SEL-751 Feeder Protection Relay

Directional Overcurrent, Arc-Flash Detection, and High-Impedance Fault Detection

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 display layout allows bay control. You can also view metered quantities and perform HMI functions including viewing and editing settings, event summaries, target status, SER, etc. This option is available with four or eight pushbuttons, with or without a fiber-optic serial port, or with or without ac voltage inputs.

➤ Added an ac currents only model (no voltages) that can be configured with four pushbuttons, four ac current inputs, and without a fiber-optic serial port.

➤ Increased the maximum number of GOOSE subscriptions to 64.
Major Features and Benefits

The SEL-751 Feeder Protection Relay provides a comprehensive combination of protection, fault-locating features, monitoring, control, and communication in an industrial package.

The SEL-751 protection features depend on the model selected. The models are configured with specific current/voltage input cards. Table 1 shows current (ACI) and voltage (AVI) card selections for the SEL-751 models.

Table 1  Current (ACI) and Voltage (AVI) Card Selection for SEL-751 Models

<table>
<thead>
<tr>
<th>Model Description</th>
<th>Slot Z Card Option (MOT String Digital Number 14, 15)</th>
<th>Slot Z Inputs</th>
<th>Slot E Card Option (MOT String Digits Number 12, 13)</th>
<th>Slot E Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base SEL-751 AC Currents Only</td>
<td>4 ACI (A1, A2, A3, A5, A6, A7)</td>
<td>IA, IB, IC, IN</td>
<td>None (0X)</td>
<td>None</td>
</tr>
<tr>
<td>SEL-751 With AC Voltages (300 Vac)</td>
<td>4 ACI/3 AVI (81, 82, 83, 85, 86, 87)</td>
<td>IA, IB, IC, IN, VA, VB, VC</td>
<td>None (0X)</td>
<td>None</td>
</tr>
<tr>
<td>SEL-751 With LEA AC Voltages (8 Vac)</td>
<td>4 ACI/3 AVI (L1, L2, L3, L5, L6, L7)</td>
<td>IA, IB, IC, IN, VA, VB, VC</td>
<td>None (0X)</td>
<td>None</td>
</tr>
<tr>
<td>SEL-751 With AC Phase Voltages (300 Vac), Vsync (300 Vac), Vbat (300 V) Input, and 4 Arc-Flash Detections Inputs</td>
<td>4 ACI/3 AVI (81, 82, 83, 85, 86, 87)</td>
<td>IA, IB, IC, IN, VA, VB, VC</td>
<td>2 AVI/4 AFDI (70)</td>
<td>VS, VBAT, AF1, AF2, AF3, AF4</td>
</tr>
<tr>
<td>SEL-751 With LEA AC Phase Voltages (8 Vac), LEA Vsync (8 Vac), Vbat (300 V) Input, and 4 Arc-Flash Detection Inputs</td>
<td>4 ACI/3 AVI (L1, L2, L3, L5, L6, L7)</td>
<td>IA, IB, IC, IN, VA, VB, VC</td>
<td>2 AVI/4 AFDI (L0)</td>
<td>VS, VBAT, AF1, AF2, AF3, AF4</td>
</tr>
</tbody>
</table>

The SEL-751 offers an extensive variety of protection features, depending on the model and options selected. Table 2 lists the protection features available in each model.

Table 2  SEL-751 Protection Elements (Sheet 1 of 2)

<table>
<thead>
<tr>
<th>Protection Element</th>
<th>Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel</th>
<th>Slot Z 4 ACI/3 AVI Card With 1 A or 5 A Neutral Channel</th>
<th>Slot Z 4 ACI/3 AVI Card With 200 mA Neutral Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>50P</td>
<td>Max. Phase Overcurrent</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>67P</td>
<td>Max. Phase Overcurrent With Directional Control</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>50Q</td>
<td>Neg.-Seq. Overcurrent</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>67Q</td>
<td>Neg.-Seq. Overcurrent With Directional Control</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>50G</td>
<td>Residual Overcurrent</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>67G</td>
<td>Residual Overcurrent With Directional Control</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>50N</td>
<td>Neutral Overcurrent</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>67N</td>
<td>Neutral Overcurrent With Directional Control</td>
<td>X</td>
<td>X&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>51mP</td>
<td>Phase Time Overcurrent (m = A, B, C)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51P</td>
<td>Max. Phase Time Overcurrent</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51P</td>
<td>Max. Phase Time Overcurrent With Directional Control</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>51G</td>
<td>Residual Time Overcurrent</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51G</td>
<td>Residual Time Overcurrent With Directional Control</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protection Element</td>
<td>Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel</td>
<td>Slot Z 4 ACI/3 AVI Card With 1 A or 5 A Neutral Channel</td>
<td>Slot Z 4 ACI/3 AVI Card With 200 mA Neutral Channel</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>51Q Neg.-Seq. Time Overcurrent</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51Q Neg.-Seq. Time Overcurrent With Directional Control</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51N Neutral Time Overcurrent</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>51N Neutral Time Overcurrent With Directional Control</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SEF Sensitive Earth Fault</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>HBL Second- and Fifth-Harmonic Blocking</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>FLOC Fault Locator</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>27 Undervoltage (Phase, Phase-to-Phase, Vsync)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>59 Overvoltage (Phase, Phase-to-Phase, Seq., Vsync)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>27I Inverse Time Undervoltage</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>59I Inverse Time Overvoltage</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>60LOP Loss of Potential</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>32 Directional Power</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>49T IEC Thermal (line/cable)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>55 Power Factor</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>78VS Vector Shift</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>81 Over- and Underfrequency</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>81R Rate-of-Change of Frequency</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>81RF Fast Rate-of-Change of Frequency</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>25 Synchronism Check</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>BF Breaker Failure</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>49RTD RTDs</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>79 Reclosing</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>HIF AST High-Impedance Fault Detection With Arc Sense Technology</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>AFT Arc-Flash Detection</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

a Available when ordered with the directional option. The 1 A/5 A neutral channel is suitable for solidly grounded systems and also impedance-grounded systems, depending on the available fault current level.
b Available when ordered with the directional option. The 200 mA neutral channel is suitable for ungrounded, low-impedance grounded, high-impedance grounded, and Petersen coil grounded applications.
c Available with the 2 AVI/4 AFDI card in Slot E.
d Available as ordering options.
The SEL-751 offers four front-panel HMI layouts that are front-panel option dependent. Table 3 lists the HMI options for the SEL-751 front panel.

### Table 3 SEL-751 Front-Panel Options

<table>
<thead>
<tr>
<th>Model/Display Description*</th>
<th>Front-Panel Option (MOT String Digit Number 16)</th>
<th>Number of Pushbuttons</th>
<th>LED Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEL-751 With Two-Line Display (2 x 16 characters)</td>
<td>0</td>
<td>8</td>
<td>Tricolor</td>
</tr>
<tr>
<td>SEL-751 With Two-Line Display (2 x 16 characters)</td>
<td>1</td>
<td>4</td>
<td>Tricolor</td>
</tr>
<tr>
<td>SEL-751 With Touchscreen Display (5-inch, color, 800 x 480 pixels)</td>
<td>A</td>
<td>8</td>
<td>Tricolor</td>
</tr>
<tr>
<td>SEL-751 With Touchscreen Display (5-inch, color, 800 x 480 pixels)</td>
<td>B</td>
<td>4</td>
<td>Tricolor</td>
</tr>
</tbody>
</table>

* For ordering options, refer to the SEL-751 MOT.

#### Standard Protection Features
Protect lines and equipment with an extensive range of protection elements, including overcurrent elements, over- and underfrequency elements, rate-of-change-of-frequency and fast rate-of-change-of-frequency elements, definite-time and inverse-time over- and undervoltage elements, directional power elements, second- and fifth-harmonic current blocking (inrush blocking), load encroachment, demand metering elements, and breaker failure protection. Implement load shedding and other control schemes with under- and overfrequency elements, under- and overvoltage elements, and powerful SELOGIC® control equations. Also protect and control equipment with cable or line thermal elements that conform to the IEC 60255-149 standard and with vector shift elements that aid in islanding detection.

