

SEL-651R

Advanced Recloser Control

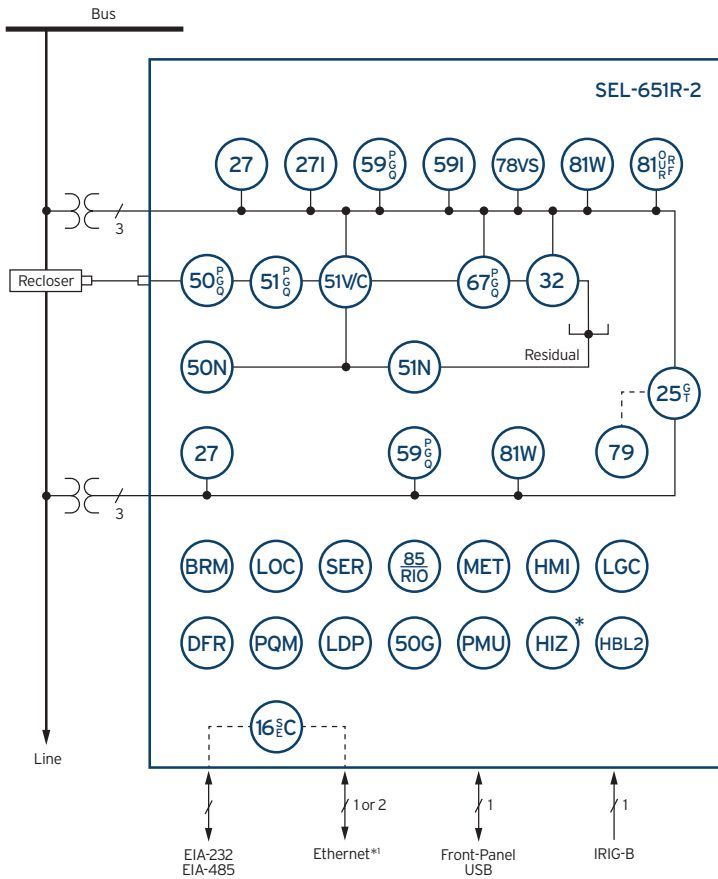


The industry's gold standard for recloser control

- Advanced recloser protection capabilities support coordinated high-speed fault isolation and restoration.
- Three- or single-phase tripping minimizes customer outages and improves reliability metrics.
- Arc Sense™ technology improves public safety and minimizes fire dangers caused by downed conductors.
- Fast islanding detection, precise synchronization, and IEEE 1547-2018 tripping let you safely interconnect distributed energy resources (DERs).
- Second-harmonic blocking secures overcurrent elements from transformer inrush.



Functional Overview



ANSI NUMBERS/ACRONYMS AND FUNCTIONS

| | |
|------------|--|
| 16 SEC | Access Security (Serial, Ethernet) |
| 25 (G,T) | Generator/Intertie Synchronism Check |
| 27 | Undervoltage |
| 27I | Inverse-Time Undervoltage |
| 32 | Directional Power |
| 50G | Best Choice Ground |
| 50N | Neutral Overcurrent |
| 50 (P,G,Q) | Overcurrent (Phase, Ground, Negative Sequence) |
| 51 (P,G,Q) | Time Overcurrent (Phase, Ground, Negative Sequence) |
| 51N | Neutral Time Overcurrent |
| 51V/C | Voltage-Restrained/-Controlled Time Overcurrent |
| 59 (P,G,Q) | Overvoltage (Phase, Ground, Negative Sequence) |
| 59I | Inverse-Time Overvoltage |
| 67 (P,G,Q) | Directional Overcurrent (Phase, Ground, Negative Sequence) |
| 78VS | Vector Shift |
| 79 | Autoreclosing |
| 81 (O,U,R) | Frequency (Over, Under, Rate) |
| 81RF | Fast Rate-of-Change of Frequency |
| 81W | Frequency Window |
| 85 RIO | SEL MIRRORING BITS® Communications |
| DFR | Event Reports |
| HIZ | SEL Arc Sense Technology (AST)* |
| HMI | Operator Interface |
| LGC | SELogic® Control Equations |
| MET | High-Accuracy Metering |
| PMU | Synchrophasors |
| PQM | Voltage Sag, Swell, and Interruption |
| SER | Sequential Events Recorder |

ADDITIONAL FUNCTIONS

| | |
|------|--------------------------|
| BRM | Breaker Wear Monitor |
| HBL2 | Second-Harmonic Blocking |
| LDP | Load Data Profiling |
| LOC | Fault Locator |

*Optional feature 1Copper or fiber-optic

Compatible With Popular Reclosers

The SEL-651R Advanced Recloser Control works with a wide range of reclosers for complete plug-and-work capability. All interfaces are designed and tested to exceed the IEEE C37.60 standard. Certificates are available at selinc.com/SEL-651R.

