Breaker Failure Relay, Control Relay, Data Recorder

Major Features and Benefits

➤ Circuit Breaker Failure Detection:
  ➢ Failure while tripping fault conditions
  ➢ Failure while tripping load conditions
  ➢ Failure to close (pole disagreement detection)
  ➢ Failure while open (breaker pole flashover detection)
  ➢ Failure to complete a trip or close (resistors still inserted)
  ➢ Loss-of-dielectric pressure

➤ Control Logic:
  ➢ Motor-operated disconnect (MOD) trip and power circuit breaker isolation security logic
  ➢ Retripping (instantaneous and time-delayed)
  ➢ Point-on-Wave (POW) breaker control functions
  ➢ Synchronism checking close logic
  ➢ Trapped charge polarity detection

➤ Data Recording:
  ➢ Event report provides 8 seconds of analog fault data and digital oscillography data at 64 samples per cycle
  ➢ 512 Sequential Event Recorder (SER) reports (inputs, outputs, and relay elements)
  ➢ 512 breaker operation events
  ➢ Six voltage measurements
  ➢ Three current measurements

➤ Additional Features:
  ➢ Multiple I/O configurations
  ➢ SELOGIC® control equations: Modify default schemes
  Complete custom applications
  Design a recloser
  ➢ Programmable targets for testing
  ➢ Detailed metering
  ➢ Three EIA-232 serial ports
  ➢ EIA-485 serial port
  ➢ Front-panel display:
    Setting and monitoring functions
  ➢ Automatic self-tests
  ➢ Clock synchronization input, IRIG-B
  ➢ Optional DNP3 Level 2 Slave
Functional Overview

General Description

The SEL-352 relay is a single- or three-pole breaker failure detection, breaker control, and data recording device. Each of the protection schemes is implemented in SELOGIC control equations, giving relay engineers unparalleled flexibility in adapting the relay to their needs. The relay provides classical overcurrent-based breaker failure protection for a wide variety of breaker arrangements. Additionally, protection is provided for circuit breaker trip and close resistors, for current through an open breaker, and for breaker flashover.

Logic to control the closing and opening of the circuit breaker is also included. Additional features include metering, sequence-of-event reporting, digital fault recording, remote setting capabilities, breaker operating time monitors, energy interruption monitors, and breaker resistor thermal protection. Simple hardware design and efficient digital signal processing ensure reliability. Extensive self-testing and communication capabilities enhance availability.

Figure 2 shows a single-phase diagram of the ac connections. All nine connections are not required for most relay functions.

Circuit Breaker Failure Detection

The SEL-352 has five fault current-driven breaker failure detection schemes, including one specifically designed for ring-bus or breaker-and-a-half applications. Tailor the relay to your circuit breaker failure detection requirements by selecting the most appropriate scheme or use SELOGIC control equations to implement your own scheme.
The relay detects failures to interrupt fault, load, or line-charging current. It also detects failure of breaker poles to complete a close sequence and can detect open breaker flashover failures. If trip or close resistors remain in service after an operation, the relay detects this failure by using a thermal model.

Independent phase current detectors, protection logic, and timers make the relay easy to apply on both simple systems and more complicated breaker arrangements such as single-pole trip installations.

The SEL-352 stores summaries of the last 512 breaker operations in nonvolatile memory. Event type, maximum current, mechanical and electrical operating times, and breaker energy are stored along with the date and time of operation. Using this breaker history, you can monitor breaker wear and effectively schedule routine breaker maintenance.

When a MOD switch is used with the protected breaker, the SEL-352 can trip the MOD to isolate the failed breaker when phase current drops below a settable value. When a MOD is not installed, use the MOD logic to indicate a “Safe to Disconnect” condition to personnel.

The relay also includes SELOGIC control equations, which allow you to configure the programmable outputs to operate when any of the protective elements pick up. You can implement complete application-specific protective schemes with a minimum of wiring and panel space. SELOGIC control equations also simplify relay testing.

**Control Logic**

Control logic provides flexibility for closing, opening, and tripping. For minimal breaker wear, the SEL-352 can be used to close the breaker at an optimum time. Close using a simple pole staggered close or use complete control by monitoring synchronism, trapped charge polarity, and zero crossings. Use controlled breaker opening in the SEL-352-2 and SEL-352-3 for synchronizing the maximum breaker contact separation to peak or zero voltage crossings to help reduce the occurrence of re-strike in reactive loads. Use ambient temperature and dc control voltage monitoring to compensate for variations in breaker close and opening times in the controlled opening and closing schemes. Control breaker tripping through lockout and reset conditions, instantaneous retripping, and time-delayed retripping.

Use the flexible SELOGIC control equations to create your own recloser, implement manual closing supervision, and/or change existing control logic to meet your needs.

**Data Recording**

A wide range of user-selectable events trigger the sequence-of-events recording and digital fault recording (DFR) functions, including any input or output assertion. Breaker Failure Trip (86BFT) output assertion automatically generates a DFR record, and you can set the relay to trigger an event for OPEN, CLOSE, or TRIP input assertions. This ensures a record of every normal circuit breaker operation as well as every circuit breaker failure.

The recorded data contain all information needed to determine the cause of relay and breaker operations. The data collected include current through the circuit breaker, voltage on both sides of the circuit breaker, input, output, and relay element data. Parameters such as event type, relay response time, circuit breaker operation time, currents, voltages, and breaker power dissipation appear directly in the breaker monitor report or can be calculated from the data stored. All event reports are time tagged by a self-contained clock/calendar.

**Additional Features**

Additional features make the SEL-352 reliable and economical. The communication functions provide remote and local examination of a wide range of data, including the voltages and currents presented to the instrument, relay settings, history of events, breaker alarms, sequence-of-events, and self-test status data. You can enter and modify relay settings remotely; you can also control all outputs via the communications channel.

