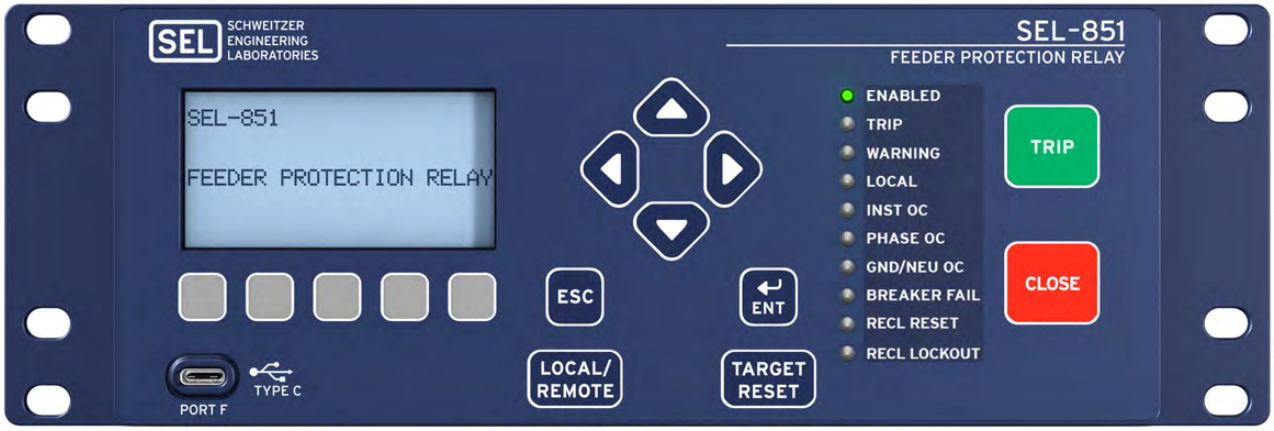
SEL-851 Feeder Protection Relay

Simplest, Safest, and Highest-Quality Relay for Utility and Industrial Feeder Protection

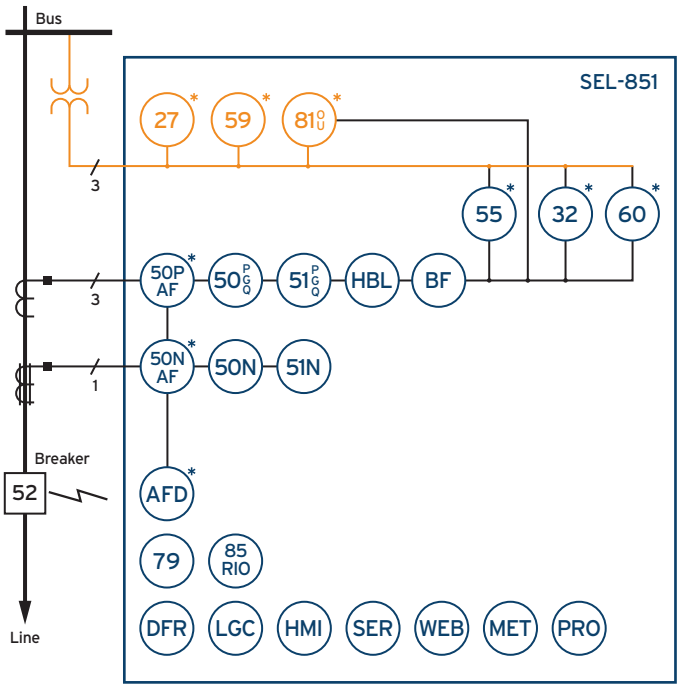


Key Features and Benefits

The SEL-851 Feeder Protection Relay provides an exceptional combination of protection, monitoring, and control in a compact and simple package.

- **Powerful and Simple Protection.** Offers fast start up time and protection that is enabled within 2 seconds. The simplest feeder relay to set up and use.
- **Fastest Arc-Flash Protection.** Increase the safety of your personnel and equipment, and significantly reduce incident energy by sending a trip signal to a breaker in as fast as 1 ms.
- **Better Visibility of the System.** Gain better visibility of your system with high-resolution currents and voltages sampled at 10 kHz.
- **Intuitive and Efficient Software.** SEL Grid Configurator is a user-friendly interface that reduces engineering and commissioning time. Improve setup efficiency by sending settings to all of your networked relays at once.
- **Reduce Downtime.** High-reliability hardware, programmable digital inputs, a universal power supply, and setting-selectable current inputs.
- **Dual Ethernet Capability With IEC 61850, DNP3, and Modbus Protocols.**

Functional Overview



ANSI Functions	
27	Undervoltage*
32	Directional power*
50PAF/NAF	Arc-flash overcurrent*
50 (P, G, Q, N)	Instantaneous overcurrent
51 (P, G, Q, N)	Time-overcurrent
55	Power factor*
59	Overvoltage*
60	Loss of potential*
79	Reclosing
81 (O, U)	Over- and underfrequency*

* Optional feature

Additional Functions	
85RIO	SEL MIRRORED BITS communications
AFD	Arc-flash detection*
BF	Breaker failure
DFR	Event reports
HBL	Harmonic blocking
HMI	Human-machine interface
LGC	SELOGIC control equations
MET	High-accuracy metering
PRO	Load profile
SER	Sequential Events Recorder
WEB	Web server

* Optional feature

Figure 1 Functional Diagram

Table 1 SEL-851 Protection Elements (Sheet 1 of 2)

Protection Element		Current Only Model	Current and Voltage Model
50P	Max. Phase Overcurrent	X	X
50Neg	Neg.-Seq. Overcurrent	X	X
50Gnd	Residual Ground Overcurrent	X	X
50N	Neutral Overcurrent	X	X
50ABC	Per-Phase Overcurrent	X	X
51P	Max. Phase Time Overcurrent	X	X
51Gnd	Residual Ground Time Overcurrent	X	X

Table 1 SEL-851 Protection Elements (Sheet 2 of 2)

Protection Element		Current Only Model	Current and Voltage Model
51Neg	Neg.-Seq. Time Overcurrent	X	X
51N	Neutral Time Overcurrent	X	X
HBlk	Second-Harmonic Blocking	X	X
27	Undervoltage (Phase-to-Phase)		X
59	Overvoltage (Phase-to-Phase, Residual)		X
60LOP	Loss of Potential		X
32	Directional Power		X
55	Power Factor		X
81	Over- and Underfrequency		X
BF	Breaker Failure	X	X
79	Reclosing	X	X
AFD	Arc-Flash Detection	X[a]	X[a]

[a] Available as an ordering option.

Features

- **Currents and Voltages.** The relay includes four current inputs and three optional voltage inputs for comprehensive current, voltage, and frequency protection.
- **Feeder Protection and Control Features.** Protect low- and medium-voltage three-phase feeders with breaker/contactor failure, phase, negative-sequence, and neutral instantaneous/time-overcurrent elements. Additionally, the relay also supports recloser control.
- **Digitally Signed Firmware.** Relay firmware can be securely downloaded to your relay via the Ethernet port. The firmware is digitally signed to prevent malicious modification.
- **Optional Protection Features.** Use the SEL-851 relay with the voltage input option to provide over- and undervoltage, over- and underfrequency, directional power, loss-of-potential, and power factor elements.
- **Operator Controls.** Increase operator safety using Local/Remote control on the front panel along with the ability to perform breaker control. Use the eight programmable LEDs on the front panel to reflect the operating conditions of the system.
- **Integrated Web Server.** Log in to the built-in web server to view metering and monitoring data, download events and the Sequential Events Recorder (SER) report, view or edit settings, and upgrade firmware.
- **Intuitive and Efficient Software.** SEL Grid Configurator is a user-friendly interface that reduces engineering costs for relay settings and logic programming.
- **Metering and Monitoring.** Use built-in metering function to eliminate separately mounted metering devices. Analyze the Sequential Events Recorder (SER) report and oscillographic event reports for rapid commissioning, testing, and post-fault diagnostics. Additional monitoring functions include signal profile monitoring and demand metering.
- **Direct Connect Voltage Inputs.** Optional voltage inputs allow for wye-connected, open delta-connected, or single-voltage inputs to the relay.
- **Control Inputs and Outputs.** Four or ten (optional) internally wetted, programmable control inputs or four or ten (optional) externally wetted, programmable control inputs (24–250 Vac/Vdc) and two hybrid contact outputs (Form A) and three electromechanical contact outputs (one Form C and two Form A) for control and status indication.