G&W

Control Power Viper-S

Viper-LT

Viper-S

Viper-SP

Viper-ST

Viper-G

Other Reclosers

Elastimold Molded Vacuum Recloser (MVR)

Joslyn TriMod 300R

Joslyn TriMod 600R

OVR-3 (15 and 27 kV only)

Gridshield 32-Pin (15, 27, and 38 kV)

Gridshield 42-Pin (15, 27, and 38 kV)

Togami FAULT CLEAR (27 kV)

VR-3S (15 and 27 kV only)

CXE

NOVA Auxiliary Powered

NOVA Control Powered

NOVA NX-T

NOVA NX-ST

NOVA-TS Triple-Single

NOVA-ST

RE

RVE

RXE

VSA

VSO

Other Reclosers, Continued

VWE

VWVE 27

VWVE 38X

WE

WVE 27

WVE 38X

GVR*

SDR Triple-Single

SDR Three-Phase

OSM AI_4

Romagnole iGrid

*When equipped with interface module

A Single Multi-Recloser Interface Works With Several Reclosers

Stock one recloser control to support several recloser models. You can connect any of the following reclosers to the SEL-651R with the Multi-Recloser Interface:

G&W

Viper-LT

Viper-ST

Other Reclosers

Elastimold MVR

Gridshield 32-Pin (15, 27, and 38 kV)

Gridshield 42-Pin (15, 27, and 38 kV)

NOVA NX-T

NOVA NX-ST

OSM AI_4

SDR Three-Phase

SDR Triple-Single

Romagnole iGrid

Key Features

Plug-and-Work Compatibility for Many Reclosers

Interfaces for the SEL-651R are available for many different reclosers. Using a common recloser control across your system simplifies installation, reduces training, and reduces operation errors.

Single-Phase Trip and Reclose

Reduce system and customer impacts with single-phase tripping and reclosing. You can improve reliability by maintaining service to customers who are not on the faulted phase of the feeder.

High-Impedance Fault Detection

SEL AST detects many high-impedance faults and downed conductors while maintaining secure protection. AST in the SEL-651R puts high-impedance fault detection out on the feeder, reducing the likelihood of an undetected fallen conductor. Tuning occurs over a cumulative time period, which allows the AST algorithm to arm in areas where the load current may temporarily drop below the minimum current threshold (2 percent of nominal load).

Intertie Protection

Use the SEL-651R to interconnect microgrids and DERs to area electric power systems (EPSs). It meets and exceeds the requirements for use at a point of interconnection or point of common coupling, per IEEE 1547-2018. Combine definite-time voltage elements with inverse-time voltage elements (27I and 59I) to improve the speed of operation for faults while maintaining coordination with area EPS relays. Back up your primary protection with voltage-based time-overcurrent elements for DER applications and improve the dependability and operating times of the protection system. Additionally, the SEL-651R supports fast islanding detection, which ensures that the DER is offline when the utility attempts to reclose on the feeder.

Advanced Communications Interfaces and Protocols

Easily integrate the SEL-651R into SCADA or distribution automation systems. Both EIA-232 and EIA-485 serial ports are available as well as two metallic or one or two fiber Ethernet ports. Protocols include DNP3, Modbus, IEC 61850, and the Parallel Redundancy Protocol (PRP). PRP is an Ethernet-based protocol that provides seamless network failover and is available on SEL-651R recloser controls with dual Ethernet ports (copper or fiber). A front USB port provides high-speed local access for loading settings or downloading reports.

Six Voltage Inputs

The SEL-651R measures the voltage on both sides of the recloser, making it especially valuable in autonomously controlled distribution automation schemes. The low-energy analog (LEA) inputs allow the use of integrated voltage sensors, which reduce costs and simplify installation.

Advanced Protection

The SEL-651R includes many advanced protection features that ensure secure and reliable operation, including second-harmonic blocking and rate-of-change-of-frequency (ROCOF) controls. These features minimize undesired operations associated with transformer inrush current and provide faster decoupling of distributed generation on a feeder. A frequency window element verifies that the frequency is within normal parameters before closing the recloser to restore power. Such frequency qualification is especially critical when DERs are providing the restoration power. Dedicated frequency window elements for each side of the recloser allow for restoration from either side of the open recloser.

Secure Ethernet Communications

Use Media Access Control Security (MACsec) to enhance the existing cybersecurity of the SEL-651R and reduce operation and maintenance expenses. MACsec secures Ethernet traffic (except IEC 61850 GOOSE and PRP) between an SEL-651R and SEL-3622 or Key Server MACsec-enabled routers/radios, providing confidential communication and maintaining message integrity between devices. Key management is automated via the MACsec Key Agreement (MKA) to simplify commissioning and improve the overall user experience.



Product Overview

Navigation controls make information readily accessible.

Optional software-programmable tricolored LEDs for improved status indication.