A three-level password scheme protects settings and circuit breaker control. The SEL-352 monitors password execution and closes the ALARM contact output to indicate possible unauthorized access. The relay requires no special communications software. Access the relay with a dumb terminal, printing terminal, or computer with serial port and terminal emulation software. The SEL-5010 Relay Assistant is also available for communication and settings database management.
Circuit Breaker Failure Detection

Protection Overview

The SEL-352 provides protection for several circuit breaker failure modes:

➤ Failure to clear a fault (five available schemes)
➤ Failure to trip during load conditions (two available schemes)
➤ Failure to complete trip sequence due to trip resistor(s) remaining inserted
➤ Failure to complete close sequence due to close resistor(s) remaining inserted
➤ Failure to close: pole disagreement detection
➤ Failure while open: breaker pole flashover detection
➤ Loss of dielectric pressure

Protection While Tripping Fault Current

The SEL-352 provides five different protection schemes to detect the failure of the circuit breaker to clear a fault. While the schemes share elements and timers, each is independent. You may enable only one protection scheme at a time. The SEL-352 applies the single chosen scheme to all three breaker poles. The SEL-352 provides instantaneous overcurrent elements (50FT) with fast reset times, even in the presence of subsidence current after the breaker opens.

In ring-bus and breaker-and-a-half installations, two circuit breakers must operate to interrupt line current. Current distribution between the two breakers is unknown until the first breaker opens. This causes an uncertainty with respect to the timing of 50FT overcurrent element assertion. This uncertainty is not present in a single breaker arrangement.

Timing uncertainty is accounted for in the SEL-352 breaker failure detection schemes intended for these complex bus/breaker arrangements. The SEL-352 is intended to monitor a single breaker, regardless of the bus/breaker arrangement. In breaker-and-a-half and ring-bus arrangements, you must use an independent breaker failure relay for each breaker.

An overview of the five protection schemes is shown below.

Scheme 1: Protection for Simple and Complex Arrangements

In this scheme, the breaker failure timer starts independently from 50FT assertion. This independence allows scheme usage in bus configurations where the 50FT element may assert after trip input assertion, such as ring-bus and breaker-and-a-half bus arrangements.
Protection While Tripping Load or Line-Charging Current

Two different schemes detect breaker failures when tripping the breaker under load or line charging current conditions. While the schemes share elements and timers, each is independent. You may enable only one protection scheme at a time or customize the logic.

Both schemes require that the breaker is closed, and the relay received a trip input. The difference between the two schemes is how they determine a closed breaker condition.

Scheme 1 determines a closed breaker condition by comparing the phase current with the 50LD setting. Because this logic is very sensitive, the trip input must be asserted for two consecutive quarter-cycles before this logic acknowledges the input.

In some applications, current through the closed breaker may be below the minimum setting of the 50LD element. Scheme 2 uses the same logic as Scheme 1 but adds the 52A monitoring condition as an additional means for determining an open or closed breaker.

Thermal Protection of Close and Trip Resistors

If the protected breaker is equipped with trip and close resistors and three-phase potentials are available on both sides of the breaker, you can use the SEL-352 thermal protective elements to protect breaker resistors. Occasionally, a trip or close resistor can be left in service following a breaker operation. The SEL-352 can detect that condition, model the energy accumulated in the resistor, and trip the protected breaker or 86 lockout relay when resistor energy reaches a preset level.

A “Close Resistor Thermal Failure” or “Trip Resistor Thermal Failure” is declared when any close or trip resistor thermal model has reached the failure energy level and current is flowing in the hot resistor phase.

The relay models cooling of the breaker resistors using settable time constants. The thermal elements do not drop out until the resistor thermal models have cooled below the element thresholds. This function helps prevent hot resistors from being returned to service.

Voltage Nulling

The thermal protection and flashover protection both require a measurement of the transient voltage difference across the circuit breaker. Voltage nulling logic removes the steady state voltage difference that appears across the breaker. With the steady state voltage difference nulled from the voltage difference measurement, any difference is due to transient conditions.

Protection for Current Through an Open Breaker (Flashover)

Two schemes to detect circuit breaker flashover are provided. While the schemes share elements and timers, each is independent. You may enable only one flashover detection scheme at a time, or you can customize the logic.

Scheme 1 uses voltage across the circuit breaker and the current through the breaker to detect flashover. Scheme 2 uses a single set of voltages on one side of the breaker, the current through the breaker, and the breaker monitor input to detect flashover.

Protection for Failure to Close

The SEL-352 includes logic which detects a failure of one or two breaker poles to close. Because the logic operates based on current flowing in the breaker poles, protection is not dependent upon the operation of auxiliary contacts. Thus, this logic is not subject to misoperation due to mechanical failure in the breaker or contacts.

Loss of Dielectric Protection

The SEL-352 loss of dielectric protection logic uses dc input from pressure switches. Breakers equipped with dielectric gas pressure switches close contacts when the pressure drops below a preset level. One input that indicates current transformer dielectric failure can be used for alarming or tripping. Two additional inputs that monitor two thresholds of the dielectric gas pressure of the interrupter can be used for alarming, tripping, or breaker failure tripping.

Control Logic

The SEL-352 provides the following control logic:

- Staggered Closing
- POW Closing, which includes:
  - Synchronism Checking
  - Zero-Crossing Detection
  - Trapped Charge Polarity Detection
- High-Resolution Controlled Close Output Timers
- Ambient Temperature Compensation (SEL-352-2 and SEL-352-3)
- DC Control Voltage Compensation (SEL-352-3)
POW Opening, which includes:
- Zero-Crossing Detection
- High-Resolution Controlled Open Output Timers
- Ambient Temperature Compensation (SEL-352-2 and SEL-352-3)
- DC Control Voltage Compensation (SEL-352-3)
- Circuit Breaker Retrip Logic
- Breaker Failure Trip and Reset Logic

Staggered Close

Scheme 1 of the controlled close logic is a staggered close scheme that allows the user to close each pole of a circuit breaker pole at a selectable time. The pickup time for each phase timer is settable to allow the user to select the delay between each phase.

