

SEL-421

Protection, Automation, and Control System

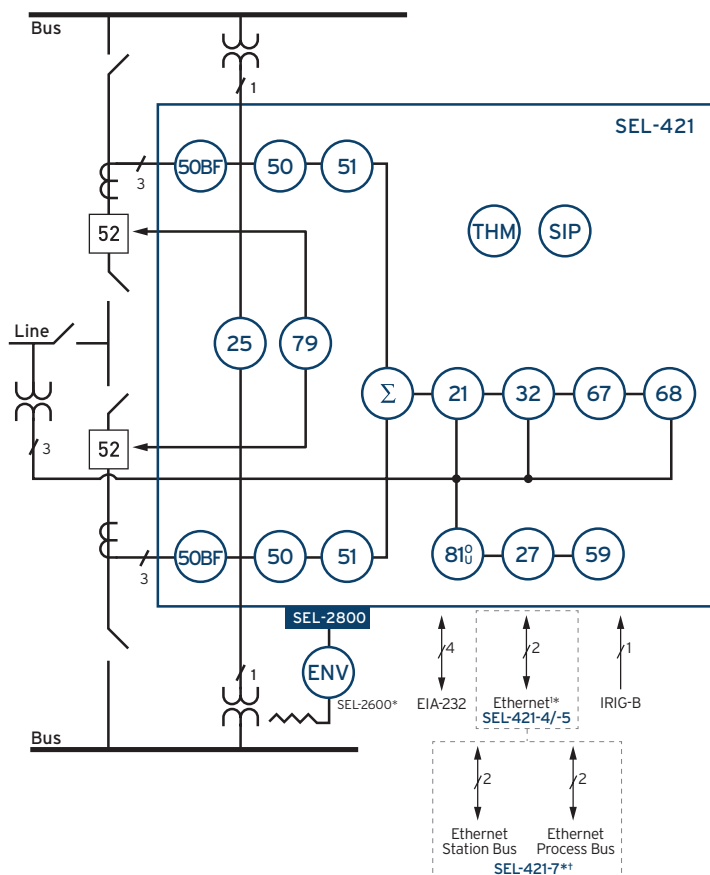


Combine subcycle line protection with complete substation bay control

- 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.



Functional Overview



ANSI Numbers/Acronyms and Functions

21	Phase and Ground Distance
25	Synchronism Check
27	Undervoltage
32	Directional Power
50	Overcurrent
50BF	Dual Breaker Failure Overcurrent
51	Time-Overcurrent
59	Overvoltage
67	Directional Overcurrent
68	Out-of-Step Block/Trip
79	Single-/Three-Pole Reclosing
81 (O,U)	Over-/Underfrequency
85 RIO	SEL MIRRORED BITS® Communications
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 or IEC 61869-9 Sampled Values*†
THM	IEC 60255-Compliant Thermal Model
TiDL	Time-Domain Link Technology*†

†Copper or fiber-optic *Optional feature

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

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

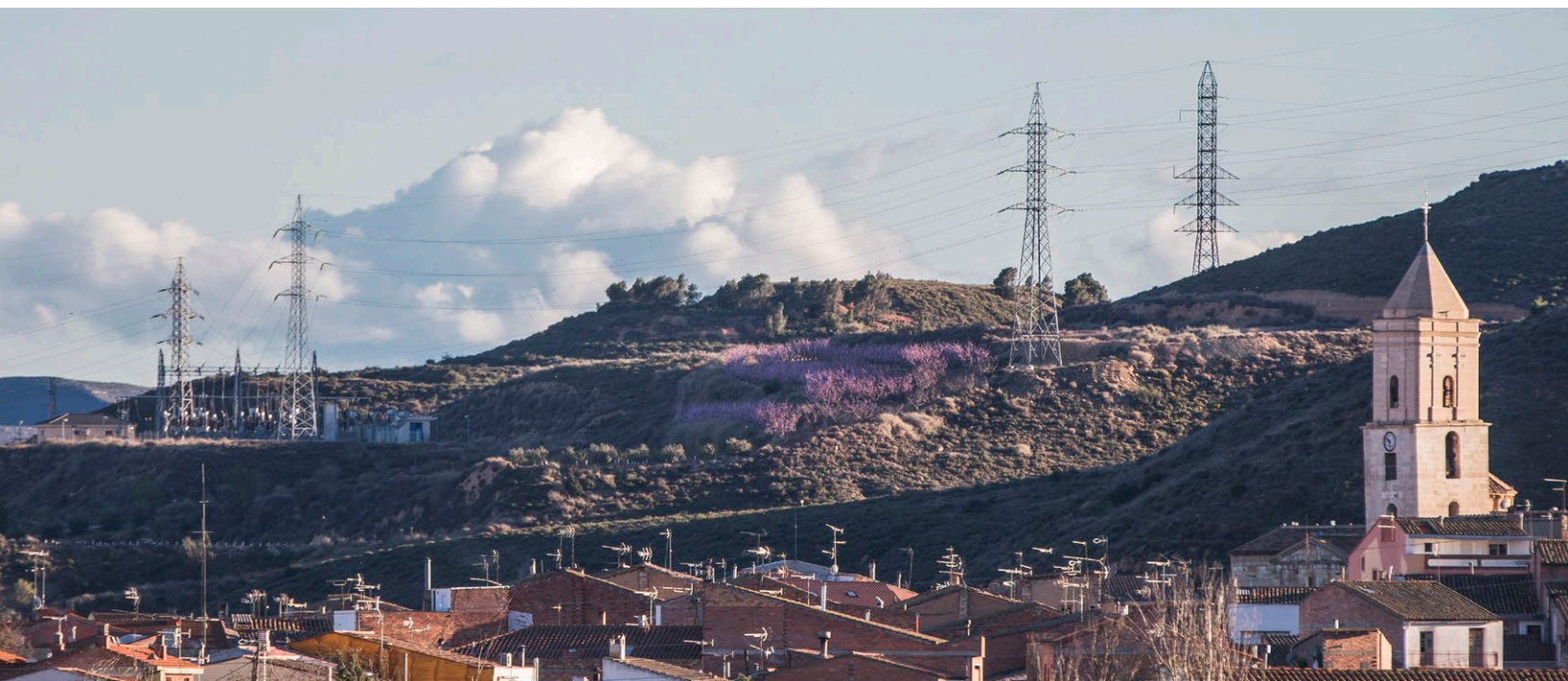
Use serial or Ethernet communications to improve station integration. A variety of protocols are available, including MIRRORING BITS communications, DNP3 LAN/WAN, the Simple Network Time Protocol (SNTP), the Parallel Redundancy Protocol (PRP), the IEEE 1588 Precision Time Protocol Version 2 (PTPv2), and IEC 61850 Edition 2.1.

