SEL-710 Motor Protection Relay

Motor Protection Relay

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, 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.** ACSELERATOR QuickSet® SEL-5030 Software reduces engineering costs for relay settings and logic programming. Tools in ACSELERATOR 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.** Built-in metering functions 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.** The SEL-710 also includes Modbus® RTU, Event Messenger support, 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

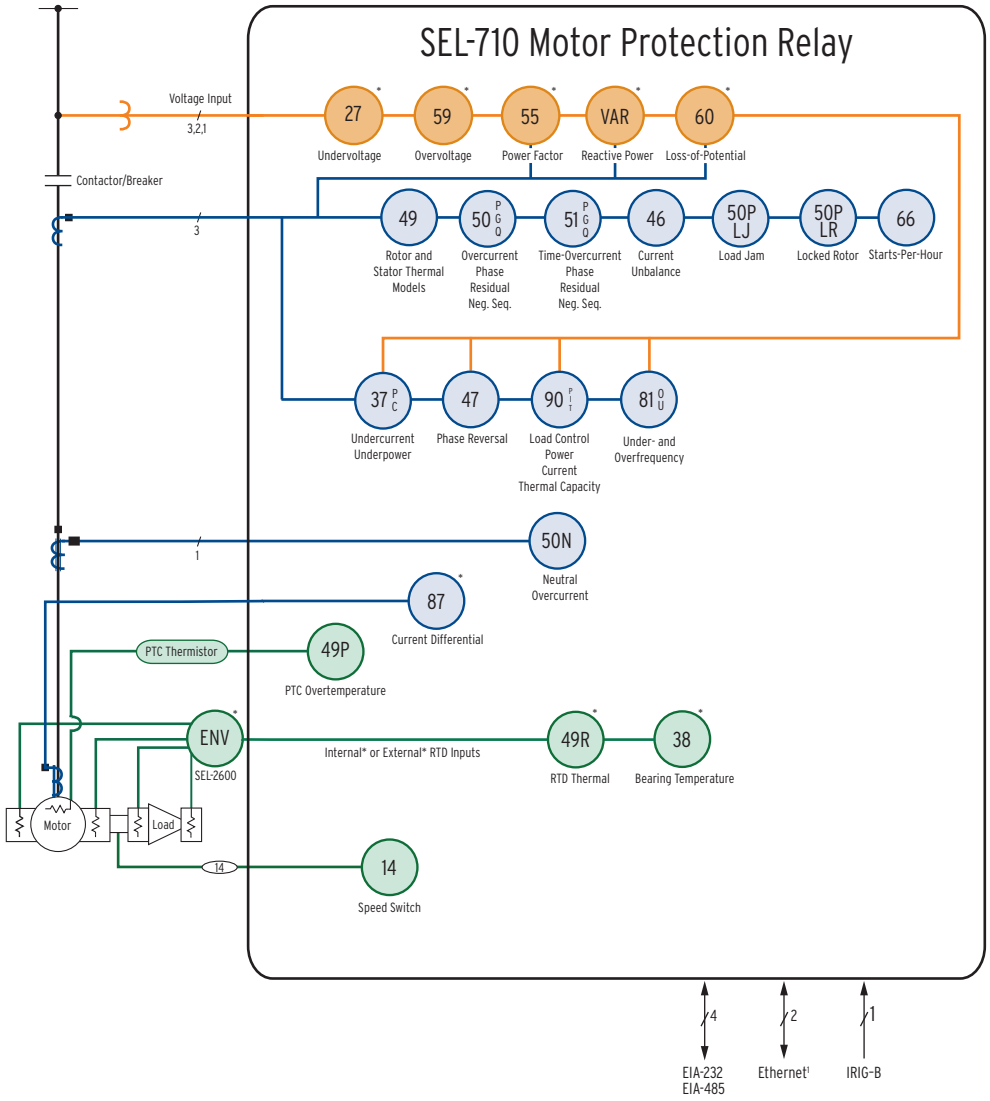


Figure 1 Functional Diagram

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 and Control 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.

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 calculated residual (3I0) current levels 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.

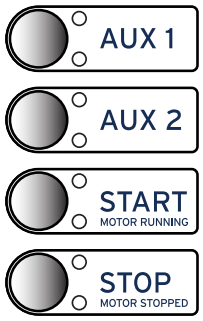


Figure 2 Operator Controls

Relay and Logic Settings Software

ACSELERATOR QuickSet Software simplifies settings and provides analytical support for the SEL-710. With ACSELERATOR 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 ACSELERATOR QuickSet you can verify settings and analyze power system events with the integrated waveform and harmonic analysis tools.

The following features of ACSELERATOR 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 22* 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 19 of the most recent 64-cycle event reports or 77 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.

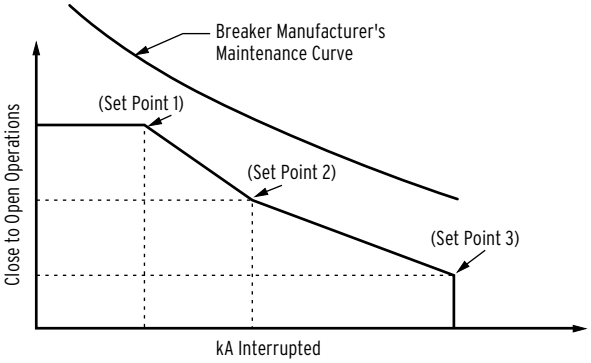


Figure 3 Breaker Contact Wear Curve and Settings

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.
Event Messenger	The SEL-3010 allows users to receive alerts sent directly to their cell phone. Alerts can be triggered through relay events and can include quantities measured by the relay.
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.

