SEL-351R Falcon™ Recloser Control

Take Control of Your Recloser

Major Features and Benefits

The SEL-351R Falcon Recloser Control provides microprocessor-based features in a slim-profile housing for long, reliable service on your distribution system.

➤ Modernize existing recloser installations to provide cost saving protection, automation, and control features. Single-person-lift size and standard control cable interconnection simplifies installation. Available in Lift-To-Open and Swing-Open enclosure options.

➤ Use automatic network reconfiguration for improved reliability. Patented MIRRORED BITS® communications speeds protection and improves security.

➤ Customize controls by using enhanced SELOGIC® control equations for improved 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.

➤ Increase efficiency of service restoration with accurate fault location when connected with three-phase voltages.

➤ 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.

➤ Power with 120 Vac or 230 Vac (or 125 Vdc or 250 Vdc).
Functional Overview

Figure 1  Functional Diagram

EZ Settings for Basic Recloser Functions
For traditional recloser functions, the SEL-351R Falcon 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. SEL OGIC 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 Falcon 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 adequate Vac power before proceeding with the auto reclose. The recloser needs either primary or secondary voltage to provide the closing power, depending on how the recloser is equipped. The Vac power into the SEL-351R Falcon 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 auto reclose 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 auto-reclose. 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 14 and Table 4).

Sequence coordination logic is enabled to prevent the SEL-351R Falcon 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.

ANSI NUMBERS/ACRONYMS AND FUNCTIONS

<table>
<thead>
<tr>
<th>ANSI NUMBERS/ACRONYMS AND FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>25  Synchronism Check*</td>
</tr>
<tr>
<td>27  Undervoltage</td>
</tr>
<tr>
<td>50N  Neutral Overcurrent</td>
</tr>
<tr>
<td>50 (P, G, Q) Overcurrent (Phase, Ground, Neg. Seq.)</td>
</tr>
<tr>
<td>51N  Neutral Time-Overcurrent</td>
</tr>
<tr>
<td>51 (P, G, Q) Time-Overcurrent (Phase, Ground, Neg. Seq.)</td>
</tr>
<tr>
<td>59  Overvoltage</td>
</tr>
<tr>
<td>59 (P, G, Q) Overvoltage (Phase, Ground, Neg. Seq.)</td>
</tr>
<tr>
<td>67N  Directional Neutral Overcurrent*</td>
</tr>
<tr>
<td>67 (P, G, Q) Directional Overcurrent (Phase, Ground, Neg. Seq.)*</td>
</tr>
<tr>
<td>79  Autoreclosing</td>
</tr>
<tr>
<td>81 (O, U)  Over-/Underfrequency</td>
</tr>
<tr>
<td>85 RIO  SEL MINIRED BITS® Communications</td>
</tr>
<tr>
<td>DFR  Event Reports</td>
</tr>
<tr>
<td>HMI  Operator Interface</td>
</tr>
<tr>
<td>LGC  SELOGIC® Control Equations</td>
</tr>
<tr>
<td>MET  High-Accuracy Metering</td>
</tr>
<tr>
<td>SER  Sequential Events Recorder</td>
</tr>
</tbody>
</table>

ADDITIONAL FUNCTIONS

<table>
<thead>
<tr>
<th>ADDITIONAL FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRM  Breaker Wear Monitor</td>
</tr>
<tr>
<td>LDP  Load Data Profiling*</td>
</tr>
<tr>
<td>LOC  Fault Locator*</td>
</tr>
</tbody>
</table>

* Optional Feature
Any fast or delay curve (phase or ground) 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-351R Falcon 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 Falcon.

Four (4) user-designed curves (created with a software package) can be downloaded to the SEL-351R Falcon. The fast and delay curves (phase or ground) can be set with the user-designed curves or the curve choices in Table 1.

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 14 and Table 4.

Figure 2 Connect True Three-Phase and Synchronism-Check Voltages to the SEL-351R Falcon

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 Falcon

<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>US 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>
<tr>
<td>Programmable curves (user designed)</td>
<td>Four (4) programmable curves</td>
</tr>
</tbody>
</table>
The SEL-351R Falcon 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 (for US or IEC curves only) 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.

