SEL-351R-4 Recloser Control

Take Control of Your Recloser

Major Features and Benefits

The SEL-351R-4 Recloser Control is the replacement for the legacy SEL-351R Recloser Control. Throughout the rest of this data sheet, the SEL-351R-4 is referred to as just the SEL-351R.

New Features

➤ Increase operation time during outages and extend battery life with the 16 Ahr battery and improved battery monitor/charger.
➤ Improve corrosion resistance with an aluminum cabinet that is also taller and lighter.
➤ Increase reliability with a maximum ambient temperature rating increase to +55°C (+131°F) for the entire unit.
➤ Take advantage of an increased power supply range that accepts ac or dc power. Power the control with ac voltage out in the field (120 or 230 Vac) or dc voltage inside the substation (125 or 250 Vdc).
➤ Use Fast SER (sequential events recorder) protocol to interleave binary time-stamped SER data with regular communications over the same serial port.

Existing Features

➤ Modernize existing recloser installations to provide cost-saving protection, automation, and control features. Use standard control cables for easy installation.
➤ Improve reliability using automatic network reconfiguration. Patented MIRRORED BITS® communications speeds protection and improves security.
➤ Use enhanced SELOGIC® control equations to customize controls and improve system operation. Configurable front-panel 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. Measure three-phase values with either three potential transformers or use “phantom” values derived from a single-phase voltage.
Functional Overview

Figure 1  Functional Diagram

Functional Replacement for Traditional Recloser Control

EZ Settings for Basic Recloser Functions
For traditional recloser functions, the SEL-351R is easy to set. Only settings such as minimum trip pickup, curve type, and reclose interval are necessary. These settings are made at an 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-351R 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.

After a reclose interval has timed out, the control waits a user-set time (close power wait time) for the presence of closing power before proceeding with the autoreclose. The recloser needs either primary or secondary (e.g., 120 Vac) voltage to provide the closing power, depending on how the recloser is equipped. The 120 Vac power into the SEL-351R is an indication of the presence of this primary or secondary voltage. The close power wait time has the same 999,999-cycle setting range as the reclose interval.

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 autoreclosing: \textit{RESET}, \textit{CYCLE}, or \textit{LOCKOUT} (see Figure 14 and Table 4).

Sequence coordination logic is enabled to prevent the SEL-351R from tripping on its fast curves for faults beyond 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 and ground overcurrent protection. For a nominal recloser CT ratio of 1000:1, these curves can be set as sensitive as 50 A and 5 A primary for phase and ground overcurrent protection, respectively.

Table 1 Curve Choices in the SEL-351R

<table>
<thead>
<tr>
<th>Curve Type</th>
<th>Curve Choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>All traditional recloser curves</td>
<td>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</td>
</tr>
<tr>
<td>U.S. curves</td>
<td>moderately inverse, inverse, very inverse, extremely inverse, short-time inverse</td>
</tr>
<tr>
<td>IEC curves</td>
<td>class A (standard inverse), class B (very inverse), class C (extremely inverse), long-time inverse, short-time inverse</td>
</tr>
</tbody>
</table>

Any fast or delay curve (phase or ground) can be set with any of the curves in Table 1. The U.S. 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-351R 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-351R.

Modify fast and delay curves (including U.S. 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 14 and Table 4.

Sensitive Earth Fault (SEF) Element

A sensitive earth fault (SEF) element with time delay (as long as 16,000 cycles) can be set as sensitive as 5 A primary (assuming nominal recloser CT ratio of 1000:1). Current channel IN with a 0.05 A secondary nominal rating provides this sensitivity (see Wiring Diagram on page 13).

Schweitzer Engineering Laboratories, Inc.
The front-panel SEF LED indicates any SEF element trip (see Figure 14 and Table 4).

**Custom Overcurrent Protection**
Customize the overcurrent protection by reprogramming the corresponding SELOGIC control equations.

