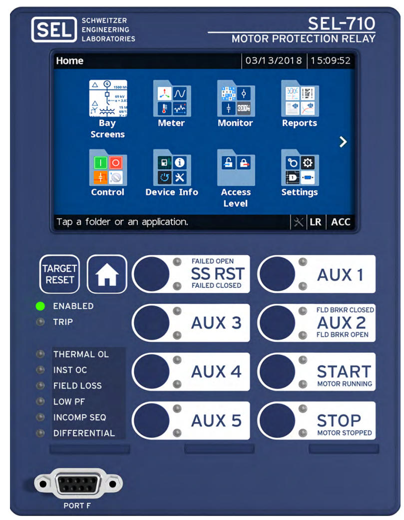
# SEL-710-5 Motor Protection Relay

## Induction and Synchronous Motor Control and Protection, Broken Rotor Bar Detection, and Arc-Flash Detection


## New Features

- IEC 61850 simulation mode, local/remote control authority, and functional naming support for easy commissioning and control.
- Rapid Spanning Tree Protocol (RSTP) provides faster recovery in response to network changes and failures in switched mode applications.
- Disconnect control from the Bay Screens application.
- Three-position disconnects for increased safety.
- A built-in web server that simplifies access to relay data and supports firmware upgrade.
- Faster firmware downloads via the Ethernet port.
- IEEE 1588-2008 firmware-based Precision Time Protocol (PTP) provides ease of integration.
- EtherNet/IP provides ease of integration for industrial automation applications.
- Early detection of cable insulation breakdown with incipient cable fault detection.
- Enhanced asset monitoring capabilities such as vibration monitoring, extended motor maintenance report, and frequency component analyzer.

# Major Features and Benefits

The SEL-710-5 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, and variable frequency drive (VFD) fed 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, phase reversal, breaker/contactor failure, positive temperature coefficient (PTC) thermistor over temperature, phase, negative-sequence, residual ground instantaneous, and inverse-time overcurrent elements. Implement load control, star-delta starting, two-speed control, and forward/reverse start control. Other standard features include broken rotor bar detection, rotor slip calculation, virtual speed switch, motor coast time, undervoltage, overvoltage, inverse-time over- and undervoltage elements, underpower, reactive power, phase reversal, power factor correction, frequency, loss of potential, breaker failure protection, incipient cable fault detection, asset monitoring capabilities, and RTD-based protection. As many as 10 RTDs can be monitored using an internal RTD card or as many as 12 RTDs using an SEL-2600 RTD Module with the ST® option.

➤ **Optional Synchronous Motor Protection and Control.** Use the SEL-710-5 with an optional synchronous motor/differential card (SYNCH/3 DIFF ACI) that provides starting control, power factor or reactive power closed loop regulation control, and loss-of-field, out-of-step, loss-of-synchronism (pull-out), field resistance, field voltage, and field current protection elements.

➤ **Optional Differential Protection.** Use the SEL-710-5 with optional current differential protection available with four-channel arc-flash card (4 AFDI/3 DIFF ACI) or synchronous motor protection and control card (SYNCH/3 DIFF ACI).

➤ **Optional Arc-Flash Protection.** Use the SEL-710-5 with optional four-channel fiber-optic arc-flash detector inputs and differential protection elements (4 AFDI/3 DIFF ACI) or the eight-channel fiber-optic arc-flash detector inputs (8 AFDI). Settable arc-flash phase and neutral overcurrent elements combined with arc-flash light detection elements provide secure, reliable, and fast-acting arc-flash event protection.

➤ **Operator Controls.** Start and stop the motor easily with eight programmable front-panel pushbuttons, each with two tricolored LEDs. Also, the SEL-710-5 provides 32 local and 32 remote control bits to help manage relay operations.

➤ **Integrated Web Server.** Log in to the built-in web server to view metering and monitoring data and download events, Sequential Events Recorder (SER), etc. Also, use the server to view relay settings and to perform relay firmware upgrades.

➤ **Relay and Logic Settings Software.** Reduce engineering costs for relay settings and logic programming with 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 Asset Monitoring.** Eliminate separately mounted metering devices with built-in metering functions. Analyze Sequential Events Recorder (SER) reports and oscillographic event reports for rapid commissioning, testing, and post-fault diagnostics. Monitor the health of your asset and accompanying devices using these asset monitoring capabilities:

- Vibration Monitoring
- Motor Monitoring Using Fourier Analysis
- Broken Rotor Bar Detection
- Motor Start Report
- Motor Maintenance Report
- Motor Operating Statistics
- Motor Start Trending
- Load Profiling
- Incipient Cable Fault Detection
- Molded Case Circuit Breaker Health
- Breaker Monitoring

➤ **Front Panel HMI.** Navigate the relay HMI through the use of a 2 x 16-character LCD or optional 5-inch, color, 800 x 480-pixel touchscreen display.

➤ **Additional Standard Features.** Use other standard features, including Modbus® RTU, MIRRORED BITS® communications, built-in web server, load profile, breaker wear monitoring, 128 remote analogs, support for 12 external RTDs (SEL-2600), IRIG-B input, advanced SELOGIC control equations, configurable labels, and an SEL-2812 compatible ST fiber-optic serial port.

➤ **Optional Features.** Select from a wide offering of optional features, including IEC 61850 Edition 2, Modbus TCP/IP, DNP3 serial and LAN/WAN, EtherNet/IP, Simple Network Time Protocol (SNTP), IEEE 1588-2008 firmware-based Precision Time Protocol (PTP), IEC 60870-5-103, RSTP, PRP, 10 internal RTDs, additional EIA-232 or EIA-485 communications ports, and single or dual, copper-wire or fiber-optic Ethernet ports. Several analog and digital options are available. These include 4 AI/4 AO, 8 AI, 4 DI/4 DO, 8 DI, 8 DO, 3 DI/4 DO/1 AO, 4 DI/3 DO, and 14 DI. Conformal coating for chemically harsh and/or high-moisture environments is available as an option.

➤ **Language Support.** Choose English or Spanish for your serial ports, including the front-panel serial port. The standard relay front-panel overlay is in English; a Spanish overlay is available as an ordering option.

# Functional Overview

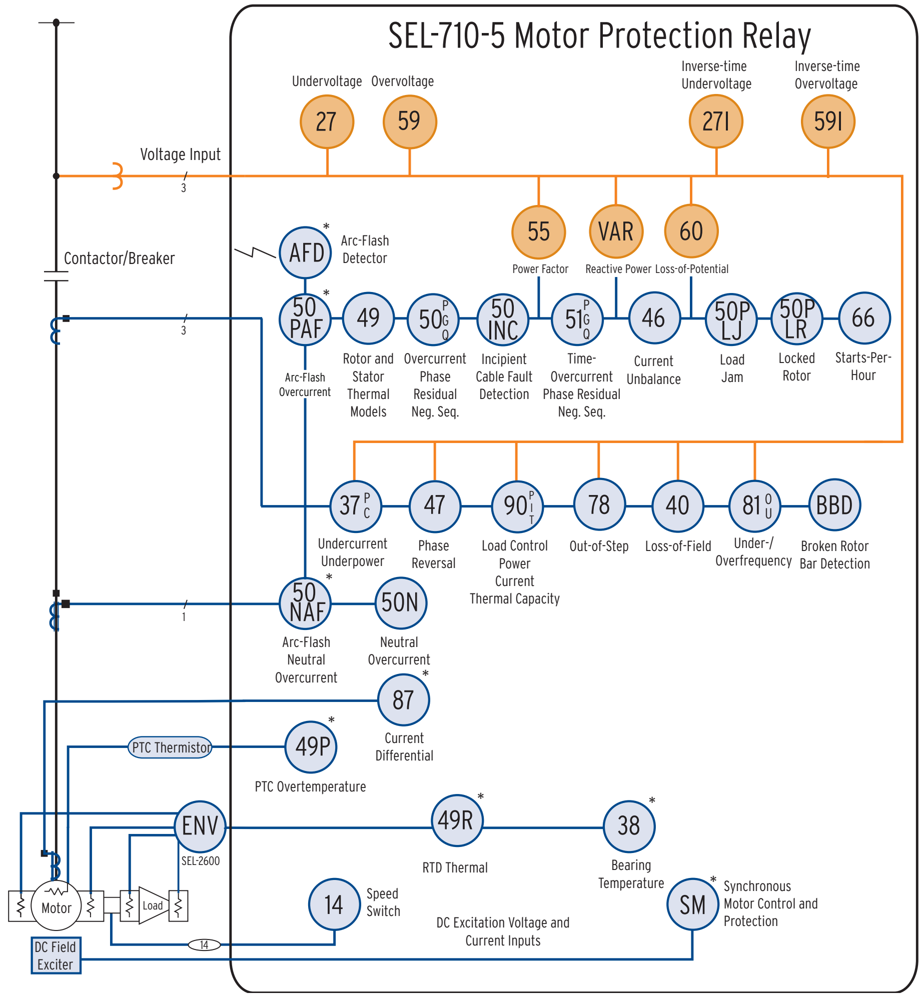



**Figure 1 Functional Diagram**

The following functions are shown in *Figure 1* and are either standard or additional ordering options for the SEL-710-5.

- Sequential Events Recorder
- Event Reports, Motor Start Reports, Motor Operating Statistics, Load Profiles, and Motor Start Trends
- Web Server
- SEL ASCII, Ethernet*, Modbus TCP/IP*, IEC 61850 Edition 2*, IEC 60870-5-103*, EtherNet/IP, RSTP*, PRP*, DNP3 LAN/WAN*, DNP3 Serial*, Modbus RTU, Telnet*, FTP*, PTP*, SNTP*, IEEE 1588-2008 firmware-based PTP*, and DeviceNet* Communications
- Eight Front-Panel Target LEDs, Six of Which 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
- Eight Programmable Pushbuttons With Two Tricolor 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
- VFD Motor Protection
- Arc-Flash Protection*
- Differential Protection*
- Synchronous Motor Control and Protection*
- Asset Monitoring Capabilities
- Front-Panel HMI with 2 x 16-Character LCD or Optional 5-Inch, Color, 800 x 480-Pixel Touchscreen Display*

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

# Protection Features

The SEL-710-5 protection and control features depend on the model selected. The models are configured with current/voltage input cards on Slot Z and specific option cards on Slot E in the relay.

Slot Z cards are assigned a two-digit code beginning with the number 8 in the SEL-710-5 Model Options Table (MOT). For example, 81 in the MOT for Slot Z indicates a SELECT 4 ACI/3 AVI card with 3-phase ac current inputs (1 A nominal), neutral ac current input (1 A nominal), and 3-phase ac voltage inputs (300 Vac).

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

*Table 1* shows the different applications for which the SEL-710-5 can be used. Current inputs are 1 A or 5 A nominal rating and voltage inputs are 300 V continuous rating.

**Table 1 Card E and Card Z Selections for SEL-710-5**

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

## Motor Thermal Protection

The SEL-710-5 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-710-5 motor thermal element provides integrated protection for all of the following motor operating conditions:

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

The SEL-710-5 dynamically calculates motor slip to precisely track motor thermal capacity used (TCU) with 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 TCU, the thermal model reduces the time between starts. It also gives the motor more time to reach its rated speed before tripping. Use the Virtual Speed Switch to back up the locked rotor protection. Also use the Coast Time setting to significantly reduce the wait time before the next start may be allowed by thermal lockout. Motors cool faster during coasting.

## Overcurrent Protection

The SEL-710-5 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-710-5 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 calculated negative-sequence current for three-phase input.

- 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. Use the 1 A or 5 A rating, or the 2.5 mA rating for sensitive neutral-current applications for high- impedance and ungrounded applications where currents are very low.

## 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 US (IEEE) time-overcurrent characteristics. Electromechanical disc reset capabilities are provided for all time-overcurrent elements.

## Differential Elements

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

## Start Monitoring/Incomplete Sequence

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

## Incipient Cable Fault Detection

Cable insulation degrades over time. The incipient cable fault detector can monitor for self-extinguishing, half-cycle overcurrent events that precede typical cable insulation failure. Monitoring the number of incipient faults can provide an early warning of cable insulation breakdown. This information can be used for preventative maintenance.

## Star-Delta (Wye-Delta) Starting

The SEL-710-5 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-710-5 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-710-5 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-710-5 provides this protection even if phase voltages are not available.

## Speed Switch and Virtual 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.

The SEL-710-5 offers a virtual speed switch (VSS) logic that can be used when a physical speed switch is not available. The logic also includes monitoring of the physical speed switch, if present, to enhance its reliability.

## Arc-Flash Protection

An arcing short circuit or a ground fault in low- or medium-voltage switchgear can cause very serious equipment damage and personal injury. They can also cause prolonged and expensive downtime.

The best way to minimize the impact of an arc-flash event is to reduce the detection and circuit breaker tripping times. Conventional protection may need several cycles to detect the resulting overcurrent fault and trip the breaker. In some cases, there may not be sufficient current to detect an overcurrent fault. Tripping may be delayed hundreds of milliseconds for sensitivity and selectivity reasons in some applications.

The arc-flash detection-based (AFD) protection can act on the circuit breaker in a few milliseconds (2–5 ms). This fast response can limit the arc-flash energy thus preventing injury to personnel and limiting or eliminating equipment damage. The arc-flash protection option for the SEL-710-5 adds eight-channel fiber-optic AFD inputs and protection elements or a four-channel fiber-optic AFD card that includes differential protection. Each channel has a fiber-optic receiver and an LED-sourced fiber-optic transmitter that continuously self-tests and monitors the optical circuit to detect and alarm for any malfunction. There are two types of applications supported by the SEL-710-5.

### Point-Sensor Application

The arc is detected by transmitting the arc-flash light captured by the optical diffuser (located appropriately in the switchgear) over a 1000 µm plastic fiber-optic cable to the optical detector in the relay. The relay performs sensor loopback tests on the optical system using an LED-based transmitter to transmit light pulses at regular intervals to the point sensor assembly (over a second fiber-optic cable). If the relay optical receiver does not detect this light, the relay declares a malfunction and alarms. *Figure 2* (top) shows a diagram for the point-sensor application.

