

# SEL-411L

Advanced Line Differential Protection, Automation, and Control System

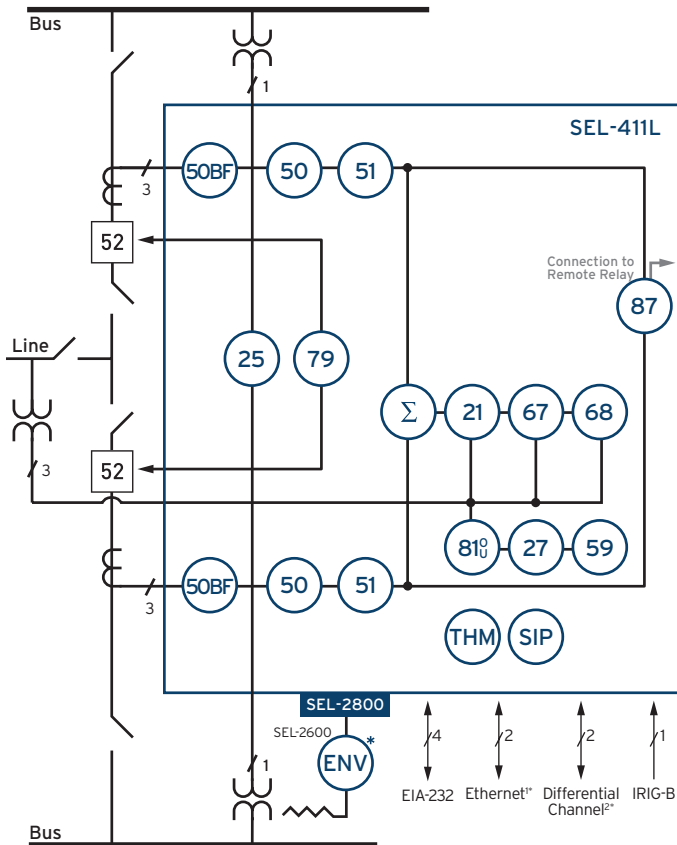


Combine subcycle line protection with traveling-wave fault locating

- Subcycle differential and distance protection minimizes damage and expensive repairs on transmission lines.
- Traveling-wave fault locating pinpoints faults within one tower span.
- Industry-leading synchrophasors monitor the overall system status.
- Comprehensive communications protocols and advanced automation functions allow customization for different applications.



# Functional Overview



## ANSI Numbers/Acronyms and Functions

21	Phase and Ground Distance
25	Synchronism Check
27	Undervoltage
32	Directional Power
50	Overcurrent
50BF	Dual Breaker Failure Overcurrent
51	Time Overcurrent
59	Overvoltage
67	Directional Overcurrent
68	Out-of-Step Block/Trip
79	Single-/Three-Pole Reclosing
81 (O,U)	Over-/Underfrequency
85 RIO	SEL MIRRORED BITS® Communications
87	Current Differential
DFR	Event Reports
ENV	SEL-2600*
HMI	Operator Interface
LGC	Expanded SELogic® Control Equations
MET	High-Accuracy Metering
PMU	Synchrophasors
SER	Sequential Events Recorder

## Additional Functions

BRM	Breaker Wear Monitor
LDE	Load Encroachment
LOC	Fault Locator
SBM	Station Battery Monitor
SIP	Software-Invertible Polarities
THM	IEC 60255-Compliant Thermal Model

<sup>1</sup>Copper or fiber-optic

<sup>2</sup>Serial or Ethernet

\*Optional feature





# Key Features

## Line Current Differential, Distance, and Directional Overcurrent Protection

Apply subcycle single- or three-pole current differential protection for up to four terminal lines, even with two breakers per terminal, using the SEL-411L Advanced Line Differential Protection, Automation, and Control System. Five zones of phase and ground distance elements as well as directional overcurrent elements provide subcycle operation and superior security. You can invert individual or grouped CT or PT polarities to account for field wiring or protection zone changes. By stocking one line protection relay that uses a combination of differential, distance, and overcurrent elements, you can meet specific application needs while reducing protection system costs.

## Comprehensive Monitoring

Implement advanced 87L channel monitoring functions to validate 87L channel health and enhance trip security. You can also incorporate IEEE C37.118 synchrophasor measurements into wide-area protection and control systems. High-accuracy time correlation improves event report analysis.