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 point-to-point solution that is easy to implement, with no external time source or network engineering required. SEL-TMU TiDL Merging Units placed in the yard digitize signals and transmit them over fiber-optic cables to the SEL-421-7 TiDL relay in the control house.

SEL SV combines protection in the merging unit with the flexibility of IEC 61850-9-2 or IEC 61869-9. The SEL-421-7 SV merging unit digitizes signals and transmits them via Ethernet over fiber-optic cables to SEL SV relays or other manufacturers' compliant relays in the control house.



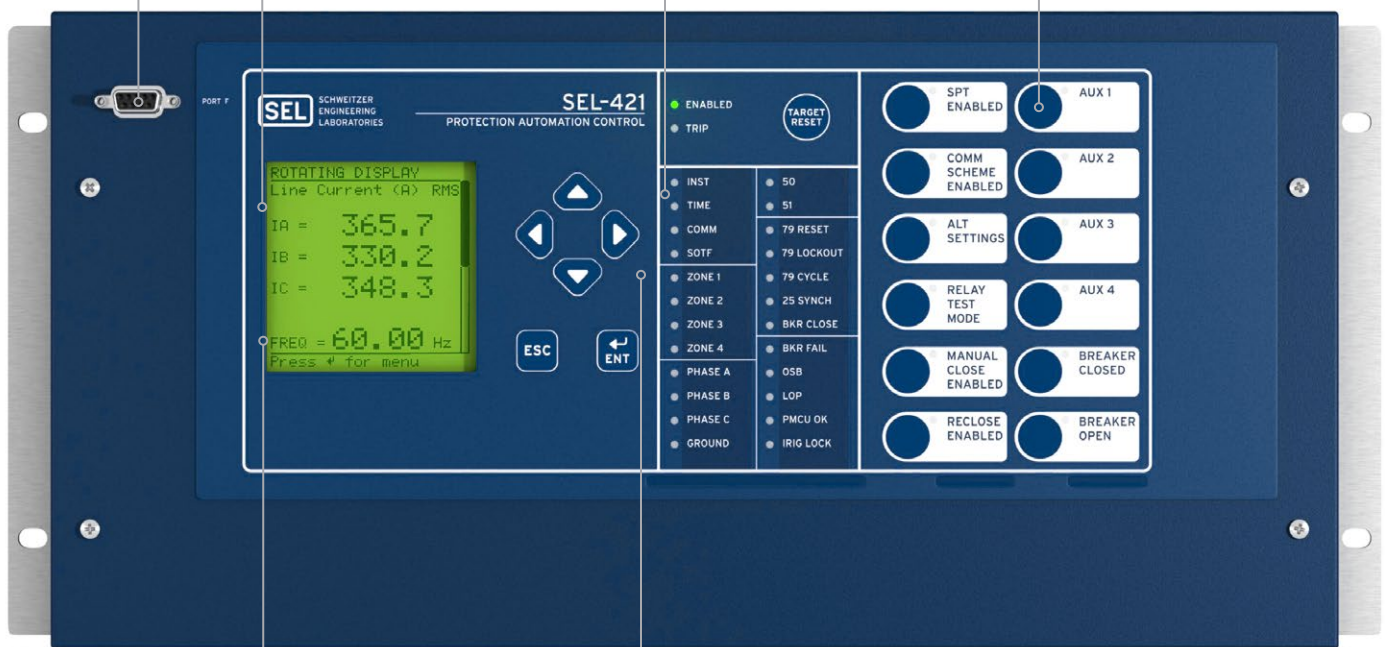
Product Overview—SEL-421-4/-5 Relay

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.



