New Features

➤ A new front-panel layout option with a 5-inch, color, 800 x 480-pixel touchscreen interface to navigate the screens, folders, and applications. The new touchscreen allows bay control. You can also view metered quantities and perform HMI functions including viewing and editing settings, event summaries, target status, SER, etc.

➤ Increased the maximum number of GOOSE subscriptions to 64

➤ I/O board option with 14 optoisolated inputs

➤ Inverse-time over- and undervoltage elements

➤ IEC 61850 Edition 2

➤ IEC 60870-5-103 protocol

➤ Parallel redundancy protocol (PRP) for dual Ethernet models

➤ Spanish language support
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, as well as 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 offered by the SEL-710-5 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, frequency, loss of potential, and RTD-based protection. As many as 10 RTDs can be monitored using an internal RTD card or as many as 12 RTDs when using an SEL-2600 RTD Module with the ST® 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 the 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.

➤ **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 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. Additional monitoring functions include the following:

- Motor start reports
- Motor start trending
- Load profile monitoring
- Motor operating statistics
- Broken rotor bar detection event reports and FFT data

➤ **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, 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, Simple Network Time Protocol (SNTP), IEC 60870-5-103, PRP with dual Ethernet ports, 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.
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
- 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*
- 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

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**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.
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>
<thead>
<tr>
<th>Model</th>
<th>Application</th>
<th>Slot E Card (MOT Digits)</th>
<th>Inputs</th>
<th>Slot Z Card (MOT Digits)</th>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>07105xxxxxx</td>
<td>Induction Motor Protection</td>
<td>None (0X)</td>
<td>NA</td>
<td>All Models</td>
<td>4 ACI/3 AVI (81, 82, 83, 85, 86, 87)</td>
</tr>
<tr>
<td>07105xxxx74xx</td>
<td>Induction Motor With 4 Arc-Flash Detection Channels and Differential Protection</td>
<td>4 AFDI/3 DIFF ACI (74)</td>
<td>AF1, AF2, AF3, AF4, IA87, IB87, IC87, COM</td>
<td>All Models</td>
<td>4 ACI/3 AVI (81, 82, 83, 85, 86, 87)</td>
</tr>
<tr>
<td>07105xxxx76xx</td>
<td>Induction Motor With 8 Arc-Flash Detection Channels</td>
<td>8 AFDI (76)</td>
<td>AF1, AF2, AF3, AF4, AF5, AF6, AF7, AF8</td>
<td>All Models</td>
<td>4 ACI/3 AVI (81, 82, 83, 85, 86, 87)</td>
</tr>
<tr>
<td>07105xxxx75xx</td>
<td>Synchronous Motor Protection With Differential Protection</td>
<td>SYNCH/3 DIFF ACI (75)</td>
<td>VDR+, VDR−, VEX+, VEX−, IEX+, IEX−, IA87, IB87, IC87, COM</td>
<td>All Models</td>
<td>1A, IB, IC, IN, VA, VB, VC, N</td>
</tr>
</tbody>
</table>

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.

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 Relay 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 relay 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.

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.
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.

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.
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.

Figure 4 Operator Controls for Standard and Optional Synchronous Motor Model

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 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 ACCELERATOR 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 Relay 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 of the breaker and 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.

![Bay Screen Builder](image)