## Advanced Automation and Communication

Reduce total project construction and operation costs by integrating four-shot recloser and relay logic to automate operations. Serial or Ethernet communications improve station integration. You can choose from a variety of available protocols, including:

- MIRRORING BITS communications
- DNP3 LAN/WAN
- Modbus®
- Simple Network Time Protocol (SNTP)
- Parallel Redundancy Protocol (PRP)
- IEEE 1588 Precision Time Protocol Version 2 (PTPv2)
- IEC 61850 Edition 2

## High-Accuracy Fault Locating

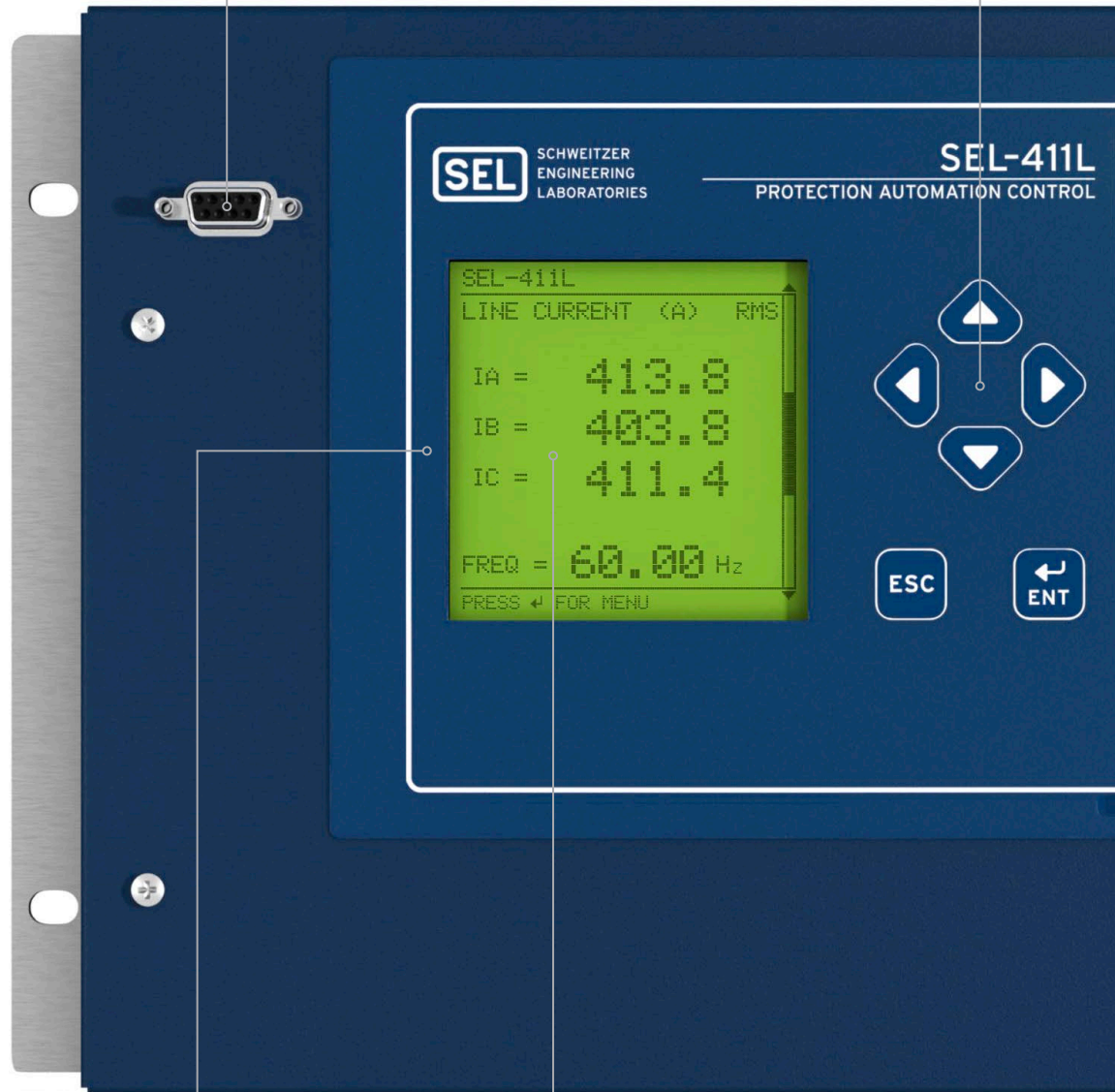
Find faults fast with optional traveling-wave fault locating. This reduces maintenance expenses because you can send crews directly to the tower nearest to the fault. You also have the option to implement single- and double-ended impedance-based fault-locating methods in parallel with traveling-wave fault locating.



# Product Overview

EIA-232 front serial port is quick and convenient for system setup and local access.

Easy-to-use keypad aids simple navigation.