**Metering and Monitoring**

**Complete Metering Capabilities**
The SEL-351R provides extensive and accurate metering capabilities. See Specifications on page 15 for metering and power measurement accuracies.

Metered quantities include phase voltages and currents (including demand currents); sequence voltages and currents; power (including demand), frequency, and energy; and maximum/minimum logging of selected quantities (see Table 2). The recloser control reports all metered quantities in primary quantities (current in A primary and voltage in kV primary).

Assign voltage inputs V1, V2, V3 and current inputs I1, I2, I3 (see Figure 15) separately to phases A, B, C—no wiring changes required.

### Table 2 Metering

<table>
<thead>
<tr>
<th>Quantities</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currents I_A, I_B, I_C, I_G</td>
<td>Input currents, residual ground current (I_G = 3I_0 = I_A + I_B + I_C).</td>
</tr>
<tr>
<td>Voltages V_A, V_B, V_C</td>
<td>Wye-connected voltage inputs, synchronism-check voltage input.</td>
</tr>
<tr>
<td>Energy MWh_A, MWh_B, MWh_C</td>
<td>Single- and three-phase megawatt-hours.</td>
</tr>
<tr>
<td>Power Factor PF_A, PF_B, PF_C</td>
<td>Single- and three-phase power factor; leading or lagging.</td>
</tr>
<tr>
<td>Sequence I_1, I_2, I_3</td>
<td>Positive-, negative-, and zero-sequence currents.</td>
</tr>
<tr>
<td>Frequency, FREQ (Hz)</td>
<td>Instantaneous power system frequency (monitored on channel V1).</td>
</tr>
</tbody>
</table>

*a* If true three-phase voltage is not connected, the voltage (V_A, B, C) uses phantom voltages derived from a single-phase voltage to calculate MW/MVAR, MWh/MVARh, and power factor metering values.

**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 in each phase. This current information is integrated on a per-phase basis.

When the result of this integration exceeds the threshold the recloser wear curve establishes, the SEL-351R asserts a logic point for the affected phase. 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 4* shows three set points necessary to emulate a breaker wear curve. Program the set points in *Figure 4* to customize the recloser wear curve.

![Figure 4 Recloser Contact Wear Curve and Settings](image-url)
Fault Locator

The SEL-351R provides an accurate estimate of fault location even during periods of substantial load flow. The fault locator uses fault type, 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. The fault locator requires three-phase voltage inputs.

Automation

Flexible Control Logic and Integration

The SEL-351R has four independently operated serial ports: one EIA-232 port on the front and two EIA-232 ports and one optional EIA-485 port on the side. The recloser control does not require special communications software. Use any system that emulates a standard terminal system. Establish communication by connecting computers, modems, protocol converters, printers, SEL communications processor (e.g., SEL-2032), SCADA serial port, and/or RTU for local or remote communication.

Apply an SEL Communications Processor as the hub of a star network, with a point-to-point fiber or copper connection between the hub and the SEL-351R, as in Figure 5. The SEL Communications Processor supports external communications links, including the public switched telephone network for engineering access to dial-out alerts and private line connections of the SCADA system.

SEL manufactures a variety of standard cables for connecting this and other IEDs to a variety of external devices. Consult your SEL representative for more information on cable availability.

Table 3 Open Communications Protocols

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple ASCII</td>
<td>Plain language commands for human- and simple-machine communications. Use for metering, setting, self-test status, event reporting, and other functions.</td>
</tr>
<tr>
<td>Compressed ASCII</td>
<td>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.</td>
</tr>
<tr>
<td>Extended Fast Meter and Fast Operate</td>
<td>Binary protocol for machine-to-machine communications. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected.</td>
</tr>
<tr>
<td>Distributed Port Switch Protocol</td>
<td>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.</td>
</tr>
<tr>
<td>Fast SER Protocol</td>
<td>Provides serial SER data transfers with original time stamps to an automated data collection system.</td>
</tr>
<tr>
<td>DNP3 Level 2 Outstation</td>
<td>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.</td>
</tr>
</tbody>
</table>

