SEL-710 Motor Protection Relay

Motor Control and Protection

Major Features and Benefits

The SEL-710 Motor Protection Relay provides an exceptional combination of protection, monitoring, control, and communication in an industrial package.

➤ **Standard Motor Protection and Control Features.** Protect low- or medium-voltage three-phase motors with an enhanced thermal model that includes locked rotor starts, time-between-starts, starts-per-hour, antibackspin timer, motor coast time, load loss, current unbalance, load jam/stalled rotor, breaker/contactor failure, frequency, and overcurrent including phase, negative-sequence, residual ground instantaneous, and inverse-time elements. Implement load control, star-delta starting, forward/reverse start control, and two-speed control.

➤ **Optional Protection Features.** Use the SEL-710 with optional voltage and differential current inputs to include rotor slip calculation, differential overcurrent (87M), undervoltage, overvoltage, positive temperature coefficient (PTC) thermistor over-temperature, underpower, reactive power, phase reversal, power factor, loss-of-potential, and RTD-based protection. As many as 10 RTDs can be monitored using an internal RTD card or as many as 12 RTDs when using an SEL-2600 RTD Module with the ST connectors option.

➤ **Operator Controls.** Start and stop the motor easily with four programmable front-panel pushbuttons, each with two LEDs. Also, the SEL-710 provides 32 local and 32 remote control bits to help manage relay operations.

➤ **Relay and Logic Settings Software.** Reduce engineering costs for relay settings and logic programming by using ACSELERATOR QuickSet® SEL-5030 Software. Tools in QuickSet make it easy to develop SELOGIC® control equations. Use the built-in phasor display to verify proper CT polarity and phasing.

➤ **Metering and Monitoring.** Take advantage of built-in metering functions that eliminate separately mounted metering devices. Analyze Sequential Events Recorder (SER) reports and oscillographic event reports for rapid commissioning, testing, and post-fault diagnostics. Additional monitoring functions include the following:
- Motor start reports
- Motor start trending
- Load profile monitoring
- Motor operating statistics

➤ **Additional Standard Features.** Take advantage of such additional standard features as Modbus RTU, MIRRORED BITS® communications, load profile, breaker wear monitoring, support for 12 external RTDs (SEL-2600), IRIG-B input, advanced SELOGIC control equations, configurable labels, and an SEL-2812 compatible fiber-optic serial port (ST connectors option only).

➤ **Optional Features.** Select from a wide offering of optional features, including IEC 61850, Modbus TCP/IP, DeviceNet™, IRIG-B time-code input or PTC (thermistor) input, 10 internal RTDs, expanded digital/analog I/O, additional EIA-232 or EIA-485 communications ports, and single or dual, copper-wire or fiber-optic Ethernet ports.

Functional Overview

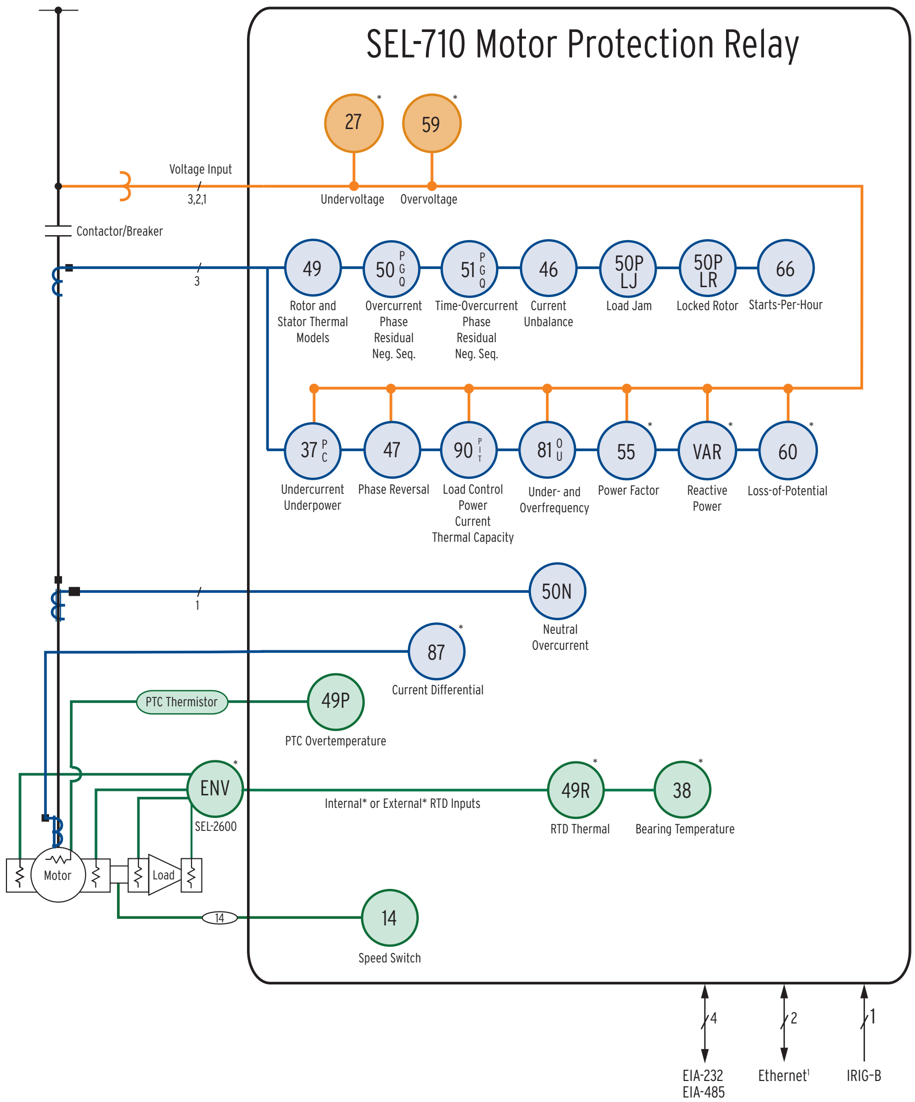


Figure 1 Functional Diagram

The following functions are shown in *Figure 1* and are either standard or additional ordering options for the SEL-710 Relay.

- Sequential Events Recorder
- Event Reports, Motor Start Reports, Motor Operating Statistics, Load Profiles, and Motor Start Trends
- SEL ASCII, Ethernet*, Modbus TCP/IP*, IEC 61850*, Modbus RTU, Telnet*, FTP*, SNTP*, and DeviceNet* Communications
- Eight Front-Panel Target LEDs, of which Six are Programmable
- Two Inputs and Three Outputs Standard
- I/O Expansion*–Additional Contact Inputs, Contact Outputs, Analog Inputs, Analog Outputs, and RTD Inputs
- Single or Dual Ethernet, Copper or Fiber-Optic Communications Port*
- PTC Input*
- Battery-Backed Clock, IRIG-B Time**, SNTP Synchronization*
- Instantaneous Metering
- Four Programmable Pushbuttons With Two LEDs Each
- Advanced SELOGIC Control Equations
- 32 Programmable Display Messages
- MIRRORED BITS Communications
- Forward/Reverse Control
- Reduced Voltage Starting
- Two-Speed Motor Control
- Breaker Wear Monitoring
- Differential Protection*

*Optional Functions-Select When Ordering
**IRIG-B is only available on models without PTC Input

Protection Features

Motor Thermal Protection

The SEL-710 uses a patented thermal model to provide locked rotor, running overload, and negative-sequence current unbalance protection. The thermal element accurately tracks the heating resulting from load current and current unbalance while the motor is accelerating and running. The relay expresses the present motor thermal estimate as % Thermal Capacity Used for stator and rotor. When either stator or rotor % Thermal Capacity reaches 100 percent, the relay trips. The SEL-710 motor thermal element provides integrated protection for all of the following motor operating conditions:

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

The SEL-710 dynamically calculates motor slip to precisely track motor temperature using the thermal model. The rotor resistance changes depending on slip and generates heat, especially during starting, when current and slip are highest. By correctly calculating rotor temperature, the thermal model reduces the time between starts. It also gives the motor more time to reach its rated speed before tripping. Use the coast time setting to significantly reduce the wait time before the next start allowed by thermal lockout.

Overcurrent Protection

The SEL-710 provides complete overcurrent protection with one set of three-phase CTs and one neutral CT input. Phase overcurrent protection is provided for three-phase input. The following instantaneous overcurrent elements are part of the SEL-710 base configuration.

- Two instantaneous phase overcurrent (50P) elements. These phase elements operate on the maximum of the phase currents. Peak detection algorithms are used to enhance element sensitivity during high fault current conditions, where severe CT saturation may occur.
- Two instantaneous negative-sequence overcurrent (50Q) elements. These elements operate on the negative-sequence current calculated from the three-phase current inputs.
- Two residual overcurrent (50G) elements. These elements use residual (3I0) current calculated from phase currents for ground fault detection.
- Two neutral-overcurrent (50N) elements. These elements operate on neutral content for three-phase input.

Time-Overcurrent Elements

One level of the inverse time element is available for phases A, B, C, and negative-sequence overcurrent. Also, two levels of inverse time elements are available for maximum phase and residual overcurrent. These time-overcurrent elements support the IEC and U.S. (IEEE) time-overcurrent characteristics. Electromechanical disc reset capabilities are provided for all time-overcurrent elements.

