SEL-710-5

Motor Protection Relay

Instruction Manual

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SCHWEITZER ENGINEERING LABORATORIES

PM710-02

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Preface

Manual Overview

The SEL-710-5 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, safety information, and conventions used to present information.

Section 1: Introduction and Specifications. Describes the basic features and functions of the SEL-710-5; lists the relay specifications.

Section 2: Installation. Describes how to mount and wire the SEL-710-5; illustrates wiring connections for various applications.

Section 3: PC Interface. Describes the built-in web server and its features, including settings, meter and monitoring, reports, and firmware upgrading. Also describes the features, installation methods, and types of help available with the ACSELERATOR QuickSet® SEL-5030 Software.

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

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

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

Section 7: Communications. Describes how to connect the SEL-710-5 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. Describes in detail the two-line display (2 x 16 characters) and the touchscreen display (5-inch, color, 800 x 480 pixels).

Section 9: Bay Control. Describes how to configure and design the bay control screens for SEL-710-5 relays with the touchscreen display (5-inch, color, 800 x 480 pixels).

Section 10: Analyzing Events. Describes event type, messages, event summary data, standard event reports, and Sequential Events Recorder (SER) report.

Section 11: 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-710-5 with SEL Communications Processors for total substation automation solutions.

Appendix D: DNP3 Communications. Describes the DNP3 protocol support provided by the SEL-710-5.

Appendix E: Modbus Communications. Describes the Modbus protocol support provided by the SEL-710-5.

Appendix F: EtherNet/IP Communications. Describes the EtherNet/IP protocol support provided by the SEL-710-5.

Appendix G: IEC 61850 Communications. Describes IEC 61850 implementation in the SEL-710-5.

Appendix H: IEC 60870-5-103 Communications. Describes the IEC 60870-5-103 protocol support provided by the SEL-710-5.

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

Appendix J: Mirrored Bits Communications. Describes how SEL protective relays and other devices can directly exchange information quickly, securely, and with minimum cost.

Appendix K: Motor Thermal Element. Contains a fundamental description of the SEL-710-5 thermal element. Describes interpretation of percent thermal capacity and thermal capacity used to start quantities.

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

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

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

SEL-710-5 Relay Command Summary. Briefly describes the serial port commands that are fully described in *Section 7: Communications*.

Safety Information

Dangers, Warnings, and Cautions

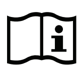
This manual uses three kinds of hazard statements, defined as follows:

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

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

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

Safety Symbols

	**⚠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. BR2330A or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device can 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 BR2330A 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 l'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.	Destiné à l'utilisation sur une surface plane d'un boîtier de Type 1.
Terminal Ratings Wire Material Use 75°C (167°F) copper conductors only. Tightening Torque 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)	Specifications des bornes Type de filage Utiliser seulement conducteurs en cuivre spécifiés à 75°C (167°F). Couple de serrage Bornes : 0,9 à 1,4 Nm (8 à 12 livres-pouce) Fiche à compression : 0,5 à 1,0 Nm (4,4 à 8,8 livres-pouce) Vis à oreille de montage de la fiche à compression : 0,18 à 0,25 Nm (1,6 à 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.

Compliance Approvals

SEL-710-5 Relay (Hazardous Locations Approved)

The SEL-710-5 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-710-5 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-710-5 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.”

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.
⚠WARNING Always isolate the relay control circuits before performing any modifications to the relay.	⚠AVERTISSEMENT Il faut toujours isoler les circuits de commande du relais avant d'apporter des modifications au relais.
⚠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

Other Safety Marks (Sheet 2 of 2)

⚠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 equipment 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 l'équipement 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-710-5:

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

Trademarks

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

SEL Trademarks	
ACSELERATOR Architect®	Synchrowave®
ACSELERATOR QuickSet®	SYNCHROWAVE®
time-overlight®	MIRRORED BITS®
SEL-2407®	SELOGIC®

Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-710-5. 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-710-5.

LED Emitter

The following table shows LED information specific to the SEL-710-5. See *Figure 2.11* for the location of the ports using these LEDs on the relay.

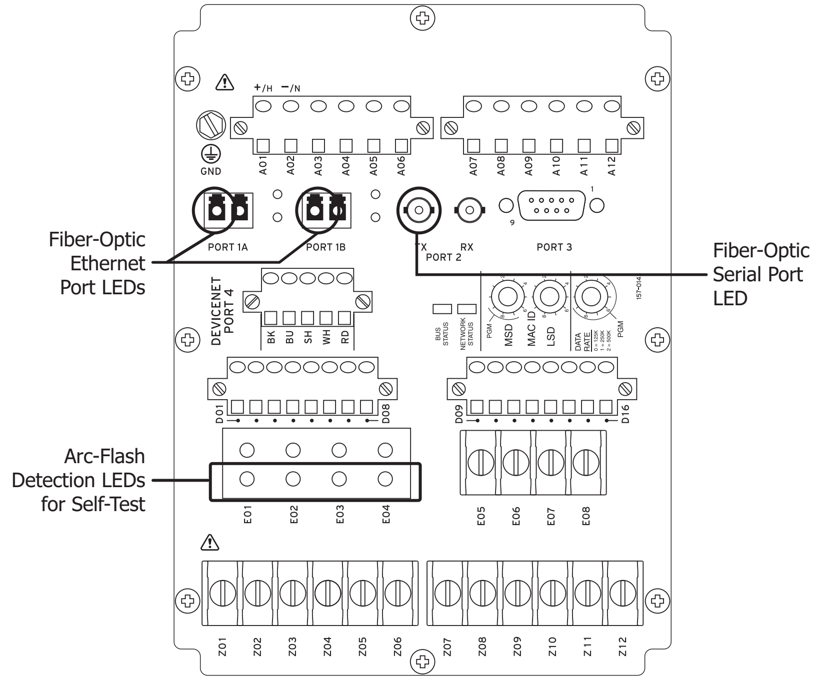
⚠CAUTION
Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

SEL-710-5 LED Information

Item	Fiber-Optic Ethernet Port 1 (1A, 1B)	Port 2	Arc-Flash Channel 1–8
Mode	Multimode	Multimode	Multimode
Wavelength	1300 nm	820 nm	640 nm
Source	LED	LED	LED
Connector type	LC	ST	V-pin
Typical output power	–15.7 dBm	–16 dBm	–12 dBm

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

The following figure shows the LED location specific to the SEL-710-5. See *Figure 2.11* for the complete rear-panel drawing.



SEL-710-5 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 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	±10% of nominal voltage
Overvoltage	Category II

Condition	Range/Description
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

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

Wire Sizes and Insulation

NOTE: Terminal blocks are best suited to accept 10 AWG wire size. Make sure to select the appropriate lug size that is compatible with the SEL relay terminal block. All SEL qualification testing of terminal blocks is performed with ring or fork terminals for wire size as high as 12 AWG.

For standard 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. See the SEL 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 (0.8 mm^2)	14 AWG (2.1 mm^2)	300 V min
Current	16 AWG (1.3 mm^2)	12 AWG (3.3 mm^2)	300 V min
Potential (Voltage)	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)	300 V min
Contact I/O	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)	300 V min
RTD[a]	28 AWG (0.08 mm^2)	16 AWG (1.30 mm^2)	300 V min
PTC[b]	20 AWG (0.5 mm^2)	14 AWG (2.1 mm^2)	300 V min
Other	18 AWG (0.8 mm^2)	14 AWG (2.1 mm^2)	300 V min

[a] See *Table 2.21*: Typical Maximum RTD Lead Length.
[b] See *Table 2.20*: PTC Cable Requirements.

Instructions for Cleaning and Decontamination

Use a mild soap or detergent solution and a damp cloth to carefully clean the SEL-710-5 chassis when necessary. Avoid using abrasive materials, polishing compounds, and harsh chemical solvents (such as xylene or acetone) on any surface of the relay.

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Section 1
Introduction and Specifications

Overview

The SEL-710-5 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-710-5. You need not review the entire manual to perform specific tasks.

Features

The SEL-710-5 protection and control features depend on the model selected. The models are configured with current/voltage input cards on Slot Z and specific option cards on Slot E in the relay. The SEL-710-5 supports both conventional current and potential transformer inputs and low-energy analog sensor inputs.

Slot Z cards are assigned a two-digit code beginning with the number 8 (for conventional current and voltage inputs) or the letter L (for LEA sensor inputs) in the SEL-710-5 Model Options Table (MOT, see *Models on page 1.5*). For example, 81 in the MOT for Slot Z indicates a SELECT 4 ACI/3 AVI card with three-phase ac current inputs (1 A nominal), neutral ac current input (1 A nominal), and three-phase ac voltage inputs (300 Vac). L1 in the MOT for Slot Z indicates a SELECT 4 ACI /3 AVI LEA card with four Rogowski coil or low-power current inputs and three LEA voltage sensor inputs. The current and voltage channels on the LEA card accept an RJ45 connector input.

Slot E cards are assigned a two-digit code beginning with the number 7 in the SEL-710-5 Model Options Table (MOT). For example, 74 in the MOT for Slot E indicates a SELECT 4 AFDI/3 DIFF ACI card with 4 arc-flash detection channels and 3 differential current channels.

Table 1.1 shows the different applications for which the SEL 710-5 can be used. Current inputs are 1 A, 5 A, or 2.5 mA (neutral only) nominal rating and voltage inputs are 300 V continuous rating.

Table 1.1 Current (ACI) and Voltage (AVI) Card Selection for SEL-710-5

Model	Application	Slot Z Card (MOT Digits)	Slot Z Inputs	Slot E Card (MOT Digits)	Slot E Inputs
07105*xxxxxxx*	Induction Motor Protection	All Models	All Models	None (0X)	NA
07105*xxx*74*xx*	Induction Motor With 4 Arc-Flash Detection Channels and Differential Protection	4 ACI/3 AVI (81, 82, 83, 85, 86, 87, L1)	IA, IB, IC, IN, VA, VB, VC	4 AFDI/3 DIFF ACI (74)	AF1, AF2, AF3, AF4, IA87, IB87, IC87, COM
07105*xxx*76*xx*	Induction Motor With 8 Arc-Flash Detection Channels			8 AFDI (76)	AF1, AF2, AF3, AF4, AF5, AF6, AF7, AF8
07105*xxx*75*xx*	Synchronous Motor Protection With Differential Protection			SYNCH/3 DIFF ACI (75)	VDR+, VDR–, VEX+, VEX–, IEX+, IEX–, IA87, IB87, IC87, COM

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)
- Incipient Cable Fault (50INC)
- Loss of Field (40)
- Out of Step (78)
- Phase Reversal (47) (current based)
- Induction 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)
- Voltage-Based Protection
  - Undervoltage (27)
  - Overvoltage (59)
  - Underpower (37)
  - Reactive Power

   - Phase Reversal (47)
   - Power Factor (55)
- Frequency (81)
- Breaker/Contactor Failure Protection
- VFD Motor Protection
- Broken Rotor Bar Detection Element (BBDE)
- Vibration Monitoring

Optional Protection and Control Features

- Synchronous Motor Protection and Control
   - Starting Control
   - Power Factor/Reactive Power Regulator
   - Loss of Synchronism (pull-out)
   - Field Resistance, Voltage, and Current Elements
- Arc-Flash Protection
   - 4 Arc-Flash Detection Inputs
   - 8 Arc-Flash Detection Inputs
- Differential Overcurrent (87M)
- PTC Overtemperature (Positive Temperature Coefficient Switching Thermistor) (49)
- RTD-Based Protection: As many as ten (10) RTDs can 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.

Front-Panel Options

The SEL-710-5 offers two front-panel HMI layouts that are model and option dependent. *Table 1.2* lists the HMI options for the SEL-710-5 front panel. For ordering options, refer to the SEL-710-5 MOT.

Table 1.2 SEL-710-5 Front-Panel Options

Model/Display Description	Front-Panel Option (MOT String Digit Number 18)	Number of Pushbuttons	LED Type	IRIG or PTC Option
SEL-710-5 With Two-Line Display (2 x 16 characters)	0	8	Tricolor	IRIG
SEL-710-5 With Two-Line Display (2 x 16 characters)	1	8	Tricolor	PTC
SEL-710-5 With Touchscreen Display (5-inch, color, 800 x 480 pixels)	A	8	Tricolor	IRIG
SEL-710-5 With Touchscreen Display (5-inch, color, 800 x 480 pixels)	B	8	Tricolor	PTC

Monitoring Features

- Event Summaries that contain relay ID, date and time, trip cause, and current/voltage magnitudes
- Event Reports including filtered and raw analog data
- Sequential Events Recorder (SER)

- Motor operating statistics since the last reset:
  - Running and stopped times
  - Number of starts and emergency starts
  - Average and peak metering values during start and run periods
  - Load profiling
  - Number of various alarms and trips
- Motor Start Reports, for as long as 240 seconds, for each of the last 30 starts
- Motor Start Trend data for the past eighteen 30-day intervals
- A complete suite of accurate metering functions
- Broken rotor bar detection reports
- Breaker Health
- Vibration Monitoring
- 97FM elements for frequency components detection
- Motor monitoring using Fourier Transform and Compressed Meter commands.

Communications and Control Features

- 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
- Built-in web server
- IRIG-B time-code input
- Modbus RTU slave, Modbus TCP/IP, DNP3 serial, DNP3 LAN/WAN, Ethernet FTP, Telnet, Simple Network Time Protocol (SNTP), IEEE-1588-2008 firmware-based Precision Time Protocol (PTP), MIRRORED BITS, IEC 61850 Edition 2, IEC 60870-5-103, EtherNet/IP, DeviceNet, Parallel Redundancy Protocol (PRP), and Rapid Spanning Tree Protocol (RSTP)
- SEL ASCII, Compressed ASCII, Fast Meter, Fast Operate, Fast SER, and Fast Message Protocols
- Programmable Boolean and math operators, logic functions, and analog compare

Language Support

- The standard relay front-panel overlay is in English; a Spanish overlay is available as an ordering option. Text displayed on the HMI display will correspond to the ENGLISH or SPANISH ordering option.
- All of the ASCII command responses can be displayed in English or Spanish. When you set the port setting LANG to either ENGLISH or SPANISH (see *Table 4.95*), the SEL-710-5 ASCII commands display in the corresponding language.
- Web server reports can be displayed in English or Spanish by setting the Ethernet Port 1 setting LANG to either ENGLISH or SPANISH.

Models, Options, and Accessories

Models

Complete ordering information is not provided in this instruction manual. See the latest Model Option Table for the SEL-710-5 with the two-line display and the SEL-710-5 with the touchscreen display at selinc.com on the SEL-710-5 product page under Documentation > Ordering Information. Options and accessories are as follows:

SEL-710-5 Base Unit

- Front panel with two-line display or with touchscreen display
  - Eight programmable pushbuttons, each with two tricolor LEDs
  - Eight target tricolor LEDs (six programmable)
  - Operator control interface
  - Front EIA-232 port
- Power supply card with two digital inputs and three digital outputs (Slot A)
- Processor and communications card (Slot B)—EIA-232 serial port, Multimode (ST) fiber-optic serial port, and IRIG-B time code input or PTC Input
- Three expansion slots for optional cards (Slots C, D, and E)
- Current/Voltage Inputs Card (Slots Z)
- Protocols
  - Modbus RTU
  - SEL ASCII and Compressed ASCII, SEL Fast Meter, Fast Operate, Fast SER
  - SEL Fast Message
  - Ymodem File Transfer
  - SEL MIRRORED BITS Communications
- Breaker Wear Monitoring
- Broken Rotor Bar Detection Element (BBDE)

Options

- Slot E Options:
  - 4 Arc Flash/Differential Inputs
  - Synchronous Motor/Differential Inputs
  - 8 Arc Flash Inputs
- Input/Output (I/O) Options:
  - Additional digital I/O (4 DI/4 DO, 4 DI/3 DO, 8 DI, 8 DO, 3 DI/4 DO/1 AO, 14 DI)
  - Additional analog I/O (4 AI/4 AO, 8 AI)
  - 10 RTD inputs
- Front-panel HMI options (see *Table 1.2*)
- Communications Options (Protocols/Ports):
  - EIA-485/EIA-232/Ethernet ports
  - Multimode (ST) fiber-optic serial port
  - Modbus RTU, Modbus TCP/IP protocol

  - DNP3 serial and LAN/WAN
  - DeviceNet (**Note:** This option has been discontinued and is no longer available as of September 25, 2017.)
  - IEC 61850 Edition 2
  - IEC 60870-5-103
  - SNTP
  - PTP (firmware-based)
  - EtherNet/IP
  - PRP
  - RSTP
- Choice of IRIG-B time-code input or PTC (thermistor) input
- Language Options
  - The relay supports English or Spanish language as an ordering option
- Conformal coating for chemically harsh and/or high-moisture environments

Accessories

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

- Synchronous Motor Voltage Divider Module (P/N 915900294)
- SEL-C804 and SEL-C814 Multimode Fiber-Optic Arc-Flash Detection (AFD) Sensors and Accessories
- External RTD protection:
  - SEL-2600 RTD Modules (ST option only)
  - A simplex 62.5/200 µm fiber-optic cable with an ST connector for connecting the external RTD module to the SEL-710-5
- 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-710-5 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 Euro Connector Kit
- Ring Terminal Kit for all connections to the relay
- Dust Protection Kit
- Relay Wire Termination Kits—See *Application Note AN2014-08*

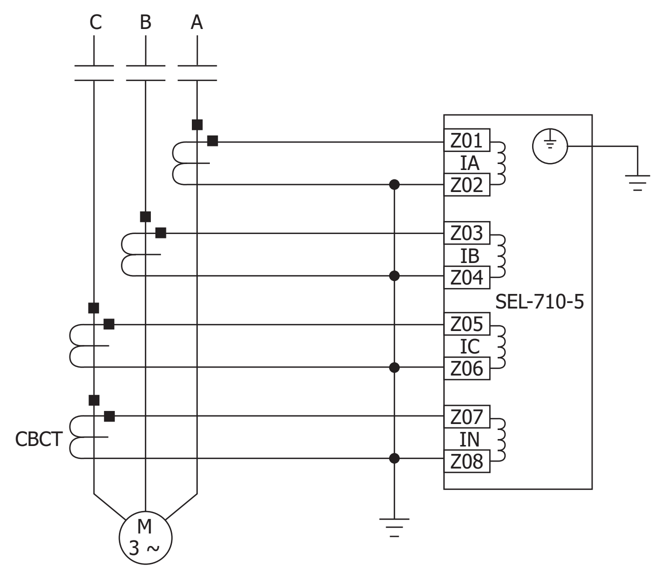
For all SEL-710-5 mounting accessories for competitor products, including adapter plates, visit selinc.com/app/mounting-selector/.

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
- VFD motor application
- Synchronous motor application
- With or without arc-flash protection

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



CBCT is core-balance current transformer. The current transformers and the SEL-710-5 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-710-5 effectively. This section presents the fundamental knowledge you need to operate the SEL-710-5, 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-710-5 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 2.24*.
- Once connected to power, the relay does an internal self-check and the **ENABLED** LED illuminates.

Establishing Communication

The SEL-710-5 has two EIA-232 serial communications ports. The following steps require PC terminal emulation software and an SEL-C234A cable (or equivalent) to connect the SEL-710-5 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-710-5 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 1.3*. 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 see the = prompt at the left side of the computer screen.

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 1.3*.

Table 1.3 SEL-710-5 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.

The relay should respond as shown in *Figure 1.2*. If you see jumbled characters, change the terminal emulation type in the PC terminal emulation program.

```
=>QUIT <Enter>
SEL-710-5              Date: 05/17/2013  Time: 10:22:14.348
MOTOR RELAY            Time Source: Internal
=
```

Figure 1.2 Response Header

Step 7. Type **ACC <Enter>** and the appropriate password (see *Table 7.16* for factory-default passwords) to go to Access Level 1.

Checking the Relay Status

Use the **STA** command to view the SEL-710-5 operational status. The status report includes the analog channel dc offset and monitored component status, as shown in *Figure 1.3*.

```
=>>STA <Enter>

SEL-710-5                                 Date: 07/08/2016   Time: 18:12:11.105
SYNCHRONOUS MTR                           Time Source: External

Serial Num = 1120340538     FID = SEL-710-5-X143-V0-Z002001-D20160630
CID = 3FA3                  PART NUM = 071050E1B6X9X7586063X

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

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.50   1.80   2.49   3.32   3.76    4.95   -1.25   -5.05   3.04

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

Offsets
   IA    IB    IC    IN    VA    VB    VC   IA87  IB87  IC87  VDR
  12    10    10    10    -9    -8    -7    -5    -4    -4    -3

  Relay Enabled

=>>
```

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

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

```
=>>STA <Enter>

SEL-710-5                                   Date: 05/14/2000   Time: 14:35:45.595
MOTOR RELAY                                 Time Source: Internal

Serial Num = 000000000000000
FID = SEL-710-5-X051-V0-Z001001-D20130506              CID = 1368
PART NUM = 071050E1BA30X7585063X

SELF TESTS (W=Warn)
  FPGA  GPSB  HMI   RAM   ROM   CR_RAM  NON_VOL  CLOCK  CID_FILE  +0.9V  +1.2V
  OK    OK    OK    OK    OK    OK      OK       OK     OK        0.90   1.21

  +1.5V  +1.8V  +2.5V  +3.3V  +3.75V  +5.0V  -1.25V  -5.0V   BATT
  1.50   1.81   2.50   3.36   3.75    4.99   -1.24   -4.96   3.00

Option Cards
  CARD_C  CARD_D  CARD_E  CARD_Z
  OK      OK      OK      OK

DeviceNet
  DN_MAC_ID     ASA      DN_RATE   DN_STATUS
  1          1a25 df42h  125kbps   0000 0001

Offsets
   IA    IB    IC    IN    VA    VB    VC    IA87  IB87  IC87  VDR
  11    14    13    13    -1    -1    0     -8    -10   -7    $$$

  Relay Enabled

=>>
```

Figure 1.4 STA Command Response—Communications Card/DeviceNet Protocol

Table 7.57 provides the definition of each status report designator and *Table 11.8* 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-710-5. If the date stored in the relay is May 29, 2013, and the DATE_F setting is MDY, the relay replies:

```
5/29/2013
```

If the DATE_F setting is YMD, the relay replies:

```
2013/5/29
```

If the DATE_F setting is DMY, the relay replies:

```
29/5/2013
```

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, 2013 (DATE_F = MDY), enter the following at the action prompt:

```
DAT 5/2/13
```

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-710-5. The relay replies with the stored time in 24-hour format. 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, or 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.

CE Mark in accordance with the requirements of the European Union

RCM Mark in accordance with the requirements of Australia

UKCA Mark in accordance with the requirements of United Kingdom

Normal Locations

UL Listed to U.S. and Canadian safety standards (File E212775, NRGU, NRGU7)

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

Hazardous Locations

UL Certified for Hazardous Locations to U.S. and Canadian standards CL I, DIV 2; GP A, B, C, D; T3C, maximum surrounding 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 Inputs (IA, IB, IC, IN)

I_{NOM} = 1 A, 5 A, or 2.5 mA secondary depending on the model

Measurement Category:	II

Phase Currents

I_{NOM} = 5 A

Continuous Rating:	3 • I_{NOM} @ 85°C 4 • I_{NOM} @ 55°C
A/D Measurement Limit:	217 A peak (154 A rms) symmetrical
Saturation Current Rating:	Linear to 96 A 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:	43 A peak (31 A rms) symmetrical
Saturation Current Rating:	Linear to 19.2 A 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:	32 A peak (22.6 A rms) symmetrical
Saturation Current Rating:	Linear to 11 A 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:	6.4 A peak (4.5 A rms) symmetrical
Saturation Current Rating:	Linear to 2.2 A 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:	40.9 mA peak (28.9 mA rms) symmetrical
Saturation Current Rating:	Linear to 12.5 mA symmetrical
1-Second Thermal:	100 A
Burden (per phase):	<0.1 mVA @ 2.5 mA

Differential Currents (IA87, IB87, IC87)

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

Rogowski Coil-Based AC Current Input–Phase and Neutral Current

Continuous Rating:	30 Vrms
Nominal Input Voltage:	65 mV to 4.16 Vrms
Number of Gain Ranges:	6
Full Scale Voltage:	4, 8, 16, 32, 64, 128 Vrms
A/D Measurement Limit:	±185 Vpeak @ 60 Hz
10-Second Thermal:	200 Vac
Input Impedance:	2 MΩ‖50 pF
Standard Compliance:	IEC 61869-6 IEC 61869-13

Low-Power Current Transformer (LPCT) Inputs—Phase and Neutral Current

Continuous Rating:	4 Vrms
Nominal Input Voltage:	16 mV to 260 mVrms
Number of Gain Ranges:	4
Full Scale Voltage:	1, 2, 4, 8 Vrms
A/D Measurement Limit:	±11.3 Vpeak
10-Second Thermal:	200 Vac
Input Impedance:	2 MΩ‖50 pF
Standard Compliance:	IEC 61869-6 IEC 61869-13

AC Voltage Inputs (VA, VB, VC)

V_{NOM} (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:	<0.1 W
Input Impedance:	4 MΩ differential (phase-to-phase) 2 MΩ common mode (phase-to-chassis)

Low-Energy Analog Voltage Sensor Inputs (RJ45 Input)

Continuous Rating	8 Vrms
Nominal Input Voltage:	0.5–6.8 Vrms
Full-Scale Voltage:	8 Vrms
A/D Measurement Limit:	±12 Vpeak
10-Second Thermal:	200 Vac
Input Impedance:	2 MΩ‖50 pF
Standard Compliance:	IEC 61869-6 IEC 61869-13

Synchronous Motor Inputs

Inputs for Synchronous Motor Voltage Divider Module (SEL P/N 915900294)

Field Discharge Voltage VDR (Motor Side, VDRM+ to VDRM−)

Rated Operating Voltage:	As high as 955 Vrms
Maximum Continuous Voltage–Thermal Limit:	1145 Vrms
10-Second Thermal:	1555 Vrms
Burden:	<0.1 VA
Input Impedance:	5 MΩ differential
VDR Divider Ratio:	5.4:1

Field Excitation Voltage VEX (Motor Side, VEXM+ to VEXM−)

Rated Operating Voltage:	0–350 Vdc
Maximum Continuous Voltage–Thermal Limit:	700 Vdc
10-Second Thermal:	1000 Vdc
Burden:	<0.1 W
Input Impedance:	2 MΩ differential
VEX Divider Ratio	2.1:1

Field Excitation Current IEX

Rated Operating Range:	0.5–2000 Adc
DC Transducer:	4–20 mA or 0–10 V nominal output
Input Impedance:	200 ohms (current mode) >10 kΩ (voltage mode)

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: (Operating 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 (Operating 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 200–312.5 Vdc
Off below 150 Vdc

220 V: On for 176–275 Vdc
Off below 132 Vdc

125 V: On for 100–156.2 Vdc
Off below 75 Vdc

110 V: On for 88–137.5 Vdc
Off below 66 Vdc

48 V: On for 38.4–60 Vdc
Off below 28.8 Vdc

24 V: On for 15–30 Vdc
Off for <5 Vdc

When Used With AC Control Signals

250 V: On for 170.6–312.5 Vac
Off below 106 Vac

220 V: On for 150.2–275 Vac
Off below 93.3 Vac

125 V: On for 85–156.2 Vac
Off below 53 Vac

110 V: On for 75.1–137.5 Vac
Off below 46.6 Vac

48 V: On for 32.8–60 Vac
Off below 20.3 Vac

24 V: On for 14–30 Vac
Off below 5 Vac

Current draw at nominal dc voltage: 2 mA (at 220–250 V)
4 mA (at 48–125 V)
10 mA (at 24 V)

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

Maximum Pickup Time: Approx. 1 cycle

Maximum Dropout Time: Approx. 2 cycles

Analog Output (Optional)

	1 A0	4 A0
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:	25 ms	25 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:	10–70 Hz
Frequency Operating Range:	15–70 Hz

Time-Code Input

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

Synchronization Accuracy

Internal Clock:	±1 µs
All Reports:	±5 ms
SNTP Accuracy:	±1 ms (in an ideal network)
PTP Accuracy:	±1 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 Mbps
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 Mbps
Typical Fiber Attenuation:	-4 dB/km

Channels 1–8 Arc-Flash Detectors (AFDI)

Diagnostic Wavelength:	640 nm
Optical Connector Type:	V-Pin
Fiber Type:	Multimode
Typical TX Power:	–12 dBm

Point Sensor

Minimum Receive Sensitivity:	–52.23 dB
Point Sensor Diagnostic Worst-Case Loss:	–28 dB
Link Budget:	12.23 dB
Black-Jacketed Fiber Worst-Case Loss:	–0.19 dBm
Black-Jacketed Fiber Typical Loss:	–0.17 dBm
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 35 m

Fiber Sensor

Minimum Receive Sensitivity:	–29.23 dB
Link Budget:	17.23 dB
Clear-Jacketed Fiber Worst Case Loss:	–0.19 dBm
Clear-Jacketed Fiber Typical Loss:	–0.17 dBm
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 70 m

Optional Communications Cards

Option 1:	EIA-232 or EIA-485 communications card
Option 2:	DeviceNet communications card (**Note:** This option has been discontinued and is no longer available as of September 25, 2017.)

Communications Protocols

SEL, Modbus, DNP3, FTP, TCP/IP, Telnet, SNTP, IEEE-1588-2008 firmware-based PTP, IEC 61850 Edition 2, IEC 60870-5-103, IEC 62439-3 PRP, IEEE 802.1Q-2014 Rapid Spanning Tree Protocol (RSTP), EtherNet/IP, MIRRORED BITS, and DeviceNet

Operating Temperature

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

Note: Not applicable to UL applications.
Note: Front panel display is impaired for temperatures below –20°C and above +70°C.

DeviceNet Communications Card Rating:	+60°C (+140°F) maximum
Optoisolated Control Inputs:	As many as 26 inputs are allowed in ambient temperatures of 85°C or less. As many as 34 inputs are allowed in ambient temperatures of 75°C or less. As many as 44 inputs are allowed in ambient temperatures of 65°C or less.

Operating Environment

Insulation Class:	I
Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Dimensions

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

Weight

2.7 kg (6.0 lb)

Relay Mounting Screw (#8—32) Tightening Torque

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

Terminal Connections

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

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

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

RTD Compression Plug Tightening Torque

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 (2-line display models) IP54 enclosed in panel (touchscreen models) 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 IP20 for terminals and the relay rear panel with optional terminal block cover

Note: If the rear terminals are accessible during normal use, the product must be mounted in a locked enclosure or restricted area accessible by trained maitenance or operation personnel.

Vibration Resistance:	IEC 60255-21-1: 1988 IEC 60255-27: 2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-21-2: 1988 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, PTC 2.0 kVdc on IRIG 2.5 kVac on contact I/O 3.6 kVdc on power supply, ac current, and voltage input terminals 820 Vac on LEA 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 0.5 J, 1.5 kV on LEA inputs 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 LEA ports compliant with IEC 61869-13 tested to 1 kV, 1 MHz line-to-earth only
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:	32 samples per power system cycle
Frequency Tracking Range:	10–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms). Analog quantities for rms data are determined through the use of data averaged over the previous 8 cycles.
Arc Flash Processing:	Arc-flash light is sampled 32 times per cycle. Arc-flash current, light, and 2 fast hybrid outputs are processed 16 times per cycle

Oscillography

Length:	15, 64, or 180 cycles
Sampling Rate:	32 samples per cycle unfiltered
	4 samples per cycle filtered
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (32 samples per cycle unfiltered)
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) for all RWBs Except RWBs Corrsponding to Digital Inputs (IN*xxx*) and Arc-Flash Element (TOL*x*, 50*x*AF, OUT*xxx*):	±5 ms
Time-Stamp Accuracy (With Respect to Time Source) for RWBs Corrsponding to Digital Inputs (IN*xxx*) and Arc-Flash Element (TOL*x*, 50*x*AF, OUT*xxx*):	1 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% ±25 ms at multiples of FLA > 2 (cold curve method)

PTC Overtemperature (49)

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

Undercurrent (Load Loss) (37)

Setting Range:	Off, 0.10–1.00 • FLA, 0.01 • FLA increment
Accuracy:	±5% of setting ±0.02 • I_{NOM} A rms 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, 0.01 s FLA increment
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, 0.01 • FLA increment
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–5.0 s, 0.01 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Ground Fault (50G)

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

Ground Fault (50N)

Setting Range:	
1 A, 5 A models:	Off, 0.01–650.00 A primary; 0.01 A rms increment
2.5 mA models:	Off, 0.01–25.00 A primary; 0.01 A rms increment
Accuracy:	
1 A, 5 A models:	±5% of setting plus ±0.01 INOM A secondary
2.5 mA models:	±5% of setting plus ±0.02 INOM A secondary
Maximum Pickup/Dropout Time:	
1 A, 5 A models:	1.5 cycles/1.5 cycles
2.5 mA models:	100 ms + 1.5 cycles/1.5 cycles (for the 2.5 mA models the 50N*x*D element includes a security timer of 100 ms)
Time Delay:	0.0–5.0 s, 0.01 s increment

Negative-Sequence Overcurrent (50Q)

Setting Range:	Off, 0.10–20.00 • FLA, 0.01 • FLA increment
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 0.01 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

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

Pickup Setting Range (50PAF), A Secondary:	
5 A models:	0.50–100.00 A, 0.01 A steps
1 A models:	0.10–20.00 A, 0.01 A steps
Pickup Setting Range (50NAF), A Secondary:	
5 A models:	0.05–10.00 A, 0.01 A steps
1 A models:	0.01–2.00 A, 0.01 A steps
Accuracy:	0 to +10% of setting ±0.02 • I_{NOM} A secondary (steady-state pickup)
Pickup/Dropout Time:	2–5 ms/1 cycle

Arc-Flash Time-Overlight (TOL1–TOL8)

Pickup Setting Range, Percent of Full Scale:	3.0%–80.0% (Point Sensor) 0.6%–80.0% (Fiber Sensor)
Pickup/Dropout Time:	2–5 ms/1 cycle

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 ±0.02 • I_{NOM} A secondary (steady-state pickup)
Time Dial:	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Accuracy:	±1.5 cycles, ±4% between 2 and 30 multiples of pickup (within rated range of current)

Differential Protection (87M)

Setting Range:	Off, 0.05–8.00 A secondary
Accuracy:	±5% of setting ±0.10 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 ±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 pu • Vnm, 0.01 increment
Accuracy:	±5% of setting ±2 V secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 0.1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

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 pu • Vnm, 0.01 increment
Accuracy:	±5% of setting ±2 V secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 0.1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Inverse-Time Undervoltage (27I)

Setting Range:	OFF, 2.00–300.00 V (Phase elements, positive-sequence elements, phase-to-phase elements with delta inputs, or synchronism-check voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 0.95 and 0.1 multiples of pickup

Inverse-Time Overvoltage (59I)

Setting Range:	OFF, 2.00–300.00 V (Phase elements, sequence elements, or phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 1.05 and 5.5 multiples of pickup

Underpower (37)

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

Reactive Power (VAR)

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

Power Factor (55)

Setting Range:	Off, 0.05–0.99, 0.01 increment
Accuracy:	±5% of full scale for current ≥ 0.5 • FLA
Maximum Pickup/Dropout Time:	10 cycles
Time Delay:	0.0–240.0 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Frequency (81)

Setting Range:	Off, 15.00–70.00 Hz, 0.01 Hz increments
Accuracy:	±0.01 Hz
Maximum Pickup/Dropout Time:	5 cycles
Time Delay:	0.00–400.00 s, 0.1 s increments
Accuracy:	±0.5% of setting ±1/4 cycle

Loss of Field (40)

Zone 1 and Zone 2 Offset:	0.0–50.0 Ω for 5 A 0.0–250.0 Ω for 1 A
Zone 1 and Zone 2 Diameter:	5 A model: 0.1–100.0 Ω 1 A model: 0.5–500.0 Ω
Steady-State Impedance Accuracy:	5 A model: ±0.1 Ω, ±5% of (offset + diameter) 1 A model: ±0.5 Ω, ±5% of (offset + diameter)
Minimum Pos.-Seq. Signals:	5 A model: 0.25 V (V1), 0.25 A (I1) 1 A model: 0.25 V (V1), 0.05 A (I1)
Directional Element Angle:	–20.0° to 0.0°
Pickup Time:	3 cycles (max)
Zone 1 and Zone 2 Definite-Time Delays:	0.00–400.00 s, 0.01 s step
Accuracy:	±0.1%, ±1/2 cycle

Speed Switch (14)

Speed Switch Time Delay Range:

Trip:	OFF, 1–240 s, 1 s increments
Warn:	OFF, 1–240 s, 1 s increments

Virtual Speed Switch Time Delay Range:

Fail Open:	0.5–2.0 s
Fail Close:	0.1–120.0 min
Time Delay Accuracy:	±0.5% of ±1/4 cycle

Phase Reversal(47)

Setting Range:	Off, On
Fixed Time Delay:	500 ± 6 ms

Out-of-Step Element (78)

Forward Reach:

5 A model:	0.1–100.0 Ω
1 A model:	0.5–500.0 Ω

Reverse Reach:

5 A model:	0.1–100.0 Ω
1 A model:	0.5–500.0 Ω

Single Blinder

Right Blinder:

5 A model:	0.1–50.0 Ω
1 A model:	0.5–250.0 Ω

Left Blinder:

5 A model:	0.1–50.0 Ω
1 A model:	0.5–250.0 Ω

Double Blinder

Outer Resistance Blinder:

5 A model:	0.2–100.0 Ω
1 A model:	1.0–500.0 Ω

Inner Resistance Blinder:

5 A model:	0.1–50.0 Ω
1 A model:	0.5–250.0 Ω

Steady-State Impedance Accuracy:

5 A model:	±0.1 Ω, ±5% of diameter
1 A model:	±0.5 Ω, ±5% of diameter

Pos.-Seq. Current Supervision:

5 A model:	0.25–30.00 A
1 A model:	0.05–6.00 A
Pickup Time:	3 cycles (Max)
Definite-Time Delay:	0.00–1.00 s, 0.01 s step
Trip Delay Range:	0.00–1.00 s, 0.01 s step
Trip Duration Range:	0.00–5.00 s, 0.01 s step
Accuracy:	±0.1% of user setting, ±8.3 ms at 60 Hz

Field Under/Overcurrent

Setting Range:	Off, 1.0–2000.0 A dc, 0.1 increment
Accuracy:	1% of full scale reading
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay Range:	
Level 1:	0.3–100.0 s, 0.1 s increment
Level 2:	0.3–100.0 s, 0.1 s increment
Time Delay Accuracy:	±0.5% +1/4 cycle

Field Under/Overvoltage

Setting Range:	Off, 1.0–350.0 Vdc, 0.1 increment
Accuracy:	1% of full scale reading
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay Range:	
Level 1:	0.3–100.0 s, 0.1 s increment
Level 2:	0.3–100.0 s, 0.1 s increment
Time Delay Accuracy:	±0.5% +1/4 cycle

Field Resistance

Setting Range:	Off, 0.10–500.00 Ω, 0.01 increment
Accuracy:	1% of full scale reading
Maximum Pickup/Dropout Time:	1.5 cycles

Timers

Setting Range:	Various
Accuracy:	±0.5% of setting ±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 Ω max. per lead
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	As high as 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Fault/Alarm/Trip Delay:	Approx. 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.

Phase Currents:	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
Three-Phase Average Current:	±1% of reading, ±0.02 • I_{NOM}
IG (Residual Current):	±2% of reading, ±0.02 •I_{NOM}, ±2°
IN (Neutral Current):	±1% of reading, ±2° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
3I2 Negative-Sequence Current:	±2% of reading, ±0.02 • I_{NOM}
IA87, IB87, IC87 Differential Currents:	±1% of reading
Current Unbalance (%):	±2% of reading, ±0.02 • I_{NOM}
System Frequency:	±0.01 Hz of reading for frequencies within 15–70 Hz (V1 > 60 V)
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:	±1% of reading, ±1° for voltages
Three-Phase Average Line-to-Line Voltage:	±1% of reading for voltages
Line-to-Neutral Voltages:	±1% of reading, ±1° for voltages
Three-Phase Average Line-to-Neutral Voltages:	±1% of reading for voltages
Voltage Imbalance (%):	±2% of reading
3V2 Negative-Sequence Voltage:	±2% of reading for voltages
Real Three-Phase Power (kW):	±3% of reading for 0.10 < pf < 1.00
Reactive Three-Phase Power (kVAR):	±3% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Power (kVA):	±3% of reading
Power Factor:	±2% of reading for 0.97 ≤ PF ≤ 1
RTD Temperatures:	±2°C
Field Voltage:	±1% of full-scale reading
Field Current:	±1% of full-scale at 25°C
Field Resistance:	±3% of full-scale reading

Energy Meter

Accumulators:	Separate IN and OUT accumulators updated once per second, transferred to non-volatile storage 4 times per day.
ASCII Report Resolution:	0.001 MWh
Accuracy:	The accuracy of the energy meter depends on applied current and power factor as shown in the power metering accuracy specifications above. The additional error introduced by accumulating power to yield energy is negligible when power changes slowly compared to the processing rate of once per second.

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

Section 2
Installation

Overview

The first steps in applying the SEL-710-5 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. Carefully plan relay placement, cable connections, and relay communication.

This section contains drawings of typical ac and dc connections to the SEL-710-5. 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-710-5 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

Physical Location

The SEL-710-5 is EN 61010-1 certified at Installation/Overvoltage Category II and Pollution Degree 2. This allows mounting of the relay in a sheltered indoor environment that does not exceed the temperature and humidity ratings for the relay. The SEL-710-5 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 1.16*.) For EN 61010-1 certification, the SEL-710-5 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-710-5 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-710-5 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. The relay is rated IP65 when the two-line display model is enclosed in a panel and rated IP54 when the touchscreen display model is enclosed in a panel.

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.

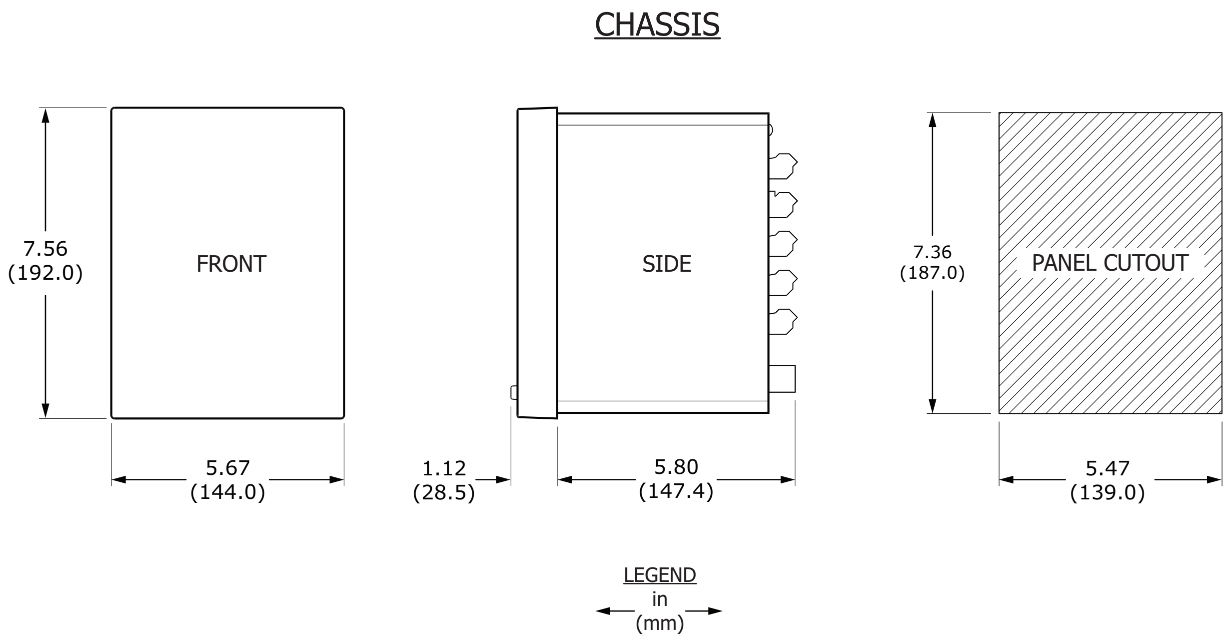


Figure 2.1 Relay Panel-Mount Dimensions

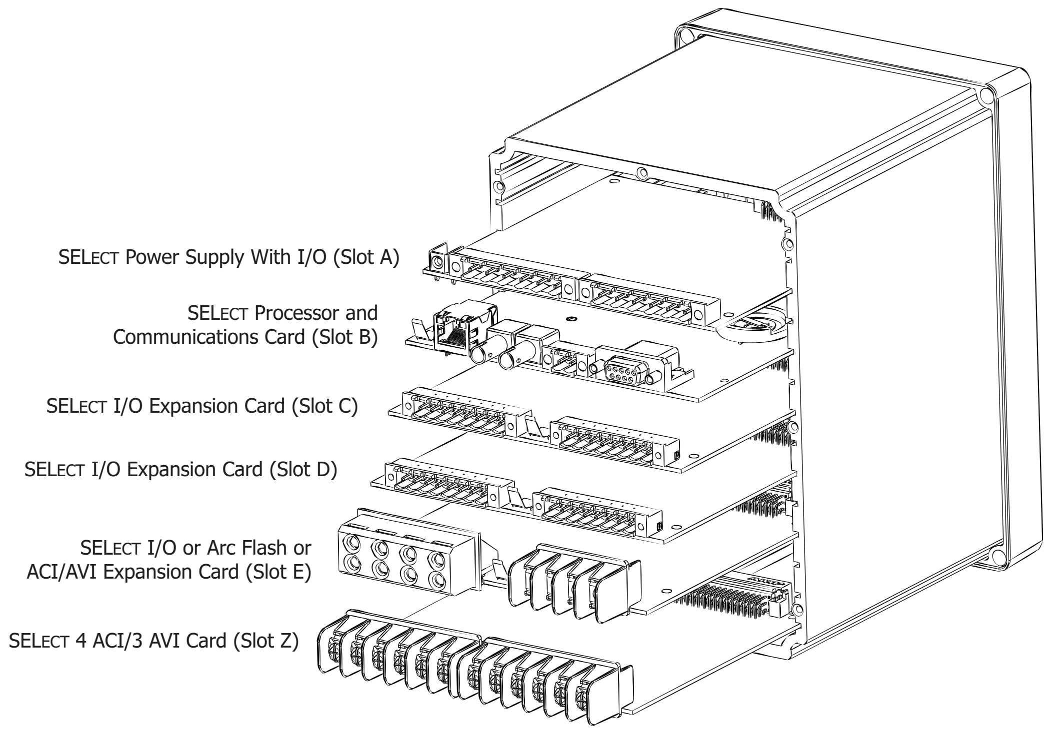
Refer to *Models, Options, and Accessories on page 1.5* for information on mounting accessories.

I/O Configuration

Your SEL-710-5 offers flexibility in tailoring I/O to your specific application. In total, the SEL-710-5 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, arc-flash detectors, and voltage/current cards are available for the SEL-710-5. *Figure 2.2* shows the slot allocations for the cards.

The SEL-710-5 comes with an orange Euro connector on the Slot A card for 24–48 Vdc low-voltage power supply and C, D, or E slots with 24–48 Vdc/Vac digital input options. Relays manufactured after May 18, 2022 will be provided with orange Euro connector for low-voltage power supply and digital inputs. Refer *Figure 2.16* and *Figure 2.18* for orange Euro connector examples.

Because installations differ substantially, the SEL-710-5 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 current/voltage card	Current/voltage 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			●	●	●	
SELECT 4 DI/3 DO (2 Form C, 1 Form B)			●	●	●	
SELECT 8 DO			●	●	●	
SELECT 8 DI			●	●	●	
SELECT 8 AI			●	●	●	
SELECT 14 DI[d]			●	●	●	
SELECT 4 AI/4 AO (one card per relay)			●	●	●	
SELECT 10 RTD				●		
SELECT 4 AFDI/3 DIFF ACI (MOT…x74x…)					●	
SELECT SYNCH/3 DIFF ACI (MOT…x75x…)					●	
SELECT 8 AFDI (MOT…x76x…)					●	
SELECT 4 ACI/3 AVI (MOT…x81/82/83/85/86/87/L1x…)						●

[a] Power supply, two inputs, and three outputs.
[b] IRIG-B, EIA-232/485, fiber-optic serial and/or Ethernet ports. The IRIG-B input option is available on terminals B01, B02 for all models except models with fiber-optic Ethernet port (P1) and dual copper Ethernet port (P1). IRIG-B is also supported via fiber-optic serial port (Port 2) and rear-panel EIA-232 serial port (Port 3). You can use only one input at a time.
[c] Digital or analog.
[d] Requires R200 or higher firmware revision.

Figure 2.2 Slot Allocations for Different Cards

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

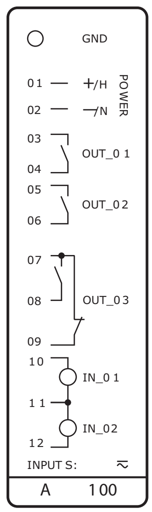
Select appropriate power supply option for the application:

- ➤ 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-710-5 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 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
- DNP3 LAN/WAN
- Simple Network Time Protocol (SNTP)
- Parallel Redundancy Protocol (PRP)
- EtherNet/IP
- Precision Time Protocol (PTP)
- IEC 61850
- FTP
- Telnet

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

- Modbus RTU Slave
- DNP3 Level 2 Outstation
- SEL ASCII and Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message Unsolicited Write
- SEL Settings File Transfer
- SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTA, MBTB)
- IEC 60870-5-103

Communications Card (Slot C)

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

Either the DeviceNet (see *Appendix I: 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 Fast Message Unsolicited Write
- SEL Settings File Transfer
- SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTB, MBTA)
- DNP3 Level 2 Outstation
- IEC 60870-5-103

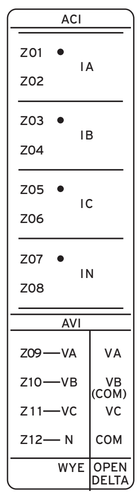
Current/Voltage Card (4 ACI/3 AVI)

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

⚠WARNING
Voltage measurement circuits have high input impedance and will respond to stray signals when left open (disconnected). Always isolate the relay control circuit before opening the voltage input test switches or performing work on the voltage circuit.

MOT…x81x… (1 A phase, 1 A neutral CTs); …x85x… (5 A phase, 5 A neutral CTs); …x82x… (1 A phase, 5 A neutral CTs); …x86x… (5 A phase, 1 A neutral CTs); …x83x… (1 A phase, 2.5 mA neutral CTs); or …x87x… (5 A phase, 2.5 mA neutral CTs). Supported in Slot Z of the SEL-710-5 relay, this card has current inputs for three-phase CTs, neutral current CTs, and voltage inputs for three-phase (wye or delta) PTs. You can order one of three neutral CT ratings, 1 A, 5 A, or 2.5 mA (high sensitivity).

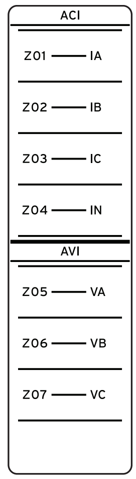
Table 2.4 Current/Voltage Inputs (4 ACI/3 AVI) Card Terminal Designation

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

MOT…xL1x… Rogowski coil or LPCT phase and neutral input and LEA voltage sensor inputs. Supported in Slot Z of the SEL-710-5, this card has current inputs for three-phase and neutral Rogowski coil or LPCTs and LEA voltage sensor inputs for three-phase PTs.

The 4 ACI/3 AVI current/voltage card inputs terminal designation for the card with LEA voltage inputs and the regular voltage inputs is as shown in *Table 2.5*.

Table 2.5 Current/Voltage Inputs (4 ACI/3 AVI) LEA Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	Z01	IA, A-phase current input
	Z02	IB, B-phase current input
	Z03	IC, C-phase current input
	Z04	IN, neutral current input
	Z05	VA, A-phase voltage input
	Z06	VB, B-phase voltage input
	Z07	VC, C-phase voltage input

The pinout assignments for RJ45 connector are in accordance with IEC 61869-10 and IEC 61869-11, as shown in *Table 2.6*.

Table 2.6 RJ45 Pinout Assignments for Current/Voltage Inputs (4 ACI/3 AVI) LPCT/Rogowski Coil and LEA Card

RJ45 Connector Pins	1	2	3	4	5	6	7	8
Passive LPVT							a[a]	n[a]
Passive LPCT/ Rogowski Coil	S1[b]	S2[b]						

[a] See Figure 2.3.
[b] See Figure 2.4.

Figure 2.3 and *Figure 2.4* show typical terminal markings for the passive LPVT and the LPCT/Rogowski coil, as shown in *Table 2.6*.

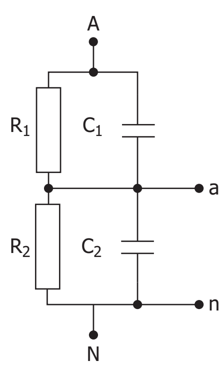


Figure 2.3 Terminal Markings for Passive LPVT

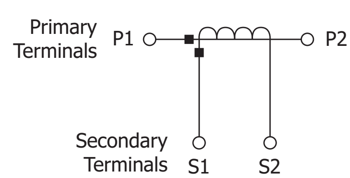


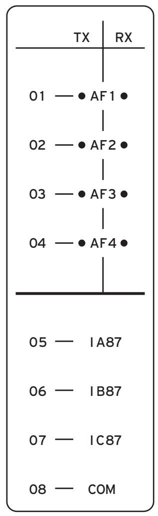
Figure 2.4 Terminal Markings for Passive LPCT

Four Arc-Flash Detection Inputs and Three AC Current Inputs (Motor Differential) (4 AFDI/3 DIFF ACI)

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

MOT…x74x… Supported only in Slot E of the SEL-710-5, this card has four arc-flash fiber-optic transmit and receive inputs (AF1–AF4) and three differential current inputs (IA87, IB87, and IC87). *Table 2.7* shows the terminal designation.

Table 2.7 Four Arc-Flash Detection Inputs and Three AC Current Inputs (4 AFDI/3 DIFF ACI) Card Terminal Designation

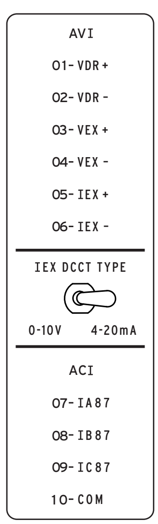
Side-Panel Connections Label	Terminal Number	Description
	E01	AF1 Channel TX and RX Inputs
	E02	AF2 Channel TX and RX Inputs
	E03	AF3 Channel TX and RX Inputs
	E04	AF4 Channel TX and RX Inputs
	E05	IA87, A-phase differential current input
	E06	IB87, B-phase differential current input
	E07	IC87, C-phase differential current input
	E08	Common for IA87, IB87, IC87

Three Synchronous Motor Inputs and Three AC Current Inputs (Motor Differential) (SYNCH/3 DIFF ACI)

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

MOT…x75x… Supported only in Slot E of the SEL-710-5, this card has three synchronous motor inputs (VDR, VEX, and IEX) and three differential current inputs (IA87, IB87, and IC87). IEX can use either (0–10 V) voltage or (4–20 mA) current input based on the position of the DCCT switch. *Table 2.8* shows the terminal designation.

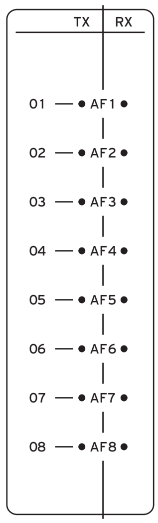
Table 2.8 Three Synchronous Motor Inputs and Three AC Current Inputs (SYNCH/3 DIFF ACI) Card Terminal Designation

Side-Panel Connections Label	Terminal Number	Description
	E01	VDR+, Field Discharge Resistor Voltage (Positive)
	E02	VDR-,Field Discharge Resistor Voltage (Negative)
	E03	VEX+, Exciter Voltage (Positive)
	E04	VEX-, Exciter Voltage (Negative)
	E05	IEX+, Exciter Current (Positive)
	E06	IEX-, Exciter Current (Negative)
	IEX DCCT Type	Selection Switch
	E07	IA87, A-phase differential current input
	E08	IB87, B-phase differential current input
	E09	IC87, C-phase differential current input
	E10	Common for IA87, IB87, IC87

Eight Arc-Flash Detection Inputs (8 AFDI)

MOT…x76x… Supported only in Slot E of the SEL-710-5, this card has eight arc-flash fiber-optic transmit and receive inputs (AF1–AF8). *Table 2.9* shows the terminal designations.

Table 2.9 Eight Arc-Flash Detection Inputs (8 AFDI) Card Terminal Designations

Side-Panel Connections Label	Terminal Number	Description
	E01	AF1 Channel TX and RX Inputs
	E02	AF2 Channel TX and RX Inputs
	E03	AF3 Channel TX and RX Inputs
	E04	AF4 Channel TX and RX Inputs
	E05	AF5 Channel TX and RX Inputs
	E06	AF6 Channel TX and RX Inputs
	E07	AF7 Channel TX and RX Inputs
	E08	AF8 Channel TX and RX Inputs

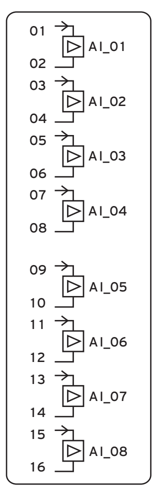
Analog Inputs Card (8 AI)

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

NOTE: Connection lengths less than 10 meters for analog inputs and outputs meet the requirements of IEC 60255-26 and IEC 60255-27.

Supported in any nonbase unit slot (Slot C through Slot E), this card has eight analog inputs. *Table 2.10* shows the terminal designation.

Table 2.10 Eight Analog Inputs (8 AI) Card Terminal Designation

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 was installed in Slot C, D, or E respectively.

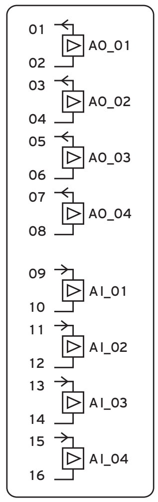
I/O Card (4 AI/4 AO)

> **NOTE:** Analog outputs (4 AI/4 AO, 3 DI/4 DO/1 AO) are isolated (dielectric level up to 1.0 kVac) from each other and from the chassis ground.

> **NOTE:** Analog inputs and outputs with connection lengths less than 10 meters meet requirements of IEC 60255-26 and IEC 60255-27.

Supported in only one of the nonbase unit slots (Slot **C** through Slot **E**), this card has four analog inputs and four analog outputs. *Table 2.11* shows the terminal designation.

Table 2.11 Four Analog Inputs/Four Analog Outputs (4 AI/4 AO) Card Terminal Designation



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 was installed in Slot C, D, or E respectively.

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

> **NOTE:** The analog output is self-powered and has an isolated power supply.

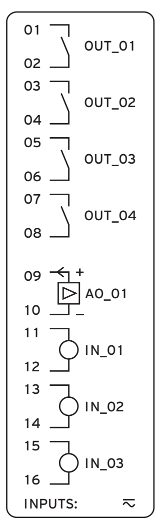
> **NOTE:** All digital input and digital output (including high-current, high-speed, hybrid) connections are polarity neutral.

> **NOTE:** Analog inputs and outputs with connection lengths less than 10 meters meet requirements of IEC 60255-26 and IEC 60255-27.

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

Supported in one nonbase unit slot (Slot **C**, **D**, or **E**), this card has three digital inputs, four digital outputs (normally open contact outputs), and one analog output. *Table 2.12* shows the terminal designation.

Table 2.12 Three Digital Inputs/Four Digital Outputs/One Analog Output (3 DI/4 DO/1 AO) Card Terminal Designation



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 was installed in Slot C, D, or E respectively.

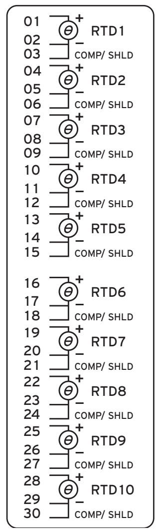
RTD Card (10 RTD)

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

NOTE: Use passive resistors to simulate temperatures. Note that using RTD simulators to test RTD inputs can damage the relay.

Supported in Slot **D** only, this card has 10 3-wire RTD inputs. *Table 2.13* shows the terminal designation.

Table 2.13 RTD Inputs (10 RTD) Card Terminal Designation

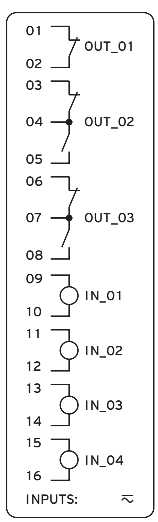


Side-Panel Connections Label	Terminal Number	Description
	01	RTD01 (+)
	02	RTD01 (–)
	03	RTD01 Comp/Shield
	04	RTD02 (+)
	05	RTD02 (–)
	06	RTD02 Comp/Shield
	07	RTD03 (+)
	08	RTD03 (–)
	09	RTD03 Comp/Shield
	•	•
	•	•
	•	•
	28	RTD10 (+)
	29	RTD10 (–)
	30	RTD10 Comp/Shield

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), and two Form C digital output contacts. *Table 2.14* shows the terminal designation.

Table 2.14 Four Digital Inputs/Three Digital Outputs (4 DI/3 DO) Card Terminal Designation



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

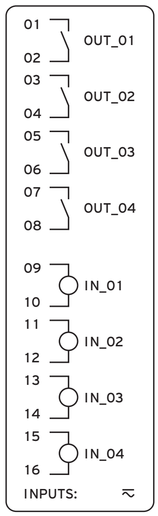
[a] x=3, 4, or 5, if the card was installed in Slot C, D, or E respectively.

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 or all fast hybrid outputs (high-speed, high-current interrupting). *Table 2.15* shows the terminal designation.

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

Table 2.15 Four Digital Input/Four Digital Output (4 DI/4 DO) Card Terminal Designation

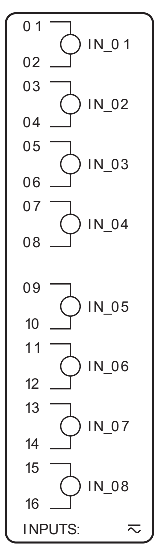
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	OUT*x*01, driven by OUT*x*01 SELOGIC equation
	03, 04	OUT*x*02, driven by OUT*x*02 SELOGIC equation
	05, 06	OUT*x*03, driven by OUT*x*03 SELOGIC equation
	07, 08	OUT*x*04, driven by OUT*x*04 SELOGIC equation
	09, 10	IN*x*01, drives IN*x*01 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 was 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 2.16* shows the terminal designation.

Table 2.16 Eight Digital Input (8 DI) Card Terminal Designation

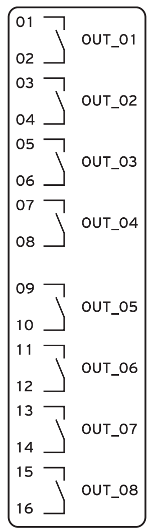
Side-Panel Connections Label	Terminal Number	Description[a]
	01, 02	INx01, drives INx01 element
	03, 04	INx02, drives INx02 element
	05, 06	INx03, drives INx03 element
	07, 08	INx04, drives INx04 element
	09, 10	INx05, drives INx05 element
	11, 12	INx06, drives INx06 element
	13, 14	INx07, drives INx07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

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

I/O Card (8 DO)

Supported in any nonbase unit slot (Slot C through Slot E), this card has eight digital outputs. *Table 2.17* shows the terminal designation.

Table 2.17 Eight Digital Output (8 DO) Card Terminal Designation



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

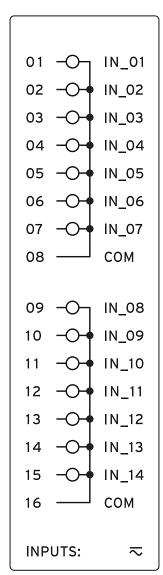
[a] x=3, 4, or 5, if the card was installed in Slot C, D, or E respectively.

The 8 DO card, shown in *Table 2.17*, has all 8 Form A contacts. Refer to the SEL-710-5 Model Option Table for all the variants available (8A, 8B, 4A/4B, 2A/6B, 6A/2B).

I/O Card (14 DI)

Supported in any nonbase unit slot (Slot C through Slot E), this card has fourteen digital inputs. *Table 2.18* shows the terminal designations.

Table 2.18 Fourteen Digital Inputs (14 DI) Card Terminal Designations



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

[a] x=3, 4, or 5, if the card was 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-710-5 offers flexibility in tailoring I/O to your specific application. The SEL-710-5 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-710-5 in Slots **C**, **D**, and **E**. Optional communications cards are available only for Slot **C**; an RTD card is available only for Slot **D**; and synchronous motor inputs, current, and arc flash cards are available only on Slot **E**. *Figure 2.2* shows the slot allocations for the cards.

Because installations differ substantially, the SEL-710-5 offers a variety of card configurations that provide options for an array of applications. Choose the combination of option cards most suited for your application.

Swapping Optional I/O Cards

When an I/O card 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 50P1T, 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-710-5 can be upgraded by adding as many as three cards.

Installation

Perform the following procedure to install or replace any one of the cards into Slots **C**, **D**, **E**, or **Z** of the base unit.

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

> **NOTE:** To replace the communications card in Slot C with a standard I/O card, remove the white, stick-on label on the back plate to see the correct slots for the selected I/O card.

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 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 the may remain inside the SEL-710-5 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.

If you have a two-line display front panel, perform *Step 11* through *Step 19*; if you have a touchscreen display front panel, proceed to *Step 20*.

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 in the wrong slot. Begin again at *Step 2*.

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
```

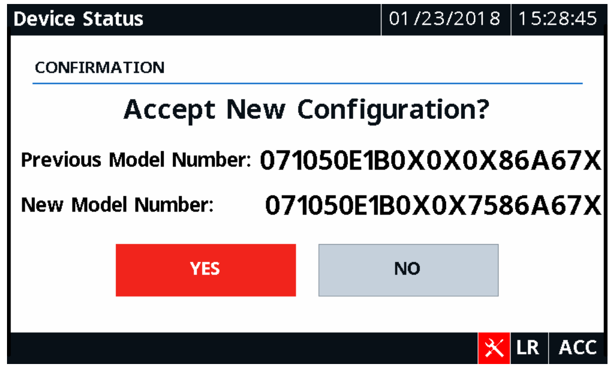
Step 18. Select `Yes` and press the **ENT** pushbutton.

The front panel displays the following:

```
Config Accepted.
Enter to Reboot
```

Step 19. Press **ENT** and proceed to *Step 22*.

Step 20. Wait for the Device Status screen to appear, and then verify the new part number and tap **Yes** to confirm the new configuration.



Step 21. Tap **OK** on the notification screen to reboot the relay.

Step 22. 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 is turned on to indicate the card was installed correctly.

After reconfiguration, the relay updates the part number, except for the digits shown below. These digits remain unchanged, i.e., these digits retain the same character as before the reconfiguration. A communications card (DeviceNet or EIA-232/485) installed in Slot C will be reflected as an empty slot in the part number. A regular 4 DI/4 DO card and a hybrid 4 DI/4 DO card have the same device ID. When interchanging these two cards, the part number for the respective slots should be updated manually. Use the **STATUS** command to view the part number.

071050E1B5X1X7586000X

NOTE: If adding a SELECT SYNCH/3 DIFF card, perform **R_S** from Access Level C after accepting the configuration and rebooting the relay.

Step 23. Update the side-panel drawing with the drawing sticker provided in the option card kit. If necessary, replace the rear panel with the one applicable for the card and attach the terminal marking label provided with the card to the rear-panel cover. Also, contact SEL for an updated product serial number label with the updated part number.

Step 24. Reconnect all connection plugs and add any additional wiring/ connectors required by the new option card.

Slot B CPU Card Replacement

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

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

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

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

Step 4. If the IEC 61850 protocol option was used previously, verify that the IEC 61850 protocol is still operational after the replacement. If not, reenable it. Refer to *Protocol Verification for Relays With IEC 61850 Option on page B.19*.

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

Step 1. Turn off the power to the relay.

Step 2. Use ground strap between yourself and relay.

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

Step 4. Remove the rear panel.

Step 5. Remove the card from its slot and insert the new card.

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

Step 7. Apply new side stickers to the relay.

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

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

Step 10. From Access Level 2, type **CAL** to enter 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 relay serial number and part number to the appropriate values, type **END**, and then save the settings.

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

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

Slot A Power Supply Card

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

Analog Input (AI) Voltage/Current Jumper Selection

Figure 2.5 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.

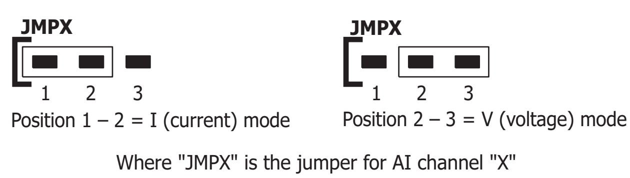


Figure 2.5 Circuit Board of Analog I/O Board, Showing Jumper Selection

Analog Output (AO) Voltage/Current Jumper Selection

Figure 2.6 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.

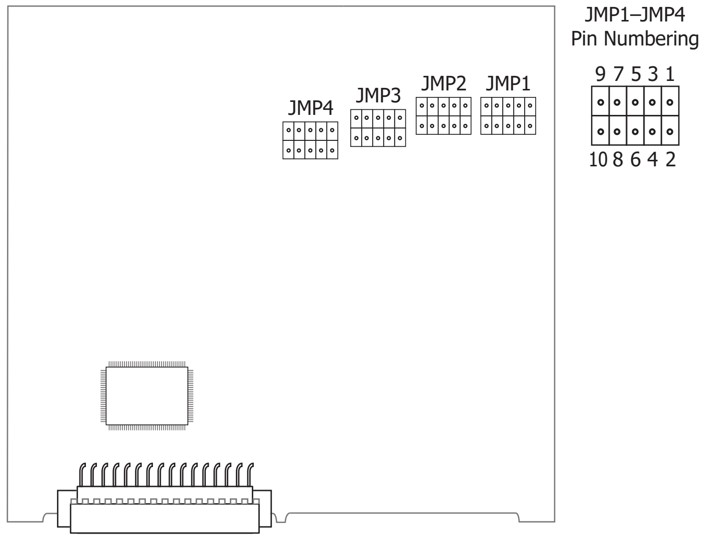


Figure 2.6 JMP1 Through JMP4 Locations on 4 AI/4 AO Board

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

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 2.7* shows JMP4 selected as a current analog output. The current analog output selection is the default setting for JMP1 through JMP4. *Figure 2.8* shows JMP1 selected as a voltage analog output.

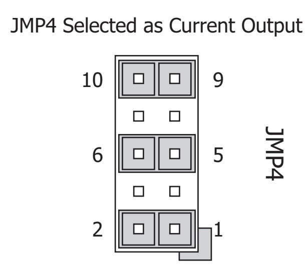


Figure 2.7 Current Output Jumpers

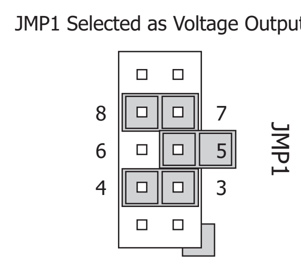


Figure 2.8 Voltage Output Jumpers

Password, Breaker (Start/Stop Control), and SELBOOT Jumper Selection

Figure 2.9 shows the major components of the B-slot card in the base unit. Notice the three sets of pins labeled A, B, and C.

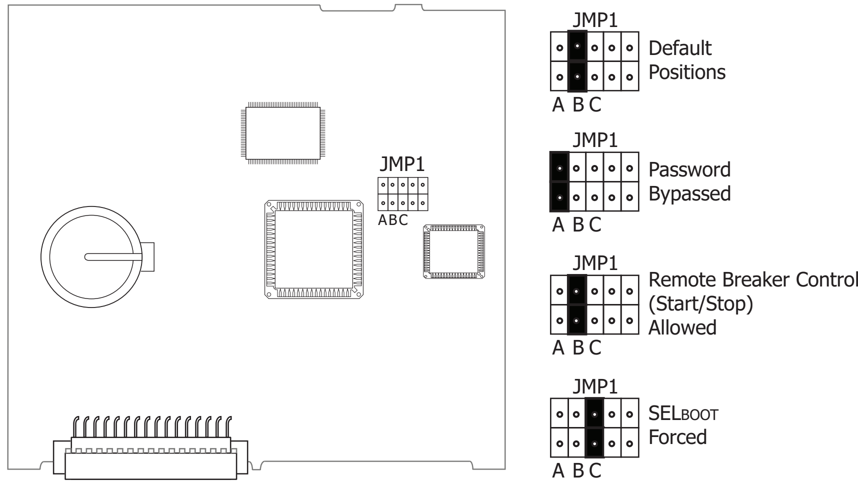


Figure 2.9 Pins for Password Jumper, Breaker Jumper (Start/Stop Control), and SELBOOT Jumper

Pins labeled A bypass the password requirement, pins labeled B enable breaker control, and pins labeled C force the relay to the SEL operating system called SELBOOT. In the unlikely event that the SEL-710-5 experiences an internal failure, communication with the relay can 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 2.9* (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, Level 2, and Level C command levels without passwords, place the jumper in Position A, as shown in *Figure 2.9* (Password Bypassed). Note that you can only access command levels without passwords to the access level set for the MAXACC setting for the port through which you are communicating. Although you gain access to Level 2 and Level C without a password, the alarm contact still closes momentarily when accessing Level 2 and Level C. See *Table 2.19* for the functions of the three sets of pins and their jumper default positions.

Table 2.19 Jumper Functions and Default Positions

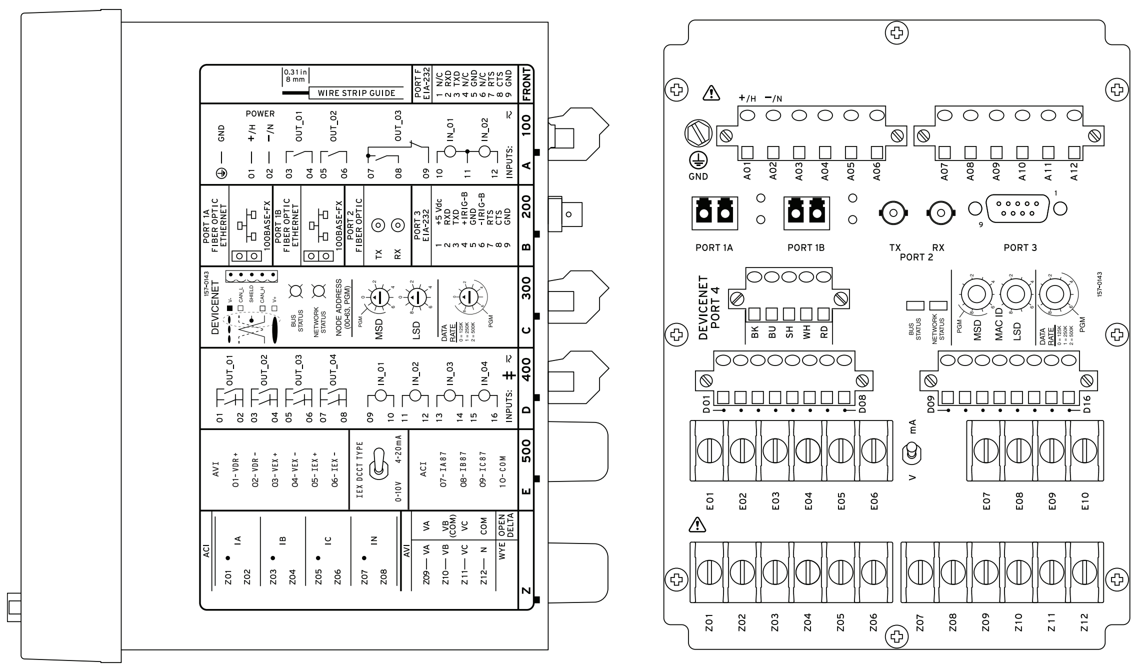
Pins	Jumper Default Position	Description
A	Not bypassed (requires password)	Password bypass
B	On (start/stop enabled)	Enable breaker (start/stop control)[a]
C	Not bypassed (not forced SELBOOT)	Forced SELBOOT

[a] Enable/disable serial port, front panel, and Fast Operate commands for breaker control. The jumper position affects the breaker control by using the STR or STO commands and output contact control by using the PULSE command via the serial port, the front-panel menu-driven user interface, or the communications protocols. The jumper position does not affect the operation of the local bits, the remote bits, or the front-panel programmable pushbuttons.

Relay Connections

Side-Panel and Rear-Panel Diagrams

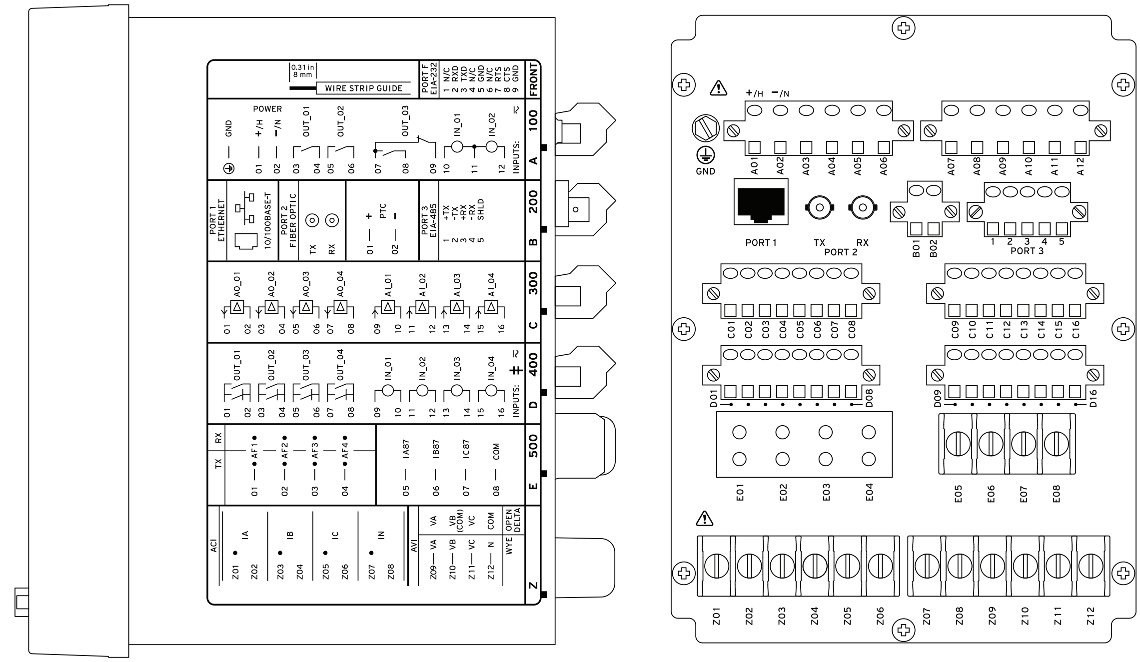
The physical layout of the connectors on the side-panel and rear-panel diagrams of three sample configurations of the SEL-710-5 are shown in *Figure 2.10* through *Figure 2.14*.



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel Input and Output Designations (b) Rear-Panel Layout

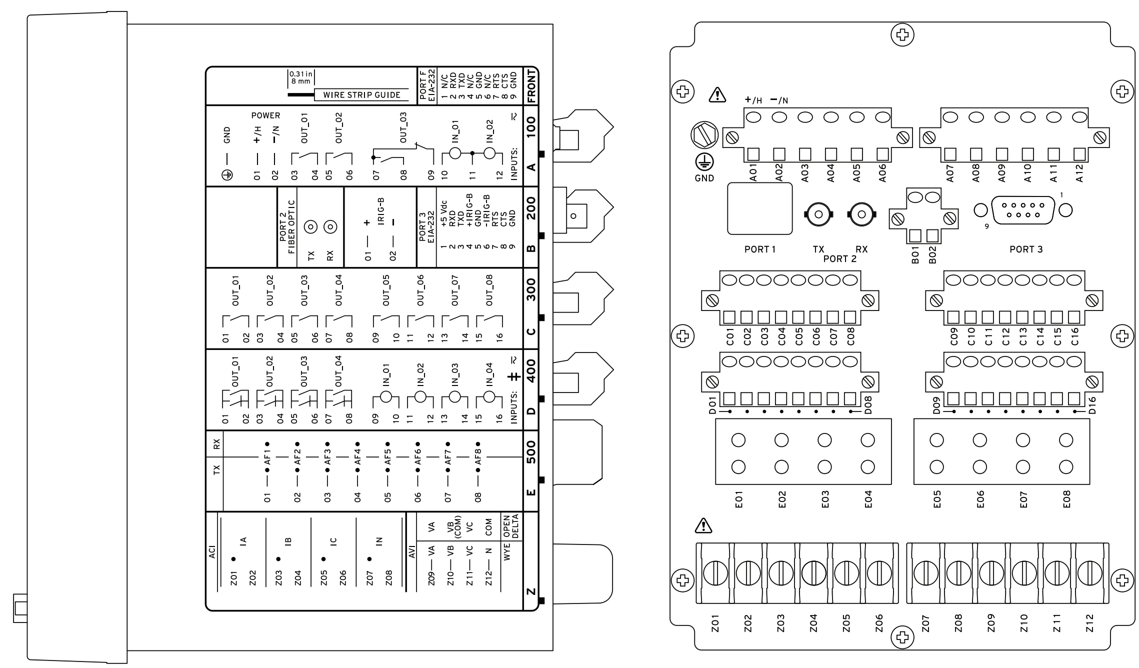
Figure 2.10 Dual Fiber-Optic Ethernet, Fiber-Optic Serial, DeviceNet, Fast Hybrid 4 DI/4 DO and Synchronous Motor/Differential Option (Relay MOT: 071050E1AA3CA75850830)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel Input and Output Designations (b) Rear-Panel Layout

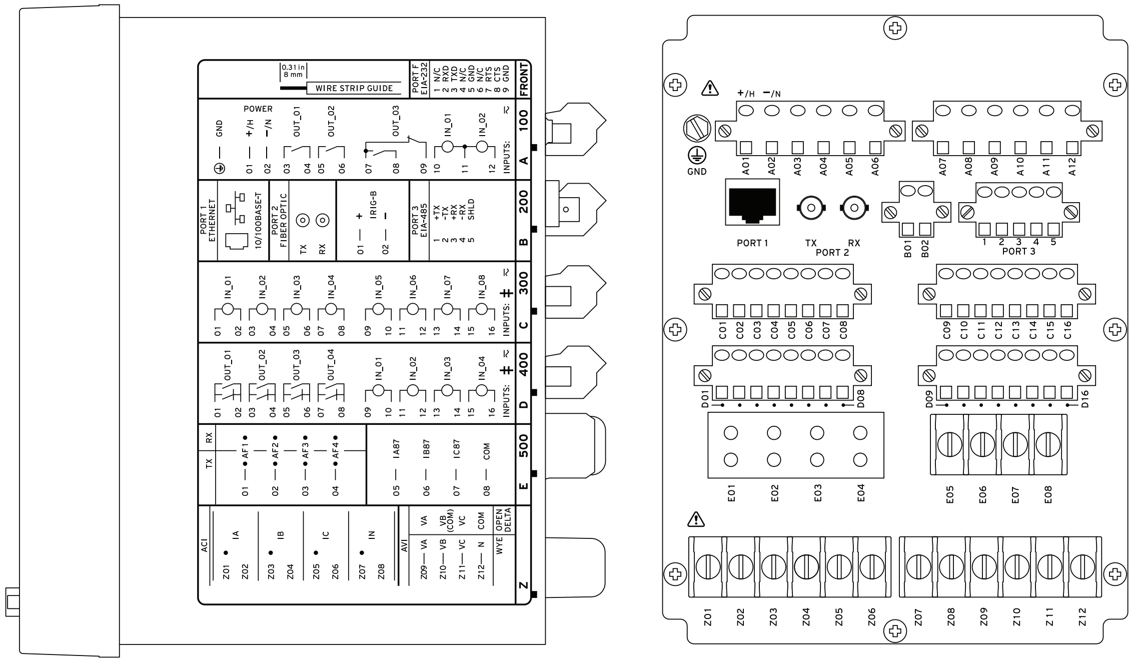
Figure 2.11 Single Copper Ethernet, Fiber-Optic Serial, EIA-485 Communications, PTC, 4 AI/4 AO, Fast Hybrid 4 DI/4 DO and 4 Arc-Flash/Differential Option (Relay MOT: 071050E1A6XCA74851300)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel Input and Output Designations (b) Rear-Panel Layout

Figure 2.12 No Ethernet, Fiber-Optic Serial, EIA-232 Communications, IRIG-B, 8 DO, Fast Hybrid 4 DI/4 DO, 8 Arc-Flash Option (Relay MOT: 071050E1A2ACA73850000)

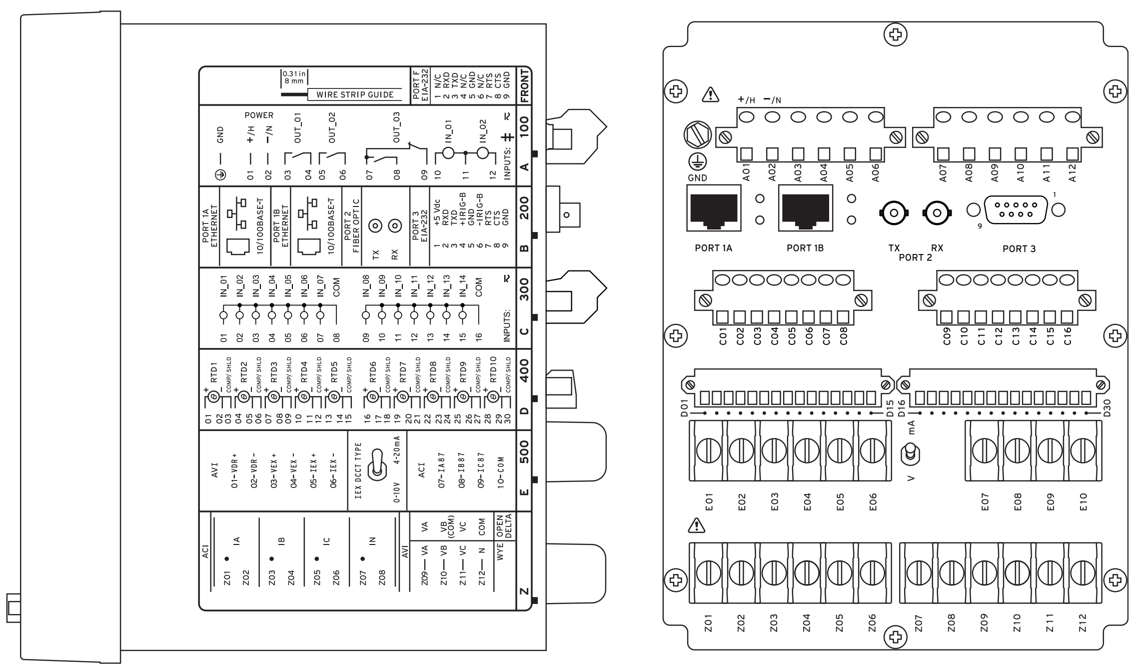


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel Input and Output Designations

(b) Rear-Panel Layout

Figure 2.13 Copper Ethernet, Fiber-Optic Serial, EIA-485 Serial Communications, IRIG-B, 8 DI, Fast Hybrid 4 DI/4 DO, 4 Arc-Flash/Differential Option (Relay MOT: 071050E1A3ACA74850300)

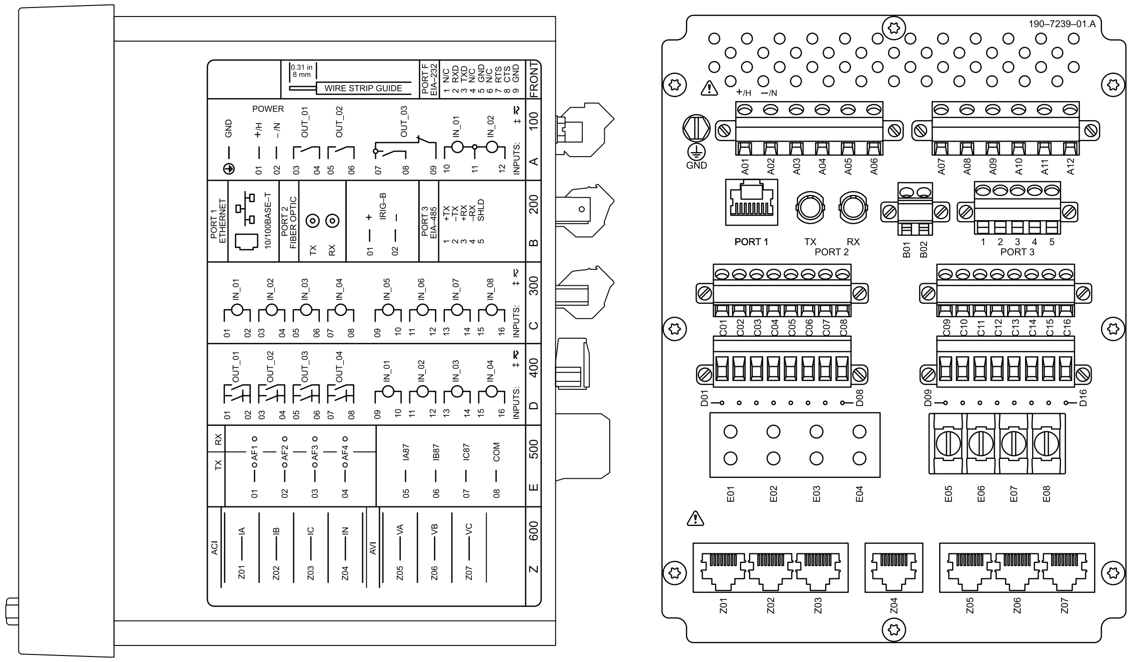


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel Input and Output Designations

(b) Rear-Panel Layout

Figure 2.14 Dual Copper Ethernet, Fiber-Optic Serial, EIA-232 Serial Communications, IRIG-B, 14 DI, 10 RTD and Synchronous Motor Differential Option (Relay MOT: 071050S1A4A9X7585A670)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(a) Side-Panel Input and Output Designations

(b) Rear-Panel Layout

Figure 2.15 Copper Ethernet, Fiber-Optic Serial, EIA-485 Serial Communications, IRIG-B, 8 DI, Fast Hybrid 4 DI/4 DO, 4 Arc-Flash/Differential Option (Relay MOT: 071050E1A3ACA74L10300)

Power Connections

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

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 1.13* 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.

The SEL-710-5 comes with an orange Euro connector on the Slot A card for 24–48 Vdc low-voltage power supply options. *Figure 2.16* shows the orange Euro connector with 24–48 Vdc power supply rating.

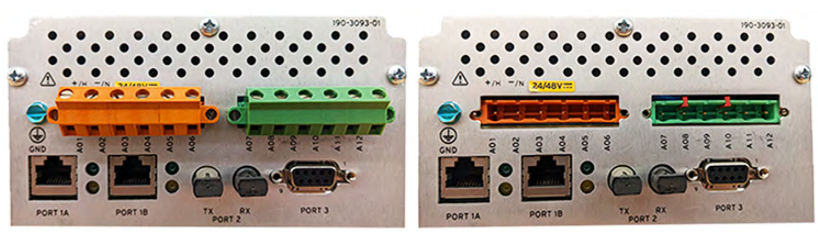


Figure 2.16 Slot A Euro Connector

⚠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.

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-710-5; 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 maximum.

Operational power is internally fused by a power supply fuse. See *Field Serviceability on page 2.52* 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 mm²) to 18 AWG (0.8 mm²) wire less than 2 m (6.6 ft) in length for the ground connection.

The relay IN input can be connected to the ground CT, as shown in *Figure 2.27*. Connecting the IN input residually requires you to select a relatively high overcurrent element pickup setting to avoid tripping due to false residual current caused by CT saturation during high starting current. The IN connection shown in *Figure 2.27* is preferred and provides for a lower ratio flux-balance CT that avoids saturation and provides greater ground fault sensitivity.

When you use a ground CT, its placement is critical and depends on the type of cable used to connect the motor to the source. As *Figure 2.17* shows, using unshielded cable requires that the CT be placed between the neutral connection to ground and the motor, with the neutral lead included in the CT window. With shielded cable, the shield connection to ground must pass through the CT window.

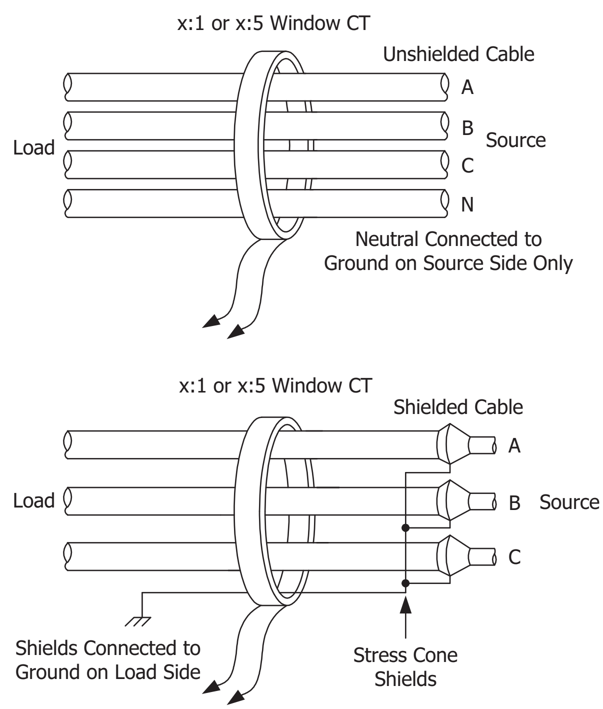


Figure 2.17 Ground CT Placement

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 26 AWG through 14 AWG. 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-710-5 accepts a demodulated IRIG-B time signal to synchronize the internal clock with an external source. Three options for IRIG-B signal input are given, but you should use only one at a time. You can use IRIG-B (**B01** and **B02**) inputs, 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, SEL-2032, or SEL-3530 RTAC and bring the IRIG-B signal with the EIA-232 input. Use a fiber-optic cable pair with ST connectors (C805, C807, C808) to connect to **Port 2** on the SEL-710-5. Refer to *Section 7: Communications* for details on IRIG-B connections examples and for details about using an SEL-2401 or 2407 Satellite-Synchronized Clock or an SEL-2488 Satellite-Synchronized Network Clock as a time source.

Ethernet Port

The SEL-710-5 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 Serial Port

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

I/O Connections

Digital inputs, when selected with 24 Vdc/Vac or 48 Vdc/Vac input voltage option, come with an orange Euro connector on the slot. *Figure 2.18* shows the orange Euro connector for the 3 DI/4 DO/1 AO digital input option on Slot C.

Figure 2.18 Slot C Euro Connector

I/O Diagram

A more functional representation of two of the control (I/O) connections is shown in *Figure 2.19* and *Figure 2.20*.

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

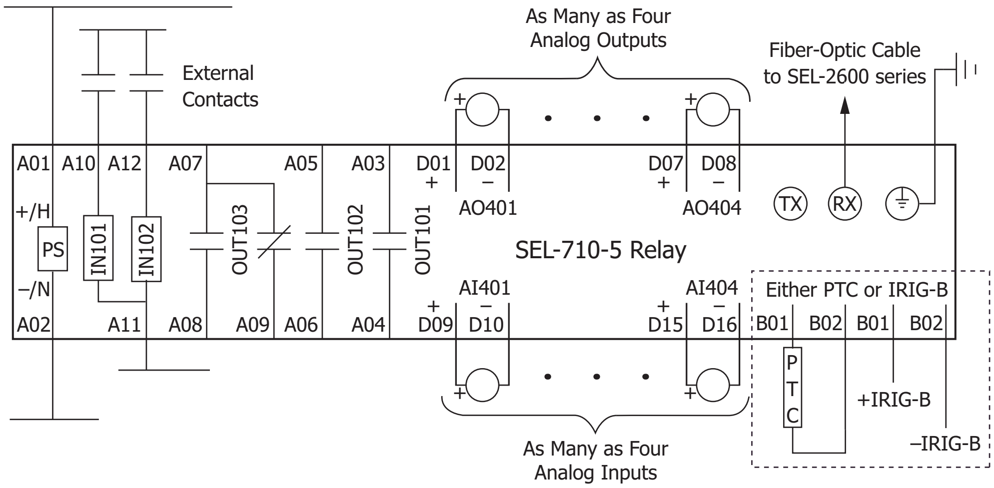
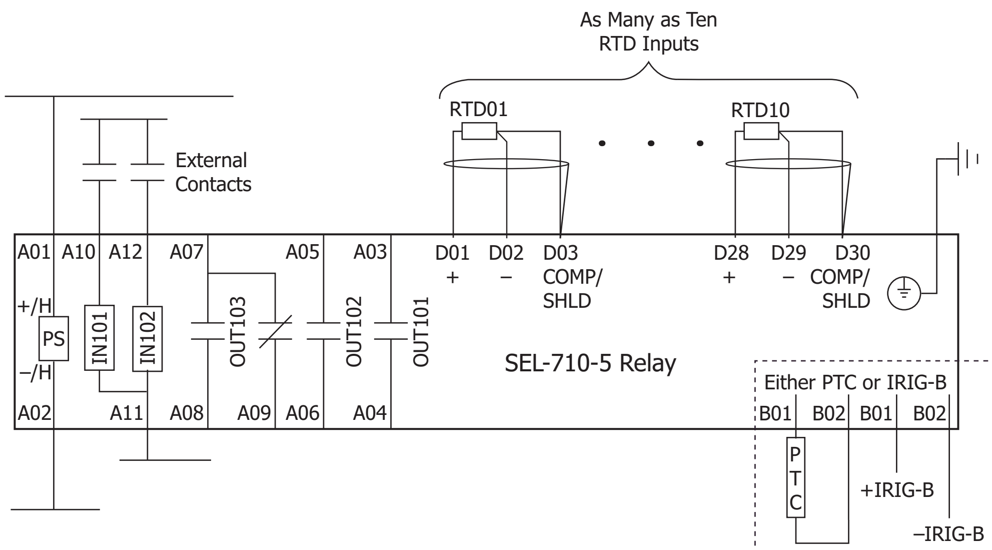


Figure 2.19 Control I/O Connections—4 AI/4 AO Option in Slot D

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

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-710-5 model number. As many as six thermistors can be connected in series. Refer to Table 2.20 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. Also, note that relays with PTC do not support IRIG-B.



Notes:

- The chassis ground connector located on the rear-panel card in Slot A must always be connected to the local ground mat.
- Power supply rating (110–240 Vac, 110–250 Vdc, or 24–48 Vdc) depends on the relay part number.
- Optoisolated Inputs IN101 and IN102 are standard and located on the card in Slot A.
- All optoisolated inputs are single-rated: 24, 48, 110, 125, 220, or 250 Vac/Vdc. Standard Inputs IN101/102 can have a different rating than the optional IN401/402/403/404 (not shown).
- Output Contacts OUT101, OUT102, and OUT103 are standard and located on the card in Slot A.
- The analog (transducer) outputs shown are located on the optional I/O expansion card in Slot D.
- The fiber-optic serial port is located on the card in Slot B. A Simplex 62.5/200 µm fiber-optic cable is required to connect the SEL-710-5 with an SEL-2600 Series RTD Module. This fiber-optic cable should be 1000 meters or shorter.

Figure 2.20 Control I/O Connections—Internal RTD Option

PTC Wiring

Table 2.20 shows the maximum cable lengths for the PTC connections.

Table 2.20 PTC Cable Requirements (Sheet 1 of 2)

Wire Size, Twisted Pair AWG No.	Maximum Length (meters) Shielded Cable	Maximum Length (meters) Unshielded Cable
20	200	100
18	300	100

Table 2.20 PTC Cable Requirements (Sheet 2 of 2)

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

RTD Wiring

NOTE: RTD inputs are not internally protected for electrical surges. External protection is recommended if surge protection is desired.

Table 2.21 shows the maximum cable lengths for the RTD connections that satisfy the 25-ohm limit required for connecting to SEL devices.

Table 2.21 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 2.21*. 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.

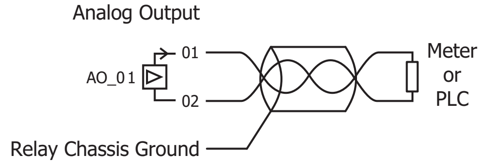


Figure 2.21 Analog Output Wiring Example

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
- ➤ Full-Voltage Reversing Starter
- ➤ VFD Motor
- ➤ Synchronous Motor

Fail-Safe/Nonfail-Safe Tripping

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 2.22 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.

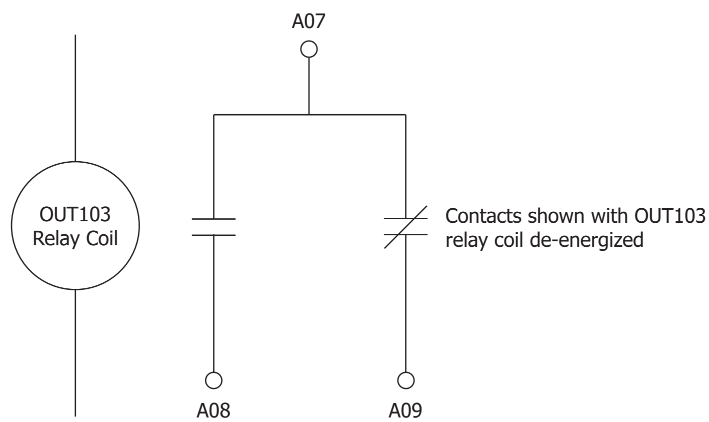


Figure 2.22 Output OUT103 Relay Output Contact Configuration

The SEL-710-5 provides fail-safe and nonfail-safe trip modes (setting selectable) for all output contacts. The following occur in fail-safe mode:

- ➤ The relay coil is energized continuously if the SEL-710-5 is powered and operational.
- ➤ When the SEL-710-5 generates a trip signal, the relay coil is de-energized.
- ➤ The relay coil is also de-energized if the SEL-710-5 power supply voltage is removed or if the SEL-710-5 fails (self-test status is FAIL).

Figure 2.23 shows fail-safe and nonfail-safe wiring methods to control breakers and contactors.

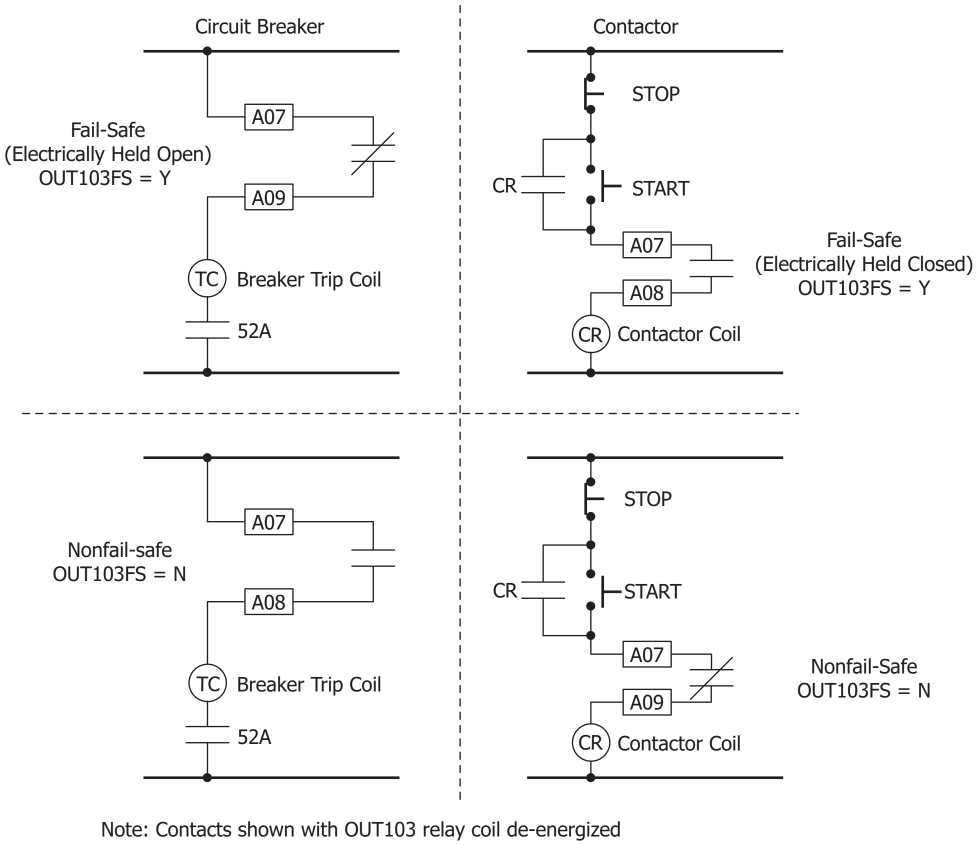


Figure 2.23 Breaker Trip Coil and Contactor Connections with OUT103FS := Y and OUT103FS := N

Figure 2.24 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. See *Figure 4.31* for the logic the relay uses to initiate motor starts.

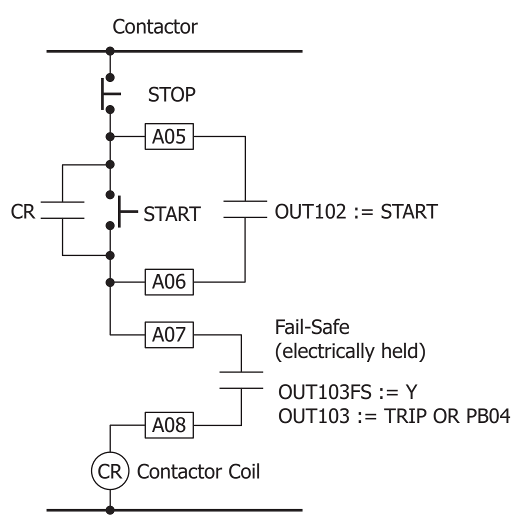


Figure 2.24 Contactor Application Using Factory-Default Settings

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 can be directly connected, wye-wye VT connected, open-delta VT connected, or a single-phase VT can be used. *Figure 2.25* and *Figure 2.26 (a–c)* show the methods of connecting single-phase and three-phase voltages. *Figure 2.26(b)* shows B-phase (Z10) grounding. You can choose to ground A-phase or C-phase instead of B-phase, but keep the jumper between terminals Z10 and Z12 as is.

Figure 2.26 (d) shows typical methods for connecting three-phase LEA sensor voltages, which support only wye-wye connections. Refer to *Undervoltage Function* and *Overvoltage Function on page 4.57* and *LEA Ratio and Angle Correction Factors (Global Settings) on page 4.11* for the LEA settings and ratio correction factor calculations. Refer to *Section 4: Protection and Logic Functions* for more details.

Figure 2.26 (e–f) and f shows typical methods for connecting three-phase voltages using the SEL-3790 voltage divider module. For specifications, installation and application details of SEL-3790, refer to the *SEL-3790 Low-Voltage Divider Module Instruction Manual*, available at selinc.com.

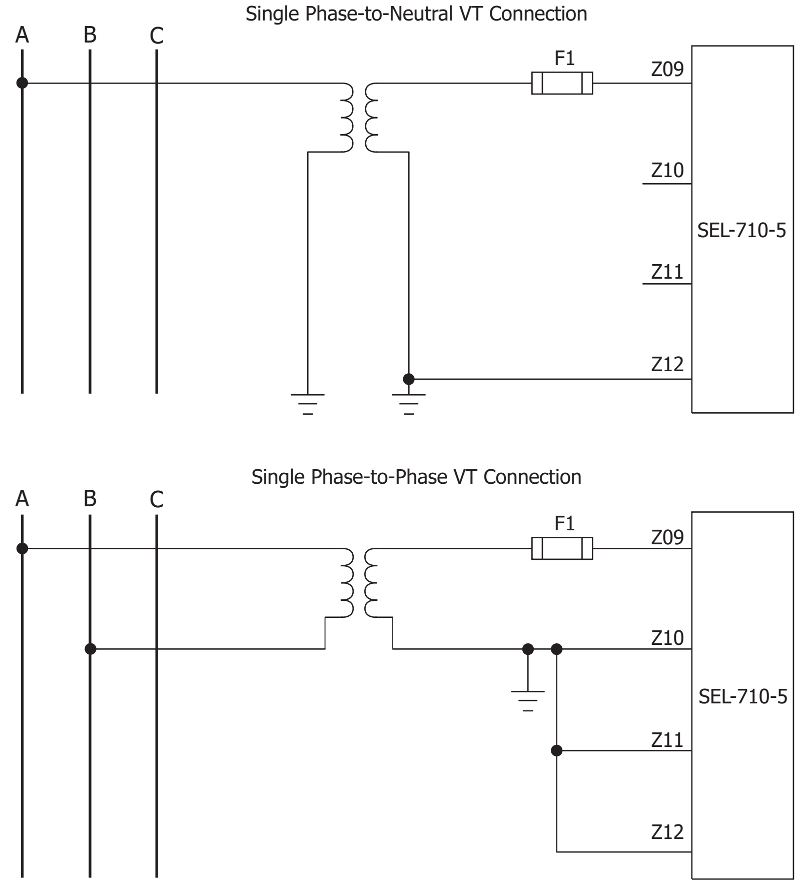
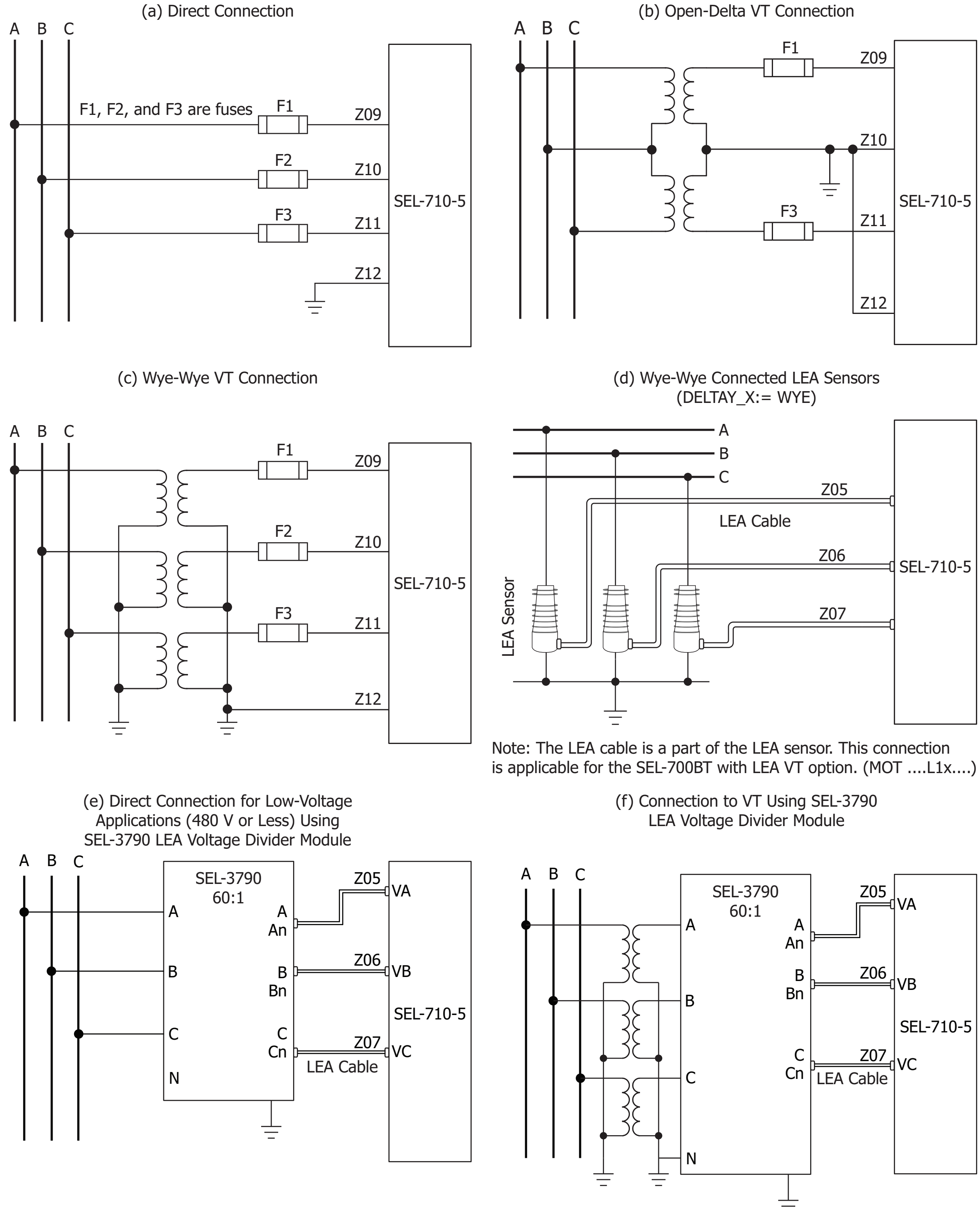


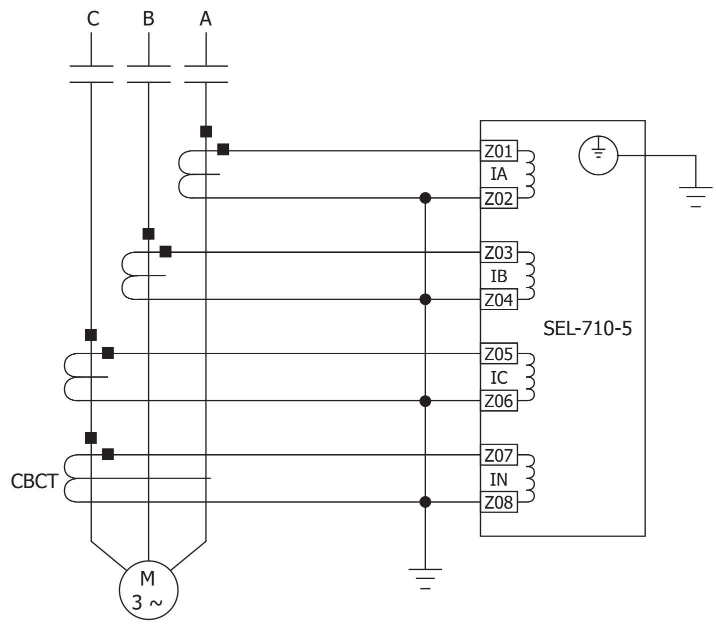
Figure 2.25 Single Phase Voltage Connections



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

Figure 2.26 Voltage Connections

Across-the-Line Starting



CBCT is core-balance current transformer.
The current transformers and the SEL-710-5 chassis should be grounded in the relay cabinet.

Figure 2.27 AC Connections With Core-Balance Neutral CT

Figure 2.28 and *Figure 2.29* show current circuit connections for the differential elements.

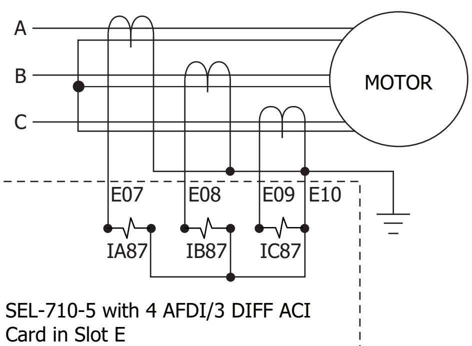


Figure 2.28 AC Connections With Core-Balance Differential CTs

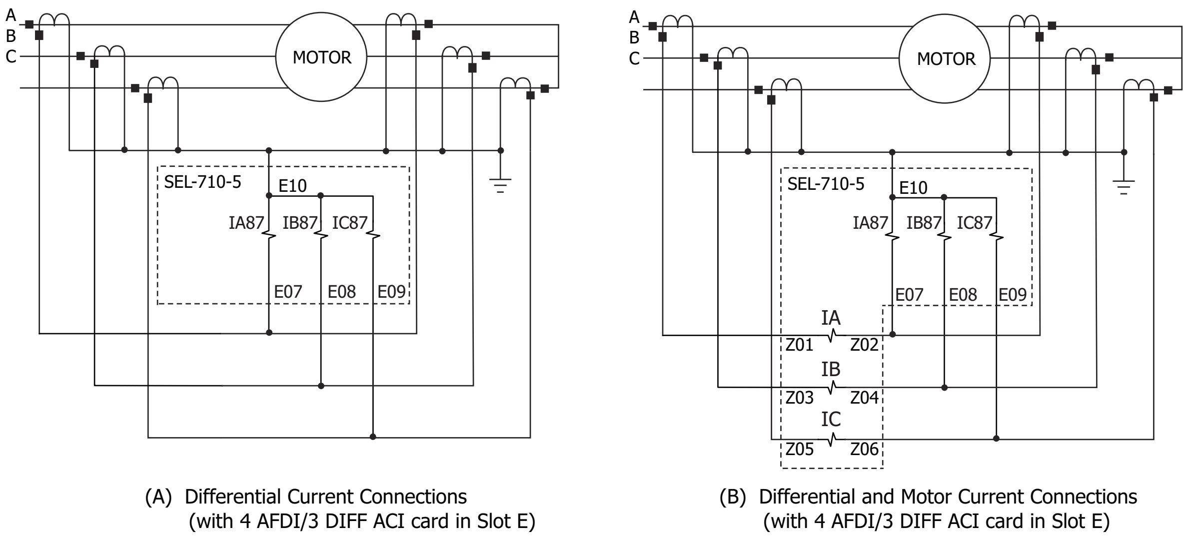


Figure 2.29 AC Connections With Source- and Neutral-Side CTs

The implementation in *Figure 2.30* requires the following settings:

OUT101 := SALARM OR HALARM

OUT103 := TRIP OR PB04

OUT103FS := Y

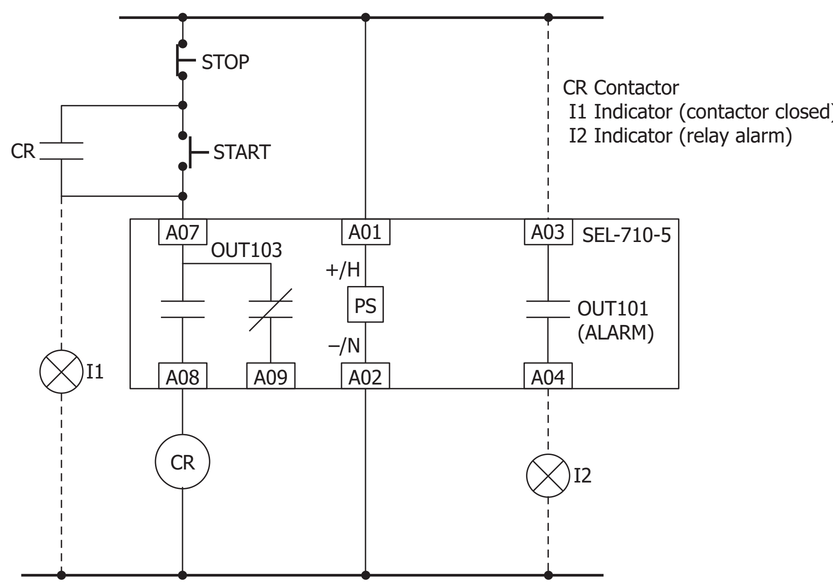


Figure 2.30 Control Connections for Fail-Safe Tripping

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 2.31* and *Figure 2.32* requires the following settings.

OUT101 := SALARM OR HALARM

OUT103 := TRIP OR PB04

OUT103FS := Y

OUT401 := DELTA

OUT402 := STAR

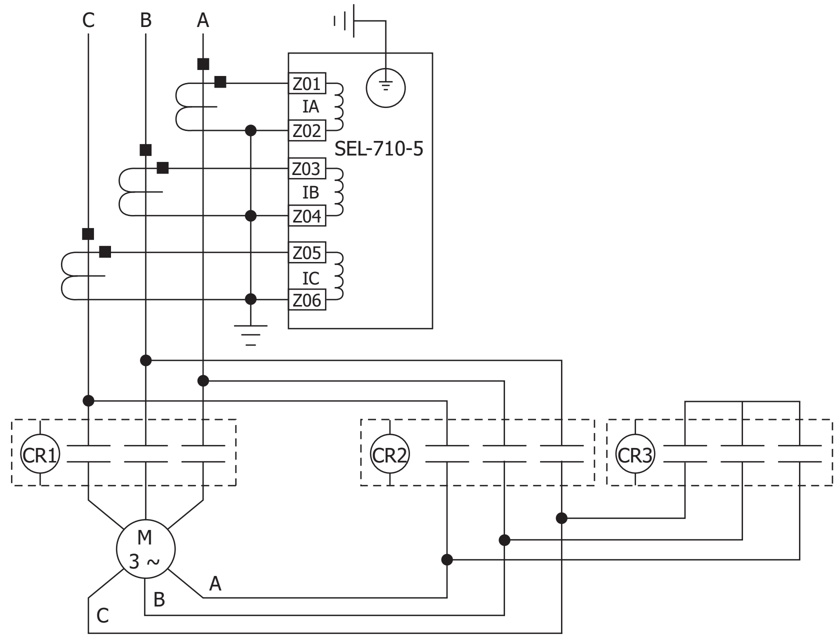


Figure 2.31 AC Connections for Star-Delta Starting

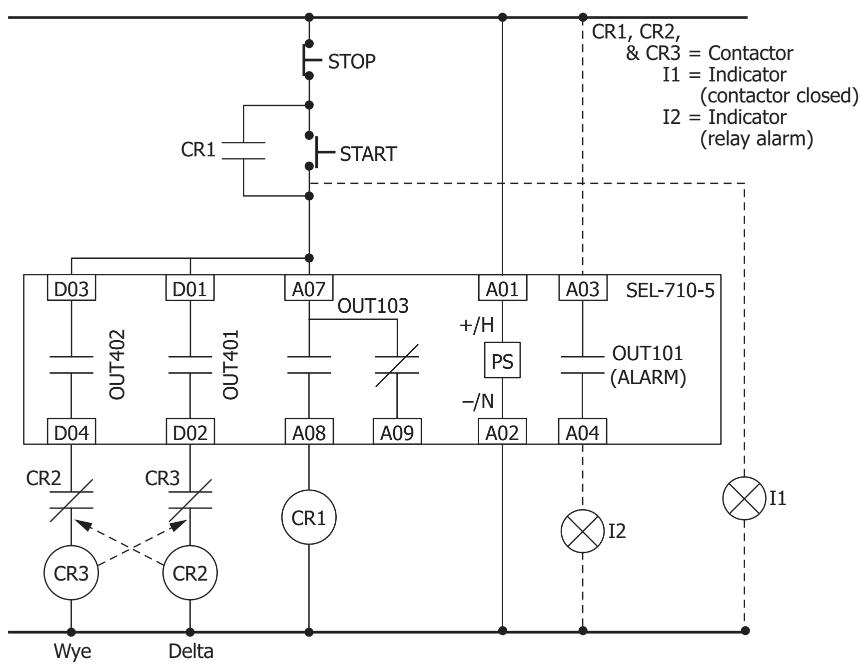


Figure 2.32 Control Connections for Star-Delta Starting

Two-Speed Motor

In *Figure 2.33*, 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

NOTE: A relay equipped with an LEA card does not support the two-speed motor application, but the relay does support full-voltage reverse starting.

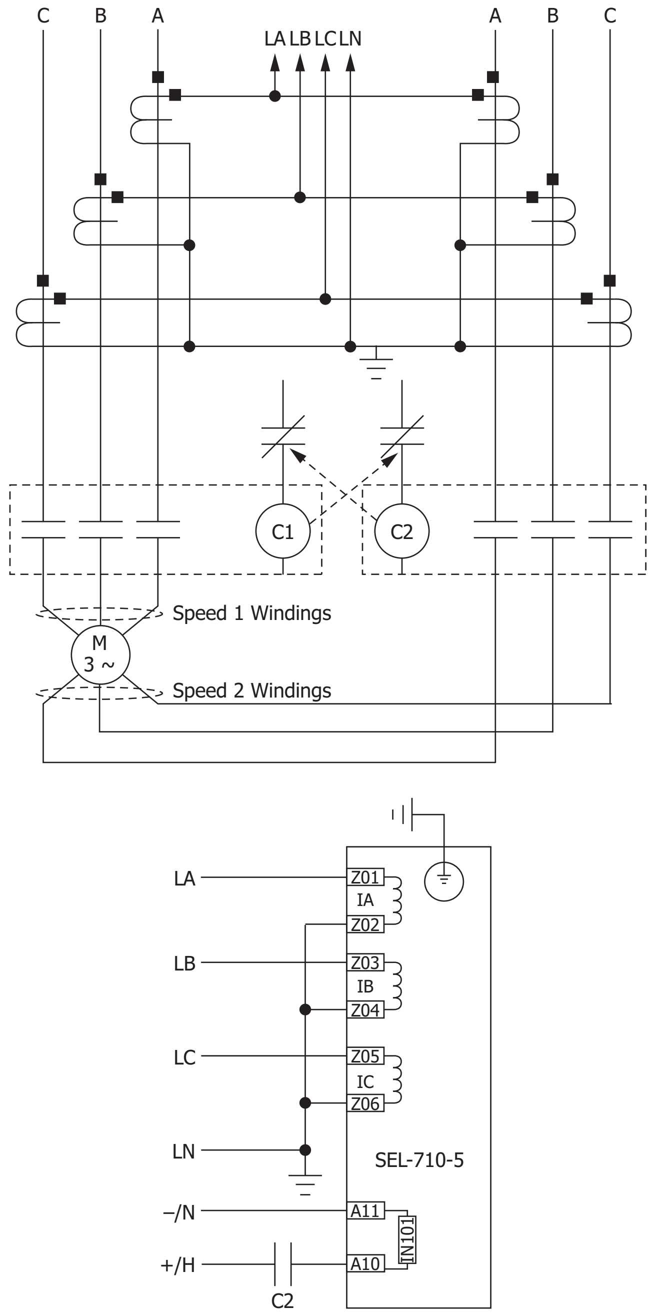


Figure 2.33 AC Connections for Two-Speed Motor—Paralleled CTs

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 2.34* 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

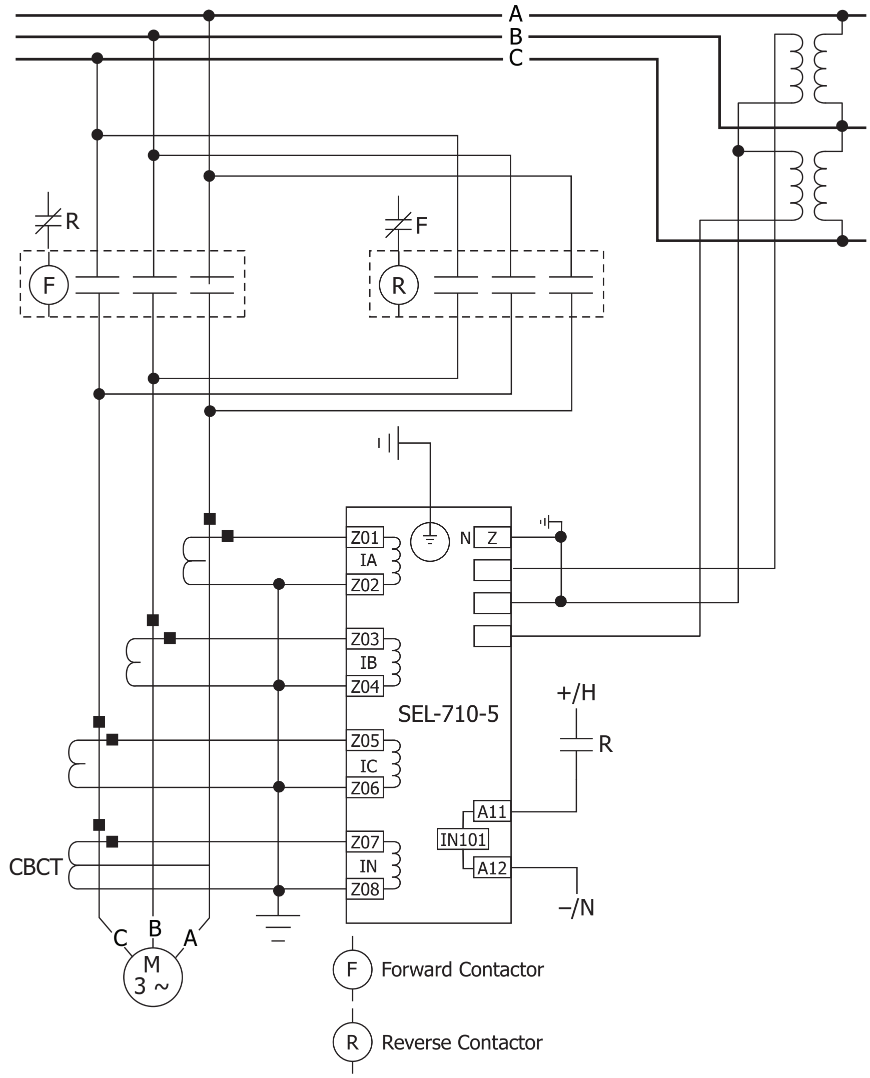


Figure 2.34 AC Connections for Full-Voltage Reversing (FVR) Starter

VFD Motor Application

The implementation in *Figure 2.35* requires the following group settings.

VFDAPP := Y

LOAD_ZS must be set ≤ FLA1. This represents load at zero speed.

Similarly, set FREQ_FL between 10 and 70 Hz. This represents the frequency below which the full load current is derated. Refer to *Configuration Settings on page 4.4* for details.

In a VFD application, the SEL-710-5 uses rms currents (that include harmonics) instead of fundamental frequency currents for the overcurrent and thermal protection (50, 51, and 49 including Motor State Logic) elements. When VFDAPP := Y, the voltage input waveforms may not be reliable for frequency tracking. The SEL-710-5 uses the phase current inputs for tracking until Relay Word bit VFDBYPAS asserts, indicating the VFD is bypassed (e.g., soft-start applications). When voltage inputs are used, they should be from the same side of the VFD as the current inputs (e.g., the motor side for connections shown in *Figure 2.35*). **SEL strongly discourages the use of voltage-based protection, including under- and overvoltage, power factor, underpower, reactive power (27/59, 55, 37, and VAR) elements unless the voltage inputs are substantially sinusoidal.**

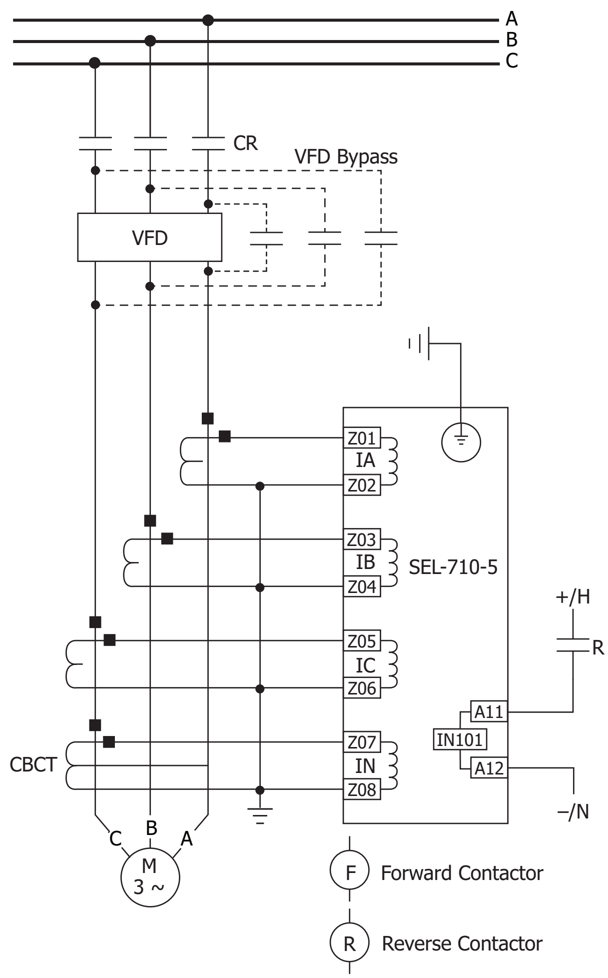
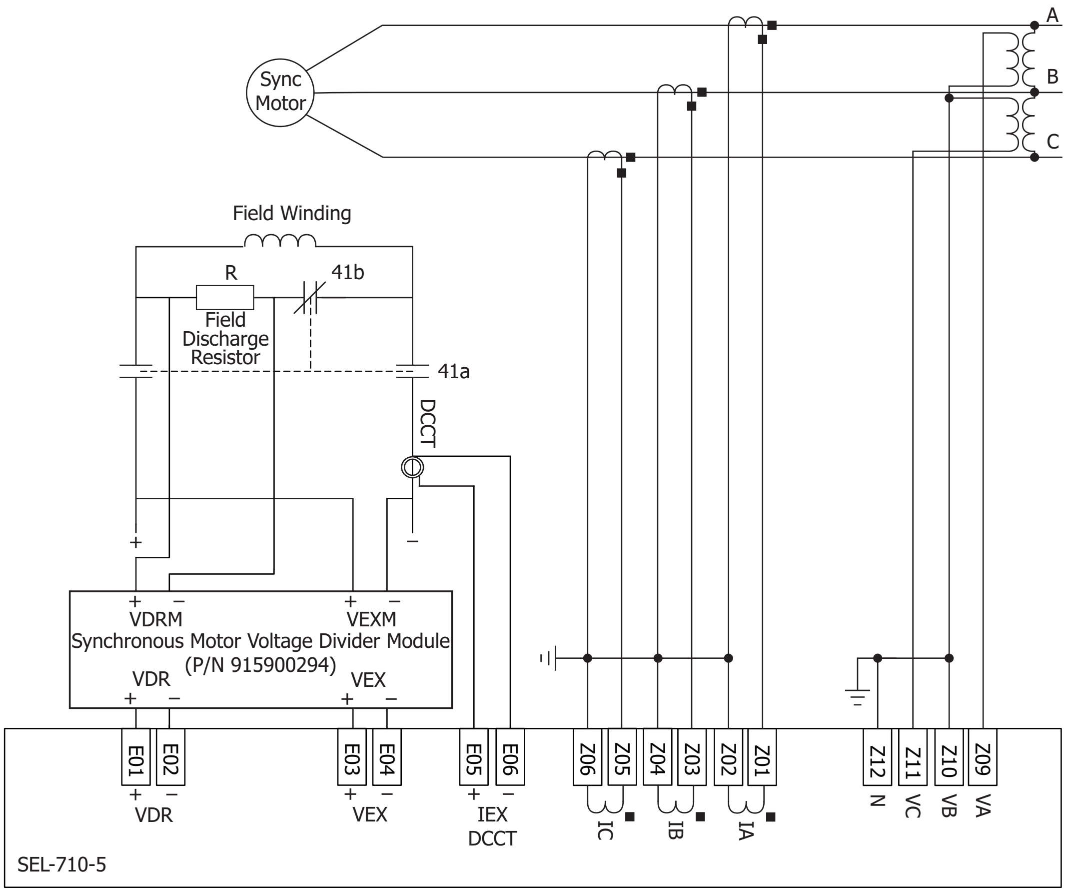


Figure 2.35 AC Connections for a VFD Motor Application

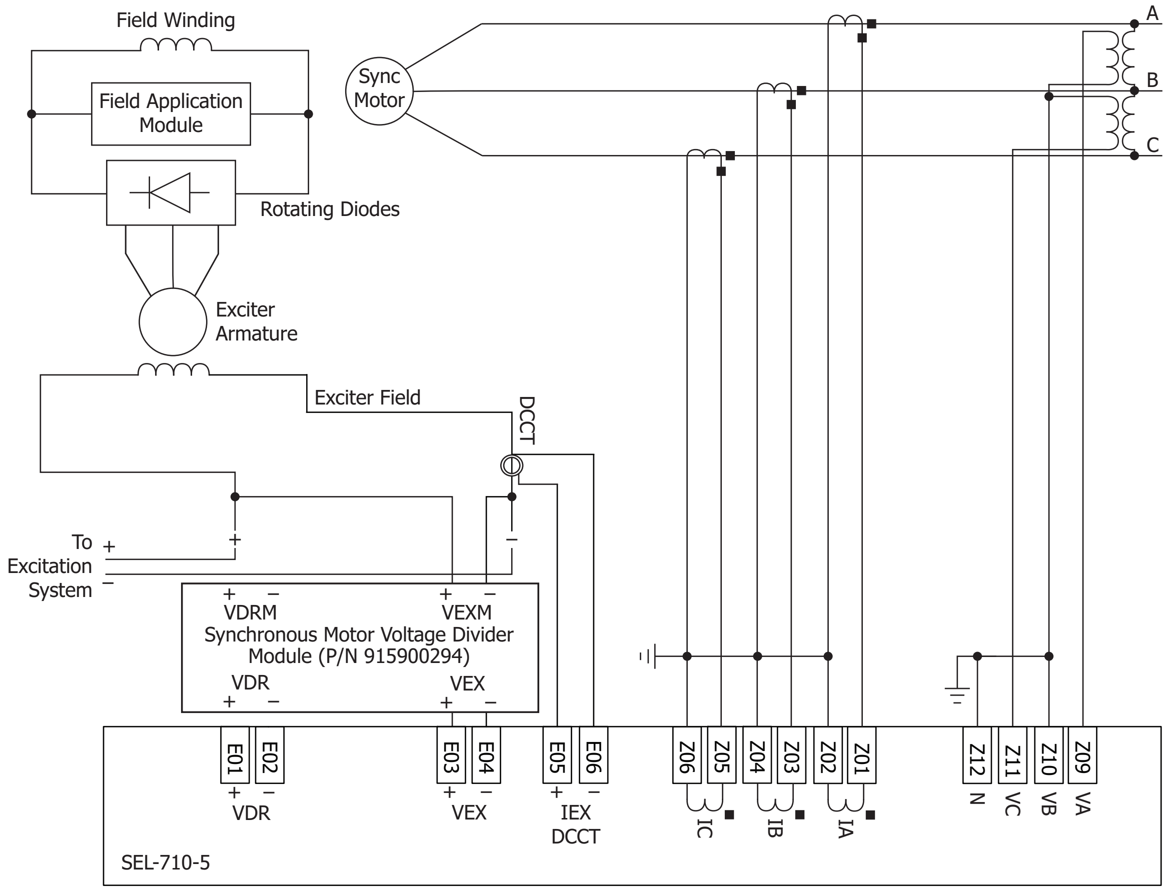
Synchronous Motor Application

The ac/dc connection diagram showing a brush type synchronous motor in *Figure 2.36* requires the group setting, SYNTYPE := BRUSH. Refer to *Synchronous Motor Settings on page 4.79* for more details on synchronous motor applications, including setting of loss-of-field, field resistance, current and voltage elements, out-of-step element, power factor, and reactive power elements.



Slot Z: 4 ACI/3 AVI card
Slot E: SYNCH/3 DIFF ACI card
Note: Differential connections are not shown for SYNCH/3 DIFF ACI card

Figure 2.36 AC/DC Connections for a Brush-Type Synchronous Motor Application



Slot Z: 4 ACI/3 AVI card
Slot E: SYNCH/3 DIFF ACI card
Note: Differential connections are not shown for SYNCH/3 DIFF ACI card

Figure 2.37 AC/DC Connections for a Brushless-Type Synchronous Motor Application

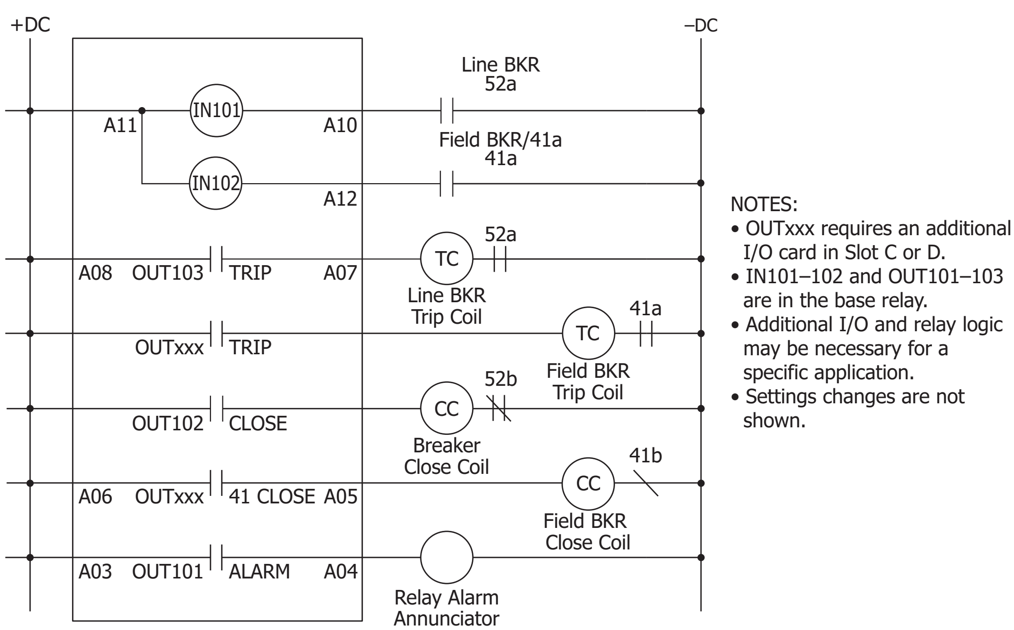


Figure 2.38 DC Control Connection Diagram for the Synchronous Motor Application

Synchronous Motor Voltage Divider Module

⚠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.

NOTE: Connection of any test meter should be limited to the input side of the divider module. This is to avoid inaccuracy in voltage measurements due to high input impedance of the module.

The voltage divider module (VDM) provides attenuation to the VDR and VEX voltages when connected to the relay.

➤ VDR Divider DC Ratio: 5.4

➤ VEX Divider DC Ratio: 2.1

Note that the cable length has a negligible impact on signal accuracy, but can impact noise pickup. To minimize noise coupling, SEL recommends that you place the module near the synchronous motor field winding and use a 14–18 AWG shielded, twisted-pair cable with the shield grounded at the relay cabinet to connect the VDM to the relay.

Charging capacitance on the wiring between the VDM and the relay attenuates the VDR voltage magnitude measurement during the first part of the motor start sequence. The start sequence logic is not affected by this voltage magnitude attenuation.

Motor Connector

Pin	Motor Side Connections
1	VDRM+, Field Discharge Resistor Voltage (Positive)
6	VDRM–, Field Discharge Resistor Voltage (Negative)
11	VEXM+, Exciter Voltage (Positive)
16	VEXM–, Exciter Voltage (Negative)

Use Twisted Pairs on This Side

Relay Connector

Pin	Relay Side Connections
1	VDR+, Field Discharge Resistor Voltage (Positive) to E01
3	VDR–, Field Discharge Resistor Voltage (Negative) to E02
6	VEX+, Exciter Voltage (Positive) to E03
8	VEX–, Exciter Voltage (Negative) to E04

Figure 2.39 Synchronous Motor Voltage Divider Module (SEL P/N 915900294)

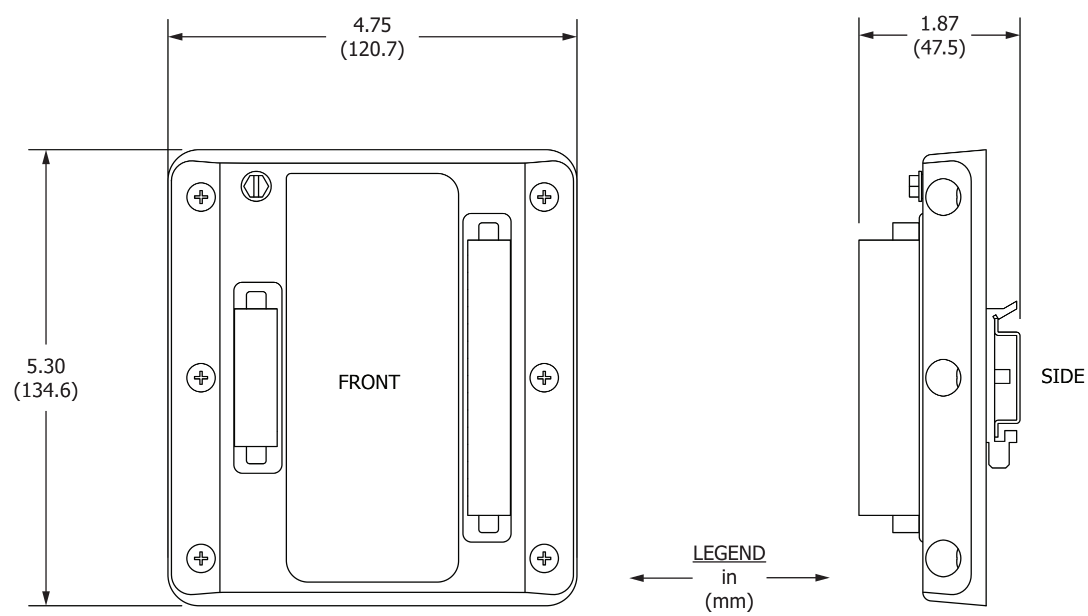


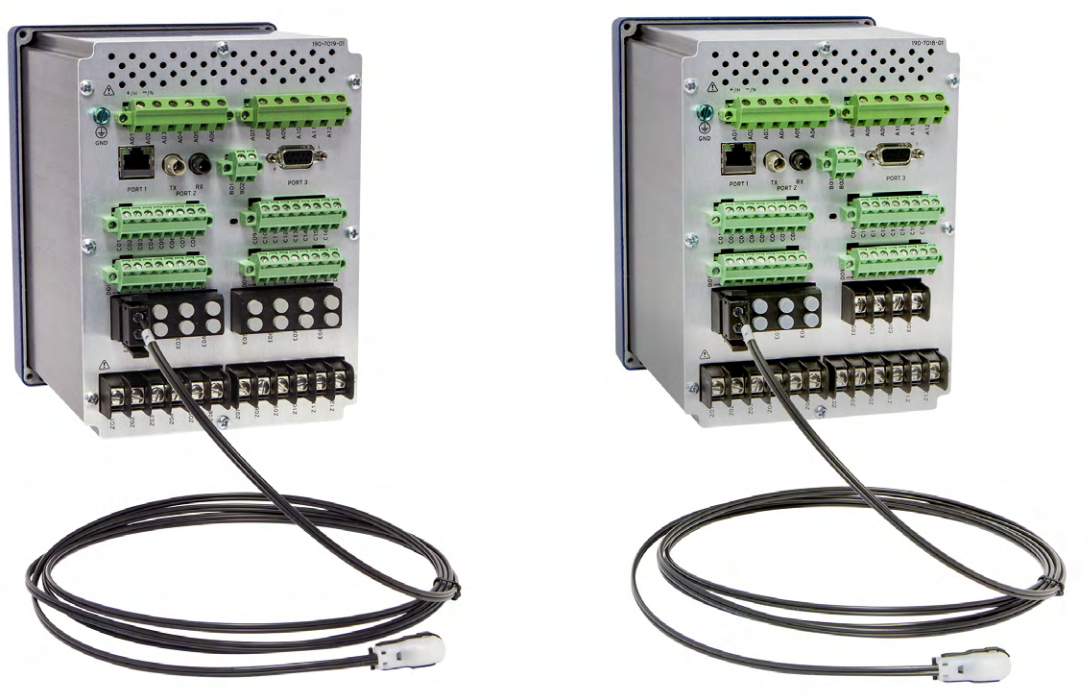
Figure 2.40 DIN-Rail Mounting Dimensions for the Module

Arc-Flash Protection

System Installation

This section describes an arc-flash system installation, the sensor characteristics, and an arc-flash application. Refer to *Section 4: Protection and Logic Functions* for a description of arc-flash protection and the relay settings. *Section 11: Testing and Troubleshooting* gives a description of the commissioning tests to verify the installation. Also refer to SEL application guide *Using the SEL-751 and SEL-751A for Arc-Flash Detection (AG2011-01)* available on the SEL website, for more details.

Figure 2.41 shows main system components comprising: current input card, the arc-flash/differential input card with sensor terminal block, and the fiber-optic-based point-sensor assembly. *Figure 2.13* shows the rear-panel layout and the side-panel I/O designations for a relay model with the 4 AFDI/3 DIFF ACI card for arc-flash protection. *Figure 2.12* shows the rear-panel layout and the side-panel I/0 designations for the relay model with the 8 AFDI card. Installation instructions for 8 AFDI are similar to the 4 AFDI/3 DIFF ACI card.



With 8 AFDI Card in Slot E | With 4 AFDI/3 DIFF ACI Card in Slot E

Figure 2.41 SEL-710-5 With an Arc-Flash Option Card and Fiber-Optic-Based Point-Sensor

Light-Sensor Installation

An arc-flash system installation starts by selecting the best sensor location and the safest path for bringing the sensor fibers back to the relay. The actual sensor location varies depending on the type of switchgear being protected. Although arc-flash light is easily reflected off painted surfaces, make sure to avoid shadows/light obstruction caused by the insulating baffles or moving parts of the breaker truck assembly.

While fiber-optic sensors are inherently nonconductive, they are not intended for direct contact with energized parts, and must be suspended within 25 mm (1 in) of the grounded surface. Make sure to observe the original high-voltage clearance and creepage requirements. Sensors should be permanently affixed using supplied mounting grommets or permanent cable ties. *Figure 2.42* shows an example of a typical jacketed-fiber installation.

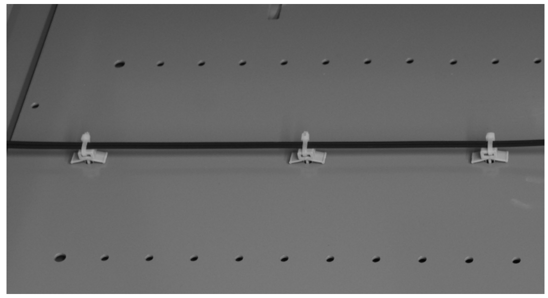


Figure 2.42 Black-Jacketed Fiber installation Example

Fiber-bending radius must be kept above 50 mm (2 in). Care should be exercised when crossing from a moving part (such as control cabinet door) to a stationary switchgear enclosure. Use standard wiring practices with bundled fibers and well-defined strain relief points. Additional attention is required to prevent moving parts, such as a breaker truck assembly, from inadvertently damaging the arc-flash sensor fibers. Although easily detected by the sensor diagnostics, such problems can be eliminated through careful installation planning. Once routed, fiber sensors are connected to the SEL-710-5 relay as shown in *Figure 2.41*.

Point-Sensor Installation

The point sensor is optimized for monitoring confined switchgear spaces where the distance between sensors and the potential sources of arc (energized parts) can be kept below 2 m. Such spaces typically include breaker compartments, outgoing and incoming cable compartments, and potential transformer (PT) compartments. *Figure 2.43* shows a schematic diagram of the point-sensor assembly.

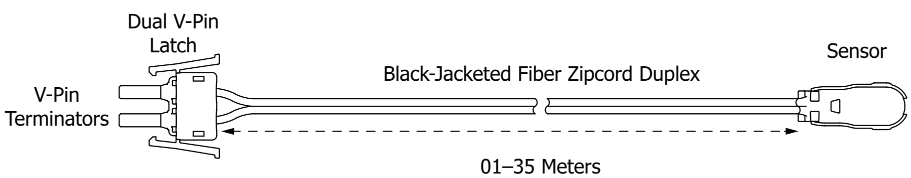


Figure 2.43 Point-Sensor Assembly

There is a standard point sensor or a window point sensor available for the point-sensor assembly.

The standard point sensor is optimized for mounting inside the switchgear compartment. *Figure 2.44* shows the standard point-sensor dimensions.

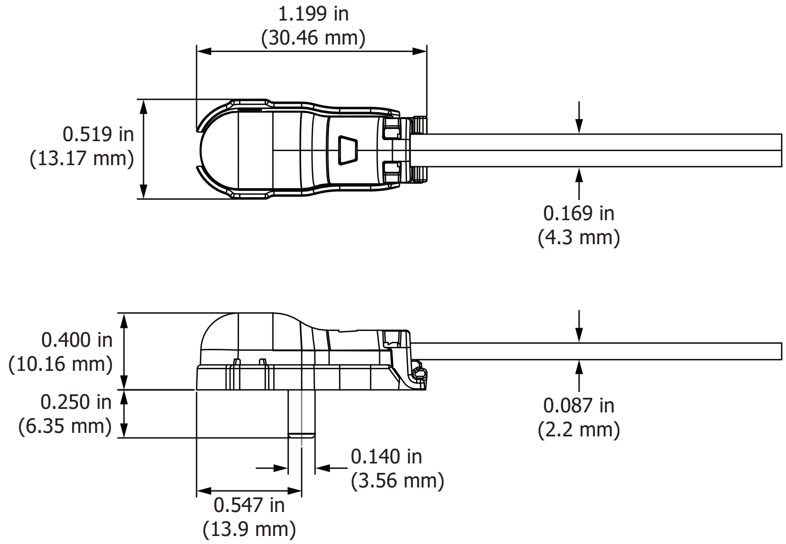
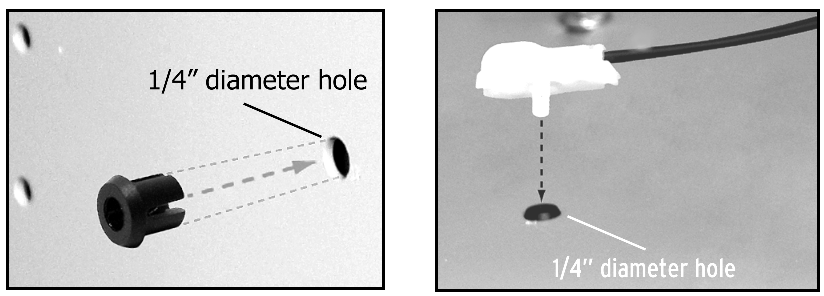


Figure 2.44 Standard Point-Senor Dimensions

The sensor is mounted flush on the switchgear cabinet wall, using a standard 1/4-inch hole. Mounting steps are shown in *Figure 2.45*.



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

Figure 2.45 Standard Point-Sensor Installation

The window point sensor is optimized for mounting outside switchgear, motor control centers, or breaker cabinets to detect an arc flash inside the enclosure. *Figure 2.46* shows the window point-sensor dimensions.

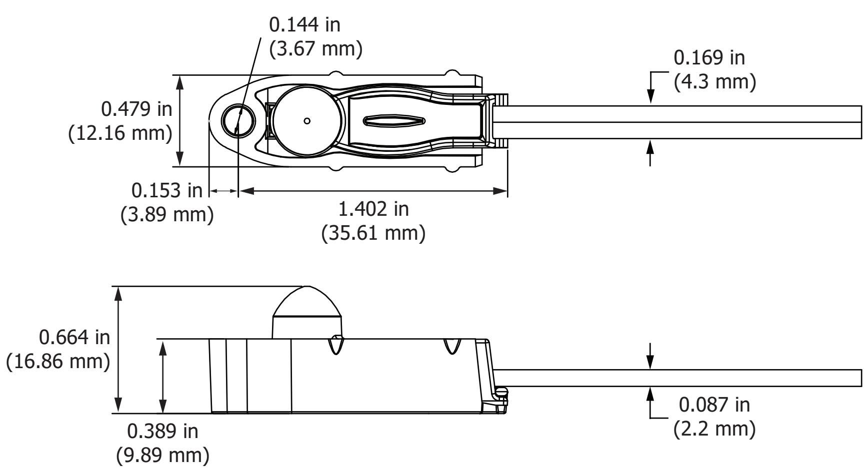


Figure 2.46 Window Point-Sensor Dimensions

The window point sensor requires two holes to be drilled on the enclosure, as shown in *Figure 2.47*. The sensor must be mounted from the outside and secured in the correct position to the switchgear by using the self-tapping screws provided.

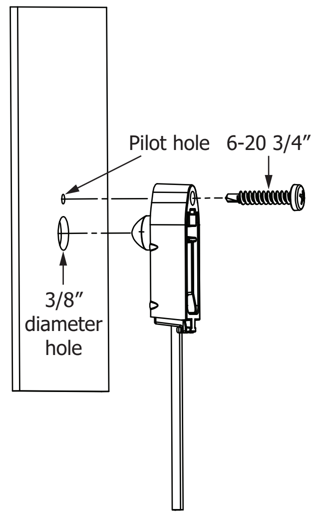


Figure 2.47 Window Point-Sensor Installation

The point sensor is omnidirectional with a slight loss of sensitivity at the fiber entry point. *Figure 2.48*, *Figure 2.49*, and *Figure 2.50* show the sensor directivity pattern. The point sensor must be located in clear view of the energized parts that are most likely to cause an arc-flash event.

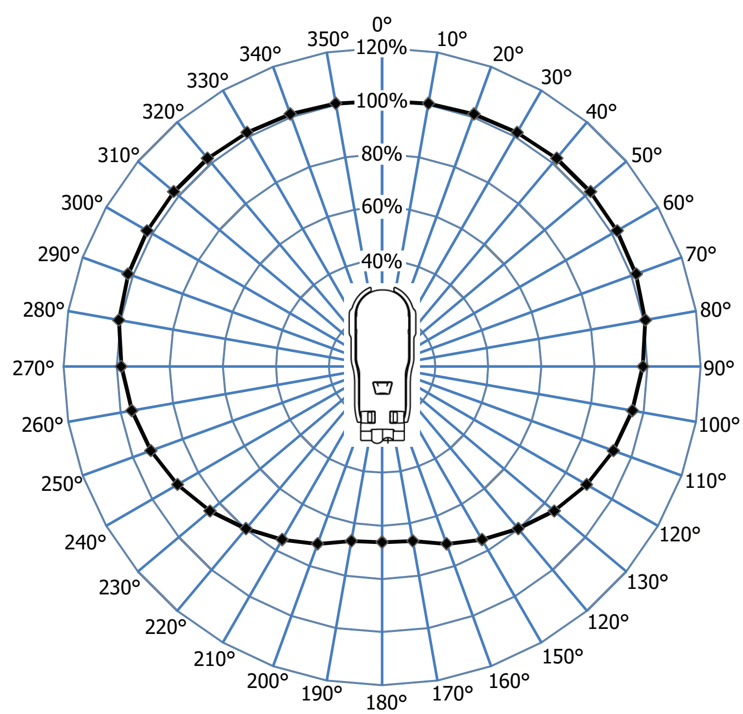


Figure 2.48 Point-Sensor Directivity (0–360° Around the Mounting Plane)

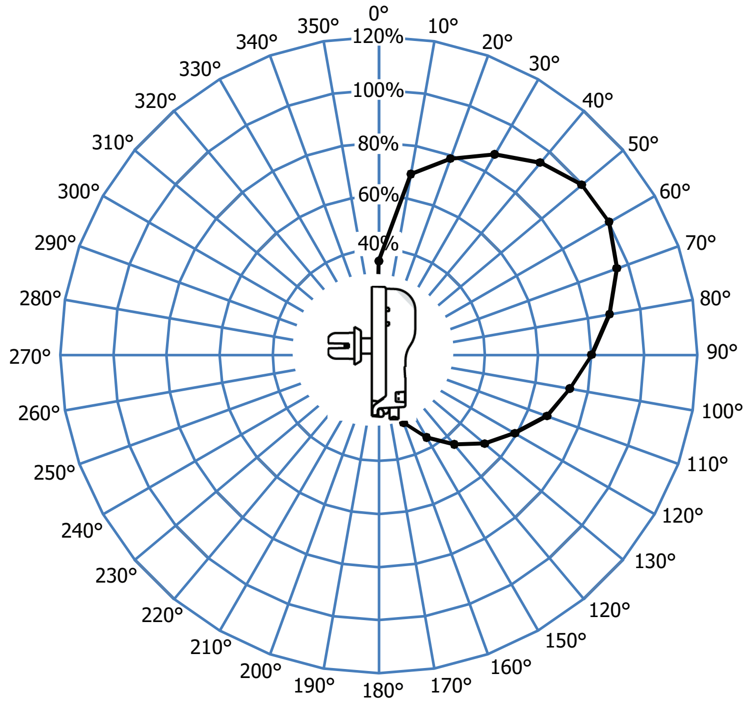


Figure 2.49 Point-Sensor Directivity (Front to Back, Above the Mounting Plane)

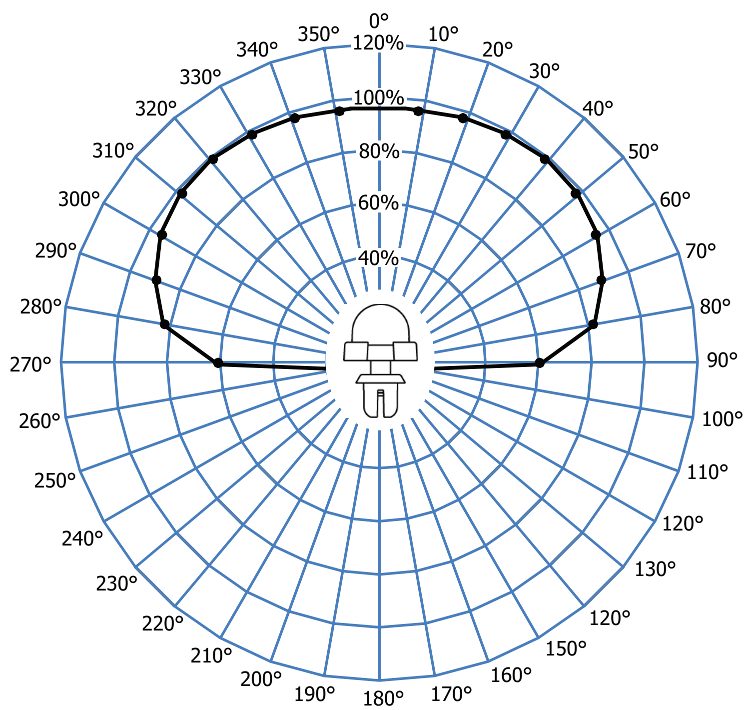


Figure 2.50 Point-Sensor Directivity (Left to Right, Above the Mounting Plane)

Fiber Sensor Installation

The clear-jacketed fiber sensor is optimized for monitoring of large distributed resources, such as switchgear system bus enclosures. The clear-jacketed fiber sensor is omnidirectional and can be mounted in close proximity to the switchgear enclosure walls. *Figure 2.51* shows a schematic diagram of the clear-jacketed fiber sensor. *Figure 2.52* shows a clear-jacketed fiber sensor mounting example photo.

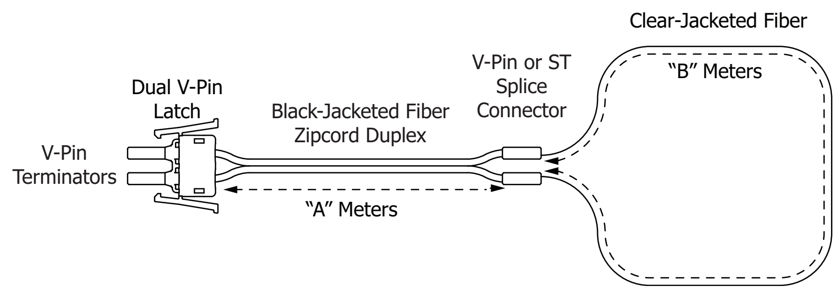


Figure 2.51 Clear-Jacketed Fiber Sensor Assembly

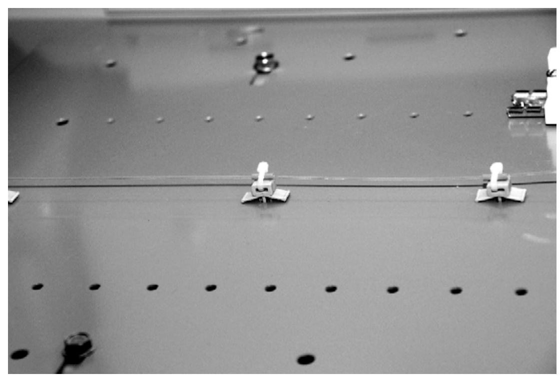


Figure 2.52 Clear-Jacketed Fiber Sensor Mounting Example

A clear-jacketed fiber sensor consists of the major components shown in *Figure 2.53*. Two connector options (V-pin and ST) are available to transition from the black-jacketed to the clear-jacketed fiber section, as shown in *Figure 2.54*. The ST connector option is generally superior because of positive locking.

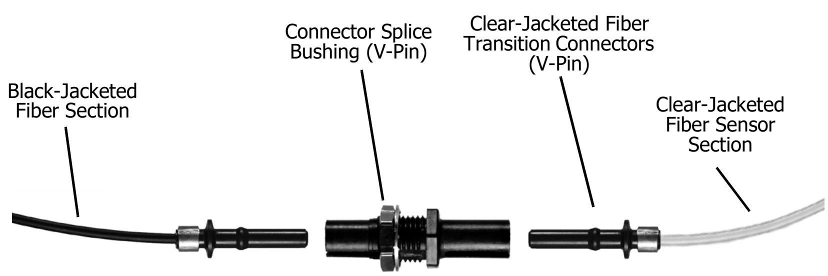
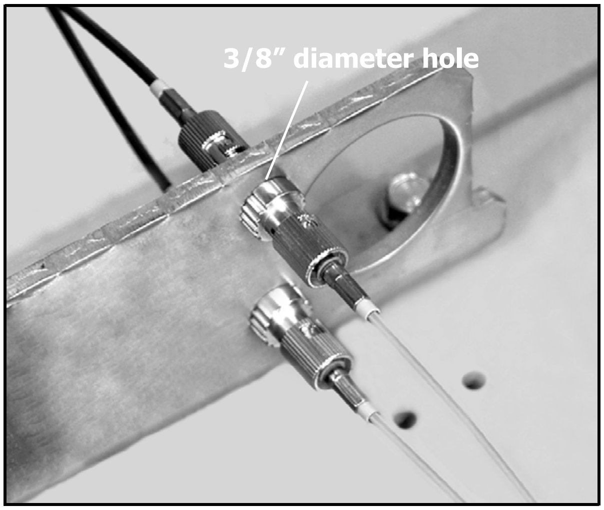
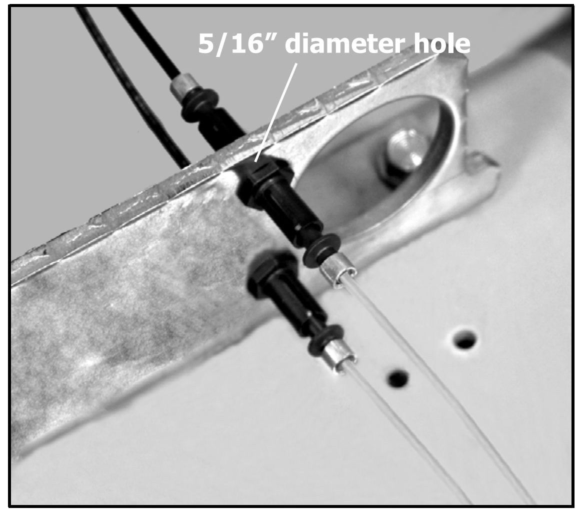


Figure 2.53 Clear-Jacketed Fiber Sensor Components (V-Pin Style)

For correct operation, a clear-jacketed fiber sensor must be located within 2 m of the arcing site, with at least 0.5 m of the fiber sensor exposed to the light. The maximum length of the clear-jacketed fiber sensor is limited to 70 m and includes both, clear-jacketed fiber and black-jacketed fiber sections (the black-jacketed section is counted twice because of its dual-fiber construction). Transition between the two sections is accomplished by using a connector splice as shown in *Figure 2.54*.



ST Connection (3/8″ diameter hole)



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

Figure 2.54 Clear-Jacketed Fiber Sensor Showing Transition From Clear- to Black-Jacketed Fiber Section

The clear-jacketed fiber loop should be returned through the same general area as the forward path, providing dual opportunity to sense the same arc-flash event. This approach ensures that the maximum distance between the relay and the light-producing event remains below 35 m, irrespective of the SEL-710-5 dual V-pin connector orientation.

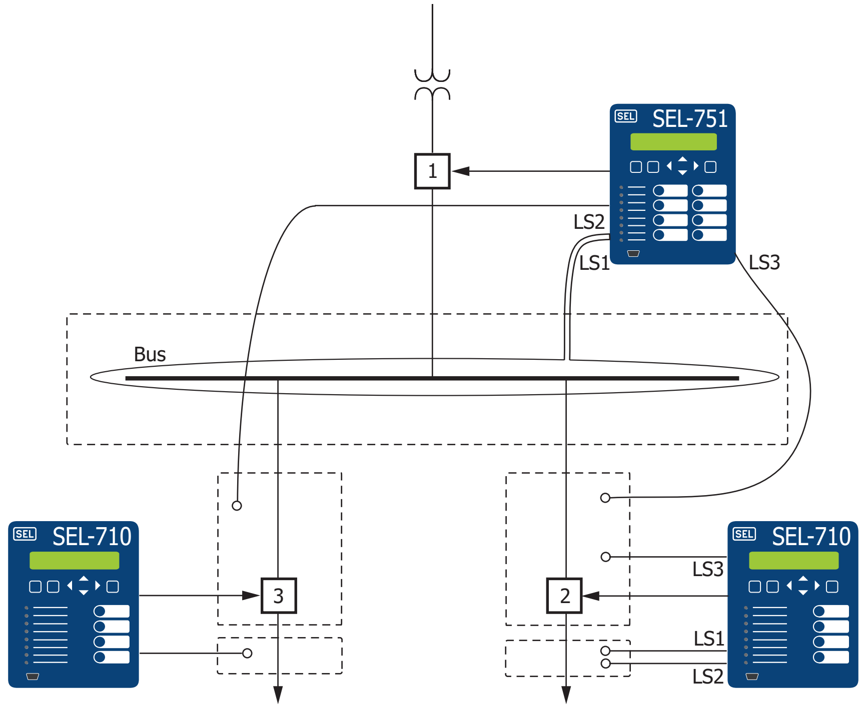
Application Example

Figure 2.55 shows a typical switchgear application example with one incoming and two radial (outgoing) feeders. Breaker 1 is protected by an SEL-751 relay and Breakers 2 and 3 are protected by SEL-710-5 relays. Radial feeder breakers 2 and 3 must be tripped for downstream faults, normally located in the outgoing cable termination compartment. To obtain better coverage, multiple sensors can be installed in the same compartment, as shown in the lower right corner of the figure with sensors marked LS1 and LS2.

⚠CAUTION
Before placing the arc-flash protection system in service, first make sure all the sensors are correctly installed, and then execute the **AFT** command to initiate a self-test.

Bus compartment and the outgoing breaker compartments for breakers 2 and 3 are protected by the incoming feeder breaker 1, with sensors LS1, LS2, and LS3 connected directly to the incoming feeder relay (upper right-hand corner of *Figure 2.55*). Sensor LS1 is implemented as a clear-jacketed fiber loop enclosing entire length of the bus.

When desired radial feeder relays sensors (such as LS3 connected to the lower right-hand relay) can be used to transfer trip the upstream breaker. Logic equations required for this function are shown in *Output Logic Programming* in *Section 4: Protection and Logic Functions*.



LS1—LS4 are arc-flash detection inputs with point or clear-jacketed fiber sensors.

Figure 2.55 Switchgear Application Example

Ordering Arc-Flash Fiber Sensors

Arc-flash fiber sensors can be ordered with or without splices. To configure the standard multimode fiber-optic arc-flash detection point and fiber-loop sensor cable assemblies without additional splice connectors, use the SEL-C804 Multimode Fiber-Optic Arc-Flash Detection (AFD) Sensors Model Option Table (MOT). For multimode fiber optic arc-flash detection sensors with additional splice connectors, refer to the SEL-C814 Arc-Flash Detection (AFD) Fiber Cables and Accessories MOT. The losses and budget values shown in *Table 2.22* are typical values. See *Table 2.23* for SEL-C804 and SEL-C814 arc-flash detection cable specifications.

NOTE: Jacketed fiber in a zipcord duplex configuration includes two fiber lengths. Loss calculations must account for the total length of the fiber. This is accounted for in the examples as a "x 2" multiplier.

Table 2.22 Optical Budget Calculations

Link Budget[a]		**Loss Data**[b]	
Bare-Fiber Sensor	17 dB	ST connector splice	2 dB
Point Sensor	12.25 dB	V-Pin connector splice	2 dB
		Bare-fiber	0.175 dB/m
		Jacketed fiber	0.175 dB/m

[a] Link budget is calculated after allowing for the losses of the dual V-pin latch. When using a point sensor it allows for the sensor loss as well.
[b] Link losses are calculated by adding up the fiber loss and the splice connector losses. The link losses should be less than the link budget.

Table 2.23 SEL-C804 and SEL-C814 Arc-Flash Detection Cable Specifications

Specifications	Cable	
	Black Jacket, Zipcord	Clear Jacket, Simplex
Operating Temperature	–40 to +85°C	–55 to +85°C
Core Material	PMMA	PMMA
Cladding Material	Fluorinated Polymer	Fluorinated Polymer
Core Diameter	980 µm	980 µm
Cladding Diameter	1000 µm	1000 µm
Jacket Material	PVC	Polyethylene
Outer Cable Diameter	2.2 mm x 4.3 mm (0.087 in x 0.17 in)	2.20 mm (0.087 in)
Weight/Unit Length	11 g/m (0.008 lb/ft)	4 g/m (0.003 lb/ft)
Maximum Cable Pull Tension	140 N (9.6 lb/ft)	70 N (4.8 lb/ft)
Maximum Connector Pull Tension	43.8 N (3 lb/ft)	43.8 N (3 lb/ft)
Minimum Bend Radius	25 mm (0.98 in)	25 mm (0.98 in)
Attenuation (Loss)	.175 dB/m	.175 dB/m

Link Optical Loss Calculation Examples

This example shows a bare-fiber sensor with two V-Pin or ST connectors and an **A** dimension of 15 meters and a **B** dimension of 40 meters. Two connectors is the standard configuration, as shown in *Figure 2.56*.

Link Budget	17 dB
– (2 dB x # of connector splices)	–4 dB
– (0.175 dB/m x **A** dimension x 2)	–5.25 dB
– (0.175 dB/m x **B** dimension)	–7 dB
Total Link Losses =	–16.25 dB

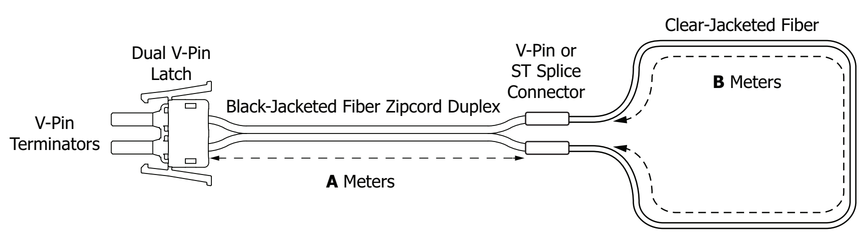


Figure 2.56 Bare-Fiber Sensor Assembly With Two Splices

This example shows a point sensor with an **A** dimension of 30 m, as shown in *Figure 2.57*.

Link Budget	12.25 dB

– (0.175 dB/m x **A** dimension x 2)	–10.5 dB
Total Link Losses =	–10.5 dB

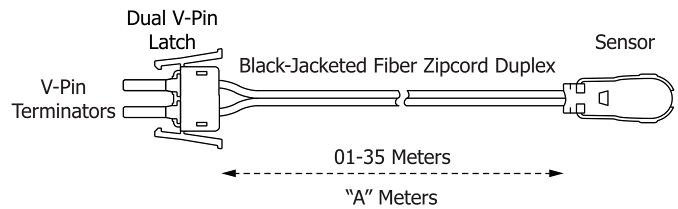


Figure 2.57 Point Sensor Assembly

Splice connectors can be added for the arc-flash fiber sensors to meet the shipping needs for large switchgears that require multiple splits for transportation. For multimode fiber-optic arc-flash detection sensors with additional splice connectors, refer to the SEL-C814 Arc-Flash Detection (AFD) Fiber Cables and Accessories MOT.

Ordering Examples Using the SEL-C814 Model Option Table

This example of a bare-fiber sensor with four ST connectors and an **A** dimension of 15 meters, as shown in *Figure 2.58*, shows the part numbers generated using an SEL-C814 MOT and the link optical loss calculations. Two connectors is the standard configuration.

Link Budget	17 dB
– (2 dB x # of connector splices)	–8 dB
– (0.175 dB x **A** dimension x 2)	–5.25 dB
Link Losses = available for **B** meters	3.75 dB
÷ (0.175 dB/m)	21.42 meters maximum **B** dimension

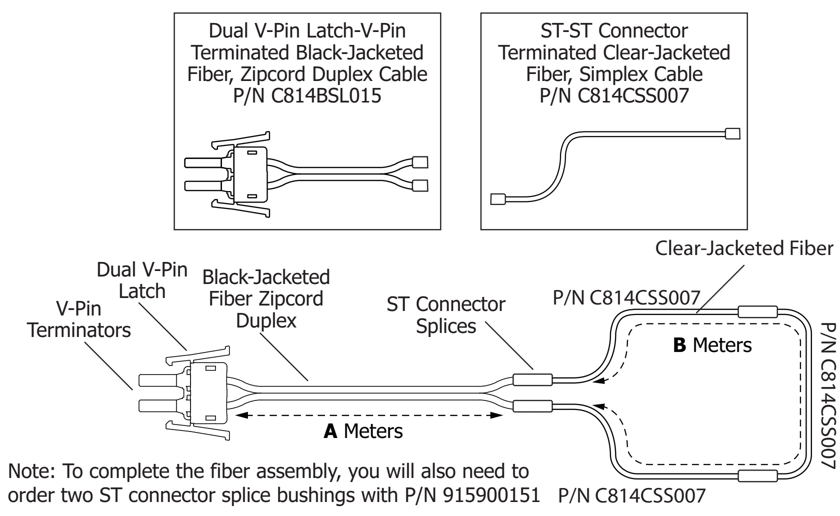
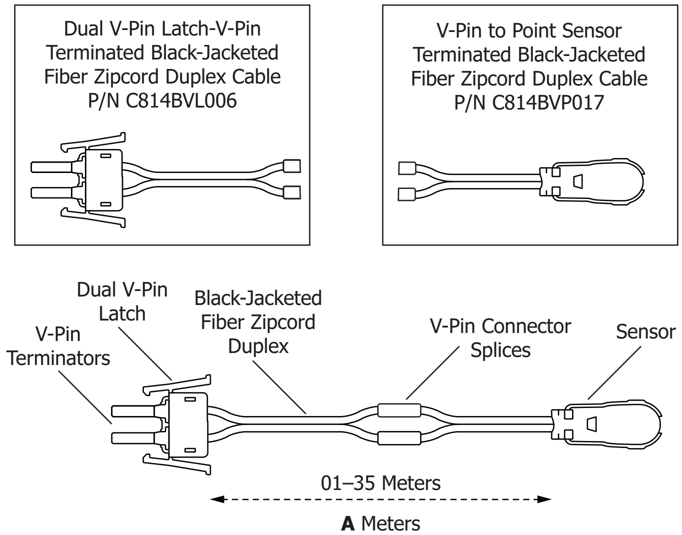


Figure 2.58 Bare-Fiber Sensor Assembly With Two Additional ST Splice Connectors

This example of a point sensor with two V-pin connectors, as shown in *Figure 2.59*, shows the part numbers generated using an SEL-C814 MOT and the link optical loss calculations.

Link Budget	12.25 dB
– (2 dB x # of connector splices)	–4 dB
Link Losses = available for **A** meters	8.25 dB
÷ (2 x 0.175 dB/m)	23.6 meters maximum **A** dimension



Note: To complete the fiber assembly, you will also need to order two ST connector splice bushings with P/N 915900148.

Figure 2.59 Point Sensor Assembly With Two V-Pin Splice Connectors

Field Serviceability

⚠CAUTION

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

The SEL-710-5 firmware can be upgraded in the field; refer to *Appendix B: Firmware Upgrade Instructions* for firmware upgrade instructions. You can know when a self-test failure has occurred by configuring an output contact to create a diagnostic alarm as explained in *Section 4: Protection and Logic Functions*. By using the metering functions, you know if the analog front-end (not monitored by relay self-test) is functional. Refer to *Section 11: Testing and Troubleshooting* for detailed testing and troubleshooting information.

The only two components that can be replaced in the field are the power supply fuse and the real-time clock battery. A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery is a 3 V lithium coin cell, Rayovac BR2330A or equivalent. At room temperature (25°C), the battery operates nominally for 10 years at rated load. When the relay is powered from an external source, the battery experiences a low self-discharge rate. Thus, battery life can extend well beyond 10 years. The battery cannot be recharged.

Fuse Replacement

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

Step 1. De-energize the relay.

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

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

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

Step 4. 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. BR2330A or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device can 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 eight 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.

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Section 3
PC Interface

Overview

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

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

The SEL-710-5 Relay is able to communicate with your computer in three different ways.

- The web server requires a web browser (Microsoft Internet Explorer, Mozilla FireFox, Google Chrome, etc.) and an Ethernet cable. The relay must have the Ethernet port option. See *Web Server* for functional details and capabilities.
- The SEL software solution requires downloading QuickSet (via Compass) to your computer. Communication to the relay is accomplished through a serial or Ethernet port. Refer to *QuickSet Software* for functional details and capabilities.
- The ASCII command line requires PC-based terminal emulation software (HyperTerminal, Tera Term, etc.), a serial or Ethernet port, and a serial or Ethernet cable to connect to the relay. Refer to *Section 7: Communications* for details on ASCII commands and functions supported.

Web Server

Connection and Login to Web Server

The web server provides a graphical user interface for the relay without loading any software on your PC. The user interface is contained in the relay firmware. To connect to the web server of the SEL-710-5, the relay and your PC must be connected to the same Ethernet network. The network can be of any size, from a company-wide network to a direct-connect from your PC to the relay. The connection from the relay is through the Ethernet port of the relay (Port 1). To start communicating with the relay, you must enter a valid IP address (SET P 1 IPADDR) and valid default router (SET P 1 DEFRTR) via the serial port of the relay. Be sure to obtain the IP address and default router from your IT resource to avoid network conflicts with duplicate IP addresses.

The SEL-710-5 comes pre-loaded with settings that enable you to communicate with the relay over a simple network. The network consists of connecting the SEL-710-5 (via Port 1) directly to the Ethernet port of your computer. Connect to Ethernet Port 1 of the relay by using a standard RJ45 connector for the copper port and an LC connector for the fiber-optic port. This connection requires that the computer not be connected to any other network (see *Figure 3.1*).

NOTE: For relays with the fiber-optic Ethernet ports, use a commercially available 100BASE-FX to 100BASE-TX media converter to interface with a PC RJ45 port. Use SEL-C808 62.5/125 µm Multimode Fiber-Optic Cable to connect to Port 1 on the relay.

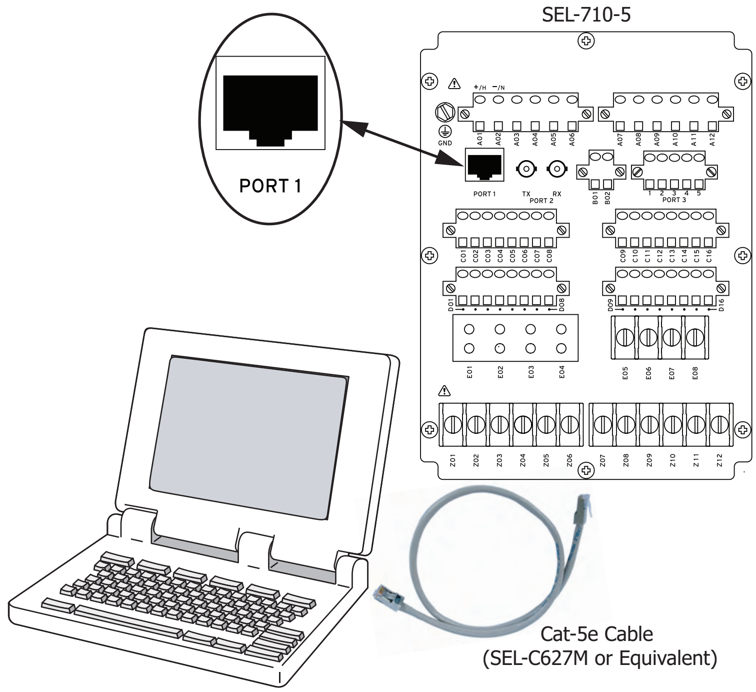

Figure 3.1 Direct Connection of SEL-710-5 to a Computer

The default IP address is 192.168.1.2 and the default router is 192.168.1.1. Once the network is configured, as shown in *Figure 3.1*, you can connect to the web server in the relay by entering 192.168.1.2 in the address bar of your web browser (as shown in *Figure 3.2*).

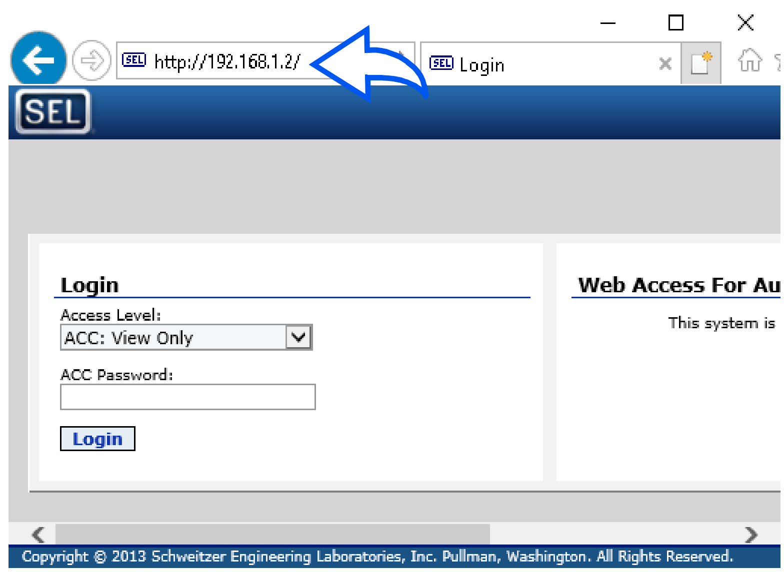

Figure 3.2 Login Page of Web Server for SEL-710-5

The Login page of the web server allows you to access either the ACC or 2AC level. The menu item you select under Access Level determines the access level at which you enter the web server (see *Figure 3.3*). For factory-default passwords, refer to *Table 7.44: Factory-Default Passwords for Access Levels 1, 2, and C*. **Meter**, **Reports**, **Communications**, **Relay Status**, and **Settings (Show Only)** require Access Level 1 or 2. **Systems/File Management** requires Access Level 2.

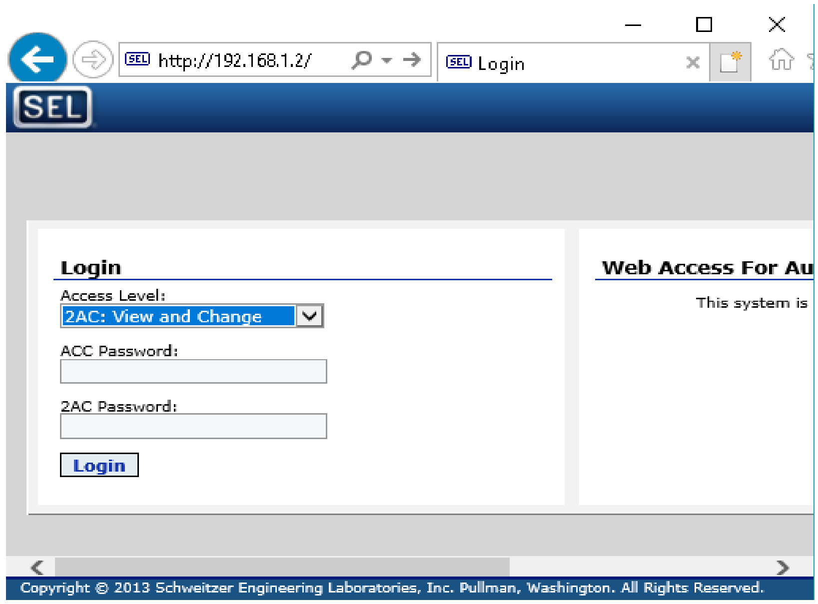

Figure 3.3 Selecting Access Level 2 From Web Server Login

Meter

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

The web server offers a convenient method for displaying all metering reports stored in the relay. Located on the navigation pane, the **Meter** menu contains categories for each of the meter reports. When you select a category from the **Meter** menu, its corresponding meter report is displayed (see *Figure 3.4*).

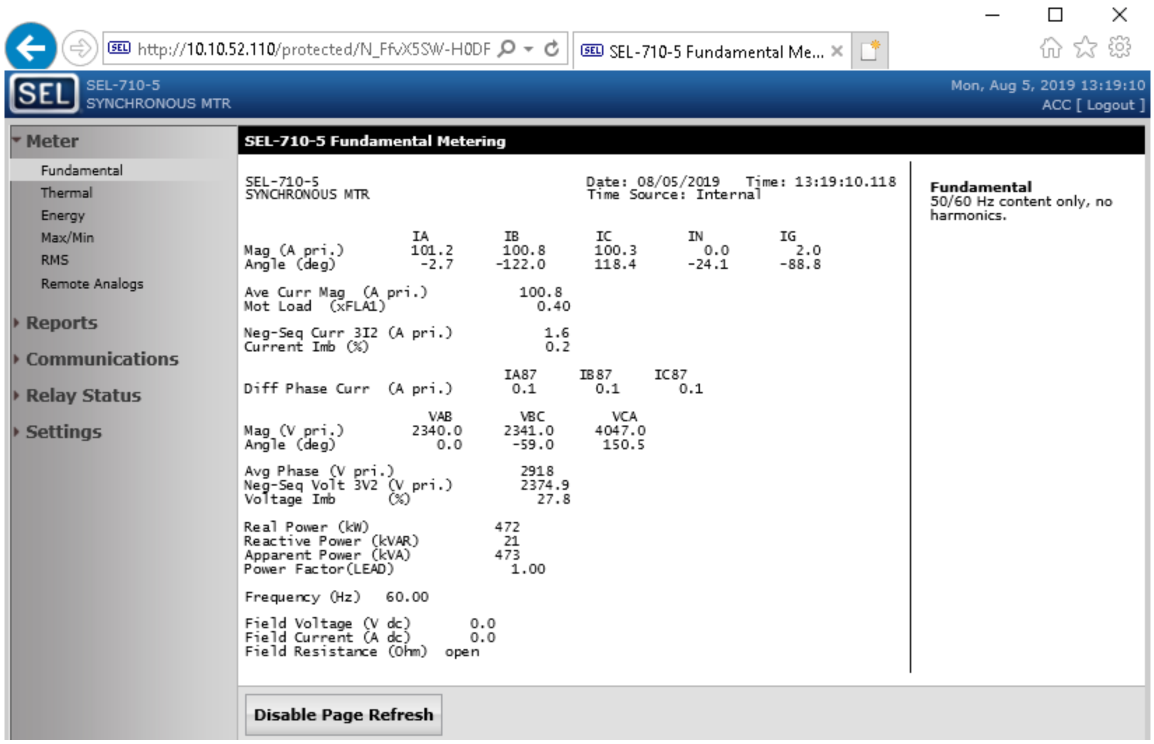

Figure 3.4 Fundamental Meter Report

Reports

In addition to metering data, the SEL-710-5 collects and stores a variety of data and statistics from the power system. These data are stored and reported through a series of reports. Located on the navigation pane, the **Report** menu contains categories for each of the reports stored in the relay (Event Reports, Sequential Events Recorder, Load Profile, etc.). When you select a category from the **Reports** menu, its corresponding report is displayed.

Event Reports

Event reports stored in the SEL-710-5 can be exported in three different formats (Binary COMTRADE, Raw CEV, or Filtered CEV format). When you select **Event Reports**, a list of all the event reports presently stored in the relay is shown (see *Figure 3.5*).

After selecting the event format to be used, select the event report to export by clicking on the event you need. When prompted, you can then open or save the event.

In addition to allowing you to retrieve events, the **Event Reports** page allows you to clear all events stored in the relay or to trigger events. Clear Event Report History erases the events from the nonvolatile memory of the relay. Trigger Event Report commands the relay to do an event capture of the present voltages and currents detected by the relay (see *Figure 3.5*).

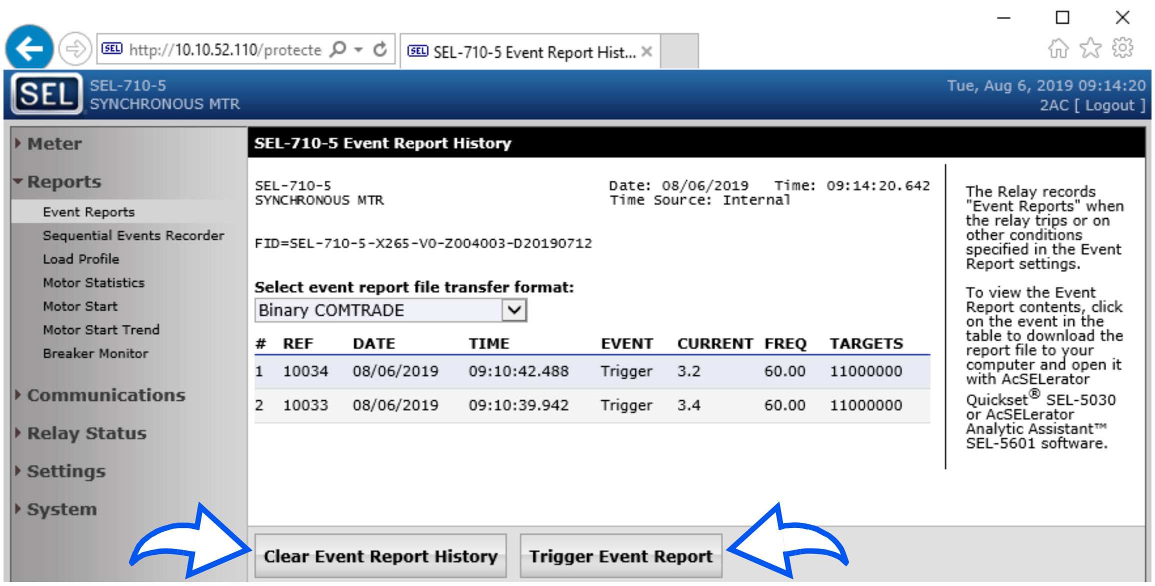

Figure 3.5 Event Report Webpage

Sequential Events Recorder

In addition to event reports, the SEL-710-5 collects and stores time-stamped data for assertion and deassertion of Relay Word bits. These data are captured in the Sequential Events Recorder (SER) and can be exported through the web server.

When you select **Sequential Events Recorder**, a list of all SER reports presently stored in the relay displays (see *Figure 3.6*). SER reports stored in the SEL-710-5 can be downloaded or cleared by clicking the appropriate button at the bottom of the webpage.

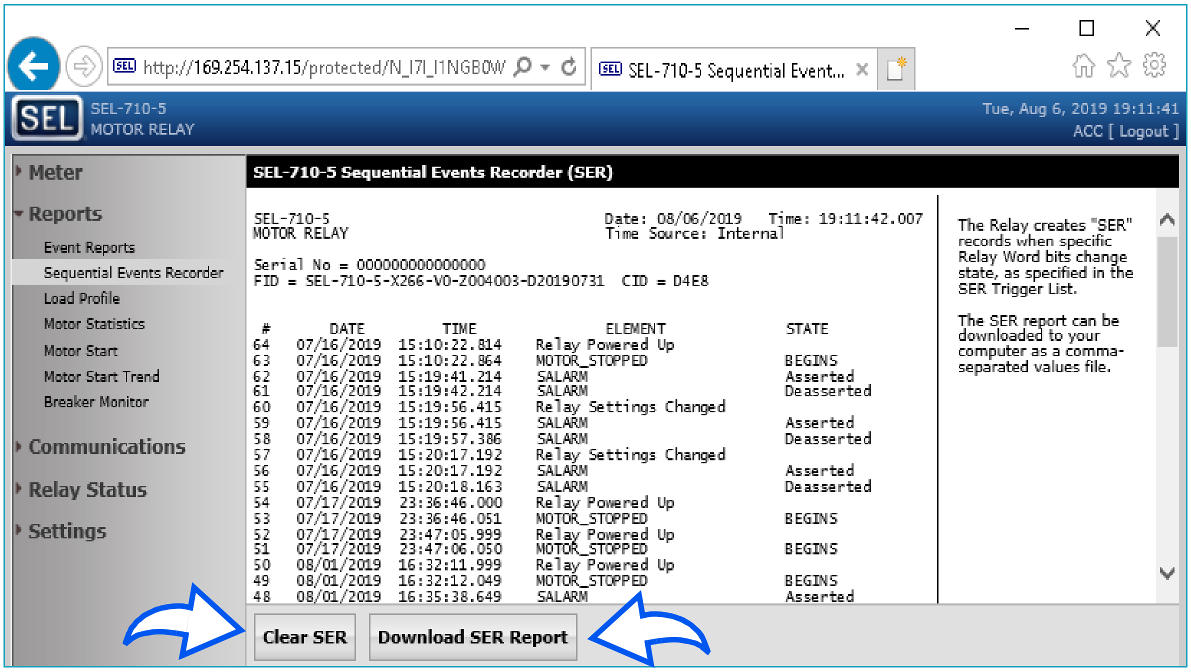

Figure 3.6 Sequential Events Recorder Report

Load Profile

The SEL-710-5 collects and stores time-stamped data of analog quantities. These data are reported in the load profile report.

When you select the **Load Profile** menu item, a list of all the load profile reports presently stored in the relay displays (see *Figure 3.7*). You can use the two buttons at the bottom of the display window to export or clear the load profile reports stored in the SEL-710-5.

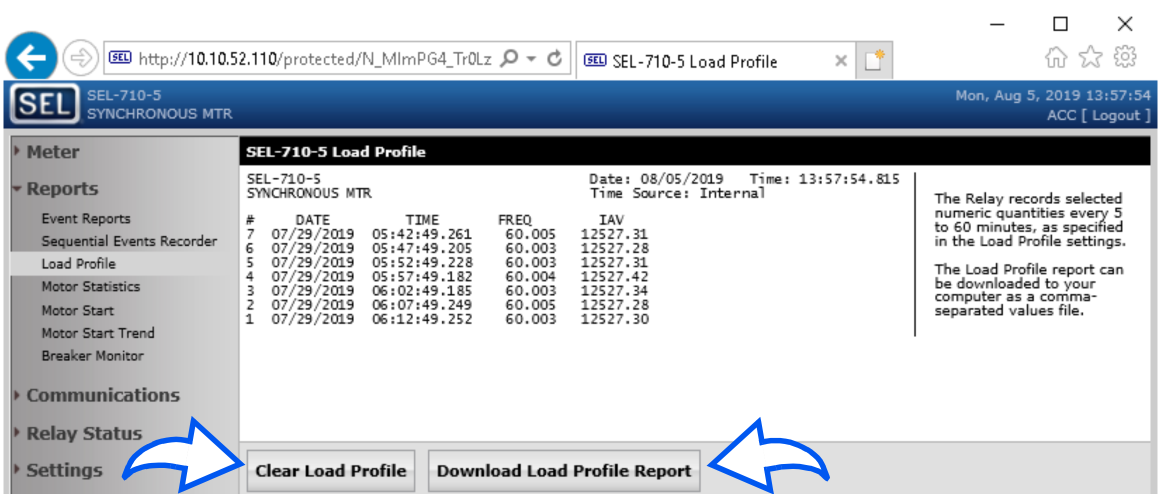

Figure 3.7 Load Profile Webpage

Motor Statistics

The SEL-710-5 collects and stores statistics of the motor service. These data are reported in the Motor Statistics report.

When you select **Motor Statistics**, all the motor operating statistics reports presently stored in the relay display (see *Figure 3.8*). Motor operating statistics reports stored in the SEL-710-5 can be cleared using the **Clear Motor Operating Statistics** button at the bottom of the screen. This webpage is updated automatically. The automatic update can be disabled by clicking **Disable Page Refresh** at the bottom of the screen.

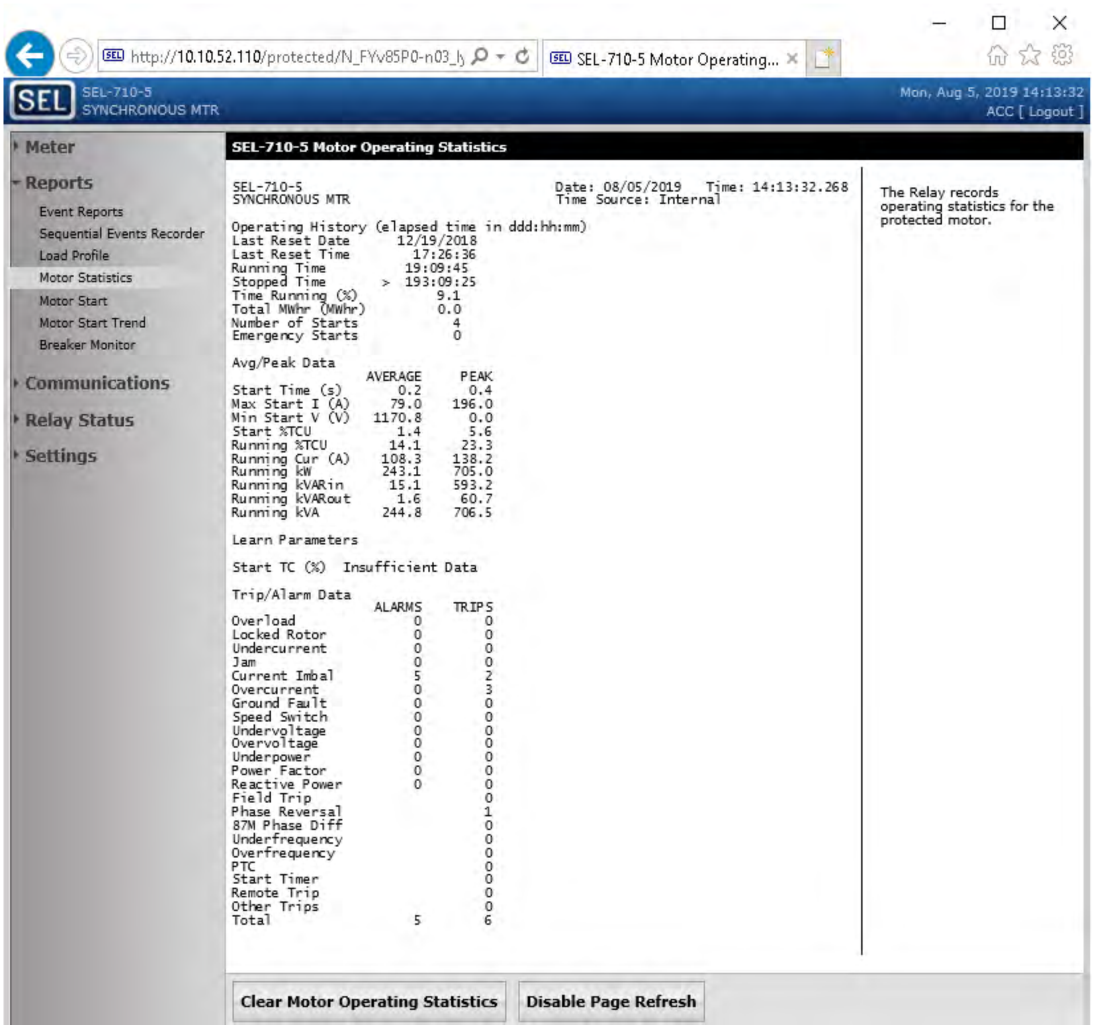

Figure 3.8 Motor Operating Statistics Webpage

Motor Start

The SEL-710-5 collects and stores statistics about each start of the motor. These data are reported in separate Motor Start reports.

When you select **Motor Start**, the Motor Start reports presently stored in the relay display (see *Figure 3.9*). Click on the report to download it to your computer and open the report with the Motor Start report viewer in QuickSet.

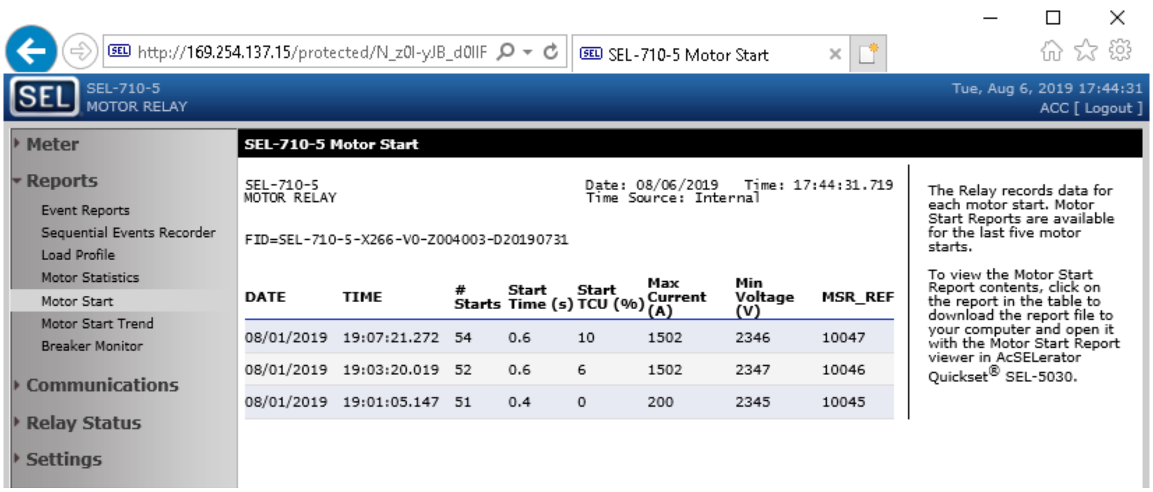

Figure 3.9 Motor Start Report Webpage

Motor Start Trend

The SEL-710-5 collects and stores statistics of each start over an 18-month period. These data are reported in the Motor Start Trend report.

When you select **Motor Start Trend**, the Motor Start Trend report presently stored in the relay displays (see *Figure 3.10*). The Motor Start Trend report stored in the SEL-710-5 can be either cleared or downloaded with the buttons at the bottom of the screen.

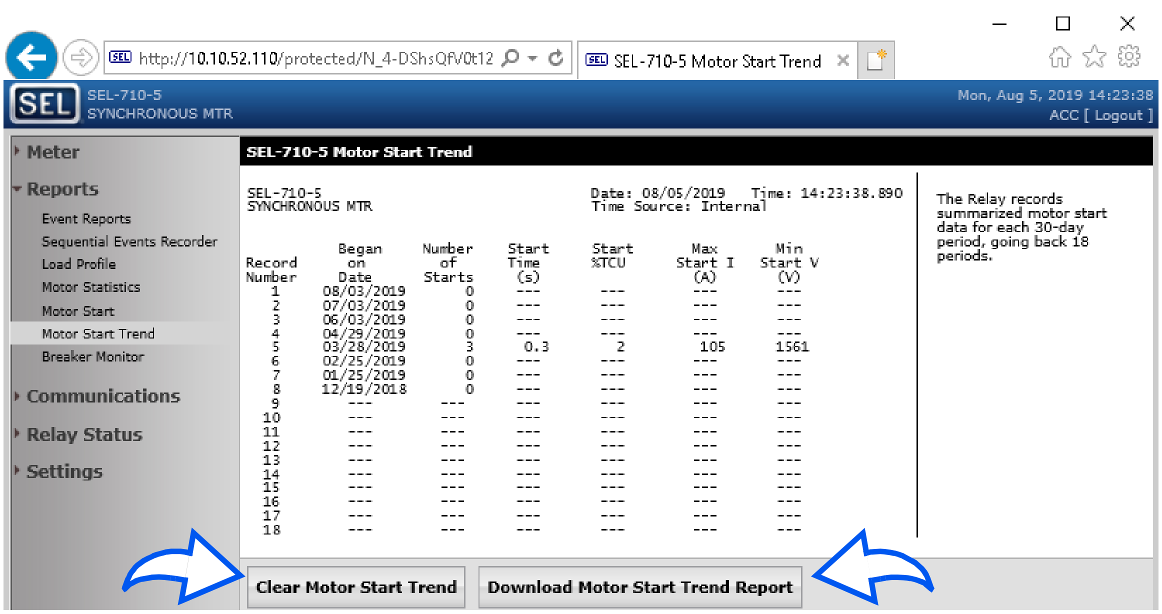

Figure 3.10 Motor Start Trend

Breaker Monitor Report

The breaker monitor in the SEL-710-5 helps in scheduling circuit breaker maintenance (see *Breaker Monitoring on page 5.24*). When you select **Breaker Monitor Report**, the breaker monitor report presently stored in the relay displays (see *Figure 3.11*). The breaker monitor report stored in the SEL-710-5 can be downloaded with the Download Breaker Monitor Report button.

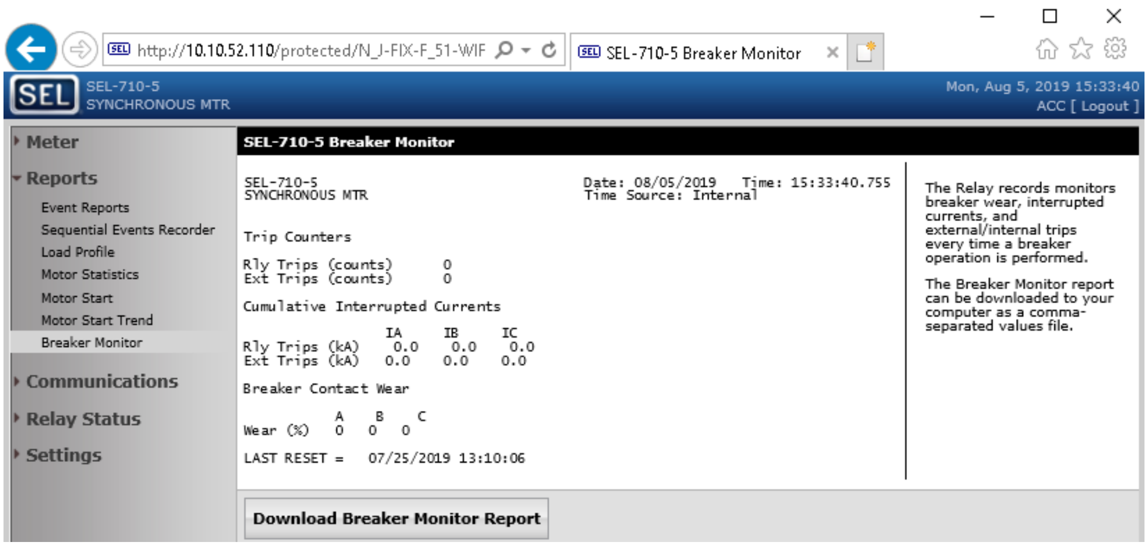

Figure 3.11 Breaker Monitor Report

Communications

You can view the Ethernet port configuration details including the MAC address of the relay by clicking **Communications > Ethernet** (see *Figure 3.12*). Use the Clear Ethernet Statistics button to clear PACKETS, BYTES, and ERRORS data. Refer to *Section 7: Communications* for further details on the Ethernet command.

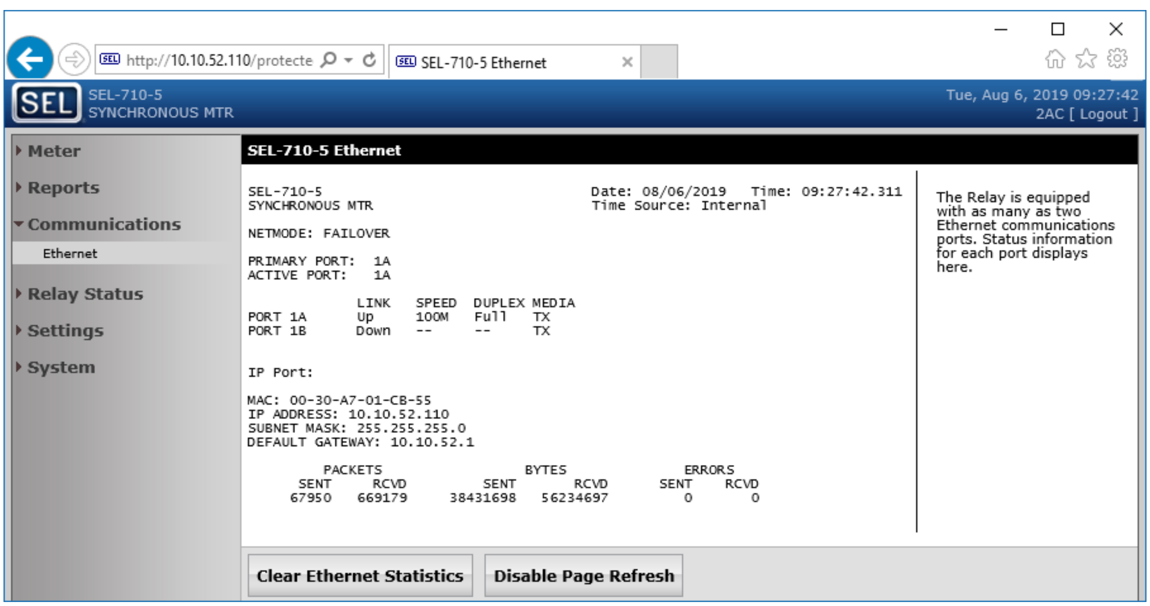

Figure 3.12 MAC Address

Relay Status

The **Relay Status** menu lists the status report pages available through the web server (Self-Tests, Relay Word Bits, and SELOGIC Counters). When you select a status report from the **Relay Status** menu, the corresponding status report displays.

Self-Tests

The SEL-710-5 has continual diagnostics that verify the status of the relay hardware. The results of these diagnostics can be viewed by selecting **Relay Status** > **Self-Tests** in the navigation pane. **Relay Status** contains categories for each of the status pages in the web server (Self-Tests, Relay Word Bits, and SELOGIC Counters).

When you select **Relay Status** > **Self-Tests**, the status of the relay, including the serial number, part number, and self-tests results, is displayed (see *Figure 3.13*).

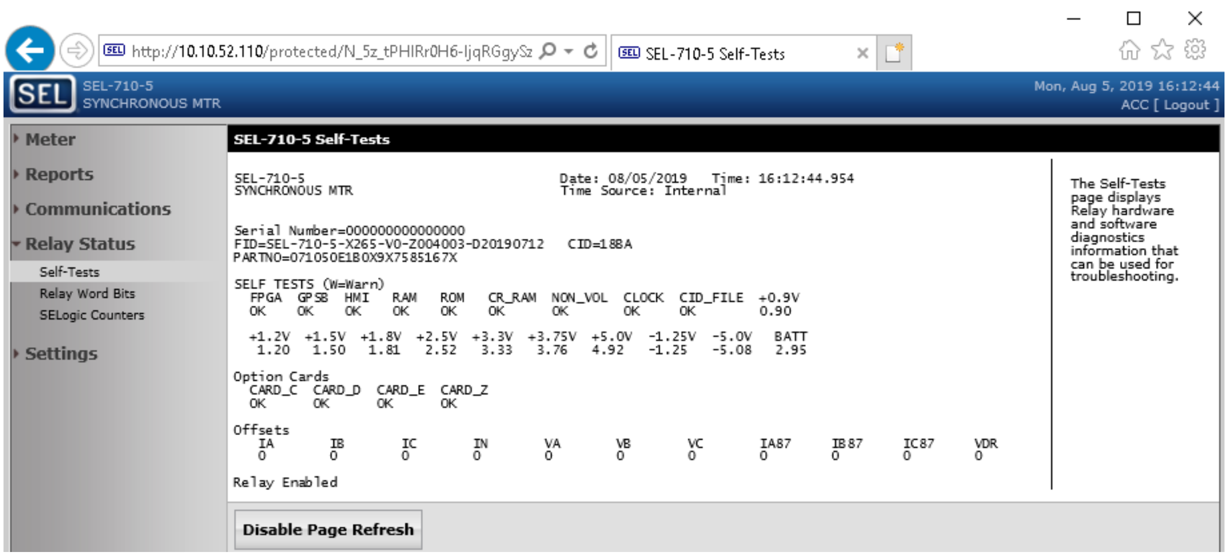

Figure 3.13 Self-Tests Webpage

Relay Word Bits

The web server can display the present state of the Relay Word bits of the relay.

Selecting **Relay Word Bits** displays the state of all the Relay Word bits (see *Figure 3.14*). Note that Relay Word bits shown in yellow are asserted. This webpage is updated automatically; you can disable the automatic updates by clicking Disable Page Refresh. Scroll up or down to view the remaining Relay Word bits not visible on the screen.

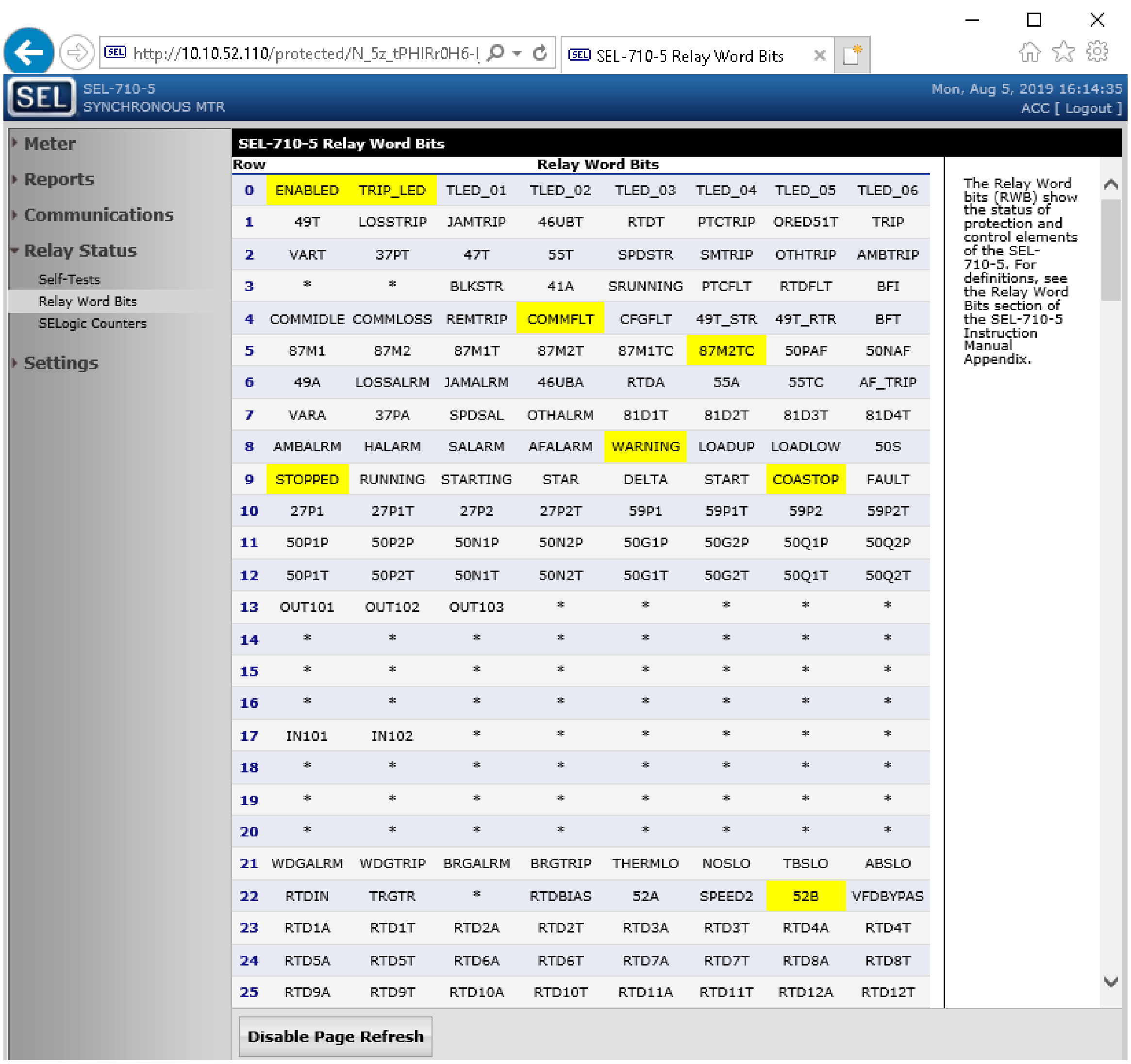

Figure 3.14 Relay Word Bits Webpage

SELogic Counters

When you select **Relay Status > SELogic Counters**, the count of each of the enabled SELogic counters displays (see *Figure 3.15*). A counter is only displayed when it is enabled.

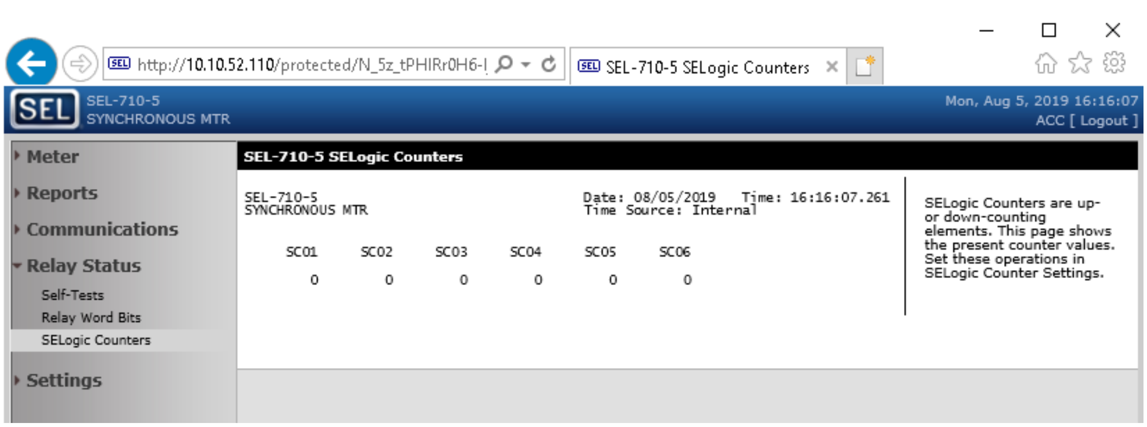

Figure 3.15 SELogic Counters Webpage

Settings

When you select **Settings** on the navigation pane, a list of all the available settings classes in the SEL-710-5 displays. Select a class of settings to view each of the settings in that class (Group, Logic, Global, Report, etc.). *Figure 3.16* shows the Group 1 settings category.

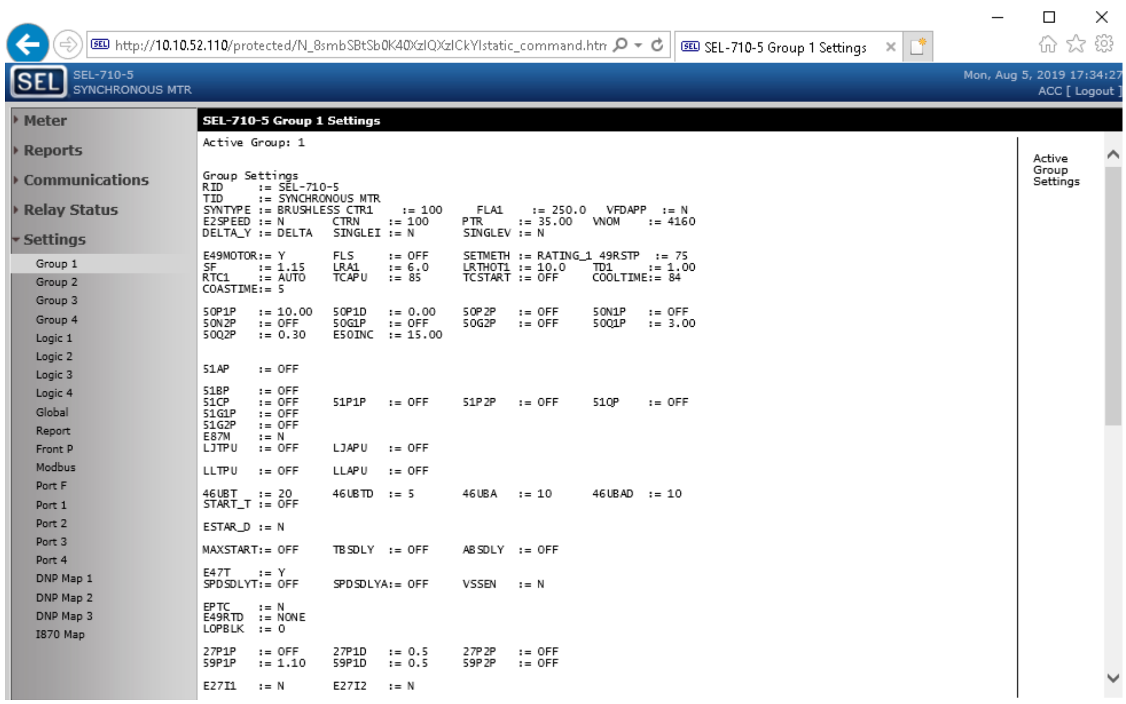

Figure 3.16 Group 1 Settings Webpage

System

File Management (Firmware Upgrade)

The web server offers a convenient method for upgrading relay firmware. Select **System > File Management** (on the navigation pane) to upgrade your relay firmware (see *Figure 3.17*).

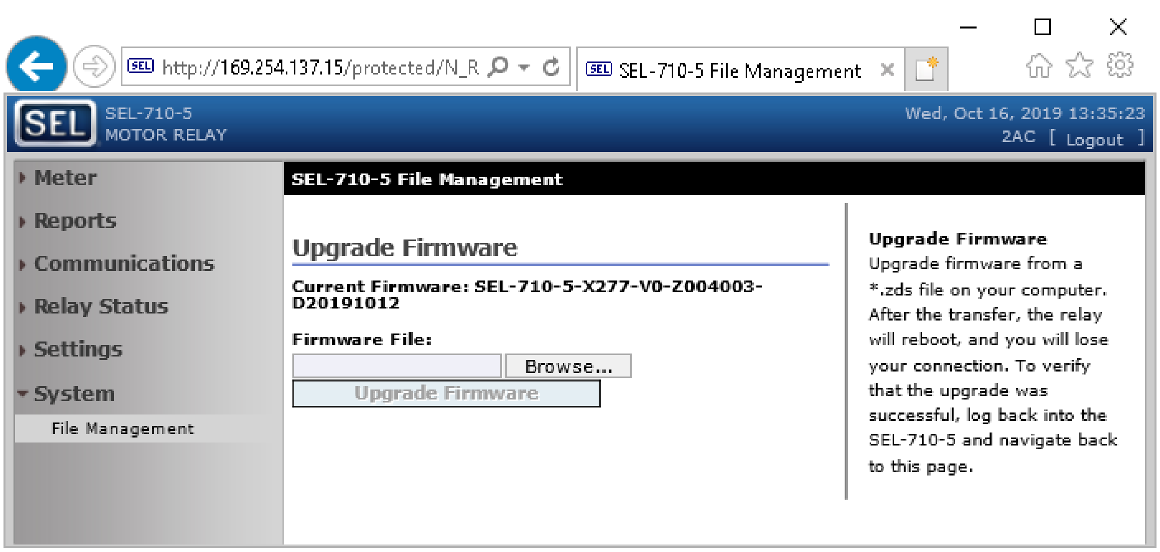

Figure 3.17 Upgrade Relay Firmware From the File Management Webpage

When preparing to upgrade relay firmware, you must first have the new relay firmware. The firmware is designated with a .zds extension. Use the **Browse** button to select the firmware you want sent to the relay, then click **Upgrade Firmware** to start the upgrade process (see *Figure 3.17*). See *Appendix B: Firmware Upgrade Instructions* for complete details on the firmware upgrade procedure.

Language Support

The web server reports can be displayed in English or Spanish by setting the Ethernet Port 1 setting LANG to ENGLISH or SPANISH.

QuickSet Software

This section describes how to get started with the SEL-710-5 Relay and ACSELERATOR QuickSet SEL-5030 Software. SEL provides many PC software solutions (applications) to support the SEL-710-5 and other SEL devices. *Table 3.1* lists SEL-710-5 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-5036	ACSELERATOR Bay Screen Builder SEL-5036 Software	Designs and manages bay screens in conjunction with SEL-5030 for the SEL-710-5 with the color touchscreen display
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-5702	SEL-5702 Synchrowave Operations	Supports a variety of power system operations and analytics applications with high-resolution time-series data, real-time analytics, and GIS location information to improve operator situational awareness
SEL-5703	SEL-5703 Synchrowave Monitoring	Provides power system situational awareness by translating data into visual information; displays and analyzes time-synchronized synchrophasor data and relay event reports
SEL-5801	SEL-5801 Cable Selector	Selects the proper SEL cables for your application

QuickSet is a powerful setting, event analysis, and measurement tool that aids in setting, applying, and using the SEL-710-5. *Table 3.2* shows the suite of QuickSet applications provided for the SEL-710-5.

Table 3.2 QuickSet Applications

Application	Description
Rules-Based Settings Editor	Provides online or offline device settings that include interdependency checks. Use this feature to create and manage settings for multiple devices in a database.
HMI	Provides a summary view of device operation. Use this feature to simplify commissioning testing.
Design Templates[a]	Allows you to customize relay settings to particular applications and to store those settings in design templates. You can lock settings to match your standards or lock and hide settings that are not used.
Event Analysis	Provides oscillography and other event analysis tools.
Bay Control	Allows you to design new bay screens and edit existing bay screens by launching the Bay Screen Builder software for SEL-710-5 Relays with the color touchscreen display.
Settings Database Management	QuickSet uses a database to manage the settings of multiple devices.
Terminal	Provides a direct connection to the SEL device. Use this feature to ensure proper communications and to directly interface with the device.
Help	Provides general QuickSet and device-specific QuickSet context.

[a] Available only in licensed versions of QuickSet.

Setup

Follow the steps outlined in *Section 2: Installation* to prepare the SEL-710-5 for use. Perform the following steps to initiate communications:

Step 1. Connect the appropriate communications cable between the SEL-710-5 and your PC.

Step 2. Apply power to the SEL-710-5.

Step 3. Start QuickSet.

Communications

QuickSet uses relay communications **Port 1** through **Port 4**, or **Port F** (front panel), to communicate with the SEL-710-5. Perform the following steps to configure QuickSet to communicate with the relay.

Step 1. Select **Communications** from the QuickSet main menu bar, as shown in *Figure 3.18*.

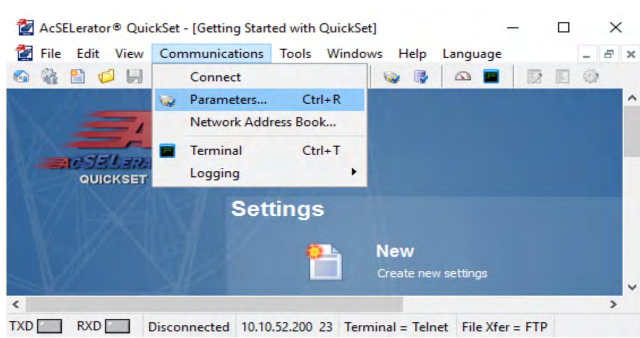

Figure 3.18 Communications Parameter Menu Selection

Step 2. Select the **Parameters** submenu to display the screen shown in *Figure 3.19*.

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

Step 4. Configure QuickSet to match the SEL-710-5 default settings by entering the Access Level 1 and Access Level 2 passwords in the respective text boxes.

Step 5. For network communications, select **Network** from the **Active Connection Type** drop-down menu and enter the network parameters as shown in *Figure 3.20*.

For the SEL-710-5, always select FTP as the file transfer option.

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

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

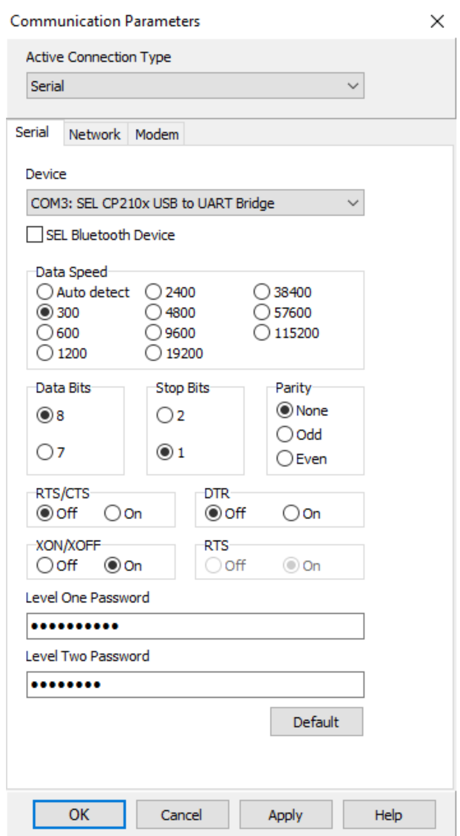

Figure 3.19 Serial Port Communication Parameters Dialog Box

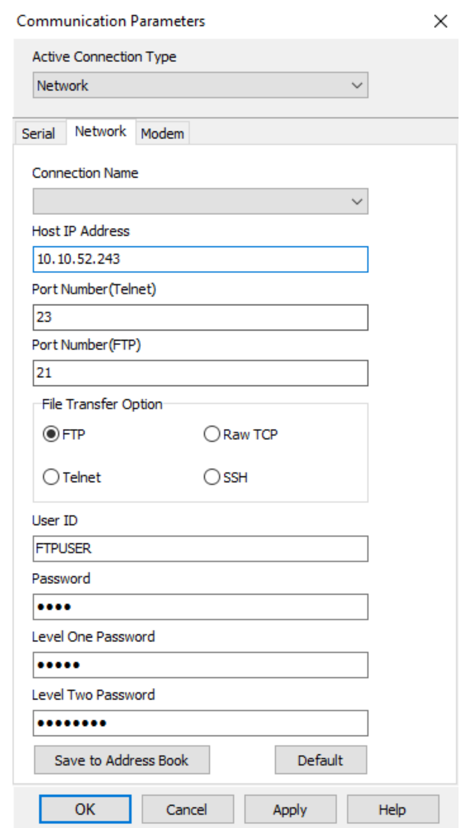

Figure 3.20 Network Communication Parameters Dialog Box

Terminal

Terminal Window

Select **Communications > Terminal** on the main menu bar (see *Figure 3.21*) to open the terminal window.

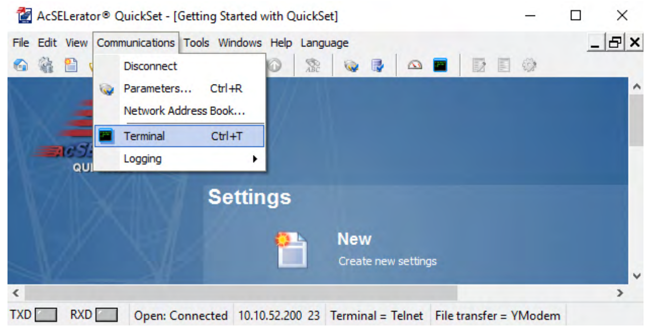

Figure 3.21 Communications Terminal Menu Selection

The terminal window is an ASCII interface with the relay. This is a basic terminal emulator. Many third-party terminal emulation programs are available with file transfer encoding schemes. Open the terminal window by either clicking **Communications > Terminal** or pressing **<Ctrl+T>**. Verify proper communications with the relay by opening a terminal window, pressing **<Enter>** a few times, and verifying that a prompt is received. If a prompt is not received, verify proper setup.

Terminal Logging

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

Driver and Part Number

After clicking **Communications > Terminal**, access the relay at Access Level 1. Issue the **ID** command to receive an identification report, as shown in *Figure 3.22*.

NOTE: The SEL display package and customer display package versions are only displayed in the touchscreen display model.