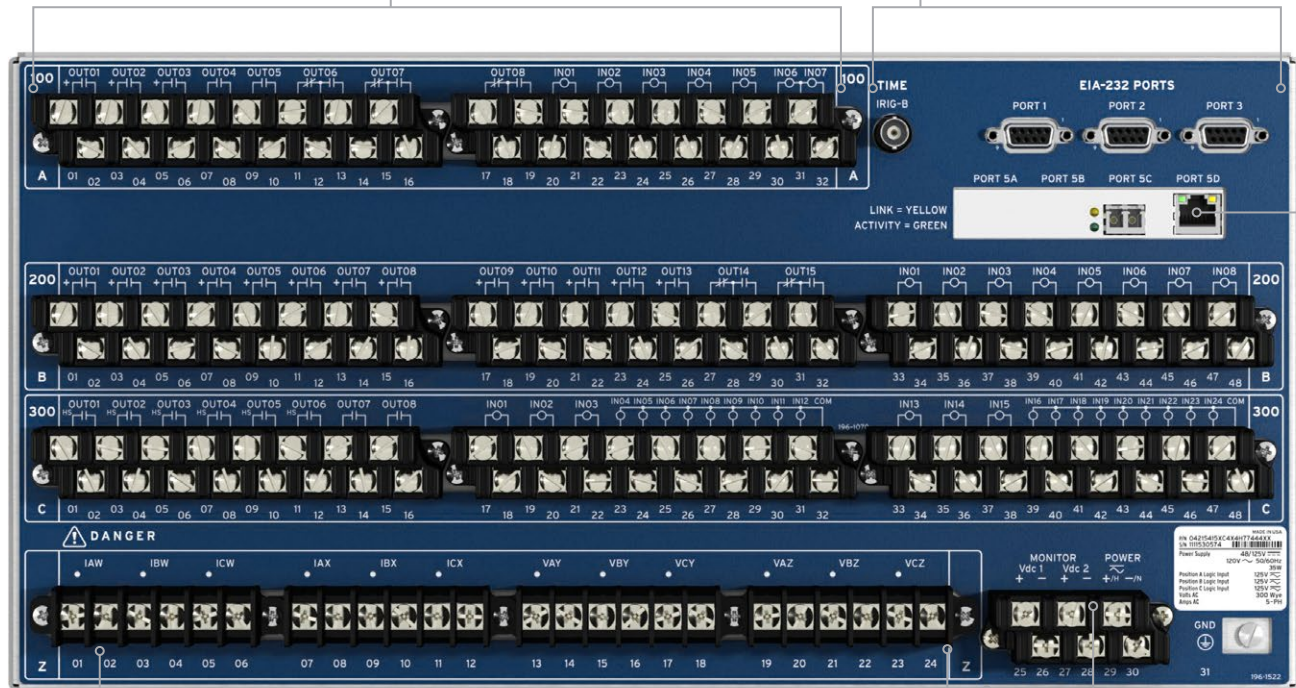
User-selectable mimic screens show the system configuration in one-line diagram format.

Easy-to-use keypad aids simple navigation.

Communications protocols include FTP, Telnet, synchrophasors, DNP3 LAN/WAN, PRP, IEEE 1588 PTPv2,** and IEC 61850 Edition 2.1.*

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

Use one front and three rear EIA-232 ports for MIRRORING 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.

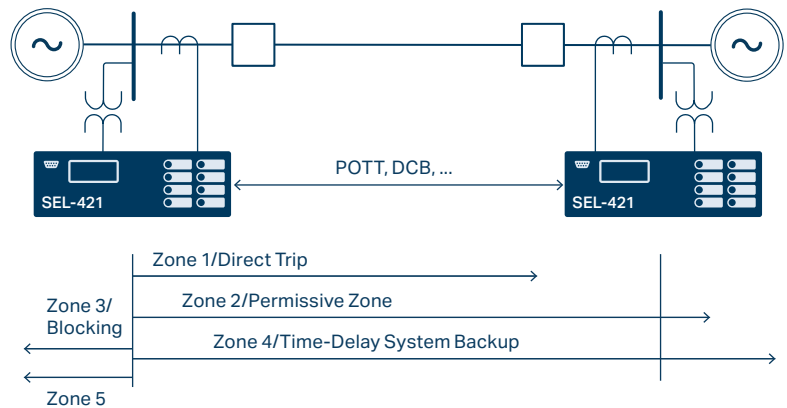
*Optional feature

**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.



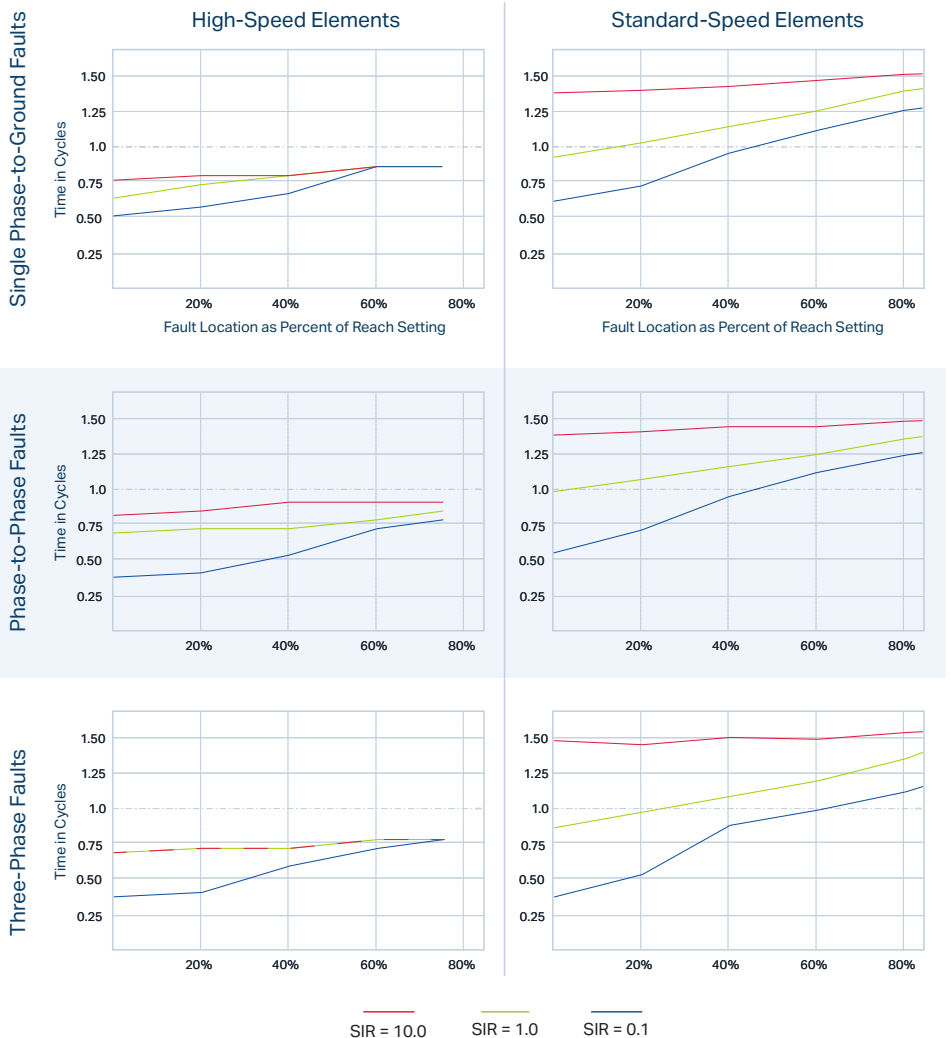
Thermal Overload Protection

Use the three independent IEC 60255-149 thermal elements to activate a control action, issue an alarm, or trip when the conductor temperature is high 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.