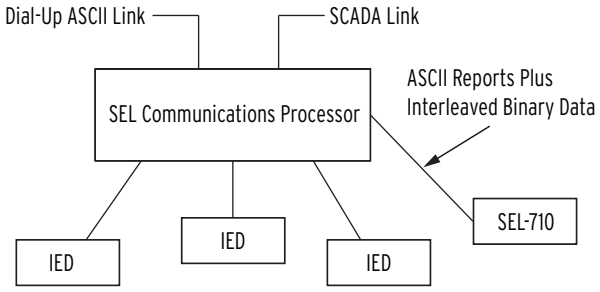


Figure 4 Example Communication System

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

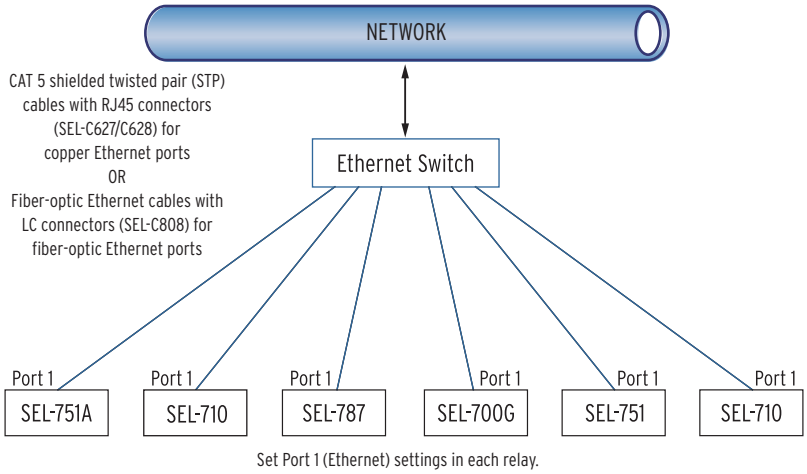


Figure 5 Simple Ethernet Network Configuration

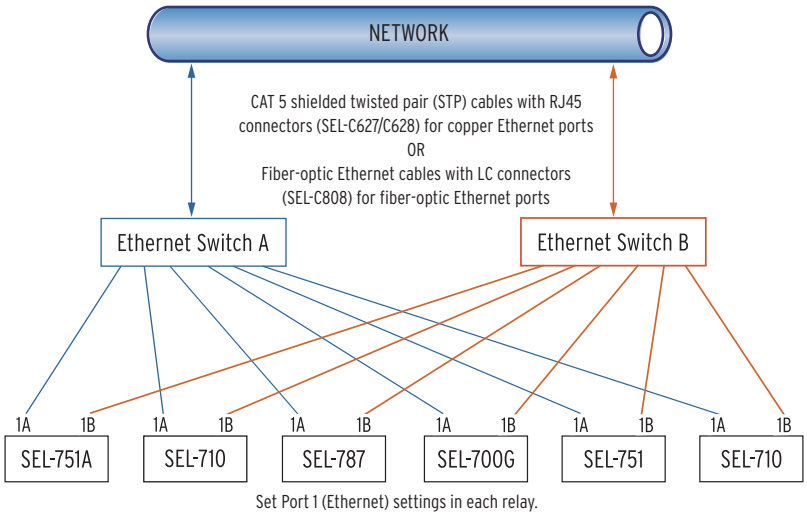


Figure 6 Simple Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

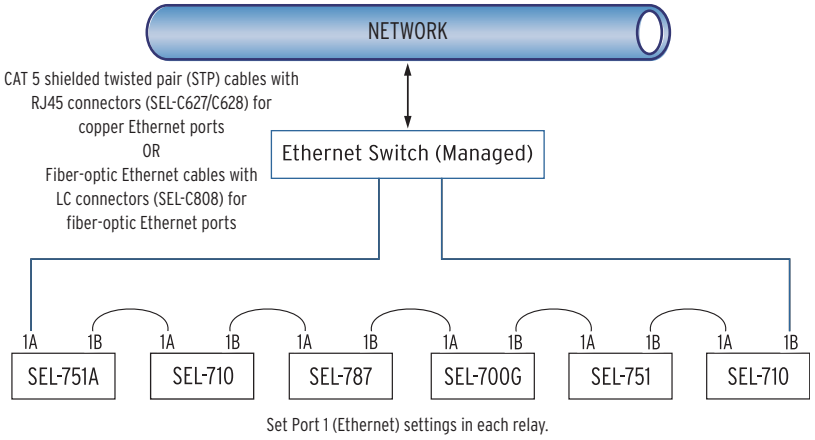


Figure 7 Simple Ethernet Network Configuration With Ring Structure (Switched Mode)

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.

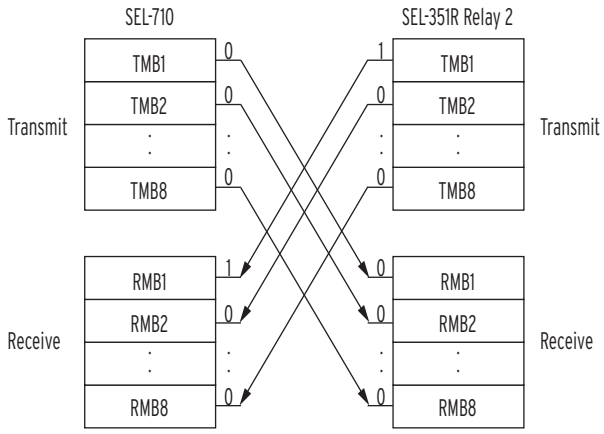


Figure 8 MIRRORED BITS Transmit and Receive Bits

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 20*. Some front-panel relabeling of LEDs may be needed if you reprogram them for unique or specific applications (see *Configurable Labels*).

Event Messenger Points

The SEL-710, when used with the SEL-3010 Event Messenger, translates as many as 32 user-defined messages from ASCII to voice, along with analog data that has been measured or calculated by the relay. This combination can allow the user to receive voice messages on any phone for alerts regarding the transition of any Relay Word bits in the relay.

Verbal notification of breaker openings, fuse failures, RTD alarms, etc., can now be sent directly to your cell phone through the use of your SEL-710 and SEL-3010 (must be connected to an analog telephone line). In addition, messages can include an analog value such as current, voltage, or power measurements made by the SEL-710.

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 20*.

Guideform Specification

Motor protection shall be provided by a microprocessor-based relay equipped with the following protection, monitoring, control, automation, and reporting functions. Self-checking functions shall be included. Specific requirements are as follows.

Protection and Control

- Motor thermal overload model (49)
  - Provides integrated thermal protection for locked rotor starts, running overload, unbalance current/negative-sequence current heating, and repeated or frequent starting
  - Processes the stator and rotor models simultaneously
  - Supports high-inertia starts (requires voltage option and full-load slip setting)
  - Has settable or learned motor-stopped cooling time constant
  - Allows settable or learned starting thermal capacity
  - Provides ambient temperature biasing via an external RTD input
- Phase, neutral, residual, and negative-sequence overcurrent elements (50P/50N/50G/50Q)
- Phase, residual, and negative-sequence time-overcurrent elements (51P/51G/51Q)
- Motor differential current (87)
- Current unbalance (46)
- Over- and underfrequency (81)
- Phase reversal (47)
- Load loss (undercurrent) (37)
- Load jam
- Antibackspin timer protection
- Starts-per-hour (notching or jogging device) (66)
- Minimum time-between-starts (66)
- Start motor timer
- Star-Delta starting
- Two-speed motor protection
- Forward/Reverse control
- Speed switch input (stall)
- Breaker/Contactor failure
- Breaker wear monitor
- Load control (current, TCU [thermal capacity used], power)

When voltage inputs are specified, the relay shall provide the following protection elements.