Differential Elements

The SEL-710 optionally provides two definite-time delayed differential overcurrent elements. The relay can be used either with core-balance differential CTs or with separate CTs on the source and neutral sides of the motor.

Load-Loss, Load-Jam, and Frequent-Starting Protection

The SEL-710 trips for load-jam and load-loss conditions. Load-loss detection causes an alarm and a trip when the relay detects such a condition. Load-jam protection trips the motor quickly to prevent overheating from stall conditions. The relay uses settable starts-per-hour and minimum time-between-starts protection functions to provide frequent-starting protection. The relay stores motor starting and thermal data in nonvolatile memory to prevent motor damage (caused by overheating resulting from frequent starts) from loss of relay power.

Current Unbalance Element

Unbalanced motor terminal voltages cause unbalanced stator currents to flow into the motor. The negative-sequence current component of the unbalanced current causes significant rotor heating. While the SEL-710 motor thermal element models the heating effect of the negative-sequence current, you may want the additional unbalanced and single-phasing protection offered by the current unbalance element.

Start Monitoring/Incomplete Sequence

The relay produces a trip if start motor time-out asserts and is included in the TRIP equation when motor starting has not finished by the START_T time. The start monitoring is independent of the overload protection provided by the thermal model.

Star-Delta (Wye-Delta) Starting

The SEL-710 issues the command to switch from star to delta (wye to delta) as soon as the starting current drops near the rated value in star (wye). The relay will make the change to delta within the maximum permissible time for star operation (if used), regardless of the magnitude of the starting current.

You can switch the maximum permissible time setting for star operation on or off. If it is off, the change to delta is made solely based on the motor current.

Start Inhibit Protection

The SEL-710 provides start inhibit protection when the protected motor reaches a specific maximum number of starts-per-hour or minimum time-between-starts. Also, in certain pump applications, fluid flowing backward through the pump may spin the pump motor for a short time after the motor is stopped. Any attempt to start the motor during this time can be damaging. The SEL-710 prevents motor starts during the backspin period. The relay will maintain the trip signal until enough time passes for the motor to be safely restarted.

Phase Reversal Protection

Relay phase reversal protection detects motor phase rotation and trips after a delay if phase rotation is incorrect. The SEL-710 provides this protection even if phase voltages are not available.

Speed Switch

When the motor is equipped with a speed switch, you may want to provide additional locked rotor protection by using the relay speed switch input. The relay can issue a warning or trip signal if the speed switch is not closed within the speed switch time delay after the motor start begins.

Over- and Undervoltage Elements

When you connect the SEL-710 voltage inputs to delta connected VTs, the relay provides two levels of phase-to-phase over- and undervoltage protection.When you connect the SEL-710 voltage inputs to wye-connected VTs, the relay provides two levels of phase-to-neutral over- and undervoltage protection.

Loss-of-Potential Logic

The SEL-710 includes loss-of-potential (LOP) logic that detects one, two, or three blown potential fuses. This patented LOP logic is unique because it does not require settings and is universally applicable. The LOP feature allows the blocking of protection elements to add security during fuse failure.

Over- and Underfrequency Protection

Four levels of secure overfrequency (81O) or underfrequency (81U) elements detect true frequency disturbances. Use the independently time-delayed output of these elements to shed load or trip local generation.

RTD Thermal Protection

When the SEL-710 is equipped with either an optional 10 RTD input expansion card or an external SEL-2600 RTD Module with as many as 12 RTD inputs, you can program as many as 12 thermal elements in the relay for two levels of thermal protection per element. Each RTD input has an alarm and trip thermal pickup setting in degrees C, has open and shorted RTD detection, and is compatible with the following three-wire RTD types:

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

Additionally, the winding RTDs and the ambient temperature RTD can be configured and used to bias the thermal model and thermal protection.

VAR Protection

The SEL-710 provides two levels of definite-time delayed positive and negative reactive power elements. If the positive or negative reactive power exceeds the appropriate level for longer than the time-delay setting, the relay can issue a warning or trip signal.

The reactive power elements are disabled when the motor is stopped or starting. These elements can be used to detect synchronous motor out-of-step or loss-of-field conditions.

Underpower Function

The SEL-710 provides two levels of definite-time delayed underpower elements. 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. These elements operate in addition to the load-loss function, and you can use them to detect motor load-loss and other underpower conditions.

Power Factor Elements

The SEL-710 provides two levels of definite-time delayed lead and lag 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. These elements can be used to detect synchronous motor out-of-step or loss-of-field conditions.

Load Control Function

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

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

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

Operator Controls

Operator Controls Eliminate Traditional Panel Control Switches

Four conveniently sized operator controls, each with two programmable LEDs, are located on the relay front panel. You can set the SER to track operator controls. You can also change operator control functions using SELOGIC control equations. The operator control descriptions in *Figure 2* are for factory-set logic. The **AUX** operator controls and LEDs are user programmable. Note that all text can be changed with the configurable labels kit.

Use the **START** and **STOP** pushbuttons to start and trip the connected motor. Program with intentional time delays to support operational requirements for breaker mounted relays. This allows the operator to press the **START** or **STOP** pushbutton, then move to an alternate location before the breaker command is executed.

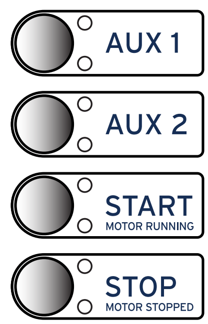


Figure 2 Operator Controls

Relay and Logic Settings Software

QuickSet Software simplifies settings and provides analytical support for the SEL-710. With QuickSet you have several ways to create and manage relay settings:

- ➤ Develop settings offline with an intelligent settings editor that only allows valid settings.
- ➤ Create SELOGIC control equations with a drag-and-drop text editor.
- ➤ Configure proper settings using online help.
- ➤ Organize settings with the relay database manager.
- ➤ Load and retrieve settings using a simple PC communications link.

With QuickSet you can verify settings and analyze power system events with the integrated waveform and harmonic analysis tools.

The following features of QuickSet can help monitor, commission, and test the SEL-710:

- ➤ The PC interface remotely retrieves power system data.
- ➤ The human-machine interface (HMI) monitors meter data, Relay Word bits, and output contacts status during testing. The control window allows resetting of metering quantities and other control functions.

Metering and Monitoring

The SEL-710, depending on the model selected, provides extensive metering capabilities. See *Specifications on page 20* for metering and power measurement accuracies. As shown in *Table 1*, metered quantities include phase voltages and currents; sequence voltages and currents; power, frequency, and energy; and maximum/minimum logging of selected quantities. The relay reports all metered quantities in primary quantities (current in A primary and voltage in V primary).

Table 1 Metering Capabilities

Quantities	Description
Currents IA, IB, IC, IN, IG, IAV, 3I2, UBI	Input currents, neutral current, residual ground current (IG = 3I0 = IA + IB + IC), average current, negative-sequence current, current unbalance
Voltages VA, VB, VC	Wye-connected voltage inputs
Voltages VAB, VBC, VCA	Delta-connected voltage inputs
Voltage VAVE, 3V2, UBV	Average voltage, negative-sequence voltage, voltage unbalance
Power kW, kVAR, kVA	Three-phase kilowatts, kilovars, and kilovolt-amps
Energy MWh3P, MVARh3P-IN, MVARh3P-OUT, MVAh3P	Three-phase megawatt-hours, megavar-hours, and megavolt-amp-hours
Power Factor PF	Three-phase power factor (leading or lagging)
IA87, IB87, IC87	Differential phase current inputs
Frequency, FREQ (Hz)	Instantaneous relay frequency
AIx01–AIx08	Analog inputs
MV01–MV32	Math variables
RTD1–RTD12	RTD temperature measurement (degrees C)
Stator TCU, Rotor TCU	% of thermal capacity used

Types of Metering		
Instantaneous	RMS	Max/Min
Math Variables	Differential	Energy
Analog Inputs	Thermal	

Event and Motor Start Reporting

Event reports and the SER simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. In response to a user selected trigger, the voltage, current, frequency, and element status information contained in each event report confirms relay, scheme, and system performance for every fault. Decide how much detail is necessary when you request an event report (e.g., 1/4-cycle or 1/16-cycle resolution and filtered or raw analog data).

The relay stores as many as 23 of the most recent 64-cycle event reports or 100 of the most recent 15-cycle event reports in nonvolatile memory. The relay always appends relay settings to the bottom of each event report.

The following analog data formats are available.

- 1/4-cycle or 1/16-cycle resolution
- Unfiltered or filtered analog data
- ASCII or Compressed ASCII

The relay SER feature stores the latest 1024 entries. Use this feature to gain a broad perspective at a glance. An SER entry helps to monitor input/output change-of-state occurrences and element pickup/dropout.

The IRIG-B time-code input synchronizes the SEL-710 internal clock time to within ±1 ms of the time-source input. Convenient sources for this time code are the SEL-2401 Satellite-Synchronized Clock, an SEL communications processor, or the SEL Real-Time Automation Controller (RTAC) (via Serial Port **2** or Port **3** on the SEL-710). For time accuracy specifications for metering and events, see *Specifications*.

Load Profile

The SEL-710 features a programmable load profile (LDP) recorder that records as many as 17 metering quantities into nonvolatile memory at fixed time intervals. The LDP saves several days to several weeks of the most recent data depending on the LDP settings (as many as 6500 time samples).