```
=ID <Enter>
"FID=SEL-710-5-X219-V0-Z003002-D20180416","0912"
"BFID=BOOTLDR-R501-V0-Z000000-D20140224","0947"
"CID=DA16","0269"
"DEVID=SEL-710-5","0424"
"DEVCODE=80","030F"
"PARTNO=071050E1B1X0X7583A21X","074A"
"CONFIG=112512000","041F"
"SEL DISPLAY PACKAGE=1.0.40710.2170","0884"
"CUSTOMER DISPLAY PACKAGE=1.575370232","0992"
"iedName=SEL_710d5_1","0664"
"type=SEL_710d5","04E3"
"configVersion=ICD-710-5-X202-V0-Z200006-D20180403","0D7E"
"LIB61850ID=3DB89FD6","04FF"
=
```

Figure 3.22 Relay Response to the ID Command

Locate and record the Z-number (Z003002) in the FID string. The first portion of the Z-number (Z003…) determines the settings driver version when you are creating or editing relay settings files in QuickSet. The use of the driver version is discussed in more detail in *Settings Editor on page 3.21*. Compare the part number (PARTNO=7105XXXXXXXXXXXXXX) with the Model Option Table (MOT) to ensure the correct relay configuration. The SEL display package version can be found in *Table A.5*. The customer display package (CDP) version has a unique ID code based on the total number of seconds from 1/1/2000 to the time stamp when the CDP was created and downloaded to the relay via QuickSet.

Settings Database Management and Driver

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

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

Step 4. Highlight a relay or settings file listed in **Settings** and click the **Copy** button to create a new set of settings.

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

Copy/Move Settings Between Databases

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

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

Step 2. Click the **Settings Database B** ... button to open a relay database.

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

a. Highlight a device or settings file in **Settings Database A**.

b. Click **Copy** or **Move**, and click the **>** button to create a new device or settings file in **Settings Database B**.

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

Create a New Database/Copy an Existing Database

To create a new database:

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

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

Step 3. Click **OK**.

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

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

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

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

Step 3. Type a new database name and click **Open**. Click **Yes**; the program creates a new empty database. Load devices or settings files into the new database as in *Copy/Move Settings Between Databases on page 3.17*.

Settings

QuickSet has the capability of creating settings for one or more SEL-710-5 Relays. Store existing relay settings downloaded from SEL-710-5 Relays with QuickSet. Create a library of relay settings, then modify and upload these settings from the settings library to an SEL-710-5. QuickSet makes setting the relay easy and efficient. However, you do not have to use QuickSet to configure the SEL-710-5; 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. 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 menu. QuickSet shows all of the settings categories in the settings tree view. The settings tree view remains constant whether settings categories are enabled or disabled.

Settings Menu

QuickSet uses a database to store and manage SEL relay settings. Each unique relay has its own settings records. Use the **File** menu to open (**Open**) an existing record, create and open a new (**New**) record, or read (**Read**) relay settings from a connected SEL-710-5 and then create and open a new record. Click **Tools** > **Settings** > **Convert** to convert and open an existing record in the settings editor.

Table 3.3 File/Tools Menus

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

File > New

To configure SEL-710-5 settings with the settings editor, click **File** > **New** on the main menu bar and select the SEL-710-5 and the latest driver version (00*X*) on the **Settings Editor Selection** screen, as shown in *Figure 3.23*.

QuickSet creates the new settings file using the driver that you specify in the **Settings Editor Selection** screen. QuickSet uses the Z-number in the FID string to create a particular settings file.

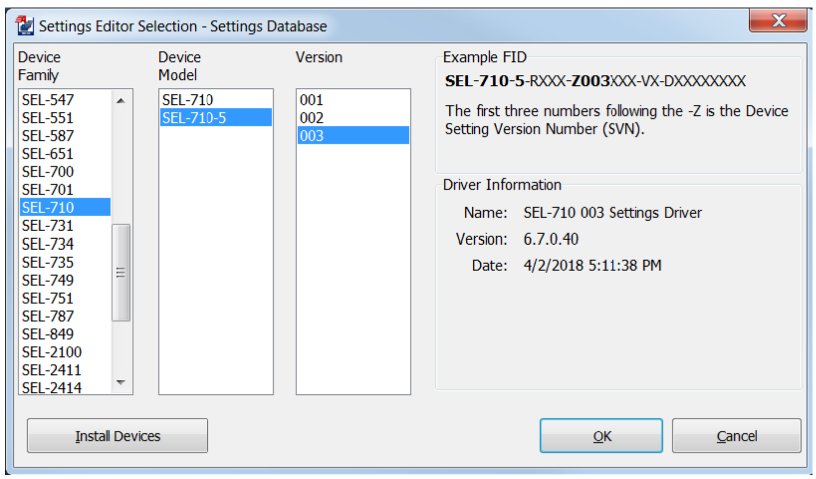

Figure 3.23 Driver Selection

After the relay model and settings driver selection, QuickSet presents the **Device Part Number** dialog box. Use this dialog box to configure the settings editor to produce settings for a relay with options determined by the part number, as shown in *Figure 3.24*. Click **OK** when finished.

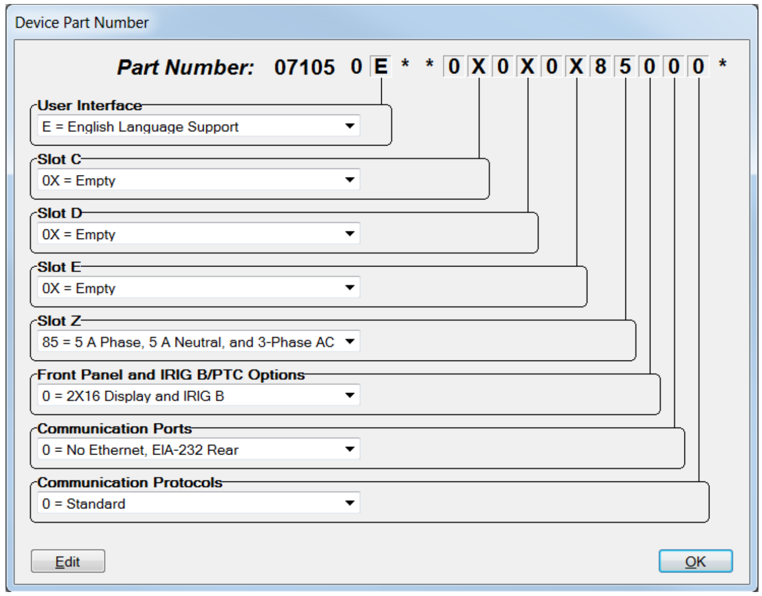

Figure 3.24 Update Part Number

Figure 3.25 shows the **Settings Editor** screen. Check the driver version number in the title bar of the **Settings Editor** screen. Compare the QuickSet settings driver number and the first portion of the Z-number in the FID string (select **Tools > HMI > HMI > Status**). These numbers must match. QuickSet uses this first portion of the Z-number to determine the correct settings editor to display.

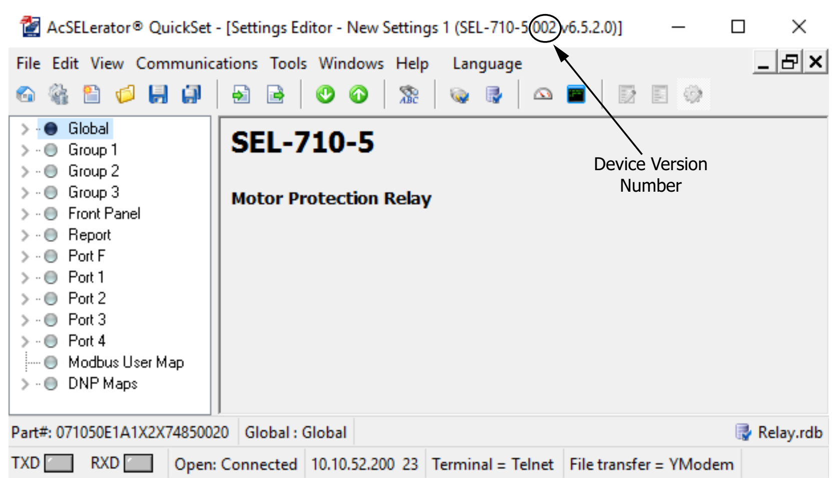

Figure 3.25 New Settings Editor Screen

File > Open

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

File > Read

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

Tools > Settings > Convert

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

Settings Editor

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

Enter Settings

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

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

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

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

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

Access Expression Builder. Use the ellipsis button ... that follows the settings text boxes in the settings editor to create an expression, as shown in *Figure 3.26*.

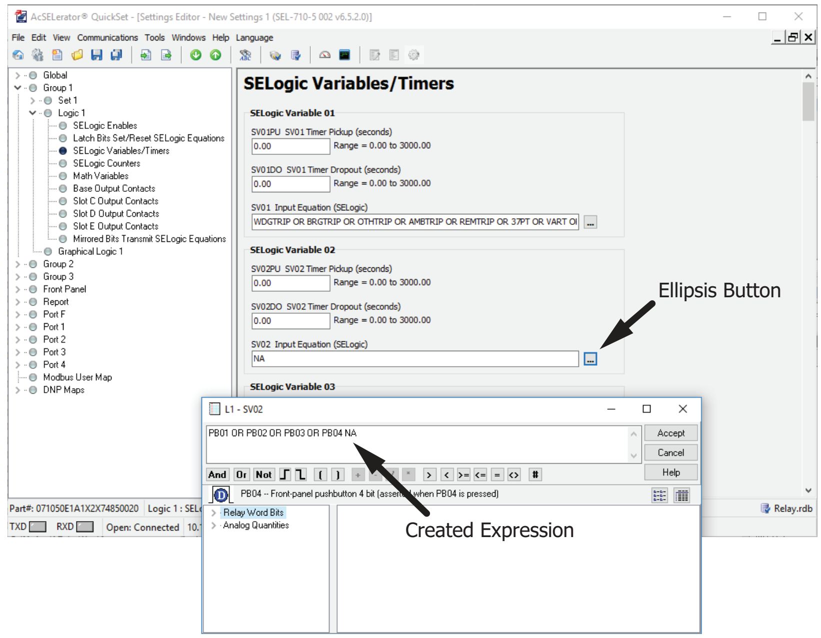

Figure 3.26 Expression Created With Expression Builder

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

Touchscreen Settings and Bay Screen Builder

The touchscreen settings are available when the touchscreen display option is selected as part of the front-panel options. This option provides you with the ability to design bay screen one-line diagrams with the help of the Bay Screen Builder. For more information, refer to *Bay Screens Design Using QuickSet and Bay Screen Builder on page 9.10*.

File > Save

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

File > Send

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

Edit > Part Number

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

Text Files

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

Event Analysis

QuickSet has integrated analysis tools that help you retrieve information about relay operations quickly and easily. Use the event information that the SEL-710-5 stores to evaluate the performance of a system (select **Tools > Events > Get Event Files**). *Figure 3.27* shows the event retrieval screen.

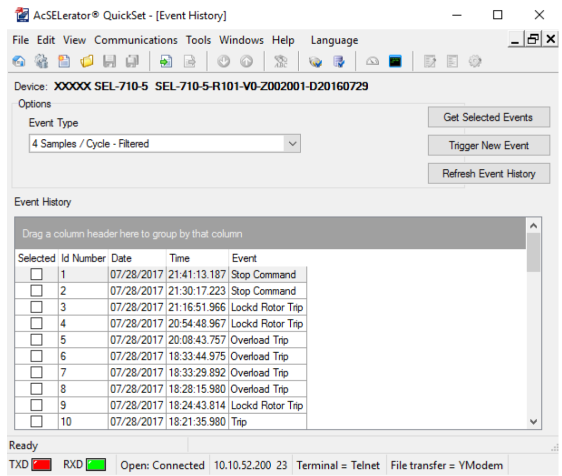

Figure 3.27 Retrieve Events Screen

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 10: 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 3.27*.

View Event History

The SEL-710-5 is capable of capturing two types of events (4 samples/cycle filtered and 32 samples/cycle raw). These two types of events can be captured in either the compressed ASCII (.cev) or COMTRADE format. Quickset allows for downloading both .cev and COMTRADE events. Use the **Event Type** drop-down menu shown in *Figure 3.27* to select the 32 samples/cycle unfiltered (raw) or COMTRADE format event data (default is 4 samples/cycle filtered data). For information on other methods of retrieving COMTRADE events from the relay, see *Retrieving COMTRADE Event Files on page 10.30*.

Get Event

Highlight the event you want to view (e.g., Event 1 in *Figure 3.27*), select the event type from the **Event Type** drop-down menu (4 samples or 32 samples), and click **Get Selected Events**. QuickSet then queries where to save the file on your computer, as shown in *Figure 3.28*.

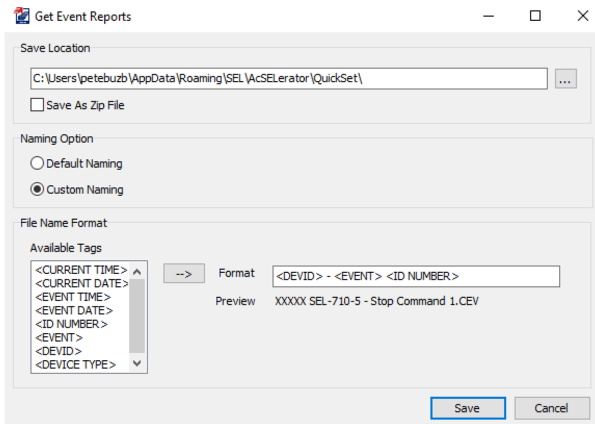

Figure 3.28 Save the Retrieved Event

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

View Event Files

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

Meter and Control

Click on **Tools > HMI > HMI** to display a screen similar to the one shown in *Figure 3.29*. The HMI tree view shows all the functions available in the HMI function. Unlike the self-configuration of the device settings tree, 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 relay 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 screen displays the status of the two inputs and three outputs of the main board. You cannot change these assignments.

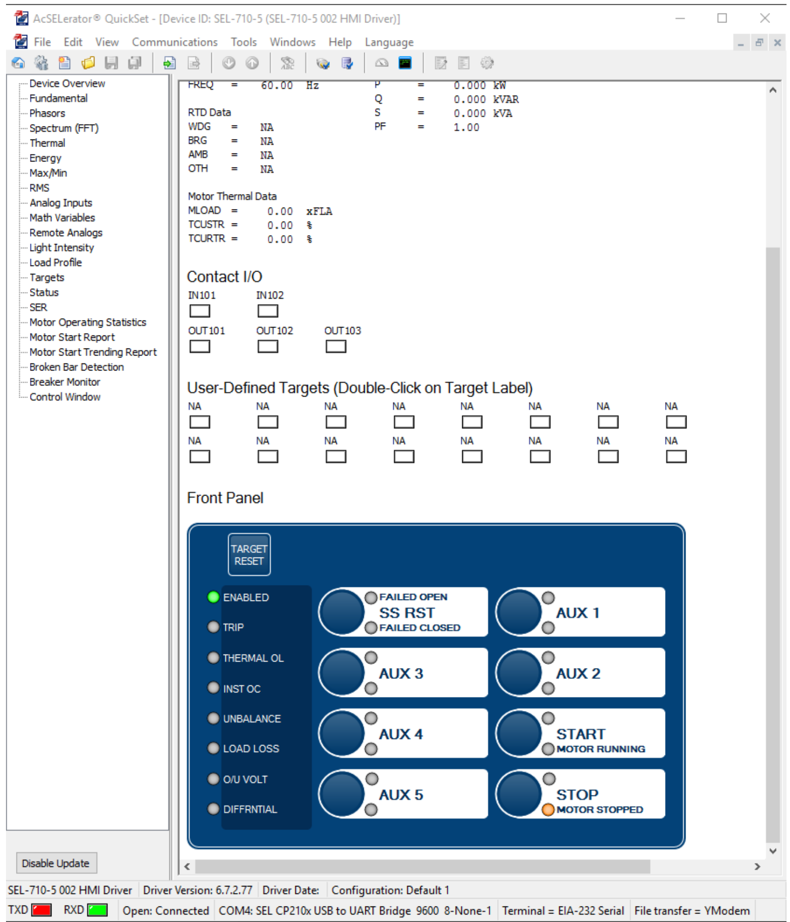

Figure 3.29 Device Overview Screen

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

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

Click **Targets** in the tree view to view the status of all the Relay Word bits. When a Relay Word bit has a value of 1 (RB02 = 1), the Relay Word bit is asserted. 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 **Tools > Open Motor Start Report File** to graphically display the compressed (*.cmsr) motor start report, and then click **View > Report Data** to view the report data. *Figure 3.30* shows the *cmsr file display using ACSELERATOR QuickSet, and *Figure 3.31* shows a COMTRADE file display using SYNCHROWAVE Event software.

NOTE: The motor start reports are available in cmsr (ASCII) and COMTRADE. The COMTRADE can be graphically displayed using SYNCHROWAVE Event Software and includes relay settings, excitation voltage, and current. See View/Retrieve MSR Data on page 5.19 for details.

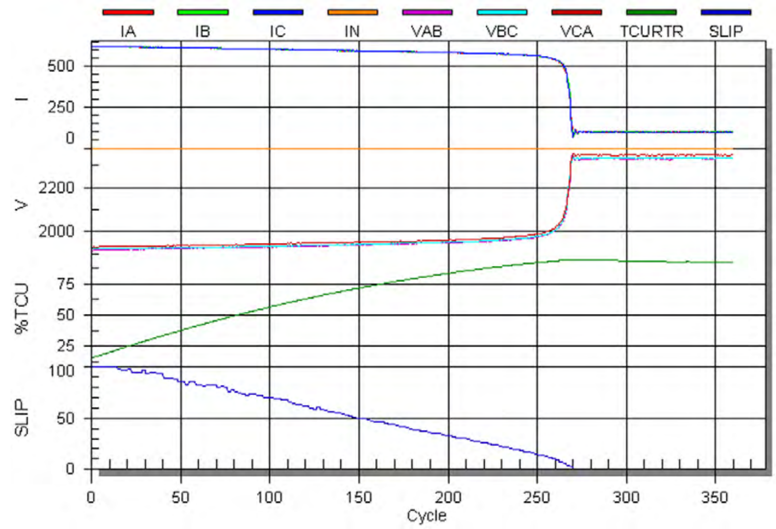

Figure 3.30 Graphical Display of Motor Start Report—ASCII CMSR File Using QuickSet Software

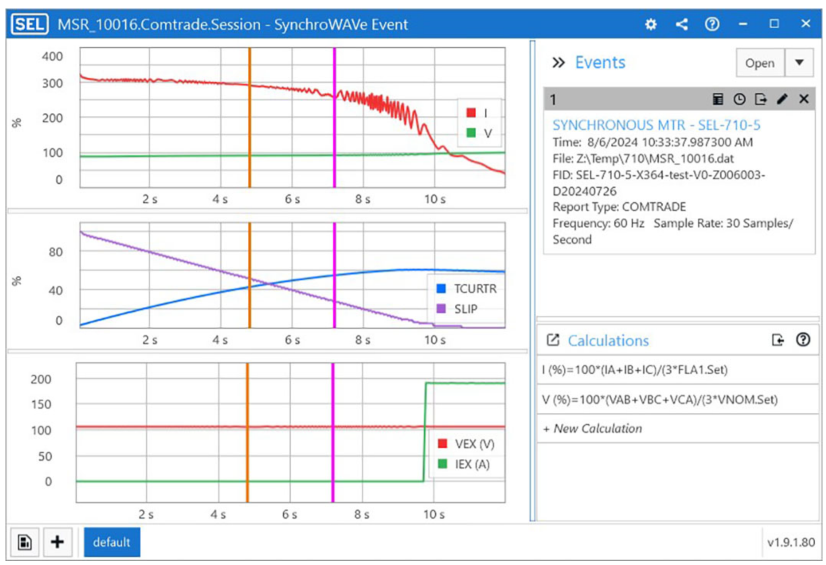

Figure 3.31 Graphical Display of Motor Start Report—COMTRADE File Using SYNCHROWAVE Event Software

Figure 3.32 shows the control screen. From here you can reset metering data; clear the event history, SER, MIRRORED BITS report, or LDP; or trigger events. You can also reset the targets, synchronize with IRIG, and set the time and date. If supported, you can run arc-flash sensor diagnostic tests.

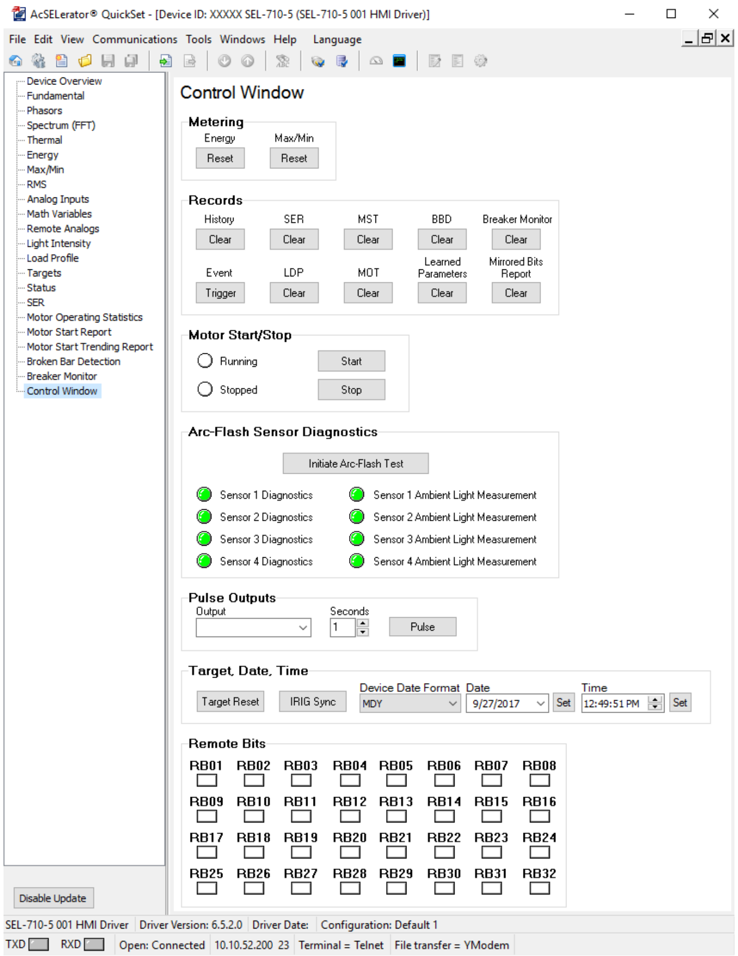

Figure 3.32 Control Screen

To control the remote bits, click on the appropriate square (RB01–RB32), then select the operation from the box shown in *Figure 3.33*.

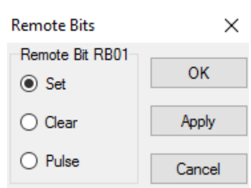

Figure 3.33 Remote Bit Operation Selection

Language Support

NOTE: If the SEL-710-5 is connected to any SEL communications processor (SEL-203x or RTAC), the corresponding LANG port setting must be set to ENGLISH.

QuickSet has multi-language support. Click on the **Language** menu to choose from English, Spanish, French, Portuguese, Russian, Turkish, or Chinese, as seen in *Figure 3.34*. Selecting any of these choices converts the menu items in QuickSet to the selected language.

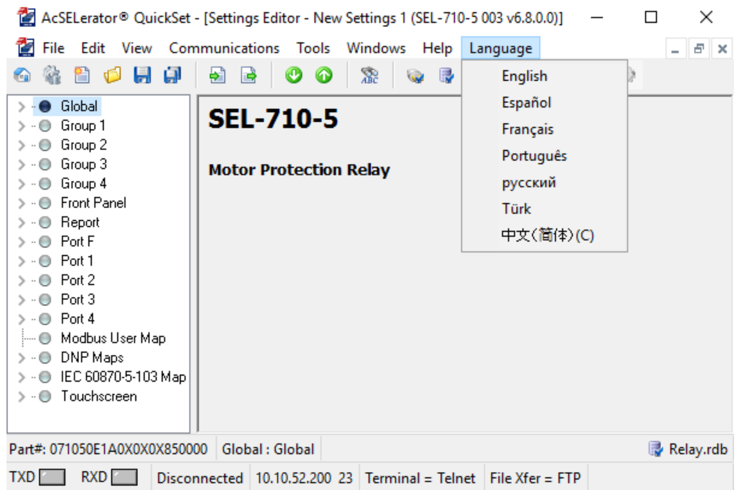

Figure 3.34 Language Support Options

Additionally, if Spanish or English is selected from the **Language** menu, the relay settings displayed by QuickSet are converted into the corresponding language as shown in *Figure 3.35*.

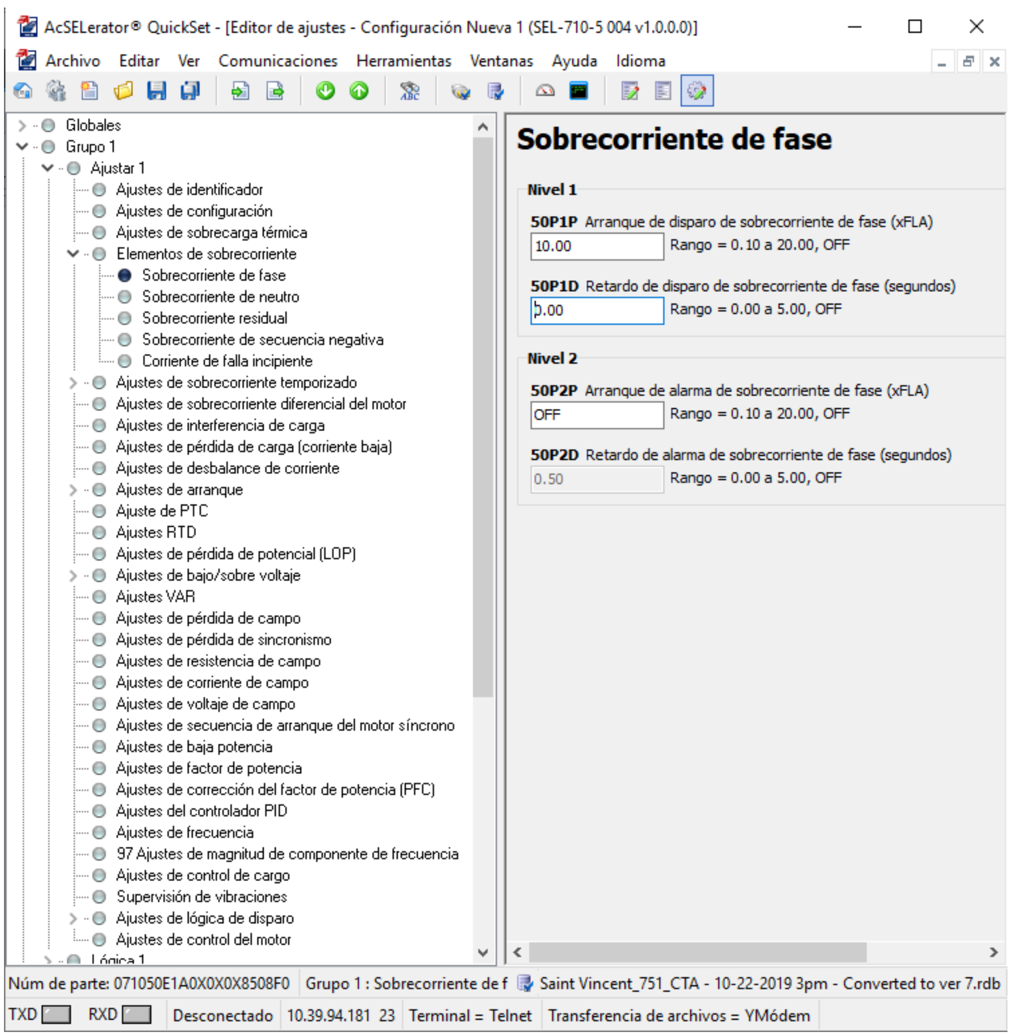

Figure 3.35 Spanish Settings QuickSet Display

NOTE: Once the HMI screen is displayed in QuickSet, the LANG setting does not affect the displayed HMI. To change the language of the HMI, close the HMI, change the LANG setting, and then reopen the HMI.

Each communications port (serial or Ethernet) on the SEL-710-5 can be independently set to display either English or Spanish. Changing the port setting LANG to SPANISH or ENGLISH results in the QuickSet HMI and all of its available functions displaying in the corresponding language. For example, if the **Control Window** is selected in the HMI while the setting LANG := SPANISH, QuickSet displays the Control Window (Ventana de Control) in *Figure 3.36*.

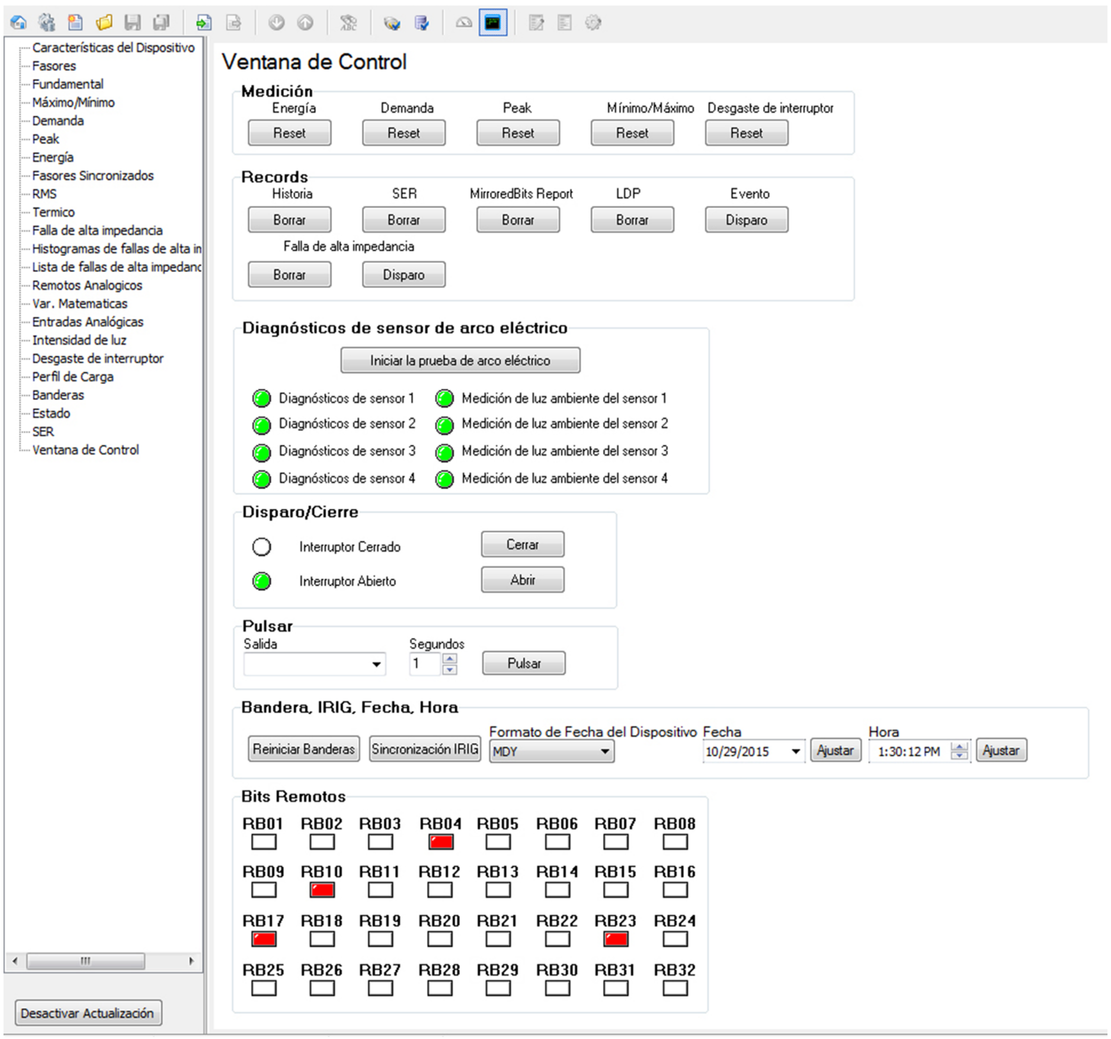

Figure 3.36 Spanish Control Window (Ventana de Control) Display

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.
SEL-710-5 Settings	Select **Settings Help** from the **Help** menu bar while the settings editor is open.

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Section 4

Protection and Logic Functions

Overview

NOTE: Factory-default settings for the SEL-710-5 are not selected for any particular application. You must compute, document, and send the appropriate settings to the relay for your application.

This section describes the SEL-710-5 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 the front-panel display.

This section includes the following subsections:

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

Group Settings (SET Command).

ID Settings and Configuration Settings. Lists the ID settings and the settings that configure the relay inputs to accurately measure and interpret the ac current and voltage input signals.

Protection Elements. Lists settings and logic associated with the protection elements, including the thermal element, overcurrent elements, load-loss functions, and load-jam functions.

- *Thermal Overload Element*
- *Slip-Dependent Thermal Model for Synchronous Motors*
- *Overcurrent Elements* and *Time-Overcurrent Elements*
- *Differential Element s*
- *Load-Jam Elements*
- *Undercurrent (Load Loss) Elements*
- *Current Unbalance Elements*
- *Start Monitoring/Incomplete Start Sequence*
- *Star-Delta (Wye-Delta) Starting*
- *Start Inhibit Function*
- *Phase Reversal Protection*
- *Speed Switch (Stalling During Start) Function*
- *Virtual Speed Switch*
- *PTC/RTD-Based Protection*
- *Undervoltage Function* and *Overvoltage Function*
- *Inverse-Time Undervoltage Protection* and *Inverse-Time Overvoltage Protection*

Synchronous Motor Settings. Lists settings associated with synchronous motor protection and control.

- *Loss-of-Field Element*
- *Out-of-Step Element*

- *Field Resistance Element*
- *Field Current Element*
- *Field (Exciter) Voltage Element*
- *Power Factor Correction*
- *PID Controller*
- *Synchronous Motor Synchronization*

Trip Logic. Lists settings associated with 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.

General Settings. Lists the global system settings like phase rotation, nominal frequency, date format, etc.

Broken Rotor Bar Protection. Lists the settings to configure Broken Rotor Bar protection. Describes the element operation and commands associated with the element.

Multiple Settings Groups. Lists settings for active group selection and describes configuration of active group selection via SELOGIC control equations.

Time and Date Management Settings. Lists settings for time and date management and describes configuration of these settings. Covers supported time protocols.

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

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

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

Analog Outputs. Describes analog output functionality, lists the settings and gives an example. Data Reset
Lists the data reset SELOGIC control equation settings for resetting targets, energy metering, max/min metering, demand metering and peak demand metering.

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

Data Reset. Lists the data reset SELOGIC control equation settings for resetting targets, energy metering, max/min metering, demand metering and peak demand metering.

Access Control. Describes the SELOGIC control equation setting you would use for disabling settings changes from the relay front panel.

Time-Synchronization Source. Describes the setting you would use for choosing IRIG1 or IRIG2 as the time-synchronization source.

Disconnect Control Settings. Lists settings that configure the relay front- and rear-panel communications ports.

Local/Remote Control. Describes the local/remote motor control function.

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

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

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

DNP Map Settings (Set D Command). Shows the DNP user map register settings.

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

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

Touchscreen Settings. The touchscreen settings apply to relays that support the color touchscreen display. (The settings are supported in ACSELERATOR QuickSet SEL-5030 Software only.)

When you calculate the protection element settings to protect your motor, proceed through the subsections listed earlier. See *Section 6: Settings* for the list of all settings (*SEL-710-5 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 I.1).

You can enter the settings by using the front-panel `SET RELAY` function (see *Section 8: Front-Panel Operations*), the serial port (see *Section 7: Communications*), the EIA-485 port (see *Appendix E: Modbus Communications*), the DeviceNet port (see *Appendix I: 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-710-5 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 (for induction motor only)
  - Locked rotor torque, per unit (for induction motor only)
- Additional data regarding the motor application, including the following information:
  - Minimum no load current or power
  - Motor accelerating time. This is the normal time required for the motor to reach full speed.

  - ➢ Maximum time to reach motor full load

    This time can be significantly longer than the motor accelerating time, particularly in pump motor applications where the motor runs at full speed for some time before the pump reaches full head and full load.
- ➤ Current transformer primary and secondary ratings and connections
- ➤ System phase rotation and nominal frequency
- ➤ Voltage transformer ratios and connections, if used
- ➤ Type and location of resistance temperature detectors (RTDs), if used
- ➤ Expected fault current magnitudes for motor or cable ground and three-phase faults

Group Settings (SET Command)

ID Settings

All models of the SEL-710-5 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-710-5
UNIT ID LINE 2	16 Characters	TID := MOTOR RELAY

The SEL-710-5 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

Table 4.2 CT Configuration and Full-Load Current Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SYN MOTOR TYPE	BRUSH, BRUSHLESS, NONE	SYNTYPE := BRUSHLESS
PHASE CT RATIO	1–5000	CTR1 := 100
CURR SENSOR TYPE	RCOIL, LPCT	CS_TYPE1 := RCOIL
RATE PRI CURR	1–6000 A pri	IPR1 := 100
RATED SENS VOLT	10.0–1000.0 mV @ FNOM	USR1 := 180[a]
NOMINAL CURRENT	1 A	INOM[b] := 1
RATED FEEDER CUR	1–6000 A pri	FDR_CUR1 := 100
PHASE ILEA SCALE	1.00–6000.00	ILEA_SC1 := 100[c]
MOTOR FLA	0.2–5000.0 A pri	FLA1 := 250[d]
VFD APPLICATION	Y, N	VFDAPP := N
LOAD @ ZEROSPEED	0.2–5000.0 A pri	LOAD_ZS := 50.0

Table 4.2 CT Configuration and Full-Load Current Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
MNFREQ @ FULLOAD	10.00–70.00 Hz	FREQ_FL := 60.00
TWO SPEED ENABLE	Y, N	E2SPEED := N
CT RATIO–2nd	1–5000	CTR2 := 100
MOTOR FLA–2nd	0.2–5000.0 A pri	FLA2 := 250.0
FVR PHASING	NONE, A, B, C	FVR_PH := NONE
NEUTRAL CT RATIO	1–2000	CTRN := 100
CURR SENSOR TYPE	RCOIL, LPCT	CS_TYPE := RCOIL
RATED PRI CURR	1–6000 A pri	IPRN := 10
RATED SENS VOLT	10.0–1000.0 mV @ FNOM	USRN := 180.0[e]
NOMINAL CURRENT	1 A	INOMN[b] := 1
RATED FEEDER CUR	1–6000 A pri	FDR_CURN := 100
PHASE ILEA SCALE	1.00–6000.00	ILEA_SCN := 100[c]
SINGLE I INPUT	N, IA, IB, IC	SINGLEI := N

[a] The setting range is 10.0–1000.0 mV and default USR1 := 22.5 mV for CS_TYPE1 := LPCT.
[b] This setting is not user settable.
[c] Autocalculated and used to scale the primary currents to an equivalent secondary current used for the pickup thresholds.
[d] FLAn default settings are 50 A for secondary phase input current of 1 A.
[e] The setting range is 10.0–1000.0 mV and default USRN1 := 22.5 mV for CS_TYPEN := LPCT.

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-710-5 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 4.67). With the LEA card (Slot Z = L1), the relay internally sets CTR2 = ILEA_SC1 and FLA2 = FLA1 and hides the settings.

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 CS_TYPE1, IPR1, USR1, INOM, FDR_CUR1, and ILEA_SC1 settings are applicable to the relay with LEA current inputs. Set the current sensor type to RCOIL or LPCT using the CS_TYPE1 setting. Obtain the rated primary current (IPR1) and rated sensor voltage (USR1) from the LEA sensor. For RCOIL, use the IPR and USR values that correspond to the system nominal frequency (FNOM). Set the rated feeder current (FDR_CUR1) setting to the full load current of the motor or the nominal primary current of a conventional CT that would otherwise be used. The ILEA_SC1 setting is autocalculated by the relay and is not available for setting. ILEA_SC1 is derived as the ratio of rated feeder current to nominal current, i.e., ILEA_SC1 = FDR_CUR1/INOM.

Similar to the LEA phase current inputs, CS_TYPEN, IPRN, USRN, INOMN, FDR_CURN, and ILEA_SCN settings are applicable to neutral LEA current inputs. Refer to *LEA Current Inputs on page 4.8* for additional details.

The FLA settings are in primary amperes, see *Example 4.9* for sample calculations of Motor FLA. See the full-voltage reversing starter in *Full-Voltage Reversing Starter on page 2.37* for a description of the setting FVR_PH. *Table 4.3* shows the voltage settings. In applications in which only a

NOTE: Single current measurement is intended for control and power factor correction applications. It is not adequate for protection.

single current is available, set SINGLEI equal to the measured phase. When SINGLEI is not equal to N, the relay performance changes in the following ways:

- **Power and Current Elements**. When you use one current, the relay assumes that the system currents are balanced in both magnitude and phase angle. Power, power factor, and positive-sequence impedance are calculated assuming balanced currents.
- **Thermal Model and Protection Elements.** When you use one current, the thermal model will operate assuming balanced currents. Since negative-sequence currents cannot be measured and cause significant additional heating during motor starting, the thermal model would underestimate the heating in the motor, under-protecting it. Protection elements that utilize zero- and negative-sequence elements are not disabled when using one current, but do not provide adequate protection.
- **Metering**. When you use one current, the relay displays that phase's magnitude and angle. The relay displays a zero for the magnitudes of the unmeasured currents. Balanced currents are assumed for power, power factor, IG, and 3I2 metering.
- **Event Reports.** When you use one current, the unmeasured currents are reported as 0.

NOTE: A minimum time delay greater than 100 ms is recommended for phase overcurrent elements when using the relay for a VFD application.

For the motors connected to a variable frequency drive (VFD), use VFDAPP := Y. The relay uses rms current magnitudes (that include harmonics) instead of fundamental for the phase overcurrent elements (50P, 51P, 51A, 51B, 51C) and the motor thermal model (49T) when VFDAPP := Y. The rest of the relay settings do not use rms magnitude for a VFD application. Exercise caution when setting protection elements using fundamental magnitude for VFD applications because rich harmonic content can distort the fundamental magnitude. **SEL strongly discourages the use of voltage-based protection, including under- and overvoltage, power factor, underpower, reactive power (27/59, 55, 37, and VAR) elements unless the voltage inputs are substantially sinusoidal.**

A sustained low-speed operation in the variable frequency drive application can cause motor damage unless overload protection accounts for the poor cooling resulting from the low speed. Set the rated load at zero speed (LOAD_ZS) to continuous current allowed at zero speed and minimum frequency at full load (FREQ_FL) to the lowest frequency at which the cooling is near normal. The relay automatically adapts the trip threshold of the stator and rotor thermal protection elements by a factor of KVF using their respective thermal time constant. *Figure 4.1* shows the typical characteristics of the KVF for specific example settings. To disable this feature, set the rated load at zero speed (LOAD_ZS) equal to the motor full load current (FLA1); this results in KVF = 1.0 at all operating frequencies irrespective of the FREQ_FL setting.

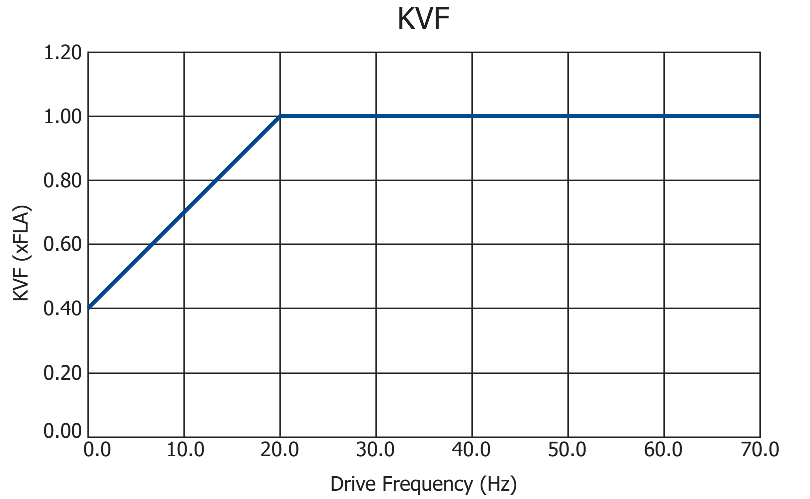


Figure 4.1 KVF Factor Versus VFD Output Frequency

Table 4.3 Voltage Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE PT RATIO	1.00–250.00	PTR := 35.00
PHASE LPVT RATIO	37.50–500000.00	LEA_R := 1312.50
PHASE LPVT SCALE	1.00–13333.33[a]	LEA_SC := 35.00
LINE VOLTAGE[b]	100–30000 V pri	VNOM := 4160
XFMR CONNECTION	WYE, DELTA	DELTA_Y := DELTA
SINGLE V INPUT	Y, N	SINGLEV := N

[a] Autocalculated.
[b] The line voltage setting is in primary volts.

The PTR setting is applicable and available for setting when the relay is ordered with conventional voltage inputs (300 Vac). The LEA_R and LEA_SC settings are applicable to the relay with LEA inputs (8 Vac). The LEA_R setting is settable while LEA_SC is autocalculated by the relay and not available for setting as explained in *LEA Voltage Inputs on page 4.10*. The DELTA_Y setting is forced to WYE for a relay with LEA inputs. The VNOM and SINGLEV settings are applicable to either of the voltage input options.

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

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.

Set the phase LEA ratio (LEA_R) setting equal to the marked LEA sensor ratio.

EXAMPLE 4.3 Phase LEA Ratio Setting Calculations

Consider a 13.8 kV feeder application where you have a 2500:1 ratio LEA sensor (connected in wye).

Set LEA_R := 2500/1 := 2500 and DELTA_Y := WYE.

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 2.25*, the single voltage must be connected to the A-phase input, but it can be an A-N or an A-B voltage. Be sure to set DELTA_Y equal to WYE for an A-N input or DELTA_Y equal to DELTA for an A-B input voltage.

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

- **Power and Voltage Elements.** When you use one voltage, the relay assumes that the system voltages are balanced in both magnitude and phase angle. Power, power factor, and positive-sequence impedance are calculated assuming balanced voltages.
- **Metering.** When you use one voltage, the relay displays 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.
- **Event Reports.** When you use one voltage, the unmeasured voltages are reported as 0.

Low-Energy Analog (LEA) Sensor Inputs

LEA sensors for measurement of primary voltages and currents are gaining popularity because of their excellent linearity and dynamic range characteristics, reduced size, reduced weight, and enhanced personnel safety. Typically, Rogowski coils and low-power CTs (LPCT) are used for current measurements, and low-power VTs (LPVT) are used for voltage measurements. The SEL-710-5 offers a card option in Slot Z for receiving signals from these sensors. Refer to the SEL-710-5 Model Option Table for the variant available.

LEA Current Inputs

The SEL-710-5 can be ordered with either a conventional 4 ACI card or an LEA input card. The LEA input card supports three LEA-based voltage inputs, three LEA-based current inputs, and an LEA-based neutral current input (IN). The LEA input card complies with the LEA specifications defined in the IEC 61869-13 standard. The card is compatible with low-power instrument transformers that comply with IEC 61869-10 and IEC 61869-11 standards and supports sensors having outputs compliant with the IEEE C37.92 standard.

The current channels of an LEA input card support two types of sensors: LPCTs and Rogowski coils. LPCTs are conventional CTs equipped with an internal shunt resistor that generates an output voltage proportional to the primary current. A Rogowski coil produces an output voltage proportional to the rate of change of the primary current. When operating in the Rogowski coil mode, the SEL-710-5 uses an internal hardware integrator to produce a signal proportional to the primary current.

Considerations for Selecting Rogowski Coil/LPCT

Rogowski coils and LPCT sensors support an exceptionally wide dynamic range that may be 20 or more times wider than the conventional CT; in practice, this means that a single 100 A sensor may be able to protect circuits with loads going as high as 2,000 A. Voltage output produced by such a sensor may easily exceed 100 V during the fault. To accommodate the wide range of applications made possible by the low-energy sensors, the SEL-710-5 adjusts its current-channel gain, allowing the relay to support Rogowski coil sensors with output between 4–128 V full scale rms during the fault. The SEL-710-5 is designed to measure as much as 30 times the nominal feeder current without clipping. The SEL-710-5 measures as much as 2.3 times the nominal neutral current without clipping. The choice of Rogowski coil and feeder current should be made such that calculated clipping voltage is within 4–128 Vrms range for Rogowski coils and 1–8 Vrms for LPCTs. Refer to *Example 4.4* for calculation of clipping voltages for the Rogowski coils and *Example 4.5* for calculation of the clipping voltages for the LPCT-based sensors.

EXAMPLE 4.4 Clipping Voltage Calculation for Rogowski Coil

Assume a Rogowski coil sensor with the following data and relay settings:

FNOM = 60 Hz
CS_TYPE1 = RCOIL
IPR1 = 100 A
USR1 = 180 mV at 60 Hz
INOM = 1 A
FDR_CUR1 = 800 A
ILEA_SC1 = 800/1 = 800, is auto-calculated
Sensor output voltage at 800 A = 180 mV/100 • 800 = 1.44 Vrms
Clipping Voltage = 1.44 Vrms • 30 = 43.2 Vrms

EXAMPLE 4.5 Clipping Voltage Calculation for LPCT

Assume an LPCT sensor with the following data:

CS_TYPE1 = LPCT
IPR1 = 100 A
USR1 = 22.5 mV
INOM = 1 A
FDR_CUR1 = 800 A
ILEA_SC1 = 800/1 = 800, is auto-calculated
Sensor output voltage at 800 A = 22.5 mV/100 • 800 = 180 mVrms
Clipping Voltage = 180.0 mV • 30 = 5.4 Vrms

Secondary Current Calculation for LEA Current Inputs

Relays with LEA current inputs calculate a secondary current equivalent to that measured by conventional current input cards. This secondary current is equal to the primary current divided by the scaling factor ILEA_SC1, which is autocalculated by the relay as ILEA_SC1 = FDR_CUR1/INOM. Because INOM := 1 A in the LEA relay, this simplifies to ILEA_SC1 := FDR_CUR1.

Example 4.6 explains the conversion of a time-overcurrent element pickup setting from a conventional 4 ACI card to an equivalent setting for the LEA input card.

EXAMPLE 4.6 Setting Conversion

Consider an application with a conventional CT card with a 1200/5 = 240 CT ratio and a pickup setting for an time-overcurrent element of 51P1P = 6 A secondary. The equivalent 51P1P setting for an LEA current input card (Rogowski coil or LPCT sensor) can be calculated as shown below.

First convert 51P1P setting to primary amperes, $I_{primary}$ = 6 * 240 = 1440 A primary.

Calculate 51P1P settings in secondary amperes for each of the LEA cards as shown in the table below.

The corresponding 51P1P settings in both conventional and LEA relays will pick up for the same primary current.

Settings/Calculations	Rogowski Coil	LPCT
IPR1	80 A	100 A
USR1	180 mV @ 60 Hz	22.5 mV
FDR_CUR1	1200	1000
INOM	1	1
ILEA_SC1	1200 (auto-calculated)	1000 (auto-calculated)
51P1P = $I_{primary}$/ILEA_SC1	1440/1200 = 1.2 A secondary	1440/1000 = 1.44 A secondary

LEA Voltage Inputs

The SEL-710-5 can be ordered with different secondary ac input voltage configurations—conventional voltage inputs rated for 300 V and LEA voltage inputs rated for 8 V. The LEA voltage inputs are suitable for IEEE C37.92-compliant high-impedance sensors, such as capacitive voltage dividers and resistive voltage dividers (see *Figure 4.2*).

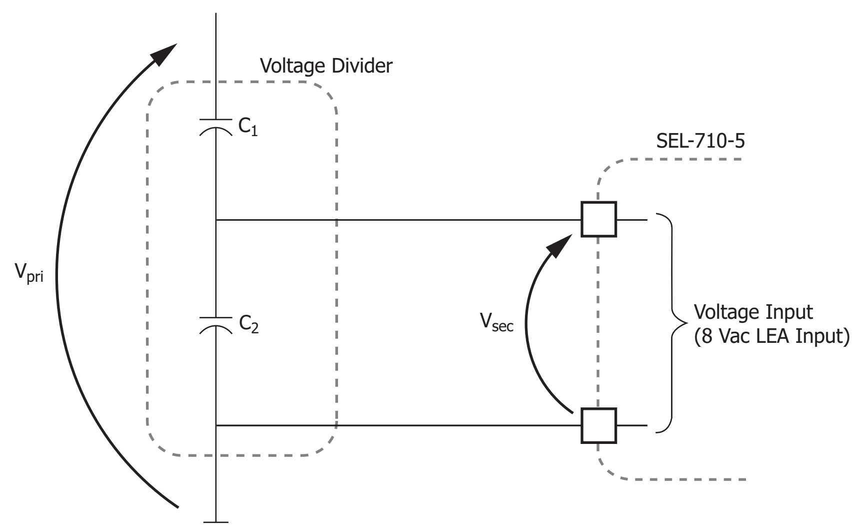


Figure 4.2 Low-Energy Analog Voltage Sensor (Capacitive Voltage Divider)

Derived LEA Scale for 8 Vac LEA Voltage Inputs and Voltage-Related Settings

Irrespective of the voltage input option, conventional (300 Vac) or LEA (8 Vac), all the voltage-related settings are based at 300 V. For example, the 59I element pickup range for conventional voltage inputs is 2.0–300.0 V and this range will remain the same for LEA inputs. To maintain the same 300 V base across different voltage options, such as LEA inputs, the relay scales up the input signal by a factor of 37.5 (300 V/8 V). Likewise, you can scale the voltage-related pickup settings to convert the settings from 8 V to 300 V base. Refer to *Example 4.7*. With LEA voltage inputs, the relay sees 8 Vac on the voltage inputs as 300 Vac secondary (8 • 37.5 = 300 V). Further, to realize accurate primary voltage metering, the relay uses the derived LEA scale, LEA_SC. This scale factor is autocalculated by the relay based on the LEA_R. The LEA scale is derived as follows:

LEA_SC = LEA_R • (8/300)

where LEA_R is the marked LEA sensor ratio.

The ratio of V_{pri} to V_{sec} of the voltage divider shown in *Figure 4.2* is referred to as true ratio. Ideally, the marked LEA sensor ratio should equal the true ratio. If not, apply the following additional ratio correction factors.

For example, if an LEA sensor has an LEA sensor ratio of 1400:1,

LEA_R = 1400

LEA_SC = 1400 • 8/300 = 37.33

EXAMPLE 4.7 Voltage Setting Conversion to 300 V Base

A voltage divider (10000 ratio) is connected between a 12.47 kV system (7.2 kV line-to-neutral) and the LEA inputs.

7200 V / 10000 = 0.72 V

(actual voltage divider output to the 8 Vac LEA inputs; 8 V base)

0.72 V • (300/8) = 27 V

(the relay thinks it is looking at 27 V on a 300 V base, not 0.72 V on an 8 V base)

27 V is the nominal adjusted secondary voltage—adjusted by the 300/8 factor from an 8 V base to a 300 V base. For this same example, if a 0.8 V output of the 8 Vac LEA (8 V base) is deemed an overvoltage condition, then an overvoltage element pickup setting (e.g., 59I1P) could be set at 59I1P = 0.8 V • (300/8) = 30 V (300 V base).

LEA Ratio and Angle Correction Factors (Global Settings)

In the SEL-710-5 with LEA inputs, Global settings VARCF, VBRCF, VCRCF, IARCF, IBRCF, ICRCF, INRCF, VAPAC, VBPAC, VCPAC, VSPAC, IAPAC, IBPAC, ICPAC, and INPAC are applied to the respective voltage and current inputs, **VA**, **VB**, **VC**, **VS**, **IA**, **IB**, and **IC**. These normalized secondary voltages and currents are used throughout the SEL-710-5. Refer to *Table 4.82* and *Table 4.83* under Global settings for these settings.

Ratio Correction Factors (RCF) for LEA Inputs

The ratio correction factor (RCF) settings minimize the magnitude error by compensating for the irregularities (on a per-phase basis) introduced by LEA sensors. The derivation of the RCF value for a voltage divider for a particular phase is defined as follows:

$$\mathrm{RCF} = \frac{\text{True ratio}}{\text{Marked ratio}} = \frac{V_{pri}/V_{sec}}{\text{LEA\_R}} = \frac{V_{pri}}{V_{sec} \bullet \text{LEA\_R}} \quad \textbf{Equation 4.1}$$

where:

V_{pri}	=	Test voltage applied to the primary side of the voltage divider
V_{sec}	=	Resultant voltage measured on the secondary side of the voltage divider
True ratio	=	V_{pri} / V_{sec}
Marked ratio	=	LEA_R = effective nominal LEA sensor ratio of the voltage divider connected between the primary voltage system and the LEA input.

Similarly, the RCF value for current sensors is defined as follows:

$$\mathrm{RCF} = \frac{\text{True ratio}}{\text{Marked ratio}} = \left(\frac{I_{\mathrm{Pri}}}{\text{Sensor output voltage}}\right) \Big/ \left(\frac{\mathrm{IPR1}}{\mathrm{USR1}}\right) \quad \textbf{Equation 4.2}$$

where:

I_{Pri}	=	Test primary current passing through the Rogowski coil or low-power CT
Sensor output voltage	=	Resultant voltage generated at the terminals of the sensor
IPR1 and USR1	=	Sensitivity parameters of the sensor used

The marked LEA sensor ratio of the voltage divider or transformation ratio for the Rogowski coil sensor is always provided by the manufacturer and often the per phase RCF values are also provided.

If the voltage divider is perfect, then

V_{pri} / V_{sec} = LEA_R and RCF = 1.000

Therefore, the measured voltage divider performance equals the marked ratio of the voltage divider, as given by the manufacturer. But such perfect conditions are usually not the case.

If the voltage divider is putting out more voltage (V_{sec}) than nominally expected for an applied voltage input (V_{pri}), then

V_{pri} / V_{sec} < LEA_R and RCF < 1.000

An example of an RCF value less than 1.000 is found in *Example 4.8*. In this example, setting VBRCF = 0.883 brings down the too-high voltage on voltage input **VB** (0.82 V is brought down to nominal 0.72 V).

If the voltage divider is putting out less voltage (V_{sec}) than nominally expected for an applied voltage input (V_{pri}), then

V_{pri} / V_{sec} > LEA_R and RCF > 1.000

Similar conclusions can be drawn for Rogowski coil and LPCT current sensors.

EXAMPLE 4.8 Normalizing Voltages With Ratio Correction Factors

A voltage divider is connected to the 8 Vac LEA voltage inputs (see Figure 4.2). The RCF values per phase for the voltage divider are given as follows:

V_{ARCF} = 1.078 (voltage input **VA**)
V_{BRCF} = 0.883 (voltage input **VB**)
V_{CRCF} = 1.112 (voltage input **VC**)

The marked ratio of the voltage divider is given as:

LEA_R = 10000

What are the true ratios of each phase of the voltage divider?

true ratio = V_{pri}/V_{sec}

V_{pri} and V_{sec} are measured in manufacturer tests to derive RCF values as shown in Equation 4.1 and accompanying explanation. From Equation 4.1:

RCF • LEA_R = V_{pri}/V_{sec} = true ratio
1.078 • 10000 = 10780 (true ratio for voltage input **VA**)
0.883 • 10000 = 8830 (true ratio for voltage input **VB**)
1.112 • 10000 = 11120 (true ratio for voltage input **VC**)

Note that these true ratios vary from 8830 to 11120, while the marked ratio of the voltage divider is given as 10000.

Consider *Example 4.8*. Assume the primary voltage (V_{pri}) is the same magnitude for each phase. When this primary voltage is run through the respective true ratios, the secondary voltage outputs vary widely. Presuming a primary voltage of 12.47 kV (7.2kV line-to-neutral), the resultant secondary voltages are as follows:

7200 V / 10780 = 0.67 V (true secondary voltage to voltage input **VA**)

7200 V / 8830 = 0.82 V (true secondary voltage to voltage input **VB**)

7200 V / 11120 = 0.65 V (true secondary voltage to voltage input **VC**)

Note that the true secondary voltages to voltage inputs **VA** and **VC** are running low (below the normalized secondary voltage 0.72 V = 7200 V / 10000), while the voltage to voltage input **VB** is running high (above the normalized secondary voltage 0.72 V). But the RCF values adjust these true secondary voltages to normalized secondary voltage:

0.67 V • 1.078 = 0.72 V (normalized voltage from voltage input **VA**)

0.82 V • 0.883 = 0.72 V (normalized voltage from voltage input **VB**)

0.65 V • 1.112 = 0.72 V (normalized voltage from voltage input **VC**)

Again, the normalized secondary voltage (0.72 V) is the same for all three phases in this example, because the primary voltage is assumed to be the same magnitude for each phase (7200 V). The relay uses these normalized secondary voltages for all the voltage-based protection elements and metering. The true secondary voltages cannot be seen (via the SEL-710-5) unless the RCF values are set to unity (RCF := 1.000).

Phase Angle Compensation (PAC) for LEA Inputs

Use the VAPAC, VBPAC, and VCPAC voltage phase-angle correction Global settings for the voltage inputs **VA**, **VB**, and **VC**, respectively. Use the IAPAC, IBPAC, ICPAC, and INPAC current phase-angle correction Global settings for the current inputs **IA**, **IB**, **IC**, and **IN**, respectively. These settings compensate for the phase error caused by the LEA sensor and the cable connected to the relay. Use a positive phase-angle correction setting if the resulting phase error is negative and vice versa. For example, if the resulting phase error on the **VA** input is –1.00 degree, then set VAPAC := 1.00 degrees.

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.

Protection Elements

Thermal Overload Element

The SEL-710-5 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 is used in the SEL-710-5. 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 amperes, service factor, run state time constant, locked rotor amperes, 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 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 the % 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 K: Motor Thermal Element* for more detail on the thermal model.

The SEL-710-5 uses setting SF as the overload pickup threshold. For IEC and NEMA motors with service factor 1.0, consider an SF setting of 1.05 or higher.

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*.

Table 4.4 Overload (Thermal Model) Settings

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
LOCKD RTR TORQUE	0.30–2.00 pu	LRQ := 0.80
SLIP SOURCE[a]	VDR, STAT, R1	SLIPSRC := STAT
THERMAL METHOD[b]	RATING, RATING_1, CURVE	SETMETH := RATING_1
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
MOTOR LRA–2nd	2.5–12.0 xFLA2	LRA2 := 6.0[c]
LOCKD RTR TIME 2	1.0–600.0 s	LRTHOT2 := 10.0[c]
ACCEL FACT–2nd	0.10–1.50	TD2 :=1.00[c]
STATOR TC–2nd	AUTO, 1–2000 min	RTC2 := AUTO[c]
THERM OL CURVE1	1–46[d]	CURVE1 := 5
THERM OL CURVE2	1–45	CURVE2 := 7[c]

[a] The setting SLIPSRC is not applicable to induction motor applications. For induction motor applications, the relay uses R1 by default when the setting FLS is not set to OFF. SLIPSRC can be set for synchronous motor applications. For more information, refer to Settings Guidelines under Slip-Dependent Thermal Model for Synchronous Motors.
[b] The Rating and Curve Methods are available for the SETMETH setting only when the FLS setting is OFF.
[c] With the LEA card (Slot Z = L1), the relay internally sets LRA2 = LRA1, LRTHOT2 = LRTHOT1, TD2 = TD1, RTC2 = RTC1, and CURVE2 = CURVE1.
[d] The range shown is for the conventional Slot Z card. For the LEA card (Slot Z = L1), the range is 1–45.

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 K: Motor Thermal Element* for details).

For high-inertia motor applications, consider the slip-dependent thermal model when the FLS and LRQ data are available from the motor manufacturer. The speed switch element (see *Table 4.28*) with the virtual speed switch incorporated provides additional locked rotor protection that is particularly useful in high-inertia motor applications and when the FLS/LRQ data are not readily available.

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-710-5.

The SEL-710-5 runs rotor and stator models simultaneously. The rotor thermal model trips in locked rotor time at locked rotor current. Set SETMETH := RATING if you want 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 SETMETH := RATING_1 if the acceleration time is close to hot locked rotor time or if the number of starts allowed from cold is important. The relay automatically uses SETMETH := RATING_1 when the FLS setting previously described is enabled.

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 is greater than 2.5 times FLA and deasserts when the current drops below 2.4 times FLA.

NOTE: The SEL-710-5 normally uses settings CTR1, FLA1, LRA1, LRTHOT1, TD1, RTC1, and CURVE1. When setting E2SPEED is Y and SPEED2 control input is asserted, the relay uses CTR2, FLA2, LRA2, LRTHOT2, TD2, RTC2, and CURVE2 (see Table 4.68) instead. With the LEA card (Slot Z = L1), the relay internally sets CTR2 = ILEA_SC1, FLA2 = FLA1, LRA2 = LRA1, LRTHOT2 = LRTHOT1, TD2 = TD1, RTC2 = RTC1, and CURVE2 = CURVE1.

EXAMPLE 4.9 Thermal Element Setting

A 4000 V, 600 HP motor is protected by the SEL-710-5 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

Phase current transformers with 100:5 A rating are selected for the application. The SEL-710-5 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

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 always accelerates in less than the rated locked rotor time, you can 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 4.28) to provide locked rotor protection. See Figure 4.3 for the thermal overload limits for selected settings. Thermal Element Trip-Time Equations on page K.9 shows the equations for these and additional curves as well as definitions for hot stator and hot rotor.

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.

We recommend that you set RTC1 (and RTC2 if E2SPEED = Y and SPEED2 control input is asserted) to the specific values supplied by the motor manufacturer for optimum overload protection. For this

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

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.

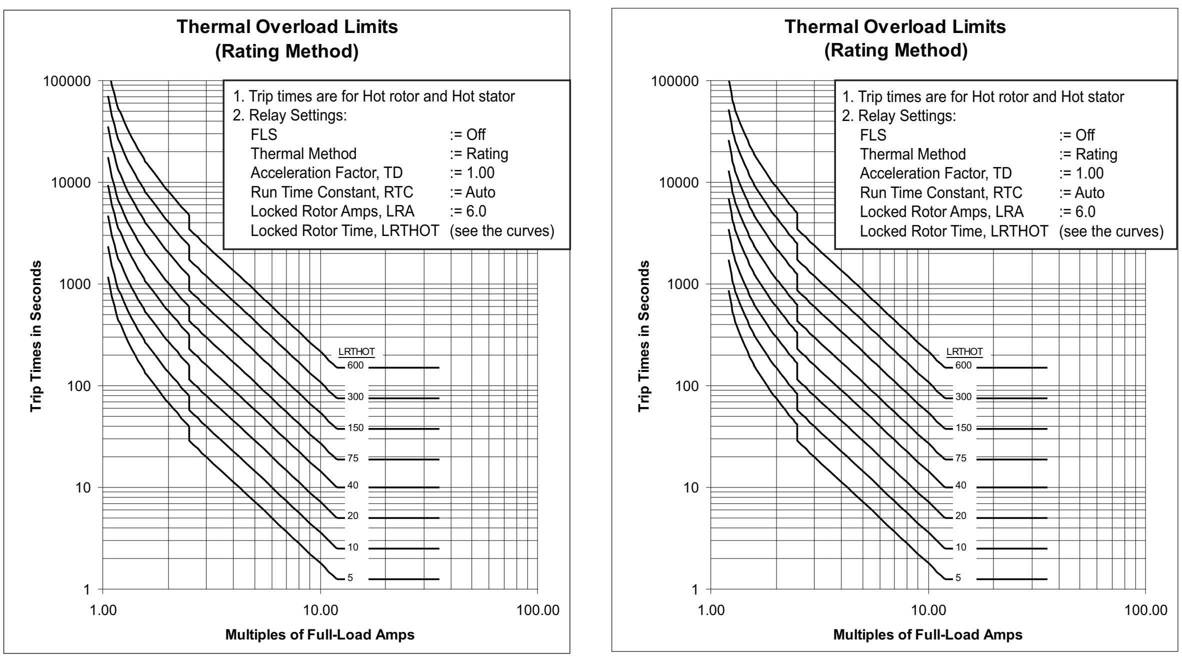
$$\mathrm{RTC} = \frac{(\mathrm{TD} + 0.2) \bullet \mathrm{LRTHOT}}{60 \bullet \ln\left[\dfrac{\mathrm{LRA}^2 - (0.9 \bullet \mathrm{SF})^2}{\mathrm{LRA}^2 - \mathrm{SF}^2}\right]} \text{ minutes}$$

$$\mathrm{RTC1} = 38 \text{ minutes}$$

$$\mathrm{COOLTIME} > 3 \bullet \mathrm{RTC1} = 3 \bullet 38 + 1 = 115 \text{ minutes}$$

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

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



(A) Service Factor = 1.01

(B) Service Factor = 1.15

Figure 4.3 Thermal Overload Limits (Rating Method)

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, is 120 percent of the time for the same motor at operating temperature (similar to the Rating_1 method). The Relay Word bit 50S asserts when the motor current is greater than 2.5 times FLA and deasserts when the current drops below 2.4 times FLA.

Figure 4.4 shows several of the available curves. *Thermal Element Trip-Time Equations on page K.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.

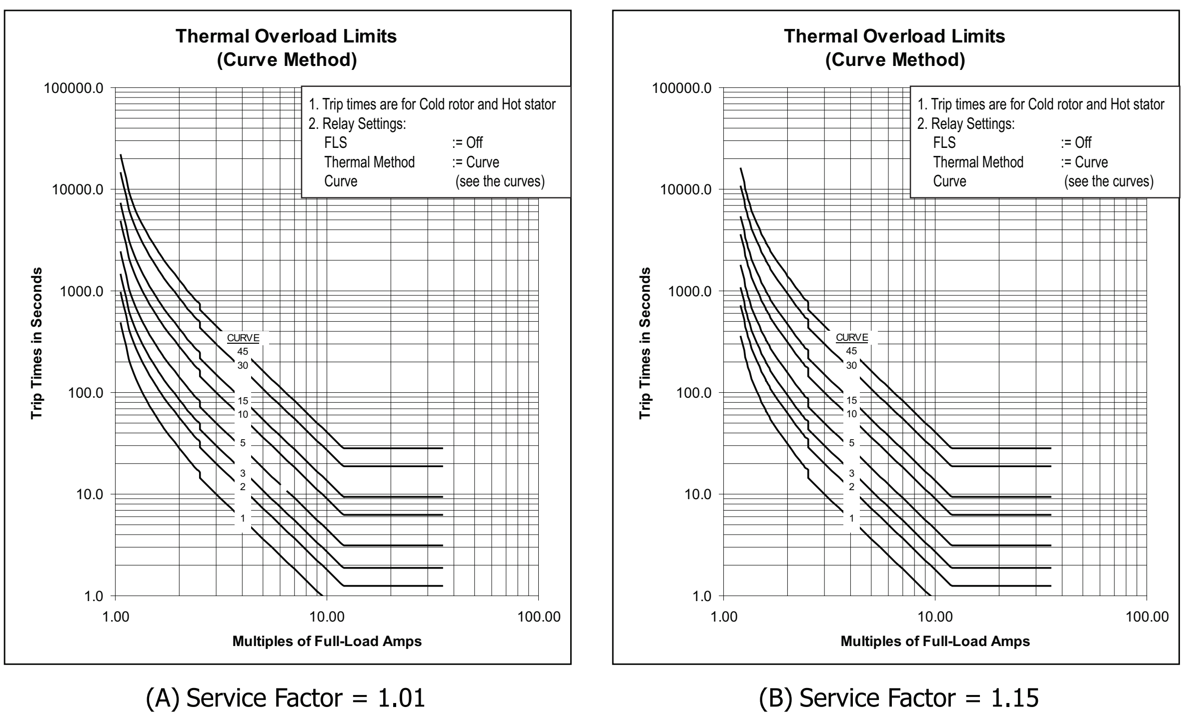


Figure 4.4 Thermal Overload Limits (Curve Method)

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]

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	
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 4.10 Thermal Element Curve Method Setting

A 4160 V, 800 HP motor is to be protected through use of the SEL-710-5 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. The SEL-710-5 settings for the application are shown below.

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 4.9 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 hot stator and cold rotor 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 can 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 4.5*. See *Table 4.6* for the available settings to construct a custom curve.

NOTE: Trip times for FL values as high as 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

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 @ 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
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 4.11 Thermal Element Curve Method, Curve := 46

A 4000 V, 3000 HP motor is to be protected using the SEL-710-5 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 4.5.

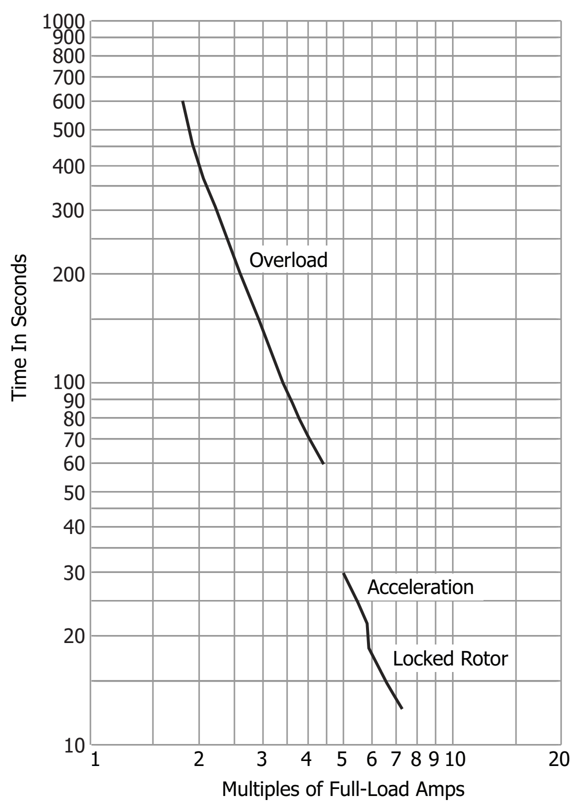


Figure 4.5 3000 HP Example Motor Thermal Limit Curve

The discontinuities in the thermal limit curve between the Overload, Acceleration, and Locked Rotor curve sections make this motor become ideal for protection by 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-710-5 settings for the application are calculated as shown below.

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

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

Equation 4.3

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

Additional Thermal Overload Settings

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	TCLRNEN := 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

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.

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 allows 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 4.4

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 4.77*, which shows the TCSTART usage for the thermal lockout logic. This feature can be disabled by setting TCSTART equal to OFF.

$$\text{TCSTART} > (\text{Start TCU}) \qquad \textbf{Equation 4.5}$$

NOTE: A 5%–10% margin is suggested for Equation 4.4, Equation 4.5, and Equation 4.6.

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.

$$49\text{RSTP} < \frac{100}{\text{SF}^2} \qquad \textbf{Equation 4.6}$$

When you use the Use Learned Starting Thermal Capacity function (TCLRNEN := Y and TCSTART≠ Off), the relay records the rotor 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.

NOTE: Reset the learned parameters prior to putting the relay in service (e.g., use the RLP Command) to erase any unintentional data learned during testing.

EXAMPLE 4.12 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 TCURTR 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 8.7*).

The relay uses the COOLTIME setting to determine the thermal model time constant when the motor is stopped. 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 stopped cooling time equation is shown in *Equation 4.7*. The relay prompts you with the minimum allowable COOLTIME when you attempt to save a value shorter than the minimum. This is useful when RTC is set to AUTO.

$$\text{COOLTIME} > 3 \bullet \text{RTC minutes} \qquad \textbf{Equation 4.7}$$

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 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 4.48.

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 lock out. *Figure 4.6* 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.

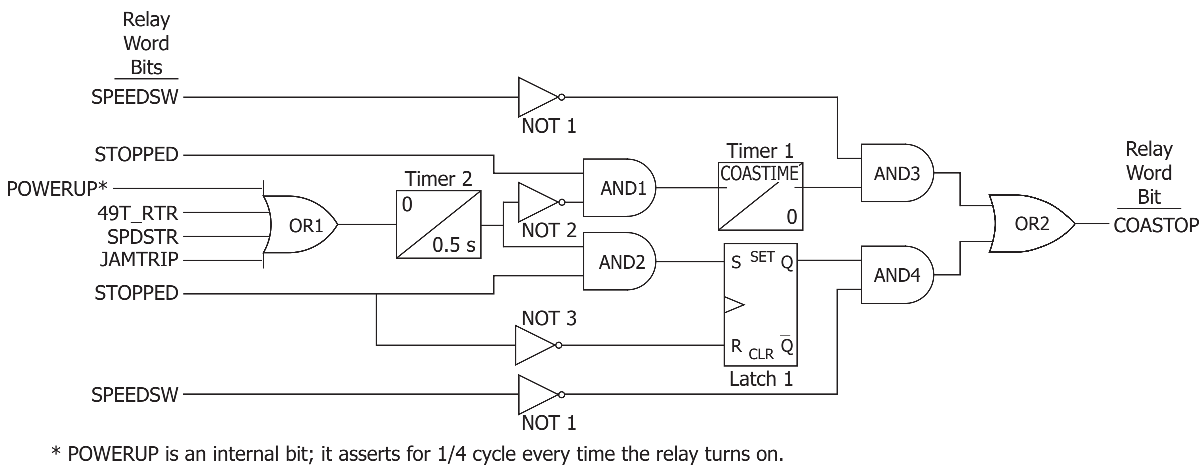


Figure 4.6 Coast-Stop Logic Diagram

NOTE: In addition to setting COOLEN := Y, you must set one RTD location equal to ambient and at least one RTD location equal to winding (see *Table 4.30* for the RTD settings).

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 4.7* shows the **MOT** command response for this case.

```
=>>MOT <Enter>

SEL-710-5                                 Date: 03/22/2017   Time: 11:02:25.671
MOTOR RELAY                               Time Source: Internal

Operating History (elapsed time in ddd:hh:mm)
Last Reset Date    06/28/2016
Last Reset Time      14:44:47
Running Time          0:01:01
Stopped Time      >  245:10:13
Time Running (%)          0.0
Total MWhr (MWhr)         0.0
Number of Starts          443
Emergency Starts           18

Avg/Peak Data
                 AVERAGE     PEAK
Start Time (s)       1.2    116.0
Max Start I (A)     97.7   1344.0
Min Start V (V)    527.9      0.0
Start %TCU          23.2   1322.2
Running %TCU         6.4    689.8
RTD %TCU            61.4    100.0
Running Cur (A)    117.7    591.8
Running kW         126.8   3862.0
Running kVARin     252.1   2299.1
Running kVARout     39.7   2306.0
Running kVA        368.1   4048.6
Max WDG RTD (C)      104      249
Max BRG RTD (C)  NA       NA
Ambient RTD (C)      219      220
Max OTH RTD (C)  NA       NA

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

=>>
```

Figure 4.7 MOTOR Command Response

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 4.30 for the RTD settings).

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

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

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

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

where

T_{AMB} = measured ambient temperature
T_{VRTDn} = biased stator winding temperature trip threshold for the *n*th winding RTD
$TRTMP_n$ = the *n*th winding trip threshold setting

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.

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

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

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-710-5 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.

In this section, we detail a procedure to set the SEL-710-5 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 computes the rotor TCU using

$$TCU[k] = 100 \bullet \frac{\Delta t \Sigma_0^k I^2[k]}{LRA^2 \bullet LRT}$$

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

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

$$\mathrm{TCU}[k] = 100 \bullet \frac{\Delta t \Sigma_0^k I^2[k] \bullet R_r}{\mathrm{LRA}^2 \bullet \mathrm{LRT} \bullet R_r}$$

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, we rewrite the TCU equation as follows:

$$\mathrm{TCU}[k] = 100 \bullet \frac{\Delta t}{\mathrm{LRA}^2 \bullet \mathrm{LRT}} \bullet \sum_0^k \frac{I^2[k] \bullet R_r(S[k])}{R_r(1)}$$

NOTE: Typically, healthy voltage inputs are required to calculate the slip-dependent rotor resistances. If a loss-of-potential is detected (Relay Word bit LOP = 1) the thermal element automatically uses Equation K.3 and Equation K.4 with slip S = 1 or 0 depending on the motor state (starting or running, respectively).

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 $S[k] \in [0, 1]$. Using R_r into the latest TCU expression:

$$\mathrm{TCU}[k] = 100 \bullet \frac{\Delta t}{\mathrm{LRA}^2 \bullet \mathrm{LRT}} \bullet \sum_0^k \frac{I^2[k] \bullet (R_1 S[k] + R_0(1 - S[k]))}{R_1}$$

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 4.8* 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.

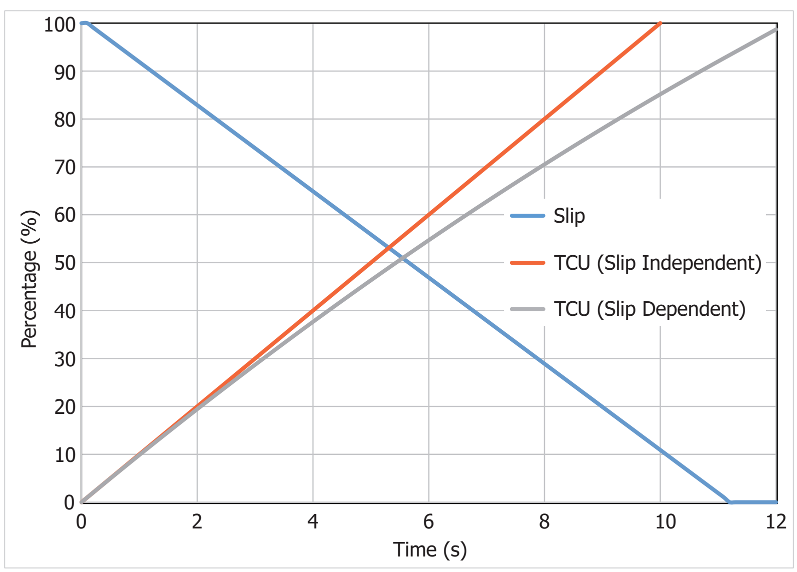


Figure 4.8 Slip-Dependent and Slip-Independent Thermal Models

For induction motors, the R_0/R_1 ratio is generally between 1/3 and 1/6. 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:

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

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

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

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

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.

VDR: The relay computes the motor slip based on the field voltage measurement (VDR). Use this method when field voltage measurements are available. When the VDR option is selected, make sure that STSEQEN asserts with the STARTING Relay Word bit.

R1: The relay computes the motor slip based on the positive-sequence resistance measured during motor start up. This method is intended for induction motor applications only. If this method is necessary for your synchronous motor application, contact SEL.

For an extensive comparison of STAT VDR and R1 methods, refer to “Synchronous rotor thermal model based on stator current modulation,” *The Journal of Engineering*, vol. 2018, no. 15, pp. 866–870, Oct. 2018.

Overcurrent Elements

If the SEL-710-5 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 value you want with an appropriate time delay.

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

NOTE: The phase overcurrent elements are disabled by the Relay Word bit BLKPROT if the setting BLK50P := Y (see Table 4.64 for details).

The phase overcurrent elements (50P1 and 50P2; see *Figure 4.9*) normally operate using the output of the cosine filter. During severe CT saturation, the cosine-filtered phase current magnitude can be substantially reduced because of the high harmonic content and reduced magnitude of the distorted secondary waveform. If the overcurrent element relied only on the output of the cosine-filtered secondary current, the operation of any high-set instantaneous overcurrent element might be severely delayed or jeopardized. For any phase instantaneous overcurrent element in the SEL-710-5 that is set greater than or equal to eight times the relay current input rating (40 A in a 5 A relay), the overcurrent element also operates on the output of a bipolar peak detector if the current waveform is highly distorted, as is the case with severe CT saturation. This ensures fast operation of the 50P*n* phase overcurrent elements even with severe CT saturation.

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

NOTE: Neutral OC trip level settings are in primary amperes.

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

NOTE: The neutral and residual overcurrent elements are disabled by the Relay Word bit BLKPROT if the setting BLK50EF := Y (see Table 4.64 for details).

NOTE: For the 2.5 mA models, the 50NxP element includes a security timer of 100 ms.

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 4.9*).

Table 4.10 Neutral Overcurrent Settings

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

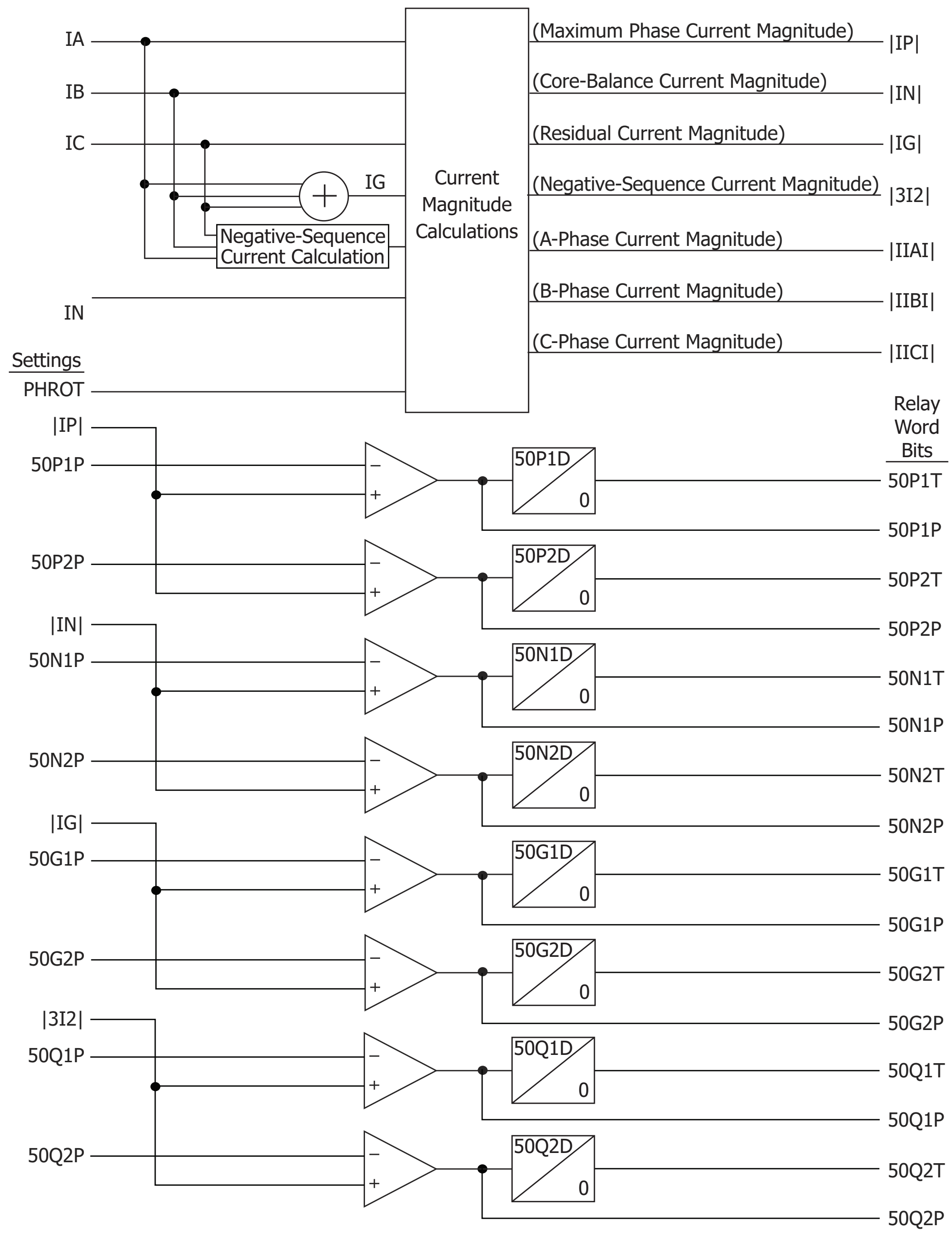


Figure 4.9 Overcurrent Element Logic

When a core-balance CT is connected to the relay **IN** input, as in *Figure 2.27*, 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.

EXAMPLE 4.13 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-710-5 **IN** current input (terminals Z07, Z08), as shown in Figure 4.10. Setting the Neutral OC CT Ratio (CTRN—see Group Settings (SET Command) on page 4.4) equal to 10 and Neutral Trip Lvl (50N1P) equal to 5 A with a 0.10-second time delay ensures that the element quickly detects and trips for motor ground faults, but prevents misoperation resulting from unequal breaker or contactor pole closing times.

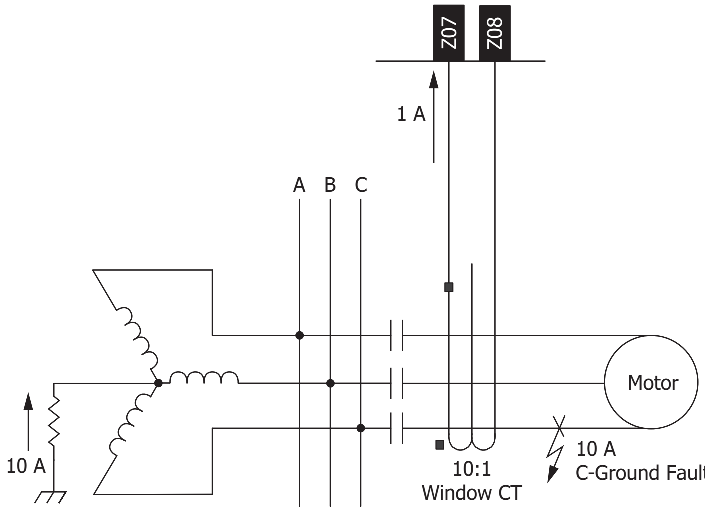


Figure 4.10 Ground Fault Protection Using Core-Balance CT

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 4.11 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	OFF, 0.00–5.00 s	50G1D := 0.50
RES OC WARN LVL	OFF, 0.10–20.00 xFLA	50G2P := OFF
RES OC WARN DLAY	OFF, 0.0–120.0 s	50G2D := 10.0

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.

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	OFF, 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	OFF, 0.1–120.0 s	50Q2D := 0.2

Incipient Cable Fault

The incipient cable fault element is used to detect self-clearing half- to one-cycle overcurrent events. This type of event is most common in cable splices and is indicative of an impending fault. As the frequency of the events increases, the likelihood of a permanent fault increases, and preventative maintenance should be scheduled.

The logic, as detailed in *Figure 4.12*, detects when two consecutive raw samples of phase current are higher than the user-defined threshold and asserts the respective phase 50INC*x* (x = A, B, or C) Relay Word bit. If the overcurrent clears within three half cycles, then an event is recorded in a history report and the counter is incremented. The phase of the cable, total number of events on each phase, and the timestamps of the most recent 32 events are kept in the report (see *Figure 4.11*), which is displayed by using the **HIS 50INC** command (see *Table 7.31*).

```
=>>HIS 50IN <Enter>

SEL-710-5                                  Date: 08/29/2019   Time: 11:09:24.098
MOTOR RELAY                                Time Source: Internal


FID=SEL-710-5-X269-V0-Z004003-D20190828

#     DATE        TIME         CNTA   CNTB   CNTC   INCF PHASE
1     08/29/2019 11:09:15.497  1      0      0       A
2     08/29/2019 11:09:15.747  2      0      0       A
3     08/29/2019 11:09:15.998  3      0      0       A
4     08/29/2019 11:09:16.248  4      0      0       A
5     08/29/2019 11:09:16.498  5      0      0       A

LAST RESET =  08/29/2019 11:09:09.024

=>>
```

Figure 4.11 HIS 50INC Report Response

To reset the counter and the event report, issue the **HIS 50INC C** command.

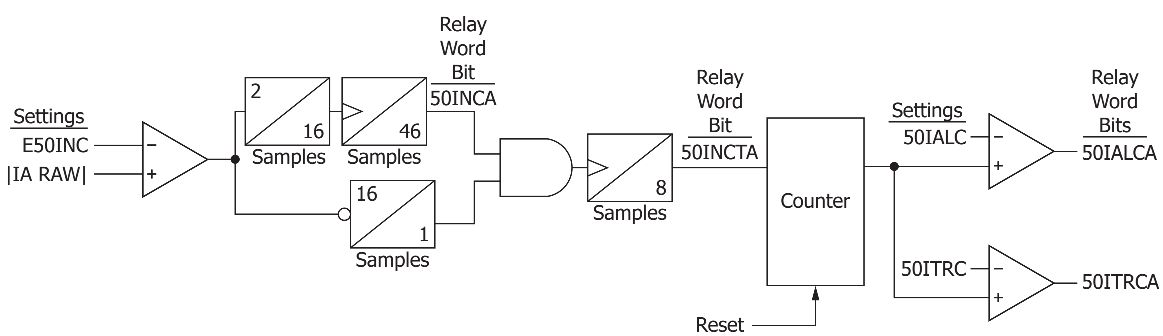


Figure 4.12 Incipient Cable Fault Logic

The logic provides a threshold for alarm via 50IALC and a threshold for tripping 50ITRC, depending on the number of detected events. These have corresponding Relay Word bits, 50IALC*x* and 50ITRC*x*, for each phase when the count on that phase is higher than the respective threshold.

Table 4.13 Incipient Cable Fault Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
50INC PU LVL	OFF, 5–50.00 A[a] 1–10.00 A[b]	E50INC := 15 E50INC := 3
50INC WARN COUNT	1–100	50IALC := 1
50INC TRIP COUNT	1–100	50ITRC := 10

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

Time-Overcurrent Elements

One level of inverse-time element is available for A-, B-, and C-phase, and negative-sequence overcurrent. Also, two levels of inverse-time elements are available for maximum phase and residual overcurrent. See *Table 4.14* through *Table 4.17* 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 4.18* and *Table 4.19* show equations for the curves and *Figure 4.17* through *Figure 4.26* 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 51_CT if you want to raise the curves by a constant time. Also, you can use 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 is operational only if IN401 is asserted).

Table 4.14 A-, B-, and C-Phase Time-Overcurrent Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a] sec, 0.10–2.00 A[b] sec	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] sec, 0.10–2.00 A[b] sec	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] sec, 0.10–2.00 A[b] sec	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

Table 4.14 A-, B-, and C-Phase Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 4.13*.

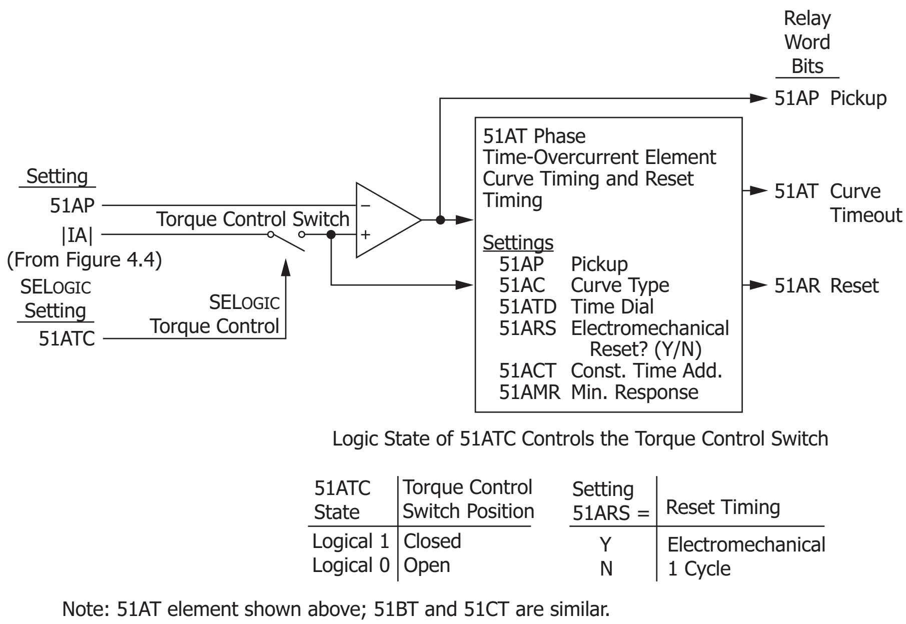


Figure 4.13 Phase Time-Overcurrent Elements 51AT, 51BT, and 51CT

Table 4.15 Maximum Phase Time-Overcurrent Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a] sec 0.10–2.00 A[b] sec	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] sec 0.10–2.00 A[b] sec	51P2P := OFF 51P2P := OFF
TOC CURVE SEL	U1, U2, U3, U4, U5, C1, C2, C3, C4, C5	51P2C := U3

Table 4.15 Maximum Phase Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 4.14*.

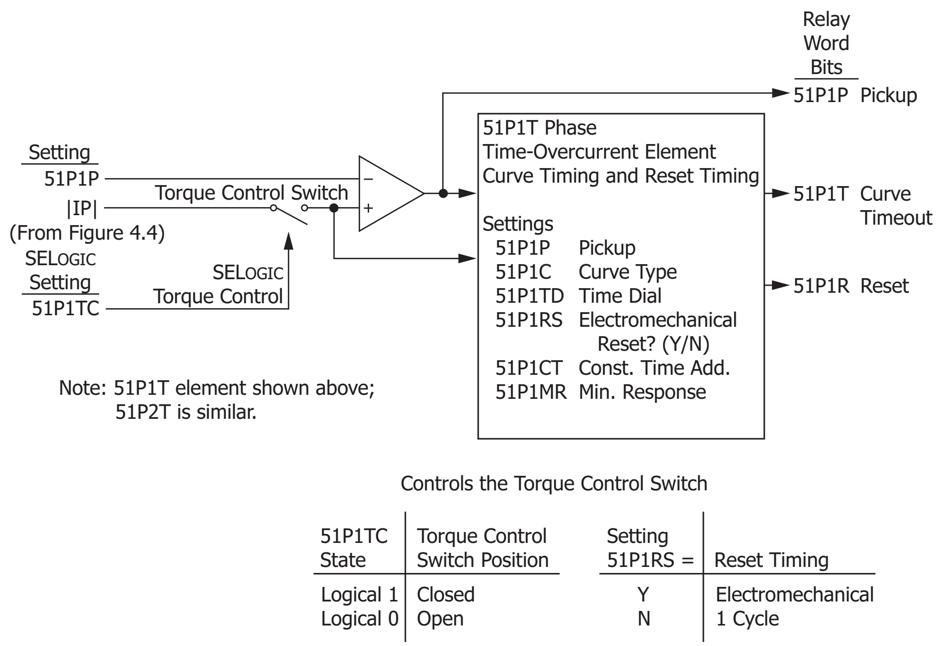


Figure 4.14 Maximum Phase Time-Overcurrent Elements 51P1T and 51P2T

Table 4.16 Negative-Sequence Time-Overcurrent Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a] sec 0.10–2.00 A[b] sec	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

Table 4.16 Negative-Sequence Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
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 4.15*.

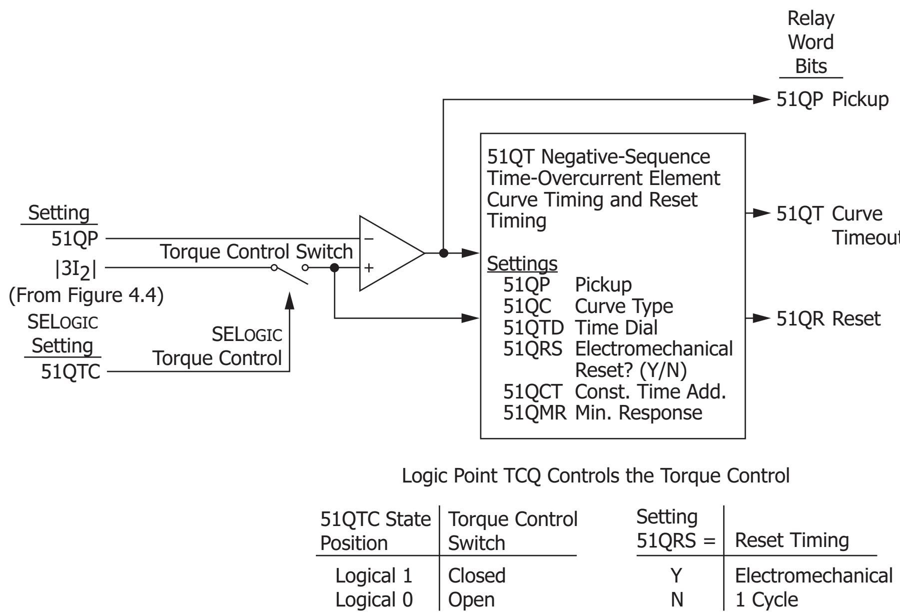


Figure 4.15 Negative-Sequence Time-Overcurrent Element 51QT

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 4.17 Residual Time-Overcurrent Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a] sec 0.10–2.00 A[b] sec	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

Table 4.17 Residual Time-Overcurrent Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOC TRIP LVL	OFF, 0.50–10.00 A[a] sec 0.10–2.00 A[b] sec	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 4.16*.

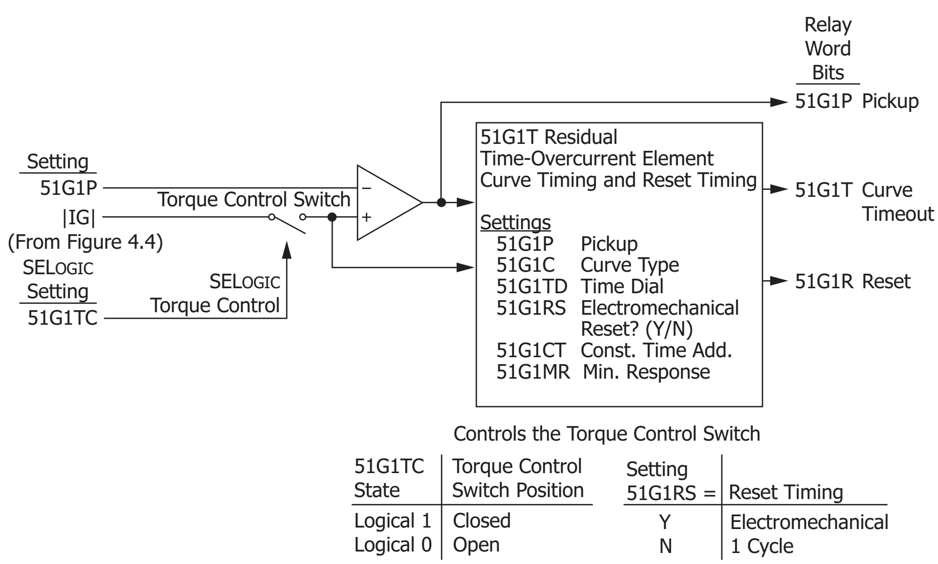


Figure 4.16 Residual Time-Overcurrent Elements 51G1T and 51G2T

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.

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 4.13* through *Figure 4.16*). The U.S. and IEC time-overcurrent relay curves are shown in *Figure 4.21* through *Figure 4.26*. Curves U1, U2, and U3 (*Figure 4.17* through *Figure 4.20*) conform to IEEE C37.112-1996, Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

Table 4.18 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 4.17*
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 4.18*
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 4.19*
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 4.20*
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 4.21*

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 4.19 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 4.22*
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 4.23*
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 4.24*
C4 (Long-Time Inverse)	$t_p = TD \bullet \left(\frac{120}{M - 1}\right)$	$t_r = TD \bullet \left(\frac{120}{1 - M^2}\right)$	*Figure 4.25*
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 4.26*

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]

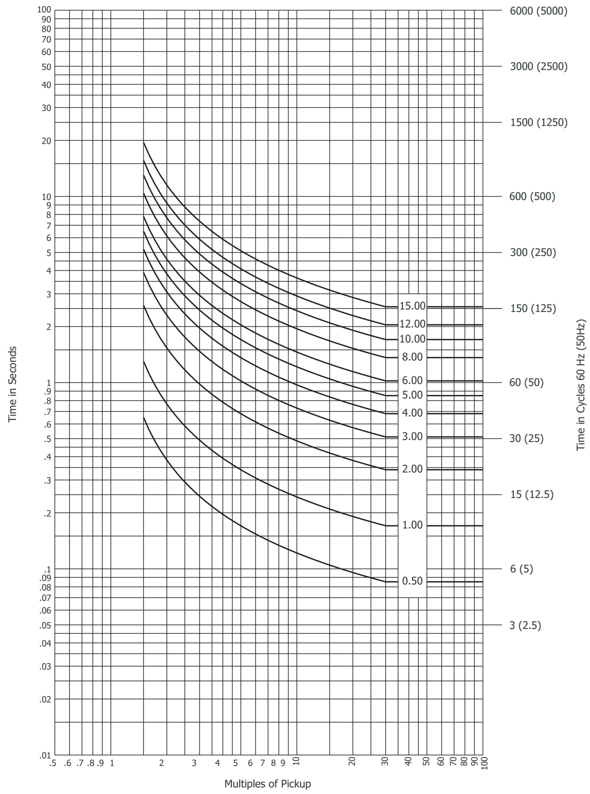


Figure 4.17 U.S. Moderately Inverse Curve: U1

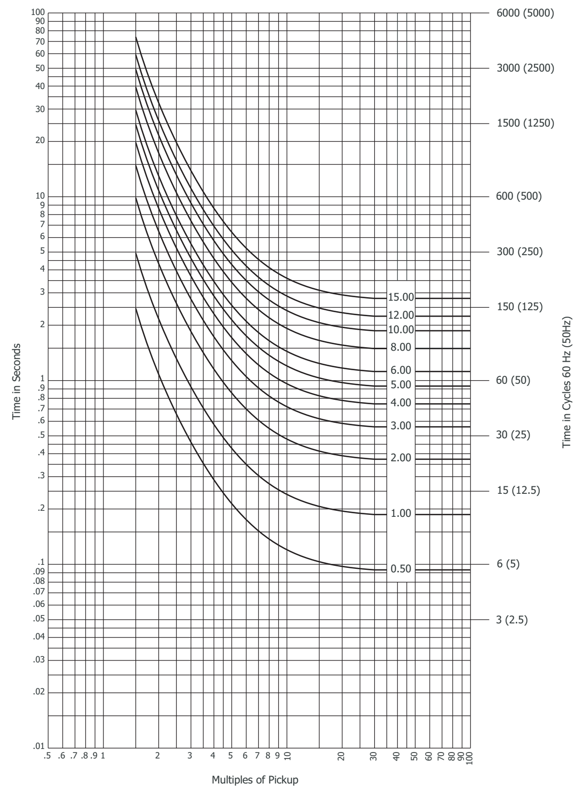


Figure 4.18 U.S. Inverse Curve: U2

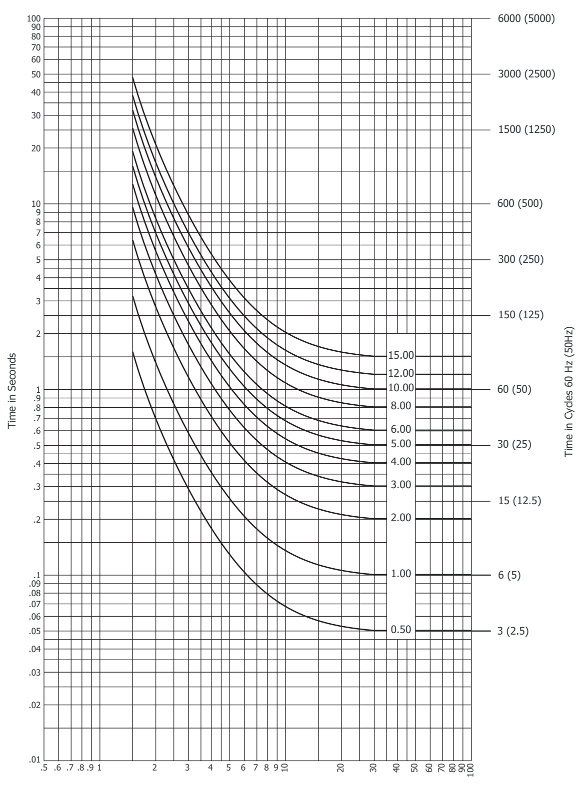


Figure 4.19 U.S. Very Inverse Curve: U3

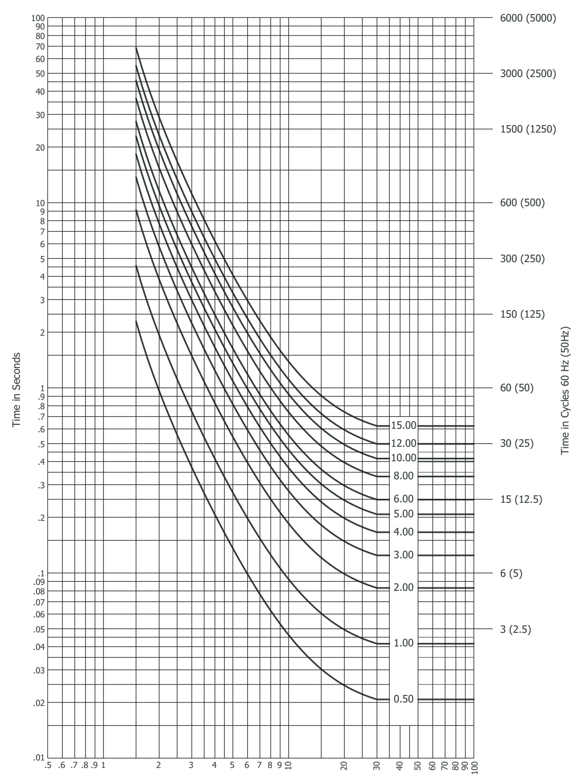


Figure 4.20 U.S. Extremely Inverse Curve: U4

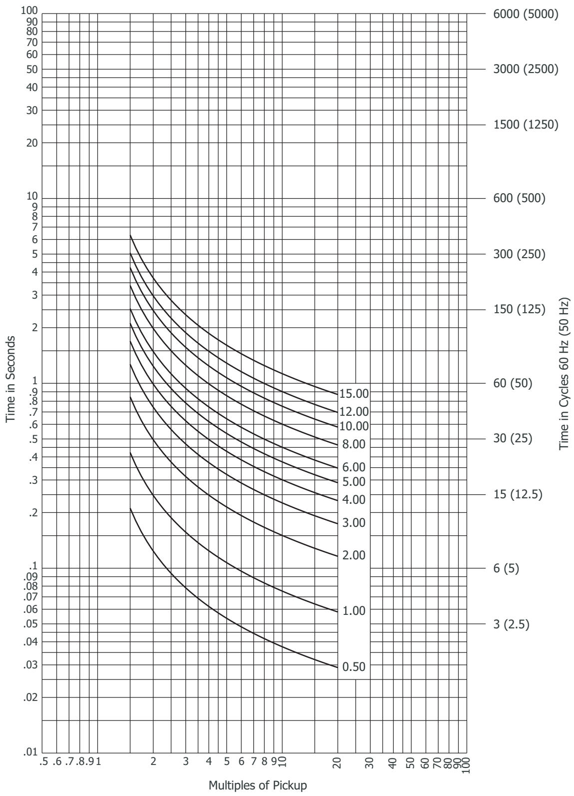


Figure 4.21 U.S. Short-Time Inverse Curve: U5

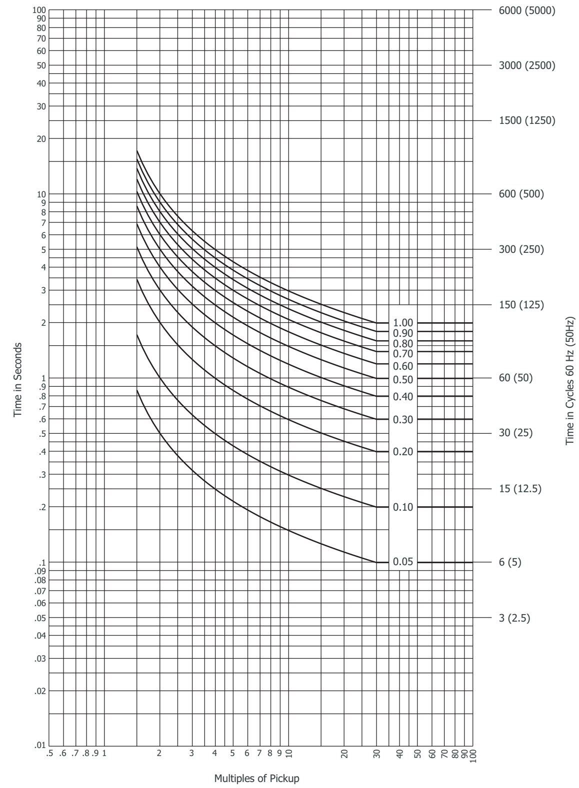


Figure 4.22 IEC Class A Curve (Standard Inverse): C1

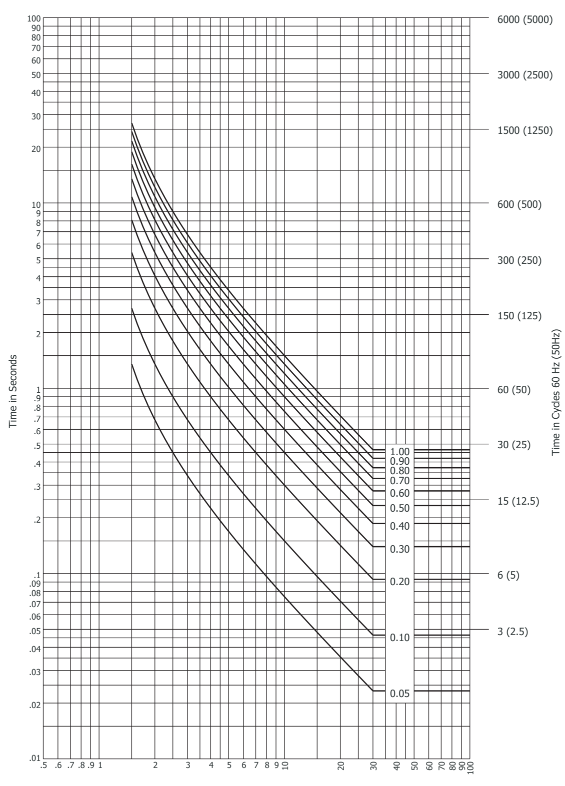


Figure 4.23 IEC Class B Curve (Very Inverse): C2

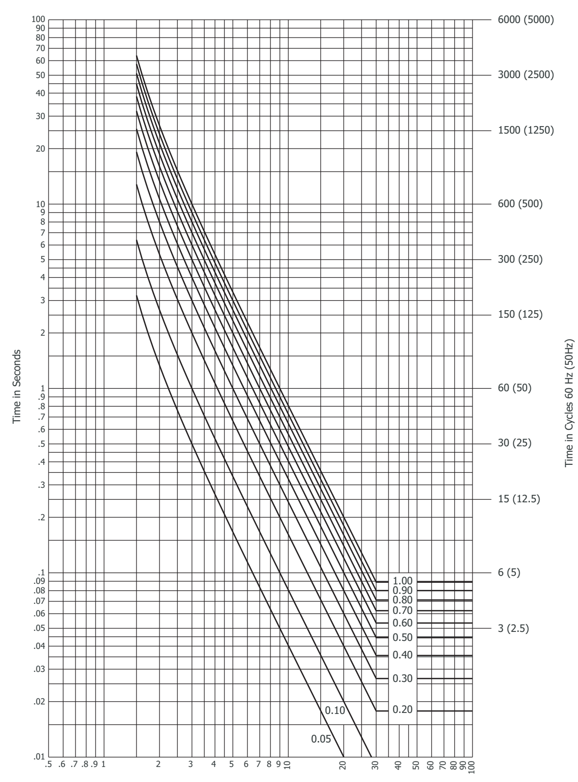


Figure 4.24 IEC Class C Curve (Extremely Inverse): C3

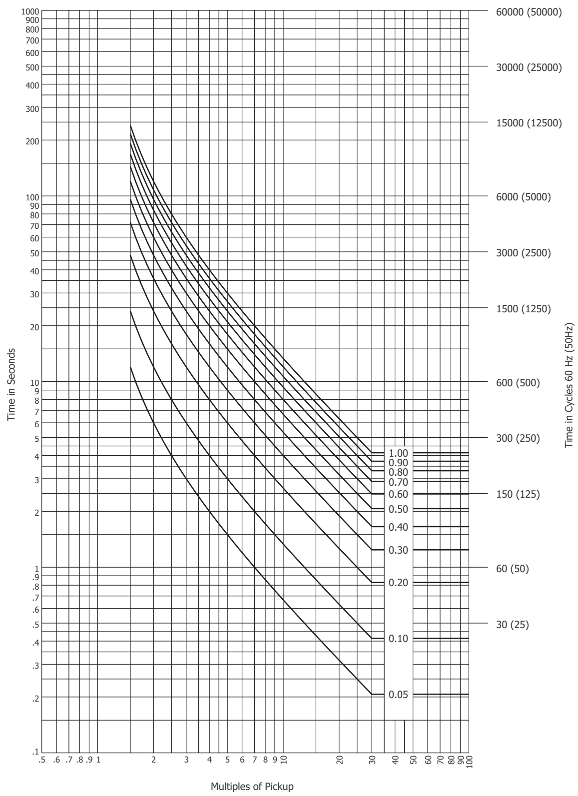


Figure 4.25 IEC Long-Time Inverse Curve: C4

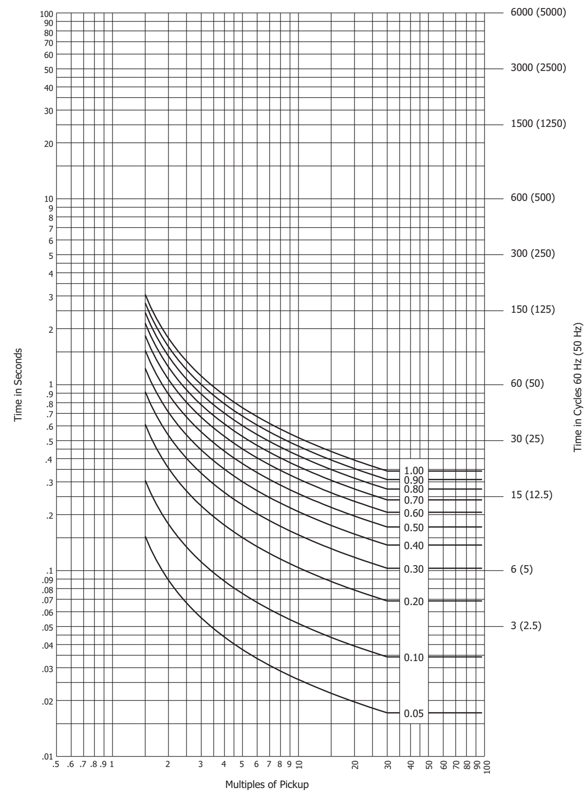


Figure 4.26 IEC Short-Time Inverse Curve: C5

Differential Elements

NOTE: If the SEL-710-5 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-710-5 optionally provides two definite-time delayed differential overcurrent elements. See *Figure 4.27* for the element logic diagrams. Use the relay with either core-balance differential CTs (see *Figure 2.28*) or with separate CTs on the source and neutral sides of the motor (see *Figure 2.29*).

Table 4.20 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 sec	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 sec	87M2P := OFF
DIFF 2 TRIP DLY	0.00–60.00 s	87M2TD := 0.10
DIFF 2 TRQ CON	SELOGIC	87M2TC := NOT 50S

A dedicated CT ratio setting (CTR87M) is provided for the differential elements. This is particularly useful when core-balance differential CTs are used because CBCT reads zero if balanced; therefore, you can detect small currents with high CT ratios.

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.

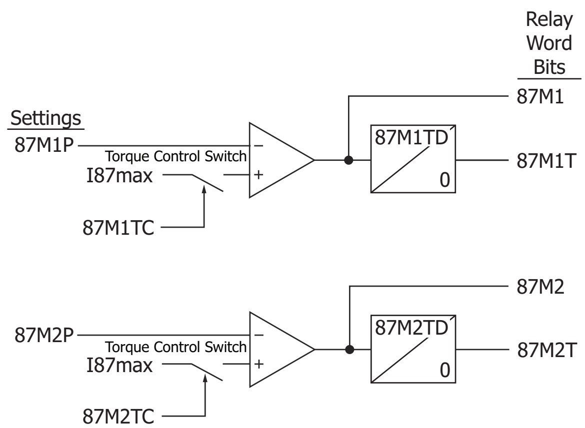


Figure 4.27 Differential Element Logic

Load-Jam Elements

NOTE: The load-jam elements are disabled by the Relay Word bit BLKPROT if the setting BLK48 := Y (see Table 4.64 for details).

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 4.28*). 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.

Table 4.21 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

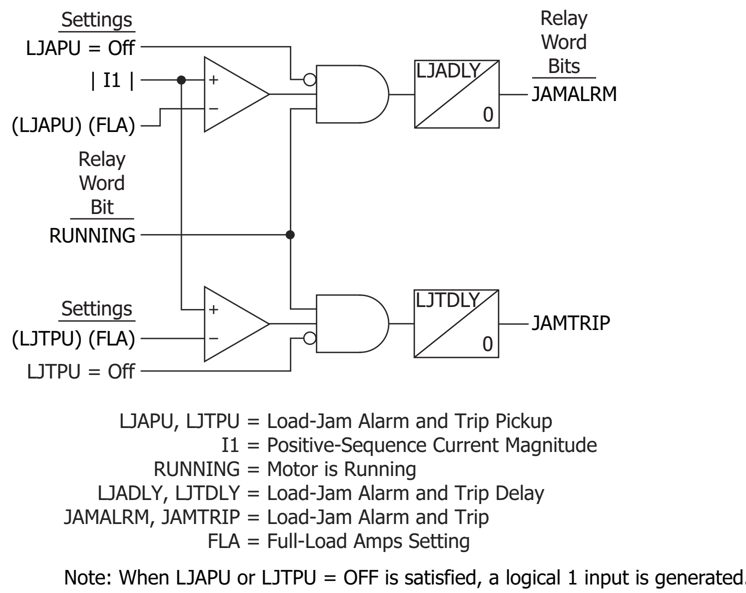


Figure 4.28 Load-Jam Element Logic

Undercurrent (Load Loss) Elements

The relay arms the load-loss detection logic a settable time after the motor starts, as defined by the undercurrent start delay time setting (LLSDLY) and shown in *Figure 4.29*. 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 4.64*).

NOTE: The undercurrent elements are disabled by the Relay Word bit BLKPROT if the setting BLK37 := Y (see Table 4.64 for details).

Table 4.22 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

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.

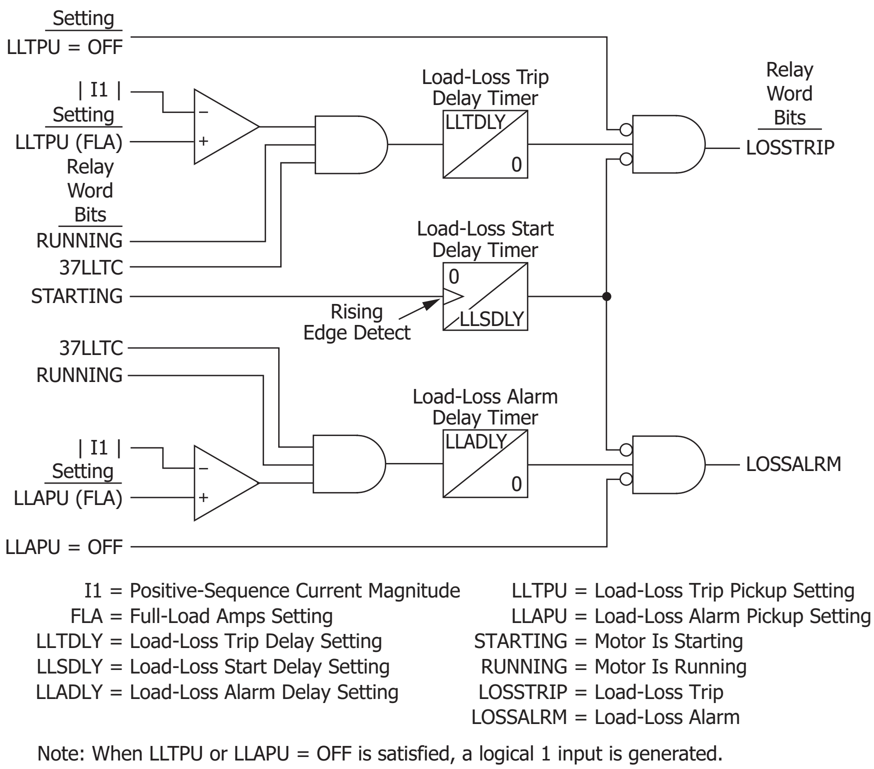


Figure 4.29 Undercurrent (Load-Loss) Logic

Current Unbalance Elements

NOTE: The current unbalance elements are disabled by the Relay Word bit BLKPROT if the setting BLK46 := Y (see Table 4.64 for details).

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-710-5 motor thermal element models the heating effect of the negative-sequence current, you may want the additional unbalanced and single-phasing protection offered by the current unbalance element.

Table 4.23 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

The SEL-710-5 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:

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

Equation 4.8

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

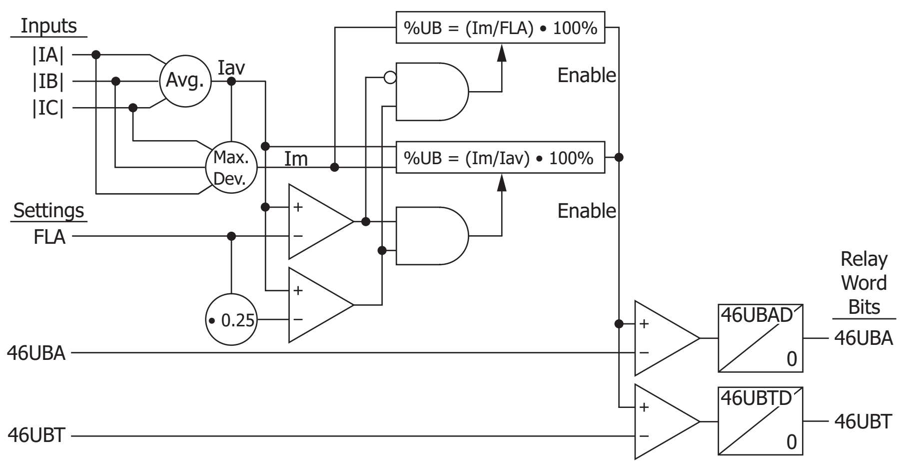
$$\text{UB\%} = 100 \bullet \frac{\text{Im}}{\text{FLA}}$$

where

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

Equation 4.9

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 4.30*).



IA = Phase Current
IB = Phase Current
IC = Phase Current
FLA = Full-Load Amps
46UBA = Phase Current Unbalance Warn Setting
46UBT = Phase Current Unbalance Trip Setting
Avg. = Average
Iav = Average Phase Current Magnitude
Im = Highest Unbalance Current Magnitude
46UBAD = Phase Current Unbalance Alarm Delay
46UBTD = Phase Current Unbalance Trip Delay

Figure 4.30 Current Unbalance Element Logic

A one percent voltage unbalance typically causes an approximate 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 approximate 2.5 percent voltage unbalance, and a 20 percent current unbalance trip setting corresponds to an approximate 3.3 percent voltage unbalance. A 10-second alarm delay and 5-second trip delay should provide adequate performance in most applications.

Start Monitoring/Incomplete Start Sequence

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

If motor starting has not finished by the START_T time, the relay produces a trip if the SMTRIP Relay Word bit (start motor time-out) asserts and is included in the TR equation. Use Start Monitoring to backup other protection and control elements, for example, the thermal model and the synchronous motor start sequence.

Table 4.24 Start Monitor Settings

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

Figure 4.31 shows the typical current during motor start and the START_T time setting. For a synchronous motor application (SYNTYPE := BRUSH OR BRUSHLESS), if the motor has not synchronized (SRUNNING := 0) by the START_T time, the relay produces a trip if the SMTRIP Relay Word bit (start motor time-out) asserts and is included in the TR equation.

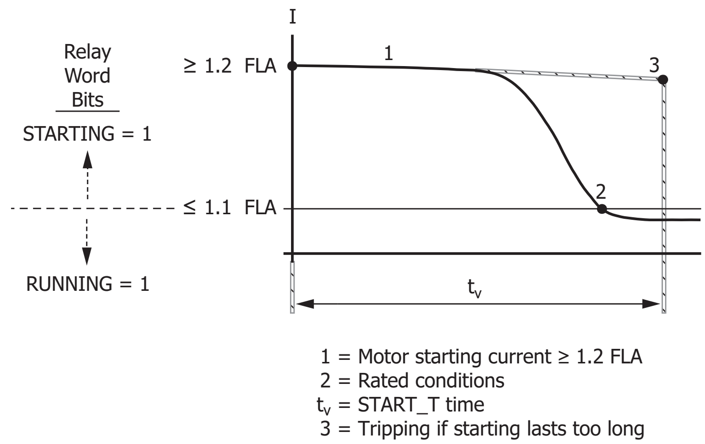


Figure 4.31 Monitoring Motor Starting Time

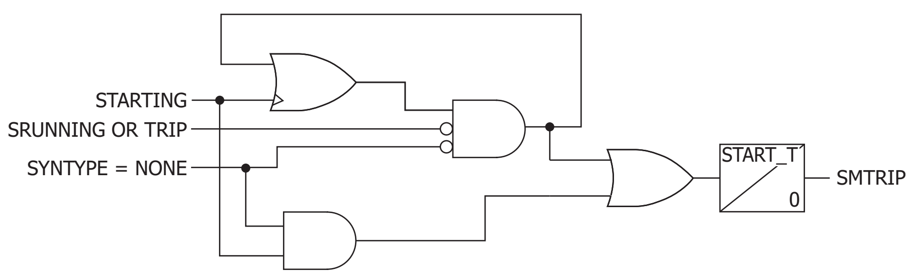


Figure 4.32 Synchronous Motor Incomplete Sequence Monitoring

Star-Delta (Wye-Delta) Starting

NOTE: In addition to enabling the star-delta, you must assign star and delta to the auxiliary output relays (one each); see Figure 2.31 for a typical connection diagram.

NOTE: When the star-delta feature is enabled, the relay automatically uses the manipulated current magnitudes during the star period of the star-delta starting sequence. The manipulated currents are 1.732 • (measured currents) and are used for the thermal model.

The SEL-710-5 issues the command to switch from star to delta (wye to delta) as soon as the starting current drops to the near-rated value in star (wye). The relay makes the change to delta within the STAR_MAX setting (if used), regardless of the magnitude of the starting current. This feature is not available when VFDAPP := Y.

Table 4.25 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

You can switch the maximum permissible time for the star (wye) operation on or off, as necessary. 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.

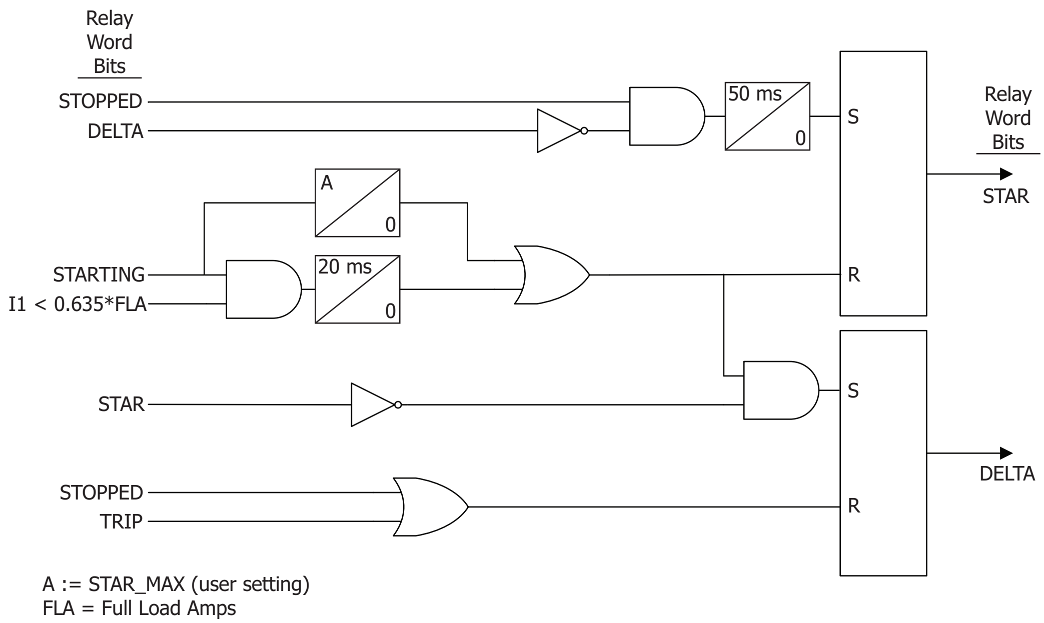


Figure 4.33 Star-Delta Starting

Start Inhibit Function

NOTE: See Figure 4.76 and Figure 4.80 for the stop/trip and start logic diagrams.

NOTE: The starts/hour element is disabled by the Relay Word bit BLKPROT if the setting BLK66 := Y (see Table 4.64 for details).

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 can 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 generates a trip signal and maintain it for at least this amount of time. The relay does not issue a start during the restart block period.

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

The emergency restart function overrides all three limits (in addition to the motor coasting; see *Figure 4.6*), allowing the motor to be placed back in service in an emergency.

Table 4.26 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

Phase Reversal Protection

The SEL-710-5 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. Incorrect phase rotation is determined using currents as voltages (see *Figure 4.34*).

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.

Table 4.27 Phase Reversal Setting

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

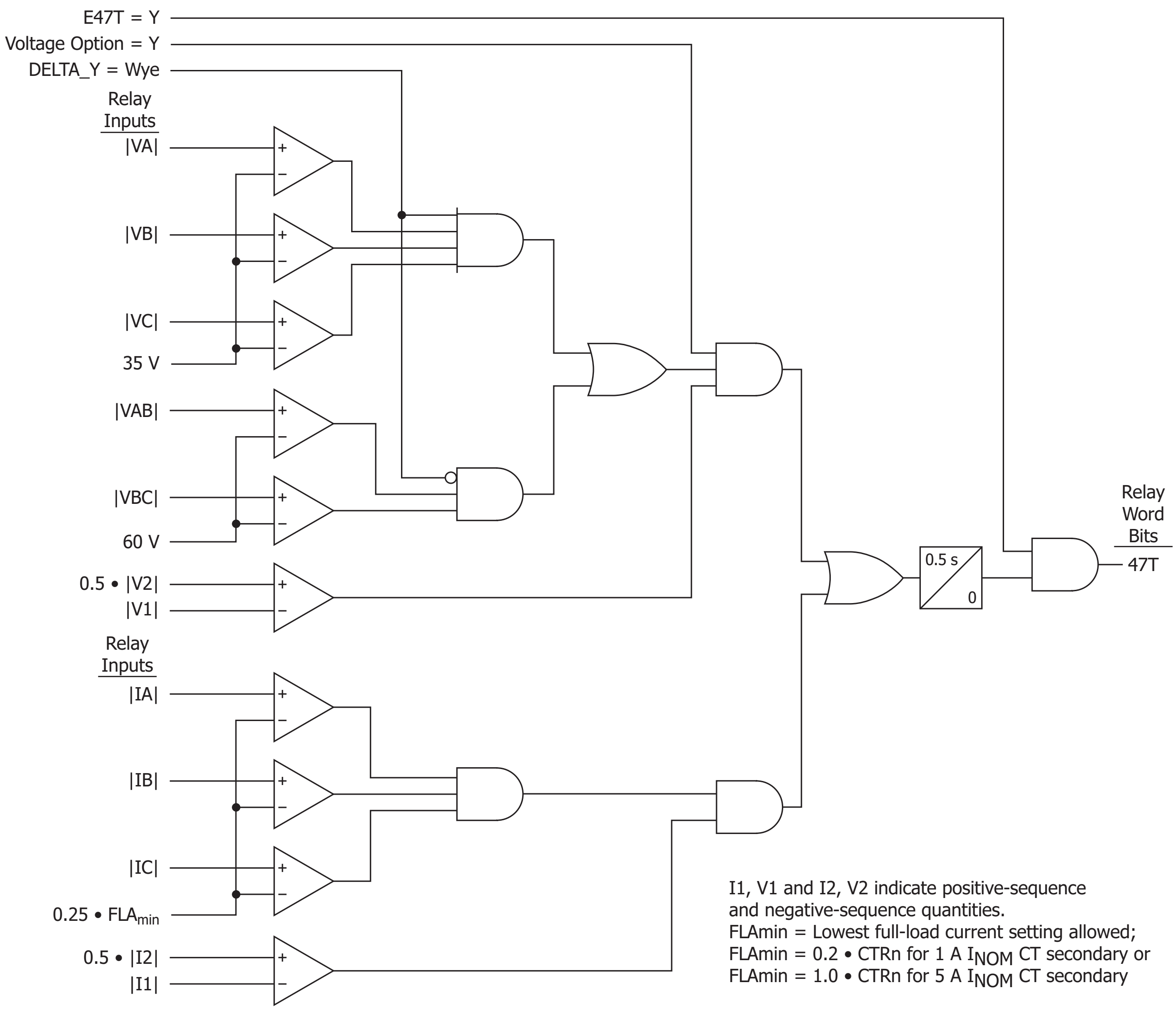


Figure 4.34 Phase Reversal Element Logic

Speed Switch (Stalling During Start) Function

NOTE: In addition to setting the SS DELAY, connect the speed switch contact (if used) to an input assigned to the speed switch (see Table 4.68 and Figure 2.19 for connection diagrams).

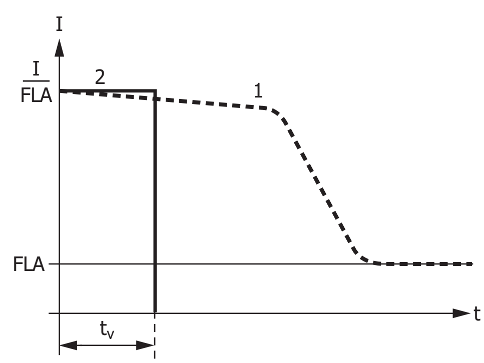
Use the physical speed switch to supplement the locked rotor (LR) protection normally provided by other elements, for example, the motor thermal model. Typically the speed switch provides faster LR protection than the other elements and is desirable in any motor application to minimize thermal and mechanical stresses caused by motor locked rotor currents. The SEL-710-5 relay offers a virtual speed switch (VSS) logic that can be used when the physical speed switch is not available. The logic also includes monitoring of the physical speed switch, if present, to enhance its reliability.

When the SPDSDLYT setting is set, the relay trips if motor speed is not detected either by the physical or virtual speed switch SPDSDLYT seconds after the motor start begins. A separate delay, SPDSDLYA, can also be set to provide a warning before the speed switch trip.

Table 4.28 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
VIR SS ENABLE	Y, N	VSSEN := N
VIR SS CONSTANT	0.80–0.98	VSSCONST := 0.95
SS FAIL OPEN DLY	OFF, 0.5–2.0 s	FAILOPND := OFF
SS FAIL CLOS DLY	0.1–120 min	FAILCLSD := 5.0
SS FAIL RESET	SELOGIC	SSFLRST := PB05

Figure 4.35 shows typical currents during motor start (normal and stall during start) and the SPDSDLYT time setting.



1 = Normal start without hindrance by high overload or stalling
2 = Stalling during starting
t_v = SS TRIP DELAY time

Figure 4.35 Stalling During Starting

Virtual Speed Switch

The virtual speed switch (VSS) provides the following major features when enabled by setting VSSEN := Y. See *Figure 4.36* for additional detail.

➤ Across-The-Line (ATL) Starting: The VSS is intended for ATL motor starting with acceleration times greater than 5 seconds.

- Subtransient Current Override: An inherent delay of 0.5 seconds overrides the subtransient inrush current typically present during ATL starts.
- Starting Current Profile Monitoring: The VSS algorithm requires both of the following occurrences to validate the rotor movement.
  - Detection of a decreasing current trend after the subtransient delay.
  - A minimum drop in starting current by a user setting VSSCONST.

  The Relay Word bit VIRSPDSW asserts if the above criteria are met. VIRSPDSW, intended for LR protection, remains asserted until the motor stops, indicated by the assertion of Relay Word bit STOPPED. The VSS logic disregards the stop coast time previously described (see *Table 4.8*).
- The following data for each motor start are stored and available as long as the motor is running. They automatically reset when the motor stops.
  - VSSCNTR: Shows the VSS logic time for the latest motor start in counts, 0.5 seconds per count from the motor start.
  - VSSCURR*n* and VSSCNT*n* (*n* = 1–3): Three current levels (in per unit of FLA) show the trend of the magnitudes and associated counts for the latest motor start.
  - VIRSPDSW: Relay Word bit that detects the rotor speed by VSS logic.

Use the VSSCONST default setting of 0.95 for most applications; however, change it to suit your specific application, as needed.

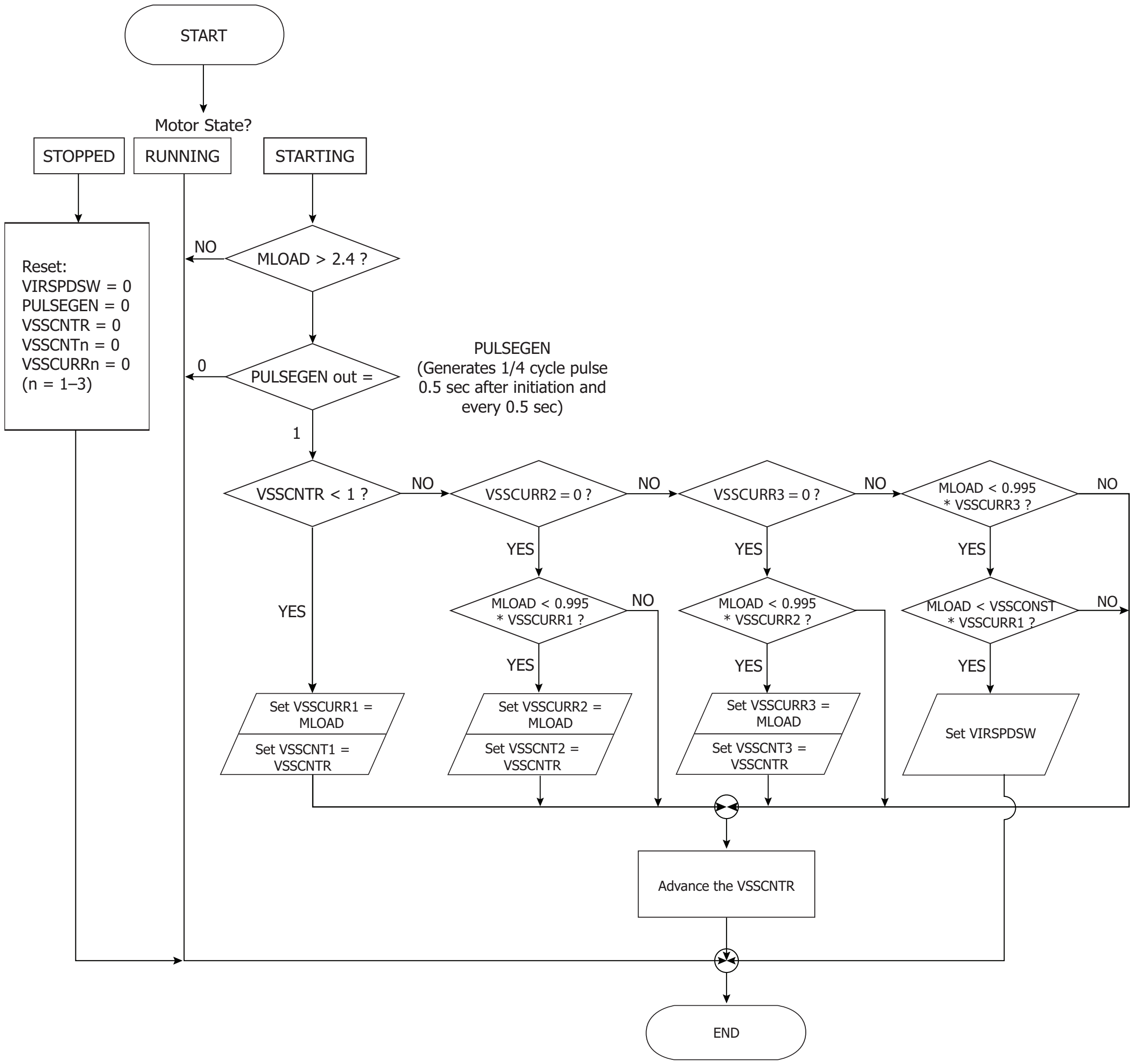


Figure 4.36 Virtual Speed Switch Flow Chart

Figure 4.37 shows the physical speed switch monitoring logic. Essentially, the logic compares the operations of the physical and virtual speed switches to detect a failure of the physical switch. There are two timer settings, one each, to detect a Failed Open and a Failed Close condition. Set the FAILOPND setting equal to the typical closing time of the physical switch to detect the rotor speed. Set the FAILCLSD setting to the longest expected rotor coasting-to-stop time plus at least a 5 percent margin. Either Relay Word bit FAILOPN or FAILCLS will assert and latch-in when detecting a Failed Open or a Failed Close condition. By default, the front-panel pushbutton PB05 and its associated LED are programmed for this feature. Change the SSFLRST SELOGIC control equation and the PB5A_LED/PB5B_LED settings if the default settings are unacceptable.

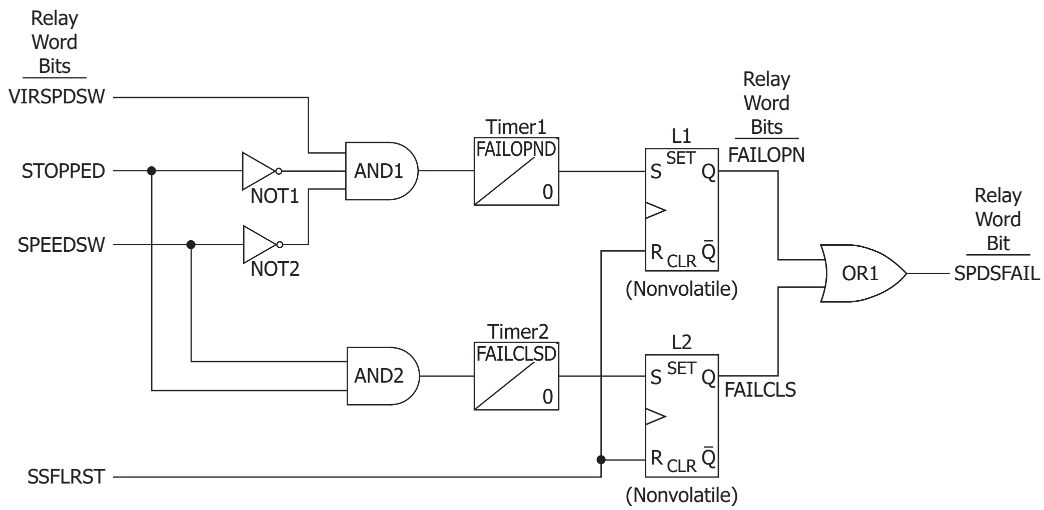


Figure 4.37 Speed Switch Monitoring Logic

Figure 4.38 shows the speed switch element logic that provides the additional LR protection with VSS and/or physical speed switch inputs. Set SPDSDLYT longer than the assert time of the physical and virtual speed switch but shorter than the locked rotor withstand time. If VSSEN := Y, set SPDSDLYT ≥ 3 seconds to coordinate with the VIRSPDSW operate time.

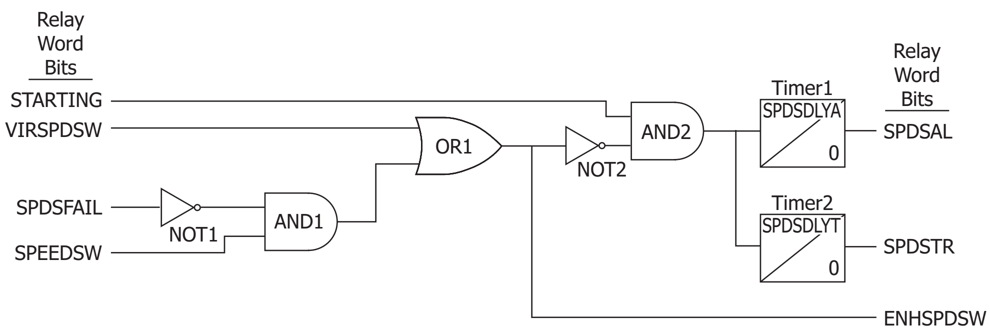


Figure 4.38 Speed Switch Element Alarm/Trip Logic

PTC/RTD-Based Protection

Thermistor (PTC) Input Function

NOTE: The PTC element is disabled by the Relay Word bit BLKPROT if the setting BLK49PTC := Y (see Table 4.64 for details).

NOTE: In addition to enabling the PTC function, you must also connect at least one thermistor to the relay (see Figure 2.20 for a connection diagram).

You can connect as many as six thermistor detectors (PTC) to the SEL-710-5 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.

Table 4.29 PTC Setting

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

The detectors and their leads are monitored for short circuits. *Figure 4.39* shows the characteristics of the PTC.

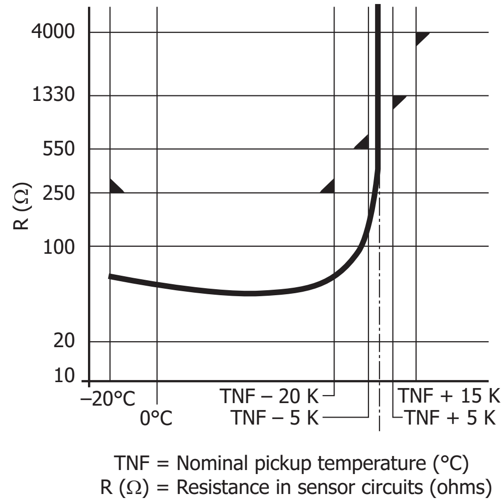


Figure 4.39 Characteristic of PTC Sensors From IEC 34-11-2

RTD Input Function

NOTE: The RTD elements are disabled by the Relay Word bit BLKPROT if the setting BLK49RTD := Y (see Table 4.64 for details).

NOTE: The SEL-710-5 monitors 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 4.30 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.

When you connect an SEL-2600 RTD Module (set E49RTD := EXT) or order the internal RTD card (set E49RTD := INT) option, the SEL-710-5 offers several protection and monitoring functions, settings for which are described in *Table 4.30*. See *Figure 2.19* for the RTD module fiber-optic cable connections. If the relay does not have internal or external RTD inputs, set E49RTD := NONE.

Table 4.30 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
• • •	• • •	• • •
RTD12 LOCATION	OFF, AMB, OTH	RTD12LOC := OFF
RTD12 IDENTIFIER	10 characters	RTD12NAM :=
RTD12 TYPE	PT100, NI100, NI120, CU10	RTD12TY := PT100
RTD12 TRIP LEVEL	OFF, 1–250°C	TRTMP12 := OFF
RTD12 WARN LEVEL	OFF, 1–250°C	ALTMP12 := 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 the following:

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

RTD Trip/Warning Levels. The SEL-710-5 provides temperature warnings and trips through use of the RTD temperature measurements and the warning and trip temperature settings in *Table 4.30*.

NOTE: To improve security, RTD FAULT, ALARM, and TRIP indicators 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. Refer to SEL Application Guide *AG2016-10: How to Identify a Faulty RTD Connected to an SEL-700 Series Relay* to determine if the RTD connected to an SEL-700 series relay is faulty.

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 a 60°C rise above ambient and the RTD % Thermal Capacity exceeds the thermal element % Thermal Capacity by more than 10 percent.

The relay uses *Equation 4.10* 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 4.10

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

When you enable RTD biasing, the SEL-710-5 automatically reduces the RTD trip temperatures for all winding RTDs when the ambient temperature is above 40°C. The relay reduces the trip temperatures by 1°C for each degree rise in ambient temperature above 40°C.

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

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 4.31 lists the RTD resistance versus temperature for the four supported RTD types.

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 than −50°C.

Table 4.31 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

Table 4.31 RTD Resistance Versus Temperature (Sheet 2 of 2)

Temp (°F)	Temp (°C)	100 Platinum	120 Nickel	100 Nickel	10 Copper
104	40.00	115.54	149.79	123.00	10.58
122	50.00	119.39	157.74	129.10	10.97
140	60.00	123.24	165.90	135.30	11.35
158	70.00	127.07	174.25	141.70	11.74
176	80.00	130.89	182.84	148.30	12.12
194	90.00	134.70	191.64	154.90	12.51
212	100.00	138.50	200.64	161.80	12.90
230	110.00	142.29	209.85	168.80	13.28
248	120.00	146.06	219.29	176.00	13.67
266	130.00	149.83	228.96	183.30	14.06
284	140.00	153.58	238.85	190.90	14.44
302	150.00	157.32	248.95	198.70	14.83
320	160.00	161.05	259.30	206.60	15.22
338	170.00	164.77	269.91	214.80	15.61
356	180.00	168.47	280.77	223.20	16.00
374	190.00	172.17	291.96	231.80	16.39
392	200.00	175.85	303.46	240.70	16.78
410	210.00	179.15	315.31	249.80	17.17
428	220.00	183.17	327.54	259.20	17.56
446	230.00	186.82	340.14	268.90	17.95
464	240.00	190.45	353.14	278.90	18.34
482	250.00	194.08	366.53	289.10	18.73

Undervoltage Function

Table 4.32 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 4.33 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 if DELTA_Y := DELTA; Vnm = VNOM/1.732 if DELTA_Y := WYE.

When you connect the SEL-710-5 voltage inputs to phase-to-phase connected VTs, as in *Figure 2.25* or *Figure 2.26*, the relay provides two levels of phase-to-phase overvoltage and undervoltage elements.

When you connect the SEL-710-5 voltage inputs to phase-to-neutral connected VTs, as in *Figure 2.25* or *Figure 2.26*, 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 4.40* and *Figure 4.41* show the logic diagram for the undervoltage and overvoltage elements, respectively. To disable any of these elements, set the level settings equal to OFF.

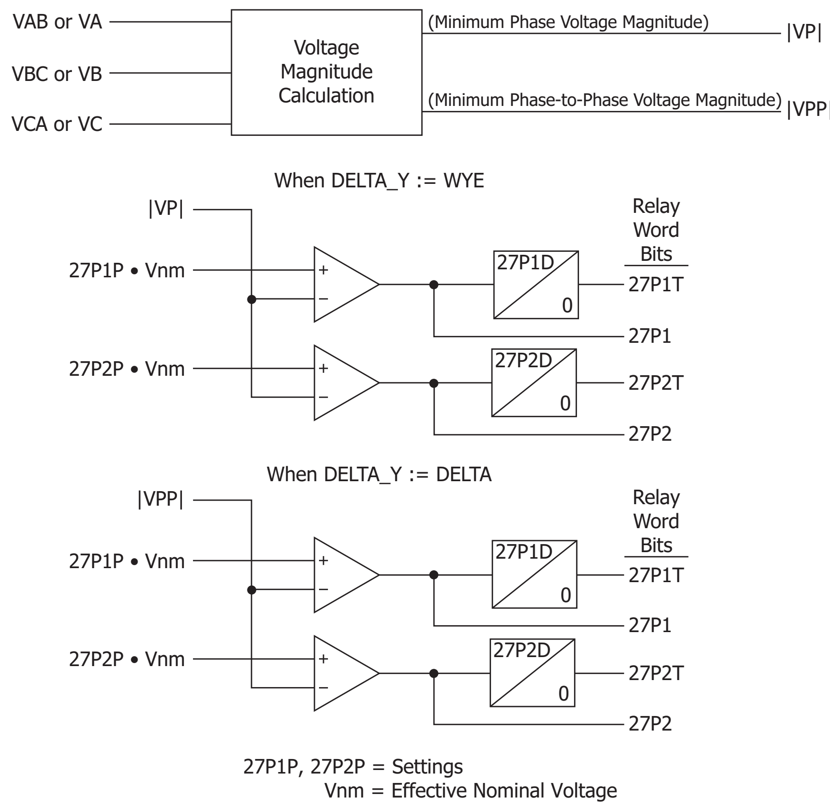


Figure 4.40 Undervoltage Element Logic

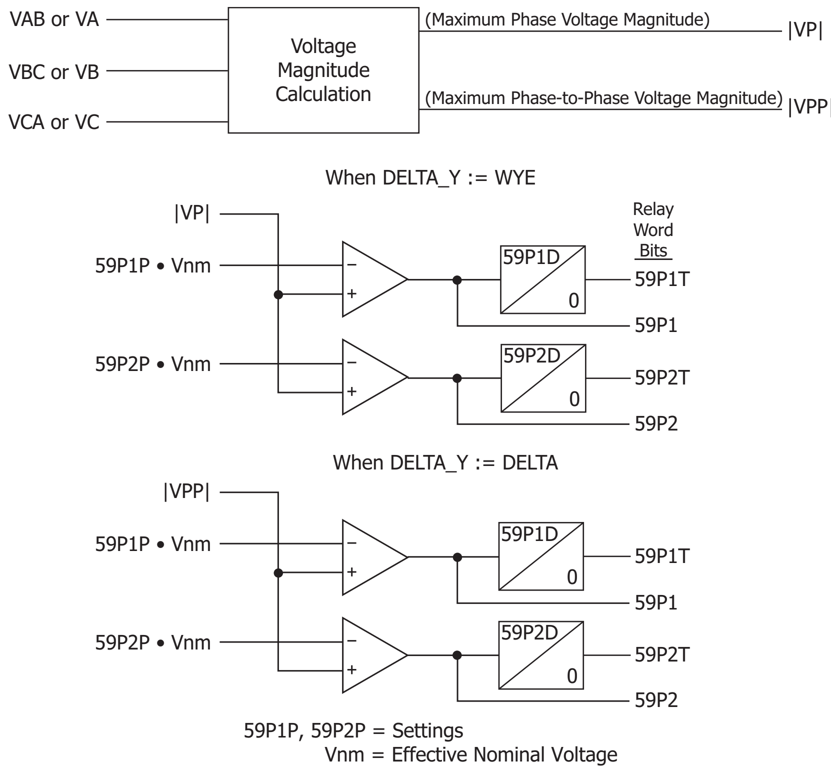


Figure 4.41 Overvoltage Element Logic

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

Inverse-Time Undervoltage Protection

The SEL-710-5 provides two inverse-time undervoltage protection elements (27I1 and 27I2). Based on relay hardware options and settings, the 27I element offers the flexibility of using various analog quantities as operating quantities. The availability of these analog quantities is contingent on the settings DELTA_Y and SINGLEV, as indicated in *Table 4.34*.

Table 4.34 Operating Quantities for the 27I Element

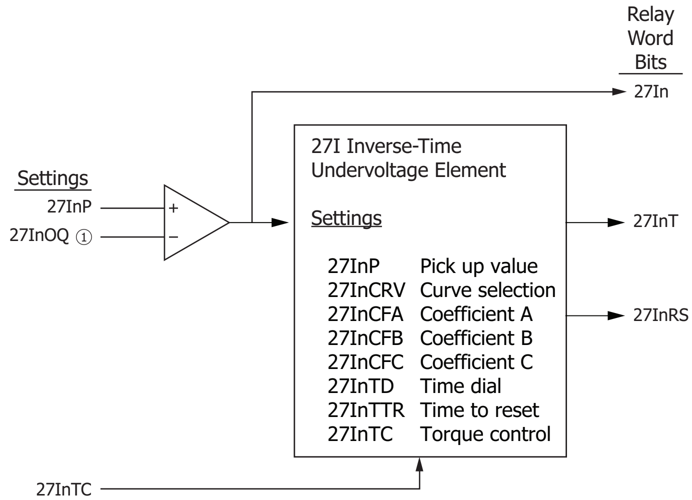
Settings		Operating Quantities Available in 27InOQ Range[a]								
DELTA_Y	**SINGLEV**	**VAB**	**VBC**	**VCA**	**VA**	**VB**	**VC**	**V1**	**MINLL**	**MINLN**
DELTA	N	#	#	#	—	—	—	#	#	—
DELTA	Y	#	—	—	—	—	—	—	—	—
WYE	N	$	$	$	#	#	#	#	$	#
WYE	Y	—	—	—	#	—	—	—	—	—

= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available
The "#" and "$" signs indicate the setting range for 27InP (n = 1 or 2).

[a] The physical meanings of the operating quantities are described as follows:

VAB: Magnitude of A-to-B-phase voltage
VBC: Magnitude of B-to-C-phase voltage
VCA: Magnitude of C-to-A-phase voltage
VA: Magnitude of A-phase voltage
VB: Magnitude of B-phase voltage
VC: Magnitude of C-phase voltage
V1: Magnitude of positive-sequence voltage
MINLL: Magnitude of the minimum phase-to-phase voltage
MINLN: Magnitude of the minimum phase-to-neutral voltage

Figure 4.42 shows the inputs, settings, and outputs of the inverse-time undervoltage element.



n = 1 or 2. ① Refer to Table 4.34.

Figure 4.42 Logic Diagram of the Inverse-Time Undervoltage Element

When the fundamental frequency component of the operating quantity falls below the pickup setting (27I*n*P), Relay Word bit 27I*n* asserts. The timer does not start to integrate unless the operating quantity falls below 0.975 • 27I*n*P. The inverse-time undervoltage protection element has the characteristic defined by *Equation 4.11*.

$$TTT_n = 27InTD \bullet \left(27InCFB + \frac{27InCFA}{\left(1 - \frac{27InOQ}{27InP}\right)^{27InCFC}} \right)$$

Equation 4.11

The settings used are listed in *Table 4.35*.

Table 4.35 Inverse-Time Undervoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
27I ENABLE	Y, N	E27I*n* := N
OPERATING QTY	Refer to *Table 4.34*	27I*n*OQ := VAB
PICKUP LVL	Refer to *Table 4.34*	27I*n*P := 120.00
CURVE	CURVEA, CURVEB, COEF	27I*n*CRV := CURVEA
COEFF A	0.00–3.00	27I*n*CFA := 1
COEFF B	0.00–3.00	27I*n*CFB := 0
COEFF C	0.01–3.00	27I*n*CFC := 1
TIME DIAL	0.00–16.00	27I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	27I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	27I*n*TC := 1

The SEL-710-5 provides three curve options for each of the 27I elements, settable via the 27I*n*CRV setting—CURVEA, CURVEB, and COEF (user programmable curve). CURVEA is compliant with IEC 60255-127 and is the IEC standard curve as shown in *Figure 4.43*. CURVEB is a non-standard curve as shown in *Figure 4.43*. The curve option COEF is the user programmable curve. Set the coefficient related settings 27I*n*CFA, 27I*n*CFB and 27I*n*CFC to realize the curve that meets your application needs. *Table 4.36* shows the parameters of the three curves. Note that when 27I*n*CRV is set to CURVEA or CURVEB the coefficient related settings 27I*n*CFA, 27I*n*CFB and 27I*n*CFC are forced to the values shown in *Table 4.36* and hidden.

Table 4.36 Specification of Inverse-Time Undervoltage Protection Element

Curve Description	Curve Defining Constants		
	27InCFA	27InCFB	27InCFC
Curve A	1	0	1
Curve B	0.98	1.28	2.171
Programmable Curve	0.00–3.00	0.00–3.00	0.01–3.00

n = 1 or 2.

When the operating quantity exceeds the pickup level, 27I*n*P, then the output remains deasserted. If the operating quantity exceeds the pickup level for the reset time setting, 27I*n*TTR, then the time integrator resets to 0.

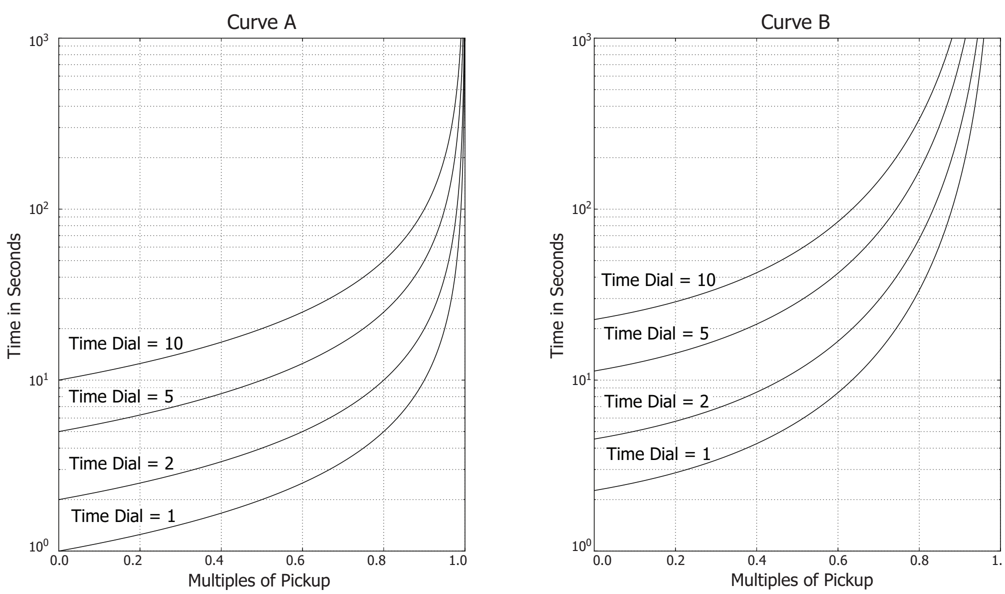


Figure 4.43 Inverse Time-Undervoltage Element Curves

Inverse-Time Overvoltage Protection

There are four inverse-time overvoltage elements (59I) available. Based on relay hardware options and settings, the 59I element offers the flexibility of using various analog quantities as operating quantities. The availability of these analog quantities is contingent on the settings DELTA_Y and SINGLEV, as indicated in *Table 4.37*.

Table 4.37 Operating Quantities for the 59I Element

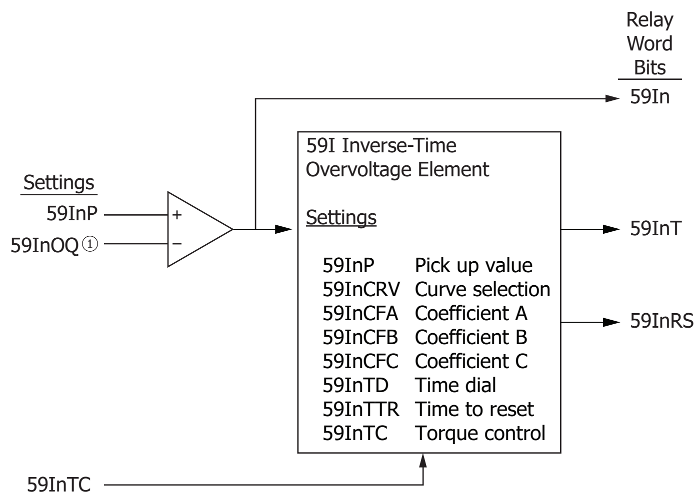
Settings		Operating Quantities Available in 59InOQ Setting Range[a]										
DELTA_Y	SINGLEV	VAB	VBC	VCA	VA	VB	VC	VG	V1	3V2	MAXLL	MAXLN
DELTA	N	#	#	#	—	—	—	—	#	#	#	—
DELTA	Y	#	—	—	—	—	—	—	—	—	—	—
WYE	N	$	$	$	#	#	#	#	#	#	$	#
WYE	Y	—	—	—	#	—	—	—	—	—	—	—

= 2.00–300.00 V $ = 2.00–520.00 V — Operating quantity is not available
The "#" and "$" signs indicate the setting range for 59InP (n = 1, 2, 3, or 4).

[a] The physical meanings of the operating quantities are described as follows:

VAB: Magnitude of A-to-B phase voltage
VBC: Magnitude of B-to-C phase voltage
VCA: Magnitude of C-to-A phase voltage
VA: Magnitude of A-phase voltage
VB: Magnitude of B-phase voltage
VC: Magnitude of C-phase voltage
VG: Magnitude of zero-sequence voltage
V1: Magnitude of positive-sequence voltage
3V2: Magnitude of negative-sequence voltage
MAXLL: Magnitude of the maximum phase-to-phase voltage
MAXLN: Magnitude of the maximum phase-to-neutral voltage

Figure 4.44 shows the inputs, settings and outputs of the inverse-time overvoltage element.



n = 1, 2, 3, or 4. ① Refer to Table 4.37.

Figure 4.44 Logic Diagram of the Inverse-Time Overvoltage Element

When the fundamental frequency component of the operating quantity exceeds the pickup setting, 59I*n*P, Relay Word bit 59I*n* asserts. The timer won't start to integrate unless the operating quantity exceeds 1.025 • 59I*n*P. The inverse-time overvoltage protection element has the characteristic defined by *Equation 4.12*.

$$TTT_n = 59InTD \bullet \left(59InCFB + \frac{59InCFA}{\left(\frac{59InOQ}{59InP}\right)^{59InCFC} - 1} \right)$$

Equation 4.12

The settings used are listed in *Table 4.38*.

Table 4.38 Inverse-Time Overvoltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
59I ENABLE	Y, N	E59I*n* := N
OPERATING QTY	Refer to *Table 4.37*	59I*n*OQ := VAB
PICKUP LVL	Refer to *Table 4.37*	59I*n*P := 120.00
CURVE	CURVEA, CURVEB, CURVEC, COEF	59I*n*CRV := CURVEA
COEFF A	0.00–6.00	59I*n*CFA := 3.88
COEFF B	0.00–3.00	59I*n*CFB := 0.96
COEFF C	0.01–3.00	59I*n*CFC := 2.00
TIME DIAL	0.00–16.00	59I*n*TD := 1.00
RESET TIME	0.00–1.00 sec	59I*n*TTR := 0.01
TRQ CONTROL	SELOGIC	59I*n*TC := 1

The SEL-710-5 provides four curve options for each of the 59I elements, settable via the 59I*n*CRV setting—CURVEA, CURVEB, CURVEC, and COEF (user-programmable curve). The characteristics of Curve A, Curve B, and Curve C are shown in *Figure 4.45*.

The curve option COEF is the user-programmable curve. Set the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC to realize the curve that meets your application needs. *Table 4.39* shows the parameters of the three curves. Note that when 59I*n*CRV is set to CURVEA, CURVEB, or CURVEC the coefficient related settings 59I*n*CFA, 59I*n*CFB, and 59I*n*CFC are forced to the values shown in *Table 4.39* and hidden.

Table 4.39 Specification of Inverse-Time Overvoltage Protection Element

	Curve Defining Constants		
Curve Description	59InCFA	59InCFB	59InCFC
Curve A	3.88	0.96	2
Curve B	5.64	0.24	2
Curve C	0.14	0	0.02
Programmable Curve	0.00–6.00	0.00–3.00	0.01–3.00

n = 1, 2, 3, or 4.

When the operating quantity remains lower than the pickup level, 59I*n*P, then the output remains deasserted. If the operating quantity gets lower than the pickup level for the reset time setting, 59I*n*TTR, then the time integrator resets to 0.

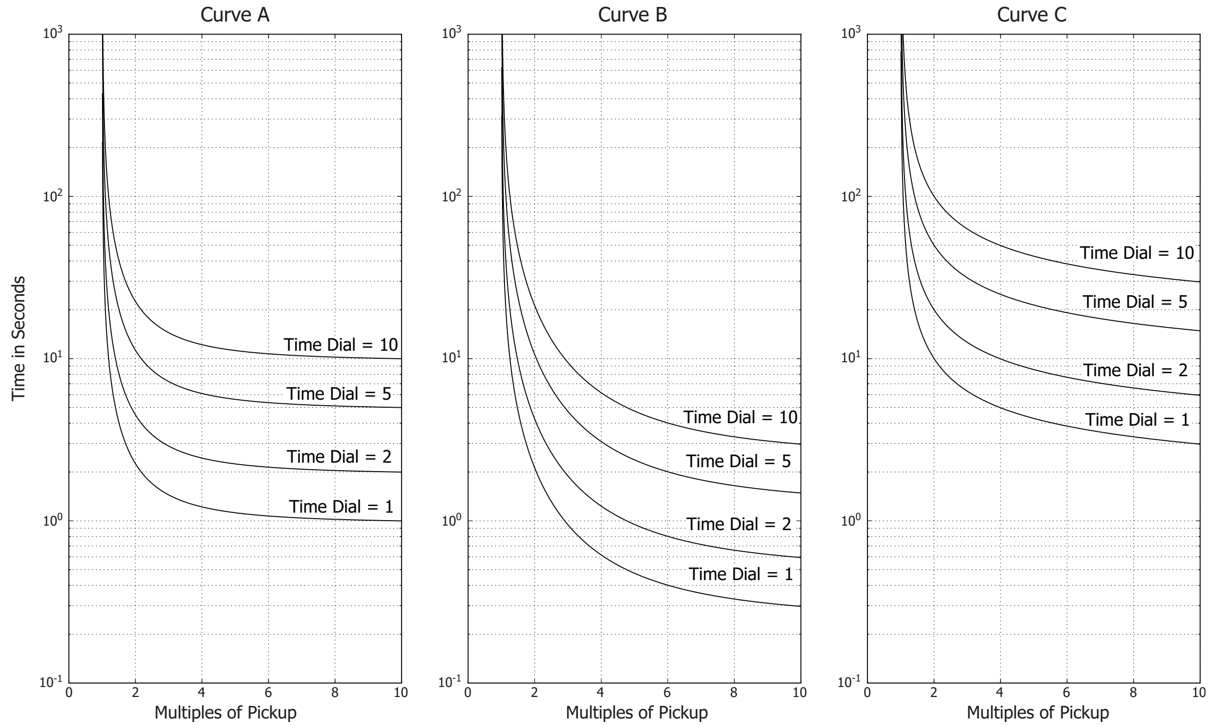


Figure 4.45 Inverse-Time Overvoltage Element Curves

VAR Function

If the positive or negative reactive power exceeds the appropriate level for longer than the time-delay setting, the relay issues a warning or trip signal. The reactive power elements are disabled when the motor is stopped or starting.

Table 4.40 VAR Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
NEG VAR TRIP LEV	OFF, 1–25000 kVAR pri	NVARTP := OFF
POS VAR TRIP LEV	OFF, 1–25000 kVAR pri	PVARTP := OFF
VAR TRIP DELAY	0–240 s	VARTD := 1
NEG VAR WARN LEV	OFF, 1–25000 kVAR pri	NVARAP := OFF
POS VAR WARN LEV	OFF, 1–25000 kVAR pri	PVARAP := OFF
VAR WARN DELAY	0–240 s	VARAD := 1
VAR ARMING DELAY	0–5000 s	VARDLY := 0

Figure 4.46 shows the logic diagram for the VAR elements. These elements detect synchronous motor out-of-step or loss-of-field conditions. In the case of synchronous motor applications, SYNTYPE := BRUSH or BRUSHLESS, program the VARDLY setting to a value that ensures that the currents and voltages are stabilized after the motor is synchronized. This prevents any nuisance trips immediately after the synchronization process.

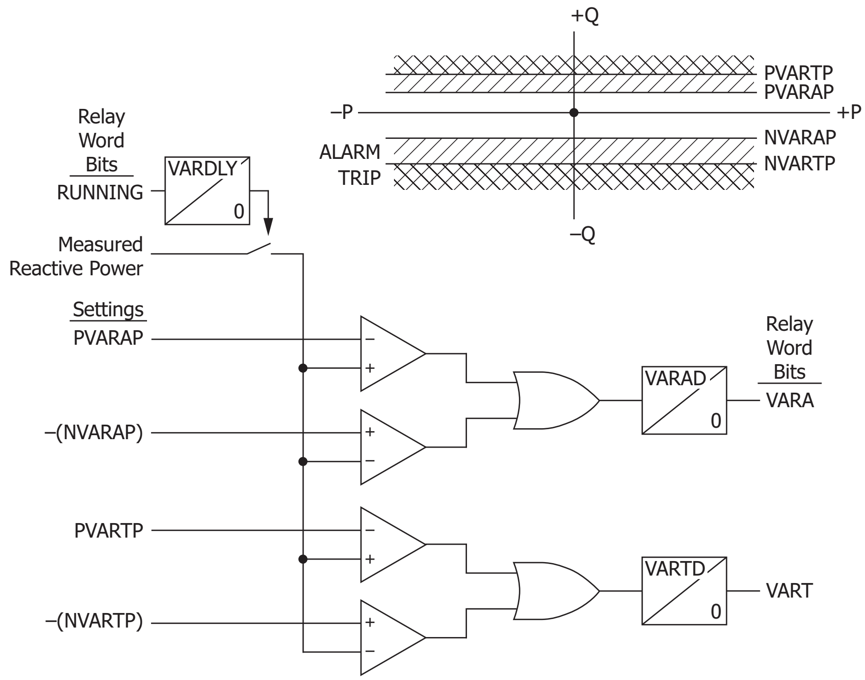


Figure 4.46 Reactive Power (VAR) Element Logic

Refer to *Figure 5.12* 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.

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.

Table 4.41 Underpower Settings

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

Figure 4.47 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.

In the case of synchronous motor applications, SYNTYPE := BRUSH or BRUSHLESS, program the 37DLY setting to a value that ensures that the currents and voltages are stabilized after the motor is synchronized. This prevents any nuisance trips immediately after the synchronization process.

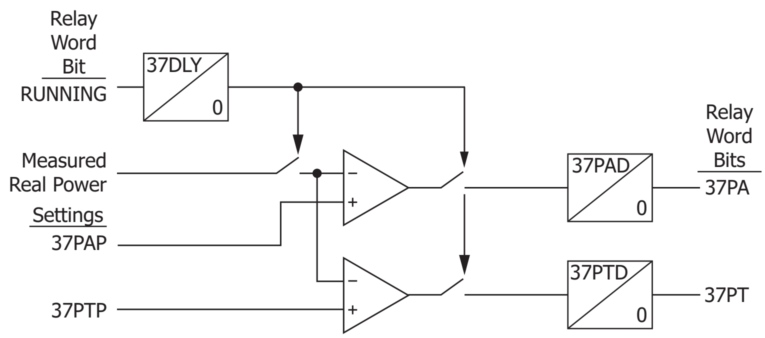


Figure 4.47 Underpower Element Logic

Power Factor Elements

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

Table 4.42 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
PF CURRENT SUP	OFF, 0.05–2.00 • I_{NOM} A sec	55I1SUP := OFF
PF TRQ CTRL	SELOGIC	55TC := SRUNNING

Figure 4.48 shows the logic diagram for power factor elements. These elements can be used to detect synchronous motor out-of-step or loss-of-field conditions. In the case of synchronous motor applications, SYNTYPE := BRUSH or BRUSHLESS, program the 55DLY setting to a value that ensures that the currents and voltages are stabilized after the motor is synchronized. This prevents any nuisance trips immediately after the synchronization process. Refer to *Figure 5.12* for the relay power measurement convention.

Disable the elements by setting all four power factor level settings to OFF.

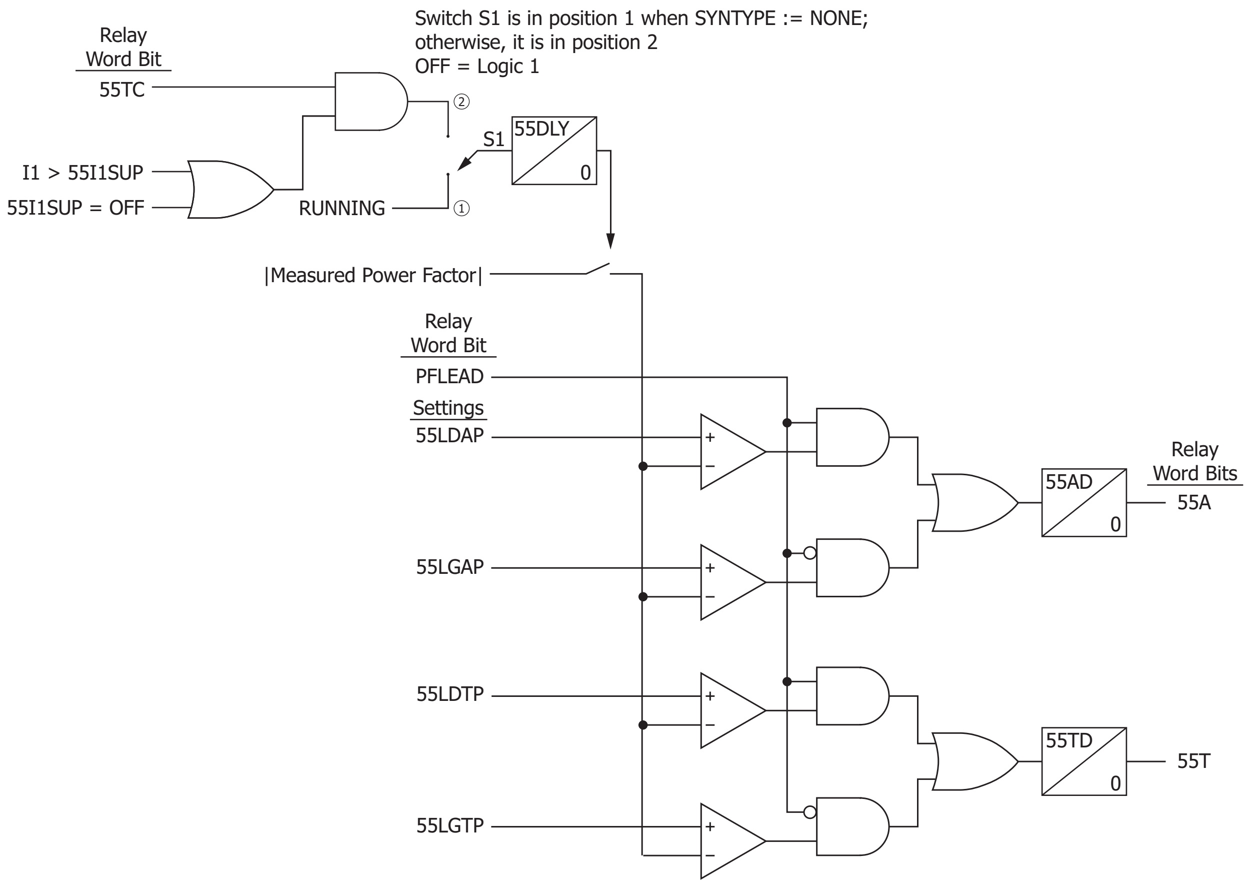


Figure 4.48 Power Factor Elements Logic

Power Factor Loss-of-Synchronism Detection

The SEL-710-5 includes a loss-of-synchronism (pull-out) detection logic that operates when the motor power factor falls below the relay setting POPFSP. As shown in *Figure 4.49*, the loss-of-synchronism logic is available for the synchronous motor only (SYNTYPE := NONE) and it is supervised by a minimum positive-sequence current and the relay RUNNING state. To accelerate operation, the logic also determines a pull-out condition when the positive-sequence current is greater than 3.5 times the full-load current. At these current levels, the pull-out condition is practically unavoidable; see the technical paper, "Performance of Synchronous Motors Loss-of-Synchronism Protection," by M. Donolo, P. Donolo, S. Patel, and V. Yedidi, presented at the 2017 Petroleum and Chemical Industry Technical Conference (PCIC). This logic is evaluated every quarter cycle. Use PORSFL for time-qualified tripping due to a detected pull-out condition for which the motor is no longer expected to resynchronize.

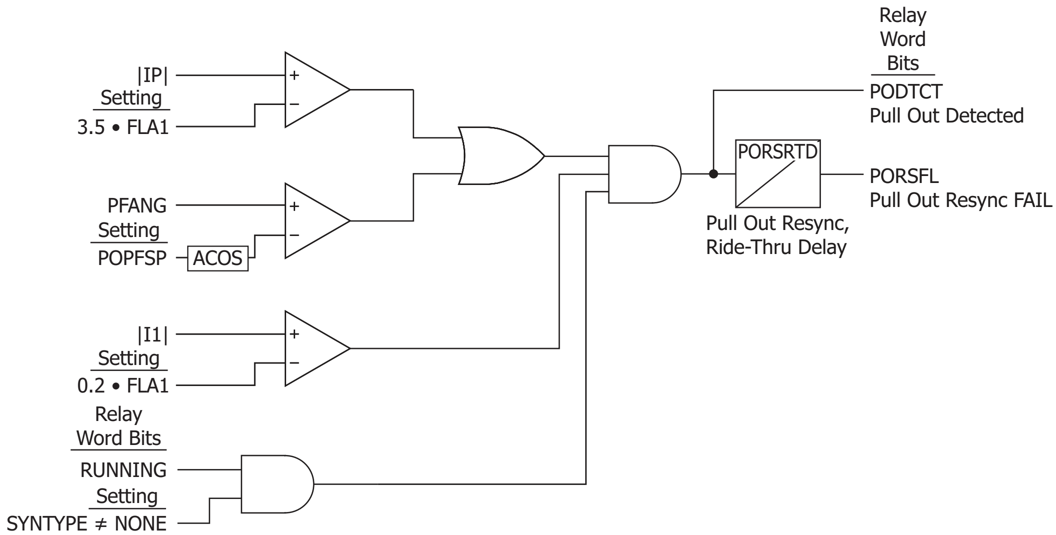


Figure 4.49 Loss-of-Synchronism Detection Logic

Table 4.43 Loss-of-Synchronism Detection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PO PF SET POINT	0.10–0.99	POPFSP := 0.70
PO PU DELAY	0.1–60.0 sec	PORSRTD := 1.0

Loss-of-Potential (LOP) Protection

The SEL-710-5 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 (for example, undervoltage 27 elements), you can use the LOP function to supervise these protection elements.

The relay declares an LOP when there is more than a 20 percent drop in the measured positive-sequence voltage (V1) with no corresponding magnitude or angle change (above a predetermined threshold) in positive-sequence (I1), negative-sequence (I2), or zero-sequence currents (I0). If this condition persists for 1 second, then the relay latches the LOP Relay Word bit at logical 1. The relay resets the LOP Relay Word bit when the conditions to the RESET input of the latch are met as shown in *Figure 4.50*.

Settings

The LOP function is always active unless blocked by the corresponding SELOGIC control equation (see *Table 4.44* for the LOPBLK setting and *Figure 4.50* for the LOP logic). The default value is LOPBLK := 0. Certain switching operations can result in LOP assertion when the drop in V1 is greater than 20 percent with no or very little change in sequence currents. Consider using LOPBLK to avoid assertion of LOP under such conditions. You must incorporate the LOP function in a SELOGIC control equation to supervise relay protection elements (see *Example 4.14*).

Table 4.44 Loss-of-Potential (LOP) Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
LOP BLOCK	SELOGIC	LOPBLK := 0

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 4.14*). 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 4.14 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...**

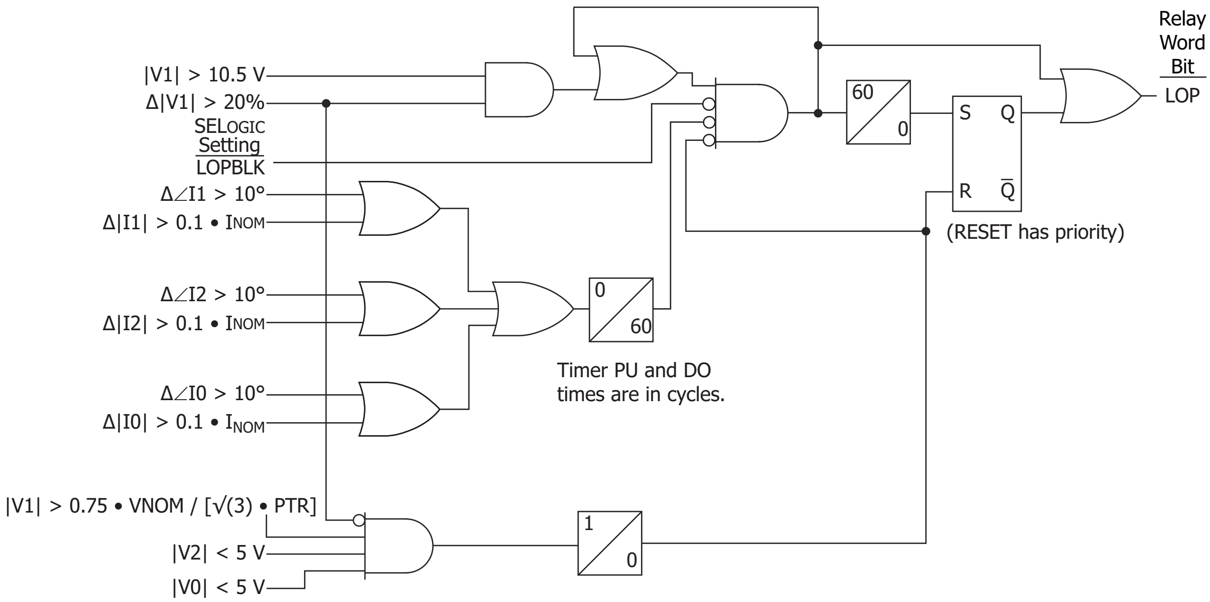
Similarly, if you want the remaining voltage-affected elements to act only when there are correct relaying potentials voltage, use the following in the equation:

...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

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.



Note:
I_{NOM} is 1 A or 5 A, depending on the part number.
I_{NOM} is the phase secondary input rating.
V_{NOM} (in primary volts) and PTR are norminal line-line voltage and PT ratio settings.

Figure 4.50 Loss-of-Potential (LOP) Logic

Frequency Elements

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.

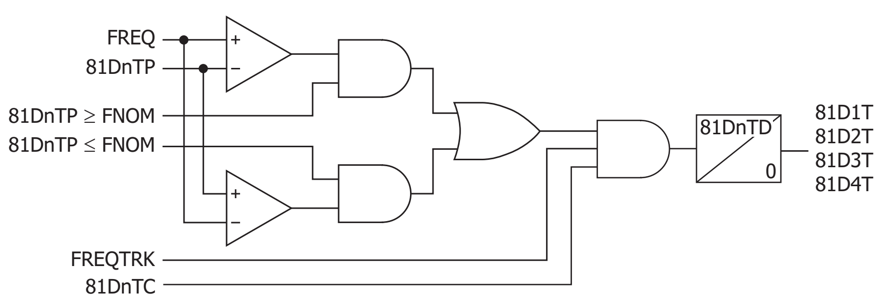
The SEL-710-5 provides four trip over- or underfrequency elements with independent level and time-delay settings. When an element level setting is less than the nominal frequency setting, the element operates as an underfrequency element. When the level setting is greater than the nominal frequency setting, the element operates as an overfrequency element.

Table 4.45 Frequency Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FREQ1 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D1TP := OFF
FREQ1 TRIP DELAY[a]	0.00–400.00 s	81D1TD := 1.00
81D1 TRQCTRL	SELOGIC	81D1TC := 1
FREQ2 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D2TP := OFF
FREQ2 TRIP DELAY[a]	0.00–400.00 s	81D2TD := 1.00
81D2 TRQCTRL	SELOGIC	81D2TC := 1
FREQ3 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D3TP := OFF
FREQ3 TRIP DELAY[a]	0.00–400.00 s	81D3TD := 1.00
81D3 TRQCTRL	SELOGIC	81D3TC := 1
FREQ4 TRIP LEVEL	OFF, 15.00–70.00 Hz	81D4TP := OFF
FREQ4 TRIP DELAY[a]	0.00–400.00 s	81D4TD := 1.00
81D4 TRQCTRL	SELOGIC	81D4TC := 1

[a] Frequency element time delays are best set at least three cycles at the lowest 81U pickup setting.

Figure 4.51 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
81DnTC = SELOGIC Setting for Torque Control of the Frequency Element

Figure 4.51 Over- and Underfrequency Element Logic

Detecting Frequency Components With the 97FM Element

The 97FM elements monitor the magnitude of a user-selected frequency component in different analog signals (see *Table 4.46*) by evaluating an individual term of the discrete Fourier transform (DFT). The SEL-710-5 Relay provides five of these elements.

Table 4.46 Operating Quantities and Associated Sampling Rates

97FMxOQ	Operating Quantity	FNOM = 60		FNOM = 50	
		Delta T	Max 97FMxFS Setting	Delta T	Max 97FMxFS Setting
VA	Raw VA	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VB	Raw VB	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VC	Raw VC	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VAB	Raw VAB	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VBC	Raw VBC	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
VCA	Raw VCA	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
IA	Raw IA	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
IB	Raw IB	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
IC	Raw IC	1/(32 FNOM) = 1/1920	960 Hz	1/(32 FNOM) = 1/1600	800 Hz
P	Three-phase active power	1/(4 FNOM) = 1/240	60 Hz	1/(4 FNOM) = 1/200	50 Hz
Q	Three-phase reactive power	1/(4 FNOM) = 1/240	60 Hz	1/(4 FNOM) = 1/200	50 Hz
S	Three-phase apparent power	1/(4 FNOM) = 1/240	60 Hz	1/(4 FNOM) = 1/200	50 Hz

The 97FM element may be configured in three different operating modes: SU_EU (secondary or engineering units) mode, seen in *Figure 4.52*, in which the magnitude of the selected quantity at the selected frequency is compared to a threshold in the corresponding secondary or engineering units; dB_DC mode, seen in *Figure 4.53*, in which the magnitude of the selected component is obtained in dB of the dc component of the same signal; and finally, dB_FN mode, also seen in *Figure 4.53*, in which the magnitude of the selected component is obtained in dB of the fundamental component. The 97*x*PT setting is used to choose the operating mode.

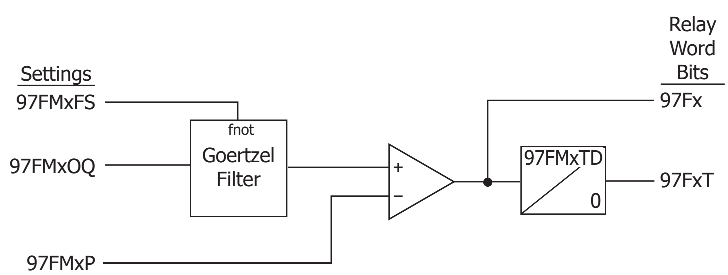
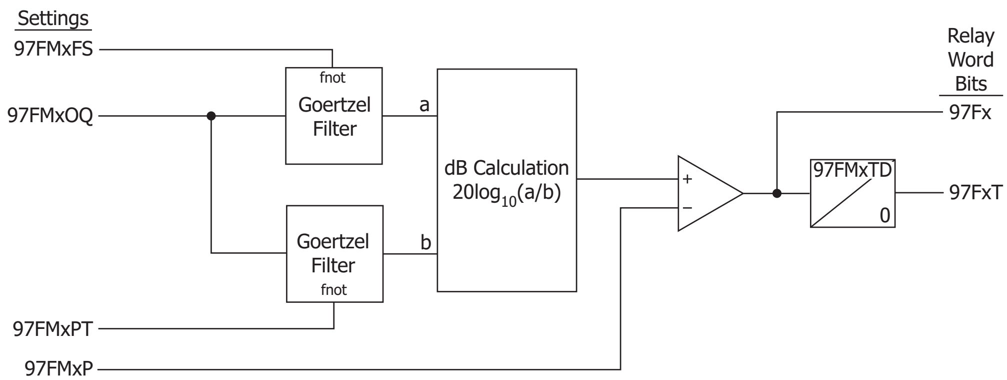


Figure 4.52 SU_EU Operating Mode (97FMxPT = SU_EU)



97FMxPT has two modes in this diagram: dB_DC and dB_FN.

Figure 4.53 dB_DC (97FM*x*PT = dB_BC) and dB_FN (97FM*x*PT = dB_FN) Operating Modes

When the 97FM*x* analog quantity exceeds the corresponding threshold 97FM*x*P, the element asserts the 97F*x* Relay Word bit and the time-delayed 97F*x*T Relay Word bit. These Relay Word bits may be directly monitored in the SER report. In some applications, these Relay Word bits may repeatedly assert and de-assert, cluttering the SER report. To avoid this, use the 97FM*x*ER timer. While 97FM*x*ERT is deasserted, the 97FM*x* element generates a report every time that 97F*x*T asserts, as shown in *Figure 4.54*.

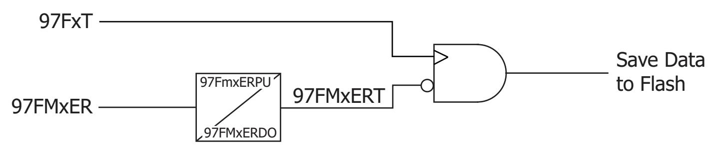


Figure 4.54 97FM*x*ER Timer Logic

You can use the **HIS FMR** command to access these reports. *Figure 4.55* details the data included in the reports.

```
=>>HIS FMR 10

SEL-710-5                                     Date: 04/16/2019   Time: 16:47:59.217
SYNCHRONOUS MTR                               Time Source: External

 #     DATE        TIME          97FMx       97FMxOQ  97FMxFS  97FMxFR  97FMxPT
1    04/16/2019  16:47:54.211    0.17        Q        1.00     0.5      DB_DC
2    04/16/2019  16:47:48.200    15.85       Q        1.00     0.5      DB_DC
3    04/16/2019  16:47:36.205    6.53        Q        1.00     0.5      DB_DC
4    04/16/2019  16:47:20.200    4.01        Q        1.00     0.5      DB_DC
5    04/16/2019  16:46:58.184    43.34       Q        1.00     0.5      DB_DC
6    04/16/2019  16:46:54.174    4.89        Q        1.00     0.5      DB_DC
7    04/16/2019  16:46:46.183    21.89       Q        1.00     0.5      DB_DC
8    04/16/2019  16:46:42.178    21.31       Q        1.00     0.5      DB_DC
9    04/16/2019  16:46:38.168    1.04        Q        1.00     0.5      DB_DC
10   04/16/2019  16:46:28.178    5.62        Q        1.00     0.5      DB_DC
```

Figure 4.55 HIS FMR Command Response

Frequency Resolution

The 97*x*FM element uses a windowed Goertzel filter to isolate the desired frequency component. The capacity of this filter to reject off frequencies is shown in *Figure 4.56*.

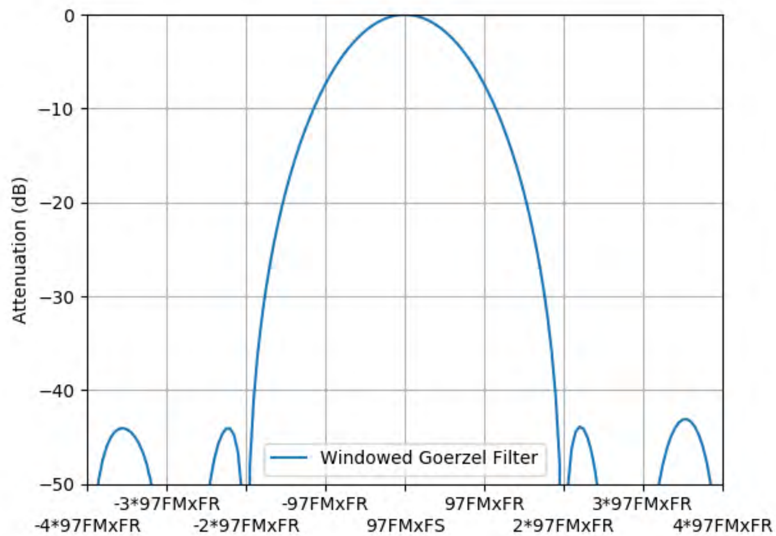


Figure 4.56 Filter Frequency Response

Frequency Tracking

The relay tracks the fundamental frequency by adjusting the sampling rate by a factor equal to FREQ / FNOM. As the sampling rate changes, the effective pickup frequency of the 97FM element also moves by the same factor. Use the following equation to find the effective pickup frequency of the 97FM element:

$$\text{Effective Pickup Frequency} = \frac{\text{FREQ} \bullet \text{97FMxFS}}{\text{FNOM}}$$

Table 4.47 Frequency Magnitude Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Default Value
97FM ENABLE	(Y, N)	E97FM*x* := N
OPERATING QTTY	IA, IB, IC, VAB, VBC, VCA, VA, VB, VC, P, Q, S	97FM*x*OQ := P
FREQ SETPOINT	0.00–960.00 Hz (for analogs and FNOM = 60) 0.00–800.00 Hz (for analogs and FNOM = 50) 0.00–60.00 Hz (for P, Q, S, and FNOM = 60) 0.00–50.00 Hz (for P, Q, S, and FNOM = 50)	97FM*x*FS := 20
PICKUP TYPE	SU_EU, DB_FN (for currents and voltages) SU_EU, DB_DC (for P, Q, and S)	97FM*x*PT := SU_EU
FREQ RESOLUTION	0.1, 0.5, 1, 5, 10, 20 Hz	97FM*x*FR := 1
PICKUP LEVEL	0.00–11250000.00 kVar (for Q) 0.00–11250000.00 kVA (for S) 0.00–11250000.00 kW (for P) 0.00–2 • I_{NOM} A sec (for I) 2.00–300.00 V sec (for V) –60.00–0.00 (for DBs)	97FM*x*P := 0.00
TIME DELAY	0.0–6000.0 sec	97FM*x*TD := 0.0

Table 4.47 Frequency Magnitude Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Default Value
TRQ CONTROL	SELOGIC	97FM*x*TC := 1
EVENT TIMER	SELOGIC	97FM*x*ER := 0
PICKUP TIMER	0–30000 min	97FM*x*PU := 0
DROPOUT TIMER	0–30000 min	97FM*x*DO := 600

Monitoring Sub-Synchronous Resonance and Load Variations

To detect low-frequency power oscillation resulting from sub-synchronous resonance or motor load oscillations, set a 97FM element as follows. If the frequency of the oscillation is known to be 1 Hz and the magnitude is 10 kW, set the 97FM element according to *Table 4.48*.

Table 4.48 97FM Element Settings for an Oscillation With 1 Hz Frequency and 10 kW Magnitude

Setting Name	Value
E97FM1	Y
97FM1OQ	P
97FM1FS	1 Hz
97FM1PT	SU_EU
97FM1FR	1 Hz
97FM1P	5 kW
97FM1TD	10 s
97FM1TC	1
97FM1ER	97F1T
97FM1PU	0 min
97FM1DO	60 min

With these settings, the element will save, at most, one event per hour.

Monitoring High-Frequency Current Oscillations

Current signature analysis is widely used to diagnose conditions such as broken rotor bars, load misalignment, bearing damage, etc. The frequency F = FREQ • (7 – 6 • SLIP) is associated with broken bar conditions and may be useful in identifying cases where the main side bands are too close to the fundamental frequency. For FREQ = 60 Hz and a SLIP of one percent, this frequency is 416.4 Hz. For this component, first use the **CMET S** or **MET FFT** commands to determine a baseline value in dB of the fundamental. Then set the 97FM element pickup value to alert you when the component exceeds this baseline. If the baseline value is –45 dB, set the element as follows:

Table 4.49 97FM Element Settings for Baseline Frequency Value of –45 dB

Setting Name	Value
E97FM1	Y
97FM1OQ	IA
97FM1FS	416 Hz
97FM1PT	dB_FN
97FM1FR	1 Hz
97FM1P	–40 dB
97FM1TD	10 s
97FM1TC	1
97FM1ER	97F1T
97FM1PU	0 min
97FM1DO	60 min

Vibration Monitoring

The SEL-710-5 provides five vibration monitoring elements, and each element can monitor a connected vibration transducer via analog inputs or math variables. For this application, these transducers are expected to measure a broadband frequency spectrum of vibration velocity at different strategically placed locations and output a 4–20 mA or 0–10 V signal that is proportional to the rms of the vibration velocity. The ISO 20816 standards describe the placement, frequency ranges, and type of vibration measurement to use for different machines and footings.

Each vibration measurement is compared against a set of thresholds that define the four evaluation zones:

- ➤ Zone A: Recently Commissioned
- ➤ Zone B: Acceptable
- ➤ Zone C: Warn
- ➤ Zone D: Damaging

Typical machine thresholds for rms velocity measurements, based on the class of motor, are included in *Table 4.50*. The class of motor and units of measurement are selectable with the VIBCLASS and VIBUN settings, respectively. The analog inputs or math variables used to monitor the vibration need to be scaled to match the units used in the VIBUN setting.

Table 4.50 Machine Class Thresholds

	VIBUN == mm/sec				VIBUN == in/sec			
VIBCLASS	Class I	Class II	Class III	Class IV	Class I	Class II	Class III	Class IV
VIBABP	1.12	1.8	2.8	4.5	0.04	0.07	0.11	0.18
VIBBCP	2.8	4.5	7.1	11.2	0.11	0.18	0.28	0.44
VIBCDP	7.1	11.2	18	28	0.28	0.44	0.70	1.10

The SEL-710-5 also allows for custom thresholds when VIBCLASS is set to MANUAL. This is useful for different machine types, orientations, and footings based on ISO 20816 tables or on-site test results.

Figure 4.57 details the threshold logic for each element, as well as the provided Relay Word bits associated with each zone condition for use in alarm or trip conditions.

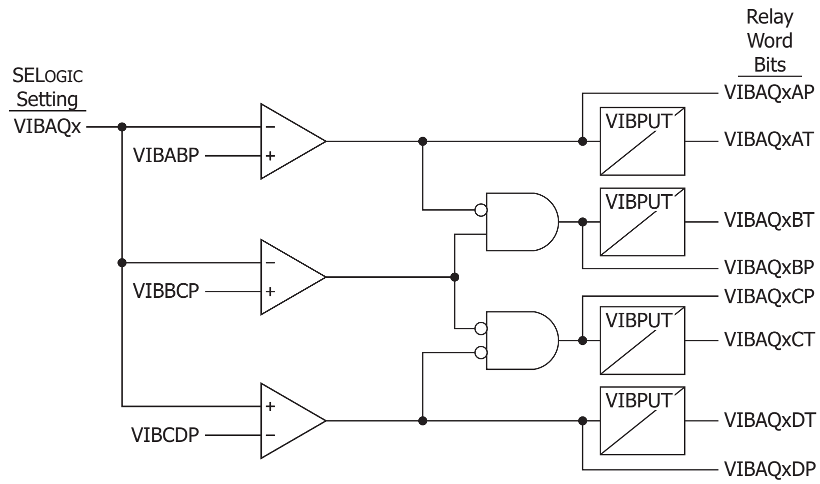


Figure 4.57 Vibration Monitoring Threshold Logic

Table 4.51 Vibration Monitoring Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ANALOG SELECTION	OFF, MV01–MV32, AIx0y	VIBAQx := OFF
PICKUP TIMER	0.00–400.00 s	VIBPUT := 10.00
TRQ CONTROL	SELOGIC	VIBTC := 1
MACHINE CLASS	CI, CII, CIII, CIV, MANUAL	VIBCLASS := CI
VELOCITY UNITS	mm/sec, in/sec	VIBUN := mm/sec
A–B THRESHOLD	0.00–100.00	VIBABP := 1.12
B–C THRESHOLD	0.00–100.00	VIBBCP := 2.80
C–D THRESHOLD	0.00–100.00	VIBCDP := 7.10

Vibration Monitoring Example

This example uses a 10 kW motor with three vibration velocity-measuring transducers (P/N LP202-0R3-2E). Due to its size, the motor would fall under Class I of the ISO 20816-1 standard. Use a 20816-*N* (*n* > 1) standard for the type of machine in your application, if available, as a reference for setting the thresholds.

The vibration transducers in this example output a 4–20 mA signal that is proportional to the rms velocity of vibration in mm/sec. The signals are connected to an analog card in Slot 4 of the relay. To configure the analog inputs on an analog card, see *Analog Inputs*. Following configuration, we ensure that the JMP*n* (*n* = 1, 2, or 3) jumpers on the board are in Position 1-2 for current measurement. The measurement range of these transducers is 0 to 12.7 mm/sec, as defined in the transducer specifications, so we start with setting AI40*n*EL set to 0 and AI40*n*EH set to 12.7. After calibrating for the dc offset, we set our analog inputs as shown in *Table 4.52* for this application.

Table 4.52 Vibration Example Analog Input Settings

Setting	Value
AI401TYP	I
AI401L	4.000
AI401H	20.000
AI401EL	–0.002
AI401EH	12.698
AI402TYP	I
AI402L	4.000
AI402H	20.000
AI402EL	–0.001
AI402EH	12.699
AI403TYP	I
AI403L	4.000
AI403H	20.000
AI403EL	–0.003
AI403EH	12.697

With the analog inputs configured, we can set the vibration monitoring settings. Given the class of the motor and the unit of measurement of the transducers, we would apply the settings listed in *Table 4.53*.

Table 4.53 Vibration Example Settings

Setting	Value
VIBAQ1	AI401
VIBAQ2	AI402
VIBAQ3	AI403
VIBCLASS	CI
VIBUN	MM/SEC

The touchscreen display option for the SEL-710-5 provides a screen to monitor the measured vibration values in a bar graph, as seen in *Figure 4.58*. You can navigate to this screen from the Home screen by selecting **Monitor > Vibration**.

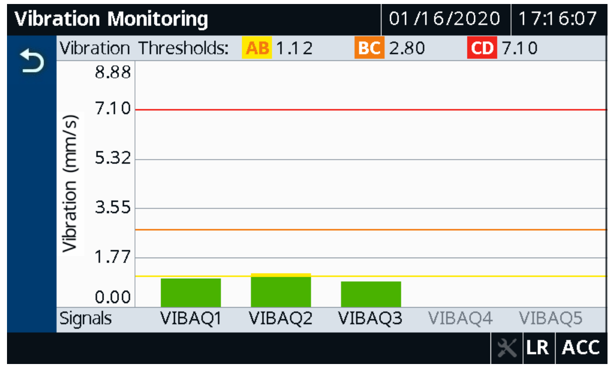


Figure 4.58 Vibration Monitoring Screen

Load Control Function

The SEL-710-5 has the capability 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.

NOTE: Prompts of the settings LOADUPP and LOADLOWP are dependent on the LOAD setting. All possible prompts are shown in Table 4.54. The relay shows only the appropriate prompts based on the LOAD setting.

NOTE: In addition to setting the load control levels, you must assign the LOADUP and LOADLOW settings to auxiliary output relays (one each); see Table 4.77, and Figure 2.12 for the connection diagrams.

Table 4.54 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 pri	LOADUPP := OFF
LD CTL PWR LOWER	OFF, 1–25000 kW pri	LOADLOWP := OFF
LD CTL TCU UPPER	OFF, 1–99 %TCU	LOADUPP := OFF
LD CTL TCU LOWER	OFF, 1–99 %TCU	LOADLOWP := OFF

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

When the selected parameter drops below the load control lower-level setting for one second, the auxiliary relay assigned to LOADLOW operates. The auxiliary relay resets 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.

Synchronous Motor Settings

Some synchronous motor settings are available when a card with three synchronous motor inputs and three ac current inputs is installed and the setting SYNTYPE := BRUSH/BRUSHLESS. Synchronous Motor Running State Relay Word bit, SRUNNING, can be used in the torque-control equation to enable brush/brushless protection functions. See *Figure 4.78* for the synchronous motor running state logic.

Loss-of-Field Element

Loss-of-field causes the synchronous motor to act as an induction motor. The SEL-710-5 uses a pair of offset mho circles to detect loss-of-field. Because loss-of-field affects all three phases, the condition is balanced. The SEL-710-5 uses measured positive-sequence impedance to form the mho circles.

Table 4.55 Loss-of-Field Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
LOSS OF FIELD EN	Y, N	E40 := N
Z1 MHO DIAMETER	OFF, 0.1–100 ohm sec[a]	40Z1P := 13.4[a]
Z1 OFFSET	0.0–50.0 ohm sec[a]	40XD1 := 2.5[a]
Z1 TIME DELAY	0.00–400.00 s	40Z1D := 0.00
Z2 MHO DIAMETER	OFF, 0.1–100 ohm sec[a]	40Z2P := 13.4[a]
Z2 OFFSET	0.0–50.0 ohm sec[a]	40XD2 := 2.5[a]
Z2 TIME DELAY	0.00–400.00 s	40Z2D := 0.50
40Z TRQCTRL	SELOGIC	40ZTC := NOT LOP AND SRUNNING

[a] Ranges and default settings shown are for 5 A CT. Multiply by 5 for 1 A rated CTs.

Typically, Zone 1 and Zone 2 are offset from the origin of the impedance plane by a value equal to half of the machine transient reactance, as shown in *Figure 4.60*. Zone 1 is intended to operate with little time delay in the event of a loss-of-field under full load conditions. Zone 2 reaches farther and operates with a longer time delay. Zone 2 is intended to trip for loss-of-field conditions that occur under light load conditions. The loss-of-field elements are supervised by the 40ZTC torque-control setting.

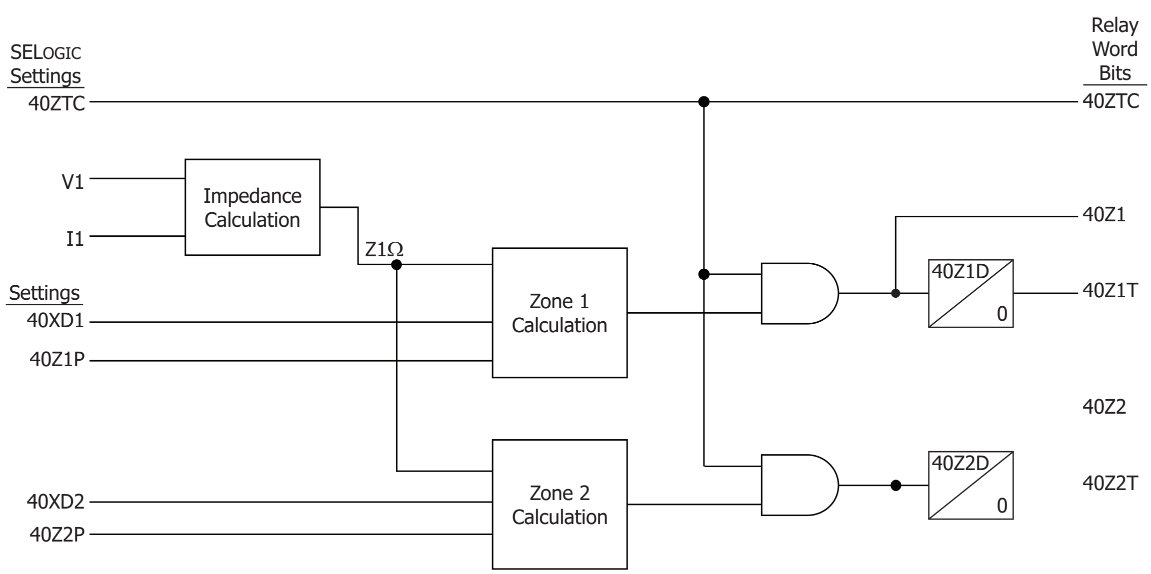


Figure 4.59 Loss-of-Field Logic Diagram

Set E40 := Y to enable loss-of-field protection elements. If loss-of-field protection is not necessary, set E40 := N.

The Zone 1 element typically is applied as a tripping function. Zone 1 diameter and offset setting guidelines are described below. Set the Zone 1 offset equal to half the motor transient reactance, X'd, in secondary ohms. Zone 1 loss-of-field tripping is typically performed with short or zero time delay. Use the 40Z1D setting to add any necessary delay.

The 40Z1 Relay Word bit asserts without time delay when the measured positive-sequence impedance falls within the Zone 1 mho circle defined by the offset and diameter settings.

The 40Z1T Relay Word bit asserts 40Z1D seconds after 40Z1 asserts.

The Zone 2 element typically is applied as a time-delayed tripping function. Zone 2 diameter and offset setting guidelines are described below.

Zone 2 loss-of-field tripping typically is performed with a time delay of 0.5 to 0.6 seconds. Set 40Z2D equal to the necessary delay.

The 40Z2 Relay Word bit asserts without time delay when the measured positive-sequence impedance falls within the Zone 2 mho circle defined by the offset and diameter settings. The 40Z2T Relay Word bit asserts 40Z2D seconds after 40Z2 asserts.

NOTE: The loss-of-field elements require at least 0.25 volts of positive-sequence voltage and 0.25 amperes of positive-sequence current to operate.

The loss-of-field elements are disabled when the 40ZTC SELOGIC control equation equals logical 0. The relay allows these elements to operate when the 40ZTC SELOGIC control equation equals logical 1. With the default setting, the loss-of-field elements operate when the relay detects that the motor is synchronized and no loss-of-potential condition exists. To prevent any nuisance trips immediately after the synchronization process, an additional pickup delay can stabilize the currents and voltages. Use the SELOGIC variables to program this delay, and add it to torque control. See the following example.

SV10PU	:=	5.00
SV10DO	:=	0.00
SV10	:=	NOT LOP AND SRUNNING
40ZTC	:=	SV10T

Setting Calculation

Collect the following information to set loss-of-field.

- Synchronous motor direct axis reactance, X_d, in secondary ohms
- Synchronous motor transient reactance, X'_d, in secondary ohms
- Synchronous motor-rated line-to-line voltage, in secondary volts (V_{NOM})
- Synchronous motor-rated phase current, in secondary amperes (I_{NOM} = Full load current, secondary)

Loss-of-Field Protection Using Offset Zone 2

When setting Zone 2 with an offset, set the Zone 1 diameter equal to 1.0 per unit impedance.

$$40Z1P = \frac{V_{NOM}}{1.73 \bullet I_{NOM}} \ \Omega$$

Set the Zone 1 offset equal to half the synchronous motor transient reactance, X'_d, in secondary ohms. Typically, the X_d is greater than 1 per unit impedance. However, if X_d is less than or equal to 1 per unit impedance, set the 40Z1P shorter so that the worst-case stable power system swing does not enter the Zone 1 characteristic.

$$40XD1 = \frac{X'_d}{2} \ \Omega$$

Zone 1 loss-of-field tripping is typically performed with short or zero time delay.

$$40Z1D = 0.0 \text{ seconds}$$

Set the Zone 2 diameter equal to the machine direct axis reactance, X_d, in secondary ohms.

$$40Z2P = X_d\Omega$$

Set the Zone 2 offset equal to the Zone 1 offset.

$$40XD2 = \frac{X'_d}{2}\ \Omega$$

Set the Zone 2 time delay long enough to avoid an incorrect operation during a worst-case stable power system swing condition, typically 0.5 to 0.6 seconds or according to the recommendations of the synchronous motor manufacturer.

$$40Z2D = 0.5 \text{ seconds}$$

The Relay Word bits 40Z1T and 40Z2T are configured to trip the synchronous motor breaker in the factory-default logic (see *Trip/Close Logic* for details). You must change the setting if your application requires a different action.

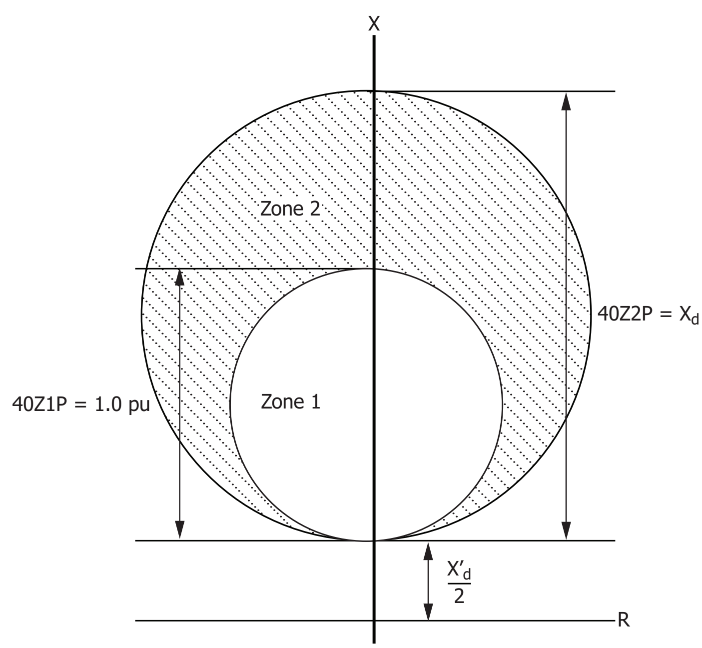


Figure 4.60 Loss-of-Field Element Operating Characteristic, Zone 2 Offset

Out-of-Step Element

The SEL-710-5 contains an out-of-step element to detect out-of-step conditions between two interconnected systems. Two interconnected systems experience an out-of-step condition for several reasons. A synchronous motor out-of-step condition (also referred to as pole-slipping) usually occurs because of an under-excited motor condition, an excessively reduced supply voltage, or an excessively loaded shaft.

Detecting and isolating an out-of-step condition as early as possible is imperative because the resulting high peak currents, winding stresses, and high shaft torques are very damaging to the synchronous motor.

The SEL-710-5 implements two out-of-step tripping schemes: single blinder and double blinder. Select whichever scheme suits your application, or you can disable out-of-step protection. Set E78 := 1B or 2B to enable out-of-step protection elements. If out-of-step protection is not necessary, set E78 := N.

Table 4.56 Out-of-Step Protection Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT-OF-STEP PROT	N, 1B, 2B	E78 := 1B
FORWARD REACH	0.1–100.0 ohm sec[a]	78FWD := 8[a]
REVERSE REACH	0.1–100.0 ohm sec[a]	78REV := 8[a]
RIGHT BLINDER[b]	0.1–50.0 ohm sec[a]	78R1 := 6[a]
LEFT BLINDER[b]	0.1–50.0 ohm sec[a]	78R2 := 6[a]
OUTER BLINDER[c]	0.2–100.0 ohm sec[a]	78R1 := 6[a]
INNER BLINDER[c]	0.1–50.0 ohm sec[a]	78R2 := 6[a]
OOS DELAY[c]	0.00–1.00 s	78D := 0.05
OOS TRIP DELAY	0.00–1.00 s	78TD := 0
OOS TRIP DUR	0.00–5.00 s	78TDURD := 0
POS-SEQ CURRENT	0.25-30.00 A sec[d]	50ABC := 0.25[d]
OOS TRQCTRL	SELOGIC	OOSTC := NOT LOP AND SRUNNING

[a] Ranges and default settings shown are for 5 A CT. Multiply by 5 for 1 A rated CTs.
[b] Right/Left Blinder settings apply to single-blinder scheme (1B) only.
[c] Outer/Inner Blinder and OOS Delay settings apply to double-blinder scheme (2B) only.
[d] Range and default setting shown are for 5 A CT. Divide by 5 for 1 A rated CTs.

Single-Blinder Scheme

The single-blinder scheme, shown in *Figure 4.61*, consists of mho element 78Z1, right blinder 78R1, and left blinder 78R2.

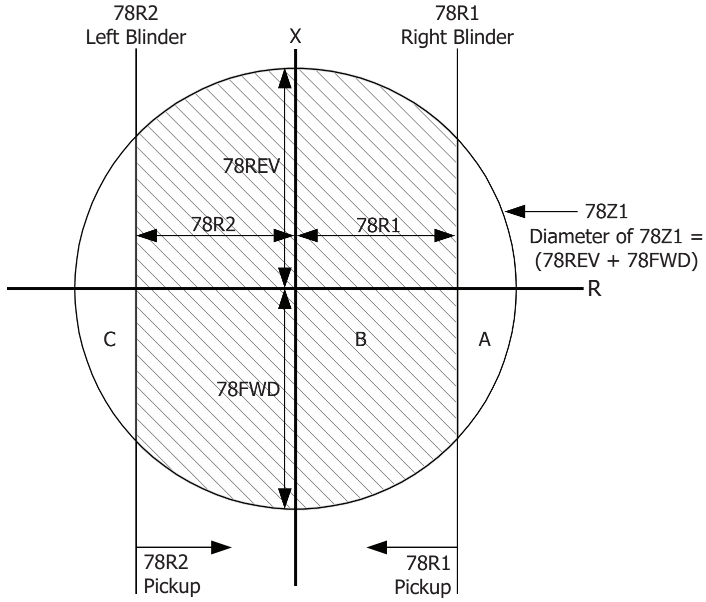


Figure 4.61 Single-Blinder Scheme Operating Characteristics

This scheme detects an out-of-step condition by tracking the path of positive-sequence impedance trajectories that pass through the protection zone. If the relay detects an out-of-step condition, the following Relay Word bits assert:

- Relay Word bit SWING picks up when the positive-sequence impedance moves from the load region into Area A (left blinder 78R2 and mho element 78Z1 assert).
- Relay Word bit OOS picks up when the impedance trajectory advances to Area B between the two blinders (right blinder 78R1, left blinder 78R2, and mho element 78Z1 assert).
- At the time the impedance trajectory exits the mho circle via Area C, the rising-edge triggered timer with 78TD pickup delay and 78TDURD dropout-delay starts timing. Relay Word bit OOST remains picked up for 78TDURD seconds after the pickup delay time 78TD expires.
- The previous description is only for trajectories traveling from right to left. Out-of-step trajectories traveling from left to right traverse the protection zone in the reverse sequence (that is, from Area C to B to A). The Relay Word bits assert in the same way, whether trajectories travel from right to left or from left to right.

The single-blinder scheme distinguishes between short-circuit faults and out-of-step conditions by tracking the path of the impedance trajectory. During short-circuit faults, the impedance moves from the load region to inside the mho element and between the two blinders almost instantaneously, preventing the out-of-step function from picking up.

Figure 4.62 shows the logic diagram for the single-blinder scheme. In the figure, the states of 78R1 and 78R2 are latched on the rising edge of SWING to determine if the swing has entered the 78Z1 mho circle from the right or the left. (For OOST to occur, the swing must exit the 78Z1 mho circle in the opposite direction from which it entered.) The latched states of 78R1 and 78R2 are retained until the next time SWING asserts, which is the next time a power system swing occurs.

The sum of the forward and reverse reaches (the diameter of the mho circle) has to be 100 ohms or less for a 5 A relay and 500 ohms or less for a 1 A relay.

The blinder settings must be greater than or equal to five percent of either the forward or the reverse reach, whichever is greater.

The relay allows the element to operate when the OOSTC SELOGIC control equation equals logical 1. With the default setting, the 78 element operates when the relay detects that the motor is synchronized and no loss-of-potential condition exists. To prevent any nuisance trips immediately after the synchronization process, an additional pickup delay can stabilize the currents and voltages. Use the SELOGIC variables to program this delay, and add it to torque control. See the following example.

SV10PU	:=	5.00
SV10DO	:=	0.00
SV10	:=	NOT LOP AND SRUNNING
OOSTC	:=	SV10T

Block the operation of the 78 element for certain conditions, such as the presence of excessive negative-sequence currents, by setting OOSTC to NOT 50Q1P. Refer to *Logic Settings (SET L Command) on page 4.110* for a detailed discussion of SELOGIC control equations.

The trip delay timer also has an adjustable dropout delay 78TDURD (Trip Duration). The 78TDURD should be set appropriately if the Relay Word bit OOST is configured to operate an output contact directly. The default setting for 78TDURD is zero because the Relay Word bit OOST is configured to trip the synchronous motor breaker with default trip logic TR (which includes an identical timer TDURD). You must change the settings (trip logic and/or 78TDURD) if your application requires a different action.

The scheme includes positive-sequence current supervision setting 50ABC, which has a setting range of 0.25–30.00 A for 5 A relays and 0.05–6.00 A for 1 A relays. Normally, a setting of 0.25 A for 5 A relays is adequate for most applications; however, a higher setting can be applied based on minimum expected swing currents. Note that the positive-sequence current levels below the 50ABC setting block the out-of-step function.

Both 78R1 and 78R2 must be within the mho circle.

Settings Calculation. Collect the following information to calculate the out-of-step protection settings.

- Synchronous motor transient reactance, X'_d, in secondary ohms
- Worst case swing locus (that passes through the motor) from a transient stability study

Convert all impedances to synchronous motor base kV.

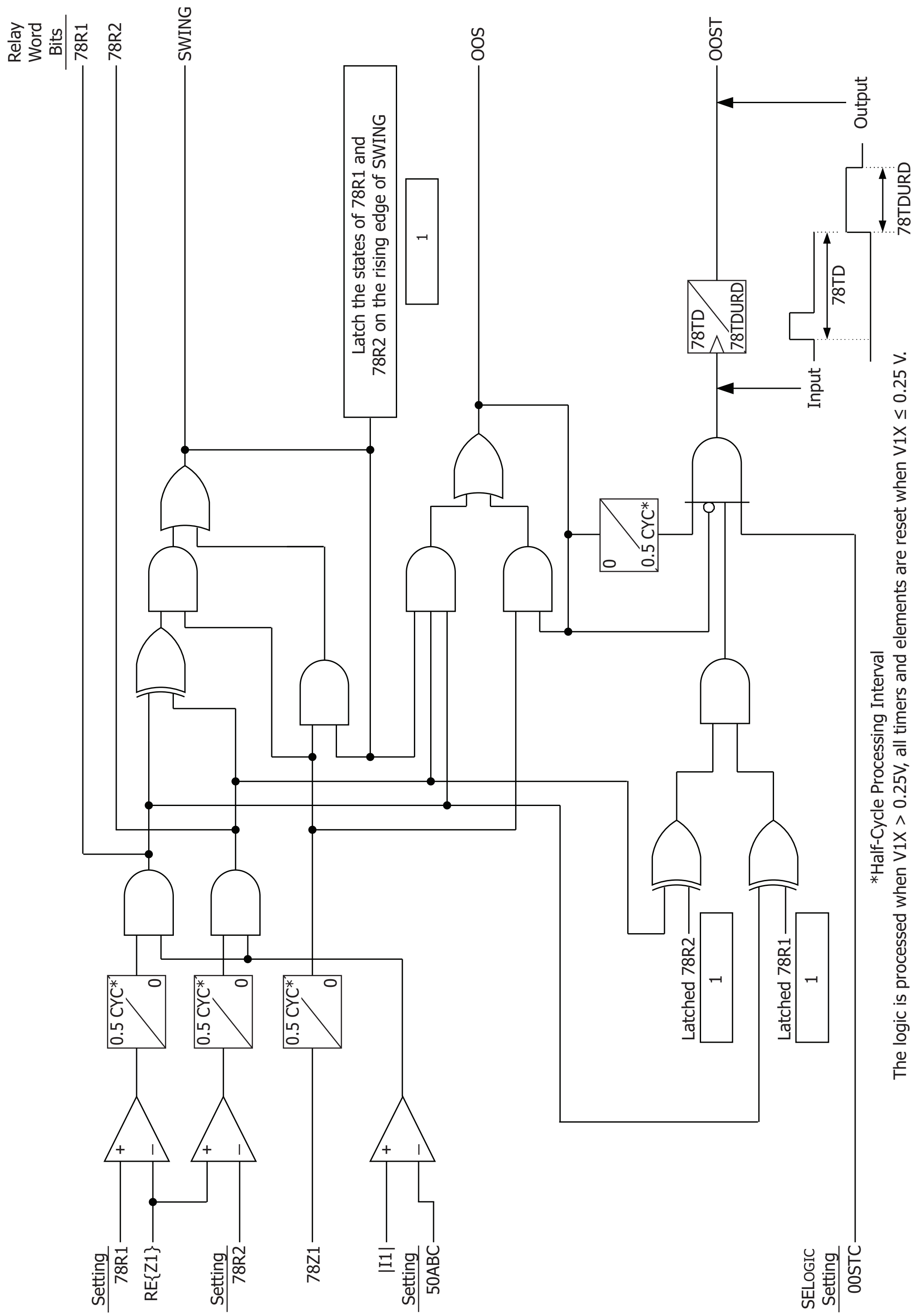


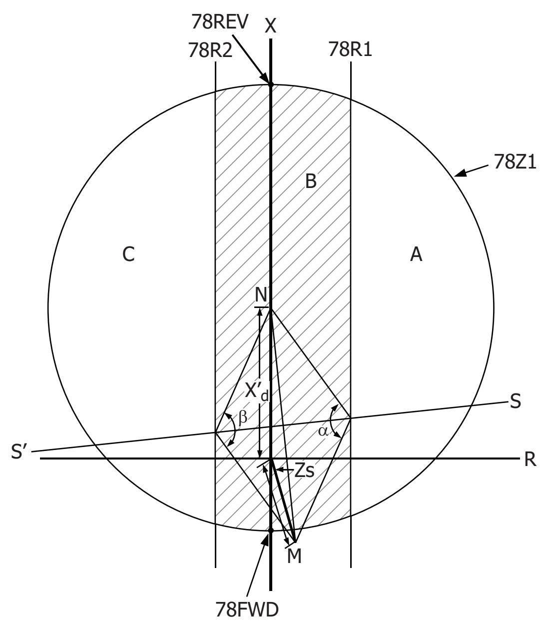
Figure 4.62 Single-Blinder Scheme Logic Diagram

Recommendations. *Figure 4.63* shows the elements set according to the following recommendations.

A transient stability study normally provides adequate data for setting the elements and timers properly. The out-of-step protection zone, which is limited by mho element 78Z1, includes the synchronous motor. Normally, set reverse reach 78REV at 2–3 times the synchronous motor transient reactance, and set forward reach 78FWD at 0.05–0.15 times the synchronous motor transient reactance, X'_d, to provide adequate coverage with a margin of error.

Set the left and right blinders to detect all out-of-step conditions. To do this, the right and left blinders are set so that the equivalent machine angles α and β are approximately 120 degrees, as shown in *Figure 4.63*. Separation angles of 120 degrees or greater between the two sources usually results in loss of synchronism.

Make sure that the mho element and the blinders do not include the maximum possible synchronous motor load, to avoid assertion of 78Z1, 78R1, and 78R2 under normal system operation.



78FWD: Forward Reach
78REV: Reverse Reach
X'_d: Synchronous Motor Transient Reactance
Zs: System Impedance
M-N: Total Impedance Between Synchronous Motor and System
S-S′: Perpendicular Bisector of M-N
α and β: Angle of Separation Between Synchronous Motor and System

Figure 4.63 Single-Blinder Typical Settings

Double-Blinder Scheme

The double-blinder scheme, shown in *Figure 4.64*, consists of mho element 78Z1 and two blinder pairs: outer resistance blinder 78R1 and inner resistance blinder 78R2. This scheme uses timer 78D as part of its logic to detect out-of-step conditions. The scheme declares an out-of-step condition if the positive-sequence impedance stays between the two blinders for more than 78D seconds and advances farther inside the inner blinder. The logic issues an out-of-step trip once an out-of-step condition is established and the positive-sequence impedance exits the mho circle.

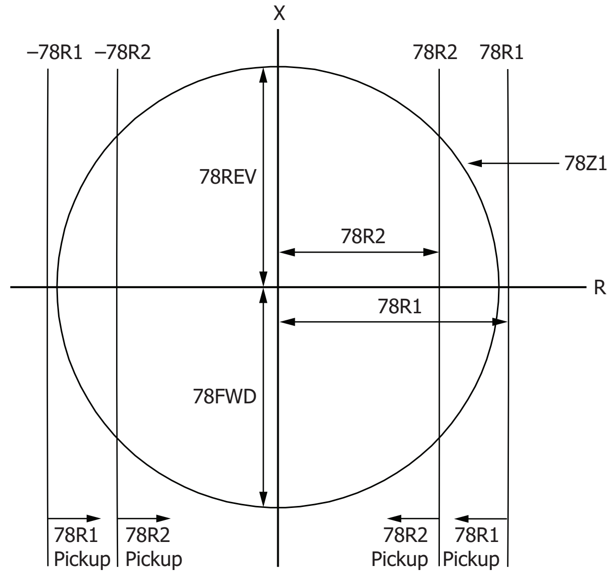


Figure 4.64 Double-Blinder Scheme Operating Characteristics

If the relay detects an out-of-step condition, it asserts the following Relay Word bits:

- Relay Word bit SWING picks up when the positive-sequence impedance stays between the outer and inner blinders for more than 78D seconds (78R1 asserts, mho element 78Z1 may or may not assert).
- Relay Word bit OOS picks up when the impedance trajectory advances farther inside the inner blinder (78R1, 78R2, and mho element 78Z1 assert).
- At the time the impedance trajectory exits the mho circle, the rising-edge triggered timer with 78TD pickup delay and 78TDURD dropout delay starts timing. Relay Word bit OOST remains picked up for 78TDURD seconds after pickup delay time 78TD expires.

The double-blinder scheme distinguishes between short-circuit faults and out-of-step conditions by monitoring the length of time that the impedance trajectory stays between the two blinders. During short-circuit faults, the impedance either moves inside the inner blinder or goes through the two blinders almost instantaneously so that the 78D does not time out. Either case prevents the out-of-step element from picking up. *Figure 4.66* shows the logic diagram for the double-blinder scheme.

The sum of the forward and reverse reaches (the diameter of the mho circle) is 100 ohms or less for a 5 A relay and 500 ohms or less for a 1 A relay.

Set the inner blinder (78R2) so that its setting is greater than or equal to five percent of either the forward or the reverse reach, whichever is greater.

The 78 element torque control SELOGIC control equation OOSTC has a default setting of one. If this value is left at one, the out-of-step element is not controlled by any other conditions external to the element. Block operation of the 78 element for certain conditions, such as the presence of excessive negative-sequence currents, by setting OOSTC to NOT 50Q1P. Refer to *Logic Settings (SET L Command)* for a detailed discussion of SELOGIC control equations.

The scheme includes positive-sequence current supervision setting 50ABC, which has a setting range of 0.25–30.00 A for 5 A relays and 0.05–6.00 A for 1 A relays. Normally, a setting of 0.25 A for 5 A relays is adequate for most applications. Apply a higher setting based on minimum expected swing currents. Note that the positive-sequence current levels below the 50ABC setting block the out-of-step function.

The trip delay timer also has an adjustable dropout delay 78TDURD (Trip Duration). The 78TDURD should be set appropriately if the Relay Word bit OOST is configured to operate an output contact directly. The default setting for the 78TDURD is zero because the Relay Word bit OOST is configured to trip the synchronous motor breaker with default trip logic TR (which includes an identical timer TDURD). Change the settings (trip logic and/or 78TDURD) if your application requires a different action.

The inner resistance blinder must be inside the mho circle while the outer resistance blinder should be outside the mho circle for the logic to operate correctly.

Settings Calculation. Collect the following information to calculate the out-of-step protection settings.

- Synchronous motor transient reactance, X'_d in secondary ohms.
- Worst case swing locus (that passes through the motor) from a transient stability study.

Convert all impedances to synchronous motor base kV.

Recommendations. *Figure 4.65* shows the elements set according to the following recommendations.

The out-of-step protection zone, which is limited by mho element 78Z1, includes the synchronous motor. Normally, set reverse reach 78REV at 2–3 times the synchronous motor transient reactance, and set forward reach 78FWD at 0.05–0.15 times the synchronous motor transient reactance, X'_d, to provide adequate coverage with a margin of error.

Set the inner blinder 78R2 to detect all out-of-step conditions. To do this, set the inner blinder so that the equivalent machine angle, shown in *Figure 4.65*, is approximately 120 degrees. A separation angle of 120 degrees or greater between two sources generally results in loss of synchronism.

Set the outer blinder 78R1 and out-of-step timer 78D to satisfy the following:

- The outer blinder should not assert on maximum load.
- The outer blinder should lie outside the mho circle, to satisfy the relay logic.
- The outer blinder should separate from the inner blinder far enough to ensure that the 78D timer accurately times the out-of-step slip cycle.

The SEL-710-5 processes the out-of-step logic every half cycle of the system frequency. To ensure that the relay times the out-of-step slip frequency accurately, separate the outer and inner blinders appropriately. For example, assume that the highest out-of-step frequency encountered is five slip cycles per second, which translates to 30 degrees per cycle (60 Hz). Set the blinders with a 70-degree separation. This separation translates to a positive-sequence impedance travel time of 2.3 cycles between the two blinders, which should provide adequate timing accuracy. Set the 78D timer at approximately 0.034 seconds (two cycles), which ensures that 78D will pick up for swings traveling at 30 degrees per cycle or less.

The out-of-step slip frequency is a system-specific value. A transient stability study normally determines this variable and, therefore, the double-blinder settings.

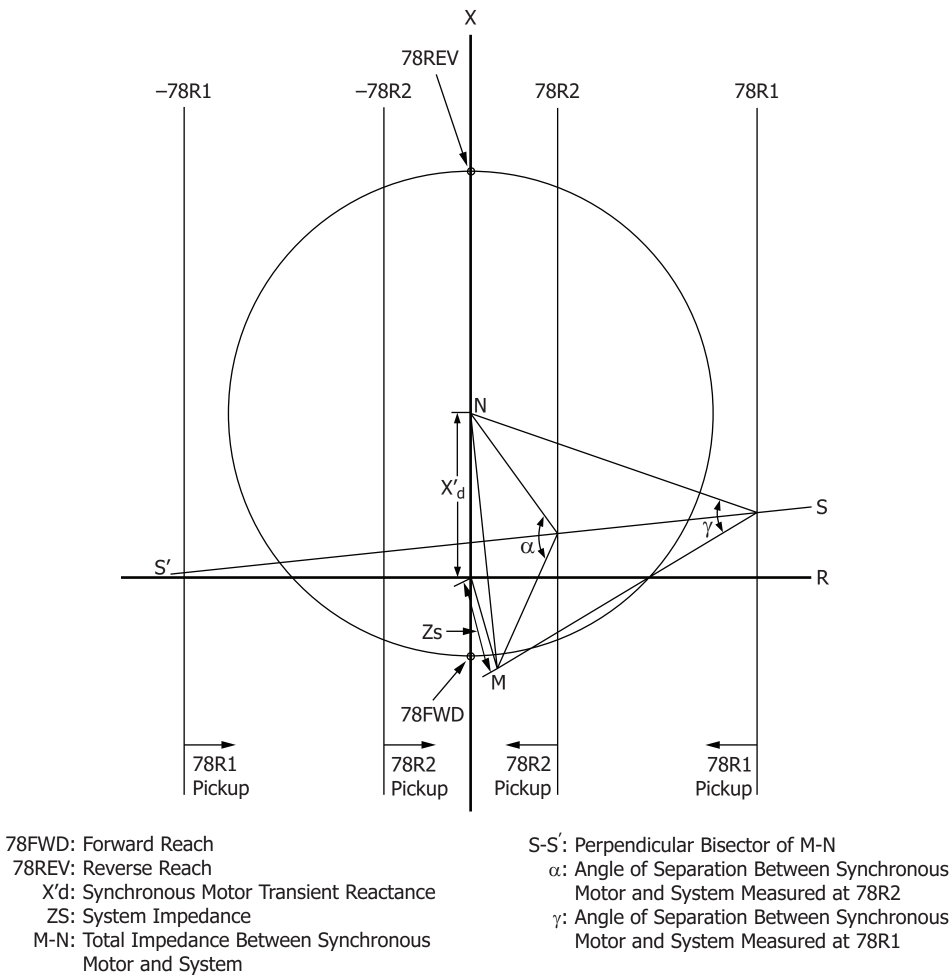


Figure 4.65 Double-Blinder Typical Settings

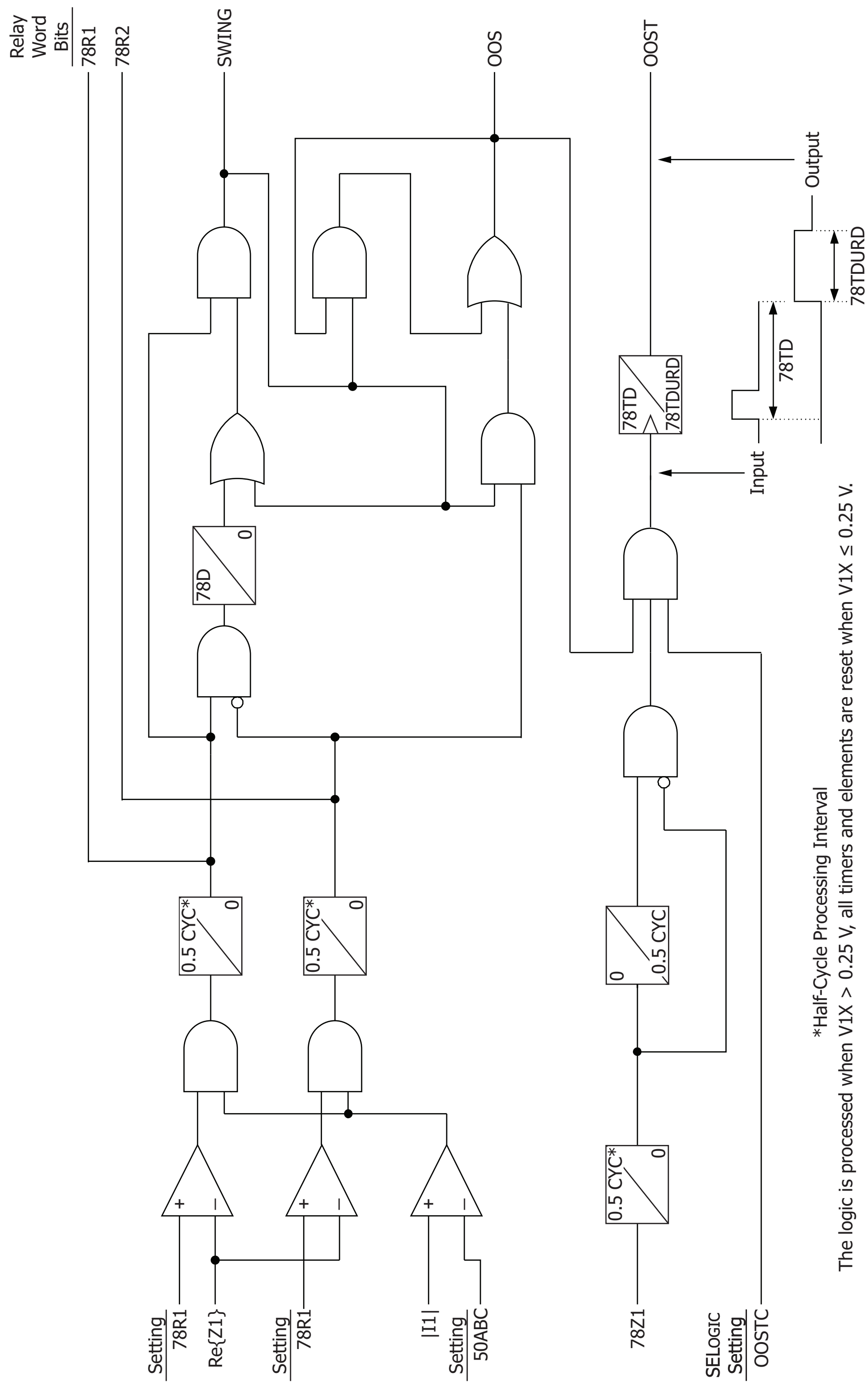


Figure 4.66 Double-Blinder Scheme Logic Diagram

Field Resistance Element

This feature is available only if an external dc transducer is used separately to convert the primary field dc current to a low level signal (4 to 20 mA dc or 0 to +10 Vdc) for the relay field current input, IEX, and an SEL external voltage divider board is connected to convert the primary field (exciter) dc voltage to a reduced voltage signal for the relay field voltage input, VEX. FDCURIN, FD_20 mA/ FD_5 V settings must be set to detect the primary field current. See *Section 2: Installation* for the board switch positions.

Primary field resistance is the ratio of the primary field voltage to the primary field current. If the primary field resistance goes above the field resistance warning or trip level for longer than a 10-second time delay, the relay issues a warning signal.

The field resistance elements operate only when the field resistance torque control, FDRESTC, asserts. You can also disable the elements by setting the field resistance warning level settings to OFF.

An increase in field resistance indicates an increase in field temperature. This function is an estimation of the field resistance as the exciter voltage measurement excludes the compensation for brush and cable voltage drop.

Table 4.57 Field Resistance Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FLD RES WARN 1	OFF, 0.10–500.00 ohm pri	FDRES1P := OFF
FLD RES WARN 2	OFF, 0.10–500.00 ohm pri	FDRES2P := OFF
FLDR TRQ CTRL	SV	FDRESTC := SRUNNING

Field Current Element

The field current feature is available only if an external dc transducer is installed separately to convert primary field/exciter dc current to low level signal (4 to 20 mA dc or 0 to +10 Vdc) for relay field current input, IEX. See *Section 2: Installation* for the board switch positions.

Set the FD_20 mA setting to a primary field current value corresponding to a dc transducer output of 20 mA or set the FD_5 V setting to a primary field current value corresponding to a dc transducer output of 5 V.

If the primary field current, IEX, falls below the field undercurrent warning or trip level for longer than the time-delay setting, the relay issues a warning or trip signal. If the primary field current, IEX, goes above the field overcurrent warning or trip level for longer than the time-delay setting, the relay issues a warning or trip signal.

The field current is operational only when the field current torque control, FDCTC, is asserted. You can also disable the elements by setting the field current warning level and trip level settings to OFF. For a brushless application, use DCCT to measure the auxiliary exciter dc field current, IEX.

Table 4.58 Field Current Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
FLD CURRENT IN	I, V	FDCURIN := I
FLD CUR @ 20 mA	1.0–2000.0 A dc pri	FD_20mA := 400.0

Table 4.58 Field Current Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
FLD CUR @ 5V	1.0–2000.0 A dc pri	FD_5V := 400.0
FLD UC TRIP LEVEL	OFF, 1.0–2000.0 A dc pri	FDUC1P := OFF
FLD UC TRIP DLY	0.3–100.0 sec	FDUC1D := 0.5
FLD UC WARN LVL	OFF, 1.0–2000.0 A dc pri	FDUC2P := OFF
FLD UC WARN DLY	0.3–100.0 sec	FDUC2D := 5.0
FLD OC TRIP LVL	OFF, 1.0–2000.0 A dc pri	FDOC1P := OFF
FLD OC TRIP DLY	0.3–100.0 sec	FDOC1D := 0.5
FLD OC WARN LVL	OFF, 1.0–2000.0 A dc pri	FDOC2P := OFF
FLD OC WARN DLY	0.3–100.0 sec	FDOC2D := 5.0
FLDC TRQ CTRL	SV	FDCTC := SRUNNING

Field (Exciter) Voltage Element

The field voltage feature is available only when an SEL external voltage divider board is installed to convert the primary field (exciter) dc voltage to reduced voltage signal for relay field voltage input, VEX.

If the primary field (exciter) voltage, VEX, falls below the field undervoltage warning or trip level for longer than the time-delay setting, the relay issues a warning or trip signal. If the primary field (exciter) voltage, VEX, goes above the field overvoltage warning or trip level for longer than the time-delay setting, the relay issues a warning or trip signal.

The field voltage elements operate only when the field voltage torque control, FDVTC, asserts. You can also disable the elements by setting the field voltage warning level and field voltage trip level settings to OFF. For a brushless application, use the auxiliary exciter dc voltage for VEX input.

Table 4.59 Field Voltage Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
FLD UV TRIP LVL	OFF, 1.0–350.0 Vdc pri	FDUV1P := OFF
FLD UV TRIP DLY	0.3–100.0 sec	FDUV1D := 0.5
FLD UV WARN LVL	OFF, 1.0–350.0 Vdc pri	FDUV2P := OFF
FLD UV WARN DLY	0.3–100.0 sec	FDUV2D := 5.0
FLD OV TRIP LVL	OFF, 1.0–350.0 Vdc pri	FDOV1P := OFF
FLD OV TRIP DLY	0.3–100.0 sec	FDOV1D := 0.5
FLD OV WARN LVL	OFF, 1.0–350.0 Vdc pri	FDOV2P := OFF
FLD OV WARN DLY	0.3–100.0 sec	FDOV2D := 5.0
FLDV TRQ CTRL	SV	FDVTC := NOT STOPPED

Power Factor Correction

The SEL-710-5 includes a power factor correction logic that compares the reactive power consumed by the motor with a required calculated reactive power set point and generates a command to raise or lower the excitation. Note that a positive required reactive power set point makes the motor behave as an inductive load and that a negative required reactive power set point makes the motor behave as a capacitive load.

NOTE: The time constants for the active power filter and reactive power filter are 30 seconds and 1 second, respectively.

With EPFC set to QSPMV, the reactive power set point is determined by a SELOGIC math variable. The SELOGIC math variable is selected using the PFQSP relay setting. For example, to select MV11, set PFQSP to 11, then the dynamically evaluated value in MV11 is used as the reactive power set point. With EPFC set to PFSP, the reactive power set point is computed using the measured active power of the motor, and power factor set point specified by PFSPAN and PFLDLG settings. *Figure 4.67* shows the reactive power set point logic.

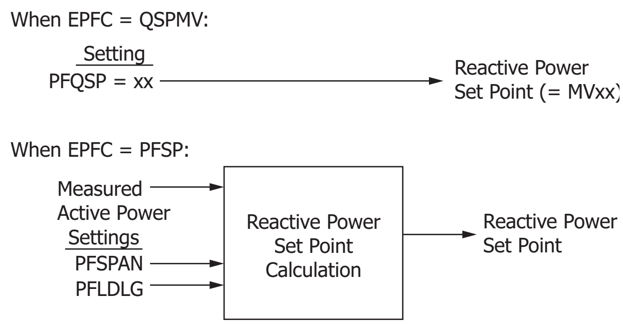


Figure 4.67 Reactive Power Set Point Calculation

Every five seconds, the difference between the measured reactive power and the reactive power set point (ΔQ) is compared to two reactive power thresholds in a double deadband logic. When ΔQ is greater than the short step reactive power threshold (PFSTH), the logic asserts the field voltage short raise Relay Word bit (FVSRT) for FVSDO seconds. Similarly, when ΔQ is greater than the long step reactive power threshold (PFLTH), the logic asserts the field voltage long raise Relay Word bit (FVLRT) for FVLDO seconds. The same thresholds and drop out timers are used to assert the field voltage short and long lower Relay Word bits (FVSLT and FVLLT) when ΔQ turns out to be negative. *Figure 4.68* details the double deadband logic.

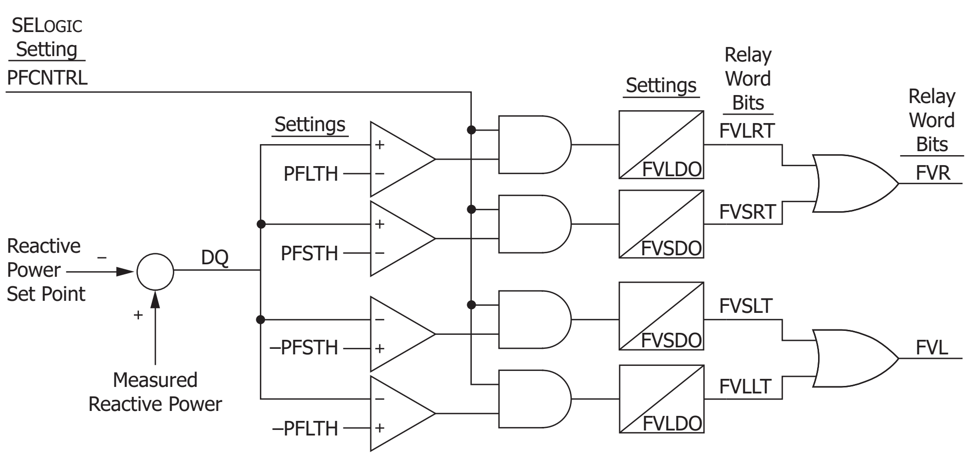


Figure 4.68 Double Deadband Logic

The SEL-710-5 uses the FVLR, FVSR, FVLL, FVSL pulses to obtain the analog quantity OUTVAL, which is used to connect to a field controller that accepts an analog input. OUTVAL is computed as follows:

IF (PFCNTRL == 0) THEN: OUTVAL = PFCOVL

ELSE: OUTVAL[k] = OUTVAL[k – 1] + (FVLR • n) + (FVSR • m) – (FVLL • n) – (FVSL • m)

where:

m = PFSTH • 1000 • 100 / (3 • FLA1 • VNOM / SQRT(3))

n = m • ((PFLTH / PFSTH) – 1)

The range of OUTVAL (0 to 100) is meant to cover the operational range of the field voltage. Ensure that the analog output range provides the field controller with the appropriate minimum and maximum operable field voltage for the machine. During a relay restart, OUTVAL is set to PFCOVL regardless of the value of PFCNTRL.

The PFINBN Relay Word bit indicates that the reactive power is within the given band. The PFGUT Relay Word bit asserts when the reactive power is outside the given band for more than 10 minutes indicating that the system did not correct the power factor.

NOTE: If you set PFSPAN below 0.50 LEAD, the motor field winding may run hotter than normal. Refer to the motor documentation for thermal capability if PFSPAN < 0.50 LEAD.

Table 4.60 Power Factor Correction Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PF CPMP	OFF, PFSP, QSPMV	EPFC := OFF
LEADLAG	LEAD, LAG	PFLDLG := LEAD
PF SET POINT	OFF, 0.10–1.00[a], 0.50–1.00[b]	PFSPAN := OFF
Q SP MATH VAR	1–32	PFQSP := 32
DEADBAND L TH	0.0 to +YYYY.0 kVAR (YYYY = 1.732 • FLA1 • VNOM in kVAR)	PFLTH := 0.05 • YYYY
DEADBAND S TH	0.0 to +YYYY.0 kVAR (YYYY = 1.732 • FLA1 • VNOM in kVAR)	PFSTH := 0.01 • YYYY
LONG STEP LENGTH	0.0–3.0 sec	FVLDO := 1.0
SHRT STEP LENGTH	0.0–3.0 sec	FVSDO := 0.5
SYNCVOLTAGE	0%–100%	PFCOVL := 100
SYNC VLTG CNTRL	SELOGIC	PFCNTRL := SRUNNING

[a] When PFLDLG := LEAD.
[b] When PFLDLG := LAG.

PID Controller

NOTE: For power factor correction, SEL strongly recommends using the double deadband algorithm described in Power Factor Correction over the PID methods because of instabilities that may arise from system conditions and parameters.

The SEL-710-5 includes a Type B PID controller with two modes of operation: as a generic controller utilizing math variables, or for power factor correction through an analog field controller. The controller assumes that the units of the set point (SP) and the process variable (PV) are in percentages and that the control action is PV-SP. The PID controller is processed with the math variables and analog quantities at an interval of 25 ms. *Figure 4.69* presents the PID internal structure. Note that the derivative is computed using the process variable rather than the error (Type B PID configuration).

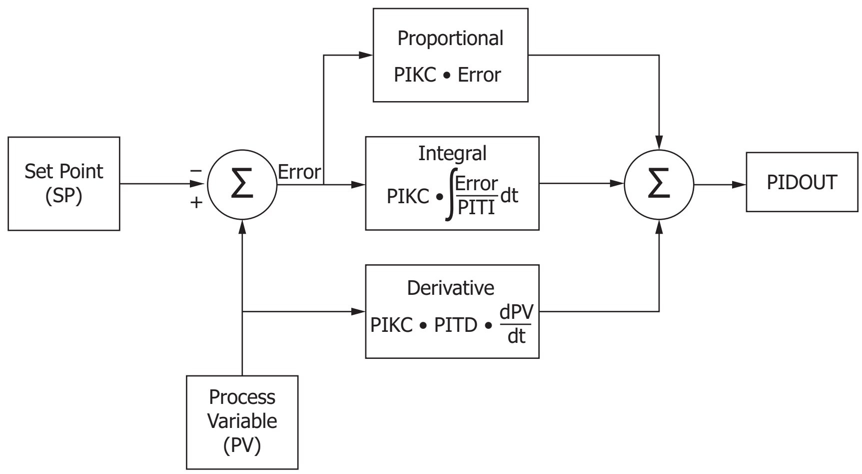


Figure 4.69 PID Controller

Table 4.61 PID Controller Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PID	N, PFSP, PIDMV	EPID := N
PF SET POINT	0.10–1.00	PISP := 1.00
LEADLAG	LEAD, LAG	PILDLG := LEAD
MV SET POINT	1–32	PISPMV := 1
MV PROCESS VAR	1–32	PIPVMV := 1
INTEGRAL INIT VAL	0.0–100.0	PISTART := 50.0
GAIN CONSTANT	0.000 to 15.000	PIKC := 1.000
INT TIME CONST	0.01 to 600.00 sec	PITI := 0.01
DERIV TIME CONST	0.000 to 5.000 sec	PITD := 0.000
OUTPUT FLOOR	0.0–99.9	PIMIN := 0.0
OUTPUT CEILING	0.1–100.0	PIMAX := 100.0
INTEGRAL FREEZE	SELOGIC	PIFRE := 0
PID LOGIC CNTRL	SELOGIC	PIRUN := 1

When EPID is set to PIDMV, the PID controller will use the values of the math variables corresponding to PISPMV and PIPVMV as the set point and the process variable, respectively (e.g., PISPMV = 1 and PIPVMV = 2 will use MV01 and MV02). Since the PID controller assumes a PV–SP control action, you can achieve an SP–PV control action by setting the math variables you use to multiply by –1.

When EPID is set to PFSP, the PID controller will calculate a reactive power set point using the measured real power with the PISP and PILDLG settings, while the process variable will use the measured reactive power These values are converted to per unit through the use of the FLA1 and VNOM settings.

The analog quantity output of the PID controller, PIDOUT, is given as a percentage and is bounded by the floor setting, PIMIN, and the ceiling setting, PIMAX. An anti-integral windup scheme is implemented by freezing the integral term when either of two scenarios occurs: the calculated PIDOUT is above the PIMAX setting and the error is positive, or the calculated PIDOUT is below the PIMIN setting and the error is negative. The integral term can also be frozen when the SELOGIC equation PIFRE evaluates to a logical 1. In either case, the Relay Word bit PIAW will assert when the integral term is frozen.

Synchronous Motor Synchronization

The SEL-710-5 provides three different methods for synchronous motor synchronization:

- ➤ Time-delayed start for brushless synchronous motors
- ➤ Slip-dependent synchronization based on field voltage measurements
- ➤ Slip-dependent synchronization based on stator current measurements

Time-Delayed Starting for Brushless Synchronous Motors

Time-delayed starting is applicable to brushless type machines when setting SYNTYPE := BRUSHLESS. The brushless motor is started by first applying ac power to the stator windings. Once the relay detects the machine is in the STARTING or RUNNING state, the relay asserts the 41CLOSE Relay Word bit after a fixed time-delay setting, 41DELAY. Use the 41CLOSE bit to operate an output contact directly. This output contact can be wired to close the field contactor or breaker circuit to apply dc excitation to the motor field winding.

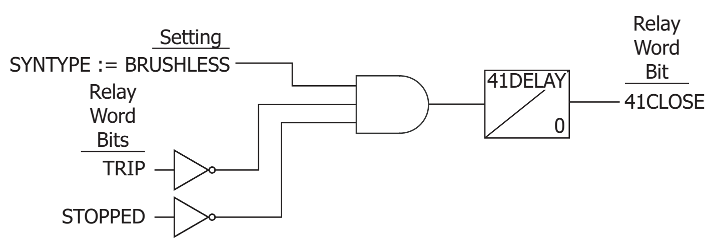


Figure 4.70 Starting Brushless Synchronous Motor

NOTE: 41DELAY must be set higher than the motor acceleration time when SYNTYPE := BRUSH or BRUSHLESS for Relay Word bit 41CLOSE2 to work properly (see Figure 4.75 for more detail).

Table 4.62 Brushless Synchronous Motor Start-Sequence Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
41 CLOSE DELAY	0.0–100.0 sec	41DELAY := 3.0

Brush-Type Synchronous Motor Synchronization

The SEL 710-5 has the capability to synchronize a brush-type synchronous motor. Use an SEL external voltage divider board to convert the voltage across the field voltage discharge resistor (VDR) to a level suitable to the relay. Refer to *Figure 2.36* for a connection diagram of the external voltage divider board. Proper polarity, as shown in *Figure 2.36*, is essential when connecting the VDR input to the relay.

The following steps are part of the synchronization process:

1. Closing of the field circuit via the field discharge resistor
2. Application of three-phase power to stator
3. Application of field excitation when desired slip and angle are reached
4. Tripping of the motor in case of incomplete sequence

⚠ **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.

NOTE: The input to VDRM should be greater than 54 V for the synchronous motor start logic to work.

The motor is started with the discharge resistor connected across the motor field winding via the 41b auxiliary contact. The brush-type motor is started by applying ac power to the stator windings. This results in a rotating magnetic field in the air gap at synchronous speed. The rotating magnetic field, in effect, induces EMF in the amortisseur windings (also referred to as damper windings) and the field winding. The torque produced by the induced currents in the amortisseur windings causes the motor to operate as an induction motor and to accelerate to near synchronous speed. On the other hand, the induced current in the field circuit circulates through the VDR. The relay uses the voltage across the VDR to determine the exact moment to energize the field winding as explained in the following text.

The relay uses the settings in *Table 4.63* as part of the start sequence.

Table 4.63 Synchronous Motor Start Sequence Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
STRT SEQ ENABLE	SELOGIC	STSEQEN := R_TRIG STARTING AND NOT 47T AND NOT SMTRIP AND NOT (FDUV1T OR FDUV2T)
STRT SEQ DELAY	0–1000 ms	STSEQDLY := 0
SYNCHRONIZE SLIP	1.0%–10.0%	SYNSLIP := 2.0
UNLATCH 41CLOSE	SELOGIC	UL41CL := TRIP OR STOPPED
FIELD BKR CL TIME	OFF, 0–1000 ms	FLDBKCL := OFF
MIN CLOSE DELAY[a]	0.1–99.0 sec	41MNDLY := 0.1

[a] This setting is related to Synchronization Based on Stator Measurements and Figure 4.75.

Figure 4.71 shows the synchronous motor start sequence enable logic. Program the SELOGIC setting STSEQEN to initiate the synchronization process. You can delay the synchronous motor start sequence by a fixed time using the STSEQDLY setting. If the field excitation voltage, VEX, is wired to the relay, a field undervoltage element is set and programmed as part of STSEQEN, ensuring that appropriate field voltage is present before the start sequence is initialized.

Program the percentage of the synchronization slip setting, SYNSLIP, as recommended in the synchronous motor data sheet. The relay calculates the slip frequency in percent from the VDR signal, FREQR, at every zero crossing, i.e., SMSLIP = (FREQR / FNOM) • 100, and compares it to the SYNSLIP setting. If the calculated rotor slip frequency is less than or equal to the SYNSLIP setting, the relay declares that the required slip is reached and sets the SLIPRECH Relay Word bit. The relay simultaneously keeps track of the positive-to-negative zero crossing (PNZC) of the VDR signal rotor angle to allow for the effective pull-in of the rotor when the field is applied to synchronize the motor.

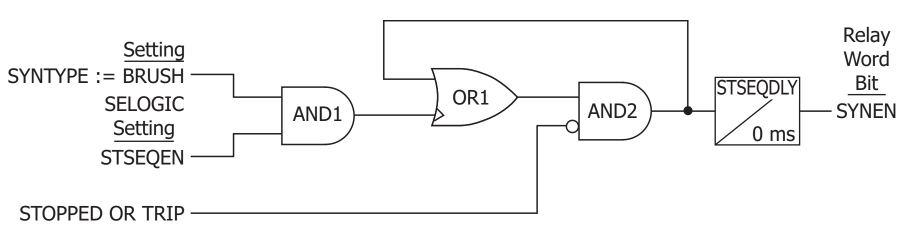


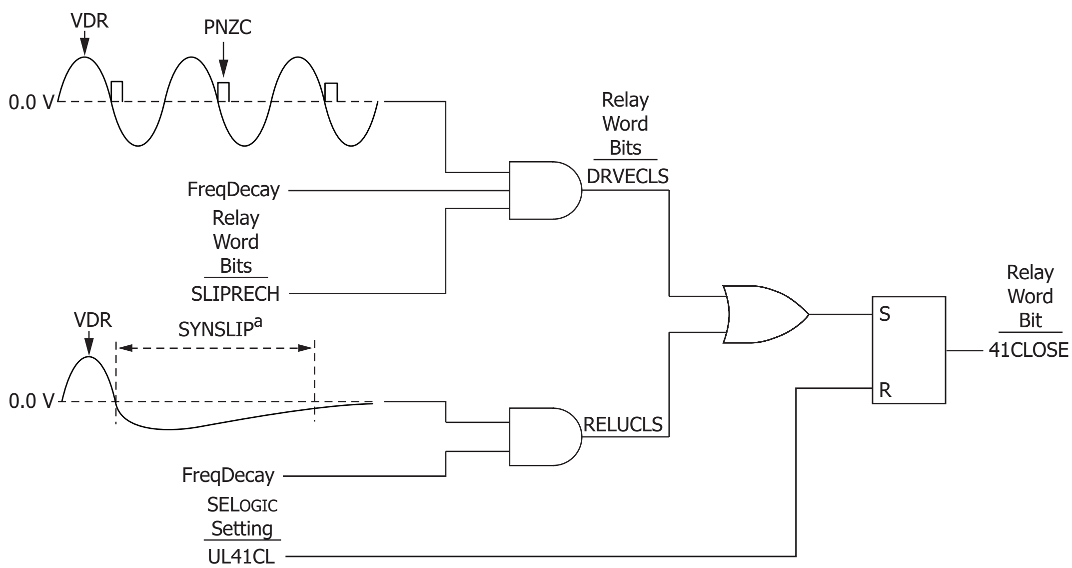
Figure 4.71 Synchronous Motor Start Sequence Enable Logic

Figure 4.72 shows the 41CLOSE logic for a brush-type synchronous motor. The DRVECLS (drive-to-close for an effective pull-in) or RELUCLS (reluctance torque synchronizing) Relay Word bits set the 41CLOSE.

The FREQDECAY input supervises both of these bits. This input qualifies a proper start sequence by ensuring that the VDR observed is favorable (e.g., negative and decreasing signal) after assertion of the SYNEN bit. The relay computes the speed of the rotor using consecutive zero crossings in the VDR signal. The relay computes two quantities to show the rotor speed:
1) SMSLIP, in percentage, where 100 means stand-still and 0 means synchronous speed; and 2) FREQR, in hertz.

Once the required slip frequency is reached, the relay issues a 41CLOSE via DRVECLS on the immediate or subsequent PNZC transition of the VDR signal for an effective pull-in of the rotor.

If the SLIPRECH asserts while the signal is unfavorable (e.g., VDR negative but increasing), the PNZC may not be dependable. In this case, the relay issues a 41CLOSE via RELUCLS for a reluctance close. For the RELUCLS Relay Word bit to assert, the VDR voltage has to be unfavorable for a period greater than the SYNSLIP setting expressed in seconds. For example, if SYNSLP = 10% and FNOM = 60 Hz, then the SYNSLP setting expressed in seconds is 1/6 Hz = 0.167 seconds. Use the 41CLOSE bit to operate an output contact directly. Wire this output contact to close the field contactor or breaker circuit, to apply dc excitation to the motor field winding, and to open the field discharge resistance circuit.



[a] Period corresponding to SYNSLIP setting in seconds.

Figure 4.72 41CLOSE Logic for Brush-Type Synchronous Motor

Use the UL41CL SELOGIC setting to unlatch the 41CLOSE Relay Word bit in the event of a TRIP or when the motor has stopped. In applications that require line current supervision, i.e., for a line current less than 1.1 • FLA1, the ADV_RUNN Relay Word bit can be programmed into UL41CL (UL41CL := TRIP OR STOPPED OR NOT ADV_RUNN) to supervise the 41CLOSE bit. Refer to *Figure 4.79* for the ADV_RUNN Relay Word bit.

Monitor the synchronous motor starting sequence with the START_T setting (see *Figure 4.31* and *Figure 4.32*) to trip the motor in case of an incomplete start sequence, i.e., the 41CLOSE does not assert within START_T time. The

SEL-710-5 decides the state of the synchronous motor based on the synchronous motor running state logic shown in *Figure 4.78*. Program the FDCMIN and 41A settings accordingly to indicate to the relay that the synchronous motor field contactor or breaker is closed.

See *Figure 4.73* for an event capture of synchronous motor starting. Along with the line currents and voltages, the CEV report in SEL-710-5 also captures the VDR voltage and rotor frequency, FREQR, measured at each zero-crossing. In *Figure 4.73*, the capture uses the following event report settings: PRE = 10 cyc, LER = 180 cyc, and ER = R_TRIG STARTING. For motors with a starting time longer than three seconds, program ER = R_TRIG STARTING OR R_TRIG 41CLOSE, as needed.

NOTE: VDR in the CEV report is in volts primary, equivalent to VDRM shown in Figure 2.36.

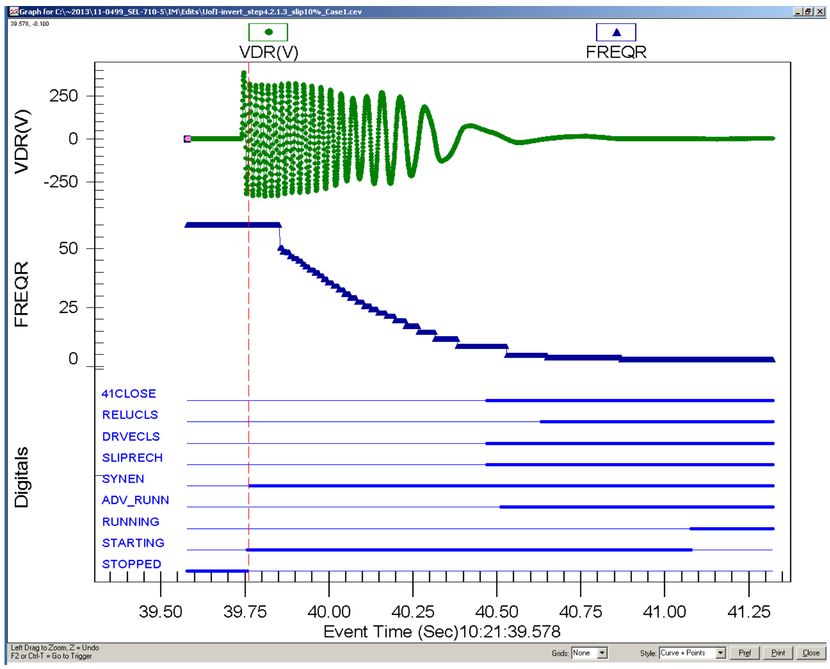


Figure 4.73 SEL-710-5 Event Capture Of Synchronous Motor Starting

Field Breaker Close Time Incorporated Brush-Type Synchronous Motor Synchronization

The 41CLOSE logic for a brush-type synchronous motor issues the close command at a negative-going-zero crossing (ZC) of the VDR signal. Depending on the field breaker closing delay, the actual field breaker closing may happen much later than the target ZC. In some situations, delayed field application could lead to an unsuccessful start of large motors with high inertia and/or high starting load.

If the field breaker close delay affects the actual field application farther away from the target ZC and leads to an unsuccessful start, you can use 41CLOSE3. The 41CLOSE3 logic is enabled by the setting FLDBKCL and the synchronous motor start sequence enable logic (see *Figure 4.71*). Program the FLDBKCL setting equal to the field breaker closing delay. Once SYNEN is satisfied, the 41CLOSE3 logic determines the correct time to issue the field breaker close command (having taken the time needed for the breaker to close [breaker closing time] into account), as shown in *Figure 4.74*.

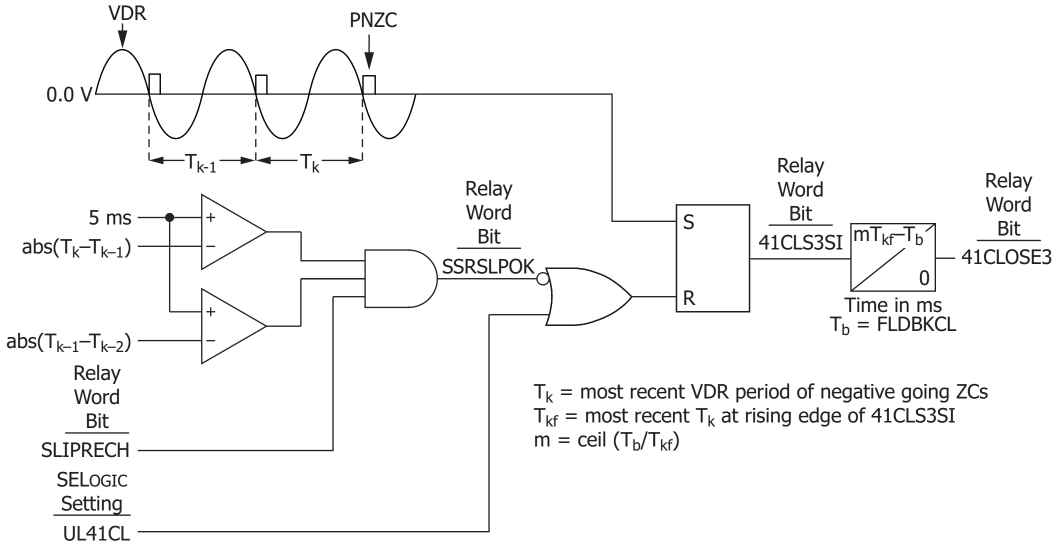


Figure 4.74 41CLOSE3 Logic for Brush-Type Synchronous Motors

To apply 41CLOSE3:

1. VDR signal should stabilize below SYNSLIP with a near constant period.
2. Motor should not go to a reluctance close.
3. SYNSLIP setting should be less than or equal to 5 percent. This is to limit the field breaker closing error at the target ZC.

When the VDR signal is periodic and the frequency is below SYNSLIP (change in VDR period during most recent 3 periods less than 5 ms and SLIPRECH satisfied), SSRSLPOK asserts. When SSRSLPOK is high and UL41CL is low, 41CLS3SI will assert at the next negative-going-ZC of the VDR signal. Then a timer is used such that 41CLOSE3 asserts FLDBKCL time in advance the target ZC. In the logic, the relay uses the most recent stable VDR period at the rising edge of 41CLS3SI (T_{kf}) as an estimate of the subsequent VDR periods.

When you enter the synchronous motor start sequence settings, the relay internally computes the maximum expected closing angle at the target ZC for a given SYNSLIP and FLDBKCL combination. If the maximum expected closing angle error is greater than 6^0, the relay issues a warning message when you enter the settings. It is recommended that you limit the maximum closing angle at the target ZC to less than 6^0. Assuming zero error in FLDBKCL, the maximum expected closing angle at the target ZC is computed as follows:

TROTORS = 100 • 1000/(SYNSLIP • FNOM)

m_max = FLDBKCL/TROTORS (round up to the nearest integer)

maximum expected closing angle at the target ZC =
m_max • (m_max+1) • 5 • 360/(2 • TROTORS)

Synchronization Based on Stator Measurements

This method is intended for synchronization of motors with salient poles and start times of at least three seconds. The SEL-710-5 Relay calculates the slip, SMSLIP2, based on the stator measurements and compares it with SYNSLIP (in percentage), as seen in *Figure 4.75* (refer to *Table 4.63* for settings). When the calculated slip, SMSLIP2, is less than the SYNSLIP setting, the relay declares that the required slip for synchronization is reached and the SLIPBT

Relay Word bit asserts. The SLIPOK Relay Word bit supervises the SLIPBT Relay Word bit. The SLIPOK Relay Word Bit asserts when the slip calculated based on the stator measurements is reliable. The motor slip computation logic is enabled by Field Close Enable or the motor state logic declaring that the motor is in the STARTING state.

NOTE: 41DELAY must be set higher than the motor acceleration time when SYNTYPE := BRUSH or BRUSHLESS for Relay Word bit 41CLOSE2 to work properly (see Figure 4.75 for more detail).

The 41CLOSE2 Relay Word bit is set by the 41CLS2 Relay Word bit. Use the 41CLOSE2 Relay Word bit to close the field breaker. A timer supervises this logic. The timer guarantees that synchronization does not happen before the minimum timer expires (Ta) or after the maximum timer expires (Tb). Program the 41MNDLY setting to 30 to 40 percent of the minimum start time. Use the UL41CL SELOGIC setting to unlatch the 41CLOSE2 Relay Word bit in the event of a TRIP or when the motor has come to a STOP.

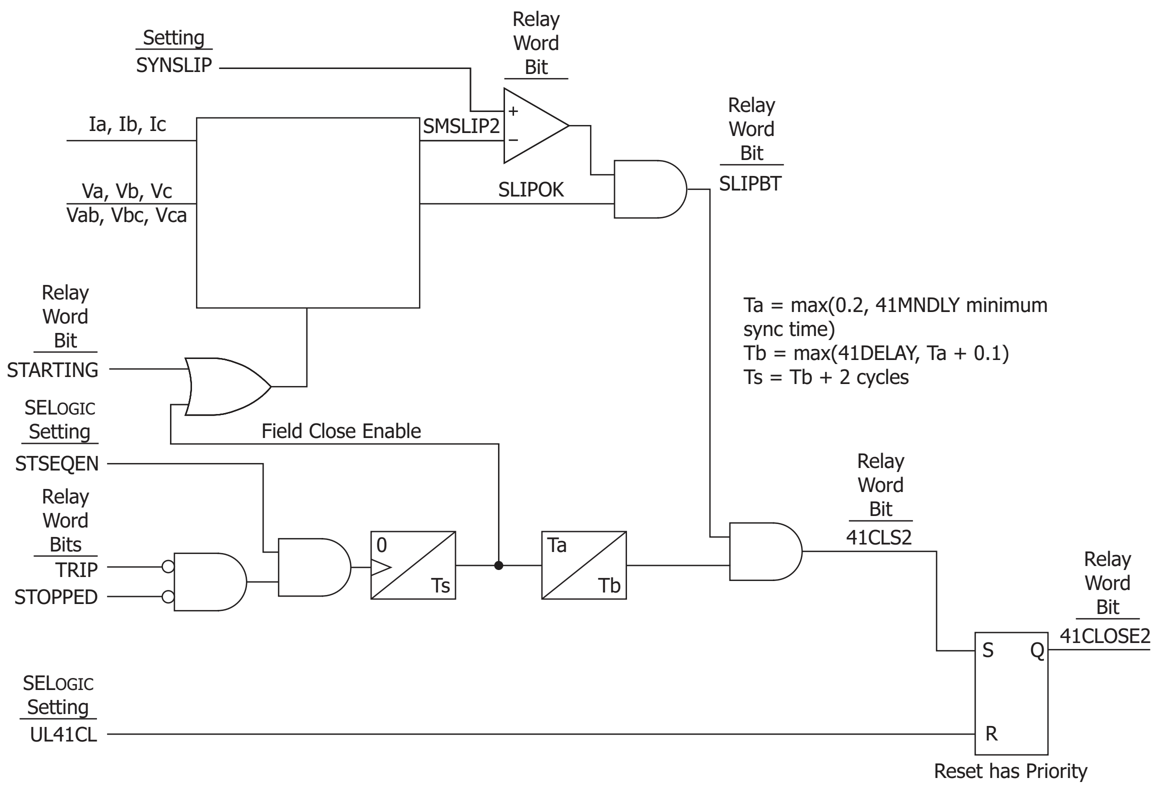


Figure 4.75 Slip-Computation Using Stator Measurements for Slip-Dependent Thermal Model and Synchronous Motor Synchronization

While this synchronization method is adequate to synchronize both brush and brushless motors, synchronization based on the VDR measurements is the preferred method for brush motors. Synchronization based on the VDR measurements allows for the closing of the field on a positive-to-negative zero crossing of the VDR signal for an effective pull-in of the rotor. Refer to *Table 4.63* for the settings related to this method.

Trip Logic

Trip Inhibit (Block) Function

You can assign any control input to the SELOGIC control equation BLKPROT. The relay uses the BLKPROT Relay Word bit to disable one or more protective functions listed in *Table 4.64* when the BLKPROT control input asserts.

Table 4.64 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

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

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

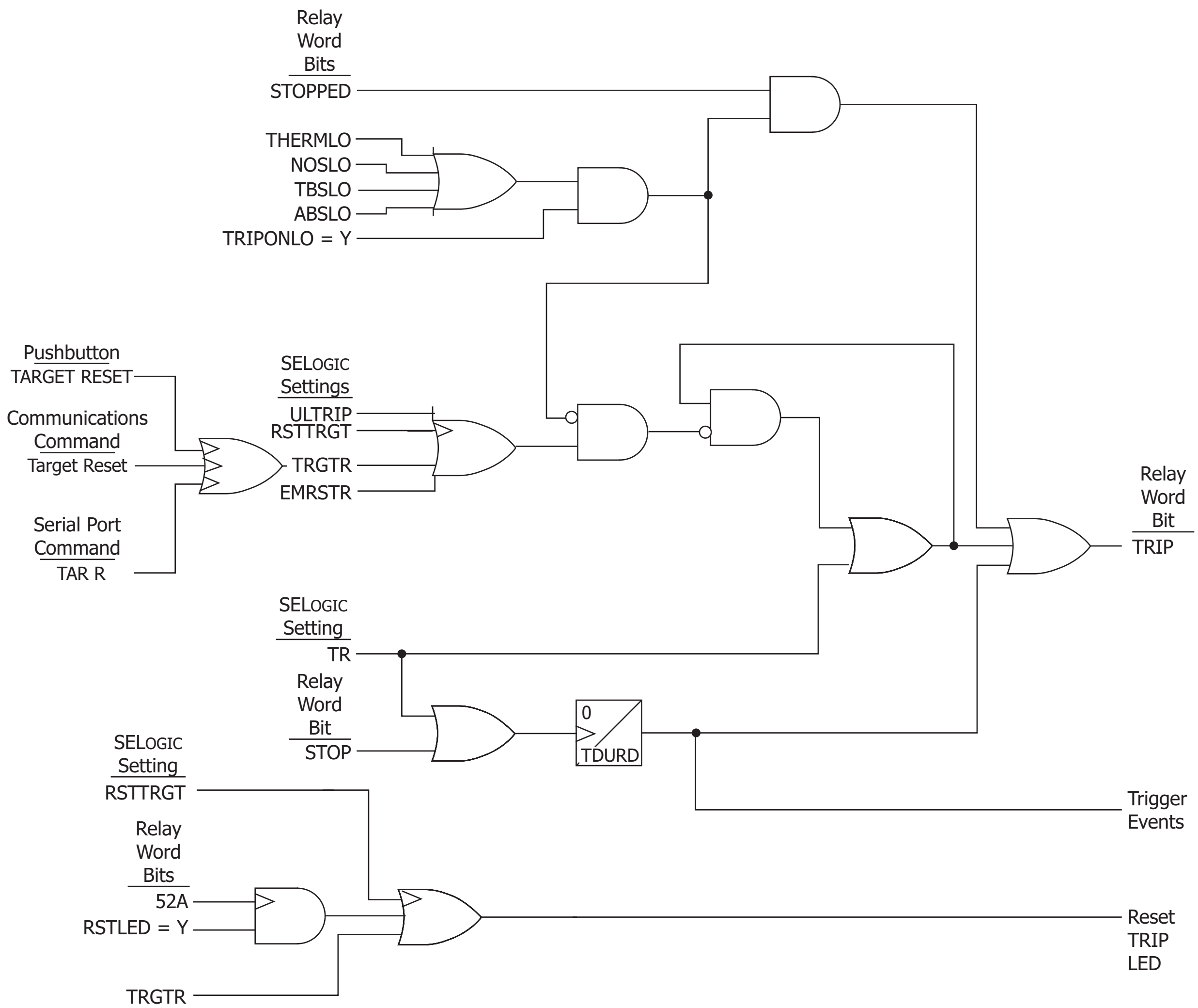
Trip/Close Logic

NOTE: The factory-default assignment of the Relay Word bit TRIP is the output **OUT103**. See Table 4.77 for the output contacts settings.

The SEL-710-5 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 4.76* illustrates the tripping logic.

Table 4.65 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 SPDSTR OR 50N1T OR SMTRIP OR (27P1T AND NOT LOP) OR SV01T OR SV03T
REMOTE TRIP EQN	SV	REMTRIP := 0
TRIP ON LOCKOUT	Y, N	TRIPONLO := Y
UNLATCH TRIP EQN	SV	ULTRIP := 0
CONTACTORSTATUS	SV	52A := 0
FLD BRKR STATUS	SV	41A := 0



STOPPED = Motor Stopped Relay Word Bit
THERMLO = Thermal Element Lockout
NOSLO = Starts-Per-Hour Lockout
TBSLO = Minimum Time Between Starts Lockout
ABSLO = Antibackspin Lockout
TRIPONLO = Trip on 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 4.76 Stop/Trip Logic

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

TDURD Minimum Trip Time

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

Trips initiated by the STOP Relay Word bit (asserted at the front panel or by the **STOP** 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-710-5 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-710-5 opens. Failure to observe this safeguard could result in damage to the SEL-710-5 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 the duration of the TDURD setting or until TRIP is unlatched, whichever is longer.

NOTE: You can use an indirect mapping (e.g., SV01T) as in the factory-default setting. See Table 4.65 for the SV01 settings.

The SEL-710-5 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 2.28*).

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 trip the breaker by input IN303 via REMTRIP.

REMTRIP := IN303

TR :=...OR REMTRIP

The HMI displays `Remote Trip` to indicate the trip by remote trip logic.

ULTRIP Unlatch Trip Conditions SELOGIC Control Equation

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

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

- Minimum trip duration time (TDURD) passes.
- The TR SELOGIC control equation result deasserts to logical 0.
- All the motor lockout functions, described below, deassert to logical 0.
- 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

When TRIPONLO := Y, the relay automatically locks out the motor by asserting the trip signal if the motor stops and any of the following conditions exist:

- **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, as shown in *Figure 4.77*.

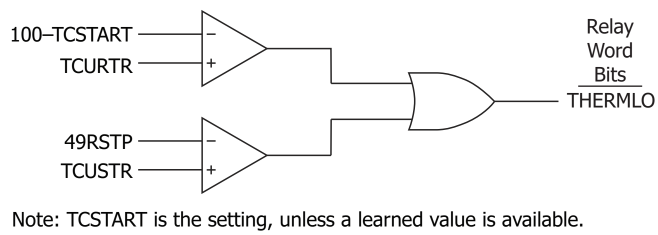


Figure 4.77 Thermal Element Lockout Logic

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 cleared once all the enabled lockout conditions are cleared.

52A and 52B Contactor/Breaker Status SELOGIC Control Equations

NOTE: When the 52A setting is used with an appropriate control input, it enhances the motor state logic (see *Figure 4.79*). This is particularly important if the motor has low operational idling current (less than 10 percent FLA).

NOTE: For the disconnect settings and logic, refer to Disconnect Control Settings on page 9.2. For the touchscreen relay option, refer to Table 9.5 for typical disconnect symbols. For the settings related to bay control disconnect symbols, refer to Table 9.7 and the corresponding descriptions.

Use the SELOGIC settings 52A and 52B to map the respective breaker or contactor auxiliary contacts to the relay. Because the 52b contact is not always available and to reduce the number of I/O required, the breaker status logic does not include the 52B contact. The relay uses the 52A Relay Word bit as the status of the breaker/contactor in conjunction with the protection elements, motor state, trip, and close logic. The default 52B setting is NOT 52A. The factory-default setting assumes no auxiliary contact connection (52A := 0).

If you connect the breaker auxiliary contacts to digital inputs, you must change the factory-default logic equations for 52A and 52B. For example, set 52A := IN101 and 52B := IN102 if you connect the 52a and 52b contacts to inputs IN101 and IN102, respectively.

NOTE: For the settings related to the local/remote breaker control function, refer to Local/Remote Control on page 9.7. For breaker control via the front-panel pushbuttons, refer to Front-Panel Operator Control Pushbuttons on page 8.19. For breaker control via the two-line display, refer to Control Menu on page 8.10. For breaker control via the touchscreen, refer to Motor/Disconnect Control Via the Touchscreen on page 9.8.

The SEL-710-5 relay with the touchscreen display option additionally provides the ability to design detailed single-line diagrams and display the breaker and disconnect status. Refer to *Table 9.1* for typical circuit breaker symbols available for display on the bay screens. For settings related to bay control breaker symbols, refer to *Table 9.7* and the corresponding description

41A Field Contactor/Breaker Status Conditions for the SELOGIC Control Equation

NOTE: When used with an appropriate control input, the 41A setting enhances the synchronous motor running state logic (see Figure 4.78).

You can connect an auxiliary contact of the 41 contactor or breaker to the relay. The SELOGIC control equation 41A allows you to configure the relay for either the 41b or 41a contact input. The factory-default setting assumes no auxiliary contact connection (41A := 0).

If you connect the breaker auxiliary contact to a digital input, you must change the factory-default logic equation for 41A. For example, set 41A := IN101 if you connect the 41a contact to input IN101.

Synchronous motor is latched to be in synchronized running state, SRUNNING, either when the relay detects the 41A field breaker status as closed or when the relay detects a field current greater than minimum field current setting, FDCMIN, while the machine is in the RUNNING state. The FDCURIN, FD_20 mA/ FD_5 V (see *Section 2: Installation* for the board switch position) settings must be set to detect primary field current. The SRUNNING state is unlatched by the motor STOPPED state.

Table 4.66 Start Sequence Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
MN FDC TO SYNC[a]	0.5–2000.0 A dc pri	FDCMIN := 400.0

[a] This setting is related to Synchronization Based on Stator Measurements and Figure 4.75.

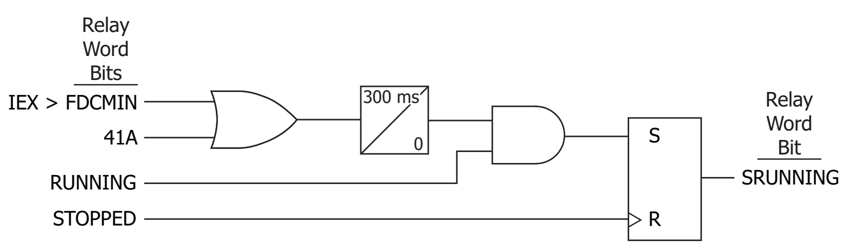


Figure 4.78 Synchronous Motor Running State Logic

Motor Control

The motor control settings interface the SEL-710-5 for external start control and motor speed control. *Table 4.67* lists these SELOGIC control equation settings.

Table 4.67 Motor Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
START EQUATION	SELOGIC	STREQ := PB03
BLK START	SELOGIC	BLKSTSR := STOPPED AND (THERMLO OR NOSLO OR TBSLO OR ABSLO)
EMERGENCY START	SELOGIC	EMRSTR := 0
SPEED2	SELOGIC	SPEED2 := 0
SPEED SWITCH	SELOGIC	SPEEDSW := 0
VFDBYPASS	SELOGIC	VFDBYPAS := 0

In VFD applications, connect the auxiliary contact of the bypass switch to the input assigned to the setting VFD Bypass (VFDBYPAS) only if the optional voltage inputs are connected. The relay automatically switches from rms to fundamental magnitudes for protection elements when the VFD is bypassed (VFDBYPAS is asserted).

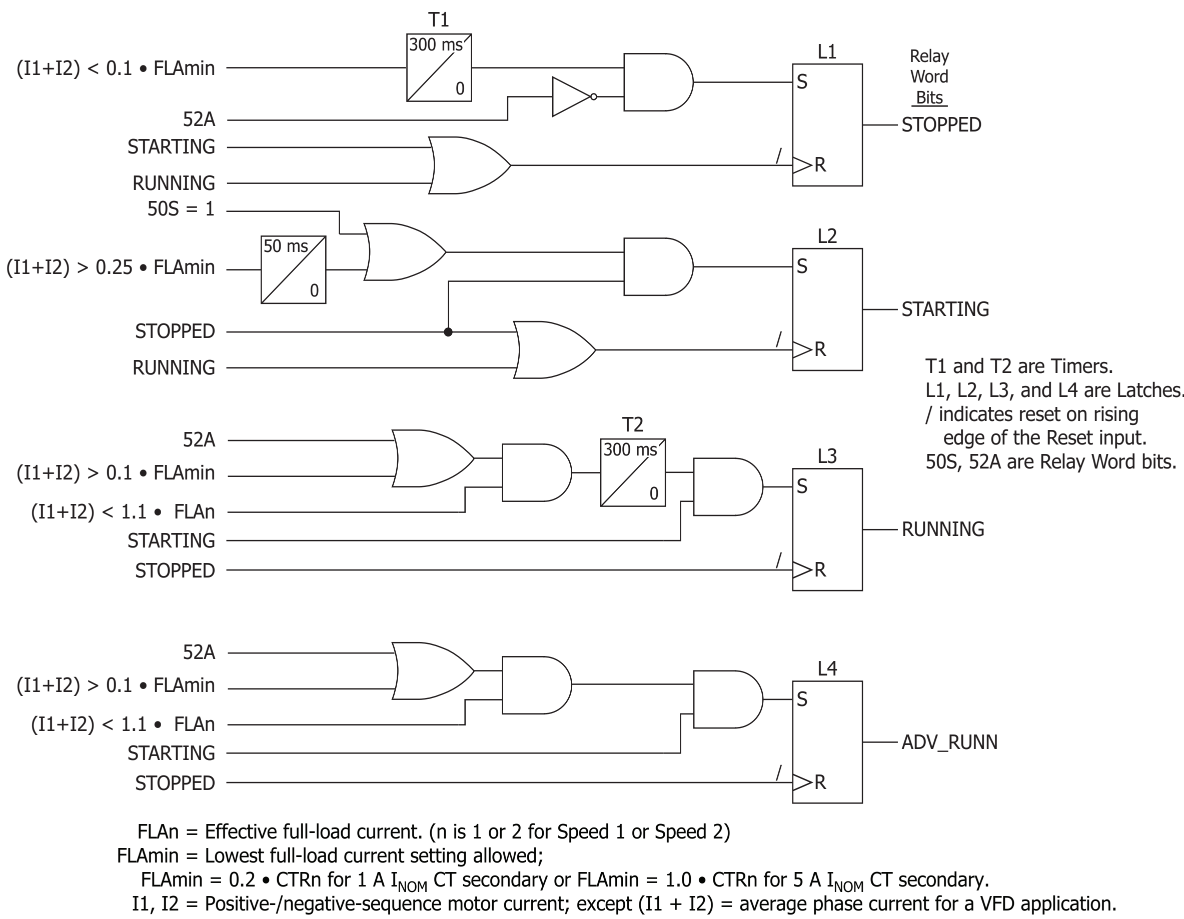


Figure 4.79 Motor State Logic

Start Controls

Figure 4.80 shows the logic the relay uses to initiate motor starts.

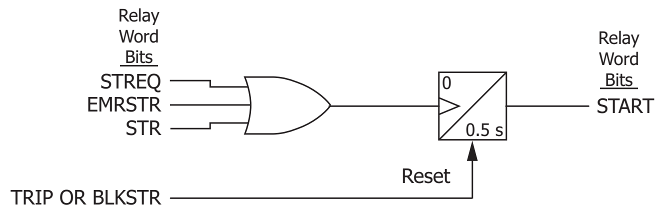


Figure 4.80 Start Logic

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 or the BLKSTR bit asserts. If the relay trips or the BLKSTR bit asserts before the 0.5 second timer expires, the relay resets the timer, clearing the START Relay Word bit.

In an emergency, it can 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 4.76*). 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 the 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 4.80*.

Speed Controls

You can assign any control input to the SELOGIC control equations SPEED2 and SPEEDSW. When the SPEED2 control input is asserted *and* the two-speed enable setting E2SPEED is Y, the SEL-710-5 selects second values for the settings shown in *Table 4.68*. See *Table 4.2* and *Table 4.4* for a 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). This feature is not available when VFDAPP := Y.

NOTE: With the LEA card (Slot Z = L1), the relay internally sets CTR2 = ILEA_SC1, FLA2 = FLA1, LRA2 = LRA1, LRTHOT2 = LRTHOT1, TD2 = TD1, RTC1 = RTC1, and CURVE2 = CURVE1.

The SPEEDSW control input provides an indication of the rotor speed to the speed switch logic. Refer to *Table 4.28* for more detail.

Table 4.68 Settings Selected by SPEED2 Input

Setting Description	Normal Setting Prompt (Normal Setting Name)	Second Setting Prompt (Second Setting Name)
Phase CT Ratio	PHASE CT RATIO (CTR1)	CT RATIO–2nd (CTR2)
Full-Load Current	MOTOR FLA (FLA1)	MOTOR FLA–2nd (FLA2)
Locked Rotor Current	MOTOR LRA (LRA1)	MOTOR LRA–2nd (LRA2)
Hot-Locked Rotor Time	LOCKD RTR TIME 1 (LRTHOT1)	LOCKD RTR TIME 2 (LRTHOT2)
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

IMPORTANT: Upon relay initial turn on, Port 1 setting changes, or Logic setting changes, you may have to wait as long as two minutes before an additional settings change can occur. Note that the relay is functional with protection enabled as soon as the ENABLED LED comes on (approximately 5–10 seconds after turn on).

Table 4.69 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 4.69 Enable Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
SELOGIC Latches	N, 1–32	ELAT := N
SV/Timers	N, 1–32	ESV := 3
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-710-5 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 goes 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 4.81*). 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).

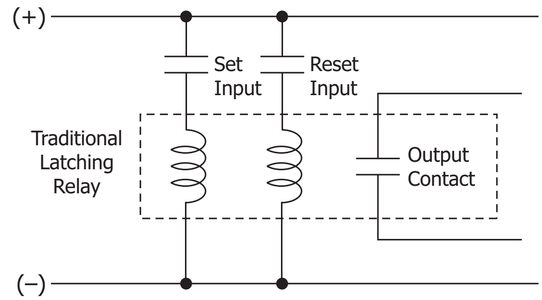


Figure 4.81 Schematic Diagram of a Traditional Latching Device

Thirty-two latch control switches in the SEL-710-5 provide latching device functionality. *Figure 4.82* 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.

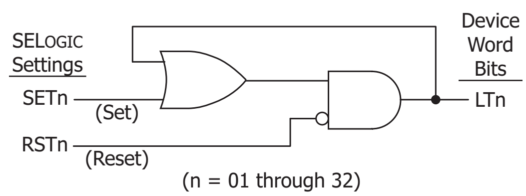


Figure 4.82 Logic Diagram of a Latch Switch

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-710-5 includes 32 latches. *Table 4.70* shows the **SET** and **RESET** default settings for Latch 1. The remaining latches have the same settings.

Table 4.70 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 4.111* explanation. If the individual settings change causes a change in SELOGIC control equation settings SET*n* or RST*n* (*n* = 1 through 32), the retained states of the latch bits can be changed, subject to the newly enabled settings SET*n* or RST*n*.

Make Latch Control Switch Settings With Care

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

Settings SET*n* and RST*n* cannot result in continuous cyclical operation of latch bit LT*n*. Use timers to qualify conditions set in settings SET*n* and RST*n*. If you use any optoisolated inputs in settings SET*n* and RST*n*, the inputs each have a 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 4.83*. Timers SV01T through SV32T in *Figure 4.83* 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).

NOTE: Any SELOGIC equation that contains a RWB/analog quantity that gets hidden because of a setting change or a configuration change would show up as a BAD SELOGIC EQUATION.

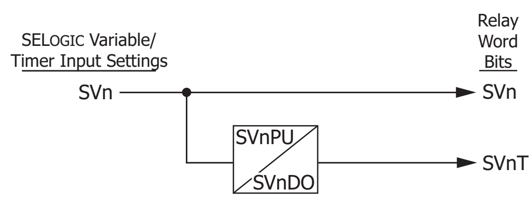


Figure 4.83 SELOGIC Control Equation Variable/Timers SV01/SV01T–SV32T

You can enter as many as 15 elements per SELOGIC equation, including a total of 14 elements in parentheses (see *Table 4.72* 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 4.72*. Math SELOGIC control equation settings operate on numerical values, using one or more of the Mathematical operators listed in *Table 4.72*. 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 4.15* for an explanation on improving the accuracy of the math operations by managing the processing order.

EXAMPLE 4.15 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 the result by 100,000 and stores it as 200,000. When the number is reported, the relay divides out the scale factor (128) and reports 1562.5.

Alternately, 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 4.15 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.

NOTE: Math variables are reset to zero if the relay loses power because the math variables are stored in volatile memory.

The executed result of a math SELOGIC control equation is stored in a math variable. The storage format of the math variable is a 32-bit fixed point signed integer; 24 bits represent the integer portion, 7 bits represent the fractional portion, and one bit represents the sign. 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 is clipped at the limit value. For example, when the MV01 := executed result is –16777219.00, MV01 is -16777215.99. Similarly, when the MV02 := executed result is +16777238.00, MV02 is +16777215.99.

Because there are only 7 bits available for the fractional portion, the result of multiplication and division with decimals has lower accuracy than one would expect with a floating point processor. As illustrated by the results in *Table 4.71*, the results vary from 20 percent at the smallest end of the fractional values to 0.2 percent at the largest. Use scaling factors where possible to avoid the error introduced by the fixed point processor when multiplying and dividing fractional numbers.

Table 4.71 Math Variable Fractional Multiplication Results

MV01 := 0.01*10	Result = 0.08	Error = 20%
MV01 := 0.05*10	Result = 0.47	Error = 6%
MV01 := 0.1*10	Result = 1.02	Error = 2.0%
MV01 := 0.5*10	Result = 5.00	Error = 0%
MV01 := 0.99*10	Result = 9.92	Error = 0.2%

You can add comments to both Boolean and math SELOGIC control equations by inserting a # symbol. Everything following the # symbol in a SELOGIC control equation is treated as a comment. See *Table 4.73* 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-710-5 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 is 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 4.72 SELOGIC Control Equation Operators (Listed in Operator Precedence)

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

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

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

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 4.84*.

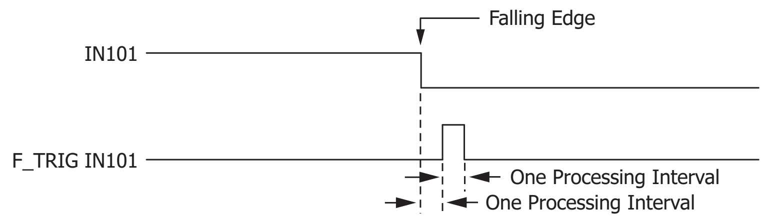


Figure 4.84 Result of Falling-Edge Operator on a Deasserting Input

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. If Relay Word bits (which are effectively Boolean resultants, equal to logical 1 or logical 0) are used in mathematical operations (*, /, +, and –), 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. Comparisons (<, >, <=, and >=) 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 than or equal to 8 in value, output contact OUT103 deasserts (OUT103 = logical 0).

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

OUT102 := **MV01 <> 45**

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

Table 4.73 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 4.85* 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)**

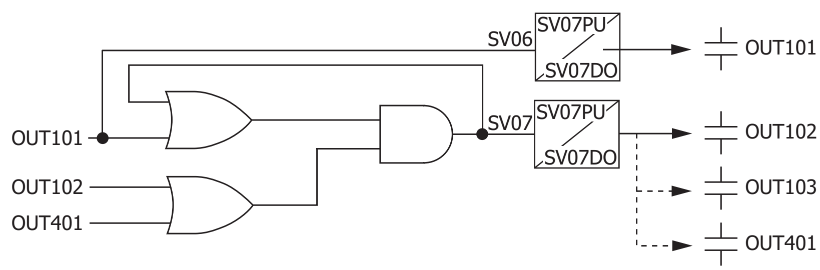


Figure 4.85 Example Use of SELOGIC Variables/Timers

SV/Timers Settings

The SEL-710-5 includes 32 SELOGIC variables. *Table 4.74* shows the pick-up, drop-out, and equation settings for SV01, SV02, and SV03. The remaining SELOGIC variables have the same default settings as SV02.

Table 4.74 SELOGIC Variable Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SV TIMER PICKUP	0.00–3000.00 sec	SV01PU := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV01DO := 0.00
SV INPUT	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

Table 4.74 SELOGIC Variable Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SV TIMER PICKUP	0.00–3000.00 sec	SV02PU := 0.000
SV TIMER DROPOUT	0.00–3000.00 sec	SV02DO := 0.000
SV INPUT	SELOGIC	SV02 := NA
SV TIMER PICKUP	0.00–3000.00 sec	SV03PU := 0.000
SV TIMER DROPOUT	0.00–3000.00 sec	SV03DO := 0.000
SV INPUT	SELOGIC	SV03 := 40Z1T OR 40Z2T OR FDUC1T OR FDOC1T OR FDUV1T OR FDOV1T OR FDRES1T OR SV01T OR OOST OR 55T
⋮	⋮	⋮
SV TIMER PICKUP	0.00–3000.00 sec	SV32 := 0.00
SV TIMER DROPOUT	0.00–3000.00 sec	SV05 := 0.00
SV INPUT	SELOGIC	SV05 := 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-710-5 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: If setting SCnnCU is set to NA, the counter counts downward only.

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 4.86* shows Counter 01, the first of 32 counters available in the device.

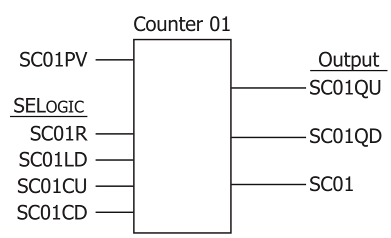


Figure 4.86 Counter 01

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 4.75* describes the counter inputs and outputs, and *Table 4.76* shows the order of precedence of the control inputs.

Table 4.75 Counter Input/Output Description (Sheet 1 of 2)

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

Table 4.75 Counter Input/Output Description (Sheet 2 of 2)

Name	Type	Description
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 can be used with analog comparison operators in a SELOGIC control equation and viewed using the **COU** command.

Table 4.76 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 4.87 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.

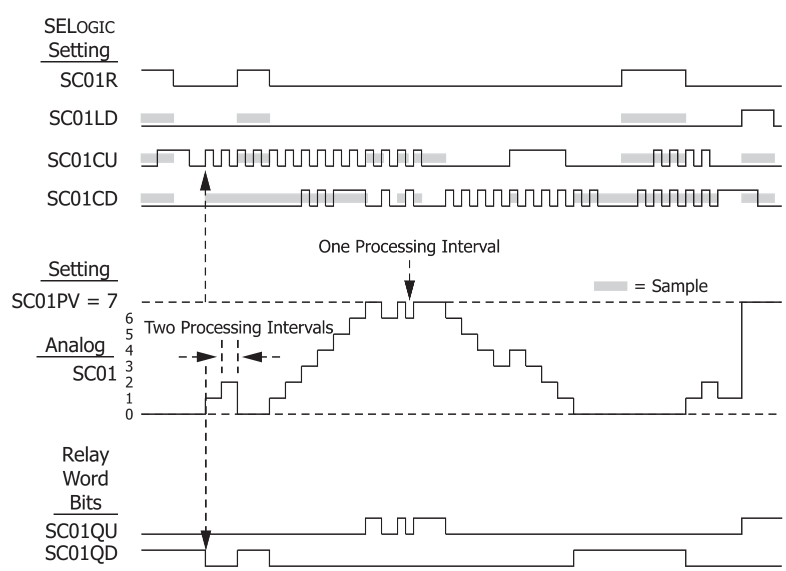


Figure 4.87 Example of the Effects of the Input Precedence

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 4.87*, just before the "one processing interval" notation.

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

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

The same operating principles apply for all of the counters: SC01–SC*mm*, where *mm* = the number of enabled counters.

Output Contacts

You can use SELOGIC control equations to map protection (trip and warning) and general-purpose control elements to the outputs with the SEL-710-5. In addition, you can enable fail-safe output contact operation for relay contacts on an individual basis.

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

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

Table 4.77 Control Output Equations and Contact Behavior Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
OUT101 FAIL-SAFE	Y, N	OUT101FS := Y
OUT101	SELOGIC	OUT101 := HALARM OR SALARM
OUT102 FAIL-SAFE	Y, N	OUT102FS := N
OUT102	SELOGIC	OUT102 := START
OUT103 FAIL-SAFE	Y, N	OUT103FS := Y
OUT103	SELOGIC	OUT103 := TRIP or PB04
• • •	• • •	• • •
OUT401 FAIL-SAFE	Y, N	OUT401FS := N
OUT401	SELOGIC	OUT401 := 0
OUT402 FAIL-SAFE	Y, N	OUT402FS := N
OUT402	SELOGIC	OUT402 := 0
OUT403 FAIL-SAFE	Y, N	OUT403FS := N
OUT403	SELOGIC	OUT403 := 0
OUT404 FAIL-SAFE	Y, N	OUT404FS := N
OUT404	SELOGIC	OUT404 := 0
• • •	• • •	• • •
OUT408 FAIL-SAFE	Y, N	OUT408FS := N
OUT408	SELOGIC	OUT408 := 0

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 2.19* and *Figure 2.20*.

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

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

MIRRORED BITS Transmit SELOGIC Control Equations

See *Appendix J: MIRRORED BITS Communications* and *SEL-710-5 Settings Sheets* for details.

Global Settings (SET G Command)

General Settings

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).

The METHRES setting governs how various metering functions behave when the metered value is smaller than a fixed threshold. Refer to *Section 5: Metering and Monitoring* for more details.

Set the SELOGIC control equation FAULT to temporarily block *Maximum and Minimum Metering on page 5.6*.

Table 4.78 General Global Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
PHASE ROTATION	ABC, ACB	PHROT := ABC
RATED FREQ	50, 60 Hz	FNOM := 60
DATE FORMAT	MDY, YMD, DMY	DATE_F := MDY
MET CUTOFF THRES	Y, N	METHRES := Y
FAULT CONDITION	SELOGIC	FAULT := STARTING OR 50S OR 50G1P OR 50N1P OR TRIP

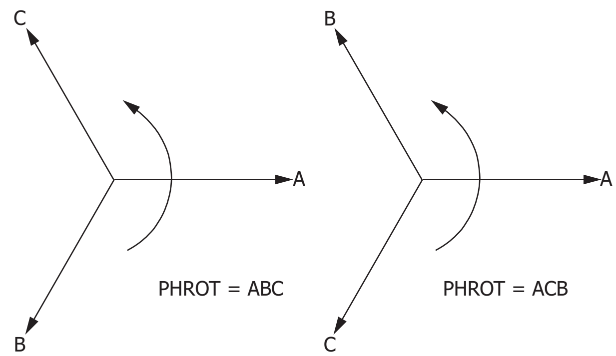


Figure 4.88 Phase Rotation Setting

Broken Rotor Bar Protection

IMPORTANT: Oscillating motor loads and ripples in the motor supply voltage can produce stator current signatures like those produced by broken bars, causing the detection element to assert the associated Relay Word bits. Refer to the SEL technical paper, "Detecting Broken Rotor Bars With Zero-Setting Protection," by Carlos Pezzani, Pablo Donolo, Guillermo Bossio, Marcos Donolo, Armando Guzman, and Stanley Zocholl (see selinc.com/literature/technical-papers/) for methods to deal with these.

The SEL-710-5 helps detect broken rotor bars when the broken rotor bar protection is enabled. This feature is not available when setting SYNTYPE := BRUSH/BRUSHLESS. Broken rotor bars cause reduced accelerating torque, increased motor heating, and increased vibrations, which can lead to further mechanical motor damage. The SEL-710-5 detects current signatures that are generated by broken rotor bars, and alerts about the problem.

When the broken bar detection element is in automatic mode (EBBD := AUTO_SET), the SEL-710-5 periodically looks in the stator current spectrum for frequency components associated with broken bars. The SEL-710-5 uses the relative magnitude of these frequency components to estimate the damage to the bars in the rotor. *Table 4.79* shows the status for the associated Relay Word bits under different operating conditions.

Table 4.79 Broken Rotor Bar Relay Word Bits

	Relay Word Bit		
Condition	**BBD1T**	**BBD2T**	**BBD3T**
No damage to rotor bars detected	0	0	0
Current signatures consistent with one broken bar	0	0	1
Current signatures consistent with multiple broken bars	0	1	1
Current signatures consistent with severe rotor bars damage	1	1	1

Relay Word bits BBD1T, BBD2T, and BBD3T show the condition of the rotor bars. When no damage is detected, all three Relay Word bits are deasserted. Relay Word bit BBD3T asserts when the stator currents show signatures consistent with at least one broken bar. Relay Word bit BBD2T asserts when the stator currents show signatures consistent with multiple broken bars. Finally, Relay Word bit BBD1T asserts when the stator currents show signatures consistent with severe rotor bar damage.

HIS BBD Command

Every time the SEL-710-5 detects a broken bar condition, the relay stores a broken bar event report that can be viewed with the **HIS BBD** command. The **HIS BBD** command shows the frequency of the detected broken bar component and its magnitude. *Figure 4.89* shows the **HIS BBD** command output.