#### Optional Directional Control
Use overcurrent elements with directional control to optimize radial and looped network protection for lines and equipment. Best Choice Ground Directional Element® logic optimizes directional element performance and eliminates the need for many directional settings.

#### Optional High-Impedance Fault Detection
Use the high-impedance fault (HIF) detection element to operate for small current ground faults typically resulting from downed conductors on ground surfaces such as earth, reinforced concrete, or other poorly conductive materials. HIF event data are available in COMTRADE or Compressed ASCII format.

#### Optional Arc-Flash Protection
Reduce or eliminate damage from arc-flash events with the optional four- or eight-channel fiber-optic arc-flash detector inputs and protection elements. Settable arc-flash phase and neutral overcurrent elements combined with arc-flash light detection elements provide secure, reliable, and fast arc-flash event protection.

#### Optional Low-Energy Analog (LEA) Voltage Inputs
Measure voltages as low as 8 Vac rms.

#### Optional Synchronism Check and DC Station Battery Monitor
Check single-phase voltage across a circuit breaker; measure dc voltage levels in the substation battery.

#### Operator Controls and Reclosing
Trip and close the breaker easily with eight programmable front-panel pushbuttons, each with two tricolor LEDs. Implement remote and local control functions, and selectively reclose with synchronism and voltage checks.

#### Relay and Logic Settings Software
Reduce engineering costs by using ACSELERATOR QuickSet® SEL-5030 Software for relay settings and logic programming. Tools in QuickSet make it easy to develop SELOGIC control equations.

#### Metering and Monitoring
Use built-in metering functions to eliminate separately mounted metering devices. Analyze Sequential Events Recorder (SER) reports and oscillographic event reports for rapid commissioning, testing, and post-fault diagnostics. Unsolicited SER protocol allows station-wide collection of binary SER messages.

#### Fault Location
Reduce fault location and repair time with built-in impedance-based fault location and faulted phase indication.

#### Wye or Delta Voltage Inputs
Connect voltage inputs that are wye-connected, open-delta-connected, or single voltage.
➤ **Additional Standard Features.** Improve your feeder protection with these additional standard features in every SEL-751: Modbus RTU; Event Messenger support and **MIRRORED BITS®** communications; load profile and breaker wear monitoring; support for 12 external RTDs (SEL-2600); IRIG-B input; advanced SÉLOGIC; and IEEE C37.118-compliant synchrophasor protocol to provide real-time measurement data.

➤ **Additional Optional Features.** Select from a wide offering of other optional features, including IEC 61850 Edition 2; IEC-60870-5-103; DNP3 serial and LAN/WAN; Modbus TCP/IP; Simple Network Time Protocol (SNTP); parallel redundancy protocol (PRP) with dual Ethernet ports; ten internal RTDs; expanded digital/analog I/O; additional EIA-232 or EIA-485 communications ports; and single or dual, copper-wire or fiber-optic Ethernet ports, and an ac currents only model (no voltages) with no fiber-optic serial port and four programmable pushbuttons.

➤ **Supported Languages.** Multiple language support with English and Spanish options.

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**Intertie Standards and Compliance**

The SEL-751 Feeder Protection Relay offers an extensive variety of protection and control features depending on the model and options selected. The SEL-751 Relay can be configured to meet or exceed the protection and control requirements specified in the ANSI/IEEE Std 1547-2014, *Standard for Interconnecting Distributed Resources with Electric Power Systems*. 
Functional Overview

- Low-Energy Analogs (LEA) for AC Voltage Inputs (8 Vac RMS)*
- Sequential Events Recorder
- Event Reports and Load Profile
- Event Messenger Compatible
- Front-Panel Tricolor LED Programmable Targets
- Two Inputs and Three Outputs Standard
- I/O Expansion*—Additional Contact Inputs, Contact Outputs, Analog Inputs, Analog Outputs, and RTD Inputs
- ST Fiber-Optic Communications Port*
- Single or Dual Ethernet, Copper or Fiber-Optic Communications Port*
- Battery-Backed Clock, IRIG-B Time Synchronization
- Instantaneous Metering
- Four or Eight Programmable Front-Panel Pushbuttons and Tricolor LED Indicators
- Advanced SELogic® Control Equations
- 32 Programmable Display Messages
- Station Battery Monitor*
- Breaker Wear Monitoring
- Synchronphasor Protocol (IEEE C37.118)
- Arc-Flash Protection*
- Peak Demand, Demand Metering
- Load Encroachment
- High-Impedance Fault Detection*
- Fault Locator
- Directional Protection*
- Touchscreen Display (5-inch, color, 400 x 800 pixels)*

*Optional
Protection Features

Overcurrent Elements

The SEL-751 includes a robust set of phase, negative-sequence, residual, and neutral overcurrent elements. Each element type has four levels of instantaneous protection with individual torque control and definite-time delay settings. Each element type has two inverse-time overcurrent elements (except negative-sequence, which has one time-overcurrent element). Table 4 lists the curves available in the SEL-751.

The SEL-751 has two reset characteristic choices for each time-overcurrent element. One choice resets the elements if current drops below pickup for at least one cycle. The other choice emulates electromechanical induction disc elements, where the reset time depends on the time dial setting, the percentage of disc travel, and the amount of current.

Table 4 Inverse-Time Overcurrent Curves

<table>
<thead>
<tr>
<th>US</th>
<th>IEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately Inverse</td>
<td>Standard Inverse</td>
</tr>
<tr>
<td>Inverse</td>
<td>Very Inverse</td>
</tr>
<tr>
<td>Very Inverse</td>
<td>Extremely Inverse</td>
</tr>
<tr>
<td>Extremely Inverse</td>
<td>Long-Time Inverse</td>
</tr>
<tr>
<td>Short-Time Inverse</td>
<td>Short-Time Inverse</td>
</tr>
</tbody>
</table>

Overcurrent Elements for Phase Fault Detection

The SEL-751 Relay provides the tools necessary for sensitive fault protection while accommodating heavily loaded circuits. Where heavy loading prevents sufficiently sensitive setting of the phase overcurrent elements to detect lower magnitude phase-to-ground faults, residual-ground overcurrent elements are available to provide sensitive ground fault protection without tripping under balanced heavy load conditions. Similarly, when heavy loading prevents sufficiently sensitive setting of the phase overcurrent elements to detect lower magnitude phase-to-phase faults, negative-sequence overcurrent elements are available to provide more sensitive phase-to-phase fault detection without tripping under balanced heavy load conditions. You can set phase overcurrent element pickup sufficiently high to accommodate heavy load while retaining sensitivity to higher magnitude three-phase faults.

On extremely heavily loaded feeders, SEL-751 load-encroachment logic adds security in cases when you cannot set phase overcurrent elements to provide adequate three-phase fault sensitivity while also accommodating load. With this logic, you can set the phase overcurrent elements below peak load current so that the relay can detect end-of-line phase faults in heavily loaded feeder applications. This load-encroachment logic uses positive-sequence load-in and load-out elements to discriminate between load and fault conditions based on the magnitude and angle of the positive-sequence impedance. When the measured positive-sequence load impedance (Z1) is within a region the load-encroachment settings define, load-encroachment logic blocks the phase overcurrent elements. As Figure 2 shows, a phase fault causes Z1 to move from a load region to the line angle and leads to operation of the phase overcurrent elements.

Overcurrent Elements for Ground Fault Detection

Residual-ground (I_G) and neutral (I_N) overcurrent elements detect ground faults. Increase security by controlling these elements using optoisolated inputs or the internal ground directional element. The SEL-751 protection system includes patented Best Choice Ground Directional Element logic, providing a selection of negative-sequence impedance, zero-sequence impedance, and zero-sequence current polarizing techniques for optimum directional ground element control.