Circuit Breaker Contact Wear Monitor

Circuit breakers experience mechanical and electrical wear every time they operate. Intelligent scheduling of breaker maintenance takes into account the manufacturer's published data of contact wear versus interruption levels and operation count. With the breaker manufacturer's maintenance curve as input data, the SEL-710 breaker monitor feature compares this input data to the measured (unfiltered) ac current at the time of trip and the number of close-to-open operations.

Every time the breaker trips, it integrates the measured current information. When the result of this integration exceeds the breaker wear curve threshold (see *Figure 3*) the relay alarms via output contact, communications port, or front-panel display. This kind of information allows timely and economical scheduling of breaker maintenance.

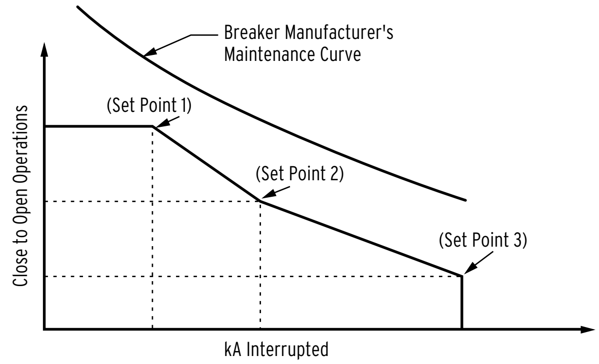


Figure 3 Breaker Contact Wear Curve and Settings

Automation

Flexible Control Logic and Integration Features

The SEL-710 is equipped with as many as four independently operated serial ports: one EIA-232 port on the front, one EIA-232 or EIA-485 port on the rear, one fiber-optic serial port, and one EIA-232 or EIA-485 port on the optional communications card. Optionally, the relay supports single or dual, copper or fiber-optic Ethernet ports. The relay does not require special communications software. You can use any system that emulates a standard terminal system. Establish communication by connecting computers, modems, protocol converters, printers, an SEL Real-Time Automation Controller (RTAC), SEL communications processor, SEL computing platform, SCADA serial port, and/or RTUs for local or remote communication. Refer to *Table 2* for a list of communications protocols available in the SEL-710.

Table 2 Communications Protocols

Type	Description
Simple ASCII	Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter and Fast Operate	Binary protocol for machine-to-machine communications. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay elements, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while a technician is transferring an event report.
Fast SER Protocol	Provides SER events to an automated data collection system.
Modbus	Serial- or Ethernet-based Modbus with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and setting groups.
IEC 61850	Ethernet-based international standard for interoperability between intelligent devices in a substation. Operates remote bits and I/O. Monitors Relay Word bits and analog quantities.
DeviceNet	Allows for connection to a DeviceNet network for access to metering data, protection elements, contact I/O, targets, and setting groups.
SNTP	Ethernet-based protocol that provides time synchronization of the relay.

Apply an SEL communications processor as the hub of a star network, with point-to-point fiber or copper connection between the hub and the SEL-710 (see *Figure 4*).

The communications processor supports external communications links including the public switched telephone network for engineering access (to dial-out alerts) and private line connections for the SCADA system.

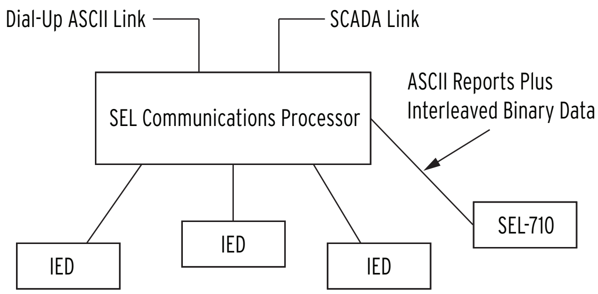


Figure 4 Example Communications System

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Consult your SEL representative for more information on cable availability.

SEL-710 control logic improves integration in the following ways.

- **Replaces traditional panel control switches.** Eliminate traditional panel control switches with 32 local bits. Set, clear, or pulse local bits with the front-panel pushbuttons and display. Program the local bits into your control scheme with SELOGIC control equations. Use the local bits to perform functions such as a trip test or a breaker trip/close.
- **Eliminates RTU-to-relay wiring with 32 remote bits.** Set, clear, or pulse remote bits using serial port commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip, close, and settings group selection.
- **Replaces traditional latching relays.** Replace as many as 32 traditional latching relays for such functions as remote control enable with latch bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the relay loses power.
- **Replaces traditional indicating panel lights.** Replace traditional indicating panel lights with 32 programmable displays. Define custom messages (e.g., `Breaker Open`, `Breaker Closed`) to report power system or relay conditions on the front-panel display. Use advanced SELOGIC control equations to control which messages the relay displays.
- **Eliminates external timers.** Eliminate external timers for custom protection or control schemes with 32 general purpose SELOGIC control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.
- **Eliminates settings changes.** Selectable setting groups make the SEL-710 ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions.

The relay stores three setting groups. Select the active setting group by optoisolated input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies.

Switching setting groups switches logic and relay element settings. You can program groups for different operating conditions, such as feeder paralleling, station maintenance, seasonal operations, emergency contingencies, loading, source changes, and downstream relay setting changes.

Fast SER Protocol

SEL Fast SER Protocol provides SER events to an automated data collection system. SEL Fast SER Protocol is available on any rear serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-710 relays.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

Ethernet Network Architectures

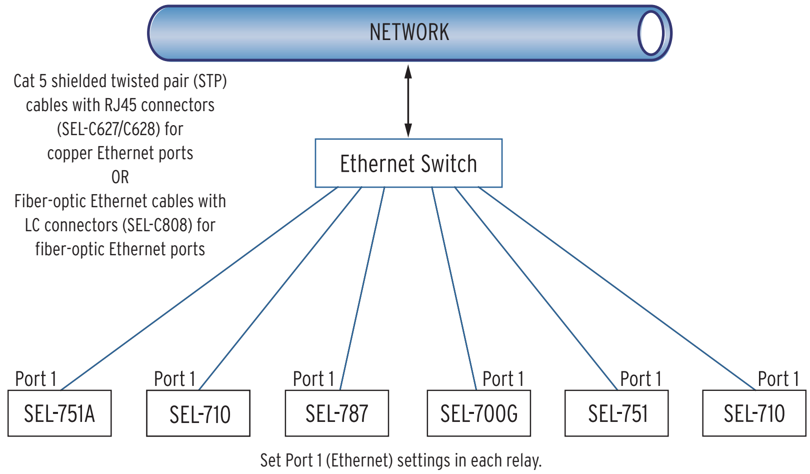


Figure 5 Simple Ethernet Network Configuration

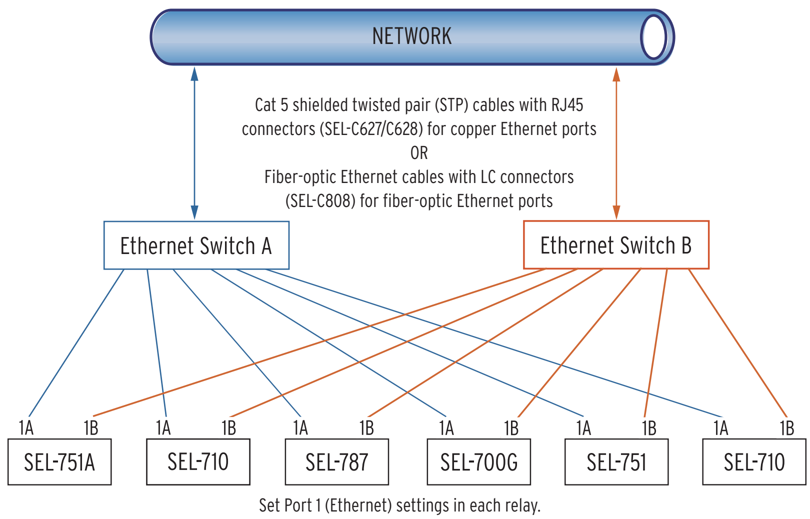


Figure 6 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

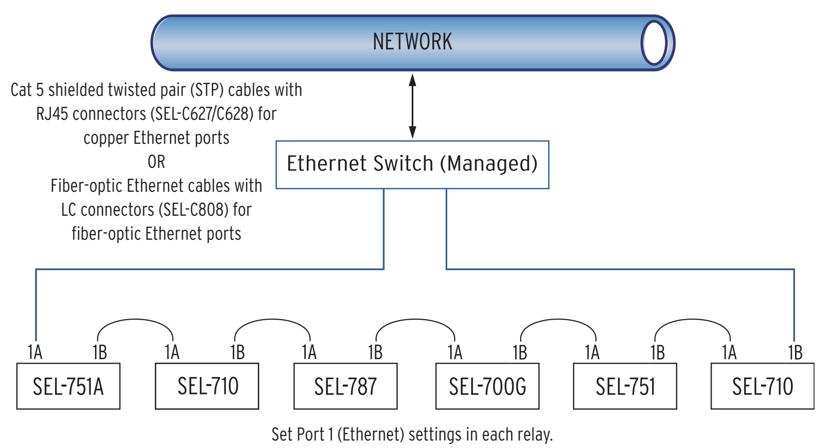


Figure 7 Ethernet Network Configuration With Ring Structure (Switched Mode)

Additional Features

MIRRORED BITS Relay-to-Relay Communications

The SEL-patented MIRRORED BITS communications technology provides bidirectional relay-to-relay digital communications. MIRRORED BITS can operate independently on as many as two EIA-232 rear serial ports and one fiber-optic rear serial port on a single SEL-710.

