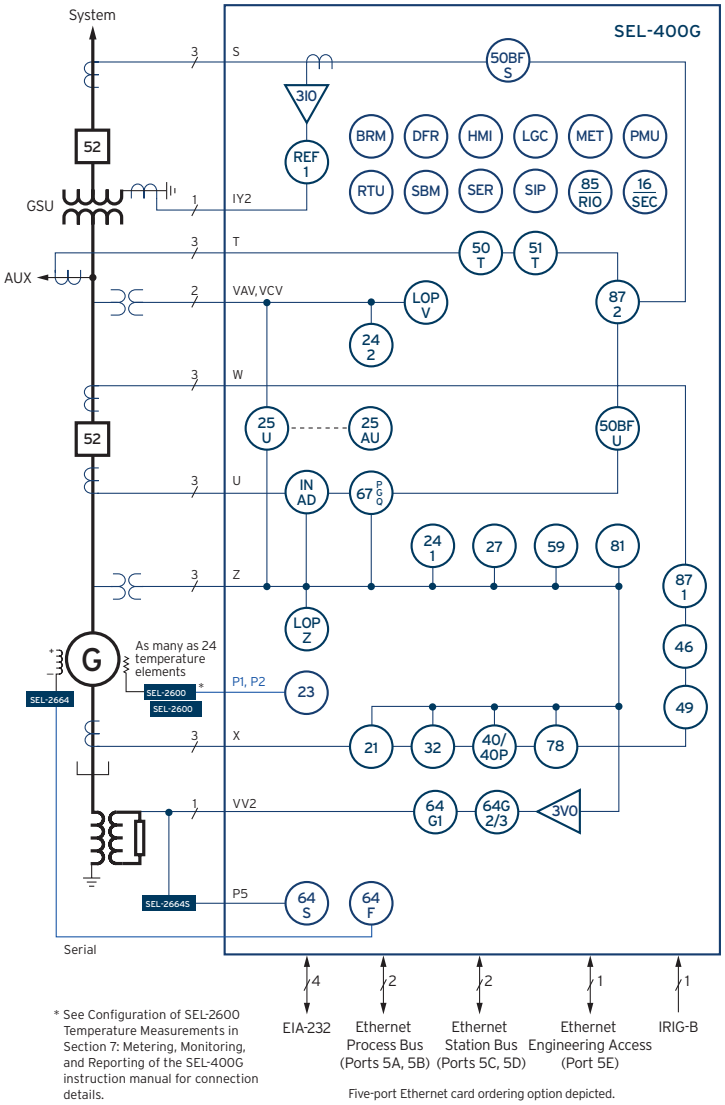
SEL-400G

Advanced Generator Protection System

Protection for hydro, pumped-storage hydro, steam turbine, and combustion gas turbine generators

- Comprehensive generator protection, generator step-up (GSU) protection, autosynchronizing, and disturbance recording are available in a single device.
- The 18 current inputs and 6 voltage inputs let you implement simple or complex schemes.
- Wide-range frequency tracking (5—120 Hz) ensures that all protection functions are secure and dependable.
- SEL Grid Configurator allows you to quickly and confidently create, manage, and deploy settings.

Functional Overview



* See Configuration of SEL-2600 Temperature Measurements in Section 7: Metering, Monitoring, and Reporting of the SEL-400G instruction manual for connection details.

Five-port Ethernet card ordering option depicted.

ANSI Numbers/Acronyms and Functions

21	Phase Distance
23	RTD Temperature—SEL-2600
24	Volts/Hertz
25	Synchronism Check
25A	Autosynchronizer
27	Undervoltage
32	Directional Power
40	Loss of Field
40P	Capability-Based Loss of Field
46	Current Unbalance
49	IEC 60255-Compliant Thermal Model
50BF	Breaker Failure Overcurrent
50N	Neutral Overcurrent
50 (P,G,Q)	Overcurrent (Phase, Ground, Neg. Seq.)
51N	Neutral Time-Overcurrent
51 (P,G,Q)	Time-Overcurrent (Phase, Ground, Neg. Seq.)
59	Overvoltage
64G1	Stator Ground (Fundamental Neutral Overvoltage)
64G2	Third-Harmonic Difference/Undervoltage
64G3	Third-Harmonic Ratio
64F	Rotor Ground—SEL-2664
64S	Stator Ground (Harmonic Injection)—SEL-2664S
67 (P,G,Q)	Directional Overcurrent (Phase, Ground, Neg. Seq.)
78	Out-of-Step
81 (O,U)	Over- and Underfrequency
81A	Accumulated Frequency
81R (O,U)	Over- and Under-Rate-of-Change of Frequency
85 (O,U)	Over- and Under-Rate-of-Change of Frequency
85 RIO	SEL Mirrored Bits® Communications
87 (U,R,Q)	Universal Differential (Unrestrained, Restrained, Neg. Seq.)
DFR	Event and Disturbance Reports
HMI	Operator Interface
INAD	Inadvertent Energization
LGC	Expanded SELogic® Control Equations
LOP	Loss of Potential
MET	High-Accuracy Metering
PMU	Synchrophasors
REF	Restricted Earth Fault
RTU	Remote Terminal Unit
SER	Sequential Events Recorder

