701 Motor Protection Relay

Accurate Motor Protection With Innovative Motor-Starting Analysis

Major Features and Benefits

The SEL-701 Relay provides complete induction motor protection combined with innovative monitoring, reporting, metering, and control capabilities.

Optional internal or external RTD modules, optional voltage-based protection and metering functions, and standard Modbus™ communications make the SEL-701 Relay the ideal choice for monitoring and protecting your induction motors.

- Load Profiling function tracks motor loading and use, storing quantities every 15 minutes for up to 48 days.
- Event Reports and Sequential Events Recorder reports decrease down time after faults.
- Motor Start Reports and Motor Start Trend data support maintenance by indicating load problems early.

Induction Motor Protection

Motor Thermal Protection

The SEL-701 Relay provides locked rotor, running overload, and negative-sequence current unbalance protection using a patented thermal model. The thermal element accurately tracks the heating effects of load current and unbalance current while the motor is accelerating and running. You can choose from three easy setting methods:

- Motor Nameplate Ratings.
- 45 Standard Thermal Limit Curves.
- Custom Curve Fitting.

For simple effective protection, enter the motor nameplate ratings for Full Load Current, Locked Rotor Current, Hot Stall Limit Time, and Motor Service Factor. To have the relay emulate existing motor protection, select the appropriate thermal limit curve from 45 standard curves. If your motor requires more complex protection, build your own customized thermal limit curve by entering points to define the curve.

Optional internal or external RTD monitoring inputs extend the thermal protection to include direct temperature measurement to protect motor windings as well as motor and load bearings. Stopped motors can cool much more slowly due to loss of coolant or airflow. The relay learns the cooling time constant of the stopped motor when you connect the relay to monitor stator winding RTD temperatures. Enable this feature to use the learned value to accurately track cooling when the motor is stopped.

Short Circuit Tripping

Phase, negative-sequence, residual, and neutral/ground overcurrent elements allow the SEL-701 Relay to detect cable and motor short circuit faults. The relay includes:

- Two phase overcurrent elements.
- Two residual overcurrent elements.
- Two neutral/ground overcurrent elements.
- One negative-sequence overcurrent element.

Set the relay to trip instantaneously or with a definite time-delay for short circuit conditions. You can easily disable the phase overcurrent elements for applications that use fused contactors.

Load-Loss, Load-Jam, and Frequent Starting Protection

The SEL-701 Relay offers tripping for load-jam and load-loss conditions. Load-loss detection provides an alarm and a trip when the condition is detected. Load-jam protection trips the motor quickly to prevent overheating from stall conditions. The relay provides frequent starting protection using settable starts-per-hour and minimum time between starts protection functions. The relay stores motor starting and thermal data in nonvolatile memory to prevent motor damage due to overheating caused by frequent starts, even if relay power is removed.

Unbalance Current and Phase Reversal Protection

In addition to the thermal element, the SEL-701 Relay provides an unbalance current element which trips in the event of a motor single-phasing condition or for heavy current unbalance. The relay phase reversal protection detects the motor phase rotation and trips after a time delay, if the phase rotation is incorrect. The SEL-701 Relay provides this protection even if phase voltages are not available.

Voltage-Based Protection Elements

The SEL-701 Relay offers optional voltage inputs that you can configure in four different ways, including:

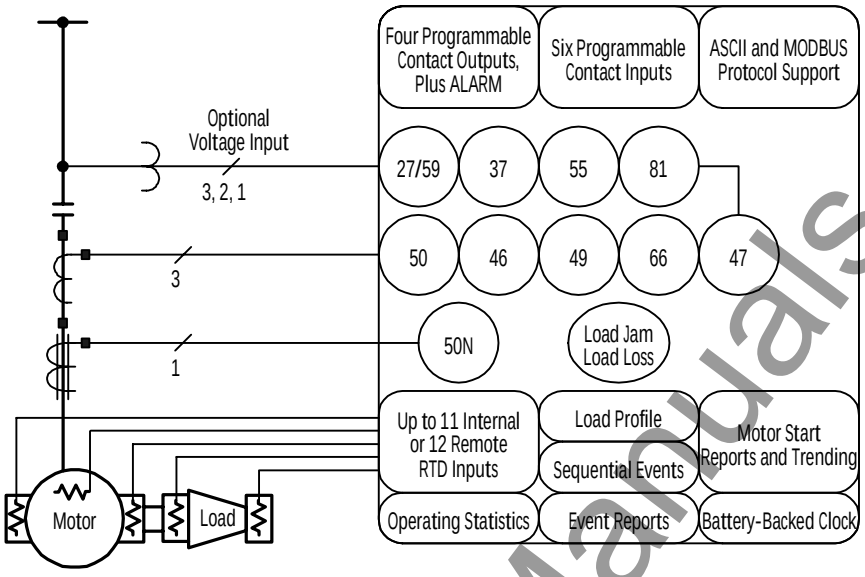
- One phase-to-phase voltage.
- One phase-to-neutral voltage.
- Open-delta voltages.
- Four-wire wye voltages.

