SEL-351RS Kestrel Single-Phase Recloser Control

SEL-351RS KESTREL®

Major Features and Benefits

The SEL-351RS Kestrel® Single-Phase Recloser Control provides microprocessor-based features in a rugged housing for long, reliable service on your distribution system.

- Install single-phase reclosers for added reliability and improve feeder performance on single-phase circuits.
- Certified to IEEE C37.60 standard.
- Apply patented MIRRORED BITS® communications for high-speed protection and improved security.
- Implement underfrequency load shedding on feeder segments for improved service to critical loads.
- Secure recloser control during transformer energization through second harmonic blocking.
- Customize controls by using enhanced SELOGIC® control equations for improved system operation. Configurable control labels simplify custom functions.
- Improve feeder loading by using built-in, high-accuracy metering functions. Use watt and VAR measurements to optimize feeder operation.
- Increase efficiency of service restoration with accurate fault location.
- Quickly integrate into Ethernet or serial-based communication networks with standard DNP3 and Modbus® protocols or optional IEC 61850.
- Gather power system information and monitor wide-area performance with IEEE C37.118 synchrophasor data.
- Reduce engineering costs with ACSELERATOR QuickSet® SEL-5030 Software for relay settings and logic programming. The built-in HMI provides phasor diagrams that help support commissioning and troubleshooting.

Functional Overview

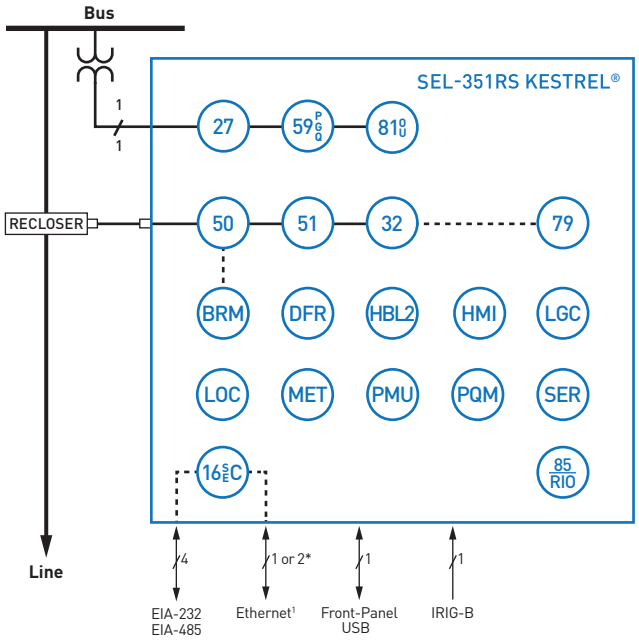


Figure 1 Functional Diagram

ANSI NUMBERS/ACRONYMS AND FUNCTIONS	
16 SEC	Access Security (Serial, Ethernet)
27	Undervoltage
32	Directional Power
50	Overcurrent
51	Time-Overcurrent
59	Overvoltage
79	Autoreclosing
81 (O, U)	Over-/Underfrequency
85 RIO	SEL MIRRORED BITS® Communications
DFR	Event Reports
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	Harmonic Blocking
LDP	Load Data Profiling
LOC	Fault Locator

[1] Copper or Fiber Optic * Optional Feature

Protection Features

EZ Settings for Basic Recloser Functions

Only settings such as minimum trip pickup, curve type, and reclose interval are necessary. These settings are made at the EZ (easy) Access Level. SELOGIC control equations cannot be changed at this access level.

Control logic is preconfigured at the factory. To customize the logic for advanced functions, the SELOGIC control equations must be reprogrammed.

Reclosing

The SEL-351RS Kestrel can reclose as many as four (4) times. This allows as many as five (5) operations of any combination of fast and delay curve overcurrent elements. Each reclose interval can be set for as many as 999,999 cycles (more than 4.5 hours), if necessary. The SEL-351RS Kestrel verifies that sufficient close power is available before issuing an autoreclose.

The reset times are set separately for reset timing for an autoreclose and reset timing for a manual/remote close from lockout. Traditionally, the reset time for a manual/remote close from lockout is set for less than the reset time for an autoreclose. The reset times have the same 999,999-cycle setting range.

Front-panel LEDs track the control state for auto-reclosing: **RESET**, **CYCLE**, or **LOCKOUT** (see *Figure 16* and *Table 4*).

Sequence coordination logic prevents fast curve trips when the SEL-351RS Kestrel detects faults on the line past a downstream recloser.

Customize reclosing logic by using SELOGIC control equations. Use programmable counters, latches, logic functions, and analog compare functions to optimize control actions.

Overcurrent Protection

Fast and Delay Curves

Use up to five cumulative fast and delay curve operations for phase overcurrent protection. For a nominal recloser CT ratio of 1000:1, these curves can be set as sensitive as 50 A primary for phase overcurrent protection.

Table 1 Curve Choices in the SEL-351RS Kestrel

Curve Type	Curve Choices
All traditional recloser curves	A, B, C, D, E, F, G, H, J, KP, L, M, N, P, R, T, V, W, Y, Z, 1, 2, 3, 4, 5, 6, 7, 8, 8PLUS, 9, KG, 11, 13, 14, 15, 16, 17, 18
U.S. curves	moderately inverse, inverse, very inverse, extremely inverse, short-time inverse
IEC curves	class A (standard inverse), class B (very inverse), class C (extremely inverse), long-time inverse, short-time inverse

Any fast or delay curve can be set with any of the curves in Table 1. The US and IEC curves conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

The traditional recloser curve choices listed in *Table 1* use the older electronic control designations. The SEL-351RS Kestrel also works with the newer microprocessor-based control designations. For example, a given traditional recloser curve has the following two designations:

Older electronic control designation: A

Newer microprocessor-based control designation: 101

Traditional recloser curve A and 101 are the same curve. Use either designation in making curve settings in the SEL-351RS Kestrel.

Modify fast and delay curves (including US or IEC curve choices) with the following traditional recloser control curve modifiers:

- Constant time adder—adds time to curve
- Vertical multiplier (time dial)—shifts whole curve up or down in time
- Minimum response time—holds off curve tripping for minimum time
- High-current trip—instantaneous trip with optional time delay
- High-current lockout—high-set lockout threshold

Front-panel target LEDs indicate any overcurrent trip in general (**TRIP** LED) and then discriminate a fast-curve trip (**FAST CURVE** LED) or a high-current trip (**HIGH CURRENT** LED). See *Figure 16* and *Table 4*.

The SEL-351RS Kestrel has two reset characteristic choices for each time-overcurrent element. One choice resets the elements if current drops below pickup for at least one cycle. The other choice emulates electromechanical induction disc elements, where the reset time depends on the time-dial setting, the percentage of disc travel, and the amount of current.

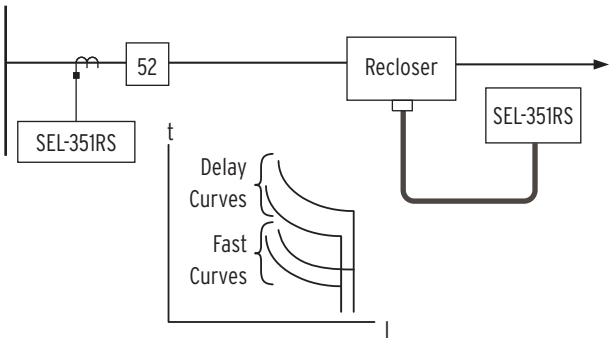


Figure 2 Coordinate Overcurrent Protective Devices

Avoid Overcurrent Element Operation for Cold-Load and Magnetizing Inrush

Distribution and feeder energization causes cold load inrush (because of loss-of-load diversity) and magnetizing inrush (because of transformer energization). The SEL-351RS Kestrel has factory-set logic (realized with SELOGIC control equations) that can be enabled to avoid phase-overcurrent element misoperation during cold-load inrush. This logic can be modified to also include second harmonic blocking elements to prevent phase overcurrent element operation because of magnetizing inrush.

Power Elements

Four independent directional power elements are available in the SEL-351RS Kestrel. You can enable individual power elements. Each enabled power element can be set to detect real power or reactive power. With SELOGIC control equations, the power elements provide a wide variety of protection and control applications. Typical applications are:

- Overpower and/or underpower protection and control.
- Reverse power protection and control.
- VAR control for capacitor banks.

Metering and Monitoring

Complete Metering Capabilities

The SEL-351RS Kestrel provides extensive and accurate metering capabilities. See *Specifications on page 19* for metering and power measurement accuracies.

As shown in *Table 2*, metering quantities include phase voltage, phase current, power frequency, and energy. The SEL-351RS Kestrel provides fundamental, demand, energy, minimum/maximum, phantom, and synchrophasor metering.

Table 2 Metering Capabilities

Quantities	Description
Current I	Input current
Voltage V	Input voltage
Power MW, MVAR	Single-phase megawatts and megavars.
Energy MWh, MVARh	Single-phase megawatt-hours and megavar-hours.
Power Factor PF	Single-phase power factor; leading or lagging.
Frequency, FREQ (Hz)	Instantaneous power system frequency (monitored on channel V).

Recloser Wear Monitor

Reclosers suffer mechanical and electrical wear every time they operate. The recloser wear monitor measures unfiltered ac current at the time of trip and the number of close-to-open operations as a means of monitoring this wear. Every time the recloser trips, the recloser control records the magnitude of the raw current. This current information is integrated, and when the result of this integration exceeds the threshold the recloser wear curve establishes, the SEL-351RS Kestrel asserts a logic point. This logic point can be routed for alarming or to modify reclosing (e.g., shorten the number of reclosures). This method of monitoring recloser wear is based solidly on methods of breaker rating from breaker manufacturers.

