SEL-421

## Protection, Automation, and Control System

Combine subcycle line protection with complete substation bay control

- Subcycle distance protection minimizes damage and expensive repairs on transmission lines.

- Comprehensive communications protocols and advanced automation functions allow customization for different applications.

- Two-breaker bay control provides protection flexibility in one device.

- SEL Time-Domain Link (TiDL®) and Sampled Values (SV) technologies transform the way you modernize your substation.

SEL

Functional Overview
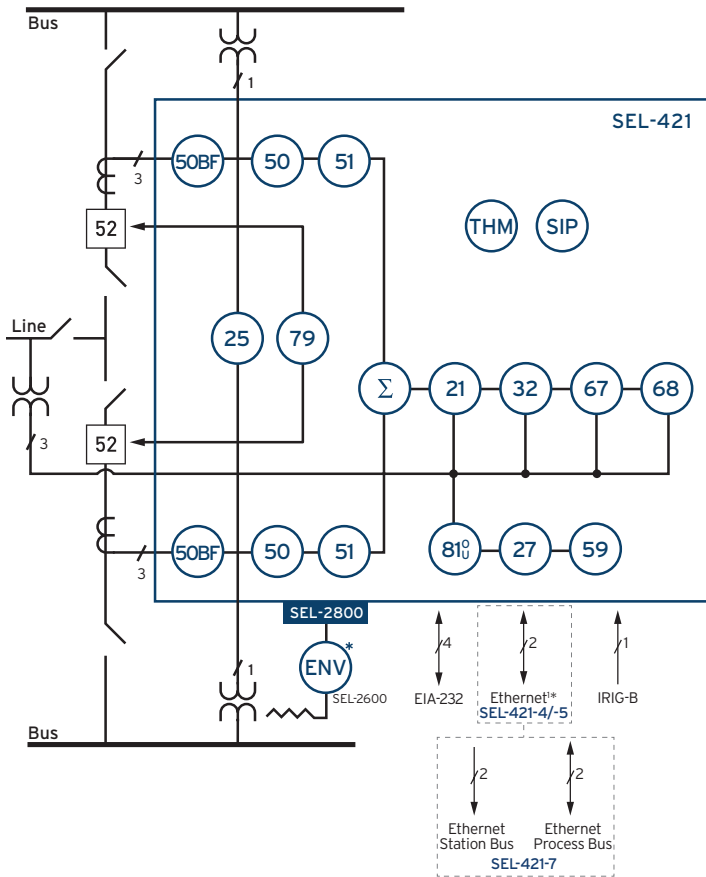
ANSI Numbers/Acronyms and Functions

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 Frequency
81 (O,U)	Over-/Underfrequency
85 RIO	SEL Mirrored Bits® Communications
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
SV	IEC 61850-9-2 Sampled Values Technology*
THM	IEC 60255-Compliant Thermal Model
TiDL	Time-Domain Link Technology*

[1] Copper or fiber-optic   *Optional feature

Key Features

Distance and Directional Overcurrent Protection

The SEL-421 Protection, Automation, and Control System protects critical transmission lines with high-speed quadrilateral, mho distance, and directional elements. Implement optional subcycle distance elements and series compensation logic to reduce operating times and improve system stability. You can invert individual or grouped CT or PT polarities to account for field wiring or protection zone changes.

Comprehensive Monitoring

Incorporate IEEE C37.118 synchrophasor measurements into wide-area protection and control systems. High-accuracy time correlation improves event report analysis.

Advanced Communications

Use serial or Ethernet communications to improve station integration. A variety of protocols are available, including MIRRORED BITS communications, DNP3 LAN/WAN, Modbus®, the Simple Network Time Protocol (SNTP), the Parallel Redundancy Protocol (PRP), the IEEE 1588 Precision Time Protocol Version 2 (PTPv2), and IEC 61850 Edition 2.

Digital Secondary System Technologies

Modernize your substation by applying SEL TiDL technology or SEL SV technology. Both of these digital secondary system solutions replace copper wires with fiber-optic cables to increase safety, reduce costs associated with using copper wires, and limit the impact of electromagnetic interference.

TiDL is a simple and secure digital secondary system solution that is easy to implement, with no external time source or network engineering required. Apply the TiDL-enabled SEL-421-4/-5 in the control house with the SEL-2240 Axion® TiDL node in the yard, which provides remote I/O, digitizes analog signals, and sends the signals over fiber-optic cables to the relay.