*Figure 5  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

<table>
<thead>
<tr>
<th>Types of Metering</th>
<th>Quantities</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantaneous</td>
<td>Currents IA, IB, IC, IN, IG, IAV, 3I2, UBI</td>
<td>Input currents, residual ground current (IG = 3I0 = IA + IB + IC), average current, negative-sequence current, current imbalance</td>
</tr>
<tr>
<td>Differential</td>
<td>Voltages VA, VB, VC</td>
<td>Wye-connected voltage inputs</td>
</tr>
<tr>
<td>Math Variables</td>
<td>Voltages VAB, VBC, VCA</td>
<td>Delta-connected voltage inputs</td>
</tr>
<tr>
<td>RMS</td>
<td>Voltage VAVE, 3V2, UBV</td>
<td>Average voltage, negative-sequence voltage, voltage imbalance</td>
</tr>
<tr>
<td>Max/Min</td>
<td>Power kW</td>
<td>Three-phase kilowatts, kilovars, and kilovolt-amps</td>
</tr>
<tr>
<td>Light</td>
<td>kVAR</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>kVA</td>
<td></td>
</tr>
<tr>
<td>Analog Inputs</td>
<td>Energy MWh3P, MVArh3P-IN, MVArh3P-OUT, MVAh3P</td>
<td>Three-phase megawatt-hours, megavar-hours, and megavolt-amp-hours</td>
</tr>
<tr>
<td></td>
<td>Power Factor PF</td>
<td>Three-phase power factor (leading or lagging)</td>
</tr>
<tr>
<td></td>
<td>IA87, IB87, IC87</td>
<td>Differential phase current inputs</td>
</tr>
<tr>
<td></td>
<td>Frequency, FREQ (Hz)</td>
<td>Instantaneous relay frequency</td>
</tr>
<tr>
<td></td>
<td>Field Voltage, Field Current, Field Resistance</td>
<td>Exciter voltage, exciter current, field resistance</td>
</tr>
<tr>
<td></td>
<td>Light Intensity (%) LS1–LS8</td>
<td>Arc-flash light inputs in percentage of full scale</td>
</tr>
<tr>
<td></td>
<td>Alx01–Alx08</td>
<td>Analog Inputs</td>
</tr>
<tr>
<td></td>
<td>MV01–MV32</td>
<td>Math Variables</td>
</tr>
<tr>
<td></td>
<td>RA001–RA128</td>
<td>Remote Analogs</td>
</tr>
<tr>
<td></td>
<td>RTD1–RTD12</td>
<td>RTD temperature measurement (degrees C)</td>
</tr>
<tr>
<td></td>
<td>Stator TCU, Rotor TCU</td>
<td>% of Thermal Capacity Used</td>
</tr>
</tbody>
</table>

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 trending tracks motor start data for the past eighteen 30-day periods.

**Improve Situational Awareness**

**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.

**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 5 of the most recent 180-cycle, 17 of the most recent 64-cycle, or 74 of the most recent 15-cycle event reports in nonvolatile memory. The relay always appends relay settings to the bottom of each event report.
The following analog data formats are available.

➤ 1/4-cycle or 1/32-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 8) the relay alarms via output contact, communications port, or front-panel display. This kind of information allows timely and economical scheduling of breaker maintenance.

![Breaker Contact Wear Curve and Settings](image-url)

**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 9. 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 10 through Figure 19.

Bay Screens Application

The SEL-710-5 Relay with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as an SLD on the touchscreen. You can create as many as five bay screens with one controllable breaker and as many as five monitor-only 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 of the breaker and disconnects, bus voltages, and power flow through the breaker. Figure 10 shows the default SLD for the touchscreen display option.

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 11).

Tap the Energy application to view the energy metering quantities (see Figure 12). A reset feature is provided for the Energy, Max/Min, and Thermal applications. Tap the Reset button (see Figure 12) to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero.
Reports Folder Applications

Tapping the Reports folder navigates you 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 13) of a particular event record, you can tap the event record on the Event History screen.

![Figure 13 Event Summary](image)

Tap the Sequential Events Recorder application to view a history of the SER reports (see Figure 14).

![Figure 14 Sequential Events Recorder](image)

Control Folders Applications

Tapping the Control folder navigates you 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 16), pulse output contacts (see Figure 17), control local bits, perform an emergency restart command, or to reset the thermal model.

![Figure 16 Stop Motor Confirmation Screen](image)

Device Info Folder Applications

Tapping the Device Info folder navigates you 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 18).
To view the trip and diagnostic messages, tap the **Trip & Diag. Messages** application (see Figure 19). When a diagnostic failure, trip, lockout, or warning occurs, the relay displays the diagnostic message on the screen until it is either overridden by the restart of the rotating display, or the inactivity timer expires.

### 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 (Sheet 1 of 2)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple ASCII</td>
<td>Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.</td>
</tr>
<tr>
<td>Compressed ASCII</td>
<td>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.</td>
</tr>
<tr>
<td>Extended Fast Meter and Fast Operate</td>
<td>Binary protocol for machine-to-machine communications. 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.</td>
</tr>
<tr>
<td>Fast SER Protocol</td>
<td>Provides SER events to an automated data collection system.</td>
</tr>
<tr>
<td>Fast Message Protocol</td>
<td>Use this protocol to write Remote Analog Data from other SEL relays or communications processors via unsolicited writes.</td>
</tr>
<tr>
<td>Modbus</td>
<td>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.</td>
</tr>
<tr>
<td>DNP3</td>
<td>Serial or Ethernet-based DNP3 protocols. 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.</td>
</tr>
</tbody>
</table>
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 20).