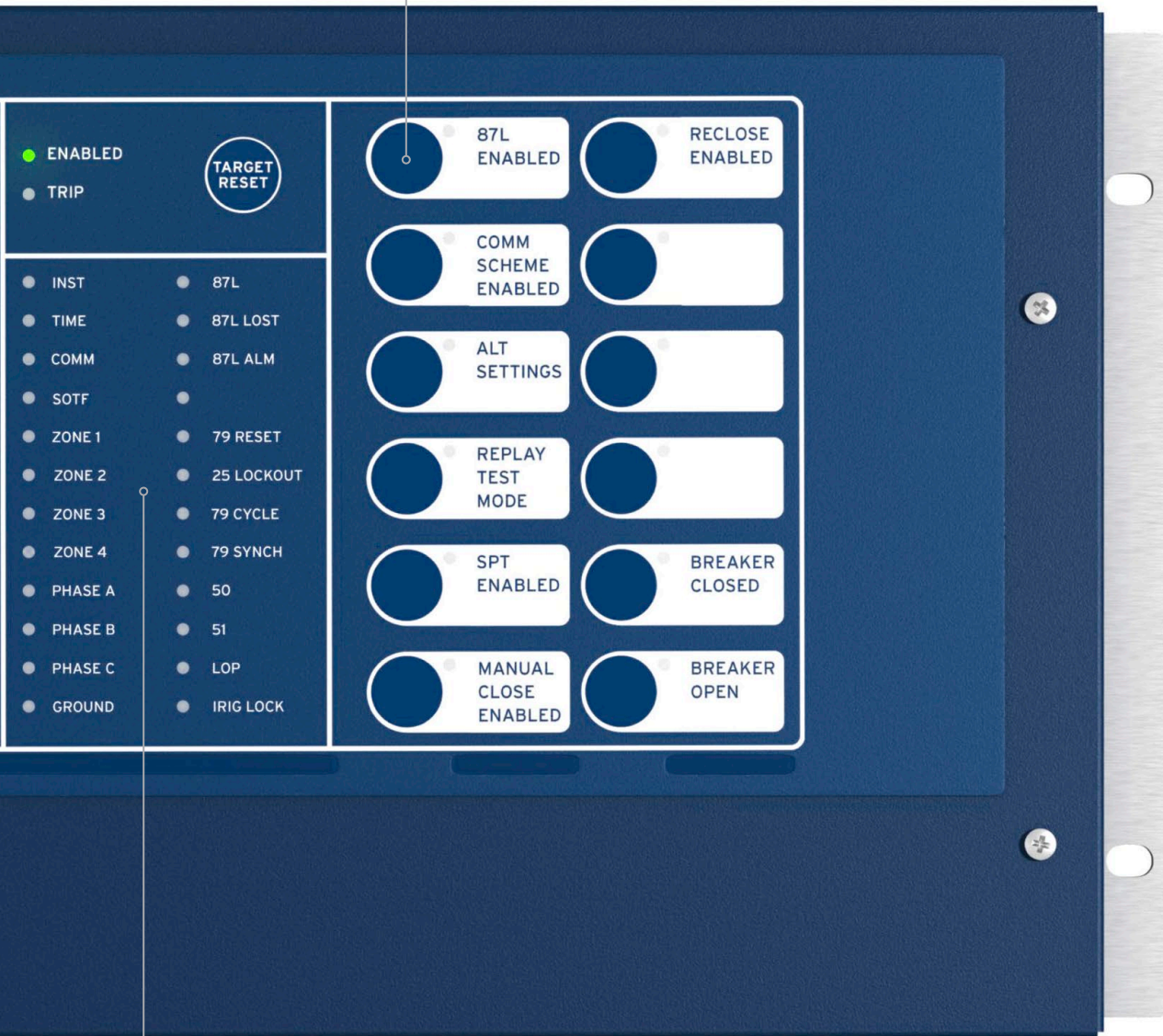


Front-panel display allows operators to control and view the status of disconnects and breakers.

User-selectable mimic screens show the system configuration in one-line diagram format.