SEL SV is the only digital secondary system solution in the world that combines protection in the merging unit with the flexibility of IEC 61850-9-2 to increase power system reliability. Apply the SEL-421-7 with SEL SV technology to publish or receive IEC 61850-9-2 SV data.
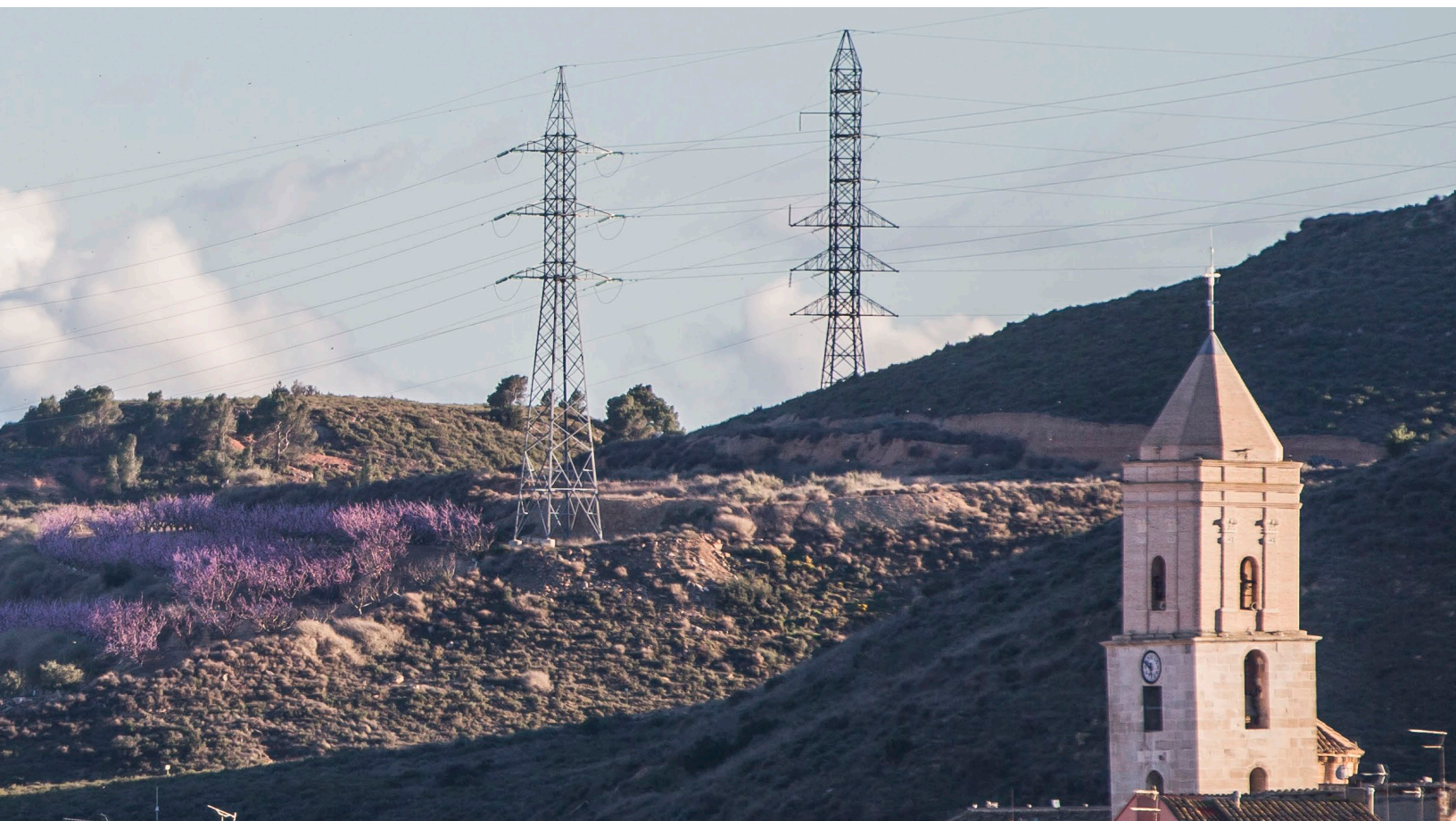
Product Overview

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

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

Front-panel LEDs indicate custom alarms and provide fast and simple information to assist dispatchers and line crews with rapid power restoration.

Programmable operator pushbuttons with user-configurable labels allow front-panel customization.
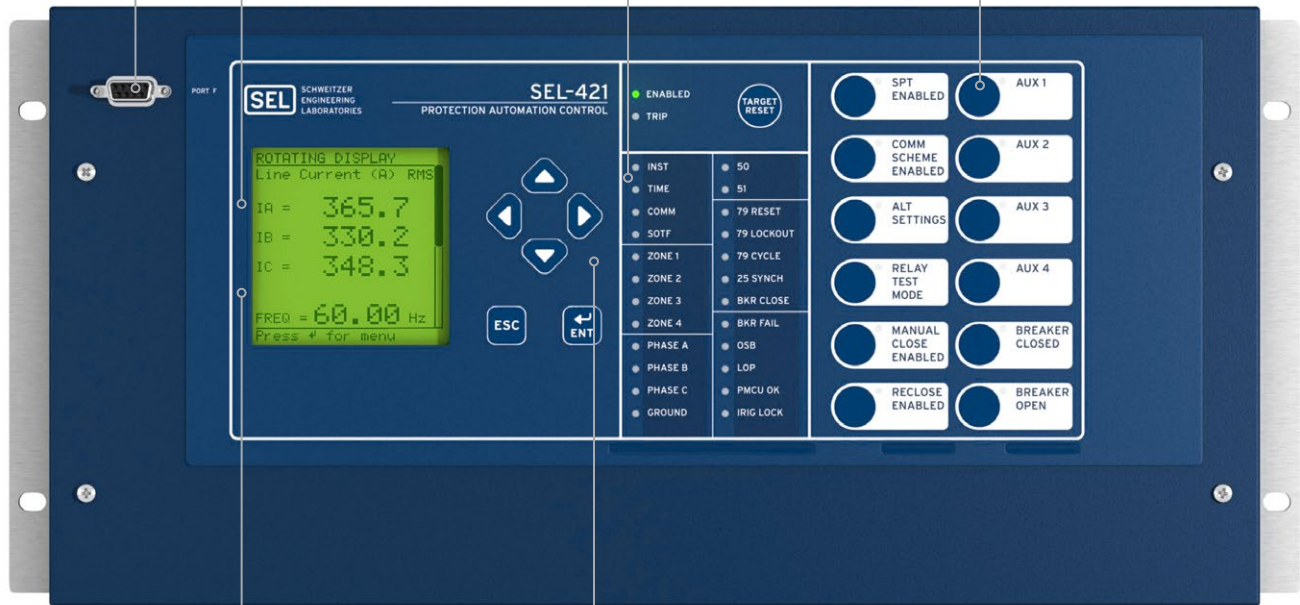
User-selectable mimic screens show the system configuration in one-line diagram format.

