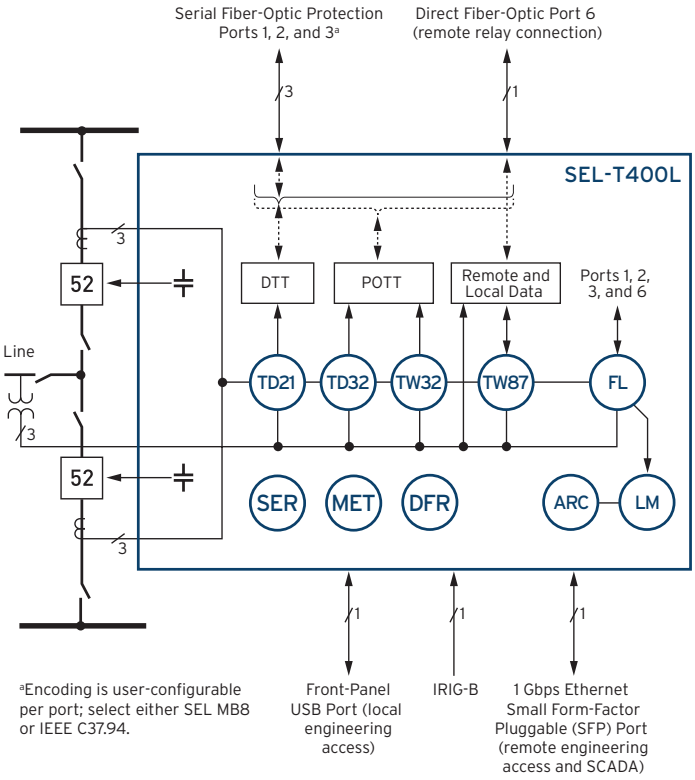
SEL-T400L

Time-Domain Line Protection

Built for speed, security, and simplicity

- Traveling-wave-based and incremental-quantity-based line protection schemes as fast as 1 ms with traditional pilot channels and over direct fiber-optic channels.
- Communications-independent Zone 1 element, operating in as fast as 3 ms.
- Suitable for single-pole tripping, series-compensated lines, and dual-breaker terminals.
- Communications-independent fault locator accurate to a single tower span.
- 1 MHz fault recorder and Fast Time-Domain Values (FTDV) streaming.

Functional Overview



[a]Encoding is user-configurable per port; select either SEL MB8 or IEEE C37.94.

ANSI Numbers/Acronyms and 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 (traveling-wave and impedance methods, single-ended and double-ended)
LM	Line Monitor
ARC	Adaptive Autoreclose Cancel Logic
MET	Metering
HMI	Operator Interface

Additional Functions
Preconfigured Trip Logic
Single-Pole Tripping Logic
Open-Pole Detection 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)

Unmatched Performance

The SEL-T400L Time-Domain Line Protection is an ultra-high-speed transmission line relay, traveling-wave fault locator, and high-resolution event recorder. The SEL-T400L is a quantum leap in line protection performance. Using traveling waves and incremental quantities, the SEL-T400L breaks the speed barrier of phasor-based relays. In power system protection, every millisecond counts. Faster fault clearing improves public and utility personnel safety, widens transient stability margins, limits equipment wear, improves power quality, and limits property damage. The SEL-T400L protects series-compensated lines and provides single-pole tripping.

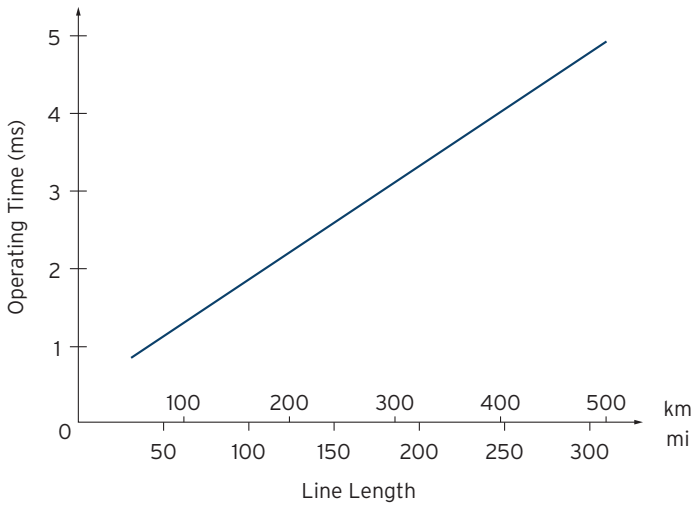
The SEL-T400L locates faults within tens of milliseconds of their occurrence using traveling-wave fault-locating technology and issues an autoreclose cancel (ARC) signal for faults on underground sections of hybrid lines with overhead and underground sections. The relay's fault-locating calculations are accurate to a single tower span, regardless of the line length, with or without a communications channel. The SEL-T400L includes a line monitoring function for condition-based line maintenance and to identify trouble spots along the line.