This bidirectional digital communication creates eight additional virtual outputs (transmitted MIRRORED BITS) and eight additional virtual inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS mode (see *Figure 8*). Use these MIRRORED BITS to transmit/receive information between upstream relays and a downstream recloser control (e.g., SEL-351R) to enhance coordination and achieve faster tripping for downstream faults. MIRRORED BITS technology also helps reduce total scheme operating time by eliminating the need to assert output contacts to transmit information.

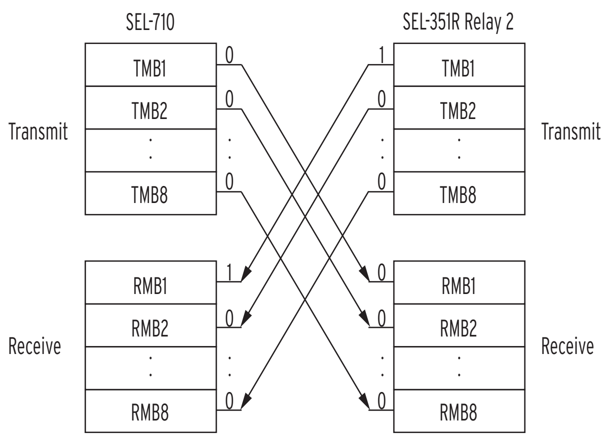


Figure 8 MIRRORED BITS Transmit and Receive Bits

Status and Trip Target LEDs

The SEL-710 includes 16 status and trip target LEDs on the front panel. When shipped from the factory, all LEDs are predefined and fixed in settings. You can reprogram these LEDs for specific applications. This combination of targets is explained and shown in *Figure 12*. Some front-panel relabeling of LEDs may be needed if you reprogram them for unique or specific applications (see *Configurable Labels*).

Configurable Labels

Use the configurable labels to relabel the operator controls and LEDs to suit the installation requirements. This feature includes preprinted labels (with factory-default text), blank label media, and a Microsoft Word template on CD-ROM. This allows you to create quick, professional-looking labels for the SEL-710. Labels may also be customized without the use of a PC by writing the new label on the blank stock provided.

The ability to customize the control and indication features allows specific utility or industry procedures to be implemented without the need for adhesive labels. All of the figures in this data sheet show the factory-default labels of the SEL-710, including the standard model shown in *Figure 12*.