Easy-to-use keypad aids simple navigation.

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

High-current interrupting output contacts increase contact robustness and reliability.

Use one front and three rear EIA-232 ports for MIRRORED BITS communications, DNP3, SCADA, and engineering access.

Six current and six voltage analog inputs support complete bay control and protection as well as two-breaker bay applications.

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

Choose from power supply options such as 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.

Applications

Reliable Distance Protection

The SEL-421 has reliable distance protection with five zones of phase and ground (mho and quadrilateral) distance elements. Coupling capacitor voltage transformer (CCVT) transient overreach logic optimizes performance and enhances Zone 1 distance element security. The Best Choice Ground Directional Element® logic eliminates the need for multiple settings. In addition, with full pilot scheme settings, it is easy to integrate the SEL-421 into your existing distance protection schemes. Choose from POTT, DCUB, PUTT, DCB, and DTT schemes.
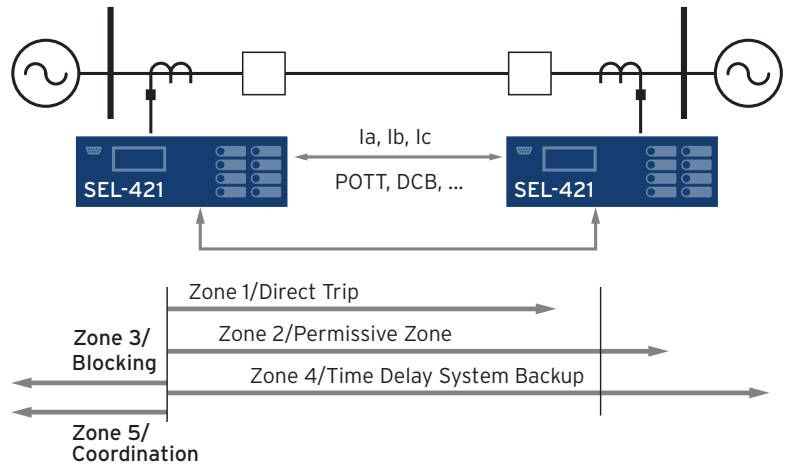
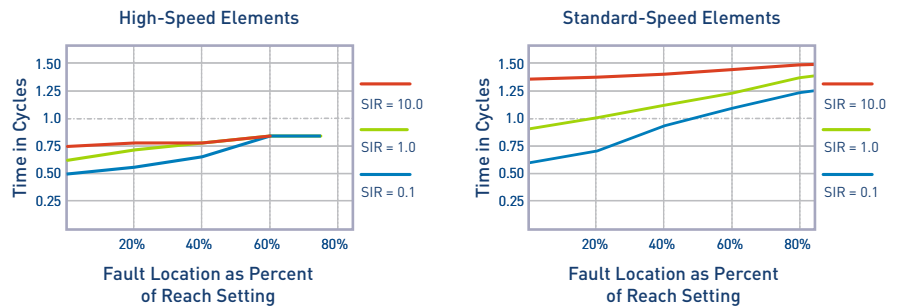## Thermal Overload Protection

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.
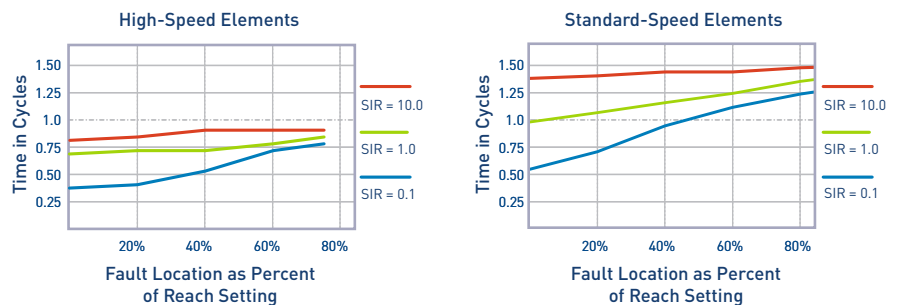
Secure, High-Speed Tripping

Optional high-speed elements use a combination of half-cycle filtered inputs with superimposed components to achieve high-speed operation while maintaining security for out-of-zone faults. Use an SEL-421 with standard-speed elements where operation times of under 1.5 cycles are sufficient, with the capability to upgrade to subcycle operation times if system conditions change.

