the Modbus communications channel and relay. When the subfunction field is 0000h, the relay returns a replica of the received message.

Table D.18 08h Loopback Diagnostic Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (identical to data in Master request)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table D.19*.

Table D.19 Responses to 08h Loopback Diagnostic Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Invalid Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, as many as 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table D.20 10h Preset Multiple Registers Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

The relay responses to errors in the query are shown below.

Table D.21 10h Preset Multiple Registers Query Error Messages

Error	Error Code Returned	Communication Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

60h Read Parameter Information Command

The SEL-710 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.22 60h Read Parameter Information Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
1 byte	Parameter Descriptor
1 byte	Parameter Conversion
2 bytes	Parameter Minimum Settable Value
2 bytes	Parameter Maximum Settable Value
2 bytes	Parameter Default Value
2 bytes	CRC-16

The Parameter Descriptor field is defined in *Table D.23*.

Table D.23 60h Read Parameter Descriptor Field Definition

Bit	Name	Description
0	RO: Read-only	1 when the setting is read-only
1	H: Hidden	1 when the setting is hidden
2	DBL: 32-bit	1 when the following setting is a fractional value of this setting
3	RA: RAM-only	1 when the setting is not saved in nonvolatile memory
4	RR: Read-only if running	1 when the setting is read-only if in running/operational state
5‘	P: Power Cycle or Reset	1 when the setting change requires a power cycle or reset
6	0	Reserved
7	Extend	Reserved to extend the descriptor table

The Parameter Conversion field is defined in *Table D.24*.

Table D.24 60h Read Parameter Conversion Field Definition (Sheet 1 of 2)

Conversion Value	Type	Multiplier	Divisor	Offset	Base
0	Boolean	1	1	0	1
1	Unsigned Integer	1	1	0	1
2	Unsigned Integer	1	10	0	1
3	Unsigned Integer	1	100	0	1
4	Unsigned Integer	1	1000	0	1
5	Hexadecimal	1	1	0	1
6	Integer	1	1	0	1
7	Integer	1	10	0	1
8	Integer	1	100	0	1

Table D.24 60h Read Parameter Conversion Field Definition (Sheet 2 of 2)

Conversion Value	Type	Multiplier	Divisor	Offset	Base
9	Integer	1	1000	0	1
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Table D.25* to calculate the actual (not scaled) value of the parameter (setting):

$$\text{value} = \frac{(\text{ParameterValue} + \text{Offset}) \bullet \text{Multiplier} \bullet \text{Base}}{\text{Divisor}} \qquad \textbf{Equation D.1}$$

Use *Table D.25* to calculate the scaled setting value:

$$\text{value} = \frac{\text{value} \bullet \text{Divisor}}{\text{Multiplier} \bullet \text{Base}} - \text{Offset} \qquad \textbf{Equation D.2}$$

The relay response to errors in the query are shown *Table D.25*.

Table D.25 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-710 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.26 61h Read Parameter Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (61h)
2 bytes	Parameter Number
16 bytes	Parameter Text (setting name)
4 bytes	Parameter Units (e.g., Amps)
2 bytes	CRC-16

The relay responses to errors in the query are shown below.

Table D.27 61h Read Parameter Text Query Error Messages

Error	Error Code Returned	Communication Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

62h Read Enumeration Text Command

The SEL-710 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.28 62h Read Enumeration Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
16 bytes	Enumeration Text
2 bytes	CRC-16

The relay responses to errors in the query are shown below.

Table D.29 61h Read Parameter Enumeration Text Query Error Messages

Error	Error Code Returned	Communication Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address
Illegal enumeration in index	Illegal Data Value (03h)	Illegal Register

7Dh Encapsulated Packet With Control Command

The SEL-710 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.30 7Dh Encapsulated Packet With Control Command (Sheet 1 of 2)

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Control Command (same as write to 2000h)
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16

Table D.30 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

Table D.31 shows the format of the relay responses to errors in the query.

Table D.31 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code is returned here and the illegal function counter is incremented. This error code is returned by the embedded function for all valid embedded functions.

7Eh NOP Command

This function code has no operation. This allows a Modbus master to perform a control operation without any other Modbus command. This is only used inside of the 7Dh when no regular Modbus query is required.

Table D.32 7Eh NOP Command

Bytes	Field
An example of a 7D message response using 7E will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information
1 byte	Function Code (7Eh)
2 bytes	CRC-16

Reading Parameter Information and Value Using Modbus

Through use of Modbus commands, you can read the present value of a parameter as well as parameter name, units, low limit, high limit, scale, and even the enumeration string (if the parameter is an enumeration type). This means that you can use a general user interface to retrieve and display specific parameter details from the relay. Use the **60h**, **61h**, and **62h** commands to retrieve parameter information, and use the **03** command to retrieve values.

Modifying Relay Settings Using Modbus

The SEL-710 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.34*) 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 time-out, the relay attempts to save the settings. If there are no errors, the settings are saved. If, however, a setting interdependency rule is violated, the settings are not saved. The relay will set the Config Fault bit in the TRIP STATUS HI register to indicate that the save settings operation has failed. The relay will also set ERROR REGISTER (4016h) flags to indicate the type of error.

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 BLOCK MODBUS SET register.

Controlling Output Contacts Using Modbus

The SEL-710 includes registers for controlling some of the outputs. See LOGIC COMMAND (2000h), RESET COMMAND (2001h), and registers in the Reset Settings region for the control features supported by the relay. Use Modbus function codes 06h or 10h to write appropriate flags. Remember that when writing to the Logic command register with output contacts, it is not a bit operation. All the bits in that register need to be written together to reflect the state you want for each of the outputs.

User-Defined Modbus Data Region and SET M Command

The SEL-710 Modbus Register Map defines an area of 125 contiguous addresses whose contents are defined by 125 user settable addresses. This feature allows you to take 125 discrete values from anywhere in the Modbus Register Map and place them in contiguous registers that you can then read in a single command. SEL ASCII command **SET M** provides a convenient method to define the user map addresses. The user map can also be defined by writing to user map registers MOD_001 to MOD_125.

To use the user-defined data region, follow the steps listed below:

Step 1. Define the list of desired quantities (as many as 125). Arrange the quantities in any order that is convenient for you to use.

Step 2. Refer to *Table D.33* for a list of the Modbus label for each quantity. For more information on the Modbus labels, refer to the respective register in the Modbus map (see *Table D.34*).

Step 3. Execute **SET M** command from the command line to map user registers 001 to 125 (MOD_001 to MOD_125) using the labels in *Table D.33*.

Note that this step can also be performed using Modbus protocol. Use Modbus Function Code 06h to write to registers MOD_001 through MOD_125.

Step 4. Use Modbus function code 03h or 04h to read the desired quantities from addresses 126 through 250 (user map values).

Table D.33 Modbus Register Labels for Use With SET M Command (Sheet 1 of 5)

Register Address	Label
610	FPGA
611	GPSB
612	HMI
613	RAM
614	ROM
615	CR_RAM
616	NON_VOL
617	CLKSTS
618	PTC
619	RTD
620	P3P3PS
621	P5PS
622	P2P5PS
623	P3P75PS
624	N1P25PS
625	N5PS
626	CLKBAT
627	CTBRD
628	CARDC
629	CARDD
630	CARDE
631	IASTS
632	IBSTS
633	ICSTS
634	INSTS
635	VASTS
636	VBSTS
637	VCSTS
638	RLYSTS
639	IA87STS
640	IB87STS
641	IC87STS
642	CID_FILE
643	SER_NUML
644	SER_NUMH
645-649[a]	
650	IA_MAG
651	IA_ANG
652	IB_MAG
653	IB_ANG
654	IC_MAG
655	IC_ANG
656	IN_MAG
657	IN_ANG
658	IG_MAG
659	IG_ANG
660	IAV
661	MLOAD
662	3I2
663	UBI
664	IA87
665	IB87
666	IC87
667	VAB_MAG
668	VAB_ANG
669	VBC_MAG
670	VBC_ANG
671	VCA_MAG
672	VCA_ANG
673	VAVE
674	VA_MAG
675	VA_ANG
676	VB_MAG
677	VB_ANG
678	VC_MAG
679	VC_ANG
680	VG_MAG
681	VG_ANG
682	VAVE
683	3V2
684	UBV
685	P
686	Q
687	S
688	PF
689	FREQ
690	MWH3PH
691	MWH3PL
692	MVRH3PIH
693	MVRH3PIL
694	MVRH3POH
695	MVRH3POL
696	MVAH3PH
697	MVAH3PL
698	ENRGY_S
699	ENRGYMN
700	ENRGY_H
701	ENRGY_D
702	ENRGYMO
703	ENRGY_Y
704-711[a]	
712	RTDWDGMX
713	RTDBRGMX
714	RTDAMB
715	RTDOTHMX
716	RTD1
717	RTD2
718	RTD3
719	RTD4
720	RTD5
721	RTD6
722	RTD7
723	RTD8
724	RTD9
725	RTD10
726	RTD11
727	RTD12
728	TCURTD
729	TCUSTR
730	TCURTR
731	THRMTP
732	TRST
733	STRTAV
734	SLIP
735-739[a]	
740	IARMS
741	IBRMS
742	ICRMS
743	INRMS
744	VARMS
745	VBRMS
746	VCRMS
747	VABRMS
748	VBCRMS
749	VCARMS
750	IAMX
751	IAX_S
752	IAXMN
753	IAX_H
754	IAX_D
755	IAXMO
756	IAX_Y
757	IAMN
758	IAN_S
759	IANMN
760	IAN_H
761	IAN_D
762	IANMO
763	IAN_Y
764	IBMX
765	IBX_S
766	IBXMN
767	IBX_H
768	IBX_D
769	IBXMO
770	IBX_Y
771	IBMN
772	IBN_S
773	IBNMN
774	IBN_H
775	IBN_D
776	IBNMO
777	IBN_Y
778	ICMX
779	ICX_S
780	ICXMN
781	ICX_H
782	ICX_D
783	ICXMO
784	ICX_Y
785	ICMN
786	ICN_S
787	ICNMN
788	ICN_H
789	ICN_D
790	ICNMO
791	ICN_Y
792	INMX
793	INX_S
794	INXMN
795	INX_H
796	INX_D
797	INXMO
798	INX_Y
799	INMN
800	INN_S
801	INNMN
802	INN_H
803	INN_D
804	INNMO
805	INN_Y
806	IGMX
807	IGX_S
808	IGXMN
809	IGX_H
810	IGX_D
811	IGXMO
812	IGX_Y
813	IGMN
814	IGN_S
815	IGNMN
816	IGN_H
817	IGN_D
818	IGNMO
819	IGN_Y
820[b]	VABMX
821[b]	VABX_S
822[b]	VABXMN
823[b]	VABX_H
824[b]	VABX_D
825[b]	VABXMO
826[b]	VABX_Y
827[b]	VABMN
828[b]	VABN_S
829[b]	VABNMN
830[b]	VABN_H
831[b]	VABN_D
832[b]	VABNMO
833[b]	VABN_Y
834[b]	VBCMX
835[b]	VBCX_S
836[b]	VBCXMN
837[b]	VBCX_H
838[b]	VBCX_D
839[b]	VBCXMO
840[b]	VBCX_Y
841[b]	VBCMN
842[b]	VBCN_S
843[b]	VBCNMN
844[b]	VBCN_H
845[b]	VBCN_D
846[b]	VBCNMO
847[b]	VBCN_Y
848[b]	VCAMX
849[b]	VCAX_S
850[b]	VCAXMN
851[b]	VCAX_H
852[b]	VCAX_D
853[b]	VCAXMO
854[b]	VCAX_Y
855[b]	VCAMN
856[b]	VCAN_S
857[b]	VCANMN
858[b]	VCAN_H
859[b]	VCAN_D
860[b]	VCANMO
861[b]	VCAN_Y
862	KW3PMX
863	KW3X_S
864	KW3XMN
865	KW3X_H
866	KW3X_D
867	KW3XMO
868	KW3X_Y
869	KW3PMN
870	KW3N_S
871	KW3NMN
872	KW3N_H
873	KW3N_D
874	KW3NMO
875	KW3N_Y
876	KVAR3PMX
877	KVR3X_S
878	KVR3XMN
879	KVR3X_H
880	KVR3X_D
881	KVR3XMO
882	KVR3X_Y
883	KVAR3PMN
884	KVR3N_S
885	KVR3NMN
886	KVR3N_H
887	KVR3N_D
888	KVR3NMO
889	KVR3N_Y
890	KVA3PMX
891	KVA3X_S
892	KVA3XMN
893	KVA3X_H
894	KVA3X_D
895	KVA3XMO
896	KVA3X_Y
897	KVA3PMN
898	KVA3N_S
899	KVA3NMN
900	KVA3N_H
901	KVA3N_D
902	KVA3NMO
903	KVA3N_Y
904	FREQMX
905	FREQX_S
906	FREQXMN
907	FREQX_H
908	FREQX_D
909	FREQXMO
910	FREQX_Y
911	FREQMN
912	FREQN_S

Table D.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
913	FREQNMN	961	RTD4X_S	1009	RTD7MN	1057	RTD10N_Y	1105	AI302XMN	1153	AI305XMN
914	FREQN_H	962	RTD4XMN	1010	RTD7N_S	1058	RTD11MX	1106	AI302X_H	1154	AI305X_H
915	FREQN_D	963	RTD4X_H	1011	RTD7NMN	1059	RTD11X_S	1107	AI302X_D	1155	AI305X_D
916	FREQNMO	964	RTD4X_D	1012	RTD7N_H	1060	RTD11XMN	1108	AI302XMO	1156	AI305XMO
917	FREQN_Y	965	RTD4XMO	1013	RTD7N_D	1061	RTD11X_H	1109	AI302X_Y	1157	AI305X_Y
918	RTD1MX	966	RTD4X_Y	1014	RTD7NMO	1062	RTD11X_D	1110	AI302MNH	1158	AI305MNH
919	RTD1X_S	967	RTD4MN	1015	RTD7N_Y	1063	RTD11XMO	1111	AI302MNL	1159	AI305MNL
920	RTD1XMN	968	RTD4N_S	1016	RTD8MX	1064	RTD11X_Y	1112	AI302N_S	1160	AI305N_S
921	RTD1X_H	969	RTD4NMN	1017	RTD8X_S	1065	RTD11MN	1113	AI302NMN	1161	AI305NMN
922	RTD1X_D	970	RTD4N_H	1018	RTD8XMN	1066	RTD11N_S	1114	AI302N_H	1162	AI305N_H
923	RTD1XMO	971	RTD4N_D	1019	RTD8X_H	1067	RTD11NMN	1115	AI302N_D	1163	AI305N_D
924	RTD1X_Y	972	RTD4NMO	1020	RTD8X_D	1068	RTD11N_H	1116	AI302NMO	1164	AI305NMO
925	RTD1MN	973	RTD4N_Y	1021	RTD8XMO	1069	RTD11N_D	1117	AI302N_Y	1165	AI305N_Y
926	RTD1N_S	974	RTD5MX	1022	RTD8X_Y	1070	RTD11NMO	1118	AI302MXH	1166	AI306MXH
927	RTD1NMN	975	RTD5X_S	1023	RTD8MN	1071	RTD11N_Y	1119	AI302MXL	1167	AI306MXL
928	RTD1N_H	976	RTD5XMN	1024	RTD8N_S	1072	RTD12MX	1120	AI302X_S	1168	AI306X_S
929	RTD1N_D	977	RTD5X_H	1025	RTD8NMN	1073	RTD12X_S	1121	AI302XMN	1169	AI306XMN
930	RTD1NMO	978	RTD5X_D	1026	RTD8N_H	1074	RTD12XMN	1122	AI302X_H	1170	AI306X_H
931	RTD1N_Y	979	RTD5XMO	1027	RTD8N_D	1075	RTD12X_H	1123	AI302X_D	1171	AI306X_D
932	RTD2MX	980	RTD5X_Y	1028	RTD8NMO	1076	RTD12X_D	1124	AI302XMO	1172	AI306XMO
933	RTD2X_S	981	RTD5MN	1029	RTD8N_Y	1077	RTD12XMO	1125	AI302X_Y	1173	AI306X_Y
934	RTD2XMN	982	RTD5N_S	1030	RTD9MX	1078	RTD12X_Y	1126	AI303MNH	1174	AI306MNH
935	RTD2X_H	983	RTD5NMN	1031	RTD9X_S	1079	RTD12MN	1127	AI303MNL	1175	AI306MNL
936	RTD2X_D	984	RTD5N_H	1032	RTD9XMN	1080	RTD12N_S	1128	AI303N_S	1176	AI306N_S
937	RTD2XMO	985	RTD5N_D	1033	RTD9X_H	1081	RTD12NMN	1129	AI303NMN	1177	AI306NMN
938	RTD2X_Y	986	RTD5NMO	1034	RTD9X_D	1082	RTD12N_H	1130	AI303N_H	1178	AI306N_H
939	RTD2MN	987	RTD5N_Y	1035	RTD9XMO	1083	RTD12N_D	1131	AI303N_D	1179	AI306N_D
940	RTD2N_S	988	RTD6MX	1036	RTD9X_Y	1084	RTD12NMO	1132	AI303NMO	1180	AI306NMO
941	RTD2NMN	989	RTD6X_S	1037	RTD9MN	1085	RTD12N_Y	1133	AI303N_Y	1181	AI306N_Y
942	RTD2N_H	990	RTD6XMN	1038	RTD9N_S	1086	AI301MXH	1134	AI303MXH	1182	AI307MXH
943	RTD2N_D	991	RTD6X_H	1039	RTD9NMN	1087	AI301MXL	1135	AI303MXL	1183	AI307MXL
944	RTD2NMO	992	RTD6X_D	1040	RTD9N_H	1088	AI301X_S	1136	AI303X_S	1184	AI307X_S
945	RTD2N_Y	993	RTD6XMO	1041	RTD9N_D	1089	AI301XMN	1137	AI303XMN	1185	AI307XMN
946	RTD3MX	994	RTD6X_Y	1042	RTD9NMO	1090	AI301X_H	1138	AI303X_H	1186	AI307X_H
947	RTD3X_S	995	RTD6MN	1043	RTD9N_Y	1091	AI301X_D	1139	AI303X_D	1187	AI307X_D
948	RTD3XMN	996	RTD6N_S	1044	RTD10MX	1092	AI301XMO	1140	AI303XMO	1188	AI307XMO
949	RTD3X_H	997	RTD6NMN	1045	RTD10X_S	1093	AI301X_Y	1141	AI303X_Y	1189	AI307X_Y
950	RTD3X_D	998	RTD6N_H	1046	RTD10XMN	1094	AI301MNH	1142	AI304MNH	1190	AI307MNH
951	RTD3XMO	999	RTD6N_D	1047	RTD10X_H	1095	AI301MNL	1143	AI304MNL	1191	AI307MNL
952	RTD3X_Y	1000	RTD6NMO	1048	RTD10X_D	1096	AI301N_S	1144	AI304N_S	1192	AI307N_S
953	RTD3MN	1001	RTD6N_Y	1049	RTD10XMO	1097	AI301NMN	1145	AI304NMN	1193	AI307NMN
954	RTD3N_S	1002	RTD7MX	1050	RTD10X_Y	1098	AI301N_H	1146	AI304N_H	1194	AI307N_H
955	RTD3NMN	1003	RTD7X_S	1051	RTD10MN	1099	AI301N_D	1147	AI304N_D	1195	AI307N_D
956	RTD3N_H	1004	RTD7XMN	1052	RTD10N_S	1100	AI301NMO	1148	AI304NMO	1196	AI307NMO
957	RTD3N_D	1005	RTD7X_H	1053	RTD10NMN	1101	AI301N_Y	1149	AI304N_Y	1197	AI307N_Y
958	RTD3NMO	1006	RTD7X_D	1054	RTD10N_H	1102	AI302MXH	1150	AI305MXH	1198	AI308MXH
959	RTD3N_Y	1007	RTD7XMO	1055	RTD10N_D	1103	AI302MXL	1151	AI305MXL	1199	AI308MXL
960	RTD4MX	1008	RTD7X_Y	1056	RTD10NMO	1104	AI302X_S	1152	AI305X_S	1200	AI308X_S

Table D.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1201	AI308XMN	1249	AI402XMN	1297	AI406XMN	1345	AI501XMN	1393	AI503XMN	1441	AI507XMN
1202	AI308X_H	1250	AI402X_H	1298	AI406X_H	1346	AI501X_H	1394	AI503X_H	1442	AI507X_H
1203	AI308X_D	1251	AI402X_D	1299	AI406X_D	1347	AI501X_D	1395	AI503X_D	1443	AI507X_D
1204	AI308XMO	1252	AI402XMO	1300	AI406XMO	1348	AI501XMO	1396	AI503XMO	1444	AI507XMO
1205	AI308X_Y	1253	AI402X_Y	1301	AI406X_Y	1349	AI501X_Y	1397	AI503X_Y	1445	AI507X_Y
1206	AI308MNH	1254	AI403MNH	1302	AI406MNH	1350	AI501MNH	1398	AI504MNH	1446	AI507MNH
1207	AI308MNL	1255	AI403MNL	1303	AI406MNL	1351	AI501MNL	1399	AI504MNL	1447	AI507MNL
1208	AI308N_S	1256	AI403N_S	1304	AI406N_S	1352	AI501N_S	1400	AI504N_S	1448	AI507N_S
1209	AI308NMN	1257	AI403NMN	1305	AI406NMN	1353	AI501NMN	1401	AI504NMN	1449	AI507NMN
1210	AI308N_H	1258	AI403N_H	1306	AI406N_H	1354	AI501N_H	1402	AI504N_H	1450	AI507N_H
1211	AI308N_D	1259	AI403N_D	1307	AI406N_D	1355	AI501N_D	1403	AI504N_D	1451	AI507N_D
1212	AI308NMO	1260	AI403NMO	1308	AI406NMO	1356	AI501NMO	1404	AI504NMO	1452	AI507NMO
1213	AI308N_Y	1261	AI403N_Y	1309	AI406N_Y	1357	AI501N_Y	1405	AI504N_Y	1453	AI507N_Y
1214	AI401MXH	1262	AI403MXH	1310	AI407MXH	1358	AI502MXH	1406	AI505MXH	1454	AI508MXH
1215	AI401MXL	1263	AI403MXL	1311	AI407MXL	1359	AI502MXL	1407	AI505MXL	1455	AI508MXL
1216	AI401X_S	1264	AI403X_S	1312	AI407X_S	1360	AI502X_S	1408	AI505X_S	1456	AI508X_S
1217	AI401XMN	1265	AI403XMN	1313	AI407XMN	1361	AI502XMN	1409	AI505XMN	1457	AI508XMN
1218	AI401X_H	1266	AI403X_H	1314	AI407X_H	1362	AI502X_H	1410	AI505X_H	1458	AI508X_H
1219	AI401X_D	1267	AI403X_D	1315	AI407X_D	1363	AI502X_D	1411	AI505X_D	1459	AI508X_D
1220	AI401XMO	1268	AI403XMO	1316	AI407XMO	1364	AI502XMO	1412	AI505XMO	1460	AI508XMO
1221	AI401X_Y	1269	AI403X_Y	1317	AI407X_Y	1365	AI502X_Y	1413	AI505X_Y	1461	AI508X_Y
1222	AI401MNH	1270	AI404MNH	1318	AI407MNH	1366	AI502MNH	1414	AI505MNH	1462	AI508MNH
1223	AI401MNL	1271	AI404MNL	1319	AI407MNL	1367	AI502MNL	1415	AI505MNL	1463	AI508MNL
1224	AI401N_S	1272	AI404N_S	1320	AI407N_S	1368	AI502N_S	1416	AI505N_S	1464	AI508N_S
1225	AI401NMN	1273	AI404NMN	1321	AI407NMN	1369	AI502NMN	1417	AI505NMN	1465	AI508NMN
1226	AI401N_H	1274	AI404N_H	1322	AI407N_H	1370	AI502N_H	1418	AI505N_H	1466	AI508N_H
1227	AI401N_D	1275	AI404N_D	1323	AI407N_D	1371	AI502N_D	1419	AI505N_D	1467	AI508N_D
1228	AI401NMO	1276	AI404NMO	1324	AI407NMO	1372	AI502NMO	1420	AI505NMO	1468	AI508NMO
1229	AI401N_Y	1277	AI404N_Y	1325	AI407N_Y	1373	AI502N_Y	1421	AI505N_Y	1469	AI508N_Y
1230	AI402MXH	1278	AI405MXH	1326	AI408MXH	1374	AI502MXH	1422	AI506MXH	1470	MXMN_R_S
1231	AI402MXL	1279	AI405MXL	1327	AI408MXL	1375	AI502MXL	1423	AI506MXL	1471	MXMN_RMN
1232	AI402X_S	1280	AI405X_S	1328	AI408X_S	1376	AI502X_S	1424	AI506X_S	1472	MXMN_R_H
1233	AI402XMN	1281	AI405XMN	1329	AI408XMN	1377	AI502XMN	1425	AI506XMN	1473	MXMN_R_D
1234	AI402X_H	1282	AI405X_H	1330	AI408X_H	1378	AI502X_H	1426	AI506X_H	1474	MXMN_RMO
1235	AI402X_D	1283	AI405X_D	1331	AI408X_D	1379	AI502X_D	1427	AI506X_D	1475	MXMN_R_Y
1236	AI402XMO	1284	AI405XMO	1332	AI408XMO	1380	AI502XMO	1428	AI506XMO	1476-1492[a]	
1237	AI402X_Y	1285	AI405X_Y	1333	AI408X_Y	1381	AI502X_Y	1429	AI506X_Y	1493	AI301H
1238	AI402MNH	1286	AI405MNH	1334	AI408MNH	1382	AI503MNH	1430	AI506MNH	1494	AI301L
1239	AI402MNL	1287	AI405MNL	1335	AI408MNL	1383	AI503MNL	1431	AI506MNL	1495	AI302H
1240	AI402N_S	1288	AI405N_S	1336	AI408N_S	1384	AI503N_S	1432	AI506N_S	1496	AI302L
1241	AI402NMN	1289	AI405NMN	1337	AI408NMN	1385	AI503NMN	1433	AI506NMN	1497	AI303H
1242	AI402N_H	1290	AI405N_H	1338	AI408N_H	1386	AI503N_H	1434	AI506N_H	1498	AI303L
1243	AI402N_D	1291	AI405N_D	1339	AI408N_D	1387	AI503N_D	1435	AI506N_D	1499	AI304H
1244	AI402NMO	1292	AI405NMO	1340	AI408NMO	1388	AI503NMO	1436	AI506NMO	1500	AI304L
1245	AI402N_Y	1293	AI405N_Y	1341	AI408N_Y	1389	AI503N_Y	1437	AI506N_Y	1501	AI305H
1246	AI402MXH	1294	AI406MXH	1342	AI501MXH	1390	AI503MXH	1438	AI507MXH	1502	AI305L
1247	AI402MXL	1295	AI406MXL	1343	AI501MXL	1391	AI503MXL	1439	AI507MXL	1503	AI306H
1248	AI402X_S	1296	AI406X_S	1344	AI501X_S	1392	AI503X_S	1440	AI507X_S	1504	AI306L

Table D.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 5)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
1505	AI307H	1558	MV06L	1606	MV30L	1658	NUMSTRT	1706	UNDV_A	1763	EVE_VCA
1506	AI307L	1559	MV07H	1607	MV31H	1659	NUMEMRST	1707	OVRV_A	1764	EVE_VG
1507	AI308H	1560	MV07L	1608	MV31L	1660	MOT_RS_S	1708	UNDP_A	1765	EVE_DY
1508	AI308L	1561	MV08H	1609	MV32H	1661	MOT_RSMN	1709	PF_A	1766	EVE_FREQ
1509	AI401H	1562	MV08L	1610	MV32L	1662	MOT_RS_H	1710	RPWR_A	1767	EVE_IA87
1510	AI401L	1563	MV09H	1611	SC01	1663	MOT_RS_D	1711	RTD_A	1768	EVE_IB87
1511	AI402H	1564	MV09L	1612	SC02	1664	MOT_RSMO	1712	TOTAL_A	1769	EVE_IC87
1512	AI402L	1565	MV10H	1613	SC03	1665	MOT_RS_Y	1713	THERM_T	1770	EVE_MAXW
1513	AI403H	1566	MV10L	1614	SC04	1666	STRT_T_A	1714	LOCKR_T	1771	EVE_MAXB
1514	AI403L	1567	MV11H	1615	SC05	1667	MAXSTI_A	1715	LDLOSS_T	1772	EVE_MAXA
1515	AI404H	1568	MV11L	1616	SC06	1668	MINSTV_A	1716	LDJAM_T	1773	EVE_MAXO
1516	AI404L	1569	MV12H	1617	SC07	1669	STRTTC_A	1717	UBI_T	1774–1779[a]	
1517	AI405H	1570	MV12L	1618	SC08	1670	RUNTC_A	1718	PHFLT_T	1780	TRIP_LO
1518	AI405L	1571	MV13H	1619	SC09	1671	RTDTC_A	1719	GRFLT_T	1781	TRIP_HI
1519	AI406H	1572	MV13L	1620	SC10	1672	RUNI_A	1720	SPDSW_T	1782	WARN_LO
1520	AI406L	1573	MV14H	1621	SC11	1673	RUNKW_A	1721	UNDV_T	1783	WARN_HI
1521	AI407H	1574	MV14L	1622	SC12	1674	RUKVRI_A	1722	OVRV_T	1784–1788[a]	
1522	AI407L	1575	MV15H	1623	SC13	1675	RUKVRO_A	1723	UNDP_T	1789	NUMRCV
1523	AI408H	1576	MV15L	1624	SC14	1676	RUNKVA_A	1724	PF_T	1790	NUMOTH
1524	AI408L	1577	MV16H	1625	SC15	1677	MAXWDG_A	1725	RPWR_T	1791	INVADR
1525	AI501H	1578	MV16L	1626	SC16	1678	MAXBRG_A	1726	RTD_T	1792	BADCRC
1526	AI501L	1579	MV17H	1627	SC17	1679	MAXAMB_A	1727	PHREV_T	1793	UARTERR
1527	AI502H	1580	MV17L	1628	SC18	1680	MAXOTH_A	1728	DIFF_T	1794	ILLFUNC
1528	AI502L	1581	MV18H	1629	SC19	1681	STRT_T_P	1729	UNDFRQ_T	1795	ILLREG
1529	AI503H	1582	MV18L	1630	SC20	1682	MAXSTI_P	1730	OVRFRQ_T	1796	ILLWR
1530	AI503L	1583	MV19H	1631	SC21	1683	MINSTV_P	1731	PTC_T	1797	BADPKTF
1531	AI504H	1584	MV19L	1632	SC22	1684	STRTTC_P	1732	STTIM_T	1798	BADPKTL
1532	AI504L	1585	MV20H	1633	SC23	1685	RUNTC_P	1733	REMTR_T	1799–1804[a]	
1533	AI505H	1586	MV20L	1634	SC24	1686	RTDTC_P	1734	OTHTR_T	1805	ROW_0
1534	AI505L	1587	MV21H	1635	SC25	1687	RUNI_P	1735	TOTAL_T	1806	ROW_1
1535	AI506H	1588	MV21L	1636	SC26	1688	RUNKW_P	1736–1745[a]		1807	ROW_2
1536	AI506L	1589	MV22H	1637	SC27	1689	RUKVRI_P	1746	NUMEVE	1808	ROW_3
1537	AI507H	1590	MV22L	1638	SC28	1690	RUKVRO_P	1747	EVESEL	1809	ROW_4
1538	AI507L	1591	MV23H	1639	SC29	1691	RUNKVA_P	1748	EVE_S	1810	ROW_5
1539	AI508H	1592	MV23L	1640	SC30	1692	MAXWDG_P	1749	EVEMN	1811	ROW_6
1540	AI508L	1593	MV24H	1641	SC31	1693	MAXBRG_P	1750	EVE_H	1812	ROW_7
1541–1546[a]		1594	MV24L	1642	SC32	1694	MAXAMB_P	1751	EVE_D	1813	ROW_8
1547	MV01H	1595	MV25H	1643–1647[a]		1695	MAXOTH_P	1752	EVEMO	1814	ROW_9
1548	MV01L	1596	MV25L	1648	MOT_E_M	1696	COOLTM	1753	EVE_Y	1815	ROW_10
1549	MV02H	1597	MV26H	1649	MOT_E_H	1697	LRNSTTC	1754	EVE_TYPE	1816	ROW_11
1550	MV02L	1598	MV26L	1650	MOT_E_D	1698	THERM_A	1755	EVE_TRGT	1817	ROW_12
1551	MV03H	1599	MV27H	1651	MOT_R_M	1699	LOCKR_A	1756	EVE_IA	1818	ROW_13
1552	MV03L	1600	MV27L	1652	MOT_R_H	1700	LDLOSS_A	1757	EVE_IB	1819	ROW_14
1553	MV04H	1601	MV28H	1653	MOT_R_D	1701	LDJAM_A	1758	EVE_IC	1820	ROW_15
1554	MV04L	1602	MV28L	1654	MOT_S_M	1702	UBI_A	1759	EVE_IN	1821	ROW_16
1555	MV05H	1603	MV29H	1655	MOT_S_H	1703	PHFLT_A	1760	EVE_IG	1822	ROW_17
1556	MV05L	1604	MV29L	1656	MOT_S_D	1704	GRFLT_A	1761	EVE_VAB	1823	ROW_18
1557	MV06H	1605	MV30H	1657	TIMERUN	1705	SPDSW_A	1762	EVE_VBC	1824	ROW_19

Table D.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 5)

Register Address	Label
1825	ROW_20
1826	ROW_21
1827	ROW_22
1828	ROW_23
1829	ROW_24
1830	ROW_25
1831	ROW_26
1832	ROW_27
1833	ROW_28
1834	ROW_29
1835	ROW_30
1836	ROW_31
1837	ROW_32
1838	ROW_33
1839	ROW_34
1840	ROW_35
1841	ROW_36
1842	ROW_37
1843	ROW_38
1844	ROW_39
1845	ROW_40
1846	ROW_41
1847	ROW_42
1848	ROW_43
1849	ROW_44
1850	ROW_45
1851	ROW_46
1852	ROW_47
1853	ROW_48
1854	ROW_49
1855	ROW_50
1856	ROW_51
1857	ROW_52
1858	ROW_53
1859	ROW_54
1860	ROW_55
1861	ROW_56
1862	ROW_57
1863	ROW_58
1864	ROW_59
1865	ROW_60
1866	ROW_61
1867	ROW_62
1868	ROW_63
1869	ROW_64
1870	ROW_65
1871	ROW_66
1872	ROW_67
1873	ROW_68
1874	ROW_69
1875	ROW_70
1876	ROW_71
1877	ROW_72
1878	ROW_73
1879	ROW_74
1880	ROW_75
1881	ROW_76
1882	ROW_77
1883	ROW_78
1884	ROW_79
1885	ROW_80
1886	ROW_81
1887	ROW_82
1888	ROW_83
1889	ROW_84
1890	ROW_85
1891	ROW_86
1892	ROW_87
1893	ROW_88
1894	ROW_89
1895	ROW_90
1896	ROW_91
1897	ROW_92
1898	ROW_93
1899	ROW_94
1900	ROW_95
1901	ROW_96
1902	ROW_97
1903	ROW_98
1904	ROW_99
1905	ROW_100
1906	ROW_101
1907	ROW_102
1908	ROW_103
1909	ROW_104
1910	ROW_105
1911	ROW_106
1912	ROW_107
1913	ROW_108
1914	ROW_109
1915	ROW_110
1916	ROW_111
1917	ROW_112
1918–1919[a]	
1920	NA
2081	INTT
2082	EXTT
2083	INTIA
2084	EXTIA
2085	INTIB
2086	EXTIB
2087	INTIC
2088	EXTIC
2089	WEARA
2090	WEARB
2091	WEARC
2092	BRKR_R_S
2093	BRKR_RMN
2094	BRKR_R_H
2095	BRKR_R_D
2096	BRKR_RMO
2097	BRKR_R_Y

[a] All the reserved registers between the data areas in the map may also be assigned to the user registers with a label RES_xxxx where xxxx is the register number.
[b] Registers report corresponding phase-to-phase values when the setting DELTA_Y = DELTA and phase-to-neutral values when the setting DELTA_Y = WYE.

Reading History Data Using Modbus

Using the Modbus Register Map (*Table D.34*), you can download a complete history of the last 50 events via Modbus. The history contains the date and time stamp, type of event that triggered the report, currents, and voltages at the time of the event. Please refer to the *Historical Data* section in the map.

To use Modbus to download history data, write the event number (1–50) to the EVENT LOG SEL register at address 1747 (when a zero is written to the register, the relay will return event number one). Then, read the history of the specific event number you requested from the registers shown in the *Historical Data* section of the Modbus Register Map (*Table D.34*). After a power cycle, the history data registers show the history data corresponding to the latest event. This information updates dynamically; whenever there is a new event, the history data registers update automatically with new event data. If specific event number data have been retrieved using a write to the EVENT LOG SEL register, the event data registers stay frozen with that specific event history. These registers return to the free-running latest event history data mode when a zero is written to the event selection register from a prior nonzero selection.