- **Communications Ports.**
  - Port 1 is an EIA-232/EIA-485 (RJ45) rear-panel port with IRIG-B time code input
  - Port 2 is a single or dual (optional) 10/100BASE-T Ethernet port(s)
  - Front-panel USB-C port
- **Time Synchronization.** Synchronize events and expedite analysis by connecting the standard IRIG-B input to a synchronized time source or using Simple Network Time Protocol (SNTP).
- **Communications Protocols.**
  - Modbus RTU, Modbus TCP/IP
  - IEC 61850 Edition 2 (optional)
  - SNTP
  - DNP3 Serial and LAN/WAN (optional)
  - Secure File Transfer Protocol (FTP)
  - Secure Telnet Protocol
  - HTTP/HTTPS
  - MIRRORED BITS communications
  - SEL protocols for metering and event data

Protection and Control

The SEL-851 relay includes a robust set of phase, negative-sequence, residual, and neutral overcurrent elements.

Each element type has at least two levels of instantaneous protection. Each element type has two time-overcurrent elements.

The SEL-851 relay has two reset characteristics for each time-overcurrent element. One characteristic resets the element if the current drops below the pickup setting for at least one cycle. The other characteristic emulates an electromechanical induction disc element, where the reset time depends on the time dial setting, the percentage of disc travel, and the amount of current.

Overcurrent Elements for Phase Fault Detection

Phase and negative-sequence overcurrent elements detect phase faults. Negative-sequence current elements ignore three-phase load to provide more sensitive coverage of phase-to-phase faults. Phase overcurrent elements detect three-phase faults, which do not have significant negative-sequence quantities.

Overcurrent Elements for Ground Fault Detection

Calculated residual current or optional measured residual current (IGnd), neutral (IN), and negative-sequence overcurrent elements detect ground faults.

Loss-of-Potential Logic

The SEL-851 relay includes optional 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.

Voltage and Frequency Elements for Extra Protection and Control

Over- and Undervoltage Elements

Optional phase-to-phase, residual overvoltage (59), and phase-to-phase undervoltage (27) elements in the SEL-851 relay 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.

Over- and Underfrequency Protection

Two levels of secure overfrequency (81O) or underfrequency (81U) elements are available for models with the voltage option to detect true frequency disturbances. Use the independently time-delayed output of these elements to shed load or trip local generation. The SEL-851 relay takes frequency measurements based on the voltage inputs and automatically switches to currents when voltage magnitudes fall below the voltage thresholds. Implement an internal multistage frequency trip/restore

scheme at each breaker location using the over- and underfrequency levels. This method avoids the cost of wiring a complicated trip and control scheme from a separate frequency relay.

Reclosing

The SEL-851 can reclose as many as four times. This allows as many as five operations of any combination of fast and delay curve overcurrent elements. Customize reclosing logic by using SELOGIC control equations.

Power Element Protection

The SEL-851 relay with optional voltage inputs 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.

Harmonic Blocking Elements Secure Protection During Transformer Energization

Transformer inrush can cause sensitive protection to operate. Use the second-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.

Arc-Flash Protection

An arcing short circuit or 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. Arc-flash detection-based (AFD) protection can act on the circuit breaker within 1–2 ms. This fast response can limit the arc-flash energy and prevent injury to personnel and limit or eliminate equipment damage. The arc-flash protection option in the SEL-851 relay adds four-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-851 relay.

Point-Sensor or Window-Point Sensor Application

An 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.

See the *SEL-851 Instruction Manual* for more details on the window point sensor, which is optimized for mounting outside the switchgear, motor control centers, or breaker cabinets to detect an arc-flash inside the enclosure.

Fiber-Sensor Application

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

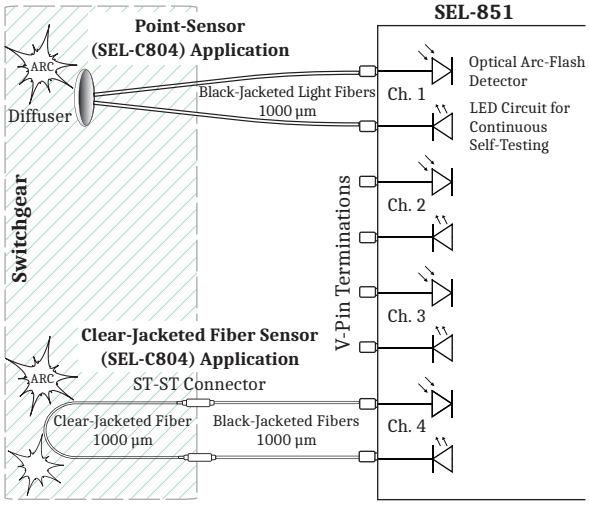


Figure 2 Arc-Flash Detection System

Clear-Jacketed Fiber Sensor Application

You can also use a clear-jacketed 1000-µm plastic fiber-optic cable located in the switchgear equipment to detect an arc. 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 transmitted 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-851 relay AFD system provides four channels per relay that can be configured for the point sensor or the clear-jacketed fiber sensor applications. The fast hybrid (high-speed, high-current) of the relay provide fast-acting trip outputs to the circuit breaker (less than 50 µs typical). Fast breaker tripping can prevent serious damage or personal injury during 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.

Metering and Monitoring

The SEL-851 relay provides accurate rms and fundamental frequency metering for input currents and optional voltages. Use the serial port, built-in web server, or built-in HMI to view phase, negative-sequence, and average magnitudes. When equipped with voltage inputs, the relay provides additional meter quantities that include the following:

- Phase, residual, negative-sequence, and average magnitudes
- Real, reactive, and apparent power (kW, kVAR, kVA)
- Power factor

Other metered values include the following:

- Maximum and minimum metering
- Energy metering
- Demand and peak demand metering
- Harmonics metering
- Math variables
- Remote analogs
- Light metering

Table 2 Metering Capabilities

Quantities	Description
Currents IA, IB, IC, IG (calculated 3I0), IN, average, I1, 3I2	Input currents, residual-ground current (IG = 3I0), neutral current, and positive- and negative-sequence current
Voltages VA, VB, VC	Wye-connected voltage inputs
Voltages VAB, VBC, VCA	Delta-connected voltage inputs
VAVG, 3V0, V1, 3V2	Average, ground, and positive- and negative-sequence voltages
Power Quantities kW, kVAR, kVA	Three-phase kilowatts, kilovars, and kilovolt-amps
PF	Power factor (leading or lagging)
Energy MWh3P-Received, MWh3P-Delivered, MVARh3P-Received, MVARh3P-Delivered, MVAh3P	Three-phase megawatt-hours, megavar-hours, and megavolt-amp-hours
Frequency (Hz)	Frequency in Hz
PMV_001–PMV_016	Protection math variables
RA_001–RA_032	Remote analogs
Light intensity (%) LS1–LS4	Arc-flash light inputs in percentage of full scale

Signal Profiling

Signal profile monitoring provides a periodic snapshot (selectable rate of every 5, 10, 15, 30, or 60 minutes) of as many as 16 selectable analog quantities from the complete list of analog quantities the SEL-851 relay generates. Examples of the analog quantities available include the following:

- Phase and neutral current magnitudes
- System frequency
- Maximum and minimum values

When the voltage option is specified, the relay can also record the following:

- Phase-to-phase voltage magnitudes
- Real power magnitude
- Reactive power magnitude
- Apparent power magnitude
- Energy values

The SEL-851 relay maintains signal profile information in nonvolatile buffer memory. The memory can hold as many as 4,000 time-stamped entries. For example, if you chose to monitor 10 values at a rate of every 15 minutes, you could store 41.67 days of data.

Improve Situational Awareness

Event Reporting and SER

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.

The relay supports COMTRADE event report format. Data are acquired at the rate of 10 kHz and stored at the rate of 2 kHz, 5 kHz, or 10 kHz. Event reports can be between 0.25 seconds and 2.00 seconds in length. The same event report file includes both the raw samples and filtered magnitude and angles of currents and voltages.

The relay SER feature stores the latest 1,024 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.

IEC 61850 Test Mode

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

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

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

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

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

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

Automation

Flexible Control Logic and Integration Features

The SEL-851 relay supports single or dual copper Ethernet ports. Additionally, the relay supports a setting selectable EIA-232/485 serial port.

You can use any system with a web browser or terminal emulation software for metering or control. Establish communication by connecting computers, modems, protocol converters, printers, an SEL real-time automation controller (RTAC), SEL computing platform, SCADA, and/or RTUs for local or remote communication. Refer to *Table 3* for a list of communications protocols available in the SEL-851 relay.

Table 3 Communications Protocols[a,b]

Type	Description
Simple ASCII	Plain language commands for human and simple machine communication. Use for metering, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Fast Meter and Fast Operate	Binary protocol for machine-to-machine communication. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element, I/O status, time tags, start and stop commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines, so there is no loss of control operator metering information while a technician transfers an event report.
Fast SER	Provides SER events to an automated data collection system.
Modbus	Serial- or Ethernet-based Modbus with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and settings.
MIRRORED BITS	The SEL-patented MIRRORED BITS communications technology provides bidirectional relay-to-relay digital communications.
DNP3	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, and relay summary event reports.
IEC 61850 Edition 2	Ethernet-based international standard for interoperability among intelligent devices in a substation. Operates remote bits and I/O. Monitors Relay Word bits and analog quantities. Supports Fixed GOOSE peer-to-peer communication with eight settings selectable analog quantities and Relay Word bits.
SNTP	Ethernet-based protocol that provides time synchronization of the relay.