Figure 3 shows three setpoints necessary to emulate a breaker wear curve. Program the setpoints in *Figure 3* to customize the recloser wear curve.

The default recloser wear settings in the SEL-351RS Kestrel are per the manufacturer's recommendation for a new G&W Viper-SP or ABB Elastimold MVR single-phase recloser.

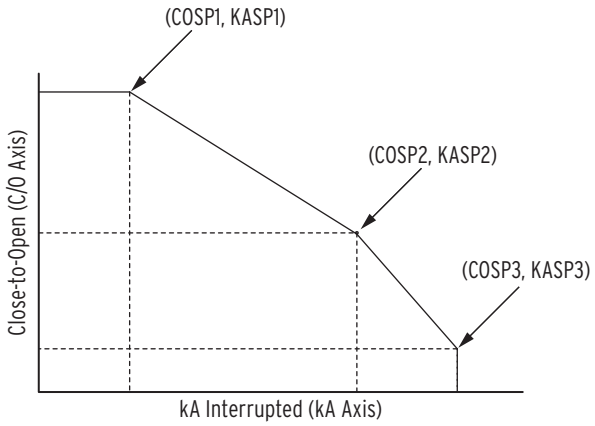


Figure 3 Recloser Contact Wear Curve and Settings

Battery System Monitor

The SEL-351RS Kestrel monitors the internal battery system, which includes the battery charger and battery. The 12 V battery powers the SEL-351RS Kestrel and provides trip and close power to the capacitors when external power is not available. The recloser control includes a temperature-compensated 12 V battery charger powered from the external source. The SEL-351RS Kestrel automatically applies a battery load test approximately once per day and includes provisions to perform a battery load test via the serial communications ports or SELOGIC.

Load Profile

The SEL-351RS Kestrel features a programmable Load Profile (LDP) recorder that records up to 15 metering quantities into nonvolatile memory at fixed time intervals. The LDP saves several days to several weeks of the most recent data depending on the LDP settings.

Synchrophasor Measurements

Send synchrophasor data using IEEE C37.118-2005 protocol to SEL synchrophasor applications. These include the SEL-3306 Synchrophasor Processor, SEL-3378 Synchrophasor Vector Processor (SVP), SEL-3530 Real-Time Automation Controller (RTAC), and the SEL SYNCHROWAVE® software suite. The SEL-3306 Synchrophasor Processor time correlates data from multiple SEL-351RS Kestrel recloser controls and other relays and concentrates the result into a single output data stream. The SEL-3378 SVP enables control applications based on synchrophasors. Directly measure the oscillation modes of your power system, and act on the result. Properly control islanding of distributed generation using wide-area phase angle slip and acceleration measurements. With the SVP you have the

power to customize synchrophasor control application based on the unique requirements of your power system. Then use SEL SYNCHROWAVE software to archive and display wide-area system measurements, which are precisely time-aligned using synchrophasor technology.

The data rate of SEL-351RS Kestrel synchrophasors is selectable with a range of one to sixty messages per second. This flexibility is important for efficient use of communication capacity. The SEL-351RS Kestrel phasor measurement accuracy meets the highest IEEE C37.118-2005 Level 1 requirement of one percent total vector error (TVE). This means you can use the low-cost SEL-351RS Kestrel in any application that otherwise would have required purchasing a separate dedicated phasor measurement unit (PMU).

Backward compatibility with the SEL Fast Message Protocol is maintained in the SEL-351RS Kestrel. Send data from one message per second to slower rates such as one message per minute using this protocol. The slow data rates are useful for integration into an existing SCADA scan rate. Use with the SEL communications processors, or the SEL-3530 RTAC, to change nonlinear state estimation into linear state estimation. If all necessary lines include synchrophasor measurements then state estimation is no longer necessary. The system state is directly measured.

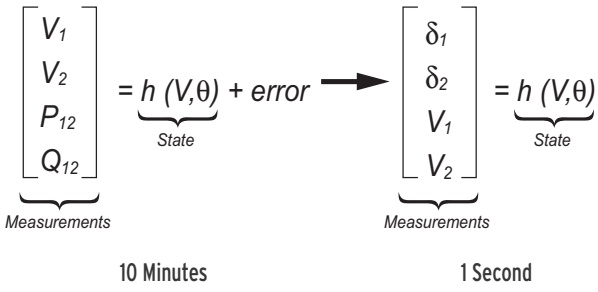


Figure 4 Synchrophasor Measurements Turn State Estimation into State Measurement

Improve Situational Awareness

Provide improved information to system operators. Advanced synchrophasor-based tools provide a real-time view of system conditions. Use system trends, alarm points, and preprogrammed responses to help operators prevent a cascading system collapse and maximize system stability. Awareness of system trends provides operators with an understanding of future values based on measured data.

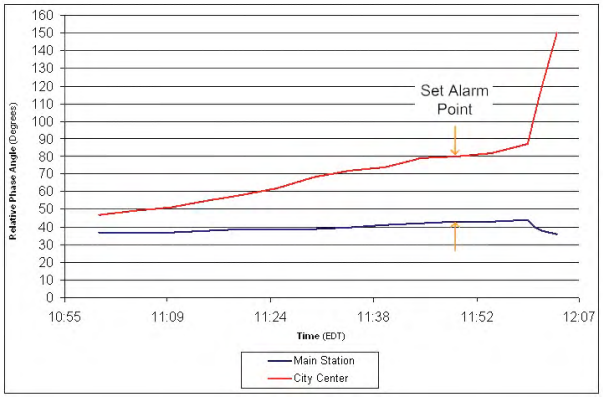


Figure 5 Visualization of Phase Angle Measurements Across a Power System

- Increase system loading while maintaining adequate stability margins.
- Improve operator response to system contingencies such as overload conditions, transmission outages, or generator shutdown.
- Advance system knowledge with correlated event reporting and real-time system visualization.
- Validate planning studies to improve system load balance and station optimization.

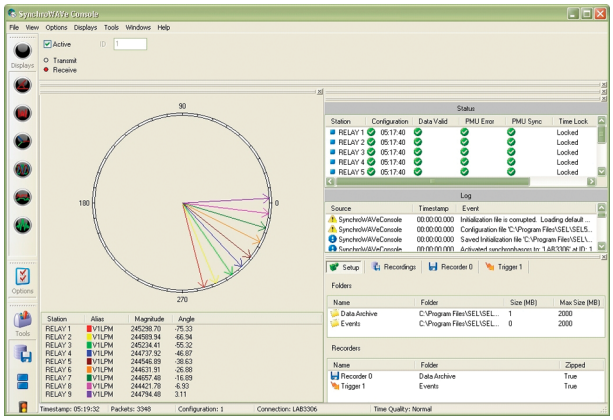


Figure 6 SEL-5078 SYNCHROWAVE Console Real-Time Wide-Area Visualization Tool

Voltage Sag, Swell, Interruption Records

The SEL-351RS Kestrel can perform automatic voltage disturbance monitoring for systems. The Sag/Swell/Interruption (SSI) Recorder uses the SSI Relay Word bits to determine when to start (trigger) and when to stop recording. The SSI recorder uses nonvolatile memory, so de-energizing the relay will not erase any stored SSI data.

The recorded data is available through the SSI Report, which includes date, time, current, voltage, and Voltage Sag/Swell/Interruption (VSSI) element status during voltage disturbances, as determined by programmable settings, VINT, VSAG, and VSWELL. When the relay is

recording a disturbance, entries are automatically added to the SSI report at one of four rates: once per quarter-cycle, once per cycle, once per 64 cycles, or once per day.

Fault Locator

The SEL-351RS Kestrel provides an accurate estimate of fault location even during periods of substantial load flow. The fault locator uses replica line impedance settings and fault conditions to develop an estimate of fault location without communications channels, special instrument transformers, or prefault information. This feature contributes to efficient dispatch of line crews and fast restoration of service.

Automation

A Multitude of Communications Options

The SEL-351RS Kestrel recloser control is equipped with Ethernet, USB, and serial communications. Ethernet options include a single fiber-optic 100BASE-FX Ethernet port, dual redundant copper 10/100BASE-T Ethernet ports, and dual redundant fiber-optic 100BASE-FX Ethernet ports. The Ethernet ports are located on the side panel. Serial port connectivity includes four independently operated ports, one EIA-232 port on the front panel, two EIA-232 ports on the side panel, and one isolated EIA-485 port on the side panel. The Type B USB port on the side panel allows for fast local communication. A special driver required for USB communication is available for download at selinc.com.

The SEL-351RS Kestrel does not require special communications software. Use any system that emulates a standard terminal system. Establish communications by connecting computers, modems, protocol converters, data concentrators, port switchers, communications processors, and printers.

Connect multiple SEL-351RS Kestrel controls to an SEL communications processor, an SEL real-time automation controller (RTAC), and SEL computing platform, or an SEL synchrophasor vector processor for advanced data collection, protection, and control schemes (see *Figure 7*).