ACSELERATOR QuickSet

Use ACSELERATOR QuickSet® SEL-5030 Software to develop settings offline. The system automatically checks interrelated settings and highlights out-of-range settings. Transfer the settings created offline to the SEL-351R using a PC communications link. The software converts event reports to oscillograms with time-coordinated element assertion and phasor/sequence element diagrams. The ACSELERATOR QuickSet interface supports Microsoft® Windows® operating systems. View real-time phasors via ACSELERATOR QuickSet.
ACSELERATOR QuickSet additionally allows users to 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 6) and watch commissioning times drop drastically.

Figure 6  Example Application Design

Advanced Capabilities for Maximum Control

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.
**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-351R. With MIRRORED BITS operating on two serial ports, there is communication upstream and downstream from the SEL-351R 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 7). 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 (see Figure 9). MIRRORED BITS technology also helps reduce total scheme operating time by eliminating the need to assert output contacts to transmit information.

**Dual Source for Premium Reliability**

Either Recloser 1 or Recloser 2 can serve the load in Figure 8. The respective SEL-351R detects the state of source- and load-side voltages. The controls communicate via fiber-optic cable to determine whether the load should be transferred quickly to the other source in the event of an outage. MIRRORED BITS communications technology (see Figure 7) and SEL-2815 Fiber-Optic Transceivers accomplish this communication reliably and economically.

**Automatic Network Reconfiguration for Distribution Flexibility**

Systems using automatic network reconfiguration, such as the one in Figure 9, improve service factors by removing permanently faulted segments without interrupting service for nonfaulted segments. Use the SEL-351R in a variety of possible systems, either with or without communication between devices (e.g., MIRRORED BITS; see Figure 7). You can set analog logic and counters, available in some SEL-351R models, to detect loss of voltage conditions indicating upstream recloser openings. Change setting groups in intermediate recloser controls to reverse direction when the tie recloser is closed. Use either reclose shot counting or time coordination to determine a faulted segment.

Optional voltage elements provide three-phase measurements from one side of the recloser and a single-phase measurement from the other side.

Check the voltage on the two other phases by using the ac setting on the level-sensitive inputs.
Figure 9  Automatic Network Reconfiguration Showing Improved Service

Selective Load Shedding for Improved System Response
Use retrofit recloser controls to preserve critical loads while balancing system loading. In the example in Figure 10, the same feeder serves both Fire Department and Hospital as residential loads. Incorporating underfrequency elements into the SEL-351R 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 10  Implement Underfrequency Load Shedding With SEL-351R Recloser Controls to Preserve Critical Loads

Hardware Overview
The convenient swing-panel construction of the SEL-351R provides easy access to all controls and connections. Communications ports, contacts, and control cable connection points are all readily available.

Figure 11  SEL-351R Side Panel
Figure 12  SEL-351R Enclosure With Swing Panel Open
Recloser Control Connections

The control cable from the recloser attaches at the bottom of the SEL-351R enclosure to a standard receptacle. The wiring from this receptacle continues into the control itself, with the currents and control landing on the side-panel terminals.

The 120 or 230 Vac power parallels voltage channel $V_1$, as shown in the retrofit of a traditional installation in Figure 13. If you order the SEL-351R with additional voltage channels $V_2$, $V_3$, and $V_S$, connect true three-phase voltage and synchronism-check voltage to the side-panel terminals.

An internal battery monitor/charger provides battery charging/discharging. Through this battery monitor/charger the SEL-351R can monitor battery voltage. The SEL-351R puts itself to sleep if voltage falls to a user-set threshold (or if a user-set timer times out) after an extended outage.

The SEL-351R can also be powered with 125 Vdc or 250 Vdc. See Specifications on page 15 for complete power supply range.