POW Close

The second closing scheme that the SEL-352 provides is a POW close. Scheme 2 controls at what point on the voltage waveform the circuit breaker closes. The POW close logic is designed to provide a closing scheme that minimizes breaker wear and system impact when the breaker closes. POW closing includes synchronism checking, zero-crossing detection, and output timers. Use the ambient temperature compensation available in the SEL-352-2 and SEL-352-3 and dc control voltage compensation in the SEL-352-3 to provide consistent POW closing results over a wide range of operating conditions.

Synchronism Checking

Angle and frequency differences between the X-side and the Y-side voltage are compared against two sets of settings. For example, one set of settings may be used to supervise automatic reclosing you programmed in SELOGIC control equations, and the other set of settings may be used to supervise manual closing through an output contact.

Zero-Crossing Detection

The SEL-352 determines when a zero crossing of the measured voltage will occur. The POW close logic closes the breaker based on this detection and the close output timers.

Trapped Charge Detection

When the SEL-352 detects a positive or negative charge on the line after the breaker opens, the POW close logic will close on a positive or negative voltage condition, respectively. This minimizes the voltage difference as the breaker closes, minimizing breaker wear.

Controlled Close Output Timers

The output timer logic allows you to set the SEL-352 according to actual breaker operate times. Pow closing has better than 200 μs accuracy for all three phases.

POW Opening

Controlled opening of the breaker is useful in helping to reduce re-ignition across the breaker contacts in specific applications. Re-ignition takes place when the arcing time is too short and the contact separation is small. This presents a low dielectric boundary to the recovery voltage after the arc is extinguished, and re-ignition occurs across the open contacts of the breaker. Re-ignition is especially prevalent in applications, such as shunt-connected reactive loads, where there is a high transient recovery voltage and low load current present at the time the breaker contacts open. The SEL-352-2 and SEL-352-3 relays are capable of providing POW opening control logic. This logic allows the synchronization of maximum breaker contact separation to occur at the voltage peak or zero-crossing point, with additional high-resolution timers and voltage and temperature compensation (SEL-352-3) to provide highly repeatable results over a wide range of operating conditions.
Retripping

Retrip your breaker instantaneously or with a time delay. The two available schemes can also be modified to conform to your specifications for qualifying a retrip condition.

86BF Trip and Reset

Lockout relay trip and reset logic is provided for installations with and without automatic breaker isolation schemes.

Use Scheme 1 for breaker failure tripping and “Safe to Reset Lockout Relay” conditions.

Use Scheme 2 to automatically isolate the failed breaker with MODs. The SEL-352 trips the MOD when current drops below a settable threshold. This scheme can also be used to indicate “Safe to Disconnect” conditions for manual disconnect switches.

Inputs/Outputs

The SEL-352 has many configurations of input and output options. The basic relay has a main board that includes inputs and outputs, but you may add up to two interface boards for expanded input and output capability.

Main Board

The main board includes seven programmable output contacts, one ALARM contact, and six optoisolated inputs. A jumper allows Output 7 to follow the ALARM.

Interface Boards

Table 1 lists the interface boards that expand the dc input and output capability of your SEL-352 to meet your specific needs. Contact the SEL Customer Service Department for ordering options.

Data Recording

Event Report

The SEL-352 saves an event report in nonvolatile memory when any of the following occur:

- The relay trips
- User-selected relay elements, input, or outputs assert
- User executes the TRIGGER command

Event reporting has three user-selectable configurations:

<table>
<thead>
<tr>
<th>Event Length</th>
<th># of Events Stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 Cycles</td>
<td>72</td>
</tr>
<tr>
<td>30 Cycles</td>
<td>36</td>
</tr>
<tr>
<td>60 Cycles</td>
<td>18</td>
</tr>
</tbody>
</table>

The header of each event gives the date and time stamps of the trigger condition and relay identification. Each event report contains all unfiltered analog measurements, all digital inputs and outputs, and selected digital relay logic elements. The event type, system frequency, and voltage nulling calculations are reported just before the settings. The settings are listed at the end of the report for verification.

The relay stores 64 samples per cycle of unfiltered data. Display options allow the user to view the event in a 4-, 8-, or 64-sample per cycle format and to select the number of event report cycles to display.

Sequential Events Recorder

The SEL-352 stores 512 changes of state for user-selected relay elements, inputs, and output contacts. Each record is time tagged to within two milliseconds. The SER command allows the user to display a specific range of events based on the date and time stamp.
**Metering**

The meter function shows the values of ac current through the breaker, voltage across and on both sides of the breaker, and three-phase real and reactive power of the system at the breaker.

**Breaker Operation Records**

The SEL-352 stores 512 breaker operation records in nonvolatile memory. The event records contain breaker operation data: event date and time, operation type, electrical and mechanical operating times, interrupted energy, and interrupted current. This information is reported on a per-pole basis.

**Breaker Operation Summary**

A breaker operation summary report uses data from the breaker operation records to provide breaker information: average and last electrical operating times, average and last mechanical operating times, total interrupted energy, and total interrupted current. The SEL-352-2 and SEL-352-3 add a percent wear estimation to the summary. Use this information to monitor breaker wear and more effectively schedule routine maintenance.

**Breaker Alarms**

The BALRM (Breaker Alarm) setting is available for indicating specific breaker alarm conditions. Depending on its setting, the BALRM bit indicates dangerous or abnormal conditions related to operation of the circuit breaker.

Breaker alarm occurrences are stored in memory; the memory resets when settings are changed or a loss of power condition occurs. You can set a programmable output contact to close and indicate when the relay detects a breaker alarm condition.

The default relay settings for BALARM set the BALRM bit for one second and store a message in the alarm message buffer when any of the following conditions are detected:

- Failed CB trip resistors put in service
- Failed CB close resistors put in service
- 52A contradicts voltage
- MOD contradicts current
- Current while open
- Volts across closed CB
- Trip while open
- Slow trip
- CD did not close
- Slow close

A history of the breaker alarms is available with the **BREAKER** command.