Additional Functions

16 SEC	Access Security (Serial, Ethernet)
BRM	Breaker Wear Monitor
LDP	Load Data Profiling
SBM	Station Battery Monitor
SIP	Software-Invertible Polarities

Key Features

Comprehensive Generator and Unit Protection

The SEL-400G offers primary and backup protection for generators of all sizes and types, including hydro, pumped-storage hydro, large steam turbine, and combustion gas turbine generators. Two independent universal differential elements provide protection for the generator and GSU transformer in a single relay. The SEL-400G also offers 18 current inputs, 6 voltage inputs, wide-range frequency tracking (5—120 Hz), advanced antimotoring protection, loss-of-field protection, and more.

Stator Winding Ground Fault Protection

The SEL-400G offers passive and active ground fault detection across 100 percent of the stator winding without sacrificing security. The stator winding ground fault protection elements include integrating timers that detect intermittent ground faults and isolate the generator before the fault evolves into a permanent fault, thereby containing generator damage. You can combine the SEL-400G with the SEL-2664S Stator Ground Protection Relay to protect against ground faults at standstill, during startup, and while running by using the multisine frequency injection and neutral overvoltage-based protection.

Rotor/Field Ground Fault Protection

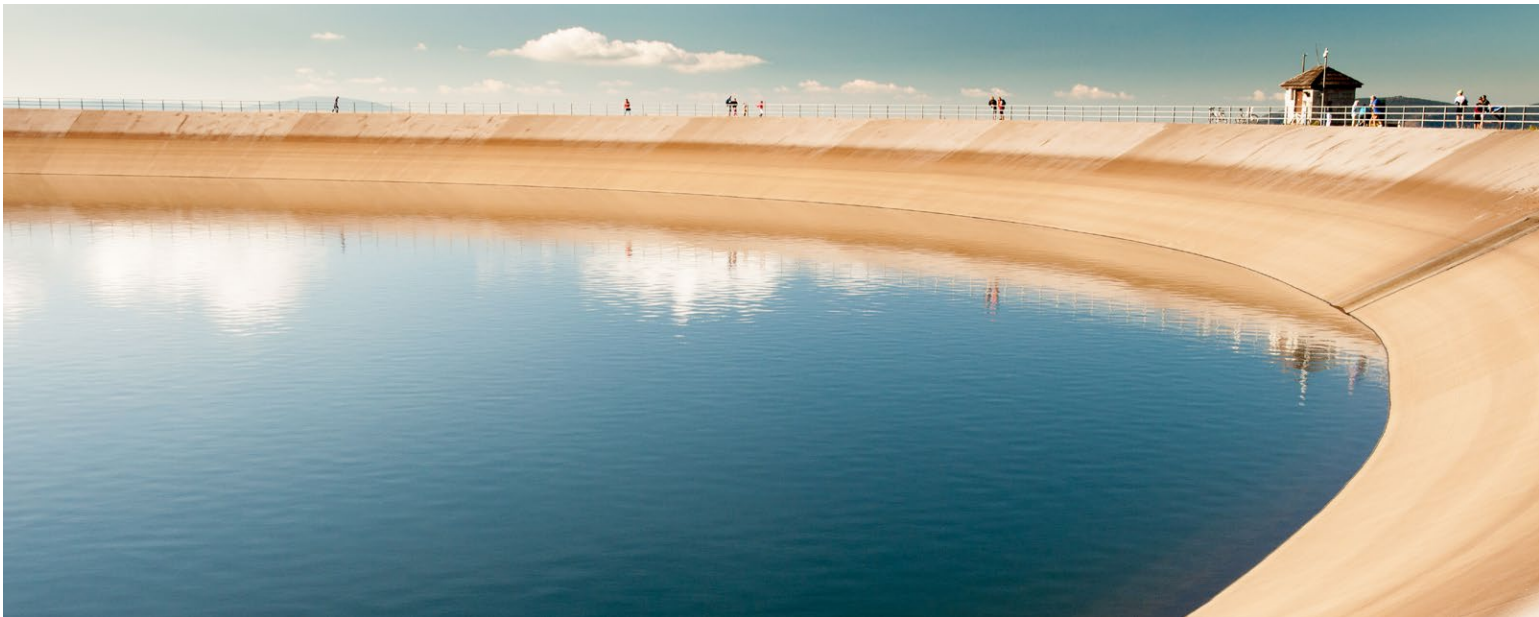
Applying the SEL-2664 Field Ground Module with the SEL-400G allows you to protect your system against rotor/field winding short circuits. The relay can show trends for deteriorating field winding insulation resistance, and it also provides rotor/field winding turn-to-turn fault protection.

