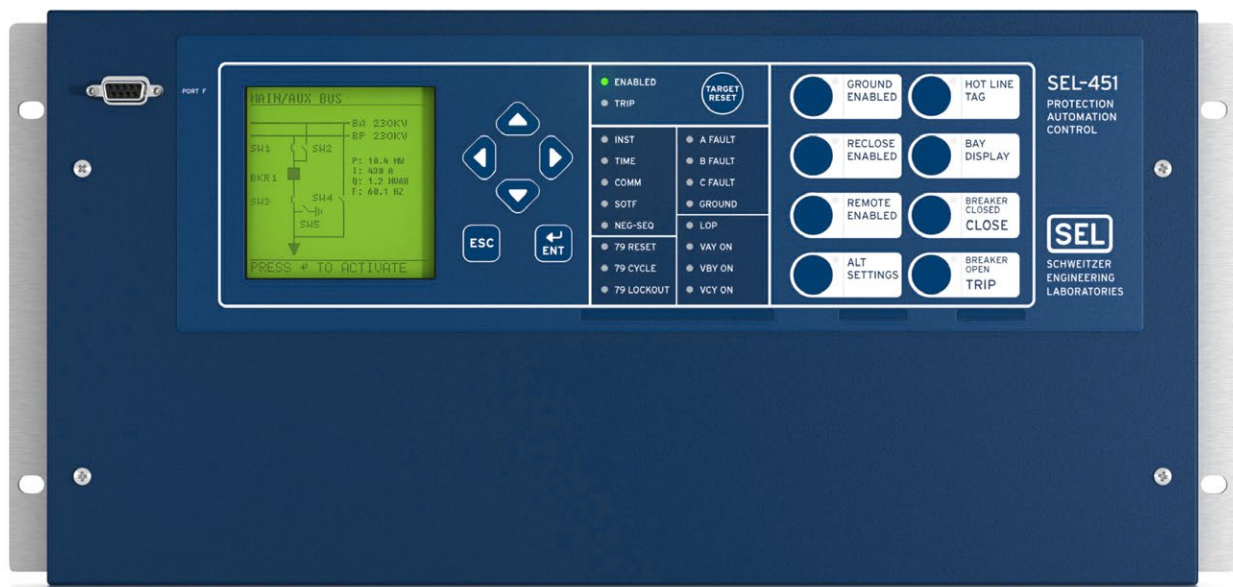


SEL-451

Protection, Automation, and Bay Control System

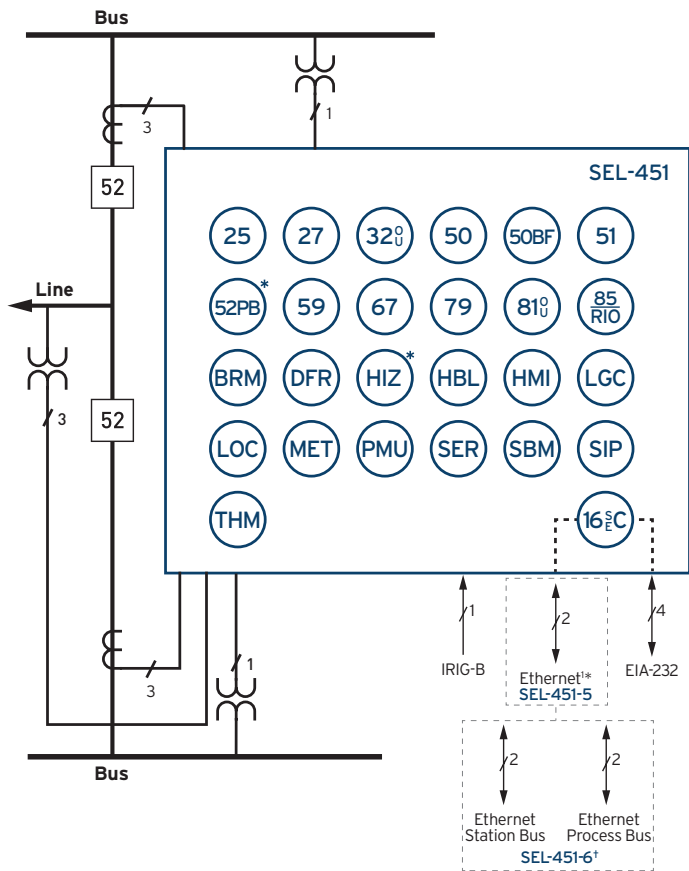


Advanced feeder protection and complete substation bay control in one economical system

- Customize distribution protection using multiple instantaneous, time-overcurrent, and directional elements.
- Detect high-impedance faults with Arc Sense™ technology (AST).
- Implement bay control with complete two-breaker control and high-speed breaker failure detection.
- Transform the way you modernize your substation with SEL Time-Domain Link (TiDL®) and Sampled Values (SV) technologies.