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.

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.

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**Ethernet Network Architectures**

**Figure 21** Simple Ethernet Network Configuration

**Figure 22** Ethernet Network Configuration With Dual Redundant Connections (Failover 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 24). 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.

**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 27. 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 27.
Relay Dimensions

Figure 25  SEL-710-5 Dimensions for Rack- and Panel-Mount Models
Hardware Overview

Figure 26  Hardware Overview for Synchronous Motor/Differential Card In Slot E
Relay Panel Diagrams

Induction Motor Protection Relay
(A) Front Panel With Default Configuration Labels

- Relay Powered Properly/Self-Tests are Okay
- Trip Occurred
- Thermal Overload Trip
- Instantaneous/Definite Time-Overcurrent Trip
- Current Unbalance Trip
- Undercurrent Trip
- Over-/Undervoltage Trip
- Differential Overcurrent Trip

(B) Rear-Panel View

(C) Side-Panel View

Figure 27 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

(A) Front Panel With Default Configuration Labels

(B) Rear-Panel View

(C) Side-Panel View

Relay Powered Properly/Self-Tests are Okay
Trip Occurred
Thermal Overload Trip
Instantaneous/Definite Time-Overcurrent Trip
Loss-of-Field Trip
Low Power Factor Trip
Incomplete Start Sequence Trip
Differential Overcurrent Trip

Figure 28  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 29 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 30  AC Connections for Induction Motor Application

Figure 31  Typical AC/DC Connection Diagram for a Brush-Type Synchronous Motor Application
Figure 32  AC/DC Connections for a Brushless-Type Synchronous Motor Application

Figure 33  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.
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.
CE Mark
RCM Mark

Hazardous locations
UL Certified for Hazardous Locations to U.S. and Canadian standards (File E470448)
EU
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)
Phase Currents
INOM = 1 A, 5 A, or 2.5 mA secondary depending on model
INOM = 5 A
Continuous Rating: 3 • INOM @ 85°C
4 • INOM @ 55°C
Saturation Current Rating: Linear to 100 A symmetrical
1-Second Thermal: 500 A
Burden (per phase): <0.1 VA @ 5 A
INOM = 1 A
Continuous Rating: 3 • INOM @ 85°C
4 • INOM @ 55°C
Saturation Current Rating: Linear to 20 A symmetrical
1-Second Thermal: 100 A
Burden (per phase): <0.01 VA @ 1 A
Neutral Currents
INOM = 5 A
Continuous Rating: 3 • INOM @ 85°C
4 • INOM @ 55°C
Saturation Current Rating: Linear to 11 A symmetrical
1-Second Thermal: 500 A
Burden (per phase): <0.1 VA @ 5 A
INOM = 1 A
Continuous Rating: 3 • INOM @ 85°C
4 • INOM @ 55°C
Saturation Current Rating: Linear to 2.2 A symmetrical
1-Second Thermal: 100 A
Burden (per phase): <0.01 VA @ 2.5 mA
INOM = 2.5 mA
Continuous Rating: 3 • INOM @ 85°C
4 • INOM @ 55°C
Saturation Current Rating: Linear to 50 mA symmetrical
1-Second Thermal: 100 A
Burden (per phase): <0.01 VA @ 1 A
Measurement Category: II

Differential Currents (IA87, IB87, IC87)
INOM = 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)
VNOM (L-L)/PT Ratio Range: 100–250 V (if DELTA_Y := DELTA)
100–440 V (if DELTA_Y := WYE)
Rated Operating Voltage (Ue): 100–250 Vac
Rated Continuous Voltage: 300 Vac
10-Second Thermal: 600 Vac
Burden: <0.1 W
Input Impedance: 4 MΩ differential (phase-to-phase)
7 MΩ common mode (phase-to-chassis)

Synchronous Motor Inputs
Inputs for Synchronous Motor Voltage Divider Module (SEL PN 915900294)
Field Discharge Voltage VDR (Motor Side, VDRM+ to VDRM–)
Rated Operating Voltage: As high as 955 Volts
Maximum Continuous Voltage–Thermal Limit: 1145 Volts
10-Second Thermal: 1555 Volts
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 Volts
Maximum Continuous Voltage–Thermal Limit: 700 Volts
10-Second Thermal: 1000 Volts
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 A
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 (Design Range): 85–264 Vac; 85–300 Vdc
Power Consumption: <50 VA (ac) <25 W (dc)
Interruptions: 50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