The SEL-T400L provides high-resolution event records sampled at 1 MHz, 18-bit resolution. Using these events, you can analyze transients, such as traveling waves from faults, breaker restrike, or partial discharge.

The SEL-T400L allows you to test its protection and fault-locating functions without the need for a physical relay test set by using the built-in event playback function.

Traveling-Wave Differential Protection Scheme

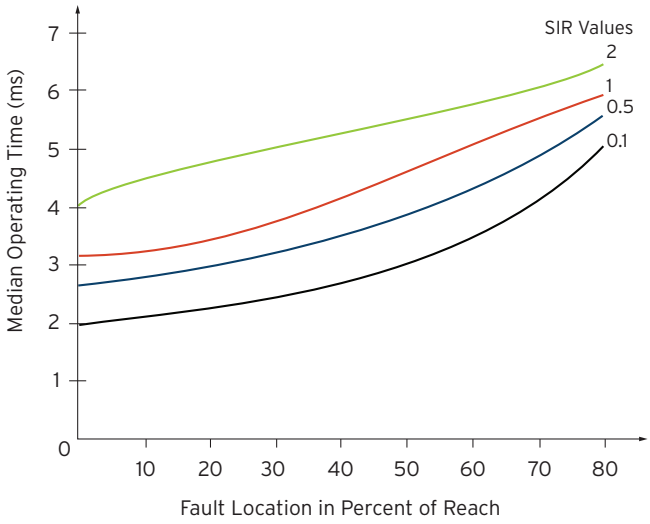
The first ever traveling-wave differential (TW87) protection scheme uses current traveling waves to detect in-zone faults with operating times in the range of 1—5 ms, depending on the line length. The TW87 scheme works over a direct point-to-point fiber-optic channel and does not rely on external time sources for aligning remote currents. It uses traditional CTs and wiring.



TW87 operating time as a function of line length.

Distance Protection Element

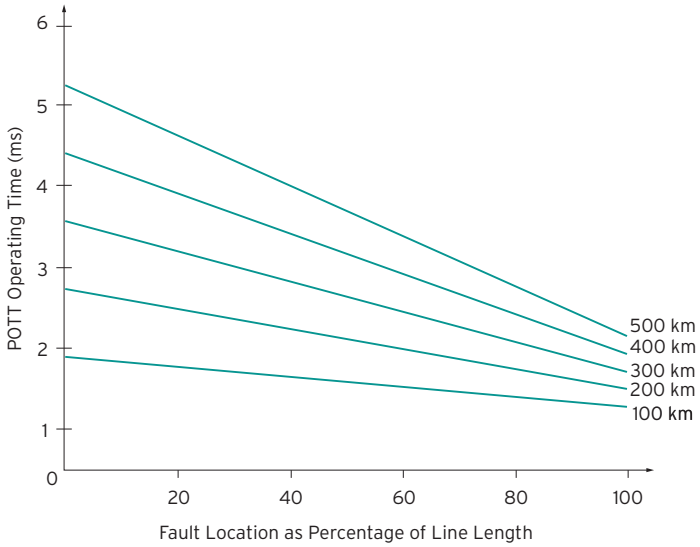
The underreaching distance (TD21) protection element uses incremental voltages and currents to make a tripping decision, independent from communications. The element can be set as high as 80 percent of the line length, has a transient overreach below 10 percent, and operates between 2 and 5 ms, depending on the fault location, system short-circuit level, fault resistance, and point on wave.