[a] Port 1 supports SEL, Modbus RTU, or DNP3 protocols.

[b] Port 2 concurrently supports two Modbus TCP, three DNP3 LAN/WAN, one FTP, two Telnet, one SNTP, six IEC 61850 sessions, and three HTTP sessions for the web server.

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

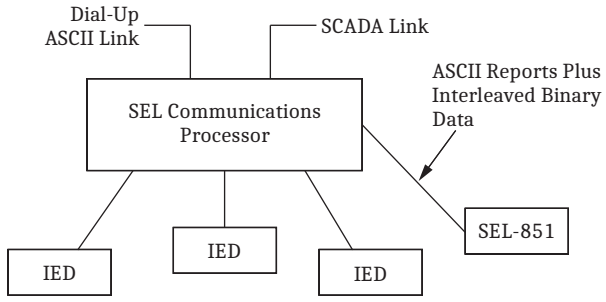


Figure 3 Example Communications System

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

SEL-851 relay control logic improves integration in the following ways.

Eliminates RTU-to-relay wiring with sixteen remote bits. Set, clear, or pulse remote bits through the use of port commands. Program the remote bits into your control scheme with SEL Grid Configurator. Use remote bits for SCADA type control operations such as trip and close.

Replaces traditional latching relays. Replace as many as 16 traditional latching relays for such functions as “remote control enable” with protection latches. Program latch set and latch reset conditions with SEL Grid Configurator. Use optoisolated inputs, remote bits, or any programmable logic condition to set or reset the nonvolatile latch bits. Each latch bit retains its state when the relay loses power.

Replaces traditional indicating panel lights. Replace traditional indicating panel lights with eight programmable displays. Define custom messages (e.g., Breaker Open, Breaker Closed) to report power system or relay conditions. Use control equations to control which messages the HMI displays.

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

Fast SER Protocol

SEL Fast SER Protocol provides SER events to an automated data collection system. SEL Fast SER Protocol is available on any serial or Ethernet port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-851 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 human readable through use of 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 use of a single communications channel for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

Ethernet Network Architectures

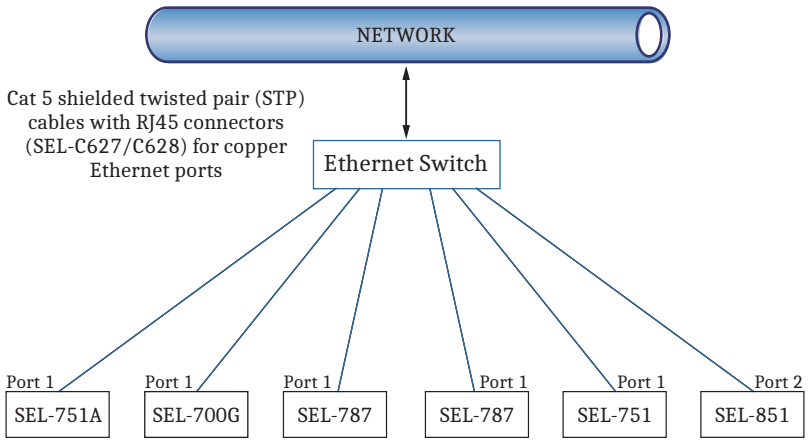


Figure 4 Simple Ethernet Network Configuration

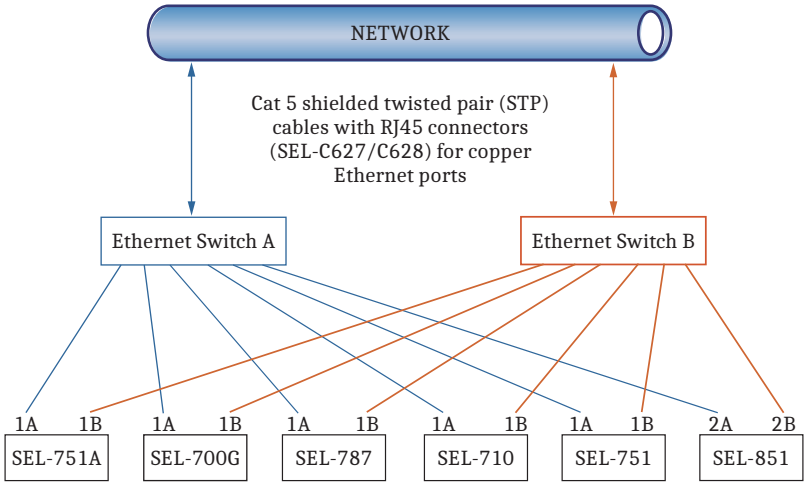


Figure 5 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

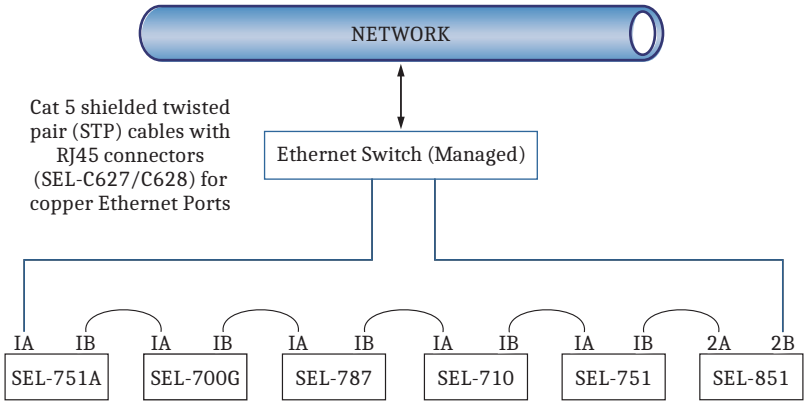


Figure 6 Ethernet Network Configuration With Ring Structure (Switched Mode)

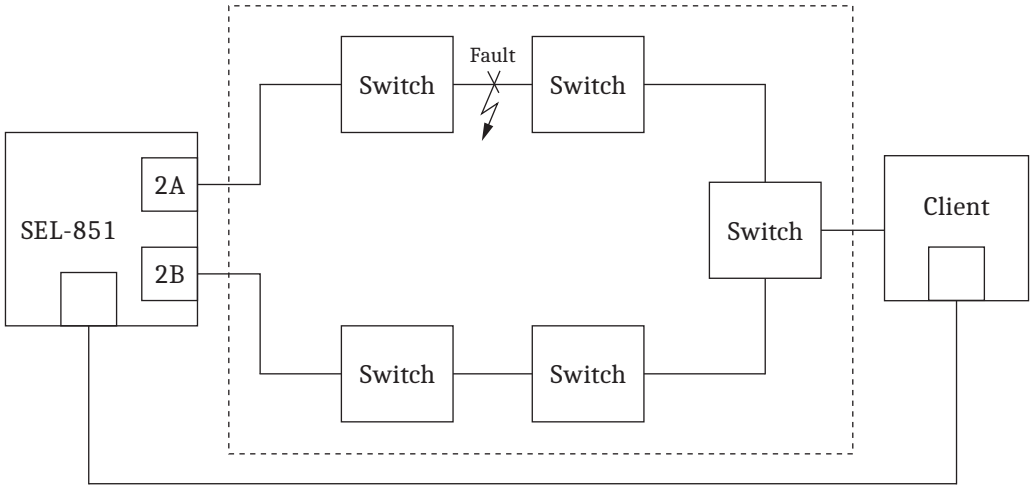


Figure 7 Dual Ethernet Configuration With NETMODE := FAILOVER and Using Network Link Failure Setting to Force Switchover

Operator Controls

There are multiple methods for accessing and using the operator interface of the relay.

Relay Front Panel

The front panel of the relay has ten tricolor LED targets (eight programmable) with configurable labels. It also has a graphical LCD display with six pushbutton navigation keys and five function keys. Four control pushbuttons are provided for **TRIP**, **CLOSE**, **LOCAL/REMOTE** selection, and **TARGET RESET**. The main menus consist of the following categories: Meter, Event, Targets, Control, Status, and Setting.