Relay Dimensions

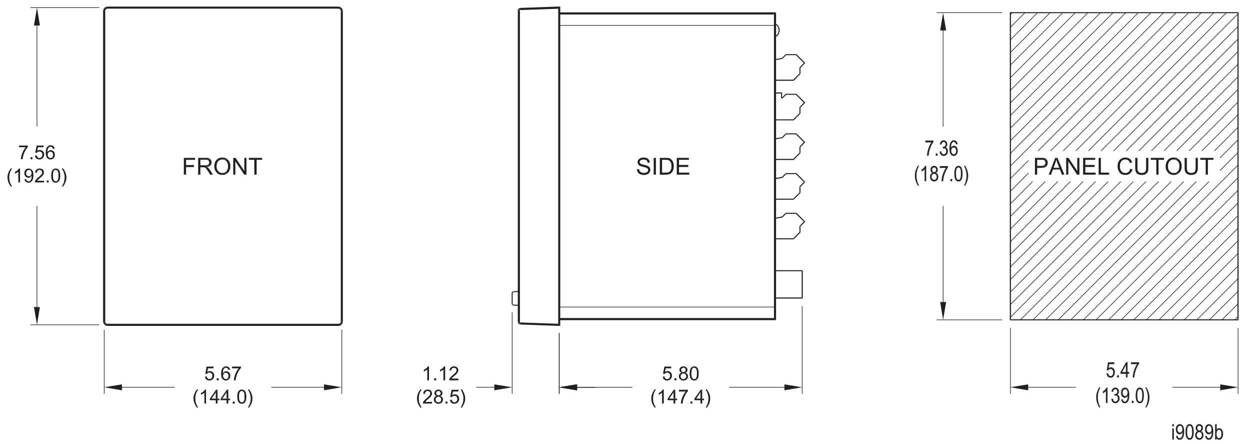


Figure 9 SEL-710 Dimensions for Rack- and Panel-Mount Models

Hardware Overview

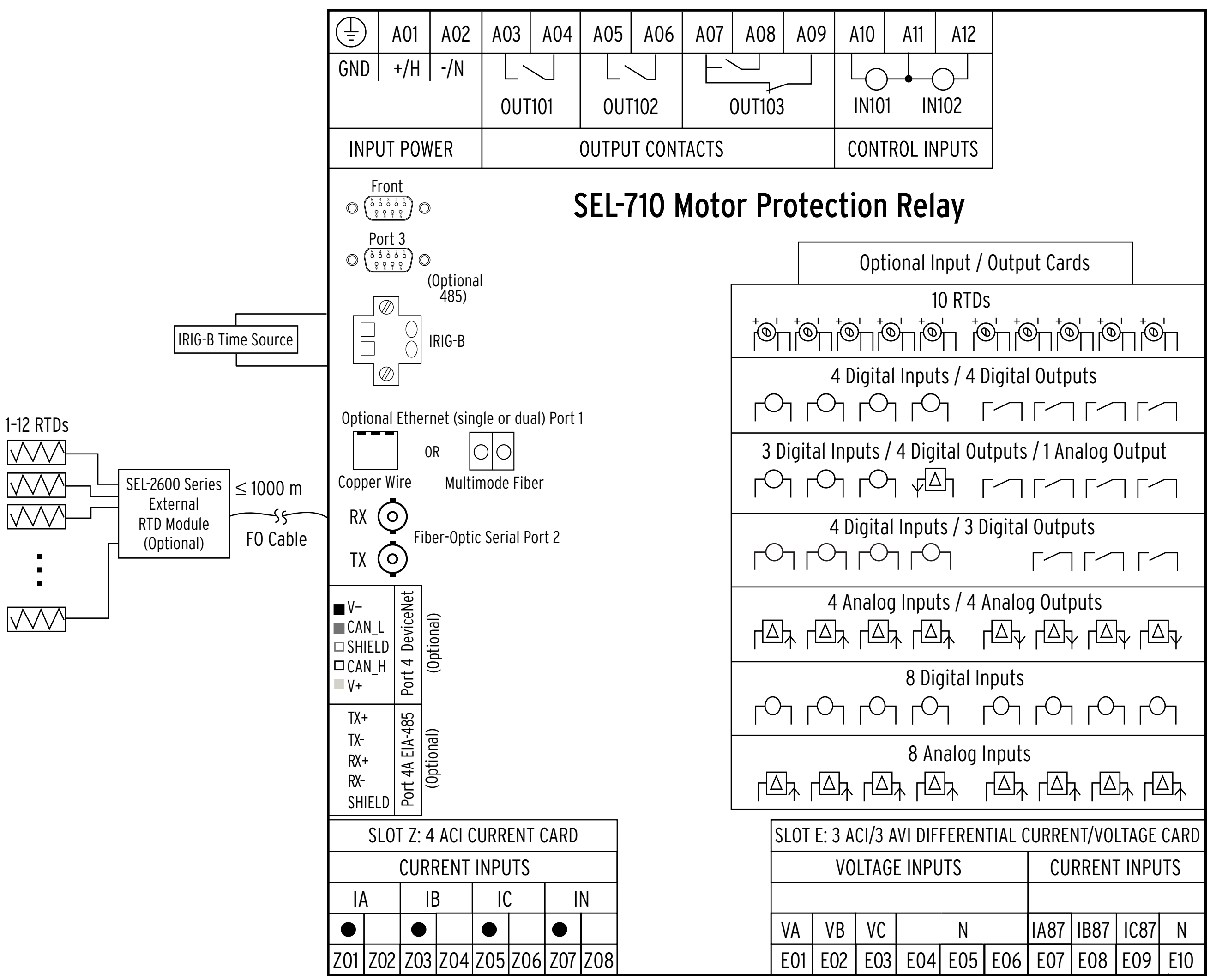


Figure 10 Hardware Overview for Differential Current/Voltage Card in Slot E

Relay Panel Diagrams

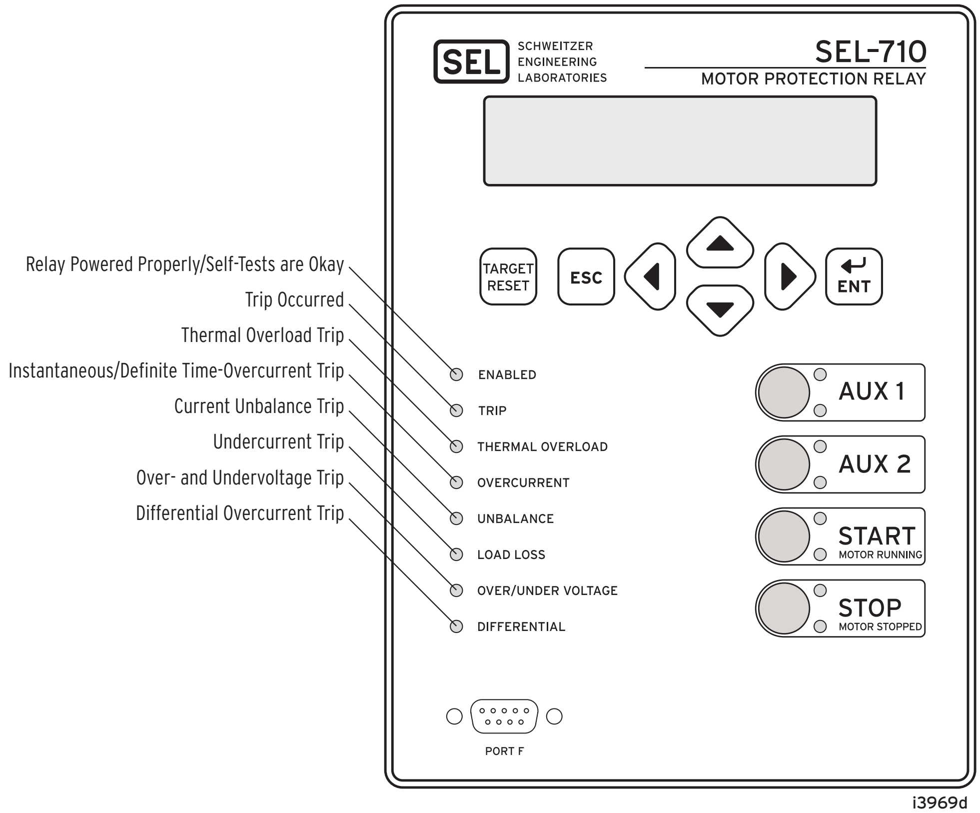
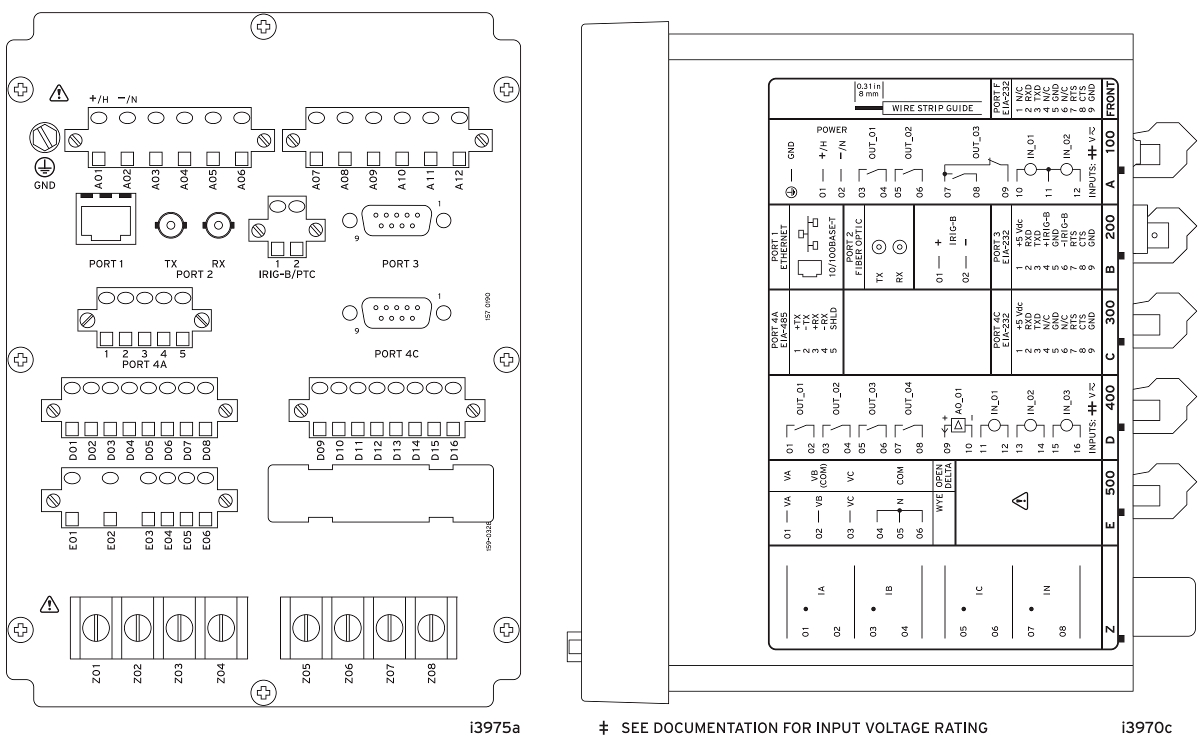
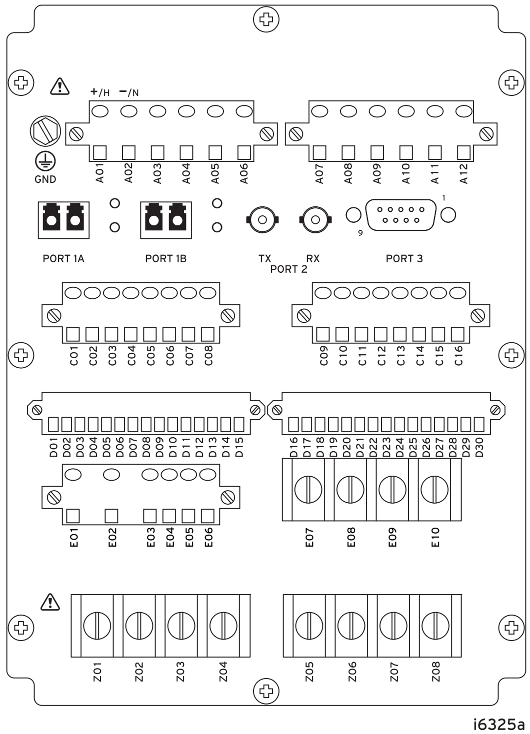


Figure 11 Front Panel

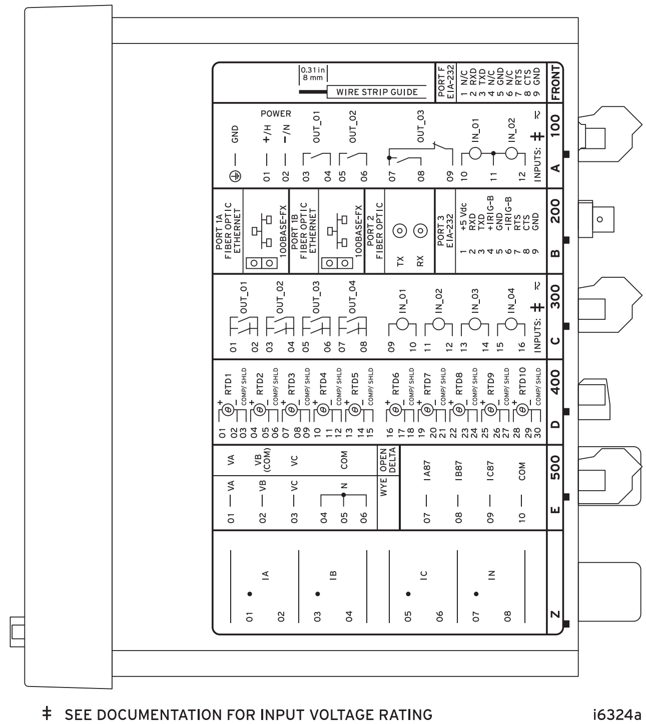


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

Figure 12 IRIG-B, Ethernet, EIA-232 Communication, 3 DI/4 DO/1 AO, and Voltage Option

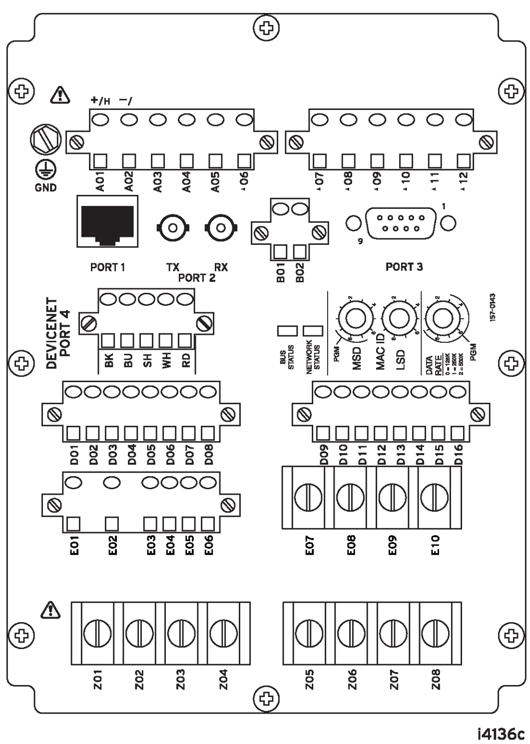


(A) Rear-Panel Layout



(B) Side-Panel Input and Output Designations

Figure 13 Dual Fiber-Optic Ethernet, Fiber-Optic Serial, Fast Hybrid 4 DI/4 DO, RTD, and Voltage/Differential Option