When one or more voltages are connected to the relay, it provides a number of added motor protection and metering functions, including:

- Over/under voltage.
- Over/under frequency.
- Underpower.
- Reactive power.
- Power factor elements.

SEL-701 Relay	
ANSII Standard	**Element Name**
Standard Function	
46	Unbalance Current
47	Phase Reversal
49	Motor Thermal
50	Phase Overcurrent
50N	Neutral and Ground Overcurrent
50Q	Negative-Sequence Overcurrent
66	Starts/Hour, Time Between Starts
	Load Jam, Load Loss
With Voltage Option	
27	Undervoltage
37	Underpower
55	Power Factor
	Reactive Power
59	Overvoltage
81	Over- and Underfrequency

Functional Description



Unique Capabilities

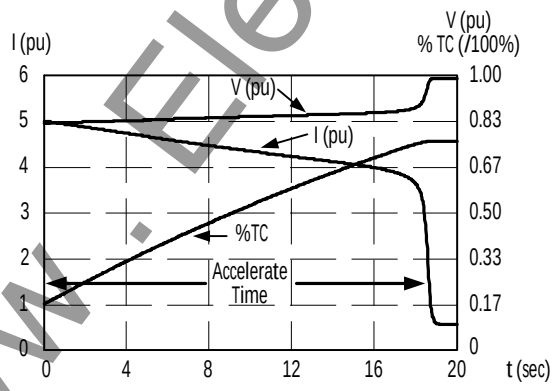
Motor Start Reports and Trends

When an induction motor starts, its rotor and windings can store heat at a rate over 100 times as high as under balanced load conditions. The SEL-701 Relay provides an unmatched view of the motor performance during the critical starting cycle. Every time the protected motor starts, the relay stores a 60-second report detailing:

- Motor currents.
- Optional voltages.
- Thermal model results.

In addition, the relay calculates the accelerating time in seconds and records the maximum current magnitude and minimum voltage magnitude seen during the start. The relay stores the five latest start reports in nonvolatile memory.

The relay also helps you spot trends in starting performance by maintaining the 18 most recent 30-day averages of start report data.

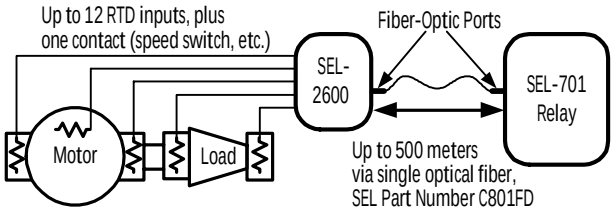


Example Plot Created Using Motor Start Report Data

Internal or External RTD Module

The SEL-701 Relay is available with an optional internal resistance temperature device module that monitors up to 11 RTDs. The relay offers thermal trips and alarms, thermal model biasing, RTD open or short alarms, and temperature measurement when equipped with RTD inputs. Configure each input to use any of four sensor types (Pt100, Ni100, Ni120, or Cu10). Settings also define the sensor locations: Motor Windings, Motor or Load Bearings, Ambient Air, and Other for uncategorized applications.

As a separate option, you may purchase an external RTD module, the SEL-2600 External RTD Module, that monitors up to 12 sensors and a single contact at the motor. This remote device sends data to the relay through a tough, flexible, optical fiber, that is routed back to the Motor Control Center, providing complete electrical isolation between the RTDs and the relay. The external module improves measuring accuracy by shortening lead runs, reducing both lead resistance and electrical noise.