**Oscillography**

Optional software is available to display the SEL-352 event reports in an oscillographic format. Contact the Customer Service Department for more information about the ACSELERATOR Analytic Assistant® SEL-5601 Software.

**Additional Features**

**Serial Interface**

The SEL-352 is equipped with three EIA-232 serial ports and one isolated EIA-485 serial port. Each serial port operates independently of the other serial ports.

For connecting devices more than 100 feet, fiber-optic transceivers are available. The SEL-2800 and SEL-2810 provide fiber-optic links between devices for electrical isolation and long distance signal transmission. Contact the SEL Customer Service Department for further information.

**Direct SEL-2600A RTD Module Communications**

Program any serial port on the SEL-352-2 or SEL-352-3 to accept fiber-based communications from the SEL-2600A RTD Module. Use an SEL-2600A with the SEL-2800 fiber-optic transceiver on the selected port to provide up to 12 temperature inputs to the relay. Use these temperature inputs for ambient temperature compensation for POW open and close operations, and as many as 24 individual thermal elements.
Figure 4 Communications with the SEL-2600A RTD Module (SEL-2800 not shown)

Front Panel

The SEL-352 front panel includes a 2-line, 16-character LCD display; 16 LED target/indicators; and 8 pushbuttons. The LCD display shows event information, metering information, and self-test status. The display is controlled with 8 multifunction pushbuttons.

Targeting

The target LEDs on the front panel illuminate based on various relay conditions. View these targets remotely by issuing the TARGET command to one of the serial ports. Front-panel targets illuminate for the conditions shown in Table 2.

Model Variations

SEL-352-1 Relay

The SEL-352-1 has provided sophisticated and reliable service for many years. It continues to satisfy the needs of most of our customers. However, we recommend using the SEL-352-2 and SEL-352-3 for new designs because of the additional features they provide.

SEL-352-2 Relay

The SEL-352-2 provides the following additional features:

- Overcurrent elements for detecting rms overcurrent conditions on a per-pole or three-phase basis (50R, 50RA, 50RB, and 50RC).
- Percent wear function for estimating the amount of breaker contact wear per pole.
- BREAKER W command for preloading the number of operations, total current, total energy, and percent wear fields in the operation summary on a per-pole basis.
- Direct SEL-2600A RTD module communications
- Ambient temperature compensation for POW breaker opening and closing operations.

Table 2 Front-Panel Target LED Indication

<table>
<thead>
<tr>
<th>Target LED</th>
<th>Condition for Illumination</th>
<th>Target LED</th>
<th>Condition for Illumination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Row:</td>
<td></td>
<td>Bottom Row:</td>
<td></td>
</tr>
<tr>
<td>EN</td>
<td>Normal Operation</td>
<td>A</td>
<td>Phase A Breaker Failure</td>
</tr>
<tr>
<td>PF</td>
<td>Breaker Pending Failure</td>
<td>B</td>
<td>Phase B Breaker Failure</td>
</tr>
<tr>
<td>86BFT</td>
<td>Lockout Relay Trip</td>
<td>C</td>
<td>Phase C Breaker Failure</td>
</tr>
<tr>
<td>86RS</td>
<td>Lockout Relay Reset</td>
<td>FAULT</td>
<td>Fault Current Protection</td>
</tr>
<tr>
<td>TRIP</td>
<td>Breaker Trip Received</td>
<td>LOAD</td>
<td>Load Current Protection</td>
</tr>
<tr>
<td>CLOSE</td>
<td>Breaker Close Received</td>
<td>UBAL</td>
<td>Current Unbalance Protection</td>
</tr>
<tr>
<td>52A</td>
<td>52A Status Input Assertion</td>
<td>FLASH</td>
<td>Flashover Protection</td>
</tr>
<tr>
<td>MOD</td>
<td>MOD Status Input Assertion</td>
<td>THERM</td>
<td>Thermal Failure Protection</td>
</tr>
</tbody>
</table>

Time Clock Synchronization (IRIG-B)

The SEL-352 accepts a demodulated IRIG-B format signal for synchronizing its internal clock to some external source such as the SEL-2030 or SEL-2020 Communications Processor or SEL-IDM.
SEL-352-3 Relay

The SEL-352-3 provides the following features in addition to those shown for the SEL-352-2 Relay:

- Battery Voltage Monitoring—up to four setpoints for monitoring station dc battery system health.
- DC Voltage compensation for POW breaker opening and closing operations.

Conventional Terminal Blocks

This model includes hardware that supports three current inputs, six voltage inputs, six optoisolated inputs, seven programmable output contacts, one alarm contact, three EIA-232 ports, one EIA-485 port, and IRIG-B time code. It uses terminal blocks that support #6 ring terminals. This robust package meets or exceeds numerous industry standard type tests.

This relay is available in a 3.50” (2U), 5.25” (3U), or 7.00” (4U) rack-mount package or 4.9”, 6.65”, or 8.40” panel-mount package. Additional optoisolated inputs and programmable output contacts are available with the larger packages.

Plug-In Connectors (Connectorized®)

This model includes hardware that supports all of the features of the conventional terminal blocks model. It differs in its use of plug-in connectors instead of terminal blocks. In addition, it provides:

- Quick connect/release hardware for rear-panel terminals
- Level-sensitive optoisolated inputs

This robust package meets or exceeds numerous industry standard type tests. It is available in a 5.25” (3U) rack-mount package or a 4.9” panel-mount package.
Wiring Diagrams

AC Diagram

Connect the SEL-352 to the breaker current transformers for current-only, breaker-failure detection. Obtain voltage monitoring with the addition of three voltages on one side of the breaker. Supply at least one voltage on each side of the breaker to obtain synchronism checking. By connecting current and supplying three voltages on each side of the breaker, you can obtain thermal protection in addition to breaker-failure detection, voltage monitoring, and synchronism checking.

Figure 5  Typical External AC Connections
**DC Diagram**

The following diagrams give a simple example of how the SEL-352 can be connected. Inputs and outputs of the SEL-352 are fully programmable for application flexibility. Optional interface boards provide additional outputs and inputs, as described in Table 1.