### Clear-Jacketed Fiber Sensor Application

A second option for AFD uses a clear-jacketed 1000 µm plastic fiber-optic cable located in the switchgear equipment. One end of the fiber is connected to the optical detector in the relay and the other end is connected to the LED transmitter in the relay. The LED transmitter injects periodic light pulses into the fiber as a sensor loopback test to verify the integrity of the loop. The relay detects and alarms for any malfunction. *Figure 2* (bottom) shows a diagram for the clear-jacketed fiber sensor application.

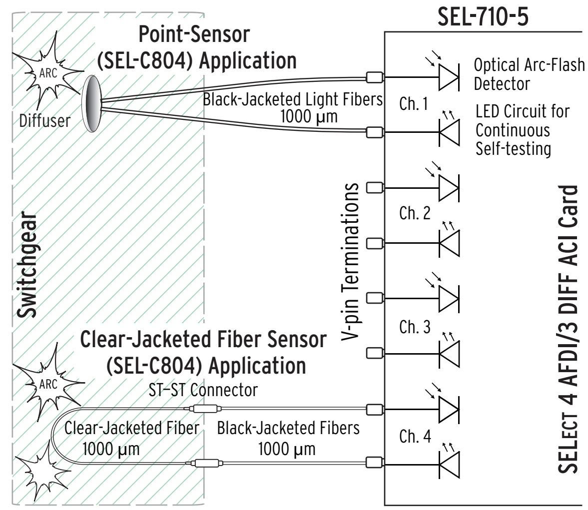



**Figure 2 Arc-Flash Detection System**

The SEL-710-5 AFD system has four or eight channels per relay that can be configured for the point-sensor or the clear-jacketed fiber sensor applications. The optional fast hybrid outputs (high speed and high current) of the relay provide fast-acting trip outputs to the circuit breaker (less than 50 µs). The fast breaker tripping can help avoid serious damage or personal injury in the case of an arc-flash event. The relay also provides light metering and light event capture to aid in setting the relay and capturing the arc-flash event for records and analysis. Settable arc-flash phase and neutral overcurrent elements are combined with arc-flash light detection elements for secure, reliable, and fast-acting arc-flash event protection.

## Over- and Undervoltage Elements

When you connect the SEL-710-5 voltage inputs to phase-to-phase connected VTs the relay provides two levels of phase-to-phase over- and undervoltage elements. When you connect the SEL-710-5 voltage inputs to phase-to-neutral connected VTs, the relay provides two levels of phase-to-neutral over- and undervoltage elements.

## Inverse-Time Over- and Undervoltage Elements

Custom programmable, IEC equation-based inverse-time overvoltage (59I) and undervoltage (27I) elements in the SEL-710-5 add flexibility in coordinating protection and control schemes. Inverse-time overvoltage and inverse-time undervoltage elements operate on the measured phase-to-neutral voltages, or phase-to-phase voltages.

## Loss-of-Potential Logic

The SEL-710-5 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-710-5 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-710-5 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-710-5 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-710-5 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-710-5 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 load control upper setting level for one second, the auxiliary relay assigned to LOADUP will operate. The auxiliary relay will reset when the parameter drops below the upper level setting for one second.

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

## Synchronous Motor Protection and Starting Control

The SEL-710-5 provides two levels of field over- and undervoltage, field over- and undercurrent, and field resistance protection. Also, loss-of-field (40), out-of-step (78), and loss-of-synchronism (pull-out) protection are available as options. This relay synchronizes automatically during starting by applying dc excitation voltage to the motor field at correct slip frequency and rotor angle to lock the motor to synchronous speed. The following event report shows the synchronous motor start sequence with slip at 10 percent of nominal. The relay offers voltage discharge resistor (VDR) based or stator current based slip measurement for field closing control.

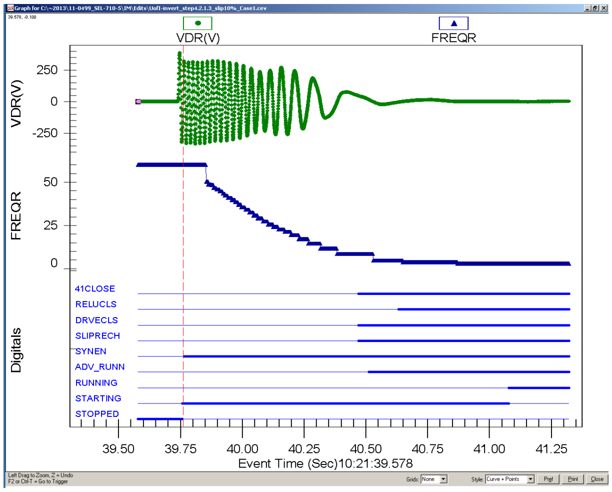



**Figure 3 Event Capture of Synchronous Motor Starting**

## Loss-of-Field Protection (40)

Two offset positive-sequence mho elements detect loss-of-field conditions. Settable time delays help reject power swings that pass through the machine impedance characteristic. The loss-of-field elements are supervised by the torque-control setting.

## Out-of-Step Protection (78)

The SEL-710-5 relays use a single or double blinder scheme, depending on user selection, to detect an out-of-step condition. In addition to the blinders, the scheme uses an mho circle that restricts the coverage of the out-of-step function to the necessary extent. Furthermore, both schemes contain current supervision and torque control to supervise the operation of the out-of-step element.

## Loss-of-Synchronism (Pull-out) Protection

The SEL-710-5 includes a loss-of-synchronism (pull-out) detection logic that operates when the motor power factor falls below a setting. The loss-of-synchronism logic also operates when the maximum phase current is greater than 3.5 times the full-load current of the motor.

## Variable Frequency Drive (VFD)

When the VFD application is selected, the relay uses rms current magnitudes instead of fundamental magnitude for the phase/residual overcurrent elements and the motor thermal model. If voltage inputs are used, make sure the inputs are nearly sinusoidal without any multiple zero crossings. Exercise caution when using power and frequency elements.

# Operator Controls

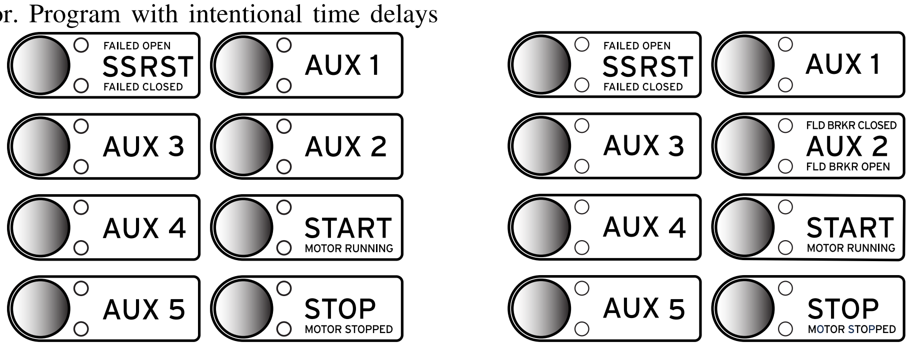
Operator controls eliminate traditional panel control switches. Eight conveniently sized operator controls, each with two programmable tricolor LEDs, are located on the relay front panel. You can set the SER to track operator controls. You can also change operator control functions using SELOGIC control equations. The operator control descriptions in *Figure 4* are for factory-set logic.

All 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.

In the SEL-710-5 with touchscreen display, you can also use the front-panel operator control pushbuttons to jump to a specific screen while using them for START/STOP operations, etc. You can program the selectable operator pushbutton screen settings under the **Touchscreen** settings category in QuickSet and map the button to a specific screen.

**Note:** All text can be changed with the configurable labels.




Standard Operator Control    Optional Synchronous Motor Operator Control

**Figure 4 Operator Controls for Standard and Optional Synchronous Motor Model**

# Built-In Web Server

Every Ethernet-equipped SEL-710-5 includes a built-in web server. Use any standard web browser to interface with the relay using any standard web browser to perform the following actions:

- ➤ Log in with password protection.
- ➤ Safely read the relay settings.
- ➤ Verify the relay self-test status and view the relay configuration.
- ➤ Inspect meter reports.
- ➤ Download SER and event reports.
- ➤ Upload new firmware (firmware upgrade).

*Figure 5* shows the fundamental metering screen that can be accessed by clicking **Meter > Fundamental**. Use the Meter menu to view all the available relay metering statistics.

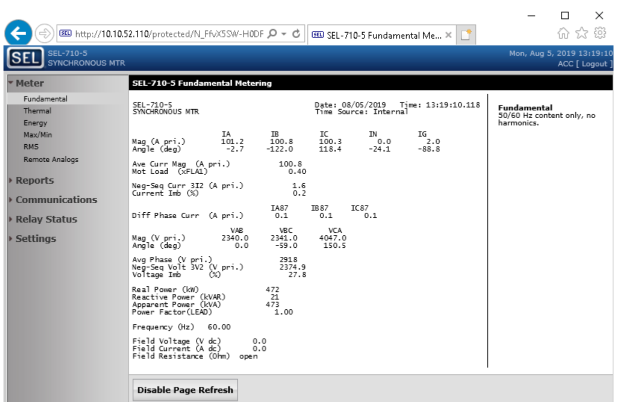



**Figure 5 Fundamental Meter Report Webpage**

*Figure 6* shows the Group 1 settings webpage. You can view the settings of each relay settings class by selecting **Settings** and the respective relay settings class.

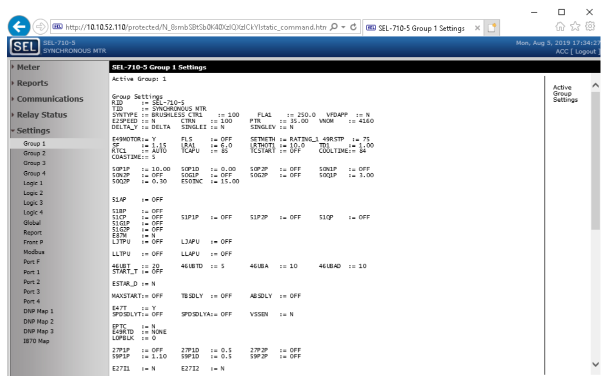



**Figure 6 Group 1 Settings Webpage**

You can upgrade the relay firmware through the relay web server by clicking **System > File Management**, available at Access Level 2, and selecting the firmware upgrade file. *Figure 7* shows the firmware upgrade webpage.

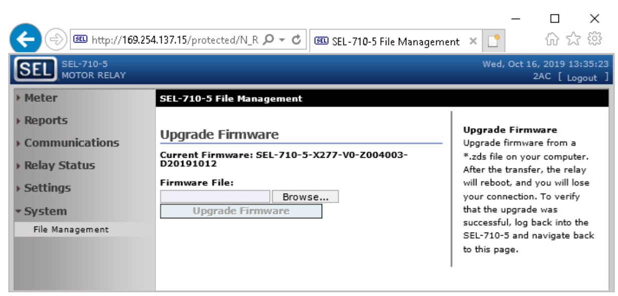



**Figure 7 Upgrade the Relay Firmware From the File Management Webpage**

# Relay and Logic Settings Software

QuickSet simplifies settings and provides analytical support for the SEL-710-5. 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 events; and analyze power system events with the integrated waveform and harmonic analysis tools.

The following features of QuickSet can help you monitor, commission, and test the SEL-710-5:

- The PC interface remotely retrieves power system data.
- The 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.
- Use the Bay Control to design new bay screens and edit existing bay screens by launching ACSELERATOR Bay Screen Builder SEL-5036 Software for SEL-710-5 relays with the touchscreen display.

## ACSELERATOR Bay Screen Builder SEL-5036 Software

The SEL-710-5 with the touchscreen display layout option provides you with the ability to design bay configuration screens to meet your system needs. You can display the bay configuration as a single-line diagram (SLD) on the touchscreen. You can use ANSI and IEC symbols, along with analog and digital labels, for the SLD to indicate the status and control of the breaker and two- or three-position disconnects, bus voltages, and power flow through the breaker. In addition to SLDs, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. You can design these screens with the help of Bay Screen Builder in conjunction with QuickSet. Bay Screen Builder provides an intuitive and powerful interface to design bay screens to meet your application needs.

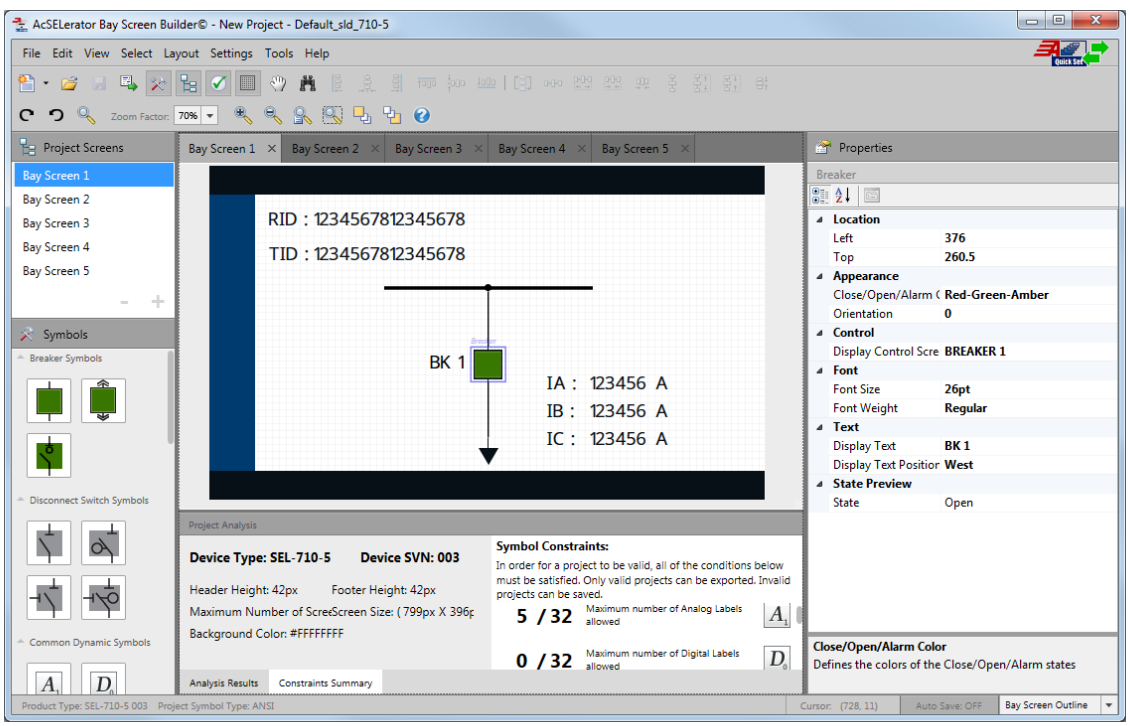



**Figure 8 Bay Screen Builder**

# Metering and Monitoring

The SEL-710-5, depending on the model selected, provides extensive metering capabilities. See *Specifications on page 27* for metering and power measurement accuracies. As shown in *Table 2*, 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 2 Metering Capabilities**

| Types of Metering | | | |
|---|---|---|---|
| Instantaneous<br>Remote Analogs<br>Energy | Differential<br>Math Variables<br>RMS | Max/Min<br>Light | Analog Inputs<br>Thermal |

| Quantities | Description |
|---|---|
| Currents IA, IB, IC, IN, IG, IAV, 3I2, UBI | Input currents, residual ground current (IG = 3I0 = IA + IB + IC), average current, negative-sequence current, current imbalance |
| 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 imbalance |
| Power kW<br>kVAR<br>kVA | Three-phase kilowatts, kilovars, and kilovolt-amps |
| Energy MWh3P,<br>MVARh3P-IN,<br>MVARh3P-OUT,<br>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 |
| Field Voltage, Field Current, Field Resistance | Exciter voltage, exciter current, field resistance |
| Light Intensity (%) LS1–LS8 | Arc-flash light inputs in percentage of full scale |
| AIx01–AIx08 | Analog Inputs |
| MV01–MV32 | Math Variables |
| RA001–RA128 | Remote Analogs |
| RTD1–RTD12 | RTD temperature measurement (degrees C) |
| Stator TCU, Rotor TCU | % of Thermal Capacity Used |