Functional Overview



ANSI Numbers/Acronyms and Functions

25	Synchronism Check
27	Undervoltage
32 (O,U)	Over- and Underpower
50	RMS Overcurrent
50BF	Dual Breaker Failure Overcurrent
51	Time-Overcurrent
52PB	Trip/Close Pushbuttons*
59	Overvoltage
67	Directional Overcurrent
79	Autoreclosing
81 (O,U)	Over-/Underfrequency

Additional Functions

16 SEC	Access Security (Serial, Ethernet)
50G	Best Choice Ground
85 RIO	SEL MIRRORED BITS® Communications
BRM	Breaker Wear Monitor
DFR	Event Reports
HBL	Harmonic Blocking
HIZ	High-Impedance Fault Detection AST*
HMI	Operator Interface
LDE	Load Encroachment
LGC	Expanded SELogic® Control Equations
LOC	Fault Locator
MET	High-Accuracy Metering
PMU	Synchrophasors
SBM	Station Battery Monitor
SER	Sequential Events Recorder
SIP	Software-Invertible Polarities
SV	IEC 61850-9-2 Sampled Values Technology*†
THM	IEC 60255-Compliant Thermal Model
TiDL	Time-Domain Link Technology*

¹Copper or fiber-optic *Optional feature

[†]SV subscriber relays have no analog input boards and instead receive voltages and current through Ethernet.



Key Features

Comprehensive Feeder Protection

Customize distribution protection in the SEL-451 Protection, Automation, and Bay Control System with multiple instantaneous, time-overcurrent, and directional elements combined with SELogic control equations. AST detects high-impedance faults, while low-energy analog (LEA) voltage inputs help protect pad-mounted switchgear.

Powerful Bay Control and High-Speed Breaker Protection

Comprehensive two-breaker control and breaker failure protection complement the versatility of the SEL-451 programmable logic to meet your bay control needs. Easily control motor-operated switches, capacitor banks, and field I/O from the front panel or remotely.

Built-In Real-Time Synchrophasor Measurements

Help system operators understand the network status with real-time visual displays of system phase angles and frequency. High-accuracy synchronized phasor measurements provide information and control to match the frequency and phase angle for critical activities, such as switching, startup, and power transfer.

Monitoring That Maximizes the Capability of Substation Equipment

Fully load equipment by monitoring power, including thermal or rolling interval demand as well as peak demand on positive-, negative-, and zero-sequence current.

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-451-5 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 combines protection in the merging unit with the flexibility of IEC 61850-9-2 to increase power system reliability. Apply the SEL-451-6 with SEL SV technology to receive IEC 61850-9-2 SV data over fiber-optic cables from SEL merging units or other SV-compliant units.