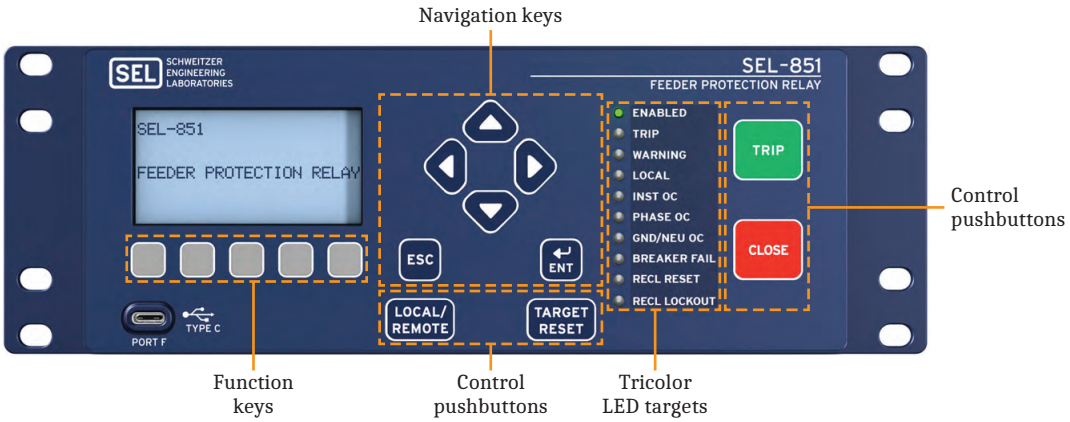


Figure 8 Relay Front Panel

Built-In Web Server

Every SEL-851 relay includes a built-in web server. Interface to the relay with any standard web browser to perform any of the following functions:

- Log in with password protection.
- Safely read, edit, save, and download relay settings.
- Verify relay self-test status and relay configuration.
- Inspect meter reports.
- Download SER, event history, and event reports from the relay.
- Display relay status, including target status, and allow control, including TRIP/CLOSE.
- Upload new firmware to the relay (firmware upgrade).

Figure 9–Figure 11 show examples of the fundamental metering, control, and protection settings screens.

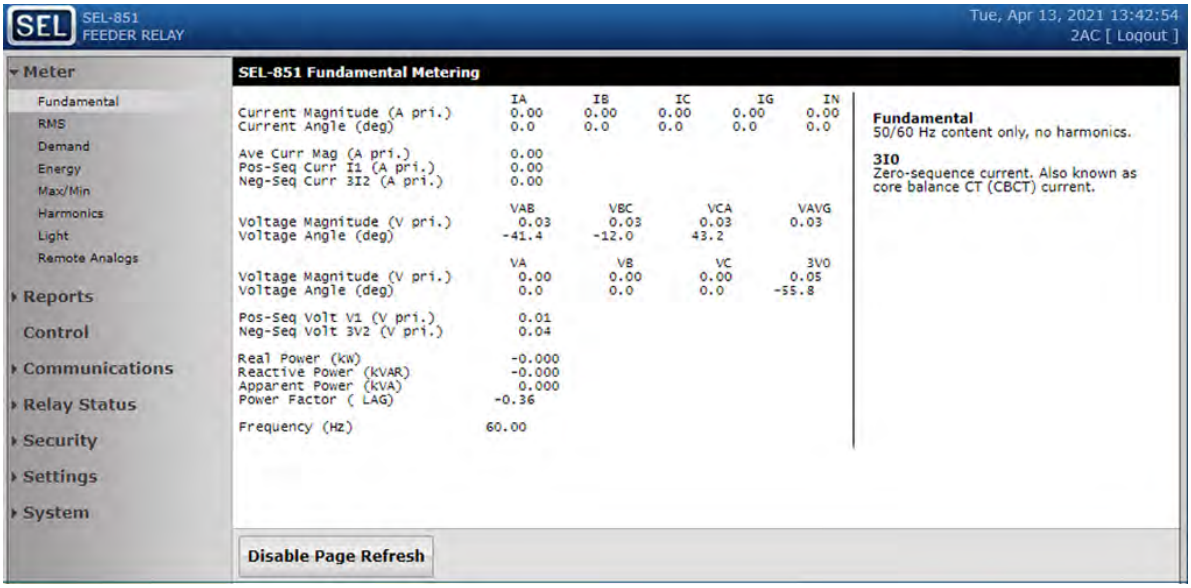


Figure 9 Web Server Fundamental Metering Screen

Figure 10 Web Server Control Screen

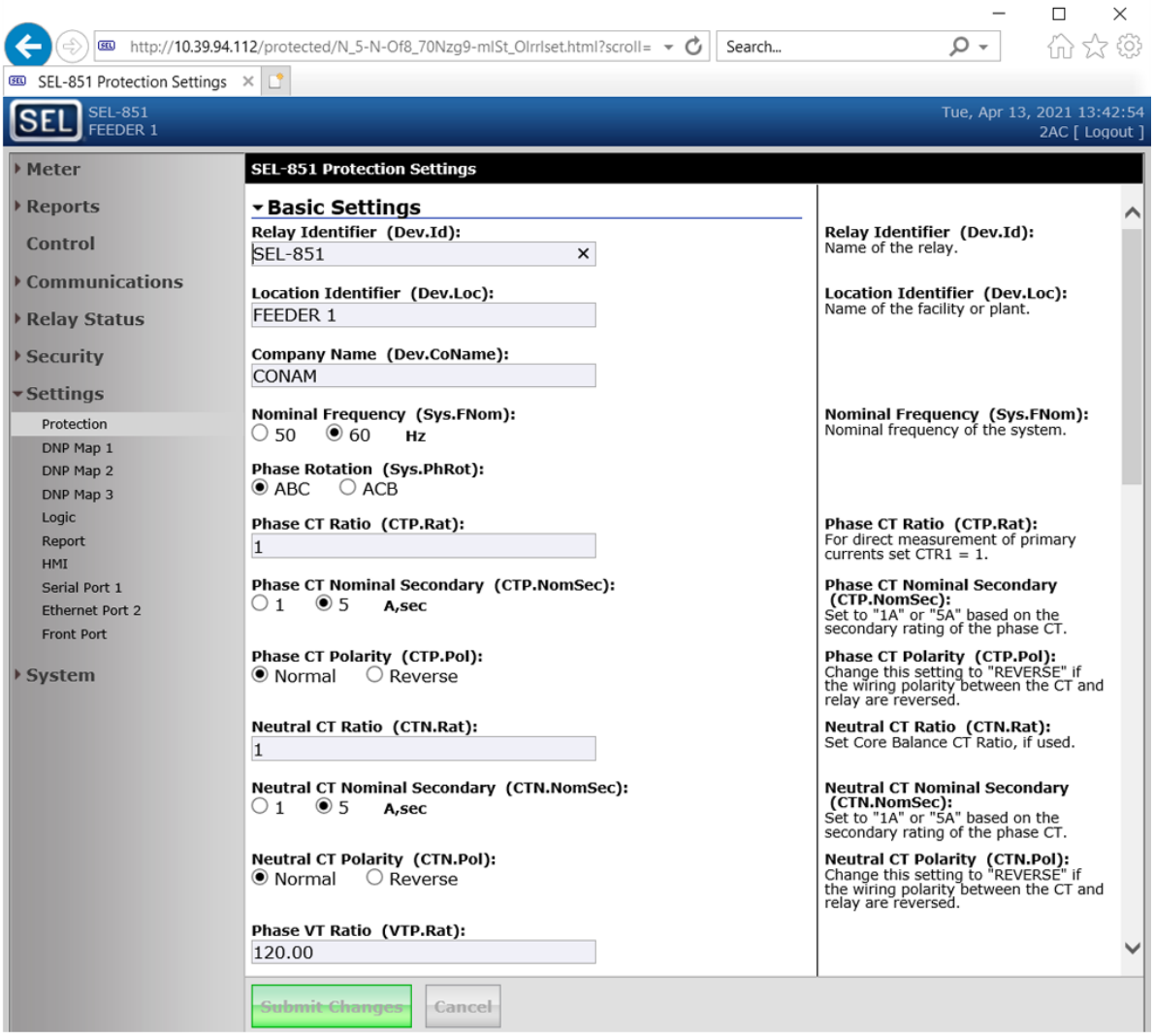


Figure 11 Web Server Protection Settings Screen (Partial)

Relay and Logic Settings Software

SEL Grid Configurator simplifies settings and provides analysis support for the SEL-851 relay. With SEL Grid Configurator Software, you have several ways to create and manage relay settings:

- Develop settings offline with an intelligent settings editor that only allows valid settings.
- Send settings to all of your networked relays at once.
- Create control logic with a drag and drop editor.
- Configure proper settings through the use of online help.
- Organize settings with the relay database manager.
- Load and retrieve settings through the use of a simple PC Ethernet communications link.

With SEL Grid Configurator, you can use integrated waveform analysis to verify settings and analyze power system events.

Use the following features of SEL Grid Configurator to monitor, commission, and test the SEL-851 relay.

- 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, start/stop control testing and diagnostics, and other control functions.
- Upgrade firmware through use of the Firmware Loader.