Directional Elements Increase Sensitivity and Security

Phase and ground directional elements come standard in an SEL-751 with the directional control option. An automatic setting mode (EDIR = AUTO) sets all directional threshold settings according to replica positive-sequence and zero-sequence line impedance settings (Z1MAG, Z1ANG, Z0MAG, and Z0ANG) for line protection applications. For all non-line protection applications, set EDIR = Y to enable and set appropriate directional element thresholds. Phase directional elements provide directional control to the phase- and negative-sequence overcurrent elements.
Phase directional characteristics include positive-sequence and negative-sequence directional elements working together. The positive-sequence directional element memory provides a reliable output for close-in, forward, or reverse three-phase faults where each phase voltage is zero.

Ground directional elements provide directional control to the residual-ground and neutral overcurrent elements. Patented negative-sequence, zero-sequence impedance directional elements, and the zero-sequence current directional element use the same principles proven in our SEL transmission line relays. Our patented Best Choice Ground Directional Element logic selects the best available ground directional element for the ORDER setting you provide.

**Directional Protection for Various System Grounding Practices**

Current channel IN, ordered with an optional 0.2 A secondary nominal rating, provides directional ground protection for the following systems:
- Ungrounded systems
- High-impedance grounded systems
- Petersen coil-grounded systems
- Low-impedance grounded systems

This optional directional control allows the faulted feeder to be identified on a multifeeder bus with an SEL-751 on each feeder (Figure 3). Alarm or trip for the ground fault condition with sensitivity down to 5 mA secondary.

**Line/Cable Thermal Elements**

Power lines and cables are designed to operate under a certain temperature range. Because the trend in power system operations is for equipment to be used as close to the operating limits as possible, the importance of protecting equipment against thermal overloads becomes more critical. The thermal overload protection element is used to protect the overhead lines and cables against thermal damage (including insulation degradation and loss of equipment life) and to monitor the thermal state of the overhead lines and cables. The temperature is calculated using a thermal model according to IEC 60255-149.

**Wye or Open-Delta Voltages**

You can apply wye-connected (four-wire) voltages or open-delta-connected (three-wire) voltages to three-phase voltage inputs VA, VB, VC, and N, as shown in Figure 4. You only need to make a global setting (DELTA_Y = WYE or DELTA_Y = DELTA) and an external wiring change—no internal relay hardware changes or adjustments are necessary. Thus, a single SEL-751 model meets all your distribution protection needs, regardless of available three-phase voltages.
In addition, the SEL-751 supports single voltage input. For customers with a single PT input, the SEL-751 will assume balanced voltage input for all protection and metering functions.

**Loss-of-Potential Logic**
The SEL-751 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.

**Synchronism Check**
When you order the Vsync, Vbat Voltage Input and 4 Arc-Flash Detection Inputs card (SELECT 2AVI/4AFDI), single-phase voltage (phase-to-neutral or phase-to-phase) is connected to voltage input VS/NS for synchronism check across a circuit breaker (or hot/dead line check). You can use synchronism-check voltage to coordinate reclosing with the optional recloser control.

**Voltage and Frequency Elements for Extra Protection and Control**

**Over- and Undervoltage Elements**
Phase-to-ground, phase-to-phase, negative-sequence, and residual overvoltage (59) and phase-to-ground or phase-to-phase undervoltage (27) elements in the SEL-751 can be used to create the following protection and control schemes.

- Trip/alarm or event report triggers for over- and undervoltage conditions.
- Undervoltage (27) load shedding scheme (having both 27 and 81U load shedding schemes allows detection of system MVAR- and MW-deficient conditions).

**Inverse-Time Over- and Undervoltage Elements**
Custom programmable, IEC equation-based inverse-time overvoltage (59I) and undervoltage (27I) elements in the SEL-751 add flexibility in voltage protection and control schemes.

**Over- and Underfrequency Protection**
Six 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. The SEL-751 uses the voltage input to make frequency measurements; it switches automatically to current input when voltages are insufficient.

Implement an internal multistage frequency trip/restore scheme at each breaker location using the multiple over- and underfrequency levels. This method avoids the cost of wiring a complicated trip and control scheme from a separate frequency relay.

**Rate-of-Change-of-Frequency Protection**
Four independent rate-of-change-of-frequency elements are provided with individual time delays for use when frequency changes occur, for example, when there is a sudden imbalance between generation and load. The elements can call for control action or switching action such as network decoupling or load shedding. Each element includes logic to detect either increasing or decreasing frequency and above or below nominal frequency.

**Fast Rate-of-Change-of-Frequency Protection for Aurora Vulnerability Mitigation**
The fast rate-of-change-of-frequency protection, 81RF, provides a faster response compared to frequency (81) and rate-of-change-of-frequency (81R) elements. Fast operating speed makes the 81RF element suitable for detecting islanding conditions. The element uses a characteristic (see Figure 6) based on the frequency deviation from nominal frequency (DF = FREQ – FNOP) and the rate-of-change of frequency (DF3C) to detect islanding conditions.
A time window of three cycles is used to calculate the value of DF3C. Under steady state conditions, the operating point is close to the origin. During islanding conditions, depending on the islanded system acceleration, the operating point enters Trip Region 1 or Trip Region 2 of the characteristic. 81RFDFP (in Hz) and 81RFPR (in Hz sec) are the settings used to configure the characteristic.

Vector Shift (78VS) Protection

When distributed generators (DG) are connected in the utility network, the vector shift (78VS) element is used to detect islanding conditions and trip the DG. Failure to trip islanded generators can lead to problems such as personnel safety, out-of-synchronization reclosing, and degradation of power quality. Based on the change in the angle of the voltage waveform, the islanding condition can be detected by the vector shift function.

Use the vector shift element with the 81RF element as a backup for fast and secure islanding detection. The vector shift element operates within three cycles, which is fast enough to prevent reclosing out-of-synchronism with the network feeders to avoid generator damage.

Harmonic Blocking Elements Secure Protection During Transformer Energization

Transformer inrush can cause sensitive protection to operate. Use the second- and fifth-harmonic blocking feature to detect an inrush condition and block selected tripping elements until the inrush subsides. Select the blocking threshold as a percentage of fundamental current, and optimize security and dependability with settable pickup and dropout times. Use the programmable torque control equation only to enable the blocking element immediately after closing the breaker.

Power Element Protection

The SEL-751 provides two power elements for detecting real (watts) or reactive (VARS) positive- or negative-power flow levels for the feeder application. Each power element has a definite-time delay setting.

High-Impedance Fault (HIF) Detection

High-impedance faults are short-circuit faults with fault currents smaller than what a traditional overcurrent protective relay can detect. The main causes of HIFs are tree branches touching a phase conductor; dirty or failing insulators that cause flashovers between a phase conductor and the ground; or downed conductors touching the ground. The SEL-751 with Arc Sense™ technology (AST) option, includes logic that can detect HIF signatures without being affected by loads or other system operation conditions. A running average provides a stable prefault reference, and adaptive tuning learns and tunes out feeder ambient noise conditions. Decision logic differentiates an HIF condition from other system conditions such as switching operations and noisy loads. The relay stores as many as 20 minutes of high-impedance fault activity in 2-cycle resolution Compressed ASCII and COMTRADE formats and it stores a summary of HIF activity that you can access through the use of ASCII commands.

Arc-Flash Protection

An arcing short circuit or a ground fault in low- or medium-voltage switchgear can cause serious equipment damage and personal injury, resulting in 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 in the SEL-751 Relay adds four- or eight-channel fiber-optic AFD inputs and protection elements. 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-751: point-sensor applications and fiber sensor applications.
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 (through a second fiber-optic cable). If the relay optical receiver does not detect this light, the relay declares a malfunction and alarms. *Figure 7* (top) shows a diagram for the point sensor application.

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 7* (bottom) shows a diagram for the clear-jacketed fiber sensor application.

The SEL-751 AFD system provides 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 prevent serious damage or personal injury in 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 to provide secure, reliable, and fast acting arc-flash event protection.

RTD Thermal Protection
When the SEL-751 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 provides an alarm and trip thermal pickup setting in degrees Celsius, 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)
Operator Controls and Reclosing

Operator Controls Eliminate Traditional Panel Control Switches

Four or eight conveniently sized operator controls, each with two programmable tricolor LEDs, are located on the relay front panel (see Figure 8). You can set the SER to track operator controls. You can also change operator control functions using SELOGIC control equations. The following operator control descriptions are for factory-set logic.