Metering & Monitoring Capabilities

Current- & Voltage-Based Metering Functions

The SEL-701 Relay provides accurate RMS and fundamental frequency metering for input currents, optional voltages, and temperature measurement for optional RTDs. View phase, neutral, residual, negative-sequence, and unbalance current magnitudes using the bright front-panel display. When equipped with voltage inputs, the relay provides additional meter quantities, including:

- Phase, residual, and negative-sequence voltage.
- Real, reactive, and apparent power (kW, kVAR, kVA).
- Real, reactive, and apparent energy (kWhr, kVARhr, kVAhr).
- Frequency, power factor, and real power in horsepower.

When you select internal or external RTD inputs, the relay reports temperatures of the individual RTDs and their locations. These values are also available using the front-panel menus or serial port commands.

Analog Output

The SEL-701 Relay offers an analog output to operate a remote panel meter or as an input to your plant's distributed control system. Configure the output to operate in the range 0–1 mA, 0–20 mA, or 4–20 mA. The relay outputs a dc current signal proportional to your choice of the following:

- Percent of full load current.
- Percent of motor thermal capacity used.
- Winding or bearing RTD temperature.
- Average or maximum phase current.

Motor Monitoring & Statistics

The SEL-701 Relay records a variety of data for your motor maintenance program. Information saved by the motor statistics function includes:

- Time running and stopped.
- Total MWhr.
- Number of starts.
- Average and peak starting time and current.
- Average and peak running current and power.
- Average and peak RTD temperatures.
- Learned motor parameters.
- Protection element alarm and trip counts.

Load Profiling

Every 15 minutes, the relay automatically records a number of measured quantities. Every SEL-701 Relay records the following quantities:

- Phase and neutral current magnitudes.
- % Thermal Capacity.
- % Current Unbalance.
- System frequency.

When RTD inputs are included, the relay automatically adds the temperatures of the hottest winding, hottest bearing, and ambient RTDs.

When the voltage option is specified, the relay also records:

- Phase-to-phase voltage magnitudes.
- Real power magnitude.
- Reactive power magnitude.
- Apparent power magnitude.

Load profile information is maintained in a nonvolatile buffer sized to allow 34 or 48 days of data storage.

SEL-701PC Software

The SEL-701 Relay is supported by a PC-based software package, SEL-701PC. The software package provides a convenient way to:

- Create relay settings for a new installation using the software's setting entry panels. Use the software to create settings for the protection elements, relay serial ports, sequential events recorder function, and Modbus User Map. The screen capture below shows the setting entry screen.
- Store settings in a file on your PC. Create valid setting files in the comfort of your office.
- Deploy setting files on diskette. Load settings into individual relays using portable setting files.
- Download relay settings with complete accuracy. Quick, secure settings transfer saves time and improves the accuracy of relay setting entry. The software range-checks all the settings as they are entered to ensure that the relay will accept them at download time. As you download, the relay and software apply CRC-16 validation to each block of transmitted data to ensure the integrity of the transferred settings.
- Leverage your engineering investment. Quickly create new settings files based on existing schemes. Use identical control and communication settings for many relays, modifying only those protection settings necessary to tailor the relay for the specific motor.

Fault Reporting Functions

The SEL-701 Relay offers a number of functions to help you diagnose and quickly correct the problem when a motor trip occurs.

Front-Panel Targets & Messages

Each time the SEL-701 Relay trips, it lights one or more of six front-panel target LEDs. The relay automatically determines the type of trip and displays it on the front-panel display. Trip type messages include:

- Thermal and Locked Rotor Trips.
- Load-Loss and Load-Jam Trips.
- Unbalance Current Trips.
- Phase and Ground Fault Trips.
- RTD Trips.

In addition to illuminating for trips, Thermal Overload, Unbalance, Load Loss, and Voltage front-panel LEDs flash when their respective alarm conditions pick up.

Event Summaries

The SEL-701 Relay captures a 15-cycle event report and creates an event summary whenever the relay trips and in response to user programmable conditions. View the summary using the front panel. Event summaries contain:

- Event number, date, and time.
- Trip type.
- System frequency.
- % Thermal Capacity used.
- % Unbalance Current.
- Magnitudes of the phase, neutral, negative-sequence, and residual currents.
- Temperatures of the hottest winding, bearing, ambient, and other RTDs.
- Magnitudes of the phase-to-phase voltages.
- Magnitudes of the real and reactive powers and power factor.

The relay saves the 14 most recent event reports and event summaries in nonvolatile memory so the information is retained even if relay power is removed.

Full-length event reports contain the event summary data, plus 15 cycles of detailed current, voltage, protection element, input and output data, shown on a quarter-cycle or sixteenth-cycle basis. Review event data as a text-based report or in oscillographic format.