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

Permissive Overreaching Transfer Trip (POTT) Protection Scheme

The POTT scheme uses ultra-fast and sensitive directional elements for fault direction discrimination. The traveling-wave directional element (TW32) operates in 0.1 ms, and the incremental quantity directional element (TD32) operates in 1 to 2 ms, depending on system conditions. Sending phase-segregated permissive trip signals, the POTT scheme has excellent performance for evolving and intercircuit faults. Use IEEE C37.94 encoding for signaling the remote-end SEL-T400L over compliant multiplexers. Use SEL MB8 encoding and a media converter to interface with multiplexers not compliant with IEEE C37.94.

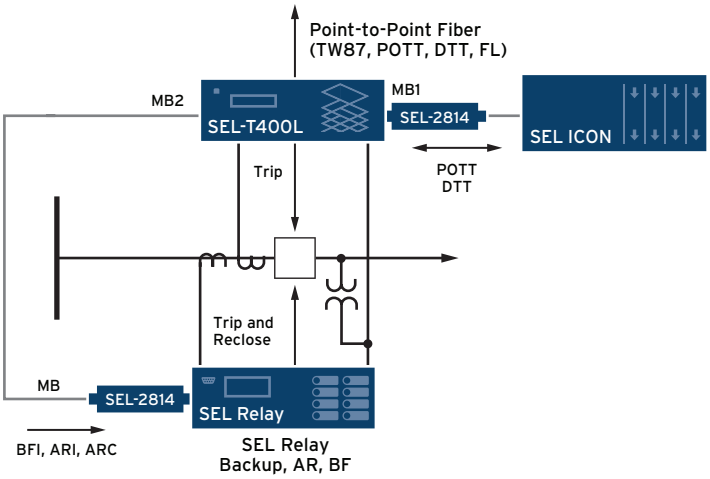


POTT operating time as a function of fault location, as a percentage of line length, assuming a point-to-point fiber-optic channel.

Refreshing Simplicity

The SEL-T400L is first and foremost a protective relay. 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 offers refreshing simplicity compared with feature-heavy multifunction intelligent electronic devices. Improve your workforce efficiency and enhance protection security by avoiding human errors.

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. Power system configuration changes have far less impact on the SEL-T400L elements than on traditional phasor-based protection. The few settings that do require protection judgment and knowledge are either multiple-choice preferences or simple overcurrent or impedance thresholds.



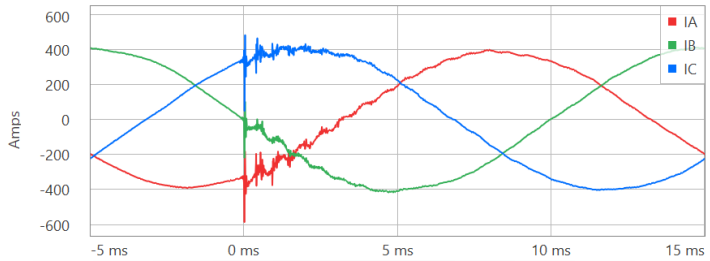
This is a recommended all-SEL application of the SEL-T400L. Use the SEL-421 Protection, Automation, and Control System or SEL-411L Advanced Line Differential Protection, Automation, and Control System for backup protection, breaker failure protection, and autoreclose functions.

Unparalleled Fault-Locating Accuracy

In the last two decades, protection engineers have come to expect an impedance-based fault locator as a standard feature in a line protective relay. From now on, expect line protective relays to offer traveling-wave fault locating with ten-fold better accuracy. The SEL-T400L incorporates a single-ended traveling-wave fault-locating method, which calculates the fault location by analyzing only the local current traveling waves without the need for a communications channel. The relay also provides a double-ended method, which uses the first traveling waves arriving at both line terminals and requires communications over the differential protection fiber-optic channel or an IEEE C37.94 multiplexed channel. The SEL-T400L performs fault-locating calculations within tens of milliseconds after the fault, and it issues an ARC signal for faults on the underground sections of hybrid lines with overhead and underground sections. The traveling-wave fault-locating technology in the SEL-T400L has a field-proven accuracy in the order of about one tower span, regardless of the line length.

Line Monitoring

The line monitoring function allows you to perform condition-based line maintenance and discover weak spots along the line. The line monitor triggers on current traveling waves launched by fault precursors, such as partial discharge due to a dirty insulator, encroaching vegetation, or an incipient cable fault. The line monitor locates fault precursors with high accuracy, tabulates the precursor events for locations along the line, and alarms if the event count exceeds a user-settable alarm threshold at any location. With this information, you can selectively wash or replace insulators and trim vegetation to reduce line faults.