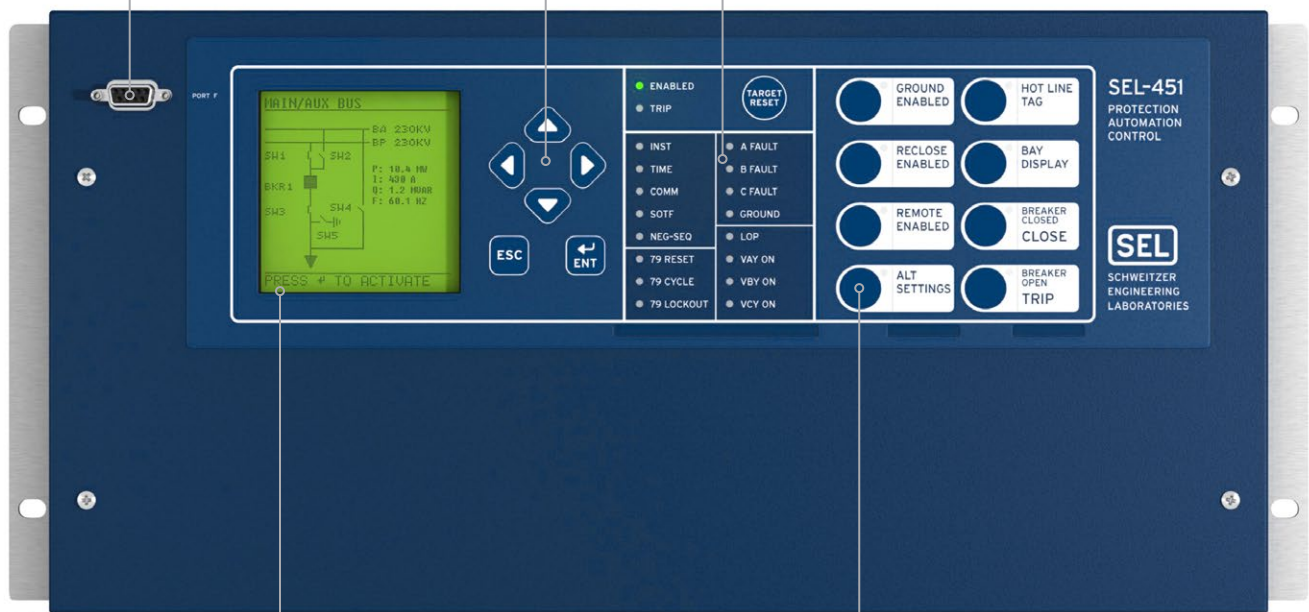


Product Overview—SEL-451-5 Relay

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

Easy-to-use keypad aids simple navigation.

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



Interactive bay display with user-configurable apparatus labels allows the operator to view the status of breakers and disconnect switches and to control them.

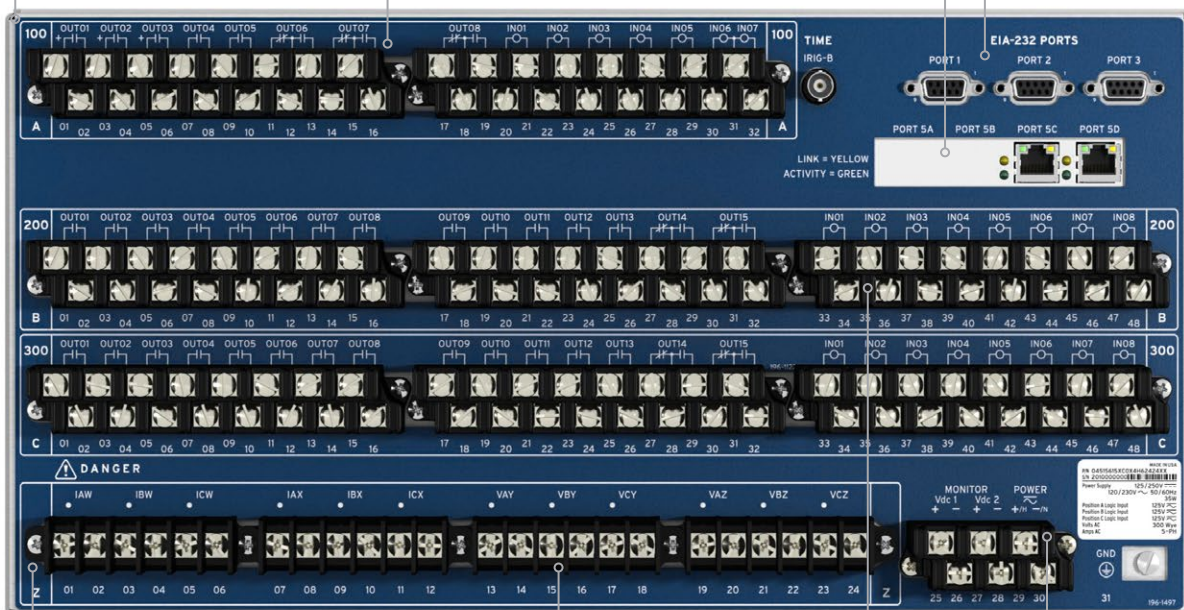
Programmable operator pushbuttons with user-configurable labels allow front-panel customization.

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

Use a maximum of 68 output contacts.¹

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.

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



Order six current inputs in standard terminal blocks (as shown) or a Connectorized[®] hardware configuration.

Use a maximum of 103 input contacts.¹

Choose six voltage inputs in either standard terminal blocks, a Connectorized hardware configuration, or an LEA hardware configuration.

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.