### 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 Figure 15).

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 Falcon provides extensive and accurate metering capabilities. See Specifications on page 17 for metering and power measurement accuracies.

#### Table 2  Metering\(^a\)

<table>
<thead>
<tr>
<th>Quantities</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currents (I_{A,B,C,N,IG})</td>
<td>Input currents, residual ground current ((I_G = 3I_0 + I_A + I_B + I_C)).</td>
</tr>
<tr>
<td>Voltages (V_{A,B,C,V_S})</td>
<td>Wye-connected voltage inputs, synchronism-check voltage input.</td>
</tr>
<tr>
<td>Energy (\text{MWh}<em>{A,B,C,3P}), (\text{MVArh}</em>{A,B,C,3P})</td>
<td>Single- and three-phase megawatt-hours and megavar-hours.</td>
</tr>
<tr>
<td>Power Factor (\text{PF}_{A,B,C,3P})</td>
<td>Single- and three-phase power factor; leading or lagging.</td>
</tr>
<tr>
<td>Sequence (I_1, 3I_2, 3I_0)</td>
<td>Positive-, negative-, and zero-sequence currents.</td>
</tr>
<tr>
<td>Frequency, FREQ (Hz)</td>
<td>Instantaneous power system frequency (monitored on channel (V_A)).</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 Falcon 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 setpoints necessary to emulate a breaker wear curve. Program the setpoints in *Figure 4* to customize the recloser wear curve.

The SEL-351R Falcon sets setpoints automatically according to recommendations for reclosers in ANSI C37.61-1973. Only the recloser type (oil or vacuum) and the interrupt rating are necessary settings.
Fault Locator

The SEL-351R Falcon 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 Falcon has three independently operated serial ports: 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, the SEL-3530 RTAC, an SEL-2032, SEL-2030 or SEL-2020 Communications Processor, SCADA serial port, and/or RTU for local or remote communication.

Apply an SEL-2032 as the hub of a star network, with a point-to-point fiber or copper connection between the hub and the SEL-351R Falcon, as in Figure 5. The SEL-2032 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.

Figure 4  Recloser Contact Wear Curve and Settings

Figure 5  Example Communication 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.
Use ACSELERATOR QuickSet SEL-5030 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-351R Falcon 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 SEL-5030 and ACSELERATOR QuickSet Designer SEL-5031**

Use ACSELERATOR QuickSet SEL-5030 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-351R Falcon 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 Designer® SEL-5031 Software** additionally allows users to create personalized Application Designs. Use Application Designs within ACSELERATOR QuickSet Designer 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.

**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. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while a technician is transferring an event report.</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>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>

**Figure 6  Example Application Design**
Advanced Capabilities for Maximum Control

Selective Load Shedding for Improved System Response

Use retrofit recloser controls to preserve critical loads while balancing system loading. In the example in Figure 7, the same feeder serves both Fire Department and Hospital as residential loads. Incorporating underfrequency elements into the SEL-351R Falcon 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 7](image-url)  
*Figure 7 Implement Underfrequency Load Shedding With SEL-351R Falcon Recloser Controls to Preserve Critical Loads*

Dual Source for Premium Reliability

Either Recloser 1 or Recloser 2 can serve the load in Figure 8. The respective SEL-351R Falcon 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 and SEL-2815 Fiber-Optic Transceivers accomplish this communication reliably and economically.

![Figure 8](image-url)  
*Figure 8 Improve Service Reliability for Load With Two SEL-351R Falcon Recloser Controls Communicating Over Fiber*

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 from nonfaulted segments. Use the SEL-351R Falcon in a variety of possible systems, either with or without communications between devices. You can set analog logic and counters 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.

**Added Capabilities**

**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 Falcon. With MIRRORED BITS operating on two serial ports, there is communication upstream and downstream from the SEL-351R Falcon site.

This bidirectional digital communication creates eight additional virtual outputs (transmitted MIRRORED BITS) and eight additional virtual inputs (received MIRRORED BITS).
BITS) for each serial port operating in the MIRRORED BITS mode (see Figure 10). 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 10  MIRRORED BITS Transmit and Receive Bits

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.