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

Fuse Ratings
LV Power Supply Fuse
Rating: 3.15 A
Maximum Rated Voltage: 300 Vdc, 250 Vac
Breaking Capacity: 1500 A at 250 Vac
Type: Time-lag T
HV Power Supply Fuse
Rating: 3.15 A
Maximum Rated Voltage: 300 Vdc, 250 Vac
Breaking Capacity: 1500 A at 250 Vac
Type: Time-lag T

Output Contacts
The relay supports Form A, B, and C outputs.
Dielectric Test Voltages: 2500 Vac
Impulse Withstand Voltage (Uimp): 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 (Uo) Rating: 240 Vac
Insulation Voltage (Ui) Rating (excluding EN 61010-1): 300 Vac
Thermal: 50 A for 1 s
Contact Rating Designation: B300

<table>
<thead>
<tr>
<th>B300 (5 A Thermal Current, 300 Vac Max)</th>
<th>Maximum Current</th>
<th>Max VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage 120 Vac</td>
<td>15 A</td>
<td>3600</td>
</tr>
<tr>
<td>Make 30 A</td>
<td>1.5 A</td>
<td>360</td>
</tr>
<tr>
<td>Break 3 A</td>
<td>1.5 A</td>
<td>360</td>
</tr>
<tr>
<td>PF &lt;0.35, 50–60 Hz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Utilization Category: AC-15

<table>
<thead>
<tr>
<th>AC-15</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Voltage (Ue)</td>
<td>120 Vac</td>
<td>240 Vac</td>
</tr>
<tr>
<td>Operational Current (Ie)</td>
<td>3 A</td>
<td>1.5 A</td>
</tr>
<tr>
<td>Make Current</td>
<td>30 A</td>
<td>15 A</td>
</tr>
<tr>
<td>Break Current</td>
<td>3 A</td>
<td>1.5 A</td>
</tr>
<tr>
<td>Electromagnetic loads &gt;72 VA, PF &lt;0.3, 50–60 Hz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Voltage Protection Across Open Contacts: 270 Vac, 115 J

Fast Hybrid Output Contacts
(High-Speed, High-Current Interrupting)

DC Output Ratings
Rated Operational Voltage: 250 Vdc
Rated Voltage Range: 19.2–275 Vdc
Rated Insulation Voltage: 300 Vdc
Make: 30 A @ 250 Vdc per IEEE C37.90
Continuous Carry: 6 A @ 70°C 4 A @ 85°C
1 s Rating: 50 A
Open State Leakage Current: <500 μA
MOV Protection (maximum voltage): 250 Vac/330 Vdc
Pickup Time: <50 μs, resistive load
Dropout Time: ≤8 ms, resistive load
Break Capacity (10,000 Operations) per IEC 60255-0-20:1974:
48 Vdc 10.0 A L/R = 40 ms
125 Vdc 10.0 A L/R = 40 ms
250 Vdc 10.0 A L/R = 20 ms
Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation) per IEC 60255-0-20:1974:
48 Vdc 10.0 A L/R = 40 ms
125 Vdc 10.0 A L/R = 40 ms
250 Vdc 10.0 A L/R = 20 ms
AC Output Ratings
See AC Output Ratings for Standard Contacts.

Optoisolated Control Inputs

When Used With DC Control Signals

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

When Used With AC Control Signals

- **250 V:**
  - On for 170.6–312.5 Vac
  - Off below 106 Vac
- **220 V:**
  - On for 150.2–275 Vac
  - Off below 93.3 Vac
- **125 V:**
  - On for 85–156.2 Vac
  - Off below 53 Vac
- **110 V:**
  - On for 75.1–137.5 Vac
  - Off below 46.6 Vac
- **48 V:**
  - On for 32.8–60 Vac
  - Off below 20.3 Vac
- **24 V:**
  - On for 14–30 Vac
  - Off below 5 Vac

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

Rated Impulse Withstand Voltage (Uimp):

- 4000 V

Maximum Pickup Time:

- Approx. 1 cycle

Maximum Dropout Time:

- Approx. 2 cycles

Analog Output (Optional)