**Figure 6** Example DC Output Contact Connections

**Figure 7** Example DC Input Connections
Front- and Rear-Panel Diagrams

Figure 8  SEL-352 Front-Panel Diagrams

Figure 9  SEL-352 Rear-Panel Diagrams
Relay Dimensions

**RACK-MOUNT CHASSIS**

**PANEL-MOUNT CHASSIS**

* 8.80 (223.5)  
* 8.80 (223.5)  
* 6.40 (162.5)  
* 6.40 (162.5)

0.35 (8.9)   
0.35 (8.9) 
2.75 (69.9)  
2.75 (69.9)

19.00 (482.6) 
19.80 (502.9) 
20.25 (513.9)

A  
B  
C  
D

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>MAIN BOARD ONLY (2U)</th>
<th>ONE I/O BOARD (3U)</th>
<th>TWO I/O BOARD (4U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.47 (88.1)</td>
<td>5.22 (132.6)</td>
<td>6.97 (177.0)</td>
</tr>
<tr>
<td>B</td>
<td>3.00 (76.2)</td>
<td>2.25 (57.2)</td>
<td>4.00 (101.6)</td>
</tr>
<tr>
<td>C</td>
<td>4.90 (124.5)</td>
<td>6.65 (168.9)</td>
<td>8.40 (213.4)</td>
</tr>
<tr>
<td>D</td>
<td>3.60 (91.4)</td>
<td>5.35 (135.9)</td>
<td>7.10 (180.3)</td>
</tr>
</tbody>
</table>

* ADD 0.65 (16.5) FOR CONNECTORIZED RELAYS

**Figure 10**  SEL-352 Dimensions for Rack- and Panel-Mount Models
Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system
UL Listed to U.S. and Canadian safety standards (File E212775; NRGU, NRGU7)
CE Mark
UKCA Mark
RCM Mark

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

General

Terminal Connections

Note: Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105°C.

Tightening Torque, Terminal Block

Minimum: 9 in-lb (1.1 Nm)
Maximum: 12 in-lb (1.3 Nm)

Tightening Torque, Connectorized

Minimum: 5 in-lb (0.6 Nm)
Maximum: 7 in-lb (0.8 Nm)

AC Current Inputs

5 A Nominal: 15 A continuous, 500 A for 1 s, linear to 100 A symmetrical, 1250 A for 1 cycle
Burden Rating: 0.27 VA at 5 A, 2.51 VA at 15 A

1 A Nominal: 3 A continuous, 100 A for 1 s, linear to 20 A symmetrical, 250 A for 1 cycle.
Burden Rating: 0.13 VA at 1 A, 1.31 VA at 3 A

AC Voltage Inputs

120 V L-N, three-phase, four-wire connection
150 V L-N, continuous (connect any voltage up to 150 Vac)
365 Vac for 10 s
Burden: 0.13 VA @ 67 V; 0.45 VA @ 120 V

Power Supply

24/48 Vdc

Rated Voltage: 24–48 Vdc
Operational Voltage Range: 20–60 Vdc polarity-dependent
Vdc Input Ripple: 5%
Interruption: 30 ms at 48 Vdc
Burden: <25 W

125/250 Vdc or Vac

Rated Voltage: 125–250 Vdc or Vac
Operational Voltage Range: 85–350 Vdc or 85–264 Vac
Vdc Input Ripple: 100%

Interruption: 30 ms at 125 Vdc
Burden: <25 W

Note: Interruption and Ripple per IEC 60255-11 [IEC 255-11]:1979

Output Contacts

Standard

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, 40 J
Pickup Time: <5 ms
Dropout Time: <5 ms, typical

Breaking Capacity (10,000 Operations) per IEC 60255-23:1994

24 V 0.75 A L/R = 40 ms
48 V 0.50 A L/R = 40 ms
125 V 0.30 A L/R = 40 ms
250 V 0.20 A L/R = 40 ms

Cyclic Capacity (10,000 Operations) per IEC 60255-23:1994
Rate: 2.5 cycles/second

24 V 0.75 A L/R = 40 ms
48 V 0.50 A L/R = 40 ms
125 V 0.30 A L/R = 40 ms
250 V 0.20 A L/R = 40 ms

High-Current Interrupting Option

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: 330 Vdc, 130 J
Pickup Time: <5 ms
Dropout Time: <8 ms, typical

Breaking Capacity (10,000 Operations) per IEC 60255-23:1994

24 V 10.0 A L/R = 40 ms
48 V 10.0 A L/R = 40 ms
125 V 10.0 A L/R = 40 ms
250 V 10.0 A L/R = 20 ms

Cyclic Capacity (10,000 Operations) per IEC 60255-23:1994
Rate: 4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation

24 V 10.0 A L/R = 40 ms
48 V 10.0 A L/R = 40 ms
125 V 10.0 A L/R = 40 ms
250 V 10.0 A L/R = 20 ms

Note: Do not use high-current interrupting output contacts to switch ac control signals. These outputs are polarity-dependent.

Fast High-Current Interrupting Option

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: 330 Vdc, 40 J
Pickup Time: <200 ms
Dropout Time: <8 μs, typical
Breaking Capacity (10,000 Operations) per IEC 60255-23:1994

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
<th>L/R (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 V</td>
<td>10.0 A</td>
<td>40 ms</td>
</tr>
<tr>
<td>48 V</td>
<td>10.0 A</td>
<td>40 ms</td>
</tr>
<tr>
<td>125 V</td>
<td>10.0 A</td>
<td>40 ms</td>
</tr>
<tr>
<td>250 V</td>
<td>10.0 A</td>
<td>20 ms</td>
</tr>
</tbody>
</table>

Cyclic Capacity (10,000 Operations) per IEC 60255-23:1994

Rate: 4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
<th>L/R (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 V</td>
<td>10.0 A</td>
<td>40 ms</td>
</tr>
<tr>
<td>48 V</td>
<td>10.0 A</td>
<td>40 ms</td>
</tr>
<tr>
<td>125 V</td>
<td>10.0 A</td>
<td>40 ms</td>
</tr>
<tr>
<td>250 V</td>
<td>10.0 A</td>
<td>20 ms</td>
</tr>
</tbody>
</table>

Note: Fast High-Current Interrupting Option output contacts are not polarity-dependent.