Applications

Figure 12 shows some typical protection applications for the SEL-851. You can use the SEL-851 overcurrent functions to protect virtually any power system circuit or device including lines, feeders, transformers, and capacitor banks. Over- and underfrequency 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.

You can use powerful SELOGIC control equations in all SEL-851 models for custom protection and control applications. SEL application guides and technical support personnel are available to help with unique applications.

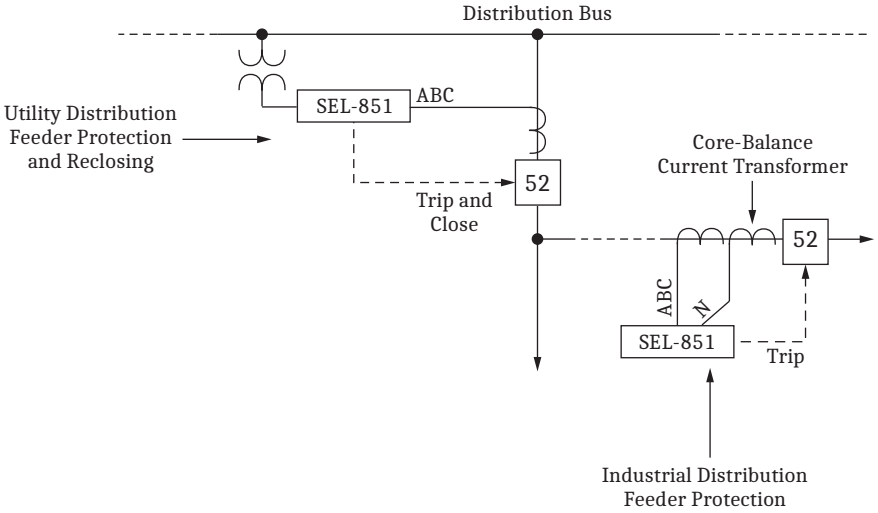


Figure 12 SEL-851 Feeder Protection Relay Applied Throughout the Power System

Relay Dimensions and Mounting Options