The LOCK operator control blocks selected functions. Press it for at least three seconds to engage or disengage the lock function. While locked in position, the following operator controls cannot change state if pressed, TRIP and CLOSE.

Use the CLOSE and TRIP operator controls to close and open the connected circuit breaker. Program with intentional time delays to support operational requirements for breaker-mounted relays. This allows the operator to press the CLOSE or TRIP pushbutton, then move to an alternate location before the breaker command is executed.

In the SEL-751 with the touchscreen display, you can use the front-panel operator control pushbuttons to jump to a specific screen while using them for LOCK/OPEN/CLOSE operations, etc. You can program the selectable operator pushbutton screen settings under the touchscreen setting category in QuickSet and map the button to the specific screen.

Programmable Autoreclosing

When ordered with optional reclosing, the SEL-751 can autoreclose a circuit breaker as many as four times before lockout. Use SELOGIC control equations to program the SEL-751 to perform the following reclosing functions.

➤ Allow closing, e.g., when the load-side line is dead, or when the two systems are in synchronism (optional).
➤ Advance the shot counter without tripping, e.g., when another protective relay clears a fault, also known as sequence coordination.
➤ Initiate reclosing, e.g., for particular protection trip operations.
➤ Drive-to-lockout, e.g., when an optoisolated input is deasserted.
➤ Delay reclosing, e.g., after a trip caused by a close-in, high-duty fault.
➤ Flexible reclose supervision failure scheme that allows going to lockout or moving to the next available shot.

The reclosing shot counter controls which protective elements are involved in each reclose interval. Applications include fuse- and trip-saving schemes. The front-panel LEDs (RECL RESET and RECL LOCKOUT) track the reclosing state.
Relay and Logic Settings Software

QuickSet Software simplifies settings and provides analysis support for the SEL-751. 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.

Use the following features of QuickSet to monitor, commission, and test the SEL-751.

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

➤ Bay control allows you to design new bay screens and edit existing bay screens by launching acSELERATOR Bay Screen Builder SEL-5036 Software for SEL-751 relays with the touchscreen display.

acSELERATOR Bay Screen Builder SEL-5036 Software

The SEL-751 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.

Figure 9 Bay Screen Builder
Metering and Monitoring

The SEL-751 provides extensive metering capabilities. See Specifications on page 30 for metering and power measurement accuracies. As shown in Table 5, 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 5 Metering Capabilities

<table>
<thead>
<tr>
<th>Types of Metering</th>
<th>Analog Inputs</th>
<th>Energy</th>
<th>Light Inputs</th>
<th>Demand and Peak Demand</th>
<th>Quantitiesa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantaneous</td>
<td>Analog Inputs</td>
<td>Energy</td>
<td>Light Inputs</td>
<td>Demand and Peak Demand</td>
<td>Quantitiesa</td>
</tr>
<tr>
<td>Math Variables</td>
<td>Remote Analogs</td>
<td>Thermal</td>
<td>RMS</td>
<td>Synchrophasors</td>
<td></td>
</tr>
<tr>
<td>Demand and Peak Demand</td>
<td>Max/Min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Quantitiesa

- Currents IA, IB, IC, IN, IG
- Voltages VA, VB, VC
- Voltages VAB, VBC, VCA
- Voltage VS
- Power kVA, kVAR, kW
- Energy MWh, MVARh, MVAr
- Power Factor PF
- Sequence I1, 3I2, 3I0, V1, 3V2, 3V0
- Frequency, FREQ, FREQS (Hz)
- Voltage VDC
- Light Intensity (%) LS1–LS8
- Current THIEQx pu
- Voltage VTHTCu
- Trip Time THTRIPx s
- Release Time THRLSx s
- RTD1–RTD12

Description

- Input currents, residual ground current (IG = 3I0 = IA + IB + IC)
- Wye-connected voltage inputs
- Delta-connected voltage inputs
- Synchronism-check voltage input
- Single and three-phase kilowatts, kilovars, and kilovolt-amps
- Three-phase megawatt-hours, megavar-hours, and megavolt-amp-hours
- Single and three-phase power factor (leading or lagging)
- Positive-, negative-, and zero-sequence currents and voltages
- Instantaneous relay frequency, synchronism-check voltage frequency
- Station battery voltage
- Arc-flash light inputs in percentage of full scale
- Analog Inputs
- Math Variables
- Remote Analogs
- Element x pu current level, thermal capacity, time to trip, and time to reset values, where x = 1, 2, or 3
- RTD temperature measurement (degrees C)

Load Profile

The SEL-751 features a programmable Load Data 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).

Synchrophasor Measurements

Use IEEE C37.118-2005 protocol to send synchrophasor data to such SEL synchrophasor applications as the SEL-3373 Station Phasor Data Concentrator (PDC), the SEL-5073 SYNCHROWAVE® PDC, the SEL-3530 Synchrophasor Vector Processor (SVP), the SEL-3530 Real-Time Automation Controller (RTAC), and the SEL SYNCHROWAVE software suite.

The SEL-3373 Station PDC and the SEL-5073 SYNCHROWAVE PDC correlate data from multiple SEL-751 Relays and concentrate the result into a single output data stream. These products also provide synchrophasor data archiving capability. The SEL-3378 SVP enables control applications based on synchrophasors. Directly measure the oscillation modes of your power system and then act on the result. Use wide-area phase angle slip and acceleration measurements to properly control islanding of distributed generation. With the SVP, you can customize a synchrophasor control application according to the unique requirements of your power system.
The data rate of SEL-751 synchrophasors is selectable with a range of 1–60 messages per second. This flexibility is important for efficient use of communication capacity.

The SEL-751 phasor measurement accuracy meets the highest IEEE C37.118-2005 Level 1 requirement of 1 percent total vector error (TVE). This means you can use any SEL-751 model in an application that otherwise would require purchasing a separate dedicated phasor measurement unit (PMU).

Use the SEL-751 with SEL communications processors, or the SEL-3530 RTAC, to change nonlinear state estimation into linear state estimation. If all necessary lines include synchrophasor measurements then state estimation is no longer necessary. The system state is directly measured.

\[
\begin{align*}
V_1 & = h(V, \theta) + \text{error} \\
V_2 & = h(V, \theta)
\end{align*}
\]

Figure 10 Synchrophasor Measurements Turn State Estimation Into State Measurement

**Improve Situational Awareness**

Provide improved information to system operators. Advanced synchrophasor-based tools produce a real-time view of system conditions. Use system trends, alarm points, and preprogrammed responses to help operators prevent a cascading system collapse and maximize system stability. Awareness of system trends provides operators with an understanding of future values based on measured data.

➤ Increase system loading while maintaining adequate stability margins.
➤ Improve operator response to system contingencies such as overload conditions, transmission outages, or generator shutdown.
➤ Advance system knowledge with correlated event reporting and real-time system visualization.
➤ Validate planning studies to improve system load balance and station optimization.

**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 6 of the most recent 180-cycle, 17 of the most recent 64-cycle, or 70 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.

The IRIG-B time-code input synchronizes the SEL-751 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, the SEL communication processor, or the SEL Real Time Automation Controller (RTAC) (via Serial Port 2 or 3 on the SEL-751). For time accuracy specifications for metering, synchrophasors, and events, see Specifications.

### Substation Battery Monitor

The SEL-751 relays that include the enhanced voltage option with the monitoring package measure and report the substation battery voltage connected to the VBAT terminals. The relay includes two programmable threshold comparators and associated logic for alarm and control. For example, if the battery charger fails, the measured dc falls below a programmable threshold. The SEL-751 alarms to alert operations personnel before the substation battery voltage falls to unacceptable levels. Monitor these thresholds with an SEL communications processor and trigger messages, telephone calls, or other actions.

The measured dc voltage appears in the meter display and the Vdc column of the event report. Use the event report column data to see an oscillographic display of the battery voltage. This display shows how much the substation battery voltage drops during trip, close, and other control operations.

