SEL-701

Motor Protection Relay

Accurate Motor Protection With Innovative Motor-Starting Analysis

Provide complete induction motor protection combined with innovative monitoring, reporting, metering, and control capabilities.

Features and Benefits

Motor Thermal Protection

The SEL-701 Motor Protection Relay provides locked rotor, running overload, and negative-sequence current unbalance protection using a patented thermal model. Add the voltage input option for metering and voltage-based protection elements.

Nameplate, Standard, or Custom Curve Setting Methods

Set protection using motor nameplate data, choose from 45 standard curves, or create custom protection curves for advanced protection.

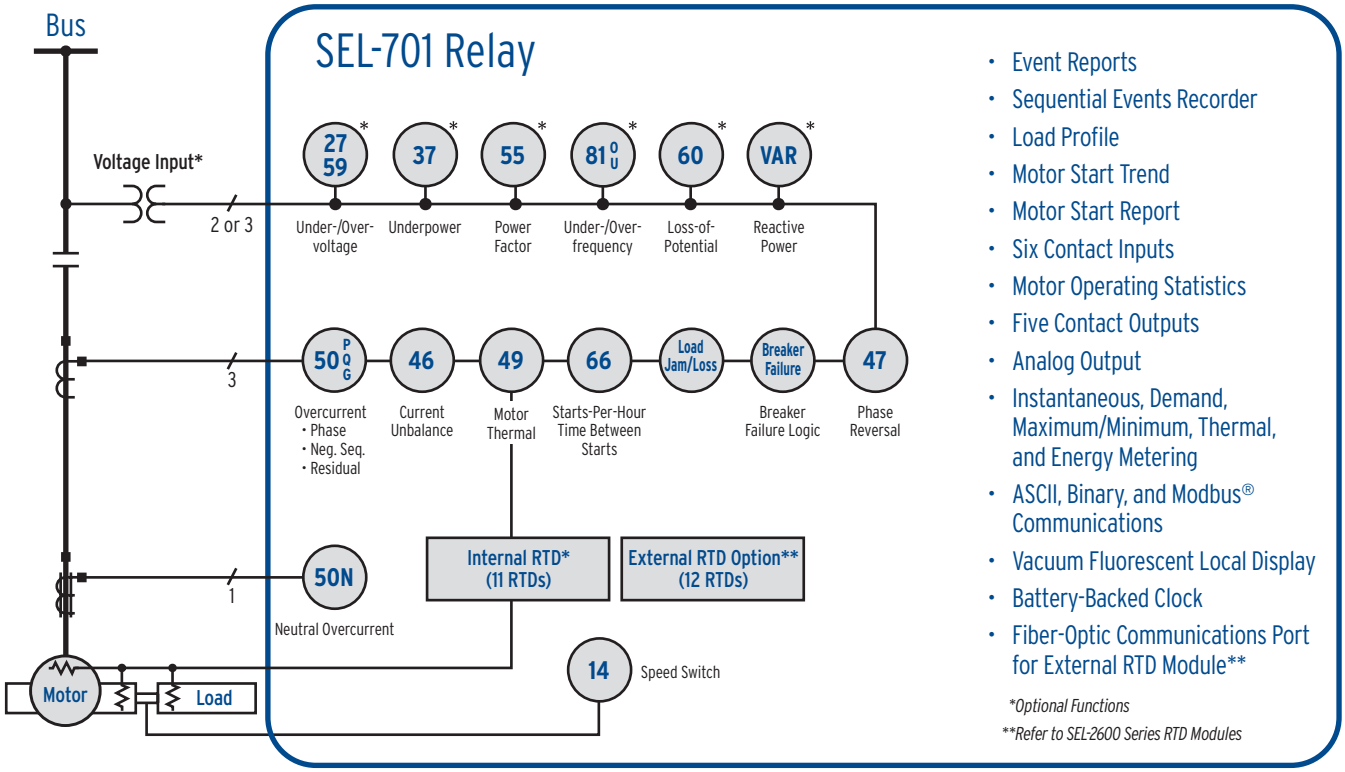
Advanced Reporting

Motor start reports and motor start trend data support maintenance by indicating load problems early. The load profiling function tracks motor loading and use, storing quantities every 15 minutes for up to 48 days.

Internal or External RTD Module

The SEL-701 is available with an optional internal resistance temperature detector (RTD) 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.

Functional Overview



- Event Reports
- Sequential Events Recorder
- Load Profile
- Motor Start Trend
- Motor Start Report
- Six Contact Inputs
- Motor Operating Statistics
- Five Contact Outputs
- Analog Output
- Instantaneous, Demand, Maximum/Minimum, Thermal, and Energy Metering
- ASCII, Binary, and Modbus® Communications
- Vacuum Fluorescent Local Display
- Battery-Backed Clock
- Fiber-Optic Communications Port for External RTD Module**

**Optional Functions*

***Refer to SEL-2600 Series RTD Modules*

Front-Panel Features

Vacuum fluorescent display shows automatic messages and supports settings entry.

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

Target LEDs flash to indicate protection alarms and are lit continuously to indicate cause of most recent trip operation.

