Transmission Protection Overview

SEL-T400L

Apply the SEL-T400L for ultra-high-speed protection of transmission lines. With breakthrough time-domain technologies, the SEL-T400L trips in as fast as 1 ms, records events with a 1 MHz sampling rate, and locates faults to the nearest tower.

SEL-T401L NEW

Apply the SEL-T401L, which was built on the field experience of the SEL-T400L, for its unprecedented operating speed and complete suite of primary and backup line protection functions. Use the SEL-T401L as a redundant protection system with other SEL relays without concerns for common-mode failures.

SEL-T4287

Test traveling-wave fault locators and line protective relays using the SEL-T4287, a simple-to-use, compact, and economical secondary pulse injection test set.

SEL-421

Employ the SEL-421 for high-speed distance and directional protection and complete control of a two-breaker bay.

SEL-411L

Apply the SEL-411L for subcycle single- or three-pole line current differential, distance, and directional overcurrent protection. Traveling-wave fault locating pinpoints faults to the nearest tower span.

SEL-311C

Apply the SEL-311C for three-pole distance protection, reclosing, monitoring, and control of transmission lines.

SEL-311L

Use the SEL-311L with four-zone distance backup for easy-to-apply, high-speed line protection.

SEL-387L

Use the SEL-387L for economical, easy-to-apply line protection with zero settings.

Applications	SEL-T400L	SEL-T401L	SEL-411L	SEL-421	SEL-311C	SEL-311L	SEL-387L
Distance Protection	■	■	■	■	■	■	
Line Current Differential			■			■	■
Traveling-Wave Protection	■	■					
Breaker Failure Protection			■	■	■	ƒ	
Undervoltage Load Shedding		ƒ	ƒ	ƒ	ƒ	ƒ	
Series-Compensated Lines	■	■	+	+			
Protection							
21 (G,P,XG,XP) Distance (Mho Ground, Mho Phase, Quad Ground, Quad Phase)		■	■	■	■	■	
25 Synchronism Check			■	■	■	■	
27/59 Under-/Overvoltage		■	■	■	■	■	
32 Directional Power			■	■			
49 Thermal			ƒ	ƒ			
50 (N,G,P,Q) Overcurrent (Neutral, Ground, Phase, Negative Sequence)		■	■	■	■	■	
51 (N,G,P,Q) Time Overcurrent (Neutral, Ground, Phase, Negative Sequence)		■	■	■	■	■	
67 (N,G,P,Q) Directional Overcurrent (Neutral, Ground, Phase, Neg. Seq.)		■	■	■	■	■	
81 Under-/Overfrequency			■	■	■	■	
87L Line Current Differential			■			■	■
Programmable Analog Math			■	■			
Out-of-Step Block and Trip		■	■	■	■	■	
Load Encroachment Supervision		■	■	■	■	■	
Switch-Onto-Fault		■	■	■	■	■	
Single-Pole Trip	■	■	■	■	+	+	
TD21 Incremental-Quantity Distance	■	■					
TD32 Incremental-Quantity Directional	■	■					
TW32 Traveling-Wave Directional	■	■					
TW87 Traveling-Wave Differential	■	■					
Zone/Level Timers		■	■	■	■	■	
Pilot Protection Logic	■	■	■	■	■	■	

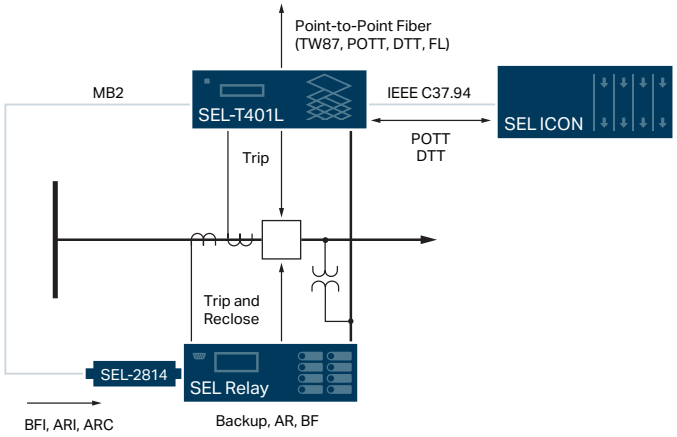
Instrumentation and Control	SEL-T400L	SEL-T401L	SEL-411L	SEL-421	SEL-311C	SEL-311L	SEL-387L
79 Automatic Reclosing			■	■	■	■	
Number of Controlled Breakers/ CT Inputs	2	2	2	2	1	1	1
Fault Locating	■	■	■	■	■	■	
Traveling-Wave Fault Locating	■	■	+				
Subcycle Distance Elements		■	+	+	+		
SELogic® Control Equations		■	■	■	■	■	
Nonvolatile Latch Control Switches		■	■	■	■	■	
SELogic Remote and Local Control Switches		■	■	■	■	■	
Display Points			■	■	+	■	
Mirrored Bits® Communications	■	■	■	■	■	■	
Substation Battery Monitor			■	■	■	■	■
Breaker Wear Monitor			■	■	■	■	
Trip Coil Monitor			ƒ	ƒ	ƒ	ƒ	
Event Report (Multicycle Data) and Sequential Events Recorder	■	■	■	■	■	■	■
1 MHz Event Reports	■	■					
Instantaneous Metering	■	■	■	■	■	■	■
Software-Invertible Polarities			■	■			
IEC 60255-Compliant Thermal Model			■	■			
DNP3 Level 2 Outstation	■	■	■	■	■	+	+
Parallel Redundancy Protocol (PRP)			■	■	■		
IEEE 1588 Precision Time Protocol Version 2 (PTPv2)			+	+			
IEEE C37.94 Protocol		■	+			+	
IEC 61850-9-2 Sampled Values Technology				+			
Time-Domain Link (TiDL®) Technology				+			
IEC 61850 Communications			+	+	+	+	
Synchrophasors			■	■	■	■	
Built-In Current and Voltage Playback Capability	■	■					
SEL Fast Time-Domain Values	■	■					
Miscellaneous							
Accepts Delta Voltage Transformers for Protection					+		
Configurable Labels	■	■	■	■	+		

■ Standard feature + Model option ƒ May be created using settings

Transmission Protection Applications

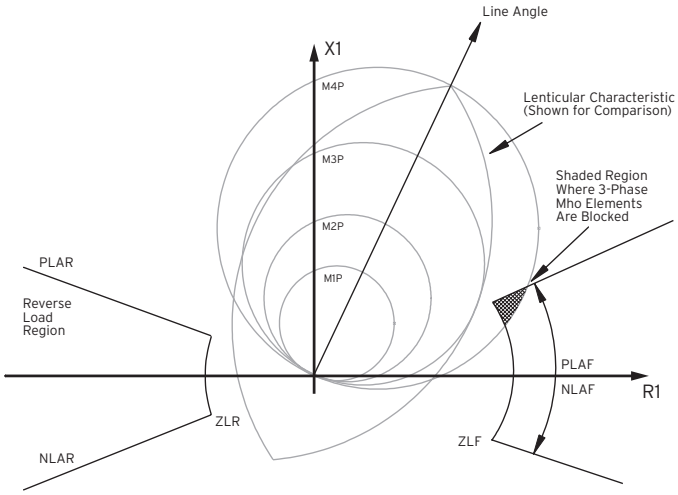
Time-domain line protection

The SEL-T400L Time-Domain Line Protection and SEL-T401L Ultra-High-Speed Line Relay are designed for speed, security, and ease of use. They can trip in as fast as 1 ms without compromising security. You can apply the SEL-T401L on its own or as part of a redundant protection system with other SEL relays without concerns for common-mode failures.



Optimized system loading

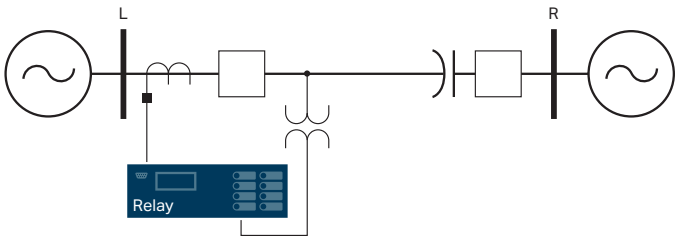
Set the phase distance and phase overcurrent elements independent of load to prevent load from causing the phase protection to operate. Under heavy load conditions, the measured impedance may fall inside the operating characteristic of a traditional phase distance element and cause an undesired operation. Traditional solutions involved reducing mho element reach or using a lenticular characteristic to prevent load encroachment. With built-in load encroachment logic, two load regions are defined on the impedance plane and the relay rejects a minimum portion of the mho element characteristic, as shown. This allows you to securely apply distance protection elements on heavily loaded transmission lines.



Series-compensated lines

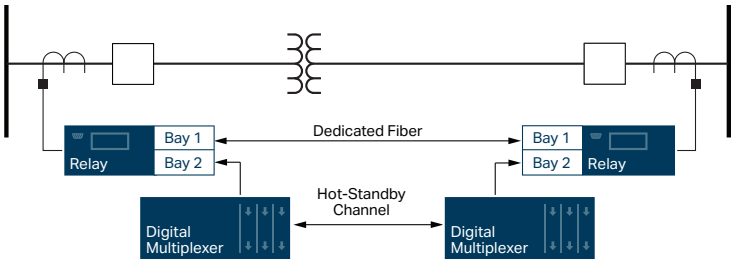
Detect faults beyond a series capacitor and prevent Zone 1 overreach on series-compensated lines with optional logic in the SEL-T400L Time-Domain Line Protection; SEL-T401L Ultra-High-Speed Line Relay; SEL-421-5 Protection, Automation, and Control System; and SEL-411L-1 Advanced Line Differential Protection, Automation, and Control System. Series compensation increases the power transfer capability of transmission lines and improves power system stability. However, when faults occur on series-compensated lines, the resulting voltage inversion or current reversal may cause traditional line protection to misoperate.

It's also important to enable this logic in parallel line applications where there is a series capacitor on the adjacent line. Series compensation logic achieves the desired sensitivity on the protected line, yet it is still secure during the voltage inversion that may occur when the neighboring series-compensated line experiences a fault.