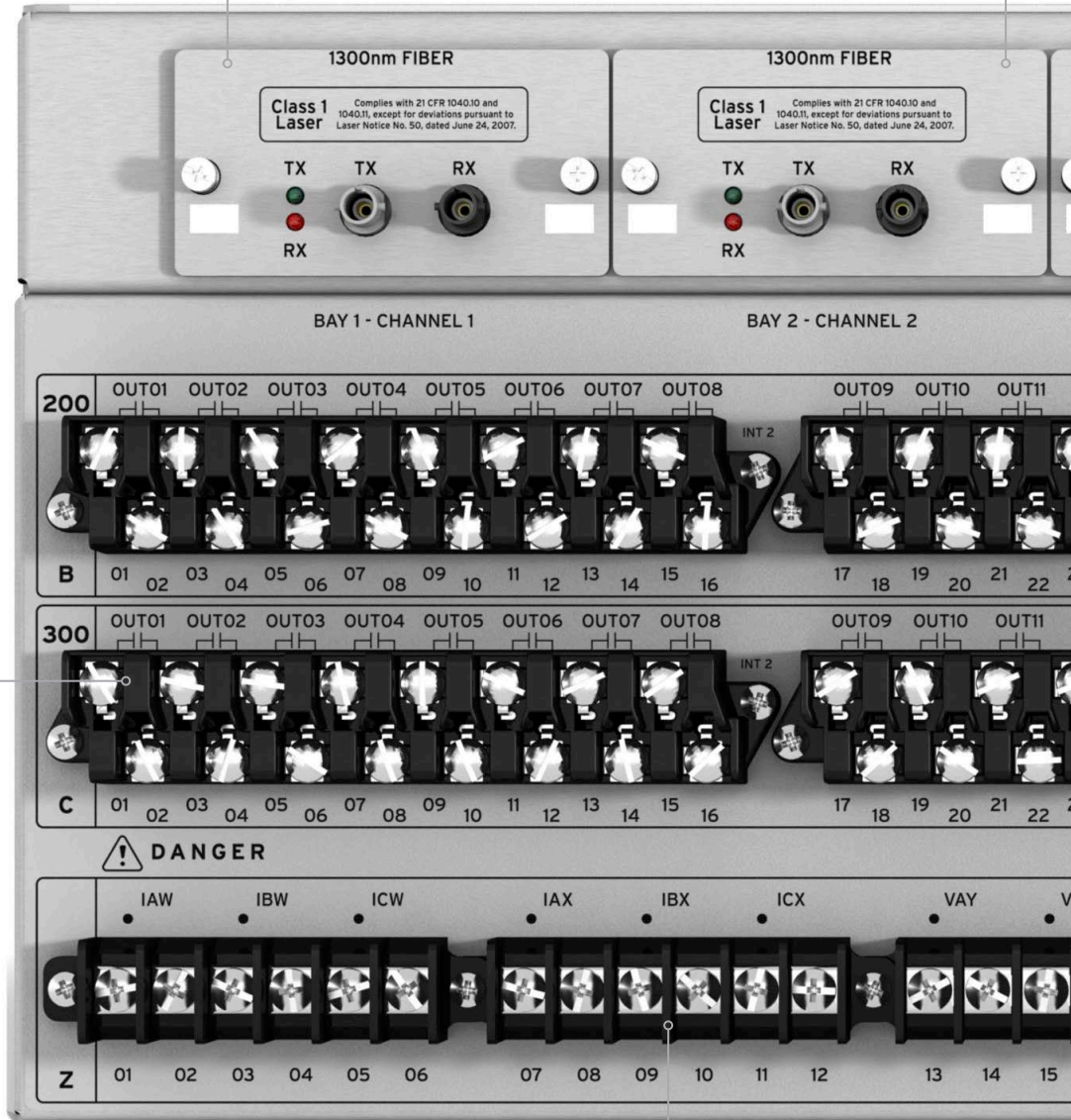


Programmable operator pushbuttons with user-configurable labels allow front-panel customization.



Up to 24 programmable target LEDs with user-configurable labels alert operators in the substation to faulted phases, the relay's status, and element operation.

Choose either fiber or copper connections for one or two 87L communications channels.