- Over- and undervoltage (59, 27)
- Underpower (37)
- Reactive power (VAR)
- Power factor (55)
- Voltage-based over- and underfrequency (81)
- Loss-of-potential (60)

Temperature Input

- The relay shall have the following features when equipped with as many as 12 RTD inputs in an external module (SEL-2600 with ST® connectors option) or 10 RTD inputs with an internal card:
  - Optical fiber transmission of RTD temperatures (using SEL-2600) to relay: range of as far as 1000 m
  - Separately field-selected RTD types: PT100, NI100, NI120, or CU10
  - Noise immunity (50 Hz and higher) on RTD inputs up to 1.4 Vac_{peak}
  - One contact input (with SEL-2600)
- RTD inputs to the motor relay shall support the following:
  - Thermal overload model biasing
  - Temperature alarms and trips (49)
  - RTD open- or short-circuit indication
- Capability of one PTC (positive temperature coefficient) thermistor input (49)

Automation

- 32 local control logic points, 32 remote control logic points, 32 latching logic points, 32 counters, 32 math variables, 32 logic variables, and 32 timers
- SELOGIC® programming language with Boolean and math equations capability for logic and control capability

Communications/Integration

- ASCII, Modbus RTU, DeviceNet, Telnet, FTP, Modbus TCP/IP, and IEC 61850 protocols
- Digital relay-to-relay communication via MIRRORED BITS® communications. The relay shall have two channels of eight transmit and eight receive logic elements for dedicated relay-to-relay communication. These elements shall be available for use in control logic.
- One front-panel EIA-232 port and one rear-panel EIA-232 or EIA-485 port, one fiber-optic serial port, and single- or dual-redundant, copper or fiber-optic Ethernet port
- Capability for an additional rear-panel EIA-232 or EIA-485 port
- Windows®-based PC software for settings and retrieving reports

Front-Panel Visualization

- The front panel shall be capable of displaying measured values, calculated values, I/O status, device status, and configuration parameters on a front-panel LCD display.
- The display shall have a capability to show rotating custom messages and data. Thirty-two display messages shall be provided.
- The front panel shall also have a minimum of six user-programmable LEDs and four user-programmable pushbutton controls with eight programmable LEDs.

Monitoring and Reporting

- **Motor start reports (as many as five of the latest starts).** Start data including currents, voltages (optional), calculated percent slip, and percent rotor thermal capacity used are sampled at a settable rate for 720 sets of the motor start data
- **Motor start trends.** Starting time, maximum start current, minimum start voltage (optional), and maximum start percent rotor thermal capacity used averages for each of the past 18 months, together with the number of starts in each month
- **Load-Profile Monitoring.** Provides periodic snapshot (selectable rate from every 5 to 60 minutes) of as many as 17 selectable analog quantities
- **Motor operating statistics.** Starts, running time, peak/average data, and trip/alarm counters
- **Breaker wear monitoring.**
- **Event summaries.** Fault type and trip data including time of tripping
- **Event reports.** 15-cycle length (as many as 77 reports) or 64-cycle length (as many as 19 reports) with 4 or 16 samples/cycle resolution
- **Sequential Events Recorder (SER).** As many as 1024 time-tagged, most recent input, output, and element transitions
- **Data stored in nonvolatile, Flash memory.**

Hardware

- Operating temperature range of –40° to +85°C
- Power supply input operating voltage range of 24/48 Vdc, 125/250 Vdc, or 120/240 Vac
- Demodulated IRIG-B time-synchronization input capability or PTC input capability
- Optional 10 internal RTD inputs or 12 external RTD inputs
- 5 A or 1 A, ac current inputs IA, IB, IC, and IN with optional 2.5 mA sensitive IN input
- 300 V maximum, three ac voltage inputs and three phase motor differential current inputs
- Flexible, configurable I/O including digital I/O and analog I/O
- Electromechanical or fast, high-current interrupting (optional) digital outputs
- Optoisolated digital inputs
- Jumper-selectable current (up to ±20 mA range) or voltage (up to ±10 V range) analog inputs
- Jumper-selectable current (up to ±20 mA range) or voltage (up to ±10 V range) analog outputs
- Relay front panel shall meet the requirements of NEMA 12/IP65
- Class I, Division 2 hazardous locations applications

Service and Support

- **Reliability.** The vendor shall supply the actual mean time between failures (MTBF) for the device upon request.
- **Manufacturer.** The device shall be manufactured in the U.S.A.
- **Conformal Coating.** The device shall have optional conformal coating to protect the circuit boards from harsh environments.
- **Warranty.** The device shall include a ten-year, no-questions-asked warranty for all material and workmanship defects. In addition, the warranty shall cover accidental customer-induced damage.