In-line transformers

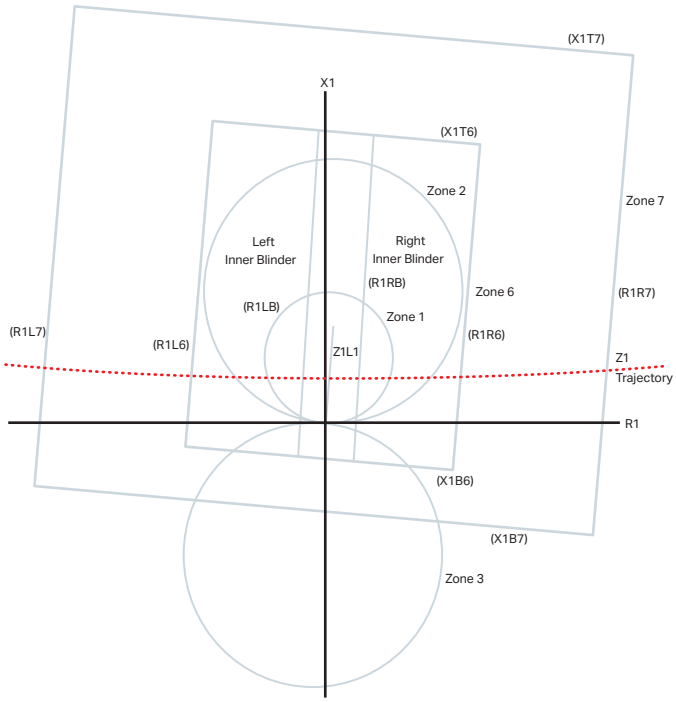
Use negative-sequence overcurrent elements in distance protection relays to protect transmission lines with in-line transformers. In differential relays, such as the SEL-411L Advanced Line Differential Protection, Automation, and Control System, the Alpha Plane operating principle provides for true differential harmonic measurements and allows harmonic blocking, harmonic restraint, or both for security during the magnetizing inrush condition. Additionally, built-in settings allow the relay to perform proper vector group compensation, zero-sequence current balancing, and ratio matching per the principles of transformer differential protection.



Improved system stability

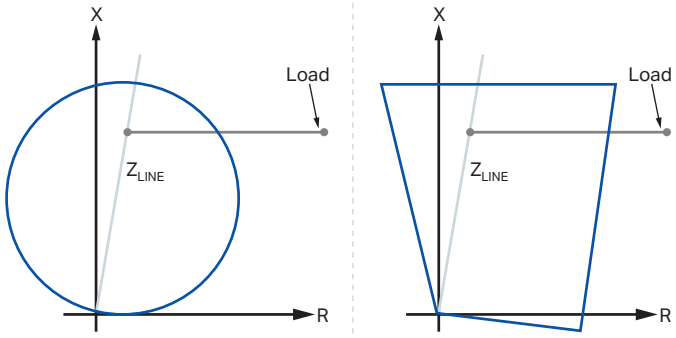
Select from either out-of-step (OOS) blocking of distance elements or OOS tripping during power swings. SEL transmission relays include multizone elements and logic for detection of an OOS condition.

The power-swing detection function differentiates faults from power swings and blocks distance or other relay elements from operating during stable or unstable power swings. The SEL-421 Protection, Automation, and Control System and SEL-411L Advanced Line Differential Protection, Automation, and Control System come with a zero-setting OOS blocking function that is based on a swing-center voltage slope detector, OOS blocking detector, and three-phase fault detector. The zero-setting OOS function improves security during power swings without time-consuming and expensive system stability studies.



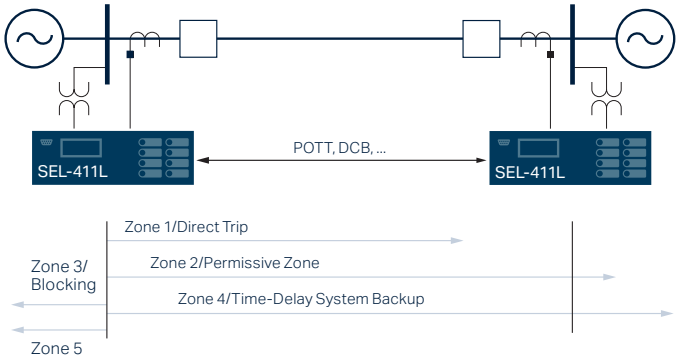
Mho and quadrilateral distance elements

Select mho distance elements, quadrilateral distance elements, or both with SEL transmission relays. Some utilities prefer the mho distance elements because they are easy to set. However, other utilities favor the quadrilateral distance elements because they offer better resistive coverage. Quadrilateral elements provide the best protection for short lines where the impedance of the transmission line is the same magnitude as the fault resistance.



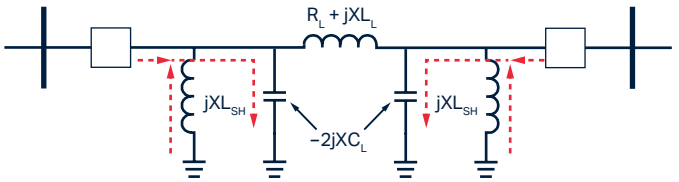
Communications-assisted tripping

Configure protection for transmission lines without any need for external coordination devices. SEL transmission protection relays offer settings to accommodate many of the common pilot protection schemes, including permissive overreaching transfer trip (POTT), directional comparison unblocking (DCUB), and directional comparison blocking (DCB). These schemes work in both two- and three-terminal line applications.



Long transmission lines

Enable line-charging current compensation in the SEL-411L Advanced Line Differential Protection, Automation, and Control System for enhanced sensitivity and security for long extra-high-voltage lines or cables. The charging current compensation is based on voltage signals and includes a built-in fallback response if the voltage source suffers loss-of-potential conditions or becomes unavailable. The function performs compensation on a per-phase basis and in the time domain. Therefore, the charging current compensation is accurate under balanced and unbalanced conditions and for line pickup with uneven breaker pole operation, internal faults, and external faults.

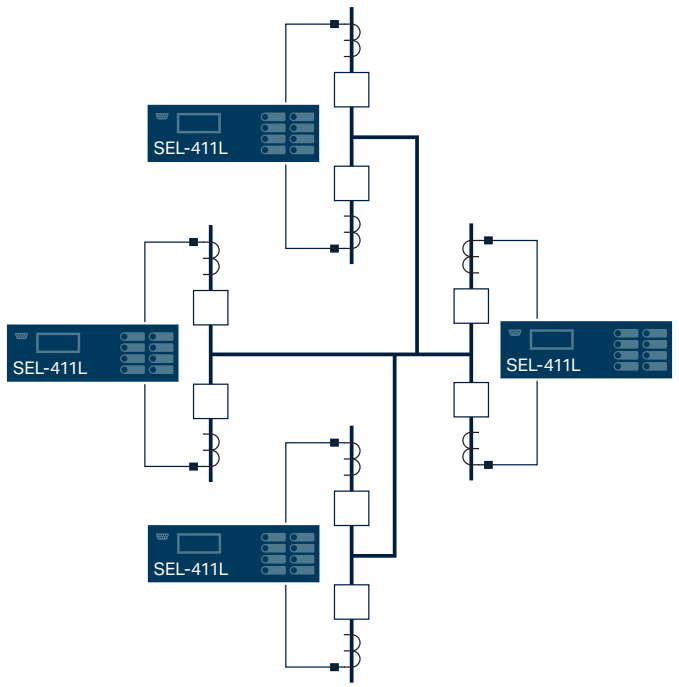


Differential protection of four-terminal and parallel transmission lines

Perform line current differential protection on lines with up to four terminals by using the 87L-over-Ethernet feature in the SEL-411L Advanced Line Differential Protection, Automation, and Control System. You can use the SEL ICON® multiplexer to interconnect the SEL-411L relays making up the differential zone. The SEL ICON ensures a dedicated LAN with the proper bandwidth and minimal latency needed for secure and reliable 87L-over-Ethernet communications.

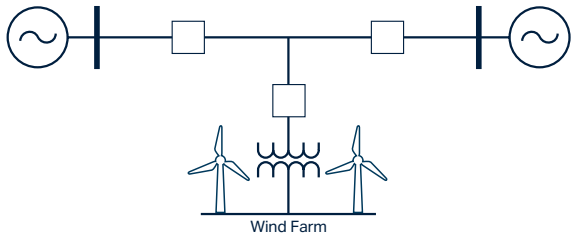
Protect up to three terminals with serial connections with the 87L scheme either in the master mode or master-outstation mode. In the master mode, all the relays act as master units, receive all the differential data, and trip directly on the data. In the case of a missing channel, you can use the relays in the master-outstation mode, where a single master unit receives all the data and sends a direct transfer trip to the slave units through a trip bit in the 87L channel. If the relays are in the master mode and a channel is suddenly lost, the scheme will automatically switch into the master-outstation mode to maintain 87L protection.

In parallel lines, the main issue is mutual coupling. Line current differential is immune to mutual coupling and is therefore very sensitive and secure in parallel-line applications.



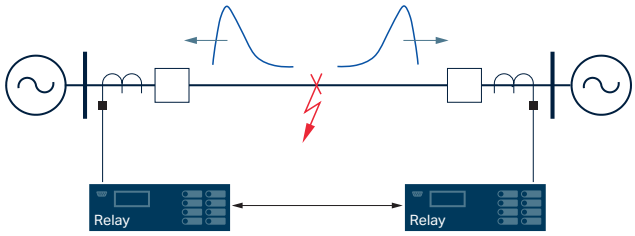
Weak systems and inverter-based sources

Choose a line current differential scheme for primary line protection when connecting wind farms to the utility grid. Fault current contributed from weak sources, such as doubly fed induction generators (DFIGs) in a wind farm, is just a fraction of the load current. This challenges any current-based distance or overcurrent protection method and requires weak infeed logic to properly protect the line. Line current differential schemes work best because the grid provides enough fault current to drive the differential signal up, while the inverter-based source doesn't create restraining.