Easy Communications

Choose from multiple copper or fiber-optic Ethernet ports, serial communications, and several protocols, including Mirrored Bits communications, IEC 61850, and the Parallel Redundancy Protocol (PRP). Multiple Modbus TCP sessions are available for custom configuration of your application. You can also use DNP3 serial or DNP3 LAN/WAN protocols.

Next-Generation SEL Configuration Software

SEL Grid Configurator—a software tool that allows engineers and technicians to quickly and confidently create, manage, and deploy settings for SEL relays—is included with the SEL-400G. It is the next evolution in SEL protective relay and meter configuration software, delivering a modern user experience.



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.

Easy-to-use keypad aids simple navigation.

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

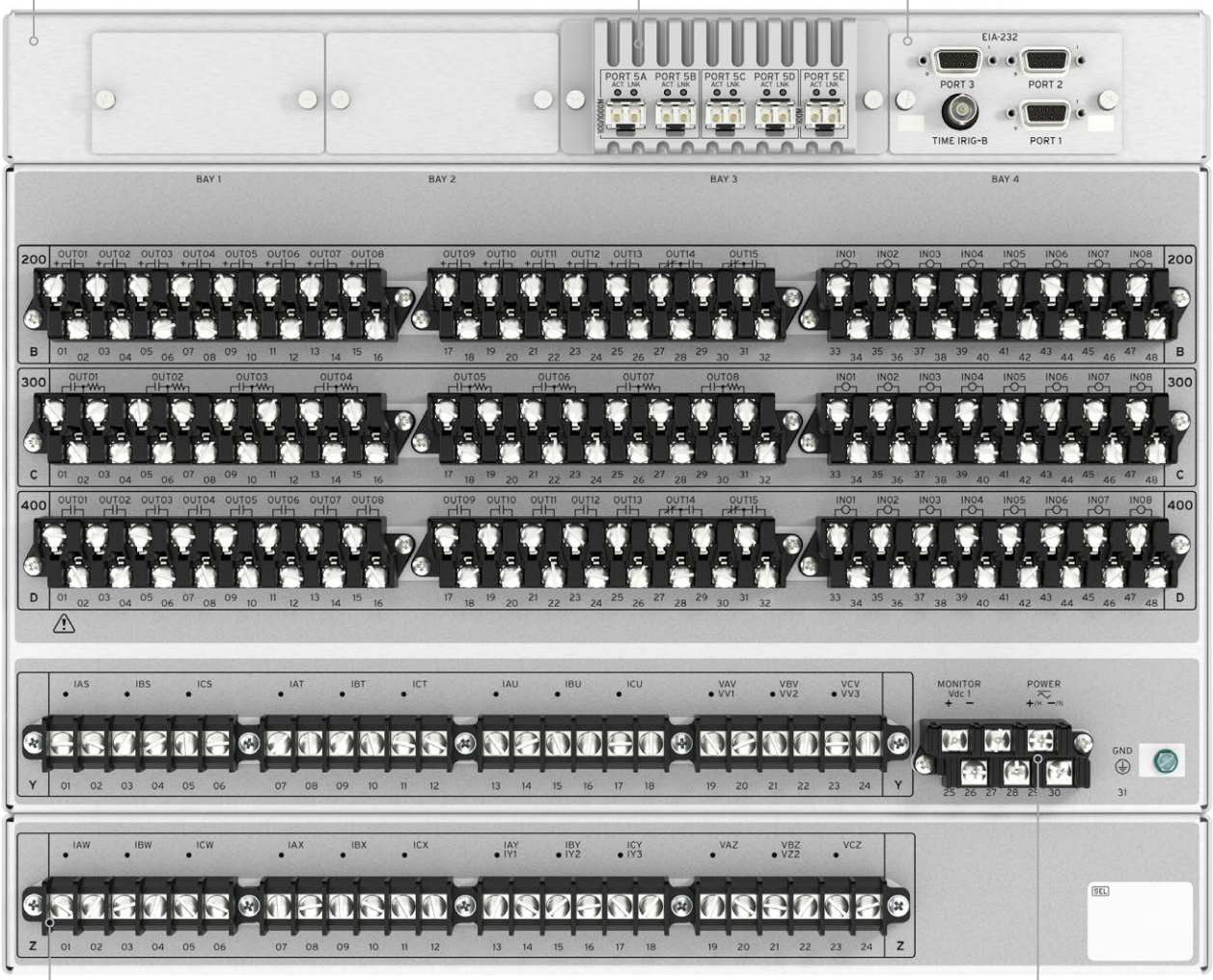
User-selectable mimic screens show the system configuration in one-line diagram format.