## Asset Monitoring

To monitor the health of your motor asset and accompanying devices, the SEL-710-5 supports the following asset monitoring capabilities:

- Vibration Monitoring
- Motor Monitoring Using Fourier Analysis
- Broken Rotor Bar Detection
- Motor Start Report
- Motor Maintenance Report
- Motor Operating Statistics
- Motor Start Trending
- Load Profiling
- Incipient Cable Fault Detection
- Molded Case Circuit Breaker Health
- Breaker Monitoring

With these asset monitoring capabilities, you can reduce production losses from unexpected equipment failures, and lower maintenance costs by switching to condition-based maintenance schedules.

## Load Profile

The SEL-710-5 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 (6500 entries total).

## Motor Start Report, Statistics, and Trend

The SEL-710-5 records motor start data for each motor start. The relay stores 30 of the latest motor start reports in nonvolatile memory. The motor start data are taken periodically after the starting current is detected. Use QuickSet to view the motor start report graphically. The SEL-710-5 also retains useful machine operating statistics information for the protected motor.

For each motor start, the relay stores a motor start report and adds these data to the motor start trending buffer. Motor start tending tracks motor start data for the past eighteen 30-day periods.

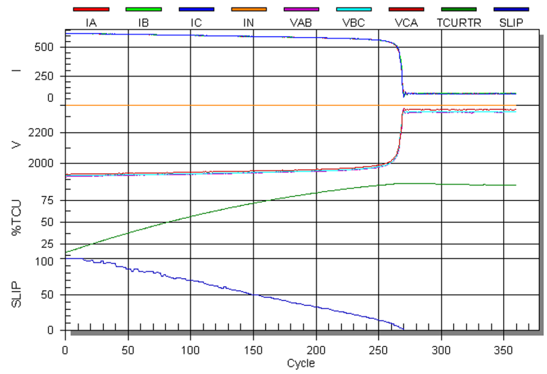



**Figure 9 Graphical Display of Motor Start Report**

## Motor Maintenance Report

The SEL-710-5 computes and stores motor parameters, such as maximum starting current, minimum starting voltage, power on start/stop, and time to start/stop, and compares them to values obtained during a baseline run. If any of the values measured during a given run deviates significantly from the values measured during the baseline run, the SEL-710-5 asserts the Relay Word bit that corresponds to that value.

# Improve Situational Awareness

## Vibration Monitoring

The SEL-710-5 provides five vibration monitoring elements and each element can monitor a connected vibration transducer via analog inputs or math variables. Each vibration measurement is compared against a set of thresholds that define the four evaluation zones: Recently Commissioned, Acceptable, Warn, or Damaging. In SEL-710-5 models with the touchscreen display option, you can also view in a bar graph the measured values of vibration transducers connected to a motor.

## Broken Rotor Bar Detection (BBD)

The SEL-710-5 detects broken rotor bars in induction motors by analyzing the current signatures under sufficient motor load conditions. BBD determines broken bars using the relative magnitudes of the signals at the sideband frequencies caused by the broken bars, with respect to the signal magnitudes at the system frequency. This normalization allows the algorithm to identify rotor failures independent of the motor characteristics.

This function provides the following features for motor monitoring and protection.

- A BBD element that uses motor current signature analysis for continuous monitoring and early detection of broken rotor bars.
- A history report that includes the date and time of the BBD operations along with the maximum sideband magnitude and associated frequency. These data help correlate the BBD operations to other events in the industrial plant.
- A Fourier transform function that calculates the frequency spectrum of the stator currents or voltages for motor diagnostics.
- The Fourier transform output can be viewed graphically via QuickSet.
- A compressed harmonic meter report for voltages and current.

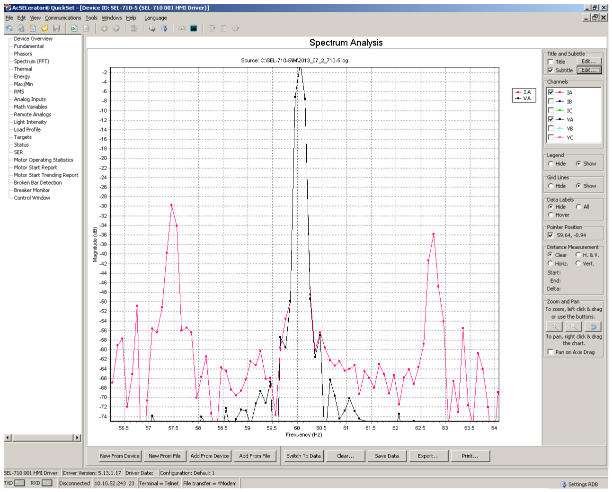



**Figure 10 Spectrum of a Running Motor With Three Broken Bars**

## Event 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 1/32-cycle resolution and filtered or raw analog data).

The relay stores as many as 9 of the most recent 180-cycle, 23 of the most recent 64-cycle, or 49 of the most recent 15-cycle event reports in nonvolatile memory. The relay always appends relay settings at the time of the event to the bottom of each event report.

The following analog data formats are available.

- 1/4-cycle or 1/32-cycle resolution, unfiltered or filtered analog, ASCII or Compressed ASCII reports
- 1/32-cycle resolution COMTRADE reports

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.

## Synchronized Measurements

The IRIG-B time-code input synchronizes the SEL-710-5 internal clock time to within ±1 µs 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 3 on the SEL-710-5). For time accuracy specifications for metering and events, see *Specifications*.

## Circuit Breaker Contact Wear Monitor

Circuit breakers experience mechanical and electrical wear every time they operate. Intelligent scheduling of breaker maintenance takes into account 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-710-5 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 11*) the relay alarms via output contact, communications port, or front-panel display. This kind of information allows timely and economical scheduling of breaker maintenance.

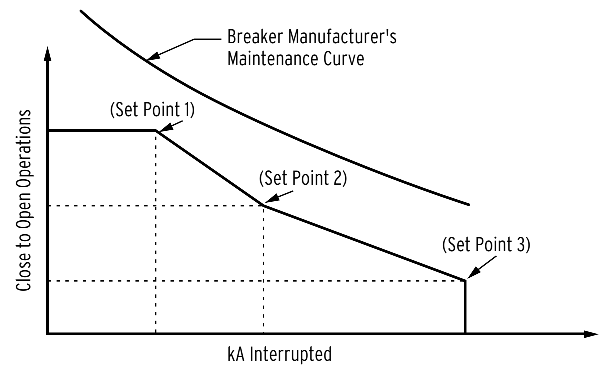



**Figure 11 Breaker Contact Wear Curve and Settings**

## Molded Case Circuit Breaker Health

The SEL-710-5 can monitor molded case circuit breaker (MCCB) health by detecting CT saturation or A/D saturation during breaker opening. You can use this function to inspect the MCCB for damage and to do preventive maintenance.

## IEC 61850 Test Mode

Test Mode allows you to test an in-service relay without accidentally operating control output contacts. Test Mode includes five different modes:

**On**: In On mode, the relay operates as normal; it reports IEC 61850 Mode/Behavior status as On and processes all inputs and outputs as normal. If the quality of the subscribed GOOSE messages satisfies the GOOSE processing, the relay processes the received GOOSE messages as valid.

**Blocked**: This mode is similar to On mode, except that the device does not trip any physical contact output.

**Test**: In Test mode, the relay processes valid incoming test signals and normal messages and operates physical contact outputs, if the outputs are triggered.

**Test/Blocked**: This is similar to Test mode, except that the device does not trip any physical contact outputs.

**Off**: The device does not process any incoming data or control commands (except commands to change the mode). All protection logic is disabled and all data quality is marked as invalid.

**Simulation**: In this mode, the relay continues to process normal GOOSE messages until a simulated GOOSE message is received for a subscription. Once a simulated GOOSE message is received, only simulated GOOSE messages are processed for that subscription. The simulated mode only terminates when LPHDSIM is returned to FALSE. When the relay is not in simulation mode, only normal GOOSE messages are processed for all subscriptions.

# Touchscreen Display

You can order the SEL-710-5 with an optional touchscreen display (5-inch, color, 800 x 480-pixel). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen display option in the SEL-710-5 features a straightforward application-driven control structure and includes intuitive and graphical screen designs.

The touchscreen display allows you to:

- View and control bay screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, SER information, and motor start trend and motor operating statistics
- View relay status and configuration
- Control relay operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen

You can navigate the touchscreen by tapping the folders and applications. The folders and applications of the Home screen are shown in *Figure 12*. Folders and applications are labeled according to functionality. Additional folder and application screens for the SEL-710-5 touchscreen display option can be seen in *Figure 13* through *Figure 23*.

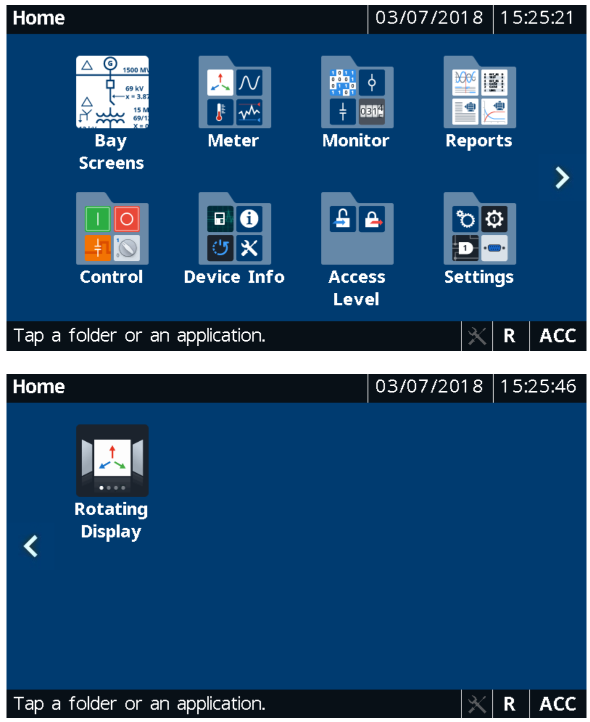



**Figure 12 Home (Default FPHome Screen)**

## Bay Screens Application

The SEL-710-5 with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as an SLD on the touchscreen. You can create as many as five bay screens with one controllable breaker, eight controllable two-position disconnects, and two controllable three-position disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed SLDs of the bay to indicate the status and control of the breaker and disconnects, bus voltages, and power flow through the breaker. *Figure 13* shows the default SLD for the touchscreen display option.

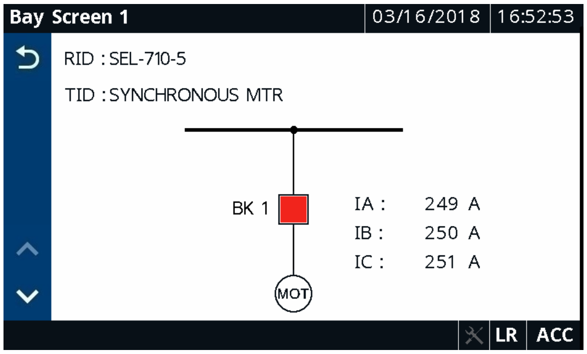



**Figure 13 Default Bay Screen**

## Meter Folder Applications

The applications in the Meter folder are part-number dependent. Only those metering applications specific to your part number appear in the Meter folder. Tapping an application in the **Meter** folder shows you the report for that particular application. Tap the **Phasor** application to view the current and voltage phasors (see *Figure 14*).

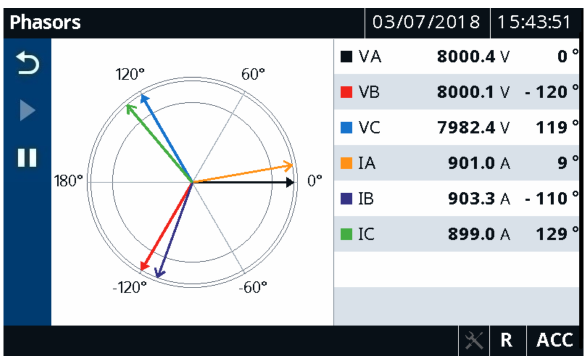



**Figure 14 Meter Phasors**

Tap the **Energy** application to view the energy metering quantities (see *Figure 15*). A reset feature is provided for the Energy, Max/Min, and Thermal applications. Tap the **Reset** button (see *Figure 15*) to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero.