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

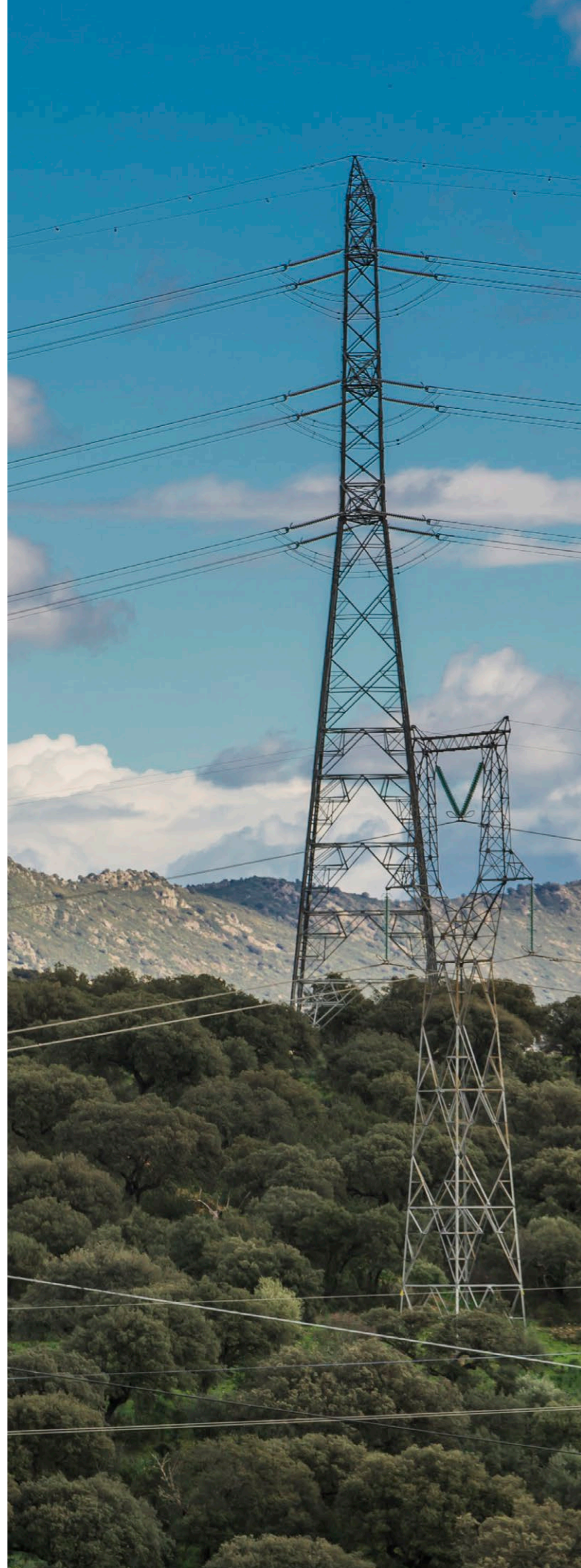
During power swings, the relay automatically selects either out-of-step blocking or tripping. Out-of-step blocking enhances your security by blocking distance elements during stable power swing conditions. During unstable power swing conditions, the SEL-421 implements out-of-step tripping to maintain generation load balance. The SEL-421 provides both conventional out-of-step logic using dual blinders and zero-settings out-of-step logic that simplifies the implementation.

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.

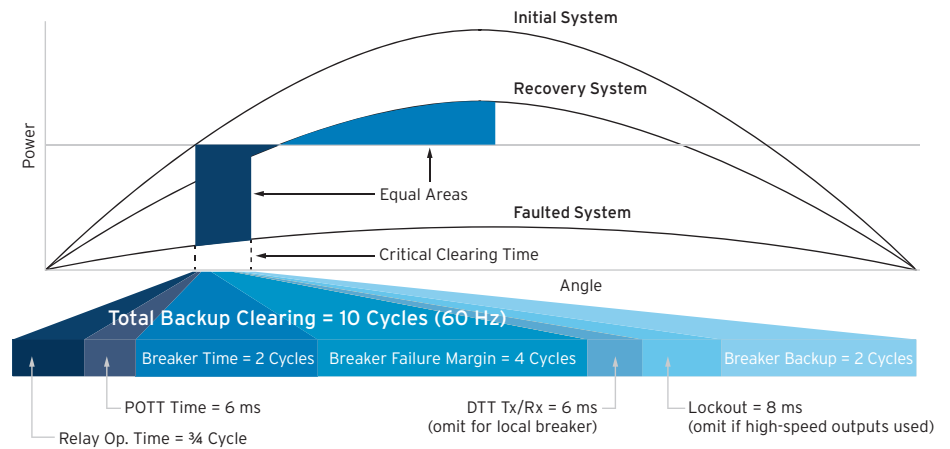
Underfrequency Load Shedding

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.