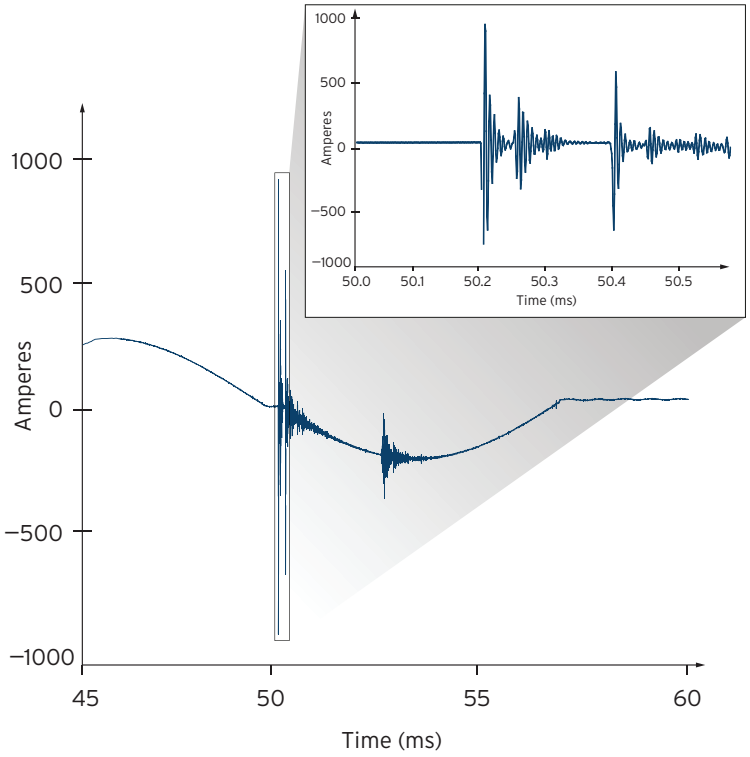


The SEL-T400L detects, locates, tabulates, and alarms on in-zone events to prevent faults and identify line weak spots.