EIA-232 front serial port provides local access.

Programmable control pushbuttons and configurable labels for ease of operation.



Single-door control option shown.

Standard three-point latch for improved physical security.

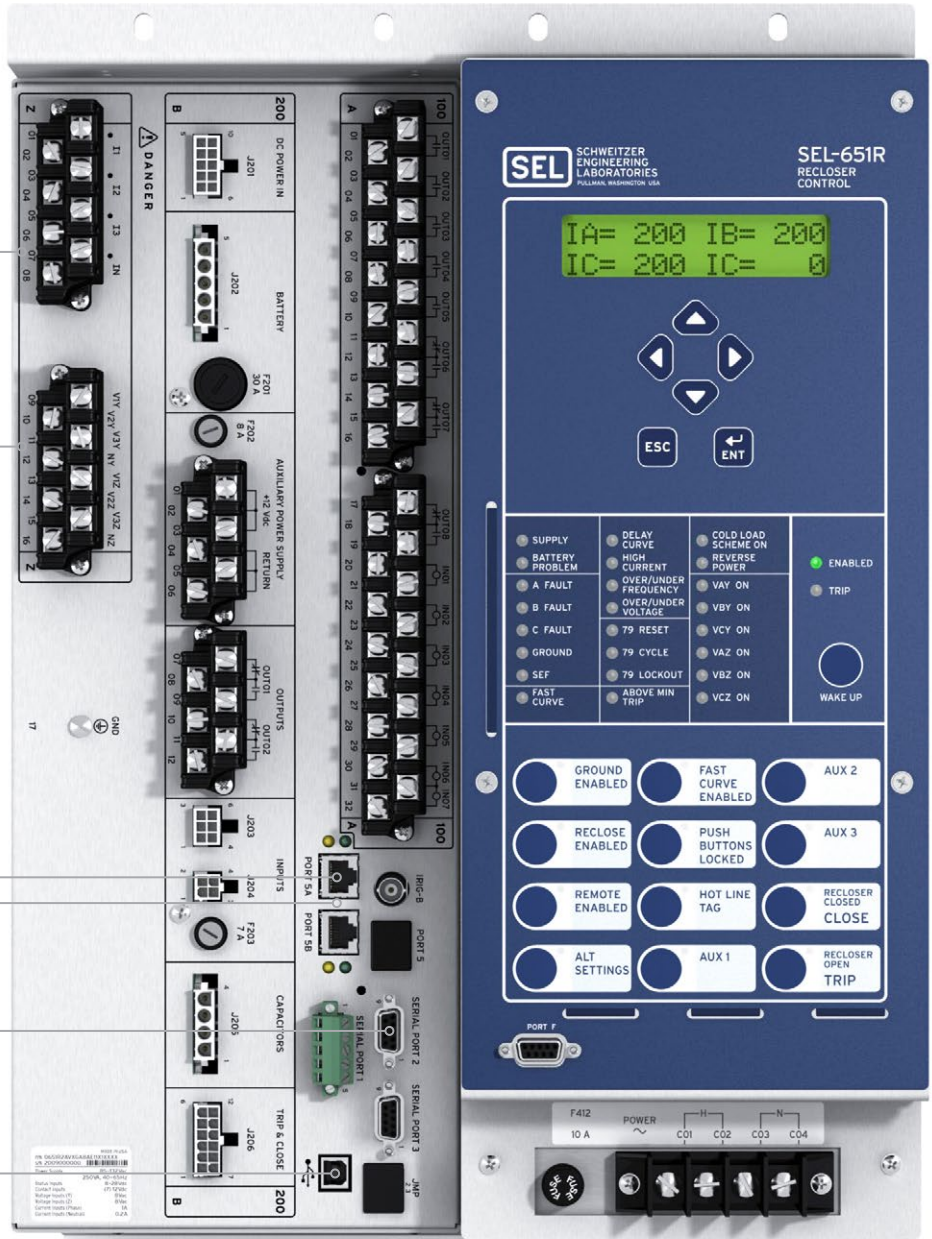
64 SELogic variables replace traditional panel switches with 32 latching, 16 local, and 32 remote control points.

Standard six voltage inputs with PT and LEA options for measurements on both sides of the recloser.

Standard multisession Modbus TCP and DNP3 and optional IEC 61850 for easy integration with existing systems.

Standard dual copper Ethernet ports allow for communication between devices and provide redundancy. An optional single or dual fiber Ethernet port or a combination with copper and fiber ports is available.

Two standard EIA-232 ports, an EIA-485 port, and a USB port provide several communications options.



Single-door control option shown.