Optoisolated Inputs

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Pickup</th>
<th>Dropout</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 Vdc</td>
<td>200–300 Vdc</td>
<td>150 Vdc</td>
</tr>
<tr>
<td>125 Vdc</td>
<td>105–150 Vdc</td>
<td>75 Vdc</td>
</tr>
<tr>
<td>110 Vdc</td>
<td>86–132 Vdc</td>
<td>66 Vdc</td>
</tr>
<tr>
<td>48 Vdc</td>
<td>38.4–60 Vdc</td>
<td>28.8 Vdc</td>
</tr>
<tr>
<td>24 Vdc</td>
<td>15.0–30 Vdc</td>
<td></td>
</tr>
</tbody>
</table>

Note: 24, 48, 125 Vdc optoisolated inputs draw approximately 4 mA of current, 110 Vdc inputs draw approximately 8 mA of current, and 250 Vdc inputs draw approximately 5 mA of current. All current ratings are at nominal input voltage.

Substation Battery Voltage Monitor

Pickup Range: 20–300 Vdc
Pickup Accuracy: ±2% of setting

Routine Dielectric Strength

AC Current and Voltage Inputs: 2500 Vac for 10 s
Power Supply, Optoisolated Inputs, and Output Contacts: 3100 Vdc for 10 s

Frequency and Rotation

System Frequency: 50 or 60 Hz
Phase Rotation: ABC or ACB

Frequency Tracking

NFREQ = 60: Tracking range is 55–63 Hz
NFREQ = 50: Tracking range is 45–55 Hz

Communications Ports

EIA-232: 1 front and 2 rear
EIA-485: 1 rear, 2100 Vdc isolation
Baud rate: 300–19200 baud

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at Port 1 or 2. Relay is time synchronized to within ±5 ms of time source input.

Operating Temperature

-40° to +85°C (−40° to +185°F)

Weight

2U Rack Unit Height: 15 lb (6.8 kg)
3U Rack Unit Height: 17.75 lb (8 kg)

Processing Specifications

64 samples per power system cycle

Type Tests

Electromagnetic Compatibility Emissions

Emissions: Canada ICES-001 (A) / NMB-001 (A)

Radiated Emissions:

EN 60255-25:2000
Severity Level: Class A

Conducted Emissions:

EN 60255-25:2000
Severity Level: Class A

Electromagnetic Compatibility (EMC) Immunity

Radiated Immunity:

10 V/m RMS; 80 MHz – 1 GHz; 1.4 GHz – 2.7 GHz: Swept
80, 160, 380, 450, 900, 1850, & 2150 MHz: Spot (> 15 V/m RMS @ 80% AM 1 kHz sine wave)

IEEE C37.90.2-2004
20 V/m RMS; 80 MHz – 1 GHz: Swept Frequency
80, 160, 450, 900 MHz: Spot Frequency (> 35 V/m RMS @ 80% AM 1 kHz sine wave)

Conducted Immunity:

EN 61000-4-6:2007
10 V RMS; 150 kHz – 80 MHz: Swept Frequency
27 MHz & 68 MHz: Spot Frequency (w/80% AM 1 kHz sine wave)

Electrostatic Discharge Immunity:

EN 61000-4-2:2000
IEEE C37.90.3 – 2001
Severity Level: 2, 4, 6, & 8 kV contact; 2, 4, 8, & 15 kV air

Fast Transient/Burst Immunity:

EN 61000-4-4:2004
Zone A: Power Input; I/O: ± 4.0 kV; 5 kV Communication Ports: ± 2.0 kV; 5 kV

Surge Immunity:

EN 60255-22-1:2008
Zone B:
± 0.5, 1.0 kV (line-to-line)
± 0.5, 1.0, 2.0 kV (line-to-earth)
± 0.5, 1.0 kV (communication ports)

IEEE Surge Withstand Capability:

IEEE C37.90.1-2002
Damped Oscillatory (1 MHz):
Power Input, CT, PT, & I/O: ± 2.5 kV (CM & DM) Communications Ports: ± kV (CM only)
Fast Transient (2.5 kHz):
Power Input, CT, PT, & I/O: ± 4.0 kV (CM & DM) Communications Ports: ± 4.0 kV (CM only)

Power Supply Immunity:

EN 60255-11:2010
Voltage dips, interruption, & ripple
EN 61000-4-11:2004
AC dips & interruptions
EN 61000-4-29:2000
DC dips & interruptions
EN 61000-4-17:1999 + A1:2004
15% ripple on dc power input

Environmental

Cold:
EN 60068-2-1:2007
Cold profile ad; -40°C ≥ 16 hrs, operational

Dry Heat:
EN 60068-2-2:2007
Dry heat profile dh; +85°C ≥ hrs, operational
Damp Heat, Cyclic: EN 60068-2-30:2005
Damp heat, profile db, –25°C to +55°C, relative humidity ≥ 93%, 6 cycles

Vibration: EN 60255-21-1:1995
Class 1 vibration endurance
Class 2 vibration response

Shock & Bump: EN 60255-21-3:1995
Class 1 shock withstand
Class 2 shock response
Class 1 bump

Seismic: EN 60255-21-3:1995
Class 2 quake response

Safety
Insulation Coordination: EN 60255-5:2001
IEEE C37.90-2005
Hi-Pot:
3.1 kVdc power supply
2.5 kVac contact I/O & analog inputs
2.2 kVdc EIA-485 & IRIG
Impulse: 0.5 J, 5 kV, 1.2/50 μS

Signal Processing Specifications

Analog Data Acquisition

–3dB cutoff at 1200 Hz, 64 samples per cycle, see Figure 11.