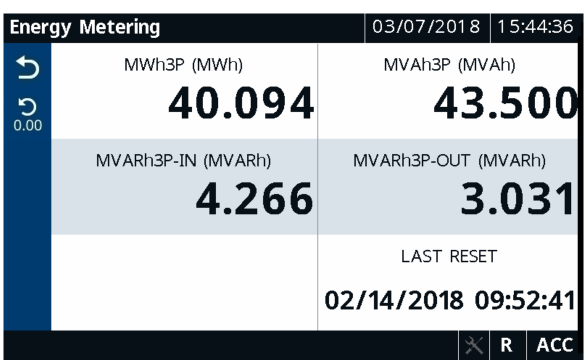



**Figure 15 Meter Energy**

## Monitor Folder Applications

Select the **Monitor** folder to navigate to the screen where you can access the Relay Word Bits, Digital Outputs, Digital Inputs, SELOGIC Counters, Breaker Wear, and Vibration applications. Tap the **Vibration** application (see *Figure 16*), which dynamically displays in a bar graph the measured values of vibration transducers connected to a motor.

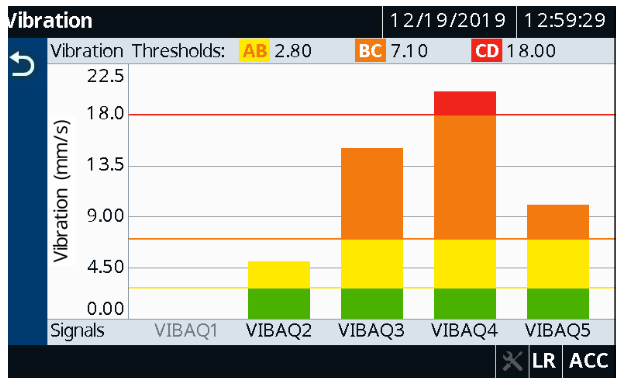



**Figure 16 Vibration Monitoring**

## Reports Folder Applications

Select the **Reports** folder to navigate to the screen where you can access the Events, SER, Motor Start Trend (MST), and Motor Statistics (MOT) applications. Use these applications to view Events, SERs, MSTs, and MOTs. To view the event summary (see *Figure 17*) of a particular event record, you can tap the event record on the Event History screen. You can also trigger an event report from the Event History screen.

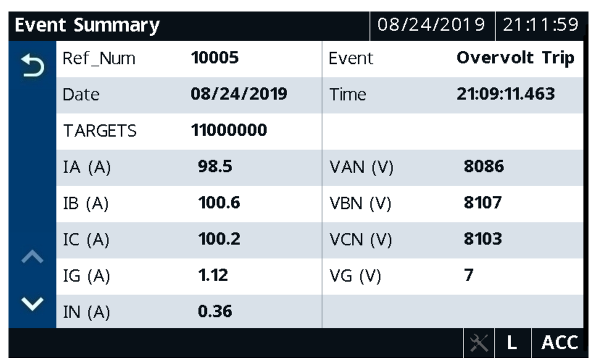



**Figure 17 Event Summary**

Tap the **Sequential Events Recorder** application to view a history of the SER reports (see *Figure 18*).

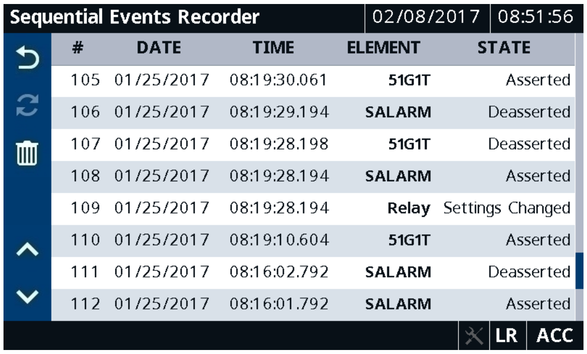



**Figure 18 Sequential Events Recorder**

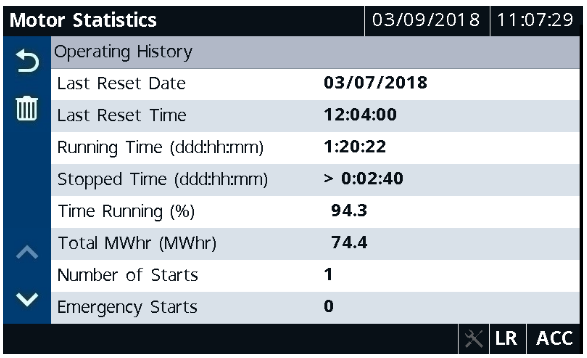



**Figure 19 Motor Statistics**

Tapping the **Trash** button on the Event History, Sequential Events Report, Motor Start Trend, and Motor Statistics screens and confirming the delete action removes the records from the relay. See *Figure 19* for the Motor Statistics report and the Trash button.

## Control Folders Applications

Select the **Control** folder to navigate to the screen where you can access the Start Motor, Stop Motor, Output Pulsing, Local Bits, Emergency Restart, and Reset TCU applications. Use the applications to perform a motor start command, motor stop command (see *Figure 20*), pulse output contacts (see *Figure 21*), control local bits, perform an emergency restart command, or to reset the thermal model.

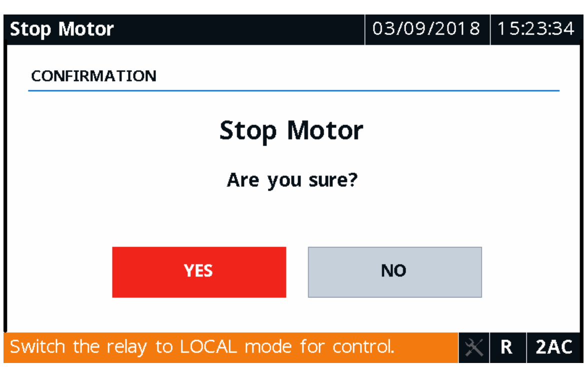



**Figure 20 Stop Motor Confirmation Screen**

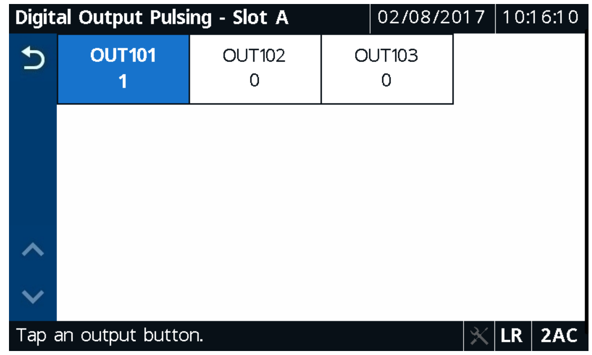



**Figure 21 Digital Output Pulsing-Slot A**

## Device Info Folder Applications

Select the **Device Info** folder to navigate to the screen where you can access specific device information applications (Status, Configuration, Arc-Flash Diagnostics, and Trip & Diag. Messages) and the Reboot application.

Tap the **Status** application to view the relay status, firmware version, part number, etc. (see *Figure 22*).

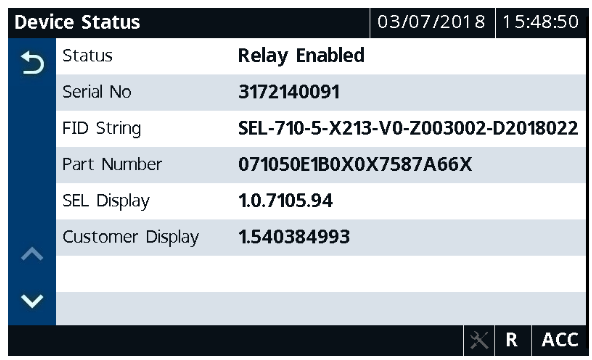



**Figure 22 Status**

To view the trip and diagnostic messages, tap the **Trip & Diag. Messages** application (see *Figure 23*). When a diagnostic failure, trip, lockout, or warning occurs, the relay displays the diagnostic message on the screen until it is either overriden by the restart of the rotating display, or the inactivity timer expires.

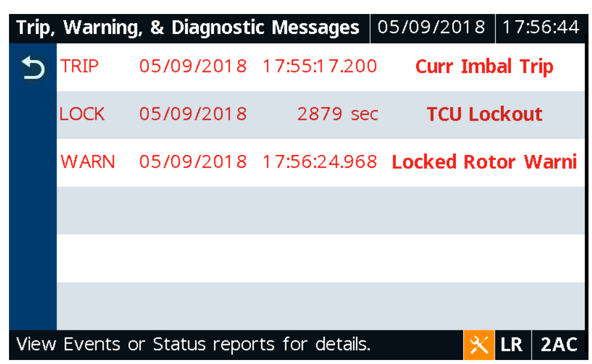



**Figure 23 Trip and Diagnostics**

# Automation

## Flexible Control Logic and Integration Features

The SEL-710-5 can be equipped with as many as four independently operated serial ports:

- ➤ EIA-232 port on the front panel
- ➤ EIA-232 or EIA-485 port on Slot B card in the rear
- ➤ EIA-232 fiber-optic port on Slot B card in the rear
- ➤ EIA-232 or EIA-485 port on the optional communications card in Slot C in the rear

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 RTAC, SEL communications processor, SEL computing platform, SCADA serial port, and/or RTUs for local or remote communication. Refer to *Table 3* for a list of communications protocols available in the SEL-710-5.

**Table 3 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.<br>Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element, 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. |
| Fast Message Protocol | Use this protocol to write Remote Analog Data from other SEL relays or communications processors via unsolicited writes. |
| DNP3 | Serial or Ethernet-based DNP3 protocols.<br>Provides default and mappable DNP3 objects that include access to metering data, protection elements, Relay Word bits, contact I/O, targets, SER, relay summary event reports, and setting group selection. |
| 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 Edition 2 | 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. The DeviceNet option has been discontinued and is no longer available to order as of September 25, 2017. |
| SNTP | Ethernet-based protocol that provides time synchronization of the relay. |
| IEEE 1588-2008 firmware-based PTP | Ethernet-based protocol that provides time synchronization of the relay. |
| PRP | Provides seamless recovery from any single Ethernet Network failure in a dual redundant Ethernet network, in accordance with IEC 62439-3. |
| IEEE 60870-5-103 | Serial communications protocol—International standard for interoperability between intelligent devices in a substation. |
| EtherNet/IP | Ethernet-based protocol that provides access to metering data, protection elements, targets, and contact I/O. |
| RSTP | Provides faster recovery in response to changes and failures in switched mode dual redundant Ethernet networks in accordance with IEEE 802.1Q-2014. |

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-710-5 (see *Figure 24*).

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

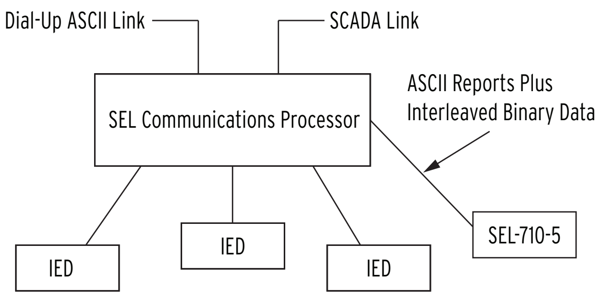



**Figure 24 Example Communication System**

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-710-5 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.
- **Eliminate 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-710-5 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-710-5 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.

## Fast Message Protocol

SEL Fast Message Protocol is a method to input or modify Remote Analogs in the SEL-710-5. These Remote Analogs can then be used in SEL Math or SELOGIC control equations. Remote Analogs can also be modified via Modbus, DNP3, and IEC 61850.

# Ethernet Network Architectures

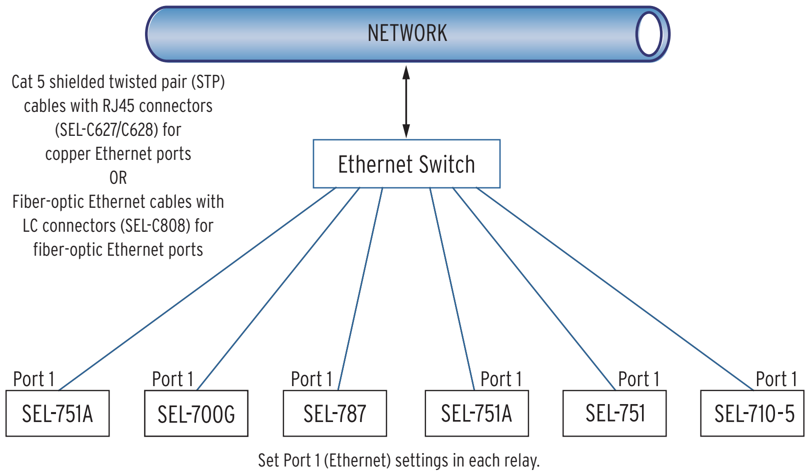



**Figure 25 Simple Ethernet Network Configuration**

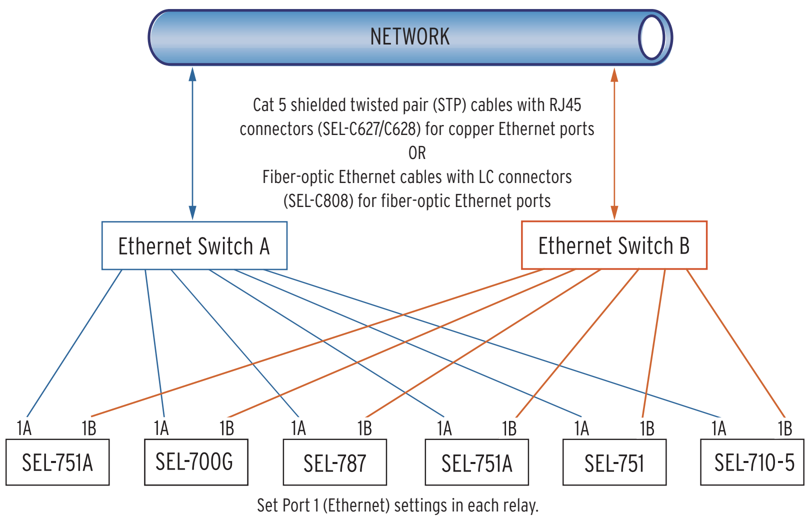



**Figure 26 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)**

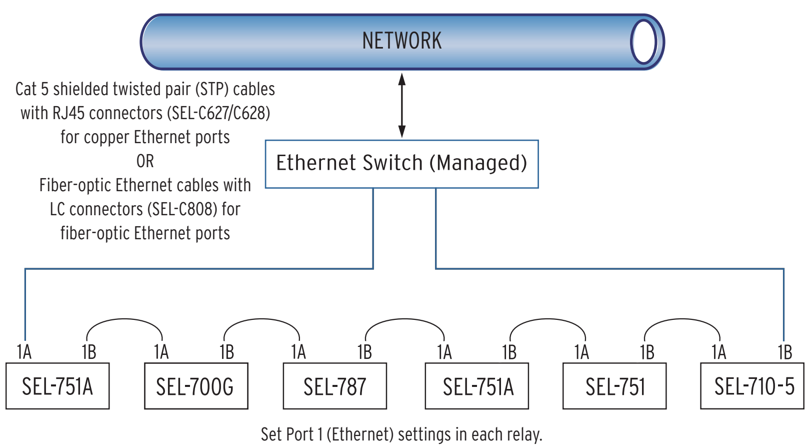



**Figure 27 Ethernet Network Configuration With Ring Structure (Switched Mode)**

# 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-710-5.

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 28*). 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.