¹Requires 8U chassis

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

Applications

Protection

Complete Overcurrent Protection

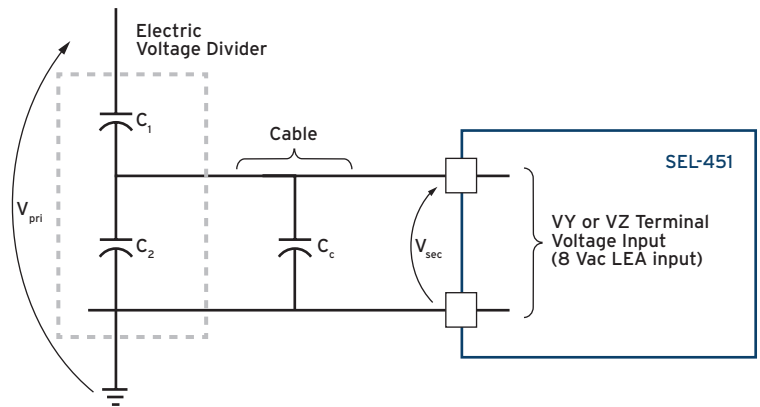
Customize distribution protection with multiple instantaneous and time-overcurrent elements combined with SELogic control equations. You can select from four phase, four negative-sequence, and four ground instantaneous overcurrent elements to best fit your application. Best Choice Ground Directional Element[®] logic optimizes directional element performance and eliminates the need for many directional settings.

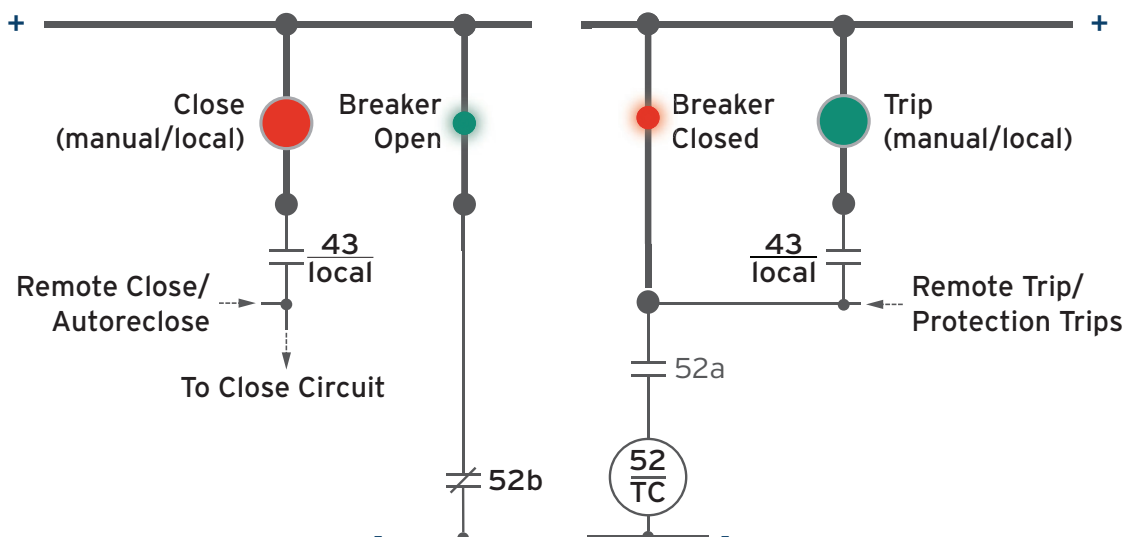
High-Impedance Fault Detection

Detect high-impedance faults with AST. High-impedance faults are a common result of a downed conductor on surfaces with poor conductivity. With AST, alarm or trip for faults that produce low fault current and are undetectable with conventional overcurrent relays.

Pad-Mounted Switchgear Protection

Protect pad-mounted switchgear using the SEL-451 with LEA voltage inputs. This helps reduce overall system costs by eliminating amplification electronics between the line sensor and the relay. Having fewer devices leads to a simpler system, a reduction in labor costs, and the elimination of a possible point of failure.





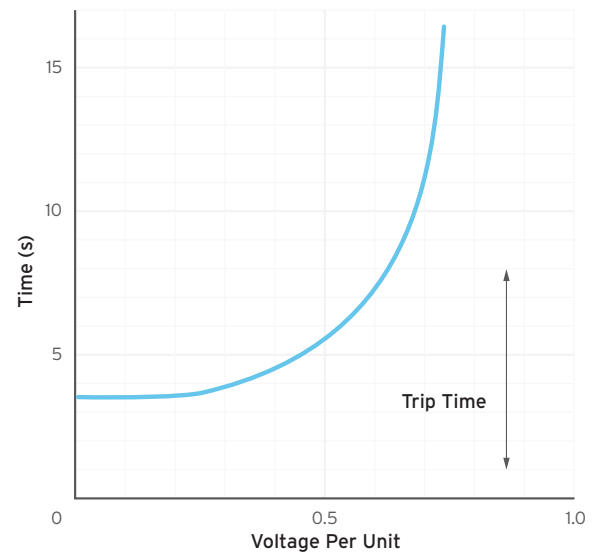
Automation

Custom Automation With SELogic Control Equations

Create your own custom applications using powerful SELogic control equations. This allows you to:

- Prevent cascading voltage collapse using VAR-supervised time-undervoltage elements.
- Monitor VAR loading, and trip only the feeders with high VAR demand to prevent voltage collapse.
- Create an adaptive inverse-time overcurrent characteristic to adjust pickup based on load conditions.
- Protect ungrounded-wye shunt capacitor banks.
- Create your own custom curves.

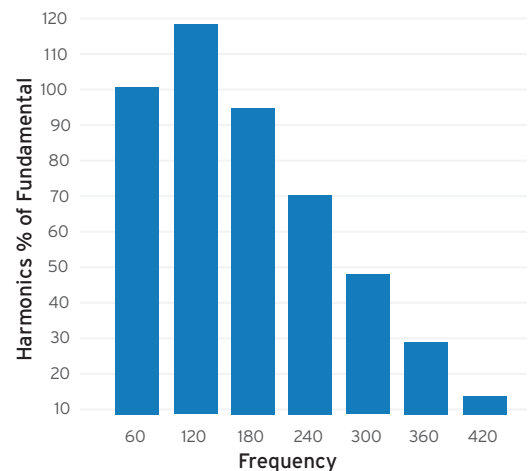
VAR-Supervised Time-Undervoltage Characteristic



Harmonic Monitoring

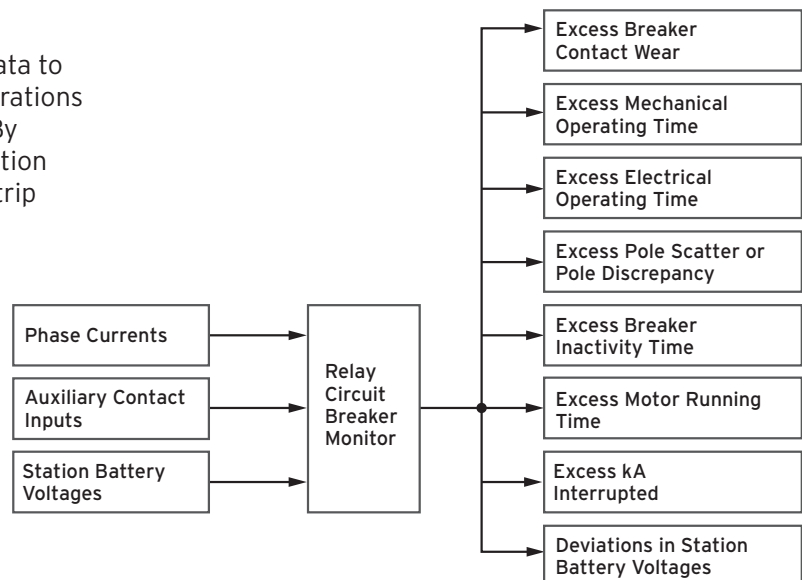
Apply the second-, fourth-, and fifth-harmonic elements with individual threshold settings to detect transformer energization and overexcitation conditions. You can use the output from these harmonic detection elements for a variety of functions. For example, modifying the relay settings can improve security, and event reporting makes the identification of transformer energization events fast and simple.

Harmonic Analysis



Breaker Wear Monitoring

Compare the breaker manufacturer's published data to the actual interrupted current and number of operations for two breakers, and create alarms accordingly. By monitoring the mechanical and electrical interruption time per pole, you can compare average and last trip times for maintenance scheduling.



Enhanced Event Analysis Software

Use the SEL-451 as a multichannel (six voltages, six currents) digital fault recorder. With SEL-5601-2 SYNCHROWAVE[®] Event Software, you can view COMTRADE files from the SEL-451 and other digital fault recorders. Event resolutions from 1 to 8 kHz and event report lengths from 0.25 to 24.00 seconds (1 kHz resolution) are possible. You can perform harmonic analysis of any voltage or current and select the prefault, fault, or post-fault portion of the event report to examine.

Synchrophasors

Significantly improve your system's performance with SEL's complete synchrophasor solutions, including hardware, communications, viewing and analysis software, data collection, and data archiving. The SEL-451 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 allow you to view and analyze system phase angles, load oscillations, voltage profiles, and other critical system information.