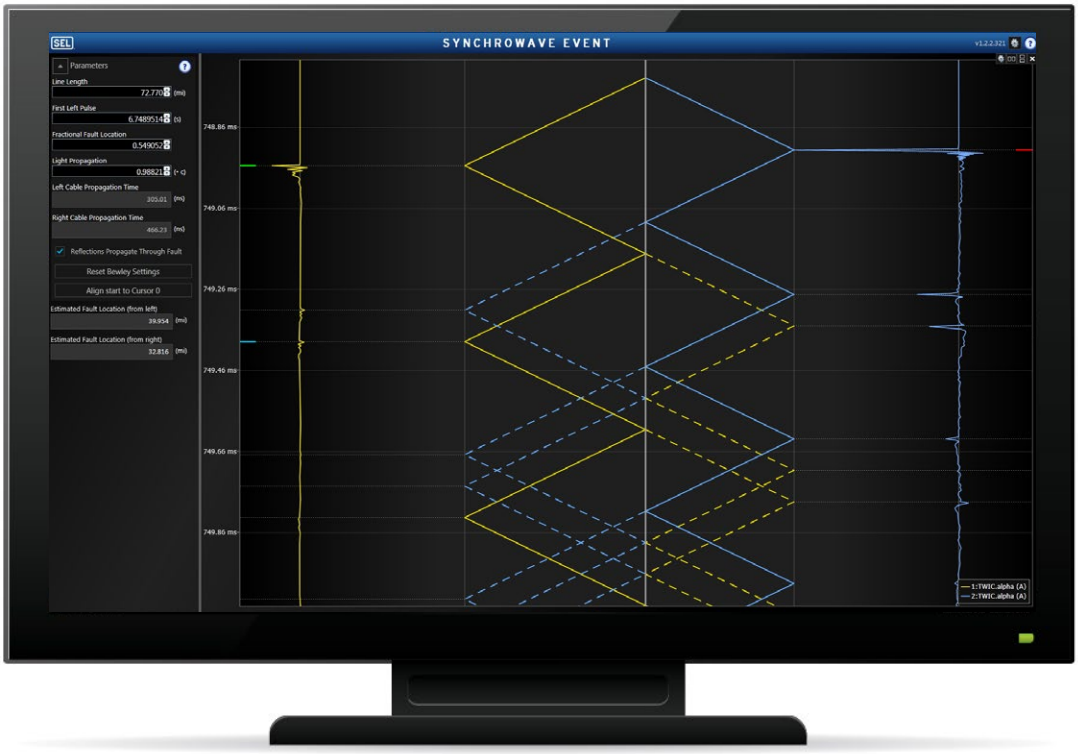
High-Resolution Oscillography

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 offers a 10 kHz COMTRADE file that contains currents and voltages sampled at 10 kHz, selected protection operating quantities, Relay Word bits, settings, and fault location and event summary data.

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



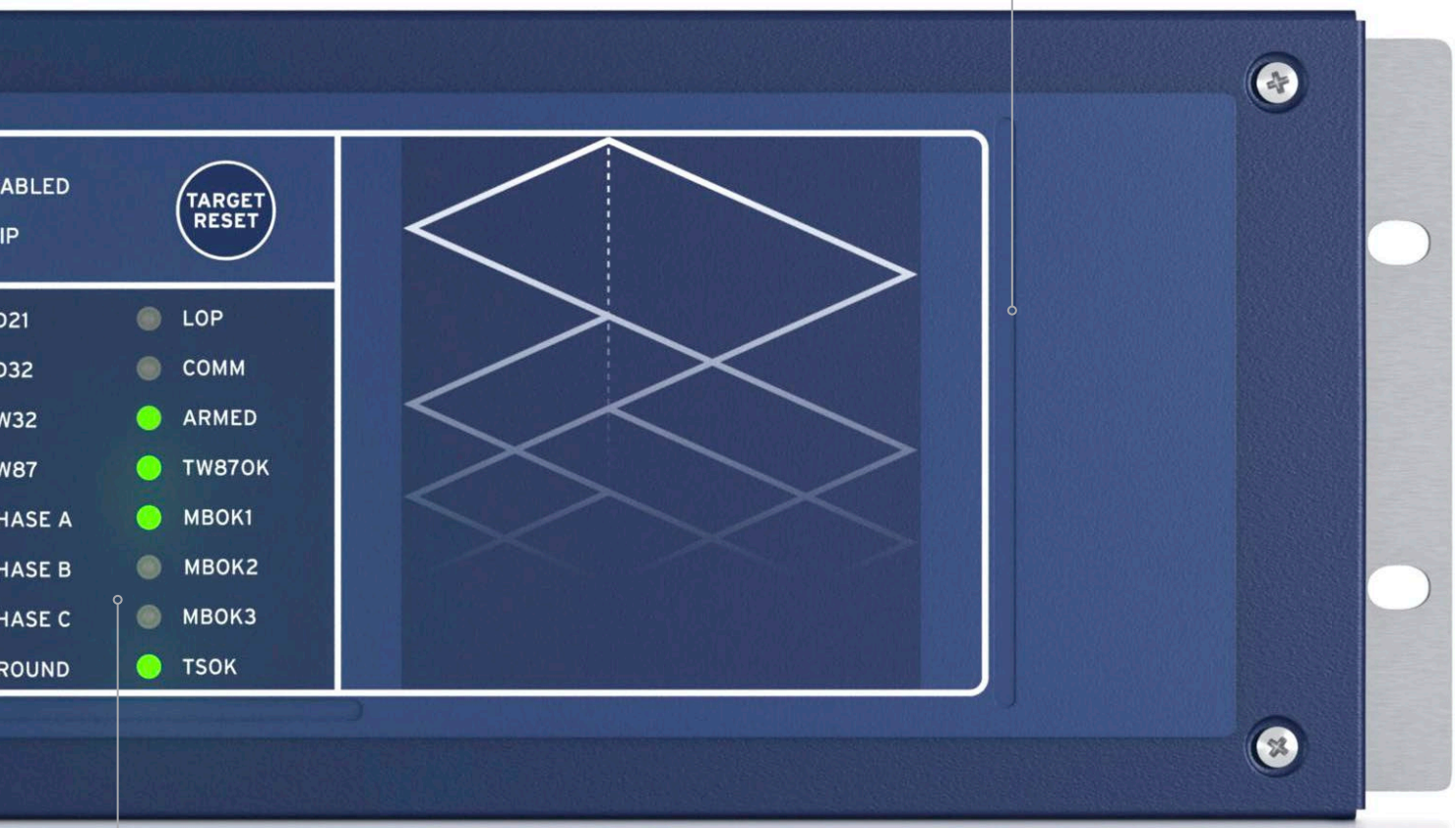
High-resolution oscillography shows a breaker restrike while de-energizing a shunt reactor.