### Circuit Breaker Contact Wear Monitor

Circuit breakers experience mechanical and electrical wear every time they operate. Intelligent scheduling of breaker maintenance takes into account a 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-751 breaker monitor feature compares this input data to the measure (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 13) 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)

**Figure 13** Breaker Contact Wear Curve and Settings

### Fault Locator

The SEL-751 provides a valuable estimate of fault location even during periods of substantial load flow. The fault locator uses fault type, replica line impedance settings, and fault conditions to calculate fault location. This feature, which operates without the use of communications channels, special instrument transformers, or pre-fault information, contributes to efficient dispatch of line crews and fast restoration of service. The fault locator uses three-phase voltage inputs. Wye-connected voltages are necessary for phase and ground fault distance calculations.

Only phase fault distance calculations are available with delta-connected voltages. The fault locator is unavailable in the absence of voltage or single-phase voltage connections.
Touchscreen Display

You can order the SEL-751 Feeder Protection Relay with an optional touchscreen display (5-inch, color, 800 x 480 pixels). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen display option in the SEL-751 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, and SER information
➤ View relay status and configuration
➤ Control relay operations
➤ View and edit settings
➤ Enable the rotating display
➤ Program control pushbuttons to jump to a specific screen

You can navigate the touchscreen by tapping the folders and applications. The folders and applications of the Home screen are shown in Figure 14. Folders and applications are labeled according to functionality. Additional folder and application screens for the SEL-751 touchscreen display option can be seen in Figure 15 through Figure 23.

Bay Screens Application

The SEL-751 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 15 shows the default SLD for the touchscreen display option.

Figure 15   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 16).

Figure 16   Meter Phasors

Tap the Energy application to view the energy metering quantities (see Figure 17). A reset feature is provided for the Energy, Max/Min, Demand, and Peak Demand.
applications. Tap the Reset button (see Figure 17) to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero.

![Energy Metering](image)

**Figure 17** Meter Energy

### Reports Folder Applications

Tapping the Reports folder navigates you to the screen where you can access the Events, HIF Events (if available), and SER applications. Use these applications to view events and SERs. To view the event summary (see Figure 18) of a particular event record, you can tap the event record on the Event History screen (for Events and HIF Events).

![Event Summary](image)

**Figure 18** Event Summary

Tap the Sequential Events Recorder application to view a history of the SER reports (see Figure 19).

![Sequential Events Recorder](image)

**Figure 19** Sequential Events Recorder

Tapping the Trash button, shown in Figure 18, on the Event History, HIF Event History, and Sequential Events Recorder screens and confirming the delete action removes the records from the relay.

### Control Folder Applications

Tapping the Control folder navigates you to the screen where you can access the Breaker Control, Output Pulsing, and Local Bits applications. Use the applications to perform breaker control operations, pulse output contacts (Figure 20), and control the local bits (Figure 21).

![Digital Output Pulsing-Slot A](image)

**Figure 20** Digital Output Pulsing-Slot A

![Local Bits](image)

**Figure 21** Local Bits

### 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 22).

![Device Info Folder](image)

**Figure 22** Device Info Folder
To view the trip and diagnostic messages, tap the **Trip & Diag. Messages** application (see Figure 23). When a diagnostic failure, trip, 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.

![Figure 22 Status](image1)

![Figure 23 Trip and Diagnostics](image2)

## Automation

### Flexible Control Logic and Integration Features

The SEL-751 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 the main board in the rear
- EIA-232 fiber-optic port on the main board 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 SEL real-time automation controller (RTAC), SEL communications processor, SEL computing platform, SCADA serial port, or RTUs for local or remote communication. Refer to Table 6 for a list of communications protocols available in the SEL-751.

![Table 6 Communications Protocols](image3)

<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 elements, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while a technician is transferring an event report.</td>
</tr>
<tr>
<td>Fast SER Protocol</td>
<td>Provides SER events to an automated data collection system.</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>
<tr>
<td>Synchrophasors</td>
<td>IEEE C37.118-compliant synchrophasors for system state, response, and control capabilities.</td>
</tr>
<tr>
<td>Event Messenger</td>
<td>The SEL-3010 allows users to receive alerts sent directly to their cell phone. Alerts can be triggered through relay events and can include quantities measured by the relay.</td>
</tr>
</tbody>
</table>
Apply an SEL communications processor as the hub of a star network with a point-to-point fiber or copper connection between the hub and the SEL-751 (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.

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-751 control logic improves integration in the following ways.

- **Replaces traditional panel control switches.** Eliminate traditional panel control switches with 32 local bits. Set, clear, or pulse local bits with the front-panel pushbuttons and display. Program the local bits into your control scheme with SELOGIC control equations. Use the local bits to perform functions such as a trip test or a breaker trip/close.

- **Eliminates RTU-to-relay wiring with 32 remote bits.** Set, clear, or pulse remote bits using serial port commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip, close, and settings group selection.

- **Replaces traditional latching relays.** Replace as many as 32 traditional latching relays for such functions as “remote control enable” with latch bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the relay loses power.

- **Replaces traditional indicating panel lights.** Replace traditional indicating panel lights with 32 programmable displays. Define custom messages (e.g., Breaker Open, Breaker Closed) to report power system or relay conditions on the front-panel display. Use advanced SELOGIC control equations to control which messages the relay displays.

- **Eliminates external timers.** Eliminate external timers for custom protection or control schemes with 32 general purpose SELogic control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.

- **Eliminates setting changes.** Selectable setting groups make the SEL-751 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 provides SER events to an automated data collection system. Fast SER 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-751 relays.

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

Ethernet Network Architectures

![Diagram of Ethernet Network Architectures](image)

**Figure 25** Simple Ethernet Network Configuration

**Figure 26** 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-751.

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.

Status and Trip Target LEDs

The SEL-751 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).

Event Messenger Points

The SEL-751, when used with the SEL-3010 Event Messenger, can allow for ASCII-to-voice translation of as many as 32 user-defined messages, along with analog data that has been measured or calculated by the relay. This combination can allow the user to receive voice messages on any phone for alerts to transition of any Relay Word bits in the relay.

Verbal notification of breaker openings, fuse failures, RTD alarms, etc. can now be sent directly to your cell phone through the use of your SEL-751 and SEL-3010 (must be connected to an analog telephone line). In addition, messages can include an analog value such as current, voltage, or power measurements made by the SEL-751.

Configurable Labels

Use the configurable labels to relabel the operator controls and LEDs to suit the installation requirements. This feature includes preprinted labels (with factory-default text), blank label media, and a Microsoft® Word template on CD-ROM. This allows you to create quick, professional-looking labels for the SEL-751. 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-751, including the standard model shown in Figure 31.

## Relay Dimensions

![Relay Dimensions Diagram](image)

**Figure 29** SEL-751 Dimensions for Rack- and Panel-Mount Models
Hardware Overview

Figure 30  Wiring Diagram SEL-751

A diagram for a four-wire wye connection is also available in the instruction manual.