Modbus Register Map

NOTE: Certain Modbus quantities are reported as 32-bit numbers; however, Modbus registers are only 16-bit. This results in displaying the Modbus quantities in a LOW and HIGH register. To determine the 32-bit number, concatenate the LOW register to the end of the HIGH register. For example, if the HIGH register value is 0x5ADC and the LOW register value is 0xF43B, the resulting 32-bit value is 0x5ADCF43B.

Table D.34 lists the data available in the Modbus interface and its description, range, and scaling information. The table also shows the parameter number for access using the DeviceNet interface. The DeviceNet parameter number is obtained by adding 100 to the Modbus register address.

Table D.34 Modbus Register Map[a] (Sheet 1 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
0 (R)	Reserved[d]		0	100	1		
User Map Register							
1–125 (R/W)	USER REG #1–USER REG #125		610	2100	1920	1	101 –225
User Map Register Values							
126–250 (R)	USER REG#1 VAL–USER REG#125 VAL		0	65535	0	1	226 – 350
251–259 (R)	Reserved[d]		0	0	0		351–359
Access Control							
260 (R/W)	BLOCK MODBUS SET 0 = NONE 1 = R_S 2 = ALL		0	2	0		360
General Settings							
261 (R/W)	APPLICATION 0 = FULL 1 = NAMEPLATE		0	1	0		361

Table D.34 Modbus Register Map[a] (Sheet 2 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
262 (R/W)	PHASE ROTATION 0 = ABC 1 = ACB		0	1	0		362
263 (R/W)	RATED FREQ. 0 = 50 Hz 1 = 60 Hz	Hz	0	1	1		363
264 (R/W)	DATE FORMAT 0 = MDY 1 = YMD 2 = DMY		0	2	0		364
Group Selection							
265 (R/W)	GRP CHG DELAY	s	0	400	3	1	365
Breaker Failure Settings							
266 (R/W)	52A INTERLOCK 0 = N 1 = Y		0	1	0		366
267 (R/W)	BK FAILURE DELAY	s	0	200	50	0.01	367
IRIG Time Source							
268 (R/W)	IRIG TIME SOURCE 0 = IRIG1 1 = IRIG2		0	1	0		368
269–272 (R)	Reserved[d]		0	0	0		369–372
Main Settings							
273 (R/W)	PHASE CT RATIO		1	5000	100	1	373
274 (R/W)	MOTOR FLA	A	2	50000	1000	0.1	374
275 (R/W)	TWO SPEED ENABLE 0 = N 1 = Y		0	1	0		375
276 (R/W)	CT RATIO - 2nd		1	5000	100	1	376
277 (R/W)	MOTOR FLA - 2nd	A	2	50000	2500	0.1	377
278 (R/W)	FVR PHASING 0 = NONE 1 = A 2 = B 3 = C		0	3	0		378
279 (R/W)	NEUTRAL CT RATIO		1	2000	100	1	379
280 (R/W)	PHASE PT RATIO		100	25000	3500	0.01	380
281 (R/W)	LINE VOLTAGE	V	100	30000	4160	1	381
282 (R/W)	XFMR CONNECTION 0 = DELTA 1 = WYE		0	1	0		382
283 (R/W)	SINGLE V INPUT 0 = N 1 = Y		0	1	0		383
Thermal Overload							
284 (R/W)	OVERLOAD ENABLE 0 = N 1 = Y		0	1	1		384

Table D.34 Modbus Register Map[a] (Sheet 3 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
285 (R/W)	FULLLOAD SLIPX10 0–9 = OFF		0	1000	0	0.0001	385
Note: For DeviceNet, Full Load Slip is reported as Full Load Slip x10 with a scale factor of 0.001							
286 (R/W)	LOCKD RTR TORQUE		30	200	80	0.01	386
287 (R/W)	THERMAL METHOD 0 = RATING 1 = CURVE 2 = RATING_1		0	2	0		387
288 (R/W)	OL RESET LEVEL	%TCU	10	99	75	1	388
289 (R/W)	SERVICE FACTOR		101	150	115	0.01	389
290 (R/W)	MOTOR LRA	xFLA	25	120	60	0.1	390
291 (R/W)	LOCKD ROTOR TIME	s	10	6000	100	0.1	391
292 (R/W)	ACCEL FACTOR		10	150	100	0.01	392
293 (R/W)	STATOR TC 0 = AUTO	min	0	2000	0	1	393
294 (R/W)	MOTOR LRA - 2nd	xFLA	25	120	60	0.1	394
295 (R/W)	MOTOR LRT - 2nd	s	10	6000	100	0.1	395
296 (R/W)	ACCEL FACT - 2nd		10	150	100	0.01	396
297 (R/W)	STATOR TC - 2nd	min	0	2000	0	1	397
298 (R/W)	THERM OL CURVE1		1	46	5	1	398
299 (R/W)	TRIP TIME@1.05FL	s	0	60000	0	0.1	399
300 (R/W)	TRIP TIME@1.10FL	s	0	60000	0	0.1	400
301 (R/W)	TRIP TIME@1.20FL	s	0	60000	0	0.1	401
302 (R/W)	TRIP TIME@1.30FL	s	0	60000	0	0.1	402
303 (R/W)	TRIP TIME@1.40FL	s	0	60000	0	0.1	403
304 (R/W)	TRIP TIME@1.50FL	s	0	60000	0	0.1	404
305 (R/W)	TRIP TIME@1.75FL	s	0	60000	6250	0.1	405
306 (R/W)	TRIP TIME@2.00FL	s	10	60000	4000	0.1	406
307 (R/W)	TRIP TIME@2.25FL	s	0	60000	0	0.1	407
308 (R/W)	TRIP TIME@2.50FL	s	10	60000	2250	0.1	408
309 (R/W)	TRIP TIME@2.75FL	s	0	60000	0	0.1	409
310 (R/W)	TRIP TIME@3.00FL	s	0	60000	0	0.1	410
311 (R/W)	TRIP TIME@3.50FL	s	0	60000	0	0.1	411
312 (R/W)	TRIP TIME@4.00FL	s	0	60000	720	0.1	412
313 (R/W)	TRIP TIME@4.50FL	s	0	60000	580	0.1	413
314 (R/W)	TRIP TIME@5.00FL	s	0	6000	300	0.1	414
315 (R/W)	TRIP TIME@5.50FL	s	10	6000	250	0.1	415
316 (R/W)	TRIP TIME@6.00FL	s	10	6000	181	0.1	416
317 (R/W)	TRIP TIME@6.50FL	s	10	6000	152	0.1	417
318 (R/W)	TRIP TIME@7.00FL	s	0	6000	132	0.1	418
319 (R/W)	TRIP TIME@7.50FL	s	0	6000	0	0.1	419
320 (R/W)	TRIP TIME@8.00FL	s	0	6000	0	0.1	420
321 (R/W)	TRIP TIME@8.50FL	s	0	6000	0	0.1	421

Table D.34 Modbus Register Map[a] (Sheet 4 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
322 (R/W)	TRIP TIME@9.00FL	s	0	6000	0	0.1	422
323 (R/W)	TRIP TIME@9.50FL	s	0	6000	0	0.1	424
324 (R/W)	TRIP TIME@10.0FL	s	0	6000	0	0.1	424
325 (R/W)	TRIP TIME@11.0FL	s	0	6000	0	0.1	425
326 (R/W)	TRIP TIME@12.0FL	s	0	6000	0	0.1	426
327 (R/W)	THERM OL CURVE2		1	45	7	1	427
328 (R/W)	OL WARN ENABLE 0 = N 1 = Y		0	1	1		428
329 (R/W)	OL WARN LEVEL	%TCU	50	99	85	1	429
330 (R/W)	START INH. LEVEL 0 = OFF	%TCU	0	99	0	1	430
331 (R/W)	LEARN START INH? 0 = N 1 = Y		0	1	1		431
332 (R/W)	STOP COOL TIME	min	1	6000	84	1	432
333 (R/W)	LEARN COOLTIME? 0 = N 1 = Y		0	1	0		433
334 (R/W)	OL RTD BIASING? 0 = N 1 = Y		0	1	0		434
335 (R/W)	SLIP SOURCE 0 = STAT 1 = R1		0	1	1		435
336 (R/W)	STOP COAST TIME	s	1	3600	5	1	436
337–339 (R)	Reserved[d]		0	0	0		437–439
Phase Overcurrent							
340 (R/W)	PH OC TRIP ENABL 0 = N 1 = Y		0	1	1		440
341 (R/W)	PH OC TRIP LVL	xFLA	10	2000	1000	0.01	441
342 (R/W)	PH OC TRIP DLAY	s	0	500	0	0.01	442
343 (R/W)	PH OC WARN ENABL 0 = N 1 = Y		0	1	0		443
344 (R/W)	PH OC WARN LVL	xFLA	10	2000	1000	0.01	444
345 (R/W)	PH OC WARN DLAY	s	0	500	50	0.01	445
Neutral Overcurrent							
346 (R/W)	NEUT OC TRIP EN 0 = N 1 = Y		0	1	0		446
347 (R/W)	NEUT OC TRIP LVL	A	1	65000	100	0.01	447
348 (R/W)	NEU OC TRIP DLAY	s	0	500	50	0.01	448
349 (R/W)	NEUT OC WARN EN 0 = N 1 = Y		0	1	0		449
350 (R/W)	NEUT OC WARN LVL	A	1	65000	100	0.01	450

Table D.34 Modbus Register Map[a] (Sheet 5 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
351 (R/W)	NEU OC WARN DLAY	s	0	1200	100	0.1	451
Residual Overcurrent							
352 (R/W)	RES OC TRIP EN 0 = N 1 = Y		0	1	0		452
353 (R/W)	RES OC TRIP LVL	xFLA	10	2000	50	0.01	453
354 (R/W)	RES OC TRIP DLAY	s	0	500	50	0.01	454
355 (R/W)	RES OC WARN EN 0 = N 1 = Y		0	1	0		455
356 (R/W)	RES OC WARN LVLL	xFLA	10	2000	50	0.01	456
357 (R/W)	RES OC WARN DLAY	s	0	1200	100	0.1	457
Negative-Sequence Overcurrent							
358 (R/W)	NSEQ OC TRIP EN 0 = N 1 = Y		0	1	1		458
359 (R/W)	NSEQ OC TRIP LVL	xFLA	10	2000	300	0.01	459
360 (R/W)	NSEQ OC TRIP DLY	s	1	1200	1	0.1	460
361 (R/W)	NSEQ OC WARN EN 0 = N 1 = Y		0	1	1		461
362 (R/W)	NSEQ OC WARN LVLL	xFLA	10	2000	30	0.01	462
363 (R/W)	NSEQ OC WARN DLY	s	0	1200	20	0.1	463
Motor Differential Overcurrent							
364 (R/W)	DIFF ENABLE 0 = N 1 = Y		0	1	0		464
365 (R/W)	DIFF CT RATIO		1	5000	100	1	465
366 (R/W)	DIFF1 TRIP EN 0 = N 1 = Y		0	1	0		466
367 (R/W)	DIFF1 TRIP LVL	Asec	5	800	50	0.01	467
368 (R/W)	DIFF1 TRIP DLY	s	0	6000	10	0.01	468
369 (R/W)	DIFF2 TRIP EN 0 = N 1 = Y		0	1	0		469
370 (R/W)	DIFF2 TRIP LVL	Asec	5	800	50	0.01	470
371 (R/W)	DIFF2 TRIP DLY	s	0	6000	10	0.01	471
372–376 (R)	Reserved[d]		0	0	0		472–476
Jam Settings							
377 (R/W)	JAM TRIP ENABLE 0 = N 1 = Y		0	1	0		477
378 (R/W)	JAM TRIP LEVEL	xFLA	100	600	200	0.01	478
379 (R/W)	JAM TRIP DELAY	s	0	1200	5	0.1	479
380 (R/W)	JAM WARN ENABLE		0	1	0		480

Table D.34 Modbus Register Map[a] (Sheet 6 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
	0 = N 1 = Y						
381 (R/W)	JAM WARN LEVEL	xFLA	100	600	200	0.01	481
382 (R/W)	JAM WARN DELAY	s	0	1200	50	0.1	482
Undercurrent Settings							
383 (R/W)	UC TRIP ENABLE 0 = N 1 = Y		0	1	0		483
384 (R/W)	UC TRIP LEVEL	xFLA	10	100	50	0.01	484
385 (R/W)	UC TRIP DELAY	s	4	1200	50	0.1	485
386 (R/W)	UC WARN ENABLE 0 = N 1 = Y		0	1	0		486
387 (R/W)	UC WARN LEVEL	xFLA	10	100	50	0.01	487
388 (R/W)	UC WARN DELAY	s	4	1200	100	0.1	488
389 (R/W)	UC START DELAY	s	0	5000	0	1	489
Current Unbalance Settings							
390 (R/W)	CI TRIP ENABLE 0 = N 1 = Y		0	1	1		490
391 (R/W)	CI TRIP LEVEL	%	5	80	20	1	491
392 (R/W)	CI TRIP DELAY	s	0	240	5	1	492
393 (R/W)	CI WARN ENABLE 0 = N 1 = Y		0	1	0		493
394 (R/W)	CI WARN LEVEL	%	5	80	10	1	494
395 (R/W)	CI WARN DELAY	s	0	240	10	1	495
Start Monitoring							
396 (R/W)	START MOTOR TIME 0 = OFF	s	0	240	0	1	496
Star Delta Settings							
397 (R/W)	STAR-DELTA ENABL 0 = N 1 = Y		0	1	0		497
398 (R/W)	MAX STAR TIME 0 = OFF	s	0	600	0	1	498
Start Inhibit Settings							
399 (R/W)	STARTS/HR 0 = OFF		0	15	0	1	499
400 (R/W)	MIN. OFF TIME 0 = OFF	min	0	150	0	1	500
401 (R/W)	RESTART BLK TIME	min	0	1500	0	1	501
Phase Reversal Settings							
402 (R/W)	PH REV. ENABLE 0 = N 1 = Y		0	1	1		502

Table D.34 Modbus Register Map[a] (Sheet 7 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Speed Switch Settings							
403 (R/W)	SS TRIP DELAY 0 = OFF	s	0	240	0	1	503
404 (R/W)	SS WARN DELAY 0 = OFF	s	0	240	0	1	504
PTC Settings							
405 (R/W)	PTC ENABLE 0 = N 1 = Y		0	1	0		505
406–410 (R)	Reserved[d]		0	0	0		506–510
RTD Settings							
411 (R/W)	RTD ENABLE 0 = NONE 1 = INT 2 = EXT		0	2	2		511
412 (R/W)	RTD1 LOCATION 0 = OFF 1 = WDG 2 = BRG 3 = AMB 4 = OTH		0	4	0		512
413 (R/W)	RTD1 TYPE 0 = PT100 1 = NI100 2 = NI120 3 = CU10		0	3	0		513
414 (R/W)	RTD1 TRIP LEVEL 0 = OFF	degC	0	250	0	1	514
415 (R/W)	RTD1 WARN LEVEL 0 = OFF	degC	0	250	0	1	515
416 (R/W)	RTD2 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		516
417 (R/W)	RTD2 TYPE (See *RTD1 TYPE* for options)		0	3	0		517
418 (R/W)	RTD2 TRIP LEVEL 0 = OFF	degC	0	250	0	1	518
419 (R/W)	RTD2 WARN LEVEL 0 = OFF	degC	0	250	0	1	519
420 (R/W)	RTD3 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		520
421 (R/W)	RTD3 TYPE (See *RTD1 TYPE* for options)		0	3	0		521
422 (R/W)	RTD3 TRIP LEVEL 0 = OFF	degC	0	250	0	1	522
423 (R/W)	RTD3 WARN LEVEL 0 = OFF	degC	0	250	0	1	523
424 (R/W)	RTD4 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		524

Table D.34 Modbus Register Map[a] (Sheet 8 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
425 (R/W)	RTD4 TYPE (See *RTD1 TYPE* for options)		0	3	0		525
426 (R/W)	RTD4 TRIP LEVEL 0 = OFF	degC	0	250	0	1	526
427 (R/W)	RTD4 WARN LEVEL 0 = OFF	degC	0	250	0	1	527
428 (R/W)	RTD5 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		528
429 (R/W)	RTD5 TYPE (See *RTD1 TYPE* for options)		0	3	0		529
430 (R/W)	RTD5 TRIP LEVEL 0 = OFF	degC	0	250	0	1	530
431 (R/W)	RTD5 WARN LEVEL 0 = OFF	degC	0	250	0	1	531
432 (R/W)	RTD6 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		532
433 (R/W)	RTD6 TYPE (See *RTD1 TYPE* for options)		0	3	0		533
434 (R/W)	RTD6 TRIP LEVEL 0 = OFF	degC	0	250	0	1	534
435 (R/W)	RTD6 WARN LEVEL 0 = OFF	degC	0	250	0	1	535
436 (R/W)	RTD7 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		536
437 (R/W)	RTD7 TYPE (See *RTD1 TYPE* for options)		0	3	0		537
438 (R/W)	RTD7 TRIP LEVEL 0 = OFF	degC	0	250	0	1	538
439 (R/W)	RTD7 WARN LEVEL 0 = OFF	degC	0	250	0	1	539
440 (R/W)	RTD8 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		540
441 (R/W)	RTD8 TYPE (See *RTD1 TYPE* for options)		0	3	0		541
442 (R/W)	RTD8 TRIP LEVEL 0 = OFF	degC	0	250	0	1	542
443 (R/W)	RTD8 WARN LEVEL 0 = OFF	degC	0	250	0	1	543
444 (R/W)	RTD9 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		544
445 (R/W)	RTD9 TYPE (See *RTD1 TYPE* for options)		0	3	0		545
446 (R/W)	RTD9 TRIP LEVEL 0 = OFF	degC	0	250	0	1	546
447 (R/W)	RTD9 WARN LEVEL 0 = OFF	degC	0	250	0	1	547

Table D.34 Modbus Register Map[a] (Sheet 9 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
448 (R/W)	RTD10 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		548
449 (R/W)	RTD10 TYPE (See *RTD1 TYPE* for options)		0	3	0		549
450 (R/W)	RTD10 TRIP LEVEL 0 = OFF	degC	0	250	0	1	550
451 (R/W)	RTD10 WARN LEVEL 0 = OFF	degC	0	250	0	1	551
452 (R/W)	RTD11 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		552
453 (R/W)	RTD11 TYPE (See *RTD1 TYPE* for options)		0	3	0		553
454 (R/W)	RTD11 TRIP LEVEL 0 = OFF	degC	0	250	0	1	554
455 (R/W)	RTD11 WARN LEVEL 0 = OFF	degC	0	250	0	1	555
456 (R/W)	RTD12 LOCATION (See *RTD1 LOCATION* for options)		0	4	0		556
457 (R/W)	RTD12 TYPE (See *RTD1 TYPE* for options)		0	3	0		557
458 (R/W)	RTD12 TRIP LEVEL 0 = OFF	degC	0	250	0	1	558
459 (R/W)	RTD12 WARN LEVEL 0 = OFF	degC	0	250	0	1	559
460 (R/W)	WIND TRIP VOTING 0 = N 1 = Y		0	1	0		560
461 (R/W)	BEAR TRIP VOTING 0 = N 1 = Y		0	1	0		561
462 (R/W)	TMP RTD BIASING? 0 = N 1 = Y		0	1	0		562
463–467 (R)	Reserved[d]		0	0	0		563–567
Undervoltage Settings							
468 (R/W)	UV TRIP ENABLE 0 = N 1 = Y		0	1	0		568
469 (R/W)	UV TRIP LEVEL	xVnm	2	100	80	0.01	569
470 (R/W)	UV TRIP DELAY	s	0	1200	5	0.1	570
471 (R/W)	UV WARN ENABLE 0 = N 1 = Y		0	1	0		571
472 (R/W)	UV WARN LEVEL	xVnm	2	100	80	0.01	572
473 (R/W)	UV WARN DELAY	s	0	1200	50	0.1	573
Overvoltage Settings							
474 (R/W)	OV TRIP ENABLE 0 = N 1 = Y		0	1	1		574

Table D.34 Modbus Register Map[a] (Sheet 10 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
475 (R/W)	OV TRIP LEVEL	xVnm	2	120	110	0.01	575
476 (R/W)	OV TRIP DELAY	s	0	1200	5	0.1	576
477 (R/W)	OV WARN ENABLE 0 = N 1 = Y		0	1	0		577
478 (R/W)	OV WARN LEVEL	xVnm	2	120	110	0.01	578
479 (R/W)	OV WARN DELAY	s	0	1200	50	0.1	579
VAR Settings							
480 (R/W)	NEG VAR TRIP EN 0 = N 1 = Y		0	1	0		580
481 (R/W)	NEG VAR TRIP LEV	kVAR	1	25000	25000	1	581
482 (R/W)	POS VAR TRIP EN 0 = N 1 = Y		0	1	0		582
483 (R/W)	POS VAR TRIP LEV	kVAR	1	25000	25000	1	583
484 (R/W)	VAR TRIP DELAY	s	0	240	1	1	584
485 (R/W)	NEG VAR WARN EN 0 = N 1 = Y		0	1	0		585
486 (R/W)	NEG VAR WARN LEV	kVAR	1	25000	25000	1	586
487 (R/W)	POS VAR WARN EN 0 = N 1 = Y		0	1	0		587
488 (R/W)	POS VAR WARN LEV	kVAR	1	25000	25000	1	588
489 (R/W)	VAR WARN DELAY	s	0	240	1	1	589
490 (R/W)	VAR ARMING DELAY	s	0	5000	0	1	590
Underpower Settings							
491 (R/W)	UP TRIP ENABLE 0 = N 1 = Y		0	1	0		591
492 (R/W)	UP TRIP LEVEL	kW	1	25000	25000	1	592
493 (R/W)	UP TRIP DELAY	s	0	240	1	1	593
494 (R/W)	UP WARN ENABLE 0 = N 1 = Y		0	1	0		594
495 (R/W)	UP WARN LEVEL	kW	1	25000	25000	1	595
496 (R/W)	UP WARN DELAY	s	0	240	1	1	596
497 (R/W)	UP ARMING DELAY	s	0	5000	0	1	597
Power Factor Settings							
498 (R/W)	PF LAG TRIP ENABL 0 = N 1 = Y		0	1	0		598
499 (R/W)	PF LAG TRIP LEVL		5	99	50	0.01	599
500 (R/W)	PF LD TRIP ENABL 0 = N 1 = Y		0	1	0		600

Table D.34 Modbus Register Map[a] (Sheet 11 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
501 (R/W)	PF LD TRIP LEVEL		5	99	50	0.01	601
502 (R/W)	PF TRIP DELAY	s	1	240	1	1	602
503 (R/W)	PF LAG WARN ENABL 0 = N 1 = Y		0	1	0		603
504 (R/W)	PF LAG WARN LEVL		5	99	50	0.01	604
505 (R/W)	PF LD WARN ENABL 0 = N 1 = Y		0	1	0		605
506 (R/W)	PF LD WARN LEVEL		5	99	50	0.01	606
507 (R/W)	PF WARN DELAY	s	1	240	1	1	607
508 (R/W)	PF ARMING DELAY	s	0	5000	0	1	608
Frequency Settings							
509 (R/W)	FREQ1 TRIP ENABL 0 = N 1 = Y		0	1	0		609
510 (R/W)	FREQ1 TRIP LEVEL	Hz	200	700	600	0.1	610
511 (R/W)	FREQ1 TRIP DELAY	s	0	2400	10	0.1	611
512 (R/W)	FREQ2 TRIP ENABL 0 = N 1 = Y		0	1	0		612
513 (R/W)	FREQ2 TRIP LEVEL	Hz	200	700	600	0.1	613
514 (R/W)	FREQ2 TRIP DELAY	s	0	2400	10	0.1	614
515 (R/W)	FREQ3 TRIP ENABL 0 = N 1 = Y		0	1	0		615
516 (R/W)	FREQ3 TRIP LEVEL	Hz	200	700	600	0.1	616
517 (R/W)	FREQ3 TRIP DELAY	s	0	2400	10	0.1	617
518 (R/W)	FREQ4 TRIP ENABL 0 = N 1 = Y		0	1	0		618
519 (R/W)	FREQ4 TRIP LEVEL	Hz	200	700	600	0.1	619
520 (R/W)	FREQ4 TRIP DELAY	s	0	2400	10	0.1	620
Load Control Settings							
521 (R/W)	LOAD CONTROL SEL 0 = OFF 1 = CURRENT 2 = POWER 3 = TCU		0	3	0		621
522 (R/W)	LD CTL UPP ENABL 0 = N 1 = Y		0	1	0		622
523 (R/W)	LD CTL CUR UPPER	xFLA	20	200	50	0.01	623
524 (R/W)	LD CTL PWR UPPER	kW	1	25000	22500	1	624
525 (R/W)	LD CTL TCU UPPER	%TCU	1	99	90	1	625

Table D.34 Modbus Register Map[a] (Sheet 12 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
526 (R/W)	LD CTL LOW ENABL 0 = N 1 = Y		0	1	0		626
527 (R/W)	LD CTL CUR LOWER	xFLA	20	200	90	0.01	627
528 (R/W)	LD CTL PWR LOWER	kW	1	25000	12500	1	628
529 (R/W)	LD CTL TCU LOWER	%TCU	1	99	50	1	629
Trip Inhibit							
530 (R/W)	TRIP INHIBIT Bit 0 = CURRENT IMBALANC Bit 1 = JAM Bit 2 = GROUND FAULT Bit 3 = OVERCURRENT Bit 4 = UNDERCURRENT Bit 5 = START INHIBIT Bit 6 = PTC Bit 7 = RTD 0 = N 1 = Y		0	255	0		630
Trip/Close Logic							
531 (R/W)	MIN TRIP TIME	s	0	4000	5	0.1	631
532–541 (R)	Reserved[d]		0	0	0		632–641
SELogic Enables							
542 (R/W)	SELogic LATCHES		0	32	0	1	642
543 (R/W)	SV/TIMERS		0	32	1	1	643
544 (R/W)	SELogic COUNTERS		0	32	0	1	644
545 (R/W)	MATH VARIABLES		0	32	0	1	645
546–550 (R)	Reserved[d]		0	0	0		646–650
Output Contacts 0 = N 1 = Y							
551 (R/W)	OUT101 FAIL-SAFE		0	1	1		651
552 (R/W)	OUT102 FAIL-SAFE		0	1	0		652
553 (R/W)	OUT103 FAIL-SAFE		0	1	1		653
554 (R/W)	OUT301 FAIL-SAFE		0	1	0		654
555 (R/W)	OUT302 FAIL-SAFE		0	1	0		655
556 (R/W)	OUT303 FAIL-SAFE		0	1	0		656
557 (R/W)	OUT304 FAIL-SAFE		0	1	0		657
558 (R/W)	OUT401 FAIL-SAFE		0	1	0		658
559 (R/W)	OUT402 FAIL-SAFE		0	1	0		659
560 (R/W)	OUT403 FAIL-SAFE		0	1	0		660
561 (R/W)	OUT404 FAIL-SAFE		0	1	0		661
562 (R/W)	OUT501 FAIL-SAFE		0	1	0		662
563 (R/W)	OUT502 FAIL-SAFE		0	1	0		663

Table D.34 Modbus Register Map[a] (Sheet 13 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
564 (R/W)	OUT503 FAIL-SAFE		0	1	0		664
565 (R/W)	OUT504 FAIL-SAFE		0	1	0		666
566–570 (R)	Reserved[d]		0	0	0		666–670
Event Report Settings							
571 (R/W)	EVENT LENGTH 0 = 15 1 = 64	cyc	0	1	0		671
572 (R/W)	PREFAULT LENGTH	cyc	1	59	5	1	672
573 (R/W)	MSR RESOLUTION 0 = 0.25 Cycles 1 = 0.5 Cycles 2 = 1 Cycles 3 = 2 Cycles 4 = 5 Cycles 5 = 20 Cycles	cyc	0	5	4		673
574 (R/W)	ENABLE ALIASES		0	20	15	1	674
575 (R/W)	LDP ACQ RATE 0 = 5 1 = 10 2 = 15 3 = 30 4 = 60	min	0	4	2		675
576–580 (R)	Reserved[d]			0	0	0	676–680
Front-Panel Settings							
581 (R/W)	DISPLAY PTS ENABL		0	32	4	1	681
582 (R/W)	LOCAL BITS ENABL		0	32	0	1	682
583 (R/W)	LCD TIMEOUT 0 = OFF	min	0	30	15	1	683
584 (R/W)	LCD CONTRAST		1	8	5	1	684
585 (R/W)	CLOSE RESET LEDS 0 = N 1 = Y		0	1	1		685
586 (R/W)	FP AUTOMESSAGES 0= OVERRIDE 1= ROTATING		0	1	0		686
587–590 (R)	Reserved[d]		0	0	0		687–690
Reset Settings							
591 (R/W)	RESET DATA Bit 0 = Trip Reset Bit 1 = Set to Defaults Bit 2 = Reset Stat Data Bit 3 = Reset Hist Data Bit 4 = Reset Comm Cntr Bit 5 = Reset MOT Data Bit 6 = Rst Enrgy Data Bit 7 = Rst Mx/Mn Data Bits 8–15 = Reserved		0	255	0		691
592–601 (R)	Reserved[d]		0	0	0		692–701

Table D.34 Modbus Register Map[a] (Sheet 14 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Date/Time Settings							
602 (R/W)	SET SEC		0	5999	0	0.01	702
603 (R/W)	SET MIN		0	59	0	1	703
604 (R/W)	SET HOUR		0	23	0	1	704
605 (R/W)	SET DAY		1	31	1	1	705
606 (R/W)	SET MONTH		1	12	1	1	706
607 (R/W)	SET YEAR		2000	9999	2000	1	707
608–609 (R)	Reserved[d]		0	0	0		708–709
Device Status 0 = OK 1 = WARN 2 = FAIL							
610 (R)	FPGA STATUS		0	2	0		710
611 (R)	GPSB STATUS		0	2	0		711
612 (R)	HMI STATUS		0	2	0		712
613 (R)	RAM STATUS		0	2	0		713
614 (R)	ROM STATUS		0	2	0		714
615 (R)	CR_RAM STATUS		0	2	0		715
616 (R)	NON_VOL STATUS		0	2	0		716
617 (R)	CLOCK STATUS		0	2	0		717
618 (R)	PTC STATUS		0	2	0		718
619 (R)	RTD STATUS		0	2	0		719
620 (R)	+3.3V STATUS		0	2	0		720
621 (R)	+5.0V STATUS		0	2	0		721
622 (R)	+2.5V STATUS		0	2	0		722
623 (R)	+3.75V STATUS		0	2	0		723
624 (R)	-1.25V STATUS		0	2	0		724
625 (R)	-5.0V STATUS		0	2	0		725
626 (R)	CLK_BAT STATUS		0	2	0		726
627 (R)	CT BOARD STATUS		0	2	0		727
628 (R)	CARD C STATUS		0	2	0		728
629 (R)	CARD D STATUS		0	2	0		729
630 (R)	CARD E STATUS		0	2	0		730
631 (R)	IA STATUS		0	2	0		731
632 (R)	IB STATUS		0	2	0		732
633 (R)	IC STATUS		0	2	0		733
634 (R)	IN STATUS		0	2	0		734
635 (R)	VA STATUS		0	2	0		735
636 (R)	VB STATUS		0	2	0		736
637 (R)	VC STATUS		0	2	0		737
638 (R)	RELAY STATUS 0 - ENABLED 1 - DISABLED		0	1	0		738
639 (R)	IA87 STATUS		0	2	0		739
640 (R)	IB87 STATUS		0	2	0		740

Table D.34 Modbus Register Map[a] (Sheet 15 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
641 (R)	IC87 STATUS		0	2	0		741
642 (R)	CID FILE STATUS		0	2	0		742
643 (R)	SERIAL NUMBER H		0	65535	0		743
644 (R)	SERIAL NUMBER L		0	65535	0		744
645–649 (R)	Reserved[d]		0	0	0		745–749
Current Data							
650 (R)	IA CURRENT	A	0	65535	0	1	750
651 (R)	IA ANGLE	deg	–1800	1800	0	0.1	751
652 (R)	IB CURRENT	A	0	65535	0	1	752
653 (R)	IB ANGLE	deg	–1800	1800	0	0.1	753
654 (R)	IC CURRENT	A	0	65535	0	1	754
655 (R)	IC ANGLE	deg	–1800	1800	0	0.1	755
656 (R)	IN CURRENT	A	0	65535	0	1	756
657 (R)	IN ANGLE	deg	–1800	1800	0	0.1	757
658 (R)	IG CURRENT	A	0	65535	0	1	758
659 (R)	IG ANGLE	deg	–1800	1800	0	0.1	759
660 (R)	AVERAGE CURRENT	A	0	65535	0	1	760
661 (R)	MOTOR LOAD	xFLA	0	120	0	0.1	761
662 (R)	NEG-SEQ CURR 3I2	A	0	65535	0	1	762
663 (R)	CURRENT IMBAL	%	0	1000	0	0.1	763
664 (R)	IA87 CURRENT	A	0	65535	0	1	764
665 (R)	IB87 CURRENT	A	0	65535	0	1	765
666 (R)	IC87 CURRENT	A	0	65535	0	1	766
Voltage Data							
667 (R)	VAB[e]	V	0	65535	0	1	767
668 (R)	VAB ANGLE[e]	deg	–1800	1800	0	0.1	768
669 (R)	VBC[e]	V	0	65535	0	1	769
670 (R)	VBC ANGLE[e]	deg	–1800	1800	0	0.1	770
671 (R)	VCA[e]	V	0	65535	0	1	771
672 (R)	VCA ANGLE[e]	deg	–1800	1800	0	0.1	772
673 (R)	AVERAGE LINE[e]	V	0	65535	0	1	773
674 (R)	VAN[f]	V	0	65535	0	1	774
675 (R)	VAN ANGLE[f]	deg	–1800	1800	0	0.1	775
676 (R)	VBN[f]	V	0	65535	0	1	776
677 (R)	VBN ANGLE[f]	deg	–1800	1800	0	0.1	777
678 (R)	VCN[f]	V	0	65535	0	1	778
679 (R)	VCN ANGLE[f]	deg	–1800	1800	0	0.1	779
680 (R)	VG	V	0	65535	0	1	780
681 (R)	VG ANGLE	deg	–1800	1800	0	0.1	781

Table D.34 Modbus Register Map[a] (Sheet 16 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
682 (R)	AVERAGE PHASE[f]	V	0	65535	0	1	782
683 (R)	NEG-SEQ VOLT 3V2	V	0	65535	0	1	783
684 (R)	VOLTAGE IMBAL	%	0	1000	0	0.1	784
Power Data							
685 (R)	REAL POWER	kW	–32768	32767	0	1	785
686 (R)	REACTIVE POWER	kVAR	–32768	32767	0	1	786
687 (R)	APPARENT POWER	kVA	–32768	32767	0	1	787
688 (R)	POWER FACTOR		-100	100	0	0.01	788
689 (R)	FREQUENCY	Hz	200	700	600	0.1	789
Energy Data							
690 (R)	MWH3P HI	MWhr	0	65535	0	0.001	790
691 (R)	MWH3P LO	MWhr	0	65535	0	0.001	791
692 (R)	MVARH3PI HI	MVARhr	0	65535	0	0.001	792
693 (R)	MVARH3PI LO	MVARhr	0	65535	0	0.001	793
694 (R)	MVARH3PO HI	MVARhr	0	65535	0	0.001	794
695 (R)	MVARH3PO LO	MVARhr	0	65535	0	0.001	795
696 (R)	MVAH3P HI	MVAhr	0	65535	0	0.001	796
697 (R)	MVAH3P LO	MVAhr	0	65535	0	0.001	797
698 (R)	LAST RST TIME ss		0	5999	0	0.01	798
699 (R)	LAST RST TIME mm		0	59	0	1	799
700 (R)	LAST RST TIME hh		0	23	0	1	800
701 (R)	LAST RST DATE dd		1	31	1	1	801
702 (R)	LAST RST DATE mm		1	12	1	1	802
703 (R)	LAST RST DATE yy		2000	9999	2000	1	803
704–711 (R)	Reserved[d]		0	0	0		804–811
RTD Data							
	The following pertains to all RTD Data: 7FFFh = Open 8000h = Short 7FFCh = Comm Fail 7FF8h = Stat Fail 7FFEh = Fail 7FF0h = NA						
712 (R)	MAX WINDING RTD	degC	–32768	32767	0	1	812
713 (R)	MAX BEARING RTD	degC	–32768	32767	0	1	813
714 (R)	MAX AMBIENT RTD	degC	–32768	32767	0	1	814
715 (R)	MAX OTHER RTD	degC	–32768	32767	0	1	815
716–727 (R)	RTD 1 –RTD 12	degC	–32768	32767	0	1	816–827
728 (R)	RTD %TCU	%	0	100	0	1	828
Overload Status							
729 (R)	STATOR %TCU	%	0	65535	0	1	829
730 (R)	ROTOR %TCU	%	0	65535	0	1	830