```
=>HIS BBD <Enter>

SEL-710-5                                   Date: 02/15/2013   Time: 14:22:39.986
MOTOR RELAY                                 Time Source: External

 #     DATE      TIME           FREQ_SB(Hz)  MAG(db)  BBD1T BBD2T BBD3T
1    02/06/2013  11:16:29.761   1.50         -36.51    0     1     1
2    02/06/2013  11:06:29.772   1.50         -36.46    0     1     1
3    02/06/2013  10:56:29.780   1.50         -36.64    0     1     1
4    02/06/2013  10:46:29.713   1.50         -36.76    0     1     1
.
.
.
1021 02/04/2013  09:56:48.807   1.50         -36.30    0     1     1
1022 02/04/2013  09:46:48.842   1.50         -35.98    0     1     1
1023 02/04/2013  09:36:48.819   1.50         -36.15    0     1     1
1024 02/04/2013  09:26:48.804   1.50         -36.25    0     1     1
```

Figure 4.89 HIS BBD Command Output

Set the broken bar detection element to manual, EBBD := MANUAL_SET, to display the internal settings of the broken bar detection algorithm shown in *Table 4.80*.

Table 4.80 Broken Bar Detection Settings

Setting prompt	Setting Range	Setting Name := Factory Default
EN BRKN BAR DET	AUTO_SET, MANUAL_SET, N	EBBD := N
BBD RUN RATE	1–180 min	BBDTD := 10
FREQ LOWER BOUND	0.0–1.0 Hz	BBDLB := 0.3
FREQ UPPER BOUND	2.0–10.0 Hz	BBDUB := 3.0
BBD LEVEL1 PU	–80 to –1 dB	BBDTH1 := –35
BBD LEVEL2 PU	–80 to –1 dB	BBDTH2 := –39
BBD LEVEL3 PU	–80 to –1 dB	BBDTH3 := –44
BBD LEVEL4 PU	–80 to –1 dB	BBDTH4 := –49
BBD MIN MARGIN	1–80 dB	MAR_AVG := 15
DF FROM FNOM	0.10–3.00 Hz	FNOM_TH := 0.50
DF FROM INI FREQ	0.01–10.00 Hz	F0_TH := 0.35
DI FROM INI CURR	0.01–1.00 xFLA	I0_TH := 0.10
BLK BELOW CUR LV	0.20–2.00 xFLA	I_TH := 0.50

The broken bar detection algorithm run rate setting (BBDTD) specifies how often the broken bar detection algorithm runs. The lower and upper frequency bound settings (BBDLB and BBDUB) determine the range of frequencies, measured from the system operating frequency, that are scanned for broken bar components.

When the operating slip of the protected motor is known, the BBDE security can be improved by narrowing the distance between the lower and upper frequency bound settings. For example, if the operating slip of a 50 Hz motor is 2 percent, the broken bar frequency components are expected to be 2 Hz (2 • 50 Hz • 2% = 2 Hz) away from the system frequency and the lower and upper frequency bound settings can be moved to 1 Hz and 2.5 Hz, respectively.

Depending on the application, different methods may be available to determine the operating slip of the protected motor. Handheld tachometer measurements are often adequate. If the PTs are mounted on the motor side of the contactors, the operating slip may be obtained by using the **MMR** command. The SEL-710-5 tracks the residual voltage frequency of the motor as it spins down. Additionally, the SEL-710-5 records the loading on the motor immediately before disconnection. The relay then uses this frequency and load to compute the full-load rotor resistance, R0, which is presented by the **MMR** command (see *MMR Command on page 7.58*). Using the values in the MMR report, you can calculate the slip/speed in pu of the motor before de-energization as follows: Slip/speed = R0 • POSTOP. From there, you can calculate the slip frequency in hertz as follows: Slip frequency = Slip/speed • FNOM.

Alternatively, the operating speed of the protected motor may be obtained by identifying the rotational speed sidebands in the current spectrum by using the **CMET S** command. The rotational speed of the sidebands (FRSB) appears at FRSB = FREQ ± FREQM, where FREQM is the rotational speed of the machine in hertz. To find FRSB, first compute the synchronous speed of the motor (FRS) in hertz using FRS = FREQ – (FREQ / NPP) where NPP is the number of pole pairs of the motor. Then use the **CMET S** command to obtain the current spectrum of the motor while operating under load. The lower FRSB sideband appears to the right of FREQ – FRS and the upper FRSB appears to the left of FREQ + FRS. *Figure 4.90* identifies each quantity in the current spectrum of a 50 Hz two pole pair motor.

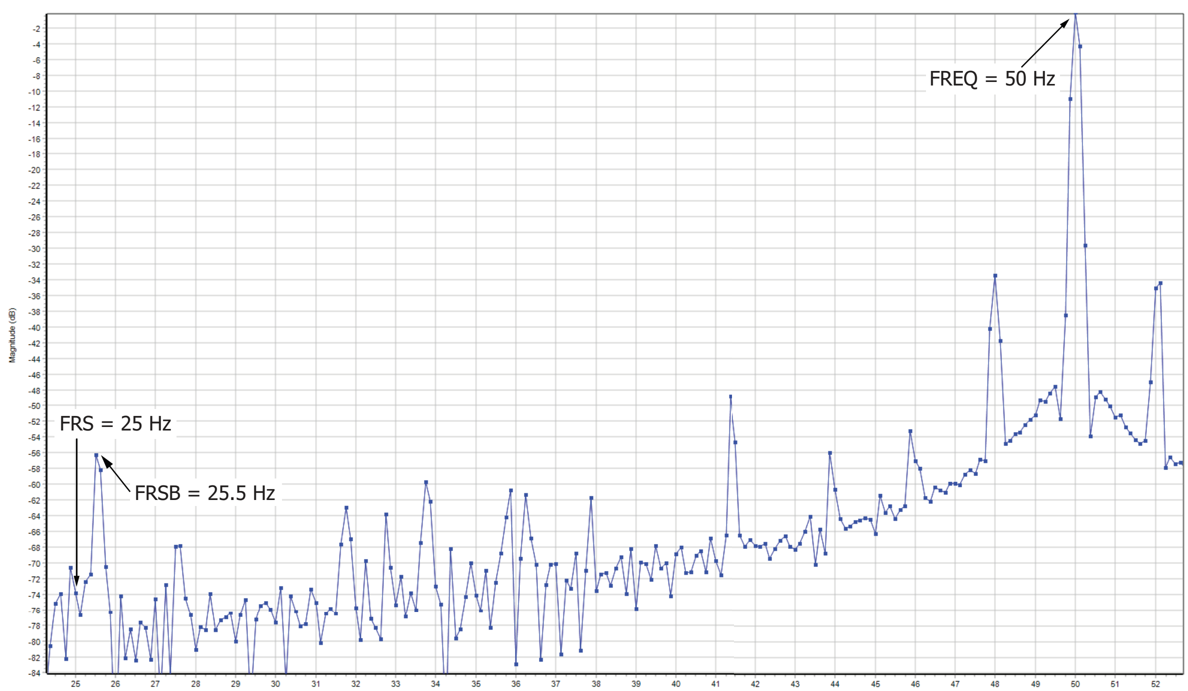


Figure 4.90 Spectrum Analysis of 50 Hz Two Pole Pair Motor

FREQM is equal to FREQ – FRSB. Using the values from *Figure 4.90*, FREQM = 50 – 25.5 = 24.5 Hz. In this case, the SLIP = (25 – 24.5) / 25 = 0.02. In turn, the broken bar sidebands should land at (1 – 2 • SLIP) • FREQ = 48 Hz and at (1 + 2 • SLIP) • FREQ = 52 Hz, as seen in *Figure 4.90*.

Thresholds BBDTH1, BBDTH2, and BBDTH3, are associated with Relay Word bits BBD1T, BBD2T, and BBD3T, respectively. When the magnitude of the broken bar frequency component in dB exceeds the BBDTH*x* threshold, the associated BBD*x*T Relay Word bit asserts. The relay uses the BBDTH4 setting as a healthy motor threshold and the MAR_AVG setting to block the element under noisy operating conditions.

When the systems frequency (FREQ) is more than FNOM_TH from FNOM, the SEL-710-5 blocks the operation of the broken bar detection element to avoid running under abnormal system conditions. The default value of FNOM_TH may need to be adjusted in systems with large frequency excursions.

The broken bar detection element does not operate if the frequency measured anywhere inside the observation window goes beyond F0_TH Hz from the frequency measured at the beginning of the observation window. Similarly, the broken bar detection elements do not operate if the current measured anywhere inside the observation window goes beyond I0_TH xFLA A from the current measured at the beginning of the observation window. Additionally, the broken bar detection element does not operate when the current on the motor is below the I_TH xFLA A setting.

The SEL technical paper, *Detecting Broken Rotor Bars With Zero-Setting Protection*, by Carlos Pezzani, et al., (see selinc.com/literature/technical-papers/) details additional information about this broken rotor bar detection method.

The SEL-710-5 includes two Fourier Transform commands; the **MET FFT** command and the **CMET S** command for monitoring the motor. Refer to *Motor Monitoring Using Fourier Analysis* in *Section 5: Metering and Monitoring*.

Multiple Settings Groups

SEL-710-5 Relays have four 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 two-line LCD using the **MAIN** > **Set/Show** > **Active Group** menus.
- Viewed using the SEL ASCII serial port **GROUP** command, as described in *Table 7.29*.
- Selected using the SEL ASCII serial port **GROUP *n*** command described in *Table 7.29*.
- Selected using SELOGIC control equation settings SS1 through SS4, as shown in *Table 4.81*.

If SELOGIC control equations SS1–SS4 are defined and evaluate to logical 1, they have priority over the **GROUP *n*** command to select the active settings group. If 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 SG4 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, SG2, and SG4 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 SS4, as shown in *Table 4.81*.

Table 4.81 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
SELECT GROUP4	SELOGIC	SS4 := 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, SS2, or SS4. If settings SS1 through SS4 all deassert to logical 0, settings Group 3 remains the active settings group.

If the active settings 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 4.

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 (e.g., settings Group 3) 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, much like in the preceding explanation. 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–SS4, the active settings group can be changed, subject to the newly enabled SS1–SS4 settings.

LEA Correction Settings

Table 4.82 LEA Ratio and Phase Correction Settings for Phase Voltages

Setting Prompt	Setting Range	Setting Name := Factory Default
VA RATIO CORRECT	0.500–1.500	VARCF := 1.000
VB RATIO CORRECT	0.500–1.500	VBRCF := 1.000
VC RATIO CORRECT	0.500–1.500	VCRCF := 1.000
VA ANGLE CORRECT	–10.0 to 10.0 deg	VAPAC := 0.0
VB ANGLE CORRECT	–10.0 to 10.0 deg	VBPAC := 0.0
VC ANGLE CORRECT	–10.0 to 10.0 deg	VCPAC := 0.0

Table 4.83 LEA Ratio and Phase Correction Settings for Phase Current

Setting Prompt	Setting Range	Setting Name := Factory Default
IA RATIO CORRECT	0.900–1.100	IARCF := 1.000
IB RATIO CORRECT	0.900–1.100	IBRCF := 1.000
IC RATIO CORRECT	0.900–1.100	ICRCF := 1.000
IA ANGLE CORRECT	–10.0 to 10.0 deg	IAPAC := 0.0
IB ANGLE CORRECT	–10.0 to 10.0 deg	IBPAC := 0.0
IC ANGLE CORRECT	–10.0 to 10.0 deg	ICPAC := 0.0
IN RATIO CORRECT	0.900–1.100	INRCF := 1.000
IN ANGLE CORRECT	–10.0 to 10.0 deg	INPAC := 0.0

The LEA ratio correction factor (RCF) settings—VARCF, VBRCF, VCRCF, IARCF, IBRCF, ICRCF, and INRCF—compensate for irregularities on the corresponding channels of voltage and current LEA inputs. The LEA phase correction (PAC) settings—VAPAC, VBPAC, VCPAC, IAPAC, IBPAC, ICPAC, and INPAC—compensate for the phase shift on the corresponding channels brining the voltages and currents to the SEL-710-5. Refer to *Ratio Correction Factors (RCF) for LEA Inputs on page 4.11* for a discussion on the RCF and PAC settings. Note that PAC does not affect the filtered event report (CEV) or the raw event report (CEV R).

Time and Date Management Settings

The SEL-710-5 supports several methods of updating the relay time and date. For SNTP applications, refer to *Simple Network Time Protocol (SNTP) on page 7.16*. For PTP applications, refer to *Precision Time Protocol (PTP) on page 7.19*. See *Table 4.84* for the time and date management settings that are available in the Global settings.

Table 4.84 Time and Date Management Settings

Setting Description	Setting Range	Setting Name := Factory Default
IRIG-B CONTROL BITS DEFINITION	NONE, C37.118	IRIGC := NONE
OFFSET FROM UTC	–24.00 to 24.00 hours, rounds up to the 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	DST_BEGD := SUN
LOCAL HOUR TO BEGIN DST	0–23	DST_BEGH := 2
MONTH TO END DST	1–12	DST_ENDM := 11
WEEK OF THE MONTH TO END DST	1–3, L	DST_ENDW := 1
DAY OF THE WEEK TO END DST	SUN, MON, TUE, WED, THU, FRI, SAT	DST_ENDD := SUN
LOCAL HOUR TO END DST	0–23	DST_ENDH := 2

IRIGC

IRIGC defines whether IEEE C37.118 control bit extensions are in use. Control bit extensions contain information such as Leap Second, UTC, Daylight Saving Time, and Time Quality. When your satellite-synchronized clock provides these extensions, your relay adjusts the synchrophasor time stamp accordingly.

➤ IRIGC := NONE will ignore bit extensions

➤ IRIGC := C37.118 will extract bit extensions and correct synchrophasor time accordingly

Coordinated Universal Time (UTC) Offset Setting

The SEL-710-5 has a Global setting UTC_OFF, settable from –24.00 to 24.00 hours, in 0.25 hour increments. The relay uses the UTC_OFF setting to calculate local (relay) time from the UTC source when configured for Simple Network Time Protocol (SNTP) updating via Ethernet. When a time source other than SNTP is updating the relay time, the UTC_OFF setting is not considered because the other time sources are defined as local time.

Automatic Daylight-Saving Time Settings

The SEL-710-5 can automatically switch to and from daylight-saving time, as specified by the eight Global settings DST_BEGM through DST_ENDH. The first four settings control the month, week, day, and time that daylight-saving time shall commence, while the last four settings control the month, week, day, and time that daylight-saving time shall cease.

Once configured, the SEL-710-5 will change to and from daylight-saving time every year at the specified time. Device Word bit DST asserts when daylight-saving time is active.

The SEL-710-5 interprets the week number settings DST_BEGW and DST_ENDW (1–3, L = Last) as follows:

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

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

As an example, consider the following settings:

DST_BEGM = 3

DST_BEGW = L

DST_BEGD = SUN

DST_BEGH = 2

DST_ENDM = 10

DST_ENDW = 3

DST_ENDD = WED

DST_ENDH = 3

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

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

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

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

Simple Network Time Protocol (SNTP)

The SEL-710-5 Port 1 (Ethernet Port) supports the SNTP Client protocol. See *Section 7: Communications*, *Simple Network Time Protocol (SNTP) on page 7.16* for a description and *Table 7.7* for the settings.

Precision Time Protocol (PTP)

The SEL-710-5 Port 1 (Ethernet Port) supports PTP. See *Precision Time Protocol (PTP) on page 7.19* and *Table 7.9* for the settings.

PTP Timekeeping

When you use PTP, the SEL-710-5 can only be synchronized by a grandmaster (GM) clock on the PTP timescale, not one on an arbitrary (ARB) timescale. With the ARB timescale, the epoch is set by an administrative procedure and can change at any time during normal operation. The PTP timescale uses the PTP epoch of January 1, 1970 00:00:00 International Atomic Time (TAI), which corresponds to December 31, 1969 23:59:51.999918 UTC. The unit of time for the PTP timescale is the SI second and accounts for leap seconds. As of June 2016, TAI is 37 seconds ahead of UTC.

When the SEL-710-5 is synchronized to a PTP master and the UTC offset information from the PTP master is valid, the PTP master instructs the SEL-710-5 when to go into daylight-saving time (DST) and when to exit DST. The PTP master also provides the UTC offset at this time. Otherwise, the SEL-710-5 uses the internal values for DST and UTC offset.

The offset between TAI and UTC is included in the PTP announce message, along with a flag that indicates whether the offset is valid. The SEL-710-5 uses the offset it receives from the GM clock to determine UTC regardless of validity. Because of this, all SEL devices and other slave devices that share this behavior and are synchronized with the GM retain relational accuracy with each other even if the GM may be incorrect in relation to UTC.

The announce message may also include the current TAI to Local offset value (required in the Power, C37.238 profile). In accordance with IEEE 1588-2008 16.3.3.4, this value must include the TAI to UTC offset to reflect local time at the node, or slave device. If the SEL-710-5 receives a TAI to Local offset value that does not include the TAI to UTC offset, it may incorrectly calculate UTC and local time. Also, if the announce message does not include the TAI to Local offset value, the SEL-710-5 uses its configured Time and Date Management Settings (UTC_OFF and DST_BEGM) to calculate local time. This is one reason that the SEL-710-5 Time and Date Management Settings must match the settings in the GM clock, or synchronized devices may have issues with time alignment.

SEL-710-5 relays only synchronize to clocks that serve TAI and do not support PTP in SWITCHED NETMODE. Additionally, the maximum synchronization interval that SEL-710-5 relays can support is 16 seconds.

If you want to use PTP, the SEL-710-5 part number must include the option for PTP and PTP must be enabled in the Port 1 settings (EPTP := Y). The SEL-710-5 must be connected to a network containing an appropriate PTP master, and all intervening switches must be IEEE 1588-aware. For SEL-710-5 relays, PTP is only available on Ethernet Ports 1A and 1B. See *Precision Time Protocol (PTP) on page 7.19* for more information on configuring the relay and the Ethernet network for PTP.

PTP Over PRP Networks

In SEL-710-5 relays, PTP over PRP is based on a first-come, first-served method. While the SEL-710-5 Relay monitors incoming traffic on both Port 1A and Port 1B, it will synchronize to the first port on which it receives its first PTP message. If incoming PTP messages stop on that synchronized port, the relay waits 70 seconds and if no PTP messages appear within those 70 seconds, it switches to the other port.

Breaker Failure Settings

Table 4.85 Breaker Failure Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
52A INTERLOCK	Y, N	52ABF := N
CURRENT DETECTOR	0.10–10.00 A[a]	50BFP := 0.1
RES CUR DETECTOR	OFF, 0.10–10.00 A[a]	50BFG := OFF
BK FAILURE DELAY	0.00–2.00 s	BFD := 0.50
AUX TIMER DELAY	OFF, 0.00–2.00 s	ATD := OFF
BK FAIL INITIATE	SELOGIC	BFI := R_TRIG TRIP
BF SEAL-IN DELAY	OFF, 0.00–2.00 s	BFISID := 0.00
BF RETRIP DELAY	OFF, 0.00–2.00 s	BFRTD := 0.05
BF TRIP EQUATION	SELOGIC	BFTR := 0
BF UNLATCH EQN	SELOGIC	BFULTR := 0

[a] Setting ranges and default values are shown for 5 A nominal CT rating. Divide by 5 for 1 A CTs.

The SEL-710-5 provides flexible breaker failure logic (see *Figure 4.91*). In the default breaker failure logic, assertion of Relay Word bit TRIP starts the BFD timer if the average motor current is higher than the 50BFP setting. If the average motor current remains greater than the threshold (50BFP) for longer than the BFD delay setting, Relay Word bit BFT asserts. Use the BFT Relay Word bit to operate a contact output to trip the appropriate backup breakers.

For added security against inadvertent breaker failure initiations (e.g., wiring or testing errors), program BFRTD to a setting other than OFF. BFRTD (breaker failure retrip delay) begins timing when BFI and one of the supervisory elements—50BF, 50BFG (if enabled), 52A (if enabled), or the aux timer (if configured)—asserts. Relay Word bit BFRT asserts when BFRTD times out. Account for any added delay to BFRTD in the BFD setting. Program BFRT in the TR SELOGIC control equation to issue a retrip to the breaker.

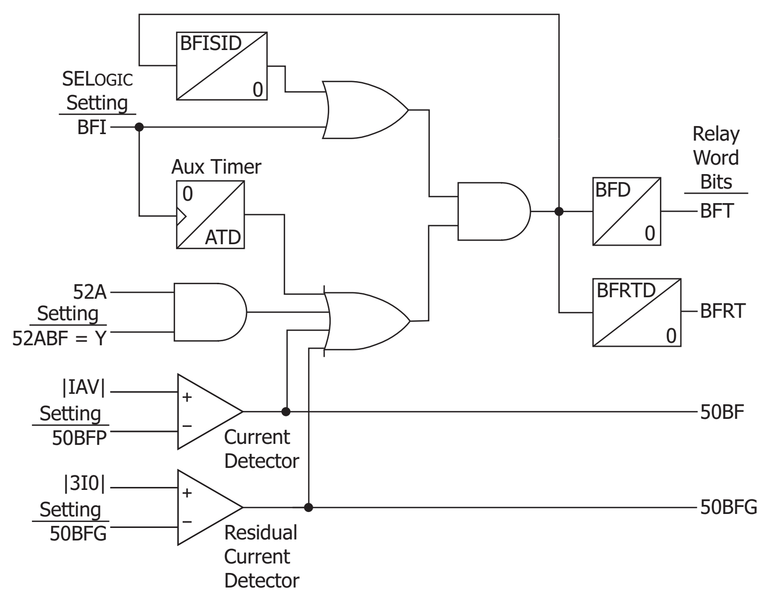


Figure 4.91 Breaker Failure Logic

Changing the BFI or the 52ABF, ATD, 50BFP, 50BFG, BFISID, or BFRTD settings will modify the default breaker failure logic.

- Set BFI in conjunction with BFISID per your application needs. If breaker failure initiation is not desired on manual trip, set BFI to the protective element Relay Word bits used in the TR SELOGIC equation (e.g., BFI := 50P1T OR 51P1T OR...).
- Set BFISID := 0 to achieve immediate seal-in, especially when breaker failure is initiated on the rising edge of the input (e.g., BFI := R_TRIG TRIP). To bias your application towards security, set BFISID to the desired delay or OFF with BFI set to the actual input instead of the rising edge (e.g., BFI := TRIP).
- Set 50BFG to operate the breaker failure logic on residual ground current check, in addition to phase current checks. This can be used in applications when a weak source drives a fault.
- Set 52ABF := Y for applications where the fault currents for protective trips are too low for the current detector to operate.
- Aux timer (ATD) can be used to start the BFD timer for dual breaker applications where the current detector may not operate on the initiation of the logic due to distribution of the fault current between the breakers. If used, the ATD timer must be set longer than the normal clearing time of the adjacent breaker to allow the current to redistribute to this breaker after the adjacent breaker opens. For secure operation, set the ATD timer shorter than the BFD timer.
- BFRTD may be set to provide a security time delay for a retrip attempt of the breaker.

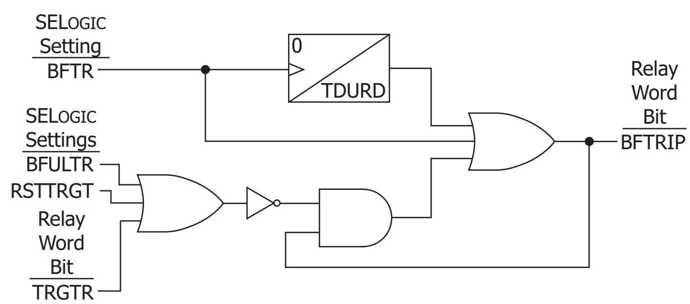


Figure 4.92 Breaker Failure Trip Logic

Include Relay Word bit BFT in the SELOGIC control equation BFTR (breaker failure trip equation), if you want to use the breaker failure trip logic shown in *Figure 4.92*. When BFTR evaluates to logical 1, Relay Word bit BFTRIP asserts and seals in. Include BFTRIP in a contact output equation to trip backup breakers via an auxiliary tripping relay, or use multiple contact outputs to direct trip adjacent breakers to clear the zone. For example:

OUT406 = BFTRIP

Relay Word bit TRGTR and SELOGIC control equations BFULTR and RST-TRGT reset BFTRIP. The minimum trip duration of BFTRIP is controlled by Group setting TDURD. See *Trip/Close Logic on page 4.103* for a description of the minimum trip duration timers, the trip unlatch conditions, and the operation of Relay Word bit TRGTR.

Arc-Flash Protection

The SEL-710-5 offers advanced arc-flash protection capability aimed at minimizing the hazards associated with high energy arc (faults) in metal-enclosed and metal-clad switchgear. The system supports as many as eight fiber-optic light sensors capable of detecting the high energy arc-flash events and tripping the breaker within milliseconds of the fault. Light sensors are supervised with an instantaneous overcurrent element offering enhanced security against false trips. Each of these sensors can be routed to multiple tripping outputs (using SELOGIC equations) offering ultimate flexibility in creating multiple protection zones (breaker truck cabinet, bus, PT cubicle, etc.).

SEL-710-5 arc-flash protection is exceptionally fast. Typical relay operating times are in the order of 2–5 ms when equipped with the optional fast hybrid (high-speed) output card. With standard, electromechanical outputs, tripping time increases to 7–13 ms. Fault clearing time is typically longer, determined by the breaker operating time, which often adds three to five cycles.

This system supports two distinct types of fiber-optic light sensors. The first type is the omnidirectional *point sensor* optimized for installation in individual switchgear compartments. The second sensor is the *clear-jacketed fiber* loop sensor optimized for protection of long, distributed resources, such as the switchgear bus compartment. Both types of sensors are supervised by using a loopback-based attenuation measurement method, and can be used interchangeably on each of the eight light inputs. Refer to *AG2011-01: Using the SEL-751 and SEL-751A for Arc-Flash Detection* for details.

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

Table 4.86 shows the settings for the arc-flash instantaneous overcurrent elements. Two elements are provided; the three-phase overcurrent element 50PAF and the neutral overcurrent element 50NAF.

NOTE: The 50NAFP setting is not available with the 2.5 mA neutral channel option.

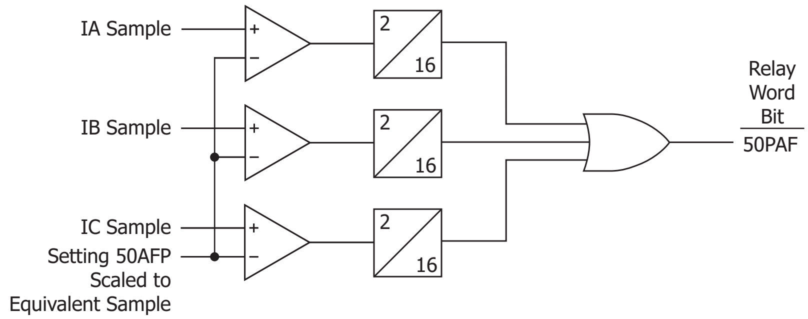
Table 4.86 Arc-Flash Overcurrent Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
AF PH OC TRP LVL	OFF, 0.50–100.00 A sec[a]	50PAFP := OFF
	0.10–20.00 A sec[b]	
AF N OC TRP LVL	OFF, 0.05–10.00 A sec[a]	50NAFP := OFF
	0.01–2.00 A sec[b]	

[a] For I_{NOM} = 5 A (Phase and Neutral respectively).
[b] For I_{NOM} = 1 A (Phase and Neutral respectively).

The arc-flash overcurrent elements use raw A/D converter samples, and process them 16 times per cycle. Individual samples are compared with the setting threshold as shown in *Figure 4.93*, followed by a security counter requiring that two samples in a row be above the setting threshold. Although both elements operate on instantaneous current values, additional scaling is applied to present settings in the user-friendly “rms” format.

Fast overcurrent detectors do not reject harmonics and therefore have a natural tendency to overreach under high harmonic load conditions. To avoid unintended element pickup, arc-flash trip level 50PAFP should be set at least 2 times the expected maximum load. Temporary activation of the arc-flash overcurrent element during inrush/load pickup conditions is expected and is normally taken into account by the arc-flash light-based supervision.



50PAF element is shown, 50NAF element is similar, responds to current measured by the IN input.

Figure 4.93 Arc-Flash Instantaneous Overcurrent Element Logic

Arc-Flash Time-Overlight Elements (TOL1 through TOL8)

The SEL-710-5 relay offers eight fiber-optic light sensor inputs. Each input is associated with one inverse time-overlight element offering enhanced security coupled with fast operation. Shape of the inverse time characteristic is fixed offering robust rejection of unrelated light events without adding unnecessary settings. *Table 4.87* shows the arc-flash time-overlight element settings.

Each sensor channel has a user-selectable sensor type (NONE, POINT, or FIBER) that represents the type of sensor installed. Keyword POINT represents a point sensor, while the keyword FIBER represents a clear-jacketed fiber loop sensor.

TOL pickup parameter makes it possible to set the individual light threshold levels for each of the eight sensors. Pickup level is expressed in the percent of full scale, which is directly related to the light intensity level measured by the sensor.

When required, channel sensitivity can be compared to a light intensity level expressed in lux as shown in *Table 4.88*. However, because of the association of light sensitivity with fiber length (which is installation dependent), TOL element settings are expressed as a percentage of the available A/D converter range.

Table 4.87 Arc-Flash Time-Overlight Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
SENSOR 1 TYPE	NONE, POINT, FIBER	AFSENS1 := NONE
TOL 1 PICKUP	3.0%–80.0%[a] 0.6%–80.0%[b]	TOL1P := 3.0
SENSOR 2 TYPE	NONE, POINT, FIBER	AFSENS2 := NONE
TOL 2 PICKUP	3.0%–80.0%[a] 0.6%–80.0%[b]	TOL2P := 3.0
⋮	⋮	⋮
SENSOR 8 TYPE	NONE, POINT, FIBER	AFSENS8 := NONE

Table 4.87 Arc-Flash Time-Overlight Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
TOL 8 PICKUP	3.0%–80.0%[a] 0.6%–80.0%[b]	TOL8P := 3.0
AFD OUTPUT SLOT	101_3, 301_4, 401_4	AOUTSLOT := 101_3

[a] Setting range with point sensor.
[b] Setting range with fiber sensor.

The default processing interval in the SEL-710-5 is 1/4 of the power system cycle. However, to obtain a faster arc-flash protection you can select as many as four outputs that are processed every 1/16 of a power system cycle. Use the setting AOUTSLOT to select these outputs. For instance, if Slot 3 (Slot C) is selected (AOUTSLOT := 301_4) the SELOGIC control equations OUT301, OUT302, OUT303, and OUT304 are processed at 1/16 of the cycle rate. To get the fastest possible operate time, use the contacts selected by the AOUTSLOT setting for tripping. For fastest output response times, use the high-current, high-speed, hybrid outputs. The Relay Word bits corresponding to these OUT*xxx* control equations, along with all of the TOL, 50PAF, and 50NAF bits are processed at 1/16 of a power system cycle. for the SER.

Figure 4.94 shows the TOL element logic diagram.

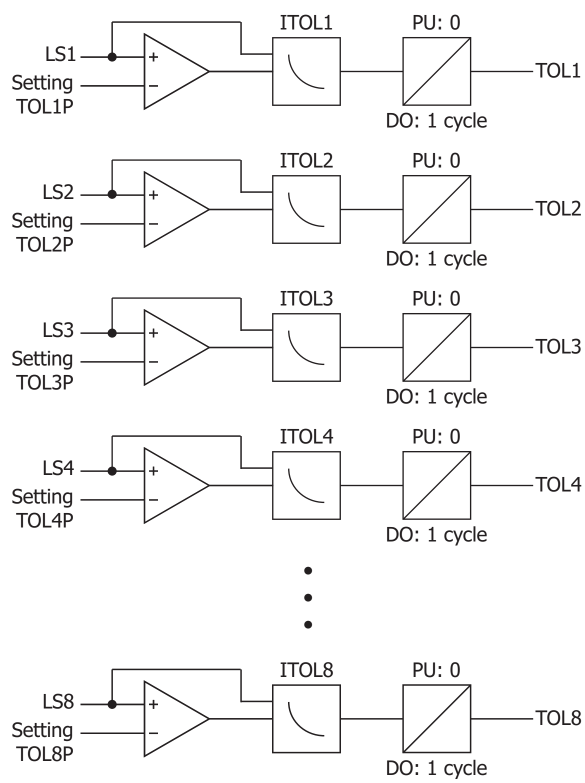


Figure 4.94 Inverse Time-Overlight Element Logic

Figure 4.95 shows the inverse time-overlight element curve shape. The element uses 32 samples per cycle data, processed 16 times per cycle. TOL element algorithm ensures that the light must be present for a minimum of two samples, regardless of the light level. It also ensures that for low light levels, element operation cannot be delayed for more than 1/4 of a power system cycle.

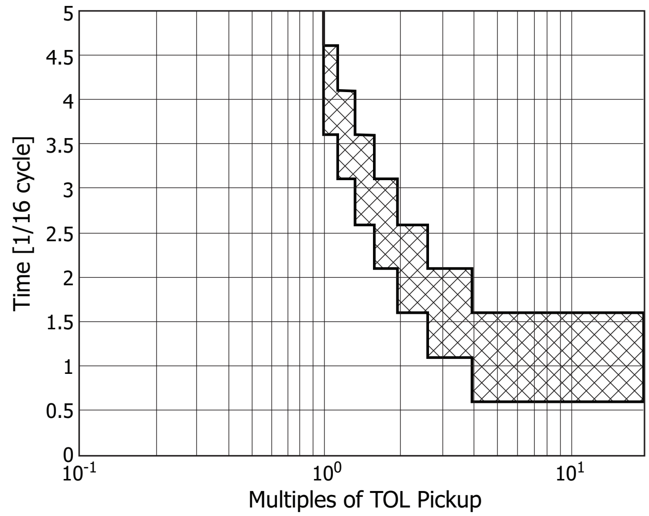


Figure 4.95 TOL Element Inverse Curve Characteristic

Setting the Arc-Flash Time-Overlight Element

Given the critical nature of the arc-flash protection function, SEL recommends that the element be set based on the ambient light level. This approach guarantees maximum sensitivity coupled with the fastest tripping time.

Typical ambient light levels are shown in *Table 4.88*. It is easy to see that the arc-flash event significantly exceeds virtually all illumination levels normally found in a substation environment. The only exception is exposure to direct sunlight, which can easily reach or exceed arc-flash TOL element setting thresholds.

TOL Pickup is typically set based on the ambient light level. Ambient light is continuously measured and can be easily displayed by using the front-panel `METER > Light Intensity` menu as well as the **MET L** command. Set the TOL pickup to the lowest possible light intensity level but above the highest-expected ambient light intensity level at each light-sensor installation.

Table 4.88 Typical Ambient Illumination Light Levels

Light Level	Example
50 lux	Living room
80 lux	Brightly lit room
500 lux	Brightly lit office
1,000 lux	TV studio
> 20,000 lux	Direct sunlight
20,000 to >1,000,000 lux	Arc-flash event[a]

[a] A. D. Stokes, D. K. Sweeting, "Electric Arc Burn Hazards," IEEE Transactions on Industry Applications, Vol. 42, No. 1. January/February 2006.

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

Arc-flash protection, in general, requires both the measuring of an overcurrent (50PAF) and the detection of light (TOL*n*). The output logic should in most cases be the AND of the 50PAF and TOL*n* outputs. In applications where intermittent loss of load can be tolerated (noncritical loads), it may be necessary to operate without overcurrent element supervision (OUTxxx := TOL*n*), relying only on the light detection element instead of having the overcurrent element (50PAF) supervise the light element (TOL*n*) in the output logic (OUTxxx := 50PAF AND TOL*n*). This approach offers fastest tripping times, but is less secure (can be tripped with the light input only).

Output Logic Programming

Arc-flash protection involves detecting an overcurrent as well as light (arc). Location of the light sensors and source(s) of the arc energy must also be considered in developing the trip output logic. If the relay detects both signals simultaneously, it is desirable to trip the source breaker(s).

The Relay Word bits for arc-flash protection (see *Figure 4.93* and *Figure 4.94*) are: 50PAF, 50NAF, TOL1, TOL2, TOL3, TOL4, TOL5, TOL6, TOL7, and TOL8.

Select two output contacts for high-speed processing by setting AOUTSLOT appropriately. The high-speed contact should be used for arc-flash tripping instead of the default OUT103 shown in *Table 4.77*. Also, to ensure all the advantages of the trip logic (trip seal-in, event report trigger, etc.), the arc-flash trip should be included in the trip equation TR (see *Table 4.86* and *Figure 4.76* for details).

To get additional speed, select the fast hybrid output option card (4 DI/4 DO). This card contains trip duty rated solid-state output contacts, which operate within 50 µs (as much as 8 ms faster than the standard electromechanical outputs).

EXAMPLE 4.16 Output Logic Programming Example 1

SEL-710-5 applied at the source breaker.

Assume light sensors LS1, LS2, and LS3 are located downstream of the source breaker and output contacts in Slot **3** are selected for high-speed processing (AOUTSLOT := 301_2).

Set:

OUT301FS := `N`

OUT301 := `(50PAF OR 50NAF) AND (TOL1 OR TOL2 OR TOL3) OR TRIP`

TR := `ORED50T OR ORED51T OR … OR (50PAF OR 50NAF) AND (TOL1 OR TOL2 OR TOL3)`

EXAMPLE 4.17 Output Logic Programming Example 2

SEL-710-5 applied at the radial feeder breaker.

Assume light sensors LS1 and LS2 are located downstream, LS3 is located upstream of the feeder breaker, and output contacts in Slot **3** are selected for the high speed processing (AOUTSLOT := 301_2).

Set:

OUT301FS := `N`, OUT302FS := `N`

OUT301 := `(50PAF OR 50NAF) AND (TOL1 OR TOL2) OR TRIP`

OUT302 := `TOL3`

TR := `ORED50T OR ORED51T OR … OR (50PAF OR 50NAF) AND (TOL1 OR TOL2)`

Use the OUT302 contact to trip upstream breaker. Note that OUT302 does not include overcurrent element supervision. When desired, this supervision should be added by upstream relay(s). For instance, you can do the following:

- ➤ Connect OUT302 of breaker 2 relay to drive IN302 of the breaker 1 relay
- ➤ Add IN302 to the OR string of TOLn in both OUT301 and TR equations of breaker 1 relay.

You can use MIRRORED BITS instead of IN302 for faster operation if desired.

Analog Inputs

The SEL-710-5 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 4.96*. Variable *x* displays the slot position (**3** through **5**), and variable *y* displays the transducer (analog) input number (1 through 4 or 8).

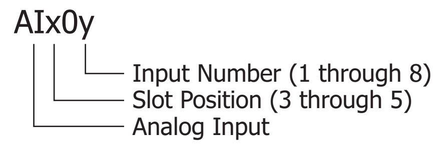


Figure 4.96 Analog Input Card Adaptive Name

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.

Calculate the signal offset compensation factor through the following procedure:

1. Turn the SEL-710-5 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. Enter the **MET AI 10** command to obtain 10 measurements for each channel.
5. Record these 10 measurements, then calculate the average of the 10 measurements. 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 2.5* for more information) for Input 1 to operate as a current input. At turn on, allow approximately five seconds for the SEL-710-5 to start up, perform self-diagnostics, and detect installed cards.

Table 4.89 summarizes the steps and describes the settings we carry out in this example.

Table 4.89 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 analog quantities, duplicate names, or other AI names. If any of these are entered, the relay will issue the Invalid Element message.

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, type **I <Enter>** (for a current-driven device) at AI301TYP, which is 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-710-5 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** as engineering units. Type **–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 4.97*. 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 4.97 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 4.90 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 AI30-NAM setting must begin with an alpha character (A–Z) and not a number.

Table 4.90 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-710-5 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 4.98* shows the *x* and *y* variable allocation for the analog output card.

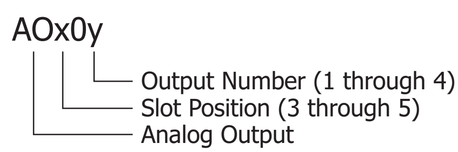


Figure 4.98 Analog Output Number Allocation

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 M: Analog Quantities*. *Table 4.91* shows the setting prompt, setting range, and factory-default settings for an analog card in Slot 3.

NOTE: The SEL-710-5 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 4.91 Output Setting for a Card in Slot 3 (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AO301 ANALOG QTY	Off, one 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

Table 4.91 Output Setting for a Card in Slot 3 (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
AO301 HI OUT VAL	–20.480 to +20.480 mA	AO301H := 20.000
AO301 LO OUT VAL	–10.240 to +10.240 V	AO301L := 0.000[a]
AO301 HI OUT VAL	–10.240 to +10.240 V	AO301H := 10.000[a]

[a] Voltage setting range for a voltage transducer, i.e., when AO301TYP := V.

In this example, assume you want to display, in the control room, the analog quantity (refer to *Appendix M: Analog Quantities*) IA_MAG, and the A-phase current magnitude in primary amperes (0 to 3000 A) using a –20 to +20 mA analog output channel. Install an analog input/output card in Slot **C** (SELECT 4 AI/4 AO) and set the card channel AO301 as shown in *Figure 4.99*. Note that the AO301 channel has to be configured as a "current analog output" channel (refer to *Figure 2.6* to *Figure 2.8*).

The display instrument expects –20 mA when the IA_MAG current is 0 amperes primary and +20 mA when it is 3000 amperes primary.

```
=>>SET G AO301AQ TERSE <Enter>

Global
AO 301 Settings
AO301 ANALOG QTY (OFF, 1 analog quantity)
AO301AQ := OFF
? IA_MAG <Enter>
AO301 TYPE (I,V)                              AO301TYP:= I        ? <Enter>
AO301 AQTY LO (-2147483647.000 to 2147483647.000)
                                              AO301AQL:= 4.000    ? 0 <Enter>
AO301 AQTY HI (-2147483647.000 to 2147483647.000)
                                              AO301AQH:= 20.000   ? 3000 <Enter>
AO301 LO OUT VAL (-20.480 to 20.480 mA)       AO301L  := 4.000    ? –20 <Enter>
AO301 HI OUT VAL (-20.480 to 20.480 mA)       AO301H  := 20.000   ? 20 <Enter>
AO 302 Settings
AO302 ANALOG QTY (OFF, 1 analog quantity)
AO302AQ := OFF

? END <Enter>

Save changes (Y,N)? Y <Enter>

Settings Saved

=>>
```

Figure 4.99 Analog Output Settings

Breaker Monitor

The breaker monitor in the SEL-710-5 helps in scheduling circuit breaker maintenance. Refer to *Breaker Monitoring on page 5.24* for a detailed description and *Table 5.7* for the settings.

Data Reset

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 4.76* for more details. The RSTENRGY and RSTMXMN settings reset the Energy and Max/Min Metering values, respectively. Use the RSTMOT setting to reset the motor statistics and the motor start reports. You can assign a contact input (for example, RSTTRGT := IN401) to each of these settings if you want remote reset.

Table 4.92 Data Reset Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
RESET TARGETS	SELOGIC	RSTTRGT := 0
RESET ENERGY	SELOGIC	RSTENRGY := 0
RESET MAX/MIN	SELOGIC	RSTMXMN := 0
RESET MOT REPORT	SELOGIC	RSTMOT := 0

Access Control

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

NOTE: Do not set maximum access level setting MAXACC := ACC on all ports at the same time when using the DSABLSET setting. This will lock you out from editing settings.

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 with serial port commands. *Table 4.93* shows the settings prompt, setting range, and factory-default settings.

Table 4.93 Settings Change Disable Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
DISABLE SETTINGS	SELOGIC	DSABLSET := 0

Time-Synchronization Source

The SEL-710-5 accepts a demodulated IRIG-B time signal. *Table 4.94* 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 2.25* and *IRIG-B on page 7.8* for additional information.

Table 4.94 Time-Synchronization Source Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
IRIG TIME SOURCE	IRIG1, IRIG2	TIME_SRC := IRIG1

Disconnect Control Settings

The SEL-710-5 supports as many as eight two-position and two three-position disconnects. For the disconnect settings and logic, refer to *Disconnect Control Settings on page 9.2*. The SEL-710-5 relay with the touchscreen display option additionally provides the ability to design detailed single-line diagrams and display the breaker and disconnect status. Refer to *Table 9.5* for typical disconnect symbols available for display on the bay screens. For the settings related to bay control disconnect symbols, refer to *Table 9.7* and the corresponding description.

Local/Remote Control

The SEL-710-5 supports local/remote control of the motor breaker/contactor and disconnect. For the settings related to the local/remote control function, refer to *Local/Remote Control on page 9.7*. For motor control via front-panel pushbuttons, refer to *Front-Panel Operator Control Pushbuttons on page 8.19*. For motor control via the two-line display, refer to *Control Menu on page 8.10*. The touchscreen allows you to control the motor through the following applications: **Bay Screen, Start Motor,** and **Stop Motor**. For motor control via the touchscreen display, refer to *Motor/Disconnect Control Via the Touchscreen on page 9.8*.

Port Settings (SET P Command)

The SEL-710-5 provides settings that allow you to configure the parameters for the communications ports. See *Section 2: Installation* for a detailed description of port connections. On the base unit: **Port F** (front panel) is an EIA-232 port; **Port 1** is an optional Ethernet port(s); **Port 2** is a fiber-optic serial port; and **Port 3** (rear) is optionally an EIA-232 or EIA-485 port. On the optional communications card, you can select **Port 4** as either EIA-485 or EIA-232 (not both) with the COMMINF setting. See *Table 4.95* through *Table 4.100* for the port settings. See the appropriate appendix for additional information on communications protocols (DNP3, Modbus, EtherNet/IP, IEC 61850, IEC 60870-5-103, DeviceNet, and MIRRORED BITS) of interest.

The EPORT and MAXACC settings provide you with access controls for the corresponding port. Setting EPORT to N disables the port and hides the remaining port settings. The MAXACC setting selects the highest access level for the port.

PORT F

Table 4.95 Front-Panel Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
ENABLE ETHERNET FIRMWARE UPGRADE	Y, N	EETHFWU := N
PROTOCOL	SEL, MOD	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
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
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE (ENGLISH, SPANISH)	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 1

Table 4.96 Ethernet Port Settings (Sheet 1 of 3)

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 sec	KAIDLE := 10

IMPORTANT: Upon relay initial turn on, Port 1 setting changes, or Logic setting changes, you may have to wait as long as two minutes before an additional setting change can occur. Note that the relay is functional with protection enabled as soon as the **ENABLED** LED comes ON (about 5–10 seconds from turn on).

NOTE: The Telnet LANG setting also applies to the web server interface.

NOTE: The FASTOP setting only functions when using SEL Fast Operate protocol to operate/set/pulse breaker bits and remote bits. This setting has no effect on other protocols.

Table 4.96 Ethernet Port Settings (Sheet 2 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
TCP KEEP-ALIVE INTERVAL RANGE	1–20 sec	KAINTV := 1
TCP KEEP-ALIVE COUNT RANGE	1–20	KACNT := 6
OPERATING MODE	FIXED, FAILOVER, SWITCHED, PRP	NETMODE := FAILOVER
FAILOVER TIMEOUT	OFF, 0.10–65.00 sec	FTIME := 1.00
PRIMARY NETPORT	A, B	NETPORT := A
PRP ENTRY TIMEOUT	400–10000 msec	PRPTOUT := 500
PRP DESTINATION ADDR LSB	0–255	PRPADDR := 0
PRP SUPERVISION TX INTERVAL	1–10 sec	PRPINTV := 2
NETWRK PORTA SPD	AUTO; 10, 100 Mbps	NETASPD := AUTO
NETWRK PORTB SPD	AUTO; 10, 100 Mbps	NETBSPD := AUTO
ENABLE TELNET	Y, N	ETELNET := Y
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
TELNET PORT	23, 1025–65534	TPORT := 23
TELNET CONNECT BANNER	254 characters	TCBAN := TERMINAL SERVER
TELNET TIME OUT	1–30 min	TIDLE := 15
FAST OP MESSAGES	Y, N	FASTOP := N
ENABLE FTP	Y, N	EFTPSERV := Y
FTP MAXIMUM ACCESS LEVEL	1, 2, C	FTPACC := 2
FTP USER NAME	20 characters	FTPUSER := FTPUSER
FTP CONNECT BANNER	254 characters	FTPBAN := FTP
FTP IDLE TIME-OUT	5–255 min	FTPIDLE := 5
ENABLE IEC 61850 PROTOCOL	Y, N	E61850 := N
ENABLE IEC 61850 GSE	Y, N	EGSE := N
ENABLE MMS FILE SERVICES	Y, N	EMMSFS := N
ENABLE 61850 MODE/ BEHAVIOR CONTROL	Y, N	E850MBC := N
ENABLE GOOSE TX IN OFF MODE	Y, N	EOFFMTX := N
ENABLE MODBUS SESSIONS	0–2	EMOD := 0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP1 := 0.0.0.0
MODBUS MASTER IP ADDRESS	zzz.yyy.xxx.www[a]	MODIP2 := 0.0.0.0
MODBUS TCP PORT 1	1–65534	MODNUM1 := 502
MODBUS TCP PORT 2	1–65534	MODNUM2 := 502
MODBUS TIMEOUT 1	15–900 sec	MTIMEO1 := 15
MODBUS TIMEOUT 2	15–900 sec	MTIMEO2 := 15

Table 4.96 Ethernet Port Settings (Sheet 3 of 3)

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE HTTP SERVER	Y, N	EHTTP := Y
HTTP MAXIMUM ACCESS LEVEL	1, 2, C	HTTPACC := 2
TCP/IP PORT	1–65535	HTTPPORT := 80
HTTP CONNECT BANNER	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only.
HTTP WEB SERVER TIMEOUT	1–60 min	HTTPIDLE := 10
ENABLE RSTP	Y, N	ERSTP := N
BRIDGE PRIORITY[b]	0–61440	BRDGPRI := 49152
PORTA PRIORITY[b]	0–240	PORTAPRI := 128
PORTB PRIORITY[b]	0–240	PORTBPRI := 128
ENABLE DNP SESSION[c]	0–5	EDNP := 0
ENABLE SNTP CLIENT[d]	OFF, UNICAST, MANYCAST, BROADCAST	ESNTP := OFF
ENABLE PTP[e]	Y, N	EPTP := N
ENABLE ETHERNET/IP[f]	Y, N	EEIP := N

[a] MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).
[b] The bridge priority and port priority settings should be in increments of 4096 and 16, respectively.
[c] See Table D.7 for a complete list of the DNP3 session settings.
[d] See Table 7.7 for a complete list of SNTP settings and their descriptions.
[e] See Table 7.9 for a complete list of PTP settings and their descriptions.
[f] See Table F.1 for a complete list of EtherNet/IP settings and their descriptions.

Port Number Settings Must be Unique

When making the SEL-710-5 Port 1 settings, the port number settings cannot be used for more than one protocol. The relay checks all the settings shown in the following table 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 that contains a duplicate value.

Table 4.97 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
DNPNUM	DNPTCP and UDP Port	EDNP > 0
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF
EPTP	Enable PTP	PTPPRO = DEFAULT and PTPTR = UDP (Ports 319 and 320 are reserved)
EEIP	Enable EtherNet/IP	EEIP ≠ N (Ports 2222/44818 are reserved)

[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 other protocols.

PORT 2

NOTE: For additional settings when PROTO := MBxx, see Table J.5.

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

Refer to Appendix H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

Table 4.98 Fiber-Optic Serial Port Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, DNET, DNP, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
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
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 3

NOTE: For additional settings when PROTO := MBxx, see Table J.5.

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

Refer to Appendix H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

Table 4.99 Rear-Panel Serial Port (EIA-232) Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE PORT	Y, N	EPORT := Y
PROTOCOL	SEL, MOD, DNET, DNP, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
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
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

PORT 4

NOTE: For additional settings when PROTO := MBxx, see Table J.5.

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

Refer to Appendix H: IEC 60870-5-103 Communications for more information on IEC 60870-5-103.

Table 4.100 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, DNP, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103	PROTO := SEL
MAXIMUM ACCESS LEVEL	1, 2, C	MAXACC := 2
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
HDWR HANDSHAKING	Y, N	RTSCTS := N
LANGUAGE	ENGLISH, SPANISH	LANG := ENGLISH
SEND AUTOMESSAGE	Y, N	AUTO := N
FAST OP MESSAGES	Y, N	FASTOP := N
MODBUS SLAVE ID	1–247	SLAVEID := 1

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

After T_OUT 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 T_OUT equal to 0 minutes.

For detailed information on communications protocols, refer to *Appendix C: SEL Communications Processors*, *Appendix D: DNP3 Communications*, *Appendix E: Modbus Communications*, *Appendix F: EtherNet/IP Communications*, *Appendix G: IEC 61850 Communications*, *Appendix H: IEC 60870-5-103 Communications*, *Appendix I: DeviceNet Communications*, and *Appendix J: MIRRORED BITS Communications*.

Use the MBT option if you are using a Pulsar MBT9600 baud modem (see *Appendix J: 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.

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

On Ports F, 2, 3, and 4, when PROTO := SEL, use the LANG setting to communicate with the relay in English or Spanish. On Port 1 with the ENABLE TELNET := Y use the LANG setting to communicate with the relay in English or Spanish, Refer to the *SEL-710-5 Relay Command Summary*.

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

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-710-5 Fast Operate commands.

Set PROTO := DNET to establish communications when the DeviceNet card is used. *Table 4.101* 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 I: DeviceNet Communications* for details on DeviceNet.

Table 4.101 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)

The SEL-710-5 supports various front-panel options (see *Table 1.2*). This section covers all of the front-panel related settings, except the touchscreen display settings. Refer to *Table 9.7* for the touchscreen display settings. The touchscreen display settings are not settable via the **SET F** command.

General Settings

Local bits provide control from the front panel (local bits), and display points display selected information on the LCD. However, you need to first enable the appropriate number of local bits and display points necessary for your application. When your SEL-710-5 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.

The EDP setting and the corresponding display point settings are not available for the touchscreen display model. The touchscreen display model provides you with the ability to configure bay screens with analog and digital labels, similar to the display point functionality in the two-line display model. Refer to *Section 9: Bay Control* for the procedure to create configurable bay screens.

Table 4.102 Display Point and Local Bit Default Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DISPLAY PTS ENABL[a]	N, 1–32	EDP := 4
LOCAL BITS ENABL	N, 1–32	ELB := N

[a] The setting EDP is not supported in the touchscreen display model.

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. The FP_TO setting is not available in the touchscreen display model. Refer to *Section 9: Bay Control* for the touchscreen display settings.If you prefer to disable the front-panel time-out function during device testing, set the LCD time-out (FP_TO) equal to OFF.

Use the front-panel LCD contrast setting FP_CONT to adjust the contrast of the LCD. The FP_CONT setting is not available in the touchscreen display model.

Use the front-panel automessage setting FP_AUTO to define the display of Trip/Warning messages. Set FP_AUTO either to OVERRIDE or ROTATING for when the relay triggers a Trip/Warning message. Choosing OVERRIDE triggers the Trip/Warning message to override the rotating display, while choosing ROTATING will add the Trip/Warning message to the rotating display. Refer to *Table 9.7* for the equivalent touchscreen display settings. Note that the FP_AUTO setting is not available in the touchscreen display model. The touchscreen display provides settings that allow you to choose from a wide range of screens, including custom screens, that can be displayed as part of the rotating display. The touchscreen automatically flashes a screen that overrides the rotating display in the case of trip or diagnostic failures. Refer to *Section 8: Front-Panel Operations* for more information on trip and diagnostic messages.

Set RSTLED := Y to automatically reset the latched LEDs when the breaker or contactor closes.

The MAXACC setting (under Front-Panel Settings) selects the highest access level for the front panel. If MAXACC is set to 1, the front panel only allows metering and read access to the settings. If MAXACC is set to 2, the front panel allows breaker control and read/write access to the settings.

NOTE: All Target LED settings can be found in Table 4.111.

Table 4.103 LCD Settings

Setting Prompt	Range	Setting Name := Factory Default
LCD TIMEOUT[a]	OFF, 1–30; min	FP_TO :=15
LCD CONTRAST[a]	1–16	FP_CONT := 10
FP AUTOMESSAGES[a]	OVERRIDE, ROTATING	FP_AUTO := OVERRIDE
CLOSE RESET LEDS	Y, N	RSTLED := Y
MAXIMUM ACCESS LEVEL[a]	1, 2, C	MAXACC := 2

[a] These settings are not supported in the touchscreen display model.

Display Points

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

Use display points to view either the state of internal relay elements (Boolean information) or analog information on the LCD. Although the LCD displays a maximum of 16 characters at a time, you can enter as many as 60 characters. For text exceeding 16 characters, the LCD displays the first 16 characters, then scrolls through the remaining text not initially displayed on the screen.

Table 4.104 Front-Panel Display Point Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
DISPLAY POINT DP01	60 characters	DP01 := RID,"{16}"
DISPLAY POINT DP02	60 characters	DP02 := TID,"{16}"
DISPLAY POINT DP03	60 characters	DP03 :=
• • •	• • •	• • •
DISPLAY POINT DP32	60 characters	DP32 :=

Boolean Display Point Entry Composition

Boolean information is the status of Relay Word bits (see *Appendix L: Relay Word Bits*). In general, the legal syntax for Boolean display points consists of the following four fields or strings, separated by commas:

"Name", "Alias", "Set String", "Clear String".

where:

Name = Relay Word bit name (IN101, for example). All binary quantities occupy one line on the front-panel display (all analog quantities occupy two lines).

Alias = A more descriptive name for the Relay Word bit (such as TRANSFORMER 3), or the analog quantity (such as TEMPERATURE).

Set String = State what should be displayed on the LCD when the Relay Word bit is asserted (CLOSED, for example)

Clear String = State what should be displayed on the LCD when the Relay Word bit is deasserted (OPEN, for example)

Any or all of Alias, Set String, or Clear String can be empty. Although the relay accepts an empty setting Name as valid, a display point with an empty Name setting is always hidden (see 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 4.105* 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 4.105* shows examples of settings that always, never, or conditionally hide a display point.

Table 4.105 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

Examples of selected display point settings, showing the resulting front-panel displays are discussed in the following text. For example, at a certain station we want to display the status of both HV and LV circuit breakers of Transformer 1. When the HV circuit breaker is open, we want the LCD to show: `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-710-5, we are ready to program the display points using the following information for the HV breaker (the LV breaker is similar):

- Name—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 4.106 Entries for the Four Strings

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

Figure 4.100 shows the settings for the example, using the **SET F** command. Use the **>** character to move to the next settings category.

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                    EDP     := 4         ? > <Enter>
.
.
.
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := RID,"{16}"
? IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP02 (60 characters)
DP02    := TID,"{16}"
? IN102,"TRFR 1 LV BRKR:",CLOSED,OPEN <Enter>
DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "IAV CURR {5} A"
? END <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.100 Display Point Settings

Figure 4.101 shows the display when both HV and LV breakers are open (both IN101 and IN102 deasserted). *Figure 4.102* shows the display when the HV breaker is closed, and the LV breaker is open (IN101 asserted, but IN102 still deasserted).

Figure 4.101 Front-Panel Display—Both HV and LV Breakers Open

Figure 4.102 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 4.103*. 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 4.104*.

Figure 4.103 Front-Panel Display—Both HV and LV Breakers Closed

Figure 4.104 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 4.105*.

Figure 4.105 Front-Panel Display—HV Breaker Open, LV Breaker Closed

Name Only

Table 4.107 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 4.107 Binary Entry in the Name String Only

Name	Alias	Set String	Clear String
IN101	—	—	—

Figure 4.106 shows the front-panel display for the entry in *Table 4.107*. Input IN101 is deasserted in this display (`IN101=0`), but changes to `IN101=1` when Input IN101 asserts.

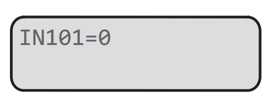


Figure 4.106 Front-Panel Display for a Binary Entry in the Name String Only

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

Table 4.108 Analog Entry in the Name String Only

Name	Alias	Set String	Clear String
AI301	—	—	—

Figure 4.107 shows the front-panel display for the entry in *Table 4.108*, using the **SET F** command as follows:

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

Figure 4.107 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 4.109* 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 4.109 Entry in the Name String and the Alias Strings

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

Figure 4.108 shows the front-panel display for the entry in *Table 4.109*. Input IN101 is deasserted in this display (0), and the display changes to `INPUT IN101=1` when Input IN101 asserts.

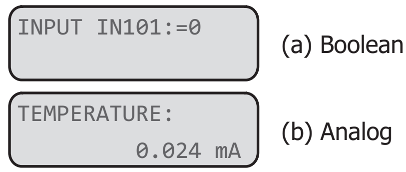


Figure 4.108 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name and User Text and Formatting Strings

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 4.109*.

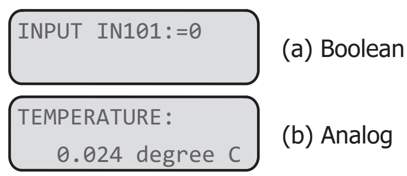


Figure 4.109 Front-Panel Display for an Entry in (a) Boolean Name and Alias Strings and (b) Analog Name, User Text and Formatting Strings, and Engineering Units

For fixed text, enter a 1 in the Name String, then enter the fixed text as the alias text. For example, to display the word DEFAULT and SETTINGS on two different lines, use a display point for each word, i.e., DP01 = 1, “DEFAULT” and DP02 = 1,“SETTINGS”. *Table 4.110* shows other options and front-panel displays for the User Text and Formatting settings.

Table 4.110 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 = {5}"	TEMP = 1234
AI301,"TEMP = {4.2,0.001} C"	TEMP = 1.23 C
AI301,"TEMP HV HS1 = {4,1000}"	TEMP HV HS1 =1234000
1,{}	Empty line
1,"Fixed Text"	Fixed Text
0	Hides the display point

The 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, install an analog card in relay Slot **C** and connect 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 4.110* shows the settings to add the three transducer measurements. (Use the **>** character to move to the next settings category.)

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

DISPLAY POINT DP03 (60 characters)
DP03    := IAV, "IAV CURR {5} A"
? AI301,"HOT SPOT TEMP" <Enter>
DISPLAY POINT DP04 (60 characters)
DP04    := IG_MAG, "GND CURR {5} %"
? AI302,"OIL TEMPERATURE" <Enter>
DISPLAY POINT DP05 (60 characters)
DP05    := IA_MAG, "IA {7.1} A pri"
? AI303,"WINDING TEMP" <Enter>
Save changes (Y,N)? Y <Enter>
Settings Saved
=>>
```

Figure 4.110 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 4.111*.

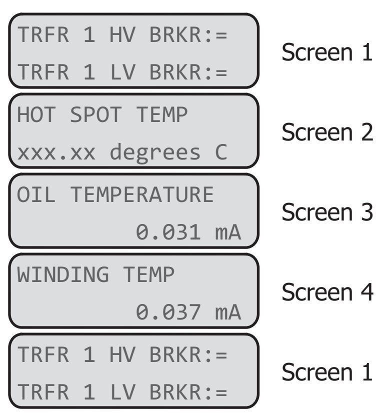


Figure 4.111 Rotating Displays

To change the temperature units to more descriptive engineering units, enter the desired units with the AI*xxx*EU (e.g., AI302EU) setting.

Local Bits

Local bits are variables (LB*nn*, where *nn* means 01 through 32) that are controlled from front-panel pushbuttons. Use local bits to replace traditional panel switches. The state of the local bits is stored in nonvolatile memory every second. When power to the device is restored, the local bits go back to their states after the device initialization. Each local bit requires 3 of the following 4 settings, using a maximum of 14 characters for the NLB*nn* setting, and a maximum 7 characters for the remainder.

- ➤ NLB*nn*: Names the switch (normally the function that the switch performs, such as SUPERV SW) that appears on the LCD.
- ➤ CLB*nn*: Clears the 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*: Sets the 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*: Pulses the 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 4.112* shows the settings to program the two local bits.

```
=>>SET F TERSE <Enter>
Front Panel
General Settings
DISPLY PTS ENABL (N,1-32)                          EDP     := 5         ? <Enter>
LOCAL BITS ENABL (N,1-32)                          ELB     := N         ? 2 <Enter>
LCD TIMEOUT (OFF,1-30 min)                         FP_TO   := 15        ? > <Enter>
.
.
.
Display Point Settings (maximum 60 characters):
(Boolean): Relay Word Bit Name, "Alias", "Set String", "Clear String"
(Analog) : Analog Quantity Name, "User Text and Formatting"
DISPLAY POINT DP01 (60 characters)
DP01    := IN101,"TRFR 1 HV BRKR:",CLOSED,OPEN
? > <Enter>
Local Bits Labels:
LB_ NAME (14 characters; Enter NA to null)
NLB01   :=
? SUPERV 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 4.112 Adding Two Local Bits

Target LED Settings

The SEL-710-5 offers the following types of LEDs. See *Figure 8.2* and *Figure 8.31* for the programmable LED locations:

- One **ENABLED** and one **TRIP** tricolored LED
- Six tricolored programmable target LEDs
- Sixteen tricolored programmable pushbutton LEDs

You can program all 22 LEDs using SELOGIC control equations, the only difference being that the target LEDs also include a latch function.

Target LEDs

The **ENABLED** and **TRIP** LEDs are not programmable. Except for choosing the LED illuminated color (LEDENAC or LEDTRPC), they are fixed-function LEDs. The **ENABLED** LED illuminates when the SEL-710-5 is powered correctly, is functional, and has no self-test failures. The **TRIP** LED illuminates and latches in at the rising-edge of any trip that comes from the trip logic. The LEDENAC setting is not supported in the touchscreen display models. For touchscreen display relays, the illuminated color of the **ENABLED** LED is fixed at green.

NOTE: If the LED latch setting (TnLEDL) is set to Y, and TRIP asserts, the LED latches to the state at TRIP assertion. The latched LED targets can be reset by pressing the **TARGET RESET** pushbutton if the target conditions are absent.

NOTE: Relay Word bits TLED_01 through TLED_06 are not accessible to the user in the SYNCHROWAVE Event file.

Settings T*n*_LEDL (*n* = 01 through 06) and T*n*_LED (*n* = 01 through 06) control the six front-panel LEDs. If the T*n*_LEDL is set to Y, the LED will assert if a trip condition occurs and the T0*n*_LED equation asserts within 1.5 cycles of the trip assertion. At this point, the LED is latched. 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 **TAR R** command.
- 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 4.111 shows the target LED settings. The factory-default settings shown match the as-shipped front-panel overlay (see *Figure 8.2*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.111 Target LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
ENA_LED COLOR[b]	R, G, A	LEDENAC := G
TRIP_LED COLOR	R, G, A	LEDTRPC :=R
TRIP LATCH T_LED	Y, N	T01LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T01LEDC := R
LED1 EQUATION	SELOGIC	T01_LED := 49T OR AMBTRIP OR BRGTRIP OR OTHTRIP OR WDGTRIP
TRIP LATCH T_LED	Y, N	T02LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T02LEDC := R
LED2 EQUATION	SELOGIC	T02_LED := 50P1T OR 50N1T OR 50G1T

Table 4.111 Target LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
TRIP LATCH T_LED	Y, N	T03LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T03LEDC := R
LED3 EQUATION	SELOGIC	T03_LED := 46UBT OR 47T
TRIP LATCH T_LED	Y, N	T04LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T04LEDC := R
LED4 EQUATION	SELOGIC	T04_LED := LOSSTRIP OR 37PT
TRIP LATCH T_LED	Y, N	T05LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T05LEDC := R
LED5 EQUATION	SELOGIC	T05_LED := (NOT STOPPED AND 27P1T) OR 59P1T
TRIP LATCH T_LED	Y, N	T06LEDL := Y
TARGET T_LED ASSERTED COLOR	R, G, A	T06LEDC := R
LED6 EQUATION	SELOGIC	T06_LED := 87M1T OR 87M2T

[a] R = Red, G = Green, and A = Amber.
[b] The setting LEDENAC is not supported in the touchscreen display model.

Pushbutton LEDs

Enter any of the Relay Word bits (or combinations of Relay Word bits) as conditions in the PB*p*_LED (*p* = 1A, 1B, . . ., 8A, 8B) SELOGIC control equation settings. When these Relay Word bits assert, the corresponding LED also asserts.

Table 4.112 shows the setting prompts, settings ranges, and default settings for the LEDs. The factory-default settings shown match the shipped front-panel overlay (see *Figure 8.2*). You can change the settings to suit your application. See *Section 8: Front-Panel Operations* for slide-in labels for custom LED designations.

Table 4.112 Pushbutton LED Settings (Sheet 1 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB1ALEDC := AO
PB1A_LED EQUATION	SELOGIC	PB1A_LED := PB01
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB1BLEDC := AO
PB1B_LED EQUATION	SELOGIC	PB1B_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB2ALEDC := AO
PB2A_LED EQUATION	SELOGIC	PB2A_LED := PB02
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB2BLEDC := AO
PB2B_LED EQUATION	SELOGIC	PB2B_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB3ALEDC := AO
PB3A_LED EQUATION	SELOGIC	PB3A_LED := PB03

Table 4.112 Pushbutton LED Settings (Sheet 2 of 2)

Setting Prompt	Setting Range[a]	Setting Name := Factory Default
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB3BLEDC := AO
PB3B_LED EQUATION	SELOGIC	PB3B_LED := STARTING OR RUNNING
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB4ALEDC := AO
PB4A_LED EQUATION	SELOGIC	PB4A_LED := PB04
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB4BLEDC := AO
PB4B_LED EQUATION	SELOGIC	PB4B_LED := STOPPED
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB5ALEDC := AO
PB5A_LED EQUATION	SELOGIC	PB5A_LED := FAILOPN
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB5BLEDC := AO
PB5B_LED EQUATION	SELOGIC	PB5B_LED := FAILCLS
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB6ALEDC := AO
PB6A_LED EQUATION	SELOGIC	PB6A_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB6BLEDC := AO
PB6B_LED EQUATION	SELOGIC	PB6B_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB7ALEDC := AO
PB7A_LED EQUATION	SELOGIC	PB7A_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB7BLEDC := AO
PB7B_LED EQUATION	SELOGIC	PB7B_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB8ALEDC := AO
PB8A_LED EQUATION	SELOGIC	PB8A_LED := 0
PB_LED ASSERTED/ DEASSRTED COLORS	AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO	PB8BLEDC := AO
PB8B_LED EQUATION	SELOGIC	PB8B_LED := 0

[a] Setting is a two-letter combination of the letters R, G, A, O, where the asserted/deasserted color choices are: R = Red, G = Green, A = Amber, O = Off. Asserted and deasserted colors must be different.

Report Settings (SET R Command)

The report settings use Relay Word bits for the SER and event report trigger as shown in *Table 4.113* and *Table 4.114*. See *Appendix L: Relay Word Bits* for details. Refer to *Section 10: Analyzing Events* for additional information about SER and event reports.

SER Trigger Lists

Table 4.113 SER[a] Trigger Settings

Setting Prompt	Setting Name := Factory Default
SER1	SER1 := IN101 IN102 ABSLO TBSLO NOSLO THERMLO PB01 PB02 PB03 PB04
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 bits separated by spaces or commas for each setting.

Relay Word Bit Aliases

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 32 unique aliases, as defined by the Enable Alias Settings (EALIAS) setting. The factory-default alias settings are shown in *Table 4.115*.

Table 4.114 Enable Alias Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Enable ALIAS Settings	N, 1–32	EALIAS = 15

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 L.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 interprets a space as the break between two strings. If you wish to clear a string, simply type **NA**.

Table 4.115 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 :=	NA	—	—	—
• • •	• • •	• • •	• • •	• • •
ALIAS32 :=	NA	—	—	—

Event Report Settings

Event reports are 15, 64, or 180 cycles in length as determined by the LER setting. For an LER of 15, the prefault length, PRE, is in the range of 1–10. For an LER of 64, the prefault length, PRE, is in the range of 1–59. For an LER of 180, the prefault length, PRE, is in the range of 1–175. The relay typically holds at least forty-nine 15-cycle event reports, twenty-three 64-cycle event reports, or nine 180-cycle event reports.

NOTE: Event report data stored in the relay are lost when you change the LER setting. Save the data before changing the setting.

Table 4.116 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, 180 cyc	LER := 15
PREFAULT LENGTH	1–175 cyc	PRE := 5

Trigger CMET S R Event Reports

The SEL-710-5 captures a 19200-sample raw event report on rising edges of CMETSRTG. For example, you can set CMETSRTG = STARTING to capture the start of the motor. By providing this lengthy, high-resolution report, the relay enables external data processing while saving standard event reports for protection functions.

Table 4.117 Meter Report Settings

Setting Prompt	Setting Range	Setting Name := Factory
CMET S R TRIGGER	SELOGIC	CMETSRTG := 0

Start Report Settings

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*.

Table 4.118 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. Using SELOGIC control equations for the starting conditions may result in incorrect data in the MST and MOT records.

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 M: Analog Quantities* for a list of the available analog quantities. Also set the LDAR to the acquisition rate for the report that you want.

IMPORTANT: All stored load data are lost when changing the LDLIST.

Table 4.119 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

DNP Map Settings (Set D Command)

Table 4.120 shows the available settings. See *Appendix D: DNP3 Communications* for additional details.

Table 4.120 DNP Map Settings[a] (Sheet 1 of 2)

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

Table 4.120 DNP Map Settings[a] (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
DNP Binary Output Label Name	10 characters	BO_00 := RB01
• • •	• • •	• • •
DNP Binary Output Label Name	10 characters	BO_31 := RB32
DNP Analog Input Label Name	24 characters	AI_00 := IA_MAG
DNP Analog Input Label Name	24 characters	AI_01 := IB_MAG
• • •	• • •	• • •
DNP Analog Input Label Name	24 characters	AI_99 := NA
DNP Analog Output Label Name	6 characters	AO_00 := NA
• • •	• • •	• • •
DNP Analog Output Label Name	6 characters	AO_31 := NA
DNP Counter Label Name	11 characters	CO_00 := NA
• • •	• • •	• • •
DNP Counter Label Name	11 characters	CO_31 := NA

[a] See Appendix D: DNP3 Communications for complete list of the DNP Map Labels and factory-default settings.

Modbus Map Settings (SET M Command)

Modbus User Map

Table 4.121 shows the available settings. See *Appendix E: Modbus Communications* for additional details.

Table 4.121 User Map Register Settings[a]

Setting Prompt	Setting Range	Setting Name := Factory Default
USER REG#1	NA, 1 Modbus Register Label	MOD_001 :=
• • •	• • •	• • •
USER REG#125	NA, 1 Modbus Register Label	MOD_125 :=

[a] See Appendix E: Modbus Communications for Modbus Register Labels and factory-default settings.

EtherNet/IP Assembly Map Settings (SET E Command)

Table 4.122 shows the available assembly map settings. See *Appendix F: EtherNet/IP Communications* for additional details.

Table 4.122 EtherNet/IP Assembly Map

Setting Prompt	Setting Range	Setting Name := Factory Default
Input Assembly (IA) Binary		
EIP Input Assembly Binary Label Name	10 characters	IAB _00 := NA
• • •	• • •	• • •
EIP Input Assembly Binary Label Name	10 characters	IAB _99 := NA
Input Assembly (IA) Analog		
EIP Input Assembly Analog Label Name	10 characters	IAA_00 := NOOP IAA_01 := NA
• • •	• • •	• • •
EIP Input Assembly Analog Label Name	10 characters	IAA_99 := NA
Output Assembly (OA) Binary		
EIP Output Assembly Binary Label Name	10 characters	OAB _00 := NA
• • •	• • •	• • •
EIP Output Assembly Binary Label Name	10 characters	OAB _31 := NA
Output Assembly (OA) Analog		
EIP Output Assembly Analog Label Name	10 characters	OAA_00 := NOOP OAA_01 := NA
• • •	• • •	• • •
EIP Output Assembly Analog Label Name	10 characters	OAA _31 := NA

Touchscreen Settings

The touchscreen settings apply to relays that support the color touchscreen display and are discussed in *Section 9: Bay Control* (see *Table 9.7*).

Section 5
Metering and Monitoring

Overview

Metering

The SEL-710-5 Motor Protection Relay includes metering functions to display the present values of current, voltage, 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
- ➤ Web server via Ethernet port
- ➤ EIA-232 serial ports (using SEL ASCII text commands or ACSELERATOR QuickSet SEL-5030 Software)
- ➤ Telnet via Ethernet port
- ➤ Modbus via EIA-232 port or EIA-485 port
- ➤ Modbus TCP via Ethernet port
- ➤ DNP3 Serial via EIA-232 port or EIA-485 port
- ➤ DNP3 LAN/WAN via Ethernet port
- ➤ DeviceNet port
- ➤ Analog outputs
- ➤ IEC 61850 Edition 2 via Ethernet port
- ➤ IEC 60870-5-103 via EIA-232 or EIA-485 port
- ➤ EtherNet/IP via Ethernet port

Asset Monitoring

Track the operating characteristics of your motor and accompanying devices with built-in asset monitoring capabilities. The SEL-710-5 can monitor items, such as vibration, motor start current, motor start times, motor stop times, broken rotor bars, incipient cable faults, and excessive wear on molded case circuit breakers, and provide useful information to the user via ASCII reports or the touchscreen display. The Fourier Transform commands provide detailed data about the behavior of the motor. Using the 97FM elements, you can detect selectable frequency components in current, voltage, and power quantities.

For monitoring and preventive maintenance purposes, the SEL-710-5 also provides motor operating statistics reports, motor start reports for the 30 latest motor starts, and motor start reports that store motor start averages for the last eighteen 30-day periods. Motor load monitoring and trending are possible using the Load Profile function.

With these asset monitoring capabilities, you can reduce production losses from unexpected equipment failures and lower maintenance costs by switching to condition-based maintenance schedules. See *Asset Monitoring* for application details.

Metering

NOTE: See Figure 5.12 for power measurement conventions.

The SEL-710-5 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 Input Metering
- *Arc-Flash Light Intensity Metering*
- *Remote Analog Metering*

Fundamental Metering

See *Table 5.1* for each of the fundamental meter data types in the SEL-710-5. Refer to *Section 8: Front-Panel Operations* and *Section 7: Communications* for how to access the various types of meter data with the relay front panel and the communications ports.

NOTE: VEX and IEX are calculated every quarter cycle as a true rms value using 32-sample data over a sliding 1-cycle window. This calculation allows the rectifier harmonics to be factored in for the calculation of the true average.

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 M: Analog Quantities.

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] 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 % Real Power (kW) Reactive Power (kVAR) Apparent Power (kVA) Power Factor System Frequency (Hz)
With Synchronous Motor/ Differential Option	Field Voltage, Field Current, Field Resistance Differential Currents IA87, IB87, IC87
With Four Arc-Flash/ Differential Option	Differential Currents IA87, IB87, IC87

[a] Current unbalance % = 0 when IAV ≤ 0.25 • I_{NOM}; Voltage unbalance = 0 when VAV ≤ 0.25 • Vnm, where Vnm = V_{NOM}/1.732 when Wye; V_{NOM} 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.

Refer to *Current Unbalance Elements on page 4.45* for equations to calculate the current unbalance percentage. Voltage unbalance percentage is calculated in a similar manner.

The relay applies a threshold to the fundamental frequency 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 • I_{NOM} • CTR A (primary) and for voltage values is 0.1 • PTR V (primary). When the excitation voltage VEX is less than 0.63 V (primary), the relay forces the meter reading to zero. When the dc field current (IEX) DCCT output in volts (0–10 V range) is less than 0.1 V or the output in mA (4–20 mA range) is less than 0.2 mA, the meter value reading is forced to zero. When the dc field current IEX is less than 0.5 A (primary), the calculated value for the field resistance is forced to show OPEN in the **MET** report.

```
=>>MET <Enter>

SEL-710-5                                 Date: 05/29/2013   Time: 08:19:46.286
SYNCHRONOUS MTR                           Time Source: Internal

                              IA       IB       IC       IN       IG
Current Magnitude (A pri.)    101.2    100.8    100.3     0.00      2.0
Current Angle (deg)            -2.7   -122.0    118.4    -24.1     -88.8

Ave Curr Mag    (A pri.)      100.8
Mot Load (xFLA1)                0.40

Neg-Seq Curr 3I2 (A pri.)       1.6
Current Imb (%)                 0.2

                               IA87     IB87     IC87
Diff Phase Curr     (A pri.)      0.1      0.1      0.1

                               VAB        VBC        VCA
Voltage Magnitude (V pri.)     2340       2341       2340
Voltage Angle (deg)               0.0      -120.0      120.0

Avg Phase (V pri.)            2918
Neg-Seq Volt 3V2 (V pri.)     2374.9
Voltage Imb (%)                 27.8

Real Power (kW)               472
Reactive Power (kVAR)          21
Apparent Power (kVA)          473
Power Factor (LAG)              1.00

Frequency (Hz)  59.99

Field Voltage (V dc)        0.0
Field Current (A dc)        0.0
Field Resistance (Ohm)   open

=>>
```

Figure 5.1 METER Command Report With Synchronous Motor and Differential Option

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.

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.

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: 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.

```
=>>MET T <Enter>

SEL-710-5                                 Date: 05/16/2013   Time: 12:49:23.891
MOTOR RELAY                               Time Source: Internal

Max Winding RTD     4 C
Max Bearing RTD  NA
Ambient RTD      NA
Max Other RTD    NA

 RTD 1 WDG     -1 C
 RTD 2 WDG      4 C

Motor Load (xFLA1)        0.0
Stator TCU (%)            0.0
Rotor TCU (%)             0.0
RTD TCU (%)               0
Thermal Trip In (sec)  9999

Time to Reset (min)       0

=>>
```

Figure 5.2 METER T Command Report With RTDs

Energy Metering

NOTE: Energy values roll over after 999,999.999 MVAh and reset to 0.

The SEL-710-5 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

Figure 5.3 shows the device response to the **METER E** command.

```
=>MET E <Enter>

SEL-710-5                                 Date: 05/16/2013   Time: 12:58:04.426
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 = 05/14/2013 11:06:38

=>>
```

Figure 5.3 Device Response to the METER E Command

To reset energy meter values, issue the **MET RE** command as shown in *Figure 5.4*.

```
=>>MET RE <Enter>

Reset Metering Quantities (Y,N)? Y
Reset Complete

=>>
```

Figure 5.4 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) VAB, VBC, and VCA or VAN, VBN, and VCN magnitudes (V) Maximum and minimum real, reactive and apparent 3-phase power (kW, kVAR, kVA)
With RTD option or SEL-2600 RTD Module	Maximum and minimum RTD temperatures (°C)
With analog input option	Maximum and minimum analog input values (engineering units)

All maximum and minimum metering values 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 5.5 shows an example device response to the **METER M** command.

```
=>MET M <Enter>

SEL-710-5                                Date: 05/16/2013   Time: 13:00:51.459
MOTOR RELAY                              Time Source: Internal

                  MAX       DATE       TIME       MIN       DATE       TIME
IA (A)            119.2  05/16/2013  12:56:32      20.1  05/14/2013  13:09:01
IB (A)             36.2  05/16/2013  12:56:33      35.7  05/16/2013  12:56:40
IC (A)             29.0  05/16/2013  12:56:33      28.5  05/16/2013  12:56:40
IN (A)          RESET                          RESET
IG (A)            184.4  05/16/2013  12:56:32     179.3  05/16/2013  12:56:40
VAB (V)         RESET                          RESET
VBC (V)         RESET                          RESET
VCA (V)         RESET                          RESET
KW3P (kW)       RESET                          RESET
KVAR3P (kVAR)   RESET                          RESET
KVA3P (kVA)     RESET                          RESET
FREQ (Hz)          60.0  05/16/2013  12:56:43      60.0  05/16/2013  12:56:39
RTD1 (C)           77    05/16/2013  12:57:53      -1    05/16/2013  12:58:38

LAST RESET = 05/14/2013 11:06:38

=>
```

Figure 5.5 Device Response to the METER M Command

To reset maximum/minimum meter values, issue the **MET RM** command as shown in *Figure 5.6*. 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 5.6 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-710-5 includes 32 math variables. When you receive your SEL-710-5, 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 5.7* 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-710-5                                Date: 05/16/2013   Time: 13:29:39.896
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 5.7 Device Response to the MET MV Command

RMS Metering

The SEL-710-5 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) RMS voltage VAB, VBC, and 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 5.8 shows the **METER RMS** command.

```
=>>MET RMS <Enter>

SEL-710-5                                 Date: 05/16/2013   Time: 13:32:13.958
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 5.8 Device Response to the METER RMS Command

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 rms metering current values is 0.03 • I_{NOM} • CTR A (primary) and for voltage values is 0.3 • PTR V (primary).

Analog Input Metering

The SEL-710-5 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 5.9* shows an example of analog input metering.

```
=>MET AI <Enter>

SEL-710-5                                Date: 05/16/2013   Time: 13:35:13.958
MOTOR RELAY                              Time Source: Internal

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 5.9 Device Response to the METER AI Command

Arc-Flash Light Intensity Metering

When the SEL-710-5 is ordered with the arc-flash detection (AFD) option (order the 4 AFDI/3 DIFF ACI or 8 AFDI card for Slot E), the relay provides light metering data with the METER LIGHT (**METER L** command) report. The light inputs LS1–LS4 for the 4 AFDI/3 DIFF ACI card or LS1–LS8 for the 8 AFDI card are given in percent of full scale. *Figure 5.10* is an example of the **METER L** (Light) command report using a 4 AFDI/3 DIFF ACI card.

```
=>>MET L <Enter>

SEL-710-5                                Date: 05/16/2013   Time: 13:36:59.886
MOTOR RELAY                              Time Source: Internal

Light Intensity
LS1 (%)    0.1
LS2 (%)    0.1
LS3 (%)    0.0
LS4 (%)    0.2

=>>
```

Figure 5.10 Device Response to the METER L Command

Remote Analog Metering

Use remote analog metering to verify the values received from an external device. The SEL-710-5 includes 128 remote analog variables. In *Appendix C: SEL Communications Processors*, we show how to enter remote analog settings in an SEL communications processor and the SEL-710-5. *Figure 5.11* shows the device response to the **METER RA** command for the settings in *Appendix C*.

```
=>>MET RA <Enter>

SEL-710-5                                   Date: 05/16/2013   Time: 13:37:56.871
MOTOR RELAY                                 Time Source: Internal

RA01 1.00
RA02 -32767.00
RA03 -1.00
RA04 0.00
RA05 1000.59
RA06 -1000.61
RA07 2411.01
RA08 2410.99
RA09 98303.00
RA10 -98303.00
RA11 -38400.00
RA12 -65536.00
RA13 0.00
RA14 0.00
RA15 0.00
. .
. .
. .
RA126 0.00
RA127 0.00
RA128 0.00

=>>
```

Figure 5.11 Device Response to the METER RA 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 fundamental metering current values is 0.01 • I_{NOM} A (secondary) and for voltage values is 0.1 V (secondary). The threshold for rms metering current values is 0.03 • I_{NOM} A (secondary) and for voltage values is 0.3 V (secondary).

Global setting METHRES (*Table 4.78*) controls how these metering functions work when the metered value is smaller than the previously stated thresholds.

METHRES := Y

Set METHRES := Y to force the fundamental and rms metering values of current and voltage to zero when the corresponding applied signals falls below the above stated thresholds.

METHRES := N

Set METHRES := N to bypass the meter threshold checks and disable the metering cutoff.

Power Measurement Conventions

The SEL-710-5 uses the IEEE convention for power measurement assuming motor action. The implications of this convention are depicted in *Figure 5.12*. In the SEL-710-5, reported positive real power is always into the motor.

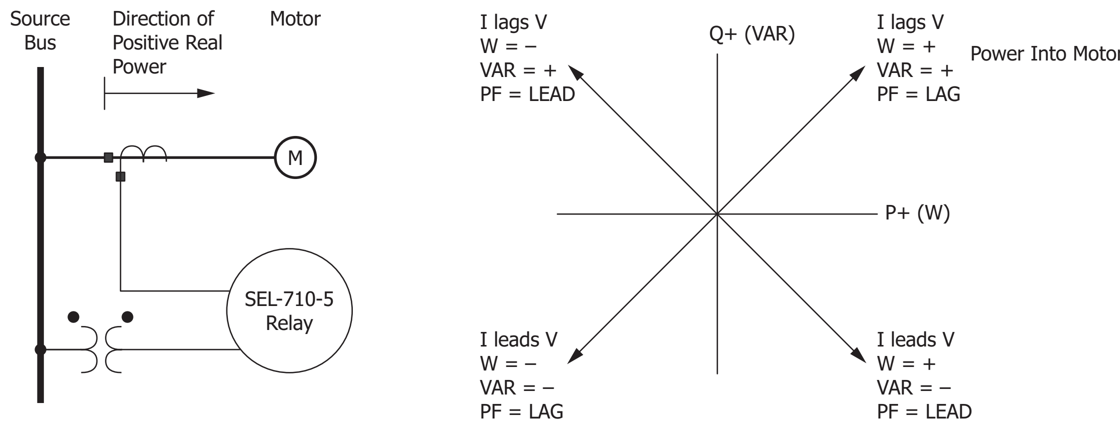


Figure 5.12 Complex Power Measurement Conventions

Asset Monitoring

To monitor the health of your motor asset and accompanying devices, and perform maintenance routines as necessary, the SEL-710-5 supports the following asset monitoring capabilities:

- *Vibration Monitoring*
- *Motor Monitoring Using Fourier Analysis*
- *Broken Rotor Bar Detection*
- *Motor Start Report*
- *Motor Maintenance Report*
- *Motor Operating Statistics*
- *Motor Start Trending*
- *Load Profiling*
- *Incipient Cable Fault Detection*
- *Molded Case Circuit Breaker Health*
- *Breaker Monitoring*

Vibration Monitoring

The SEL-710-5 provides five vibration monitoring elements and each element can monitor a connected vibration transducer via analog inputs or math variables. Each vibration measurement is compared against a set of thresholds that define the four evaluation zones: Recently Commissioned, Acceptable, Warn, or Damaging. In SEL-710-5 models with the touchscreen display option, you can also view in a bar graph the measured values of vibration transducers connected to a motor. See *Vibration Monitoring on page 4.76* for setting and application details.

Motor Monitoring Using Fourier Analysis

The Fourier Transform commands provide protection engineers with detailed data about the behavior of the motor. These commands can be used to periodically collect motor status reports. Differences among historic reports point to developing problems in the motor or the load driven by it. Comparing reports taken from a number of motors performing the same task helps to identify motor, load, and voltage supply problems.

Detect Frequency Components Using 97FM

The 97FM elements monitor the magnitude of a user-selected frequency component in different analog signals by evaluating an individual term of the discrete Fourier transform (DFT). The SEL-710-5 provides five of these elements. These elements can be used to detect conditions such as sub-synchronous resonance, bearing failure, load oscillations, etc. See *Detecting Frequency Components With the 97FM Element on page 4.71* for more details.

CMET S Command

The data processing phase of the **CMET S** command is the same as the one in the **MET FFT** command, but the **CMET S** command collects data from all Ia, Ib, Ic, Va, Vb, and Vc simultaneously, and the output contains frequencies and associated magnitudes. *Figure 5.13* shows the **CMET S** command output.

```
=>>CMET S <Enter>

Recording data ...........

"FREQ","IA","IB","IC","VA","VB","VC","07A7" 0.00,-27.75,-22.47,-23.46,-100.00,-
    100.00,-100.00,"095A" 0.08,-35.31,-29.74,-30.94,-15.52,-23.66,-17.56,"08FF"
    0.17,-68.16,-59.54,-53.91,-40.48,-44.32,-40.52,"0902" 0.25,-65.81,-57.10,-
    56.34,-47.40,-59.71,-47.38,"0909" 0.33,-64.14,-58.75,-52.68,-40.72,-51.58,-
    44.99,"0911"
.
.
.
799.58,-69.48,-66.06,-70.11,-47.30,-46.94,-47.73,"098A"
799.67,-65.73,-68.36,-59.91,-42.87,-48.37,-50.37,"0998"
799.75,-66.18,-63.51,-59.68,-41.69,-52.70,-57.42,"098D"
799.83,-74.40,-72.52,-61.98,-40.65,-48.27,-57.05,"0984"
799.92,-67.21,-72.89,-64.05,-44.57,-49.42,-51.30,"0981"
```

Figure 5.13 CMET S Command Output

CMET S R Command

The **CMET S R** command displays the raw compressed meter report in CASCII format. The report triggers on the rising edge of CMETSRTG. Refer to *Table 4.117*. The report captures 10 seconds, 19200 samples, of raw current and voltage data. All rising edges of CMETSRTG will be ignored during the data capture. The Fourier transformer is not processed in the report. Only one report is stored in the RAM of the relay at a time. The report is lost upon removing and restoring power to the relay.

When there is no report stored in the relay, the relay responds with the following:

```
=>>CMET S R <Enter>

No data available. Set CMETSRTG to collect data.

=>>
```

When the relay is recording the report, the relay responds with the following:

```
=>>CMET S R <Enter>

Collecting Data. Try again in 10 seconds.

=>>
```

In the report, the analog samples are captured in counts, and the conversions to secondary scales (COUNTS2ASEC and COUNTS2VSEC) are included in the header. The sample time is also captured in counts, and the conversion to seconds (COUNTS2S) is included in the header. In addition, the report header also captures relay settings CTR1, FLA1, E2SPEED, CTR2, FLA2, PTR, VNOM, and DELTA_Y. *Figure 5.14* shows the **CMET S R** command output.

```
=>>CMET S R <Enter>

"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
10,22,2019,18,16,40,293,"0497"
"CTR1","FLA1","E2SPEED","CTR2","FLA2","PTR","VNOM","DELTA_Y","COUNTS2ASEC","COUNTS2
    VSEC","COUNTS2S","1818"
100,500,"NO",100,500,3500,11885,"DELTA",200,100,50000000,"0B36"
"TIME","IA","IB","IC","VAB","VBC","VCA","086E"
0,-591,909,-240,-2232,3251,-983,"0627"
.
.
.
500029750,-301,925,-537,-1156,3283,-2092,"07F1"
500055800,-458,931,-393,-1742,3329,-1549,"07FE"
500081850,-594,908,-229,-2259,3246,-945,"07D6"
500107900,-709,850,-56,-2688,3036,-308,"0795"
500133950,-795,764,121,-3013,2710,341,"075B"

=>>
```

Figure 5.14 CMET S R Command Output

MET FFT Command

Figure 5.15 shows a block diagram for the **MET FFT** command. Any of the phase voltages or currents can be analyzed. The command syntax is:

=>>**MET FFT** [ch]

where [ch] is the channel data source selected from [Ia, Ib, Ic, Va, Vb, Vc]. The data are multiplied by a Hamming window of the same length, and the Fourier Transform is computed. The relay compensates the magnitudes for the attenuation of the low-pass filter and corrects the frequency according to the actual sampling rate that is a multiple of the system frequency.

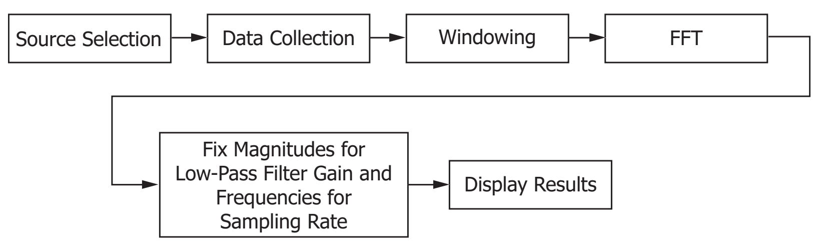


Figure 5.15 Block Diagram for the MET FFT Command

Finally, the relay displays the raw data collected and the frequencies and their associated magnitudes and phase angles on its console port. *Figure 5.16* shows the **MET FFT** command output.

```
=>>MET FFT <Enter>
 Recording data ...........

SEL-710-5                                 Date: 02/20/2013   Time: 17:59:46.722
MOTOR RELAY                               Time Source: Internal

Selected Channel:IA
CTR:1
 #     Signal(A)
1      -0.01
2      0.01
.
.
.
19199  -0.07
19200  -0.04

Processing data ......
Frequency(Hz)       Magnitude(dB)       Angle(deg)
0.00                -100.00             0.00
0.083               -49.44              -75.84
.
.
.
49.853              -31.74              -34.33
49.936              -7.25               87.01
50.020              0.00                -95.69
50.103              -7.53               87.07
50.186              -32.24              19.98
.
.
.
800.148             -61.59              -39.60
800.232             -65.82              140.37
```

Figure 5.16 MET FFT Command Output

Use QuickSet to retrieve, save and study the Fourier Transform reports. To access the QuickSet Fourier Transform interface, click **HMI > HMI** from the Tools menu, then select **Spectrum (FFT)** from the navigation pane on the left side of the window. Because the spectrum report contains detailed information about the status of the motor, we recommend that an Ethernet connection be used to reduce the download time.

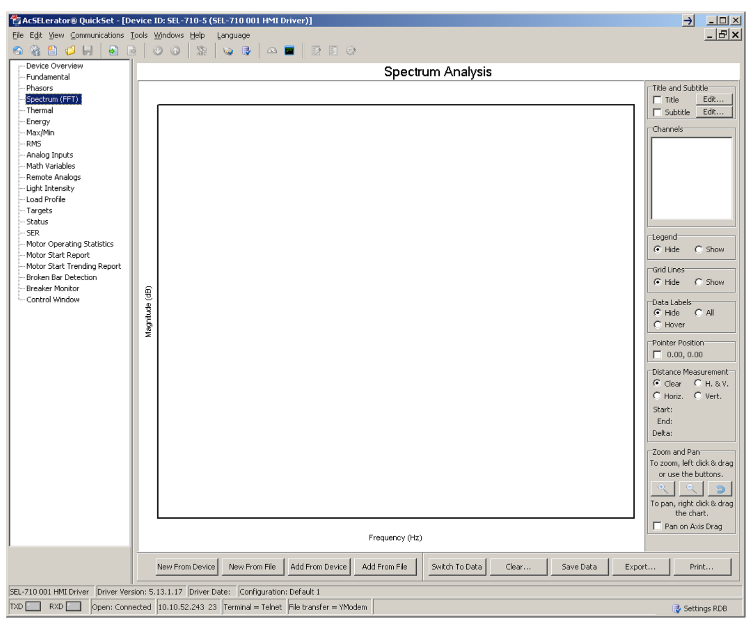


Figure 5.17 QuickSet Fourier Transform Interface

Click **New From Device** to connect to the SEL-710-5, download the spectrum information, and generate a gain frequency plot, as shown in *Figure 5.18*.

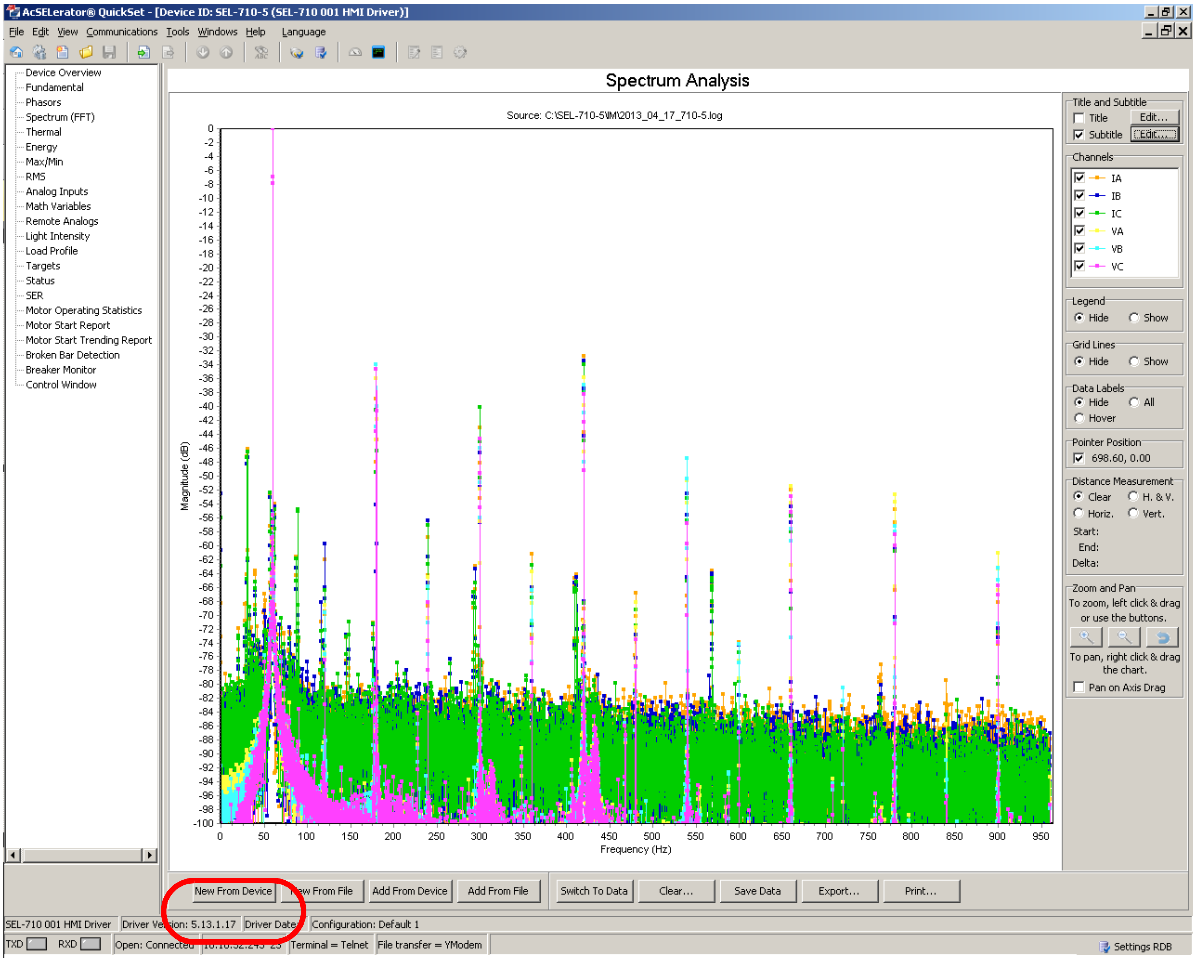


Figure 5.18 Spectrum of a Running Motor

Zoom and Pan on the taskpane allows you to highlight areas of interest on the spectrum, while **Channels** shows and hides individual channels and handles color selection. *Figure 5.19* compares A-phase current and voltage and highlights sidebands associated with a motor running with three broken bars.

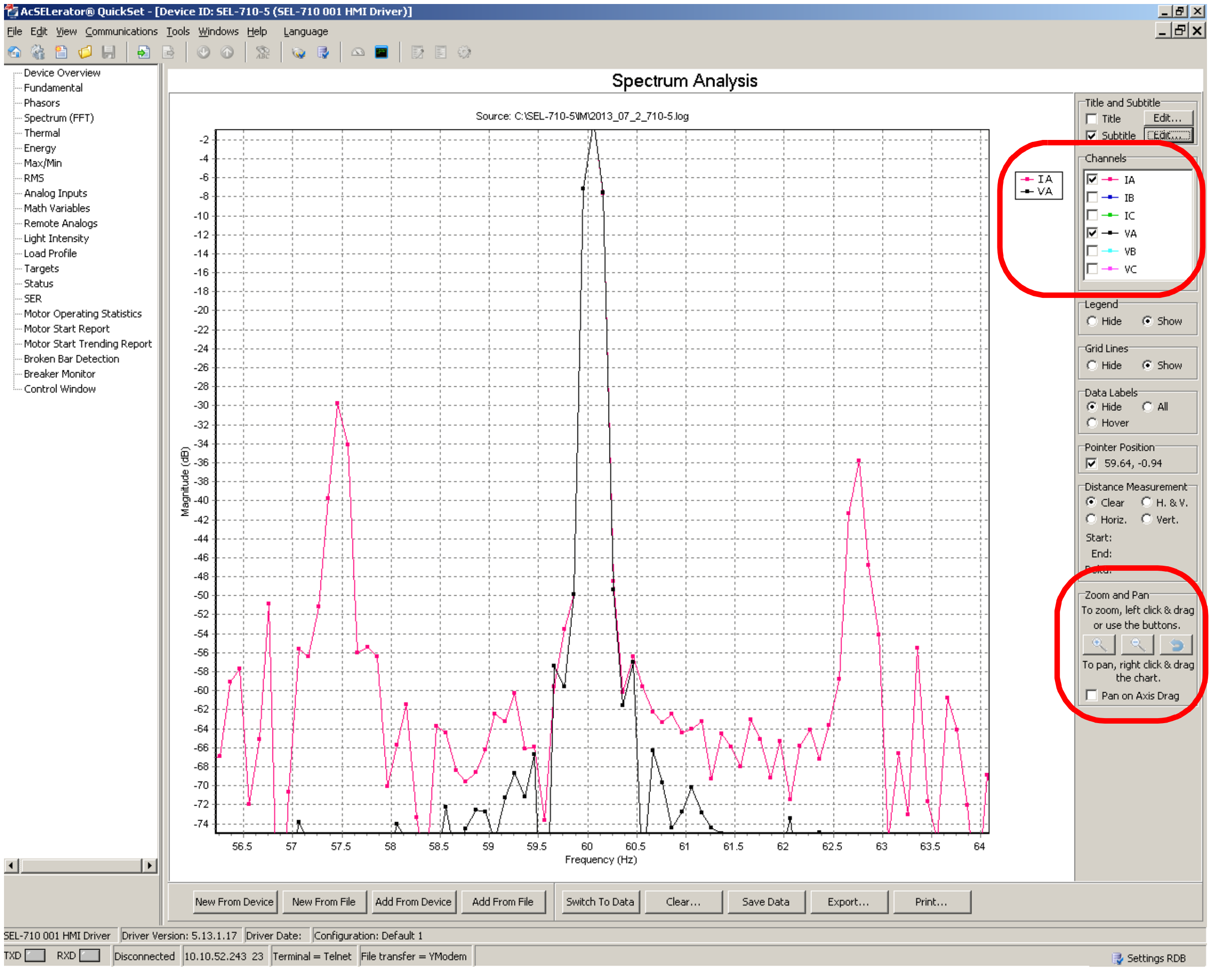


Figure 5.19 Spectrum of a Running Motor With Three Broken Bars

Clicking **Save Data** saves the spectral information to a file for later reference. Clicking **Add From File** allows you to compare the newly downloaded spectrum with a previously saved one. *Figure 5.20* shows that the size of the sideband grew 22.81 dBs between the first and the second report.

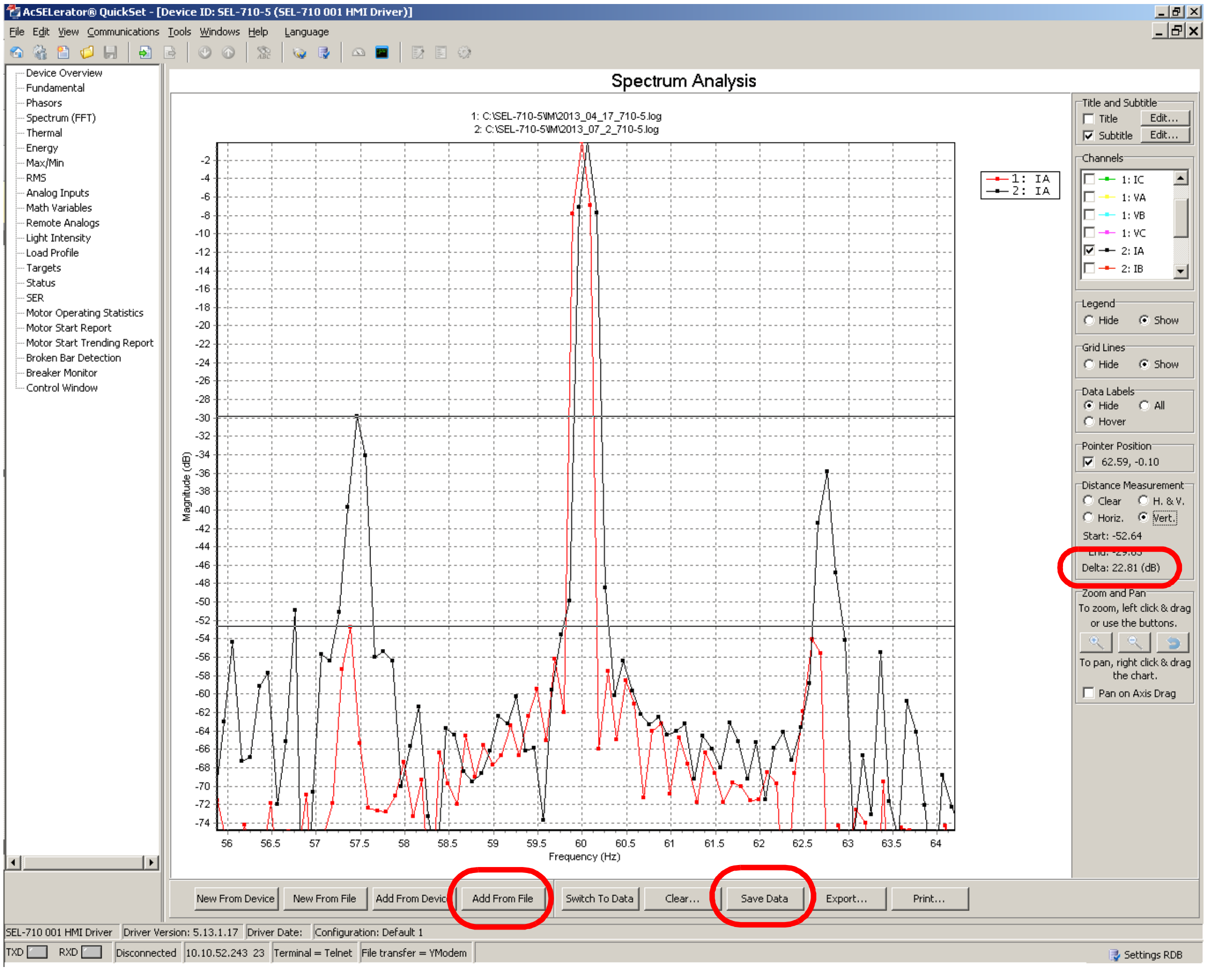


Figure 5.20 Comparison of the Spectrum of a Running Motor With One and Three Broken Bars

Broken Rotor Bar Detection

The SEL-710-5 detects broken rotor bars in induction motors by analyzing the current signatures under sufficient motor load conditions. Broken rotor bar detection determines broken bars using the relative magnitudes of the signals at the sideband frequencies caused by the broken bars, with respect to the signal magnitudes at the system frequency. This normalization allows the algorithm to identify rotor failures independent of the motor characteristics. See *Broken Rotor Bar Protection on page 4.122* for more details.

Motor Start Report

The SEL-710-5 records motor start data for each motor start. The relay stores 30 of the latest motor start reports in nonvolatile memory. To view any of the 30 latest motor start reports, use the serial port **MSR *n*** command, where *n* = 1–30 or 10000–42767 (MSR_REF number), and *n* = 1 is the most recent report. The MSR_REF is a unique number assigned to each report. The data in the Motor Start Reports, except the MSR_REF numbers, are automatically reset when the Motor Statistics Data are reset (see *Motor Operating Statistics on page 5.21*). Each report consists of two parts:

- a summary
- the start data

Summary Data

The summary shows the following information:

- Date and time of the motor start
- Number of starts since last reset
- Motor start time
- Start % Rotor Thermal Capacity Used (%RotorTCU)
- Maximum Start Current
- Minimum Start Voltage, if voltage inputs card option installed
- Motor Start Report Reference Number

NOTE: The relay reports %TCU values during starting based upon the starting model trip value, thus providing the appropriate %TCU magnitude scaling.

The relay calculates motor start time from the time the starting current is detected until the running state is declared (see *Figure 5.25*). 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, if FLS is not set to OFF
- Magnitude of the field voltage VEX and current IEX (requires synchronous motor option)

Figure 5.21 shows data from an example motor start report.

```
=>>MSR <Enter>

710-5                                     Date: 06/27/2013   Time: 15:12:02.495
SYNCHRONOUS MTR                           Time Source: External

FID  SEL-710-5-X061-V0-Z001001-D20130621

Start Date  06/26/2013
Start Time  16:40:32.835

# Starts                  52
Start Time (s)           3.1
Start TCU  (%)            84
MaxCurrent (A)            50
MinVoltage (V)           193
MSR_REF Number         10000
```

Figure 5.21 Motor Start Report Example

CYCLE	IA (A)	IB (A)	IC (A)	IN (A)	VAB (V)	VBC (V)	VCA (V)	TCURTR (%)
5.00	50	43	35	0	193	199	201	66.8
10.00	46	44	35	0	195	197	200	68.0
15.00	45	37	42	0	197	201	197	69.0
20.00	36	40	37	0	199	198	200	70.0
25.00	35	37	37	0	200	199	200	70.8
30.00	34	35	35	0	200	200	200	71.7
35.00	32	32	33	0	201	201	201	72.4
40.00	32	31	31	0	202	203	202	73.1
45.00	32	31	30	0	202	203	203	73.7
50.00	32	32	31	0	203	203	203	74.3
55.00	32	32	31	0	203	203	203	75.0
60.00	30	32	31	0	204	204	204	75.5
65.00	35	34	33	0	202	203	203	76.2
70.00	30	31	32	0	205	204	204	76.9
75.00	29	32	30	0	204	202	203	77.5
80.00	32	34	30	0	202	201	203	78.2
85.00	32	34	31	0	202	201	203	78.9
90.00	26	30	30	0	204	202	203	79.5
95.00	31	29	33	0	206	207	205	80.2
100.00	35	37	33	0	200	199	201	80.8
105.00	36	32	35	0	204	206	205	81.5
110.00	29	27	31	0	207	208	206	82.2
115.00	37	33	34	0	204	206	206	82.8
120.00	26	29	29	0	202	199	201	83.3
125.00	32	33	31	0	201	199	201	83.8
130.00	20	21	21	0	204	203	203	84.1
135.00	17	17	17	0	209	209	209	84.4
140.00	6	6	6	0	211	212	211	84.5
145.00	10	10	10	0	208	207	207	84.5
150.00	6	6	6	0	210	210	210	84.5
155.00	5	4	4	0	214	214	214	84.5
160.00	1	2	2	0	212	212	212	84.5
165.00	6	6	7	0	209	209	209	84.5
170.00	4	4	4	0	210	210	210	84.6
175.00	3	3	3	0	213	213	213	84.6
180.00	1	1	1	0	212	212	212	84.6
185.00	5	5	5	0	210	209	209	84.6
190.00	3	3	3	0	211	211	211	84.6
195.00	2	2	2	0	213	213	213	84.2
200.00	1	1	1	0	212	212	212	84.2
205.00	4	4	4	0	210	210	210	84.2
210.00	3	3	3	0	211	211	211	84.2
215.00	2	2	1	0	212	212	212	84.2
220.00	1	1	1	0	212	212	212	84.2
225.00	3	3	3	0	210	210	210	84.2
230.00	2	3	2	0	211	211	211	84.2
235.00	1	1	1	0	212	212	212	84.2
240.00	1	1	1	0	212	212	212	84.2
245.00	3	3	3	0	210	210	210	83.9
250.00	2	2	2	0	211	211	211	83.9
255.00	1	1	1	0	212	212	212	83.9
260.00	1	1	1	0	212	211	211	83.9
265.00	3	3	3	0	210	210	210	83.9
270.00	2	2	2	0	211	211	211	83.9
275.00	1	1	1	0	212	212	212	83.9
280.00	1	1	1	0	211	211	211	83.9
285.00	2	2	2	0	211	210	210	83.9
290.00	2	2	2	0	211	211	211	83.9
295.00	1	1	1	0	212	212	211	83.9
300.00	1	1	1	0	211	211	211	83.6
305.00	2	2	2	0	211	211	210	83.6
310.00	2	2	2	0	211	211	211	83.6
315.00	1	1	1	0	212	212	211	83.6
320.00	1	1	1	0	211	211	211	83.6
325.00	2	2	2	0	211	211	211	83.6
330.00	2	2	2	0	211	211	211	83.6

Figure 5.21 Motor Start Report Example (Continued)

View/Retrieve MSR Data

You can view motor start report data via QuickSet or retrieve it as a file using any of the file transfer protocols. Refer to *Meter and Control on page 3.24* for details. Motor start report data is also available in COMTRADE format as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File Transfer are enabled (E61850 := Y, EMMSFS := Y). See *File*

Transfer Protocol (FTP) and MMS File Transfer on page 7.15, *Virtual File Interface on page 7.75*, and *MMS on page G.5* for additional information.

Motor Maintenance Report

The SEL-710-5 computes and stores motor parameters and compares them to values obtained during a baseline run. If any of the values measured during a given run deviate significantly from the values measured during the baseline run, the SEL-710-5 asserts the Relay Word bit that corresponds to those values, as detailed below. The **MMR** command displays the values recorded during the baseline run and each of the subsequent runs, as shown in *Figure 5.22*.

```
=>>MMR <Enter>

SEL-710-5                                Date: 04/02/2020   Time: 17:10:26.726
MOTOR RELAY                              Time Source: External

#         DATE_STR   TIME_STR    MAX_I  MIN_V  STR_R  TTST  POSTR   DATE_STP    TIME_STP   POSTOP  RO   COASTTIME
BASELINE 04/02/2020 15:53:22.185  3.5   0.60   0.047  22.4  0.00   04/02/2020 15:54:54.803   0.10  -----    52
1        04/02/2020 17:08:37.556  3.9   0.59   0.047  26.2  0.20   04/02/2020 17:10:10.176   0.60  0.005    18
2        04/02/2020 16:06:22.311  3.7   0.59   0.047  24.2  0.10   04/02/2020 16:07:54.929   0.30  0.011    18
3        04/02/2020 16:02:09.935  3.4   0.60   0.047  22.3  0.00   04/02/2020 16:03:42.553   0.20  -----    26
=>>
```

Figure 5.22 MMR Report

The **MMR C** command clears all of the stored motor parameters computed by this function and readies the relay to compute a new set of baseline run parameters in the following start/stop cycle.

The SEL-710-5 records the maximum start current in pu of FLA and asserts the IMAX_A Relay Word bit in any start in which the maximum current is more than double the value recorded in the baseline run. In *Figure 5.23*, IMAX_0 represents the maximum current measured during the baseline run, and IMAX represents the latest IMAX measured.

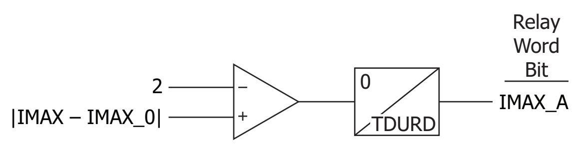


Figure 5.23 Max Starting Current Alarm

Similarly, the relay asserts the VMIN_A Relay Word bit when the minimum voltage during a start deviates by more then 0.1 pu from the value recorded in the baseline run, and the POSTRT_A Relay Word bit when the active power measured one minute after Relay Word bit RUNNING asserts deviates by more than 0.2 pu from the value recorded during the baseline run. Additionally, the SEL-710-5 records the active power immediately before a **STOP** command and asserts the POSTOP_A Relay Word bit when the active power deviates by more than 0.2 pu from the baseline run.

The SEL-710-5 tracks the time to start in seconds and asserts the TTST_A Relay Word bit when the start time deviates by more than 20 percent from the time measured in the baseline run. In *Figure 5.24*, TTST_0 represents the time to start measured during the baseline run, and TTST represents the latest TTST measured.

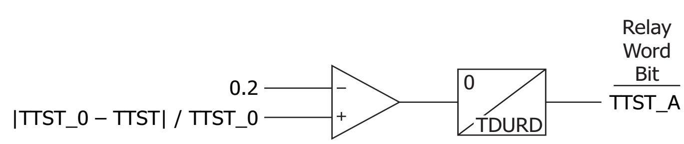


Figure 5.24 Time to Start Alarm

When connected to measure the voltages on the motor side of the contactor/breaker (residual voltages), the SEL-710-5 tracks the coast time of the relay. The spinning of the motor forces air around the motor, enhancing cooling. The thermal model accounts for this enhanced cooling while the motor is energized. To account for the extra cooling achieved while the motor is deenergized but still spinning, the relay also includes the setting COASTIME, which tells the relay that the motor takes COASTIME seconds to stop spinning after a **TRIP/CLOSE** command. The SEL-710-5 uses the frequency decay of the residual voltage for as long as two seconds after a **STOP** command to extrapolate the coast time of the motor.

The SEL-710-5 computes the locked rotor positive sequence motor resistance in pu, STR_R, and full-load rotor resistance (R0). The full-load rotor resistance is only computed when the residual voltages are available and the power before stop exceeds 0.2 pu.

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-710-5 retains useful machine operating statistics information for the protected motor. Use the **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., **MOTOR R** command), SELOGIC setting RSTMOT, or the front-panel MONITOR menu. The Motor Start Reports are also reset when the Motor Statistics Data are reset. Items included in the report are shown in *Figure 5.25*.

MOT data is also available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File Transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.75*, and *MMS on page G.5* for additional information.

NOTE: The > character in the MOT report indicates the current state of the system.

```
=>>MOT <Enter>

SEL-710-5                                 Date: 05/16/2013   Time: 13:59:27.753
MOTOR RELAY                               Time Source: Internal

Operating History (elapsed time in ddd:hh:mm)
Last Reset Date    04/25/2013
Last Reset Time      11:18:22
Running Time      >  10:10:27
Stopped Time          9:16:25
Time Running (%)         51.9
Total MWhr (MWhr)         0.0
Number of Starts           28
Emergency Starts            0
Avg/Peak Data
                 AVERAGE     PEAK
Start Time (s)       0.2      1.0
Max Start I (A)     63.4    137.0
Min Start V (V)      0.0      0.0
Start %TCU           0.1      0.7
Running %TCU         0.3      5.1
RTD %TCU             0.0      0.0
Running Cur (A)     25.5     82.5
Running kW           0.0      0.3
Running kVARin       0.0      0.0
Running kVARout      0.0      3.8
Running kVA          0.0      6.4
Max WDG RTD (C)        6      240
Max BRG RTD (C)       NA       NA
Ambient RTD (C)       NA       NA
Max OTH RTD (C)       NA       NA
```

Figure 5.25 MOTOR Command Example

NOTE: The relay records motor operating statistics to nonvolatile memory every six hours. If the power is removed from the relay, the relay loses the information collected between the last save and the time of the power removal.

NOTE: Trip data in the motor operating statistics are supervised by the TR equation.

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

Trip/Alarm Data
                 ALARMS  TRIPS
Overload              0      0
Locked Rotor          2      1
Undercurrent          0      0
Jam                   0      0
Current Imbal       195      7
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                   4      4
Phase Reversal               0
Arc Flash Trip               0
Broken Rotor Bar      0
87M Phase Diff               0
Underfrequency               0
Overfrequency                0
Start Timer                  0
Remote Trip                  0
Other Trips                358
Total               201    370

=>>
```

Figure 5.25 MOTOR Command Example (Continued)

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 5.18*) 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

View the motor start trending data using the serial port **MST** command. *Figure 5.26* shows data from an example Motor Start Trend Report.

MST data is also available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File Transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.75*, and *MMS on page G.5* for additional information.

```
=>MST <Enter>

SEL-710-5                                 Date: 07/17/2013   Time: 09:31:49.029
MOTOR RELAY                               Time Source: Internal

           Began      Number    Start     Start       Max       Min
Record      on          of      Time      %TCU      Start I   Start V
Number     Date       Starts     (s)                  (A)       (V)
   1     06/30/2013        0     ---       ---        ---       ---
   2     05/31/2013        4     14.3      216          48       103
   3     05/01/2013        3     12.3       96          38       116
   4        ---         ---      ---       ---        ---       ---
   5        ---         ---      ---       ---        ---       ---
   6        ---         ---      ---       ---        ---       ---
   7        ---         ---      ---       ---        ---       ---
   8        ---         ---      ---       ---        ---       ---
   9        ---         ---      ---       ---        ---       ---
  10        ---         ---      ---       ---        ---       ---
  11        ---         ---      ---       ---        ---       ---
  12        ---         ---      ---       ---        ---       ---
  13        ---         ---      ---       ---        ---       ---
  14        ---         ---      ---       ---        ---       ---
  15        ---         ---      ---       ---        ---       ---
  16        ---         ---      ---       ---        ---       ---
  17        ---         ---      ---       ---        ---       ---
  18        ---         ---      ---       ---        ---       ---
=>
```

Figure 5.26 Motor Start Trending Report Example

Load Profiling

The SEL-710-5 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 4.164*). Choose which analog quantities you want to monitor from the analog quantities listed in *Appendix M: Analog Quantities*. Set these quantities into the LDLIST load profile list report setting.

The relay memory can hold data for as many as 6500 time-stamped entries, depending on the LDP acquisition rate. For example, if you chose to monitor 10 values at a rate of every 15 minutes, you could store 67 days worth of data.

Download the load rate profile data using the **LDP** command described in *LDP Command (Load Profile Report) on page 7.56*. *Figure 5.27* shows an example **LDP** command response. LDP data is also available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File Transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.75*, and *MMS on page G.5* for additional information.

```
=>>LDP <Enter>

SEL-710-5                                 Date: 05/29/2013   Time: 10:33:35.893
SYNCHRONOUS MTR                           Time Source: Internal

#     DATE         TIME        FREQ        IAV
8  05/29/2013  09:58:09.262     60.000      0.000
7  05/29/2013  10:03:09.230     60.000      0.000
6  05/29/2013  10:08:09.203     60.000      0.000
5  05/29/2013  10:13:09.191     59.987    100.691
4  05/29/2013  10:18:09.225     59.990    100.650
3  05/29/2013  10:23:09.183     59.989    100.714
2  05/29/2013  10:28:09.214     59.988    100.620
1  05/29/2013  10:33:09.209     59.992    100.699

=>>
```

Figure 5.27 LDP Command Response

Incipient Cable Fault Detection

The incipient cable fault element is used to detect self-clearing half- to one cycle overcurrent events. This type of event is most common in cable splices and is indicative of an impending fault. As the frequency of the events increases, the likelihood of a permanent fault increases, and preventative maintenance should be scheduled. See *Incipient Cable Fault on page 4.32* for more details.

Molded Case Circuit Breaker Health

On detecting severe CT saturation (through the distortion indices DI_*n*, where *n* = A, B, or C) or if the maximum measured phase current (raw samples) exceeds the A-D saturation limit (measuring limit) of the relay, along with opening the breaker to clear that high current, Relay Word bit IBRK asserts and flags the operator to inspect the molded case circuit breaker for damage. Because IBRK asserts momentarily, you may program this bit in a latch control switch (SET*n*) and use the latch bit to assert a continuous alarm until it is reset by the user. *Figure 5.28* provides the logic for IBRK assertion.

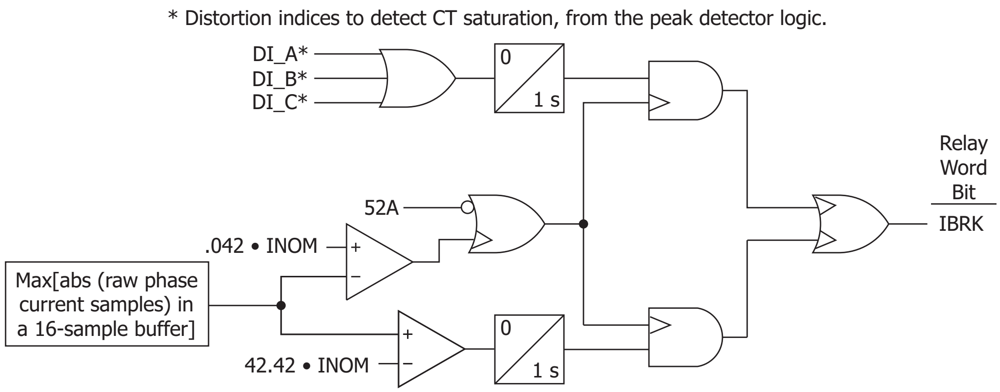


Figure 5.28 IBRK Assertion Logic

Breaker Monitoring

The breaker monitor in the SEL-710-5 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 7.36* and *BRE W or R Command (Preload/Reset Breaker Wear) on page 7.36*.

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 5.29*.

Table 5.6 Breaker Maintenance Information for a 25 kV Circuit Breaker (Sheet 1 of 2)

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

Table 5.6 Breaker Maintenance Information for a 25 kV Circuit Breaker (Sheet 2 of 2)

Current Interruption Level (kA)	Permissible Number of Close/Open Operations[a]
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 5.29* for a breaker maintenance curve. To estimate this breaker maintenance curve in the SEL-710-5 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[e]
kA PRI INTERRPTD 3	0.10–999.00 kA	KASP3 := 20.00[f]
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] KASP2 must be set less than or equal to KASP3.
[f] 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 5.29*. *Figure 5.30* shows the resultant breaker maintenance curve.

COSP1 = **10000**	KASP1 = **1.20**
COSP2 = **150**	KASP2 = **8.00**
COSP3 = **12**	KASP3 = **20.00**

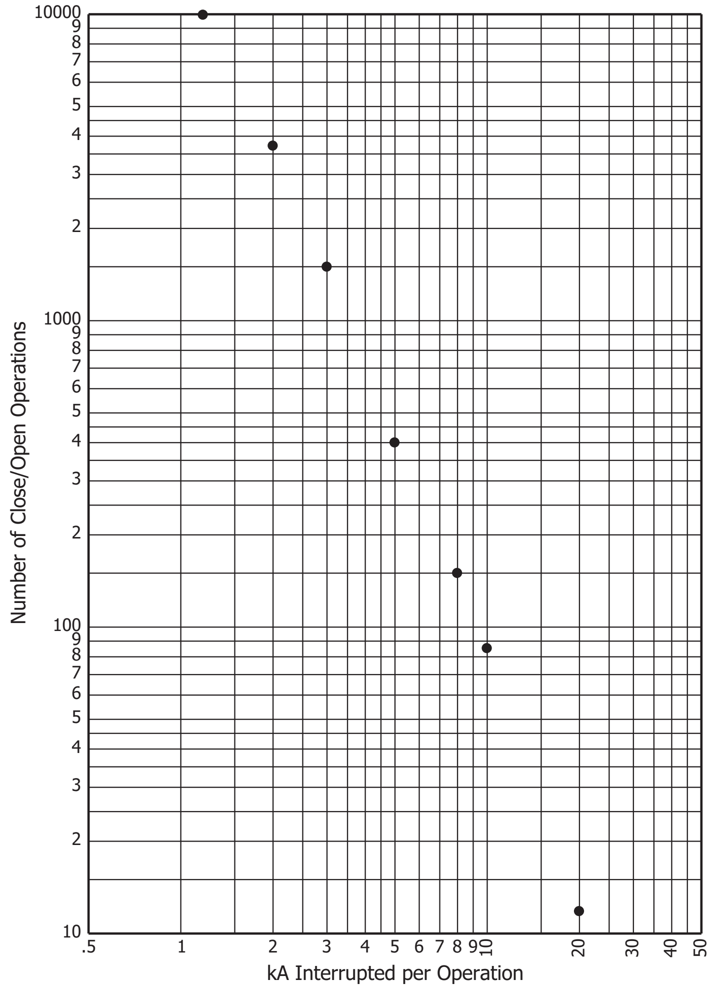


Figure 5.29 Plotted Breaker Maintenance Points for a 25 kV Circuit Breaker

Breaker Maintenance Curve Details

In *Figure 5.30*, 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 5.29*.

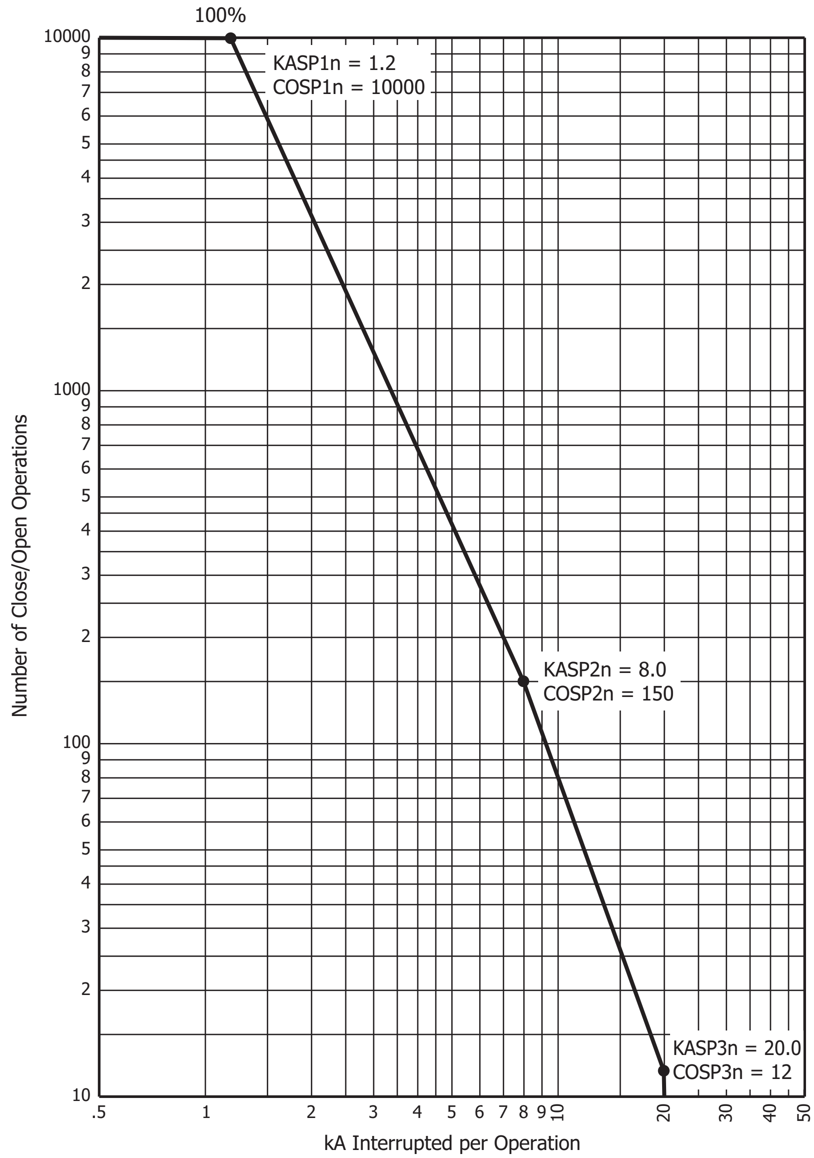


Figure 5.30 SEL-710-5 Breaker Maintenance Curve for a 25 kV Circuit Breaker

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 5.29*, 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 5.29*.

Each phase (A, B, and C) has its own breaker maintenance curve (like that in *Figure 5.30*), 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 5.30*, 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 5.30*) and the breaker monitor accumulated currents/trips (see *BRE Command (Breaker Monitor Data) on page 7.36*).

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 4.40*)

Refer to *Figure 5.31*. 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 5.31*, 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 increasing 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.

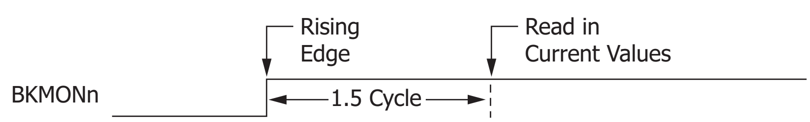


Figure 5.31 Operation of SELOGIC Control Equation Breaker Monitor Initiation Setting

See *Figure 5.36* 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 5.32–Figure 5.35*. 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 5.32–Figure 5.35*) that the interrupted current in a given figure is the same magnitude for all the interruptions (e.g., in *Figure 5.33*, 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 5.32*. The 7.0 kA value 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.

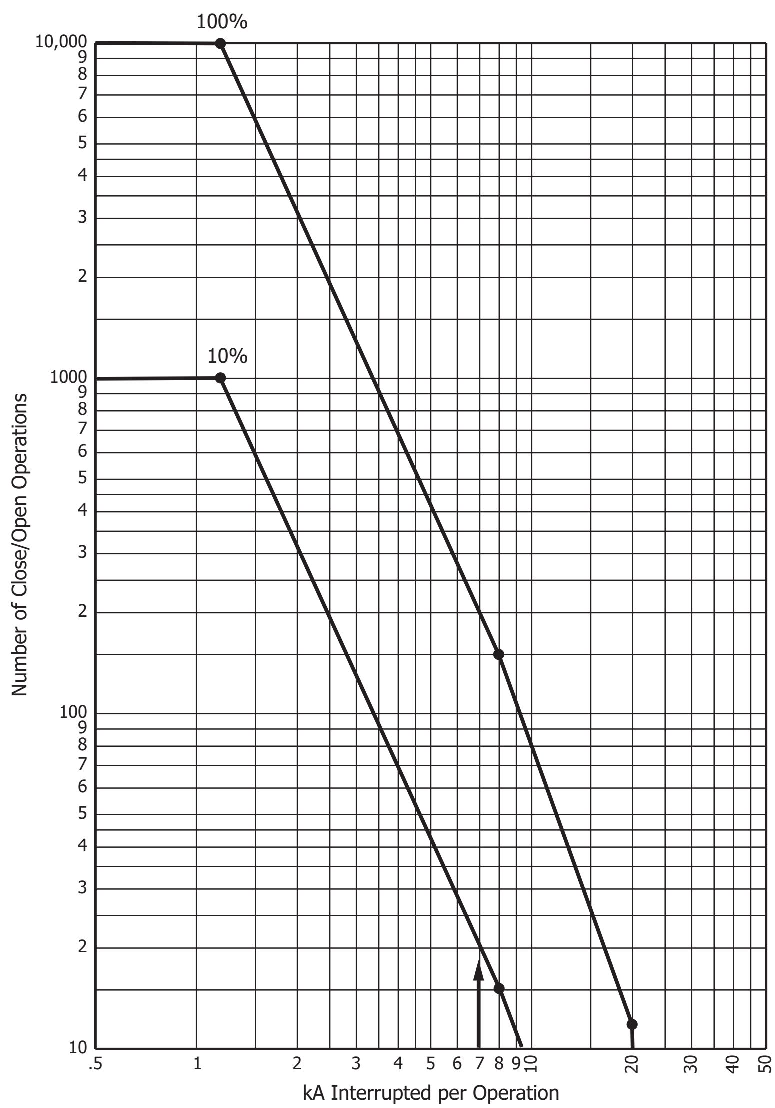


Figure 5.32 Breaker Monitor Accumulates 10 Percent Wear

10 Percent to 25 Percent Breaker Wear

Refer to *Figure 5.33*. The current value changes from 7.0 kA to 2.5 kA. The 2.5 kA value 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.

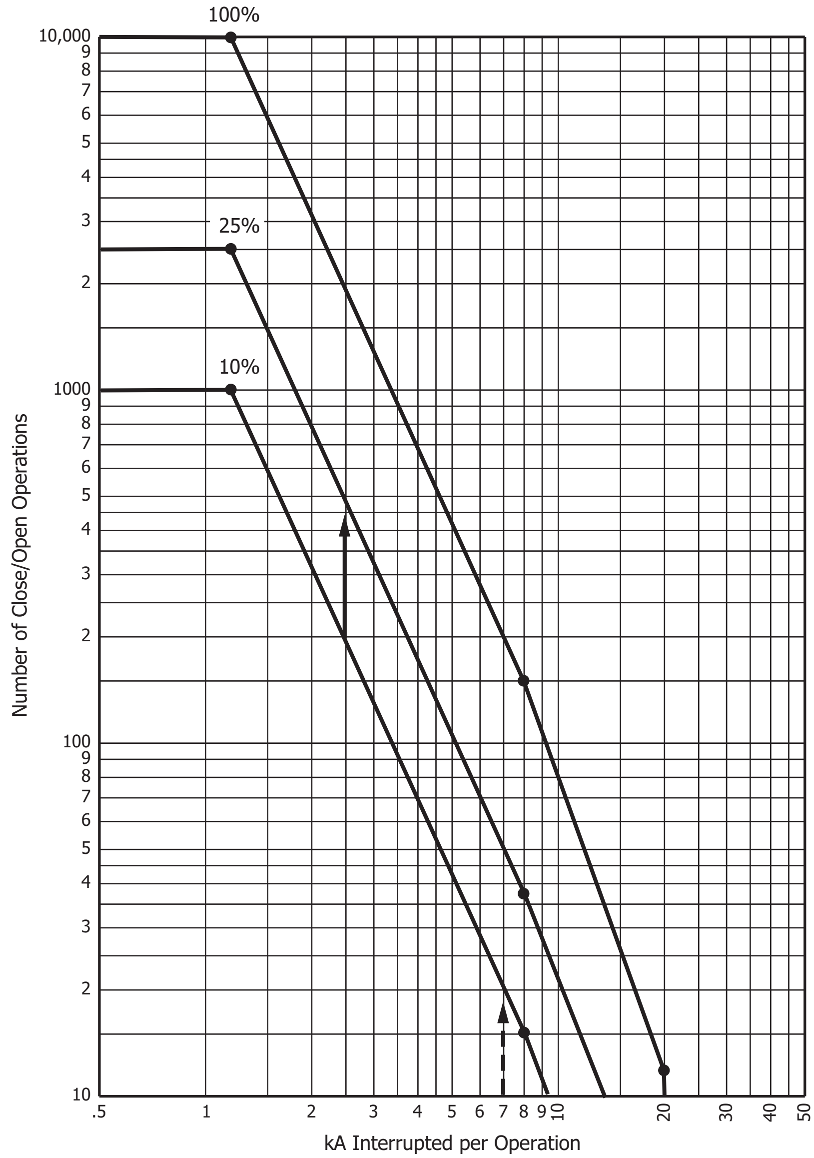


Figure 5.33 Breaker Monitor Accumulates 25 Percent Wear

25 Percent to 50 Percent Breaker Wear

Refer to *Figure 5.34*. The current value changes from 2.5 kA to 12.0 kA. The12.0 kA value 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.

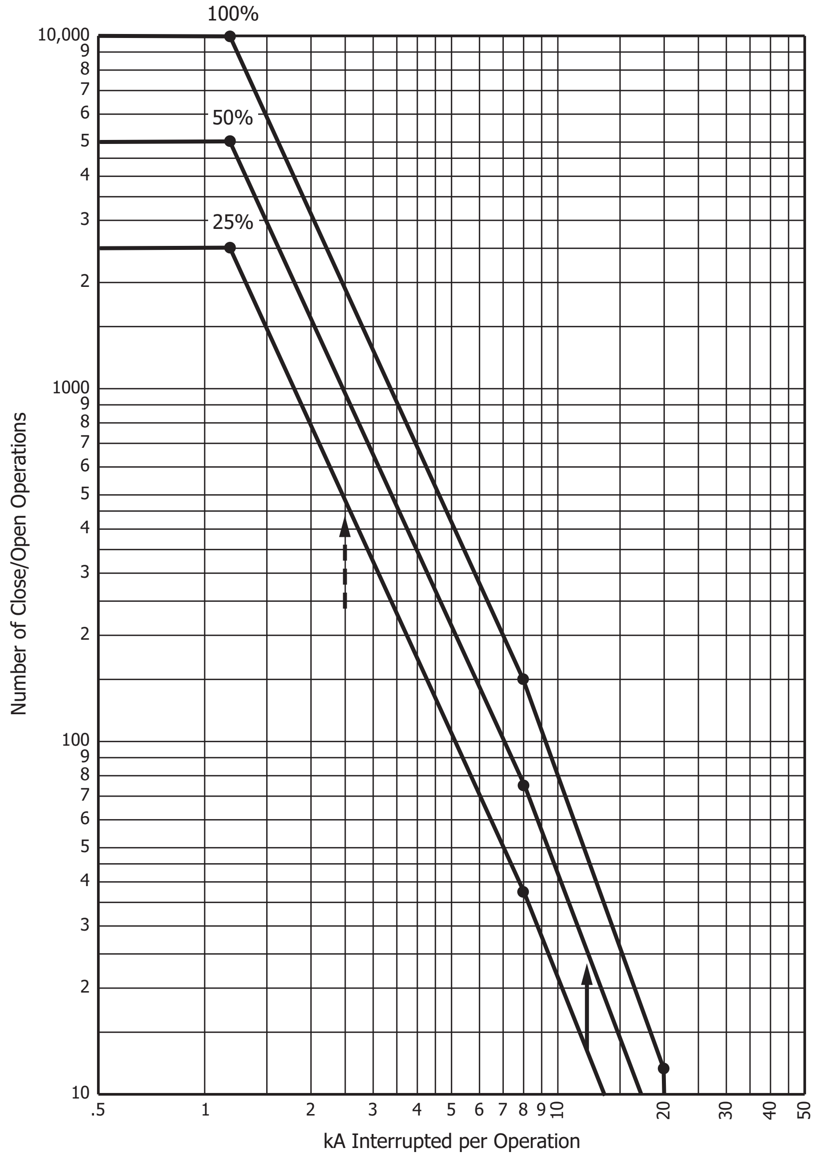


Figure 5.34 Breaker Monitor Accumulates 50 Percent Wear

50 Percent to 100 Percent Breaker Wear

Refer to *Figure 5.35*. The current value changes from 12.0 kA to 1.5 kA. The 1.5 kA value 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 5.33*). 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.

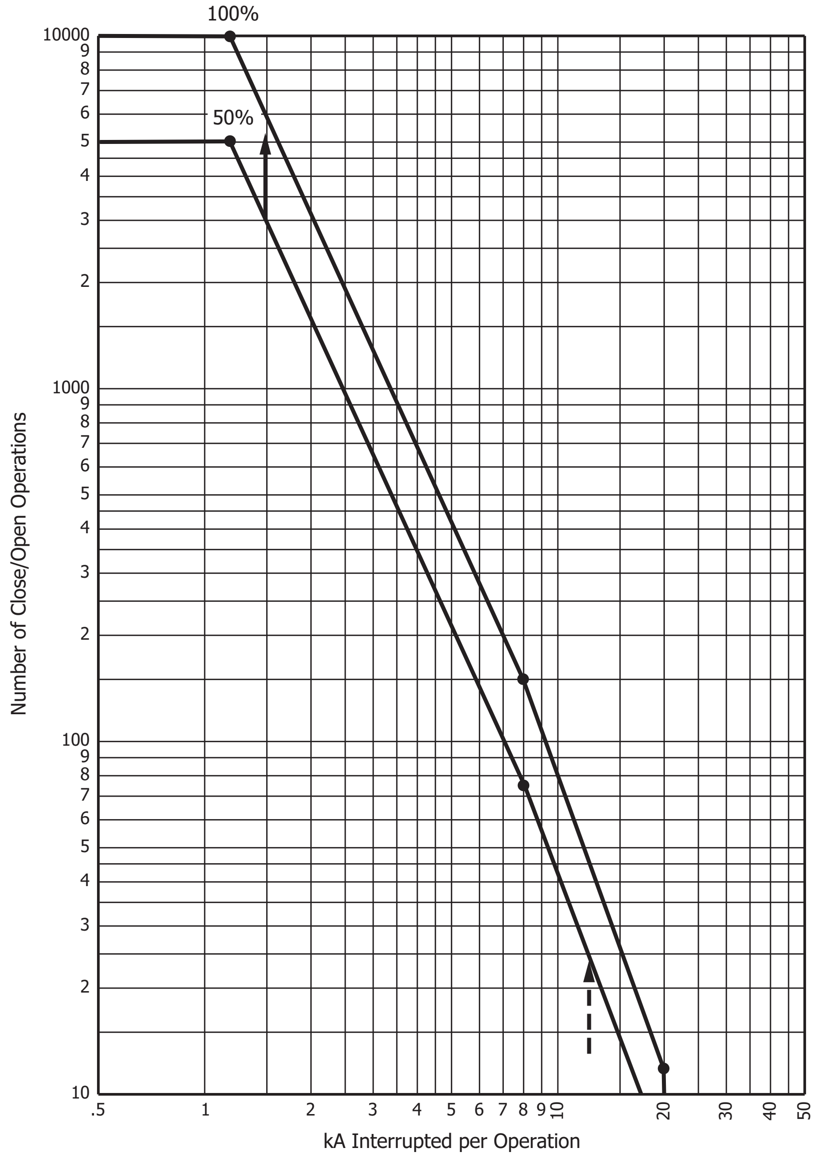


Figure 5.35 Breaker Monitor Accumulates 100 Percent Wear

Breaker Monitor Output

When the breaker maintenance curve for a particular phase (A, B, or C) reaches the 100 percent wear level (see *Figure 5.35*), a corresponding Relay Word bit (BCWA, BCWB, or BCWC) asserts.

Relay Word Bits	Definition
BCWA	A-phase breaker contact wear has reached the 100 percent wear level
BCWB	B-phase breaker contact wear has reached the 100 percent wear level
BCWC	C-phase 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.

Breaker wear data is also available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File Transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.75*, and *MMS on page G.5* for additional information.

Determination of Relay-Initiated Trips and Externally Initiated Trips

See *Section 7: Communications*. Note in the **BRE** *n* command response that the accumulated number of trips and accumulated interrupted current are separated into two groups of data: those generated by relay-initiated trips (Rly Trips), and those generated by externally initiated trips (Ext Trips). The categorization of these data is determined by the status of the TRIP*n* Relay Word bit when the SELOGIC control equation breaker monitor initiation setting BKMON*n* operates.

Refer to *Figure 5.31* and accompanying explanation. If BKMON*n* newly asserts (logical 0 to logical 1 transition), the relay reads in the current values (Phases A, B, and C). Now, the relay must determine whether to accumulate this current and trip count information under relay-initiated trips or externally initiated trips.

To make this determination, the relay checks the status of the TRIP*n* Relay Word bit at the instant BKMON*n* newly asserts (TRIP*n* is the logic output of *Figure 4.40*). If TRIP*n* is asserted (TRIP*n* = logical 1), the current and trip count information is accumulated under relay-initiated trips (Rly Trips). If TRIP*n* is deasserted (TRIP*n* = 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 5.31–Figure 5.35*).

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 is deemed to be 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 5.36. 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.

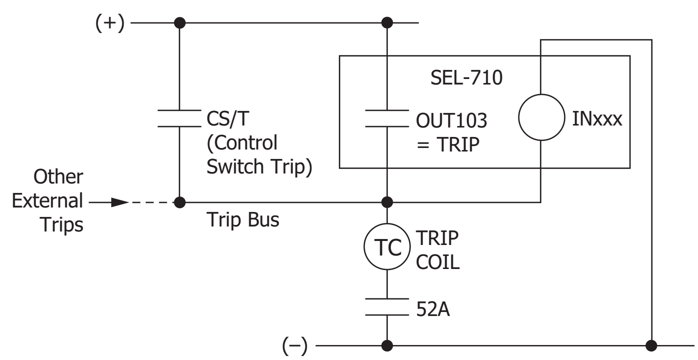


Figure 5.36 Input INxxx Connected to Trip Bus for Breaker Monitor Initiation

If the SELOGIC control equation breaker monitor initiation setting is set:

BKMON = **INxxx**

then the SEL-710-5 breaker monitor sees all trips.

If output contact **OUT103** asserts, energizing the trip bus, the breaker monitor deems 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 deems 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-710-5 Motor Protection Relay stores the settings you enter in nonvolatile memory. Settings are divided into the following 11 settings classes:

1. Group *n* (*n* = 1, 2, 3, or 4)
2. Logic Group *n* (*n* = 1, 2, 3, or 4)
3. Global
4. Port *p* (where *p* = F, 1 [Ethernet], 2, 3, or 4)
5. Front Panel
6. EtherNet/IP
7. Report
8. Modbus
9. DNP3
10. IEC 60870-5-103
11. Touchscreen (this setting class is only available for models with the color touchscreen display)

IMPORTANT: Upon relay initial turn on or Port 1 setting changes or Logic setting changes, you may have to wait as long as two minutes before an additional setting change can occur. Note that the relay is functional with protection enabled as soon as the **ENABLED** LED comes on (about 5–10 seconds from turn on).

Some settings classes have multiple instances. In the previous list, there are five port setting instances, one for each port. Settings can be viewed or set in several ways, as shown in *Table 6.1*.

Table 6.1 Methods of Accessing Settings[a]

	Web Server[b]	Serial Port Commands[c]	Front-Panel HMI Set/Show Menu[d]	ACSELERATOR QuickSet SEL-5030 Software[b]
Display Settings	All settings	All settings (**SHO** command)	Global, Group, and Port settings	All settings
Change Settings	Not available	All settings (**SET** command)	Global, Group, and Port settings	All settings

[a] These settings access methods do not apply to the touchscreen settings.
[b] Refer to Section 3: PC Interface for detailed information.
[c] Refer to Section 7: Communications for detailed information on set up and use of the serial communications port and Ethernet port.
[d] Refer to Section 8: Front-Panel Operations for detailed information on the front-panel layout, menus and screens, and operator control pushbuttons.

Setting entry error messages, together with corrective actions, are also presented in this section to assist in correct settings entry.

The *SEL-710-5 Settings Sheets* at the end of this section list all SEL-710-5 settings, the setting definitions, and input ranges. Refer to *Section 4: Protection and Logic Functions* for detailed information on individual elements and settings.

Touchscreen settings are only available through QuickSet for models with the color touchscreen display. These settings are not available via the ASCII terminal, unlike the other relay settings. Refer to *Section 9: Bay Control* for detailed information on individual settings.

View/Change Settings With the Two-Line Front Panel

You can use the pushbuttons on the front panel to view/change settings. See *Section 8: Front-Panel Operations* for the details on front-panel operation.

Enter the front-panel menu by pushing the **ESC** pushbutton. The following message appears:

```
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 pressing the **ENT** pushbutton. The display shows the following message:

```
SET/SHOW
Global
```

Enter the underlined `RELAY` message with the **ENT** pushbutton, and the relay presents you with the `RELAY` settings as listed in the *SEL-710-5 Settings Sheets*. Use the **Up Arrow**, **Down Arrow**, **Left Arrow**, and **Right Arrow** pushbuttons to scroll through the relay settings. View and change the settings according to your needs by selecting and editing them. After viewing or changing the `RELAY` settings, press the **ESC** pushbutton until the following message appears:

NOTE: Each SEL-710-5 is shipped with factory-default settings. Calculate the settings for your motor to ensure secure and dependable protection. Document the settings on the SEL-710-5 Settings Sheets at the end of this section before entering new settings in the relay.