Traveling-wave fault locating

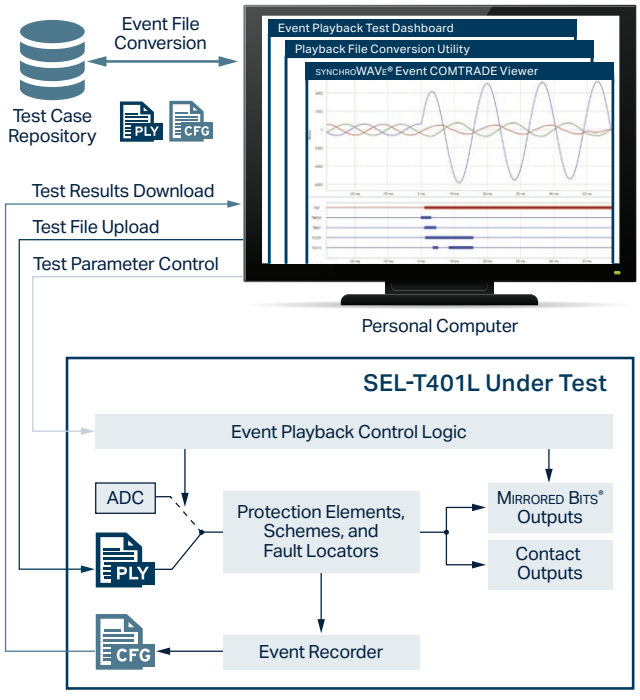
With advanced microprocessor-based relays, you can compute fault locations using four different methods: single-ended impedance-based, double-ended impedance-based, single-ended traveling-wave fault locating (available in the SEL-T400L Time-Domain Line Protection and SEL-T401L Ultra-High-Speed Line Relay), and double-ended traveling-wave fault locating (available in the SEL-411L Advanced Line Differential Protection, Automation, and Control System;, SEL-T400L; and SEL-T401L). Based on input data availability, the relay selects one method of fault locating to provide in a summary report. Traveling-wave fault-locating methods accurately locate faults to within one tower span, allowing you to quickly send crews out to address the problem.



Testing made easy

The built-in current and voltage playback feature in the SEL-T400L Time-Domain Line Protection and SEL-T401L Ultra-High-Speed Line Relay provides you with new opportunities for relay testing. To test either relay, upload and play back either files generated using transient simulation software or current and voltage signals recorded by the SEL-T400L, the SEL-T401L, SEL-400 series relays, or digital fault recorders in the field.

Secondary injection testing of SEL-T400L and SEL-T401L I/O, metering, and protection elements (except TW32 and TW87) is straightforward. Today's relay test sets provide adequate signals to test incremental-quantity protection elements. Use the SEL-T4287 Traveling-Wave Test System to perform secondary injection testing of the TW32 and TW87 protection and the traveling-wave fault-locating methods.



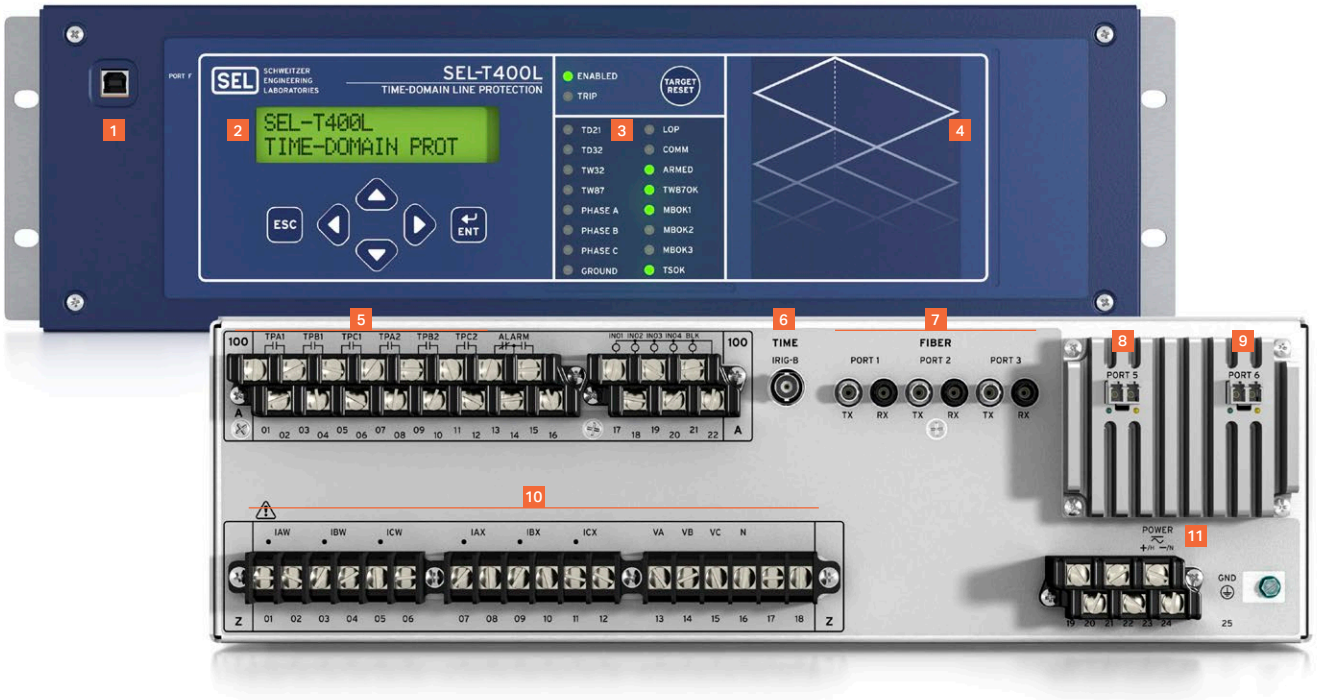
SEL-T400L

Time-Domain Line Protection

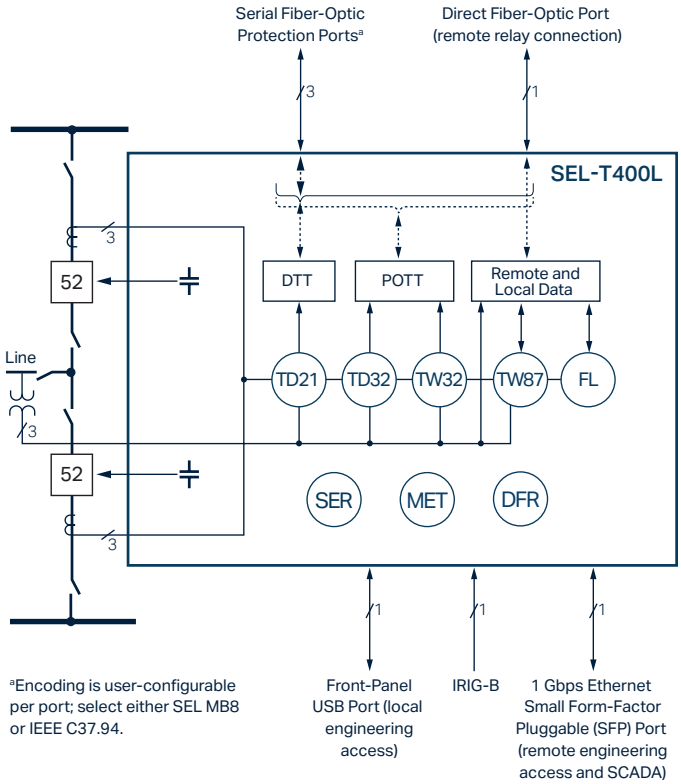
Starting price
$12,000 USD

selinc.com/products/T400L | Select models typically ship in 2 days

The SEL-T400L provides ultra-high-speed protection of transmission lines. With breakthrough time-domain technologies, the SEL-T400L trips securely in as fast as 1 ms, records events with a 1 MHz sampling rate, and locates faults to the nearest tower. Adding the SEL-T400L to your line protection system can dramatically reduce your fault-clearing time and let you achieve the many benefits associated with speed.



1. USB 2.0 port for SEL Fast Meter and Fast SER protocols as well as for local engineering access.
2. Display for viewing metering, event, and fault location information.
3. LEDs show faulted phases, element operation, and status of relay and communications.
4. Large slide-in label pocket for diagrams or asset labels.
5. High-speed trip-rated output contacts for ultra-high-speed protection.
6. IRIG-B time input for nanosecond-accurate event reports.
7. Millisecond Mirrored Bits® communications ports for connecting to a remote SEL-T400L (POTT and DTT applications), to a local SEL relay (breaker failure and autoreclose applications), or to an SEL remote I/O module for legacy applications over contact I/O.
8. An 850 nm 1000BASE-SX multimode small form-factor pluggable (SFP) transceiver is installed in Port 5 for remote engineering access with FTP and Telnet and for SCADA applications with SEL Fast Meter, SEL Fast SER protocols, DNP3 LAN/WAN, and Fast Time-Domain Values (FTDV).
9. Install a Gigabit SFP transceiver in Port 6 for the point-to-point fiber-optic differential (TW87) protection channel.
10. Three voltage and six current inputs for single- and dual-breaker applications.
11. Universal power supply operating voltage range:
    85–300 Vdc
    85–264 Vac



ANSI Functions

1	Arming and Starting Logic
TD21	Incremental-Quantity Distance
TD32	Incremental-Quantity Directional
TW32	Traveling-Wave Directional
TW87	Traveling-Wave Differential
TD50	Incremental-Quantity Nondirectional Overcurrent Supervision
TD67	Incremental-Quantity Directional Overcurrent Supervision
DTT	Direct Transfer Trip Logic
POTT	Permissive Overreaching Transfer Trip Logic
94	High-Speed Trip-Rated Outputs
85 RIO	SEL Mirrored Bits Communications
LOP	Loss-of-Potential Logic
TWDD	Traveling-Wave Disturbance Detection
DFR	1 MHz Event Recorder
SER	Sequential Events Recorder
FL	Fault Locator (with traveling-wave and impedance methods, single-ended and double-ended)
MET	Metering
HMI	Operator Interface

Additional Functions

Preconfigured Trip Logic

Single-Pole Tripping Logic

Open-Pole Detection Logic

Adaptive Autoreclose Cancel Logic

Traveling-Wave Test Mode

Event Playback

Front-Panel USB 2.0 Port for Engineering Access

Ethernet Port for Engineering and SCADA Access

Multilevel Passwords for Secure Access

Electromagnetic Interference Monitoring

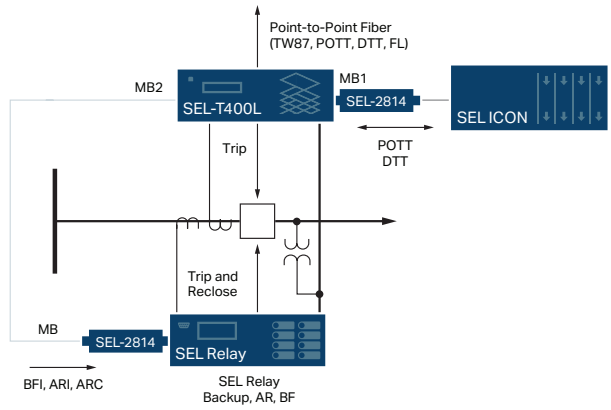
Enhanced Self-Monitoring

Fast Time-Domain Values (FTDV)

Powerful applications

The SEL-T400L is an easy-to-use ultra-high-speed and secure transmission line protective relay. It provides protection of two-terminal and multiterminal lines with in-line and adjacent series compensation, in three-pole and single-pole tripping applications, for single- or dual-breaker line terminations.