EIA-232 serial port allows easy connection to a local PC for settings upload and relay data download. Weather cap protects connector.

NEMA 12/IP54-rated front panel resists splashes and dust.

Motor state LED is dark when motor is stopped, flashes when motor is starting, and is lit continuously when motor is running.

Six-button keypad allows navigation through the menu-driven, front-panel interface to view meter values, review event summaries, view or change settings, etc.

Induction Motor Protection

Motor Thermal Protection

The SEL-701 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 current unbalance while the motor is accelerating and running. You can choose from three easy settings 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 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 a fused contactor.

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

The SEL-701 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.

Current Unbalance and Phase Reversal Protection

In addition to the thermal element, the SEL-701 provides a current unbalance 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 provides this protection even if phase voltages are not available.

Voltage-Based Protection Elements

The SEL-701 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-/undervoltage
- Over-/underfrequency
- Underpower
- Reactive power
- Power factor elements
- Loss-of-potential

ANSI Standard	Element Name
Standard Function	
46	Current Unbalance
47	Phase Reversal
49	Motor Thermal
50P	Phase Overcurrent
50G	Residual Overcurrent
50N	Neutral and Ground Overcurrent
50Q	Negative-Sequence Overcurrent
66	Starts/Hour, Time Between Starts
	Load Jam, Load Loss
	Breaker Failure
With Voltage Option	
27	Undervoltage
37	Underpower
55	Power Factor
VAR	Reactive Power
59	Overvoltage
60	Loss-of-Potential
81	Over- and Underfrequency

Metering and Monitoring Capabilities

Current- and Voltage-Based Metering Functions

The SEL-701 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 current unbalance 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 (kWh, kVARh, kVAh)
- 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 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 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 and Statistics

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

- Time running and stopped
- Total MWh
- 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 records the following quantities:

- Phase and neutral current magnitudes
- Percent thermal capacity used
- Percent current unbalance
- System frequency

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

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

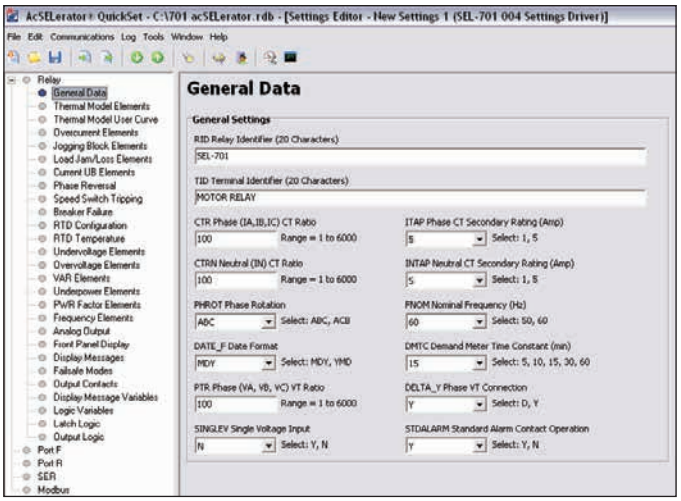
- Phase-to-phase voltage magnitudes
- Real power magnitude
- Reactive power magnitude
- Apparent power magnitude

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

Simple or Advanced Settings

Use acSELERATOR QuickSet® SEL-5030 Software to Set, Monitor, and Control the SEL-701

- Save engineering time while keeping flexibility. Communicate with the SEL-701 through any ASCII terminal, or use the acSELERATOR QuickSet graphical user interface.
- Develop settings offline with a menu-driven interface and completely documented help screens. Speed installation by copying existing settings files and modifying application-specific items. Interface supports Microsoft® Windows® operating systems.
- Simplify the settings procedure with rules-based architecture to automatically check interrelated settings. Out-of-range or conflicting settings are highlighted for correction.
- Transfer settings files by using a PC communications link with the SEL-701.



acSELERATOR QuickSet settings window.

Fault Reporting Functions

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

Front-Panel Targets and Messages

Each time the SEL-701 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
- Current unbalance 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 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
- Percent thermal capacity used
- Percent current unbalance
- Magnitudes of the phase, neutral, negative-sequence, and residual currents
- Temperatures of the 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 16th-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 tracks the pickup and dropout of protection elements, contact inputs, and contact outputs that you select. The date and time of each transition are available in an 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.

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; and settable motor-stopped cooling time constant
- Phase, neutral, and negative-sequence overcurrent elements for short-circuit fault detection
- Current unbalance, 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
- SER 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° to +85°C and a power supply input operating voltage range of 95–240 ±10% Vac or 20–250 ±20% Vdc. The relay front panel shall meet the requirements of NEMA 12/IP54.

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 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.