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

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

Communications protocols include FTP, Telnet, synchrophasors, Modbus TCP, DNP3 LAN/WAN, PRP, the IEEE 1588 Precision Time Protocol Version 2 (PTPv2),* and IEC 61850 Edition 2.1.

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



The 18 current and 6 voltage channels support differential protection for up to 6 three-phase terminals, 3 independent REF elements, and voltage elements.

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.

*A four-port Ethernet communications card option supports PTPv2 on Ports 5A and 5B. A five-port Ethernet communications card option (shown) supports PTPv2 on Ports 5A, 5B, 5C, and 5D.

Applications

Dual Differential and Dual Frequency Zones

Two independent universal elements provide protection for two protection zones, which allows independent protection of both the generator and GSU transformer with a single SEL-400G. Implemented with an external fault detector, the two zones are sensitive to internal faults while secure against external faults. Wide-range frequency tracking (5—120 Hz) ensures that all protection functions are secure and dependable across a wide range of system frequencies or generator speeds. This provides protection during events such as unit overspeed, inverter driven startup, or variable-speed pumped storage.

Pumped Storage Logic

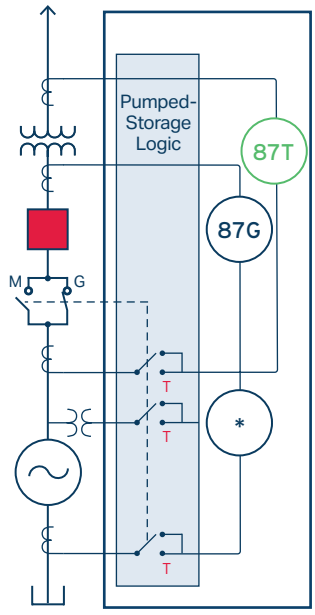
In addition, pumped-storage logic enables pumped-storage hydropower protection without the need for external relays to switch CT wiring, which lowers costs and improves reliability. The SEL-400G internally rolls the phasing of selected CTs to correct the phase change introduced in the primary circuit during pump operation, or it corrects the transposition introduced by the reversing switch in a pumped-storage application.