```
Save Changes?
Yes   No
```

Select and enter the appropriate command by pressing 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.

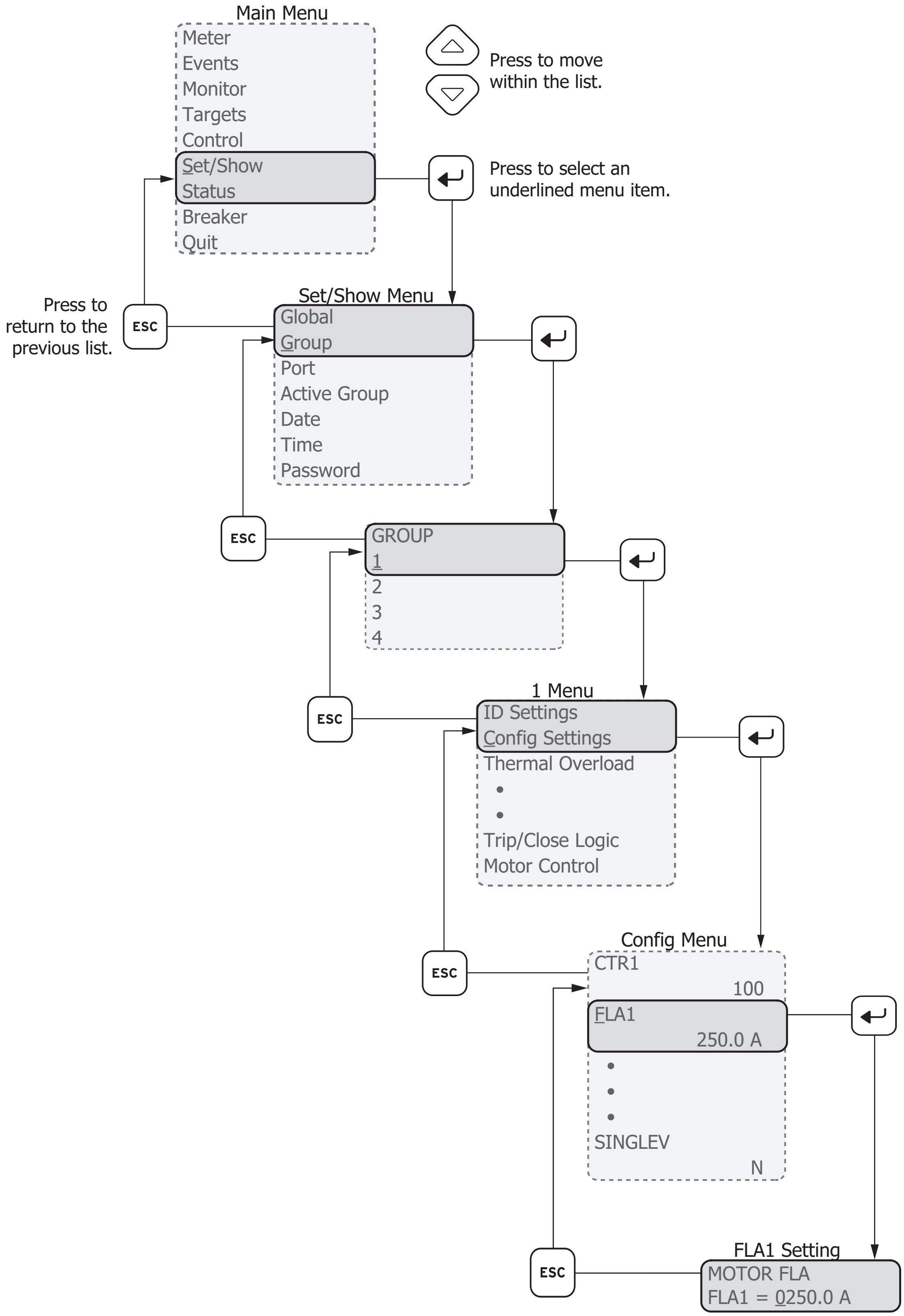


Figure 6.1 Front-Panel Setting Entry Example

View/Change Settings With the Touchscreen Front Panel

You can view or change Port, Global, Group, Date and Time, and Touchscreen settings by using the touchscreen display. Tapping the **Settings** folder on the **Home** screen navigates you to the **Settings** screen through which you can view or change settings. Refer to *Touchscreen Display Front Panel on page 8.20* for detailed information on how to view or change settings by using the touchscreen display.

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 via a personal computer and how to use ASCII commands to communicate with the relay.

View Settings

Use the **SHO** command to view relay settings. The **SHO** command is available from Access Level 1 and Access Level 2. *Table 6.2* lists the **SHO** command options.

Table 6.2 SHO Command Options

Command	Description
SHO *n*	Shows relay group settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to active settings group if not listed.
SHO L *n*	Shows logic settings: *n* specifies the settings group (1, 2, 3, or 4); *n* defaults to active settings group if not listed.
SHO G	Shows global configuration settings
SHO P *n*	Shows serial port settings for Port *n* (*n* = F, 1, 2, 3, or 4)
SHO F	Shows front-panel display and LED settings
SHO E	Show EtherNet/IP assembly map settings
SHO R	Shows Sequential Event Report (SER) and event report settings
SHO M	Shows Modbus map settings
SHO D	Shows DNP3 map settings
SHO I	Shows IEC 60870-5-103 map settings

You can append a setting name to each of the commands to specify the first setting to display (e.g., **SHO 50P1P** displays the relay settings starting with setting **50P1P**). The default is the first setting. The **SHO** command displays only the enabled settings.

Enter Settings

The **SET** command (available from Access Level 2) allows you to view or change settings. *Table 6.3* lists the **SET** command options.

NOTE: The **SET** command is not available for as long as 90 seconds after the relay is powered up and as long as 40 seconds after a settings 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 (Sheet 1 of 2)

Command	Settings Type	Description
SET *n*	Group	Protection elements, timers, etc., for settings Group *n* (1, 2, 3, or 4)
SET L *n*	Logic	SELOGIC control equations for settings Group *n* (1, 2, 3, or 4)
SET G	Global	Global configuration settings

Table 6.3 SET Command Options (Sheet 2 of 2)

Command	Settings Type	Description
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 E	EtherNet/IP	EtherNet/IP assembly map settings
SET R	Reports	SER and Event Report settings
SET M	Modbus	Modbus user map
SET D	DNP3	DNP3 map settings
SET I	IEC 60870-5-103	IEC 60870-5-103 user map settings

You can append a setting name to each of the commands to specify the first setting to display (e.g., **SET 50P1P** displays the relay settings starting with setting 50P1P). The default is the first setting.

When you issue the **SET** command, the relay presents a list of settings one at a time. Enter a new setting or press **<Enter>** to accept the existing setting. Editing keystrokes are listed in *Table 6.4*.

Table 6.4 SET Command Editing Keystrokes

Press Key(s)	Results
<Enter>	Retains the setting and moves to the next setting.
^ <Enter>	Returns to the previous setting.
< <Enter>	Returns to the previous setting category.
> <Enter>	Moves to the next setting category.
END <Enter>	Exits the editing session, then prompts you to save the settings.
<Ctrl+X>	Aborts the editing session without saving changes.

The relay checks each entry to ensure that the entry is within the setting range. If it is not in range, an `Out of Range` message is generated, and the relay prompts you for the setting again.

When all the settings are entered, the relay displays the new settings and prompts you for approval to enable them. Press **Y <Enter>** to enable the new settings. The relay is disabled for as long as five seconds while it saves the new settings. The SALARM Relay Word bit is set momentarily, and in the two-line display model, the **ENABLED** LED extinguishes while the relay is disabled. In the touchscreen display model, the **ENABLED** LED stays illuminated while the relay saves the setting.

To change a specific setting, enter the command shown in *Table 6.5*.

Table 6.5 SET Command Format (Sheet 1 of 2)

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 1, 2, 3, or 4 when *n* = G or L for group settings; *m* defaults to 1 if the parameter is left blank.
	is F, 1, 2, 3, or 4 when *n* = P for port settings; *m* defaults to the active port if the parameter is left blank.

Table 6.5 SET Command Format (Sheet 2 of 2)

SET n m s TERSE	
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 (Sheet 1 of 2)

Error Message	Setting/Function	Correct the Condition
`50PmP • FLAn/CTRn must be greater than or equal to 0.50 Amp` (*m* = 1 or 2, *n* = 1 or 2)	Phase Overcurrent and Main Settings	Modify the 50P*m*P (or FLA*n*/CTR*n*) to satisfy: 50P*m*P • (FLA*n*/CTR*n*) ≥ 0.5
`50PmP • FLAn/CTRn must be greater than or equal to 0.10 Amp` (*m* = 1 or 2, *n* = 1 or 2)	Phase Overcurrent and Main Settings	Modify the 50P*m*P (or FLA*n*/CTR*n*) to satisfy: 50P*m*P • (FLA*n*/CTR*n*) ≥ 0.1
`50NnP must be within (0.050 • CTRN) xx.xx and (10.0 • CTRN) yy.yy` (*n* = 1 or 2)	Neutral Overcurrent	Modify the 50N*n*P (or CTR*n*) setting to satisfy the requirement shown in the error message.
`50NnP must be within (0.010 • CTRN) xx.xx and (2.0 • CTRN) yy.yy` (*n* = 1 or 2)	Neutral Overcurrent	Modify the 50N*n*P (or 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.
`50NnP must be within (0.000125 • CTRN) xx.xx and (0.0125 • CTRN) yy.yy` (*n* = 1 or 2)	Neutral Overcurrent	Modify the 50N*n*P (or CTR*n*) setting to satisfy the requirement shown in the error message.
`CTRn,FLAn 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

Table 6.6 Setting Interdependency Error Messages (Sheet 2 of 2)

Error Message	Setting/Function	Correct the Condition
`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: $100 \le (VNOM/PTR) \le 250$ for DELTA_Y := DELTA; $100 \le (VNOM/PTR) \le 440$ for DELTA_Y := WYE

View Settings Using the Web Server

Refer to *Section 3: PC Interface* for information on how to set up communication and how to access the relay on an Ethernet port with a personal computer.

View Settings

Once communication with the relay is established through the web server, the home page screen appears in your browser window. Click on **Settings** from the navigation pane to view all the available settings classes, as shown in *Figure 6.2*. Access Level 1 and Access Level 2 are both view only. At this level, settings are dimmed and you cannot modify them. Click on a settings class to view its settings.

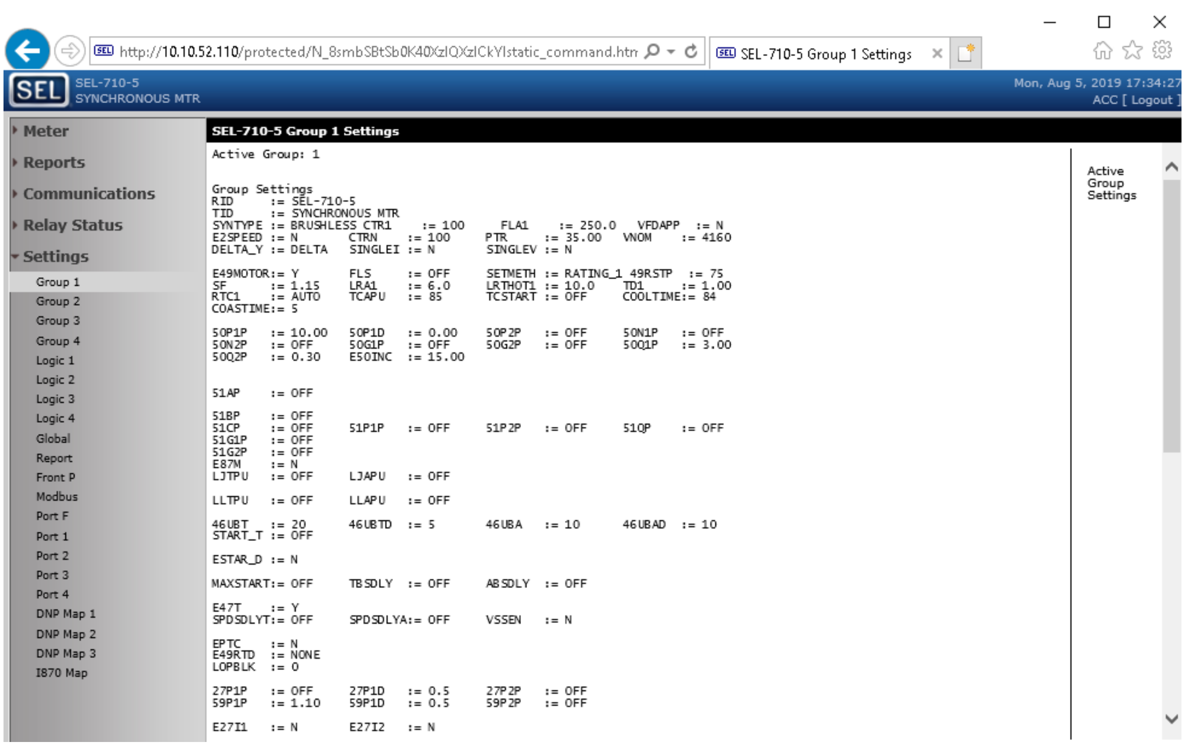


Figure 6.2 Web Server Settings Screen

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SEL-710-5 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 communications ports. See *Section 4: Protection and Logic Functions* in the instruction manual for detailed descriptions of the settings.

- Some settings require an optional module. Refer to the SEL-710-5 Model Option Table and the notes with the following settings for details on which settings are available in a specific model. ACSELERATOR QuickSet SEL-5030 Software, which shows and hides settings depending on the MOT part number selected, is the best way to view the settings available in a specific model. Some of the settings ranges can be more restrictive than shown because of settings interdependency checks performed when new settings are saved.
- 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

SYN MOTOR TYPE (BRUSH, BRUSHLESS, NONE) *(SYNTYPE forced to NONE and hidden when Slot E ≠ 75)*	**SYNTYPE :=** ________
PHASE CT RATIO (1–5000) *(CTR1 forced to ILEA_SC1 and hidden when Slot Z = L1)*	**CTR1 :=** ________
CURR SENSOR TYPE (RCOIL, LPCT) *(Shown if Slot Z = L1)*	**CS_TYPE1 :=** ________
RATED PRI CURR (1–6000 A pri) *(Shown if Slot Z = L1)*	**IPR1 :=** ________
RATED SENS VOLT (10.0–1000.0 mV at FNOM {if CS_TYPE1 = RCOIL}, 10.0–1000.0 mV {if CS_TYPE1 = LPCT}) *(Shown if Slot Z = L1)*	**USR1 :=** ________
NOMINAL CURRENT (1 A) *(Shown if Slot Z = L1. This setting is not user-settable.)*	**INOM :=** ________
RATED FEEDER CUR (1–6000 A pri) *(Shown if Slot Z = L1)*	**FDR_CUR1 :=** ________
PHASE ILEA SCALE (1.00–6000.00 [auto-calculated]) *(Shown if Slot Z = L1)*	**ILEA_SC1 :=** ________
MOTOR FLA (0.2–5000.0 A)	**FLA1 :=** ________
VFD APPLICATION (Y, N)	**VFDAPP :=** ________
LOAD @ ZEROSPEED (0.2–5000.0 A) *(Shown when VFDAPP:= Y)*	**LOAD_ZS :=** ________
MNFREQ @ FULLOAD (10.00–70.00 Hz) *(Shown when VFDAPP:= Y)*	**FREQ_FL :=** ________
TWO SPEED ENABLE (Y, N) *(E2SPEED forced to N and hidden when VFDAPP:= Y)*	**E2SPEED :=** ________

CT RATIO–2ND (1–5000) *(Hidden when E2SPEED := N; CTR2 forced to ILEA_SC1 and hidden when Slot Z = L1)*	**CTR2 :=** ________
MOTOR FLA–2ND (0.2–5000.0 A) *(Hidden when E2SPEED := N; FLA2 forced to FLA1 and hidden when Slot Z = L1)*	**FLA2 :=** ________
FVR PHASING (NONE, A, B, C) *(Hidden when E2SPEED := N)*	**FVR_PH :=** ________
NEUTRAL CT RATIO (1–2000)	**CTRN :=** ________
CURR SENSOR TYPE (RCOIL, LPCT) *(Shown if Slot Z = L1)*	**CS_TYPEN :=** ________
RATED PRI CURR (1–6000 A pri) *(Shown if Slot Z = L1)*	**IPRN :=** ________
RATED SENS VOLT (10.0–1000.0 mV at FNOM {if CS_TYPEN = RCOIL}, 10.0–1000.0 mV {if CS_TYPEN = LPCT}) *(Shown if Slot Z = L1)*	**USRN :=** ________
NOMINAL CURRENT (1 A) *(Shown if Slot Z = L1. This setting is not user-settable.)*	**INOMN :=** ________
RATED FEEDER CUR (1–6000 A pri) *(Shown if Slot Z = L1)*	**FDR_CURN :=** ________
PHASE ILEA SCALE (1.00–6000.00 [auto-calculated]) *(Shown if Slot Z = L1)*	**ILEA_SCN :=** ________
PHASE PT RATIO (1.00–250.00)	**PTR :=** ________
LINE VOLTAGE (100–30000 V)	**VNOM :=** ________
XFMR CONNECTION (DELTA, WYE)	**DELTA_Y :=** ________
SINGLE I INPUT (N, IA, IB, IC)	**SINGLEI :=** ________
SINGLE V INPUT (Y, N)	**SINGLEV :=** ________

Thermal Overload

OVERLOAD ENABLE (Y, N)	**E49MOTOR :=** ________
(All of the following thermal overload settings are hidden when E49MOTOR := N)	
FULL LOAD SLIP (OFF, 0.0010–0.1000 pu) *(Forced to OFF and hidden when any of the following apply: E2SPEED := Y; ESTAR_D := Y; or VFDAPP := Y)*	**FLS :=** ________
SLIP SOURCE (VDR, STAT, R1) *(Forced to R1 and hidden when E2SPEED := Y, ESTAR_D := Y, or VFDAPP := Y; Hidden when no synchronous motor card is available; Hidden when FLS := OFF; VDR hidden from range when SYNTYPE := BRUSHLESS)*	**SLIPSRC :=** ________
LOCKD RTR TORQUE (0.30–2.00 pu) *(Hidden when FLS := OFF)*	**LRQ :=** ________
THERMAL METHOD (RATING, RATING_1, CURVE) *(CURVE and RATING hidden when 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) *(Forced to 6 and hidden when SETMETH := CURVE)*	**LRA1 :=** ________
LOCKD RTR TIME 1 (1.0–600.0 sec) *(Hidden when SETMETH := CURVE)*	**LRTHOT1 :=** ________
ACCEL FACTOR (0.10–1.50) *(Hidden when SETMETH := CURVE or when 0.001 ≤ FLS ≤ 0.10; forced to 1.00 when 1 ≤ CURVE1 ≤ 45 or when 0.001 ≤ FLS ≤ 0.10)*	**TD1 :=** ________

STATOR TC (AUTO, 1–2000 min) *(Hidden when SETMETH := CURVE)*	**RTC1 :=** ______________
MOTOR LRA–2ND (2.5–12.0 xFLA) *(Hidden when E2SPEED := N; forced to 6 and hidden when SETMETH := CURVE; LRA2 forced to LRA1 and hidden when Slot Z = L1)*	**LRA2 :=** ______________
LOCKD RTR TIME 2 (1.0–600.0 sec) *(Hidden when E2SPEED := N; hidden when SETMETH := CURVE; LRTHOT2 forced to LRTHOT1 and hidden when Slot Z = L1)*	**LRTHOT2 :=** ______________
ACCEL FACT–2ND (0.10–1.50) *(Hidden when E2SPEED := N; hidden and forced to 1.00 when SETMETH := CURVE; TD2 forced to TD1 and hidden when Slot Z = L1)*	**TD2 :=** ______________
STATOR TC–2ND (AUTO, 1–2000 min) *(Hidden when E2SPEED := N; hidden when SETMETH := CURVE; RTC2 forced to RTC1 and hidden when Slot Z = L1)*	**RTC2 :=** ______________
THERM OL CURVE1 (1–46 if Slot Z ≠ L1, 1–45 if Slot Z = L1) *(Hidden when SETMETH := RATING or RATING_1)*	**CURVE1 :=** ______________
TRIP TIME @ 1.05FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1; hidden and not used when SF ≥ 1.05)*	**TTT105 :=** ______________
TRIP TIME @ 1.10FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1; hidden and not used when SF ≥ 1.10)*	**TTT110 :=** ______________
TRIP TIME @ 1.20FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE := 1–45 or SETMETH := RATING or RATING_1; hidden and not used when SF ≥ 1.20)*	**TTT120 :=** ______________
TRIP TIME @ 1.30FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1; hidden and not used when SF ≥ 1.30)*	**TTT130 :=** ______________
TRIP TIME @ 1.40FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1; hidden and not used when SF ≥ 1.40)*	**TTT140 :=** ______________
TRIP TIME @ 1.50FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1; hidden and not used when SF := 1.50)*	**TTT150 :=** ______________
TRIP TIME @ 1.75FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT175 :=** ______________
TRIP TIME @ 2.00FL (1.0–6000.0 sec) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT200 :=** ______________
TRIP TIME @ 2.25FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT225 :=** ______________
TRIP TIME @ 2.50FL (1.0–6000.0 sec) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT250 :=** ______________
TRIP TIME @ 2.75FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT275 :=** ______________
TRIP TIME @ 3.00FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT300 :=** ______________
TRIP TIME @ 3.50FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT350 :=** ______________
TRIP TIME @ 4.00FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT400 :=** ______________
TRIP TIME @ 4.50FL (1.0–6000.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT450 :=** ______________
TRIP TIME @ 5.00FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT500 :=** ______________

TRIP TIME @ 5.50FL (1.0–600.0 sec) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT550 :=** ______________
TRIP TIME @ 6.00FL (1.0–600.0 sec) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT600 :=** ______________
TRIP TIME @ 6.50FL (1.0–600.0 sec) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT650 :=** ______________
TRIP TIME @ 7.00FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT700 :=** ______________
TRIP TIME @ 7.50FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT750 :=** ______________
TRIP TIME @ 8.00FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT800 :=** ______________
TRIP TIME @ 8.50FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT850 :=** ______________
TRIP TIME @ 9.00FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT900 :=** ______________
TRIP TIME @ 9.50FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT950 :=** ______________
TRIP TIME @ 10.0FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT1000 :=** ______________
TRIP TIME @ 11.0FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT1100 :=** ______________
TRIP TIME @ 12.0FL (1.0–600.0 sec, AUTO) *(Hidden when CURVE1 := 1–45 or SETMETH := RATING or RATING_1)*	**TTT1200 :=** ______________
THERM OL CURVE2 (1–45) *(Hidden when SETMETH := RATING or RATING_1 or when E2SPEED := N; CURVE2 forced to CURVE1 and hidden when Slot Z = L1)*	**CURVE2 :=** ______________
OL WARN LEVEL (OFF, 50–99% TCU)	**TCAPU :=** ______________
START INH. LEVEL (OFF, 1–99% TCU)	**TCSTART :=** ______________
LEARN TCSTART? (Y, N) *(Hidden when TCSTART := OFF)*	**TCLRNEN :=** ______________
STOP COOL TIME (1–6000 min)	**COOLTIME :=** ______________
STOP COAST TIME (1–3600 sec)	**COASTIME :=** ______________
LEARN COOLTIME? (Y, N) *(Hidden when E49RTD := NONE)*	**COOLEN :=** ______________
OL RTD BIASING? (Y, N) *(Hidden when E49RTD := NONE)*	**ETHMBIAS :=** ______________

Phase Overcurrent

PH OC TRIP LVL (OFF, 0.10–20.00 xFLA)	**50P1P :=** ______________
PH OC TRIP DLAY (OFF, 0.00–5.00 sec) *(Hidden when associated pickup is OFF)*	**50P1D :=** ______________
PH OC WARN LVL (OFF, 0.10–20.00 xFLA)	**50P2P :=** ______________
PH OC WARN DLAY (OFF, 0.00–5.00 sec) *(Hidden when associated pickup is OFF)*	**50P2D :=** ______________

Neutral Overcurrent

(Refer to Table 6.6 for setting interdependency checks. The following pickup settings are in primary amperes.)

NEUT OC TRIP LVL (OFF, 0.01–25.00 A) **50N1P :=** _____________
(Hidden when a 1 A or 5 A neutral input is detected.)
NEUT OC TRIP LVL (OFF, 0.01–650.00 A)
(Hidden when a high-sensitive neutral input is detected.)

NEU OC TRIP DLAY (OFF, 0.00–5.00 sec) **50N1D :=** _____________
(Hidden when associated pickup is OFF)

NEUT OC WARN LVL (OFF, 0.01–25.00 A) **50N2P :=** _____________
(Hidden when a 1 A or 5 A neutral input is detected.)
NEUT OC WARN LVL (OFF, 0.01–650.00 A)
(Hidden when a high-sensitive neutral input is detected.)

NEU OC WARN DLAY (OFF, 0.0–120.0 sec) **50N2D :=** _____________
(Hidden when associated pickup is OFF)

Residual Overcurrent

RES OC TRIP LVL (OFF, 0.10–20.00 xFLA) **50G1P :=** _____________

RES OC TRIP DLAY (OFF, 0.00–5.00 sec) **50G1D :=** _____________
(Hidden when associated pickup is OFF)

RES OC WARN LVL (OFF, 0.10–20.00 xFLA) **50G2P :=** _____________

RES OC WARN DLAY (OFF, 0.0–120.0 sec) **50G2D :=** _____________
(Hidden when associated pickup is OFF)

Negative-Sequence Overcurrent

NSEQ OC TRIP LVL (OFF, 0.10–20.00 xFLA) **50Q1P :=** _____________

NSEQ OC TRIP DLAY (OFF, 0.1–120.0 sec) **50Q1D :=** _____________
(Hidden when associated pickup is OFF)

NSEQ OC WARN LVL (OFF, 0.10–20.00 xFLA) **50Q2P :=** _____________

NSEQ OC WARN DLAY (OFF, 0.1–120.0 sec) **50Q2D :=** _____________
(Hidden when associated pickup is OFF)

Incipient Cable Fault

50INC PU LVL (OFF, (1.00–10.00) • INOM A) **E50INC :=** _____________

50INC WARN COUNT (1, 2, . . . 100) **50IALC :=** _____________

50INC TRIP COUNT (1, 2, . . . 100) **50ITRC :=** _____________

Phase Time Overcurrent

TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A) **51AP :=** _____________

TOC CURVE SEL (U1–U5, C1–C5) **51AC :=** _____________
(Hidden when associated pickup is OFF)

TOC TIME DIAL (0.50–15.00 for U1–U5 OR 0.05–1.00 for C1–C5) **51ATD :=** _____________
(Hidden when associated pickup is OFF)

EM RESET DELAY (Y, N) **51ARS :=** _____________
(Hidden when associated pickup is OFF)

CONST TIME ADDER (0.00–1.00 sec) **51ACT :=** _____________
(Hidden when associated pickup is OFF)

MIN RESPONSE TIM (0.00–1.00 sec) **51AMR :=** _____________
(Hidden when associated pickup is OFF)

TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51ATC :=** ____________
TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A)	**51BP :=** ____________
TOC CURVE SEL (U1–U5, C1–C5) *(Hidden when associated pickup is OFF)*	**51BC :=** ____________
TOC TIME DIAL (0.50–15.00 for U1–U5 OR 0.05–1.00 for C1–C5) *(Hidden when associated pickup is OFF)*	**51BTD :=** ____________
EM RESET DELAY (Y, N) *(Hidden when associated pickup is OFF)*	**51BRS :=** ____________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51BCT :=** ____________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden is associated pickup is OFF)*	**51BMR :=** ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51BTC :=** ____________
TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A)	**51CP :=** ____________
TOC CURVE SEL (U1–U5, C1–C5) *(Hidden when associated pickup is OFF)*	**51CC :=** ____________
TOC TIME DIAL (0.50–15.00 for U1–U5 OR 0.05–1.00 for C1–C5) *(Hidden when associated pickup is OFF)*	**51CTD :=** ____________
EM RESET DELAY (Y, N) *(Hidden when associated pickup is OFF)*	**51CRS :=** ____________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51CCT :=** ____________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51CMR :=** ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51CTC :=** ____________

Maximum Phase Time Overcurrent

TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A)	**51P1P :=** ____________
TOC CURVE SEL (U1–U5, C1–C5) *(Hidden when associated pickup is OFF)*	**51P1C :=** ____________
TOC TIME DIAL (0.50–15.00 for U1–U5 OR 0.05–1.00 for C1–C5)	**51P1TD :=** ____________
EM RESET DELAY (Y, N) *(Hidden when associated pickup is OFF)*	**51P1RS :=** ____________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51P1CT :=** ____________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51P1MR :=** ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51P1TC :=** ____________
TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A)	**51P2P :=** ____________
TOC CURVE SEL (U1–U5, C1–C5) *(Hidden when associated pickup is OFF)*	**51P2C :=** ____________
TOC TIME DIAL (0.50–15.00 for U1–U5 OR 0.05–1.00 for C1–C5)	**51P2TD :=** ____________
EM RESET DELAY (Y, N) *(Hidden when associated pickup is OFF)*	**51P2RS :=** ____________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51P2CT :=** ____________

MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51P2MR :=** ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51P2TC :=** ____________

Negative-Sequence Time-Overcurrent

TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A) *(I_{NOM} 5 or 1 for 5 A or 1 A phase CTs)*	**51QP :=** ____________
TOC CURVE SEL (U1–U5, C1–C5) *(Hidden when associated pickup is OFF)*	**51QC :=** ____________
TOC TIME DIAL (0.50–15.00 for U1–U5 or 0.05–1.00 for C1–C5) *(Hidden when associated pickup is OFF)*	**51QTD :=** ____________
EM RESET DELAY (Y, N) *(Hidden when associated pickup is OFF)*	**51QRS :=** ____________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51QCT :=** ____________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51QMR :=** ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51QTC :=** ____________

Residual Ground Time-Overcurrent

TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A)	**51G1P :=** ____________
TOC CURVE SEL (U1–U5, C1–C5) *(Hidden when associated pickup is OFF)*	**51G1C :=** ____________
TOC TIME DIAL (0.50–15.00 for U1–U5 OR 0.05–1.00 for C1–C5) *(Hidden when associated pickup is OFF)*	**51G1TD :=** ____________
EM RESET DELAY (Y, N) *(Hidden when associated pickup is OFF)*	**51G1RS :=** ____________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51G1CT :=** ____________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51G1MR :=** ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51G1TC :=** ____________
TOC TRIP LVL (OFF, (0.10–2.00) • I_{NOM} A)	**51G2P :=** ____________
TOC CURVE SEL (U1–U5, C1–C5) *(Hidden when associated pickup is OFF)*	**51G2C :=** ____________
TOC TIME DIAL (0.50–15.00 for U1–U5 OR 0.05–1.00 for C1–C5) *(Hidden when associated pickup is OFF)*	**51G2TD :=** ____________
EM RESET DELAY (Y, N) *(Hidden when associated pickup is OFF)*	**51G2RS :=** ____________
CONST TIME ADDER (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51G2CT :=** ____________
MIN RESPONSE TIM (0.00–1.00 sec) *(Hidden when associated pickup is OFF)*	**51G2MR :=** ____________
TOC TRQ CONTROL (SELOGIC) *(Hidden when associated pickup is OFF)*	**51G2TC :=** ____________

Motor Differential Overcurrent

DIFF ENABLE (Y, N)	**E87M :=** ______________
DIFF CT RATIO (1–5000) *(Hidden when E87M := N)*	**CTR87M :=** ______________
DIFF 1 TRIP LVL (OFF, 0.05–8.00 A) *(Hidden when E87M := N)*	**87M1P :=** ______________
DIFF 1 TRIP DLY (0.00–60.00 sec) *(Hidden when 87M1P := OFF)*	**87M1TD :=** ______________
DIFF 1 TRQ CON (SELOGIC) *(Hidden when 87M1P := OFF)*	**87M1TC :=** ______________
DIFF 2 TRIP LVL (OFF, 0.05–8.00 A) *(Hidden when E87M := N)*	**87M2P :=** ______________
DIFF 2 TRIP DLY (0.00–60.00 sec) *(Hidden when 87M2P := OFF)*	**87M2TD :=** ______________
DIFF 2 TRQ CON (SELOGIC) *(Hidden when 87M2P := OFF)*	**87M2TC :=** ______________

Jam

JAM TRIP LEVEL (OFF, 1.00–6.00 xFLA)	**LJTPU :=** ______________
JAM TRIP DELAY (0.0–120.0 sec) *(When LJTPU := OFF, LJTDLY is hidden and JAMTRIP is deasserted all the time)*	**LJTDLY :=** ______________
JAM WARN LEVEL (OFF, 1.00–6.00 xFLA)	**LJAPU :=** ______________
JAM WARN DELAY (0.0–120.0 sec) *(When LJAPU := OFF, LJADLY is hidden and JAMALRM is deasserted all the time)*	**LJADLY :=** ______________

Undercurrent

UC TRIP LEVEL (OFF, 0.10–1.00 xFLA)	**LLTPU :=** ______________
UC TRIP DELAY (0.4–120.0 sec) *(Hidden when associated pickup is OFF)*	**LLTDLY :=** ______________
UC WARN LEVEL (OFF, 0.10–1.00 xFLA)	**LLAPU :=** ______________
UC WARN DELAY (0.40–120.0 sec) *(Hidden when associated pickup is OFF)*	**LLADLY :=** ______________
UC START DELAY (0–5000 sec) *(Hidden when LLTPU and LLAPU are OFF)*	**LLSDLY :=** ______________

Current Unbalance

CI TRIP LEVEL (OFF, 5–80%)	**46UBT :=** ______________
CI TRIP DELAY (0–240 sec) *(Hidden when the associated pickup is OFF)*	**46UBTD :=** ______________
CI WARN LEVEL (OFF, 5–80%)	**46UBA :=** ______________
CI WARN DELAY (0–240 sec) *(Hidden when the associated pickup is OFF)*	**46UBAD :=** ______________

Start Monitoring

START MOTOR TIME (OFF, 1–240 sec)	**START_T :=** ______________

Star-Delta

(Forced to N and hidden when VFDAPP := Y)

STAR-DELTA ENABL (Y, N)	**ESTAR_D :=** ____________
MAX STAR TIME (OFF, 1–600 sec) *(Hidden when 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 sec)	**SPDSDLYT :=** ____________
SS WARN DELAY (OFF, 1–240 sec)	**SPDSDLYA :=** ____________
VIR SS ENABLE (Y, N) *(Forced to N and hidden when VFDAPP := Y)*	**VSSEN :=** ____________
VIR SS CONSTANT (0.80–0.98) *(Hidden when VSSEN := N)*	**VSSCONST :=** ____________
SS FAIL OPEN DLY (OFF, 0.5–2.0 sec) *(Forced to OFF and hidden when VSSEN := N)*	**FAILOPND :=** ____________
SS FAIL CLOS DLY (0.1–120.0 min) *(Hidden when VSSEN := N or FAILOPND := OFF)*	**FAILCLSD :=** ____________
SS FAIL RESET (SELOGIC) *(Hidden when VSSEN := N or FAILOPND := OFF)*	**SSFLRST :=** ____________

PTC

PTC ENABLE (Y, N) *(Hidden when the PTC option is not selected)*	**EPTC :=** ____________

RTD

RTD ENABLE (INT, EXT, NONE) *(The INT option is hidden from the range when there is no internal RTD card installed; all the following RTD settings are hidden when E49RTD := NONE)*	**E49RTD :=** ____________
RTD1 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD1TY, TRTMP1, and ALTMP1 settings are hidden when RTD1LOC := OFF)*	**RTD1LOC :=** ____________
RTD1 TYPE (PT100, NI100, NI120, CU10)	**RTD1TY :=** ____________
RTD1 TRIP LEVEL (OFF, 1–250°C)	**TRTMP1 :=** ____________
RTD1 WARN LEVEL (OFF, 1–250°C)	**ALTMP1 :=** ____________
RTD2 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD2TY, TRTMP2, and ALTMP2 settings are hidden when RTD2LOC := OFF)*	**RTD2LOC :=** ____________
RTD2 TYPE (PT100, NI100, NI120, CU10)	**RTD2TY :=** ____________
RTD2 TRIP LEVEL (OFF, 1–250°C)	**TRTMP2 :=** ____________
RTD2 WARN LEVEL (OFF, 1–250°C)	**ALTMP2 :=** ____________

RTD3 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD3TY, TRTMP3, and ALTMP3 settings are hidden when RTD3LOC := OFF)*	**RTD3LOC :=** ____________
RTD3 TYPE (PT100, NI100, NI120, CU10)	**RTD3TY :=** ____________
RTD3 TRIP LEVEL (OFF, 1–250°C)	**TRTMP3 :=** ____________
RTD3 WARN LEVEL (OFF, 1–250°C)	**ALTMP3 :=** ____________
RTD4 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD4TY, TRTMP4, and ALTMP4 settings are hidden when RTD4LOC := OFF)*	**RTD4LOC :=** ____________
RTD4 TYPE (PT100, NI100, NI120, CU10)	**RTD4TY :=** ____________
RTD4 TRIP LEVEL (OFF, 1–250°C)	**TRTMP4 :=** ____________
RTD4 WARN LEVEL (OFF, 1–250°C)	**ALTMP4 :=** ____________
RTD5 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD5TY, TRTMP5, and ALTMP5 settings are hidden when RTD5LOC := OFF)*	**RTD5LOC :=** ____________
RTD5 TYPE (PT100, NI100, NI120, CU10)	**RTD5TY :=** ____________
RTD5 TRIP LEVEL (OFF, 1–250°C)	**TRTMP5 :=** ____________
RTD5 WARN LEVEL (OFF, 1–250°C)	**ALTMP5 :=** ____________
RTD6 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD6TY, TRTMP6, and ALTMP6 settings are hidden when RTD6LOC := OFF)*	**RTD6LOC :=** ____________
RTD6 TYPE (PT100, NI100, NI120, CU10)	**RTD6TY :=** ____________
RTD6 TRIP LEVEL (OFF, 1–250°C)	**TRTMP6 :=** ____________
RTD6 WARN LEVEL (OFF, 1–250°C)	**ALTMP6 :=** ____________
RTD7 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD7TY, TRTMP7, and ALTMP7 settings are hidden when RTD7LOC := OFF)*	**RTD7LOC :=** ____________
RTD7 TYPE (PT100, NI100, NI120, CU10)	**RTD7TY :=** ____________
RTD7 TRIP LEVEL (OFF, 1–250°C)	**TRTMP7 :=** ____________
RTD7 WARN LEVEL (OFF, 1–250°C)	**ALTMP7 :=** ____________
RTD8 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD8TY, TRTMP8, and ALTMP8 settings are hidden when RTD8LOC := OFF)*	**RTD8LOC :=** ____________
RTD8 TYPE (PT100, NI100, NI120, CU10)	**RTD8TY :=** ____________
RTD8 TRIP LEVEL (OFF, 1–250°C)	**TRTMP8 :=** ____________
RTD8 WARN LEVEL (OFF, 1–250°C)	**ALTMP8 :=** ____________
RTD9 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD9TY, TRTMP9, and ALTMP9 settings are hidden when RTD9LOC := OFF)*	**RTD9LOC :=** ____________
RTD9 TYPE (PT100, NI100, NI120, CU10)	**RTD9TY :=** ____________
RTD9 TRIP LEVEL (OFF, 1–250°C)	**TRTMP9 :=** ____________
RTD9 WARN LEVEL (OFF, 1–250°C)	**ALTMP9 :=** ____________
RTD10 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD10TY, TRTMP10, and ALTMP10 settings are hidden when RTD10LOC := OFF)*	**RTD10LOC :=** ____________
RTD10 TYPE (PT100, NI100, NI120, CU10)	**RTD10TY :=** ____________
RTD10 TRIP LEVEL (OFF, 1–250°C)	**TRTMP10 :=** ____________
RTD10 WARN LEVEL (OFF, 1–250°C)	**ALTMP10 :=** ____________
RTD11 LOCATION (OFF, WDG, BRG, AMB, OTH) *(RTD11TY, TRTMP11, and ALTMP11 settings are hidden when RTD11LOC := OFF); RTD11LOC is hidden and forced to OFF when E49RTD := INT)*	**RTD11LOC :=** ____________
RTD11 TYPE (PT100, NI100, NI120, CU10)	**RTD11TY :=** ____________
RTD11 TRIP LEVEL (OFF, 1–250°C)	**TRTMP11 :=** ____________

RTD11 WARN LEVEL (OFF, 1–250°C) **ALTMP11 :=** _____________

RTD12 LOCATION (OFF, WDG, BRG, AMB, OTH) **RTD12LOC :=** _____________
(RTD12TY, TRTMP12, and ALTMP12 settings are hidden when RTD12LOC := OFF); RTD12LOC hidden and forced to OFF when E49RTD := INT)

RTD12 TYPE (PT100, NI100, NI120, CU10) **RTD12TY :=** _____________

RTD12 TRIP LEVEL (OFF, 1–250°C) **TRTMP12 :=** _____________

RTD12 WARN LEVEL (OFF, 1–250°C) **ALTMP12 :=** _____________

WIND TRIP VOTING (Y, N) **EWDGV :=** _____________
(When less than two locations are WDG, the associated trip voting settings are hidden)

BEAR TRIP VOTING (Y, N) **EBRGV :=** _____________
(When less than two locations are BRG, the associated trip voting settings are hidden)

TMP RTD BIASING? (Y, N) **ERTDBIAS :=** _____________
(Shown only when one RTD location is set to AMB and at least one RTD location is set to WDG)

Loss of Potential

LOP BLOCK (SELOGIC) **LOPBLK :=** _____________

Undervoltage

UV TRIP LEVEL (OFF, 0.02–1.00 xVnm) **27P1P :=** _____________

UV TRIP DELAY (0.0–120.0 sec) **27P1D :=** _____________
(Hidden when associated pickup is OFF)

UV WARN LEVEL (OFF, 0.02–1.00 xVnm) **27P2P :=** _____________

UV WARN DELAY (0.0–120.0 sec) **27P2D :=** _____________
(Hidden when associated pickup is OFF)

Overvoltage

OV TRIP LEVEL (OFF, 0.02–1.20 xVnm) **59P1P :=** _____________

OV TRIP DELAY (0.0–120.0 sec) **59P1D :=** _____________
(Hidden when associated pickup is OFF)

OV WARN LEVEL (OFF, 0.02–1.20 xVnm) **59P2P :=** _____________

OV WARN DELAY (0.0–120.0 sec) **59P2D :=** _____________
(Hidden when associated pickup is OFF)

27 Inverse-Time Undervoltage

27I ENABLE (Y, N) **E27I1 :=** _____________

(The following 27I1 inverse-time undervoltage settings are hidden if E27I1 := N)

OPERATING QTY
See Table SET.1 for range dependencies. **27I1OQ :=** _____________

Table SET.1 Range Dependencies for 27I Operating Quantities

Settings		Operating Quantities								
DELTA_Y	SINGLEV	VAB	VBC	VCA	VA	VB	VC	V1	MINLL	MINLN
DELTA	N	#	#	#	—	—	—	#	#	—
DELTA	Y	#	—	—	—	—	—	—	—	—
WYE	N	$	$	$	#	#	#	#	$	#
WYE	Y	—	—	—	#	—	—	—	—	—
# = 2.00–300.00 V		$ = 2.00–520.00 V								

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.1*) **27I1P :=** _______________

CURVE (CURVEA, CURVEB, COEF) **27I1CRV :=** _______________

COEFF A (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFA :=** _______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFB :=** _______________

COEFF C (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I1CFC :=** _______________

TIME DIAL (0.00–16.00) **27I1TD :=** _______________

RESET TIME (0.00–1.00 s) **27I1TTR :=** _______________

TRQ CONTROL (SELOGIC) **27I1TC :=** _______________

27I ENABLE (Y, N) **E27I2 :=** _______________

(The following 27I2 settings are hidden if E27I2 := N)

OPERATING QTY
See Table SET.1 for range dependencies. **27I2OQ :=** _______________

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.1*) **27I2P :=** _______________

CURVE (CURVEA, CURVEB, COEF) **27I2CRV :=** _______________

COEFF A (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFA :=** _______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFB :=** _______________

COEFF C (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **27I2CFC :=** _______________

TIME DIAL (0.00–16.00) **27I2TD :=** _______________

RESET TIME (0.00–1.00 s) **27I2TTR :=** _______________

TRQ CONTROL (SELOGIC) **27I2TC :=** _______________

59 Inverse-Time Overvoltage

59I ENABLE (Y, N) **E59I1 :=** _______________

(The following 59I1 inverse-time overvoltage settings are hidden if E59I1 := N)

OPERATING QTY
See Table SET.2 for range dependencies. **59I1OQ :=** _______________

Table SET.2 Range Dependencies for 59I Operating Quantities

Settings		Operating Quantities										
DELTA_Y	SINGLEV	VAB	VBC	VCA	VA	VB	VC	VG	V1	3V2	MAXLN	MAXLN
DELTA	N	#	#	#	—	—	—	—	#	#	#	—
DELTA	Y	#	—	—	—	—	—	—	—	—	—	—
WYE	N	$	$	$	#	#	#	#	#	#	$	#
WYE	Y	—	—	—	#	—	—	—	—	—	—	—

= 2.00–300.00 V $ = 2.00–520.00 V

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*) **59I1P :=** ______________

CURVE (CURVEA, CURVEB, COEF) **59I1CR :=** ______________

COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I1CFA :=** ______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I1CFB :=** ______________

COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I1CFC :=** ______________

TIME DIAL (0.00–16.00) **59I1TD :=** ______________

RESET TIME (0.00–1.00 s) **59I1TTR :=** ______________

TRQ CONTROL (SELOGIC) **59I1TC :=** ______________

59I ENABLE (Y, N) **E59I2 :=** ______________

(The following 59I2 settings are hidden if E59I2 := N)

OPERATING QTY
See Table SET.2 for range dependencies. **59I2OQ :=** ______________

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*) **59I2P :=** ______________

CURVE (CURVEA, CURVEB, COEF) **59I2CRV :=** ______________

COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I2CFA :=** ______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I2CFB :=** ______________

COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I2CFC :=** ______________

TIME DIAL (0.00–16.00) **59I2TD :=** ______________

RESET TIME (0.00–1.00 s) **59I2TTR :=** ______________

TRQ CONTROL (SELOGIC) **59I2TC :=** ______________

59I ENABLE (Y, N) **E59I3 :=** ______________

(The following 59I3 settings are hidden if E59I3 := N)

OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*)
See Table SET.2 for range dependencies. **59I3OQ :=** ______________

PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*) **59I3P :=** ______________

CURVE (CURVEA, CURVEB, COEF) **59I3CRV :=** ______________

COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I3CFA :=** ______________

COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I3CFB :=** ______________

COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)* **59I3CFC :=** ______________

TIME DIAL (0.00–16.00) **59I3TD :=** ______________

RESET TIME (0.00–1.00 s) **59I3TTR :=** ______________

TRQ CONTROL	**59I3TC :=** ______________
59I ENABLE (Y, N)	**E59I4 :=** ______________
(The following 59I4 settings are hidden if E59I4 := N)	
OPERATING QTY (*VS option is hidden if Slot E ≠ 70 or L0*) *See Table SET.2 for range dependencies.*	**59I4OQ :=** ______________
PICKUP LVL (2.00–300.00 V or 2.00–520.00 V from *Table SET.2*)	**59I4P :=** ______________
CURVE (CURVEA, CURVEB, COEF)	**59I4CRV :=** ______________
COEFF A (0.00–6.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFA :=** ______________
COEFF B (0.00–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFB :=** ______________
COEFF C (0.01–3.00) *(Hidden if CURVE is set to CURVEA or CURVEB)*	**59I4CFC :=** ______________
TIME DIAL (0.00–16.00)	**59I4TD :=** ______________
RESET TIME (0.00–1.00 s)	**59I4TTR :=** ______________
TRQ CONTROL (SELOGIC)	**59I4TC :=** ______________

Var

NEG VAR TRIP LEV (OFF, 1–25000 kVAR)	**NVARTP :=** ______________
POS VAR TRIP LEV (OFF, 1–25000 kVAR)	**PVARTP :=** ______________
VAR TRIP DELAY (1–240 sec) *(Hidden when NVARTP and PVARTP are 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 sec) *(Hidden when NVARAP and PVARAP are OFF)*	**VARAD :=** ______________
VAR ARMING DELAY (0–5000 sec) *(Hidden when NVARTP, PVARTP, NVARAP, and PVARAP are OFF)*	**VARDLY :=** ______________

Loss of Field

(Hidden when SYNTYPE := NONE and E40 forced to default, N)

LOSS OF FIELD EN (Y, N) *(All the following settings are hidden when E40 := N)*	**E40 :=** ______________
Z1 MHO DIAMETER (OFF, (0.5–500.0)/I_{NOM} ohm sec) *(I_{NOM} = 5 A or 1 A)*	**40Z1P :=** ______________
Z1 OFFSET ((0.0–250.0)/I_{NOM} ohm sec) *(Hidden when 40Z1P := OFF)*	**40XD1 :=** ______________
Z1 TIME DELAY (0.00–400.00 sec) *(Hidden when 40Z1P := OFF)*	**40Z1D :=** ______________
Z2 MHO DIAMETER (OFF, (0.5–500.0)/I_{NOM} ohm sec) *(I_{NOM} := 5 or 1)*	**40Z2P :=** ______________
Z2 OFFSET ((0.0–250.0)/I_{NOM} ohm sec) *(Hidden when 40Z2P := OFF)*	**40XD2 :=** ______________
Z2 TIME DELAY (0.00–400.00 sec) *(Hidden when 40Z2P := OFF)*	**40Z2D :=** ______________
40Z TRQ CTRL (SELOGIC)	**40ZTC :=** ______________

Out of Step

OUT-OF-STEP PROT (N, 1B, 2B) *(The following settings are hidden when E78 := N)*	**E78 :=** ____________
FORWARD REACH ((0.5–500.0)/I_{NOM} ohm sec)	**78FWD :=** ____________
REVERSE REACH ((0.5–500.0)/I_{NOM} ohm sec)	**78REV :=** ____________
RIGHT BLINDER ((0.5–250.0)/I_{NOM} ohm sec) *(Hidden when E78 := 2B)*	**78R1 :=** ____________
LEFT BLINDER ((0.5–250.0)/I_{NOM} ohm sec) *(Hidden when E78 := 2B)*	**78R2 :=** ____________
OUTER BLINDER ((1.0–500.0)/I_{NOM} ohm sec) *(Hidden when E78 := 1B)*	**78R1 :=** ____________
INNER BLINDER ((0.5–250.0)/I_{NOM} ohm sec) *(Hidden when E78 := 1B)*	**78R2 :=** ____________
OOS DELAY (0.00–1.00 sec) *(Hidden when E78 := 1B)*	**78D :=** ____________
OOS TRIP DELAY (0.00–1.00 sec)	**78TD :=** ____________
OOS TRIP DUR (0.00–5.00 sec)	**78TDURD :=** ____________
POS-SEQ CURRENT ((0.05–6.00) • I_{NOM} A)	**50ABC :=** ____________
OOS TRQ CTRL (SELOGIC)	**OOSTC :=** ____________

Field Resistance

(Hidden when SYNTYPE := NONE; FDRES1P and FDRES2P forced to default, OFF)

FLD RES WARN 1 (OFF, 0.10–500.00 ohm)	**FDRES1P :=** ____________
FLD RES WARN 2 (OFF, 0.10–500.00 ohm)	**FDRES2P :=** ____________
FLDR TRQ CTRL (SELOGIC)	**FDRESTC :=** ____________

Field Current

(Hidden when SYNTYPE := NONE; FDUC1P, FDUC2P, FDOC1P, and FDOC2P forced to default, OFF)

FLD CURRENT IN (I, V)	**FDCURIN :=** ____________
FLD CUR @ 20 mA (1.0–2000.0 A) *(Shown when FDCURIN := I)*	**FD_20mA :=** ____________
FLD CUR @ 5V (1.0–2000.0 A) *(Shown when FDCURIN := V)*	**FD_5V :=** ____________
FLD UC TRIP LEVEL (OFF, 1.0–2000.0 A)	**FDUC1P :=** ____________
FLD UC TRIP DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDUC1D :=** ____________
FLD UC WARN LVL (OFF, 1.0–2000.0 A)	**FDUC2P :=** ____________
FLD UC WARN DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDUC2D :=** ____________
FLD OC TRIP LVL (OFF, 1.0–2000.0 A)	**FDOC1P :=** ____________
FLD OC TRIP DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDOC1D :=** ____________
FLD OC WARN LVL (OFF, 1.0–2000.0 A)	**FDOC2P :=** ____________
FLD OC WARN DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDOC2D :=** ____________
FLDC TRQ CTRL (SELOGIC)	**FDCTC :=** ____________

Field Voltage

(Hidden when SYNTYPE := NONE; FDUV1P, FDUV2P, FDOV1P, FDOV2P forced to default, OFF)

FLD UV TRIP LVL (OFF, 1.0–350.0 V)	**FDUV1P :=** _______________
FLD UV TRIP DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDUV1D :=** _______________
FLD UV WRN LVL (OFF, 1.0–350.0 V)	**FDUV2P :=** _______________
FLD UV WARN DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDUV2D :=** _______________
FLD OV TRIP LVL (OFF, 1.0–350.0 V)	**FDOV1P :=** _______________
FLD OV TRIP DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDOV1D :=** _______________
FLD OV WARN LVL (OFF, 1.0–350.0 V)	**FDOV2P :=** _______________
FLD OV WARN DLY (0.3–100.0 sec) *(Hidden when associated pickup is OFF)*	**FDOV2D :=** _______________
FLD TRQ CTRL (SELOGIC)	**FDVTC :=** _______________

Start Sequence

(Hidden when SYNTYPE := NONE; hidden and not processed when VFDAPP := Y)

STRT SEQ ENABLE (SELOGIC)	**STSEQEN :=** _______________
STRT SEQ DELAY (0–1000 ms)	**STSEQDLY :=** _______________
SYNCHRONIZE SLIP (1.0–10.0%)	**SYNSLIP :=** _______________
UNLATCH 41CLOSE (SELOGIC)	**UL41CL :=** _______________
41 CLOSE DELAY (0.0–100.0 sec)	**41DELAY :=** _______________
FIELD BKR CL TIME (OFF, 0–1000 ms)	**FLDBKCL :=** _______________
MN FDC TO SYNC (0.5–2000.0 A)	**FDCMIN :=** _______________
MIN CLOSE DELAY (0.1–99.0 sec)	**41MNDLY :=** _______________

Underpower

UP TRIP LEVEL (OFF, 1–25000 kW)	**37PTP :=** _______________
UP TRIP DELAY (1–240 sec) *(Hidden when associated pickup is OFF)*	**37PTD :=** _______________
UP WARN LEVEL (OFF, 1–25000 kW)	**37PAP :=** _______________
UP WARN DELAY (1–240 sec) *(Hidden when associated pickup is OFF)*	**37PAD :=** _______________
UP ARMING DELAY (0–5000 sec)	**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 sec) *(Hidden when 55LDTP and 55LG TP are OFF)*	**55TD :=** _______________
PF LAG WARN LEVL (OFF, 0.05–0.99)	**55LGAP :=** _______________
PF LD WARN LEVEL (OFF, 0.05–0.99)	**55LDAP :=** _______________

PF WARN DELAY (1–240 sec) *(Hidden when 55LDAP and 55LGAP are OFF)*	**55AD :=** ______________
PF ARMING DELAY (0–5000 sec) *(Hidden when 55LGTP, 55LDTP, 55LGAP, and 55LDAP are OFF)*	**55DLY :=** ______________
PF CURRENT SUP (OFF, 0.05–2.00 • I_{NOM} A) *(Hidden when SYNTYPE := NONE; I_{NOM} := 5 or 1)*	**55I1SUP :=** ______________
PF TRQ CTRL (SELOGIC) *(Hidden when SYNTYPE := NONE)*	**55TC :=** ______________
PO PF SET POINT (0.10-0.99) *(Hidden when SYNTYPE := NONE)*	**POPFSP :=** ______________
PO PU DELAY (0.1-60.0 sec) *(Hidden when SYNTYPE := NONE)*	**PORSRTD :=** ______________

Power Factor Correction

ENABLE PF CPMP (OFF, PFSP, QSPMV)	**EPFC :=** ______________
(The following power factor correction settings are hidden when EPFC := OFF)	
LEADLAG (LEAD, LAG) *(Hidden when EPFC := QSPMV)*	**PFLDLG :=** ______________
PF SET POINT (OFF, 0.50–1.00 *[hidden when EPFC := QSPMV or PFLDLG := LEAD)* or 0.10–1.00 *[hidden when EPFC := QSPMV or PFLDLG := LAG]*)	**PFSPAN :=** ______________
Q SP MATH VAR (1–32) *(Hidden when EPFC := PFSP)*	**PFQSP :=** ______________
DEADBAND L TH (0.0 to +YYYY.0 kVAR) (YYYY = 1.732 • FLA1 • VNOM in kVAR) (PFLTH > PFSTH)	**PFLTH :=** ______________
DEADBAND S TH (0.0 to +YYYY.0 kVAR) (YYYY = 1.732 • FLA1 • VNOM in kVAR) (PFSTH < PFLTH)	**PFSTH :=** ______________
LONG STEP LENGTH (0.0–3.0 sec) (FVLDO > FVSDO)	**FVLDO :=** ______________
SHRT STEP LENGTH (0.0–3.0 sec) (FVSDO < FVLDO)	**FVSDO :=** ______________
SYNCVOLTAGE (0–100%)	**PFCOVL :=** ______________
SYNC VLTG CNTRL (SELOGIC)	**PFCNTRL :=** ______________

Frequency

FREQ1 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D1TP :=** ______________
FREQ1 TRIP DELAY (0.00–400.00 sec) *(Hidden when associated pickup is OFF)*	**81D1TD :=** ______________
81D1 TRQCTRL (SELOGIC) *(Hidden when associated pickup is OFF)*	**81D1TC :=** ______________
FREQ2 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D2TP :=** ______________
FREQ2 TRIP DELAY (0.00–400.00 sec) *(Hidden when associated pickup is OFF)*	**81D2TD :=** ______________
81D2 TRQCTRL (SELOGIC) *(Hidden when associated pickup is OFF)*	**81D2TC :=** ______________
FREQ3 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D3TP :=** ______________
FREQ3 TRIP DELAY (0.00–400.00 sec) *(Hidden when associated pickup is OFF)*	**81D3TD :=** ______________
81D3 TRQCTRL (SELOGIC) *(Hidden when associated pickup is OFF)*	**81D3TC :=** ______________
FREQ4 TRIP LEVEL (OFF, 15.00–70.00 Hz)	**81D4TP :=** ______________

FREQ4 TRIP DELAY (0.00–400.00 sec) *(Hidden when associated pickup is OFF)*	**81D4TD :=** ______________
81D4 TRQCTRL (SELOGIC) *(Hidden when associated pickup is OFF)*	**81D4TC :=** ______________

Load Control

LOAD CONTROL SEL (OFF, CURRENT, POWER, TCU) *(When LOAD := OFF, the rest of the load control settings are hidden)*	**LOAD :=** ______________
LD CTL CUR UPPER (OFF, 0.20–2.00 xFLA) *(Shown when LOAD := CURRENT)*	**LOADUPP :=** ______________
LD CTL CUR LOWER (OFF, 0.20–2.00 xFLA) *(Shown when LOAD := POWER)*	**LOADLOWP :=** ______________
LD CTL PWR UPPER (OFF, 1–25000 kW) *(Shown when LOAD := POWER)*	**LOADUPP :=** ______________
LD CTL PWR LOWER (OFF, 1–25000 kW) *(Shown when LOAD := POWER)*	**LOADLOWP :=** ______________
LD CTL TCU UPPER (OFF, 1–99% TCU) *(Shown when LOAD := TCU)*	**LOADUPP :=** ______________
LD CTL TCU LOWER (OFF, 1–99% TCU) *(Shown when LOAD := TCU)*	**LOADLOWP :=** ______________

Vibration Monitoring

ANALOG SELECTION (OFF, MV01, . . . MV32, AIx0y)	**VIBAQ1 :=** ______________
ANALOG SELECTION (OFF, MV01, . . . MV32, AIx0y)	**VIBAQ2 :=** ______________
ANALOG SELECTION (OFF, MV01, . . . MV32, AIx0y)	**VIBAQ3 :=** ______________
ANALOG SELECTION (OFF, MV01, . . . MV32, AIx0y)	**VIBAQ4 :=** ______________
ANALOG SELECTION (OFF, MV01, . . . MV32, AIx0y)	**VIBAQ5 :=** ______________
PICKUP TIMER (0.00–400.00)	**VIBPUT :=** ______________
TRQ CONTROL (SELOGIC)	**VIBTC :=** ______________
MACHINE CLASS (CI, CII, CIII, CIV, MANUAL)	**VIBCLASS :=** ______________
VELOCITY UNITS (mm/sec, in/sec)	**VIBUN :=** ______________
A–B THRESHOLD (0.00–100.00)	**VIBABP :=** ______________
B–C THRESHOLD (0.00–100.00)	**VIBBCP :=** ______________
C–D THRESHOLD (0.00–100.00)	**VIBCDP :=** ______________

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 when the PTC option is not selected)* **BLK49PTC :=** ____________

RTD (Y, N) **BLK49RTD :=** ____________

Trip/Close

MIN TRIP TIME (0.0–400.0 sec) **TDURD :=** ____________

TRIP EQUATION (SELOGIC) **TR :=** ____________

____

REMOTE TRIP EQN (SELOGIC) **REMTRIP :=** ____________

TRIP ON LOCKOUT (Y, N) **TRIPONLO :=** ____________

UNLATCH TRIP EQN (SELOGIC) **ULTRIP :=** ____________

CONTACTOR STATUS (SELOGIC) **52A :=** ____________

CONTACTOR STATUS (SELOGIC) **52B :=** ____________

FLD BRKR STATUS (SELOGIC) **41A :=** ____________
(Hidden when SYNTYPE := NONE)

Motor Control

START EQUATION (SELOGIC) **STREQ :=** ____________

BLK START (SELOGIC) **BLKSTR :=** ____________

EMERGENCY START (SELOGIC) **EMRSTR :=** ____________

SPEED 2 (SELOGIC) **SPEED2 :=** ____________
(Hidden and not processed when E2SPEED := NONE)

SPEED SWITCH (SELOGIC) **SPEEDSW :=** ____________

VFD BYPASS (SELOGIC) **VFDBYPAS :=** ____________
(Hidden and not processed when VFDAPP := N)

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 sec)	**SV01PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV01DO :=** ________
SV INPUT (SELOGIC)	**SV01 :=** ________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV02PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV02DO :=** ________
SV INPUT (SELOGIC)	**SV02 :=** ________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV03PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV03DO :=** ________
SV INPUT (SELOGIC)	**SV03 :=** ________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV04PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV04DO :=** ________
SV INPUT (SELOGIC)	**SV04 :=** ________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV05PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV05DO :=** ________
SV INPUT (SELOGIC)	**SV05 :=** ________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV06PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV06DO :=** ________
SV INPUT (SELOGIC)	**SV06 :=** ________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV07PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV07DO :=** ________
SV INPUT (SELOGIC)	**SV07 :=** ________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV08PU :=** ________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV08DO :=** ________

SV INPUT (SELOGIC)	**SV08 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV09PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV09DO :=** ____________
SV INPUT (SELOGIC)	**SV09 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV10PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV10DO :=** ____________
SV INPUT (SELOGIC)	**SV10 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV11PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV11DO :=** ____________
SV INPUT (SELOGIC)	**SV11 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV12PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV12DO :=** ____________
SV INPUT (SELOGIC)	**SV12 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV13PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV13DO :=** ____________
SV INPUT (SELOGIC)	**SV13 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV14PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV14DO :=** ____________
SV INPUT (SELOGIC)	**SV14 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV15PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV15DO :=** ____________
SV INPUT (SELOGIC)	**SV15 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV16PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV16DO :=** ____________
SV INPUT (SELOGIC)	**SV16 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV17PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV17DO :=** ____________
SV INPUT (SELOGIC)	**SV17 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV18PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV18DO :=** ____________
SV INPUT (SELOGIC)	**SV18 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV19PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV19DO :=** ____________
SV INPUT (SELOGIC)	**SV19 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV20PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV20DO :=** ____________
SV INPUT (SELOGIC)	**SV20 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV21PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV21DO :=** ____________
SV INPUT (SELOGIC)	**SV21 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV22PU :=** ____________

SV TIMER DROPOUT (0.00–3000.00 sec)	**SV22DO :=** ____________
SV INPUT (SELOGIC)	**SV22 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV23PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV23DO :=** ____________
SV INPUT (SELOGIC)	**SV23 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV24PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV24DO :=** ____________
SV INPUT (SELOGIC)	**SV24 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV25PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV25DO :=** ____________
SV INPUT (SELOGIC)	**SV25 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV26PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV26DO :=** ____________
SV INPUT (SELOGIC)	**SV26 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV27PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV27DO :=** ____________
SV INPUT (SELOGIC)	**SV27 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV28PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV28DO :=** ____________
SV INPUT (SELOGIC)	**SV28 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV29PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV29DO :=** ____________
SV INPUT (SELOGIC)	**SV29 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV30PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV30DO :=** ____________
SV INPUT (SELOGIC)	**SV30 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV31PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV31DO :=** ____________
SV INPUT (SELOGIC)	**SV31 :=** ____________
SV TIMER PICKUP (0.00–3000.00 sec)	**SV32PU :=** ____________
SV TIMER DROPOUT (0.00–3000.00 sec)	**SV32DO :=** ____________
SV INPUT (SELOGIC)	**SV32 :=** ____________

Counters Equations

SC PRESET VALUE (1–65000)	**SC01PV :=** ____________________________
SC RESET INPUT (SELOGIC)	**SC01R :=** ____________________________
SC LOAD PV INPUT (SELOGIC)	**SC01LD :=** ____________________________
SC CNT UP INPUT (SELOGIC)	**SC01CU :=** ____________________________
SC CNT DN INPUT (SELOGIC)	**SC01CD :=** ____________________________
SC PRESET VALUE (1–65000)	**SC02PV :=** ____________________________
SC RESET INPUT (SELOGIC)	**SC02R :=** ____________________________

SC LOAD PV INPUT (SELOGIC)	**SC02LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC02CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC02CD :=**	
SC PRESET VALUE (1–65000)	**SC03PV :=**	
SC RESET INPUT (SELOGIC)	**SC03R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC03LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC03CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC03CD :=**	
SC PRESET VALUE (1–65000)	**SC04PV :=**	
SC RESET INPUT (SELOGIC)	**SC04R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC04LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC04CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC04CD :=**	
SC PRESET VALUE (1–65000)	**SC05PV :=**	
SC RESET INPUT (SELOGIC)	**SC05R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC05LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC05CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC05CD :=**	
SC PRESET VALUE (1–65000)	**SC06PV :=**	
SC RESET INPUT (SELOGIC)	**SC06R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC06LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC06CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC06CD :=**	
SC PRESET VALUE (1–65000)	**SC07PV :=**	
SC RESET INPUT (SELOGIC)	**SC07R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC07LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC07CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC07CD :=**	
SC PRESET VALUE (1–65000)	**SC08PV :=**	
SC RESET INPUT (SELOGIC)	**SC08R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC08LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC08CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC08CD :=**	
SC PRESET VALUE (1–65000)	**SC09PV :=**	
SC RESET INPUT (SELOGIC)	**SC09R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC09LD :=**	
SC CNT UP INPUT (SELOGIC)	**SC09CU :=**	
SC CNT DN INPUT (SELOGIC)	**SC09CD :=**	
SC PRESET VALUE (1–65000)	**SC10PV :=**	
SC RESET INPUT (SELOGIC)	**SC10R :=**	
SC LOAD PV INPUT (SELOGIC)	**SC10LD :=**	

SC CNT UP INPUT (SELOGIC)	**SC10CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC10CD :=**	________________
SC PRESET VALUE (1–65000)	**SC11PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC11R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC11LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC11CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC11CD :=**	________________
SC PRESET VALUE (1–65000)	**SC12PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC12R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC12LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC12CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC12CD :=**	________________
SC PRESET VALUE (1–65000)	**SC13PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC13R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC13LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC13CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC13CD :=**	________________
SC PRESET VALUE (1–65000)	**SC14PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC14R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC14LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC14CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC14CD :=**	________________
SC PRESET VALUE (1–65000)	**SC15PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC15R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC15LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC15CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC15CD :=**	________________
SC PRESET VALUE (1–65000)	**SC16PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC16R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC16LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC16CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC16CD :=**	________________
SC PRESET VALUE (1–65000)	**SC17PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC17R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC17LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC17CU :=**	________________
SC CNT DN INPUT (SELOGIC)	**SC17CD :=**	________________
SC PRESET VALUE (1–65000)	**SC18PV :=**	________________
SC RESET INPUT (SELOGIC)	**SC18R :=**	________________
SC LOAD PV INPUT (SELOGIC)	**SC18LD :=**	________________
SC CNT UP INPUT (SELOGIC)	**SC18CU :=**	________________

SC CNT DN INPUT (SELOGIC)	**SC18CD :=** ______
SC PRESET VALUE (1–65000)	**SC19PV :=** ______
SC RESET INPUT (SELOGIC)	**SC19R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC19LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC19CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC19CD :=** ______
SC PRESET VALUE (1–65000)	**SC20PV :=** ______
SC RESET INPUT (SELOGIC)	**SC20R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC20LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC20CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC20CD :=** ______
SC PRESET VALUE (1–65000)	**SC21PV :=** ______
SC RESET INPUT (SELOGIC)	**SC21R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC21LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC21CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC21CD :=** ______
SC PRESET VALUE (1–65000)	**SC22PV :=** ______
SC RESET INPUT (SELOGIC)	**SC22R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC22LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC22CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC22CD :=** ______
SC PRESET VALUE (1–65000)	**SC23PV :=** ______
SC RESET INPUT (SELOGIC)	**SC23R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC23LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC23CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC23CD :=** ______
SC PRESET VALUE (1–65000)	**SC24PV :=** ______
SC RESET INPUT (SELOGIC)	**SC24R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC24LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC24CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC24CD :=** ______
SC PRESET VALUE (1–65000)	**SC25PV :=** ______
SC RESET INPUT (SELOGIC)	**SC25R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC25LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC25CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC25CD :=** ______
SC PRESET VALUE (1–65000)	**SC26PV :=** ______
SC RESET INPUT (SELOGIC)	**SC26R :=** ______
SC LOAD PV INPUT (SELOGIC)	**SC26LD :=** ______
SC CNT UP INPUT (SELOGIC)	**SC26CU :=** ______
SC CNT DN INPUT (SELOGIC)	**SC26CD :=** ______

SC PRESET VALUE (1–65000)	**SC27PV :=**	______
SC RESET INPUT (SELOGIC)	**SC27R :=**	______
SC LOAD PV INPUT (SELOGIC)	**SC27LD :=**	______
SC CNT UP INPUT (SELOGIC)	**SC27CU :=**	______
SC CNT DN INPUT (SELOGIC)	**SC27CD :=**	______
SC PRESET VALUE (1–65000)	**SC28PV :=**	______
SC RESET INPUT (SELOGIC)	**SC28R :=**	______
SC LOAD PV INPUT (SELOGIC)	**SC28LD :=**	______
SC CNT UP INPUT (SELOGIC)	**SC28CU :=**	______
SC CNT DN INPUT (SELOGIC)	**SC28CD :=**	______
SC PRESET VALUE (1–65000)	**SC29PV :=**	______
SC RESET INPUT (SELOGIC)	**SC29R :=**	______
SC LOAD PV INPUT (SELOGIC)	**SC29LD :=**	______
SC CNT UP INPUT (SELOGIC)	**SC29CU :=**	______
SC CNT DN INPUT (SELOGIC)	**SC29CD :=**	______
SC PRESET VALUE (1–65000)	**SC30PV :=**	______
SC RESET INPUT (SELOGIC)	**SC30R :=**	______
SC LOAD PV INPUT (SELOGIC)	**SC30LD :=**	______
SC CNT UP INPUT (SELOGIC)	**SC30CU :=**	______
SC CNT DN INPUT (SELOGIC)	**SC30CD :=**	______
SC PRESET VALUE (1–65000)	**SC31PV :=**	______
SC RESET INPUT (SELOGIC)	**SC31R :=**	______
SC LOAD PV INPUT (SELOGIC)	**SC31LD :=**	______
SC CNT UP INPUT (SELOGIC)	**SC31CU :=**	______
SC CNT DN INPUT (SELOGIC)	**SC31CD :=**	______
SC PRESET VALUE (1–65000)	**SC32PV :=**	______
SC RESET INPUT (SELOGIC)	**SC32R :=**	______
SC LOAD PV INPUT (SELOGIC)	**SC32LD :=**	______
SC CNT UP INPUT (SELOGIC)	**SC32CU :=**	______
SC CNT DN INPUT (SELOGIC)	**SC32CD :=**	______

Math Variables

MV01 :=	______
MV02 :=	______
MV03 :=	______
MV04 :=	______
MV05 :=	______
MV06 :=	______
MV07 :=	______
MV08 :=	______
MV09 :=	______

MV10 := ______________________________

MV11 := ______________________________

MV12 := ______________________________

MV13 := ______________________________

MV14 := ______________________________

MV15 := ______________________________

MV16 := ______________________________

MV17 := ______________________________

MV18 := ______________________________

MV19 := ______________________________

MV20 := ______________________________

MV21 := ______________________________

MV22 := ______________________________

MV23 := ______________________________

MV24 := ______________________________

MV25 := ______________________________

MV26 := ______________________________

MV27 := ______________________________

MV28 := ______________________________

MV29 := ______________________________

MV30 := ______________________________

MV31 := ______________________________

MV32 := ______________________________

Base Output

OUT101 FAIL-SAFE (Y, N) **OUT101FS** := __________

OUT101 := ______________________________

OUT102 FAIL-SAFE (Y, N) **OUT102FS** := __________

OUT102 := ______________________________

OUT103 FAIL-SAFE (Y, N) **OUT103FS** := __________

OUT103 := ______________________________

Slot C Output

(Hidden when an output option is not included. The number of outputs depends on the I/O card option.)

OUT301 FAIL-SAFE (Y, N) **OUT301FS** := __________

OUT301 := ______________________________

OUT302 FAIL-SAFE (Y, N) **OUT302FS** := __________

OUT302 := ______________________________

OUT303 FAIL-SAFE (Y, N) **OUT303FS** := __________

OUT303 := ______________________________

OUT304 FAIL-SAFE (Y, N) **OUT304FS :=** ______________

OUT304 := ____

OUT305 FAIL-SAFE (Y, N) **OUT305FS :=** ______________

OUT305 := ____

OUT306 FAIL-SAFE (Y, N) **OUT306FS :=** ______________

OUT306 := ____

OUT307 FAIL-SAFE (Y, N) **OUT307FS :=** ______________

OUT307 := ____

OUT308 FAIL-SAFE (Y, N) **OUT308FS :=** ______________

OUT308 := ____

Slot D Output

(Hidden when an output option is not included. The number of outputs depends on the I/O card option.)

OUT401 FAIL-SAFE (Y, N) **OUT401FS :=** ______________

OUT401 := ____

OUT402 FAIL-SAFE (Y, N) **OUT402FS :=** ______________

OUT402 := ____

OUT403 FAIL-SAFE (Y, N) **OUT403FS :=** ______________

OUT403 := ____

OUT404 FAIL-SAFE (Y, N) **OUT404FS :=** ______________

OUT404 := ____

OUT405 FAIL-SAFE (Y, N) **OUT405FS :=** ______________

OUT405 := ____

OUT406 FAIL-SAFE (Y, N) **OUT406FS :=** ______________

OUT406 := ____

OUT407 FAIL-SAFE (Y, N) **OUT407FS :=** ______________

OUT407 := ____

OUT408 FAIL-SAFE (Y, N) **OUT408FS :=** ______________

OUT408 := ____

Slot E Output

(Hidden when an output option is not included. The number of outputs depends on the I/O card option.)

OUT501 FAIL-SAFE (Y, N) **OUT501FS :=** ______________

OUT501 := ____

OUT502 FAIL-SAFE (Y, N) **OUT502FS :=** ______________

OUT502 := ____

OUT503 FAIL-SAFE (Y, N) **OUT503FS :=** ______________

OUT503 := ____

OUT504 FAIL-SAFE (Y, N) **OUT504FS :=** ______________

OUT504 := ____

OUT505 FAIL-SAFE (Y, N) **OUT505FS :=** ______________

OUT505 := ____

OUT506 FAIL-SAFE (Y, N) **OUT506FS :=** ____________

OUT506 := ____

OUT507 FAIL-SAFE (Y, N) **OUT507FS :=** ____________

OUT507 := ____

OUT508 FAIL-SAFE (Y, N) **OUT508FS :=** ____________

OUT508 := ____

MIRRORED BITS Transmit SELOGIC Control Equations

(Hidden if PROTO is not MBxx on any of the communications ports)

TMB1A := ____

TMB2A := ____

TMB3A := ____

TMB4A := ____

TMB5A := ____

TMB6A := ____

TMB7A := ____

TMB8A := ____

TMB1B := ____

TMB2B := ____

TMB3B := ____

TMB4B := ____

TMB5B := ____

TMB6B := ____

TMB7B := ____

TMB8B := ____

Global Settings

General

PHASE ROTATION (ABC, ACB) **PHROT :=** ____________

RATED FREQ. (50, 60 Hz) **FNOM :=** ____________

DATE FORMAT (MDY, YMD, DMY) **DATE_F :=** ____________

MET CUTOFF THRES (Y, N) **METHRES :=** ____________

FAULT CONDITION (SELOGIC) **FAULT :=** ____________

Broken Bar Detection

(Shown when SYNTYPE := NONE)

EN BRKN BAR DET (AUTO_SET, MANUAL_SET, N) **EBBD :=** ____________

(The following broken bar detection settings are hidden and set to default values when EBBD := AUTO_SET; they are shown when EBBD := MANUAL_SET; and they are hidden when EBBD := N)

BBD RUN RATE (1–180 min) **BBDTD :=** ____________

FREQ LOWER BOUND (0.0–1.0 Hz)	**BBDLB :=** _____________
FREQ UPPER BOUND (2.0–10.0 Hz)	**BBDUB :=** _____________
BBD LEVEL1 PU (–80 to –1 dB)	**BBDTH1 :=** _____________
BBD LEVEL2 PU (–80 to –1 dB)	**BBDTH2 :=** _____________
BBD LEVEL3 PU (–80 to –1 dB)	**BBDTH3 :=** _____________
BBD LEVEL4 PU (–80 to –1 dB)	**BBDTH4 :=** _____________
BBD MIN MARGIN (1–80 dB)	**MAR_AVG :=** _____________
DF FROM FNOM (0.10–3.00 Hz)	**FNOM_TH :=** _____________
DF FROM INI FREQ (0.01–10.00 Hz)	**F0_TH :=** _____________
DI FROM INI CURR (0.01–1.00 xFLA)	**I0_TH :=** _____________
BLK BELOW CUR LV (0.20–2.00 xFLA)	**I_TH :=** _____________

LEA Phase Voltages

(The following LEA phase voltage settings are shown if Slot Z = L1)

VA RATIO CORRECT (0.500–1.500)	**VARCF :=** _____________
VB RATIO CORRECT (0.500–1.500)	**VBRCF :=** _____________
VC RATIO CORRECT (0.500–1.500)	**VCRCF :=** _____________
VA ANGLE CORRECT (–10.0 to 10.0 deg)	**VAPAC :=** _____________
VB ANGLE CORRECT (–10.0 to 10.0 deg)	**VBPAC :=** _____________
VC ANGLE CORRECT (–10.0 to 10.0 deg)	**VCPAC :=** _____________

LEA Phase Currents

(The following LEA phase current settings are shown if Slot Z = L1)

IA RATIO CORRECT (0.900–1.100)	**IARCF :=** _____________
IB RATIO CORRECT (0.900–1.100)	**IBRCF :=** _____________
IC RATIO CORRECT (0.900–1.100)	**ICRCF :=** _____________
IA ANGLE CORRECT (–10.0 to 10.0 deg)	**IAPAC :=** _____________
IB ANGLE CORRECT (–10.0 to 10.0 deg)	**IBPAC :=** _____________
IC ANGLE CORRECT (–10.0 to 10.0 deg)	**ICPAC :=** _____________
IN RATIO CORRECT (0.900–1.100)	**INRCF :=** _____________
IN ANGLE CORRECT (–10.0 to 10.0 deg)	**INPAC :=** _____________

Group Selection

GRP CHG DELAY (0–400 sec)	**TGR :=** _____________
SELECT GROUP1 (SELOGIC)	**SS1 :=** _____________
SELECT GROUP2 (SELOGIC)	**SS2 :=** _____________
SELECT GROUP3 (SELOGIC)	**SS3 :=** _____________
SELECT GROUP4 (SELOGIC)	**SS4 :=** _____________

Time and Date Management

CTRL BITS DEFN (NONE, C37.118) *(Hidden when the PTC option is selected)*	**IRIGC :=** ______________
OFFSET FROM UTC (–24.00 to 24.00 hours) *(Automatically rounds up to the nearest quarter)*	**UTC_OFF :=** ______________
MONTH TO BEGIN DST (OFF, 1–12)	**DST_BEGM :=** ______________
WEEK OF THE MONTH TO BEGIN DST (1–3, L) *(Hidden when DST_BEGM is OFF; L is the last week of the month)*	**DST_BEGW :=** ______________
DAY OF THE WEEK TO BEGIN DST (SUN–SAT) *(Hidden when DST_BEGM is OFF)*	**DST_BEGD :=** ______________
LOCAL HOUR TO BEGIN DST (0–23) *(Hidden when DST_BEGM is OFF)*	**DST_BEGH :=** ______________
MONTH TO END DST (1–12) *(Hidden when DST_BEGM is OFF)*	**DST_ENDM :=** ______________
WEEK OF THE MONTH TO END DST (1–3, L) *(Hidden when DST_BEGM is OFF; L is the last week of the month)*	**DST_ENDW :=** ______________
DAY OF THE WEEK TO END DST (SUN–SAT) *(Hidden when DST_BEGM is OFF)*	**DST_ENDD :=** ______________
LOCAL HOUR TO END DST (0–23) *(Hidden when DST_BEGM is OFF)*	**DST_ENDH :=** ______________

Breaker Failure

52A INTERLOCK (Y, N)	**52ABF :=** ______________
CURRENT DETECTOR (0.10–10.00 A {5 A nom}, 0.02–2.00 A {1 A nom})	**50BFP :=** ______________
RES CUR DETECTOR (OFF, 0.10–10.00 A {5 A nom}, 0.02–2.00 A {1 A nom})	**50BFG :=** ______________
BK FAILURE DELAY (0.00–2.00 sec) *(When ATD ≠ OFF, BFD should be <ATD)*	**BFD :=** ______________
AUX TIMER DELAY (OFF, 0.00–2.00 sec)	**ATD :=** ______________
BK FAIL INITIATE (SELOGIC)	**BFI :=** ______________
BF SEAL-IN DELAY (OFF, 0.00–2.00 sec)	**BFISID :=** ______________
BF RETRIP DELAY (OFF, 0.00–2.00 sec)	**BFRTD :=** ______________
BF TRIP EQUATION (SELOGIC)	**BFTR :=** ______________
BF UNLATCH EQN (SELOGIC)	**BFULTR :=** ______________

Arc-Flash Protection

(The following arc-flash settings are hidden until an arc-flash card (74 or 76) is inserted in Slot E)

AF PH OC TRIP LVL (OFF, 0.50–100.00 A {5 A nom phase}, 0.10–20.00 A {1 A nom phase})	**50PAFP :=**___________
AF N OC TRP LVL (OFF, 0.01-2.00 A for 1 A nominal neutral; OFF, 0.05-10.00 A for 5 A nominal neutral) (*Hidden if 2.5 mA neutral*) *(Hidden if 50AFP := OFF)*	**50NAFP :=**___________
SENSOR 1 TYPE (NONE, POINT, FIBER)	**AFSENS1 :=**___________
TOL 1 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) *(Hidden if AFSENS1 := NONE)*	**TOL1P :=**___________
SENSOR 2 TYPE (NONE, POINT, FIBER)	**AFSENS2 :=**___________
TOL 2 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) *(Hidden if AFSENS2 := NONE)*	**TOL2P :=**___________
SENSOR 3 TYPE (NONE, POINT, FIBER)	**AFSENS3 :=**___________

TOL 3 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER})
(Hidden if AFSENS3 := NONE) **TOL3P :=**__________

SENSOR 4 TYPE (NONE, POINT, FIBER) **AFSENS4 :=**__________

TOL 4 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER})
(Hidden if AFSENS4 := NONE) **TOL4P :=**__________

SENSOR 5 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*) **AFSENS5 :=**__________

TOL 5 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*) **TOL5P :=**__________

SENSOR 6 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*) **AFSENS6 :=**__________

TOL 6 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*) **TOL6P :=**__________

SENSOR 7 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*) **AFSENS7 :=**__________

TOL 7 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*) **TOL7P :=**__________

SENSOR 8 TYPE (None, Point, Fiber) (*Shown if Slot E = 77*) **AFSENS8 :=**__________

TOL 8 PICKUP (3.0–80.0% {POINT}, 0.6–80.0% {FIBER}) (*Shown if Slot E = 77*) **TOL8P :=**__________

AFD OUTPUT SLOT (101_3, 301_4, 401_4) **AOUTSLOT :=**__________
(301_4 and 401_4 are not available when the slots do not have an output card.)

AIx01

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx01 TAG NAME (8 characters) **AIx01NAM :=** __________
(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)

AIx01 TYPE (I, V) **AIx01TYP :=** __________
(The type selection must match the hardware jumper selection on the card)

AIx01 LOW IN VAL (–20.480 to 20.480 mA) **AIx01L :=** __________
(Hidden when AIx01TYP := V)

AIx01 HI IN VAL (–20.480 to 20.480 mA) **AIx01H :=** __________
(Hidden when AIx01TYP := V)

AIx01 LOW IN VAL (–10.240 to 10.240 V) **AIx01L :=** __________
(Hidden when AIx01TYP := I)

AIx01 HI IN VAL (–10.240 to 10.240 V) **AIx01H :=** __________
(Hidden when AIx01TYP := I)

AIx01 ENG UNITS (16 characters) **AIx01EU :=** __________

AIx01 EU LOW (–99999.000 to 99999.000) **AIx01EL :=** __________

AIx01 EU HI (–99999.000 to 99999.000) **AIx01EH :=** __________
(Must be greater than AIx01EL setting)

AIx01 LO WARN L1 (OFF, –99999.000 to 99999.000) **AIx01LW1 :=** __________

AIx01 LO WARN 2 (OFF, –99999.000 to 99999.000) **AIx01LW2 :=** __________

AIx01 LO ALARM (OFF, –99999.000 to 99999.000) **AIx01LAL :=** __________

AIx01 HI WARN L1 (OFF, –99999.000 to 99999.000) **AIx01HW1 :=** __________

AIx01 HI WARN L2 (OFF, –99999.000 to 99999.000) **AIx01HW2 :=** __________

AIx01 HI ALARM (OFF, –99999.000 to 99999.000) **AIx01HAL :=** __________

AIx02

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx02 TAG NAME (8 characters) **AIx02NAM :=** ____________
(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)

AIx02 TYPE (I, V) **AIx02TYP :=** ____________
(The type selection must match the hardware jumper selection on the card)

AIx02 LOW IN VAL (–20.480 to 20.480 mA) **AIx02L :=** ____________
(Hidden when AIx02TYP := V)

AIx02 HI IN VAL (–20.480 to 20.480 mA) **AIx02H :=** ____________
(Hidden when AIx02TYP := V)

AIx02 LOW IN VAL (–10.240 to 10.240 V) **AIx02L :=** ____________
(Hidden when AIx02TYP := I)

AIx02 HI IN VAL (–10.240 to 10.240 V) **AIx02H :=** ____________
(Hidden when AIx02TYP := I)

AIx02 ENG UNITS (16 characters) **AIx02EU :=** ____________

AIx02 EU LOW (–99999.000 to 99999.000) **AIx02EL :=** ____________

AIx02 EU HI (–99999.000 to 99999.000) **AIx02EH :=** ____________
(Must be greater than AIx02EL setting)

AIx02 LO WARN L1 (OFF, –99999.000 to 99999.000) **AIx02LW1 :=** ____________

AIx02 LO WARN 2 (OFF, –99999.000 to 99999.000) **AIx02LW2 :=** ____________

AIx02 LO ALARM (OFF, –99999.000 to 99999.000) **AIx02LAL :=** ____________

AIx02 HI WARN L1 (OFF, –99999.000 to 99999.000) **AIx02HW1 :=** ____________

AIx02 HI WARN L2 (OFF, –99999.000 to 99999.000) **AIx02HW2 :=** ____________

AIx02 HI ALARM (OFF, –99999.000 to 99999.000) **AIx02HAL :=** ____________

AIx03

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx03 TAG NAME (8 characters) **AIx03NAM :=** ____________
(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)

AIx03 TYPE (I, V) **AIx03TYP :=** ____________
(The type selection must match the hardware jumper selection on the card)

AIx03 LOW IN VAL (–20.480 to 20.480 mA) **AIx03L :=** ____________
(Hidden when AIx03TYP := V)

AIx03 HI IN VAL (–20.480 to 20.480 mA) **AIx03H :=** ____________
(Hidden when AIx03TYP := V)

AIx03 LOW IN VAL (–10.240 to 10.240 V) **AIx03L :=** ____________
(Hidden when AIx03TYP := I)

AIx03 HI IN VAL (–10.240 to 10.240 V) **AIx03H :=** ____________
(Hidden when AIx03TYP := I)

AIx03 ENG UNITS (16 characters) **AIx03EU :=** ____________

AIx03 EU LOW (–99999.000 to 99999.000) **AIx03EL :=** ____________

AIx03 EU HI (–99999.000 to 99999.000) **AIx03EH :=** ____________
(Must be greater than AIx03EL setting)

AIx03 LO WARN L1 (OFF, –99999.000 to 99999.000) **AIx03LW1 :=** ______________

AIx03 LO WARN 2 (OFF, –99999.000 to 99999.000) **AIx03LW2 :=** ______________

AIx03 LO ALARM (OFF, –99999.000 to 99999.000) **AIx03LAL :=** ______________

AIx03 HI WARN L1 (OFF, –99999.000 to 99999.000) **AIx03HW1 :=** ______________

AIx03 HI WARN L2 (OFF, –99999.000 to 99999.000) **AIx03HW2 :=** ______________

AIx03 HI ALARM (OFF, –99999.000 to 99999.000) **AIx03HAL :=** ______________

AIx04

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx04 TAG NAME (8 characters) **AIx04NAM :=** ______________
(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)

AIx04 TYPE (I, V) **AIx04TYP :=** ______________
(The type selection must match the hardware jumper selection on the card)

AIx04 LOW IN VAL (–20.480 to 20.480 mA) **AIx04L :=** ______________
(Hidden when AIx04TYP := V)

AIx04 HI IN VAL (–20.480 to 20.480 mA) **AIx04H :=** ______________
(Hidden when AIx04TYP := V)

AIx04 LOW IN VAL (–10.240 to 10.240 V) **AIx04L :=** ______________
(Hidden when AIx04TYP := I)

AIx04 HI IN VAL (–10.240 to 10.240 V) **AIx04H :=** ______________
(Hidden when AIx04TYP := I)

AIx04 ENG UNITS (16 characters) **AIx04EU :=** ______________

AIx04 EU LOW (–99999.000 to 99999.000) **AIx04EL :=** ______________

AIx04 EU HI (–99999.000 to 99999.000) **AIx04EH :=** ______________
(Must be greater than AIx04EL setting)

AIx04 LO WARN L1 (OFF, –99999.000 to 99999.000) **AIx04LW1 :=** ______________

AIx04 LO WARN 2 (OFF, –99999.000 to 99999.000) **AIx04LW2 :=** ______________

AIx04 LO ALARM (OFF, –99999.000 to 99999.000) **AIx04LAL :=** ______________

AIx04 HI WARN L1 (OFF, –99999.000 to 99999.000) **AIx04HW1 :=** ______________

AIx04 HI WARN L2 (OFF, –99999.000 to 99999.000) **AIx04HW2 :=** ______________

AIx04 HI ALARM (OFF, –99999.000 to 99999.000) **AIx04HAL :=** ______________

AIx05

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx05 TAG NAME (8 characters) **AIx05NAM :=** ______________
(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)

AIx05 TYPE (I, V) **AIx05TYP :=** ______________
(The type selection must match the hardware jumper selection on the card)

AIx05 LOW IN VAL (–20.480 to 20.480 mA) **AIx05L :=** ______________
(Hidden when AIx05TYP := V)

AIx05 HI IN VAL (–20.480 to 20.480 mA) *(Hidden when AIx05TYP := V)*	**AIx05H :=** ______________
AIx05 LOW IN VAL (–10.240 to 10.240 V) *(Hidden when AIx05TYP := I)*	**AIx05L :=** ______________
AIx05 HI IN VAL (–10.240 to 10.240 V) *(Hidden when AIx05TYP := I)*	**AIx05H :=** ______________
AIx05 ENG UNITS (16 characters)	**AIx05EU :=** ______________
AIx05 EU LOW (–99999.000 to 99999.000)	**AIx05EL :=** ______________
AIx05 EU HI (–99999.000 to 99999.000) *(Must be greater than AIx05EL setting)*	**AIx05EH :=** ______________
AIx05 LO WARN L1 (OFF, –99999.000 to 99999.000)	**AIx05LW1 :=** ______________
AIx05 LO WARN 2 (OFF, –99999.000 to 99999.000)	**AIx05LW2 :=** ______________
AIx05 LO ALARM (OFF, –99999.000 to 99999.000)	**AIx05LAL :=** ______________
AIx05 HI WARN L1 (OFF, –99999.000 to 99999.000)	**AIx05HW1 :=** ______________
AIx05 HI WARN L2 (OFF, –99999.000 to 99999.000)	**AIx05HW2 :=** ______________
AIx05 HI ALARM (OFF, –99999.000 to 99999.000)	**AIx05HAL :=** ______________

AIx06

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx06 TAG NAME (8 characters) *(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)*	**AIx06NAM :=** ______________
AIx06 TYPE (I, V) *(The type selection must match the hardware jumper selection on the card)*	**AIx06TYP :=** ______________
AIx06 LOW IN VAL (–20.480 to 20.480 mA) *(Hidden when AIx06TYP := V)*	**AIx06L :=** ______________
AIx06 HI IN VAL (–20.480 to 20.480 mA) *(Hidden when AIx06TYP := V)*	**AIx06H :=** ______________
AIx06 LOW IN VAL (–10.240 to 10.240 V) *(Hidden when AIx06TYP := I)*	**AIx06L :=** ______________
AIx06 HI IN VAL (–10.240 to 10.240 V) *(Hidden when AIx06TYP := I)*	**AIx06H :=** ______________
AIx06 ENG UNITS (16 characters)	**AIx06EU :=** ______________
AIx06 EU LOW (–99999.000 to 99999.000)	**AIx06EL :=** ______________
AIx06 EU HI (–99999.000 to 99999.000) *(Must be greater than AIx06EL setting)*	**AIx06EH :=** ______________
AIx06 LO WARN L1 (OFF, –99999.000 to 99999.000)	**AIx06LW1 :=** ______________
AIx06 LO WARN 2 (OFF, –99999.000 to 99999.000)	**AIx06LW2 :=** ______________
AIx06 LO ALARM (OFF, –99999.000 to 99999.000)	**AIx06LAL :=** ______________
AIx06 HI WARN L1 (OFF, –99999.000 to 99999.000)	**AIx06HW1 :=** ______________
AIx06 HI WARN L2 (OFF, –99999.000 to 99999.000)	**AIx06HW2 :=** ______________
AIx06 HI ALARM (OFF, –99999.000 to 99999.000)	**AIx06HAL :=** ______________

AIx07

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx07 TAG NAME (8 characters) **AIx07NAM :=** _____________
(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)

AIx07 TYPE (I, V) **AIx07TYP :=** _____________
(The type selection must match the hardware jumper selection on the card)

AIx07 LOW IN VAL (–20.480 to 20.480 mA) **AIx07L :=** _____________
(Hidden when AIx07TYP := V)

AIx07 HI IN VAL (–20.480 to 20.480 mA) **AIx07H :=** _____________
(Hidden when AIx07TYP := V)

AIx07 LOW IN VAL (–10.240 to 10.240 V) **AIx07L :=** _____________
(Hidden when AIx07TYP := I)

AIx07 HI IN VAL (–10.240 to 10.240 V) **AIx07H :=** _____________
(Hidden when AIx07TYP := I)

AIx07 ENG UNITS (16 characters) **AIx07EU :=** _____________

AIx07 EU LOW (–99999.000 to 99999.000) **AIx07EL :=** _____________

AIx07 EU HI (–99999.000 to 99999.000) **AIx07EH :=** _____________
(Must be greater than AIx07EL setting)

AIx07 LO WARN L1 (OFF, –99999.000 to 99999.000) **AIx07LW1 :=** _____________

AIx07 LO WARN 2 (OFF, –99999.000 to 99999.000) **AIx07LW2 :=** _____________

AIx07 LO ALARM (OFF, –99999.000 to 99999.000) **AIx07LAL :=** _____________

AIx07 HI WARN L1 (OFF, –99999.000 to 99999.000) **AIx07HW1 :=** _____________

AIx07 HI WARN L2 (OFF, –99999.000 to 99999.000) **AIx07HW2 :=** _____________

AIx07 HI ALARM (OFF, –99999.000 to 99999.000) **AIx07HAL :=** _____________

AIx08

For the following settings, x indicates 3, 4, or 5 for Slot C, D, or E, respectively.
(The heading and all of the associated AI card settings for Slot x appear only when an AI card is installed in the corresponding slot)

AIx08 TAG NAME (8 characters) **AIx08NAM :=** _____________
(Only alphanumeric and underscore characters are permitted, any lowercase entry shall be converted to uppercase; setting must begin with an alpha character A–Z; this setting cannot accept analog quantities or other AI names)

AIx08 TYPE (I, V) **AIx08TYP :=** _____________
(The type selection must match the hardware jumper selection on the card)

AIx08 LOW IN VAL (–20.480 to 20.480 mA) **AIx08L :=** _____________
(Hidden when AIx08TYP := V)

AIx08 HI IN VAL (–20.480 to 20.480 mA) **AIx08H :=** _____________
(Hidden when AIx08TYP := V)

AIx08 LOW IN VAL (–10.240 to 10.240 V) **AIx08L :=** _____________
(Hidden when AIx08TYP := I)

AIx08 HI IN VAL (–10.240 to 10.240 V) **AIx08H :=** _____________
(Hidden when AIx08TYP := I)

AIx08 ENG UNITS (16 characters) **AIx08EU :=** _____________

AIx08 EU LOW (–99999.000 to 99999.000) **AIx08EL :=** _____________

AIx08 EU HI (–99999.000 to 99999.000) **AIx08EH :=** _____________
(Must be greater than AIx08EL setting)

AIx08 LO WARN L1 (OFF, –99999.000 to 99999.000)	**AIx08LW1 :=** _______________
AIx08 LO WARN 2 (OFF, –99999.000 to 99999.000)	**AIx08LW2 :=** _______________
AIx08 LO ALARM (OFF, –99999.000 to 99999.000)	**AIx08LAL :=** _______________
AIx08 HI WARN L1 (OFF, –99999.000 to 99999.000)	**AIx08HW1 :=** _______________
AIx08 HI WARN L2 (OFF, –99999.000 to 99999.000)	**AIx08HW2 :=** _______________
AIx08 HI ALARM (OFF, –99999.000 to 99999.000)	**AIx08HAL :=** _______________

AOx01

For the following settings, x indicates numbers 3, 4, or 5 for slots C, D, or E, respectively.
(The heading and all of the associated AO card settings for Slot x appear only when an AO card is installed in the corresponding slot)

AOx01 ANALOG QTY (OFF, 1 analog quantity) *(Analog quantity to assign to this analog output)*	**AOx01AQ :=** _______________
AOx01 TYPE (I, V) *(Hidden when AOx01AQ := OFF; the type selection must match the hardware jumper selection on the card; the setting is always hidden for 4 DO/3 DI/1 AO card)*	**AOx01TYP :=** _______________
AOx01 AQTY LO (–2147483647.000 to 2147483647.000) *(Hidden when AOx01AQ := OFF)*	**AOx01AQL :=** _______________
AOx01 AQTY HI (–2147483647.000 to 2147483647.000) *(Hidden when AOx01AQ := OFF; must be greater than AOx01AQL setting)*	**AOx01AQH :=** _______________
AOx01 LO OUT VAL (–20.480 to 20.480 mA) *(Hidden when AOx01AQ := OFF or AOx01TYP := V; always hidden for 4 DO/3 DI/1 AO card)*	**AOx01L :=** _______________
AOx01 HI OUT VALUE (–20.480 to 20.480 mA) *(Hidden when AOx01AQ := OFF or AOx01TYP := V; always hidden for 4 DO/3 DI/1 AO card)*	**AOx01H :=** _______________
AOx01 LO OUT VAL (–10.240 to 10.240 V) *(Hidden when AOx01AQ := OFF or AOx01TYP := I; always hidden for 4 DO/3 DI/1 AO card)*	**AOx01L :=** _______________
AOx01 HI OUT VAL (–10.240 to 10.240 V) *(Hidden when AOx01AQ := OFF or AOx01TYP := I; always hidden for 4 DO/3 DI/1 AO card)*	**AOx01H :=** _______________

AOx02

For the following settings, x indicates numbers 3, 4, or 5 for slots C, D, or E, respectively.
(The heading and all of the associated AO card settings for Slot x appear only when an AO card is installed in the corresponding slot)

AOx02 ANALOG QTY (OFF, 1 analog quantity) *(Analog quantity to assign to this analog output)*	**AOx02AQ :=** _______________
AOx02 TYPE (I, V) *(Hidden when AOx02AQ := OFF; the type selection must match the hardware jumper selection on the card; the setting is always hidden for 4 DO/3 DI/1 AO card)*	**AOx02TYP :=** _______________
AOx02 AQTY LO (–2147483647.000 to 2147483647.000) *(Hidden when AOx02AQ := OFF)*	**AOx02AQL :=** _______________
AOx02 AQTY HI (–2147483647.000 to 2147483647.000) *(Hidden when AOx02AQ := OFF; must be greater than AOx02AQL setting)*	**AOx02AQH :=** _______________
AOx02 LO OUT VAL (–20.480 to 20.480 mA) *(Hidden when AOx02AQ := OFF or AOx02TYP := V; always hidden for 4 DO/3 DI/1 AO card)*	**AOx02L :=** _______________

AOx02 HI OUT VALUE (–20.480 to 20.480 mA) **AOx02H := ______________**
(Hidden when AOx02AQ := OFF or AOx02TYP := V; always hidden for 4 DO/3 DI/1 AO card)

AOx02 LO OUT VAL (–10.240 to 10.240 V) **AOx02L := ______________**
(Hidden when AOx02AQ := OFF or AOx02TYP := I; always hidden for 4 DO/3 DI/1 AO card)

AOx02 HI OUT VAL (–10.240 to 10.240 V) **AOx02H := ______________**
(Hidden when AOx02AQ := OFF or AOx02TYP := I; always hidden for 4 DO/3 DI/1 AO card)

AOx03

For the following settings, x indicates numbers 3, 4, or 5 for slots C, D, or E, respectively.
(The heading and all of the associated AO card settings for Slot x appear only when an AO card is installed in the corresponding slot)

AOx03 ANALOG QTY (OFF, 1 analog quantity) **AOx03AQ := ______________**
(Analog quantity to assign to this analog output)

AOx03 TYPE (I, V) **AOx03TYP := ______________**
(Hidden when AOx03AQ := OFF; the type selection must match the hardware jumper selection on the card; the setting is always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx03 AQTY LO (–2147483647.000 to 2147483647.000) **AOx03AQL := ______________**
(Hidden when AOx03AQ := OFF)

AOx03 AQTY HI (–2147483647.000 to 2147483647.000) **AOx03AQH := ______________**
(Hidden when AOx03AQ := OFF; must be greater than AOx03AQL setting)

AOx03 LO OUT VAL (–20.480 to 20.480 mA) **AOx03L := ______________**
(Hidden when AOx03AQ := OFF or AOx03TYP := V; always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx03 HI OUT VALUE (–20.480 to 20.480 mA) **AOx03H := ______________**
(Hidden when AOx03AQ := OFF or AOx03TYP := V; always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx03 LO OUT VAL (–10.240 to 10.240 V) **AOx03L := ______________**
(Hidden when AOx03AQ := OFF or AOx03TYP := I; always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx03 HI OUT VAL (–10.240 to 10.240 V) **AOx03H := ______________**
(Hidden when AOx03AQ := OFF or AOx03TYP := I; always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx04

For the following settings, x indicates numbers 3, 4, or 5 for slots C, D, or E, respectively.
(The heading and all of the associated AO card settings for Slot x appear only when an AO card is installed in the corresponding slot)

AOx04 ANALOG QTY (OFF, 1 analog quantity) **AOx04AQ := ______________**
(Analog quantity to assign to this analog output)

AOx04 TYPE (I, V) **AOx04TYP := ______________**
(Hidden when AOx04AQ := OFF; the type selection must match the hardware jumper selection on the card; the setting is always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx04 AQTY LO (–2147483647.000 to 2147483647.000) **AOx04AQL := ______________**
(Hidden when AOx04AQ := OFF)

AOx04 AQTY HI (–2147483647.000 to 2147483647.000) **AOx04AQH := ______________**
(Hidden when AOx04AQ := OFF; must be greater than AOx04AQL setting)

AOx04 LO OUT VAL (–20.480 to 20.480 mA) **AOx04L := ______________**
(Hidden when AOx04AQ := OFF or AOx04TYP := V; always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx04 HI OUT VALUE (–20.480 to 20.480 mA) **AOx04H :=** ______________
(Hidden when AOx04AQ := OFF or AOx04TYP := V; always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx04 LO OUT VAL (–10.240 to 10.240 V) **AOx04L :=** ______________
(Hidden when AOx04AQ := OFF or AOx04TYP := I; always hidden when a 4 DO/3 DI/1 AO card is installed)

AOx04 HI OUT VAL (–10.240 to 10.240 V) **AOx04H :=** ______________
(Hidden when AOx04AQ := OFF or AOx04TYP := I; always hidden when a 4 DO/3 DI/1 AO card is installed)

Breaker Monitor

BREAKER MONITOR (Y, N) **EBMON :=** ______________
(Hidden if EBMON := N)

CL/OPN OPS SETPT 1 (0–65000) **COSP1 :=** ______________
(COSP1 must be > COSP2)

CL/OPN OPS SETPT 2 (0–65000) **COSP2 :=** ______________
(COSP2 must be ≥ COSP3)

CL/OPN OPS SETPT 3 (0–65000) **COSP3 :=** ______________

kA PRI INTERRPTD 1 (0.10–999.00) **KASP1 :=** ______________
(KASP1 must be < KASP2)

kA PRI INTERRPTD 2 (0.10–999.00) **KASP2 :=** ______________
(KASP2 must be ≤ KASP3)

kA PRI INTERRPTD 3 (0.10–999.00) **KASP3 :=** ______________
(KASP3 must be at least 5 times but no more than 100 times the KASP1 value)

BRKR MON CONTROL (SELOGIC) **BKMON :=** ______________

____

Data Reset

RESET TARGETS (SELOGIC) **RSTTRGT :=** ______________

____

RESET ENERGY (SELOGIC) **RSTENRGY :=** ______________

____

RESET MAX/MIN (SELOGIC) **RSTMXMN :=** ______________

____

RESET MOT REPORT (SELOGIC) **RSTMOT :=** ______________

____

Access Control

(DSABLSET applies only to the front panel, DSABLSET := 1 does not prevent settings change via the SET serial port command)

DISABLE SETTINGS (SELOGIC) **DSABLSET :=** ______________

____

Time-Synchronization Source

(Category is hidden when PTC is available)

IRIG TIME SOURCE (IRIG1, IRIG2) **TIME_SRC :=** ______________

Two-Position Disconnect

EN 2P DISC (N, 1–8)	**89EN2P** := ______________
2P DISC 1 NAME (16 characters)	**89NM2P1** := ______________
2P DISC 1 MODE (Control, Monitor)	**89MD2P1** := ______________
DISC 1 N/O CONT (SELOGIC)	**89A2P1** := ______________
DISC 1 N/C CONT (SELOGIC)	**89B2P1** := ______________
DISC 1 ALM PU (0.00–300.00 sec)	**89A2P1D** := ______________
DISC 1 SEALIN (0.00–300.00 sec)	**89S2P1D** := ______________
DISC 1 IMMOBI (0.00–300.00 sec)	**89I2P1D** := ______________
DISC 1 CL CONT (SELOGIC)	**89RC2P1** := ______________
DISC 1 CL BLK (SELOGIC)	**89CB2P1** := ______________
DISC 1 CL RST (SELOGIC)	**89CR2P1** := ______________
DISC 1 CL IM RS (SELOGIC)	**89CT2P1** := ______________
DISC 1 OP CONT (SELOGIC)	**89RO2P1** := ______________
DISC 1 OP BLK (SELOGIC)	**89OB2P1** := ______________
DISC 1 OP RST (SELOGIC)	**89OR2P1** := ______________
DISC 1 OP IM RS (SELOGIC)	**89OT2P1** := ______________
2P DISC 2 NAME (16 characters)	**89NM2P2** := ______________
2P DISC 2 MODE (Control, Monitor)	**89MD2P2** := ______________
DISC 2 N/O CONT (SELOGIC)	**89A2P2** := ______________
DISC 2 N/C CONT (SELOGIC)	**89B2P2** := ______________
DISC 2 ALM PU (0.00–300.00 sec)	**89A2P2D** := ______________
DISC 2 SEALIN (0.00–300.00 sec)	**89S2P2D** := ______________
DISC 2 IMMOBI (0.00–300.00 sec)	**89I2P2D** := ______________
DISC 2 CL CONT (SELOGIC)	**89RC2P2** := ______________
DISC 2 CL BLK (SELOGIC)	**89CB2P2** := ______________
DISC 2 CL RST (SELOGIC)	**89CR2P2** := ______________
DISC 2 CL IM RS (SELOGIC)	**89CT2P2** := ______________
DISC 2 OP CONT (SELOGIC)	**89RO2P2** := ______________
DISC 2 OP BLK (SELOGIC)	**89OB2P2** := ______________
DISC 2 OP RST (SELOGIC)	**89OR2P2** := ______________
DISC 2 OP IM RS (SELOGIC)	**89OT2P2** := ______________
2P DISC 3 NAME (16 characters)	**89NM2P3** := ______________
2P DISC 3 MODE (Control, Monitor)	**89MD2P3** := ______________
DISC 3 N/O CONT (SELOGIC)	**89A2P3** := ______________
DISC 3 N/C CONT (SELOGIC)	**89B2P3** := ______________
DISC 3 ALM PU (0.00–300.00 sec)	**89A2P3D** := ______________
DISC 3 SEALIN (0.00–300.00 sec)	**89S2P3D** := ______________
DISC 3 IMMOBI (0.00–300.00 sec)	**89I2P3D** := ______________
DISC 3 CL CONT (SELOGIC)	**89RC2P3** := ______________
DISC 3 CL BLK (SELOGIC)	**89CB2P3** := ______________

DISC 3 CL RST (SELOGIC)	**89CR2P3 :=** _______________
DISC 3 CL IM RS (SELOGIC)	**89CT2P3 :=** _______________
DISC 3 OP CONT (SELOGIC)	**89RO2P3 :=** _______________
DISC 3 OP BLK (SELOGIC)	**89OB2P3 :=** _______________
DISC 3 OP RST (SELOGIC)	**89OR2P3 :=** _______________
DISC 3 OP IM RS (SELOGIC)	**89OT2P3 :=** _______________
2P DISC 4 NAME (16 characters)	**89NM2P4 :=** _______________
2P DISC 4 MODE (Control, Monitor)	**89MD2P4 :=** _______________
DISC 4 N/O CONT (SELOGIC)	**89A2P4 :=** _______________
DISC 4 N/C CONT (SELOGIC)	**89B2P4 :=** _______________
DISC 4 ALM PU (0.00–300.00 sec)	**89A2P4D :=** _______________
DISC 4 SEALIN (0.00–300.00 sec)	**89S2P4D :=** _______________
DISC 4 IMMOBI (0.00–300.00 sec)	**89I2P4D :=** _______________
DISC 4 CL CONT (SELOGIC)	**89RC2P4 :=** _______________
DISC 4 CL BLK (SELOGIC)	**89CB2P4 :=** _______________
DISC 4 CL RST (SELOGIC)	**89CR2P4 :=** _______________
DISC 4 CL IM RS (SELOGIC)	**89CT2P4 :=** _______________
DISC 4 OP CONT (SELOGIC)	**89RO2P4 :=** _______________
DISC 4 OP BLK (SELOGIC)	**89OB2P4 :=** _______________
DISC 4 OP RST (SELOGIC)	**89OR2P4 :=** _______________
DISC 4 OP IM RS (SELOGIC)	**89OT2P4 :=** _______________
2P DISC 5 NAME (16 characters)	**89NM2P5 :=** _______________
2P DISC 5 MODE (Control, Monitor)	**89MD2P5 :=** _______________
DISC 5 N/O CONT (SELOGIC)	**89A2P5 :=** _______________
DISC 5 N/C CONT (SELOGIC)	**89B2P5 :=** _______________
DISC 5 ALM PU (0.00–300.00 sec)	**89A2P5D :=** _______________
DISC 5 SEALIN (0.00–300.00 sec)	**89S2P5D :=** _______________
DISC 5 IMMOBI (0.00–300.00 sec)	**89I2P5D :=** _______________
DISC 5 CL CONT (SELOGIC)	**89RC2P5 :=** _______________
DISC 5 CL BLK (SELOGIC)	**89CB2P5 :=** _______________
DISC 5 CL RST (SELOGIC)	**89CR2P5 :=** _______________
DISC 5 CL IM RS (SELOGIC)	**89CT2P5 :=** _______________
DISC 5 OP CONT (SELOGIC)	**89RO2P5 :=** _______________
DISC 5 OP BLK (SELOGIC)	**89OB2P5 :=** _______________
DISC 5 OP RST (SELOGIC)	**89OR2P5 :=** _______________
DISC 5 OP IM RS (SELOGIC)	**89OT2P5 :=** _______________
2P DISC 6 NAME (16 characters)	**89NM2P6 :=** _______________
2P DISC 6 MODE (Control, Monitor)	**89MD2P6 :=** _______________
DISC 6 N/O CONT (SELOGIC)	**89A2P6 :=** _______________
DISC 6 N/C CONT (SELOGIC)	**89B2P6 :=** _______________
DISC 6 ALM PU (0.00–300.00 sec)	**89A2P6D :=** _______________

DISC 6 SEALIN (0.00–300.00 sec)	89S2P6D := _______________
DISC 6 IMMOBI (0.00–300.00 sec)	89I2P6D := _______________
DISC 6 CL CONT (SELOGIC)	89RC2P6 := _______________
DISC 6 CL BLK (SELOGIC)	89CB2P6 := _______________
DISC 6 CL RST (SELOGIC)	89CR2P6 := _______________
DISC 6 CL IM RS (SELOGIC)	89CT2P6 := _______________
DISC 6 OP CONT (SELOGIC)	89RO2P6 := _______________
DISC 6 OP BLK (SELOGIC)	89OB2P6 := _______________
DISC 6 OP RST (SELOGIC)	89OR2P6 := _______________
DISC 6 OP IM RS (SELOGIC)	89OT2P6 := _______________
2P DISC 7 NAME (16 characters)	89NM2P7 := _______________
2P DISC 7 MODE (Control, Monitor)	89MD2P7 := _______________
DISC 7 N/O CONT (SELOGIC)	89A2P7 := _______________
DISC 7 N/C CONT (SELOGIC)	89B2P7 := _______________
DISC 7 ALM PU (0.00–300.00 sec)	89A2P7D := _______________
DISC 7 SEALIN (0.00–300.00 sec)	89S2P7D := _______________
DISC 7 IMMOBI (0.00–300.00 sec)	89I2P7D := _______________
DISC 7 CL CONT (SELOGIC)	89RC2P7 := _______________
DISC 7 CL BLK (SELOGIC)	89CB2P7 := _______________
DISC 7 CL RST (SELOGIC)	89CR2P7 := _______________
DISC 7 CL IM RS (SELOGIC)	89CT2P7 := _______________
DISC 7 OP CONT (SELOGIC)	89RO2P7 := _______________
DISC 7 OP BLK (SELOGIC)	89OB2P7 := _______________
DISC 7 OP RST (SELOGIC)	89OR2P7 := _______________
DISC 7 OP IM RS (SELOGIC)	89OT2P7 := _______________
2P DISC 8 NAME (16 characters)	89NM2P8 := _______________
2P DISC 8 MODE (Control, Monitor)	89MD2P8 := _______________
DISC 8 N/O CONT (SELOGIC)	89A2P8 := _______________
DISC 8 N/C CONT (SELOGIC)	89B2P58 := _______________
DISC 8 ALM PU (0.00–300.00 sec)	89A2P8D := _______________
DISC 8 SEALIN (0.00–300.00 sec)	89S2P8D := _______________
DISC 8 IMMOBI (0.00–300.00 sec)	89I2P8D := _______________
DISC 8 CL CONT (SELOGIC)	89RC2P8 := _______________
DISC 8 CL BLK (SELOGIC)	89CB2P8 := _______________
DISC 8 CL RST (SELOGIC)	89CR2P8 := _______________
DISC 8 CL IM RS (SELOGIC)	89CT2P8 := _______________
DISC 8 OP CONT (SELOGIC)	89RO2P8 := _______________
DISC 8 OP BLK (SELOGIC)	89OB2P8 := _______________
DISC 8 OP RST (SELOGIC)	89OR2P8 := _______________
DISC 8 OP IM RS (SELOGIC)	89OT2P8 := _______________

Three-Position Disconnect

EN 3P DISC (N, 1–2)	**89EN3P** := ______________
3P DISC 1 NAME (16 characters)	**89NM3P1** := ______________
3P DISC 1 MODE (Control, Monitor)	**89MD3P1** := ______________
LDISC 1 N/O CONT (SELOGIC)	**89A3PL1** := ______________
LDISC 1 N/C CONT (SELOGIC)	**89B3PL1** := ______________
LDISC 1 ALM PU CONT (0.00–300.00 sec)	**89A3PL1D** := ______________
LDISC 1 SEALIN (0.00–300.00 sec)	**89S3PL1D** := ______________
LDISC 1 IMMOBI (0.00–300.00 sec)	**89I3PL1D** := ______________
LDISC 1 CL CONT (SELOGIC)	**89RC3PL1** := ______________
LDISC 1 CL BLK (SELOGIC)	**89CB3PL1** := ______________
LDISC 1 CL RST (SELOGIC)	**89CR3PL1** := ______________
LDISC 1 CL IM RS (SELOGIC)	**89CT3PL1** := ______________
LDISC 1 OP CONT (SELOGIC)	**89RO3PL1** := ______________
LDISC 1 OP BLK (SELOGIC)	**89OB3PL1** := ______________
LDISC 1 OP RST (SELOGIC)	**89OR3PL1** := ______________
LDISC 1 OP IM RS (SELOGIC)	**89OT3PL1** := ______________
EDISC 1 N/O CONT (SELOGIC)	**89A3PE1** := ______________
EDISC 1 N/C CONT (SELOGIC)	**89B3PE1** := ______________
EDISC 1 ALM PU CONT (0.00–300.00 sec)	**89A3PE1D** := ______________
EDISC 1 SEALIN (0.00–300.00 sec)	**89S3PE1D** := ______________
EDISC 1 IMMOBI (0.00–300.00 sec)	**89I3PE1D** := ______________
EDISC 1 CL CONT (SELOGIC)	**89RC3PE1** := ______________
EDISC 1 CL BLK (SELOGIC)	**89CB3PE1** := ______________
EDISC 1 CL RST (SELOGIC)	**89CR3PE1** := ______________
EDISC 1 CL IM RS (SELOGIC)	**89CT3PE1** := ______________
EDISC 1 OP CONT (SELOGIC)	**89RO3PE1** := ______________
EDISC 1 OP BLK (SELOGIC)	**89OB3PE1** := ______________
EDISC 1 OP RST (SELOGIC)	**89OR3PE1** := ______________
EDISC 1 OP IM RS (SELOGIC)	**89OT3PE1** := ______________
3P DISC 2 NAME (16 characters)	**89NM3P2** := ______________
3P DISC 2 MODE (Control, Monitor)	**89MD3P2** := ______________
LDISC 2 N/O CONT (SELOGIC)	**89A3PL2** := ______________
LDISC 2 N/C CONT (SELOGIC)	**89B3PL2** := ______________
LDISC 2 ALM PU CONT (0.00–300.00 sec)	**89A3PL2D** := ______________
LDISC 2 SEALIN (0.00–300.00 sec)	**89S3PL2D** := ______________
LDISC 2 IMMOBI (0.00–300.00 sec)	**89I3PL2D** := ______________
LDISC 2 CL CONT (SELOGIC)	**89RC3PL2** := ______________
LDISC 2 CL BLK (SELOGIC)	**89CB3PL2** := ______________
LDISC 2 CL RST (SELOGIC)	**89CR3PL2** := ______________
LDISC 2 CL IM RS (SELOGIC)	**89CT3PL2** := ______________

LDISC 2 OP CONT (SELOGIC)	**89RO3PL2 :=** ______________
LDISC 2 OP BLK (SELOGIC)	**89OB3PL2 :=** ______________
LDISC 2 OP RST (SELOGIC)	**89OR3PL2 :=** ______________
LDISC 2 OP IM RS (SELOGIC)	**89OT3PL2 :=** ______________
EDISC 2 N/O CONT (SELOGIC)	**89A3PE2 :=** ______________
EDISC 2 N/C CONT (SELOGIC)	**89B3PE2 :=** ______________
EDISC 2 ALM PU CONT (0.00–300.00 sec)	**89A3PE2D :=** ______________
EDISC 2 SEALIN (0.00–300.00 sec)	**89S3PE2D :=** ______________
EDISC 2 IMMOBI (0.00–300.00 sec)	**89I3PE2D :=** ______________
EDISC 2 CL CONT (SELOGIC)	**89RC3PE2 :=** ______________
EDISC 2 CL BLK (SELOGIC)	**89CB3PE2 :=** ______________
EDISC 2 CL RST (SELOGIC)	**89CR3PE2 :=** ______________
EDISC 2 CL IM RS (SELOGIC)	**89CT3PE2 :=** ______________
EDISC 2 OP CONT (SELOGIC)	**89RO3PE2 :=** ______________
EDISC 2 OP BLK (SELOGIC)	**89OB3PE2 :=** ______________
EDISC 2 OP RST (SELOGIC)	**89OR3PE2 :=** ______________
EDISC 2 OP IM RS (SELOGIC)	**89OT3PE2 :=** ______________

Control Configuration

ENABLE LOC REM CON (Y, N)	**EN_LRC :=** ______________
LOCAL CONTROL (SELOGIC)	**LOCAL :=** ______________

61850 Mode Control

(Hidden when IEC 61850 is not supported)

CONTROL FOR IEC 61850 BLOCKED MODE (SELOGIC)	**SC850BM :=** ______________
CONTROL FOR IEC 61850 TEST MODE (SELOGIC)	**SC850TM :=** ______________

61850 Simulation Mode

(Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR IEC 61850 SIMULATION MODE (SELOGIC)	**SC850SM :=** ______________

61850 Local Remote

(Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR CONTROL AUTHORITY AT STATION LEVEL (SELOGIC)	**SC850LS :=** ______________
SELOGIC CONTROL FOR CONTROL AUTHORITY AT LOCAL/BAY LEVEL (SELOGIC)	**LOC :=** ______________
SELOGIC CONTROL FOR MULTILEVEL MODE OF CONTROL AUTHORITY (SELOGIC)	**MLTLEV :=** ______________

IEC 61850 Breaker CILO

(Hidden when IEC 61850 is not supported)

SELOGIC CONTROL FOR BREAKER OPEN SUPERVISION (SELOGIC)	**SCBK1BO :=** ______________
SELOGIC CONTROL FOR BREAKER CLOSE SUPERVISION (SELOGIC)	**SCBK1BC :=** ______________

SET PORT p (p = F, 1, 2, 3, or 4) Command

PORT F

ENABLE PORT (Y, N)	**EPORT :=** ____________
PROTOCOL (SEL, MOD)	**PROTO :=** ____________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC :=** ____________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED :=** ____________
DATA BITS (7, 8 bits) *(Hidden when PROTO := MOD)*	**BITS :=** ____________
PARITY (O, E, N)	**PARITY :=** ____________
STOP BITS (1, 2 bits) *(Hidden when PROTO := MOD)*	**STOP :=** ____________
PORT TIME-OUT (0–30 min) *(Hidden and forced to 0 when PROTO := MOD)*	**T_OUT :=** ____________
HDWR HANDSHAKING (Y, N) *(Hidden and forced to N when PROTO := MOD)*	**RTSCTS :=** ____________
LANGUAGE (ENGLISH, SPANISH)	**LANG :=** ____________
SEND AUTOMESSAGE (Y, N) *(Hidden and forced to N when PROTO := MOD)*	**AUTO :=** ____________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden when PROTO := SEL)*	**SLAVEID :=** ____________

PORT 1

Ethernet Port in Slot B.
(Hidden when Ethernet option is not included) (IP addresses are entered using zzz = 1–126, 128–223; yyy = 0–255; xxx = 0–255; www = 0–255)

ENABLE PORT (Y, N)	**EPORT :=** ____________
ENABLE ETHERNET FIRMWARE UPGRADE (Y, N)	**EETHFWU :=** ____________
IP ADDRESS (zzz.yyy.xxx.www)	**IPADDR :=** ____________
SUBNET MASK (zzz.yyy.xxx.www)	**SUBNETM :=** ____________
DEFAULT ROUTER (zzz.yyy.xxx.www) **Note:** Setting DEFRTR := 0.0.0.0 disables the default router.	**DEFRTR :=** ____________
ENABLE TCP KEEP-ALIVE (Y, N)	**ETCPKA :=** ____________
TCP Keep-Alive Idle Range (1–20 sec) *(Hidden when ETCPKA := N)*	**KAIDLE :=** ____________
TCP Keep-Alive Interval Range (1–20 sec) *(Hidden when ETCPKA := N)*	**KAINTV :=** ____________
TCP Keep-Alive Count Range (1–20) *(Hidden when ETCPKA := N)*	**KACNT :=** ____________
OPERATING MODE (FIXED, FAILOVER, SWITCHED, PRP) *(Hidden when dual redundant Ethernet Port option is not included)*	**NETMODE :=** ____________
FAILOVER TIMEOUT (OFF, 0.10–65.00 sec) *(Hidden when dual redundant Ethernet Port option is not included or when NETMODE is not set to FAILOVER)*	**FTIME :=** ____________

PRIMARY NETPORT (A, B) *(Hidden when dual redundant Ethernet Port option is not included)*	**NETPORT :=** ______________
PRP ENTRY TIMEOUT (400–10000 ms) *(Hidden when dual redundant Ethernet Port option is not included or if NETMODE is not equal to PRP)*	**PRPTOUT :=** ______________
PRP DESTINATION ADDR LSB (0–255) *(Hidden when dual redundant Ethernet Port option is not included or if NETMODE is not equal to PRP)*	**PRPADDR :=** ______________
PRP SUPERVISION TX INTERVAL (1–10 s) *(Hidden when dual redundant Ethernet Port option is not included or if NETMODE is not equal to PRP)*	**PRPINTV :=** ______________
NETWRK PORTA SPD (AUTO, 10, 100 Mbps) *(Hidden when dual redundant Ethernet Port option is not included)*	**NETASPD :=** ______________
NETWRK PORTB SPD (AUTO, 10, 100 Mbps) *(Hidden when dual redundant Ethernet Port option is not included)*	**NETBSPD :=** ______________
ENABLE TELNET (Y, N)	**ETELNET :=** ______________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC :=** ______________
LANGUAGE (ENGLISH, SPANISH)	**LANG :=** ______________
TELNET PORT (23, 1025–65534) **Note**: See *Table SET.1* and the note at the end of *PORT 1* settings.	**TPORT :=** ______________
TELNET CONNECT BANNER (254 characters)	**TCBAN :=** ______________
TELNET TIME-OUT (1–30 min)	**TIDLE :=** ______________
FAST OP MESSAGES (Y, N) **Note**: The FAST OP MESSAGES setting only functions when using SEL Fast Operate protocol to operate/set/pulse breaker bits and remote bits. This setting has no effect on Modbus, DNP, EtherNet/IP, or IEC 61850 protocols.	**FASTOP :=** ______________
ENABLE FTP (Y, N)	**EFTPSERV :=** ______________
FTP MAXIMUM ACCESS (LEVEL 1, 2, C)	**FTPACC :=** ______________
FTP USER NAME (20 characters)	**FTPUSER :=** ______________
FTP CONNECT BANNER (254 characters)	**FTPCBAN :=** ______________
FTP IDLE TIME-OUT (5–255 min)	**FTPIDLE :=** ______________
ENABLE IEC 61850 PROTOCOL (Y, N) *(Hidden and forced to N when IEC 61850 is not supported)*	**E61850 :=** ______________
ENABLE IEC 61850 GSE (Y, N) *(Hidden and forced to N when E61850 := N)*	**EGSE :=** ______________
ENABLE MMS FILE SERVICES (Y, N)	**EMMSFS :=** ______________
ENABLE 61850 MODE/BEHAVIOR CONTROL (Y, N)	**E850MBC :=** ______________
ENABLE GOOSE Tx IN OFF MODE (Y, N)	**EOFFMTX :=** ______________
ENABLE MODBUS SESSIONS (0–2)	**EMOD :=** ______________
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0)*	**MODIP1 :=** ______________
MODBUS MASTER IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if EMOD := 0 or 1)*	**MODIP2 :=** ______________

Note: MODIP1 and MODIP2 cannot share an address and must be unique (except when 0.0.0.0, which effectively disables security and allows any master to communicate).

MODBUS TCP PORT1 (1–65534) *(Hidden when EMOD := 0)* *See Table SET.3 and the note at the end of PORT 1 settings.*	**MODNUM1 :=** ______________

MODBUS TCP PORT2 (1–65534) **MODNUM2 :=** ______________
(Hidden when EMOD := 0 or 1)
See Table SET.3 and the note at the end of PORT 1 settings.

MODBUS TIMEOUT 1 (15–900 sec) **MTIMEO1 :=** ______________
(Hidden when EMOD := 0)

MODBUS TIMEOUT 2 (15–900 sec) **MTIMEO2 :=** ______________
(Hidden when EMOD := 0 or 1)

ENABLE HTTP SERVER (Y, N) **EHTTP :=** ______________

HTTP MAXIMUM ACCESS LEVEL (1, 2, C) **HTTPACC :=** ______________
(Hidden when EHTTP := N)

HTTP SERVER TCP/IP PORT NUMBER (1–65534) **HTTPPORT :=** ______________
(Hidden when EHTTP := N)
(NOTE: See Table SET.3 and the note at the end of PORT 1settings)

HTTP CONNECT BANNER (254 ASCII printable characters **HTTPBAN :=** ______________
(Hidden when EHTTP := N)

HTTP WEB SERVER TIMEOUT (1–60 min) **HTTPIDLE :=** ______________
(Hidden when EHTTP := N)

ENABLE RSTP (Y, N) **ERSTP :=** ______________
(Hidden when the dual redundant Ethernet port option is not included or if NETMODE ≠ SWITCHED)

BRIDGE PRIORITY (0–61440) **BRDGPRI :=** ______________
(Hidden if ERSTP := N; input must be set in increments of 4096)

PORTA PRIORITY (0–240) **PORTAPRI :=** ______________
(Hidden if ERSTP := N; input must be set in increments of 16)

PORTB PRIORITY (0–240) **PORTBPRI :=** ______________
(Hidden if ERSTP := N; input must be set in increments of 16)

DNP3 Protocol

(All of the following DNP3 settings are hidden when DNP3 is not an option)

ENABLE DNP SESSIONS (0–5) **EDNP :=** ______________
(The following DNP3 settings are hidden when EDNP := 0)

DNP TCP AND UDP PORT (1–65534) **DNPNUM :=** ______________
See Table SET.3 and the note at the end of PORT 1 settings.

DNP ADDRESS (0–65519) **DNPADR :=** ______________

Session 1

(The DNP IP address of each session (DNPIP1, DNPIP2, etc.) must be unique)

DNP MASTER IP ADDRESS (zzz.yyy.xxx.www; 15 characters) **DNPIP1 :=** ______________

TRANSPORT PROTOCOL (UDP, TCP) **DNPTR1 :=** ______________

UDP RESPONSE PORT (REQ, 1–65534) **DNPUDP1 :=** ______________

DNP ADDRESS TO REPORT TO (0–65519) **REPADR1 :=** ______________

DNP MAP (1–3) **DNPMAP1 :=** ______________

ANALOG INPUT DEFAULT VARIATION (1–6) **DVARAI1 :=** ______________
(Only applies to objects 30 and 32)

CLASS FOR BINARY EVENT DATA (0–3) **ECLASSB1 :=** ______________

CLASS FOR COUNTER EVENT DATA (0–3) **ECLASSC1 :=** ______________

CLASS FOR ANALOG EVENT DATA (0–3) **ECLASSA1 :=** ______________

CURRENTS SCALING DECIMAL PLACES (0–3) **DECPLA1 :=** ______________

VOLTAGES SCALING DECIMAL PLACES (0–3) **DECPLV1 :=** ______________

MISC DATA SCALING DECIMAL PLACES (0–3) **DECPLM1 :=** __________

AMPS REPORTING DEADBAND COUNTS (0–32767) **ANADBA1 :=** __________
(Hidden when ECLASSA1 := 0)

VOLTS REPORTING DEADBAND COUNTS (0–32767) **ANADBV1 :=** __________
(Hidden when ECLASSA1 := 0)

MISC DATA REPORTING DEADBAND COUNTS (0–32767) **ANADBM1 :=** __________
(Hidden when ECLASSA1 := 0 and ECLASSC1 := 0)

MINUTES FOR REQUEST INTERVAL (I, M, 1–32767) **TIMERQ1 :=** __________

SECONDS TO SELECT/OPERATE TIME-OUT (0.0–30.0) **STIMEO1 :=** __________

SECONDS TO SEND DATA LINK HEARTBEAT (0–7200) **DNPINA1 :=** __________
(Hidden when DNPTR1 := UDP)

EVENT MESSAGE CONFIRM TIME-OUT (1–50 sec) **ETIMEO1 :=** __________

ENABLE UNSOLICITED REPORTING (Y, N) **UNSOL1 :=** __________
(Hidden and forced to N when ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC1 := 0)
(All subsequent settings are hidden and forced to N if UNSOL1 := N)

ENABLE UNSOLICITED REPORTING AT POWER-UP (Y, N) **PUNSOL1 :=** __________

NUMBER OF EVENTS TO TRANSMIT ON (1–200) **NUMEVE1 :=** __________

OLDEST EVENT ON TX ON (0.0–99999.0 sec) **AGEEVE1 :=** __________

UNSOLICITED MESSAGE MAX RETRY ATTEMPTS (2–10) **URETRY1 :=** __________

UNSOLICITED MESSAGE OFFLINE TIME-OUT (1–5000 sec) **UTIMEO1 :=** __________

Session 2

(All Session 2 settings are hidden when EDNP < 2)

DNP MASTER IP ADDRESS (zzz.yyy.xxx.www; 15 characters) **DNPIP2 :=** __________

TRANSPORT PROTOCOL (UDP, TCP) **DNPTR2 :=** __________

UDP RESPONSE PORT (REQ, 1–65534) **DNPUDP2 :=** __________

DNP ADDRESS TO REPORT TO (0–65519) **REPADR2 :=** __________

DNP MAP (1–3) **DNPMAP2 :=** __________

ANALOG INPUT DEFAULT VARIATION (1–6) **DVARAI2 :=** __________

CLASS FOR BINARY EVENT DATA (0–3) **ECLASSB2 :=** __________

CLASS FOR COUNTER EVENT DATA (0–3) **ECLASSC2 :=** __________

CLASS FOR ANALOG EVENT DATA (0–3) **ECLASSA2 :=** __________

CURRENTS SCALING DECIMAL PLACES (0–3) **DECPLA2 :=** __________

VOLTAGES SCALING DECIMAL PLACES (0–3) **DECPLV2 :=** __________

MISC DATA SCALING DECIMAL PLACES (0–3) **DECPLM2 :=** __________

AMPS REPORTING DEADBAND COUNTS (0–32767) **ANADBA2 :=** __________
(Hidden when ECLASSA2 := 0)

VOLTS REPORTING DEADBAND COUNTS (0–32767) **ANADBV2 :=** __________
(Hidden when ECLASSA2 := 0)

MISC DATA REPORTING DEADBAND COUNTS (0–32767) **ANADBM2 :=** __________
(Hidden when ECLASSA2 := 0 and ECLASSC2 := 0)

MINUTES FOR REQUEST INTERAL (I, M, 1–32767) **TIMERQ2 :=** __________

SECONDS TO SELECT/OPERATE TIME-OUT (0.0–30.0) **STIMEO2 :=** __________

SECONDS TO SEND DATA LINK HEARTBEAT (0–7200) **DNPINA2 :=** __________
(Hidden when DNPTR2 := UDP)

EVENT MESSAGE CONFIRM TIME-OUT (1–50 sec)	**ETIMEO2 :=** ______________
ENABLE UNSOLICITED REPORTING (Y, N) *(Hidden and forced to N when ECLASSA2 := 0, ECLASSB2 := 0, and ECLASSC2 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL2 := N)*	**UNSOL2 :=** ______________
ENABLE UNSOLICITED REPORTING AT POWER-UP (Y, N)	**PUNSOL2 :=** ______________
NUMBER OF EVENTS TO TRANSMIT ON (1–200)	**NUMEVE2 :=** ______________
OLDEST EVENT TO TX ON (0.0–99999.0 sec)	**AGEEVE2 :=** ______________
UNSOLICITED MESSAGE MAX RETRY ATTEMPTS (2–10)	**URETRY2 :=** ______________
UNSOLICITED MESSAGE OFFLINE TIME-OUT (1–5000 sec)	**UTIMEO2 :=** ______________

Session 3

(All Session 3 settings are hidden when EDNP < 3)

DNP MASTER IP ADDRESS (zzz.yyy.xxx.www; 15 characters)	**DNPIP3 :=** ______________
TRANSPORT PROTOCOL (UDP, TCP)	**DNPTR3 :=** ______________
UDP RESPONSE PORT (REQ, 1–65534)	**DNPUDP3 :=** ______________
DNP ADDRESS TO REPORT TO (0–65519)	**REPADR3 :=** ______________
DNP MAP (1–3)	**DNPMAP3 :=** ______________
ANALOG INPUT DEFAULT VARIATION (1–6)	**DVARAI3 :=** ______________
CLASS FOR BINARY EVENT DATA (0–3)	**ECLASSB3 :=** ______________
CLASS FOR COUNTER EVENT DATA (0–3)	**ECLASSC3 :=** ______________
CLASS FOR ANALOG EVENT DATA (0–3)	**ECLASSA3 :=** ______________
CURRENTS SCALING DECIMAL PLACES (0–3)	**DECPLA3 :=** ______________
VOLTAGES SCALING DECIMAL PLACES (0–3)	**DECPLV3 :=** ______________
MISC DATA SCALING DECIMAL PLACES (0–3)	**DECPLM3 :=** ______________
AMPS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA3 := 0)*	**ANADBA3 :=** ______________
VOLTS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA3 := 0)*	**ANADBV3 :=** ______________
MISC DATA REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA3 := 0 and ECLASSC3 := 0)*	**ANADBM3 :=** ______________
MINUTES FOR REQUEST INTERVAL (I, M, 1–32767)	**TIMERQ3 :=** ______________
SECONDS TO SELECT/OPERATE TIME-OUT (0.0–30.0)	**STIMEO3 :=** ______________
SECONDS TO SEND DATA LINK HEARTBEAT (0–7200) *(Hidden when DNPTR3 := UDP)*	**DNPINA3 :=** ______________
EVENT MESSAGE CONFIRM TIME-OUT (1–50 sec)	**ETIMEO3 :=** ______________
ENABLE UNSOLICITED REPORTING (Y, N) *(Hidden and forced to N when ECLASSA3 := 0, ECLASSB3 := 0, and ECLASSC3 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL3 := N)*	**UNSOL3 :=** ______________
ENABLE UNSOLICITED REPORTING AT POWER-UP (Y, N)	**PUNSOL3 :=** ______________
NUMBER OF EVENT TO TRANSMIT ON (1–200)	**NUMEVE3 :=** ______________
OLDEST EVENT TO TX ON (0.0–99999.0 sec)	**AGEEVE3 :=** ______________
UNSOLICITED MESSAGE MAX RETRY ATTEMPTS (2–10)	**URETRY3 :=** ______________
UNSOLICITED MESSAGE OFFLINE TIME-OUT (1–5000 sec)	**UTIMEO3 :=** ______________

Session 4

(All Session 4 settings are hidden when EDNP < 4)

DNP MASTER IP ADDRESS (zzz.yyy.xxx.www; 15 characters)	**DNPIP4 :=** ______________
TRANSPORT PROTOCOL (UDP, TCP)	**DNPTR4 :=** ______________
UDP RESPONSE PORT (REQ, 1–65534)	**DNPUDP4 :=** ______________
DNP ADDRESS TO REPORT TO (0–65519)	**REPADR4 :=** ______________
DNP MAP (1–3)	**DNPMAP4 :=** ______________
ANALOG INPUT DEFAULT VARIATION (1–6)	**DVARAI4 :=** ______________
CLASS FOR BINARY EVENT DATA (0–3)	**ECLASSB4 :=** ______________
CLASS FOR COUNTER EVENT DATA (0–3)	**ECLASSC4 :=** ______________
CLASS FOR ANALOG EVENT DATA (0–3)	**ECLASSA4 :=** ______________
CURRENTS SCALING DECIMAL PLACES (0–3)	**DECPLA4 :=** ______________
VOLTAGES SCALING DECIMAL PLACES (0–3)	**DECPLV4 :=** ______________
MISC DATA SCALING DECIMAL PLACES (0–3)	**DECPLM4 :=** ______________
AMPS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA4 := 0)*	**ANADBA4 :=** ______________
VOLTS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA4 := 0)*	**ANADBV4 :=** ______________
MISC DATA REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA4 := 0 and ECLASSC4 := 0)*	**ANADBM4 :=** ______________
MINUTES FOR REQUEST INTERVAL (I, M, 1–32767)	**TIMERQ4 :=** ______________
SECONDS TO SELECT/OPERATE TIME-OUT (0.0–30.0)	**STIMEO4 :=** ______________
SECONDS TO SEND DATA LINK HEARTBEAT (0–7200) *(Hidden when DNPTR4 := UDP)*	**DNPINA4 :=** ______________
EVENT MESSAGE CONFIRM TIME-OUT (1–50 sec)	**ETIMEO4 :=** ______________
ENABLE UNSOLICITED REPORTING (Y, N) *(Hidden and forced to N when ECLASSA4 := 0, ECLASSB4 := 0, and ECLASSC4 := 0)* *(All subsequent settings are hidden and forced to N if UNSOL4 := N)*	**UNSOL4 :=** ______________
ENABLE UNSOLICITED REPORTING AT POWER-UP (Y, N) *(Hidden when UNSOL3 := N)*	**PUNSOL4 :=** ______________
NUMBER OF EVENT TO TRANSMIT ON (1–200)	**NUMEVE4 :=** ______________
OLDEST EVENT TO TX ON (0.0–99999.0 sec)	**AGEEVE4 :=** ______________
UNSOLICITED MESSAGE MAX RETRY ATTEMPTS (2–10)	**URETRY4 :=** ______________
UNSOLICITED MESSAGE OFFLINE TIME-OUT (1–5000 sec)	**UTIMEO4 :=** ______________

Session 5

(All Session 5 settings are hidden when EDNP < 5)

DNP MASTER IP ADDRESS (zzz.yyy.xxx.www; 15 characters)	**DNPIP5 :=** ______________
TRANSPORT PROTOCOL (UDP, TCP)	**DNPTR5 :=** ______________
UDP RESPONSE PORT (REQ, 1–65534)	**DNPUDP5 :=** ______________
DNP ADDRESS TO REPORT TO (0–65519)	**REPADR5 :=** ______________
DNP MAP (1–3)	**DNPMAP5 :=** ______________
ANALOG INPUT DEFAULT VARIATION (1–6)	**DVARAI5 :=** ______________
CLASS FOR BINARY EVENT DATA (0–3)	**ECLASSB5 :=** ______________

CLASS FOR COUNTER EVENT DATA (0–3) **ECLASSC5 :=** ____________

CLASS FOR ANALOG EVENT DATA (0–3) **ECLASSA5 :=** ____________

CURRENTS SCALING DECIMAL PLACES (0–3) **DECPLA5 :=** ____________

VOLTAGES SCALING DECIMAL PLACES (0–3) **DECPLV5 :=** ____________

MISC DATA SCALING DECIMAL PLACES (0–3) **DECPLM5 :=** ____________

AMPS REPORTING DEADBAND COUNTS (0–32767) **ANADBA5 :=** ____________
(Hidden when ECLASSA5 := 0)

VOLTS REPORTING DEADBAND COUNTS (0–32767) **ANADBV5 :=** ____________
(Hidden when ECLASSA5 := 0)

MISC DATA REPORTING DEADBAND COUNTS (0–32767) **ANADBM5 :=** ____________
(Hidden when ECLASSA5 := 0 and ECLASSC5 := 0)

MINUTES FOR REQUEST INTERVAL (I, M, 1–32767) **TIMERQ5 :=** ____________

SECONDS TO SELECT/OPERATE TIME-OUT (0.0–30.0) **STIMEO5 :=** ____________

SECONDS TO SEND DATA LINK HEARTBEAT (0–7200) **DNPINA5 :=** ____________
(Hidden when DNPTR5 := UDP)

EVENT MESSAGE CONFIRM TIME-OUT (1–50 sec) **ETIMEO5 :=** ____________

ENABLE UNSOLICITED REPORTING (Y, N) **UNSOL5 :=** ____________
(Hidden and forced to N when ECLASSA5 := 0, ECLASSB5 := 0, and ECLASSC5 := 0)
(All subsequent settings are hidden and forced to N if UNSOL5 := N)

ENABLE UNSOLICITED REPORTING AT POWER-UP (Y, N) **PUNSOL5 :=** ____________

NUMBER OF EVENT TO TRANSMIT ON (1–200) **NUMEVE5 :=** ____________

OLDEST EVENT TO TX ON (0.0–99999.0 sec) **AGEEVE5 :=** ____________

UNSOLICITED MESSAGE MAX RETRY ATTEMPTS (2–10) **URETRY5 :=** ____________

UNSOLICITED MESSAGE OFFLINE TIME-OUT (1–5000 sec) **UTIMEO5 :=** ____________

SNTP Client Protocol Settings

ENABLE SNTP CLIENT (OFF, UNICAST, MANYCAST, BROADCAST) **ESNTP :=** ____________
(All subsequent category settings are hidden if ESNTP := OFF)

PRIMARY SERVER IP ADDRESS (zzz.yyy.xxx.www) **SNTPPSIP :=** ____________
(To accept updates from any server when ESNTP := BROADCAST, set SNTPPSIP to 0.0.0.0; only IP addresses in the range 224.0.0.1 through 239.255.255.255 are valid when ESNTP := MANYCAST)

Make the following setting when ESNTP := UNICAST

BACKUP SERVER IP ADDRESS (zzz.yyy.xxx.www) **SNTPBSIP :=** ____________
(Hidden if ESNTP is not equal to UNICAST)

SNTP IP (LOCAL) PORT NUMBER (1–65534) **SNTPPORT :=** ____________
See Port Number Settings Must be Unique and Table SET.3

SNTP UPDATE RATE (15–3600 sec) **SNTPRATE :=** ____________

Make the following setting when ESNTP := UNICAST or MANYCAST

SNTP TIMEOUT (5–20 sec) **SNTPTO :=** ____________
(Hidden and forced to 5 if ESNTP := BROADCAST)
(SNTPTO must be less than setting SNTPRATE)

PTP Settings

ENABLE PTP (Y, N) *(All subsequent category settings are hidden if EPTP := N)* *(Hidden and forced to N if NETMODE := SWITCHED)*	**EPTP :=** ____________
PTP PROFILE (DEFAULT, C37.238) *(Hidden and forced to C37.238 if NETMODE := PRP)*	**PTPPRO :=** ____________
PTP TRANSPORT MECHANISM (UDP, LAYER2) *(Hidden and forced to LAYER2 if PTPPRO := C37.238 or if NETMODE := PRP)*	**PTPTR :=** ____________
PTP DOMAIN NUMBER (0–255)	**DOMNUM :=** ____________
PTP PATH DELAY MECHANISM (P2P, E2E, OFF) *(Hidden and forced to P2P if PTPPRO := C37.238 or if NETMODE := PRP)*	**PTHDLY :=** ____________
PEER DELAY REQUEST INTERVAL (1, 2, 4, 8, 16, 32, 64 seconds) *(Hidden if PTHDLY ≠ P2P and if PTPPRO ≠ C37.238 and if NETMODE ≠ PRP)*	**PDINT :=** ____________
PTP NUMBER OF ACCEPTABLE MASTERS, (OFF, 1–5)	**AMNUM :=** ____________
PTP ACCEPTABLE MASTER *n* IP (zzz.yyy.xxx.www) *(Hidden if n > AMNUM or if AMNUM := OFF or if PTPTR := LAYER2 or if NETMODE := PRP or if PTPPRO := C37.238)*	**AMIP*n* :=** ____________
PTP ACCEPTABLE MASTER *n* MAC (xx:xx:xx:xx:xx:xx) *(Hidden if AMNUM := OFF or if NETMODE ≠ PRP and if PTPTR ≠ LAYER2 and if PTPPRO ≠ C37.238)*	**AMMAC*n* :=** ____________
PTP ALTERNATIVE PRIORITY1 FOR MASTER *n* (0–255) *(Hidden if n > AMNUM or if AMNUM := OFF)*	**ALTPRI*n* :=** ____________
PTP VLAN IDENTIFIER (1–4094) *(Hidden if NETMODE ≠ PRP and PTPPRO ≠ C37.238)*	**PVLAN :=** ____________
PTP VLAN PRIORITY (0–7) *(Hidden if NETMODE ≠ PRP and PTPPRO ≠ C37.238)*	**PVLANPR :=** ____________

EtherNet/IP Settings

ENABLE ETHERNET IP (Y, N)	**EEIP :=** ____________
CONFIGURATION ID (0–255)	**CONFIGID :=** ____________
MAJOR EDS REVISION (1–255)	**MAJOREDS :=** ____________
MINOR EDS REVISION (1–255)	**MINOREDS :=** ____________
NUMBER OF IP ADDRESSES FOR EIP SCANNER (OFF, 1–8) *(OFF allows anonymous clients)*	**NUMIP :=** ____________
IP ADDRESS (zzz.yyy.xxx.www) *(Hidden if NUMIP := OFF, or if n > NUMIP* *NOTE: EIPIPn settings shall not be equal to the value of the IPADDR setting. EIPIP1 through EIPIP8 must be unique)*	**EIPIP*n* :=** ____________
NUMBER OF IO CONNECTIONS (1–6)	**NUMCONN :=** ____________
APLLICATION TYPE (EXCLUSIVE_OWNER, INPUT_ONLY) *(NOTE: At most, three EXCLUSIVE_OWNER types are allowed)*	**APPTYP*n* :=** ____________
INPUT ASSEMBLY (IA1, IA2, IA3, OA1, OA2, OA3)	**INASSM*n* :=** ____________
OUTPUT ASSEMBLY (OA1, OA2, OA3) *(Hidden if APPTYPn := INPUT_ONLY)*	**OUTASSM*n* :=** ____________

Port Number Settings Must be Unique

When making the SEL-710-5 Port 1 settings, the port number settings cannot be used for more than one protocol. The relay checks all the settings shown in *Table SET.3* 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 that contains a duplicate value.

Table SET.3 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
DNPNUM	DNPTCP and UDP Port	EDNP > 0
SNTPPORT	SNTPIP (Local) Port Number	ESNTP ≠ OFF
EPTP	Enable PTP	PTPPRO := DEFAULT and PTPTR := UDP, Ports 319 and 320 are reserved
EEIP	Enable EtherNet/IP	EEIP ≠ N (Ports 2222/44818 are reserved)

[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 other protocols.

PORT 2

(Fiber-Optic Serial Port in Slot B; the following settings are autoset and hidden if E49RTD := EXT)

ENABLE PORT (Y, N) **EPORT :=** ____________

PROTOCOL (SEL, DNP, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103) **PROTO :=** ____________

MAXIMUM ACCESS LEVEL (1, 2, C) **MAXACC :=** ____________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps) **SPEED :=** ____________

DATA BITS (7, 8 bits) **BITS :=** ____________
(Hidden when PROTO := MOD, DNP, MB_, or 103)

PARITY (O, E, N) **PARITY :=** ____________
(Hidden when E49RTD := EXT or PROTO := MB_)

STOP BITS (1, 2 bits) **STOP :=** ____________
(Hidden when PROTO := MOD or MB_)

PORT TIME-OUT (0–30 min) **T_OUT :=** ____________
(Hidden and forced to 0 when PROTO := MOD, MB_, or 103)

HDWR HANDSHAKING (Y, N) **RTSCTS :=** ____________
(Hidden and forced to N when PROTO := MOD, DNP, SEL, or MB_)

LANGUAGE (ENGLISH, SPANISH) **LANG :=** ____________

SEND AUTOMESSAGE (Y, N) **AUTO :=** ____________
(Hidden and forced to N when PROTO := MOD, DNP, MB_, or 103)

FAST OP MESSAGES (Y, N) **FASTOP :=** ____________
(Hidden and forced to N when PROTO := MOD, DNP, MB_, or 103)

Modbus

MODBUS SLAVE ID (1–247) **SLAVEID :=** ____________
(Hidden when PROTO := SEL, 103, DNP, or MB_)

DNP3 Protocol

(Hidden when PROTO := SEL, MB_, 103,or MOD)

DNP ADDRESS (0–65519) **DNPADR :=** ____________

DNP ADDRESS TO REPORT TO (0–65519) **REPADR1 :=** ____________

DNP MAP (1–3) **DNPMAP1 :=** ____________

ANALOG INPUT DEFAULT VARIATION (1–6) **DVARAI1 :=** ____________

CLASS FOR BINARY EVENT DATA (0–3) **ECLASSB1 :=** ____________

CLASS FOR COUNTER EVENT DATA (0–3)	**ECLASSC1 :=** _____________
CLASS FOR ANALOG EVENT DATA (0–3)	**ECLASSA1 :=** _____________
CURRENTS SCALING DECIMAL PLACES (0–3)	**DECPLA1 :=** _____________
VOLTAGES SCALING DECIMAL PLACES (0–3)	**DECPLV1 :=** _____________
MISC DATA SCALING DECIMAL PLACES (0–3)	**DECPLM1 :=** _____________
AMPS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA1 := 0)*	**ANADBA1 :=** _____________
VOLTS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA1 := 0)*	**ANADBV1 :=** _____________
MISC DATA REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1 :=** _____________
MINUTES FOR REQUEST INTERVAL (I, M, 1–32767)	**TIMERQ1 :=** _____________
SECONDS TO SELECT/OPERATE TIME-OUT (0.0–30.0)	**STIMEO1 :=** _____________
DATA LINK RETRIES (0–15)	**DRETRY1 :=** _____________
SECONDS TO DATA LINK TIME-OUT (0–5) *(Hidden when DRETRY1 := 0)*	**DTIMEO1 :=** _____________
EVENT MESSAGE CONFIRM TIME-OUT (1–50 sec)	**ETIMEO1 :=** _____________
ENABLE UNSOLICITED REPORTING (Y, N) *(Hidden and forced to N when ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC := 0)* *(All subsequent settings are hidden and forced to N if UNSOL1 := N)*	**UNSOL1 :=** _____________
ENABLE UNSOLICITED REPORTING AT POWER-UP (Y, N)	**PUNSOL1 :=** _____________
NUMBER OF EVENTS TO TRANSMIT ON (1–200)	**NUMEVE1 :=** _____________
OLDEST EVENT TO TX ON (0.0–99999.0 sec)	**AGEEVE1 :=** _____________
UNSOLICITED MESSAGE MAX RETRY ATTEMPTS (2–10)	**URETRY1 :=** _____________
UNSOLICITED MESSAGE OFFLINE TIME-OUT (1–5000 sec)	**UTIMEO1 :=** _____________

MIRRORED BITS Protocol

(Hidden when PROTO:= SEL, 103, DNP, 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 PIKCUP DEBOUNCE MESSAGES (1–8)	**RMB2PU :=** _____________
RMB2 DROPOUT DEBOUNCE MESSAGES (1–8)	**RMB2DO :=** _____________
RMB3 PIKCUP 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 :=** ____________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO:= 103)

103 DEVICE ADDRESS (0–254)	**103ADDR :=** ____________
CYCLIC DATA REPORTING PERIOD (1–3600 sec)	**103CYC :=** ____________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 sec)	**103ACYC :=** ____________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word bit)	**103ATRI :=** ____________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME :=** ____________

PORT 3

EIA-232/485 Port in Slot B.

ENABLE PORT (Y, N)	**EPORT :=** ____________
PROTOCOL (SEL, DNP, MOD, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103)	**PROTO :=** ____________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC :=** ____________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps)	**SPEED :=** ____________
DATA BITS (7, 8 bits) *(Hidden when PROTO := DNP, MOD, MB_, or 103)*	**BITS :=** ____________
PARITY (O, E, N) *(Hidden when PROTO := MB_)*	**PARITY :=** ____________
STOP BITS (1, 2 bits) *(Hidden when PROTO := MOD or MB_)*	**STOP :=** ____________
PORT TIME-OUT (0–30 min) *(Hidden and forced to 0 when PROTO := MOD, MB_, or 103)*	**T_OUT :=** ____________
HDWR HANDSHAKING (Y, N) *(Hidden and forced to N when COMMINF := 485 or PROTO := MOD, DNP, or MB_)*	**RTSCTS :=** ____________
LANGUAGE (ENGLISH, SPANISH)	**LANG :=** ____________
SEND AUTOMESSAGE (Y, N) *(Hidden and forced to N when PROTO := MOD, DNP, MB_, or 103)*	**AUTO :=** ____________
FAST OP MESSAGES (Y, N) *(Hidden and forced to N when PROTO := MOD, DNP, MB_, or 103)*	**FASTOP :=** ____________
MINIMUM SECONDS FROM DCD TO TX (0.00–1.00) *(Hidden if PROTO is not equal to DNP)*	**MINDLY :=** ____________
MAXIMUM SECONDS FROM DCD TO TX (0.00–1.00) *(Hidden if PROTO is not equal to DNP)*	**MAXDLY :=** ____________
SETTLE TIME FROM RTS ON TO TX (OFF, 0.00–30.00 sec) *(Hidden if PROTO is not equal to DNP or 103)*	**PREDLY :=** ____________
SETTLE TIME FROM TX TO RTS (OFF, 0.00–30.00 sec) *(Hidden if PROTO is not equal to DNP or 103)*	**PSTDLY :=** ____________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden when PROTO := SEL, 103, DNP, or MB_)*	**SLAVEID :=** _____________

DNP3 Protocol

(Hidden when PROTO := SEL, 103, MB_, or MOD)

DNP Address (0–65519)	**DNPADR :=** _____________
DNP Address to Report to (0–65519)	**REPADR1 :=** _____________
DNP Map (1–3)	**DNPMAP1 :=** _____________
Analog Input Default Variation (1–6)	**DVARAI1 :=** _____________
Class for Binary Event Data (0–3)	**ECLASSB1 :=** _____________
Class for Counter Event Data (0–3)	**ECLASSC1 :=** _____________
Class for Analog Event Data (0–3)	**ECLASSA1 :=** _____________
Currents Scaling Decimal Places (0–3)	**DECPLA1 :=** _____________
Voltages Scaling Decimal Places (0–3)	**DECPLV1 :=** _____________
Misc Data Scaling Decimal Places (0–3)	**DECPLM1 :=** _____________
Amps Reporting Deadband Counts (0–32767) *(Hidden when ECLASSA1 := 0)*	**ANADBA1 :=** _____________
Volts Reporting Deadband Counts (0–32767) *(Hidden when ECLASSA1 := 0)*	**ANADBV1 :=** _____________
Misc Data Reporting Deadband Counts (0–32767) *(Hidden when ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1 :=** _____________
Minutes for Request Interval (I, M, 1–32767)	**TIMERQ1 :=** _____________
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO1 :=** _____________
Data Link Retries (0–15)	**DRETRY1 :=** _____________
Seconds to Data Link Time-Out (0–5) *(Hidden when DRETRY1 := 0)*	**DTIMEO1 :=** _____________
Event Message Confirm Time-Out (1–50 sec)	**ETIMEO1 :=** _____________
Enable Unsolicited Reporting (Y, N) *(Hidden and forced to N when ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC1 := 0)* *(All subsequent settings are hidden and forced to N when UNSOL1 := N)*	**UNSOL1 :=** _____________
Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL1 :=** _____________
Number of Events to Transmit On (1–200)	**NUMEVE1 :=** _____________
Oldest Event to Tx On (0.0–99999.0 sec)	**AGEEVE1 :=** _____________
Unsolicited Message Max Retry Attempts (2–10)	**URETRY1 :=** _____________
Unsolicited Message Offline Time-Out (1–5000 sec)	**UTIMEO1 :=** _____________

Modem Protocol

For DNP3 session and EIA-232 Port only.

Modem Connected to Port (Y, N)	**MODEM :=** _____________
Modem Startup String (30 characters)	**MSTR :=** _____________
Phone Number for Dial-Out (30 characters)	**PH_NUM1 :=** _____________
Phone Number for Dial-Out (30 characters)	**PH_NUM2 :=** _____________
Retry Attempts for Phone 1 Dial-Out (1–20)	**RETRY1 :=** _____________

Retry Attempts for Phone 2 Dial-Out (1–20)	**RETRY2 :=** ____________
Time to Attempt Dial (5–300 sec)	**MDTIME :=** ____________
Time Between Dial-Out Attempts (5–3600 sec)	**MDRET :=** ____________

MIRRORED BITS Protocol

(Hidden when PROTO := SEL, DNP, 103, 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 :=** ____________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO:= 103)

103 DEVICE ADDRESS (0–254)	**103ADDR :=** ____________
CYCLIC DATA REPORTING PERIOD (1–3600 s)	**103CYC :=** ____________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 s)	**103ACYC :=** ____________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI :=** ____________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME :=** ____________

PORT 4

EIA-232/485 Port or DeviceNet Port in Slot C.

ENABLE PORT (Y, N)	**EPORT :=** ____________
PROTOCOL (SEL, DNP, MOD, DNET, MBA, MBB, MB8A, MB8B, MBTA, MBTB, 103)	**PROTO :=** ____________
MAXIMUM ACCESS LEVEL (1, 2, C)	**MAXACC :=** ____________

Interface Select

(Hidden when PROTO := DNET)

COMM INTERFACE (232, 485)	**COMMINF :=** ______________

Communications

SPEED (300, 1200, 2400, 4800, 9600, 19200, 38400 bps) *(Hidden when PROTO := DNET)*	**SPEED :=** ______________
DATA BITS (7, 8 bits) *(Hidden when PROTO := DNP, MOD, MB_, DNET, or 103)*	**BITS :=** ______________
PARITY (O, E, N) *(Hidden when PROTO := DNET or MB_)*	**PARITY :=** ______________
STOP BITS (1, 2 bits) *(Hidden when PROTO := MOD, MB_, or DNET)*	**STOP :=** ______________
PORT TIME-OUT (0–30 min) *(Hidden when PROTO := MOD, MB_, DNET, or 103)*	**T_OUT :=** ______________
HDWR HANDSHAKING (Y, N) *(Hidden and forced to N when COMMINF := 485 or PROTO := MOD, DNP, 103, MB_, or DNET)*	**RTSCTS :=** ______________
LANGUAGE (ENGLISH, SPANISH)	**LANG :=** ______________
SEND AUTOMESSAGE (Y, N) *(Hidden when PROTO := DNP, MOD, MB_, DNET, or 103)*	**AUTO :=** ______________
FAST OP MESSAGES (Y, N) *(Hidden and forced to N when PROTO := DNP, MOD, MB_, DNET, or 103)*	**FASTOP :=** ______________
MINIMUM SECONDS FROM DCD TO TX (0.00–1.00 sec) *(Hidden if PROTO is not equal to DNP)*	**MINDLY :=** ______________
MAXIMUM SECONDS FROM DCD TO TX (0.00–1.00 sec) *(Hidden if PROTO is not equal to DNP)*	**MAXDLY :=** ______________
SETTLE TIME FROM RTS ON TO TX (OFF, 0.00–30.00 sec) *(Hidden if PROTO is not equal to DNP or 103)*	**PREDLY :=** ______________
SETTLE TIME FROM TX TO RTS (OFF, 0.00–30.00 sec) *(Hidden if PROTO is not equal to DNP or 103)*	**PSTDLY :=** ______________

Modbus

MODBUS SLAVE ID (1–247) *(Hidden when PROTO := SEL, 103, MB_, or DNET)*	**SLAVEID :=** ______________

DNP3 Protocol

(Hidden when PROTO := SEL, MB_, DNET, 103, or MOD)

DNP ADDRESS (0–65519)	**DNPADR :=** ______________
DNP ADDRESS TO REPORT TO (0–65519)	**REPADR1 :=** ______________
DNP MAP (1–3)	**DNPMAP1 :=** ______________
ANALOG INPUT DEFAULT VARIATION (1–6)	**DVARAI1 :=** ______________
CLASS FOR BINARY EVENT DATA (0–3)	**ECLASSB1 :=** ______________
CLAS FOR COUNTER EVENT DATA (0–3)	**ECLASSC1 :=** ______________
CLASS FOR ANALOG EVENT DATA (0–3)	**ECLASSA1 :=** ______________
CURRENTS SCALING DECIMAL PLACES (0–3)	**DECPLA1 :=** ______________
VOLTAGES SCALING DECIMAL PLACES (0–3)	**DECPLV1 :=** ______________
MISC DATA SCALING DECIMAL PLACES (0–3)	**DECPLM1 :=** ______________

AMPS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA1 := 0)*	**ANADBA1** := ______________
VOLTS REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA1 := 0)*	**ANADBV1** := ______________
MISC DATA REPORTING DEADBAND COUNTS (0–32767) *(Hidden when ECLASSA1 := 0 and ECLASSC1 := 0)*	**ANADBM1** := ______________
MINUTES FOR REQUEST INTERVAL (I, M, 1–32767)	**TIMERQ1** := ______________
SECONDS TO SELECT/OPERATE TIME-OUT (0.0–30.0 sec)	**STIMEO1** := ______________
DATA LINK RETRIES (0–15)	**DRETRY1** := ______________
SECONDS TO DATA LINK TIME-OUT (0–5 sec) *(Hidden when DRETRY1 := 0)*	**DTIMEO1** := ______________
EVENT MESSAGE CONFIRM TIME-OUT (1–50 sec)	**ETIMEO1** := ______________
ENABLE UNSOLICITED REPORTING (Y, N) *(Hidden and forced to N when ECLASSA1 := 0, ECLASSB1 := 0, and ECLASSC1 := 0)* *(All subsequent settings are hidden and forced to N when UNSOL1 := N)*	**UNSOL1** := ______________
ENABLE UNSOLICITED REPORTING AT POWER-UP (Y, N)	**PUNSOL1** := ______________
NUMBER OF EVENTS TO TRANSMIT ON (1–200)	**NUMEVE1** := ______________
OLDEST EVENT TO TX ON (0.0–99999.0 sec)	**AGEEVE1** := ______________
UNSOLICITED MESSAGE MAX RETRY ATTEMPTS (2–10)	**URETRY1** := ______________
UNSOLICITED MESSAGE OFFLINE TIME-OUT (1–5000 sec)	**UTIMEO1** := ______________

Modem Protocol

For DNP3 session and EIA-232 Port only.

MODEM CONNECTED TO PORT (Y, N)	**MODEM** := ______________
MODEM STARTUP STRING (30 characters)	**MSTR** := ______________
PHONE NUMBER FOR DIAL-OUT (30 characters)	**PH_NUM1** := ______________
PHONE NUMBER FOR DIAL-OUT (30 characters)	**PH_NUM2** := ______________
RETRY ATTEMPTS FOR PHONE 1 DIAL-OUT (1–20)	**RETRY1** := ______________
RETRY ATTEMPTS FOR PHONE 2 DIAL-OUT (1–20)	**RETRY2** := ______________
TIME TO ATTEMPT DIAL (5–300 sec)	**MDTIME** := ______________
TIME BETWEEN DIAL-OUT ATTEMPTS (5–3600 sec)	**MDRET** := ______________

MIRRORED BITS Protocol

(Hidden when PROTO := SEL, DNP, DNET, 103, 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 :=** ______________

IEC 60870-5-103 Protocol

(Hidden unless serial port with PROTO:= 103)

103 DEVICE ADDRESS (0–254)	**103ADDR :=** ______________
CYCLIC DATA REPORTING PERIOD (1–3600 sec)	**103CYC :=** ______________
ACCUMULATOR REPORTING PERIOD (OFF, 1–3600 sec)	**103ACYC :=** ______________
ACCUMULATOR REPORTING TRIGGER (1 Relay Word Bit)	**103ATRI :=** ______________
ENABLE TIME SYNCHRONIZATION (Y, N)	**103TIME :=** ______________

Front-Panel Settings (Set F Command)

General

DISPLY PTS ENABL (N, 1–32) *(Hidden and forced to N if the front-panel MOT option is A/B)*	**EDP :=** ______________
LOCAL BITS ENABL (N, 1–32)	**ELB :=** ______________
LCD TIMEOUT (OFF, 1–30 min) *(Hidden and forced to OFF if the front-panel MOT option is A/B)*	**FP_TO :=** ______________
LCD CONTRAST (1–8) *(Hidden if the front-panel MOT option is A/B)*	**FP_CONT :=** ______________
FP AUTOMESSAGES (OVERRIDE, ROTATING) *(Hidden and forced to N if the front-panel MOT option is A/B)*	**FP_AUTO :=** ______________
CLOSE RESET LEDS (Y, N)	**RSTLED :=** ______________
ENA_LED COLOR (R = Red, G = Green, A = Amber) *(Hidden and forced to N if the front-panel MOT option is A/B)*	**LEDENAC :=** ______________
TRIP_LED COLOR (R = Red, G = Green, A = Amber)	**LEDTRPC :=** ______________
MAXIMUM ACCESS LEVEL (1, 2) *(Hidden if the front-panel MOT option is A/B)*	**MAXACC :=** ______________

Target LED

(R = Red, G = Green, A= Amber)

TRIP LATCH T_LED (Y, N)	**T01LEDL :=** ______________
TARGET_LED ASSERTED COLOR (R, G, A)	**T01LEDC :=** ______________
LED1 EQUATION (SELOGIC)	**T01_LED :=** ______________

TRIP LATCH T_LED (Y, N)	**T02LEDL :=** ______________
TARGET_LED ASSERTED COLOR (R, G, A)	**T02LEDC :=** ______________
LED2 EQUATION (SELOGIC)	**T02_LED :=** ______________
TRIP LATCH T_LED (Y, N)	**T03LEDL :=** ______________
TARGET_LED ASSERTED COLOR (R, G, A)	**T03LEDC :=** ______________
LED3 EQUATION (SELOGIC)	**T03_LED :=** ______________
TRIP LATCH T_LED (Y, N)	**T04LEDL :=** ______________
TARGET_LED ASSERTED COLOR (R, G, A)	**T04LEDC :=** ______________
LED4 EQUATION (SELOGIC)	**T04_LED :=** ______________
TRIP LATCH T_LED (Y, N)	**T05LEDL :=** ______________
TARGET_LED ASSERTED COLOR (R, G, A)	**T05LEDC :=** ______________
LED5 EQUATION (SELOGIC)	**T05_LED :=** ______________
TRIP LATCH T_LED (Y, N)	**T06LEDL :=** ______________
TARGET_LED ASSERTED COLOR (R, G, A)	**T06LEDC :=** ______________
LED6 EQUATION (SELOGIC)	**T06_LED :=** ______________

Operator Control LED

Asserted/deasserted color choices: R = Red, G = Green, A = Amber, O = Off. Asserted and deasserted colors must be different.

PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB1ALEDC :=** ______________
PB1A_LED EQUATION (SELOGIC)	**PB1A_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB1BLEDC :=** ______________
PB1B_LED EQUATION (SELOGIC)	**PB1B_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB2ALEDC :=** ______________
PB2A_LED EQUATION (SELOGIC)	**PB2A_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB2BLEDC :=** ______________
PB2B_LED EQUATION (SELOGIC)	**PB2B_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB3ALEDC :=** ______________
PB3A_LED EQUATION (SELOGIC)	**PB3A_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB3BLEDC :=** ______________
PB3B_LED EQUATION (SELOGIC)	**PB3B_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB4ALEDC :=** ______________
PB4A_LED EQUATION (SELOGIC)	**PB4A_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB4BLEDC :=** ______________
PB4B_LED EQUATION (SELOGIC)	**PB4B_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB5ALEDC :=** ______________
PB5A_LED EQUATION (SELOGIC)	**PB5A_LED :=** ______________

PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB5BLEDC :=** ______________
PB5B_LED EQUATION (SELOGIC)	**PB5B_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB6ALEDC :=** ______________
PB6A_LED EQUATION (SELOGIC)	**PB6A_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB6BLEDC :=** ______________
PB6B_LED EQUATION (SELOGIC)	**PB6B_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB7ALEDC :=** ______________
PB7A_LED EQUATION (SELOGIC)	**PB7A_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB7BLEDC :=** ______________
PB7B_LED EQUATION (SELOGIC)	**PB7B_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB8ALEDC :=** ______________
PB8A_LED EQUATION (SELOGIC)	**PB8A_LED :=** ______________
PB_LED ASSERTED/DEASSERTED COLORS (AG, AO, AR, GA, GO, GR, OA, OG, OR, RA, RG, RO)	**PB8BLEDC :=** ______________
PB8B_LED EQUATION (SELOGIC)	**PB8B_LED :=** ______________

Display Point

(The following display point settings are hidden if the front-panel MOT option is A/B)
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	**DP01 :=** ______________________________
DISPLAY POINT DP02	**DP02 :=** ______________________________
DISPLAY POINT DP03	**DP03 :=** ______________________________
DISPLAY POINT DP04	**DP04 :=** ______________________________
DISPLAY POINT DP05	**DP05 :=** ______________________________
DISPLAY POINT DP06	**DP06 :=** ______________________________
DISPLAY POINT DP07	**DP07 :=** ______________________________
DISPLAY POINT DP08	**DP08 :=** ______________________________
DISPLAY POINT DP09	**DP09 :=** ______________________________
DISPLAY POINT DP10	**DP10 :=** ______________________________
DISPLAY POINT DP11	**DP11 :=** ______________________________
DISPLAY POINT DP12	**DP12 :=** ______________________________
DISPLAY POINT DP13	**DP13 :=** ______________________________
DISPLAY POINT DP14	**DP14 :=** ______________________________
DISPLAY POINT DP15	**DP15 :=** ______________________________
DISPLAY POINT DP16	**DP16 :=** ______________________________
DISPLAY POINT DP17	**DP17 :=** ______________________________
DISPLAY POINT DP18	**DP18 :=** ______________________________
DISPLAY POINT DP19	**DP19 :=** ______________________________

DISPLAY POINT DP20	**DP20 :=**	____________
DISPLAY POINT DP21	**DP21 :=**	____________
DISPLAY POINT DP22	**DP22 :=**	____________
DISPLAY POINT DP23	**DP23 :=**	____________
DISPLAY POINT DP24	**DP24 :=**	____________
DISPLAY POINT DP25	**DP25 :=**	____________
DISPLAY POINT DP26	**DP26 :=**	____________
DISPLAY POINT DP27	**DP27 :=**	____________
DISPLAY POINT DP28	**DP28 :=**	____________
DISPLAY POINT DP29	**DP29 :=**	____________
DISPLAY POINT DP30	**DP30 :=**	____________
DISPLAY POINT DP31	**DP31 :=**	____________
DISPLAY POINT DP32	**DP32 :=**	____________

Local Bits Labels

LB_NAME (14 characters); CLEAR LB_ LABEL, SET LB_ LABEL, and PULSE LB_ LABEL (7 characters)

LB_NAME	**NLB01 :=**	____________
CLEAR LB_ LABEL	**CLB01 :=**	____________
SET LB_ LABEL	**SLB01 :=**	____________
PULSE LB_ LABEL	**PLB01 :=**	____________
LB_NAME	**NLB02 :=**	____________
CLEAR LB_ LABEL	**CLB02 :=**	____________
SET LB_ LABEL	**SLB02 :=**	____________
PULSE LB_ LABEL	**PLB02 :=**	____________
LB_NAME	**NLB03 :=**	____________
CLEAR LB_ LABEL	**CLB03 :=**	____________
SET LB_ LABEL	**SLB03 :=**	____________
PULSE LB_ LABEL	**PLB03 :=**	____________
LB_NAME	**NLB04 :=**	____________
CLEAR LB_ LABEL	**CLB04 :=**	____________
SET LB_ LABEL	**SLB04 :=**	____________
PULSE LB_ LABEL	**PLB04 :=**	____________
LB_NAME	**NLB05 :=**	____________
CLEAR LB_ LABEL	**CLB05 :=**	____________
SET LB_ LABEL	**SLB05 :=**	____________
PULSE LB_ LABEL	**PLB05 :=**	____________
LB_NAME	**NLB06 :=**	____________
CLEAR LB_ LABEL	**CLB06 :=**	____________
SET LB_ LABEL	**SLB06 :=**	____________
PULSE LB_ LABEL	**PLB06 :=**	____________
LB_NAME	**NLB07 :=**	____________
CLEAR LB_ LABEL	**CLB07 :=**	____________
SET LB_ LABEL	**SLB07 :=**	____________
PULSE LB_ LABEL	**PLB07 :=**	____________
LB_NAME	**NLB08 :=**	____________
CLEAR LB_ LABEL	**CLB08 :=**	____________
SET LB_ LABEL	**SLB08 :=**	____________
PULSE LB_ LABEL	**PLB08 :=**	____________
LB_NAME	**NLB09 :=**	____________
CLEAR LB_ LABEL	**CLB09 :=**	____________
SET LB_ LABEL	**SLB09 :=**	____________
PULSE LB_ LABEL	**PLB09 :=**	____________
LB_NAME	**NLB10 :=**	____________
CLEAR LB_ LABEL	**CLB10 :=**	____________
SET LB_ LABEL	**SLB10 :=**	____________
PULSE LB_ LABEL	**PLB10 :=**	____________
LB_NAME	**NLB11 :=**	____________
CLEAR LB_ LABEL	**CLB11 :=**	____________
SET LB_ LABEL	**SLB11 :=**	____________
PULSE LB_ LABEL	**PLB11 :=**	____________
LB_NAME	**NLB12 :=**	____________
CLEAR LB_ LABEL	**CLB12 :=**	____________
SET LB_ LABEL	**SLB12 :=**	____________
PULSE LB_ LABEL	**PLB12 :=**	____________
LB_NAME	**NLB13 :=**	____________
CLEAR LB_ LABEL	**CLB13 :=**	____________

SET LB_ LABEL	**SLB13 :=**	__________________
PULSE LB_ LABEL	**PLB13 :=**	__________________
LB_NAME	**NLB14 :=**	__________________
CLEAR LB_ LABEL	**CLB14 :=**	__________________
SET LB_ LABEL	**SLB14 :=**	__________________
PULSE LB_ LABEL	**PLB14 :=**	__________________
LB_NAME	**NLB15 :=**	__________________
CLEAR LB_ LABEL	**CLB15 :=**	__________________
SET LB_ LABEL	**SLB15 :=**	__________________
PULSE LB_ LABEL	**PLB15 :=**	__________________
LB_NAME	**NLB16 :=**	__________________
CLEAR LB_ LABEL	**CLB16 :=**	__________________
SET LB_ LABEL	**SLB16 :=**	__________________
PULSE LB_ LABEL	**PLB16 :=**	__________________
LB_NAME	**NLB17 :=**	__________________
CLEAR LB_ LABEL	**CLB17 :=**	__________________
SET LB_ LABEL	**SLB17 :=**	__________________
PULSE LB_ LABEL	**PLB17 :=**	__________________
LB_NAME	**NLB18 :=**	__________________
CLEAR LB_ LABEL	**CLB18 :=**	__________________
SET LB_ LABEL	**SLB18 :=**	__________________
PULSE LB_ LABEL	**PLB18 :=**	__________________
LB_NAME	**NLB19 :=**	__________________
CLEAR LB_ LABEL	**CLB19 :=**	__________________
SET LB_ LABEL	**SLB19 :=**	__________________
PULSE LB_ LABEL	**PLB19 :=**	__________________
LB_NAME	**NLB20 :=**	__________________
CLEAR LB_ LABEL	**CLB20 :=**	__________________
SET LB_ LABEL	**SLB20 :=**	__________________
PULSE LB_ LABEL	**PLB20 :=**	__________________
LB_NAME	**NLB21 :=**	__________________
CLEAR LB_ LABEL	**CLB21 :=**	__________________
SET LB_ LABEL	**SLB21 :=**	__________________
PULSE LB_ LABEL	**PLB21 :=**	__________________
LB_NAME	**NLB22 :=**	__________________
CLEAR LB_ LABEL	**CLB22 :=**	__________________
SET LB_ LABEL	**SLB22 :=**	__________________
PULSE LB_ LABEL	**PLB22 :=**	__________________

LB_NAME	**NLB23 :=**	__________________
CLEAR LB_ LABEL	**CLB23 :=**	__________________
SET LB_ LABEL	**SLB23 :=**	__________________
PULSE LB_ LABEL	**PLB23 :=**	__________________
LB_NAME	**NLB24 :=**	__________________
CLEAR LB_ LABEL	**CLB24 :=**	__________________
SET LB_ LABEL	**SLB24 :=**	__________________
PULSE LB_ LABEL	**PLB24 :=**	__________________
LB_NAME	**NLB25 :=**	__________________
CLEAR LB_ LABEL	**CLB25 :=**	__________________
SET LB_ LABEL	**SLB25 :=**	__________________
PULSE LB_ LABEL	**PLB25 :=**	__________________
LB_NAME	**NLB26 :=**	__________________
CLEAR LB_ LABEL	**CLB26 :=**	__________________
SET LB_ LABEL	**SLB26 :=**	__________________
PULSE LB_ LABEL	**PLB26 :=**	__________________
LB_NAME	**NLB27 :=**	__________________
CLEAR LB_ LABEL	**CLB27 :=**	__________________
SET LB_ LABEL	**SLB27 :=**	__________________
PULSE LB_ LABEL	**PLB27 :=**	__________________
LB_NAME	**NLB28 :=**	__________________
CLEAR LB_ LABEL	**CLB28 :=**	__________________
SET LB_ LABEL	**SLB28 :=**	__________________
PULSE LB_ LABEL	**PLB28 :=**	__________________
LB_NAME	**NLB29 :=**	__________________
CLEAR LB_ LABEL	**CLB29 :=**	__________________
SET LB_ LABEL	**SLB29 :=**	__________________
PULSE LB_ LABEL	**PLB29 :=**	__________________
LB_NAME	**NLB30 :=**	__________________
CLEAR LB_ LABEL	**CLB30 :=**	__________________
SET LB_ LABEL	**SLB30 :=**	__________________
PULSE LB_ LABEL	**PLB30 :=**	__________________
LB_NAME	**NLB31 :=**	__________________
CLEAR LB_ LABEL	**CLB31 :=**	__________________
SET LB_ LABEL	**SLB31 :=**	__________________
PULSE LB_ LABEL	**PLB31 :=**	__________________
LB_NAME	**NLB32 :=**	__________________
CLEAR LB_ LABEL	**CLB32 :=**	__________________
SET LB_ LABEL	**SLB32 :=**	__________________
PULSE LB_ LABEL	**PLB32 :=**	__________________

Touchscreen Settings

(Shown if the front-panel and IRIG-B/PTC MOT option is A or B)
(Note: The Touchscreen settings category is only available in QuickSet, with the exception of the settings FPTO, FPDUR, and FPBAB, which are also available to set via the touchscreen display.)

Touchscreen Configuration

DISPLAY HOME SCREEN (Refer to *Table 8.17* for setting range)	**FPHOME :=** ______________
DISPLAY TIME-OUT (1–30 min)	**FPTO :=** ______________
ROTATING DISPLAY TRANSITION TIME (3–15 sec)	**FPDUR :=** ______________
BACKLIGHT ACTIVE BRIGHTNESS (1–10)	**FPBAB :=** ______________

Rotating Display

(Refer to Table 8.7 for the setting range)

ROTATING DISPLAY 01	**FPRD01 :=** ______________
ROTATING DISPLAY 02	**FPRD02 :=** ______________
ROTATING DISPLAY 03	**FPRD03 :=** ______________
ROTATING DISPLAY 04	**FPRD04 :=** ______________
ROTATING DISPLAY 05	**FPRD05 :=** ______________
ROTATING DISPLAY 06	**FPRD06 :=** ______________
ROTATING DISPLAY 07	**FPRD07 :=** ______________
ROTATING DISPLAY 08	**FPRD08 :=** ______________
ROTATING DISPLAY 09	**FPRD09 :=** ______________
ROTATING DISPLAY 10	**FPRD10 :=** ______________
ROTATING DISPLAY 11	**FPRD11 :=** ______________
ROTATING DISPLAY 12	**FPRD12 :=** ______________
ROTATING DISPLAY 13	**FPRD13 :=** ______________
ROTATING DISPLAY 14	**FPRD14 :=** ______________
ROTATING DISPLAY 15	**FPRD15 :=** ______________
ROTATING DISPLAY 16	**FPRD16 :=** ______________

Pushbuttons

(OFF, refer to Table 8.17 for the setting range)

PUSHBUTTON 01 HMI SCREEN	**FPPB01 :=** ______________
PUSHBUTTON 02 HMI SCREEN	**FPPB02 :=** ______________
PUSHBUTTON 03 HMI SCREEN	**FPPB03 :=** ______________
PUSHBUTTON 04 HMI SCREEN	**FPPB04 :=** ______________
PUSHBUTTON 05 HMI SCREEN	**FPPB05 :=** ______________
PUSHBUTTON 06 HMI SCREEN	**FPPB06 :=** ______________
PUSHBUTTON 07 HMI SCREEN	**FPPB07 :=** ______________
PUSHBUTTON 08 HMI SCREEN	**FPPB08 :=** ______________

Bay Control Breaker

BREAKER TRIP TYPE (3)	**BK01TTY :=** _______________
BREAKER MODE (CONTROL, MONITOR)	**BK01MOD :=** _______________
BREAKER CLOSE STATUS (Relay Word bit)	**BK01CS :=** _______________
BREAKER OPEN STATUS (Relay Word bit)	**BK01OS :=** _______________
BREAKER ALARM STATUS (Relay Word bit)	**BK01AS :=** _______________
BREAKER HMI CLOSE COMMAND (Relay Word bit)	**BK01CLC :=** _______________
BREAKER HMI OPEN COMMAND (Relay Word bit)	**BK01OPC :=** _______________

Bay Control Two-Position Disconnect

TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D01MOD :=** _______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS01CS :=** _______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS01OS :=** _______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS01IS :=** _______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS01AS :=** _______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS01CL :=** _______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS01OP :=** _______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D02MOD :=** _______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS02CS :=** _______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS02OS :=** _______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS02IS :=** _______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS02AS :=** _______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS02CL :=** _______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS02OP :=** _______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D03MOD :=** _______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS03CS :=** _______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS03OS :=** _______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS03IS :=** _______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS03AS :=** _______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS03CL :=** _______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS03OP :=** _______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D04MOD :=** _______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS04CS :=** _______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS04OS :=** _______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS04IS :=** _______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS04AS :=** _______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS04CL :=** _______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS04OP :=** _______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D05MOD :=** _______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS05CS :=** _______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS05OS :=** _______________

TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS05IS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS05AS :=** ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS05CL :=** ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS05OP :=** ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D06MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS06CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS06OS :=** ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS06IS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS06AS :=** ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS06CL :=** ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS06OP :=** ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D07MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS07CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS07OS :=** ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS07IS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS07AS :=** ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS07CL :=** ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS07OP :=** ______________
TWO-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**2D08MOD :=** ______________
TWO-POSITION DISCONNECT CLOSE STATUS (Relay Word bit)	**2DS08CS :=** ______________
TWO-POSITION DISCONNECT OPEN STATUS (Relay Word bit)	**2DS08OS :=** ______________
TWO-POSITION DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**2DS08IS :=** ______________
TWO-POSITION DISCONNECT ALARM STATUS (Relay Word bit)	**2DS08AS :=** ______________
TWO-POSITION DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**2DS08CL :=** ______________
TWO-POSITION DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**2DS08OP :=** ______________

Bay Control Three-Position Disconnect

THREE-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**3D01MOD :=** ______________
THREE-POSITION IN-LINE DISCONNECT CLOSE STATUS (Relay Word bit)	**3ID01CS :=** ______________
THREE-POSITION IN-LINE DISCONNECT OPEN STATUS (Relay Word bit)	**3ID01OS :=** ______________
THREE-POSITION IN-LINE DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ID01IS :=** ______________
THREE-POSITION IN-LINE DISCONNECT ALARM STATUS (Relay Word bit)	**3ID01AS :=** ______________
THREE-POSITION IN-LINE DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ID01CL :=** ______________
THREE-POSITION IN-LINE DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ID01OP :=** ______________
THREE-POSITION EARTHING DISCONNECT CLOSE STATUS (Relay Word bit)	**3ED01CS :=** ______________
THREE-POSITION EARTHING DISCONNECT OPEN STATUS (Relay Word bit)	**3ED01OS :=** ______________
THREE-POSITION EARTHING DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ED01IS :=** ______________
THREE-POSITION EARTHING DISCONNECT ALARM STATUS (Relay Word bit)	**3ED01AS :=** ______________
THREE-POSITION EARTHING DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ED01CL :=** ______________

THREE-POSITION EARTHING DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ED01OP** := ______________
THREE-POSITION DISCONNECT MODE (CONTROL, MONITOR)	**3D02MOD** := ______________
THREE-POSITION IN-LINE DISCONNECT CLOSE STATUS (Relay Word bit)	**3ID02CS** := ______________
THREE-POSITION IN-LINE DISCONNECT OPEN STATUS (Relay Word bit)	**3ID02OS** := ______________
THREE-POSITION IN-LINE DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ID02IS** := ______________
THREE-POSITION IN-LINE DISCONNECT ALARM STATUS (Relay Word bit)	**3ID02AS** := ______________
THREE-POSITION IN-LINE DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ID02CL** := ______________
THREE-POSITION IN-LINE DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ID02OP** := ______________
THREE-POSITION EARTHING DISCONNECT CLOSE STATUS (Relay Word bit)	**3ED02CS** := ______________
THREE-POSITION EARTHING DISCONNECT OPEN STATUS (Relay Word bit)	**3ED02OS** := ______________
THREE-POSITION EARTHING DISCONNECT IN-PROGRESS STATUS (Relay Word bit)	**3ED02IS** := ______________
THREE-POSITION EARTHING DISCONNECT ALARM STATUS (Relay Word bit)	**3ED02AS** := ______________
THREE-POSITION EARTHING DISCONNECT HMI CLOSE COMMAND (Relay Word bit)	**3ED02CL** := ______________
THREE-POSITION EARTHING DISCONNECT HMI OPEN COMMAND (Relay Word bit)	**3ED02OP** := ______________

Analog Label

ANALOG QUANTITY	**ALAB01** := ______________
ANALOG QUANTITY	**ALAB02** := ______________
ANALOG QUANTITY	**ALAB03** := ______________
ANALOG QUANTITY	**ALAB04** := ______________
ANALOG QUANTITY	**ALAB05** := ______________
ANALOG QUANTITY	**ALAB06** := ______________
ANALOG QUANTITY	**ALAB07** := ______________
ANALOG QUANTITY	**ALAB08** := ______________
ANALOG QUANTITY	**ALAB09** := ______________
ANALOG QUANTITY	**ALAB10** := ______________
ANALOG QUANTITY	**ALAB11** := ______________
ANALOG QUANTITY	**ALAB12** := ______________
ANALOG QUANTITY	**ALAB13** := ______________
ANALOG QUANTITY	**ALAB14** := ______________
ANALOG QUANTITY	**ALAB15** := ______________
ANALOG QUANTITY	**ALAB16** := ______________
ANALOG QUANTITY	**ALAB17** := ______________
ANALOG QUANTITY	**ALAB18** := ______________
ANALOG QUANTITY	**ALAB19** := ______________
ANALOG QUANTITY	**ALAB20** := ______________
ANALOG QUANTITY	**ALAB21** := ______________
ANALOG QUANTITY	**ALAB22** := ______________

ANALOG QUANTITY	**ALAB23 :=** _______________
ANALOG QUANTITY	**ALAB24 :=** _______________
ANALOG QUANTITY	**ALAB25 :=** _______________
ANALOG QUANTITY	**ALAB26 :=** _______________
ANALOG QUANTITY	**ALAB27 :=** _______________
ANALOG QUANTITY	**ALAB28 :=** _______________
ANALOG QUANTITY	**ALAB29 :=** _______________
ANALOG QUANTITY	**ALAB30 :=** _______________
ANALOG QUANTITY	**ALAB31 :=** _______________
ANALOG QUANTITY	**ALAB32 :=** _______________

Digital Label

RELAY WORD BIT	**DLAB01 :=** _______________
RELAY WORD BIT	**DLAB02 :=** _______________
RELAY WORD BIT	**DLAB03 :=** _______________
RELAY WORD BIT	**DLAB04 :=** _______________
RELAY WORD BIT	**DLAB05 :=** _______________
RELAY WORD BIT	**DLAB06 :=** _______________
RELAY WORD BIT	**DLAB07 :=** _______________
RELAY WORD BIT	**DLAB08 :=** _______________
RELAY WORD BIT	**DLAB09 :=** _______________
RELAY WORD BIT	**DLAB10 :=** _______________
RELAY WORD BIT	**DLAB11 :=** _______________
RELAY WORD BIT	**DLAB12 :=** _______________
RELAY WORD BIT	**DLAB13 :=** _______________
RELAY WORD BIT	**DLAB14 :=** _______________
RELAY WORD BIT	**DLAB15 :=** _______________
RELAY WORD BIT	**DLAB16 :=** _______________
RELAY WORD BIT	**DLAB17 :=** _______________
RELAY WORD BIT	**DLAB18 :=** _______________
RELAY WORD BIT	**DLAB19 :=** _______________
RELAY WORD BIT	**DLAB20 :=** _______________
RELAY WORD BIT	**DLAB21 :=** _______________
RELAY WORD BIT	**DLAB22 :=** _______________
RELAY WORD BIT	**DLAB23 :=** _______________
RELAY WORD BIT	**DLAB24 :=** _______________
RELAY WORD BIT	**DLAB25 :=** _______________
RELAY WORD BIT	**DLAB26 :=** _______________
RELAY WORD BIT	**DLAB27 :=** _______________
RELAY WORD BIT	**DLAB28 :=** _______________
RELAY WORD BIT	**DLAB29 :=** _______________

RELAY WORD BIT	**DLAB30 :=** ______________
RELAY WORD BIT	**DLAB31 :=** ______________
RELAY WORD BIT	**DLAB32 :=** ______________

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 the 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 in length. Use NA to disable the setting.

ENABLE ALIAS (N, 1–32) **EALIAS :=** ______________________________

(All subsequent ALIAS settings are hidden and forced to NA if EALIAS := N)

ALIAS1	**ALIAS1 :=** ______________________________
ALIAS2	**ALIAS2 :=** ______________________________
ALIAS3	**ALIAS3 :=** ______________________________
ALIAS4	**ALIAS4 :=** ______________________________
ALIAS5	**ALIAS5 :=** ______________________________
ALIAS6	**ALIAS6 :=** ______________________________
ALIAS7	**ALIAS7 :=** ______________________________
ALIAS8	**ALIAS8 :=** ______________________________
ALIAS 9	**ALIAS9 :=** ______________________________
ALIAS10	**ALIAS10 :=** ______________________________
ALIAS11	**ALIAS11 :=** ______________________________
ALIAS12	**ALIAS12 :=** ______________________________
ALIAS13	**ALIAS13 :=** ______________________________
ALIAS14	**ALIAS14 :=** ______________________________
ALIAS15	**ALIAS15 :=** ______________________________
ALIAS16	**ALIAS16 :=** ______________________________
ALIAS17	**ALIAS17 :=** ______________________________
ALIAS18	**ALIAS18 :=** ______________________________
ALIAS19	**ALIAS19 :=** ______________________________
ALIAS20	**ALIAS20 :=** ______________________________
ALIAS21	**ALIAS21 :=** ______________________________
ALIAS22	**ALIAS22 :=** ______________________________
ALIAS23	**ALIAS23 :=** ______________________________
ALIAS24	**ALIAS24 :=** ______________________________

ALIAS25	**ALIAS25 :=** ________________
ALIAS26	**ALIAS26 :=** ________________
ALIAS27	**ALIAS27 :=** ________________
ALIAS28	**ALIAS28 :=** ________________
ALIAS29	**ALIAS29 :=** ________________
ALIAS30	**ALIAS30 :=** ________________
ALIAS31	**ALIAS31 :=** ________________
ALIAS32	**ALIAS32 :=** ________________

Event Report

EVENT TRIGGER (SELOGIC) **ER :=** ________

EVENT LENGTH (15, 64, 180 cycles) **LER :=** ________

PREFAULT LENGTH (1–10 cycles {if LER := 15}, 1–59 cycles {if LER := 64}, 1–175 cycles {if LER := 180}) **PRE :=** ________

Start Report

MSR RESOLUTION (0.25, 0.5, 1, 2, 5, 20 cycles) **MSRR :=** ________

MSR TRIGGER (SELOGIC) **MSRTRG :=** ________

Fast Message Read Settings

FMRnNAM := any valid string (no spaces allowed; should be different from other FMRxNAM).
FMRn := as many as 24 analog quantities separated by spaces or commas (analog quantities listed here are included in the Fast Message read request).
Use NA to disable the setting.

FMR1 NAME (9 characters) **FMR1NAM :=** ________

FAST MESSAGE READ FMR1 (24 analog quantities) **FMR1 :=** ________

FMR2 NAME (9 characters) **FMR2NAM :=** ________

FAST MESSAGE READ FMR2 (24 analog quantities) **FMR2 :=** ________

FMR3 NAME (9 characters) **FMR3NAM :=** ________

FAST MESSAGE READ FMR3 (24 analog quantities) **FMR3 :=** ________

FMR4 NAME (9 characters) **FMR4NAM :=** ________

FAST MESSAGE READ FMR4 (24 analog quantities) **FMR4 :=** ________

Fast Message Remote Analog Settings

Remote Analog Value Type (I, F, L), I = Integer, F = Float, L = Long

RA01TYPE := ________________

RA02TYPE := ________________

RA03TYPE := ________________

RA04TYPE := ________________

RA05TYPE := ________________

RA06TYPE := ________________

RA07TYPE := ________________

RA08TYPE := ________________

RA09TYPE := ________________

RA10TYPE := ________________

RA11TYPE := ________________

RA12TYPE := ________________

RA13TYPE := ________________

RA14TYPE := ________________

RA15TYPE := ________________

RA16TYPE := ________________

RA17TYPE := ________________

RA18TYPE := ________________

RA19TYPE := ______________________

RA20TYPE := ______________________

RA21TYPE := ______________________

RA22TYPE := ______________________

RA23TYPE := ______________________

RA24TYPE := ______________________

RA25TYPE := ______________________

RA26TYPE := ______________________

RA27TYPE := ______________________

RA28TYPE := ______________________

RA29TYPE := ______________________

RA30TYPE := ______________________

RA31TYPE := ______________________

RA32TYPE := ______________________

Load Profile

LDP LIST (NA, as many as 17 analog quantities) **LDLIST :=** __________

LDP ACQ RATE (5, 10, 15, 30, 60 min) **LDAR :=** __________

Modbus Map Settings (SET M Command)

Modbus User Map

User Map Register Label Name (8 characters); see Appendix E: Modbus Communications for additional details.

MOD_001 := ______________________

MOD_002 := ______________________

MOD_003 := ______________________

MOD_004 := ______________________

MOD_005 := ______________________

MOD_006 := ______________________

MOD_007 := ______________________

MOD_008 := ______________________

MOD_009 := ______________________

MOD_010 := ______________________

MOD_011 := ______________________

MOD_012 := ______________________

MOD_013 := ______________________

MOD_014 := ______________________

MOD_015 := ______________________

MOD_016 := ______________________

MOD_017 := ______________________

MOD_018 := ______________________

MOD_019 := ______________________

MOD_020 := ______________________

MOD_021 := ______________________

MOD_022 := ______________________

MOD_023 := ______________________

MOD_024 := ______________________

MOD_025 := ______________________

MOD_026 := ______________________

MOD_027 := ______________________

MOD_028 := ______________________

MOD_029 := ______________________

MOD_030 := ______________________

MOD_031 := ______________________

MOD_032 := ______________________

MOD_033 := ______________________

MOD_034 := ______________________

MOD_035 := ______________________

MOD_036 := ______________________

MOD_037 := ______________________________
MOD_038 := ______________________________
MOD_039 := ______________________________
MOD_040 := ______________________________
MOD_041 := ______________________________
MOD_042 := ______________________________
MOD_043 := ______________________________
MOD_044 := ______________________________
MOD_045 := ______________________________
MOD_046 := ______________________________
MOD_047 := ______________________________
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MOD_104 := ______________________________
MOD_105 := ______________________________
MOD_106 := ______________________________
MOD_107 := ______________________________
MOD_108 := ______________________________
MOD_109 := ______________________________
MOD_110 := ______________________________
MOD_111 := ______________________________
MOD_112 := ______________________________
MOD_113 := ______________________________
MOD_114 := ______________________________
MOD_115 := ______________________________
MOD_116 := ______________________________
MOD_117 := ______________________________

MOD_118 := ______________________________

MOD_119 := ______________________________

MOD_120 := ______________________________

MOD_121 := ______________________________

MOD_122 := ______________________________

MOD_123 := ______________________________

MOD_124 := ______________________________

MOD_125 := ______________________________

DNP3 Map Settings (Set DNP n Command)

(Hidden when the DNP option is not included)

Use the ***SET DNP n*** *command with n = 1, 2, or 3 to create as many as three DNP User Maps. Refer to Appendix D: DNP3 Communications for details. DNP Map1 is shown below (DNP Map 2 and DNP Map 3 tables are identical to DNP Map 1 table).*

Binary Input Map

DNP Binary Input Label Name (10 characters)

BI_00 := ______________________________

BI_01 := ______________________________

BI_02 := ______________________________

BI_03 := ______________________________

BI_04 := ______________________________

BI_05 := ______________________________

BI_06 := ______________________________

BI_07 := ______________________________

BI_08 := ______________________________

BI_09 := ______________________________

BI_10 := ______________________________

BI_11 := ______________________________

BI_12 := ______________________________

BI_13 := ______________________________

BI_14 := ______________________________

BI_15 := ______________________________

BI_16 := ______________________________

BI_17 := ______________________________

BI_18 := ______________________________

BI_19 := ______________________________

BI_20 := ______________________________

BI_21 := ______________________________

BI_22 := ______________________________

BI_23 := ______________________________

BI_24 := ______________________________

BI_25 := ______________________________

BI_26 := ______________________________

BI_27 := ______________________________

BI_28 := ______________________________

BI_29 := ______________________________

BI_30 := ______________________________

BI_31 := ______________________________

BI_32 := ______________________________

BI_33 := ______________________________

BI_34 := ______________________________

BI_35 := ______________________________

BI_36 := ______________________________

BI_37 := ______________________________

BI_38 := ______________________________

BI_39 := ______________________________

BI_40 := ______________________________

BI_41 := ______________________________

BI_42 := ______________________________

BI_43 := ______________________________

BI_44 := ______________________________

BI_45 := ______________________________

BI_46 := ______________________________

BI_47 := ______________________________

BI_48 := ______________________________

BI_49 := ________________

BI_50 := ________________

BI_51 := ________________

BI_52 := ________________

BI_53 := ________________

BI_54 := ________________

BI_55 := ________________

BI_56 := ________________

BI_57 := ________________

BI_58 := ________________

BI_59 := ________________

BI_60 := ________________

BI_61 := ________________

BI_62 := ________________

BI_63 := ________________

BI_64 := ________________

BI_65 := ________________

BI_66 := ________________

BI_67 := ________________

BI_68 := ________________

BI_69 := ________________

BI_70 := ________________

BI_71 := ________________

BI_72 := ________________

BI_73 := ________________

BI_74 := ________________

BI_75 := ________________

BI_76 := ________________

BI_77 := ________________

BI_78 := ________________

BI_79 := ________________

BI_80 := ________________

BI_81 := ________________

BI_82 := ________________

BI_83 := ________________

BI_84 := ________________

BI_85 := ________________

BI_86 := ________________

BI_87 := ________________

BI_88 := ________________

BI_89 := ________________

BI_90 := ________________

BI_91 := ________________

BI_92 := ________________

BI_93 := ________________

BI_94 := ________________

BI_95 := ________________

BI_96 := ________________

BI_97 := ________________

BI_98 := ________________

BI_99 := ________________

Binary Output Map

DNP Binary Output Label Name (10 characters)

BO_00 := ________________

BO_01 := ________________

BO_02 := ________________

BO_03 := ________________

BO_04 := ________________

BO_05 := ________________

BO_06 := ________________

BO_07 := ________________

BO_08 := ________________

BO_09 := ________________

BO_10 := ________________

BO_11 := ________________

BO_12 := ________________

BO_13 := ________________

BO_14 := ________________

BO_15 := ________________

BO_16 := ________________

BO_17 := ________________

BO_18 := ________________

BO_19 := ________________

BO_20 := ________________

BO_21 := ______________________

BO_22 := ______________________

BO_23 := ______________________

BO_24 := ______________________

BO_25 := ______________________

BO_26 := ______________________

BO_27 := ______________________

BO_28 := ______________________

BO_29 := ______________________

BO_30 := ______________________

BO_31 := ______________________

Analog Input Map

DNP Analog Input Label Name (24 characters)

AI_00 := ______________________

AI_01 := ______________________

AI_02 := ______________________

AI_03 := ______________________

AI_04 := ______________________

AI_05 := ______________________

AI_06 := ______________________

AI_07 := ______________________

AI_08 := ______________________

AI_09 := ______________________

AI_10 := ______________________

AI_11 := ______________________

AI_12 := ______________________

AI_13 := ______________________

AI_14 := ______________________

AI_15 := ______________________

AI_16 := ______________________

AI_17 := ______________________

AI_18 := ______________________

AI_19 := ______________________

AI_20 := ______________________

AI_21 := ______________________

AI_22 := ______________________

AI_23 := ______________________

AI_24 := ______________________

AI_25 := ______________________

AI_26 := ______________________

AI_27 := ______________________

AI_28 := ______________________

AI_29 := ______________________

AI_30 := ______________________

AI_31 := ______________________

AI_32 := ______________________

AI_33 := ______________________

AI_34 := ______________________

AI_35 := ______________________

AI_36 := ______________________

AI_37 := ______________________

AI_38 := ______________________

AI_39 := ______________________

AI_40 := ______________________

AI_41 := ______________________

AI_42 := ______________________

AI_43 := ______________________

AI_44 := ______________________

AI_45 := ______________________

AI_46 := ______________________

AI_47 := ______________________

AI_48 := ______________________

AI_49 := ______________________

AI_50 := ______________________

AI_51 := ______________________

AI_52 := ______________________

AI_53 := ______________________

AI_54 := ______________________

AI_55 := ______________________

AI_56 := ______________________

AI_57 := ______________________

AI_58 := ______________________

AI_59 := ______________________

AI_60 := ______________________

AI_61 := ______________________

AI_62 := ______________________

AI_63 := ______________________

AI_64 := ______________________________
AI_65 := ______________________________
AI_66 := ______________________________
AI_67 := ______________________________
AI_68 := ______________________________
AI_69 := ______________________________
AI_70 := ______________________________
AI_71 := ______________________________
AI_72 := ______________________________
AI_73 := ______________________________
AI_74 := ______________________________
AI_75 := ______________________________
AI_76 := ______________________________
AI_77 := ______________________________
AI_78 := ______________________________
AI_79 := ______________________________
AI_80 := ______________________________
AI_81 := ______________________________
AI_82 := ______________________________
AI_83 := ______________________________
AI_84 := ______________________________
AI_85 := ______________________________
AI_86 := ______________________________
AI_87 := ______________________________
AI_88 := ______________________________
AI_89 := ______________________________
AI_90 := ______________________________
AI_91 := ______________________________
AI_92 := ______________________________
AI_93 := ______________________________
AI_94 := ______________________________
AI_95 := ______________________________
AI_96 := ______________________________
AI_97 := ______________________________
AI_98 := ______________________________
AI_99 := ______________________________

Analog Output Map

DNP Analog Output Label Name (10 characters)

AO_00 := ______________________________
AO_01 := ______________________________
AO_02 := ______________________________
AO_03 := ______________________________
AO_04 := ______________________________
AO_05 := ______________________________
AO_06 := ______________________________
AO_07 := ______________________________
AO_08 := ______________________________
AO_09 := ______________________________
AO_10 := ______________________________
AO_11 := ______________________________
AO_12 := ______________________________
AO_13 := ______________________________
AO_14 := ______________________________
AO_15 := ______________________________
AO_16 := ______________________________
AO_17 := ______________________________
AO_18 := ______________________________
AO_19 := ______________________________
AO_20 := ______________________________
AO_21 := ______________________________
AO_22 := ______________________________
AO_23 := ______________________________
AO_24 := ______________________________
AO_25 := ______________________________
AO_26 := ______________________________
AO_27 := ______________________________
AO_28 := ______________________________
AO_29 := ______________________________
AO_30 := ______________________________
AO_31 := ______________________________

Counter Map

DNP Counter Label Name (11 characters)

CO_00 := ______________________
CO_01 := ______________________
CO_02 := ______________________
CO_03 := ______________________
CO_04 := ______________________
CO_05 := ______________________
CO_06 := ______________________
CO_07 := ______________________
CO_08 := ______________________
CO_09 := ______________________
CO_10 := ______________________
CO_11 := ______________________
CO_12 := ______________________
CO_13 := ______________________
CO_14 := ______________________
CO_15 := ______________________
CO_16 := ______________________
CO_17 := ______________________
CO_18 := ______________________
CO_19 := ______________________
CO_20 := ______________________
CO_21 := ______________________
CO_22 := ______________________
CO_23 := ______________________
CO_24 := ______________________
CO_25 := ______________________
CO_26 := ______________________
CO_27 := ______________________
CO_28 := ______________________
CO_29 := ______________________
CO_30 := ______________________
CO_31 := ______________________

IEC 60870-5-103 Map Settings (SET I Command)

(Hidden if the IEC 60870-5-103 option is not included)
*Use the **SET I** command to input the map required for the IEC 60870-5-103 protocol.*

Binary Input Map

103BI00 := ______________________
103BI01 := ______________________
103BI02 := ______________________
103BI03 := ______________________
103BI04 := ______________________
103BI05 := ______________________
103BI06 := ______________________
103BI07 := ______________________
103BI08 := ______________________
103BI09 := ______________________
103BI10 := ______________________
103BI11 := ______________________
103BI12 := ______________________
103BI13 := ______________________
103BI14 := ______________________
103BI15 := ______________________
103BI16 := ______________________
103BI17 := ______________________
103BI18 := ______________________
103BI19 := ______________________
103BI20 := ______________________
103BI21 := ______________________
103BI22 := ______________________
103BI23 := ______________________
103BI24 := ______________________
103BI25 := ______________________
103BI26 := ______________________
103BI27 := ______________________
103BI28 := ______________________
103BI29 := ______________________
103BI30 := ______________________
103BI31 := ______________________

103BI32 := ________________
103BI33 := ________________
103BI34 := ________________
103BI35 := ________________
103BI36 := ________________
103BI37 := ________________
103BI38 := ________________
103BI39 := ________________
103BI40 := ________________
103BI41 := ________________
103BI42 := ________________
103BI43 := ________________
103BI44 := ________________
103BI45 := ________________
103BI46 := ________________
103BI47 := ________________
103BI48 := ________________
103BI49 := ________________
103BI50 := ________________
103BI51 := ________________
103BI52 := ________________
103BI53 := ________________
103BI54 := ________________
103BI55 := ________________
103BI56 := ________________
103BI57 := ________________
103BI58 := ________________
103BI59 := ________________
103BI60 := ________________
103BI61 := ________________
103BI62 := ________________
103BI63 := ________________
103BI64 := ________________
103BI65 := ________________
103BI66 := ________________
103BI67 := ________________
103BI68 := ________________
103BI69 := ________________
103BI70 := ________________
103BI71 := ________________
103BI72 := ________________
103BI73 := ________________
103BI74 := ________________
103BI75 := ________________
103BI76 := ________________
103BI77 := ________________
103BI78 := ________________
103BI79 := ________________
103BI80 := ________________
103BI81 := ________________
103BI82 := ________________
103BI83 := ________________
103BI84 := ________________
103BI85 := ________________
103BI86 := ________________
103BI87 := ________________
103BI88 := ________________
103BI89 := ________________
103BI90 := ________________
103BI91 := ________________
103BI92 := ________________
103BI93 := ________________
103BI94 := ________________
103BI95 := ________________
103BI96 := ________________
103BI97 := ________________
103BI98 := ________________
103BI99 := ________________

Binary Target Map

103BT00 := ________________
103BT01 := ________________
103BT02 := ________________
103BT03 := ________________
103BT04 := ________________
103BT05 := ________________
103BT06 := ________________
103BT07 := ________________

Fault Analog Map

103FA00 := ______________
103FA01 := ______________
103FA02 := ______________
103FA03 := ______________
103FA04 := ______________
103FA05 := ______________
103FA06 := ______________
103FA07 := ______________
103FA08 := ______________
103FA09 := ______________
103FA10 := ______________
103FA11 := ______________
103FA12 := ______________
103FA13 := ______________
103FA14 := ______________
103FA15 := ______________
103FA16 := ______________
103FA17 := ______________
103FA18 := ______________
103FA19 := ______________
103FA20 := ______________
103FA21 := ______________
103FA22 := ______________
103FA23 := ______________
103FA24 := ______________
103FA25 := ______________
103FA26 := ______________
103FA27 := ______________
103FA28 := ______________
103FA29 := ______________
103FA30 := ______________
103FA31 := ______________

Binary Control Map

103BO00 := ______________
103BO01 := ______________
103BO02 := ______________
103BO03 := ______________
103BO04 := ______________
103BO05 := ______________
103BO06 := ______________
103BO07 := ______________
103BO08 := ______________
103BO09 := ______________
103BO10 := ______________
103BO11 := ______________
103BO12 := ______________
103BO13 := ______________
103BO14 := ______________
103BO15 := ______________
103BO16 := ______________
103BO17 := ______________
103BO18 := ______________
103BO19 := ______________
103BO20 := ______________
103BO21 := ______________
103BO22 := ______________
103BO23 := ______________
103BO24 := ______________
103BO25 := ______________
103BO26 := ______________
103BO27 := ______________
103BO28 := ______________
103BO29 := ______________
103BO30 := ______________
103BO31 := ______________

Measurand Map

3MLB000 := ______________
3MLB001 := ______________
3MLB002 := ______________
3MLB003 := ______________

3MLB004 := ______________________

3MLB005 := ______________________

3MLB006 := ______________________

3MLB007 := ______________________

3MLB008 := ______________________

3MLB009 := ______________________

3MLB010 := ______________________

3MLB011 := ______________________

3MLB012 := ______________________

3MLB013 := ______________________

3MLB014 := ______________________

3MLB015 := ______________________

3MLB016 := ______________________

3MLB017 := ______________________

3MLB018 := ______________________

3MLB019 := ______________________

3MLB020 := ______________________

3MLB021 := ______________________

3MLB022 := ______________________

3MLB023 := ______________________

3MLB024 := ______________________

3MLB025 := ______________________

3MLB026 := ______________________

3MLB027 := ______________________

3MLB028 := ______________________

3MLB029 := ______________________

3MLB030 := ______________________

3MLB031 := ______________________

3MLB032 := ______________________

3MLB033 := ______________________

3MLB034 := ______________________

3MLB035 := ______________________

3MLB036 := ______________________

3MLB037 := ______________________

3MLB038 := ______________________

3MLB039 := ______________________

3MLB040 := ______________________

3MLB041 := ______________________

3MLB042 := ______________________

3MLB043 := ______________________

3MLB044 := ______________________

3MLB045 := ______________________

3MLB046 := ______________________

3MLB047 := ______________________

3MLB048 := ______________________

3MLB049 := ______________________

3MLB050 := ______________________

EtherNet/IP Assembly Map Settings (SET E Command)

EtherNet/IP Assembly Map

(See Appendix F: EtherNet/IP Communications for additional details)
(EtherNet/IP Assembly Map settings are hidden if EtherNet/IP is not included)
(Use SET E n command where n = 1, 2, or 3 to create as many as three EtherNet/IP Assembly Maps)
(This is EtherNet/IP Assembly Map 1 (EtherNet/IP Assembly Map 2 and EtherNet/IP Assembly Map 3 are identical to EtherNet/IP Assembly Map 1))

Input Assembly (IA) Binary

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_00** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_01** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_02** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_03** := ______________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_04** := ______________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_05** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_06** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_07** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_08** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_09** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_10** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_11** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_12** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_13** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_14** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_15** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_16** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_17** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_18** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_19** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_20** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_21** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_22** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_23** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_24** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_25** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_26** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_27** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_28** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_29** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_30** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_31** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_32** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_33** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_34** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_35** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_36** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_37** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_38** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_39** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_40** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_41** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_42** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_43** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_44** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_45** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_46** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_47** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_48** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_49** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_50** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_51** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_52** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_53** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_54** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_55** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_56** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_57** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_58** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_59** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_60** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_61** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_62** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_63** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_64** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_65** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_66** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_67** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_68** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_69** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_70** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_71** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_72** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_73** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_74** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_75** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_76** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_77** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_78** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_79** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_80** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_81** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_82** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_83** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_84** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_85** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_86** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_87** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_88** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_89** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_90** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_91** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_92** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_93** := ______________________
EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters)	**IAB_94** := ______________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_95** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_96** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_97** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_98** := ____________________

EIP INPUT ASSEMBLY BINARY LABEL NAME (10 characters) **IAB_99** := ____________________

Input Assembly (IA) Analog

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_00** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_01** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_02** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_03** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_04** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_05** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_06** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_07** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_08** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_09** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_10** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_11** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_12** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_13** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_14** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_15** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_16** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_17** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_18** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_19** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_20** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_21** := ____________________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_22** := ____________________

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EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**IAA_24** := ________________
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EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_97** := ____________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_98** := ____________

EIP INPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **IAA_99** := ____________

Output Assembly (OA) Binary

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_00** := ____________

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_01** := ____________

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_02** := ____________

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_03** := ____________

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_04** := ____________

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_05** := ____________

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EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_10** := ____________

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_11** := ____________

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EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_30** := ____________

EIP OUTPUT ASSEMBLY BINARY LABEL NAME (10 characters) **OAB_31** := ____________

Output Assembly (OA) Analog

EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_00** := ____________

EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_01** := ____________

EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters) **OAA_02** := ____________

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EIP OUTPUT ASSEMBLY ANALOG LABEL NAME (10 characters)	**OAA_31** := ____________________

Section 7
Communications

Overview

A communications interface and protocol are required for communicating with the SEL-710-5 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-710-5 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-710-5 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 Serial (ST connector)	Rear	Standard
PORT 3	Option 1: EIA-232 Option 2: EIA-485	Rear	Ordering Option
PORT 4	Option 1: EIA-232 or EIA-485 Serial Communications Card Option 2: DeviceNet Communications Card [b]	Rear	Ordering Option

[a] This port can receive the RTD measurement information from the optional external SEL-2600 RTD Module. Refer to the SEL-2600 RTD Module Instruction Manual for information on the fiber-optic interface.
[b] Refer to Appendix I: 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-710-5. For example, consider the fiber-optic interface in noisy installations or for large communications distances. Following is general information on possible applications of the different interfaces.

Serial (EIA-232 and EIA-485) Port

Use the EIA-232 port for communications distances as 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 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-710-5 Relay

Some of the SEL devices available for integration or communications system robustness are included in the following list:

- SEL communications processors
- 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 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 optional fiber-optic port (Port 2) for safety and communications distances as far as 1 km. For communications distances as far as 4 km, use an SEL-2812 transceiver on Port 3. Although Port 2 and the SEL-2812 are compatible, Port 2 is less sensitive than the SEL-2812, which limits the distance to 1 km. Port 2 can receive the RTD measurement information from the optional external SEL-2600 RTD Module.

Telnet or the Web Server

Factory-default settings for the Ethernet ports disable all Ethernet protocols except for Telnet, HTTP, and PING. Command **SET P 1** accesses settings for both Ethernet ports on the SEL-710-5: Port 1A and Port 1B. See the Ethernet port settings in *Table 4.96* for a sample of the **SET P 1** command with factory-default settings.

Set the listed settings to the following using the **SET P 1** command:

- IPADDR := IP address assigned by the network administrator
- DEFRTR := Default router IP address assigned by the network administrator
- NETMODE := SWITCHED (available with dual Ethernet ports)
- ETELNET := Y
- EHTTP := Y

NOTE: Telnet and the web server work with other NETMODE settings as well, but NETMODE = SWITCHED is the easiest to begin communication. The relay hides setting NETMODE when it is equipped with a single Ethernet port.

Leave all other settings at their default values.

Connect an Ethernet cable between your PC or a network switch and any Ethernet port on the relay. Verify that the amber **Link** LED illuminates on the connected relay port. Many computers and most Ethernet switches support autocrossover, so nearly any Cat 5 Ethernet cable with RJ45 connectors, such as an SEL-C627 cable, will work. If the computer does not support autocrossover, use a crossover cable, such as an SEL-C628 cable. If your relay is equipped with dual Ethernet ports, connect to either port. Use a Telnet application of QuickSet on the host PC to communicate with the relay. To terminate a Telnet session, use the command **EXI** from any access level.

In addition, you can communicate with the relay through your web browser. Launch a web browser and go to http://IPADDR, where IPADDR is the Port 1 IPADDR setting.

To terminate the session, close the web browser (see *Section 3: PC Interface* for more details).

Ethernet Port

Use the Ethernet port for interfacing with an Ethernet network environment. SEL-710-5 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. The basic concept in the Parallel Redundancy Protocol (PRP) mode of operation is that the Ethernet network and all traffic are fully duplicated, with the two copies operating in parallel. The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure. In addition to failover and PRP modes, the unit can operate in a “fixed connection (to netport) mode” or in a “switched mode” (as an unmanaged switch).

Carefully design your Ethernet network to maximize reliability, minimize system administrator efforts, and provide adequate security. SEL recommends that you work with a networking professional to design your substation Ethernet network.

Several settings control how the relay with the optional Ethernet card operates on an Ethernet network. These settings include IP addressing information, network port failover options, and network speed.

Use the network configuration settings shown in *Table 4.96* to configure the relay for operation on an IP network and to set other parameters affecting the physical Ethernet network interface operation.

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.

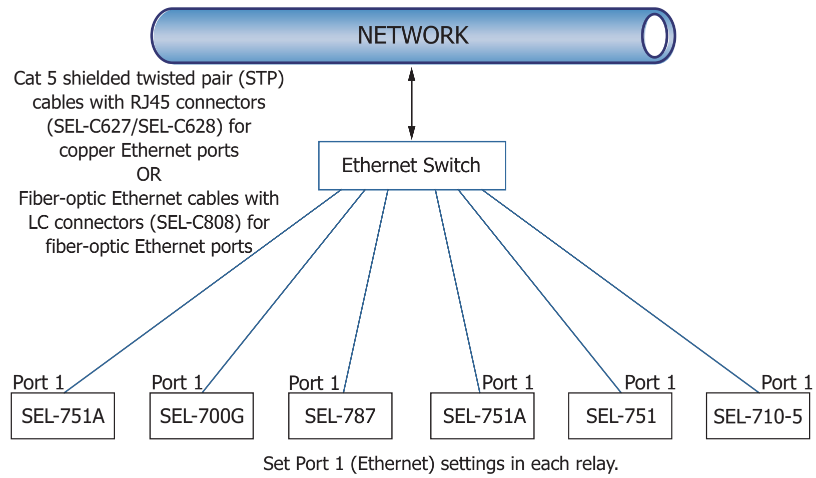


Figure 7.1 Simple Ethernet Network Configuration

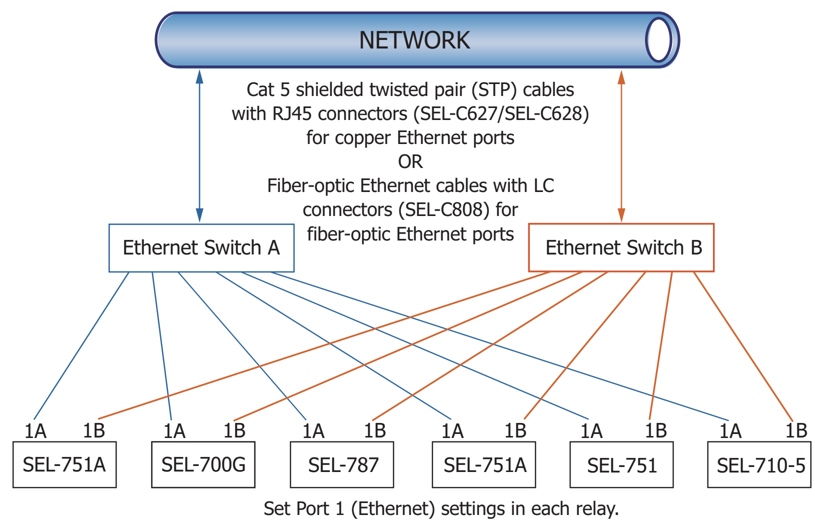


Figure 7.2 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

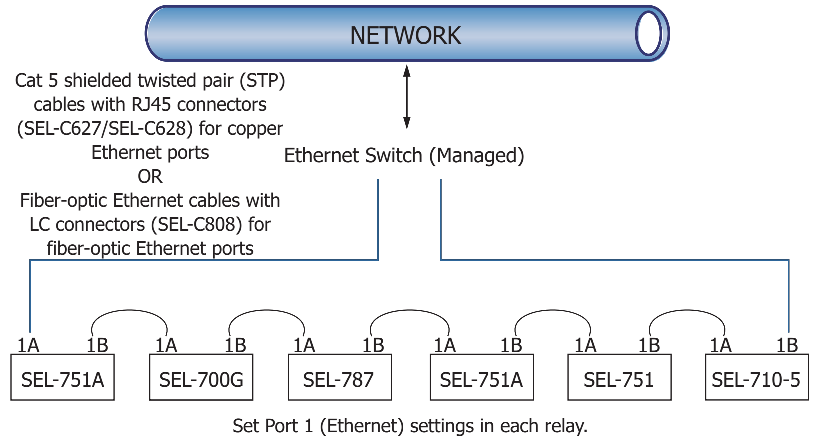


Figure 7.3 Ethernet Network Configuration With Ring Structure (Switched Mode)

Dual Network Port Operation

The SEL-710-5 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. (OFF, 0.10–65.00 seconds).

Step 3. Set NETPORT to the preferred network interface.

On startup, the relay communicates via the NETPORT (primary port) selected. If the SEL-710-5 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.

Setting FTIME := OFF allows fast port switching (with no intentional delay). Fast port switching occurs within one processing interval (typically 4 to 5 ms) and helps with IEC 61850 GOOSE performance.

After failover, while communicating via standby port, the SEL-710-5 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.

Switched Mode

If you have a network configuration where you want to use the relay as an unmanaged or managed switch, set NETMODE to SWITCHED. Set ERSTP := Y to use it as a managed switch. In SWITCHED mode, both links are enabled. The relay responds to the messages it receives on either port. All the messages received on one network port that are not addressed to the relay are transmitted out of the other port without any modifications. In this mode, the relay ignores the NETPORT setting.

SWITCHED mode is often used to connect several relays to each other, creating a network of relays, then connecting at least two relays to a managed switch for redundancy. This configuration is popular because it reduces cost and reduces the number of devices in a network without sacrificing redundancy. Basically, each relay has a redundant path to the network. Refer to *Figure 7.3*.

There are compromises to be made in this configuration, however. When connecting cables between multiple switches in an Ethernet network, physical loops (rings) may occur that cause traffic storms, total bandwidth consumption, and other improper functioning. As a result, a subset of the relays in this configuration can seem unresponsive for extended periods of time.

For example, in *Figure 7.3*, imagine that a DNP master is receiving DNP UDP unsolicited messages from the relays. When a link is broken, it can sometimes take as long as 5 minutes for communications to be restored. For a similar network involving IEC 61850 GOOSE and a broken link, the restoration time can be greater than 5 seconds. The relay offers Rapid Spanning Tree Protocol (RSTP) mode to improve restoration times in such configurations. With RSTP enabled, the expected restoration time of the before-mentioned GOOSE network is around 100 ms.

RSTP protocol controls active paths in an Ethernet network to avoid loops and enable a level of redundancy. All Port 1 protocols are supported when RSTP is enabled. Refer to *Rapid Spanning Tree Protocol (RSTP) on page 7.22* for additional details.

Fixed Connection Mode

If you have a single network and want to use only one network port, or if you have both ports connected but want to force usage of only one port for various reasons, set NETMODE to FIXED and set NETPORT to the port you want to use. Only the selected network port operates and the other port is disabled.

PRP Connection Mode

Parallel Redundancy Protocol (PRP) is part of an IEC standard for high-availability automation networks (IEC 62439-3). The purpose of the protocol is to provide seamless recovery from any single Ethernet network failure.

The basic concept is that the Ethernet network and all traffic are fully duplicated with the two copies operating in parallel.

Make the following settings for Port 1 to configure the relay for PRP mode.

- NETMODE = PRP
- PRPTOUT = desired timeout for PRP frame entry
- PRPADDR = PRP destination MAC address LSB (least significant byte of "01-15-4E-00-01-*XX*," converted to decimal and entered as 0–255)
- PRPINTV = desired supervision frame transmit interval

When NETMODE is not set to PRP, the settings shown in *Table 7.2* are hidden.

Table 7.2 PRP Settings

Setting Prompt	Setting Description	Setting Range	Setting Name := Factory Default
PRP ENTRY TIMEOUT	PRP Entry Timeout	400–10000 ms	PRPTOUT := 500
PRP DESTINATION ADDR LSB	The multicast MAC address of PRP supervision frames is 01-15-4E-00-01-*XX* where *XX* is specified by this setting in decimal notation as 0–255	0–255	PRPADDR := 0
PRP SUSPERVISION TX INTERVAL	PRP Supervision TX Interval	1–10 second	PRPINTV := 2

Autonegotiation, Speed, and Duplex Mode

Single or dual copper Ethernet ports are capable of autonegotiating to determine the link speed and duplex mode. Accomplish this by setting the NETASPD and NETBSPD (network speed) to AUTO. Set single or dual copper ports 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.

Network Storm Detection

In an Ethernet network, a storm of messages can occur when an incorrect network configuration causes network loops. These network storms can disrupt relay communication. To detect such storms, the relay periodically checks the number of messages received over the Ethernet ports. When the relay receives an excessive amount of Ethernet traffic, the relay asserts the STORMDET (storm detect) Relay Word bit and stops processing Ethernet messages. However, the Bridge Protocol Data Units (BPDUs) are processed irrespective of the state of the STORMDET Relay Word bit.

NETPORT Selection

The NETPORT setting gives you the option of selecting the primary port of communication in failover or fixed communication modes.

TCP Keep Alive

NOTE: The ETCPKA setting applies to all TCP traffic on Ethernet ports, including Telnet, FTP, IEC 61850, and MMS.

The ETCPKA setting, along with the KAIDLE, KAINTV, and KACNT settings, can be used to verify that the computer at the remote end of a TCP connection is still available. If ETCPKA is enabled and the relay does not transmit any TCP data within the interval specified by the KAIDLE setting, the relay sends a keep-alive packet to the remote computer. If the relay does not receive a response from the remote computer within the time specified by KAINTV, the keep-alive packet is re-transmitted as many as KACNT times. After this count is reached, the relay considers the remote device no longer available, so the relay terminates the connection without waiting for the idle timer (TIDLE or FTPIDLE) to expire.

The relay monitors MMS inactivity to identify and disconnect MMS clients that have stopped communicating. You can set it from 0 to 4,200,000 seconds via the IED Properties MMS Settings in ACSELERATOR Architect SEL-5032

Software. The MMS inactivity default value is either 120 seconds or 900 seconds, depending on the relay firmware version. Setting this value to 0 disables the MMS inactivity timer. If enabled, the relay starts a timer for an MMS session after it receives an MMS request from the client on that session. It resets the timer whenever it receives a new MMS request from that client. When the timer runs out, the relay disconnects the MMS session, making it available for other MMS clients.

This feature was implemented in addition to the TCP keep-alive timer to specifically handle MMS clients that do not disconnect properly. As there are a limited number of MMS sessions available, this ensures that misbehaving MMS clients do not take up multiple MMS sessions. Note that the MMS inactivity time-out can still disconnect an MMS session even if the relay receives TCP keep-alive messages from that MMS client.

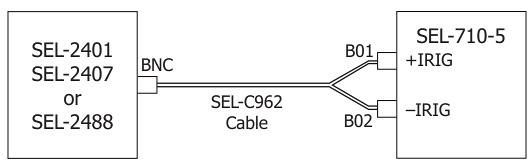
IRIG-B

NOTE: Relays with the PTC option do not have IRIG-B capability.

The SEL-710-5 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 a dual Ethernet port, a fiber-optic Ethernet port, or a PTC option. Refer to *Figure 7.4* for a connection diagram.



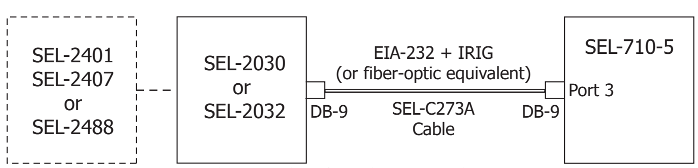
B01–B02 IRIG-B input is available on all models except those with the fiber-optic Ethernet, dual-copper Ethernet, or PTC options.
You cannot bring IRIG-B via Port 2 or 3 if **B01–B02** input is used.
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.4 IRIG-B Input (Relay Terminals B01–B02)

Option 2: Port 3 (EIA-232 Option Only)

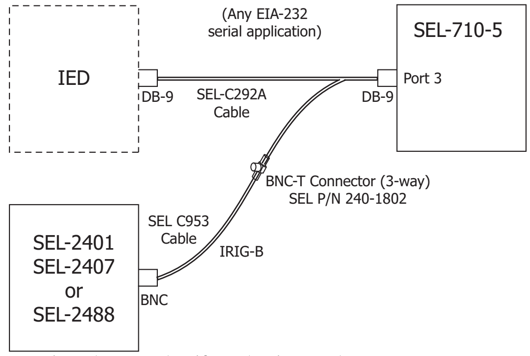
This input is available on all models except those with the PTC option. Connect to an SEL communications processor with an SEL-C273A cable to bring IRIG-B input with the EIA-232 Port. Refer to *Figure 7.5* for a connection diagram.

Refer to *Figure 7.6* on how to connect an SEL Time Source (SEL-2401 or SEL-2407 Satellite-Synchronized Clock or an SEL-2488 Satellite-Synchronized Network Clock) for IRIG-B input to Port 3.



You 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)

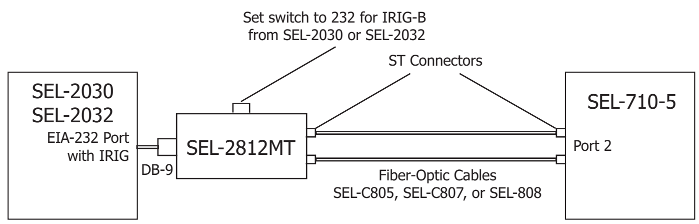


Cannot use **B01–B02** input or Port 2 if Port 3 is used.
Set Global setting IRIG TIME SOURCE to TIME_SRC := IRIG1.

Figure 7.6 IRIG-B Input Via EIA-232 Port 3 (SEL-2401/2407/2488 Time Source)

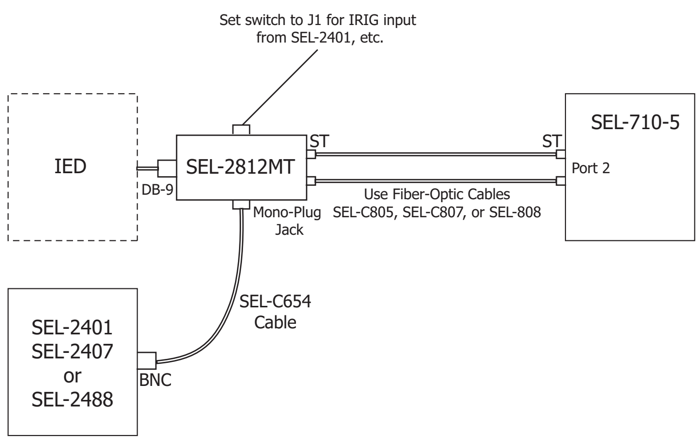
Option 3: Port 2 (Fiber-Optic Serial Port)

This input is available on all models except those with the PTC option. 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 7.3* indicate the present status of the timekeeping function of the SEL-710-5.

Table 7.3 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 Relay Word bit TSOK indicates that the time synchronization is OK. The SEL-710-5 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.

The SEL-710-5 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).

When IRIGC := NONE, the relay asserts TSOK only when the first test is met. When IRIGC := C37.118 and an appropriate IRIG-B signal is connected, the Relay Word bit TSOK asserts only when these two tests are met. The time error information in the IRIG-B control field is mapped to the TQUAL bits in the relay. *Table 7.4* 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. However, TSOK remains asserted for a holdover period of as long as 15 seconds. If the IRIG signal is not restored within 15 seconds, TSOK also deasserts.

Table 7.4 TQUAL Bits Translation to Time Quality (Sheet 1 of 2)

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

Table 7.4 TQUAL Bits Translation to Time Quality (Sheet 2 of 2)

TQUAL8	TQUAL4	TQUAL2	TQUAL1	Value	Time Quality
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 power is available on Pin 1 only on EIA-232 Port 3 and EIA-232 Port 4.

Connect Your PC to the Relay

The front port of the SEL-710-5 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 7.5*. You can connect to a standard 9-pin computer port with an SEL-C234A cable; wiring for this cable is shown in *Figure 7.10*. The SEL-C234A cable and other cables are available from SEL. Use the SEL-5801 Cable Selector software to select an appropriate cable for another application. This software is available for free download from the SEL website at selinc.com.

For the best performance, use an SEL-C234A cable not 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-710-5.

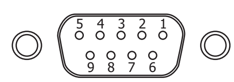


Figure 7.9 EIA-232 DB-9 Connector Pin Numbers

Table 7.5 shows the pin functions for the EIA-232 and EIA-485 serial ports.

Table 7.5 EIA-232/EIA-485 Serial Port Pin Functions

Pin[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.

NOTE: Serial communications cables that are used in the 710-5 relays for the MIRRORED BITS protocol should have the R designation at the end of the SEL cable number instead of an A. For example, use SEL-C234**R** instead of SEL-C234**A**. The SEL-C234**R** cable is double shielded and provides better data integrity compared to the SEL-C234**A**.

The following cable diagrams show several types of EIA-232 serial communications cables that connect the SEL-710-5 to other devices. These and other cables are available from SEL. Contact the factory for more information.

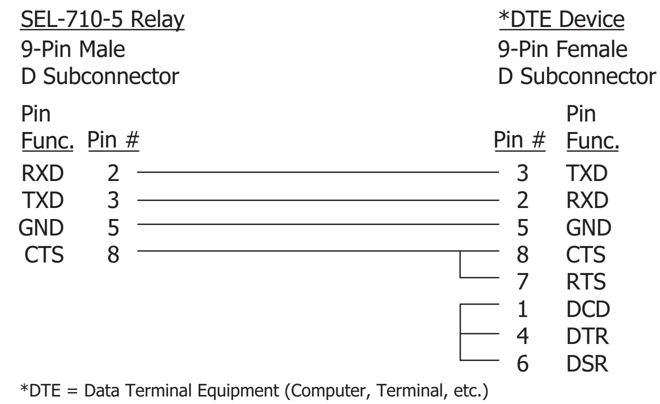


Figure 7.10 SEL-C234A Cable—SEL-710-5 to DTE Device

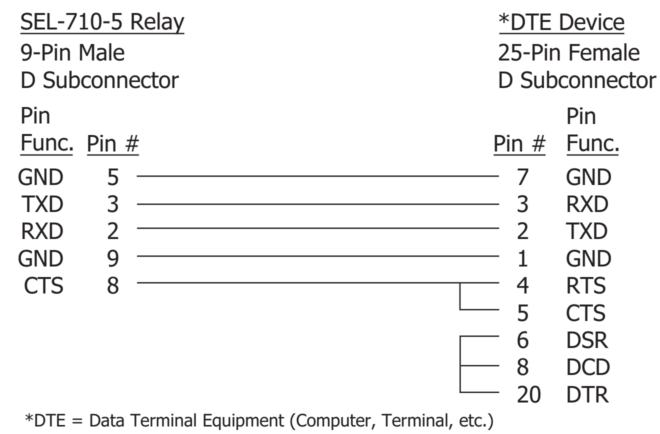


Figure 7.11 SEL-C227A Cable—SEL-710-5 to DTE Device

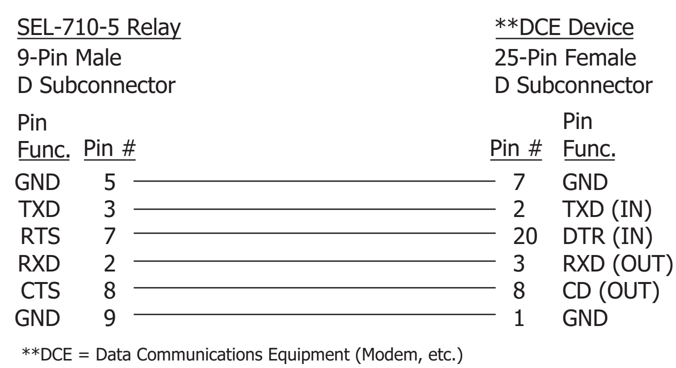


Figure 7.12 SEL-C222 Cable—SEL-710-5 to Modem

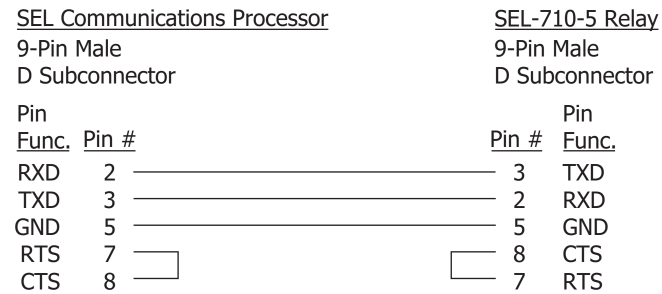


Figure 7.13 SEL-C272A Cable—SEL-710-5 to SEL Communications Processor (Without IRIG-B Signal)

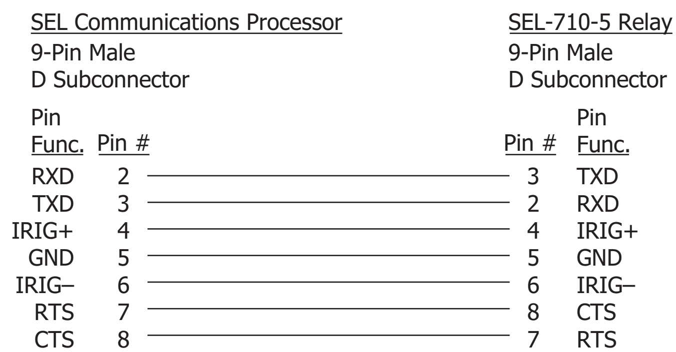


Figure 7.14 SEL-C273A Cable—SEL-710-5 to SEL Communications Processor (With IRIG-B Signal)

Communications Protocols

Protocols

Although the SEL-710-5 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 7.6* shows the ports and the protocols available on each port.

NOTE: FTP, Modbus, and DeviceNet protocols ignore the hide rules of the settings.

Table 7.6 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, IEC 61850, DNP3 LAN/WAN, EtherNet/IP, SNTP, PTP, and Telnet (SEL ASCII, Compressed ASCII, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message, web server (HTTP), PRP, and RSTP)
PORT 2	SEL ASCII and Compressed ASCII Protocols, SEL Fast Meter, SEL Fast Operate, SEL Fast SER, SEL Fast Message, SEL Settings File Transfer, SEL MIRRORED BITS, DNP3, IEC 60870-5-103, and Modbus RTU Slave
PORT 3	All the protocols supported by PORT 2
PORT 4	All the protocols supported by PORT 2 or DeviceNet

[a] PORT 1 concurrently supports two Modbus, two FTP, two Telnet, five DNP3 LAN/WAN, one SNTP, one PTP, and seven IEC 61850 sessions, as well as two EIP I/O connections and six EIP message connections.

SEL Communications Protocols

SEL ASCII.

This protocol is described in *SEL ASCII Protocol and Commands on page 7.26*.

SEL Compressed ASCII

This protocol provides compressed versions of some of the ASCII commands. The compressed commands are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Meter

This protocol supports binary messages to transfer metering and digital element messages. Compressed ASCII commands that support Fast Meter are described in *SEL ASCII Protocol and Commands*, and the protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Operate

This protocol supports binary messages to transfer operation messages. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast Message.

This protocol uses binary messages to receive and transmit data from or to an SEL Communications Processor. The protocol is described in *Appendix C: SEL Communications Processors*.

SEL Fast SER.

This protocol is used to receive binary Sequential Events Record unsolicited responses. The protocol is described in *Appendix C: SEL Communications Processors*.

Other Supported Protocols

MIRRORED BITS Protocol

The SEL-710-5 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. The MIRRORED BITS protocol is described in *Appendix J: MIRRORED BITS Communications*.

Modbus RTU Protocol

The SEL-710-5 provides Modbus RTU support. Modbus is a standard protocol described in *Appendix E: Modbus Communications*.

Distributed Network Protocol (DNP3)

The SEL-710-5 provides DNP3 protocol support if the option is selected. The DNP3 protocol is described in *Appendix D: DNP3 Communications*.

DeviceNet Protocol

The SEL-710-5 provides DeviceNet Support. DeviceNet is an optional protocol described in *Appendix I: DeviceNet Communications*.

IEC 60870-5-103 Protocol

The SEL-710-5 provides IEC 60870-5-103 protocol support if the option is selected. The protocol is available on Ports 2, 3, and 4. All ports operate using the same map settings. The IEC 60870-3-105 protocol is described in *Appendix H: IEC 60870-5-103 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, HTTP, DNP3 LAN/WAN, and IEC 61850 protocols.

Carefully design your Ethernet network to maximize reliability, minimize system administration effort, and provide adequate security. Work with a networking professional to design your substation Ethernet network.

File Transfer Protocol (FTP) and MMS File Transfer

FTP is a standard protocol for exchanging files between computers over a TCP/IP network. The SEL-710-5 operates as an FTP server, presenting files to FTP clients. To create an FTP session, you need the FTP username and password. The default username and password are FTPUSER and TAIL, respectively. The SEL-710-5 supports two FTP sessions at a time. Requests to establish additional FTP sessions are denied.

Manufacturing Message Specification (MMS) is used in IEC 61850 applications and provides services for the transfer of real-time data, including files, within a substation LAN.

File Structure

The file structure is organized as a directory and subdirectory tree similar to that used by Windows and other common operating systems. See *Virtual File Interface on page 7.75* for information on available files.

File dates within the last 12 months are displayed with month, day, hour, and minutes. Dates older than twelve months have the year, month, and day. The times are UTC.

Access Control

To log in to the FTP server, enter the value of the Port 1 setting FTPUSER as the username in your FTP application. Enter the Port 1 setting FTPACC level password as the password in your FTP application. Note that FTP does not encrypt passwords before sending them to the server.

MMS is enabled when the Port 1 setting E61850 is set to Y. No authentication is required. MMS File Transfer is enabled when setting EMMSFS is set to Y. If MMS Authentication is enabled via the CID file, then an authenticated connection must be established via MMS for MMS file transfer to take place.

Using FTP and MMS

A free FTP application is included with most web browsers and PC operating systems. You can also obtain free or inexpensive FTP applications from the Internet. Once you have retrieved the necessary files, be sure to close the FTP connection by using the disconnect function of your FTP application or completely closing the application. Failure to do so can cause the FTP connection to remain open, which blocks subsequent connection attempts until FTPIDLE time expires. See *Appendix G: IEC 61850 Communications* for information about using MMS.

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:

- Fast SER
- 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 remains 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

Ping is an application based on ICMP over an IP network. A free Ping application is included with most computer operating systems. Use a Ping client with the relay Ping server to verify that your network configuration is correct.

IEC 61850

Use as many as seven 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 64 incoming messages and 8 outgoing messages. For more details on the IEC 61850 protocol, see *Appendix G: 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 7.7* shows each setting associated with SNTP.

Table 7.7 Settings Associated With SNTP

Setting	Setting Description	Setting Range	Factory Default Setting
ESNTP	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes on page 7.17*.	UNICAST, MANY-CAST, BROADCAST	OFF
SNTPPSIP	Selects primary NTP server when ESNTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.	Valid IP Address	192.168.1.1
SNTPPSIB	Selects backup NTP server when ESNTP = UNICAST.	Valid IP Address	192.168.1.1
SNTPPORT	Ethernet port used by SNTP. Leave at default value unless otherwise required.	1–65534	123
SNTPRATE	Determines the rate at which the relay asks for the updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the amount of time the relay waits for an NTP broadcast when ESNTP = BROADCAST.	15–3600 seconds	60
SNTPTO	Determines the amount of time the relay waits for the NTP master to respond when ESNTP = UNICAST or MANY-CAST.	5–20 seconds	5

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 listens for and synchronizes to any broadcasting NTP server. If setting SNTPPSIP is set to a specific IP address while setting ESNTP = BROADCAST, then the relay listens for and synchronizes 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-710-5. 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-710-5 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.

Embedded Web Server (HTTP)

When Port 1 setting EHTTP := Y, the relay serves webpages displaying settings, metering, status reports, event files, etc. The relay-embedded web server has been optimized and tested to work with the most popular web browsers, but should work with any standard web browser. As many as three users can access the embedded web server simultaneously. To begin using the embedded read-only web server, launch your web browser and browse to http://IPADDR, where IPADDR is the Port 1 setting IPADDR (e.g., http://192.168.1.2).

Login using your username and password to view or export various reports, view settings, monitor communications or relay status, or upgrade firmware (Access Level 2 only).

To log out of the web server, either close the web browser window or click on Logout in the banner bar near the top of the webpage.For more information on the web server, see *Section 3: PC Interface*.

Table 7.8 lists the HTTP settings that are available for configuring the web server.

Table 7.8 HTTP Server Configuration Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE HTTP SERVER	Y, N	EHTTP := Y
HTTP MAXIMUM ACCESS LEVEL	1, 2	HTTPACC := 2
TCP/IP PORT	1–65535	HTTPPORT := 80
HTTP CONNECT BANNER	254 ASCII printable characters	HTTPBAN := This system is for the use of authorized personnel only.
HTTP WEB SERVER TIMEOUT	1–60 min	HTTPIDLE := 10

Precision Time Protocol (PTP)

Configuring PTP in the Relay

PTP implementation in the SEL-710-5 is firmware-based only. If the EPTP setting is available and set to Y, the SEL-710-5 supports PTP Version 2 (PTPv2) as a slave-only clock as defined by IEEE 1588-2008 on Port 1A and Port 1B. *Table 7.9* shows the settings associated with PTP.

Table 7.9 Settings Associated With PTP

Setting	Range	Description	Factory Default Setting
EPTP	Y, N	When set to Y, the device becomes a slave PTP clock	N
PTPPRO	DEFAULT, C37.238	Sets the PTP profile	DEFAULT
PTPTR	UDP, LAYER2	Transport mechanism for PTP messages	UDP
DOMNUM	0–255	PTP domain number of the clock	0
PTHDLY	P2P, E2E, OFF	Path delay measurement method to be used on the PTP network	E2E
PDINT	1, 2, 4, 8, 16, 32, 64 sec	Duration of time between transmissions of peer delay request messages	1
AMNUM	1–5, OFF	Number of acceptable PTP masters	OFF
AMIP[n][a]	*zzz.yyy.xxx.www* *zzz*: 1–126, 128–223 *yyy*: 0–255 xxx: 0–255 www: 0–255	Acceptable master IP addresses	192.168.1.12*n*[a]
AMMAC[n][a]		Acceptable master MAC addresses	00-30-A7-00-00-0*m*[b]
ALTPRI[n][a]	0–255	If the acceptable table master option is enabled and this setting value is not zero, the Priority 1 value received in the announce message from the specified master will be replaced by this value and used in the Best Master Clock Algorithm (BMCA)	0
PVLAN	1–4094	VLAN ID for a C37.238 Ethernet frame	1
PVLANPR	0–7	VLAN priority for a C37.238 Ethernet frame	4

[a] n = 1–5.
[b] m = A–E.

To achieve the best accuracy (< 1 ms), it is necessary to have one or more PTP master clocks and for all intervening equipment (e.g., Ethernet switches) to be IEEE 1588-aware (i.e., all intervening network devices need to be transparent or boundary clocks).

In PTP, a clock that provides time to other devices, typically based on GPS input, is a master clock. The intervening switches are transparent clocks. You can use boundary clocks to connect networks together and pass time from one network to another. Transparent and boundary clocks are important because they provide time correction in the PTP messages that pass through them, whereas devices that are not IEEE 1588-aware do not provide this correction. Because it is possible for a network to have multiple master clocks, PTP clocks implement algorithms to select the best available clock. The one selected for use by an end device is the grandmaster clock. You can learn more about configuring a PTP network in the following application notes:

- L. Thoma, "Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality in a Redundant Network Topology," SEL Application Note (AN2015-07), 2015. Available: selinc.com.
- L. Thoma, "Using the SEL-2488 to Provide IEEE 1588 Version 2 Grandmaster Functionality to Isolated Ethernet Networks," SEL Application Note (AN2015-06), 2015. Available: selinc.com.

To configure PTP, update the Port 1 PTP settings as described in *Table 7.9*. By default, PTP is disabled in the SEL-710-5. Set EPTP to **Y** to enable PTP and to make the other PTP settings available.

PTP implementation in the SEL-710-5 supports both one-step and two-step clocks. A one-step clock uses a single event message to provide time information. A two-step clock uses the combination of an event message and a subsequent general message to provide time information.

Within PTP, there are multiple clock profiles available. A profile defines the set of PTP features available in a specific application domain. SEL-710-5 relays support two profiles: Default and Power (C37.238-2011).

The Default profile has many optional features and is intended to address common applications. The Default profile supports both UDP and Layer 2 (802.3) Ethernet transport, and it can use either the end-to-end (E2E) or the peer-to-peer (P2P) delay mechanism. Grandmaster clocks can send Announce, Sync, and Delay request messages over a wide range of intervals. A Default profile network can consist of boundary clocks or transparent clocks anywhere between the grandmaster and the end devices. The only performance requirement for the Default profile is that a master clock must maintain frequency accuracy to within 0.01 percent.

The Power profile has minimal optional features in order to facilitate interoperability and performance predictability. The Power profile is only supported on Layer 2 networks and exclusively uses the peer-to-peer delay mechanism. All messages must be sent at 1-second intervals, have 802.1Q VLAN tags, and include grandmaster ID and (maximum) inaccuracy fields in the announce message. Transparent clocks are mandatory in a Power profile network while boundary clocks are not allowed. Select the profile by using the PTPPRO setting.

PTP defines a logical grouping of clocks in a network as a clock domain. This allows a logical separation among clocks that participate in different application domains to coexist on the same network. Domains are identified by domain numbers. The DOMNUM setting determines the domain number for the SEL-710-5. Set DOMNUM to match the domain number configured in the master clocks to which the SEL-710-5 should synchronize.

The SEL-710-5 supports transport of PTP messages over UDP or Layer 2 (Ethernet). Use the PTPTR setting to select the PTP transport mechanism. This needs to match the transport mechanism used in the master clocks. Only Layer 2 is available with the Power profile. If operating in a UDP network, PTP operates on Ports 319 or 320. Except for peer delay messages, the SEL-710-5 sets the time allowed to live (TTL) value in the UDP/IP header of PTP messages to 64. This allows you to use routers across a WAN to synchronize the SEL-710-5 PTP master. High-accuracy synchronization may not be achievable across the WAN, so it is left to you to determine if the accuracy meets the needs of your application.

When using the Power profile, use the VLAN identifier and priority settings, PVLAN and PVLANPR, to set the VLAN ID and priority, respectively, of the Ethernet frames. Be sure to set PVLAN unique from other VLANs used within the SEL-710-5 Relay.

PTP defines two methods for calculating and correcting the communications path delay between the SEL-710-5 and the master clock: end-to-end (Delay Request-Response) and peer-to-peer (Peer Delay Request Response). The end-to-end mechanism calculates the total path delay between the SEL-710-5 and the master clock.

The peer-to-peer mechanism calculates the total path delay in a piecemeal fashion between each device in the path. Peer-to-peer is the more accurate method and is recommended for use in the SEL-710-5. Only the peer-to-peer mechanism is available for the Power profile. The SEL-710-5 periodically initiates path delay calculations. Use the PTHDLY and PDINT settings to configure the path delay method and the path delay request rate. If PTHDLY is set to OFF, the SEL-710-5 will not calculate and correct for path delay.

By default, the SEL-710-5 synchronizes to any clock on the network that it evaluates to be the best clock based on the Best Master Clock Algorithm (BMCA). Use the settings to specify a list of master (grandmaster or boundary) clocks to which the SEL-710-5 may synchronize. The SEL-710-5 will not synchronize to any master clock that is not in the list. Use this feature for additional security. The AMNUM setting selects the number of master clocks you list. The default value is OFF, which results in the SEL-710-5 synchronizing to any master clock on the network. If you set AMNUM to a value other than OFF, you must identify the number of allowable masters in accordance with the PTP transport you have chosen, i.e., MAC address for 802.3 or IP address for UDP transport.

If the PTP transport (PTPTR) is set to UDP, use the AMIP*n* settings to specify the IP addresses of the clocks to which the SEL-710-5 is permitted to synchronize. If PTP transport is set to Layer 2, use the AMMAC*n* settings to specify the MAC addresses of the clocks to which the SEL-710-5 is permitted to synchronize.

If the ALTPRI*n* (Alternate Priority1 for Master *n*) setting is set to a positive value, the ALTPRI*n* value replaces the Priority1 value in received Announce messages from the corresponding master clock before the application of the BMCA. The ALTPRI*n* values reprioritize the master clocks locally.

EtherNet/Industrial Protocol (IP)

EtherNet/IP is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets. You can enable EtherNet/IP on Port 1 for a maximum of eight simultaneous CIP connections. Of these eight simultaneous connections, you can have as many as two Class 1 (I/O) connections and as many as six combined Class 3 messages and Unconnected Message Manager (UCMM) messages.

When configuring EIP on Port 1, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the remaining six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining number of connection configurations must be Input Only connection configurations. EtherNet/IP is described in detail in *Appendix F: EtherNet/IP Communications*.

Rapid Spanning Tree Protocol (RSTP)

RSTP is a protocol and is a distributed algorithm that is defined in the IEEE 802.1Q-2014 standard. Devices communicate RSTP through packets called Bridge Protocol Data Units (BPDUs) that travel between adjacent RSTP-enabled devices. These frames allow the devices to determine the root bridge in the network, as well as defines the state and role of each port of devices connected in the RSTP network.

Table 7.10 and *Table 7.11* provide the various roles and states supported by the SEL-710-5. Use the **RSTP** command to view the assigned state and role of a port. The relay keeps a log of the states and roles in the Sequential Events Recorder (SER) report.

Table 7.10 RSTP Roles Supported in the SEL-710-5

Roles	Definition
Root Port	A port with the shortest path[a] to the root bridge. All STP and RSTP capable bridges must have exactly one except the root bridge, which cannot have any.
Designated Port	The port that connects a LAN to its designated bridge.
Alternate Port	Represents the best alternate path to the root bridge. This path is different than using the root port. The alternate port moves to the forwarding state if there is a failure on the designated port for the segment.
Backup Port	Represents a redundant path to a segment where another port on the bridge already connects.
Disabled	The port is disabled during the role initialization or it is disabled due to a link or hardware failure.

[a] This is not always the shortest path. The settings in the network define the path costs, so the root port is the one with the smallest path costs to the root switch. There may be a physically shorter path, but because of the path costs of the other devices, a longer path to the root may be used.

Table 7.11 RSTP States Supported in the SEL-710-5

States	Definition
Forwarding	A port receiving and transmitting message frames and BPDUs.
Learning	A port receiving and transmitting BPDUs; this port does not receive or transmit message frames.
Discarding	A port receiving BPDUs; this port does not receive or transmit message frames.

NOTE: Exercise caution when disabling RSTP (ERSTP := N) in a relay connected in a switched network because doing so could introduce network loops.

There are three RSTP settings available to set on Port 1 after RSTP is enabled. They include the bridge priority (BRDGPRI), which is used to help determine the root bridge in the network, and the port priorities (PORTAPRI and

PORTBPRI) for Ports 1A and 1B, which are used to help determine the root port of the device. See *Table 7.50* for more information regarding these settings.

Example of a Simple Topology

The simplest example of a loop is a network of devices connected in a ring (*Figure 7.15*). Devices connected in a ring topology allow traffic to go from one port on one device to another port on another device in either direction around the ring, as the two green lines show in *Figure 7.15* between Devices 1 and 6.

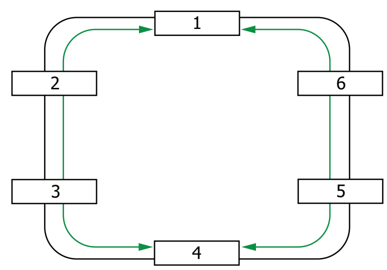


Figure 7.15 Physical Ring Without Loop Mitigation

Disabling the link between Devices 3 and 4 forces traffic to follow a single path across the network (as the green line in *Figure 7.16* shows). The process of disabling links to logically remove loops from the network is called convergence because the devices use RSTP to converge the network into a stable configuration without any loops.

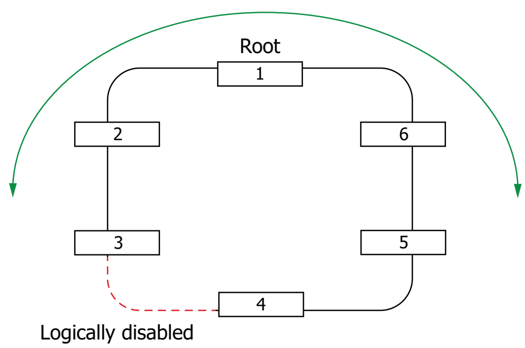


Figure 7.16 Network Convergence With Logically Disabled Link

The logically disabled connections remain physically present and can be quickly enabled by RSTP to provide an alternative path for the network traffic in the event of a physical network failure. For example, if the link between Devices 2 and 3 were to fail, traffic would be disrupted on the network, as indicated by the dashed green line in *Figure 7.17*. Devices 2 and 3 would respond by using RSTP and BPDUs to inform the other devices in the network that an event occurred. The rapid spanning tree algorithm (RSTA) in each network device would then use BPDUs over RSTP to communicate with their respective connected devices, in turn, and eventually the logically disabled link between Devices 3 and 4 would be re-enabled, as shown in *Figure 7.18*.

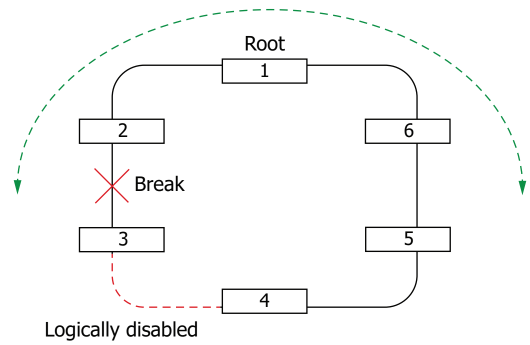


Figure 7.17 Physical Link Failure Between Devices

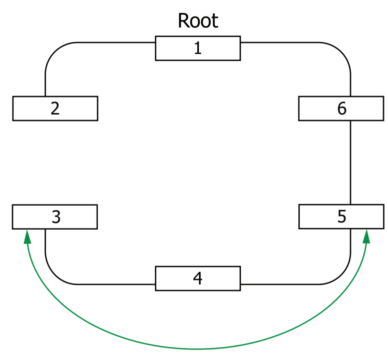


Figure 7.18 Network Convergence

As the green line in *Figure 7.18* shows, traffic can still flow between Devices 3 and 5 but now it is through a different path. The process of re-enabling disabled links to allow traffic to flow and heal the network is called reconvergence. During this change in the network, traffic is temporarily disrupted. *Figure 7.3* shows a typical network diagram that uses SEL-710-5 in a switched network with ERSTP := Y. Refer to SEL application guide "Understanding RSTP and Choosing the Best Network Topology" (AG2017-21) at selinc.com for additional information on RSTP.

RSTP Performance Measurement

Figure 7.19 shows a convergence example involving a ring network where both SEL-2730M switches and all seven SEL-700 series relays are configured with default RSTP settings. In this example, there is a transmitting device connected to the North SEL-2730M switch and a receiving device connected to the South SEL-2730M switch.

As a result of the devices being configured with default RSTP settings, the network converges to break the loop at Relay 14. This configuration results in the port for Relay 14 to be in discarding state (indicated by "D"). In this state, traffic flows from the North SEL-2730M switch to the South SEL-2730M switch by passing through Link L1.

For this example, consider a link-down event occurring at Link L1. A link-down event is when the cable that connects two devices is physically broken (indicated by the slash). After this link-down event, the network takes approximately 150 ms to reconverge such that the discarding port on Relay 14 transitions into a forwarding state. This allows traffic to flow from the North SEL-2730M switch to the South SEL-2730M switch by passing through all seven relays.

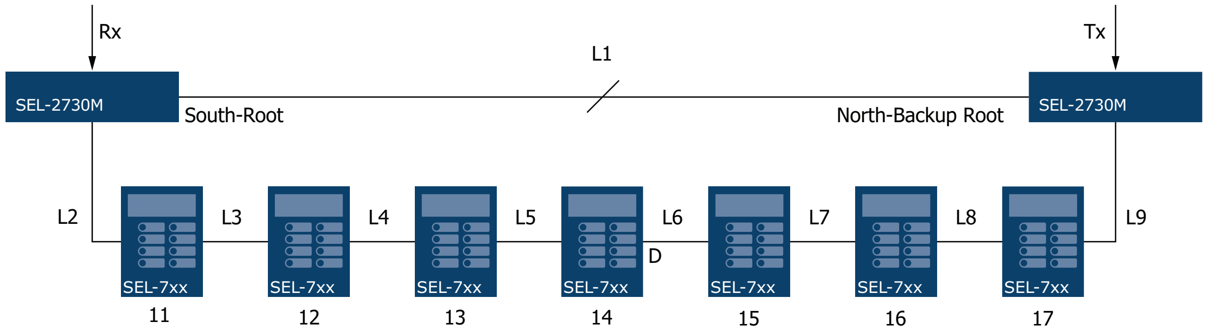


Figure 7.19 Link-Down Event at Link L1

If additional relays are added to this example network, the reconvergence time increases by approximately 20 ms per additional relay.

SEL-700 series relays are configured with a Max Age value of 40. This means that a network with SEL-700 series RSTP devices should be created with the understanding that the maximum number of hops from the root in the network should not exceed 40.

To understand the importance of enabling RSTP in an SEL-700 series relay ring network in comparison to leaving it disabled, refer to the SEL application guide “Maintaining Switched-Mode Relay Responsiveness in an RSTP Network” (AG2019-15).

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-710-5.

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 are accepted after the relay receives XON.

The relay transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking is enabled) when the relay input buffer drops below 25 percent full.

The relay transmits XOFF (ASCII hex 13) when the buffer is more than 75 percent full. If hardware handshaking is enabled, the relay deasserts the RTS output when the buffer is approximately 95 percent full. Automatic transmission sources should monitor for the XOFF character to avoid overwriting the buffer. Transmission should terminate at the end of the message in progress when XOFF is received and can resume when the relay sends XON.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful for terminating an unwanted transmission. You can send control characters from most keyboards with the following keystrokes:

- XOFF**: <Ctrl+S>** (hold down the **<Ctrl>** key and press **S**)
- XON: **<Ctrl+Q>** (hold down the **<Ctrl>** key and press **Q**)
- CAN: **<Ctrl+X>** (hold down the **<Ctrl>** key and press **X**)

Automatic Messages

When the serial port AUTO setting is Y, the relay sends automatic messages to indicate specific conditions. *Table 7.12* lists these messages.

Table 7.12 Serial Port Automatic Messages

Condition	Description
Start 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 10: Analyzing Events*.
Self-Test Warning or Failure	The SEL-710-5 sends a status report each time a self-test warning or failure condition is detected. See *STATUS Command (Relay Self-Test Status) on page 7.68*.

Access Levels

You can issue commands to the SEL-710-5 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-710-5 Relay Command Summary* at the end of this manual. You can access these commands only from the corresponding access level, as shown in the *SEL-710-5 Relay Command Summary*. The access levels are:

- ➤ Access Level 0 (the lowest access level)
- ➤ Access Level 1
- ➤ Access Level 2 (the highest access level)
- ➤ Access Level C (restricted access level; should be used under direction of SEL only)

The EPORT and MAXACC settings provide you with access controls for the corresponding port. Set EPORT to N to disable the port and hide the remaining port settings. The MAXACC setting selects the highest access level for the port.

Access Level 0

Once serial port communication is established with the SEL-710-5, 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-710-5 Relay Command Summary* at the end of this manual. Enter the **ACC** command at the Access Level 0 prompt:

```
=ACC <Enter>
```

The **ACC** command takes the SEL-710-5 to Access Level 1. See *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.32* for more detail.

Access Level 1

When the SEL-710-5 is in Access Level 1, the relay sends the following prompt:

```
=>
```

See the *SEL-710-5 Relay Command Summary* at the end of this manual for the commands available from Access Level 1. The relay can go to Access Level 2 from this level.

The **2AC** command places the relay in Access Level 2. See *Access Commands (ACCESS, 2ACCESS, and CAL)* for more detail. Enter the **2AC** command at the Access Level 1 prompt:

```
=>2AC <Enter>
```

Access Level 2

When the relay is in Access Level 2, the SEL-710-5 sends the prompt:

```
=>>
```

See the *SEL-710-5 Relay Command Summary* at the end of this manual for the commands available from Access Level 2.

All of the Access Level 1 commands are also available in Access Level 2.

Access Level C

Access Level C is used exclusively by the SEL factory and SEL field service personnel to diagnose troublesome installations. Do not enter Access Level C 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-710-5 Relay Command Summary* at the end of this manual lists the serial port commands alphabetically. Much of the information available from the serial port commands is also available via the front-panel pushbuttons.

Access Level Functions

The serial port commands at the different access levels offer varying levels of control:

- The Access Level 0 commands provide the first layer of security. In addition, Access Level 0 supports several commands required by SEL communications processors.
- The Access Level 1 commands are primarily for reviewing information only (settings, metering, etc.), not changing it.

- ➤ The Access Level 2 commands are primarily for changing relay settings.
- ➤ Access Level C is a restricted access level, and should only be used under direction of SEL

The SEL-710-5 responds with `Invalid Access Level` when a command is entered from an access level lower than the specified access level for the command. The relay responds with `Invalid Command` to commands that are not available or are entered incorrectly.

Header

Many of the command responses display the following header at the beginning:

```
[RID Setting]                                    Date: mm/dd/yyyy  Time: hh:mm:ss.sss
[TID Setting]                                    Time Source: external
```

Table 7.13 lists the header items and their definitions.

Table 7.13 Command Response Header Definitions

Item	Definition
`[RID Setting]:`	This is the RID (Relay Identifier) setting. The relay ships with the default setting `RID = 710-5`; see *ID Settings on page 4.4*.
`[TID Setting]:`	This is the TID (Terminal Identifier) setting. The relay ships with the default setting `TID = MOTOR RELAY`; see *ID Settings on page 4.4*.
`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.

89CLOSE Command (Close Disconnect)

The **89C** command (see *Table 7.14* for the command description and the format) is used to close a two-position disconnect, or the respective in-line or earthing disconnect for a three-position disconnect. The **89C *m*** command asserts Relay Word Bit 89CC2P*m* for a quarter-cycle when executed, while the **89C *n m*** command asserts Relay Word bit 89CC3P*nm* for a quarter-cycle when executed. See *Table 9.2* for how these Relay Word bits are used in the disconnect close control logic.

Table 7.14 89CLOSE Command

Command	Description	Access Level
89C *m*	Closes Two-position Disconnect *m*	2
89C *n m*	Closes Three-position Disconnect *m*, where *n* signals for an in-line or earthing disconnect	2
Parameters		
m	Specifies which two-position disconnect (m = 1–8) or three-position disconnect (m = 1–2) to close.	
n	L or E, to signal an in-line or earthing disconnect, respectively.	

To issue the **89C 1** command, enter the following:

```
=>>89C 1 <Enter>
Close 2P1 (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Operation In Progress...
Disconnect Closed
=>>
```

Typing **N <Enter>** after either of the prompts aborts the command.

Following successful issue of the command, the relay displays `Operation In Progress....` While 89IP2P*m* or 89IP3P*nm* is asserted and the respective Relay Word bits 89OP2P*m*/89OP3P*nm*, 89CL2P*m*/89CL3P*nm*, and 89AL2P*m*/89AL3P*nm* are deasserted, a dot (.) is appended to the previous message every half-second to show progress. While the operation is in progress, communications are unavailable on the port where the **89C** command was executed. If none of the Relay Word bits asserts within 60 seconds, the relay exits the **89C** command. Following the in-progress state, the Relay Word bit that asserts determines the subsequent status message displayed in the terminal: `Disconnect Open` if 89OP2P*m* or 89OP3P*nm* is asserted, `Disconnect Closed` if 89CL2P*m* or 89CL3P*nm* is asserted, or `Status Undetermined—Check Wiring` if 89AL2P*m* or 89AL3P*nm* is asserted. See *Disconnect Control Settings on page 9.2*.

The **89C** command is supervised by the main board breaker control jumper (see *Table 2.19*). If the breaker control jumper is not in place (breaker control jumper = OFF), the relay does not execute the **89C** command and responds with the following:

```
=>>89C L 1 <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **89C** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **89C** command and responds with the following:

```
=>>89C L 1 <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

89OPEN Command (Open Disconnect)

The **89O** command (see *Table 7.15* for the command description and the format) is used to open a two-position disconnect, or the respective in-line or earthing disconnect for a three-position disconnect. The **89O *m*** command asserts Relay Word Bit 89OC2P*m* for a quarter-cycle when executed, while the **89O *n m*** command asserts Relay Word bit 89OC3P*nm* for a quarter-cycle when executed. See *Figure 9.3* for how these Relay Word bits are used in the disconnect close control logic.

Table 7.15 89OPEN Command

Command	Description	Access Level
89O *m*	Opens Two-position Disconnect *m*	2
89O *n m*	Opens Three-position Disconnect *m*, where *n* signals for an in-line or earthing disconnect	2
Parameters		
m	Specifies which two-position disconnect (m = 1–8) or three-position disconnect (m = 1–2) to open.	
n	L or E, to signal an in-line or earthing disconnect, respectively.	

To issue the **89O 1** command, enter the following:

```
=>>89O 1 <Enter>

Open 2P1 (Y,N)? Y <Enter>

Are you sure (Y,N)? Y <Enter>

Operation In Progress...

Disconnect Open

=>>
```

Typing **N <Enter>** after either of the prompts aborts the command.

Following successful issue of the command, the relay displays `Operation In Progress....` While 89IP2P*m* or 89IP3P*nm* is asserted and the respective Relay Word bits 89OP2P*m*/89OP3P*nm*, 89CL2P*m*/89CL3P*nm*, and 89AL2P*m*/89AL3P*nm* are deasserted, a dot (.) is appended to the previous message every half-second to show progress. While the operation is in progress, communications are unavailable on the port where the **89O** command was executed. If none of the Relay Word bits asserts within 60 seconds, the relay exits the **89O** Command. Following the in-progress state, the Relay Word bit that asserts determines the subsequent status message displayed in the terminal: `Disconnect Open` if 89OP2P*m* or 89OP3P*nm* is asserted, `Disconnect Closed` if 89CL2P*m* or 89CL3P*nm* is asserted, or `Status Undetermined—Check Wiring` if 89AL2P*m* or 89AL3P*nm* is asserted. See *Disconnect Control Settings on page 9.2*.

The **89O** command is supervised by the main board breaker control (see *Table 2.19*). If the breaker control jumper is not in place (breaker control jumper = OFF), the relay does not execute the **89O** command and responds with the following:

```
=>>89O L 1 <Enter>

Command Aborted: No Breaker Jumper

=>>
```

When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the **89O** command. If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **89O** command and responds with the following:

```
=>>89O L 1 <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

Access Commands (ACCESS, 2ACCESS, and CAL)

The **ACC**, **2AC**, and **CAL** commands (see *Table 7.16*) provide entry to the multiple access levels. Different commands are available at the different access levels, as shown in the *SEL-710-5 Relay Command Summary* at the end of this manual. Commands **ACC** and **2AC** are explained together because they operate similarly. See *Access Levels on page 7.27* for a discussion of placing the relay in an access level.

Table 7.16 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 7.59* 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 7.59*. 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.

AFT Command (Arc-Flash Detection Channels Self-Test)

Use the **AFT** command (from Access Level 2) to initiate a self-test of the arc-flash detection channels 1 to 4. This test requires that the relay has the SELECT 4 AFDI/3 DIFF ACI or the SELECT 8 AFDI card in Slot E and that the external fiber-optic connections are complete. The test checks the integrity of the arc-flash detection system. *Figure 7.20* shows an example of the **AFT** command response. Refer to *Section 11: Testing and Troubleshooting* for details on the arc-flash self-tests.

```
=>>AFT <Enter>
Arc Flash Diagnostic in progress . . . . . . . . . . . . .

SEL-710-5                                  Date: 6/09/2013    Time: 09:20:13
FEEDER RELAY                              Time Source: Internal

Channel #   Sensor  Test Light Limits  Measured      Sensor      Excess Ambient
            Type     Min(%)   Max(%)   Test Light(%) Diagnostic  Light

AF Input 1  Fiber    10.00    100.00   31.94         Pass        OK
AF Input 2  Fiber    10.00    100.00   27.08         Pass        OK
AF Input 3  None     ---.--   ---.--   ---.--        ---         ---
AF Input 4  Point    0.10     79.00    2.27          Pass        OK

=>>
```

Figure 7.20 AFT Command Response

The relay asserts the AFALARM Relay Word bit when the sensor diagnostics fail or the relay detects excessive ambient light. Sensor diagnostics failure is indicated by the assertion of the AFS*n*DIAG Relay Word bits and excessive ambient light is indicated by the assertion of the AFS*n*EL Relay Word bits, where n = 1 to 8. The relay asserts the AFS*n*EL Relay Word bits when the corresponding TOL*n* Relay Word bits stay asserted continuously for 10 seconds.

ANALOG Command

Use the **ANA** command to test an analog output by temporarily assigning a value to an analog output channel (see *Table 7.17* for the command description and for the format). After entering the **ANA** command, the device suspends normal operation of the analog output channel and scales the output to a percentage of full scale. After assigning the specified value for the specified time, the device returns to normal operation. Entering any character (including pressing the space key) ends the command before 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 7.17 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 Monitoring on page 5.24* for further details on the breaker monitor.

```
=>BRE <Enter>

SEL-710-5                                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

=>
```

BRE W or R 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 (Access Level 2) 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 Monitoring on page 5.24* for further details on the breaker monitor.

CEV Command

The SEL-710-5 provides Compressed ASCII event reports to facilitate event report storage and display. SEL communications processors and the SYNCHROWAVE Event SEL-5601-2 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 *n*** (**CEV *n***) command to display Compressed ASCII event reports. Parameter *n* indicates the event number. The events can be accessed by the event record number or by their unique reference number. The most recent event report is record number one (1), the next most recent report is record number two (2), and so on. Reference numbers start at 10000 and increment by 1 with each event. When the event report list is cleared, the reference number resets to 10000. See *Table C.2* for further information. Compressed ASCII Event Reports contain all of the Relay Word bits. The **CEV *n* R** command gives the raw Compressed ASCII event report. Additionally, the compressed event report has the arc-flash detector light measurements.

CMET S and CMET S R Commands

The **CMET S** command collects data simultaneously from all Ia, Ib, Ic, Va, Vb, and Vc and the output contains frequencies and associated magnitudes. The **CMET S R** command displays the raw compressed meter report in CASCII format. The report triggers on the rising edge of CMETSRTG. Refer to *Motor Monitoring Using Fourier Analysis on page 5.11* for further details.

COM PTP Command

The **COM PTP** command provides a report of the PTP data sets maintained by the device as well as statistics for the measured time offsets with the parent (master) clock. The PTP data sets contain information about the state, identity, and configuration of the local, parent, and grandmaster clocks, in addition to properties of the time being distributed by the grandmaster clock.

Table 7.18 COM PTP Command

Command	Description	Access Level
COM PTP	Displays the PTP data sets and offset statistics for the active PTP slave port of the last active PTP slave port before all PTP slave ports went down.	1
COM PTP C or **R**	Clears or resets the PTP offset statistics for all ports.	1

If the EPTP setting is set to NO, and the **COM PTP** command (with or without any parameters) is sent to the relay, the relay responds with:

```
=>COM PTP <Enter>

PTP not enabled
```

If a temporary resource shortage exists, a settings change is in progress, or the PTP component is not yet initialized, and the **COM PTP** command is sent to the relay, the relay responds with:

```
=>COM PTP <Enter>

Command is not available
```

If EPTP is enabled and the **COM PTP C** or **R** command is sent to the SEL-710-5, the SEL-710-5 responds with:

```
=>COM PTP C <Enter>

Clear PTP offset statistics?
Are you sure? Y N
```

If you select **Y**, the relay responds with: `Clearing Complete`. If you select **N**, the relay responds with: `Command Canceled`. If you select anything else, the relay responds with: `Command Canceled`.

If a **COM PTP C** or **R** command is sent to the SEL-710-5 and the PTP component is enabled but not yet initialized, the SEL-710-5 responds with:

```
=>COM PTP R <Enter>

Command is not available
```

The SEL-710-5 Relay saves the date and time when the PTP offset statistics are cleared. The format of the offset clearing data matches the DATE_F Global Setting. The statistic clearing date and time is the time of the last user reset through an ASCII command, the last Port 1 settings change, or the last power up. The time stamp of the most recent event is displayed.

An example response to the **COM PTP** command when PTP is available is shown in *Figure 7.21*.

```
=>>COM PTP <Enter>

SEL-710-5                              Date: 05/13/2019   Time: 10:01:41.976
MOTOR RELAY                            Time Source: External


PTP offset statistics previously cleared on 05/09/2019 09:32:18 (UTC)


Settings Data Set
  PTP Profile : Default
  Transport Mechanism : UDP
  Path Delay : P2P


Default Data Set
  Two Step : true
  Clock Identity : 00 30 A7 FF FE 12 32 22
  Number of Ports : 1
  Clock Quality
    Clock Class : 255
    Clock Accuracy : 254
    Offset Log Variance : 0
  Priority1 : 255
  Priority2 : 255
  Domain Number : 0
  Slave Only : true

Current Data Set
  Steps Removed : 1


Parent Data Set
  Parent Port Identity
  Clock Identity : 00 30 A7 FF FE 0B 29 91
    Port Number : 1
  Grandmaster Clock Identity : 00 30 A7 FF FE 0B 29 91
  Grandmaster Clock Quality
    Clock Class : Synchronized with PTP timescale 6
    Clock Accuracy : Within 100 ns
    Offset Log Variance : 18887
  Grandmaster Priority1 : 128
  Grandmaster Priority2 : 128


Time Properties Data Set
  Current UTC Offset : 37
  Current UTC Offset Valid : true
  Leap59 : false
  Leap61 : false
  Time Traceable : true
  Frequency Traceable : true
  PTP Timescale : true
  Time Source : GPS
  Local Time Offset
    Offset Valid : true
    Name : UTC-07:00
    Current Offset : -25237 s
    Jump Seconds : -3600 s
    Time of Next Jump : 1572771637 s


Port Data Set
  Port Identity
    Clock Identity : 00 30 A7 FF FE 12 32 22
    Port Number : 1
  Port State : SLAVE
  Log Pdelay Request Interval : 0
  Peer Mean Path Delay : 0 ns
  Announce Receipt Timeout : 4 intervals
  Path Delay Mechanism : P2P
  Failed to Receive Response : true
  Received Multiple Pdelay Responses : false
  Reason for Non-synchronization :
  Port status : A, ACTIVE

=>>
```

Figure 7.21 COM PTP Command Response

A description of each PTP data set displayed in *Figure 7.21* is given in *Table 7.19*.

Table 7.19 PTP Data Set Descriptions (Sheet 1 of 5)

Type of Data Set	Information Field	Description
Settings	PTP Profile	This value is the same as PTPPRO.
	Transport Mechanism	This value is the same as PTPTR.
	Path Delay	This value is the same as PTHDLY.
Default	Two Step	For the default data set, this is set to TRUE. A two-step clock uses the combination of an event message and a subsequent general message to provide time information. A one-step clock uses a single event message to provide time information.
	Clock Identity	This is an 8-octet number that uniquely identifies the clock on the network. It is derived from the Ethernet MAC address.
	Number of Ports	This is the number of Ethernet ports used to communicate PTP messages. It is always 1 for SEL-710-5 relays.
	Clock Quantity	This contains information about clock class, accuracy, and variance of the SEL-710-5.
	Priority1	This is the first priority for the SEL-710-5 used in the default BMCA. It is always set to 255.
	Priority2	This is the second priority for the SEL-710-5 used in the default BMCA. It is always set to 255.
	Domain Number	This value is the same as DOMNUM. It is the PTP domain number to which the clock belongs.
	Slave Only	This value is always TRUE for SEL-710-5 relays.
Current	Steps Removed	This is the number of communication paths between the SEL-710-5 Relay and the grandmaster clock. A communication path is the link between a master and a slave port. Hence, links to transparent clocks do not count as separate paths. The values range from 1 to 65535.
Parent	Parent Port Identity	This contains the clock identity and port number of the adjacent clock to which the SEL-710-5 clock is synchronized. The port number identifies the specific port on the adjacent clock from which the SEL-710-5 clock is receiving PTP messages.
	Grandmaster Clock Identity	This is the clock identity of the grandmaster clock to which the SEL-710-5 is synchronized.
	Grandmaster Clock Quality	This contains the class, accuracy, and variance of the grandmaster clock.

Table 7.19 PTP Data Set Descriptions (Sheet 2 of 5)

Type of Data Set	Information Field	Description
	Grandmaster Clock Class	This field displays an ASCII message based on the received clock class code as described in the following table.

Code (decimal)	Message
68–122, 133–170, 216–232	Profile specific value
6	Synchronized with PTP timescale
13	Holdover with PTP timescale
14	Synchronized with ARB timescale
52	Holdover degrade A with PTP timescale
58	Holdover degrade A with ARB timescale
187	Holdover degrade B with PTP timescale
193	Holdover degrade B with ARB timescale
248	Default
255	Slave only
All other codes	Reserved with decimal code value (xxx)

Table 7.19 PTP Data Set Descriptions (Sheet 3 of 5)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>Grandmaster Clock Accuracy</td><td>This field displays an ASCII message based on the received clock accuracy enumeration value as described in the following table.
<table>
<tr><th>Value (Hex)</th><th>Message</th></tr>
<tr><td>20</td><td>Within 25 ns</td></tr>
<tr><td>21</td><td>Within 100 ns</td></tr>
<tr><td>22</td><td>Within 250 ns</td></tr>
<tr><td>23</td><td>Within 1 µs</td></tr>
<tr><td>24</td><td>Within 2.5 µs</td></tr>
<tr><td>25</td><td>Within 10 µs</td></tr>
<tr><td>26</td><td>Within 25 µs</td></tr>
<tr><td>27</td><td>Within 100 µs</td></tr>
<tr><td>28</td><td>Within 250 µs</td></tr>
<tr><td>29</td><td>Within 1 ms</td></tr>
<tr><td>2A</td><td>Within 2.5 ms</td></tr>
<tr><td>2B</td><td>Within 10 ms</td></tr>
<tr><td>2C</td><td>Within 25 ms</td></tr>
<tr><td>2D</td><td>Within 100 ms</td></tr>
<tr><td>2E</td><td>Within 1 s</td></tr>
<tr><td>2F</td><td>Within 10 s</td></tr>
<tr><td>30</td><td>Within 10 s</td></tr>
<tr><td>31</td><td>Greater than 10 s</td></tr>
<tr><td>80–FD</td><td>Profile specific value (0xyy)</td></tr>
<tr><td>FE</td><td>Unknown</td></tr>
<tr><td>All other values</td><td>Reserved (0xyy)</td></tr>
</table></td></tr>
<tr><td></td><td>Grandmaster Priority1</td><td>This is the priority1 value set in the grandmaster clock. If the setting ALTPRIn > 0, its value is used as the reported priority1 value for grandmaster n. The expected value is between 0 to 255.</td></tr>
<tr><td></td><td>Grandmaster Priority 2</td><td>This is the priority2 value set in the grandmaster clock. The expected value is between 0 to 255.</td></tr>
<tr><td></td><td>C37.238 TLV Information</td><td>This is the C37.238 TLV information received. It is valid only in the Power profile. In the case of Default profile, this section is hidden.</td></tr>
<tr><td>Time Properties</td><td>Current UTC Offset</td><td>This is the current number of leap seconds between TAI and UTC.</td></tr>
<tr><td></td><td>Current UTC Offset Valid</td><td>This attribute is TRUE if the Current UTC Offset is valid and should be used. It is FALSE otherwise.</td></tr>
<tr><td></td><td>Leap59</td><td>This is set to TRUE if there is an impending leap second removal, i.e., the last minute of the current day contains 59 seconds.</td></tr>
<tr><td></td><td>Leap61</td><td>This is set to TRUE if there is an impending leap second insertion, i.e., the last minute of the current day contains 61 seconds.</td></tr>
<tr><td></td><td>Time Traceable</td><td>This indicates if the time being served is traceable to UTC reference time.</td></tr>
<tr><td></td><td>Frequency Traceable</td><td>This indicates if the frequency being distributed is traceable to a primary source.</td></tr>
</table>

Table 7.19 PTP Data Set Descriptions (Sheet 4 of 5)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>PTP Timescale</td><td>This is TRUE if the time being served uses the PTP/UTC timescale. Otherwise, it is FALSE.</td></tr>
<tr><td></td><td>Time Sources</td><td>This shows the source of the time being distributed based on the value of the time source enumeration as shown in the following table.
<table>
<tr><th>Code (decimal)</th><th>Message</th></tr>
<tr><td>10</td><td>ATOMIC_CLOCK</td></tr>
<tr><td>20</td><td>GPS</td></tr>
<tr><td>30</td><td>TERRESTRIAL_RADIO</td></tr>
<tr><td>40</td><td>PTP</td></tr>
<tr><td>50</td><td>NTP</td></tr>
<tr><td>60</td><td>HAND_SET</td></tr>
<tr><td>90</td><td>OTHER</td></tr>
<tr><td>A0</td><td>INTERNAL_OSCILLATOR</td></tr>
<tr><td>F0–FE</td><td>PROFILE SPECIFIC VALUE (0xyy)</td></tr>
<tr><td>All other values</td><td>RESERVED (0xyy)</td></tr>
</table></td></tr>
<tr><td></td><td>Local Time Offset</td><td>This is the offset of local time from UTC and information about impending change in the offset.</td></tr>
<tr><td>Port</td><td>Port Identity</td><td>This contains the clock ID and port number of the SEL-710-5 Relay on the PTP network.</td></tr>
<tr><td></td><td>Port State</td><td>This is the synchronization state of the SEL-710-5: LISTENING, SLAVE, UNCALIBRATED, or FAULTY. The relay is synchronized if the state is SLAVE.</td></tr>
<tr><td></td><td>Log Delay Request Interval</td><td>If the end-to-end delay mechanism is enabled, this is the logarithm to base 2 of the delay request intervals (in seconds) received from the master clock. If the peer-to-peer (P2P) delay mechanism is enabled, these data are hidden. Also, these data are hidden when delay mechanism is set to OFF.</td></tr>
<tr><td></td><td>Log Pdelay Request Interval</td><td>If the peer-to-peer (P2P) delay mechanism is enabled, this is the logarithm to base 2 of the configured peer delay request intervals (PDINT). If the end-to-end delay mechanism is enabled, these data are hidden. Also, these data are hidden when the delay mechanism is set to OFF.</td></tr>
<tr><td></td><td>Peer Mean Path Delay</td><td>If the peer-to-peer (P2P) delay mechanism is enabled, this is the measured mean peer delay on the SEL-710-5. If the peer-to-peer (P2P) delay mechanism is not selected (PTHDLY := P2P), these data are hidden.</td></tr>
<tr><td></td><td>Announce Receipt Timeout</td><td>This value is always four announce intervals.</td></tr>
<tr><td></td><td>Path Delay Mechanism</td><td>This is the same value as PTHDLY.</td></tr>
<tr><td></td><td>Failed to Receive Response</td><td>The value is TRUE if no response is received after five consecutive Delay or Pdelay Requests from the port. Otherwise, the value is FALSE. These data are hidden if PTHDLY := OFF.</td></tr>
<tr><td></td><td>Received Multiple Pdelay Responses</td><td>This is set to TRUE if a response is received from more than one clock to a Pdelay request from the SEL-710-5. The port state will transition to faulty when this happens. The value is reset to FALSE when only one clock responds to Pdelay requests from the SEL-710-5. These data are hidden if PTHDLY := P2P.</td></tr>
</table>

Table 7.19 PTP Data Set Descriptions (Sheet 5 of 5)

<table>
<tr><th>Type of Data Set</th><th>Information Field</th><th>Description</th></tr>
<tr><td></td><td>Reason for Non-synchronization</td><td>If the SEL-710-5 fails to synchronize, this field provides one of the following reasons for the failure: incorrect domain number, clock not in the acceptable master table, or missing TLV in Announce messages. Otherwise, the string is empty. See the following table.
<table>
<tr><th>Number</th><th>Reason for Non-synchronization Display Strings</th></tr>
<tr><td>1</td><td>Received Announce message for a different domain:
<domain number></td></tr>
<tr><td>2</td><td>Received Announce message from an unacceptable master:
<MAC or IP address></td></tr>
<tr><td>3</td><td>Required TLV is missing or incorrectly formatted by clock:
<clock ID></td></tr>
</table>
</td></tr>
<tr><td></td><td>Port Status</td><td>This displays the Port 1A or 1B time-synchronization status. If the port is not synchronized to a PTP master, NA is displayed. If a port is in the SLAVE state and it is chosen as master, ACTIVE is displayed.
Additional port status indications are available via Relay Word bits PTPA, PTPB, PASEL, and PBSEL. When Ethernet Port 1A is active, PASEL asserts. Similarly, when Ethernet Port 1B is active, PBSEL asserts. If the operating mode on Port 1 of the relay is PRP, PTP is enabled. If the relay is receiving PTP messages on Port 1A, PTPA asserts. Similarly, in PTP mode, if PTP is enabled and the relay is receiving PTP messages on Port 1B, PTPB asserts.</td></tr>
</table>

COMMUNICATIONS Command

The **COM *x*** command (see *Table 7.20*) displays communications statistics for the MIRRORED BITS communications channels. For more information on MIRRORED BITS communications, see *Appendix J: MIRRORED BITS Communications*. The summary report includes information on the failure of Relay Word bits 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 7.20 COM Command (Sheet 1 of 2)

Command	Description	Access Level
COM S A or **COM S B**	Returns 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	Returns a summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.	1
COM B	Returns 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

Table 7.20 COM Command (Sheet 2 of 2)

Command	Description	Access Level
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 7.21*) 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 7.21*.

Table 7.21 CONTROL Command

Command	Description	Access Level
CON RB*nn k*	Sets 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 *j k*** command (see *Table 7.22*) to copy the settings of Group *j* to the settings of Group *k*. The settings of Group *j* effectively overwrite the settings of Group *k*. Parameters *j* and *k* can be any available settings group number 1 through 4.

Table 7.22 COPY Command

Command	Description	Access Level
COP *j k*	Copies settings in Group *j* to settings in Group *k*.	2
Parameters		
j	1, 2, 3, or 4.	
k	1, 2, 3, or 4.	

For example when you enter the **COP 1 3** command, the relay responds, `Are you sure (Y/N)?` Answer **Y <Enter>** (for yes) to complete copying. The settings in Group 1 overwrite the settings in Group 3.

COUNTER Command (Counter Values)

The device generates the values of the 32 counters in response to the **COU** command (see *Table 7.23*).

Table 7.23 COUNTER Command

Command	Description	Access Level
COU *n*	Displays 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 7.24*) to view and set the relay date.

Table 7.24 Date Command

Command	Description	Access Level
DATE	Displays the internal clock date.	1
DATE *mm/dd/yyyy, yyyy/mm/dd,* or ***dd/mm/yyyy***	Sets 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) can be used to display the Ethernet port (Port 1) status, as shown in *Figure 7.22*, for the redundant fiber-optic (FX) Ethernet **Port 1A** and **Port 1B** configuration. The copper Ethernet port is labeled as TX. The response is similar for relays with the single Ethernet port option.

Different Ethernet configurations and different NETMODE settings result in slightly different information being displayed, as shown in *Figure 7.22* through *Figure 7.26*.

```
=>ETH <Enter>

SEL-710-5                                Date: 07/10/2015   Time: 20:16:05.914
MOTOR RELAY                                Time Source: External

NETMODE: PRP

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX
PORT 1B      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
      5098     1000       645526      88876         0       0

=>
```

Figure 7.22 Ethernet Port (PORT 1) Status Report When NETMODE := PRP

```
=>ETH <Enter>

SEL-710-5                                Date: 07/10/2015   Time: 20:18:11.791
MOTOR RELAY                                Time Source: External

NETMODE: FIXED

 PRIMARY PORT:  PORT 1A
 ACTIVE PORT:   PORT 1A

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
       143      107        14652       7861         0       0

=>
```

Figure 7.23 Ethernet Port (PORT 1) Status Report When NETMODE := FIXED

NOTE: Relays with older CPU cards can be upgraded to firmware versions R200 or higher, but the relay will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

```
=>ETH <Enter>

SEL-710-5                                Date: 10/25/2016   Time: 10:59:25.558
MOTOR RELAY                                Time Source: Internal

NETMODE: FAILOVER

PRIMARY PORT:  1A
ACTIVE PORT:   1A

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX
PORT 1B      Down   --     --     TX


IP Port:

MAC: 00-30-A7-67-32-10
IP ADDRESS: 10.10.52.244
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
        36       72         2660       5081         0       0

GOOSE Port:

MAC: 00-30-A7-78-10-20

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
         0        0            0          0         0       0

=>
```

Figure 7.24 Ethernet Port (PORT 1) Status Report When NETMODE := FAILOVER, E61850 := Y, and EGSE := Y

```
=>ETH <Enter>

SEL-710-5                                Date: 07/10/2015   Time: 20:21:34.698
MOTOR RELAY                                Time Source: External

NETMODE: SWITCHED

             LINK   SPEED  DUPLEX MEDIA
PORT 1A      Up     100M   Full   TX
PORT 1B      Up     100M   Full   TX

IP Port:

MAC: 00-30-A7-01-02-04
IP ADDRESS: 10.10.52.221
SUBNET MASK: 255.255.255.0
DEFAULT GATEWAY: 10.10.52.1

         PACKETS                BYTES              ERRORS
      SENT     RCVD         SENT       RCVD      SENT    RCVD
         93       74         8537       5096         0       0

=>
```

Figure 7.25 Ethernet Port (PORT 1) Status Report When NETMODE := SWITCHED

The command response for the single Ethernet port option is as shown in *Figure 7.26*.

```
=>ETH <Enter>

SEL-710-5                                  Date: 06/05/2010   Time: 10:41:44
MOTOR 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 7.26 Ethernet Port (PORT 1) Status Report for the Single Ethernet Port Option

EVENT Command (Event Reports)

Use the **EVE** command (see *Table 7.25*) to view event reports. See *Section 10: Analyzing Events* for further details on retrieving and analyzing event reports. See the *HISTORY Command on page 7.54* for details on clearing event reports.

Table 7.25 EVENT Command (Event Reports)

Command	Description	Access Level
EVE	Return the most recent event report (including settings and summary) at full length with 4 samples per cycle data	1
EVE [DIF] ***n***	Returns the *n* event report (standard or differential) with 4 samples/cycle data.	1
EVE [DIF] ***n*** **R**	Returns the *n* event report (standard or differential) with raw (unfiltered) 32 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 displays a standard event report.	
n	Indicates a record or event reference number. The most recent event has a record number of 1 and increments by 1 with each event, whereas the event reference number is a unique number that starts at 10000 and increments by 1 with each event (see *Event Reference Number on page 10.4* for details). If *n* is not specified, the relay displays the latest event report by default.	

FILE Command

The **FIL** command (see *Table 7.26*) is intended to be a safe and efficient means of transferring files between intelligent electronic devices (IEDs) and external support software (ESS). The **FIL** command ignores the hide rules and transfers visible as well as hidden settings, except the settings hidden by a part number. The **FIL** command is supported if you connect over the serial or Ethernet ports.

Table 7.26 FILE Command

Command	Description	Access Level
FIL DIR	Returns a list of files.	1
FIL READ ***filename***	Transfers settings file *filename* from the relay to the PC.	1
FIL WRITE ***filename***	Transfers settings file *filename* from the PC to the relay.	2
FIL SHOW ***filename***	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 7.27*.

Table 7.27 GOOSE Command Variants

Command Variant	Description	Access Level
GOOSE	Displays GOOSE information.	1
GOOSE ***k***	Displays GOOSE information *k* times.	1
GOOSE S	Displays a list of GOOSE subscriptions with their ID.	1
GOOSE S ***n***	Displays GOOSE statistics for all subscription ID *n*.	1
GOOSE S ALL	Displays GOOSE statistics for all subscriptions.	1
GOOSE S ***n*** **L**	Displays GOOSE statistics for subscription ID *n* including error history.	1
GOOSE S ALL L	Displays GOOSE statistics for all subscriptions including error history.	1
GOOSE S ***n*** **C**	Clears GOOSE statistics for subscription ID *n*.	1
GOOSE S ALL C	Clears GOOSE statistics for all subscriptions.	1

The information displayed for each GOOSE IED is described in the following table.

Information Field	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_351S_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_351S_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.

Information Field	Description
SqNum (Sequence Number)	This hexadecimal field represents the sequence number that increments with each retransmitted GOOSE message sent.
TTL (Time to Live)	This field contains the time (in ms) before the next message is expected.
Code	When appropriate, this text field contains warning or error condition text 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_351S_1CFG/LLN0$DSet13).
Receive Data Set Reference	This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_351S_1CFG/LLN0$DSet13).
Ctrl Ref/ ControlBlockReference	This is the GOOSE control block reference. It is a concatenation of the logical device name, LLN0 (logical node containing the control block), GO (functional constraint), and the GSEControl name. (e.g. SEL_351S_1CFG/LLN0GOGooseDSet13)
AppID	This is the application identifier as a decimal number.
From	This is the date and time the current statistics collection started.
To	This is the date and time the GOOSE statistics command was executed.
Accumulated downtime duration	This represents the total amount of time a subscription was in an error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Maximum downtime duration	This represents the maximum amount of time a subscription was continuously in error state. The duration is displayed in the format: hhhh:mm:ss.zzz.
Date & time maximum downtime began	This is the date and time the recorded maximum downtime started.
Number of messages received out-of-sequence (OOS)	This represents the total number of messages received with either the state number and/or sequence number out-of-sequence. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Number of time-to-live (TTL) violations detected	This represents the total number of times a message was not received within the expected period/interval.
Number of messages incorrectly encoded or corrupted	This represents the total number of messages that were identified with this subscription but were either incorrectly encoded or encoded with a wrong dataset.
Number of messages lost due to receive overflow	This represents the total number of messages that were not processed because memory resources were exhausted. This includes cases where more than one instance of a message is received within a single relay processing interval. In this case, the most recent message is processed and the others are discarded.
Calculated max. sequential messages lost due to OOS	This represents the maximum estimated number of messages that were missed after receiving a message with a higher state or sequence number than expected.
Calculated number of messages lost due to OOS	This represents the total of all estimated number of messages lost due to state or sequence number skip in received messages.

Table 7.28 Warning and Error Codes for GOOSE Subscriptions

Code	Enumeration[a]	Definition	Error/Warning
–	0	No errors present.	–
HOST DISABLED	1	Optional code for when the subscribing device is disabled or becomes unresponsive after the **GOOSE** command has been issued.	Error
CONF REV MISMA	2	Configuration revision mismatch. Displayed when the value of the configuration revision number in the received GOOSE message does not match with the value of the configuration revision number present in the CID file.	Error
NEED COMMISSIO	3	Needs commissioning. Displayed when the received GOOSE message has NdsCom = true.	Error
MSG CORRUPTED	4	Message corrupted. Displayed when a received GOOSE message does not meet the proper format or is corrupted.	Error
TTL EXPIRED	5	Time-to-live expired.	Error
OUT OF SEQUENC	6	Out-of-sequence (OOS) error. This error is present when the StNum or SqNum value between received GOOSE messages is not sequential.	Warning
INVALID QUAL	7	Invalid date quality received.	Warning

[a] Enumerations are used to communicate GOOSE error codes in the LGOS logical node.

Figure 7.27 shows an example response to the **GOOSE** command.

```
=>GOOSE

GOOSE Transmit Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_710d5_1CFG/LLN0$GO$GPub01
 01-0C-CD-01-00-18 4:1     4120   1          5580       362
 Data Set: SEL_710d5_1CFG/LLN0$GPDSet01

SEL_710d5_1CFG/LLN0$GO$NewGOOSEMessage
 01-0C-CD-01-00-04 4:3     4      11119      3          944
 Data Set: SEL_710d5_1CFG/LLN0$NewDataset


GOOSE Receive Status

 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
-----------------------------------------------------------------------------
SEL_700G_1CFG/LLN0$GO$NewGOOSEMessage
 01-0C-CD-01-00-05 4:3     5      1          5563       2000
 Data Set: SEL_700G_1CFG/LLN0$NewDataset

SEL_787d4_1CFG/LLN0$GO$NewGOOSEMessage
 01-0C-CD-01-00-03 4:3     3      1          5522       2000
 Data Set: SEL_787d4_1CFG/LLN0$NewDataset


=>GOO S 1 L
```

Figure 7.27 GOOSE Command Response

```
SubsID 1
----------------------------------------------------------------------------
 Ctrl Ref: SEL_700G_1CFG/LLN0$GO$NewGOOSEMessage
 AppID   : 5
 From    : 04/20/2018 12:38:30.275  To: 04/20/2018 14:13:43.289

 Accumulated downtime duration                      : 0000:00:09.891
 Maximum downtime duration                          : 0000:00:09.891
 Date & time maximum downtime began                 : 04/20/2018 12:40:21.460
 Number of messages received out-of-sequence(OOS)   : 0
 Number of time-to-live(TTL) violations detected    : 1
 Number of messages incorrectly encoded or corrupted: 0
 Number of messages lost due to receive overflow    : 0
 Calculated max. sequential messages lost due to OOS: 0
 Calculated number of messages lost due to OOS      : 0

 #    Date        Time          Duration        Failure
 1    04/20/2018  12:40:21.460  0000:00:09.891  TTL EXPIRED
```

Figure 7.27 GOOSE Command Response (Continued)

GROUP Command

Use the **GROUP** command (see *Table 7.29*) to display the active settings group or try to force an active settings group change.

Table 7.29 GROUP Command

Command	Description	Access Level
GROUP	Displays the active group.	1
GROUP *n*	Modifies the active Group *n*.	2
Parameter		
n	Indicates group numbers 1–4.	

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 fails. The relay responds: `Command Unavailable: Active setting group SELOGIC equations have priority over the GROUP command`.

HELP Command

The **HELP** command (see *Table 7.30*) 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 7.30 HELP Command

Command	Description	Access Level
HELP	Displays a list of each command available at the present access level with a one-line description.	1
HELP *command*	Displays information on the command *command*.	1

HISTORY Command

Use the **HIS** command (see *Table 7.31*) to view a list of one-line descriptions of relay events or clear the list (and corresponding event reports) from nonvolatile memory. For more information on event reports, see *Section 10: Analyzing Events*.

Table 7.31 HISTORY Command

Command	Description	Access Level
HIS	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list.	1
HIS [50INC or **BBD]** ***n***	Returns event histories with the oldest at the bottom of the list and the most recent at the top of the list, beginning at event *n*.	1
HIS [50INC or **BBD] C** or **R**	Clears/resets the event history and all corresponding event reports from nonvolatile memory.	1
HIS ***date1***	Return the event summaries on date *date1*[a].	1
HIS ***date1 date 2***	Return the event summaries from *date1* to *date2*, with *date1* at the bottom of the list and *date2* at the top of the list.	1
HIS CA or **RA**	Clears/resets the event history and all corresponding event reports from nonvolatile memory and resets the unique reference number to 10000.	1
Parameter		
BBD	Returns event histories for the broken bar detection element. If BBD is not specified, the relay displays histories for the standard event report.	
50INC	Returns event histories for the incipient cable fault detection element. If 50INC is not specified, the relay displays histories for the standard event report.	
n	Indicates an event reference number. The event reference number is a unique number that starts at 10000 and increments by 1 with each event (see *Event Reference Number on page 10.4* for details).	
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.	

[a] Use the same date format as Global setting DATE_F.

ID Command

Use the **ID** command (see *Table 7.32*) to extract device identification codes, as shown in *Figure 7.28*. You can use the information in the SPECIAL field in the **ID** command response to determine the hardware and firmware compatibility of the relay. Contact SEL technical support before you downgrade the relay firmware.

Table 7.32 ID Command

Command	Description	Access Level
ID	Returns a list of device identification codes.	0

```
=ID <Enter>

"FID=SEL-710-5-X323-V0-Z005003-D20220415","090B"
"BFID=SLBT7XX-R600-V0-Z000000-D20200331","0949"
"CID=43D5","025D"
"DEVID=SEL-710-5","0424"
"DEVCODE=80","030F"
"PARTNO=071050E1B1X0X758506FX","0754"
"CONFIG=111112010","041B"
"SPECIAL=0","02DE"
"SEL DISPLAY PACKAGE=3.0.50710.3004","0884"
"CUSTOMER DISPLAY PACKAGE=1.575370232","0992"
"iedName=SEL_710d5_default","0918"
"type=SEL_710d5","04E3"
"configVersion=ICD-710-5-X204-V0-Z302006-D20220401","0D7C"
"LIB61850ID=DF8157E4","04ED"
```

Figure 7.28 ID Command Response

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 7.33*).

Table 7.33 IRIG Command

Command	Description	Access Level
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.	1

To force the relay to synchronize to IRIG-B, enter the following command:

```
=>IRIG <Enter>
```

If the relay successfully synchronizes to IRIG-B, it sends the following header and access level prompt:

```
SEL-710-5                   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 7.34*) 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. Only download firmware to the front port.

Table 7.34 L_D Command (Load Firmware)

Command	Description	Access Level
L_D	Loads firmware to the relay.	2

LDP Command (Load Profile Report)

Use the **LDP** commands (see *Table 7.35*) to view and manage the Load Profile report (see *Figure 5.27*). If there are no stored data and an **LDP** command is issued, the relay responds with `No data available`.

Table 7.35 LDP Commands

Command	Description	Access Level
LDP ***row1 row2*** **LDP** ***date1 date2***	Displays 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	Clears 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 7.36*) is used for testing the MIRRORED BITS communications channel for proper communication. For more information on MIRRORED BITS, see *Appendix J: MIRRORED BITS Communications*. With the transmitter of the communications channel physically looped back to the receiver, the MIRRORED BITS addressing is wrong and ROK is 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 asserts 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 7.36 LOO Command

Command	Description	Access Level
LOO	Enables loopback testing of MIRRORED BITS channels.	2
LOO A	Enables loopback on MIRRORED BITS Channel A for the next 5 minutes.	2
LOO B	Enables loopback on MIRRORED BITS Channel B for the next 5 minutes.	2
LOO R	Cancels the loopbackl test.	2

```
=>>LOO A <Enter>
Loopback will be enabled on Mirrored Bits channel A for the next 5 minutes.
The RMB values will be forced to default values while loopback is enabled.
Are you sure (Y/N)?
=>>
```

If only one MIRRORED BITS port is enabled, the channel specifier (A or B) can be omitted. To enable loopback mode for other than the 5-minute default, enter the 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 causes both channels to be disabled.

```
=>>LOO R <Enter>
Loopback is disabled on both channels.
=>>
```

MAC Command

NOTE: Relays with older CPU cards can be upgraded to firmware versions R200 or higher, but the relay will not have the GOOSE performance improvements (i.e., a GOOSE port with a dedicated MAC address).

Use the **MAC** command to display the MAC addresses of PORT 1, as shown below.

```
=>>MAC <Enter>

Port 1 (IP) MAC Address:      00-30-A7-67-32-10
Port 1 (GOOSE) MAC Address:   00-30-A7-78-10-20

=>>
```

MET Command (Metering Data)

The **MET** command (see *Table 7.37* and *Table 7.38*) provides access to the relay metering data.

Table 7.37 Meter Command

Command	Description	Access Level
MET ***c n***	Displays metering data.	1
MET ***c*** **R**	Resets metering data.	2
Parameters		
c	Identifies meter class. If *c* is not specified, the relay displays the fundamental meter report.	
n	Specifies the number of times (1–32767) to repeat the meter response.	

Table 7.38 Meter Class (Sheet 1 of 2)

c	Meter Class
F	Fundamental Metering
E[a]	Energy Metering
M[a]	Maximum/Minimum Metering
RMS	RMS Metering

Table 7.38 Meter Class (Sheet 2 of 2)

c	Meter Class
FFT	Fast Fourier Transform Data Metering
T	Thermal and RTD Metering
AI	Analog Input (transducer) Metering
L	Light Metering for arc-flash detection (AFD)
MV	SELOGIC Math Variable Metering
RA	Remote Analog Metering

[a] Reset command 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)?` Confirm by selecting `Y` and pressing **ENT**. The metering quantities are reset and the relay responds with `Reset Complete`.