Sequential Events Recorder (SER)

In addition to storing event summaries and full-length reports, the SEL-701 Relay tracks the pickup and dropout of protection elements, contact inputs, and contact outputs that you select. The date and time of each transition is available in a Sequential Events Recorder (SER) report that you can download using your PC. This chronological report helps you determine the order and cause of events and assists in troubleshooting.

SEL-701 Motor Protection Relay Guideform Specification

Motor protection shall be provided by a microprocessor-based relay equipped with the following protection functions:

- Motor thermal model accounting for phase and negative-sequence current heating during starting and running states; settable motor-stopped cooling time constant shall be provided.
- Phase, neutral, and negative-sequence overcurrent elements for short circuit fault detection.
- Unbalance current, phase reversal, load-loss, and load-jam detection.
- Starts-per-hour and minimum time between starts limit protection.

When voltage inputs are specified, the relay shall provide the following protection elements: over/undervoltage, over/underfrequency, underpower, reactive power, and power factor.

The relay shall be available with 11 internal RTD inputs or with 12 RTD inputs in an external module. When included, the external module shall send RTD temperatures and one contact input status to the relay using an optical fiber with a range not less than 400 m. The RTD types shall be individually field selected from four supported types. RTD inputs shall provide the following:

- Thermal model biasing.
- Temperature alarm and trip.
- RTD open or short indication.

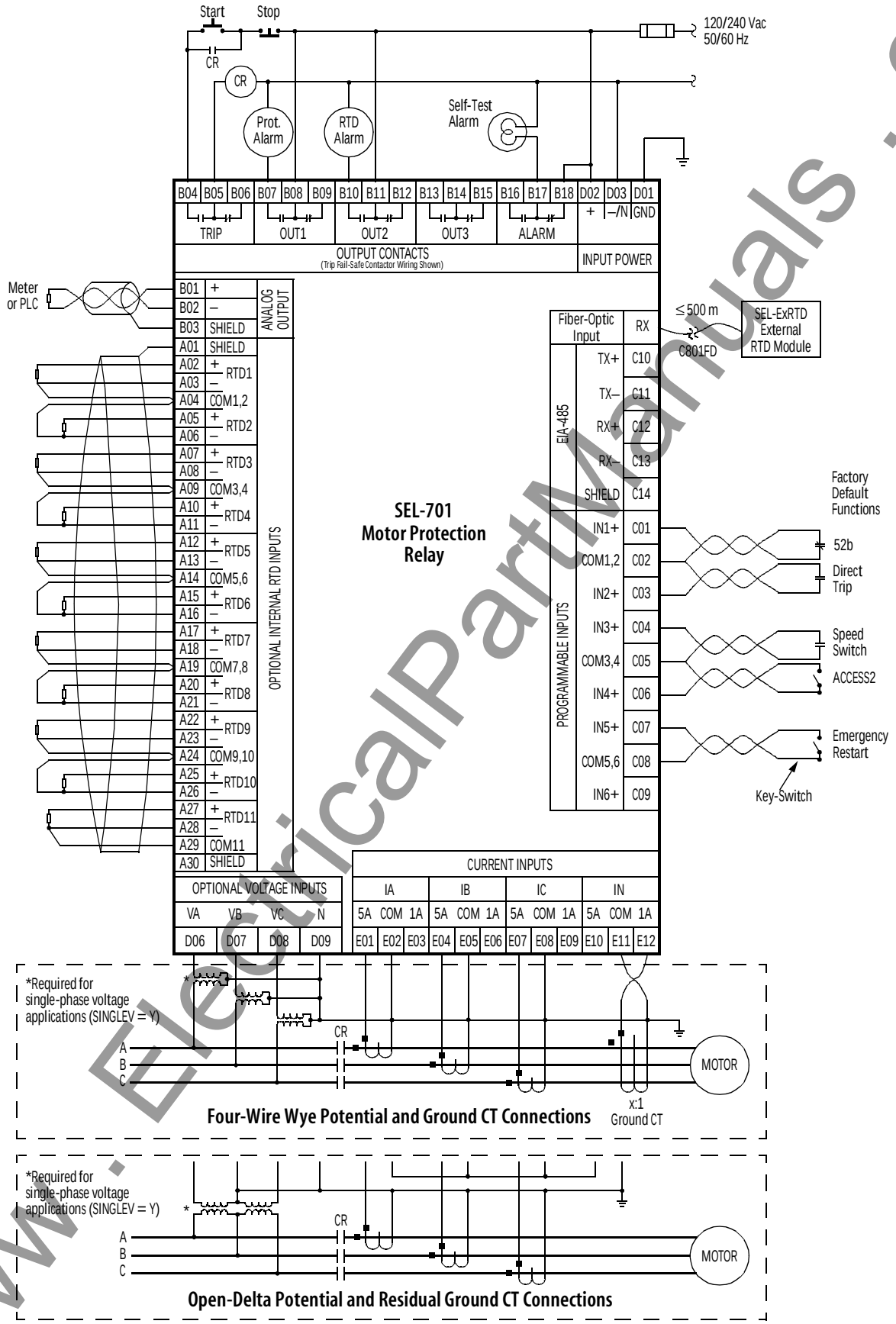
The relay shall provide the following monitoring and reporting functions:

- Fault summaries showing faulted motor type and conditions.
- Event reports containing 15 cycles of oscillographic data with 16 samples/cycle resolution.
- Sequential Events Recorder report showing the last 512 input, output, and element transitions.
- Motor start reports showing the currents and thermal estimate every 5 cycles during the first 60 seconds of the motor start.
- Motor start trending showing acceleration time, maximum current, and maximum thermal estimate averages for each of the past eighteen 30-day periods.
- Load profiling that records up to 17 values every 15 minutes for 34 or 48 days.
- Motor Operating Statistics report.

These data shall be available from front- and rear-panel serial ports using a PC, terminal emulation software, and a serial cable. For integration purposes, Modbus® protocol shall be supported at the relay rear-panel port.

The relay shall have an operating temperature range of -40°C to +85°C and a power supply input operating voltage range of 20–250 ±20% Vdc or 95–240 ±10% Vac. The relay front panel shall meet the requirements of NEMA12/IP54.

Wiring Diagrams



Detailed Specifications

Standard Relay Features & Functions

Phase Current Inputs

Nominal Current, I_{NOM}: 1 A or 5 A
Range: 0.05–20.00 • I_{NOM}
Burden: 0.14 VA @ 5 A, 5 A tap
0.06 VA @ 1 A, 1 A tap
Continuous: 3 • I_{NOM}
200 Second Thermal: 10 • I_{NOM}
10 Second Thermal: 20 • I_{NOM}
1 Second Thermal: 50 • I_{NOM}
Measuring Error: ±1%, ±0.01 • I_{NOM}

Neutral/Ground Current Input

Nominal Current, IN_{NOM}: 1 A or 5 A
Range: 0.005–2.000 • IN_{NOM}
Burden: 0.28 VA @ 5 A, 5 A tap
0.19 VA @ 1 A, 1 A tap
Continuous: 0.3 • IN_{NOM}
1 Second Thermal: 5.0 • IN_{NOM}
Measuring Error: ±1%, ±0.01 • I_{NOM}

Motor Thermal Model

Locked Rotor Time: 1.0–240.0 s
Locked Rotor Current: 2.5–16.0 • I_{NOM}
Service Factor: 1.0–1.5
Setting Modes:
45 standard curve shapes
Nameplate ratings
Custom curve shape
Pickup Error: <±1%, ±0.01 • I_{NOM}
Timing Error: ±2% ±15 ms
Independent Stop/Run Cooling Rates
Thermal estimate retained through relay power cycle.

Overcurrent Elements (Phase, Residual, Negative-Sequence)

Setting Range: 0.05–20.00 • I_{NOM}
Time Delays: 0.00–400.00 s

Neutral/Ground Overcurrent Element

Setting Range: 0.005–2.000 • IN_{NOM}
Time Delays: 0.00–400.00 s

Current Unbalance Element

Alarm and Trip Elements
Setting Range: 2%–80%
Time Delays: 0.00–400.00 s
Error: <±1%
Definitions
For I_{av} > FLA
UB% = 100% • $|I_m–I_{av}|/I_{av}$
For I_{av} < FLA
UB% = 100% • $|I_m–I_{av}|$/FLA
Where:
I_{av} = Avg phase current
I_m = Phase most different from I_{av}
FLA = Motor rated full load amps

Load-Loss/Load-Jam Function

Load-Loss Alarm and Trip
Setting Range: 0.03–1.00 • FLA
Load-Jam Trip
Setting Range: 0.5–6.0 • FLA
Time Delays: 0.00–400.00 s

Starts Per Hour, Time Between Starts

Max. Starts/Hour: 1–15 starts
Min. Time Bet. Starts: 1–150 minutes
Start data retained through relay power cycle.