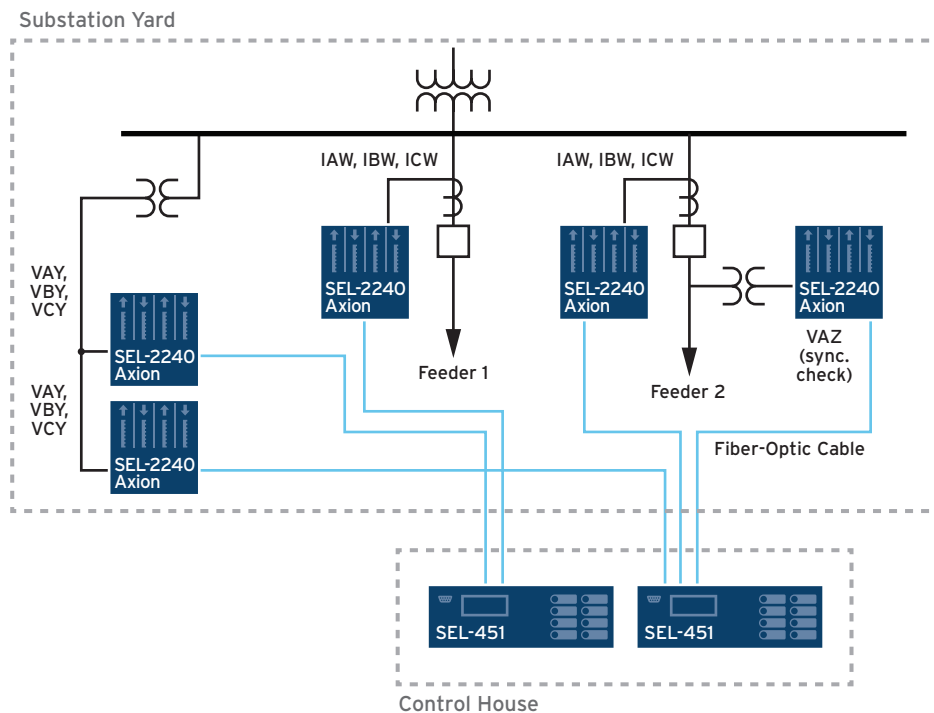


TiDL Technology

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-451 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-451-5 With TiDL Technology

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

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

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



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.

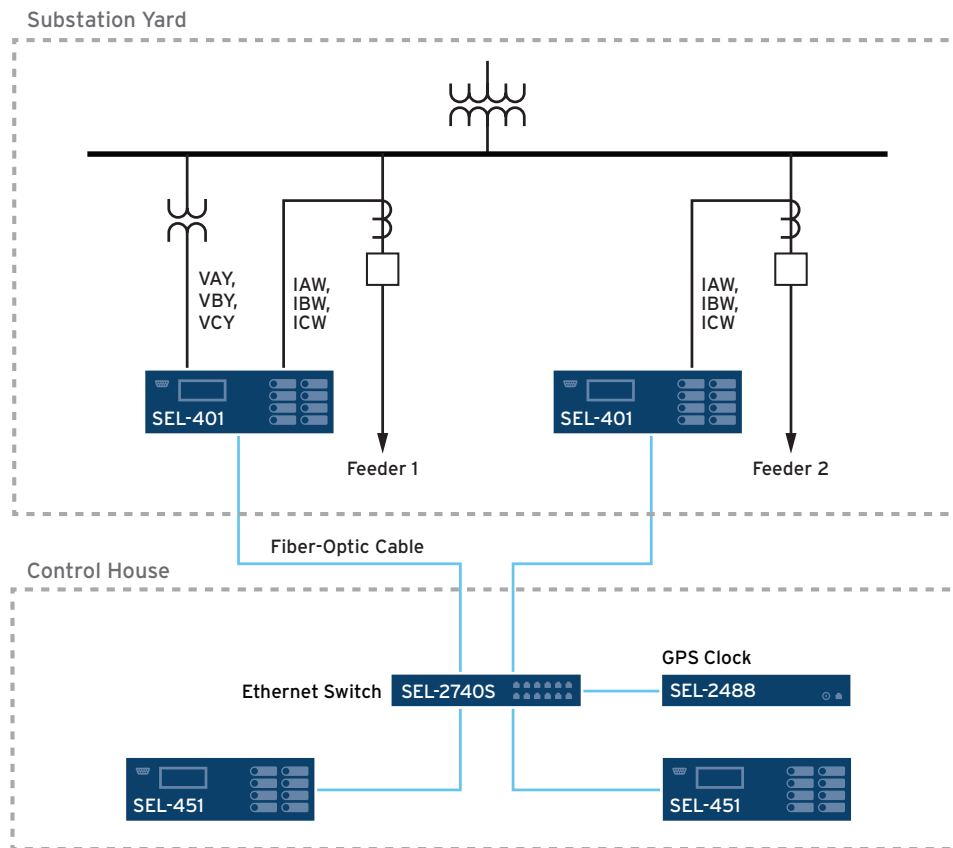
LEDs indicate a valid configuration and successful commissioning.