<table>
<thead>
<tr>
<th>1 A0</th>
<th>4 A0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current:</td>
<td>4–20 mA</td>
</tr>
<tr>
<td>Voltage:</td>
<td>—</td>
</tr>
<tr>
<td>Load at 1 mA:</td>
<td>—</td>
</tr>
<tr>
<td>Load at 20 mA:</td>
<td>0–300 Ω</td>
</tr>
<tr>
<td>Load at 10 V:</td>
<td>—</td>
</tr>
<tr>
<td>Refresh Rate:</td>
<td>25 ms</td>
</tr>
<tr>
<td>% Error, Full Scale, at 25°C:</td>
<td>≤±1%</td>
</tr>
<tr>
<td>Select From:</td>
<td>Analog quantities available in the relay</td>
</tr>
</tbody>
</table>

Analog Inputs (Optional)

| Maximum Input Range: | ±20 mA | ±10 V |
| Operational range set by user |
| Input Impedance: | 200 Ω (current mode) | >10 kΩ (voltage mode) |

Accuracy at 25°C:
- With user calibration: 0.05% of full scale (current mode)
- 0.025% of full scale (voltage mode)
- Without user calibration: Better than 0.5% of full scale at 25°C

Accuracy Variation With Temperature:

- ±0.015% per °C of full-scale

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: Vih ≥ 2.2 V
- Off (0) State: Vil ≤ 0.8 V
- Input Impedance: 2 kΩ

Synchronization Accuracy
- Internal Clock: ±1 μs
- All Reports: ±5 ms

Simple Network Time Protocol (SNTP) Accuracy
- Internal Clock: ±5 ms
- Unsynchronized Clock Drift
  - Relay Powered: 2 minutes per year, typically

Communications Ports

Standard EIA-232 (2 Ports)
- Location: Front Panel
- 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

Communications Protocols
SEL, Modbus, DNP3, FTP, TCP/IP, Telnet, SNTP, IEC 61850
Edition 2, IEC 60870-5-103, PRP, MIRRORED BITS, and DeviceNet

Operating Temperature
IEC Performance Rating: –40° to +85°C (–40° to +185°F)
(per IEC/EN 60608-2-1 and IEC/EN 60608-2-2)

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

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

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

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

Weight
2.7 kg (6.0 lb)

Relay Mounting Screw (#8–32) Tightening Torque
Minimum: 1.4 Nm (12 in-lb)
Maximum: 1.7 Nm (15 in-lb)

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

Terminal Block Tightening Torque
Minimum: 0.9 Nm (8 in-lb)
Maximum: 1.4 Nm (12 in-lb)

Compression Plug Tightening Torque
Minimum: 0.5 Nm (4.4 in-lb)
Maximum: 1.0 Nm (8.8 in-lb)

Compression Plug Mounting Ear Screw Tightening Torque
Minimum: 0.18 Nm (1.6 in-lb)
Maximum: 0.25 Nm (2.2 in-lb)

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

Environmental Tests
IP65 enclosed in panel (2-line display models)
IP54 enclosed in panel (touchscreen models)
IP50-rated for terminals enclosed in the dust-protection assembly (protection against solid foreign objects only) (SEL P/N 915901070).
The 10°C temperature derating applies to the temperature specifications of the relay.
IEC 60255-27: 2013, Section 10.6.2.1
Endurance: Class 2
Response: Class 2

IEC 60255-27: 2013, Section 10.6.2.2
IEC 60255-27: 2013, Section 10.6.2.3
Withstand: Class 1
Response: Class 2
Bump: Class 1

Seismic (Quake Response): IEC 60255-21-3: 1993
IEC 60255-27: 2013, Section 10.6.2.4
Response: Class 2

Cold: IEC 60068-2-1: 2007
IEC 60255-27: 2013, Section 10.6.1.2
IEC 60255-27: 2013, Section 10.6.1.3
–40°C, 16 hours

IEC 60255-27: 2013, Section 10.6.1.4
85°C, 16 hours

IEC 60255-27: 2013, Section 10.6.1.5
40°C, 93% relative humidity, 10 days

Damp Heat, Cyclic: IEC 60068-2-20: 2001
IEC 60255-27: 2013, Section 10.6.1.6
25°–55°C, 6 cycles, 95% relative humidity

Change of Temperature: IEC 60068-2-14: 2009
IEC 60255-1: 2010 section 6.12.3.5
–40° to +85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests

Dielectric (HiPot): IEC 60255-27: 2013, Section 10.6.4.3
IEEE C37.90-2005
1.0 kVac on analog outputs, ethernet ports
2.0 kVac on analog inputs, IRIG, PTC
2.5 kVac on contact I/O
3.6 kVdc on power supply IN, VN terminals