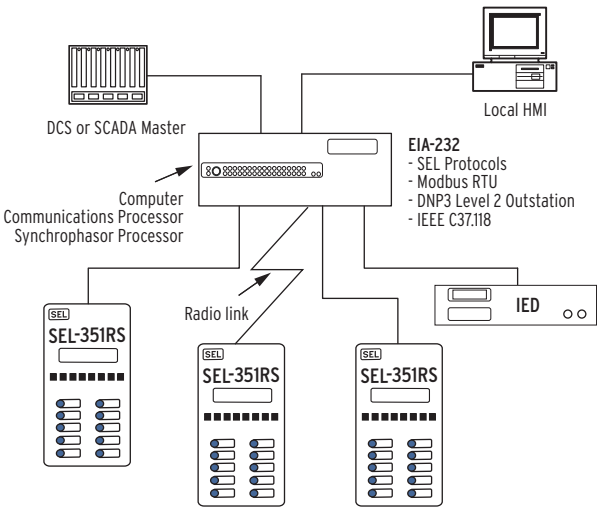


Figure 7 Typical Serial Communications Architecture

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Consult your SEL representative for more information on cable availability. The SEL-351RS Kestrel can communicate directly with SCADA systems, computers, and RTUs via serial or Ethernet port for local or remote communications (see *Figure 8*).

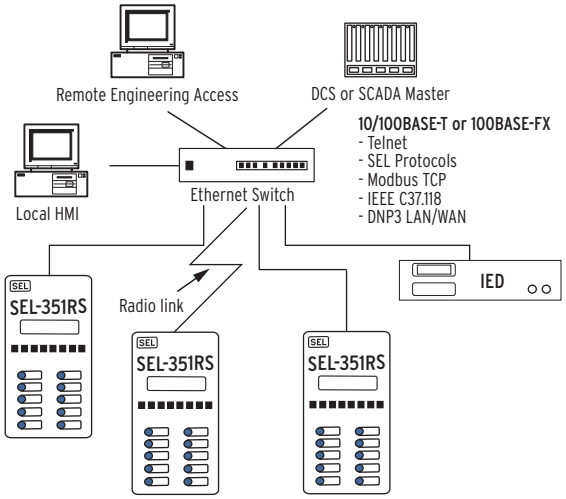


Figure 8 Typical Ethernet Communications Architecture

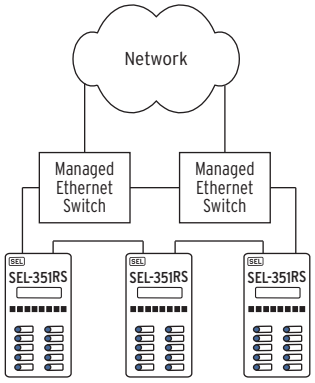


Figure 9 Self-Healing Ring Using Internal Ethernet Switch

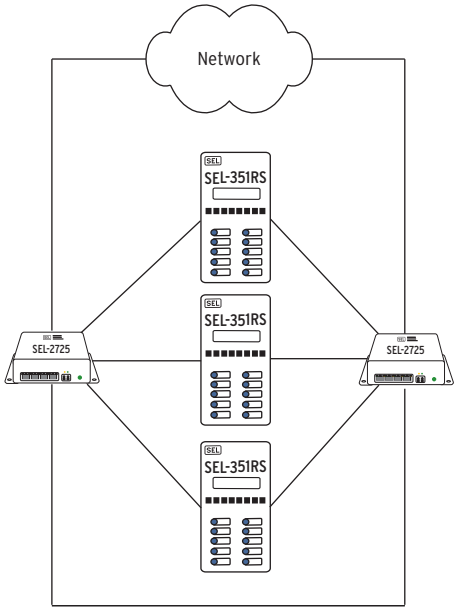


Figure 10 Failover Network Topology

Dual-Port Ethernet Network Configuration Options

The dual-port Ethernet option increases network reliability and availability by incorporating the relay with external managed or unmanaged switches. Implement a self-healing ring structure with managed switches, or use unmanaged switches in a dual-redundant configuration (see *Figure 9* and *Figure 10*).

Table 3 lists the communications protocols available on the SEL-351RS Kestrel for protection, monitoring, control, interrogation, setting, and reporting.

Table 3 Open Communications Protocol (Sheet 1 of 2)

Type	Description
IEC 61850	Ethernet-based international standard for interoperability between intelligent devices in a substation. Operates remote bits, breaker controls, and I/O. Monitors Relay Word bits and analog quantities.
Simple ASCII	Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter and Fast Operate	Serial or Telnet binary protocol for machine-to-machine communications. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element and I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so binary SCADA metering information is not lost while an engineer or technician is transferring an event report or communicating with the relay using ASCII communications through the same relay communications port.
SEL Distributed Port Switch (LMD) Protocol	Enables multiple SEL devices to share a common communications bus (two-character address setting range is 01–99). Use this protocol for low-cost, port-switching applications.
Fast SER Protocol	Provides serial or Ethernet SER data transfers with original time stamps to an automated data collection system.
Modbus RTU or TCP	Serial or Ethernet-based Modbus with point remapping. Includes access to metering data, protection elements, contact I/O, targets, relay summary events, and settings groups.

Table 3 Open Communications Protocol (Sheet 2 of 2)

Type	Description
DNP3 Serial or LAN/WAN	Serial or Ethernet-based Distributed Network Protocol with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and setting groups.
IEEE C37.118	Serial or Ethernet Phasor Measurement Protocol. Streams synchrophasor data to archiving historian for post-disturbance analysis, to visualization software for real-time monitoring, or to synchrophasor data processor for real-time control.

Flexible Control Logic and Integration

SEL-351RS Kestrel control logic improves integration in the following ways:

- **Program pushbuttons, LEDs, and local control switches to your specific scheme.** Nine conveniently sized programmable operator control pushbutton controls and associated programmable LEDs are located on the SEL-351RS Kestrel front panel (see *Figure 16*). In addition, up to 16 local control switch functions (local bits LB1–LB16) can be programmed for operation through the **CNTRL** front-panel pushbutton. Set, clear, or pulse selected local bits with the front-panel pushbuttons and display. Program the front-panel operator pushbuttons and LEDs and the local bits into your control scheme with SELOGIC control equations. Use the front-panel operator pushbuttons and the local bits to perform functions such as turning autoreclosing on and off.
- **Control remote switches through various communications.** Use serial or LAN/WAN communications to control up to 16 remote control switches (remote bits RB1–RB16). Set, clear, or pulse selected remote bits over serial port or network communications using ASCII, DNP, or Modbus commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip, close, and turning autoreclose on or off.
- **Use latch control switches to maintain status through power loss.** Perform traditional latching relay functions, such as "remote control enable", with 16 internal logic latch control switches (latch bits LT1–LT16). Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote control switches, local control switches, or any programmable logic condition. The latch bits retain their state when the control loses power.
- **Customize the rotating display and LEDs.** Use 16 programmable rotating messages on the front-panel LCD display to define custom text messages (e.g., Recloser Open, Recloser Closed, and real-time analog quantities) that report power system or relay conditions. In addition, all but one of the 16 target LEDs are programmable for either trip-latch or real-time status indication. The operator pushbutton LEDs can also be programmed for status indication.
- **Eliminate settings changes.** Selectable setting groups make the SEL-351RS Kestrel ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions.

  The control stores six setting groups. Select the active setting group by optoisolated input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies.

  Changing setting groups switches logic and group settings. Program groups for different operating conditions, such as feeder paralleling, station maintenance, seasonal operations, emergency contingencies, loading, source changes, and downstream relay setting changes.
- **SELOGIC counters.** The SEL-351RS Kestrel has eight counters that can be programmed to increment, decrement, and reset using SELOGIC control equations. Applications include setting analog logic and counters to detect loss of voltage conditions indicating upstream recloser openings.

Fast SER Protocol

SEL Fast Sequential Events Recorder (SER) protocol provides SER events to an automated data collection system. SEL Fast SER protocol is available on any serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-351RS Kestrel recloser controls.

SEL controls and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

ACSELERATOR QuickSet SEL-5030

Use ACSELERATOR QuickSet to develop settings off-line. The system automatically checks interrelated settings and highlights out-of-range settings. Transfer the settings created off-line to the SEL-351RS Kestrel using a PC communications link. The software converts event reports to oscillograms with time-coordinated element assertion and phasor/sequence element diagrams. View real-time phasors via ACSELERATOR QuickSet. The ACSELERATOR QuickSet interface supports Microsoft® Windows® 7, Windows Vista, Windows XP, Windows Server 2003, and Windows Server 2000 operating systems.

With the licensed version of ACSELERATOR QuickSet, you can create personalized Application Designs. Use Application Designs within ACSELERATOR QuickSet to quickly implement advanced schemes such as automatic network reconfiguration. Application Designs hide settings you do not want changed (e.g., SELOGIC control equations), while making visible the minimum necessary settings (e.g., timer and pickup settings) to implement the scheme. You can alias and manipulate mathematically all settings for simple end-user interfacing. You can also define custom notes and settings ranges. Application Designs enhance security by allowing access to only a specified group of settings. Create Application Designs that include the most commonly used relay features and settings for your system (see *Figure 11*) and watch commissioning times drop drastically.