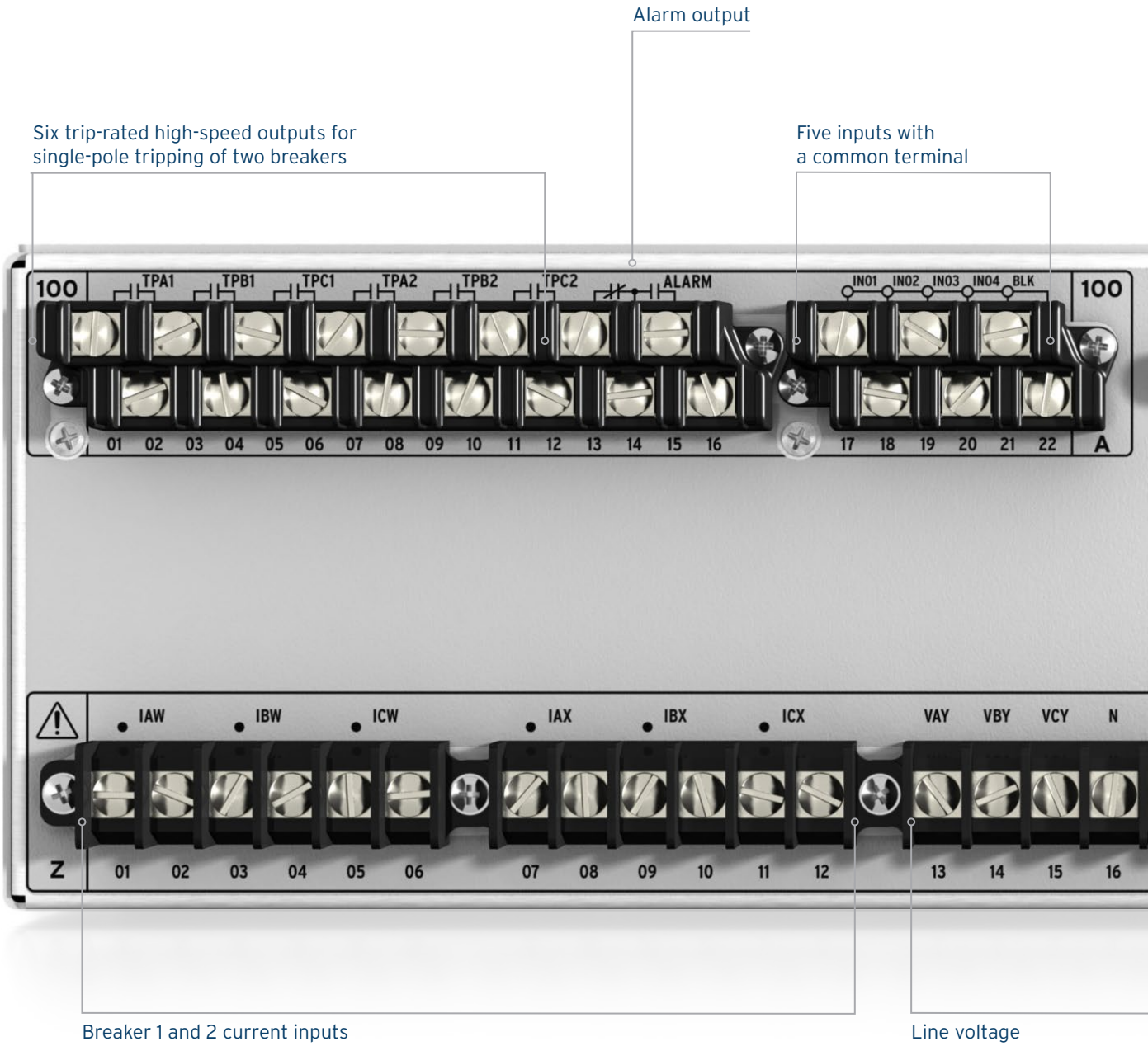
Visualize traveling-wave event reports using SEL-5601-2 SYNCHROWAVE® Event Software.