Apply MIRRORED BITS communications between relays using fiber-optic transceivers for relay-to-relay signal transmission in 3 to 6 ms. CCVT transient detection, fast and secure loss-of-potential (LOP) blocking, and load-encroachment logic provide additional security in all SEL-421 models.

Ia, Ib, Ic

POTT, DCB, ...

Zone 1/Direct Trip

Zone 3/Blocking

Zone 2/Permissive Zone

Zone 4/Time Delay System Backup

Zone 5/Coordination

Single Phase-to-Ground Faults

High-Speed Elements

Standard-Speed Elements

Time in Cycles

Fault Location as Percent of Reach Setting

SIR = 10.0
SIR = 1.0
SIR = 0.1

Phase-to-Phase Faults

High-Speed Elements

Standard-Speed Elements

Time in Cycles

Fault Location as Percent of Reach Setting

SIR = 10.0
SIR = 1.0
SIR = 0.1

Three-Phase Faults

High-Speed Elements

Standard-Speed Elements

Time in Cycles

Fault Location as Percent of Reach Setting

SIR = 1.0, 10.0
SIR = 0.1

SIR = 10.0
SIR = 1.0
SIR = 0.1
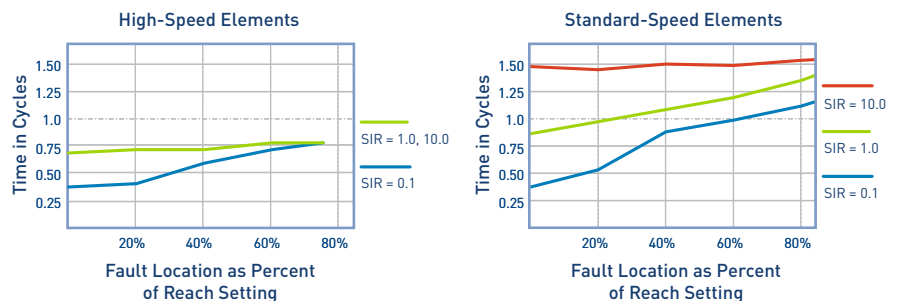
Dual CT Applications

The SEL-421 works with ring-bus, breaker-and-a-half, or other two-breaker schemes. You can combine currents within the relay from two sets of CTs for protection functions while keeping them separately available for monitoring and station integration applications.

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 power swing conditions. During unstable power swing conditions, the SEL-421 implements out-of-step tripping to maintain generation load balance.

Bay Control, Reclosing, and Breaker Failure Detection

The SEL-421 provides complete bay control, reclosing, and breaker failure protection, increasing your flexibility for different station configurations. For double-breaker arrangements, you can monitor the current for each breaker separately or combine the currents for protection purposes. You can also monitor the circuit breaker performance, including average and last tripping times, motor run times, and contact interrupting duty.
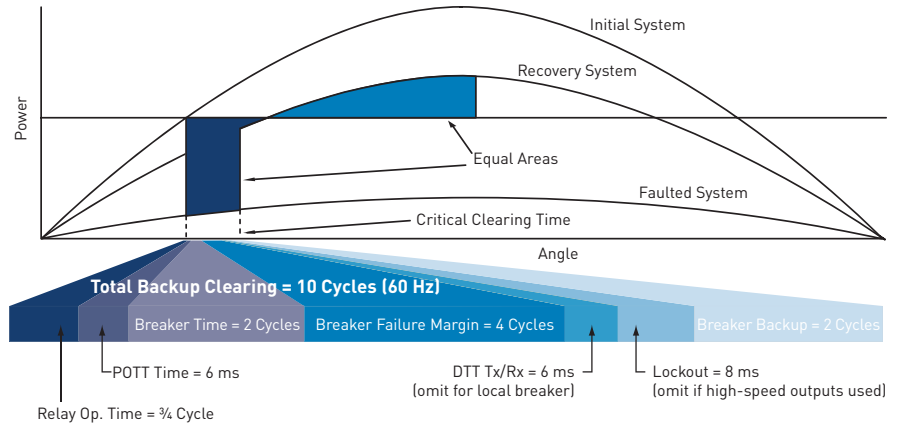
Underfrequency Load Shedding