Dimensions

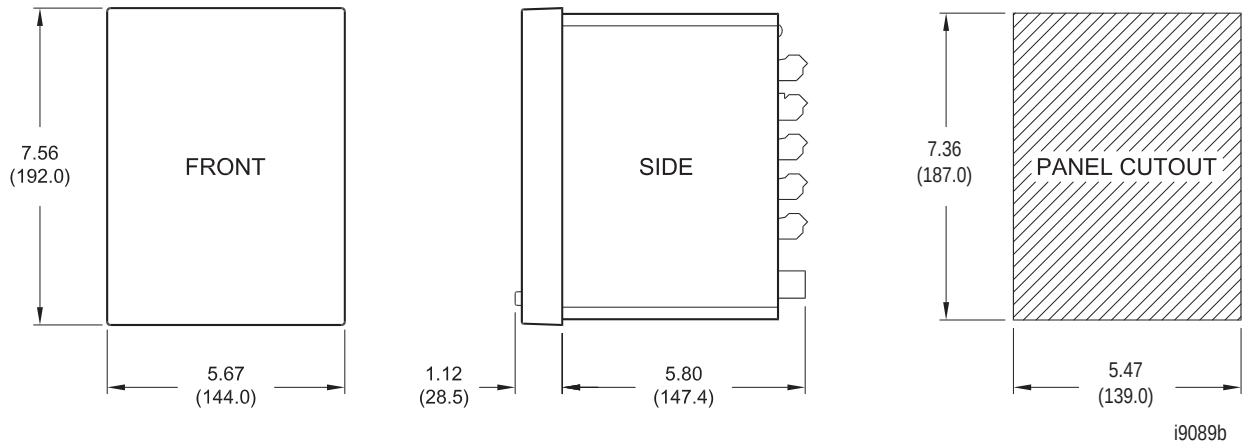


Figure 9 SEL-710 Dimensions for Rack- and Panel-Mount Models

Hardware Overview

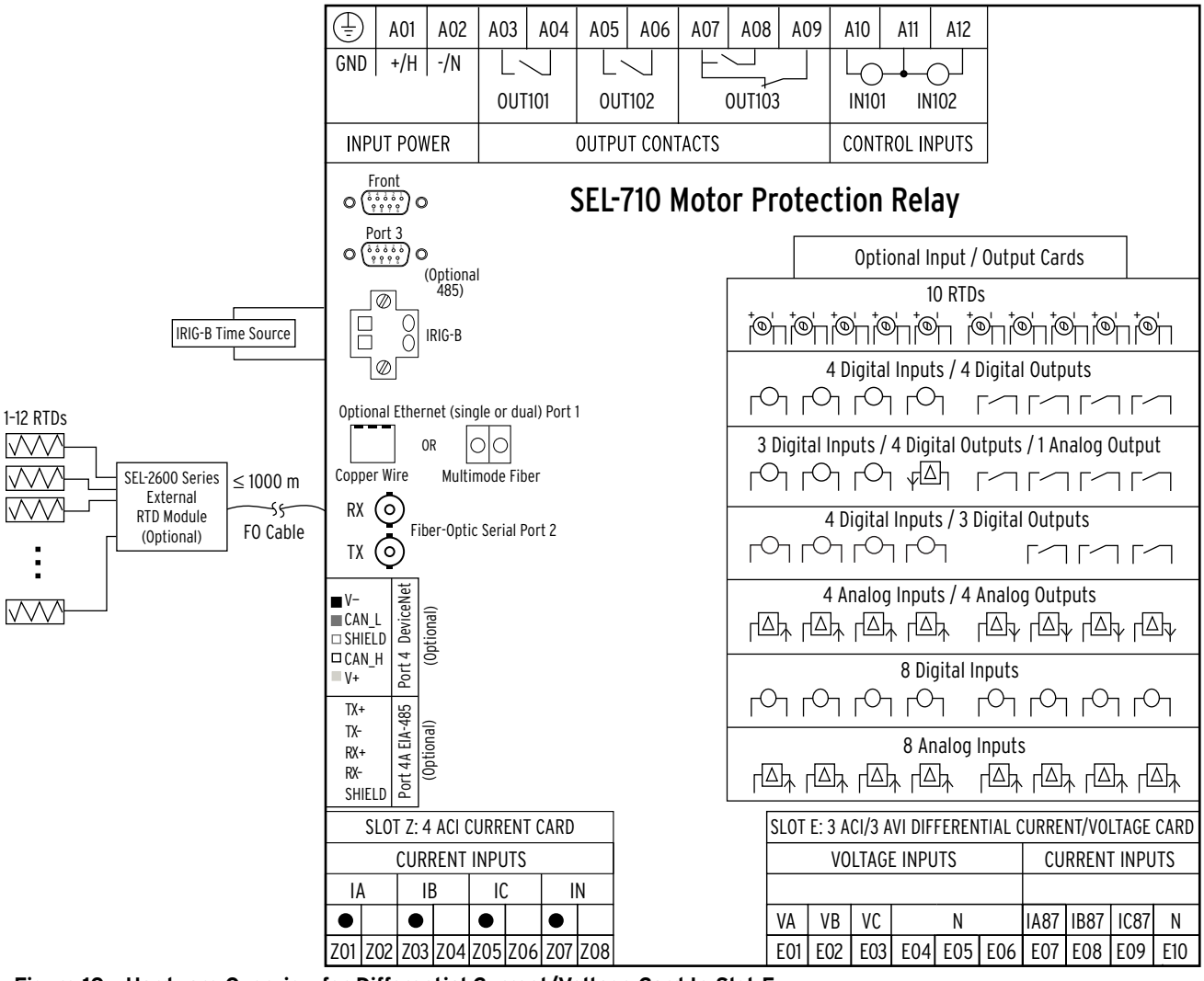


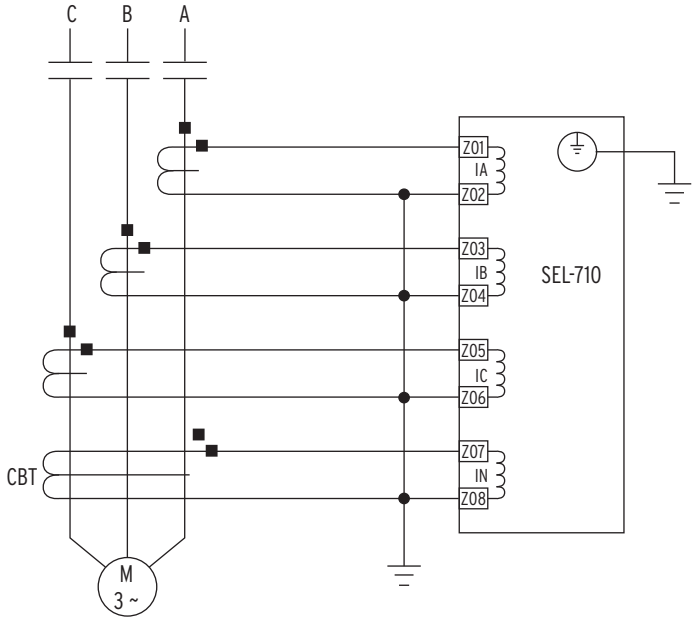
Figure 10 Hardware Overview for Differential Current/Voltage Card In Slot E

SEL-710 Motor Relay Application Examples

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 11 AC Connections With Core-Balance Neutral CT

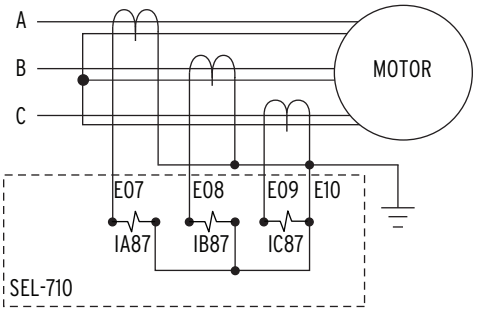
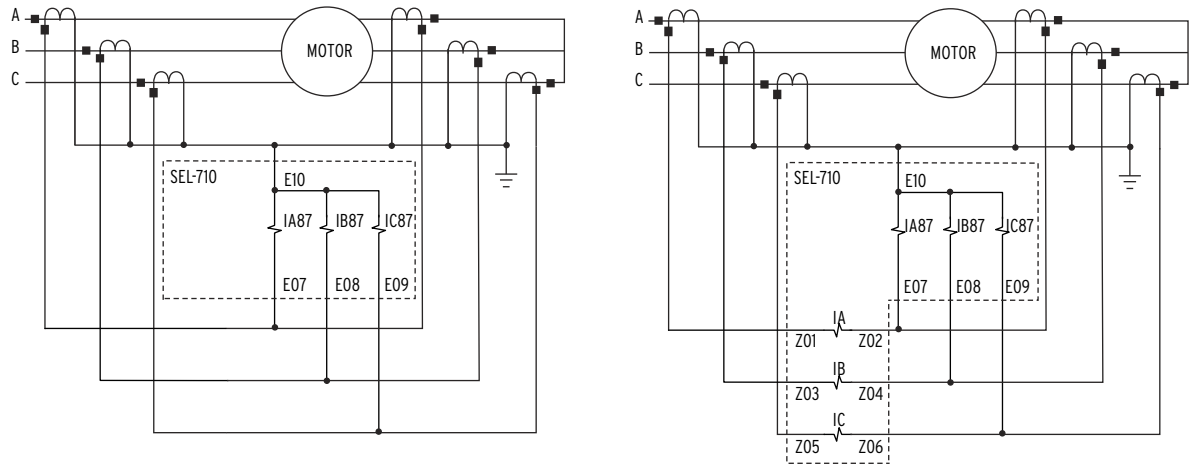