Phase Reversal Tripping

Phase reversal tripping based on current or optional voltage inputs.

Meter Accuracy

Current Metering: ±1%, ±0.01 • I_{NOM}
Demand Current Metering: ±1%
Optional Voltage Metering: ±1%, ±0.2 V
Optional Power Metering: ±2%
Optional Power Factor Metering: <±4%
Optional Frequency Metering: ±0.01 Hz
Optional kW, kVa, kVAR Demand: ±2%

Analog Output

Single Analog Current Output
Settable Range: 0–1 mA
0–20 mA
4–20 mA
Max Load: 8 k or 400 ohms
Error: <±0.5%, Full Scale
Select From:
%FLA, %Thermal Cap, Hottest RTD, Avg phase current, Max phase current

Contact Inputs

6 Self-Wetted Contact Inputs, Programmable Function

Contact Outputs

1 Trip Contact, 3 Programmable Contacts, Relay Self-Test Alarm
Form C Contacts
Make/Carry/Interrupt Ratings
Make: 30 A
Carry: 6 A
Interrupt: 8 A Resistive @ 250 Vac
0.75 A, L/R = 40 ms @ 24 Vdc
0.50 A, L/R = 40 ms @ 48 Vdc
0.30 A, L/R = 40 ms @125 Vdc
0.20 A, L/R = 40 ms @250 Vdc

Serial Ports

Front-Panel
EIA-232 Port: 300–19200 baud
ASCII text communication
Rear Panel
ASCII EIA-232 port: 300–19200 baud
Or Modbus® EIA-485 port: 300–19200 baud
EIA-485 port isolation: 500 V

Optional Features & Functions

Optional Phase Voltage Inputs

Nominal Voltage: 0–300 Vac
Four-Wire Wye or Open-Delta Voltages
Burden: <2 VA at 300 V
Measuring Error: ±1%, ±0.2 V

Over-Undervoltage Elements

Setting Range: 1–300 Vac
Two Phase Overvoltage Elements
Two Phase Undervoltage Elements
One Residual Overvoltage Element

Power Factor Element

Alarm and Trip Levels
Setting Range: 0.05–0.99 pf
Time Delays: 0.00–400.00 s
Measuring Error: <±4%

Reactive Power Element

Alarm and Trip Levels
Setting Range: 30–2000 VAR, 5 A tap
6–400 VAR, 1 A tap
Time Delays: 0.00–400.00 s
Measuring Error: <±2%

Underpower Element

Alarm and Trip Levels
Setting Range: 30–2000 W, 5 A tap
6–400 W, 1 A tap
Time Delays: 0.00–400.00 s
Measuring Error: <±2%

Over/Underfrequency Elements

Three Settable Levels
Setting Range: 20.00–70.00 Hz
Time Delays: 0.00–400.00 s
Error: <±0.01 Hz

Optional Internal RTD Inputs

11 Internal RTD Inputs
Monitor Winding, Bearing, Ambient, or Other Temperatures
PT100, Ni100, Ni120, and Cu10 RTD-Types Supported, Field Selectable

Trip and Alarm Temperatures

Setting Range: 0°–250°C
Error: <±2°C
Open and Short Circuit Detection
Trip Voting
Thermal Model Biasing
Motor Cooling Time Learning

Optional External RTD Module

12 Remote RTD Inputs
Trip, Alarm, and Thermal features, as with Internal RTDs.
Up to 500 m Away Using Fiber-Optic Cable
Adds Remote Contact Input

Reporting Functions

Event Summaries/Event Reports

14 Latest Summaries and 15-Cycle Oscillographic Records
Resolution: 4 or 16 samples/cycle

Load Profile Function

Stores up to 17 quantities every 15 minutes for 48 days (without voltage option) or 34 days (with voltage option).

Sequential Events Records

512 Latest Time-Tagged Events

Motor Start Reports

5 Latest Starts
Report Length: 3600 cycles
Quantities stored every 5 cycles during and immediately after each start.

Motor Start Trend

Stores 30-day averages of starting data for each of the past eighteen 30-day periods.

