

SEL-651RD

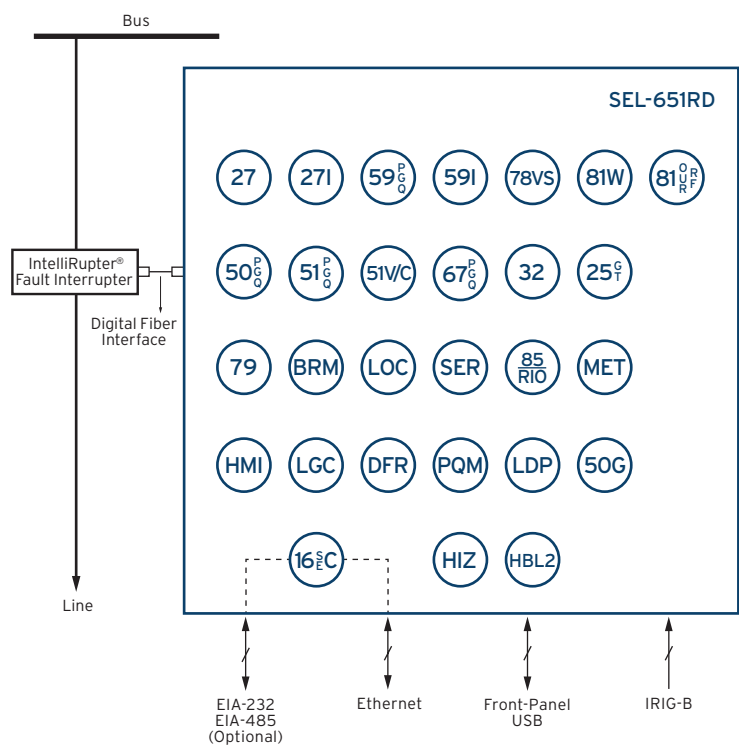
Advanced Digital Control



Compatible with the S&C IntelliRupter® PulseCloser® Fault Interrupter

- Apply the industry-first digital fiber-optic control cable interface designed for communications between the SEL-651RD and the IntelliRupter fault interrupter.
- Leverage the powerful capabilities and familiar interface of the SEL-651R Advanced Recloser Control.
- Retrofit existing IntelliRupter fault interrupters, or deploy with new installations.
- Combine Arc Sense™ technology (AST) in the SEL-651RD with IntelliRupter fault interrupter PulseClosing® Technology to support wildfire mitigation strategies.

Functional Overview



Compatible With the IntelliRupter Fault Interrupter

The SEL-651RD is compatible with specific models of the IntelliRupter fault interrupter. Contact S&C Electric Company for compatibility details.

Communications between the SEL-651RD and the IntelliRupter fault interrupter are entirely digital. The fiber-optic Ethernet cable exchanges current, voltage, and status indications from the IntelliRupter fault interrupter to the SEL-651RD and status indication from the SEL-651RD to the IntelliRupter fault interrupter.

Installation Requirements

- A power transformer to power the SEL-651RD
- An SEL-C860 outdoor-rated fiber-optic cable
- A compatible IntelliRupter fault interrupter control module. (Upgrade an R3 control module to a compatible firmware version.)
- A compatible IntelliRupter fault interrupter communications module

Contact S&C Electric Company to learn more about IntelliRupter fault interrupter compatibility.

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
50 (P,G,Q)	Overcurrent (Phase, Ground, Negative Sequence)
51 (P,G,Q)	Time Overcurrent (Phase, Ground, Negative Sequence)
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 MIRRORED BITS® Communications
DFR	Event Reports
HIZ	SEL Arc Sense Technology (AST) (Optional)
HMI	Operator Interface
LGC	SELogIC® Control Equations
MET	High-Accuracy Metering
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

Key Features

Pre-Engineered Solution

The SEL-651RD settings template in acSELERATOR QuickSet® SEL-5030 Software provides a single point of configuration for the IntelliRupter fault interrupter. This approach simplifies setup, reduces complexity, and minimizes implementation and maintenance efforts.

Single-Phase Tripping

Single-phase tripping in the SEL-651RD improves reliability metrics and reduces fault-related system stress. The single-phase tripping also maintains uninterrupted service to customers who are not on the affected phase.