** SEL Fiber-Optic Cables
240-1506 — 1 m (3.3 ft) ST/ST
240-1507 — 5 m (16.4 ft) ST/ST
240-1508 — 15 m (49.2 ft) ST/ST
Other lengths available by request

SEL-2600 Series External RTD Module With ST Option (Optional)
Relay Panel Diagrams

Figure 31 Front Panel With Default Configurable Labels in Base Relay

Figure 32 Dual Fiber Ethernet With 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs, DeviceNet Card, and Fast Hybrid 4 DI/4 DO Card (Relay MOT 751501AA3CA70850830)
Figure 33  Single Copper Ethernet, EIA-485 Communication, 8 DO (Form A) Card, 4 AI/4 AO Card, and 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs (Relay MOT 751201A2A6X70810320)

Figure 34  Single Copper Ethernet With EIA-232 Communication, 10 RTD Card, 4 DI/4 DO Card, and 2 AVI/4 AFDI Voltage Option Card With Arc-Flash Detector Inputs (Relay MOT 751501A1A9X70850230)
Figure 35  No Ethernet, EIA-232 Serial Communications, EIA-232/EIA-485 Communications Card, 8 DI Card, and 8 DO Card (Form A) (Relay MOT 751401AA03A2A850000)

Figure 36  Dual Copper Ethernet, 4 DI/4 DO Card, 14 DI Card, 8 AFDI Card With Arc-Flash Detector Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and 3-Phase AC Voltage Inputs (300 Vac) (Relay MOT 7515S1A1A4A77870671)
Figure 37 Dual Copper Ethernet, 14 DI Card, 8 DO (Form B) Card, 2 AVI/4 AFDI Card With LEA Vsync, Vbat Inputs, and 4 Arc-Flash Detection Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and 3-Phase LEA Voltage Inputs (8 Vac) (Relay MOT 751501A4A2BL0L70671)

Figure 38 Dual 10/100 Base-T Ethernet, EIA-232 Rear Port, Without Single Multimode ST Fiber-Optic Serial Port Rear, With DeviceNet Card, Fast Hybrid 4 DI/4 DO Card, 8 DI Card, and 4 ACI Card (No Voltage Inputs) (Relay MOT 751001AA3CA3AA50F30)
Applications

Figure 39 shows some typical protection applications for the SEL-751. You can use the SEL-751 directional and non-directional overcurrent functions to protect virtually any power system circuit or device including lines, feeders, transformers, capacitor banks, reactors, and generators. Over- and underfrequency, over- and undervoltage, vector shift elements, rate-of-change-of-frequency elements, and synchronism-check elements are well suited for applications at distributed generation sites. Directional power elements make the relay suitable for utility and customer interface protection in applications with customer generation. IEC cable/line thermal elements can be used to prevent insulation damage.

Special relay versions can be ordered to provide sensitive earth fault (SEF) protection on high-impedance grounded systems, and directional overcurrent ground fault protection on ungrounded, high-impedance grounded and tuned reactance (Petersen coil) grounded systems.

You can use powerful SELOGIC control equations in all SEL-751 models for custom protection and control applications. SEL application guides and technical support personnel are available to help with unique applications.

Figure 39  SEL-751 Feeder Protection Relay Applied Throughout the Power System
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 Location Certification tests are applicable to rated supply specifications only and do not apply to the absolute operating ranges, continuous thermal, or short circuit duration specifications.

General

AC Current Input

Phase and Neutral Currents

I_{NOM} = 200 mA, 1 A, or 5 A secondary, depending on model.

I_{NOM} = 5 A

Continuous Rating: 3 \cdot I_{NOM} @ 85°C, linear to 100 A symmetrical
4 \cdot I_{NOM} @ 55°C, linear to 100 A symmetrical
1-Second Thermal: 500 A
Burden (per phase): <0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating: 3 \cdot I_{NOM} @ 85°C, linear to 20 A symmetrical
4 \cdot I_{NOM} @ 55°C, linear to 20 A symmetrical
1-Second Thermal: 100 A
Burden (per phase): <0.01 VA @ 1 A

I_{NOM} = 200 mA

Continuous Rating: 4 A, linear to 4 A symmetrical
1-Second Thermal: 500 A
Burden (per phase): <0.01 VA @ 0.2 A
Measurement Category: II

AC Voltage Input

V_{NOM} (L-L) Setting Range: 20–250 V (if DELTA_Y := DELTA) 20–480 V (if DELTA_Y := WYE)

300 Vac Voltage Inputs

Rated Continuous Voltage: 300 Vac (phase-to-neutral)
10-Second Thermal: 600 Vac (phase-to-neutral)

<table>
<thead>
<tr>
<th>Burden</th>
<th>Input Impedance (Per Phase)</th>
<th>Input Impedance (Phase-to-Phase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_{phase}</td>
<td>0.008 VA @ 120 Vac</td>
<td>2 MΩ</td>
</tr>
<tr>
<td>V_{bat/Vs}</td>
<td>0.003 VA @ 120 Vac</td>
<td>5 MΩ</td>
</tr>
</tbody>
</table>

Low-Energy Analog (LEA) Voltage Inputs

Rated Continuous Voltage: 8 Vac (phase-to-neutral)
Nominal LEA Voltage: 0.5–6.8 Vrms (phase-to-neutral)
Input Range: ±12 V_{peak}
10-Second Thermal: 300 Vac (phase-to-neutral)
Burden: 0.0001 VA
Input Impedance: 2 MΩ single-ended (phase-to-neutral)
4 MΩ differential (phase-to-phase)

Power Supply

Relay Start-Up Time: Approximately 5–10 seconds (after power is applied until the 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): 19.2–60.0 Vdc
Power Consumption: <25 W (dc)
Interruptions: 10 ms @ 24 Vdc
50 ms @ 48 Vdc

Fuse Ratings

Low-Voltage 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
High-Voltage 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
General
The relay supports Form A, B, and C outputs.
Dielectric Test Voltage: 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
1-Second Thermal: 50 A
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 (Ue) Rating: 240 Vac
Insulation Voltage (Ui) Rating (excluding EN 61010-1): 300 Vac
1-Second Thermal: 50 A
Contact Rating Designation: B300

<table>
<thead>
<tr>
<th>B300 (5 A Thermal Current, 300 Vac Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
</tr>
<tr>
<td>Make</td>
</tr>
<tr>
<td>Break</td>
</tr>
<tr>
<td>PF &lt; 0.35, 50–60 Hz</td>
</tr>
</tbody>
</table>

Utilization Category: AC-15

AC-15
Operational Voltage (Ue) 120 Vac 240 Vac
Operational Current (Ie) 3 A 1.5 A
Make 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, 40 J

Fast Hybrid (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
Carry: 6 A @ 70°C
4 A @ 85°C
1-Second Thermal: 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
Breaking 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
Pickup/Dropout Time: Depends on the input debounce settings
250 V: ON for 200.0–312.5 Vdc
OFF below 150 Vdc
220 V: ON for 176–275 Vdc
OFF below 132 Vdc
125 V: ON for 100.0–156.2 Vdc
OFF below 75 Vdc
110 V: ON for 88.0–137.5 Vdc
OFF below 66 Vdc
48 V: ON for 38.4–60.0 Vdc
OFF below 28.8 Vdc
24 V: ON for 14–30 Vdc
OFF below 5 Vdc

When Used With AC Control Signals
Pickup Time: 2 ms
Dropout Time: 16 ms
250 V: ON for 170.6–312.5 Vac
OFF below 106 Vac
220 V: ON for 150.2–275 Vac
OFF below 93.3 Vac
125 V: ON for 85–156.2 Vac
OFF below 53 Vac
110 V: ON for 75.1–137.5 Vac
OFF below 46.6 Vac
48 V: ON for 32.8–60 Vac
OFF below 20.3 Vac
24 V: ON for 14–30 Vac
OFF below 5 Vac
### Current Draw at Nominal DC Voltage:
- 2 mA (at 220–250 V)
- 4 mA (at 48–125 V)
- 10 mA (at 24 V)

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

### Analog Output (Optional)

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

### Analog Inputs (Optional)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Input Range:</td>
<td>±20 mA</td>
<td>±10 V</td>
</tr>
<tr>
<td>Operational range set by user:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Impedance:</td>
<td>200 Ω (current mode)</td>
<td>&gt;10 kΩ (voltage mode)</td>
</tr>
<tr>
<td>Accuracy at 25°C:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With User Calibration:</td>
<td>0.05% of full scale (current mode)</td>
<td>0.025% of full scale (voltage mode)</td>
</tr>
<tr>
<td>Without User Calibration:</td>
<td>Better than 0.5% of full scale at 25°C</td>
<td></td>
</tr>
<tr>
<td>Accuracy Variation With Temperature:</td>
<td>±0.015% per °C of full-scale (±20 mA or ±10 V)</td>
<td></td>
</tr>
</tbody>
</table>

### Arc-Flash Detectors (Optional)

- Multimode fiber-optic receiver/transmitter pair
- Fiber Type: 1000 µm diameter, 640 nm wavelength, plastic, clear-jacketed, or black-jacketed
- Connector Type: V-pin