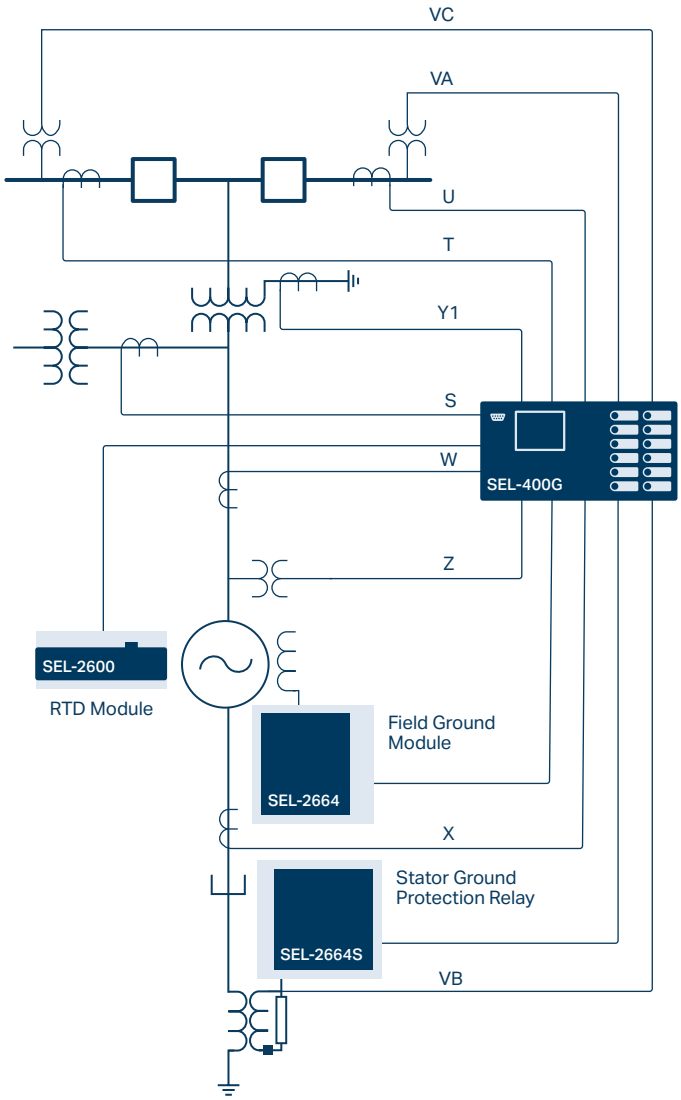
Rotor/Field Winding Protection

Detecting field-winding-to-ground faults allows you to take appropriate action before a generator sustains serious damage from severe vibration. With the field ground protection element, the first fault will trigger an alarm and a second fault results in a trip signal.

Stator Ground Fault Protection

The 64G1, 64G2, and 64G3 elements provide 100 percent stator winding ground fault protection through passive methods. With the SEL-2664S, the SEL-400G offers active protection even at standstill. Adding the neutral voltage connection provides protection for most machines, based on fundamental-frequency and third-harmonic neutral voltage measurements. Connecting the neutral current input provides protection for solidly grounded or resistance-grounded machines. Voltage injection provided by the SEL-2664 allows you to monitor field ground insulation resistance. You can protect generators from damage by responding to low field ground insulation resistance warnings.

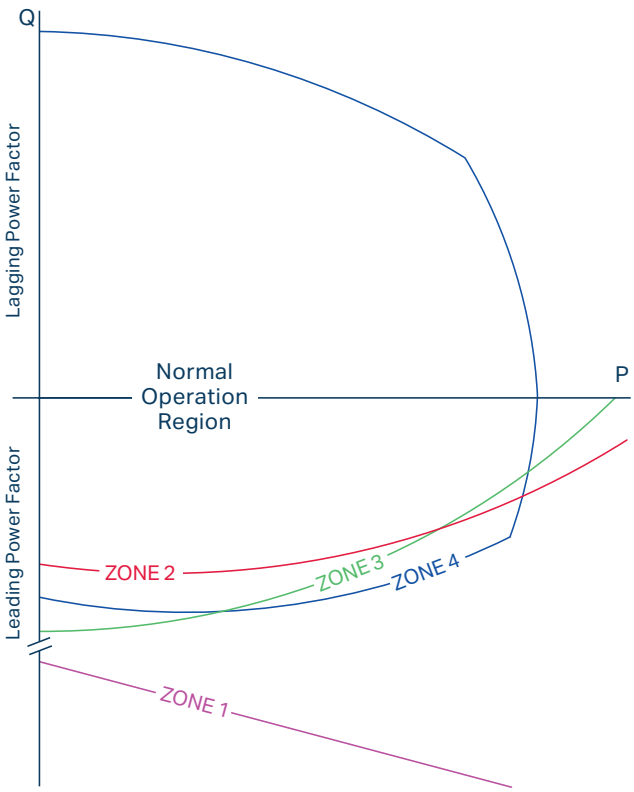




Loss-of-Field Protection

To protect the generator during loss-of-field events, the SEL-400G offers two impedance-based schemes: a negative offset Zone 2 scheme with two mho elements and a positive offset Zone 2 scheme (or qualified trip scheme) supervised by undervoltage and directional elements.

The SEL-400G also includes a capability-based method for loss-of-field protection. This method is based on the real and reactive power plane and works by coordinating with the generator capability curve, steady-state stability limit, and under-excitation limiter.



Dependable Directional Power Element

The wide-range frequency tracking capability ensures that the directional power elements are secure and dependable across a wide range of system frequencies or generator speeds and can be used for backup protection. It includes four elements, can be assigned to a dedicated CT, and has a biased option. This provides extra dependability when motoring power is very low and reactive power is high.