The SEL-351R Falcon has the same SELOGIC control equations capability as the established SEL-351R-2.

Hardware Overview

The convenient side-panel construction of the SEL-351R Falcon provides easy access to all controls and connections.

Communications ports, contacts, and control cable connection points are all readily available. Labeling is shown in Figure 14 (right-hand side).
Recloser Control Connections

Available in Lift-To-Open (Figure 16) and Swing-Open (Figure 17) enclosure options.

The control cable from the recloser attaches at the bottom of the SEL-351R Falcon 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 V1, as shown in the retrofit of a traditional installation in Figure 13. If you order the SEL-351R Falcon with additional voltage channels V2, V3, and VS, 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 Falcon can monitor battery voltage. The SEL-351R Falcon 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 Falcon can also be powered with 125 Vdc or 250 Vdc.
Front-Panel Interface

The control panel on the SEL-351R Falcon 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.

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

Figure 14  SEL-351R Falcon Recloser Control Front-Panel Interface
### Table 4  Factory Default Front-Panel Interface Definitions (see Figure 14)

<table>
<thead>
<tr>
<th>Function</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>➀</strong> PUSHBUTTONS</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>➁</strong> CONTROL ENABLED²</td>
<td>SEL-351R Falcon Recloser Control is enabled.</td>
</tr>
<tr>
<td>AC SUPPLY</td>
<td>Adequate Vac power is present.</td>
</tr>
<tr>
<td>BATTERY PROBLEM</td>
<td>Indicates battery problems.</td>
</tr>
<tr>
<td>HOT LINE TAG</td>
<td>No closing or autoreclosing can take place via the control.</td>
</tr>
<tr>
<td>TRIP</td>
<td>Trip occurred.</td>
</tr>
<tr>
<td>FAST CURVE</td>
<td>Fast curve overcurrent element trip.</td>
</tr>
<tr>
<td>HIGH CURRENT</td>
<td>High-set overcurrent element trip.</td>
</tr>
<tr>
<td>81</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 a</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><strong>➂</strong> 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/disseengage.</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 a</td>
<td>Wakes up the control after it has been put to sleep.</td>
</tr>
<tr>
<td>CLOSE/RECLOSER CLOSED</td>
<td>Close recloser/recloser closed status.</td>
</tr>
<tr>
<td>TRIP/RECLOSER OPEN</td>
<td>Trip recloser (go to lockout)/recloser open status.</td>
</tr>
</tbody>
</table>

² 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).

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.
Guideform Specification

The microprocessor-based recloser control shall provide a combination of functions including protection, monitoring, control, fault locating, and automation. Recloser control self-checking functions shall be included. Specific operational and functional requirements are as follows.

➤ **Autoreclosing Control.** The recloser control shall incorporate a four-shot control. It shall include four independently set open time intervals, an independently set reset time from reclose cycle, and an independently set reset time from lockout.

➤ **Coordination With Downstream Reclosers.** The recloser control shall include 38 standard recloser time-overcurrent curves and sequence coordination logic for secure and dependable operation.

➤ **Phase Fault Overcurrent Protection.** The recloser control shall incorporate phase and negative-sequence overcurrent elements for detection of phase faults. For added security, the recloser control shall provide directional elements, load-encroachment logic, and torque-control capability (internal and external).

➤ **Ground Fault Overcurrent Protection.** The recloser control shall incorporate residual ground overcurrent elements for detection of ground faults. For added security, the recloser control shall provide directional elements and torque-control capability (internal and external).

➤ **Phase Under- and Overvoltage Elements.** The recloser control shall incorporate undervoltage and overvoltage elements for creating protection and control schemes, including but not limited to voltage checks (e.g., hot bus/dead line) for reclosing; blown transformer high-side fuse-detection logic; and control schemes for capacitor banks.

➤ **Sequence Voltage Elements.** The recloser control shall incorporate positive-, negative-, and zero-sequence voltage elements that can be logically configured for either under- or overvoltage applications.