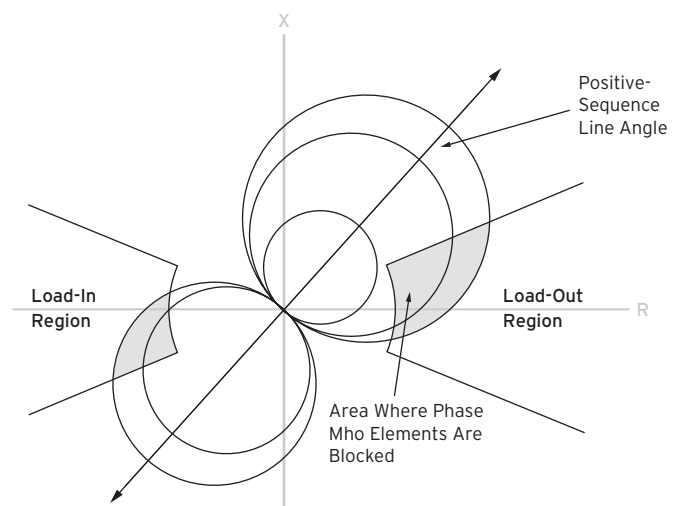
High-Speed Breaker Failure for Two Breakers

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.



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.



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 μ s. 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.



SEL TiDL Process Bus Solutions

SEL Time-Domain Link (TiDL) technology is a protection-centered digital secondary system solution engineered with simplicity in mind. This technology minimizes cybersecurity risks and network engineering by using point-to-point communications and a nonroutable protocol. A TiDL-based solution does not require an external time reference.

Simple Architecture

SEL-TMU devices are placed in the yard close to the primary equipment and digitize discrete I/O signals and analog data, such as voltages and currents. These data are then transported over fiber-optic cables to an SEL-421-7 TiDL relay in the control house. The point-to-point architecture simplifies implementation and drives overall maintenance and maintenance costs down.

Data-Sharing Capabilities

Each SEL-TMU can be paired with up to four SEL-400 series TiDL relays. This data-sharing capability allows design flexibility, and point-to-point connections simplify system expansion.

Built-In Data Synchronization

TiDL relays measure the path delay between the relay and the merging unit on each connected port to align current and voltage measurements acquired from different merging units. This eliminates the need for external time sources, such as GPS clocks, for synchronization. All data from the SEL-TMU devices are synchronized with each other regardless of the number of units connected to the SEL-421-7 relay or the length of the fiber.

Strong Cybersecurity Posture

The dedicated, deterministic TiDL system helps secure mission-critical systems. The isolated point-to-point connections and the absence of switches and routers reduce the electronic security perimeter and limit attack points. This security-minded architecture prevents remote access, and its simplicity eliminates the need for managing port access.

Minimal Training Required

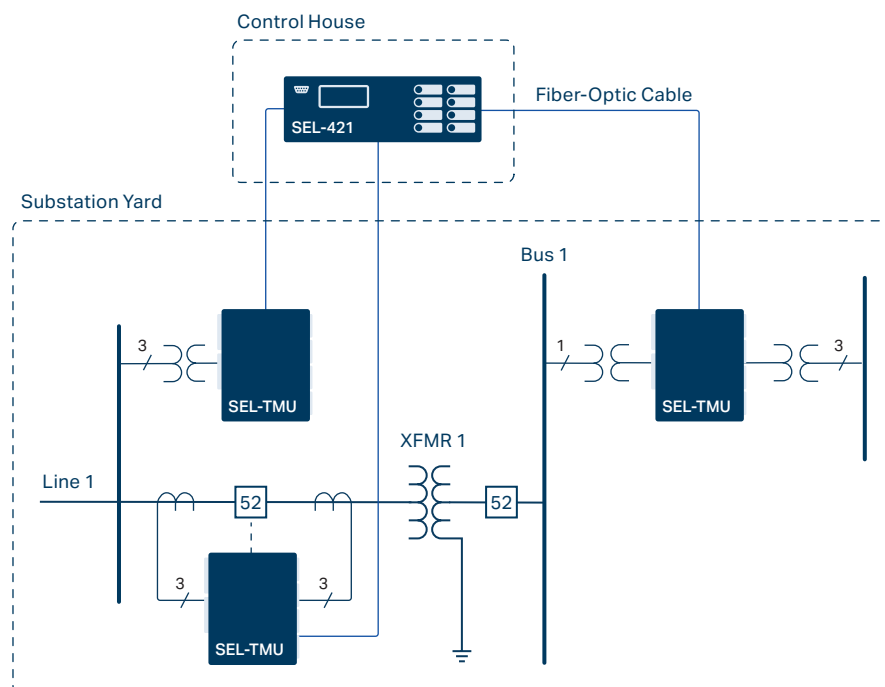
The relay settings for the SEL-421-7 TiDL relay are the same as those in all popular SEL-400 series models, providing consistency and simplicity. You can use the same protection schemes and applications for complete feeder protection.

Flexible Communications Options

The SEL-421 can be configured with a five-port Ethernet card supporting PRP or failover functionality to increase system availability. Use PTPv2 on process bus or station bus ports to provide time synchronization.

This card also features dedicated ports and IP addresses for station bus and engineering access networks to provide selective access control.