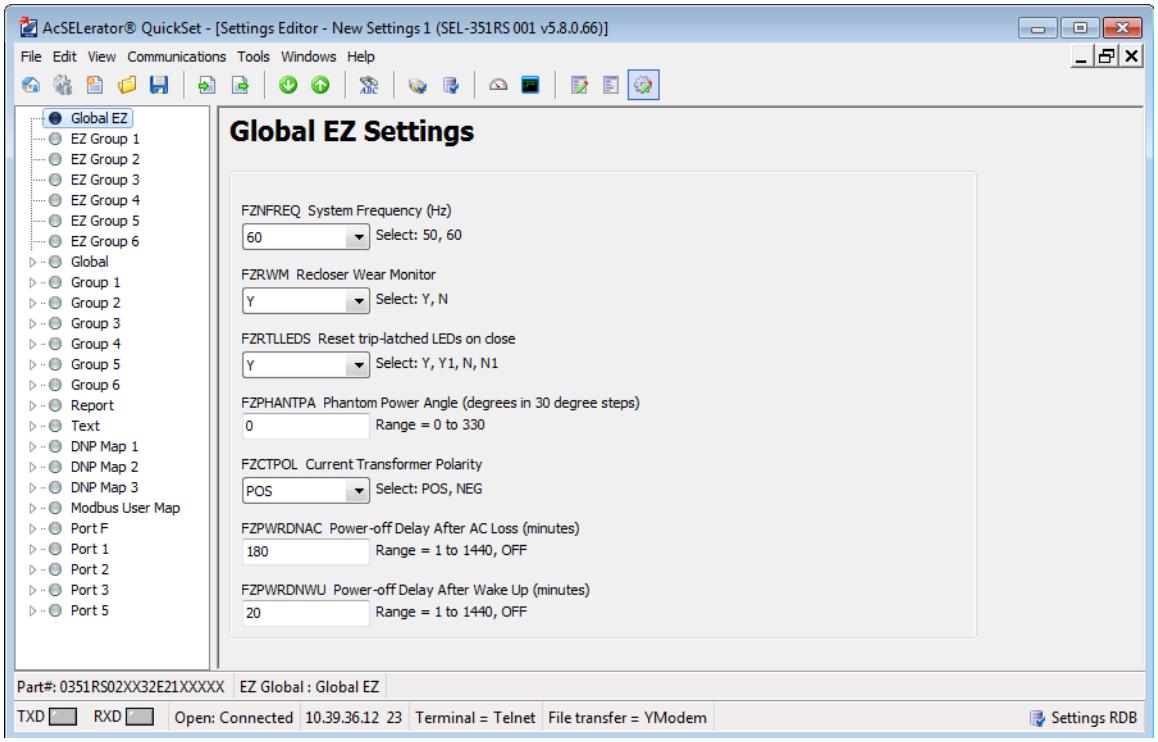


Figure 11 Example Application Design

Integrated Web Server

An embedded read-only web server is included in every SEL-351RS Kestrel recloser control. Browse to the recloser control with any standard web browser to safely read settings, verify recloser control self-test status, inspect meter reports, and read recloser control configuration and event history. The web server allows no control or modification actions, so users can be confident that an inadvertent button press will have no averse effects. *Figure 12* shows the settings display web page.

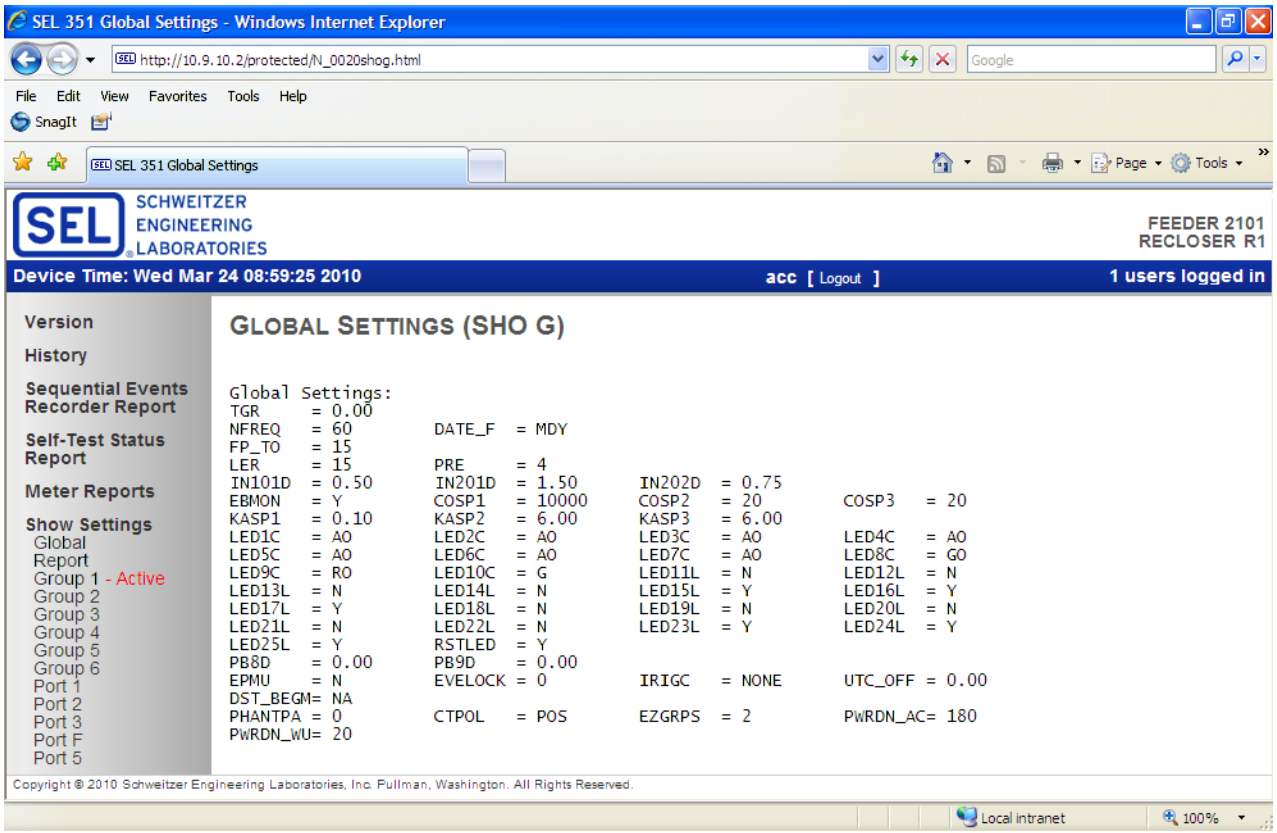


Figure 12 Settings Display Web Page

Advanced Capabilities for Maximum Control

Selective Load Shedding for Improved System Response

Use the SEL-351RS Kestrel to preserve critical loads while balancing system loading. In the example in *Figure 13*, the same feeder serves both a fire department and a hospital as well as residential loads. Incorporating underfrequency elements into the SEL-351RS Kestrel recloser control provides you the power to segment the feeder to maximize load preservation while still responding to system conditions. You can set the reclosers serving the residential loads with as many as six levels of frequency and time conditions to coordinate with other controls during a loss of generation.

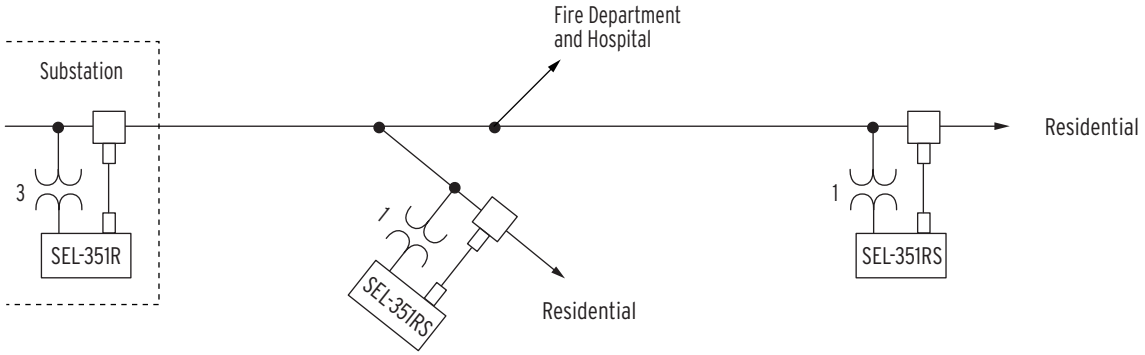


Figure 13 Implement Underfrequency Load Shedding With SEL-351RS Kestrel Recloser Controls to Preserve Critical Loads

MIRRORED BITS Relay-to-Relay Communications

The SEL-patented MIRRORED BITS communications technology provides bidirectional relay-to-relay digital communication. MIRRORED BITS can operate independently on as many as two EIA-232 serial ports on a single SEL-351RS Kestrel. With MIRRORED BITS operating on two serial ports, there is communication upstream and downstream from the SEL-351RS Kestrel site.

This bidirectional digital communication creates eight additional virtual outputs (transmitted MIRRORED BITS) and eight additional virtual inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS mode (see *Figure 14*). Use these MIRRORED BITS to transmit/receive information between an upstream relay and a downstream recloser control to enhance coordination and achieve faster tripping for downstream faults. MIRRORED BITS technology also helps reduce total scheme operating time by eliminating the need to assert output contacts to transmit information.

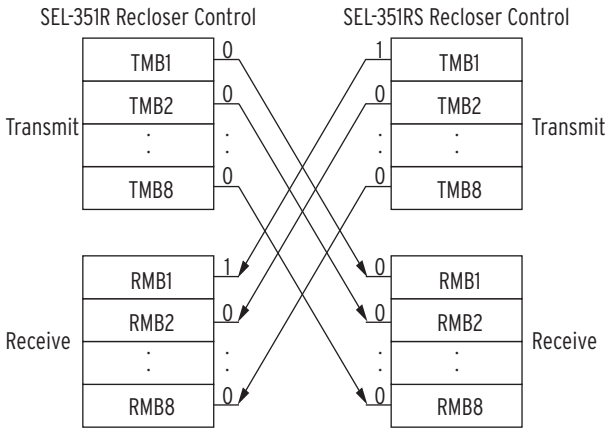


Figure 14 MIRRORED BITS Transmit and Receive Bits

Coordinate Three-Phase Lockout for Single-Phase Faults

The SEL-351RS Kestrel may be coordinated with other single-phase reclosers at a single location or with upstream three-phase devices. For a single-phase permanent fault it may be preferred to trip and lock out all three phases. Using MIRRORED BITS for fast relay-to-relay communication, the SEL-351RS Kestrel can send a signal to coordinating devices, these devices can then trip and lock out until repairs are made or network reconfiguration is complete.