The SEL-T400L also provides key line protection elements and schemes. For auxiliary functions, such as reclosing, synchronism check, breaker failure, communications protocols, and backup protection, you can use a companion relay, such as an SEL-421 Protection, Automation, and Control System or an SEL-411L Advanced Line Differential Protection, Automation, and Control System.



Recommended application of the SEL-T400L.

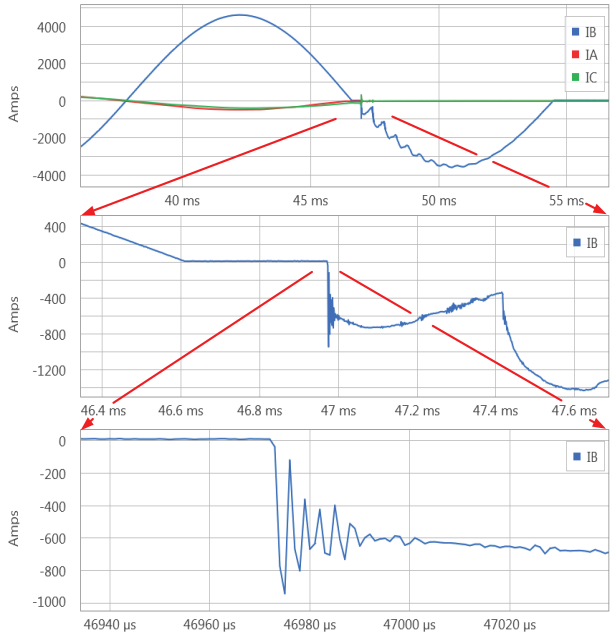
Ultra-high-speed line protection with security

The SEL-T400L features a traveling-wave differential scheme (TW87) over a dedicated point-to-point fiber channel; an incremental-quantity distance element (TD21); and a POTT scheme with traveling-wave (TW32) and incremental-quantity (TD32) directional elements over a digital or analog protection channel. You can achieve 1–5 ms trip times, depending on the channel, line length, and system conditions.

High-resolution oscillography

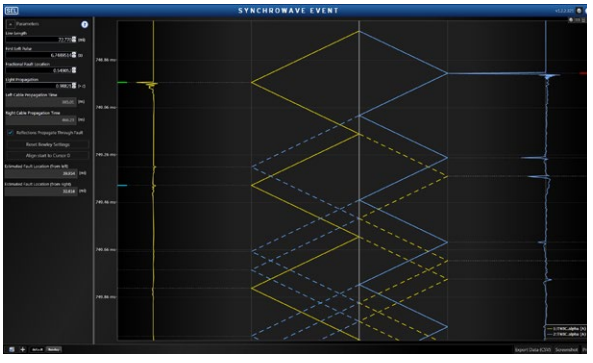
Using the SEL-T400L is like applying an oscilloscope to the power system. Now you can look at currents and voltages through a 1 MHz lens. The SEL-T400L stores as many as 50 events with a back-to-back recording capability and a duration of 1.2 seconds per event. The SEL-T400L also provides a COMTRADE file that contains currents and voltages sampled at 10 kHz, selected operating quantities, Relay Word bits, settings, and fault location and event summary data.

When using a direct fiber-optic channel, the local 1 MHz and 10 kHz records also contain remote voltages and line currents.



Unparalleled fault-locating accuracy

The SEL-T400L provides you with state-of-the-art fault-locating technology. A simple and robust double-ended traveling-wave fault-locating method gives you a very accurate fault location in the vast majority of cases. The method works over a multiplexed IEEE C37.94 channel with accurate external IRIG-B-connected time sources at both line terminals and over a direct fiber channel (external time not required). The method works well on overhead lines, underground cable lines, and hybrid lines composed of both overhead and underground cable sections. Benefit from the single-ended traveling-wave fault-locating method in applications without relay-to-relay communications or when your digital protection channel is down. Obtain good fault-locating results from the backup double- and single-ended impedance-based fault-locating methods when the point on wave or termination effects prevent the traveling-wave methods from locating the fault.



Visualize traveling-wave event reports using SEL-5601-2 SYNCHROWAVE® Event Software.

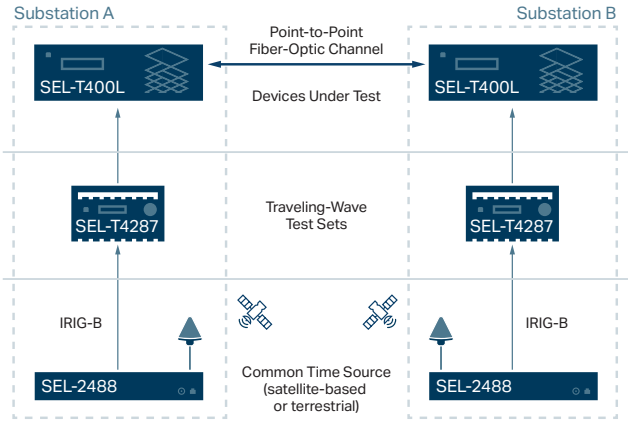
Refreshing simplicity

Designed with simplicity in mind, the SEL-T400L minimizes the number of settings and keeps the settings selection as straightforward as possible. The SEL-T400L uses preconfigured, easy-to-set protection logic. The relay requires only a handful of protection settings, and most of them are nameplate data, such as CT and PT ratios, line length and impedance, nominal voltage and frequency, and so on.

The SEL-T400L offers refreshing simplicity compared with feature-heavy multifunction IEDs. This simplicity improves your workforce efficiency and enhances protection security by helping you avoid errors.

Testing made easy

Requiring only a few protection settings, the SEL-T400L is easy to commission. You can apply any standard relay test set for testing the TD21 distance and TD32 directional elements. The SEL-T4287 Traveling-Wave Test System provides end-to-end testing of the TW87 scheme, the TW32 element, and the traveling-wave fault locator. You can upload ultra-high-resolution current and voltage files (recorded by SEL-T400L relays in the field or obtained from your transient simulation software) to the SEL-T400L and test the relay by executing built-in playback.



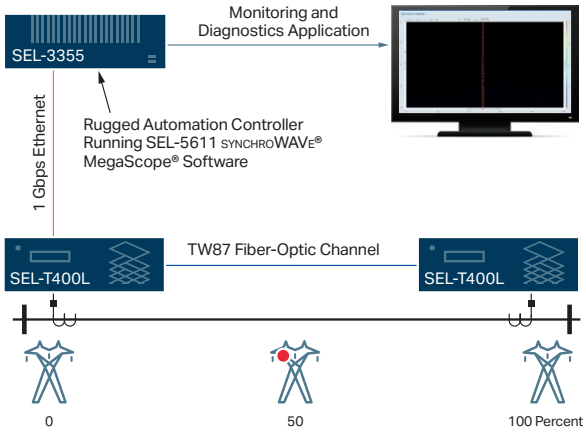
The SEL-T4287 generates nanosecond-timed traveling-wave currents. Perform end-to-end testing with two SEL-T4287 test sets synchronized via satellite clocks.

Hassle-free installation

Use the SEL-T400L with standard control cables and wiring to connect to conventional current and voltage transformers, including coupling capacitor voltage transformers (CCVTs), and directly to breaker trip coil circuits. The relay uses current traveling waves that are adequately measured with standard CTs and cabling, providing dependable TW32 operation. The SEL-T400L includes SEL protocols for ease of integration with SEL systems; DNP3 over Ethernet for interconnecting with DNP3-based SCADA systems; generic Ethernet file transfer methods for ease of integration with Ethernet-based substation automation systems; and access to relay metering data.

MegaScope® applications for remote monitoring and diagnostics

With voltages and currents sampled at an unprecedented rate and resolution (1 MHz, 18 bits), the SEL-T400L is a power data acquisition device for advanced remote monitoring and diagnostics applications. The relay streams the high-resolution FTDV data in real time via a Gigabit Ethernet port, opening a whole suite of new applications for viewing power system events. These applications run in real time on high-performance computing platforms, such as the SEL-3355 Automation Controller. You can record and analyze insulation problems, breaker transient voltage recovery or restrike events, switching events, and other high-frequency signatures over wide areas using the SEL-T400L data. For the first time, you have the ability to monitor your system continually across multiple buses at a 1 MHz sampling rate. Contact SEL (selinc.com/support) to obtain a detailed format description and tools (such as the preliminary MegaScope client software) to experiment with this advanced SEL-T400L functionality.