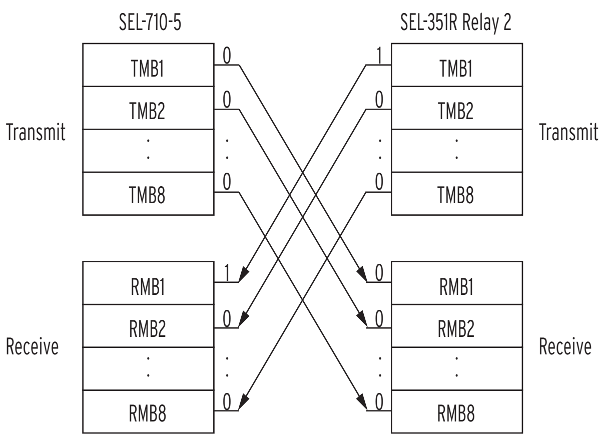



**Figure 28 MIRRORED BITS Transmit and Receive Bits**

## Status and Trip Target LEDs

The SEL-710-5 includes 24 status and trip target tricolor 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 31*. 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 quick, professional-looking labels for the SEL-710-5. 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-710-5, including the standard model shown in *Figure 31*.

## Web Server

Web Server allows you to communicate with the relay via the Ethernet Port without the need for additional communication software (web browser required). Web Server allows you to access metering and monitoring data, and also supports firmware upgrade.

## Firmware Download Via Ethernet Ports

Relay firmware can be securely downloaded to your relay via the Ethernet port. The firmware is digitally signed to prevent malicious modification. Additionally, the Ethernet firmware download allows you to access and update all your network relays simultaneously.

# Relay Dimensions

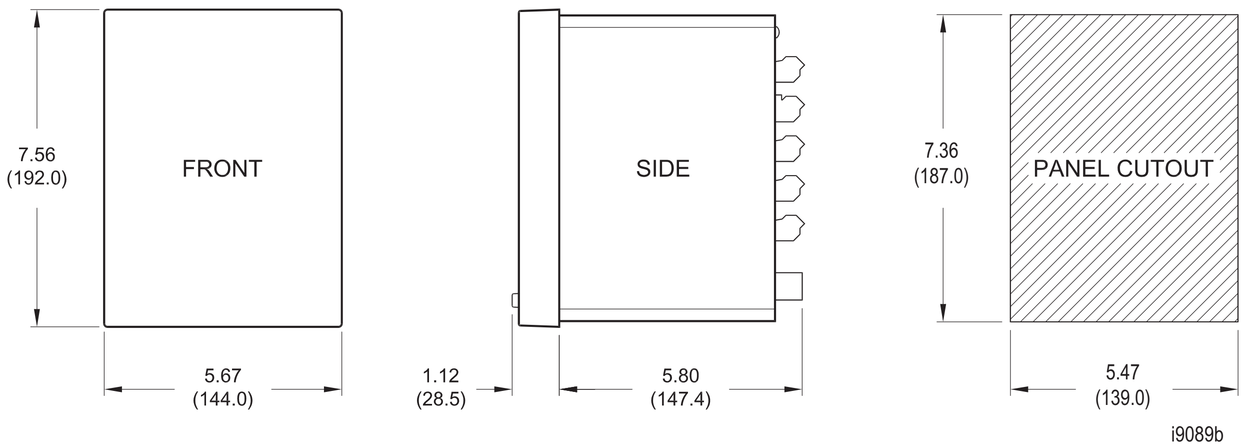



**Figure 29 SEL-710-5 Dimensions for Rack- and Panel-Mount Models**

# Hardware Overview

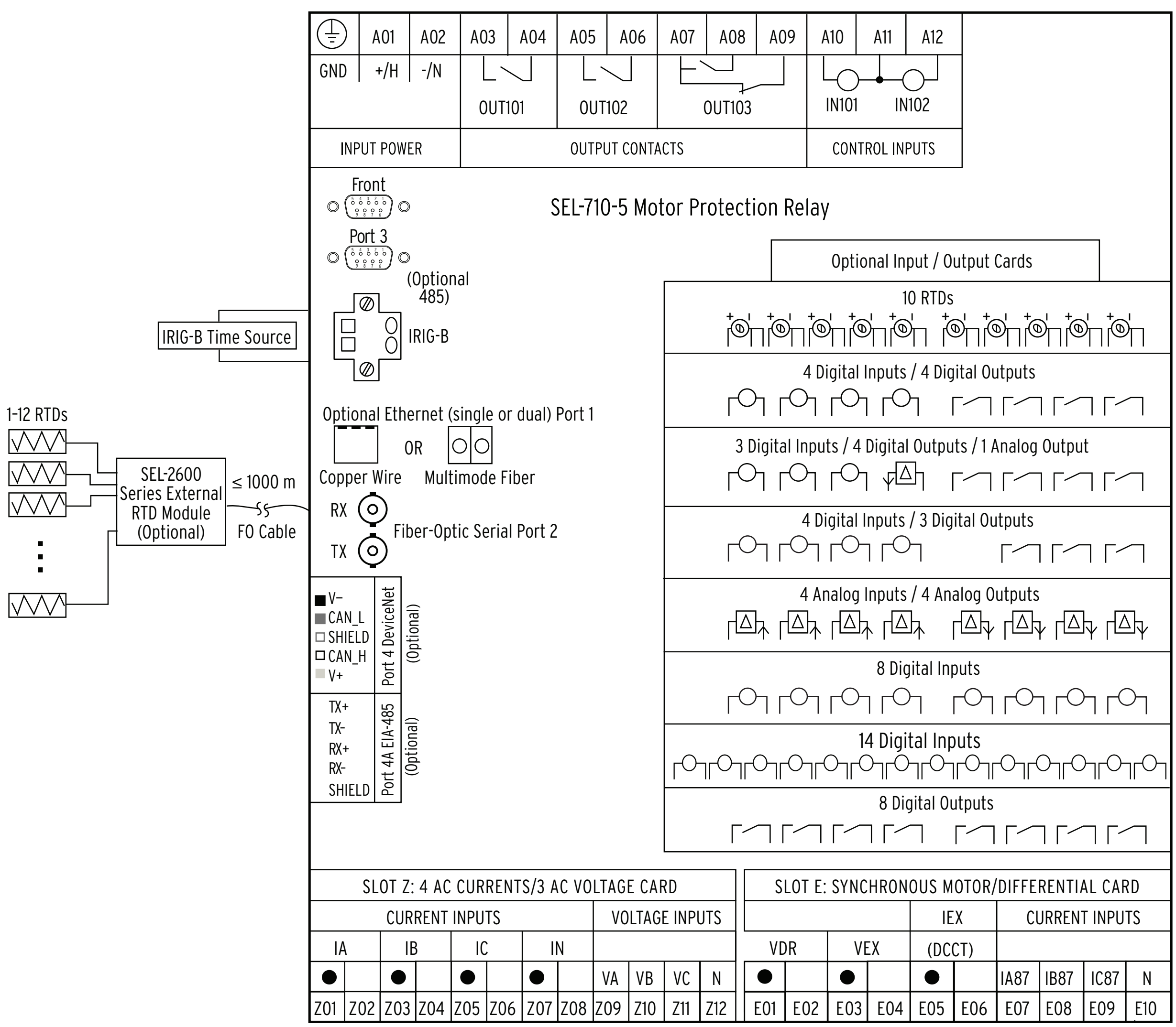
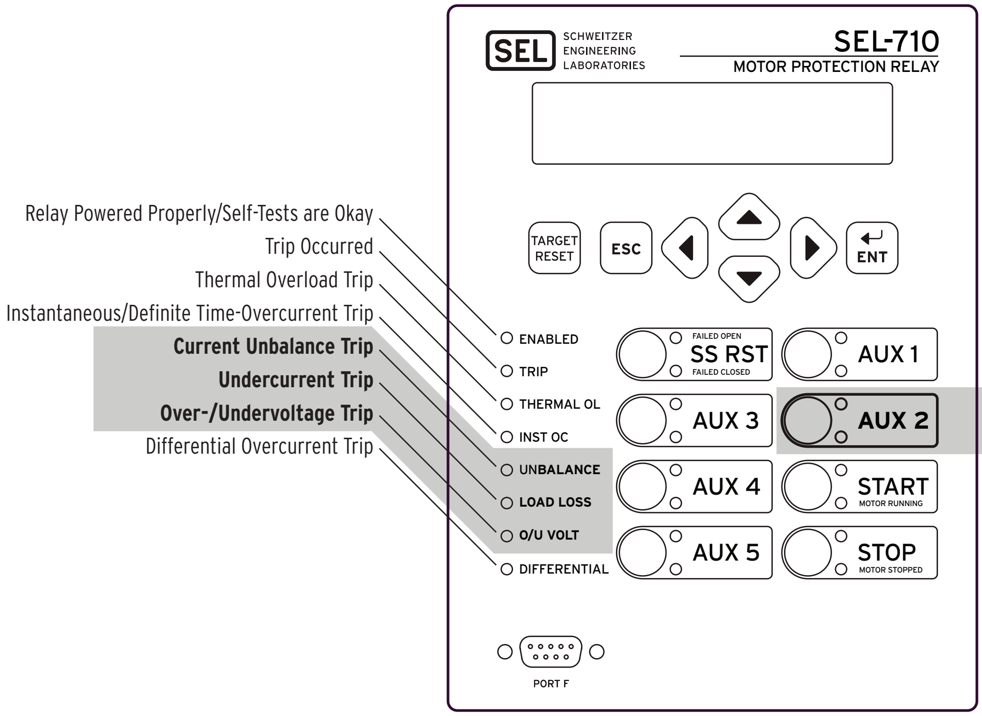



**Figure 30 Hardware Overview for Synchronous Motor/Differential Card In Slot E**

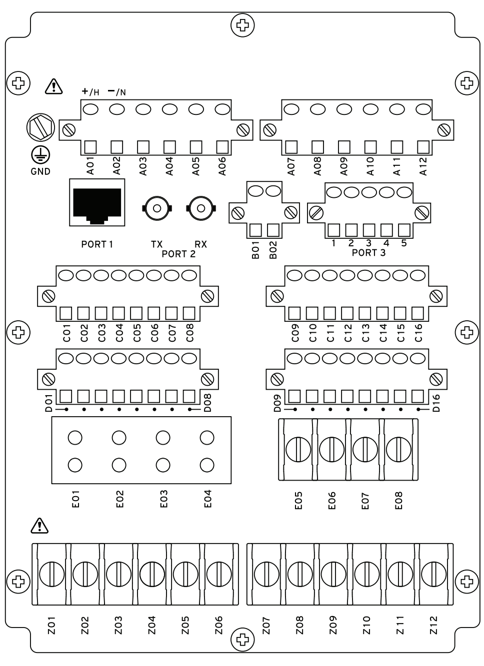
# Relay Panel Diagrams

## Induction Motor Protection Relay

(A) Front Panel With Default Configuration Labels




(B) Rear-Panel View




(C) Side-Panel View

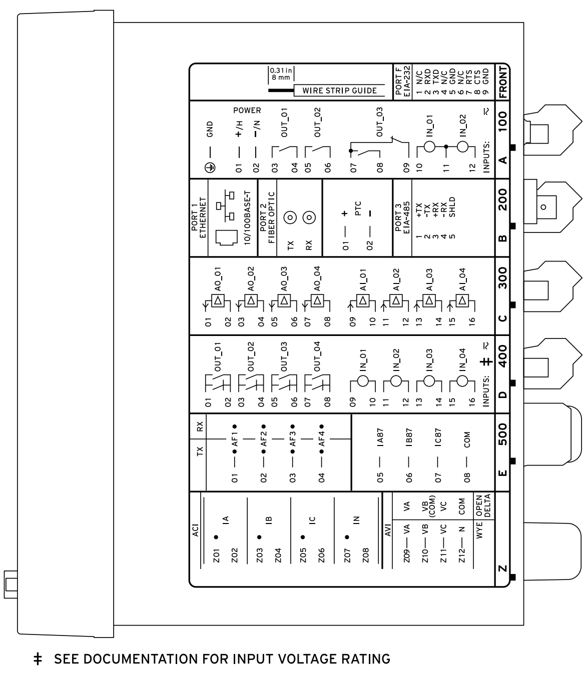



**Figure 31 Single Copper Ethernet, Fiber-Optic Serial, EIA-485 Communications, PTC, 4 AI/4 AO, Fast Hybrid 4 DI/4 DO, and 4 Arc Flash/Differential Option (MOT: 071050E1A6XCA74851300)**