Figure 12 AC Connections With Core-Balance Differential CTs



(A) Differential Current (B) Differential and Motor Current

Figure 13 AC Connections With Source- and Neutral-Side CTs

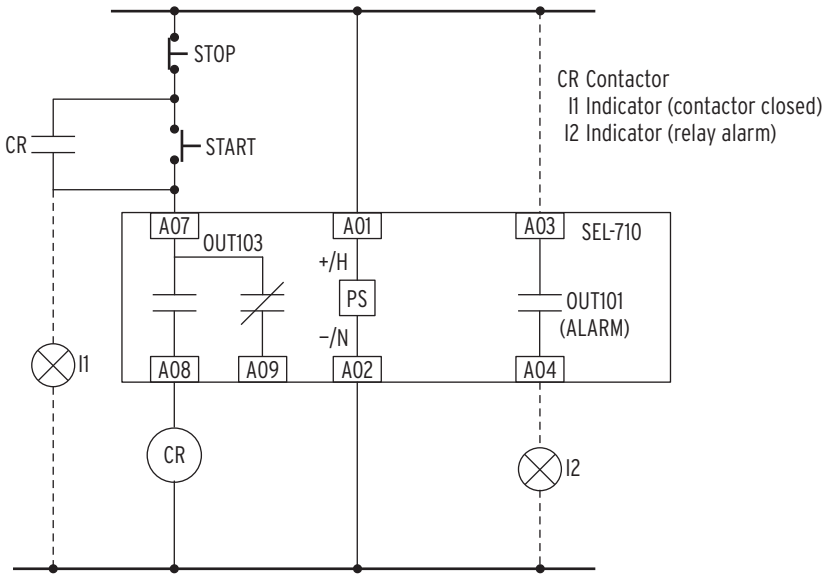


Figure 14 Control Connections for Fail-Safe Tripping

Star-Delta Starting

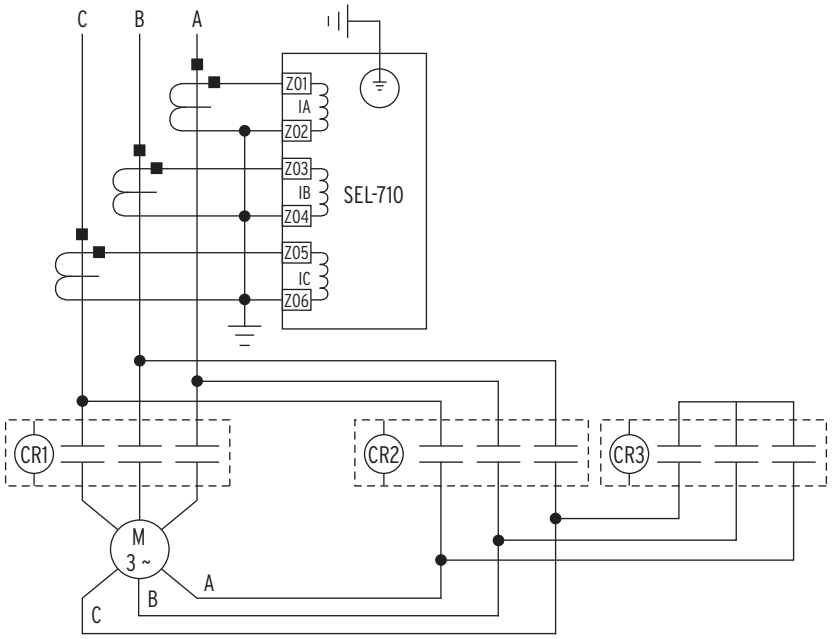


Figure 15 AC Connections for Star-Delta Starting

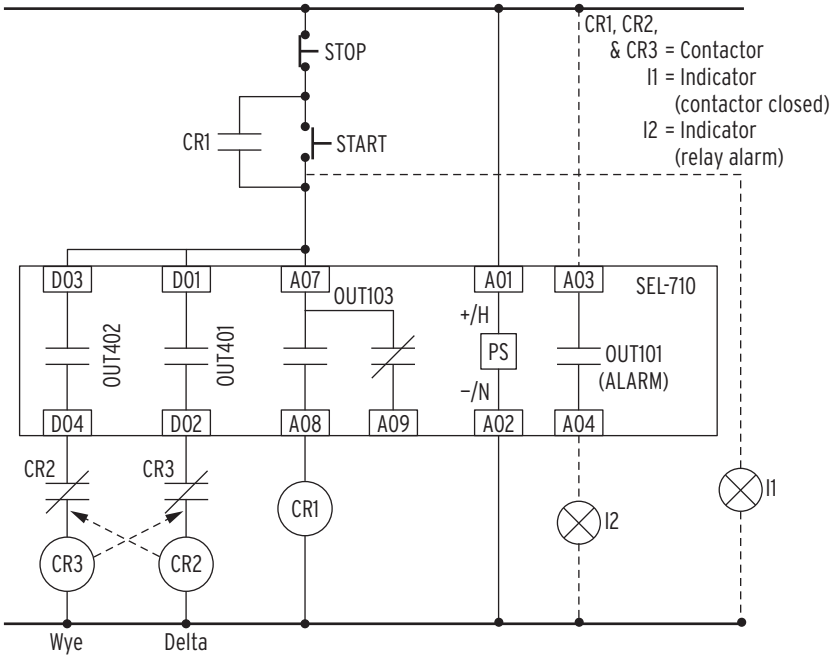


Figure 16 Control Connections for Star-Delta Starting

Two-Speed Motor

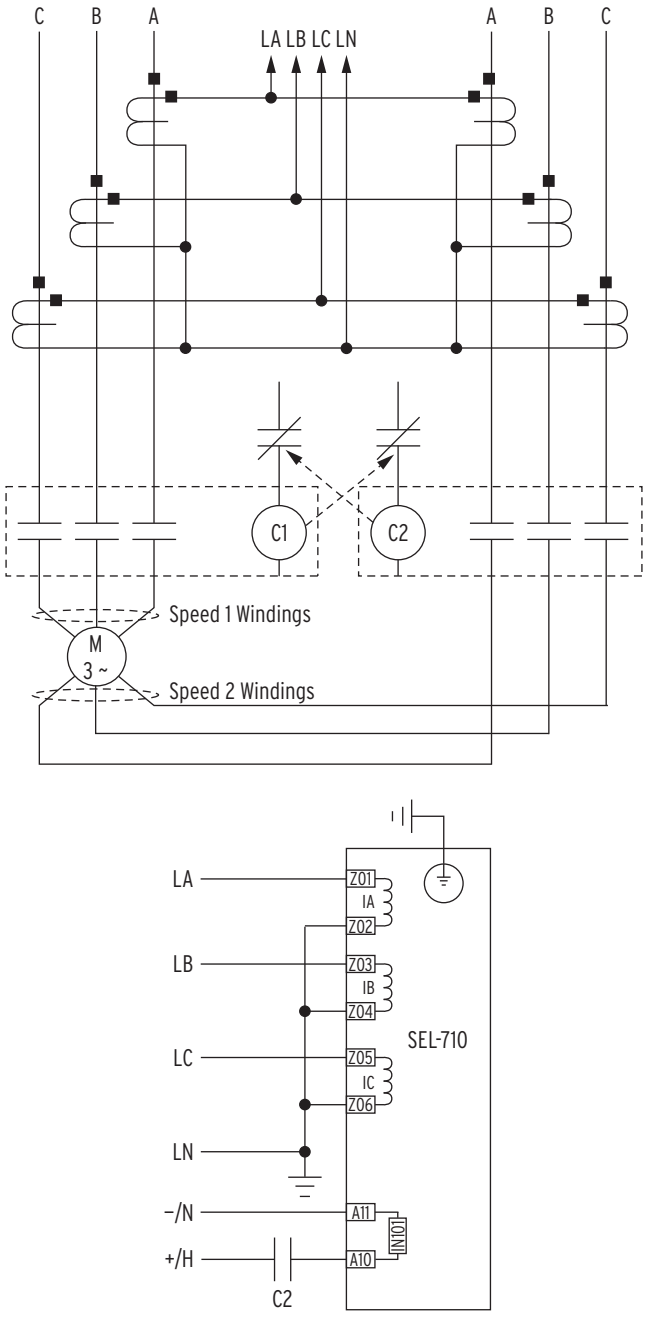