MMR Command

Use the **MMR** (motor maintenance report) command to review for each start/stop cycle motor parameters, such as:

- Time to start/stop
- Power on start/stop
- Maximum starting current
- Minimum starting voltage
- Slip on stop

The **MMR** command displays the values recorded during a baseline run and each subsequent run. The MMR report includes data for the latest 360 start/stop cycles, along with the data captured in the baseline run.

Table 7.39 MMR Command

Command	Description	Access Level
MMR	Displays stored motor parameters for each start/stop cycle along with the baseline run.	1
MMR C	Clears stored motor parameters for each start/stop cycle and readies the relay to compute a new set of baseline run parameters in the following start/stop cycle.	2

See *Motor Maintenance Report on page 5.20* for information on the contents of the motor maintenance report.

MOTOR Command

The **MOT** command (see *Table 7.40*) 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 7.40 MOTOR Command

Command	Description	Access Level
MOT	Displays machine operating statistical monitoring of the protected device.	1
MOT C or **R**	Use this command to clear/reset the motor statistic and motor start report records.	2

Section 5: Metering and Monitoring includes additional details on the motor operating statistics report. Issuing the **MOT R** or **MOT C** command from Access Level 2 clears both motor statistics and motor start reports.

MSR or CMSR Command

Use the **MSR** (Motor Start Report) command (see *Table 7.41*) 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. QuickSet supports viewing of the compressed motor start reports (*.cmsr).

Table 7.41 MSR (Motor Start Report) Command

Command	Description	Access Level
MSR *n*	Returns the *n* motor start report where *n* is event record or reference number. The *n* defaults to 1, where 1 is the most recent event.	1
CMSR *n*	Shows compressed motor start record data, where *n* is the event record or reference number.	1

See *Section 5: Metering and Monitoring* for information on the contents of motor start reports. Issuing the **MOT R** or **MOT C** command from Access Level 2 clears both motor statistics and motor start reports.

MST Command

Use the **MST** (Motor Start Trend) command (see *Table 7.42*) 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 7.42 MST (Motor Start Trend) Command

Command	Description	Access Level
MST	Returns the motor start trend data	1
MST R or **C**	Resets or clears 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 7.43*) to change existing passwords.

Table 7.43 PASSWORD Command

Command	Description	Access Level
PAS *level*	Changes password for Access Level *level*.	2, C
Parameter		
level	Parameter *level* represents the relay Access Levels 1, 2, or C.	

The factory-default passwords are as shown in *Table 7.44*.

Table 7.44 Factory-Default Passwords for Access Levels 1, 2, and C

Access Level	Factory-Default Passwords
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 the Access Level 2 password and **PAS C** to change the Access Level C password.

Table 7.45 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

Passwords can contain as many as 12 characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of 12 characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are 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 1) allows a user of the relay to determine if a host is reachable across an IP network and/or if the Ethernet port (Port 1) is functioning or configured correctly. A typical **PING** command response is shown in *Figure 7.29*.

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 **Q**.

```
=>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 7.29 PING Command Response

PULSE Command

NOTE: The **PULSE** command is available when the breaker control jumper on the main board is in the ENABLED position.

Use the **PULSE** command (see *Table 7.46*) to pulse any of the relay outputs for a specified time. This function aids you in relay testing and commissioning. When a **PUL** command is issued, the selected contact closes or opens 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 outputs are OUT*nnn*, where *nnn* represents 101–103 (standard), 301–308 (optional), 401–408 (optional), or 501–508 (optional). For example, OUTPUT 301 refers to Output 01 in Slot C.

Table 7.46 PUL OUT*nnn* Command

Command	Description	Access Level
PUL OUT*nnn*	Pulses output OUT*nnn* for 1 second.	2
PUL OUT*nnn s*	Pulses output OUT*nnn* for *s* seconds.	2
Parameters		
nnn	Output number.	
s	Time in seconds, with a range of 1–30.	

QUIT Command

Use the **QUIT** command (see *Table 7.47*) to revert to Access Level 0.

Table 7.47 QUIT Command

Command	Description	Access Level
QUIT	Goes to Access Level 0.	0

Access Level 0 is the lowest access level; the SEL-710-5 performs no password check to descend to this level (or to remain at this level).

R_S Command (Restore Factory Defaults)

NOTE: In firmware versions R302-V0 and higher, the relay firmware retains the IP address, subnet mask, and default router settings after an **R_S** command is issued.

Use the **R_S** command (see *Table 7.48*) to restore factory-default settings.

Table 7.48 R_S Command (Restore Factory Defaults)

Command	Description	Access Level
R_S	Restores the factory-default settings and passwords and reboots the system.[a]	2

[a] Only available after a settings or critical RAM failure.

RSTP Command

Use the **RSTP** command (see *Figure 7.49*) to display the RSTP statistics and the present RSTP configuration when RSTP is enabled.

Table 7.49 RSTP Command

Command	Description	Access Level
RSTP	Displays the RSTP statistics and the present RSTP configuration.	1

Table 7.50 describes the information displayed in the output of the **RSTP** command.

Table 7.50 RSTP Command Definitions (Sheet 1 of 2)

Information Field	Description
ROOT BRIDGE	Reveals the role of the relay in the RSTP configuration. It will either display YES or NO.
BRIDGE ID	Displays the Bridge ID of the relay, which consists of the bridge priority (in decimal format) and the MAC address of the relay.
ROOT BRIDGE ID	Displays the Bridge ID of the root bridge, which consists of the bridge priority (in decimal format) and the MAC address of the root bridge.
ROOT PORT	Displays the port number (i.e., Port 1A or Port 1B) that is forwarding towards the root bridge when the relay is a designated bridge. If the relay is the root bridge, this displays NA.
TIME SINCE TOPOLOGY CHANGE	Displays the number of seconds since the last topology change occurred.
BRIDGE PRIORITY	Determines the root bridge. The bridge with the lowest value becomes the root bridge. It can be set under the Port 1 settings.
HELLO TIME	Interval in which the relay sends BPDUs. It is fixed at 2 seconds.
MAX AGE	Maximum number of hops before a BPDU is discarded. It is fixed at 40.
FORWARD DELAY	The time that the relay must spend in the listening and learning states before transitioning to forwarding. It is fixed at 21 seconds. This is only used when the relay is in STP compatibility mode.
PORT 1A PROTOCOL	Displays either STP or RSTP.
PORT 1B PROTOCOL	Displays either STP or RSTP.
PORT 1A STATE	The state of Port 1A.
PORT 1B STATE	The state of Port 1B.
PORT 1A ROLE	The role of Port 1A.
PORT 1B ROLE	The role of Port 1B.
PORT 1A PRIORITY	Determines which port the device selects as a root port when there is a tie between two ports. The port with the lower value will become the root port. It can be set under the Port 1 settings.

Table 7.50 RSTP Command Definitions (Sheet 2 of 2)

Information Field	Description
PORT 1B PRIORITY	Determines which port the device selects as a root port when there is a tie between two ports. The port with the lower value will become the root port. It can be set under the Port 1 settings.
PORT 1A PATH COST	Helps determine which path the device selects to a root bridge. The device selects paths with the lowest overall cost first. It is fixed at 200000.
PORT 1B PATH COST	Helps determine which path the device selects to a root bridge. The device selects paths with the lowest overall cost first. It is fixed at 200000.
PORT 1A EDGE PORT	If YES, Port 1A is an edge port. If NO, it is not.
PORT 1B EDGE PORT	If YES, Port 1B is an edge port. If NO, it is not.
PORT 1A BPDU COUNT	Displays the number of BPDUs received on Port 1A.
PORT 1B BPDU COUNT	Displays the number of BPDUs received on Port 1B.

Figure 7.30 shows an example response to the **RSTP** command.

```
=>RSTP <Enter>

SEL-710-5                                Date: 08/26/2022   Time: 10:37:34.788
MOTOR RELAY                          Time Source: External

RSTP Communication Statistics:

Root Bridge: NO
Bridge Id: 36864-0030A7169000
Root Bridge Id: 12288-0030A70B64F9
Root Port: 1A
Time Since Topology Change: 76601 sec
Bridge Priority: 36864;   Hello Time:  2 sec
Max Age: 40;   Forward Delay:  21 sec

PORT PROTOCOL  STATE       ROLE    PRIORITY  PATHCOST EDGE #BPDU-RCVD
 1A   RSTP   Forwarding   Rootport    128    200000   False     39608
 1B   RSTP   Discarding   Disabled    128    200000   False      1077

=>
```

Figure 7.30 RSTP Command Response

RLP Command

Use the **RLP** command (see *Table 7.51*) to reset learned motor parameters.

Table 7.51 RLP Command

Command	Description	Access Level
RLP	Resets learned motor parameters	2

In response to the **RLP** command, the device responds with the following prompt: `Reset Cooltime (Y/N)?` If you confirm 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 then responds: `Reset Start TC (Y/N)?` If you confirm the prompt, the device resets 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 7.52*) to view and manage the Sequential Events Recorder report. See *Section 10: Analyzing Events* for further details on SER reports. If there is no SER report row stored, the relay responds with `No Data Available`.

Table 7.52 SER Command (Sequential Events Recorder Report)

Command	Description	Access Level
SER	Displays 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**	Clears/resets 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 date beginning with *date1* and ending with *date2*. Enter the oldest date first to display a chronological progression through the report. Enter the newest date first to display a reverse chronological progression. Date entries are dependent on the date format setting DATE_F. For example, use **SER 1/5/2003 1/7/2003** to return all records for January 5, 6, and 7, 2003.	

SET Command (Change Settings)

Use the **SET** command to view or change the relay settings (see *Table 7.53*).

Table 7.53 SET Command (Change Settings) (Sheet 1 of 2)

Command	Description	Access Level
SET *n s* TERSE	Sets the relay settings, beginning at the first setting for Group *n*.	2
SET E TERSE	Sets the EtherNet/IP settings.	2
Parameters		
k	Parameter *k* indicates the port number 1, 2, 3, 4, or F.	
m	Parameter *m* indicates the DNP map number 1, 2, or 3.	
n	Parameter *n* indicates the group number 1, 2, 3, or 4.	
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.	
TERSE	Append TERSE or TE 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.	

Table 7.53 SET Command (Change Settings) (Sheet 2 of 2)

Command	Description	Access Level
SET L *n s* TERSE	Sets the general logic settings for Group *n*.	2
SET G *s* TERSE	Sets the global settings.	2
SET P *k s* TERSE	Sets the serial port settings. *k* specifies the port; *k* defaults to the active port if not listed.	2
SET R *s* TERSE	Sets the report settings such as Sequential Events Recorder (SER) and Event Report (ER) settings.	2
SET F *s* TERSE	Sets the front-panel settings.	2
SET I TERSE	Sets the IEC 60870-5-103 settings.	2
SET M *s* TERSE	Sets the Modbus User Map settings.	2
SET DNP *m s* TERSE	Sets the DNP Map *m* settings.	2
Parameters		
k	Parameter *k* indicates the port number 1, 2, 3, 4, or F.	
m	Parameter *m* indicates the DNP map number 1, 2, or 3.	
n	Parameter *n* indicates the group number 1, 2, 3, or 4.	
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.	
TERSE	Append TERSE or TE 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 7.54*.

Table 7.54 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 7.55* for the **SHOW** command settings and format.

Table 7.55 SHOW Command (Show/View Settings)

Command	Description	Access Level
SHO *n s*	Shows the relay settings for Group *n*.	1
SHO E	Shows the EtherNet/IP assembly map settings.	1
SHO L *n s*	Shows the general logic settings for Group *n*.	1
SHO G *s*	Shows the Global settings.	1
SHO P *k s*	Shows the serial port settings. ***k*** specifies the port (1, 2, 3, 4, or F); *k* defaults to the active port if not listed.	1
SHO R *s*	Shows the report settings, such as Sequential Events Recorder (SER) and Event Report (ER) settings.	1
SHO F *s*	Shows the front-panel settings.	1
SHO I	Shows the IEC 60870-5-103 settings.	1
SHO M *s*	Shows the Modbus User Map settings.	1
SHO DNP *m s*	Shows the DNP Map *m* settings.	1
Parameters		
k	Parameter *k* indicates the port number 1, 2, 3, 4, or F.	
m	Parameter *m* indicates the DNP map number 1, 2, or 3.	
n	Parameter *n* indicates the group number 1, 2, 3, or 4.	
s	The name of the specific setting you want to view. Jumps to this setting. If *s* is not entered, the relay starts at the first setting.	

```
=>SHO <Enter>

Group 1
Relay Settings

ID Settings
RID      := SEL-710-5
TID      := SYNCHRONOUS MTR

Config Settings
SYNTYPE  := BRUSHLESS     CTR1     := 100           FLA1     := 250.0
VFDAPP   := N             CTRN     := 100           PTR      := 35.00
VNOM     := 4160          DELTA_Y  := DELTA         SINGLEV  := N

Thermal Overload
E49MOTOR := Y             SETMETH  := RATING        49RSTP   := 75
SF       := 1.15          LRA1     := 6.0           LRTHOT1  := 10.0
TD1      := 1.00          RTC1     := AUTO          TCAPU    := 85
TCSTART  := OFF           COOLTIME := 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
```

Figure 7.31 SHOW Command Example

```
Phase TOC
51AP     := OFF           51BP     := OFF           51CP     := OFF

Maximum Ph TOC
51P1P    := OFF           51P2P    := OFF

Negative Seq TOC
51QP     := OFF

Residual TOC
51G1P    := OFF           51G2P    := OFF

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

RTD Settings
E49RTD   := NONE

Undervoltage Set
27P1P    := OFF           27P2P    := OFF

Overvoltage Set
59P1P    := 1.10          59P1D    := 0.5           59P2P    := OFF



27 Inverse Time
E27I1    := N             E27I2    := N

59 Inverse Time
E59I1    := N             E59I2    := N             E59I3    := N
E59I4    := N

VAR Settings
NVARTP   := OFF           PVARTP   := OFF           NVARAP   := OFF
PVARAP   := OFF

Loss of Field Set
E40      := N

Out of Step
E78      := N

Field Res Set
FDRES1P  := OFF           FDRES2P  := OFF
FDRESTC  := SRUNNING

Field Current Set
FDCURIN  := I             FD_20mA  := 400.0         FDUC1P   := OFF
FDUC2P   := OFF           FDOC1P   := OFF           FDOC2P   := OFF
FDCTC    := SRUNNING

Field Voltage Set
FDUV1P   := OFF           FDUV2P   := OFF           FDOV1P   := OFF
FDOV2P   := OFF
FDVTC    := NOT STOPPED

Start Seq Set
41DELAY  := 3.0           FDCMIN   := 400.0
```

Figure 7.31 SHOW Command Example (Continued)

```
Underpower Set
37PTP    := OFF           37PAP    := OFF

Power Factor Set
55LGTP   := OFF           55LDTP   := OFF           55LGAP   := OFF
55LDAP   := OFF           55I1SUP  := OFF
55TC     := SRUNNING

Frequency Set
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 SPDSTR OR 50N1T OR SMTRIP OR ( 27P1T AND NOT LOP ) OR SV01T
            OR SV03T
REMTRIP  := 0
TRIPONLO := Y
ULTRIP   := 0

52A      := 0
41A      := 0

Motor Control
STREQ    := PB03
BLKSTR   := STOPPED AND ( THERMLO OR NOSLO OR TBSLO OR ABSLO )
EMRSTR   := 0
SPEEDSW  := 0

=>
```

Figure 7.31 SHOW Command Example (Continued)

STATUS Command (Relay Self-Test Status)

The **STA** command (see *Table 7.56*) displays the status report. See *Figure 7.32* for an example of a status report.

Table 7.56 STATUS Command (Relay Self-Test Status)

Command	Description	Access Level
STA *n*	Displays the relay self-test information *n* times (*n* = 1–32767). Defaults to 1 if *n* is not specified.	1
STA S	Displays the memory and execution utilization for the SELOGIC control equations.	1
STA C or **R**	Reboots the relay and clears self-test warning and failure status results.	2

Refer to *Section 11: Testing and Troubleshooting* for self-test thresholds and corrective actions, as well as hardware configuration conflict resolution. *Table 7.57* 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 7.57 STATUS Command Report and Definitions

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, IA87, IB87, IC87)	Measurement of dc offset in hardware circuits of current channels	Measurement of dc Offset/WARN
Voltage Offset (VA, VB, VC, VDR)	Measurement of 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
CARD_Z	Integrity of Card Z	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 7.32 shows the typical relay output for the **STATUS S** command, showing available SELOGIC control equation capability.

NOTE: The STA S report shows the available SELOGIC capacity of the relay. For example, execution 90% means that 90% of the execution capacity is still available.

```
=>STA S <Enter>
SEL-710-5                                   Date: 05/09/2006   Time: 15:44:46
MOTOR RELAY                                 Time Source: Internal
Part Number  071050E1B0X0X7286023X
Global (%)    76
FP (%)        77
Report (%)    62
               GROUP 1  GROUP 2  GROUP 3  GROUP 4
Execution (%)   90       95       95       95
Group (%)       67       70       70       70
Logic (%)       89       90       90       90

=>
```

Figure 7.32 Typical Relay Output for STATUS S Command

STOP Command

The **STOP** command (see *Table 7.58*) causes the relay to trip, opening the motor contactor or circuit breaker and stopping the motor. For further details refer to *Figure 4.76*.

Table 7.58 STOP Command

Command	Description	Access Level
STOP	Initiates user operation of an output to stop the motor.	2

When setting EN_LRC := Y, the Relay Word bit LOCAL supervises the **STOP** command (see *Table 9.6*). If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **STOP** command, and it responds with the following:

```
=>>STO <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

STR Command

The **STR** command (see *Table 7.59*) uses internal relay logic to initiate a motor start. For further details refer to *Section 4: Protection and Logic Functions*.

Table 7.59 STR Command

Command	Description	Access Level
STR	Initiates user operation of an output to start and run the motor.	2

When setting EN_LRC := Y, the Relay Word bit LOCAL supervises the **STR** command (see *Table 9.6*). If the LOCAL bit is asserted (LOCAL = 1), the relay does not execute the **STR** command from the ASCII terminal, and it responds with the following:

```
=>>STR <Enter>

Command Aborted: Device in Local Control

=>>
```

The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

SUMMARY Command

The **SUM** command (see *Table 7.60*) displays an event summary in human readable format.

Table 7.60 SUMMARY Command

Command	Description	Access Level
SUM *n*	Displays event summary *n* (where *n* is either the event record or the reference number).	1
SUM R or **C**	Clears 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 7.61*) displays the status of front-panel target LEDs or Relay Word bits, whether these LEDs or Relay Word bits are asserted or deasserted.

Table 7.61 TARGET Command (Display Relay Word Bit Status)

Command	Description	Access Level
TAR	Displays Relay Word Row 0 or the last displayed target row.	1
TAR *name k*	Displays the target row with target *name* in the row. Repeat display of this row for repeat count *k*.	1
TAR *n*	Displays target row *n*.	1
TAR *n k*	Displays target row *n*. Repeat display of row *n* for repeat count *k*.	1
TAR R	Clears front-panel tripping targets. Unlatches the trip logic for testing purposes (see *Figure 8.2*). Shows Relay Word Row 0.	1
Parameters		
name	Displays the Relay Word row with Relay Word bit *name*.	
n	Shows Relay Word row number *n*.	
k	Repeats *k* times (1–32767).	

NOTE: The **TARGET R** command cannot reset the latched targets if a TRIP condition is present.

The elements are represented as Relay Word bits and are listed in rows of eight, called Relay Word rows. The first four rows, representing the front-panel operation and target LEDs, correspond to *Table 7.62*. All Relay Word rows are described in *Table L.1* and *Table L.2*. Relay Word bits are used in SELOGIC control equations. See *Appendix L: Relay Word Bits*.

The **TAR** command does *not* remap the front-panel target LEDs, as is done in some previous SEL relays.

Table 7.62 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

TEST DB Command

Use the **TEST DB** command to temporarily force the relay to send fixed analog and/or digital values over communications interfaces for protocol testing.

If the relay is enabled to control IEC 61850 mode/behavior, then the **TEST DB** command can only be used when the relay is in On mode. The **TEST DB** command cannot be used in any other mode.

If the **TEST DB** command is active while the relay is in On mode, a change of mode will deactivate the **TEST DB** command.

Table 7.63 TEST DB Commands

Command	Description	Access Level
TEST DB	Displays the present status of digital and analog overrides.	2
TEST DB A *name value*	Forces the protocol analog element *name* to override *value*.	2
TEST DB D *name value*	Forces the protocol digital element *name* to override *value*.	2
TEST DB *name* OFF	Clears (analog or digital) override for element *name*.	2
TEST DB A OFF	Clears all analog overrides.	2
TEST DB D OFF	Clears all digital overrides	2
TEST DB OFF	Clears all analog and digital overrides.	2

⚠WARNING
To reduce the chance of a false operating decision when using the **TEST DB** command, ensure that protocol master device(s) flag the data as “forced or test data”. One possible method is to monitor the TESTDB Relay Word bit.

NOTE: The **TEST DB** command does not support digital points in the case of SEL Fast Message protocol.

The **TEST DB** command provides a method to override Relay Word bits or analog values to aid testing and commissioning of communications interfaces only and should not be used on an energized system. The command overrides values in the communications interfaces (ASCII, SEL Fast Message, DNP, Modbus, EtherNet/IP, IEC 60870-5-103, and IEC 61850) only. The actual values used by the relay for protection and control are not changed. However, remote devices may use these analog and digital signals to make control decisions. Ensure that remote devices are properly configured to receive the overridden data before using the **TEST DB** command.

R1*xx* firmware versions use a previous version of the **TEST DB** command that aids testing and commissioning of IEC 61850 protocol only. Note that the **TEST DB** command supported by R1*xx* firmware versions provides a method to override Relay Word bits only and should not be used on an energized system. If used on an energized system, the command can lead to undesired operations including a potential trip.

NOTE: When using the **TEST DB** command to generate values for Fast Meter testing, you may need to override all current and voltage angles (IA_ANG, VA_ANG, etc.) to ensure the expected phase relationship.

NOTE: When using the **TEST DB** command, specifying a negative value may yield an unexpected display in some instances.

To override analog data in a communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB A name value <Enter>
```

where *value* is a numerical value and *name* is an analog label from *Table M.1*, Analog Quantities, with an "x" in the DNP, Modbus, EtherNet/IP, Fast Meter, IEC 60870 5-103, or IEC 61850 column. For example, the **TEST DB** command can be used to force the value of the A-phase current magnitude transmitted to a remote device to 100 amperes:

```
=>>TEST DB A IA_MAG 100 <Enter>
```

To override digital data in an SEL ASCII, Modbus, EtherNet/IP, DNP, IEC 60870-5-103, or IEC 61850 communications interface, enter the following from Access Level 2 or higher:

```
=>>TEST DB D name value <Enter>
```

where *name* is a Relay Word bit (see *Table L.1*) and *value* is 1 or 0. For example, if Relay Word bit 51P1T := logical 0, the **TEST DB** command can be used effectively to test the communications interface by forcing the communicated status of this Relay Word bit to logical 1:

```
=>>TEST DB D 51P1T 1 <Enter>
```

Values listed in the SER triggers SER1, SER2, SER3, and SER4 cannot be overridden.

When the relay is not in Test Mode, the relay responds to either the digital or analog override request with the following message:

```
WARNING:  TEST MODE is not a regular operation.
Communication outputs of the device will be overridden by simulated values.

Are you sure (Y/N)? Y <Enter>
```

The relay responds:

```
Test Mode Active.  Use Test DB OFF command to exit Test Mode.
Override Added
```

Relay Word bit TESTDB will also assert to indicate that Test Mode is active. If the relay is already in the test mode (overrides are already active), the relay responds:

```
Override Added
```

The **TEST DB** command alone displays the present status of digital and analog overrides. An example **TEST DB** response after two analogs follows:

```
=>>TEST DB <Enter>

SEL-710-5                          Date: 02/02/09    Time: 16:24:38.764
FEEDER RELAY                     Time Source: Internal

NAME          OVERRIDE VALUE
IA_MAG             100.0000
FREQ                60.0000

=>>
```

Individual overrides are cleared using the **TEST DB** command with the OFF parameter:

```
=>>TEST DB D or A name OFF <Enter>
```

Entering **TEST DB A OFF** clears all analog overrides and **TEST DB D OFF** clears all digital overrides. Entering **TEST DB OFF** without any parameters clears all overrides. When there are no overrides, the relay automatically exits the Test Mode and clears all overrides if no **TEST DB** commands are entered for 30 minutes.

TIME Command (View/Change Time)

The **TIME** command (see *Table 7.64*) returns information about the SEL-710-5 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 7.64 TIME Command (View/Change Time)

Command	Description	Access Level
TIME	Displays the present internal clock time.	1
TIME *hh*	Sets the internal clock to *hh*.	1
TIME *hh:mm*	Sets the internal clock to *hh:mm*.	1
TIME *hh:mm:ss*	Sets 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-710-5 responds with `Invalid Time`.

TRIGGER Command (Trigger Event Report)

Use the **TRI** command (see *Table 7.65*) to trigger the SEL-710-5 to record data for high-resolution oscillographs and event reports.

Table 7.65 TRIGGER Command (Trigger Event Report)

Command	Description	Access Level
TRI	Triggers an event report data capture.	1

When you issue the **TRI** command, the SEL-710-5 responds with `Triggered`. If the event does not trigger within one second, the relay responds with `Did not trigger`. See *Section 10: 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 7.66 VEC Command

Command	Description	Access Level
VEC D	Displays the standard vector report.	2
VEC E	Displays the extended vector report.	2

Language Support

All of the ASCII commands can be displayed in multiple languages (English or Spanish). When you set the port setting LANG (see *Table 4.98*) to either ENGLISH or SPANISH, the SEL-710-5 displays the ASCII commands in the corresponding language. See the *SEL-710-5 Relay Command Summary* for a list of commands.

Virtual File Interface

You can retrieve and send data as files through the relay virtual file interface. Devices with embedded computers can also use the virtual file interface. When using serial ports with SEL ASCII protocol or an Ethernet port with Telnet, use the **FILE DIR** command to access the file interface. When using the Ethernet port, the FTP and MMS protocols supported by the Ethernet port present the file structure and send and receive files.

Send and receive files using the following three protocols:

Protocol	Port Availability
File Transfer Protocol (FTP)	Ethernet Only
Manufacturing Message Specification (MMS)	Ethernet Only
Ymodem	Serial and Ethernet

FTP and MMS File Structure

The Ethernet FTP and the IEC 61850 MMS have a two-level file structure. Files are available at the root level and subdirectories. *Table 7.67* shows the directories and their contents.

Table 7.67 FTP and MMS Virtual File Structure (Sheet 1 of 2)

Directory	Contents
/ (Root)	CFG.TXT file, CFG.XML file, ERR.TXT file and SET_61850.CID and the SETTINGS, REPORTS, EVENTS, COMTRADE[a], and HMI[b] directories
/SETTINGS	Relay settings
/REPORTS	SER, LDP, MOT, MST, MSR, BRE, and HIS reports

Table 7.67 FTP and MMS Virtual File Structure (Sheet 2 of 2)

Directory	Contents
/EVENTS	CEV, COMTRADE, and HIS reports
/COMTRADE[a]	COMTRADE events
/HMI[b]	Touchscreen settings (SET_HMI.zds and CDP.zds) and diagnostics (HMI_ALL.zip)

[a] The COMTRADE directory is only available in MMS file structure.
[b] Available only in the SEL-710-5 touchscreen display model. HMI_ALL.zip is not available in the MMS file structure.

Root Directory

The root directory (/) contains files and subdirectories as shown in *Table 7.67*.

CFG.TXT File (Read-Only)

The CFG.TXT file contains general configuration information about the relay and each settings class. External support software retrieves the CFG.TXT file to interact automatically with the relay. Calibration settings are included only when the file is read at Access Level C.

```
[INFO]
RELAYTYPE=SEL-710-5
FID=SEL-710-5-X209-V0-Z003002-D20180124
BFID=BOOTLDR-R500-V0-Z000000-D20090925
PARTNO=071050E1BA3BX7486A270
[FRONTPANEL]
BDP=1.0.40710.2081
[CLASSES]
PF,"Port F"
P4,"Port 4"
P2,"Port 2"
P3,"Port 3"
P1,"Port 1"
G,"Global"
1,"Group 1"
2,"Group 2"
3,"Group 3"
4,"Group 4"
L1,"Logic 1"
L2,"Logic 2"
L3,"Logic 3"
L4,"Logic 4"

M,"Modbus User Map"
R,"Report"
F,"Front Panel"
D1,"DNP Map 1 Settings"
D2,"DNP Map 2 Settings"
D3,"DNP Map 3 Settings"
I,"IEC 60870-5-103 Map"
E1,"EtherNet/IP Assembly Map 1 Settings"
E2,"EtherNet/IP Assembly Map 2 Settings"
E3,"EtherNet/IP Assembly Map 3 Settings"
```

Figure 7.33 CFG.TXT File

CFG.XML File (Read-Only)

Present only in units with the Ethernet option, the CFG.XML file is supplementary to the CFG.TXT file. The CFG.XML file describes the IED configuration and any options such as the Ethernet port, and includes firmware identification, settings class names, and configuration file information.

ERR.TXT (Read-Only) and SET_61850.CID File

Present if ordered with the IEC 61850 protocol option. The ERR.TXT file contents is based on the most recent SET_61850.CID file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file. The SET_61850.CID file contains the IEC 61850 configured IED description in XML. ACSELERATOR Architect SEL-5032 Software generates and then downloads this file to the relay. See *Appendix G: IEC 61850 Communications* for more information.

Settings Directory (Available for FTP and MMS)

You can access the relay settings through files in the SETTINGS directory. We recommend that you use support software to access the settings files, rather than directly accessing them via other means. External settings support software reads settings from all of these files to perform its functions. The relay only allows you to write to the individual SET_cn files, where c is the settings class code and n is the settings instance. Except for the SET_61850 CID file, changing settings with external support software involves the following steps:

Step 1. Read the CFG.TXT and the SET_ALL.TXT files from the relay using a support software.

Step 2. Modify the settings for each settings class and send the corresponding SET_cn.TXT file to the relay using the support software.

Step 3. Read the ERR.TXT file from the relay. If the ERR.TXT file is empty, the relay detected no errors in the SET_Cn.TXT file and it is accepted.

Step 4. For any detected errors, fix the SET_cn.TXT file as indicated by the ERR.TXT file and send the SET_cn.TXT file to the relay.

Step 5. Repeat *Step 2* to *Step 4* for each setting class that you want to modify.

Step 6. After all setting changes are complete, test and commission the relay.

SET_ALL.TXT File (Read-Only)

The SET_ALL.TXT file contains the settings for all of the settings classes in the relay. Calibration settings are included only when the file is read at Access Level C.

SET_cn.TXT Files (Read and Write)

There is a file for each instance of each setting class. *Table 7.68* summarizes the settings files. The settings class is designated by c, and the settings instance number is designated by n.

ERR.TXT (Read-Only)

The ERR.TXT file contents are based on the most recent SET_cn.TXT file written to the relay. If there were no errors, the file is empty. If errors occurred, the relay logs these errors in the ERR.TXT file.

Table 7.68 Settings Directory Files (Sheet 1 of 2)

File Name	Settings Description
SET_*n*.TXT	Group; *n* in range 1-4
SET_D*n*.TXT	DNP3 Map; *n* in range 1-4
SET_E*n*.TXT	EtherNet/IP Assembly Map; *n* in range 1–3
SET_F.TXT	Front panel

Table 7.68 Settings Directory Files (Sheet 2 of 2)

File Name	Settings Description
SET_G.TXT	Global
SET_I.TXT	60870 Map
SET_L*n*.TXT	Logic; *n* in range 1-4
SET_M.TXT	Modbus Map
SET_P*n*.TXT	Port; *n* in range 1, 2, 3, 4, F
SET_R.TXT	Report
SET_ALL.TXT	All instances of all settings classes
ERR.TXT	Error log for most recently written settings file

Reports Directory (Read-Only) (Available for FTP and MMS)

Use the REPORTS directory to retrieve files that contain the reports shown in *Table 7.69*. Note that the relay provides a report file that contains the latest information each time you request the file. Each time you request a report, the relay stores its corresponding command response in the designated text file.

Table 7.69 Reports Directory Files

File Name	Description	Equivalent Command Response
BRE.TXT	Breaker Report	BRE
CHISTORY.TXT	Compressed ASCII History Report	CHI
HISTORY.TXT	History Report	HIS
CLDP.TXT	Compressed Load Profile Data	CLDP
LDP.TXT	Load Profile Data	LDP
CSER.TXT	Compressed Sequence of Events	CSER
SER.TXT	Sequence of Events	SER
MOT.TXT	Motor Statistics Report	MOT
MST.TXT	Motor Start Trend Report	MST
HIS_BBD.TXT	Broken Bar Detection History Report	HIS BBD
CM_*nnnnn*.CEV	Compressed Motor Start Report; event ID number = *nnnnn*	CMSR *nnnnn*
MSR_nnnnn.CFG[a]	Motor Start Report COMTRADE configuration file; event ID number = *nnnnn*	N/A
MSR_*nnnnn*.DAT[a]	Motor Start Report COMTRADE binary data file; event ID number = *nnnnn*	N/A
MSR_*nnnnn*.HDR[a]	Motor Start Report COMTRADE header file; event ID number = *nnnnn*	N/A

[a] Also available in the COMTRADE directory for MMS only.

Events Directory (Read-Only)

The relay provides history, event reports, and oscillography files in the EVENTS directory as shown in *Table 7.70*.

Event reports are available in the following formats:

- SEL Compressed ASCII
- Binary COMTRADE format (IEEE C37.111-1999)

The size of each event report file is determined by the LER setting in effect at the time the event is triggered.

Compressed SEL ASCII event report files are generated, when requested, by storing the appropriate command response shown in *Table 7.70*.

Oscillography files are generated at the time the event is triggered (see *Event Reporting on page 10.2*). Higher resolution oscillography is available with SEL Compressed ASCII 32 sample/cycle raw event reports and binary COMTRADE files.

COMTRADE event files are available to read as a batch. See *Batch File Access on page 7.81*.

Table 7.70 Event Directory Files

File Name	Description	Equivalent Command Response
CHISTORY.TXT[a]	Compressed ASCII History Report	CHI
HISTORY.TXT[a]	History Report	HIS
C4_*nnnnn*.CEV	Compressed 4-samples/cycle ASCII filtered event report; event ID number = *nnnnn*	CEV *nnnnn*
CR_*nnnnn*.CEV	Compressed 32-samples/cycle ASCII raw event report; event ID number = *nnnnn*	CEV R *nnnnn*
HR_*nnnnn*.CFG[b]	COMTRADE configuration file; event ID number = *nnnnn*	N/A
HR_*nnnnn*.DAT[b]	COMTRADE binary data file; event ID number = *nnnnn*	N/A
HR_*nnnnn*.HDR[b]	COMTRADE header file; event ID number = *nnnnn*	N/A

[a] Also available in the Reports directory for convenience.
[b] Also available in the COMTRADE directory for MMS only.

HR_*nnnnn*.* (Read-Only)

The three files HR_*nnnnn*.CFG, HR_*nnnnn*.DAT, and HR_*nnnnn*.HDR shown in *Table 7.70* are used to create an event report that conforms to the COMTRADE standard. The event is an unfiltered (raw) 32 samples/cycle event. The field, *nnnnn*, corresponds to the unique event identification number displayed by the HIS command. For details on event reports see *Section 10: Analyzing Events*.

COMTRADE Directory (Available Only for MMS)

When using MMS file transfer, conveniently retrieve all of the COMTRADE files from the COMTRADE directory. Note that the COMTRADE files are also available in the Events directory. Refer to *Table 7.70* for all the files available in the COMTRADE directory.

HMI Directory (Read and Write)

Use the HMI directory to retrieve the diagnostic information and the setting files that apply to the touchscreen. Refer to *Table 7.67* for all the files available in the HMI directory.

Ymodem File Structure

All the files available (see *Table 7.71*) for Ymodem protocol are in the root directory. See *FILE Command on page 7.49* for a response to the **FIL DIR** command.

Table 7.71 Files Available for Ymodem Protocol (Sheet 1 of 2)

File Name	Description	Read Access Level	Write Access Level
CFG.TXT	See *Root Directory on page 7.76*	1, 2, C	N/A
ERR.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	N/A
SET_ALL.TXT[a]	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	N/A
SET_*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_C.TXT[a]	See *Settings Directory (Available for FTP and MMS) on page 7.77*	C	C
SET_D*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_F.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_G.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_I.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_L*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_M.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_P*n*.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
SET_R.TXT	See *Settings Directory (Available for FTP and MMS) on page 7.77*	1, 2, C	2, C
C4_*nnnnn*.CEV	See *Events Directory (Read-Only) on page 7.79*	1, 2, C	N/A
CM_*nnnnn*.CMSR	See *Events Directory (Read-Only) on page 7.79*	1, 2, C	N/A
CR_*nnnnn*.CEV	See *Events Directory (Read-Only) on page 7.79*	1, 2, C	N/A
HR_*nnnnn*.CFG	See *Events Directory (Read-Only) on page 7.79*	1, 2, C	N/A
HR_*nnnnn*.DAT	See *Events Directory (Read-Only) on page 7.79*	1, 2, C	N/A
HR_*nnnnn*.HDR	See *Events Directory (Read-Only) on page 7.79*	1, 2, C	N/A
BRE.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
CHISTORY.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
HISTORY.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
CLDP.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
LDP.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
CSER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
SER.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
MOT.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A

Table 7.71 Files Available for Ymodem Protocol (Sheet 2 of 2)

File Name	Description	Read Access Level	Write Access Level
MST.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
HIS_BBD.TXT	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
MSR_nnnnn.CFG[b]	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
MSR_*nnnnn*.DAT[b]	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
MSR_*nnnnn*.HDR[b]	See *Reports Directory (Read-Only) (Available for FTP and MMS) on page 7.78*	1, 2, C	N/A
SET_HMI.zds	See *HMI Directory (Read and Write) on page 7.80*	1, 2, C	2, C
CDP.zds	See *HMI Directory (Read and Write) on page 7.80*	1, 2, C	2, C
HMI_ALL.zip	See *HMI Directory (Read and Write) on page 7.80*	1, 2, C	N/A

[a] Calibration settings are included only when accessed at Access Level C.
[b] Also available in the COMTRADE directory for MMS only.

Batch File Access

Files can be accessed as a batch by using the supported wildcard character, *.

FTP and MMS Wildcard Usage

Table 7.72 shows examples using supported wildcards. Note that these wildcards may be appended to a directory path (e.g., /specified_directory/*.txt).

Table 7.72 FTP and MMS Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files and/or subdirectories in a specified directory whose name (including extension) ends with xyz.	/*.TXT	List all files with the .TXT extension.
abc*	Lists all files and/or subdirectories in a specified directory whose name begins with abc.	/SETTINGS/SET*	List all settings files that start with SET.
mno	Lists all files and/or subdirectories in a specified directory whose name contains mno.	/EVENTS/*_100*	List all events that contain _100 in the ID number.

Ymodem Wildcard Usage

NOTE: Ymodem protocol does not support wildcards for settings files.

Event, report, and diagnostic files can also be accessed as a batch using wildcards.

Table 7.73 Ymodem Wildcard Usage Examples

Usage	Description	Example	Note
*xyz	Lists all files that end with xyz.	FILE DIR HIS*.TXT	Lists all of the metering files (HISTORY.TXT)
abc*	Lists all files whose name begins with abc.	FILE READ HR_10007*	Retrieves all of the three files for the COMTRADE event 10007 (HR_10007.CFG,HR_10007.DAT, and HR_10007.HDR)

Section 8

Front-Panel Operations

Overview

The front panel of the SEL-710-5 Motor Protection Relay makes data collection and control quick and efficient. You can order the SEL-710-5 with either the two-line LCD, or the 5-inch, color, 800 x 480-pixel touchscreen display, as shown in *Table 1.2* and *Figure 8.1*. Each display option comes with eight control pushbuttons. Use either front panel to analyze operating information, view and change relay settings, and perform control functions. You can use the front-panel to accomplish the following activities:

- Read metering
- Inspect targets
- Access settings
- Control relay operations
- View diagnostics

Figure 8.1 SEL-710-5 Front-Panel Options

The two-line display and the touchscreen display front-panel models are similar in all aspects except the display and navigation scheme. The touchscreen display model offers additional features with respect to monitoring, control, and device status that are discussed in *Touchscreen Display Front Panel*. The function of operation and target LEDs and the **TARGET RESET** and control pushbuttons are similar in both front-panel variations.

This section includes the following:

➤ *Two-Line Display Front Panel on page 8.2*. Discusses the navigation scheme in the two-line display models, the operation of target LEDs, and programming of the control pushbuttons.

➤ *Touchscreen Display Front Panel on page 8.21*. Discusses the navigation scheme and the display screens in the touchscreen display model.

Two-Line Display Front Panel

Front-Panel Layout

NOTE: Refer to Figure 8.31 for the pushbutton and LED numbering conventions.

NOTE: If the relay part number specifies the Spanish language option, all of the front-panel pushbuttons and LED labels will be in Spanish.

Figure 8.2 shows and identifies 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.

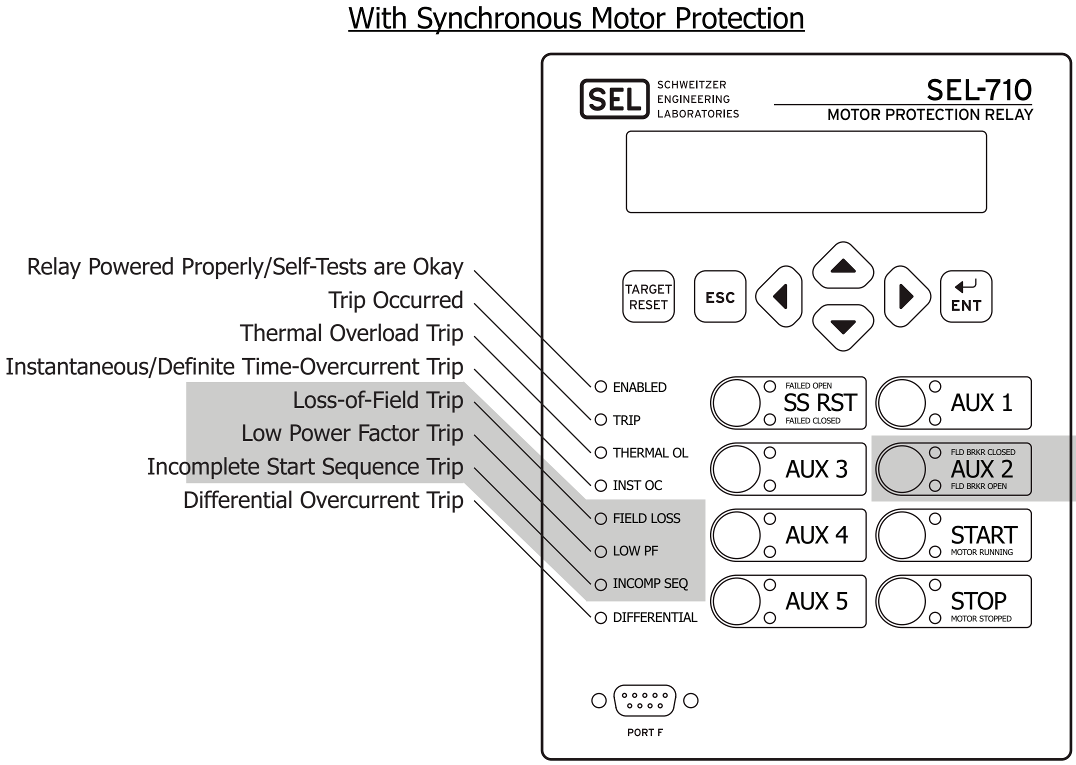
You can customize the versatile front panel of the SEL-710-5 by using the following features:

➤ Rotating display on the HMI

➤ Programmable tricolor target LEDs

➤ Programmable tricolor pushbutton LEDs

➤ Slide-in configurable front-panel labels to change the identification of target LEDs, pushbuttons, pushbutton LEDs and their operation.



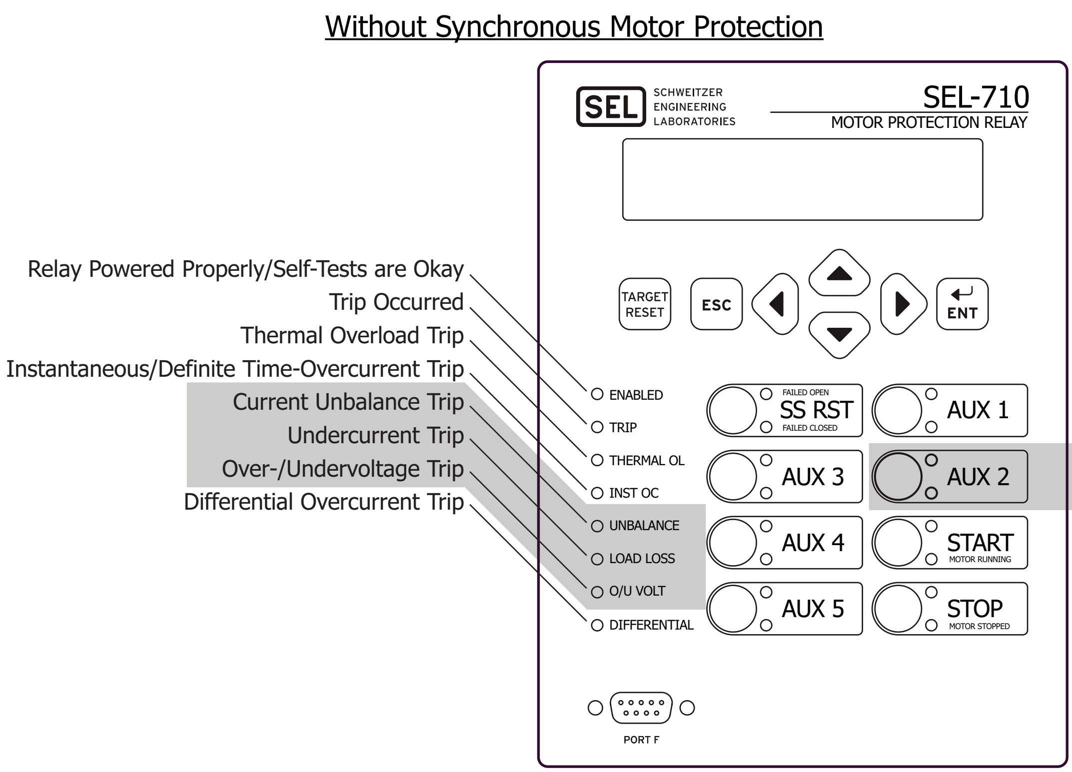


Figure 8.2 Front-Panel Overview

Two-Line Display HMI

Contrast

NOTE: See the Preface for an explanation of typographic conventions used to describe menus, the front-panel display, and the front-panel pushbuttons.

NOTE: The two-line display updates every second.

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-710-5 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 still overrides the rotating display.

Table 8.1 Front-Panel Automatic Messages (FP_AUTO := OVERRIDE)

Condition	Front-Panel Message
Relay detects any self-test failure	Displays the type of latest failure (see *Section 11: Testing and Troubleshooting*).
Relay trip occurs without any lockouts	Displays the latest trip reason until the targets are unlatched.
Relay trip occurs along with a lockout	Displays the type or cause of the trip and when the **TARGET RESET** pushbutton is pressed, displays the time to reset and lockout type. Refer to *Table 10.1* for a list of trip display messages.
When the relay has lockout because of the number of starts or time between starts or antibackspin or thermal lockout	Displays the type of lockout condition, lockout time remaining, and TRIP* at the end of the lockout if TRIPONLO := Y. Use TARGET RESET to clear TRIP*. If TRIPONLO := N, the relay displays the type of lockout condition and the lockout time remaining, but no TRIP* message is displayed and the TRIP bit is not latched. If a start is attempted on a lockout, the type of lockout condition and the lockout time remaining are displayed.
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. See *Table 8.3* for a list of alarm conditions.
During emergency start	Displays Emergency Start.

Front-Panel Security

Front-Panel Access Levels

The SEL-710-5 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.

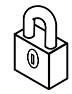


Figure 8.3 Access Level Security Padlock Symbol

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 8.4* for you to enter the password.

Figure 8.4 Password Entry Screen

See *PASSWORD Command (Change Passwords) on page 7.59* for the list of default passwords and for more information on changing passwords.

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-710-5 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-710-5 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. Use the keypad (shown in *Figure 8.5*) 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.

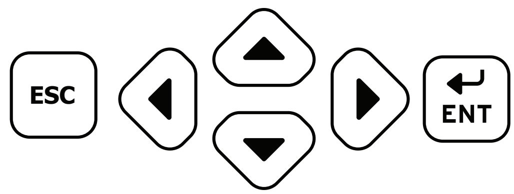


Figure 8.5 Front-Panel Pushbuttons

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-710-5 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 8.6 shows the `MAIN` menu screen. Using the **Up Arrow** or **Down Arrow** and **ENT** pushbuttons, you can navigate to specific menu item in the `MAIN` menu. Each menu item is explained in detail in the following paragraphs.

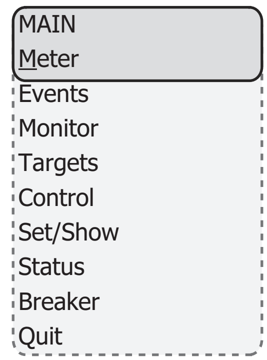


Figure 8.6 Main Menu

Meter Menu. Select the `Meter` menu item from the `MAIN` menu as shown in *Figure 8.7* 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.

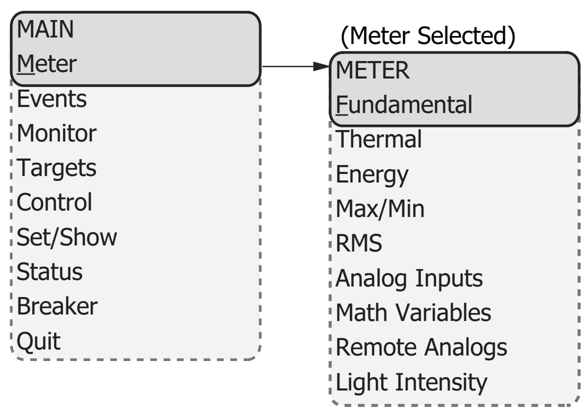


Figure 8.7 MAIN Menu and METER Submenu

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 8.8*.

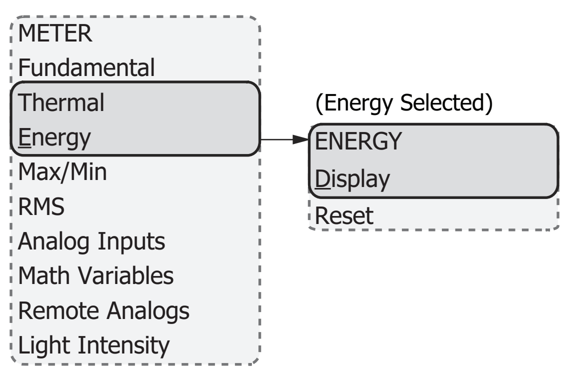


Figure 8.8 METER Menu and ENERGY Submenu

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 8.9*.

Figure 8.9 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 8.10*.

Figure 8.10 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 8.11*.

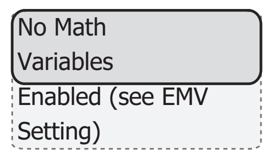


Figure 8.11 Relay Response When No Math Variables Enabled

Events Menu. Select the `Events` menu item from the `MAIN` menu as shown in *Figure 8.12*. `EVENTS` menu has `Display` and `Clear` as menu items. Select `Display` to view events and `Clear` to delete all the events data.

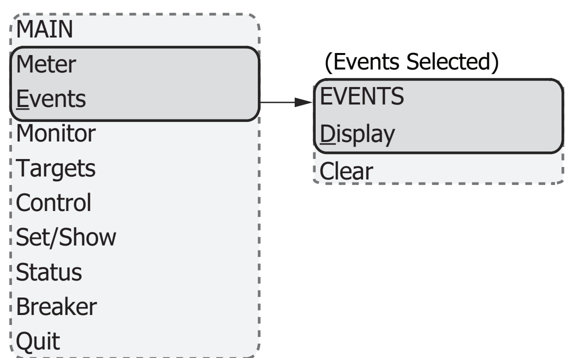


Figure 8.12 MAIN Menu and EVENTS Submenu

Figure 8.13 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.

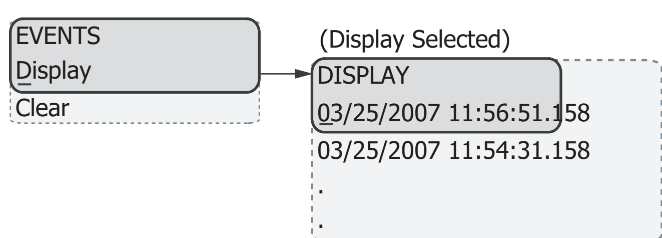


Figure 8.13 EVENTS Menu and DISPLAY Submenu

When `Display` is selected and no event data are available, the relay displays as shown in *Figure 8.14*.

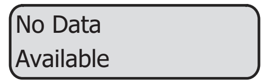


Figure 8.14 Relay Response When No Event Data Available

When `Clear` is selected from the `EVENTS` menu and confirming the selection, the relay displays as shown in *Figure 8.15* after clearing the events data.

Figure 8.15 Relay Response When Events Are Cleared

NOTE: Reset Learn Data is available only when TCLRNEN = Y or COOLEN = Y.

Monitor Menu. Select the `Monitor` menu item on the `MAIN` menu as shown in *Figure 8.16*. The `Monitor` menu has `Display Mot Data`, `Clear Motor Data` and `Reset Learn Data` as menu items.

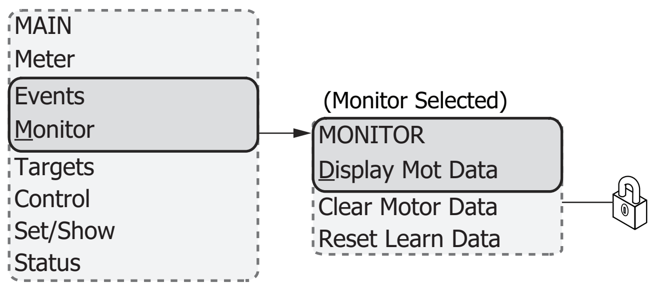


Figure 8.16 MAIN Menu and MONITOR Submenu

Select `Display Mot Data` from the `MONITOR` menu as shown in *Figure 8.17* to view motor operating statistics. See *Motor Operating Statistics on page 5.21* for a description of the data available.

NOTE: Learn Parameters is available only when TCLRNEN = Y or COOLEN = Y.

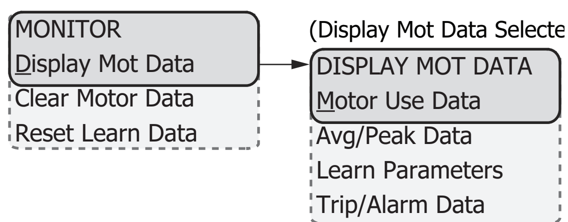


Figure 8.17 MONITOR Menu and DISPLAY MOT DATA Submenu

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 8.18* 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.

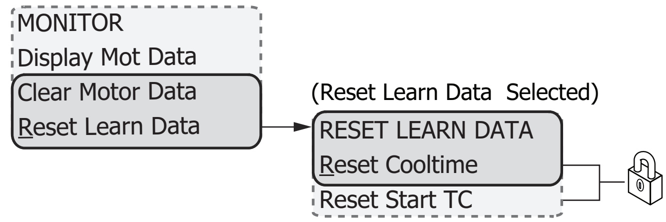


Figure 8.18 MONITOR Menu and RESET LEARN DATA Submenu

Targets Menu. Select the `Targets` menu item on the `MAIN` menu as shown in *Figure 8.19* to view the binary state of the target rows. Each target row has eight Relay Word bits as shown in *Table L.1*.

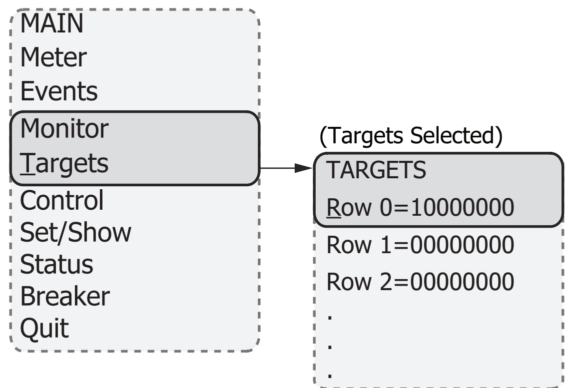


Figure 8.19 MAIN Menu and TARGETS Submenu

Select the target row to display two consecutive Relay Word bits with name and binary state as shown in *Figure 8.20*.

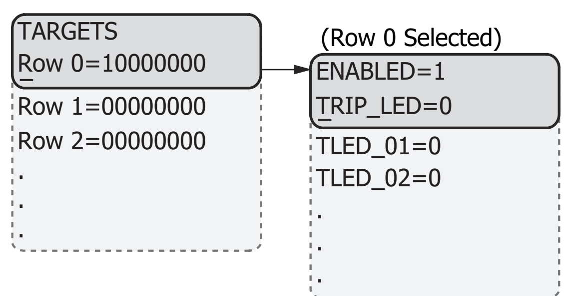


Figure 8.20 TARGETS Menu Navigation

Control Menu. Select the `Control` menu item on the `MAIN` menu as shown in *Figure 8.21* to go to the `CONTROL` menu.

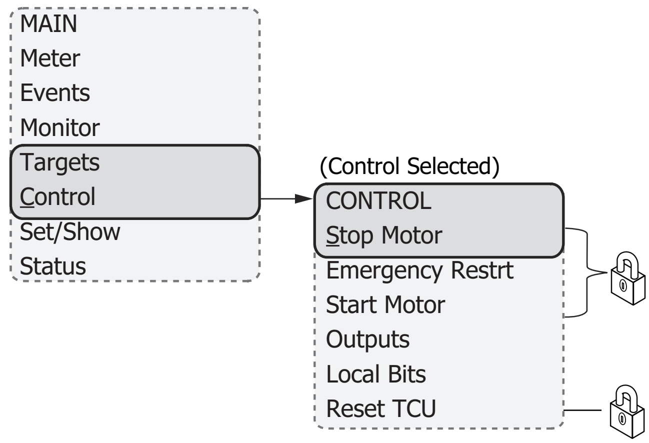


Figure 8.21 MAIN Menu and CONTROL Submenu

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 4.76*).

Select the `Start Motor` menu item to assert Relay Word bit STR that initiates a motor start (see *Figure 4.80*).

Stop Motor and *Start Motor* control actions via the front panel are supervised by the position of the breaker jumper (refer to *Table 2.19*), the status of the LOCAL bit when EN_LRC := Y, and the access level (requires Access Level 2). *Start Motor* is additionally supervised by any lockouts that are configured. For a list of lockouts, refer to *Lockout After Stop on page 4.106*. For more details on local/remote control function, refer to *Local/Remote Control on page 9.7*.

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 4.80*). Note that the *Emergency Restart* control action via the front panel is supervised by the position of the breaker jumper (refer to *Table 2.19*) and the access level (requires Access Level 2).

Select the `Outputs` menu item from the `CONTROL` menu as shown in *Figure 8.22* to test (pulse) SEL-710-5 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.

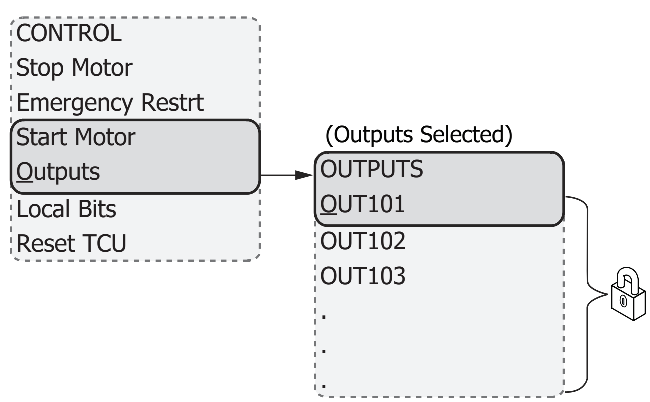


Figure 8.22 CONTROL Menu and OUTPUTS Submenu

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 4.157* for more information), local bit 1 replaces a supervisory switch. *Figure 8.23* 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 8.23*.

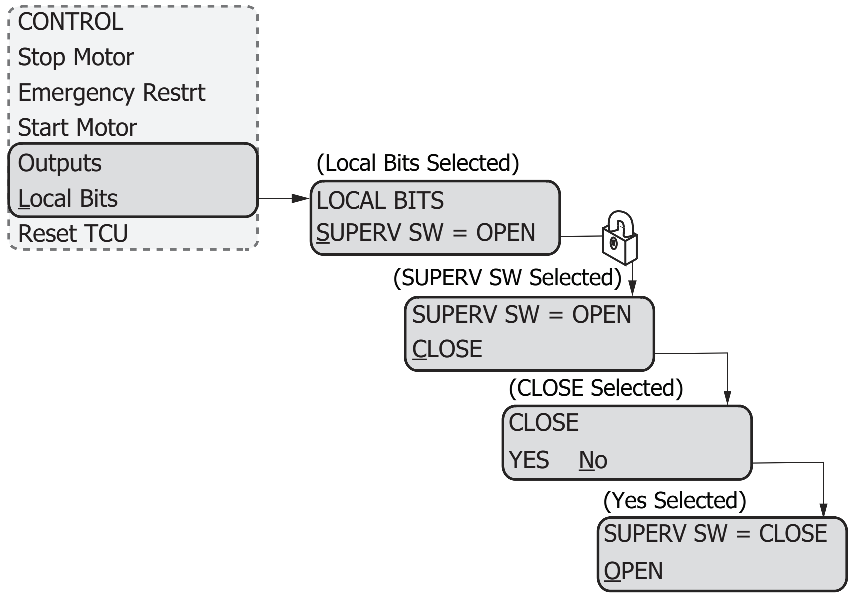


Figure 8.23 CONTROL Menu and LOCAL BITS Submenu

Select the `Reset TCU` menu item to reset the thermal capacity used (see *Thermal Overload Element on page 4.14* for description). Note that resetting TCU requires Level 2 access and for the motor to be in the STOPPED state. The SER report is updated with a thermal capacity reset message upon a successful manual reset of the thermal capacity (see *SER Triggering on page 10.31* for an example).

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.

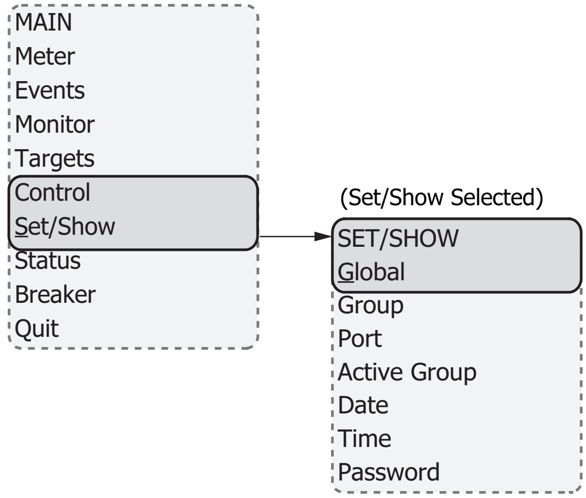


Figure 8.24 MAIN Menu and SET/SHOW Submenu

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.

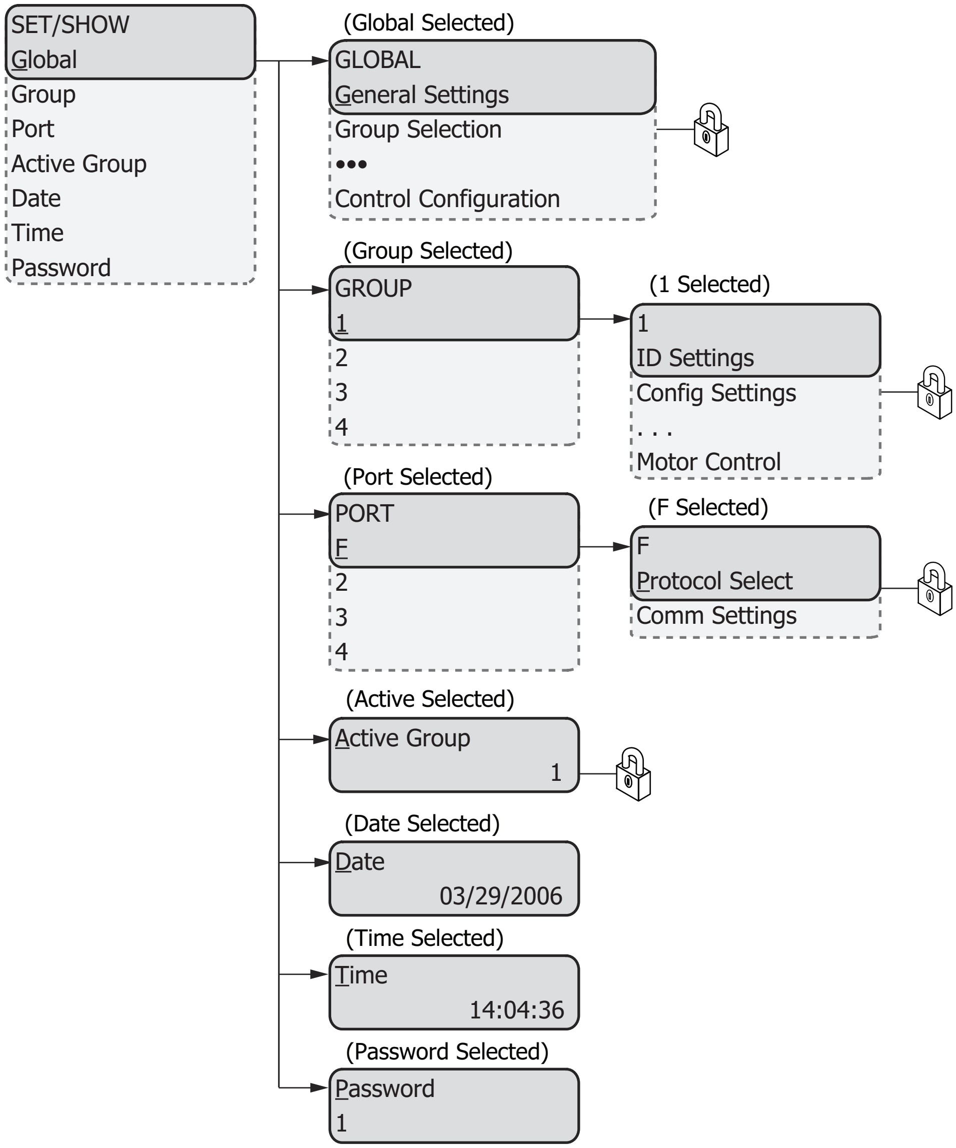


Figure 8.25 SET/SHOW Menu

Status Menu. Select the `Status` menu item on the `MAIN` menu as shown in *Figure 8.26* to access `Relay Status` data and `Reboot Relay`. See *STATUS Command (Relay Self-Test Status) on page 7.68* for the **STATUS** data field description.

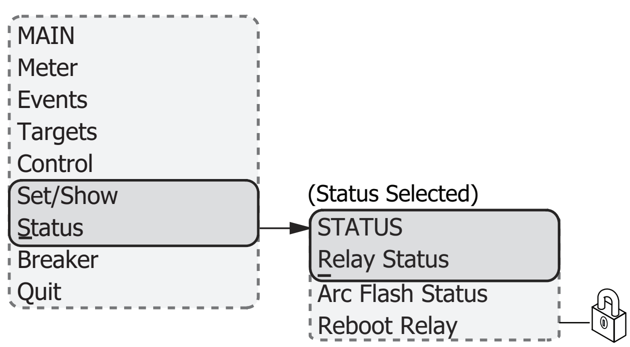


Figure 8.26 MAIN Menu and Status Submenu

Breaker Menu. Select the `Breaker` menu item on the `MAIN` menu as shown in *Figure 8.27* to access `Breaker Monitor` data or `Reset` the data. See *Breaker Monitoring on page 5.24*, in *Section 5: Metering and Monitoring* for a detailed description.

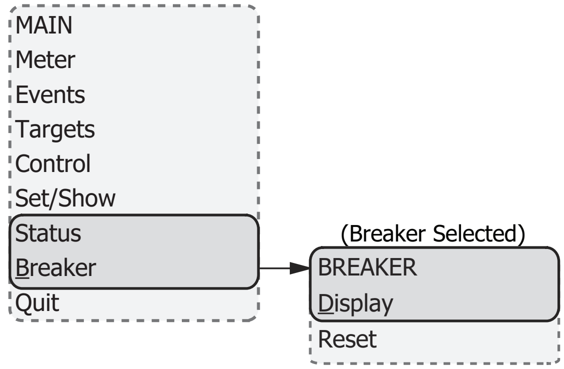


Figure 8.27 MAIN Menu and Breaker Submenu

Quit. Use the `Quit` menu item to exit Access Level 2 and go to Access Level 1.

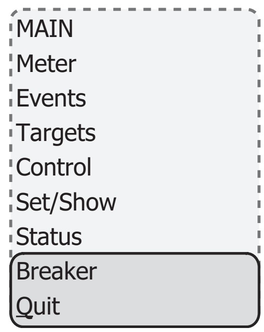


Figure 8.28 Quit Menu Item

Language Support

All of the HMI messages can be displayed in English or Spanish. The relay part number determines which language is displayed on the HMI. The HMI can display either ENGLISH or SPANISH. See the *SEL-710-5 Relay Command Summary* for a list of commands.

Operation and Target LEDs

Programmable LEDs

The SEL-710-5 provides quick confirmation of relay conditions via operation and target LEDs. *Figure 8.29* shows this region with factory-default text on the front-panel configurable labels. See *Target LED Settings on page 4.159* for the SELOGIC control equations and the tricolor LED color selection settings.

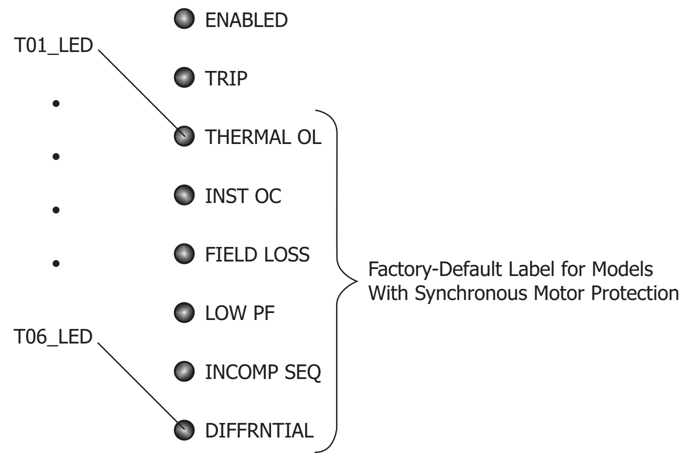


Figure 8.29 Factory-Default Front-Panel LEDs

You can reprogram all of these indicators except the ENABLED and TRIP LEDs to reflect operating conditions other than the factory-default programming described in this subsection.

Settings T0*n*_LED are SELOGIC control equations that work with the corresponding T0*n*LEDL latch settings to illuminate the LEDs shown in *Figure 8.29*. Use settings T0*n*LEDC to select the LED color (R–red, G–green, A–amber). Parameter *n* is a number from 1 through 6 that indicates each LED. If the latch setting (T0*n*LEDL) for a certain LED is set to N, then the LED follows the status of the corresponding control equation (T0*n*_LED). When the equation asserts, the LED illuminates, and when the equation deasserts, the LED extinguishes. If the latch setting is set to Y, the LED will assert if a trip condition occurs and the T0*n*_LED equation is asserted within 1.5 cycles of the trip assertion. At this point, the LED latches 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 4.111*.

NOTE: The target LEDs are restored to their previous state after a power cycle is done on the relay.

The SEL-710-5 comes with slide-in labels for custom LED designations that match custom LED logic. The Configurable Label kit (includes blank labels, word processor templates, and instructions) is provided when the SEL-710-5 is ordered.

The ENABLED LED indicates that the relay is powered correctly, is functional, and has no self-test failures. Trip events illuminate the TRIP LED. The prominent location of the TRIP LED in the top target area aids in recognizing trip events quickly.

The TRIP LED has an additional function that notifies you of warning conditions. When the TRIP LED is flashing, the warning conditions in *Table 8.3* are active when you set the corresponding relay element. Note that the TRIP LED can indicate a warning condition only if the LED is not latched due to any active TRIP condition. For Relay Word bit definitions see *Appendix L: Relay Word Bits*.

Table 8.3 Possible Warning Conditions (Flashing TRIP LED) (Sheet 1 of 2)

Warning Message	Relay Word Bit Logic Condition
Arc Flash Status Warning	AFALARM
Overload Warning	49A AND RUNNING
Locked Rotor Warning	49A AND STARTING

Table 8.3 Possible Warning Conditions (Flashing TRIP LED) (Sheet 2 of 2)

Warning Message	Relay Word Bit Logic Condition
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 ORAMBALRM OR OTH-ALRM
RTD Failure	RTDFLT
PTC Failure	PTCFLT
Field Undercurrent Warning	FDUC2T
Field Overcurrent Warning	FDOC2T
Field Undervoltage Warning	FDUV2T
Field Overvoltage Warning	FDOV2T
Field Resistance Warning	FDRES2T
Broken Bar Warning	BBD1T OR BBD2T OR BBD3T
Comm. Loss Warning	COMMLOSS
Comm. Idle Warning	COMMIDLE
Comm. Fault Warning	COMMFLT

TARGET RESET Pushbutton

Target Reset

For a trip event, the SEL-710-5 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 8.30 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 7.61* 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 4.142* for further information.

Front-Panel Operator Control Pushbuttons

The SEL-710-5 features eight operator-controlled pushbuttons, each with two programmable tricolor pushbutton LEDs, for local control as shown in *Figure 8.31*.

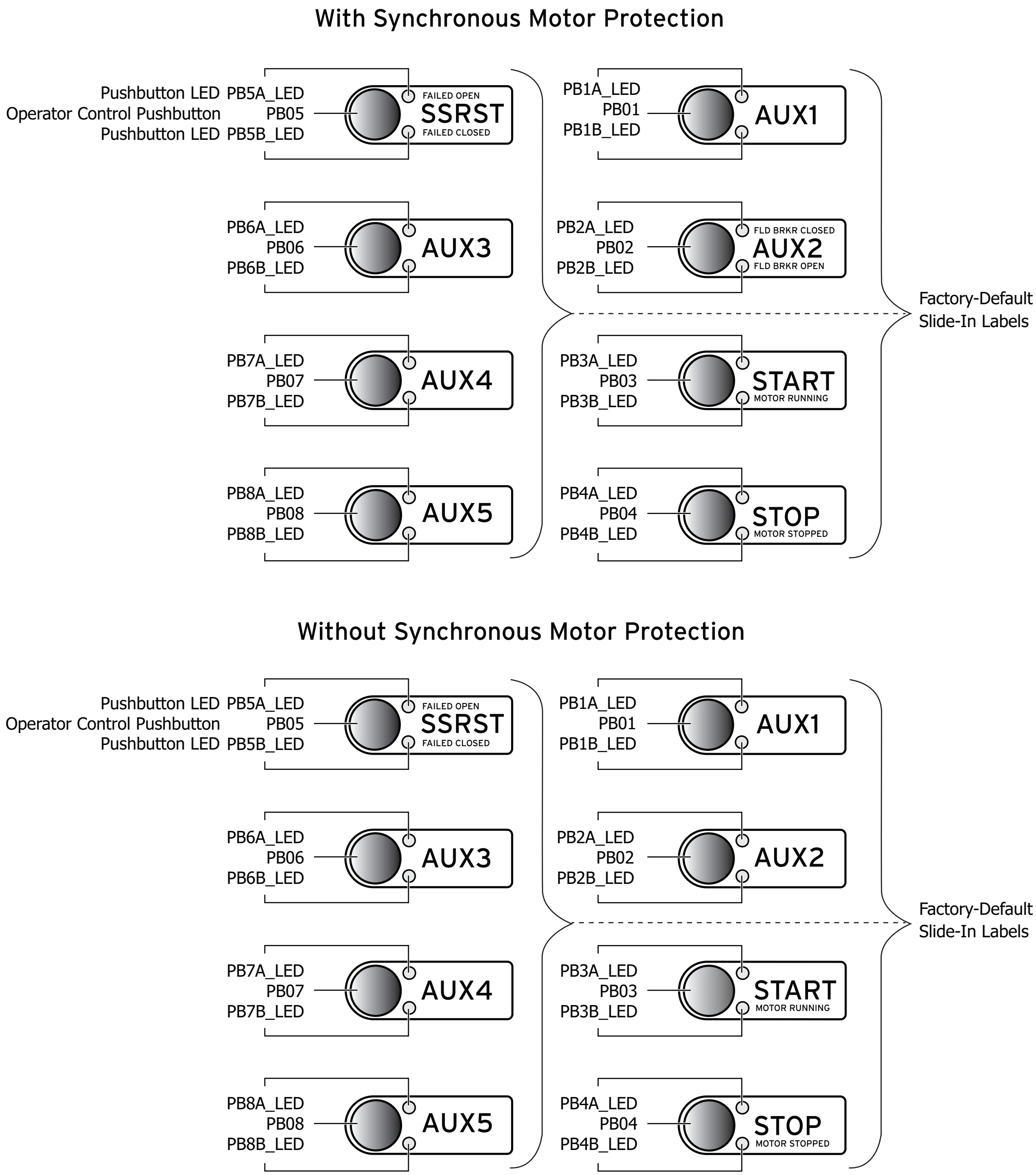


Figure 8.31 Operator Control Pushbuttons and LEDs

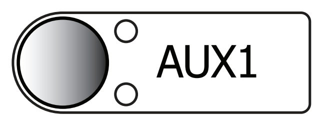
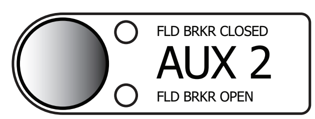
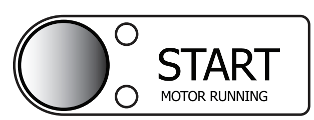
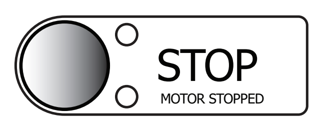
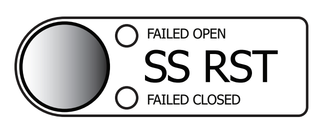
Pressing any one of these eight pushbuttons asserts the corresponding PB*n* (*n* = 01 through 08) Relay Word bit, and the corresponding PB*n*_PUL Relay Word bit. The PB*n* Relay Word bit remains asserted as long as the pushbutton is pressed, but the PB*n*_PUL Relay Word bit asserts only for the initial processing interval, even if the button is still being pressed. Releasing the pushbutton, and then pressing the pushbutton again asserts the corresponding PB*n*_PUL Relay Word bit for another processing interval. The pushbutton LEDs are independent of the pushbutton.

Pushbutton LEDs are programmable using front-panel settings PB*nm*_LED (where *n* = 1 through 8 and *m* = A or B). PB*nm* _LED settings are SELOGIC control equations that, when asserted, illuminate the corresponding LED for as long as the input is asserted. When the input deasserts, the LED also deasserts without latching. Use PB*nm*LEDC settings to select the LED color (R–red, G–green, A–amber) for both the asserted and deasserted state of the LED.

Using SELOGIC control equations, you can readily change the default LED and pushbutton functions. Use the slide-in label to mark the pushbuttons and pushbutton LEDs with custom names to reflect any programming changes that you make. Included on the SEL-710-5 Product Literature CD are word processor templates for printing slide-in labels. See the instructions included in the Configurable Label kit for more information on changing the slide-in labels.

Table 8.4 describes front-panel operator controls based on the factory-default settings and operator control labels.

Table 8.4 SEL-710-5 Front-Panel Operator Control Functions

Control Functions	Labels
Press the **AUXn** operator control pushbutton to enable/disable user-programmed auxiliary control. The corresponding LED can be programmed to illuminate during the enabled state. **NOTE:** The **AUXn** operator control does not perform any function with the factory settings. Also, AUX1 to AUX6 pushbuttons do not perform any function in the factory-default settings. These pushbuttons are available to configure any application you may select.	
For Models With Synchronous Motor Protection: The **AUX2** pushbutton is not used in the factory settings but can be easily programmed to perform a user control function. The top LED is programmed to indicate FLD BRKR CLOSED (Relay Word bit 41A—field breaker is closed) in the factory settings. The bottom LED is programmed to indicate FLD BRKR OPEN (Relay Word bit NOT 41A—field breaker is open).	
For All Models: Press the **START** operator control pushbutton to close the breaker and start the motor. The pushbutton corresponds to Relay Word bit PB03. The PB03 Relay Word bit is used in the default SELOGIC control equation for STREQ (Start Equation, see *Figure 4.80*). The corresponding **MOTOR RUNNING** LED (Relay Word bit STARTING or RUNNING asserts) illuminates, indicating that the breaker is closed and the motor is running.	
Press the **STOP** operator control pushbutton to trip the breaker and stop the motor. The pushbutton corresponds to Relay Word bit PB04. The PB04 Relay Word bit is used in the default SELOGIC control equation for OUT103 (see *Figure 4.76*). The corresponding **MOTOR STOPPED** LED (Relay Word bit STOPPED asserts) illuminates, indicating that the breaker is open and the motor is stopped.	
Press the **SS RST** operator control pushbutton to reset the FAILOPN or FAILCLS Relay Word bits that assert and latch-in when detecting a Failed Open or a Failed Close condition of the physical speed switch. See *Figure 4.37* for more details.	

Touchscreen Display Front Panel

The SEL-710-5 Feeder Protection Relay can be ordered with an optional touchscreen display (5-inch, color, 800 x 480 pixels). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen display option in the SEL-710-5 features a straightforward application-driven control structure and includes intuitive and graphical screen designs.

Front-Panel Layout

The touchscreen front panel is the same as the two-line display in regards to the target LEDs, operator control pushbuttons, and the **TARGET RESET** pushbutton. Refer to *Operation and Target LEDs on page 8.15* for a detailed description of these features. In addition, the touchscreen front panel features a **HOME** pushbutton.

Touchscreen Display HMI

NOTE: The touchscreen display updates every 250 ms.

This section explains the navigation of the front-panel touchscreen and all the features it supports.

The touchscreen display allows you to:

- View and control bay screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, and SER information
- View relay status and configuration
- Control relay operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen

Figure 8.32 shows the relay touchscreen display components and indicators.

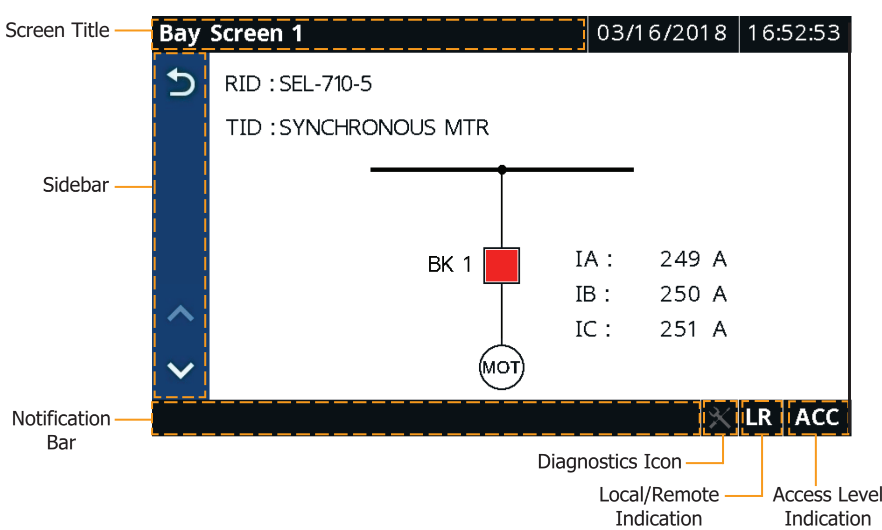
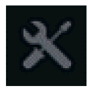


Figure 8.32 Touchscreen Display Components and Indicators

Table 8.5 Touchscreen Display Component and Indicator Descriptions

Display Components and Indicators	Function or Indication
Screen Title	Shows the display name of a screen (see *Figure 8.32*).
Sidebar	Shows the navigation icons (see *Figure 8.32*).
Notification Bar	Shows the notification messages and help text for screens (see *Figure 8.32*).
Diagnostics Icon	ON if there are any warning/diagnostic failures on the unit.
	Normal (no warnings or diagnostic failures present). Icon is OFF.
	Warning. Icon asserts in amber.
	Diagnostic failure. Icon asserts in red.
Local/Remote Indication	Indicates the status of the local/remote control. Refer to *Local/ Remote Control on page 9.7* for more details.
L	When EN_LRC := Y and LOCAL := 1, relay control is in local mode, i.e., STR and STOP bits can be processed via the front panel only.
R	When EN_LRC := Y and LOCAL := 0, relay control is in remote mode, i.e., STR and STOP bits can be processed via remote sources/protocols only.
LR	When EN_LRC := N, relay control is in local/remote control, i.e., STR and STOP bits can be processed from both the front panel and the remote sources/protocols.
Access Level Indication	Indicates the access level that the device is on at the time. Shows ACC if the device is on access level 1 and 2AC if on access level is 2.

Home Pushbutton

Use the **HOME** pushbutton to wake up the touchscreen after the inactivity timer expires and the screen goes dark. While the default mapping of the **HOME** pushbutton is the Home screen (see *Figure 8.33*), you can program the **HOME** pushbutton to jump to any screen. Refer to *Table 8.17* for a list of screens available for the **HOME** pushbutton. Use the FPHOME setting in the Touchscreen settings of QuickSet to program a specific screen.

Touchscreen Backlight

Adjustment

Touchscreen displays have an LED backlight. You can adjust the touchscreen backlight to suit your viewing angle and lighting conditions. To change the backlight settings, tap the Settings folder and then tap the Touchscreen application. Use the FPBAB setting to adjust the brightness of the display. The backlight of the display goes dark 60 minutes after the inactivity timer (1–30 min) expires.

Front-Panel Automatic Messages

The relay displays automatic messages that override the present display under the conditions described in *Table 8.6*. When the relay has a failure, trip, lockout, or alarm condition, the trip and diagnostic messages screen will appear on the display. These messages can also be accessed by tapping the Trip & Diag. Messages application in the Device Info folder.

Table 8.6 Front-Panel Automatic Messages

Condition	Front-Panel Message
Relay detects any failure	Displays the latest failure type (refer to *Section 11: Testing and Troubleshooting*).
Relay trip occurs	Displays the type or cause of the trip (refer to *Table 10.1* for a list of trip display messages).
When the relay has a lockout because of the number of starts, time between starts, antibackspin, or thermal lockout	Displays the type of lockout condition and time remaining of the lockout with the greatest time remaining. If TRIPONLO := Y, then at the end of the lockout TRIP* will be displayed as a trip message if no other trip condition is present. Use TARGET RESET to clear TRIP*. If TRIPONLO := N, then no TRIP* message is displayed and the TRIP bit is not latched.
Motor running overload	Displays the predicted time to thermal element trip in seconds.
Relay alarm condition occurs	Displays the type of alarm. The TRIP LED also flashes during an alarm condition (refer to *Table 8.3* for a list of the warning conditions).

Front-Panel Security

Use the Access Level folder on the Home screen for login/logout operations.

The SEL-710-5 front panel typically operates at Access Level 1 and allows you to view relay measurements and settings. Particular activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 password.

When an activity requires Access Level 2, an authentication screen appears on the display, which requires you to enter the Level 2 password to proceed further. After you have correctly entered the password, you can perform other Access Level 2 operations without re-entering the password. You will have to re-enter the password if the front-panel inactivity timer, FPTO, expires.

See *PASSWORD Command (Change Passwords) on page 7.59* for the list of default passwords and for more information on changing the passwords.

Front-Panel Timeout

To help prevent unauthorized access to password-protected functions, the SEL-710-5 provides a front-panel timeout setting, FPTO, in the Touchscreen application in the Settings folder. The timeout resets each time you press a front-panel pushbutton or tap the display. Once the timeout expires, the access level resets to the ACC access level. You can manually reset the access level by tapping Logout in the Access Level folder.

Touchscreen

Navigating the Touchscreen Folders and Applications

Use the front-panel touchscreen and pushbuttons to access data measured and stored by the relay and to perform relay operations. All relay information and operations are available through the touchscreen via folders, applications, and the buttons in the sidebar. *Table 8.7* describes the functions of the sidebar buttons.

Table 8.7 Sidebar Buttons

Button	Button Name	Function	Button	Button Name	Function
	Up	Pages up in applications with multiple screens; when on the first screen, this button is disabled.		Back	Returns to the preceding screen, e.g., from applications to folders.
	Down	Pages down in applications with multiple screens; when on the last screen, this button is disabled.		Pause	Stops updating the phasors.
	Left	Pages left on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the left.		Play	Updates the phasor values from the relay as the screen refreshes.
	Right	Pages right on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the right.		Refresh	Reloads the data when new data are available.
	Reset	Resets the accumulating quantities, such as energy, to zero.		Trigger Event	Triggers an event
	Save	Saves the edited settings to the relay.		Search	Search tool (e.g., search for the status of a Relay Word bit).
	Cancel Save	Cancels the setting edits.		Trash	Deletes the records from the report.

The relay wakes up to the screen set in the FPHOME setting, unless the rotating display is enabled. If the rotating display is enabled and the inactivity time has expired, the relay wakes up to the rotating display. Pressing the **HOME** pushbutton a second time returns you to the screen set in the FPHOME setting.

You can navigate the touchscreen by tapping the folders and applications. Tap a folder or an application to view available applications or access an application, respectively. Folders and applications are labeled according to functionality.

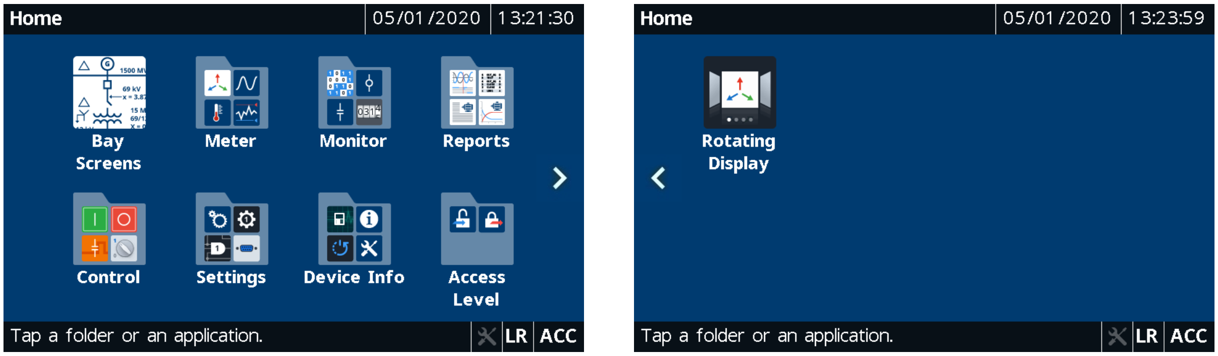


Figure 8.33 Home (Default FPHOME Setting)

Table 8.8 shows a list of folders and applications available on the Home screen.

Table 8.8 Home Folders and Applications

Screen Name	Folder or Application Name	Comments
Home	Bay Screens	Always available
	Meter	Always available
	Monitor	Always available
	Reports	Always available
	Control	Always available
	Settings	Always available
	Device Info	Always available
	Access Level	Always available
	Rotating Display	Always available

The applications shown in the folders are based on the part number. For example, if the relay does not support arc flash, the Light Intensity and Arc-Flash Diagnostics applications are not shown in the Meter and Device Info folders, respectively.

Descriptions of the folders and applications on the Home screen follow.

Bay Screens

NOTE: Five bay screens are always rendered on the touchscreen. Any unused screens are blank.

Tap this application to navigate to as many as five customer-designed screens (Bay Screen 1 through Bay Screen 5, see *Table 8.17*). You can design these screens using ACSELERATOR Bay Screen Builder SEL-5036 Software. Refer to *Section 9: Bay Control* for the procedure to create custom screens.

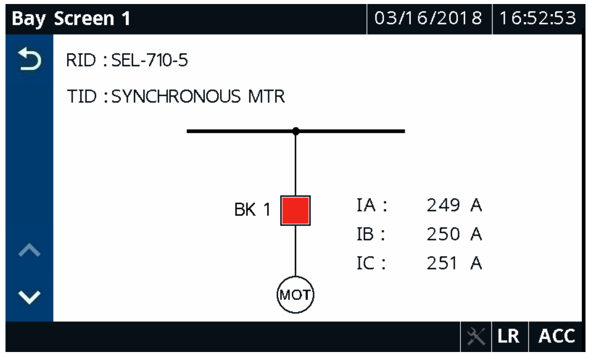


Figure 8.34 Bay Screens Application

Meter

Tapping this folder navigates you to the Meter screen, as shown in *Figure 8.35*. This screen lists all of the available metering applications. The applications on the Meter screen are part number dependent. Only those metering applications specific to your part number appear on the Meter screen. Tapping an application on the Meter screen shows you the report for that particular application.

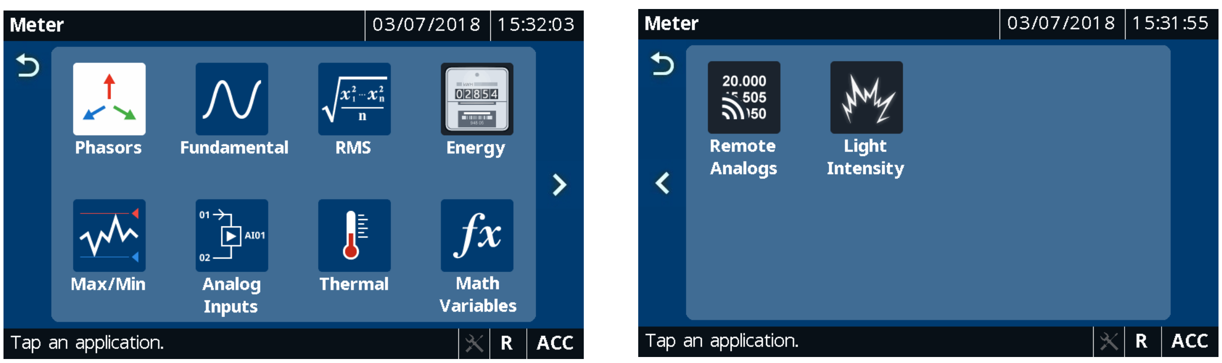


Figure 8.35 Meter Applications

Table 8.9 identifies all the applications available in the Meter folder.

Table 8.9 Meter Application Availability

Folder Name	Application Name	Comments[a]
Meter	Phasors	Always available
	Fundamental	Always available
	RMS	Always available
	Energy	Available if the relay supports voltages
	Max/Min	Always available
	Analog Inputs	Shown when (Slot C = 5*x* or 6*x*) or (Slot D = 5*x* or 6*x*) or (Slot E = 5*x* or 6*x*)
	Thermal	Always available
	Math Variables	Always available
	Remote Analogs	Always available
	Light Intensity	Shown when Slot E = 74 or 76

[a] Refer to the relay part number.

Figure 8.36 and *Figure 8.37* show typical screens for phasor and fundamental metering.

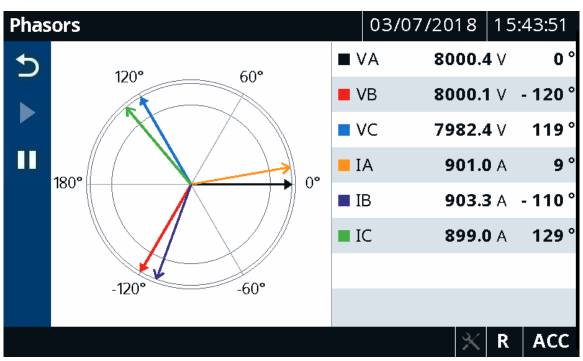


Figure 8.36 Meter Phasors

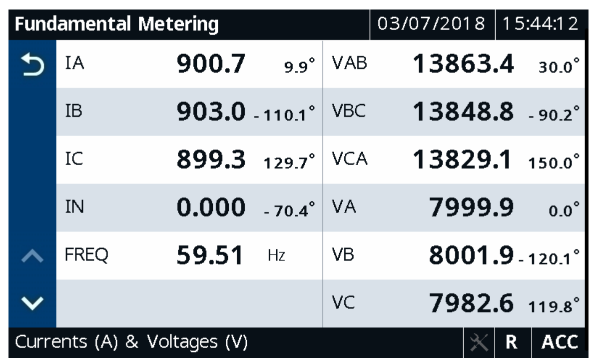


Figure 8.37 Meter Fundamental

A reset feature is provided for the Energy, Max/Min, and Thermal applications. Tap the **Reset** button to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero. *Figure 8.38* and *Figure 8.39* show typical screens for energy metering and reset confirmation.

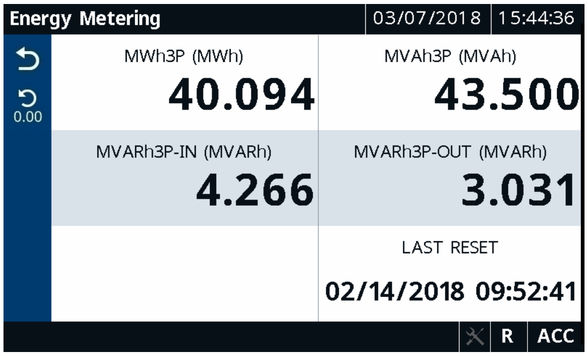


Figure 8.38 Meter Energy

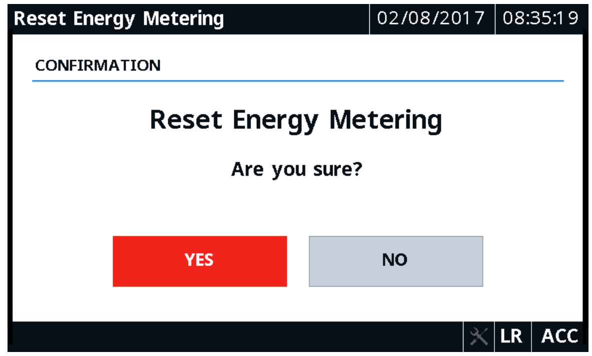


Figure 8.39 Meter Energy Reset

Monitor

Tapping this folder navigates you to the Monitor screen, as shown in *Figure 8.40*. Monitor the status of the Relay Word bits (targets), digital outputs, digital inputs, SELogic counters, and breaker wear data using the respective applications (Relay Word Bits, Digital Outputs, Digital Inputs, SELogic Counters, Breaker Wear, and Vibration).

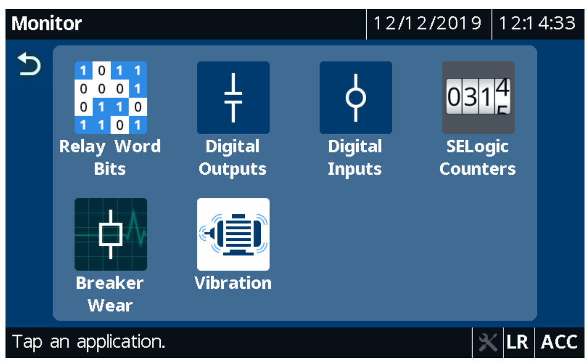


Figure 8.40 Monitor Applications

Table 8.10 identifies all the applications available in the Monitor folder.

Table 8.10 Monitor Application Availability

Folder Name	Application Name	Comments
Monitor	Relay Word Bits	Always available
	Digital Outputs	Always available
	Digital Inputs	Always available
	SELogic Counters	Always available
	Breaker Wear	Always available
	Vibration	Always available

Tap the Breaker Wear application to view accumulated breaker wear/ operations. You can reset the accumulated data by tapping the **Reset** button provided in the sidebar of the Breaker Wear application. Typical screens for the Breaker Wear application follow.

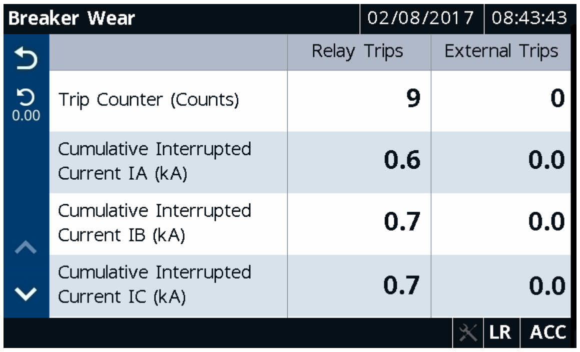


Figure 8.41 Breaker Wear Trips

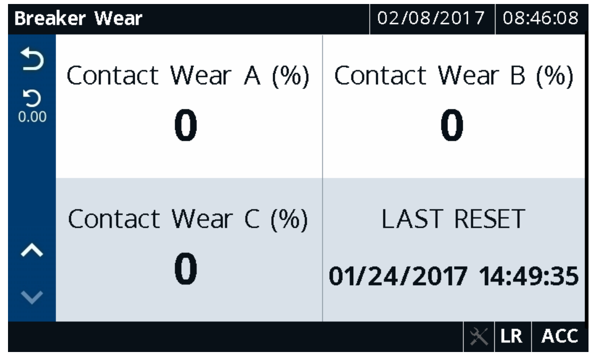


Figure 8.42 Breaker Wear A, B, C, and Last Reset

Monitor the status of the Relay Word bits using the Relay Word Bits screen. Note that asserted Relay Word bits are highlighted in blue. You can use the **Search** button in the Relay Word Bits application to view the status of a Relay Word bit. To search for a Relay Word bit, you must enter the full name of the Relay Word bit in the screen Search Relay Word Bit SEARCH field. *Figure 8.43* and *Figure 8.44* show typical Relay Word bits monitoring screens.

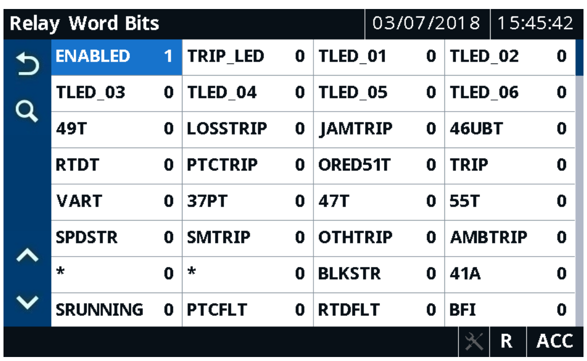


Figure 8.43 Monitor Relay Word Bits

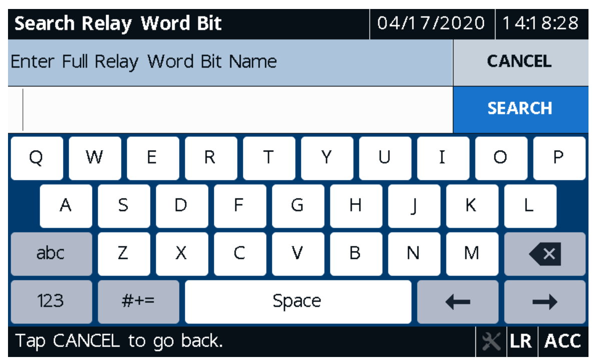


Figure 8.44 Search Relay Word Bits

The Vibration application dynamically displays the measured values of vibration in a bar graph, as shown in *Figure 8.45*. See *Vibration Monitoring on page 4.76* for additional information.

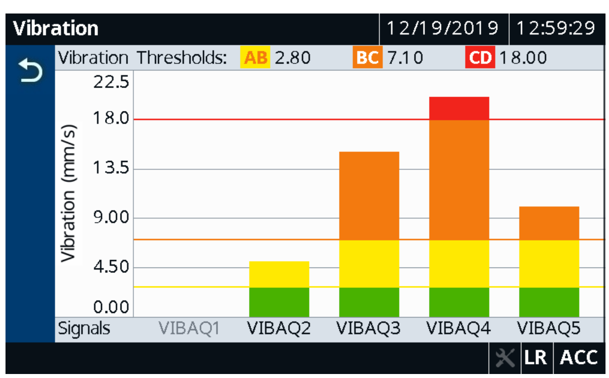


Figure 8.45 Vibration

Reports

Tapping this folder navigates you to the Reports screen where you can access the Events, SER, Motor Start Trend, and Motor Statistics applications. Use these applications to view events, SERs, MSTs, and MOTs.

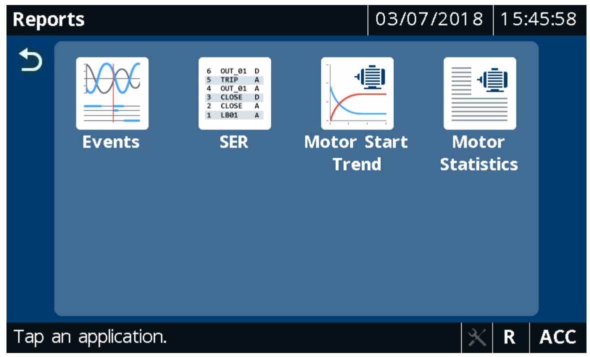


Figure 8.46 Reports Applications

Table 8.11 identifies all the applications available in the Reports folder.

Table 8.11 Reports Application Availability

Folder Name	Application Name	Comments
Reports	Events	Always available
	SER	Always available
	Motor Start Trend	Always available
	Motor Statistics	Always available

To view the summary of a particular event record, tap the event record on the Event History screen. You can also trigger an event from the Event History screen using the **Trigger Event** Button. When new records become available while viewing Events or SER, the up and down buttons are disabled and the footer displays a message to refresh the screen. You can use the **Refresh** button to update the screen. Tap the **Trash** button on the Event History, Sequential Event Report, Motor Start Trend, and Motor Statistics screens and confirm the delete action to remove the records from the relay. *Figure 8.47* through *Figure 8.49* show typical Event History, Sequential Event Report, and Motor Statistics screens.

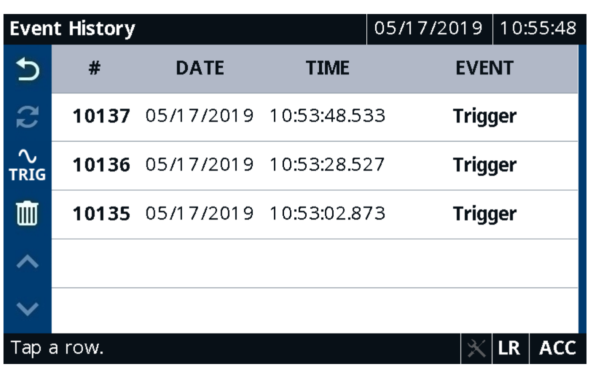


Figure 8.47 Event History

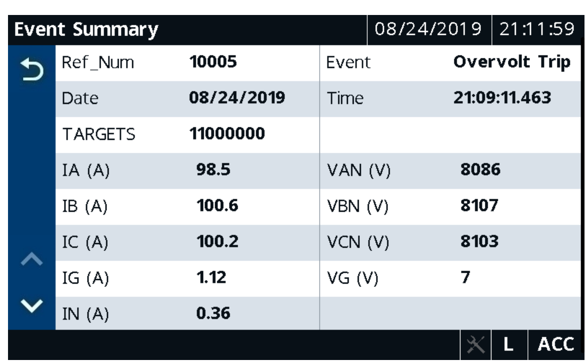


Figure 8.48 Event Summary

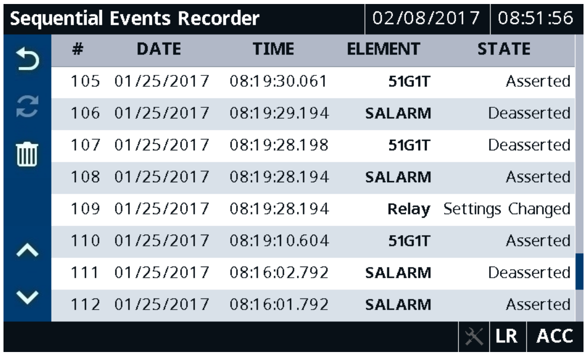


Figure 8.49 Sequential Events Recorder

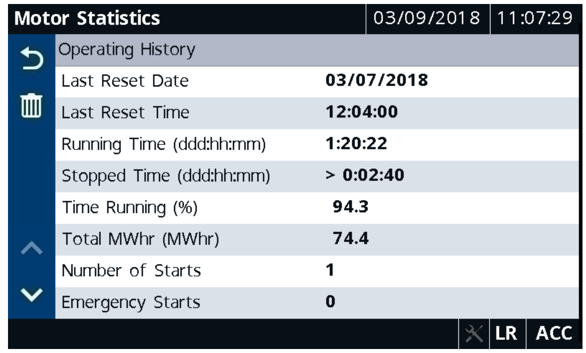


Figure 8.50 Motor Statistics

Control

NOTE: Reset TCU requires Level 2 access and the motor in the STOPPED state. An SER log is updated with a thermal capacity reset message upon a successful manual reset of the thermal capacity (see *SER Triggering on page 10.31* for an example).

Tapping this folder navigates you to the Control screen, as shown in *Figure 8.51*. Use the Control folder applications Start Motor, Stop Motor, Output Pulsing, Local Bits, Emergency Restart, and Reset TCU to perform a motor start command, perform a motor stop command, pulse output contacts, control local bits, perform an emergency restart command, or to reset the thermal model.

Start Motor, Stop Motor, and Output Pulsing applications require that the breaker jumper be installed on the slot B board. Refer to *Password, Breaker (Start/Stop Control), and SELBOOT Jumper Selection on page 2.19* for information on the breaker jumper.

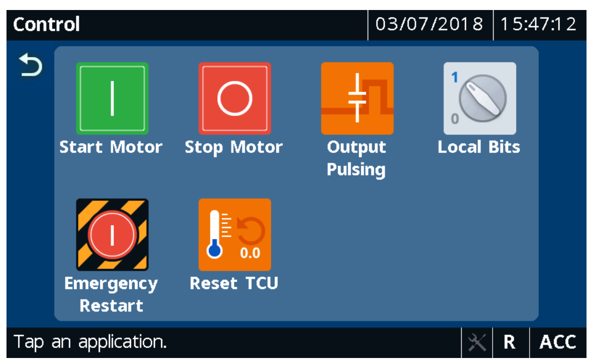


Figure 8.51 Control Applications

Table 8.12 identifies all the applications available in the Control folder.

Table 8.12 Control Application Availability

Folder Name	Application Name	Comments
Control	Start Motor	Always available
	Stop Motor	Always available
	Output Pulsing	Always available
	Local Bits	Always available
	Emergency Restart	Always available
	Reset TCU	Always available

To perform motor control, tap the Start Motor or Stop Motor application and then tap and confirm the control action. Motor control through the touchscreen is supervised by (1) the status of the LOCAL bit when EN_LRC := Y, (2) the position of the breaker jumper, and (3) the access level (requires 2AC). Start Motor is additionally supervised by any lockouts that are configured. For a list of lockouts, refer to *Lockout After Stop on page 4.106*. If there is an active lockout, the relay displays a notification screen as shown in *Figure 8.52*. When EN_LRC := N, supervision through the LOCAL bit is ignored, while supervision through the breaker jumper and access level are maintained.

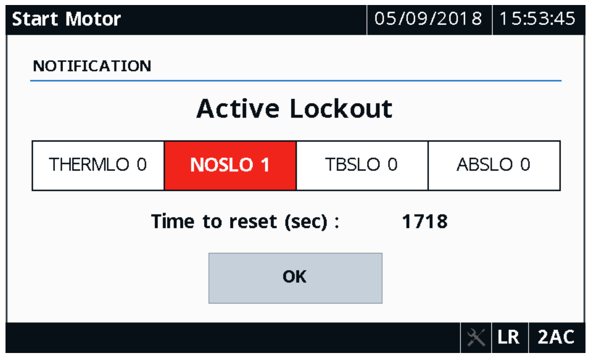


Figure 8.52 Active Lockout Notification

When local/remote supervision setting EN_LRC := Y and LOCAL := 0, the Start Motor and Stop Motor applications block the control action with an associated footer notification. *Figure 8.53* shows a Motor Stop confirmation screen with a remote supervision block notification. For the settings related to the local/remote control function, refer to *Local/Remote Control on page 9.7*.

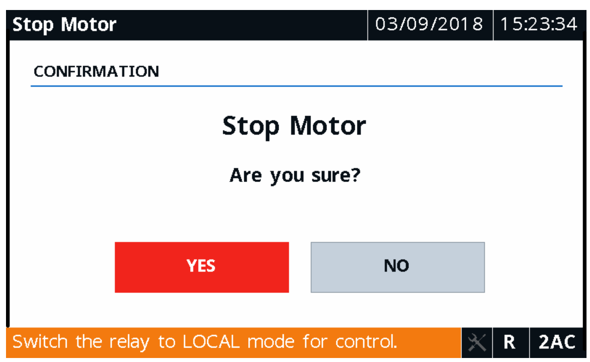


Figure 8.53 Stop Motor Confirmation Screen

Tap the Emergency Restart application and confirm the control action allowing the motor to be placed back in service in an emergency. Note that the Emergency Restart control action via the touchscreen is supervised by the position of the breaker jumper (refer to *Table 2.19*) and the access level (requires Access Level 2).

To pulse a digital output contact, tap the Output Pulsing application. Navigate to the desired output contact screen, tap the desired output, and confirm the control action. The output tile will be highlighted in blue on assertion, as shown in *Figure 8.54*. An output contact cannot be pulsed if it is already asserted. Pulsing the output contact requires that the breaker jumper be installed and that you have Level 2 access.

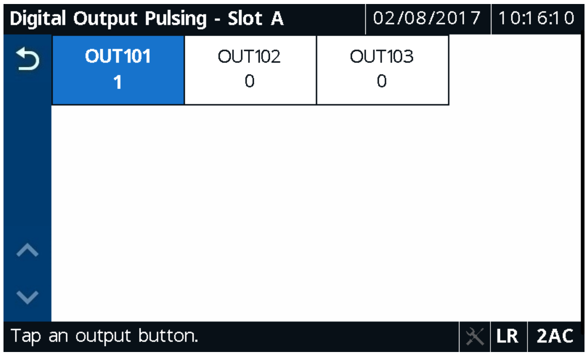


Figure 8.54 Digital Output Pulsing—Slot A

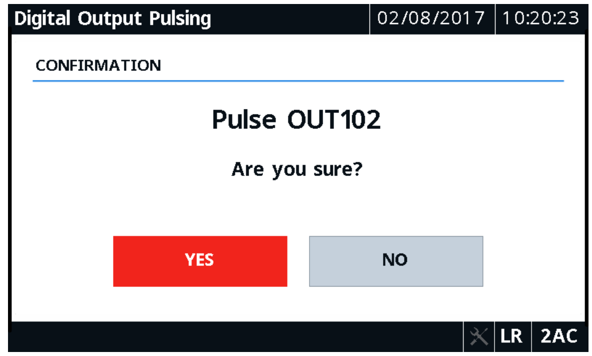


Figure 8.55 Digital Output Pulsing Confirmation

To control the local bits, tap the Local Bits application. You can control the desired local bit by tapping on the corresponding row. Depending on the state, tap and confirm the type of action you would like to perform. *Figure 8.56* through *Figure 8.58* show typical local bits control screens.

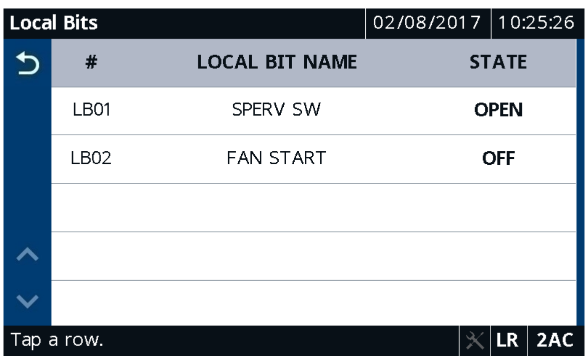


Figure 8.56 Local Bits

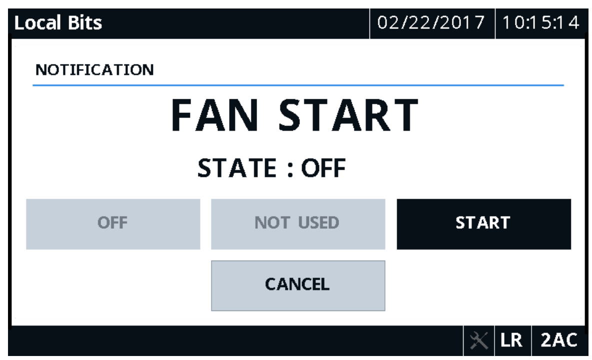


Figure 8.57 Local Bits Notification

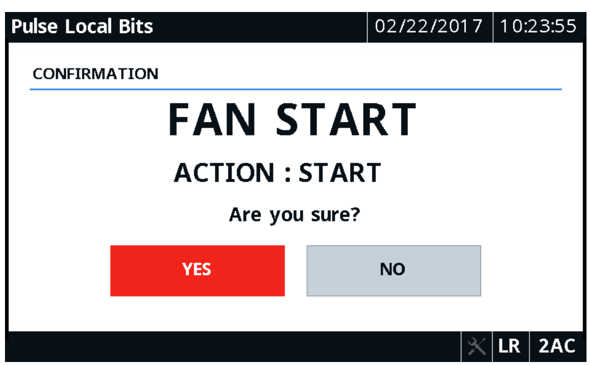


Figure 8.58 Local Bits Confirmation

Device Info

Tapping this folder navigates you to the Device Info screen where you can access specific device information applications (Status, Configuration, Arc-Flash Diagnostics, and Trip & Diag. Messages) and the Reboot application.

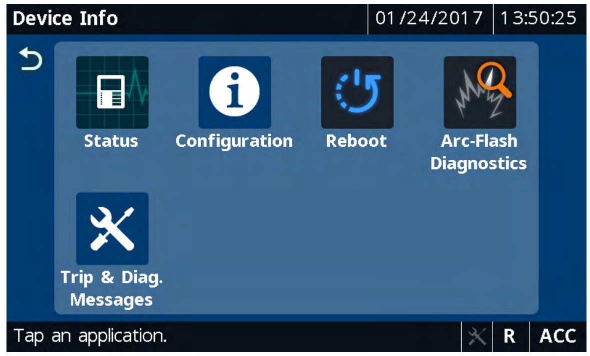


Figure 8.59 Device Info Applications

Table 8.13 identifies all the applications available in the Device Info folder.

Table 8.13 Device Info Application Availability

Folder Name	Application Name	Comments[a]
Device Info	Status	Always available
	Configuration	Always available
	Reboot	Always available
	Arc-Flash Diagnostics	Shown when Slot E = 74 or 76
	Trip & Diag. Messages	Always available

[a] Refer to the relay part number.

Tap the Status application to view the relay status, firmware version, part number, etc., as shown in *Figure 8.60*. Use the Configuration application to view port information, the jumper positions for the breaker, etc., as shown in *Figure 8.61*. If the relay detects any new card in one of the slots, it disables and directs you to accept the change in configuration, as shown in *Figure 8.62*. *Figure 8.60* through *Figure 8.62* show typical screens for device configuration, device status, and trip and diagnostic messages.

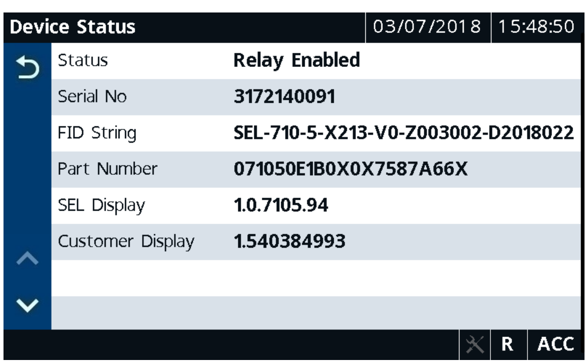


Figure 8.60 Device Status

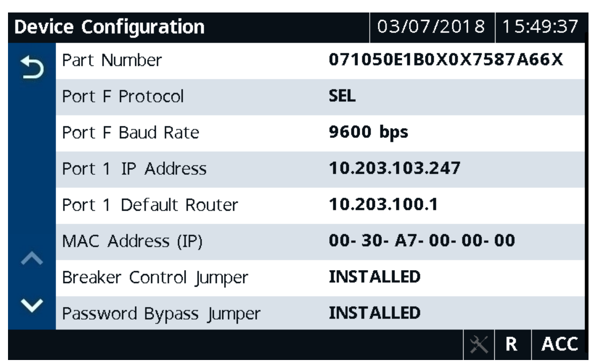


Figure 8.61 Device Configuration

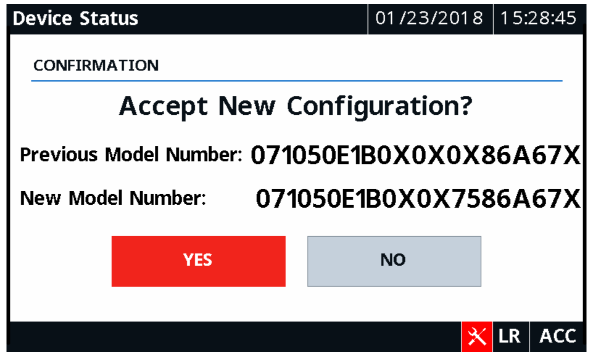


Figure 8.62 Model Number Confirmation

When a diagnostic failure, trip, lockout, or warning occurs, the relay displays the diagnostic message on the screen until it is either overridden by the restart of the rotating display or the inactivity timer expires. To view the trip and diagnostic messages, tap the Trip & Diag. Messages application in the Device Info folder.

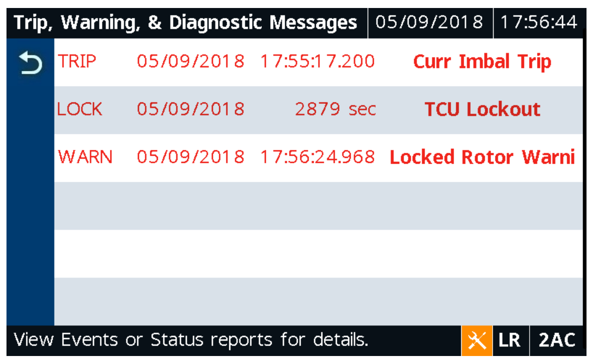


Figure 8.63 Trip and Diagnostic Messages

Tap on the Arc-Flash Diagnostics application to run a diagnostic check on the arc-flash sensors. *Figure 8.64* and *Figure 8.65* show typical arc-flash diagnostics screens.

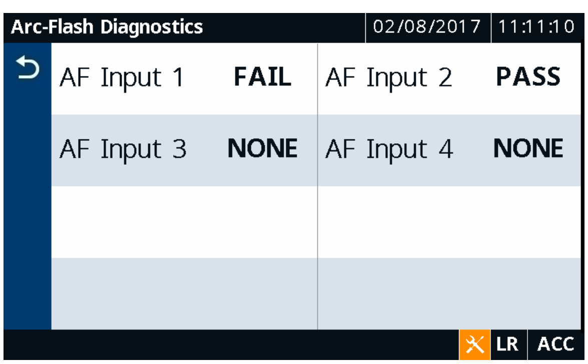


Figure 8.64 Arc-Flash Diagnostics

Figure 8.65 Arc-Flash Diagnostics Confirmation

Access Level

Tapping this folder navigates you to the Access Level screen where you can either log in to or log out of Access Level 2.

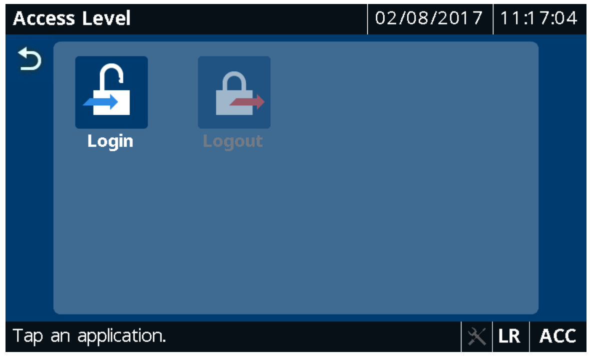


Figure 8.66 Access Level Applications

Table 8.14 identifies all of the applications available in the Access Level folder.

Table 8.14 Access Level Application Availability

Folder Name	Application Name	Comments
Access Level	Login	Always available
	Logout	Always available

Note that when an application requires Access Level 2 and the relay is at Access Level 1, the relay automatically displays the authentication screen requiring you to enter the password before performing a control operation, editing setting, etc.

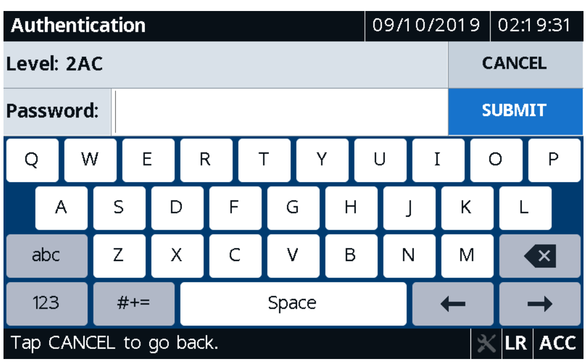


Figure 8.67 Authentication

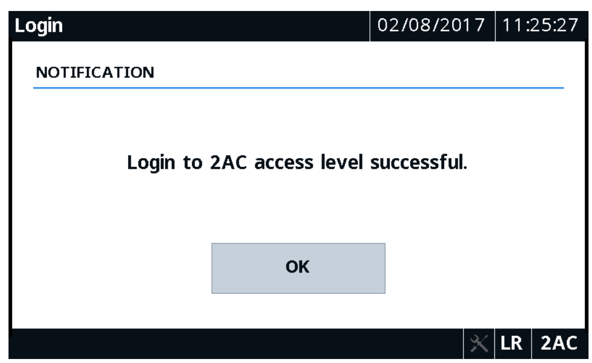


Figure 8.68 Login Confirmation

Settings

Tapping this folder navigates you to the Settings screen where you can access settings applications (Global, Touchscreen) or settings folders (Port, Group, Date and Time) through which you can set or show settings.

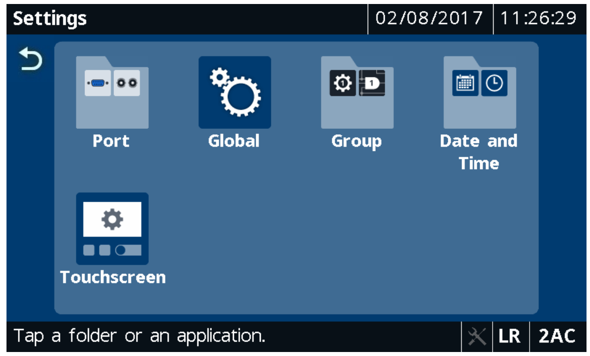


Figure 8.69 Settings Folders and Applications

Table 8.15 identifies all of the folders and applications available in the Settings folder.

Table 8.15 Settings Folder and Application Availability

Folder Name	Folder or Application Name	Comments
Settings	Port	Always available
	Global	Always available
	Group	Always available
	Date and Time	Always available
	Touchscreen	Always available

Table 8.16 identifies all the applications available in each folder (Port, Group, Date and Time) in the Settings folder.

Table 8.16 Settings Folders Port, Group, and Date and Time Application Availability

Folder Name	Application Name	Comments[a]
Port	Port F	Always available
	Port 1	Shown when Slot B ≠ *x*0*x* or *x*1*x*
	Port 2	Shown when E49RTD ≠ EXT
	Port 3	Always available
	Port 4	Shown when Slot C = A*x* or 0*x*, i.e., Slot C has a comms card or is empty
Group	Set 1	Always available
	Logic 1	Always available
	Set 2	Always available
	Logic 2	Always available
	Set 3	Always available
	Logic 3	Always available
	Set 4	Always available
	Logic 4	Always available
Date and Time	Date	Always available
	Time	Always available

[a] Refer to the relay part number.

Figure 8.70 and *Figure 8.71* show typical port and group settings screens.

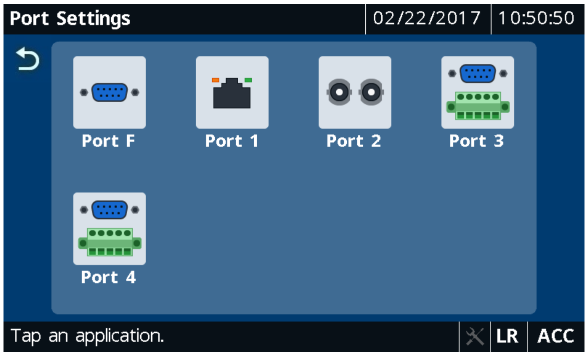


Figure 8.70 Port Settings

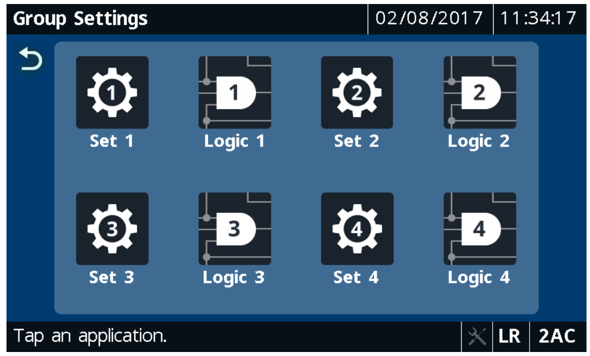


Figure 8.71 Group Settings

To edit a setting, tap on a setting row and enter the Access Level 2 password. If the relay is already at Level 2, the relay does not prompt for password authentication. After entering the value, tap the **Save** button to save your edit, or click the **Cancel Save** button to cancel the edit (see *Table 8.7*). If the Save/Cancel Save buttons are not visible, tap the **Back** button until they appear. When editing a settings class (e.g., Set 1 in Group Settings), you cannot navigate to another class (e.g., Logic 1) without saving or discarding the settings change made in Set 1.

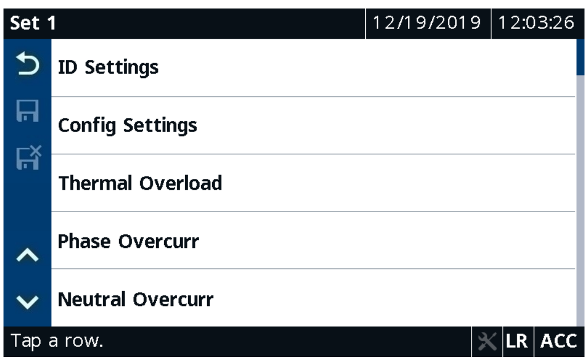


Figure 8.72 Set 1 Settings

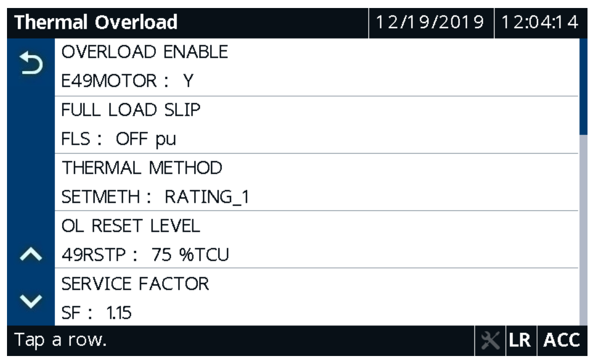


Figure 8.73 Thermal Overload Settings

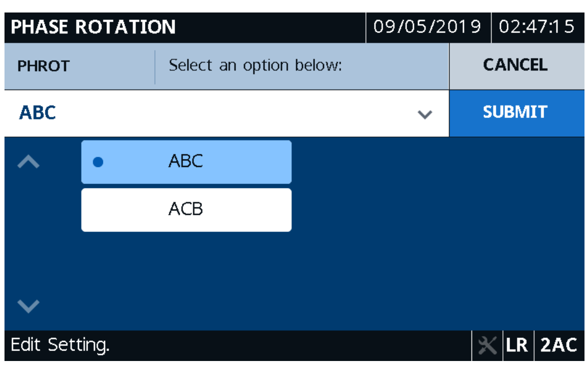


Figure 8.74 Set/Show Settings Edit

You can control the screen brightness, the screen inactivity timer settings, etc., through the Touchscreen application.

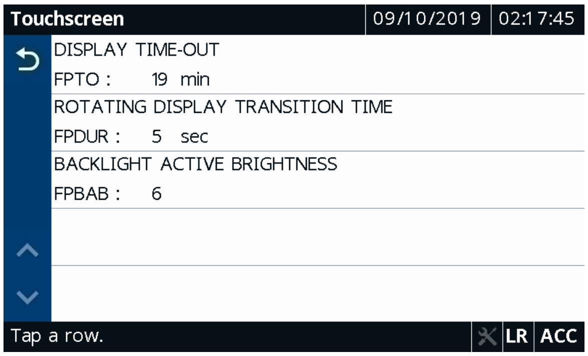


Figure 8.75 Touchscreen Settings

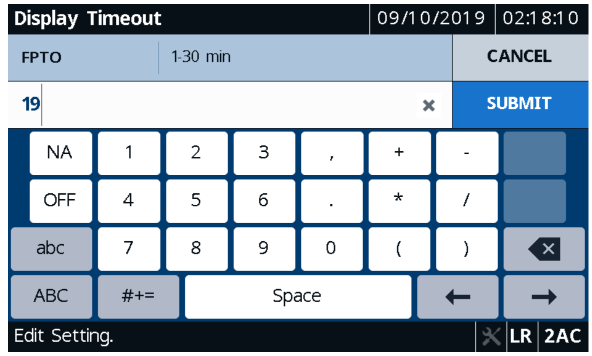


Figure 8.76 Touchscreen Settings Edit

Rotating Display

Tapping this application allows you to start the rotating display. You can pick as many as 16 screens through which the display can rotate after the inactivity timer expires. Refer to *Table 9.7* for the equivalent touchscreen display settings.

Tapping any screen while the display is rotating takes you to that particular screen. You can perform the needed operation and use the **Back** button to return to the Home screen.

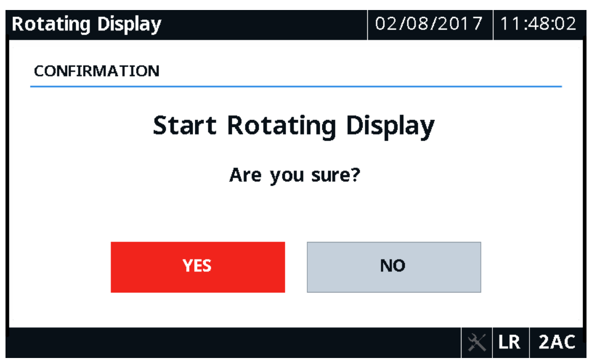


Figure 8.77 Rotating Display

Language Support

All of the HMI messages can be displayed in English or Spanish. The relay part number determines which language is displayed on the HMI. See the *SEL-710-5 Relay Command Summary* for a list of the commands.

Operation and Target LEDs

Programmable LEDs

The SEL-710-5 provides quick confirmation of relay conditions via operation and target LEDs. Refer to *Operation and Target LEDs on page 8.15* for details on the **ENABLED**, **TRIP**, and other programmable LEDs and their operation, and possible warning conditions on the relay.

TARGET RESET Pushbutton

Refer to *TARGET RESET Pushbutton on page 8.18* for the operation of the **TARGET RESET** pushbutton, the lamp test, and other target reset options.

Front-Panel Operator Control Pushbuttons

The SEL-710-5 touchscreen display features eight operator-controlled pushbuttons, each with two programmable tricolor pushbutton LEDs, for local control, as shown in *Table 8.4*. Refer to *Front-Panel Operator Control Pushbuttons on page 8.19* for details on operator control pushbuttons and LEDs and their programming.

You can use the front-panel operator control pushbuttons to jump to a specific screen while using them for START/STOP operations, etc. You can program the selectable operator pushbutton screen settings under the Touchscreen settings category in QuickSet and map the button to a specific screen. For example, **PB03**, which is used to start a motor by default, can be programmed to jump to a bay screen by mapping the pushbutton touchscreen setting FPPB03 to Bay Screen 1. When you press **PB03**, the display jumps to Bay Screen 1, where you can see a visual confirmation of the START action.

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 1 of 6)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Bay Screens				
		Bay Screen 1		Displays Bay Screen 1
		Bay Screen 2		Displays Bay Screen 2
		Bay Screen 3		Displays Bay Screen 3
		Bay Screen 4		Displays Bay Screen 4
		Bay Screen 5		Displays Bay Screen 5
Meter				
	Phasors			
		Phasor Screen 1	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, VAB_MAG, VAB_ANG, VBC_MAG, VBC_ANG, VCA_MAG, VCA_ANG	Shown when DELTA_Y = DELTA
		Phasor Screen 2	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, VA_MAG, VA_ANG, VB_MAG, VB_ANG, VC_MAG, VC_ANG	Shown when DELTA_Y = WYE
	Fundamental			
		Fundamental Screen 1	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, IN_MAG, IN_ANG, FREQ, VAB_MAG, VAB_ANG, VBC_MAG, VBC_ANG, VCA_MAG, VCA_ANG	Shown when DELTA_Y = DELTA
		Fundamental Screen 2	IG_MAG, IG_ANG, 3I2, IAV, UBI, MLOAD, 3V2, VAVE, UBV	Shown when DELTA_Y = DELTA

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 2 of 6)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Fundamental Screen 3	IA_MAG, IA_ANG, IB_MAG, IB_ANG, IC_MAG, IC_ANG, IN_MAG, IN_ANG, FREQ, VAB_MAG, VAB_ANG, VBC_MAG, VBC_ANG, VCA_MAG, VCA_ANG, VA_MAG, VA_ANG, VB_MAG, VB_ANG, VC_MAG, VC_ANG	Shown when DELTA_Y = WYE
		Fundamental Screen 4	IG_MAG, IG_ANG, 3I2, IAV, UBI, VG_MAG, VG_ANG, MLOAD, 3V2, VAVE, UBV	Shown when DELTA_Y = WYE
		Fundamental Screen 5	P, Q, S, PF	Always available
		Fundamental Screen 6	IA87, IB87, IC87, VEX, IEX, Rf	Shown when Slot E = 74 or 75
	RMS			
		RMS Screen 1	IARMS, IBRMS, ICRMS, INRMS, VABRMS, VBCRMS, VCARMS	Shown when DELTA_Y = DELTA
		RMS Screen 2	IARMS, IBRMS, ICRMS, INRMS, VARMS, VBRMS, VCRMS	Shown when DELTA_Y = WYE
	Energy			
		Energy Screen 1	MWH3P, MVARH3PI, MVARH3PO, MVAH3P	Always available
		Energy Reset Screen	Reset Energy data	Always available
	Max/Min			
		Max/Min Screen 1	IAMX, IAMN, IBMX, IBMN, ICMX, ICMN, INMX, INMN, IGMX, IGMN, VABMX, VABMN, VAMX, VAMN, VBCMX, VBCMN, VBMX, VBMN, VCAMX, VCAMN, VCMX, VCMN, VSMX, VSMN, kW3MX, kW3MN, kVAR3MX, kVAR3MN, kVA3MX, kVA3MN, FREQMX, FREQMN, RTD1MX–RTD12MX, RTD1MN–RTD12MN, AI301MX–AI308MX, AI301MN–AI308MN, AI401MX–AI408MX, AI401MN–AI408MN, AI501MX–AI508MX, AI501MN–AI508MN, MM_LRD	Always available
		Max/Min Reset Screen	Reset Max/Min data	Always available

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 3 of 6)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	Analog Inputs			
		Analog Inputs Screen 1	AI301–AI308, AI401–AI408, AI501–AI508	Available if the relay supports analog inputs
	Thermal			
		Thermal Screen 1	RTDWDGMX, RTDBRGMX, RTDAMB, RTDOTHMX	Shown when E49RTD ≠ NONE
		Thermal Screen 2	RTD1– RTD12	Shown when E49RTD ≠ NONE
		Thermal Screen 3	MLOAD, TCUSTR, TCURTR, THRMTP, TRST, STRTAV	Always available
	Math Variables			
		Math Variables Screen 1	MV01–MV32	Shown when EMV ≠ N; shows 12 math variables per page
	Remote Analogs			
		Remote Analogs Screen 1	RA001–RA012	Always available
		Remote Analogs Screen 2	RA013–RA024	Always available
		Remote Analogs Screen 3	RA025–RA036	Always available
		Remote Analogs Screen 4	RA037–RA048	Always available
		Remote Analogs Screen 5	RA049–RA060	Always available
		Remote Analogs Screen 6	RA061–RA072	Always available
		Remote Analogs Screen 7	RA073–RA084	Always available
		Remote Analogs Screen 8	RA085–RA096	Always available
		Remote Analogs Screen 9	RA097–RA108	Always available
		Remote Analogs Screen 10	RA109–RA120	Always available
		Remote Analogs Screen 11	RA121–RA128	Always available
	Light Intensity			
		Light Screen 1	LSENS1, LSENS2, LSENS3, LSENS4	Shown when Slot E = 74
		Light Screen 2	LSENS1, LSENS2, LSENS3, LSENS4, LSENS5, LSENS6, LSENS7, LSENS8	Shown when Slot E = 76
Monitor				
	Relay Word Bits			
		Relay Word Bits Screen 1	Shows status of all the relay word bits	Shows 32 RWBs per page

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 4 of 6)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
	Digital Inputs			
		Digital Inputs Screen 1	IN101, IN102	Always available
		Digital Inputs Screen 2	IN301, IN302, IN303, IN304	Shown when Slot C= Dx or 1x or Cx
		Digital Inputs Screen 3	IN301, IN302, IN303	Shown when Slot C = Bx
		Digital Inputs Screen 4	IN301, IN302, IN303, IN304, IN305, IN306, IN307, IN308	Shown when Slot C = 3x
		Digital Inputs Screen 5	IN301, IN302, IN303, IN304, IN305, IN306, IN307, IN308, IN309, IN310, IN311, IN312, IN313, IN314	Shown when Slot C = 4x
		Digital Inputs Screen 6	IN401, IN402, IN403, IN404	Shown when Slot D = Dx or 1x or Cx
		Digital Inputs Screen 7	IN401, IN402, IN403	Shown when Slot D = Bx
		Digital Inputs Screen 8	IN401, IN402, IN403, IN404, IN405, IN406, IN407, IN408	Shown when Slot D = 3x
		Digital Inputs Screen 9	IN401, IN402, IN403, IN404, IN405, IN406, IN407, IN408, IN409, IN410, IN411, IN412, IN413, IN414	Shown when Slot D = 4x
		Digital Inputs Screen 10	IN501, IN502, IN503, IN504	Shown when Slot E = Dx or 1x or Cx
		Digital Inputs Screen 11	IN501, IN502, IN503	Shown when Slot E = Bx
		Digital Inputs Screen 12	IN501, IN502, IN503, IN504, IN505, IN506, IN507, IN508	Shown when Slot E = 3x
		Digital Inputs Screen 13	IN501, IN502, IN503, IN504, IN505, IN506, IN507, IN508, IN509, IN510, IN511, IN512, IN513, IN514	Shown when Slot E = 4x
	Digital Outputs			
		Digital Outputs Screen 1	OUT101, OUT102, OUT103	Always available
		Digital Outputs Screen 2	OUT301, OUT302, OUT303, OUT304	Shown when Slot C = Bx or 1x or Cx
		Digital Outputs Screen 3	OUT301, OUT302, OUT303	Shown when Slot C = Dx
		Digital Outputs Screen 4	OUT301, OUT302, OUT303, OUT304, OUT305, OUT306, OUT307, OUT308	Shown when Slot C = 2x
		Digital Outputs Screen 5	OUT401, OUT402, OUT403, OUT404	Shown when Slot D = Bx or 1x or Cx
		Digital Outputs Screen 6	OUT401, OUT402, OUT403	Shown when Slot D = Dx
		Digital Outputs Screen 7	OUT401, OUT402, OUT403, OUT404, OUT405, OUT406, OUT407, OUT408	Shown when Slot D = 2x
		Digital Outputs Screen 8	OUT501, OUT502, OUT503, OUT504	Shown when Slot E = Bx or 1x or Cx

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 5 of 6)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Digital Outputs Screen 9	OUT501, OUT502, OUT503	Shown when Slot E = Dx
		Digital Outputs Screen 10	OUT501, OUT502, OUT503, OUT504, OUT505, OUT506, OUT507, OUT508	Shown when Slot E = 2x
	SELOGIC Counters			
		SELOGIC Counters Screen 1	SC01–SC32	Shown when ESC ≠ N; shows 12 SELOGIC counters per page
	Breaker Wear			
		Breaker Wear Screen 1	INTT, EXTT, INTIA, INTIB, INTIC, EXTIA, EXTIB, EXTIC	Shown when EBMON = Y
		Breaker Wear Screen 2	WEARA, WEARB, WEARC	Shown when EBMON = Y
	Vibration			
		Vibration Screen 1	VIBAQ1, VIBAQ2, VIBAQ3, VIBAQ4, VIBAQ5	Always available
Reports				
	Events			
		Event History Screen 1		Shows the event records in the relay
	SER			
		SER Screen 1		Shows the Sequential Event Records (SERs) in the relay
	MST			
		MST Screen 1		Shows the Motor Start Trend data in the relay
	MOT			
		MOT Screen 1		Shows the Motor Operating Statistics in the relay

Table 8.17 Screens Available for the Rotating Display, HOME Pushbutton[a], and Programmable Pushbuttons (Sheet 6 of 6)

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Device Info				
	Status			
		Status Screen 1	Status, serial number, FID string, part number, SEL display, customer display, IEC 61850 CID	Always available
		Status Screen 2	Diagnostic status for the relay cards and power supply rails. CARD_C, CARD_D, CARD_E, CARD_Z, FPGA, GPSB, HMI, RAM, ROM, CR_RAM, NON_VOL, CLOCK, RTD, CID_FILE, +0.9V CHK (V), +1.2V CHK (V), +1.5V CHK (V), +1.8V CHK (V), +2.5V CHK (V), +3.3V CHK (V), +3.75V CHK (V), +5.0V CHK (V), –1.25V CHK (V), –5.0V CHK (V), BATT CHK (V)	Always available
		Status Screen 3	DN_MAC_ID, ASA, DN_RATE, DN_STATUS	Shown if the DeviceNet option is available
		Status Screen 4	OFFSETS: IA, IB, IC, IN, VA, VB, VC, IA87, IB87, IC87, VDR	Always available
	Configuration			
		Configuration Screen 1	Part number, Port F protocol, Port F baud rate, Port 1 IP address, Port 1 default router, MAC address (IP), MAC address (GOOSE), breaker control jumper, password bypass jumper, rated frequency, phase rotation, nominal phase CT rating, nominal/neutral CT rating, PT connection, date format	Some of the quantities are part-number dependent and will be hidden if the part number does not support them
	Trip and Diagnostics			
		Trip and Diagnostic Screen 1	Diagnostic failures, trip event types, lockouts, and warnings	Always available

[a] In addition to the listed screens, the Home screen is available for the HOME pushbutton. By default, the HOME pushbutton is programmed to the Home screen.

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Section 9

Bay Control

Overview

The SEL-710-5 Relay with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as a single-line diagram (SLD) on the touchscreen. You can create as many as five bay screens with one controllable breaker, as many as eight two-position disconnects, and as many as two three-position disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed single-line diagrams of the bay to indicate the status of the breaker and disconnects, bus voltages, and power flow through the breaker. In addition to single-line diagrams, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. These screens can be designed with the help of ACSELERATOR Bay Screen Builder SEL-5036 Software in conjunction with ACSELERATOR QuickSet SEL-5030 Software. Note that the bay screen related settings can only be set via QuickSet (setting via an ASCII terminal is not supported).

This section covers all aspects of the SEL-710-5 Relay bay control.

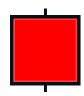
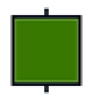
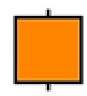
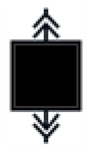
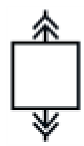
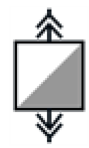
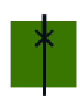
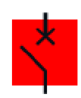
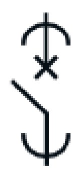
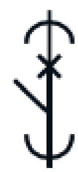
Circuit Breaker Symbol Settings and Status Logic

The SEL-710-5 supports one breaker that can be controlled and monitored via the bay screen. Use the SELOGIC settings 52A and 52B to map the respective breaker auxiliary contacts to the relay. Because the 52B contact is not always available in all applications, the breaker status logic does not include the 52B contact. The relay uses the 52A Relay Word bit as the status of the breaker in conjunction with the protection elements and trip and close logic. The default setting for 52B is NOT 52A. Map 52A and 52B Relay Word bits to the settings associated with the breaker symbol under the **Bay Control** settings in QuickSet to display the status of the breaker on the bay screen.

Use SELOGIC to create dual-point status of the breaker with breaker alarm indication. Refer to *Table 9.7* for the **Bay Control** breaker settings. Refer to *Bay Control Application Example on page 9.19* for example settings. Refer to *Table 4.65* and *52A and 52B* ***Contactor/Breaker Status SELOGIC Control Equations on page 4.106*** for 52A and 52B settings and descriptions. Refer to *Trip/Close Logic on page 4.103* for more information on the breaker trip and close logic.

Table 9.1 provides typical ANSI and IEC breaker symbols that are supported by Bay Screen Builder. Column 1 identifies the standard (ANSI/IEC) and the type of breaker. Columns 3, 4, and 5 identify closed, open, and alarm states of the breaker image, respectively. Bay Screen Builder allows you to set the breaker color sequence property (identified in Column 2) for each of these states. Select the breaker color sequence based on your system convention. For a complete list of ANSI and IEC circuit breaker symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available in the **Help > Contents** menu of Bay Screen Builder.

Table 9.1 Circuit Breaker Symbols

Type	Breaker Color Sequence	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI Breaker	Red, Green, Amber			
ANSI Truck Operated Breaker	Black, White, Grey			
IEC Breaker	Green, Red, Amber			
IEC Truck Operated Breaker	Transparent			

Disconnect Control Settings

The SEL-710-5 supports control of as many as eight two-position and two three-position disconnects. Refer to *Table 9.2* and *Table 9.3* for the two- and three-position switch settings. The following description applies to both the two- and three-position switches enabled by the 89EN2P and 89EN3P settings. Generic setting names are used in the following description for simplicity. For example, the label setting for two-position Switch 1 (89NM2P1) is represented by 89NM*km*, where *k* is the switch type (2P, 3PL, or 3PE) and *m* is the switch number (*m* = 1–8 if *k* = 2P and *m* = 1–2 if *k* = 3PL or 3PE).

Use the 89NM*km* setting to name the disconnect using a maximum of sixteen characters. The 89A*km* and 89B*km* SELOGIC control equation settings represent the normally open and normally close disconnect auxiliary contacts. Typically, these SELOGIC control equation settings are set to SEL-710-5 inputs that are wired to the corresponding auxiliary contacts. *Figure 9.1* shows the dual-point disconnect status logic. The Relay Word bits 89CL*km* and 89OP*km* indicate whether the disconnect is in a fully close or fully open state, respectively. 89AL*km* indicates the alarm status of the disconnect and asserts when the disconnect is in an undetermined state for longer than the 89A*km*D time setting. The 89AL*km* alarm bit also asserts if the switch fails to start close or open operation after a successful command is issued. Set the 89A*km*D timer longer than the highest expected operation time (undetermined state).

Table 9.2 Two-Position Disconnect Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
EN 2P DISC	N, 1–8	89EN2P := 8
Disconnect *m*[a]		
2P DISC *m* NAME	16 characters	89NM2P*m* := 2P*m*
DIS *m* N/O CONT	SELOGIC	89A2P*m* := 0
DIS *m* N/C CONT	SELOGIC	89B2P*m* := NOT 89A2P*m*
DIS *m* ALM PU	0.00–300.00 sec	89A2P*m*D := 5.00
DIS *m* SEALIN	OFF, 0.00–300.00 sec	89S2P*m*D := 4.67
DIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I2P*m*D := 0.33
DIS *m* CL CONT	SELOGIC	89RC2P*m* := 89CC2P*m*
DIS *m* CL BLK	SELOGIC	89CB2P*m* := 89AL2P*m*
DIS *m* CL RST	SELOGIC	89CR2P*m* := 89CL2P*m* OR 89CS2P*m* OR 89 ALP2*m*
DIS *m* CL IM RS	SELOGIC	89CT2P*m* := NOT 89OP2P*m*
DIS *m* OP CONT	SELOGIC	89RO2P*m* := 89OCP*m*
DIS *m* OP BLK	SELOGIC	89OB2P*m* := 89AL2P*m*
DIS *m* OP RST	SELOGIC	89OR2P*m* := 89OP2P*m* OR 89OS2P*m* OR 89AL2P*m*
DIS *m* OP IM RS	SELOGIC	89OT2P*m* := NOT 89CL2P *m*

[a] The value of *m* can be set to any number between 1 and the value of setting 89EN2P.

Table 9.3 Three-Position Disconnect Settings (Sheet 1 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
EN 3P DISC	N, 1–2	89EN3P := N
Disconnect *m*[a]		
3P DISC *m* NAME	16 characters	89NM3P*m* := 3P*m*
In-Line Disconnect		
LDIS *m* N/O CONT	SELOGIC	89A3PL*m* := 0
LDIS *m* N/C CONT	SELOGIC	89B3PL*m* := NOT 89A3PL*m*
LDIS *m* ALM PU	0.00–300.00 sec	89A3PL*m*D := 5.00
LDIS *m* SEALIN	OFF, 0.00–300.00 sec	89S3PL*m*D := 4.67
LDIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I3PL*m*D := 0.33
LDIS *m* CL CONT	SELOGIC	89RC3PL*m* := 89CC3PL*m*
LDIS *m* CL BLK	SELOGIC	89CB3PL*m* := 89CL3PE*m* OR 89AL3PL*m* OR 89 AL3PE*m*
LDIS *m* CL RST	SELOGIC	89CR3PL*m* := 89CL3PL*m* OR 89CS3PL*m* OR 89AL3PL*m*
LDIS *m* CL IM RS	SELOGIC	89CT3PL*m* := NOT 89OP3PL*m*

Table 9.3 Three-Position Disconnect Settings (Sheet 2 of 2)

Setting Prompt	Setting Range	Setting Name := Factory Default
LDIS *m* OP CONT	SELOGIC	89RO3PL*m* := 89OC3PL*m*
LDIS *m* OP BLK	SELOGIC	89OB3PL*m* := 89CL3PE*m* OR 89AL3PL*m* OR 89AL3PE*m*
LDIS *m* OP RST	SELOGIC	89OR3PL*m* := 89OP3PL*m* OR 89OS3PL*m* OR 89AL3PL*m*
LDIS *m* OP IM RS	SELOGIC	89OT3PL*m* := NOT 89CL3PL*m*
Earthing Disconnect		
EDIS *m* N/O CONT	SELOGIC	89A3P*m* := 0
EDIS *m* N/C CONT	SELOGIC	89B3P*m* := NOT 89A3PE*m*
EDIS *m* ALM PU	0.00–300.00 sec	89A3PE*m*D := 5.00
EDIS *m* SEALIN	OFF, 0.00–300.00 sec	89S3PE*m*D := 4.67
EDIS *m* IMMOBI	OFF, 0.00–300.00 sec	89I3PE*m*D := 0.33
EDIS *m* CL CONT	SELOGIC	89RC3PE*m* := 89CC3PE*m*
EDIS *m* CL BLK	SELOGIC	89CB3PE*m* := 89CL3PL*m* OR 89AL3PL*m* OR 89AL3PE*m*
EDIS *m* CL RST	SELOGIC	89CR3PE*m* := 89CL3PE*m* OR 89CS3PE*m* OR 89AL3PE*m*
EDIS *m* CL IM RS	SELOGIC	89CT3PE*m* := NOT 89OP3PE*m*
EDIS *m* OP CONT	SELOGIC	89RO3PE*m* := 89OC3PE*m*
EDIS *m* OP BLK	SELOGIC	89OB3PE*m* := 89CL3PL*m* OR 89AL3PL*m* OR 89AL3PE*m*
EDIS *m* OP RST	SELOGIC	89OR3PE*m* := 89OP3PE*m* OR 89OS3PE*m* OR 89AL3PE*m*
EDIS *m* OP IM RS	SELOGIC	89OT3PE*m* := NOT 89CE3PL*m*

[a] The value of *m* can be set to any number between 1 and the value of setting 89EN3P.

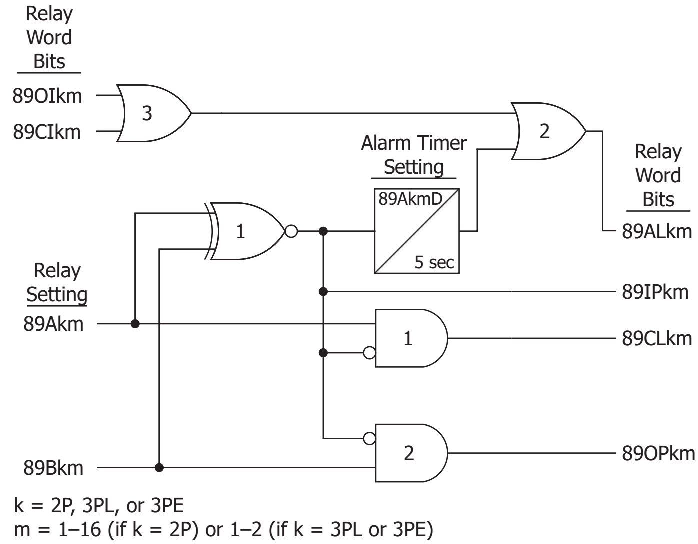


Figure 9.1 Dual-Point Disconnect Status Logic

The close and open logic shown in *Figure 9.2* and *Figure 9.3* are primarily for control of motor operated disconnects. The settings and control described below are not intended for manually operated disconnects and can be ignored. The description of close and open control logic applies to all two- and three-position motor operate disconnects that are enabled.

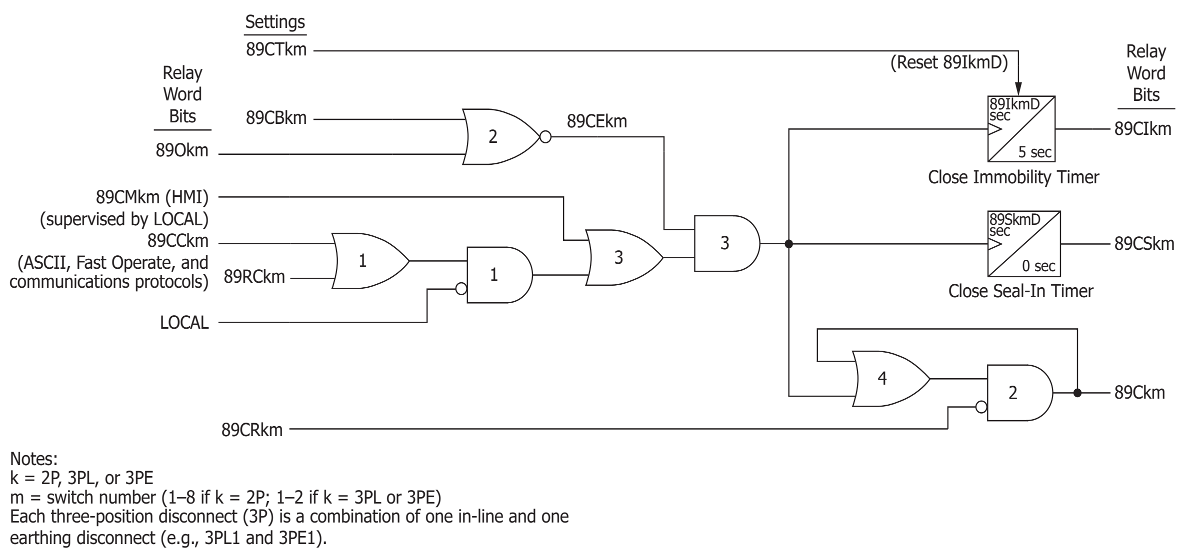


Figure 9.2 Disconnect Close Logic

Close control action of a disconnect can be initiated via the front-panel HMI Bay Screen application (Relay Word bit 89CM*km*) or remotely (i.e., via communications protocols [Relay Word bit 89CC*km*] or the SELOGIC control equation setting [89RC*km*]). Close control from the HMI requires that local control be enabled (Relay Word bit LOCAL asserted). When Relay Word bit LOCAL is asserted, remote close control is blocked. Use the 89CB*km* SELOGIC control equation setting to block both local and remote control, if required. The logic automatically seals-in a successful close signal (Relay Word bit 89C*km*) until the user-defined reset Relay Word bit 89CR*km* asserts. By default, the relay uses the seal-in timer output to avoid a premature reset of the close signal. An immobility timer detects if the disconnect remains in the fully open position for longer than the 89I*km*D time setting after the close signal is issued (89C*km* asserts) by the assertion of Relay Word bit 89CI*km*.

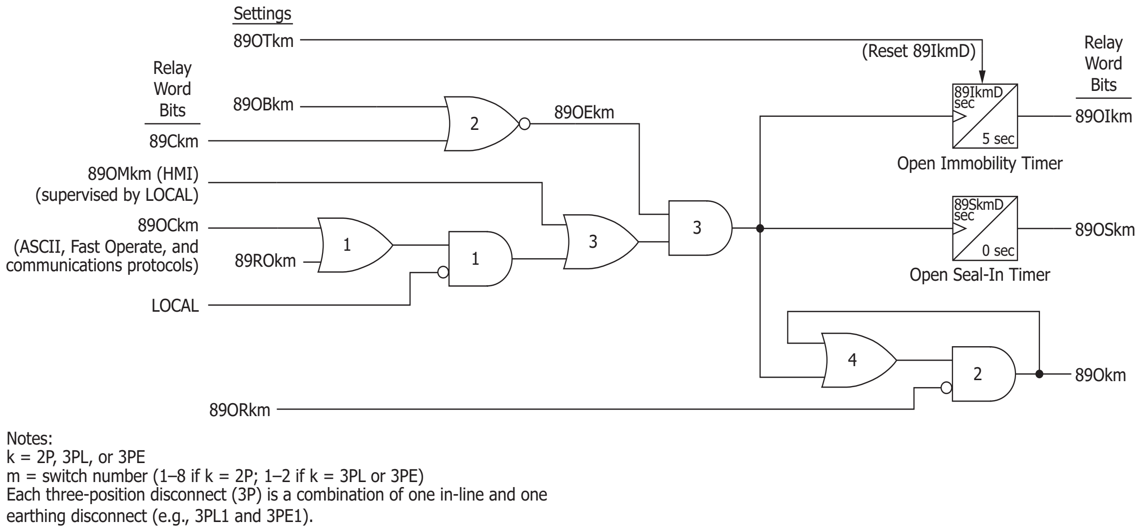


Figure 9.3 Disconnect Open Logic

Similarly, open control action of a disconnect can be initiated via the front-panel HMI (Relay Word bit 89OM*km*) or remotely (i.e., communications protocols [Relay Word bit 89OC*km*] or the SELOGIC control equation setting [89RO*km*]). Open control from the HMI requires that local control be enabled (Relay Word bit LOCAL asserted). When Relay Word bit LOCAL is asserted, remote close is blocked. Use the 89OB*km* SELOGIC control equation setting to block both local and remote control, if required. The logic automatically seals-in a successful open signal (Relay Word bit 89O*km*) until the user-defined reset Relay Word bit 89OR*km* asserts. By default, the relay uses the seal-in timer output to avoid premature reset of the open signal. An immobility timer detects if the disconnect remains in the fully close position for longer than the 89I*km*D time setting after the open signal is issued (89O*km* asserts) by the assertion of Relay Word bit 89OI*km*.

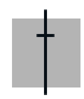
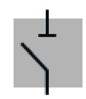
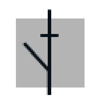
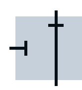
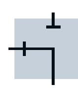
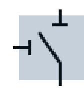
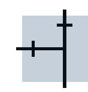
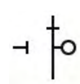
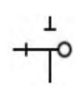
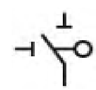
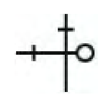
Table 9.4 Disconnect Control Setting Guidelines

Setting	Remarks
89EN*k*	Enable required number of 2- and 3-position switches
89NM*km*	Label each switch with a unique name
89A*km*	SELOGIC control equation for normally open auxiliary contact of the switch
89B*km*	SELOGIC control equation for normally close auxiliary contact of the switch
89A*km*D	Operate alarm delay; set longer than the highest expected operate time of the switch
89S*km*D	Seal-in delay; set longer than the highest expected operate time of the motor operated switch

The factory-default values of all the other settings should be suitable for most applications, however, they must be reviewed and edited for specific requirements.

Refer to *Table 9.5* for the Bay Control disconnect settings. Refer to *Bay Control Application Example on page 9.19* for example settings. *Table 9.5* provides typical ANSI and IEC disconnect symbols that are available to use in bay screen design. Column 1 identifies the standard (ANSI/IEC) and the type of disconnect. Column 2 identifies the interior color property of the disconnect. Columns 3, 4, and 5 identify closed, open, and alarm states of the disconnect. For a complete list of ANSI and IEC disconnect symbols available to use with the bay screens, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*.

Table 9.5 Disconnect Symbols

Type	Interior Color	State 1 (Closed)	State 2 (Open)	State 3 (Alarm)
ANSI and IEC Disconnect (Two-Position)	Gray			
ANSI and IEC Motor-Operated Disconnect (Two-Position)	Transparent			
ANSI and IEC Disconnect (Three-Position)	Gray	 		
ANSI and IEC Motor-Operated Disconnect (Three-Position)	Transparent	 		

Local/Remote Control

The SEL-710-5 supports local/remote motor control functionality through supervision of the STR and STOP motor control Relay Word bits and local/remote disconnect control functionality through supervision in the disconnect open and close control logic (See *Figure 9.2* and *Figure 9.3*). The supervision can be enabled or disabled with the global setting EN_LRC (see *Table 9.6*). To enable local/remote supervision of the breaker and disconnect control, set EN_LRC := Y. When EN_LC := Y, the LOCAL SELOGIC control equation is available.

Table 9.6 Local/Remote Motor Control Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE LOC REM CON	Y, N	EN_LRC := N
LOCAL CONTROL[a]	SELOGIC	LOCAL := 0

[a] This setting is hidden when EN_LRC := N.

The relay controls the status of the LOCAL Relay Word bit based on the EN_LRC setting and the selection applies to both the breaker and the disconnect control.

- When EN_LRC := Y and LOCAL := 1, the relay processes the **STR** and **STOP** commands from the front panel (two-line display or touchscreen). The **STR** and **STOP** commands from remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.) are blocked.
- When EN_LRC := Y and LOCAL := 0, the relay processes the **STR** and **STOP** commands from remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.). The commands from the front panel are blocked (two-line display or touchscreen).
- When EN_LRC := N, the relay processes the **STR** and **STOP** commands from both the front panel (two-line display or touchscreen) and remote sources/protocols (ASCII terminal, SEL Fast Operate, DNP, Modbus, EtherNet/IP, IEC 61850, etc.).

Enable the local/remote control for proper supervision of motor control and operator safety. Map the LOCAL SELOGIC control equation to the status of the local/remote switch on the panel, if available. Alternatively, program one of the front-panel pushbuttons and an LED in conjunction with a SELOGIC latch to mimic the local/remote switch and map it to the LOCAL SELOGIC control equation.

When EN_LRC := Y, the status of the local/remote control is indicated on the footer of the touchscreen as "L" for local (LOCAL = 1) and "R" for remote (LOCAL = 0). If you do not intend to use the built-in local/remote function, and prefer to create your own control function using SELOGIC and remote bits, then set EN_LRC := N. In which case, the footer indicates "LR," as shown in *Figure 9.4*, indicating that STR and STOP bits are processed from both the touchscreen and the remote sources/protocols. Local/remote indication is only available on the SEL-710-5 touchscreen display model. Refer to *Bay Control Application Example on page 9.19* for example settings.

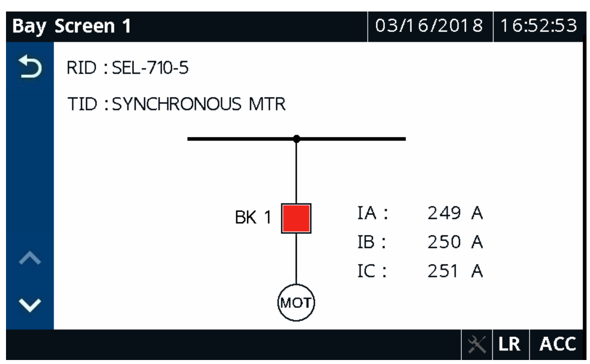


Figure 9.4 Local/Remote Control Mode Indication

Motor/Disconnect Control Via the Touchscreen

The SEL-710-5 enables you to control the motor from the touchscreen or the two-line LCD and the disconnect from the touchscreen. Motors and disconnects can also be controlled through the front-panel operator control pushbuttons. Refer to *Front-Panel Operator Control Pushbuttons on page 8.40* for a discussion on motor control via the control pushbuttons. Refer to *Control Menu on page 8.10* for instructions on motor control via the two-line LCD. This section discusses motor and disconnect control via touchscreen.

The touchscreen allows you to control the motor via two applications: Bay Screens and Motor Start/Stop Control; however, only the Bay Screens application allows control of the disconnects. The Bay Screens application is available on the Home screen. Breaker and disconnect control via the Bay Screens application requires you to design a bay control single-line diagram. *Figure 9.5* shows a sample single-line diagram with a controllable breaker, disconnect, and analog quantities. For more details on how to design this screen, refer to *Bay Control Application Example*.

You can also control the motor via Motor Start and Motor Stop applications, which are available in the **Control** folder. These application are built-in and are always available for you to perform motor control. *Figure 9.6* shows the Start Motor application display and *Figure 9.7* shows the Stop Motor application display.

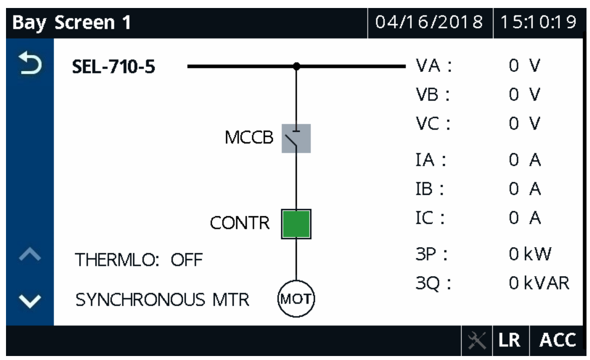


Figure 9.5 Bay Screens Application Display With a Single-Line Diagram

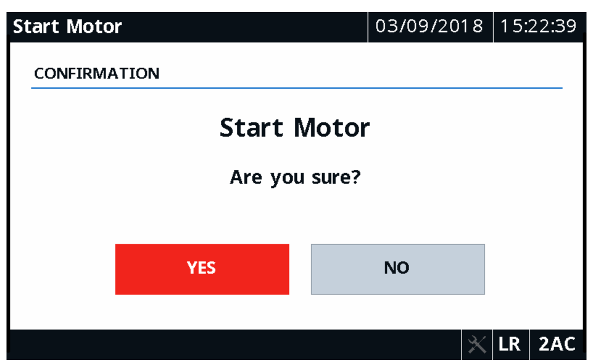


Figure 9.6 Start Motor Application

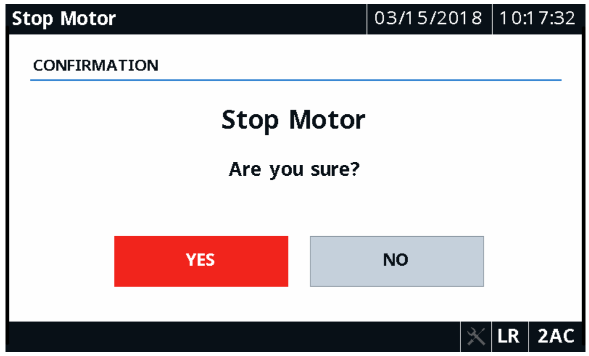


Figure 9.7 Stop Motor Application

The Bay Screens, Motor Start, and Motor Stop applications use the STR and STOP bits and require you use their respective START and TRIP bits to perform motor control. For more details on how to program these bits, refer to *Bay Control Application Example*. The Bay Screens and Breaker Control applications use the 89OM*km* and 89CM*km* bits to perform disconnect control (see *Figure 9.2* and *Figure 9.3* for details). The relay checks for the following conditions, in the order shown. Only when the conditions are satisfied can you perform breaker or disconnect control.

1. EN_LRC := Y and Relay Word bit LOCAL is asserted. If EN_LRC := N, then this check is ignored.

2. The breaker control jumper on the slot B board is installed. The Relay Word bit BKJMP stays asserted when the breaker control jumper is installed. Refer to *Password, Breaker (Start/Stop Control), and SELBOOT Jumper Selection on page 2.19* for information on the breaker jumper.

3. You are at Access Level 2. The relay prompts for the Access Level 2 password if you are not at Access Level 2.

4. There are no active lockouts. If there is one or more active lockout, the relay displays those which are active and the greatest time remaining. This condition is only checked when issuing a START via Motor Start or CLOSE via Bay Screen application.

When the conditions are satisfied, the application pulses the STR or STOP bit, respectively, depending on your selection for motor start or stop.

Bay Screens Design Using QuickSet and Bay Screen Builder

QuickSet and Bay Screen Builder provide user-friendly interfaces to set the touchscreen settings. The touchscreen settings are not available for setting via ASCII terminal, unlike the other relay settings. The touchscreen settings are only available if the relay part number is configured with the touchscreen display under **Front-Panel Options** drop down as shown in *Figure 9.8*. *Figure 9.9* shows the **Touchscreen** settings in QuickSet.

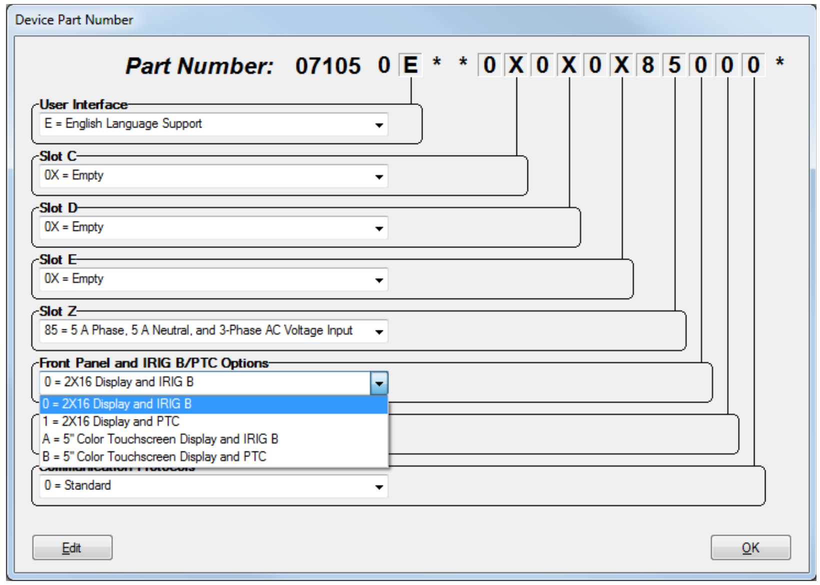


Figure 9.8 QuickSet Front-Panel Options

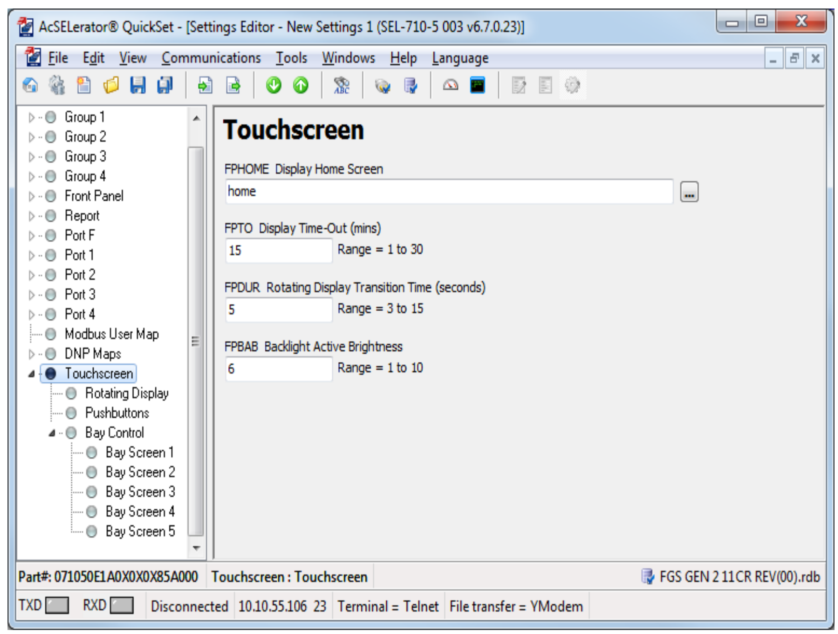


Figure 9.9 QuickSet Touchscreen Settings

NOTE: The settings in Table 9.7 shall be populated under each of the custom screens (sld1–sld5) based on the dynamic symbols chosen by the user.

Table 9.7 Touchscreen Settings (Sheet 1 of 4)

Setting Prompt	Setting Range	Setting Name := Factory Default
Display Settings		
Display Home Screen	See *Table 8.17*	FPHOME := HOME
Display Time-Out	1–30 min	FPTO := 15
Rotating Display Transition Time	3–15 sec	FPDUR := 5
Backlight Active Brightness	1–10	FPBAB := 6

Table 9.7 Touchscreen Settings (Sheet 2 of 4)

Setting Prompt	Setting Range	Setting Name := Factory Default
Rotating Display Screen Settings		
Rotating Display 01	See *Table 8.17*	FPRD01 := Bay Screen 1
Rotating Display 02	See *Table 8.17*	FPRD02 :=
• • •	• • •	• • •
Rotating Display 15	See *Table 8.17*	FPRD15 :=
Rotating Display 16	See *Table 8.17*	FPRD16 :=
Pushbutton Settings (nn = 01–08)		
Pushbutton *nn* HMI Screen	OFF, See *Table 8.17*	FPPB*nn* := OFF
Bay Control Breaker Settings		
Breaker Trip Type	3	BK01TTY := 3
Breaker Mode	CONTROL, MONITOR	BK01MOD := MONITOR
Breaker 1 Close Status	Relay Word Bit	BK01CS := 52A1
Breaker 1 Open Status	Relay Word Bit	BK01OS := 52B1
Breaker 1 Alarm Status	Relay Word Bit	BK01AS := NA
Breaker 1 HMI Close Command	Relay Word Bit	BK01CLC := NA
Breaker 1 HMI Open Command	Relay Word Bit	BK01OPC := NA
Breaker 2 Close Status	Relay Word Bit	BK02CS := 52A2
Breaker 2 Open Status	Relay Word Bit	BK02OS := 52B2
Breaker 2 Alarm Status	Relay Word Bit	BK02AS := NA
Breaker 2 HMI Close Command	Relay Word Bit	BK02CLC := NA
Breaker 2 HMI Open Command	Relay Word Bit	BK02OPC := NA
Breaker 3 Close Status	Relay Word Bit	BK03CS := 52A3
Breaker 3 Open Status	Relay Word Bit	BK03OS := 52B3
Breaker 3 Alarm Status	Relay Word Bit	BK03AS := NA
Breaker 3 HMI Close Command	Relay Word Bit	BK03CLC := NA
Breaker 3 HMI Open Command	Relay Word Bit	BK03OPC := NA
Breaker 4 Close Status	Relay Word Bit	BK04CS := 52A4
Breaker 4 Open Status	Relay Word Bit	BK04OS := 52B4
Breaker 4 Alarm Status	Relay Word Bit	BK04AS := NA
Breaker 4 HMI Close Command	Relay Word Bit	BK04CLC := NA
Breaker 4 HMI Open Command	Relay Word Bit	BK04OPC := NA

Table 9.7 Touchscreen Settings (Sheet 3 of 4)

Setting Prompt	Setting Range	Setting Name := Factory Default
Bay Control Disconnect Settings Two-Position Disconnects (m = 1–8)		
Two-Position Disconnect Close Status	Relay Word bit	2DS*m*CS :=
Two-Position Disconnect Open Status	Relay Word Bit	2DS*m*OS :=
Two-Position Disconnect In-Progress Status	Relay Word Bit	2DS*m*IS := NA
Two-Position Disconnect Alarm Status	Relay Word Bit	2DS*m*AS := NA
Two-Position Disconnect HMI Close Command	89CM2P1–89CM2P8	2DS*m*CL := NA
Two-Position Disconnect HMI Open Command	89OM2P1–89OM2P8	2DS*m*OP := NA
Bay Control Disconnect Settings Three-Position Disconnects (m = 1–2)		
Three-Position In-Line Disconnect Close Status	Relay Word bit	3ID*m*CS :=
Three-Position In-Line Disconnect Open Status	Relay Word Bit	3ID*m*OS :=
Three-Position In-Line Disconnect In-Progress Status	Relay Word Bit	3ID*m*IS := NA
Three-Position In-Line Disconnect Alarm Status	Relay Word Bit	3ID*m*AS := NA
Three-Position In-Line Disconnect HMI Close Command	89CM3PL1–89CM3PL2	3ID*m*CL := NA
Three-Position In-Line Disconnect HMI Open Command	89OM3PL1–89OM3PL2	3ID*m*OP := NA
Three-Position Earthing Disconnect Close Status	Relay Word Bit	3EDmCS :=
Three-Position Earthing Disconnect Open Status	Relay Word Bit	3EDmOS :=
Three-Position Earthing Disconnect In-Progress Status	Relay Word Bit	3EDmIS := NA
Three-Position Earthing Disconnect Alarm Status	Relay Word Bit	3EDmAS := NA
Three-Position Earthing Disconnect HMI Close Command	89CM3PE1–89CM3PE2	3EDmCL := NA
Three-Position Earthing Disconnect HMI Open Command	89OM3PE1–89OM3PE2	3EDmOP := NA
Bay Control Analog Label Settings (qq = 01–32)		
Analog Quantity	Analog Quantity	ALAB01 := STRING_RID
Analog Quantity	Analog Quantity	ALAB02 := STRING_TID

Table 9.7 Touchscreen Settings (Sheet 4 of 4)

Setting Prompt	Setting Range	Setting Name := Factory Default
Analog Quantity	Analog Quantity	ALAB03 := IAW1_MAG
Analog Quantity	Analog Quantity	ALAB04 := IBW1_MAG
Analog Quantity	Analog Quantity	ALAB05 := ICW1_MAG
Analog Quantity	Analog Quantity	ALAB06 := IAW2_MAG
Analog Quantity	Analog Quantity	ALAB07 := IBW2_MAG
Analog Quantity	Analog Quantity	ALAB08 := ICW2_MAG
Analog Quantity	Analog Quantity	ALAB*qq* :=
Bay Control Digital Label Settings (qq = 01–32)		
Relay Word Bit	Relay Word Bit Name	DLAB*qq* :=

Display Settings

Use these settings to configure the touchscreen. Pressing the **HOME** pushbutton on the front panel takes you to the screen configured as part of the FPHOME setting. By default, FPHOME is set to the **Home** screen, which displays the **Home** screen folders and applications. You can set FPHOME to any screen that you like to view when the **HOME** pushbutton is pressed (see *Table 8.17* for the list of available screens).

To help prevent unauthorized access to password-protected functions, the SEL-710-5 provides a front-panel timeout setting, FPTO. The timeout resets each time you press a front-panel pushbutton or the screen detects a touch. When the timeout expires, the access level resets to Access Level 1 and switches to the rotating display if at least one screen is configured as part of the rotating display settings, FPRD*kk* (*kk* = 01–16), if not, the display switches to the **Home** screen. The rotating display transition time setting FPDUR defines the duration that each screen is displayed on the rotating display. Set FPDUR to a transition time most suitable to your application.

Use the FPBAB setting to control the backlight active brightness.

Rotating Display Settings

The SEL-710-5 allows you to configure as many as 16 screens for the rotating display. Configure the settings FPRD*kk* (*kk* = 01–16) to the screens most suitable to your application. Refer to *Table 8.17* for the list of screens available as part of the FPRD*kk* settings.

Pushbutton Settings

The pushbutton settings FPPB*nn* (*nn* = 01–08) allow you to quickly navigate to a specific screen by pressing the programmed pushbutton. Refer to *Table 8.17* for the list of screens available for the FPPB*nn* settings. Note that a given pushbutton can be configured to navigate to a specific screen while being used in SELOGIC (e.g., PB04 Relay Word bit). The relay does not prevent you from configuring a pushbutton for two purposes. Make sure to set dual-purpose pushbuttons with care to ensure safe operation.

Bay Control Breaker Settings

Bay control breaker settings are only available if the designed single-line diagram has a breaker symbol. When QuickSet detects a breaker symbol as part of the single-line diagram, it populates the corresponding settings. The SEL-710-5 supports one three-pole breaker. The setting BK01TTY is forced to 3 by default and is not settable. The breaker on the single-line can be configured as monitor-only or as a controllable breaker. Set BK01MOD = MONITOR if you do not want to allow breaker control via the touchscreen. Set BK01MOD = CONTROL if you want to allow breaker control via the touchscreen. Set BK01CS and BK01OS settings to the corresponding Relay Word bits that indicate the close and open status of the breaker. The relay does not support breaker alarm logic, but it can be programmed using SELOGIC. To display breaker alarm status, set the breaker alarm status setting BK01AS to the corresponding SELOGIC bit. When BK01MOD := CONTROL, both BK01CLC and BK01OPC settings are forced to STR and STOP, respectively, and are not settable. Refer to *Bay Control Application Example on page 9.19* for sample breaker settings.

Bay Control Disconnect Settings

The bay control disconnect settings are only available if the designed single-line diagram has at least one disconnect symbol. When QuickSet detects one or more disconnect symbols as part of the single-line diagram, it populates the corresponding settings. The SEL-710-5 supports eight two-position and two three-position disconnects. Set the DS*n*CS and DS*n*OS settings to the corresponding Relay Word bits that indicate the close and open status of the disconnect. Map the output of the disconnect alarm logic, 89AL*km* (see *Figure 9.1*), to the corresponding DS*n*AS setting. A successful close or open command from the HMI asserts the corresponding 89CM*km* or 89OM*km* Relay Word bit used in *Figure 9.2* or *Figure 9.3*, respectively. Refer to *Bay Control Application Example on page 9.19* for sample disconnect settings.

Bay Control Analog Label Settings

The analog label settings are only available if the designed bay screen has at least one analog label. When QuickSet detects one or more analog labels as part of the bay screen, it populates the corresponding settings. The SEL-710-5 supports as many as 32 analog labels. Set ALAB*qq* (*qq* = 01–32) to display the desired analog quantity on the bay screen. Refer to the display points column of *Table M.1* for the list of analog quantities available to program into analog labels.

Bay Control Digital Label Settings

The digital label settings are only available if the designed bay screen has at least one digital label. When QuickSet detects one or more digital labels as part of the bay screen, it populates the corresponding settings. The SEL-710-5 supports as many as 32 digital labels. Set DLAB*qq* (*qq* = 01–32) to display the desired Relay Word bits on the bay screen. Refer to *Table L.1* for the list of Relay Word bits available to program into digital labels.

Bay Screen Builder Software

NOTE: Refer to the Product Literature CD for a list of UTF-8 characters that can be rendered on the bay screen in Bay Screen Builder.

The Bay Screen Builder Software provides an intuitive and powerful interface to design bay screens to meet your application needs. This instruction manual provides only a brief overview of the Bay Screen Builder Software. For more details, refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual* available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com.

Several of the settings identified in *Table 9.7* are available for you to set depending on the symbols chosen for your single-line diagram. *Figure 9.10* shows the layout of Bay Screen Builder and identifies different menus, panes, and information.

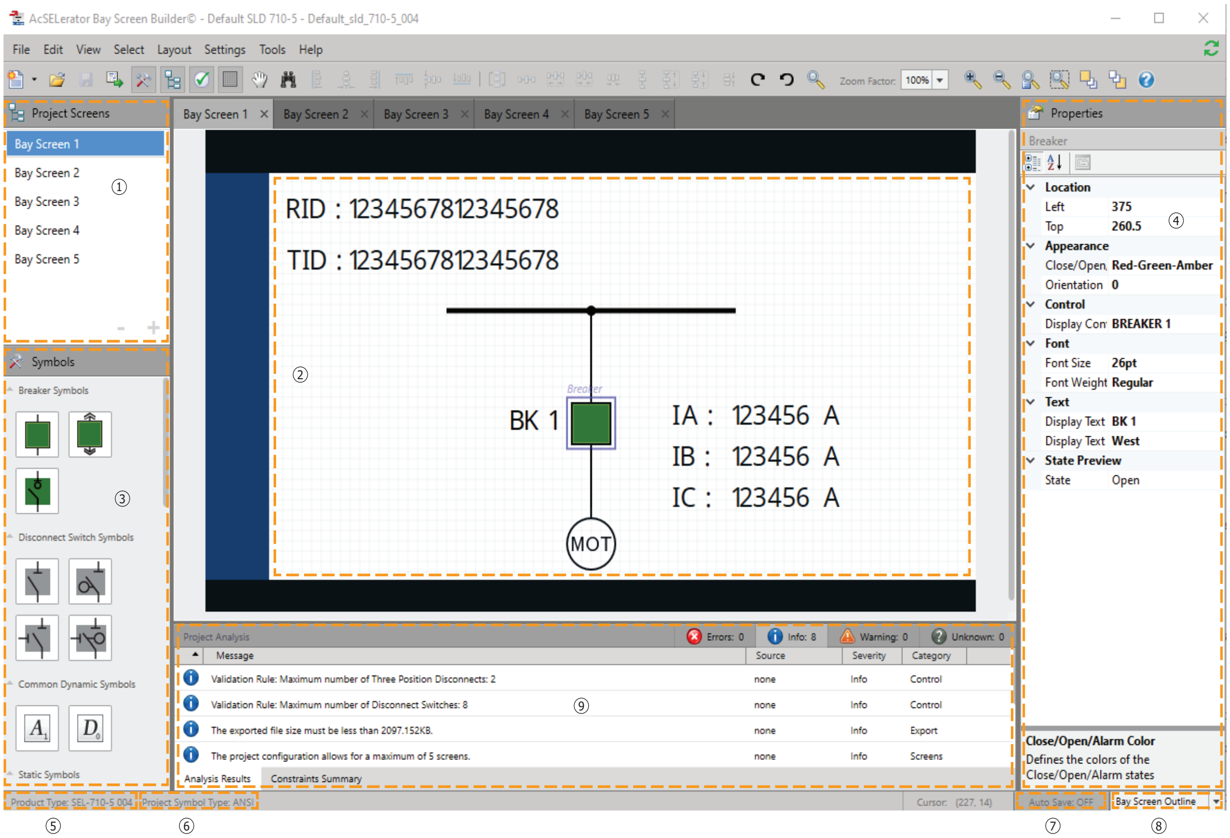


Figure 9.10 Layout of Bay Screen Builder

Descriptions of the different menus, panes, and information in Bay Screen Builder are as follows:

① **Project Screens Pane:** Displays the names of the screens (as many as 5) present in a project. Click a screen name to open the screen, and double-click or right-click a screen name to access additional options for that screen.

② **Screen Area:** Displays the selected project screen and its symbols. Create a single-line diagram or a metering or status screen by dragging and dropping symbols from the **Symbols** pane.

③ **Symbols Pane:** Displays the symbols available for selection. Bay Screen Builder supports several static and a limited number of dynamic ANSI and IEC symbols. Note that for a given project, you can only use either ANSI *or* IEC symbols, not both. While there are no constraints on the number of static symbols, Bay Screen Builder limits the number of dynamic symbols. The following table provides the number of breakers, disconnects, analog labels, and digital labels supported in a given project.

Symbols	Number of Supported Symbols per Project
Breakers	1
Two-Position Disconnects	8
Three-Position Disconnects	2
Analog Labels	32
Digital Labels	32

④ **Properties Pane:** Displays the properties of a selected symbol. Edit the symbol properties as needed for your application. For instance, the breaker color sequence property identified in *Table 9.1* can be set via the appearance property of the breaker symbol (refer to *Edit Symbol Properties on page 9.22*). Bay Screen Builder supports UTF-8 character encoding. Refer to the Product Literature CD for a complete list of UTF-8 characters that can be rendered on the touchscreen display.

⑤ **Product Type:** Displays the name of the QuickSet driver version of the product associated with the selected project (e.g., SEL-710-5 003, as shown in *Figure 9.10*). Select the product type in Bay Screen Builder when you create a new project independent of QuickSet. View **Product Type** though **Settings** > **Project Settings**. If a project is edited via QuickSet, Bay Screen Builder inherits the product type from the QuickSet settings file.

⑥ **Project Symbol Type:** Displays the symbol type (IEC or ANSI) associated with the selected project as shown in *Figure 9.10*. Select the symbol type when you create a new project. If a project is edited via QuickSet, the ANSI symbol type is selected by default.

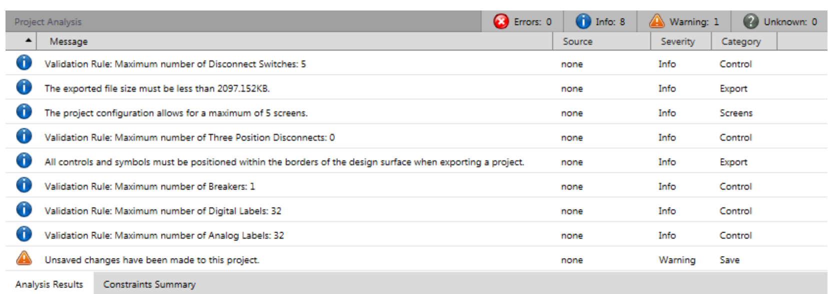
⑦ **Auto Save:** Provides a shortcut for changing the auto save setting for the application. Enable **Auto Save** to allow Bay Screen Builder to automatically save your project periodically. Your auto save setting preference is saved when you exit the application and is applied the next time you launch Bay Screen Builder. You can also set **Auto Save** through **Settings** > **Application Settings** > **File Handling**.

⑧ **Bay Screen Outline:** Displays the drop-down list of symbols on the presently open screen. Click a symbol from the list to make it active. The bay screen outline provides an alternate way to select the symbols and is most useful in cases where symbols are crowded or stacked.

⑨ **Project Analysis Pane:** Displays troubleshooting information/ messages about the project (Errors, Info, Warning, Unknown). The project analysis pane supports two tabs: **Analysis Results** and **Constraints Summary**, as shown in *Figure 9.9* and *Figure 9.10*, respectively.

The **Analysis Results** tab displays details about the error, information, warning, and unknown messages for the project. You can use these messages for troubleshooting. Select a message type button to view the messages for that category. For example, click the **Errors** button to view the error messages for the project. Click a column header to sort by the information in that column (see *Figure 9.11*).

The **Constraints Summary** tab provides information about the rules that apply to the present project. All conditions listed under **Symbol Constraints** must be satisfied for a project to be valid. You can only publish a valid project, but you can save a project with errors (see *Figure 9.12*).



Message	Source	Severity	Category
Validation Rule: Maximum number of Disconnect Switches: 5	none	Info	Control
The exported file size must be less than 2097.152KB.	none	Info	Export
The project configuration allows for a maximum of 5 screens.	none	Info	Screens
Validation Rule: Maximum number of Three Position Disconnects: 0	none	Info	Control
All controls and symbols must be positioned within the borders of the design surface when exporting a project.	none	Info	Export
Validation Rule: Maximum number of Breakers: 1	none	Info	Control
Validation Rule: Maximum number of Digital Labels: 32	none	Info	Control
Validation Rule: Maximum number of Analog Labels: 32	none	Info	Control
Unsaved changes have been made to this project.	none	Warning	Save

Figure 9.11 Project Analysis Pane: Analysis Results Tab

NOTE: The **Constraints Summary** tab shows the usage and limits of dynamic symbols for an entire project (all screens). Although not constrained, it is recommended that you limit the dynamic symbols to 32 symbols per screen for faster screen updates.

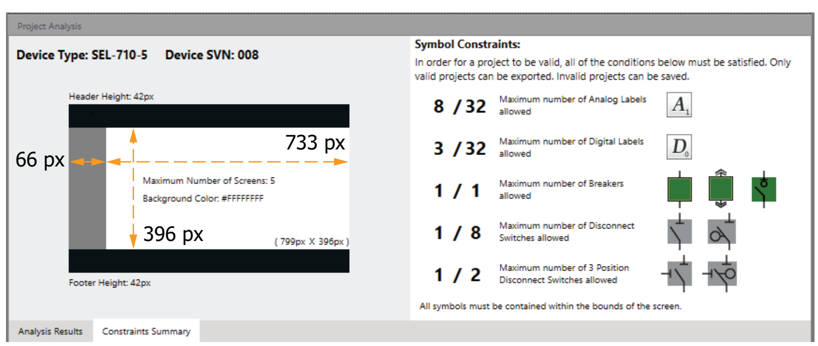


Figure 9.12 Project Analysis Pane: Constraints Summary Tab

You can adjust the size of the panes in the application. If you reconfigure the size of any of these panes, the new size is saved when you exit the application and applies the next time you launch Bay Screen Builder.

Bay Control Application Example

Specific components of bay screens are covered in *Bay Screens Design Using QuickSet and Bay Screen Builder*. This section provides a summarized application example tying all the components together. Refer to the *ACSELERATOR Bay Screen Builder SEL-5036 Software Instruction Manual*, available from the **Help** > **Contents** menu in Bay Screen Builder or at selinc.com, for more specific details regarding bay screen creation and symbol properties.

The SEL-710-5 supports as many as five custom screens. You can edit the predefined bay screen (Bay Screen 1) and the blank screens (Bay Screen 2, Bay Screen 3, Bay Screen 4, Bay Screen 5) (see *Figure 9.15*). You can also import one of the six predefined bay control single-line diagrams from the SEL-710-5 Product Literature CD. Refer to *Predefined Bay Control Single-Line Diagrams on page 9.28* for more details.

Consider if you were to create the single-line diagram shown in *Figure 9.13* as part of your application. Use the following step-by-step approach to design the single-line diagram beginning with the predefined bay screen (Bay Screen 1).

Before creating your own diagram, ensure that the number of dynamic symbols in your schematic does not exceed the number allowed by the SEL-710-5 (see *Figure 9.10* and the symbols pane description).

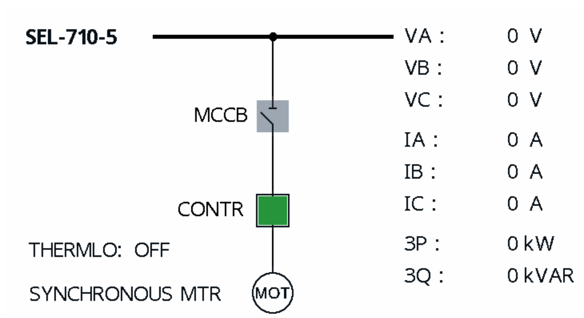


Figure 9.13 Bay Control Single-Line Diagram Schematic

Configure QuickSet for Bay Screen Builder

NOTE: The touchscreen display option is only available for SEL-710-5 QuickSet drivers 003 and higher.

To use QuickSet and Bay Screen Builder to create bay screens for the SEL-710-5, your relay must have the touchscreen MOT configuration (an "A" or "B" in the 18th place of the part number). When your relay is configured for the touchscreen option, perform the following steps to configure QuickSet to work with Bay Screen Builder.

Step 1. Create an SEL-710-5 settings file configured for the touchscreen display. Use the **Front-Panel Options** drop down to select the touchscreen option (see *Figure 9.14*).

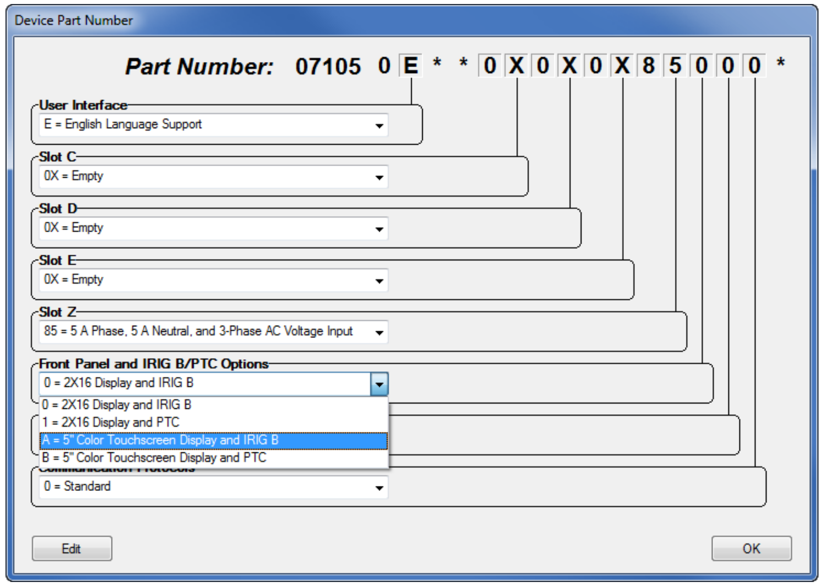


Figure 9.14 Device Part Number Touchscreen Configuration Option

Step 2. Click **OK**.

Step 3. Expand the **Touchscreen** settings class.

Step 4. Click **Bay Control**.

QuickSet displays project management buttons and a project preview that includes a small-scale view of five project screens (one screen with a predefined single-line diagram and four blank screens) and an enlarged view of the predefined single-line diagram, which is selected by default (see *Figure 9.15*).

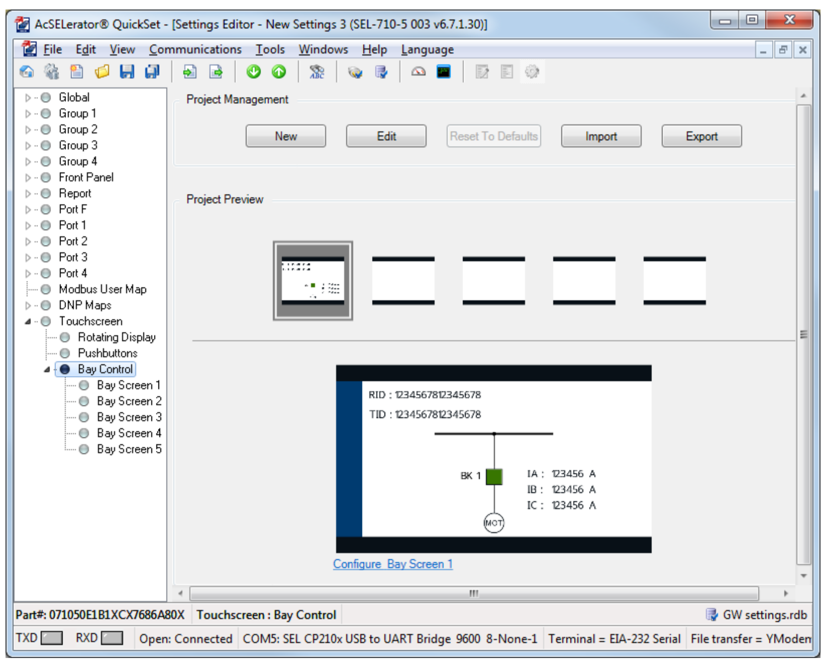


Figure 9.15 QuickSet Bay Control Project Management and Project Preview Display

Build Single-Line Diagrams in Bay Screen Builder

Use Bay Screen Builder to create single-line diagrams to load onto the SEL-710-5 Relay through QuickSet. To create the single-line diagram shown in *Figure 9.13*, perform the following steps.

Step 1. Select the screen with the predefined single-line diagram shown in *Figure 9.16* as a starting point for your single-line diagram.

Step 2. Click the **Edit** button (*Figure 9.16*) to open the screen with the predefined single-line diagram in Bay Screen Builder.

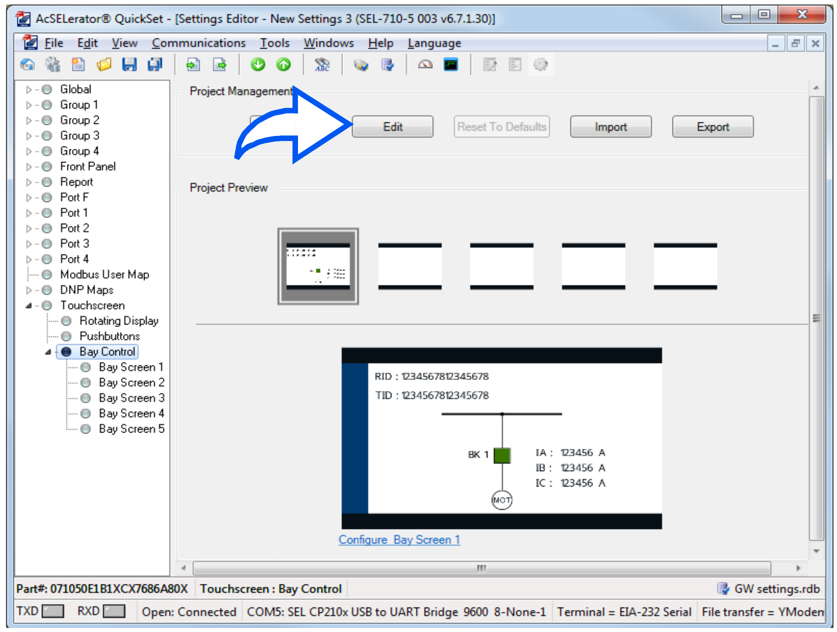


Figure 9.16 Open Single-Line Diagram in Bay Screen Builder

Step 3. Drag-and-drop the additional symbols required for your single-line diagram onto the screen area from the **Symbols** pane (see *Figure 9.17*). Remove the unused labels (RID/TID).

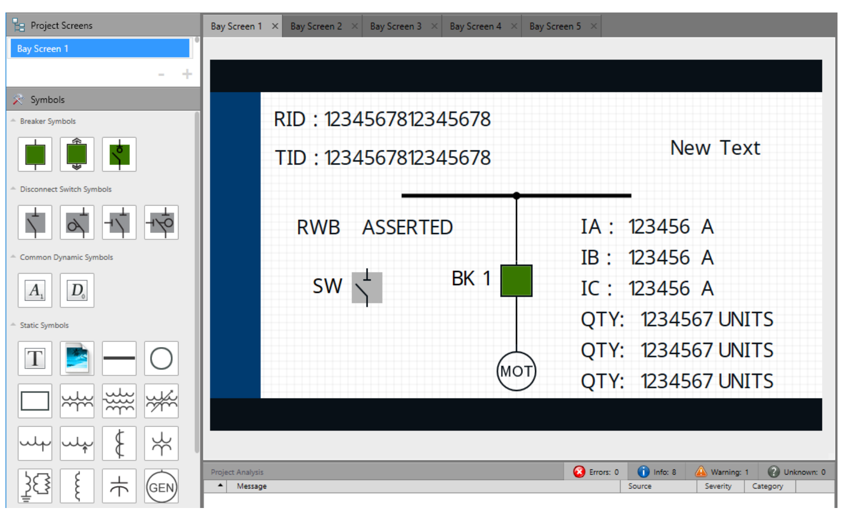
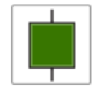
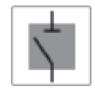
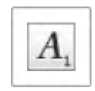
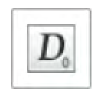
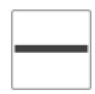


Figure 9.17 Drag-and-Drop Symbols

Table 9.8 lists the number of each symbol required to draw the single-line diagram shown in *Figure 9.13*.

Table 9.8 Symbols Required for the Single-Line Diagram Schematic in Figure 9.13

Symbols Required	Number of Symbols Required	Symbol
Breaker	1	
Disconnect	1	
Motor	1	
Analog labels (display voltages, currents, and power)	8	
Digital label (display thermal lockout ON or OFF)	1	
Text boxes (identify the relay, motor name)	2	
Line (draw the bus and connections)	As Needed	

Edit Symbol Properties

All of the symbols in Bay Screen Builder include editable properties. These properties allow you to customize the symbols to your specific application. These properties appear in the right **Properties** pane of Bay Screen Builder either when you drag a symbol from the left **Symbols** pane and drop it in the screen area or when a symbol in the screen area is selected.

For example, you can use the **Close/Open/Alarm Color** property in the **Appearance** tab of the breaker properties to select a color scheme for your single-line diagram breaker.

Step 1. Select the existing breaker symbol in the predefined single-line diagram to display the breaker symbol properties in the **Properties** pane, as shown in *Figure 9.18*.

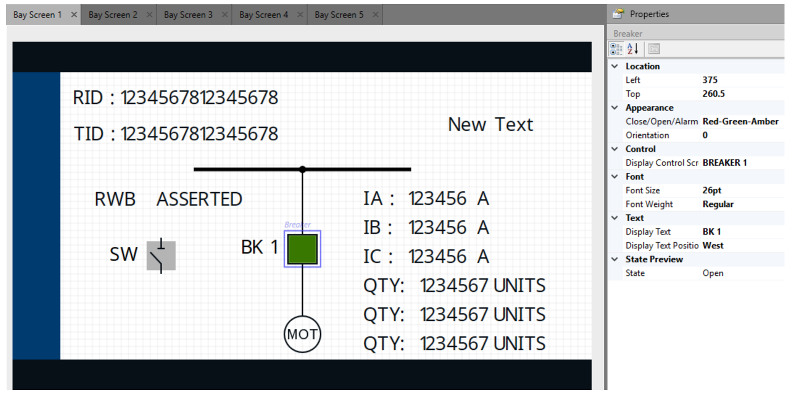


Figure 9.18 Selected Breaker Symbol Settings Displayed in the Properties Pane

Step 2. Select a color option from the drop down menu to edit the **Close/Open/Alarm Color** property in the **Appearance** tab (see *Figure 9.19*).

Table 9.1 lists the available options and breaker appearance in each state based on the selected property.

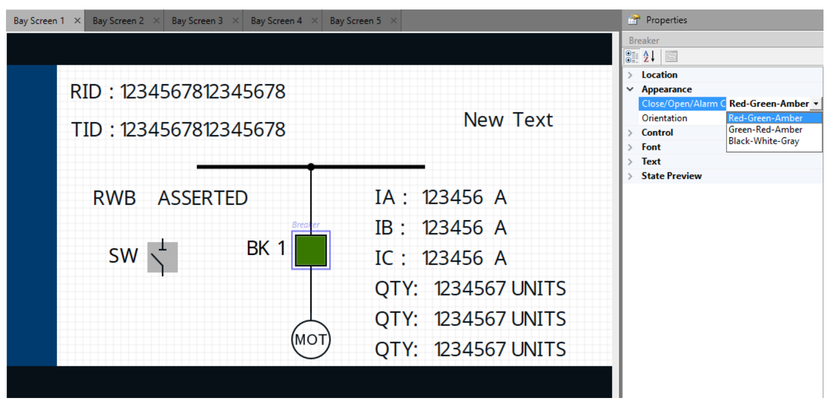


Figure 9.19 Close/Open/Alarm Color Property Drop Down Menu

Step 3. Use the **State Preview** tab to view your breaker close, open, and alarm state color selections.

Step 4. Edit the additional properties as needed for your application.

NOTE: If sufficient width is not provided for the value field of the analog label it will be rendered as '$$$$$'.

NOTE: The assignment of breaker Relay Word bits (e.g., 52A, 52B) to breaker symbols, or analog quantities (e.g., VA_MAG) to analog labels, cannot be made in Bay Screen Builder. These assignments can only be made in QuickSet.

Select and edit the disconnect, dynamic labels (analog and digital labels), and static symbols, similar to the breaker symbol. Note that some of the symbols have the **Text** tab that can be edited for custom labeling.

In this example, only **Bay Screen 1** has been modified in the project. You can also modify the other screens to add analog/digital labels to monitor the status of the quantities, if necessary. Publish the project using the following process after saving your edits.

Publish Bay Screen Builder Project

When you have completed your single-line diagram in Bay Screen Builder, you are ready to publish your project to QuickSet.

Step 1. Click **Save Project** in the **File** menu to save your project.

Step 2. Click **Publish Package** in the **File** menu to publish your project (see *Figure 9.20*). Bay Screen Builder exports the project into QuickSet.

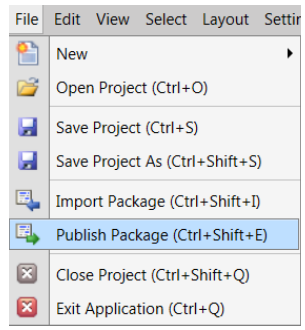


Figure 9.20 Publish Bay Screen Builder Project to QuickSet

Step 3. Allow a few seconds for Bay Screen Builder to publish the project to QuickSet. Respond to the QuickSet prompt, if presented. QuickSet then populates the settings of the updated single-line diagram (see *Figure 9.21*).

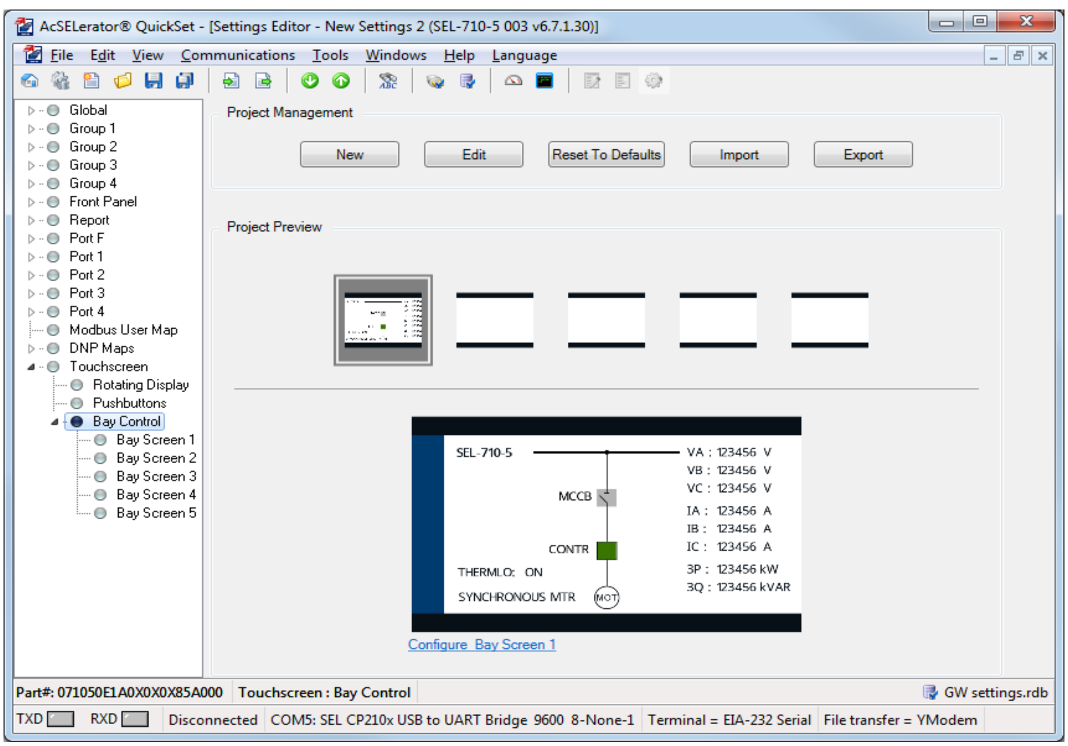


Figure 9.21 QuickSet Updated Single-Line Diagram and Corresponding Settings

Enter QuickSet Settings

The breaker, disconnect, analog and digital label, local/remote, and trip and close settings that follow are the settings applicable to the single-line diagram shown in *Figure 9.13*.

Breaker Settings

NOTE: The relay does not support dual-point breaker status (see Bay Control Breaker Settings) and uses the 52A Relay Word bit as the state of the breaker in several of the protection elements, including trip and close logic. If you intend to indicate dual-point status on the bay control single-line diagram, make use of SELOGIC to program this logic similar to the one shown in Figure 9.1.

For *Figure 9.13*, assume the breaker auxiliary contacts 52A and 52B are wired to digital inputs IN101 and IN102, respectively. SELOGIC settings SV01–SV03 are programmed to create dual-point breaker status with alarm to mimic the logic shown in *Figure 9.1*. Breaker settings are included in more than one settings class in QuickSet (**Set 1** and **Logic 1** in **Group**, **Bay Control**). Enter the following settings:

Setting	Example Setting	Comment
Group 1 > Set 1 > Trip and Close Logic		
52A	IN101	
52B	IN102	
Group 1 > Logic 1 > SELOGIC Variables and Timers		
SV01	(52A AND 52B) OR (NOT 52A AND NOT 52B)	(XNOR gate)
SV01PU	0.5	Set pickup time to indicate alarm for undetermined breaker state
SV01DO	0.0	
SV02	NOT SV01 AND 52A	Indicates breaker close status when asserted
SV02PU	0.0	
SV02DO	0.0	
SV03	NOT SV01 AND 52B	Indicates breaker open status when asserted
SV03PU	0.0	
SV03DO	0.0	
Touchscreen > Bay Control > Bay Screen 1		
Breaker Mode	CONTROL	Controllable breaker
Breaker Close Status	SV02T	
Breaker Open Status	SV03T	
Breaker Alarm Status	SV01T	
Breaker HMI Close Command[a]	STR	
Breaker HMI Open Command[a]	STOP	

[a] Settings are forced to STR and STOP, respectively, and are not available to be set.

Disconnect Settings

For this example, the relay has an 8 DI card in Slot C. Also, the disconnect auxiliary contacts 89A and 89B for the disconnect are wired to digital inputs IN301 and disconnect settings are included in more than one settings class in QuickSet (**Global**, **Bay Control**). Enter the following settings:

Setting	Example Setting	Comment
Global > Two-Position Disconnect Settings		
89A2P1	IN301	Disconnect 1, A contact
89B2P1	IN302	Disconnect 1, B contact

Setting	Example Setting	Comment
Touchscreen > Bay Control > Bay Screen 1		
Two-position disconnect close status	89CL2P1	Switch MCCB
Two-position disconnect open status	89OP2P1	
Two-position disconnect in-progress status	89IP2P1	
Two-position disconnect alarm status	89AL2P1	
Two-position disconnect HMI close command	89CM2P1	
Two-position disconnect HMI open command	89OM2P1	

Analog Label Settings

Enter the following **Bay Control**, **Bay Screen 1** settings:

Setting	Example Setting
VA	VA_MAG
VB	VB_MAG
VC	VC_MAG
IA	IA_MAG
IB	IB_MAG
IC	IC_MAG
3P	P
3Q	Q

Digital Label Settings

As shown in *Figure 9.13*, monitor the thermal lockout status of the motor by entering the following **Bay Control, Bay Screen 1** setting:

Setting	Example Setting	Comment
THERMLO	THERMLO	Thermal lockout active/deactive

Local/Remote Control Setting

The schematic shown in *Figure 9.13* is programmed with the local/remote functionality.

Enter the following **Global**, **Control Configuration** setting:

Setting	Example Setting	Comment
EN_LRC	Y	Enable local/remote control

Application With Handheld Local Remote Breaker Control Switch

Assume that the handheld local remote breaker control switch status is wired to IN304 of the relay. In this particular application, when IN304 is asserted, it implies that the motor control is in LOCAL mode (or SCADA is cut off).

Enter the following **Global**, **Control Configuration** setting:

Setting	Example Setting	Comment
LOCAL	IN304	Local/remote control selection

Application Without Handheld Local Remote Motor Control Switch

Assume that no handheld local remote motor control switch is available. In such case you can program one of the programmable pushbuttons (e.g., PB05) in conjunction with SELOGIC to switch the motor control between local and remote. Enter the following settings:

Setting	Example Setting	Comment
Group 1 > Logic 1 > SELOGIC Variables and Timers		
ELAT	1	
SET01	PB05_PUL AND NOT LT01	Local when LT01 is asserted
RST01	PB05_PUL AND LT01	Remote when LT01 is deasserted
Front Panel[a]		
PB5ALEDC	GO	
PB5A_LED	LT01	
PB5BLEDC	GO	
PB5B_LED	NOT LT01	
Global > Control Configuration		
LOCAL	LT01	

[a] Use configurable labels to assign PB5A LED to LOCAL and PB5B LED to REMOTE.

Send all active settings to the relay.

To view the designed bay control single-line diagram on the touchscreen display, perform the following steps:

Step 1. Navigate to the **Home** screen.

Step 2. Select the **Bay Screens** application.

Step 3. Use the **Up** and **Down** arrows to view your screens.

With all the previous settings applied to the relay, you have a bay control single-line diagram that provides the status of the breaker and disconnect and provides you with the ability to perform motor control via the touchscreen, as shown in *Figure 9.22*. In addition, you have the ability to monitor the voltages at the bus, the flow of currents and power through the breaker, and the status of the motor thermal lockout.

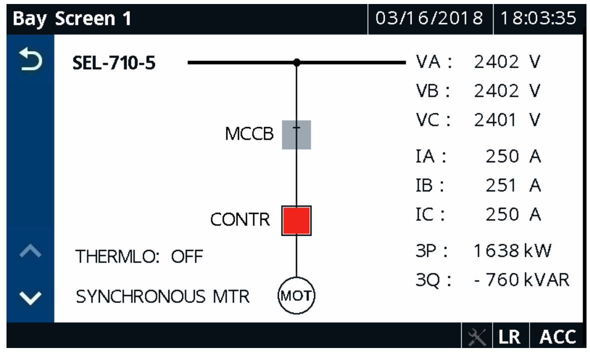


Figure 9.22 Final Bay Screen Builder Rendering

Export/Import Bay Screen Builder Project File

If you plan to use the same Bay Screen Builder project file (*.ldme) across multiple relays, export the file as shown in *Figure 9.23* and save the file to import it to another relay. The *.ldme file does not save the settings associated with the bay control symbols.

Alternately, QuickSet allows you to save the Bay Screen as well as all of the corresponding analog and digital quantities settings (**Tools** > **Settings** > **Export** > **Touchscreen**).

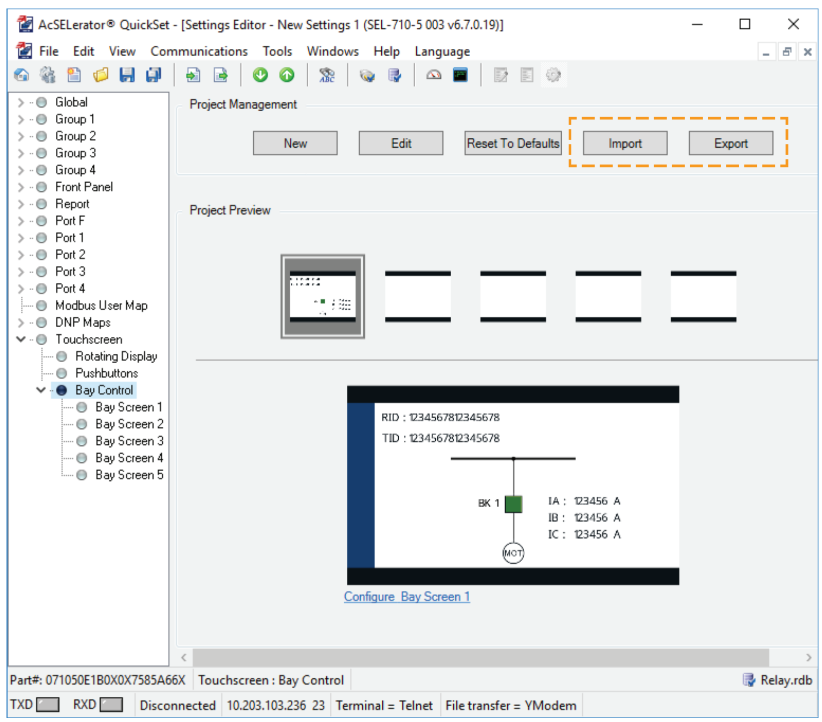


Figure 9.23 Import/Export of the Bay Control Screen in QuickSet

Reset to Defaults

Click **Reset to Defaults** in the QuickSet **Project Management** section to restore the default project in QuickSet.

Predefined Bay Control Single-Line Diagrams

Bay Screen Builder provides the ability to design bay control single-line diagrams. The following predefined single-line diagrams are available on the instruction manual CD. You can use them as is or edit them to fit your specific application. Any one of the following single-line diagrams can be imported into Bay Screen Builder in place of the existing predefined single-line diagram. Use the **Import** button in the **Project Management** area of QuickSet to import one of the screens provided on the instruction manual CD.

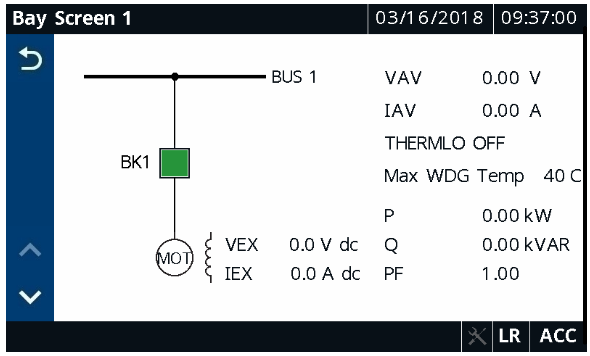


Figure 9.24 ANSI Synchronous Motor Single-Line Diagram

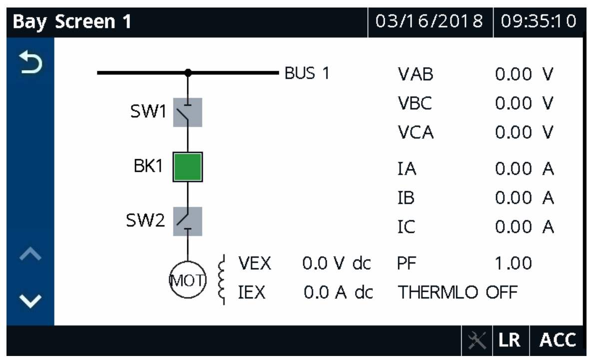


Figure 9.25 ANSI Synchronous Motor with Disconnects Single-Line Diagram

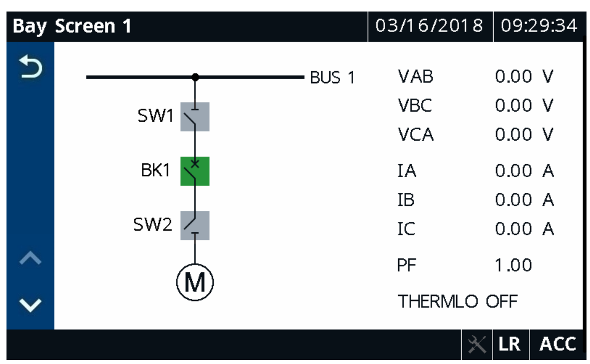


Figure 9.26 IEC Induction Motor with Disconnects Single-Line Diagram

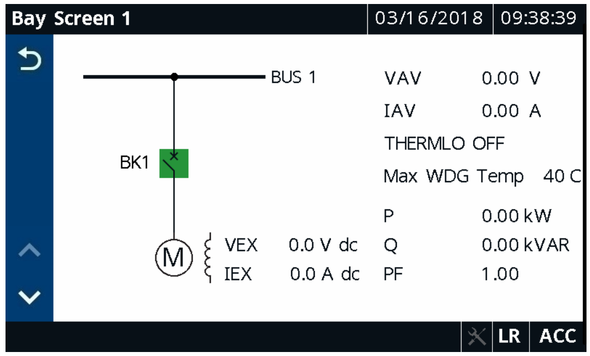


Figure 9.27 IEC Synchronous Motor Single-Line Diagram

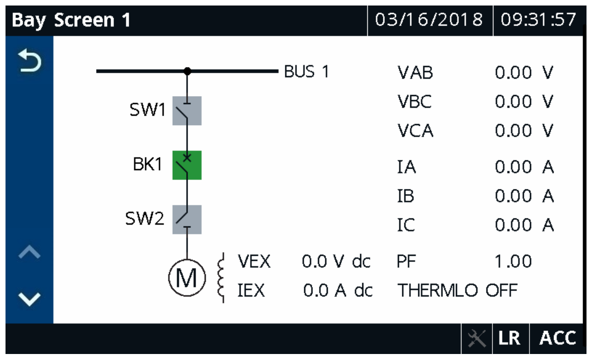


Figure 9.28 IEC Synchronous Motor with Disconnects Single-Line Diagram

Section 10
Analyzing Events

Overview

The SEL-710-5 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-710-5 does not result in lost data. The SEL-710-5 offers four types of event reports: Standard ASCII (EVE) reports, Compressed ASCII (CEV) reports, Binary Comtrade reports, and Sequential Event Recorder (SER) reports.

Event Reporting

NOTE: Arc-flash sensor light values and frequency are available only in Compressed ASCII event reports (CEV or CEV R commands).

Analyze events with the following event reporting functions:

- Event Summaries—Enable automatic messaging to allow the relay to send event summaries out a serial port when port setting AUTO := Y. A summary provides a quick overview of an event. You can also retrieve the summaries by using the **SUMMARY** command.
- Event History—The relay keeps an index of stored nonvolatile event reports. Use the **HISTORY** command to obtain this index. The index includes some of the event summary information so that you can identify and retrieve the appropriate event report.
- Event Reports—These detailed reports are stored in nonvolatile memory for later retrieval and detailed analysis.

Each time an event occurs, a new summary, history record, and report are created. Event report information includes:

- Date and time of the event
- Individual sample analog inputs (currents and voltages)
- Digital states of selected Relay Word bits (listed in *Table L.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 triggered)
- Relay part number and serial number to identify the relay model type

Compressed Event Reports

The SEL-710-5 provides Compressed ASCII and COMTRADE event reports to facilitate event report storage and display. SEL communications processors and the SEL-5601-2 SYNCHROWAVE Event Software take advantage of the Compressed ASCII and COMTRADE formats. Use the **CHIS** command to display Compressed ASCII event history information. Use the **CSUM** command to display Compressed ASCII event summary information. Use the **CEVENT** command to display Compressed ASCII event reports.

For accurate event report analysis, use the Compressed Event report with raw (unfiltered) data (**CEV R** command). The regular ASCII Event report is useful for a quick check. See *Table C.2* for further information.

Compressed ASCII Event Reports contain all of the Relay Word bits.

Additionally, the SEL-710-5 Compressed Event (**CEV** command) report includes analog channels for the % arc-flash sensor light values and frequency measurements that are not available in the regular ASCII Event (**EVE** command) report.

Sequential Events Recorder (SER)

The SER report captures digital element state changes over time. Settings allow as many as 96 Relay Word bits to be monitored, in addition to the automatically generated triggers for relay power up, settings changes, and the 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 clears all events in memory. Be sure to save critical event data prior to changing the LER setting.

The SEL-710-5 provides selectable event report length (LER) and prefault length (PRE). Event report length is either 15, 64, or 180 cycles. Prefault length is 1–10 cycles for LER = 15, 1–59 cycles for LER = 64, and 1–175 cycles for LER = 180. Prefault length is the first part of the total event report length and precedes the event report triggering point. Changing the PRE setting has no effect on the stored reports. The relay stores as many as nine of the most recent 180-cycle, twenty-three of the most recent 64-cycle, or as many as forty-nine of the most recent 15-cycle event reports in nonvolatile memory. Refer to the **SET R** command in *SET Command (Change Settings) on page 7.64* and *Report Settings (SET R Command) on page SET.71*.

Triggering

The SEL-710-5 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 4.76*. 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 7.64*). When setting ER detects a logical 0 to logical 1 transition, it generates an event report (if the SEL-710-5 is not already generating a report that encompasses the new transition). The factory setting is shown in *Event Report Settings on page 4.163*.

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 7.74* for more information on the **TRI** (Trigger Event Report) command.

Event Summaries

IMPORTANT: Clearing the history report with the **HIS C** or **HIS CA** command clears all event data within the SEL-710-5 event memory.

NOTE: The **HIS CA** command resets the unique event reference number to 10000.

For every triggered event, the relay generates and stores an event summary. The relay stores as many as 49 of the most recent event summaries (if event report length setting LER := 15), as many as 22 (if LER := 64), or as many as 9 (if LER := 180) event summaries. When the relay stores a new event summary, it discards the oldest event and event summary if the event memory is full. Event summaries contain the following information:

- Relay and Terminal Identification (RID and TID)
- Event number, unique event reference number, date, time, event type (see *Table 10.1*), and frequency
- Primary magnitudes of line, neutral and residual currents
- Primary magnitudes of the line-to-neutral voltage and residual voltage (if DELTA_Y := WYE) or phase-to-phase voltages (if DELTA_Y := DELTA)
- Primary magnitudes of differential currents (if Differential Input card is available)
- Hottest RTD temperatures (if SEL-2600 RTD Module or internal RTD card is available)

NOTE: Figure 10.3 is on multiple pages.

The relay includes the event summary in the event report. The identifiers, date, and time information are at the top of the event report, and the remaining information follows at the end, as shown in *Figure 10.3*. The example event summary in *Figure 10.1* corresponds to the standard 15-cycle event report in *Figure 10.3*.

```
=>>SUM <Enter>

SEL-710-5                              Date: 04/30/2002   Time: 22:01:01.592
MOTOR RELAY

Serial No = 000000000000000
FID = SEL-710-5-X211-V0-Z003002-D20180221              CID = 88C2
EVENT LOGS =  6            REF_NUM = 32838

Event:     Trigger
Targets    11010000
Freq (Hz)  60.00

Current Mag
        IA            IB            IC            IN       IG
(A)       0.0           0.0           0.0          0.02     0.06

Voltage Mag
       VAN    VBN    VCN    VG
(V)       0      0      0      0

Differential Current Mag
       IA87     IB87     IC87
(A)      0.00     0.00     0.00

=>>
```

Figure 10.1 Example Event Summary

The relay sends event summaries to all serial ports with setting AUTO := Y each time an event triggers.

Event Logs

The `Event Logs` field shows the number of events presently stored in the Flash memory of the relay

Event Reference Number

The Event Reference Number is a unique event identification number assigned to the event. The unique event identification number of any event can be found by issuing the **HIS** command (see *Viewing the Event History on page 10.7* for details). The Event Reference Number starts at 10000 and increments with each new event to a maximum of 42767. The Event Reference Number rolls over to 10000 after reaching the next event after event 42767. The Event Reference Number can be reset to 10000 by using the **HIS CA** command.

Event Type

The `Event` field displays the event type. Event types and the logic used to determine event types are shown in the order of priority in *Table 10.1*.

Table 10.1 Event Types (Sheet 1 of 3)

Event Type	Event Type Logic
`Arc Flash Trip`	(50PAF + 50NAF) • (TOL1 + TOL2 + TOL3 + TOL4 + TOL5 + TOL6 + TOL7 + TOL8) • TRIP
`Overload Trip`	(49T • RUNNING) • TRIP
`Lockd Rotor Trip`	(49T • STARTING) • TRIP
`Undercurr Trip`	LOSSTRIP • TRIP
`Jam Trip`	JAMTRIP • TRIP
`Curr Imbal Trip`	(46UBT + 50Q1T) • TRIP
`Overcurrent Trip`	50P1T • TRIP

Table 10.1 Event Types (Sheet 2 of 3)

Event Type	Event Type Logic
Ground Flt Trip	(50N1T + 50G1T) • TRIP
Phase A 51 Trip	51AT • TRIP
Phase B 51 Trip	51BT • TRIP
Phase C 51 Trip	51CT • TRIP
Phase 51 Trip	(51P1T + 51P2T) • TRIP
GND 51 Trip	(51G1T + 51G2T) • TRIP
NEG SEQ 51 Trip	(51QT) • TRIP
Speed Sw Trip	SPDSTR • TRIP
Loss of Fld Trip	(40Z1T + 40Z2T) • TRIP
Start Time Trip	SMTRIP • TRIP
87M Diff Trip	(87M1T + 87M2T) • TRIP
Underpower Trip	37PT • TRIP
Pwr Factor Trip	55T • TRIP
React Pwr Trip	VART • TRIP
Phase Rev Trip	47T • TRIP
Underfreq Trip	(81D*n*T • TRIP) when 81D*n*TP < FNOM setting, *n* = 1, 2, 3, or 4
Overfreq Trip	(81D*n*T • TRIP) when 81D*n*TP > FNOM setting, *n* = 1, 2, 3, or 4
RTD Trip	(WDGTRIP + BRGTRIP + AMBTRIP + OTHTRIP) • TRIP
PTC Trip	PTCTRIP • TRIP
Undervolt Trip	(27P1T + 27P2T + 27I1T + 27I2T) • !LOP • TRIP
Overvolt Trip	(59P1T + 59P2T + 59I1T + 59I2T + 59I3T + 59I4T) • TRIP
BRK Failure Trip	BFT • TRIP
Out of Step Trip	OOST • TRIP
Fld UnderC Trip	(FDUC1T) • TRIP
Fld OverC Trip	(FDOC1T) • TRIP
Fld UnderV Trip	(FDUV1T) • TRIP
Fld OverV Trip	(FDOV1T) • TRIP
FldResistnce Trip	(FDRES1T) • TRIP
RTD Fail Trip	RTDFLT • TRIP
PTC Fail Trip	PTCFLT • TRIP
Phase A INC Trip	50INCTA • TRIP
Phase B INC Trip	50INCTB • TRIP
Phase C INC Trip	50INCTC • TRIP
Trigger	Trigger Command
CommIdleLoss Trip	(COMMIDLE + COMMLOSS) • TRIP
Remote Trip	REMTRIP • TRIP
Stop Command	Commanded Stop from serial port or front panel
ER Trigger	ER equation assertion

Table 10.1 Event Types (Sheet 3 of 3)

Event Type	Event Type Logic
`Trip`	TRIP with no known cause
`Trip*`	Upon cycling power on the relay, if **TRIP** LED is latched and no active TRIP exists, or upon expiration of lockout timer display with TRIPONLO := Y.

Currents, Voltages, and RTD Temperatures

The relay determines the maximum cosine-filtered phase current during an event. The instant the maximum cosine-filtered phase current occurs is marked by an asterisk (*) in the event report (see *Figure 10.3*). This row of data corresponds to the analogs shown in the summary report for the event. Further, the relay looks at DI_A, DI_B, DI_C Relay Word bits to determine if the peak detector is active at the trigger point (>) of the event. If active, it shows the peak detector output current in the summary report appended with the "pk" string for the corresponding phase current instead of the maximum cosine-filtered phase current identified by the asterisk (*).

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`)

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 10.2* for a sample event history. Use this report to view the events that are presently stored in the SEL-710-5.

The event history contains the following:

- Standard report header
  - Relay and terminal identification
  - Date and time of report
  - Time source (if IRIG-B model)
- E vent number, unique event reference number, date, time, event type (see *Table 10.1*)
- Maximum motor current
- Frequency
- Target LED status

```
=>>HIS <Enter>

SEL-710-5                              Date: 05/02/2002   Time: 21:43:48.656
MOTOR RELAY                            Time Source: Internal

FID=SEL-710-5-X211-V0-Z003002-D20180221

#      REF        DATE           TIME           EVENT          CURRENT   FREQ     TARGETS
1      32838   04/30/2002    22:01:01.592    Trigger              0.0   60.00    11010000
2      32837   04/25/2002    20:43:37.185    ER Trigger           0.0   60.00    11010000
3      32836   04/25/2002    20:36:26.188    ER Trigger           0.0   60.00    11010000
4      32835   04/25/2002    20:25:01.146    ER Trigger          20.1   60.00    11010000
5      32834   04/18/2002    04:09:02.737    Trigger              0.0   60.00    11010000
6      32833   04/18/2002    04:05:49.034    Trigger              0.0   60.00    11010000
```

Event Number | Reference Number | Event Type | Maximum Current | Frequency | User-Defined Target LEDs

Figure 10.2 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 7.54* for information on the **HIS** command.

Use the front-panel `MAIN > Events > Display Events` menu to display event history data on the SEL-710-5 front-panel display.

Use QuickSet to retrieve the relay event history. View the **Relay Event History** dialog box via the **Tools > Events > Get Event Files** menu.

Clearing

Use the **HIS C** command to clear or reset history data from Access Levels 1 and higher. Clear/reset history data at any communications port. This clears all event summaries, history records, and reports. The **HIS C** command does not reset the unique event reference number. This number continues to increment from the present value with each subsequent event. Use the **HIS CA** command to clear all event data and reset the unique event reference number to 10000.

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 (includes relay model number and serial number in Compressed ASCII event reports)
- ➤ Settings in service at the time of event triggering, 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. See *EVENT Command (Event Reports) on page 7.49* for information on the **EVE** command.

The SEL-710-5 supports two separate event report types (model dependent):

- ➤ Standard Event Report (**EVE** command)
- ➤ Differential Event Report (**EVE DIF** command)

Filtered and Unfiltered Event Reports

The SEL-710-5 samples the power system measurands (ac voltage and ac current) 32 times per power system cycle. A digital filter extracts the fundamental frequency component of the measurands. The relay operates on the filtered values and reports these values in the standard, filtered event report.

To view the raw inputs to the relay, 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.

Standard Event Report (**EVE** Command)

The standard event report includes:

- ➤ Analog values of currents IA, IB, IC, IN, and IG, and voltages VA (VAB), VB (VBC), VC (VCA), VAY (VABY), VBY (VBCY), VCY (VCAY)
- ➤ Digital states of the protection and control elements, including overcurrent and voltage elements, plus status of digital output and input states
- ➤ Event summary
- ➤ Relay settings

Standard Event Report Column Definitions

Refer to the example event report in *Figure 10.3* 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 **SUM** command (see *SUMMARY Command on page 7.71*) to retrieve event summary reports.

Table 10.2 gives the standard event report column definitions for the analog quantities. *Table 10.3* gives the standard event report column definitions for digital elements, including the protection and control elements, and the base model inputs and outputs.

Table 10.2 Standard Event Report Column Definitions for Analogs

Column Heading	Description
IA	Current measured by channel IA (primary A)
IB	Current measured by channel IB (primary A)
IC	Current measured by channel IC (primary A)
IG	Residual current (IA + IB + IC, primary A)
IN	Current measured by channel IN (primary A)
VAN or VAB	Voltage measured by channel VAN or VAB (primary V)
VBN or VBC	Voltage measured by channel VBN or VBC (primary V)
VCN or VCA	Voltage measured by channel VCN or VCA calculated from VAB and VBC (primary V)

Table 10.3 Standard Even Report Column Definitions for Protection, Control, and I/O Elements (Sheet 1 of 2)

Column Heading	Column Symbols	Description
Motor	S R .	STARTING asserted RUNNING asserted STOPPED asserted
Load	J I L	JAMTRIP asserted LOSSALARM AND NOT LOSSTRIP LOSSTRIP
46	A T	46UBA AND NOT 46UBT 46UBT
47	T	47T
49	A T	49A AND NOT 49T 49T
O/C 50P	1 2 b	50P1T AND NOT 50P2T NOT 50P1T AND 50P2T 50P1T AND 50P2T
O/C 50G	1 2 b	50G1T AND NOT 50G2T NOT 50G1T AND 50G2T 50G1T AND 50G2T
O/C 50N	1 2 b	50N1T AND NOT 50N2T NOT 50N1T AND 50N2T 50N1T AND 50N2T
RTD Wdg (SEL-2600 RTD Module or RTD card required)	w W	WDGALRM AND NOT WDGTRIP WDGTRIP

Table 10.3 Standard Even Report Column Definitions for Protection, Control, and I/O Elements (Sheet 2 of 2)

Column Heading	Column Symbols	Description
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 10.3*, indicating the sinusoidal nature of the waveforms.

Other figures help in understanding the information available in the event report current columns:

➤ *Figure 10.4* shows how event report current column data relate to the actual sampled current waveform and rms current values.

➤ *Figure 10.5* shows how event report current column data can be converted to phasor rms current values.

Standard Event Report Example (15-Cycle)

The following example of a standard 15-cycle event report in *Figure 10.3* also corresponds to the example SER report in *Figure 10.11*.

In *Figure 10.3*, 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 10.4* and *Figure 10.5*). These currents are listed at the end of the event report in the event summary. If the trigger row (>) and the maximum phase current row (*) are the same row, the * symbol takes precedence.

```
=>>EVE <Enter>

SEL-710-5                    Date: 03/28/2018   Time: 10:01:04.045
```
Date and Time of Event

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution

```
MOTOR RELAY
Serial Number=123456789047

FID=SEL-710-5-X215-V0-Z003002-D20180319   CID=88C2
```

Firmware Identifier and Firmware Checksum Identifier

```
                                                      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]

 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 .... ... . ..
 -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 .... ... . ..
```

One Cycle of Data

```
[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
[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
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
[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

[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

Serial No = 123456789047
FID = SEL-710-5-X215-V0-Z003002-D20180319              CID = 88C2

EVENT LOGS = 13             REF_NUM = 32845

Event:     ER Trigger
Targets    11010000
Freq (Hz)  59.99

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
PHROT   := ABC     FNOM    := 60      DATE_F  := MDY     METHRES := Y
FAULT   := STARTING OR 50S OR 50G1P OR 50N1P OR TRIP

EBBD    := N       TGR     := 3       SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       BFD     := 0.50    BFI     := R_TRIG TRIP

50PAFP  := OFF
50NAFP  := OFF
AFSENS1 := NONE    AFSENS2 := NONE
AFSENS3 := NONE    AFSENS4 := NONE    AOUTSLOT:= 101_3
EBMON   := Y       COSP1   := 10000   COSP2   := 150     COSP3   := 12
KASP1   := 1.20    KASP2   := 8.00    KASP3   := 20.00   BKMON   := TRIP

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTMOT  := 0


DSABLSET:= 0

89A2P1  := 0
89B2P1  := NOT 89A2P1
89A2P1D := 5.00    89A2P2  := 0
89B2P2  := NOT 89A2P2
89A2P2D := 5.00    89A2P3  := 0
89B2P3  := NOT 89A2P3
89A2P3D := 5.00    89A2P4  := 0
89B2P4  := NOT 89A2P4
89A2P4D := 5.00    89A2P5  := 0
89B2P5  := NOT 89A2P5
89A2P5D := 5.00
EN_LRC  := N       EN_LRC  := N
```

See *Figure 10.4* and *Figure 10.5*

Firmware Identifier and Firmware Checksum Identifier

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
Group Settings
RID     := SEL-710-5
TID     := MOTOR RELAY
CTR1    := 2       FLA1    := 5.0     VFDAPP  := N       E2SPEED := N
CTRN    := 100     PTR     := 35.00   VNOM    := 4160    DELTA_Y := DELTA
SINGLEV := N
E49MOTOR:= Y       FLS     := OFF     SETMETH := RATING_1 49RSTP  := 75
SF      := 1.15    LRA1    := 6.0     LRTHOT1 := 10.0    TD1     := 1.00
RTC1    := AUTO    TCAPU   := 85      TCSTART := OFF     COOLTIME:= 84
COASTIME:= 5

50P1P   := 8.50    50P1D   := 0.01    50P2P   := 8.50    50P2D   := 0.01
50N1P   := OFF     50N2P   := OFF     50G1P   := OFF     50G2P   := OFF
50Q1P   := 3.00    50Q1D   := 0.1     50Q2P   := 0.30    50Q2D   := 0.2

51AP    := OFF
51BP    := OFF
51CP    := OFF     51P1P   := OFF     51P2P   := OFF     51QP    := OFF
51G1P   := OFF
51G2P   := OFF
E87M    := N
LJTPU   := OFF     LJAPU   := OFF
LLTPU   := OFF     LLAPU   := OFF

46UBT   := 20      46UBTD  := 5       46UBA   := 10      46UBAD  := 10
START_T := OFF

ESTAR_D := N
MAXSTART:= OFF     TBSDLY  := OFF     ABSDLY  := OFF
E47T    := Y
SPDSDLYT:= OFF     SPDSDLYA:= OFF     VSSEN   := N
EPTC    := N
E49RTD  := NONE
LOPBLK  := 0
27P1P   := OFF     27P2P   := OFF
59P1P   := 1.10    59P1D   := 0.5     59P2P   := OFF
E27I1   := N       E27I2   := N
E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N
NVARTP  := OFF     PVARTP  := OFF     NVARAP  := OFF     PVARAP  := OFF
E40     := N       E78     := N
37PTP   := OFF     37PAP   := OFF
55LGTP  := OFF     55LDTP  := OFF     55LGAP  := OFF     55LDAP  := OFF
EPFC    := 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       BLK49PTC:= N       BLK49RTD:= N
TDURD   := 0.5
TR      := 50P1T OR 50P2T
REMTRIP := 0
TRIPONLO:= Y       ULTRIP  := 0
52A     := 0
52B     := NOT 52A

STREQ   := RB01
BLKSTR  := STOPPED AND (THERMLO OR NOSLO OR TBSLO OR ABSLO)
EMRSTR  := 0
SPEEDSW := 0
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
Report Settings
SER1    := RB01 RB02 RB03 RB04 RB04 RB06 RB07 RB08
SER2    := STOP STR
SER3    := STOPPED START
SER4    := NA

EALIAS  := 15
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

ER     := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 37PA OR R_TRIG
    55A OR R_TRIG VARA
LER     := 15      PRE     := 5
MSRR    := 5       MSRTRG  := 0

FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA
RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
RA04TYPE:= I
RA05TYPE:= I
RA06TYPE:= I
RA07TYPE:= I
RA08TYPE:= I
RA09TYPE:= I
RA10TYPE:= I
RA11TYPE:= I
RA12TYPE:= I
RA13TYPE:= I
RA14TYPE:= I
RA15TYPE:= I
RA16TYPE:= I
RA17TYPE:= I
RA18TYPE:= I
RA19TYPE:= I
RA20TYPE:= I
RA21TYPE:= I
RA22TYPE:= I
RA23TYPE:= I
RA24TYPE:= I
RA25TYPE:= I
RA26TYPE:= I
RA27TYPE:= I
RA28TYPE:= I
RA29TYPE:= I
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I
LDLIST  := NA LDAR    := 15      LDAR    := 15
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
Logic Settings
ELAT    := N       ESV     := 3       ESC     := N       EMV     := 7
SV01PU  := 0.00    SV01DO  := 0.00
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
SV02PU  := 0.00    SV02DO  := 0.00
SV02    := NA
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := 40Z1T OR 40Z2T OR FDUC1T OR FDOC1T OR FDUV1T OR FDOV1T OR
 FDRES1T OR SV01T OR OOST OR 55T

Math Variables
MV01    := PF
MV02    := NA
MV03    := NA
MV04    := NA
MV05    := NA
MV06    := NA
MV07    := NA

OUT101FS:= Y       OUT101  := HALARM OR SALARM OR AFALARM
OUT102FS:= N       OUT102  := START
OUT103FS:= Y       OUT103  := TRIP OR PB04
OUT401FS:= N       OUT401  := 0
OUT402FS:= N       OUT402  := 0
OUT403FS:= N       OUT403  := 0
OUT404FS:= N       OUT404  := 0

=>>
```

Figure 10.3 Example Standard 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

Figure 10.4 and *Figure 10.5* look in detail at one cycle of A-phase current (channel IA) identified in *Figure 10.3*. *Figure 10.4* shows how the event report ac current column data relate to the actual sampled waveform and rms values. *Figure 10.5* shows how the event report current column data can be converted to phasor rms values. Voltages are processed similarly.

In *Figure 10.4*, note that any two rows of current data from the event report in *Figure 10.3*, 1/4 cycle apart, can be used to calculate rms current values.

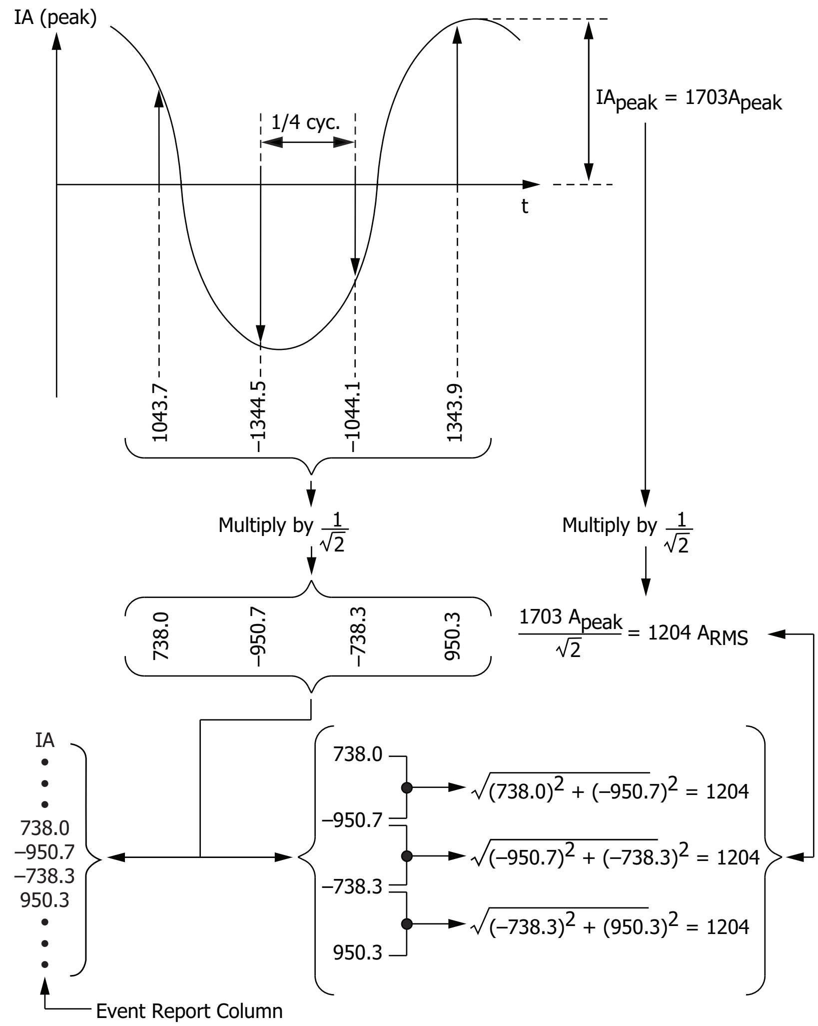


Figure 10.4 Derivation of Event Report Current Values and RMS Current Values From Sampled Current Waveform

In *Figure 10.5*, note that two rows of current data from the event report in *Figure 10.3*, 1/4 cycle apart, can be used to calculate phasor rms current values. In *Figure 10.5*, at the present sample, the phasor rms current value is:

$$IA = 1204\ A\ \angle{-37.8°} \qquad \textbf{Equation 10.1}$$

The present sample (IA = 940.7 A) is a real rms current value that relates to the phasor rms current value:

$$1204\ A \bullet \cos(-37.8°) = 950.7\ A \qquad \textbf{Equation 10.2}$$

NOTE: The arctan function of many calculators and computing programs does not return the correct angle for the second and third quadrants (when X is negative). When in doubt, graph the X and Y quantities to confirm that the angle that your calculator reports is correct.