SEL-T401L

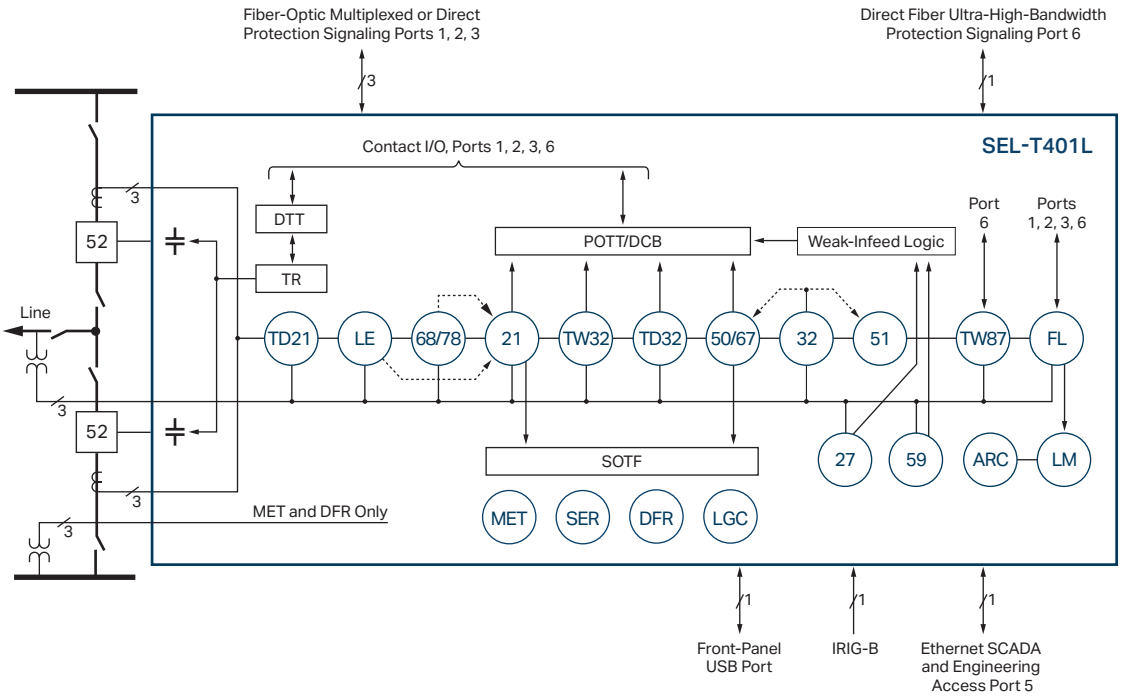
Ultra-High-Speed Line Relay NEW

Starting price
$15,000 USD

selinc.com/products/T401L | Select models typically ship in 2 days

The SEL-T401L provides ultra-high-speed protection of transmission lines by using field-proven traveling-wave and incremental-quantity technologies pioneered in the SEL-T400L Time-Domain Line Protection. The SEL-T401L trips in 1 to 5 ms, samples at 1 MHz, processes data every microsecond, uses high-speed protection signaling, and trips with solid-state trip-rated outputs. It also offers high-performance distance protection with five zones of ground and phase elements and has dependable protection, flexible programming, and supervisory functions. You can apply the SEL-T401L on its own or as part of a redundant protection system with other SEL relays without concern for common-mode failures.

1. USB 2.0 port for local engineering access.
2. Display for viewing metering, event, fault location, and relay status information.
3. Simple HMI navigation.
4. LED targets for viewing trip cause, fault type, and basic relay status.
5. Large slide-in label pocket for diagrams or asset information.
6. Six trip-rated high-speed outputs for single-pole tripping of two breakers.
7. Alarm output.
8. Five inputs with a common terminal.
9. IRIG-B time input.
10. Three fiber-optic ports for multiplexed or direct protection signaling (SEL MB8 or IEEE C37.94).
11. 100 Mbps or 1 Gbps small form-factor pluggable (SFP) Ethernet port for engineering access and SCADA.
12. SFP fiber-optic port for ultra-high-bandwidth protection signaling over direct fiber.
13. Eight outputs for POTT, DCB, DTT, breaker failure initiation (BFI), and other signaling.
14. Eight inputs for POTT, DCB, DTT, triggering, and other signaling.
15. Breaker 1 and 2 current inputs.
16. Line voltage.
17. Auxiliary voltage (metering and digital fault recorder).
18. Power supply: 125–250 Vdc, 110–240 Vac; 48–125 Vdc, 110–120 Vac; or 48–125 Vdc, 110–240 Vac.



ANSI Functions

21	Phase and Ground Distance
TD21	Incremental-Quantity Phase and Ground Distance
27	Undervoltage (Phase, Phase to Phase, and Positive Seq.)
32	Directional (Phase, Zero Seq., and Negative Seq.)
TD32	Incremental-Quantity Directional
TW32	Traveling-Wave Directional
50	Instantaneous Overcurrent (Phase, Zero Sequence, and Negative Sequence)
51	Inverse-Time Overcurrent (Phase, Zero Sequence, and Negative Sequence)
59	Overvoltage (Phase, Phase to Phase, Positive Sequence, Zero Sequence, and Negative Sequence)
67	Instantaneous and Definite-Time Directional Overcurrent (Phase, Zero Sequence, and Negative Sequence)
68	Power-Swing Blocking
78	Out-of-Step Tripping
85 RIO	SEL Mirrored Bits® I/O With Selectable SEL MB8 or IEEE C37.94 Encoding
TW87	Traveling-Wave Differential
94	High-Speed Trip-Rated Outputs
POTT	Permissive Overreaching Transfer Trip Logic
CBECHO	Open-Breaker Echo Logic
WI	Weak-Infeed Logic
DCB	Directional Comparison Blocking Logic

ANSI Functions (Continued)

SOTF	Switch-Onto-Fault Logic
DTT	Direct Transfer Trip Logic (Intertripping)
LOP	Loss-of-Potential Logic
OP	Open-Pole Detection Logic
LE	Load Encroachment Logic
DFR	Digital Fault Recorder
SER	Sequential Events Recorder
FL	Fault Locator
LM	Line Monitor
LGC	SELogic® Control Equations
MET	Metering
ARC	Adaptive Autoreclose Cancel Logic
HMI	Local Operator Interface
DNP3	Distributed Network Protocol 3.0 (Ethernet)
FTP	File Transfer Protocol

Additional Functions

- Arming and Starting Logic for Time-Domain Protection
- Electromagnetic Interference Monitoring for Traveling-Wave Functions
- Traveling-Wave Test Mode
- Event Playback
- Fast Time-Domain Values

Built on the SEL-T400L Time-Domain Line Protection

The SEL-T401L offers the same capabilities as the field-proven SEL-T400L, including:

Time-domain protection

Using the field-proven SEL time-domain technologies of traveling waves and incremental quantities, the SEL-T401L trips in 1 to 5 ms. The underreaching distance (TD21) protection element trips using incremental voltages and currents. Not dependent on a protection channel, the TD21 element operates as fast as 2 ms for heavy close-in faults. The incremental-quantity directional (TD32) element is dependable and operates in 1 to 2 ms. The traveling-wave directional (TW32) element operates as fast as 0.1 ms. A field-proven SEL innovation, the traveling-wave differential (TW87) protection scheme uses current traveling waves to detect in-zone faults with operating times in the range of 1 to 5 ms, depending on the line length.

Unparalleled fault-locating technology

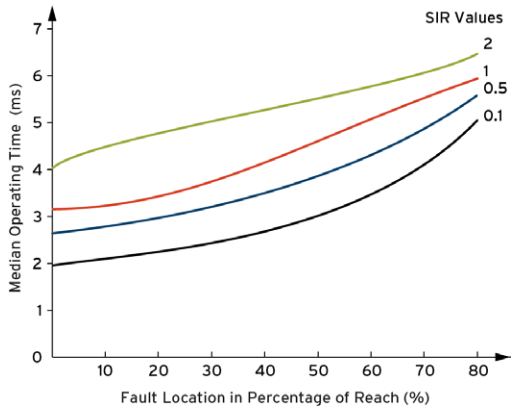
Single- and double-ended traveling-wave and impedance-based fault locating is accurate to a single tower span, making it possible to find and fix faults fast. Autoreclose cancel logic allows you to distinguish faults on overhead line sections from faults on underground cable sections and to control your autoreclose logic accordingly. New in the SEL-T401L is the line-monitoring function, which allows you to perform condition-based line maintenance and discover weak spots along the line.

High-fidelity recording

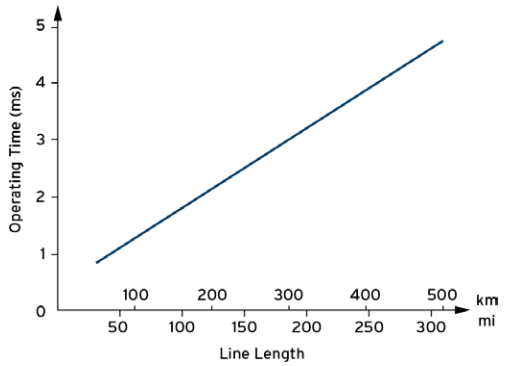
High-resolution voltage and current recording with a 1 MHz sampling rate and an 18-bit resolution provides a detailed view of your system.

Testing made easy

Built-in current and voltage playback gives you new opportunities for relay testing.



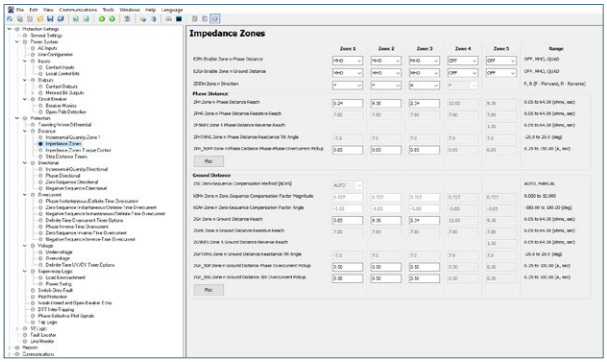
TD21 operating time for a varying fault location under different source-to-line impedance ratios.



TW87 operating time as a function of line length.

Refreshing Simplicity

The SEL-T401L allows you to reset the complexity of your line protection applications with its simple and robust protection philosophies and a considerably lower setting count, all in a convenient 3U package. The SEL-T401L design balances flexibility and ease of use. Settings are streamlined, named, grouped, and presented for intuitive application and ease of use. Apply the relay with preconfigured logic, or adjust the factory defaults with SELOGIC control equations with gates, timers, and latches.



Dependable, Flexible, and Simple Protection

Distance protection

The SEL-T401L provides a total of five phase and ground distance zones for direct tripping, pilot protection, step distance, and switch-onto-fault (SOTF) applications. Zones 1 through 4 are directional; each has an individual direction setting (forward or reverse). Zone 5 is nondirectional (offset) with separate forward and reverse reach settings. You can configure the phase and ground distance elements of each zone as either a mho characteristic or a quadrilateral characteristic. Each ground distance zone uses its own zero-sequence compensation factor. All zones use an overcurrent supervision condition with thresholds that can be set individually for the phase and ground distance elements of each zone.