<table>
<thead>
<tr>
<th>Harmonic</th>
<th>Correction Factor (60 Hz)</th>
<th>Correction Factor (50 Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental through 8th</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9th</td>
<td>1.01</td>
<td>1</td>
</tr>
<tr>
<td>10th</td>
<td>1.02</td>
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<tr>
<td>11th</td>
<td>1.03</td>
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<td>12th</td>
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<td>1.42</td>
<td>1.21</td>
</tr>
<tr>
<td>21st</td>
<td>1.50</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Relay Element Specifications

Overcurrent Elements

50FT Fault Current Element with Subsidence Current Logic
Setting Ranges: 0.50–45.00 A secondary, 0.01-A steps
(\(I_{\text{NOM}} = 5\) A)
0.10–9.00 A secondary, 0.01-A steps
(\(I_{\text{NOM}} = 1\) A)
Pickup Time: <0.55 cycle at 2 multiples of pickup
Dropout Time: <0.75 cycle
Pickup and Dropout: ±0.025 A secondary ± 5% of setting
Transient Overreach: ±14% of setting

50MD/50LD MOD and Load/Line Current Elements
Setting Ranges: 0.10–45.00 A secondary, 0.01-A steps
(\(I_{\text{NOM}} = 5\) A)
0.02–9.00 A secondary, 0.01-A steps
(\(I_{\text{NOM}} = 1\) A)
Pickup Time: <0.9 cycle at 2 multiples of pickup
Dropout Time: <1.35 cycles
Pickup and Dropout: ±0.03 A secondary ± 5% of setting
Transient Overreach: ±5% of setting

50MN Minimum Current Element
Current Threshold (Fixed): 0.10 A secondary (\(I_{\text{NOM}} = 5\) A)
0.02 A secondary (\(I_{\text{NOM}} = 1\) A)
Pickup Time: <0.9 cycle at 2 multiples of pickup
Dropout Time: <1.35 cycles
Pickup and Dropout: ±0.03 A secondary
Transient Overreach: ±5% of setting

50N Ground Overcurrent Element
Setting Ranges: 0.10–45.00 A secondary, 0.01-A steps (INOM = 5 A)
0.02–9.00 A secondary, 0.01-A steps (INOM = 1 A)
Pickup Time: <0.9 cycle at 2 multiples of pickup
Dropout Time: <1.35 cycles
Pickup and Dropout: ±0.025 A secondary ± 5% of setting
Transient Overreach: ±5% of setting

50RMS RMS Overcurrent Element
(Only available in the SEL-352-2 and SEL-352-3 Relays)
Setting Ranges: 0.50–45.00 A secondary, 0.10-A steps (INOM = 5 A)
0.10–9.00 A secondary, 0.02-A steps (INOM = 1 A)
Pickup Time: <0.9 cycle at 2 multiples of pickup
Dropout Time: <1.125 cycles
Pickup and Dropout: ±0.01•INOM A secondary ± 5% of setting
Transient Overreach: ±5% of setting

Pickup/Dropout Curves
Figure 12 through Figure 15 are based on actual test data at room temperature using various settings. Relay element specifications given previously in this section include the entire temperature range of the relay. Output contact times are not included.

Voltage Elements

87H/87FO/87TH Voltage Across Breaker Overvoltage Elements
Setting Range: 1.0–150.0 V secondary, 0.1-V steps
Pickup Time: <1.35 cycles
Dropout Time: <1.55 cycles
Pickup and Dropout: ±0.09 V secondary ± 5% of setting
Transient Overreach: ±5% of setting

X47Q/Y47Q Negative-Sequence Overvoltage Element
Setting Range: 2.0–140.0 V secondary, 0.1-V steps
Pickup Time: <1.35 cycles
Dropout Time: <1.55 cycles
Pickup and Dropout: ±0.27 V secondary ± 6% of setting
Transient Overreach: ±5% of setting

X59H High-Set Overvoltage Element
Setting Range: 1.0–130.0 V secondary, 0.1-V steps
Pickup Time: <1.35 cycles
Dropout Time: <1.55 cycles
Pickup and Dropout: ±0.09 V secondary ± 5% of setting
Transient Overreach: ±5% of setting

X27D/Y27D Dead Line Undervoltage Element
Setting Range: 1.0–120.0 V secondary, 0.1-V steps
Pickup Time: <1.35 cycles
Dropout Time: <1.55 cycles
Pickup and Dropout: ±0.09 V secondary ± 5% of setting
Transient Overreach: ±5% of setting

X59L/Y59L Live Line Overvoltage Element
Setting Range: 10.0–120.0 V secondary, 0.1-V steps
Pickup Time: <1.35 cycles
Dropout Time: <1.55 cycles
Pickup and Dropout: ±0.09 V secondary ± 5% of setting
Transient Overreach: ±5% of setting

Synchronism-Check Elements
25SC/25SM  Maximum Slip Frequency for Controlled/Manual Close
Setting Range: 0.005–0.500 Hz, 0.001-Hz steps
Pickup and Dropout: ±0.002 Hz ± 2% of setting
25AC  Maximum Controlled Close Angle
Setting Range: 32° (25SC) to 90°, min = 1°, 0.1° steps
Pickup and Dropout: ±0.5° ± 5% of setting
25AM  Maximum Manual Close Angle
Setting Range: 32° (25SC) to 90°, min = 1°, 0.1° steps
Pickup and Dropout: ±0.5° ± 5% of setting

Current Unbalance Element
46P  Phase Current Unbalance Element
46P detects phase discordance when the protected breaker closes. For example, A-Phase is unbalanced if phase current is above the 50LD setting in one or more phases and:
\[|I_A| < \left(\frac{|I_A| + |I_B| + |I_C|}{4}\right)\]
\[46UB\text{ setting} = 8, 16, 32, \text{ or } 64.\]
Time to stabilize measurement because of transient conditions: < 1.35 cycles