SEL SV Technology

In an SEL SV solution, the SEL-451-6 Relay (subscriber) in the control house receives digitized analog signals from an SV merging unit (publisher) in the yard via a fiber-based Ethernet network. The system uses precise time synchronization via IRIG-B or PTP.

The SEL-451-6 offers the traditional protection available in the SEL-451-5 and can also receive SV data. Because all SEL SV devices are 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, with other manufacturers' SV-compliant units, or with SEL merging units that offer built-in protection (such as the SEL-401 Merging Unit and the SEL-421-7 Protection, Automation, and Control Merging Unit).

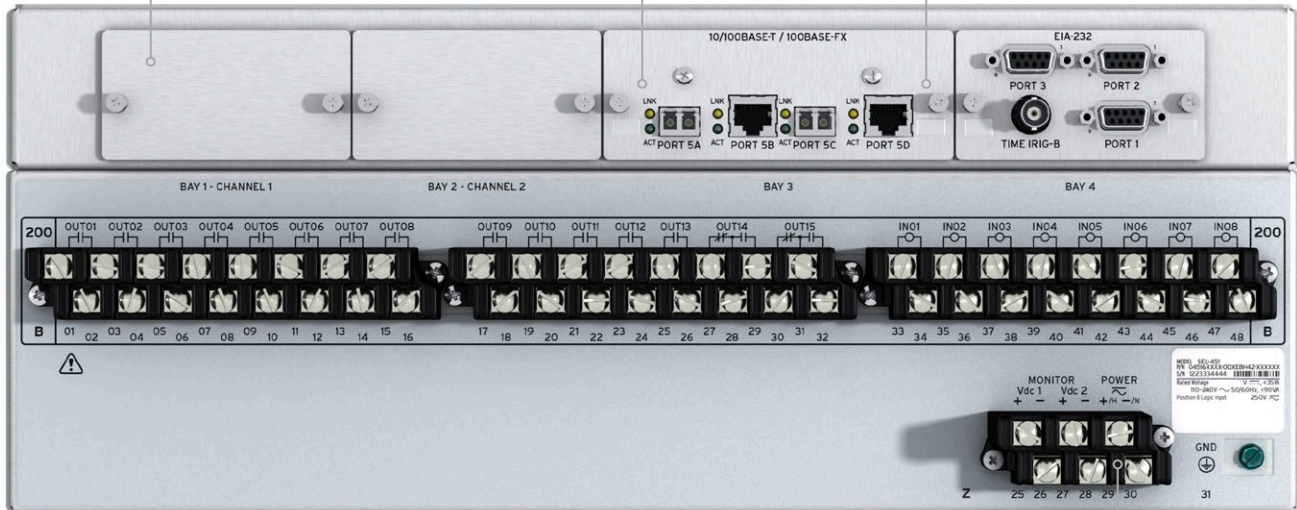
SEL SV technology allows you to create a flexible Ethernet-based point-to-multipoint network using tools such as software-defined networks or VLANs to fit your application needs. You can use the SEL-2740S Software-Defined Network Switch to provide centralized traffic engineering and improve Ethernet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



SEL-451-6 With SV Technology

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.