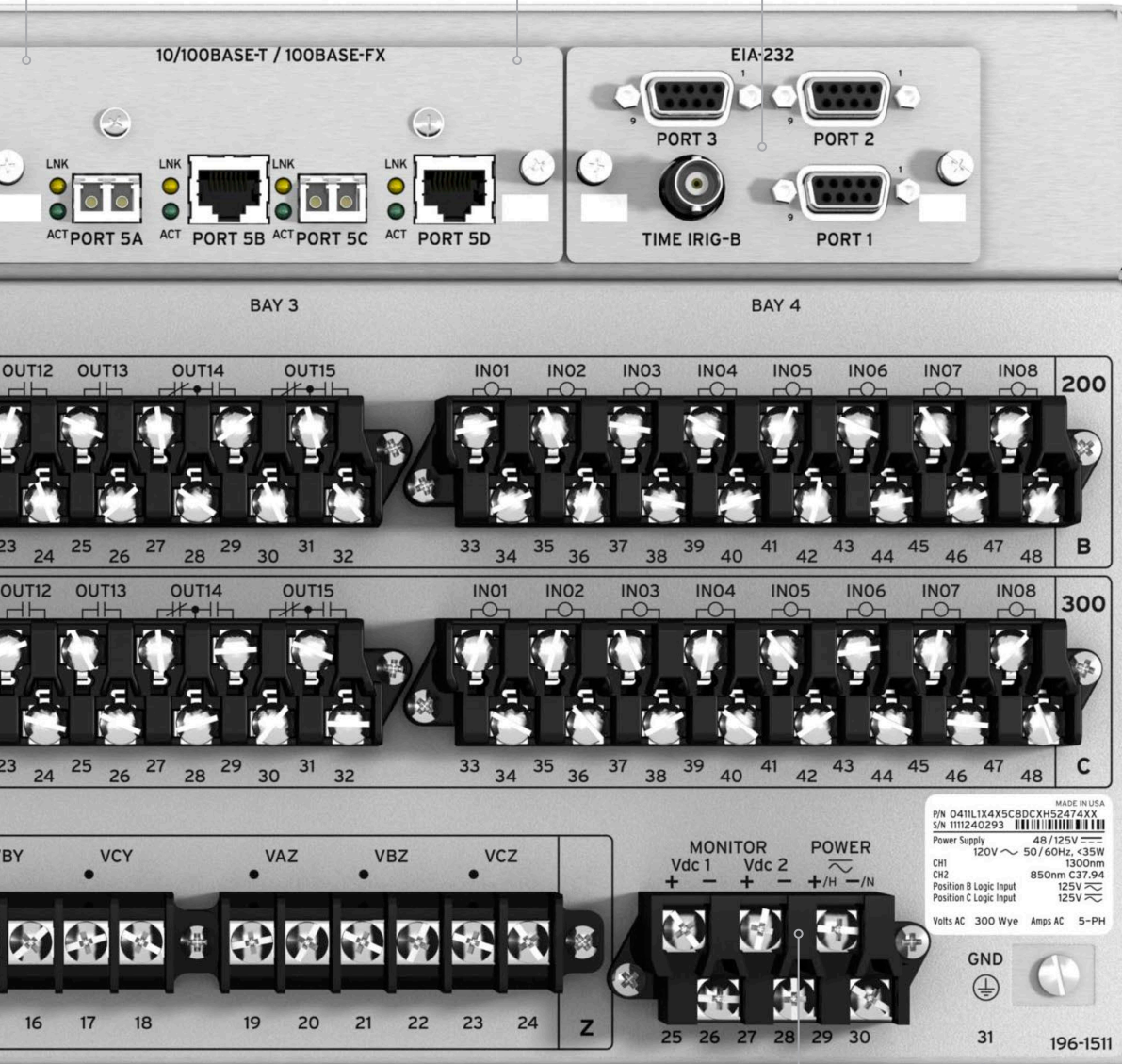
Choose from a vertical or horizontal, panel-mount or rack-mount chassis and different size options.

Six current and six voltage analog inputs support protection for substations with dual-breaker schemes.



Communications protocols include FTP, Telnet, synchrophasors, DNP3 LAN/WAN, PRP, IEEE 1588 PTPv2,\* and IEC 61850 Edition 2.\*\*

Three EIA-232 serial ports for MIRRORRED BITS communications, SCADA, and engineering access provide flexibility to communicate with other devices and control systems. The ports include demodulated IRIG-B for precise-time input.

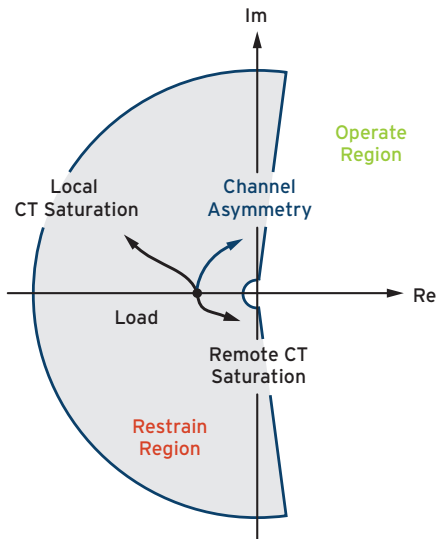


The power supply allows different options: 48/125 Vdc or 110/120 Vac, or 125/250 Vdc or 120/240 Vac.

\*For PTPv2 implementation, Ports 5A and 5B must be used for engineering access and SCADA.

\*\*Optional feature.

# Applications



Accommodate channel asymmetry and CT saturation with Alpha Plane restrain and operate regions.

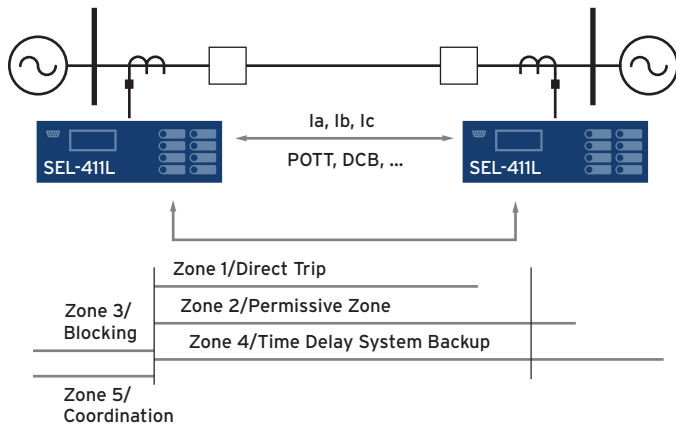
## Line Current Differential Protection

The SEL-411L provides subcycle single- or three-pole line current differential protection along with reliable backup distance protection for your critical transmission lines. The patented generalized Alpha Plane technology combined with overcurrent supervision, external fault detection, optional charging current compensation, and disturbance detection logic enables the 87L function to operate with exceptional security and sensitivity. The SEL-411L supports data exchange over a serial network or a dedicated Ethernet network to provide line current differential protection for transmission lines with as many as four terminals, even with two breakers per terminal.