Figure 17 AC Connections for a Two-Speed Motor—Paralleled CTs

Full-Voltage Reversing Starter

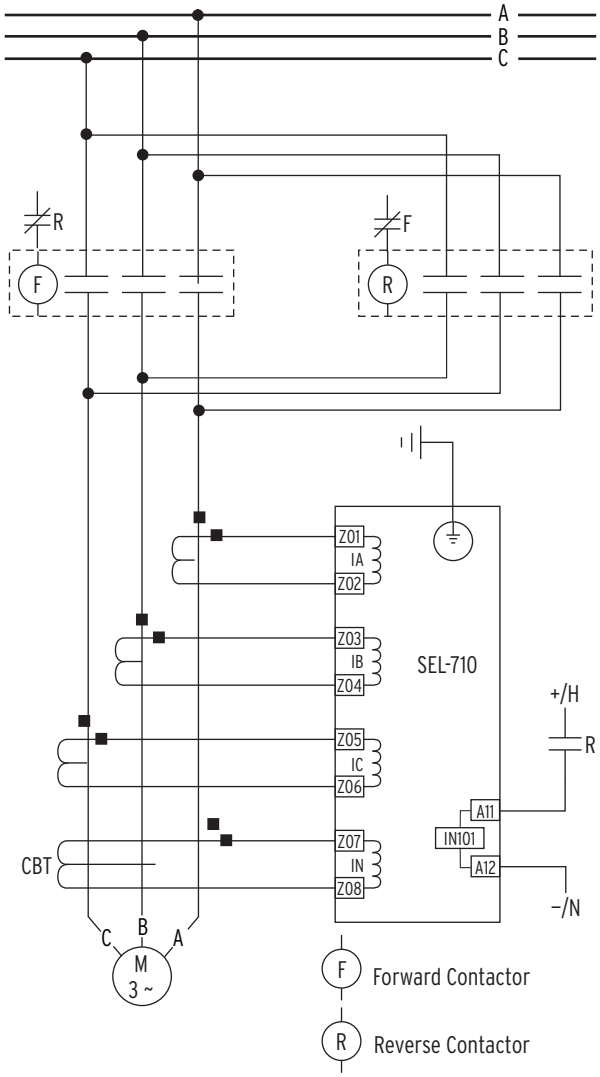


Figure 18 AC Connections for Full-Voltage Reversing (FVR) Starter

Front- and Rear-Panel Diagrams

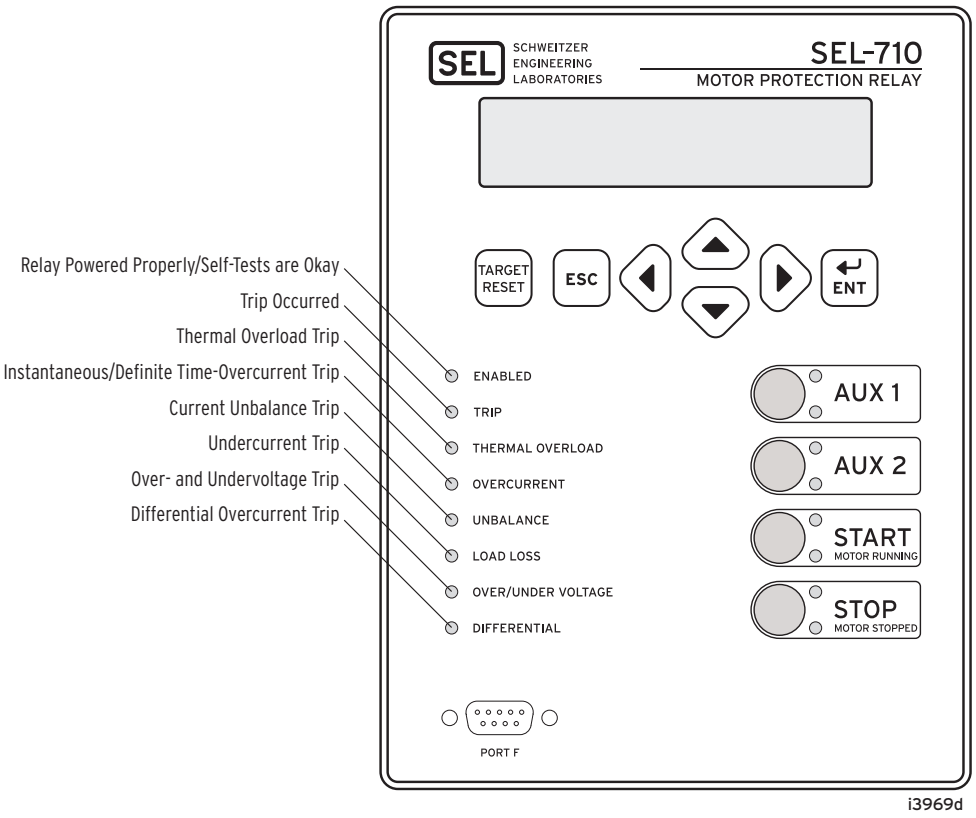


Figure 19 Front Panel

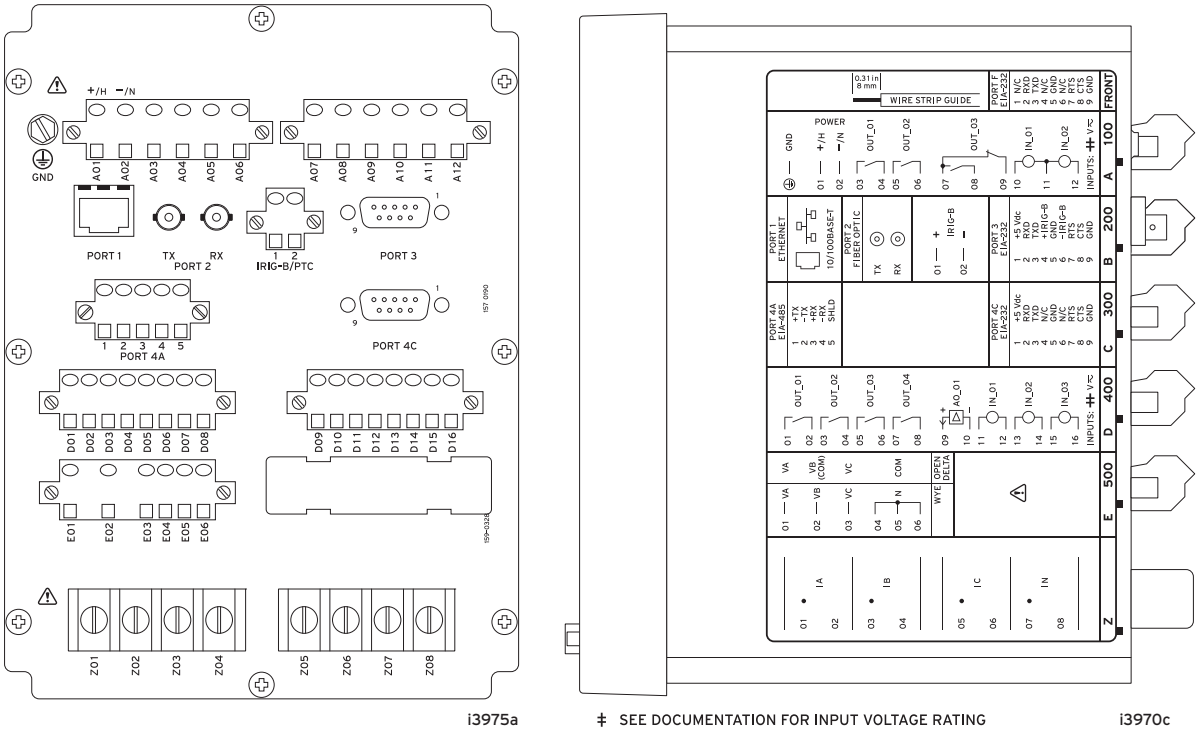
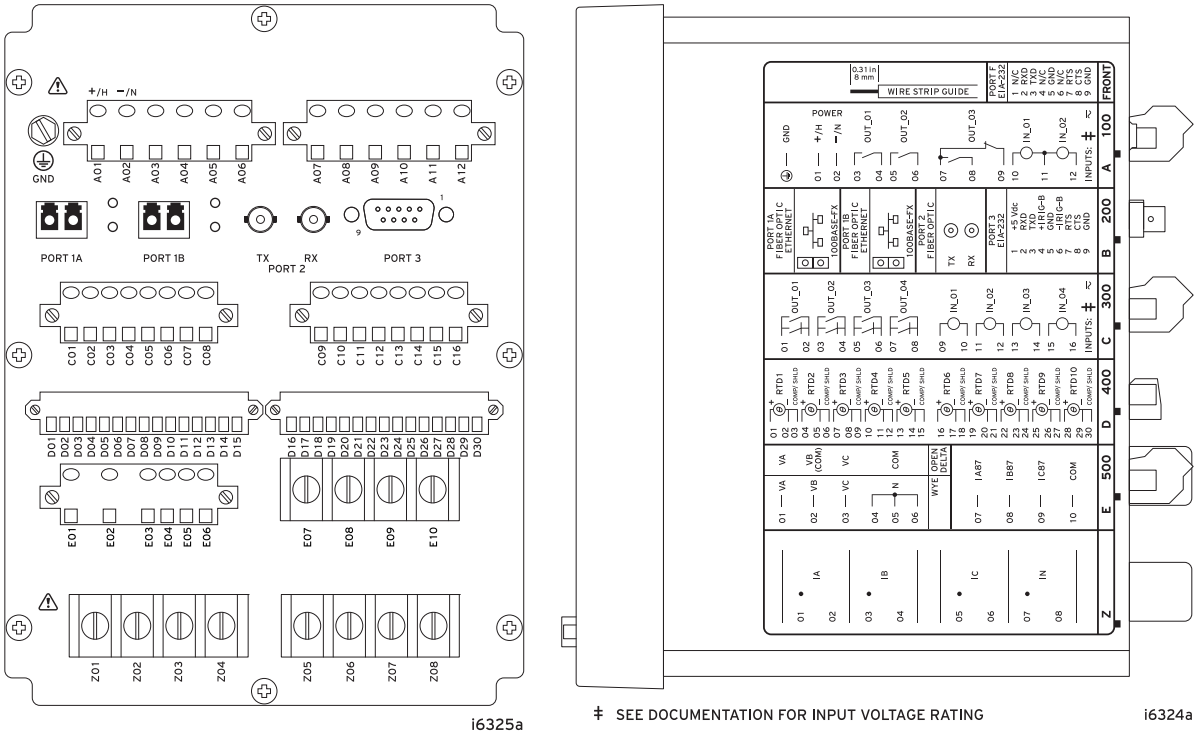


Figure 20 IRIG-B, Ethernet, EIA-232 Communication, 3 DI/4 DO/1 AO, and Voltage Option



(A) Rear-Panel Layout

(B) Side-Panel Input and Output Designations