Applications

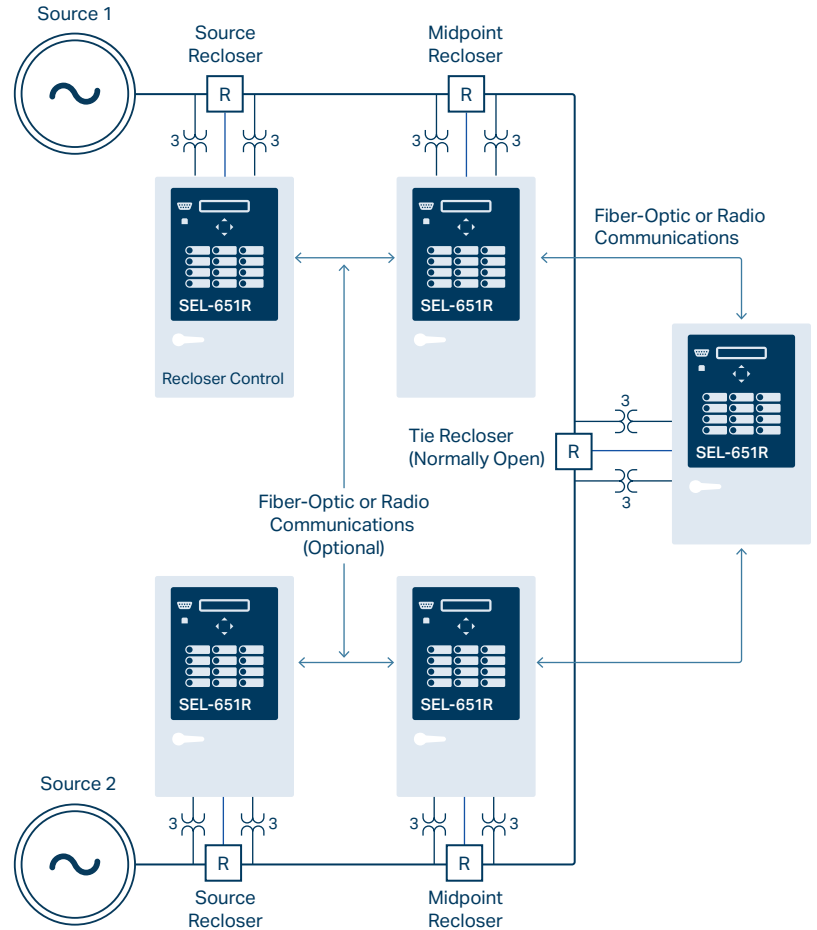
Advanced Control for Distribution Automation

Automatically reconfigure your distribution system with the SEL-651R to isolate faults and restore service quickly to impact the fewest customers. The SEL-651R is an integral part of the SEL distribution automation solution—DNA® (Distribution Network Automation). With DNA, you can improve reliability and increase operational efficiency while reducing operating costs.

Automatic Network Reconfiguration (ANR) improves service reliability by isolating permanently faulted segments and quickly restoring service to nonfaulted segments. You can apply the SEL-651R in various systems, either with or without communication between devices.

The SEL-651R includes logic and counter options to detect loss-of-voltage conditions that indicate upstream recloser openings. You can change the settings sensitivity in intermediate recloser controls before the tie recloser is closed. Reclose shot counting or time coordination lets you determine the faulted segment.

The SEL-651R includes six voltage inputs to monitor voltages on both sides of the recloser, ensuring safe and secure ANR.

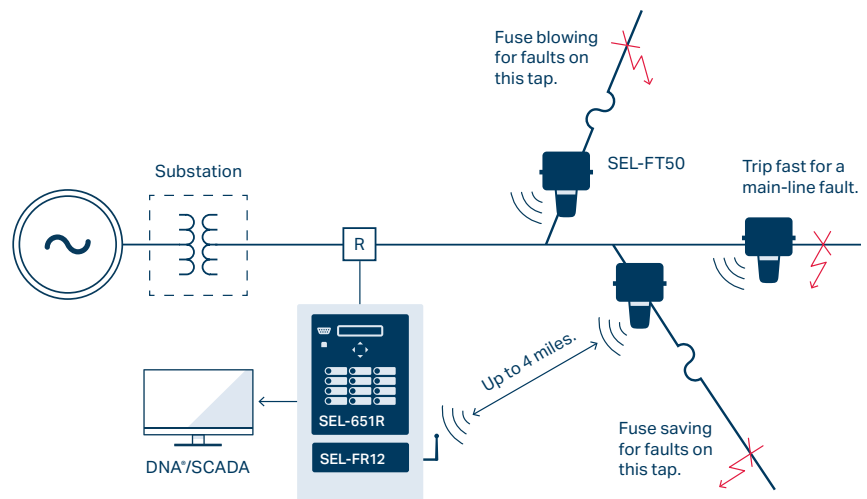


Communicate directly with any SEL-651R via serial or Ethernet communications without the need of a field remote terminal unit (RTU).