Table D.34 Modbus Register Map[a] (Sheet 17 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
731 (R)	TIME TO TRIP	s	0	9999	0	1	831
732 (R)	TIME TO RESET	min	0	9999	0	1	832
733 (R)	STARTS AVAILABLE		0	255	0	1	833
734 (R)	SLIP	%	0	1000	0	0.1	834
735–739 (R)	Reserved[d]		0	0	0		835–839
RMS Data							
740 (R)	IA RMS	A	0	65535	0	1	840
741 (R)	IB RMS	A	0	65535	0	1	841
742 (R)	IC RMS	A	0	65535	0	1	842
743 (R)	IN RMS	A	0	65535	0	1	843
744 (R)	VA RMS[f]	V	0	65535	0	1	844
745 (R)	VB RMS[f]	V	0	65535	0	1	845
746 (R)	VC RMS[f]	V	0	65535	0	1	846
747 (R)	VAB RMS[e]	V	0	65535	0	1	847
748 (R)	VBC RMS[e]	V	0	65535	0	1	848
749 (R)	VCA RMS[e]	V	0	65535	0	1	849
MAX/MIN Data							
750 (R)	IA MAX	A	0	65535	0	1	850
751 (R)	IA MAX TIME ss	seconds	0	5999	0	0.01	851
752 (R)	IA MAX TIME mm	minutes	0	59	0	1	852
753 (R)	IA MAX TIME hh	hours	0	23	0	1	853
754 (R)	IA MAX DAY dd	days	1	31	1	1	854
755 (R)	IA MAX DAY mm	months	1	12	1	1	855
756 (R)	IA MAX DAY yy	years	2000	9999	2000	1	856
•	•						•
•	•						•
•	•						•
799 (R)	IN MIN	A	0	65535	0	1	892
800–805 (R)	IN MIN TIME ss–IN MIN TIME yy (See *IA MAX* for series structure and data.)						893–905
806 (R)	IG MAX	A	0	65535	0	1	906
807–812 (R)	IG MAX TIME ss–IG MAX TIME yy (See *IA MAX* for series structure and data.)						907–912
813 (R)	IG MIN	A	0	65535	0	1	913
814–819 (R)	IG MIN TIME ss–IG MIN TIME yy (See *IA MAX* for series structure and data.)						914–919
820 (R)	VAB/VA MAX	V	0	65535	0	1	920
821–826 (R)	VAB/VA MX TIM ss–VAB/VA MX TIM yy (See *IA MAX* for series structure and data.)						921–926
827 (R)	VAB/VA MIN	V	0	65535	0	1	927
828–833 (R)	VAB/VA MN TIM ss–VAB/VA MN TIM yy (See *IA MAX* for series structure and data.)						928–933
834 (R)	VBC/VB MAX	V	0	65535	0	1	934
835–840 (R)	VBC/VB MX TIM ss–VBC/VB MX TIM yy (See *IA MAX* for series structure and data.)						935–940

Table D.34 Modbus Register Map[a] (Sheet 18 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
841 (R)	VBC/VB MIN	V	0	65535	0	1	941
842–847 (R)	VBC/VB MN TIM ss–VBC/VB MN TIM yy (See *IA MAX* for series structure and data.)						942–947
848 (R)	VCA/VC MAX	V	0	65535	0	1	948
849–854 (R)	VCA/VC MX TIM ss–VCA/VC MX TIM yy (See *IA MAX* for series structure and data.)						949–954
855 (R)	VCA/VC MIN	V	0	65535	0	1	955
856–861 (R)	VCA/VC MN TIM ss–VCA/VC MN TIM yy (See *IA MAX* for series structure and data.)						956–961
862 (R)	KW3P MAX	kW	–32768	32767	0	1	962
863–868 (R)	KW3P MX TIM ss–KW3P MX TIM yy (See *IA MAX* for series structure and data.)						963–968
869 (R)	KW3P MIN	kW	–32768	32767	0	1	969
870–875 (R)	KW3P MN TIM ss–KW3P MN TIM yy (See *IA MAX* for series structure and data.)						970–975
876 (R)	KVAR3P MAX	kVAR	–32768	32767	0	1	976
877–882 (R)	KVAR3P MX TIM ss–KVAR3P MX TIM yy (See *IA MAX* for series structure and data.)						977–982
883 (R)	KVAR3P MIN	kVAR	–32768	32767	0	1	983
884–889 (R)	KVAR3P MN TIM ss–KVAR3P MN TIM y (See *IA MAX* for series structure and data.)						984–989
890 (R)	KVA3P MAX	kVA	–32768	32767	0	1	990
891–896 (R)	KVA3P MX TIM ss–KVA3P MX TIM yy (See *IA MAX* for series structure and data.)						991–996
897 (R)	KVA3P MIN	kVA	–32768	32767	0	1	997
898–903 (R)	KVA3P MN TIM ss–KVA3P MN TIM yy (See *IA MAX* for series structure and data.)						998–1003
904 (R)	FREQ MAX	Hz	0	65535	0	0.1	1004
905–910 (R)	FREQ MX TIM ss–FREQ MX TIM yy (See *IA MAX* for series structure and data.)						1005–1010
911 (R)	FREQ MIN	Hz	0	65535	0	0.1	1011
912–917 (R)	FREQ MN TIM ss–FREQ MN TIM yy (See *IA MAX* for series structure and data.)						1012–1017
918 (R)	RTD1 MAX	degC	–32768	32767	0	1	1018
919–924 (R)	RTD1 MX TIM ss–RTD1 MX TIM yy (See *IA MAX* for series structure and data.)						1019–1024
925 (R)	RTD1 MIN	degC	–32768	32767	0	1	1025
926–1001 (R)	RTD1 MN TIM ss–RTD1 MN TIM yy (See *IA MAX* for series structure and data.)						1026–1101
•	•						•
•	•						•
•	•						•
1072 (R)	RTD12 MAX	degC	–32768	32767	0	1	1172
1073–1078 (R)	RTD12 MX TIM ss–RTD12 MX TIM yy (See *IA MAX* for series structure and data.)						1173–1178
1079 (R)	RTD12 MIN	degC	–32768	32767	0	1	1179
1080–1085 (R)	RTD12 MN TIM ss–RTD12 MN TIM yy (See *IA MAX* for series structure and data.)						1180–1185
1086 (R)	AI301 MX - HI	Engineering Units	–32768	32767	0	0.001	1186
1087 (R)	AI301 MX - LO		–32768	32767	0	0.001	1187
1088–1093 (R)	AI301 MX TIM ss–AI301 MX TIM yy (See *IA MAX* for series structure and data.)						1188–1193
1094 (R)	AI301 MN - HI	Engineering Units	–32768	32767	0	0.001	1194
1095 (R)	AI301 MN - LO		–32768	32767	0	0.001	1195

Table D.34 Modbus Register Map[a] (Sheet 19 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1096–1101 (R)	AI301 MN TIM ss–AI301 MN TIM yy (See *IA MAX* for series structure and data.)						1196–1201
•	•						•
•	•						•
•	•						•
1198 (R)	AI308 MX - HI	Engineering Units	–32768	32767	0	0.001	1298
1199 (R)	AI308 MX - LO		–32768	32767	0	0.001	1299
1200–1205 (R)	AI308 MX TIM ss–AI308 MX TIM yy (See *IA MAX* for series structure and data.)						1300–1305
1206 (R)	AI308 MN - HI	Engineering Units	–32768	32767	0	0.001	1306
1207 (R)	AI308 MN - LO		–32768	32767	0	0.001	1307
1208–1213 (R)	AI308 MN TIM ss–AI308 MN TIM yy (See *IA MAX* for series structure and data.)						1308–1313
1214 (R)	AI401 MX - HI	Engineering Units	–32768	32767	0	0.001	1314
1215 (R)	AI401 MX - LO		–32768	32767	0	0.001	1315
1216–1221 (R)	AI401 MX TIM ss–AI401 MX TIM yy (See *IA MAX* for series structure and data.)						1316–1321
1222 (R)	AI401 MN - HI	Engineering Units	–32768	32767	0	0.001	1322
1223 (R)	AI401 MN - LO		–32768	32767	0	0.001	1323
1224–1229 (R)	AI401 MN TIM ss–AI401 MN TIM yy (See *IA MAX* for series structure and data.)						1324–1329
•	•						•
•	•						•
•	•						•
1326 (R)	AI408 MX - HI	Engineering Units	–32768	32767	0	0.001	1426
1327 (R)	AI408 MX - LO		–32768	32767	0	0.001	1427
1328–1333 (R)	AI408 MX TIM ss–AI408 MX TIM yy (See *IA MAX* for series structure and data.)						1428–1433
1334 (R)	AI408 MN - HI	Engineering Units	–32768	32767	0	0.001	1434
1335 (R)	AI408 MN - LO		–32768	32767	0	0.001	1435
1336–1341 (R)	AI408 MN TIM ss– AI408 MN TIM yy (See *IA MAX* for series structure and data.)						1436–1441
1342 (R)	AI501 MX - HI	Engineering Units	–32768	32767	0	0.001	1442
1343 (R)	AI501 MX - LO		–32768	32767	0	0.001	1443
1344–1349 (R)	AI501 MX TIM ss–AI501 MX TIM yy (See *IA MAX* for series structure and data.)						1444–1449
1350 (R)	AI501 MN - HI	Engineering Units	–32768	32767	0	0.001	1450
1351 (R)	AI501 MN - LO		–32768	32767	0	0.001	1451
1352–1357 (R)	AI501 MN TIM ss–AI501 MN TIM yy (See *IA MAX* for series structure and data.)						1452–1457
•	•						•
•	•						•
•	•						•
1454 (R)	AI508 MX - HI	Engineering Units	–32768	32767	0	0.001	1554
1455 (R)	AI508 MX - LO		–32768	32767	0	0.001	1555
1456–1461 (R)	AI508 MX TIM ss–AI508 MX TIM yy (See *IA MAX* for series structure and data.)						1556–1561
1462 (R)	AI508 MN - HI	Engineering Units	–32768	32767	0	0.001	1562
1463 (R)	AI508 MN - LO		–32768	32767	0	0.001	1563
1464–1469 (R)	AI508 MN TIM ss–AI508 MN TIM yy (See *IA MAX* for series structure and data.)						1564–1569

Table D.34 Modbus Register Map[a] (Sheet 20 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1470–1475 (R)	MX/MN RST TIM ss–MX/MN RST TIM yy (See *IA MAX* for series structure and data.)						1570–1575
1476–1492 (R)	Reserved[d]		0	0	0		1576–1592
Analog Input Data							
1493 (R)	AI301 - HI	Engineering Units	–32768	32767	0	0.001	1593
1494 (R)	AI301 - LO		–32768	32767	0	0.001	1594
•	•						•
•	•						•
•	•						•
1507 (R)	AI308 - HI	Engineering Units	–32768	32767	0	0.001	1607
1508 (R)	AI308 - LO		–32768	32767	0	0.001	1608
1509 (R)	AI401 - HI	Engineering Units	–32768	32767	0	0.001	1609
1510 (R)	AI401 - LO		–32768	32767	0	0.001	1610
•	•						•
•	•						•
•	•						•
1523 (R)	AI408 - HI	Engineering Units	–32768	32767	0	0.001	1623
1524 (R)	AI408 - LO		–32768	32767	0	0.001	1624
1525 (R)	AI501 - HI	Engineering Units	–32768	32767	0	0.001	1625
1526 (R)	AI501- LO		–32768	32767	0	0.001	1626
•	•						•
•	•						•
•	•						•
1539 (R)	AI508 - HI	Engineering Units	–32768	32767	0	0.001	1639
1540 (R)	AI508 - LO		–32768	32767	0	0.001	1640
1541–1546 (R)	Reserved[d]		0	0	0		1641–1646
Math Variables							
1547 (R)	MV01 - HI		–32768	32767	0	0.01	1647
1548 (R)	MV01 - LO		–32768	32767	0	0.01	1648
•	•						•
•	•						•
•	•						•
1609 (R)	MV32 - HI		–32768	32767	0	0.01	1709
1610 (R)	MV32 - LO		–32768	32767	0	0.01	1710
Device Counters							
1611 (R)	COUNTER SC01		0	65000	1	1	1711
•	•						•
•	•						•
•	•						•

Table D.34 Modbus Register Map[a] (Sheet 21 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1642 (R)	COUNTER SC32		0	65000	1	1	1742
1643–1647 (R)	Reserved[d]		0	0	0		1743–1747
Motor Statistics							
1648 (R)	ELAPSED TIME mm		0	59	0	1	1748
1649 (R)	ELAPSED TIME hh		0	23	0	1	1749
1650 (R)	ELAPSED TIME dd		0	65535	0	1	1750
1651 (R)	RUNNING TIME mm		0	59	0	1	1751
1652 (R)	RUNNING TIME hh		0	23	0	1	1752
1653 (R)	RUNNING TIME dd		0	65535	0	1	1753
1654 (R)	STOPPED TIME mm		0	59	0	1	1754
1655 (R)	STOPPED TIME hh		0	23	0	1	1755
1656 (R)	STOPPED TIME dd		0	65535	0	1	1756
1657 (R)	% TIME RUNNING	%	0	1000	0	0.1	1757
1658 (R)	STARTS COUNT		0	65535	0	1	1758
1659 (R)	EMER START COUNT		0	65535	0	1	1759
1660 (R)	MOT RST TIME ss		0	5999	0	0.01	1760
1661 (R)	MOT RST TIME mm		0	59	0	1	1761
1662 (R)	MOT RST TIME hh		0	23	0	1	1762
1663 (R)	MOT RST DATE dd		1	31	1	1	1763
1664 (R)	MOT RST DATE mm		1	12	1	1	1764
1665 (R)	MOT RST DATE yy		2000	9999	2000	1	1765
Average Statistics							
1666 (R)	START TIME (S)	s	0	9999	0	0.1	1766
1667 (R)	MAX START I (A)	A	0	65535	0	1	1767
1668 (R)	MIN START V (V)	V	0	65535	0	1	1768
1669 (R)	START %TCU	%	0	65535	0	0.1	1769
1670 (R)	RUNNING %TCU	%	0	65535	0	0.1	1770
1671 (R)	RTD %TCU	%	0	65535	0	1	1771
1672 (R)	RUNNING CUR (A)	A	0	65535	0	0.1	1772
1673 (R)	RUNNING KW	kW	0	65535	0	0.1	1773
1674 (R)	RUNNING KVARIN	kVAR	0	65535	0	0.1	1774
1675 (R)	RUNNING KVAROUT	kVAR	0	65535	0	0.1	1775
1676 (R)	RUNNING KVA	kVA	0	65535	0	0.1	1776
1677 (R)	MAX WDG RTD (C)	degC	–32768	32767	0	1	1777
1678 (R)	MAX BRG RTD (C)	degC	–32768	32767	0	1	1778
1679 (R)	AMBIENT RTD (C)	degC	–32768	32767	0	1	1779
1680 (R)	MAX OTH RTD (C)	degC	–32768	32767	0	1	1780

Table D.34 Modbus Register Map[a] (Sheet 22 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Peak Statistics							
1681 (R)	START TIME (S)	s	0	9999	0	0.1	1781
1682 (R)	MAX START I (A)	A	0	65535	0	1	1782
1683 (R)	MIN START V (V)	V	0	65535	0	1	1783
1684 (R)	START %TCU	%	0	65535	0	0.1	1784
1685 (R)	RUNNING %TCU	%	0	65535	0	0.1	1785
1686 (R)	RTD %TCU	%	0	65535	0	1	1786
1687 (R)	RUNNING CUR (A)	A	0	65535	0	0.1	1787
1688 (R)	RUNNING KW	kW	0	65535	0	0.1	1788
1689 (R)	RUNNING KVARIN	kVAR	0	65535	0	0.1	1789
1690 (R)	RUNNING KVAROUT	kVAR	0	65535	0	0.1	1790
1691 (R)	RUNNING KVA	kVA	0	65535	0	0.1	1791
1692 (R)	MAX WDG RTD (C)	degC	–32768	32767	0	1	1792
1693 (R)	MAX BRG RTD (C)	degC	–32768	32767	0	1	1793
1694 (R)	AMBIENT RTD (C)	degC	–32768	32767	0	1	1794
1695 (R)	MAX OTH RTD (C)	degC	–32768	32767	0	1	1795
Learn Parameters							
1696 (R)	COOL TIME (S)	s	0	9999	0	0.1	1796
1697 (R)	START TC	%	0	65535	0	0.1	1797
Alarm Counters							
1698 (R)	OVERLOAD		0	65535	0	1	1798
1699 (R)	LOCKED ROTOR		0	65535	0	1	1799
1700 (R)	UNDERCURRENT		0	65535	0	1	1800
1701 (R)	JAM		0	65535	0	1	1801
1702 (R)	CURRENT IMBAL		0	65535	0	1	1802
1703 (R)	OVERCURRENT		0	65535	0	1	1803
1704 (R)	GROUND FAULT		0	65535	0	1	1804
1705 (R)	SPEED SWITCH		0	65535	0	1	1805
1706 (R)	UNDERVOLTAGE		0	65535	0	1	1806
1707 (R)	OVERVOLTAGE		0	65535	0	1	1807
1708 (R)	UNDERPOWER		0	65535	0	1	1808
1709 (R)	POWER FACTOR		0	65535	0	1	1809
1710 (R)	REACTIVE POWER		0	65535	0	1	1810
1711 (R)	RTD		0	65535	0	1	1811
1712 (R)	TOTAL ALARMS		0	65535	0	1	1812
Trip Counters							
1713 (R)	OVERLOAD		0	65535	0	1	1813
1714 (R)	LOCKED ROTOR		0	65535	0	1	1814
1715 (R)	UNDERCURRENT		0	65535	0	1	1815

Table D.34 Modbus Register Map[a] (Sheet 23 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1716 (R)	JAM		0	65535	0	1	1816
1717 (R)	CURRENT IMBAL		0	65535	0	1	1817
1718 (R)	OVERCURRENT		0	65535	0	1	1818
1719 (R)	GROUND FAULT		0	65535	0	1	1819
1720 (R)	SPEED SWITCH		0	65535	0	1	1820
1721 (R)	UNDERVOLTAGE		0	65535	0	1	1821
1722 (R)	OVERVOLTAGE		0	65535	0	1	1822
1723 (R)	UNDERPOWER		0	65535	0	1	1823
1724 (R)	POWER FACTOR		0	65535	0	1	1824
1725 (R)	REACTIVE POWER		0	65535	0	1	1825
1726 (R)	RTD		0	65535	0	1	1826
1727 (R)	PHASE REVERSAL		0	65535	0	1	1827
1728 (R)	87M PHASE DIFF		0	65535	0	1	1828
1729 (R)	UNDERFREQUENCY		0	65535	0	1	1829
1730 (R)	OVERFREQUENCY		0	65535	0	1	1830
1731 (R)	PTC		0	65535	0	1	1831
1732 (R)	START TIMER		0	65535	0	1	1832
1733 (R)	REMOTE TRIP		0	65535	0	1	1833
1734 (R)	OTHER TRIPS		0	65535	0	1	1834
1735 (R)	TOTAL TRIPS		0	65535	0	1	1835
1736–1745 (R)	Reserved[d]		0	0	0		1836–1845
Historical Data							
1746 (R)	NO. EVENT LOGS		0	50	0	1	1846
1747 (R/W)	EVENT LOG SEL.		0	50	0	1	1847
1748 (R)	EVENT TIME ss		0	5999	0	0.01	1848
1749 (R)	EVENT TIME mm		0	59	0	1	1849
1750 (R)	EVENT TIME hh		0	23	0	1	1850
1751 (R)	EVENT DAY dd		1	31	1	1	1851
1752 (R)	EVENT DAY mm		1	12	1	1	1852
1753 (R)	EVENT DAY yy		2000	9999	2000	1	1853

Table D.34 Modbus Register Map[a] (Sheet 24 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1754 (R)	EVENT TYPE 0 = NA 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 = PHASE A 51 TRIP 9 = PHASE B 51 TRIP 10 = PHASE C 51 TRIP 11 = PHASE 51 TRIP 12 = GND 51 TRIP 13 = NEG SEQ 51 TRIP 14 = SPEED SW TRIP 15 = UNDERVOLT TRIP 16 = OVERVOLT TRIP 17 = UNDERPOWER TRIP 18 = PWR FACTOR TRIP 19 = REACT PWR TRIP 20 = PHASE REV TRIP 21 = UNDERFREQ TRIP 22 = OVERFREQ TRIP 23 = RTD TRIP 24 = PTC TRIP 25 = START TIME TRIP 26 = 87M DIFF TRIP 27 = RTD FAIL TRIP 28 = PTC FAIL TRIP 29 = BKR FAILURE TRIP 30 = TRIGGER 31 = COMMIDLELOSSTRIP 32 = REMOTE TRIP 33 = STOP COMMAND 34 = ER TRIGGER 35 = TRIP		0	35	0		1854
1755 (R)	EVENT TARGETS Bit 0 = T06_Led Bit 1 = T05_Led Bit 2 = T04_Led Bit 3 = T03_Led Bit 4 = T02_Led Bit 5 = T01_Led Bit 6 = Trip Bit 7 = Enabled		0	255	0		1855
1756 (R)	EVENT IA	A	0	65535	0	1	1856
1757 (R)	EVENT IB	A	0	65535	0	1	1857
1758 (R)	EVENT IC	A	0	65535	0	1	1858
1759 (R)	EVENT IN	A	0	65535	0	1	1859
1760 (R)	EVENT IG	A	0	65535	0	1	1860
1761 (R)	EVENT VAB/VAN	V	0	65535	0	1	1861
1762 (R)	EVENT VBC/VBN	V	0	65535	0	1	1862
1763 (R)	EVENT VCA/VCN	V	0	65535	0	1	1863
1764 (R)	EVENT VG	V	0	65535	0	1	1864
1765 (R)	EVENT DELTA/WYE 0 = DELTA 1 = WYE		0	1	0		1865
1766 (R)	EVENT FREQ		2000	7000	6000	0.01	1866
1767 (R)	EVENT IA87		0	65535	0	1	1867
1768 (R)	EVENT IB87		0	65535	0	1	1868
1769 (R)	EVENT IC87		0	65535	0	1	1869
1770 (R)	EVNT MAX WDG RTD	degC	–32768	32767	0	1	1870
1771 (R)	EVNT MAX BRG RTD	degC	–32768	32767	0	1	1871
1772 (R)	EVNT MAX AMB RTD	degC	–32768	32767	0	1	1872
1773 (R)	EVNT MAX OTH RTD	degC	–32768	32767	0	1	1873
1774–1779 (R)	Reserved[d]		0	0	0		1874–1879

Table D.34 Modbus Register Map[a] (Sheet 25 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Trip/Warn Data							
Note: The Trip/Warn Status register bits are momentarily set as long as the trip/warn condition exists. When a trip event occurs, the elements are latched to the rising edge of the TRIP Relay Word bit and they are not cleared until a target reset is issued from an interface.							
1780 (R)	TRIP STATUS LO Bit 0 = Thermal (49T)[g] Bit 1 = Undercurrent Bit 2 = Jam Bit 3 = Curr. Unbalance 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	0	1	1880
1781 (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 = 87 Differential Bit 14 = Reserved Bit 15 = Breaker Fail		0	65535	0	1	1881
1782 (R)	WARN STATUS LO Bit 0 = Thermal (49A)[h] Bit 1 = Undercurrent Bit 2 = Jam Bit 3 = Curr. Unbalance 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 3 Bit 14 = Frequency 4 Bit 15 = RTD-Other		0	65535	0	1	1882

Table D.34 Modbus Register Map[a] (Sheet 26 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1783 (R)	WARN STATUS HI Bit 0 = RTD-Ambient Bit 1 = SALARM Bit 2 = Warning Bit 3–Bit15 = Reserved		0	65535	0	1	1883
1784–1788 (R)	Reserved[d]		0	0	0		1884–1888
Communications Counters							
1789 (R)	NUM MSG RCVD		0	65535	0	1	1889
1790 (R)	NUM OTHER MSG		0	65535	0	1	1890
1791 (R)	INVALID ADDR		0	65535	0	1	1891
1792 (R)	BAD CRC		0	65535	0	1	1892
1793 (R)	UART ERROR		0	65535	0	1	1893
1794 (R)	ILLEGAL FUNCTION		0	65535	0	1	1894
1795 (R)	ILLEGAL REGISTER		0	65535	0	1	1895
1796 (R)	ILLEGAL WRITE		0	65535	0	1	1896
1797 (R)	BAD PKT FORMAT		0	65535	0	1	1897
1798 (R)	BAD PKT LENGTH		0	65535	0	1	1898
1799–1804 (R)	Reserved[d]		0	0	0	1	1899–1904
Relay Elements							
Note: Only a few Relay Element rows have bit enumerations specific to that row. Other Relay Element rows have generic bit enumerations, as shown for row 10. See *Table I.1* for element information in these rows.							
1805 (R)	LATCHED TAR ROW 0 Bit 0 = TO6_LED Bit 1 = TO5_LED Bit 2 = T04_LED Bit 3 = T03_LED Bit 4 = T02_LED Bit 5 = T01_LED Bit 6 = TRIP Bit 7 = ENABLED		0	255	0	1	1905
1806 (R)	ROW 1 Bit 0 = 50G1T Bit 1 = PTCTRIP Bit 2 = RTDT Bit 3 = 50P1T Bit 4 = 46UBT Bit 5 = JAMTRIP Bit 6 = LOSSTRIP Bit 7 = 49T		0	255	0	1	1906
1807 (R)	ROW 2 Bit 0 = 50N1T Bit 1 = SPDSTR Bit 2 = 55T Bit 3 = 47T Bit 4 = 59P1T Bit 5 = 27P1T Bit 6 = 37PT Bit 7 = VART		0	255	0	1	1907

Table D.34 Modbus Register Map[a] (Sheet 27 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1808 (R)	ROW 3 Bit 0 = BFI Bit 1 = RTDFLT Bit 2 = PTCFLT Bit 3 = AMBTRIP Bit 4 = OTHTRIP Bit 5 = 81D2T Bit 6 = 81D1T Bit 7 = SMTRIP		0	255	0	1	1908
1809 (R)	ROW 4 Bit 0 = BFT Bit 1 = 49T_RTR Bit 2 = 49T_STR Bit 3 = CFGFLT Bit 4 = COMMFLT Bit 5 = REMTRIP Bit 6 = COMMLOSS Bit 7 = COMMIDLE		0	255	0	1	1909
1810 (R)	ROW 5 Bit 0 = * Bit 1 = * Bit 2 = * Bit 3 = 50Q2T Bit 4 = 50Q1T Bit 5 = 87M1T Bit 6 = 87M2T Bit 7 = ORED51T		0	255	0	1	1910
1811 (R)	ROW 6 Bit 0 = 50G2T Bit 1 = 50N2T Bit 2 = 55A Bit 3 = RTDA Bit 4 = 46UBA Bit 5 = JAMALRM Bit 6 = LOSSALRM Bit 7 = 49A		0	255	0	1	1911
1812 (R)	ROW 7 Bit 0 = OTHALRM Bit 1 = 81D4T Bit 2 = 81D3T Bit 3 = SPDSAL Bit 4 = 59P2T Bit 5 = 27P2T Bit 6 = 37PA Bit 7 = VARA		0	255	0	1	1912
1813 (R)	ROW 8 Bit 0 = 50P2T Bit 1 = 50S Bit 2 = * Bit 3 = LOADLOW Bit 4 = LOADUP Bit 5 = WARNING Bit 6 = SALARM Bit 7 = AMBALRM		0	255	0	1	1913

Table D.34 Modbus Register Map[a] (Sheet 28 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1814 (R)	ROW 9		0	255	0	1	1914
	Bit 0 = FAULT						
	Bit 1 = IRIGOK						
	Bit 2 = START						
	Bit 3 = DELTA						
	Bit 4 = STAR						
	Bit 5 = STARTING						
	Bit 6 = RUNNING						
	Bit 7 = STOPPED						
1815 (R)	ROW 10		0	255	0	1	1915
	Bit 0 = RW_BIT0						
	Bit 1 = RW_BIT1						
	Bit 2 = RW_BIT2						
	Bit 3 = RW_BIT3						
	Bit 4 = RW_BIT4						
	Bit 5 = RW_BIT5						
	Bit 6 = RW_BIT6						
	Bit 7 = RW_BIT7						
1816 (R)	ROW 11		0	255	0	1	1916
1817 (R)	ROW 12		0	255	0	1	1917
	Bit 0 = 59P1						
	Bit 1 = 27P1						
	Bit 2 = 50G2P						
	Bit 3 = 50G1P						
	Bit 4 = 50N2P						
	Bit 5 = 50N1P						
	Bit 6 = 50P2P						
	Bit 7 = 50P1P						
1818–1821 (R)	Row 13–ROW 16		0	255	0	1	1918–1921
1822 (R)	ROW 17		0	255	0	1	1922
	Bit 0 = ABSLO						
	Bit 1 = TBSLO						
	Bit 2 = NOSLO						
	Bit 3 = THERMLO						
	Bit 4 = BRGTRIP						
	Bit 5 = BRGALRM						
	Bit 6 = WDGTRIP						
	Bit 7 = WDGALRM						
1823 (R)	ROW 18		0	255	0	1	1923
	Bit 0 = HALARM						
	Bit 1 = SPEED2						
	Bit 2 = 52A						
	Bit 3 = RTDBIAS						
	Bit 4 = SPEEDSW						
	Bit 5 = TRGTR						
	Bit 6 = RTDIN						
	Bit 7 = 50Q1P						
1824–1826 (R)	ROW 19–ROW 21		0	255	0	1	1924–1926

Table D.34 Modbus Register Map[a] (Sheet 29 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1827 (R)	ROW 22 Bit 0 = 49RTDTC Bit 1 = 49PTCTC Bit 2 = 66JOGTC Bit 3 = 37LLTC Bit 4 = 50PTC Bit 5 = 50EFTC Bit 6 = 48LJTC Bit 7 = 46UBTC						1927
1828 (R)	ROW 23 Bit 0 = 59P2 Bit 1 = 27P2 Bit 2 = LOP Bit 3 = BLKPROT Bit 4 = RSTTRGT Bit 5 = DSABLSET Bit 6 = RSTMXMN Bit 7 = RSTENRGY		0	255	0	1	1928
1829 (R)	ROW 24 Bit 0 = DI_A Bit 1 = DI_B Bit 2 = DI_C Bit 3 = 50Q2P Bit 4 = MSRTRG Bit 5 = SG3 Bit 6 = SG2 Bit 7 = SG1		0	255	0	1	1929
1830–1917 (R)	ROW 25 through ROW 112		0	255	0	1	1930–2017
1918–1920 (R)	Reserved[d]		0	0	0	na	2018–2020
Extra Settings							
Phase Time Overcurrent							
1921 (R/W)	PHA TOC TRIP EN 0 = N 1 = Y		0	1	0		2021
1922 (R/W)	PHA TOC TRIP LVL	A	10	1000	120	0.01	2022
1923 (R/W)	PHA TOC CURVE 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2		2023
1924 (R/W)	PHA TOC TIM DIAL		5	1500	300	0.01	2024
1925 (R/W)	PHA EM RST DLAY 0 = N 1 = Y		0	1	0		2025
1926 (R/W)	PHA CONST TIME	s	0	100	0	0.01	2026
1927 (R/W)	PHA MIN RESP TIM	s	0	100	0	0.01	2027
1928 (R/W)	PHB TOC TRIP EN 0 = N 1 = Y		0	1	0		

Table D.34 Modbus Register Map[a] (Sheet 30 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1929 (R/W)	PHB TOC TRIP LVL	A	10	1000	120	0.01	2029
1930 (R/W)	PHB TOC CURVE 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2		2030
1931 (R/W)	PHB TOC TIM DIAL		5	1500	300	0.01	2031
1932 (R/W)	PHB EM RST DLAY 0 = N 1 = Y		0	1	0		2032
1933 (R/W)	PHB CONST TIME	s	0	100	0	0.01	2033
1934 (R/W)	PHB MIN RESP TIM	s	0	100	0	0.01	2034
1935 (R/W)	PHC TOC TRIP EN 0 = N 1 = Y		0	1	0		2035
1936 (R/W)	PHC TOC TRIP LVL	A	10	1000	120	0.01	2036
1937 (R/W)	PHC TOC CURVE 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2	1	2037
1938 (R/W)	PHC TOC TIM DIAL		5	1500	300	0.01	2038
1939 (R/W)	PHC EM RST DLAY 0 = N 1 = Y		0	1	0		2039
1940 (R/W)	PHC CONST TIME	s	0	100	0	0.01	2040
1941 (R/W)	PHC MIN RESP TIM	s	0	100	0	0.01	2041
Maximum Phase Time Overcurrent							
1942 (R/W)	TOC TRIP L1 EN 0 = N 1 = Y		0	1	0		2042
1943 (R/W)	TOC TRIP LVL1	A	10	1000	120	0.01	2043
1944 (R/W)	TOC CURVE SEL1 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2	1	2044

Table D.34 Modbus Register Map[a] (Sheet 31 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1945 (R/W)	TOC TIME DIAL1		5	1500	300	0.01	2045
1946 (R/W)	EM RESET DELAY1 0 = N 1 = Y		0	1	0		2046
1947 (R/W)	CONST TIME1	s	0	100	0	0.01	2047
1948 (R/W)	MIN RESP TIME1	s	0	100	0	0.01	2048
1949 (R/W)	TOC TRIP L2 EN 0 = N 1 = Y		0	1	0		2049
1950 (R/W)	TOC TRIP LVL2	A	10	1000	120	0.01	2050
1951 (R/W)	TOC CURVE SEL2 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2	1	2051
1952 (R/W)	TOC TIME DIAL2		5	1500	300	0.01	2052
1953 (R/W)	EM RESET DELAY2 0 = N 1 = Y		0	1	0		2053
1954 (R/W)	CONST TIME2	s	0	100	0	0.01	2054
1955 (R/W)	MIN RESP TIME2	s	0	100	0	0.01	2055
Negative-Sequence Time Overcurrent							
1956 (R/W)	NSTOC TRIP EN 0 = N 1 = Y		0	1	1	0	2056
1957 (R/W)	NSTOC TRIP LVL	A	10	1000	120	0.01	2057
1958 (R/W)	NSTOC CURVE SEL 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2	1	2058
1959 (R/W)	NSTOC TIME DIAL		5	1500	300	0.01	2059
1960 (R/W)	NSTOC EM RST DLY 0 = N 1 = Y		0	1	0		2060
1961 (R/W)	NSTOC CONST TIME	s	0	100	0	0.01	2061
1962 (R/W)	NSTOC MIN RESP	s	0	100	0	0.01	2062
Residual Time Overcurrent							
1963 (R/W)	RES TOC L1 EN 0 = N 1 = Y		0	1	0		2063
1964 (R/W)	RES TOC TRIP L1	A	10	1000	50	0.01	2064

Table D.34 Modbus Register Map[a] (Sheet 32 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1965 (R/W)	RES TOC CURVE1 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2	1	2065
1966 (R/W)	RES TOC TIM DL1		5	1500	150	0.01	2066
1967 (R/W)	RES EM RST DLAY1 0 = N 1 = Y		0	1	0		2067
1968 (R/W)	RES CONST TIME1	s	0	100	0	0.01	2068
1969 (R/W)	RES MIN RESP T1	s	0	100	0	0.01	2069
1970 (R/W)	RES TOC L2 EN 0 = N 1 = Y		0	1	0		2070
1971 (R/W)	RES TOC TRIP L2	A	10	1000	50	0.01	2071
1972 (R/W)	RES TOC CURVE2 0 = U1 1 = U2 2 = U3 3 = U4 4 = U5 5 = C1 6 = C2 7 = C3 8 = C4 9 = C5		0	9	2	1	2072
1973 (R/W)	RES TOC TIM DL2		5	1500	150	0.01	2073
1974 (R/W)	RES EM RST DLAY2 0 = N 1 = Y		0	1	0		2074
1975 (R/W)	RES CONST TIME2	s	0	100	0	0.01	2075
1976 (R/W)	RES MIN RESP T2	s	0	100	0	0.01	2076
1977–2020 (R)	Reserved[d]		0	0	0		2077–2120
Breaker Monitor Settings							
2021 (R/W)	BREAKER MONITOR 0 = N 1 = Y		0	1	1		2121
2022 (R/W)	CL/OPN OPS SETP1		0	65000	10000	1	2122
2023 (R/W)	CL/OPN OPS SETP2		0	65000	150	1	2123
2024 (R/W)	CL/OPN OPS SETP3		0	65000	12	1	2124
2025 (R/W)	KA PRI INTRPD1-I		0	999	1	1	2125
2026 (R/W)	KA PRI INTRPD1-F		0	99	20	0.01	2126
2027 (R/W)	KA PRI INTRPD2-I		0	999	8	1	2127
2028 (R/W)	KA PRI INTRPD2-F		0	99	0	0.01	2128