## Flexible 87L Data Channel Selection

Choose the 87L communications channel option that fits your application needs:

- Isolated EIA-422
- Isolated ITU-T G.703
- 850 nm (2 km limit) or 1,300 nm (15 km limit) fiber, IEEE C37.94 encoding
- 1,300 nm single-mode (80 km limit) or multimode (30 km limit) fiber
- 1,550 nm single-mode fiber (120 km limit)
- Ethernet (10/100BASE-T or 100BASE-FX connections)



## Reliable Distance Protection

The SEL-411L has reliable distance protection with five zones of phase and ground (mho and quadrilateral) distance elements. The coupling capacitor voltage transformer (CCVT) transient overreach logic optimizes performance and enhances Zone 1 distance element security. The Best Choice Ground Directional Element<sup>®</sup> eliminates the need for multiple settings. In addition, with full pilot scheme settings, it is easy to integrate the SEL-411L into your existing distance protection schemes. Choose from POTT, DCUB, PUTT, DCB, and DTT schemes.

## Thermal Overload Protection

Use the three independent IEC 60255-149 thermal elements to activate a control action, issue an alarm, or trip when equipment overheats as a result of adverse operating conditions. The SEL-2600 RTD Module can provide ambient temperature measurements.

## Series Compensation Line Logic

The optional series compensation logic detects when a fault is beyond a series capacitor and prevents Zone 1 overreach on series-compensated lines. This provides secure protection for your power system, resulting in higher power transfers and reliable service to customers.



### Out-of-Step Blocking and Tripping

During power swings, the relay automatically selects either out-of-step blocking or tripping. Out-of-step blocking enhances your security by blocking distance elements during stable swing conditions. During unstable power swing conditions, out-of-step tripping maintains generation load balance.

### Multiterminal Transmission Lines

Protect transmission lines with up to four terminals, even for breaker-and-a-half bus configurations or other two-breaker schemes with dual CT and PT inputs. The unique fault-locating algorithm uses information from all terminals to identify the faulted branch on multiterminal transmission lines. This allows you to dispatch line crews more efficiently so that line problems are quickly isolated and power is restored to customers faster.

### Line-Charging Current Compensation

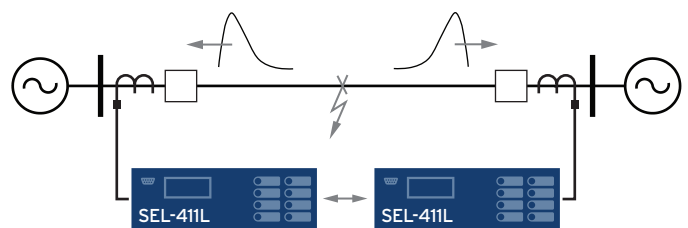
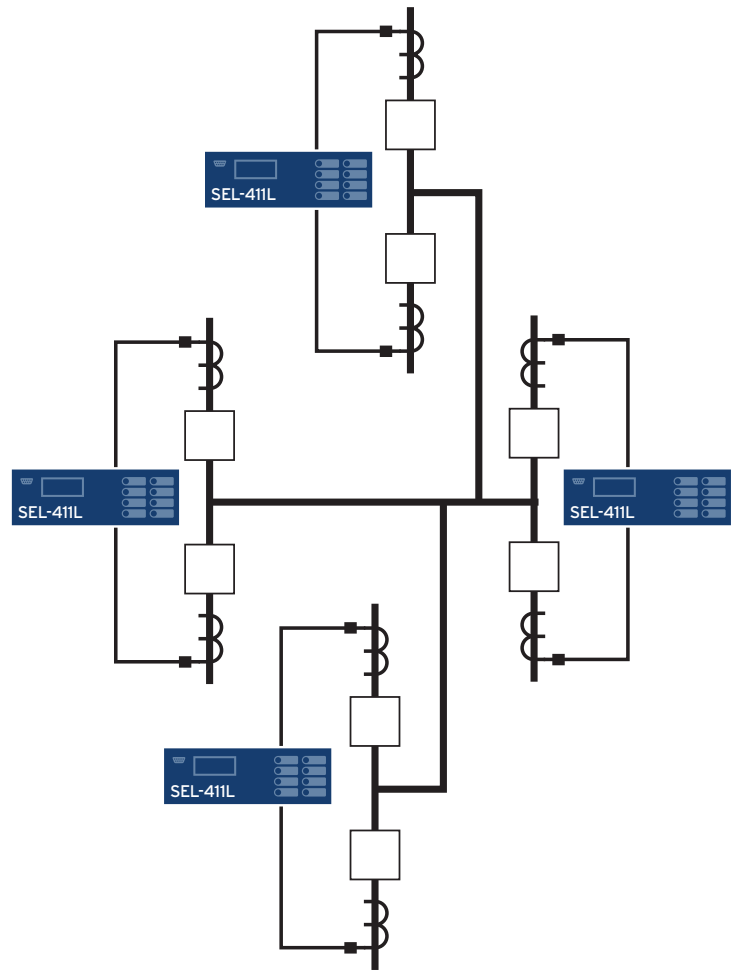
Built-in charging compensation improves the sensitivity and speed of differential protection for long, extra-high-voltage lines or cables. The SEL-411L uses an adaptive algorithm based on voltages measured in the differential scheme to provide accurate compensation. In the event of a loss-of-potential condition, the relay uses automatic fallback logic to keep the differential scheme secure.