Speed Up Distribution Protection

Combine the SEL-FT50 and SEL-FR12 Fault Transmitter and Receiver System with the SEL-651R for more intelligent protection. SEL-FT50 Fault Transmitters, located on branches, laterals, and the main line, wirelessly communicate the fault location to the SEL-651R in 6 ms. This allows you to adapt your coordination fast.

- Trip as fast as possible for main-line faults—no waiting for coordination of fuses or downstream recloser controls.
- Combine adaptive fuse-saving and fuse-blowing schemes based on the fault location.
- Disable reclosing for faults located in underground feeder sections.



Adapt your coordination scheme in the SEL-651R based on the location of the fault. The SEL-FT50 and SEL-FR12 System wirelessly sends fault information in 6 ms to the recloser control.

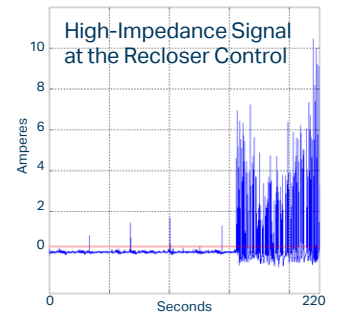
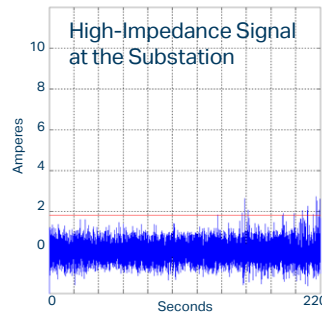
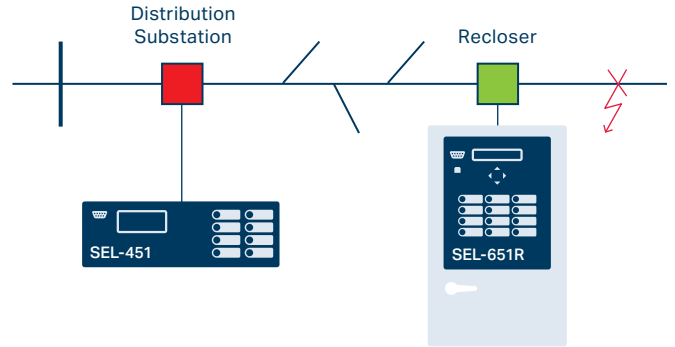
High-Impedance Fault Detection

High-impedance faults, such as downed conductors on poorly conductive surfaces, create fault current levels that are too low to be detected by conventional overcurrent protection elements. The SEL-651R with AST detects many high-impedance faults while maintaining secure protection. Tuning occurs over a cumulative time period, which allows the AST algorithm to arm in areas where the load current may temporarily drop below the minimum current threshold (2 percent of nominal load).

The SEL-651R with AST is easy to understand, set, and test. It includes straightforward protection algorithms with two sensitivity levels and a test mode.

Coordination

When AST is present in multiple devices on a single feeder, the relay or control closest to a high-impedance fault detects the stronger signal and isolates the fault to coordinate with other relays or controls on the system. This coordination isolates only the faulted segment of the line and minimizes the number of customers affected by a high-impedance fault. You can use communications between relays to improve AST protection performance on complex feeder arrangements or in the case of feeder reconfiguration.



The SEL-651R offers high-impedance fault detection, providing improved detection by being closer to the fault.

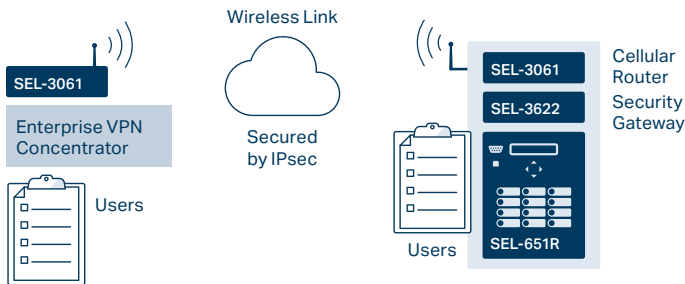


Multilayer Security

Configure the SEL-651R with MACsec to obtain point-to-point security. Add IPsec to the SEL-3622 to obtain end-to-end network security.

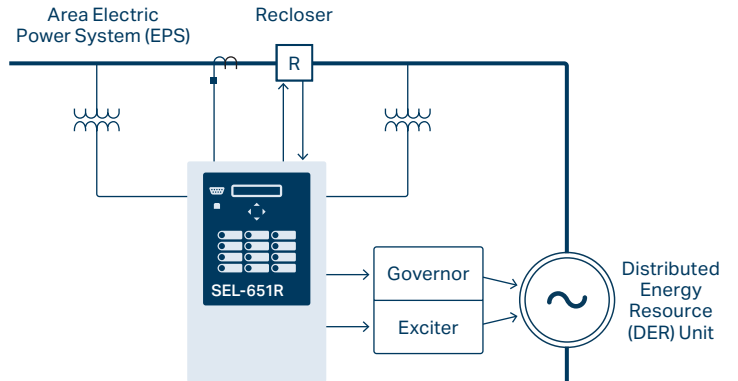
IPsec

Add the SEL-3622 Security Gateway for encrypted IPsec VPN access to the SEL-651R. The SEL-3622 also acts as a firewall and protects against malware with exe-GUARD® allowlist antivirus. The SEL-3622 authenticates users, manages passwords, logs and reports Syslog events, and has physical security sensors to alert on unauthorized access to the SEL-651R cabinet.