Table D.34 Modbus Register Map[a] (Sheet 33 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
2029 (R/W)	KA PRI INTRPD3-I		0	999	20	1	2129
2030 (R/W)	KA PRI INTRPD3-F		0	99	0	0.01	2130
2031–2039 (R)	Reserved[d]		0	0	0		2131–2139
Time and Date Management Settings							
2040 (R/W)	CTRL BITS DERN 0 = N 1 = C37.118			0	1	0	2140
2041 (R/W)	OFFSET FROM UTC	hour	–2400	2400	0	0.01	2141
2042 (R/W)	ENABLE DST 0 = N 1 = Y		0	1	0		2142
2043 (R/W)	MONTH DST BEGINS		1	12	1	1	2143
2044 (R/W)	WEEK DST BEGINS 0 = L 1 = 1 2 = 2 3 = 3		0	3	2		2144
2045 (R/W)	DAY DST BEGINS 0 = SUN 1 = MON 2 = TUE 3 = WED 4 = THU 5 = FRI 6 = SAT		0	6	0		2145
2046 (R/W)	HOUR DST BEGINS		0	23	2	1	2146
2047 (R/W)	MONTH DST ENDS		1	12	11	1	2147
2048 (R/W)	WEEK DST ENDS 0 = L 1 = 1 2 = 2 3 = 3		0	3	1		2148
2049 (R/W)	DAY DST ENDS 0 = SUN 1 = MON 2 = TUE 3 = WED 4 = THU 5 = FRI 6 = SAT		0	6	0		2149
2050 (R/W)	HOUR DST ENDS		0	23	2	1	2150
2051–2080 (R)	Reserved[d]		0	0	0		2151–2180
Breaker Monitor Data							
2081	RLY TRIPS		0	65535	0	1	2181
2082	EXT TRIPS		0	65535	0	1	2182
2083	IA RLY	kA	0	65535	0	1	2183
2084	IA EXT	kA	0	65535	0	1	2184
2085	IB RLY	kA	0	65535	0	1	2185
2086	IB EXT	kA	0	65535	0	1	2186
2087	IC RLY	kA	0	65535	0	1	2187

Table D.34 Modbus Register Map[a] (Sheet 34 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
2088	IC EXT	kA	0	65535	0	1	2188
2089	A WEAR	%	0	100	0	1	2189
2090	B WEAR	%	0	100	0	1	2190
2091	C WEAR	%	0	100	0	1	2191
2092	BRKR RST TIM-ss	s	0	5999	0	0.01	2192
2093	BRKR RST TIM-mm	min	0	59	0	1	2193
2094	BRKR RST TIM-hh	hr	0	23	0	1	2194
2095	BRKR RST DAT-dd		1	31	1	1	2195
2096	BRKR RST DAT-mm		1	12	1	1	2196
2097	BRKR RST DAT-yy		2000	9999	2000	1	2197
2098–2100	Reserved[d]		0	0	0		2198–2200
Control I/O Commands							
2000H (Hex) (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 = Reserved		0	65535	0	na	
2001H (W)	RESET COMMAND Bit 0 = Trip Reset Bit 1 = Set to Defaults Bit 2 = Reset Stat Data Bit 3 = Reset Hist Data Bit 4 = Reset Comm Cntr Bit 5 = Reset MOT Data Bit 6 = Rst Enrgy Data Bit 7 = Rst Mx/Mn Data		0	255	0	na	
Relay Elements							
2100H (R)	FAST STATUS 0 Bit 0 = Faulted Bit 1 = Warning Bit 2 = IN101/IN1 Status Bit 3 = IN102/IN2 Status Bit 4 = IN401/IN3 Status Bit 5 = IN402/IN4 Status Bit 6 = IN403/IN5 Status Bit 7 = Starting		0 Bit 8 = OUT101/Aux1 Status Bit 9 = OUT102/Aux2 Status Bit 10 = OUT401/Aux3 Status Bit 11 = OUT402/Aux4 Status Bit 12 = OUT403/Aux5 Status Bit 13 = OUT404/Aux6 Status Bit 14 = Running Bit 15 = Stopped	65535	0	na	

Table D.34 Modbus Register Map[a] (Sheet 35 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
2101H (R)	FAST STATUS 1		0	65535	0	na	
	Bit 0 = Reserved Bit 1 = Reserved Bit 2 = IN404/IN6 Status Bit 3 = IN501/IN7 Status Bit 4 = IN502/IN8 Status Bit 5 = IN503/IN9 Status Bit 6 = IN504/IN10 Status Bit 7 = Reserved Bit 8 = OUT501/Aux7 Status Bit 9 = OUT502/Aux8 Status Bit 10 = OUT503/Aux9 Status Bit 11 = OUT504/Aux10 Status Bit 12–15 = Reserved						
2102H (R)	TRIP STATUS LO					na	
2103H (R)	TRIP STATUS HI					na	
2104H (R)	WARN STATUS LO					na	
2105H (R)	WARN STATUS HI					na	
2106H (R)	AVERAGE CURRENT					na	
2107H (R)	IA CURRENT					na	
2108H (R)	IB CURRENT					na	
2109H (R)	IC CURRENT					na	
210AH (R)	STATOR TCU					na	
210BH (R)	CURRENT IMBAL					na	
210CH (R)	MAX WINDING RTD					na	
210DH (R)	IG CURRENT					na	
210EH (R)	IN CURRENT					na	
210FH (R)	ROTOR TCU					na	
2110H (R)	FAST STATUS 2		0	65535	0	na	
	Bit 0 = IN301 Status Bit 1 = IN302 Status Bit 2 = IN303 Status Bit 3 = IN304 Status Bit 4 = OUT301 Status Bit 5 = OUT302 Status Bit 6 = OUT303 Status Bit 7 = OUT304 Status Bit 8– Bit 15 = Reserved						
PAR Group Indices							
3000H (R)	Reserved[d]		0	0	0	na	
3001H (R)	USER MAP REG		1	125	1		
3002H (R)	USER MAP REG VAL		126	250	126		
3003H (R)	RESERVED AREA1		251	259	251		
3004H (R)	ACCESS CONTROL		260	260	260		
3005H (R)	GENERAL SETTINGS		261	264	261		
3006H (R)	GROUP SELECTION		265	265	265		
3007H (R)	BK FAILURE SET		266	267	266		
3008H (R)	IRIG TIME SOURCE		268	272	268		
3009H (R)	MAIN SETTINGS		273	283	273		
300AH (R)	THERMAL OVERLOAD		284	339	284		

Table D.34 Modbus Register Map[a] (Sheet 36 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
300BH (R)	PHASE OVERCURR		340	345	340		
300CH (R)	NEUTRAL OVERCURR		346	351	346		
300DH (R)	RESIDUAL OVERCUR		352	357	352		
300EH (R)	NEG SEQ OVERCURR		358	363	358		
300FH (R)	MOTOR DIFF OC		364	376	364		
3010H (R)	JAM SETTINGS		377	382	377		
3011H (R)	UNDERCURRENT SET		383	389	383		
3012H (R)	CURRENT IMB SET		390	395	390		
3013H (R)	START MONITORING		396	396	396		
3014H (R)	STAR DELTA SET		397	398	397		
3015H (R)	START INHIBIT SET		399	401	399		
3016H (R)	PHASE REV SET		402	402	402		
3017H (R)	SPEED SW SET		403	404	403		
3018H (R)	PTC SETTINGS		405	410	405		
3019H (R)	RTD SETTINGS		411	467	411		
301AH (R)	UNDERVOLTAGE SET		468	473	468		
301BH (R)	OVERVOLTAGE SET		474	479	474		
301CH (R)	VAR SETTINGS		480	490	480		
301DH (R)	UNDERPOWER SET		491	497	491		
301EH (R)	POWER FACTOR SET		498	508	498		
301FH (R)	FREQ SETTINGS		509	520	509		
3020H (R)	LOAD CONTROL SET		521	529	521		
3021H (R)	TRIP INHIBIT		530	530	530		
3022H (R)	TRIP/CLOSE LOGIC		531	541	531		
3023H (R)	SELOGIC ENABLES		542	550	542		
3024H (R)	OUTPUT CONTACTS		551	570	551		
3025H (R)	EVENT REPORT SET		571	580	571		
3026H (R)	FRONT PANEL SET		581	590	581		
3027H (R)	RESET SETTINGS		591	601	591		
3028H (R)	DATE/TIME SET		602	609	602		
3029H (R)	DEVICE STATUS		610	649	610		
302AH (R)	CURRENT DATA		650	666	650		
302BH (R)	VOLTAGE DATA		667	684	667		
302CH (R)	POWER DATA		685	689	685		
302DH (R)	ENERGY DATA		690	711	690		
302EH (R)	RTD DATA		712	728	712		
302FH (R)	OVERLOAD STATUS		729	739	729		
3030H (R)	RMS DATA		740	749	740		
3031H (R)	MAX/MIN MTR DATA		750	917	750		
3032H (R)	MAX/MIN RTD DATA		918	1085	918		

Table D.34 Modbus Register Map[a] (Sheet 37 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
3033H (R)	MAX/MIN AI3 DATA		1086	1213	1086		
3034H (R)	MAX/MIN AI4 DATA		1214	1341	1214		
3035H (R)	MAX/MIN AI5 DATA		1342	1469	1342		
3036H (R)	MAX/MIN RST DATA		1470	1492	1470		
3037H (R)	ANA INP DATA		1493	1546	1493		
3038H (R)	MATH VARIABLES		1547	1610	1547		
3039H (R)	DEVICE COUNTERS		1611	1647	1611		
303AH (R)	MOTOR STATISTICS		1648	1665	1648		
303BH (R)	AVG STATISTICS		1666	1680	1666		
303CH (R)	PEAK STATISTICS		1681	1695	1684		
303DH (R)	LEARN PARAMETERS		1696	1697	1696		
303EH (R)	ALARM COUNTERS		1698	1712	1698		
303FH (R)	TRIP COUNTERS		1713	1745	1713		
3040H (R)	HISTORICAL DATA		1746	1779	1746		
3041H (R)	TRIP/WARN DATA		1780	1788	1780		
3042H (R)	COMMN COUNTERS		1789	1804	1789		
3043H (R)	RELAY ELEMENTS		1805	1920	1805		
3044H (R)	EXTRA SETTINGS		1921	2080	1921		
3045H (R)	BREAKER MONITOR		2081	2100	2081		
Product Information							
4000H (R)	VENDOR CODE 865 = SEL		0	65535	865	na	
4001H (R)	PRODUCT CODE		0	65535	101	na	
4002H (R/W)	ASA NUMBER LOW		0	65535		na	
4003H (R/W)	ASA NUMBER HIGH		0	65535		na	
4004H (R)	FIRMWARE REVISION		1	32639		na	
4005H (R)	NUM OF PAR		1	2100	2100	na	
4006H (R)	NUM OF PAR GROUP		1	100	69	na	
4007H (R/W)	MAC ID		1	99	0	na	
4008H (R/W)	DN BAUD RATE 0 = 125 kbps 1 = 250 kbps 2 = 500 kbps 3 = AUTO		0	9	0	na	
4009H (R/W)	DN STATUS Bit 0 = Explicit Cnxn Bit 1 = I/O Cnxn Bit 2 = Explicit Fault Bit 3 = I/O Fault Bit 4 = I/O Idle Bit 5–Bit 15 = Reserved		0	31	0 Bit 0	na	
400AH	not used						
400BH (R)	CONFIG PAR CKSUM				0	na	

Table D.34 Modbus Register Map[a] (Sheet 38 of 38)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
400CH (R)	LANGUAGE CODE 0 = English 1 = French 2 = Spanish (Mexican) 3 = Italian 4 = German 5 = Japanese 6 = Portuguese 7 = Mandarin Chinese 8 = Russian 9 = Dutch				0	na	
400DH (R)	FIRMWARE BUILD		16400	16400	0	na	
400EH	not used						
400FH (R)	PRODUCT SUPPORT Bit 0 = 2nd IO Card installed Bits 1–15 = Reserved					na	
4010H (R/W)	SETTINGS TIMEOUT	ms	500	65535	500	na	
4011H–4013H	Reserved[d]		0	0	0		
4014H (R)	CONFIGURED BIT Bit 0 = Unit Configured Bits 1–15 = Reserved				0	na	
4015H (R)	Reserved[d]		0	0	0	na	
4016H (R)	ERROR REGISTER Bit 0 = Settings Read Error Bit 1 = Setting Write Error Bit 2 = Settings Update Error Bit 3 = Settings Resource Error Bit 4 = Settings Locked Bit 5 = Group Settings Error Bit 6 = Global Settings Error Bit 7 = Logic Settings Error Bit 8 = Report Settings Error Bit 9 = Front Panel Settings Error Bit 10 = Memory Not Available Bit 11 = Settings Prep Error Bit 12 = Setting Changes Disabled Bit 13 = Memory Diag Error Bit 14 = Reserved Bit 15 = Reserved		0	65535	0	na	
4017H (R)	ERROR ADDRESS		0	65535	0	na	
4018H–401FH (R)	Reserved[d]		0	0	0	na	

[a] All addresses in this table refer to the register addresses in the Modbus packet.
[b] Registers labeled (R/W) are read-write registers. Registers labeled (W) are write-only registers. Registers Labeled (R) are read-only registers.
[c] Register value • multiplier = system value as seen by the relay. For example, if the register 651 (IA angle) reads 300 in decimal, then the system value is 30 degrees (multiplier = 0.1).
[d] Reserved addresses return 0.
[e] Read this register only when the PT connection is DELTA.
[f] Read this register only when the PT connection is WYE.
[g] Asserts when the relay issues a thermal element trip because of locked rotor or running overload conditions.
[h] Asserts when the relay issues a thermal element alarm because of locked rotor or running overload conditions.

Appendix E
IEC 61850 Communications

Features

NOTE: The SEL-710 supports one CID file, which should be transferred only if a change in the relay configuration is required. If an invalid CID file is transferred, the relay will no longer have a valid IEC 61850 configuration, and the protocol will stop operating. To restart protocol operation, a valid CID must be transferred to the relay.

The SEL-710 Motor Protection Relay supports the following features using Ethernet and IEC 61850:

- SCADA—Connect as many as six simultaneous IEC 61850 MMS client sessions. The SEL-710 also supports as many as six buffered and six unbuffered report control blocks. See the CON Logical Device Table for Logical Node mapping that enables SCADA control via a Manufacturing Messaging Specification (MMS) browser. Controls support the direct control, Select Before Operate control (SBO), and SBO with enhanced security control models.
- Peer-to-Peer Real-Time Status and Control—Use GOOSE with as many as 16 incoming (receive) and 8 outgoing (transmit) messages. Virtual bits (VB001–VB128), motor stop (STOP), and motor start (STR) bits can be mapped from incoming GOOSE messages.
- Configuration—Use an FTP client software or ACSELERATOR Architect SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- Commissioning and Troubleshooting—Use software such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc., to browse the relay logical nodes and verify functionality.

This appendix presents the information you need to use the IEC 61850 features of the SEL-710:

- *IEC 61850 Introduction*
- *IEC 61850 Operation*
- *IEC 61850 Configuration*
- *Logical Node Extensions*
- *Logical Nodes*
- *Protocol Implementation Conformance Statement*
- *ACSI Conformance Statements*

IEC 61850 Introduction

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards. The IEC 61850 standard consists of the parts listed in *Table E.1*.

Table E.1 IEC 61850 Document Set

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communication requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communications structure for substations and feeder equipment-Principles and models
IEC 61850-7-2	Basic communications structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communications structure for substations and feeder equipment-Common data classes
IEC 61850-7-4	Basic communications structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes
IEC 61850-8-1	SCSM-Mapping to Manufacturing Messaging Specification (MMS) (ISO/IEC 9506-1 and ISO/IEC 9506-2 over ISO/IEC 8802-3)
IEC 61850-9-1	SCSM-Sampled values over serial multidrop point-to-point link
IEC 61850-9-2	SCSM-Sampled values over ISO/IEC 8802-3
IEC 61850-10	Conformance testing

The IEC 61850 document set, which is available directly from the IEC at http://www.iec.ch, contains the information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 61850 systems be familiar with the appropriate sections of these documents.

IEC 61850 Operation

Ethernet Networking

IEC 61850 and Ethernet networking are available as options in the SEL-710. In addition to IEC 61850, the Ethernet port provides support protocols and data exchange, including FTP and Telnet. Access the SEL-710 **Port 1** settings to configure all of the Ethernet settings, including IEC 61850 enable settings.

The SEL Ethernet port supports IEC 61850 services, including transport of Logical Node objects, over TCP/IP. The Ethernet port can coordinate a maximum of six concurrent IEC 61850 sessions.

Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) model to define a set of service and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. These abstract models are used to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs and CDC attributes are used as building blocks for defining Local Nodes.

UCA2 uses GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED may contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

Logical nodes can be organized into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices, and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table E.2* shows how the A-phase current expressed as MMXUAphsA$cVal is broken down into its component parts.

Table E.2 Example IEC 61850 Descriptor Components

Components		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
PhsA	Sub-Data Object	Phase A
cVal	Data Attribute	Complex value

Data Mapping

Device data are mapped to IEC 61850 Logical Nodes (LN) according to rules defined by SEL. Refer to IEC 61850-5:2003(E) and IEC 61850-7-4:2003(E) for the mandatory content and usage of these LNs. The SEL-710 Logical Nodes are grouped under Logical Devices for organization based on function. See *Table E.3* for descriptions of the Logical Devices in an SEL-710. See Logical Nodes for a description of the LNs that make up these Logical Devices.

Table E.3 SEL-710 Logical Devices

Logical Device	Description
ANN	Annunciator elements—alarms, status values
CFG	Configuration elements—datasets and report control blocks
CON	Control elements—Remote bits
MET	Metering or Measurement elements—currents, voltages, power, etc.
PRO	Protection elements—protection functions and breaker control

MMS

Manufacturing Messaging Specification (MMS) provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can be unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers. MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from that start, and why the IEC chose to keep it for IEC 61850.

GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the messages several times, increasing the likelihood that other devices receive the messages.

IEC 61850 GOOSE objects can quickly and conveniently transfer status, controls, and measured values between peers on an IEC 61850 network. Configure SEL devices to respond to GOOSE messages from other network with ACSELERATOR Architect. Also, configure outgoing GOOSE messages for SEL devices in ACSELERATOR Architect. See the ACSELERATOR Architect online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference) in each outgoing message and an Ethernet multicast group address. Devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages.

NOTE: Virtual bits mapped to GOOSE subscriptions retain their state until they are overwritten, a new CID file is loaded, or the device is restarted. To reset the virtual bits and remote analogs by restarting the device, issue an **STA C** command or remove and then restore power to the device.

Virtual bits (VB001–VB128) are control inputs that you can map to GOOSE receive messages using ACSELERATOR Architect. See the VB*nnn* bits in *Table E.17* for details on which logical nodes and names are used for these bits. This information can be useful when searching through device data with MMS browsers. If you intend to use any SEL-710 Virtual bits for controls, you must create SELOGIC equations to define these operations. The Virtual Bit Logical Nodes only contain Virtual bit status, and only those Virtual bits that are assigned to an SER report are able to track bit transitions (via reporting) between LN data update scans. In addition to the Virtual bits, the motor stop (STOP) and motor start (STR) can also be mapped to GOOSE receive messages.

File Services

The Ethernet File System allows reading or writing data as files. The File System supports FTP. The File System provides:

- A means for the devices to transfer data as files
- A hierarchical file structure for the device data (root level only for SEL-700 series devices)

SCL Files

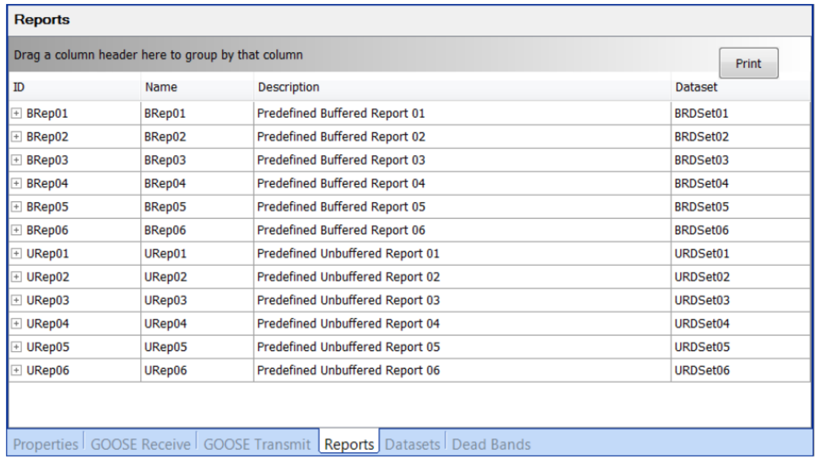
Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- IED Capability Description file (.ICD)
- System Specification Description (.SSD) file
- Substation Configuration Description file (.SCD)
- Configured IED Description file (.CID)

The ICD file described the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the required LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Reports

The SEL-710 supports buffered and unbuffered report control blocks in the report model as defined in IEC 61850-8-1:2004(E). The predefined reports shown in *Figure E.1* are available by default via IEC 61850.


Reports

Drag a column header here to group by that column

Print

ID	Name	Description	Dataset
BRep01	BRep01	Predefined Buffered Report 01	BRDSet01
BRep02	BRep02	Predefined Buffered Report 02	BRDSet02
BRep03	BRep03	Predefined Buffered Report 03	BRDSet03
BRep04	BRep04	Predefined Buffered Report 04	BRDSet04
BRep05	BRep05	Predefined Buffered Report 05	BRDSet05
BRep06	BRep06	Predefined Buffered Report 06	BRDSet06
URep01	URep01	Predefined Unbuffered Report 01	URDSet01
URep02	URep02	Predefined Unbuffered Report 02	URDSet02
URep03	URep03	Predefined Unbuffered Report 03	URDSet03
URep04	URep04	Predefined Unbuffered Report 04	URDSet04
URep05	URep05	Predefined Unbuffered Report 05	URDSet05
URep06	URep06	Predefined Unbuffered Report 06	URDSet06

Properties | GOOSE Receive | GOOSE Transmit | Reports | Datasets | Dead Bands

Figure E.1 SEL-710 Predefined Reports

There are twelve report control blocks, six buffered and six unbuffered reports. For each report control block, there can be just one client association, i.e., only one client can be associated to a report control block (BRCB or URCB) at any given time. The number of reports (12) and the type of reports (buffered or unbuffered) cannot be changed. However, by using ACSELERATOR Architect, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets. For buffered reports, connected clients may edit the report parameters shown in *Table E.4*.

Table E.4 Buffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep06
RptEna	YES	YES	FALSE
OptFlds	YES		SeqNum
			timeStamp
			dataSet
			configRef
			reasonCode
			dataRef
BufTm	YES		500
TrgOp	YES		dchg
			qchg
IntgPd	YES		0
GI	YES[a b]	YES[a]	FALSE
PurgeBuf	YES[a]		FALSE
EntryId	YES		0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.
[b] When disabled, a GI will be processed and the report buffered if a buffer has been previously established. A buffer is established when the report is enabled for the first time.

Similarly, for unbuffered reports, connected clients may edit the report parameters shown in *Table E.5*.

Table E.5 Unbuffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep06
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		segNum
			timeStamp
			dataSet
			configRef
			reasonCode
			dataRef
BufTm	YES		250
TrgOps	YES		dchg qchg
IntgPd	YES		0
GI		YES[a]	0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.

For Buffered Reports, only one client can enable the RptEna attribute of the BRCB at a time resulting in a client association for that BRCB. Once enabled, the associated client has exclusive access to the BRCB until the connection is closed or the client disables the RptEna attribute. Once enabled, all unassociated clients have read only access to the BRCB.

For Unbuffered Reports, as many as six (6) clients can enable the RptEna attribute of the URCB at a time, resulting in multiple client associations for that URCB. Once enabled, each client has independent access to a copy of that URCB. The Resv attribute is writable, however, the SEL-710 does not support reservations. Writing any field of the URCB causes the client to obtain their own copy of the URCB-in essence, acquiring a reservation.

Reports are serviced at a 2 Hz rate. The client can set the IntgPd to any value with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The report service rate of 2 Hz results in a report being sent within 500 ms of expiration of the IntgPd. The new IntgPd begins at the time that the current report is serviced.

Datasets

Datasets are configured using ACSELERATOR Architect and contain data attributes that represent real data values within the SEL-710 device. See *Logical Nodes* for logical node tables listing the available data attributes for each logical node and the Relay Word bit mapping for these data attributes. The datasets listed in *Figure E.2* are the defaults for an SEL-710 device. Datasets BRDSet01–BRDSet06 and URDSet01–URDSet06 are preconfigured with common FCDAs to be used for reporting. These data sets can be configured to represent the data you want to monitor. Dataset GPDSet01, which contains breaker status and control data attributes, is used in the default GOOSE Control Publication.

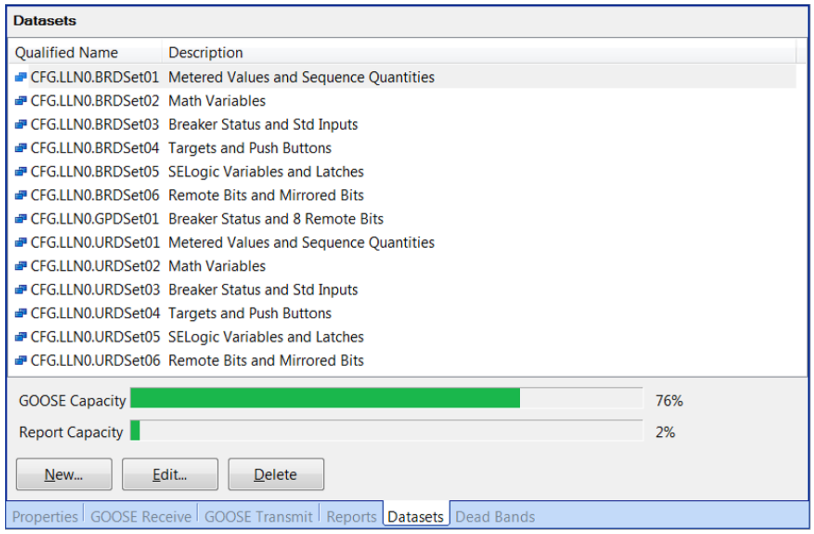


Figure E.2 SEL-710 Datasets

Within Architect, IEC 61850 datasets have two main purposes:

➤ GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.

NOTE: Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

➤ Reports: Twelve predefined datasets (BRDSet01–BRDSet06 and URDSet01–URDSet06) correspond to the default six buffered and six unbuffered reports. Note that you cannot change the number (12) or type of reports (buffered or unbuffered) within ACSELERATOR Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client receives with a report.

Supplemental Software

Examine the data structure and value of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 MMS from Sisco, Inc. The settings needed to browse an SEL-710 with an MMS browser are shown below:

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The time stamp is determined when data or quality change is detected.

The time stamp is applied to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion when a data or quality change is detected. However, there is a difference in how the change is detected between the different attribute types. For points that are assigned as SER points, i.e., programmed in the SER report, the change is detected as the receipt of an SER record (which contains the SER time stamp) within the relay.

For all other Booleans or Bstrings, the change is detected via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the deadband configured for the point to indicate a change and apply the time stamp. In all cases, these time stamps are used for the reporting model.

Functionally Constrained Data Attributes mapped to points in the SER dataset have 1 ms SER-accurate time stamps for data change events. In order to ensure that you will get SER-quality time stamps for changes to certain points, you must include those points in the SER report. All other FCDAs are scanned for data changes on a 1/2-second interval and have 1/2-second time stamp accuracy. See the **SET R** command for information on programming the SER report.

The SEL-710 uses GOOSE quality attributes to indicate the quality of the data in its transmitted GOOSE messages. Under normal conditions, all attributes are zero, indicating good quality data. *Figure E.3* shows the GOOSE quality attributes available to devices that subscribe to GOOSE messages from SEL-710 datasets that contain them. Internal status indicators provide the information necessary for the device to set these attributes. For example, if the device becomes disabled, as shown via status indications (e.g., an internal self-test failure), the SEL-710 will set the Validity attribute to invalid and the Failure attribute to TRUE. Note that the SEL-710 does not set any of the other quality attributes. These attributes will always indicate FALSE (0). See the ACSELERATOR Architect online help for additional information on GOOSE Quality attributes.

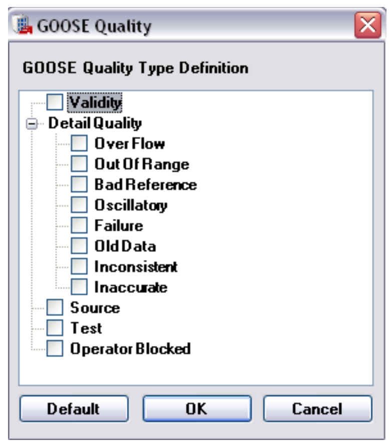


Figure E.3 Goose Quality

GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2003(E), IEC 61850-7-2:2003(E), and IEC 61850-8-1:2004(E) via the installed Ethernet port. Outgoing GOOSE messages are processed in accordance with the following constraints:

- The user can define as many as eight outgoing GOOSE messages consisting of any Data Attribute (DA) from any Logical Node. A single DA can be mapped to one or more outgoing GOOSE, or one or more times within the same outgoing GOOSE. A user can also map a single GOOSE dataset to multiple GOOSE control blocks.
- The SEL-710 will transmit all configured GOOSE immediately upon successful initialization. If a GOOSE is not retriggered, then, following initial transmission, the SEL-710 will retransmit that GOOSE on a curve. The curve begins at 10 ms and doubles for each retransmission until leveling at the maximum specified in the CID file for that GOOSE. For example, a message with a maximum retransmit interval of 100 ms is retransmitted at intervals of 10 ms, 20 ms, 40 ms, 80 ms, and 100 ms, then repeated every 100 ms until a trigger causes

the transmission sequence to be repeated. The time-to-live reported in each transmitted message, is three times the current interval, or two times the interval, if the maximum time-to-live has been reached (30 ms, 60 ms, 120 ms, 240 ms, and 200 ms for the previous example; see IEC 61850-8-1, Sec. 18.1).

- GOOSE transmission is squelched (silenced) after a permanent (latching) self-test failure.
- Each outgoing GOOSE includes communications parameters (VLAN, Priority, and Multicast Address) and is transmitted entirely in a single network frame.
- The SEL-710 will maintain the configuration of outgoing GOOSE through a power cycle and device reset.

Incoming GOOSE messages are processed in accordance with the following constraints:

- You can configure the SEL-710 to subscribe to as many as 16 incoming GOOSE messages.
- Control bits in the relay get data from incoming GOOSE messages which are mapped to virtual bits (VB*nnn*). Virtual bits are volatile and are reset to zero when a new CID file is loaded, the device is restarted, or they are overwritten by data from a subscribed GOOSE message.
- The SEL-710 recognizes incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks shall be rejected.
  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference
- Rejection of all DA contained in an incoming GOOSE, based on the accumulation of the following error indications created by inspection of the received GOOSE:
  - **Configuration Mismatch**: the configuration number of the incoming GOOSE changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE is true.
  - **Test Mode**: this Boolean parameter of the incoming GOOSE is true.
  - **Decode Error**: the format of the incoming GOOSE is not as configured.
- The SEL-710 will discard incoming GOOSE under the following conditions:
  - after a permanent (latching) self-test failure
  - when EGSE is set to No
  - when the relay is disabled

Link-layered priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2004(E).

IEC 61850 Configuration

Settings

Table E.6 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol.

Table E.6 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 interface enable	Y, N	N
EGSE	Outgoing IEC 61850 GSE message enable	Y[a], N	N

[a] Requires E61850 set to Y to send IEC 61850 GSE messages.

Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with ACSELERATOR Architect SEL-5032 Software.

Architect Software

The Architect software enables users to design and commission IEC 61850 substations containing SEL IEDs. Users can use Architect to do the following:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.
- Edit and create GOOSE datasets.
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options.
- Use or edit preconfigured datasets for reports.
- Load IEC 61850 CID files into SEL IEDs.
- Generate ICD and CID files that will provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit deadband settings for measured values.

Architect provides a GUI for users to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the user first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The user can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain.

Some measured values are reported to IEC 61850 only when the value changes beyond a defined deadband value. Architect allows a deadband to be changed during the CID file configuration. Check and set the deadband values for your particular application when configuring the CID file for a device.

Architect has the capability to read other manufacturers' ICD and CID files, enabling the user to map the data seamlessly into SEL IED logic. See the Architect online help for more information.

SEL ICD File Versions

Architect generates CID files from ICD files so the ICD file version Architect uses also determines the CID file version generated. Details about the different SEL-710 ICD files can be found in *Table A.7*.

Logical Node Extensions

The following Logical Nodes and Data Classes were created in this device as extensions to the IEC 61850 standard, in accordance with the IEC 61850 guidelines.

Table E.7 New Logical Node Extensions

Logical Node	IEC 61850	Description or Comments
Thermal Measurements (for equipment or ambient temperature readings)	MTHR	This LN shall be used to represent values from RTDs and to calculate thermal capacity and usage; mainly used for Thermal Monitoring.
Demand Metering Statistics	MDST	This LN shall be used for calculation of demand currents in a three-phase system. This shall not be used for billing purposes.
Motor Measurement Data	MMOT	This LN shall be used for the motor measurement data.
Circuit Breaker Supervision	SCBR	This LN shall be used for circuit breaker supervision abrasion and operation values.

Table E.8 defines the data class, Thermal Metering Data. This class is a collection of simultaneous measurements (or evaluations) that represent the RTD thermal metering values. Valid data depends on the presence and configuration of the RTD module(s).

Table E.8 Thermal Metering Data Logical Node Class Definition (Sheet 1 of 2)

MTHR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
EEHealth	INS	External equipment health (RTD Communications Status)		E
Data Objects				
Measured Values				
MaxAmbTmp	MV	Maximum Ambient Temperature		E
MaxBrgTmp	MV	Maximum Bearing Temperature		E
MaxOthTmp	MV	Maximum Other Temperature		E

Table E.8 Thermal Metering Data Logical Node Class Definition (Sheet 2 of 2)

MTHR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
MaxWdgTmp	MV	Maximum Winding Temperature		E
Tmp	MV	Temperature		E

[a] Transient data objects-the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table E.9 defines the data class Demand Metering Statistics. This class is a collection of demand currents and energy.

Table E.9 Demand Metering Statistics Logical Node Class Definition

MDST Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from the Common Logical Node Class.		M
Data Objects				
Measured Values				
NegVArh	MV	Reactive energy supply (default supply direction: energy flow towards busbar)		E
DmdWh	MV	Real energy demand (default demand direction: energy flow from busbar away)		E
PosVArh	MV	Reactive energy demand (default demand direction: energy flow from busbar away)		E

[a] Transient data objects-the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table E.10 defines the data class Motor Measurement Data. This class is a collection of motor measurement data.

Table E.10 Motor Measurement Data Logical Node Class Definition (Sheet 1 of 2)

MMOT Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from the Common Logical Node Class.		M

Table E.10 Motor Measurement Data Logical Node Class Definition (Sheet 2 of 2)

MMOT Class				
Attribute Name	**Attr. Type**	**Explanation**	**T[a]**	**M/O/ C/E[b]**
Data Objects				
Measured Values				
StrTcu	MV	Stator % Thermal Capacity Used		E
RtrTcu	MV	Rotor % Thermal Capacity Used		E
RtdTcu	MV	RTD % Thermal Capacity Used		E
Mload	MV	Motor Load, pu of FLA		E
ThrmTp	MV	Thermal Trip, seconds		E
Trst	MV	Time to reset, minutes		E
StrtAv	MV	Starts available		E
Slip	MV	Slip, %		E
Mrt	MV	Motor Running Time, hours		E

[a] Transient data objects-the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table E.11 Circuit Breaker Supervision (Per-Phase) Logical Node Class Definition

SCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/ C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from the Common Logical Node Class.		M
Data Objects				
Status Information				
ColOpn	SPS	Open command of trip coil		M
Measured Values				
AbrPrt	MV	Calculated or measured wear (e.g. of main contact), expressed in % where 0 % corresponds to new condition		E

[a] Transient data objects-the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table E.12 Compatible Logical Nodes With Extensions

Logical Node	IEC 61850	Description or comments
Metering Statistics	MSTA	This LN is used for power system metering statistics.
Circuit Breaker	XCBR	This LN is used for circuit breaker status and measurement data.