Antimotoring Protection

Steam and combustion turbines can be vulnerable to turbine or generator damage when motoring. The SEL-400G offers advanced antimotoring protection, including four sensitive power elements with independent time delays to sense motoring. It also provides a biased characteristic that ensures both security and dependability when motoring during significant reactive power output conditions.

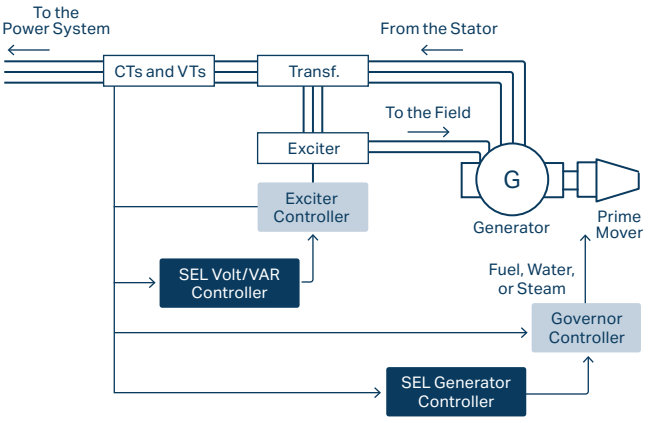
Out-of-Step (OOS) Blocking and Tripping

When a generator loses synchronism with the utility system, it must be separated immediately to avoid widespread outages and equipment damage. The SEL-400G provides robust OOS tripping capabilities with two detection schemes: a single-blinder scheme and a double-blinder scheme. In addition, a pole slip counter feature enables precise tripping.

Automatic Generator Control

The SEL-400G, in combination with the SEL POWERMAX® Power Management and Control System, can balance generation loading, control the tie line power flow, and maintain the bus voltage. The SEL generation control system regulates generator power outputs and manages utility interties to maximize system stability, minimize electrical disturbances, and mitigate load-shedding requirements.

The automatic MVAR and voltage control system maintains MVAR flows on interties and system bus voltages by controlling load tap changers, generator field and large synchronous motor exciters, synchronous and static condensers, and capacitor banks.

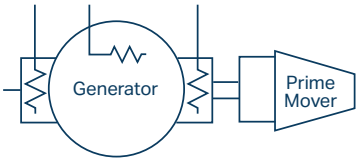


Autosynchronization

Use the additional, built-in automatic synchronizer function to automatically synchronize the frequency, voltage, and phase angle of the generator and connect to the power system. You can synchronize up to three breakers and choose from three pulse control options. Control actions as well as governor and automatic voltage regulator responses are available on event or disturbance reports. Autosynchronization eliminates the need for expensive external synchronizing equipment.

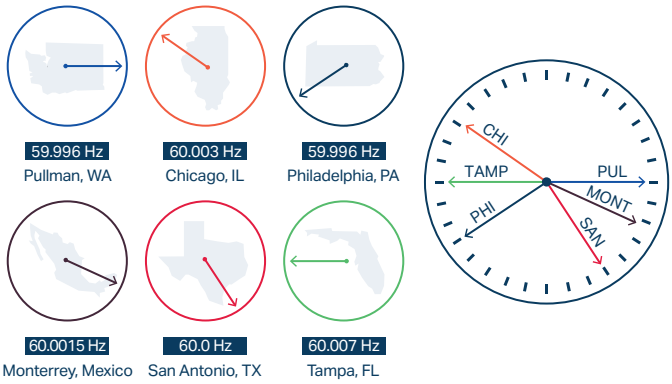
Resistance Temperature Detector (RTD)-Based Thermal Protection

Acquire thermal data for alarm, monitoring, and trip functions in the SEL-400G with an external 12 RTD SEL-2600 RTD Module.