## Synchronous Motor Protection Relay

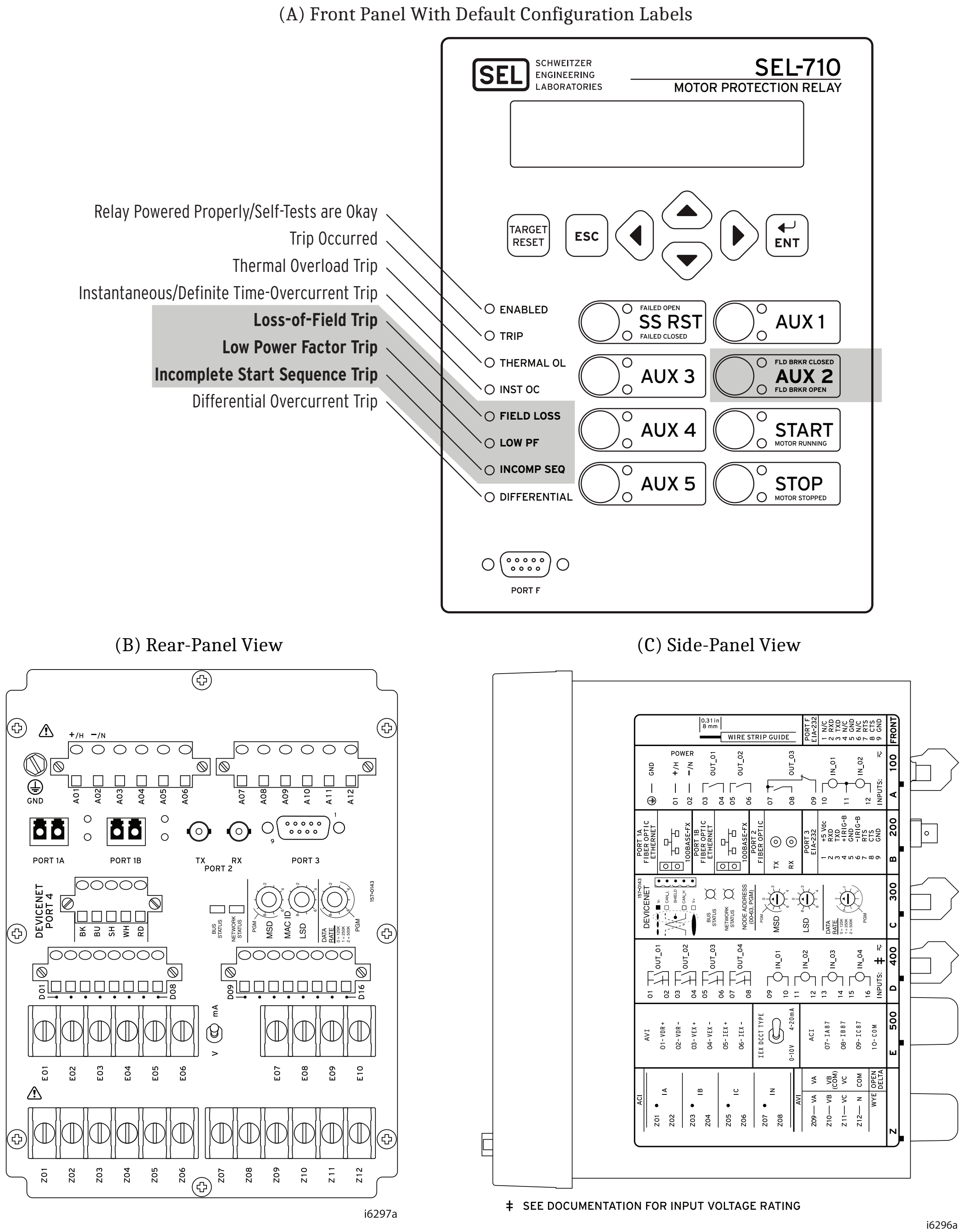
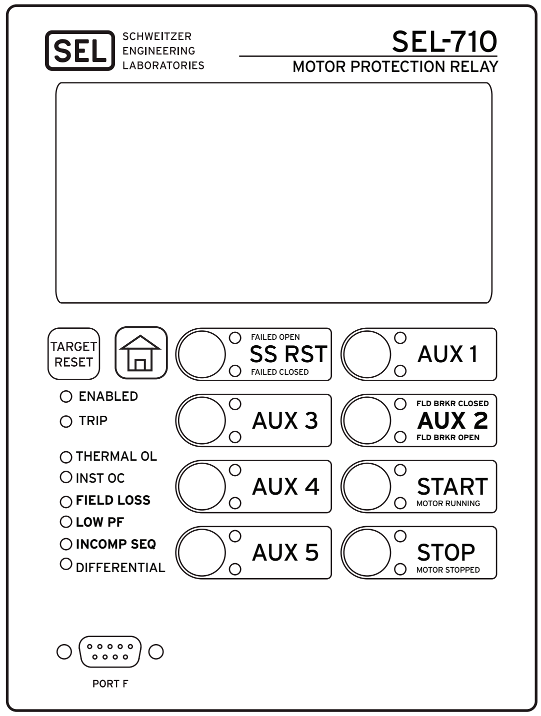


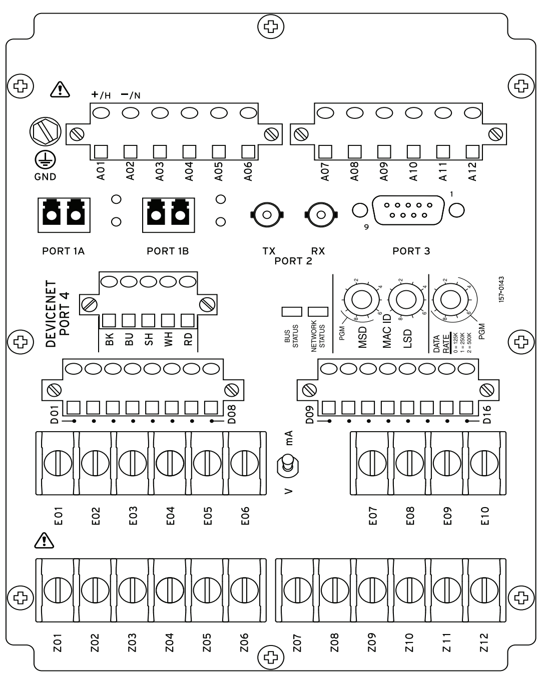

**Figure 32 Dual Fiber-Optic Ethernet, Fiber-Optic Serial, DeviceNet, Fast Hybrid 4 DI/4 DO, and Synchronous Motor/Differential Option (MOT: 071050E1AA3CA75850830)**

## Synchronous Motor Protection Relay with Touchscreen

(A) Front Panel with Default Configuration Labels




(B) Rear-Panel View




(C) Side-Panel View

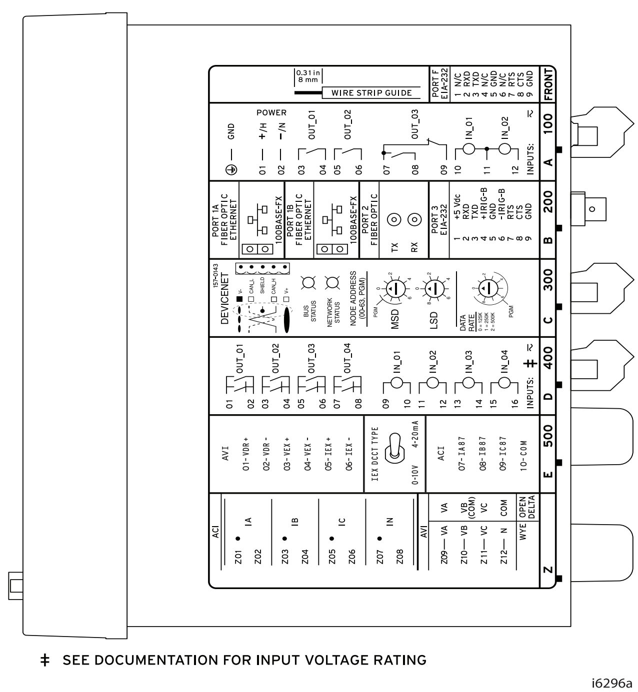



**Figure 33 Color Touchscreen Display, Dual Fiber-Optic Ethernet, Fiber-Optic Serial, DeviceNet, Fast Hybrid 4 DI/4 DO, and Synchronous Motor/Differential Option (MOT: 071050E1AA3CA7585A830)**