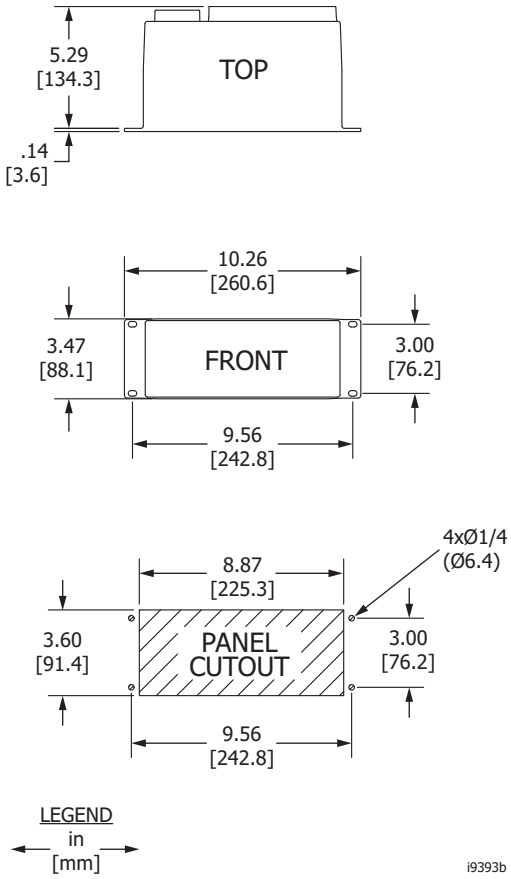


Figure 13 Horizontal Rack Mount Option Dimensions

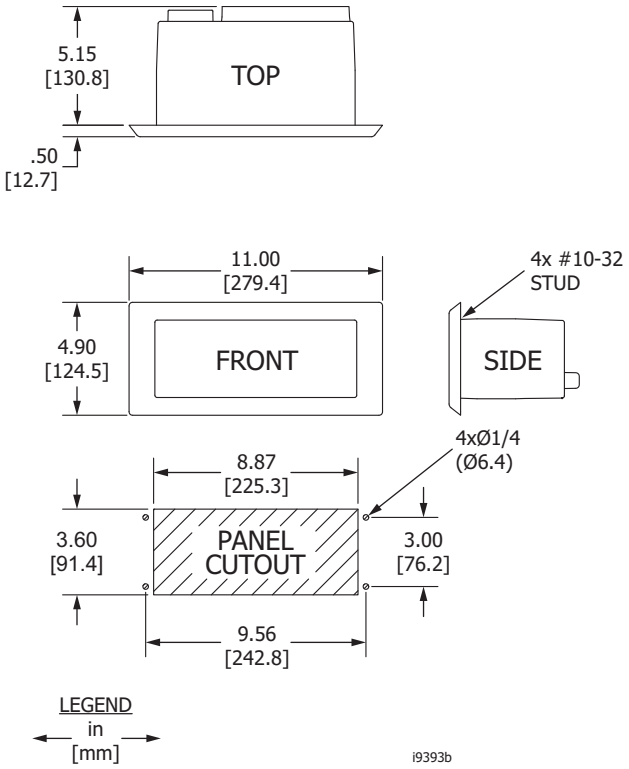


Figure 14 Horizontal Panel Mount Option Dimensions

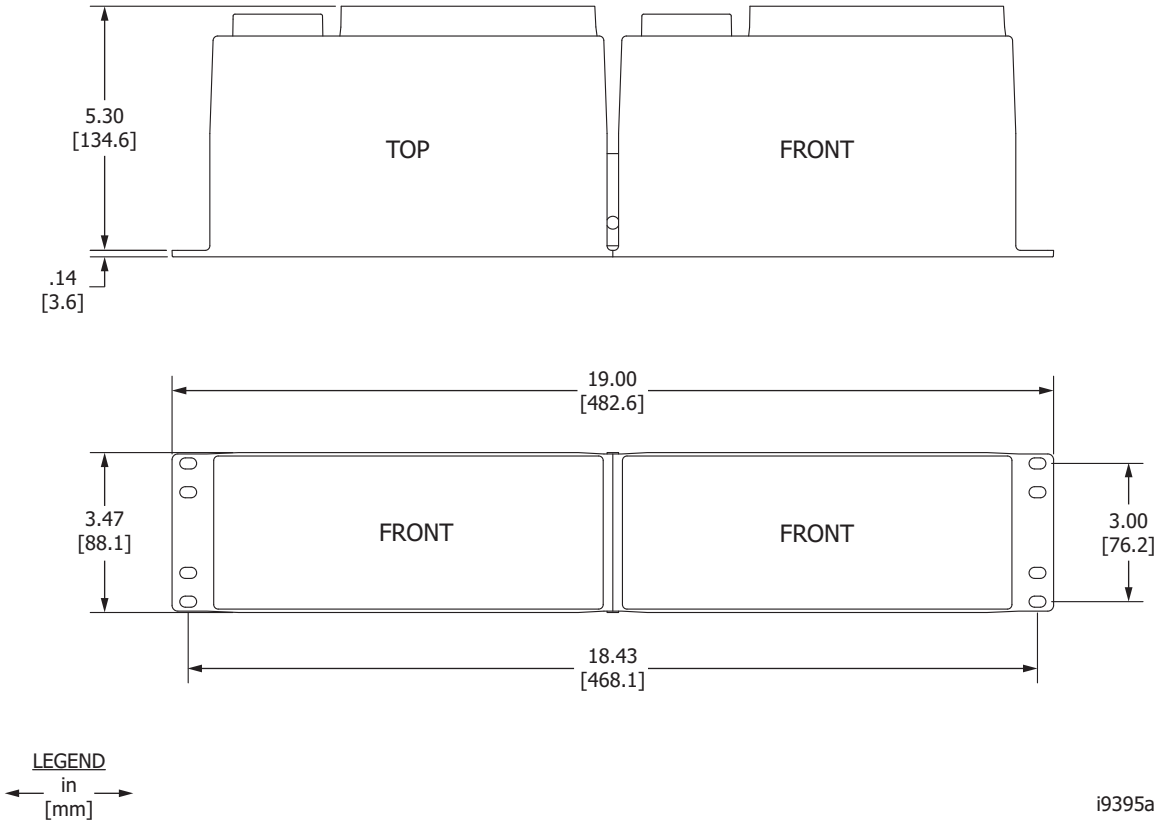


Figure 15 Ganged Rack Mount Option Dimensions

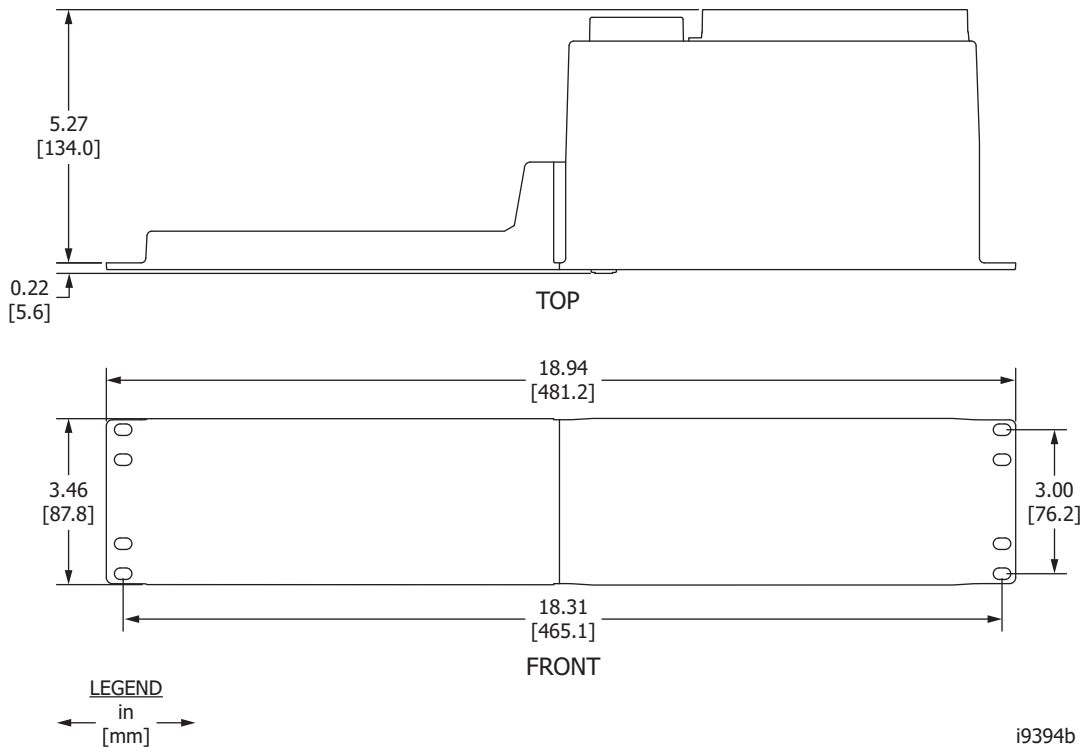


Figure 16 19-Inch Horizontal Rack Mount With Adapter Plate Option Dimensions

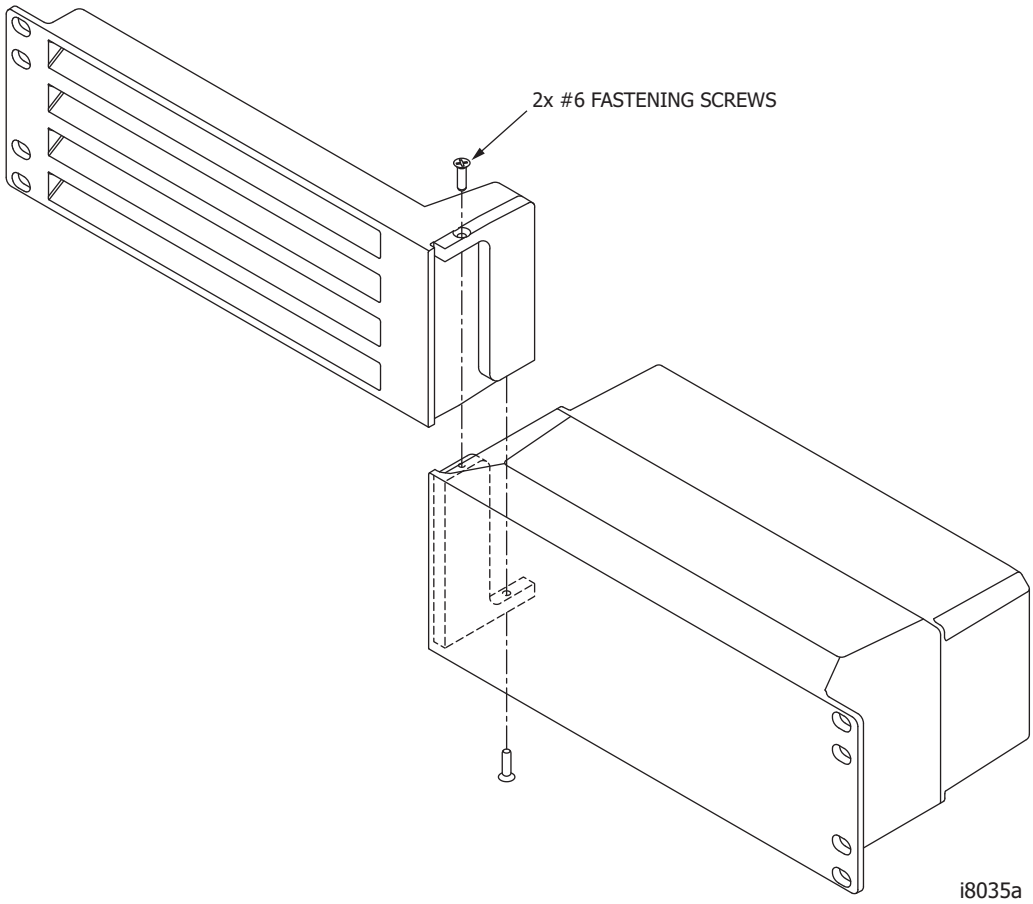


Figure 17 SEL-851 19-Inch Horizontal Rack-Mount Assembly

Hardware Overview

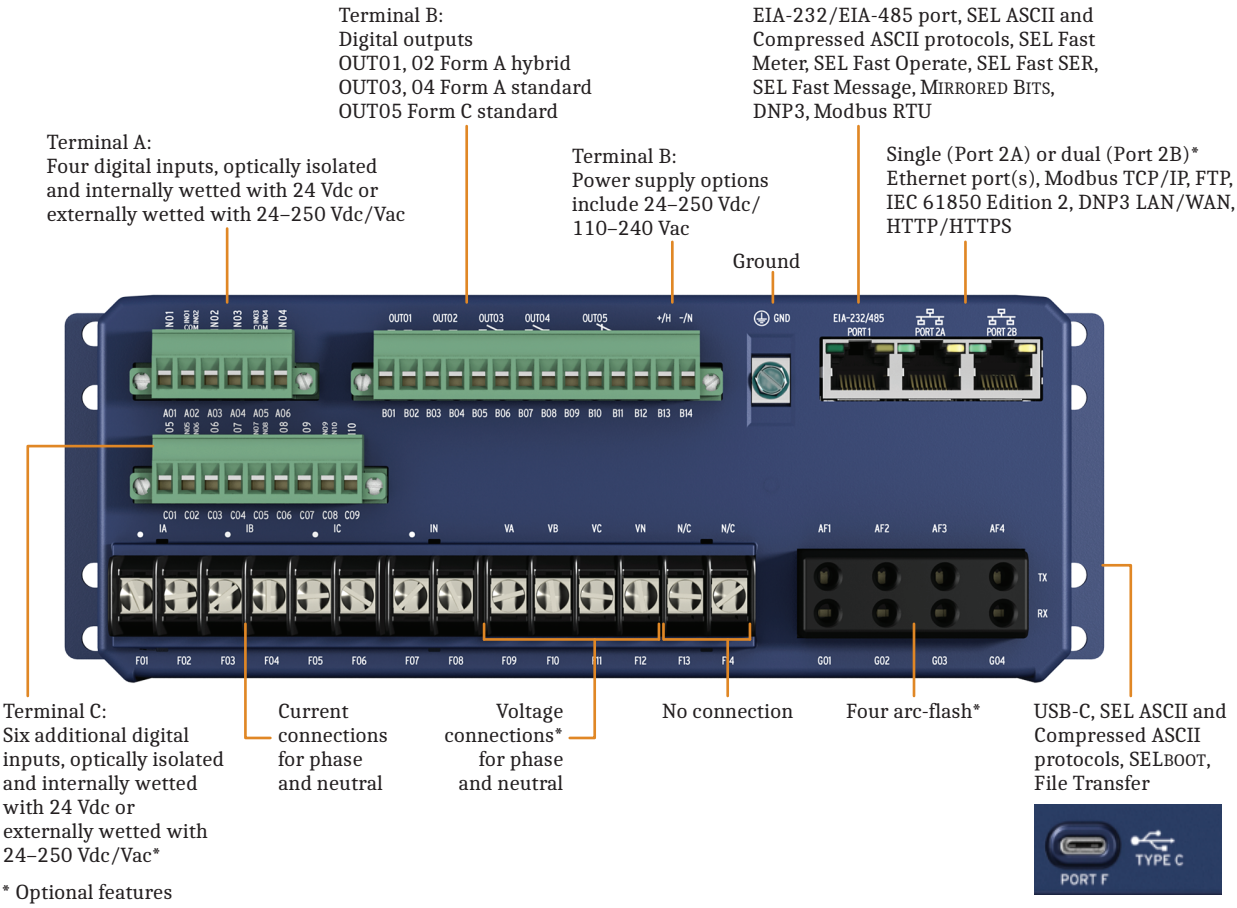


Figure 18 SEL-851 Relay Features and Options

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 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.