Overpower Elements
37OP  Breaker Overpower Element
Setting Range: 0.10–3400.00 W secondary, 0.01-W steps (INOM = 5 A)
0.02–680.00 W secondary, 0.01-W steps (INOM = 1 A)
Pickup Time: <2.10 cycles
Dropout Time: <3.00 cycles
Maximum Element Error, Secondary Units:
±2.25 mW ±10.25%
( measured input power)
±2.63% (measured voltage)
±9.45% (measured current)

Breaker Resistor Thermal Elements
26CF  Close Resistor Failure Element
26CP  Close Resistor Pending Failure Element
26TF  Trip Resistor Failure Element
26TP  Trip Resistor Pending Failure Element
Setting Range: 0.010–1000.000 Joules secondary,
0.001 J-steps (INOM = 5 A)
0.002–200.000 Joules secondary,
0.001 J-steps (INOM = 1 A)
Pickup error is based on 37OP element over time.

Settable Timers
SYNCT  Synchronizing Time Dropout (SYNCdo)
Setting Range: 0.00–99999.00 cycles, 1/4-cycle steps
Pickup Setting: ±0.25 cycles or ±0.25% of setting
62TT  Failure-to-Trip Fault Current Trip Input Timer
62FC  Failure-to-Trip Fault Current Failure Timer
62T1  General Purpose Timer I
62M2  Maximum Bus Clearing Time
62M3  Maximum MOD Operate Time

Fixed Timers
62F1  Flashover Voltage Time Delayed Dropout Timer
5 cycles ±0.25 cycles
62F2  Load Current Pickup Timer (Flashover Logic)
5 cycles ±0.25 cycles
62F3  Trip or Close Dropout Timer (Flashover Logic)
6 cycles ±0.25 cycles
62M1  86BF Reset Signal Duration Timer
60 cycles ±0.125 cycles
62M4  86BF Reset Time Delay, MOD Logic Enabled
300 cycles ±0.125 cycles
62LT1  Loss-of-Dielectric Input Debounce Timer
60 cycles ±0.25 cycles
62LT3  Loss-of-Dielectric Input Debounce Timer
60 cycles ±0.25 cycles
MCT  Manual Close Input Dropout Timer
2 cycles ±0.25 cycles
SEN  Synchronism Calculation Enable Pickup Timer
15 cycles ±0.25 cycles
SS  Slip Security Pickup Timer
4.5 cycles ±0.25 cycles

Internal Logic Timers
62XZPB  B-Phase Positive Zero-Crossing Delay Timer for X Side
62XZNB  B-Phase Negative Zero-Crossing Delay Timer for X Side
0.33 cycles
62XZPC  C-Phase Positive Zero-Crossing Delay Timer for X-Side
62XZNC  C-Phase Negative Zero-Crossing Delay Timer for X-Side
0.66 cycles

62YZPB  B-Phase Positive Zero-Crossing Delay Timer for Y-Side
62YZNB  B-Phase Negative Zero-Crossing Delay Timer for Y-Side
0.33 cycles

62YZPC  C-Phase Positive Zero-Crossing Delay Timer for Y-Side
62YZNC  C-Phase Negative Zero-Crossing Delay Timer for Y-Side
0.66 cycles

62T    Trapped Charge Trip Input Dropout Timer
4 cycles

62V    Trapped Charge Voltage Dropout Timer
7 cycles

TCDpu  Trapped Charge Detection Pickup Timer
1 cycle

TCDdo  Trapped Charge Detection Dropout Timer
12 cycles

62BALRM  Breaker Alarm Dropout Timer
60 cycles

62OII  Operation Input Dropout Timer for Breaker Alarms
5 cycles

62BDNC  BDNC Breaker Alarm Close Inputs Pickup Timer
3 seconds

62TWO  Trip Input Dropout Debounce Timer
0.25 cycles

T1A    Controlled Open Trip Reset Timer
10.00 cycles

T2A    Controlled Open Dropout Delay Timer
0.75 cycles

T3A    Controlled Open Peak Delay Timer
0.25 cycles

Metering
VAX    A-Phase Voltage for the X-Side ac inputs
Units: kilovolts (kV) primary
Accuracy: ±0.67 V secondary
IA     A-Phase current ac input
Units: Amperes (A) primary
Accuracy: ±0.05 A secondary (I_{NOM} = 5 A)
±0.01 A secondary (I_{NOM} = 1 A)

VBY    B-Phase Voltage for the Y-Side ac inputs
VCY    C-Phase Voltage for the Y-Side ac inputs

AMBI   Ambient Temperature
Units: °C
Accuracy: ±2°C

Multiple Setting Groups
SS1    Setting group selection input 1
SS2    Setting group selection input 2
Number of Setting Groups: 3
Setting Group Change Delay: TGR setting and as long as 3 seconds uncertainty

Data Recording Specifications
Event Records
MER    Event Report Trigger
Pickup Accuracy: 0.000 to 0.125 cycles
Number of Events: 1200 + LER setting (15, 30, or 60 cycles)
SER1   Sequential-Event-Recorder Trigger List 1
SER2   Sequential-Event-Recorder Trigger List 2
SER3   Sequential-Event-Recorder Trigger List 3
Pickup Accuracy: 0.000 to 0.125 cycles
Number of Trigger Elements: 24 per list, 72 total
Number of Events Displayed: 512

Breaker Monitor Reporting
Electrical Operate Time
Units: ms
Mechanical Operate Time
Units: ms
Energy Units: MJ, primary
Current Units: A, primary
Breaker Contact Wear***: %
Number Of Operations Displayed: 512
Other Relay Elements Determine Accuracy
Note: *** SEL-352-2 and SEL-352-3 Relays Only

Serial Port Specifications
Port 1: EIA-485 with IRIG-B input
Port 2: EIA-232 with IRIG-B input and +5 Vdc output.
Maximum total current draw on +5 Vdc supply through serial ports is 1 A.
Port 3: EIA-232 with +5 Vdc output
Port 4: EIA-232
Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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