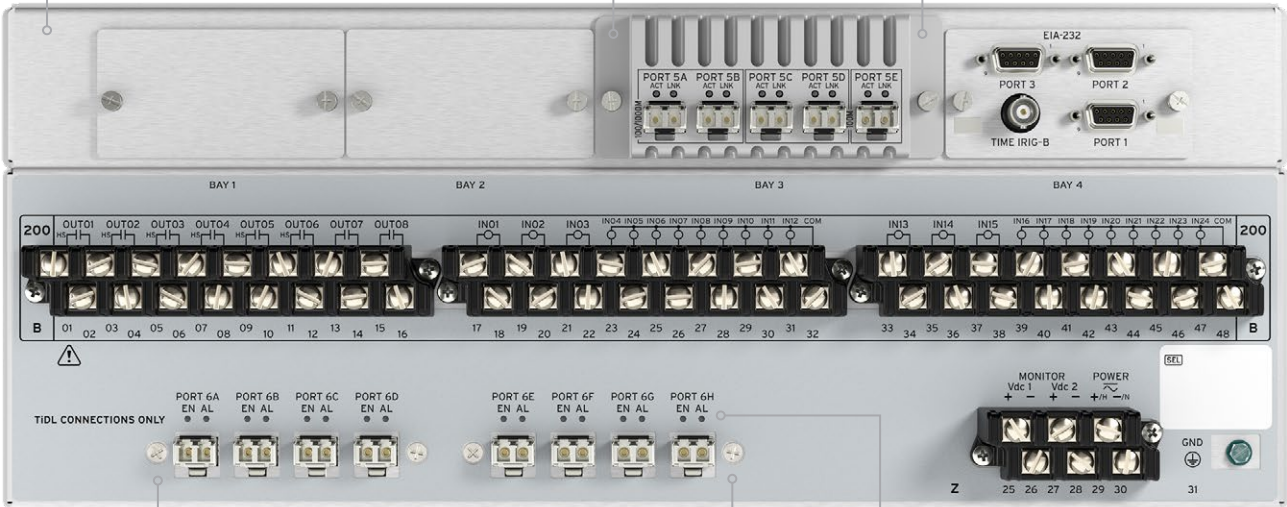
Use small form-factor pluggable (SFP) transceivers on process bus, station bus, and engineering access ports. Single- and multimode communications options provide increased flexibility.



SEL-421-7 With TiDL Technology

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

Select a five-port Ethernet card for dedicated station bus and engineering access ports.



Eight SFP ports allow the TiDL relay to connect with eight remote SEL-TMU devices and to receive remote analog and digital data.

LEDs for viewing the connection status to an SEL-TMU on a per-port basis.

SEL SV-Based Process Bus Solutions

SEL Sampled Values (SV)-based solutions are communications-centric, network-based solutions that combine protection in the merging unit with the flexibility of IEC 61850-9-2 or IEC 61869-9 protocols.

Networked Architecture

The SEL-421-7 SV relay (subscriber) in the control house receives digitized analog signals from SV merging units (publishers) in the yard via a fiber-based Ethernet network. SEL SV-based solutions allow you to create a flexible Ethernet-based network using tools such as software-defined networks or VLANs. You can use SEL software-defined networking (SDN) switches to provide centralized traffic engineering and improve Ethernet performance. SEL SDN switches act as transparent PTP clocks that support the IEEE C37.238 power system profile, ensuring submicrosecond time synchronization of the end devices.

Merging Units With Built-In Protection

Apply the SEL-421-7 SV publisher to provide full SEL-421 protection locally while sending digitized voltage and current signals to other SV relays. All SEL SV merging units offer local protection for a variety of applications, depending on the model. If network communications are lost, the SEL merging units continue to provide standalone protection.

Interoperability

SEL-421-7 SV relays and merging units as well as other SEL SV devices are fully compliant with IEC 61850-9-2 and the UCA 61850-9-2LE guideline as well as IEC 61869-9. You can use them with primary equipment that generates SV streams or with other manufacturers' SV-compliant units.

Advanced Network Monitoring and Diagnostic Tools

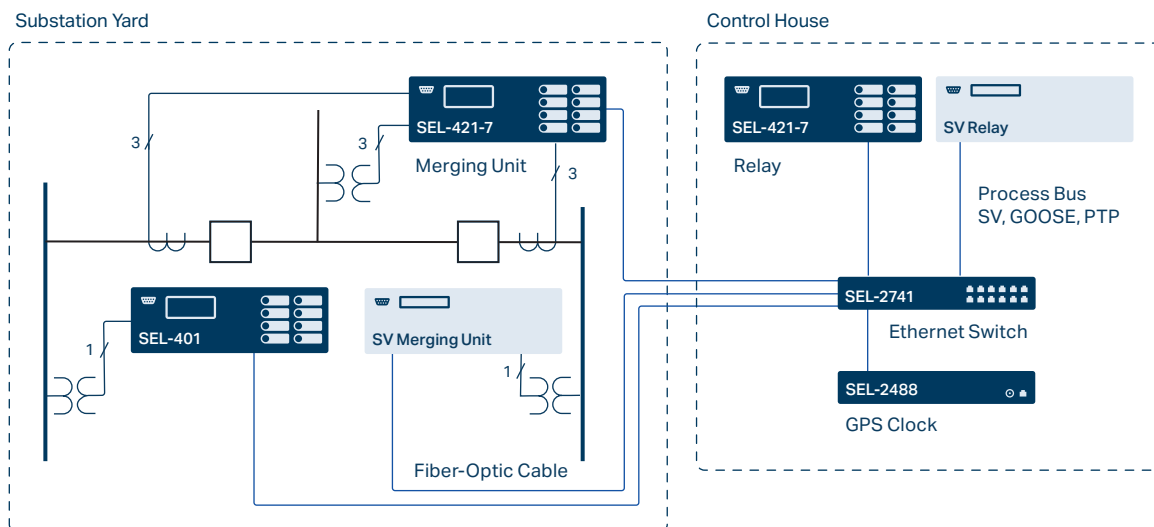
The SEL-421-7 SV relay provides advanced network monitoring and diagnostic tools through standard IEC 61850 logical nodes. Additional diagnostic information and statistics are available through COM SV, GOO, ETH, and COM PRP commands, which aid in troubleshooting. The TEST SV command allows you to check the network connectivity as well as the CT and PT ratios between publisher and subscriber devices.

Flexible Communications Options

The SEL-421 can be configured with a five-port Ethernet card supporting PRP or failover functionality to increase system availability. Use PTPv2 on process bus or station bus ports to provide time synchronization.