Operate six levels of frequency elements as either an underfrequency or an overfrequency element. The frequency elements are suited for applications such as underfrequency load shedding and restoration control systems.
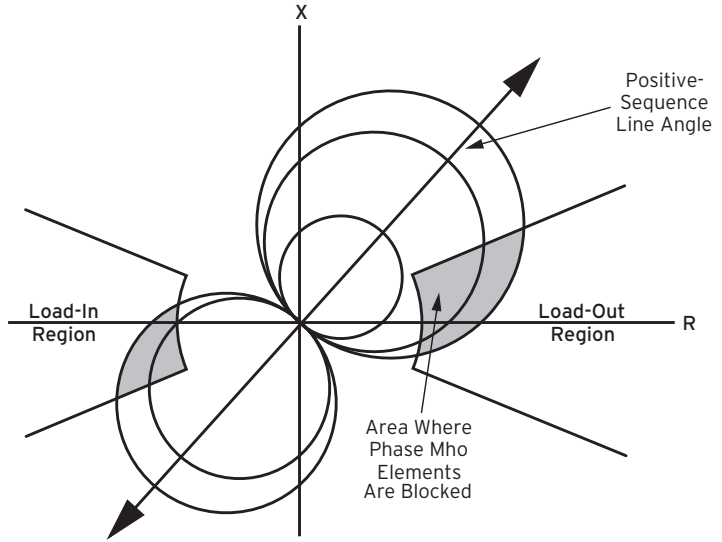
High-Speed Breaker Failure for Two Breakers

The SEL-421 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 SEL-421 helps increase line loading while maintaining stability.

Power / Angle chart:
- Initial System
- Recovery System
- Equal Areas
- Faulted System
- Critical Clearing Time

Total Backup Clearing = 10 Cycles (60 Hz)

| Breaker Time = 2 Cycles | Breaker Failure Margin = 4 Cycles | Breaker Backup = 2 Cycles |

- POTT Time = 6 ms
- Relay Op. Time = ¾ Cycle
- DTT Tx/Rx = 6 ms (omit for local breaker)
- Lockout = 8 ms (omit if high-speed outputs used)

Secure Protection Under High Loads

Prevent operation of the phase distance elements under high-load conditions with built-in load-encroachment logic. This feature permits the load to enter a predefined area of the phase distance characteristic without causing a trip.

- X
- R
- Positive-Sequence Line Angle
- Load-In Region
- Load-Out Region
- Area Where Phase Mho Elements Are Blocked

Load-encroachment characteristic.

Synchrophasors

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-421 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.

High-Accuracy Time Stamping

The SEL-421 time-tags binary COMTRADE event reports with real-time accuracy of better than 10 μs. View system state information at the time of faults or with timed triggers, across the entire system. Use system state information to validate system models as well as to improve transfer limits and system stability. SNTP is capable of 5 ms accuracy over Ethernet and makes a good backup to more accurate IRIG-B or PTP time synchronization.

Simplified System Setup and Analysis

With acSELerator QuickSet® SEL-5030 Software, you can develop relay settings offline, program SELogic control equations, and analyze post-fault event reports.

Enhanced Automation

The SEL-421 provides enhanced automation features, including 32 programmable elements for local control, remote control, protection latching, and automation latching.

synchroWAVe Central Software provides visualization and analysis of power system operating conditions.

Custom Applications With SELogic Control Equations

The SEL-421 enables math and logic combinations of analog and digital values. You can adapt system control based on prefault conditions, scale analog values, and latch momentary inputs for SCADA retrieval.

Digital Fault Recording

Combine relaying reliability with true digital fault recorder (DFR) functionality. The SEL-421 Relay's high-speed sampling (8 kHz) and COMTRADE output provide advanced oscillography. Use the QuickSet graphical user interface for harmonic analysis and easy report generation.
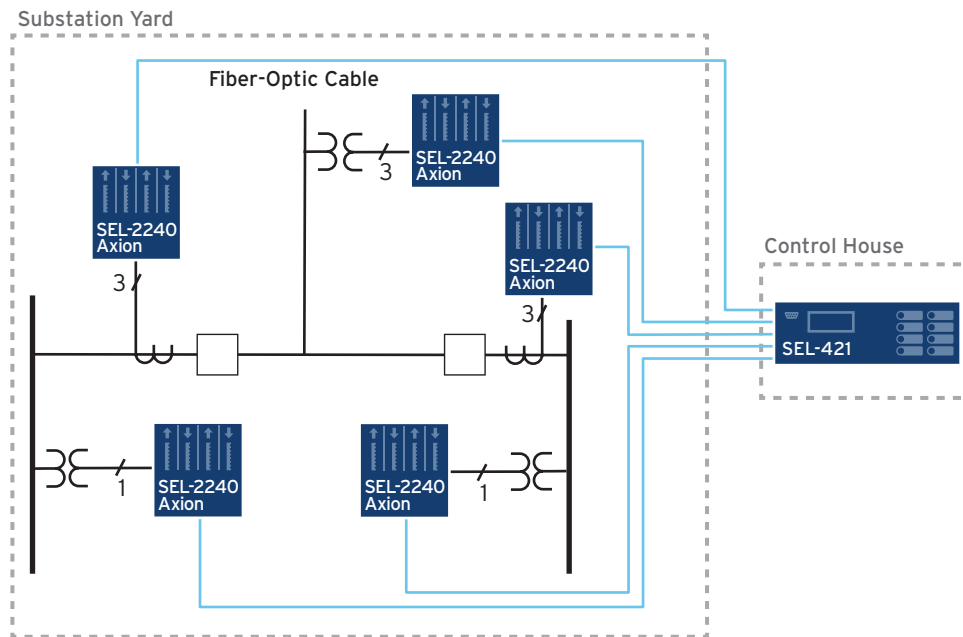
TiDL Technology

In a TiDL solution, Axion TiDL nodes are placed in the yard close to the primary equipment to digitize discrete I/O signals and analog data and then transport them over a fiber-optic cable to the TiDL-enabled SEL-421 in the control house.