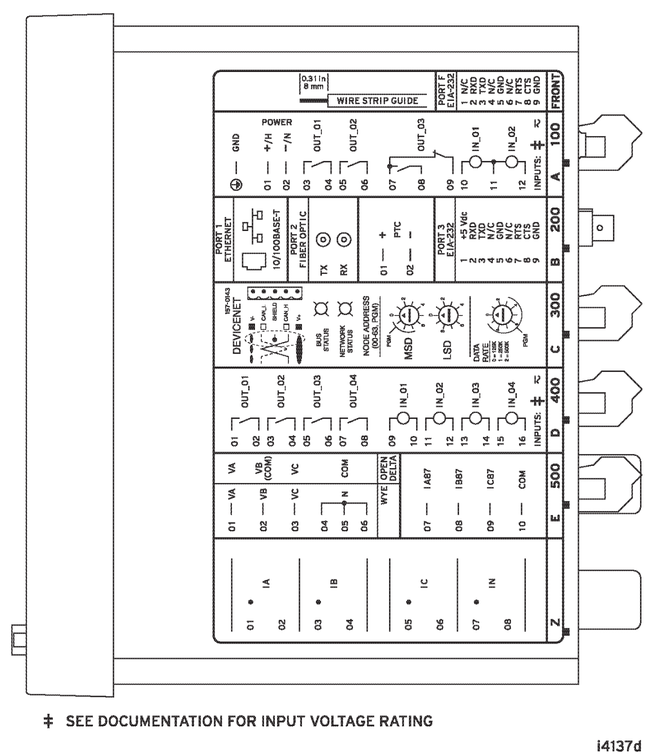


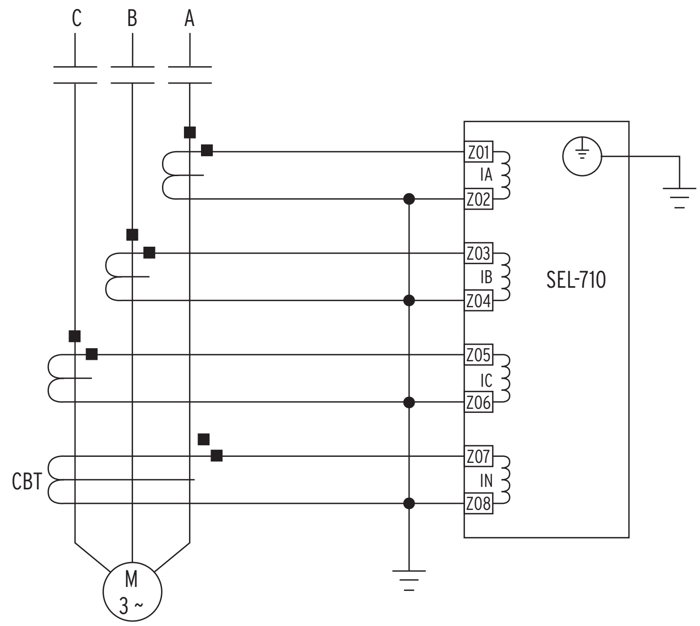
Figure 14 PTC, DeviceNet, 4 DI/4 DO, and Voltage Differential Option

Applications

The following is a list of possible application scenarios:

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

Across-the-Line Starting



CBT (core-balance current transformer)