# Applications

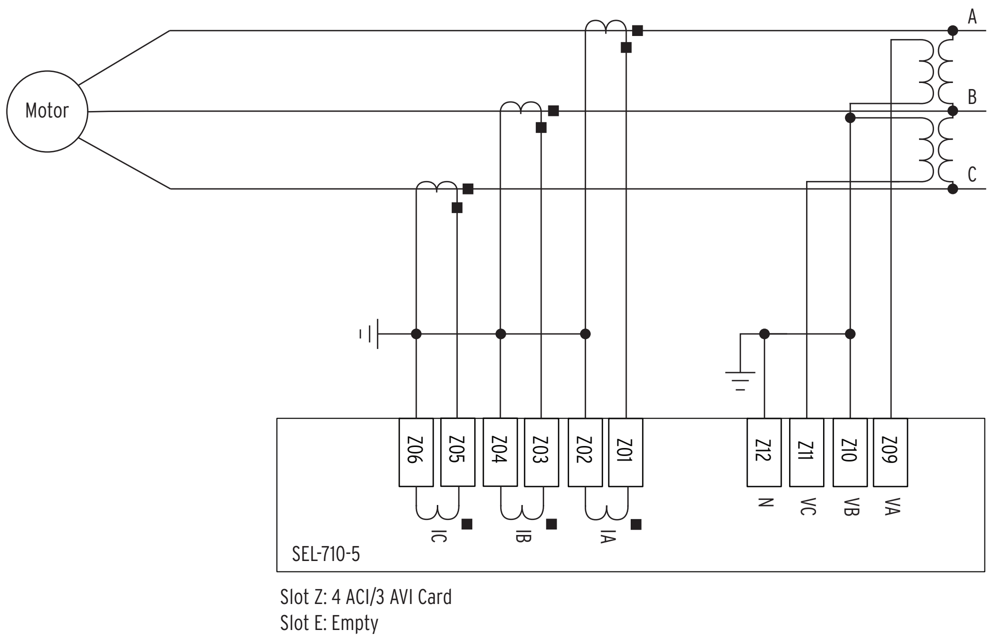



**Figure 34 AC Connections for Induction Motor Application**

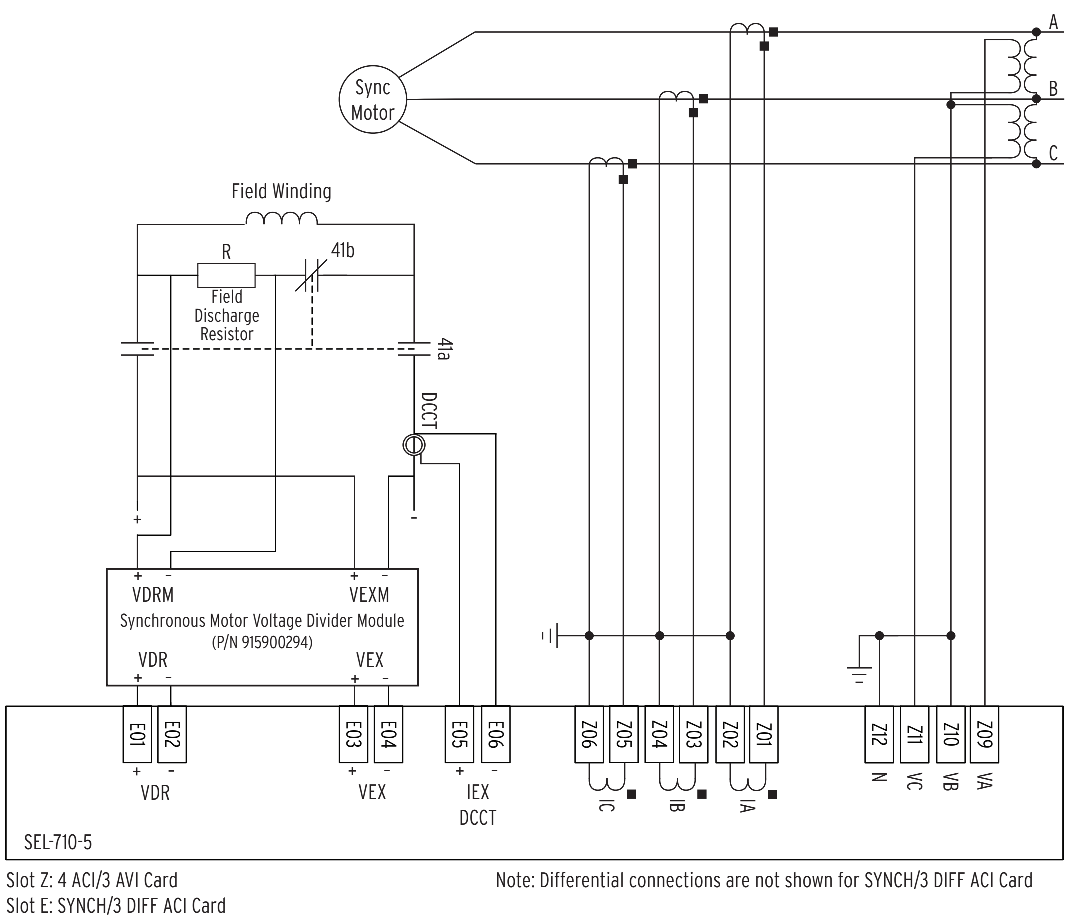
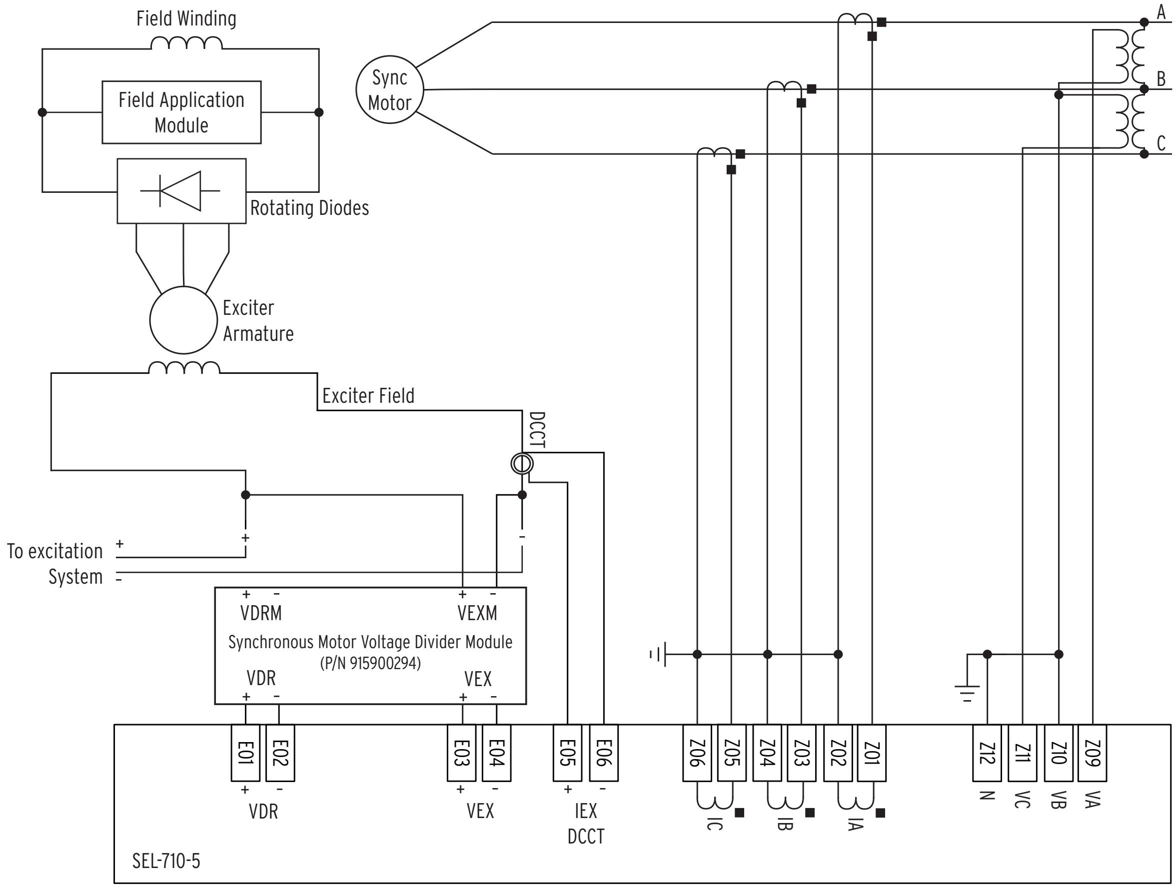
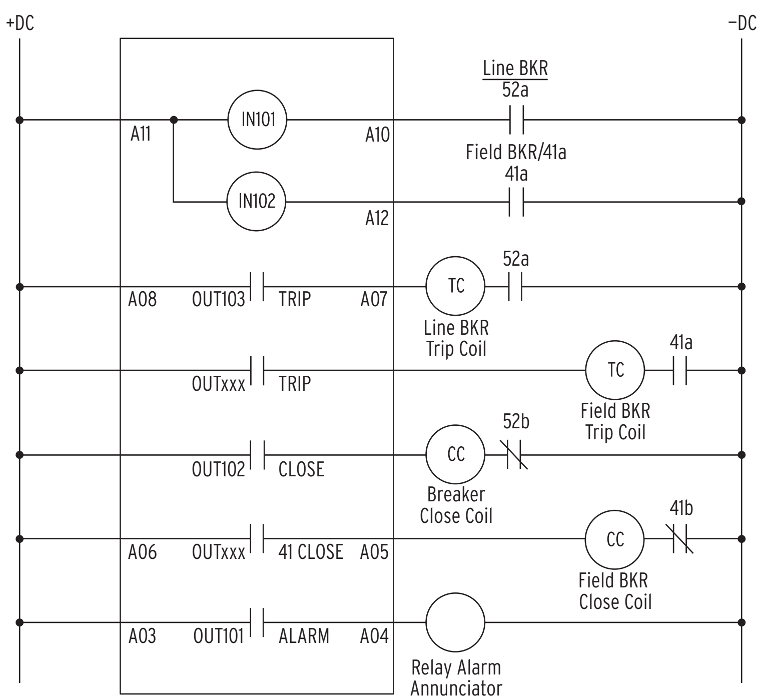



**Figure 35 Typical AC/DC Connection Diagram for a Brush-Type Synchronous Motor Application**




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

**Figure 36 AC/DC Connections for a Brushless-Type Synchronous Motor Application**




NOTES:
- OUTxxx requires an additional I/O card in Slot C or D.
- IN101–102 and OUT101–103 are in the "base" relay.
- Additional I/O and relay logic may be necessary for a specific application.
- Settings changes are not shown.

**Figure 37 Typical DC Control Connection Diagram (Shown for the Synchronous Motor Application)**

# Specifications

## Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

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

CE Mark in accordance with the requirements of the European Union

RCM Mark in accordance with the requirements of Australia

UKCA Mark in accordance with the requirements of United Kingdom

### Normal Locations

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

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

### Hazardous Locations

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

EU

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

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

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

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

## General

### AC Current Inputs (IA, IB, IC, IN)

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

| | |
|---|---|
| Measurement Category: | II |

#### Phase Currents

$I_{NOM}$ = 5 A

| | |
|---|---|
| Continuous Rating: | 3 • $I_{NOM}$ @ 85°C<br>4 • $I_{NOM}$ @ 55°C |
| A/D Measurement Limit: | 217 A peak (154 A rms) symmetrical |
| Saturation Current Rating: | Linear to 96 A symmetrical |
| 1-Second Thermal: | 500 A |
| Burden (per phase): | <0.1 VA @ 5 A |

$I_{NOM}$ = 1 A

| | |
|---|---|
| Continuous Rating: | 3 • $I_{NOM}$ @ 85°C<br>4 • $I_{NOM}$ @ 55°C |
| A/D Measurement Limit: | 43 A peak (31 A rms) symmetrical |
| Saturation Current Rating: | Linear to 19.2 A symmetrical |
| 1-Second Thermal: | 100 A |
| Burden (per phase): | <0.01 VA @ 1 A |

#### Neutral Currents

$I_{NOM}$ = 5 A

| | |
|---|---|
| Continuous Rating: | 3 • $I_{NOM}$ @ 85°C<br>4 • $I_{NOM}$ @ 55°C |
| A/D Measurement Limit: | 32 A peak (22.6 A rms) symmetrical |
| Saturation Current Rating: | Linear to 11 A symmetrical |
| 1-Second Thermal: | 500 A |
| Burden (per phase): | <0.1 VA @ 5 A |

$I_{NOM}$ = 1 A

| | |
|---|---|
| Continuous Rating: | 3 • $I_{NOM}$ @ 85°C<br>4 • $I_{NOM}$ @ 55°C |
| A/D Measurement Limit: | 6.4 A peak (4.5 A rms) symmetrical |
| Saturation Current Rating: | Linear to 2.2 A symmetrical |
| 1-Second Thermal: | 100 A |
| Burden (per phase): | <0.01 VA @ 1 A |

$I_{NOM}$ = 2.5 mA

| | |
|---|---|
| Continuous Rating: | 3 • $I_{NOM}$ @ 85°C<br>4 • $I_{NOM}$ @ 55°C |
| A/D Measurement Limit: | 40.9 mA peak (28.9 mA rms) symmetrical |
| Saturation Current Rating: | Linear to 12.5 mA symmetrical |
| 1-Second Thermal: | 100 A |
| Burden (per phase): | <0.1 mVA @ 2.5 mA |

### Differential Currents (IA87, IB87, IC87)

$I_{NOM}$ = 1 A/5 A Universal

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

### AC Voltage Inputs (VA, VB, VC)

| | |
|---|---|
| $V_{NOM}$ (L-L)/PT Ratio Range: | 100–250 V (if DELTA_Y := DELTA)<br>100–440 V (if DELTA_Y := WYE) |
| Rated Continuous Voltage: | 300 Vac |
| 10-Second Thermal: | 600 Vac |
| Burden: | <0.1 W |
| Input Impedance: | 4 MΩ differential (phase-to-phase)<br>7 MΩ common mode (phase-to-chassis) |

### Synchronous Motor Inputs

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

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

| | |
|---|---|
| Rated Operating Voltage: | As high as 955 Vrms |
| Maximum Continuous Voltage–Thermal Limit: | 1145 Vrms |
| 10-Second Thermal: | 1555 Vrms |

Burden: <0.1 VA

Input Impedance: 5 MΩ differential

VDR Divider Ratio: 5.4:1

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

Rated Operating Voltage: 0–350 Vdc

Maximum Continuous Voltage–Thermal Limit: 700 Vdc

10-Second Thermal: 1000 Vdc

Burden: <0.1 W

Input Impedance: 2 MΩ differential

VEX Divider Ratio 2.1:1

Field Excitation Current IEX

Rated Operating Range: 0.5–2000 Adc

DC Transducer: 4–20 mA or 0–10 V nominal output

Input Impedance: 200 ohms (current mode)
>10 kΩ (voltage mode)

## Power Supply

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

High-Voltage Supply

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

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

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

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

Low-Voltage Supply

Rated Supply Voltage: 24–48 Vdc

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

Power Consumption: <25 W (dc)

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

## Fuse Ratings

LV Power Supply Fuse

Rating: 3.15 A

Maximum Rated Voltage: 300 Vdc, 250 Vac

Breaking Capacity: 1500 A at 250 Vac

Type: Time-lag T

HV Power Supply Fuse

Rating: 3.15 A

Maximum Rated Voltage: 300 Vdc, 250 Vac

Breaking Capacity: 1500 A at 250 Vac

Type: Time-lag T

## Output Contacts

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

Dielectric Test Voltages: 2500 Vac

Impulse Withstand Voltage ($U_{IMP}$): 5000 V

Mechanical Durability: 100,000 no load operations

## Standard Contacts

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

DC Output Ratings

Rated Operational Voltage: 250 Vdc

Rated Voltage Range: 19.2–275 Vdc

Rated Insulation Voltage: 300 Vdc

Make: 30 A @ 250 Vdc per IEEE C37.90

Continuous Carry: 6 A @ 70°C
4 A @ 85°C

Thermal: 50 A for 1 s

Contact Protection: 360 Vdc, 115 J MOV protection across open contacts

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

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

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

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

AC Output Ratings

Maximum Operational Voltage ($U_e$) Rating: 240 Vac

Insulation Voltage ($U_i$) Rating (excluding EN 61010-1): 300 Vac

Thermal: 50 A for 1 s

Contact Rating Designation: B300

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

Utilization Category: AC-15

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

Voltage Protection Across Open Contacts: 270 Vac, 115 J

## Fast Hybrid Output Contacts

(High-Speed, High-Current Interrupting)

DC Output Ratings

Rated Operational Voltage: 250 Vdc

Rated Voltage Range: 19.2–275 Vdc

Rated Insulation Voltage: 300 Vdc

Make: 30 A @ 250 Vdc per IEEE C37.90

Continuous Carry: 6 A @ 70°C
4 A @ 85°C

1 s Rating: 50 A

Open State Leakage Current: <500 µA

| | |
|---|---|
| MOV Protection (maximum voltage): | 250 Vac/330 Vdc |
| Pickup Time: | <50 µs, resistive load |
| Dropout Time: | ≤8 ms, resistive load |

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

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

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

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

#### AC Output Ratings

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

### Optoisolated Control Inputs

#### When Used With DC Control Signals

| | |
|---|---|
| 250 V: | On for 200–312.5 Vdc<br>Off below 150 Vdc |
| 220 V: | On for 176–275 Vdc<br>Off below 132 Vdc |
| 125 V: | On for 100–156.2 Vdc<br>Off below 75 Vdc |
| 110 V: | On for 88–137.5 Vdc<br>Off below 66 Vdc |
| 48 V: | On for 38.4–60 Vdc<br>Off below 28.8 Vdc |
| 24 V: | On for 15–30 Vdc<br>Off for <5 Vdc |

#### When Used With AC Control Signals

| | |
|---|---|
| 250 V: | On for 170.6–312.5 Vac<br>Off below 106 Vac |
| 220 V: | On for 150.2–275 Vac<br>Off below 93.3 Vac |
| 125 V: | On for 85–156.2 Vac<br>Off below 53 Vac |
| 110 V: | On for 75.1–137.5 Vac<br>Off below 46.6 Vac |
| 48 V: | On for 32.8–60 Vac<br>Off below 20.3 Vac |
| 24 V: | On for 14–30 Vac<br>Off below 5 Vac |
| Current draw at nominal dc voltage: | 2 mA (at 220–250 V)<br>4 mA (at 48–125 V)<br>10 mA (at 24 V) |
| Rated Impulse Withstand Voltage ($U_{imp}$): | 4000 V |
| Maximum Pickup Time: | Approx. 1 cycle |
| Maximum Dropout Time: | Approx. 2 cycles |

### Analog Output (Optional)

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

### Analog Inputs (Optional)

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

### Frequency and Phase Rotation

| | |
|---|---|
| System Frequency: | 50, 60 Hz |
| Phase Rotation: | ABC, ACB |
| Frequency Tracking: | 10–70 Hz |
| Frequency Operating Range: | 15–70 Hz |

### Time-Code Input

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

#### Synchronization Accuracy

| | |
|---|---|
| Internal Clock: | ±1 µs |
| All Reports: | ±5 ms |
| SNTP Accuracy: | ±1 ms (in an ideal network) |
| PTP Accuracy: | ±1 ms |
| Unsynchronized Clock Drift Relay Powered: | 2 minutes per year, typically |

### Communications Ports

#### Standard EIA-232 (2 Ports)

| | |
|---|---|
| Location: | Front Panel<br>Rear Panel |
| Data Speed: | 300–38400 bps |