This innovative technology uses point-to-point connections and a nonroutable protocol, providing a simple and secure solution. Because it does not require an external time source or Ethernet switches, it is easy to implement with no network engineering required.

TiDL combines the proven protection of the SEL-400 series relays with the modularity of the Axion, reducing training requirements and providing a scalable and flexible solution. It also provides built-in time synchronization and synchronous sampling, ensuring protection is available in the relay regardless of whether or not an external time signal is available.

SEL-421-4/-5 With TiDL Technology

LEDs indicate a valid configuration and successful commissioning.

LEDs indicate the connection status to a remote Axion TiDL node on a per-port basis.

4U chassis with mounting options (vertical or horizontal; panel or rack) accommodates your application needs.

Eight 100 Mbps fiber-optic ports allow the TiDL-enabled relay to connect with eight remote Axion TiDL nodes and to receive remote analog and digital data.

Commission button usage prompts the relay to communicate with the Axion TiDL nodes.

SEL SV Technology

In an SEL SV solution, the SEL-421-7 Merging Unit (publisher) digitizes analog signals from primary equipment and then transmits the signals to an SEL-421-7 Relay (subscriber) in the control house via a fiber-based Ethernet network. The system uses precise time synchronization via IRIG-B or PTP.

The SEL-421-7 Merging Unit is the only standalone merging unit in the world with complete line protection built in. This allows you to have the protection right next to the primary equipment for increased speed and reliability and to easily duplicate the SV data streams for redundant protection. The SEL-421-7 Relay offers the traditional protection available in the SEL-421-5 and can also receive SV data.

Because all SEL SV devices are fully compliant with IEC 61850-9-2 and the UCA 61850-9-2LE guideline, they can be used with primary equipment that generates similar SV streams or with other manufacturers' SV-compliant units.

SEL SV technology allows you to create a robust and flexible Ethernet-based point-to-multipoint network using tools such as software-defined networks or VLANs to fit your application needs. You can use the SEL-2740S Software-Defined Network Switch to provide centralized traffic engineering and improve Ethernet performance. The switch acts as a transparent PTP clock that supports the IEEE C37.238 power system profile, ensuring submicrosecond time synchronization of the end devices.
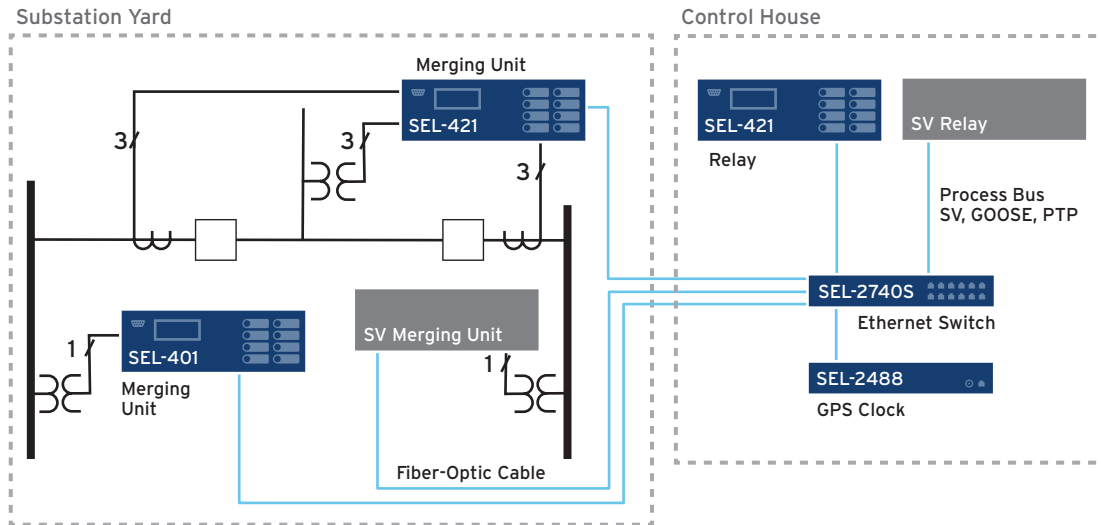
SEL-421-7 Merging Unit

Chassis options (for up to three I/O boards) and mounting options accommodate hardware needs.