Pilot tripping logic

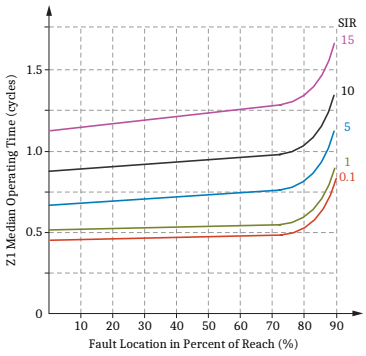
The SEL-T401L offers fast, secure, dependable, and flexible yet easy-to-use POTT and DCB schemes. Select traveling-wave (TW32), incremental-quantity (TD32), negative-sequence (32Q), zero-sequence (32G), or phase (32P) directional elements as well as overreaching distance elements (Zone 2) to detect line faults. A combination of the time-domain TW32 and TD32 elements (speed), the sequence-based 32Q and 32G elements (speed, dependability, and sensitivity), and the distance elements (speed and dependability) allows your POTT scheme to trip with extraordinary speed, iron-clad dependability, and very high sensitivity. Enable open breaker echo and weak-infeed logic in your POTT scheme for dependability on tapped and multiterminal lines and during weak system conditions.

Supplementary and backup protection

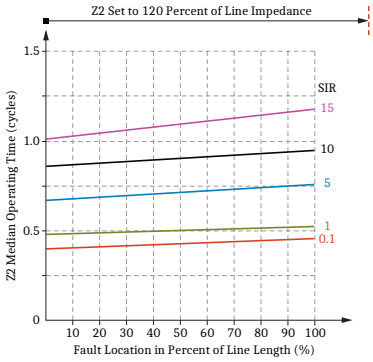
The SEL-T401L offers all core protection elements that you typically want duplicated between the primary and backup relays in a flexible yet easy-to-use package. Cover high-resistance faults through inverse-time and definite-time ground directional overcurrent elements (zero- and negative-sequence). Use phase, zero-, and negative-sequence instantaneous overcurrent elements to clear heavy close-in faults without reliance on voltage or protection channels. Use the inverse-time and definite-time overcurrent elements to coordinate with adjacent relays for backup protection. Use over- and undervoltage instantaneous and time-delayed voltage elements to address out-of-bound voltage system conditions.

Supervisory elements

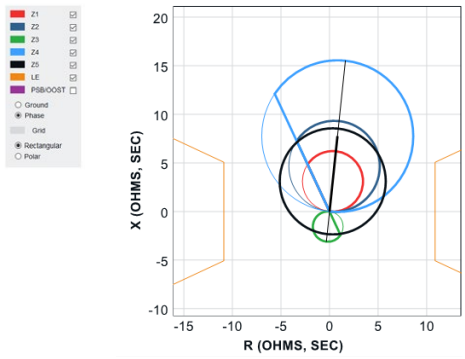
Apply load encroachment logic to secure the SEL-T401L distance and phase overcurrent elements for heavy load conditions. Optimize your single-pole tripping applications by applying separate load encroachment settings for the phase and ground measurement loops. Apply the power-swing blocking logic to secure the SEL-T401L distance elements during power swings. Phase-segregated operation allows dependable blocking of ground elements for power swings under external unbalance conditions, such as single-pole tripping and reclosing on adjacent lines. Two separate unblocking mechanisms allow dependable SEL-T401L operation for faults during power-swing conditions. Apply the out-of-step tripping logic to trip for unstable power swings traversing the protected line. The out-of-step tripping logic is settings-free and applies a simple trip-on-the-way-out operating principle based on the impedance-rate-of-change measurement.



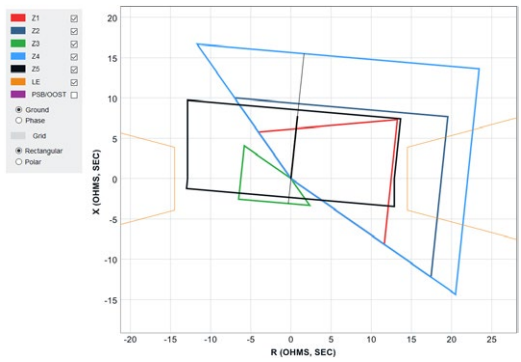
Distance Zone 1 median operating time for varying fault locations and different source-to-impedance ratios (SIRs).



Distance Zone 2 median operating time for varying fault locations and different SIRs.



Phase distance mho elements characteristic plot in ACSELERATOR QuickSet® SEL-5030 Software.



Ground distance quadrilateral elements characteristic plot in QuickSet.

SEL-T4287

Traveling-Wave Test System

Starting price
$4,287 USD

selinc.com/products/T4287 | Select models typically ship in 2 days

The SEL-T4287 is a simple-to-use, compact, and economical secondary pulse injection test set for traveling-wave fault locators and line protective relays.

Secondary traveling-wave injection

Traveling-wave fault locators and protection elements and schemes measure sharp changes in their input currents and voltages with rise times as fast as 1 µs. These fault locators and relays respond to relative polarities and the relative timing of these sharp signal changes. The SEL-T4287 generates output current signals with a short rise time, adequately slow decay, and the nanosecond precision necessary for testing traveling-wave protective relays, standalone traveling-wave fault locators, and traveling-wave fault locators embedded in line protective relays.

Versatile applications

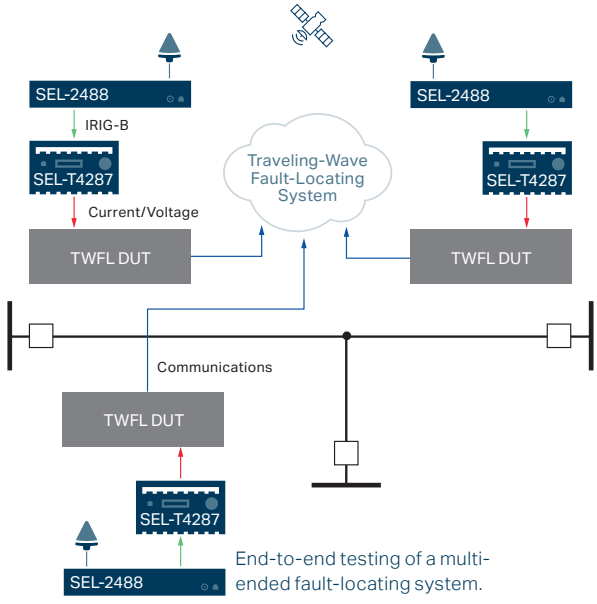
The SEL-T4287 generates two three-phase sets of secondary traveling-wave currents. An included voltage module accessory (containing low-inductance resistors) allows you to convert one current output set into one voltage output set to simulate traveling-wave voltage signals. The SEL-T4287 lets you test current- or voltage-based fault locators or protection elements and schemes, including the single- and multi-ended fault locators, traveling-wave directional element, and traveling-wave differential scheme found in the SEL-T400L Time-Domain Line Protection and SEL-T401L Ultra-High-Speed Line Relay. You can time-synchronize or cross-trigger multiple SEL-T4287 test sets to generate more than two three-phase traveling-wave signals with desired timing patterns as needed by the device under test (DUT).

Simple test parameter configuration

Specify line and fault parameters, and let the SEL-T4287 calculate and apply the traveling-wave test signals. The simple and intuitive SEL-T4287 HMI allows you to specify test parameters and offers full control of tests without the need for a PC and software.

End-to-end testing

Perform end-to-end testing of traveling-wave protection schemes and multi-ended fault locators with multiple SEL-T4287 test sets synchronized to substation satellite clocks via IRIG-B inputs. You can preconfigure each test set, schedule a test time, and let the multiple SEL-T4287 test sets apply the right test signals at all terminals of the line. The SEL-T4287 can test multi-ended traveling-wave fault locators for lines with more than two terminals. End-to-end testing is a standard feature included in the base product and can be used with any IEEE C37.118-compliant satellite clock with IRIG-B output.



End-to-end testing of a multi-ended fault-locating system.

SEL-421

Protection, Automation, and Control System

Starting price
$7,180 USD

selinc.com/products/421

The SEL-421 provides high-speed distance and directional protection and complete control of a two-breaker bay. You can protect any transmission line using a combination of five zones of phase- and ground-distance and directional overcurrent elements. A graphical user interface provides logic and application templates for typical line protection schemes. Patented capacitively coupled voltage transformer (CCVT) transient overreach logic enhances the security of Zone 1 distance elements. Best Choice Ground Directional Element® logic optimizes directional element performance and eliminates many directional settings. Optional additional logic prevents Zone 1 overreach on series-compensated lines. In addition, you can select incremental components for subcycle operation on critical lines requiring high-speed fault clearing. Optional Time-Domain Link (TiDL®) technology and SEL Sampled Values (SV) technology using IEC 61850-9-2 transform the way you modernize your substation.

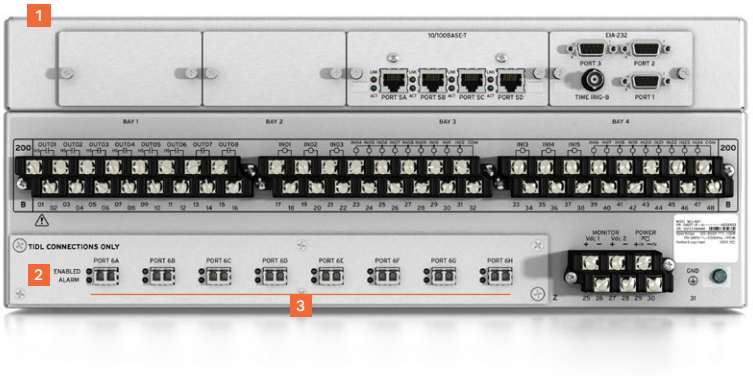
1. EIA-232 front serial port is quick and convenient for system setup and local access.
2. Front-panel display allows operators to control and view the status of disconnects and breakers.
3. User-selectable mimic screens show the system configuration in one-line diagram format.
4. Easy-to-use keypad aids simple navigation.
5. Front-panel LEDs indicate custom alarms and provide fast and simple information to assist dispatchers and line crews with rapid power restoration.
6. Programmable operator pushbuttons with user-configurable labels allow front-panel customization.
7. Choose from a vertical or horizontal, panel-mount or rack-mount chassis and different size options.
8. High-current interrupting output contacts increase contact robustness and reliability.
9. Use one front and three rear EIA-232 ports for Mirrored Bits® communications, DNP3, SCADA, and engineering access.
10. Communications protocols include FTP, Telnet, synchrophasors, DNP3 LAN/WAN, the Parallel Redundancy Protocol (PRP), the IEEE 1588 Precision Time Protocol Version 2 (PTPv2),** and IEC 61850 Edition 2.*
11. Six current and six voltage analog inputs support complete bay control and protection as well as two-breaker bay applications.
12. Power supply options include 24–48 Vdc; 48–125 Vdc or 110–120 Vac; or 125–250 Vdc or 110–240 Vac.