#### EIA-485 Port (Optional)

| | |
|---|---|
| Location: | Rear Panel |
| Data Speed: | 300–19200 bps |

#### Ethernet Port (Optional)

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

#### Standard Multimode Fiber-Optic Port

| | |
|---|---|
| Location: | Rear Panel |
| Data Speed: | 300–38400 bps |

### Fiber-Optic Ports Characteristics

#### Port 1 (or 1A, 1B) Ethernet

| | |
|---|---|
| Wavelength: | 1300 nm |
| Optical Connector Type: | LC |
| Fiber Type: | Multimode |
| Link Budget: | 16.1 dB |
| Typical TX Power: | –15.7 dBm |
| RX Min. Sensitivity: | –31.8 dBm |
| Fiber Size: | 62.5/125 µm |
| Approximate Range: | ~6.4 km |

| | |
|---|---|
| Data Rate: | 100 Mbps |
| Typical Fiber Attenuation: | –2 dB/km |

Port 2 Serial

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

Channels 1–8 Arc-Flash Detectors (AFDI)

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

Point Sensor

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

Fiber Sensor

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

### Optional Communications Cards

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

### Communications Protocols

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

### Operating Temperature

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

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

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

### Operating Environment

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

### Dimensions

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

### Weight

2.7 kg (6.0 lb)

### Relay Mounting Screw (#8–32) Tightening Torque

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

### Terminal Connections

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

Terminal Block Tightening Torque

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

Compression Plug Tightening Torque

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

Compression Plug Mounting Ear Screw Tightening Torque

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

## Product Standards

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

## Type Tests

### Environmental Tests

| | |
|---|---|
| Enclosure Protection: | IEC 60529:2001 + CRDG:2003<br>IP65 enclosed in panel (2-line display models)<br>IP54 enclosed in panel (touchscreen models)<br>IP20 for relay backside panel<br>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. |
| Vibration Resistance: | IEC 60255-21-1: 1988<br>IEC 60255-27: 2013, Section 10.6.2.1<br>Endurance: Class 2<br>Response: Class 2 |
| Shock Resistance: | IEC 60255-21-2: 1988<br>IEC 60255-27: 2013, Section 10.6.2.2<br>IEC 60255-27: 2013, Section 10.6.2.3<br>Withstand: Class 1<br>Response: Class 2<br>Bump: Class 1 |
| Seismic (Quake Response): | IEC 60255-21-3: 1993<br>IEC 60255-27: 2013, Section 10.6.2.4<br>Response: Class 2 |
| Cold: | IEC 60068-2-1: 2007<br>IEC 60255-27: 2013, Section 10.6.1.2<br>IEC 60255-27: 2013, Section 10.6.1.4<br>–40°C, 16 hours |
| Dry Heat: | IEC 60068-2-2: 2007<br>IEC 60255-27: 2013, Section 10.6.1.1<br>IEC 60255-27: 2013, Section 10.6.1.3<br>85°C, 16 hours |
| Damp Heat, Steady State: | IEC 60068-2-78:2001<br>IEC 60255-27:2013, Section 10.6.1.5<br>40°C, 93% relative humidity, 10 days |
| Damp Heat, Cyclic: | IEC 60068-2-30:2001<br>IEC 60255-27:2013, Section 10.6.1.6<br>25°–55°C, 6 cycles, 95% relative humidity |
| Change of Temperature: | IEC 60068-2-14: 2009<br>IEC 60255-1: 2010 section 6.12.3.5<br>–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<br>IEEE C37.90-2005<br>1.0 kVac on analog outputs, ethernet ports<br>2.0 kVac on analog inputs, IRIG, PTC<br>2.5 kVac on contact I/O<br>3.6 kVdc on power supply, ac current, and voltage input terminals |
| Impulse: | IEC 60255-27:2013, Section 10.6.4.2<br>Severity Level: 0.5 J, 5 kV on power supply, contact I/O, ac current and voltage inputs<br>0.5 J, 530 V on analog outputs, PTC<br>IEEE C37.90:2005<br>Severity Level: 0.5 J, 5 kV<br>0.5 J, 530 V on analog outputs, PTC |

### RFI and Interference Tests

#### EMC Immunity

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

#### EMC Emissions

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

## Processing Specifications and Oscillography

| | |
|---|---|
| AC Voltage and Current Inputs: | 32 samples per power system cycle |
| Frequency Tracking Range: | 10–70 Hz |
| Digital Filtering: | One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental. |
| Protection and Control Processing: | Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms). Analog quantities for rms data are determined through the use of data averaged over the previous 8 cycles. |
| Arc Flash Processing: | Arc-flash light is sampled 32 times per cycle. Arc-flash current, light, and 2 fast hybrid outputs are processed 16 times per cycle |

### Oscillography

| | |
|---|---|
| Length: | 15, 64, or 180 cycles |
| Sampling Rate: | 32 samples per cycle unfiltered |
| | 4 samples per cycle filtered |
| Trigger: | Programmable with Boolean expression |
| Format: | ASCII and Compressed ASCII<br>Binary COMTRADE (32 samples per cycle unfiltered) |
| Time-Stamp Resolution: | 1 ms |
| Time-Stamp Accuracy: | ±5 ms |

### Sequential Events Recorder

| | |
|---|---|
| Time-Stamp Resolution: | 1 ms |
| Time-Stamp Accuracy (With Respect to Time Source) for all RWBs Except RWBs Corrsponding to Digital Inputs (IN*xxx*) and Arc-Flash Element (TOL*x*, 50*x*AF, OUT*xxx*): | ±5 ms |
| Time-Stamp Accuracy (With Respect to Time Source) for RWBs Corrsponding to Digital Inputs (IN*xxx*) and Arc-Flash Element (TOL*x*, 50*x*AF, OUT*xxx*): | 1 ms |

## Relay Elements

### Thermal Overload (49)

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

### PTC Overtemperature (49)

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

### Undercurrent (Load Loss) (37)

| | |
|---|---|
| Setting Range: | Off, 0.10–1.00 • FLA, 0.01 • FLA increment |
| Accuracy: | ±5% of setting ±0.02 • $I_{NOM}$ A rms secondary |
| Maximum Pickup/Dropout Time: | 1.5 cycles |
| Time Delay: | 0.4–120.0 s, 1 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

### Current Unbalance and Phase Loss (46)

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

### Overcurrent (Load Jam)

| | |
|---|---|
| Setting Range: | Off, 1.00–6.00 • FLA, 0.01 s FLA increment |
| Accuracy: | ±5% of setting ±0.02 • $I_{NOM}$ A rms secondary |
| Maximum Pickup/Dropout Time: | 1.5 cycles |
| Time Delay: | 0–120 s, 0.1 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

### Short Circuit (50P)

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

### Ground Fault (50G)

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

### Ground Fault (50N)

| | |
|---|---|
| Setting Range: | |
| 1 A, 5 A models: | ±5% of setting plus ±0.01 INOM A secondary |
| 2.5 mA models: | ±5% of setting plus ±0.02 INOM A secondary |
| Accuracy: | ±5% of setting ±0.05 mA secondary |
| Maximum Pickup/Dropout Time: | |
| 1 A, 5 A models: | 1.5 cycles/1.5 cycles |
| 2.5 mA models: | 100 ms + 1.5 cycles/1.5 cycles (for the 2.5 mA models the 50N*x*D element includes a security timer of 100 ms) |

| | |
|---|---|
| Time Delay: | 0.0–5.0 s, 0.01 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |
| Maximum Pickup/Dropout Time: | 100 ms* + 1.5 cycles/1.5 cycles |
| Time Delay: | 0.0–5.0 s, 0.01 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

* For the 2.5 mA models the 50N*x*D element includes a security timer of 100 ms).

### Negative-Sequence Overcurrent (50Q)

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

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

Pickup Setting Range (50PAF), A Secondary:

| | |
|---|---|
| 5 A models: | 0.50–100.00 A, 0.01 A steps |
| 1 A models: | 0.10–20.00 A, 0.01 A steps |

Pickup Setting Range (50NAF), A Secondary:

| | |
|---|---|
| 5 A models: | 0.05–10.00 A, 0.01 A steps |
| 1 A models: | 0.01–2.00 A, 0.01 A steps |
| Accuracy: | 0 to +10% of setting ±0.02 • $I_{NOM}$ A secondary (steady-state pickup) |
| Pickup/Dropout Time: | 2–5 ms/1 cycle |

### Arc-Flash Time-Overlight (TOL1–TOL8)

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

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

Pickup Setting Range, A Secondary

| | |
|---|---|
| 5 A models: | Off, 0.50–10.00 A, 0.01 A steps |
| 1 A models: | Off, 0.10–2.00 A, 0.01 A steps |
| Accuracy: | ±5% of setting ±0.02 • $I_{NOM}$ A secondary (steady-state pickup) |

Time Dial:

| | |
|---|---|
| U.S.: | 0.50–15.00, 0.01 steps |
| IEC: | 0.05–1.00, 0.01 steps |
| Accuracy: | ±1.5 cycles, ±4% between 2 and 30 multiples of pickup (within rated range of current) |

### Differential Protection (87M)

| | |
|---|---|
| Setting Range: | Off, 0.05–8.00 A secondary |
| Accuracy: | ±5% of setting ±0.10 A secondary |
| Maximum Pickup/Dropout Time: | 1.5 cycles |
| Time Delay: | 0.0–60.0 s, 0.01 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

### Undervoltage (27)

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

| | |
|---|---|
| Setting Range: | Off, 0.02–1.00 pu • Vnm, 0.01 increment |
| Accuracy: | ±5% of setting ±2 V secondary |
| Maximum Pickup/Dropout Time: | 1.5 cycles |
| Time Delay: | 0.0–120.0 s, 0.1 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

### Overvoltage (59)

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

| | |
|---|---|
| Setting Range: | Off, 0.02–1.20 pu • Vnm, 0.01 increment |
| Accuracy: | ±5% of setting ±2 V secondary |
| Maximum Pickup/Dropout Time: | 1.5 cycles |
| Time Delay: | 0.0–120.0 s, 0.1 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

### Inverse-Time Undervoltage (27I)

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

### Inverse-Time Overvoltage (59I)

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

### Underpower (37)

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

### Reactive Power (VAR)

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

### Power Factor (55)

| | |
|---|---|
| Setting Range: | Off, 0.05–0.99, 0.01 increment |
| Accuracy: | ±5% of full scale for current ≥ 0.5 • FLA |

| | |
|---|---|
| Maximum Pickup/Dropout Time: | 10 cycles |
| Time Delay: | 0.0–240.0 s, 1 s increment |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

### Frequency (81)

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

### Loss of Field (40)

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

### Out-of-Step Element (78)

| | |
|---|---|
| Forward Reach: | |
| 5 A model: | 0.1–100.0 Ω |
| 1 A model: | 0.5–500.0 Ω |
| Reverse Reach: | |
| 5 A model: | 0.1–100.0 Ω |
| 1 A model: | 0.5–500.0 Ω |
| Single Blinder | |
| Right Blinder: | |
| 5 A model: | 0.1–50.0 Ω |
| 1 A model: | 0.5–250.0 Ω |
| Left Blinder: | |
| 5 A model: | 0.1–50.0 Ω |
| 1 A model: | 0.5–250.0 Ω |
| Double Blinder | |
| Outer Resistance Blinder: | |
| 5 A model: | 0.2–100.0 Ω |
| 1 A model: | 1.0–500.0 Ω |
| Inner Resistance Blinder: | |
| 5 A model: | 0.1–50.0 Ω |
| 1 A model: | 0.5–250.0 Ω |
| Steady-State Impedance Accuracy: | |
| 5 A model: | ±0.1 Ω, ±5% of diameter |
| 1 A model: | ±0.5 Ω, ±5% of diameter |
| Pos.-Seq. Current Supervision: | |
| 5 A model: | 0.25–30.00 A |
| 1 A model: | 0.05–6.00 A |
| Pickup Time: | 3 cycles (Max) |
| Definite-Time Delay: | 0.00–1.00 s, 0.01 s step |
| Trip Delay Range: | 0.00–1.00 s, 0.01 s step |
| Trip Duration Range: | 0.00–5.00 s, 0.01 s step |
| Accuracy: | ±0.1% of user setting, ±8.3 ms at 60 Hz |

### Field Under/Overcurrent

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

### Field Under/Overvoltage

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

### Field Resistance

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

### Timers

| | |
|---|---|
| Setting Range: | Various |
| Accuracy: | ±0.5% of setting ±1/4 cycle |

### RTD Protection

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

## Metering

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

| | |
|---|---|
| Phase Currents: | ±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with $I_{NOM}$ = 1 A) |
| Three-Phase Average Current: | ±1% of reading, ±0.02 • $I_{NOM}$ |
| IG (Residual Current): | ±2% of reading, ±0.02 •$I_{NOM}$, ±2° |
| IN (Neutral Current): | ±1% of reading, ±2° (±2.5° at 0.2–0.5 A for relays with $I_{NOM}$ = 1 A) |
| 3I2 Negative-Sequence Current: | ±2% of reading, ±0.02 • $I_{NOM}$ |

| | |
|---|---|
| IA87, IB87, IC87 Differential Currents: | ±1% of reading |
| Current Unbalance (%): | ±2% of reading, ±0.02 • $I_{NOM}$ |
| System Frequency: | ±0.01 Hz of reading for frequencies within 15–70 Hz (V1 > 60 V) |
| Thermal Capacity: | ±1% TCU<br>Time to trip ±1 second |
| Slip: | ±5% slip for 100% > speed ≥ 40% |
| | ±10% slip for 40% > speed > 0% |
| Line-to-Line Voltages: | ±1% of reading, ±1° for voltages |
| Three-Phase Average Line-to-Line Voltage: | ±1% of reading for voltages |
| Line-to-Neutral Voltages: | ±1% of reading, ±1° for voltages |
| Three-Phase Average Line-to-Neutral Voltages: | ±1% of reading for voltages |
| Voltage Imbalance (%): | ±2% of reading |
| 3V2 Negative-Sequence Voltage: | ±2% of reading for voltages |
| Real Three-Phase Power (kW): | ±3% of reading for 0.10 < pf < 1.00 |
| Reactive Three-Phase Power (kVAR): | ±3% of reading for 0.00 < pf < 0.90 |
| Apparent Three-Phase Power (kVA): | ±3% of reading |
| Power Factor: | ±2% of reading for 0.97 ≤ PF ≤ 1 |
| RTD Temperatures: | ±2°C |
| Field Voltage: | ±1% of full-scale reading |
| Field Current: | ±1% of full-scale at 25°C |
| Field Resistance: | ±3% of full-scale reading |

### Energy Meter

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

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

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