Figure 13 Connections Inside the SEL-351R Enclosure
## Front-Panel Interface

The control panel on the SEL-351R is designed to provide easy-to-use and flexible operation by field personnel. *Figure 14* shows default functions. You can change most functions by programming to meet system requirements (see *Table 4*). Use the optional configurable labels to customize the targets and control pushbuttons to best meet operational needs.

### Display

- **Display**: 2 x 16 liquid crystal display (LCD)

### Pushbuttons

1. Pushbuttons

### Status and Trip Target LEDs

2. Status and Trip Target LEDs

3. Operator Controls

### Operator Controls

- Ample spacing allows for protective glove operation of all basic recloser control function (note the corresponding status LED just to the right of each operator control, except WAKE UP).

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

### Figure 14  SEL-351R Recloser Control Front-Panel Interface

### Table 4  Factory-Default Front-Panel Interface Definitions (see Figure 14)  (Sheet 1 of 2)

<table>
<thead>
<tr>
<th>Function</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> PUSHDuttons</td>
<td>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.</td>
</tr>
<tr>
<td><strong>2</strong> CONTROL ENABLED&lt;sup&gt;a&lt;/sup&gt;</td>
<td>SEL-351R Recloser Control is enabled. Adequate ac power is present. Indicates battery problems. No closing or autoreclosing can take place via the control. Trip occurred. Fast curve overcurrent element trip.</td>
</tr>
<tr>
<td>AC SUPPLY</td>
<td></td>
</tr>
<tr>
<td>BATTERY PROBLEM</td>
<td></td>
</tr>
<tr>
<td>HOT LINE TAG</td>
<td></td>
</tr>
<tr>
<td>TRIP</td>
<td></td>
</tr>
<tr>
<td>FAST CURVE</td>
<td></td>
</tr>
</tbody>
</table>
Table 4  Factory-Default Front-Panel Interface Definitions (see Figure 14) (Sheet 2 of 2)

<table>
<thead>
<tr>
<th>Function</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH CURRENT</td>
<td>High-set overcurrent element trip.</td>
</tr>
<tr>
<td>8F</td>
<td>Underfrequency trip.</td>
</tr>
<tr>
<td>RESET</td>
<td>The control is in the reset state, ready for a reclose cycle.</td>
</tr>
<tr>
<td>CYCLE</td>
<td>The control is actively in the trip/reclose cycle mode.</td>
</tr>
<tr>
<td>LOCKOUT</td>
<td>All reclose attempts were unsuccessful.</td>
</tr>
<tr>
<td>A, B, C&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A-, B-, or C-phase involved in fault.</td>
</tr>
<tr>
<td>G</td>
<td>Ground involved in fault.</td>
</tr>
<tr>
<td>SEF</td>
<td>Sensitive earth fault overcurrent element trip.</td>
</tr>
<tr>
<td>GROUND ENABLED</td>
<td>Enables/disables ground overcurrent elements.</td>
</tr>
<tr>
<td>RECLOSE ENABLED</td>
<td>Enables/disables autoreclosing.</td>
</tr>
<tr>
<td>REMOTE ENABLED</td>
<td>Enables/disables remote control.</td>
</tr>
<tr>
<td>ALTERNATE SETTINGS</td>
<td>Switches active setting group between main and alternate setting groups.</td>
</tr>
<tr>
<td>LOCK (press for 3 seconds)</td>
<td>Blocks the function of other operator controls (except WAKE UP and TRIP). Three-second delay to engage/disengage.</td>
</tr>
<tr>
<td>AUX 1</td>
<td>User programmable; e.g., program to Trip Test—test autoreclose logic without applying current.</td>
</tr>
<tr>
<td>AUX 2</td>
<td>User programmable; e.g., program to enable/disable fast-curve tripping.</td>
</tr>
<tr>
<td>WAKE UP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Wakes up the control after it has been put to sleep.</td>
</tr>
<tr>
<td>CLOSE/RECLSOER CLOSED</td>
<td>Close recloser/recloser closed status.&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>TRIP/RECLSOER OPEN</td>
<td>Trip recloser (go to lockout)/recloser open status.&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> These indicated LEDs and the operator control have fixed functions. Programming at a higher logic level can change functions of all other LEDs and operator controls (with corresponding status LEDs).