*Optional feature

**For PTPv2 implementation, Ports 5A and 5B must be ordered as an option.

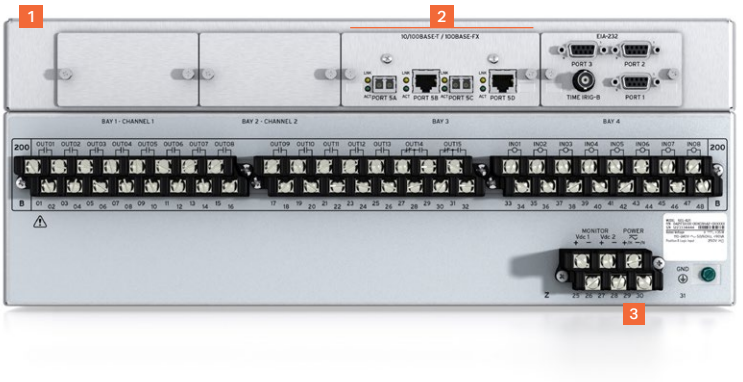
SEL-421 TiDL OPTION

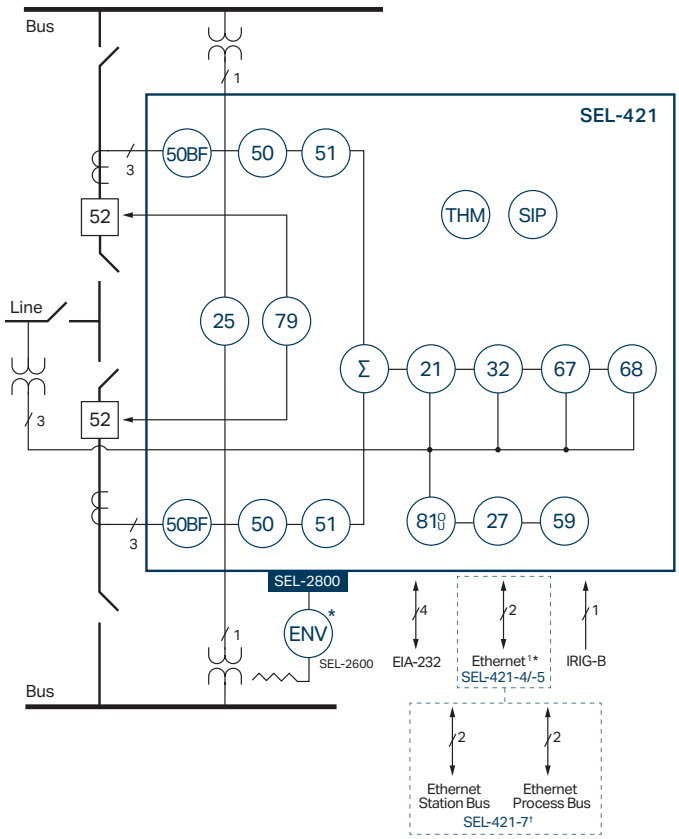
1. 4U chassis with mounting options (vertical or horizontal; panel or rack) accommodate users' application needs.
2. LEDs indicate the connection status to an SEL-TMU TiDL Merging Unit on a per-port basis.
3. Eight 100 Mbps fiber-optic ports allow the TiDL-enabled relay to connect with eight remote SEL-TMU nodes and to receive remote analog and digital data over the network.



SEL-421 SV OPTION

1. The 4U chassis has various mounting options to accommodate users' hardware needs.
2. Select fiber-optic, copper, or mixed Ethernet with separate ports for SV data and engineering access.
3. Power supply options include 24–48 Vdc; 48–125 Vdc or 110–120 Vac; or 125–250 Vdc or 110–240 Vac.





ANSI 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
DFR	Event Reports
ENV	SEL-2600 RTD Module*
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
SV	IEC 61850-9-2 Sampled Values Technology*†
THM	IEC 60255-Compliant Thermal Model
TiDL	Time-Domain Link Technology*

*Optional feature †Copper or fiber-optic

†TiDL and SV relays receive current and voltage values from remote merging units.

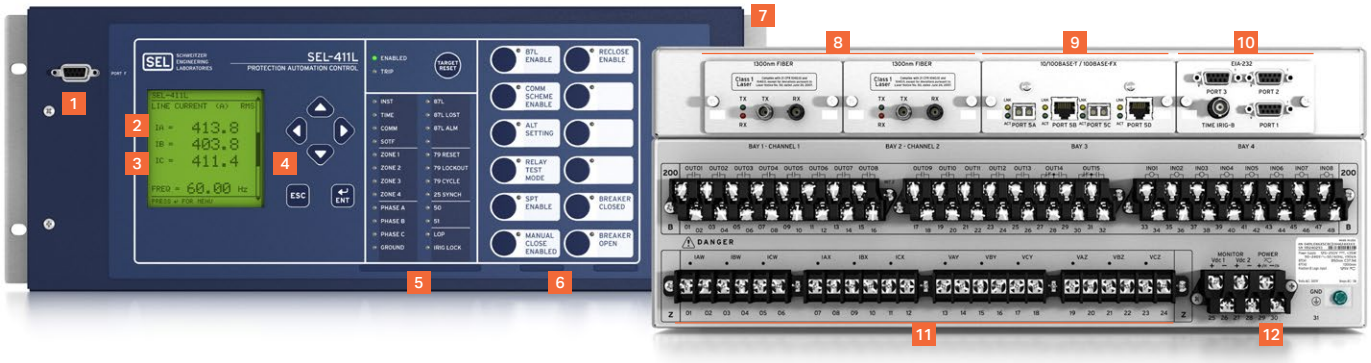
SEL-411L

Advanced Line Differential Protection, Automation, and Control System

Starting price
$8,820 USD

selinc.com/products/411L

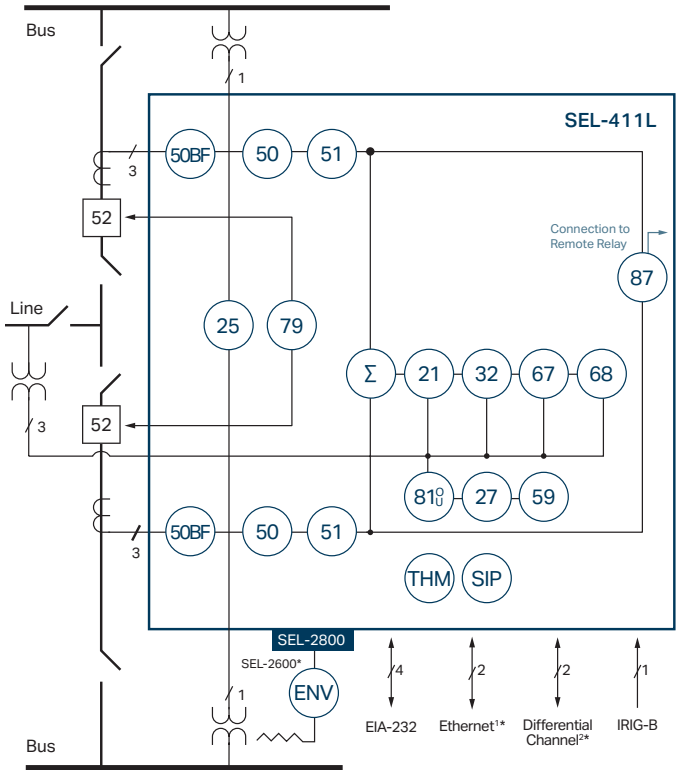
The SEL-411L offers complete protection and control of any transmission line (short, long, or series-compensated) with up to four terminals. Differential protection with both phase- and sequence-based operating elements provides sensitivity and high-speed operation. Complete distance and directional elements provide standalone protection or backup protection in differential schemes in the event communications are lost. In addition to the differential protection, the SEL-411L includes all the features of the SEL-421 Protection, Automation, and Control System. Many popular fiber and multiplexed communications options are available. The SEL-411L accurately locates faults to within a tower span using optional traveling-wave fault locating.



1. EIA-232 front serial port is quick and convenient for system setup and local access.
2. Front-panel display allows operators to control and view the status of disconnects and breakers.
3. User-selectable mimic screens show the system configuration in one-line diagram format.
4. Easy-to-use keypad aids simple navigation.
5. 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.
6. Programmable operator pushbuttons with user-configurable labels allow front-panel customization.
7. Choose from a vertical or horizontal, panel-mount or rack-mount chassis and different size options.
8. Choose either fiber or copper connections for one or two 87L communications channels.
9. Communications protocols include FTP, Telnet, synchrophasors, DNP3 LAN/WAN, the Parallel Redundancy Protocol (PRP), the IEEE 1588 Precision Time Protocol Version 2 (PTPv2),** and IEC 61850 Edition 2.*
10. Three EIA-232 serial ports for Mirrored 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.
11. Six current and six voltage analog inputs support protection for substations with dual-breaker schemes.
12. The power supply allows different options: 24–48 Vdc; 48–125 Vdc or 110–120 Vac; or 125–250 Vdc or 120–240 Vac.