Figure 21 Dual Fiber-Optic Ethernet, Fiber-Optic Serial, Fast Hybrid 4 DI/4 DO, RTD, and Voltage/Differential Option

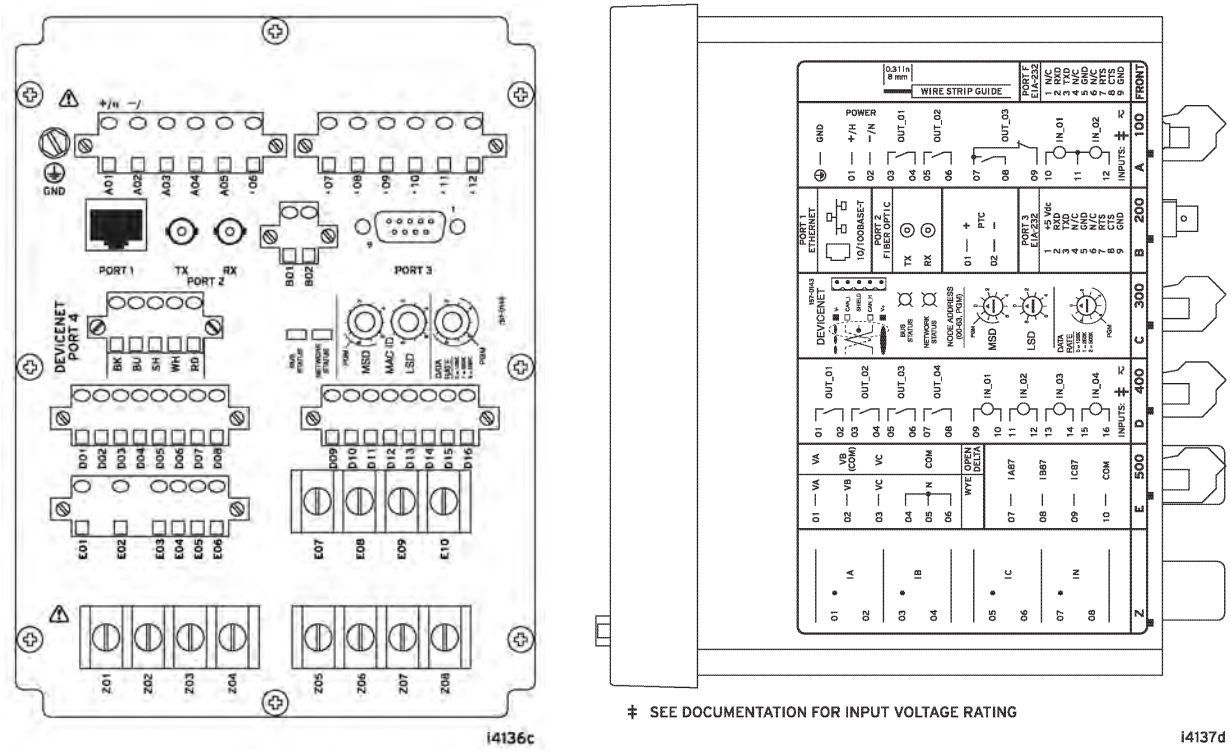


Figure 22 PTC, DeviceNet, 4 DI/4 DO, and Voltage Differential Option

Specifications

Compliance

ISO 9001:2008 Certified

UL, cUL:	Protective Relay Category NRGU, NRGU7 per UL 508, C22.2 No. 14
CSA:	C22.2 No. 61010-1
CE:	CE Mark–EMC Directive Low Voltage Directive IEC 61010-1:2001 IEC 60947-1 IEC 60947-4-1 IEC 60947-5-1
Hazardous Locations Approvals:	Complies with UL 1604, ISA 12.12.01, CSA 22.2 No. 213, and EN 60079-15 (Class I, Division 2).