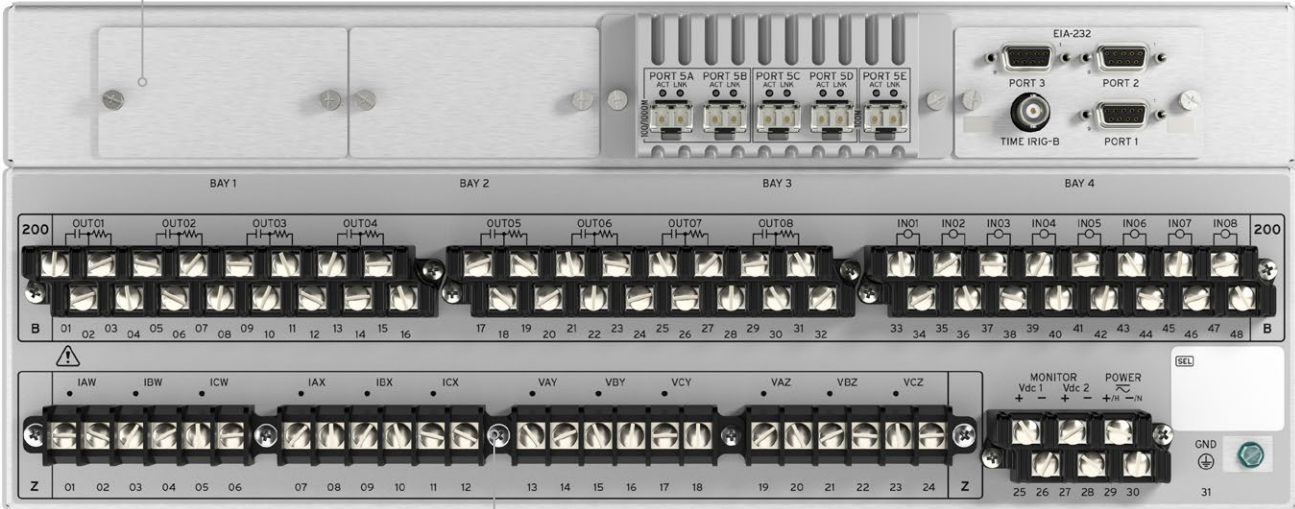
This card also features dedicated ports and IP addresses for station bus and engineering access networks to provide selective access control.

Use SFP transceivers on process bus, station bus, and engineering access ports. Single- and multimode communications options provide increased flexibility. All ports support 100 Mbps SFPs, and process bus ports also support 1 Gbps SFPs.



SEL-421-7 SV Merging Unit

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



Six current and six voltage analog inputs support signal digitization and local protection schemes.

SEL-421-7 SV Relay

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

Select a five-port Ethernet card for dedicated process bus, station bus, and engineering access ports.

Select fiber-optic, copper, or mixed Ethernet with separate ports for SV data and engineering access.



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.

SEL

SCHWEITZER
ENGINEERING
LABORATORIES

STATION A
RELAY 1

1 users logged in

Device Time: Thu Jan 27 11:49:16

ACC [Log]

Version

History

Sequential Events Recorder

Self-Test Status

Metering

Show Settings

Group Protection

Automation

Global

Report

Foot Print

Alarms

Bay Mimic

DNP

Notes

Communications

Targets

GROUP 1 (SHO)

Line Configuration

Relay Configuration

Mho Phase Distance Element Reach

Quad Phase Distance Element Reach

Phase Distance Element Time Delay

Mho Ground Distance Element Reach

Zero-Sequence Compensation Factor

Ground Distance Element Reach

CTRW := 200
PTR2 := 2000.0
Z0MAG := 24.80

CTRX := 200
VNOHZ := 115
Z0ANG := 81.50

PTRY := 2000.0
Z1MAG := 7.80
EFLOC := Y

VNOHY := 115
Z1ANG := 84.00

E2IMP := 3
ECVT := N
ELOAD := Y
E31 := N
E32 := AUTO
E79 := Y
EADVS := N

E2IMP := 3
ECOTD := N
E3OP := 1
E31 := N
ECORH := N
EBANCL := Y

E21MG := 3
ESOTF := N
E3OG := N
E32 := N
EBFL1 := N
EBOP := Y1
EDEH := N

E21MG := N
E3OGS := N
E3OG := N
E32 := N
EB2SK1 := N
E32 := N

Z1MP := 6.24
Z3MP := 1.87

Z2MP := 9.36

XP1 := OFF
XP3 := OFF

XP2 := OFF

Z1PD := 0.000
Z3PD := 60.000

Z2PD := 20.000

Z1MG := 6.24
Z3MG := 1.87

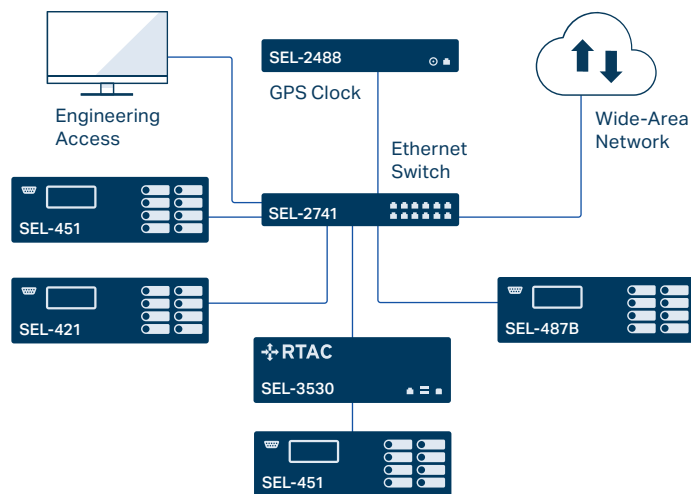
Z2MG := 9.36

k0M1 := 0.726
k0A1 := -3.69

Copyright © 2010 Schweitzer Engineering Laboratories, Inc. Patent, Design and Rights Reserved.