Table E.13 Metering Statistics Logical Node Class Definition

MSTA Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured and Metered Values				
AvAmps	MV	Average current		O
AvVolts	MV	Average voltage		O
MaxVA	MV	Maximum apparent power		O
MinVA	MV	Minimum apparent power		O
MaxW	MV	Maximum real power		O
MinW	MV	Minimum real power		O
MaxVAr	MV	Maximum reactive power		O
MinVAr	MV	Minimum reactive power		O
MaxA	WYE	Maximum phase currents		E
MinA	WYE	Minimum phase currents		E
MaxPhV	WYE	Maximum phase-to-ground voltages		E
MinPhV	WYE	Minimum phase-to-ground voltages		E
MaxP2PV	DEL	Maximum phase-to-phase voltages		E
MinP2PV	DEL	Minimum phase-to-phase voltages		E

[a] Transient data objects-the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension

Table E.14 Circuit Breaker Logical Node Class Definition

XCBR Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix, and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from the Common Logical Node Class.		M
Data Objects				
Status Information				
Loc	SPS	Local control behavior		M
OpCnt	INS	Operation counter		M
OpCntEx	INS	Operation counter – external		E
Measured and Metered Values				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M

[a] Transient data objects-the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Logical Nodes

The following tables, *Table E.15* through *Table E.19*, show the Logical Nodes (LN) supported in the SEL-710 and the associated Relay Word bits or measured quantities. *Table E.15* shows the LN associated with protection elements defined as Logical Device PRO.

Table E.15 Logical Device: PRO (Protection) (Sheet 1 of 4)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
MCCSWI1	Pos.Oper.ctlVal	STR[a]	Breaker/Contactor close/open command
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = ST			
A49PTTR1	Op.general	49A	Thermal alarm
A55POPF1	Op.general	55A	Power factor alarm
A55POPF1	Str.general	55A	Power factor alarm
A55POPF1	Str.dirGeneral	unknown	Direction undefined
ABSLOPMRI1	Op.general	ABSLO	Antibackspin lockout condition
ATPTOC8	Op.general	51AT	Phase A time-overcurrent element trip
ATPTOC8	Str.general	51AP	Phase A time-overcurrent element pickup
ATPTOC8	Str.dirGeneral	unknown	Direction undefined
BFR1RBRF1	OpEx.general	BFT	Breaker failure trip
BFR1RBRF1	Str.general	BFI	Breaker failure initiation
BK1XCBR1	BlkCls.stVal	0	Breaker/Contactor close blocking not configured by default
BK1XCBR1	BlkOpn.stVal	0	Breaker/Contactor open blocking not configured by default
BK1XCBR1	CBOpCap.stVal	None	Breaker/Contactor physical operation capabilities not known to relay
BK1XCBR1	Loc.stVal	0	Breaker/Contactor local control status not configured by default
BK1XCBR1	OpCnt.stVal	INTT	Internal trip counter
BK1XCBR1	OpCntEx.stVal	EXTT	External trip counter
BK1XCBR1	Pos.stVal	52A?1:2[b]	Breaker position (52A = false, breaker opened; 52A = true, breaker closed)
BTPTOC9	Op.general	51BT	Phase B time-overcurrent element trip
BTPTOC9	Str.general	51BP	Phase B time-overcurrent element pickup
BTPTOC9	Str.dirGeneral	unknown	Direction undefined
CTPTOC10	Op.general	51CT	Phase C time-overcurrent element trip
CTPTOC10	Str.general	51CP	Phase C time-overcurrent element pickup
CTPTOC10	Str.dirGeneral	unknown	Direction undefined
D1TPTOF1	Op.general	81D1T	Level 2 trip definite time over- and underfrequency elements
D1TPTOF1	Str.general	81D1T	Level 2 trip definite time over- and underfrequency elements
D1TPTOF1	Str.dirGeneral	unknown	Direction undefined
D2TPTOF2	Op.general	81D2T	Level 2 trip definite time over- and underfrequency elements
D2TPTOF2	Str.general	81D2T	Level 2 trip definite time over- and underfrequency elements
D2TPTOF2	Str.dirGeneral	unknown	Direction undefined
D3TPTOF3	Op.general	81D3T	Level 3 trip definite time over- and underfrequency elements
D3TPTOF3	Str.general	81D3T	Level 3 trip definite time over- and underfrequency elements
D3TPTOF3	Str.dirGeneral	unknown	Direction undefined
D4TPTOF4	Op.general	81D4T	Level 4 trip definite time over- and underfrequency elements
D4TPTOF4	Str.general	81D4T	Level 4 trip definite time over- and underfrequency elements
D4TPTOF4	Str.dirGeneral	unknown	Direction undefined
G1TPIOC5	Op.general	50G1T	Definite-time residual overcurrent trip
G1TPIOC5	Str.general	50G1P	Definite-time residual overcurrent trip pickup
G1TPIOC5	Str.dirGeneral	unknown	Direction undefined

Table E.15 Logical Device: PRO (Protection) (Sheet 2 of 4)

Logical Node	Attribute	Data Source	Comment
G1TPTOC5	Op.general	51G1T	Level 1 residual ground time-overcurrent element trip
G1TPTOC5	Str.general	51G1P	Level 1 residual ground time-overcurrent element pickup
G1TPTOC5	Str.dirGeneral	unknown	Direction undefined
G2TPIOC6	Op.general	50G2T	Definite-time residual overcurrent alarm
G2TPIOC6	Str.general	50G2P	Definite-time residual overcurrent alarm pickup
G2TPIOC6	Str.dirGeneral	unknown	Direction undefined
G2TPTOC6	Op.general	51G2T	Level 2 residual ground time-overcurrent element trip
G2TPTOC6	Str.general	51G2P	Level 2 residual ground time-overcurrent element pickup
G2TPTOC6	Str.dirGeneral	unknown	Direction undefined
JALRMPMSS1	Op.general	JAMALRM	Load-jam trip
JALRMPMSS1	Str.general	JAMALRM	Load-jam trip
JALRMPMSS1	Str.dirGeneral	unknown	Direction undefined
JTRIPPMSS2	Op.general	JAMTRIP	Load-jam trip
JTRIPPMSS2	Str.general	JAMTRIP	Load-jam trip
JTRIPPMSS2	Str.dirGeneral	unknown	Direction undefined
LALRMPTUC1	Op.general	LOSSALRM	Level 1 trip definite time differential element
LALRMPTUC1	Str.general	LOSSALRM	Level 1 pickup definite time differential element
LALRMPTUC1	Str.dirGeneral	unknown	Direction undefined
LOPPTUV3	Op.general	LOP	Level 1 trip definite time differential element
LOPPTUV3	Str.general	LOP	Level 1 pickup definite time differential element
LOPPTUV3	Str.dirGeneral	unknown	Direction undefined
LTRIPPTUC2	Op.general	LOSSTRIP	Level 1 trip definite time differential element
LTRIPPTUC2	Str.general	LOSSTRIP	Level 1 pickup definite time differential element
LTRIPPTUC2	Str.dirGeneral	unknown	Direction undefined
M1PDIF1	Op.general	87M1T	Level 1 trip definite time differential element
M1PDIF1	Str.general	87M1	Level 1 pickup definite time differential element
M1PDIF1	Str.dirGeneral	unknown	Direction undefined
M2PDIF2	Op.general	87M2T	Level 2 trip definite time differential element
M2PDIF2	Str.general	87M2	Level 2 pickup definite time differential element
M2PDIF2	Str.dirGeneral	unknown	Direction undefined
MCCSWI1	OpCls.general	STR	Breaker/Contactor close control
MCCSWI1	OpOpn.general	STOP	Breaker/Contactor open control
MCCSWI1	Pos.stVal	52A?1:2[b]	Breaker/Contactor position (52A = false, breaker opened; 52A = true, breaker closed)
N1TPIOC3	Op.general	50N1T	Definite-time neutral overcurrent trip
N1TPIOC3	Str.general	50N1P	Definite-time neutral overcurrent trip pickup
N1TPIOC3	Str.dirGeneral	unknown	Direction undefined
N2TPIOC4	Op.general	50N2T	Definite-time neutral overcurrent alarm
N2TPIOC4	Str.general	50N2P	Definite-time neutral overcurrent alarm pickup
N2TPIOC4	Str.dirGeneral	unknown	Direction undefined
NOSLOPMRI2	Op.general	NOSLO	Starts-per-hour lockout condition
P1TPIOC1	Op.general	50P1T	Definite-time phase overcurrent trip
P1TPIOC1	Str.general	50P1P	Definite-time phase overcurrent trip pickup
P1TPIOC1	Str.dirGeneral	unknown	Direction undefined
P1TPTOC3	Op.general	51P1T	Level 1 maximum phase time-overcurrent element trip
P1TPTOC3	Str.general	51P1P	Level 1 maximum phase time-overcurrent element pickup
P1TPTOC3	Str.dirGeneral	unknown	Direction undefined
P1TPTOV1	Op.general	59P1T	Phase overvoltage Level 1 trip
P1TPTOV1	Str.general	59P1	Phase overvoltage Level 1 trip pickup
P1TPTOV1	Str.dirGeneral	unknown	Direction undefined
P1TPTUV1	Op.general	27P1T	Definite-time phase overcurrent alarm

Table E.15 Logical Device: PRO (Protection) (Sheet 3 of 4)

Logical Node	Attribute	Data Source	Comment
P1TPTUV1	Str.general	27P1	Definite-time phase overcurrent alarm pickup
P1TPTUV1	Str.dirGeneral	unknown	Direction undefined
P2TPIOC2	Op.general	50P2T	Definite-time phase overcurrent alarm
P2TPIOC2	Str.general	50P2P	Definite-time phase overcurrent alarm pickup
P2TPIOC2	Str.dirGeneral	unknown	Direction undefined
P2TPTOC4	Op.general	51P2T	Level 2 maximum phase time-overcurrent element trip
P2TPTOC4	Str.general	51P2P	Level 2 maximum phase time-overcurrent element pickup
P2TPTOC4	Str.dirGeneral	unknown	Direction undefined
P2TPTOV2	Op.general	59P2T	Phase undervoltage Level 2 trip
P2TPTOV2	Str.general	59P2	Phase undervoltage Level 2 pickup
P2TPTOV2	Str.dirGeneral	unknown	Direction undefined
P2TPTUV2	Op.general	27P2T	Phase undervoltage Level 2 trip
P2TPTUV2	Str.general	27P2	Phase undervoltage Level 2 pickup
P2TPTUV2	Str.dirGeneral	unknown	Direction undefined
PA37PDUP1	Op.general	37PA	Underpower alarm
PA37PDUP1	Str.general	37PA	Underpower alarm
PA37PDUP1	Str.dirGeneral	unknown	Direction undefined
PT37PDUP2	Op.general	37PT	Underpower trip
PT37PDUP2	Str.general	37PT	Underpower trip
PT37PDUP2	Str.dirGeneral	unknown	Direction undefined
PTCTPTTR7	Op.general	PTCTRIP	Asserts when measured PTC loop resistance is greater than set value
Q1TPIOC7	Op.general	50Q1T	Definite-time negative-sequence overcurrent trip
Q1TPIOC7	Str.general	50Q1P	Definite-time negative-sequence overcurrent trip pickup
Q1TPIOC7	Str.dirGeneral	unknown	Direction undefined
Q2TPIOC8	Op.general	50Q2T	Definite-time negative-sequence overcurrent alarm
Q2TPIOC8	Str.general	50Q2P	Definite-time negative-sequence overcurrent alarm pickup
Q2TPIOC8	Str.dirGeneral	unknown	Direction undefined
QTPTOC7	Op.general	51QT	Negative-sequence time-overcurrent element trip
QTPTOC7	Str.general	51QP	Negative-sequence time-overcurrent element pickup
QTPTOC7	Str.dirGeneral	unknown	Direction undefined
R49PTTR4	Op.general	49T_RTR	Thermal trip, rotor thermal model
RTDAPTTR5	Op.general	RTDA	Winding/Bearing RTD overtemperature alarm
RTDTPTTR6	Op.general	RTDT	Winding/Bearing RTD overtemperature trip
S49PTTR3	Op.general	49T_STR	Thermal trip, stator thermal model
SPDSALPZSU1	Op.general	SPDSAL	Speed switch alarm
SPDSALPZSU1	Str.general	SPDSAL	Speed switch alarm
SPDSALPZSU1	Str.dirGeneral	unknown	Direction undefined
SPDSTRPZSU2	Op.general	SPDSTR	Speed switch trip
SPDSTRPZSU2	Str.general	SPDSTR	Speed switch trip
SPDSTRPZSU2	Str.dirGeneral	unknown	Direction undefined
T47PTOV3	Op.general	47T	Thermal trip
T47PTOV3	Str.general	47T	Thermal trip
T47PTOV3	Str.dirGeneral	unknown	Direction undefined
T49PTTR2	Op.general	49T	Thermal trip
T55POPF2	Op.general	55T	Power factor trip
T55POPF2	Str.general	55T	Power factor trip
T55POPF2	Str.dirGeneral	unknown	Direction undefined
TBSLOPMRI3	Op.general	TBSLO	Time between starts lockout condition
THRMLOPMRI4	Op.general	THERMLO	Thermal lockout condition
TRIPPTRC1	Tr.general	TRIP	Trip logic output
UB46APTOC1	Op.general	46UBA	Phase current unbalance alarm

Table E.15 Logical Device: PRO (Protection) (Sheet 4 of 4)

Logical Node	Attribute	Data Source	Comment
UB46APTOC1	Str.general	46UBA	Phase current unbalance alarm
UB46APTOC1	Str.dirGeneral	unknown	Direction undefined
UB46TPTOC2	Op.general	46UBT	Phase current unbalance trip
UB46TPTOC2	Str.general	46UBT	Phase current unbalance trip
UB46TPTOC2	Str.dirGeneral	unknown	Direction undefined
VARAPDOP1	Op.general	VARA	Reactive power alarm$
VARAPDOP1	Str.dirGeneral	unknown	Direction undefined
VARAPDOP1	Str.general	VARA	Reactive power trip
VARTPDOP2	Op.general	VART	Reactive power trip
VARTPDOP2	Str.dirGeneral	unknown	Direction undefined
VARTPDOP2	Str.general	VART	Reactive power trip

[a] Writing a 0 to MCCSWI1.CO.Pos.Oper.ctlVal causes STOP to assert and writing any other value causes STR to assert.
[b] If breaker/contactor is closed, value = 10 (2). If breaker/contactor is open, value = 01 (1).

Table E.16 shows the LN associated with measuring elements defined as Logical Device MET.

Table E.16 Logical Device: MET (Metering) (Sheet 1 of 3)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a b]			
DIFFMMXU3	A.phsA.instCVal.mag.f	IA87	Differential current, A-phase, magnitude
DIFFMMXU3	A.phsB.instCVal.mag.f	IB87	Differential current, B-phase, magnitude
DIFFMMXU3	A.phsC.instCVal.mag.f	IC87	Differential current, C-phase, magnitude
METMDST1	DmdWh.instMag.f	MWH3P	Real energy, three-phase OUT
METMDST1	NegVArh.instMag.f	MVARH3PI	Reactive energy, three-phase IN
METMDST1	PosVArh.instMag.f	MVARH3PO	Reactive energy, three-phase OUT
METMMXU1	A.phsA.instCVal.ang.f	IA_ANG	Current, A-phase, angle
METMMXU1	A.phsA.instCVal.mag.f	IA_MAG	Current, A-phase, magnitude
METMMXU1	A.phsB.instCVal.ang.f	IB_ANG	Current, B-phase, angle
METMMXU1	A.phsB.instCVal.mag.f	IB_MAG	Current, B-phase, magnitude
METMMXU1	A.phsC.instCVal.ang.f	IC_ANG	Current, C-phase, angle
METMMXU1	A.phsC.instCVal.mag.f	IC_MAG	Current, C-phase, magnitude
METMMXU1	A.res.instCVal.ang.f	IG_ANG	Current, calculated-residual, angle
METMMXU1	A.res.instCVal.mag.f	IG_MAG	Current, calculated-residual, magnitude
METMMXU1	A.neut.instCVal.ang.f	IN_ANG	Neutral current, angle
METMMXU1	A.neut.instCVal.mag.f	IN_MAG	Neutral current, magnitude
METMMXU1	Hz.instMag.f	FREQ	Frequency
METMMXU1	PhV.phsA.instCVal.ang.f	VA_ANG	Voltage, A-phase-to-neutral, angle
METMMXU1	PhV.phsA.instCVal.mag.f	VA_MAG	Voltage, A-phase-to-neutral, magnitude
METMMXU1	PhV.phsB.instCVal.ang.f	VB_ANG	Voltage, B-phase-to-neutral, angle
METMMXU1	PhV.phsB.instCVal.mag.f	VB_MAG	Voltage, B-phase-to-neutral, magnitude
METMMXU1	PhV.phsC.instCVal.ang.f	VC_ANG	Voltage, C-phase-to-neutral, angle
METMMXU1	PhV.phsC.instCVal.mag.f	VC_MAG	Voltage, C-phase-to-neutral, magnitude
METMMXU1	PhV.res.instCVal.ang.f	VG_ANG	Zero-sequence voltage, angle
METMMXU1	PhV.res.instCVal.mag.f	VG_MAG	Zero-sequence voltage, magnitude
METMMXU1	PPV.phsAB.instCVal.ang.f	VAB_ANG	Voltage, A-to-B-phase, angle
METMMXU1	PPV.phsAB.instCVal.mag.f	VAB_MAG	Voltage, A-to-B-phase, magnitude
METMMXU1	PPV.phsBC.instCVal.ang.f	VBC_ANG	Voltage, B-to-C-phase, angle

Table E.16 Logical Device: MET (Metering) (Sheet 2 of 3)

Logical Node	Attribute	Data Source	Comment
METMMXU1	PPV.phsBC.instCVal.mag.f	VBC_MAG	Voltage, B-to-C-phase, magnitude
METMMXU1	PPV.phsCA.instCVal.ang.f	VCA_ANG	Voltage, C-to-A-phase, angle
METMMXU1	PPV.phsCA.instCVal.mag.f	VCA_MAG	Voltage, C-to-A-phase, magnitude
METMMXU1	TotPF.instMag.f	PF	Power factor, three-phase, magnitude
METMMXU1	TotVA.instMag.f	S	Apparent power, three-phase, magnitude
METMMXU1	TotVAr.instMag.f	Q	Reactive power, three-phase, magnitude
METMMXU1	TotW.instMag.f	P	Real power, three-phase, magnitude
METMSQI1	MaxImbA.instMag.f	UBI	Current unbalance
METMSQI1	MaxImbV.instMag.f	UBV	Voltage unbalance
METMSQI1	SeqA.c1.instCVal.ang.f	I1_ANG	Positive-sequence current, angle
METMSQI1	SeqA.c1.instCVal.mag.f	I1_MAG	Positive-sequence current, magnitude
METMSQI1	SeqA.c2.instCVal.ang.f	I2_ANG	Negative-sequence current, angle
METMSQI1	SeqA.c2.instCVal.mag.f	I2_MAG	Negative-sequence current, magnitude
METMSQI1	SeqA.c3.instCVal.ang.f	IG_ANG	Current, calculated-residual, angle
METMSQI1	SeqA.c3.instCVal.mag.f	IG_MAG	Current, calculated-residual, magnitude
METMSQI1	SeqV.c1.instCVal.ang.f	V1_ANG	Positive-sequence voltage, angle
METMSQI1	SeqV.c1.instCVal.mag.f	V1_MAG	Positive-sequence voltage, magnitude
METMSQI1	SeqV.c2.instCVal.ang.f	V2_ANG	Negative-sequence voltage, angle
METMSQI1	SeqV.c2.instCVal.mag.f	V2_MAG	Negative-sequence voltage, magnitude
METMSQI1	SeqV.c3.instCVal.ang.f	VG_ANG	Zero-sequence voltage, angle
METMSQI1	SeqV.c3.instCVal.mag.f	VG_MAG	Zero-sequence voltage, magnitude
METMSTA1	AvAmps.instMag.f	IAV	Current, average current, magnitude
METMSTA1	AvVolts.instMag.f	VAVE	Average voltage, magnitude
METMSTA1	MaxA.phsA.instCVal.mag.f	IAMX	Current, A-phase, maximum magnitude
METMSTA1	MaxA.phsB.instCVal.mag.f	IBMX	Current, B-phase, maximum magnitude
METMSTA1	MaxA.phsC.instCVal.mag.f	ICMX	Current, C-phase, maximum magnitude
METMSTA1	MaxA.res.instCVal.mag.f	IGMX	Current, residual, maximum magnitude
METMSTA1	MaxA.neut.instCVal.mag.f	INMX	Current, neutral, maximum magnitude
METMSTA1	MaxP2PV.phsAB.instCVal.mag.f	VABMX	Voltage, A-to-B-phase, maximum magnitude
METMSTA1	MaxP2PV.phsBC.instCVal.mag.f	VBCMX	Voltage, B-to-C-phase, maximum magnitude
METMSTA1	MaxP2PV.phsCA.instCVal.mag.f	VCAMX	Voltage, C-to-A-phase, maximum magnitude
METMSTA1	MaxPhV.phsA.instCVal.mag.f	VAMX	Voltage, A-phase-to-neutral, maximum magnitude
METMSTA1	MaxPhV.phsB.instCVal.mag.f	VBMX	Voltage, B-phase-to-neutral, maximum magnitude
METMSTA1	MaxPhV.phsC.instCVal.mag.f	VCMX	Voltage, C-phase-to-neutral, maximum magnitude
METMSTA1	MaxVA.instMag.f	KVA3PMX	Apparent power, three-phase, maximum magnitude
METMSTA1	MaxVAr.instMag.f	KVAR3PMX	Reactive power, three-phase, maximum magnitude
METMSTA1	MaxW.instMag.f	KW3PMX	Real power, three-phase, maximum magnitude
METMSTA1	MinA.phsA.instCVal.mag.f	IAMN	Current, A-phase, minimum magnitude
METMSTA1	MinA.phsB.instCVal.mag.f	IBMN	Current, B-phase, minimum magnitude
METMSTA1	MinA.phsC.instCVal.mag.f	ICMN	Current, C-phase, minimum magnitude
METMSTA1	MinA.res.instCVal.mag.f	IGMN	Current, residual, minimum magnitude
METMSTA1	MinA.neut.instCVal.mag.f	INMN	Current, neutral, minimum magnitude
METMSTA1	MinP2PV.phsAB.instCVal.mag.f	VABMN	Voltage, A-to-B-phase, minimum magnitude
METMSTA1	MinP2PV.phsBC.instCVal.mag.f	VBCMN	Voltage, B-to-C-phase, minimum magnitude
METMSTA1	MinP2PV.phsCA.instCVal.mag.f	VCAMN	Voltage, C-to-A-phase, minimum magnitude
METMSTA1	MinPhV.phsA.instCVal.mag.f	VAMN	Voltage, A-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsB.instCVal.mag.f	VBMN	Voltage, B-phase-to-neutral, minimum magnitude
METMSTA1	MinPhV.phsC.instCVal.mag.f	VCMN	Voltage, C-phase-to-neutral, minimum magnitude
METMSTA1	MinVA.instMag.f	KVA3PMN	Apparent power, three-phase, minimum magnitude
METMSTA1	MinVAr.instMag.f	KVAR3PMN	Reactive power, three-phase, minimum magnitude
METMSTA1	MinW.instMag.f	KW3PMN	Real power, three-phase, minimum magnitude

Table E.16 Logical Device: MET (Metering) (Sheet 3 of 3)

Logical Node	Attribute	Data Source	Comment
MOTORMMOT1	Mload.instMag.f	MLOAD	Motor load
MOTORMMOT1	Mrt.instMag.f	MRT	Motor running time
MOTORMMOT1	RtdTcu.instMag.f	TCURTD	RTD % thermal capacity used
MOTORMMOT1	RtrTcu.instMag.f	TCURTR	Rotor % thermal capacity used
MOTORMMOT1	Slip.instMag.f	SLIP	Slip
MOTORMMOT1	StrtAv.instMag.f	STRTAV	Starts available
MOTORMMOT1	StrTcu.instMag.f	TCUSTR	Stator % thermal capacity used
MOTORMMOT1	ThrmTp.instMag.f	THRMTP	Thermal trip in
MOTORMMOT1	Trst.instMag.f	TRST	Time to reset
RMSMMXU2	A.phsA.instCVal.mag.f	IARMS	RMS current, A-phase, magnitude
RMSMMXU2	A.phsB.instCVal.mag.f	IBRMS	RMS current, B-phase, magnitude
RMSMMXU2	A.phsC.instCVal.mag.f	ICRMS	RMS current, C-phase, magnitude
RMSMMXU2	A.neut.instCVal.mag.f	INRMS	RMS current, neutral, magnitude
RMSMMXU2	PhV.phsA.instCVal.mag.f	VARMS	RMS voltage, A-phase, magnitude
RMSMMXU2	PhV.phsB.instCVal.mag.f	VBRMS	RMS voltage, B-phase, magnitude
RMSMMXU2	PhV.phsC.instCVal.mag.f	VCRMS	RMS voltage, C-phase, magnitude
RMSMMXU2	PPV.phsAB.instCVal.mag.f	VABRMS	RMS voltage, AB-phase-to-phase, magnitude
RMSMMXU2	PPV.phsBC.instCVal.mag.f	VBCRMS	RMS voltage, BC-phase-to-phase, magnitude
RMSMMXU2	PPV.phsCA.instCVal.mag.f	VCARMS	RMS voltage, CA-phase-to-phase, magnitude
THERMMTHR1	MaxAmbTmp.instMag.f	RTDAMB[c]	Ambient RTD temperature
THERMMTHR1	MaxBrgTmp.instMag.f	RTDBRGMX[c]	Maximum bearing RTD temperature
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[c]	Other maximum RTD temperature
THERMMTHR1	MaxWdgTmp.instMag.f	RTDWDGMX[c]	Maximum winding RTD temperature
THERMMTHR1	Tmp01.instMag.f–Tmp12.instMag.f	RTD1–RTD12[c]	RTD1–RTD12 temperature
Functional Constraint = ST			
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[c]	RTD input or communication status

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates and other attributes that are only updated when the source goes outside the data source's deadband (mag and cVal). Only the instantaneous values are shown in the table.
[b] Data validity depends on the relay model and installed card options. Refer to Section 1: Introduction and Specifications for different relay models and available card options. Refer to Section 5: Metering and Monitoring for the model dependent metering quantities.
[c] Valid data depends on E49RTD and RTD1LOC—RTD12LOC settings.

Table E.17 shows the LN associated with control elements defined as Logical Device CON.

Table E.17 Logical Device: CON (Remote Control) (Sheet 1 of 2)

Logical Node	Status	Control	Relay Word Bits	Comments
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01Oper.ctlVal–SPCSO08Oper.ctlVal	RB01–RB08	Remote Bits RB01–RB08
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09Oper.ctlVal–SPCSO16Oper.ctlVal	RB09–RB16	Remote Bits RB09–RB16

Table E.17 Logical Device: CON (Remote Control) (Sheet 2 of 2)

Logical Node	Status	Control	Relay Word Bits	Comments
RBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17Oper.ctlVal–SPCSO24Oper.ctlVal	RB17–RB24	Remote Bits RB17–RB24
RBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25Oper.ctlVal–SPCSO32Oper.ctlVal	RB25–RB32	Remote Bits RB25–RB32

Table E.18 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table E.18 Logical Device: ANN (Annunciation) (Sheet 1 of 3)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a]			
AINCGGIO21	AnIn01.instMag.f–AnIn08.instMag.f	AI301–AI308[b]	Analog Inputs (AI301–AI308)—Slot C
AINDGGIO22	AnIn01.instMag.f–AnIn08.instMag.f	AI401–AI408[b]	Analog Inputs (AI401–AI408)—Slot D
AINEGGIO23	AnIn01.instMag.f–AnIn08.instMag.f	AI501–AI508[b]	Analog Inputs (AI501–AI508)—Slot E
BWASCBR1	AbrPrt.instMag.f	WEARA	Breaker—Contact A wear
BWBSCBR2	AbrPrt.instMag.f	WEARB	Breaker—Contact B wear
BWCSCBR3	AbrPrt.instMag.f	WEARC	Breaker—Contact C wear
MVGGIO12	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[c]	Math Variables (MV01–MV32)
SCGGIO20	AnIn01.instMag.f–AnIn32.instMag.f	SC01–SC32[d]	SELOGIC Counters (SC01–SC32)
Functional Constraint = ST			
BWASCBR1	ColOpn.stVal	STOP	Stop motor/open breaker
BWBSCBR2	ColOpn.stVal	STOP	Stop motor/open breaker
BWCSCBR3	ColOpn.stVal	STOP	Stop motor/open breaker
INAGGIO1	Ind01.stVal–Ind02.stVal	IN101–IN102	Digital Inputs (IN101–IN102)—Slot A
INCGGIO13	Ind01.stVal–Ind08.stVal	IN301–IN308[b]	Digital Inputs (IN301–IN308)—Slot C
INDGGIO15	Ind01.stVal–Ind08.stVal	IN401–IN408[b]	Digital Inputs (IN401–IN408)—Slot D
INEGGIO17	Ind01.stVal–Ind08.stVal	IN501–IN508[b]	Digital Inputs (IN501–IN508)—Slot E
LBGGIO33	Ind01.stVal–Ind32.stVal	LB01–LB32[e]	Local Bits (LB01–LB32)
LTGGIO5	Ind01.stVal–Ind32.stVal	LT01–LT32[f]	Latch Bits (LT01–LT32)
MBOKGGIO25	Ind01.stVal	ROKA	Channel A, received data OK
MBOKGGIO25	Ind02.stVal	RBADA	Channel A, outage duration over threshold
MBOKGGIO25	Ind03.stVal	CBADA	Channel A, channel unavailability over threshold
MBOKGGIO25	Ind04.stVal	LBOKA	Channel A, looped back OK
MBOKGGIO25	Ind05.stVal	ROKB	Channel B, received data OK
MBOKGGIO25	Ind06.stVal	RBADB	Channel B, outage duration over threshold
MBOKGGIO25	Ind07.stVal	CBADB	Channel B, channel unavailability over threshold
MBOKGGIO25	Ind08.stVal	LBOKB	Channel B, looped back OK
MISCGGIO29	Ind01.stVal–Ind03.stVal	SG1–SG3	Setting Group 1–3 selection

Table E.18 Logical Device: ANN (Annunciation) (Sheet 2 of 3)

Logical Node	Attribute	Data Source	Comment
MISCGGIO29	Ind04.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM
MISCGGIO29	Ind05.stVal	SALARM	Indication of software or user activity that warrants an ALARM
MISCGGIO29	Ind06.stVal	WARNING	Relay Word WARNING
MISCGGIO29	Ind07.stVal	IRIGOK	IRIG-B time sync input data are valid
MISCGGIO29	Ind08.stVal	TSOK	Time synchronization OK
MISCGGIO29	Ind09.stVal	DST	Daylight Savings Time active
MISCGGIO29	Ind10.stVal	LINKA	Asserted when a valid link is detected on Port 1A
MISCGGIO29	Ind11.stVal	LINKB	Asserted when a valid link is detected on Port 1B
MISCGGIO29	Ind12.stVal	LINKFAIL	Asserted when a valid link is not detected on the active port(s)
MISCGGIO29	Ind13.stVal	PASEL	Asserted when Port 1A is active
MISCGGIO29	Ind14.stVal	PBSEL	Asserted when Port 1B is active
MISCGGIO29	Ind15.stVal	COMMLOSS	DeviceNet communication failure
MISCGGIO29	Ind16.stVal	COMMFLT	DeviceNet internal communication failure
MISCGGIO29	Ind17.stVal	MATHERR	Error in SEL Math computation
MISCGGIO29	Ind18.stVal–Ind32.stVal	0	Reserved for future use
MOTGGIO26	Ind01.stVal	RUNNING	Asserts when motor is running
MOTGGIO26	Ind02.stVal	STARTING	Asserts when protected motor is starting
MOTGGIO26	Ind03.stVal	STOPPED	Asserts when motor is stopped
MOTGGIO26	Ind04.stVal	STAR	Star control
MOTGGIO26	Ind05.stVal	DELTA	Delta control
MOTGGIO26	Ind06.stVal	50S	Overcurrent threshold for starting
MOTGGIO26	Ind07.stVal	SPEEDSW	Speed switch input
MOTGGIO26	Ind08.stVal	SPEED2	Asserts when protected motor run with second speed
MOTGGIO26	Ind09.stVal	EMRSTR	Emergency restart SELOGIC control equation or Comm Protocol command
MOTGGIO26	Ind10.stVal	STREQ	Start motor SELOGIC control equation
MOTGGIO26	Ind11.stVal–Ind16.stVal	0	Reserved for future use
OUTAGGIO2	Ind01.stVal–Ind03.stVal	OUT101–OUT103	Digital Outputs (OUT101–OUT103)—Slot A
OUTCGGIO14	Ind01.stVal–Ind04.stVal	OUT301–OUT304[b]	Digital Outputs (OUT301–OUT304)—Slot C
OUTDGGIO16	Ind01.stVal–Ind04.stVal	OUT401–OUT404[b]	Digital Outputs (OUT401–OUT404)—Slot D
OUTEGGIO18	Ind01.stVal–Ind04.stVal	OUT501–OUT504[b]	Digital Outputs (OUT501–OUT504)—Slot E
PBLEDGGIO7	Ind01.stVal	PB1A_LED	Pushbutton PB1A LED
PBLEDGGIO7	Ind02.stVal	PB1B_LED	Pushbutton PB1B LED
PBLEDGGIO7	Ind03.stVal	PB2A_LED	Pushbutton PB2A LED
PBLEDGGIO7	Ind04.stVal	PB2B_LED	Pushbutton PB2B LED
PBLEDGGIO7	Ind05.stVal	PB3A_LED	Pushbutton PB3A LED
PBLEDGGIO7	Ind06.stVal	PB3B_LED	Pushbutton PB3B LED
PBLEDGGIO7	Ind07.stVal	PB4A_LED	Pushbutton PB4A LED
PBLEDGGIO7	Ind08.stVal	PB4B_LED	Pushbutton PB4B LED
PROGGIO28	Ind01.stVal	AMBALRM	Ambient temperature alarm
PROGGIO28	Ind02.stVal	OTHALRM	Other temperature alarm
PROGGIO28	Ind03.stVal	WDGALRM	Winding temperature alarm
PROGGIO28	Ind04.stVal	BRGALRM	Bearing temperature alarm
PROGGIO28	Ind05.stVal	FREQTRK	Frequency tracking enable bit
PROGGIO28	Ind06.stVal	RTDBIAS	RTD bias alarm

Table E.18 Logical Device: ANN (Annunciation) (Sheet 3 of 3)

Logical Node	Attribute	Data Source	Comment
PROGGIO28	Ind07.stVal–Ind16.stVal	0	Reserved for future use
RMBAGGIO8	Ind01.stVal–Ind08.stVal	RMB1A–RMB8A	Receive MIRRORED BITS (RMB1A–RMB8A)
RMBBGGIO10	Ind01.stVal–Ind08.stVal	RMB1B–RMB8B	Receive MIRRORED BITS (RMB1B–RMB8B)
SVGGIO3	Ind01.stVal–Ind32.stVal	SV01–SV32[g]	SELOGIC Variables (SV01–SV32)
SVTGGIO4	Ind01.stVal–Ind32.stVal	SV01T–SV32T[g]	SELOGIC Variable Timers (SV01T–SV32T)
TLEDGGIO6	Ind01.stVal	ENABLED	ENABLED LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	TRIP LED
TLEDGGIO6	Ind03.stVal–Ind08.stVal	TLED_01–TLED_06	Target LEDs TLED_01–TLED_06
TMBAGGIO9	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS (TMB1A–TMB8A)
TMBBGGIO11	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS (TMB1B–TMB8B)
TRIPGGIO27	Ind01.stVal	SMTRIP	Asserts when the start motor timer times out
TRIPGGIO27	Ind02.stVal	REMTRIP	Remote trip
TRIPGGIO27	Ind03.stVal	LOADUP	Load control upper limit
TRIPGGIO27	Ind04.stVal	LOADLOW	Load control lower limit
TRIPGGIO27	Ind05.stVal	PTCFLT	Indicates faulted/shorted thermistor
TRIPGGIO27	Ind06.stVal	RTDFLT	Asserts when an open or short circuit condition is detected on any enabled RTD input, or communication with the external RTD module has been interrupted
TRIPGGIO27	Ind07.stVal	FAULT	Indicates fault condition
TRIPGGIO27	Ind08.stVal	AMBTRIP	Ambient temperature trip
TRIPGGIO27	Ind09.stVal	OTHTRIP	Other temperature trip
TRIPGGIO27	Ind10.stVal	WDGTRIP	Winding temperature trip
TRIPGGIO27	Ind11.stVal	BRGTRIP	Bearing temperature trip
TRIPGGIO27	Ind12.stVal	ULTRIP	Unlatch (auto reset) trip from SELOGIC equation
TRIPGGIO27	Ind13.stVal–Ind16.stVal	0	Reserved for future use
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	Virtual Bits (VB001–VB128)

[a] MX values contain instantaneous attributes (instMag and instCVal), which are updated whenever the source updates and other attributes that are only updated when the source goes outside the data source's deadband (mag and cVal). Only the instantaneous values are shown in the table.
[b] Active data only if optional I/O card is installed in the slot.
[c] Active data depends on the EMV setting.
[d] Active data depends on the ESC setting.
[e] Active data depends on the ELB setting.
[f] Active data depends on the ELAT setting
[g] Active data depends on the ESV setting.