Advanced SELOGIC Control Equations

Advanced SELOGIC control equations allow you to assign relay outputs to any logical combination of Relay Word elements or inputs.

Program SELOGIC control equations by combining relay elements, inputs, and outputs with SELOGIC control equation operators. Bits in a table called the Relay Word reflect the state of all logical elements in the recloser control. These logical elements include all current (50/51) and directional-level detecting elements, timer elements, SELOGIC control equation variables, inputs, outputs, and remote, local, and latched bits.

SELOGIC control equation operators include OR, AND, invert, parentheses, and rising and falling edges of element state changes. Analog compare functions (<, >, =, < >) are also available. These functions add control flexibility to customize logic based on recloser shot count or other control values.

The basic building blocks of SELOGIC control equations are the Relay Word bits. The Relay Word bits are simple digital quantities having a logical value of either 0 or 1. The terms “assert” or “asserted” refer to a Relay Word bit that has a value of 1 or is changing from 0 to 1. The terms “deassert” or “deasserted” refer to a Relay Word bit that has a value of 0 or is changing from 1 to 0. Various elements within the recloser control assert or deassert Relay Word bits. Use these elements in the fixed internal logic of the recloser control to make decisions, to interpret inputs, or to drive outputs. These bits are available so that you can exercise flexibility in defining inputs or outputs, in specifying control variables for internal logic, or in creating special customized logic through the use of SELOGIC control equations.

In addition to Boolean logic, 16 general purpose SELOGIC control equation timers eliminate external timers for custom protection or control schemes. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any element (e.g., time qualify a voltage element) you specify. Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.

Hardware Overview

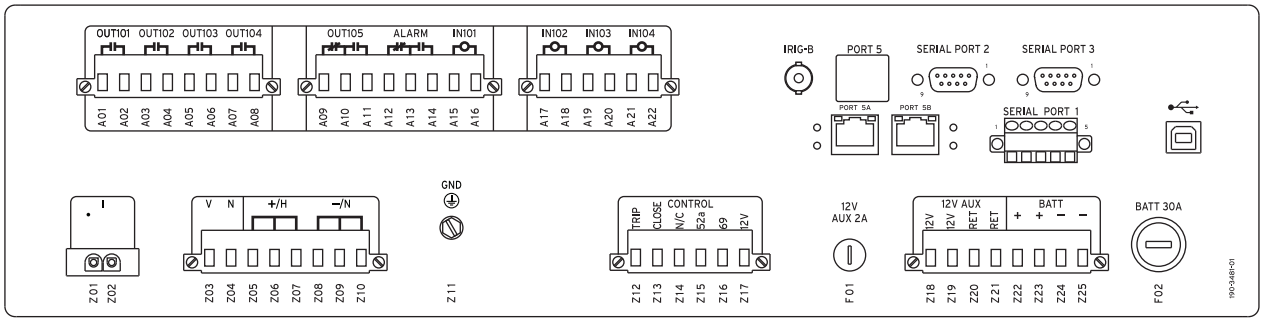
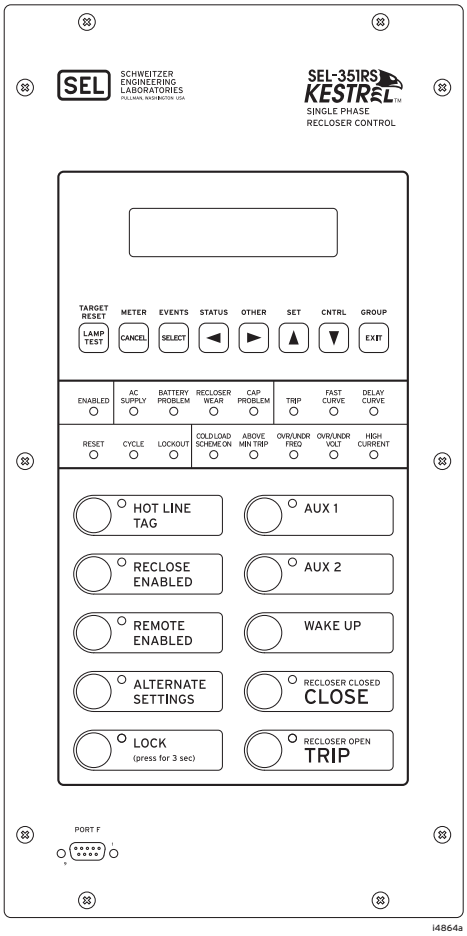


Figure 15 SEL-351RS Kestrel Side Panel

Front-Panel Interface

The control panel on the SEL-351RS Kestrel is designed to provide easy-to-use and flexible operation by field personnel. *Figure 16* shows default functions. You can change most functions by programming to meet system requirements (see *Table 4*). Use the configurable labels to customize the targets and control pushbuttons to best meet operational needs.



See noted safety features for CLOSE and TRIP operator controls in Table 4.

Figure 16 SEL-351RS Kestrel Recloser Control Front-Panel Interface

Table 4 Factory Default Front-Panel Interface Definitions (see Figure 16)

Function	Definition
PUSHBUTTONS	Except for **TARGET RESET/LAMP TEST**, the pushbuttons have dual functions (primary/secondary). After you select a primary function (i.e., **METER** pushbutton), the pushbuttons operate on their secondary functions (**CANCEL**, **SELECT**, left/right arrows, up/down arrows, **EXIT**) so you can scroll through information, activate settings/control, etc., on the LCD.
ENABLED[a]	SEL-351RS Kestrel Recloser Control is enabled.
AC SUPPLY	Control power is present.
BATTERY PROBLEM	Indicates battery problems.
BREAKER WEAR	Breaker contact wear has reached the 100 percent wear level.
CAP. PROBLEM	Indicates capacitor or capacitor charger problem.
TRIP	Trip occurred.
FAST CURVE	Fast curve overcurrent element trip.
DELAY CURVE	Delay curve overcurrent element trip.
RESET	The control is in the reset state, ready for a reclose cycle.
CYCLE	The control is actively in the trip/reclose cycle mode.
LOCKOUT	All reclose attempts were unsuccessful.
COLD LOAD SCHEME ON	Cold-load scheme active.
ABOVE MIN. TRIP	Current level above minimum set overcurrent element pickup.
OVER/UNDER FREQ.	Over/underfrequency element trip.
OVER/UNDER VOLT.	Over/undervoltage element trip.
HIGH CURRENT	High-set overcurrent element trip.
HOT LINE TAG	No closing or autoreclosing can take place via the control.
RECLOSE ENABLED	Enable/disable autoreclosing.
REMOTE ENABLED	Enable/disable remote control.
ALTERNATE SETTINGS	Switches active setting group between main and alternate setting groups.
LOCK (press for 3 seconds)	Blocks the function of other operator controls (except **WAKE UP** and **TRIP**). Three-second delay to engage/disengage.
AUX 1	User programmable; e.g., program to trip Test—test autoreclose logic without applying current.
AUX 2	User programmable; e.g., program to enable/disable fast-curve tripping.
WAKE UP[a]	Wakes up the control after it has been put to sleep.
CLOSE/RECLOSER CLOSED	Close recloser/recloser closed status.[b]
TRIP/RECLOSER OPEN	Trip recloser (go to lockout)/recloser open status.[c]

[a] These indicated LEDs and the operator controls have fixed functions. Programming at a higher logic level can change functions of all other LEDs and operator controls (with corresponding status LEDs).

[b] You can set the CLOSE operator control with a delay, which allows an operator to press CLOSE and then move a safe distance away from the recloser before closing proceeds.

[c] You can set the TRIP operator control with a delay, which allows an operator to press TRIP and then move a safe distance away from the recloser before tripping proceeds.