Synchrophasor Measurement

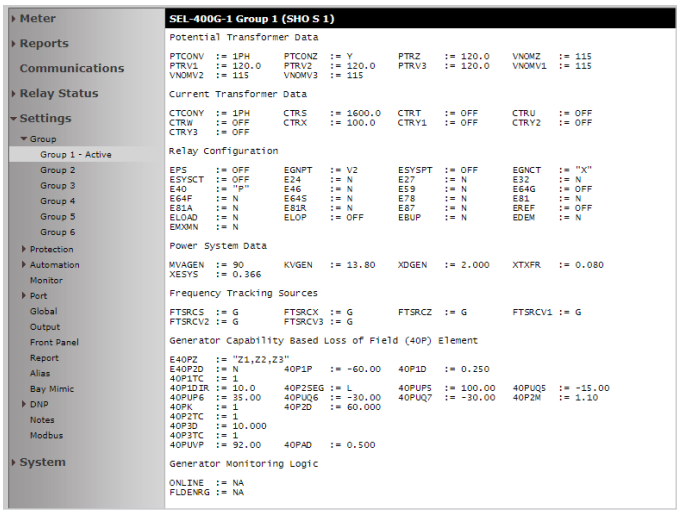
Combine the SEL-400G with an SEL IRIG-B time source to measure the system angle in real time with a timing accuracy of ±1 µs. You can measure instantaneous voltage and current phase angles in real time to improve system operation.



Accessibility and Communications

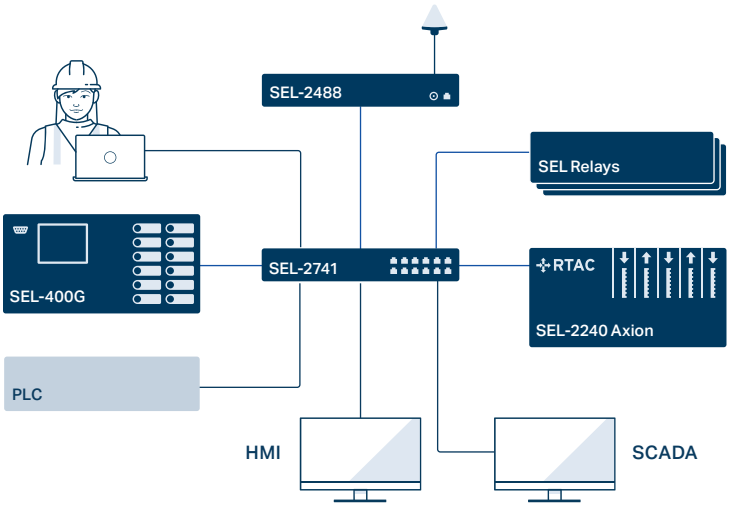
Built-In Web Server

Access basic SEL-400G 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.



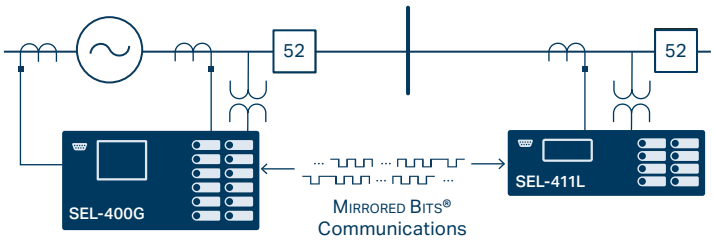
Ethernet-Based Communications

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

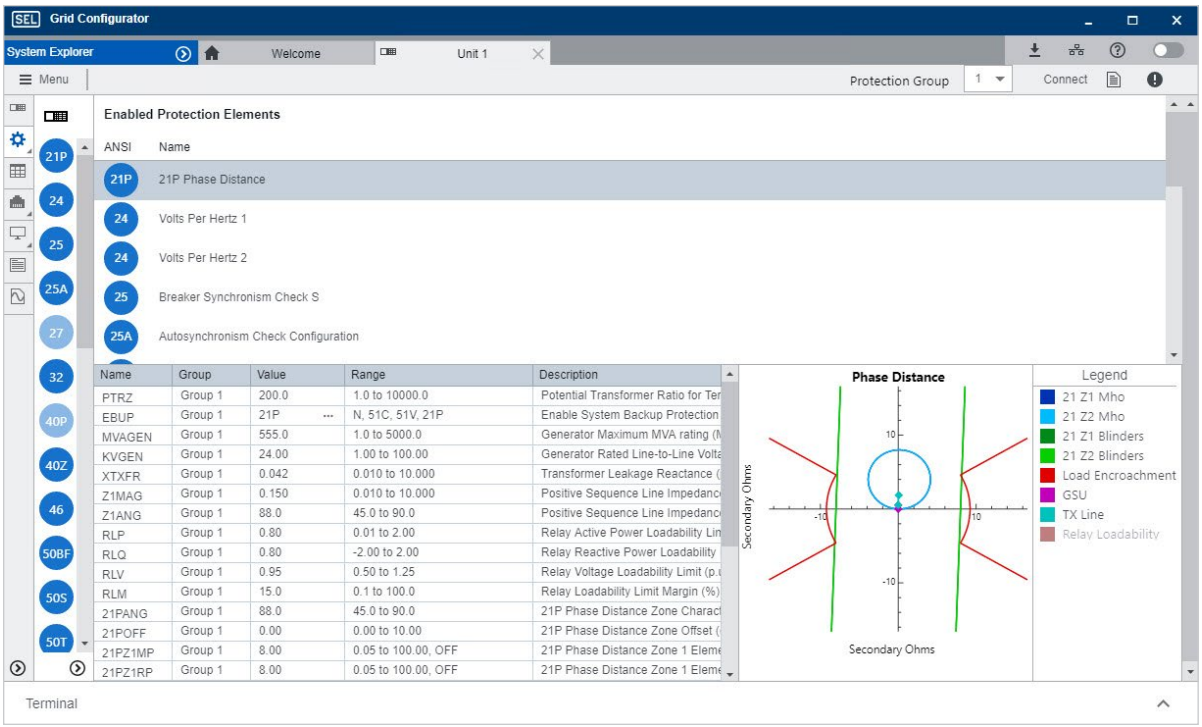
This field-proven technology provides simple and powerful bidirectional digital communications between devices. Mirrored Bits communications can transmit/receive information between relays for better coordination.