Protect DER Interconnections

Use the SEL-651R to interconnect microgrids and DERs to area electric power systems. Together, the SEL-651R and recloser provide a compact pole-top solution for interconnecting DERs with overhead distribution lines. Utilities, consultants, microgrid owners, and DER owners can use this solution at the point of common coupling, as defined in IEEE 1547-2018. The SEL-651R works with microgrid controllers and generator control systems, and provides fast islanding detection to ensure protection of the DER.



Typical utility and DER interconnection.

MACsec

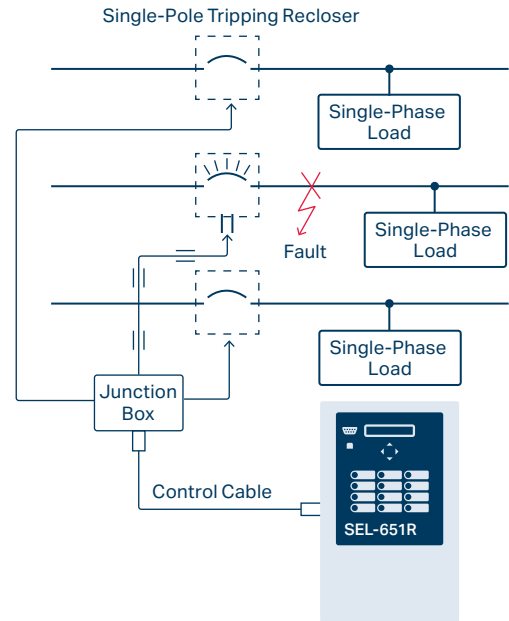
The SEL-651R utilizes MACsec to secure Ethernet traffic (except IEC 61850 GOOSE and PRP), providing integrity, authenticity, replay prevention, and optional confidentiality to communications. MACsec is a nonroutable, "hop-by-hop" cryptographic protocol that protects Ethernet frames starting at the data link layer (OSI Layer 2).

When enabled, MACsec establishes a secure, bidirectional link between connected devices after security keys have been exchanged and verified. Key management is automated with MKA, which provides capabilities including network discovery, mutual authentication, key management, parameter management, and bounded delay. Commissioning can be further simplified with a configuration mode that autopopulates the necessary settings.

Minimize Outage Impact on Customers With Single-Phase Tripping in the SEL-651R

Improve reliability by maintaining service to customers who are not on the faulted phase of the feeder. Available trip-reclose-lockout operation modes for single-phase tripping are:

- Three-phase trip/reclose, three-phase lockout.
- Single-phase trip/reclose, three-phase lockout.
- Single-phase trip/reclose, single-phase lockout.
- Single-phase trip/reclose, single-phase lockout, three-phase lockout if two or more phases are involved.

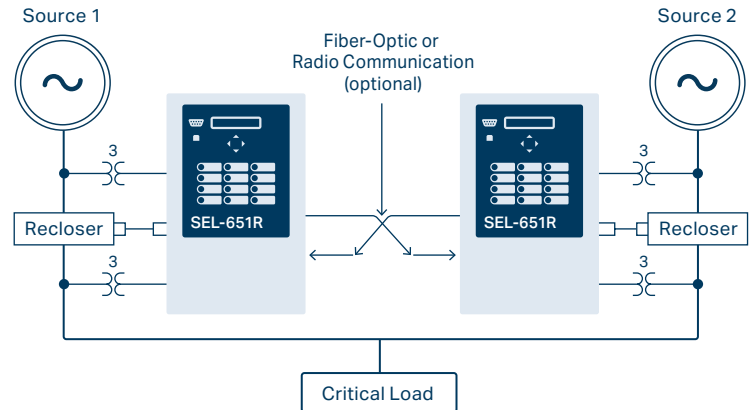


Single-phase tripping isolates only the faulted phase.

Apply Autosource Transfer Schemes

The SEL-651R lets you maintain reliable power for critical loads that require dual-feeder service. Using SEL MIRRORRED BITS communications technology between recloser controls, you can make intelligent operation decisions to bring nonfaulted loads back online. MIRRORRED BITS lets you communicate securely and share recloser status, source status, and other logic information between SEL-651R Recloser Controls.

Customize the return-to-normal action by incorporating a synchronism check for parallel source return or break-before-make when source voltages are not in phase.