General

AC Current Input

Phase and Neutral Currents

Note: I_{NOM} = 1 A, 5 A, or 2.5 mA (high sensitivity) secondary depending on model.

I_{NOM} = 5 A

Continuous Rating:	15 A, 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 A, linear to 19.2 A symmetrical
1 Second Thermal:	100 A
Burden (per phase):	<0.01 VA @ 1 A

I_{NOM} = 2.5 mA

Continuous Rating:	3 A, linear to 12.5 mA 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, 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:	<0.1 W
Input Impedance:	10 MΩ differential (phase-to-phase) 5 MΩ common mode (phase-to-chassis)

Power Supply

125/250 Vdc or 120/240 Vac

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

24/48 Vdc

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range:	19.2–60 Vdc
Power Consumption:	<20 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Output Contacts

General

OUT103 is Form C trip output, all other outputs are Form A, except for the SELECT 4 DI/3 DO card, which supports two Form C outputs and one Form B output.

Mechanical Durability:	100,000 no load operations
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, 40 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
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Voltage Protection Across Open Contacts:	270 Vac, 40 J
Rated Operational Current (I_e):	3 A @ 120 Vac 1.5 A @ 240 Vac
Conventional Enclosed Thermal Current (I_{the}) Rating:	5 A
Rated Frequency:	50/60 ±5 Hz
Electrical Durability Make VA Rating:	3600 VA, $\cos\phi = 0.3$
Electrical Durability Break VA Rating:	360 VA, $\cos\phi = 0.3$

UL/CSA Digital Output Contact Temperature Derating for Operating at Elevated Temperatures

Digital Output Cards Installed	Operating Ambient	Maximum Value of Current (I_{the})	Duty Factor
1–3	≤60°C	5.0 A	Continuous
1–3	60°–70°C	2.5 A	Continuous

Fast Hybrid (High-Speed High-Current Interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
Open State Leakage Current:	<100 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):

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):

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

Note: Per IEC 60255-23:1994, using the simplified method of assessment.

Note: Make rating per IEEE C37.90-1989.

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)

	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 7.3* 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

2.0 kg (4.4 lbs)

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)

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 IP65 enclosed in panel IP20 for terminals IP50-rated terminal dust protection assembly (SEL Part #915900170). 10°C temperature derating applies to the temperature specifications of the relay.
Vibration Resistance:	IEC 60068-2-6:1995 3 G, 10–150 Hz IEC 60255-21-1:1988, Class 1 IEC 60255-21-3:1993, Class 2
Shock Resistance:	IEC 60255-21-2:1988, Class 1
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 40°C, 93% relative humidity, 4 days
Damp Heat, Cyclic:	IEC 60068-2-30:1980 25–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 85°C, 16 hours

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-5:2000 IEEE C37.90-2005 2.5 kVac on current inputs, contact I/O 2.0 kVac on ac voltage inputs, analog inputs 1.0 kVac on PTC input and analog output 2.83 kVdc on power supply
Impulse:	IEC 60255-5:2000 0.5 J, 4.7 kV on power supply, contact I/O, ac current and voltage inputs 0.5 J, 530 V on PTC and analog outputs

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-22-2:2008 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2008 IEC 60255-22-3:2007 10 V/m IEEE C37.90.2-2004 35 V/m
Digital Radio Telephone RF Immunity:	ENV 50204:1995

Fast Transient, Burst Immunity:	IEC 61000-4-4:2004 IEC 60255-22-4:2008 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity:	IEC 61000-4-5:2005 IEC 60255-22-5:2008 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 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 61000-4-6:2006 IEC 60255-22-6:2001 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2001 1000 A/m for 3 seconds 100 A/m for 1 minute IEC 61000-4-9:2009 1000 A/m
Power Supply Immunity:	IEC 60255-11:1979

EMC Emissions

Conducted Emissions:	EN 55011:1998, Class A IEC 60255-25:2000
Radiated Emissions:	EN 55011:1998, Class A IEC 60255-25:2000

Electromagnetic Compatibility

Product Specific:	EN 50263:1999

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

Current Unbalance and Phase Loss (46)

Setting Range:	Off, 5–80%
Accuracy:	±10% of setting

Overcurrent (Load Jam)

Setting Range:	Off, 1.00–6.00 • FLA
Accuracy:	±5% of setting

Short Circuit (50P)

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

Ground Fault (50G)

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

Ground Fault (50N)

Setting Range:	Off, 0.01–650 A or 0.01–25 A primary
Accuracy:	±5% of setting plus ±0.01 A secondary

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:	
U.S.:	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 (up to 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

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

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

Underpower (37)

Setting Range:	Off, 1–25000 kW primary
Accuracy:	±3% of setting plus ±5 W secondary

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

Power Factor (55)

Setting Range:	Off, 0.05–0.99
Accuracy:	±5% of full scale for current ≥ 0.5 • FLA

Frequency (81)

Setting Range:	Off, 20.0–70.0 Hz
Accuracy:	±0.1 Hz

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 Trip/Alarm Time Delay:	Approximately 6 s

Metering

Accuracies are specified at 20°C, nominal frequency, ac currents within (0.2–20.0) • 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°
3-Phase Average Motor Current:	±2% of reading plus ±1.5% of I_{NOM}
3-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
3-Phase Average Line-to-Line Voltage:	±2% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±2% of reading, ±1° for voltages within 24–264 V
3-Phase Average Line-to-Ground Voltages:	±2% of reading for voltages within 24–264 V
Voltage Unbalance (%):	±2% of reading for voltages within 24–264 V
3V2 Negative-Sequence Voltage:	±3% of reading for voltages within 24–264 V
Real 3-Phase Power (kW):	±5% of reading for 0.10 < pf < 1.00
Reactive 3-Phase Power (kVAR):	±5% of reading for 0.00 < pf < 0.90
Apparent 3-Phase Power (kVA):	±2% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C
Real 3-Phase Energy (out of bus) (MWh3P):	±5% of reading for 0.10 < pf < 1.00
Negative Reactive 3-Phase Energy-IN (into bus) (MVARh3P):	±5% of reading for 0.00 < pf < 0.90
Positive Reactive 3-Phase Energy- OUT (out of bus) (MVARh3P):	±5% of reading for 0.00 < pf < 0.90
Apparent 3-Phase Energy (out of bus) (MVAh3P):	±2% of reading

Notes

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