Ratings, Type Tests, & Certifications

Operating Temperature Range

–40°C to +85°C
–40°F to +185°F

Power Supply Voltage Range

20–250 ±20% Vdc
95–240 ±10% Vac 50/60 Hz
<15 VA Total Burden
Hold-Up Time: 50 ms @125 Vdc
150 ms @ 120 Vac

Type Tests

Front Panel:	NEMA12/IP54
Dielectric:	2.5 kV rms, 1 minute
Environmental:	IEC 68-2-1 : 1990 IEC 68-2-2 : 1974
Damp Heat Cycle:	IEC 68-2-30 : 1980
Impulse:	IEC 255-5 : 1977, 5 kV 0.5 j
Electrostatic Discharge:	IEC 801-2 : 1991, Level 4 IEC 255-22-2 : 1989 Level 4
Radio Frequency Immunity:	IEC 801-3 : 1984 IEC 255-22-3 : 1989
Fast Transient Burst:	IEC 801–4 : 1988, Level 4 IEC 255-22-4 : 1992, Level 4
Surge Withstand:	IEC 255-22-1 : 1988 IEEE C37.90.1 : 1989
5 kV Impulse:	IEC 255-5 : 1997
Magnetic Field Immunity:	EN 61000-4-8 : 1993, Level 5
Vibration:	IEC 255-21-1 : 1988
Endurance:	Class 1
Response:	Class 2
Shock and Bump:	IEC 255-21-2 : 1988
Bump:	Class 1
Shock Withstand:	Class 1
Shock Response:	Class 2
Seismic:	IEC 255-21-3 : 1993, Level 2

Certifications

ISO: Relay is designed and manufactured to an ISO-9001 certified quality program.
UL/CSA: UL recognized to the requirements of UL-508; CSA C22.2, N.14 for Industrial Control Equipment; and UL-1053, “Ground-Fault Sensing and Relay Equipment.”
CE: CE Mark.

Schweitzer Engineering Laboratories, Inc.

Schweitzer Engineering Laboratories, Inc. is committed to quality. Our certification to the ISO 9001 quality standard and our ten-year product warranty are examples of this commitment. We encourage and appreciate your feedback about the use of SEL equipment, and we will use this information to continually improve our products and services.

Schweitzer Engineering provides customer service and application assistance from locations around the world. For the location nearest you:

- Visit our web site at www.selinc.com, and click on the "Technical Service Centers" button.
- Call us! Our customer service representatives and application engineers are happy to assist you.

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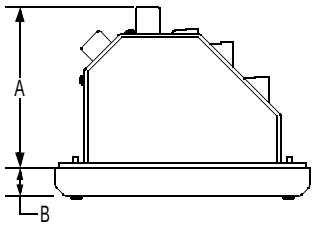
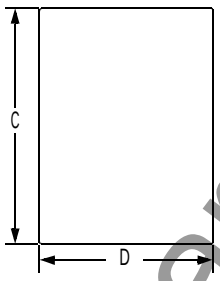
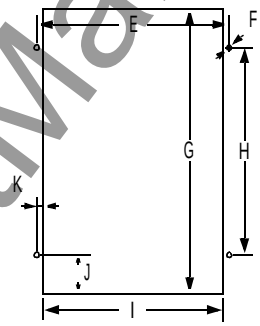
Mechanical Diagrams



A–4.45 in (113.0 mm)
B–0.77 in (19.4 mm)



C–9.60 in (243.8 mm)
D–7.00 in (177.8 mm)



E–5.88 in (149.4 mm)
F–ϕ0.188 in (4.78 mm)
G–8.40 in (213.4 mm)
H–5.88 in (149.4 mm)
I–5.50 in (139.7 mm)
J–1.26 in (typ) (32.0 mm)
K–0.19 in (typ) (4.8 mm)

SEL-701 Relay Front-Panel Features

NEMA12/IP54 Rated Front Panel. Resists splashes and dust.

Enable LED. Lit when relay is in operation to indicate relay health.

Target LEDs. Flash to indicate protection alarms. Steady-on to indicate cause of most recent trip operation.

EIA-232 Serial Port. Allows easy connection to a local PC for setting upload and relay data download. Weather cap protects connector.

Vacuum Fluorescent Display. Shows automatic messages and supports setting entry.

Motor State LED. Dark when motor is stopped Flashes when motor is starting, and steady-on when motor is running.

Six-Button Keypad. Navigate quickly through the menu-driven front-panel interface to view meter values, review event summaries, view or change settings, etc.