Enhance Advanced Wildfire Mitigation Strategies

Combine AST in the SEL-651RD with PulseClosing Technology in the IntelliRupter fault interrupter to enhance existing wildfire mitigation strategies.

Intertie Protection

Use the SEL-651RD to interconnect microgrids and distributed energy resources (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-651RD 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-651RD into SCADA or distribution automation systems. Port 5A can be configured to be either Ethernet 10/100BASE-T copper or Ethernet 100BASE-FX fiber. Port 5B is a dedicated Ethernet 100BASE-FX fiber interface to the IntelliRupter fault interrupter.

Communications protocols include DNP3, Modbus, ASCII, Fast SER, Extended Fast Meter, and Fast Operate. The File Transfer Protocol (FTP) provides the ability to read and write settings files and read COMTRADE event reports from the SEL-651RD over Ethernet. A front USB port provides high-speed local access for loading settings or downloading reports.

Advanced Protection

The SEL-651RD includes many advanced protection features that ensure secure and reliable operation, including second-harmonic blocking and rate-of-change-of-frequency elements. 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 IntelliRupter fault interrupter 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 IntelliRupter fault interrupter allow for restoration from either side of the open IntelliRupter fault interrupter.

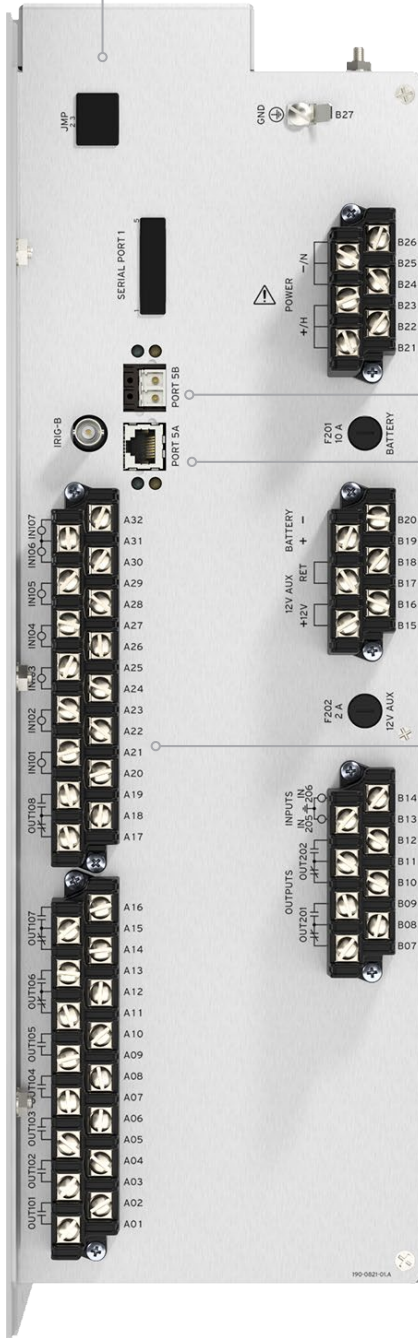
Secure Ethernet Communications

The SEL-651RD enhances cybersecurity by using the Media Access Control Security (MACsec) cryptographic protocol to provide confidential Ethernet communications and maintain message integrity between the SEL-651RD and communications equipment, such as the SEL-3622 Security Gateway and Key Server MACsec-enabled routers or radios. Key management is automated via the MACsec Key Agreement (MKA) to simplify commissioning and improve the overall user experience. MACsec is available on Port 5A.

Product Overview



Two standard EIA-232 ports and an EIA-485 port provide several communications options. (EIA-232 ports are hidden from this view.)



Port 5B is a dedicated 100BASE-FX fiber connection to the IntelliRupter fault interrupter.

Port 5A is available for use with options for either Ethernet 10/100BASE-T copper or Ethernet 100BASE-FX fiber.

7 optoisolated inputs and 8 standard outputs (ordering option).

Applications

Advanced Control for Distribution Loop Schemes

Automatically reconfigure your distribution system with the SEL-651RD to isolate faults and restore service quickly to impact the fewest customers. Automatic Network Reconfiguration (ANR) improves service reliability by isolating permanently faulted segments and quickly restoring service to nonfaulted segments. You can apply the SEL-651RD in various systems, either with or without communication between devices.