External Connections

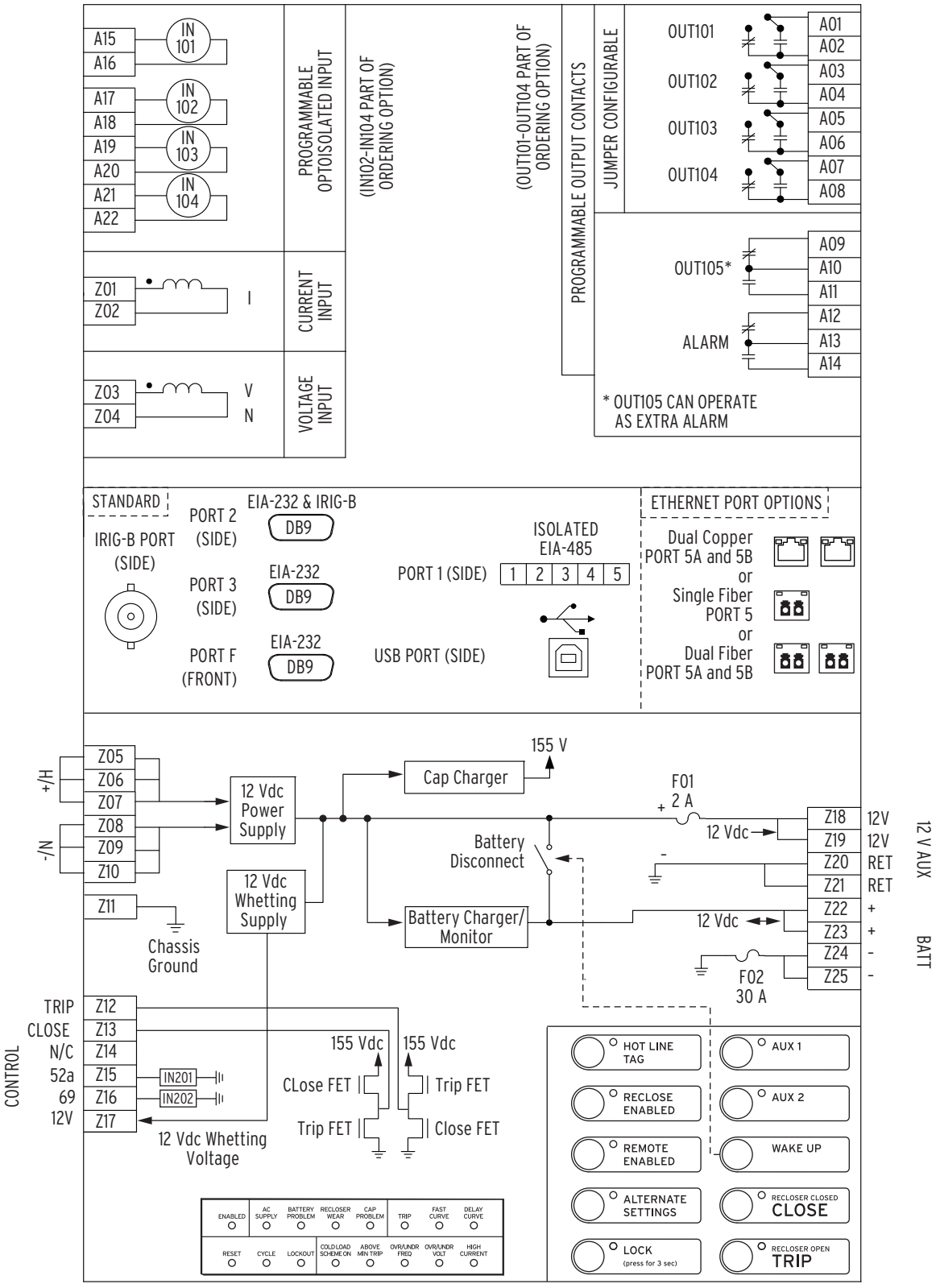


Figure 17 SEL-351RS Kestrel Module Inputs, Outputs, and Communications Ports

Table 5 Control Cable Receptacle Pin Descriptions

A	Monitored Auxiliary Contact (52a)	**F**	Current Return (500:1 CT ratio)[a]
B	Monitored 69 Contact	**G**	Recloser Ground
C	Terminal Current, I (1000:1 CT ratio)	**H**	+12 Vdc (Whetting Voltage) for monitoring recloser status
D	Current Return (1000:1 CT ratio)	**J**	Trip
E	Terminal Current, I (500:1 CT ratio)[a]	**K**	Close

[a] Only applicable for G&W Viper-SP single-phase recloser.

Figure 18 shows the pinout for the control cable receptacle.

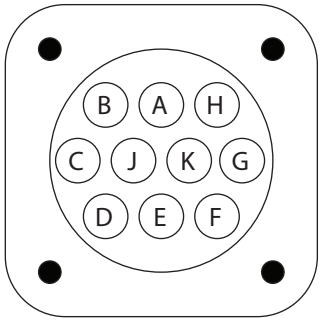
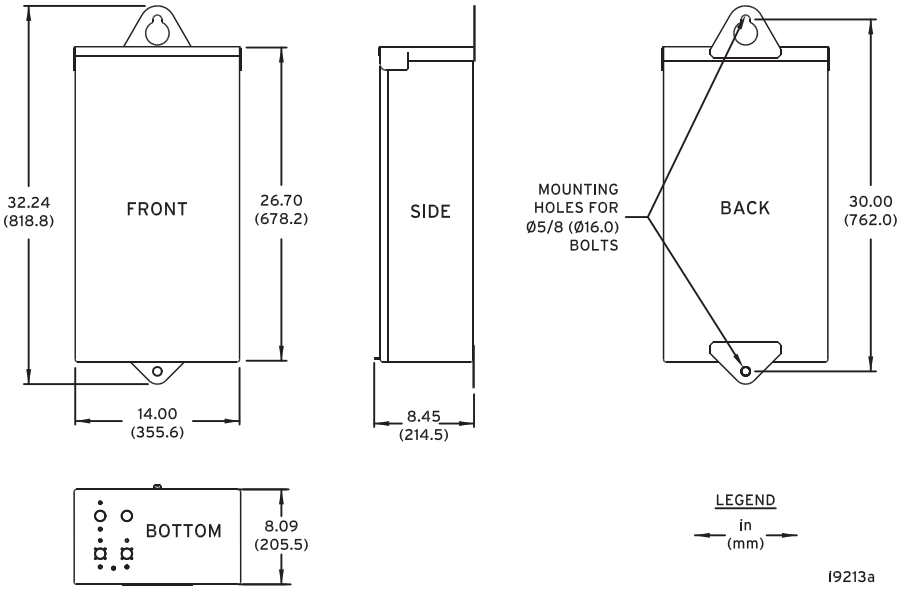


Figure 18 Control Cable Receptacle Pinouts (View From Inside Enclosure)

Relay Mounting



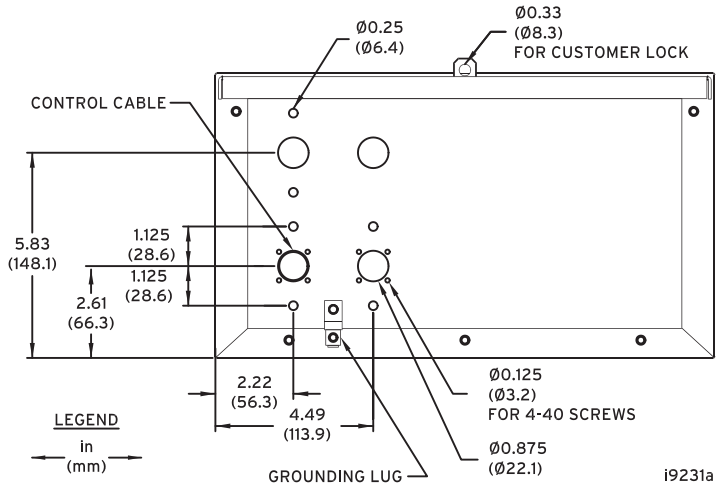
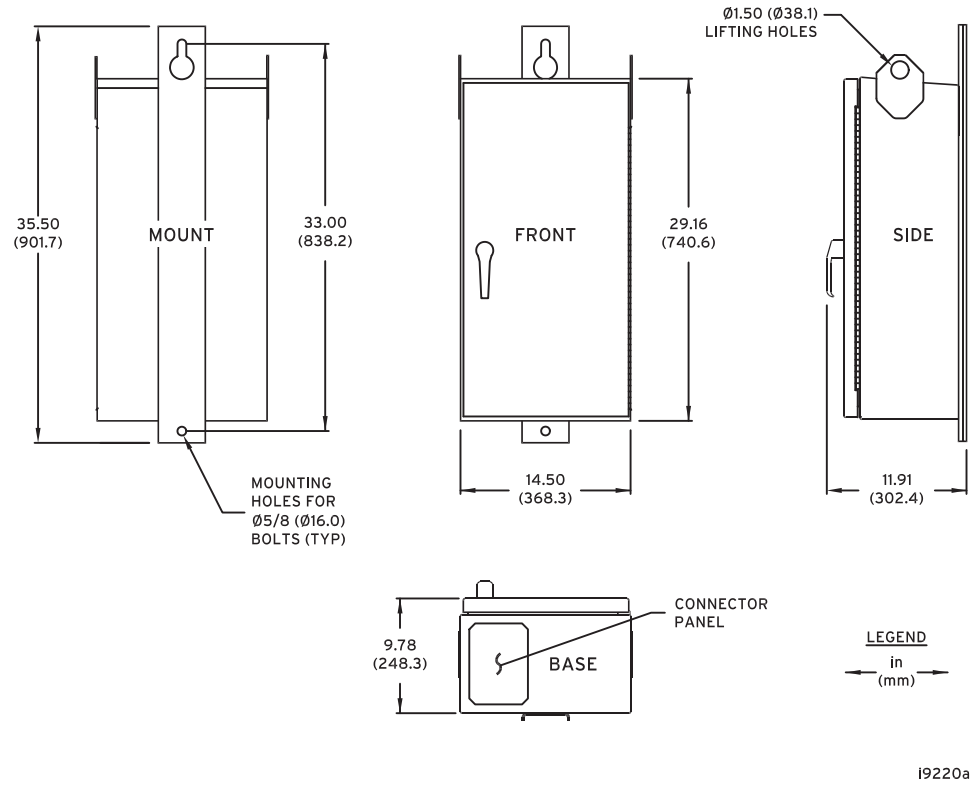