Product Overview

Large slide-in label pocket
for diagrams or asset labels



Slide-in label pocket and LED targets for viewing
trip cause, fault type, and basic relay status


Alarm output
Six trip-rated high-speed outputs for single-pole tripping of two breakers
Five inputs with a common terminal
100
TPA1
TPB1
TPC1
TPA2
TPB2
TPC2
ALARM
IN01
IN02
IN03
IN04
BLK
100
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
17 18 19 20 21 22
A
IAW
IBW
ICW
IAX
IBX
ICX
VAY
VBY
VCY
N
Z
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Breaker 1 and 2 current inputs
Line voltage

IRIG-B time input

Three fiber-optic ports for multiplexed or direct protection signaling (SEL MB8 or IEEE C37.94)

1 Gbps small form-factor pluggable (SFP) Ethernet port for engineering access and SCADA

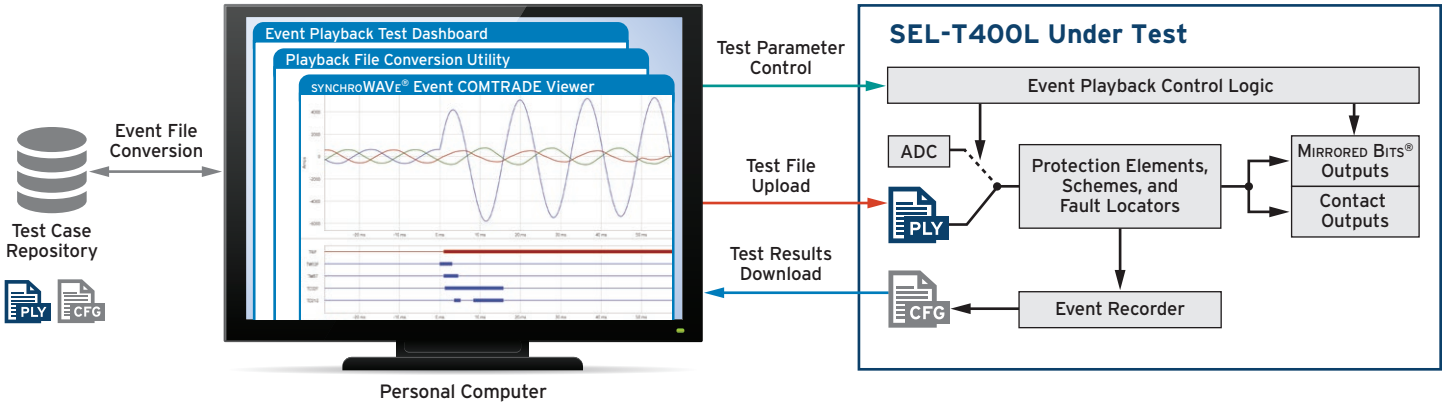
Power supply

SFP fiber-optic port for ultra-high-bandwidth protection signaling over direct fiber

Testing Made Easy

The built-in current and voltage playback feature of the SEL-T400L provides new opportunities for relay testing. To test the SEL-T400L, you can upload and play back current and voltage signals recorded by SEL-T400L or SEL-400 series relays or digital fault recorders in the field or generated using transient simulation software. This capability allows a protection engineer to easily validate relay settings and carry out trip analysis using only a "bench top" relay (no test set required). It allows a commissioning engineer to test relay settings without the need for secondary injection after verifying the relay hardware, especially the voltage and current inputs and the tripping outputs.