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

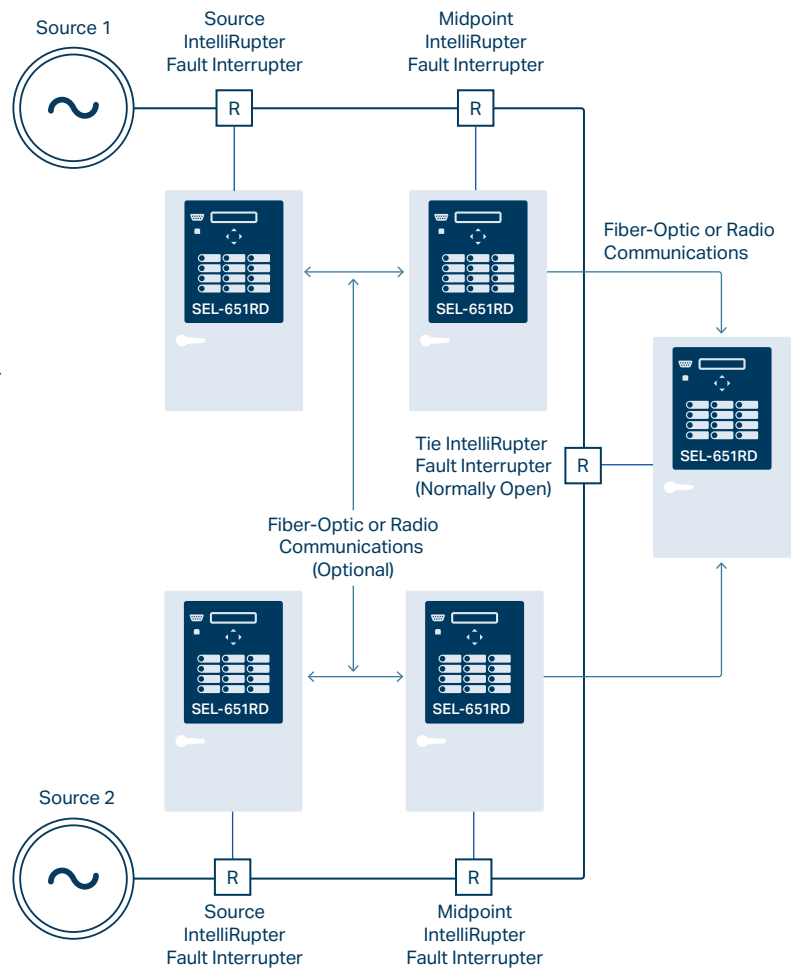
Improve System Reliability Metrics

Improve system reliability by increasing the number of reclosers that are installed on your distribution system. High-Density Coordination™ (HDC) allows reclosers to be added to both new and existing systems without having to conduct a coordination study. HDC can be implemented using a voltage-based stepped reclosing approach or a communications-assisted method. In both implementations of HDC, the scheme scales with your system when it is time to add new reclosers to the system.

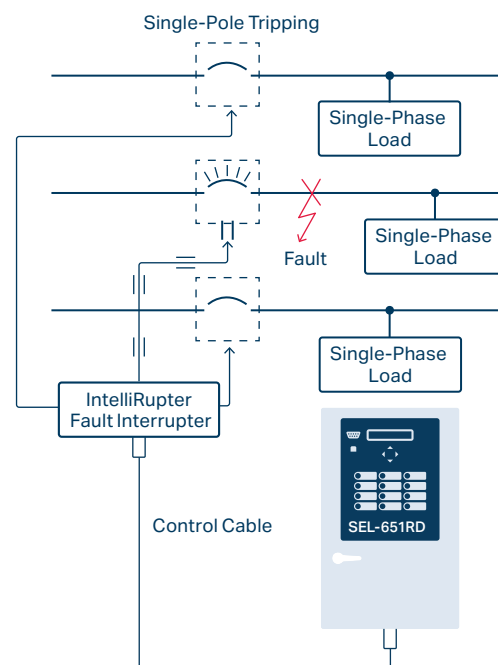
Minimize Outage Impact on Customers With Single-Phase Tripping in the SEL-651RD

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.