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

Figure 15 AC Connections With Core-Balance Neutral CT

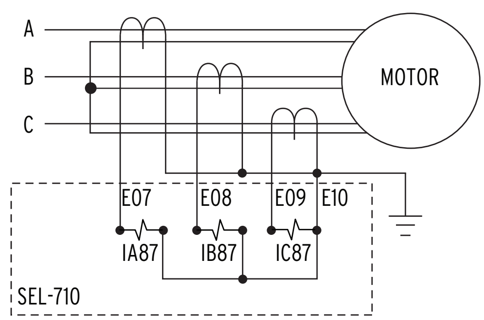


Figure 16 AC Connections With Core-Balance Differential CTs

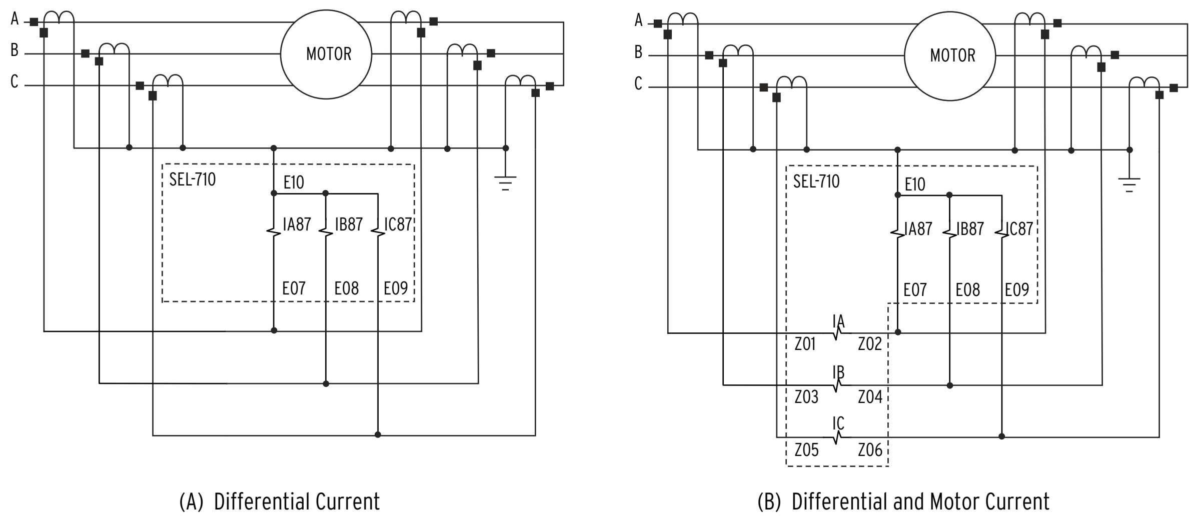


Figure 17 AC Connections With Source- and Neutral-Side CTs

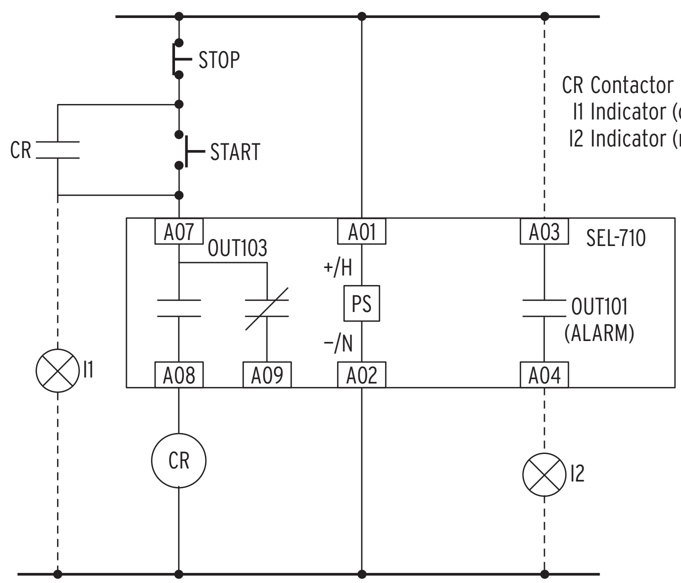


Figure 18 Control Connections for Fail-Safe Tripping

Star-Delta Starting

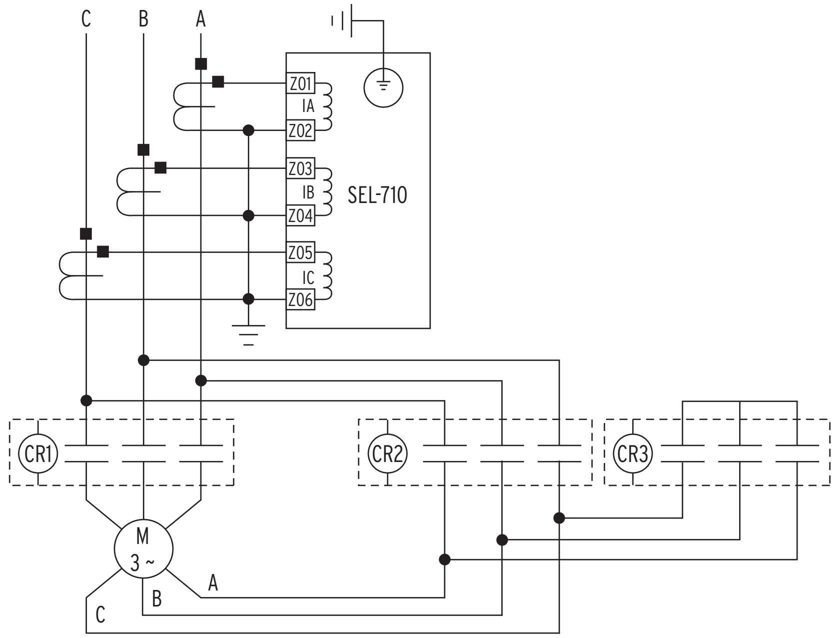


Figure 19 AC Connections for Star-Delta Starting

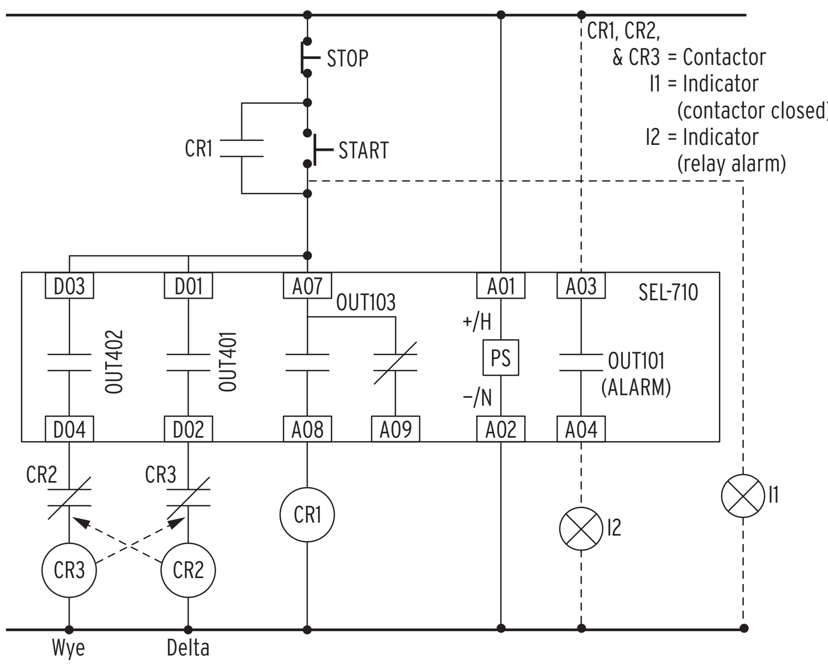


Figure 20 Control Connections for Star-Delta Starting

Two-Speed Motor

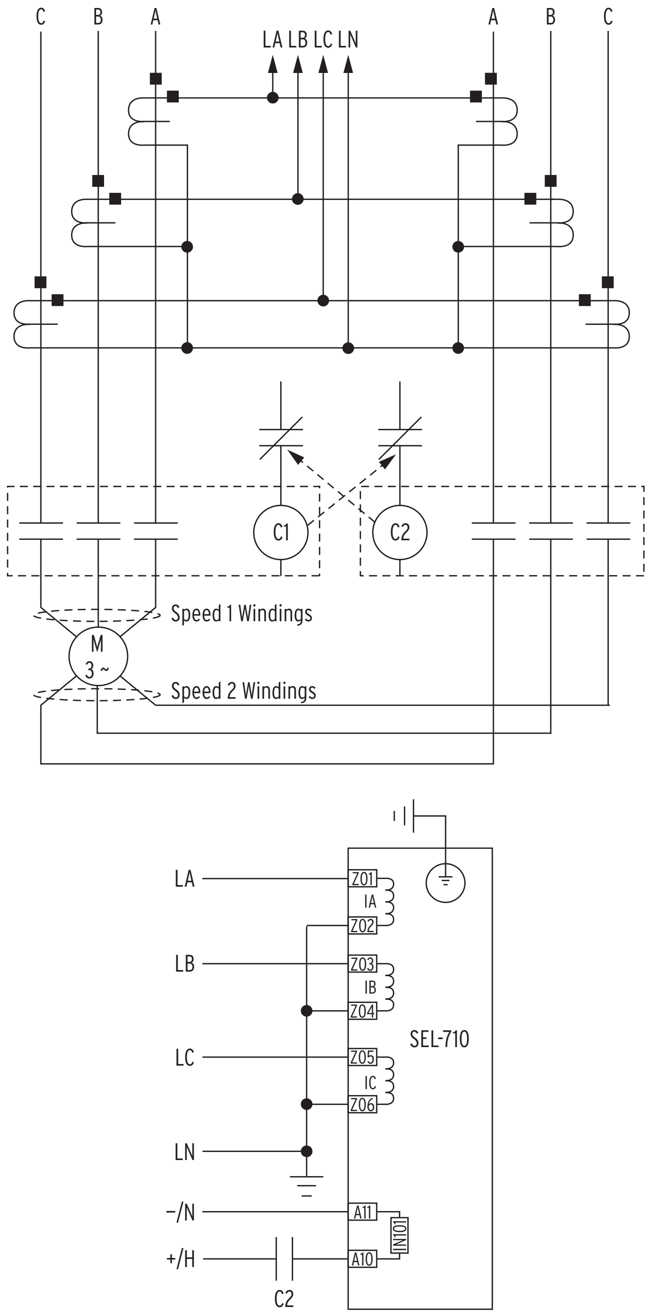


Figure 21 AC Connections for a Two-Speed Motor—Paralleled CTs

Full-Voltage Reversing Starter

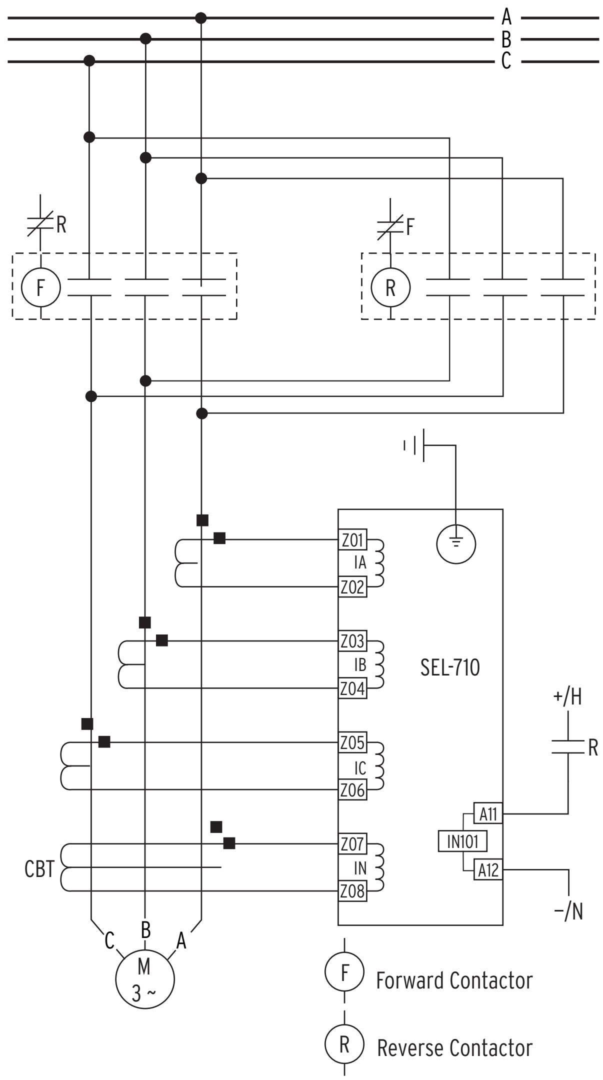


Figure 22 AC Connections for Full-Voltage Reversing (FVR) Starter

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

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

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

CE Mark

RCM Mark

UKCA Mark

Hazardous locations

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

EU

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

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

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

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

General

AC Current Input

Phase Currents

I_{NOM} = 5 A

Continuous Rating: 3 • I_{NOM} @ 85°C
4 • I_{NOM} @ 55°C

A/D Measurement Limit: 156 A peak (110 A rms symmetrical)

1-Second Thermal: 500 A

Burden (per phase): <0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating: 3 • I_{NOM} @ 85°C
4 • I_{NOM} @ 55°C

A/D Measurement Limit: 31.2 A peak (22 A rms symmetrical)

1-Second Thermal: 100 A

Burden (per phase): <0.01 VA @ 1 A

Neutral Currents

I_{NOM} = 5 A

Continuous Rating: 3 • I_{NOM} @ 85°C
4 • I_{NOM} @ 55°C

A/D Measurement Limit: 16.7 A peak (11.8 A rms symmetrical)

1-Second Thermal: 500 A

Burden (per phase): <0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating: 3 • I_{NOM} @ 85°C
4 • I_{NOM} @ 55°C

A/D Measurement Limit: 3.3 A peak (2.4 A rms symmetrical)

1-Second Thermal: 100 A

Burden (per phase): <0.01 VA @ 1 A

I_{NOM} = 2.5 mA

Continuous Rating: 3 • I_{NOM} @ 85°C
4 • I_{NOM} @ 55°C

A/D Measurement Limit: 21 mA peak (14.8 mA rms symmetrical)

1-Second Thermal: 100 A

Burden (per phase): <0.1 mVA @ 2.5 mA

Measurement Category: II

Differential Currents

I_{NOM} = 1 A/5 A Universal

Continuous Rating: 15 A

Saturation Current Rating: Linear to 8 A symmetrical

1-Second Thermal: 500 A

Burden (per phase): <0.01 VA @ 5 A

AC Voltage Inputs

[VNOM (L-L)/PT Ratio] Range: 100–250 V (if DELTA_Y = DELTA)
100–440 V (if DELTA_Y = WYE)

Rated Continuous Voltage: 300 Vac

10-Second Thermal: 600 Vac

	Burden	Input Impedance (Per Phase)	Input Impedance (Phase-to-Phase)
Vphase	0.003 VA @ 120 Vac	5 MΩ	10 MΩ

Power Supply

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

High-Voltage Supply

Rated Supply Voltage: 110–240 Vac, 50/60 Hz; 110–250 Vdc

Input Voltage Range: (Design Range) 85–264 Vac; 85–300 Vdc

Power Consumption: <50 VA (ac)
<25 W (dc)

Interruptions: 50 ms @ 125 Vac/Vdc
100 ms @ 250 Vac/Vdc

Low-Voltage Supply

Rated Supply Voltage: 24–48 Vdc

Input Voltage Range (Design Range): 19.2–60 Vdc

Power Consumption: <25 W (dc)