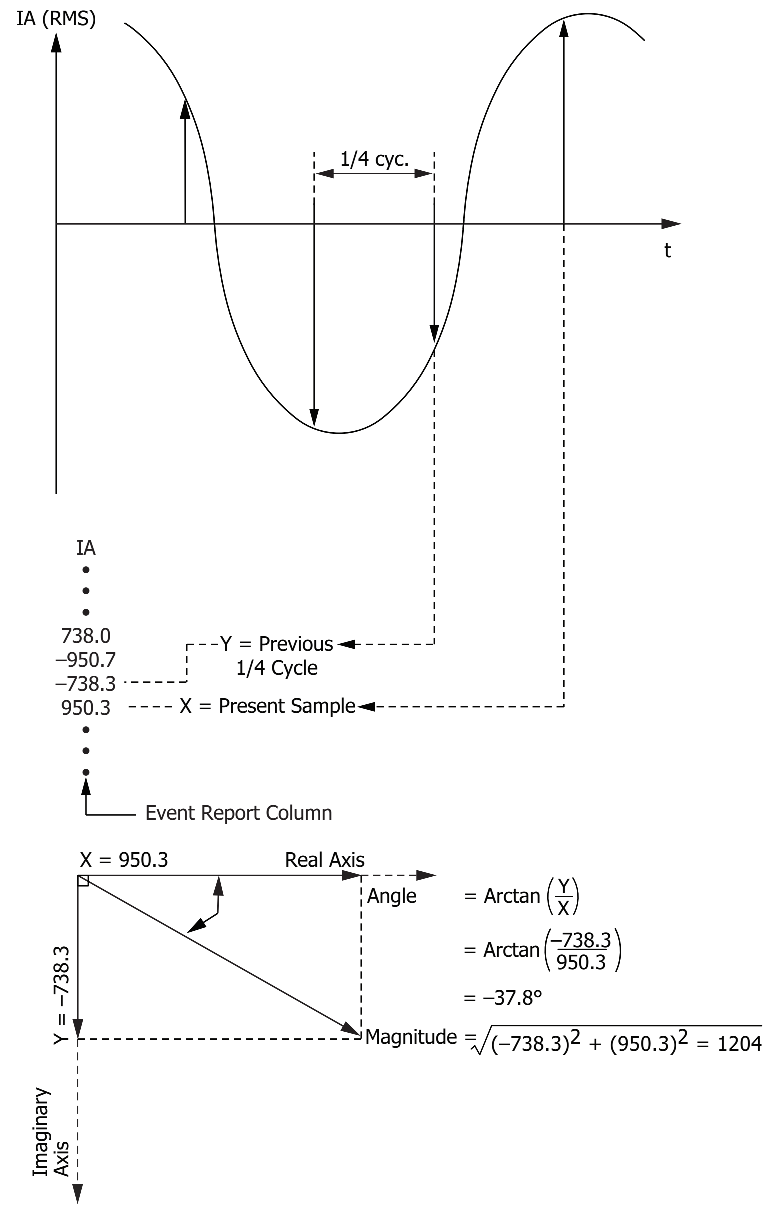


Figure 10.5 Derivation of Phasor RMS Current Values From Event Report Current Values

Differential Event Report (**EVE DIF** Command)

Use the **EVE DIF** command to retrieve a differential event report, which includes:

- Analog values of currents IA, IB, IC, IN, and IG, and differential currents IA87, IB87, and IC87
- Digital states of the differential elements, plus status of the base model digital inputs and outputs
- Event summary
- Relay Settings

Use the **EVE DIF *n*** command to view the normal differential report with 4 samples/cycle for report *n* (if not listed, *n* is assumed to be 1). This command is only available in models with the differential element.

Differential Event Reports Column Definitions

Refer to the example event report in *Table 10.6* to view the differential event report columns. This example differential event report displays rows of information each 1/4 cycle. Retrieve this report with the **EVE DIF** command.

Table 10.4 gives the differential event report column definitions for the analog quantities. *Table 10.5* gives the differential event report column definitions for digital elements, including the differential elements and the base model inputs and outputs.

Table 10.4 Differential Event Report Column Definitions for the Analog Quantities

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)
IN	Current measured by channel IN (primary A)
IG	Residual current (IA + IB + IC, 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)

Table 10.5 Differential Event Report Digital Column Definitions for Differential and I/O Elements

Column Heading	Column Symbols	Description
87MTC	1	87M1TC AND NOT 87M2TC
	2	87M2TC AND NOT 87M1TC
	b	87M1TC AND 87M2TC
87M	1	87M1T AND NOT 87M2T
	2	87M2T AND NOT 87M1T
	b	87M1T AND 87M2T
In 12	1	IN101 AND NOT IN102
	2	NOT IN101 AND IN102
	b	IN101 AND IN102
OUT 12	1	OUT101 AND NOT 0UT102
	2	NOT OUT101 AND OUT102
	b	OUT101 AND OUT102
OUT 3	3	OUT103

Differential Event Report Example (15-Cycle)

```
=>>eve dif

SEL-710-5                          Date: 04/10/2018   Time: 13:16:30.081

MOTOR RELAY
Serial Number=123456789047

FID=SEL-710-5-X218-V0-Z003002-D20180406    CID=812D
```

Date and Time of Event

Firmware Identifier and Firmware Checksum Identifier

Figure 10.6 Example Differential 15-Cycle Event Report 1/4-Cycle Resolution

```
                                                              8     O
                                                              7   I u
                                                              M 8 n t
       Currents (A Pri)                Differential (A Pri)   T 7 1 13
    IA     IB     IC     IN     IG    IA87   IB87   IC87      C M 2 2
 [1]
   -5.4  -17.2   27.2   -0.0    4.6   -0.0    0.5    0.0      1 . . ..
  -21.4   16.9    7.2    0.0    2.7   -0.0   -0.1   -0.0      1 . . ..
    5.4   17.2  -27.2    0.0   -4.6    0.0   -0.4   -0.0      1 . . ..
   21.4  -16.9   -7.2   -0.0   -2.8    0.0    0.5    0.0      1 . . ..

 [2]
   -5.4  -17.2   27.2   -0.0    4.6   -0.0    0.2   -0.0      1 . . ..
  -21.4   16.9    7.2   -0.0    2.7    0.0   -0.7   -0.0      1 . . ..
    5.4   17.2  -27.2    0.0   -4.6   -0.0    0.1    0.0      1 . . ..
   21.4  -16.9   -7.2    0.0   -2.8   -0.0    0.0   -0.1      1 . . ..

 [3]
   -5.5  -17.1   27.2   -0.0    4.6    0.0   -0.3   -0.0      1 . . ..
  -21.4   16.9    7.2   -0.0    2.7    0.0    0.6    0.0      1 . . ..
    5.5   17.1  -27.2    0.0   -4.6   -0.0   -0.1    0.0      1 . . ..
   21.4  -16.9   -7.2    0.0   -2.8    0.0   -0.5   -0.1      1 . . ..
 [4]
   -5.5  -17.1   27.2   -0.0    4.6    0.0    0.4    0.0      1 . . ..
  -21.4   16.9    7.2   -0.0    2.7   -0.0    0.3    0.0      1 . . ..
    5.5   17.1  -27.2    0.0   -4.6    0.0   -0.5   -0.0*     1 . . ..
   21.4  -17.0   -7.2    0.0   -2.7    0.0   -0.1   -0.0      1 . . ..
 [5]
   -5.5  -17.1   27.2   -0.0    4.6   -0.1    0.4    0.0      1 . . ..
  -21.4   17.0    7.1    0.0    2.7   -0.0   -0.4   -0.0      1 . . ..
    5.5   17.1  -27.2    0.0   -4.6    0.0    0.0    0.0      1 . . ..
   21.3  -17.0   -7.1   -0.0   -2.7    0.0    0.3    0.0>     1 . . ..
 [6]
   -5.5  -17.1   27.2   -0.0    4.6   -0.0   -0.6   -0.1      1 . . ..
  -21.3   17.0    7.1    0.0    2.7   -0.0    0.0    0.0      1 . . ..
    5.5   17.1  -27.2    0.0   -4.6   -0.0    0.6    0.0      1 . . ..
   21.3  -17.0   -7.1    0.0   -2.7   -0.0   -0.4   -0.0      1 . . ..
 [7]
   -5.5  -17.1   27.2   -0.0    4.6    0.0   -0.2   -0.0      1 . . ..
  -21.4   17.0    7.0   -0.0    2.7   -0.0    0.0    0.0      1 . . ..
    5.5   17.1  -27.2    0.0   -4.6   -0.0   -0.4   -0.0      1 . . ..
   21.3  -17.0   -7.0    0.0   -2.7    0.0    0.1    0.0      1 . . ..

 [8]
   -5.6  -17.1   27.2   -0.0    4.6   -0.0    0.8    0.0      1 . . ..
  -21.3   17.0    7.0   -0.0    2.7    0.0    0.1   -0.0      1 . . ..
    5.6   17.0  -27.2    0.0   -4.6    0.0   -0.6   -0.0      1 . . ..
   21.3  -17.0   -7.0   -0.0   -2.7   -0.0    0.2    0.0      1 . . ..
 [9]
   -5.6  -17.0   27.2   -0.0    4.6   -0.0   -0.1   -0.0      1 . . ..
  -21.3   17.0    7.0    0.0    2.7    0.0   -0.5   -0.0      1 . . ..
    5.6   17.0  -27.3    0.0   -4.6   -0.0    0.4    0.0      1 . . ..
   21.3  -17.1   -7.0    0.0   -2.7   -0.0   -0.3   -0.0      1 . . ..

 [10]
   -5.6  -17.0   27.2   -0.0    4.6    0.0   -0.3   -0.0      1 . . ..
  -21.3   17.1    7.0    0.0    2.7    0.0    0.6    0.0      1 . . ..
    5.6   17.0  -27.3    0.0   -4.6   -0.0    0.0   -0.0      1 . . ..
   21.3  -17.1   -7.0   -0.0   -2.7    0.0   -0.7   -0.0      1 . . ..
 [11]
   -5.7  -17.0   27.3   -0.0    4.6    0.0    0.2    0.0      1 . . ..
  -21.3   17.1    6.9   -0.0    2.7   -0.0    0.3   -0.0      1 . . ..
    5.7   17.0  -27.3    0.0   -4.6    0.0   -0.4   -0.0      1 . . ..
   21.3  -17.1   -6.9    0.0   -2.7    0.0    0.2    0.0      1 . . ..
 [12]
   -5.7  -17.0   27.3   -0.0    4.6   -0.0   -0.2   -0.0      1 . . ..
  -21.3   17.1    6.9    0.0    2.7    0.0   -0.5   -0.0      1 . . ..
    5.7   17.0  -27.3    0.0   -4.6    0.0    0.7    0.0      1 . . ..
   21.3  -17.1   -6.9   -0.0   -2.7   -0.0   -0.1   -0.0      1 . . ..

 [13]
   -5.7  -17.0   27.3    0.0    4.6    0.0   -0.4    0.0      1 . . ..
  -21.3   17.1    6.9   -0.0    2.7   -0.0    0.5    0.0      1 . . ..
    5.7   16.9  -27.3    0.0   -4.6   -0.0   -0.4   -0.0      1 . . ..
   21.3  -17.1   -6.9   -0.0   -2.7    0.0   -0.4   -0.0      1 . . ..
```

One Cycle of Data

Figure 10.6 Example Differential 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

```
[14]
   -5.7  -16.9   27.3   -0.0    4.6    0.0    0.7    0.0     1 . . ..
  -21.3   17.1    6.8    0.0    2.7   -0.0   -0.1   -0.0     1 . . ..
    5.7   16.9  -27.3   -0.0   -4.7    0.0   -0.6   -0.0     1 . . ..
   21.3  -17.2   -6.8   -0.0   -2.7   -0.0    0.3    0.0     1 . . ..
[15]
   -5.8  -16.9   27.3    0.0    4.6   -0.0    0.0   -0.0     1 . . ..
  -21.3   17.2    6.8   -0.0    2.7    0.0   -0.5   -0.1     1 . . ..
    5.8   16.9  -27.3    0.0   -4.6    0.0    0.4    0.0     1 . . ..
   21.3  -17.2   -6.8    0.0   -2.7   -0.0    0.0    0.0     1 . . ..

Serial No = 123456789047
FID = SEL-710-5-X218-V0-Z003002-D20180406              CID = 812D
```

Firmware Identifier and Firmware Checksum Identifier

```
EVENT LOGS = 70            REF_NUM = 32976

Event:     ER Trigger
Targets    11000000
Freq (Hz)  59.99

Current Mag
        IA            IB            IC            IN       IG
(A)      22.1          24.1          28.1          0.02     5.37

Voltage Mag
       VAB    VBC    VCA
(V)    2344   1994   3746

Differential Current Mag
       IA87     IB87     IC87
(A)      0.03     0.59     0.03

Hottest RTD
      WINDING  BEARING  AMBIENT  OTHER
(C)   Fail     Fail     Fail     Fail

SETTINGS CHANGED SINCE EVENT

Global Settings
PHROT   := ABC     FNOM    := 60      DATE_F  := MDY     METHRES := Y
FAULT   := STARTING OR 50S OR 50G1P OR 50N1P OR TRIP

. . . . . .


Group Settings
RID     := SEL-710-5
TID     := MOTOR RELAY
CTR1    := 2       FLA1    := 5.0     VFDAPP  := N       E2SPEED := N
. . . . . .


Report Settings

SER1    := RB01 RB02 RB03 RB04 RB04 RB06 RB07 RB08
SER2    := TR TRIP
SER3    := OUT301 OUT302 OUT303 OUT304
SER4    := OUT101 OUT102 OUT103 OUT401 OUT402 OUT403 OUT404

. . . . . .

Logic Settings


ELAT    := N       ESV     := 3       ESC     := N       EMV     := 7

. . . . . .

=>>
```

Figure 10.6 Example Differential 15-Cycle Event Report 1/4-Cycle Resolution (Continued)

Retrieving Event Reports Via Ethernet File Transfer

Selected event reports are available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.75*, and *MMS on page G.5* for additional information.

The Ethernet file server EVENTS folder contains two types of files for each event stored in the relay:

- ➤ Compressed, 4 sample/cycle, filtered event, equivalent to issuing a **CEV** command. These files are named C4.*nnnnn*.cev, where *nnnnn* is the unique event identifier.
- ➤ Compressed, 32 sample/cycle, unfiltered event, equivalent to issuing a **CEV R** command. These files are named CR.*nnnnn*.cev, where *nnnnn* is the unique event identifier.

The date and time displayed for events are from the time of event trigger. The times are UTC.

The EVENTS folder also contains the event history with unique event identification number (equivalent to the **HIS** command) and the compressed event history (equivalent to the **CHIS** command). See *HISTORY Command on page 7.54*. The Event files can also be retrieved with the **FIL** command. See *FILE Command on page 7.49* and the information on **CHIS** Command under *Compressed Event Reports on page 10.2* for additional information.

CEVENT

The relay provides a Compressed ASCII event report for SCADA and other automation applications. QuickSet uses Compressed ASCII commands to gather event report data. If you want to view the Compressed ASCII event report data, use a terminal to issue ASCII command **CEV**. A sample of the report appears in *Figure 10.7*; this is a comma-delimited ASCII file. The relay appends a four-digit hex checksum at the end of the line in the Compressed ASCII report.

Items included in the Compressed ASCII event report are similar to the event report, although the relay reports the items in a special order. CEV files (and COMTRADE files) include all Relay Word bits (see *Appendix L: Relay Word Bits*). See *SEL Compressed ASCII Commands on page C.1* for more information on the Compressed ASCII command set.

```
=>CEV <Enter>
```

Report Header

```
"FID","CEV_VER","PART_NUM","SER_NUM","097C"
"FID=SEL-710-5-X215-V0-Z003002-D20180319","2.0.1","071050E1B0X1X7486167X","123456789047","128C"
"MONTH","DAY","YEAR","HOUR","MIN","SEC","MSEC","0ACA"
3,28,2018,10,1,4,45,"03CB"
```

Summary Labels

```
"REC_NUM","REF_NUM","NUM_CH_A","NUM_CH_D","FREQ","NFREQ","SAM/CYC_A","SAM/CYC_D","NUM_OF_CYC","PR
 IM_VAL","CTR_IA","CTR_IB","CTR_IC","CTR_IN","CTR_IG","PTR_VAB","PTR_VBC","PTR_VCA","CTR_IA87","CTR_
 IB87","CTR_IC87","EVENT","GROUP","IA(A)","IB(A)","IC(A)","IN(A)","IG(A)","VAB(V)","VBC(V)","VCA(V)"
 ,"IA87(A)","IB87(A)","IC87(A)","WDG(C)","BRG(C)","AMB(C)","OTH(C)","5576"
```

Summary Data

```
1,32845,29,1216,60.0,60,4,4,15,"YES",2.00,2.00,2.00,100.00,2.00,35.00,35.00,35.00,100.00,100.00,100.
 00,"ER Trigger",1,22.1,24.1,28.1,0.00,5.36,2344.494,1994.284,3746.482,0.05,0.08,0.05,"NA","NA","NA"
 ,"NA","28D1"
```

Figure 10.7 Sample Compressed ASCII Event Report

```
"IA(A)","IB(A)","IC(A)","IN(A)","IG(A)","VAB(V)","VBC(V)","VCA(V)","IA87(A)","IB87(A)","IC87(A)","*"
,"*","*","LSENS1(%)","LSENS2(%)","LSENS3(%)","LSENS4(%)","*","*","*","*","IARMS(A)","IBRMS(A)","ICR
MS(A)","FREQ","*","SMSLIP","SMSLIP2","TRIG","49T LOSSTRIP JAMTRIP 46UBT RTDT PTCTRIP ORED51T TRIP
VART 37PT 47T 55T SPDSTR SMTRIP OTHTRIP AMBTRIP * * BLKSTR 41A SRUNNING PTCFLT RTDFLT BFI COMMIDLE
COMMLOSS REMTRIP COMMFLT CFGFLT 49T_STR 49T_RTR BFT 87M1 87M2 87M1T 87M2T 87M1TC 87M2TC 50PAF 50NAF
49A LOSSALRM JAMALRM 46UBA RTDA 55A 55TC AF_TRIP VARA 37PA SPDSAL OTHALRM 81D1T 81D2T 81D3T 81D4T
AMBALRM HALARM SALARM AFALARM WARNING LOADUP LOADLOW 50S STOPPED RUNNING STARTING STAR DELTA START
COASTOP FAULT 27P1 27P1T 27P2 27P2T 59P1 59P1T 59P2 59P2T 50P1P 50P2P 50N1P 50N2P 50G1P 50G2P 50Q1P
50Q2P 50P1T 50P2T 50N1T 50N2T 50G1T 50G2T 50Q1T 50Q2T OUT101 OUT102 OUT103 * * * * * * * * * * * * *
OUT401 OUT402 OUT403 OUT404 * * * * * * * * * * * * IN101 IN102 * * * * * * * * * * * * * * IN401
IN402 IN403 IN404 * * * * * * * * * * * WDGALRM WDGTRIP BRGALRM BRGTRIP THERMLO NOSLO TBSLO ABSLO
RTDIN TRGTR * RTDBIAS 52A SPEED2 52B VFDBYPAS RTD1A RTD1T RTD2A RTD2T RTD3A RTD3T RTD4A RTD4T RTD5A
RTD5T RTD6A RTD6T RTD7A RTD7T RTD8A RTD8T RTD9A RTD9T RTD10A RTD10T RTD11A RTD11T RTD12A RTD12T
46UBTC 48LJTC 50EFTC 50PTC 37LLTC 66JOGTC 49PTCTC 49RTDTC RSTENRGY RSTMXMN DSABLSET RSTTRGT BLKPROT
LOP RSTMOT * SG1 SG2 SG3 SG4 MSRTRG DI_C DI_B DI_A STR STOP EMRSTR ER ULTRIP TR FREQTRK STREQ DNAUX1
DNAUX2 DNAUX3 DNAUX4 DNAUX5 DNAUX6 DNAUX7 DNAUX8 DNAUX9 DNAUX10 DNAUX11 RELAY_EN BBD1T BBD2T BBD3T
ZCFREQ PB01 PB02 PB03 PB04 PB05 PB06 PB07 PB08 PB01_PUL PB02_PUL PB03_PUL PB04_PUL PB05_PUL PB06_PUL
PB07_PUL PB08_PUL PB1A_LED PB1B_LED PB2A_LED PB2B_LED PB3A_LED PB3B_LED PB4A_LED PB4B_LED PB5A_LED
PB5B_LED PB6A_LED PB6B_LED PB7A_LED PB7B_LED PB8A_LED PB8B_LED * * T01_LED T02_LED T03_LED T04_LED
T05_LED T06_LED LB01 LB02 LB03 LB04 LB05 LB06 LB07 LB08 LB09 LB10 LB11 LB12 LB13 LB14 LB15 LB16 LB17
LB18 LB19 LB20 LB21 LB22 LB23 LB24 LB25 LB26 LB27 LB28 LB29 LB30 LB31 LB32 RB01 RB02 RB03 RB04 RB05
RB06 RB07 RB08 RB09 RB10 RB11 RB12 RB13 RB14 RB15 RB16 RB17 RB18 RB19 RB20 RB21 RB22 RB23 RB24 RB25
RB26 RB27 RB28 RB29 RB30 RB31 RB32 SV01 SV02 SV03 SV04 SV05 SV06 SV07 SV08 SV01T SV02T SV03T SV04T
SV05T SV06T SV07T SV08T SV09 SV10 SV11 SV12 SV13 SV14 SV15 SV16 SV09T SV10T SV11T SV12T SV13T SV14T
SV15T SV16T SV17 SV18 SV19 SV20 SV21 SV22 SV23 SV24 SV17T SV18T SV19T SV20T SV21T SV22T SV23T SV24T
SV25 SV26 SV27 SV28 SV29 SV30 SV31 SV32 SV25T SV26T SV27T SV28T SV29T SV30T SV31T SV32T LT01 LT02
LT03 LT04 LT05 LT06 LT07 LT08 LT09 LT10 LT11 LT12 LT13 LT14 LT15 LT16 LT17 LT18 LT19 LT20 LT21 LT22
LT23 LT24 LT25 LT26 LT27 LT28 LT29 LT30 LT31 LT32 SC01QU SC02QU SC03QU SC04QU SC05QU SC06QU SC07QU
SC08QU SC01QD SC02QD SC03QD SC04QD SC05QD SC06QD SC07QD SC08QD SC09QU SC10QU SC11QU SC12QU SC13QU
SC14QU SC15QU SC16QU SC09QD SC10QD SC11QD SC12QD SC13QD SC14QD SC15QD SC16QD SC17QU SC18QU SC19QU
SC20QU SC21QU SC22QU SC23QU SC24QU SC17QD SC18QD SC19QD SC20QD SC21QD SC22QD SC23QD SC24QD SC25QU
SC26QU SC27QU SC28QU SC29QU SC30QU SC31QU SC32QU SC25QD SC26QD SC27QD SC28QD SC29QD SC30QD SC31QD
SC32QD * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * RMB8A RMB7A RMB6A RMB5A RMB4A RMB3A RMB2A RMB1A TMB8A TMB7A TMB6A TMB5A TMB4A TMB3A TMB2A TMB1A
RMB8B RMB7B RMB6B RMB5B RMB4B RMB3B RMB2B RMB1B TMB8B TMB7B TMB6B TMB5B TMB4B TMB3B TMB2B TMB1B
LBOKB CBADB RBADB ROKB LBOKA CBADA RBADA ROKA LINKA LINKB LINKFAIL PASEL PBSEL * * * VB001 VB002
VB003 VB004 VB005 VB006 VB007 VB008 VB009 VB010 VB011 VB012 VB013 VB014 VB015 VB016 VB017 VB018
VB019 VB020 VB021 VB022 VB023 VB024 VB025 VB026 VB027 VB028 VB029 VB030 VB031 VB032 VB033 VB034
VB035 VB036 VB037 VB038 VB039 VB040 VB041 VB042 VB043 VB044 VB045 VB046 VB047 VB048 VB049 VB050
VB051 VB052 VB053 VB054 VB055 VB056 VB057 VB058 VB059 VB060 VB061 VB062 VB063 VB064 VB065 VB066
VB067 VB068 VB069 VB070 VB071 VB072 VB073 VB074 VB075 VB076 VB077 VB078 VB079 VB080 VB081 VB082
VB083 VB084 VB085 VB086 VB087 VB088 VB089 VB090 VB091 VB092 VB093 VB094 VB095 VB096 VB097 VB098
VB099 VB100 VB101 VB102 VB103 VB104 VB105 VB106 VB107 VB108 VB109 VB110 VB111 VB112 VB113 VB114
VB115 VB116 VB117 VB118 VB119 VB120 VB121 VB122 VB123 VB124 VB125 VB126 VB127 VB128 51AP 51BP 51CP
51P1P 51P2P 51QP 51G1P 51G2P 51AT 51BT 51CT 51P1T 51P2T 51QT 51G1T 51G2T 51AR 51BR 51CR 51P1R 51P2R
51QR 51G1R 51G2R BKMON BCW BCWA BCWB BCWC * IRIGOK TSOK TQUAL1 TQUAL2 TQUAL4 TQUAL8 DST DSTP LPSEC
LPSECP TSNTPB TSNTPP TUTCS TUTC1 TUTC2 TUTC4 TUTC8 TUTCH AFS1DIAG AFS2DIAG AFS3DIAG AFS4DIAG
AFS5DIAG AFS6DIAG AFS7DIAG AFS8DIAG TOL1 TOL2 TOL3 TOL4 TOL5 TOL6 TOL7 TOL8 AFS1EL AFS2EL AFS3EL
AFS4EL AFS5EL AFS6EL AFS7EL AFS8EL FDVTC FDCTC 40ZTC * 40Z1 40Z1T 40Z2 40Z2T FDUV1 FDUV1T FDUV2
FDUV2T FDOV1 FDOV1T FDOV2 FDOV2T FDUC1 FDUC1T FDUC2 FDUC2T FDOC1 FDOC1T FDOC2 FDOC2T FDRES1T FDRES2T
FDRESTC 41CLOSE UL41CL STSEQEN * * 78R1 78R2 78Z1 SWING OOS OOST * OOSTC 51ATC 51BTC 51CTC 51P1TC
51P2TC 51QTC 51G1TC 51G2TC MATHERR TESTDB * SYNEN SLIPRECH DRVECLS RELUCLS ADV_RUNN * VIRSPDSW
SPEEDSW ENHSPDSW SSFLRST SPDSFAIL FAILCLS FAILOPN * * RELUCLS2 SLIPOK 41CLOSE2 41CLS2TO 41CLS2
SLIPBT FVLR FVLRT FVLL FVLLT FVSL FVSLT FVSR FVSRT FVR FVL PFINBND PFGUT * * PORSFL PODTCT * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * 27I1 27I1T
27I1RS 27I1TC 27I2 27I2T 27I2RS 27I2TC 59I1 59I1T 59I1RS 59I1TC 59I2 59I2T 59I2RS 59I2TC 59I3 59I3T
59I3RS 59I3TC 59I4 59I4T 59I4RS 59I4TC 89A2P1 89B2P1 89CL2P1 89OP2P1 89AL2P1 * * * 89A2P2 89B2P2
89CL2P2 89OP2P2 89AL2P2 * * * 89A2P3 89B2P3 89CL2P3 89OP2P3 89AL2P3 * * * 89A2P4 89B2P4 89CL2P4
89OP2P4 89AL2P4 * * * 89A2P5 89B2P5 89CL2P5 89OP2P5 89AL2P5 * * * ENLRC LOCAL BKJMP * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *","8ACA"
```

Column Labels

```
-3.2,-18.8,26.3,-0.0,4.3,-446,-1894,2340,-0.0,-0.1,-0.0,0.0,0.0,0.0,0.00,0.04,0.00,0.04,0.00,0.00,0.
00,0.00,22.04,24.07,28.12,59.98,0.00,0.00,100.00, ,"00200000080000092100030300000000000000000002000
000FF0080020011000004000800000000000000000A0A0000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000480000000000000000000000000000000000000FF00000000000080000
00000FF00000000000000000000000111111505050505020000000000000","569D"
-21.8,15.0,10.0,-0.0,3.2,-2301,-622,2924,0.0,-0.6,-0.0,0.0,0.0,0.0,0.03,0.05,0.02,0.02,0.00,0.00,0.0
0,0.00,22.04,24.07,28.11,59.98,0.00,0.00,100.00, ,"002000000800000921000303000000000000000000020000
00FF0080020011000004000800000000000000000A0A00000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000048000000000000000000000000000000000000FF000000000000800000
0000FF00000000000000000000000111111505050505020000000000000","565E"
3.2,18.8,-26.3,0.0,-4.3,447,1895,-2342,-0.0,0.4,0.0,0.0,0.0,0.0,0.01,0.06,0.00,0.03,0.00,0.00,0.00,0
.00,22.04,24.07,28.11,59.98,0.00,0.00,100.00, ,"0020000008000009210003030000000000000000000002000000F
F0080020011000004000800000000000000000A0A00000000000000000000000000000000000000000000000000000000000
00000000000000000000000000000000000000048000000000000000000000000000000000000FF0000000000000800000000
0FF00000000000000000000000111111505050505020000000000000","55F1"
21.8,-15.1,-10.0,0.0,-3.2,2301,622,-2923,-0.1,0.0,0.0,0.0,0.0,0.0,0.00,0.06,0.00,0.05,0.00,0.00,0.00
,0.00,22.04,24.06,28.10,59.98,0.00,0.00,100.00, ,"0020000008000009210003030000000000000000000200000
0FF0080020011000004000800000000000000000A0A0000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000480000000000000000000000000000000000000FF0000000000000800000000
000FF00000000000000000000000111111505050505020000000000000","5629"
```

Event Data (Cycle 1)
The block shown represents four quarter cycles of data.

Figure 10.7 Sample Compressed ASCII Event Report (Continued)

```
.
.
.

21.8,-15.1,-9.9,-0.0,-3.2,2300,618,-2917,0.0,0.2,-0.0,0.0,0.0,0.0,0.00,0.03,0.01,0.00,0.00,0.00,0.00
 ,0.00,22.04,24.06,28.11,59.99,0.00,0.00,100.00, ,"0020000008000009210003030000000000000000000200000
 0FF008002001100000400080000000000000000A0A000000000000000000000000000000000000000000000000000000000
 00000000000000000000000000000000000000048000000000000000000000000000000000000FF0000000000008000000
 000FF00000000000000000000011111505050505050200000000000000","563A"
-3.3,-18.8,26.3,-0.0,4.3,-455,-1896,2351,0.0,-0.4,0.0,0.0,0.0,0.0,0.00,0.04,0.00,0.01,0.00,0.00,0.00
 ,0.00,22.04,24.06,28.12,59.99,0.00,0.00,100.00, ,"0020000008000009210003030000000000000000000200000
 0FF008002001100000400080000000000000000A0A000000000000000000000000000000000000000000000000000000000
 00000000000000000000000000000000000000048000000000000000000000000000000000000FF0000000000008000000
 000FF00000000000000000000011111505050505050200000000000000","5648"
-21.8,15.1,9.9,0.0,3.2,-2300,-616,2916,-0.1,0.1,0.0,0.0,0.0,0.0,0.01,0.08,0.00,0.05,0.00,0.00,0.00,0
 .00,22.04,24.06,28.11,59.99,0.00,0.00,100.00, ,"00200000080000092100030300000000000000000002000000F
 F00800200110000040008000000000000000A0A00000000000000000000000000000000000000000000000000000000000
 000000000000000000000000000000000000048000000000000000000000000000000000000FF000000000000800000000
 0FF00000000000000000000011111505050505050200000000000000","55E7"
```

```
3.3,18.7,-26.3,0.0,-4.3,455,1897,-2352,0.0,0.0,-0.1,0.0,0.0,0.0,0.01,0.04,0.00,0.01,0.00,0.00,0.00,0
 .00,22.04,24.06,28.12,59.99,0.00,0.00,100.00,"*","0020000008000009210003030000000000000000000200000
 0FF008002001100000400080000000000000000A0A000000000000000000000000000000000000000000000000000000000
 00000000000000000000000000000000000000048000000000000000000000000000000000000FF0000000000008000000
 000FF00000000000000000000011111505050505050200000000000000","563B"
```

Event Data
The quarter cycle with the “*” symbol represents the row with the largest measured current for the event. This is the row used for the summary data.

```
-21.8,-15.1,-9.9,0.0,-3.2,2299,615,-2914,0.0,-0.2,0.0,0.0,0.0,0.0,0.00,0.04,0.02,0.02,0.00,0.00,0.00
 ,0.00,22.04,24.06,28.11,59.99,0.00,0.00,100.00, ,"0020000008000009210003030000000000000000000200000
 0FF008002001100000400080000000000000000A0A000000000000000000000000000000000000000000000000000000000
 00000000000000000000000000000000000000048000000000000000000000000000000000000FF0000000000008000000
 000FF00000000000000000000011111505050505050200000000000000","561C"
-3.3,-18.7,26.3,-0.0,4.3,-457,-1896,2353,-0.0,-0.4,0.0,0.0,0.0,0.0,0.00,0.06,0.00,0.02,0.00,0.00,0.0
 0,0.00,22.03,24.06,28.11,59.99,0.00,0.00,100.00, ,"002000000800000921000303000000000000000000020000
 00FF008002001100000400080000000000000000A0A00000000000000000000000000000000000000000000000000000000
 000000000000000000000000000000000000000048000000000000000000000000000000000000FF000000000000800000
 0000FF00000000000000000000011111505050505050200000000000000","5679"
-21.8,15.1,9.9,-0.0,3.2,-2299,-614,2913,-0.0,0.4,-0.1,0.0,0.0,0.0,0.00,0.04,0.00,0.04,0.00,0.00,0.00
 ,0.00,22.04,24.06,28.10,59.99,0.00,0.00,100.00, ,"0020000008000009210003030000000000000000000200000
 0FF008002001100000400080000000000000000A0A000000000000000000000000000000000000000000000000000000000
 00000000000000000000000000000000000000048000000000000000000000000000000000000FF0000000000008000000
 000FF00000000000000000000011111505050505050200000000000000","5649"
3.3,18.7,-26.3,-0.0,-4.3,458,1897,-2356,0.0,0.4,-0.0,0.0,0.0,0.0,0.03,0.04,0.02,0.02,0.00,0.00,0.00,
 0.00,22.03,24.06,28.11,59.99,0.00,0.00,100.00, ,"00200000081000092100030300000000000000000002000000
 FF008002001100000400080000000000000000A0A0000000000000000000000000000000000000000000000000000000000
 0000000000000000000000000000000000000048000000000000000000000000000000000000FF00000000000080000000
 00FF00000000000000000000011111505050505050200000000000000","5628"
```

```
21.8,-15.1,-9.9,0.0,-3.2,2299,613,-2912,0.0,-0.2,0.0,0.0,0.0,0.0,0.00,0.04,0.00,0.02,0.00,0.00,0.00,
 0.00,22.04,24.06,28.11,59.99,0.00,0.00,100.00,">","002000000810000921000303000000000000000000020000
 00FF008012001100000400080000000000000000A0A00000000000000000000000000000000000000000000000000000000
 000000000000000000000000000000000000000048000000000000000000000000000000000000FF000000000000800000
 0000FF00000000000000000000011111505050505050200000000000000","567A"
```

Event Data
The quarter cycle with the “>” symbol represents the trigger row for the event.

```
-3.3,-18.7,26.3,-0.0,4.3,-460,-1897,2357,-0.0,-0.1,0.0,0.0,0.0,0.0,0.00,0.07,0.00,0.05,0.00,0.00,0.0
 0,0.00,22.04,24.06,28.12,59.99,0.00,0.00,100.00, ,"002000000810000921000303000000000000000000020000
 00FF008002001100000400080000000000000000A0A00000000000000000000000000000000000000000000000000000000
 000000000000000000000000000000000000000048000000000000000000000000000000000000FF000000000000800000
 0000FF00000000000000000000011111505050505050200000000000000","567C"

.
.
.

21.8,-15.4,-9.5,0.0,-3.1,2293,591,-2884,0.0,-0.2,0.0,0.0,0.0,0.0,0.00,0.05,0.02,0.02,0.00,0.00,0.00,
 0.00,22.05,24.06,28.11,59.99,0.00,0.00,100.00, ,"00200000081000092100030300000000000000000002000000
 FF008002001100000400080000000000000000A0A0000000000000000000000000000000000000000000000000000000000
 0000000000000000000000000000000000000048000000000000000000000000000000000000FF00000000000080000000
 00FF00000000000000000000011111505050505050200000000000000","5620"

"SETTINGS","02E1"

"
```

```
Global Settings

PHROT   := ABC     FNOM    := 60      DATE_F  := MDY     METHRES := Y
FAULT   := STARTING OR 50S OR 50G1P OR 50N1P OR TRIP
EBBD    := N       TGR     := 3       SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

.
.
.
```

Global Settings

Figure 10.7 Sample Compressed ASCII Event Report (Continued)

```
Group Settings

RID     := SEL-710-5
TID     := MOTOR RELAY
CTR1    := 2       FLA1    := 5.0     VFDAPP  := N       E2SPEED := N
CTRN    := 100     PTR     := 35.00   VNOM    := 4160    DELTA_Y := DELTA
SINGLEV := N
E49MOTOR:= Y       FLS     := OFF     SETMETH := RATING_1 49RSTP  := 75
SF      := 1.15    LRA1    := 6.0     LRTHOT1 := 10.0    TD1     := 1.00
RTC1    := AUTO    TCAPU   := 85      TCSTART := OFF     COOLTIME:= 84
COASTIME:= 5
50P1P   := 8.50    50P1D   := 0.01    50P2P   := 8.50    50P2D   := 0.01
.
.
.
```

Group Settings

```
Report Settings

SER1    := RB01 RB02 RB03 RB04 RB04 RB06 RB07 RB08
SER2    := STOP STR
SER3    := STOPPED START
SER4    := NA
EALIAS  := 15
.
.
.
```

Report Settings

```
Logic Settings

ELAT    := N       ESV     := 3       ESC     := N       EMV     := 7
.
.
.

=>
```

Logic Settings

Figure 10.7 Sample Compressed ASCII Event Report (Continued)

The order of the labels in the digital portion of the Column Labels field matches the order of the HEX-ASCII Relay Word. Each numeral in the HEX-ASCII Relay Word reflects the status of four Relay Word bits from the Digital Column Labels field of the Compressed ASCII event report. The HEX-ASCII Relay Word from the trigger cycle from *Figure 10.7*, follows.

```
0020000008100009210003030000000000000000000002000000FF0080020011000004000800000
 00000000000A0A00000000000000000000000000000000000000000000000000000000000000
 0000000000000000000000000000000000048000000000000000000000000000000000000FF0
 000000000008000000000FF0000000000000000000000111111505050505020000000000000
```

In this HEX-ASCII Relay Word, the third numeral in the HEX-ASCII Relay Word is a 2. In binary, this is 0010. Mapping the labels to the digital Column Labels yields the following:

VART	37PT	47T	55T
0	0	1	0

The 50A1P element picked up at the first sample of the trigger cycle row (see *Figure 10.7*)

Viewing Compressed Event (CEV) Reports

The CEV is viewed in the following ways:

- ➤ SYNCHROWAVE Event (SEL-5601-2)
- ➤ ACSELERATOR QuickSet SEL-5030 Software via SYNCHROWAVE Event (SEL-5601-2)

Using the SEL-5030 software, navigate to the **Options** menu under **Tools** and select SYNCHROWAVE Event (SEL-5601-2) as the event viewer.

To view the saved events using the SEL-5030 software, click **Tools > Events** to view an event with SYNCHROWAVE Event and select the event you want to view (QuickSet remembers the location where you stored the previous event record). You can view multiple events by clicking on **Local Event > Add New Event** in SYNCHROWAVE Event.

As shown in *Figure 10.8*, all the analog and digital data can be viewed with SYNCHROWAVE Event (SEL-5601-2) or QuickSet via SYNCHROWAVE Event (SEL-5601-2). Using the Export Event feature, you can export the CEV report in COMTRADE format. Using the Export Data feature, you can also export the CEV report in comma-separated values (CSV) format.

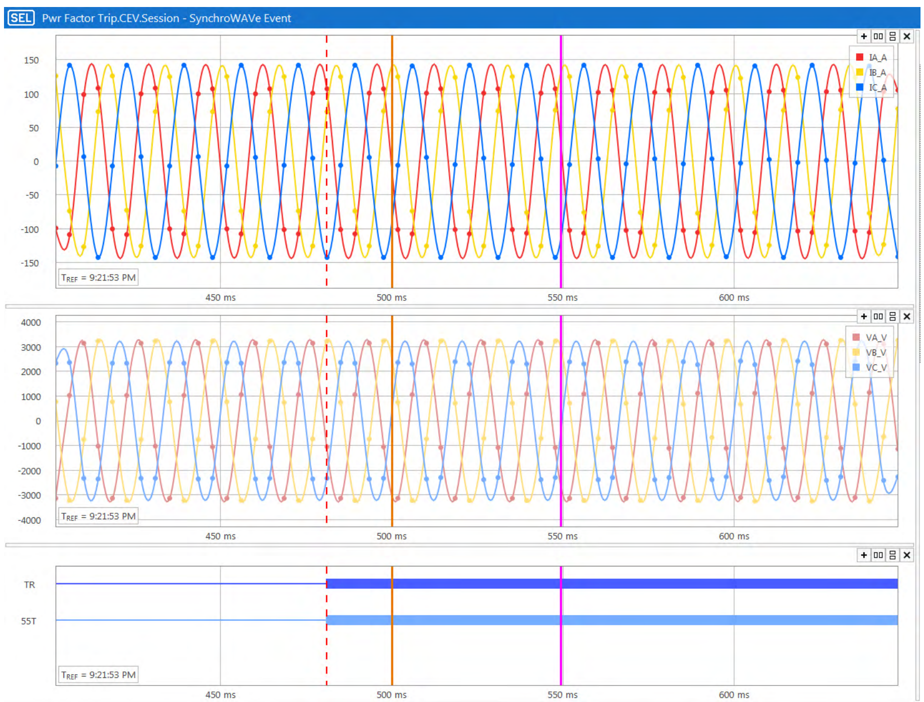


Figure 10.8 Sample CEV Report Viewed With SYNCHROWAVE Event

With SYNCHROWAVE Event you have six options for converting CEV reports to COMTRADE:

- COMTRADE 1999 ASCII
- COMTRADE 1999 Binary
- COMTRADE 2013 ASCII
- COMTRADE 2013 Binary
- COMTRADE 2013 Binary32
- COMTRADE 2013 Float32

COMTRADE File Format Event Reports

NOTE: COMTRADE event reports are sampled at 32 samples per cycle, which are equivalent to CEV R event reports..

The SEL-710-5 stores high-resolution raw data oscillography in binary format and uses COMTRADE file types to output these data:

- .HDR—header file
- .CFG—configuration file
- .DAT—high-resolution raw data file

NOTE: COMTRADE events can be extracted using the **FILE** command (see Section 7: Communications), Ethernet File Transfer Protocol (FTP), or the IEC 61850 Manufacturing Message Specification (MMS). To transfer files using MMS, set EMMSFS to Y

The .HDR file contains summary information about the event in ASCII format. The .CFG file is an ASCII configuration file that describes the layout of the .DAT file. The .DAT file is in binary format and contains the values for each input channel for each sample in the record. These data conform to the IEEE C37.111-1999 COMTRADE standard.

.HDR File

The .HDR file contains the event summary and relay settings information that appears in the event report for the data capture. The settings portion is in a comma-delimited format as illustrated in *Figure 10.9*.

```
FID,"SEL-710-5-X211-V0-Z003002-D20180221"
Event_Report_Type,"UVR"
Part_Number,"071050E1B0X1X7486167X"
Serial_Number,"000000000000000"

[Summary]
Date,"30/04/2002"
Time,"22:01:01.591900"
Time_Source,"Internal"
Event_Logs,"6"
Event_Number,"32838"
Event,"Trigger"
Targets,"11010000"
Freq,"60.00"
IA (A),"0.0100"
IB (A),"0.0200"
IC (A),"0.0316"
IN (A),"0.0160"
IG (A),"0.0608"
VAN (V),"0"
VBN (V),"0"
VCN (V),"0"
VG (V),"0"
IA87 (A),"0.0000"
IB87 (A),"0.0000"
IC87 (A),"0.0000"
```

Event Summary Information

```
[Settings]
Global Settings
PHROT   := ABC     FNOM    := 60      DATE_F  := MDY     METHRES := Y
FAULT   := STARTING OR 50S OR 50G1P OR 50N1P OR TRIP

EBBD    := N       TGR     := 3       SS1     := 1
SS2     := 0
SS3     := 0
SS4     := 0

UTC_OFF := 0.00    DST_BEGM:= OFF
52ABF   := N       BFD     := 0.50    BFI     := R_TRIG TRIP

50PAFP  := OFF
50NAFP  := OFF
AFSENS1 := NONE    AFSENS2 := NONE
AFSENS3 := NONE    AFSENS4 := NONE    AOUTSLOT:= 101_3
EBMON   := Y       COSP1   := 10000   COSP2   := 150     COSP3   := 12
KASP1   := 1.20    KASP2   := 8.00    KASP3   := 20.00   BKMON   := TRIP

RSTTRGT := 0
RSTENRGY:= 0
RSTMXMN := 0
RSTMOT  := 0

DSABLSET:= 0

89A2P1  := 0
89B2P1  := NOT 89A2P1
89A2P1D := 5.00    89A2P2  := 0
89B2P2  := NOT 89A2P2
89A2P2D := 5.00    89A2P3  := 0
89B2P3  := NOT 89A2P3
89A2P3D := 5.00    89A2P4  := 0
89B2P4  := NOT 89A2P4
89A2P4D := 5.00    89A2P5  := 0
89B2P5  := NOT 89A2P5
89A2P5D := 5.00
EN_LRC  := N       EN_LRC  := N
```

Global Settings

Figure 10.9 Sample COMTRADE .HDR Header File

```
Group Settings
RID     := SEL-710-5
TID     := MOTOR RELAY
CTR1    := 2       FLA1    := 5.0     VFDAPP  := N       E2SPEED := N
CTRN    := 100     PTR     := 35.00   VNOM    := 4160    DELTA_Y := WYE
SINGLEV := N

E49MOTOR:= Y       FLS     := OFF     SETMETH := RATING_1 49RSTP  := 75
SF      := 1.15    LRA1    := 6.0     LRTHOT1 := 10.0    TD1     := 1.00
RTC1    := AUTO    TCAPU   := 85      TCSTART := OFF     COOLTIME:= 84
COASTIME:= 5

50P1P   := 8.50    50P1D   := 0.01    50P2P   := 8.50    50P2D   := 0.01
50N1P   := OFF     50N2P   := OFF     50G1P   := OFF     50G2P   := OFF
50Q1P   := 3.00    50Q1D   := 0.1     50Q2P   := 0.30    50Q2D   := 0.2

51AP    := OFF
51BP    := OFF
51CP    := OFF     51P1P   := OFF     51P2P   := OFF     51QP    := OFF
51G1P   := OFF
51G2P   := OFF
E87M    := N
LJTPU   := OFF     LJAPU   := OFF

LLTPU   := OFF     LLAPU   := OFF

46UBT   := 20      46UBTD  := 5       46UBA   := 10      46UBAD  := 10
START_T := OFF

ESTAR_D := N

MAXSTART:= OFF     TBSDLY  := OFF     ABSDLY  := OFF

E47T    := Y
SPDSDLYT:= OFF     SPDSDLYA:= OFF     VSSEN   := N

EPTC    := N
E49RTD  := NONE
LOPBLK  := 0

27P1P   := OFF     27P2P   := OFF
59P1P   := 1.10    59P1D   := 0.5     59P2P   := OFF

E27I1   := N       E27I2   := N

E59I1   := N       E59I2   := N       E59I3   := N       E59I4   := N
NVARTP  := OFF     PVARTP  := OFF     NVARAP  := OFF     PVARAP  := OFF
E40     := N       E78     := N
37PTP   := OFF     37PAP   := OFF
55LGTP  := OFF     55LDTP  := OFF     55LGAP  := OFF     55LDAP  := OFF
EPFC    := 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       BLK49PTC:= N       BLK49RTD:= N

TDURD   := 0.5
TR      := 50P1T OR 50P2T
REMTRIP := 0
TRIPONLO:= Y       ULTRIP  := 0
52A     := 0
52B     := NOT 52A

STREQ   := PB03
BLKSTR  := STOPPED AND (THERMLO OR NOSLO OR TBSLO OR ABSLO)
EMRSTR  := 0
SPEEDSW := 0
```

Group Settings

Figure 10.9 Sample COMTRADE .HDR Header File (Continued)

```
Report Settings
SER1    := RB01 RB02 RB03 RB04 RB04 RB06 RB07 RB08
SER2    := STOP STR
SER3    := STOPPED START
SER4    := NA

EALIAS  := 15

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

ER      := R_TRIG LOSSALRM OR R_TRIG 46UBA OR R_TRIG 49A OR R_TRIG 37PA OR R_TRIG 55A OR
 R_TRIG VARA
LER     := 15      PRE     := 5
MSRR    := 5       MSRTRG  := 0

FMR1NAM := FMR1
FMR1    :=NA
FMR2NAM := FMR2
FMR2    :=NA
FMR3NAM := FMR3
FMR3    :=NA
FMR4NAM := FMR4
FMR4    :=NA

RA01TYPE:= I
RA02TYPE:= I
RA03TYPE:= I
RA04TYPE:= I
RA05TYPE:= I
RA06TYPE:= I
RA07TYPE:= I
RA08TYPE:= I
RA09TYPE:= I
RA10TYPE:= I
RA11TYPE:= I
RA12TYPE:= I
RA13TYPE:= I
RA14TYPE:= I
RA15TYPE:= I
RA16TYPE:= I
RA17TYPE:= I
RA18TYPE:= I
RA19TYPE:= I
RA20TYPE:= I
RA21TYPE:= I
RA22TYPE:= I
RA23TYPE:= I
RA24TYPE:= I
RA25TYPE:= I
RA26TYPE:= I
RA27TYPE:= I
RA28TYPE:= I
RA29TYPE:= I
RA30TYPE:= I
RA31TYPE:= I
RA32TYPE:= I
LDLIST  := NA LDAR    := 15      LDAR    := 15
```

Report Settings

Figure 10.9 Sample COMTRADE .HDR Header File (Continued)

```
Logic Settings


ELAT    := N       ESV     := 3       ESC     := N       EMV     := 4


SV01PU  := 0.00    SV01DO  := 0.00
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
SV02PU  := 0.00    SV02DO  := 0.00
SV02    := NA
SV03PU  := 0.00    SV03DO  := 0.00
SV03    := 40Z1T OR 40Z2T OR FDUC1T OR FDOC1T OR FDUV1T OR FDOV1T OR FDRES1T OR SV01T OR
 OOST OR 55T

Math Variables
MV01    := FIA
MV02    := FIB
MV03    := FIC
MV04    := FIN

OUT101FS:= Y       OUT101  := HALARM OR SALARM OR AFALARM
OUT102FS:= N       OUT102  := START
OUT103FS:= Y       OUT103  := TRIP OR PB04
OUT401FS:= N       OUT401  := 0
OUT402FS:= N       OUT402  := 0
OUT403FS:= N       OUT403  := 0
OUT404FS:= N       OUT404  := 0
```

Logic Settings

```
SAM/CYC_A = 32
SAM/CYC_D = 4
```

Analog, Digital, and Input Samples per Cycle Data

Figure 10.9 Sample COMTRADE .HDR Header File (Continued)

.CFG File

The .CFG file contains data that is used to reconstruct the input signals to the relay and the status of Relay Word bits during the event report (see *Figure 10.10*). A <CR><LF> follows each line. If control inputs or control outputs are unavailable because of board loading and configuration, the relay does not report these inputs and outputs in the analog and digital sections of the .CFG file.

```
SEL-710-5,FID=SEL-710-5-X211-V0-Z003002-D20180221,1999
```

COMTRADE Standard

```
1232,16A,1216D
```

Total Channels, Analog, Digital

```
1,IA,A,,A,0.014142,0.0,0,-32767,32767,2.0,1.0,P
2,IB,B,,A,0.014142,0.0,0,-32767,32767,2.0,1.0,P
3,IC,C,,A,0.014142,0.0,0,-32767,32767,2.0,1.0,P
4,IN,,,A,0.010102,0.0,0,-32767,32767,100.0,1.0,P
5,IG,,,A,0.014142,0.0,0,-32767,32767,2.0,1.0,P
6,VA,A,,V,0.494975,0.0,0,-32767,32767,35.0,1.0,P
7,VB,B,,V,0.494975,0.0,0,-32767,32767,35.0,1.0,P
8,VC,C,,V,0.494975,0.0,0,-32767,32767,35.0,1.0,P
9,IA87,,,A,0.038222,0.0,0,-32767,32767,100.0,1.0,P
10,IB87,,,A,0.038222,0.0,0,-32767,32767,100.0,1.0,P
11,IC87,,,A,0.038222,0.0,0,-32767,32767,100.0,1.0,P
12,LSENS1,,,%,1.000000,0.0,0,0,100,1.0,1.0,P
13,LSENS2,,,%,1.000000,0.0,0,0,100,1.0,1.0,P
14,LSENS3,,,%,1.000000,0.0,0,0,100,1.0,1.0,P
15,LSENS4,,,%,1.000000,0.0,0,0,100,1.0,1.0,P
16,FREQ,,,Hz,0.01,0.0,0,0,12000,1.0,1.0,P
```

Analog Channel Data
[a]Scale_factor is the value used to convert the equivalent channel analog data in the DAT file to primary units (A or kV peak-to-peak)

```
1,rwb_label[b,c],,,0
2,rwb_label[b,c],,,0
.
.
.
nnnn[d],rwb label[b,c],,,0
```

Digital (Status) Channel Data
[b]rwb_label is replaced with Relay Word bit labels as seen in Table L.1
[c]Place holders denoted by asterisk (*), are labeled as UNUSEDxxx (where xxx is the number of the associated label)
[d]nnnn = number of the last Relay Word bit

```
<NFREQ>
0
0,<# of samples>
```

```
dd/mm/yyyy,hh:mm:ss.ssssss
```

First Data Point

Figure 10.10 Sample COMTRADE .CFG Configuration File Data

`dd/mm/yyyy,hh:mm:ss.ssssss`	Trigger Point
`BINARY` `<time stamp multiplication factor>`	

Figure 10.10 Sample COMTRADE .CFG Configuration File Data (Continued)

The configuration file has the following format:

- Relay ID, firmware ID, COMTRADE standard year
- Number and type of channels
- Channel name units and conversion factors
- Digital Relay Word bit names
- System frequency
- Sample rate and number of samples
- Date and time of first data point
- Date and time of trigger point
- Data file type
- Time stamp multiplication factor

.DAT File

The .DAT file follows the COMTRADE binary standard. The format of the binary data files is sample number, time stamp, data value for each analog channel, and digital channel status data for each sample in the file. There are no data separators in the binary file, and the file contains no carriage return/line feed characters. The sequential position of the data in the binary file determines the data translation. Refer to the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111–1999 for more information. Many software applications can read binary COMTRADE files, including SYNCHROWAVE Event and QuickSet.

Retrieving COMTRADE Event Files

COMTRADE files are available as read-only files that can be retrieved using the **FILE** command and Ymodem file transfer, Ethernet File Transfer Protocol (FTP), web server (EHTTP := Y), or Manufacturing Message Specification (MMS). MMS file transfer is only available in models that support IEC 61850 and only when IEC 61850 is enabled (E61850 := Y) and MMS file services is enabled (EMMSFS := Y). See *FILE Command on page 7.49*, *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, and *MMS on page G.5* for additional information. You can also retrieve COMTRADE files via QuickSet. Refer to *View Event History on page 3.23* for details.

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.

NOTE: A file containing an SER report can be extracted using the **FILE** command (see *Section 7: Communications*), the Ethernet File Transfer Protocol (FTP), or the IEC 61850 Manufacturing Message Specifications (MMS). To transfer files using MMS, set EMMSFS to Y.

The relay adds a message to the SER to indicate power up, settings change, or manual reset of TCU conditions:

```
Relay Powered Up
.
.
.
Thermal capacity reset
.
.
.
Relay Settings Changed
```

Each entry in the SER includes the SER row number, date, time, element name, and element state.

SER Aliases

You can rename as many as 32 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 shows the date and time of MOTOR_STARTING BEGINS. When Relay Word bit STARTING is deasserted, the SER report shows 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 4.162* for additional details.

Retrieving and Clearing SER Reports

See *SER Command (Sequential Events Recorder Report) on page 7.64* for details on retrieving and clearing SER reports with the **SER** command.

SER data is also available as read-only files that can be retrieved using Ethernet File Transfer Protocol (FTP) or Manufacturing Message Specification (MMS). MMS is only available in models that support IEC 61850 and only when IEC 61850 and MMS File Transfer are enabled (E61850 := Y, EMMSFS := Y). See *File Transfer Protocol (FTP) and MMS File Transfer on page 7.15*, *Virtual File Interface on page 7.75*, and *MMS on page G.5* for additional information.

Example SER Report

The example SER report in *Figure 10.11* includes records of events that occurred before the beginning of the event summary report in *Figure 10.3*.

```
=>>SER <Enter>

SEL-710-5                                   Date: 04/19/2013   Time: 11:09:33.952
SYNCHRONOUS MTR                              Time Source: Internal

Serial No = 000000000000000
FID = SEL-710-5-X047-V0-Z001001-D20130415              CID = 6495

#      DATE         TIME                 ELEMENT               STATE
9   04/19/2013  10:24:00.014   Relay Settings Changed
8   04/19/2013  10:24:00.014   SALARM                       Asserted
7   04/19/2013  10:24:01.010   SALARM                       Deasserted
6   04/19/2013  10:24:07.504   50P1T                        Asserted
5   04/19/2013  10:24:07.550   WARNING                      Asserted
4   04/19/2013  10:24:07.550   MOTOR_STARTING               BEGINS
3   04/19/2013  10:24:07.550   MOTOR_STOPPED                ENDS
2   04/19/2013  10:24:07.800   MOTOR_STARTING               ENDS
1   04/19/2013  10:24:07.800   MOTOR_RUNNING                BEGINS

=>>
```

Figure 10.11 Example Sequential Events Recorder (SER) Event Report

Section 11
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-710-5 Motor Protection Relay. Because the SEL-710-5 is equipped with extensive self-tests, traditional periodic test procedures can be eliminated or greatly reduced.

Should a problem arise during either commissioning or periodic tests, the section on *Troubleshooting on page 11.17* 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, 64, or 180-cycle event report in response to faults or disturbances. Each report contains current, voltage, and other pertinent analog 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 10: 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 10: 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*. Similar results can be achieved using the web server. See *Section 3: PC Interface*.

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.

NOTE: The SEL-710-5 with the Rogowski coil or low-power current transformer (RJ45 inputs) and LEA voltage sensor (RJ45 inputs) model option is not supported by the SEL-RTS Low-Level Relay Test System.

The SEL-710-5 has a low-level test interface on the current and voltage input printed circuit boards. You can test the relay in one 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 11.1* shows the test interface connectors.

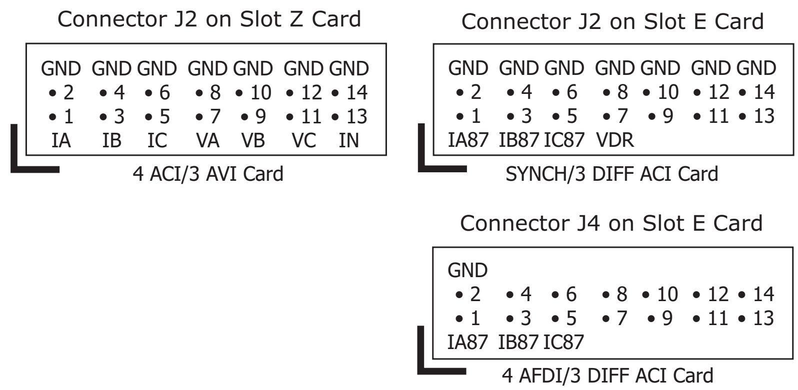


Figure 11.1 Low-Level Test Interface (J2 and J4)

Table 11.1 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 nominal input of 2.5 mA, the scale factor of 43.27 is in units of mA/V. This requires that the magnitude of the current applied to the IN channel be 1000 times the desired value. To simulate 1.0 mA, set the SEL-5401 IN current magnitude to 1.0 A.

Table 11.1 Resultant Scale Factors for Inputs

Channel Label	Circuit Board and Connector	SEL-5401 Channel No.	Nominal Input	Scale Factor (A/V,V/V,mA/V)
IA	J2 on Slot Z card	1	5 A/1 A	106.14/21.23
IB	J2 on Slot Z card	2	5 A/1 A	106.14/21.23
IC	J2 on Slot Z card	3	5 A/1 A	106.14/21.23
VA	J2 on Slot Z card	4	250 V	218.4
VB	J2 on Slot Z card	5	250 V	218.4
VC	J2 on Slot Z card	6	250 V	218.4
IN	J2 on Slot Z card	7	5 A/1 A/2.5 mA	11.09/2.26/43.27
IA87	J2 or J4 on Slot E card	8	1–5 A	14.48
IB87	J2 or J4 on Slot E card	9	1–5 A	14.48
IC87	J2 or J4 on Slot E card	10	1–5 A	14.48
VDR	J2 on Slot E card	11	250 V	218.4

⚠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.

NOTE: The 14-pin connectors of the SEL-RTS ribbon cable C709 can be used. The connectors are not keyed; make sure Pin 1 is connected to the IA/IA87 channel on the 4 ACI/3 AVI and SYNCH/3 DIFF ACI or 4 AFDI/3 DIFF ACI boards, respectively.

Access the low-level test interface connectors by using the following procedure. Make sure to turn off the relay at the start of *Step 1*. Turn on the relay after *Step 9*. Refer to the *SEL-RTS Instruction Manual* for additional detail.

Step 1. Remove the control voltage and ac signals from the SEL-710-5 by opening the appropriate breaker(s) or removing fuses.

Step 2. Remove the eight rear-panel screws and the ground screw on the back and remove the back cover.

Step 3. Remove the 4 ACI/3 AVI board from Slot Z.

Step 4. Locate connector J3 and change it from Pin CT (normal position) to Pin AMS (low-level test position).

Step 5. Locate connector J2 and connect the low-level signal connector (Slot Z label on C709 SEL-RTS Test cable).

Step 6. Insert the 4 ACI/3 AVI board back into Slot Z.

Step 7. If Slot E has either a SYNCH/3 DIFF ACI or 4 AFDI/3 DIFF ACI card, remove it.

Step 8. Locate connector J2 (SYNCH/3 DIFF ACI) or J4 (4 AFDI/3 DIFF ACI) and connect the low-level signal connector (Slot E label on C709 SEL-RTS Test cable).

Step 9. Insert the board back into Slot E. Refer to the *SEL-RTS Instruction Manual* for additional detail.

Commissioning Tests

SEL performs a complete functional check and calibration of each SEL-710-5 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 the tests verify control signal inputs and outputs.

The following connection tests help you enter settings into the SEL-710-5 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-710-5, installed and connected according to your protection design
- A PC with serial port, terminal emulation software, and serial communications cable
- *SEL-710-5 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-710-5 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.

⚠**CAUTION**
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-C234A cable or equivalent) to connect a PC to the relay.

Step 6. Start the PC terminal emulation software and establish communication with the relay.

Refer to *Section 7: Communications* for more information on serial port communications.

Step 7. Set the correct relay time and date by using either the front-panel or serial port commands.

Step 8. Using the **SET**, **SET P**, **SET G**, **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.

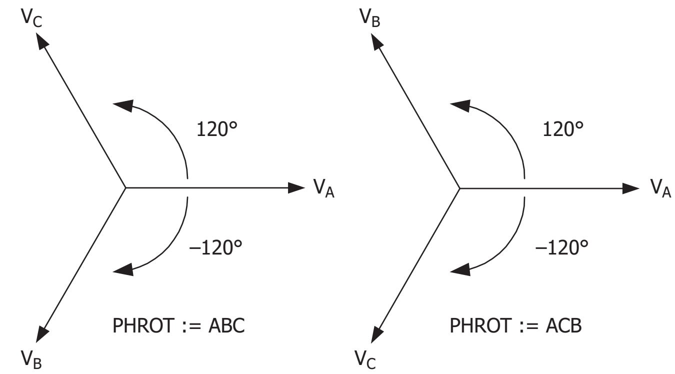
Step 11. Connect the ac test source current or voltage to the appropriate relay terminals.

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 11.2*.

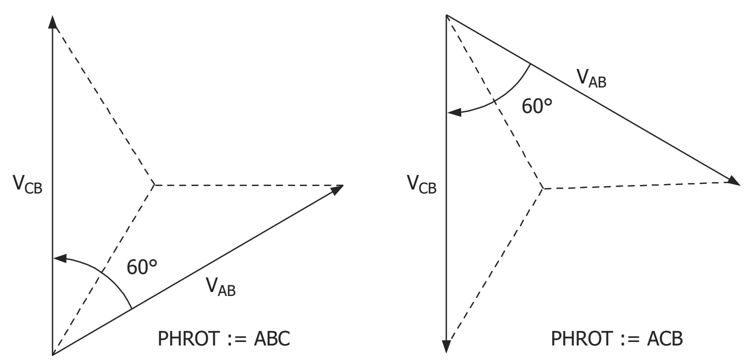
c. If you set the relay to accept delta voltages (DELTA_Y := DELTA), set the current and/or voltage phase angles as shown in *Figure 11.3*.



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 11.2 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 11.3 Three-Phase Open-Delta AC Connections

Step 12. Apply rated current (1 A or 5 A).

Step 13. 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 17` function, check the control input status in the relay.

As you apply rated voltage to each input, the position in Row 17 corresponding to that input should change from zero (0) to one (1).

Step 18. Verify output contact operation:

a. For each output contact, set the input to logical 1. This causes the output contact to close. For example, setting OUT101 = 1 causes the output **OUT101** contact to close.

b. Repeat the process for all contact outputs.

Make sure that each contact closure does what you want it to do in the annunciation, control, or trip circuit associated with that contact closure.

Step 19. Perform any 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 11.2* 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 11.2 Serial Port Commands That Clear Data Buffers

Serial Port Command	Task Performed
LDP C	Clears Load Profile Data
MMR C	Clears Motor Maintenance 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 the **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. For 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-710-5 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 11.4*. (For differential current accuracy tests, use the appropriate relay terminals for IA87, IB87, and IC87, per *Figure 2.10* and *Figure 2.12*, Slot E.)

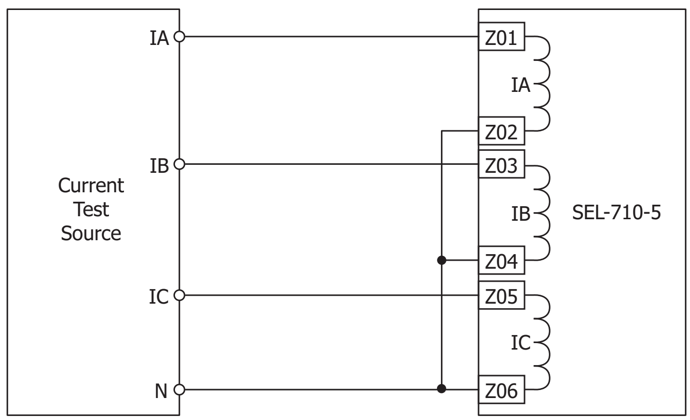


Figure 11.4 Current Source Connections

Step 2. Using the front-panel `SET/SHOW` or the **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 11.2*.

Step 4. Set each phase current magnitude equal to the values listed in Column 1 of *Table 11.3*. Use the front panel to view the phase current values. The relay should display the applied current magnitude times the CTR1 setting.

Table 11.3 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 amperes (1 or 5).

Current Unbalance Element Accuracy

Step 1. Connect the current source to the relay, as shown in *Figure 11.4*.

Step 2. Using the front-panel `SET/SHOW` function or the **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 11.2*.

Step 4. Apply the appropriate magnitude for each phase current, as shown in Column 1 of *Table 11.4*.

Table 11.4 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 11.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 11.5*. Make sure that DELTA_Y := WYE.

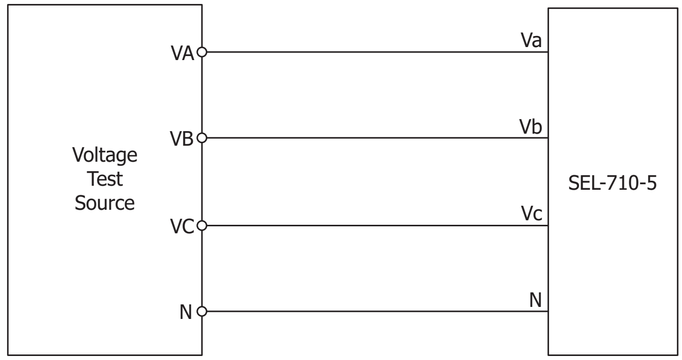


Figure 11.5 Wye Voltage Source Connections

Step 3. Using the front-panel `SET/SHOW` or the **SHOW** command, record the CTR1, PTR, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 11.5*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel `METER` function or the **MET** command to verify the results.

Table 11.5 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 11.4*.

Step 2. Connect the voltage source to the relay, as shown in *Figure 11.6*. Make sure that DELTA_Y := DELTA.

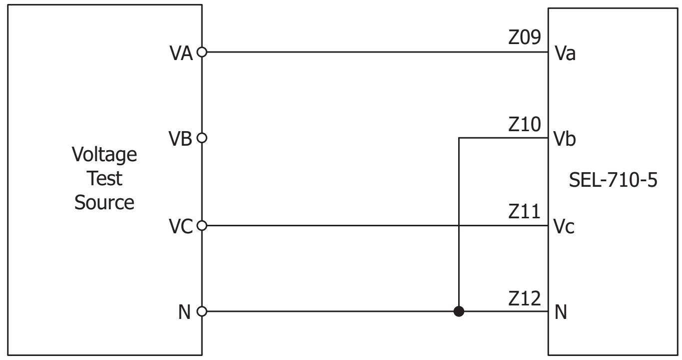


Figure 11.6 Delta Voltage Source Connections

Step 3. Using the front-panel SET/SHOW or the **SHOW** command, record the CTR1, PTR, and PHROT setting values.

Step 4. Apply the current and voltage quantities shown in Column 1 of *Table 11.6*.

Values are given for PHROT := ABC and PHROT := ACB.

Step 5. Use the front-panel METER or the **MET** command to verify the results.

Table 11.6 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:**

Arc-Flash Protection Tests

Follow the procedures described in *Section 2: Installation* to complete the installation of the arc-flash detection (AFD) fiber-optic sensors in the switchgear equipment to be protected. Make sure the switchgear doors, panels, etc., are closed and in the final operating configuration. This ensures that the ambient light as measured by the sensors is indicative of the normal operating condition. DO NOT ENERGIZE the switchgear for the commissioning tests described below. The relay must have the application settings as required, be energized, and be in the ENABLED state. Refer to *AG2011-01: Using the SEL-751 and SEL-751A for Arc-Flash Detection* for more details. The SEL-4520 Arc-Flash Test module provides a convenient way to test the operation of arc-flash detection relays installed in metal-clad and metal-enclosed switchgear. The SEL-4520 is used to test the SEL-710-5 Motor Protection Relays and other arc-flash detection relays that use light and overcurrent to sense an arc-flash event.

Arc-Flash Detection (AFD) System Continuous Self-Testing

The SEL-710-5 relay continuously tests (periodic) and monitors all eight arc-flash sensor subsystems and reports the status. The test period is constant, set to 10 minutes.

1. Point-Sensor AFD Self-Test

   Each point-sensor AFD subsystem on the relay has a Transmit LED channel and a Light Detector channel. The LED periodically sends a light pulse through the transmit fiber cable, which is "coupled" into the receive fiber cable in the point sensor. The light travels back to the light detector on the relay. The light measurement by the detector is used to determine the integrity of the point-sensor AFD loop and report PASS/FAIL status.

2. Clear-Jacketed Fiber Sensor AFD Self-Test

   The clear-jacketed fiber sensor is basically a loop, starting from the Transmit LED and returning to the Light Detector. The relay self-test involves sending a light pulse around the loop and measuring the light received at the detector. The light measurement by the detector is used to determine the integrity of the clear-jacketed fiber sensor AFD loop and report PASS/FAIL status.

NOTE: The point-sensor diagnostics signal does not affect the response time of the sensor. The fiber-sensor diagnostics signal can cause a 1 ms delay if the arc-flash event occurs at the same time as the diagnostics test. The fiber-sensor diagnostic test injects a 1 ms pulse through the fiber once every 10 minutes.

METER LIGHT Report

Use the serial port ASCII command **METER L** and view the METER LIGHT report as shown in *Figure 5.10*.

The report shows the light intensity measurements in percent of full scale (%) for the four AFD channels. This measurement represents the background or the ambient light in the switchgear areas being monitored for arc-flash. This measurement is used in determining the time-overlight TOL1–TOL4 (or TOL1–TOL8) settings for arc-flash protection (refer to *Section 4: Protection and Logic Functions* for details). If there is excessive background light (any of the Relay Word bits AFS*n*EL picks up) or if there is a diagnostic failure (any of the Relay Word bits AFS*n*DIAG picks up), the AFALARM Relay Word bit picks up and gives a warning on the relay front panel and asserts the ALARM output contact.

Command AFT (Arc-Flash Test)

The relay performs the arc-flash self-test periodically as previously discussed. Additionally, by using the serial port ASCII command **AFT**, the relay performs the self-test on demand in all four channels and reports the status of each channel. This same test is also available from the Control Window in the QuickSet and the relay front panel STATUS sub-menu. Refer to *Figure 7.20* for the **AFT** command response example. The response shows the light measurements in percent of full scale and the PASS/FAIL status. The PASS indication means the channel is healthy and ready to detect an arc-flash event. The FAIL indication means the channel in question is not healthy and needs repair and testing when a convenient outage is available for maintenance.

Testing the Arc-Flash Time-Overlight Elements TOL1 to TOL8

Test the TOL elements once the relay has been set, as described in *Section 4: Protection and Logic Functions* for the arc-flash protection elements. The TOL1 to TOL8 Relay Word bits should be added to the SER (Sequence of events report) settings so that the relay can capture the TOL element assertion and dropout. Apply a bright light source near the light sensor (either point or fiber) in the switchgear cabinet and note that the appropriate TOL element Relay Word bit picks up and drops out as expected.

Capture the arc-flash test as a **CEV** event report by triggering the event report with the TOL*n* Relay Word bit. You can view the **CEV R** (raw data) event report using SEL-5601-2 SYNCHROWAVE Event Software. View the % light intensity analog quantity together with the TOL*n* Relay Word bit to verify the correct operation.

Testing the Arc-Flash Overcurrent Elements 50PAF and 50NAF

These current elements are similar to the 50P and 50N elements, except that they use raw current input samples and act instantaneously to achieve fast response. These elements can be tested just like the 50P and 50N elements. Use the **CEV R** report as previously discussed to analyze the event.

Testing the Complete Arc-Flash Protection System

It is necessary to verify the complete protection subsystem, even though the relay is tested at the factory before shipping, as it is a critical protection function. If a synchronized light and current pulse test source is available to simulate an arc, it can be used to exercise the arc-flash protection TOL*n* elements together with the 50PAF or the 50NAF elements. If the relay has been set for the arc-flash protection including the tripping logic, the test could exercise the breaker tripping (unenergized state). The total event can be captured with appropriate event report trigger settings and the **CEV R** (raw data) report can be viewed and analyzed using SYNCHROWAVE Event. The **CEV R** report shows the analog currents and light channels together with the Relay Word bits so that the response can be analyzed and qualified. *Figure 11.7* shows an example event report for a simulated arc-flash incident.

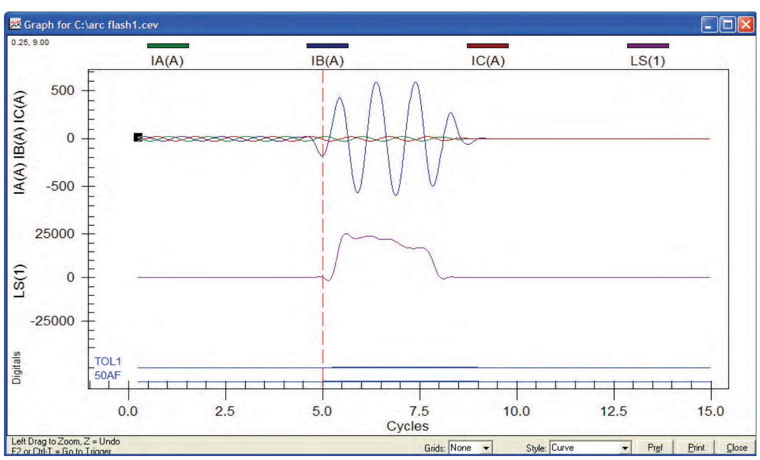


Figure 11.7 CEV R Light Event Capture Example

Periodic Tests (Routine Maintenance)

Because the SEL-710-5 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-710-5 does not require specific routine tests, but your operation standards can require some degree of periodic relay verification. If you need or want to perform periodic relay verification, the following checks are recommended.

Table 11.7 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.
Arc-Flash Detection (AFD) Status	Use the serial port **AFT** command to verify that the AFD channel self-tests have not detected any FAIL condition in any of the channels.
Meter	Verify that the relay is correctly measuring current and voltage (if included) by comparing the relay meter readings to separate external meters.
Control Input	Using the front-panel MAIN > Targets > Row 17 function, check the control input status in the relay. As you apply rated voltage to each input, the position in Row 17 corresponding to that input should change from zero (0) to one (1).
Contact Output	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-710-5 runs a variety of self-tests. The relay takes the following corrective actions for out-of-tolerance conditions (see *Table 11.8*):

- 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) on page R.7.32* 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 firmware upgrade attempts via Ethernet, settings changes, access level changes, unsuccessful password entry attempts, active group change, copy command, and password change. HALARM is pulsed for hardware self-test warnings. HALARM is continuously asserted (set to logical 1) for hardware self-test failures. A diagnostic alarm can be configured as explained in *Section 4: Protection and Logic Functions*. In the Alarm Status column of

Table 11.8, 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 for failures.
- For certain failures, the relay automatically restarts as many as three times. In many instances, this corrects the failure. The failure message might not be fully displayed before automatic restart occurs. Indication that the relay restarted is recorded in the Sequential Events Recorder (SER).

NOTE: "W" in the STA response indicates a warning for the corresponding quantity.

Use the serial port **STATUS** command or front-panel to view relay self-test status. Based on the self-test type, issue the **STA C** command as directed in the Corrective Actions column. Contact SEL if this does not correct the problem.

Table 11.8 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 (turn on)	Fail if main board Field Programmable Gate Array does not accept program or the version number is incorrect		Yes	Latched	Yes	Status Fail FPGA Failure	Automatic restart. Contact SEL if failure returns.
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 (turn on)	Two-line display: Fail if ID registers do not match or if FPGA programming is unsuccessful Touchscreen display: Automatic diagnostics identify an issue		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External RAM (turn on)	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 (turn on)	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 (turn on)	SELBOOT qualifies code with a checksum		NA	NA	NA	NA	
Data Flash (turn on)	Checksum is computed on critical data		Yes	Latched	Yes	Status Fail Non_Vol Failure	

Table 11.8 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 (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 Fail-ure	Automatic restart. Contact SEL if failure returns.
Critical RAM (run time)	Verify instruction matches FLASH image		Yes	Latched	Yes	Status Fail CR_RAM Fail-ure	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	
Card Z (turn on)	Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail Card Z Fail	
Card Z A/D Offset Warn	Measure dc offset at each input channel	–50 mV to +50 mV	No	Not Latched	No	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
ADCCHK (Slot Z)	A/D reference channel check	<2.375 V or >2.625 V	Yes	Latched	Yes	Status Fail Card Z Fail	Automatic restart. Contact SEL, if failure returns.
Card E (turn on)	Fail if ID register does not match part number		Yes	Latched	Yes	Status Fail Card E Fail	
Card E A/D Offset Warn	Measure dc offset at each input channel	–50 to +50 mV	No	Not Latched	No	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
ADCCHK (Slot E)	A/D reference channel check	<2.375 V or >2.625 V	Yes	Latched	Yes	Status Fail Card E Fail	Automatic restart. 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	

Table 11.8 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
+3.3 V Fail	Monitor +3.3 V power supply	3.07 to 3.53 V	Yes	Latched	Yes	Status Fail +3.3 V Failure	
+5 V Fail	Monitor +5 V power supply	4.65 to 5.35 V	Yes	Latched	Yes	Status Fail +5 V Failure	
+2.5 V Fail	Monitor +2.5 V power supply	2.32 to 2.68 V	Yes	Latched	Yes	Status Fail +2.5 V Failure	
+3.75 V Fail	Monitor +3.75 V power supply	3.48 to 4.02 V	Yes	Latched	Yes	Status Fail +3.75 V Failure	
–1.25 V Fail	Monitor -1.25 V power supply	–1.16 to –1.34 V	Yes	Latched	Yes	Status Fail –1.25 V Failure	
–5 V Fail	Monitor -5 V power supply	–4.65 to –5.35 V	Yes	Latched	Yes	Status Fail –5 V Failure	
Clock Battery	Monitor Clock Battery	2.3 to 3.5 V	No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip	Unable to communicate with clock or fails time keeping test		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
Clock Chip RAM	Clock chip static RAM fails		No	Not Latched	Yes	NA	STA C, to clear the warning in the status report. Contact SEL if failure returns.
External/Internal RTD	Fails if the internal RTD card or the external RTD module reports that at least one enabled RTD input is open or shorted, if there is no comm, or if there is a power supply failure for the external RTD module		NA	NA	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 11.9 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/Home** 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-710-5-**R100**-V0-Z001001-D*xxxxxxxx*

Standard release firmware:

FID=SEL-710-5-**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-710-5-R100-**V0**-Z001001-D*xxxxxxxx*

Point release firmware:

FID=SEL-710-5-R100-**V1**-Z001001-D*xxxxxxxx*

NOTE: R1*xx* series firmware can be upgraded to any of the latest firmware versions.

The date code is after the D. For example, the following is firmware version number R100, date code July 25, 2013.

FID=SEL-710-5-R100-V0-Z001001-**D20130725**

Table A.1, *Table A.2*, and *Table A.3* list the firmware versions, a description of modifications, and the instruction manual date code that corresponds to the firmware versions of each series of 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 R300 Series Firmware Revision History (Sheet 1 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R303-V0-Z006003-D20240826	➤ [Cybersecurity] Resolved an issue where a Bridge Protocol Data Unit (BPDU) packet of invalid size could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Resolved an issue where the SALARM Relay Word bit did not pulse for an incorrect password entered via the touchscreen. ➤ Added an ordering option for the 4 ACI/3 AVI low-energy analog (LEA) card in Slot Z. ➤ Added Incipient Cable Fault Trip as an event type. ➤ Improved the accuracy of data time stamp in the COMTRADE event report. ➤ Added LOP supervision to the slip dependent thermal model. ➤ Added an RTD location setting dependency check for ETHMBIAS and COOLEN settings. ➤ Enhanced the MSR and CMSR reports to show the VEX and IEX quantities. ➤ Added the PFLEAD Relay Word bit to indicate power factor lead/lag. ➤ Expanded the setting range for the PFSPAN setting to 0.10–1.00 when PFLDLG = LEAD. ➤ Added residual current (3I0) supervision settings to the breaker failure logic. Also added the RSTTRGT Relay Word bit to the breaker failure trip reset logic. ➤ Added an entry to the Sequential Events Recorder (SER) for when the thermal capacity is reset manually. ➤ Added the FDCTFLT Relay Word bit to indicate an IEX measurement of less than 4 mA. ➤ Added the 41CLOSE3 logic to allow for the field breaker close command to be issued at a specific time with the breaker closing time included. ➤ Updated the frequency tracking algorithm for VFD applications. ➤ Modified the prompt for the slip source setting SLIPSRC. ➤ Extended the voltage threshold constraint for frequency measurement to VFD applications with VFDBYPAS set to Y. ➤ Increased resolution of frequency trip delay setting 81D*n*TP (*n* = 1–4) to two digits. ➤ Improved performance of relay in Switched mode during a network storm. ➤ Added SELOGIC settings SCBK1BO and SCBK1BC for IEC 61850 breaker control interlocking (CILO) logical node. ➤ Modified the TEST DB functionality to override Relay Word bits that are in the SER. ➤ Resolved an issue where Port 1B became occasionally unresponsive after changing the NETMODE setting value from SWITCHED to PRP. ➤ Resolved an issue where the relay could experience a NON VOL failure under certain conditions. ➤ Resolved an issue where the GOOSE messages did not use the correct MAC address after the MAC address was updated. ➤ Resolved an issue where entering a special character for a settings value via the terminal session may cause the device to interpret the setting as 0. ➤ Resolved an issue where an arc-flash test would fail when the relay was put in IEC 61850 Blocked or Test/Blocked modes.	20240826

Table A.1 R300 Series Firmware Revision History (Sheet 2 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R302-V2-Z005003-D20240826	Includes all the functions of SEL-710-5-R302-V1-Z005003-D20240329 with the following additions: ➤ [Cybersecurity] Resolved an issue where a Bridge Protocol Data Unit (BPDU) packet of invalid size could cause the relay to perform a diagnostic restart. ➤ [Cybersecurity] Resolved an issue where the SALARM Relay Word bit did not pulse for an incorrect password entered via the touchscreen. ➤ Improved the accuracy of data time stamp in the COMTRADE event report. ➤ Updated the frequency tracking algorithm for VFD applications. ➤ Modified the prompt for the slip source setting SLIPSRC. ➤ Extended the voltage threshold constraint for frequency measurement to VFD applications with VFDBYPAS set to Y. ➤ Improved performance of relay in Switched mode during a network storm. ➤ Modified the TEST DB functionality to override Relay Word bits that are in the SER. ➤ Resolved an issue where Port 1B became occasionally unresponsive after changing the NETMODE setting value from SWITCHED to PRP. ➤ Resolved an issue where the GOOSE messages did not use the correct MAC address after the MAC address was updated. ➤ Resolved an issue where entering a special character for a settings value via the terminal session may cause the device to interpret the setting as 0. **NOTE:** We recommend that you save all the events stored in the relay before upgrading to firmware version R302-V2. Clear the event history buffer after the firmware upgrade.	20240826
SEL-710-5-R302-V1-Z005003-D20240329	Includes all the functions of SEL-710-5-R302-V0-Z005003-D20220826 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from Access Level C. ➤ Improved the resolution of the frequency measurement in the COMTRADE event report. ➤ Resolved an issue where the Precision Time Protocol (PTP) was not able to synchronize the time if the PTP transport mechanism setting PTPTR was set equal to LAYER2. This issue affects firmware version R302-V0 only. ➤ Resolved an issue where simultaneous read or write operations of multiple files could cause a General Purpose Serial Bus (GPSB) failure. ➤ Resolved an issue where the relay failed to synchronize with the SNTP server when Rapid Spanning Tree Protocol (RSTP) was enabled. This issue impacts firmware version R302-V0 only. ➤ Resolved an issue with the incorrect operation of the 97F*n*T time-out bit. ➤ Resolved an issue where multiple motor starts with the 97FM element enabled could cause a nonvolatile memory (NON_VOL) failure. ➤ Resolved an issue with maximum phase time-overcurrent element chatter when VFDAPP was set to Y. ➤ Resolved an issue where an event with a duplicate event record number, caused by a defective event record, could not be retrieved. ➤ Resolved an issue with the processing of the math variables.	20240329

Table A.1 R300 Series Firmware Revision History (Sheet 3 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R302-V0-Z005003-D20220826	➤ [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, which removes low-risk security vulnerabilities that could result in temporary loss of Ethernet communications. ➤ Added firmware support for new hardware component suppliers. ➤ Added support for IEEE 802.1Q-2014 Rapid Spanning Tree Protocol (RSTP) for models with the dual Ethernet port option. ➤ Added support for the IEC 61850 Local/Remote control feature defined in the IEC 61850-7-4 standard. ➤ Added support for the IEC 61850 functional naming feature. ➤ Added SELOGIC variable SC850SM for IEC 61850 simulation mode. ➤ Increased the number of Relay Word bit aliases to 32. ➤ Improved performance to allow touchscreen operation after a firmware downgrade. ➤ Enhanced the relay firmware to retain configuration settings for the IP address, subnet mask, and default router for Port 1 during a firmware upgrade from any previous 3*xx* firmware version. ➤ Resolved an issue where the relay failed to evaluate analog quantity I850MOD when mapped to a SELOGIC control equation. ➤ Resolved an issue where the relay always remained in IEC 61850 ON mode after issuing an **R_S** command independent of the selected IEC 61850 mode/behavior. ➤ Resolved an issue that caused the touchscreen to incorrectly display “Resend the Touchscreen settings.”	20220826
SEL-710-5-R301-V0	**Note:** SEL-710-5 R301-V0 was not production released. R302-V0 follows R300-V6.	—
SEL-710-5-R300-V6-Z004003-D20220826	Includes all the functions of SEL-710-5-R300-V5-Z004003-D20220225 with the following additions: ➤ Added firmware support for new hardware component suppliers. ➤ Improved performance to allow touchscreen operation after a firmware downgrade. ➤ Resolved an issue where the relay always remained in IEC 61850 ON mode after issuing an **R_S** command independent of the selected IEC 61850 mode/behavior.	20220826
SEL-710-5-R300-V5-Z004003-D20220225	Includes all the functions of SEL-710-5-R300-V4-Z004003-D20211213 with the following additions: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network. ➤ Resolved an issue with the 14 digital input card where the digital inputs incorrectly processed an ac control signal input.	20220225
SEL-710-5-R300-V4-Z004003-D20211213	Includes all the functions of SEL-710-5-R300-V3-Z004003-D20210917 with the following addition: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part.	20211213
SEL-710-5-R300-V3-Z004003-D20210917	Includes all the functions of SEL-710-5-R300-V2-Z004003-D20210104 with the following additions: ➤ Added the IEC 61850 blocked-by-interlocking control error response. ➤ Resolved an issue where a large number of file read operations could lead to a data retrieval error.	20210917

Table A.1 R300 Series Firmware Revision History (Sheet 4 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue where EtherNet/IP communication stopped after approximately 25 days. ➤ Resolved an issue where the power factor lead/lag label, shown on the fundamental metering screen for touchscreen models, did not update when any of the applied secondary phase currents were less than 0.5 A. ➤ Resolved an issue in which the power factor label PFL, used in DNP, IEC 61850, and EtherNet/IP protocols, did not update when any of the applied secondary phase currents were less than 0.5 A.	
SEL-710-5-R300-V2-Z004003-D20210104	Includes all the functions of SEL-710-5-R300-V1-Z004003-D20200921 with the following additions: ➤ Resolved a rare issue where Telnet traffic could cause a diagnostic restart of the relay. ➤ Resolved an issue in touchscreen relay models where repeated triggering of the TRIP/WARN messages resulted in the relay becoming disabled. ➤ Resolved an issue in which the **MOT** command response reported the total number of trips incorrectly. ➤ Resolved an issue with MIRRORED BITS communications over channels using an eight data bit format.	20210104
SEL-710-5-R300-V1-Z004003-D20200921	Includes all the functions of SEL-710-5-R300-V0-Z004003-D20200331 with the following additions: ➤ Resolved an issue with the EPORT setting for the Ethernet port. ➤ Resolved an issue where the **HIS 50INC C** command did not reset the alarm and trip Relay Word bits for the incipient cable fault logic. ➤ Resolved an issue in the relay where Modbus Register addresses did not match the Modbus Register Map.	20200921
SEL-710-5-R300-V0-Z004003-D20200331	➤ Added support for zipped and digitally signed (.zds) firmware files. These .zds firmware files require the SELBOOT firmware version to be upgraded to R600 first. Firmware files with the .s19 and .z19 extensions cannot be sent to relays with SELBOOT firmware R600. ➤ Added the ability to upgrade relay firmware remotely over an Ethernet network. ➤ Added web server capability to relays equipped with Ethernet. ➤ Increased the number of two-position disconnects to eight and added control support to the two-position disconnects. ➤ Added two three-position disconnects with control support. ➤ Added support for IEEE 1588-2008 firmware-based Precision Time Protocol (PTP) for time synchronization. ➤ Added IEC 61850 Test Mode with standard operating modes, including On, Blocked, Test, Test/Blocked, and Off. ➤ Added the EtherNet/IP communications option for relays equipped with Ethernet. ➤ Added a Type B PID controller that can be used for generic control applications or power factor regulation for synchronous motor applications. ➤ Added the ability to monitor vibrations based on the ISO 20816 standard. In touchscreen models, you can also view in a bar graph the measured values of vibration transducers connected to a motor. ➤ Added the Motor Maintenance Record (MMR), which tracks motor parameters, such as time to start/stop, power on start/stop, maximum starting current, minimum starting voltage, and slip on stop for offline analysis to monitor the health of the motor.	20200331

Table A.1 R300 Series Firmware Revision History (Sheet 5 of 5)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Added 97FM elements to monitor the magnitude of user-selected frequency components in different analog signals. ➤ Added the **CMET S R** command, which displays the raw compressed meter report in CASCII format. ➤ Added the incipient cable fault detection (50INC) element. ➤ Added the ability to detect CT saturation or A/D saturation during breaker opening to monitor molded case circuit breaker health. ➤ Added the SINGLEI setting to allow motor applications in which only single-phase current is available. ➤ Improved Sequential Events Recorder (SER) time-stamp accuracy for digital inputs and arc flash elements (50PAF, 50NAF, TOL, and digital outputs) to 1 ms. ➤ Improved event reports to include settings at the time of the event. ➤ Added the ability to trigger event reports from the Event History application on the touchscreen display. ➤ 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. ➤ Updated the TCP keep-alive settings so they can be turned off or configured as desired. This update applies to all TCP protocols, including Telnet, File Transfer Protocol (FTP), MMS, and C37.118 phasor measurement unit (PMU). ➤ Increased the upper limit of the frequency trip delay setting 81D*n*TD (*n* = 1 to 4) from 240.00 to 400.00 seconds. ➤ Resolved an issue in which the power factor element did not operate correctly when real power was negative. ➤ Resolved an issue where the state of Target LED (TLED) data points was not correctly reported in GOOSE messages. ➤ Resolved an issue where the Global access control setting DSABLSET did not disable settings edits via the touchscreen interface when DSABLSET := Y. ➤ Resolved an issue in the touchscreen models where editing the DNP3 setting, TIMERQ, resulted in an unresponsive screen until the **HOME** pushbutton was pressed. ➤ Resolved an issue where the COMTRADE events included event data four times. Firmware versions R200-V0 and higher are affected by this issue. ➤ Modified firmware to increment the state number (stNum) in GOOSE messages for any change of the quality attribute.	

Table A.2 R200 Series Firmware Revision History (Sheet 1 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R201-V5-Z003002-D20220826	Includes all the functions of SEL-710-5-R201-V4-Z003002-D20220225 with the following addition: ➤ Added firmware support for new hardware component suppliers.	20220826
SEL-710-5-R201-V4-Z003002-D20220225	Includes all the functions of SEL-710-5-R201-V3-Z003002-D20211213 with the following addition: ➤ [Cybersecurity] Resolved an issue where GOOSE receive messages would no longer be processed during or after a GOOSE data storm on the network.	20220225

Table A.2 R200 Series Firmware Revision History (Sheet 2 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R201-V3-Z003002-D20211213	Includes all the functions of SEL-710-5-R201-V2-Z003002-D20210917 with the following addition: ➤ Revised the firmware to allow replacement of the field-programmable gate array (FPGA) part.	20211213
SEL-710-5-R201-V2-Z003002-D20210917	Includes all the functions of SEL-710-5-R201-V1-Z003002-D20210104 with the following additions: ➤ Resolved an issue where a large number of file read operations could lead to a data retrieval error. ➤ Resolved an issue where the power factor lead/lag label, shown on the fundamental metering screen for touchscreen models, did not update when any of the applied secondary phase currents were less than 0.5 A. ➤ Resolved an issue in which the power factor label PFL, used in DNP, IEC 61850, and EtherNet/IP protocols, did not update when any of the applied secondary phase currents were less than 0.5 A.	20210917
SEL-710-5-R201-V1-Z003002-D20210104	Includes all the functions of SEL-710-5-R201-V0-Z003002-D20200331 with the following additions: ➤ Resolved a rare issue where Telnet traffic could cause a diagnostic restart of the relay. ➤ Resolved an issue in touchscreen relay models where repeated triggering of the TRIP/WARN messages resulted in the relay becoming disabled. ➤ Resolved an issue in which the **MOT** command response reported the total number of trips incorrectly.	20210104
SEL-710-5-R201-V0-Z003002-D20200331	➤ Resolved an issue in which the power factor element did not operate correctly when real power was negative. ➤ Resolved an issue where the state of Target LED (TLED) data points was not correctly reported in GOOSE messages. ➤ Resolved an issue in the touchscreen models where editing the DNP3 setting, TIMERQ, resulted in an unresponsive screen until the HOME pushbutton was pressed. ➤ Resolved an issue where the relay enabled 1/2 cycle before the front-end analogs settled down, leading to nuisance events on relay turn on. This issue affects firmware versions R200-V0 and R200-V1 only.	20200331
SEL-710-5-R200-V1-Z003002-D20181228	Includes all the functions of SEL-710-5-R200-V0-Z003002-D20180629 with the following additions: ➤ Resolved an issue in which RTD measurements were not updated when setting BLK49RTD := Y and the Relay Word bit BLKPROT was asserted. ➤ Addressed a mismatch between the event type strings for **CHI** and **CEV** commands. Due to the mismatch, SEL RTACs were not able to collect events with event type strings longer than 14 characters from the relay. ➤ Resolved an issue in which the relay continued to send Fast SER data to the RTAC even after the relay acknowledged an RTAC disable command. ➤ Resolved an issue in which the power factor label PFL, used in the DNP reference map, was not updating when SINGLEV := Y. ➤ Resolved an issue in which the power factor lead/lag label shown in the fundamental metering screen for touchscreen models was not updating when setting SINGLEV := Y.	20181228

Table A.2 R200 Series Firmware Revision History (Sheet 3 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R200-V0-Z003002-D20180629	➤ Added the touchscreen display front-panel option. ➤ Added Spanish language support on all communications ports. Also added an ordering option for a relay with the Spanish overlay and Spanish front-panel HMI. ➤ Enhanced the CPU card design, including the addition of a GOOSE port with a dedicated MAC address to improve GOOSE performance. Note that relays with older CPU cards can be upgraded to firmware version R200 or higher, but the relay will not have the GOOSE performance improvements. ➤ Updated IEC 61850 protocol implementation to IEC 61850 Edition 2. ➤ Added file transfer support in IEC 61850 for CEV events; COMTRADE events; MST, MOT, CMSR, LDP, HIS, SER, and BRE reports; CID files; and settings files. ➤ Increased the maximum number of GOOSE subscriptions to 64. ➤ Added password authentication and session timeout for MMS services. ➤ Added IEC 62439 Parallel Redundancy Protocol (PRP) for models with the dual Ethernet port option. ➤ Added IEC-60870-5-103 protocol. ➤ Increased the number of DNP sessions from 3 to 5. ➤ Added Modbus Master IP settings. ➤ Added the enable port setting EPORT to all the communications ports to enhance port security. ➤ Added the MAXACC setting to all communications ports, including the front panel, to control limited or full access. Note that the front-panel MAXACC setting is not supported for relays with the touchscreen option. ➤ Added Telnet access setting ETELNET and FTP access setting EFTPSERV to Ethernet Port 1. ➤ Added an ordering option for a 14 digital input card in Slots C, D, and E. ➤ Added COMTRADE support for Events and compressed Motor Start Reports in the relay. ➤ Added a unique reference numbering system for HIS, CHIS, SUM, CSUM, EVE, CEV, MSR, and CMSR reports. ➤ Increased the number of settings groups from 3 to 4. ➤ Added OFF to all the 50 elements delay settings ranges. ➤ Added the inverse-time over- and undervoltage elements. ➤ Added a setting, METHRES, in the Global settings category that allows for turning off the squelching of currents and voltages below a certain level. ➤ Added disconnect status logic with double point indication to monitor the status of as many as five disconnects. ➤ Increased the TOL pickup setting to 80% for both the point- and bare-fiber sensors. ➤ Added torque-control settings for the frequency (81) elements with the default value set to 1. ➤ Enhanced SELOGIC processing capacity in the relay. ➤ Resolved an issue with the analog quantity for frequency getting reset to 0 after a settings change.	20180629

Table A.2 R200 Series Firmware Revision History (Sheet 4 of 4)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Modified GPSB diagnostics logic to show failure only if the GPSB diagnostics fail three consecutive times within 24 hours. ➤ Addressed an issue with 41 close logic in the presence of high frequency noise. ➤ Resolved an issue with the load loss element, which did not operate when LLSDLY := 0. ➤ Resolved an issue with output contact OUT*xxx* chattering continuously when selected for arc flash, i.e., AOUTSLOT := OUT*xxx* setting, and mapped to TRIP equation, i.e., OUT*xxx* := TRIP. ➤ Resolved an issue with the NOSLO Relay Word bit asserting for a second when BLKPROT := STARTING and BLK66 := Y. ➤ Resolved an issue with the **PULSE/CON PULSE/TEST DO** command on any output blocking the processing of all the remaining outputs for the duration of the pulse. ➤ Addressed an issue where the relay could assert Thermal overload Trip incorrectly when there is a rapid drop in VFD frequency and the LOAD_ZS setting is being applied (not equal to motor full load current). ➤ Addressed an issue with breaker wear data not getting saved upon cycling power to the relay. ➤ Added **TEST DB** command to support relay testing.	

Table A.3 R100 Series Firmware Revision History (Sheet 1 of 3)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R102-V0-Z002001-D20170330	➤ Improved the 41CLOSE logic to avoid closing the field breaker while the VDR signal is positive. ➤ Revolved an issue where the analog quantities for the light metering were reading incorrect values when more than 50% light was applied to the relay. ➤ Revised the firmware to allow power factor current supervision setting 55I1SUP for relays with MOT x81 for the Slot Z 4 ACI/3 AVI card. ➤ Revised the firmware to allow AFD output slot setting, AOUTSLOT, to accept the 401_4 option when a DO card is installed in Slot D. ➤ Resolved an issue with the 41DELAY setting that caused the relay to disable when set to less than 0.4 seconds. ➤ Enhanced the MSR and CMSR reports to show the slip calculated from the stator quantities or the VDR signal when the slip source setting SLIPSRC is set to STAT or VDR, respectively. ➤ Improved the accuracy of the slip calculation in the slip dependent thermal model for brushless synchronous motor applications with the slip source setting, SLIPSRC := STAT. The revised firmware allows for longer start times. ➤ Revised the R101-V0 firmware version for the slip dependent thermal model in induction motor applications, which under reported the rotor TCU. The issue is present in only the R101-V0 firmware version and it affects induction motor applications in which the full-load slip setting, FLS, is not set to OFF. ➤ Fixed Telnet and Modbus/TCP multiple session availability issue present in firmware revision R101 only.	20170330

Table A.3 R100 Series Firmware Revision History (Sheet 2 of 3)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
SEL-710-5-R101-V0-Z002001-D20160729	➤ Added a power factor loss-of-synchronism (pull-out) detection logic that operates when the motor power factor falls below the relay setting POPFSP. ➤ Added a power factor regulation logic that compares the reactive power consumed by the motor with a reactive power set point (QSP) and generates a raise or lower excitation command. ➤ Enhanced the firmware to allow synchronous motor start sequence for motor applications where field measurements are not available. ➤ Enhanced the motor thermal model by allowing for faster cooling rate during coasting to stop. Based on the new COASTIME setting, the relay automatically delays the use of the slower cooling rate (based on COOLTIME), which significantly reduces the wait time before the next start is allowed by thermal lockout. ➤ Enhanced the slip-dependent thermal model to use slip derived from VDR (SMSLIP) for brush-type synchronous motors or slip derived from stator measurements (SMSLIP2) primarily for brushless synchronous motors. ➤ Added to the CEV report slip derived from VDR (SMSLIP) for brush-type synchronous motors and slip derived from stator measurements (SMSLIP2). ➤ Enhanced the Motor State Logic to use average rms instead of sequence currents for VFD application. ➤ Added OFF to the setting range of the failover time setting, FTIME, to support fast failover switching in dual Ethernet models. ➤ Revised to allow loss-of-field (40) and out-of-step (78) functions for the base model relay and to not require synchronous motor card in Slot E. ➤ Enhanced the firmware to include synchronous motor applications for Full-Voltage Reversing Starter. ➤ Added the LOPBLK SELOGIC control equation setting with the default value set to 0 to allow for blocking of the LOP logic under user-defined conditions. Also, raised the minimum threshold for positive-sequence voltage V1 from 5 V to 10.5 V. ➤ Revised the firmware to allow an anonymous TCP connection from DNP masters when DNPIP*n* is set to 0.0.0.0. ➤ Modified the prompt for the DNP Master IP Address DNPIP*n* to distinguish it from the device IP Address. ➤ Resolved an issue with the DNP binary outputs so that they are no longer reported as OFFLINE when the binary output is also present in the binary input map and the SER (Sequential Events Recorder). ➤ Added a 2.5 mA high-sensitivity neutral current input channel to the slot Z 4 ACI/3 AVI cards. ➤ Revised the firmware to address an issue where the oldest 180-cycle event disappeared from the event history after the relay power cycled or restarted with STA C. ➤ Added the RSTMOT SELOGIC control equation setting to reset MOT data. ➤ Added virtual speed switch functionality based on current profile during across-the-line motor starting with subtransient current override. ➤ Removed option D from the NETPORT setting. ➤ Resolved an issue that caused small jumps in the angle calculations for analog quantities.	20160729

Table A.3 R100 Series Firmware Revision History (Sheet 3 of 3)

Firmware Identification (FID) String	Summary of Revisions	Manual Date Code
	➤ Resolved an issue with settings change (STSET) being reported as OFFLINE via DNP. ➤ Resolved an issue with the reset command for Max/Min and Energy metering functions. ➤ Resolved an issue with the TRIPONLO setting. ➤ Resolved an issue with RTD biasing that, in certain cases, caused the relay to TRIP on 49T even when currents were not applied.	
SEL-710-5-R100-V0-Z001001-D20130725	➤ Initial version.	20130725

SELBOOT Firmware Version and Relay Firmware Compatibility

The SELBOOT revision and the compatible relay firmware versions are listed in *Table A.6*. The new SELBOOT firmware R600 ensures that the relay firmware upgrade file is digitally signed by SEL using a secure hash algorithm that ensures that the file has been provided by SEL and that its contents have not been altered. R300-V0 firmware requires that the SELBOOT firmware be upgraded to R600.

Table A.4 SELBOOT Firmware Revision History

Boot Firmware Identification Number	Summary of Revisions	Firmware Revision Supported	Release Date
SLBT7XX-R602-V0-Z000000-D20220826	➤ Improved the restart performance of the SELBOOT firmware.	R300 and higher	20220826
SLBT7XX-R601-V0-Z000000-D20211116	➤ Revised the SELBOOT firmware to allow replacement of the field-programmable gate array (FPGA) part.	R300 and higher	20211116
SLBT7XX-R600-V0-Z000000-D20200331	➤ The new SELBOOT supports zipped and digitally signed (.zds) firmware files.	R300 and higher	20200331
BOOTLDR-R502-V0-Z000000-D20211116	➤ Revised the SELBOOT firmware to allow replacement of the field-programmable gate array (FPGA) part.	R1*xx*, R2*xx*	20211116
BOOTLDR-R501-V0-Z000000-D20160729	➤ Changed RAM integrated circuit.	R101 to R2*xx*	20160729
BOOTLDR-R500-V0-Z000000-D20130725	➤ Initial version.	R100	20130725

SEL Display Package Versions

The SEL-710-5 with the touchscreen display option has display packages for the SEL display and default custom display. *Table A.5* lists the display package version, a description of the modifications, and the instruction manual date code that corresponds to the display package versions. The most recent firmware version is listed first. The version number of this firmware is accessible through the Device Info folder.

Table A.5 SEL Display Package Revision History (Sheet 1 of 2)

SEL Display Package Version	Revisions	Release Date
3.0.50710.3006	➤ Added support for new hardware component suppliers. ➤ Improved performance to allow touchscreen operation during a firmware downgrade.	20220826
3.0.50710.3004	➤ Added support for new hardware component suppliers. ➤ Modified the color touchscreen backlight brightness for more consistent dimming while in standby mode.	20211213

Table A.5 SEL Display Package Revision History (Sheet 2 of 2)

SEL Display Package Version	Revisions	Release Date
	➤ Improved the performance of the touchscreen display in rotating display mode. ➤ Resolved an issue where the backlight could flicker during power up.	
3.0.50710.3000	➤ Added the Vibration Monitor application. ➤ Updated the keyboard layout on the touchscreen display for ease of data entry. ➤ Added pick list feature for settings that have a fixed list in the setting range. ➤ Added the ability to keep the backlight of the touchscreen display always on after the inactivity timer expires. Relays shipped after May 21, 2020 support this feature.	20200331
1.0.50710.2013	➤ Added support for new hardware component suppliers.	20211213
1.0.50710.2000	➤ Initial release.	20180629

SEL Display Package and Relay Firmware Compatibility

The display package and the compatible relay firmware versions are listed in *Table A.6*. The version number of the display package is accessible through the Device Info folder. Display packages may be compatible with more than one relay firmware version.

Table A.6 SEL Display Package Compatibility With Relay Firmware

SEL Display Package Version	Relay Firmware Versions Supported	Release Date
3.0.50710.3006	R300-V6 or higher	20220826
3.0.50710.3004	R300-V4 or higher	20211213
3.0.50710.3000	R300	20200331
1.0.50710.2013	R201-V3 or higher	20211213
1.0.50710.2000	R200, R201	20180629

DeviceNet and Firmware Versions

The firmware on the DeviceNet interface has two versions (major and minor) as listed in *Table A.7*. The version number of this firmware is accessible via the DeviceNet interface. The SEL-710-5 needs DeviceNet firmware version 1.005.

The Electronic Data Sheet (EDS) file is not updated every time a firmware release is made. A new EDS file is released only when there is a change in the Modbus/DeviceNet parameters. The EDS file and an ICON file for the SEL-710-5 are zipped together on the SEL-710-5 Product Literature CD (SEL-710-5R*xxx*.zip). The file can also be downloaded from the SEL website at selinc.com. *Table A.8* lists the compatibility among the EDS files and the various firmware versions of the relay.

Table A.7 DeviceNet Card Versions

DeviceNet Card Software Revision	Revisions	Release Date
Major Rev: 1, Minor Rev: 5 (Rev 1.005)	Reads product code, DeviceNet card parameter descriptions, etc., from the relay.	20080407

Table A.8 EDS File Compatibility

EDS File	Firmware Revisions Supported	Release Date
SEL-710-5R300.EDS	R300	20200331
SEL-710-5R200.EDS	R200, R201	20180629
SEL-710-5R100.EDS	R100, R101, R102	20130514

ICD File

Determining the ICD File Version

To find the ICD revision number in your relay, view the configVersion using the serial port **ID** command. The configVersion is the last item displayed in the information returned from the **ID** command.

configVersion=ICD-710-5-R200-V0-Z200006-D20180629

NOTE: The Z number representation is implemented with ICD File Revision R101. Previous ICD File Revisions do not provide an informative Z number.

The ICD revision number is after the R (e.g., 200) 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.

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., 200). The second three digits represent the ICD ClassFileVersion (e.g., 006). The ClassFileVersion increments when there is a major addition or change to the IEC 61850 implementation of the relay.

Table A.9 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.9 SEL-710-5 ICD File Revision History (Sheet 1 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
ICD-710-5-R204-V0-Z303006-D20240826	➤ Conformance related changes. ➤ Modified Pos attribute in BK1XCBR1 logical node to report 52A|52B breaker status. ➤ Modified EnaOpn and EnaCls datasource in MCCILO1 logical node. ➤ Modified Pos attribute in MCCSWI1 logical node to report 52A|52B breaker status.	R303-V0 and higher	006	SEL-710-5 Edition 2, R303-V0 or higher	20240826
ICD-710-5-R203-V0-Z302006-D20220826	➤ Added system logical nodes LGOS, LTIM, LTMS, and LCCH. ➤ Added the IEC 61850 LTRK logical node for service tracking. ➤ Added the IEC 61850 feature for simulation mode.	R302-V0 and higher	006	SEL-710-5 Edition 2, R302-V0 or higher	20220826

Table A.9 SEL-710-5 ICD File Revision History (Sheet 2 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ Added support for the IEC 61850 Local/ Remote control feature defined in the IEC 61850-7-4 standard. Control messages need to include the orCat value associated with the active control authority. ➤ Added support for the IEC 61850 Functional naming feature. ➤ Added PRBGGIO logical nodes to support pulsing remote bits.				
ICD-710-5-R202-V0-Z300006-D20210917	➤ Added the blocked-by-interlocking AddCause to the control error response when an operation fails due to a control interlocking (CILO) check. ➤ Added the new MCCILO1logical node and attribute to the PRO logical device for breaker control and status.	R300-V3 and higher	006	SEL-710-5 Edition 2, R300-V3 or higher	20210917
ICD-710-5-R201-V0-Z300006-D20200331	➤ Added the ability to control mode and behavior through an MMS write to the LPHD logical node mode data object (Mod.ctlVal) in logical device CFG. ➤ Added new DC1CSWI1–DC12CSWI12, DC1CILO1–DC12CILO12, and DC1XSWI1–DC12XSWI12 logical nodes and attributed to PRO LDevice for Disconnect Control and Status.	R300 and higher	006	SEL-710-5 Edition 2, R300 or higher	20200331
ICD-710-5-R200-V0-Z200006-D20180629	➤ Initial ICD file release with Edition 2 support and compatibility. ➤ Updated ClassFileVersion to 006. ➤ Increased maximum GOOSE subscriptions to 64. ➤ Added MMS authentication support. ➤ Made MMS Inactivity Timeout user-configurable with a default value of 900 seconds. ➤ Added filehandling service. ➤ Added support for IEC 61850 group switch, Simulated Goose and stSeld. ➤ Increased number of MMS reports to 14. ➤ Increased number of default datasets to 15. ➤ Removed maxEntries and maxMappedItems. ➤ Added new I1PTUV6, I2PTUV7, I1PTOV6, I2PTOV7, I3PTOV8, I4PTOV9, and FLTRDRE1 Logical Nodes and attributes to PRO LDevice.	R200 and higher	006	SEL-710-5 Edition 2, R200 or higher	20180629

Table A.9 SEL-710-5 ICD File Revision History (Sheet 3 of 3)

configVersion	Summary of Revisions	Relay Firmware Compatibility	ClassFile Version	ACSELERATOR Architect File Description	Manual Date Code
	➤ Modified Loc attribute of BK1XCBR1 Logical Node to report LOCAL/Remote Control status. ➤ Added new attributes Loc to MCCSWI1 Logical Node to report Local/Remote Control status. ➤ Added new attributes NumStrt and NumEmrst to MOTORMMOT1 Logical Node. ➤ Added new FLTGGIO37, DCST1GGIO35, and SCGGIO36 Logical Nodes and attributes to ANN LDevice. ➤ Added new attributes Ind09–Ind14 to INCGGIO13, INDGGIO15, and INEGGIO17 Logical Nodes. ➤ Added new attributes Ind05–Ind08 to OUTCGGIO14, OUTDGGIO16, and OUTEGGIO18 Logical Nodes. ➤ Added new attributes Ind09–Ind16 to PBLEDGGIO7 Logical Node. ➤ Modified Ind01–Ind15 attributes of MISCGGIO31 Logical Node. ➤ Modified Ind16–Ind17 attributes of PROGGIO26 Logical Node.				
ICD-710-5-R101-V0-Z100004-D20131125	➤ 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 configVersion for new format. ➤ Added new P1TPTOC3, P2TPTOC4, G1TPTOC5, G2TPTOC6, QTPTOC7, ATPTOC8, BTPTOC9, and CTPTOC10 Logical Nodes and attributes to PRO LDevice. ➤ Corrected dataNs attribute of RAGGIO29, RAGGIO30, RAGGIO31, and RAGGIO32 Logical Nodes.	R100 and higher	004	710-5 Standard	20130802
ICD-710-5-R100-V0-Z000000-D20130725	➤ Initial ICD File Release.	R100 and higher	004	710-5 with R100 F/W	20130725

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date. *Table A.10* lists the instruction manual versions and revision descriptions. The most recent instruction manual version is listed first.

Table A.10 Instruction Manual Revision History (Sheet 1 of 14)

Revision Date	Summary of Revisions
20240826	Section 1 ➤ Updated *Features*, including *Table 1.1: Current (ACI) and Voltage (AVI) Card Selection for SEL-710-5*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Figure 2.2: Slot Allocations for Different Cards*. ➤ Updated *Current/Voltage Card (4 ACI/3 AVI)* and added *Table 2.5: Current/Voltage Inputs (4 ACI/3 AVI) LEA Card Terminal Designations*, *Table 2.6: RJ45 Pinout Assignments for Current/Voltage Inputs (4 ACI/3 AVI) LPCT/Rogowski Coil and LEA Card*, *Figure 2.3: Terminal Markings for Passive LPVT*, and *Figure 2.4: Terminal Markings for Passive LPCT*. ➤ Added *Figure 2.15: Copper Ethernet, Fiber-Optic Serial, EIA-485 Serial Communications, IRIG-B, 8 DI, Fast Hybrid 4 DI/4 DO, 4 Arc-Flash/Differential Option (Relay MOT: 0710050E1A3ACA74L10300)*. ➤ Updated *Figure 2.26: Voltage Connections*, *Figure 2.28: AC Connections With Core-Balance Differential CTs*, and *Figure 2.29: AC Connections With Source- and Neutral-Side CTs*. ➤ Added a note regarding the LEA card and support for two-speed motor applications to *Two-Speed Motor*. ➤ Updated *VFD Motor Application*. Section 3 ➤ Updated *Meter and Control*, *Device Overview* and added *Figure 3.31: Graphical Display of Motor Start Report–COMTRADEW File Using SYNCHROWAVE Event Software*. ➤ Added a note on motor start reports to *Device Overview*. Section 4 ➤ Updated *Configuration Settings*, including *Table 4.2: CT Configuration and Full-Load Current Settings* and *Table 4.3: Voltage Configuration Settings*. ➤ Added *Low-Energy Analog (LEA) Sensor Inputs*. ➤ Updated *Overcurrent Elements*. ➤ Added a note on the star-delta feature and manipulated current magnitudes to *Star-Delta (Wye-Delta) Starting*. ➤ Updated *Figure 4.47: Power Factor Element Logic*. ➤ Updated *Table 4.45: Frequency Settings* and *Table 4.60: Power Factor Correction Settings*. ➤ Updated *Brush-Type Synchronous Motor Synchronization*, including *Table 4.63: Synchronous Motor Start Sequence Settings* and *Figure 4.70: Synchronous Motor Start Sequence Enable Logic*. ➤ Added *Field Breaker Close Time Incorporated Brush-Type Synchronous Motor Synchronization* and *Synchronization Based on Stator Measurements*. ➤ Updated *Lockout After Stop*. ➤ Updated *Figure 4.88: Spectrum Analysis of 50 Hz Two Pole Pair Motor*. ➤ Added *LEA Ratio Correction Settings*. ➤ Updated *Breaker Failure Settings*. Section 5 ➤ Updated *Start Data*. ➤ Updated *Load Profiling*. Settings Sheets ➤ Updated *Configuration, Power Factor Correction*, *Start Sequence*, *Group Selection*, and *Breaker Failure*. ➤ Added *IEC 61850 Breaker CILO*. Section 8 ➤ Added a note on Reset TCU to *Control*. Section 10 ➤ Updated *Table 10.1: Event Types*. ➤ Updated *SER Triggering*. Section 11 ➤ Added a note about the relay test system to *Low-Level Test Interface*. Appendix A ➤ Updated for firmware revisions R302-V2 and R303-V0. ➤ Updated *Table A.9: SEL-710-5 ICD File Revision History* for firmware revision R204-V0. Appendix G ➤ Updated *Control Interlocking*. ➤ Updated *Table G.37: Logical Device: PRO (Protection)*.

Table A.10 Instruction Manual Revision History (Sheet 2 of 14)

Revision Date	Summary of Revisions
	Appendix L ➤ Updated *Table L.1: SEL-710-5 Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-710-5*. Glossary ➤ Added Rogowski coil.
20240329	Preface ➤ Updated *Compliance Approvals*, *SEL-710-5 Relay (Hazardous Locations Approval)*. ➤ Updated *Trademarks*. Section 2 ➤ Updated *Figure 2.20: Breaker Trip Coil and Contactor Connections with OUT103FS := Y and OUT103FS := N*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions*. Section 4 ➤ Updated *Table 4.46: Operating Quantities and Associated Sampling Rates* and *Table 4.108: Example Settings and Displays*. Section 7 ➤ Updated *RSTP Command* for a note on the **R_S** command. Appendix A ➤ Updated for firmware version R302-V1. Appendix G ➤ Updated *Optional Control Configurations*. ➤ Updated *Table G.38: Logical Device: MET (Metering)*. Appendix N ➤ Updated *Settings Erasure* for a note on the **R_S** command. ➤ Updated *Table G.38: Logical Device: MET (Metering)*.
20220826	Preface ➤ Updated *Wire Sizes and Insulation*. Section 1 ➤ Updated *Specifications*, including *Compliance*, *Communications Protocols*, *Dielectric Strength and Impulse Tests*, and *Frequency*. Section 2 ➤ Updated *I/O Configuration*, *Power Connections*, and *Grounding (Earthing) Connections*. ➤ Added *I/O Connections*. ➤ Updated *Point-Sensor Installation*. Section 4 ➤ Updated *Example 4.3: Thermal Element Setting*. ➤ Updated *Power Factor Loss-of-Synchronism Detection*, including *Figure 4.48: Loss-of-Synchronism Detection Logic*. ➤ Updated *Figure 4.49: Loss-of-Potential (LOP) Logic* and *Table 4.45: Frequency Settings*. ➤ Updated *Time and Date Management Settings* and *Relay Word Bit Aliases*. ➤ Updated *Table 4.94: Ethernet Port Settings*. Settings Sheets ➤ Added *61850 Simulation Mode* and *61850 Local Remote*. ➤ Updated *Port 1* for the RSTP settings. ➤ Updated *Relay Word Bit Aliases*. Section 7 ➤ Updated *Table 7.6: Protocols Supported on the Various Ports*. ➤ Added *Switched Mode* and *Rapid Spanning Tree Protocol (RSTP)*. ➤ Added *Table 7.28: Warning and Error Codes for GOOSE Subscriptions*. ➤ Updated *ID Command* and added *RSTP Command*. Section 10 ➤ Updated *Standard Event Report (EVE Command)*.

Table A.10 Instruction Manual Revision History (Sheet 3 of 14)

Revision Date	Summary of Revisions
	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revisions R201-V5, R300-V6, R302-V0. ➤ Updated *Table A.4: SELBOOT Firmware Revision History* for R602-V0. ➤ Updated *Table A.5: SEL Display Package Revision History* and *Table A.6: SEL Display Package Compatibility With Relay Firmware* for 3.0.50710.3006. ➤ Updated *Table A.9: SEL-710-5 ICD File Revision History* for firmware revision R203-V0. Appendix B ➤ Updated *Table B.1: Firmware Upgrade Methods*. ➤ Added *Upgrade the SELBOOT Firmware Loader Using a Terminal Emulator*. Appendix G ➤ Added *Functional Naming*, *Local/Remote Control Authority*, and *Service Tracking*. ➤ Updated *Simulation Mode*. ➤ Updated *Table G.23: New Logical Node Extensions* and added *Table G.27: LCCH Physical Communication Channel Supervision*, *Table G.28: LGOS GOOSE Subscription*, and *Table G.29: LTMS Time Master Supervision*. ➤ Updated *Table G.37: Logical Device: PRO (Protection)*, *Table G.38: Logical Device: MET (Metering)*, *Table G.39: Logical Device: CON (Remote Control)*, *Table G.40: Logical Device: ANN (Annunciation)*, and *Table G.41: Logical Device: CFG (Configuration)*. Appendix L ➤ Updated *Table L.1: SEL-710-5 Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-710-5*. Appendix N ➤ Updated *Table N.1: IP Port Numbers*. Glossary ➤ Updated for RSTP. Command Summary ➤ Added the **RSTP** command.
20220225	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R300-V5. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware revision R201-V4.
20211213	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R300-V4. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware revision R201-V3. ➤ Updated *Table A.4: SELBOOT Firmware Revision History* for firmware revisions R502-V0 and R601-V0. ➤ Updated *Table A.5: SEL Display Package Revision History* and *Table A.6: SEL Display Package Compatibility With Relay Firmware*.
20210917	Section 1 ➤ Updated *RFI and Interference Tests* conducted and radiated emissions. Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R300-V3. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware revision R201-V2. ➤ Updated *Table A.9: SEL-710-5 ICD File Revision History*. Appendix G ➤ Added *Control Interlocking*, including *Figure G.4: CSWI Logical Node Direct Operate Command Request*. ➤ Updated *Table G.6: AddCause Descriptions*. ➤ Updated *Table G.29: Logical Device: PRO (Protection)*.
20210104	Section 1 ➤ Updated *Models*. Section 2 ➤ Updated *Application Example*. Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R300-V2. ➤ Updated *Table A.2: R200 Series Firmware Revision History* for firmware revision R201-V1.

Table A.10 Instruction Manual Revision History (Sheet 4 of 14)

Revision Date	Summary of Revisions
	Appendix D ➤ Updated *Transmission Control*. Appendix K ➤ Updated *Figure K.7: Stator Thermal Element*.
20200921	Appendix A ➤ Updated *Table A.1: R300 Series Firmware Revision History* for firmware revision R300-V1.
20200331	Preface ➤ Updated compliance and product labels. Section 1 ➤ Updated *Specifications.* Section 2 ➤ Added footnote to *Figure 2.2: Slot Allocations for Different Cards*. ➤ Added note to *RTD Card (10 RTD).* ➤ Added note to *Analog Inputs Card (8 AI)*. ➤ Added note to *Figure 2.33: Synchronous Motor Voltage Divider Module (SEL P/N 915900294).* ➤ Added caution text to *Application Example.* ➤ Updated *Point-Sensor Installation.* ➤ Updated *Ordering Arc-Flash Fiber Sensors.* Section 3 ➤ Updated *Overview* for web server information. ➤ Added *Web Server*. Section 4 ➤ Updated *Overview*. ➤ Updated *Table 4.2: CT Configuration and Full-Load Current Settings* to include single I input. ➤ Added *Incipient Cable Fault.* ➤ Updated *Configuration Settings.* ➤ Added note to *Table 4.30: RTD Resistance Versus Temperature.* ➤ Updated setting ranges for trip delays in *Table 4.44: Frequency Settings.* ➤ Added *Vibration Monitoring*. ➤ Added *Detecting Frequency Components with the 97FM Element.* ➤ Added note to *TR Trip Conditions SELOGIC Control Equation.* ➤ Added *PID Controller*. ➤ Updated *HIS BBD Command*. ➤ Added *Precision Time Protocol (PTP).* ➤ Updated the existing note and added a new note to *Access Control.* ➤ Removed note on TCP Keep Alive settings from beside and added PTP settings to *Table 4.84: Ethernet Port Settings.* ➤ Added PTP settings to *Table 4.85: Port Number Settings That Must Be Unique.* ➤ Updated *Table 4.92: Ethernet Port Settings.* ➤ Updated *Disconnect Control Settings*. ➤ Updated *Local/Remote Control.* ➤ Updated *Event Report Settings*. Section 5 ➤ Added *Breaker Health.* ➤ Added *Asset Monitoring*. ➤ Added *CMET S R Command.* Section 6 ➤ Updated *Table 6.1: Methods of Accessing Settings*. ➤ Added *View Settings Using the Web Server.*

Table A.10 Instruction Manual Revision History (Sheet 5 of 14)

Revision Date	Summary of Revisions
	Settings Sheets ➤ Updated *Frequency* under *Group Settings (SET Command)*. ➤ Added *PTP Settings.* ➤ Updated *Two-Position Disconnect* and added *Three-Position Disconnect* to account for new disconnect settings. ➤ Added *61850 Mode Control*. ➤ Updated *Port 1 under SET PORTp (p = F, 1, 2, 3, or 4) Command.* ➤ Added PTP settings to *Table SET.3: Port Number Settings That Must Be Unique.* ➤ Updated *Bay Control Two-Position Disconnect* and added *Bay Control Three-Position Disconnect* to account for new disconnect settings. Section 7 ➤ Added *Telnet or the Web Server*. ➤ Updated *Ethernet Port*. ➤ Added *TCP Keep Alive*. ➤ Added *Embedded Web Server (HTTP).* ➤ Added *Precision Time Protocol (PTP).* ➤ Added *89CLOSE Command (Close Disconnect)* and *89OPEN Command (Open Disconnect)*. ➤ Added *COM PTP Command.* ➤ Updated *HISTORY Command.* ➤ Added *MMR Command*. ➤ Updated *TEST DB Command.* Section 8 ➤ Updated *Table 8.7: Sidebar Buttons*. ➤ Updated *Reports* for use of trigger event button. Section 9 ➤ Updated *Disconnect Control Settings.* ➤ Updated *Table 9.5: Disconnect Symbols.* ➤ Updated *Local/Remote Control.* ➤ Updated *Motor/Disconnect Control Via the Touchscreen.* ➤ Updated *Table 9.7: Touchscreen Settings.* ➤ Updated *Bay Control Disconnect Settings.* Section 10 ➤ Updated *Viewing Compressed Event (CEV) Reports.* Appendix B ➤ Added *Upgrade the Relay Firmware to R300 Series Firmware*. ➤ Added *Upgrade the Relay SELBOOT Firmware Loader Using a Terminal Emulator.* ➤ Added *Digitally signed Firmware Files.* ➤ Added *Upgrade Relay Firmware Using the Web Server.* ➤ Added a note to and updated Step 3 of *Upgrade Firmware Using QuickSet.* ➤ Updated Step 9 and added a note to *Upgrade Firmware Using a Terminal Emulator.* Appendix D ➤ Updated *Time Synchronization* for priority information. ➤ Added note to *Modem Support.* ➤ Updated footnotes for *Table. D.7: Port DNP3 Protocol Settings.* ➤ Added new values to the binary outputs in *Table D.10: DNP3 Reference Data Map*. ➤ Updated *Table D.12: SEL-710-5 Object 12 Control Operations.* Appendix E ➤ Updated description for Trip/Warn Data in *Table E.34: Modbus Register Map*. ➤ Updated *Table E.33: Modbus Register Labels for Use With SET M Command.* ➤ Updated *Table E.34: Modbus Register Map.* ➤ Added *Table E.35: Corresponding Relay Word Bits for Trip/Warn Registers.* Appendix G ➤ Added *IEC 61850 Mode/Behavior*. ➤ Updated *Mode, Behavior,* and *Health* under *Logical Nodes.* ➤ Updated *Table G.29: Logical Device: PRO (Protection), Table G.30: Logical Device: MET (Metering), Table G.32: Logical Device: ANN (Annunciation), Table G.33: Logical Device: CFG Configuration.*

Table A.10 Instruction Manual Revision History (Sheet 6 of 14)

Revision Date	Summary of Revisions
	Appendix L ➤ Updated *Table L.1: SEL-710-5 Relay Word Bits* and *Table L.2: Relay Word Bit Definitions for the SEL-710-5.* Appendix M ➤ Updated *Table M.1: Analog Quantities.* Appendix N ➤ Added PTP and HTTP information to *Table N.1: IP Port Numbers.* Command Summary ➤ Added **89C *m***, **89O *m***, **89C *n m***, and **89O *n m*** commands to *Access Level 2 Commands.*
20181228	Preface ➤ Removed caution statement from beginning of *Safety Information* and added it to *General Safety Marks*. ➤ Updated temperature class to T3C in *Compliance Approvals.* Section 1 ➤ Updated *AC Current Inputs (IA, IB, IC, IN)* and *Differential Currents (IA87, IB87, IC87)* in *Specifications*. Section 2 ➤ Updated temperature class to T3C in *Physical Location*. ➤ Removed note from *Fail-Safe/Nonfail-Safe Tripping.* ➤ Updated *Figure 2.22: AC Connections With Core-Balance Differential CTs, Figure 2.23: AC Connections With Source- and Neutral-Side CTs, Figure 2.27: AC Connections for Two-Speed Motor-Paralleled CTs, Figure 2.28: AC Connections for Full-Voltage Reversing (FVR) Starter,* and *Figure 2.29: AC Connections for a VFD Motor Application.* Section 4 ➤ Added note to *Curve Thermal Method*. ➤ Updated *Figure 4.64: Stop/Trip Logic.* ➤ Replaced *Group Selection* with *Multiple Settings Groups*. Appendix E ➤ Added footnote to *Table E.33: Modbus Register Labels for Use With SET M Command.* Appendix L ➤ Updated Note 3 in *Table L.1: Analog Quantities.*.
20180629	Preface ➤ Updated *Compliance Approvals*, including the relay compliance label. ➤ Updated *Safety Marks*. ➤ Updated *Trademarks*. ➤ Updated *Product Labels* for the high- and low-voltage supply models. ➤ Updated *LED Emitter*. ➤ Updated *Wire Sizes and Insulation*. ➤ Added *Copyrighted Software*. Section 1 ➤ Added *Table 1.2: SEL-710-5 Front-Panel Options*. ➤ Updated *Communications and Control Features* and *Options* for IEC 61850 Edition 2 and IEC 60870-5-103. ➤ Updated *Options* for conformal coating. ➤ Added *Language Support*. ➤ Updated *SEL-710-5 Base Unit* and *Accessories*. ➤ Updated *Specifications, Compliance* for the hazardous locations and ATEX; *General* for power consumption and supply, *Fuse Ratings, Standard Contacts,* and *Optoisolated Control Inputs*; *Type Tests*; *Relay Elements*; *Communications Protocols* for IEC 61850 Edition 2, IEC 60870-5-103, and PRP; and *Oscillography* for Binary COMTRADE.

Table A.10 Instruction Manual Revision History (Sheet 7 of 14)

Revision Date	Summary of Revisions
	Section 2 ➤ Updated *Relay Placement*, *I/O Configuration,* and *AC/DC Control Connection Diagrams*. ➤ Added note to de-energize all external connections before opening the device to *Installation* under *Card Configuration Procedure*. ➤ Updated *Card Configuration Procedure* for the touchscreen display relay. ➤ Updated *Table 2.18: Typical Maximum RTD Lead Length*. ➤ Updated *Figure 2.7: Pins for Password Jumper, Breaker Jumper (Start/Stop Control), and SELBOOT Jumper* for default jumper positions. ➤ Updated *Figure 2.15: Output OUT103 Relay Output Contact Configuration*. ➤ Updated *Figure 2.16: Breaker Trip Coil and Contactor Connections with OUT103FS := Y and OUT103FS := N*. Section 3 ➤ Updated *Table 3.1: SEL Software Solutions* for ACSELERATOR Bay Screen Builder SEL-5036 Software, SEL-5601-2 SYNCHROWAVE Event Software, and SEL-5806 Curve Designer Software. ➤ Updated driver and part number for the SEL display package and updated *Figure 3.5: Relay Response to the ID Command* for the SEL and customer display packages. ➤ Updated *Figure 3.6: Driver Selection* and *Figure 3.7: Updated Part Number*. ➤ Added *Touchscreen Settings* and *Bay Screen Builder*. ➤ Updated *View Event History* for capturing events in Compressed ASCII or COMTRADE file formats. ➤ Updated the section to match the software interface. Section 4 ➤ Updated example settings in *Figure 4.1: KVF Factor Versus VFD Output Frequency*. ➤ Updated *Example 4.3: Thermal Element Setting*. ➤ Added *Inverse-Time Undervoltage Protection* and *Inverse-Time Overvoltage Protection*. ➤ Updated *Settings* under *Loss-of-Potential (LOP) Protection*. ➤ Updated *Phase Reversal Protection* under *Group Settings (SET Command)* to specify how incorrect phase rotation is determined. ➤ Updated *Table 4.44: Frequency Settings* and *Figure 4.48: Over- and Underfrequency Element Logic* to include torque control of the frequency element. ➤ Updated *52A and 52B Contactor/Breaker Status SELOGIC Control Equations*. ➤ Updated *Table 4.59: Enable Settings*. ➤ Added note to *Counter Variables* addressing relay power loss during storage of SELOGIC counters. ➤ Updated *SELOGIC Control Equation Variables/Timers* under *Logic Settings (SET L Command)* to clarify how the results of multiplication and division are calculated. ➤ Updated *Global Settings (SET G Command)* to include the METHRES setting. ➤ Added note about the availability of the 50NAFP setting to *Arc-Flash Overcurrent Elements (50PAF, 50NAF)*. ➤ Updated *Table 4.75: Arc-Flash Time-Overlight Settings*. ➤ Added *89A and 89B Disconnect Status SELOGIC Control Equations*. ➤ Added *Local/Remote Breaker Control*. ➤ Updated *Port Settings (SET P Command)*, including *Table 4.82: Time-Synchronization Source Settings, Table 4.83: Front-Panel Serial Port Settings, Table 4.84: Ethernet Port Settings, Table 4.85: Port Number Settings That Must Be Unique,* and *Table 4.86: Fiber-Optic Serial Port Settings*. ➤ Updated *Port 2*, *Port 3*, and *Port 4*. ➤ Updated *General Settings* under *Front-Panel Settings (SET F Command)* for the touchscreen display. ➤ Added *Table 4.91: LCD Point Settings* ➤ Updated *Table 4.98: Target LED Settings*. ➤ Added *DNP Map Settings* and *Touchscreen Settings*. Section 5 ➤ Updated *Overview*. ➤ Added *Remote Analog Metering*. ➤ Updated *Small Signal Cutoff for Metering* for METHRES := Y and METHRES := N. ➤ Updated *Motor Start Report* for the MSR_REF number. Section 6 ➤ Updated *Overview* for setting Group 4, IEC 60870-5-103, and touchscreen settings classes, and added a note on relay initial power up and settings changes. ➤ Added *View/Change Settings With the Touchscreen Front Panel*. ➤ Updated *Table 6.2: SHO Command Options* and *Table 6.3: SET Command Options* for IEC 60870-5-103 map settings.

Table A.10 Instruction Manual Revision History (Sheet 8 of 14)

Revision Date	Summary of Revisions
	Settings Sheets ➤ Updated for PRP, Telnet, FTP, MMS, Modbus, and touchscreen settings. ➤ Updated *Frequency* for torque-control settings. ➤ Updated *General*, *Group Selection,* and *Arc-Flash Protection* under *Global Settings*. ➤ Added *27 Inverse-Time Undervoltage* and *59 Inverse-Time Overvoltage*. ➤ Updated *Trip/Close*. ➤ Updated *Breaker Monitor*. ➤ Added *Two-Position Disconnect* and *Control Configuration Settings Categories.* ➤ Updated *Port F*, *Port 1*, *Port 2*, *Port 3*, and *Port 4*. ➤ Added *Touchscreen Settings*. ➤ Updated *Event Report* under *Report Settings (SET R Command)* to specify the prefault length for different LER. ➤ Added *IEC 60870-5-102 Map Settings (SET I Command).*
	Section 7 ➤ Updated *Communications Interfaces.* ➤ Updated *Communications Protocols* for IEC 60870-5-103. ➤ Updated *Access Levels* for EPORT and MAXACC settings. ➤ Updated *File Transport Protocol (FTP) and MMS File Transfer* and *IEC 61850.* ➤ Updated *Ethernet Port* for PRP mode and added *PRP Connection Mode*. ➤ Updated *ANALOG Command*, *CEV Command, Copy Command, ETH Command, MAC Command, PING Command, STOP Command,* and *STR Command*. ➤ Removed *Figure 7.16: Raw Compressed ASCII Event Report*. ➤ Updated *Table 7.17: EVENT Command (Event Reports)* for the definition of parameter *n.* ➤ Updated *Table 7.19: GOOSE Command Variants.* ➤ Updated *Table 7.22: HISTORY Command* to include **HIS CA** or **RA** command. ➤ Updated *Table 7.31: MSR (Motor Start Report) Command*. ➤ Updated Table *7.41: SET Command (Change Settings)* for setting Group 4 and **SET I TERSE** command. ➤ Updated *Table 7.42: SHOW Command (Show/View Settings)* for **SHO I** command and setting Group 4. ➤ Added *TEST DB Command.* ➤ Added *Language Support.* ➤ Added *Virtual File Interface.* ➤ Updated *Table 7.58: Report Directory Files*. ➤ Updated *Table 7.60: Files Available for Ymodem Protocol.*
	Section 8 ➤ Updated *Overview*; added *Figure 8.1: SEL 710-5 Front-Panel Options.* ➤ Updated *Two-Line Display Front Panel*. ➤ Updated *Figure 8.24: SET/SHOW Menu*. ➤ Added *Language Support.* ➤ Added *Touchscreen Display Front Panel*.
	Section 9 ➤ Added *Section 9: Bay Control*.
	Section 10 ➤ Updated *Overview* for the types of event reports. ➤ Updated *Event Reporting*. ➤ Updated *Event Summaries f*or the unique reference number, added a note for the reset of the unique reference number to 100000 using the **HIS CA** command, and added *Event Logs* and *Event Reference Number.* ➤ Updated *Clearing*. ➤ Added *Retrieving Event Reports Via Ethernet File Transfer*. ➤ Added *COMTRADE File Format Event Reports.* ➤ Updated *SER Triggering* with a note on extracting an SER report.
	Section 11 ➤ Updated *Table 11.7: Periodic Relay Checks to include* Arc-Flash Detection Status. ➤ Updated *Self-Test*, including *Table 11.8: Relay Self-Tests* and added a note for SALARM and access level changes.

Table A.10 Instruction Manual Revision History (Sheet 9 of 14)

Revision Date	Summary of Revisions
	Appendix A ➤ Updated for standard and point releases. ➤ Updated *Table A.1: R200 Series Firmware Revision History* for firmware revision R200. ➤ Added *SEL Display Package Versions*, including *Table A.3: SEL Display Package Revision History*, and *SEL Display Package and Relay Firmware Compatibility*, including *Table A.4: SEL Display Package Compatibility with Relay Firmware*. ➤ Updated *Table A.6: EDS File Compatibility* for firmware revision R200. ➤ Updated *Table A.7: SEL-710-5 ICD File Revision History*. Appendix B ➤ Updated *Overview*. ➤ Updated *Upgrade Firmware Using a Terminal Emulator* with a note about saving the touchscreen settings before upgrading the firmware and a note to change the relay serial port data rate before issuing the **L_D** command. Appendix D ➤ Updated *Table D.7: Port DNP3 Protocol Settings*. ➤ Updated *Table D.10: DNP3 Reference Data Map.* ➤ Updated *Control Point Operation* and *Configurable Data Mapping*. ➤ Updated *Table E.34: Modbus Register Map*. Appendix E ➤ Updated *Table E.7: 02H SEL-710-5 Inputs*. ➤ Added note to *Table E.16: 06h Preset Single Register Command* to address the function of Relay Word bit LOCAL. ➤ Updated *Table E.33: Modbus Register Labels for Use With SET M Command*. ➤ Added note to *Modbus Register Map* on how to calculate the Modbus register. Appendix F ➤ Updated *Features* for the number of SCADA client sessions and GOOSE messages. ➤ Updated *Introduction to IEC 61850.* ➤ Updated *IEC 61850 Operation*. ➤ Updated *IEC 61850 Configuration*. ➤ Updated *Logical Nodes*. ➤ Updated *Table F.22: Logical Devices: ANN (Annunciation)* for setting Group 4 and comments on broken bar detection. ➤ Updated *Protocol Implementation Conformance Statement*. ➤ Added *Potential Client and Automation Application Issues With Edition 2 Upgrades*. Appendix G ➤ Added *Appendix G: IEC 60870-5-103 Communications*. Appendix K ➤ Updated *Table K.1: SEL-710-5 Relay Word Bits*. ➤ Updated *Table K.2: Relay Word Bit Definitions for the SEL-710-5*. Appendix L ➤ Updated for IEC 61850 and IEC 60870-5-103. ➤ Updated *Table L.1: Analog Quantities*. Appendix M ➤ Added *Appendix M: Cybersecurity Features*. Command Summary ➤ Updated for new commands. ➤ Updated for Spanish commands.
20170508	Preface ➤ Updated *Compliance Approvals* and *Product Labels*. Section 1 ➤ Updated *PTC Overtemperature* and *Ground Fault (50N)* in *Specifications*. Section 4 ➤ Added a note for the 2.5 mA models with the 100 ms delay for the pickup of the 50N element.

Table A.10 Instruction Manual Revision History (Sheet 10 of 14)

Revision Date	Summary of Revisions
	Section 7 ➤ Updated *Serial (EIA-232 and EIA-485) Port*. Section 10 ➤ Updated *Low-Level Test Interface* and *Table 10.1: Resultant Scale Factors for Inputs* for the IN channel with a nominal input of 2.5 mA. Appendix C ➤ Updated *Setting the SEL-710-5*. Appendix F ➤ Updated *Features*.
20170330	Preface ➤ Updated *Technical Assistance*. Section 1 ➤ Updated *Accessories*. ➤ Added *Differential Currents (IA87, IB87, IC87)* and updated *Synchronous Motor Inputs*, *Fuse Ratings*, and *Environmental Tests* in *Specifications*. Section 4 ➤ Updated *Additional Thermal Overload Settings* and added *Figure 4.6: MOTOR Command Response*. ➤ Updated *Settings Guidelines* for setting LRQ and the R1 source for motor slip. ➤ Updated *Figure 4.28: Monitoring Starting Time*, *Figure 4.41: Power Factor Elements Logic*, and *Figure 4.45: Loss-of-Field Logic Diagram*. ➤ Updated *Power Factor Correction* and also added a note for the time constants of active and reactive power filters and updated *Figure 4.53: Reactive Power Set Point Calculation* and *Figure 4.54: Double Deadband Logic*. ➤ Updated *Time-Delayed Starting for Brushless Synchronous Motors* and added a note for the 41DELAY setting. ➤ Updated *Brush-Type Synchronous Motor Synchronization*, including *Table 4.46: Synchronous Motor Start Sequence Settings*. ➤ Updated *Figure 4.57: 41CLOSE Logic for Brush-Type Synchronous Motor*. ➤ Updated *Synchronization Based on Stator Measurements*, including *Figure 4.59: Slip Computation Using Stator Measurements for Slip-Dependent Thermal Model and Synchronous Motor Synchronization*. ➤ Updated *Port Number Settings Must Be Unique*. ➤ Added a note for SELOGIC control equation MSRTRG to *Start Report Settings*. Section 5 ➤ Added a note for VEX and IEX calculations. ➤ Updated *Start Data*. Settings Sheets ➤ Updated *Configuration* and *Motor Control* settings and *Port Number Settings Must Be Unique*. Section 9 ➤ Updated *Triggering*. Section 10 ➤ Updated *Figure 10.6: Delta Voltage Source Connections*. ➤ Updated *Factory Assistance*. Appendix A ➤ Updated *Determining the Firmware Version* for standard and point release firmware. ➤ Updated for firmware revision R102. Appendix B ➤ Updated *Overview* for standard and point release firmware. ➤ Updated *Factory Assistance*. Appendix J ➤ Updated the SLIPOK definition in *Table J.2: Relay Word Bit Definitions for the SEL-710-5*. Appendix K ➤ Updated the SMSLIP2 description in *Table K.1: Analog Quantities*.

Table A.10 Instruction Manual Revision History (Sheet 11 of 14)

Revision Date	Summary of Revisions
20160729	**Preface** ➤ Added hazard statement to *Safety Information*. ➤ Updated *Wire Sizes and Insulation* information. **Section 1** ➤ Updated *Figure 1.3: STA Command Response—No Communications Card or EIA-232/EIA-485 Communications Card*. **Specifications** ➤ Added *Fuse Ratings* specifications. ➤ Updated *Phase and Neutral Currents Continuous Ratings*. ➤ Added *Arc-Flash Detectors* specifications. ➤ Updated *Phase Currents for Metering*. ➤ Updated *Output Contacts*. **Section 2** ➤ Updated *Table 2.16: OUT103 Contact Fail-Safe and Nonfail-Safe Options*; *Table 2.18: Typical Maximum RTD Lead Length*; and *Figure 2.32 Synchronous Motor Voltage Divider Module (SEL P/N 915900294)*. ➤ Updated *Figure 2.27: AC Connections for Full-Voltage Reversing (FVR) Starter*. **Section 3** ➤ Updated *Figure 3.6 Selection of Drivers*. ➤ Updated *Figure 3.12 Device Overview Screen*. **Section 4** ➤ Updated *Overview* section. ➤ Updated *Figure 4.24: Undercurrent (Load Loss) Logic*. ➤ Added *Slip Dependent Thermal Model for Synchronous Motors* subhead with *Figure 4.6: Slip-Dependent and Slip-Independent Thermal Models*. ➤ Added *Virtual Speed Switch* section with *Figure 4.32 Virtual Speed Switch Flow Chart*; *Figure 4.33 Speed Switch Monitoring Logic;* and *Figure 4.34: Speed Switch Element Alarm/Trip Logic*. ➤ *Added Power Factor Correction* with *Figure 4.52: Reactive Power Set Point Calculation*; *Figure 4.53; Double Deadband Logic* and *Table 4.44 Power Factor Correction Settings*. ➤ Added *Slip-Dependent Synchronization Based on Stator Current Measurements* section and *Figure 4.58: Slip-Dependent Synchronization Using Stator Current Measurements*. ➤ Expanded explanation of COASTIME setting; added *Figure 4.5: Coast-Stop Logic Diagram.* ➤ Revised *Curve Thermal Method*. ➤ Added *Example 4.10: Improving the Accuracy of Math Operations*. ➤ Updated *Figure 4.1: KVF Factor Versus VFD Output Frequency*; *Table 4.4: Overload (Thermal Model) Settings*; *Table 4.8: Overload Settings (Alarm, Start Inhibit, Cooling, and RTD Bias)*; *Table 4.27: Speed Switch Settings*; *Table 4.87: Pushbutton LED Settings*; *Figure 4.54: Motor State Logic*; and *Table 4.73: Data Reset Settings*. ➤ Added *Figure 4.41: Loss-of-Synchronism Detection Logic* to *Power Factor Loss-of-Synchronism Detection*. **Section 5** ➤ Updated *Motor Operating Statistics* and *Motor Start Report* sections. **Section 6** ➤ Updated *Table 6.6: Setting Interdependency Error Messages*.

Table A.10 Instruction Manual Revision History (Sheet 12 of 14)

Revision Date	Summary of Revisions
	Settings Sheets ➤ Added COASTIME setting. ➤ Updated *Neutral Overcurrent* settings. ➤ Updated *Negative-Sequence Overcurrent* settings. ➤ Updated *Negative-Sequence Time Overcurrent* settings. ➤ Updated *Speed Switch* settings. ➤ Updated *RTD* settings. ➤ Updated *Out of Step* settings. ➤ Updated *Field Resistance* settings. ➤ Updated *Start Sequence* settings. ➤ Updated *Power Factor* settings. ➤ Added *Power Factor Correction* settings. ➤ Updated *Load Control* settings. ➤ Updated *Arc-Flash Protection* settings. ➤ Updated *Data Reset* settings. ➤ Updated *DNP Sessions* IP address. Section 7 ➤ Updated *Table 7.3: TQUAL Bits Translation to Time Quality*. ➤ Updated *Table 7.27: MOTOR Command*. Section 8 ➤ Updated *Figure 8.29 Operator Control Pushbuttons and LEDs*. ➤ Added Note regarding target LEDs. Section 9 ➤ Inserted *Viewing Compressed Event (CEV) Reports section* with *Figure 9.7: Sample CEV Report Viewed With Analytic Assistant or QuickSet Via SEL-5601* and *Figure 9.8: Options for Converting CEV Reports to COMTRADE in Analytic Assistant*. Section 10 ➤ Updated *Table 10.8: Relay Self-Tests*. Appendix A ➤ Updated *Table A.1: R100 Series Firmware Revision History* and *Table A.3: Instruction Manual Revision History*. Appendix D ➤ Added paragraph regarding TCP connection to *DNP3in the SEL-710-5*. Appendix E ➤ Updated scale factors in *Table E.34: Modbus Register Map*. Appendix J ➤ Updated *Table J.1: SEL-710-5 Relay Word Bits*. ➤ Updated definitions in *Table J.2: Relay Word Bit Definitions for the SEL-710-5*. Appendix K ➤ Updated *Table K.1: Analog Quantities*. Command Summary ➤ Updated *Access Level 1 Commands* and *Access Level 2 Commands*.
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 *Specifications*. ➤ Added the applied current at which the burden is measured for I_{NOM} = 1 A or 5 A in *Specifications*. ➤ Updated *Type Test* compliance specifications in *Specifications*. ➤ Updated the setting range for *Ground Fault (50N)* and the field voltage for *Metering* in *Specifications*.

Table A.10 Instruction Manual Revision History (Sheet 13 of 14)

Revision Date	Summary of Revisions
	Section 2 ➤ Updated *Card Configuration Procedure*. ➤ Added a warning on CT circuits to applicable current card descriptions. ➤ Added *Analog Output Wiring*, including *Figure 2.14: Analog Output Wiring Example*. ➤ Added a note stating that the fail-safe option should not be used for fast hybrid output contacts in fail-safe/nonfail-safe tripping. ➤ Added *Figure 2.30: AC/DC Connections for a Brushless-Type Synchronous Motor Application*. ➤ Added a cable length impact note for *Figure 2.32: Synchronous Motor Voltage Divider Module (SEL P/N 915900294)*. Section 3 ➤ Updated *Settings Database Management and Drivers*. Section 4 ➤ Updated *Rating Thermal Method* and *Curve Thermal Method*. ➤ Updated *Figure 4.22: Load-Jam Element Logic* note. ➤ Added a note to *Figure 4.23: Undercurrent (Load-Loss) Logic*. ➤ Added *Figure 4.27: Star-Delta Starting*. ➤ Updated *Brush-Type Synchronous Motor Synchronization*. ➤ Updated *Arc-Flash Time-Overlight Elements (TOL1 through TOL8)* as well as the setting range and factory default for setting prompt AFD OUTPUT SLOT in *Table 4.65: Arc-Flash Time-Overlight Settings*. Section 5 ➤ Updated the number of time-stamp entries that the relay memory can hold for load profiling. ➤ Added time to thermal trip calculation note to *Thermal Metering*. Section 7 ➤ Updated *PULSE Command*. ➤ Updated *AFT Command (Arc-Flash Detection Channels Self-Test)*. Added *VEC Command (Show Diagnostic Information)*. Section 10 ➤ Added a warning on CT circuits. ➤ Updated *Table 10.8: Relay Self-Tests*. Appendix A ➤ Added *ICD File*, including *Table A.2:* SEL-710-5 *ICD File Revision History*. Appendix B ➤ Added a note to save the calibration settings before the upgrade in *Upgrade Firmware Using a Terminal Emulator*. Appendix E ➤ Updated the scale factor for *Power Data*, Modbus Register Address 364 (R). Appendix F ➤ Added a note in *GOOSE* regarding GOOSE subscriptions when loading a new CID file. Updated *ACSELERATOR Architect* and *SEL ICD File Versions*. Appendix H ➤ Updated the RBADPU setting prompt description in *Table H.5: MIRRORED BITS Protocol Settings*. Appendix I ➤ Updated *Figure I.4: Rotor Thermal Element During Motor Start* and *Figure I.5: Stator Thermal Element With Resistance and Trip Level Undefined*. ➤ Added rating and curve method equations for cold stator. Appendix J ➤ Updated the definitions for Relay Word bits 49T and AFS1EL–AFS8EL in *Table J.2: Relay Word Bit Definitions for the SEL-710-5*. Appendix K ➤ Added a note to *Table K.1: Analog Quantities* for RTDWDGMX, RTDBRGMX, RTDAMB, and RTDOTHMX analog quantities.

Table A.10 Instruction Manual Revision History (Sheet 14 of 14)

Revision Date	Summary of Revisions
20131220	**Preface** ➤ Updated the product compliance label. ➤ Added the voltage divider module compliance label. **Section 1** ➤ Updated the *Specifications* for cUL and UL approvals, ac current input, and power supply.
20130725	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Overview

These instructions guide you through the process of upgrading firmware in the device. The firmware upgrade will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-710-5-**R100**-V0-Z001001-Dxxxxxxxx

Standard release firmware:

FID=SEL-710-5-**R101**-V0-Z001001-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-710-5-R100-**V0**-Z001001-Dxxxxxxxx

Point release firmware:

FID=SEL-710-5-R100-**V1**-Z001001-Dxxxxxxxx

SEL occasionally offers firmware upgrades to improve the performance of your relay. Because SEL-710-5 relays store firmware in flash memory, changing physical components is unnecessary. Upgrade the relay firmware by downloading a file from a personal computer to the relay via the Ethernet port through the use of the web server, FTP, or Telnet. You can also use the front-panel serial port through the use of ACSELERATOR QuickSet SEL-5030 Software or a terminal emulator, as outlined in the following sections. For relays with the IEC 61850 option, verify the IEC 61850 protocol after the upgrade (see *Protocol Verification for Relays With IEC 61850 Option*).

Table B.1 details the available firmware upgrade methods. Available methods depend on your existing firmware and the firmware version to which you are upgrading.

Table B.1 Firmware Upgrade Methods

Existing Firmware	Upgrade Version	SELBOOT Upgrade Required?	Firmware Upgrade Methods Supported	
			Serial	**Ethernet**
R1*xx*	R2*xx*	NA	Terminal emulator QuickSet	—
R1*xx* or R2*xx*	R3*xx*	Yes (R600 or higher)	Terminal emulator[a]	—
R3*xx*	R3*xx*[b]	No	Terminal emulator QuickSet	Web server FTP FILE command Terminal emulator

[a] When upgrading from R1xx or R2xx to R3xx, you must first perform the Special Instructions for Upgrading to R300 Series Firmware and then follow the Protocol Verification for Relays With IEC 61850 Option instructions to upgrade your relay firmware.
[b] In firmware versions R302-V0 and higher, the relay firmware retains the Port 1 IP address, subnet mask, and default router settings during a firmware upgrade from any previous R3xx firmware version.

Required Equipment

Gather the following equipment before starting this firmware upgrade:

- PC
- Terminal emulation software that supports Xmodem/CRC or 1k Xmodem/CRC protocol
- Serial communications cable (SEL-C234A or equivalent, or a null-modem cable) or Ethernet cable
- Disk containing the firmware upgrade file (e.g., r*xxx*-v*x*7105.s19, r*xxx*-v*x*7105.z19, or r*xxx*-v*x*7105.zds)
- QuickSet software

Digitally Signed Firmware Files

The SEL-710-5 supports digitally signed firmware files for firmware versions R300-V0 and higher. These firmware files are compressed to reduce file transfer times and are digitally signed by SEL using a secure hash algorithm. The signature ensures that the file has been provided by SEL and that its contents have not been altered. Once the firmware is uploaded to the relay, the signature of the firmware is verified with a public key number that is stored on the relay from the factory. If the relay cannot verify the signature, it rejects the file.

The name of the digitally signed firmware file is of the form r*xxx*-v*x*7105.zds, where r*xxx*-v*x* is the firmware revision number, 7105 indicates the relay type, and .zds is the file extension reserved for digitally signed files. Firmware files with the .s19 extension are not available for firmware versions R300-V0 and higher.

Ethernet Firmware Upgrades

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

You can upgrade firmware over an Ethernet connection by sending the .zds firmware upgrade files via FTP, HTTP, or Telnet protocols to a relay running SELBOOT version R600 or newer and a relay firmware version identified in *Table B.1*. FTP, HTTP, and Telnet are plain text protocols and do not inherently support message encryption (of relay passwords, etc.). Because of this, SEL strongly recommends you use between the relay and your network a security gateway that provides encrypted communications along with SEL SDN technology to harden your network cybersecurity.

Special Instructions for Upgrading to R300 Series Firmware

The SELBOOT firmware in relays shipped with firmware versions earlier than R300 must be upgraded before you can use digitally signed firmware files. The SELBOOT firmware can be upgraded from version R500, R501, or R502 to version R601 by uploading a special SELBOOT Loader firmware to the relay.

The following instructions assume you have a working knowledge of your PC terminal emulation software.

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-710-5 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: Change the data rate of the relay serial port to 9600 bps before issuing the **L_D** command to start the upgrade process.

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 (see *Section 3: PC Interface*) to save and restore settings, or you can 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 reentry after the firmware upgrade.

We recommend that you save all stored data in the relay, including events, before the upgrade.

Step 4. Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 5. Download the SELBOOT Loader firmware to the relay.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay sends the `!>` prompt.

Step 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing SELBOOT and relay firmwares can be erased.

Step 8. Press any key (e.g., **<Enter>**) when the relay sends a prompt.

Step 9. Use the Xmodem protocol to send the special SELBOOT Loader firmware (e.g., slbtldr_r6017*xx*.s19) to the relay. The special SELBOOT Loader firmware erases the existing SELBOOT and relay firmwares and loads SELBOOT firmware version SLBT7XX-R601-V0-Z000000-D20211116.

The file transfer typically takes less than 5 minutes at 9600 bps, depending on the product. After the transfer is complete, the relay reboots and displays the SELBOOT `!>` prompt. After the SELBOOT upgrade is complete, upgrade your relay firmware using a terminal emulator. You do not need to save the relay settings and other data again during the firmware upgrade process if you saved them before upgrading SELBOOT. Proceed to *Step 5* in *Upgrade the Firmware Using a Terminal Emulator*.

Figure B.1 shows the entire special SELBOOT upgrade process.

```
=>>L_D <Enter>
Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled


BFID=BOOTLDR-R501-V0-Z000000-D20140224
!>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.
Erasing firmware.
Erase successful.
Writing new firmware.
Upload completed successfully. Attempting a restart.

Upgrading SELBoot


 Preparing S Record...

 Validating S Record...


* * * * * * * * * W A R N I N G * * * * * * * * *

 Do not turn off or cycle power to the relay or it may
 become inoperative and require factory repair !!!

  Performing this operation will require firmware
      to be downloaded to relay after reboot.

 * * * * * * * * * * * * * * * * * * * * * * * * *

 Removing Old SELBoot...

 Writing New SELBoot...

 Removing SELBoot Loader

 SELBoot Loader cleared... Resetting Relay!!!


BFID=SLBT7XX-R601-V0-Z000000-D20211116
!>
```

Figure B.1 Special SELBOOT Upgrade Process

Upgrade the SELBOOT Firmware Loader Using a Terminal Emulator

NOTE: Make sure the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

The process for upgrading SELBOOT is similar to *Upgrade the Firmware Using a Terminal Emulator on page B.6*. To determine if SELBOOT must be updated, do the following:

Step 1. Establish communication between the relay and a personal computer.

Step 2. From the computer, type **ID <Enter>**.

The relay responds with the following:

```
=ID <Enter>

"FID=SEL-710-5-X323-V0-Z005003-D20220415","090B"
"BFID=SLBT7XX-R600-V0-Z000000-D20200331","0949"
"CID=43D5","025D"
"DEVID=SEL-710-5","0424"
"DEVCODE=80","030F"
"PARTNO=071050E1B1X0X758506FX","0754"
"CONFIG=111112010","041B"
"SPECIAL=0","02DE"
"SEL DISPLAY PACKAGE=3.0.50710.3004","0884"
"CUSTOMER DISPLAY PACKAGE=1.575370232","0992"
"iedName=SEL_710d5_default","0918"
"type=SEL_710d5","04E3"
"configVersion=ICD-710-5-X204-V0-Z302006-D20220401","0D7C"
"LIB61850ID=DF8157E4","04ED"
```

NOTE: When you are upgrading an SEL-710-5 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: Change the data rate of the relay serial port to 9600 bps before issuing the **L_D** command to start the upgrade process.

NOTE: The web server can be used to upgrade the relay firmware versions after R300-V0.

NOTE: In instances where the SELBOOT needs to be upgraded first, the web server cannot be used to upgrade the relay firmware. Use a terminal emulator to upgrade the SELBOOT first, followed by the relay firmware.

Step 3. Locate the Boot Firmware Identifier String (BFID).

Step 4. Find the SELBOOT revision number in the BFID (R*xxx*). If the revision number is lower than the one you see on the firmware CD, follow the process mentioned below. Otherwise, upgrade the relay firmware using one of the methods mentioned later in the section.

Step 5. To upgrade SELBOOT, locate the new SELBOOT file (r*xxx*7*xx*.zds) on the desk provided with the firmware upgrade materials. Follow the instructions under *Upgrade the Firmware Using a Terminal Emulator on page B.6*. In *Step 6*, replace the **REC** command with **REC BOOT** and follow the prompts.

Step 6. When the relay prompts: `Press any key to begin transfer and then start transfer at the terminal`, press **<Enter>** and select the SELBOOT file.

Step 7. When the SELBOOT upgrade is successful, the relay prompts:

`Erasing SELboot. Writing SELboot.`

`SELBOOT upload completed successfully. Restarting SELBOOT.`

Change the data rate of the communications software to 9600 bps and press **<Enter>**.

Step 8. Type **EXI <Enter>** at the SELBOOT `!>` prompt to exit SELBOOT. The relay should display the = prompt.

If the relay does not return the SELBOOT `!>` prompt within two minutes after displaying `Restarting SELboot`, cycle the relay power. The relay should restart and display the = prompt.

Once the SELBOOT upgrade is complete, select a firmware upgrade method as discussed later in the section. It is not necessary to save the relay settings and other data again if you did this before upgrading SELBOOT.

Upgrade the Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your PC terminal emulation software.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the front-panel serial or Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can 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.

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

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 Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

Step 4. Start upgrading the firmware.

a. Issue the **L_D** command.

b. Type **Y <Enter>** at the following prompt:

```
Disable relay to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The relay sends the `!>` prompt.

If you are using an Ethernet port, proceed to *Step 6*.

Step 5. Change the data rate, if necessary.

a. Type **BAU 115200 <Enter>**.

This changes the data rate of the communications port to 115200 bps.

b. Change the data rate of the PC to 115200 bps to match the relay.

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 6. Issue the **REC** command to receive the new firmware.

Step 7. Type **Y** to confirm that the existing firmware can be erased.

Step 8. Press any key (e.g., **<Enter>**) when the relay sends a prompt.

Step 9. Start the file transfer.

Use the Xmodem protocol to send the file that contains the new firmware (e.g., r*xxx*-v*x*7105.s19, r*xxx*-v*x*7105.z19, or r*xxx*-v*x*7105.zds).

Firmware files for firmware versions R1xx and R2xx have a .s19 or .z19 extension. Firmware files for firmware versions R300 and higher have a. zds extension. Firmware files with the .s19 or .z19 extension are not available for firmware versions R300 and higher.

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.2 shows the entire upgrade process.

```
=>>L_D <Enter>

Disable relay to receive firmware (Y,N)? Y <Enter>
Are you sure (Y,N)? Y <Enter>
Relay Disabled

BFID=SLBT7XX-R600-V0-Z000000-D20200331
!>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.2 Firmware File Transfer Process

Step 10. The relay front-panel **ENABLED** LED illuminates if the relay settings are 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 saves the relay calibration settings.

The relay responds:

`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 6*, 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.

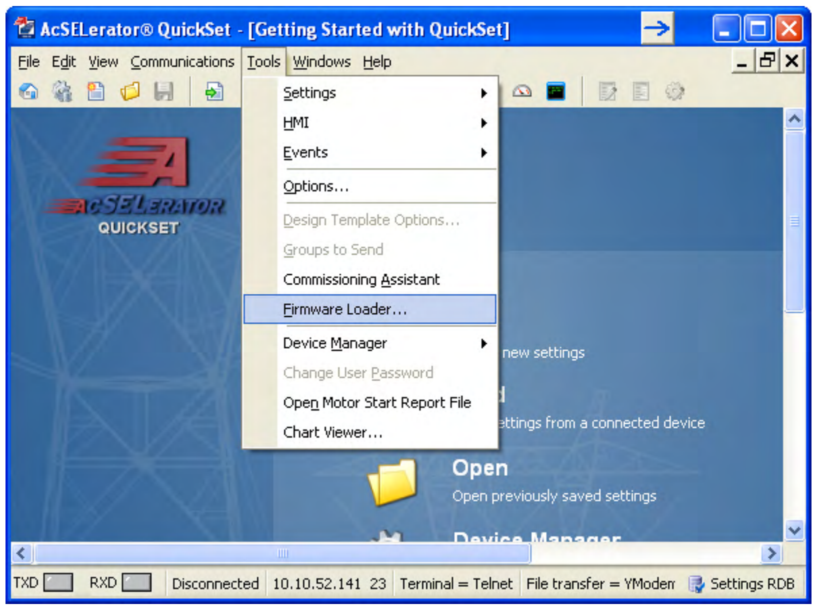
Step 14. Issue the **METER** command; verify that the current and voltage signals are correct.

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.

Upgrade the 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 Interface* for setup and connection procedures for QuickSet.



NOTE: The firmware loader is not supported on Ethernet port connections.

NOTE: In instances where SELBOOT needs to be upgraded, QuickSet cannot be used to upgrade the relay firmware. Use a terminal emulator to upgrade SELBOOT and then upgrade the relay firmware.

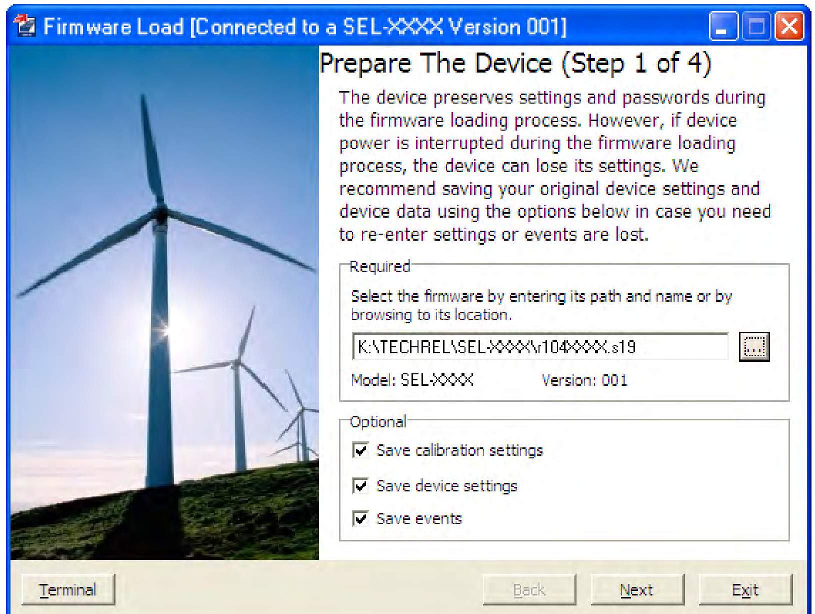
Firmware Loader does not start if:

- The device is unsupported by QuickSet.
- The device is not connected to the computer with a communications cable.
- The device is disabled.

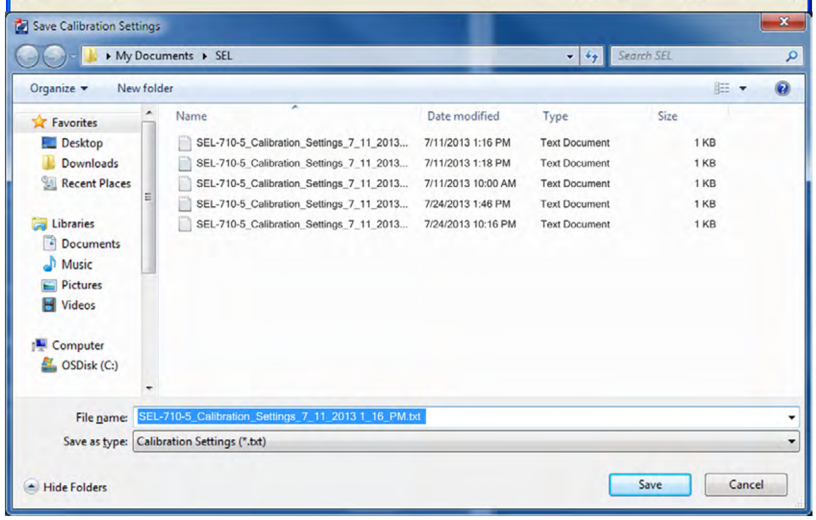
Step 1. If the relay is in service, open the relay control circuits.

Step 2. Prepare the device.

a. Select the firmware to be loaded using the browse control and select **Save calibration settings**, **Save device settings**, and **Save events**. Select **Next** to continue the wizard.

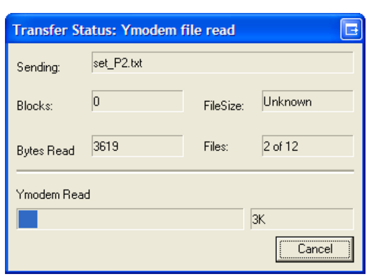


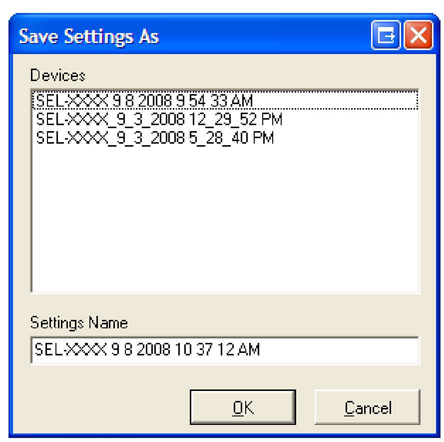
b. Select a file name to save the selected settings or accept the defaults as shown. Click **Save**.



c. The **Transfer Status**: **Ymodem file read** window shows the transfer progress of the settings file.

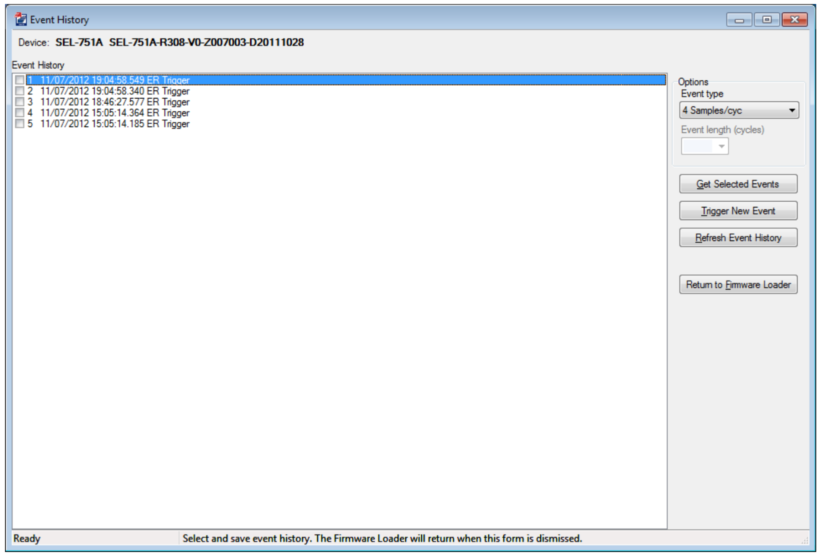
After the device settings are downloaded, select a file name and path to save the settings or accept the default, as shown..





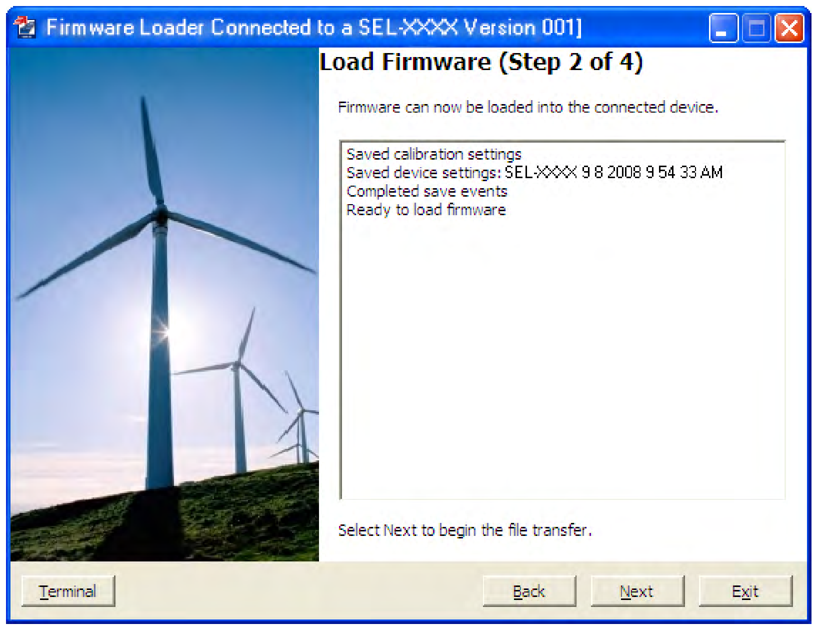
d. Click **Return to Firmware Loader** if this device does not have any event reports.

If there are any event reports to be saved, select the events and click **Get Selected Events**. After saving them, click **Return to Firmware Loader**.



Step 3. Transfer firmware.

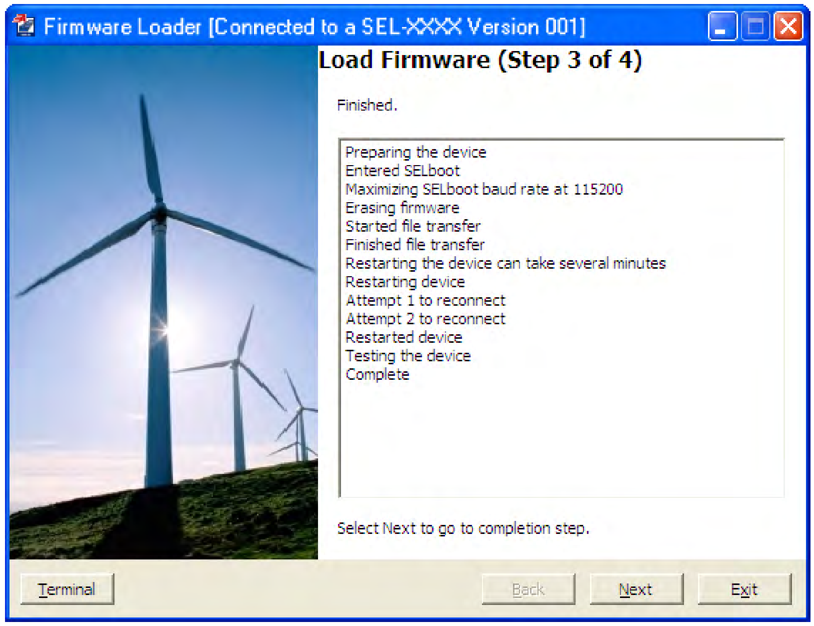
Click **Next** to begin the firmware transfer.



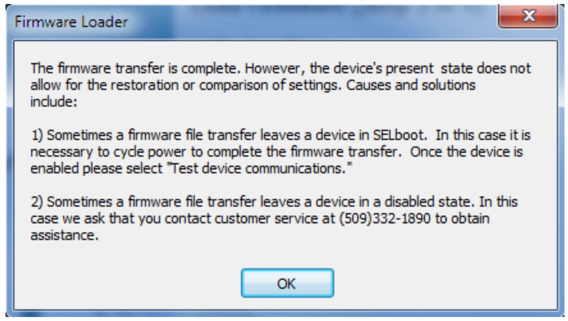
Step 4. Load firmware.

During this step, the device is put in SELBOOT mode. The transfer speed is maximized and the firmware transfer begins.

Step 5. Click **Next** to complete the firmware upgrade..



NOTE: The following screen can appear if you have one of the two conditions mentioned.



If the relay is disabled as a result of a settings mismatch between a previous firmware version and a new firmware version, check 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` on the two-line display model, or a settings mismatch notification screen on the touchscreen model, 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.

The relay reboots and comes up enabled.

Note that the port settings will be restored to the default settings due to the **R_S** command.

If the relay is still disabled, use the following procedure:

e. Enter Access Level 2.

f. Issue the **STATUS** command.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

```
Confirm Hardware Config
Accept & Reboot (Y/N)?
```

Enter **Y**.

This saves the relay calibration settings. The relay responds:

```
Config Accepted
```

The relay reboots and comes up enabled.

Step 6. 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 that are saved in the database to the device. Settings are converted automatically, if necessary.

Load Firmware into Another Device. Returns the wizard to *Step 2*: *Prepare Device* to repeat the firmware-loading process with another device.

Upgrade the Firmware Using the Web Server

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

The web server offers a convenient method for upgrading the relay firmware. Located on the left navigation pane of the screen, the System menu contains the File Management category that allows you to upgrade firmware in the relay. To upgrade the firmware using the web server, the firmware in your relay must be R300-V0 or higher. The firmware is designated with a .zds extension. Refer to *Section 3: PC Interface* for connecting and logging in to the SEL-710-5 web server using the Ethernet port.

To upgrade relay firmware by using the web server, set the Port 1 settings HTTPACC := 2 and EETHFWU := Y. The web server login page provides Access Level 2 as a user-selectable login access level. If EETHFWU is set to N, you cannot upgrade the firmware over Ethernet regardless of the HTTPACC setting.

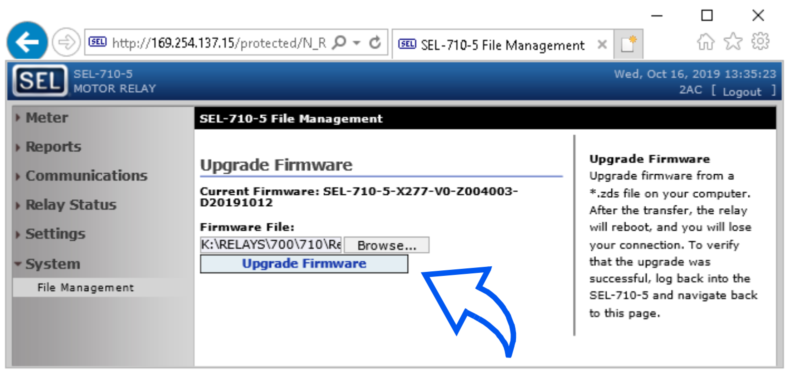
Step 1. In QuickSet, save the current relay settings and other data.

Step 2. Proceed with the firmware upgrade process by performing the following steps:

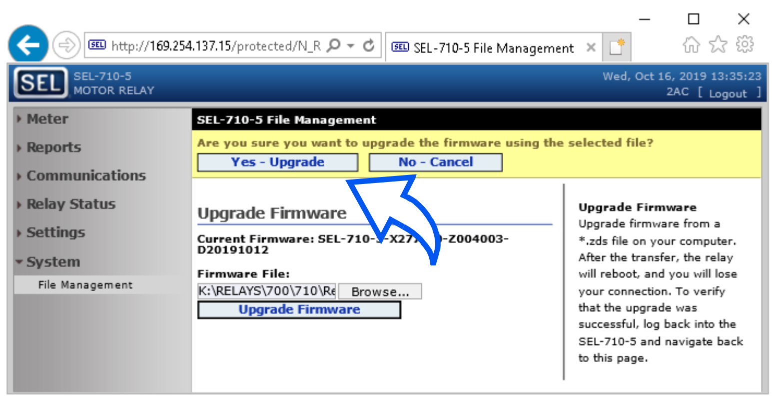
a. Click **System > File Management** from the left navigation pane of the webpage.

b. Click **Browse** to select the firmware you want to send to the relay.

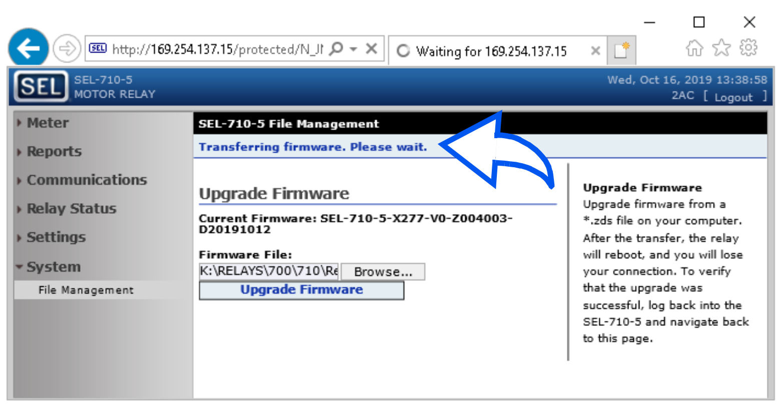
c. Click **Upgrade Firmware** to start the upgrade process.



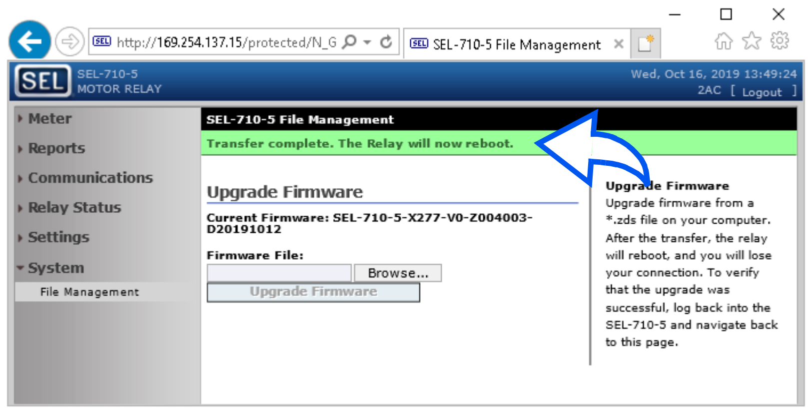
Step 3. Click **Yes - Upgrade** if you want to upgrade using the file selected.



Once the upgrade process is in progress, the relay acknowledges the transfer with the message, **Transferring firmware. Please wait**.



After the relay finishes the firmware transfer, an acknowledgment message appears and the relay reboots.



NOTE: After the relay reboots, if the **ENABLED** LED is not illuminated or if the front panel displays STATUS FAIL Non_Vol Failure on the two-line display model, or a settings mismatch notification screen on the touchscreen model, then open a terminal emulator using the serial port and use the following procedure to restore the factory-default settings. Refer to Protocol Verification for Relays With IEC 61850 Option for terminal emulator setup and connections.

a. Set the communications software settings to 9600 bps, 8 data bits, and 1 stop bit.

b. Enter Access Level 2 by issuing the **2AC** command.

c. Issue the **R_S** command to restore the factory default.

The relay reboots and comes up enabled.

Note that the port settings will be restored to the factory-default settings due to the **R_S** command.

If the relay is still disabled, use the following procedure:

d. Enter Access Level 2.

e. Issue the **STATUS** command.

If the STATUS report shows option card `FAIL` and `Relay Disabled` and the message:

```
Confirm Hardware Config
Accept & Reboot (Y/N)?
```

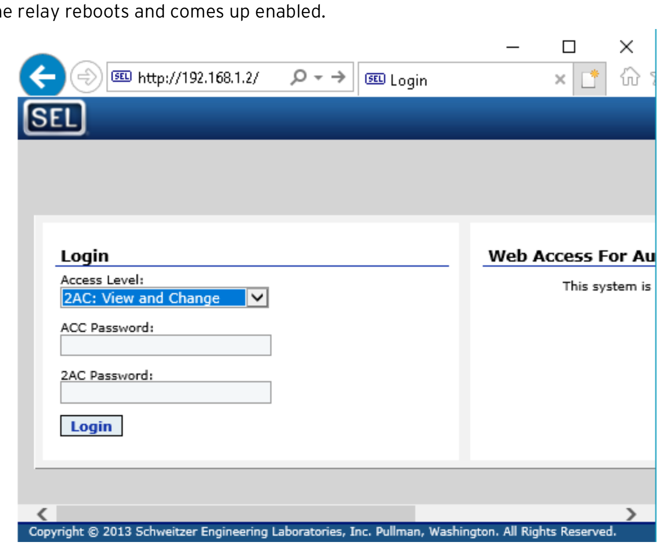
Enter **Y**.

This saves the relay calibration settings. The relay responds:

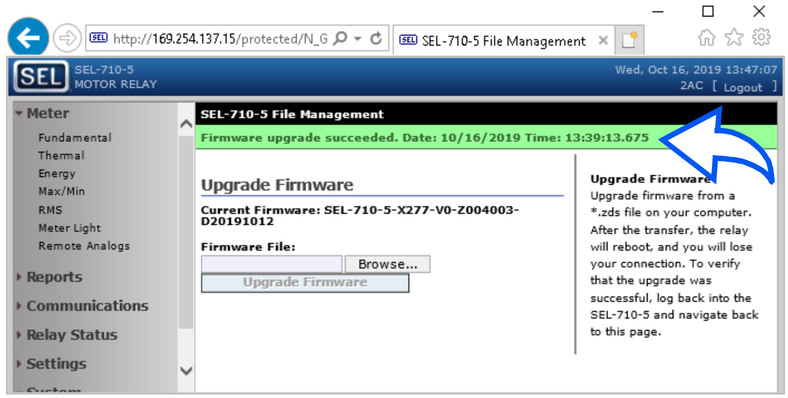
```
Config accepted
```

The relay reboots and comes up enabled.

Step 4. After the relay reboots, the Login screen appears on the web server. Log in to the relay to verify completion of the firmware upgrade process.



An acknowledgment message appears that verifies a successful firmware upgrade.



Step 5. Check that the relay firmware version matches the version that was used for the upgrade and that the relay is enabled.

Click on **Relay Status** > **Self-Tests** to view the status report.

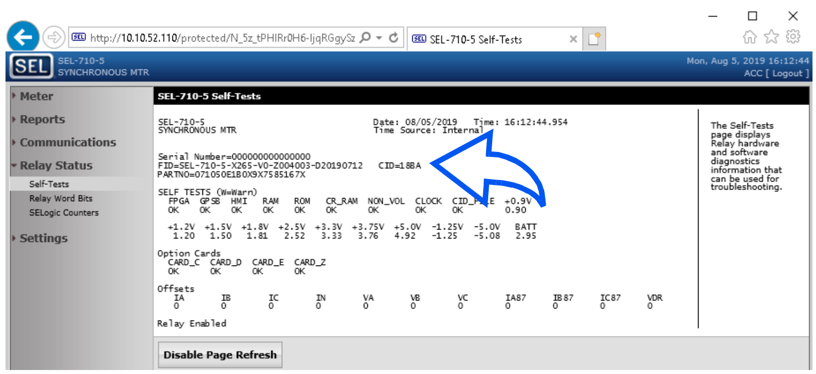


Table B.2 provides messages displayed in the web browser and the relay condition associated with those messages.

Table B.2 Messages Displayed in the Web Browser

User Message	Relay Condition
Firmware upgrade succeeded.	The previous firmware upgrade with a .zds file was successful.
Invalid upgrade file.	The .zds file was not successfully received or validated by the relay.
Upgrade in progress on another interface.	A firmware upgrade is currently being performed through another connection.
Errors during Upgrade File Transfer.	Upgrade failed due to errors during file transfer.

Upgrade the Firmware Using File Transfer Protocol

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

To upgrade firmware using File Transfer Protocol (FTP), the firmware in your relay must be R300-V0 or higher. The firmware is designated with a .zds extension.

To upgrade relay firmware by using FTP, the Port 1 setting FTPACC must be set to 2 or C and EETHFWU must be set to Y. If EETHFWU is set to N, upgrading firmware over an Ethernet connection is disabled regardless of the FTPACC setting.

The following instructions assume you have a working knowledge of the Windows command prompt.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can 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.

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 Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-710-5 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: File name RELAY.zds is not case sensitive.

Step 4. Rename the r*xxx*-v*x*7105.zds file as RELAY.zds.

Step 5. Create an FTP session to connect to the relay using the relay IP address.

Step 6. Enter your FTP username and password.

Step 7. Issue the **CD UPGRADE** command to switch the present relay directory to the UPGRADE directory.

Step 8. Issue the **PUT RELAY.ZDS** command to place the RELAY.zds file in the UPGRADE directory and to send the file to the relay.

When the download is complete, the relay reboots and comes up enabled. During this upgrade process, you will lose the FTP connection, and you must re-establish the FTP connection after the upgrade is complete. Then, navigate to the relay UPGRADE directory, read the error file ERR.TXT and review for any error messages. If the firmware upgraded properly, no errors occurred during the upgrade process and the file is empty. If messages are contained within the file, see *Table B.2* for the error message and what the error means.

Figure B.3 shows the entire upgrade process via Windows command prompt.

```
Microsoft Windows [Version 10.0.17763.805]
(c) 2018 Microsoft Corporation. All rights reserved.

Y:\>FTP 10.39.94.180 <Enter>
Connected to 10.39.94.180.
220 FTP SERVER
550 NOOP requested action not taken.
User (10.39.94.180:(none)): xxxxxx <Enter>
331 User name okay, need password.
Password: xxxxxx <Enter>
230 User logged in, proceed.
ftp> CD UPGRADE <Enter>
250 CWD  requested file action okay, completed.
ftp> PUT RELAY.ZDS <Enter>
200 PORT Command okay.
150 File status okay; about to open data connection.
Connection closed by remote host.
ftp>
```

Figure B.3 Firmware Upgrade Via FTP

Upgrade the Firmware Via Terminal Emulator Using the FILE Command Over Telnet

NOTE: Make sure that the relay and SELBOOT firmware revisions are compatible. Refer to Appendix A: Firmware, ICD, and Manual Versions in this manual. If needed, upgrade the SELBOOT firmware prior to upgrading the relay firmware.

NOTE: The relay pulses the SALARM bit and writes an entry to the relay SER log whenever a firmware upgrade is attempted over Ethernet. Monitoring this bit and reviewing the SER log can help identify possible unauthorized firmware upgrade attempts.

NOTE: To save the calibration settings, perform **SHO C** from the terminal by logging into Access Level C using the Access Level C password. The factory-default password for Access Level C is CLARKE.

NOTE: When you are upgrading an SEL-710-5 with a touchscreen front-panel display, save all of the relay settings, including the touchscreen settings, using QuickSet.

NOTE: File name RELAY.zds is not case sensitive.

To upgrade firmware using the **FILE** command over Telnet, the firmware in your relay must be R300-V0 or higher. The firmware is designated with a .zds extension.

To upgrade relay firmware by using the **FILE** Command over Ethernet, the Port 1 setting MAXACC must be set to 2 or C and EETHFWU must be set to Y. If EETHFWU is set to N, upgrading firmware over an Ethernet connection is disabled regardless of the MAXACC setting.

The following procedure assumes that you have a working knowledge of the software being used to upgrade the firmware via **FILE** command.

Step 1. If the relay is in service, open the relay control circuits.

Step 2. Connect the PC to the Ethernet port and enter Access Level 2.

Step 3. Save the present relay settings.

You can use the PC software (see *Section 3: PC Interface*) to save and restore settings, or you can 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.

We recommend that you save all stored data in the relay, including events, before the upgrade.

Step 4. Rename the r*xxx*-v*x*7105.zds file as RELAY.zds.

Step 5. Save the RELAY.zds file to a directory.

Step 6. Update the active directory to be the directory where the RELAY.zds file is saved.

Step 7. Issue the **FILE WRITE RELAY.ZDS** command to the relay.

Step 8. Send the RELAY.zds file to the relay via Ymodem transfer.

When the upgrade is complete, the relay reboots and comes up enabled. During this upgrade process, you will lose the Telnet connection, and you must re-establish the Telnet connection after the upgrade is complete. Then, navigate to the relay UPGRADE directory, read the error file ERR.TXT and review for any error messages. If the firmware upgraded properly, no errors occurred during the upgrade process and the file is empty. If messages are contained within the file, see *Table B.2* for the error message and what the error means.

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. 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 disables 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:

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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

Appendix C
SEL Communications Processors

SEL Communications Protocols

The SEL-710-5 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 Fast Message	Use this protocol to write Remote Analog Data via unsolicited writes.

SEL ASCII Commands

We originally designed SEL ASCII commands for communication between the relay and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the relay, collect data, and issue commands.

SEL Compressed ASCII Commands

The relay supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the relay can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor 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
CBRE	Breaker monitor	1
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, remote analogs, light 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-710-5 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-710-5 and use the ASCII data stream for commands and responses.

SEL Fast Meter, Fast Operate, Fast SER, and Unsolicited Write

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The relay can also send unsolicited Fast SER messages automatically and receive unsolicited SEL Fast Messages (used in the SEL-710-5 for Remote Analogs). If the relay is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Communications Processor

SEL offers SEL communications processors, powerful tools for system integration and automation. The SEL-2030 series and the SEL-2020 communications processors are similar, except that the SEL-2030 series has two slots for network protocol cards. These devices provide a single point of contact for integration networks with a star topology, as shown in *Figure C.1*.

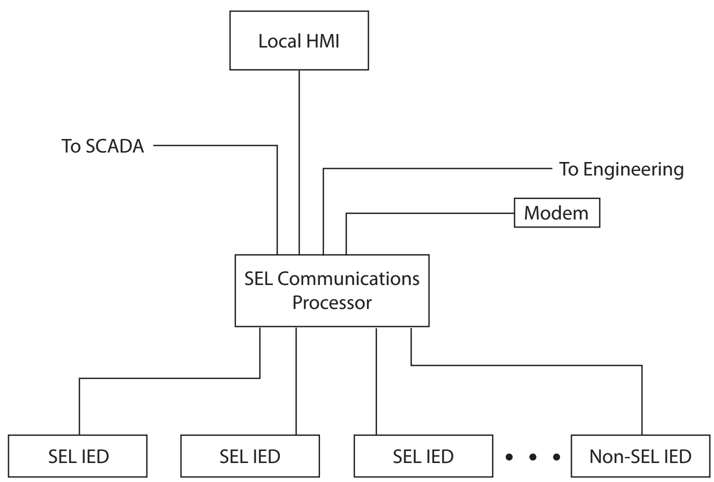

Figure C.1 SEL Communications Processor Star Integration Network

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.

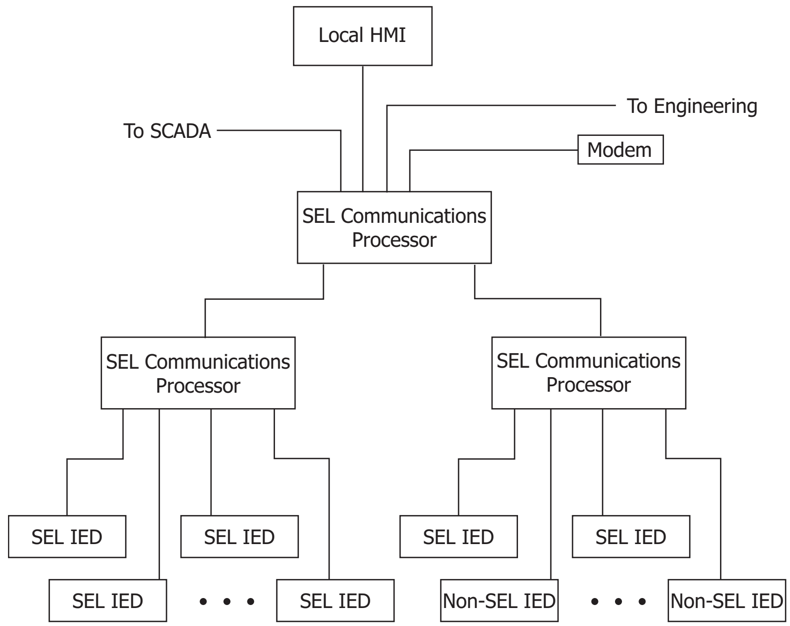

Figure C.2 Multitiered SEL Communications Processor Architecture

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 (Sheet 1 of 2)

Protocol	Connect to
DNP3 Level 2 Outstation	DNP3 masters
Modbus RTU Protocol	Modbus masters
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL relays
ASCII and Binary 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

Table C.3 SEL Communications Processors Protocol Interfaces (Sheet 2 of 2)

Protocol	Connect to
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 using SEL communications processors involve either developing a star network or enhancing a multidrop network.

Developing Star Networks

The simplest architecture using both the SEL-710-5 and an SEL communications processor is shown in *Figure C.1*. In this architecture, the SEL communications processor collects data from the SEL-710-5 and other station IEDs. The SEL communications processor acts as a single point of access for local and remote data consumers (local HMI, SCADA, engineers). The communications processor also provides a single point of access for engineering operations including configuration and the collection of report-based information.

By configuring a data set optimized to each data consumer, you can significantly increase the utilization efficiency on each link. A system that uses an SEL communications processor to provide a protocol interface to an RTU has a shorter lag time (data latency); communication overhead is much less for a single data exchange conversation to collect all substation data (from a communications processor) than for many conversations required to collect data directly from each individual IED. You can further reduce data latency by connecting any SEL communications processor directly to the SCADA master and eliminating redundant 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 provide a UCA2 interface to SEL-710-5 relays and other serial IEDs. The SEL-710-5 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 uses either an Ethernet network connection through the SEL-2701 or a serial port connection. This versatility accommodates the channel that is available between the station and the engineering center. SEL software uses 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.

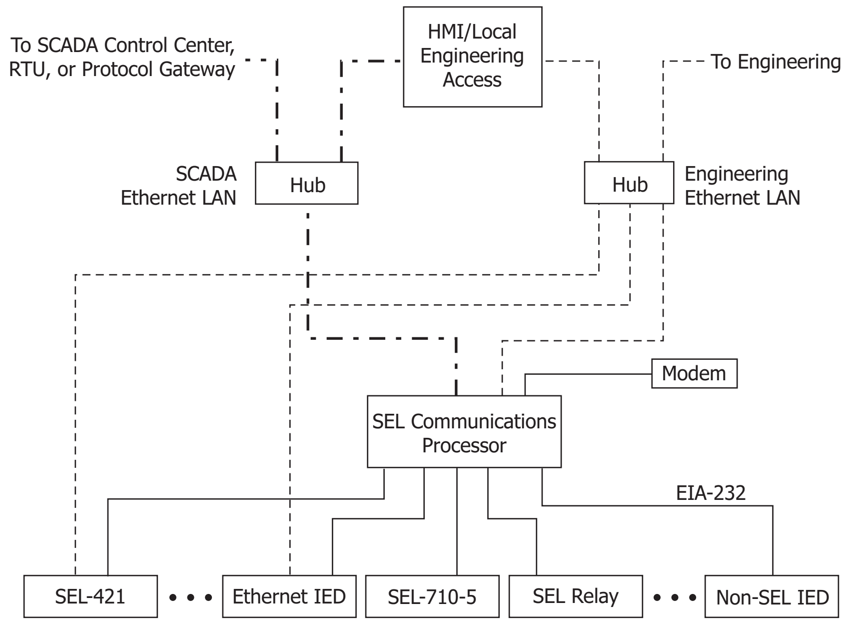

Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

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-710-5. The physical configuration used in this example is shown in *Figure C.4*. In this example, the communications processor is an RTAC that is connected to the SEL-710-5 by using SEL Protocol via ACSELERATOR RTAC software. For more information regarding the RTAC and ACSELERATOR RTAC software, refer to selinc.com.

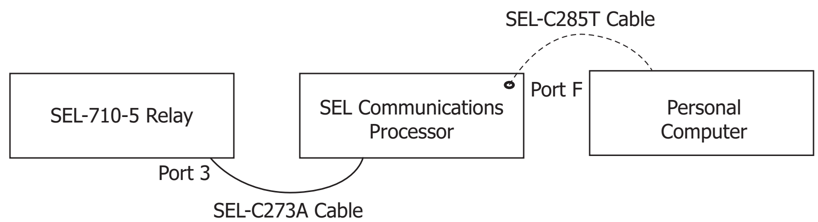

Figure C.4 Example of SEL Relay and SEL Communications Processor Configuration

Table C.4 shows the **Port 1** settings for the RTAC.

Table C.4 RTAC Port 1 Settings (Sheet 1 of 2)

Setting	Range	Value
Communications		
SERIAL COMMUNICATIONS PORT	The number of ports depends on the RTAC MOT	Com_01
SERIAL COMMUNICATIONS PORT TYPE	EIA-232, EIA-485/EIA-422	EIA232
BAUD RATE	Auto-Baud, 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	115200
DATA BITS	8	8
PARITY BIT	None	None
STOP BIT	1	1
RTS_CTS	True, False	False
XON/XOFF	True, False	True
LEVEL 1 PASSWORD	0–32 characters	**********
LEVEL 2 PASSWORD	0–32 characters	**********
ENABLE PASSWORD MONITOR	True, False	False
POLL CASCII RETRIES	0–255	3
POLL CASCII INACTIVITY TIMEOUT	100–65535 ms	8000
POLL BINARY RETRIES	0–255	3
POLL BINARY INACTIVITY TIMEOUT	<min>–65535 ms	2500
SLOW POLL MODE MULTIPLIER	1–65535	5

Table C.4 RTAC Port 1 Settings (Sheet 2 of 2)

Setting	Range	Value
TRANSMIT FAST UNSOLICITED WRITE MESSAGING ON STARTUP	True, False	False
Date-Time		
UTC OFFSET	–720 to 840 minutes	0
DST ENABLED	True, False	True
Event		
ENABLE EVENT COLLECTION	True, False	False
ENABLE COMTRADE COLLECTION	True, False	False
LIST OF EVENT TYPES TO BE COLLECTED		HR
SEL		
VIRTUAL PORT NUMBER	1–254	1

After these settings are configured to align with the Port 1 settings of the SEL-710-5, the RTAC will auto-configure the connection. Refer to *Figure C.5* to see what a healthy connection looks like after auto-configuration is complete. Note that ENO and EN are TRUE and that Offline is FALSE.

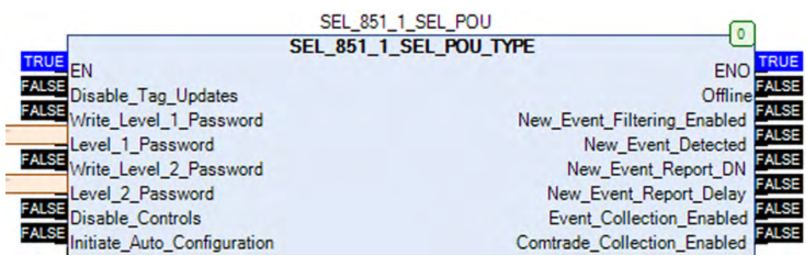

Figure C.5 Healthy Communications Between an RTAC and an SEL Relay

Data Collection

In this example, the RTAC is configured to collect data from the SEL-710-5 via SEL Protocol, using the list in *Table C.5*.

Table C.5 RTAC Data Collection Automessages

Message Name	Message Type	Command	Poll Period
History	Compressed ASCII	CHI	0
Load Data	Compressed ASCII	CLDP	0
SER	Compressed ASCII	CSE	0
Status	Compressed ASCII	CST	0
Demand Meter	Fast Meter	D2	0
Meter	Fast Meter	D1	1000
Peak Meter	Fast Meter	D3	0

You have the ability to set the poll period for each of the commands in *Table C.5*.

Control Points

The RTAC can pass control messages, called Fast Operate messages, to the SEL-710-5 automatically. You must enable Fast Operate messages by using the FASTOP setting in the SEL-710-5 port settings for the port connected to the SEL communications processor.

NOTE: To use the Fast Operate function, the FASTOP setting must be set to Y (see Section 6: Settings).

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the relay for changes in remote bits RB01–RB32 on the corresponding SEL communications processor port.

SEL Communications Processor to SEL-710-5 Unsolicited Write Remote Analog Example

There are two settings that must be configured in the RTAC if you need to write to remote analogs in the SEL-710-5. In this example, the required settings needed to write to RA_001.Val and RA_002.Val are provided. The first set of settings is under the Tx UW Messages tab. See *Figure C.6*.

Unsolicited Write TX	Unsolicited Write TX Period	Unsolicited Write TX Port	Unsolicited Write TX Start Address
1	1000	Com_001	0xf800
2	1000	Com_001	0xf802

Figure C.6 Unsolicited Write Remote Analogs Tx UW Messages Settings

In the settings, note the unsolicited write Tx starting addresses. After these two settings are properly configured, Tx UW Message 1 must be configured. See *Figure C.7*. Note the Tag Types being MV and the Datatype being REAL. Use a similar setup to write to all of the remote analogs.

Drag a column header here to group by that column

Enable	Tag Name	Tag Type	Tag Alias	Address Range Start	Address Range Stop	Bit Index	Treat As	Status Value
True	SEL_851_1_SEL.Tx_UW_1_F800	MV		0xf800	0xf801		REAL	
True	SEL_851_1_SEL.Tx_UW_1_F802	MV		0xf802	0xf803		REAL	

Figure C.7 Tag Type and Datatype for RA_001.Val–RA_032.Val

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Appendix D
DNP3 Communications

Overview

The SEL-710-5 Motor Protection Relay provides a Distributed Network Protocol Version 3.0 (DNP3) Level 2 Outstation interface for direct serial and LAN/WAN network connections to the device.

This section covers the following topics:

Introduction to DNP3

A supervisory control and data acquisition (SCADA) manufacturer developed the first versions of DNP from the lower layers of IEC 60870-5. Originally designed for use in telecontrol applications, Version 3.0 of the protocol has also become popular for local substation data collection. DNP3 is one of the protocols included in the IEEE Recommended Practice for Data Communications Between Remote Terminal Units and Intelligent Electronic Devices in a Substation.

The DNP Users Group maintains and publishes DNP3 standards. See the DNP Users Group website, www.dnp.org, for more information on standards, implementers, and tools for working with DNP3.

DNP3 Specifications

DNP3 is a feature-rich protocol with many ways to accomplish tasks, defined in an eight-volume series of specifications. Volume 8 of the specification, called the Interoperability Specification, simplifies DNP3 implementation by providing four standard interoperable implementation levels. The levels are listed in *Table D.1*.

Table D.1 DNP3 Implementation Levels

Level	Description	Equipment Types
1	Simple: limited communication requirements	Meters, simple IEDs
2	Moderately complex: monitoring and metering devices and multifunction devices that contain more data	Protective relays, RTUs
3	Sophisticated: devices with great amounts of data or complex communication requirements	Large RTUs, SCADA masters
4	Enhanced: additional data types and functionality for more complex requirements	Large RTUs, SCADA masters

Each level is a proper superset of the previous lower-numbered level. A higher-level device can act as a master to a lower-level device, but can only use the data types and functions implemented in the lower level device. For example, a typical SCADA master is a Level 3 device and can use Level 2 (or lower) functions to poll a Level 2 (or lower) device for Level 2 (or lower) data. Similarly, a lower-level device can poll a higher-level device, but the lower level device can only access the features and data available to its level.

In addition to the eight-volume DNP3 specification, the protocol is further refined by conformance requirements, optional features, and a series of technical bulletins. The technical bulletins supplement the specifications with discussions and examples of specific features of DNP3.

Data Handling

Objects

DNP3 uses a system of data references called objects, defined by the Basic 4 standard object library. Each subset level specification requires a minimum implementation of object types and recommends several optional object types. DNP3 object types, commonly referred to as objects, are specifications for the type of data the object carries. An object can include a single value or more complex data. Some objects serve as shorthand references for special operations, including collections of data, time synchronization, or even all data within the DNP3 device.

If there can be more than one instance of a type of object, then each instance of the object includes an index that makes it unique. For example, each binary status point (Object 1) has an index. If there are 16 binary status points, these points are Object 1, Index 0 through Object 1, Index 15.

Each object also includes multiple versions called variations. For example, Object 1 (binary inputs) has three variations: 0, 1, and 2. You can use Variation 0 to request all variations, Variation 1 to specify binary input values only, and Variation 2 to specify binary input values with status information.

Each DNP3 device has both a list of objects and a map of object indices. The list of objects defines the available objects, variations, and qualifier codes. The map defines the indices for objects that have multiple instances and defines what data or control points correspond with each index.

A master initiates all DNP3 message exchanges except unsolicited data. DNP3 terminology describes all points from the perspective of the master. Binary points for control that move from the master to the outstation are called binary outputs, while binary status points within the outstation are called binary inputs.

Function Codes

Each DNP3 message includes a function code. Each object has a limited set of function codes that a master can use to manipulate the object. The object listing for the device shows the permitted function codes for each type of object. The most common DNP3 function codes are listed in *Table D.2*.

Table D.2 Selected DNP3 Function Codes

Function Code	Function	Description
1	Read	Request data from the outstation
2	Write	Send data to the outstation
3	Select	First part of a Select-Before-Operate operation
4	Operate	Second part of a Select-Before-Operate operation
5	Direct operate	One-step operation with reply
6	Direct operate, no reply	One-step operation with no reply

Qualifier Codes and Ranges

DNP3 masters use qualifier codes and ranges to make requests for specific objects by index. Qualifier codes specify the style of range, and the range specifies the indices of the objects of interest. DNP3 masters use qualifier codes to compose the shortest, most concise message possible when requesting points from a DNP3 outstation.

For example, the qualifier code 01 specifies that the request for points includes a start address and a stop address. Each of these two addresses uses two bytes. An example request using qualifier code 01 might have the four hexadecimal byte range field, 00h 04h 00h 10h, which specifies points in the range 4 to 16.

Access Methods

DNP3 has many features that help obtain maximum possible message efficiency. DNP3 masters send requests with the least number of bytes using special objects, variations, and qualifiers that reduce the message size. Other features eliminate the continual exchange of static (unchanging) data values. These features optimize use of bandwidth and maximize performance over a connection of any speed.

DNP3 event data collection eliminates the need to use bandwidth to transmit values that have not changed. Event data are time-stamped records that show when observed measurements changed. For binary points, the remote device (DNP3 outstation) logs changes from logical 1 to logical 0 and from logical 0 to logical 1. For analog points, the outstation device logs changes that exceed a deadband. DNP3 outstation devices collect event data in a buffer that either the master can request or the device can send to the master without a request message. Data sent from the outstation to the master without a polling request are called unsolicited data.

DNP3 data fit into one of four event classes: 0, 1, 2, or 3. Class 0 is reserved for reading the present value data (static data). Classes 1, 2, and 3 are event data classes. The meaning of Classes 1 to 3 is arbitrary and defined by the application at hand. With outstations that contain great amounts of data or in large systems, the three event classes provide a framework for prioritizing different types of data. For example, you can poll once a minute for Class 1 data, once an hour for Class 2 data, and once a day for Class 3 data.

DNP3 also supports static polling: simple polling of the present value of data points within the outstation. By combining event data, unsolicited polling, and static polling, you can operate your system in one of the four access methods shown in *Table D.3*.

The access methods listed in *Table D.3* are listed in order of increasing communication efficiency. With various trade-offs, each method is less demanding of communication bandwidth than the previous one. For example, unsolicited report-by-exception consumes less communication bandwidth than polled report-by-exception because that method does not require polling messages from the master. To properly evaluate which access method provides optimum performance for your application, you must also consider overall system size and the volume of data communication expected.

Table D.3 DNP3 Access Methods

Access Method	Description
Polled static	Master polls for present value (Class 0) data only
Polled report-by-exception	Master polls frequently for event data and occasionally for Class 0 data
Unsolicited report-by-exception	Outstation devices send unsolicited event data to the master, and the master occasionally polls for Class 0 data
Quiescent	Master never polls and relies on unsolicited reports only

Binary Control Operations

DNP3 masters use Object 12, control device output block, to perform DNP3 binary control operations. The control device output block has both a trip/close selection and a code selection. The trip/close selection allows a single DNP3 index to operate two related control points such as trip and close or raise and lower. Trip/close pair operation is not recommended for new DNP3 devices, but is often included for interoperability with older DNP3 master implementations.

The control device output block code selection specifies either a latch or pulse operation on the point. In many cases, DNP3 outstations have only a limited subset of the possible combinations of the code field. Sometimes, DNP3 outstations assign special operation characteristics to the latch and pulse selections. *Table D.12* describes control point operation for the SEL-710-5.

Conformance Testing

In addition to the protocol specifications, the DNP Users Group has approved conformance-testing requirements for Level 1 and Level 2 devices. Some implementers perform their own conformance specification testing, while some contract with independent companies to perform conformance testing.

Conformance testing does not always guarantee that a master and outstation are fully interoperable (that is, work together properly for all implemented features). Conformance testing does help to standardize the testing procedure and move the DNP3 implementers toward a higher level of interoperability.

DNP3 Serial Network Issues

Data Link Layer Operation

DNP3 employs a three-layer version of the seven-layer OSI (Open System Interconnection) model called the enhanced performance architecture. The layer definition helps to categorize functions and duties of various software components that make up the protocol. The middle layer, the Data Link Layer, includes several functions for error checking and media access control.

A feature called data link confirmation is a mechanism that provides positive confirmation of message receipt by the receiving DNP3 device. While this feature helps you recognize a failed device or failed communications link quickly, it also adds significant overhead to the DNP3 conversation. Consider whether you require this link integrity function in your application at the expense of overall system speed and performance.

The DNP3 technical bulletin (*DNP Confirmation and Retry Guidelines 9804-002*) on confirmation processes recommends against using data link confirmations because these processes can add to traffic in situations where communications are marginal. The increased traffic reduces connection throughput further, possibly preventing the system from operating properly.

Network Medium Contention

When more than one device requires access to a single (serial) network medium, you must provide a mechanism to resolve the resulting network medium contention. For example, unsolicited reporting results in network medium contention if you do not design your serial network as a star topology of point-to-point connections or use carrier detection on a multidrop network.

To avoid collisions among devices trying to send messages, DNP3 includes a collision avoidance feature. Before sending a message, a DNP3 device listens for a carrier signal to verify that no other node is transmitting data. The device transmits if there is no carrier or waits for a random time before transmitting. However, if two nodes both detect a lack of carrier at the same instant, these two nodes could begin simultaneous transmission of data and cause a data collision. If your serial network allows for spontaneous data transmission including unsolicited event data transmissions, you also must use application confirmation to provide a retry mechanism for messages lost in data collisions.

DNP3 LAN/WAN Overview

The main process for carrying DNP3 over an Ethernet network (LAN/WAN) involves encapsulating the DNP3 data link layer data frames within the transport layer frames of the IP suite. This allows the IP stack to deliver the DNP3 data link layer frames to the destination in place of the original DNP3 physical layer.

The DNP User Group Technical Committee has recommended the following guidelines for carrying DNP3 over a network:

NOTE: Link layer confirmations are explicitly disabled for DNP3 LAN/WAN. The IP suite provides a reliable delivery mechanism, which is backed up at the application layer by confirmations when required.

- DNP3 shall use the IP suite to transport messages over a LAN/WAN
- Ethernet is the recommended physical link, though you can use others
- TCP must be used for WANs
- TCP is strongly recommended for LANs
- UDP can be used for highly reliable single-segment LANs
- UDP is necessary if broadcast messages are required
- The DNP3 protocol stack shall be retained in full
- Link layer confirmations shall be disabled

The technical committee has registered a standard port number, 20000, for DNP3 with the Internet Assigned Numbers Authority (IANA). This port is used for either TCP or UDP.

TCP/UDP Selection

The committee recommends the selection of TCP or UDP protocol as per the guidelines in *Table D.4*.

Table D.4 TCP/UDP Selection Guidelines

Use in the case of...	TCP	UDP
Most situations	X	
Non-broadcast or multicast	X	
Mesh Topology WAN	X	
Broadcast		X
Multicast		X
High-reliability single-segment LAN		X
Pay-per-byte, non-mesh WAN, for example, Cellular Digital Packet Data (CDPD)		X
Low priority data, for example, data monitor or configuration information		X

DNP3 in the SEL-710-5

The SEL-710-5 is a DNP3 Level 2 remote (outstation) device, without dual end point.

Data Access

Table D.5 lists DNP3 data access methods along with their corresponding SEL-710-5 settings. You must select a data access method and configure each DNP3 master for polling as specified.

NOTE: Because unsolicited messaging is problematic in most circumstances, SEL recommends using the polled report-by-exception access method to maximize performance and minimize risk of configuration problems.

NOTE: In the settings in Table D.5, the suffix n represents the DNP3 session number from 1 to 5. All settings with the same numerical suffix comprise the complete DNP3 session configuration.

Table D.5 Configuring DNP3 Access Methods

Access Method	Master Polling	SEL-710-5 Settings
Polled static	Class 0	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to 0; UNSOL*n* to No
Polled report-by-exception	Class 0 occasionally, Class 1, 2, 3 frequently	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; UNSOL*n* to No
Unsolicited report-by-exception	Class 0 occasionally, optional Class 1, 2, 3 less frequently; mainly relies on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* to Yes and PUNSOL*n* to Yes or No
Quiescent	Class 0, 1, 2, 3 never; relies completely on unsolicited messages	Set ECLASSB*n*, ECLASSC*n*, ECLASSA*n* to the desired event class; set UNSOL*n* and PUNSOL*n* to Yes.

The SEL-710-5 is an outstation device without dual end point. For a TCP connection, the relay sends out unsolicited messages only if a DNP3 master has already established a session and enabled unsolicited messaging for that session. However, for a Serial/Modem/UDP connection, the relay automatically dials out and sends unsolicited messages as defined by the settings.

In both the unsolicited report-by-exception and quiescent polling methods shown in *Table D.5*, you must make a selection for the PUNSOL*n* setting. This setting enables or disables unsolicited data reporting when the device is turned on. If your DNP3 master can send a message to enable unsolicited reporting on the SEL-710-5, set PUNSOL*n* to No.

While automatic unsolicited data transmission on power up is convenient, this can cause problems if your DNP3 master is not prepared to start receiving data immediately on power up. If the master does not acknowledge the unsolicited data with an Application Confirm, the device resends the data until it is acknowledged. On a large system, or in systems where the processing power of the master is limited, you can have problems when several devices simultaneously begin sending data and waiting for acknowledgment messages.

The SEL-710-5 allows you to set the conditions for transmitting unsolicited event data on a class-by-class basis. It also allows you to assign points to event classes on a point-by-point basis (see *DNP3 Documentation on page D.14*). You can prioritize data transmission with these event class features. For example, you might place high-priority points in event Class 1 and set it with low thresholds (NUMEVE*n* and AGEEVE*n* settings) so that changes to these points are sent to the master quickly. You can then place low priority data in event Class 2 with higher thresholds.

If the SEL-710-5 does not receive an Application Confirm in response to unsolicited data, it waits for ETIMEO*n* seconds and then repeats the unsolicited message. To prevent clogging of the network with unsolicited data retries, the SEL-710-5 uses the URETRY*n* and UTIMEO*n* settings to increase retry time when the number of retries set in URETRY*n* is exceeded. After URETRY*n* has been exceeded, the SEL-710-5 pauses UTIMEO*n* seconds and then transmits the unsolicited data again. *Figure D.1* provides an example with URETRY*n* = 2.

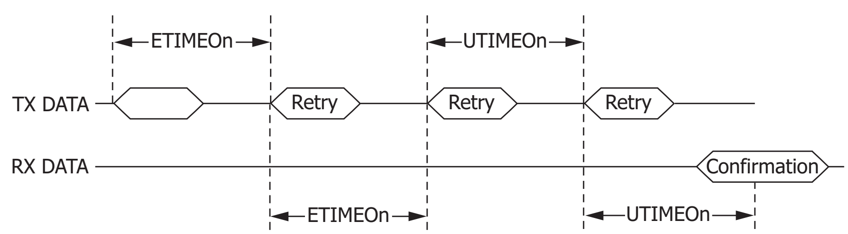

Figure D.1 Application Confirmation Timing With URETRY*n* = 2

Collision Avoidance

If your application uses unsolicited reporting on a serial network, you must select a half-duplex medium or a medium that includes carrier detection to avoid data collisions. EIA-485 two-wire networks are half-duplex. EIA-485 four-wire networks do not provide carrier detection, while EIA-232 systems can support carrier detection. DNP3 LAN/WAN uses features of the IP suite for collision avoidance, so does not require these settings.

The SEL-710-5 uses Application Confirmation messages to guarantee delivery of unsolicited event data before erasing the local event data buffer. Data collisions are typically resolved when messages are repeated until confirmed.

The SEL-710-5 pauses for a random delay between the settings MAXDLY and MINDLY when it detects a carrier through data on the receive line or the CTS pin. For example, if you use the settings of 0.10 seconds for MAXDLY and 0.05 seconds for MINDLY, the SEL-710-5 inserts a random delay of 50 to

100 ms between the end of carrier detection and the start of data transmission (see *Figure D.2*).

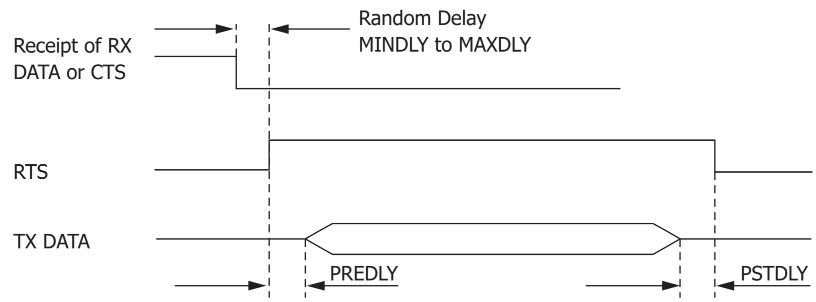

Figure D.2 Message Transmission Timing

Transmission Control

NOTE: PREDLY and POSTDLY settings are only available for EIA-232 and EIA-485 serial port sessions.

If you use a media transceiver (for example, EIA-232 to EIA-485) or a radio system for your DNP network, you may need to adjust data transmission properties. Use the PREDLY and POSTDLY settings to provide a delay between RTS signal control and data transmission (see *Figure D.2*). For example, an EIA-485 transceiver typically requires 10 to 20 ms to change from receive to transmit. If you set the pre-delay to 30 ms, you avoid data loss resulting from the data transmission beginning at the same time as the RTS signal assertion.

Event Data

DNP3 event data objects contain change-of-state and time-stamp information that the SEL-710-5 collects and stores in a buffer. Points assigned in the Binary Input Map that are also assigned in the Sequential Events Recorder (SER) settings carry the time stamp of actual occurrence. Binary input points not assigned in the SER settings carry a time stamp based on the DNP map scan time. This may be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. The DNP map is scanned approximately twice per second to generate events. You can configure the SEL-710-5 to either report the data without a polling request from the master (unsolicited data) or hold the data until the master requests it with an event poll message.

With the event class settings ECLASSB*n*, ECLASSC*n*, and ECLASSA*n*, you can set the event class for binary, counter, and analog inputs for Session *n*. You can use the classes as a simple priority system for collecting event data. The SEL-710-5 does not treat data of different classes differently with respect to message scanning, but it does allow the master to perform independent class polls.

NOTE: Most RTUs that act as substation DNP3 masters perform an event poll that collects event data of all classes simultaneously. You must confirm that the polling configuration of your master allows independent polling for each class before implementing separate classes in the SEL-710-5.

For event data collection you must also consider and enter appropriate settings for deadband and scaling operation on analog points shown in *Table D.7*. You can either:

- set and use default deadband and scaling according to data type, or
- use a custom data map to select deadbands on a point-by-point basis.

See *DNP3 Documentation on page D.14* for a discussion of how to set scaling and deadband operation on a point-by-point basis. You can modify deadbands for analog inputs at run-time by writing to Object 34.

The settings ANADBA*n*, ANADBV*n*, and ANADBM*n* control default dead-band operation for each type of analog data. Because DNP3 Objects 30 and 32 use integer data, you must use scaling to send digits after the decimal point and avoid rounding to a simple integer value.

With no scaling, the value of 12.632 would be sent as 12. With a scaling setting of 1, the value transmitted is 126. With a scaling setting of 3, the value transmitted is 12632. You must make certain that the maximum value does not exceed 32767 if you are polling the default 16-bit variations for Objects 30 and 32, but you can send some decimal values using this technique. You must also configure the master to perform the appropriate division on the incoming value to display it properly.

You can set the default analog value scaling with the DECPLA*n*, DECPLV*n*, and DECPLM*n* settings. Application of event reporting deadbands occurs after scaling. For example, if you set DECPLA*n* to 2 and ANADBA*n* to 10, a measured current of 10.14 Amps would be scaled to the value 1014 and would have to increase to more than 1024 or decrease to less than 1004 (a change in magnitude of ± 0.1 Amps) for the device to report a new event value.

The SEL-710-5 uses the NUMEVE*n* and AGEEVE*n* settings to decide when to send unsolicited data to the master. The device sends an unsolicited report when the total number of events accumulated in the event buffer for Master *n* reaches NUMEVE*n*. The device also sends an unsolicited report if the age of the oldest event in the master n buffer exceeds AGEEVE*n*. The SEL-710-5 has the buffer capacities listed in *Table D.6*.

Table D.6 SEL-710-5 Event Buffer Capacity

Type	Maximum Number of Events
Binary	1024
Analog	100
Counters	32

Binary Controls

The SEL-710-5 provides more than one way to control individual points. The SEL-710-5 maps incoming control points either to remote bits or to internal command bits that cause circuit breaker operations. *Table D.12* lists control points and control methods available in the SEL-710-5.

A DNP3 technical bulletin (*Control Relay Output Block Minimum Implementation 9701-002*) recommends that you use one point per Object 12, control block output device. You can use this method to perform Pulse On, Pulse Off, Latch On, and Latch Off operations on selected remote bits.

If your master does not support the single-point-per-index messages or single operation database points, you can use the trip/close operation or use the code field in the DNP3 message to specify operation of the points shown in *Control Point Operation on page D.24*.

Time Synchronization

The accuracy of DNP3 time synchronization is insufficient for most protection and oscillography needs. DNP3 time synchronization provides backup time synchronization in the event the device loses primary synchronization through the IRIG-B input. You can enable time synchronization with the TIMERQ*n* setting and then use Object 50, Variation 1, and Object 52, Variation 2, to set the time via the Session *n* DNP3 master (Object 50, Variation 3 for DNP3 LAN/WAN).

By default, the SEL-710-5 accepts and ignores time set requests (TIMERQ*n* = I for “ignore”). (This mode allows the SEL-710-5 to use a high accuracy, IRIG time source, but still interoperate with DNP3 masters that send time-synchronization messages.) You can set the SEL-710-5 to request time synchronization periodically by setting the TIMERQ*n* setting to the desired period. You can also set it to not request, but accept, time synchronization (TIMERQ*n* = M for "master").

The SEL-710-5 prioritizes its time-synchronization sources. These time sources fall under one of two categories: primary time sources and secondary time sources. IRIG-B (BNC and Serial), PTP, and SNTP are primary time sources. All other time sources such as DNP, IEC 60870-5-103, Modbus, and serial port time and date commands are secondary time sources.

If an IRIG-B BNC time source is available, the SEL-710-5 synchronizes its time with that time source regardless of what other time sources are available. If an IRIG-B BNC time source is not available and an IRIG-B Serial time source is, the SEL-710-5 synchronizes its time with that IRIG-B Serial time source even if other time sources are available. If an IRIG-B Serial time source is not available and PTP is, the SEL-710-5 synchronizes its time with that PTP time source even if other time sources are available. If IRIG-B (BNC and Serial) and PTP are not available, but SNTP is, the SEL-710-5 synchronizes its time with that SNTP time source even if other time sources are available. And finally, if IRIG-B (BNC and Serial), PTP, and SNTP are not available, the SEL-710-5 synchronizes with the remaining time sources that could be available. These include DNP, IEC 60870-5-103, Modbus, or serial port time and date commands. These four time sources take on the same priority. At any given time, the relay synchronizes with the one that most recently established synchronization with the relay. In summary, time-synchronization prioritization starts with IRIG-B BNC, followed by IRIG-B Serial, followed by PTP, followed by SNTP, followed by DNP, IEC 60870-5-103, Modbus, or serial port time and date commands.

Note that when IRIG-B BNC or IRIG-B Serial time sources are available, any remaining time source that could be available can only be used to update the year.

Modem Support

The SEL-710-5 DNP implementation includes modem support for serial ports. Your DNP3 master can dial-in to the SEL-710-5 and establish a DNP3 connection. The SEL-710-5 can automatically dial out and deliver unsolicited DNP3 event data.

When the device dials out, it waits for the "CONNECT" message from the local modem and for assertion of the device CTS line before continuing the DNP transaction. This requires a connection from the modem DCD to the device CTS line.

NOTE: Contact SEL for information on serial cable configurations and requirements for connecting your SEL-710-5 to other devices.

NOTE: To enable hardware handshaking, set the modem settings to Y if you are using a Null modem cable for DOP protocol implementation.

You can either connect the modem to a computer and configure it before connecting it to the SEL-710-5, or program the appropriate modem setup string in the modem startup string setting MSTR. Use the PH_NUM1 and (optional) PH_NUM2 settings to set the phone numbers that you want the SEL-710-5 to call. The SEL-710-5 automatically sends the ATDT modem dial command and then the contents of the PH_NUM1 setting when dialing the modem. If PH_NUM2 is set, use the RETRY1 setting to configure the number of times the SEL-710-5 tries to dial PH_NUM1 before dialing PH_NUM2. Similarly, the RETRY2 setting is the number of attempts the SEL-710-5 tries to dial PH_NUM2 before trying PH_NUM1. MDTIME sets the length of time from initiating the call to declaring it failed because of no connection, and MDRET sets the time between dial-out attempts.

NOTE: RTS/CTS hardware flow control is not available for a DNP3 modem connection. You must use either X-ON/X-OFF software flow control or set the port data speed slower than the effective data rate of the modem.

The settings PH_NUM1 and PH_NUM2 must conform to the AT modem command set dialing string standard, including:

- ➤ A comma (,) inserts a four second pause
- ➤ If necessary, use a 9 to reach an outside line
- ➤ Include a 1 and the area code if the number requires long distance access
- ➤ Add any special codes your telephone service provider designates to block call waiting and other telephone line features.

DNP3 Settings

The DNP3 port configuration settings available on the SEL-710-5 are shown in *Table D.7*. You can enable DNP3 on Ethernet Port 1 or on any of the serial Ports 2 through 4, to a maximum of five concurrent DNP3 sessions. Each session defines the characteristics of the connected DNP3 Master, to which you assign one of the three available custom maps. Some settings only apply to DNP3 LAN/WAN, and are visible only when configuring the Ethernet port. For example, you only have the ability to define multiple sessions on Port 1, the Ethernet port. Likewise, settings applicable to serial DNP3 are visible only when configuring a serial port.

Table D.7 Port DNP3 Protocol Settings (Sheet 1 of 3)

Name	Description	Range	Default
EDNP[a]	Enable DNP3 Sessions	0–5	0
DNPNUM[a]	DNP3 TCP and UDP Port	1–65534	20000
DNPADR	Device DNP3 address	0–65519	0
Session 1 Settings			
DNPIP1[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR1[a]	Transport protocol	UDP, TCP	TCP
DNPUDP1[a]	UDP response port	REQ, 1–65534	20000
REPADR1	DNP3 address of the Master to send messages to	0–65519	1
DNPMAP1	DNP3 Session Custom Map	1–3	1
DVARAI1	Analog Input Default Variation	1–6	4
ECLASSB1	Class for binary event data, 0 disables	0–3	1
ECLASSC1	Class for counter event data, 0 disables	0–3	0
ECLASSA1	Class for analog event data, 0 disables	0–3	2
DECPLA1	Decimal places scaling for Current data	0–3	1
DECPLV1	Decimal places scaling for Voltage data	0–3	1
DECPLM1	Decimal places scaling for Miscellaneous data	0–3	1
ANADBA1	Analog reporting deadband for current; hidden if ECLASSA1 set to 0	0–32767	100
ANADBV1	Analog reporting deadband for voltages; hidden if ECLASSA1 set to 0	0–32767	100
ANADBM1	Analog reporting deadband for miscellaneous analogs; hidden if ECLASSA and ECLASSC set to 0	0–32767	100
TIMERQ1	Time-set request interval, minutes (M = Disables time sync requests, but still accepts and applies time syncs from Master; I = Ignores (does not apply) time syncs from Master)	I, M, 1–32767	I
STIMEO1	Select/operate time-out, seconds	0.0–30.0	1.0

Table D.7 Port DNP3 Protocol Settings (Sheet 2 of 3)

Name	Description	Range	Default
DNPINA1[a,c]	Send Data Link Heartbeat, seconds; hidden if DNPTR1 set to UDP	0.0–7200	120
DRETRY1[d]	Data link retries	0–15	3
DTIMEO1[d]	Data link time-out, seconds; hidden if DRETRY1 set to 0	0.0–5.0	1
ETIMEO1	Event message confirm time-out, seconds	1–50	5
UNSOL1	Enable unsolicited reporting; hidden and set to N if ECLASSB1, ECLASSC1, and ECLASSA1 set to 0	Y, N	N
PUNSOL1	Enable unsolicited reporting at turn on; hidden and set to N if UNSOL1 set to N	Y, N	N
NUMEVE1[e]	Number of events to transmit on	1–200	10
AGEEVE1[e]	Oldest event to transmit on, seconds	0.0–99999.0	2.0
URETRY1[e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO1[e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 2 Settings			
DNPIP2[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR2[a]	Transport protocol	UDP, TCP	TCP
• • •			
URETRY2[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO2[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 3 Settings			
DNPIP3[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR3[a]	Transport protocol	UDP, TCP	TCP
• • •			
URETRY3[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO3[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 4 Settings			
DNPIP4[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR4[a]	Transport protocol	UDP, TCP	TCP
• • •			
URETRY4[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO4[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60
Session 5 Settings			
DNPIP5[a,b]	DNP3 Master IP address (zzz.yyy.xxx.www)	15 characters	“”
DNPTR5[a]	Transport protocol	UDP, TCP	TCP
• • •			
URETRY5[a,e]	Unsolicited messages maximum retry attempts	2–10	3
UTIMEO5[a,e]	Unsolicited messages offline time-out, seconds	1–5000	60

Table D.7 Port DNP3 Protocol Settings (Sheet 3 of 3)

Name	Description	Range	Default
Serial Port Settings			
MINDLY[d]	Minimum delay from DCD to TX, seconds	0.00–1.00	0.05
MAXDLY[d]	Maximum delay from DCD to TX, seconds	0.00–1.00	0.10
PREDLY[d]	Settle time from RTS on to TX; Off disables PSTDLY	OFF, 0.00–30.00	0.00
PSTDLY[d]	Settle time from TX to RTS off; hidden if PREDLY set to Off	0.00–30.00	0.00

[a] Available only on Ethernet ports.
[b] Set DNPIP*n* = 0.0.0.0 to accept connections from any DNP master.
[c] DNPINA*n* allows the user to set the wait time to detect a bad TCP connection. The relay closes the unused TCP connection after the DNPINA*n* response timeout. It is recommended you set this value to less than 20 seconds. Disabling DNPINA*n* violates the DNP3 standard and should only be done for testing.
[d] Available only on serial ports.
[e] Hidden if UNSOLn set to N.

The modem settings in *Table D.8* are available only for DNP3 serial port sessions.

Table D.8 Serial Port DNP3 Modem Settings

Name	Description	Range	Default
MODEM	Modem connected to port; all following settings are hidden if MODEM set to N	Y, N	N
MSTR	Modem startup string	As many as 30 characters	“E0X0& D0S0 = 4”
PH_NUM1	Primary phone number for dial-out	As many as 30 characters	“”
PH_NUM2	Secondary phone number for dial-out	As many as 30 characters	“”
RETRY1	Retry attempts for primary dial-out; hidden and unused if PH_NUM2 set to “”	1–20	5
RETRY2	Retry attempts for secondary dial-out; hidden and unused if PH_NUM2 set to “”	1–20	5
MDTIME	Time from initiating call to failure because of no connection, seconds	5–300	60
MDRET	Time between dial-out attempts	5–3600	120

DNP3 Documentation

Object List

Table D.9 lists the objects and variations with supported function codes and qualifier codes available in the SEL-710-5. The list of supported objects conforms to the format laid out in the DNP specifications and includes both supported and unsupported objects for DNP3 implementation Level 2 and higher and non-supported objects for DNP3 implementation Level 2 only. Those that are supported include the function and qualifier codes. The objects that are not supported are shown without any corresponding function and qualifier codes.

Table D.9 SEL-710-5 DNP3 Object List (Sheet 1 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	211	Device Attributes—User-specific sets of attributes	1	0	129	0,17
0	212	Device Attributes—Master data set prototypes	1	0	129	0,17
0	213	Device Attributes—Outstation data set prototypes	1	0	129	0,17
0	214	Device Attributes—Master data sets	1	0	129	0,17
0	215	Device Attributes—Outstation data sets	1	0	129	0,17
0	216	Device Attributes—Max binary outputs per request	1	0	129	0,17
0	219	Device Attributes—Support for analog output events	1	0	129	0,17
0	220	Device Attributes—Max analog output index	1	0	129	0,17
0	221	Device Attributes—Number of analog outputs	1	0	129	0,17
0	222	Device Attributes—Support for binary output events	1	0	129	0,17
0	223	Device Attributes—Max binary output index	1	0	129	0,17
0	224	Device Attributes—Number of binary outputs	1	0	129	0,17
0	225	Device Attributes—Support for frozen counter events	1	0	129	0,17
0	226	Device Attributes—Support for frozen counters	1	0	129	0,17
0	227	Device Attributes—Support for counter events	1	0	129	0,17
0	228	Device Attributes—Max counter index	1	0	129	0,17
0	229	Device Attributes—Number of counters	1	0	129	0,17
0	230	Device Attributes—Support for frozen analog inputs	1	0	129	0,17
0	231	Device Attributes—Support for analog input events	1	0	129	0,17
0	232	Device Attributes—Max analog input index	1	0	129	0,17
0	233	Device Attributes—Number of analog inputs	1	0	129	0,17
0	234	Device Attributes—Support for double-bit events	1	0	129	0,17
0	235	Device Attributes—Max double-bit binary index	1	0	129	0,17
0	236	Device Attributes—Number of double-bit binaries	1	0	129	0,17
0	237	Device Attributes—Support for binary input events	1	0	129	0,17
0	238	Device Attributes—Max binary input index	1	0	129	0,17
0	239	Device Attributes—Number of binary inputs	1	0	129	0,17
0	240	Device Attributes—Max transmit fragment size	1	0	129	0,17

Table D.9 SEL-710-5 DNP3 Object List (Sheet 2 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
0	241	Device Attributes—Max receive fragment size	1	0	129	0,17
0	242	Device Attributes—Device manufacturer’s software version	1	0	129	0,17
0	243	Device Attributes—Device manufacturer’s hardware version	1	0	129	0,17
0	245	Device Attributes—User-assigned location name	1	0	129	0,17
0	246	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	247	Device Attributes—User assigned ID code/number	1	0	129	0,17
0	248	Device Attributes—Device serial number	1	0	129	0,17
0	249	Device Attributes—DNP subset and conformance	1	0	129	0,17
0	250	Device Attributes—Device manufacturer’s product name and model	1	0	129	0,17
0	252	Device Attributes—Device manufacturer’s name	1	0	129	0,17
0	254	Device Attributes—Non-specific all attributes request	1	0	129	0,17
0	255	Device Attributes—List of attribute variations	1	0	129	0,17
1	0	Binary Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
1	1	Binary Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
1	2[e]	Binary Input With Status	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
2	0	Binary Input Change—All Variations	1	6, 7, 8		
2	1	Binary Input Change Without Time	1	6, 7, 8	129	17, 28
2	2[e]	Binary Input Change With Time	1	6, 7, 8	129, 130	17, 28
2	3	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output—All Variations	1	0, 1, 6, 7, 8		
10	1	Binary Output				
10	2[e]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	0	Control Block—All Variations				
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
12	2	Pattern Control Block	3, 4, 5, 6	7	129	echo of request
12	3	Pattern Mask	3, 4, 5, 6	0, 1	129	echo of request
20	0	Binary Counter—All Variations	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28		
20	1	32-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	2	16-Bit Binary Counter	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	3	32-Bit Delta Counter				
20	4	16-Bit Delta Counter				
20	5	32-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	6[e]	16-Bit Binary Counter Without Flag	1, 7, 8, 9, 10	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	7	32-Bit Delta Counter Without Flag				
20	8	16-Bit Delta Counter Without Flag				
21	0	Frozen Counter—All Variations				

Table D.9 SEL-710-5 DNP3 Object List (Sheet 3 of 6)

Obj.	Var.	Description	Request[a] Funct. Codes[c]	Request[a] Qual. Codes[d]	Response[b] Funct. Codes[c]	Response[b] Qual. Codes[d]
21	1	32-Bit Frozen Counter				
21	2	16-Bit Frozen Counter				
21	3	32-Bit Frozen Delta Counter				
21	4	16-Bit Frozen Delta Counter				
21	5	32-Bit Frozen Counter With Time of Freeze				
21	6	16-Bit Frozen Counter With Time of Freeze				
21	7	32-Bit Frozen Delta Counter With Time of Freeze				
21	8	16-Bit Frozen Delta Counter With Time of Freeze				
21	9	32-Bit Frozen Counter Without Flag				
21	10	16-Bit Frozen Counter Without Flag				
21	11	32-Bit Frozen Delta Counter Without Flag				
21	12	16-Bit Frozen Delta Counter Without Flag				
22	0	Counter Change Event—All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2[e]	16-Bit Counter Change Event Without Time	1	6, 7, 8	129, 130	17, 28
22	3	32-Bit Delta Counter Change Event Without Time				
22	4	16-Bit Delta Counter Change Event Without Time				
22	5	32-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
22	7	32-Bit Delta Counter Change Event With Time				
22	8	16-Bit Delta Counter Change Event With Time				
23	0	Frozen Counter Event—All Variations				
23	1	32-Bit Frozen Counter Event Without Time				
23	2	16-Bit Frozen Counter Event Without Time				
23	3	32-Bit Frozen Delta Counter Event Without Time				
23	4	16-Bit Frozen Delta Counter Event Without Time				
23	5	32-Bit Frozen Counter Event With Time				
23	6	16-Bit Frozen Counter Event With Time				
23	7	32-Bit Delta Counter Change Event With Time				
23	8	16-Bit Delta Counter Change Event With Time				
30[f]	0	Analog Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
30[f]	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	4	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30[f]	5	Short Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	6	Long Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28

Table D.9 SEL-710-5 DNP3 Object List (Sheet 4 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
31	0	Frozen Analog Input—All Variations				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input With Time of Freeze				
31	4	16-Bit Frozen Analog Input With Time of Freeze				
31	5	32-Bit Frozen Analog Input Without Flag				
31	6	16-Bit Frozen Analog Input Without Flag				
31	7	Short Floating Point Frozen Analog Input				
31	8	Long Floating Point Frozen Analog Input				
32	0	Analog Change Event—All Variations	1	6, 7, 8		
32[f]	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32[f]	2	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32[f]	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	5	Short Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	6	Long Floating Point Analog Change Event	1	6, 7, 8	129	17, 28
32[f]	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
32[f]	8	Long Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
33	0	Frozen Analog Event—All Variations				
33	1	32-Bit Frozen Analog Event Without Time				
33	2	16-Bit Frozen Analog Event Without Time				
33	3	32-Bit Frozen Analog Event With Time				
33	4	16-Bit Frozen Analog Event With Time				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Short Floating Point Frozen Analog Event With Time				
33	8	Long Floating Point Frozen Analog Event With Time				
34	0	Analog Deadband—All Variations				
34	1[e]	16-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	3	Floating Point Analog Input Reporting Deadband Object	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8	129	
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	2[e]	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	3	Short Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28
40	4	Long Floating Point Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1, 17, 28

Table D.9 SEL-710-5 DNP3 Object List (Sheet 5 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
41	0	Analog Output Block—All Variations				
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	2[e]	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
41	3	Short Floating Point Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	0	Time and Date—All Variations				
50	1	Time and Date	1, 2	7, 8 index=0	129	07, quantity=1
50	2	Time and Date With Interval				
50	3	Time and Date Last Recorded	2	7 quantity = 1	129	
51	0	Time and Date CTO—All Variations				
51	1	Time and Date CTO				
51	2	Unsynchronized Time and Date CTO			129	07, quantity=1
52	0	Time Delay—All Variations				
52	1	Time Delay, Coarse				
52	2	Time Delay, Fine			129	7, quantity=1
60	0	All Classes of Data	1, 20, 21	6, 7, 8		
60	1	Class 0 Data	1, 20, 21	6, 7, 8		
60	2	Class 1 Data	1	6, 7, 8		
60	3	Class 2 Data	1, 20, 21	6, 7, 8		
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
70	1	File Identifier				
70	2	Authentication Object				
70	3	File Command Object				
70	4	File Command Status Object				
70	5	File Transport Object				
70	6	File Transport Status Object				
70	7	File Descriptor Object				
80	1	Internal Indications	2	0, 1 index=7		
81	1	Storage Object				
82	1	Device Profile				
83	1	Private Registration Object				
83	2	Private Registration Object Descriptor				
90	1	Application Identifier				
100	1	Short Floating Point				
100	2	Long Floating Point				
100	3	Extended Floating Point				
101	1	Small Packed Binary-Coded Decimal				
101	2	Medium Packed Binary-Coded Decimal				

Table D.9 SEL-710-5 DNP3 Object List (Sheet 6 of 6)

Obj.	Var.	Description	Request[a]		Response[b]	
			Funct. Codes[c]	Qual. Codes[d]	Funct. Codes[c]	Qual. Codes[d]
101	3	Large Packed Binary-Coded Decimal				
110	all	Octet String				
111	all	Octet String Event				
112	All	Virtual Terminal Output Block				
113	All	Virtual Terminal Event Data				
N/A		No object required for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

[a] Supported in requests from master.
[b] May generate in response to master.
[c] Decimal.
[d] Hexadecimal.
[e] Default variation.
[f] Default variation specified by serial port setting DVARAI (or DVARAIn for Ethernet session n [n = 1, 2, 3, 4, or 5]).

Device Profile

The DNP3 Device Profile document, available on the supplied CD or as a download from the SEL website, contains the standard device profile information for the SEL-710-5. This information is also available in XML format. Please refer to this document for complete information on DNP3 Protocol support in the SEL-710-5.

Reference Data Map

Table D.10 shows the SEL-710-5 reference data map. The reference map shows the data available to a DNP3 master. You can use the default map or the custom DNP3 mapping functions of the SEL-710-5 to retrieve only the points required by your application.

NOTE: Deadband changes via Object 34 are not stored in nonvolatile memory. Make sure to reissue the Object 34 deadbands after a warm (**STA C**) or cold start (power cycle).

The SEL-710-5 scales analog values by the indicated settings or fixed scaling indicated in the description. Analog deadbands for event reporting use the indicated settings, or ANADBM if you have not specified a setting.

NOTE: Although the reference maps do not include Relay Word bit labels, you can use these labels in creating custom maps.

Table D.10 DNP3 Reference Data Map (Sheet 1 of 3)

Object	Labels	Description
Binary Inputs		
01, 02	STFAIL	Relay Diagnostic Failure (HALARM is latched)
	STWARN	Relay Diagnostic Warning (HALARM is pulsed)
	STSET	Relay Settings Change Or Restart
	Enabled–T06_LED[a]	Relay Word Elements Target Row 0 (see *Table L.1*)
	49T–SC850BM[a]	Relay Word Elements (see *Table L.1*)
	PFL	Power Factor Leading for Three-Phase Currents
	0	Logical 0
	1	Logical 1

Table D.10 DNP3 Reference Data Map (Sheet 2 of 3)

Object	Labels	Description
Binary Outputs		
10, 12	RB01–RB32	Remote bits RB01–RB32
	RB01:RB02 RB03:RB04 RB05:RB06 … RB29:RB30 RB31:RB32	Remote bit pairs RB01–RB32
	STOP	Stop motor command, pulse to stop the motor
	STR	Start motor command, pulse to start the motor
	STOP:STR	Stop/start motor pair
	89OC2P1–89OC2P8	Pulse Open Two-position Disconnects 1–8 command
	89CC2P1–89CC2P8	Pulse Close Two-position Disconnects 1–8 command
	89OC2P1:89CC2P1 89OC2P2:89CC2P2 … 89OC2P8:89CC2P8	Open/Close pair for Two-position Disconnects 1–8
	89OC3PL1	Pulse Open Three-position In-line Disconnect 1 command
	89CC3PL1	Pulse Close Three-position In-line Disconnect 1 command
	89OC3PL1:89CC3PL1	Open/Close pair for Three-position In-line Disconnect 1
	89OC3PL2	Pulse Open Three-position In-line Disconnect 2 command
	89CC3PL2	Pulse Close Three-position In-line Disconnect 2 command
	89OC3PL2:89CC3PL2	Open/Close pair for Three-position In-line Disconnect 2
	89OC3PE1	Pulse Open Three-position Earthing Disconnect 1 command
	89CC3PE1	Pulse Close Three-position Earthing Disconnect 1 command
	89OC3PE1:89CC3PE1	Open/Close pair for Three-position Earthing Disconnect 1
	89OC3PE2	Pulse Open Three-position Earthing Disconnect 2 command
	89CC3PE2	Pulse Close Three-position Earthing Disconnect 2 command
	89OC3PE2:89CC3PE2	Open/Close pair for Three-position Earthing Disconnect 2
Counters		
20, 22	SC*xx*	SELOGIC Counter Values (*xx* = 01–32)
	GROUP	Active Settings Group

NOTE: When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the STOP and STR, 89CC2P*m* and 89OC2P*m* (m = 1–8), and 89CC3P*nm* and 89OC3P*nm* (m = 1–2, n = L or E) bits. To set the aforementioned binaries, ensure that the relay is in remote control mode (i.e., LOCAL = 0. The Relay Word bit LOCAL is dertermined by the LOCAL SELOGIC control equation (see *Table 9.6*).

Table D.10 DNP3 Reference Data Map (Sheet 3 of 3)

Object	Labels	Description
Analog Inputs		
30, 32, 34	IA_MAG–RA128[b, c]	Analog Quantities from *Appendix M* with an "x" in the DNP3 column
	SER_NUM	Serial Number
	0	Numeric 0
	1	Numeric 1
Analog Outputs		
40, 41	RAxxx	Remote Analogs (RA001 to RA128)
	GROUP	Active Settings Group
	NOOP	No operation, no error

[a] Valid Relay Word bits depend on the relay model.
[b] Valid analog inputs depend on the relay model.
[c] Refer to *Default Analog Inputs* for default analog input scaling and deadbands.

NOTE: All fault information analog inputs contain data from the latest captured event (see Appendix M: Analog Quantities).

Default Data Map

The default data map is an automatically generated subset of the reference map. All data maps are initialized to the default values, based on the SEL-710-5 part number. *Table D.11* shows the SEL-710-5 default data map. If the default maps are not appropriate, you can also use the custom DNP mapping commands **SET DNP** and **SHOW DNP** to create the map required for your application.

Table D.11 DNP3 Default Data Map (Sheet 1 of 2)

Object	Default Index	Point Label
01, 02	0	ENABLED
	1	TRIP_LED
	2	TLED_01
	3	TLED_02
	4	TLED_03
	5	TLED_04
	6	TLED_05
	7	TLED_06
	8	STFAIL
	9	STSET
	10	IN101
	11	IN102
	12–99	A portion of these binary inputs can have default values as described in *Default Binary Inputs on page D.22*. Outside that scope, they contain the value NA.
10, 12	0–31	RB01–RB32 Remote Bits
20, 22	0–31	NA
30, 32, 34	0	IA_MAG
	1	IB_MAG
	2	IC_MAG
	3	IG_MAG
	4	IN_MAG
	5	IAV
	6	3I2
	7	FREQ

Table D.11 DNP3 Default Data Map (Sheet 2 of 2)

Object	Default Index	Point Label
	8	VAB_MAG
	9	VBC_MAG
	10	VCA_MAG
	11	VAVE
	12	3V2
	13	P
	14	Q
	15	S
	16	PF
	17–99	A portion of these analog inputs can have default values as described in *Default Analog Inputs on page D.22*. Outside that scope, they contain the value NA.
40, 41	0–31	NA

Default Binary Inputs

The SEL-710-5 dynamically creates the default binary input map after you issue an **R_S** command. The SEL-710-5 uses the part number to determine the presence of digital input cards in Slots 3, 4, and 5. If present, each digital input point label, IN*x*0*y* (where *x* is the slot number and *y* is the point), is added to the default map in numerical order.