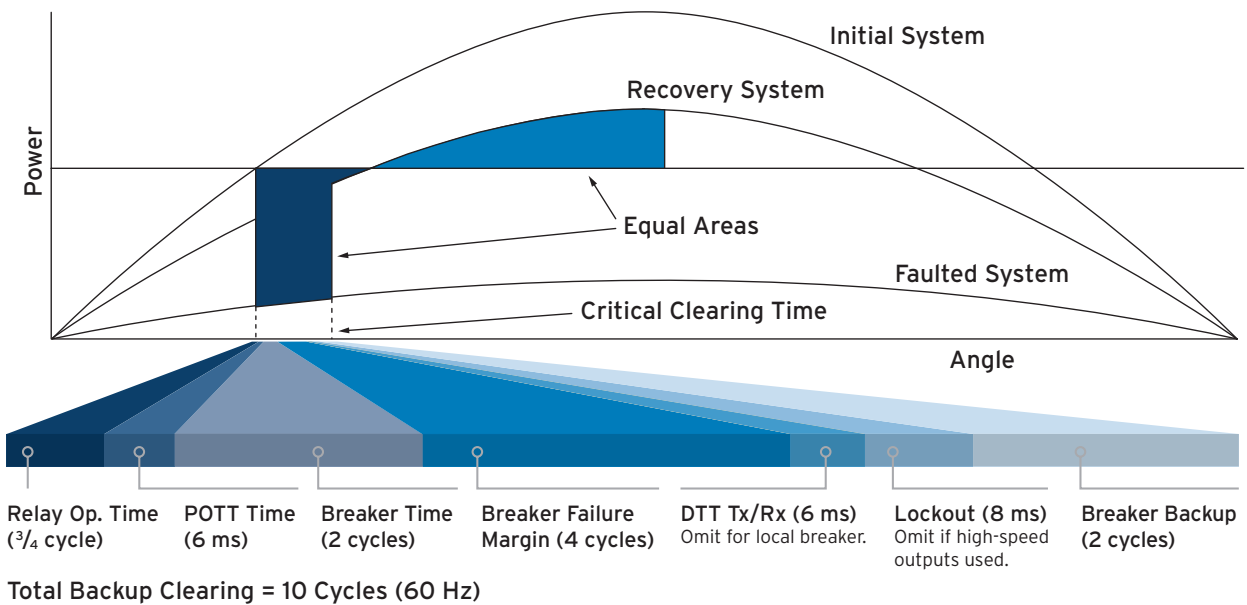
### In-Line Transformers

By providing complete protection for the combined line and transformer, the SEL-411L simplifies protection schemes and reduces equipment costs. The relay compensates for vector group, ratio, and zero-sequence current to protect transmission lines with in-line transformer applications. You can use harmonic blocking, restraint, or both for stabilization under magnetizing inrush conditions.

### Traveling-Wave Fault Locating

Optional traveling-wave fault locating provides greater accuracy and lets you send your line crew to the nearest tower or span to quickly address the problem. With the GPS clocks and communications channel already in your system, the relay automatically calculates the fault location. Without a communications channel, the relay still measures and records the traveling-wave event. Using the traveling-wave event data, you can calculate an accurate fault location by hand or with SEL-5601-2 SYNCHROWAVE® Event Software. Traveling-wave fault locating is the best method for series-compensated and parallel transmission line configurations. You will get precise results regardless of the line configuration or fault impedance.





## High-Speed Breaker Failure for Two Breakers

The SEL-411L applies fast open-phase detection logic to detect an open phase in less than one cycle, leading to shorter breaker failure margin times. By combining high-speed tripping with shorter breaker failure margin times, the relay helps improve the power transfer capability while maintaining stability.