Impulse: IEC 60255-27: 2013, Section 10.6.4.2
Severity Level: 0.5 J, 5 kV on power supply, contact I/O, ac current and voltage inputs
0.5 J, 530 V on analog outputs, PTC
IEEE C37.90: 2005
Severity Level: 0.5 J, 5 kV
0.5 J, 530 V on analog outputs, PTC

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity: IEC 61000-4-2: 2008
IEC 60255-26: 2013, Section 7.2.3
IEEE C37.90-2001
Severity Level: 4
8 kV contact discharge
15 kV air discharge

Radiated RF Immunity: IEC 61000-4-3: 2010
IEC 60255-26: 2013, Section 7.2.4
10 V/m
IEEE C37.90-2004
20 V/m

EMC Emissions

Conducted Emissions:
IEC 60255-26: 2013 Class A
FCC 47 CFR Part 15.107 Class A
ICES-003 Issue 6
EN 55011: 2009 + A1: 2010 Class A
EN 55022: 2010 + AC: 2011 Class A
EN 55032: 2012 + AC: 2013 Class A
CISPR 11: 2009 + A1: 2010 Class A
CISPR 22: 2008 Class A
CISPR 32: 2015 Class A

Radiated Emissions:
IEC 60255-26: 2013 Class A
FCC 47 CFR Part 15.109 Class A
ICES-003 Issue 6
EN 55011: 2009 + A1: 2010 Class A
EN 55022: 2010 + AC: 2011 Class A
EN 55032: 2012 + AC: 2013 Class A
CISPR 11: 2009 + A1: 2010 Class A
CISPR 22: 2008 Class A
CISPR 32: 2015 Class A

EMC Emissions

Processing Specifications and Oscillography

AC Voltage and Current Inputs:
32 samples per power system cycle

Frequency Tracking Range:
10–70 Hz

Digital Filtering:
One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing: Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms). Analog quantities for rms data are determined through the use of data averaged over the previous 8 cycles.

Arc Flash Processing: Arc-flash light is sampled 32 times per cycle. Arc-flash current, light, and 2 fast hybrid outputs are processed 16 times per cycle.

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

Sequential Events Recorder
Time-Stamp Resolution: 1 ms
Time-Stamp Accuracy (With Respect to Time Source): ±5 ms

Relay Elements

Thermal Overload (49)
Full-Load Current (FLA) Limits:
- 0.2–5000.0 A primary (limited to 20–160% of CT rating)
Locked Rotor Current: 2.5–12.0 • FLA
Hot Locked Rotor Time: 1.0–600.0 seconds
Service Factor: 1.01–1.50
Accuracy: 5% ±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 • INOM 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 • INOM A rms secondary
Maximum Pickup/Dropout Time: 1.5 cycles

Overcurrent (Load Jam)
Setting Range: Off, 1.00–6.00 • FLA, 0.01 s FLA increment
Accuracy: ±5% of setting ±0.02 • INOM 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 • INOM A secondary
Maximum Pickup/Dropout Time: 1.5 cycles
Time Delay: 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 • INOM A secondary
Maximum Pickup/Dropout Time: 1.5 cycles
Time Delay: 0–5.0 s, 0.01 s increment
Accuracy: ±0.5% of setting ±1/4 cycle

Ground Fault (50N)
Setting Range:
- 1 A, 5 A models: Off, 0.01–650.00 A primary; 0.01 A rms increment
- 2.5 mA models: Off, 0.01–25.00 A primary; 0.01 A rms increment
Accuracy: ±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, a fixed delay of 100 ms is added to the entered delay setting for the 50N element (50NxD))
Time Delay: 0–5.0 s, 0.01 s increment
Accuracy: ±0.5% of setting ±1/4 cycle
* For the 2.5 mA models, a fixed delay of 100 ms is added to the entered delay setting for the 50N element (50NxD).