Default Analog Inputs

NOTE: Deadband changes via Object 34 are stored in nonvolatile memory. Make sure to reissue the Object 34 deadbands after a warm (STA C) or cold start (power cycle).

The SEL-710-5 dynamically creates the default analog input map after you issue an **R_S** command. The SEL-710-5 uses the part number to determine the presence of analog input cards in Slots 3, 4, and 5. If present, each analog input point label, AI*x*0*y* (where *x* is the slot and *y* is the point number), is added to the default map in numerical order.

Device Attributes (Object 0)

Table D.9 includes the supported Object 0 device attributes and variations. In response to Object 0 requests, the SEL-710-5 sends attributes that apply to that particular DNP3 session. Because the SEL-710-5 supports custom DNP3 maps, these values are likely to be different for each session. The SEL-710-5 uses its internal settings for the following variations:

- Variation 242—FID string
- Variation 243—Part Number
- Variation 245—TID setting
- Variation 246—RID setting
- Variation 247—RID setting
- Variation 248—Serial Number

Variation 249 shall contain the DNP subset and conformance, “2:2009”. Variation 250 shall contain the product model, “SEL-710-5” and Variation 252 shall contain “SEL.”

Binary Inputs

Binary inputs (Objects 1 and 2) are supported as defined by *Table D.11*. The default variation for both static and event inputs is 2. Only the Read function code (1) is allowed with these objects. All variations are supported. Object 2, variation 3 will be responded to, but will contain no data.

Binary inputs are scanned approximately twice per second to generate events. When time is reported with these event objects, it is the time at which the scanner observed the bit change. This can be significantly delayed from when the original source changed and should not be used for sequence-of-events determination. Binary inputs registered with SER are derived from the SER and carry the time stamp of actual occurrence. Some additional binary inputs are available only to communication protocols such as DNP and EtherNet/IP. For example, STWARN and STFAIL are derived from the diagnostic task data. Another binary input, STSET, is derived from the SER and carries the time stamp of actual occurrence. Static reads of this input will always show 0.

Binary Outputs

Binary output status (Object 10, Variation 2) is supported. Static reads of points RB01–RB32, STOP/START, 89OC2P*m*/89CC2P*m* (m = 1–8), or 89OC3P*nm*/89CC3P*nm* (n = L or E, m = 1 or 2) respond with the on-line bit set and the state of the requested bit. Reads from control-only binary output points respond with the online bit set and a state of 0.

The SEL-710-5 supports Control Relay Output Block objects (Object 12,Variation 1). The control relays correspond to the remote bits and other functions as shown previously. Each DNP Control message contains a Trip/Close code (TRIP, CLOSE, or NUL) and an Operation type (PULSE ON, LATCH ON, LATCH OFF, or NUL). The Trip/Close code works with the Operation Type to produce set, clear, and pulse operations.

Control operations differ slightly for single-point controls compared to paired outputs. Paired outputs correspond to the complementary two-output model, and single-point controls follow the complementary latch or activation model. In the complementary two-output model, paired points only support Trip or Close operations, which, when issued, Pulse On the first or second point in the pair, respectively. An operation in progress can be canceled by issuing a NUL Trip/Close Code with a NUL Operation Type. Single output points support both Pulse and Latch operations. See *Control Point Operation on page D.24* for details on control operations.

The Status field is used exactly as defined. All other fields are ignored. A pulse operation is asserted for a single processing interval. Exercise caution if sending multiple remote bit pulses in a single message (i.e., point count > 1), because this can result in some of the pulse commands being ignored and the return of an already active status message. The SEL-710-5 only honors the first 10 points in an Object 12, Variation 1 request. Any additional points in the request returns the DNP3 status code TOO_MANY_OBJS.

The SEL-710-5 also supports Pattern Control Blocks (Object 12, Variations 2 and 3) to control multiple binary output points. Variation 2 defines the control type (Trip/Close, Set/Clear, or Pulse) and the range of points to operate. Variation 3 provides a pattern mask that indicates which points in that range should be operated. Object 12, Variations 2 and 3 define the entire control command: the DNP3 master must send both for a successful control. For example, the DNP3 master sends an Object 12, Variation 2 message to request a Trip of the range of indices 0–7. The DNP3 master then sends an Object 12, Variation 3 message with a hexadecimal value of “BB” as the pattern mask (converted to binary notation: 10111011). Read right to left in increasing bit order, the Pattern Block Control command results in a TRIP of indexes 0, 1, 3 to 5, and 7. Multiple binary output point control operations are not guaranteed to occur during the same processing interval.

Control Point Operation

Use the Trip and Close, Latch On/Off and Pulse On operations with Object 12 control relay output block command messages to operate the points shown in *Table D.12*. Pulse operations provide a pulse with duration of one protection processing interval. When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises STOP and STR, 89CC2P*m* and 89OC2P*m* (m = 1–8), and 89CC3P*nm* and 89OC3P*nm* (n = L or E, m = 1 or 2) bits. If the LOCAL bit is asserted (LOCAL = 1), the relay does not set the aforementioned bits. The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

Table D.12 SEL-710-5 Object 12 Control Operations (Sheet 1 of 2)

Label	Close/Pulse On	Trip/Pulse On	Nul/Latch On	Nul/Latch Off	Nul/Pulse On
RB01–RB32	Pulse Remote Bit RB01–RB32	Pulse Remote Bit RB01–RB32	Set Remote Bit RB01–RB32	Clear Remote Bit RB01–RB32	Pulse Remote Bit RB01–RB32
RB*xx*:RB*yy*	Pulse RB*yy* RB01–RB32	Pulse RB*xx* RB01–RB32	Pulse RB*yy* RB01–RB32	Pulse RB*xx* RB01–RB32	Pulse RB*yy* RB01–RB32
STOP	Stop Motor (Pulse STOP)	Stop Motor (Pulse STOP)	Stop Motor (Pulse STOP)	No action	Stop Motor (Pulse STOP)
STR	Start Motor (Pulse STR)	Start Motor (Pulse STR)	Start Motor (Pulse STR)	No action	Start Motor (Pulse STR)
STOP:STR	Start Motor (Pulse STR)	Stop Motor (Pulse STOP)	Start Motor (Pulse STR)	Stop Motor (Pulse STOP)	Start Motor (Pulse STR)
89OC2P1-89OC2P8	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	No Action	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)
89CC2P1-89CC2P8	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	No Action	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)
89OC2Pm: 89CC2Pm	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)	Open 2-Position Disconnect (Pulse 89OC2P1–89OC2P8)	Close 2-Position Disconnect (Pulse 89CC2P1–89CC2P8)
89OC3PL1	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	No Action	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)
89CC3PL1	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	No Action	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)
89OC3PL1: 89CC3PL1	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL1)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL1)
89OC3PL2	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	No Action	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)
89CC3PL2	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	No Action	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)

Table D.12 SEL-710-5 Object 12 Control Operations (Sheet 2 of 2)

Label	Close/Pulse On	Trip/Pulse On	Nul/Latch On	Nul/Latch Off	Nul/Pulse On
89OC3PL2: 89CC3PL2	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)	Open 3-Position In-Line Disconnect (Pulse 89OC3PL2)	Close 3-Position In-Line Disconnect (Pulse 89CC3PL2)
89OC3PE1	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	No Action	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)
89CC3PE1	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	No Action	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)
89OC3PE1: 89CC3PE1	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE1)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE1)
89OC3PE2	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	No Action	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)
89CC3PE2	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	No Action	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)
89OC3PE2: 89CC3PE2	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)	Open 3-Position Earthing Disconnect (Pulse 89OC3PE2)	Close 3-Position Earthing Disconnect (Pulse 89CC3PE2)

Analog Inputs

Analog Inputs (30) and Analog Change Events (32) are supported as defined in *Table D.9* and *Table D.10*. The DVARAI1 (DVARAI*n* for DNP3 LAN/WAN Session *n*) setting defines the default variation for both static and event inputs. Only the Read function code (1) is allowed with these objects.

NOTE: Deadband changes via Object 34 are not stored in nonvolatile memory. Be sure to reissue the Object 34 deadband changes you want to retain after changing DNP port settings, issuing a **STA C** command, or cold-starting the relay (power-cycle).

Unless otherwise indicated, analog values are reported in primary units. See *Appendix M: Analog Quantities* for a list of all available analog inputs.

For all currents, the default scaling is the DECPLA setting on magnitudes and scale factor of 100 on angles. The default deadband for currents is ANADBV on magnitudes and ANADBM on angles. For all voltages, the default scaling is the DECPLV setting on magnitudes and scale factor of 100 on angles. The default deadband for voltages is ANADBV on magnitudes and ANADBM on angles. For all powers and energies, the default scaling is the DECPLM setting and default deadband is ANADBM. For all other quantities, the default scaling is 1 and default deadband is ANADBM.

Default scaling and deadbands can be overridden by per-point scaling and deadband. See *Configurable Data Mapping on page D.26* for more information. deadbands for analog inputs can also be modified by writing to Object 34.

A deadband check is done after any scaling has been applied. Event class messages are generated whenever an input changes beyond the value given by the appropriate deadband setting. The voltage and current phase angles only generate an event if, in addition to their deadband check, the corresponding magnitude changes beyond its own deadband. Analog inputs are scanned at approximately twice a second. All events generated during a scan use the time the scan was initiated.

Configurable Data Mapping

One of the most powerful features of the SEL-710-5 implementation is the ability to remap DNP3 data and, for analog values, specify per-point scaling and deadbands. Remapping is the process of selecting data from the reference map and organizing it into a data subset optimized for your application. The SEL-710-5 uses object and point labels, rather than point indices, to streamline the remapping process. This enables you to quickly create a custom map without having to search for each point index in a large reference map.

You can use any of the three available DNP3 maps simultaneously with as many as five unique DNP3 masters. Each map is initially populated with default data points, as described in *Default Data Map on page D.21*. You can remap the points in a default map to create a custom map with as many as:

- ➤ 100 Binary Inputs
- ➤ 32 Binary Outputs
- ➤ 100 Analog Inputs
- ➤ 32 Analog Outputs
- ➤ 32 Counters

You can use the **SHOW DNP *x* <Enter>** command to view the DNP data map settings, where *x* is the DNP3 map number from 1 to 3. See *Figure D.3* for an example display of Map 1.

```
=>>SHO DNP 1 <Enter>

DNP Map 1 Settings

Binary Input Map
BI_00    := ENABLED
BI_01    := T01_LED
BI_02    := T02_LED
BI_03    := T03_LED
…
BI_97    := IN101
BI_98    := IN102
BI_99    := 52A

Binary Output Map
BO_00    := RB01
BO_01    := RB02
BO_02    := RB03
…
BO_29    := RB30
BO_30    := RB31
BO_31    := RB32


Analog Input Map
AI_00    := IA_MAG
AI_01    := IB_MAG
AI_02    := IC_MAG
…
AI_95    := FREQ
AI_96    := P
AI_97    := Q
AI_98    := S
AI_99    := PF
```

Figure D.3 Sample Response to SHO DNP Command

```
Analog Output Map
AO_00    := GROUP
AO_01    := RA001
AO_02    := RA002
…
AO_29    := RA029
AO_30    := RA030
AO_31    := RA031

Counter Map
CO_00    := SC01
CO_01    := SC02
CO_02    := SC03
…
CO_29    := SC30
CO_30    := SC31
CO_31    := SC32

=>>
```

Figure D.3 Sample Response to SHO DNP Command (Continued)

You can also use the **MAP DNP *y s* <Enter>** command to display DNP3 maps, but the parameter ***y*** is the port number from 1 to 4. Because Port 1, the Ethernet port, can support multiple DNP3 sessions, it can have a different map assigned to each session selected by parameter *s* for Sessions 1 to 5. See *Figure D.4* for an example of a **MAP DNP** command.

```
=> MAP DNP 1 1 <Enter>

SEL-710-5                                  Date: 05/02/2013   Time: 14:43:54.161
MOTOR RELAY                                Time Source: External

Map                           1
Transport                     TCP
Device IP Address             10.10.52.243
Master IP Address             192.168.1.3
Device DNP TCP and UDP Port   20000
Device DNP Address            0
Master DNP Address            1

Binary Inputs
--------------------------------------------------------------------------------
  INDEX  POINT LABEL  EVENT CLASS  SER TIMESTAMP
  0      ENABLED      1
  1      TRIP_LED     1
  2      TLED_01      1
  3      TLED_02      1
  4      TLED_03      1
  5      TLED_04      1
  6      TLED_05      1
  7      TLED_06      1
  8      STFAIL       1
  9      STSET        1
  10     IN101        1
  11     IN102        1
  12     IN501        1
  13     IN502        1
  14     IN503        1
  15     IN504        1
```

Figure D.4 Port MAP Command

```
Binary Outputs
-------------------------------------------------------------------------------
  INDEX  POINT LABEL
  0      RB01
  1      RB02
  2      RB03
  3      RB04
  4      RB05
  5      RB06
  6      RB07
  7      RB08
  8      RB09
  9      RB10
  10     RB11
  11     RB12
  12     RB13
  13     RB14
  14     RB15
  15     RB16
  16     RB17
  17     RB18
  18     RB19
  19     RB20
  20     RB21
  21     RB22
  22     RB23
  23     RB24
  24     RB25
  25     RB26
  26     RB27
  27     RB28
  28     RB29
  29     RB30
  30     RB31
  31     RB32

Counters
-------------------------------------------------------------------------------
Analog Inputs
-------------------------------------------------------------------------------
  INDEX  POINT LABEL  EVENT CLASS  SCALE FACTOR  DEADBAND
  0      IA_MAG       2                 10.0000  100
  1      IB_MAG       2                 10.0000  100
  2      IC_MAG       2                 10.0000  100
  3      IG_MAG       2                 10.0000  100
  4      IN_MAG       2                 10.0000  100
  5      IAV          2                 10.0000  100
  6      3I2          2                 10.0000  100
  7      FREQ         2                  1.0000  100
  8      VAB_MAG      2                 10.0000  100
  9      VBC_MAG      2                 10.0000  100
  10     VCA_MAG      2                 10.0000  100
  11     VAVE         2                 10.0000  100
  12     3V2          2                 10.0000  100
  13     P            2                 10.0000  100
  14     Q            2                 10.0000  100
  15     S            2                 10.0000  100
  16     PF           2                 10.0000  100

Analog Outputs
-------------------------------------------------------------------------------
  INDEX  POINT LABEL
  0      GROUP
  1      RA001
  2      RA002
  ...
  ...
  30     RA030
  31     RA031

=>
```

Figure D.4 Port MAP Command (Continued)

You can use the command **SET DNP *x***, where ***x*** is the map number, to edit or create custom DNP3 data maps. You can also use ACSELERATOR QuickSet SEL-5030 Software, which is recommended for this purpose.

Scaling factors allow you to overcome the limitations imposed by the integer nature of the default variations of Objects 30 and 32. For example, the device rounds a value of 11.4 A to 11 A. You can use scaling to include decimal point values by multiplying by a number larger than one. If you use 10 as a scaling factor, 11.4 A is transmitted as 114. You must divide the value by 10 in the master to see the original value including one decimal place.

You can also use scaling to avoid overflowing the 16-bit maximum integer value of 32767. For example, if you have a value that can reach 157834, you cannot send it using DNP3 16-bit analog object variations. You could use a scaling factor of 0.1 so that the maximum value reported is 15783. You can then multiply the value by 10 in the master to see a value of 157830. You lose some precision as the last digit is rounded off in the scaling process, but you can transmit the scaled value using standard DNP3 Objects 30 and 32.

You can customize the DNP3 analog input map with per-point scaling, and deadband settings. Per-point customization is not required, but class scaling (DECPLA, DECPLV, and DECPLM) and deadband (ANADBA, ANADBV, and ANADBM) settings are applied to indices that do not have per-point entries. Unlike per-point scaling described above, class-level scaling is specified by an integer in the range 0–3 (inclusive), which indicates the number of decimal place shifts. In other words, select 0 to multiply by 1, 1 for 10, 2 for 100, or 3 for 1000.

If it is important to maintain tight data coherency (that is, all data read of a certain type was sampled or calculated at the same time), then group those data together within your custom map. For example, if you want all the currents to be coherent, group points IA_MAG, IB_MAG, IC_MAG, and IG_MAG together in the custom map. If points are not grouped together, they might not come from the same data sample.

The following example describes how to create a custom DNP3 map by point type. The example demonstrates the SEL ASCII command **SET DNP** for each point type, but the entire configuration can be completed without saving changes between point types. To do this, you simply continue entering data and save the entire map at the end. Alternately, you can use QuickSet to simplify custom data map creation.

Consider a case where you want to set the AI points in a map, as shown in *Table D.13*.

Table D.13 Sample Custom DNP3 AI Map

Desired Point Index	Description	Label	Scaling	Deadband
0	IA magnitude	IA_MAG	default	default
1	IB magnitude	IB_MAG	default	default
2	IC magnitude	IC_MAG	default	default
3	IG magnitude	IG_MAG	default	default
4	Three-Phase Real Power	P	5	default
5	AB Phase-to-Phase Voltage Magnitude	VAB_MAG	default	default
6	AB Phase-to-Phase Voltage Angle	VAB_ANG	1	15
7	Frequency	FREQ	.01	1

To set these points as part of custom Map 1, you can use the command **SET DNP 1 AI_00 TERSE <Enter>** command as shown in *Figure D.5*.

```
=>>SET DNP 1 AI_00 TERSE <Enter>
Analog Input Map

DNP Analog Input Label Name (23 characters)
AI_00   := NA
? > IA_MAG <Enter>
AI_01   := NA
? > IB_MAG <Enter>

AI_02   := NA
? > IC_MAG <Enter>


AI_03   := NA
? > IG_MAG <Enter>

AI_04   := NA
? > P:5 <Enter>

AI_05   := NA
? > VAB_MAG <Enter>

AI_06   := NA
? > VAB_ANG:1:15 <Enter>

AI_07   := NA
? > FREQ:.01:1 <Enter>

AI_08   := NA
? > end <Enter>

Save changes (Y/N) ? Y <Enter>

=>>
```

Figure D.5 Sample Custom DNP3 AI Map Settings

You can also use QuickSet to enter the above AI map settings as shown in the screen capture in *Figure D.6*. Enter scaling and deadband settings in the same pop-up dialog used to select the AI point, as shown in *Figure D.7*.

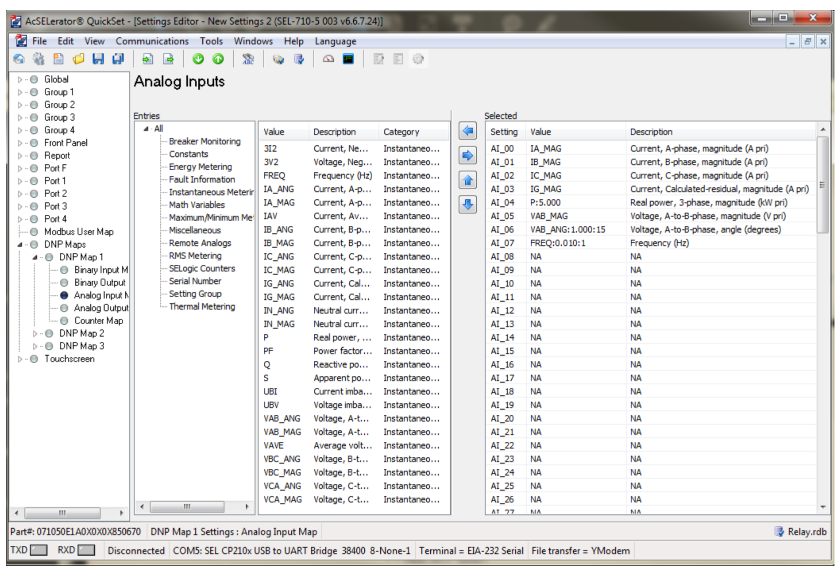

Figure D.6 Analog Input Map Entry in QuickSet Software

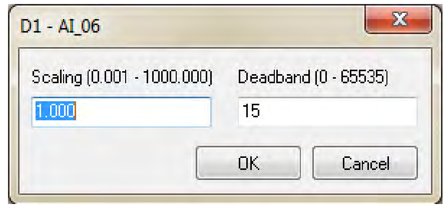

Figure D.7 AI Point, Scaling and Deadband in QuickSet Software

The **SET DNP *x* AO_00<Enter>** command allows you to populate the DNP analog output map with any of the 128 Remote Analogs (RA001–RA128) or the GROUP variable (present settings group) as shown in *Figure D.8*.

```
=>>SET DNP 1 AO_00 TERSE <Enter>

DNP Map 1 Settings

Analog Output Map

DNP Analog Output Label Name (6 characters)    AO_00   := NA        ? group
DNP Analog Output Label Name (6 characters)    AO_01   := NA        ? ra001
DNP Analog Output Label Name (6 characters)    AO_02   := NA        ? ra002
DNP Analog Output Label Name (6 characters)    AO_03   := NA        ? ra120
DNP Analog Output Label Name (6 characters)    AO_04   := NA        ? ra128
DNP Analog Output Label Name (6 characters)    AO_05   := NA        ?
DNP Analog Output Label Name (6 characters)    AO_06   := NA        ? end
Save changes (Y,N)? y
Settings Saved

=>>
```

Figure D.8 Sample Custom DNP3 AO Map Settings

You can also use QuickSet to enter the AO map settings as shown in the screen capture in *Figure D.9*.

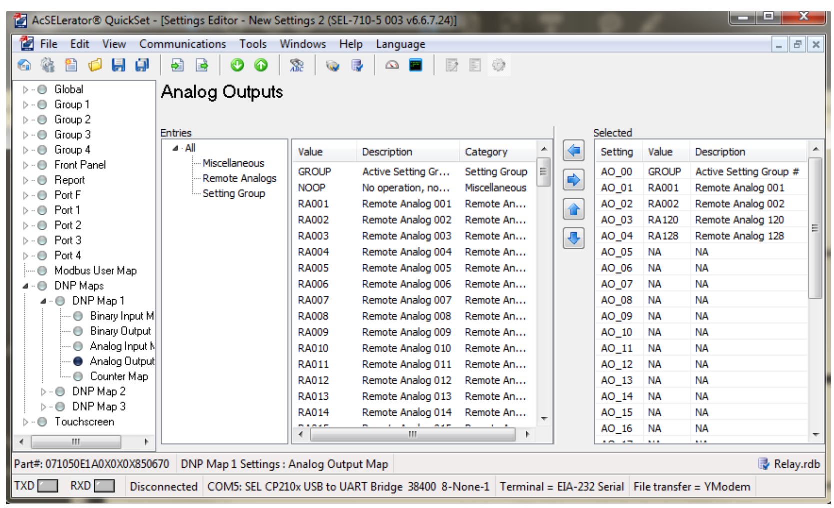

Figure D.9 Analog Output Map Entry in QuickSet Software

The **SET DNP *x* CO_00 <Enter>** command allows you to populate the DNP counter map with per-point deadbands. Entering these settings is similar to defining the analog input map settings.

Use the command **SET DNP *x* BO_00 TERSE <Enter>** to change the binary output Map *x* as shown in *Figure D.10*. You can populate the custom BO map with any of the 32 remote bits (RB01–RB32). Define bit pairs in BO maps by including a colon (:) between the bit labels.

```
=>>SET DNP 1 BO_00 TERSE <Enter>
Binary Output Map

DNP Binary Output Label Name (23 characters)
BO_00    := NA
? > RB01 <Enter>

DNP Binary Output Label Name (23 characters)
BO_01    := NA
? > RB02 <Enter>

DNP Binary Output Label Name (23 characters)
BO_02    := NA
? > RB03:RB04 <Enter>

DNP Binary Output Label Name (23 characters)
BO_03    := NA
? > RB05:RB06 <Enter>

DNP Binary Output Label Name (23 characters)
BO_04    := NA
? > end <Enter>

=>>
```

Figure D.10 Sample Custom DNP3 BO Map Settings

You can also use QuickSet to enter the BO map settings as shown in the screen capture in *Figure D.11*.

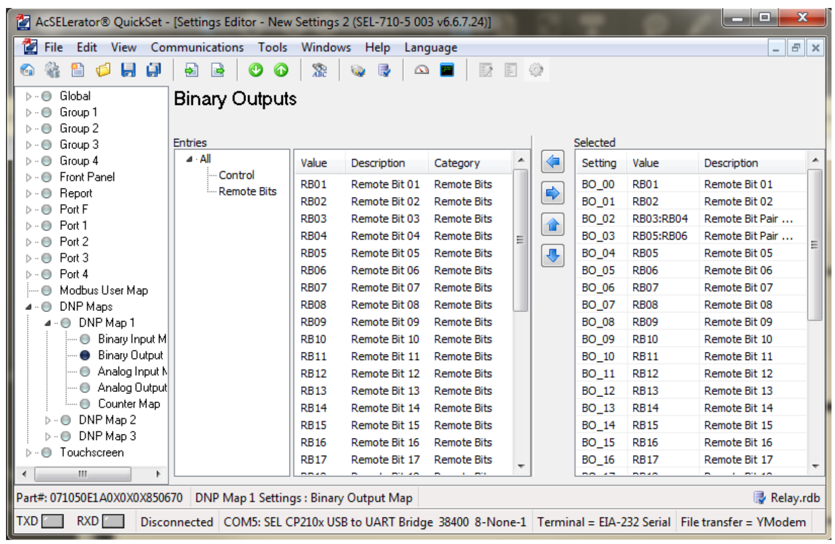

Figure D.11 Binary Output Map Entry in QuickSet Software

The binary input (BI) maps are modified in a similar manner, but pairs are not allowed.

Appendix E
Modbus Communications

Overview

This appendix describes Modbus RTU and TCP communications features supported by the SEL-710-5 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 by 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 specified slave device. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-710-5 Modbus communication allows a Modbus master device to do the following:

- ➤ Acquire metering, monitoring, and event data from the relay.
- ➤ Control SEL-710-5 output contacts.
- ➤ Read the SEL-710-5 self-test status and learn the present condition of all the relay protection elements.

Communications Protocol

Modbus Queries

Modbus RTU master devices initiate all exchanges by sending a query. The query consists of the fields shown in *Table E.1*.

Table E.1 Modbus Query Fields

Field	Number of Bytes
Slave Device Address	1 byte
Function Code	1 byte
Data Region	0–251 bytes
Cyclical Redundancy Check (CRC)	2 bytes

The SEL-710-5 SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two slave devices can have the same address.

The cyclical redundancy check detects errors in the received data. If 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-710-5 supports the Modbus function codes shown in *Table E.2*.

Table E.2 SEL-710-5 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-710-5 sends an exception code under the conditions described in *Table E.3*.

Table E.3 SEL-710-5 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-710-5 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 E.3* occur, the relay assembles a response message that includes the exception code in the data field. The relay sets the most significant bit in the function code field to indicate to the master that the data field contains an error code, instead of the required data.

Cyclical Redundancy Check

The SEL-710-5 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-710-5, the master device uses the data received. If there is no match, the check fails and the message is ignored. The devices use a similar process when the master sends queries.

01h Read Discrete Output Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils) (see the Modbus Register Map shown in *Table E.34*). You can read the status of as many as 2000 bits per query, using the fields shown in *Table E.4*. Note that the SEL-710-5 coil addresses start at 0 (e.g., Coil 1 is located at address zero). The coil status is packed one coil per bit of the data field. The least significant bit (LSB) of the first data byte contains the starting coil address in the query. The other coils follow towards the high-order end of this byte and from low order to high order in subsequent bytes.

Table E.4 01h Read Discrete Output Coil Status Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the first bit
2 bytes	Number of bits to read
2 bytes	CRC-16

Table E.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-710-5 calculates the number of bytes required to contain the number of bits requested. If the number of bits requested is not evenly divisible by eight, the device adds one more byte to maintain the balance of bits, padded by zeros to make an even byte. *Table E.14* includes the coil number and lists all possible coils (identified as Outputs and Remote bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

The relay responses to errors in the query are shown in *Table E.5*.

Table E.5 Responses to 01h Read Discrete Output Coil Query Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

02h Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs), as shown in *Table E.6*. You can read the status of as many as 2000 bits per query. Note that input addresses start at 0 (e.g., Input 1 is located at address zero). The input status is packed one input per bit of the data field. The LSB of the first data byte contains the starting input address in the query. The other inputs follow towards the high order end of this byte, and from low order to high order in subsequent bytes.

Table E.6 02h Read Input Status Command

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 zeroes to make an even byte.

In each row, the input numbers are assigned from the right-most input to the left-most input (i.e., Input 1 is TLED_06 and Input 8 is ENABLED). Input addresses start at 0000 (i.e., Input 1 is located at Input Address 0000). *Table E.7* includes the coil address in decimal and lists all possible inputs (Relay Word bits) available in the device. Note that the command depends on the device hardware configuration; the device responds only to installed cards.

Table E.7 02h SEL-710-5 Inputs

Coil Address (Decimal)	Function Code Supported	Coil Description[a]
0–7	2	Relay Element Status Row 0
8–15	2	Relay Element Status Row 1
16–23	2	Relay Element Status Row 2
•	•	•
•	•	•
•	•	•
1528–1535	2	Relay Element Status Row 191
1536–1543	2	Relay Element Status Row 192
1544–1551	2	Relay Element Status Row 193

[a] The input numbers are assigned from the right-most input to the left-most input in the Relay row as shown in the following example.
Address 7 = ENABLED
Address 6 = TRIP
Address 5 = T01_LED
Address 4 = T02_LED
Address 3 = T03_LED
Address 2 = T04_LED
Address 1 = T05_LED
Address 0 = T06_LED

The relay responses to errors in the query are shown in *Table E.8*.

Table E.8 Responses to 02h Read Input Query Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

Table E.9 03h Read Holding Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.10*.

Table E.10 Responses to 03h Read Holding Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

04h Read Input Register Command

Use function code 04h to read directly from the Modbus Register Map shown in *Table E.34*. You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

Table E.11 04h Read Input Register Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data (*n*)
n bytes	Data (2–250)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.12*.

Table E.12 Responses to 04h Read Input Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

05h Force Single Coil Command

Use function code 05h to set or clear a coil. In *Table E.13*, the command response is identical to the command request.

Table E.13 05h Force Single Coil Command

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

Table E.14 lists the coil numbers supported by the SEL-710-5. The physical coils (coils 0–26) are self-resetting. Pulsing a Set remote bit (decimal address 59 through 90) causes the remote bit to be cleared at the end of the pulse.

Table E.14 01h, 05h SEL-710-5 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	Pulse OUT305 1 second
8	01, 05	Pulse OUT306 1 second
9	01, 05	Pulse OUT307 1 second
10	01, 05	Pulse OUT308 1 second
11	01, 05	Pulse OUT401 1 second
12	01, 05	Pulse OUT402 1 second
13	01, 05	Pulse OUT403 1 second
14	01, 05	Pulse OUT404 1 second
15	01, 05	Pulse OUT405 1 second
16	01, 05	Pulse OUT406 1 second
17	01, 05	Pulse OUT407 1 second
18	01, 05	Pulse OUT408 1 second

Table E.14 01h, 05h SEL-710-5 Output (Sheet 2 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
19	01, 05	Pulse OUT501 1 second
20	01, 05	Pulse OUT502 1 second
21	01, 05	Pulse OUT503 1 second
22	01, 05	Pulse OUT504 1 second
23	01, 05	Pulse OUT505 1 second
24	01, 05	Pulse OUT506 1 second
25	01, 05	Pulse OUT507 1 second
26	01, 05	Pulse OUT508 1 second
27	01, 05	RB01
28	01, 05	RB02
29	01, 05	RB03
30	01, 05	RB04
31	01, 05	RB05
32	01, 05	RB06
33	01, 05	RB07
34	01, 05	RB08
35	01, 05	RB09
36	01, 05	RB10
37	01, 05	RB11
38	01, 05	RB12
39	01, 05	RB13
40	01, 05	RB14
41	01, 05	RB15
42	01, 05	RB16
43	01, 05	RB17
44	01, 05	RB18
45	01, 05	RB19
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]

Table E.14 01h, 05h SEL-710-5 Output (Sheet 3 of 3)

Coil Address (Decimal)	Function Code Supported	Coil Description
61	01, 05	Pulse RB03[a]
62	01, 05	Pulse RB04[a]
63	01, 05	Pulse RB05[a]
64	01, 05	Pulse RB06[a]
65	01, 05	Pulse RB07[a]
66	01, 05	Pulse RB08[a]
67	01, 05	Pulse RB09[a]
68	01, 05	Pulse RB10[a]
69	01, 05	Pulse RB11[a]
70	01, 05	Pulse RB12[a]
71	01, 05	Pulse RB13[a]
72	01, 05	Pulse RB14[a]
73	01, 05	Pulse RB15[a]
74	01, 05	Pulse RB16[a]
75	01, 05	Pulse RB17[a]
76	01, 05	Pulse RB18[a]
77	01, 05	Pulse RB19[a]
78	01, 05	Pulse RB20[a]
79	01, 05	Pulse RB21[a]
80	01, 05	Pulse RB22[a]
81	01, 05	Pulse RB23[a]
82	01, 05	Pulse RB24[a]
83	01, 05	Pulse RB25[a]
84	01, 05	Pulse RB26[a]
85	01, 05	Pulse RB27[a]
86	01, 05	Pulse RB28[a]
87	01, 05	Pulse RB29[a]
88	01, 05	Pulse RB30[a]
89	01, 05	Pulse RB31[a]
90	01, 05	Pulse RB32[a]

[a] Pulsing a set remote bit causes 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 responds with error code 4 (Device Error). In addition to Error Code 4, the device responses to errors in the query are shown in *Table E.15*.

Table E.15 Responses to 05h Force Single Coil Query Errors

Error	Error Code Returned	Communication Counter Increments
Invalid bit (coil)	Illegal Data Address (02h)	Invalid Address
Invalid bit state requested	Illegal Data Value (03h)	Illegal Register
Format Error	Illegal Data Value (03h)	Bad Packet Format

06h Preset Single Register Command

The SEL-710-5 uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Register Map in *Table E.34* for a list of registers that 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.

NOTE: When setting EN_LRC := Y (see *Table 9.6*), the Relay Word bit LOCAL supervises the STOP and STR, 89CC2P*m* and 89OC2P*m* (m = 1–8), and 89CC3P*nm* and 89OC3P*nm* (m = 1–2, n = L or E) bits. To set the aforementioned binaries, ensure that the relay is in remote control mode (i.e., LOCAL = 0). The Relay Word bit LOCAL is determined by the LOCAL SELOGIC control equation (see *Table 9.6*).

In *Table E.16*, the command response is identical to the command required by the master.

Table E.16 06h Preset Single Register Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.17*.

Table E.17 Responses to 06h Preset Single Register Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format

08h Loopback Diagnostic Command

The SEL-710-5 uses this function to allow a Modbus master to perform a diagnostic test on the Modbus communications channel and relay. When the subfunction field is 0000h, the relay returns a replica of the received message.

Table E.18 08h Loopback Diagnostic Command (Sheet 1 of 2)

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field
2 bytes	CRC-16

Table E.18 08h Loopback Diagnostic 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 (08h)
2 bytes	Subfunction (0000h)
2 bytes	Data Field (identical to data in Master request)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.19*.

Table E.19 Responses to 08h Loopback Diagnostic Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal subfunction code	Illegal Data Value (03h)	Invalid Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

10h Preset Multiple Registers Command

This function code works much like code 06h, except that it allows you to write multiple registers at once, as many as 100 per operation. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

Table E.20 10h Preset Multiple Registers Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Number of Bytes of Data (*n*)
n bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.21*.

Table E.21 10h Preset Multiple Registers Query Error Messages

Error	Error Code Returned	Communication Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

60h Read Parameter Information Command

The SEL-710-5 uses this function to allow a Modbus master to read parameter information from the relay. One parameter (setting) is read in each query.

Table E.22 60h Read Parameter Information Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (60h)
2 bytes	Parameter Number
1 byte	Parameter Descriptor
1 byte	Parameter Conversion
2 bytes	Parameter Minimum Settable Value
2 bytes	Parameter Maximum Settable Value
2 bytes	Parameter Default Value
2 bytes	CRC-16

The Parameter Descriptor field is defined in *Table E.23*.

Table E.23 60h Read Parameter Descriptor Field Definition

Bit	Name	Description
0	RO: Read-only	1 when the setting is read-only
1	H: Hidden	1 when the setting is hidden
2	DBL: 32-bit	1 when the following setting is a fractional value of this setting
3	RA: RAM-only	1 when the setting is not saved in nonvolatile memory
4	RR: Read-only if running	1 when the setting is read-only if in running/operational state
5	P: Power Cycle or Reset	1 when the setting change requires a power cycle or reset
6	0	Reserved
7	Extend	Reserved to extend the descriptor table

The Parameter Conversion field is defined in *Table E.24*.

Table E.24 60h Read Parameter Conversion Field Definition

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
9	Integer	1	1000	0	1
10	Enumeration	1	1	0	1
11	Bit Enumeration	1	1	0	1

Use *Equation E.1* to calculate the actual (not scaled) value of the parameter (setting):

$$\text{value} = \frac{(\text{ParameterValue} + \text{Offset}) \bullet \text{Multiplier} \bullet \text{Base}}{\text{Divisor}}$$

Equation E.1

Use *Equation E.2* to calculate the scaled setting value:

$$\text{value} = \frac{\text{value} \bullet \text{Divisor}}{\text{Multiplier} \bullet \text{Base}} - \text{Offset}$$

Equation E.2

The relay response to errors in the query are shown *Table E.25*.

Table E.25 Responses to 60h Read Parameter Information Query Errors

Error	Error Code Returned	Communication Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address

61h Read Parameter Text Command

The SEL-710-5 uses this function to allow a Modbus master to read parameter text from the relay. One parameter text (setting name) is read in each query.

Table E.26 61h Read Parameter Text Command (Sheet 1 of 2)

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

Table E.26 61h Read Parameter Text 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 (61h)
2 bytes	Parameter Number
16 bytes	Parameter Text (setting name)
4 bytes	Parameter Units (e.g., Amps)
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.27*.

Table E.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-710-5 uses this function to allow a Modbus master to read parameter enumeration or bit enumeration values (setting lists) from the relay. One parameter enumeration is read in each query.

Table E.28 62h Read Enumeration Text Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (62h)
2 bytes	Parameter Number
1 byte	Enumeration Index
16 bytes	Enumeration Text
2 bytes	CRC-16

The relay responses to errors in the query are shown in *Table E.29*.

Table E.29 61h Read Parameter Enumeration Text Query Error Messages

Error	Error Code Returned	Communication Counter Increments
Illegal parameter to read	Illegal Address (02h)	Invalid Address
Illegal enumeration in index	Illegal Data Value (03h)	Illegal Register

7Dh Encapsulated Packet With Control Command

The SEL-710-5 uses this function to allow a Modbus master to perform control operations and another Modbus function with one query. The DeviceNet card transmits this command periodically to achieve high-speed I/O processing and establish a heartbeat between the DeviceNet card and the main board.

Table E.30 7Dh Encapsulated Packet With Control Command

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Control Command (same as write to 2000h)
1 byte	Embedded Modbus Function
n bytes	Optional Data to Support Modbus Function (0–250)
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Embedded Modbus Function
n bytes	Optional data to support the Modbus function (0–250)
2 bytes	CRC-16

Table E.31 shows the format of the relay responses to errors in the query.

Table E.31 7Dh Encapsulated Packet Query Errors

Bytes	Field
Queries from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information (Register 2100h or 2101h based on Bit 3 in Control Command Word)
1 byte	Modbus Function with Error Flag
1 bytes	Function Error Code[a]
2 bytes	CRC-16

[a] If the embedded function code is invalid, then an illegal function code 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 E.32 7Eh NOP Command

Bytes	Field
An example of a 7D message response using 7E will have the following format:	
1 byte	Slave Address
1 byte	Function Code (7Dh)
2 bytes	Status Information
1 byte	Function Code (7Eh)
2 bytes	CRC-16

Reading Parameter Information and Value Using Modbus

Through use of Modbus commands, you can read the present value of a parameter as well as parameter name, units, low limit, high limit, scale, and even the enumeration string (if the parameter is an enumeration type). This means that you can use a general user interface to retrieve and display specific parameter details from the relay. Use the **60h**, **61h**, and **62h** commands to retrieve parameter information, and use the **03** command to retrieve values.

Controlling Output Contacts Using Modbus

The SEL-710-5 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-710-5 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 quantities you want (as many as 125). Arrange the quantities in any order convenient for you.

Step 2. Refer to *Table E.33* for a list of the Modbus label for each quantity. For more information on the Modbus labels, refer to the respective register in *Table E.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 E.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 quantities from addresses 126 through 250 (user map values).

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 1 of 7)

Register Address	Label
251–260	Reserved
261	RSTDAT
262–269	Reserved
270	SEC
271	MIN
272	HOUR
273	DAY
274	MONTH
275	YEAR
276–279	Reserved
280	FPGA
281	GPSB
282	HMI
283	RAM
284	ROM
285	CR_RAM
286	NON_VOL
287	CLKSTS
288	PTC
289	RTD
290	CID_FILE
291	P3P3PS
292	P5PS
293	P2P5PS
294	P3P75PS
295	N1P25PS
296	N5PS
297	CLKBAT
298	CARDC
299	CARDD
300	CARDE
301	CARDZ
302	IASTS
303	IBSTS
304	ICSTS
305	INSTS
306	VASTS
307	VBSTS
308	VCSTS
309	RLYSTS
310	IA87STS
311	IB87STS
312	IC87STS
313	VDRSTS
314	SER_NUMH
315	SER_NUML
316–319	Reserved
320	IA_MAG
321	IA_ANG
322	IB_MAG
323	IB_ANG
324	IC_MAG
325	IC_ANG
326	IN_MAG
327	IN_ANG
328	IG_MAG
329	IG_ANG
330	IAV
331	MLOAD
332	3I2
333	UBI
334	IA87
335	IB87
336	IC87
337–339	Reserved
340	VAB_MAG
341	VAB_ANG
342	VBC_MAG
343	VBC_ANG
344	VCA_MAG
345	VCA_ANG
346	VAVE
347	VA_MAG
348	VA_ANG
349	VB_MAG
350	VB_ANG
351	VC_MAG
352	VC_ANG
353	VG_MAG
354	VG_ANG
355	VAVE
356	3V2
357	UBV
358	RES_358
359	RES_359
360	P
361	Q
362	S
363	PF
364	FREQ
365–369	Reserved
370	VEX
371	IEX
372	RF
373–379	Reserved
380	MWH3PH
381	MWH3PL
382	MVRH3PIH
383	MVRH3PIL
384	MVRH3POH
385	MVRH3POL
386	MVAH3PH
387	MVAH3PL
388	ENRGY_S
389	ENRGYMN
390	ENRGY_H
391	ENRGY_D
392	ENRGYMO
393	ENRGY_Y
394–399	Reserved
400	RTDWDGMX
401	RTDBRGMX
402	RTDAMB
403	RTDOTHMX
404	RTD1
405	RTD2
406	RTD3
407	RTD4
408	RTD5
409	RTD6
410	RTD7
411	RTD8
412	RTD9
413	RTD10
414	RTD11
415	RTD12
416	TCURTD
417–419	Reserved
420	TCUSTR
421	TCURTR
422	THRMTP
423	TRST
424	STRTAV
425	SLIP
426	MRT
427–429	Reserved
430	LSENS1
431	LSENS2
432	LSENS3
433	LSENS4
434	LSENS5
435	LSENS6
436	LSENS7
437	LSENS8
438	RES_438
439	RES_439
440	INTT
441	EXTT
442	INTIA
443	EXTIA
444	INTIB
445	EXTIB
446	INTIC
447	EXTIC
448	WEARA
449	WEARB
450	WEARC
451	BRKR_R_S
452	BRKR_RMN
453	BRKR_R_H
454	BRKR_R_D
455	BRKR_RMO
456	BRKR_R_Y
457–459	Reserved
460	IARMS
461	IBRMS
462	ICRMS
463	INRMS
464	VARMS
465	VBRMS
466	VCRMS
467	VABRMS
468	VBCRMS
469	VCARMS
470	IAMX
471	IAX_S
472	IAXMN
473	IAX_H
474	IAX_D
475	IAXMO
476	IAX_Y
477	IAMN
478	IAN_S
479	IANMN
480	IAN_H
481	IAN_D
482	IANMO
483	IAN_Y
484	IBMX
485	IBX_S
486	IBXMN
487	IBX_H
488	IBX_D
489	IBXMO
490	IBX_Y
491	IBMN
492	IBN_S
493	IBNMN
494	IBN_H
495	IBN_D
496	IBNMO
497	IBN_Y
498	ICMX
499	ICX_S
500	ICXMN
501	ICX_H
502	ICX_D
503	ICXMO
504	ICX_Y
505	ICMN
506	ICN_S
507	ICNMN
508	ICN_H
509	ICN_D
510	ICNMO
511	ICN_Y
512	INMX
513	INX_S
514	INXMN
515	INX_H
516	INX_D
517	INXMO
518	INX_Y
519	INMN
520	INN_S
521	INNMN
522	INN_H
523	INN_D
524	INNMO
525	INN_Y
526	IGMX
527	IGX_S
528	IGXMN
529	IGX_H
530	IGX_D
531	IGXMO
532	IGX_Y
533	IGMN
534	IGN_S
535	IGNMN
536	IGN_H
537	IGN_D
538	IGNMO
539	IGN_Y
540	VABMX[a]
541	VABX_S[a]
542	VABXMN[a]
543	VABX_H[a]
544	VABX_D[a]
545	VABXMO[a]

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 2 of 7)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
546	VABX_Y[a]	596	KVAR3PMX	646	RTD1X_Y	696	RTD5MX	746	RTD8N_S
547	VABMN[a]	597	KVR3X_S	647	RTD1MN	697	RTD5X_S	747	RTD8NMN
548	VABN_S[a]	598	KVR3XMN	648	RTD1N_S	698	RTD5XMN	748	RTD8N_H
549	VABNMN[a]	599	KVR3X_H	649	RTD1NMN	699	RTD5X_H	749	RTD8N_D
550	VABN_H[a]	600	KVR3X_D	650	RTD1N_H	700	RTD5X_D	750	RTD8NMO
551	VABN_D[a]	601	KVR3XMO	651	RTD1N_D	701	RTD5XMO	751	RTD8N_Y
552	VABNMO[a]	602	KVR3X_Y	652	RTD1NMO	702	RTD5X_Y	752	RTD9MX
553	VABN_Y[a]	603	KVAR3PMN	653	RTD1N_Y	703	RTD5MN	753	RTD9X_S
554	VBCMX[a]	604	KVR3N_S	654	RTD2MX	704	RTD5N_S	754	RTD9XMN
555	VBCX_S[a]	605	KVR3NMN	655	RTD2X_S	705	RTD5NMN	755	RTD9X_H
556	VBCXMN[a]	606	KVR3N_H	656	RTD2XMN	706	RTD5N_H	756	RTD9X_D
557	VBCX_H[a]	607	KVR3N_D	657	RTD2X_H	707	RTD5N_D	757	RTD9XMO
558	VBCX_D[a]	608	KVR3NMO	658	RTD2X_D	708	RTD5NMO	758	RTD9X_Y
559	VBCXMO[a]	609	KVR3N_Y	659	RTD2XMO	709	RTD5N_Y	759	RTD9MN
560	VBCX_Y[a]	610	KVA3PMX	660	RTD2X_Y	710	RTD6MX	760	RTD9N_S
561	VBCMN[a]	611	KVA3X_S	661	RTD2MN	711	RTD6X_S	761	RTD9NMN
562	VBCN_S[a]	612	KVA3XMN	662	RTD2N_S	712	RTD6XMN	762	RTD9N_H
563	VBCNMN[a]	613	KVA3X_H	663	RTD2NMN	713	RTD6X_H	763	RTD9N_D
564	VBCN_H[a]	614	KVA3X_D	664	RTD2N_H	714	RTD6X_D	764	RTD9NMO
565	VBCN_D[a]	615	KVA3XMO	665	RTD2N_D	715	RTD6XMO	765	RTD9N_Y
566	VBCNMO[a]	616	KVA3X_Y	666	RTD2NMO	716	RTD6X_Y	766	RTD10MX
567	VBCN_Y[a]	617	KVA3PMN	667	RTD2N_Y	717	RTD6MN	767	RTD10X_S
568	VCAMX[a]	618	KVA3N_S	668	RTD3MX	718	RTD6N_S	768	RTD10XMN
569	VCAX_S[a]	619	KVA3NMN	669	RTD3X_S	719	RTD6NMN	769	RTD10X_H
570	VCAXMN[a]	620	KVA3N_H	670	RTD3XMN	720	RTD6N_H	770	RTD10X_D
571	VCAX_H[a]	621	KVA3N_D	671	RTD3X_H	721	RTD6N_D	771	RTD10XMO
572	VCAX_D[a]	622	KVA3NMO	672	RTD3X_D	722	RTD6NMO	772	RTD10X_Y
573	VCAXMO[a]	623	KVA3N_Y	673	RTD3XMO	723	RTD6N_Y	773	RTD10MN
574	VCAX_Y[a]	624	FREQMX	674	RTD3X_Y	724	RTD7MX	774	RTD10N_S
575	VCAMN[a]	625	FREQX_S	675	RTD3MN	725	RTD7X_S	775	RTD10NMN
576	VCAN_S[a]	626	FREQXMN	676	RTD3N_S	726	RTD7XMN	776	RTD10N_H
577	VCANMN[a]	627	FREQX_H	677	RTD3NMN	727	RTD7X_H	777	RTD10N_D
578	VCAN_H[a]	628	FREQX_D	678	RTD3N_H	728	RTD7X_D	778	RTD10NMO
579	VCAN_D[a]	629	FREQXMO	679	RTD3N_D	729	RTD7XMO	779	RTD10N_Y
580	VCANMO[a]	630	FREQX_Y	680	RTD3NMO	730	RTD7X_Y	780	RTD11MX
581	VCAN_Y[a]	631	FREQMN	681	RTD3N_Y	731	RTD7MN	781	RTD11X_S
582	KW3PMX	632	FREQN_S	682	RTD4MX	732	RTD7N_S	782	RTD11XMN
583	KW3X_S	633	FREQNMN	683	RTD4X_S	733	RTD7NMN	783	RTD11X_H
584	KW3XMN	634	FREQN_H	684	RTD4XMN	734	RTD7N_H	784	RTD11X_D
585	KW3X_H	635	FREQN_D	685	RTD4X_H	735	RTD7N_D	785	RTD11XMO
586	KW3X_D	636	FREQNMO	686	RTD4X_D	736	RTD7NMO	786	RTD11X_Y
587	KW3XMO	637	FREQN_Y	687	RTD4XMO	737	RTD7N_Y	787	RTD11MN
588	KW3X_Y	638	RES_638	688	RTD4X_Y	738	RTD8MX	788	RTD11N_S
589	KW3PMN	639	RES_639	689	RTD4MN	739	RTD8X_S	789	RTD11NMN
590	KW3N_S	640	RTD1MX	690	RTD4N_S	740	RTD8XMN	790	RTD11N_H
591	KW3NMN	641	RTD1X_S	691	RTD4NMN	741	RTD8X_H	791	RTD11N_D
592	KW3N_H	642	RTD1XMN	692	RTD4N_H	742	RTD8X_D	792	RTD11NMO
593	KW3N_D	643	RTD1X_H	693	RTD4N_D	743	RTD8XMO	793	RTD11N_Y
594	KW3NMO	644	RTD1X_D	694	RTD4NMO	744	RTD8X_Y	794	RTD12MX
595	KW3N_Y	645	RTD1XMO	695	RTD4N_Y	745	RTD8MN	795	RTD12X_S

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 3 of 7)

Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label	Register Address	Label
796	RTD12XMN	846	AI303X_H	896	AI306XMO	946	AI401XMO	996	AI404MNH
797	RTD12X_H	847	AI303X_D	897	AI306X_Y	947	AI401X_Y	997	AI404MNL
798	RTD12X_D	848	AI303XMO	898	AI306MNH	948	AI401MNH	998	AI404N_S
799	RTD12XMO	849	AI303X_Y	899	AI306MNL	949	AI401MNL	999	AI404NMN
800	RTD12X_Y	850	AI303MNH	900	AI306N_S	950	AI401N_S	1000	AI404N_H
801	RTD12MN	851	AI303MNL	901	AI306NMN	951	AI401NMN	1001	AI404N_D
802	RTD12N_S	852	AI303N_S	902	AI306N_H	952	AI401N_H	1002	AI404NMO
803	RTD12NMN	853	AI303NMN	903	AI306N_D	953	AI401N_D	1003	AI404N_Y
804	RTD12N_H	854	AI303N_H	904	AI306NMO	954	AI401NMO	1004	AI405MXH
805	RTD12N_D	855	AI303N_D	905	AI306N_Y	955	AI401N_Y	1005	AI405MXL
806	RTD12NMO	856	AI303NMO	906	AI307MXH	956	AI402MXH	1006	AI405X_S
807	RTD12N_Y	857	AI303N_Y	907	AI307MXL	957	AI402MXL	1007	AI405XMN
808	RES_808	858	AI304MXH	908	AI307X_S	958	AI402X_S	1008	AI405X_H
809	RES_809	859	AI304MXL	909	AI307XMN	959	AI402XMN	1009	AI405X_D
810	AI301MXH	860	AI304X_S	910	AI307X_H	960	AI402X_H	1010	AI405XMO
811	AI301MXL	861	AI304XMN	911	AI307X_D	961	AI402X_D	1011	AI405X_Y
812	AI301X_S	862	AI304X_H	912	AI307XMO	962	AI402XMO	1012	AI405MNH
813	AI301XMN	863	AI304X_D	913	AI307X_Y	963	AI402X_Y	1013	AI405MNL
814	AI301X_H	864	AI304XMO	914	AI307MNH	964	AI402MNH	1014	AI405N_S
815	AI301X_D	865	AI304X_Y	915	AI307MNL	965	AI402MNL	1015	AI405NMN
816	AI301XMO	866	AI304MNH	916	AI307N_S	966	AI402N_S	1016	AI405N_H
817	AI301X_Y	867	AI304MNL	917	AI307NMN	967	AI402NMN	1017	AI405N_D
818	AI301MNH	868	AI304N_S	918	AI307N_H	968	AI402N_H	1018	AI405NMO
819	AI301MNL	869	AI304NMN	919	AI307N_D	969	AI402N_D	1019	AI405N_Y
820	AI301N_S	870	AI304N_H	920	AI307NMO	970	AI402NMO	1020	AI406MXH
821	AI301NMN	871	AI304N_D	921	AI307N_Y	971	AI402N_Y	1021	AI406MXL
822	AI301N_H	872	AI304NMO	922	AI308MXH	972	AI403MXH	1022	AI406X_S
823	AI301N_D	873	AI304N_Y	923	AI308MXL	973	AI403MXL	1023	AI406XMN
824	AI301NMO	874	AI305MXH	924	AI308X_S	974	AI403X_S	1024	AI406X_H
825	AI301N_Y	875	AI305MXL	925	AI308XMN	975	AI403XMN	1025	AI406X_D
826	AI302MXH	876	AI305X_S	926	AI308X_H	976	AI403X_H	1026	AI406XMO
827	AI302MXL	877	AI305XMN	927	AI308X_D	977	AI403X_D	1027	AI406X_Y
828	AI302X_S	878	AI305X_H	928	AI308XMO	978	AI403XMO	1028	AI406MNH
829	AI302XMN	879	AI305X_D	929	AI308X_Y	979	AI403X_Y	1029	AI406MNL
830	AI302X_H	880	AI305XMO	930	AI308MNH	980	AI403MNH	1030	AI406N_S
831	AI302X_D	881	AI305X_Y	931	AI308MNL	981	AI403MNL	1031	AI406NMN
832	AI302XMO	882	AI305MNH	932	AI308N_S	982	AI403N_S	1032	AI406N_H
833	AI302X_Y	883	AI305MNL	933	AI308NMN	983	AI403NMN	1033	AI406N_D
834	AI302MNH	884	AI305N_S	934	AI308N_H	984	AI403N_H	1034	AI406NMO
835	AI302MNL	885	AI305NMN	935	AI308N_D	985	AI403N_D	1035	AI406N_Y
836	AI302N_S	886	AI305N_H	936	AI308NMO	986	AI403NMO	1036	AI407MXH
837	AI302NMN	887	AI305N_D	937	AI308N_Y	987	AI403N_Y	1037	AI407MXL
838	AI302N_H	888	AI305NMO	938	RES_938	988	AI404MXH	1038	AI407X_S
839	AI302N_D	889	AI305N_Y	939	RES_939	989	AI404MXL	1039	AI407XMN
840	AI302NMO	890	AI306MXH	940	AI401MXH	990	AI404X_S	1040	AI407X_H
841	AI302N_Y	891	AI306MXL	941	AI401MXL	991	AI404XMN	1041	AI407X_D
842	AI303MXH	892	AI306X_S	942	AI401X_S	992	AI404X_H	1042	AI407XMO
843	AI303MXL	893	AI306XMN	943	AI401XMN	993	AI404X_D	1043	AI407X_Y
844	AI303X_S	894	AI306X_H	944	AI401X_H	994	AI404XMO	1044	AI407MNH
845	AI303XMN	895	AI306X_D	945	AI401X_D	995	AI404X_Y	1045	AI407MNL

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 4 of 7)

Register Address	Label
1046	AI407N_S
1047	AI407NMN
1048	AI407N_H
1049	AI407N_D
1050	AI407NMO
1051	AI407N_Y
1052	AI408MXH
1053	AI408MXL
1054	AI408X_S
1055	AI408XMN
1056	AI408X_H
1057	AI408X_D
1058	AI408XMO
1059	AI408X_Y
1060	AI408MNH
1061	AI408MNL
1062	AI408N_S
1063	AI408NMN
1064	AI408N_H
1065	AI408N_D
1066	AI408NMO
1067	AI408N_Y
1068	RES_1068
1069	RES_1069
1070	AI501MXH
1071	AI501MXL
1072	AI501X_S
1073	AI501XMN
1074	AI501X_H
1075	AI501X_D
1076	AI501XMO
1077	AI501X_Y
1078	AI501MNH
1079	AI501MNL
1080	AI501N_S
1081	AI501NMN
1082	AI501N_H
1083	AI501N_D
1084	AI501NMO
1085	AI501N_Y
1086	AI502MXH
1087	AI502MXL
1088	AI502X_S
1089	AI502XMN
1090	AI502X_H
1091	AI502X_D
1092	AI502XMO
1093	AI502X_Y
1094	AI502MNH
1095	AI502MNL
1096	AI502N_S
1097	AI502NMN
1098	AI502N_H
1099	AI502N_D
1100	AI502NMO
1101	AI502N_Y
1102	AI503MXH
1103	AI503MXL
1104	AI503X_S
1105	AI503XMN
1106	AI503X_H
1107	AI503X_D
1108	AI503XMO
1109	AI503X_Y
1110	AI503MNH
1111	AI503MNL
1112	AI503N_S
1113	AI503NMN
1114	AI503N_H
1115	AI503N_D
1116	AI503NMO
1117	AI503N_Y
1118	AI504MXH
1119	AI504MXL
1120	AI504X_S
1121	AI504XMN
1122	AI504X_H
1123	AI504X_D
1124	AI504XMO
1125	AI504X_Y
1126	AI504MNH
1127	AI504MNL
1128	AI504N_S
1129	AI504NMN
1130	AI504N_H
1131	AI504N_D
1132	AI504NMO
1133	AI504N_Y
1134	AI505MXH
1135	AI505MXL
1136	AI505X_S
1137	AI505XMN
1138	AI505X_H
1139	AI505X_D
1140	AI505XMO
1141	AI505X_Y
1142	AI505MNH
1143	AI505MNL
1144	AI505N_S
1145	AI505NMN
1146	AI505N_H
1147	AI505N_D
1148	AI505NMO
1149	AI505N_Y
1150	AI506MXH
1151	AI506MXL
1152	AI506X_S
1153	AI506XMN
1154	AI506X_H
1155	AI506X_D
1156	AI506XMO
1157	AI506X_Y
1158	AI506MNH
1159	AI506MNL
1160	AI506N_S
1161	AI506NMN
1162	AI506N_H
1163	AI506N_D
1164	AI506NMO
1165	AI506N_Y
1166	AI507MXH
1167	AI507MXL
1168	AI507X_S
1169	AI507XMN
1170	AI507X_H
1171	AI507X_D
1172	AI507XMO
1173	AI507X_Y
1174	AI507MNH
1175	AI507MNL
1176	AI507N_S
1177	AI507NMN
1178	AI507N_H
1179	AI507N_D
1180	AI507NMO
1181	AI507N_Y
1182	AI508MXH
1183	AI508MXL
1184	AI508X_S
1185	AI508XMN
1186	AI508X_H
1187	AI508X_D
1188	AI508XMO
1189	AI508X_Y
1190	AI508MNH
1191	AI508MNL
1192	AI508N_S
1193	AI508NMN
1194	AI508N_H
1195	AI508N_D
1196	AI508NMO
1197	AI508N_Y
1198	RES_1198
1199	RES_1199
1200	MXMN_R_S
1201	MXMN_RMN
1202	MXMN_R_H
1203	MXMN_R_D
1204	MXMN_RMO
1205	MXMN_R_Y
1206	RES_1206
1207	RES_1207
1208	RES_1208
1209	RES_1209
1210	RES_1210
1211	RES_1211
1212	RES_1212
1213	RES_1213
1214	RES_1214
1215	RES_1215
1216	RES_1216
1217	RES_1217
1218	RES_1218
1219	RES_1219
1220	AI301H
1221	AI301L
1222	AI302H
1223	AI302L
1224	AI303H
1225	AI303L
1226	AI304H
1227	AI304L
1228	AI305H
1229	AI305L
1230	AI306H
1231	AI306L
1232	AI307H
1233	AI307L
1234	AI308H
1235	AI308L
1236	AI401H
1237	AI401L
1238	AI402H
1239	AI402L
1240	AI403H
1241	AI403L
1242	AI404H
1243	AI404L
1244	AI405H
1245	AI405L
1246	AI406H
1247	AI406L
1248	AI407H
1249	AI407L
1250	AI408H
1251	AI408L
1252	AI501H
1253	AI501L
1254	AI502H
1255	AI502L
1256	AI503H
1257	AI503L
1258	AI504H
1259	AI504L
1260	AI505H
1261	AI505L
1262	AI506H
1263	AI506L
1264	AI507H
1265	AI507L
1266	AI508H
1267	AI508L
1268	RES_1268
1269	RES_1269
1270	MV01H
1271	MV01L
1272	MV02H
1273	MV02L
1274	MV03H
1275	MV03L
1276	MV04H
1277	MV04L
1278	MV05H
1279	MV05L
1280	MV06H
1281	MV06L
1282	MV07H
1283	MV07L
1284	MV08H
1285	MV08L
1286	MV09H
1287	MV09L
1288	MV10H
1289	MV10L
1290	MV11H
1291	MV11L
1292	MV12H
1293	MV12L
1294	MV13H

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 5 of 7)

Register Address	Label
1295	MV13L
1296	MV14H
1297	MV14L
1298	MV15H
1299	MV15L
1300	MV16H
1301	MV16L
1302	MV17H
1303	MV17L
1304	MV18H
1305	MV18L
1306	MV19H
1307	MV19L
1308	MV20H
1309	MV20L
1310	MV21H
1311	MV21L
1312	MV22H
1313	MV22L
1314	MV23H
1315	MV23L
1316	MV24H
1317	MV24L
1318	MV25H
1319	MV25L
1320	MV26H
1321	MV26L
1322	MV27H
1323	MV27L
1324	MV28H
1325	MV28L
1326	MV29H
1327	MV29L
1328	MV30H
1329	MV30L
1330	MV31H
1331	MV31L
1332	MV32H
1333	MV32L
1334	SC01
1335	SC02
1336	SC03
1337	SC04
1338	SC05
1339	SC06
1340	SC07
1341	SC08
1342	SC09
1343	SC10
1344	SC11

Register Address	Label
1345	SC12
1346	SC13
1347	SC14
1348	SC15
1349	SC16
1350	SC17
1351	SC18
1352	SC19
1353	SC20
1354	SC21
1355	SC22
1356	SC23
1357	SC24
1358	SC25
1359	SC26
1360	SC27
1361	SC28
1362	SC29
1363	SC30
1364	SC31
1365	SC32
1366–1369	Reserved
1370	RA001_H
1371	RA001_L
1372	RA002_H
1373	RA002_L
1374	RA003_H
1375	RA003_L
1376	RA004_H
1377	RA004_L
1378	RA005_H
1379	RA005_L
1380	RA006_H
1381	RA006_L
1382	RA007_H
1383	RA007_L
1384	RA008_H
1385	RA008_L
1386	RA009_H
1387	RA009_L
1388	RA010_H
1389	RA010_L
1390	RA011_H
1391	RA011_L
1392	RA012_H
1393	RA012_L
1394	RA013_H
1395	RA013_L
1396	RA014_H
1397	RA014_L

Register Address	Label
1398	RA015_H
1399	RA015_L
1400	RA016_H
1401	RA016_L
1402	RA017_H
1403	RA017_L
1404	RA018_H
1405	RA018_L
1406	RA019_H
1407	RA019_L
1408	RA020_H
1409	RA020_L
1410	RA021_H
1411	RA021_L
1412	RA022_H
1413	RA022_L
1414	RA023_H
1415	RA023_L
1416	RA024_H
1417	RA024_L
1418	RA025_H
1419	RA025_L
1420	RA026_H
1421	RA026_L
1422	RA027_H
1423	RA027_L
1424	RA028_H
1425	RA028_L
1426	RA029_H
1427	RA029_L
1428	RA030_H
1429	RA030_L
1430	RA031_H
1431	RA031_L
1432	RA032_H
1433	RA032_L
1434	RA033_H
1435	RA033_L
1436	RA034_H
1437	RA034_L
1438	RA035_H
1439	RA035_L
1440	RA036_H
1441	RA036_L
1442	RA037_H
1443	RA037_L
1444	RA038_H
1445	RA038_L
1446	RA039_H
1447	RA039_L

Register Address	Label
1448	RA040_H
1449	RA040_L
1450	RA041_H
1451	RA041_L
1452	RA042_H
1453	RA042_L
1454	RA043_H
1455	RA043_L
1456	RA044_H
1457	RA044_L
1458	RA045_H
1459	RA045_L
1460	RA046_H
1461	RA046_L
1462	RA047_H
1463	RA047_L
1464	RA048_H
1465	RA048_L
1466	RA049_H
1467	RA049_L
1468	RA050_H
1469	RA050_L
1470	RA051_H
1471	RA051_L
1472	RA052_H
1473	RA052_L
1474	RA053_H
1475	RA053_L
1476	RA054_H
1477	RA054_L
1478	RA055_H
1479	RA055_L
1480	RA056_H
1481	RA056_L
1482	RA057_H
1483	RA057_L
1484	RA058_H
1485	RA058_L
1486	RA059_H
1487	RA059_L
1488	RA060_H
1489	RA060_L
1490	RA061_H
1491	RA061_L
1492	RA062_H
1493	RA062_L
1494	RA063_H
1495	RA063_L
1496	RA064_H
1497	RA064_L

Register Address	Label
1498	RA065_H
1499	RA065_L
1500	RA066_H
1501	RA066_L
1502	RA067_H
1503	RA067_L
1504	RA068_H
1505	RA068_L
1506	RA069_H
1507	RA069_L
1508	RA070_H
1509	RA070_L
1510	RA071_H
1511	RA071_L
1512	RA072_H
1513	RA072_L
1514	RA073_H
1515	RA073_L
1516	RA074_H
1517	RA074_L
1518	RA075_H
1519	RA075_L
1520	RA076_H
1521	RA076_L
1522	RA077_H
1523	RA077_L
1524	RA078_H
1525	RA078_L
1526	RA079_H
1527	RA079_L
1528	RA080_H
1529	RA080_L
1530	RA081_H
1531	RA081_L
1532	RA082_H
1533	RA082_L
1534	RA083_H
1535	RA083_L
1536	RA084_H
1537	RA084_L
1538	RA085_H
1539	RA085_L
1540	RA086_H
1541	RA086_L
1542	RA087_H
1543	RA087_L
1544	RA088_H
1545	RA088_L
1546	RA089_H
1547	RA089_L

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 6 of 7)

Register Address	Label
1548	RA090_H
1549	RA090_L
1550	RA091_H
1551	RA091_L
1552	RA092_H
1553	RA092_L
1554	RA093_H
1555	RA093_L
1556	RA094_H
1557	RA094_L
1558	RA095_H
1559	RA095_L
1560	RA096_H
1561	RA096_L
1562	RA097_H
1563	RA097_L
1564	RA098_H
1565	RA098_L
1566	RA099_H
1567	RA099_L
1568	RA100_H
1569	RA100_L
1570	RA101_H
1571	RA101_L
1572	RA102_H
1573	RA102_L
1574	RA103_H
1575	RA103_L
1576	RA104_H
1577	RA104_L
1578	RA105_H
1579	RA105_L
1580	RA106_H
1581	RA106_L
1582	RA107_H
1583	RA107_L
1584	RA108_H
1585	RA108_L
1586	RA109_H
1587	RA109_L
1588	RA110_H
1589	RA110_L
1590	RA111_H
1591	RA111_L
1592	RA112_H
1593	RA112_L
1594	RA113_H
1595	RA113_L
1596	RA114_H
1597	RA114_L
1598	RA115_H
1599	RA115_L
1600	RA116_H
1601	RA116_L
1602	RA117_H
1603	RA117_L
1604	RA118_H
1605	RA118_L
1606	RA119_H
1607	RA119_L
1608	RA120_H
1609	RA120_L
1610	RA121_H
1611	RA121_L
1612	RA122_H
1613	RA122_L
1614	RA123_H
1615	RA123_L
1616	RA124_H
1617	RA124_L
1618	RA125_H
1619	RA125_L
1620	RA126_H
1621	RA126_L
1622	RA127_H
1623	RA127_L
1624	RA128_H
1625	RA128_L
1626	Reserved
1627	RES_1627
1628	RES_1628
1629	RES_1629
1630	MOT_E_M
1631	MOT_E_H
1632	MOT_E_D
1633	MOT_R_M
1634	MOT_R_H
1635	MOT_R_D
1636	MOT_S_M
1637	MOT_S_H
1638	MOT_S_D
1639	TIMERUN
1640	NUMSTRT
1641	NUMEMRST
1642	MOT_RS_S
1643	MOT_RSMN
1644	MOT_RS_H
1645	MOT_RS_D
1646	MOT_RSMO
1647	MOT_RS_Y
1648	RES_1648
1649	RES_1649
1650	STRT_T_A
1651	MAXSTI_A
1652	MINSTV_A
1653	STRTTC_A
1654	RUNTC_A
1655	RTDTC_A
1656	RUNI_A
1657	RUNKW_A
1658	RUKVRI_A
1659	RUKVRO_A
1660	RUNKVA_A
1661	MAXWDG_A
1662	MAXBRG_A
1663	MAXAMB_A
1664	MAXOTH_A
1665–1669	Reserved
1670	STRT_T_P
1671	MAXSTI_P
1672	MINSTV_P
1673	STRTTC_P
1674	RUNTC_P
1675	RTDTC_P
1676	RUNI_P
1677	RUNKW_P
1678	RUKVRI_P
1679	RUKVRO_P
1680	RUNKVA_P
1681	MAXWDG_P
1682	MAXBRG_P
1683	MAXAMB_P
1684	MAXOTH_P
1685–1689	Reserved
1690	97FM1_H
1691	97FM1_L
1692	97FM2_H
1693	97FM2_L
1694	97FM3_H
1695	97FM3_L
1696	97FM4_H
1697	97FM4_L
1698	97FM5_H
1699	97FM5_L
1700–1717	Reserved
1718	COOLTM
1719	LRNSTTC
1720	THERM_A
1721	LOCKR_A
1722	LDLOSS_A
1723	LDJAM_A
1724	UBI_A
1725	PHFLT_A
1726	GRFLT_A
1727	SPDSW_A
1728	UNDV_A
1729	OVRV_A
1730	UNDP_A
1731	PF_A
1732	RPWR_A
1733	RTD_A
1734	BBD_A
1735	TOTAL_A
1736–1739	Reserved
1740	THERM_T
1741	LOCKR_T
1742	LDLOSS_T
1743	LDJAM_T
1744	UBI_T
1745	PHFLT_T
1746	GRFLT_T
1747	SPDSW_T
1748	UNDV_T
1749	OVRV_T
1750	UNDP_T
1751	PF_T
1752	RPWR_T
1753	RTD_T
1754	ARC_T
1755	FIELD_T
1756	PHREV_T
1757	DIFF_T
1758	UNDFRQ_T
1759	OVRFRQ_T
1760	PTC_T
1761	STTIM_T
1762	REMTR_T
1763	OTHTR_T
1764	TOTAL_T
1765–1769	Reserved
1770	NUMEVE
1771	EVESEL
1772	EVE_S
1773	EVEMN
1774	EVE_H
1775	EVE_D
1776	EVEMO
1777	EVE_Y
1778	EVE_TYPE
1779	EVE_TRGT
1780	EVE_IA
1781	EVE_IB
1782	EVE_IC
1783	EVE_IN
1784	EVE_IG
1785	EVE_VAB
1786	EVE_VBC
1787	EVE_VCA
1788	EVE_VG
1789	EVE_DY
1790	EVE_FREQ
1791	EVE_IA87
1792	EVE_IB87
1793	EVE_IC87
1794	EVE_MAXW
1795	EVE_MAXB
1796	EVE_MAXA
1797	EVE_MAXO
1798–1809	Reserved
1810	TRIP_LO
1811	TRIP_HI
1812	WARN_LO
1813	WARN_HI
1814–1819	Reserved
1820	NUMRCV
1821	NUMOTH
1822	INVADR
1823	BADCRC
1824	UARTERR
1825	ILLFUNC
1826	ILLREG
1827	ILLWR
1828	BADPKTF
1829	BADPKTL
1830–1839	Reserved
1840	ROW_0
1841	ROW_1
1842	ROW_2
1843	ROW_3
1844	ROW_4
1845	ROW_5
1846	ROW_6
1847	ROW_7
1848	ROW_8
1849	ROW_9
1850	ROW_10
1851	ROW_11
1852	ROW_12

Table E.33 Modbus Register Labels for Use With SET M Command (Sheet 7 of 7)

Register Address	Label
1853	ROW_13
1854	ROW_14
1855	ROW_15
1856	ROW_16
1857	ROW_17
1858	ROW_18
1859	ROW_19
1860	ROW_20
1861	ROW_21
1862	ROW_22
1863	ROW_23
1864	ROW_24
1865	ROW_25
1866	ROW_26
1867	ROW_27
1868	ROW_28
1869	ROW_29
1870	ROW_30
1871	ROW_31
1872	ROW_32
1873	ROW_33
1874	ROW_34
1875	ROW_35
1876	ROW_36
1877	ROW_37
1878	ROW_38
1879	ROW_39
1880	ROW_40
1881	ROW_41
1882	ROW_42
1883	ROW_43
1884	ROW_44
1885	ROW_45
1886	ROW_46
1887	ROW_47
1888	ROW_48
1889	ROW_49
1890	ROW_50
1891	ROW_51
1892	ROW_52
1893	ROW_53
1894	ROW_54
1895	ROW_55
1896	ROW_56
1897	ROW_57
1898	ROW_58
1899	ROW_59
1900	ROW_60
1901	ROW_61
1902	ROW_62
1903	ROW_63
1904	ROW_64
1905	ROW_65
1906	ROW_66
1907	ROW_67
1908	ROW_68
1909	ROW_69
1910	ROW_70
1911	ROW_71
1912	ROW_72
1913	ROW_73
1914	ROW_74
1915	ROW_75
1916	ROW_76
1917	ROW_77
1918	ROW_78
1919	ROW_79
1920	ROW_80
1921	ROW_81
1922	ROW_82
1923	ROW_83
1924	ROW_84
1925	ROW_85
1926	ROW_86
1927	ROW_87
1928	ROW_88
1929	ROW_89
1930	ROW_90
1931	ROW_91
1932	ROW_92
1933	ROW_93
1934	ROW_94
1935	ROW_95
1936	ROW_96
1937	ROW_97
1938	ROW_98
1939	ROW_99
1940	ROW_100
1941	ROW_101
1942	ROW_102
1943	ROW_103
1944	ROW_104
1945	ROW_105
1946	ROW_106
1947	ROW_107
1948	ROW_108
1949	ROW_109
1950	ROW_110
1951	ROW_111
1952	ROW_112
1953	ROW_113
1954	ROW_114
1955	ROW_115
1956	ROW_116
1957	ROW_117
1958	ROW_118
1959	ROW_119
1960	ROW_120
1961	ROW_121
1962	ROW_122
1963	ROW_123
1964	ROW_124
1965	ROW_125
1966	ROW_126
1967	ROW_127
1968	ROW_128
1969	ROW_129
1970	ROW_130
1971	ROW_131
1972	ROW_132
1973	ROW_133
1974	ROW_134
1975	ROW_135
1976	ROW_136
1977	ROW_137
1978	ROW_138
1979	ROW_139
1980	Reserved
1981	ROW_140
1982	ROW_141
1983	ROW_142
1984	ROW_143
1985	ROW_144
1986	ROW_145
1987	ROW_146
1988	ROW_147
1989	ROW_148
1990	ROW_149
1991	ROW_150
1992	ROW_151
1993	ROW_152
1994	ROW_153
1995	ROW_154
1996	ROW_155
1997	ROW_156
1998	ROW_157
1999	ROW_158
2000	ROW_159
2001	ROW_160
2002	ROW_161
2003	ROW_162
2004	ROW_163
2005	ROW_164
2006	ROW_165
2007	ROW_166
2008	ROW_167
2009	ROW_168
2010	ROW_169
2011	ROW_170
2012	ROW_171
2013	ROW_172
2014	ROW_173
2015	ROW_174
2016	ROW_175
2017	ROW_176
2018	ROW_177
2019	ROW_178
2020	ROW_179
2021	ROW_180
2022	ROW_181
2023	ROW_182
2024	ROW_183
2025	ROW_184
2026	ROW_185
2027	ROW_186
2028	ROW_187
2029	ROW_188
2030	ROW_189
2031	ROW_190
2032	ROW_191
2033	ROW_192
2034	ROW_193
2035	Reserved
2036	Reserved
2037	Reserved

[a] Registers report corresponding phase-to-phase values when setting DELTA_Y = DELTA and phase-to-neutral values when setting DELTA _Y = WYE.

Reading History Data Using Modbus

Through use of the Modbus Register Map (*Table E.34*), you can download a complete history of the last 50 events via Modbus. The history contains the date and time stamp, type of event that triggered the report, currents, and voltages at the time of the event. Please refer to the Historical Data section in the map.

To use Modbus to download history data, including TRIP TYPE information, write the event number of interest (1–50) to the EVENT LOG SEL register at address 1747. Then read the history of the specific event number you requested from the registers shown in the Historical Data section of the Modbus Register Map (*Table E.34*). After a power cycle, the history data registers show the history data corresponding to the latest event. This is dynamically updated, as whenever there is a new event, the history data registers are automatically updated with new event data. If specific event number data have been retrieved using a write to the EVENT LOG SEL register, the event data registers stay frozen with that specific event history. This returns to the free running mode when a zero is written to the event selection register from a prior non-zero 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 E.34 lists the data available in the Modbus interface and their description, range, and scaling information. The table also shows the parameter number for access using the DeviceNet interface. The DeviceNet parameter number is obtained by adding 100 to the Modbus register address.

Table E.34 Modbus Map[a] (Sheet 1 of 24)

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		280	2037		1	101–225
User Map Register Values								
126–250	(R)	USER REG#1 VAL–USER REG#125 VAL		0	65535	0	1	226–350
251–260	(R)	Reserved[d]		0	0	0		351–360

Table E.34 Modbus Map[a] (Sheet 2 of 24)

Modbus Register Address[b]	Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Reset Settings							
261 (R/W)	RESET DATA Bit 0 = TRIP RESET Bit 1 = Reserved[d] 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 Bit 8 = Reserved[d] Bit 9 = Reserved[d] Bit 10 = RST BKMON DATA Bits 11–15 = Reserved[d]		0	2047	0		361
262–269 (R)	Reserved[d]		0	0	0	1	362–369
Date/Time Settings							
270 (R/W)	SET SEC		0	5999	0	0.01	370
271 (R/W)	SET MIN		0	59	0	1	371
272 (R/W)	SET HOUR		0	23	0	1	372
273 (R/W)	SET DAY		1	31	1	1	373
274 (R/W)	SET MONTH		1	12	1	1	374
275 (R/W)	SET YEAR		2000	9999	2000	1	375
276–279 (R)	Reserved[d]		0	0	0	1	376–379
Device Status 0 = OK 1 = WARN 2 = FAIL							
280 (R)	FPGA STATUS		0	2	0		380
281 (R)	GPSB STATUS		0	2	0		381
282 (R)	HMI STATUS		0	2	0		382
283 (R)	RAM STATUS		0	2	0		383
284 (R)	ROM STATUS		0	2	0		384
285 (R)	CR_RAM STATUS		0	2	0		385
286 (R)	NON_VOL STATUS		0	2	0		386
287 (R)	CLOCK STATUS		0	2	0		387
288 (R)	PTC STATUS		0	2	0		388
289 (R)	RTD STATUS		0	2	0		389
290 (R	CID FILE STATUS		0	2	0	1	390
291 (R)	+3.3V STATUS		0	2	0		391
292 (R)	+5.0V STATUS		0	2	0		392
293 (R)	+2.5V STATUS		0	2	0		393
294 (R)	+3.75V STATUS		0	2	0		394
295 (R)	–1.25V STATUS		0	2	0		395
296 (R)	–5.0V STATUS		0	2	0		396
297 (R)	CLK_BAT STATUS		0	2	0		397
298 (R)	CARD C STATUS		0	2	0		398
299 (R)	CARD D STATUS		0	2	0		399

Table E.34 Modbus Map[a] (Sheet 3 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
300	(R)	CARD E STATUS		0	2	0		400
301	(R)	CARD Z STATUS		0	2	0		401
302	(R)	IA STATUS		0	2	0	1	402
303	(R)	IB STATUS		0	2	0		403
304	(R)	IC STATUS		0	2	0		404
305	(R)	IN STATUS		0	2	0		405
306	(R)	VA STATUS		0	2	0		406
307	(R)	VB STATUS		0	2	0		407
308	(R)	VC STATUS		0	2	0		408
309	(R)	RELAY STATUS 0 - ENABLED 1 - DISABLED		0	1	0		409
310	(R)	IA87 STATUS		0	2	0		410
311	(R)	IB87 STATUS		0	2	0		411
312	(R)	IC87 STATUS		0	2	0		412
313	(R)	VDR STATUS		0	2	0		413
314	(R)	SERIAL NUMBER H		0	65535	0		414
315	(R)	SERIAL NUMBER L		0	65535	0		415
316–319	(R)	Reserved[d]		0	0	0		
Current Data								
320	(R)	IA CURRENT	A	0	65535	0	1	420
321	(R)	IA ANGLE	deg	–1800	1800	0	0.1	421
322	(R)	IB CURRENT	A	0	65535	0	1	422
323	(R)	IB ANGLE	deg	–1800	1800	0	0.1	423
324	(R)	IC CURRENT	A	0	65535	0	1	424
325	(R)	IC ANGLE	deg	–1800	1800	0	0.1	425
326	(R)	IN CURRENT	A	0	65535	0	1	426
327	(R)	IN ANGLE	deg	–1800	1800	0	0.1	427
328	(R)	IG CURRENT	A	0	65535	0	1	428
329	(R)	IG ANGLE	deg	–1800	1800	0	0.1	429
330	(R)	AVERAGE CURRENT	A	0	65535	0	1	430
331	(R)	MOTOR LOAD	xFLA	0	120	0	0.1	431
332	(R)	NEG-SEQ CURR 3I2	A	0	65535	0	1	432
333	(R)	CURRENT IMBAL	%	0	1000	0	0.1	433
334	(R)	IA87 CURRENT	A	0	65535	0	1	434
335	(R)	IB87 CURRENT	A	0	65535	0	1	435
336	(R)	IC87 CURRENT	A	0	65535	0	1	436
337–339	(R)	Reserved[d]		0	0	0		
Voltage Data								
340	(R)	VAB	kV	0	65535	0	0.01	440
341	(R)	VAB ANGLE	deg	–1800	1800	0	0.1	441

Table E.34 Modbus Map[a] (Sheet 4 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
342	(R)	VBC	kV	0	65535	0	0.01	442
343	(R)	VBC ANGLE	deg	–1800	1800	0	0.1	443
344	(R)	VCA	kV	0	65535	0	0.01	444
345	(R)	VCA ANGLE	deg	–1800	1800	0	0.1	445
346	(R)	AVERAGE LINE[e]	kV	0	65535	0	0.01	446
347	(R)	VAN	kV	0	65535	0	0.01	447
348	(R)	VAN ANGLE	deg	–1800	1800	0	0.1	448
349	(R)	VBN	kV	0	65535	0	0.01	449
350	(R)	VBN ANGLE	deg	–1800	1800	0	0.1	450
351	(R)	VCN	kV	0	65535	0	0.01	451
352	(R)	VCN ANGLE	deg	–1800	1800	0	0.1	452
353	(R)	VG	kV	0	65535	0	0.01	453
354	(R)	VG ANGLE	deg	–1800	1800	0	0.1	454
355	(R)	AVERAGE PHASE[f]	kV	0	65535	0	0.01	455
356	(R)	NEG-SEQ VOLT 3V2	kV	0	65535	0	0.01	456
357	(R)	VOLTAGE IMBAL	%	0	1000	0	0.1	457
358–359	(R)	Reserved[d]		0	0	0		458–459
Power Data								
360	(R)	REAL POWER	kW	–32768	32767	0	1	460
361	(R)	REACTIVE POWER	kVAR	–32768	32767	0	1	461
362	(R)	APPARENT POWER	kVA	–32768	32767	0	1	462
363	(R)	POWER FACTOR		–100	100	0	0.01	463
364	(R)	FREQUENCY	Hz	1000	7000	6000	0.01	464
365–369	(R)	Reserved[d]		0	0	0		465–469
Synchronous Data								
370	(R)	FIELD VOLTAGE	V	–32768	32767	0	1	470
371	(R)	FIELD CURRENT	A	–32768	32767	0	1	471
372	(R)	FIELD RESISTANCE	Ohm	0	65535	0	1	472
373–379	(R)	Reserved[d]		0	0	0		473–479
Energy Data								
380	(R)	MWH3P HI	MWhr	0	65535	0	0.001	480
381	(R)	MWH3P LO	MWhr	0	65535	0	0.001	481
382	(R)	MVARH3PI HI	MVARhr	0	65535	0	0.001	482
383	(R)	MVARH3PI LO	MVARhr	0	65535	0	0.001	483
384	(R)	MVARH3PO HI	MVARhr	0	65535	0	0.001	484
385	(R)	MVARH3PO LO	MVARhr	0	65535	0	0.001	485
386	(R)	MVAH3P HI	MVAhr	0	65535	0	0.001	486
387	(R)	MVAH3P LO	MVAhr	0	65535	0	0.001	487
388	(R)	LAST RST TIME ss		0	5999	0	0.01	488

Table E.34 Modbus Map[a] (Sheet 5 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
389	(R)	LAST RST TIME mm		0	59	0	1	489
390	(R)	LAST RST TIME hh		0	23	0	1	490
391	(R)	LAST RST DATE dd		1	31	1	1	491
392	(R)	LAST RST DATE mm		1	12	1	1	492
393	(R)	LAST RST DATE yy		2000	9999	2000	1	493
394–399	(R)	Reserved[d]		0	0	0		494–499
RTD Data								
400	(R)	MAX WINDING RTD 7FFFh = Open 8000h = Short 7FFCh = Comm Fail 7FF8h = Stat Fail 7FFEh = Fail 7FF0h = NA	degC	–32768	32767	0	1	500
401	(R)	MAX BEARING RTD	degC	–32768	32767	0	1	501
402	(R)	MAX AMBIENT RTD	degC	–32768	32767	0	1	502
403	(R)	MAX OTHER RTD	degC	–32768	32767	0	1	503
404–415	(R)	RTD 1–RTD 12	degC	–32768	32767	0	1	504–515
416	(R)	RTD % TCU	%	0	100	0	1	516
417–419	(R)	Reserved[d]		0	0	0		517–519
Overload Status								
420	(R)	STATOR % TCU	%	0	65535	0	1	520
421	(R)	ROTOR % TCU	%	0	65535	0	1	521
422	(R)	TIME TO TRIP	s	0	9999	0	1	522
423	(R)	TIME TO RESET	min	0	9999	0	1	523
424	(R)	STARTS AVAILABLE		0	255	0	1	524
425	(R)	SLIP	%	0	1000	0	0.1	525
426	(R)	RUNNING TIME	hrs	0	65535	0	1	526
427–429	(R)	Reserved[d]		0	0	0		527–529
Light Meter Data								
430	(R)	LS1	%	0	1000	0	0.1	530
431	(R)	LS2	%	0	1000	0	0.1	531
432	(R)	LS3	%	0	1000	0	0.1	532
433	(R)	LS4	%	0	1000	0	0.1	533
434	(R)	LS5	%	0	1000	0	0.1	534
435	(R)	LS6	%	0	1000	0	0.1	535
436	(R)	LS7	%	0	1000	0	0.1	536
437	(R)	LS8	%	0	1000	0	0.1	537
438	(R)	Reserved[d]		0	0	0		538
439	(R)	Reserved[d]		0	0	0		539

Table E.34 Modbus Map[a] (Sheet 6 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Break Monitor Data Note: In addition to the Breaker Monitor data, the time when Breaker Monitor Data was last reset is also reported in Modbus.								
440	(R)	RLY TRIPS		0	65535	0	1	540
441	(R)	EXT TRIPS		0	65535	0	1	541
442	(R)	IA RLY	kA	0	65535	0	1	542
443	(R)	IA EXT	kA	0	65535	0	1	543
444	(R)	IB RLY	kA	0	65535	0	1	544
445	(R)	IB EXT	kA	0	65535	0	1	545
446	(R)	IC RLY	kA	0	65535	0	1	546
447	(R)	IC EXT	kA	0	65535	0	1	547
448	(R)	A WEAR	%	0	100	0		548
449	(R)	B WEAR	%	0	100	0		549
450	(R)	C WEAR	%	0	100	0		550
451	(R)	BRKR RST TIM-ss		0	5999	0	0.01	551
452	(R)	BRKR RST TIM-mm		0	59	0		552
453	(R)	BRKR RST TIM-hh		0	23	0		553
454	(R)	BRKR RST DAT-dd		1	31	1		554
455	(R)	BRKR RST DAT-mm		1	12	1		555
456	(R)	BRKR RST DAT-yy		2000	9999	2000		556
457–459	(R)	Reserved[d]		0	0	0	1	557–559
RMS Data								
460	(R)	IA RMS	A	0	65535	0	1	560
461	(R)	IB RMS	A	0	65535	0	1	561
462	(R)	IC RMS	A	0	65535	0	1	562
463	(R)	IN RMS	A	0	65535	0	1	563
464	(R)	VA RMS	kV	0	65535	0	0.01	564
465	(R)	VB RMS	kV	0	65535	0	0.01	565
466	(R)	VC RMS	kV	0	65535	0	0.01	566
467	(R)	VAB RMS	kV	0	65535	0	0.01	567
468	(R)	VBC RMS	kV	0	65535	0	0.01	568
469	(R)	VCA RMS	kV	0	65535	0	0.01	569
Maximum/Minimum Motor Data								
470	(R)	IA MAX	A	0	65535	0	1	570
471	(R)	IA MAX TIME ss	seconds	0	5999	0	0.01	571
472	(R)	IA MAX TIME mm	minutes	0	59	0	1	572
473	(R)	IA MAX TIME hh	hours	0	23	0	1	573
474	(R)	IA MAX DAY dd	days	1	31	1	1	574
475	(R)	IA MAX DAY mm	months	1	12	1	1	575
476	(R)	IA MAX DAY yy	years	2000	9999	2000	1	576

Table E.34 Modbus Map[a] (Sheet 7 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
477	(R)	IA MIN	A	0	65535	0	1	577
478–483	(R)	IA MIN TIME ss–IA MIN TIME yy (See *IA MAX* for series structure and data.)						578–583
484	(R)	IB MAX	A	0	65535	0	1	584
485–490	(R)	IB MAX TIME ss–IB MAX TIME yy (See *IA MAX* for series structure and data.)						585–590
491	(R)	IB MIN	A	0	65535	0	1	591
492–497	(R)	IB MIN TIME ss–IB MIN TIME yy (See *IA MAX* for series structure and data.)						592–597
498	(R)	IC MAX	A	0	65535	0	1	598
499–504	(R)	IC MAX TIME ss–IC MAX TIME yy (See *IA MAX* for series structure and data.)						599–504
505	(R)	IC MIN	A	0	65535	0	1	605
506–511	(R)	IC MIN TIME ss–IC MIN TIME yy (See *IA MAX* for series structure and data.)						606–611
512	(R)	IN MAX	A	0	65535	0	1	612
513–518	(R)	IN MAX TIME ss–IN MAX TIME yy (See *IA MAX* for series structure and data.)						613–618
519	(R)	IN MIN	A	0	65535	0	1	619
520–525	(R)	IN MIN TIME ss–IN MIN TIME yy (See *IA MAX* for series structure and data.)						620–625
526	(R)	IG MAX	A	0	65535	0	1	626
527–532	(R)	IG MAX TIME ss–IG MAX TIME yy (See *IA MAX* for series structure and data.)						627–632
533	(R)	IG MIN	A	0	65535	0	1	633
534–539	(R)	IG MIN TIME ss–IG MIN TIME yy (See *IA MAX* for series structure and data.)						634–639
540	(R)	VAB/VA MAX	kV	0	65535	0	0.01	640
541–546	(R)	VAB/VA MX TIM ss–VAB/VA MX TIM yy (See *IA MAX* for series structure and data.)						641–646
547	(R)	VAB/VA MIN	kV	0	65535	0	0.01	647
548–553	(R)	VAB/VA MN TIM ss–VAB/VA MN TIM yy (See *IA MAX* for series structure and data.)						648–653
554	(R)	VBC/VB MAX	kV	0	65535	0	0.01	654
555–560	(R)	VBC/VB MX TIM ss–VBC/VB MX TIM yy (See *IA MAX* for series structure and data.)						655–660
561	(R)	VBC/VB MIN	kV	0	65535	0	0.01	661
562–567	(R)	VBC/VB MN TIM ss–VBC/VB MN TIM yy (See *IA MAX* for series structure and data.)						662–667
568	(R)	VCA/VC MAX	kV	0	65535	0	0.01	668
569–570	(R)	VCA/VC MX TIM ss–VCA/VC MX TIM yy (See *IA MAX* for series structure and data.)						669–670
575	(R)	VCA/VC MIN	kV	0	65535	0	0.01	675
576–581	(R)	VCA/VC MN TIM ss–VCA/VC MN TIM yy (See *IA MAX* for series structure and data.)						676–681
582	(R)	KW3P MAX	kW	–32768	32767	0	1	682
583–588	(R)	KW3P MX TIM ss–KW3P MX TIM yy (See *IA MAX* for series structure and data.)						683–688
589	(R)	KW3P MIN	kW	–32768	32767	0	1	689
590–595	(R)	KW3P MN TIM ss–KW3P MN TIM yy (See *IA MAX* for series structure and data.)						690–695
596	(R)	KVAR3P MAX	kVAR	–32768	32767	0	1	696
597–602	(R)	KVAR3P MX TIM ss–KVAR3P MX TIM yy (See *IA MAX* for series structure and data.)						697–702
603	(R)	KVAR3P MIN	kVAR	–32768	32767	0	1	703
604–609	(R)	KVAR3P MN TIM ss–KVAR3P MN TIM y (See *IA MAX* for series structure and data.)						704–709
610	(R)	KVA3P MAX	kVA	–32768	32767	0	1	710
611–616	(R)	KVA3P MX TIM ss–KVA3P MX TIM yy (See *IA MAX* for series structure and data.)						711–716

Table E.34 Modbus Map[a] (Sheet 8 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
617	(R)	KVA3P MIN	kVA	–32768	32767	0	1	717
618–623	(R)	KVA3P MN TIM ss–KVA3P MN TIM yy (See *IA MAX* for series structure and data.)						718–723
624	(R)	FREQ MAX	Hz	0	65535	0	0.01	724
625–630	(R)	FREQ MX TIM ss–FREQ MX TIM yy (See *IA MAX* for series structure and data.)						725–730
631	(R)	FREQ MIN	Hz	0	65535	0	0.01	731
632–637	(R)	FREQ MN TIM ss–FREQ MN TIM yy (See *IA MAX* for series structure and data.)						732–737
638–639	(R)	Reserved[d]						
Maximum/Minimum RTD Data								
640	(R)	RTD1 MAX	degC	–32768	32767	0	1	740
641–646	(R)	RTD1 MX TIM ss–RTD1 MX TIM yy (See *IA MAX* for series structure and data.)						741–746
647	(R)	RTD1 MIN	degC	–32768	32767	0	1	747
648–653	(R)	RTD1 MN TIM ss–RTD1 MN TIM yy (See *IA MAX* for series structure and data.)						748–753
• • •		• • •						• • •
794	(R)	RTD12 MAX	degC	–32768	32767	0	1	894
795–800	(R)	RTD12 MX TIM ss–RTD12 MX TIM yy (See *IA MAX* for series structure and data.)						895–900
801	(R)	RTD12 MIN	degC	–32768	32767	0	1	901
802–807	(R)	RTD12 MN TIM ss–RTD12 MN TIM yy (See *IA MAX* for series structure and data.)						902–907
808–809	(R)	Reserved[d]						
Maximum/Minimum AI3 Data								
810	(R)	AI301 MX - HI	Engineering Units	–32768	32767	0	0.001	910
811	(R)	AI301 MX - LO		–32768	32767	0	0.001	911
812–817	(R)	AI301 MX TIME ss–AI301 MX TIME yy (See *IA MAX* for series structure and data.)						912–917
818	(R)	AI301 MN - HI	Engineering Units	–32768	32767	0	0.001	918
819	(R)	AI301 MN - LO		–32768	32767	0	0.001	919
820–825	(R)	AI301 MN TIME ss–AI301 MN TIME yy (See *IA MAX* for series structure and data.)						920–925
• • •		• • •						• • •
922	(R)	AI308 MX - HI	Engineering Units	–32768	32767	0	0.001	1022
923	(R)	AI308 MX - LO		–32768	32767	0	0.001	1023
924–929	(R)	AI308 MX TIM ss–AI308 MX TIM yy (See *IA MAX* for series structure and data.)						1024–1029
930	(R)	AI308 MN - HI	Engineering Units	–32768	32767	0	0.001	1030
931	(R)	AI308 MN - LO		–32768	32767	0	0.001	1031
932–937	(R)	AI308 MN TIM ss–AI308 MN TIM yy (See *IA MAX* for series structure and data.)						1032–1037
938–939	(R)	Reserved[d]						

Table E.34 Modbus Map[a] (Sheet 9 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Maximum/Minimum AI4 Data								
940	(R)	AI401 MX - HI	Engineering Units	–32768	32767	0	0.001	1040
941	(R)	AI401 MX - LO		–32768	32767	0	0.001	1041
942–947	(R)	AI401 MX TIM ss–AI401 MX TIM yy (See *IA MAX* for series structure and data.)						1042–1047
948	(R)	AI401 MN - HI	Engineering Units	–32768	32767	0	0.001	1048
949	(R)	AI401 MN - LO		–32768	32767	0	0.001	1049
950–955	(R)	AI401 MN TIM ss–AI401 MN TIM yy (See *IA MAX* for series structure and data.)						1050–1055
• • •		• • •						• • •
1052	(R)	AI408 MX - HI	Engineering Units	–32768	32767	0	0.001	1152
1053	(R)	AI408 MX - LO		–32768	32767	0	0.001	1153
1054–1059	(R)	AI408 MX TIM ss–AI408 MX TIM yy (See *IA MAX* for series structure and data.)						1154–1159
1060	(R)	AI408 MN - HI	Engineering Units	–32768	32767	0	0.001	1160
1061	(R)	AI408 MN - LO		–32768	32767	0	0.001	1161
1062–1067	(R)	AI408 MN TIM ss– AI408 MN TIM yy (See *IA MAX* for series structure and data.)						1162–1167
1068–1069	(R)	Reserved[d]						
Maximum/Minimum AI5 Data								
1070	(R)	AI501 MX - HI	Engineering Units	–32768	32767	0	0.001	1170
1071	(R)	AI501 MX - LO		–32768	32767	0	0.001	1171
1072–1077	(R)	AI501 MX TIM ss–AI501 MX TIM yy (See *IA MAX* for series structure and data.)						1172–1177
1078	(R)	AI501 MN - HI	Engineering Units	–32768	32767	0	0.001	1178
1079	(R)	AI501 MN - LO		–32768	32767	0	0.001	1179
1080–1085	(R)	AI501 MN TIM ss–AI501 MN TIM yy (See *IA MAX* for series structure and data.)						1180–1185
• • •		• • •						• • •
1182	(R)	AI508 MX - HI	Engineering Units	–32768	32767	0	0.001	1282
1183	(R)	AI508 MX - LO		–32768	32767	0	0.001	1283
1184–1189	(R)	AI508 MX TIM ss–AI508 MX TIM yy (See *IA MAX* for series structure and data.)						1284–1289
1190	(R)	AI508 MN - HI	Engineering Units	–32768	32767	0	0.001	1290
1191	(R)	AI508 MN - LO		–32768	32767	0	0.001	1291
1192–1197	(R)	AI508 MN TIM ss–AI508 MN TIM yy (See *IA MAX* for series structure and data.)						1292–1299
1198–1199	(R)	Reserved[d]						

Table E.34 Modbus Map[a] (Sheet 10 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Maximum/Minimum Reset Data								
1200–1205	(R)	MX/MN RST TIM ss–MX/MN RST TIM yy (See *IA MAX* for series structure and data.)						1300–1305
1206–1219	(R)	Reserved[d]		0	0	0		1306–1319
Analog Input Data								
1220	(R)	AI301 - HI	Engineering Units	–32768	32767	0	0.001	1320
1221	(R)	AI301 - LO		–32768	32767	0	0.001	1321
• • •		• • •						• • •
1234	(R)	AI308 - HI	Engineering Units	–32768	32767	0	0.001	1334
1235	(R)	AI308 - LO		–32768	32767	0	0.001	1335
1236	(R)	AI401 - HI	Engineering Units	–32768	32767	0	0.001	1336
1237	(R)	AI401 - LO		–32768	32767	0	0.001	1337
• • •		• • •						• • •
1250	(R)	AI408 - HI	Engineering Units	–32768	32767	0	0.001	1350
1251	(R)	AI408 - LO		–32768	32767	0	0.001	1351
1252	(R)	AI501 - HI	Engineering Units	–32768	32767	0	0.001	1352
1253	(R)	AI501- LO		–32768	32767	0	0.001	1353
• • •		• • •						• • •
1266	(R)	AI508 - HI	Engineering Units	–32768	32767	0	0.001	1366
1267	(R)	AI508 - LO		–32768	32767	0	0.001	1367
1268–1269	(R)	Reserved[d]		0	0	0		1368–1369
Math Variables								
1270	(R)	MV01 - HI		–32768	32767	0	0.01	1370
1271	(R)	MV01 - LO		–32768	32767	0	0.01	1371
• • •		• • •						• • •
1332	(R)	MV32 - HI		–32768	32767	0	0.01	1432
1333	(R)	MV32 - LO		–32768	32767	0	0.01	1433

Table E.34 Modbus Map[a] (Sheet 11 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Device Counters								
1334	(R)	COUNTER SC01		0	65000	1	1	1434
•		•						•
•		•						•
•		•						•
1365	(R)	COUNTER SC32		0	65000	1	1	1465
1366–1369	(R)	Reserved[d]		0	0	0		1466–1469
Remote Analogs 1								
1370	(R/W)	RA001 (0:UW)		–32768	32767	0	0.01	1470
1371	(R/W)	RA001 (1:LW)		–32768	32767	0	0.01	1471
•		•						•
•		•						•
•		•						•
1496	(R/W)	RA064 (0:UW)		–32768	32767	0	0.01	1596
1497	(R/W)	RA064 (1:LW)		–32768	32767	0	0.01	1597
Remote Analogs 2								
1498	(R/W)	RA065 (0:UW)		–32768	32767	0	0.01	1598
1499	(R/W)	RA001 (1:LW)		–32768	32767	0	0.01	1599
•		•						•
•		•						•
•		•						•
1624	(R/W)	RA064 (0:UW)		–32768	32767	0	0.01	1724
1625	(R/W)	RA064 (1:LW)		–32768	32767	0	0.01	1725
1626–1629	(R)	Reserved[d]		0	0	0		1726–1729
Motor Statistics								
1630	(R)	ELAPSED TIME mm		0	59	0	1	1730
1631	(R)	ELAPSED TIME hh		0	23	0	1	1731
1632	(R)	ELAPSED TIME dd		0	65535	0	1	1732
1633	(R)	RUNNING TIME mm		0	59	0	1	1733
1634	(R)	RUNNING TIME hh		0	23	0	1	1734
1635	(R)	RUNNING TIME dd		0	65535	0	1	1735
1636	(R)	STOPPED TIME mm		0	59	0	1	1736
1637	(R)	STOPPED TIME hh		0	23	0	1	1737
1638	(R)	STOPPED TIME dd		0	65535	0	1	1738
1639	(R)	% TIME RUNNING	%	0	1000	0	0.1	1739
1640	(R)	STARTS COUNT		0	65535	0	1	1740
1641	(R)	EMER START COUNT		0	65535	0	1	1741
1642	(R)	MOT RST TIME ss		0	5999	0	0.01	1742
1643	(R)	MOT RST TIME mm		0	59	0	1	1743
1644	(R)	MOT RST TIME hh		0	23	0	1	1744
1645	(R)	MOT RST DATE dd		1	31	1	1	1745

Table E.34 Modbus Map[a] (Sheet 12 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1646	(R)	MOT RST DATE mm		1	12	1	1	1746
1647	(R)	MOT RST DATE yy		2000	9999	2000	1	1747
1648–1649	(R)	Reserved[d]		0	0	0		1726–1729
Average Statistics								
1650	(R)	START TIME (S)	s	0	9999	0	0.1	1750
1651	(R)	MAX START I (A)	A	0	65535	0	1	1751
1652	(R)	MIN START V (V)	V	0	65535	0	1	1752
1653	(R)	START % TCU	%	0	65535	0	0.1	1753
1654	(R)	RUNNING % TCU	%	0	65535	0	0.1	1754
1655	(R)	RTD % TCU	%	0	65535	0	1	1755
1656	(R)	RUNNING CUR (A)	A	0	65535	0	0.1	1756
1657	(R)	RUNNING KW	kW	0	65535	0	0.1	1757
1658	(R)	RUNNING KVARIN	kVAR	0	65535	0	0.1	1758
1659	(R)	RUNNING KVAROUT	kVAR	0	65535	0	0.1	1759
1660	(R)	RUNNING KVA	kVA	0	65535	0	0.1	1760
1661	(R)	MAX WDG RTD (C)	degC	–32768	32767	0	1	1761
1662	(R)	MAX BRG RTD (C)	degC	–32768	32767	0	1	1762
1663	(R)	AMBIENT RTD (C)	degC	–32768	32767	0	1	1763
1664	(R)	MAX OTH RTD (C)	degC	–32768	32767	0	1	1764
1665–1669	(R)	Reserved[d]		0	0	0		1765–1769
Peak Statistics								
1670	(R)	START TIME (S)	s	0	9999	0	0.1	1770
1671	(R)	MAX START I (A)	A	0	65535	0	1	1771
1672	(R)	MIN START V (V)	V	0	65535	0	1	1772
1673	(R)	START % TCU	%	0	65535	0	0.1	1773
1674	(R)	RUNNING % TCU	%	0	65535	0	0.1	1774
1675	(R)	RTD % TCU	%	0	65535	0	1	1775
1676	(R)	RUNNING CUR (A)	A	0	65535	0	0.1	1776
1677	(R)	RUNNING KW	kW	0	65535	0	0.1	1777
1678	(R)	RUNNING KVARIN	kVAR	0	65535	0	0.1	1778
1679	(R)	RUNNING KVAROUT	kVAR	0	65535	0	0.1	1779
1680	(R)	RUNNING KVA	kVA	0	65535	0	0.1	1780
1681	(R)	MAX WDG RTD (C)	degC	–32768	32767	0	1	1781
1682	(R)	MAX BRG RTD (C)	degC	–32768	32767	0	1	1782
1683	(R)	AMBIENT RTD (C)	degC	–32768	32767	0	1	1783
1684	(R)	MAX OTH RTD (C)	degC	–32768	32767	0	1	1784
1685–1689	(R)	Reserved[d]		0	0	0		1785–1789

Table E.34 Modbus Map[a] (Sheet 13 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
97FM Element								
1690	(R)	97FM1 HI		–32768	32767	0	0.01	1790
1691	(R)	97FM1 LO		–32768	32767	0	0.01	1791
1692	(R)	97FM2 HI		–32768	32767	0	0.01	1792
1693	(R)	97FM2 LO		–32768	32767	0	0.01	1793
1694	(R)	97FM3 HI		–32768	32767	0	0.01	1794
1695	(R)	97FM3 LO		–32768	32767	0	0.01	1795
1696	(R)	97FM4 HI		–32768	32767	0	0.01	1796
1697	(R)	97FM4 LO		–32768	32767	0	0.01	1797
1698	(R)	97FM5 HI		–32768	32767	0	0.01	1798
1699	(R)	97FM5 LO		–32768	32767	0	0.01	1799
1700–1717		Reserved[d]		0	0	0		1800–1817
Learned Parameters								
1718	(R)	COOL TIME (S)	s	0	9999	0	0.1	1818
1719	(R)	START TC	%	0	65535	0	0.1	1819
Alarm Counters								
1720	(R)	OVERLOAD		0	65535	0	1	1820
1721	(R)	LOCKED ROTOR		0	65535	0	1	1821
1722	(R)	UNDERCURRENT		0	65535	0	1	1822
1723	(R)	JAM		0	65535	0	1	1823
1724	(R)	CURRENT IMBAL		0	65535	0	1	1824
1725	(R)	OVERCURRENT		0	65535	0	1	1825
1726	(R)	GROUND FAULT		0	65535	0	1	1826
1727	(R)	SPEED SWITCH		0	65535	0	1	1827
1728	(R)	UNDERVOLTAGE		0	65535	0	1	1828
1729	(R)	OVERVOLTAGE		0	65535	0	1	1829
1730	(R)	UNDERPOWER		0	65535	0	1	1830
1731	(R)	POWER FACTOR		0	65535	0	1	1831
1732	(R)	REACTIVE POWER		0	65535	0	1	1832
1733	(R)	RTD		0	65535	0	1	1833
1734	(R)	BBD		0	65535	0	1	1834
1735	(R)	TOTAL ALARMS		0	65535	0	1	1835
1736–1739	(R)	Reserved[d]		0	0	0		1836–1839
Trip Counters								
1740	(R)	OVERLOAD		0	65535	0	1	1840
1741	(R)	LOCKED ROTOR		0	65535	0	1	1841
1742	(R)	UNDERCURRENT		0	65535	0	1	1842
1743	(R)	JAM		0	65535	0	1	1843
1744	(R)	CURRENT IMBAL		0	65535	0	1	1844

Table E.34 Modbus Map[a] (Sheet 14 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1745	(R)	OVERCURRENT		0	65535	0	1	1845
1746	(R)	GROUND FAULT		0	65535	0	1	1846
1747	(R)	SPEED SWITCH		0	65535	0	1	1847
1748	(R)	UNDERVOLTAGE		0	65535	0	1	1848
1749	(R)	OVERVOLTAGE		0	65535	0	1	1849
1750	(R)	UNDERPOWER		0	65535	0	1	1850
1751	(R)	POWER FACTOR		0	65535	0	1	1851
1752	(R)	REACTIVE POWER		0	65535	0	1	1852
1753	(R)	RTD		0	65535	0	1	1853
1754	(R)	ARC FLASH TRIP		0	65535	0	1	1854
1755	(R)	FIELD TRIP		0	65535	0	1	1855
1756	(R)	PHASE REVERSAL		0	65535	0	1	1856
1757	(R)	87M PHASE DIFF		0	65535	0	1	1857
1758	(R)	UNDERFREQUENCY		0	65535	0	1	1858
1759	(R)	OVERFREQUENCY		0	65535	0	1	1859
1760	(R)	PTC		0	65535	0	1	1860
1761	(R)	START TIMER		0	65535	0	1	1861
1762	(R)	REMOTE TRIP		0	65535	0	1	1862
1763	(R)	OTHER TRIPS		0	65535	0	1	1863
1764	(R)	TOTAL TRIPS		0	65535	0	1	1864
1765–1769	(R)	Reserved[d]		0	0	0		1865–1869
Historical Data								
1770	(R)	NO. EVENT LOGS		0	50	0	1	1870
1771	(R/W)	EVENT LOG SEL		0	50	0	1	1871
1772	(R)	EVENT TIME ss		0	5999	0	0.01	1872
1773	(R)	EVENT TIME mm		0	59	0	1	1873
1774	(R)	EVENT TIME hh		0	23	0	1	1874
1775	(R)	EVENT DAY dd		1	31	1	1	1875
1776	(R)	EVENT DAY mm		1	12	1	1	1876
1777	(R)	EVENT DAY yy		2000	9999	2000	1	1877

Table E.34 Modbus Map[a] (Sheet 15 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1778	(R)	EVENT TYPE 0 = NA 1 = ARC FLASH TRIP 2 = OVERLOAD TRIP 3 = LOCKD ROTOR TRIP 4 = UNDERCURR TRIP 5 = JAM TRIP 6 = CURR IMBAL TRIP 7 = OVERCURRENT TRIP 8 = GROUND FLT TRIP 9 = PHASE A 51 TRIP 10 = PHASE B 51 TRIP 11 = PHASE C 51 TRIP 12 = PHASE 51 TRIP 13 = GND 51 TRIP 14 = NEG SEQ 51 TRIP 15 = SPEED SW TRIP 16 = FLD LOSS TRIP 17 = START TIME TRIP 18 = 87M DIFF TRIP 19 = UNDERPOWER TRIP 20 = PWR FACTOR TRIP 21 = REACT PWR TRIP 22 = PHASE REV TRIP 23 = UNDERFREQ TRIP 24 = OVERFREQ TRIP 25 = RTD TRIP 26 = PTC TRIP 27 = UNDERVOLT TRIP 28 = OVERVOLT TRIP 29 = BKR FAILURE TRIP 30 = OUT OF STEP TRIP 31 = FLD UNDERC TRIP 32 = FLD OVERC TRIP 33 = FLD UNDERV TRIP 34 = FLD OVERV TRIP 35 = FLDRESISTNCETRIP 36 = RTD FAIL TRIP 37 = PTC FAIL TRIP 38 = TRIGGER 39 = COMMIDLELOSSTRIP 40 = REMOTE TRIP 41 = STOP COMMAND 42 = ER TRIGGER 43 = TRIP		0	43	0		1878
1779	(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		1879
1780	(R)	EVENT IA	A	0	65535	0	1	1880
1781	(R)	EVENT IB	A	0	65535	0	1	1881
1782	(R)	EVENT IC	A	0	65535	0	1	1882
1783	(R)	EVENT IN	A	0	65535	0	1	1883
1784	(R)	EVENT IG	A	0	65535	0	1	1884
1785	(R)	EVENT VAB/VAN	kV	0	65535	0	0.01	1885
1786	(R)	EVENT VBC/VBN	kV	0	65535	0	0.01	1886
1787	(R)	EVENT VCA/VCN	kV	0	65535	0	0.01	1887
1788	(R)	EVENT VG	kV	0	65535	0	0.01	1888
1789	(R)	EVENT DELTA/WYE 0 = DELTA 1 = WYE		0	1	0		1889
1790	(R)	EVENT FREQ		1000	7000	6000	0.01	1890
1791	(R)	EVENT IA87		0	65535	0	1	1891
1792	(R)	EVENT IB87		0	65535	0	1	1892
1793	(R)	EVENT IC87		0	65535	0	1	1893
1794	(R)	EVNT MAX WDG RTD	degC	–32768	32767	0	1	1894
1795	(R)	EVNT MAX BRG RTD	degC	–32768	32767	0	1	1895

Table E.34 Modbus Map[a] (Sheet 16 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1796	(R)	EVNT MAX AMB RTD	degC	–32768	32767	0	1	1896
1797	(R)	EVNT MAX OTH RTD	degC	–32768	32767	0	1	1897
1798–1809	(R)	Reserved[d]		0	0	0		1898–1909
Trip/Warn Data								
The Trip/Warn Status register bits are momentarily set as long as a trip/warn condition exists (see *Table E.35* for the trigger conditions). 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 any interface								
1810	(R)	TRIP STATUS LO Bit 0 = OVERLOAD OR LOCKED ROTOR Bit 1 = UNDERCURRENT Bit 2 = JAM Bit 3 = CURR. UNBALANCE Bit 4 = INST OVERCURRENT Bit 5 = RTD 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 = 87M DIFFERENTIAL		0	65535	0	1	1910
1811	(R)	TRIP STATUS HI Bit 0 = START TIME Bit 1 = FREQUENCY Bit 2 = TOC OVERCURRENT Bit 3 = ARC FLASH TRIP Bit 4 = FIELD TRIP Bit 5 = OUT OF STEP Bit 6 = BREAKER FAIL Bit 7 = REMOTE TRIP Bit 8 = DNET COMM Bits 9– 15 = Reserved[d]		0	65535	0	1	1911
1812	(R)	WARN STATUS LO Bit 0 = OVERLOAD OR LOCKED ROTOR Bit 1 = UNDERCURRENT Bit 2 = INST OVERCURRENT Bit 3 = JAM Bit 4 = CURR. IMBALANCE Bit 5 = RTD Bit 6 = POWER FACTOR Bit 7 = GROUND FAULT Bit 8 = BROKEN ROTOR BAR Bit 9 = VAR Bit 10 = UNDERPOWER Bit 11 = UNDERVOLTAGE Bit 12 = OVERVOLTAGE Bit 13 = SPEED SWITCH Bit 14 = ARC FLASH Bit 15 = PTC		0	65535	0	1	1912
1813	(R)	WARN STATUS HI Bit 0 = FIELD WARNING Bit 1 = DNET COMM Bit 2 = SALARM Bit 3 = WARNING Bit 4–Bit15 = Reserved[d]		0	65535	0	1	1913
1814–1819	(R)	Reserved[d]		0	0	0		1914–1919
Common Counters								
1820		NUM MSG RCVD		0	65535	0	1	1920
1821		NUM OTHER MSG		0	65535	0	1	1921
1822		INVALID ADDR		0	65535	0	1	1922

Table E.34 Modbus Map[a] (Sheet 17 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
1823		BAD CRC		0	65535	0	1	1923
1824		UART ERROR		0	65535	0	1	1924
1825		ILLEGAL FUNCTION		0	65535	0	1	1925
1826		ILLEGAL REGISTER		0	65535	0	1	1926
1827		ILLEGAL WRITE		0	65535	0	1	1927
1828		BAD PKT FORMAT		0	65535	0	1	1928
1829		BAD PKT LENGTH		0	65535	0	1	1929
1830–1839	(R)	Reserved[d]		0	0	0		1930–1939
Relay Elements								
1840–1979	(R)	ROW 0–ROW 139		0	255	0	1	1940–2079
1980	(R)	Reserved[d]		0	0	0		2080
1981–2034	(R)	ROW 140–ROW 193		0	255	0	1	2081–2134
2035–2037	(R)	Reserved[d]		0	0	0		2135–2137
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[d]		0	65535	0	na	
2001H	(W)	RESET COMMAND Bit 0 = Trip Reset Bit 1 = Reserved[d] 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	

Table E.34 Modbus Map[a] (Sheet 18 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
2002H	(W)	LOGIC COMMAND		0	255	0	na	
		Bit 0 = 3-position Disconnect In-Line 1 Close						
		Bit 1 = 3-position Disconnect In-Line 1 Open						
		Bit 2 = 3-position Disconnect Earthing 1 Close						
		Bit 3 = 3-position Disconnect Earthing 1 Open						
		Bit 4 = 3-position Disconnect In-Line 2 Close						
		Bit 5 = 3-position Disconnect In-Line 2 Open						
		Bit 6 = 3-position Disconnect Earthing 2 Close						
		Bit 7 = 3-position Disconnect Earthing 2 Open						
		Bit 8 = 2-position Disconnect 1 Close						
		Bit 9 = 2-position Disconnect 1 Open						
		Bit 10 = 2-position Disconnect 2 Close						
		Bit 11 = 2-position Disconnect 2 Open						
		Bit 12 = 2-position Disconnect 3 Close						
		Bit 13 = 2-position Disconnect 3 Open						
		Bit 14 = 2-position Disconnect 4 Close						
		Bit 15 = 2-position Disconnect 4 Open						
2003H	(W)	LOGIC COMMAND		0	255	0	na	
		Bit 0 = 2-position Disconnect 5 Close						
		Bit 1 = 2-position Disconnect 5 Open						
		Bit 2 = 2-position Disconnect 6 Close						
		Bit 3 = 2-position Disconnect 6 Open						
		Bit 4 = 2-position Disconnect 7 Close						
		Bit 5 = 2-position Disconnect 7 Open						
		Bit 6 = 2-position Disconnect 8 Close						
		Bit 7 = 2-position Disconnect 8 Open						
		Bit 8 = Reserved[d]						
		Bit 9 = Reserved[d]						
		Bit 10 = Reserved[d]						
		Bit 11 = Reserved[d]						
		Bit 12 = Reserved[d]						
		Bit 13 = Reserved[d]						
		Bit 14 = Reserved[d]						
		Bit 15 = Reserved[d]						

Table E.34 Modbus Map[a] (Sheet 19 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Relay Elements								
2100H	(R)	FAST STATUS 0 Bit 0 = Faulted/Trip Bit 1 = Warning Bit 2 = IN101 Status Bit 3 = IN102 Status Bit 4 = IN401 Status Bit 5 = IN402 Status Bit 6 = IN403 Status Bit 7 = Starting Bit 8 = OUT101 Status Bit 9 = OUT102 Status Bit 10 = OUT401 Status Bit 11 = OUT402 Status Bit 12 = OUT403 Status Bit 13 = OUT404 Status Bit 14 = Running Bit 15 = Stopped		0	65535	0	na	
2101H	(R)	FAST STATUS 1 Bit 0 = Enabled Bit 1 = Reserved[d] Bit 2 = IN404 Status Bit 3 = IN501 Status Bit 4 = IN502 Status Bit 5 = IN503 Status Bit 6 = IN504 Status Bit 7 = Reserved[d] Bit 8 = OUT501 Status Bit 9 = OUT502 Status Bit 10 = OUT503 Status Bit 11 = OUT504 Status Bit 12–15 = Reserved[d]		0	65535	0	na	
2102H	(R)	TRIP STATUS LO					na	
2103H	(R)	TRIP STATUS HI					na	
2104H	(R)	WARN STATUS LO					na	
2105H	(R)	WARN STATUS HI					na	
2106H	(R)	AVERAGE CURRENT					na	
2107H	(R)	IA CURRENT					na	
2108H	(R)	IB CURRENT					na	
2109H	(R)	IC CURRENT					na	
210AH	(R)	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 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[d]		0	65535	0	na	
PAR Group Indices								
3000H	(R)	Reserved[d]		0	0	0	na	
3001H	(R)	USER MAP REG		1	125	1	1	
3002H	(R)	USER MAP REG VAL		126	250	126	1	

Table E.34 Modbus Map[a] (Sheet 20 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
3003H	(R)	RESERVED AREA1		251	260	251	1	
3004H	(R)	RESET SETTINGS		261	269	261	1	
3005H	(R)	DATE/TIME SET		270	279	270	1	
3006H	(R)	DEVICE STATUS		280	319	280	1	
3007H	(R)	CURRENT DATA		320	339	320	1	
3008H	(R)	VOLTAGE DATA		340	359	340	1	
3009H	(R)	POWER DATA		360	369	360	1	
300AH	(R)	SYNCHRONOUS DATA		370	379	370	1	
300BH	(R)	ENERGY DATA		380	399	389	1	
300CH	(R)	RTD DATA		400	419	400	1	
300DH	(R)	OVERLOAD STATUS		420	429	420	1	
300EH	(R)	LIGHT MTR DATA		430	439	430	1	
300FH	(R)	BREAKER MONITOR		440	459	440	1	
3010H	(R)	RMS DATA		460	469	460	1	
3011H	(R)	MAX/MIN MTR DATA		470	639	470	1	
3012H	(R)	MAX/MIN RTD DATA		640	809	640	1	
3013H	(R)	MAX/MIN AI3 DATA		810	939	810	1	
3014H	(R)	MAX/MIN AI4 DATA		940	1069	940	1	
3015H	(R)	MAX/MIN AI5 DATA		1070	1199	1070	1	
3016H	(R)	MAX/MIN RST DATA		1200	1219	1200	1	
3017H	(R)	ANA INP DATA		1220	1269	1220	1	
3018H	(R)	MATH VARIABLES		1270	1333	1270	1	
3019H	(R)	DEVICE COUNTERS		1334	1369	1334	1	
301AH	(R)	REMOTE ANALOGS1		1370	1497	1370	1	
301BH	(R)	REMOTE ANALOGS2		1498	1629	1498	1	
301CH	(R)	MOTOR STATISTICS		1630	1649	1630	1	
301DH	(R)	AVG STATISTICS		1650	1669	1650	1	
301EH	(R)	PEAK STATISTICS		1670	1689	1670	1	
301FH	(R)	RESERVED AREA5		1690	1717	1690	1	
3020H	(R)	LEARN PARAMETERS		1718	1719	1718	1	
3021H	(R)	ALARM COUNTERS		1720	1739	1720	1	
3022H	(R)	TRIP COUNTERS		1740	1769	1740	1	
3023H	(R)	HISTORICAL DATA		1770	1809	1770	1	
3024H	(R)	TRIP/WARN DATA		1810	1819	1810	1	
3025H	(R)	COMMN COUNTERS		1820	1839	1820	1	
3026H	(R)	RELAY ELEMENTS		1840	2037	1840	1	

Table E.34 Modbus Map[a] (Sheet 21 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
Product Information								
4000H	(R)	VENDOR CODE 865 = SEL		0	65535	865	na	
4001H	(R)	PRODUCT CODE		0	65535	109	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	2037	na	
4006H	(R)	NUM OF PAR GROUP		1	100	38	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 4–9 = Swr Configurable		0	9	0	na	
4009H	(R/W)	DN STATUS Bit 0 = Explicit Cnxn Bit 1 = I/O Cnxn Bit 2 = Explicit Fault Bit 3 = I/O Fault Bit 4 = I/O Idle Bit 5–Bit 15 = Reserved[d]		0	31	0	na	
400AH		not used						
400BH	(R)	CONFIG PAR CKSUM				0	na	
400CH	(R)	LANGUAGE CODE 0 = English 1 = French 2 = Spanish (Mexican) 3 = Italian 4 = German 5 = Japanese 6 = Portuguese 7 = Mandarin Chinese 8 = Russian 9 = Dutch				0	na	
400DH	(R)	FIRMWARE BUILD NUM		16400	16400	0	na	
400EH		not used						
400FH	(R)	PRODUCT SUPPORT BITS Bit 0 = 2nd IO Card installed Bits 1–15 = Reserved[d]					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[d]				0	na	
4015H	(R)	Reserved[d]		0	0	0	na	

Table E.34 Modbus Map[a] (Sheet 22 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
4016H	(R)	ERROR REGISTER Bit 0–Bit 15 = Reserved[d]		0	65535	0	na	
4017H	(R)	ERROR ADDRESS		0	65535	0	na	
4018H–401FH	(R)	Reserved[d]		0	0	0	na	
DeviceNet Card Parameters								
FF9DH	(R)	Hdw Inputs		na	na	0	na	na
		Bit 0 = Input IN101 Bit 1 = Input IN102 Bit 2 = Input IN401 Bit 3 = Input IN402 Bit 4 = Input IN403 Bit 5 = Input IN404 Bit 6 = Input IN501 Bit 7 = Input IN502		Bit 8 = Input IN503 Bit 9 = Input IN504 Bit 10–15 = Reserved[d]				
FF9EH	(R)	Hdw Outputs		na	na	0	na	na
		Bit 0 = Output OUT101 Bit 1 = Output OUT102 Bit 2 = Output OUT401 Bit 3 = Output OUT402 Bit 4 = Output OUT403 Bit 5 = Output OUT404 Bit 6 = Output OUT501 Bit 7 = Output OUT502		Bit 8 = Output OUT503 Bit 9 = Output OUT504 Bit 10–15 = Reserved[d]				
FF9FH	(R)	Trip Status 1		na	na	0	na	na
		Bit 0 = OVERLOAD OR LOCKED ROTOR Bit 1 = UNDERCURRENT Bit 2 = JAM Bit 3 = CURR. IMBALANCE Bit 4 = INST OVERCUR-RENT Bit 5 = RTD 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 = 87M DIFFERENTIAL				
FFA0H	(R)	Trip Status 2 Bit = START TIME Bit 1 = FREQUENCY Bit 2 = TOC OVERCURRENT Bit 3 = ARC FLASH TRIP Bit 4 = FIELD TRIP Bit 5 = OUT OF STEP Bit 6 = BREAKER FAIL Bit 7 = REMOTE TRIP Bit 8 = DNET COMM Bit 9–15 = Reserved[d]		na	na	0	na	na

Table E.34 Modbus Map[a] (Sheet 23 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
FFA1H	(R)	Warn Status 1 Bit 0 = OVERLOAD OR LOCKED ROTOR Bit 1 = UNDERCURRENT Bit 2 = INST OVERCUR-RENT Bit 3 = JAM Bit 4 = CURR. IMBALANCE Bit 5 = RTD Bit 6 = POWER FACTOR Bit 7 = GROUND FAULT Bit 8 = BROKEN ROTOR BAR Bit 9 = VAR Bit 10 = UNDERPOWER Bit 11 = UNDERVOLTAGE Bit 12 = OVERVOLTAGE Bit 13 = SPEED SWITCH Bit 14 = ARC FLASH Bit 15 = PTC		na	na	0	na	na
FFA2H	(R)	Warn Status 2 Bit 0 = FIELD WARNING Bit 1 = DNET COMM Bit 2 = SALARM Bit 3 = WARNING Bit 5–15 = Reserved[d]		na				
FFA3H	(R)	Module Status Bit 0 = Exp Cnxn Bit 1 = IO Cnxn Bit 2 = Exp Flt Bit 3 = IO Flt Bit 4 = IO Idle Bit 5 = Reserved[d] Bit 6 = Reserved[d] Bit 7 = Reserved[d] Bit 8 = Fault Bit 9 = Warning Bit 10 = Starting Bit 11 = Running Bit 12 = Stopped Bit 13 = Reserved[d] Bit 14 = Reserved[d] Bit 15 = Reserved[d]		na				
FFA4H–FFB0H	(R)	Reserved[d]		na	2	0		364
FFB1H	(R)	Status COS Mask1 Bit 0 = Fault Bit 1 = Warning Bit 2 = IN101 Status Bit 3 = IN102 Status Bit 4 = IN401 Status Bit 5 = IN402 Status Bit 6 = IN403 Status Bit 7 = Starting Bit 8 = OUT101 Status Bit 9 = OUT102 Status Bit 10 = OUT401 Status Bit 11 = OUT402 Status Bit 12 = OUT403 Status Bit 13 = OUT404 Status Bit 14 = Running Bit 15 = Stopped		na				
FFB2H	(R)	Status COS Mask2 Bit 0 = Enabled Bit 1 = Reserved[d] Bit 2 = IN404 Status Bit 3 = IN501 Status Bit 4 = IN502 Status Bit 5 = IN503 Status Bit 6 = IN504 Status Bit 7 = Reserved[d] Bit 8 = OUT501 Status Bit 9 = OUT502 Status Bit 10 = OUT503 Status Bit 11 = OUT504 Status Bit 12 = Reserved[d] Bit 13 = Reserved[d] Bit 14 = Reserved[d] Bit 15 = Reserved[d]		na	50000	1000	0.1	374

Table E.34 Modbus Map[a] (Sheet 24 of 24)

Modbus Register Address[b]		Name/Enums	Units	Min	Max	Default	Multiplier[c]	DeviceNet Parameter Number
FFB3H	(R)	Trip COS Mask1		na	na	0	na	na
		Bit 0 = OVERLOAD OR LOCKED ROTOR Bit 1 = UNDERCURRENT Bit 2 = JAM Bit 3 = CURR. IMBALANCE Bit 4 = INST OVERCUR-RENT Bit 5 = RTD 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 = 87M DIFFERENTIAL						
FFB4H	(R)	Trip COS Mask2 Bit 0 = START TIME Bit 1 = FREQUENCY Bit 2 = TOC OVERCURRENT Bit 3 = ARC FLASH TRIP Bit 4 = FIELD TRIP Bit 5 = OUT OF STEP Bit 6 = BREAKER FAIL Bit 7 = REMOTE TRIP Bit 8 = DNET COMM Bit 9–15 = Reserved[d]		na	na	0	na	na
FFB5H	(R)	Warn COS Mask1		na	na	0	na	na
		Bit 0 = OVERLOAD OR LOCKED ROTOR Bit 1 = UNDERCURRENT Bit 2 = INST OVERCUR-RENT Bit 3 = JAM Bit 4 = CURR. IMBALANCE Bit 5 = RTD Bit 6 = POWER FACTOR Bit 7 = GROUND FAULT Bit 8 = BROKEN ROTOR BAR Bit 9 = VAR Bit 10 = UNDERPOWER Bit 11 = UNDERVOLTAGE Bit 12 = OVERVOLTAGE Bit 13 = SPEED SWITCH Bit 14 = ARC FLASH Bit 15 = PTC						
FFB6H	(R)	Warn COS Mask2 Bit 0 = FIELD WARNING Bit 1 = DNET COMM Bit 2 = SALARM Bit 3 = WARNING Bit 4–Bit 15 = Reserved[d]		na	na	0	na	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 321 (IA Angle) reads 300 in decimal, then the system value is 30 deg (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.

Table E.35 Trigger Conditions for Trip/Warn Status Register Bits (Sheet 1 of 2)

Register #	Bit #	Description	Trigger Condition
1810	—	TRIP STATUS LO	—
	Bit 0	OVERLOAD	49T
	Bit 1	UNDERCURRENT	LOSSTRIP
	Bit 2	JAM	JAMTRIP
	Bit 3	CURR. IMBALANCE	46UBT OR 50Q1T
	Bit 4	INST OVERCURRENT	50P1T
	Bit 5	RTD	RTDT OR OTHTRIP OR AMBTRIP OR RTDFLT
	Bit 6	PTC	PTCTRIP OR PTCFLT
	Bit 7	GROUND CURR	50G1T OR 50N1T
	Bit 8	VAR	VART
	Bit 9	UNDERPOWER	37PT
	Bit 10	UNDERVOLTAGE	27P1T
	Bit 11	OVERVOLTAGE	59P1T
	Bit 12	PHASE REVERSAL	47T
	Bit 13	POWER FACTOR	55T
	Bit 14	SPEED SWITCH	SPDSTR
	Bit 15	87M DIFFERENTIAL	87M1T OR 87M2T
1811	—	TRIP STATUS HI	—
	Bit 0	START TIME	SMTRIP
	Bit 1	FREQUENCY	81D1T OR 81D2T OR 81D3T OR 81D4T
	Bit 2	TOC OVERCURRENT	51AT OR 51BT OR 51CT OR 51P1T OR 51P2T OR 51G1T OR 51G2T OR 51QT
	Bit 3	ARC FLASH TRIP	AF_TRIP
	Bit 4	FIELD TRIP	40Z1T OR 40Z2T OR FDUC1T OR FDOC1T OR FDUV1T OR FDOV1T OR FDRES1T
	Bit 5	OUT OF STEP	OOST
	Bit 6	BREAKER FAIL	BFT
	Bit 7	REMOTE TRIP	REMTRIP
	Bit 8	DNET COMM	COMMIDLE OR COMMLOSS OR COMMFLT
	Bit 9	Reserved	—
	Bit 10	Reserved	—
	Bit 11	Reserved	—
	Bit 12	Reserved	—
	Bit 13	Reserved	—
	Bit 14	Reserved	—
	Bit 15	Reserved	—

Table E.35 Trigger Conditions for Trip/Warn Status Register Bits (Sheet 2 of 2)

Register #	Bit #	Description	Trigger Condition
1812		WARN STATUS LO	
	Bit 0	OVERLOAD	49A
	Bit 1	UNDERCURRENT	LOSSALRM
	Bit 2	INST OVERCURRENT	50P2T
	Bit 3	JAM	JAMALRM
	Bit 4	CURR. IMBALANCE	46UBA OR 50Q2T
	Bit 5	RTD	RTDA OR AMBALRM OR OTHALRM OF RTDFLT
	Bit 6	POWER FACTOR	55A
	Bit 7	GROUND FAULT	50N2T OR 50G2T
	Bit 8	BROKEN ROTOR BAR	BBD1T OR BBD2T OR BBD3T
	Bit 9	VAR	VARA
	Bit 10	UNDERPOWER	37PA
	Bit 11	UNDERVOLTAGE	27P2T
	Bit 12	OVERVOLTAGE	59P2T
	Bit 13	SPEED SWITCH	SPDSAL
	Bit 14	ARC FLASH	AFALARM
	Bit 15	PTC	PTCFLT
1813	—	WARN STATUS HI	—
	Bit 0	FIELD WARNING	FDUC2T OR FDOC2T OR FDUV2T OR FDOV2T OR FDRES2T
	Bit 1	DNET COMM	COMMIDLE OR COMMLOSS OR COMMFLT
	Bit 2	SALARM	SALARM
	Bit 3	WARNING	WARNING
	Bit 4	Reserved	—
	Bit 5	Reserved	—
	Bit 6	Reserved	—
	Bit 7	Reserved	—
	Bit 8	Reserved	—
	Bit 9	Reserved	—
	Bit 10	Reserved	—
	Bit 11	Reserved	—
	Bit 12	Reserved	—
	Bit 13	Reserved	—
	Bit 14	Reserved	—
	Bit 15	Reserved	—

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Appendix F
EtherNet/IP Communications

Overview

EtherNet/IP, or Ethernet/Industrial Protocol, is an industrial protocol that uses standard Ethernet and TCP/IP technology to transport Common Industrial Protocol (CIP) packets.

The SEL-710-5 Motor Protection Relay supports EtherNet/IP. This section discusses general specifications for EtherNet/IP implementation, as well as the CIP data model, the allocation of the CIP connections, the EtherNet/IP Port 1 settings, and the Electronic Data Sheet (EDS) file in the SEL-710-5.

The SEL-710-5 supports two ways of exchanging data via EtherNet/IP:

- **Implicit Message Adapter**. The I/O data is mapped into Assembly object instances. The SEL-710-5 exchanges this I/O data via EtherNet/IP Implicit Class 1 connections with a remote EtherNet/IP Scanner device using UDP packets.
- **Explicit Message Server.** The I/O data is mapped into Assembly object instances. The SEL-710-5 responds to generic TCP EtherNet/IP Explicit message requests initiated by a remote EtherNet/IP Client device.

For more information on EtherNet/IP, visit www.odva.org.

Specifications

Table F.1 EtherNet/IP Specifications (Sheet 1 of 2)

EtherNet/IP Services
Implicit Message Adapter (Class 1) Explicit Message Server (Class 3 and unconnected)
CIP Model-Implemented Objects
Identity Object Message Router Object Assembly Object Connection Manager Object File Object TCP/IP Interface Object Ethernet Link Object Vendor Specific Object

Table F.1 EtherNet/IP Specifications (Sheet 2 of 2)

Implicit Message Adapter	
Number of Connections	As many as eight (two Class 1 connections and six Class 3/unconnected connections)
Class 1 Connection Types	Unicast Multicast
Class 1 Connection Transport Types	Exclusive Owner Input Only Listen Only
Class 1 Connection Trigger Types	Cyclic Change of State
Input Only Heartbeat Connection Point	238
Listen Only Heartbeat Connection Point	237

CIP Data Model

Profile

Table F.2 CIP Data Model Profile

Class Name	Class ID	Number of Instances
Identity Object	0x01	1
Message Router Object	0x02	1
Assembly Object	0x04	Determined by the user/based on the application.
Connection Manager Object	0x06	1
File Object	0x37	2
TCP/IP Interface Object	0xF5	1
Ethernet Link Object	0xF6	See *Ethernet Link Object (0xF6)*
Vendor Specific Object	0x64	1

Identity Object (0x01)

Instances Implemented

The SEL-710-5 supports one instance (Instance ID = 1) or the Identity Object.

Table F.3 Identity Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object.
2	Max Instance	GET	UINT	1	The maximum Identity Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Identity Objects
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1, [21]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]

Table F.3 Identity Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	21	Maximum Instance Attribute ID
Instance Attributes					
1	Vendor ID	GET	UINT	865	
2	Device Type	GET	UINT	0x2B	
3	Product Code	GET	UINT		The most significant byte is the Device Code (DEVCODE as found in the **ID** command of the SEL-710-5) and its least significant byte is the user-configurable Configuration ID as provided in the Ethernet port settings.
4	[Major Revision, Minor Revision]	GET	[USINT, USINT]	[1,1]	
5	Status	GET	WORD		Refer to *Table F.4*.
6	Serial Number	GET	UDINT		The low-order 32 bits of the MAC address of the Ethernet port
7	Product Name	GET	STRING		The existing default product name (the default RID string) of the SEL-710-5 plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, “<Default RID>-<Configuration ID>”.
21	Catalog Number	GET	STRING		The existing default product name (the default RID string) of the SEL-710-5 plus the value of the user-configurable Configuration ID as provided in the Ethernet port settings. The general format is, “<Default RID>-<Configuration ID>”.

Table F.4 Status WORD Bits Descriptions

Bit Number[a]	Name	Description
0	Owned	TRUE, if at least one scanner has established an Exclusive Owner Class 1 connection to the SEL-710-5. FALSE, if the SEL-710-5 has no active Exclusive Owner connections to a scanner.
2	Configured	Always TRUE.
4 to 7	Extended Device Status	Hexadecimal value: 2: A Class 1 connection has timed out. 3: No Class 1 connection has been established. 6: At least one Class 1 connection is active. 7: In any other case.
11	Major Unrecoverable Fault	TRUE if the product is disabled due to an unrecoverable fault; otherwise, it is FALSE.

[a] The Status WORD bits not listed in this table are always set to FALSE.

Table F.5 Identity Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attributes All	Yes	Yes	Returns a list of all of the values of the attributes.
0x05	Reset	No	Yes	Restarts the EtherNet/IP service in the SEL-710-5. Only reset type 0 is allowed.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Message Router Object (0x02)

Table F.6 Message Router Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Message Router Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Message Router Object Instances.
4	Optional Attribute List	GET	[UINT, Array of UINT]	[3,[1,2,3]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
5	Optional Service List	GET	[UINT, Array of UINT]	[1.[10]]	Number of Optional Service Codes followed by the List of Optional Service Codes
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	3	Maximum Instance Attribute ID
Instance Attributes					
1	Class List	GET	[UINT, Array of UINT]		Implemented object list
2	Maximum Connections	GET	UINT		Maximum number of connections supported
3	Number of Connections	GET	UINT		Number of connections currently used

Table F.7 Message Router Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x0A	Multiple Service Packet	No	Yes	

Assembly Object (0x04)

Instances Implemented

The SEL-710-5 relay settings define the number of Assembly Object Instances based on the number and type of connections configured and the data content of each instance. Each assembly is as large as 500 bytes in size. The SEL-710-5 supports a total of six assemblies (three Input Assemblies and three Output Assemblies).

Table F.8 Assembly Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	2	The revision of this CIP Object
2	Max Instance	GET		Determined by the settings	The maximum Assembly Object Instance ID defined by the user
3	Number of Instances	GET		Determined by the settings	Total number of Assembly Object instances defined by the user.
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[4]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	4	Maximum Instance Attribute ID
Instance Attributes					
1	Number of Members	GET	UINT		Number of Assembly Members defined by the user.
2	Member List	GET	Array of [UINT, UINT, EPATH]		Only 500 bytes are allowed.
3	Data	GET, SET	Array of Bytes		Data map defined with **SET E**, **1**, **2**, or **3**
4	Size	GET	UINT		Number of bytes in Instance Attribute 3

Table F.9 Assembly Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x18	Get Member	No	Yes	Returns the value of a member of the data attribute.
0x19	Set Member	No	Yes	Modifies the value of a member of the data attribute.

Connection Manager Object (0x06)

Table F.10 Connection Manager Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Connection Manager Object Instance ID
3	Number of Instances	GET	UINT		Total number of Connection Manager Object Instances
4	Optional Attribute List	GET	[UINT,Array of UINT]	[8,[1,2,3,4,5,6,7,8]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	8	Maximum Instance Attribute ID
Instance Attributes					
1	Open Requests	GET/SET	UINT		Number of FWD Open service requests received
2	Open Format Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of bad format
3	Open Resource Rejects	GET/SET	UINT		Number of FWD Open service requests rejected because of lack of resources
4	Open Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format or lack or resources
5	Close Requests	GET/SET	UINT		Number of FWD Close service requests received
6	Close Format Rejects	GET/SET	UINT		Number of FWD Close service requests rejected because of bad format
7	Close Other Rejects	GET/SET	UINT		Number of FWD Open service requests rejected for reasons other than bad format
8	Connection Timeouts	GET/SET	UINT		Number of connection timeouts

Table F.11 Connection Manager Object Supported Services (Sheet 1 of 2)

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.
0x02	Set Attribute All	No	Yes	Sets the value of all attributes.
0x54	Forward Open	No	Yes	Establishes a CIP connection.
0x4E	Forward Close	No	Yes	Closes a CIP connection.

Table F.11 Connection Manager Object Supported Services (Sheet 2 of 2)

Service Code	Service Name	Class	Instance	Description
0x5B	Large Forward Open	No	Yes	Establishes a CIP connection that allows a large connection size.
0x5A	Get Connection Owner	No	Yes	Returns data about the connection that owns the object.

File Object (0x37)

The File Object stores the EDS and icon files. The EDS file is generated by the SEL-710-5 based on the EtherNet/IP Port 1 settings and the SET E 1, 2, or 3 settings. The relay can retrieve the file using the File Object services. You cannot write an EDS file to the relay using the File Object services.

The SEL-710-5 implements two instances of the File Object:

- ➤ Instance 0xC8 returns an uncompressed version of the EDS file with an embedded icon.
- ➤ Instance 0xC9 returns a compressed version of the icon file.

Table F.12 File Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	201	
3	Number of Instances	GET	UINT	2	
6	Maximum ID Number Class Attributes	GET	UINT	32	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
32	Directory	GET	[UINT, STRINGI, STRINGI] [UINT, STRINGI, STRINGI]	[0xC8,(ENG)'EDS and Icon Files', (ENG)'EDS.txt'] [0xC9, (ENG)'Related EDS and Icon Files', (ENG)'EDSCollection.gz']	List of all File Object instance and file names present in the SEL-710-5 and the associated instance numbers
0xC8 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)'EDS and Icon Files'	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)'EDS.txt'	
5	File Revision	GET	[USINT, USINT]		[Major EDS revision Ethernet port setting, Minor EDS revision Ethernet port setting]
6	File Size	GET	UDINT		Size of the EDS file in bytes
7	File Checksum	GET	UINT		Checksum of the EDS file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	0	

Table F.12 File Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
0xC9 Instance Attributes					
1	State	GET	USINT	2	
2	Instance Name	GET	STRINGI	(ENG)‘Related EDS and Icon Files’	
3	File Format Version	GET	UINT	1	
4	File Name	GET	STRINGI	(ENG)‘EDSCollection.gz’	
5	File Revision	GET	[USINT, USINT]	[1,1]	[Major Revision, Minor Revision]
6	File Size	GET	UDINT		Size of the loaded file in bytes
7	File Checksum	GET	UINT		Checksum of the EDSCollection file (2s complement of the 16-bit sum of all octets in the file)
8	Invocation Method	GET	USINT	255	
9	File Save Parameters	GET	USINT	0	
10	File Access Rule	GET	USINT	1	
11	File Encoding Format	GET	USINT	1	

Table F.13 File Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x4B	Initiate Upload	No	Yes	
0x4F	Upload Transfer	No	Yes	

TCP/IP Interface Object (0xF5)

Instances Implemented

The number of instances of the TCP/IP Interface Object is always 1, regardless of whether the CPU card contains a single Ethernet port or a dual Ethernet port.

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 1 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum TCP/IP Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of TCP/IP Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[4,[8,9,16,17]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID

Table F.14 TCP/IP Interface Object List of Attributes (Sheet 2 of 2)

Attribute ID	Name	Access	Data Type	Default	Description
7	Maximum ID Number Instance Attributes	GET	UINT	17	Maximum Instance Attribute ID
Instance Attributes					
1	Status	GET	DWORD	2	
2	Configuration Capability	GET	DWORD	32	Any change in the configuration will be updated when the server is restarted.
3	Configuration Control	GET	DWORD	0	IP addresses must be configured statically. DHCP and DNS are not supported.
4	Physical Link Object	GET	[UINT, EPATH]		[Path size, Path to the corresponding Ethernet link object instance] For a dual Ethernet port CPU card, the value is 00 00 (path size of 0). For a single Ethernet port CPU card, the value is 02 00 20 F6 24 01, where 02 00 is the path size (number of 16-bit words), 20 is the 8-bit class segment type, F6 is the Ethernet Link Object class, 24 is the 8-bit instance segment type, and 01 is Instance 1.
5	Interface Configuration	GET	[UDINT, UDINT, UDINT, UDINT, UDINT, STRING]		[IP address, Network mask, Gateway address, 0, 0, null]
6	Host Name	GET	STRING		When converted to ASCII, this displays, "[Product Name]-[Serial Number]". This attribute cannot be set by the scanner.
8	TTL Value	GET/SET	USINT	1	The scanner can set this attribute.
9	Mcast Config	GET/SET	[USINT, USINT, UINT, UDINT]	[Alloc control, Reserved, Num Mcast, Mcast Start Address]	The scanner can set this attribute only if the control is 01 00. 1st and 2nd Byte: This represents the control. When the value is 00 00, the scanner cannot change the number of multicast connections nor the Mcast Start Address. To change these, all eight bytes must be written at once, e.g., 01 00 *xx xx yy yy yy yy*. 3rd and 4th Byte: Number of multicast connections supported by the product in little endian order. 02 00 is the default value. The maximum number of multicast connections supported is two. 5th–8th Byte: Mcast Start Address according to the default algorithm specified in Section 3-5.3 of Volume 2 of the standard.
13	Encapsulation Inactivity Timeout	GET/SET	UINT	120	The scanner can set this value.
16	Active TCP Connections	GET	UINT	1	
17	Non-CIP Encapsulation Messages per Second	GET	UDINT	0	

Table F.15 TCP/IP Interface Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.
0x10	Set Attribute Single	No	Yes	Sets the value of a specific attribute.

Ethernet Link Object (0xF6)

Instances Implemented

The number of instances of the Ethernet Link Object depends on whether the CPU card contains a single Ethernet port or a dual Ethernet port. The value will be 1 for a single Ethernet port and 2 for a dual Ethernet port.

Table F.16 Ethernet Link Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	4	The revision of this CIP Object
2	Max Instance	GET	UINT		The maximum Ethernet Link Object Instance ID
3	Number of Instances	GET	UINT		Total number of Ethernet Link Object Instances
4	Optional Attribute List	GET	[UINT, Array of UINT]	[1,[10]]	[Number of Optional Instance Attributes, List of Optional Instance Attributes]
6	Maximum ID Number Class Attributes	GET	UINT	7	Maximum Class Attribute ID
7	Maximum ID Number Instance Attributes	GET	UINT	11	Maximum Instance Attribute ID
Instance Attributes					
1	Interface Speed	GET	UINT		Speed (MBPS) in use on the corresponding interface
2	Interface Flags	GET	DWORD		See *Table F.17*
3	Physical Address	GET	USINT[6]		MAC address of the corresponding interface
10	Interface Label	GET	STRING		SEL-710-5 interface name, e.g., “PORT 1”
11	Interface Capability	GET	[DWORD, USINT]		[Capability bits, Array Element Count]

Table F.17 Interface Flags Bits Descriptions (Sheet 1 of 2)

Bit Number	Name	Description
0	Link Status	0: The Ethernet interface link is inactive. 1: The link is active.
1	Half/Full Duplex	0: The interface is running half duplex. 1: The interface is running full duplex.

Table F.17 Interface Flags Bits Descriptions (Sheet 2 of 2)

Bit Number	Name	Description
2–4	Negotiation Status	Octal unsigned value: 0: Auto negotiation in progress. 1: Auto negotiation and speed detection failed. Using default values. 2: Auto negotiation failed, but detected speed. 3: Successfully negotiated speed and duplex. 4: Auto negotiation not attempted.
5	Manual Setting Requires Reset	Set to 1.

Table F.18 Ethernet Link Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

Vendor Specific Object (0x64)

Instances Implemented

The SEL-710-5 supports one instance (Instance ID = 1) of the Vendor Specific Object.

Table F.19 Vendor Specific Object List of Attributes

Attribute ID	Name	Access	Data Type	Default	Description
Class Attributes					
1	Revision	GET	UINT	1	The revision of this CIP Object
2	Max Instance	GET	UINT	1	The maximum Vendor Specific Object Instance ID
3	Number of Instances	GET	UINT	1	Total number of Vendor Specific Object Instances
Instance Attributes					
100	Enabled[a]	GET	BOOL		Relay Enabled Status
101	Trip	GET	BOOL		Protection Trip

[a] This attribute reflects the value of the Relay Word bit indicating Enabled status of the SEL-710-5.

Table F.20 Vendor Specific Object Supported Services

Service Code	Service Name	Class	Instance	Description
0x01	Get Attribute All	Yes	Yes	Returns a list of all of the attributes.
0x0E	Get Attribute Single	Yes	Yes	Returns the value of a specific attribute.

CIP Connections and Corresponding Assembly Maps

The SEL-710-5 supports as many as eight simultaneous CIP connections. Of the eight simultaneous connections, as many as two of them can be Class 1 (I/O) connections and as many as six of them can be a combination of Class 3 messages and Unconnected Message Manager (UCMM) messages. Class 3 connections are created internally by the SEL-710-5 when the appropriate connection is made by the EtherNet/IP scanner.

When configuring EtherNet/IP (EIP) on Port 1, you can create as many as six Class 1 (I/O) connection configurations. Of these six, only two can be used simultaneously. Of the six available connection configurations, as many as three can be Exclusive Owner connection configurations. The remaining number of connection configurations must be Input Only connection configurations.

An Exclusive Owner connection configuration contains both a Target to Originator (T->O, data flows from the SEL-710-5 to the scanner) connection and an Originator to Target (O->T, data flows from the scanner to the SEL-710-5) connection. An Input Only connection configuration contains a (T->O) connection only. For every distinct (T->O) connection, the SEL-710-5 automatically creates a Listen Only connection configuration. Listen Only connection configurations do not count against the six Class 1 (I/O) connection configurations. For the SEL-710-5, the types of supported connections are shown in *Table F.21*.

The flow of data is represented via assemblies. Input Assemblies 100, 102, and 104 are always associated with (T->O) connections and Output Assemblies 101, 103, and 105 are always associated with (O->T) connections. Note that these Output Assemblies can also be associated with (T->O) connections. The Input Assemblies can contain both binary input (from *Table L.1*) and analog input (from *Table M.1*) data. The Output Assemblies can contain both binary output and analog output data. Input Assembly 100 and Output Assembly 101 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 1 settings using the **SET E 1** command. Similarly, Input Assembly 102 and Output Assembly 103 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 2 settings using the **SET E 2** command. Input Assembly 104 and Output Assembly 105 consist of data that can be chosen by setting the EtherNet/IP Assembly Map 3 settings using the **SET E 3** command. Each of these assembly maps contains 100 binary input points, 100 analog input points, 32 binary output points, and 32 analog output points. It is important to note that the binary output points can take on the value of any remote bit (SET/CLEAR) or any 89OC/89CC bit (SET by the scanner and pulsed by the SEL-710-5 outside of the EIP library) within the SEL-710-5. The STOP and STR bits are also allowed (SET by the scanner and pulsed by the SEL-710-5 outside of the EIP library). The analog output points can take on the value of NOOP (writing to this point reports no errors and modifies no internal values). All the remote analogs and the active settings group are controllable.

Both the EIP settings on Port 1 and the configured assembly maps are used by the SEL-710-5 to create the Electronic Data Sheet (EDS) file. Only the SEL-710-5 can create and modify the EDS file. Refer to *Electronic Data Sheet File* for more information.

Table F.21 Class 1 Connection Support

Class 1 Connections	Supported Connections
Input Only	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast
Listen Only	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast
Exclusive Owner	Point-to-point Point to-multicast Multicast-to-point Multicast-to-multicast

EtherNet/IP Settings

Table F.22 shows the EtherNet/IP Port 1 settings in the SEL-710-5.

Table F.22 Port 1 EtherNet/IP Protocol Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
ENABLE ETHERNET/IP	Y, N	EEIP := N
CONFIGURATION ID	0–255	CONFIGID := 0
MAJOR EDS REVISION	1–255	MAJOREDS := 1
MINOR EDS REVISION	1–255	MINOREDS := 1
NUMBER OF IP ADDRESSES FOR EIP SCANNER	OFF, 1–8	NUMIP := 1
IP ADDRESS *zzz.yyy.xxx.www*	*zzz*: 1–126, 128–223 *yyy*: 0–255 *xxx*: 0–255 *www*: 0–255	EIPIP1 := 192.168.1.151 EIPIP2 := 192.168.1.152 EIPIP3 := 192.168.1.153 EIPIP4 := 192.168.1.154 EIPIP5 := 192.168.1.155 EIPIP6 := 192.168.1.156 EIPIP7 := 192.168.1.157 EIPIP8 := 192.168.1.158
NUMBER OF I/O CONNECTIONS	1–6	NUMCONN := 1
APPLICATION TYPE	EXCLUSIVE_OWNER, INPUT_ONLY	APPTYP*n* := INPUT_ONLY
INPUT ASSEMBLY	IA1, IA2, IA3, OA1, OA2, OA3	INASSM*n* := IA1
OUTPUT ASSEMBLY	OA1, OA2, OA3	OUTASSM*n* := OA1

Electronic Data Sheet File

EtherNet/IP uses an EDS file to define the interface between the EIP library and the scanner. The scanner uses this information to determine what objects, attributes, and services are supported by the SEL-710-5.

In the SEL-710-5, the EDS file consists of the following sections:

- *File Description Section, [File]*
- *Device Description Section, [Device]*
- *Device Classification Section, [Device Classification]*
- *Parameters Section, [Params]*
- *Assembly Section, [Assembly]*
- *Connections Section, [Connection Manager]*
- *Vendor Specific Object Section*
- *Capacity Section, [Capacity]*
- *Ethernet Link Class, [Ethernet Link Class]*

File Description Section, [File]

The File Description Section of the EDS file contains the entries listed in *Table F.23*.

Table F.23 File Description Section Entries

Name	Keyword	Value
File Description Text	DescText	Contains the product specific name <Prod Name> as specified by the product. It is of the format "<Prod Name> EtherNet/IP Adapter EDS File".
File Creation Date	CreateDate	UTC date value that is hardcoded to match the R-release date of the firmware.
File Creation Time	CreateTime	UTC time value that is hardcoded to match the R-release time of the firmware.
Last Modification Date	ModDate	UTC data value that is determined when the EDS file is generated.
Last Modification Time	ModTime	UTC time value that is determined when the EDS file is generated.
EDS Revision	Revision	The format is MAJOREDS.MINOREDS, where MAJOREDS and MINOREDS are populated by the correspondingly named parameters in the Port 1 settings.

Device Description Section, [Device]

The Device Description Section of the EDS file contains the entries listed in *Table F.24*

Table F.24 Device Description Section Entries (Sheet 1 of 2)

Name	Keyword	Value
Vendor ID	VendCode	SEL Vendor ID number, 865
Vendor Name	VendName	"Schweitzer Engineering Laboratories"
Device Type	ProdType	43

Table F.24 Device Description Section Entries (Sheet 2 of 2)

Name	Keyword	Value
Device Type String	ProdTypeStr	"Generic Device Type"
Product Code	ProdCode	The number derived from the Device Code (DEVCODE as found in the **ID** command of the SEL-710-5) and Configuration ID as provided in the Ethernet port settings
Major Revision	MajRev	The Major Revision is assigned internally by the SEL-710-5
Minor Revision	MinRev	The Minor Revision is assigned internally by the SEL-710-5
Product Name	ProdName	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touchscreen display model) of the SEL-710-5 plus the value of the user-configurable Configuration ID as provided in the Port 1 settings. The general format is "<Default RID>-<Configuration ID>".
Catalog Number	Catalog	Takes on the existing default product name (the default RID string in a two-line display model or the default STRING RID in a touchscreen display model) of the SEL-710-5 plus the value of the user-configurable Configuration ID as provided in the Port 1 settings. The general format is "<Default RID>-<Configuration ID>".
Icon File Name	Icon	SEL7105.ICO
Icon Contents	IconContents	Uncompressed content of characters

Device Classification Section, [Device Classification]

The Device Classification Section of the EDS file contains the entry listed in *Table F.25*.

Table F.25 Device Classification Section Entry

Name	Keyword	Value
Device Classification	Class1	"EtherNetIP"

Parameters Section, [Params]

Each parameter entry is named as *ParamN,* where *N* is a sequential number starting from 1 and ending at the maximum number of parameter object instances as defined in the corresponding assembly map.

All parameters of the EDS file are defined for *ParamN* in *Table F.26*.

Table F.26 Parameters of the EDS File (Sheet 1 of 2)

Label	Value
Reserved	0
Path Size, Path	Left empty
Descriptor	0x0000

Table F.26 Parameters of the EDS File (Sheet 2 of 2)

Label	Value
Data Type	Digitals: BOOL (0xC1) 1 Byte (0 or 1) Analogs: SINT (0xC2) Signed 1 Byte Integer, USINT (0xC6) Unsigned 1 Byte Integer, INT (0xC3) Signed 2 Byte Integer, UINT (0xC7) Unsigned 2 Byte Integer, DINT (0xC4) Signed 4 Byte Integer, UDINT (0xC8) Unsigned 4 Byte Integer, REAL (0xCA) 4 Byte Float, LREAL (0xCB) 8 Byte Float, LINT (0xC5) Signed 8 Byte Integer, or ULINT (0xC9) Unsigned 8 Byte Integer
Data Size (Bytes)	See previous
Name	Takes on the label name as defined in the corresponding assembly map. Names are unique.
Units	The value is “” for digitals. The value is determined internally by the SEL-710-5 for analogs.
Help String	“”
Min, max, default data values	It is 0,1,0 for digitals and ,,0, for analogs
Mult, div, base, offset scaling	It is ,,,, for all instances
Mult, div, base, offset links	It is ,,,, for all instances
Decimal places	0

RPI Parameter

The Requested Packet Interval (RPI) parameter entry falls immediately after the last parameter object instance as defined previously. This RPI parameter entry, Param(N+1), follows the structure detailed in *Table F.27*.

Table F.27 RPI Parameter Structure

Label	Value
Reserved	0
Path Size, Path	,,
Descriptor	0x0004
Data Type	0xC8
Data Size (Bytes)	4
Name	“RPI Range”
Units	“ms”
Help String	“This parameter limits the range of the RPI value”
Min, max, default data values	100000,,1000000
Mult, div, base, offset scaling	1,1000,1,0
Mult, div, base, offset links	,,,,
Decimal Places	1

Assembly Section, [Assembly]

The Assembly Section of the EDS file contains the entries listed in *Table F.28* for all of the available assemblies in the product.

Table F.28 Assembly Section Entries

Label	Value
Name	*Name* reflects the name of the Assembly type and instance, e.g., Input Assembly 1, Output Assembly 1, Input Assembly 2, etc.
Path	Set to "20 04 24 *InstID* 30 03" where InstID is the hexadecimal representation of the Assembly instance ID number.
Size	*Size_Bytes* reflects the total size in bytes of the mapped parameters in the Assembly instance.
Descriptor	0x0000
Reserved	Left empty
Member Size	Each mapped parameter in the corresponding Assembly instance is included in the EDS file using the following format: Member Size, Member Reference, Member Size, Member Reference, ... Member Size, Member Reference *MemberSize* reflects the data size for each parameter mapped in the corresponding Assembly instance in bits.
Member Reference	*MemberReference* reflects the name of each parameter entry "ParamN" (where N is the parameter instance) mapped in the corresponding Assembly instance.

Connections Section, [Connection Manager]

The Connections Section of the EDS file contains the entries listed in *Table F.29*, *Table F.30*, and *Table F.31*.

Table F.29 Input Only Connection Entries (Sheet 1 of 2)

Field	Value
Trigger and transport	0x02030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0
O->T format	Left empty
T->O RPI	Set to "*ParamN*" where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to "*AssemN*" where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains "INPUT ONLY" as part of the string. All names are enumerated, e.g., "INPUT ONLY 1", etc.

Table F.29 Input Only Connection Entries (Sheet 2 of 2)

Field	Value
Help string	“”
Path	Set to “20 04 2C EE 2C *In*” where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.30 Listen Only Connection Entries

Field	Value
Trigger and transport	0x01030002
Connection parameters	0x44640305
O->T RPI	Left empty
O->T size	0
O->T format	Left empty
T->O RPI	Set to “*ParamN*” where *N* is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to “AssemN” where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains “LISTEN ONLY” as part of the string. All names shall be enumerated, e.g., “LISTEN ONLY 1”, etc.
Help string	“”
Path	Set to “20 04 2C ED 2C *In*” where *In* is the hexadecimal representation of the configured input assembly instance ID number.

Table F.31 Exclusive Owner Connection Entries (Sheet 1 of 2)

Field	Value
Trigger and transport	0x04030002
Connection parameters	0x44640405
O->T RPI	Set to *“ParamN*” where *N* is the parameter entry that defines the RPI for the device.
O->T size	Left empty
O->T format	*Output_Assem* is set to *“AssemN*” where *N* is the configured output assembly for the connection point.
T->O RPI	Set to *“ParamN*” where N is the parameter entry that defines the RPI for the device.
T->O size	Left empty
T->O format	*Input_Assem* is set to *“AssemN*” where *N* is the configured input assembly for the connection point.
Connection name string	*Connection_Name* contains “EXCLUSIVE OWNER” as part of the string. All names are enumerated, e.g., “EXCLUSIVE OWNER 1”, etc.

Table F.31 Exclusive Owner Connection Entries (Sheet 2 of 2)

Field	Value
Help string	“”
Path	“20 04 2C *Out* 2C *In*” where *Out* is the hexadecimal representation of the configured output assembly instance ID number and *In* is the hexadecimal representation of the configured input assembly instance ID number.

Vendor Specific Object Section

The Vendor Specific Object Section of the EDS file contains the entries listed in *Table F.32*.

Table F.32 Vendor Specific Object Section Entries

Label	Value
Revision	1
Maximum Instance Number	1
Number of Static Instances	1
Maximum Number of Dynamic Instances	0
Object Name	“Relay Status”
Object Class Code	0x64

Capacity Section, [Capacity]

The Capacity Section of the EDS file contains the entries listed in *Table F.33*.

Table F.33 Capacity Section Entries

Keyword	Value
MaxIOConnections	2
MaxMsgConnections	6

Ethernet Link Class, [Ethernet Link Class]

The Ethernet Link Class Section of the EDS file contains the entries listed in *Table F.34*.

Table F.34 Ethernet Link Class Entries

Keyword	Value
Revision	4
Object_Name	"Ethernet Link Object"
Object_Class_Code	0xF6
MaxInst	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Number_Of_Static_ Instances	It is 2 if a dual Ethernet port CPU card is used. It is 1 if a single Ethernet port CPU card is used.
Max_Number_Of_ Dynamic_Instances	0
InterfaceLabel1	It is “PORT 1” if a single Ethernet port CPU card is used. It is “PORT 1A” if a dual Ethernet port CPU card is used.
InterfaceLabel2	Does not exist if a single Ethernet port CPU card is used. It is “PORT 1B” if a dual Ethernet port CPU card is used.

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Appendix G
IEC 61850 Communications

Features

NOTE: The SEL-710-5 relay ships with a default CID file installed which supports basic IEC 61850 functionality. A new CID file should be loaded if a change in the relay configuration is required. If an invalid CID file is transferred, the relay will reject the file and revert to the previous valid CID file.

The SEL-710-5 Relay uses Ethernet and IEC 61850 to support the following features:

- **SCADA**—Connect as many as seven simultaneous IEC 61850 Manufacturing Message Specification (MMS) client sessions. The SEL-710-5 also supports as many as seven buffered and seven unbuffered report control blocks. See *Table G.39* for Logical Node mapping that enables SCADA control via an MMS browser. Controls support the Direct Normal Security and Enhanced Security (Direct or Select Before Operate) control models.
- **Peer-to-Peer Real-Time Status and Control**—Use GOOSE with as many as 64 incoming (receive) and 8 outgoing (transmit) messages. Virtual bits (VB001–VB128) and Remote Analogs (RA001–RA128) can be mapped from incoming GOOSE messages.
- **Configuration**—Use FTP client software or ACSELERATOR Architect SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the relay.
- **Commissioning and Troubleshooting**—Use software such as AX-S4 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-710-5:

Introduction to IEC 61850

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards. The IEC 61850 standard consists of the parts listed in *Table G.1*. These parts were first published between 2001 and 2004, and they are often referred to as IEC 61850 Edition 1 (Ed1). Selected parts of these standards were released in 2011 and tagged as Edition 2 (Ed2). The SEL-710-5 relay is compliant with Ed2.

It is possible, and even likely, that an installation can have a mixture of devices that conform to either Ed1 or Ed2. The standard supports backwards compatibility, i.e., Ed2 devices can send and receive messages to and from Ed1 devices. However, there are important considerations to be made when adding Ed2 devices to an existing Ed1 system. Please refer to *Potential Client and Automation Application Issues With Edition 2 Upgrades on page F.40* for more information.

Table G.1 IEC 61850 Document Set (Sheet 1 of 2)

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communications requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communications structure for substations and feeder equipment—Principles and models
IEC 61850-7-2	Basic communications structure for substations and feeder equipment—Abstract Communication Service Interface (ACSI)
IEC 61850-7-3	Basic communications structure for substations and feeder equipment—Common data classes
IEC 61850-7-4	Basic communications structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes

Table G.1 IEC 61850 Document Set (Sheet 2 of 2)

IEC 61850 Sections	Definitions
IEC 61850-8-1	SCSM-Mapping to Manufacturing Message Specification (MMS) (ISO/IEC 9506-1 and ISO/IEC 9506-2 over ISO/IEC 8802-3)
IEC 61850-9-1	SCSM-Sampled values over serial multidrop point-to-point link
IEC 61850-9-2	SCSM-Sampled values over ISO/IEC 8802-3
IEC 61850-10	Conformance testing

The IEC 61850 document set, available directly from the IEC at www.iec.ch, contains information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 61850 systems be familiar with the appropriate sections of this standard.

IEC 61850 Operation

Ethernet Networking

IEC 61850 and Ethernet networking are available as options in the SEL-710-5. In addition to IEC 61850, the Ethernet port provides support protocols and data exchange, including FTP and Telnet. Access the SEL-710-5 Port 1 settings to configure all of the Ethernet settings, including IEC 61850 enable settings.

The SEL-710-5 Ethernet port supports IEC 61850 services, including transport of logical node objects, over TCP/IP. The Ethernet port can coordinate a maximum of seven concurrent IEC 61850 MMS sessions.

Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) model to define a set of service and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. You can use these abstract models to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs and CDC attributes are used as building blocks for defining Local Nodes.

UCA2 uses GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains measurement data and other points associated with three-phase metering including voltages and currents. Each IED can contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

You can organize logical nodes into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices, and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table G.2* shows how the A-phase current expressed as MMXUAphsA$cVal is broken down into its component parts.

Table G.2 Example IEC 61850 Descriptor Components

Components		Description
MMXU	Logical Node	Polyphase measurement unit
A	Data Object	Phase-to-ground amperes
PhsA	Sub-Data Object	A-phase
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 61850-5:2013(E) and IEC 61850-7-4:2010(E) for the mandatory content and usage of these LNs. The SEL-710-5 logical nodes are grouped under Logical Devices for organization based on function. See *Table G.3* for descriptions of the Logical Devices in an SEL-710-5. See *Logical Nodes on page F.19* for a description of the LNs that make up these Logical Devices.

Table G.3 SEL-710-5 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

Functional Naming

Substation design typically starts with a one-line diagram and progresses down to the assignment of functions to IEDs. In this top-down approach, the functions are identified and named independently from the IEDs to which they are assigned.

NOTE: Functional naming is not supported by all MMS clients and GOOSE subscribers. Verify support for this feature before configuring functional names in a publishing IED.

Because a logical device is a grouping of logical nodes that perform a certain high-level function at a substation, the associated name often indicates the assigned function. The functional naming feature allows users to name a logical device based on the function it provides independent of the name of the IED to which the function is assigned. The alternative is product naming, which prepends the IED name to the logical device instance to create the logical device name. The functional name is used on the communications interface for all references to data in the logical device.

The SEL-710-5 supports functional naming of logical devices. You can add functional names in Architect for supported Edition 2 relays. To enable it in Architect, navigate to **Edit** > **Project Settings** and select the **Enable functional name editing on Server Model tab of supporting IEDs** check box, as shown in *Figure G.1*.

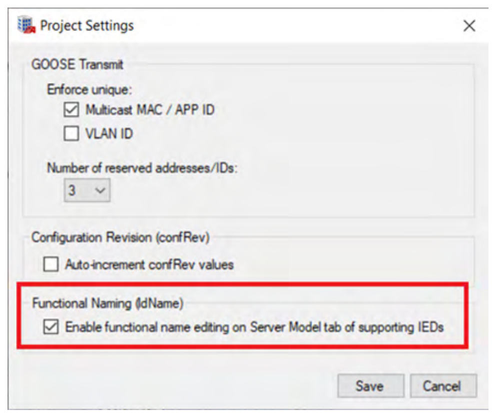


Figure G.1 Enable Functional Naming in Architect

To provide functional names to the logical devices, navigate to the Server Model tab for the IED. Because datasets and control blocks are in the CFG logical device, any functional name given to the CFG logical device instance is used in dataset references, control block references, and in published GOOSE messages, as shown in *Figure G.2*. The IED Server Model also allows the user to change the default logical node prefix and instance values.

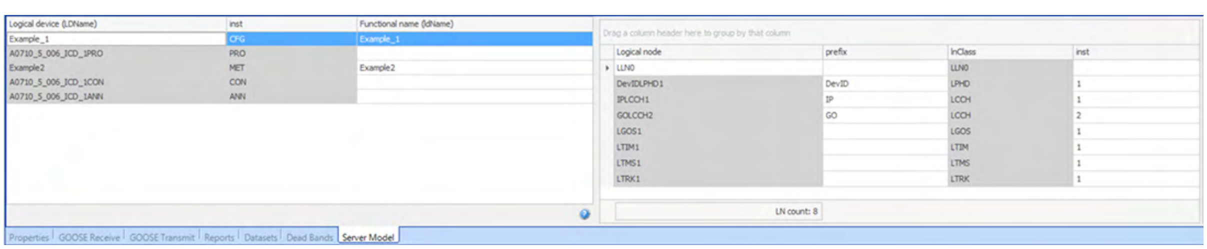


Figure G.2 Server Model View in Architect

MMS

Manufacturing Message Specification (MMS) provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can be unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers. MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from the start, and why the IEC chose to keep it for IEC 61850. MMS associations are discussed within IEC 61850-8-1, clause 10 of the Edition 1 standard.

If MMS authentication is enabled, the device authenticates each MMS association by requiring the client to provide the password authentication parameter with a value that is equal to the Access Level 2 password of the SEL-710-5.

- ➤ If the correct password authentication parameter is not received, the device returns a not authenticated error code.
- ➤ If the correct password authentication parameter value is received, the device gives a successful association response.

Once an authenticated association is established, the device allows access to all supported MMS services for that association.

File Services

The Ethernet file system allows reading or writing data as files. The file system supports FTP and MMS file transfer. The file system provides:

- ➤ A means for the devices to transfer data as files
- ➤ A hierarchical file structure for the device data

The SEL-710-5 supports MMS file transfer with or without authentication; the service is intended to support the following:

- ➤ CID file download and upload
- ➤ Settings Files download and upload
- ➤ Retrieval of events, and reports

MMS file services are enabled or disabled via Port 1 settings. See *Virtual File Interface* for details on the files available for MMS file services. For additional details, see *File Transfer Protocol (FTP) and MMS File Transfer*, *Retrieving COMTRADE Event Files*, and *Retrieving Event Reports Via Ethernet File Transfer*. for details.

SCL Files

Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- ➤ IED Capability Description file (.ICD)
- ➤ System Specification Description (.SSD) file
- ➤ Substation Configuration Description file (.SCD)
- ➤ Configured IED Description file (.CID)

The ICD file described the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the necessary LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

Datasets

IEC 61850 datasets are lists of references to DataObject attributes for the purpose of efficient observation and transmission of data. Architect ICD files come with predefined datasets that can be used to transfer data via GOOSE messages or MMS reports. The datasets listed in *Figure G.3* are the defaults for an SEL-710-5 device. Datasets BRDSet01–BRDSet07 and URDSet01–URDSet07 are preconfigured with common FCDAs to be used for reporting. These datasets can be configured to represent the data you want to monitor. Dataset GPDSet01, which contains breaker status and control data attributes, is used in the default Goose Control Publication.

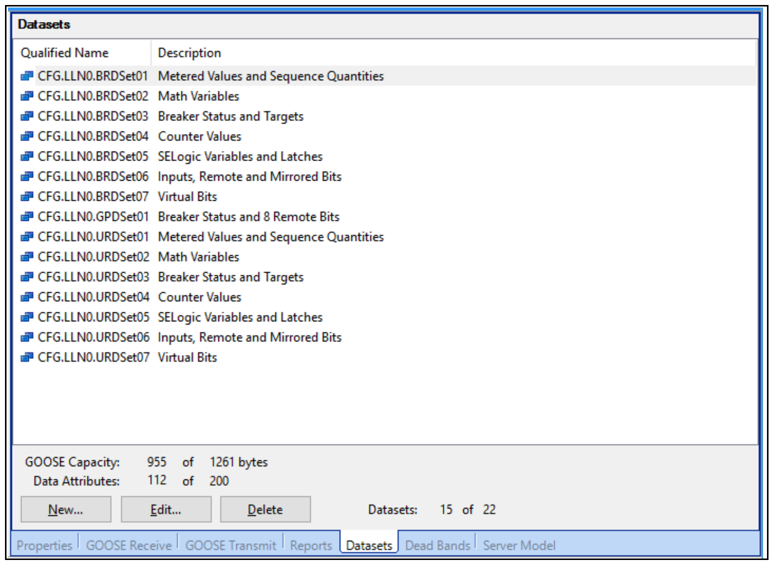


Figure G.3 SEL-710-5 Datasets

- GOOSE: You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.

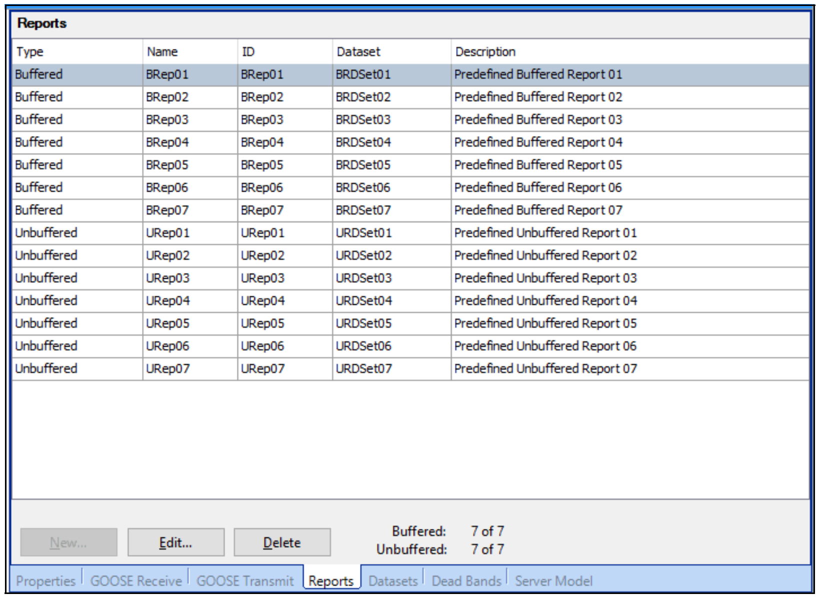
NOTE: Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

- Reports: Fourteen predefined datasets (BRDSet01–BRDSet07 and URDSet01–URDSet07) correspond to the default seven buffered and seven unbuffered reports, respectively. Note that you cannot change the number (14) or type of reports (buffered or unbuffered) within 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.
- MMS: You can use predefined or edited datasets, or create new datasets to be monitored by MMS clients.

Reports

The SEL-710-5 supports buffered and unbuffered report control blocks in the report model as defined in IEC 61850-8-1:2011. The predefined reports shown in *Figure G.4* are available by default via IEC 61850. There are 14 report control blocks, seven buffered reports and seven unbuffered.

NOTE: When configuring buffered and unbuffered reports that contain analog values, only a change in the magnitude values (mag or cVal data attributes) will trigger a data change report.



Type	Name	ID	Dataset	Description
Buffered	BRep01	BRep01	BRDSet01	Predefined Buffered Report 01
Buffered	BRep02	BRep02	BRDSet02	Predefined Buffered Report 02
Buffered	BRep03	BRep03	BRDSet03	Predefined Buffered Report 03
Buffered	BRep04	BRep04	BRDSet04	Predefined Buffered Report 04
Buffered	BRep05	BRep05	BRDSet05	Predefined Buffered Report 05
Buffered	BRep06	BRep06	BRDSet06	Predefined Buffered Report 06
Buffered	BRep07	BRep07	BRDSet07	Predefined Buffered Report 07
Unbuffered	URep01	URep01	URDSet01	Predefined Unbuffered Report 01
Unbuffered	URep02	URep02	URDSet02	Predefined Unbuffered Report 02
Unbuffered	URep03	URep03	URDSet03	Predefined Unbuffered Report 03
Unbuffered	URep04	URep04	URDSet04	Predefined Unbuffered Report 04
Unbuffered	URep05	URep05	URDSet05	Predefined Unbuffered Report 05
Unbuffered	URep06	URep06	URDSet06	Predefined Unbuffered Report 06
Unbuffered	URep07	URep07	URDSet07	Predefined Unbuffered Report 07

Figure G.4 SEL-710-5 Predefined 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 (14) and the type of reports (buffered or unbuffered) cannot be changed. However, by using Architect, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets. For buffered reports, connected clients can edit the report parameters shown in *Table G.4*.

Table G.4 Buffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		BRep01–BRep07
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum timeStamp dataSet 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 returns to zero. Always read as zero.
[b] When disabled, a GI is processed and the report buffered if a buffer has been previously established. A buffer is established when the report is enabled for the first time.

Similarly, for unbuffered reports, connected clients can edit the report parameters shown in *Table G.5*.

Table G.5 Unbuffered Report Control Block Client Access

RCB Attribute	User changeable (Report Disabled)	User changeable (Report Enabled)	Default Values
RptId	YES		URep01–URep07
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		seqNum
			timeStamp
			dataSet
			configRef
			reasonCode
			dataRef
BufTm	YES		250
TrgOps	YES		dchg
			qchg
IntgPd	YES		0
GI		YES[a]	

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted, returns to zero. Always read as zero.

For buffered reports, only one client can enable the RptEna attribute of the BRCB at a time resulting in a client association for that BRCB. Once enabled, the associated client has exclusive access to the BRCB until the connection is closed or the client disables the RptEna attribute. Once enabled, all unassociated clients have read only access to the BRCB.

For unbuffered reports, as many as seven 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-710-5 does not support reservations. Writing any field of the URCB causes the client to obtain its own copy of the URCB-in essence, acquiring a reservation.

Reports are serviced at a 2 Hz rate. The client can set the IntgPd to any value with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The report service rate of 2 Hz results in a report being sent within 500 ms of expiration of the IntgPd. The new IntgPd begins at the time that the current report is serviced.

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 61850 from Sisco, Inc. The settings necessary to browse an SEL-710-5 with an MMS browser are as follows:

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

Time Stamps and Quality

In addition to the various data values, the two attributes quality and t (time stamp) are available at any time. The relay determines the time stamp when it detects a change in quality or data.

The relay applies a time stamp to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion as when it detects a data or quality change. However, there is a difference in how the relay detects the change between the different attribute types. For points that are assigned as SER points, i.e., programmed in the SER report, the relay detects the change as the receipt of an SER record (which contains the SER time stamp) within the relay.

For all other Booleans or Bstrings, the relay detects the change via the scanner, which compares the last state against the previous state to detect the change. For analogs, the scanner looks at the amount of change relative to the deadband configured for the point to indicate a change and apply the timestamp. In all cases, the relay uses these time stamps for the reporting model.

LN data attributes mapped to points assigned to the SER report have 4 ms SER-accurate time stamps for data change events. To ensure that you get SER-quality time stamps for changes to certain points, you must include those points in the SER report. All other LN data attributes are scanned for data changes on a 1/2-second interval and have 1/2-second time-stamped accuracy. See the **SET R** command for information on programming the SER report.

The SEL-710-5 uses GOOSE quality attributes to indicate the quality of the data in its transmitted GOOSE messages. Under normal conditions, all attributes are zero, indicating good quality data. *Figure G.5* shows the GOOSE quality attributes available to devices that subscribe to GOOSE messages from SEL-710-5 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-710-5 sets the Validity attribute to invalid and the Failure attribute to TRUE. Note that the SEL-710-5 does not set any of the other quality attributes. These attributes always indicate FALSE (0). See the Architect online help for additional information on GOOSE Quality attributes.

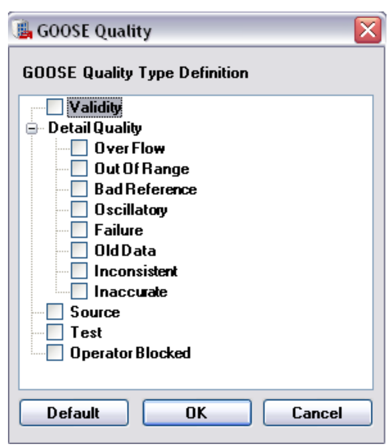


Figure G.5 GOOSE Quality

Control

IEC 61850 Controls

An IEC 61850 server may allow a client to manipulate data related to its outputs, external devices, or internal functions. This is accomplished by the IEC 61850 control model, which provides services to execute control commands. The control models are defined in IEC 61850-7-2 and the mapping to the MMS (Manufacturing Message Specification) application protocol is defined in IEC 61850-8-1. The former describes control functionality while the latter maps the IEC 61850 control primitives to MMS.

The SEL-710-5 Relay supports four different control models:

- Status Only
- Direct with Normal Security
- Direct with Enhanced Security
- SBO with Enhanced Security

The SEL-710-5 Relay supports the above control models for SPC and DPC controllable common data classes (CDCs) as defined in IEC 61850-8-1:2004. Other controllable CDCs defined in the standard are either unsupported or must be configured with the status-only control model. Supported CDCs include remote bits RBGGIOn in the CON Logical Device (LD), and breaker and disconnect controls xxXCBRnn and xxXSWInn in the PRO LD. One control model must be selected during initial IED configuration in Architect and is applied throughout the CID file. This control model will apply to all controls in the IED.

Direct Control Models

The “Direct” control models provide the simplest means to initiate actions on the server. In these models, the client issues a control request via MMS, the server validates the request. Once validated, the server attempts to act upon the request. Note that if multiple clients are trying to perform control actions, the server will do nothing to prevent this.

SBO Control Model

The SBO control model supports the Select or SelectWithValue Service and can be used to prevent multiple clients from performing simultaneous control actions. In this mode, a client has to “reserve” the control object by sending a “select” control command. Once an object is selected, only the client that made the selection is allowed to perform control actions on it. If that client does not send a valid operate request for the object by the time the ten-second selection timer runs out, the object becomes available for selection again. The relay will support as many as ten pending control object selections at any time.

NOTE: When an IED is configured with the SBO with Enhanced Security control model, the sboTimeout attribute of the controllable CDCs in the CID file is set to ten seconds. The time-out is not configurable via Architect.

The attribute stSeld (selected status) of the controllable CDC is set to TRUE when a client successfully selects the control object. The attribute is reset to FALSE when either the control (operate) command is successfully executed, an error occurs, or no operate command is received within the select time-out period. The stSeld attribute may trigger a report just like any data attribute with trigger option.

Security in Control Models

NOTE: The maximum time required for a control operation to be completed should be less than the configured time-out period to avoid erroneous command termination reports including failure.

"Security" in the control model context refers to additional supervision of the status value by the control object. The "enhanced security" models report additional error information on failed operations to the requesting client than the models with "normal security". Enhanced security control models also provide a command termination report indicating if the control actually reached the new state as commanded within a configurable time-out period.

The time-out period between the execution of a control and the generation of a command termination report indicating failure has a default value of 1 s and is configurable via the CID file. This time-out is not configurable via Architect.

Optional Control Configurations

The SEL-710-5 supports the pulse configuration option specified in Clause 6.7 of IEC 61850-7-3. Contact the factory if any of these features is necessary for your application.

Control Interlocking

The SEL-710-5 relay uses control interlocking to supervise the open and close control command from MMS Clients. The relay accomplishes it by checking the CSWI logical node control object against an associated CILO logical node data object. The CILO logical node has two data objects: Enable Open (EnaOpn) and Enable Close (EnaCls). When the associated CILO logical node EnaCls and EnaOpn data objects are not asserted, the relay blocks the control operation and sends the AddCause "Blocked-by-interlocking" to the MMS Client.

Program SELOGIC setting SCBK1BO to supervise opening and SCBK1BC to supervise closing of the circuit breaker/contactor. For example, when SCBK1BO and SCB1BC are asserted, the associated bits, BKENO1 of CILO EnaOpn and BKENC1 of CILO EnaCls, respectively, deassert, and the relay blocks the control command of the circuit breaker/contactor. Use settings 89CB*km* and 89OB*km* (*k* = 2P, 3PL, or 3PE, *m* = switch number [1–8 if *k* = 2P; 1–2 if *k* = 3PL or 3PE]) to supervise closing and opening of the 2- or 3-position disconnect switches, respectively.

Figure G.6 shows how the relay responds to a CSWI logical node write command request from the MMS client when IEC 61850 control interlocking is applied.

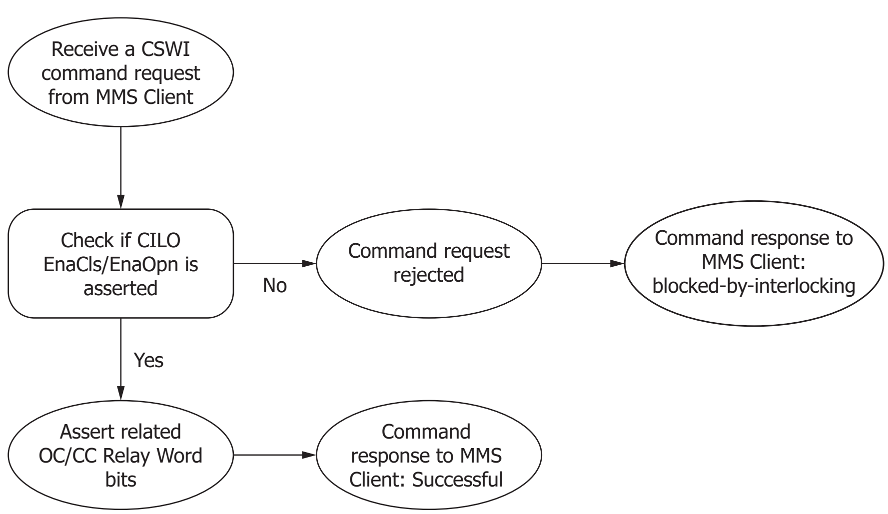


Figure G.6 CSWI Logical Node Direct Operate Command Request

Local/Remote Control Authority

Control commands at a substation originate from one of three levels: remote (network control center) level, station level, or bay level. Under certain operational conditions (e.g., during maintenance), it may be necessary to block control commands from one or more of these levels. The local/remote control feature allows users to enable or disable control authority at any of the three levels. The level at which a control command originates is determined by the value of the origin.orCat (originator category) attribute in the command.

The SEL-710-5 supports the local/remote control feature defined in IEC 61850-7-4. The feature is supported at the IED level with identical and configurable attributes in the LLN0 logical node in each logical device. *Table G.6* describes the attributes and their data sources.

Table G.6 Control Authority Attributes

Attribute	Data Source	Description
LLN0.Loc.stVal	LOC	Control authority at local (bay) level
LLN0.LocSta.stVal	LOCSTA	Control authority at station level
LLN0.MltLev.setVal	MLTLEV	Multilevel control authority

Using these three attributes, you can enable or disable control authority at any of the three switching levels, as shown in *Table G.7*.

Table G.7 Control Authority Settings

LLN0			orCat Value		
Loc.stVal	**LocSta.stVal**	**MltLev.setVal**	**Bay (1 or 4)**	**Station (2 or 5)**	**Remote (3 or 6)**
F	F	F	NA	NA	AA
F	F	T	AA	AA	AA
F	T	F	NA	AA	NA
T	X	X	AA[a]	NA	NA
F	T	T	AA	AA	NA

[a] Commands to CSWI logical nodes that control process level equipment (XCBR/XSWI) are not allowed.
T = True (asserted)
F = False (deasserted)
X = Do not care (true or false)
AA = Command is allowed
NA = Command is not allowed

By default, all three attributes are set to False, so only remote commands are allowed.

You can control the Relay Word bits LOC, LOCSTA, and MLTLEV through SELOGIC control equations. LOCSTA is set to True when the SELOGIC control equation SC850LS asserts and set to False when SC850LS deasserts. LOCSTA may also be controlled through MMS, but if it is set to True through SELOGIC control equations, it cannot be set to False through MMS.

In the SEL-710-5, you can place only the XCBR and XSWI logical nodes in local mode by asserting the LOCAL Relay Word bit. This blocks all control commands to the associated CSWI logical nodes.

Control Requests

IEC 61850 control services are implemented by reading and writing to pseudovariables in the relay in response to MMS requests. Similar to how client requests are generated and mapped to MMS read or write service requests, server actions are also mapped to internal commands, read and write actions and MMS information report messages. In the case of an unsuccessful control request, the relay will send the appropriate response PDU indicating that there was a problem and an MMS information report that contains more detailed information about the problem that occurred.

When writing controls, the client must select and write the entire Oper, SBOw or Cancel structure to the relay. See *Figure G.7* for the attributes of the CON Logical Device and ST and CO functional constraints (FC) of LN RBGGIO1 used for controls of RB01 through RB08.

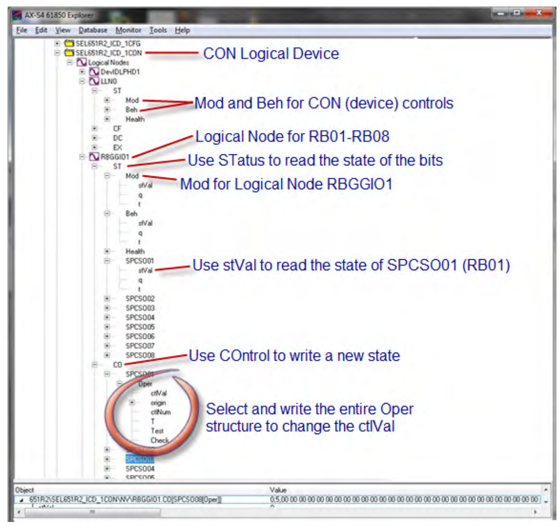


Figure G.7 MMS Client View of the CON Logical Device

Control Error Messages

If a control request results in an error condition, the relay will respond with an AddCause value in an MMS information report. See Clause 20.5.2.9 of IEC 61850-7-2 for additional information on the AddCause values. The SEL-710-5 Relay supports the AddCause values in *Table G.8*as part of the LastApplError information report.

Table G.8 AddCause Descriptions (Sheet 1 of 2)

AddCause Enumeration	AddCause Description	Error Condition
0	Unknown	No other AddCause value defined within this section applies
2	Blocked-by-switching-hierarchy	Logical node is set to local mode, i.e., Loc.stVal = True
3	Select-failed	Originator category not allowed to issue control commands or SelectWithValue operation fails
4	Invalid-position	For controls with enhanced security, an AddCause of “Invalid-position” (4) will be sent if the control status changes to an unexpected value. If no control status change is detected after the operate time-out period, an AddCause of “Time-limit-over” (16) will be sent.
5	Position-reached	Control status is already at the desired state

Table G.8 AddCause Descriptions (Sheet 2 of 2)

AddCause Enumeration	AddCause Description	Error Condition
6	Parameter-change-in-execution	Control object is already selected by the client, and 1. Logical node is set to local mode i.e., Loc.stVal = true, or 2. Originator category not allowed to issue control commands
8	Blocked-by-mode	Mode of logical device or node is not ON
10	Blocked-by-interlocking	Control operation of switch device failed due to interlock check
12	Command-already-in-execution	Execution of a previous control is not completed
13	Blocked-by-health	Health of logical device or node is not OK
16	Time-limit-over	CommandTermination gives a negative response. (The control failed to reach its intended state prior to time-out)
18	Object-not-selected	Cancel operation fails

Any AddCause value not specified above is not supported. Control CDC data attributes which are associated with unsupported AddCause values and are not part of a control structure will be accepted but ignored. For example, the attribute CmdBlk.stVal which is associated with the AddCause value "blocked-by-command" and is not part of a SBOw, Oper or Cancel structure will be ignored.

Group Switch Via MMS

The Group Switch feature in IEC 61850 is primarily a convenience feature for users so that they can institute a settings group switch from an IEC 61850 client without having to revert to the command line or some other tool. However, this has great potential for integration with IEC 61850 SCADA systems which would be able to control setting groups through IEC 61850 MMS.

The IEC 61850 specification outlines a method for switching the current settings group to another preconfigured settings group. The setting group control block, or SGCB, contains the SettingControl element which enables settings group control. An SEL-710-5 CID file that supports group switch functionality will only contain one SGCB. The SGCB contains the number of settings groups in the relay and may also contain the current active setting group, ActSG. Note that if the CID file contains a value for ActSG, it will be ignored and the relay will use the actual active setting group value for ActSG at the time of CID file download.

When the IEC 61850 functions of the relay are enabled, the selectActiveSG service allows an MMS client to request that the relay change the active setting group. The MMS client can request a group switch by writing a valid setting group number to ActSG. The relay updates the ActSG value under the following conditions:

- The value written to ActSG is valid and not the current active group
- There is no group switch in progress
- The setting of the active group was successful.

Note that if the value written to ActSG is the same as the current group, the relay will not attempt to switch settings groups. Please refer to *Multiple Settings Groups on page 4.103* for more information on setting group selection.

Service Tracking

The IEC 61850 standard defines many services to be provided by an IED (server). These services include control services, reporting services, logging services, and group switch control services. IEC 61850 Edition 2 defines the service tracking feature to allow these services to be reported or logged, whether they succeed or fail.

The SEL-710-5 supports the service tracking feature for control commands, report control block edits, and group switch selection. You can report these services.

Tracking of these services is enabled by data objects in the service tracking logical node LTRK. *Table G.9* lists the service tracking data objects. Their data attributes mirror those in the service request or in the control block that was the target of the service request.

Table G.9 Service Tracking Data Objects

Data Object	CDC	Description
SpcTrk	CTS	Tracks control service requests targeted at a controllable single-point object
DpcTrk	CTS	Tracks control service requests targeted at a controllable double-point object
EncTrk	CTS	Tracks control service requests targeted at a controllable enumerated status object
UrcbTrk	UTS	Tracks unbuffered report control block edits
BrcbTrk	BTS	Tracks buffered report control block edits
SgcbTrk	STS	Tracks active settings group selection

Refer to *Table G.41* for information regarding the available attributes in each tracking data object.

Each tracking data object includes the data attributes objRef, serviceType, and errorCode. The attribute objRef provides the reference to the control object or control block instance that was the target of the service request. The attribute serviceType provides an enumerated value for the specific service requested or executed. *Table G.10* defines the service type enumerations.

Table G.10 IEC 61850 Service Type Enumeration (Sheet 1 of 2)

Service Type	Service Name	Description
16	SelectActiveSG	Active settings group switch request
24	SetBRCBValues	Write request on one or more of the following buffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, PurgeBuf, EntryID, or GI
26	SetURCBValues	Write request on one or more of the following unbuffered report control block attributes: RptID, RptEna, OptFlds, BufTm, TrgOps, IntgPd, Resv, or GI
44	SelectWithValue	Select control request
45	Cancel	Cancel control request

Table G.10 IEC 61850 Service Type Enumeration (Sheet 2 of 2)

Service Type	Service Name	Description
46	Operate	Operate control request
47	CommandTermination	Control processing completed on a control object configured with enhanced security control model
54	InternalChange	Report control block has been automatically disabled, i.e., RptEna is set to False after a loss of association with the client

The attribute errorCode provides the error code that indicates whether the service was successful or unsuccessful. *Table G.11* lists the codes and the corresponding ACSI errors.

Table G.11 IEC 61850 ACSI Service Error

Error Code	ACSI Error
0	no-error
1	instance-not-available
3	access-violation
5	parameter-value-inappropriate
6	parameter-value-inconsistent
7	class-not-supported
8	instance-locked-by-other-client
10	type-conflict
11	failed-due-to-communications-constraint
12	failed-due-to-server-constraint

When creating datasets to track the services through information reporting, it is important to include the tracking data objects as a whole object (FCD—functionally constrained data), and not as individual data attributes (FCDA—functional constrained data attribute). Only the objRef attribute has a trigger option (dupd—data update) and can trigger a report. The dupd trigger option must also be enabled in the report control block that is reporting changes in the tracking data objects.

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 Architect software. Also, configure outgoing GOOSE messages for SEL devices in Architect. See the Architect online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference) in each outgoing message and an Ethernet multicast group address. Devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages.

NOTE: Virtual bits and remote analogs mapped to GOOSE subscriptions retain their state until they are overwritten, a new CID file is loaded, or the device is restarted. To reset the virtual bits and remote analogs by restarting the device, issue 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 by using the Architect software. See the VB*nnn* bits in *Table G.34* 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-710-5 virtual bits for controls, you must create SELOGIC control equations to define these operations. The Virtual Bit Logical Nodes only contain Virtual Bit status, and only those Virtual Bits that are assigned to an SER report are able to track bit transitions (via reporting) between LN data update scans.

The relay is capable of receiving analog values via peer-to-peer GOOSE messages. Remote Analogs (RA001–RA128) are analog inputs that you can map to values from incoming GOOSE messages.

GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2011(E), IEC 61850-7-2:2010(E), and IEC 61850-8-1:2011(E) via the Ethernet port.

Outgoing GOOSE messages are processed within the following constraints:

- You can define as many as eight datasets for outgoing GOOSE messages consisting of any data attribute (DA) from any logical node. You can map a single DA to one or more outgoing GOOSE datasets, or one or more times within the same outgoing GOOSE dataset. You can also map a single GOOSE dataset to multiple GOOSE control blocks. The number of unique Boolean variables is limited to a combined total of 128 digital bits across all eight outgoing messages.
- The relay transmits all configured GOOSE immediately upon successful initialization. If a GOOSE message is not retriggered; then, following the initial transmission, the relay retransmits that GOOSE based on the minimum time and maximum time configured for that GOOSE message. The first transmission occurs immediately on triggering of an element within the GOOSE dataset. The second transmission occurs Min. Time later. The third transmission occurs Min. Time after the second transmission. The fourth transmission occurs twice Min. Time after the third transmission. All subsequent transmissions occur at the Max Time interval. For example, a message with a Min. Time of 4 ms and Max. Time of 1000 ms is transmitted upon triggering, then retransmitted at intervals of 4 ms, 4 ms, 8 ms, and then at 1000 ms indefinitely or until another change triggers a new GOOSE message (See IEC 61850-8-1, Sec. 18.1). The default Min. Time value is 8 ms. This is also the suggested Min. Time value to use.
- 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-710-5 maintains the configuration of outgoing GOOSE through a power cycle and device reset.

Incoming GOOSE messages are processed within the following constraints:

- You can configure the SEL-710-5 to subscribe to as many as 64 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-710-5 recognizes incoming GOOSE messages as valid based on the following content. Any GOOSE message that fails these checks is rejected.
  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference
- Rejection of all DA contained in an incoming GOOSE, based on the accumulation of the following error indications created by inspection of the received GOOSE:
  - **Configuration Mismatch**: the configuration number of the incoming GOOSE changes.
  - **Needs Commissioning**: this Boolean parameter of the incoming GOOSE is true.
  - **Test Mode**: this Boolean parameter of the incoming GOOSE is true.
  - **Decode Error**: the format of the incoming GOOSE is not as configured.
- The SEL-710-5 discards incoming GOOSE under the following conditions:
  - after a permanent (latching) self-test failure
  - when the relay is disabled
  - when EGSE is set to No

Link-layered priority tagging and virtual LAN is supported as described in Annex C of IEC 61850-8-1:2011.

Simulation Mode

The SEL-710-5 relay can be configured to operate in simulation mode.

In this mode, the SEL-710-5 continues to process normal GOOSE messages until a simulated GOOSE message is received for a subscription. Once a simulated GOOSE message is received, only simulated GOOSE messages are processed for that subscription. The simulated mode only terminates when LPHDSIM is returned to FALSE. When the relay is not in simulation mode, only normal GOOSE messages are processed for all subscriptions.

A user can place the SEL-710-5 in simulation mode by setting LPHDSIM (CFG.DevIDLPHD1.Sim.stVal) to TRUE via MMS messaging.

Alternatively, you can use SELOGIC variable SC850SM to set LPHDSIM. The rising edge of SC850SM sets LPHDSIM, and the falling edge of SC850SM clears LPHDSIM. When you use SC850SM to enter simulation mode, the relay rejects MMS attempts to enter or exit simulation mode until SC850SM deasserts.

IEC 61850 Mode/Behavior

The IEC 61850-7-4:2010 standard defines the behavior of the different modes to facilitate testing. The different modes are only available in IEDs with IEC 61850 Edition 2 support.

SEL-710-5 relays support the following modes:

- On
- Blocked
- Test
- Test/Blocked
- Off

IEC 61850 Behavior is determined by the logical device mode and its logical node mode according to the IEC 61850 standard. For SEL-710-5 relays, the selected IEC 61850 Mode/Behavior applies to the entire IED, including all the logical devices and all the logical nodes. The behavior of the IED is always the same as the selected mode. *Table G.12* describes the available services based on the mode/behavior of the IED.

Table G.12 IEC 61850 Services Based on Mode/Behavior

Mode	MMS	GOOSE Publication and Subscription
On	Available	Available
Blocked	Available	Available
Test	Available	Available
Test/Blocked	Available	Available
Off	No services[a]	Publication[b]

[a] All MMS control requests to change the mode with Test = false will be processed.
[b] GOOSE publication in Off mode is disabled if EOFFMTX = N.

The analog quantity I850MOD is an enumerated number that corresponds to mode and behavior as shown in *Table G.13*. One way to view the value of this analog quantity is by assigning it to a math variable.

Table G.13 Analog Quantity I850MOD Status Based on the Selected IEC 61850 Mode/Behavior (Sheet 1 of 2)

I850MOD	IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked

Table G.13 Analog Quantity I850MOD Status Based on the Selected IEC 61850 Mode/Behavior (Sheet 2 of 2)

I850MOD	IEC 61850 Mode/Behavior
5	Off
0	Not Supported

Mode/Behavior Control

Enable Mode/Behavior Control

IEC 61850 Mode/Behavior, by default, is disabled in SEL-710-5 relays. To enable IEC 61850 Mode/Behavior, you must set the Port 1 setting E61850 equal to Y. To enable IEC 61850 Mode/Behavior control, you must set port setting E850MBC equal to Y and the CID file setting controllableModeSupported to True. You can set the controllableModeSupported setting by selecting **Enable control of IEC 61850 Mode/Behavior** when adding an IED to an ACSELERATOR Architect SEL-5032 Software project, as shown in *Figure G.8*.

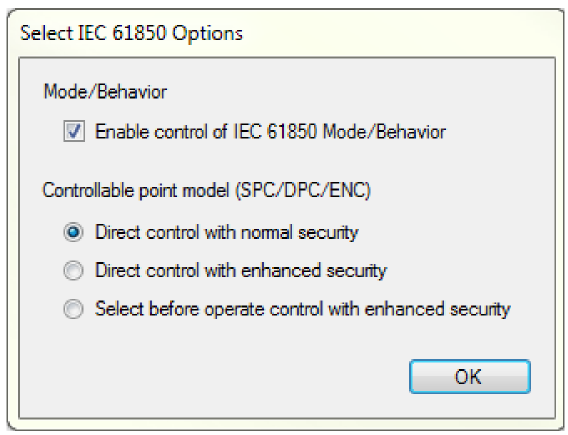


Figure G.8 Set controllableModeSupported = True

Enhances Secure Mode Control

Relay setting E850MBC and CID file setting controllableModeSupported provide security to prevent accidental switching into an unplanned IEC 61850 Mode/Behavior during normal operations. For example, following IED testing, a technician can disable unplanned switching of IEC 61850 Mode/Behavior by setting E850MBC to N after switching the relay back to On mode.

Change Mode Via MMS or SELOGIC

If IEC 61850 Mode/Behavior is set as controllable, you can control the IEC 61850 Mode/Behavior via MMS writes to the LLN0 logical node mode data object (Mod.ctlVal) in logical device CFG. Note that Mod.ctVal in other logical devices does not accept MMS writes. See *Table G.14* for the list of writable values.

Table G.14 IEC 61850 Mode/Behavior List of Writable Values

Write Values to Mod.ctVal in Logical Device CFG	Selected IEC 61850 Mode/Behavior
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off

You can also control IEC 61850 Mode/Behavior through use of the **SET G** command with protection SELOGIC variables SC850TM and SC850BM on the left side of the SELOGIC control equations. These variables are the SELOGIC controls for the Test mode and the Blocked mode, respectively.

Table G.15 IEC 61850 Mode/Behavior Evaluated States of SC850TM and SC850BM

SC850TM	SC850BM	Selected IEC 61850 Mode/Behavior
0	0	See note[a]
1	0	Test
0	1	Blocked
1	1	Test/Blocked
See note[b]	See note[b]	Off

[a] The SELOGIC controls have higher priority than MMS clients in controlling the Test mode and Blocked mode. When SC850TM and SC850BM both evaluate to 0 (false), IEC 61850 Mode/Behavior control is available to MMS clients. If either SC850TM or SC850BM evaluates to 1 (true), SELOGIC determines the IEC 61850 Mode/Behavior of the IED regardless of MMS control values.

[b] You cannot control Off mode by using SC850TM and SC850BM. When an MMS client causes the IED to be in Off mode, the SELOGIC controls are disabled and SC850TM and SC850BM are not evaluated.

EXAMPLE G.1 Change Mode Via SELOGIC

In this example, Pushbuttons PB01 and PB02 control SC850TM. Pushbuttons PB03 and PB04 control SC850BM. If you press PB01, the relay enters Test mode. If you press PB03, the relay transitions from Test mode into Test/Blocked mode. Press PB02 and PB04 to reset Test mode and Blocked mode, respectively.

```
=>>SHO L <Enter>

Latch Bits Eqns
SET01    := PB01
RST01    := PB02
SET02    := PB03
RST02    := PB04
```

```
=>>SHO G <Enter>

IEC 61850 Mode/Behavior Configuration
SC850BM    := LT02
SC850TM    := LT01
```

Mode and Behavior Control

Regardless of mode (On, Blocked, Test, Test/Blocked, Off) the Mod, Beh, and Health quality bitstring will always be quality.validity = Good, quality.failure = False, and quality.test = False. This behavior differs from and is independent of behavior during the use of the **TEST DB** command.

Incoming Messages Processing

IEC 61850 incoming data processing is jointly determined by quality validity, test, and operatorBlocked. SEL-710-5 relays, by default, check if the quality operatorBlocked equals False; if not, the relays treat the messages as invalid. You can disable the default check by changing the quality mask of GOOSE subscriptions. *Figure G.9* illustrates the default quality check for GOOSE subscription in SEL-710-5 relays.

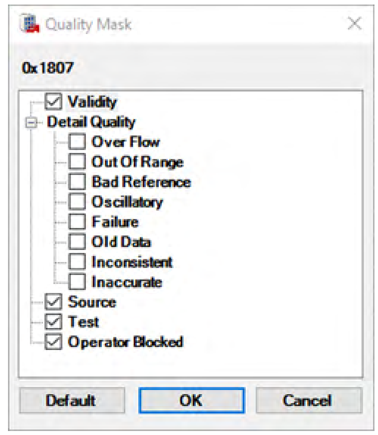


Figure G.9 Default Quality Check on GOOSE Subscription if Quality is Present

Relay Operation for Different IEC 61850 Modes/Behaviors

Mode: On

In On mode, the relay operates as normal; it reports IEC 61850 Mode/Behavior status as On and processes all inputs and outputs as normal. If the quality of the subscribed GOOSE messages satisfies the GOOSE processing (see *GOOSE Processing*), the relay processes the received GOOSE messages as valid. *Table G.16* and *Table G.17* illustrate how the relay handles incoming and outgoing messages while in On Mode.

Table G.16 IEC 61850 Incoming Message Handling in On Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Processed	Processed as invalid
GOOSE	Processed	Processed as invalid

Table G.17 IEC 61850 Outgoing Message Handling in On Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	False
GOOSE	False

Figure G.10 illustrates the On Mode/Behavior.

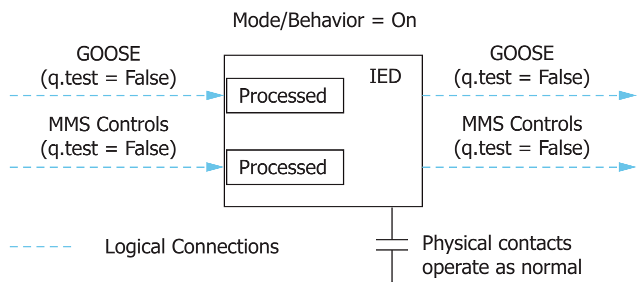


Figure G.10 Relay Operations in On Mode

Mode: Blocked

Blocked mode is similar to On mode, but in Blocked mode, none of the physical contact outputs are operated. However, in Blocked mode, control bits, such as remote bits and output contact bits, do continue to operate. *Figure G.11* illustrates the Blocked Mode/Behavior.

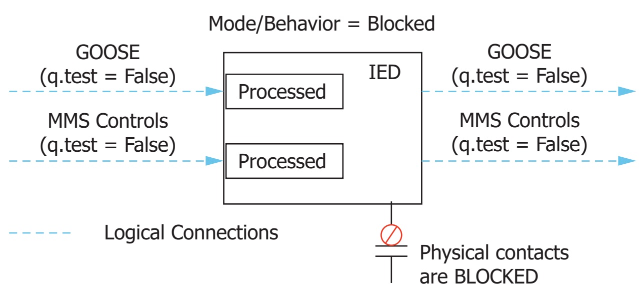


Figure G.11 Relay Operations in Blocked Mode

Mode: Test

In Test mode, the relay processes valid incoming test signals or normal messages and operates physical contact outputs, if triggered. In this mode/behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False—see *GOOSE Processing*), the relay processes the received GOOSE messages as valid. *Table G.18* and *Table G.19* illustrate how the relay handles incoming and outgoing messages while in Test Mode.

Table G.18 IEC 61850 Incoming Message Handling in Test Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Message With Quality Test Bit Set to True (1)
MMS	Not Processed	Processed
GOOSE	Processed	Processed

Table G.19 IEC 61850 Outgoing Message Handling in Test Mode

IEC 61850 Messages	Outgoing Message Quality Test Bit Status
MMS	True
GOOSE	True

Figure G.12 illustrates the Test Mode/Behavior.

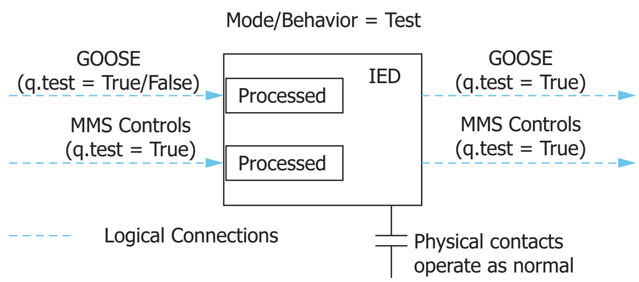


Figure G.12 Relay Operations in Test Mode

Mode: Test/Blocked

In Test/Blocked mode, the relay processes valid incoming test signals or normal messages but blocks any physical contact outputs from operating. In this mode/behavior, outgoing MMS and GOOSE messages have the quality test bit set to True if the quality test bit is present. If the quality of the subscribed GOOSE messages satisfies the user-defined quality type definition (regardless of whether the quality test bit is set to True or False— see *GOOSE Processing*), the relay processes the received GOOSE messages as valid.

Figure G.13 illustrates the Test/Blocked Mode/Behavior.

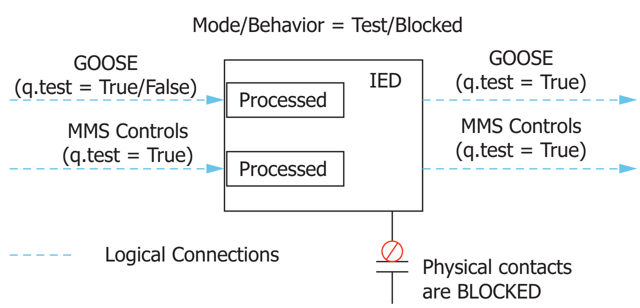


Figure G.13 Relay Operations in Test/Blocked Mode

Mode: Off

In Off mode, the relay no longer processes incoming GOOSE messages. The relay processes MMS control requests to change the IEC 61850 Mode/Behavior if the quality Test bit is set to False. In this mode, the relay is in a disabled state and it no longer trips any physical contact outputs. The Relay Word bit ENABLED is set to False. The device processes MMS control requests to change the active mode of IEC 61850 Mode/Behavior if the quality test bit of the control is set to False. If EOFFMTX is set to Y, the relay continues to transmit GOOSE messages with the quality test bit set to False (0) and the validity set to Invalid (01) if the quality bit is present in the messages. If EOFFMTX is set to N, the relay does not transmit GOOSE messages in this mode. *Table G.20* and *Table G.21* describe how the relay handles incoming and outgoing messages while in Off Mode.

Table G.20 IEC 61850 Incoming Message Handling in Off Mode

IEC 61850 Messages	Incoming Message With Quality Test Bit Set to False (0)	Incoming Messages With Quality Test Bit Set to True (1)
MMS	Relay Only Processes Messages to Control the Mode	Not Processed
GOOSE	Not Processed	Not Processed

Table G.21 IEC 61850 Outgoing Message Handling in Off Mode

IEC 61850 Messages	Outgoing Message Quality Validity Bit
MMS	Invalid
GOOSE	Invalid

Figure G.14 illustrates the Off Mode/Behavior.

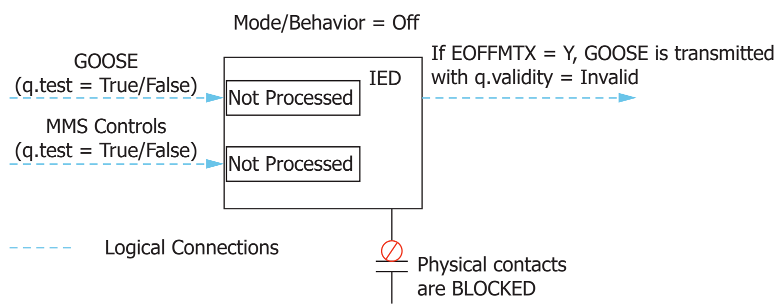


Figure G.14 Relay Operations in Off Mode

IEC 61850 Configuration

Settings

Table G.22 lists IEC 61850 settings. IEC 61850 settings are only available if your device includes the optional IEC 61850 protocol. Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with Architect.

Table G.22 IEC 61850 Settings

Label	Description	Range	Default
E61850	Enables IEC 61850 protocol	Y, N	N
EGSE[a]	Enables IEC 61850 GSE	Y[b], N	N
EMMSFS[a]	Enables MMS file services	Y[b], N	N
E850MBC	Enables IEC 61850 Mode/Behavior Control	Y[b], N	N
EOFFMTX	Enables Goose Tx in Off Mode	Y[b], N	N

[a] Settings EGSE and EMMSFS are hidden when E61850 is set to N.
[b] Requires that E61850 be set to Y.

ACSELERATOR Architect Software

Architect allow you to design and commission IEC 61850 substations containing SEL IEDs. Use Architect to perform 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 provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit deadband settings for measured values.

NOTE: The ICD and CID files of other manufacturers must have IEC 61850 outgoing GOOSE messages with Application IDs (APPIDs) of exactly four characters and VLAN IDs of exactly three characters so that the relay can successfully subscribe to them. If you attempt to configure a relay to subscribe to a GOOSE message that does not meet these criteria, the relay will reject the CID file upon download. Edit the ICD and CID files of other manufacturers prior to importing them into Architect by adding leading zeros to the APPID and VLAN ID of outgoing GOOSE messages, as necessary.

Architect provides a graphical user interface (GUI) for you to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, you first place icons representing IEDs in a substation container, then edit the outgoing GOOSE messages or create new ones for each IED. You 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 you to map the data seamlessly into SEL IED logic. See the Architect online help for more information.

SEL ICD File Versions

Architect version R.1.1.69.0 and later supports multiple ICD file versions for each type of IED in a project. Because relays with different firmware versions may require different CID file versions, users can manage the CID files of all IEDs within a single project.

Please ensure that you work with the appropriate version of Architect relative to your current configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL relay, obtain the latest version of Architect and select the appropriate ICD version(s) for your needs. 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-710-5 ICD files can be found in *Table A.10*.

The Logical Nodes description detailed in this manual revision corresponds to the SEL-710-5 006 ICD file. Information about the previous SEL-710-5 004 ICD files can be found in the previous manual revisions. Please refer to *Table A.10* to find the manual revision corresponding to the ICD file you are using.

Logical Nodes

Each logical device (LD) has a set of common data objects at the top level LN0. These represent the current state of the device, as well as some informational data. These data objects are: Mod (Mode), Beh (Behavior), Health, and NamPlt.See below for a brief description of each object.

Mode

The SEL-700 series relays include at the top-level LN0 within each LD the following enumerations for Mod stVal:

Mod stVal Enumeration	Description
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	IEC 61850 Mode/Behavior Disabled

The top-level logical node of each LD also includes the following Mod attributes:

Mod.q represents quality.

Mod.t represents time stamps.

Mod.stVal represents the current mode/behavior.

You can control IEC 61850 Mode/Behavior via LLN0COMod$Oper in your CFG logical device.

Behavior

The SEL-700 series relay LNs include the following enumerations for **Beh stVal**:

Beh stVal Enumeration	Description
1	On
2	Blocked
3	Test
4	Test/Blocked
5	Off
0	IEC 61850 Mode/Behavior Disabled

Logical nodes also include the following Beh attributes:

Beh q and **Beh t** per the *Time Stamps and Quality* section.

Health

The SEL-700 series relays include at the top-level LN0 within each LD the following enumerations for **Health stVal**:

Health stVal Enumeration	Health stVal Value	Description
1	Ok	RELAY_EN Relay Word bit = 1
3	Alarm	RELAY_EN Relay Word bit = 0

The top-level logical node of each LD also includes the following Health attributes:

Health q and **Health t** per the *Time Stamps and Quality* section.

NamPlt

The top-level LN0 of each LD includes the following NamPlt attributes:

- NamPlt vendor which is set to "SEL".
- NamPlt swRev which contains the relay FID string value
- NamPlt d, which is the LD description.

Logical Node Extensions

The following Logical Nodes and Data Classes were created in this device as extensions to the IEC 61850 standard, in accordance with IEC 61850 guidelines.

Table G.23 New Logical Node Extensions

Logical Node	IEC 61850	Description or Comments
Arc-Flash Detection	PAFD	This LN shall be used to represent arc-flash detection status.
Thermal Measurements (for equipment or ambient temperature readings)	MTHR	This LN shall be used to represent values from RTDs and to calculate thermal capacity and usage mainly used for thermal monitoring.
Demand Metering Statistics	MDST	This LN shall be used for calculation of demand currents in a three-phase system. This shall not be used for billing purposes.
Motor Measurement Data	MMOT	This LN shall be used to represent motor measurement data.
Metering Statistics	MSTA	This LN shall be used for power system metering statistics.
Physical Communication Channel Supervision	LCCH	This LN is used for supervision of physical communication channels
GOOSE Subscription	LGOS	This LN is used for GOOSE subscription statistics
Time Master Supervision	LTMS	This LN is used for time synchronization master supervision

Table G.24 defines the data class Arc-Flash Detection. This class represents Arc-Flash Detection status.

Table G.24 Arc-Flash Detection Logical Node Class Definition

PAFD Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Status Information				
Str	ACD	Start		E
Op	ACT	Operate	T	E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.25 defines the data class, Thermal Metering Data. This class is a collection of simultaneous measurements (or evaluations) that represent the RTD thermal metering values. Valid data depend on the presence and configuration of the RTD module(s).

Table G.25 Thermal Metering Data Logical Node Class Definition

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
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 G.26 defines the data class Demand Metering Statistics. This class is a collection of demand currents and energy.

Table G.26 Demand Metering Statistics Logical Node Class Definition

MDST Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured Values				
NegVArh	BCR[c]	Reactive energy supply (default supply direction: energy flow towards busbar)		E
DmdWh	BCR[c]	Real energy demand (default demand direction: energy flow from busbar away)		E
PosVArh	BCR[c]	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.
[c] For IEC 61850 Edition 1 relays, this data object is defined as MV common data class.

Table G.27 LCCH Physical Communication Channel Supervision (Sheet 1 of 2)

LCCH 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, Clause 22.		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
ChLiv	SPS	Physical channel status		M
RedChLiv	SPS	Physical channel status of redundant channel		C
FerCh	INS	Frame error rate on this channel		O
RedFerCh	INS	Frame error rate on redundant channel		O

Table G.27 LCCH Physical Communication Channel Supervision (Sheet 2 of 2)

LCCH Class				
Measured and Metered Values				
RxCnt	BCR	Number of received messages		O
RedRxCnt	BCR	Number of received messages on redundant channel		O
TxCnt	BCR	Number of sent messages		O
Controls				
RsStat	SPC	Reset device statistics		E
Settings				
NetMod	ENG	Network mode		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.28 LGOS GOOSE Subscription (Sheet 1 of 2)

LGOS 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, Clause 22.		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
NdsCom	SPS	Subscription needs commissioning		O
St	SPS	Status of the subscription		M
SimSt	SPS	Status showing that Sim messages are received and accepted		O
LastStNum	INS	Last state number received		O
LastSqNum	INS	Last sequence number received		E
LastTal	INS	Last time-allowed-to-live received		E
ConfRevNum	INS	Expected configuration revision number		O
RxConfRevNum	INS	Configuration revision number of the received messages		O
ErrSt	ENS	Current error status of the subscription		E
OosCnt	INS	Number of out-of-sequence (OOS) errors		E
TalCnt	INS	Number of time-allowed-to-live violations		E
DecErrCnt	INS	Number of messages that failed decoding		E
BufOvflCnt	INS	Number of messages lost due to buffer overflow		E

Table G.28 LGOS GOOSE Subscription (Sheet 2 of 2)

LGOS Class				
MsgLosCnt	INS	Number of messages lost due to OOS errors (estimated)		E
MaxMsgLos	INS	Max. number of sequential messages lost due to OOS error (estimated)		E
InvQualCnt	INS	Number of mapped incoming GOOSE data with invalid quantity		E
Measured and Metered Values				
TotDwnTm	MV	Total downtime in seconds		E
MaxDwnTm	MV	Maximum continuous downtime in seconds		E
Controls				
RsStat	SPC	Reset/clear statistics		E
Settings				
GoCBRef	ORG	Reference to the subscribed GOOSE control block		O
DatSet	ORG	Configured dataset reference		E
GoID	VSG	Configured GOOSE ID		E
Addr	VSG	Configured multicast MAC address		E
VlanID	ING	Configured VLAN ID		E
VlanPri	ING	Configured VLAD priority		E
AppID	ING	Configured APPID		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.29 LTMS Time Master Supervision (Sheet 1 of 2)

LTMS 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, Clause 22.		
Data Objects				
Common Logical Node Information				
Beh	ENS	Behavior		M
NamPlt	LPL	Name plate		O
Status Information				
TmAcc	INS	Number of significant bits in fraction of second in the time accuracy part of the time stamp		O
TmSrc	VSS	Current time source identity		M
SelTmSrcTyp	ENS	Type of the clock source		E
SelTmSyn	ENS	Actual time synchronization applied		E
SelTmSynLkd	ENS	Locked status of clock synchronization		E

Table G.29 LTMS Time Master Supervision (Sheet 2 of 2)

LTMS Class				
Measured and Metered Values				
SelTmTosPer	MV	Duration, in milliseconds, between two consecutive top-of-second points on the synchronized time		E

[a] Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.30 defines the data class Motor Measurement Data. This class is a collection of motor measurement data.

Table G.30 Motor Measurement Data Logical Node Class Definition

MMOT Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2).		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured Values				
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 in, 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
NumStrt	MV	Number of Motor Starts Counter		E
NumEmrst	MV	Number of Emergency Motor Starts Counter		E

[a] Transient data object—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.31 Metering Statics Logical Node Class Definition (Sheet 1 of 2)

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).		

Table G.31 Metering Statics Logical Node Class Definition (Sheet 2 of 2)

MSTA Class				
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		E
AvVolts	MV	Average Voltage		E
MaxVA	MV	Maximum apparent power		E
MinVA	MV	Minimum apparent power		E
MaxW	MV	Maximum real power		E
MinW	MV	Minimum real power		E
MaxVAr	MV	Maximum reactive power		E
MinVAr	MV	Minimum reactive power		E
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 object—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.32 Compatible Logical Nodes With Extensions

Logical Node	IEC 61850	Description or Comments
Measurement	MMXU	This LN is used for power system measurement data.
Circuit Breaker	XCBR	This LN is used for circuit breaker status and measurement data.
Generic Process I/O	GGIO	This LN is used for remote analog data.
Circuit Breaker Wear Supervision	SCBR	This LN is used for supervision of circuit breakers.

Table G.33 Measurement Logical Node Class Definition (Sheet 1 of 2)

MMXU 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

Table G.33 Measurement Logical Node Class Definition (Sheet 2 of 2)

Data Objects				
Measured and Metered Values				
TotW	MV	Total active power		O
TotVAr	MV	Total reactive power		O
TotVA	MV	Total apparent power		O
TotPF	MV	Average power factor		O
Hz	MV	Frequency		O
PPV	DEL	Phase to phase voltages		O
PhV	WYE	Phase to ground voltages		O
A	WYE	Phase currents		O
Vex	CMV	Field voltage		E
Data Objects				
Measured and Metered Values				
Iex	CMV	Field current		E
Rf	MV	Field resistance		E

[a] Transient data object—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.34 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 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 object—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.35 Generic Process I/O Logical Node Class Definition

GGIO Class				
Data Object Name	**Common Data Class**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
Common Logical Node Information				
		LN shall inherit all Mandatory Data from Common Logical Node Class.		M
Data Objects				
Measured Values				
AnIn	MV	Analog input		O
Ra	MV	Remote analog		E
Controls				
SPCSO	SPC	Single point controllable status output		O
Status Information				
Ind	SPS	General indication (binary input)		O

[a] Transient data object—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table G.36 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 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 object—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.

Device Logical Nodes

The following tables, *Table G.37* through *Table G.41*, show the Logical Nodes (LN) supported in the SEL-710-5 and the associated Relay Word bits or analog quantities.

Table G.37 shows the LN associated with protection elements defined as Logical Device PRO.

Table G.37 Logical Device: PRO (Protection) (Sheet 1 of 10)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
MCCSWI1	Pos.Oper.ctlVal	STR:STOP[a]	Breaker/contactor close/open command
DC1CSWI1	Pos.Oper.ctlVal	89CC2P1:89OC2P1[a]	Two-position Disconnect 1 close/open command
DC2CSWI2	Pos.Oper.ctlVal	89CC2P2:89OC2P2[a]	Two-position Disconnect 2 close/open command
DC3CSWI3	Pos.Oper.ctlVal	89CC2P3:89OC2P3[a]	Two-position Disconnect 3 close/open command
DC4CSWI4	Pos.Oper.ctlVal	89CC2P4:89OC2P4[a]	Two-position Disconnect 4 close/open command
DC5CSWI5	Pos.Oper.ctlVal	89CC2P5:89OC2P5[a]	Two-position Disconnect 5 close/open command
DC6CSWI6	Pos.Oper.ctlVal	89CC2P6:89OC2P6[a]	Two-position Disconnect 6 close/open command
DC7CSWI7	Pos.Oper.ctlVal	89CC2P7:89OC2P7[a]	Two-position Disconnect 7 close/open command
DC8CSWI8	Pos.Oper.ctlVal	89CC2P8:89OC2P8[a]	Two-position Disconnect 8 close/open command
DC9CSWI9	Pos.Oper.ctlVal	89CC3PL1:89OC3PL1[a]	Three-position In-Line Disconnect 1 close/open command
DC10CSWI10	Pos.Oper.ctlVal	89CC3PL2:89OC3PL2[a]	Three-position In-Line Disconnect 2 close/open command
DC11CSWI11	Pos.Oper.ctlVal	89CC3PE1:89OC3PE1[a]	Three-position Earthing Disconnect 1 close/open command
DC12CSWI12	Pos.Oper.ctlVal	89CC3PE2:89OC3PE2[a]	Three-position Earthing Disconnect 2 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
ABSLOPMRI1	Op.general	ABSLO	Antibackspin lockout condition
ATPTOC8	Op.general	51AT	A-phase time-overcurrent element trip
ATPTOC8	Str.general	51AP	A-phase time-overcurrent element pickup
BFRBRF1	OpEx.general	BFT	Breaker failure trip
BFRBRF1	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	LOCAL	Breaker/contactor local control status. Asserted when relay is in Local mode.

Table G.37 Logical Device: PRO (Protection) (Sheet 2 of 10)

Logical Node	Attribute	Data Source	Comment
BK1XCBR1	OpCnt.stVal	INTT	Internal trip counter
BK1XCBR1	OpCntEx.stVal	EXTT	External trip counter
BK1XCBR1	Pos.stVal	52A|52B?0:1:2:3[b]	Breaker/contactor close/open status
BTPTOC9	Op.general	51BT	B-phase time-overcurrent element trip
BTPTOC9	Str.general	51BP	B-phase time-overcurrent element pickup
CTPTOC10	Op.general	51CT	C-phase time-overcurrent element trip
CTPTOC10	Str.general	51CP	C-phase time-overcurrent element pickup
D1TPTOF1	Op.general	81D1T	Level 1 trip definite-time over- and underfrequency element
D1TPTOF1	Str.general	81D1T	Level 1 trip definite-time over- and underfrequency element
D2TPTOF2	Op.general	81D2T	Level 2 trip definite-time over- and underfrequency element
D2TPTOF2	Str.general	81D2T	Level 2 trip definite-time over- and underfrequency element
D3TPTOF3	Op.general	81D3T	Level 3 trip definite-time over- and underfrequency element
D3TPTOF3	Str.general	81D3T	Level 3 trip definite-time over- and underfrequency element
D4TPTOF4	Op.general	81D4T	Level 4 trip definite-time over- and underfrequency element
D4TPTOF4	Str.general	81D4T	Level 4 trip definite-time over- and underfrequency element
DC1CILO1	EnaCls.stVal	89CE2P1	Two-position Disconnect 1 close enabled
DC1CILO1	EnaOpn.stVal	89OE2P1	Two-position Disconnect 1 open enabled
DC2CILO2	EnaCls.stVal	89CE2P2	Two-position Disconnect 2 close enabled
DC2CILO2	EnaOpn.stVal	89OE2P2	Two-position Disconnect 2 open enabled
DC3CILO3	EnaCls.stVal	89CE2P3	Two-position Disconnect 3 close enabled
DC3CILO3	EnaOpn.stVal	89OE2P3	Two-position Disconnect 3 open enabled
DC4CILO4	EnaCls.stVal	89CE2P4	Two-position Disconnect 4 close enabled
DC4CILO4	EnaOpn.stVal	89OE2P4	Two-position Disconnect 4 open enabled
DC5CILO5	EnaCls.stVal	89CE2P5	Two-position Disconnect 5 close enabled
DC5CILO5	EnaOpn.stVal	89OE2P5	Two-position Disconnect 5 open enabled
DC6CILO6	EnaCls.stVal	89CE2P6	Two-position Disconnect 6 close enabled
DC6CILO6	EnaOpn.stVal	89OE2P6	Two-position Disconnect 6 open enabled
DC7CILO7	EnaCls.stVal	89CE2P7	Two-position Disconnect 7 close enabled
DC7CILO7	EnaOpn.stVal	89OE2P7	Two-position Disconnect 7 open enabled
DC8CILO8	EnaCls.stVal	89CE2P8	Two-position Disconnect 8 close enabled
DC8CILO8	EnaOpn.stVal	89OE2P8	Two-position Disconnect 8 open enabled
DC9CILO9	EnaCls.stVal	89CE3PL1	Three-position In-Line Disconnect 1 close enabled
DC9CILO9	EnaOpn.stVal	89OE3PL1	Three-position In-Line Disconnect 1 open enabled

Table G.37 Logical Device: PRO (Protection) (Sheet 3 of 10)

Logical Node	Attribute	Data Source	Comment
DC10CILO10	EnaCls.stVal	89CE3PL2	Three-position In-Line Disconnect 2 close enabled
DC10CILO10	EnaOpn.stVal	89OE3PL2	Three-position In-Line Disconnect 2 open enabled
DC11CILO11	EnaCls.stVal	89CE3PE1	Three-position Earthing Disconnect 1 close enabled
DC11CILO11	EnaOpn.stVal	89OE3PE1	Three-position Earthing Disconnect 1 open enabled
DC12CILO12	EnaCls.stVal	89CE3PE2	Three-position Earthing Disconnect 2 close enabled
DC12CILO12	EnaOpn.stVal	89OE3PE2	Three-position Earthing Disconnect 2 open enabled
DC1CSWI1	OpCls.general	89C2P1	Two-position Disconnect 1 closed
DC1CSWI1	OpOpn.general	89O2P1	Two-position Disconnect 1 open
DC1CSWI1	Loc.stVal	LOC	Control authority at local (bay) level
DC1CSWI1	LocSta.stVal	LOCSTA	Control authority at station level
DC1CSWI1	Pos.stVal	89CL2P1|89OP2P1?0:1:2:3[b]	Two-position Disconnect 1 close/open status
DC2CSWI2	OpCls.general	89C2P2	Two-position Disconnect 2 closed
DC2CSWI2	OpOpn.general	89O2P2	Two-position Disconnect 2 open
DC2CSWI2	Loc.stVal	LOC	Control authority at local (bay) level
DC2CSWI2	LocSta.stVal	LOCSTA	Control authority at station level
DC2CSWI2	Pos.stVal	89CL2P2|89OP2P2?0:1:2:3[b]	Two-position Disconnect 2 close/open status
DC3CSWI3	OpCls.general	89C2P3	Two-position Disconnect 3 closed
DC3CSWI3	OpOpn.general	89O2P3	Two-position Disconnect 3 open
DC3CSWI3	Loc.stVal	LOC	Control authority at local (bay) level
DC3CSWI3	LocSta.stVal	LOCSTA	Control authority at station level
DC3CSWI3	Pos.stVal	89CL2P3|89OP2P3?0:1:2:3[b]	Two-position Disconnect 3 close/open status
DC4CSWI4	OpCls.general	89C2P4	Two-position Disconnect 4 closed
DC4CSWI4	OpOpn.general	89O2P4	Two-position Disconnect 4 open
DC4CSWI4	Loc.stVal	LOC	Control authority at local (bay) level
DC4CSWI4	LocSta.stVal	LOCSTA	Control authority at station level
DC4CSWI4	Pos.stVal	89CL2P4|89OP2P4?0:1:2:3[b]	Two-position Disconnect 4 close/open status
DC5CSWI5	OpCls.general	89C2P5	Two-position Disconnect 5 closed
DC5CSWI5	OpOpn.general	89O2P5	Two-position Disconnect 5 open
DC5CSWI5	Loc.stVal	LOC	Control authority at local (bay) level
DC5CSWI5	LocSta.stVal	LOCSTA	Control authority at station level
DC5CSWI5	Pos.stVal	89CL2P5|89OP2P5?0:1:2:3[b]	Two-position Disconnect 5 close/open status
DC6CSWI6	OpCls.general	89C2P6	Two-position Disconnect 6 closed
DC6CSWI6	OpOpn.general	89O2P6	Two-position Disconnect 6 open
DC6CSWI6	Loc.stVal	LOC	Control authority at local (bay) level
DC6CSWI6	LocSta.stVal	LOCSTA	Control authority at station level
DC6CSWI6	Pos.stVal	89CL2P6|89OP2P6?0:1:2:3[b]	Two-position Disconnect 6 close/open status
DC7CSWI7	OpCls.general	89C2P7	Two-position Disconnect 7 closed
DC7CSWI7	OpOpn.general	89O2P7	Two-position Disconnect 7 open

Table G.37 Logical Device: PRO (Protection) (Sheet 4 of 10)

Logical Node	Attribute	Data Source	Comment
DC7CSWI7	Loc.stVal	LOC	Control authority at local (bay) level
DC7CSWI7	LocSta.stVal	LOCSTA	Control authority at station level
DC7CSWI7	Pos.stVal	89CL2P7|89OP2P7?0:1:2:3[b]	Two-position Disconnect 7 close/open status
DC8CSWI8	OpCls.general	89C2P8	Two-position Disconnect 8 closed
DC8CSWI8	OpOpn.general	89O2P8	Two-position Disconnect 8 open
DC8CSWI8	Loc.stVal	LOC	Control authority at local (bay) level
DC8CSWI8	LocSta.stVal	LOCSTA	Control authority at station level
DC8CSWI8	Pos.stVal	89CL2P8|89OP2P8?0:1:2:3[b]	Two-position Disconnect 8 close/open status
DC9CSWI9	OpCls.general	89C3PL1	Three-position In-Line Disconnect 1 closed
DC9CSWI9	OpOpn.general	89O3PL1	Three-position In-Line Disconnect 1 open
DC9CSWI9	Loc.stVal	LOC	Control authority at local (bay) level
DC9CSWI9	LocSta.stVal	LOCSTA	Control authority at station level
DC9CSWI9	Pos.stVal	89CL3PL1|89OP3PL1?0:1:2:3[b]	Three-position In-Line Disconnect 1 close/open status
DC10CSWI10	OpCls.general	89C3PL2	Three-position In-Line Disconnect 2 closed
DC10CSWI10	OpOpn.general	89O3PL2	Three-position In-Line Disconnect 2 open
DC10CSWI10	Loc.stVal	LOC	Control authority at local (bay) level
DC10CSWI10	LocSta.stVal	LOCSTA	Control authority at station level
DC10CSWI10	Pos.stVal	89CL3PL2|89OP3PL2?0:1:2:3[b]	Three-position In-Line Disconnect 2 close/open status
DC11CSWI11	OpCls.general	89C3PE1	Three-position Earthing Disconnect 1 closed
DC11CSWI11	OpOpn.general	89O3PE1	Three-position Earthing Disconnect 1 open
DC11CSWI11	Loc.stVal	LOC	Control authority at local (bay) level
DC11CSWI11	LocSta.stVal	LOCSTA	Control authority at station level
DC11CSWI11	Pos.stVal	89CL3PE1|89OP3PE1?0:1:2:3[b]	Three-position Earthing Disconnect 1 close/open status
DC12CSWI12	OpCls.general	89C3PE2	Three-position Earthing Disconnect 2 closed
DC12CSWI12	OpOpn.general	89O3PE12	Three-position Earthing Disconnect 2 open
DC12CSWI12	Loc.stVal	LOC	Control authority at local (bay) level
DC12CSWI12	LocSta.stVal	LOCSTA	Control authority at station level
DC12CSWI12	Pos.stVal	89CL3PE2|89OP3PE2?0:1:2:3[b]	Three-position Earthing Disconnect 2 close/open status
DC1XSWI1	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC1XSWI1	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC1XSWI1	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC1XSWI1	OpCnt.stVal	0	
DC1XSWI1	Pos.stVal	89CL2P1?1:2[c]	Disconnect 1 position
DC1XSWI1	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC1XSWI1	SwTyp.stVal	Disconnector	Disconnect type
DC2XSWI12	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC2XSWI12	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC2XSWI12	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits

Table G.37 Logical Device: PRO (Protection) (Sheet 5 of 10)

Logical Node	Attribute	Data Source	Comment
DC2XSWI12	OpCnt.stVal	0	
DC2XSWI12	Pos.stVal	89CL2P2?1:2[c]	Disconnect 2 position
DC2XSWI12	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC2XSWI12	SwTyp.stVal	Disconnector	Disconnect type
DC3XSWI3	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC3XSWI3	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC3XSWI3	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC3XSWI3	OpCnt.stVal	0	
DC3XSWI3	Pos.stVal	89CL2P3?1:2[c]	Disconnect 3 position
DC3XSWI3	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC3XSWI3	SwTyp.stVal	Disconnector	Disconnect type
DC4XSWI4	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC4XSWI4	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC4XSWI4	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC4XSWI4	OpCnt.stVal	0	
DC4XSWI4	Pos.stVal	89CL2P4?1:2[c]	Disconnect 4 position
DC4XSWI4	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC4XSWI4	SwTyp.stVal	Disconnector	Disconnect type
DC5XSWI5	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC5XSWI5	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC5XSWI5	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC5XSWI5	OpCnt.stVal	0	
DC5XSWI5	Pos.stVal	89CL2P5?1:2[c]	Disconnect 5 position
DC5XSWI5	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC5XSWI5	SwTyp.stVal	Disconnector	Disconnect type
DC6XSWI6	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC6XSWI6	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC6XSWI6	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC6XSWI6	OpCnt.stVal	0	
DC6XSWI6	Pos.stVal	89CL2P6?1:2[c]	Disconnect 6 position
DC6XSWI6	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC6XSWI6	SwTyp.stVal	Disconnector	Disconnect type
DC7XSWI7	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC7XSWI7	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC7XSWI7	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC7XSWI7	OpCnt.stVal	0	
DC7XSWI7	Pos.stVal	89CL2P7?1:2[c]	Disconnect 7 position
DC7XSWI7	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay

Table G.37 Logical Device: PRO (Protection) (Sheet 6 of 10)

Logical Node	Attribute	Data Source	Comment
DC7XSWI7	SwTyp.stVal	Disconnector	Disconnect type
DC8XSWI8	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC8XSWI8	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC8XSWI8	Loc.stVal	OREDLOC	Logical OR or LOC and LOCAL Relay Word bits
DC8XSWI8	OpCnt.stVal	0	
DC8XSWI8	Pos.stVal	89CL2P8?1:2[c]	Disconnect 8 position
DC8XSWI8	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC8XSWI8	SwTyp.stVal	Disconnector	Disconnect type
DC9XSWI9	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC9XSWI9	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC9XSWI9	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC9XSWI9	OpCnt.stVal	0	
DC9XSWI9	Pos.stVal	89CL2PL1?1:2[c]	In-Line Disconnect 1 position
DC9XSWI9	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC9XSWI9	SwTyp.stVal	Disconnector	Disconnect type
DC10XSWI10	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC10XSWI10	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC10XSWI10	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC10XSWI10	OpCnt.stVal	0	
DC10XSWI10	Pos.stVal	89CL2PL2?1:2[c]	In-Line Disconnect 2 position
DC10XSWI10	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC10XSWI10	SwTyp.stVal	Disconnector	Disconnect type
DC11XSWI11	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC11XSWI11	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC11XSWI11	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC11XSWI11	OpCnt.stVal	0	
DC11XSWI11	Pos.stVal	89CL2PE1?1:2[c]	Earthing Disconnect 1 position
DC11XSWI11	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC11XSWI11	SwTyp.stVal	Disconnector	Disconnect type
DC12XSWI12	BlkCls.stVal	false	Disconnect close blocking not configured by default
DC12XSWI12	BlkOpn.stVal	false	Disconnect open blocking not configured by default
DC12XSWI12	Loc.stVal	OREDLOC	Logical OR of LOC and LOCAL Relay Word bits
DC12XSWI12	OpCnt.stVal	0	
DC12XSWI12	Pos.stVal	89CL2PE2?1:2[c]	Earthing Disconnect 2 position
DC12XSWI12	SwOpCap.stVal	None	Disconnect operation capabilities not known to relay
DC12XSWI12	SwTyp.stVal	Disconnector	Disconnect type
FDPIOC11	Op.general	FDOC1T	Field overcurrent Level 1 definite-time delayed element
FDPIOC11	Str.general	FDOC1	Field overcurrent Level 1 pickup

Table G.37 Logical Device: PRO (Protection) (Sheet 7 of 10)

Logical Node	Attribute	Data Source	Comment
FDPIOC12	Op.general	FDOC2T	Field overcurrent Level 2 definite-time delayed element
FDPIOC12	Str.general	FDOC2	Field overcurrent Level 2 pickup
FDPTOV4	Op.general	FDOV1T	Field overvoltage Level 1 definite-time delayed element
FDPTOV4	Str.general	FDOV1	Field overvoltage Level 1 pickup
FDPTOV5	Op.general	FDOV2T	Field overvoltage Level 2 definite-time delayed element
FDPTOV5	Str.general	FDOV2	Field overvoltage Level 2 pickup
FDPTUC3	Op.general	FDUC1T	Field undercurrent Level 1 definite-time delayed element
FDPTUC3	Str.general	FDUC1	Field undercurrent Level 1 pickup
FDPTUC4	Op.general	FDUC2T	Field undercurrent Level 2 definite-time delayed element
FDPTUC4	Str.general	FDUC2	Field undercurrent Level 2 pickup
FDPTUV4	Op.general	FDUV1T	Field undervoltage Level 1 definite-time delayed element
FDPTUV4	Str.general	FDUV1	Field undervoltage Level 1 pickup
FDPTUV5	Op.general	FDUV2T	Field undervoltage Level 2 definite-time delayed element
FDPTUV5	Str.general	FDUV2	Field undervoltage Level 2 pickup
FLTRDRE1	RcdMade.stVal	FLREP	Event report present
FLTRDRE1	FltNum.stVal	FLRNUM	Unique event ID number
G1TPIOC5	Op.general	50G1T	Definite-time residual overcurrent trip
G1TPIOC5	Str.general	50G1P	Definite-time residual overcurrent trip pickup
G1TPTOC5	Op.general	51G1T	Level 1 residual ground time-overcurrent element trip
G1TPTOC5	Str.general	51G1P	Level 1 residual ground time-overcurrent element pickup
G2TPIOC6	Op.general	50G2T	Definite-time residual overcurrent alarm
G2TPIOC6	Str.general	50G2P	Definite-time residual overcurrent alarm pickup
G2TPTOC6	Op.general	51G2T	Level 2 residual ground time-overcurrent element trip
G2TPTOC6	Str.general	51G2P	Level 2 residual ground time-overcurrent element pickup
I1TPTOV6	Op.general	59I1T	Level 1 inverse overvoltage element trip
I1TPTOV6	Str.general	59I1	Level 1 inverse overvoltage element pickup
I1TPTOV6	Str.dirGeneral	unknown	Direction undefined
I2TPTOV7	Op.general	59I2T	Level 2 inverse overvoltage element trip
I2TPTOV7	Str.general	59I2	Level 2 inverse overvoltage element pickup
I2TPTOV7	Str.dirGeneral	unknown	Direction undefined
I3TPTOV8	Op.general	59I3T	Level 3 inverse overvoltage element trip
I3TPTOV8	Str.general	59I3	Level 3 inverse overvoltage element pickup
I3TPTOV8	Str.dirGeneral	unknown	Direction undefined
I4TPTOV9	Op.general	59I4T	Level 4 inverse overvoltage element trip
I4TPTOV9	Str.general	59I4	Level 4 inverse overvoltage element pickup
I4TPTOV9	Str.dirGeneral	unknown	Direction undefined

Table G.37 Logical Device: PRO (Protection) (Sheet 8 of 10)

Logical Node	Attribute	Data Source	Comment
I1TPTUV6	Op.general	27I1T	Level 1 inverse undervoltage element trip
I1TPTUV6	Str.general	27I1	Level 1 inverse undervoltage element pickup
I1TPTUV6	Str.dirGeneral	unknown	Direction undefined
I2TPTUV7	Op.general	27I2T	Level 2 inverse undervoltage element trip
I2TPTUV7	Str.general	27I2	Level 2 inverse undervoltage element pickup
I2TPTUV7	Str.dirGeneral	unknown	Direction undefined
JALRMPMSS1	Op.general	JAMALRM	Load-jam alarm
JALRMPMSS1	Str.general	JAMALRM	Load-jam alarm
JTRIPPMSS2	Op.general	JAMTRIP	Load-jam trip
JTRIPPMSS2	Str.general	JAMTRIP	Load-jam trip
LALRMPTUC1	Op.general	LOSSALRM	Load-loss alarm
LALRMPTUC1	Str.general	LOSSALRM	Load-loss alarm
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LOPPTUV3	Op.general	LOP	Loss of potential
LOPPTUV3	Str.general	LOP	Loss of potential
LTRIPPTUC2	Op.general	LOSSTRIP	Load-loss trip
LTRIPPTUC2	Str.general	LOSSTRIP	Load-loss trip
M1PDIF1	Op.general	87M1T	Level 1 trip definite-time differential element
M1PDIF1	Str.general	87M1	Level 1 pickup definite-time differential element
M2PDIF2	Op.general	87M2T	Level 2 trip definite-time differential element
M2PDIF2	Str.general	87M2	Level 2 pickup definite-time differential element
MCCILO1	EnaCls.stVal	BKENC1	BKENC1 supervises the close operation of the breaker/ contactor
MCCSWI1	OpCls.general	STR	Breaker/contactor close control
MCCSWI1	OpOpn.general	STOP	Breaker/contactor open control
MCCSWI1	Loc.stVal	LOC	Control authority at local (bay) level
MCCSWI1	LocSta.stVal	LOCSTA	Control authority at station level
MCCSWI1	Pos.stVal	52A|52B?0:1:2:3[b]	Breaker/contactor close/open status
MCCILO1	EnaOpn.stVal	BKENO1	BKENO1 supervises the open operation of the breaker/ contactor
N1TPIOC3	Op.general	50N1T	Definite-time neutral overcurrent trip
N1TPIOC3	Str.general	50N1P	Definite-time neutral overcurrent trip pickup
N2TPIOC4	Op.general	50N2T	Definite-time neutral overcurrent alarm
N2TPIOC4	Str.general	50N2P	Definite-time neutral overcurrent alarm pickup
NAFPIOC10	Op.general	50NAF	Sample based neutral overcurrent element pickup
NAFPIOC10	Str.general	50NAF	Sample based neutral overcurrent element pickup
NOSLOPMRI2	Op.general	NOSLO	Starts per hour lockout condition
OOSPPAM1	Op.general	OOST	Out-of-step trip

Table G.37 Logical Device: PRO (Protection) (Sheet 9 of 10)

Logical Node	Attribute	Data Source	Comment
OOSPPAM1	Str.general	OOS	Out-of-step element
P1TPIOC1	Op.general	50P1T	Definite-time phase overcurrent trip
P1TPIOC1	Str.general	50P1P	Definite-time phase overcurrent trip pickup
P1TPTOC3	Op.general	51P1T	Level 1 maximum phase time-overcurrent element trip
P1TPTOC3	Str.general	51P1P	Level 1 maximum phase time-overcurrent element pickup
P1TPTOV1	Op.general	59P1T	Phase overvoltage Level 1 trip
P1TPTOV1	Str.general	59P1	Phase overvoltage Level 1 trip pickup
P1TPTUV1	Op.general	27P1T	Phase undervoltage Level 1 trip
P1TPTUV1	Str.general	27P1	Phase undervoltage Level 1 trip pickup
P2TPIOC2	Op.general	50P2T	Definite-time phase overcurrent alarm
P2TPIOC2	Str.general	50P2P	Definite-time phase overcurrent alarm pickup
P2TPTOC4	Op.general	51P2T	Level 2 maximum phase time-overcurrent element trip
P2TPTOC4	Str.general	51P2P	Level 2 maximum phase time-overcurrent element pickup
P2TPTOV2	Op.general	59P2T	Phase overvoltage Level 2 trip
P2TPTOV2	Str.general	59P2	Phase overvoltage Level 2 pickup
P2TPTUV2	Op.general	27P2T	Phase undervoltage Level 2 trip
P2TPTUV2	Str.general	27P2	Phase undervoltage Level 2 pickup
PA37PDUP1	Op.general	37PA	Underpower alarm
PA37PDUP1	Str.general	37PA	Underpower alarm
PAFPIOC9	Op.general	50PAF	Sample based phase overcurrent element pickup
PAFPIOC9	Str.general	50PAF	Sample based phase overcurrent element pickup
PT37PDUP2	Op.general	37PT	Underpower trip
PT37PDUP2	Str.general	37PT	Underpower trip
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
Q2TPIOC8	Op.general	50Q2T	Definite-time negative-sequence overcurrent alarm
Q2TPIOC8	Str.general	50Q2P	Definite-time negative-sequence overcurrent alarm pickup
QTPTOC7	Op.general	51QT	Negative-sequence time-overcurrent element trip
QTPTOC7	Str.general	51QP	Negative-sequence time-overcurrent element pickup
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
SPDSTRPZSU2	Op.general	SPDSTR	Speed switch trip

Table G.37 Logical Device: PRO (Protection) (Sheet 10 of 10)

Logical Node	Attribute	Data Source	Comment
SPDSTRPZSU2	Str.general	SPDSTR	Speed switch trip
T47PTOV3	Op.general	47T	Phase reversal trip
T47PTOV3	Str.general	47T	Phase reversal trip
T49PTTR2	Op.general	49T	Thermal trip
T55POPF2	Op.general	55T	Power factor trip
T55POPF2	Str.general	55T	Power factor trip
TBSLOPMRI3	Op.general	TBSLO	Time between starts lockout condition
THRMLOPMRI4	Op.general	THERMLO	Thermal lockout condition
TOL1PAFD1	Op.general	TOL1[d]	Arc-Flash Light Input 1 element pickup
TOL1PAFD1	Str.general	TOL1[d]	Arc-Flash Light Input 1 element pickup
TOL2PAFD2	Op.general	TOL2[d]	Arc-Flash Light Input 2 element pickup
TOL2PAFD2	Str.general	TOL2[d]	Arc-Flash Light Input 2 element pickup
TOL3PAFD3	Op.general	TOL3[d]	Arc-Flash Light Input 3 element pickup
TOL3PAFD3	Str.general	TOL3[d]	Arc-Flash Light Input 3 element pickup
TOL4PAFD4	Op.general	TOL4[d]	Arc-Flash Light Input 4 element pickup
TOL4PAFD4	Str.general	TOL4[d]	Arc-Flash Light Input 4 element pickup
TOL5PAFD5	Op.general	TOL5[d]	Arc-Flash Light Input 5 element pickup
TOL5PAFD5	Str.general	TOL5[d]	Arc-Flash Light Input 5 element pickup
TOL6PAFD6	Op.general	TOL6[d]	Arc-Flash Light Input 6 element pickup
TOL6PAFD6	Str.general	TOL6[d]	Arc-Flash Light Input 6 element pickup
TOL7PAFD7	Op.general	TOL7[d]	Arc-Flash Light Input 7 element pickup
TOL7PAFD7	Str.general	TOL7[d]	Arc-Flash Light Input 7 element pickup
TOL8PAFD8	Op.general	TOL8[d]	Arc-Flash Light Input 8 element pickup
TOL8PAFD8	Str.general	TOL8[d]	Arc-Flash Light Input 8 element pickup
TRIPPTRC1	Tr.general	TRIP	Trip logic output
UB46APTOC1	Op.general	46UBA	Phase current unbalance alarm
UB46APTOC1	Str.general	46UBA	Phase current unbalance alarm
UB46TPTOC2	Op.general	46UBT	Phase current unbalance trip
UB46TPTOC2	Str.general	46UBT	Phase current unbalance trip
VARAPDOP1	Op.general	VARA	Reactive power alarm
VARAPDOP1	Str.general	VARA	Reactive power alarm
VARTPDOP2	Op.general	VART	Reactive power trip
VARTPDOP2	Str.general	VART	Reactive power trip
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] Writing a 0 to Pos.Oper.ctlVal will cause the Open control bit to assert and writing any other value will cause the Close control bit to assert.
[b] If the breaker/disconnect is closed, value = 10(2). If the breaker/disconnect is open, value = 01(1). Value = 00(0) indicates an in-progress or intermediate state and value = 11(3) indicates an alarm or bad state.
[c] If the disconnect is closed, value = 10(2). If the disconnect is opened, value = 01(1).
[d] Valid data depend on installed arc-flash card.