<sup>b</sup> 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.

<sup>c</sup> 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.
Figure 15  SEL-351R Module Inputs, Outputs, and Communications Ports
Relay Mounting

Figure 16  SEL-351R Grounding Lug Location and Other Dimensional Information (Bottom View)

Figure 17  SEL-351R Dimensions and Mounting Drill Plan
## Specifications

### Compliance

Designed and manufactured under an ISO 9001 certified quality management system

### General

#### AC Current Inputs

<table>
<thead>
<tr>
<th>Nominal</th>
<th>Continuous, linear to 20 A symmetrical; 20 A for 1 s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>3 A</td>
</tr>
<tr>
<td>Burden</td>
<td>0.13 VA @ 1 A</td>
</tr>
<tr>
<td></td>
<td>1.31 VA @ 3 A</td>
</tr>
</tbody>
</table>

#### Sensitive Earth Fault (SEF) Channel IN Current Input

<table>
<thead>
<tr>
<th>Nominal</th>
<th>Continuous, linear to 1.5 A symmetrical; 20 A for 1 s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 A</td>
<td>1.5 A</td>
</tr>
<tr>
<td>Burden</td>
<td>0.0004 VA @ 0.05 A, 0.36 VA @ 1.5 A</td>
</tr>
</tbody>
</table>

#### AC Voltage Inputs

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Continuous, connect any voltage up to 300 Vac. 600 Vac for 10 s.</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 V</td>
<td>270 Vac/360 Vdc</td>
</tr>
<tr>
<td>Burden</td>
<td>0.03 VA @ 67 V, 0.06 VA @ 120 V, 0.80 VA @ 300 V</td>
</tr>
</tbody>
</table>

#### Power Supply

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Frequency</th>
<th>Burden</th>
</tr>
</thead>
<tbody>
<tr>
<td>85–264 V</td>
<td>40.1–65 Hz</td>
<td>&lt; 30 VA</td>
</tr>
</tbody>
</table>

#### 12 V Radio Supply

11–14 Vdc, 6 W continuous, 13 W for 1 s

### Output Contacts

#### Standard

<table>
<thead>
<tr>
<th>Make</th>
<th>30 A, per IEEE C37.90-1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carry</td>
<td>6 A continuous carry at 70°C</td>
</tr>
<tr>
<td></td>
<td>4 A continuous carry at 85°C</td>
</tr>
<tr>
<td>1 s Rating</td>
<td>100 A</td>
</tr>
</tbody>
</table>

#### MOV Protection: 270 Vac/360 Vdc, 40 J

#### Pickup Time:

< 5 ms

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

<table>
<thead>
<tr>
<th>Voltage</th>
<th>0.75 A</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 V</td>
<td>0.50 A</td>
</tr>
<tr>
<td>48 V</td>
<td>0.30 A</td>
</tr>
<tr>
<td>125 V</td>
<td>0.20 A</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Voltage</th>
<th>0.75 A</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 V</td>
<td>0.50 A</td>
</tr>
<tr>
<td>48 V</td>
<td>0.30 A</td>
</tr>
<tr>
<td>125 V</td>
<td>0.20 A</td>
</tr>
</tbody>
</table>

#### Note:


### Trip and Close Outputs

3 A continuous @ –40°C to 40°C, 1 min @ 85°C

Make and Carry: 5 A for 0.2 s @ 1 s intervals

### Optoisolated Input

#### DC Range

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Pickup 200–300 Vdc, Dropout 150 Vdc</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 Vdc</td>
<td></td>
</tr>
<tr>
<td>125 Vdc</td>
<td></td>
</tr>
<tr>
<td>48 Vdc</td>
<td></td>
</tr>
<tr>
<td>24 Vdc</td>
<td></td>
</tr>
</tbody>
</table>

#### AC Range

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Pickup 170.6–300 Vac, Dropout 106 Vac</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 Vdc</td>
<td></td>
</tr>
<tr>
<td>125 Vdc</td>
<td></td>
</tr>
<tr>
<td>48 Vdc</td>
<td></td>
</tr>
<tr>
<td>24 Vdc</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Optoisolated inputs draw approximately 4 mA of current. All current ratings are at nominal input voltages.