## Synchphasors

To significantly improve your system's performance, SEL offers complete synchrophasor solutions, including hardware, communications, viewing and analysis software, data collection, and data archiving. The SEL-411L provides real-time system state measurement with time-synchronized voltages and currents in the IEEE C37.118 standard format. In addition, SEL-5078-2 synchroWAVE Central Software or third-party software allows you to view and analyze system phase angles, load oscillations, voltage profiles, and other critical system information.

## Bay Control, Reclosing, and Breaker Failure Detection

Increase flexibility for different station configurations with complete bay control, reclosing, and breaker failure protection. For double-breaker arrangements, the SEL-411L can monitor the current for each breaker separately or combine the currents for protection purposes. The relay can also monitor the circuit breaker performance, including average and last tripping times, motor run times, and contact interrupting duty.



SEL-5078-2 SYNCHROWAVE Central Software provides visualization and analysis of power system operating conditions.



# Accessibility and Communications

## Web Server

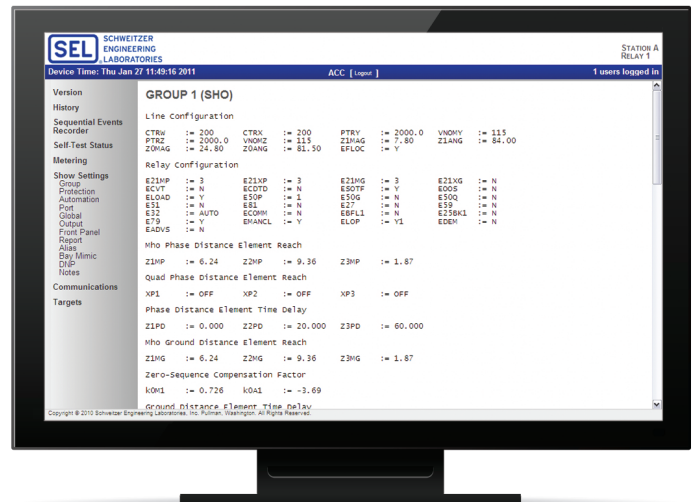
Access basic SEL-411L information on a standard Ethernet network with the built-in web server. From there you can view the relay status, Sequential Events Recorder (SER) data, metering information, and settings. For increased security, obtaining web server access requires a relay password and the information is limited to a read-only view.

## Ethernet-Based Communications

The Ethernet ports enable you to communicate using a variety of protocols, including FTP, DNP3, MMS, PTPv2, and IEC 61850 Edition 2. By using failover, switched mode, or PRP, you can increase your system's reliability. For PTPv2 implementation, Ports 5A and 5B must be used for engineering access and SCADA.

## MIRRORED BITS Communications

This field-proven technology provides simple and powerful bidirectional digital communications between devices. MIRRORED BITS communications can transmit/receive information between upstream relays and downstream recloser controls to enhance coordination and generate faster tripping for downstream faults.



A built-in web server provides easy access to settings, relay status, metering, and event data.





# SEL-411L Specifications

General	
<b>AC Current Inputs</b> (6 total)	5 A nominal 1 A nominal
<b>AC Voltage Inputs</b> (6 total)	300 V <sub>L-N</sub> continuous
<b>Serial</b>	3 rear-panel and 1 front-panel EIA-232 serial ports; SEL ASCII commands, SEL Fast Messages, DNP3, IEEE C37.118 synchrophasors
<b>Ethernet</b>	Communications protocols include FTP, Telnet, synchrophasors, DNP3 LAN/WAN, PRP, PTPv2, and IEC 61850 Edition 2 (optional). For PTPv2 implementation, Ports 5A and 5B must be used for engineering access and SCADA.  Choose from the following port options:  Four 10/100BASE-T twisted-pair network ports Four 100BASE-FX fiber-optic network ports  Two 10/100BASE-T twisted-pair network ports and two 100BASE-FX fiber-optic network ports
<b>Traveling-Wave Fault Locating</b>	Type: Double-ended method  Accuracy: ±25 m for step change in current applied simultaneously to both relays
<b>Precise-Time Input</b>	Demodulated IRIG-B time input and PTPv2
<b>Synchrophasors</b>	IEEE C37.118 Standard Up to 50 messages per second (50 Hz system) Up to 60 messages per second (60 Hz system)  UDP Multicast Capability  SEL Fast Message Protocol Up to 10 messages per second (50 Hz system) Up to 20 messages per second (60 Hz system)
<b>Processing</b>	AC voltage and current inputs: 8,000 samples per second  Protection and control processing: 8 times per power system cycle
<b>Power Supply</b>	125/250 Vdc or 120/240 Vac  48/125 Vdc or 110/120 Vac
<b>Operating Temperature</b>	−40° to +85°C (−40° to +185°F)

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