Example for ANR.



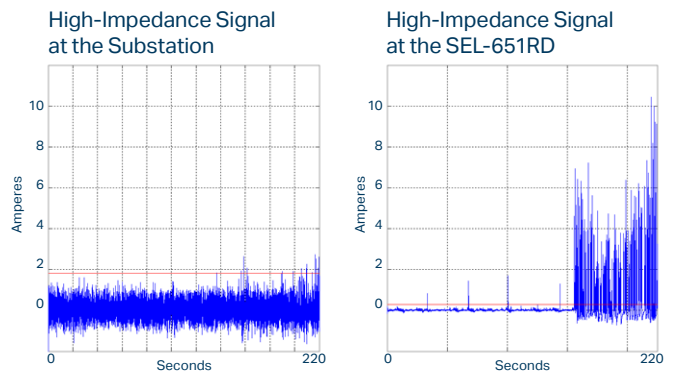
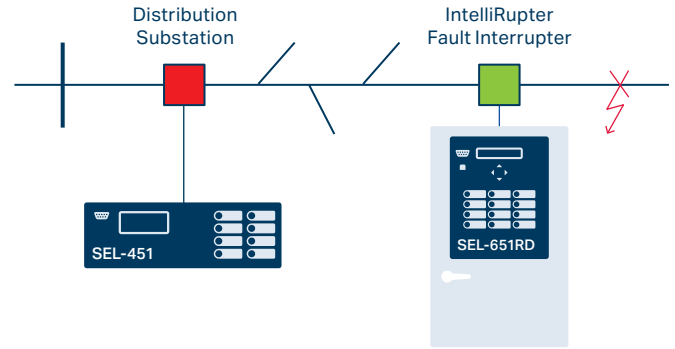
Single-phase tripping isolates only the faulted phase.

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-651RD 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).

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.

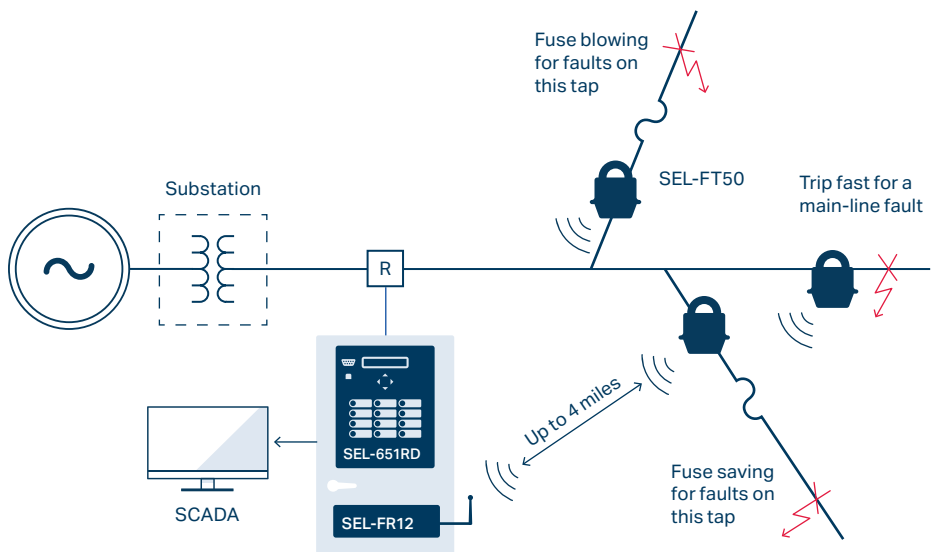


The SEL-651RD offers high-impedance fault detection, providing improved detection by being closer to the fault.