### Frequency and Rotation

#### System Frequency:

50 or 60 Hz

#### Phase Rotation:

ABC or ACB

#### Frequency Tracking

Range: 40.1–65 Hz

**Note:** Voltage connected to V1 required for frequency tracking.

### Communications Ports

#### EIA-232

1 Front; 2 Side

#### EIA-485 (Optional)

1 Side, 2100 Vdc of isolation

Baud Rate: 300–38400 baud

### Time-Code Input

Recloser control accepts demodulated IRIG-B time-code input at Port 1 (optional) and Port 2. Do not connect the time-code input into both Port 1 and Port 2 at the same time. Recloser control time is synchronized to within ±5 ms of time-source input.

### Operating Temperature

#### Relay Module:

–40°C to +85°C (–40° to +185°F)

#### Batteries:

–40°C to +80°C (–40° to +176°F)

#### Entire SEL-351R Unit:

–40°C to +55°C (–40° to +131°F)

**Note:** LCD contrast impaired for temperatures below –20°C (–4°F).

Temperature rise due to sunlight.

### Weight

34 kg (75 lb) including batteries

21.2 kg (46.7 lb) without batteries

### Battery Specifications

#### Normal Capacity:

16.0 amp-hours at +25°C (+77°F)

#### Run Time:

54 hours at +25°C (+77°F)

8 hours at –40°C (+40°F)

#### Estimated Life:

≥ 4 years at +25°C (+77°F)

≥ 1 year at +80°C (+176°F)

#### Recharge Time:

120 hours at +25°C (+77°F)

### Type Tests

### Emissions

Radiated and Conducted: IEC 60255-25:2000

FCC Part 15

Class A
Environmental
Cold: IEC 60068-2-1:2007
Test Ad: 16 hours at −40°C
Damp Heat, Cyclic: IEC 60068-2-30:2005
Test Db: 55°C, 12 + 12-hour cycles, 95% humidity
Test Bd: Dry heat, 16 hours at +85°C

Dielectric Strength and Impulse
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 1 min; 2200 Vdc on EIA-485 communications port

EMC Immunity
(8 kV contact discharge all points except serial ports, 15 kV air discharge to all other points)
(2500 V common, 1000 V differential)
IEEE C37.90.1-2002
(2.5 kV oscillatory; 4 kV fast transient)
(4000 V, 5 kHz)
Radiated EMI: IEC 60255-22-3:2007 Level 3, 10 V/m
IEEE C37.90.2-2004, 35 V/m

Vibration and Shock
Sinusoidal Vibration: IEC 60255-21-1:1998, Class 1
Shock and Bump: IEC 60255-21-2:1998, Class 1
Seismic: IEC 60255-21-3:1993, Class 2

Miscellaneous

Recloser Type Tests
IEEE Std C37.60-2003 Clause 6.13.2, Simulated surge arrester operation test, performed with the following recloser.
G&W Electric Viper-S, Solid Dielectric
Model: VIP388ER-12S
Voltage Rating: 27 kV
Current Break Rating: 12.5 kA
Continuous Current Rating: 800 A

Processing Specifications
AC Voltage and Current Inputs
16 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 560 Hz.

Digital Filtering
One cycle cosine after low-pass analog filtering.
Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Protection and Control Processing
Four times per power system cycle.