UL Listed Protective Relays (E212775)

CE Mark in accordance with the requirements of the European Union

RCM Mark in accordance with the requirements of Australia

UKCA Mark in accordance with the requirements of the United Kingdom

General

AC Current Inputs—Phase and Neutral

Rated Range:	1 A/5 A software selectable
Continuous Rating:	20 Arms @ 55°C
1-Second Thermal:	500 Arms
A/D Measurement Limit:	286 A peak (202 Arms symmetrical)
Rated Frequency:	50/60 Hz
Burden (Per Phase):	<0.1 VA @ 5 A

AC Voltage Inputs

Rated Operating Voltage (Ue):	50–250 Vac
Rated Continuous Voltage:	300 Vac
10-Second Thermal:	600 Vac
A/D Measurement Limit:	540 V peak (381 Vrms symmetrical)
Rated Frequency:	50/60 Hz
Input Impedance:	2 MΩ single-ended (phase-to-neutral) 2 MΩ differential (phase-to-phase)
Burden:	<0.1 VA at 120 Vac

Universal Power Supply

Rated Supply Voltage:	24–250 Vdc/110–240 Vac, 50/60 Hz
Absolute Operating Range:	19.2–264 Vac 19.2–275 Vdc
Power Consumption:	<35 VA (ac) <12 W (dc)
Interruptions:	20 ms minimum

Fuse Ratings

Rating:	1.25 A
Maximum Rated Voltage:	600 Vac 250 Vdc
Breaking Capacity:	60 A at 250 Vac
Type:	Time-lag T

Output Contacts

General

The relay supports Form A and Form C outputs

Mechanical Durability:	100,000 no-load operations

Standard

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

DC Output Ratings

Form A and Form C

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	24–250 Vdc
Rated Insulation Voltage:	300 Vdc
Make (Short-Duration Contact Current):	30 Adc (per IEC 60255-27:2013, C37.90-2005, tested for the number of cycles shown) 1000 operations @ 250 Vdc 1000 operations @ 125 Vdc
Continuous Carry:	6 A @ 70°C 5 A @ 85°C
1-Second Thermal:	50 A
Contact Rating Designation:	8 A, 24 Vdc (resistive) 100 k 0.27 A, 250 Vdc
Contact Protection:	385 Vdc, 65 J MOV protection across open contacts

Breaking Capacity (10,000 Operations):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 20 ms

Cyclic Capacity (2.5 Cycle/Second):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 20 ms

AC Output Ratings

Contact Rating Designation:	8 A, 250 Vac (resistive) 100 k C150, B300
Utilization Category:	AC-15

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

Voltage Protection Across Open Contacts:	385 Vdc, 65 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 (Short-Duration Contact Current):	30 Adc (per IEC 60255-27:2013, C37.90-2005, tested for the number of cycles shown) 1000 operations @ 250 Vdc 1000 operations @ 125 Vdc

Carry:	6 A @ 70°C 4 A @ 85°C
1-Second Thermal:	50 A
Open State Leakage Current:	<500 µA
MOV Protection (Maximum Voltage):	330 Vdc, 145 J MOV
Pickup Time:	≤50 µs, resistive load
Dropout Time:	≤8 ms, resistive load

Breaking Capacity (10,000 Operations)

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

Cyclic Capacity (4 cycles in 1 second followed by 2 minutes idle for thermal dissipation)

48 V	8.0 A	L/R = 40 ms
125 V	8.0 A	L/R = 40 ms
250 V	8.0 A	L/R = 20 ms

AC Output Ratings

See *AC Output Ratings* for standard contacts.

Optoisolated Control Inputs

Externally Wetted (24–250 Vdc/Vac)

Rated Range:	24, 48, 110, 125, 220, and 250 Vdc/Vac, setting selectable
Minimum Current Draw:	1.5 mA
Pickup Time:	2 ms plus ±1 ms (24–250 Vac) 2 ms plus ±1 ms (48–250 Vdc) 4 ms plus ±1 ms (24 Vdc)
Dropout Time:	10 ms plus ±1 ms (24–250 Vac) 2 ms plus ±1 ms (48–250 Vdc) 4 ms plus ±1 ms (24 Vdc)

Nominal Voltage AC/DC	Deassertion Range (±5%)		Assertion Range (±5%)	
	V_{DC} (V)	V_{AC} (V)	V_{DC} (V)	V_{AC} (V)
24 V	0.0–14.4	0.0–10.1	19.2–30.0	16.8–26.4
48 V	0.0–28.8	0.0–20.2	38.4–60.0	33.6–52.6
110 V	0.0–66.0	0.0–46.2	88.0–132.0	77.0–116.2
125 V	0.0–75.0	0.0–52.5	100.0–156.2	87.5–137.5
220 V	0.0–132.0	0.0–92.4	176.0–264.0	154.0–232.3
250 V	0.0–150.0	0.0–105	200.0–300.0	175.0–264.0

Internally Wetted (24 Vdc)

Wetting-Voltage Range:	18–24 Vdc
Guaranteed Pickup Requirements:	<2.50 kΩ
Guaranteed Dropout Requirements:	>4.25 kΩ
Pickup Time:	4 ms plus ±1 ms
Dropout Time:	2 ms plus ±1 ms

Frequency and Rotation

System Frequency:	50, 60 Hz
Phase Rotation:	ABC, ACB
Frequency Tracking:	15.0–70.0 Hz

Time-Code Input

IRIG-B

Format:	Demodulated IRIG-B
On (1) State:	Vih ≥ 2.2 V
Off (0) State:	Vil ≤ 0.8 V
Input Impedance:	2 kΩ

Simple Network Time Protocol (SNTP) Accuracy

Internal Clock:	±5 ms
Unsynchronized Clock Drift Relay Powered:	13 minutes per year, typically
Frequency Tracking:	12.5–72.5 Hz

Communications Ports

Serial EIA-232/EIA-485 Port

Communication Interface:	EIA-232 or EIA-485 software selectable
Connector Type:	RJ45
Data Speed:	EIA-232: 300–115200 bps EIA-485: 300–115200 bps

Communications Protocols

ASCII, Modbus RTU, Modbus TCP, MIRRORED BITS, FTP, TCP/IP, Telnet, SNTP, and HTTP/HTTPS and optional DNP3 serial and LAN/WAN and IEC 61850 Edition 2

Operating Temperature

Rated Range:	–40° to +85°C (–40° to +185°F)
UL Applications:	–20 to 40 (per IEC/EN 61010-1)

Operating Environment

Pollution Degree:	2
Overvoltage Category:	III
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Insulation Class:	1
Maximum Altitude Without Derating (Consult Factory for Higher-Altitude Derating):	2000 m

Dimensions

260.6 mm (10.26 in) x 88.14 mm (3.47 in) x 137.9 mm (5.43 in)

Weight

1.13 kg (2.5 lb)

Tightening Torque

Relay Mounting Screw Maximum:	2.0 Nm (18 in-lb)
Ganged Unit Fastening Screw Maximum:	1.4 Nm (12 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)

Note: Crimp ferrule is recommended.

Product Standards

Electromagnetic Compatibility:	IEC 60255-26:2013
Safety Standards:	IEC 60255-27:2013 IEC 61010-1:2010 + AM1:2016 IEC 61010-2-030:2017 IEC 61010-2-201:2017 UL 61010-1, Third Edition UL 61010-2-030, Second Edition UL 61010-2-201, Second Edition UL 1053, Seventh Edition CSA C22.2 No. 61010-1-12 CSA C22.2 No. 61010-2-030:18 CSA C22.2 No. 61010-2-201:18

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 IP30 without the relay front-panel cover IP54 with the relay front-panel cover IP1X for the terminals and the relay rear panel
Vibration Resistance:	IEC 60255-21-1:1988
Endurance:	Class 2 (horizontal mount, 19-inch horizontal rack mount with adapter plate, and panel mount) Class 1 (ganged rack mount)
Response:	Class 2
Shock Resistance:	IEC 60255-21-2:1988
Withstand:	Class 1
Response:	Class 2
Bump:	Class 1
Seismic (Quake) Response:	IEC 60255-21-3:1993, Class 2
Cold:	IEC 60068-2-1:2007, –40°C, 16 hours
Damp Heat, Cyclic:	IEC 60068-2-30:2005, 25–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007, 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Change of Temperature:	IEC 60068-2-14:2009 IEC 60255-1:2010, Section 6.12.3.5 –40° to +85°C