Table E.19 Logical Device: CFG (Configuration)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
DevIDLPHD1	PhyNam.serNum	SER_NUM	Serial number
LLN0	NamPlt.swRev	FID	Firmware revision

Protocol Implementation Conformance Statement

The following tables are as shown in the IEC 61850 standard, Part 8-1, Section 24. Because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table E.20 PICS for A-Profile Support

Profile		Client	Server	Value/Comment
A1	Client/Server	N	Y	
A2	GOOSE/GSE management	Y	Y	Only GOOSE, not GSSE Management
A3	GSSE	N	N	
A4	Time Sync	N	N	

Table E.21 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSE	Y	Y	Only GOOSE, not GSSE
T4	GSSE	N	N	
T5	Time Sync	N	N	

Refer to the ACSI Conformance statement for information on the supported services.

MMS Conformance

The Manufacturing Messaging Specification (MMS) stack provides the basis for many IEC 61850 Protocol services. *Table E.22* defines the service support requirement and restrictions of the MMS services in the SEL-700 series products supporting IEC 61850. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table E.22 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		

Table E.22 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
deleteNamedType		
input		
output		
takeControl		
relinquishControl		
defineSemaphore		
deleteSemaphore		
reportPoolSemaphoreStatus		
reportSemaphoreStatus		
initiateDownloadSequence		
downloadSegment		
terminateDownloadSequence		
initiateUploadSequence		
uploadSegment		
terminateUploadSequence		
requestDomainDownload		
requestDomainUpload		
loadDomainContent		
storeDomainContent		
deleteDomain		
getDomainAttributes		Y
createProgramInvocation		
deleteProgramInvocation		
start		
stop		
resume		
reset		
kill		
getProgramInvocationAttributes		
obtainFile		
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		

Table E.22 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR Supported	Server-CR Supported
fileRead		
fileClose		
fileRename		
fileDelete		
fileDirectory		
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
ReconfigureProgramInvocation		

Table E.23 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table E.23 MMS Parameter CBB

MMS Parameter CBB	Client-CR Supported	Server-CR Supported
STR1		Y
STR2		Y
VNAM		Y
VADR		Y
VALT		Y
TPY		Y
VLIS		Y
CEI		

The following Variable Access conformance statements are listed in the order specified in the IEC 61850 standard, Part 8-1. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table E.24 Alternate Access Selection Conformance Statement (Sheet 1 of 2)

Alternate Access Selection	Client-CR Supported	Server-CR Supported
accessSelection		Y
component		Y
index		
indexRange		
allElements		

Table E.24 Alternate Access Selection Conformance Statement (Sheet 2 of 2)

Alternate Access Selection	Client-CR Supported	Server-CR Supported
alternateAccess		Y
selectAccess		Y
component		Y
index		
indexRange		
allElements		

Table E.25 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y
variableListName		Y

Table E.26 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		Y
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table E.27 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		Y
listOfAccessResult		Y

Table E.28 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		Y
address		
typeSpecification		Y

Table E.29 DefineNamedVariableList Conformance Statement

DefineNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table E.30 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		Y
listOfVariable		Y
variableSpecification		Y
alternateAccess		Y

Table E.31 DeleteNamedVariableList Statement

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table E.32 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	Y	Y	
SendGOOSEMessage		Y	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		Y	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		Y	

ACSI Conformance Statements

Table E.33 ACSI Basic Conformance Statement

		Client/Subscriber	Server/Publisher	SEL-710 Support
Client-Server Roles				
B11	Server side (of Two-Party Application-Association)	-	c1[a]	YES
B12	Client side (of Two-Party Application-Association)	c1[a]	-	
SCMS Supported				
B21	SCSM: IEC 61850-8-1 used			YES
B22	SCSM: IEC 61850-9-1 used			
B23	SCSM: IEC 61850-9-2 used			
B24	SCSM: other			
Generic Substation Event Model (GSE)				
B31	Publisher side	-	O[b]	YES
B32	Subscriber side	O[b]	-	YES
Transmission of Sampled Value Model (SVC)				
B41	Published side	-	O[b]	
B42	Subscriber side	O[b]	-	

[a] c1 shall be mandatory if support for LOGICAL-DEVICE model has been declared.
[b] O = optional.

Table E.34 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-710 Support
If Server Side (B11) Supported				
M1	Logical device	c2[a]	c2[a]	YES
M2	Logical node	c3[b]	c3[b]	YES
M3	Data	c4[c]	c4[c]	YES
M4	Data set	c5[d]	c5[d]	YES
M5	Substation	O[e]	O[e]	
M6	Setting group control	O[e]	O[e]	
Reporting				
M7	Buffered report control	O[e]	O[e]	YES
M7-1	sequence-number			YES
M7-2	report-time-stamp			YES
M7-3	reason-for-inclusion			YES
M7-4	data-set-name			YES
M7-5	data-reference			YES
M7-6	buffer-overflow			YES
M7-7	entryID			YES
M7-8	BufTm			YES
M7-9	IntgPd			YES
M7-10	G1			YES
M8	Unbuffered report control	O[e]	O[e]	YES
M8-1	sequence-number			YES
M8-2	report-time-stamp			YES
M8-3	reason-for-inclusion			YES
M8-4	data-set-name			YES
M8-5	data-reference			YES

Table E.34 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-710 Support
M8-6	BufTm			YES
M8-7	IntgPd			YES
M-8-8	GI			YES
Logging		O[e]	O[e]	
M9	Log control	O[e]	O[e]	
M9-1	IntgPd			
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[g]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataRefInc			YES
M13	GSSE	O[e]	O[e]	
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	
M16	Time	M[f]	M[f]	
M17	File Transfer	O[e]	O[e]	

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = optional.
[f] M = mandatory.
[g] M = mandatory.

Table E.35 ACSI Services Conformance Statement (Sheet 1 of 3)

Services		AA: TP/MC	Client/Subscriber	Service/Publisher	SEL-710 Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES
Data (Clause 10)					
S8	GetDataValues	TP	M[a]	M[a]	YES
S9	SetDataValues	TP	O[b]	O[b]	
S10	GetDataDirectory	TP	O[b]	M[a]	YES
S11	GetDataDefinition	TP	O[b]	M[a]	YES
Data Set (Clause 11)					
S12	GetDataSetValues	TP	O[b]	M[a]	YES
S13	SetDataSetValues	TP	O[b]	O[b]	
S14	CreateDataSet	TP	O[b]	O[b]	
S15	DeleteDataSet	TP	O[b]	O[b]	
S16	GetDataSetDirectory	TP	O[b]	O[b]	YES

Table E.35 ACSI Services Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client/Subscriber	Service/Publisher	SEL-710 Support
Substitution (Clause 12)					
S17	SetDataValues	TP	M[a]	M[a]	
Setting Group Control (Clause 13)					
S18	SelectActiveSG	TP	O[b]	O[b]	
S19	SelectEditSG	TP	O[b]	O[b]	
S20	SetSGvalues	TP	O[b]	O[b]	
S21	ConfirmEditSGVal	TP	O[b]	O[b]	
S22	GetSGValues	TP	O[b]	O[b]	
S23	GetSGCBValues	TP	O[b]	O[b]	
S24	Report	TP	c6[c]	c6[c]	YES
S24-1	data-change (dchg)				YES
S24-2	qchg-change (qchg)				YES
S24-3	data-update (dupd)				
S25	GetBRCBValues	TP	c6[c]	c6[c]	YES
S26	SetBRCBValues	TP	c6[c]	c6[c]	YES
Unbuffered Report Control Block (URCB)					
S27	Report	TP	c6[c]	c6[c]	YES
S27-1	data-change (dchg)				YES
S27-2	qchg-change (qchg)				YES
S27-3	data-update (dupd)				
S28	GetURCBValues	TP	c6[c]	c6[c]	YES
S29	SetURCBValues	TP	c6[c]	c6[c]	YES
Logging (Clause 14)					
Log Control Block					
S30	GetLCBValues	TP	M[a]	M[a]	
S31	SetLCBValues	TP	O[b]	M[a]	
LOG					
S32	QueryLogByTime	TP	c7[d]	M[a]	
S33	QueryLogByEntry	TP	c7[d]	M[a]	
S34	GetLogStatusValues	TP	M[a]	M[a]	
Generic Substation Event Model (GSE) (Clause 14.3.5.3.4)					
GOOSE-Control-Block					
S35	SendGOOSEMessage	MC	c8[e]	c8[e]	YES
S36	GetReference	TP	O[b]	c9[f]	
S37	GetGOOSEElement				
Number	TP	O[b]	c9[f]		
S38	GetGoCBValues	TP	O[b]	O[b]	YES
S39	SetGoCBValues	TP	O[b]	O[b]	
ONLY					
GSSE-Control-Block					
S40	SendGSSEMessage	MC	c8[e]	c8[e]	
S41	GetReference	TP	O[b]	c9[f]	
S42	GetGSSEElement				
Number	TP	Ob	c9[f]		
S43	GetGsCBValues	TP	O[b]	O[b]	
S44	GetGsCBValues	TP	O[b]	O[b]	

Table E.35 ACSI Services Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client/Subscriber	Service/Publisher	SEL-710 Support
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[g]	c10[g]	
S46	GetMSVCBValues	TP	O[b]	O[b]	
S47	SetMSVCBValues	TP	O[b]	O[b]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[g]	c10[g]	
S49	GetUSVCBValues	TP	O[b]	O[b]	
S50	SetUSVCBValues	TP	O[b]	O[b]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	
S52	SelectWithValue	TP	Ma	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)				20 (1 µs)
T2	Time accuracy of internal clock				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B
	T1				YES for IRIG-B
	T2				YES for IRIG-B
	T3				YES for IRIG-B
	T4				YES for IRIG-B
T3	Supported TimeStamp resolution (nearest negative power of 2 in seconds)				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B

[a] M = mandatory.
[b] O = optional.
[c] c6 shall declare support for at least one (BRCB or URCB).
[d] c7 shall declare support for at least one (QueryLogByTime or QueryLogAfter).
[e] c8 shall declare support for at least one (SendGOOSEMessage or SendGSSEMessage).
[f] c9 shall declare support if TP association is available.
[g] c10 shall declare support for at least one (SendMSVMessage or SendUSVMessage).

Appendix F
DeviceNet Communications

Overview

This appendix describes DeviceNet communications features supported by the SEL-710 Motor Protection Relay.

DeviceNet is a low-level communications network that provides direct connectivity among industrial devices, resulting in improved communications and device-level diagnostics that are otherwise either unavailable or inaccessible through expensive hardwired I/O interfaces. Industrial devices for which DeviceNet provides this direct connectivity include limit switches, photoelectric sensors, valve manifolds, motor starters, process sensors, bar code readers, variable frequency drives, panel displays, and operator interfaces.

The *SEL DeviceNet Communications Card User's Guide* contains more information on the installation and use of the DeviceNet card.

NOTE: Be aware of the following setting in the relay:
Under Global settings =====>>
Access Control, there is a setting called BLOCK MODBUS SET.

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

You are strongly advised to change the BLKMBSET (BLOCK MODBUS SET) := ALL if you do not want the PLC (Programmable Logic Controller) or DCS (Distributed Control System) to send the settings to the SEL-710 Relay. There is a strong possibility that under special conditions like a reboot, the PLC/DCS will send default settings to the relay, overwriting the existing settings. To protect the existing settings under these conditions it is highly recommended to set the setting to ALL.

DeviceNet Card

NOTE: The DeviceNet option has been discontinued and is no longer available as of September 25, 2017.

The DeviceNet Card is an optional accessory that enables connection of the SEL-710 to the DeviceNet automation network. The card (see *Figure F.1*) occupies the communications expansion Slot **C** in the relay.

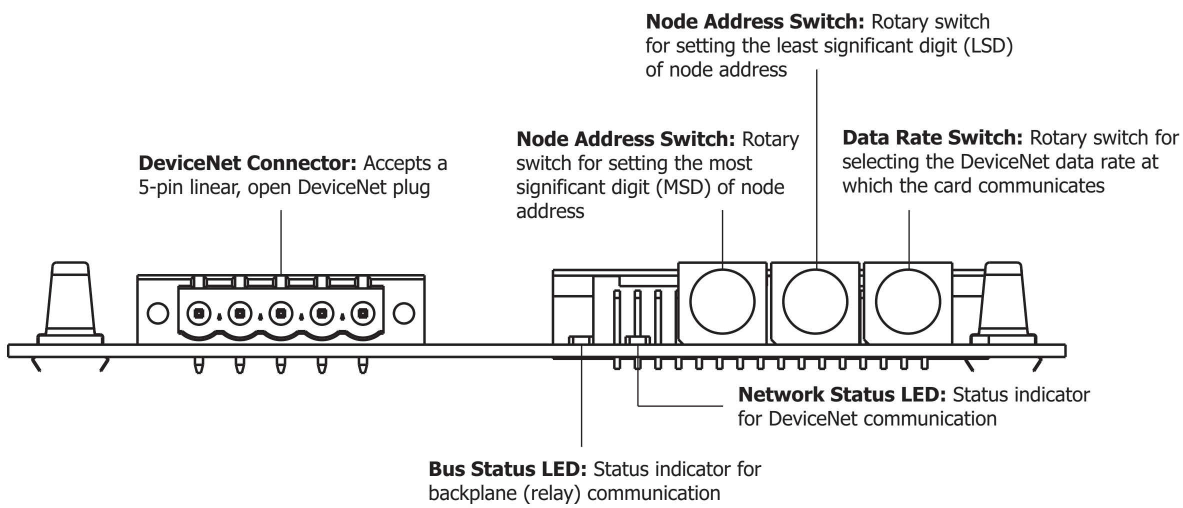


Figure F.1 DeviceNet Card Component Overview

Features

The DeviceNet 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-710 and applying power. Alternatively, the switches can be set to positions that allow for configuration of these settings over the DeviceNet network, utilizing 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-710 as installed.

You can do the following with the DeviceNet interface:

- ➤ Retrieve metering data such as the following:
  - ➢ Currents
  - ➢ Voltages
  - ➢ Power
  - ➢ Energy
  - ➢ Max/Min
  - ➢ Analog Inputs
  - ➢ Counters
- ➤ Retrieve 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
- 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

The Electronic Data Sheet (EDS) is a specially formatted file that includes configurable parameters for the device and public interfaces to those parameters. The EDS file contains information such as number of parameters; groupings; parameter name; minimum, maximum, and default values; units; data format; and scaling. This information makes possible user-friendly configuration tools (e.g., RSNetWorx for DeviceNet or DeviceNet Configurator from OMRON) for device parameter monitoring, modification, or both. The interface to the device can also be easily updated without revision of the configuration software tool itself.

All the registers defined in the Modbus Register Map (*Table D.34*) are available as parameters in a DeviceNet configuration. Parameter names, data ranges, and scaling; enumeration values and strings; parameter groups; and product information are the same as specified in the Modbus Register Map defined in *Table D.34*. The parameter numbers are offset by a count of 100 from the register numbers.

The EDS file for the SEL-710, SEL-*xxx*R*xxx*.zip, can be downloaded from selinc.com.

Complete specifications for the DeviceNet protocol are available on the Open DeviceNet Vendor's Association (ODVA) website www.odva.org. ODVA is an independent supplier organization that manages the DeviceNet specification and supports the worldwide growth of DeviceNet.

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Appendix G
MIRRORED BITS Communications

Overview

IMPORTANT: Be sure to configure the port before connecting to a MIRRORED BITS device. If you connect an unconfigured port to a MIRRORED BITS device, the device will appear to be locked up.

NOTE: Complete all of the port settings for a port that you use for MIRRORED BITS communications before you connect an external MIRRORED BITS communications device. If you connect a MIRRORED BITS communications device to a port that is not set for MIRRORED BITS communications operation, the port will be continuously busy.

MIRRORED BITS communications is a direct relay-to-relay communications protocol that allows IEDs to exchange information quickly, securely, and with minimal expense. Use MIRRORED BITS for functions such as remote control and remote sensing. The SEL-710 Motor Protection Relay supports two MIRRORED BITS communications channels, designated A and B. Use the port setting PROTO to assign one of the MIRRORED BITS communications channels to a serial port; PROTO := MBA for MIRRORED BITS communications Channel A or PROTO := MBB for MIRRORED BITS communications Channel B. MIRRORED BITS are either Transmit MIRRORED BITS (TMB) or Received MIRRORED BITS (RMB). Transmit MIRRORED BITS include TMB1A–TMB8A (channel A) and TMB1B–TMB8B (channel B). The last letter (A or B) designates with which channel the bits are associated. Received bits include RMB1A–RMB8A and RMB1B–RMB8B. Control the transmit MIRRORED BITS in SELOGIC control equations. Use the received MIRRORED BITS as arguments in SELOGIC control equations. The channel status bits are ROKA, RBADA, CBADA, LBOKA, ROKB, RBADB, CBADB, and LBOKB. You can also use these channel status bits as arguments in SELOGIC control equations. Use the **COM** command (see *Section 7: Communications*) for additional channel status information.

Because of different applications, the SEL product range supports several variations of the MIRRORED BITS communications protocol. Through port settings, you can set the SEL-710 for compatible operation with SEL-300 series devices, SEL-2505 Remote I/O Modules (ST option only), and SEL-2100 Logic Processors. When communicating with an SEL-400 series relay, be sure to set the transmission mode setting in the SEL-400 series relay to paced transmission (TXMODE := P).

Operation

Message Transmission

In the SEL-710, the MIRRORED BITS transmission rate is a function of both the data rate and the power system cycle. At data rates below 9600, the SEL-710 transmits MIRRORED BITS as fast as possible for the given rate. At rates at and above 9600 bps the SEL-710 self-paces, using a technique similar to the SEL-400 series pacing mode. There are no settings to enable or disable the self-pacing mode; the SEL-710 automatically enters the self-pacing mode at data rates of 9600, 19200, and 38400. *Table G.1* shows the transmission rates of the MIRRORED BITS messages at different rates.

Table G.1 Number of MIRRORED BITS Messages for Different Data Rates

Data Rate	Transmission Rate of MIRRORED BITS Packets
2400	15 ms
4800	7.5 ms
9600	4 times a power system cycle (automatic pacing mode)
19200	4 times a power system cycle (automatic pacing mode)
38400	4 times a power system cycle (automatic pacing mode)

Transmitting at longer intervals for data rates above 9600 avoids overflowing relays that receive MIRRORED BITS at a slower rate.

Message Reception Overview

During synchronized MIRRORED BITS communications with the communications channel in normal state, the relay decodes and checks each received message. If the message is valid, the relay sends each received logic bit (RMB*n*, where *n* = 1 through 8) to the corresponding pickup and dropout security counters, that in turn set or clear the RMB*n*A and RMB*n*B relay element bits.

Message Decoding and Integrity Checks

Set the RX_ID of the local SEL-710 to match the TX_ID of the remote SEL-710. The SEL-710 provides indication of the status of each MIRRORED BITS communications channel with Relay Word bits ROKA (receive OK) and ROKB. During normal operation, the relay sets the ROK*c* (*c* = A or B). Upon detecting any of the following conditions, the relay clears the ROK*c* bit when:

- The relay is disabled.
- MIRRORED BITS are not enabled.
- Parity, framing, or overrun errors.
- Receive message identification error.
- No message received in the time three messages have been sent when PROTO = MB*c*, or seven messages have been sent when PROTO = MB8*c*.
- Loopback is enabled.

The relay asserts ROK*c* only after successful synchronization as described below and two consecutive messages pass all of the data checks previously described. After ROK*c* is reasserted, received data may be delayed while passing through the security counters described below.

While ROK*c* is deasserted, the relay does not transfer new RMB data to the pickup-dropout security counters described below. Instead, the relay sends one of the user-definable default values to the security counter inputs. For each RMB*n*, use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if an error condition is detected. The setting is a mask of 1s, 0s, and/or Xs (for RMB1A–RMB8A), where X represents the most recently received valid value. The positions of the 1s and 0s correspond to the respective positions of the MIRRORED BITS in the Relay Word bits (see *Appendix I: Relay Word Bits*). *Table G.2* is an extract of *Appendix I: Relay Word Bits*, showing the positions of the MIRRORED BITS.

Table G.2 Positions of the MIRRORED BITS

Bit/Row	7	6	5	4	3	2	1	0
84	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
86	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B

Table G.3 shows an example of the values of the MIRRORED BITS for a RXDFLT setting of 10100111.

Table G.3 MIRRORED BITS Values for a RXDFLT Setting of 10100111

Bit/Row	7	6	5	4	3	2	1	0
84	1	0	1	0	0	1	1	1

Individual pickup and dropout security counters supervise the movement of each received data bit into the corresponding RMB*n* element. You can set each pickup/dropout security counter from 1 to 8. A setting of 1 causes a security counter to pass every occurrence, while a setting of 8 causes a counter to wait for eight consecutive occurrences in the received data before updating the data bits. The pickup and dropout security count settings are separate. Control the security count settings with the settings RMB*n*PU and RMB*n*DO.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that the counter uses units of counted received messages instead of time. Select a setting for the security counter in accordance with the transmission rate (see *Table G.1*). For example, when transmitting at 2400 bps, a security counter set to 2 counts delays a bit by about 30 ms. However, when operating at 9600 bps, a setting of 2 counts delays a bit by about 8.5 ms.

You must consider the impact of the security counter settings in the receiving relay to determine the channel timing performance, particularly when two relays of different processing rates are communicating via MIRRORED BITS, such as an SEL-321 and an SEL-710. The SEL-321 processes power system information each 1/8 power system cycle, but, when transmitting at 19200 bps, the SEL-710 processes MIRRORED BITS messages at 4.15 ms at 60 Hz (4 times per power system cycle at 60 Hz). Although the SEL-321 processes power system information each 1/8 power system cycle, the relay processes the MIRRORED BITS pickup/dropout security counters as MIRRORED BITS messages are received. Because the SEL-710 transmits messages at approximately 1/4-cycle processing interval (9600 bps and above, see *Table G.1*), a counter set to two in the SEL-321 delays a received bit by another approximately 1/2 cycle. However, a security counter in the SEL-710 with a setting of two delays a received bit from the SEL-321 by 1/4 cycle, because the SEL-710 is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Channel Synchronization

When an SEL-710 detects a communications error, it deasserts ROKA or ROKB. If an SEL-710 detects two consecutive communications errors, it transmits an attention message, which includes the TXID setting. The relay transmits an attention message until it receives an attention message that includes a match to the TXID setting value. If the attention message is successful, the relay has properly synchronized and data transmission resumes. If the attention message is not successful, the relay repeats the attention message until it is successful.

In summary, when a relay detects an error, it transmits an attention message until it receives an attention message with its own TX_ID included. If three or four relays are connected in a ring topology, the attention message will go all the way around the loop until the originating relay receives it. The message then dies and data transmission resumes. This method of synchronization allows the relays to reliably determine which byte is the first byte of the message. It also forces unsynchronized UARTs to become resynchronized. On the down side, this method takes down the entire loop for a receive error at any relay in the loop. This decreases availability. It also makes one-way communications impossible.

Loopback Testing

Use the **LOOP** command to enable loopback testing. In the loopback mode, you loop the transmit port to the receive port of the same relay to verify transmission messages. While in loopback mode, ROK*c* is deasserted, and another user accessible Relay Word bit, LBOK*c* (Loop Back OK) asserts and deasserts based on the received data checks (see the *Section 7: Communications* for the ACSII commands).

Channel Monitoring

Based on the results of data checks (previously described), the relay collects information regarding the 255 most recent communications errors. Each record contains at least the following fields:

- ➤ DATE—Date when the dropout occurred
- ➤ TIME—Time when the dropout occurred
- ➤ RECOVERY_DATE—Date when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- ➤ RECOVERY_TIME—Time when the channel returned to service (if the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested)
- ➤ DURATION—Time elapsed during dropout
- ➤ CAUSE—Reason for dropout (see *Message Decoding and Integrity Checks on page G.2*)

There is a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but framing errors can extend the outage. If the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested.

NOTE: Combine error conditions including RBADA, RBADB, CBADA, and CBADB with other alarm conditions using SELOGIC control equations. You can use these alarm conditions to program the relay to take appropriate action when it detects a communications channel failure.

When the duration of an outage on Channel A or B exceeds a user-definable threshold, the relay asserts a user-accessible Relay Word bit, RBADA or RBADB. When channel unavailability exceeds a user-definable threshold for Channel A or B, the relay asserts a user-accessible Relay Word bit, CBADA or CBADB. Use the **COMM** command to generate a long or summary report of the communications errors.

Use the RBADPU setting to determine how long a channel error must last before the meter element RBADA is asserted. RBADA is deasserted when the channel error is corrected. RBADPU is accurate to ±1 second.

Use the CBADPU setting to determine the ratio of channel down time to the total channel time before the meter element CBADA is asserted. The times used in the calculation are those that are available in the COM records. See the *COMMUNICATIONS Command* in *Section 7: Communications* for more information.

MIRRORED BITS Protocol for the Pulsar 9600 BPS Modem

To use a Pulsar MBT modem, set setting PROTO := MBTA or MBTB (Port settings). Setting PROTO := MBTA or MBTB hides setting SPEED (forces the data rate to 9600), hides setting PARITY (forces parity to a value of 0), hides setting RTSCTS (forces RTSCTS to a value of N), and forces the transmit time to be faster than double the power system cycle. *Table G.4* shows the difference in message transmission periods when not using the Pulsar modem (PROTO ≠ MBTA or MBTB), and using the Pulsar MBT modem (PROTO = MBTA or MBTB).

NOTE: You must consider the idle time in calculations of data transfer latency through a Pulsar MBT modem system.

Table G.4 MIRRORED BITS Communications Message Transmission Period

Data Rate	PROTO ≠ MBTA or MBTB	PROTO = MBTA or MBTB
38400	4 times a power system cycle	n/a
19200	4 times a power system cycle	n/a
9600	4 times a power system cycle	2 times a power system cycle
4800	7.5 ms	n/a

The relay sets RTS to a negative voltage at the EIA-232 connector to signify that MIRRORED BITS communications matches this specification.

Settings

Set PROTO = MBA or MB8A to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB or MB8B to enable the MIRRORED BITS protocol channel B on this port. The standard MIRRORED BITS protocols MBA and MBB use a 6-data bit format for data encoding. The MB8 protocols MB8A and MB8B use an 8-data bit format, which allows MIRRORED BITS to operate on communications channels requiring an 8-data bit format. For the remainder of this section, PROTO = MBA is assumed. *Table G.5* shows the MIRRORED BITS protocol port settings, ranges, and default settings for Port F, Port 3, and Port 4.

Table G.5 MIRRORED BITS Protocol Settings (Sheet 1 of 2)

Setting Prompt	Setting Description	Factory-Default Setting
TXID	MIRRORED BITS ID of This Device (1–4)	2
RXID	MIRRORED BITS ID of Device Receiving From (1–4)	1
RBADPU	Outage Duration to Set RBAD (1–10000 seconds)	60
CBADPU	Channel Unavailability to Set CBAD (1–10000 ppm)	1000
RXDFLT	8 char string of 1s, 0s, or Xs	XXXXXXXX
RMB1PU	RMB1 Pickup Debounce Messages (1–8 messages)	1
RMB1DO	RMB1 Dropout Debounce Messages (1–8 messages)	1
RMB2PU	RMB2 Pickup Debounce Messages (1–8 messages)	1
RMB2DO	RMB2 Dropout Debounce Messages (1–8 messages)	1
RMB3PU	RMB3 Pickup Debounce Messages (1–8 messages)	1
RMB3DO	RMB3 Dropout Debounce Messages (1–8 messages)	1
RMB4PU	RMB4 Pickup Debounce Messages (1–8 messages)	1
RMB4DO	RMB4 Dropout Debounce Messages (1–8 messages)	1
RMB5PU	RMB5 Pickup Debounce Messages (1–8 messages)	1
RMB5DO	RMB5 Dropout Debounce Messages (1–8 messages)	1
RMB6PU	RMB6 Pickup Debounce Messages (1–8 messages)	1
RMB6DO	RMB6 Dropout Debounce Messages (1–8 messages)	1
RMB7PU	RMB7 Pickup Debounce Messages (1–8 messages)	1
RMB7DO	RMB7 Dropout Debounce Messages (1–8 messages)	1

Table G.5 MIRRORED BITS Protocol Settings (Sheet 2 of 2)

Setting Prompt	Setting Description	Factory-Default Setting
RMB8PU	RMB8 Pickup Debounce Messages (1–8 messages)	1
RMB8DO	RMB8 Dropout Debounce Messages (1–8 messages)	1

Appendix H
Motor Thermal Element

Overview

The SEL-710 Motor Protection 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 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 numeric estimates analogous to the heat energy in the rotor and the stator of the motor.
- Adjusts the heat estimates based on the measured positive-sequence and negative-sequence current flowing in the motor.
- Rotor Model (with optional voltage card): The rotor model dynamically weights the heating effect of each of the negative-sequence and positive-sequence currents as a function of calculated slip. For high inertia applications where the motor acceleration time is longer than the locked rotor time, this feature avoids tripping during a start.
- Rotor Model (without optional voltage card): Weights the heating effect of negative-sequence current as five times the heating effect of positive-sequence currents when the motor is running (weights them equally when the motor is starting).
- Stator Model: Weights the heating effects of positive- and negative-sequence current equally when the motor is starting or running.

- Models the heat lost to the surroundings when the motor is running.
- Compares the present heat estimate of rotor and stator to the trip threshold of rotor and stator models respectively.
- Provides a trip output if either of the present heat estimates exceeds the respective trip threshold.
- Provides an alarm output if either of the present heat estimates exceeds the alarm threshold (user settable as a percentage of the trip threshold).
- Adjusts the rotor and stator trip thresholds based on RTD ambient temperature measurement when enabled.

Purpose of Motor Thermal Protection

A typical induction motor draws six times the full-load current 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 $6^2 \cdot 3$ or 108 times the I^2r heating when the motor runs normally. Consequently, the motor must tolerate an extreme temperature for a limited time to start. Manufacturers state 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 H.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-710 thermal element offers distinct advantages over the use of overcurrent elements.

The SEL-710 thermal element individually tracks the heat energies in rotor and stator. The rotor trip threshold represents rated locked rotor current and time, providing locked rotor protection. The stator trip threshold represents the service factor and two other motor parameters, providing overload protection.

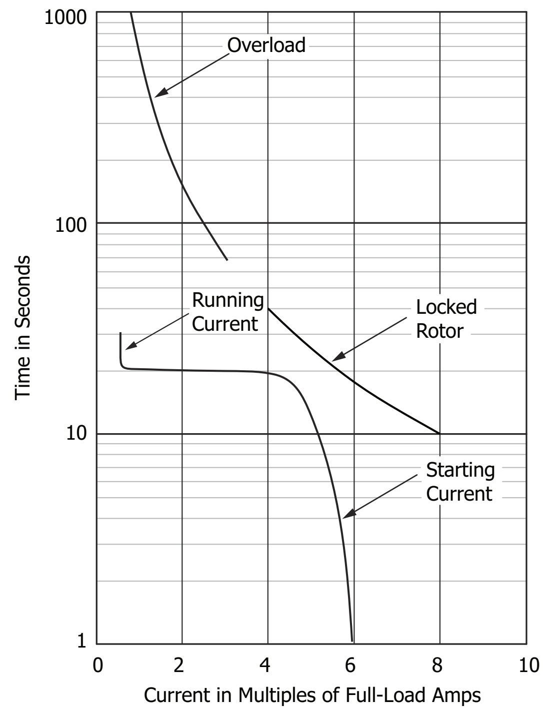

Figure H.1 Motor Thermal Limit Characteristic Plotted With Motor Starting Current

Basic Thermal Element

Figure H.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 resistance, modeled as a resistor.
- ➤ A comparator, to compare the present heat estimate, U, to the thermal trip value.

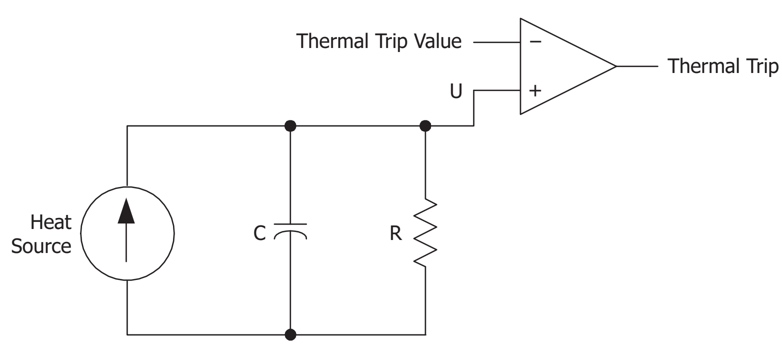

Figure H.2 Electrical Analog of a Thermal System

To define a thermal element for an induction motor, the characteristics of each component in *Figure H.2* must be defined, starting with the heat source. In an induction motor, heat principally is caused by I^2r losses. *Equation H.1* shows the motor heat source as a function of positive- and negative-sequence currents.

$$\text{Heat Source} = I_1^2 \cdot K_1 + I_2^2 \cdot K_2$$ **Equation H.1**

Heating factors K_1 and K_2 are defined by the positive-sequence rotor resistance and negative-sequence rotor resistance, respectively.

Figure H.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.

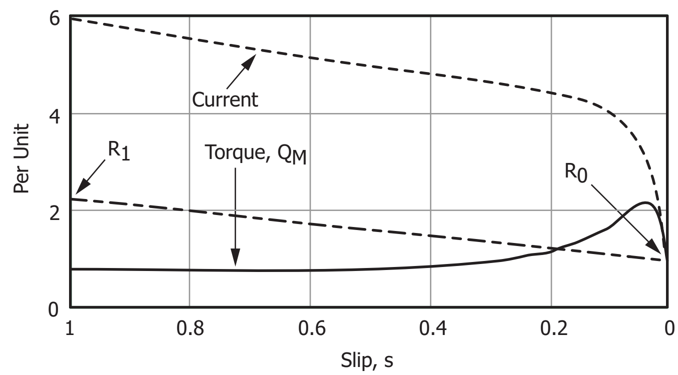

Figure H.3 Typical Induction Motor Current, Torque, and Rotor Resistance Versus Slip

Use *Equation H.2* to calculate the positive-sequence rotor resistance plotted in *Figure H.3*.

$$R_r = \left(\frac{Q_M}{I^2}\right) \cdot S$$ **Equation H.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 H.3*.

$$R_{r+} = (R_1 - R_0) \cdot S + R_0$$ **Equation H.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 induce a counter-rotating magnetic flux. When rotor speed is zero, the counter-rotating flux induces 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 flux induces 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 H.3*, calculate negative-sequence rotor resistance, R_{r-}.

$$R_{r-} = (R_1 - R_0) \cdot (2 - S) + R_0$$

Equation H.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 H.3* and *Equation H.4* by R_0. For the locked rotor case (slip, S = 1).

$$\left.\frac{R_{r+}}{R_0}\right|_{S=1} = \left.\frac{R_{r-}}{R_0}\right|_{S=1} = \frac{R_1}{R_0}$$

Equation H.5

Unless otherwise known, the R1/R0 can be assumed to be equal to 3. When the motor is running ($S \approx 0$), the positive-sequence heating factor, K_1, is found.

$$\left.\frac{R_{r+}}{R_0}\right|_{S=0} = \frac{R_0}{R_0} = 1$$

Equation H.6

Using the assumed value of R1/R0, the negative-sequence heating factor, K_2, at $S \approx 0$ is found:

$$\left.\frac{R_{r-}}{R_0}\right|_{S=0} = 2 \cdot \left(\frac{R_1}{R_0}\right) - 1 = 5$$

Equation H.7

To summarize, based on the assumption that the locked-rotor resistance is three times the running rotor resistance:

- The heating factor of positive-sequence current, K_1, when the motor is running is 1 per unit.
- The heating factor of negative-sequence current, K_2, when the motor is running is 5 per unit.
- Both K_1 and K_2 are 3 per unit when the rotor is locked.

NOTE: Starting and running states for the thermal element described here are not the same as STARTING and RUNNING bits described in Figure 4.42: Motor State Logic.

The differences in the positive- and negative-sequence heating factors immediately suggest that the rotor thermal element should have two states representing the starting and running of the motor. The SEL-710 thermal element automatically selects which state to use based on the sum of positive and negative-sequence current magnitude. When the sum is greater than 2.5 times the motor rated full-load current setting, the relay uses the starting state (50S asserts). When current is less than 2.5 times rated full-load current, the relay uses the running state (50S deasserts).

Motor Starting Protection

Figure H.4 shows the rotor thermal element used (relay without voltage card) 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 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 when the rating method is used. If the less conservative curve method is used, 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.