*Optional feature

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



ANSI 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 RTD Module*
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

*Optional feature [1]Copper or fiber-optic [2]Serial or Ethernet

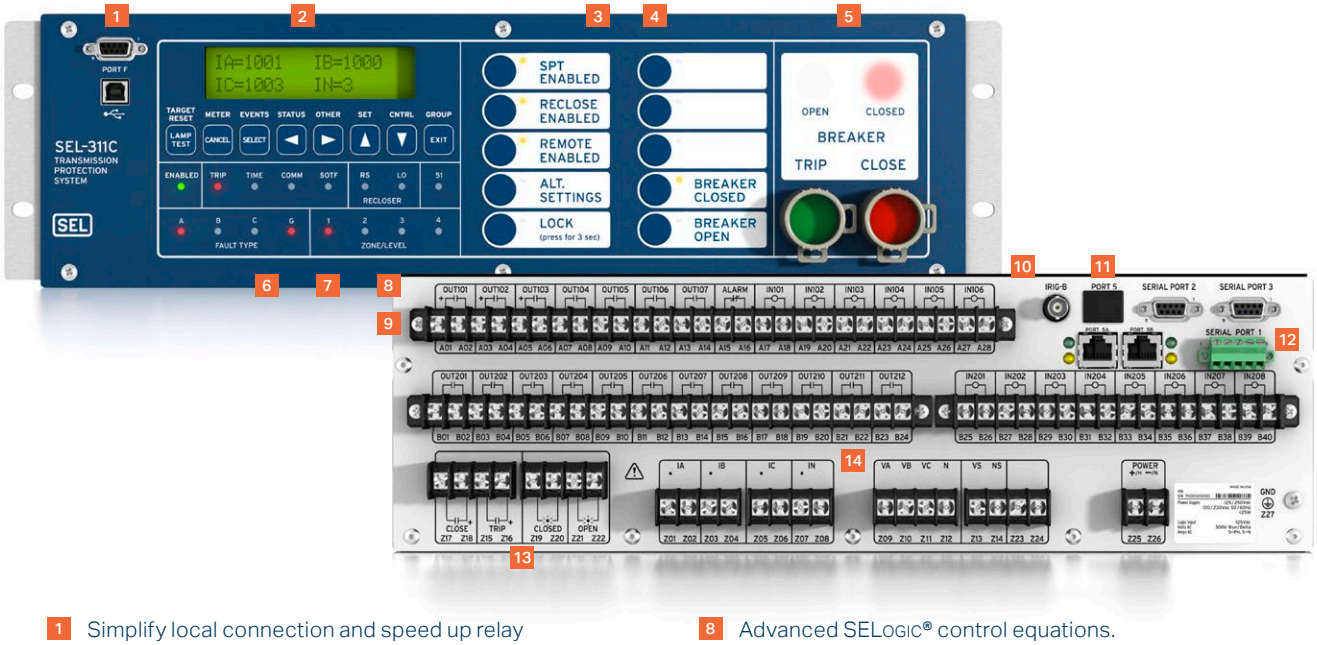
SEL-311C

Transmission Protection System

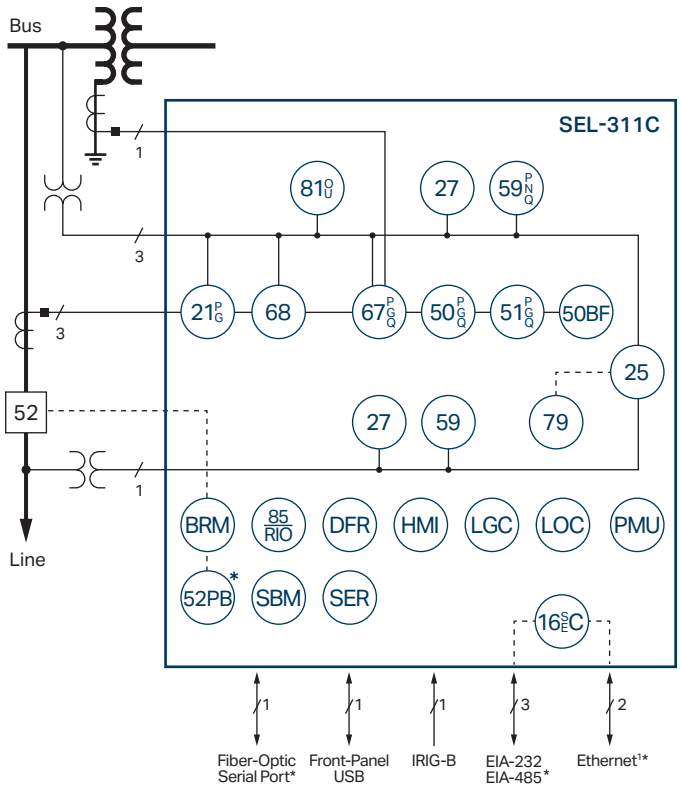
Starting price
$4,670 USD

selinc.com/products/311C

The SEL-311C provides protection, reclosing, monitoring, and control of transmission lines. Features include a four-shot recloser; patented capacitance voltage transformer (CVT) transient overreach logic to enhance the security of Zone 1 distance elements; and overcurrent elements with directional control, monitoring, and metering. You can apply three-pole tripping logic or select the SEL-311C-3 for single-pole tripping. The SEL-311C comes standard with EIA-232 serial ports and a 10/100BASE-T Ethernet port for local/remote access and system integration. IEEE C37.118-compliant synchrophasors improve situational awareness.



1. Simplify local connection and speed up relay communications with the front-panel USB port.
2. Use default displays, or program custom messages.
3. Optional field-configurable, programmable operator pushbuttons with user-configurable labels.
4. Optional programmable front-panel LEDs for custom alarms.
5. Optional independent SafeLock® trip/close pushbuttons with high-visibility indication.
6. Mirrored Bits® communications.
7. Built-in phasor measurement unit.
8. Advanced SELogic® control equations.
9. High-current interrupting output contacts.
10. Standard multisession Modbus TCP and DNP3. Optional IEC 61850.
11. Standard dual copper, optional single or dual fiber-optic Ethernet ports, or one copper and one fiber-optic Ethernet port.
12. Standard EIA-485 or fiber-optic serial port, or optional fiber-optic serial port.
13. Independent terminals for SafeLock trip/close pushbuttons.
14. Optional expanded I/O.



ANSI Functions

16 SEC	Access Security (Serial, Ethernet)
21 (P,G)	Distance (Phase Mho, Ground Mho, Ground Quad)
25	Synchronism Check
27	Undervoltage
50 (P,G,Q)	Overcurrent (Phase, Ground, Negative Sequence)
50BF	Breaker Failure Overcurrent
51 (P,G,Q)	Time Overcurrent (Phase, Ground, Negative Sequence)
52PB	Trip/Close Pushbuttons*
59 (P,N,Q)	Overvoltage (Phase, Neutral, Negative Sequence)
67 (P,G,Q)	Directional Overcurrent (Phase, Ground, Negative Sequence)
68	Out-of-Step Block/Trip
79	Autoreclosing
81 (O,U)	Over-/Underfrequency
85 RIO	SEL Mirrored Bits Communications
DFR	Event Reports
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

*Optional feature [1]Copper or fiber-optic

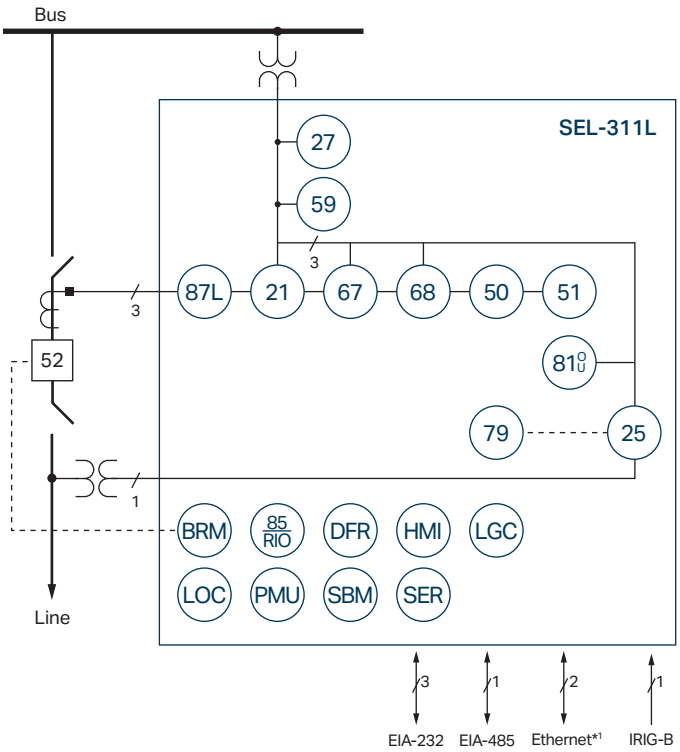
SEL-311L

Line Current Differential Protection and Automation System

Starting price
$5,180 USD

selinc.com/products/311L

The SEL-311L offers four-zone distance and directional overcurrent backup for easy-to-apply, high-speed line current differential protection. Single or dual differential communications channels provide reliability and security. The SEL-311L can accommodate two- or three-terminal lines, even with weak infeed. In addition, measuring elements provide coordination with tapped loads. You can reduce total project construction and operation costs by integrating the included four-shot recloser and relay logic operators into your automation system.



ANSI Functions

21	Phase and Ground Distance
25	Synchronism Check
27/59	Under-/Overvoltage
50	Overcurrent
51	Time Overcurrent
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
87L	Current Differential
DFR	Event Reports
HMI	Operator Interface
LGC	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

*Optional feature [1] Copper or fiber-optic

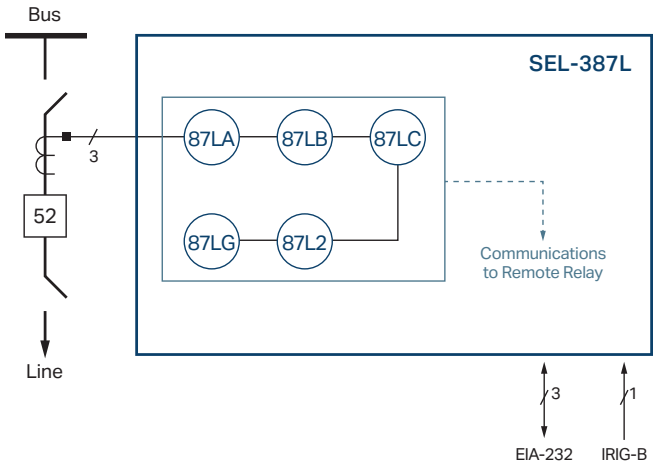
SEL-387L

Line Current Differential Protection and Automation System

Starting price
$3,050 USD

selinc.com/products/387L

The SEL-387L offers sensitive, fast (subcycle), and secure three-pole current differential protection with zero settings. Negative- and zero-sequence differential elements detect high-resistance ground faults while remaining secure for external faults. The Alpha Plane restraint principle provides security for CT saturation and channel asymmetry. Direct fiber and IEEE C37.94 synchronous optical interfaces are available. Channel monitoring provides measurement of communications quality and prevents misoperation due to channel failure.



ANSI Functions

87L	Current Differential
DFR	Event Reports
HMI	Operator Interface
LGC	SELOGIC® Control Equations
Met	High-Accuracy Metering
SER	Sequential Events Recorder
SBM	Station Battery Monitor