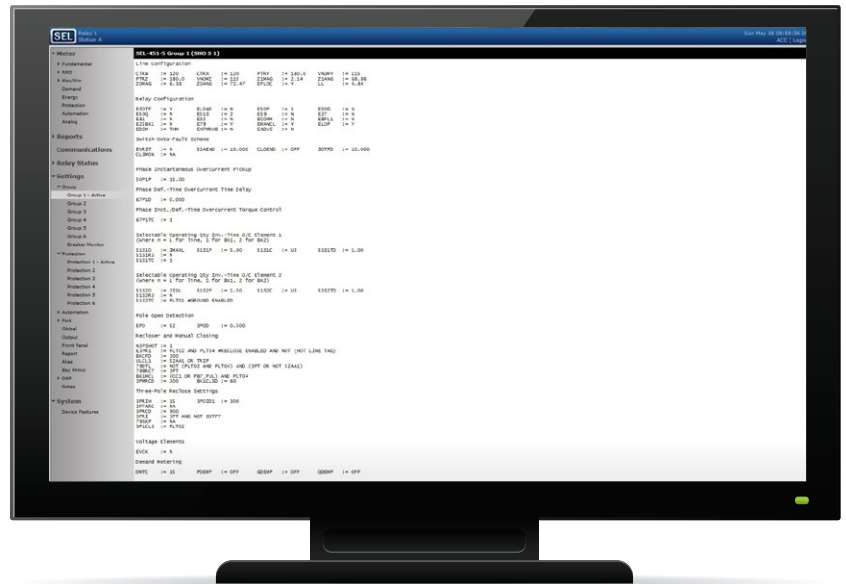


Choose from power supply options such as 24–48 Vdc; 48–125 Vdc or 110–120 Vac; or 125–250 Vdc or 110–240 Vac.

Accessibility and Communications

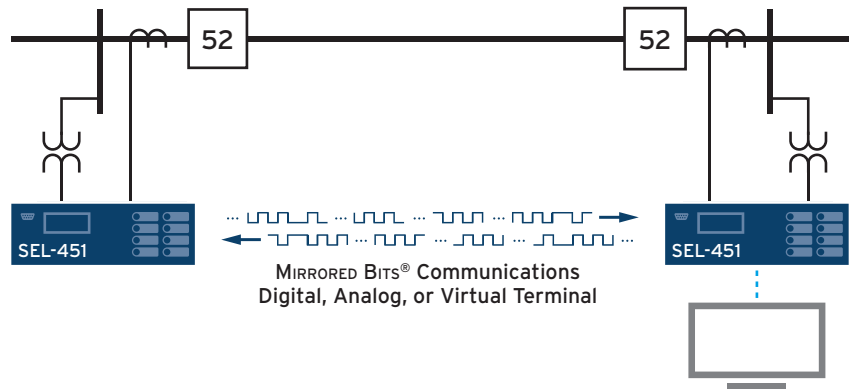
Built-In Web Server

Access basic SEL-451 information on a standard Ethernet network with the built-in web server. From there you can view the relay status, Sequential Events Recorder (SER) data, metering information, and settings with easy access within a local network. For increased security, web server access requires a relay password and the information is limited to a read-only view.



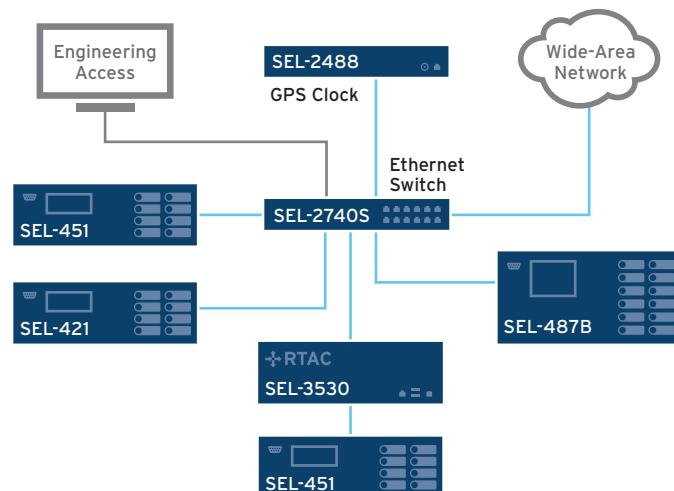
MIRRORED BITS Communications

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



Ethernet-Based Communications

An Ethernet card option provides two copper, fiber, or mixed ports for failover redundancy. Simplify the Ethernet network topology and reduce external equipment with dual Ethernet ports that offer a switched mode for looped Ethernet networks. Available Ethernet communications protocols include FTP, Telnet, DNP3 LAN/WAN, IEEE 1588 PTPv2, IEC 61850 Edition 2, IEEE C37.118 synchrophasors, and PRP.



SEL-451 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
LEA Voltage Inputs	0–8 V _{L-N} continuous, 300 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 100BASE-FX fiber-optic network ports Two 10/100BASE-T twisted-pair 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 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	24–48 Vdc 48–125 Vdc or 110–120 Vac 125–250 Vdc or 110–240 Vac
Operating Temperature	–40° 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).



Making Electric Power Safer, More Reliable, and More Economical
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