Negative-Sequence Overcurrent (500)
Setting Range: Off, 0.10–20.00 • FLA, 0.01 • FLA increment
Accuracy: ±5% of setting ±0.02 • INOM 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: 0.10–2.00 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: ±0.5% of setting ±1/4 cycle
Pickup/Dropout Time: 2–5 ms/1 cycle

Arc-Flash Time-Overcurrent (TOL1–TOL8)
Pickup Setting Range, Percent of Full Scale:
  Point Sensor: 3.0%–80.0%
  Fiber Sensor: 0.6%–80.0%
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 (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

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)
V_{nm} = \left[V_{NOM}/\text{PT Ratio}\right] \text{if DELTA Y := DELTA}
V_{nm} = \left[V_{NOM}/(1.732 \times \text{PT Ratio})\right] \text{if DELTA_Y := WYE}
Setting Range: Off, 0.02–1.00 pu × V_{nm}, 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)
V_{nm} = \left[V_{NOM}/\text{PT Ratio}\right] \text{if DELTA Y := DELTA}
V_{nm} = \left[V_{NOM}/(1.732 \times \text{PT Ratio})\right] \text{if DELTA_Y := WYE}
Setting Range: Off, 0.02–1.20 pu × V_{nm}, 0.01 increment
Accuracy: ±5% of setting ±2 V secondary
Maximum Pickup/Dropout Time: 1.5 cycles

Time Delay: 0.0–120.0 s, 0.1 s increment
Accuracy: ±0.5% of setting ±1/4 cycle

Inverse-Time Undervoltage (27I)
Setting Range:
  OFF, 2.00–300.00 V (Phase elements, positive-sequence elements, phase-to-phase elements with delta inputs, or synchronism-check voltage input)
  OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy: ±1% of setting ±0.5 V
Time Delay: 0.00–16.00 s
Accuracy: ±1.5 cyc plus ±4% between 0.95 and 1.1 multiples of pickup

Inverse-Time Overvoltage (59I)
Setting Range:
  OFF, 2.00–300.00 V (Phase elements, sequence elements, or phase-to-phase elements with delta inputs or synchronism voltage input)
  OFF, 2.00–520.00 V (Phase-to-phase elements with wye inputs)
Accuracy: ±1% of setting ±0.5 V
Time Delay: 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
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, 15.0–70.0 Hz, 0.01 Hz increments
Accuracy: ±0.01 Hz
Maximum Pickup/Dropout Time: 5 cycles
Time Delay: 0.0–240.0 s, 1 s increment
Accuracy: ±0.5% of setting ±1/4 cycle
### Loss of Field (40)

- **Zone 1 and Zone 2 Offset:**
  - 0.0–50.0 Ω for 5 A
  - 0.0–250.0 Ω for 1 A

- **Zone 1 and Zone 2 Diameter:**
  - 5 A model: 0.1–100.0 Ω
  - 1 A model: 0.5–500.0 Ω

- **Steady-State Impedance Accuracy:**
  - 5 A model: ±0.1 Ω, ±5% of (offset + diameter)
  - 1 A model: ±0.5 Ω, ±5% of (offset + diameter)

- **Minimum Pos.-Seq. Signals:**
  - 5 A model: 0.25 V (V1), 0.25 A (I1)
  - 1 A model: 0.25 V (V1), 0.05 A (I1)

### Steady-State Impedance Accuracy:

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

### 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 Range:**
  - 0.00–1.00 s, 0.01 s step

- **Trip Delay Range:**
  - 0.00–5.00 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/Overvoltage

- **Setting Range:** Off, 1.0–350.0 Vdc, 0.1 increment
- **Accuracy:** ±0.2% 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:** ±0.5% 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, –250°C to 250°C
- **Accuracy:** ±0.2°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 Trip/Alarm Delay:** Approx. 6 s

### Metering

- **Phases Currents:** ±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with INOM = 1 A)
- **Three-Phase Average Current:** ±1% of reading, ±0.02 • INOM
- **IG (Residual Current):** ±2% of reading, ±0.02 • INOM, ±2°
- **IN (Neutral Current):** ±1% of reading, ±2° at 0.2–0.5 A for relays with INOM = 1 A

- **3I2 Negative-Sequence Current:** ±2% of reading, ±0.02 • INOM

- **IA87, IB87, IC87 Differential Currents:** ±1% of reading

- **Current Unbalance (%):** ±2% of reading, ±0.02 • INOM

- **System Frequency:** ±0.01 Hz of reading for frequencies within 15–70 Hz (V1 > 60 V)

- **Thermal Capacity:** ±1% TCU

- **Time to trip ±1 second**

- **Slip:** ±5% slip for 100% > speed ≥ 40%

- **Line-to-Line Voltages:** ±1% of reading, ±1° for voltages

- **Line-to-Neutral Voltages:** ±1% of reading, ±1° for voltages

- **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.

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