Speed Up Distribution Protection

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

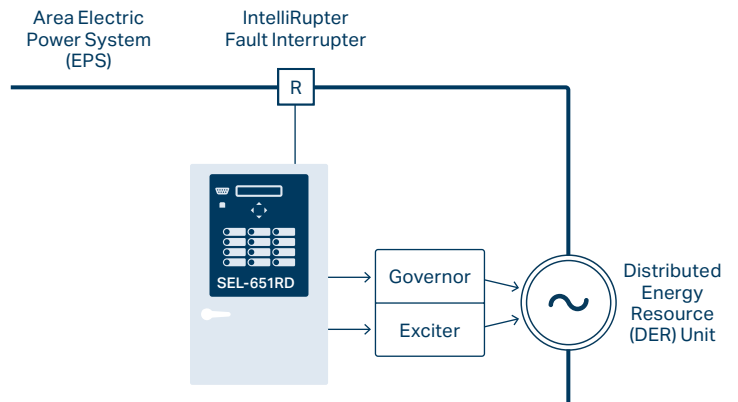
- Trip as fast as possible for main-line faults—no waiting for coordination of fuses or downstream recloser controls.
- Combine adaptive fuse-saving and fuse-blowing schemes based on the fault location.
- Disable reclosing for faults located in underground feeder sections.



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

Protect DER Interconnections

Use the SEL-651RD to interconnect microgrids and DERs to area EPSs. Together, the SEL-651RD and IntelliRupter fault interrupter 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-651RD works with microgrid controllers and generator control systems, and provides fast islanding detection to ensure protection of the DER.



Typical utility and DER interconnection.

Multilayer Security

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

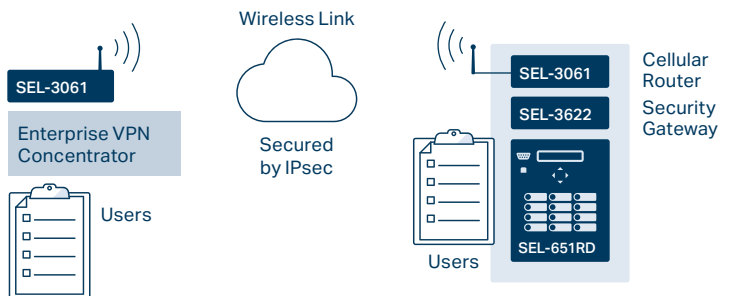
IPsec

Add the SEL-3622 Security Gateway for encrypted IPsec VPN access to the SEL-651RD. 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-651RD cabinet.

MACsec

The SEL-651RD uses MACsec to secure Ethernet traffic, 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. MACsec is available on Port 5A. Port 5B is a dedicated port for the IntelliRupter fault interrupter and does not support MACsec.

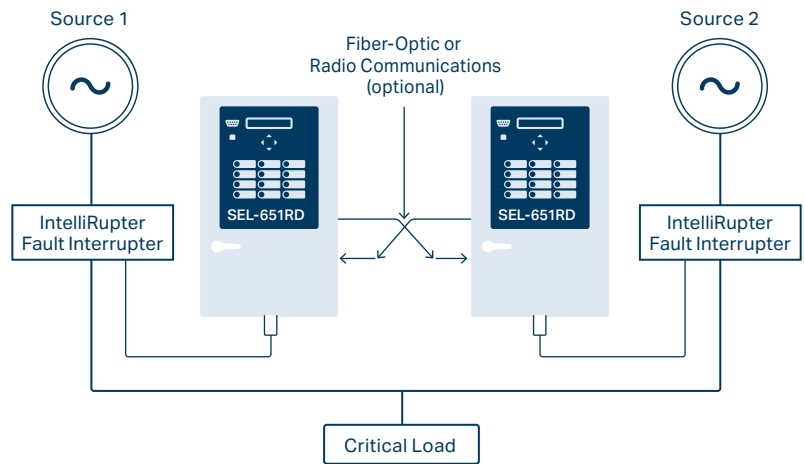


Example for Multilayer Security.

Apply Autosource Transfer Schemes

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

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



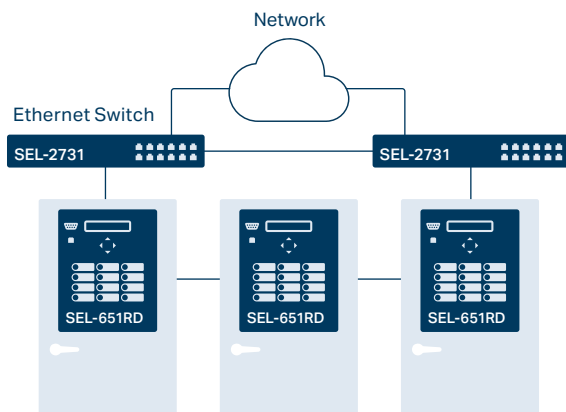
Use the SEL-651RD as part of an autosource transfer scheme.