Table G.38 shows the LN associated with measuring elements defined as Logical Device MET.

Table G.38 Logical Device: MET (Metering) (Sheet 1 of 4)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a,b]			
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
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	Iex.instCVal.mag.f	IEX	Field current
METMMXU1	PhV.phsA.instCVal.ang.f	VA_ANG	Voltage, A-phase-to-neutral, angle
METMMXU1	PhV.phsA.instCVal.mag.f	VA_MAG	Voltage, A-phase-to-neutral, magnitude
METMMXU1	PhV.phsB.instCVal.ang.f	VB_ANG	Voltage, B-phase-to-neutral, angle
METMMXU1	PhV.phsB.instCVal.mag.f	VB_MAG	Voltage, B-phase-to-neutral, magnitude
METMMXU1	PhV.phsC.instCVal.ang.f	VC_ANG	Voltage, C-phase-to-neutral, angle
METMMXU1	PhV.phsC.instCVal.mag.f	VC_MAG	Voltage, C-phase-to-neutral, magnitude
METMMXU1	PhV.res.instCVal.ang.f	VG_ANG	Zero-sequence voltage, angle
METMMXU1	PhV.res.instCVal.mag.f	VG_MAG	Zero-sequence voltage, magnitude
METMMXU1	PPV.phsAB.instCVal.ang.f	VAB_ANG	Voltage, A-to-B-phase, angle
METMMXU1	PPV.phsAB.instCVal.mag.f	VAB_MAG	Voltage, A-to-B-phase, magnitude
METMMXU1	PPV.phsBC.instCVal.ang.f	VBC_ANG	Voltage, B-to-C-phase, angle
METMMXU1	PPV.phsBC.instCVal.mag.f	VBC_MAG	Voltage, B-to-C-phase, magnitude
METMMXU1	PPV.phsCA.instCVal.ang.f	VCA_ANG	Voltage, C-to-A-phase, angle
METMMXU1	PPV.phsCA.instCVal.mag.f	VCA_MAG	Voltage, C-to-A-phase, magnitude
METMMXU1	Rf.instMag.f	RF	Field resistance
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

Table G.38 Logical Device: MET (Metering) (Sheet 2 of 4)

Logical Node	Attribute	Data Source	Comment
METMMXU1	TotW.instMag.f	P	Real power, three-phase, magnitude
METMMXU1	Vex.instCVal.mag.f	VEX	Field voltage
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

Table G.38 Logical Device: MET (Metering) (Sheet 3 of 4)

Logical Node	Attribute	Data Source	Comment
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
METMSTA1	MinVAr.instMag.f	KVAR3PMN	Reactive power, three-phase, minimum magnitude
METMSTA1	MinW.instMag.f	KW3PMN	Real power, three-phase, minimum magnitude
MOTORMMOT	Mload.instMag.f	MLOAD	Motor load
MOTORMMOT	Mrt.instMag.f	MRT	Motor running time
MOTORMMOT	NumEmrst.instMag.f	EMSTRT	Number of emergency starts counter
MOTORMMOT	NumStrt.instMag.f	STRT	Number of starts counter
MOTORMMOT	RtdTcu.instMag.f	TCURTD	RTD % thermal capacity used
MOTORMMOT	RtrTcu.instMag.f	TCURTR	Rotor % thermal capacity used
MOTORMMOT	Slip.instMag.f	SLIP	Slip
MOTORMMOT	StrtAv.instMag.f	STRTAV	Starts available
MOTORMMOT	StrTcu.instMag.f	TCUSTR	Stator % thermal capacity used
MOTORMMOT	ThrmTp.instMag.f	THRMTP	Thermal trip in
MOTORMMOT	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[c]	RMS voltage, A-phase, magnitude
RMSMMXU2	PhV.phsB.instCVal.mag.f	VBRMS[c]	RMS voltage, B-phase, magnitude
RMSMMXU2	PhV.phsC.instCVal.mag.f	VCRMS[c]	RMS voltage, C-phase, magnitude
RMSMMXU2	PPV.phsAB.instCVal.mag.f	VABRMS[c]	RMS voltage, AB-phase-to-phase, magnitude
RMSMMXU2	PPV.phsBC.instCVal.mag.f	VBCRMS[c]	RMS voltage, BC-phase-to-phase, magnitude
RMSMMXU2	PPV.phsCA.instCVal.mag.f	VCARMS[c]	RMS voltage, CA-phase-to-phase, magnitude
THERMMTHR1	MaxAmbTmp.instMag.f	RTDAMB[d]	Ambient RTD temperature
THERMMTHR1	MaxBrgTmp.instMag.f	RTDBRGMX[d]	Maximum bearing RTD temperature
THERMMTHR1	MaxOthTmp.instMag.f	RTDOTHMX[d]	Other maximum RTD temperature
THERMMTHR1	MaxWdgTmp.instMag.f	RTDWDGMX[d]	Maximum winding RTD temperature
THERMMTHR1	Tmp01.instMag.f– Tmp12.instMag.f	RTD1–RTD12[d]	RTD1–RTD12 temperature
Functional Constraint = ST			
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
METMDST1[e]	DmdWh.actVal	MWH3P	Real energy, three-phase OUT
METMDST1[d]	NegVArh.actVal	MVARH3PI	Reactive energy, three-phase IN
METMDST1[d]	PosVArh.actVal	MVARH3PO	Reactive energy, three-phase OUT

Table G.38 Logical Device: MET (Metering) (Sheet 4 of 4)

Logical Node	Attribute	Data Source	Comment
THERMMTHR1	EEHealth.stVal	RTDFLT?1:3[c]	RTD input or communication status
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] MX values contain instantaneous attributes (instMag and instCVal) that are updated whenever the source updates and other attributes that are only updated when the source goes outside the deadband (mag and cVal) of the data source. Only the instantaneous values are shown in the table.
[b] Data validity depend 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] If DELTA_Y := WYE, only VARMS, VBRMS, and VCRMS are calculated. If DELTA_Y := DELTA, only VABRMS, VBCRMS, and VCARMS are calculated.
[d] Valid data depend on E49RTD and RTD1LOC–RTD12LOC settings.
[e] For IEC 61850 Edition 1 relays, this quantity is located under Functional Constraint MX.

(e) If DELTA_Y := WYE, only VARMS, VBRMS, and VCRMS are calculated. If DELTA_Y := DELTA, only VABRMS, VBCRMS, and VCARMS are
calculated.

Table G.39 shows the LN associated with control elements defined as Logical Device CON.

Table G.39 Logical Device: CON (Remote Control)

Logical Node	Status	Control	Relay Word Bit	Comment
Functional Constraint = CO				
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB01–RB08	Remote Bits RB01–RB08
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB09–RB16	Remote Bits RB09–RB16
RBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Remote Bits RB17–RB24
RBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Remote Bits RB25–RB32
PRBGGIO1	SPCSO01.stVal–SPCSO08.stVal	SPCSO01.Oper.ctlVal–SPCSO08.Oper.ctlVal	RB01–RB08	Pulse Remote Bits RB01–RB08
PRBGGIO2	SPCSO09.stVal–SPCSO16.stVal	SPCSO09.Oper.ctlVal–SPCSO16.Oper.ctlVal	RB09–RB16	Pulse Remote Bits RB09–RB16
PRBGGIO3	SPCSO17.stVal–SPCSO24.stVal	SPCSO17.Oper.ctlVal–SPCSO24.Oper.ctlVal	RB17–RB24	Pulse Remote Bits RB17–RB24
PRBGGIO4	SPCSO25.stVal–SPCSO32.stVal	SPCSO25.Oper.ctlVal–SPCSO32.Oper.ctlVal	RB25–RB32	Pulse Remote Bits RB25–RB32
Functional Constraint = ST				
LLN0	Loc.stVal	—	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LocSta.Oper.ctlVal	LOCSTA	Control authority at station level
Functional Constraint = SP				
LLN0	GrRef.setSrcRef	—	IdName	Functional name
LLN0	MltLev.setVal	—	MLTLEV	Multilevel mode of control authority

Table G.40 shows the LN associated with annunciation elements defined as Logical Device ANN.

Table G.40 Logical Device: ANN (Annunciation) (Sheet 1 of 5)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
Functional Constraint = MX[a]			
AINCGGIO21	AnIn01.instMag.f–AnIn08.instMag.f	AI301–AI308[b]	Analog Inputs (AI301 to AI308)—Slot C
AINDGGIO22	AnIn01.instMag.f–AnIn08.instMag.f	AI401–AI408[b]	Analog Inputs (AI401 to AI408)—Slot D
AINEGGIO23	AnIn01.instMag.f–AnIn08.instMag.f	AI501–AI508[b]	Analog Inputs (AI501 to AI508)—Slot E
BWASCBR1	AccAbr.instMag.f	WEARA	Breaker—Contact A wear
BWBSCBR2	AccAbr.instMag.f	WEARB	Breaker—Contact B wear
BWCSCBR3	AccAbr.instMag.f	WEARC	Breaker—Contact C wear
FLTGGIO37	AnIn01.instMag.f	FIA	A-phase current of the most recent fault event
FLTGGIO37	AnIn02.instMag.f	FIB	B-phase current of the most recent fault event
FLTGGIO37	AnIn03.instMag.f	FIC	C-phase current of the most recent fault event
FLTGGIO37	AnIn04.instMag.f	FIG	Ground current of the most recent fault event
FLTGGIO37	AnIn05.instMag.f	FIN	Neutral current of the most recent fault event
FLTGGIO37	AnIn06.instMag.f	FIA87	Differential A-phase current of the most recent fault event
FLTGGIO37	AnIn07.instMag.f	FIB87	Differential B-phase current of the most recent fault event
FLTGGIO37	AnIn08.instMag.f	FIC87	Differential C-phase current of the most recent fault event
FLTGGIO37	AnIn09.instMag.f	FFREQ	Frequency of the most recent fault event
LSGGIO28	AnIn01.instMag.f–AnIn08.instMag.f	LSENS1–LSENS8[c]	Arc-flash sensor light (LSENS1–LSENS8)
MVGGIO12	AnIn01.instMag.f–AnIn32.instMag.f	MV01–MV32[d]	Math Variables (MV01 to MV32)
PFLLIGGIO38	AnIn01.instMag.f	PFL	Three-phase Power Factor Lead/Lag Indicator (1: LEAD, 0: LAG)
RAGGIO29	Ra001.instMag.f–Ra032.instMag.f	RA001–RA032	Remote Analogs (RA001 to RA032)
RAGGIO30	Ra033.instMag.f–Ra064.instMag.f	RA033–RA064	Remote Analogs (RA033 to RA064)
RAGGIO31	Ra065.instMag.f–Ra096.instMag.f	RA065–RA096	Remote Analogs (RA065 to RA096)
RAGGIO32	Ra097.instMag.f–Ra128.instMag.f	RA097–RA128	Remote Analogs (RA097 to RA128)
SCGGIO20	AnIn01.instMag.f–AnIn32.instMag.f	SC01–SC32[e]	SELOGIC Counters (SC01 to 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
DCTSGGIO35	Ind01.stVal	89A2P1	Two-Position Disconnect 1 N/O contact
DCTSGGIO35	Ind02.stVal	89B2P1	Two-Position Disconnect 1 N/C contact
DCTSGGIO35	Ind03.stVal	89CL2P1	Two-Position Disconnect 1 closed
DCTSGGIO35	Ind04.stVal	89OP2P1	Two-Position Disconnect 1 open
DCTSGGIO35	Ind05.stVal	89AL2P1	Two-Position Disconnect 1 alarm
DCTSGGIO35	Ind06.stVal	89A2P2	Two-Position Disconnect 2 N/O contact

Table G.40 Logical Device: ANN (Annunciation) (Sheet 2 of 5)

Logical Node	Attribute	Data Source	Comment
DCTSGGIO35	Ind07.stVal	89B2P2	Two-Position Disconnect 2 N/C contact
DCTSGGIO35	Ind08.stVal	89CL2P2	Two-Position Disconnect 2 closed
DCTSGGIO35	Ind09.stVal	89OP2P2	Two-Position Disconnect 2 open
DCTSGGIO35	Ind10.stVal	89AL2P2	Two-Position Disconnect 2 alarm
DCTSGGIO35	Ind11.stVal	89A2P3	Two-Position Disconnect 3 N/O contact
DCTSGGIO35	Ind12.stVal	89B2P3	Two-Position Disconnect 3 N/C contact
DCTSGGIO35	Ind13.stVal	89CL2P3	Two-Position Disconnect 3 closed
DCTSGGIO35	Ind14.stVal	89OP2P3	Two-Position Disconnect 3 open
DCTSGGIO35	Ind15.stVal	89AL2P3	Two-Position Disconnect 3 alarm
DCTSGGIO35	Ind16.stVal	89A2P4	Two-Position Disconnect 4 N/O contact
DCTSGGIO35	Ind17.stVal	89B2P4	Two-Position Disconnect 4 N/C contact
DCTSGGIO35	Ind18.stVal	89CL2P4	Two-Position Disconnect 4 closed
DCTSGGIO35	Ind19.stVal	89OP2P4	Two-Position Disconnect 4 open
DCTSGGIO35	Ind20.stVal	89AL2P4	Two-Position Disconnect 4 alarm
DCTSGGIO35	Ind21.stVal	89A2P5	Two-Position Disconnect 5 N/O contact
DCTSGGIO35	Ind22.stVal	89B2P5	Two-Position Disconnect 5 N/C contact
DCTSGGIO35	Ind23.stVal	89CL2P5	Two-Position Disconnect 5 closed
DCTSGGIO35	Ind24.stVal	89OP2P5	Two-Position Disconnect 5 open
DCTSGGIO35	Ind25.stVal	89AL2P5	Two-Position Disconnect 5 alarm
INAGGIO1	Ind01.stVal–Ind02.stVal	IN101–IN102	Digital Inputs (IN101 to IN102)—Slot A
INCGGIO13	Ind01.stVal–Ind14.stVal	IN301–IN314[b]	Digital Inputs (IN301 to IN314)—Slot C
INDGGIO15	Ind01.stVal–Ind14.stVal	IN401–IN414[b]	Digital Inputs (IN401 to IN414)—Slot D
INEGGIO17	Ind01.stVal–Ind14.stVal	IN501–IN514[b]	Digital Inputs (IN501 to IN514)—Slot E
LBGGIO33	Ind01.stVal–Ind32.stVal	LB01–LB32[f]	Local Bits (LB01 to LB32)
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LTGGIO5	Ind01.stVal–Ind32.stVal	LT01–LT32[g]	Latch Bits (LT01 to LT32)
MBOKGGIO34	Ind01.stVal	ROKA	Channel A, received data OK
MBOKGGIO34	Ind02.stVal	RBADA	Channel A, outage duration over threshold
MBOKGGIO34	Ind03.stVal	CBADA	Channel A, channel unavailability over threshold
MBOKGGIO34	Ind04.stVal	LBOKA	Channel A, looped back OK
MBOKGGIO34	Ind05.stVal	ROKB	Channel B, received data OK
MBOKGGIO34	Ind06.stVal	RBADB	Channel B, outage duration over threshold
MBOKGGIO34	Ind07.stVal	CBADB	Channel B, channel unavailability over threshold
MBOKGGIO34	Ind08.stVal	LBOKB	Channel B, looped back OK
MISCGGIO27	Ind01.stVal	HALARM	Indication of a diagnostic failure or warning that warrants an ALARM
MISCGGIO27	Ind02.stVal	SALARM	Indication of software or user activity that warrants an ALARM
MISCGGIO27	Ind03.stVal	WARNING	Relay Word Warning
MISCGGIO27	Ind04.stVal	IRIGOK	IRIG-B time synch input data are valid
MISCGGIO27	Ind05.stVal	TSOK	Time synchronization OK

Table G.40 Logical Device: ANN (Annunciation) (Sheet 3 of 5)

Logical Node	Attribute	Data Source	Comment
MISCGGIO27	Ind06.stVal	DST	Daylight-saving time active (DST)
MISCGGIO27	Ind07.stVal	LINKA	Asserted when a valid link is detected on Port 1A
MISCGGIO27	Ind08.stVal	LINKB	Asserted when a valid link is detected on Port 1B
MISCGGIO27	Ind09.stVal	LINKFAIL	Asserted when a valid link is not detected on the active port(s)
MISCGGIO27	Ind10.stVal	PASEL	Asserted when Port 1A is active
MISCGGIO27	Ind11.stVal	PBSEL	Asserted when Port 1B is active
MISCGGIO27	Ind12.stVal	MATHERR	Error in SELMath computation
MISCGGIO27	Ind13.stVal	COMMLOSS	DeviceNet communication failure
MISCGGIO27	Ind14.stVal	COMMFLIT	Time-out of internal communication between CPU board and DeviceNet board
MISCGGIO27	Ind15.stVal	TESTDB	Indicates when TESTDB override is active
MISCGGIO27	Ind16.stVal–Ind32.stVal	0	Reserved for future use
MOTGGIO24	Ind01.stVal	RUNNING	Asserts when motor is running
MOTGGIO24	Ind02.stVal	STARTING	Asserts when protected motor is starting
MOTGGIO24	Ind03.stVal	STOPPED	Asserts when motor is stopped
MOTGGIO24	Ind04.stVal	SRUNNING	Asserts when synchronous motor is running
MOTGGIO24	Ind05.stVal	STAR	Star control
MOTGGIO24	Ind06.stVal	DELTA	Delta control
MOTGGIO24	Ind07.stVal	50S	Overcurrent threshold for starting
MOTGGIO24	Ind08.stVal	SPEEDSW	Speed switch input
MOTGGIO24	Ind09.stVal	SPEED2	Asserts when protected motor runs with second speed
MOTGGIO24	Ind10.stVal	VFDBYPAS	Variable frequency driver bypass SELOGIC control equation
MOTGGIO24	Ind11.stVal	EMRSTR	Emergency restart SELOGIC equation or Comm Protocol command
MOTGGIO24	Ind12.stVal	STREQ	Start motor SELOGIC equation
MOTGGIO24	Ind13.stVal	STSEQEN	Synchronous start sequence enable
MOTGGIO24	Ind14.stVal	BLKSTR	Block start SELOGIC control equation
MOTGGIO24	Ind15.stVal	41A	Motor field contactor or field circuit breaker is closed
MOTGGIO24	Ind16.stVal	41CLOSE	Field breaker close initiation
MOTGGIO24	Ind17.stVal	UL41CL	Unlatch 41 breaker close
MOTGGIO24	Ind18.stVal	FDRESTC	Field resistance torque control
MOTGGIO24	Ind19.stVal	AMBALRM	Ambient temperature alarm
MOTGGIO24	Ind20.stVal	OTHALRM	Other temperature alarm
MOTGGIO24	Ind21.stVal	WDGALRM	Winding temperature alarm
MOTGGIO24	Ind22.stVal	BRGALRM	Bearing temperature alarm
OUTAGGIO2	Ind01.stVal–Ind03.stVal	OUT101–OUT103	Digital Outputs (OUT101 to OUT103)—Slot A
OUTCGGIO14	Ind01.stVal–Ind08.stVal	OUT301–OUT308[b]	Digital Outputs (OUT301 to OUT308)—Slot C
OUTDGGIO16	Ind01.stVal–Ind08.stVal	OUT401–OUT408[b]	Digital Outputs (OUT401 to OUT408)—Slot D

Table G.40 Logical Device: ANN (Annunciation) (Sheet 4 of 5)

Logical Node	Attribute	Data Source	Comment
OUTEGGIO18	Ind01.stVal–Ind08.stVal	OUT501–OUT508[b]	Digital Outputs (OUT501 to OUT508)—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
PBLEDGGIO7	Ind09.stVal	PB5A_LED	Pushbutton PB5A LED
PBLEDGGIO7	Ind10.stVal	PB5B_LED	Pushbutton PB5B LED
PBLEDGGIO7	Ind11.stVal	PB6A_LED	Pushbutton PB6A LED
PBLEDGGIO7	Ind12.stVal	PB6B_LED	Pushbutton PB6B LED
PBLEDGGIO7	Ind13.stVal	PB7A_LED	Pushbutton PB7A LED
PBLEDGGIO7	Ind14.stVal	PB7B_LED	Pushbutton PB7B LED
PBLEDGGIO7	Ind15.stVal	PB8A_LED	Pushbutton PB8A LED
PBLEDGGIO7	Ind16.stVal	PB8B_LED	Pushbutton PB8B LED
PROGGIO26	Ind01.stVal	AFALARM	Arc-flash system integrity alarm
PROGGIO26	Ind02.stVal	FREQTRK	Frequency tracking enable bit
PROGGIO26	Ind03.stVal	ZCFREQ	Zero crossing detection bit status
PROGGIO26	Ind04.stVal–Ind11.stVal	AFS1EL–AFS8EL[c]	AF light input 1–8 excessive ambient light pickup
PROGGIO26	Ind12.stVal	78R1	Out-of-step right blinder or outer resistance blinder
PROGGIO26	Ind13.stVal	78R2	Out-of-step left blinder or inner resistance blinder
PROGGIO26	Ind14.stVal	78Z1	Out-of-step mho element
PROGGIO26	Ind15.stVal	SWING	Single blinder: 78R1/78R2 and 78Z1 assert Double blinder: 78R1 and 78R2 assert or only 78R1 asserts
PROGGIO26	Ind16.stVal	COASTOP	Rotor coast to stop
PROGGIO26	Ind17.stVal	VIRSPDSW	Virtual speed switch
PROGGIO26	Ind18.stVal–Ind32.stVal	0	Reserved for future use
RMBBGGIO10	Ind01.stVal–Ind08.stVal	RMB1B–RMB8B	Receive MIRRORED BITS (RMB1B to RMB8B)
SVGGIO36	Ind01.stVal–Ind04.stVal	SG1–SG4	Setting Group 1 to 4 selection
SVGGIO3	Ind01.stVal–Ind32.stVal	SV01–SV32[h]	SELOGIC Variables (SV01 to SV32)
SVTGGIO4	Ind01.stVal–Ind32.stVal	SV01T–SV32T[g]	SELOGIC Variable Timers (SV01T to SV32T)
TLEDGGIO6	Ind01.stVal	ENABLED	**ENABLED** LED
TLEDGGIO6	Ind02.stVal	TRIP_LED	**TRIP** LED
TLEDGGIO6	Ind03.stVal–Ind08.stVal	TLED_01–TLED_06	Target LEDs TLED_01 to TLED_06
TMBAGGIO9	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	Transmit MIRRORED BITS (TMB1A to TMB8A)
TMBBGGIO11	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	Transmit MIRRORED BITS (TMB1B to TMB8B)
TRIPGGIO25	Ind01.stVal	SMTRIP	Asserts when start motor timer times-out

Table G.40 Logical Device: ANN (Annunciation) (Sheet 5 of 5)

Logical Node	Attribute	Data Source	Comment
TRIPGGIO25	Ind02.stVal	LOADUP	Load control upper limit
TRIPGGIO25	Ind03.stVal	LOADLOW	Load control lower limit
TRIPGGIO25	Ind04.stVal	PTCFLT	Indicates faulted/shorted thermistor
TRIPGGIO25	Ind05.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
TRIPGGIO25	Ind06.stVal	FAULT	Indicates fault condition
TRIPGGIO25	Ind07.stVal	AF_TRIP	Arc-flash trip
TRIPGGIO25	Ind08.stVal	AMBTRIP	Ambient temperature trip
TRIPGGIO25	Ind09.stVal	OTHTRIP	Other temperature trip
TRIPGGIO25	Ind10.stVal	WDGTRIP	Winding temperature trip
TRIPGGIO25	Ind11.stVal	BRGTRIP	Bearing temperature trip
TRIPGGIO25	Ind12.stVal	ULTRIP	Unlatch (auto reset) trip from SELOGIC equation
TRIPGGIO25	Ind13.stVal	BBD1T	Severe rotor bar damage
TRIPGGIO25	Ind14.stVal	BBD2T	One or more broken bars
TRIPGGIO25	Ind15.stVal	BBD3T	Rotor high impedance points
TRIPGGIO25	Ind16.stVal	FDRES1T	Field resistance Level 1 trip
TRIPGGIO25	Ind17.stVal	FDRES2T	Field resistance Level 2 trip
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	Virtual Bits (VB001 to VB128)
Functional Constraint = SP			
LLN0	GrRef.setSrcRef	IdName	Functional name
LLN0	MltLev.setVal	MLTLEV	Multilevel mode of control authority

[a] MX values contain instantaneous attributes (instMag and instCVal) that 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 an optional I/O card is installed in the slot.
[c] Active data only if an optional arc-flash card is installed.
[d] Active data depend on the EMV setting.
[e] Active data depend on the ESC setting.
[f] Active data depend on the ELB setting.
[g] Active data depend on the ELAT setting.
[h] Active data depend on the ESV setting.

Table G.41 Logical Device: CFG (Configuration) (Sheet 1 of 6)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = CO			
DevIDLPHD1	Sim.Oper.ctlVal	LPHDSIM	IEC 61850 logical node for physical device simulation
GOLCCH2	RsStat.Oper.ctlVal	GORST[a]	Reset statistics for GOOSE traffic
IPLCCH1	RsStat.Oper.ctlVal	IPRST[a]	Reset statistics for general IP traffic (excluding GOOSE traffic)
LLN0	LocSta.Oper.ctlVal	SC850LS	SELOGIC control for control authority at station level
LLN0	Mod.Oper.ctlVal[b]	I60MOD[c]	IEC 61850 mode/behavior control
LGOS*n*[d]	RsStat.Oper.ctlVal	GRST*n*[e]	Reset GOOSE statistics for Message *n*
Functional Constraint = DC			
DevIDLPHD1	PhyNam.model	PARTNO	Part number
DevIDLPHD1	PhyNam.serNum	SER_NUM	Serial number

Table G.41 Logical Device: CFG (Configuration) (Sheet 2 of 6)

Logical Node	Attribute	Data Source	Comment
LLN0	NamPlt.swRev	FID	Firmware revision
Functional Constraint = ST			
DevIDLPHD1	Sim.stVal	LPHDSIM	IEC 61850 logical node for physical device simulation
DevIDLPHD1	PhyHealth.stVal	RELAY_EN	Relay enabled
GOLCCH2	ChLiv.stVal	GOCH[a]	Status of primary GOOSE channel
GOLCCH2	RedChLiv.stVal	GORCH[a]	Status of redundant GOOSE channel. Always reported as false.
GOLCCH2	RxCnt.actVal	GORX[a]	Number of frames received over the primary GOOSE channel
GOLCCH2	RedRxCnt.actVal	GORRX[a]	Number of frames received over the redundant GOOSE channel. Always reported as 0.
GOLCCH2	TxCnt.actVal	GOTX[a]	Number of frames transmitted on both primary and redundant GOOSE channels
GOLCCH2	FerCh.stVal	GOFER[a]	Frame error rate on the primary GOOSE channel
GOLCCH2	RedFerCh.stVal	GORFER[a]	Frame error rate on the redundant GOOSE channel. Always reported as 0.
GOLCCH2	RsStat.stVal	GORST[a]	Status of statistics reset for GOOSE traffic
IPLCCH1	ChLiv.stVal	IPCH[a]	Status of primary IP channel
IPLCCH1	RedChLiv.stVal	IPRCH[a]	Status of redundant IP channel. Always reported as false.
IPLCCH1	RxCnt.actVal	IPRX[a]	Number of frames received over the primary IP channel
IPLCCH1	RedRxCnt.actVal	IPRRX[a]	Number of frames received over the redundant IP channel. Always reported as 0.
IPLCCH1	TxCnt.actVal	IPTX[a]	Number of frames transmitted on both primary and redundant IP channels
IPLCCH1	FerCh.stVal	IPFER[a]	Frame error rate on the primary IP channel
IPLCCH1	RedFerCh.stVal	IPRFER[a]	Frame error rate on the redundant IP channel. Always reported as 0.
IPLCCH1	RsStat.stVal	IPRST[a]	Status of statistics reset for general IP traffic (excludes GOOSE traffic)
LLN0	Mod.stVal	I60MOD[c]	IEC 61850 mode/behavior status
LLN0	Health.stVal	RELAY_EN	Relay enabled
LLN0	Loc.stVal	LOC	Control authority at local (bay) level
LLN0	LocSta.stVal	LOCSTA	Control authority at station level
LGOS*n*[d]	NdsCom.stVal	GNCM*n*[e]	Subscription needs commissioning for GOOSE Message *n*. True if ConfRevNum does not match RxConfRevNum
LGOS*n*[d]	St.stVal	GST*n*[e]	Status of the subscription (True = active, False = not active) for GOOSE Message *n*
LGOS*n*[d]	SimSt.stVal	GSIM*n*[e]	Status showing that simulation messages are received and accepted for GOOSE Message *n*
LGOS*n*[d]	LastStNum.stVal	GLST*n*[e]	Last state number received (StNum) for GOOSE Message *n*
LGOS*n*[d]	LastSqNum.stVal	GLSQ*n*[e]	Last sequence number received (SqNum) for GOOSE Message *n*
LGOS*n*[d]	LastTal.stVal	GTAL*n*[e]	Last time-allowed-to-live received (TTL) for GOOSE Message *n*
LGOS*n*[d]	ConfRevNum.stVal	[f]	Expected configuration revision number for GOOSE Message *n*
LGOS*n*[d]	RxConfRevNum.stVal	GCNF*n*[e]	Received configuration revision number for GOOSE Message *n*
LGOS*n*[d]	ErrSt.stVal[g]	GERR*n*[e]	Error status of the subscription for GOOSE Message *n*

Table G.41 Logical Device: CFG (Configuration) (Sheet 3 of 6)

Logical Node	Attribute	Data Source	Comment
LGOS*n*[d]	OosCnt.stVal	GOOS*n*[e]	Number of out-of-sequence (OOS) errors for GOOSE Message *n*
LGOS*n*[d]	TalCnt.stVal	GTLC*n*[e]	Number of time-allowed-to-live violations for GOOSE Message *n*
LGOS*n*[d]	DecErrCnt.stVal	GDER*n*[e]	Number of messages that failed decoding for GOOSE Message *n*
LGOS*n*[d]	BufOvflCnt.stVal	GBFO*n*[e]	Number of messages lost because of buffer overflow for GOOSE Message *n*
LGOS*n*[d]	MsgLosCnt.stVal	GMSL*n*[e]	Number of messages lost due to OOS errors (estimated) for GOOSE Message *n*
LGOS*n*[d]	MaxMsgLos.stVal	GMXM*n*[e]	Maximum number of sequential messages lost because of OOS error (estimated) for GOOSE Message *n*
LGOS*n*[d]	InvQualCnt.stVal	GIDQ*n*[e]	Number of mapped data with invalid quality for GOOSE Message *n*
LGOS*n*[d]	RsStat.stVal	GRST*n*[e]	Status of statistics reset for GOOSE messages
LTIM	TmDT.stVal	TMDT[a]	Indicates daylight-saving time is currently in effect at the IED location
LTMS	TmAcc.stVal	TSACC[a]	Number of significant bits in the FractionOfSecond (an attribute of TimeStamp) 18: 4 µs accuracy (2^{-18}) 10: 1 ms accuracy (2^{-10}) 7: 10 ms accuracy (2^{-7}) 31: Unknown accuracy
LTMS	TmSrc.stVal	TSSRC[a]	Time-source identity If TmSrcTyp is PTP, TmSrc indicates the grandmaster clock class as defined by IEEE 1588-2008 If TmSrcTyp is SNTP, TmSrc indicates the IP address of the SNTP server For all other values of TmSrcTyp, TmSrc is set to NA
LTMS	SelTmSrcTyp.stVal	TSTYPE[a]	Type of the clock source as defined by Relay Word bits Time.SNTP_PriSrvr, Time.SNTP_BackupSrvr, Time.SyncOk, and Time.IRIG_Ok 1: Unknown 2: SNTP 3: PTP 4: IRIG-B
LTMS	SelTmSyn.stVal	TSSYN[a]	Traceability of the reference time to which the IED is synchronized 3: GlobalAreaClock—TmSrcTyp is PTP with grandmaster clock class of 6, TmSrcTyp is IRIG-B with IRIGC = C37.118, or TmSrcTyp is SNTP 2: LocalAreaClock—TmSrcTyp is PTP with grandmaster clock other than 6 (Future), or TmSrcTyp is IRIG-B with IRIGC ≠ C37.118 1: InternalClock—TmSrcTyp is unknown
LTMS	SelTmSynLkd.stVal	TSSYNLK[a]	Status of clock synchronization: 1: Locked 2: Unlocked for 0–10 seconds 3: Unlocked for 10–100 seconds 4: Unlocked for 100–1000 seconds 5: Unlocked for more than 1000 seconds
Functional Constraint = MX			
LGOS*n*[d]	TotDwnTm.instMag.f	GDWT*n*[e]	Total downtime in seconds for GOOSE Message *n*
LGOS*n*[d]	MaxDwnTm.instMag.f	GMXD*n*[e]	Maximum continuous downtime in seconds for GOOSE Message *n*
LTMS	SelTmTosPer.instMag.f	TSPER[a]	Duration, in milliseconds, between two consecutive top-of-second points on the synchronized time; TmTosPer is set to 0 for time sources other than high-accuracy PTP or IRIG-B

Table G.41 Logical Device: CFG (Configuration) (Sheet 4 of 6)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = SP			
GOLCCH2	NetMod.setVal	NETMODE	Port 1 network operating mode setting 1: Fixed 2: Failover 3: Switched 4: PRP
IPLCCH1	NetMod.setVal	NETMODE	Port 1 network operating mode setting 1: Fixed 2: Failover 3: Switched 4: PRP
LGOS*n*[d]	GoCBRef.setSrcRef	[f]	Configured GOOSE control block reference for GOOSE Message *n*
LGOS*n*[d]	DatSet.setSrcRef	[f]	Configured data set reference for GOOSE Message *n*
LGOS*n*[d]	GoID.setVal	[f]	Configured ID for GOOSE Message *n*
LGOS*n*[d]	Addr.setVal	[f]	Configured multicast MAC address for GOOSE Message *n*
LGOS*n*[d]	VlanID.setVal	[f]	Configured VLAN ID for GOOSE Message *n*
LGOS*n*[d]	VlanPri.setVal	[f]	Configured VLAN priority for GOOSE Message *n*
LGOS*n*[d]	AppID.setVal	[f]	Configured APPID for GOOSE Message *n*
LLN0	MtlLev.setVal	MLTLEV	Multilevel mode of control authority
LTIM	TmOfsTmm.setVal	TMOFFS[a]	Offset of local time from UTC in minutes
LTIM	TmUseDT.setVal	TMUSEDT[a]	Set to True if daylight-saving time is enabled
LTIM	TmChgDT.setTm	TMCHGDT[a]	Local time of next change to daylight-saving time
LTIM	TmChgST.setTm	TMCHGST[a]	Local time of next change to standard time
Functional Constraint = SR			
LTRK1	SpcTrk.objRef	[h]	ACSI reference to the SPC object targeted in the request
LTRK1	SpcTrk.serviceType	[h, i]	Type of service requested or executed
LTRK1	SpcTrk.errorCode	[h, j]	ACSI service error status
LTRK1	SpcTrk.ctlVal	[h]	Control value in the request
LTRK1	SpcTrk.ctlNum	[h]	Control number in the request
LTRK1	SpcTrk.origin.orCat	[h]	Originator category value in the request
LTRK1	SpcTrk.origin.orIdent	[h]	Originator identity value in the request
LTRK1	SpcTrk.T	[h]	Time-stamp value in the request
LTRK1	SpcTrk.Test	[h]	Test value in the request
LTRK1	SpcTrk.Check	[h]	Check condition value in the request
LTRK1	SpcTrk.respAddCause	[h]	AddCause value returned in the response
LTRK1	DpcTrk.objRef	[h]	ACSI reference to the DPC object targeted in the request
LTRK1	DpcTrk.serviceType	[h, i]	Type of service requested or executed
LTRK1	DpcTrk.errorCode	[h, j]	ACSI service error status
LTRK1	DpcTrk.ctlVal	[h]	Control value in the request
LTRK1	DpcTrk.ctlNum	[h]	Control number in the request
LTRK1	DpcTrk.origin.orCat	[h]	Originator category value in the request
LTRK1	DpcTrk.origin.orIdent	[h]	Originator identity value in the request

Table G.41 Logical Device: CFG (Configuration) (Sheet 5 of 6)

Logical Node	Attribute	Data Source	Comment
LTRK1	DpcTrk.T	h	Time-stamp value in the request
LTRK1	DpcTrk.Test	h	Test value in the request
LTRK1	DpcTrk.Check	h	Check condition value in the request
LTRK1	DpcTrk.respAddCause	h	AddCause value returned in the response
LTRK1	EncTrk.objRef	h	ACSI reference to the ENC object targeted in the request
LTRK1	EncTrk.serviceType	h, i	Type of service requested or executed
LTRK1	EncTrk.errorCode	h, j	ACSI service error status
LTRK1	EncTrk.ctlVal	h	Control value in the request
LTRK1	EncTrk.ctlNum	h	Control number in the request
LTRK1	EncTrk.origin.orCat	h	Originator category value in the request
LTRK1	EncTrk.origin.orIdent	h	Originator identity value in the request
LTRK1	EncTrk.T	h	Time-stamp value in the request
LTRK1	EncTrk.Test	h	Test value in the request
LTRK1	EncTrk.Check	h	Check condition value in the request
LTRK1	EncTrk.respAddCause	h	AddCause value returned in the response
LTRK1	BrcbTrk.objRef	h	ACSI reference of the BRCB object targeted in the request
LTRK1	BrcbTrk.serviceType	h, i	Type of service requested or executed
LTRK1	BrcbTrk.errorCode	h, j	ACSI service error status
LTRK1	BrcbTrk.rptID	h	RptID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.rptEna	h	RptEna attribute value in the request or target BRCB object
LTRK1	BrcbTrk.datSet	h	DatSet attribute value in the target BRCB object
LTRK1	BrcbTrk.confRev	h	ConfRev attribute value in the target BRCB object
LTRK1	BrcbTrk.optFlds	h	OptFlds attribute value in the request or target BRCB object
LTRK1	BrcbTrk.bufTm	h	BufTm attribute value in the request or target BRCB object
LTRK1	BrcbTrk.sqNum	h	SqNum attribute value in the target BRCB object
LTRK1	BrcbTrk.trgOps	h	TrgOps attribute value in the request or target BRCB object
LTRK1	BrcbTrk.intgPd	h	IntgPd attribute value in the request or target BRCB object
LTRK1	BrcbTrk.gi	h	GI attribute value in the request or target BRCB object
LTRK1	BrcbTrk.purgeBuf	h	PurgeBuf attribute value in the request or target BRCB object
LTRK1	BrcbTrk.entryID	h	EntryID attribute value in the request or target BRCB object
LTRK1	BrcbTrk.timeOfEntry	h	TimeOfEntry attribute value in the request or target BRCB object
LTRK1	UrcbTrk.objRef	h	ACSI reference of the URCB object targeted in the request
LTRK1	UrcbTrk.serviceType	h, i	Type of service requested or executed
LTRK1	UrcbTrk.errorCode	h, j	ACSI service error status
LTRK1	UrcbTrk.rptID	h	RptID attribute value in the request or target URCB object
LTRK1	UrcbTrk.rptEna	h	RptEna attribute value in the request or target URCB object
LTRK1	UrcbTrk.resv	h	Resv attribute value in the request or target URCB object
LTRK1	UrcbTrk.datSet	h	DatSet attribute value in the target URCB object
LTRK1	UrcbTrk.confRev	h	ConfRev attribute value in the target URCB object

Table G.41 Logical Device: CFG (Configuration) (Sheet 6 of 6)

Logical Node	Attribute	Data Source	Comment
LTRK1	UrcbTrk.optFlds	[h]	OptFlds attrbute value in the request or target URCB object
LTRK1	UrcbTrk.bufTm	[h]	BufTm attribute value in the request or target URCB object
LTRK1	UrcbTrk.sqNum	[h]	SqNum attribute value in the target URCB object
LTRK1	UrcbTrk.trgOps	[h]	TrgOps attribute value in the request or target URCB object
LTRK1	UrcbTrk.intgPd	[h]	IntgPd attribute value in the request or target URCB object
LTRK1	UrcbTrk.gi	[h]	GI attribute value in the request or target URCB object
LTRK1	SgcbTrk.objRef	[h]	ACSI reference of the SGCB object targeted in the request
LTRK1	SgcbTrk.serviceType	[h, i]	Type of service requested (SelectActiveSG)
LTRK1	SgcbTrk.errorCode	[h, j]	ACSI service error status
LTRK1	SgcbTrk.numOfSG	[h]	NumOfSG attribute value in the target SGCB object
LTRK1	SgcbTrk.actSG	[h]	ActSG attribute value in the request
LTRK1	SgcbTrk.editSG	[h]	EditSG attribute value in the target SGCB object (0)
LTRK1	SgcbTrk.cnfEdit	[h]	CnfEdit attribute value in the target SGCB object (FALSE)
LTRK1	SgcbTrk.lActTm	[h]	LActTm attribute value in the target SGCB object after activation of the settings group

[a] Internal data source and not available to the user.
[b] MMS controls to Mod.Oper are only accepted if IEC 61850 Mode/Behavior is enabled on the relay. Refer to Mode/Behavior Control on page G.21 for more details.
[c] I60MOD is an internal data source derived from the I850MOD analog quantity and is not available to the user.
[d] Where n = 1–16, corresponding to the first 16 GOOSE message subscriptions.
[e] Internal data source not available to the user. See GOOSE on page G.17 for more information.
[f] Data source defined in the IEC 61850 Configured IED Description (CID) file.
[g] Refer to Table 7.28 for a description of each enumeration.
[h] The value depends on the ACSI service type requested, the target object, and the error status.
[i] Refer to Table G.10 for the IEC 61850 service type enumeration.
[j] Refer to Table G.11 for the IEC 61850 ACSI service error.

SEL Nameplate

The CID file contains information that describes the physical device attributes according to IEC 61850 standards. The LN0 logical node of each logical device contains the Nameplate DOI (instantiated data object) with the following data.

Table G.42 SEL Nameplate Data

Data Attribute	Value
vendor	“SEL”
swRev	Contents of FID string from **ID** command
configRev	Always 0
1dNs	IEC 61850-7-4:2007A

Protocol Implementation Conformance Statement

The following tables are as shown in the IEC 61850 standard, Part 8-1, Section 24. Note that because the standard explicitly dictates which services and functions must be implemented to achieve conformance, only the optional services and functions are listed.

Table G.43 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 G.44 PICS for T-Profile Support

Profile		Client	Server	Value/Comment
T1	TCP/IP	N	Y	
T2	OSI	N	N	
T3	GOOSE/GSE	Y	Y	Only GOOSE, Not GSSE
T4	GSSE	N	N	
T5	Time Sync	Y	N	

Refer to *ACSI Conformance Statements* for information on the supported services.

MMS Conformance

The Manufacturing Message Specification (MMS) stack provides the basis for many IEC 61850 Protocol services. *Table G.45* defines the service support requirement and restrictions of the MMS services in the SEL-700 series relays supporting IEC 61850. Generally, only those services whose implementation is not mandatory are shown. Refer to the IEC 61850 standard Part 8-1 for more information.

Table G.45 MMS Service Supported Conformance (Sheet 1 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
status		Y
getNameList		Y
identify		Y
rename		
read		Y
write		Y
getVariableAccessAttributes		Y
defineNamedVariable		
defineScatteredAccess		
getScatteredAccessAttributes		
deleteVariableAccess		
defineNamedVariableList		
getNamedVariableListAttributes		Y
deleteNamedVariableList		
defineNamedType		
getNamedTypeAttributes		
deleteNamedType		
input		

Table G.45 MMS Service Supported Conformance (Sheet 2 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
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		Y
defineEventCondition		
deleteEventCondition		
getEventConditionAttributes		
reportEventConditionStatus		
alterEventConditionMonitoring		
triggerEvent		
defineEventAction		
deleteEventAction		
alterEventEnrollment		
reportEventEnrollmentStatus		
getEventEnrollmentAttributes		
acknowledgeEventNotification		
getAlarmSummary		
getAlarmEnrollmentSummary		

Table G.45 MMS Service Supported Conformance (Sheet 3 of 3)

MMS Service Supported CBB	Client-CR	Server-CR
	Supported	Supported
readJournal		
writeJournal		
initializeJournal		
reportJournalStatus		
createJournal		
deleteJournal		
fileOpen		Y
fileRead		Y
fileClose		Y
fileRename		
fileDelete		
fileDirectory		Y
unsolicitedStatus		
informationReport		Y
eventNotification		
attachToEventCondition		
attachToSemaphore		
conclude		Y
cancel		Y
getDataExchangeAttributes		
exchangeData		
defineAccessControlList		
getAccessControlListAttributes		
reportAccessControlledObjects		
deleteAccessControlList		
alterAccessControl		
reconfigureProgramInvocation		

Table G.46 lists specific settings for the MMS parameter Conformance Building Block (CBB).

Table G.46 MMS Parameter CBB

MMS Parameter CBB	Client-CR	Server-CR
	Supported	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 G.47 AlternateAccessSelection Conformance Statement

AlternateAccessSelection	Client-CR Supported	Server-CR Supported
accessSelection		YES
component		YES
index		
indexRange		
allElements		
alternateAccess		YES
selectAccess		YES
component		YES
index		
indexRange		
allElements		

Table G.48 VariableAccessSpecification Conformance Statement

VariableAccessSpecification	Client-CR Supported	Server-CR Supported
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES
variableListName		YES

Table G.49 VariableSpecification Conformance Statement

VariableSpecification	Client-CR Supported	Server-CR Supported
name		YES
address		
variableDescription		
scatteredAccessDescription		
invalidated		

Table G.50 Read Conformance Statement

Read	Client-CR Supported	Server-CR Supported
Request		
specificationWithResult		
variableAccessSpecification		
Response		
variableAccessSpecification		YES
listOfAccessResult		YES

Table G.51 GetVariableAccessAttributes Conformance Statement

GetVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
name		
address		
Response		
mmsDeletable		YES
address		
typeSpecification		YES

Table G.52 DefineNamedVariableList Conformance Statement

DefineVariableAccessAttributes	Client-CR Supported	Server-CR Supported
Request		
variableListName		
listOfVariable		
variableSpecification		
alternateAccess		
Response		

Table G.53 GetNamedVariableListAttributes Conformance Statement

GetNamedVariableListAttributes	Client-CR Supported	Server-CR Supported
Request		
ObjectName		
Response		
mmsDeletable		YES
listOfVariable		YES
variableSpecification		YES
alternateAccess		YES

Table G.54 DeleteNamedVariableList

DeleteNamedVariableList	Client-CR Supported	Server-CR Supported
Request		
Scope		
listOfVariableListName		
domainName		
Response		
numberMatched		
numberDeleted		
DeleteNamedVariableList-Error		

GOOSE Services Conformance Statement

Table G.55 GOOSE Conformance

	Subscriber	Publisher	Value/Comment
GOOSE Services	YES	YES	
SendGOOSEMessage		YES	
GetGoReference			
GetGOOSEElementNumber			
GetGoCBValues		YES	
SetGoCBValues			
GSENotSupported			
GOOSE Control Block (GoCB)		YES	

ACSI Conformance Statements

Table G.56 ACSI Basic Conformance Statement

		Client/Subscriber	Server/Publisher	SEL-710-5 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 G.57 ACSI Models Conformance Statement (Sheet 1 of 2)

		Client/Subscriber	Server/Publisher	SEL-710-5 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

Table G.57 ACSI Models Conformance Statement (Sheet 2 of 2)

		Client/Subscriber	Server/Publisher	SEL-710-5 Support
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
M8-6	BufTm			YES
M8-7	IntgPd			YES
M8-8	GI			YES
Logging				
M9	Log control	O[e]	O[e]	
M9-1	IntgPd	O[e]	O[e]	
M10	Log	O[e]	O[e]	
M11	Control	M[f]	M[f]	YES
If GSE (B31/32) Is Supported				
M12	GOOSE	O[e]	O[e]	YES
M12-1	entryID			YES
M12-2	DataReflnc			YES
M13	GSSE	O[e]	O[e]	
If GSE (B41/42) Is Supported				
M14	Multicast SVC	O[e]	O[e]	
M15	Unicast SVC	O[e]	O[e]	
M16	Time	M[f]	M[f]	
M17	File Transfer	O[e]	O[e]	

[a] c2 shall be "M" if support for LOGICAL-NODE model has been declared.
[b] c3 shall be "M" if support for DATA model has been declared.
[c] c4 shall be "M" if support for DATA-SET, Substitution, Report, Log Control, or Time model has been declared.
[d] c5 shall be "M" if support for Report, GSE, or SV models has been declared.
[e] O = Optional.
[f] M = Mandatory.

Table G.58 ACSI Services Conformance Statement (Sheet 1 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-710-5 Support
Server (Clause 6)					
S1	ServerDirectory	TP		M[a]	YES
Application Association (Clause 7)					
S2	Associate		M[a]	M[a]	YES
S3	Abort		M[a]	M[a]	YES
S4	Release		M[a]	M[a]	YES
Logical Device (Clause 8)					
S5	LogicalDeviceDirectory	TP	M[a]	M[a]	YES
Logical Node (Clause 9)					
S6	LogicalNodeDirectory	TP	M[a]	M[a]	YES
S7	GetAllDataValues	TP	O[b]	M[a]	YES
Data (Clause 10)					
S8	GetDataValues	TP	M[a]	M[a]	YES
S9	SetDataValues	TP	O[b]	O[b]	
S10	GetDataDirectory	TP	O[b]	M[a]	YES
S11	GetDataDefinition	TP	O[b]	M[a]	YES
Data Set (Clause 11)					
S12	GetDataSetValues	TP	O[b]	M[a]	YES
S13	SetDataSetValues	TP	O[b]	O[b]	
S14	CreateDataSet	TP	O[b]	O[b]	
S15	DeleteDataSet	TP	O[b]	O[b]	
S16	GetDataSetDirectory	TP	O[b]	O[b]	YES
Substitution (Clause 12)					
S17	SetDataValues	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)				

Table G.58 ACSI Services Conformance Statement (Sheet 2 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-710-5 Support
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]	
Transmission of Sample Value Model (SVC) (Clause 16)					
Multicast SVC					
S45	SendMSVMessage	MC	c10[g]	c10[g]	
S46	GetMSVCBValues	TP	O[b]	O[b]	
S47	SetMSVCBValues	TP	O[b]	O[b]	
Unicast SVC					
S48	SendUSVMessage	MC	c10[g]	c10[g]	
S49	GetUSVCBValues	TP	O[b]	O[b]	
S50	SetUSVCBValues	TP	O[b]	O[b]	
Control (Clause 16.4.8)					
S51	Select		M[a]	O[b]	
S52	SelectWithValue	TP	Ma	O[b]	YES
S53	Cancel	TP	O[b]	M[a]	YES
S54	Operate	TP	M[a]	M[a]	YES
S55	Command-Termination	TP	M[a]	M[a]	YES
S56	TimeActivated-Operate	TP	O[b]	O[b]	

Table G.58 ACSI Services Conformance Statement (Sheet 3 of 3)

Services		AA: TP/MC	Client/ Subscriber	Service/ Publisher	SEL-710-5 Support
File Transfer (Clause 20)					
S57	GetFile	TP	O[b]	M[a]	
S58	SetFile	TP	O[b]	O[b]	
S59	DeleteFile	TP	O[b]	O[b]	
S60	GetFileAttributeValues	TP	O[b]	M[a]	
Time (Clause 5.5)					
T1	Time resolution of internal clock (nearest negative power of 2 in seconds)				20 (1 µs)
T2	Time accuracy of internal clock				7 (10 ms) for SNTP 18 (4 µs) for IRIG-B
	T1				YES (for IRIG-B)
	T2				YES (for IRIG-B)
	T3				YES (for IRIG-B)
	T4				YES (for IRIG-B)
T3	Supported Time Stamp 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).

Potential Client and Automation Application Issues With Edition 2 Upgrades

The following are issues that IEC 61850 Edition 1 (Ed1)-based client or automation applications may experience with IEC 61850 Edition 2 (Ed2) ICD and firmware changes. However, such issues may be resolved by reconfiguring the client or automation application or worked around by restoring the Ed1 (CID) configuration. None of these should prevent a client application from dynamically discovering the data in the IED as long as the application adheres to the specification of the standard. Note that upgrading to Ed2 firmware will not break existing Ed1 configurations (CID files) in the field, nor require loading an Ed2 version of the CID file.

Unexpected Error Messages

Some MMS and control errors have been changed in Ed2. Hence, the firmware now issues only the Ed2-compliant errors. Clients or automation applications that rely on the Ed1-compliant errors will not function correctly. You can resolve this by reconfiguring the client or automation application to accept Ed2-compliant errors.

Missing or Unknown Data Objects and Attributes

Ed2 has changed some data object and attribute names, as well as the data types of some attributes. Ed2 also prohibits the use of proprietary CDCs. See *Logical Nodes on page F.23* and the logical nodes tables in each product-specific manual to determine the Ed2 names. This may cause the failure of clients or automation applications that rely on the Ed1 names. A workaround is to use the Ed1 version of the CID file, if available, to configure the IED. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 names.

Unable to Find Operate Time-Out

A proprietary method was used to specify the operate time-out of control objects in the CID files. A client or automation application that relies on this proprietary method will fail to find the operate time-out in the CID file. A workaround is to use the Ed1 CID file to configure the IED. You can also resolve this by reconfiguring the client or automation application to accept the Ed2 control object operate time-outs.

Unexpected Control Block Data Attribute Type

The string type data attributes in control blocks (RptID, DatSet, etc.) have been changed from a maximum length of 65 to 129 characters, i.e., VisString65 to Vis-String129. Some clients and automation applications might see this as an error when the type is reported in the MMS GetVariableAccessAttributes response. You can resolve this by reconfiguring the client or automation application.

Unexpected Reports

Ed2 requires report buffering to start when the device is turned on, unlike in the Ed1 implementation where report buffering started after the first report enable. If a client or automation application relies on the Ed1 behavior, it might fail or indicate an error if the IED sends buffered reports immediately after the first enable. You can resolve this by reconfiguring the client or automation application.

Failure to Reselect a Control Object Before the Timeout

In Ed1, if a client reselected a control object before the select-before-operate time-out expired, the reselection would succeed and cause the selected time-out to restart. According to Ed2, this reselection is supposed to fail. Ed1-based clients or automation applications that rely on successful reselection might operate incorrectly. You can resolve this by reconfiguring the client or automation application.

Test Control Commands Fail Immediately

In Ed1, if the test attribute was set in a control command structure, the relay would accept the command but perform no action on the target control object. With enhanced control models, the IED would eventually report an operate timeout error after the operate time-out expired. However, in Ed2, any such test commands will fail immediately with an error indicating that the command is blocked because the IED is not in the appropriate mode. Clients or automation applications that depend on the Ed1 behavior might fail. You can resolve this by reconfiguring the client or automation application.

No Reports

Ed2 specifies that no reports are to be generated for a deadbanded attribute if the deadband is set to 0. Previously in Ed1, a deadband of 0 would cause the relay to generate reports for any change in the instantaneous value. Ed1-based clients or automation applications might not operate correctly because of the lack of reports. You can resolve this by reconfiguring the client or automation application.

Appendix H

IEC 60870-5-103 Communications

Overview

The SEL-710-5 Motor Protection Relay provides the IEC 60870-5-103 interface for direct serial connections to the device.

This section covers the following topics:

- *Introduction to IEC 60870-5-103*
- *IEC 60870-5-103 in the SEL-710-5*
- *IEC 60870-5-103 Documentation*

Introduction to IEC 60870-5-103

The International Electrotechnical Commission (IEC) 60870-5 is a protocol standard developed by the IEC Technical Committee of teleprotection, telecontrol, and telecommunications for electrical engineering and power system automation. It defines systems used for supervisory control and data acquisition (SCADA), including details related to communications between devices. IEC 60870-5-103 is a companion standard that allows interoperability between devices in a control system and protection equipment. The IEC 60870-5 standard consists of the documents listed in *Table H.1*.

Table H.1 IEC 60870-5 Standard Documents

Document	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding of Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-6	Guidelines for Conformance Testing IEC 60870-5 Companion Standards
IEC 60870-5-7	Security extensions to IEC 60870-5-1010 and IEC 60870-5-104 protocols

The IEC 60870-5-103 document 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 60870-5-103 systems be familiar with the appropriate sections of this document.

IEC 60870-5 was designed for wide-spread telecontrol networks. It is an international standard based on an international accepted and proven enhanced performance architecture (EPA) model (see *Table H.2*). The standard provides a balance between efficiency and reliability while using minimal hardware.

Table H.2 IEC 60870-5 Enhanced Performance Architecture Model

Layer	Layer Type
7	Application
–	–
–	–
–	–
–	–
2	Datalink
1	Physical

Layer seven implementation is described in the IEC 60870-5-3 and IEC 60870-5-4 sections of the standard. Layer two implementation is described in the IEC 60870-5-2 and IEC 60870-5-1 sections of the standard.

The history of IEC 60870-5 spans from 1990 to 2006. *Table H.3* shows the history during this time period. The first five sections are the basic parts of the standard. The next six describe the companion standards, and the last two sections are test procedures of the standard.

Table H.3 History of IEC 60870-5

Section	Description
IEC 60870-5-1	Transmission Frame Formats
IEC 60870-5-2	Data Link Transmission Services
IEC 60870-5-3	General Structure of Application Data
IEC 60870-5-4	Definition and Coding Information Elements
IEC 60870-5-5	Basic Application Functions
IEC 60870-5-101	CS For Basic Telecontrol Tasks
IEC 60870-5-102	CS For Transmission Of Integrated Totals In Electric Power Systems
IEC 60870-5-103	CS for Informative Interface Of Protection Equipment
IEC 60870-5-104	Network Access For TCS101 Using Standard Transport Profiles
IEC 60870-5-101 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-104 Ed 2	Addendums Incorporated In Standard
IEC 60870-5-601	Conformance Test Procedures For TCS 101
IEC 60870-5-604	Conformance Test Procedures For TCS 104

Data Handling

Master/Slave Communication

The IEC 60870-5-103 standard is such that the IED only sends a message when the Master asks for it. Communication is set up by the Master and the Master controls the communication between the Master and the IED.

Interoperability

The method of data exchange in the SEL-710-5 involves Application Service Data Units (ASDUs) along with application procedures for transmission of standardized data messages (see *Table H.4*). The data are recognized by any IEC 60870-5-103 Master because the application data take the form of an IEC 60870-5-103 data type and pairs with an IEC 60870-5-103 address, resulting in device interoperability.

Table H.4 SEL-710-5 ASDU Types

ASDU Type	Description
1	Time Tagged Message
2	Time Tagged Message With Relative Time
4	Time Tagged Measurands With Relative Time
5	Identification
6	Time Synchronization
7	General Interrogation Start
8	General Interrogation Termination
9	Measurands II
20	General Command
205	Non-Standard (defined below)

<table>
<tr><td>Type Identification</td><td colspan="8">0xCD (205)</td></tr>
<tr><td>Variable Structure Qualifier</td><td colspan="8">0x81</td></tr>
<tr><td>Cause of Transmission</td><td colspan="8">0x01</td></tr>
<tr><td>Device Address</td><td colspan="8">ADDR</td></tr>
<tr><td>Function Type</td><td colspan="8">FUN</td></tr>
<tr><td>Information Number</td><td colspan="8">INF</td></tr>
<tr><td rowspan="4">Information Element Meter value: 29-bit signed integer ER: 0 valid, 1 invalid</td><td>2^{7}</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>2^{0}</td></tr>
<tr><td>2^{15}</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>2^{8}</td></tr>
<tr><td>2^{23}</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td><td>2^{16}</td></tr>
<tr><td>0</td><td>ER</td><td>0</td><td>-2^{28}</td><td>•</td><td>•</td><td>•</td><td>2^{24}</td></tr>
<tr><td>Four Octet Binary Time</td><td colspan="8">Defined in 60870-5-103, 7.2.6.28</td></tr>
</table>

Table H.5 lists the available category map settings in the SEL-710-5. When configuring the settings with the command line, categories can be selected by entering “>” or “<”.

Table H.5 IEC 60870-5-103 Category Map Settings

Setting Prompt	Scaling/Nominal Value Range	Information Number Range	Function Type Range	Setting Name
103 Binary Input Label	NA	0–255	0–255	103BI00
103 Binary Input Label	NA	0–255	0–255	103BI01
• • •	• • •	• • •	• • •	• • •
103 Binary Input Label	NA	0–255	0–255	103BI99
103 Binary Target Label	NA	0–255	0–255	103BT00
103 Binary Target Label	NA	0–255	0–255	103BT01
• • •	• • •	• • •	• • •	• • •
103 Binary Target Label	NA	0–255	0–255	103BT07
103 Binary Control Label	NA	0–255	0–255	103BO00
103 Binary Control Label	NA	0–255	0–255	103BO01
• • •	• • •	• • •	• • •	• • •
103 Binary Control Label	NA	0–255	0–255	103BO31
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA00
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA01
• • •	• • •	• • •	• • •	• • •
103 Fault Analog Label	0.000–99999	0–255	0–255	103FA31
103 Measurand Label	0.001–999999	0–255	0–255	3MLB000
103 Measurand Label	0.001–999999	0–255	0–255	3MLB001
• • •	• • •	• • •	• • •	• • •
103 Measurand Label	0.001–999999	0–255	0–255	3MLB127
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ00
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ01
• • •	• • •	• • •	• • •	• • •
103 Meter Quantity Label	0.000–99999	0–255	0–255	103MQ31

Cause of Transmission

The Cause of Transmission (COT) represents the reason the SEL-710-5 sends a message to the Master. See *Table H.6* for the possible COTs.

Table H.6 IEC 60870-5-103 Cause Of Transmission

Cause of Transmission	Description
1	Spontaneous Events
2	Cyclic
3	Reset Frame Count Bit (FCB)
4	Reset Communication Unit (CU)
5	Start/Restart
6	Power On
7	Test Mode
8	Time Synchronization
9	Initiation Of General Interrogation
10	Termination Of General Interrogation
12	Remote Operation
20	General Command (Control Direction), Positive Acknowledgment Of Command (Monitor)
21	Negative Acknowledgment Of Command (Monitor)
31	Disturbance Recorder
40–44	Generic Commands And Data

Information Number

The Information Number (INF) is one of the two octets of the information object identifier. See *Table H.7* for the range and description of Information Numbers in IEC 60870-5-103.

Table H.7 IEC 60870-5-103 Information Numbers (Sheet 1 of 2)

Function Type	Description
Monitor Direction	
0–15	System Functions
16–31	Status
32–47	Supervision
48–63	Earth Fault
64–127	Short Circuit
128–143	Auto Reclose
144–159	Measurands
160–239	Not Used
240–255	Generic Functions

Table H.7 IEC 60870-5-103 Information Numbers (Sheet 2 of 2)

Function Type	Description
Control Direction	
0–15	System Functions
16–31	General Commands
32–239	Not Used
240–255	Generic Functions

Function Type

The Function Type (FUN) is the second of the two octets of the information object identifier.

Together, the pair [INF, FUN] distinctly characterizes each point within each data class. *Table H.8* and *Table H.9* give the Standard Function Types and Data Map for the IEC 60870-5-103 standard.

Table H.8 IEC 60870-5-103 Standard Function Types

Function Type	Description
128	Distance protection
160	Overcurrent protection
176	Transformer Differential Protection
192	Line Differential Protection
254	Generic Function Type
255	Global Function Type

Table H.9 IEC 60870-5-103 Data Map (Sheet 1 of 3)

INF	Description	GI	ASDU Type	COT	FUN
System functions in monitor direction					
0[a]	End of general interrogation	–	8	10	255
0[a]	Time synchronization	–	6	8	255
2[a]	Reset FCB	–	5	3	According to main FUN
3[a]	Reset CU	–	5	4	According to main FUN
4[a]	Start/restart	–	5	5	According to main FUN
5[a]	Power on	–	5	6	According to main FUN
Status indications in monitor direction[b]					
16	Auto-recloser active	Yes	1	1,7,9,11,12,20,21	128, 160, 192
17	Teleprotection active	Yes	1	1,7,9,11,12,20,21	128, 160
18	Protection active	Yes	1	1,7,9,11,12,20,21	128, 160, 176, 192
19	LED Reset	–	1	1,7,11,12,20,21	128, 160, 176, 192
20	Monitor direction blocked	Yes	1	9,11	128, 160, 176, 192
21	Test mode	Yes	1	9,11	128, 160, 176, 192
22	Local parameter setting	Yes	1	9,11	128, 160, 176, 192

Table H.9 IEC 60870-5-103 Data Map (Sheet 2 of 3)

INF	Description	GI	ASDU Type	COT	FUN
23	Characteristic 1[c]	Yes	1	1,7,9,11,12,20,21	128
24	Characteristic 2[c]	Yes	1	1,7,9,11,12,20,21	128
25	Characteristic 3[c]	Yes	1	1,7,9,11,12,20,21	128
26	Characteristic 4[c]	Yes	1	1,7,9,11,12,20,21	128
27	Auxiliary input 1[d]	Yes	1	1,7,9,11	128, 160, 176, 192
28	Auxiliary input 2[d]	Yes	1	1,7,9,11	128, 160, 176, 192
29	Auxiliary input 3[d]	Yes	1	1,7,9,11	128, 160, 176, 192
30	Auxiliary input 4[d]	Yes	1	1,7,9,11	128, 160, 176, 192
Supervision indications in monitor direction[b]					
32	Measurand supervision I	Yes	1	1,7,9	128, 160
33	Measurand supervision V	Yes	1	1,7,9	128, 160
35	Phase sequence supervision	Yes	1	1,7,9	128, 160
36	Trip circuit supervision	Yes	1	1,7,9	128, 160, 176, 192
37	I>> back-up operation	Yes	1	1,7,9	128
38	Voltage transformer fuse failure	Yes	1	1,7,9	128, 160
39	Teleprotection disturbed	Yes	1	1,7,9	128, 160, 192
46	Group warning	Yes	1	1,7,9	128, 160, 176, 192
47	Group alarm	Yes	1	1,7,9	128, 160, 176, 192
Earth fault indications in monitor direction[b]					
48	Earth Fault L_1	Yes	1	1,7,9	128, 160
49	Earth Fault L_2	Yes	1	1,7,9	128, 160
50	Earth Fault L_3	Yes	1	1,7,9	128, 160
51	Earth fault forward, i.e., line	Yes	1	1,7,9	128, 160
52	Earth fault reverse, i.e., busbar	Yes	1	1,7,9	128, 160
Fault indications in monitor direction[e]					
64	Start/pick-up L[b]	Yes	2	1,7,9	128, 160, 192
65	Start/pick-up L[c]	Yes	2	1,7,9	128, 160, 192
66	Start/pick-up L[d]	Yes	2	1,7,9	128, 160, 192
67	Start/pick-up N	Yes	2	1,7,9	128, 160, 192
68	General trip	–	2	1,7	128, 160, 176, 192
69	Trip L_1	–	2	1,7	128, 160, 176, 192
70	Trip L_2	–	2	1,7	128, 160, 176, 192
71	Trip L_3	–	2	1,7	128, 160, 176, 192
72	Trip I>> (back-up operation)	–	2	1,7	128, 160, 176, 192
73	Fault Location X in ohms	–	4	1,7	128
74	Fault forward / line	–	2	1,7	128, 160
75	Fault reverse / busbar	–	2	1,7	128, 160
76	Teleprotection signal transmitted	–	2	1,7	128, 160
77	Teleprotection signal received	–	2	1,7	128, 160
78	Zone 1	–	2	1,7	128

Table H.9 IEC 60870-5-103 Data Map (Sheet 3 of 3)

INF	Description	GI	ASDU Type	COT	FUN
79	Zone 2	–	2	1,7	128
80	Zone 3	–	2	1,7	128
81	Zone 4	–	2	1,7	128
82	Zone 5	–	2	1,7	128
83	Zone 6	–	2	1,7	128
84	General start / pick-up	Yes	2	1,7,9	128, 160, 176, 192
85	Breaker failure	–	2	1,7	128, 160
86	Trip measuring system L_1	–	2	1,7	176
87	Trip measuring system L_2	–	2	1,7	176
88	Trip measuring system L_3	–	2	1,7	176
89	Trip measuring system E	–	2	1,7	176
90	Trip I>	–	2	1,7	160
91	Trip I>>	–	2	1,7	160
92	Trip IN>	–	2	1,7	160
93	Trip IN>>	–	2	1,7	160
Auto-recloser indications in monitor direction[b]					
128	Circuit breaker on by Auto-recloser	–	1	1,7	128, 160, 192
129	Circuit breaker on by long-time Auto-recloser	–	1	1,7	128, 160, 192
130	Auto-recloser blocked	Yes	1	1,7,9	128, 160, 192
Measurands in monitor direction					
144	Measurand I	–	3.1	2,7	128, 160
145	Measurands I, V	–	3.2	2,7	128, 160
146	Measurands I, V, P, Q	–	3.3	2,7	128
147	Measurands I_N, V_{EN}	–	3.4	2,7	128, 160
148	Measurands $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, f	–	9	2,7	128
System functions in control direction					
0[a]	Initiation of General Interrogation		7	9	255
0[a]	Time synchronization		6	8	255
General commands in control direction[f]					
16	Auto-recloser on/off	ON/OFF	20	20	128, 160, 192
65	Teleprotection on/off	ON/OFF	20	20	128, 160
66	Protection on/off	ON/OFF	20	20	128, 160, 176, 192
67	LED Reset	ON	20	20	128, 160, 176, 192
68	Activate characteristic 1[c]	ON	20	20	128
69	Activate characteristic 2[c]		20	20	128
70	Activate characteristic 3[c]		20	20	128
71	Activate characteristic 4[c]		20	20	128

[a] The SEL-710-5 supports these points at the specified INF and FUN.
[b] Referred to as Binary Data in the SEL-710-5.
[c] Mapped to settings group indications and control in the SEL-710-5.
[d] Mapped to device contact inputs in the SEL-710-5.
[e] Referred to as Binary Targets and other Fault Information in the SEL-710-5.
[f] Referred to as Binary Controls in the SEL-710-5.

IEC 60870-5-103 in the SEL-710-5

The IEC 60870-5-103 protocol settings in the SEL-710-5 contain five parameters that must be set properly to get the most out of the protocol. These parameters are called 103ADDR, 103CYC, 103ACYC, 103ATRI, and 103TIME. *Table H.10* describes each of these parameters.

Table H.10 SEL-710-5 IEC 60870-5-103 Port Settings

Parameter	Description	Range/Valid Input
103ADDR	Link layer address of the product	0–254
103CYC	Period at which to report cyclic data (measurands)	1–3600 seconds
103ACYC	Meter quantity period to report type ASDU 205 data	OFF, 1–3600 seconds
103ATRI	Relay Word bit used as a meter quantity reporting trigger for type ASDU 205 data	1 Relay Word bit
103TIME	Time synchronization enable	Y, N

The IEC 60870-5-103 standard in the SEL-710-5 provides six category types namely, Binary Inputs, Binary Targets, Binary Controls, Measurands, Fault Analogs, and Meter Quantities. Each data point within each class type requires an Information Number and a Function Type. Binary Inputs, Binary Targets, and Binary Controls are defined within the map by a Label Name followed by an Information Number followed by a Function Type. Measurands, Fault Analogs, and Meter Quantities are defined within the map by a Label Name followed by the Scale Factor/Nominal Value followed by the Information Number followed by the Function Type. The Nominal Value pertains only to Measurands and is defined within the following formula.

$$\text{Value seen by Master} = \frac{4096 \bullet \text{Label\_Value}}{2.4 \bullet \text{Nominal\_Value}}$$

Consider for example frequency in the Measurand point (FREQ, 60, 0, 1). Conceptually, when the frequency is 60 Hz, which is 0.4167 of 2.4 • Nominal Value (2.4 • 60 = 144), then the value 0.4167 gets encoded as a 13-bit, fixed-point number that has the same bit-wise representation as the integer that is equal to the Value seen by Master or

$$\frac{4096 \bullet \text{FREQ}}{2.4 \bullet 60\ \text{Hz}}$$

Binary Inputs

In the SEL-710-5, binary data are reported as ASDU type 1 (Time Tagged Message). Those points, monitored by the SER function of the device, have their changes reported as COT type 1 (Spontaneous Events). The format of a binary input point within the binary input map is "Label, [INF, FUN]." The Label represents any valid binary input point accepted by the SEL-710-5. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. The Label can be entered by itself with the SEL-710-5 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-710-5. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-710-5 does not accept only one member of the [INF, FUN] pair. Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-710-5.

Binary Targets

The binary targets are Relay Word bits within the SEL-710-5 under row zero. They also appear as LEDs on the front panel of the SEL-710-5. There are eight binary targets in the SEL-710-5 namely, ENABLED, TRIP_LED, TLED_01, TLED_02, TLED_03, TLED_04, TLED_05, and TLED_06. In the SEL-710-5, binary targets are reported as ASDU type 2 (Time Tagged Message with Relative Time) with COT type 1 (Spontaneous Events). The format of a binary target point within the binary target map is “Label, [INF, FUN].” Label represents any valid binary target point accepted by the SEL-710-5. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-710-5 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-710-5. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-710-5 does not accept only one member of the [INF, FUN] pair. Also, Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-710-5.

Fault Analogs

The fault analogs are analog quantities in the SEL-710-5 used to describe faults recognized by the relay, such as fault current or fault location. These quantities are listed in *Table H.11*. In the SEL-710-5, fault analog quantities are reported as ASDU type 4 (Time Tagged Measurands with Relative Time) with COT type 1 (Spontaneous Events). The format of a fault analog point within the fault analog map is “Label, [Scaling, [INF, FUN]].” Label represents any valid fault analog point accepted by the SEL-710-5. Scaling is the scaling factor applied to the point prior to being sent out of the relay via the protocol. Its range is 0.000 to 99999.000. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-710-5 choosing default parameters for Scaling, INF, and FUN. The Label and Scaling values can also be entered together with the SEL-710-5 choosing default parameters for the INF and FUN. The default parameter for INF is an available, unique value that is selected by the SEL-710-5. The default parameter for FUN is 250. The default value for Scaling is 1.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-710-5 does not accept only one member of the [INF, FUN] pair. If the [INF, FUN] pair has been entered, then Scaling must also be entered.

For a single Master/SEL-710-5 session, the SEL-710-5 stores as many as three sets of event data into a buffer. If the buffer is full as a result of multiple events with the poll cycle, any new event data is discarded. When the buffered data have been reported (using the first-in first-out (FIFO) principle) to the Master, those data are removed from the buffer to make room for the next event.

Table H.11 SEL-710-5 Analog Fault Quantities (Sheet 1 of 2)

Analog Fault Quantity	Description
FIA	A-phase current of the fault event
FIB	B-phase current of the fault event

Table H.11 SEL-710-5 Analog Fault Quantities (Sheet 2 of 2)

Analog Fault Quantity	Description
FIC	C-phase current of the fault event
FIG	Ground current of the fault event
FIN	Neutral current of the fault event
FIA87	Differential A-phase current of the fault event
FIB87	Differential B-phase current of the fault event
FIC87	Differential C-phase current of the fault event
FFREQ	Frequency of the fault event

Binary Controls

In the SEL-710-5, two types of controls are permitted under this protocol. They are as follows:

- ➤ Latching Single-Point: On/Off operations latch the point to 1 or 0, respectively. The points format is (Label, INF, FUN)
- ➤ Pulsing Single-Point: On operation pulses the point or triggers the point. Off has no effect. The point format is (Label, INF, FUN)

When controls are sent to the SEL-710-5 successfully, the relay responds with ASDU type 1 (Time Tagged Message) and COT type 20 (Positive Acknowledgment on Command) as well as with ASDU type 1 (Time Tagged Message) and COT type 12 (Remote Operation) if the control was sent remotely. The format of a binary control point within the binary control map is "Label, [INF, FUN]." Label represents any valid binary control point accepted by the SEL-710-5. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-710-5 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-710-5. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-710-5 does not accept only one member of the [INF, FUN] pair. Also, the Label, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-710-5.

Measurands

In the SEL-710-5, a measurand is defined as a group of at most 16 analog quantities with the same [INF, FUN] pair. The SEL-710-5 allows at most 8 measurands even if the measurand map is not completely filled with analog quantities (total of 128). Measurands are refreshed for the Master at the expiration of the 103CYC parameter and sent to the Master, once polled by the Master.

In the SEL-710-5, measurands are reported as ASDU type 9 (Measurands II) with COT type 2 (Cyclic). The format of an analog quantity within a measurand in the measurand map is "Label, Nominal, [INF, FUN]." Label represents any valid analog quantity accepted by the SEL-710-5. Nominal is the nominal value applied to the point prior to being sent out of the relay via the protocol. Its range is 0.001 to 999999.000. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. You are required to enter the Nominal value. The Label and Nominal values can be entered by themselves with the SEL-710-5 choosing default parameters for INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-710-5. The default parameter for FUN is 250.

The [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-710-5 does not accept only one member of the [INF, FUN] pair. And of course, the Label, Nominal, INF, and FUN can all be manually entered. No other combinations are valid with the SEL-710-5.

Meter Quantities

The meter quantities are analog quantities in the SEL-710-5. In the SEL-710-5, meter quantities are reported as ASDU type 205 (Non-Standard) with COT type 1 (Spontaneous Events). The format of a meter quantity point within the meter quantity map is "Label, [Scaling, [INF, FUN]]." Label represents any valid meter quantity point accepted by the SEL-710-5. Scaling is the scaling factor applied to the point prior to being sent out of the relay via the protocol. Its range is 0.000 to 99999. The INF parameter is an integer in the range of 0 to 255. Similarly, the FUN parameter is an integer in the range of 0 to 255. Label can be entered by itself with the SEL-710-5 choosing default parameters for the Scaling, INF, and FUN. Label and Scaling can also be entered together with the SEL-710-5 choosing default parameters for the INF and FUN. The default parameter for INF is an available, unique value to use that is selected by the SEL-710-5. The default parameter for FUN is 250. The default value for Scaling is 1.

In any case, the [INF, FUN] pair needs to either be entered together or not entered at all. The SEL-710-5 does not accept only one member of the [INF, FUN] pair. If the [INF, FUN] pair has been entered, then Scaling must also be entered.

The SEL-710-5 begins its response within 45 milliseconds of receiving a complete request. The above classes define the IEC 60870-5-103 data map in the SEL-710-5. The SEL-710-5 provides for only one IEC 60870-5-103 map. The map consists of 332 definable points. These points include 100 binary input points, 8 binary targets, 32 binary controls, 8 measurands (totaling 128 analog quantities), 32 fault analogs, and 32 meter quantities.

Time Synchronization

The SEL-710-5 supports time synchronization as indicated with the 103TIME parameter under the device port settings. If the value is set to yes, then the device uses the time provided by the Master when the command is given, as long as the SEL-710-5 is not connected to an external time source, e.g., IRIG, PTP, or SNTP. The SEL-710-5 sets the internal time validity bit to indicate proper reception of the time-synchronization command sequence from the Master. The date and time should not be trusted unless the validity bit is set. Time synchronization in the SEL-710-5 should only be used if IRIG, PTP, or SNTP sources are not available.

IEC 60870-5-103 Documentation

The *IEC 60870-5-103 Configuration/Interoperability Guide for the SEL-710-5* is available on the supplied CD or as a download from the SEL website and contains the standard device profile information for the SEL-710-5. Please refer to this document for complete information on IEC 60870-5-103 configuration and interoperability in the SEL-710-5.

Appendix I
DeviceNet Communications

Overview

This appendix describes DeviceNet communications features supported by the SEL-710-5 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.

DeviceNet Card

NOTE: The DeviceNet option has been discontinued and is no longer available to order as of September 25, 2017.

The DeviceNet Card is an optional accessory that enables connection of the SEL-710-5 to the DeviceNet automation network. The card (see *Figure I.1*) occupies the communications expansion Slot **C** in the relay.

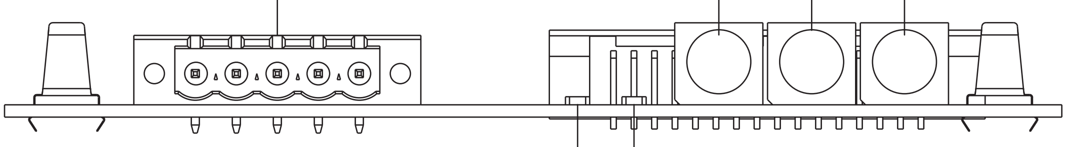


Figure I.1 DeviceNet Card Component Overview

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-710-5 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-710-5 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
- Read and set time
- Monitor device status, trip/warning status, and I/O status
- Perform high-speed control
- Reset trip, target, and accumulated data
- Retrieve events history

You can configure the DeviceNet interface through the use of address and data transmission rate switches. Indicators on the card at the back of the relay show network status and network activity.

Electronic Data Sheet

The Electronic Data Sheet (EDS) is a specially formatted file that includes configurable parameters for the device and public interfaces to those parameters. The EDS file contains information such as number of parameters; groupings; parameter name; minimum, maximum, and default values; units; data format; and scaling. This information makes possible user-friendly configuration tools (e.g., RSNetWorx for DeviceNet or DeviceNet Configurator from OMRON) for device parameter monitoring, modification, or both. The interface to the device can also be easily updated without revision of the configuration software tool itself.

All the registers defined in the Modbus Register Map (*Table E.34*) are available as parameters in a DeviceNet configuration. Parameter names, data ranges, and scaling; enumeration values and strings; parameter groups; and product information are the same as specified in the Modbus Register Map defined in *Table E.34*. The parameter numbers are offset by a count of 100 from the register numbers.

The EDS file for the SEL-710-5, SEL-xxxRxxx.EDS, can be found on the SEL-710-5 Product Literature CD, or on the SEL website at selinc.com.

Complete specifications for the DeviceNet protocol are available on the Open DeviceNet Vendor's Association (ODVA) website www.odva.org. ODVA is an independent supplier organization that manages the DeviceNet specification and supports the worldwide growth of DeviceNet.

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Appendix J

MIRRORED BITS Communications

Overview

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-710-5 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.

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 appears 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.

Control the transmit MIRRORED BITS with SELOGIC control equations. Use the received MIRRORED BITS as arguments in SELOGIC control equations. You can also use the ROKA, RBADA, CBADA, LBOKA, ROKB, RBADB, CBADB, and LBOKB 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 the Port settings, you can set the SEL-710-5 for compatible operation with SEL-300 series devices, SEL-2505 Remote I/O Modules (ST option only), SEL-700 series devices, 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-710-5, 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-710-5 transmits MIRRORED BITS as fast as possible for the given rate. At rates at and above 9600 bps, the SEL-710-5 self-paces by 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-710-5 automatically enters the self-pacing mode at data rates of 9600, 19200, and 38400. *Table J.1* shows the transmission rates of the MIRRORED BITS messages at different rates.

NOTE: Exercise caution when applying a MIRRORED BITS channel to relays that protect systems which may not be synchronized, because the automatic pacing modes operate under the assumption that both relays are protecting systems of similar frequency. To maintain MIRRORED BITS channel dependability for this application, it is best to use a data rate of either 2400 or 4800 bps.

Table J.1 Number of MIRRORED BITS Messages for Different Data Rates

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 faster than 9600 avoids overflowing relays that receive MIRRORED BITS at a slower rate.

Message Reception Overview

During synchronized MIRRORED BITS communications with the communications channel in normal state, the relay decodes and checks each received message. If the message is valid, the relay sends each received logic bit (RMB*n*, where *n* = 1 through 8) to the corresponding pickup and dropout security counters, which 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-710-5 to match the TX_ID of the remote SEL-710-5. The SEL-710-5 indicates 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). The relay clears the ROK*c* bit when it detects any of the following conditions.

- The relay is disabled.
- MIRRORED BITS are not enabled.
- Parity, framing, or overrun errors occur.
- Receive message identification error occurs.
- 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 after two consecutive messages pass all of the data checks previously described. After ROK*c* is reasserted, received data can be delayed while passing through the security counters described in the following paragraph.

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 L: Relay Word Bits*). *Table J.2* is an extract of *Appendix L: Relay Word Bits*, showing the positions of the MIRRORED BITS.

Table J.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 J.3 shows an example of the values of the MIRRORED BITS for the RXD-FLT setting of 10100111.

Table J.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 J.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-710-5. The SEL-321 processes power system information each 1/8 power system cycle, but, when transmitting at 19200 bps, the SEL-710-5 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-710-5 transmits messages at approximately a 1/4-cycle processing interval (9600 bps and faster, see *Table J.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-710-5 with a setting of two delays a received bit from the SEL-321 by a 1/4 cycle, because the SEL-710-5 is receiving new MIRRORED BITS messages each 1/8 cycle from the SEL-321.

Channel Synchronization

When an SEL-710-5 detects a communications error, it deasserts ROKA or ROKB. If an SEL-710-5 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 goes 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 J.2*)

There is a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but framing errors can extend the outage. If the channel is currently failed, it is displayed and included in the calculations, as if its recovery were to occur at the time the report was requested.

NOTE: Combine error conditions, including RBADA, RBADB, CBADA, and CBADB, with other alarm conditions by using SELOGIC control equations. 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 downtime 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 Pulsar 9600 Baud Modem

To use a Pulsar MBT modem, set setting PROTO := MBTA or MBTB (Port settings). Setting PROTO := MBTA or MBTB hides setting SPEED (forces the 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 J.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 J.4 MIRRORED BITS Communications Message Transmission Period

Bps	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 J.5* shows the MIRRORED BITS protocol port settings, ranges, and default settings for Port F, Port 3, and Port 4.

Table J.5 MIRRORED BITS Protocol Settings (Sheet 1 of 2)

Setting Prompt	Setting Description	Factory-Default Settings
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

Table J.5 MIRRORED BITS Protocol Settings (Sheet 2 of 2)

Setting Prompt	Setting Description	Factory-Default Settings
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
RMB8PU	RMB8 Pickup Debounce Messages (1–8 messages)	1
RMB8DO	RMB8 Dropout Debounce Messages (1–8 messages)	1

Appendix K
Motor Thermal Element

Overview

The SEL-710-5 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 *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: 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).
- Rotor Model (with slip calculation): 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.
- 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.
- Adjusts the rotor and stator trip thresholds based on measured frequency (for VFD applications) when enabled.
- Uses true rms current magnitude for the model (for VFD applications) instead of the sequence current magnitudes.

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 $6^2 \bullet 3$, or 108, times the I^2r heating when the motor runs normally.

Consequently, the motor must tolerate extreme heating for a limited time in order to start. Manufacturers state the motor tolerance through the maximum locked rotor time and locked rotor amperes 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 thermal energy exceeds those ratings because of overloads, negative-sequence current, or locked rotor starting.

Figure K.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-710-5 thermal element offers distinct advantages over the use of overcurrent elements.

The SEL-710-5 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, as defined and shown in *Figure K.7*, providing overload protection.

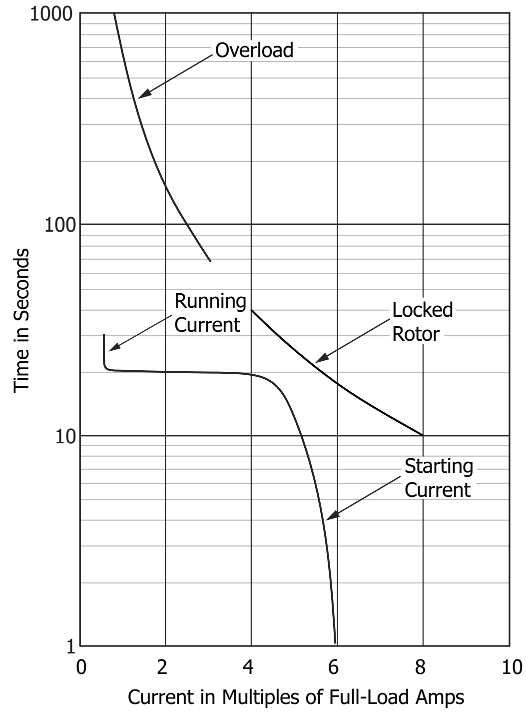

Figure K.1 Motor Thermal Limit Characteristic Plotted With Motor Starting Current

Basic Thermal Element

Figure K.2 shows a simple electrical analog for a thermal system. The thermal element includes:

- ➤ A heat source, modeled as a current source.
- ➤ Thermal inertia, modeled as a capacitor.
- ➤ Thermal dissipation, modeled as a resistor.
- ➤ A comparator, to compare the present heat estimate, U, to the Thermal Trip Value.

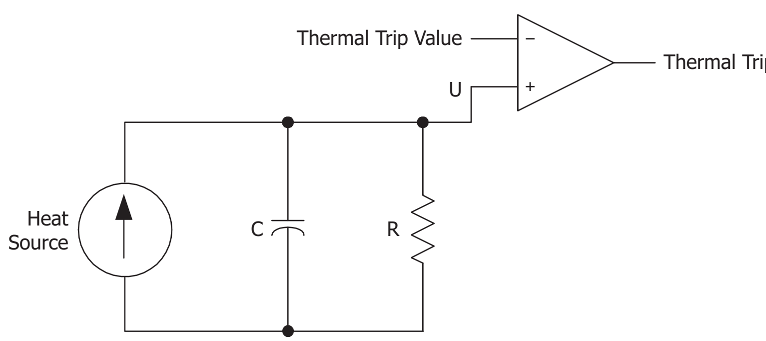

Figure K.2 Electrical Analog of a Thermal System

To define a thermal element for an induction motor, the characteristics of each component in *Figure K.2* must be defined, starting with the heat source. In an induction motor, heat principally is caused by I^2r losses. *Equation K.1* shows the motor heat source as a function of positive- and negative-sequence currents.

$$\text{Heat Source} = I_1^2 \bullet K_1 + I_2^2 \bullet K_2$$

Equation K.1

Heating factors K_1 and K_2 are defined by the positive-sequence rotor resistance and negative-sequence rotor resistance, respectively.

Figure K.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.

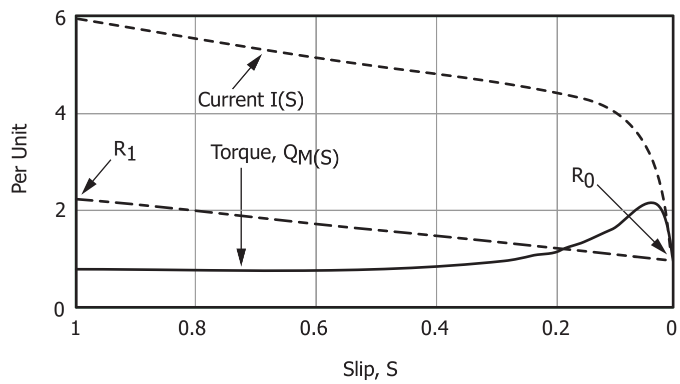

Figure K.3 Typical Induction Motor Current, Torque, and Rotor Resistance Versus Slip

Use *Equation K.2* to calculate the positive-sequence rotor resistance plotted in *Figure K.3*.

$$R_r = \left(\frac{Q_{M(S)}}{I(S)^2}\right) \bullet S$$

Equation K.2

where:

S = Motor slip
$Q_{M(S)}$ = Motor torque at slip S
$I(S)$ = Motor positive-sequence current at slip S

The positive-sequence rotor resistance is represented as a linear function of slip S by *Equation K.3*.

$$R_{r+} = (R_1 - R_0) \bullet S + R_0$$

Equation K.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 K.3*, calculate negative-sequence rotor resistance, R_{r-}.

$$R_{r-} = (R_1 - R_0) \bullet (2 - S) + R_0$$

Equation K.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 K.3* and *Equation K.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 K.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 K.6

Using the assumed value of R1/R0, the negative-sequence heating factor, K_2, at $S \approx 0$ is found:

$$\left.\frac{R_{r-}}{R_0}\right|_{S=0} = 2 \bullet \left(\frac{R_1}{R_0}\right) - 1 = 5$$

Equation K.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 4.79.

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-710-5 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. When current is less than 2.5 times rated full-load current, the relay uses the running state.

Motor Starting Protection

Figure K.4 shows the rotor thermal element used (without slip calculation) 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 a Rating_1 or curve method is used, the locked rotor trip time adapts 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.

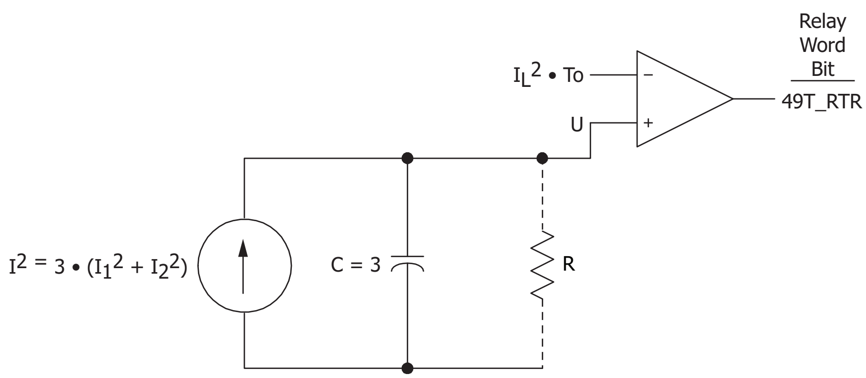

Figure K.4 Rotor Thermal Element During Motor Start (When SETMETH = RATING)

NOTE: Typically, healthy voltage inputs are required to calculate the slip-dependent rotor resistances. If a loss-of-potential is detected (Relay Word bit LOP = 1), the thermal element automatically uses Equation K.3 and Equation K.4 with slip S = 1 or 0 depending on the motor state (starting or running, respectively).

When the LRQ, FLS, and SLIPSRC (optional settings) are available, the SEL-710-5 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 K.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 dissipates 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 dissipation through the resistor R, as shown in *Figure K.5*.

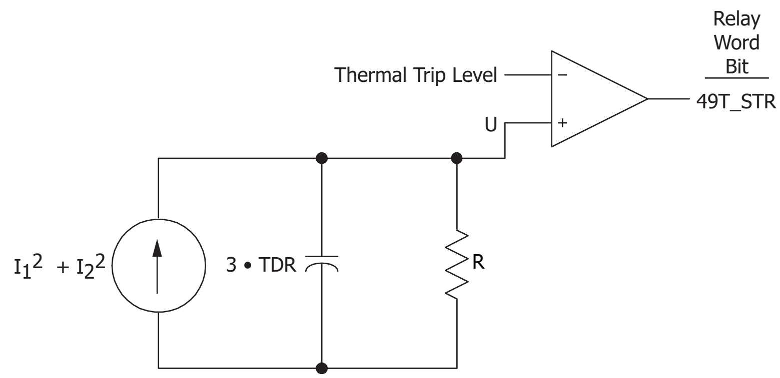

Figure K.5 Stator Thermal Element With Resistance and Trip Level Undefined

To determine the value of the resistor, recall that the motor reaches 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 K.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.

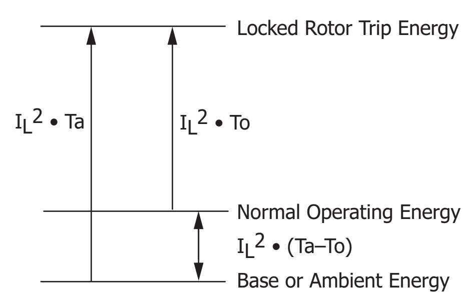

Figure K.6 Calculating the Normal Operating Energy by Using Locked Rotor Trip Times

$$\frac{I_L^2 \bullet Ta}{I_L^2 \bullet (Ta - To)} = 6$$

$$\therefore \frac{Ta}{To} = 1.2$$

$$\therefore (Ta - To) = 0.2 \bullet To$$

Equation K.9

TDR is an time-dial variable calculated using *Equation K.10*. RTC is the run state time constant (setting in minutes; see *Table 4.4* and *Example 4.9*).

$$TDR = RTC/(3 \bullet IL^2 \bullet (Ta - To))$$

Equation K.10

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 K.7* shows the stator thermal element.

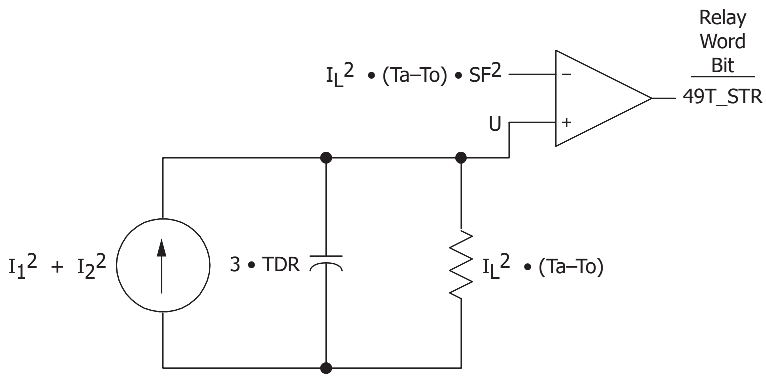

Figure K.7 Stator Thermal Element

Example K.1 illustrates the difference between the trip thresholds of the rotor and stator thermal elements.

EXAMPLE K.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 amperes
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 • To
= 36 • 12
= 432
Stator Trip Threshold
= I_L^2 • (Ta–To) • SF^2
= 36 • 2.4 • 1.323
= 114.3

Interpreting Percent Thermal Capacity Values

Several of the SEL-710-5 reporting functions include % Thermal Capacity values. At all times, the relay uses *Equation K.11* to calculate the percent thermal capacity used for the rotor and the stator.

$$\%\ \text{Thermal Capacity} = \frac{\left(\begin{array}{c}\text{Present Heat}\\ \text{Estimate, U}\end{array}\right)}{\left(\begin{array}{c}\text{Thermal}\\ \text{Trip Value}\end{array}\right)} \bullet 100\%$$

Equation K.11

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 can 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 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 usually takes place while the motor is stopped or running at a reduced load.

The SEL-710-5 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 4.5*, *Equation 4.6*, *Figure 4.76*, and the associated description for setting criteria.

Thermal Element Trip-Time Equations

Figure 4.3 and *Figure 4.4* 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 K.4* and *Figure K.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
0 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 4.9*)

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 K.12 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 K.12

Equation K.13 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 K.13

Rating Method Equations

Equation K.14 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 K.12*. (Also use *Equation K.12* 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 K.14

Equation K.15 and *Equation K.16* apply to the stator element when I > SF and SETMETH = Rating or Rating_1. To obtain the trip time (hot stator), substitute $I_0 = (0.9 \bullet SF)$ and RTC in *Equation K.13*.

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 K.15

RTC ≠ Auto

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2 - (0.9 \bullet SF)^2}{I^2 - SF^2}\right]$$

Equation K.16

To obtain the trip time for cold stator, substitute $I_0 = 0$ and RTC in *Equation K.13*.

RTC = Auto

$$T_p = \left[\frac{T_O \bullet (TD + 0.2)}{\ln\left[\frac{I_L^2 - (0.9 \bullet SF)^2}{I_L^2 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right]$$ **Equation K.17**

RTC ≠ Auto

$$T_p = 60 \bullet RTC \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right]$$ **Equation K.18**

Curve Method Equations

Equation K.19 and *Equation K.20* 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 K.12*

$$T_p = \frac{90 \bullet CURVE}{I^2}$$

Equation K.19

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 K.12*

$$T_p = \frac{75 \bullet CURVE}{I^2}$$

Equation K.20

Equation K.21 applies to the stator element when I > SF and SETMETH = Curve. To obtain the trip time (hot stator), substitute $I_0 = (0.9 \bullet SF)$, and RTC in *Equation K.13*.

$$T_p = \left[\frac{2.5 \bullet CURVE}{\ln\left[\frac{36 - (0.9 \bullet SF)^2}{36 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2 - (0.9 \bullet SF)^2}{I^2 - SF^2}\right]$$

Equation K.21

To obtain the trip time for cold stator, substitute $I_0 = 0$ and RTC in *Equation K.13*.

$$T_p = \left[\frac{2.5 \bullet CURVE}{\ln\left[\frac{36 - (0.9 \bullet SF)^2}{36 - SF^2}\right]}\right] \bullet \ln\left[\frac{I^2}{I^2 - SF^2}\right]$$ **Equation K.22**

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Appendix L

Relay Word Bits

Overview

The protection and control element results are represented by Relay Word bits in the SEL-710-5 Motor Protection Relay. Each Relay Word bit has a label name and is 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 L.1 and *Table L.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 R.7.71*).

Any Relay Word bit (except Row 0) can be used in SELOGIC control equations (see *Section 4: Protection and Logic Functions*) and the Sequential Events Recorder (SER) trigger list settings (see *Section 10: Analyzing Events*).

Table L.1 SEL-710-5 Relay Word Bits (Sheet 1 of 6)

Bit/Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
TAR 0	ENABLED	TRIP_LED	TLED_01	TLED_02	TLED_03	TLED_04	TLED_05	TLED_06
1	49T	LOSSTRIP	JAMTRIP	46UBT	RTDT	PTCTRIP	ORED51T	TRIP
2	VART	37PT	47T	55T	SPDSTR	SMTRIP	OTHTRIP	AMBTRIP
3	PFLEAD	a	BLKSTR	41A	SRUNNING	PTCFLT	RTDFLT	BFI
4	COMMIDLE	COMMLOSS	REMTRIP	COMMFLT	CFGFLT	49T_STR	49T_RTR	BFT
5	87M1	87M2	87M1T	87M2T	87M1TC	87M2TC	50PAF	50NAF
6	49A	LOSSALRM	JAMALRM	46UBA	RTDA	55A	55TC	AF_TRIP
7	VARA	37PA	SPDSAL	OTHALRM	81D1T	81D2T	81D3T	81D4T
8	AMBALRM	HALARM	SALARM	AFALARM	WARNING	LOADUP	LOADLOW	50S
9	STOPPED	RUNNING	STARTING	STAR	DELTA	START	COASTOP	FAULT
10	27P1	27P1T	27P2	27P2T	59P1	59P1T	59P2	59P2T
11	50P1P	50P2P	50N1P	50N2P	50G1P	50G2P	50Q1P	50Q2P
12	50P1T	50P2T	50N1T	50N2T	50G1T	50G2T	50Q1T	50Q2T
13	OUT101	OUT102	OUT103	a	a	a	a	a

Table L.1 SEL-710-5 Relay Word Bits (Sheet 2 of 6)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
14	OUT301	OUT302	OUT303	OUT304	OUT305	OUT306	OUT307	OUT308
15	OUT401	OUT402	OUT403	OUT404	OUT405	OUT406	OUT407	OUT408
16	OUT501	OUT502	OUT503	OUT504	OUT505	OUT506	OUT507	OUT508
17	IN101	IN102	[a]	[a]	[a]	[a]	[a]	[a]
18	IN301	IN302	IN303	IN304	IN305	IN306	IN307	IN308
19	IN401	IN402	IN403	IN404	IN405	IN406	IN407	IN408
20	IN501	IN502	IN503	IN504	IN505	IN506	IN507	IN508
21	WDGALRM	WDGTRIP	BRGALRM	BRGTRIP	THERMLO	NOSLO	TBSLO	ABSLO
22	RTDIN	TRGTR	IBRK	RTDBIAS	52A	SPEED2	52B	VFDBYPAS
23	RTD1A	RTD1T	RTD2A	RTD2T	RTD3A	RTD3T	RTD4A	RTD4T
24	RTD5A	RTD5T	RTD6A	RTD6T	RTD7A	RTD7T	RTD8A	RTD8T
25	RTD9A	RTD9T	RTD10A	RTD10T	RTD11A	RTD11T	RTD12A	RTD12T
26	46UBTC	48LJTC	50EFTC	50PTC	37LLTC	66JOGTC	49PTCTC	49RTDTC
27	RSTENRGY	RSTMXMN	DSABLSET	RSTTRGT	BLKPROT	LOP	RSTMOT	CMETSRTG
28	SG1	SG2	SG3	SG4	MSRTRG	DI_C	DI_B	DI_A
29	STR	STOP	EMRSTR	ER	ULTRIP	TR	FREQTRK	STREQ
30	DNAUX1	DNAUX2	DNAUX3	DNAUX4	DNAUX5	DNAUX6	DNAUX7	DNAUX8
31	DNAUX9	DNAUX10	DNAUX11	RELAY_EN	BBD1T	BBD2T	BBD3T	ZCFREQ
32	PB01	PB02	PB03	PB04	PB05	PB06	PB07	PB08
33	PB01_PUL	PB02_PUL	PB03_PUL	PB04_PUL	PB05_PUL	PB06_PUL	PB07_PUL	PB08_PUL
34	PB1A_LED	PB1B_LED	PB2A_LED	PB2B_LED	PB3A_LED	PB3B_LED	PB4A_LED	PB4B_LED
35	PB5A_LED	PB5B_LED	PB6A_LED	PB6B_LED	PB7A_LED	PB7B_LED	PB8A_LED	PB8B_LED
36	[a]	[a]	T01_LED	T02_LED	T03_LED	T04_LED	T05_LED	T06_LED
37	LB01	LB02	LB03	LB04	LB05	LB06	LB07	LB08
38	LB09	LB10	LB11	LB12	LB13	LB14	LB15	LB16
39	LB17	LB18	LB19	LB20	LB21	LB22	LB23	LB24
40	LB25	LB26	LB27	LB28	LB29	LB30	LB31	LB32
41	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
42	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
43	RB17	RB18	RB19	RB20	RB21	RB22	RB23	RB24
44	RB25	RB26	RB27	RB28	RB29	RB30	RB31	RB32
45	SV01	SV02	SV03	SV04	SV05	SV06	SV07	SV08
46	SV01T	SV02T	SV03T	SV04T	SV05T	SV06T	SV07T	SV08T
47	SV09	SV10	SV11	SV12	SV013	SV14	SV15	SV16
48	SV09T	SV10T	SV11T	SV12T	SV13T	SV14T	SV15T	SV16T
49	SV17	SV18	SV19	SV20	SV21	SV22	SV23	SV24

Table L.1 SEL-710-5 Relay Word Bits (Sheet 3 of 6)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
50	SV17T	SV18T	SV19T	SV20T	SV21T	SV22T	SV23T	SV24T
51	SV25	SV26	SV27	SV28	SV29	SV30	SV31	SV32
52	SV25T	SV26T	SV27T	SV28T	SV29T	SV30T	SV31T	SV32T
53	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
54	LT09	LT10	LT11	LT12	LT13	LT14	LT15	LT16
55	LT17	LT18	LT19	LT20	LT21	LT22	LT23	LT24
56	LT25	LT26	LT27	LT28	LT29	LT30	LT31	LT32
57	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
58	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD
59	SC09QU	SC10QU	SC11QU	SC12QU	SC13QU	SC14QU	SC15QU	SC16QU
60	SC09QD	SC10QD	SC11QD	SC12QD	SC13QD	SC14QD	SC15QD	SC16QD
61	SC17QU	SC18QU	SC19QU	SC20QU	SC21QU	SC22QU	SC23QU	SC24QU
62	SC17QD	SC18QD	SC19QD	SC20QD	SC21QD	SC22QD	SC23QD	SC24QD
63	SC25QU	SC26QU	SC27QU	SC28QU	SC29QU	SC30QU	SC31QU	SC32QU
64	SC25QD	SC26QD	SC27QD	SC28QD	SC29QD	SC30QD	SC31QD	SC32QD
65	AILW1	AILW2	AILAL	[a]	AIHW1	AIHW2	AIHAL	[a]
66	AI301LW1	AI301LW2	AI301LAL	[a]	AI301HW1	AI301HW2	AI301HAL	[a]
67	AI302LW1	AI302LW2	AI302LAL	[a]	AI302HW1	AI302HW2	AI302HAL	[a]
68	AI303LW1	AI303LW2	AI303LAL	[a]	AI303HW1	AI303HW2	AI303HAL	[a]
69	AI304LW1	AI304LW2	AI304LAL	[a]	AI304HW1	AI304HW2	AI304HAL	[a]
70	AI305LW1	AI305LW2	AI305LAL	[a]	AI305HW1	AI305HW2	AI305HAL	[a]
71	AI306LW1	AI306LW2	AI306LAL	[a]	AI306HW1	AI306HW2	AI306HAL	[a]
72	AI307LW1	AI307LW2	AI307LAL	[a]	AI307HW1	AI307HW2	AI307HAL	[a]
73	AI308LW1	AI308LW2	AI308LAL	[a]	AI308HW1	AI308HW2	AI308HAL	[a]
74	AI401LW1	AI401LW2	AI401LAL	[a]	AI401HW1	AI401HW2	AI401HAL	[a]
75	AI402LW1	AI402LW2	AI402LAL	[a]	AI402HW1	AI402HW2	AI402HAL	[a]
76	AI403LW1	AI403LW2	AI403LAL	[a]	AI403HW1	AI403HW2	AI403HAL	[a]
77	AI404LW1	AI404LW2	AI404LAL	[a]	AI404HW1	AI404HW2	AI404HAL	[a]
78	AI405LW1	AI405LW2	AI405LAL	[a]	AI405HW1	AI405HW2	AI405HAL	[a]
79	AI406LW1	AI406LW2	AI406LAL	[a]	AI406HW1	AI406HW2	AI406HAL	[a]
80	AI407LW1	AI407LW2	AI407LAL	[a]	AI407HW1	AI407HW2	AI407HAL	[a]
81	AI408LW1	AI408LW2	AI408LAL	[a]	AI408HW1	AI408HW2	AI408HAL	[a]
82	AI501LW1	AI501LW2	AI501LAL	[a]	AI501HW1	AI501HW2	AI501HAL	[a]
83	AI502LW1	AI502LW2	AI502LAL	[a]	AI502HW1	AI502HW2	AI502HAL	[a]
84	AI503LW1	AI503LW2	AI503LAL	[a]	AI503HW1	AI503HW2	AI503HAL	[a]
85	AI504LW1	AI504LW2	AI504LAL	[a]	AI504HW1	AI504HW2	AI504HAL	[a]

Table L.1 SEL-710-5 Relay Word Bits (Sheet 4 of 6)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
86	AI505LW1	AI505LW2	AI505LAL	a	AI505HW1	AI505HW2	AI505HAL	a
87	AI506LW1	AI506LW2	AI506LAL	a	AI506HW1	AI506HW2	AI506HAL	a
88	AI507LW1	AI507LW2	AI507LAL	a	AI507HW1	AI507HW2	AI507HAL	a
89	AI508LW1	AI508LW2	AI508LAL	a	AI508HW1	AI508HW2	AI508HAL	a
90	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
91	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
92	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
93	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
94	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
95	LINKA	LINKB	LINKFAIL	PASEL	PBSEL	a	STORMDET	LINK1
96	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
97	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
98	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
99	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
100	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
101	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
102	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
103	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
104	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
105	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
106	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
107	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
108	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
109	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
110	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
111	VB121	VB122	VB123	VB124	VB125	VB126	VB127	VB128
112	51AP	51BP	51CP	51P1P	51P2P	51QP	51G1P	51G2P
113	51AT	51BT	51CT	51P1T	51P2T	51QT	51G1T	51G2T
114	51AR	51BR	51CR	51P1R	51P2R	51QR	51G1R	51G2R
115	BKMON	BCW	BCWA	BCWB	BCWC	a	IRIGOK	TSOK
116	TQUAL1	TQUAL2	TQUAL4	TQUAL8	DST	DSTP	LPSEC	LPSECP
117	TSNTPB	TSNTPP	TUTCS	TUTC1	TUTC2	TUTC4	TUTC8	TUTCH
118	AFS1DIAG	AFS2DIAG	AFS3DIAG	AFS4DIAG	AFS5DIAG	AFS6DIAG	AFS7DIAG	AFS8DIAG
119	TOL1	TOL2	TOL3	TOL4	TOL5	TOL6	TOL7	TOL8
120	AFS1EL	AFS2EL	AFS3EL	AFS4EL	AFS5EL	AFS6EL	AFS7EL	AFS8EL
121	FDVTC	FDCTC	40ZTC	a	40Z1	40Z1T	40Z2	40Z2T

Table L.1 SEL-710-5 Relay Word Bits (Sheet 5 of 6)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
122	FDUV1	FDUV1T	FDUV2	FDUV2T	FDOV1	FDOV1T	FDOV2	FDOV2T
123	FDUC1	FDUC1T	FDUC2	FDUC2T	FDOC1	FDOC1T	FDOC2	FDOC2T
124	FDRES1T	FDRES2T	FDRESTC	41CLOSE	UL41CL	STSEQEN	FDCTFLT	a
125	78R1	78R2	78Z1	SWING	OOS	OOST	a	OOSTC
126	51ATC	51BTC	51CTC	51P1TC	51P2TC	51QTC	51G1TC	51G2TC
127	MATHERR	TESTDB	a	SYNEN	SLIPRECH	DRVECLS	RELUCLS	ADV_RUNN
128	a	VIRSPDSW	SPEEDSW	ENHSPDSW	SSFLRST	SPDSFAIL	FAILCLS	FAILOPN
129	a	a	RELUCLS2	SLIPOK	41CLOSE2	41CLS2TO	41CLS2	SLIPBT
130	FVLR	FVLRT	FVLL	FVLLT	FVSL	FVSLT	FVSR	FVSRT
131	FVR	FVL	PFINBND	PFGUT	a	a	PORSFL	PODTCT
132	PIAW	a	50ITRCC	50ITRCB	50ITRCA	50IALCC	50IALCB	50IALCA
133	a	a	a	a	a	a	a	a
134	IN309	IN310	IN311	IN312	IN313	IN314	a	a
135	IN409	IN410	IN411	IN412	IN413	IN414	a	a
136	IN509	IN510	IN511	IN512	IN513	IN514	a	a
137	a	a	50INCTC	50INCTB	50INCTA	50INCC	50INCB	50INCA
138	27I1	27I1T	27I1RS	27I1TC	27I2	27I2T	27I2RS	27I2TC
139	59I1	59I1T	59I1RS	59I1TC	59I2	59I2T	59I2RS	59I2TC
140	59I3	59I3T	59I3RS	59I3TC	59I4	59I4T	59I4RS	59I4TC
141	89A2P1	89B2P1	89CL2P1	89OP2P1	89AL2P1	TTSTOP_A	POSTOP_A	POSTRT_A
142	89A2P2	89B2P2	89CL2P2	89OP2P2	89AL2P2	IMAX_A	VMIN_A	TTSTRT_A
143	89A2P3	89B2P3	89CL2P3	89OP2P3	89AL2P3	a	a	a
144	89A2P4	89B2P4	89CL2P4	89OP2P4	89AL2P4	a	a	a
145	89A2P5	89B2P5	89CL2P5	89OP2P5	89AL2P5	a	a	a
146	ENLRC	LOCAL	BKJMP	97FM1TC	97FM2TC	97FM3TC	97FM4TC	97FM5TC
147	97F1	97F1T	97FM1ER	97FM1ERT	97F2	97F2T	97FM2ER	97FM2ERT
148	97F3	97F3T	97FM3ER	97FM3ERT	97F4	97F4T	97FM4ER	97FM4ERT
149	97F5	97F5T	97FM5ER	97FM5ERT	a	a	a	a
150	a	a	a	a	a	a	a	a
151	PTP_TIM	PTP_OK	PTPSYNC	PTPA	PTPB	a	a	a
152	89O2P1	89OS2P1	89OI2P1	89OE2P1	89C2P1	89CS2P1	89CI2P1	89CE2P1
153	89O2P2	89OS2P2	89OI2P2	89OE2P2	89C2P2	89CS2P2	89CI2P2	89CE2P2
154	89O2P3	89OS2P3	89OI2P3	89OE2P3	89C2P3	89CS2P3	89CI2P3	89CE2P3
155	89O2P4	89OS2P4	89OI2P4	89OE2P4	89C2P4	89CS2P4	89CI2P4	89CE2P4
156	89O2P5	89OS2P5	89OI2P5	89OE2P5	89C2P5	89CS2P5	89CI2P5	89CE2P5
157	89O2P6	89OS2P6	89OI2P6	89OE2P6	89C2P6	89CS2P6	89CI2P6	89CE2P6
158	89O2P7	89OS2P7	89OI2P7	89OE2P7	89C2P7	89CS2P7	89CI2P7	89CE2P7

Table L.1 SEL-710-5 Relay Word Bits (Sheet 6 of 6)

Bit/ Row	Relay Word Bits							
	7	6	5	4	3	2	1	0
159	89O2P8	89OS2P8	89OI2P8	89OE2P8	89C2P8	89CS2P8	89CI2P8	89CE2P8
160	89OC2P1	89RO2P1	89OM2P1	[a]	89CC2P1	89RC2P1	89CM2P1	[a]
161	89OC2P2	89RO2P2	89OM2P2	[a]	89CC2P2	89RC2P2	89CM2P2	[a]
162	89OC2P3	89RO2P3	89OM2P3	[a]	89CC2P3	89RC2P3	89CM2P3	[a]
163	89OC2P4	89RO2P4	89OM2P4	[a]	89CC2P4	89RC2P4	89CM2P4	[a]
164	89OC2P5	89RO2P5	89OM2P5	[a]	89CC2P5	89RC2P5	89CM2P5	[a]
165	89OC2P6	89RO2P6	89OM2P6	[a]	89CC2P6	89RC2P6	89CM2P6	[a]
166	89OC2P7	89RO2P7	89OM2P7	[a]	89CC2P7	89RC2P7	89CM2P7	[a]
167	89OC2P8	89RO2P8	89OM2P8	[a]	89CC2P8	89RC2P8	89CM2P8	[a]
168	89OC3PL1	89RO3PL1	89OM3PL1	[a]	89CC3PL1	89RC3PL1	89CM3PL1	[a]
169	89OC3PE1	89RO3PE1	89OM3PE1	[a]	89CC3PE1	89RC3PE1	89CM3PE1	[a]
170	89OC3PL2	89RO3PL2	89OM3PL2	[a]	89CC3PL2	89RC3PL2	89CM3PL2	[a]
171	89OC3PE2	89RO3PE2	89OM3PE2	[a]	89CC3PE2	89RC3PE2	89CM3PE2	[a]
172	BFTR	BFTRIP	BFULTR	BFRT	50BF	50BFG	[a]	[a]
173	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
174	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
175	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
176	89IP2P1	89IP2P2	89IP2P3	89IP2P4	89IP2P5	89IP2P6	89IP2P7	89IP2P8
177	89A3PL1	89B3PL1	89CL3PL1	89OP3PL1	89AL3PL1	89IP3PL1	89AL	[a]
178	89A3PE1	89B3PE1	89CL3PE1	89OP3PE1	89AL3PE1	89IP3PE1	89IP	[a]
179	89A3PL2	89B3PL2	89CL3PL2	89OP3PL2	89AL3PL2	89IP3PL2	[a]	[a]
180	89A3PE2	89B3PE2	89CL3PE2	89OP3PE2	89AL3PE2	89IP3PE2	[a]	[a]
181	89O3PL1	89OS3PL1	89OI3PL1	89OE3PL1	89C3PL1	89CS3PL1	89CI3PL1	89CE3PL1
182	89O3PE1	89OS3PE1	89OI3PE1	89OE3PE1	89C3PE1	89CS3PE1	89CI3PE1	89CE3PE1
183	89O3PL2	89OS3PL2	89OI3PL2	89OE3PL2	89C3PL2	89CS3PL2	89CI3PL2	89CE3PL2
184	89O3PE2	89OS3PE2	89OI3PE2	89OE3PE2	89C3PE2	89CS3PE2	89CI3PE2	89CE3PE2
185	89A2P6	89B2P6	89CL2P6	89OP2P6	89A2P7	89B2P7	89CL2P7	89OP2P7
186	89A2P8	89B2P8	89CL2P8	89OP2P8	[a]	89AL2P6	89AL2P7	89AL2P8
187	VIBAQ1AP	VIBAQ1BP	VIBAQ1CP	VIBAQ1DP	VIBAQ1AT	VIBAQ1BT	VIBAQ1CT	VIBAQ1DT
1881	VIBAQ2AP	VIBAQ2BP	VIBAQ2CP	VIBAQ2DP	VIBAQ2AT	VIBAQ2BT	VIBAQ2CT	VIBAQ2DT
189	VIBAQ3AP	VIBAQ3BP	VIBAQ3CP	VIBAQ3DP	VIBAQ3AT	VIBAQ3BT	VIBAQ3CT	VIBAQ3DT
190	VIBAQ4AP	VIBAQ4BP	VIBAQ4CP	VIBAQ4DP	VIBAQ4AT	VIBAQ4BT	VIBAQ4CT	VIBAQ4DT
191	VIBAQ5AP	VIBAQ5BP	VIBAQ5CP	VIBAQ5DP	VIBAQ5AT	VIBAQ5BT	VIBAQ5CT	VIBAQ5DT
192	LPHDSIM	[a]	[a]	[a]	SCBK1BC	SCBK1BO	BKENC1	BKENO1
193	SC850TM	SC850BM	SC850SM	SC850LS	LOC	MLTLEV	LOCSTA	OREDLOC
194	SSRSLPOK	41CLS3SI	41CLOSE3	[a]	[a]	[a]	[a]	[a]

[a] Reserved for future use.

Definitions

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 1 of 22)

Bit	Definition	Row
27I1	Level 1 inverse undervoltage element pickup	138
27I1T	Level 1 inverse undervoltage element time out	138
27I1RS	Level 1 inverse undervoltage element reset	138
27I1TC	Level 1 inverse undervoltage element torque control	138
27I2	Level 2 inverse undervoltage element pickup	138
27I2T	Level 2 inverse undervoltage element time out	138
27I2RS	Level 2 inverse undervoltage element reset	138
27I2TC	Level 2 inverse undervoltage element torque control	138
27P1	Phase undervoltage Level 1 trip pickup	10
27P1T	Phase undervoltage Level 1 trip definite-time delayed	10
27P2	Phase undervoltage Level 2 trip pickup	10
27P2T	Phase undervoltage Level 2 definite-time delayed	10
37LLTC	37LL torque control	26
37PA	Underpower alarm—asserts when the relay issues an underpower element alarm	7
37PT	Underpower trip—asserts when the relay issues an underpower element trip	2
40Z1	Zone 1 instantaneous loss-of-field mho element	121
40Z1T	Zone 1 time-delayed loss-of-field mho element	121
40Z2	Zone 2 instantaneous loss-of-field mho element	121
40Z2T	Zone 2 time-delayed loss-of-field mho element	121
40ZTC	Loss-of-field torque control	121
41A	Asserts when the SELOGIC control equation 41A result is logical 1. Use to indicate that the motor field contactor or field circuit breaker is closed.	3
41CLOSE	Field breaker close initiation for time-delayed start of brushless synchronous motors or slip-dependent synchronization based on field voltage measurements	124
41CLOSE2	Field breaker close initiation for slip-dependent synchronization based on stator current measurements	129
41CLOSE3	Field breaker close initiation for breaker close time incorporated synchronization	194
41CLS2TO	Slip dependent close OK	129
41CLS2	Start sequence time-out (synchronization based on stator current measurements)	129
41CLS3SI	Start sequence sealed-in for breaker close time incorporated synchronization	194
46UBA	Phase current unbalance alarm—asserts when the relay issues an alarm in response to a current unbalance condition, as defined by that function and its settings	6
46UBT	Phase current unbalance trip—asserts when the relay issues a trip in response to a current unbalance condition, as defined by that function and its settings	1
46UBTC	46UB torque control	26
47T	Phase reversal trip—asserts when the relay detects a phase reversal condition, if phase reversal tripping is enabled by the relay settings	2
48LJTC	48LJ torque control	26

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 2 of 22)

Bit	Definition	Row
49A	Thermal alarm—asserts when the relay issues a thermal element alarm because of locked rotor starting or running overload conditions	6
49PTCTC	49PTC torque control	26
49RTDTC	49RTD torque control	26
49T	Thermal trip—asserts when the relay issues a thermal element trip because of locked rotor or running overload conditions, i.e., 49T = 49T_RTR OR 49T_STR	1
49T_RTR	Thermal trip, rotor thermal model	4
49T_STR	Thermal trip, stator thermal model	4
50EFTC	50EF torque control	26
50BF	50 breaker failure current detector	172
50BFG	50 breaker failure residual current detector	172
50G1P	Definite-time residual overcurrent trip pickup	11
50G1T	Definite-time residual overcurrent trip definite-time delayed	12
50G2P	Definite-time residual overcurrent alarm pickup	11
50G2T	Definite-time residual overcurrent alarm definite-time delayed	12
50IALCA	Counter alarm level A-phase	132
50IALCB	Counter alarm level B-phase	132
50IALCC	Counter alarm level C-phase	132
50INCA	Element pickup A-phase	137
50INCB	Element pickup B-phase	137
50INCC	Element pickup C-phase	137
50INCTA	Element time out A-phase, self-clearing	137
50INCTB	Element time out B-phase, self-clearing	137
50INCTC	Element time out C-phase, self-clearing	137
50ITRCA	Counter trip level A-phase	132
50ITRCB	Counter trip level B-phase	132
50ITRCC	Counter trip level C-phase	132
50N1P	Definite-time neutral overcurrent trip pickup	11
50N1T	Definite-time neutral overcurrent trip definite-time delayed	12
50N2P	Definite-time neutral overcurrent alarm pickup	11
50N2T	Definite-time neutral overcurrent alarm definite-time delayed	12
50NAF	Sample based neutral overcurrent element pickup	5
50P1P	Definite-time phase overcurrent trip pickup	11
50P1T	Definite-time phase overcurrent trip definite-time delayed	12
50P2P	Definite-time phase overcurrent alarm pickup	11
50P2T	Definite-time phase overcurrent alarm definite-time delayed	12
50PAF	Sample based phase overcurrent element pickup	5
50PTC	50P torque control	26
50Q1P	Definite-time negative-sequence overcurrent trip pickup	11

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 3 of 22)

Bit	Definition	Row
50Q1T	Definite-time negative-sequence overcurrent trip definite-time delayed	12
50Q2P	Definite-time negative-sequence overcurrent alarm pickup	11
50Q2T	Definite-time negative-sequence overcurrent alarm definite-time delayed	12
50S	Overcurrent threshold for starting	8
51AP	A-phase time-overcurrent element pickup	112
51AR	A-phase time-overcurrent element reset	114
51AT	A-phase time-overcurrent element trip	113
51ATC	A-phase time-overcurrent torque control	126
51BP	B-phase time-overcurrent element pickup	112
51BR	B-phase time-overcurrent element reset	114
51BT	B-phase time-overcurrent element trip	113
51BTC	B-phase time-overcurrent torque control	126
51CP	C-phase time-overcurrent element pickup	112
51CR	C-phase time-overcurrent element reset	114
51CT	C-phase time-overcurrent element trip	113
51CTC	C-phase time-overcurrent torque control	126
51G1P	Level 1 residual ground time-overcurrent element pickup	112
51G1R	Level 1 residual ground time-overcurrent element reset	114
51G1T	Level 1 residual ground time-overcurrent element trip	113
51G1TC	Level 1 residual ground time-overcurrent torque control	126
51G2P	Level 2 residual ground time-overcurrent element pickup	112
51G2R	Level 2 residual ground time-overcurrent element reset	114
51G2T	Level 2 residual ground time-overcurrent element trip	113
51G2TC	Level 2 residual ground time-overcurrent torque control	126
51P1P	Level 1 maximum phase time-overcurrent element pickup	112
51P1R	Level 1 maximum phase time-overcurrent element reset	114
51P1T	Level 1 maximum phase time-overcurrent element trip	113
51P1TC	Level 1 maximum phase time-overcurrent torque control	126
51P2P	Level 2 maximum phase time-overcurrent element pickup	112
51P2R	Level 2 maximum phase time-overcurrent element reset	114
51P2T	Level 2 maximum phase time-overcurrent element trip	113
51P2TC	Level 2 maximum phase time-overcurrent torque control	126
51QP	Negative-sequence, time-overcurrent element pickup	112
51QR	Negative-sequence, time-overcurrent element reset	114
51QT	Negative-sequence, time-overcurrent element trip	113
51QTC	Negative-sequence, time-overcurrent torque control	126
52A	Motor contactor or circuit breaker N/O contact	22
52B	Motor contactor or circuit breaker N/C contact	22

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 4 of 22)

Bit	Definition	Row
55A	Power factor alarm—asserts when the relay issues a power factor element alarm	6
55T	Power factor trip—asserts when the relay issues a power factor element alarm or trip	2
55TC	55 torque control	6
59I1	Level 1 inverse overvoltage element pickup	139
59I1T	Level 1 inverse overvoltage element time out	139
59I1RS	Level 1 inverse overvoltage element reset	139
59I1TC	Level 1 inverse overvoltage element torque control	139
59I2	Level 2 inverse overvoltage element pickup	139
59I2T	Level 2 inverse overvoltage element time out	139
59I2RS	Level 2 inverse overvoltage element reset	139
59I2TC	Level 2 inverse overvoltage element torque control	139
59I3	Level 3 inverse overvoltage element pickup	140
59I3T	Level 3 inverse overvoltage element time out	140
59I3RS	Level 3 inverse overvoltage element reset	140
59I3TC	Level 3 inverse overvoltage element torque control	140
59I4	Level 4 inverse overvoltage element pickup	140
59I4T	Level 4 inverse overvoltage element time out	140
59I4RS	Level 4 inverse overvoltage element reset	140
59I4TC	Level 4 inverse overvoltage element torque control	140
59P1	Phase overvoltage Level 1 trip pickup	10
59P1T	Phase overvoltage Level 1 trip definite-time delayed	10
59P2	Phase overvoltage Level 2 trip pickup	10
59P2T	Phase overvoltage Level 2 trip definite-time delayed	10
66JOGTC	66JOG torque control	26
78R1	Out-of-step right blinder or outer resistance blinder	125
78R2	Out-of-step left blinder or inner resistance blinder	125
78Z1	Out-of-step mho element	125
81D1T	Level 1 trip definite-time over- and underfrequency elements—asserts when the frequency has been either above or below the element set point for a definite-time.	7
81D2T	Level 2 trip definite-time over- and underfrequency elements—asserts when the frequency has been either above or below the element set point for a definite-time.	7
81D3T	Level 3 trip definite-time over- and underfrequency elements—asserts when the frequency has been either above or below the element set point for a definite-time.	7
81D4T	Level 4 trip definite-time over- and underfrequency elements—asserts when the frequency has been either above or below the element set point for a definite-time.	7
87M1	Level 1 pickup definite-time differential element	5
87M1T	Level 1 trip definite-time differential element	5
87M1TC	Torque control—Level 1 definite-time differential element	5
87M2	Level 2 pickup definite-time differential element	5
87M2T	Level 2 trip definite-time differential element	5

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 5 of 22)

Bit	Definition	Row
87M2TC	Torque control—Level 2 definite-time differential element	5
89A2P1	Two-position Disconnect 1 N/O contact	141
89A2P2	Two-position Disconnect 2 N/O contact	142
89A2P3	Two-position Disconnect 3 N/O contact	143
89A2P4	Two-position Disconnect 4 N/O contact	144
89A2P5	Two-position Disconnect 5 N/O contact	145
89A2P6	Two-position Disconnect 6 N/O contact	159
89A2P7	Two-position Disconnect 7 N/O contact	160
89A2P8	Two-position Disconnect 8 N/O contact	160
89A3PE1	Three-position Earthing Disconnect 1 N/O auxiliary contact	160
89A3PE2	Three-position Earthing Disconnect 2 N/O auxiliary contact	160
89A3PL1	Three-position In-Line Disconnect 1 N/O auxiliary contact	160
89A3PL2	Three-position In-Line Disconnect 2 N/O auxiliary contact	160
89AL	Any two-position or three-position disconnect in alarm	160
89AL2P1	Two-position Disconnect 1 alarm	141
89AL2P2	Two-position Disconnect 2 alarm	142
89AL2P3	Two-position Disconnect 3 alarm	143
89AL2P4	Two-position Disconnect 4 alarm	144
89AL2P5	Two-position Disconnect 5 alarm	145
89AL2P6	Two-position Disconnect 6 alarm	160
89AL2P7	Two-position Disconnect 7 alarm	161
89AL2P8	Two-position Disconnect 8 alarm	161
89AL3PE1	Three-position Earthing Disconnect 1 alarm	161
89AL3PE2	Three-position Earthing Disconnect 2 alarm	161
89AL3PL1	Three-position In-Line Disconnect 1 alarm	161
89AL3PL2	Three-position In-Line Disconnect 2 alarm	161
89B2P1	Two-position Disconnect 1 N/C contact	141
89B2P2	Two-position Disconnect 2 N/C contact	142
89B2P3	Two-position Disconnect 3 N/C contact	143
89B2P4	Two-position Disconnect 4 N/C contact	144
89B2P5	Two-position Disconnect 5 N/C contact	145
89B2P6	Two-position Disconnect 6 N/C contact	161
89B2P7	Two-position Disconnect 7 N/C contact	161
89B2P8	Two-position Disconnect 8 N/C contact	162
89B3PE1	Three-position Earthing Disconnect 1 N/C auxiliary contact	162
89B3PE2	Three-position Earthing Disconnect 2 N/C auxiliary contact	162
89B3PL1	Three-position In-Line Disconnect 1 N/C auxiliary contact	162
89B3PL2	Three-position In-Line Disconnect 2 N/C auxiliary contact	162

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 6 of 22)

Bit	Definition	Row
89C2P1	Two-position Disconnect 1 close output	162
89C2P2	Two-position Disconnect 2 close output	162
89C2P3	Two-position Disconnect 3 close output	162
89C2P4	Two-position Disconnect 4 close output	163
89C2P5	Two-position Disconnect 5 close output	163
89C2P6	Two-position Disconnect 6 close output	163
89C2P7	Two-position Disconnect 7 close output	163
89C2P8	Two-position Disconnect 8 close output	163
89C3PE1	Three-position Earthing Disconnect 1 close output	163
89C3PE2	Three-position Earthing Disconnect 2 close output	163
89C3PL1	Three-position In-Line Disconnect 1 close output	163
89C3PL2	Three-position In-Line Disconnect 2 close output	164
89CC2P1	Two-position Disconnect 1 close command for control via communication protocols	164
89CC2P2	Two-position Disconnect 2 close command for control via communication protocols	164
89CC2P3	Two-position Disconnect 3 close command for control via communication protocols	164
89CC2P4	Two-position Disconnect 4 close command for control via communication protocols	164
89CC2P5	Two-position Disconnect 5 close command for control via communication protocols	164
89CC2P6	Two-position Disconnect 6 close command for control via communication protocols	164
89CC2P7	Two-position Disconnect 7 close command for control via communication protocols	164
89CC2P8	Two-position Disconnect 8 close command for control via communication protocols	165
89CC3PE1	Three-position Earthing Disconnect 1 close command for control via communication protocols	165
89CC3PE2	Three-position Earthing Disconnect 2 close command for control via communication protocols	165
89CC3PL1	Three-position In-Line Disconnect 1 close command for control via communication protocols	165
89CC3PL2	Three-position In-Line Disconnect 2 close command for control via communication protocols	165
89CE2P1	Two-position Disconnect 1 close enable	165
89CE2P2	Two-position Disconnect 2 close enable	165
89CE2P3	Two-position Disconnect 3 close enable	165
89CE2P4	Two-position Disconnect 4 close enable	166
89CE2P5	Two-position Disconnect 5 close enable	166
89CE2P6	Two-position Disconnect 6 close enable	166
89CE2P7	Two-position Disconnect 7 close enable	166
89CE2P8	Two-position Disconnect 8 close enable	166
89CE3PE1	Three-position Earthing Disconnect 1 close enable	166
89CE3PE2	Three-position Earthing Disconnect 2 close enable	166
89CE3PL1	Three-position In-Line Disconnect 1 close enable	166
89CE3PL2	Three-position In-Line Disconnect 2 close enable	167
89CI2P1	Two-position Disconnect 1 close immobility timer timed out	167
89CI2P2	Two-position Disconnect 2 close immobility timer timed out	167

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 7 of 22)

Bit	Definition	Row
89CI2P3	Two-position Disconnect 3 close immobility timer timed out	167
89CI2P4	Two-position Disconnect 4 close immobility timer timed out	167
89CI2P5	Two-position Disconnect 5 close immobility timer timed out	167
89CI2P6	Two-position Disconnect 6 close immobility timer timed out	167
89CI2P7	Two-position Disconnect 7 close immobility timer timed out	167
89CI2P8	Two-position Disconnect 8 close immobility timer timed out	168
89CI3PE1	Three-position Earthing Disconnect 1 close immobility timer timed out	168
89CI3PE2	Three-position Earthing Disconnect 2 close immobility timer timed out	168
89CI3PL1	Three-position In-Line Disconnect 1 close immobility timer timed out	168
89CI3PL2	Three-position In-Line Disconnect 2 close immobility timer timed out	168
89CL2P1	Two-position Disconnect 1 closed	141
89CL2P2	Two-position Disconnect 2 closed	142
89CL2P3	Two-position Disconnect 3 closed	143
89CL2P4	Two-position Disconnect 4 closed	144
89CL2P5	Two-position Disconnect 5 closed	145
89CL2P6	Two-position Disconnect 6 closed	168
89CL2P7	Two-position Disconnect 7 closed	168
89CL2P8	Two-position Disconnect 8 closed	168
89CL3PE1	Three-position Earthing Disconnect 1 closed	169
89CL3PE2	Three-position Earthing Disconnect 2 closed	169
89CL3PL1	Three-position In-Line Disconnect 1 closed	169
89CL3PL2	Three-position In-Line Disconnect 2 closed	169
89CM2P1	Two-position Disconnect 1 close command for control via front-panel HMI	169
89CM2P2	Two-position Disconnect 2 close command for control via front-panel HMI	169
89CM2P3	Two-position Disconnect 3 close command for control via front-panel HMI	169
89CM2P4	Two-position Disconnect 4 close command for control via front-panel HMI	169
89CM2P5	Two-position Disconnect 5 close command for control via front-panel HMI	170
89CM2P6	Two-position Disconnect 6 close command for control via front-panel HMI	170
89CM2P7	Two-position Disconnect 7 close command for control via front-panel HMI	170
89CM2P8	Two-position Disconnect 8 close command for control via front-panel HMI	170
89CM3PE1	Three-position Earthing Disconnect 1 close command for control via front-panel HMI	170
89CM3PE2	Three-position Earthing Disconnect 2 close command for control via front-panel HMI	170
89CM3PL1	Three-position In-Line Disconnect 1 close command for control via front-panel HMI	170
89CM3PL2	Three-position In-Line Disconnect 2 close command for control via front-panel HMI	170
89CS2P1	Two-position Disconnect 1 close seal-in timer timed out	171
89CS2P2	Two-position Disconnect 2 close seal-in timer timed out	171
89CS2P3	Two-position Disconnect 3 close seal-in timer timed out	171
89CS2P4	Two-position Disconnect 4 close seal-in timer timed out	171

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 8 of 22)

Bit	Definition	Row
89CS2P5	Two-position Disconnect 5 close seal-in timer timed out	171
89CS2P6	Two-position Disconnect 6 close seal-in timer timed out	171
89CS2P7	Two-position Disconnect 7 close seal-in timer timed out	171
89CS2P8	Two-position Disconnect 8 close seal-in timer timed out	171
89CS3PE1	Three-position Earthing Disconnect 1 close seal-in timer timed out	172
89CS3PE2	Three-position Earthing Disconnect 2 close seal-in timer timed out	172
89CS3PL1	Three-position In-Line Disconnect 1 close seal-in timer timed out	172
89CS3PL2	Three-position In-Line Disconnect 2 close seal-in timer timed out	172
89IP	Any two-position or three-position disconnect in alarm	172
89IP2P1	Two-position Disconnect 1 operation in-progress	172
89IP2P2	Two-position Disconnect 2 operation in-progress	172
89IP2P3	Two-position Disconnect 3 operation in-progress	172
89IP2P4	Two-position Disconnect 4 operation in-progress	173
89IP2P5	Two-position Disconnect 5 operation in-progress	173
89IP2P6	Two-position Disconnect 6 operation in-progress	173
89IP2P7	Two-position Disconnect 7 operation in-progress	173
89IP2P8	Two-position Disconnect 8 operation in-progress	173
89IP3PE1	Three-position Earthing Disconnect 1 operation in-progress	173
89IP3PE2	Three-position Earthing Disconnect 2 operation in-progress	173
89IP3PL1	Three-position In-Line Disconnect 1 operation in-progress	173
89IP3PL2	Three-position In-Line Disconnect 2 operation in-progress	174
89O2P1	Two-position Disconnect 1 open output	174
89O2P2	Two-position Disconnect 2 open output	174
89O2P3	Two-position Disconnect 3 open output	174
89O2P4	Two-position Disconnect 4 open output	174
89O2P5	Two-position Disconnect 5 open output	174
89O2P6	Two-position Disconnect 6 open output	174
89O2P7	Two-position Disconnect 7 open output	174
89O2P8	Two-position Disconnect 8 open output	175
89O3PE1	Three-position Earthing Disconnect 1 open output	175
8903PE2	Three-position Earthing Disconnect 2 open output	175
89O3PL1	Three-position In-Line Disconnect 1 open output	175
89O3PL2	Three-position In-Line Disconnect 2 open output	175
89OC2P1	Two-position Disconnect 1 open command for control via communication protocols	175
89OC2P2	Two-position Disconnect 2 open command for control via communication protocols	175
89OC2P3	Two-position Disconnect 3 open command for control via communication protocols	175
89OC2P4	Two-position Disconnect 4 open command for control via communication protocols	176
89OC2P5	Two-position Disconnect 5 open command for control via communication protocols	176

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 9 of 22)

Bit	Definition	Row
89OC2P6	Two-position Disconnect 6 open command for control via communication protocols	176
89OC2P7	Two-position Disconnect 7 open command for control via communication protocols	176
89OC2P8	Two-position Disconnect 8 open command for control via communication protocols	176
89OC3PE1	Three-position Earthing Disconnect 1 open command for control via communication protocols	176
89OC3PE2	Three-position Earthing Disconnect 2 open command for control via communication protocols	176
89OC3PL1	Three-position In-Line Disconnect 1 open command for control via communication protocols	176
89OC3PL2	Three-position In-Line Disconnect 2 open command for control via communication protocols	177
89OE2P1	Two-position Disconnect 1 open enable	177
89OE2P2	Two-position Disconnect 2 open enable	177
89OE2P3	Two-position Disconnect 3 open enable	177
89OE2P4	Two-position Disconnect 4 open enable	177
89OE2P5	Two-position Disconnect 5 open enable	177
89OE2P6	Two-position Disconnect 6 open enable	177
89OE2P7	Two-position Disconnect 7 open enable	177
89OE2P8	Two-position Disconnect 8 open enable	178
89OE3PE1	Three-position Earthing Disconnect 1 open enable	178
89OE3PE2	Three-position Earthing Disconnect 2 open enable	178
89OE3PL1	Three-position In-Line Disconnect 1 open enable	178
89OE3PL2	Three-position In-Line Disconnect 2 open enable	178
890I2P1	Two-position Disconnect 1 open immobility timer timed out	178
890I2P2	Two-position Disconnect 2 open immobility timer timed out	178
890I2P3	Two-position Disconnect 3 open immobility timer timed out	178
890I2P4	Two-position Disconnect 4 open immobility timer timed out	179
890I2P5	Two-position Disconnect 5 open immobility timer timed out	179
890I2P6	Two-position Disconnect 6 open immobility timer timed out	179
890I2P7	Two-position Disconnect 7 open immobility timer timed out	179
890I2P8	Two-position Disconnect 8 open immobility timer timed out	179
89OI3PE1	Three-position Earthing Disconnect 1 open immobility timer timed out	179
89OI3PE2	Three-position Earthing Disconnect 2 open immobility timer timed out	179
89OI3PL1	Three-position In-Line Disconnect 1 open immobility timer timed out	179
89OI3PL2	Three-position In-Line Disconnect 2 open immobility timer timed out	180
89OM2P1	Two-position Disconnect 1 open command for control via front-panel HMI	180
89OM2P2	Two-position Disconnect 2 open command for control via front-panel HMI	180
89OM2P3	Two-position Disconnect 3 open command for control via front-panel HMI	180
89OM2P4	Two-position Disconnect 4 open command for control via front-panel HMI	180
89OM2P5	Two-position Disconnect 5 open command for control via front-panel HMI	180
89OM2P6	Two-position Disconnect 6 open command for control via front-panel HMI	180
89OM2P7	Two-position Disconnect 7 open command for control via front-panel HMI	180

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 10 of 22)

Bit	Definition	Row
89OM2P8	Two-position Disconnect 8 open command for control via front-panel HMI	181
89OM3PE1	Three-position Earthing Disconnect 1 open command for control via front-panel HMI	181
89OM3PE2	Three-position Earthing Disconnect 2 open command for control via front-panel HMI	181
89OM3PL1	Three-position In-Line Disconnect 1 open command for control via front-panel HMI	181
89OM3PL2	Three-position In-Line Disconnect 2 open command for control via front-panel HMI	181
89OP2P1	Two-position Disconnect 1 open	141
89OP2P2	Two-position Disconnect 2 open	142
89OP2P3	Two-position Disconnect 3 open	143
89OP2P4	Two-position Disconnect 4 open	144
89OP2P5	Two-position Disconnect 5 open	145
89OP2P6	Two-position Disconnect 6 open	181
89OP2P7	Two-position Disconnect 7 open	181
89OP2P8	Two-position Disconnect 8 open	181
89OP3PE1	Three-position Earthing Disconnect 1 open	182
89OP3PE2	Three-position Earthing Disconnect 2 open	182
89OP3PL1	Three-position In-line Disconnect 1 open	182
89OP3PL2	Three-position In-line Disconnect 2 open	182
89OS2P1	Two-position Disconnect 1 open seal-in timer timed out	182
89OS2P2	Two-position Disconnect 2 open seal-in timer timed out	182
89OS2P3	Two-position Disconnect 3 open seal-in timer timed out	182
89OS2P4	Two-position Disconnect 4 open seal-in timer timed out	182
89OS2P5	Two-position Disconnect 5 open seal-in timer timed out	183
89OS2P6	Two-position Disconnect 6 open seal-in timer timed out	183
89OS2P7	Two-position Disconnect 7 open seal-in timer timed out	183
89OS2P8	Two-position Disconnect 8 open seal-in timer timed out	183
89OS3PE1	Three-position Earthing Disconnect 1 open seal-in timer timed out	183
89OS3PE2	Three-position Earthing Disconnect 2 open seal-in timer timed out	183
89OS3PL1	Three-position In-line Disconnect 1 open seal-in timer timed out	183
89OS3PL2	Three-position In-line Disconnect 2 open seal-in timer timed out	183
89RC2P1	Two-position Disconnect 1 remote close control SELOGIC equation	184
89RC2P2	Two-position Disconnect 2 remote close control SELOGIC equation	184
89RC2P3	Two-position Disconnect 3 remote close control SELOGIC equation	184
89RC2P4	Two-position Disconnect 4 remote close control SELOGIC equation	184
89RC2P5	Two-position Disconnect 5 remote close control SELOGIC equation	184
89RC2P6	Two-position Disconnect 6 remote close control SELOGIC equation	184
89RC2P7	Two-position Disconnect 7 remote close control SELOGIC equation	184
89RC2P8	Two-position Disconnect 8 remote close control SELOGIC equation	184
89RC3PE1	Three-position Earthing Disconnect 1 remote close control SELOGIC equation	185

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 11 of 22)

Bit	Definition	Row
89RC3PE2	Three-position Earthing Disconnect 2 remote close control SELOGIC equation	185
89RC3PL1	Three-position In-line Disconnect 1 remote close control SELOGIC equation	185
89RC3PL2	Three-position In-line Disconnect 2 remote close control SELOGIC equation	185
89RO2P1	Two-position Disconnect 1 remote open control SELOGIC equation	185
89RO2P2	Two-position Disconnect 2 remote open control SELOGIC equation	185
89RO2P3	Two-position Disconnect 3 remote open control SELOGIC equation	185
89RO2P4	Two-position Disconnect 4 remote open control SELOGIC equation	185
89RO2P5	Two-position Disconnect 5 remote open control SELOGIC equation	186
89RO2P6	Two-position Disconnect 6 remote open control SELOGIC equation	186
89RO2P7	Two-position Disconnect 7 remote open control SELOGIC equation	186
89RO2P8	Two-position Disconnect 8 remote open control SELOGIC equation	186
89RO3PE1	Three-position Earthing Disconnect 1 remote open control SELOGIC equation	186
89RO3PE2	Three-position Earthing Disconnect 2 remote open control SELOGIC equation	186
89RO3PL1	Three-position In-Line Disconnect 1 remote open control SELOGIC equation	186
89RO3PL2	Three-position In-Line Disconnect 2 remote open control SELOGIC equation	186
97F1	Frequency component magnitude element pick up	146
97F1T	Frequency component magnitude element time out	146
97F2	Frequency component magnitude element pick up	146
97F2T	Frequency component magnitude element time out	146
97F3	Frequency component magnitude element pick up	146
97F3T	Frequency component magnitude element time out	147
97F4	Frequency component magnitude element pick up	147
97F4T	Frequency component magnitude element time out	147
97F5	Frequency component magnitude element pick up	147
97F5T	Frequency component magnitude element time out	147
97FM1ER	Event report timer pick up	147
97FM1ERT	Event report timer time out	147
97FM1TC	Frequency component magnitude element torque control	147
97FM2ER	Event report timer pick up	148
97FM2ERT	Event report timer time out	148
97FM2TC	Frequency component magnitude element torque control	148
97FM3ER	Event report timer pick up	148
97FMERT	Event report timer time out	148
97FM3TC	Frequency component magnitude element torque control	148
97FM4ER	Event report timer pick up	148
97FM4ERT	Event report timer time out	148
97FM4TC	Frequency component magnitude element torque control	149
97FM5ER	Event report timer pick up	149

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 12 of 22)

Bit	Definition	Row
97FM5ERT	Event report timer time out	149
97FM5TC	Frequency component magnitude element torque control	149
ABSLO	Motor lockout conditions—asserted by the thermal element (THERMLO), starts per hour function (NOSLO), minimum time between starts (TBSLO), and the antibackspin timer (ABSLO).	21
ADV_RUNN	Same as RUNNING Relay Word bit without the 300 ms time delay (for use in starting sequence for synchronous motor)	
AF_TRIP	Any arc-flash trip as given by equation (50PAF OR 50NAF) AND (TOL1 OR TOL2 OR…OR TOL8) AND TRIP	6
AFALARM	Arc-flash system integrity alarm, logical OR of all AF diagnostics and excessive light bits (AFS*n*DIAG and AFS*n*SEL)	8
AFS1DIAG–AFS8DIAG	AF Light Input 1 diagnostic failure—AF Light Input 8 diagnostic failure	118
AFS1EL–AFS8EL	If TOL*n* is asserted for 10 seconds continuously, the corresponding AFS*n*EL Relay Word bit asserts, where *n* = 1 to 8. This can be used as a warning for excessive ambient light detection.	120
AIHAL	Analog inputs high alarm limit. If any AIxxxHAL = 1, then AIHAL = 1.	65
AIHW1	Analog inputs high warning, Level 1. If any AIxxxHW1 = 1, then AIHW1 = 1.	65
AIHW2	Analog inputs high warning, Level 2. If any AIxxxHW2 = 1, then AIHW2 = 1 .	65
AILAL	Analog inputs low alarm limit. If any AIxxxLAL = 1, then AILAL = 1.	65
AILW1	Analog inputs low warning, Level 1. If any AIxxxLW1 = 1, then AILW1 = 1.	65
AILW2	Analog inputs low warning, Level 2. If any AIxxxLW2 = 1, then AILW2 = 1.	65
AIxxxHAL	High alarm limit	89
AIxxxHW1	High warning, Level 1	89
AIxxxHW2	High warning, Level 2	89
AIxxxLAL	Low alarm limit	89
AIxxxLW1	Low warning, Level 1	89
AIxxxLW2	Low warning, Level 2	89
AMBALRM	Ambient temperature alarm—asserts if the healthy ambient RTD temperature exceeds its alarm set point	8
AMBTRIP	Ambient temperature trip—asserts when the healthy Ambient RTD temperature exceeds its trip set point	2
BBD1T	Severe rotor bar damage	31
BBD2T	One or more broken bars	31
BBD3T	Rotor high impedance points	31
BCW	BCWA OR BCWB OR BCWC	115
BCWA	A-phase breaker contact wear has reached the 100 percent wear level	115
BCWB	B-phase breaker contact wear has reached the 100 percent wear level	115
BCWC	C-phase breaker contact wear has reached the 100 percent wear level	115
BFI	Breaker failure initiation—asserts when the SELOGIC control equation BFI results in a logical 1. Use to indicate that the breaker failure logic has started.	3
BFRT	Breaker failure retrip	172
BFT	Breaker failure trip—asserts when the relay issues a breaker failure trip	4
BFTRIP	Breaker failure trip logic output	172

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 13 of 22)

Bit	Definition	Row
BKENC1	SELOGIC control for breaker/contactor close interlocking supervision	192
BKENO1	SELOGIC control for breaker/contactor open interlocking supervision	192
BKMON	Breaker monitor initiation	115
BLKPROT	SELOGIC control equation—asserts enabled torque control elements when logic 1.	27
BLKSTR	Block start SELOGIC control equation	3
BRGALRM	Bearing temperature alarm—BRGALRM asserts when any healthy bearing RTD temperature exceeds its alarm set point	21
BRGTRIP	Bearing temperature trip—BRGTRIP asserts when one or two (when EBRGV = Y) healthy bearing RTD temperatures exceed their trip set points	21
BKJMP	Asserts if breaker control jumper is installed on main board	146
CBADA	Channel A, channel unavailability over threshold	94
CBADB	Channel B, channel unavailability over threshold	94
CFGFLT	Asserts on failed settings interdependency check during Modbus setting change	4
CMETSRTG	Meter report trigger SELOGIC control equation	27
COASTOP	Rotor coast to stop	9
COMMFLT	Time-out of internal communication between CPU board and DeviceNet board	4
COMMIDLE	DeviceNet card in programming mode	4
COMMLOSS	DeviceNet communication failure	4
DELTA	Delta control	9
DI_A	Distortion index A-phase	28
DI_B	Distortion index B-phase	28
DI_C	Distortion index C-phase	28
DNAUX1–DNAUX8	DeviceNet/Modbus AUX1–AUX8 assert bits	30
DNAUX9–DNAUX11	DeviceNet/Modbus AUX9–AUX11 assert bits	31
DRVECLS	Synchronous motor field breaker close initiated via drive-to-close path	
DSABLSET	SELOGIC control equation: Do not allow settings changes from front-panel interface when asserted	27
DST	Daylight-saving time	116
DSTP	Daylight-saving time pending	116
EMRSTR	Emergency restart SELOGIC control equation—asserts when input assigned to EMRSTR asserts or when a Modbus/DeviceNet EMRSTR command is received	29
ENHSPDSW	Enhance speed switch	128
ENLRC	Asserted when Local/Remote is enabled by EN_LRC := Y	146
ER	Event report trigger SELOGIC control equation	29
FAILCLS	Speed switch failed close	128
FAILOPN	Speed switch failed open	128
FAULT	Indicates Fault condition—asserts when SELOGIC control equation FAULT results in a logical 1	9
FDCTC	Field current torque control	121
FDCTFLT	Field current transducer fault	124

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 14 of 22)

Bit	Definition	Row
FDOC1	Field overcurrent Level 1 pickup	123
FDOC1T	Field overcurrent Level 1 definite-time delayed	123
FDOC2	Field overcurrent Level 2 pickup	123
FDOC2T	Field overcurrent Level 2 definite-time delayed	123
FDOV1	Field overvoltage Level 1 pickup	122
FDOV1T	Field overvoltage Level 1 definite-time delayed	122
FDOV2	Field overvoltage Level 2 pickup	122
FDOV2T	Field overvoltage Level 2 definite-time delayed	122
FDRES1T	Field resistance Level 1 trip	124
FDRES2T	Field resistance Level 2 warn	124
FDRESTC	Field resistance torque control	124
FDUC1	Field undercurrent Level 1 pickup	123
FDUC1T	Field undercurrent Level 1 definite-time delayed	123
FDUC2	Field undercurrent Level 2 pickup	123
FDUC2T	Field undercurrent Level 2 definite-time delayed	123
FDUV1	Field undervoltage Level 1 pickup	122
FDUV1T	Field undervoltage Level 1 definite-time delayed	122
FDUV2	Field undervoltage Level 2 pickup	122
FDUV2T	Field undervoltage Level 2 definite-time delayed	122
FDVTC	Field voltage torque control	121
FREQTRK	Frequency tracking enable bit—tracking enabled when bit is asserted	29
FVL	Lower field voltage digital interphase	131
FVLL	Lower field voltage long step	130
FVLLT	Lower field voltage long step time-out	130
FVLR	Raise field voltage long step	130
FVLRT	Raise field voltage long step time-out	130
FVR	Raise field voltage digital interphase	131
FVSL	Lower field voltage short step	130
FVSLT	Lower field voltage short step time-out	130
FVSR	Raise field voltage short step	130
FVSRT	Raise field voltage short step time-out	130
HALARM	Diagnostics failure	8
IBRK	Inspect breaker	22
IMAX_A	Maximum start current alarm	142
IN101and IN102	Contact Inputs IN101 and IN102	17
IN301–IN304	Contact Inputs IN301–IN304 (available only with optional I/O module)	18
IN305–IN308	Contact Inputs IN305–IN308 (available only with optional I/O module)	18
IN309–IN314	Contact Inputs IN309–IN314 (available only with optional 14 DI I/O module)	134

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 15 of 22)

Bit	Definition	Row
IN401–IN404	Contact Inputs IN401–IN404 (available only with optional I/O module)	19
IN405–IN408	Contact Inputs IN405–IN408 (available only with optional I/O module)	19
IN409–IN414	Contact Inputs IN409–IN414 (available only with optional 14 DI I/O module)	135
IN501–IN504	Contact Inputs IN501–IN504 (available only with optional I/O module)	20
IN505–IN508	Contact Inputs IN505–IN508 (available only with optional I/O module)	20
IN509–IN514	Contact Inputs IN509–IN514 (available only with optional 14 DI I/O module)	136
IRIGOK	IRIG-B time sync input data are valid	115
JAMALRM	Load-jam alarm	6
JAMTRIP	Load-jam trip	1
LB01–LB08	Local Bits 1–8	37
LB09–LB16	Local Bits 9–16	38
LB17–LB24	Local Bits 17–24	39
LB25–LB32	Local Bits 25–32	40
LBOKA	Channel A, looped back OK	94
LBOKB	Channel B, looped back OK	94
LINK1	Asserts when a valid link is detected on Port 1	95
LINKA	Asserts if Ethernet Port A detects link	95
LINKB	Asserts if Ethernet Port B detects link	95
LINKFAIL	Failure of active Ethernet port link	95
LOC	SELOGIC control for control authority at local/bay level	193
LOCAL	Asserted when relay control configuration is in Local mode	146
LOCSTA	SELOGIC control for control authority at station level	193
LOADLOW	Load control lower limit	8
LOADUP	Load control upper limit	8
LOP	Loss-of-potential	27
LOPBLK	SELOGIC equation to block LOP element from asserting	117
LOSSALRM	Load-loss alarm—asserts when the relay detects a load-loss as defined by that function and its settings	6
LOSSTRIP	Load-loss trip—asserts when the relay detects a load-loss as defined by that function and its settings	1
LPHDSIM	IEC 61850 simulation mode	192
LPSEC	Direction of the upcoming leap second. During the time that LPSECP is asserted, if LPSEC is asserted, the upcoming leap second is deleted; otherwise, the leap second is added.	116
LPSECP	Leap second pending	116
LT01–LT08	Latch bits 1–8	53
LT09–LT16	Latch bits 9–16	54
LT17–LT24	Latch bits 17–24	55
LT25–LT32	Latch bits 25–32	56
MATHERR	SELOGIC math error bit asserted for divide-by-zero, etc, in SELOGIC math functions	127
MLTLEV	SELOGIC control for multilevel mode of control authority	193

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 16 of 22)

Bit	Definition	Row
MSRTRG	Motor start report trigger SELOGIC control equation	28
NOSLO	Motor lockout conditions—asserted by the thermal element (THERMLO), starts per hour function (NOSLO), minimum time between starts (TBSLO), and the antibackspin timer (ABSLO)	21
OOS	Out-of-step element	125
OOST	Out-of-step trip	125
OOSTC	Out-of-step torque control	125
ORED51T	Logical OR of all the time overcurrent elements tripped outputs	1
OREDLOC	Logical OR of LOC and LOCAL Relay Word bits	193
OTHALRM	Other temperature alarm—asserts when any healthy other RTD temperature exceeds its alarm set point	7
OTHTRIP	Other temperature trip—asserts when one or more healthy Other RTD temperatures exceed their trip set points	2
OUT101–OUT103	Control equation for contact outputs OUT101–OUT103	13
OUT301–OUT304	Control equation for contact outputs OUT301–OUT304 (available only with optional I/O module)	14
OUT305–OUT308	Control equation for contact outputs OUT305–OUT308 (available only with optional I/O module)	14
OUT401–OUT404	Control equation for contact outputs OUT401–OUT404 (available only with optional I/O module)	15
OUT405–OUT408	Control equation for contact outputs OUT405–OUT408 (available only with optional I/O module)	15
OUT501–OUT504	Control equation for contact outputs OUT501–OUT504 (available only with optional I/O module)	16
OUT505–OUT508	Control equation for contact outputs OUT505–OUT508 (available only with optional I/O module)	16
PASEL	Ethernet Port A is selected for communication	95
PB01	Front-panel Pushbutton 1 bit (asserted when PB01 is pressed)	32
PB01_PUL	Front-panel Pushbutton 1 pulse bit (asserted for one processing interval when PB01 is pressed)	33
PB02	Front-panel Pushbutton 2 bit (asserted when PB02 is pressed)	32
PB02_PUL	Front-panel Pushbutton 2 pulse bit (asserted for one processing interval when PB02 is pressed)	33
PB03	Front-panel Pushbutton 3 bit (asserted when PB03 is pressed)	32
PB03_PUL	Front-panel Pushbutton 3 pulse bit (asserted for one processing interval when PB03 is pressed)	33
PB04	Front-panel Pushbutton 4 bit (asserted when PB04 is pressed)	32
PB04_PUL	Front-panel Pushbutton 4 pulse bit (asserted for one processing interval when PB04 is pressed)	33
PB05	Front-panel Pushbutton 5 bit (asserted when PB05 is pressed)	32
PB05_PUL	Front-panel Pushbutton 5 pulse bit (asserted for one processing interval when PB05 is pressed)	33
PB06	Front-panel Pushbutton 6 bit (asserted when PB06 is pressed)	32
PB06_PUL	Front-panel Pushbutton 6 pulse bit (asserted for one processing interval when PB06 is pressed)	33

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 17 of 22)

Bit	Definition	Row
PB07	Front-panel Pushbutton 7 bit (asserted when PB07 is pressed)	32
PB07_PUL	Front-panel Pushbutton 7 pulse bit (asserted for one processing interval when PB07 is pressed)	33
PB08	Front-panel Pushbutton 8 bit (asserted when PB08 is pressed)	32
PB08_PUL	Front-panel Pushbutton 8 pulse bit (asserted for one processing interval when PB08 is pressed)	33
PB1A_LED–PB4A_LED	SELOGIC control equation: drives LEDs PB1A–PB4A	34
PB1B_LED–PB4B_LED	SELOGIC control equation: drives LEDs PB1B–PB4B	34
PB5A_LED–PB8A_LED	SELOGIC control equation: drives LEDs PB5A–PB8A	35
PB5B_LED–PB8B_LED	SELOGIC control equation: drives LEDs PB5B–PB8B	35
PBSEL	Ethernet Port B is selected for communication	95
PFGUT	Asserts when the reactive power is outside the given band for more than 10 minutes	131
PFINBND	Asserts when the reactive power is within the given band	131
PFLEAD	Three-phase power factor lead indication	3
PIAW	PID controller anti-windup active	132
PODTCT	Asserts when loss of synchronism (pull-out) is detected	131
PORSFL	Pull out resync FAIL ride-through trip	131
POSTOP_A	Active power before stop alarm	141
POSTRT_A	Active power after a start alarm	141
PTPA	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1A	151
PTPB	Asserts when PTP is enabled in PRP mode and the relay is receiving PTP messages on Port 1B	151
PTPSYNC	Asserts if the relay is using PTP time to do time sync	151
PTP_OK	Asserts if PTP time is within the 4 ms local offset	151
PTP_TIM	Asserts if a valid PTP time source is detected	151
PTCFLT	Indicates faulted/shorted thermistor	3
PTCTRIP	Asserts when measured PTC loop resistance is greater than set value	1
RB01–RB08	Remote Bits 1–8	41
RB09–RB16	Remote Bits 9–16	42
RB17–RB24	Remote Bits 17–24	43
RB25–RB32	Remote Bits 25–32	44
RBADA	Channel A, outage duration over threshold	94
RBADB	Channel B, outage duration over threshold	94
RELAY_EN	Relay OK flag. RELAY_EN status follows the ENABLED LED status.	31
RELUCLS	Synchronous motor field breaker close initiated via reluctance close path (synchronization based on field voltage measurements)	128
RELUCLS2	Start sequence reluctance close	129
REMTRIP	Remote trip	4
RMB1A–RMB8A	Channel A Received MIRRORED BITS RMB1A through RMB8A	90

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 18 of 22)

Bit	Definition	Row
RMB1B–RMB8B	Channel B Received MIRRORED BITS RMB1B through RMB8B	92
ROKA	Channel A, received data OK	94
ROKB	Channel B, received data OK	94
RSTENRGY	Reset energy metering—asserts when the SELOGIC control equation RSTENRG result is logical 1	27
RSTMOT	Reset motor statistic metering—asserts when the SELOGIC control equation RSTMOT result is logical 1	27
RSTMXMN	Reset max/min metering—asserts when the SELOGIC control equation RSTMXMN result is logical 1	27
RSTTRGT	SELOGIC control equation: reset trip logic and targets when asserted	27
RTD1A–RTD4A RTD1T–RTD4T	RTD1 through RTD4: alarms and trips	23
RTD5A–RTD8A RTD5T–RTD8T	RTD5 through RTD8: alarms and trips	24
RTD9A–RTD12A RTD9T–RTD12T	RTD9 through RTD12: alarms and trips	25
RTDA	Winding/bearing RTD overtemperature alarm	6
RTDBIAS	RTD bias alarm. When enabled, asserts when the motor winding temperature rise is greater than 60°C over ambient and the RTD % Thermal Capacity is more than ten percentage points higher than the motor thermal element % Thermal Capacity. Typically indicates a loss of motor cooling efficiency.	22
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-2600A RTD module	22
RTDT	Winding/bearing RTD overtemperature trip	1
RUNNING	Asserts when motor is running	9
SALARM	Software alarms: invalid password, changing access levels, settings changes, active group change, copy command, and password change	8
SC01QD–SC08QD	SELOGIC Counters 01 through 08 assert when counter = 0	58
SC01QU–SC08QU	SELOGIC Counters 01 through 08 assert when counter = preset value	57
SC09QD–SC16QD	SELOGIC Counters 09 through 16 assert when counter = 0	60
SC09QU–SC16QU	SELOGIC Counters 09 through 16 assert when counter = preset value	59
SC17QD–SC24QD	SELOGIC Counters 17 through 24 assert when counter = 0	62
SC17QU–SC24QU	SELOGIC Counters 17 through 24 assert when counter = preset value	61
SC25QD–SC32QD	SELOGIC Counters 25 through 32 assert when counter = 0	64
SC25QU–SC32QU	SELOGIC Counters 25 through 32 assert when counter = preset value	63
SC850BM	SELOGIC control for IEC 61850 block mode	193
SC850LS	SELOGIC control for control authority at station level	193
SC850SM	SELOGIC control for IEC 61850 simulation mode	193
SC850TM	SELOGIC control for IEC 61850 test mode	193
SCBK1BC	SELOGIC control for breaker/contactor closing interlocking supervision equation	192
SCBK1BO	SELOGIC control for breaker/contactor open interlocking supervision equation	192

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 19 of 22)

Bit	Definition	Row
SG1	Asserts when setting Group 1 is active	28
SG2	Asserts when setting Group 2 is active	28
SG3	Asserts when setting Group 3 is active	28
SG4	Asserts when setting Group 4 is active	28
SLIPBT	Asserts when slip is below the SYNSLIP setting	129
SLIPOK	Asserts when the slip calculation is reliable enough to successfully synchronize the motor based on stator measurements	129
SLIPRECH	Synchronous motor rotor slip frequency reached SYNSLIP setting	
SMTRIP	Asserts when start motor timer times out	2
SPDSAL	Speed switch alarm—asserts when the relay does not detect a speed switch contact closure within a settable period from the beginning of a motor start, if the function is enabled by relay settings	7
SPDSFAIL	Speed switch failed	128
SPDSTR	Speed switch trip—asserts when the relay does not detect a speed switch contact closure within a settable period from the beginning of a motor start, if the function is enabled by relay settings	2
SPEED2	Asserts when protected motor run with second speed	22
SPEEDSW	Speed switch input—asserts when the SELOGIC control equation SPEEDSW result is logical 1. Used to indicate that the motor speed switch contact is closed.	22
SRUNNING	Asserts when synchronous motor is running	3
SSFLRST	Reset speed switch monitor logic	128
SSRSLPOK	Steady state rotor slip satisfied	194
STAR	Star control	9
START	Motor start (see *Figure 4.80*)	9
STARTING	Asserts when protected motor is starting	9
STOP	Stop motor—asserts when serial port command STOP or front-panel or Modbus/DeviceNet Stop command is issued	29
STOPPED	Asserts when motor is stopped	9
STORMDET	Asserts if a network storm has been detected	95
STR	Start motor—asserts when serial port command STR or front-panel or Modbus/DeviceNet Start command is issued	29
STREQ	Start motor SELOGIC control equation	29
STSEQEN	Synchronous motor start sequence enable SELOGIC control equation	124
SV01–SV08	SELOGIC control equation variables SV01 through SV08	45
SV01T–SV08T	SELOGIC control equation variable SV01T through SV08T with settable pickup and dropout time delay	46
SV09–SV16	SELOGIC control equation variables SV09 through SV16	47
SV09T–SV16T	SELOGIC control equation variable SV09T through SV16T with settable pickup and dropout time delay	48
SV17–SV24	SELOGIC control equation variables SV17 through SV24	49
SV17T–SV24T	SELOGIC control equation variable SV17T through SV24T with settable pickup and dropout time delay	50
SV25–SV32	SELOGIC control equation variables SV25 through SV32	51

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 20 of 22)

Bit	Definition	Row
SV25T–SV32T	SELOGIC control equation variable SV25T through SV32T with settable pickup and dropout time delay	52
SWING	Single blinder: 78R1/78R2 and 78Z1 assert double blinder: 78R1 and 78R2 assert or only 78R1 asserts	125
SYNEN	Synchronous motor start sequence enabled	
T01_LED–T06_LED	SELOGIC control equation: drives T01_LED–T06_LED	36
TBSLO	Motor lockout conditions—asserted by the thermal element (THERMLO), starts per hour function (NOSLO), minimum time between starts (TBSLO), and the antibackspin timer (ABSLO)	21
TESTDB	Command **TESTDB** (asserts when analog and digital values reported via Modbus, IEC 61850, or Fast meter protocol may be overridden)	127
THERMLO	Motor lockout conditions—asserted by the thermal element (THERMLO), starts per hour function (NOSLO), minimum time between starts (TBSLO), and the antibackspin timer (ABSLO)	21
TMB1A–TMB8A	Channel A Transmit MIRRORED BITS TMB1A through TMB8A	91
TMB1B–TMB8B	Channel B Transmit MIRRORED BITS TMB1B through TMB8B	93
TOL1 – TOL8	Arc-flash light Input 1 element pickup—Arc-flash light Input 8 element pickup	119
TQUAL1	Time quality bit, add 1 when asserted	116
TQUAL2	Time quality bit, add 2 when asserted	116
TQUAL4	Time quality bit, add 4 when asserted	116
TQUAL8	Time quality bit, add 8 when asserted	116
TR	Trip SELOGIC control equation (Also referred to as TRIPEQ)	29
TRDCPTR	Meter report trigger SELOGIC equation	27
TRGTR	Target reset—asserts for one quarter-cycle when you execute a front-panel, serial port target reset command, or Modbus target reset	22
TRIP	Trip logic output (see *Figure 4.76*)	1
TSNTPB	SNTP secondary server is active	117
TSNTPP	SNTP primary server is active	117
TSOK	Asserts if current time-source accuracy is sufficient for synchronized phasor measurements	115
TTSTOP_A	Time to stop alarm	141
TTSTRT_A	Time to start alarm	142
TUTC1	Offset hours from UTC, binary, add 1 if asserted	117
TUTC2	Offset hours from UTC, binary, add 2 if asserted	117
TUTC4	Offset hours from UTC, binary, add 4 if asserted	117
TUTC8	Offset hours from UTC, binary, add 8 if asserted	117
TUTCH	Offset half-hour from UTC, binary, add 0.5 if asserted	117
TUTCS	Offset hours sign from UTC, subtract the UTC offset if TUTCS is asserted; otherwise, add	
UL41CL	Unlatch 41breaker close	124
ULTRIP	Unlatch (auto reset) trip from SELOGIC control equation	29
VARA	Reactive power alarm—asserts when the relay issues a reactive power element alarm	7
VART	Reactive power trip—asserts when the relay issues a reactive power element trip	2

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 21 of 22)

Bit	Definition	Row
VB*xxx*	Virtual bits used for incoming GOOSE messages (*xxx* = 1–128)	96–111
VFDBYPAS	Variable frequency driver bypass SELOGIC control equation—used to bypass the VFD application	22
VIBAQ1AP	Newly commissioned machinery picked up 1	187
VIBAQ1AT	Newly commissioned machinery time out 1	187
VIBAQ1BP	Unrestricted operation picked up 1	187
VIBAQ1BT	Unrestricted operation time out 1	187
VIBAQ1CP	Restricted operation picked up 1	187
VIBAQ1CT	Restricted operation time out 1	187
VIBAQ1DP	Damage occurs picked up 1	187
VIBAQ1DT	Damage occurs time out 1	187
VIBAQ2AP	Newly commissioned machinery picked up 2	188
VIBAQ2AT	Newly commissioned machinery time out 2	188
VIBAQ2BP	Unrestricted operation picked up 2	188
VIBAQ2BT	Unrestricted operation time out 2	188
VIBAQ2CP	Restricted operation picked up 2	188
VIBAQ2CT	Restricted operation time out 2	188
VIBAQ2DP	Damage occurs picked up 2	188
VIBAQ2DT	Damage occurs time out 2	188
VIBAQ3AP	Newly commissioned machinery picked up 3	189
VIBAQ3AT	Newly commissioned machinery time out 3	189
VIBAQ3BP	Unrestricted operation picked up 3	189
VIBAQ3BT	Unrestricted operation time out 3	189
VIBAQ3CP	Restricted operation picked up 3	189
VIBAQ3CT	Restricted operation time out 3	189
VIBAQ3DP	Damage occurs picked up 3	189
VIBAQ3DT	Damage occurs time out 3	189
VIBAQ4AP	Newly commissioned machinery picked up 4	190
VIBAQ4AT	Newly commissioned machinery time out 4	190
VIBAQ4BP	Unrestricted operation picked up 4	190
VIBAQ4BT	Unrestricted operation time out 4	190
VIBAQ4CP	Restricted operation picked up 4	190
VIBAQ4CT	Restricted operation time out 4	190
VIBAQ4DP	Damage occurs picked up 4	190
VIBAQ4DT	Damage occurs time out 4	190
VIBAQ5AP	Newly commissioned machinery picked up 5	191
VIBAQ5AT	Newly commissioned machinery time out 5	191
VIBAQ5BP	Unrestricted operation picked up 5	191
VIBAQ5BT	Unrestricted operation time out 5	191

Table L.2 Relay Word Bit Definitions for the SEL-710-5 (Sheet 22 of 22)

Bit	Definition	Row
VIBAQ5CP	Restricted operation picked up 5	191
VIBAQ5CT	Restricted operation time out 5	191
VIBAQ5DP	Damage occurs picked up 5	191
VIBAQ5DT	Damage occurs time out 5	191
VIRSPDSW	Indicates detection of rotor speed by VSS logic	128
VMIN_A	Minimum start voltage	142
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 its alarm set point.	21
WDGTRIP	Winding temperature trip. WDGTRIP asserts when one or two (when EWDGV = Y) healthy winding RTD temperatures exceed their trip set points.	21
ZCFREQ	Zero crossing detection bit status	31

Appendix M
Analog Quantities

The SEL-710-5 Motor Protection Relay contains several analog quantities that are used for more than one function. The actual analog quantities available depend on the part number of the relay used. Analog quantities are typically generated and used by a primary function, such as metering, and selected quantities are made available for one or more supplemental functions, for example, the load profile.

Note that all analog quantities available for use in SELOGIC control equations are processed every 25 ms and are not suitable for fast-response control and protection applications. Analog quantities for rms data are derived from data averaged from the previous 8 cycles. RMS Metering Analog Quantities (see *Table M.1*) are derived from data from the last 32 samples (one cycle).

Table M.1 lists analog quantities that are used in the following specific functions:

- Display points (see *Section 8: Front-Panel Operations*)
- SELOGIC control equations (see *Section 4: Protection and Logic Functions*)
- Load profile recorder (see *Section 5: Metering and Monitoring*)
- DNP3 (see *Appendix D: DNP3 Communications*)
- Fast Message Read
- EtherNet/IP (see *Appendix F: EtherNet/IP Communications*)
- IEC 60870-5-103 (see *Appendix H: IEC 60870-5-103 Communications*)
- Modbus (see *Appendix E: Modbus Communications*)
- Fast Meter (see *Appendix C: SEL Communications Processors*)
- IEC 61850 (see *Appendix G: IEC 61850 Communications*)

Table M.1 Analog Quantities (Sheet 1 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
Instantaneous (Fundamental) Metering Note 1: The RF value is forced to 9999 when the motor-side dc field current IEX is less than 0.5 A dc.									
IA_MAG	Current, A-phase, magnitude	A pri	x	x	x	x	x	x	x
IA_ANG	Current, A-phase, angle	degrees	x	x	x	x	x		x
IB_MAG	Current, B-phase, magnitude	A pri	x	x	x	x	x	x	x
IB_ANG	Current, B-phase, angle	degrees	x	x	x	x	x		x
IC_MAG	Current, C-phase, magnitude	A pri	x	x	x	x	x	x	x
IC_ANG	Current, C-phase, angle	degrees	x	x	x	x	x		x
IN_MAG	Neutral current, magnitude	A pri	x	x	x	x	x	x	x
IN_ANG	Neutral current, angle	degrees	x	x	x	x	x		x
IG_MAG	Current, calculated-residual, magnitude	A pri	x	x	x	x	x	x	x
IG_ANG	Current, calculated-residual, angle	degrees	x	x	x	x	x		x
IAV	Current, average current, magnitude	A pri	x	x	x	x	x		x
3I2	Current, negative-sequence current, magnitude	A pri	x	x	x	x	x		x
UBI	Current imbalance	%	x	x	x	x	x	x	x
VA_MAG	Voltage, A-phase-to-neutral, magnitude	V pri	x	x	x	x	x	x	x
VA_ANG	Voltage, A-phase-to-neutral, angle	degrees	x	x	x	x	x		x
VB_MAG	Voltage, B-phase-to-neutral, magnitude	V pri	x	x	x	x	x	x	x
VB_ANG	Voltage, B-phase-to-neutral, angle	degrees	x	x	x	x	x		x
VC_MAG	Voltage, C-phase-to-neutral, magnitude	V pri	x	x	x	x	x	x	x
VC_ANG	Voltage, C-phase-to-neutral, angle	degrees	x	x	x	x	x		x
VAB_MAG	Voltage, A-to-B-phase, magnitude	V pri	x	x	x	x	x	x	x
VAB_ANG	Voltage, A-to-B-phase, angle	degrees	x	x	x	x	x		x
VBC_MAG	Voltage, B-to-C-phase, magnitude	V pri	x	x	x	x	x	x	x
VBC_ANG	Voltage, B-to-C-phase, angle	degrees	x	x	x	x	x		x
VCA_MAG	Voltage, C-to-A-phase, magnitude	V pri	x	x	x	x	x	x	x
VCA_ANG	Voltage, C-to-A-phase, angle	degrees	x	x	x	x	x		x
VG_MAG	Zero-sequence voltage, magnitude	V pri	x	x	x	x	x	x	x
VG_ANG	Zero-sequence voltage, angle	degrees	x	x	x	x	x		x

Table M.1 Analog Quantities (Sheet 2 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
VAVE	Average voltage, magnitude	V pri	x	x	x	x	x		x
3V2	Voltage, negative-sequence, magnitude	V pri	x	x	x	x	x		x
UBV	Voltage imbalance	%	x	x	x	x	x	x	x
S	Apparent power, three-phase, magnitude	kVA pri	x	x	x	x	x	x	x
P	Real power, three-phase, magnitude	kW pri	x	x	x	x	x	x	x
Q	Reactive power, three-phase, magnitude	kVAR pri	x	x	x	x	x	x	x
PF	Power factor, three-phase, magnitude		x	x	x	x	x	x	x
FREQ	Frequency	Hz	x	x	x	x	x	x	x
VEX	Field voltage	V pri	x	x	x	x	x		x
IEX	Field current	A pri	x	x	x	x	x		x
RF[1]	Field resistance	Ohm	x	x	x	x	x		x
SMSLIP	Brush-type synchronous motor slip	%	x	x					
SMSLIP2	Synchronous motor slip	%	x	x					
Differential Metering									
IA87	Differential current, A-phase, magnitude	A pri	x	x		x	x		x
IB87	Differential current, B-phase, magnitude	A pri	x	x		x	x		x
IC87	Differential current, C-phase, magnitude	A pri	x	x		x	x		x
Fault Information									
FIA	A-phase fault current from maximum current event report row	A pri	x	x		x			x
FIB	B-phase fault current from maximum current event report row	A pri	x	x		x			x
FIC	C-phase fault current from maximum current event report row	A pri	x	x		x			x
FIG	Ground fault current from maximum current event report row	A pri	x	x		x			x
FIN	Neutral fault current from maximum current event report row	A pri	x	x		x			x
FIA87	Differential A-phase fault current from maximum current event report row	A pri	x	x		x			x
FIB87	Differential B-phase fault current from maximum current event report row	A pri	x	x		x			x

Table M.1 Analog Quantities (Sheet 3 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
FIC87	Differential C-phase fault current from maximum current event report row	A pri	x	x		x			x
FFREQ	Fault frequency	Hz	x	x		x			x
FLREP	Event Report Present (shall be 1 when an event report is present. and 0 otherwise)								x
FLRNUM	Unique identification number of the latest event								x
Thermal Metering Note 2: SEL Fast Message label names for RTDWDFMX, RTDBRGMX, RTDAMB, and RTDOTHMX are WDG, BRG, AMB, and OTH, respectively. Note 3: 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[2]	Maximum winding RTD temperature	°C	x	x	x	x	x	x	x
RTDBRGMX[2]	Maximum bearing RTD temperature	°C	x	x	x	x	x	x	x
RTDAMB[2]	Ambient RTD temperature	°C	x	x	x	x	x	x	x
RTDOTHMX[2]	Other maximum RTD temperature	°C	x	x	x	x	x	x	x
RTD1 to RTD12[3]	RTD1 temperature to RTD12 temperature	°C	x	x	x	x	x		x
MLOAD	Motor load	pu of FLA	x	x	x	x	x	x	x
TCURTR	Rotor % thermal capacity used	%	x	x	x	x	x	x	x
TCUSTR	Stator % thermal capacity used	%	x	x	x	x	x	x	x
TCURTD	RTD % thermal capacity used	%	x	x	x	x	x		x
THRMTP	Thermal trip in	seconds	x	x	x	x	x		x
TRST	Time to reset	minutes	x	x	x	x	x		x
STRTAV	Starts available		x	x	x	x	x		x
SLIP	Slip	%	x	x	x	x	x		x
MRT	Motor running time	hours	x	x	x	x	x		x
STRT	Number of starts counter		x	x		x			x
EMSTRT	Number of emergency starts counter		x	x		x			x
Virtual Speed Switch Logic									
VSSCNTR	Virtual speed switch logic time (0.5 s per count)	counts		x	x				
VSSCNT1	Virtual speed switch time to Current Level 1 (0.5 s per count)	counts		x	x				
VSSCNT2	Virtual speed switch time to Current Level 2 (0.5 s per count)	counts		x	x				

Table M.1 Analog Quantities (Sheet 4 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
VSSCNT3	Virtual speed switch time to Current Level 3 (0.5 s per count)	counts		x	x				
VSSCURR1	Virtual speed switch current level 1(MLOAD at VSSCNT1)	pu of FLA		x	x				
VSSCURR2	Virtual speed switch current level 2 (MLOAD at VSSCNT2)	pu of FLA		x	x				
VSSCURR3	Virtual speed switch current level 3 (MLOAD at VSSCNT3)	pu of FLA		x	x				
Light Metering									
LSENS1	Arc-Flash Sensor 1 light	%	x	x	x	x	x		x
LSENS2	Arc-Flash Sensor 2 light	%	x	x	x	x	x		x
LSENS3	Arc-Flash Sensor 3 light	%	x	x	x	x	x		x
LSENS4	Arc-Flash Sensor 4 light	%	x	x	x	x	x		x
LSENS5	Arc-Flash Sensor 5 light	%	x	x	x	x	x		x
LSENS6	Arc-Flash Sensor 6 light	%	x	x	x	x	x		x
LSENS7	Arc-Flash Sensor 7 light	%	x	x	x	x	x		x
LSENS8	Arc-Flash Sensor 8 light	%	x	x	x	x	x		x
Analog Input Metering Note 4: EU is engineering units.									
AI301 to AI308	Analog inputs for an analog card in Slot C	EU[4]	x	x	x	x	x		x
AI401 to AI408	Analog inputs for an analog card in Slot D	EU[4]	x	x	x	x	x		x
AI501 to AI508	Analog inputs for an analog card in Slot E	EU[4]	x	x	x	x	x		x
Energy Metering Note 5: This analog quantity is not available for FMR.									
EM_LRDH	Energy last reset date/time high word					x[5]			
EM_LRDM	Energy last reset date/time middle word					x[5]			
EM_LRDL	Energy last reset date/time low word					x[5]			
MWH3P	Real energy, three-phase OUT	MWh pri	x	x	x	x	x		x
MVARH3PI	Reactive energy, three-phase IN	MVARh pri	x	x	x	x	x		x
MVARH3PO	Reactive energy, three-phase OUT	MVARh pri	x	x	x	x	x		x
MVAH3P	Apparent energy, three-phase OUT	MVAh pri	x	x	x	x	x		x

Table M.1 Analog Quantities (Sheet 5 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
Maximum and Minimum Metering Note 6: For each of the maximum or minimum analog quantities, the corresponding time stamp is also reported in Modbus. In addition, the time when Max/Min data was last reset is also reported in Modbus (the actual labels used in the Modbus map are not MM_LRDH, MM_LRDM, MM_LRDL). Note 7: Maximum and Minimum Metering quantities upon reset read +16777216 for MN and -16777216 for MX.									
MM_LRDH[6]	Max/min last reset date/time high word					x[5]			
MM_LRDM[6]	Max/min last reset date/time middle word					x[5]			
MM_LRDL[6]	Max/min last reset date/time low word					x[5]			
IAMX	Current, A-phase, maximum magnitude	A pri	x	x	x	x	x		x
IBMX	Current, B-phase, maximum magnitude	A pri	x	x	x	x	x		x
ICMX	Current, C-phase, maximum magnitude	A pri	x	x	x	x	x		x
INMX	Current, neutral, maximum magnitude	A pri	x	x	x	x	x		x
IGMX	Current, residual, maximum magnitude	A pri	x	x	x	x	x		x
IAMN	Current, A-phase, minimum magnitude	A pri	x	x	x	x	x		x
IBMN	Current, B-phase, minimum magnitude	A pri	x	x	x	x	x		x
ICMN	Current, C-phase, minimum magnitude	A pri	x	x	x	x	x		x
INMN	Current, neutral, minimum magnitude	A pri	x	x	x	x	x		x
IGMN	Current, residual, minimum magnitude	A pri	x	x	x	x	x		x
VABMX	Voltage, A-to-B-phase, maximum magnitude	V pri	x	x	x	x	x		x
VBCMX	Voltage, B-to-C-phase, maximum magnitude	V pri	x	x	x	x	x		x
VCAMX	Voltage, C-to-A-phase, maximum magnitude	V pri	x	x	x	x	x		x
VAMX	Voltage, A-phase-to-neutral, maximum magnitude	V pri	x	x	x	x	x		x
VBMX	Voltage, B-phase-to-neutral, maximum magnitude	V pri	x	x	x	x	x		x
VCMX	Voltage, C-phase-to-neutral, maximum magnitude	V pri	x	x	x	x	x		x
VABMN	Voltage, A-to-B-phase, minimum magnitude	V pri	x	x	x	x	x		x
VBCMN	Voltage, B-to-C-phase, minimum magnitude	V pri	x	x	x	x	x		x
VCAMN	Voltage, C-to-A-phase, minimum magnitude	V pri	x	x	x	x	x		x
VAMN	Voltage, A-phase-to-neutral, minimum magnitude	V pri	x	x	x	x	x		x
VBMN	Voltage, B-phase-to-neutral, minimum magnitude	V pri	x	x	x	x	x		x
VCMN	Voltage, C-phase-to-neutral, minimum magnitude	V pri	x	x	x	x	x		x
KVA3PMX	Apparent power, three-phase, maximum magnitude	kVA pri	x	x	x	x	x		x

Table M.1 Analog Quantities (Sheet 6 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
KW3PMX	Real power, three-phase, maximum magnitude	kW pri	x	x	x	x	x		x
KVAR3PMX	Reactive power, three-phase, maximum magnitude	kVAR pri	x	x	x	x	x		x
KVA3PMN	Apparent power, three-phase, minimum magnitude	kVA pri	x	x	x	x	x		x
KW3PMN	Real power, three-phase, minimum magnitude	kW pri	x	x	x	x	x		x
KVAR3PMN	Reactive power, three-phase, minimum magnitude	kVAR pri	x	x	x	x	x		x
FREQMX	Maximum frequency	Hz	x	x	x	x	x		x
FREQMN	Minimum frequency	Hz	x	x	x	x	x		x
RTD1MX to RTD12MX	RTD1 maximum to RTD12 maximum	°C	x	x	x	x	x		x
RTD1MN to TD12MN	RTD1 minimum to RTD12 minimum	°C	x	x	x	x	x		x
AI301MX to I308MX	Analog Transducer Input 301–308 maximum	EU[4]	x	x	x	x	x		x
AI301MN to I308MN	Analog Transducer Input 301–308 minimum	EU[4]	x	x	x	x	x		x
AI401MX toAI408MX	Analog Transducer Input 401–408 maximum	EU[4]	x	x	x	x	x		x
AI401MN toAI408MN	Analog Transducer Input 401–408 minimum	EU[4]	x	x	x	x	x		x
AI501MX to AI508MX	Analog Transducer Input 501–508 maximum	EU[4]	x	x	x	x	x		x
AI501MN to AI508MN	Analog Transducer Input 501–508 minimum	EU[4]	x	x	x	x	x		x
RMS Metering Note 8: RMS metering analog quantities are derived from data from the last 32 samples (one cycle).									
IARMS	RMS current, A-phase, magnitude	A pri	x	x	x	x	x		x
IBRMS	RMS current, B-phase, magnitude	A pri	x	x	x	x	x		x
ICRMS	RMS current, C-phase, magnitude	A pri	x	x	x	x	x		x
INRMS	RMS current, neutral, magnitude	A pri	x	x	x	x	x		x
VARMS	RMS voltage, A-phase, magnitude	V pri	x	x	x	x	x		x
VBRMS	RMS voltage, B-phase, magnitude	V pri	x	x	x	x	x		x
VCRMS	RMS voltage, C-phase, magnitude	V pri	x	x	x	x	x		x
VABRMS	RMS voltage, AB-phase-to-phase, magnitude	V pri	x	x	x	x	x		x
VBCRMS	RMS voltage, BC-phase-to-phase, magnitude	V pri	x	x	x	x	x		x
VCARMS	RMS voltage, CA-phase-to-phase, magnitude	V pri	x	x	x	x	x		x

Table M.1 Analog Quantities (Sheet 7 of 8)

Name	Description	Units	Display Points	SELOGIC	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
Breaker Monitoring									
INTT	Internal trips—counter		x	x		x	x		x
INTIA	Accumulated current—internal trips, A-phase	kA pri	x	x		x	x		x
INTIB	Accumulated current—internal trips, B-phase	kA pri	x	x		x	x		x
INTIC	Accumulated current—internal trips, C-phase	kA pri	x	x		x	x		x
EXTT	External trips—counter		x	x		x	x		x
EXTIA	Accumulated current—external trips, A-phase	kA pri	x	x		x	x		x
EXTIB	Accumulated current—external trips, B-phase	kA pri	x	x		x	x		x
EXTIC	Accumulated current—external trips, C-phase	kA pri	x	x		x	x		x
WEARA	Breaker wear, A-phase	%	x	x		x	x		x
WEARB	Breaker wear, B-phase	%	x	x		x	x		x
WEARC	Breaker wear, C-phase	%	x	x		x	x		x
Power Factor Correction									
OUTVAL	Power factor correction analog output	%	x	x	x				
PFANG	Power factor angle	deg	x	x	x				
PID Controller									
PIDOUT	PID controller analog output	%	x	x	x				
97FM Element									
97FM1–97FM5	Magnitude of selected frequency component for elements 1–5		x	x	x	x	x		
Date/Time Note 9: DATE and TIME are also available as DNP Object 50.									
DATE	Present date		x				x		
TIME	Present time		x				x		
YEAR	Year number (0000–9999)			x			x		
DAYY	Day of year number (1–366)			x					
WEEK	Week number (1–52)			x					
DAYW	Day of week number (1–7)			x					
MINSM	Minutes since midnight			x					

Table M.1 Analog Quantities (Sheet 8 of 8)

Name	Description	Units	Display Points	SELogic	Load Profile	DNP3/Fast Message Read/ IEC 60870-5-103/EtherNet/IP via Ethernet Port	Modbus	Fast Meter	IEC 61850[a]
RID/TID Note 10: RID and TID are only available as display point settings (DP01 to DP32) in the two-line display model. Note 11: STRING_RID and STRING_TID are only available as analog label quantities for the bay screen in the touchscreen model.									
RID[10]	Relay Identifier		x						
TID[10]	Terminal Identifier		x						
STRING_RID[11]	Relay Identifier (Bay Screen)		x						
STRING_TID[11]	Terminal Identifier (Bay Screen)		x						
Serial Number Note 12: SER_NUM is available for use with display points in the two-line display model, but it is not available for use with analog labels in the touchscreen display model.									
SER_NUM[5,12]	Serial number of the relay		x			x	x		x
Setting Group									
GROUP	Active setting group #		x	x	x	x	x		x
Math Variables									
MV01 to MV32	Math Variable 01 to Math Variable 32		x	x	x	x	x		x
SELogic Counters Note 13: Also available as DNP counter object.									
SC01 to SC32	SELogic Counter 01 to SELogic Counter 32		x	x	x	x	x		x
Remote Analogs Note 14: FM refers to Fast Message support for remote analogs. Remote analogs can be written by issuing an unsolicited Fast Message Write command.									
RA001 to RA128	Remote analog 001 to remote analog 128		x	x	x	x	x	x[14]	x
IEC 61850 Test Mode Note 15: The IEC 61850 label name for I850MOD is I60MOD.									
I850MOD	IEC 61850 Test Mode Status			x					x

[a] See Device Logical Nodes for a list of the analog quantities mapped in the default ICD file.

Appendix N
Cybersecurity Features

The SEL-710-5 provides a number of features to help meet cybersecurity design requirements.

Access Control

The SEL-710-5 has a number of mechanisms for managing electronic access. These include ways to limit access, provide user authentication, and monitor electronic and physical access.

Physical Port Controls

Each physical serial port and the Ethernet port can be individually disabled using the EPORT setting. By default, all of the ports are enabled. It is good security practice to disable unused ports.

IP Ports

When using Ethernet, there are a number of IP ports available within the SEL-710-5. Many of these IP port numbers are configurable. All IP ports can be disabled. *Table N.1* describes each of these.

Table N.1 IP Port Numbers

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
21	--	TCP	Enabled	EFTPSERV	FTP protocol access for file transfer of settings and reports
23	TPORT	TCP	Enabled	ETELNET	Telnet access for general engineering terminal access
80	HTTPPORT	TCP	Enabled	EHTTP	Web server access to various relay information
102	--	TCP	Disabled	E61850	IEC 61850 MMS for SCADA functionality
123	SNTPPORT	UDP	Disabled	ESNTP	SNTP time synchronization
319/320	--	UDP	Disabled	EPTP[a]	PTP time synchronization
502	MODNUM1/ MODNUM2	TCP	Disabled	EMOD	MODBUS for SCADA functionality
2222/44818	--	TCP/ UDP	Disabled	EEIP	EtherNet/IP for SCADA
20000	DNPNUM	TCP/ UDP	Disabled	EDNP	DNP for SCADA functionality

[a] When PTPPRO = DEFAULT and PTPTR = UDP.

See *PORT 1 on page 4.144* and *Ethernet Port on page 7.3* for more information on these settings.

Authentication and Authorization

The SEL-710-5 supports four levels of access, as described in *Access Levels on page 7.27*. Refer to this section to learn how each level is accessed and how to change passwords. It is good security practice to change the default passwords of each access level and to use a unique password for each level.

The MAXACC setting limits the level of access for each port. This permits you to operate under the principle of *least privilege*, restricting ports to the levels necessary for the functions performed on those ports.

The SEL-710-5 supports strong passwords with as many as 12 characters, using any printable character, allowing users to select complex passwords if they so choose. SEL recommends that passwords have a minimum of 8 characters and include at least one of each of the following: lowercase letter, uppercase letter, number, and special character.

Ethernet protocols Telnet and FTP require the proper passwords to gain access to level-protected functions. Ethernet protocol MMS requires a password to gain access if MMS Authentication is enabled via the CID file. See *Section 7: Communications* for more information on access restrictions for the Ethernet protocols.

Monitoring and Logging

NOTE: Refer to *Access Commands (ACCESS, 2ACCESS, and CAL) on page 7.32* for more information on when SALARM is pulsed for access level changes and unsuccessful password entry attempts.

The SEL-710-5 provides Relay Word bits that are useful for monitoring relay access:

- SALARM—Pulses for approximately one second whenever a user gains access to Level 2 or higher, when an incorrect password is entered, or when a setting is changed.
- PASEL, PBSEL—Asserted while the Ethernet port(s) is active.
- LINK1, LINKA, LINKB—Asserted while the link is active on the Ethernet port(s). Loss of a link can be an indication that an Ethernet cable has been disconnected.
- LINKFAIL—Asserted if link is lost on the active IP port (ports 1A or 1B).

These bits can be mapped for SCADA monitoring via DNP3, IEC 61850, Modbus, EtherNet/IP, or SEL Fast Message. They also may be added to the SER for later analysis or assigned to output contacts for alarm purposes.

The SEL-710-5 SER is a useful tool for capturing a variety of relay events. In addition to capturing state changes of user selected Relay Word bits, it captures all power-ups, settings changes, and group switches. See *Sequential Events Recorder (SER) Report on page 10.30* for more information about SER.

Configuration Management

Many users are concerned about managing the configuration of their relays. The SEL-710-5 provides mechanisms to help users manage relay configuration.

All settings changes are logged to the SER log. Analysis of this log indicates if any unauthorized settings changes occurred. The SALARM Relay Word bit also indicates changes in the relay configuration by pulsing for approximately one second when any of the following occur:

- Settings are changed or saved
- A password changes
- The relay switches settings groups

See *Self-Test on page 11.13* for more information regarding the Relay Word bit SALARM.

Malware Protection

The SEL-710-5 has inherent and continuous monitoring for Malware. For a full description of this, see selinc.com/mitigating_malware/.

Firmware Hash Verification

This device supports digitally signed firmware upgrades. SEL uses the SHA-256 secure hash algorithm to compress and digitally sign firmware upgrade files. The signature ensures that the file has been provided by SEL and that its contents have not been altered. When the file is uploaded to the relay, the signature is verified using a public key stored in the relay. If the relay cannot verify the signature, it rejects the file. See *Appendix B: Firmware Upgrade Instructions* for more information on firmware upgrades.

Operating System/ Firmware

SEL-710-5 relays are embedded devices that do not allow additional software to be installed. SEL-710-5 relays include a self-test that continually checks running code against the known good baseline version of code in nonvolatile memory. This process is outlined in more detail in the *The SEL Process for Mitigating Malware Risk to Embedded Devices* located at selinc.com/mitigating_malware/.

SEL-710-5 relays run in an embedded environment for which there is no commercial anti-virus software available.

Software/Firmware Verification

SEL-710-5 relays can install firmware updates in the field. Authenticity and integrity of firmware updates can be verified using the Firmware Hash page at selinc.com/products/firmware.

Physical Access Security

Physical security of cybersecurity assets is a common concern. Typically, relays are installed within a control enclosure that provides physical security. Other times, they are installed in boxes within the switch yard. The relay provides some tools that may be useful to help manage physical security, especially when the unit is installed in the switch yard.

You can monitor physical ingress by wiring a door sensor to one of the relay contact inputs. This input can then be mapped for SCADA monitoring or added to the SER log so that you can detect when physical access to the relay occurs. It is also possible to wire an electronic latch to a relay contact output. You could then map this output for SCADA control.

Vulnerability Notification Process

Security Vulnerability Process

SEL provides security disclosure alerts to customers, and SEL instruction manuals document all releases. SEL security vulnerability disclosures are described in *The SEL Process for Disclosing Security Vulnerabilities* located at selinc.com.

Emailed Security Notifications

You can sign up to receive email notifications when SEL releases security notices and service bulletins at selinc.com/support/security-notifications/.

Settings Erasure

NOTE: Do not erase the settings when sending the relay to the factory for service. SEL needs to be able to see how the relay was configured to properly diagnose any problems.

NOTE: In firmware versions R302-V0 and later, the relay firmware retains the IP address, subnet mask, and default router settings after an **R_S** command is issued.

It is often desirable to erase the settings from the relay when it is removed from service. You can completely erase all the configuration settings from the SEL-710-5 using this procedure:

Step 1. Enter the Calibration Access Level. See *Access Levels on page 7.27*.

Step 2. Execute the **R_S** command.

Step 3. Allow the relay to restart.

Once this procedure is complete, all internal instances of user settings and passwords will be erased. Do not do this when sending in the relay for service at the factory. SEL needs to see how the relay was configured in order to properly diagnose many problems.

Glossary

A — Abbreviation for Amps or amperes; units of electrical current magnitude.

ACSELERATOR Architect SEL-5032 Software — Design and commissioning tool for IEC 61850 communications.

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
27I Inverse-Time Undervoltage Element
32 Directional Power Element
37 Underpower Element
40 Loss-of-Field 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
59I Inverse-Time Overvoltage Element
60 Loss-of-Potential Element
66 Jogging Device (limits number of operations within a given time of each other)
78 Out-of-Step Element
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-amperes (VA), kilovolt-amperes (kVA), or megavolt-amperes (MVA). Accounts for both real (P) and reactive (Q) power dissipated in a circuit: $S = P + jQ$.

Arc-Flash Detection The sensing of an arc-flash condition by detection of light and overcurrent by the relay.

Clear-Jacketed Fiber Sensor—The fiber-optic loop sensor used for arc-flash detection.

Point Sensor—The fiber-optic cable sensor with a light diffuser on the end and used for arc-flash detection.

Arc-Flash Hazard A dangerous condition associated with the release of energy caused by an electric arc.

Arc-Flash Protection (Relay) An action performed by the relay to minimize the arc-flash hazard.

ASCII Abbreviation for American Standard Code for Information Interchange. Defines a standard way to communicate text characters between two electronic devices. The SEL-710-5 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 necessary to operate a device. To apply a short-circuit or closed contact to an SEL-710-5 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.

Bay Screen Builder SEL-5036 Software An intuitive and powerful interface to design bay screens to meet application needs.

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.

Broken Bar Rotor Protection A protection in the relay active for induction motor applications. Broken rotor bars cause reduced accelerating torque, increased motor heating, and increased vibrations, which can lead to further mechanical motor damage. The SEL-710-5 detects current signatures that are generated by broken rotor bars, and alarms the problem.

C37.238 IEEE C37.238, standard profile for use of IEEE 1588 Precision Time Protocol in power system applications.

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.

CID File IEC 61850 Configured IED Description file. XML file that contains the configuration for a specific IED.

COMTRADE Abbreviation for Common Format for Transient Data Exchange. The SEL-710-5 supports the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, IEEE C37.111-1999.

Contiguous Items in sequence; the second immediately following the first.

CR_RAM Abbreviation for Critical RAM. Refers to the area of relay Random Access Memory (RAM) where the relay stores mission-critical data.

CRC-16 Abbreviation for Cyclical Redundancy Check-16. A mathematical algorithm applied to a block of digital information to produce a unique, identifying number. Used to ensure that the information was received without data corruption.

CT Abbreviation for current transformer.

Current Unbalance The SEL-710-5 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 amperes 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-710-5, 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-710-5 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.

DNP (Distributed Network Protocol) Manufacturer-developed, hardware-independent communications protocol.

Dropout Time The time measured from the removal of an input signal until the output signal deasserts. The time can be settable, as in the case of a logic variable timer, or can be a result of the characteristics of an element algorithm, as in the case of an overcurrent element dropout time.

Ethernet A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

EtherNet/IP An Ethernet-based protocol that provides ease of integration for industrial automation applications and provides access to metering data, protection elements, targets, and contact I/O.

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.

FTP File transfer protocol.

Fundamental Frequency The component of the measured electrical signal for which frequency is equal to the normal electrical system frequency, usually 50 or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.

Fundamental Meter Type of meter data presented by the SEL-710-5 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.

GOOSE IEC 61850 Generic Object Oriented Substation Event. GOOSE objects can quickly and conveniently transfer status, controls, and measured values among peers on an IEC 61850 network.

HP Abbreviation for horsepower. 1 HP = 745.7 W.

IA, IB, IC Measured A-, B-, and C-phase currents.

ICD File IEC 61850 IED Capability Description file. An XML file that describes IED capabilities, including information on logical node and GOOSE support.

IEC 60870-5-103 Standard protocol developed by the IEC Technical Committee of teleprotection, telecontrol, and telecommunications for electrical engineering and power system automation. It defines systems used for supervisory control and data acquisition (SCADA), including details related to communications between devices.

IEC 61850 Standard protocol for real-time exchange of data between databases in multi-vendor devices.

IEX Measured dc field current for the synchronous motor excitation system.

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.

IP Address An identifier for a computer or device on a TCP/IP network. Networks using the TCP/IP protocol route messages based on the IP address of the destination. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be 0 to 255. For example, 1.160.10.240 could be an IP address.

IRIG-B A time code input that the relay can use to set the internal relay clock.

LCD Abbreviation for Liquid Crystal Display. Used as the relay front-panel alphanumeric display.

LED Abbreviation for Light-Emitting Diode. Used as indicator lamps on the relay front panel.

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.

Logical Node In IEC 61850, the smallest part of a function that exchanges data. A logical node (LN) is an object defined by its data and methods. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function.

Loss-of-Field Element A synchronous motor protection element that detects the loss of dc field excitation and can trip the motor.

Loss-of-Potential Loss of one or more phase voltage inputs to the relay.

MAC Address The Media Access Control (hardware) address of a device connected to a shared network medium, most often used with Ethernet networks.

MIRRORED BITS Protocol for direct relay-to-relay communications.

MMS Manufacturing Message Specification, a data exchange protocol used by IEC 61850.

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.

Out-of-Step Element A synchronous motor application element used to detect loss of synchronism conditions and trip the motor to protect it, if necessary.

Overfrequency Element A protection element that causes the relay to trip when the measured electrical system frequency exceeds a settable frequency.

Phase Differential Element A protection element that measures the difference current between two CTs located on the two ends of a winding (generator) or on two windings (transformer) to detect internal faults.

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.

PID Controller Abbreviation for Proportional-Integral-Derivative controller. A PID controller continuously calculates an error value as the difference between a desired set point and a measured process variable and applies a correction based on proportional, integral, and derivative terms.

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, Q Reactive part of the complex power (S) expressed in units of Vars (Var), kilovars (kVar), or megavars (MVar).

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.

Protection and Control Processing Processing interval is four times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms).

PT Abbreviation for potential transformer. Also referred to as a voltage transformer or VT.

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.

PTP Precision Time Protocol, as defined in IEEE 1588-2008 for high-accuracy clock synchronization.

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.

Rogowski Coil An air-core coil around a current-carrying conductor that generates a voltage proportional to the rate-of-change of current. An integrator is used to derive current from the output of the Rogowski coil.

ROM Abbreviation for Read-Only Memory. Nonvolatile memory where the relay firmware is stored.

RSTP Abbreviation for Rapid Spanning Tree Protocol. RSTP provides an improved failover response in Ethernet networks in accordance with IEEE 802.1Q-2014.

RTD Abbreviation for Resistance Temperature Detector. An RTD is made of a metal having a precisely known resistance and temperature coefficient of resistance. The SEL-710-5 (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.

Self-Test A function that verifies the correct operation of a critical device subsystem and indicates if the relay has detected an out-of-tolerance condition. The SEL-710-5 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.

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).

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.

VDR Field discharge resistor voltage (during synchronous motor starting).

VEX Measured dc field voltage for the synchronous motor excitation system.

VG Residual voltage calculated from the sum of the three phase-to-neutral voltages, if connected.

VT Abbreviation for voltage transformer. Also referred to as a potential transformer or PT.

Wye As used in this instruction manual, a phase-to-neutral connection of voltage transformers for electrical measuring purposes. Three voltage transformers are used with one primary lead of the first transformer connected to A-phase and the other lead connected to ground. The second and third voltage transformers are connected to measure the voltage from B-phase and C-phase-to-ground, respectively. This connection is frequently called "four-wire wye," alluding to the three phase leads plus the neutral lead.

Z-Number That portion of the relay RID string that identifies the proper ACSELERATOR QuickSet SEL-5030 Software relay driver version when creating or editing relay settings files.

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SEL-710-5 Relay Command Summary

The following table lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but you can also enter these with lowercase letters. 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.

La siguiente tabla muestra los comandos ASCII del puerto serie frontal asociados con diferentes actividades. Los comandos se pueden usar en mayúsculas o minúsculas. Los comandos se pueden ejecutar usando las primeras tres letras del nombre. Por más detalles consulte la guía *SEL ASCII Protocol and Commands*.

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 entry of the Access Level 1 password.
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 entry of the Access Level 2 password.
BRE	Displays breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed event report number *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* R	Shows compressed raw event report number *n*, at 1/32-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CMSR *n*	Shows compressed motor start record data, where *n* is the record or reference 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 communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.
COM C A	Clears all communications records for Channel A.
COM C B	Clears all communications records for Channel B.

Comando del Puerto Serial	Descripción del Comando
Comandos de Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos de Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 2.
INT	Mostrar información sobre disparos, corriente interrumpida, desgaste.
CEV *n*	Mostrar el reporte comprimido de evento número *n*, resolución de 1/4 de ciclo.
CEV *n* R	Agregue R para mostrar el reporte de evento comprimido sin filtro, resolución 1/32 de ciclo. Si no se especifica *n* se muestra el evento comprimido mas reciente.
CMSR *n*	Mostrar el reporte de inicio de motor *n* en formato comprimido.
COM A	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal A.
COM B	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal B.
COM D	Borra todos los registros de comunicaciones. Si los dos canales MIRRORED BITS están habilitados, suprimiendo el especificador de canales (A o B) se borran los dos canales.
COM D A	Borra todos los registros de comunicaciones del Canal A.
COM D B	Borra todos los registros de comunicaciones del Canal B.

Serial Port Command	Command Description
COM L	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM S	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DATE	Shows the date.
DATE *dd/mm/yyyy*	Sets the date in DMY format if DATE_F setting is DMY.
DATE *mm/dd/yyyy*	Sets the date in MDY format if DATE_F setting is MDY.
DATE *yyyy/mm/dd*	Sets 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, most recent report is displayed.
EVE *n* R	Shows event report *n* with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.
EVE DIF *n* R	Shows differential event report. Parameters *n* and R are optional.
FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	*Filename* displays contents of the file *filename*.
GOOSE *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is omitted, all of the event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.

Comando del Puerto Serial	Descripción del Comando
COM L	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.
COM L A	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM L B	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM S	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.
COU *n*	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada informe.
FEC	Ver fecha.
FEC *dd/mm/yyyy*	Si DATE_F es igual a DMY, ingrese fecha en formato Día Mes Año
FEC *mm/dd/yyyy*	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
FEC *yyyy/mm/dd*	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Mostrar el estado del puerto de Ethernet.
EVE *n*	Mostrar el reporte de evento estándar número *n*, con 4 muestras por ciclo. Omitiendo *n*, se muestra el informe más reciente.
EVE *n* R	Muestra el evento número *n* (32 muestras analógicas y 4 muestras digitales por ciclo)
EVE DIF *n* R	Muestra el reporte de veento differencial. Los parámetros n y R son opcionales.
FIL DIR	Mostrar lista de archivos.
FIL READ *filename*	Transferir el archivo de configuración *filename* del relé a la computadora.
FIL SHOW *filename*	Muestra el contenido del archivo *filename*.
GOOSE *k*	Mostrar información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Mostrar el grupo de ajustes activo.
AYU	Mostrar una descripción corta de los comandos elegidos.
HIS *n*	Mostrar el resumen de los últimos *n* informes de eventos, donde *n* = 1 es la entrada más reciente. Si *n* es no está especificado, muestra todos los resúmenes de reportes de eventos.
HIS D o **R**	Borrar la historia de eventos.

Serial Port Command	Command Description
HIS CA or **RA**	Clears history events and resets reference number.
HIS BBD	Displays the frequency of the detected broken bar component and its magnitude.
HIS BBD C or **R**	Clears or resents **HIS BBD**.
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays load profile data.
LDP *row1 row2*	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP *date1 date2*	Displays load profile report rows from *date1* to *date2*, starting with *date1*.
LDP C	Clears load profile data.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET or **MET FUN**	Displays fundamental instantaneous metering data.
MET *k*	Displays fundamental metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET E	Displays energy metering data.
MET FFT	Displays the raw data collected and the frequencies and their associated magnitudes and phase angles (broken bar data).
MET L	Displays arc-flash detector (AFD) light input (relay requires the arc-flash detection (AFD) option with a 2 AVI/4 AFDI card or 8 AFDI card in Slot E).
MET M	Display minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET RA	Displays remote analog metering data.
MET RE	Resets energy metering data.
MET RM	Resets minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET T	Displays RTD and thermal metering data.
MMR	Displays stored motor parameters for each start/stop cycle along with the baseline run.
MOT	Displays motor operating statistics report.
MSR *n*	Displays motor start record data where *n* is the record or reference number.
MST	Displays motor start trend data.

Comando del Puerto Serial	Descripción del Comando
HIS DT or **RT**	Borrar eventos y restablecer los numeros de referencia.
HIS BBD	Monstrar la frecuencia de la componente de barras rotas detectada y su magnitud.
HIS BBD C or **R**	Borrar el historial de eventos de barras rotos.
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP	Mostrar los datos de perfil carga.
LDP *row1 row2*	Mostrar los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP *date1 date2*	Mostrar los datos de perfil carga entra las filas *date1* y *date2*.
LDP D	Borrar los datos de perfil de la señal.
MAC	Mostrar la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED FUN**	Mostrar los datos de medición fundamentales.
MED *k*	Mostrar los datos de medición fundamentales *k* veces. *k* entre 1 y 32767
MED EA	Mostrar los datos de entrada analógica.
MED E	Mostrar los datos de medición de energía.
MED FFT	Mostrar reporte incluyendo muestras sin filtrar y espectro de frecuencia de la señal.
MED L	Muestra la entrada de luz de los sensores AFD (arco de voltaje). Requiere sensores AFD tarjeta 2 AVI/4 AFDI o 8 AFDI en Slot E.
MED M	Mostrar datos de medición mínimos y máximos.
MED V	Mostrar variables matemáticas SELOGIC.
MED RA	Mostrar datos analogicos de medición remota.
MED RE	Reiniciar los datos de medición de energía.
MED RM	Reiniciar los datos de medición mínima y máxima.
MED RMS	Mostrar los datos de medición rms.
MED T	Mostrar los datos de medición RTD y termicos
MMR	Mostrar reporte de mantenimiento del motor de cada ciclo de arranque/parada, incluyendo el ciclo inicial.
MOT	Mostrar estadísticas de operación del motor
MSR *n*	Mostrar datos de arranque del motor. Donde *n* es el número de evento.
MST	Mostrar tendencias de arranque del motor.

Serial Port Command	Command Description
PING ***x.x.x.x t***	Determines if 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.
RSTP	Displays the RSTP statistics and the current RSTP configuration of Port 1.
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 dates *date1* and *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 SER data.
SHO ***n***	Displays relay settings for group *n,* where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SHO DNP ***m***	Displays the DNP data map settings for Map *m*, where *m* = 1, 2, or 3.
SHO E ***m***	Displays EtherNet/IP assembly map settings for Map *m* (*m* = 1, 2, or 3).
SHO F	Displays the front-panel settings.
SHO G	Displays the global settings.
SHO I	Displays the IEC 60870-5-103 map settings.
SHO L ***n***	Displays the general logic settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, 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 ***n***	Displays event summary *n*. If *n* is omitted, displays the most recent event summary.
SUM C or **R**	Resets the event summary buffer.
TAR	Displays the default target row or the most recently viewed target row.
TAR ***n***	Displays target row *n*.

Comando del Puerto Serial	Descripción del Comando
PING ***x.x.x.x t***	Determinar si el puerto Ethernet esta funcionando y configurado adecuadamente. *x.x.x.x* es la dirección IP. *t* es el intervalo entre PINGs, *t* es ajustable entre 2 y 255 segundos. Por omisión, *t* = 1 segundo. Oprima Q para detener.
RSTP	Muestra estadisticas y configuracion RSTP actual.
SER	Mostrar el reporte completo del Registrador de Eventos Secuenciales (SER).
SER ***date1***	Mostrar todos las filas en el reporte SER del dia *date1* (vea el commando **DATE** por el formato de fecha).
SER ***date1 date2***	Mostrar todos las filas en el reporte SER entre el dia date1 y el dia date2 (vea el commando **DATE** por el formato de fecha)
SER ***row1***	Mostrar las ultimas *row1* filas en el reporte SER (*row1* = 1–1024, 1 es la fila más reciente).
SER ***row1 row2***	Mostrar las filas entre *row1–row2*.
SER D	Borrar los datos SER.
MOS ***n***	Mostrar ajustes del grupo *n* del relé (*n* = 1, 2, 3, o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP ***m***	Mostrar ajustes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2, o 3).
MOS E ***m***	Mostrar ajustes EtherNet/IP del mapa número *m* (*m* = 1, 2, o 3).
MOS F	Mostrar ajustes del panel frontal.
MOS G	Mostrar ajustes globales.
MOS I	Mostrar mapa de ajustes IEC 60870-5-103.
MOS L ***n***	Mostrar la lógica de configuración general del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS M	Mostrar ajustes del Mapa del Usuario Modbus.
MOS P ***n***	Mostrar configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Mostrar configuración de reportes.
EST	Muestar resultados de autotest.
EST S	Mostrar reporte de utilización SELOGIC.
SUM ***n***	Muestra un resumen del evento *n*.
SUM D o **R**	Borrar el buffer de resúmenes de evento.
BAN	Mostrar la fila de banderas por defecto o la última fila de banderas mostrada.
BAN ***n***	Mostrar la fila de banderas *n*.

Serial Port Command	Command Description
TAR *n k*	Displays target row *n*. Repeats 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 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	
89C *m*	Closes Two-position Disconnect *m*, where *m* = 1–8
89O *m*	Opens Two-position Disconnect *m*, where *m* = 1–8
89C *n m*	Closes Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
89O *n m*	Opens Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
AFT	Tests arc-flash detector channels.
ANA *c p t*	Tests analog output channel, where *c* is the channel name or number, *p* is a percentage of full scale or either letter “R” or “r” indicates ramp mode, and *t* is the duration of the test in decimal minutes.
BRE R	Resets 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 the relay and logic settings from Group *m* to Group *n*.

Comando del Puerto Serial	Descripción del Comando
BAN *n k*	Mostrar la fila de banderas *n k* veces.
BAN *name*	Mostrar la fila de banderas que contiene la bandera name.
BAN *name k*	Mostrar la fila de banderas que contiene la bandera name *k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HORA	Ver hora.
HORA *hh*	Configurar la hora ingresando **HORA** seguido por horas como se muestra (relog 24 horas).
HORA *hh:mm*	Configurar la hora ingresando **HORA** seguido por horas y minutos como se muestra (relog 24 horas).
HORA *hh:mm:ss*	Configurar la hora ingresando **HORA** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
Comandos del Nivel de Acceso 2	
89C *m*	Cierra el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89A *m*	Abre el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89C *n m*	Cierra el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
89A *n m*	Abre el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
AFT	AFT Probar detectores arc-flash en canales.
ANA *c p t*	Probar el canal de salida analógica donde *c* es el nombre o el número del canal, *p* es el porcentaje de escala completa, o las letras “R” o “r” para indicar el modo de rampa y *t* para indicar la duración de la prueba en minutos decimales.
INT R	Reiniciar datos del interruptor.
INT W	Precargar datos del interruptor.
CAL	Ingresar al Nivel de Acceso C. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel C. El Nivel de Acceso C está reservado para uso exclusivo de SEL.
CON RB*nn k*	Seleccionar un bit remoto para activar, desactivar o pulsar donde *nn* es un número del 01 al 32, representando desde RB01 hasta RB32. *k* es A, D o P para Activar, Deactivar o Pulsar.
COPY *m n*	Copiar configuración del relé y la configuración lógica del Grupo *m* al Grupo *n*.

Serial Port Command	Command Description
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.
GROUP *n*	Changes the active group to Group *n* (where *n* = 1, 2, 3, or 4).
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.
LOO R	Disables the loopback on both channels and returns the device to normal operation.
LOO *xx* DATA	Enables loopback mode for *xx* minutes and allows the loopback data to modify the RMB values.
MOT R or **C**	Clears all motor statistics and motor start report data except for the learned parameters.
MMR C	Clears stored motor parameters for each start/stop cycle and readies the relay to compute a new set of baseline run parameters in the following start/stop cycle.
MST R or **C**	Resets motor start trend data.
PARTNO	Allows for updates to the part number after the relay hardware configuration has been changed.
PAS 1	Changes the Access Level 1 password.
PAS 2	Changes the Access Level 2 password.
PUL OUT *nnn*	Pulse output contact *nnn*.
PUL OUT *nnn s*	Pulses Output Contact *nnn*, where *nnn* = OUT101…, for *s* (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 learned motor parameters
SET *n*	Modifies the relay settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET *name*	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET DNP *n*	Modifies the DNP data map settings for map *n*, where *n* = 1, 2, or 3.
SET E *m*	Modifies EtherNet/IP assembly map settings for Map *m* (*m* = 1, 2, or 3).

Comando del Puerto Serial	Descripción del Comando
FIL WRITE *filename*	Transferir el archivo de configuración *filename* de la computadora al relé.
GRUPO *n*	Usar Grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
L_D	Cargar un firmware nuevo.
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B y regresa al modo normal de operación.
LOO *xx* DATA	Habilita loopback for *xx* minutos y permite modificar valores RMB.
MOT D	Borra todas las estadísticas del motor y de los eventos de arranque del motor excepto por los parámetros aprendidos.
MMR C	Borra los reportes de mantenimiento del motor y prepara el relé para juntar datos de ciclo inicial.
MST R o **C**	Reiniciar datos de tendencia de arranque del motor.
PARTNO	Cambia el número de parte del relé use despues de cambiar una tarjeta del relé.
PAS 1	Cambiar la contraseña del Nivel de Acceso 1.
PAS 2	Cambiar la contraseña del Nivel de Acceso 2.
PUL OUT *nnn*	Pulsar el contacto de salida *nnn*.
PUL OUT *nnn s*	Pulsar el contacto de salida *nnn* (*nnn* = OUT101…) por *t* (de 1 a 30), el numero predeterminado es 1 segundos.
R_S	Resetea el relé usando ajustes y passwords por defacto y después reinicia el relé. Disponible solamente después de una actualización de firmware.
RLP	Reinicia parámetros aprendidos.
AJU *n*	Modificar el grupo *n* de ajustes del relé, donden *n* =1, 2, 3 o 4. Si no se especifica n, se modifica el grupo activo.
AJU *name*	Para todos los comandos **SET**, adelántese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50P11P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el mapa *n*, donde *n* = 1, 2, o 3.
AJU E *m*	Modificar ajustes EtherNet/IP del mapa número *n* (*n* = 1, 2, o 3).

Serial Port Command	Command Description
SET F	Modifies the front-panel settings.
SET G	Modifies the global settings.
SET I	Modifies the IEC 60870-5-103 settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for Group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus User Map settings.
SET P *n*	Modifies the port *n* settings, where *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 **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA C or **R**	Clears the self-test status and restarts the relay.
STO	Stops motor.
STR	Starts motor.
TEST DB	Displays the present status of digital and analog overrides.
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.

Comando del Puerto Serial	Descripción del Comando
AJU F	Modificar la configuración del panel frontal.
AJU G	Modificar las ajustes globales.
AJU I	Modificar ajustes IEC 60870-5-103.
AJU L *n*	Modifica ajustes SELOGIC, laches, variables lógicas (SV) y matemáticas (MV) en el grupo de ajustes *n*. Si no se especifica *n*, se modifica el grupo activo.
AJU M	Modificar las configuración del Mapa del Usuario Modbus.
AJU P *n*	Modificar la configuración del puerto *n*, donde *n* = 1, 2, 3, 4 o F. Si *n* no está especificado, el puerto predeterminado es el puerto activo.
AJU R	Modificar la configuración de reportes.
AJU...TERSO	Para todos los comandos **AJU**, **TERSO** desactiva los comandos automáticos **MOS** después de modificar las configuraciones.
EST R	Salir del modo de diagnostico automático y reiniciar el relé.
PARA	Iniciar el motor.
INI	Parar el motor.
TEST DB	Mostrar el estado actual de variable digitales y analógicas con valores forzados.
VEC D	Mostar reporte standard de reinicio del relé.
VEC E	Mostar reporte de reinicio del relé.
Comandos del Nivel del Acceso C	
PAS C	Cambiar la contraseña del Nivel de Acceso C.

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SEL-710-5 Relay Command Summary

The following table lists the front serial port ASCII commands associated with particular activities. The commands are shown in uppercase letters, but you can also enter these with lowercase letters. 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.

La siguiente tabla muestra los comandos ASCII del puerto serie frontal asociados con diferentes actividades. Los comandos se pueden usar en mayúsculas o minúsculas. Los comandos se pueden ejecutar usando las primeras tres letras del nombre. Por más detalles consulte la guía *SEL ASCII Protocol and Commands*.

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 entry of the Access Level 1 password.
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 entry of the Access Level 2 password.
BRE	Displays breaker monitor data (trips, interrupted current, wear).
CEV *n*	Shows compressed event report number *n*, at 1/4-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CEV *n* R	Shows compressed raw event report number *n*, at 1/32-cycle resolution. If *n* is omitted, the most recent compressed event report is displayed.
CMSR *n*	Shows compressed motor start record data, where *n* is the record or reference 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 communications records. If both MIRRORED BITS channels are enabled, omitting the channel specifier (A or B) clears both channels.
COM C A	Clears all communications records for Channel A.
COM C B	Clears all communications records for Channel B.

Comando del Puerto Serial	Descripción del Comando
Comandos de Nivel de Acceso 0	
ACC	Ir a Nivel de Acceso 1. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 1.
ID	Código de identificación del relé.
SAL	Ir al Nivel de Acceso 0.
Comandos de Nivel de Acceso 1	
2AC	Ir a Nivel de Acceso 2. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel 2.
INT	Mostrar información sobre disparos, corriente interrumpida, desgaste.
CEV *n*	Mostrar el reporte comprimido de evento número *n*, resolución de 1/4 de ciclo.
CEV *n* R	Agregue R para mostrar el reporte de evento comprimido sin filtro, resolución 1/32 de ciclo. Si no se especifica *n* se muestra el evento comprimido mas reciente.
CMSR *n*	Mostrar el reporte de inicio de motor *n* en formato comprimido.
COM A	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal A.
COM B	Presentar un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS Canal B.
COM D	Borra todos los registros de comunicaciones. Si los dos canales MIRRORED BITS están habilitados, suprimiendo el especificador de canales (A o B) se borran los dos canales.
COM D A	Borra todos los registros de comunicaciones del Canal A.
COM D B	Borra todos los registros de comunicaciones del Canal B.

Serial Port Command	Command Description
COM L	Appends a long report to the summary report of the last 255 records in the MIRRORED BITS communications buffer.
COM L A	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel A.
COM L B	Appends a long report to the summary report of the last 255 records in the communications buffer for MIRRORED BITS communications Channel B.
COM S	Returns a summary report of the last 255 records in the MIRRORED BITS communications buffer.
COU *n*	Shows current state of device counters. *n* = repeat the report *n* times, with a 1/2 second delay between each report.
DATE	Shows the date.
DATE *dd/mm/yyyy*	Sets the date in DMY format if DATE_F setting is DMY.
DATE *mm/dd/yyyy*	Sets the date in MDY format if DATE_F setting is MDY.
DATE *yyyy/mm/dd*	Sets 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, most recent report is displayed.
EVE *n* R	Shows event report *n* with raw (unfiltered) 32 samples per cycle analog data and 4 samples per cycle digital data.
EVE DIF *n* R	Shows differential event report. Parameters *n* and R are optional.
FIL DIR	Returns a list of files.
FIL READ *filename*	Transfers settings file *filename* from the relay to the PC.
FIL SHOW *filename*	*Filename* displays contents of the file *filename*.
GOOSE *k*	Displays transmit and receive GOOSE messaging information. Enter number *k* to scroll the GOOSE data *k* times on the screen.
GROUP	Displays active group setting.
HELP	Displays a short description of selected commands.
HIS *n*	Shows summary of *n* latest event reports, where *n* = 1 is the most recent entry. If *n* is omitted, all of the event report summaries are displayed.
HIS C or **R**	Clears or resets history buffer.

Comando del Puerto Serial	Descripción del Comando
COM L	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.
COM L A	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal A.
COM L B	Anexa un informe detallado al informe de síntesis de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS del Canal B.
COM S	Muestra un resumen de los últimos 255 registros en el buffer de comunicaciones MIRRORED BITS.
COU *n*	Muestra el estado actualizado de los contadores del dispositivo. *n* = repite el informe *n* veces, con ½ segundos entre cada informe.
FEC	Ver fecha.
FEC *dd/mm/yyyy*	Si DATE_F es igual a DMY, ingrese fecha en formato Día Mes Año
FEC *mm/dd/yyyy*	Si DATE_F es MDA, ingrese fecha en formato Mes Día Año.
FEC *yyyy/mm/dd*	Si DATE_F es AMD, ingrese fecha en formato Año Mes Día.
ETH	Mostrar el estado del puerto de Ethernet.
EVE *n*	Mostrar el reporte de evento estándar número *n*, con 4 muestras por ciclo. Omitiendo *n*, se muestra el informe más reciente.
EVE *n* R	Muestra el evento número *n* (32 muestras analógicas y 4 muestras digitales por ciclo)
EVE DIF *n* R	Muestra el reporte de veento differencial. Los parámetros n y R son opcionales.
FIL DIR	Mostrar lista de archivos.
FIL READ *filename*	Transferir el archivo de configuración *filename* del relé a la computadora.
FIL SHOW *filename*	Muestra el contenido del archivo *filename*.
GOOSE *k*	Mostrar información de transmisión y recepción de mensajes GOOSE. Ingresar el numero *k* para mostrar los datos GOOSE *k* veces en la pantalla.
GRUPO	Mostrar el grupo de ajustes activo.
AYU	Mostrar una descripción corta de los comandos elegidos.
HIS *n*	Mostrar el resumen de los últimos *n* informes de eventos, donde *n* = 1 es la entrada más reciente. Si *n* es no está especificado, muestra todos los resúmenes de reportes de eventos.
HIS D o **R**	Borrar la historia de eventos.

Serial Port Command	Command Description
HIS CA or **RA**	Clears history events and resets reference number.
HIS BBD	Displays the frequency of the detected broken bar component and its magnitude.
HIS BBD C or **R**	Clears or resents **HIS BBD**.
IRIG	Forces synchronization of internal control clock to IRIG-B time-code input.
LDP	Displays load profile data.
LDP *row1 row2*	Displays load profile report rows from *row1* to *row2*, starting with *row1*. If *row2* is omitted, displays the first *row1* rows.
LDP *date1 date2*	Displays load profile report rows from *date1* to *date2*, starting with *date1*.
LDP C	Clears load profile data.
MAC	Displays the MAC address of the Ethernet port (PORT 1).
MET or **MET FUN**	Displays fundamental instantaneous metering data.
MET *k*	Displays fundamental metering data *k* times, where *k* is between 1 and 32767.
MET AI	Displays analog input (transducer) data.
MET E	Displays energy metering data.
MET FFT	Displays the raw data collected and the frequencies and their associated magnitudes and phase angles (broken bar data).
MET L	Displays arc-flash detector (AFD) light input (relay requires the arc-flash detection (AFD) option with a 2 AVI/4 AFDI card or 8 AFDI card in Slot E).
MET M	Display minimum and maximum metering data.
MET MV	Displays SELOGIC math variable data.
MET RA	Displays remote analog metering data.
MET RE	Resets energy metering data.
MET RM	Resets minimum and maximum metering data.
MET RMS	Displays rms metering data.
MET T	Displays RTD and thermal metering data.
MMR	Displays stored motor parameters for each start/stop cycle along with the baseline run.
MOT	Displays motor operating statistics report.
MSR *n*	Displays motor start record data where *n* is the record or reference number.
MST	Displays motor start trend data.

Comando del Puerto Serial	Descripción del Comando
HIS DT or **RT**	Borrar eventos y restablecer los numeros de referencia.
HIS BBD	Monstrar la frecuencia de la componente de barras rotas detectada y su magnitud.
HIS BBD C or **R**	Borrar el historial de eventos de barras rotos.
IRIG	Forzar la sincronización del reloj interno a IRIG-B.
LDP	Mostrar los datos de perfil carga.
LDP *row1 row2*	Mostrar los datos de perfil carga entra las filas *row1* y *row2*. Si se omite *row2*, muestra las primeras *row1* columnas.
LDP *date1 date2*	Mostrar los datos de perfil carga entra las filas *date1* y *date2*.
LDP D	Borrar los datos de perfil de la señal.
MAC	Mostrar la dirección MAC del puerto de Ethernet (PUERTO 1).
MED o **MED FUN**	Mostrar los datos de medición fundamentales.
MED *k*	Mostrar los datos de medición fundamentales *k* veces. *k* entre 1 y 32767
MED EA	Mostrar los datos de entrada analógica.
MED E	Mostrar los datos de medición de energía.
MED FFT	Mostrar reporte incluyendo muestras sin filtrar y espectro de frecuencia de la señal.
MED L	Muestra la entrada de luz de los sensores AFD (arco de voltaje). Requiere sensores AFD tarjeta 2 AVI/4 AFDI o 8 AFDI en Slot E.
MED M	Mostrar datos de medición mínimos y máximos.
MED V	Mostrar variables matemáticas SELOGIC.
MED RA	Mostrar datos analogicos de medición remota.
MED RE	Reiniciar los datos de medición de energía.
MED RM	Reiniciar los datos de medición mínima y máxima.
MED RMS	Mostrar los datos de medición rms.
MED T	Mostrar los datos de medición RTD y termicos
MMR	Mostrar reporte de mantenimiento del motor de cada ciclo de arranque/parada, incluyendo el ciclo inicial.
MOT	Mostrar estadísticas de operación del motor
MSR *n*	Mostrar datos de arranque del motor. Donde *n* es el número de evento.
MST	Mostrar tendencias de arranque del motor.

Serial Port Command	Command Description
PING ***x.x.x.x t***	Determines if 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.
RSTP	Displays the RSTP statistics and the current RSTP configuration of Port 1.
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 dates *date1* and *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 SER data.
SHO ***n***	Displays relay settings for group *n,* where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SHO DNP ***m***	Displays the DNP data map settings for Map *m*, where *m* = 1, 2, or 3.
SHO E ***m***	Displays EtherNet/IP assembly map settings for Map *m* (*m* = 1, 2, or 3).
SHO F	Displays the front-panel settings.
SHO G	Displays the global settings.
SHO I	Displays the IEC 60870-5-103 map settings.
SHO L ***n***	Displays the general logic settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, 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 ***n***	Displays event summary *n*. If *n* is omitted, displays the most recent event summary.
SUM C or **R**	Resets the event summary buffer.
TAR	Displays the default target row or the most recently viewed target row.
TAR ***n***	Displays target row *n*.

Comando del Puerto Serial	Descripción del Comando
PING ***x.x.x.x t***	Determinar si el puerto Ethernet esta funcionando y configurado adecuadamente. *x.x.x.x* es la dirección IP. *t* es el intervalo entre PINGs, *t* es ajustable entre 2 y 255 segundos. Por omisión, *t* = 1 segundo. Oprima Q para detener.
RSTP	Muestra estadisticas y configuracion RSTP actual.
SER	Mostrar el reporte completo del Registrador de Eventos Secuenciales (SER).
SER ***date1***	Mostrar todos las filas en el reporte SER del dia *date1* (vea el commando **DATE** por el formato de fecha).
SER ***date1 date2***	Mostrar todos las filas en el reporte SER entre el dia date1 y el dia date2 (vea el commando **DATE** por el formato de fecha)
SER ***row1***	Mostrar las ultimas *row1* filas en el reporte SER (*row1* = 1–1024, 1 es la fila más reciente).
SER ***row1 row2***	Mostrar las filas entre *row1–row2*.
SER D	Borrar los datos SER.
MOS ***n***	Mostrar ajustes del grupo *n* del relé (*n* = 1, 2, 3, o 4). Por omisión, muestra grupo de ajustes 1.
MOS DNP ***m***	Mostrar ajustes de mapa de datos DNP para el Mapa *m* (*m* = 1, 2, o 3).
MOS E ***m***	Mostrar ajustes EtherNet/IP del mapa número *m* (*m* = 1, 2, o 3).
MOS F	Mostrar ajustes del panel frontal.
MOS G	Mostrar ajustes globales.
MOS I	Mostrar mapa de ajustes IEC 60870-5-103.
MOS L ***n***	Mostrar la lógica de configuración general del grupo *n* del relé (*n* = 1, 2, 3 o 4). Por omisión, muestra grupo de ajustes 1.
MOS M	Mostrar ajustes del Mapa del Usuario Modbus.
MOS P ***n***	Mostrar configuraciones de puerto, donde *n* especifica el puerto (1, 2, 3, 4 o F); por defecto muestra ajustes del puerto activo.
MOS R	Mostrar configuración de reportes.
EST	Muestar resultados de autotest.
EST S	Mostrar reporte de utilización SELOGIC.
SUM ***n***	Muestra un resumen del evento *n*.
SUM D o **R**	Borrar el buffer de resúmenes de evento.
BAN	Mostrar la fila de banderas por defecto o la última fila de banderas mostrada.
BAN ***n***	Mostrar la fila de banderas *n*.

Serial Port Command	Command Description
TAR *n k*	Displays target row *n*. Repeats 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 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	
89C *m*	Closes Two-position Disconnect *m*, where *m* = 1–8
89O *m*	Opens Two-position Disconnect *m*, where *m* = 1–8
89C *n m*	Closes Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
89O *n m*	Opens Three-position Disconnect *m*, where *m* = 1–2 and *n* = L or E for in-line or earthing disconnect, respectively
AFT	Tests arc-flash detector channels.
ANA *c p t*	Tests analog output channel, where *c* is the channel name or number, *p* is a percentage of full scale or either letter “R” or “r” indicates ramp mode, and *t* is the duration of the test in decimal minutes.
BRE R	Resets 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 the relay and logic settings from Group *m* to Group *n*.

Comando del Puerto Serial	Descripción del Comando
BAN *n k*	Mostrar la fila de banderas *n k* veces.
BAN *name*	Mostrar la fila de banderas que contiene la bandera name.
BAN *name k*	Mostrar la fila de banderas que contiene la bandera name *k* veces.
BAN R	Resetea todas las banderas selladas y la fila de banderas mostrada mas recientemente.
HORA	Ver hora.
HORA *hh*	Configurar la hora ingresando **HORA** seguido por horas como se muestra (relog 24 horas).
HORA *hh:mm*	Configurar la hora ingresando **HORA** seguido por horas y minutos como se muestra (relog 24 horas).
HORA *hh:mm:ss*	Configurar la hora ingresando **HORA** seguido por horas, minutos y segundos como se muestra (relog 24 horas).
TRI	Disparar la captura de un reporte de evento.
Comandos del Nivel de Acceso 2	
89C *m*	Cierra el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89A *m*	Abre el seccionador de dos-posiciones *m*, donde *m* = 1–8.
89C *n m*	Cierra el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
89A *n m*	Abre el seccionador de tres-posiciones *m*, donde *m* = 1–2, y *n* = L o E (Línea o Tierra).
AFT	AFT Probar detectores arc-flash en canales.
ANA *c p t*	Probar el canal de salida analógica donde *c* es el nombre o el número del canal, *p* es el porcentaje de escala completa, o las letras “R” o “r” para indicar el modo de rampa y *t* para indicar la duración de la prueba en minutos decimales.
INT R	Reiniciar datos del interruptor.
INT W	Precargar datos del interruptor.
CAL	Ingresar al Nivel de Acceso C. Si el jumper de acceso en la tarjeta principal no está en su lugar, el relé pedirá la contraseña de Acceso del Nivel C. El Nivel de Acceso C está reservado para uso exclusivo de SEL.
CON RB*nn k*	Seleccionar un bit remoto para activar, desactivar o pulsar donde *nn* es un número del 01 al 32, representando desde RB01 hasta RB32. *k* es A, D o P para Activar, Deactivar o Pulsar.
COPY *m n*	Copiar configuración del relé y la configuración lógica del Grupo *m* al Grupo *n*.

Serial Port Command	Command Description
FIL WRITE *filename*	Transfers settings file *filename* from the PC to the relay.
GROUP *n*	Changes the active group to Group *n* (where *n* = 1, 2, 3, or 4).
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.
LOO R	Disables the loopback on both channels and returns the device to normal operation.
LOO *xx* DATA	Enables loopback mode for *xx* minutes and allows the loopback data to modify the RMB values.
MOT R or **C**	Clears all motor statistics and motor start report data except for the learned parameters.
MMR C	Clears stored motor parameters for each start/stop cycle and readies the relay to compute a new set of baseline run parameters in the following start/stop cycle.
MST R or **C**	Resets motor start trend data.
PARTNO	Allows for updates to the part number after the relay hardware configuration has been changed.
PAS 1	Changes the Access Level 1 password.
PAS 2	Changes the Access Level 2 password.
PUL OUT *nnn*	Pulse output contact *nnn*.
PUL OUT *nnn s*	Pulses Output Contact *nnn*, where *nnn* = OUT101…, for *s* (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 learned motor parameters
SET *n*	Modifies the relay settings for group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET *name*	For all **SET** commands, jump ahead to a specific setting by entering the setting name, e.g., 50P1P.
SET DNP *n*	Modifies the DNP data map settings for map *n*, where *n* = 1, 2, or 3.
SET E *m*	Modifies EtherNet/IP assembly map settings for Map *m* (*m* = 1, 2, or 3).

Comando del Puerto Serial	Descripción del Comando
FIL WRITE *filename*	Transferir el archivo de configuración *filename* de la computadora al relé.
GRUPO *n*	Usar Grupo de configuraciones *n*, donde *n* = 1, 2, 3 o 4.
L_D	Cargar un firmware nuevo.
LOO	Habilitar loopback de los canales MIRRORED BITS.
LOO A	Habilitar loopback en Canal MIRRORED BITS A por los siguientes 5 minutos.
LOO B	Habilitar loopback en Canal MIRRORED BITS B por los siguientes 5 minutos.
LOO R	Deshabilita loopback en canales MB A y B y regresa al modo normal de operación.
LOO *xx* DATA	Habilita loopback for *xx* minutos y permite modificar valores RMB.
MOT D	Borra todas las estadísticas del motor y de los eventos de arranque del motor excepto por los parámetros aprendidos.
MMR C	Borra los reportes de mantenimiento del motor y prepara el relé para juntar datos de ciclo inicial.
MST R o **C**	Reiniciar datos de tendencia de arranque del motor.
PARTNO	Cambia el número de parte del relé use despues de cambiar una tarjeta del relé.
PAS 1	Cambiar la contraseña del Nivel de Acceso 1.
PAS 2	Cambiar la contraseña del Nivel de Acceso 2.
PUL OUT *nnn*	Pulsar el contacto de salida *nnn*.
PUL OUT *nnn s*	Pulsar el contacto de salida *nnn* (*nnn* = OUT101…) por *t* (de 1 a 30), el numero predeterminado es 1 segundos.
R_S	Resetea el relé usando ajustes y passwords por defacto y después reinicia el relé. Disponible solamente después de una actualización de firmware.
RLP	Reinicia parámetros aprendidos.
AJU *n*	Modificar el grupo *n* de ajustes del relé, donden *n* =1, 2, 3 o 4. Si no se especifica n, se modifica el grupo activo.
AJU *name*	Para todos los comandos **SET**, adeléntese a un ajuste ingresando el nombre del ajuste, por ejemplo, 50P11P.
AJU DNP *n*	Modificar la configuración del mapa de datos DNP para el mapa *n*, donde *n* = 1, 2, o 3.
AJU E *m*	Modificar ajustes EtherNet/IP del mapa número *n* (*n* = 1, 2, o 3).

Serial Port Command	Command Description
SET F	Modifies the front-panel settings.
SET G	Modifies the global settings.
SET I	Modifies the IEC 60870-5-103 settings.
SET L *n*	Modifies the SELOGIC variable and timer settings for Group *n*, where *n* = 1, 2, 3, or 4. If *n* is not specified, default is the active settings group.
SET M	Modifies the Modbus User Map settings.
SET P *n*	Modifies the port *n* settings, where *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 **SET** commands, **TERSE** disables the automatic **SHO** command after the settings entry.
STA C or **R**	Clears the self-test status and restarts the relay.
STO	Stops motor.
STR	Starts motor.
TEST DB	Displays the present status of digital and analog overrides.
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.

Comando del Puerto Serial	Descripción del Comando
AJU F	Modificar la configuración del panel frontal.
AJU G	Modificar las ajustes globales.
AJU I	Modificar ajustes IEC 60870-5-103.
AJU L *n*	Modifica ajustes SELOGIC, laches, variables lógicas (SV) y matemáticas (MV) en el grupo de ajustes *n*. Si no se especifica *n*, se modifica el grupo activo.
AJU M	Modificar las configuración del Mapa del Usuario Modbus.
AJU P *n*	Modificar la configuración del puerto *n*, donde *n* = 1, 2, 3, 4 o F. Si *n* no está especificado, el puerto predeterminado es el puerto activo.
AJU R	Modificar la configuración de reportes.
AJU...TERSO	Para todos los comandos **AJU**, **TERSO** desactiva los comandos automáticos **MOS** después de modificar las configuraciones.
EST R	Salir del modo de diagnostico automático y reiniciar el relé.
PARA	Iniciar el motor.
INI	Parar el motor.
TEST DB	Mostrar el estado actual de variable digitales y analógicas con valores forzados.
VEC D	Mostar reporte standard de reinicio del relé.
VEC E	Mostar reporte de reinicio del relé.
Comandos del Nivel del Acceso C	
PAS C	Cambiar la contraseña del Nivel de Acceso C.

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