Select fiber-optic, copper, or mixed Ethernet with separate ports for SV data and engineering access.
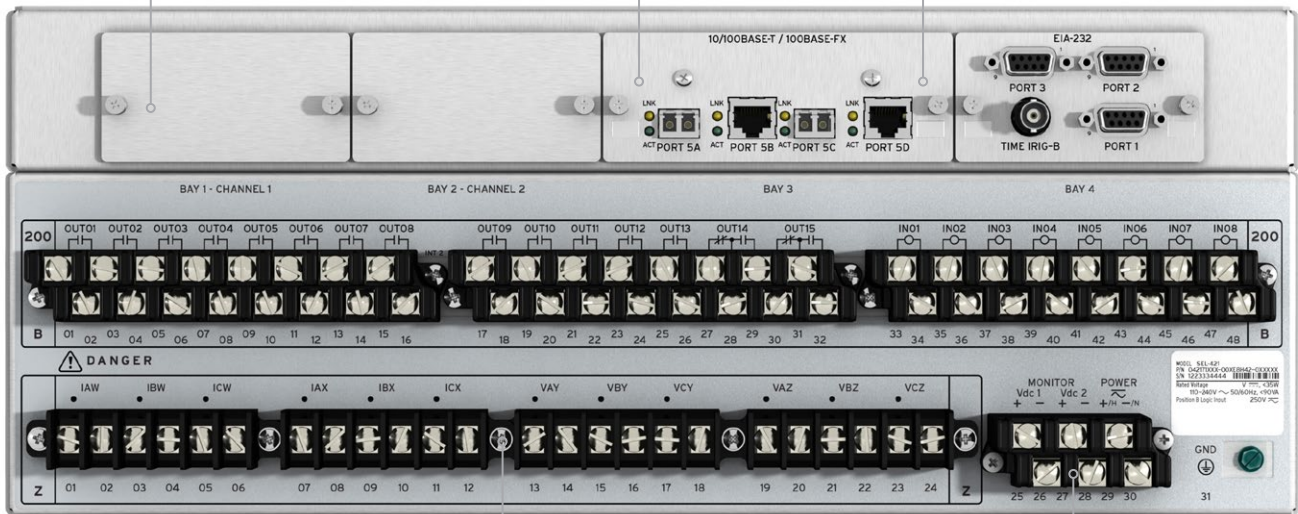
Six current and six voltage analog inputs support signal digitization and local protection schemes.

Choose from power supply options such as 48–125 Vdc or 110–120 Vac, or 125–250 Vdc or 110–240 Vac.

SEL-421-7 Relay

The 4U chassis has various mounting options to accommodate hardware needs.

Select fiber-optic, copper, or mixed Ethernet with separate ports for SV data and engineering access.
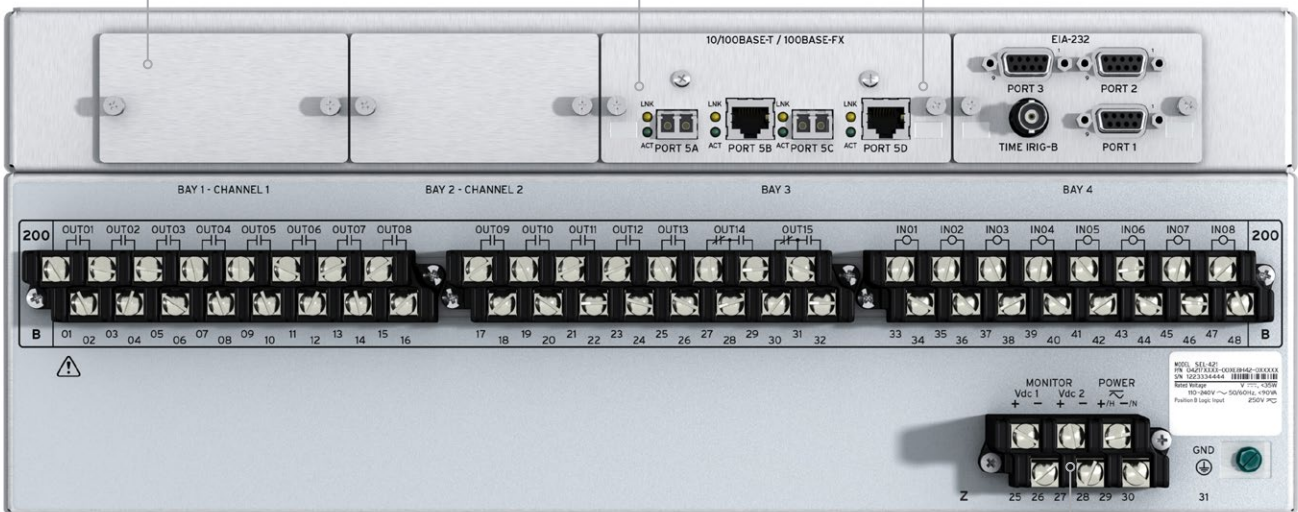
Choose from power supply options such as 48–125 Vdc or 110–120 Vac, or 125–250 Vdc or 110–240 Vac.