Integration

Quickly integrate the SEL-651RD into Ethernet or serial communications networks with standard DNP3 and Modbus protocols. The SEL-651RD comes with three independent EIA-232 serial ports, one optional EIA-485 port, one USB port, and one configurable Ethernet port for external communications. The options for the Ethernet port are either 100BASE-FX fiber or 10/100BASE-T copper.

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

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



Communications Protocols

MIRRORED BITS communications

Modbus TCP

Modbus RTU

Telnet

DNP3 Serial

DNP3 IP

Web server

Simple Network Time Protocol (SNTP)

FTP

SEL Fast Messages

ASCII

IRIG-B

Communications Media

10/100BASE-T Ethernet

100BASE-FX Ethernet*

EIA-232 serial

EIA-485 serial*

USB Type B

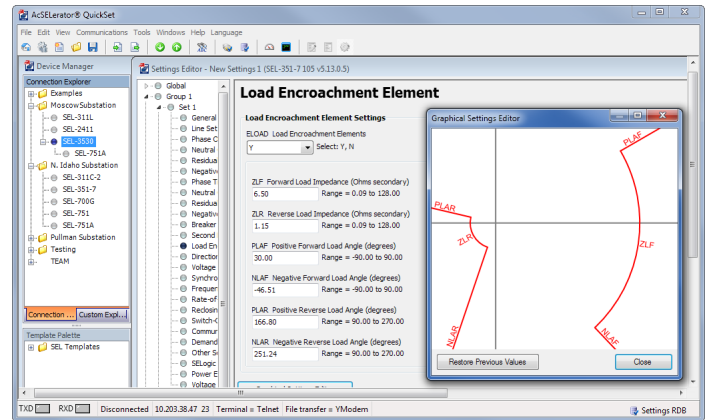
BNC (IRIG-B)

*Optional feature

ACSELERATOR® Software

Save time and simplify settings with free QuickSet.
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 the SEL-651RD. Use settings templates to customize the interface so field personnel see only the settings they need when working with the advanced digital control. Sample templates for common applications are available on the SEL website.
- Access your settings template anytime. You can store templates on the SEL-651RD 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-651RD measures signal distortions up to the 16th harmonic for each current and voltage input. The SEL-651RD 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 the SEL-651RD 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 solution.

SEL-2401 Satellite-Synchronized Clock

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



Laptop Tray Kit

Provide a stable, ergonomic platform for easier interaction with the SEL-651RD in the field. Laptop trays are easy to retrofit into existing cabinets.



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 the SEL-651RD, 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-651RD. The SEL-3622 helps create a user audit trail through strong, centralized, user-based authentication and authorization to the SEL-651RD. 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 cabinet 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-651RD with the SEL Wireless Protection System or SEL fault indicators to provide fault location information for more intelligent protection decisions and to reduce restoration times.



SEL-651RD Specifications

General Specifications	
Compatibility	S&C IntelliRupter® PulseCloser® Fault Interrupter
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 (optional) Ethernet port: Single 10/100BASE-T (RJ45 connector) Single 100BASE-FX (LC connector) (optional)
Communications Protocols	SEL, MIRRORED BITS communications, Modbus, DNP3, ASCII protocols, SNTP, built-in web server
DER Interconnection	IEEE 1547-2018
Power Supply	120–240 Vac or 125–250 Vdc Rated range: 85–264 Vac or 100–350 Vdc
Weight	<75 lb without accessories
Battery Reserve	≥8 hours at –40°C and ≥25 hours at +25°C (16 Ah standard) ≥27 hours at –40°C and ≥83 hours at +25°C (40 Ah optional)
Operating Temperature	Relay module: –40° to +85°C (–40° to +185°F) Batteries: –40° to +80°C (–40° to +176°F) Entire SEL-651RD unit: –40° to +55°C (–40° to +131°F)



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