Figure 19 SEL-351RS Kestrel Lift-to-Open Enclosure Dimensions and Mounting



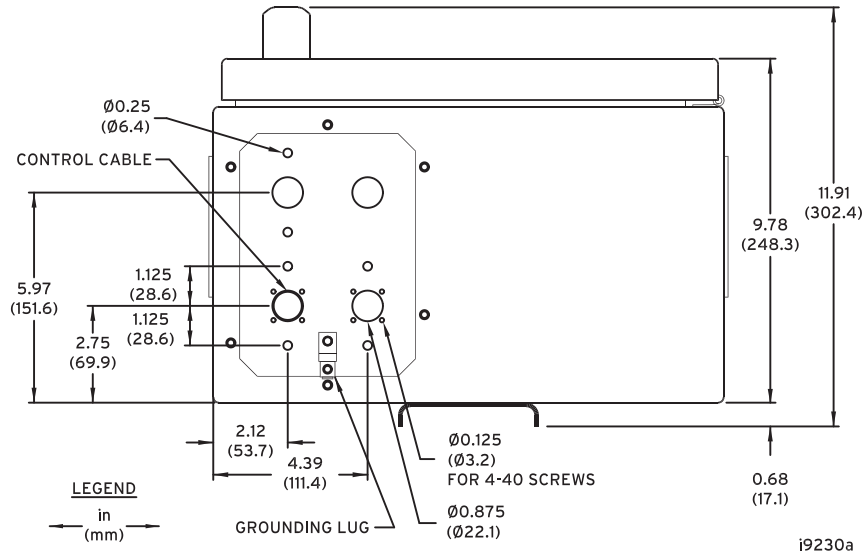


Figure 20 SEL-351RS Kestrel Swing Open Enclosure Dimensions and Mounting

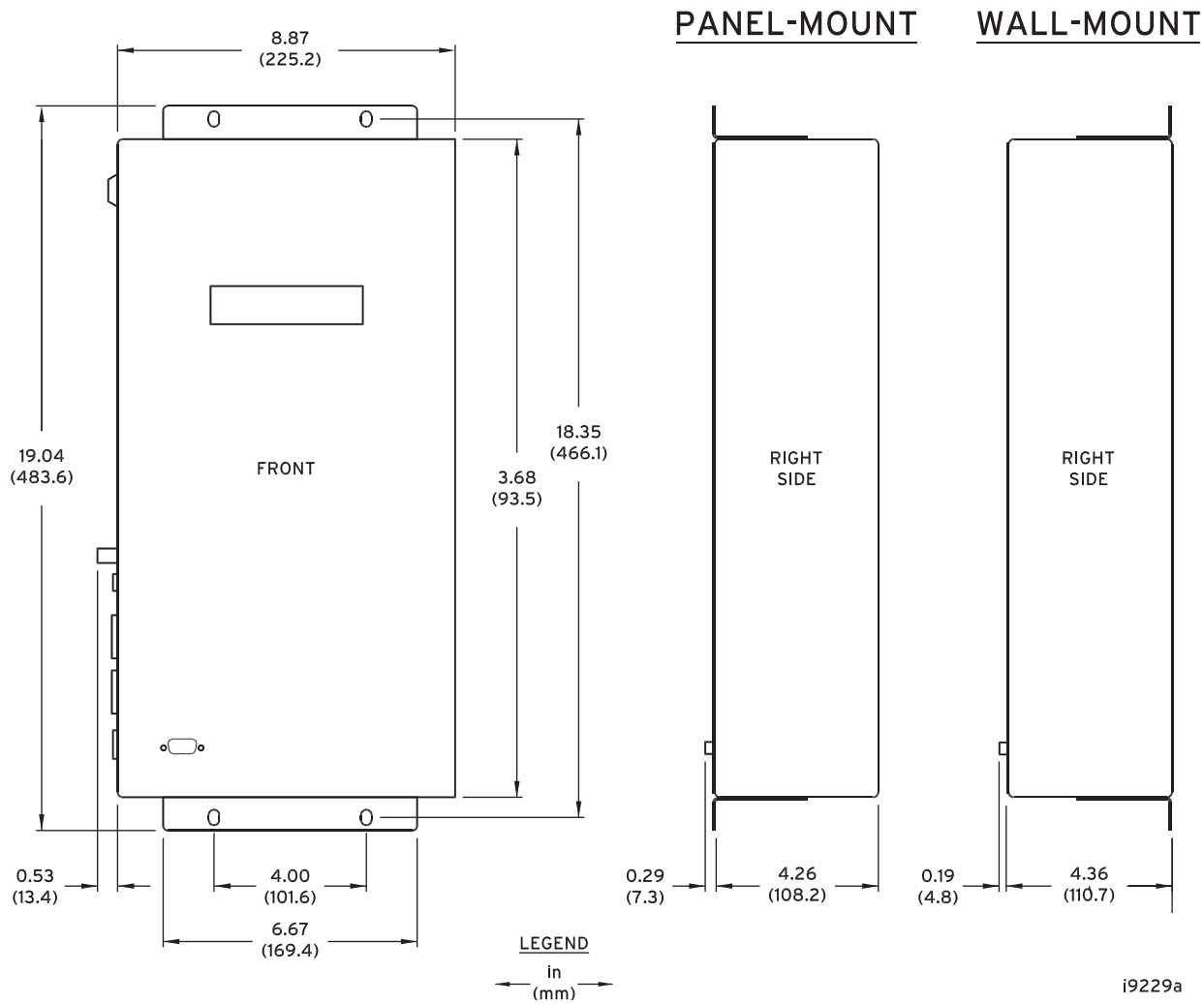


Figure 21 SEL-351RS Kestrel Control Module Dimensions

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

General

AC Current Input

1 A Nominal:	3 A continuous, linear to 20 A symmetrical; 100 A for 1 s, 125 A peak for one cycle
Burden:	0.13 VA @ 1 A 1.31 VA @ 3 A

AC Voltage Input

Nominal Range:	67–120 Vrms Line-to-Neutral
Continuous:	300 Vrms Line-to-Neutral (connect any voltage up to 300 Vac)
Short-Term Overvoltage:	600 Vac for 10 seconds
Burden:	0.03 VA @ 67 V 0.06 VA @ 120 V 0.80 VA @ 300 V

Power Supply

Rated Range:	85–264 Vac 100–350 Vdc
Frequency Range:	40.1–65 Hz
Burden:	< 90 VA

12 V Auxiliary Power Supply

With AC Present:	12 Vdc ± 10%
Without AC Present:	10.2–16 Vdc (Battery Voltage)
Power:	13 W continuous

Output Contacts

Make:	30 A per IEEE C37.90-1989
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	270 Vac / 360 Vdc; 75 J
Pickup Time:	< 5 ms, typical
Dropout Time:	< 5 ms, typical

Breaking Capacity (10000 operations, L/R = 40 ms):

24 V	0.75 A
48 V	0.50 A
125 V	0.30 A
250 V	0.20 A

Cyclic Capacity (2.5 cycle/second, L/R = 40 ms):

24 V	0.75 A
48 V	0.50 A
125 V	0.30 A
250 V	0.20 A

Note: Make per IEEE C37.90-1989
Note: Breaking and Cyclic Capacity per IEC 60255-0-20:1974.

Trip and Close Outputs

Coil Voltage:	155 + 5, –3 Vdc
Coil Current:	12–17 A (Close), 4 A (Trip)
Pulse Duration:	53–55 ms (Close), 28–30 ms (Trip)

Optoisolated Input

DC Range

12 Vdc:	Pickup 9.6–14.4 Vdc

Note: Optoisolated inputs draw approximately 4–10 mA of current.

Frequency

System Frequency:	50 or 60 Hz
Frequency Tracking Range:	40.1–65 Hz

Note: Voltage connected to V required for frequency tracking.

Communications Ports

EIA-232:	One front; two side
EIA-485:	One side, 2100 Vdc of isolation
Per Port Baud Rate Selections:	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600
USB:	One side, (Type B connector, CDC class device)
Ethernet:	One 10/100BASE-T side port (RJ45 connector) (discontinued option) Two 10/100BASE-T side port optional (RJ45 connector) One or two 100BASE-FX side ports optional multimode (LC connectors) Internal Ethernet switch included with second Ethernet port.

Time-Code Input

Recloser control accepts demodulated IRIG-B time-code input at isolated BNC and Port 2 on the side panel. Do not connect the time-code input into both the BNC and Port 2 at the same time. Recloser control time is synchronized to within ±5 ms of time-source input.

Synchronization Accuracy

Internal Clock:	± 1 µs
Synchrophasor Reports (e.g., **MET PM**, **EVE P**, **CEV P**):	± 10 µs
All Other Reports:	± 5 ms

Simple Network Time Protocol (SNTP) Accuracy

Internal Clock:	± 5 ms

Unsynchronized Clock Drift

Relay Powered:	2 minutes per year, typical

Operating Temperature

Relay Module:	–40° to +85°C (–40° to +185°F)
Batteries:	–40° to +80°C (–40° to +176°F)
Entire SEL-351RS Kestrel Unit:	–40° to +60°C (–40° to +140°F)

Note: LCD contrast impaired for temperatures below – 20°C (–4°F). The entire SEL-351RS Kestrel unit was tested at +70°C (+158°F). The difference in ratings allows for temperature rise due to sunlight.