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-27:2013 Section 10.6.4.3 Section 10.6.4.4 Section 10.6.4.5 IEEE C37.90-2005 3.6 kVdc on voltage inputs and binary inputs 2.5 kVac on current inputs and output contacts 5.2 kVdc on power supply 1.5 kVdc on the communication ports; Port 2A and Port 2B tested jointly as a group
Impulse:	IEC 60255-27:2013 Section 10.6.4.2 0.5 J, 5.0 kV on power supply, contact I/O, ac current, and ac voltage inputs 0.5 J, 2 kV on serial and Ethernet ports

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 60255-26:2013 Section 7.2.3 IEC 61000-4-2:2009 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 60255-26:2013 Section 7.2.4 IEC 61000-4-3:2008 10 V/m IEEE C37.90.2-2004 35 V/m
Fast Transient, Burst Immunity[a]:	IEC 60255-26:2013 Section 7.2.5 IEC 61000-4-4:2012 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity[ab]:	IEC 60255-26:2013 Section 7.2.7 IEC 61000-4-5:2005 2 kV line-to-line 4 kV line-to-earth
Radiated Emissions:	FCC 47 CFR 15.109:2012, Class A IEC 60255-26:2013 Section 7.1, Class A CISPR 11:2009+A1:2010 CISPR 22:2008 ICES-001, Issue 5 Canada ICES-001 (A) / NMB-001 (A)
Conducted Emissions:	FCC 47 CFR 15.107:2012, Class A IEC 60255-26:2013 Section 7.1, Class A CISPR 22:2008 ICES-001, Issue 5 Canada ICES-001 (A) / NMB-001 (A)
Surge Withstand Capability Immunity[a]:	IEC 60255-26:2013 Section 7.2.6 IEC 61000-4-18:2006 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2012 2.5 kV oscillatory 4 kV fast transient
Conducted RF Immunity:	IEC 60255-26:2013 Section 7.2.8 IEC 61000-4-6:2013 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60255-26:2013, Section 7.2.10 Severity Level 5 1000 A/m for 3 seconds 100 A/m for 1 minute IEC 61000-4-9:2001 IEC 61000-4-10:2001 100 A/m
Power Supply Immunity:	IEC 60255-26:2013 Sections 7.2.11, 7.2.12, and 7.2.13 IEC 61000-4-11:2004 + A1:2001 + A2:2008 IEC 61000-4-17:1999 + A1:2001 + A2:2008 IEC 61000-4-29:2000

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	10 kHz
Frequency Tracking Range:	15–70 Hz
Digital Filtering:	Discrete Fourier Transform after low-pass analog filtering Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental
Protection and Control Processing:	4 ms rate (math variables are processed at a 24 ms rate; for analog quantities, refer to the applicable appendix)
Arc-Flash Processing:	Arc-flash light is sampled at 10 kHz; arc-flash current and light are processed at a 1 ms rate
Contact Inputs and Outputs:	Processed at 1 ms rate

Oscillography

Length:	0.25–2.00 s, 0.01 steps
Sampling Rate:	10 kHz sampling rate for raw (unfiltered) data and 4 ms rate for filtered data
Trigger:	Programmable with Boolean expression
Format:	Files in binary COMTRADE format (ANSI C37.111-2013) for raw and filtered data.
Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy:	±5 ms

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (Time Source):	±5 ms

Relay Elements

Instantaneous Overcurrent (50P, 50ABC, 50N)

Setting Range:	(0.10–20.00) • NomSec setting
Accuracy (Fundamental):	±3% of setting ±0.01 A
Accuracy (RMS):	±3% of setting ±0.02 A
Maximum Pickup/Dropout Time:	1.25 cycles

Instantaneous Overcurrent (50Gnd, 50Neg)

Setting Range:	(0.10–20.00) • CTP.NomSec setting
Accuracy:	±5% of setting ±0.01 A
Maximum Pickup/Dropout Time:	1.25 cycles

Arc-Flash Instantaneous Overcurrent (AFD.50P/AFD.50N)

Setting Range:	OFF, (0.10–20.00) • NomSec setting
Accuracy:	±5% of setting ±0.01 A
Pickup/Dropout Time:	1 ms/16 ms plus ±1 ms

Arc-Flash Time-Overlight (AFD.Sen01–AFD.Sen04)

Setting Range (Point):	OFF, 3.0%–80.0%
Setting Range (Fiber):	OFF, 0.6%–80.0%
Pickup/Dropout Time:	1 ms/16 ms plus ±1 ms

Inverse-Time Overcurrent (51P, 51N)

Setting Range:	(0.10–4.80) • NomSec setting
Accuracy (Fundamental):	±3% of setting ±0.01 A
Accuracy (RMS):	±3% of setting ±0.02 A
Time Dial	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.01–1.50, 0.01 steps
Accuracy:	±1.25 cycles, ±4% between 2 and 30 multiples of pickup (within rated range of current)

Inverse-Time Overcurrent (51Gnd, 51Neg)

Setting Range:	(0.10–4.80) • CTP.NomSec setting
Accuracy:	±5% of setting ±0.01 A
Time Dial	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.01–1.50, 0.01 steps
Accuracy:	±1.25 cycles, ±4% between 2 and 30 multiples of pickup (within rated range of current)

Undervoltage (27PP)

Setting Range:	5.00–300.00 V (with delta inputs) 5.00–520.00 V (with wye inputs)
Accuracy:	±2% (±5% for transient) of setting ±2 V
Maximum Pickup/Dropout Time:	1.25 cycles

Overvoltage (59PP, 59Gnd)

Setting Range:	5.00–300.00 V (59PP elements with delta inputs and 59Gnd elements) 5.00–520.00 V (59PP elements with wye inputs)
Accuracy:	±2% (±5% for transient) of setting ±2 V
Maximum Pickup/Dropout Time:	1.25 cycles

Harmonic Blocking

Pickup Range (% of Fundamental):	5%–100%
Accuracy:	±5% plus ±0.02 A of harmonic current
Time Delay Accuracy:	±0.5% plus ±4 ms

Directional Power (32)

Setting Range:	20.0–200.0 %VA (% of nominal VA)
Accuracy:	±3% of setting ±5 VA
Pickup Types:	+WATTS, –WATTS, +VARS, –VARS
Maximum Pickup/Dropout Time:	3 cycles

Power Factor (55)

Setting Range:	0.05–0.99
Accuracy:	±5% of full scale for current > 0.2 at 120 V
Maximum Pickup/Dropout Time:	3 cycles

Frequency (81)

Setting Range:	15.00–70.00 Hz
Accuracy:	±0.01 Hz
Maximum Pickup/Dropout Time:	3 cycles

Timers

Setting Range:	Various
Accuracy:	±0.5% of setting ±4 ms

Metering Accuracy

Accuracies are specified at 20°C, 50 or 60 Hz nominal frequency, ac currents within 0.1 to 40.0 A, and ac voltages within 50.0–250.0 V unless otherwise specified.

Phase and Neutral Currents:	Magnitude ±1% of reading ±0.01 A; phase ±2°
Average Current:	±1% of reading ±0.01 A
Current Unbalance (%):	±1% of reading of ±0.01 A
IG (Residual Ground Current):	Magnitude ±2% of maximum phase current ±0.01 A
3I2 Negative-Sequence Current:	±2% of maximum phase current ±0.01 A
System Frequency:	±0.01 Hz of reading for frequencies within 15–70 Hz (V1 > 60 V or I1 > 0.8 A
Line-to-Line Voltages:	Magnitude ±1% of reading ±0.1 V, phase ±2°
Three-Phase Average Line-to-Line Voltage:	±2% of reading and ±0.2 V
Line-to-Ground Voltages:	Magnitude ±1% of reading ±0.1 V, phase ±2°
Three-Phase Average Line-to-Ground Voltages:	±2% of reading and ±0.2 V
Voltage Unbalance (%):	±2% of reading and ±0.2 V
3V2 Negative-Sequence Voltage:	Magnitude ±2% of maximum line-to-ground or line-to-line voltage and ±0.2 V

The real, reactive, and apparent power quantities are calculated based on the voltage and current phasors. No additional errors are introduced by this calculation.

Power Factor:	±2% of reading for 0.97 < pf < 1.00

RMS Metering Accuracies

Phase and Neutral (IN) Currents:	±2% of reading ±0.02 A, for current range 0.2 to 15 A (includes signal bandwidth from 1 to 300 Hz)
Voltages:	±2% of reading ±0.1 V (includes signal bandiwdth from 1 to 300 Hz)
Harmonic and THD Metering Range:	0–100%
Accuracy:	5% of full scale

[a] Front-panel serial cable (non-fiber) lengths assumed to be <3 m.
[b] To ensure the correct operation of MIRRORED BITS during surge immunity, Cable SEL-C472N is required.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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

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