Modbus TCP

The Modbus TCP option provides Modbus functionality over Ethernet. It allows a Modbus master device to acquire metering, monitoring, and event data from the relay; control relay output contacts; read the SEL-400G self-test status; and learn the present condition of all the relay protection elements. Up to two Modbus TCP sessions can be configured with one custom Modbus map.

Configuration Software



Grid Configurator's visualization tools help you easily adjust a device's protection elements.

SEL Grid Configurator

Grid Configurator allows you to quickly and confidently 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.

Easy Device Configuration

A user-configurable device hierarchy allows you to quickly identify power system devices, such as relays, meters, and distribution controllers. The spreadsheet-style editor makes finding and editing one or many settings simple. Powerful compare and merge features allow you to manage settings across multiple devices within a single screen.

Powerful Protection Visualization

The Device Overview feature provides an immediate high-level summary of how you are using your devices' capabilities. You can also see a graphical configuration for many relay protection functions.

Comprehensive Reporting

With Grid Configurator, viewing and downloading reports for an entire substation at once is simple. You can filter by date, report type, or device type and download the reports to your laptop with a click.

Quick Settings Deployment

Grid Configurator makes it simple to send settings to multiple networked devices at once—no more moving cables from device to device. It provides a report at the end of the process to let you know if there were any concerns during download.

acSELerator QuickSet® SEL-5030 Software

The SEL-400G relay's QuickSet driver provides you with another configuration software option. It allows you to select the tool that best fits your application and allows you to transition to Grid Configurator at your own pace.

SEL-400G Specifications

General

AC Current Inputs (18 total)	5 A nominal 1 A nominal 5 A/1 A/0.2 A nominal (Y terminal only)
AC Voltage Inputs (6 total)	0—300 V_{L-N} operational
Output Contacts	The relay supports Form A and C outputs.
Optoisolated Control Inputs	DC/AC control signals: 24, 48, 110, 125, 220, and 250 V
Communications Protocols	Modbus TCP, FTP, Telnet, SEL ASCII, SEL Fast Message, synchrophasors, DNP3, PRP, PTPv2, and IEC 61850 Edition 2.1 (optional)
Communications Ports	**Serial Ports** One front-panel and three rear-panel EIA-232 serial ports 300—57,600 bps **Four-Port Ethernet Card** Four 10/100BASE-T twisted-pair network ports, or Four 100BASE-FX fiber-optic network ports, or Two 10/100BASE-T twisted-pair network ports and two 100BASE-FX fiber-optic network ports **Five-Port Ethernet Card** Two 100/1000BASE SFP ports Three 100BASE SFP ports
Precise-Time Input	Demodulated IRIG-B time input and PTPv2
Frequency and Phase Rotation	System frequency: 50, 60 Hz Phase rotation: ABC, ACB Frequency tracking: 5—120 Hz (requires ac voltage inputs)
Autosynchronizing	Control: As many as three breakers Control pulse modes: Proportional width, fixed duration, and proportional frequency
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)

SEL SCHWEITZER ENGINEERING LABORATORIES

Making Electric Power Safer, More Reliable, and More Economical
+1.509.332.1890 | info@selinc.com | selinc.com

PF00649 • 20250313