Battery Monitor/Charger
Processing once per second

Relay Elements
Instantaneous/Definite-Time Overcurrent Elements (50)
Current Pickup Range (A Secondary)
1 A Nominal Channel: 0.05–20.00 A, 0.01 A steps
0.20–34.00 A, 0.01 A steps for phase-to-phase elements
SEF (0.05 A IN)
Channel: 0.005–1.500 A, 0.001 A steps
Steady-State Pickup Accuracy
1 A Nominal Channel: ±0.01 A, ±3%
SEF (0.05 A IN)
Channel: ±0.001 A, ±5%
Transient Overreach: ±5% of pickup
Time Delay: 0.00–16,000.00 cycles, 0.25-cycle steps
Timer Accuracy: ±0.25 cycle, ±0.1%

Time-Overcurrent Elements (51)
Current Pickup Range (A Secondary)
1 A Nominal Channel: 0.05–3.2 A, 0.01 A steps
SEF (0.05 A IN)
Channel: 0.005–0.160 A, 0.001 A steps
Steady-State Pickup Accuracy
1 A Nominal Channel: ±0.01 A, ±3%
SEF (0.05 A IN)
Channel: ±0.001 A, ±5%
Transient Overreach: ±5% of pickup
Time Dials
U.S.: 0.5–15.0, 0.01 steps
IEC: 0.05–1.00, 0.01 steps
Recloser Curves: 0.10–2.00, 0.01 steps
Curve Timing Accuracy
1 A Nominal Channel: ±1.50 cycles, ±4%
between 2 and 30 multiples of pickup
SEF (0.05 A IN)
Channel: ±1.50 cycles, ±4%
between 2 and 30 multiples of pickup

Under- (27)/Overvoltage (59) Elements
Pickup Ranges (V Secondary)
Various Elements: 0.00–300.00 V, 0.01 V steps
Phase-to-Phase Elements: 0.00–520.00 V, 0.01 V steps
Steady-State Pickup Accuracy: ±2 V, ±5%
Transient Overreach: ±5%

Synchronism-Check Elements (25)
Pickup Ranges (V Secondary)
Slip Frequency Pickup Range: 0.005–0.500 Hz, 0.001 Hz steps
Slip Frequency Pickup Accuracy: ±0.003 Hz
Phase Angle Range: 0–80°, 1° steps
Transient Accuracy: ±4°
**Under-/Overfrequency Elements (81)**

- **Frequency:** 40.1–65.00 Hz, 0.01 Hz steps
- **Time Delays:** 2.00–16,000.00 cycles, 0.25-cycle steps
- **Timer Accuracy:** ±0.25 cycle, ±0.1%
- **Steady-State plus Transient Overshoot:** ±0.01 Hz
- **Undervoltage Frequency Element Block Range:** 25.00–300.00 V

**SELogic Control Equation Variable Timers**

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

**Metering Accuracy**

- Accuracies are specified at 20°C and at nominal system frequency unless noted otherwise.
- **Voltages** $V_A$, $V_B$, $V_C$, $V_S$:
  - $3V_O$, $V_1$, $V_2$: ±0.2%, (67–300.0 V, wye connected)
- **Currents** $I_A$, $I_B$, $I_C$:
  - 1 A nominal ±5 mA, ±0.1% (0.1–20 A)
- **Temperature Coefficient:** $[(0.0002\%/°C)^2] \cdot (°C–20°C)^2$
- **Phase Angle Accuracy:** ±1.0°
- **Currents** $I_1$, $I_3I_O$, $I_3I_2$:
  - 1 A nominal ±0.01 A, ±3% (0.1–20.0 A)
- **$I_Q$ (SEF):**
  - 0.05 A IN nominal ±1 mA
  - ±5% (0.01–1.5 A)

Example metering accuracy calculation for currents $I_A$, $I_B$, and $I_C$ due to preceding stated temperature coefficient:

For temperature of 40°C, the additional error for currents $I_A$, $I_B$, and $I_C$ is: $[(0.0002\%/°C)^2] \cdot (40°C–20°C)^2 = 0.08%$
Notes