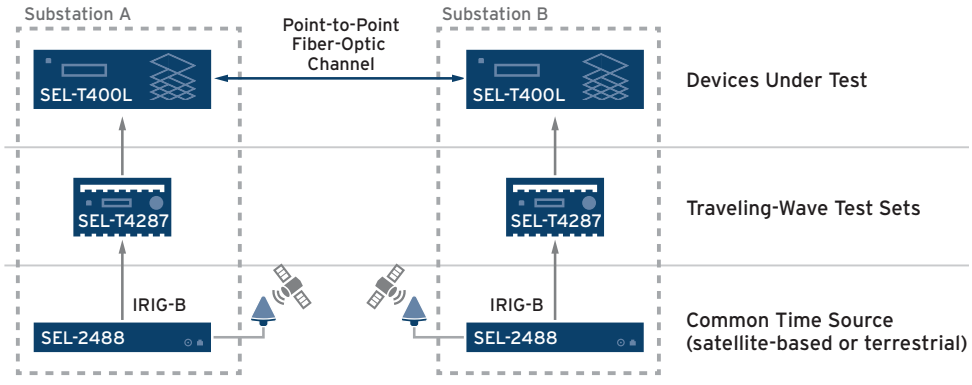
Use the SEL Playback File Conversion Utility in ACSELERATOR QuickSet SEL-5030 Software to convert any IEEE C37.111 COMTRADE file that is suitable for SEL-T400L testing into the SEL playback file format. You can use field records captured at 1 kHz sampling rate or above to test incremental quantity elements and impedance-based fault locators, and field records captured at 1 MHz and above for testing traveling-wave elements, schemes, and fault locators. Use the Event Playback Test Dashboard in QuickSet to upload and manage test files in the relay memory and to execute and control the event playback tests. You can schedule and execute event playback in multiple relays based on the absolute time for end-to-end testing of SEL-T400L protection schemes and double-ended fault locators.



Upload and play back test files using the built-in event playback capability.

Secondary injection testing of SEL-T400L I/O, metering, and incremental- quantity protection elements is straight-forward. 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 traveling-wave protection elements and the traveling-wave fault locator.



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

Remote Monitoring and Diagnostics

With voltages and currents sampled at an unprecedented rate and resolution (1 MHz, 18 bits), the SEL-T400L is a powerful data acquisition device for advanced remote monitoring and diagnostics applications. The relay streams the high-resolution local and remote FTDV in real time via a Gigabit Ethernet port. Using SEL-T400L data in real time, you can spot insulation problems, breaker transient voltage recovery or restrike events, switching events, and other high-frequency signatures. 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 to experiment with this advanced SEL-T400L functionality.

SEL-T400L Specifications

General

Six AC Current Inputs	Rated input current (5 A model): 5 A Rated input current (1 A model): 1 A Sampling rate: 1 MHz A/D resolution: 18 bits
Three AC Voltage Inputs	Rated voltage range: 57.7—144.3 V LN (V_{NOM} = 100—250 V LL) Connection: Four-wire connection with a shared neutral Sampling rate: 1 MHz A/D resolution: 18 bits
Control Outputs	Rated voltage: 125—250 Vdc Operational voltage range: 0—300 Vdc **Six Fast Hybrid (High-Speed, High-Current Interrupting) Form A Outputs** Operating time (pickup): ≤10 µs (resistive load) **Alarm Output (Form C)**
Control Inputs	Optoisolated (bipolar operation): 5 inputs with a shared common terminal Sampling rate: 10 kHz Rated voltage: 125 Vdc
Three Fiber Serial Ports	Data rates: 19,200 to 115,200 bps (SEL MIRRORED BITS encoding) or 64 kbps (IEEE C37.94 encoding) Connector type: ST Fiber type: Multimode Wavelength: 820 nm
Front-Panel Port	USB type: 2.0 Connector type: Type B
Fiber-Optic Ethernet Port	Data rate: 1 Gbps Fiber type and range: Multimode, 2 km for typical continuous fiber-optic cable Connector type: LC
Differential Protection Port	Data rate: 1 Gbps Fiber type and range: Multimode, 0.3/0.55 km; single-mode, 10 km to 200 km Connector type: LC (order SFP transceiver separately)
Time Input	IRIG-B input format: Demodulated IRIG-B
Power Supply	Rated voltage range: 125—250 Vdc, 110—240 Vac
Operating Temperature Range	−40° to +85°C (−40° to +185°F)
Weight and Dimensions	3U rack unit 6.01 kg (13.25 lb) 482.6 mm W × 132.6 mm H × 235.7 mm D (19.00 in W × 5.22 in H × 9.28 in D)

SEL SCHWEITZER ENGINEERING LABORATORIES

Making Electric Power Safer, More Reliable, and More Economical
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