Interruptions: 10 ms @ 24 Vdc
50 ms @ 48 Vdc

Fuse Ratings

LV Power Supply Fuse

Rating: 3.15 A

Maximum Rated Voltage: 300 Vdc, 250 Vac

Breaking Capacity: 1500 A at 250 Vac

Type: Time-lag T

HV Power Supply Fuse

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

Output Contacts

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

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

Standard Contacts

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

DC Output Ratings

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

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

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

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

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

AC Output Ratings

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

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

Utilization Category:	AC-15

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

Voltage Protection Across Open Contacts:	270 Vac, 115 J

Fast Hybrid Output Contacts

(High-Speed, High-Current Interrupting)

DC Output Ratings

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

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

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

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

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

AC Output Ratings

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

Optoisolated Control Inputs

When Used With DC Control Signals

250 V:	ON for 200.0–312.5 Vdc OFF below 150 Vdc
220 V:	ON for 176–275 Vdc OFF below 132 Vdc
125 V:	ON for 100.0–156.2 Vdc OFF below 75 Vdc
110 V:	ON for 88.0–137.5 Vdc OFF below 66 Vdc
48 V:	ON for 38.4–60.0 Vdc OFF below 28.8 Vdc
24 V:	ON for 19.2–30.0 Vdc OFF below 5 Vdc

When Used With AC Control Signals

250 V:	ON for 200.0–312.5 Vac OFF below 106 Vac
220 V:	ON for 180–275 Vac OFF below 93.3 Vac
125 V:	ON for 95.0–156.2 Vac OFF below 53 Vac
110 V:	ON for 90.0–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 37.5–60.0 Vac OFF below 20.3 Vac
24 V:	ON for 18–30 Vac OFF below 5 Vac
Current Draw at Nominal DC Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Impulse Withstand Voltage (U_{imp}):	4000 V
Maximum Pickup Time:	Approx. 1 cycle
Maximum Dropout Time:	Approx. 2 cycles

Analog Output (Optional)

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

Analog Inputs (Optional)

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

Frequency and Phase Rotation

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

Time-Code Input

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

Synchronization Accuracy

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

Simple Network Time Protocol (SNTP) Accuracy

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

Communications Ports

Standard EIA-232 (2 Ports)

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

EIA-485 Port (Optional)

Location:	Rear Panel
Data Speed:	300–19200 bps

Ethernet Port (Optional)

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

Standard Multimode Fiber-Optic Port

Location:	Rear Panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

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

Port 2 Serial

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

Optional Communications Cards

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

Communications Protocols

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

Operating Temperature

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

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

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

Operating Environment

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

Dimensions

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

Weight

2.7 kg (6.0 lb)

Relay Mounting Screws (#8–32) Tightening Torque

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

Terminal Connections

Terminal Block

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

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

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

Product Standards

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

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel IP50-rated for terminals enclosed in the dust-protection assembly (protection against solid foreign objects only) (SEL P/N 915900170). The 10°C temperature derating applies to the temperature specifications of the relay. IP10 for terminals and the relay rear panel
Vibration Resistance:	IEC 60255-21-1: 1998 IEC 60255-27: 2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-21-2: 1998 IEC 60255-27: 2013, Section 10.6.2.2 IEC 60255-27: 2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3: 1993 IEC 60255-27: 2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1: 2007 IEC 60255-27: 2013, Section 10.6.1.2 IEC 60255-27: 2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2: 2007 IEC 60255-27: 2013, Section 10.6.1.1 IEC 60255-27: 2013, Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013, Section 10.6.1.6 25°–55°C, 6 cycles, 95% relative humidity
Change of Temperature:	IEC 60068-2-14: 2009 IEC 60255-1: 2010 section 6.12.3.5 –40° to +85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-27:2013, Section 10.6.4.3 IEEE C37.90-2005 1.0 kVac on analog outputs, Ethernet ports 2.0 kVac on analog inputs, IRIG, PTC 2.5 kVac on contact I/O 3.6 kVdc on power supply, current and voltage inputs
Impulse:	IEC 60255-27:2013, Section 10.6.4.2 Severity Level: 0.5 J, 5 kV on power supply, contact I/O, ac current and voltage inputs 0.5 J, 530 V on analog outputs, PTC IEEE C37.90:2005 Severity Level: 0.5 J, 5 kV 0.5 J, 530 V on analog outputs, PTC

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013, Section 7.2.3 IEEE C37.90.3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013, Section 7.2.4 10 V/m IEEE C37.90.2-2004 20 V/m
Fast Transient, Burst Immunity[a]:	IEC 61000-4-4:2012 IEC 60255-26:2013, Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity[a, b]:	IEC 61000-4-5:2005 IEC 60255-26:2013, Section 7.2.7 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity[a]:	IEC 61000-4-18:2010 IEC 60255-26:2013, Section 7.2.6 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2002 2.5 kV oscillatory 4 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-26:2013, Section 7.2.8 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60225-26:2013, Section 7.2.10 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute; 50/60 Hz IEC 61000-4-9:2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m (100 kHz and 1 MHz)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000 IEC 60255-26:2013, Section 7.2.11 IEC 60255-26:2013, Section 7.2.12 IEC 60255-26:2013, Section 7.2.13

EMC Emissions

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

Processing Specifications and Oscillography

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

Oscillography

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

Sequential Events Recorder

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

Relay Elements

Thermal Overload (49)

Full-Load Current (FLA) Limits:	0.2–5000.0 A primary (limited to 20–160% of CT rating)
Locked Rotor Current:	2.5–12.0 • FLA
Hot Locked Rotor Time:	1.0–600.0 seconds
Service Factor:	1.01–1.50
Accuracy:	5% plus ±25 ms at multiples of FLA > 2 (cold curve method)

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

PTC Overtemperature (49)

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

Undercurrent (Load Loss) (37)

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

Current Unbalance and Phase Loss (46)

Setting Range:	Off, 5–80%
Accuracy:	±10% of setting ±0.02 I_{NOM} A rms secondary
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0–240 s, 1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Overcurrent (Load Jam)

Setting Range:	Off, 1.00–6.00 • FLA
Accuracy:	±5% of setting ±0.02 • I_{NOM} A rms secondary
Maximum Pickup Dropout Time:	1.5 cycles
Time Delay:	0–120 s, 0.1 s increment
Accuracy:	±0.5% of setting ±1/4 cycle

Short Circuit (50P)

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

Ground Fault (50G)

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

Ground Fault (50N)

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

Negative-Sequence Overcurrent (50Q)

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

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

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

Differential Protection (87M)

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

Undervoltage (27)

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

Setting Range:	Off, 0.02–1.00 • Vnm
Accuracy:	±5% of setting plus ±2 V
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 0.1 s increment
Accuracy:	±0.5% of setting or ±1/4 cycle

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

Overvoltage (59)

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

Setting Range:	Off, 0.02–1.20 • Vnm
Accuracy:	±5% of setting plus ±2 V
Maximum Pickup/Dropout Time:	1.5 cycles
Time Delay:	0.0–120.0 s, 0.1 s increment
Accuracy:	±0.5% of setting or ±1/4 cycle

Underpower (37)

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

Reactive Power (VAR)

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

Power Factor (55)

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

Frequency (81)

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

Timers

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

RTD Protection

Setting Range:	Off, 1–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	1.4 Vac (peak) at 50 Hz or greater frequency
RTD Fault, Trip, and Alarm Time Delay:	Approximately 12 s

Metering

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

Motor Phase Currents:	±2% of reading plus ±1.5% of I_{NOM}, ±2°
Three-Phase Average Motor Current:	±2% of reading plus ±1.5% of I_{NOM}
Three-Phase Average Motor Load (%FLA):	±2% of reading plus ±1.5% of I_{NOM}
Current Unbalance (%):	±2% of reading plus ±1.5% of I_{NOM}
IG (Residual Current):	±3% of reading plus ±1.5% of I_{NOM}, ±2°
IN (Neutral Current):	±2% of reading plus ±1.5% of I_{NOM}, ±2°
3I2 Negative-Sequence Current:	±3% of reading
System Frequency:	±0.1 Hz of reading for frequencies within 20–70 Hz
Thermal Capacity:	±1% TCU Time to trip ±1 second
Slip:	±5% slip for 100% > speed ≥ 40% ±10% slip for 40% > speed > 0%
Line-to-Line Voltages:	±2% of reading, ±1° for voltages within 24–264 V
Three-Phase Average Line-to-Line Voltage:	±2% of reading for voltages within 24–264 V

Line-to-Ground Voltages:	±2% of reading, ±1° for voltages within 24–264 V
Three-Phase Average Line-to-Ground Voltages:	±2% of reading for voltages within 24–264 V
Voltage Unbalance (%):	±2% of reading for voltages within 24–264 V
3V2 Negative-Sequence Voltage:	±3% of reading for voltages within 24–264 V
Real Three-Phase Power (kW):	±5% of reading for 0.10 < pf < 1.00
Reactive Three-Phase Power (kVAR):	±5% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Power (kVA):	±5% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C
Real Three-Phase Energy (out of bus) (MWh3P):	±5% of reading for 0.10 < pf < 1.00
Negative Reactive Three-Phase Energy-IN (into bus) (MVARh3P):	±5% of reading for 0.00 < pf < 0.90
Positive Reactive Three-Phase Energy- OUT (out of bus) (MVARh3P):	±5% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Energy (out of bus) (MVAh3P):	±2% of reading

[a] Front-port serial cable (non-fiber) lengths assumed to be <3 m.
[b] RTD cable lengths assumed to be <10 m.

Notes

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
selinc.com • info@selinc.com

PDS710-01