Weight

< 34 kg (75 lbs) including batteries

Battery Specifications

Base Version Requirement

Normal Capacity:	16.0 amp-hours at +25°C (+77°F)
Run Time (Relay electronics operate at typical load plus one trip/close cycle):	≥ 15 hours at +25°C (+77°F) ≥ 5 hours at –40°C (–40°F)
Estimated Life:	≥ 4 years at +25°C (+77°F) ≥ 1 year at +80°C (+176°F)
Recharge Time:	≤ 16 hours at +25°C (+77°F)

Extended Capacity Option Requirement

Normal Capacity:	40 amp-hours at +25°C (+77°F)
Run Time (Relay electronics operate at typical load plus one trip/close cycle):	≥ 48 hours at +25°C (+77°F)
Estimated Life:	≥ 4 years at +25°C (+77°F) ≥ 1 year at +80°C (+176°F)
Recharge Time:	≤ 40 hours at +25°C (+77°F)

Type Tests

Environmental Tests

Cold:	IEC 60068-2-1:2007 Environmental testing procedures, Part 2-1: Tests—Test Ad: Cold
Dry Heat:	IEC 60068-2-2:2007 Environmental testing procedures, Part 2-2: Tests—Test Bd: Dry Heat
Damp Heat Cyclic:	IEC 60068-2-30:2005 Basic environmental testing procedures, Part 2-30: Tests, Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle), (six-day type test)

Dielectric Strength and Impulse Tests

Dielectric:	IEC 60255-5:2000 IEEE C37.90-2005 2500 Vac on analogs, contact inputs, and contact outputs except Trip and Close; 3100 Vdc on power supply for 10 s
Impulse:	IEC 60255-5:2000 Electrical relays, Part5: Insulation tests for electrical relays. Section 6.1.3: Impulse Voltage Tests Severity Level: 0.5 Joule, 5 kV

Electrostatic Discharge Test

ESD:	IEC 60255-22-2:2008 IEC 61000-4-2:2008 Electrical disturbance tests for measuring relays and protective equipment, Electrostatic discharge tests, Severity Level: 2, 4, 6, 8 kV contact discharge all points except serial ports, 15 kV air discharge to all other points IEEE C37.90.3-2001 IEEE Standard for Electrostatic Discharge Tests for Protective Relays. Severity Level: 2, 4, and 8 kV contact; 4, 8, and 15 kV air

RFI and Interference Tests

Conducted RF Immunity:	IEC 60255-22-6:2001 IEC 61000-4-6:2008 Immunity to conducted disturbance induced by radio frequency fields. Severity Level: 10 Vrms
RFI Immunity:	IEC 61000-4-3:2008 Radiated, radio-frequency, electromagnetic field immunity, Severity Level: 10 V/m IEEE C37.90.2-2004 Standard for withstand capability of relay systems to radiated electromagnetic interference from transceivers, Severity Level: 35 V/m
Digital Radio Telephone RF Immunity:	ENV 50204:1995 Radiated electromagnetic field from digital radiotelephones—Immunity test Severity Level: 10V/m at 900 MHz and 1.89 GHz
Surge Withstand:	IEEE C37.90.1-2002 Severity Level: 2.5 kV oscillatory; 4.0 kV fast transient

Electromagnetic Compatibility Emissions Tests

Radiated and Conducted Emissions:	Canada ICES-001(A) / NMB-001(A)

Vibration and Shock Tests

Sinusoidal Vibration:	IEC 60255-21-1:1988 Severity Level: Class 1 Endurance, Class 2 Response
Shock and Bump:	IEC 60255-21-2:1988 Severity Level: Class 1—Shock withstand, Bump, Class 2—Shock Response
Seismic:	IEC 60255-21-3:1993 Severity Level: Class 2—Quake response

Miscellaneous

Enclosure Protection:	NEMA 250-2008 Enclosures for Electrical Equipment, Enclosure type 3R IEC 60529:2001 + CRGD:2003 BS EN 60529 Second Edition:1992 + REAF:2004 IP45 (Swing Open Enclosure only)

Recloser Type Tests

ANSI/IEEE C37.60-2003, performed with the following single-phase reclosers:

G&W Viper-SP	27 kV, 12.5 kA interrupting 800 A continuous
ABB Elastimold MVR	27 kV, 12.5 kA interrupting 800 A continuous

Section 6.3 Switching Tests

Performed at ≥ 27 kV and 60 Hz, using Table 9.

Load-Switching:	10 close-open operations at ≥ 800 A
Line-Charging Switching:	20 close-open operations at ≥ 5 A
Cable-Charging Switching:	20 close-open operations at ≥ 25 A

Section 6.5 Rated Symmetrical Interrupting Current Tests

Performed at ≥ 27 kV and 60 Hz, using Table 6 and Table 10b.
Each operation is an open-close-open-close-open sequence.
16 operations at 11.25 kA to 12.5 kA
56 operations at 5.63 kA to 6.87 kA
44 operations at 1.88 kA to 2.5 kA

Section 6.13 Control Electronic Elements Surge Withstand Capability (SWC) Tests

Clause 6.13.1 Oscillatory and fast transient surge tests
Performed in accordance with IEEE Std. C37.90.1-2002

Clause 6.13.2 Simulated surge arrester operation test
Gap flashover at 0.8 • BIL rating
Peak surge current of 7000 A following gap flashover

ANSI/IEEE C37.60-2012, performed with the following single-phase reclosers:

G&W Viper-SP	38 kV, 12.5 kA interrupting 800 A continuous
ABB Elastimold MVR	38 kV, 12.5 kA interrupting 800 A continuous

Section 6.111 Control Electronic Elements Surge Withstand Capability (SWC) Tests

Clause 6.111.2 Oscillatory and fast transient surge tests
Performed in accordance with IEEE Std. C37.90.1-2002

Clause 6.111.3 Simulated surge arrester operation test
Gap flashover at 0.8 • BIL rating
Peak surge current of 6000 A following gap flashover

Processing Specifications and Oscillography

AC Voltage and Current Inputs

128 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 3 kHz.

Digital Filtering

Digital low-pass filter then decimate to 32 samples per cycle followed by one cycle cosine filter.
Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Protection and Control Processing

Four times per power system cycle.

Oscillography

Length:	15, 30, or 60 cycles
Total Storage:	11 seconds of analog and binary
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII
Time-Stamp Resolution:	1 µs when high-accuracy time source is connected (**EVE P** or **CEV P** commands)
Time-Stamp Accuracy:	See *Time-Code Input on page x.x*

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (with respect to time source):	± 5 ms

Relay Elements Pickup Ranges and Accuracies

Instantaneous/Definite-Time Overcurrent Elements (50)

Pickup Range:	0.05–20.00 A, 0.01 A steps
Steady-State Pickup Accuracy:	±3% of setting and ±0.01 A
Transient Overreach:	±5% of pickup
Time Delay:	0.00–16,000.00 cycles, 0.25–cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting

Time-Overcurrent Elements (51)

Pickup Range:	0.05–3.2. A, 0.01 A steps
Steady-State Pickup Accuracy:	±3% of setting and ±0.01 A
Time Dial Range:	0.5–15.0, 0.01 steps (US) 0.05–1.00, 0.01 steps (IEC) 0.10–2.00, 0.01 steps (Recloser curves)
Curve Timing Accuracy:	±1.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup

Second Harmonic Blocking Elements

Pickup Range:	5–100 % of fundamental, 1% steps
Steady-State Pickup Accuracy:	2.5 percentage points
Pickup/Dropout Time:	< 1.25 cycles
Time Delay:	0.00–16,000.00 cycles, 0.25 cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting

Under- (27)/Overvoltage (59) Elements

Pickup Range:	0.00–300.00 V, 0.01 V, or 0.02 V steps
Steady-State Pickup Accuracy:	±1% and ± 2 V for 12.5–300.00 V
Transient Overreach:	±5% of pickup

Under-/Overfrequency Elements (81)

Pickup Range:	40.10–65.00 Hz, 0.01 Hz steps
Time Delays:	2.00–16,000.00 cycles, 0.25-cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting
Steady-State *plus* Transient Overshoot:	±0.01 Hz for 1 Hz step change
Undervoltage Frequency Element Block Range:	25.00–300.00 V

Timers

Pickup Ranges:	0.00–999,999.00 cycles 0.25-cycle steps (reclosing relay and some programmable timers) 0.25-cycle steps (some programmable and other timers)
Pickup/Dropout Accuracy:	±0.25 cycle and ±0.1% of setting

Metering Accuracy

Accuracies are specified at 20°C and at nominal system frequency and voltages < 250 V unless noted otherwise.

Voltage V:	±0.2%, (67–300.0 V)
Current I:	±0.1% and ±1 mA (0.1–20 A)
Phase Angle Accuracy:	±0.5°
Power Accuracy (MW/MVAR):	at load angle

Accuracy (MW/MVAR)	**at load angle**
for phase current ≥ 0.2 A secondary:	
0.35% / –	0° or 180° (unity power factor)
0.40% / 6.00%	±8 or ±172°
0.75% / 1.50%	±30° or ±150°
1.00% / 1.00%	±45° or ±135°
1.50% / 0.75%	±60° or ±120°
6.00% / 0.40%	±82° or ±98°
– / 0.35%	±90° (power factor = 0)

Energy Meter Accumulators:	Separate IN and OUT accumulators updated twice per second, transferred to nonvolatile storage once per day.
ASCII Report Resolution:	0.1 MWh

Accuracy:	The accuracy of the energy meter depends on applied current and power factor as shown in the power metering accuracy table above. The additional error introduced by accumulating power to yield energy is negligible when power changes slowly compared to the processing rate of twice per second.

Synchrophasor Accuracy

Maximum Data Rate in Messages per Second

IEEE C37.118 Protocol:	60 (nominal 60 Hz system) 50 (nominal 50 Hz system)
IEEE C37.118 Accuracy:	Level 1 at maximum message rate when phasor has the same frequency as phase voltage
Current Range:	(0.1–2) • I_{NOM}
Frequency Range:	± 5 Hz of nominal (50 or 60 Hz)
Voltage Range:	30 V–300 V
Phase Angle Range:	–179.99° to 180.00°

Power Element Accuracy

Pickup Setting 0.07–0.4 VA:	±0.01 A • $V_{SECONDARY}$ and ± 10% of setting at unity power factor for power elements and zero power factor for reactive power elements
Pickup Setting 0.4–2600 VA:	±0.005 A • $V_{SECONDARY}$ and ± 5% of setting at unity power factor

Notes

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