### Frequency and Phase Rotation

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

### Time-Code Input

- Format: Demodulated IRIG-B
- On (1) State: $V_H > 2.2 V$
- Off (0) State: $V_L < 0.8 V$
- Input Impedance: 2 kΩ
- Synchronization Accuracy Internal Clock: ±1 µs
- Synchronphasor Reports (e.g., MET PM): ±10 µs
- All other reports: ±5 ms
- Simple Network Time Protocol (SNTP) Accuracy Internal Clock: ±5 ms
- Unsynchronized Clock Drift: 2 minutes per year typical

### Communications Ports

**Standard EIA-232 (2 ports)**
- Location: Front Panel, Rear Panel
- Data Speed: 300–38400 bps

**EIA-485 Port (optional)**
- Location: Rear panel
- Data Speed: 300–19200 bps

**Ethernet Port (optional)**
- Single/Dual 10/100BASE-T copper (RJ45 connector)
- Single/Dual 100BASE-FX (LC connector)
- 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
### Terminal Connections

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Block</td>
<td></td>
</tr>
<tr>
<td>Screw Size</td>
<td>#6</td>
</tr>
<tr>
<td>Ring Terminal Width</td>
<td>0.310-inch maximum</td>
</tr>
<tr>
<td>Terminal Block Tightening Torque</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>0.9 Nm (8 in-lb)</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.4 Nm (12 in-lb)</td>
</tr>
<tr>
<td>Compression Plug Tightening Torque</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>0.5 Nm (4.4 in-lb)</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.0 Nm (8.8 in-lb)</td>
</tr>
<tr>
<td>Compression Plug Mounting Ear Screw Tightening Torque</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>0.18 Nm (1.6 in-lb)</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.25 Nm (2.2 in-lb)</td>
</tr>
</tbody>
</table>

### Product Standards

<table>
<thead>
<tr>
<th>Category</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetic Compatibility</td>
<td>IEC 60255-26:2013</td>
</tr>
<tr>
<td>Compatibility</td>
<td>IEC 60255-27:2013</td>
</tr>
<tr>
<td></td>
<td>UL 508</td>
</tr>
<tr>
<td></td>
<td>CSA C22.2 No. 14-05</td>
</tr>
</tbody>
</table>

### Environmental Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2-line display models)</td>
</tr>
<tr>
<td></td>
<td>IP65 enclosed in panel</td>
</tr>
<tr>
<td></td>
<td>(touchscreen models)</td>
</tr>
<tr>
<td></td>
<td>IP54 enclosed in panel</td>
</tr>
<tr>
<td></td>
<td>IEC 60255-27:2013, Section 10.6.2.1</td>
</tr>
<tr>
<td></td>
<td>Endurance: Class 2</td>
</tr>
<tr>
<td></td>
<td>Response: Class 2</td>
</tr>
<tr>
<td>Seismic (Quake Response)</td>
<td>IEC 60255-21-3:1993</td>
</tr>
<tr>
<td></td>
<td>IEC 60255-27:2013, Section 10.6.2.4</td>
</tr>
<tr>
<td></td>
<td>Response: Class 2</td>
</tr>
<tr>
<td></td>
<td>Bump: Class 1</td>
</tr>
<tr>
<td>Cold</td>
<td>IEC 60068-2-1:2007</td>
</tr>
<tr>
<td></td>
<td>IEC 60068-2-2:2007</td>
</tr>
<tr>
<td></td>
<td>IEC 60255-27:2013, Section 10.6.1.2</td>
</tr>
<tr>
<td></td>
<td>IEC 60255-27:2013, Section 10.6.1.3</td>
</tr>
<tr>
<td></td>
<td>85°C, 16 hours</td>
</tr>
<tr>
<td>Dry Heat</td>
<td>IEC 60068-2-7:2001</td>
</tr>
<tr>
<td></td>
<td>IEC 60255-27:2013, Section 10.6.1.5</td>
</tr>
<tr>
<td></td>
<td>40°C, 93% relative humidity, 10 days</td>
</tr>
</tbody>
</table>

### Operating Temperature

<table>
<thead>
<tr>
<th>Temperature Rating</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC Performance Rating</td>
<td>–40° to +85°C (~–40° to +185°F)</td>
</tr>
<tr>
<td></td>
<td>(per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)</td>
</tr>
</tbody>
</table>

### Operating Environment

| Insulation Class                          | 1                                       |
| 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

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>144.0 mm (5.67 in) x 192.0 mm (7.56 in) x 147.4 mm (5.80 in)</td>
</tr>
</tbody>
</table>

### Weight

<table>
<thead>
<tr>
<th>Weight</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7 kg (6.0 lb)</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Torque</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1.4 Nm (12 in-lb)</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.7 Nm (15 in-lb)</td>
</tr>
</tbody>
</table>
Change of Temperature: IEC 60068-2-14:2009
-40° to +85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests
Dielectric (Hi-Pot): 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
2.5 kVac on contact I/O
3.6 kVdc on power supply, IN and VN terminals
IEEE C37.90:2005
0.5 J, 5 kV on power supply, contact I/O, ac current, and voltage inputs
0.5 J, 530 V on analog outputs
0.5 J, 5 kV on power supply, contact I/O
0.5 J, 530 V on analog outputs

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

RFI and Interference Tests
Electrostatic Discharge Immunity: IEC 61000-4-2:2008
IEC 60255-26:2013; Section 7.2.3
IEEE C37.90.3:2001
Severity Level 4
8 kV contact discharge
15 kV air discharge

Radiated RF Immunity: IEC 61000-4-3:2010
IEC 60255-26:2013; Section 7.2.4
10 V/m
IEEE C37.90.2-2004
20 V/m

Fast Transient, Burst Immunity: IEC 61000-4-4:2011
IEC 60255-26:2013; Section 7.2.5
4 kV @ 5.0 kHz
2 kV @ 5.0 kHz for comm. ports

Surge Immunity: IEC 61000-4-5:2005
IEC 60255-26:2013; Section 7.2.7
2 kV line-to-line
4 kV line-to-earth

Surge Withstand Capability Immunity: EN 61000-4-18:2010
IEC 60255-26:2013; Section 7.2.6
2.5 kV common mode
1 kV differential mode
1 kV common mode on comm. ports
IEEE C37.90.1-2002
2.5 kV oscillatory
4 kV fast transient

Conducted RF Immunity: IEC 61000-4-6:2008
IEC 60255-26:2013; Section 7.2.8
10 Vrms

Magnetic Field Immunity: IEC 61000-4-8:2009
IEC 60255-26:2013, Section 7.2.10
Severity Level:
1000 A/m for 3 seconds
100 A/m for 1 minute; 50/60 Hz
IEEE 61000-4-9:2001
Severity Level: 1000 A/m
IEEE 61000-4-10:2001
Severity Level: 100 A/m
(100 kHz and 1 MHz)

Power Supply Immunity: IEC 61000-4-11:2004
IEC 61000-4-17:1999
IEC 61000-4-29:2000
IEC 60255-26:2013, Section 7.2.11
IEC 60255-26:2013, Section 7.2.12
IEC 60255-26:2013, Section 7.2.13

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

Processing Specifications and Oscillography
AC Voltage and Current Inputs: 32 samples per power system cycle
Frequency Tracking Range: 15–70 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 derived from data averaged from 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: 16 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
Instantaneous/Definite-Time Overcurrent (50P, 50G, 50N, 50Q)
Pickup Setting Range, A Secondary:
5 A models: 0.25–100.00 A, 0.01 A steps
1 A models: 0.05–20.00 A, 0.01 A steps
200 mA model: 0.01–4.00 A, 0.01 A steps (50N)
Accuracy: ±3% plus ±0.02 • I_{NOM} A secondary (steady state)
±5% plus ±0.02 • I_{NOM} A secondary (transient)
±6% plus ±0.02 • I_{NOM} A secondary (transient for 50Q)

Time Delay: 0.00–400.00 seconds, 0.01 seconds steps
0.1–400.0 seconds, 0.1 second steps (50Q)