➤ **Under- and Overfrequency Protection.** The recloser control shall incorporate six levels of under- and overfrequency elements for detection of power system frequency disturbances. Each setting level shall use an independently set timer for load-shedding or generator-tripping schemes.

➤ **Synchronism Check.** The recloser control shall include two synchronism-check elements with separate maximum angle settings (e.g., one for autoreclosing and one for manual closing). The synchronism-check function shall compensate for close time and constant phase-angle differences between the two voltage sources used for synchronism check (phase-angle differences are settable in 30-degree increments).

➤ **IED Communications.** The recloser control shall include the capability for communication of internal logic values to a remote relay or recloser control via serial communications. These values shall be available for use in control logic.

➤ **Secure Communications.** The recloser control shall include an optional accessory for converting an EIA-232 serial port to encrypted and authenticated IEEE 802.11b wireless communication. Software shall be provided with this accessory to allow a personal computer (PC) or personal data assistant (PDA) access to the wireless port.

➤ **Operator Controls.** The recloser control shall include 10 operator controls on the recloser control front panel; these functions shall also be accessible in the recloser control logic. Nine of the operator controls shall include pushbuttons and LEDs with programmable functions and indications.

➤ **Event Reporting and Sequential Events Recorder (SER).** The recloser control shall be capable of automatically recording disturbance events of 15 or 30 cycles with settable prefault duration and user-defined triggering. Events shall be stored in non-volatile memory. The recloser control shall include an SER that stores the latest 512 entries.

➤ **Status and Trip Target LEDs.** The recloser control shall include 16 status and trip target LEDs.

➤ **Recloser Wear Monitor.** The recloser control shall include a recloser wear monitor with user-definable wear curves, operation counter, and accumulated interrupted currents by phase.

➤ **Battery Monitor.** The recloser control shall measure and report the battery voltage level. User-selectable parameters shall be provided to put the control to sleep for low battery voltage or for a lengthy outage.

➤ **Fault Locator.** The recloser control shall include a fault-locating algorithm to provide an accurate estimate of fault location without communications channels, special instrument transformers, or prefault information.

➤ **Automation.** The recloser control shall include 16 local control elements, 16 remote control logic points, 16 latching logic points, and 16 display messages in conjunction with a local display panel. The recloser control shall have the capability to display custom messages.

➤ **Recloser Control Logic.** The recloser control shall include programmable-logic functions for a wide range of user-configurable protection, monitoring, and control schemes.

➤ **Communication.** The recloser control shall include two independent EIA-232 serial ports and one optional EIA-485 serial port for external communication. There shall be an option for DNP3 Level 2 protocol with bitmapping.

➤ **IRIG-B.** The recloser control shall include an interface port for a demodulated IRIG-B time synchronization input signal.

➤ **PC Software.** The recloser control shall include compatibility with a PC software program for use in programming control settings and logic functions, and retrieving event data. The PC software shall be included, but it is not necessary to use the recloser control.

➤ **Power Supply.** The recloser control shall accept 120 Vac or 230 Vac (or 125 Vdc or 250 Vdc).

➤ **Warranty.** The relay shall have a minimum 10-year worldwide warranty.
Figure 15  SEL-351R Falcon Module Inputs, Outputs, and Communications Ports

Note: Power with 120 Vac or 230 Vdc (or 125 Vdc or 250 Vdc)
Relay Mounting

**Figure 16** SEL-351R Falcon Lift-To-Open Enclosure Dimensions and Mounting
Figure 17  SEL-351R Falcon Swing-Open Enclosure Dimensions and Mounting
Specifications

Compliance

ISO 9001:2008 Certified

General

AC Current Inputs (Channels I1, I2, I3)

1 A nominal: 3 A continuous, linear to 20 A symmetrical; 100 A for 1 s
Burden: 0.13 VA @ 1 A
1.31 VA @ 3 A

Sensitive Earth Fault (SEF) Channel IN Current Input

0.05 A nominal: 1.5 A continuous, linear to 1.5 A symmetrical; 20 A for 1 s
Burden: 0.0004 VA @ 0.05 A, 0.36 VA @ 1.5 A

AC Voltage Inputs

300 VLN continuous, (connect any voltage up to 300 Vac). 600 Vac for 10 s.
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: <30 VA

12 V Radio Supply

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

Output Contacts (Except Trip and Close)

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: 100 A
MOV Protection: 270 Vac / 360 Vdc; 40 J
Pickup Time: < 5 ms
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: Per IEC 60255-0-20:1974, using the simplified method of assessment.