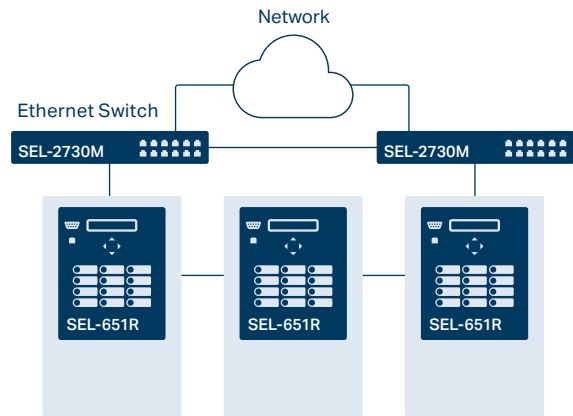
Use the SEL-651R as part of an autosource transfer scheme.

Integration

Quickly integrate the SEL-651R into Ethernet or serial communications networks with standard DNP3 and Modbus protocols or optional IEC 61850. The SEL-651R comes standard with three independent EIA-232 serial ports, one EIA-485 port, one USB port, and two metallic Ethernet ports for external communication. Optional Ethernet ports for the external communication include a single fiber port, dual-redundant fiber ports, and the single copper port and single fiber port option. PRP is available as a standard option on SEL-651R recloser controls with dual Ethernet ports. PRP is an Ethernet-based redundancy protocol that provides seamless network failover for systems such as electrical substations.

Using an Ethernet connection, you can upload firmware to the SEL-651R in less than a minute. You can also download 60-cycle-length, 128-samples-per-cycle event reports.

The Ethernet ports provide access for local and remote engineering, SCADA, real-time protection and control, loop restoration, islanding detection, blocking, and fast bus tripping schemes. The SEL-651R works well in distribution automation systems, including loop schemes and high-speed, peer-to-peer systems.



Communications Protocols

MIRRORED BITS communications

IEEE C37.118 synchrophasors

IEC 61850 GOOSE*

IEC 61850 MMS*

Modbus TCP

Modbus RTU

Telnet

DNP3 Serial

DNP3 IP

Web server

Simple Network Time Protocol (SNTP)

FTP

SEL Fast Messages

ASCII

IRIG-B

PRP

Communications Media

10/100BASE-T Ethernet

10/100BASE-FX Ethernet*

EIA-232 serial

EIA-485 serial

USB Type B

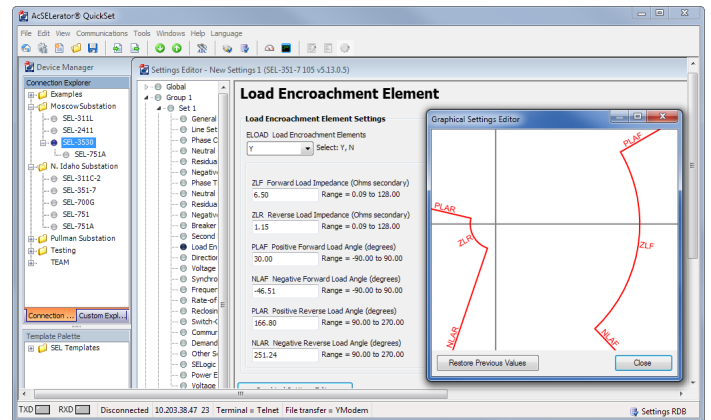
BNC (IRIG-B)

*Optional feature

ACSELERATOR® Software

Save time and simplify settings with free ACSELERATOR QuickSet® SEL-5030 Software. QuickSet lets you:

- Develop settings offline with a menu-driven interface and direct links to the instruction manual for easy help reference. You can speed up installation by copying existing settings files and modifying application-specific items.
- Quickly commission SEL-651R Recloser Controls. You can use settings templates to customize the interface so field personnel see only the settings they need when working with the recloser control. Sample templates for common applications are available on the SEL website.
- Access your settings template anytime. You can store templates on the SEL-651R and retrieve them for easy access in the field.
- See more pre-fault and post-fault data with high-resolution 60-cycle-length event reports at 128 samples per cycle to identify the root cause of problems or make decisions about system design.



View system data and streamline relay settings with QuickSet.

Monitoring and Metering

The SEL-651R measures signal distortions up to the 16th harmonic for each current and voltage input. The recloser control calculates total harmonic distortion and provides the value as a control element for alarming and tripping.

You can reduce the installed cost of feeder control panels by avoiding separately mounted metering devices. SEL high-accuracy metered quantities include root-mean-square (rms) phase voltages, currents, and power.

Customization

SEL offers a variety of accessories to optimize recloser control efficiency and operation. You can create a customized solution to meet your application needs. Some popular accessories include a cabinet heater, an accessory shelf, fuse blocks, and prewired connectors. Many accessories are available for factory installation or as field upgrade kits. Listed below are some of the accessories available to create a robust recloser solution.