Pickup/Dropout Time: <1.5 cycles

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

Pickup Setting Range, 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

Accuracy: 0 to +10% of setting plus ±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, % 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, 51N, 51Q)**

Pickup Setting Range, A Secondary:
- 5 A models: 0.25–24.00 A, 0.01 A steps
- 1 A models: 0.05–4.80 A, 0.01 A steps
- 200 mA models: 10.00–960.00 mA, 0.01 mA steps (51N)

Accuracy: ±5% of setting plus ±0.02 • I_{NOM} A secondary (steady state pickup)

Pickup/Dropout Time: <1.5 cycles

**Inverse-Time Undervoltage (27P, 27PP, 27S)**

Setting Range: OFF, 2.00–300.00 V (phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) or OFF, 2.00–520.00 V (phase-to-phase elements with wye inputs)

Accuracy: ±1% of setting plus ±0.5 V

Time Delay: 0.00–120.00 seconds, 0.01-second steps

Pickup/Dropout Time: <1.5 cycles


Setting Range: OFF, 2.00–300.00 V (phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) or OFF, 2.00–520.00 V (phase-to-phase elements with wye inputs)

Accuracy: ±1% of setting plus ±0.5 V

Time Delay: 0.00–16.00 s

Pickup Accuracy: ±1.5 cyc plus ±4% between 1.05 and 5.5 multiples of pickup

**Harmonic Blocking**

Pickup Range (% of fundamental): 5%–100%

Pickup Accuracy (A secondary):
- 5 A models: ±5% plus ±0.10 A of harmonic current
- 1 A models: ±5% plus ±0.02 A of harmonic current

Time Delay Accuracy: ±0.5% plus ±0.25 cycle

**Vector Shift (78VS)**

Pickup Setting Range: 2.0°–30.0°, 0.1-degree increment

Accuracy: ±10% of the pickup setting, ±1 degree

Voltage Supervision Threshold: 20.0%–100.0% + V_{NOM}

Pickup Time: <3 cycles

**Power Elements (32)**

Instantaneous/Definite Time, Three-Phase Elements Type: +W, –W, +VAR, –VAR

Pickup Setting Range, VA Secondary:
- 5 A models: 1.0–6500.0 VA, 0.1 VA steps
- 1 A models: 0.2–1300.0 VA, 0.1 VA steps

Schweitzer Engineering Laboratories, Inc. SEL-751 Data Sheet
Accuracy: ±0.10 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (5 A nominal) ±0.02 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (1 A nominal)

Time Delay: 0.0–240.0 seconds, 0.1-second steps

Pickup/Dropout Time: <10 cycles

Power Factor (55)
Setting Range: OFF, 0.05–0.99
Accuracy: ±5% of full scale for current ≥ 0.5 • INOM
Time Delay: 1–240 seconds, 1-second steps

Frequency (81)
Setting Range: Off, 15.00–70.00 Hz
Accuracy: ±0.01 Hz (V1 >60 V) with voltage tracking ±0.05 Hz (I1 >0.8 • INOM) with current tracking
Time Delay: 0.00–240.00 seconds, 0.01 second steps
Pickup/Dropout Time: <4 cycles

Rate-of-Change of Frequency (8IR)
Setting Range: OFF, 0.10–15.00 Hz/s
Accuracy: ±100 mHz/s, plus ±3.33% of pickup
Time Delay: 0.10–60.00 seconds, 0.01 second steps

Synchronism Check (25)
Pickup Setting Range
Voltage: 0.00–300.00 V
Pickup Accuracy, Secondary Voltage: ±1% plus ±0.5 V (over the range of 2–300 V)
Slip Frequency Pickup Range: 0.05 Hz–0.50 Hz
Slip Frequency Pickup Accuracy: ±0.02 Hz
Phase Angle Range: 0°–80°
Phase Angle Accuracy: ±4°

Load-Encroachment Detection
Pickup Setting Range
5 A Model: 0.10–128.00 Ω secondary, 0.01 Ω steps
1 A Model: 0.50–640.00 Ω secondary, 0.01 Ω steps
Forward Load Angle: -90° to +90°
Forward Load Angle: +90° to +270°
Accuracy
Impedance Measurement: ±5% plus ±0.5 Ω
Angle Measurement: ±3°

Station Battery Voltage Monitor
Operating Range: 0–350 Vdc (300 Vdc for UL purposes)
Pickup Range: 20.00–300.00 Vdc
Pickup accuracy: ±2% of setting plus ±2 Vdc

Timers
Setting Range: Various
Accuracy: ±0.5% of setting plus ±1/4 cycle

RTD Protection
Setting Range: Off, 1°–250°C
Accuracy: ±2°C
RTD Open-Circuit Detection: >250°C
RTD Short-Circuit Detection: <-50°C
RTD Types: PT100, NI100, NI120, CU10
RTD Lead Resistance: 25 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 Time Delay: Approx. 6 s

Metering
Accuracies are specified at 20°C, nominal frequency, ac currents within (0.2–20.0) • INOM A secondary, and ac voltages within 50–250 V secondary (1.33–6.67 V secondary with 8 V LEA option), unless otherwise noted.

Phase Currents: ±1% of reading, ±3° of pickup for relays with INOM = 1 A
Three-Phase Average Current: ±1% of reading
IG (Residual Current): ±2% of reading, ±3° of pickup for relays with INOM = 1 A
IN (Neutral Current): ±1% of reading, ±3° of pickup for relays with INOM = 1 A
IMax: ±1.6 mA and ±1% (0.04–4.0 A) (0.2 A nominal channel IN current input)

I1 Positive-Sequence Current: ±2% of reading

3V2 Negative-Sequence Current: ±2% of reading

System Frequency: ±0.01 Hz of reading for frequencies within 15–70 Hz (V1 > 60 V)
Line-to-Line Voltages: ±1% of reading, ±3° of pickup
Three-Phase Average Line-to-Line Voltage: ±1% of reading for voltages within 24–264 V
Line-to-Ground Voltages: ±1% of reading for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
Real Three-Phase Power (kW): ±2% of reading for 0.10 < pf < 1.00
Reactive Three-Phase Power (kVAR): ±2% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Power (kVA): ±3% of reading
Power Factor: ±2% of reading
RTD Temperatures: ±2°C
Energy Meter
Accumulators: Separate IN and OUT accumulators updated once per second, transferred to nonvolatile 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.

Synchrophasor Accuracy

Maximum Message Rate
Nominal 60 Hz System: 60 messages per second
Nominal 50 Hz System: 50 messages per second

The voltage accuracy specifications are only applicable for the model options with standard voltage inputs (not applicable to LEA option). The current accuracy specifications are applicable for all 1 A and 5 A options.

Note: For the SEL-751 current only model, the accuracy specifications for currents are only applicable when the applied signal frequency equals FNOM.

Accuracy for Voltages
Level 1 compliant as specified in IEEE C37.118 under the following conditions for the specified range.

Conditions
➤ At maximum message rate
➤ When phasor has the same frequency as the positive-sequence voltage
➤ Frequency-based phasor compensation is enabled (PHCOMP := Y)
➤ The narrow bandwidth filter is selected (PMAPP := N)

Range
Frequency: ±5.0 Hz of nominal (50 or 60 Hz)
Magnitude: 30 V–250 V
Phase Angle: –179.99° to 180.00°
Out-of-Band Interfering Frequency (Fs): 10 Hz ≤ Fs ≤ (2 • FNOM)

Accuracy for Currents
Level 1 compliant as specified in IEEE C37.118 under the following conditions for the specified range.

Conditions
➤ At maximum message rate
➤ When phasor has the same frequency as the positive-sequence voltage
➤ Frequency-based phasor compensation is enabled (PHCOMP := Y)
➤ The narrow bandwidth filter is selected (PMAPP := N)

Range
Frequency: ±5.0 Hz of nominal (50 or 60 Hz)
Magnitude: (0.4–2) • INOM (INOM = 1 A or 5 A)
Phase Angle: –179.99° to 180.00°
Out-of-Band Interfering Frequency (Fs): 10 Hz ≤ Fs ≤ (2 • FNOM)

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