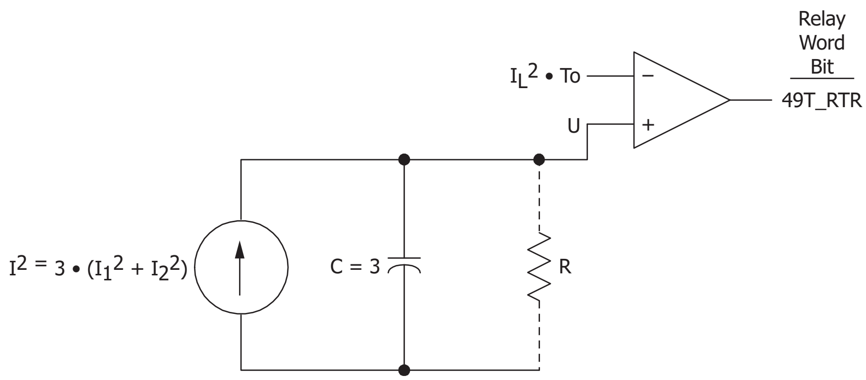

Figure H.4 Rotor Thermal Element During Motor Start

When an optional voltage card is used, the SEL-710 uses the following heat source and capacitance values in the rotor thermal element:

$$I^2 = \frac{R_{r+}}{R_0} \bullet I_1^2 + \frac{R_{r-}}{R_0} \bullet I_2^2$$

$$C = \frac{R_1}{R_0}$$

$$R_1 = \frac{LRQ}{LRA1^2}$$

$$R_0 = FLS$$

Equation H.8

where: R_{r+} and R_{r-} are calculated slip-dependent rotor resistances
LRQ, LRA1, and FLS are relay settings

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, in *Figure H.5*.

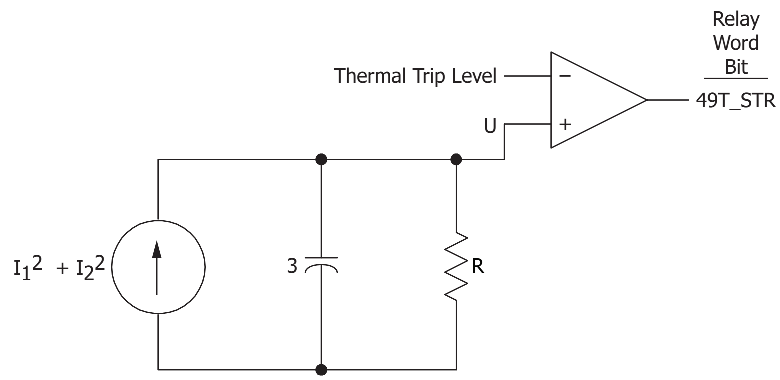

Figure H.5 Stator Thermal Element With Resistance and Trip Level Undefined

To determine the value of the 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, K_1, is 1 in the running model, and 1 per unit of I_1 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 H.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.

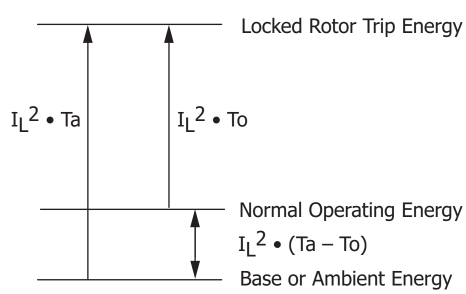

Figure H.6 Calculating the Normal Operating Energy by Using Locked Rotor Trip Times

$$\frac{I_L^2 \bullet Ta}{I_L^2 \bullet (Ta - To)} = 6$$

$$\therefore \frac{Ta}{To} = 1.2$$

$$\therefore (Ta - To) = 0.2 \bullet To$$

Equation H.9

The motor ratings allow the motor to be run continuously at the motor service factor. The service factor, SF, is accounted for in the stator thermal element trip threshold. *Figure H.7* shows the stator thermal element.

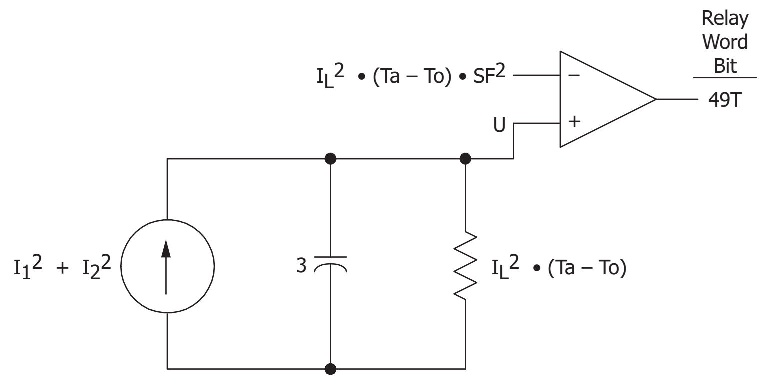

Figure H.7 Stator Thermal Element

Example H.1 illustrates the difference between the trip thresholds of the rotor and stator thermal elements.

EXAMPLE H.1 Rotor and Stator Trip Level Calculations

Given a motor with the following characteristics, calculate the stator and rotor thermal model trip thresholds.

Service Factor, SF = 1.15
Locked Rotor Current, I_L= 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
Rotor Trip Threshold
= $I_L^2 \bullet To$
= 36 • 12
= 432
Stator Trip Threshold
= $I_L^2 \bullet (Ta-To) \bullet SF^2$
= 36 • 2.4 • 1.323
= 114.3

Interpreting Percent Thermal Capacity Values

Several of the SEL-710 reporting functions include % Thermal Capacity values. At all times, the relay uses *Equation H.10* to calculate the percent thermal capacity used for the rotor and the stator.

$$\%\ \text{Thermal Capacity} = \frac{\left(\begin{matrix}\text{Present Heat}\\ \text{Estimate, U}\end{matrix}\right)}{\left(\begin{matrix}\text{Thermal}\\ \text{Trip Value}\end{matrix}\right)} \cdot 100\%$$

Equation H.10

By this definition, when either the stator or the rotor % Thermal Capacity reaches 100%, the heat estimate equals the respective trip value and the thermal element trips.

You can compare the rotor % 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 Rotor % Thermal Capacity, the final Rotor % Thermal Capacity value when the motor state changes from starting to running. This could indicate gradually increasing load torque, which could eventually result in an unwanted locked rotor trip and subsequent downtime.

A normal motor start or an overload trip is expected to use a significant percentage of the available rotor and/or stator thermal capacity. After a motor start and an overload trip, 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-710 provides a facility to help ensure that a motor start is not attempted while either the stator or the rotor is still too hot to be started safely. The TCSTART and 49RSTP settings allow you to define a fixed value of the rotor and the stator thermal capacity used previously, in which the relay asserts the Thermal Lockout until the motor is cool. See *Equation 4.3*, *Equation 4.4*, *Figure 4.40*, 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 rotor and stator thermal elements (see *Figure H.4* and *Figure H.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 H.11 applies to the rotor element when $12 \geq I \geq 2.5$.

$$T_p = \frac{[(TD + 0.2) \bullet T_O \bullet I_L^2] - U_O}{I^2}$$

Equation H.11

Equation H.12 applies to the stator element when I > SF.

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2 - I_0^2}{I^2 - SF^2}\right]$$

Equation H.12

Rating Method Equations

Equation H.13 applies to the rotor element when $12 \geq I \geq 2.5$ and SETMETH = Rating. To obtain the trip time (hot or cold rotor), substitute $U_0 = R$ in *Equation H.11*. (Also use *Equation H.11* when SETMETH := Rating_1, with U_o = R or 0 for hot or cold rotor, respectively.)

$$T_p = \frac{TD \bullet T_O \bullet I_L^2}{I^2}$$

Equation H.13

Equation H.14 and *Equation H.15* apply to the stator element when I > SF and SETMETH = Rating or Rating_1.

To obtain the trip time for hot stator, substitute $I_0 = (0.9 \bullet SF)$ and RTC in *Equation H.12*.
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 H.14

RTC ≠ Auto

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2 - (0.9 \bullet SF)^2}{I^2 - SF^2}\right]$$

Equation H.15

To obtain the trip time for cold stator, substitute $I_0 = 0$ and RTC in *Equation H.12*.

RTC = Auto

$$T_p = \left[\frac{T_O \bullet (TD + 0.2)}{\ln\left[\frac{I_L^2 - (0.9 \bullet SF)^2}{I_L^2 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right] \quad \textbf{Equation H.16}$$

RTC ≠ Auto

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right] \quad \textbf{Equation H.17}$$

Curve Method Equations

Equation H.18 and *Equation H.19* apply to the rotor element when $12 \geq I \geq 2.5$ and SETMETH = Curve. To obtain the trip time (cold rotor), substitute $U_0 = 0$, $TD = 1.0$, $T_O = (2.08 \bullet CURVE)$, and $I_L = 6.0$ in *Equation H.11*

$$T_p = \frac{90 \bullet CURVE}{I^2} \quad \textbf{Equation H.18}$$

To obtain the trip time (hot rotor), substitute $U_0 = R$, $TD = 1.0$, $T_O = (2.08 \bullet CURVE)$, and $I_L = 6.0$ in *Equation H.11*

$$T_p = \frac{75 \bullet CURVE}{I^2} \quad \textbf{Equation H.19}$$

Equation H.20 applies to the stator element when I > SF and SETMETH = Curve.

To obtain the trip time for hot stator, substitute $I_0 = (0.9 \bullet SF)$, and RTC in *Equation H.12*.

$$T_p = \left[\frac{2.5 \bullet CURVE}{\ln\left[\frac{36 - (0.9 \bullet SF)^2}{36 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2 - (0.9 \bullet SF)^2}{I^2 - SF^2}\right] \quad \textbf{Equation H.20}$$

To obtain the trip time for cold stator, substitute $I_0 = 0$ and RTC in *Equation H.12*.

$$T_p = \left[\frac{2.5 \bullet CURVE}{\ln\left[\frac{36 - (0.9 \bullet SF)^2}{36 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right] \quad \textbf{Equation H.21}$$

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Appendix I
Relay Word Bits

Overview

The protection and control element results are represented by Relay Word bits in the SEL-710 Motor Protection Relay. Each Relay Word bit has a label name and can be in either of the following states:

- ➤ 1 (logical 1)
- ➤ 0 (logical 0)

Logical 1 represents an element being picked up or otherwise asserted. Logical 0 represents an element being dropped out or otherwise deasserted.

Table I.1 and *Table I.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 7.43*).

You can use any Relay Word bit (except Row 0) in SELogic control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 9: Analyzing Events*).

Table I.1 SEL-710 Relay Word Bits (Sheet 1 of 4)

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	BFI
4	COMMIDLE	COMMLOSS	REMTRIP	COMMFLT	CFGFLT	49T_STR	49T_RTR	BFT
5	ORED51T	87M1T	87M2T	50Q1T	50Q2T	COASTOP	*a	*a
6	49A	LOSSALRM	JAMALRM	46UBA	RTDA	55A	50N2T	50G2T
7	VARA	37PA	27P2T	59P2T	SPDSAL	81D3T	81D4T	OTHALRM
8	AMBALRM	SALARM	WARNING	LOADUP	LOADLOW	*a	50S	50P2T
9	STOPPED	RUNNING	STARTING	STAR	DELTA	START	IRIGOK	FAULT
10	TRIP	OUT101	OUT102	OUT103	OUT301	OUT302	OUT303	OUT304
11	OUT401	OUT402	OUT403	OUT404	OUT501	OUT502	OUT503	OUT504
12	50P1P	50P2P	50N1P	50N2P	50G1P	50G2P	27P1	59P1
13	IN101	IN102	*a	*a	*a	*a	*a	*a
14	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308

Table I.1 SEL-710 Relay Word Bits (Sheet 2 of 4)

Bit/Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
15	IN401	IN402	IN403	IN404	IN405	IN406	IN407	IN408
16	IN501	IN502	IN503	IN504	IN505	IN506	IN507	IN508
17	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP	THERMLO	NOSLO	TBSLO	ABSLO
18	50Q1P	RTDIN	TRGTR	SPEEDSW	RTDBIAS	52A	SPEED2	HALARM
19	RTD1A	RTD1T	RTD2A	RTD2T	RTD3A	RTD3T	RTD4A	RTD4T
20	RTD5A	RTD5T	RTD6A	RTD6T	RTD7A	RTD7T	RTD8A	RTD8T
21	RTD9A	RTD9T	RTD10A	RTD10T	RTD11A	RTD11T	RTD12A	RTD12T
22	46UBTC	48LJTC	50EFTC	50PTC	37LLTC	66JOGTC	49PTCTC	49RTDTC
23	RSTENRGY	RSTMXMN	DSABLSET	RSTTRGT	BLKPROT	LOP	27P2	59P2
24	SG1	SG2	SG3	MSRTRG	50Q2P	DI_C	DI_B	DI_A
25	STR	STOP	EMRSTR	ER	ULTRIP	TR	FREQTRK	STREQ
26	DNAUX1	DNAUX2	DNAUX3	DNAUX4	DNAUX5	DNAUX6	DNAUX7	DNAUX8
27	DNAUX9	DNAUX10	DNAUX11	RELAY_EN	87M1	87M2	87M1TC	87M2TC
28	PB01	PB02	PB03	PB04	PB01_PUL	PB02_PUL	PB03_PUL	PB04_PUL
29	PB1A_LED	PB1B_LED	PB2A_LED	PB2B_LED	PB3A_LED	PB3B_LED	PB4A_LED	PB4B_LED
30	*[a]	*[a]	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED
31	LB01	LB02	LB03	LB04	LB05	LB06	LB07	LB08
32	LB09	LB10	LB11	LB12	LB13	LB14	LB15	LB16
33	LB17	LB18	LB19	LB20	LB21	LB22	LB23	LB24
34	LB25	LB26	LB27	LB28	LB29	LB30	LB31	LB32
35	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
36	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
37	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
38	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
39	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
40	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
41	SV09	SV10	SV11	SV12	SV013	SV14	SV15	SV16
42	SV09T	SV10T	SV11T	SV12T	SV13T	SV14T	SV15T	SV16T
43	SV17	SV18	SV19	SV20	SV21	SV22	SV23	SV24
44	SV17T	SV18T	SV19T	SV20T	SV21T	SV22T	SV23T	SV24T
45	SV25	SV26	SV27	SV28	SV29	SV30	SV31	SV32
46	SV25T	SV26T	SV27T	SV28T	SV29T	SV30T	SV31T	SV32T
47	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
48	LT09	LT10	LT11	LT12	LT13	LT14	LT15	LT16
49	LT17	LT18	LT19	LT20	LT21	LT22	LT23	LT24
50	LT25	LT26	LT27	LT28	LT29	LT30	LT31	LT32
51	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
52	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD
53	SC09QU	SC10QU	SC11QU	SC12QU	SC13QU	SC14QU	SC15QU	SC16QU
54	SC09QD	SC10QD	SC11QD	SC12QD	SC13QD	SC14QD	SC15QD	SC16QD

Table I.1 SEL-710 Relay Word Bits (Sheet 3 of 4)

Bit/Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
55	SC17QU	SC18QU	SC19QU	SC20QU	SC21QU	SC22QU	SC23QU	SC24QU
56	SC17QD	SC18QD	SC19QD	SC20QD	SC21QD	SC22QD	SC23QD	SC24QD
57	SC25QU	SC26QU	SC27QU	SC28QU	SC29QU	SC30QU	SC31QU	SC32QU
58	SC25QD	SC26QD	SC27QD	SC28QD	SC29QD	SC30QD	SC31QD	SC32QD
59	AILW1	AILW2	AILAL	*[a]	AIHW1	AIHW2	AIHAL	*[a]
60	AI301LW1	AI301LW2	AI301LAL	*[a]	AI301HW1	AI301HW2	AI301HAL	*[a]
61	AI302LW1	AI302LW2	AI302LAL	*[a]	AI302HW1	AI302HW2	AI302HAL	*[a]
62	AI303LW1	AI303LW2	AI303LAL	*[a]	AI303HW1	AI303HW2	AI303HAL	*[a]
63	AI304LW1	AI304LW2	AI304LAL	*[a]	AI304HW1	AI304HW2	AI304HAL	*[a]
64	AI305LW1	AI305LW2	AI305LAL	*[a]	AI305HW1	AI305HW2	AI305HAL	*[a]
65	AI306LW1	AI306LW2	AI306LAL	*[a]	AI306HW1	AI306HW2	AI306HAL	*[a]
66	AI307LW1	AI307LW2	AI307LAL	*[a]	AI307HW1	AI307HW2	AI307HAL	*[a]
67	AI308LW1	AI308LW2	AI308LAL	*[a]	AI308HW1	AI308HW2	AI308HAL	*[a]
68	AI401LW1	AI401LW2	AI401LAL	*[a]	AI401HW1	AI401HW2	AI401HAL	*[a]
69	AI402LW1	AI402LW2	AI402LAL	*[a]	AI402HW1	AI402HW2	AI402HAL	*[a]
70	AI403LW1	AI403LW2	AI403LAL	*[a]	AI403HW1	AI403HW2	AI403HAL	*[a]
71	AI404LW1	AI404LW2	AI404LAL	*[a]	AI404HW1	AI404HW2	AI404HAL	*[a]
72	AI405LW1	AI405LW2	AI405LAL	*[a]	AI405HW1	AI405HW2	AI405HAL	*[a]
73	AI406LW1	AI406LW2	AI406LAL	*[a]	AI406HW1	AI406HW2	AI406HAL	*[a]
74	AI407LW1	AI407LW2	AI407LAL	*[a]	AI407HW1	AI407HW2	AI407HAL	*[a]
75	AI408LW1	AI408LW2	AI408LAL	*[a]	AI408HW1	AI408HW2	AI408HAL	*[a]
76	AI501LW1	AI501LW2	AI501LAL	*[a]	AI501HW1	AI501HW2	AI501HAL	*[a]
77	AI502LW1	AI502LW2	AI502LAL	*[a]	AI502HW1	AI502HW2	AI502HAL	*[a]
78	AI503LW1	AI503LW2	AI503LAL	*[a]	AI503HW1	AI503HW2	AI503HAL	*[a]
79	AI504LW1	AI504LW2	AI504LAL	*[a]	AI504HW1	AI504HW2	AI504HAL	*[a]
80	AI505LW1	AI505LW2	AI505LAL	*[a]	AI505HW1	AI505HW2	AI505HAL	*[a]
81	AI506LW1	AI506LW2	AI506LAL	*[a]	AI506HW1	AI506HW2	AI506HAL	*[a]
82	AI507LW1	AI507LW2	AI507LAL	*[a]	AI507HW1	AI507HW2	AI507HAL	*[a]
83	AI508LW1	AI508LW2	AI508LAL	*[a]	AI508HW1	AI508HW2	AI508HAL	*[a]
84	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
85	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
86	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
87	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
88	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
89	LINKA	LINKB	LINKFAIL	PASEL	PBSEL	SLIPOK	*[a]	*[a]
90	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
91	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
92	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
93	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
94	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040

Table I.1 SEL-710 Relay Word Bits (Sheet 4 of 4)

Bit/Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
95	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
96	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
97	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
98	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
99	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
100	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
101	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
102	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
103	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
104	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
105	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
106	51AP	51BP	51CP	51P1P	51P2P	51QP	51G1P	51G2P
107	51AT	51BT	51CT	51P1T	51P2T	51QT	51G1T	51G2T
108	51AR	51BR	51CR	51P1R	51P2R	51QR	51G1R	51G2R
109	BKMON	BCW	BCWA	BCWB	BCWC	*[a]	*[a]	TSOK
110	TQUAL1	TQUAL2	TQUAL4	TQUAL8	DST	DSTP	LPSEC	LPSECP
111	TSNTPB	TSNTPP	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
112	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	*[a]	MATHERR

[a] Reserved for future use.

Definitions

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 1 of 11)

Bit	Definition	Row
*	Reserved for future use.	—
27P1	Phase Undervoltage Level 1 trip pickup (see *Figure 4.32*).	12
27P1T	Phase undervoltage trip definite-time delayed (see *Figure 4.32*).	2
27P2	Phase Undervoltage Level 2 alarm pickup (see *Figure 4.32*).	23
27P2T	Phase undervoltage alarm/warning definite-time delayed (see *Figure 4.32*).	7
37LLTC	37LL torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
37PA	Underpower alarm. Assert when the relay issues an underpower element alarm/warning (see *Figure 4.36*).	7
37PT	Underpower trip. Assert when the relay issues an underpower element trip (see *Figure 4.36*).	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 4.26*).	6
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 4.26*).	1

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 2 of 11)

Bit	Definition	Row
46UBTC	Phase current unbalance trip torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
47T	Phase reversal trip. Asserts when the relay detects a phase reversal condition (see *Figure 4.27*).	2
48LJTC	Load jam torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
49A	Thermal (overload) alarm. Assert when the relay issues a thermal element alarm/warning because of locked rotor starting or running overload conditions.	6
49PTCTC	49PTC torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
49RTDTC	49RTD torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
49T	Thermal (overload) trip. Assert when the relay issues a thermal element trip because of locked rotor or running overload conditions, i.e., 49T = 49T_RTR OR 49T_STR.	1
49T_RTR	Thermal (overload) trip. Assert when the relay issues a thermal element trip because of rotor overload.	4
49T_STR	Thermal (overload) trip. Assert when the relay issues a thermal element trip because of stator overload.	4
50EFTC	50EF torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
50G1P	Definite-time residual overcurrent trip pickup (see *Figure 4.7*).	12
50G1T	Definite-time residual overcurrent trip output (see *Figure 4.7*).	1
50G2P	Definite-time residual overcurrent alarm pickup (see *Figure 4.7*).	12
50G2T	Definite-time residual overcurrent alarm output (see *Figure 4.7*).	6
50N1P	Definite-time neutral overcurrent trip pickup (see *Figure 4.7*).	12
50N1T	Definite-time neutral overcurrent trip output (see *Figure 4.7*).	2
50N2P	Definite-time neutral overcurrent alarm pickup (see *Figure 4.7*).	12
50N2T	Definite-time neutral overcurrent alarm output (see *Figure 4.7*).	6
50P1P	Definite-time phase overcurrent trip pickup (see *Figure 4.7*).	12
50P1T	Definite-time phase overcurrent trip output (see *Figure 4.7*).	1
50P2P	Definite-time phase overcurrent alarm pickup (see *Figure 4.7*).	12
50P2T	Definite-time phase overcurrent alarm output (see *Figure 4.7*).	8
50PTC	50P torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
50Q1P	Definite-time negative-sequence overcurrent trip pickup (see *Figure 4.7*).	18
50Q1T	Definite-time negative-sequence overcurrent trip output (see *Figure 4.7*).	5
50Q2P	Definite-time negative-sequence overcurrent alarm pickup (see *Figure 4.7*).	24
50Q2T	Definite-time negative-sequence overcurrent alarm output (see *Figure 4.7*).	5
50S	Motor starting overcurrent element (pickup = 2.5 • full-load current).	8
51AP	Phase A time-overcurrent element pickup (see *Figure 4.9*).	106
51AR	Phase A time-overcurrent element reset (see *Figure 4.9*).	108
51AT	Phase A time-overcurrent element trip (see *Figure 4.9*).	107
51BP	Phase B time-overcurrent element pickup (see *Figure 4.9*).	106
51BR	Phase B time-overcurrent element reset (see *Figure 4.9*).	108

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 3 of 11)

Bit	Definition	Row
51BT	Phase B time-overcurrent element trip (see *Figure 4.9*).	107
51CP	Phase C time-overcurrent element pickup (see *Figure 4.9*).	106
51CR	Phase C time-overcurrent element reset (see *Figure 4.9*).	108
51CT	Phase C time-overcurrent element trip (see *Figure 4.9*).	107
51G1P	Residual Time-Overcurrent Trip 1 pickup (see *Figure 4.12*).	106
51G1R	Residual Time-Overcurrent Trip 1 reset (see *Figure 4.12*).	108
51G1T	Residual Time-Overcurrent Trip 1 output (see *Figure 4.12*).	107
51G2P	Residual Time-Overcurrent Trip 2 pickup (see *Figure 4.12*).	106
51G2R	Residual Time-Overcurrent Trip 2 reset (see *Figure 4.12*).	108
51G2T	Residual Time-Overcurrent Trip 2 output (see *Figure 4.12*).	107
51P1P	Maximum Phase Time-Overcurrent Trip 1 pickup (see *Figure 4.7*).	106
51P1R	Maximum Phase Time-Overcurrent Trip 1 reset (see *Figure 4.7*).	108
51P1T	Maximum Phase Time-Overcurrent Trip 1 output (see *Figure 4.7*).	107
51P2P	Maximum Phase Time-Overcurrent Trip 2 pickup (see *Figure 4.7*).	106
51P2R	Maximum Phase Time-Overcurrent Trip 2 reset (see *Figure 4.7*).	108
51P2T	Maximum Phase Time-Overcurrent Trip 2 output (see *Figure 4.7*).	107
51QP	Negative-sequence time-overcurrent element pickup (see *Figure 4.11*).	106
51QR	Negative-sequence time-overcurrent element reset (see *Figure 4.11*).	108
51QT	Negative-sequence time-overcurrent element trip output (see *Figure 4.11*).	107
52A	Asserts when the SELOGIC control equation 52A result is logical 1. Use to indicate that the motor contactor or circuit breaker is closed.	18
55A	Power factor alarm. Asserts when the relay issues a power factor element alarm/warning (see *Figure 4.37*).	6
55T	Power factor trip. Asserts when the relay issues a power factor element alarm or trip (see *Figure 4.37*).	2
59P1	Phase Overvoltage Level 1 trip pickup (see *Figure 4.34*).	12
59P1T	Phase Overvoltage Level 1 trip output (see *Figure 4.34*).	2
59P2	Phase Overvoltage Level 2 alarm pickup (see *Figure 4.34*).	23
59P2T	Phase Overvoltage Level 2 alarm output (see *Figure 4.34*).	7
66JOGTC	66JOG torque control. Bit controlled by trip inhibit settings (see *Table 4.38*).	22
81D1T	Definite-time over- and underfrequency element (Trip Level 1). Asserts when the frequency has been either above or below the element set point for a definite time (see *Figure 4.39*).	3
81D2T	Definite-time over- and underfrequency element (Trip Level 2). Asserts when the frequency has been either above or below the element set point for a definite time (see *Figure 4.39*).	3
81D3T	Definite-time over- and underfrequency element (Trip Level 3). Asserts when the frequency has been either above or below the element set point for a definite time (see *Figure 4.39*).	7
81D4T	Definite-time over- and underfrequency element (Trip Level 4). Asserts when the frequency has been either above or below the element set point for a definite time (see *Figure 4.39*).	7

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 4 of 11)

Bit	Definition	Row
87M1	Definite-time differential overcurrent trip pickup (Level 1).	27
87M1T	Definite-time differential overcurrent trip output (Level 1).	5
87M1TC	Definite-time differential overcurrent element torque control (Level 1).	27
87M2	Definite-time differential overcurrent trip pickup (Level 2).	27
87M2T	Definite-time differential overcurrent trip output (Level 2).	5
87M2TC	Definite-time differential overcurrent element torque control (Level 2).	27
ABSLO	Motor lockout condition. Antibackspin timer.	17
AIHAL	Analog inputs high alarm Limit. If any AI*xxx*HAL = 1, then AIHAL = 1.	59
AIHW1	Analog inputs high warning, Level 1. If any AI*xxx*HW1 = 1, then AIHW1 = 1.	59
AIHW2	Analog inputs high warning, Level 2. If any AI*xxx*HW2 = 1, then AIHW2 = 1.	59
AILAL	Analog inputs low alarm Limit. If any AI*xxx*LAL = 1, then AILAL = 1.	59
AILW1	Analog inputs low warning, Level 1. If any AI*xxx*LW1 = 1, then AILW1 = 1.	59
AILW2	Analog inputs low warning, Level 2. If any AI*xxx*LW2 = 1, then AILW2 = 1.	59
AI*xxx*HAL	Analog Inputs 301–508 warnings/alarms (where *xxx* = 301–508) high alarm limit.	60–83
AI*xxx*HW1	Analog Inputs 301–508 warnings/alarms (where *xxx* = 301–508) high warning, Level 1.	60–83
AI*xxx*HW2	Analog Inputs 301–508 warnings/alarms (where *xxx* = 301–508) high warning, Level 2.	60–83
AI*xxx*LAL	Analog inputs 301–508 warnings/alarms (where *xxx* = 301–508) low alarm limit.	60–83
AI*xxx*LW1	Analog Inputs 301–508 warnings/alarms (where *xxx* = 301–508) low warning, Level 1.	60–83
AI*xxx*LW2	Analog Inputs 301–508 warnings/alarms (where *xxx* = 301–508) low warning, Level 2.	60–83
AMBALRM	Ambient temperature alarm. Asserts if the healthy ambient RTD temperature exceeds the alarm/warning set point for that temperature.	8
AMBTRIP	Ambient temperature trip. Asserts when the healthy ambient RTD temperature exceeds its trip set point.	3
BCW	BCWA OR BCWB OR BCWC.	109
BCWA	Phase A breaker contact wear has reached the 100 percent wear level.	109
BCWB	Phase B breaker contact wear has reached the 100 percent wear level.	109
BCWC	Phase C breaker contact wear has reached the 100 percent wear level.	109
BFI	Breaker failure initiation. Asserts when the SELOGIC control equation BFI result in a logical 1.	3
BFT	Breaker failure trip. Asserts when the relay issues a breaker failure trip (see *Figure 4.52*).	4
BKMON	Breaker monitor initiation.	109
BLKPROT	Asserts when the SELOGIC control equation BLKPROT result is logical 1 (see *Table 4.37*).	23
BRGALRM	Bearing temperature alarm. BRGALRM asserts when any healthy bearing RTD temperature exceeds the corresponding alarm set point.	17
BRGTRIP	Bearing temperature trip. BRGTRIP asserts when one or two (when EBRGV = Y) healthy bearing RTD temperatures exceed corresponding trip set points.	17
CBADA	Channel A, channel unavailability over threshold.	88
CBADB	Channel B, channel unavailability over threshold.	88

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 5 of 11)

Bit	Definition	Row
CFGFLT	Asserts on failed settings interdependency check during Modbus setting change.	4
COASTOP	Rotor coast to stop.	5
COMMFLT	Time-out of internal communication between CPU board and DeviceNet board.	4
COMMIDLE	DeviceNet card in programming mode.	4
COMMLOSS	DeviceNet card communications failure.	4
DELTA	Asserts when the Star-Delta starting function issues a command to switch motor configuration to Delta (see *Table 4.24 on page 4.37*).	9
DI_A	Distortion index Phase A (see *Overcurrent Elements on page 4.21*).	24
DI_B	Distortion index Phase B (see *Overcurrent Elements on page 4.21*).	24
DI_C	Distortion index Phase C (see *Overcurrent Elements on page 4.21*).	24
DNAUX*n*	DeviceNet/Modbus AUX*n* assert bit, where *n* = 1 to 8.	26
DNAUX*n*	DeviceNet/Modbus AUX*n* assert bit, where *n* = 9 to 11.	27
DSABLSET	Settings changes not allowed from the front-panel interface—when asserted.	23
DST	Daylight-saving time.	110
DSTP	Daylight-saving time pending.	110
EMRSTR	Emergency restart asserts when input assigned to EMRSTR asserts or when front-panel Emergency Restart or Modbus/DeviceNet **EMRSTR** command is received.	25
ENABLE	Relay Enabled.	0
ER	Event report trigger SELOGIC control equation (see *Table 4.74*).	25
FAULT	Fault indication. Asserts when the SELOGIC control equation FAULT result in a logical 1.	9
FREQTRK	Asserts when relay is tracking frequency.	25
HALARM	Hardware alarm (see *Self-Test on page 10.11*).	18
IN101	Contact input.	13
IN102	Contact input.	13
IN*nnn*	Contact Input *nnn*, where *nnn* = 301 to 308 (available only with optional I/O module).	14
IN*nnn*	Contact Input *nnn*, where *nnn* = 401 to 408 (available only with optional I/O module).	15
IN*nnn*	Contact Input *nnn*, where *nnn* = 501 to 508 (available only with optional I/O module).	16
IRIGOK	IRIG-B input OK.	9
JAMALRM	Load-jam alarm/warning (see *Figure 4.24*).	6
JAMTRIP	Load-jam trip (see *Figure 4.24*).	1
LB01 to LB08	Local Bit *n* asserted, where *n* = 1 to 8.	31
LB09 to LB16	Local Bit *n* asserted, where *n* = 9 to 16.	32
LB17 to LB24	Local Bit *n* asserted, where *n* = 17 to 24.	33
LB25 to LB32	Local Bit *n* asserted, where *n* = 25 to 32.	34
LBOKA	Channel A, looped back OK.	88

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 6 of 11)

Bit	Definition	Row
LBOKB	Channel B, looped back OK.	88
LINKA	Assert if Ethernet Port A detects link.	89
LINKB	Assert if Ethernet Port B detects link.	89
LINKFAIL	Failure of active Ethernet port link.	89
LOADLOW	Asserts when the selected load parameter drops below a lower level setting (see *Table 4.37*).	8
LOADUP	Asserts when the selected load parameter exceeds an upper level setting (see *Table 4.37*).	8
LOP	Loss-of-potential logic asserted (see *Figure 4.38*).	23
LOSSALRM	Load-loss alarm/warning. Assert when the relay detects a load-loss as defined by that function and corresponding settings (see *Figure 4.25*).	6
LOSSTRIP	Load-loss trip. Assert when the relay detects a load-loss as defined by that function and corresponding settings (see *Figure 4.25*).	1
LPSEC	Direction of the upcoming leap second. During the time that LPSECP is asserted, if LPSEC is asserted, the upcoming leap seconds is deleted; otherwise, the leap second is added.	110
LPSECP	Leap second pending.	110
LT*nn*	Latch Bit *nn* asserted, where *nn* = 01 to 08 (see *Figure 4.45*).	47
LT*nn*	Latch Bit *nn* asserted, where *nn* = 09 to 16 (see *Figure 4.45*).	48
LT*nn*	Latch Bit *nn* asserted, where *nn* = 17 to 24 (see *Figure 4.45*).	49
LT*nn*	Latch Bit *nn* asserted, where *nn* = 25 to 32 (see *Figure 4.45*).	50
MATHERR	SELOGIC math error bit asserted for divide-by-zero, etc., in SELOGIC math functions.	112
MSRTRG	Motor start report trigger. Asserts when the SELOGIC control equation MSRTRG result in a logical 1.	24
NOSLO	Motor lockout condition, starts per hour function (NOSLO).	17
ORED51T	Logical OR of all the time-overcurrent elements tripped outputs (see *Figure 4.9* through *Figure 4.12*).	5
OTHALRM	Other temperature alarm. Asserts when any healthy Other RTD temperature exceeds the alarm/warning set point for that temperature.	7
OTHTRIP	Other temperature trip. Asserts when one (or more) healthy Other RTD temperature exceeds the trip set points.	3
OUT101	Control equation for contact output.	10
OUT102	Control equation for contact output.	10
OUT103	Control equation for contact output.	10
OUT301	Control equation for contact output (available only with optional I/O module).	10
OUT302	Control equation for contact output (available only with optional I/O module).	10
OUT303	Control equation for contact output (available only with optional I/O module).	10
OUT304	Control equation for contact output (available only with optional I/O module).	10
OUT401	Control equation for contact output (available only with optional I/O module).	11
OUT402	Control equation for contact output (available only with optional I/O module).	11
OUT403	Control equation for contact output (available only with optional I/O module).	11

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 7 of 11)

Bit	Definition	Row
OUT404	Control equation for contact output (available only with optional I/O module).	11
OUT501	Control equation for contact output (available only with optional I/O module).	11
OUT502	Control equation for contact output (available only with optional I/O module).	11
OUT503	Control equation for contact output (available only with optional I/O module).	11
OUT504	Control equation for contact output (available only with optional I/O module).	11
PASEL	Ethernet Port A is selected for communication.	89
PBSEL	Ethernet Port B is selected for communication.	89
PB01	Front-Panel Pushbutton 1 bit.	28
PB01_PUL	Front-Panel Pushbutton 1 pulse bit (asserted for one processing interval when PB01 is pressed).	28
PB02	Front-Panel Pushbutton 2 bit.	28
PB02_PUL	Front-Panel Pushbutton 2 pulse bit (asserted for one processing interval when PB02 is pressed).	28
PB03	Front-Panel Pushbutton 3 bit.	28
PB03_PUL	Front-Panel Pushbutton 3 pulse bit (asserted for one processing interval when PB03 is pressed).	28
PB04	Front-Panel Pushbutton 4 bit.	28
PB04_PUL	Front-Panel Pushbutton 4 pulse bit (asserted for one processing interval when PB04 is pressed).	28
PB1A_LED	Asserts when the SELOGIC control equation PB1A_LED results in logical 1.	29
PB1B_LED	Asserts when the SELOGIC control equation PB1B_LED results in logical 1.	29
PB2A_LED	Asserts when the SELOGIC control equation PB2A_LED results in logical 1.	29
PB2B_LED	Asserts when the SELOGIC control equation PB2B_LED results in logical 1.	29
PB3A_LED	Asserts when the SELOGIC control equation PB3A_LED results in logical 1.	29
PB3B_LED	Asserts when the SELOGIC control equation PB3B_LED results in logical 1.	29
PB4A_LED	Asserts when the SELOGIC control equation PB4A_LED results in logical 1.	29
PB4B_LED	Asserts when the SELOGIC control equation PB4B_LED results in logical 1.	29
PTCFLT	Indicates faulted/shorted thermistor.	3
PTCTRIP	Asserts when measured PTC loop resistance is greater than trip value.	1
RBADA	Channel A, outage duration over threshold.	88
RBADB	Channel B, outage duration over threshold.	88
RB*nn*	Remote Bit *nn* asserted, where *nn* = 01 to 08.	35
RB*nn*	Remote Bit *nn* asserted, where *nn* = 09 to 16.	36
RB*nn*	Remote Bit *nn* asserted, where *nn* = 17 to 24.	37
RB*nn*	Remote Bit *nn* asserted, where *nn* = 25 to 32.	38
RELAY_EN	Relay OK flag. RELAY_EN status follows the **ENABLED** LED status.	27
REMTRIP	Remote trip control input asserted (see *Table 4.40*).	4
RMB1A to RMB8A	Channel A receives MIRRORED BITS RMB1A through RMB8A.	84