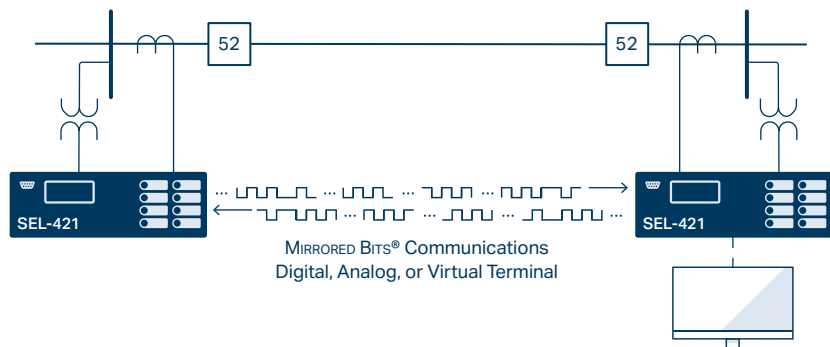
Ethernet-Based Communications

An Ethernet communications card enables you to communicate using a variety of protocols, including FTP, HTTP, DNP3, PTPv2, PRP, Telnet, Synchrophasors, and IEC 61850 Edition 2.1. Select between copper, fiber, or a combination of port types.



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.

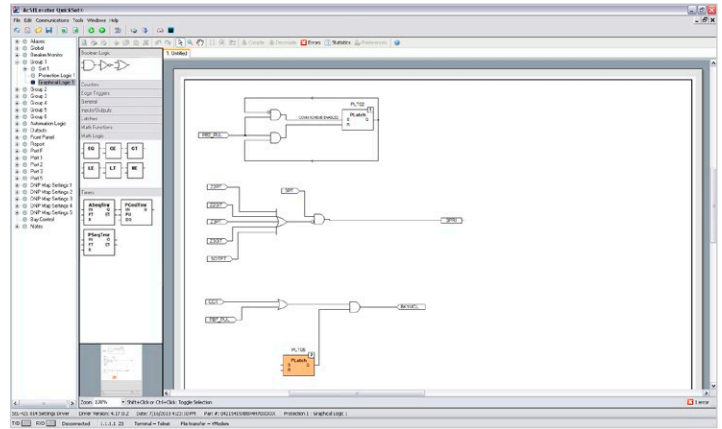


Setting and Commissioning Software

Simplify the SEL-421 Configuration Process With the Graphical Logic Editor (GLE)

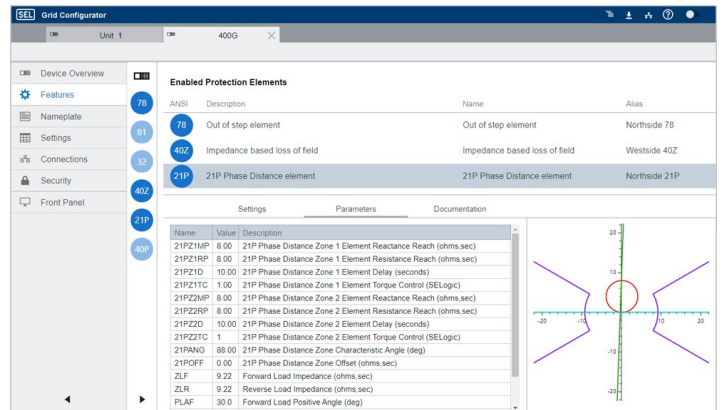
With the GLE, you can view SELoGic control equations graphically and document settings files for easier validation and commissioning. You can also convert existing SELoGic control equations to easy-to-read diagrams and save diagrams with your QuickSet software settings.

The GLE capability in QuickSet makes it easy to design new SELoGic control equations with the convenient diagram navigation tool, drag-and-drop interface, function block diagrams, and automatic layout function. You can manage your control diagrams with a full element palette. The GLE aids in reducing design errors and reducing the time and expense of commissioning relays.



Next-Generation Configuration Software

Included with the TiDL and SV relays, SEL Grid Configurator allows engineers and technicians to quickly create, manage, and deploy settings for SEL power system devices. It features a modern interface designed for ease of use, with powerful protection visualization and comprehensive reporting to reduce device deployment complexity.



SEL-421 Specifications

General			
AC Current Inputs (6 total)	5 A nominal	TiDL Ports	Fiber-optic ports: 8
	1 A nominal		Range: ~2 km
AC Voltage Inputs (6 total)	0–300 V _{L-N} operational	SV Ports	Data rate: 100 Mbps
			Protocol: SEL T-Protocol
Communications Protocols	FTP, Telnet, SEL ASCII, SEL Fast Message, synchrophasors, DNP3, PRP, PTPv2, and IEC 61850 Edition 2.1 (optional)	Precise-Time Input	Subscriber: As many as 7 SV data streams
Communications Ports	Serial Ports		Publisher: As many as 7 SV data streams
	One front-panel and three rear-panel EIA-232 serial ports	Processing	Data rate: 4.8 kHz
	300–57,600 bps		Protocol: IEC 61850-9-2 or IEC 61869-9
	Two-Port Ethernet Card	Power Supply	Demodulated IRIG-B time input and PTPv2
	Two 100BASE-FX fiber-optic network ports		AC voltage and current inputs: 8,000 samples per second
	Four-Port Ethernet Card	Operating Temperature	Protection and control processing: 8 times per power system cycle
	Four 10/100BASE-T twisted-pair network ports, or		24–48 Vdc
	Four 100BASE-FX fiber-optic network ports, or		48–125 Vdc or 110–120 Vac
	Two 10/100BASE-T twisted-pair network ports and two 100BASE-FX fiber-optic network ports		125–250 Vdc or 110–240 Vac
	Five-Port Ethernet Card		
	Two 100/1000BASE SFP ports		
	Three 100BASE SFP ports		