Trip and Close Outputs

3 A continuous @ –40° to 40° C, 1 min @ 85°C
Make and Carry: 5 A for 0.2 s @ 1 s intervals

Optoisolated Inputs

DC Range
24 Vdc: Pickup 15.0–30 Vdc

AC Range
24 Vdc: Pickup 12.8–30 Vdc

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: 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° to +85°C (–40° to +185°F)
Batteries: –40° to +60°C (–40° to +140°F)
Entire SEL-351R Falcon Unit: –40° to +50°C (–40° to +122°F)

Note: LCD contrast impaired for temperatures below –20°C (–4°F). The entire SEL-351R Falcon unit was operation tested up to +70°C (+158°F). The 20°C (36°F) difference between the +50°C rating and +70°C allows for temperature rise due to sunlight.

Weight

16.7 kg (37 lbs) including batteries

Battery Specifications

Normal Capacity: 8.0 amp-hours at +25°C (+77°F)
Run Time: 20 hours at +25°C (+77°F)
8 hours at –40°C (–40°F)
Estimated Life: 4 years at +25°C (+77°F)
8 months at +60°C (+140°F)
Recharge Time: 55 hours at +25°C (+77°F)

Type Tests

Environmental Test

Cold: IEC 60068-2-1:1990
Test Ad: 16 hours at –40°C

Test Db; 55°C, 12 + 12-hour cycles, 95% humidity

Test Bd: Dry heat, 16 hours at +85°C

Dielectric Strength and Impulse Tests

Dielectric: IEC 60255-5:1977
IEEE C37.90-1989
2500 Vac on analogs, contact inputs, and contact outputs except Trip and Close; 3100 Vdc on power supply for 10 s; 2200 Vdc on EIA-485 communications port
Electrostatic Discharge Test
ESD: IEC 60255-22-2:1996 (8 kV contact discharge all points except serial ports, 15 kV air discharge to all other points)

RFI and Interference Tests
1 MHz Burst Disturbance: IEC 60255-22-1:1988 Level 3 (2500 V common, 1000 V differential)

Exception:
5.5.2(2): Performed with 200 frequency steps per octave.
5.5.3: Digital Equipment Modulation Test not performed.
5.5.4: Test signal off between frequency steps to simulate keying.

Surge Withstand:
IEEE C37.90.1-1989
3.0 kV oscillatory; 5.0 kV fast transient

Vibration and Shock Tests
Sinusoidal Vibration: IEC 60255-21-1:1988 Class 1
Shock and Bump: IEC 60255-21-2:1988 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: VIP398ER-12S
Voltage Rating: 38 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
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
SEF (0.05 A IN) Channel: 0.05–34.00 A, 0.01 A steps for phase-to-phase elements
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
US: ±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)
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 some programmable timers)
- 0.00–16,000.00 cycles: 0.25-cycle steps (some programmable and other 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 $V_A$, $V_B$, $V_C$, $V_S$, $3V_0$, $V_1$, $V_2$: ±0.2%, (67–300.0 V; wye connected)

Currents $I_A$, $I_B$, $I_C$: 1 A nominal ±3 mA, ±0.1% (0.1–20 A)

Temperature Coefficient: \[ \left( \frac{0.0002 \%}{^\circ C} \right)^2 	imes (T-20)^2 \]

(see example below)

Phase Angle Accuracy: ±1°

Currents $I_2$, $3I_0$, $3I_2$: 1 A nominal ±0.01 A, ±3% (0.1–20.0 A)

$I_N$ (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: \[ \left( \frac{0.0002 \%}{^\circ C} \right)^2 \times (40-20)^2 = 0.08\% \]