Accessibility and Communications

Built-In Web Server

Access basic SEL-421 information on a standard Ethernet network with the built-in web server. From there you can view relay status, Sequential Events Recorder (SER) data, metering information, and settings. For increased security, web server access requires a relay password and the information is limited to a read-only view.
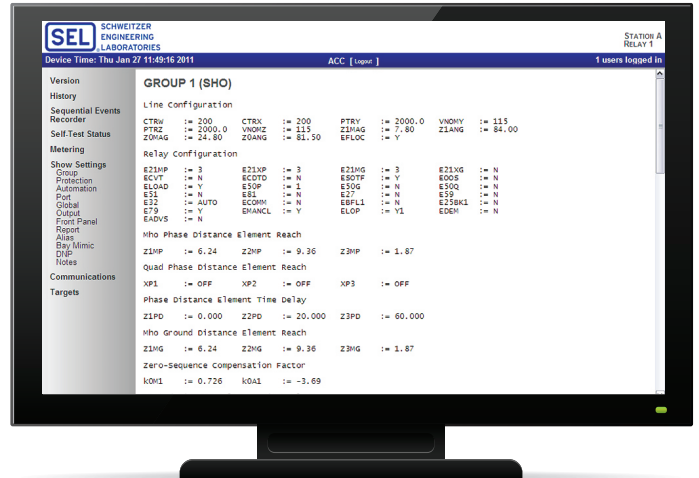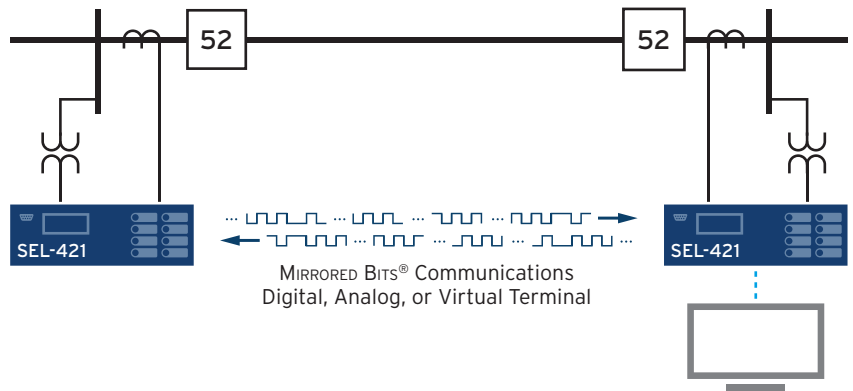

Ethernet-Based Communications

The Ethernet ports on the SEL-421 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 ordered as an option in the SEL-421-4/-5.
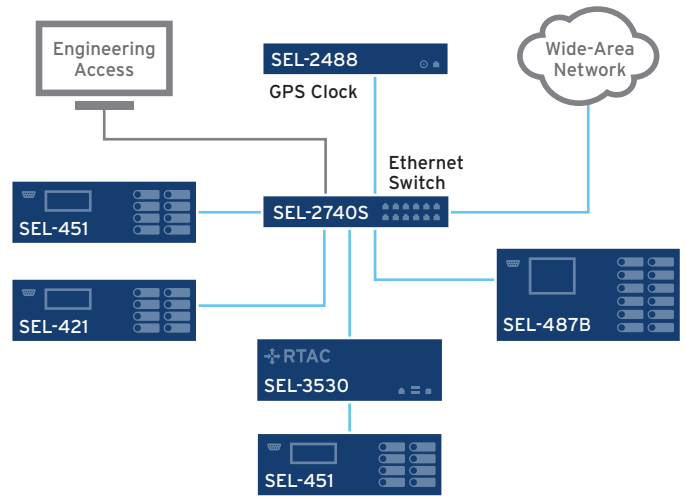
Mirrored Bits Communications

Mirrored Bits communications is a field-proven technology that 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.

Mirrored Bits® Communications
Digital, Analog, or Virtual Terminal

SEL-421 Specifications

General	
AC Current Inputs (6 total)	5 A nominal
	1 A nominal
AC Voltage Inputs (6 total)	300 V_{L-N} continuous, 600 Vac for 10 seconds
Serial	1 front-panel and 3 rear-panel EIA-232 serial ports
	300—57,600 bps
Ethernet	Communications protocols include FTP, Telnet, synchrophasors, DNP3 LAN/WAN, PRP, PTPv2, and IEC 61850 Edition 2 (optional).
	Choose from the following port options:
	Two 10/100BASE-T twisted-pair network ports
	Two 100BASE-FX fiber-optic network ports
	One 10/100BASE-T twisted-pair network port and one 100BASE-FX fiber-optic network port
TiDL Ports	Fiber-optic ports: 8
	Range: ~2 km
	Data rate: 100 Mbps
SV Ports	Choose from the following communications 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
	Subscriber: As many as 4 SV data streams
	Publisher: As many as 7 SV data streams
	Data rate: 80 samples per cycle
Precise-Time Input	Demodulated IRIG-B time input and PTPv2
Synchrophasors	IEEE C37.118 Standard
	Up to 60 messages per second
Processing	AC voltage and current inputs: 8,000 samples per second
	Protection and control processing: 8 times per power system cycle
Power Supply	SEL-421-4/-5
	24—48 Vdc
	48—125 Vdc or 110—120 Vac
	125—250 Vdc or 110—240 Vac
	SEL-421-7
	48—125 Vdc or 110—120 Vac
	125—250 Vdc or 110—240 Vac
Operating Temperature	−40°C to +85°C (−40 to +185°F)
	Note: LCD contrast is impaired for temperatures below −20°C (−4°F) and above +70°C (+158°F).