SEL-2401 Satellite-Synchronized Clock

Provide precise time for synchrophasor measurements with the SEL-2401, which has ± 100 nanosecond accuracy for automatically updated time.



SEL-3031 Serial Radio Transceiver

Combine three serial ports into one radio, allowing up to three different connections and protocols to operate simultaneously. The spread-spectrum, frequency-hopping radio transmits data in the license-free 900 MHz ISM band, providing an economical communications path or backup communications system.



SEL-3061 Cellular Router

The SEL-3061 is a secure wireless communications solution designed for critical applications. For electric utilities, the router provides connectivity to devices like recloser controls, motor-operated switches, capacitor banks, voltage regulators, substations, and much more. The combination of serial and Ethernet ports provides application flexibility, and using public networks with secure tunneling makes installation easy without sacrificing security.



SEL-3622 Security Gateway

A router, VPN endpoint, and firewall device, the SEL-3622 can perform secure and proxy user access for the SEL-651R. The SEL-3622 helps create a user audit trail through strong, centralized, user-based authentication and authorization to the recloser control. The SEL-3622 secures your control system communications with a stateful deny-by-default firewall, strong cryptographic protocols, and logs for system awareness.



Door Position Indication Switch

Monitor the position of the enclosure door, and send an alarm to SCADA when the cabinet has been opened. You can use this simple security feature to detect and respond to unwanted intruders.



SEL Fault Indicators and Sensors

Team the SEL-651R with the SEL-FT50 and SEL-FR12 System or SEL faulted circuit indicators to provide fault location information for more intelligent protection decisions and to reduce restoration times.

SEL-651R Specifications

General Specifications

| | |
|-------------------------------------|---|
| Compatible Reclosers | G&W Electric: Control Power Viper-S, Viper-LT, Viper-S, Viper-SP, Viper-ST, and Viper-G Other reclosers: Elastimold Molded Vacuum Recloser (MVR), Joslyn TriMod 300R, Joslyn TriMod 600R, OVR-3 (15 and 27 kV only), Gridshield 32-Pin (15, 27, and 38 kV), Gridshield 42-Pin (15, 27, and 38 kV), VR-3S (15 and 27 kV only), and Togami FAULT CLEAR 32-Pin (27 kV) CXE, NOVA Auxiliary Powered, NOVA Control Powered, NOVA NX-T, NOVA NX-ST, NOVA-TS Triple-Single, NOVA-ST Triple-Single, RE, RVE, RXE, VSA, VSO, VWE, VWVE 27, VWVE 38X, WE, WVE27, and WVE38X GVR (when equipped with interface module) SDR Triple-Single and SDR Three-Phase OSM AI_4 Romagnole iGrid |
| Current Inputs | IA, IB, and IC: 1 A nominal IN: 0.2 A nominal |
| AC Voltage Inputs | 300 V maximum (PT) 8 V maximum LEA (IEEE C37.92) Eaton (Cooper) internal LEA (37 V) Lindsey SVM1 LEA (200 V, 1 M Ω) Siemens SDR LEA inputs |
| Frequency and Phase Rotation | 60/50 Hz system frequency ABC or ACB phase rotation |
| Communications Ports | EIA-232 (3 ports) USB Type B EIA-485 Ethernet port: Dual 10/100BASE-T RJ-45 connectors Single 100BASE-FX LC connector (optional) Dual 100BASE-FX LC connectors (optional) Single 10/100BASE-T RJ45 connector and single 100BASE-FX LC connector (optional) |
| Communications Protocols | SEL, IEC 61850 (optional), PRP (for dual Ethernet copper or fiber models), MIRRORRED BITS communications, Modbus, DNP3, ASCII protocols, SNTP, IEEE C37.118 (synchrophasors), built-in web server |
| DER Interconnection | IEEE 1547-2018 |
| Power Supply | 120 Vac, 230 Vac, 48 Vdc, or 125 Vdc |
| Weight | <125 lb without accessories |
| Battery Reserve | ≥ 3.2 hours at -40°C , and ≥ 9.6 hours at $+25^{\circ}\text{C}$ (16 Ah standard) ≥ 8 hours at -40°C , and ≥ 24 hours at $+25^{\circ}\text{C}$ (40 Ah optional) |
| Operating Temperature | Relay module: -40° to $+85^{\circ}\text{C}$ (-40° to $+185^{\circ}\text{F}$) Batteries: -40° to $+80^{\circ}\text{C}$ (-40° to $+176^{\circ}\text{F}$) Entire SEL-651R unit: -40° to $+55^{\circ}\text{C}$ (-40° to $+131^{\circ}\text{F}$) |

SEL SCHWEITZER ENGINEERING LABORATORIES

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

© 2024 by Schweitzer Engineering Laboratories, Inc.
PF00295 • 20240730