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 8 of 11)

Bit	Definition	Row
RMB1B to RMB8B	Channel B receives MIRRORED BITS RMB1B through RMB8B.	86
ROKA	Channel A, received data OK.	88
ROKB	Channel B, received data OK.	88
RSTENRGY	Reset energy metering.	23
RSTMXMN	Reset max/min metering.	23
RSTTRGT	Asserts when the SELOGIC control equation RSTTRGT result is logical 1. Used to reset trip logic and target LEDs (see *Table 4.57*).	23
RTD10A	RTD10 alarm.	21
RTD10T	RTD10 trip.	21
RTD11A	RTD11 alarm.	21
RTD11T	RTD11 trip.	21
RTD12A	RTD12 alarm.	21
RTD12T	RTD12 trip.	21
RTD1A	RTD1 alarm.	19
RTD1T	RTD1 trip.	19
RTD2A	RTD2 alarm.	19
RTD2T	RTD2 trip.	19
RTD3A	RTD3 alarm.	19
RTD3T	RTD3 trip.	19
RTD4A	RTD4 alarm.	19
RTD4T	RTD4 trip.	19
RTD5A	RTD5 alarm.	20
RTD5T	RTD5 trip.	20
RTD6A	RTD6 alarm.	20
RTD6T	RTD6 trip.	20
RTD7A	RTD7 alarm.	20
RTD7T	RTD7 trip.	20
RTD8A	RTD8 alarm.	20
RTD8T	RTD8 trip.	20
RTD9A	RTD9 alarm.	21
RTD9T	RTD9 trip.	21
RTDA	Winding/Bearing RTD overtemperature alarm/warning.	6

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 9 of 11)

Bit	Definition	Row
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 10 percentage points higher than the motor thermal element % Thermal Capacity. Typically indicates a loss of motor cooling efficiency.	18
RTDFLT	Asserts when an open or short circuit condition is detected on any enabled RTD input, or communication with the external RTD module has been interrupted.	3
RTDIN	Indicates status of contact connected to SEL-2600 RTD module.	18
RTDT	Winding and bearing RTD overtemperature trip.	1
RUNNING	Asserts when the motor is running (see *Figure 4.42*).	9
SALARM	Pulses for the following conditions: setting changes, access level changes, active group changes, copy commands, password changes, and three unsuccessful password entry attempts.	8
SC01QD to SC08QD	SELOGIC Counters 01 through 08 asserted when counter = 0.	52
SC01QU to SC08QU	SELOGIC Counters 01 through 08 asserted when counter = preset value.	51
SC09QD to SC16QD	SELOGIC Counters 09 through 16 asserted when counter = 0.	54
SC09QU to SC16QU	SELOGIC Counters 09 through 16 asserted when counter = preset value.	53
SC17QD to SC24QD	SELOGIC Counters 17 through 24 asserted when counter = 0.	56
SC17QU to SC24QU	SELOGIC Counters 17 through 24 asserted when counter = preset value.	55
SC25QD to SC32QD	SELOGIC Counters 25 through 32 asserted when counter = 0.	58
SC25QU to SC32QU	SELOGIC Counters 25 through 32 asserted when counter = preset value.	57
SG*n*	Setting Group *n* active, where *n* = 1 to 3.	24
SLIPOK	Asserts when the slip calculated based on the stator measurements is OK.	89
SMTRIP	Asserts when the 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 4.31*).	7
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 4.31*).	2
SPEED2	Asserts when the SELOGIC control equation SPEED2 result is logical 1 (see *Table 4.41*).	18
SPEEDSW	Speed switch input. Asserts when the SELOGIC control equation SPEEDSW result is logical 1 (see *Table 4.41*).	18
STAR	Asserts when the Star-Delta Starting function issues a command to switch motor configuration to Star (see *Table 4.24*).	9
START	Output of the motor start logic (see *Figure 4.43*).	9
STARTING	Asserts when the protected motor is starting (see *Figure 4.42*).	9
STOP	Stop motor—asserts when serial port command STOP or Front-Panel or Modbus/DeviceNet Stop command is issued.	25
STOPPED	Asserts when the motor is stopped (see *Figure 4.42*).	9
STR	Start motor—asserts when serial port command STR (START) or Front-Panel or Modbus/DeviceNet Start command is issued.	25
STREQ	Start motor SELOGIC control equation (see *Table 4.41*).	25
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 01 to 08 (see *Figure 4.46*).	39

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 10 of 11)

Bit	Definition	Row
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 09 to 16 (see *Figure 4.46*).	41
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 17 to 24 (see *Figure 4.46*).	43
SV*nn*	SELOGIC control equation variable timer input SV*nn* asserted, where *nn* = 25 to 32 (see *Figure 4.46*).	45
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 01 to 08 (see *Figure 4.46*).	40
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 09 to 16 (see *Figure 4.46*).	42
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 17 to 24 (see *Figure 4.46*).	44
SV*nn*T	SELOGIC control equation variable timer output SV*nn*T asserted, where *nn* = 25 to 32 (see *Figure 4.46*).	46
T01_LED	Asserts when the SELOGIC control equation T01_LED result is logical 1 (see *Table 4.76*).	30
T02_LED	Asserts when the SELOGIC control equation T02_LED result is logical 1 (see *Table 4.76*).	30
T03_LED	Asserts when the SELOGIC control equation T03_LED result is logical 1 (see *Table 4.76*).	30
T04_LED	Asserts when the SELOGIC control equation T04_LED result is logical 1 (see *Table 4.76*).	30
T05_LED	Asserts when the SELOGIC control equation T05_LED result is logical 1 (see *Table 4.76*).	30
T06_LED	Asserts when the SELOGIC control equation T06_LED result is logical 1 (see *Table 4.76*).	30
TBSLO	Motor lockout condition, minimum time between starts.	17
THERMLO	Motor lockout conditions, asserted by the TCURTR or TCUSTR too high (see the logic diagram on *page 4.56*).	17
TLED_01	Front-panel T01_LED.	0
TLED_02	Front-panel T02_LED.	0
TLED_03	Front-panel T03_LED.	0
TLED_04	Front-panel T04_LED.	0
TLED_05	Front-panel T05_LED.	0
TLED_06	Front-panel T06_LED.	0
TMB1A to TMB8A	Channel A transmit MIRRORED BITS TMB1A through TMB8A.	85
TMB1B to TMB8B	Channel B transmit MIRRORED BITS TMB1B through TMB8B.	87
TR	Trip SELOGIC control equation (see *Table 4.40*).	25
TRGTR	Target reset. Asserts for one quarter-cycle when you execute a front-panel, serial port target reset command, or Modbus target reset.	18
TRIP	Output of trip logic (see *Figure 4.40*).	10
TRIP_LED	Front-panel **TRIP** LED.	0
TQUAL1	Time quality bit, add 1 when asserted.	110
TQUAL2	Time quality bit, add 2 when asserted.	110
TQUAL4	Time quality bit, add 4 when asserted.	110
TQUAL8	Time quality bit, add 8 when asserted.	110

Table I.2 Relay Word Bit Definitions for the SEL-710 (Sheet 11 of 11)

Bit	Definition	Row
TSNTPB	SNTP secondary server is active.	111
TSNTPP	SNTP primary server is active.	111
TSOK	Assert if current time source accuracy is sufficient for synchronized phasor measurements.	109
TUTCS	Offset hours sign from UTC time, subtract the UTC offset if TUTCS is asserted; otherwise, add.	111
TUTC1	Offset hours from UTC time, binary, add 1 if asserted.	111
TUTC2	Offset hours from UTC time, binary, add 2 if asserted.	111
TUTC4	Offset hours from UTC time, binary, add 4 if asserted.	111
TUTC8	Offset hours from UTC time, binary, add 8 if asserted.	111
TUTCH	Offset half-hour from UTC time, binary, add 0.5 if asserted.	111
ULTRIP	Unlatch (auto reset) trip from SELOGIC control equation (see *Table 4.40*).	25
VARA	Reactive power alarm. Assert when the relay issues a reactive power element alarm/warning (see *Figure 4.35*).	7
VART	Reactive power trip. Assert when the relay issues a reactive power element trip (see *Figure 4.35*).	2
VB*xxx*	Virtual bits used for incoming GOOSE messages (*xxx* = 001 to 128)	90–105
WARNING	Warning bit asserts for possible warning conditions, as shown in *Table 8.3*. These conditions also trigger a flashing **TRIP** LED.	8
WDGALRM	Winding temperature alarm. WDGALRM asserts when any healthy winding RTD temperature exceeds the corresponding alarm set point.	17
WDGTRIP	Winding temperature trip. WDGTRIP asserts when one or two (when EWDGV = Y) healthy winding RTD temperatures exceed corresponding trip set points.	17

Appendix J

Analog Quantities

The SEL-710 Motor Protection Relay contains several analog quantities that you can use for more than one function. The actual analog quantities available depend on the part number of the relay used. Analog quantities are typically generated and used by a primary function, such as metering. Selected quantities are made available for one or more supplemental functions, for example, the load profile.

Note that all analog quantities available for use in SELOGIC are processed every 100 ms and may not be suitable for fast-response control and protection applications. Analog quantities for rms data are determined through the use of data averaged over the previous 8 cycles.

Table J.1 lists analog quantities that can be used in the following specific functions:

- ➤ SELOGIC control equations (see *Section 4: Protection and Logic Functions*)
- ➤ Display points (see *Section 8: Front-Panel Operations*)
- ➤ Load profile recorder (see *Section 5: Metering and Monitoring*)
- ➤ Fast Meter (see *Appendix C: SEL Communications Processors*)

For a list of analog quantities available for Modbus communications, see *Appendix D: Modbus Communications*.

Table J.1 Analog Quantities (Sheet 1 of 5)

Name	Description	Unit	Display Points	SELOGIC	Load Profile	Fast Meter
Fundamental Instantaneous Metering						
IA_MAG	Current, A-phase, magnitude	A primary	x	x	x	x
IA_ANG	Current, A-phase, angle	degrees	x	x	x	
IB_MAG	Current, B-phase, magnitude	A primary	x	x	x	x
IB_ANG	Current, B-phase, angle	degrees	x	x	x	
IC_MAG	Current, C-phase, magnitude	A primary	x	x	x	x
IC_ANG	Current, C-phase, angle	degrees	x	x	x	
IN_MAG	Neutral current, magnitude	A primary	x	x	x	x
IN_ANG	Neutral current, angle	degrees	x	x	x	
IG_MAG	Current, calculated-residual, magnitude	A primary	x	x	x	x
IG_ANG	Current, calculated-residual, angle	degrees	x	x	x	
IAV	Current, average current, magnitude	A primary	x	x	x	
3I2	Current, negative-sequence current, magnitude	A primary	x	x	x	
UBI	Current unbalance, %	%	x	x	x	x
VA_MAG	Voltage, A-phase-to-neutral, magnitude	V primary	x	x	x	x

Table J.1 Analog Quantities (Sheet 2 of 5)

Name	Description	Unit	Display Points	SELOGIC	Load Profile	Fast Meter
VA_ANG	Voltage, A-phase-to-neutral, angle	degrees	x	x	x	
VB_MAG	Voltage, B-phase-to-neutral, magnitude	V primary	x	x	x	x
VB_ANG	Voltage, B-phase-to-neutral, angle	degrees	x	x	x	
VC_MAG	Voltage, C-phase-to-neutral, magnitude	V primary	x	x	x	x
VC_ANG	Voltage, C-phase-to-neutral, angle	degrees	x	x	x	
VAB_MAG	Voltage, A-to-B-phase, magnitude	V primary	x	x	x	x
VAB_ANG	Voltage, A-to-B-phase, angle	degrees	x	x	x	
VBC_MAG	Voltage, B-to-C-phase, magnitude	V primary	x	x	x	x
VBC_ANG	Voltage, B-to-C-phase, angle	degrees	x	x	x	
VCA_MAG	Voltage, C-to-A-phase, magnitude	V primary	x	x	x	x
VCA_ANG	Voltage, C-to-A-phase, angle	degrees	x	x	x	
VG_MAG	Zero-sequence voltage, magnitude	V primary	x	x	x	x
VG_ANG	Zero-sequence voltage, angle	degrees	x	x	x	
VAVE	Average voltage, magnitude	V primary	x	x	x	
3V2	Voltage, negative-sequence, magnitude	V primary	x	x	x	
UBV	Voltage unbalance, magnitude	%	x	x	x	x
S	Apparent power, three-phase, magnitude	kVA primary	x	x	x	x
P	Real power, three-phase, magnitude	kW primary	x	x	x	x
Q	Reactive power, three-phase, magnitude	kVAR primary	x	x	x	x
PF	Power factor, three-phase, magnitude		x	x	x	x
FREQ	Frequency	Hz	x	x	x	x
SMSLIP2	Synchronous motor slip	%	x	x		
Thermal Metering						
NOTE: Use caution when assigning RTD analog quantities to SELOGIC control equations or math variables because the conditions RTD open, short, comm fail, stat fail, fail, and NA will be reported as +32767, –32768, +32764, +32760, +32766, and +32752, respectively.						
RTDWDGMX[a]	Maximum winding RTD temperature	°C	x	x	x	x
RTDBRGMX[a]	Maximum bearing RTD temperature	°C	x	x	x	x
RTDAMB[a]	Ambient RTD temperature	°C	x	x	x	x
RTDOTHMX[a]	Other maximum RTD temperature	°C	x	x	x	x
RTD1–RTD12	RTD1 temperature to RTD12 temperature[b]	°C	x	x	x	
MLOAD	Motor load	pu of FLA	x	x	x	x
TCURTR	Rotor % thermal capacity used	%	x	x	x	x
TCUSTR	Stator % thermal capacity used	%	x	x	x	x
TCURTD	RTD % thermal capacity used	%	x	x	x	
THRMTP	Thermal trip in	s	x	x	x	
TRST	Time to reset	min	x	x	x	
STRTAV	Starts available		x	x	x	
SLIP	Slip	%	x	x	x	
MRT	Motor running time	hours	x	x	x	

Table J.1 Analog Quantities (Sheet 3 of 5)

Name	Description	Unit	Display Points	SELogic	Load Profile	Fast Meter
Analog Input Metering						
AI301–AI308	Analog inputs for an analog card in Slot C	EU	x	x	x	
AI401–AI408	Analog inputs for an analog card in Slot D	EU	x	x	x	
AI501–AI508	Analog inputs for an analog card in Slot E	EU	x	x	x	
Energy Metering						
MWH3P	Real energy, three-phase OUT	MWh primary	x	x	x	
MVARH3PI	Reactive energy, three-phase IN	MVARh primary	x	x	x	
MVARH3PO	Reactive energy, three-phase OUT	MVARh primary	x	x	x	
MVAH3P	Apparent energy, three-phase	MVAh primary	x	x	x	
Maximum/Minimum Metering						
NOTE: For each of the maximum or minimum analog quantities, the corresponding time stamp is also reported in Modbus. In addition, the time when the max/min data was last reset is also reported in Modbus.						
IAMX	Current, A-phase, maximum magnitude	A primary	x	x	x	
IBMX	Current, B-phase, maximum magnitude	A primary	x	x	x	
ICMX	Current, C-phase, maximum magnitude	A primary	x	x	x	
INMX	Current, neutral, maximum magnitude	A primary	x	x	x	
IGMX	Current, residual, maximum magnitude	A primary	x	x	x	
IAMN	Current, A-phase, minimum magnitude	A primary	x	x	x	
IBMN	Current, B-phase, minimum magnitude	A primary	x	x	x	
ICMN	Current, C-phase, minimum magnitude	A primary	x	x	x	
INMN	Current, neutral, minimum magnitude	A primary	x	x	x	
IGMN	Current, residual, minimum magnitude	A primary	x	x	x	
VABMX	Voltage, A-to-B-phase, maximum magnitude	V primary	x	x	x	
VBCMX	Voltage, B-to-C-phase, maximum magnitude	V primary	x	x	x	
VCAMX	Voltage, C-to-A-phase, maximum magnitude	V primary	x	x	x	
VAMX	Voltage, A-phase-to-neutral, maximum magnitude	V primary	x	x	x	
VBMX	Voltage, B-phase-to-neutral, maximum magnitude	V primary	x	x	x	
VCMX	Voltage, C-phase-to-neutral, maximum magnitude	V primary	x	x	x	
VABMN	Voltage, A-to-B-phase, minimum magnitude	V primary	x	x	x	
VBCMN	Voltage, B-to-C-phase, minimum magnitude	V primary	x	x	x	
VCAMN	Voltage, C-to-A-phase, minimum magnitude	V primary	x	x	x	
VAMN	Voltage, A-phase-to-neutral, minimum magnitude	V primary	x	x	x	
VBMN	Voltage, B-phase-to-neutral, minimum magnitude	V primary	x	x	x	
VCMN	Voltage, C-phase-to-neutral, minimum magnitude	V primary	x	x	x	
KVA3PMX	Apparent power, three-phase, maximum magnitude	kVA primary	x	x	x	
KW3PMX	Real power, three-phase, maximum magnitude	kW primary	x	x	x	
KVAR3PMX	Reactive power, three-phase, maximum magnitude	kVAR primary	x	x	x	
KVA3PMN	Apparent power, three-phase, minimum magnitude	kVA primary	x	x	x	
KW3PMN	Real power, three-phase, minimum magnitude	kW primary	x	x	x	
KVAR3PMN	Reactive power, three-phase, minimum magnitude	kVAR primary	x	x	x	

Table J.1 Analog Quantities (Sheet 4 of 5)

Name	Description	Unit	Display Points	SELOGIC	Load Profile	Fast Meter
FREQMX	Maximum frequency	Hz	x	x	x	
FREQMN	Minimum frequency	Hz	x	x	x	
RTD1MX–RTD12MX	RTD1 maximum to RTD12 maximum	°C	x	x	x	
RTD1MN–RTD12MN	RTD1 minimum to RTD12 minimum	°C	x	x	x	
AI301MX–AI308MX	Analog Transducer Input 301–308 maximum[c]	EU	x	x	x	
AI301MN–AI308MN	Analog Transducer Input 301–308 minimum	EU	x	x	x	
AI401MX–AI408MX	Analog Transducer Input 401–408 maximum	EU	x	x	x	
AI401MN–AI408MN	Analog Transducer Input 401–408 minimum	EU	x	x	x	
AI501MX–AI508MX	Analog Transducer Input 501–508 maximum	EU	x	x	x	
AI501MN–AI508MN	Analog Transducer Input 501–508 minimum	EU	x	x	x	
NOTE: EU is Engineering Units						
RMS Metering						
IARMS	RMS current, A-phase, magnitude	A primary	x	x	x	
IBRMS	RMS current, B-phase, magnitude	A primary	x	x	x	
ICRMS	RMS current, C-phase, magnitude	A primary	x	x	x	
INRMS	RMS current, neutral, magnitude	A primary	x	x	x	
VARMS	RMS voltage, A-phase, magnitude	V primary	x	x	x	
VBRMS	RMS voltage, B-phase, magnitude	V primary	x	x	x	
VCRMS	RMS voltage, C-phase, magnitude	V primary	x	x	x	
VABRMS	RMS voltage, AB-phase-to-phase, magnitude	V primary	x	x	x	
VBCRMS	RMS voltage, BC-phase-to-phase, magnitude	V primary	x	x	x	
VCARMS	RMS voltage, CA-phase-to-phase, magnitude	V primary	x	x	x	
Differential Metering (Source SRS: Meter Fundamental Report)						
IA87	Differential current, A-phase, magnitude	A primary	x	x		
IB87	Differential current, B-phase, magnitude	A primary	x	x		
IC87	Differential current, C-phase, magnitude	A primary	x	x		
Breaker Monitoring						
INTT	Internal trips—counter		x	x		
INTIA	Accumulated current—internal trips, A-phase	kA primary	x	x		
INTIB	Accumulated current—internal trips, B-phase	kA primary	x	x		
INTIC	Accumulated current—internal trips, C-phase	kA primary	x	x		
EXTT	External trips—counter		x	x		
EXTIA	Accumulated current—external trips, A-phase	kA primary	x	x		
EXTIB	Accumulated current—external trips, B-phase	kA primary	x	x		
EXTIC	Accumulated current—external trips, C-phase	kA primary	x	x		
WEARA	Breaker wear, A-phase	%	x	x		
WEARB	Breaker wear, B-phase	%	x	x		
WEARC	Breaker wear, C-phase	%	x	x		

Table J.1 Analog Quantities (Sheet 5 of 5)

Name	Description	Unit	Display Points	SELogic	Load Profile	Fast Meter
Date/Time						
DATE	Present date[d]		x			
TIME	Present time		x			
YEAR	Year number (0000–9999)			x	x	
DAYY	Day of year number (1–366)			x	x	
WEEK	Week number (1–52)			x	x	
DAYW	Day of week number (1–7)			x	x	
MINSM	Minutes since midnight			x	x	
RID/TID						
RID	Relay identifier		x			
TID	Terminal identifier		x			
Setting Group (Source SRS: Group Switch)						
GROUP	Active setting group #		x	x	x	
Math Variables						
MV01–MV32	Math Variable 01 to Math Variable 32		x	x	x	
SELogic Counters						
SC01–SC32	SELogic Counter 01 to SELogic Counter 32		x	x	x	

[a] SEL Fast Message Label names for RTDWDGMX, RTDBRGMX, RTDAMB, and RTDOTHMX are WDG, BRG, AMB, and OTH, respectively.
[b] RTD open is equivalent to +32767 and RTD short is equivalent to –32768 when RTDs are monitored via LDP.
[c] See the Engineering Unit settings (e.g., AI301EU) of the respective analog input quantity for the unit.
[d] DATE, TIME, RID, and TID are only available for display point settings (DP01–DP32).

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Glossary

A Abbreviation for amps or amperes; units of electrical current magnitude.

ACSELERATOR QuickSet SEL-5030 Software A Windows-based program that simplifies settings and provides analysis support.

Ambient Temperature Temperature of the motor cooling air at the cooling air inlet. Measured by an RTD whose location setting is AMB.

Analog In this instruction manual, Analog is synonymous with Transducer.

ANSI Standard Device Numbers A list of standard numbers used to represent electrical protection and control relays. The standard device numbers used in this instruction manual include:

27	Undervoltage Element
37	Underpower Element
46	Phase Balance or Current Unbalance Element
47	Phase Sequence Element
49	Thermal Element
50	Instantaneous Overcurrent Element
51	Inverse Time-Overcurrent
52	AC Circuit Breaker
55	Power Factor Element
59	Overvoltage Element
66	Jogging Device (limits number of operations within a given time of each other)
81	Frequency Element
87	Differential 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-710 Motor Protection Relay uses ASCII text characters to communicate using the relay front- and rear-panel EIA-232 serial ports.

Assert To activate; to fulfill the logic or electrical requirements needed to operate a device. To apply a short-circuit or closed contact to an SEL-710 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-710, this element works together with the motor thermal element, which also provides unbalance current protection.

Deassert To deactivate; to remove the logic or electrical requirements needed to operate a device. To remove a short-circuit or closed contact from an SEL-710 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. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

EEPROM Abbreviation for Electrically Erasable Programmable Read-Only Memory. Nonvolatile memory where relay settings, event reports, SER records, and other nonvolatile data are stored.

Event History A quick look at recent relay activity that includes a standard report header; event number, date, time, and type; maximum fault phase current; and targets.

Event Report A text-based collection of data stored by the relay in response to a triggering condition, such as a fault or command. The data show relay measurements before and after the trigger, in addition to the states of protection elements, relay inputs, and relay outputs each processing interval. After an electrical system fault, use event reports to analyze relay and system performance.

Event Summary A shortened version of stored event reports. An event summary includes items such as event date and time, event type, fault voltages, currents, etc. The relay sends an event report summary (if auto messaging is enabled) to the relay serial port a few seconds after an event.

Fail-Safe 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-710 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.

IEC 61850 Standard protocol for real-time exchange of data between databases in multi-vendor devices.

IG Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero. When a motor ground fault occurs, this current can be large.

IN Neutral current measured by the relay **IN** input. The **IN** input is typically connected to the secondary winding of a window-CT 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 because of 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.

MIRRORED BITS Protocol for direct relay-to-relay communications.

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 degrees, and the C-phase voltage lags B-phase voltage by 120 degrees. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120 degrees, and the B-phase voltage lags the C-phase voltage by 120 degrees.

Pickup Time The time measured from the application of an input signal until the output signal asserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element pickup time.

Pinout The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Power, P Real part of the complex power (S) expressed in units of Watts (W), kilowatts (kW), or megawatts (MW).

Power Factor The cosine of the angle by which phase current lags phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a resistive load.

Power, Q Reactive part of the complex power (S) expressed in units of Vars (W), kilovars (kVar), or megavars (MVar).

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 Device. An RTD is made of a metal having a precisely known resistance and temperature coefficient of resistance. The SEL-710 (and the SEL-2600 RTD module RTD modules) 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.

Thermistor (ITC) Positive temperature coefficient thermistor.

Transducer Device that converts the input to the device to an analog output quantity of either current (±1, 2.5, 5, 10 and 20 mA, or 4–20 ma), or voltage (±1, 2.5, 5, or 10 V).

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if an out-of-tolerance condition is detected. The SEL-710 is equipped with self-tests that validate the relay power supply, microprocessor, memory, and other critical systems.

SELOGIC® Control Equation A relay setting that allows you to control a relay function (such as an output contact) by using a logical combination of relay element outputs and fixed logic outputs. Logical AND, OR, INVERT, rising edge [/], and falling edge [\] operators, plus a single level of parentheses are available to use in each control equation setting.

Sequential Events Recorder A relay function that stores a record of the date and time of each assertion and deassertion of every Relay Word bit in a settable list. Provides a useful way to determine the order and timing of events following a relay operation.

SER Abbreviation for Sequential Events Recorder or the relay serial port command to request a report of the latest 1024 sequential events.

Speed Switch An electrical contact that closes to indicate that a motor speed exceeds a certain value.

Star Motor winding configuration during Star-Delta starting.

Terminal Emulation Software Personal computer (PC) software that can be used to send and receive ASCII text messages via the PC serial port.

Underfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency is less than a settable frequency.

Underpower Element A protection element that causes the relay to trip when the measured electrical power consumed by a motor is less than a settable value.

VA, VB, VC Measured A-, B-, and C-phase-to-neutral voltages.

VAB, VBC, VCA Measured or calculated phase-to-phase voltages.

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 QuickSet relay driver version when creating or editing relay settings files.

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Index

Page numbers appearing in bold mark the location of the topic's primary discussion.

R

S

T

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V

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SEL-710 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 using lowercase letters. Commands can be initiated with the three initial letters of the command. Refer to *SEL ASCII Protocol and Commands* for additional details and capabilities of each command.

Serial Port Command	Command Description
Access Level 0 Commands	
ACC	Goes to Access Level 1. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 1 command.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 2 command.
BRE	Displays the breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed Event Report *n*, at 1/4-cycle resolution. Attach R for compressed raw report, at 1/16-cycle resolution.
CMSR *n*	Shows the compressed motor start record data, where *n* is the record number.
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM C	Clears all the communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.
COM C A	Clears all the communications records for Channel A.
COM C B	Clears all the communications records for Channel B.
COM L	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM S	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows the current state of the device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DATE	Views the date.
DATE *dd/mm/yyyy*	Enters the date in DMY format if DATE_F setting is DMY.
DATE *mm/dd/yyyy*	Enters the date in MDY format if DATE_F setting is MDY.
DATE *yyyy/mm/dd*	Enters the date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
EVE *n*	Shows Event Report *n* with 4-samples per cycle. If *n* is omitted, the most recent report is displayed.

Serial Port Command	Command Description
EVE *n* R	Shows Event Report *n* with raw (unfiltered) 16-samples per cycle analog data and 4-samples per cycle digital data.
EVE DIF *n* R	Shows differential Event Report *n* with raw (unfiltered) 16-samples per cycle analog data and 4-samples per cycle digital data.
FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers the settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Displays contents of the file *filename*.
GOOSE *k*	Displays the transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays the active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows a summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all the event report summaries are displayed.
HIS C or **R**	Clears or resets the history buffer.
IRIG	Forces the synchronization of the internal control clock to the IRIG-B time-code input.
LDP	Displays the signal profile data.
LDP C	Clears the signal profile data.
MAC	Displays the MAC address of the Ethernet port (**Port 1**).
MET or **MET F**	Displays the instantaneous metering data.
MET *k*	Displays the instantaneous metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays the analog input (transducer) data.
MET E	Displays the energy metering data.
MET M	Displays the minimum and maximum metering data.
MET MV	Displays the SELOGIC math variable data.
MET RE	Resets the energy metering data.
MET RM	Resets the minimum and maximum metering data.
MET RMS	Displays the rms metering data.
MET T	Displays the thermal and RTD metering data.
MOT	Displays the motor operating statistics report.
MSR *n*	Displays the motor start record data where *n* is the record number.
MST	Displays the motor start trend data.
SER	Displays the entire Sequential Events Recorder (SER) report.
SER *date1*	Displays all the rows in the SER report recorded on the specified date (see **DATE** command for date format).
SER *date1 date2*	Displays all the rows in the SER report recorded between *date1* to *date2*, inclusive.
SER *row1*	Displays the latest *row1* rows in the SER report (row1 = 1–1024, where 1 is the most recent entry).
SER *row1 row2*	Displays rows *row1–row2* in the SER report.
SER C or **R**	Clears the SER data.
SHO *n*	Displays the relay settings for Group *n* (*n* = 1, 2, or 3). If *n* is not specified, the default is the active settings group.
SHO F	Displays the front-panel settings.
SHO G	Displays the global settings.

Serial Port Command	Command Description
SHO L *n*	Displays the general logic settings for Group *n* (*n* = 1, 2, or 3). If *n* is not specified, the default is the active settings group.
SHO M	Displays the Modbus user map settings.
SHO P *n*	Displays the port settings, where *n* specifies Port (1, 2, 3, 4, or F); *n* defaults to the active port if not listed.
SHO R	Displays the report settings.
STA	Displays the relay self-test status.
STA S	Displays the SELOGIC usage status report.
SUM	Displays an event summary.
SUM R or **C**	Resets the event summary buffer.
TAR	Displays the default target row or the most recently viewed target row.
TAR *n*	Displays target Row *n*.
TAR *n k*	Displays target Row *n*. Repeats the display of Row *n* for repeat count *k*.
TAR *name*	Displays the target row with target *name* in the row.
TAR *name k*	Displays the target row with target *name* in the row. Repeats the display of this row for repeat count *k*.
TAR R	Resets any latched targets and the most recently viewed target row.
TIME	Displays the time.
TIME *hh*	Sets the time by entering **TIME** followed by hours, as shown (24-hour clock).
TIME *hh:mm*	Sets the time by entering **TIME** followed by hours and minutes, as shown (24-hour clock).
TIME *hh:mm:ss*	Sets the time by entering **TIME** followed by hours, minutes, and seconds, as shown (24-hour clock).
TRI	Triggers an event report data capture.
Access Level 2 Commands	
ANA *c p t*	Tests the analog output channel where *c* is the channel name or number, *p* is a percentage of full scale or either letter “R” or “r” indicates ramp mode, and *t* is the duration of the test in decimal minutes.
BRE R	Resets the breaker data.
BRE W	Preloads the breaker data.
CAL	Enters Access Level C. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level C password. Access Level C is reserved for SEL use only.
CON RB*nn k*	Selects a remote bit to set, clear, or pulse where *nn* is a number from 01 to 32, representing RB01 through RB32. *k* is S, C, or P for Set, Clear, or Pulse.
COPY *m n*	Copies relay and logic settings from Group *m* to Group *n*.
FIL WRITE *filename*	Transfers the settings file *filename* from the PC to the relay.
GRO *n*	Modifies the active group setting.
L_D	Loads new firmware.
LOO	Enables loopback testing of MIRRORED BITS channels.
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.
MOT R or **C**	Clears all the motor statistics data except for the learned parameters.
MST R or **C**	Resets the motor start trend data.
PAS 1 *xxxxxxxx*	Changes the Access Level 1 password to *xxxxxxxx*.
PAS 2 *xxxxxxxx*	Changes the Access Level 2 password to *xxxxxxxx*.
PING *x.x.x.x t*	Determines if the Ethernet port is functioning and configured properly. *x.x.x.x* is the IP address and *t* is the PING interval settable from 2 to 255 seconds. Default *t* is 1 second. Press **Q** to stop.

Serial Port Command	Command Description
PUL *n t*	Pulses Output Contact *n* (*n* = OUT101…) for *t* (1 to 30, default is 1) seconds.
R_S	Restores the factory-default settings and passwords and reboots the relay; available only after a firmware upgrade.
RLP	Resets the learned motor parameters.
SET *n*	Modifies the relay settings for Group *n* (*n* = 1, 2, or 3). If *n* is not specified, default is the active settings group.
SET *name*	For all the **SET** commands, jumps ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET F	Modifies the front-panel settings.
SET G	Modifies the global settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for Group *n* (*n* = 1, 2, or 3). If *n* is not specified, the default is the active settings group.
SET M	Modifies the Modbus user map settings.
SET P *n*	Modifies the Port *n* settings (*n* = 1, 2, 3, 4, or F; if not specified, the default is the active port).
SET R	Modifies the report settings.
SET…TERSE	For all the **SET** commands, TERSE disables the automatic **SHO** command after the settings entry.
STA R or **C**	Clears the self-test status and restarts the relay.
STO	Stops the motor.
STR	Starts the motor.
VEC D	Displays the diagnostic vector report.
VEC E	Displays the exception vector report.
Access Level CAL Commands	
PAS C	Changes the Access Level C password.

SEL-710 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 using lowercase letters. Commands can be initiated with the three initial letters of the command. Refer to *SEL ASCII Protocol and Commands* for additional details and capabilities of each command.

Serial Port Command	Command Description
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ACC	Goes to Access Level 1. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 1 command.
ID	Relay identification code.
QUIT	Goes to Access Level 0.
Access Level 1 Commands	
2AC	Goes to Access Level 2. If the main board access jumper is not in place, the relay prompts for the entry of the Access Level 2 command.
BRE	Displays the breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed Event Report *n*, at 1/4-cycle resolution. Attach R for compressed raw report, at 1/16-cycle resolution.
CMSR *n*	Shows the compressed motor start record data, where *n* is the record number.
COM A	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM B	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM C	Clears all the communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.
COM C A	Clears all the communications records for Channel A.
COM C B	Clears all the communications records for Channel B.
COM L	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM S	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows the current state of the device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DATE	Views the date.
DATE *dd/mm/yyyy*	Enters the date in DMY format if DATE_F setting is DMY.
DATE *mm/dd/yyyy*	Enters the date in MDY format if DATE_F setting is MDY.
DATE *yyyy/mm/dd*	Enters the date in YMD format if DATE_F setting is YMD.
ETH	Shows the Ethernet port status.
EVE *n*	Shows Event Report *n* with 4-samples per cycle. If *n* is omitted, the most recent report is displayed.

Serial Port Command	Command Description
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FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers the settings file *filename* from the relay to the PC.
FIL SHOW *filename*	Displays contents of the file *filename*.
GOOSE *k*	Displays the transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays the active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows a summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is not specified, all the event report summaries are displayed.
HIS C or **R**	Clears or resets the history buffer.
IRIG	Forces the synchronization of the internal control clock to the IRIG-B time-code input.
LDP	Displays the signal profile data.
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MAC	Displays the MAC address of the Ethernet port (**Port 1**).
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SET L *n*	Modifies the SELOGIC variable and timer settings for Group *n* (*n* = 1, 2, or 3). If *n* is not specified, the default is the active settings group.
SET M	Modifies the Modbus user map settings.
SET P *n*	Modifies the Port *n* settings (*n* = 1, 2, 3, 4, or F; if not specified, the default is the active port).
SET R	Modifies the report settings.
SET…TERSE	For all the **SET** commands, TERSE disables the automatic **SHO** command after the settings entry.
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