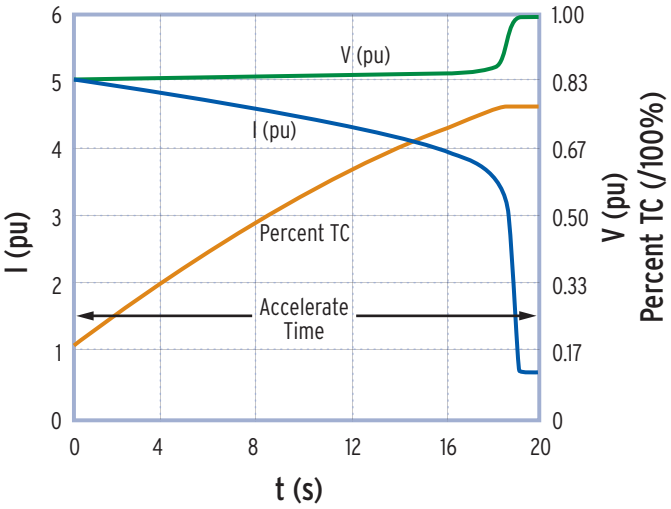
The relay also helps you spot trends in starting performance by maintaining the 18 most recent 30-day averages of start report data.

Internal or External RTD Module

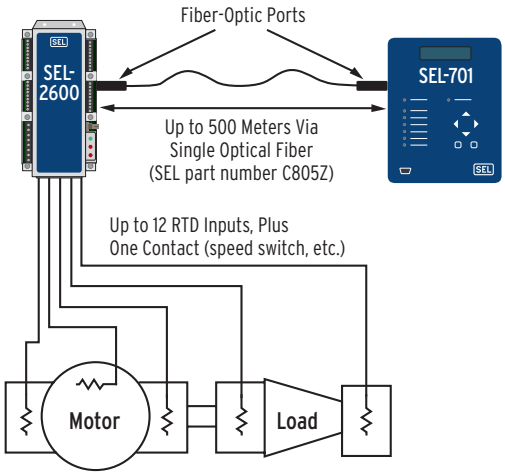
The SEL-701 is available with an optional internal RTD module that monitors up to 11 RTDs. The relay offers thermal trips and alarms, thermal model biasing, RTD open or short alarms, and temperature measurement when equipped with RTD inputs. Configure each input to use any of four sensor types (Pt100, 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 SEL-2600A or SEL-2600D 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.

SEL-2600 Series RTD Module.

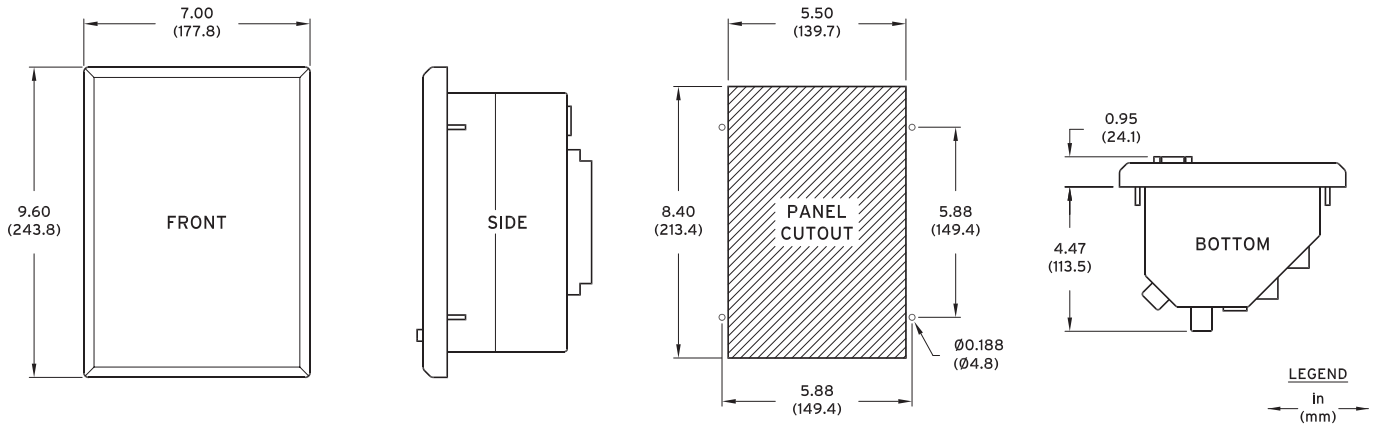


Use the data from the motor start reports to generate graphical motor start reports.



Install the rugged SEL-2600 Series RTD Module near the motor to shorten RTD leads and save installation costs.

Dimensions



Specifications

Standard Relay Features and 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	3.0 • I_{NOM}
200 s thermal	10.0 • I_{NOM}
10 s thermal	20.0 • I_{NOM}
1 s thermal	50.0 • 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	3.0 • IN_{NOM}
1 s thermal	50.0 • IN_{NOM}
Measuring error	±1%, ±0.01 • I_{NOM}

Motor Thermal Model

Locked rotor time	1.0–240.0 s
Locked rotor current	0.5–16.0 • I_{NOM}
Service factor	1.01–1.50
Setting Modes	
45 standard curve shapes Nameplate ratings Custom curve shape	
Pickup error	<±1%, ±0.01 • I_{NOM}
Timing error	±2.5%, ±25 ms for currents >1.1 times multiples of pickup

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
Transient overreach	<5% of pickup

Neutral/Ground Overcurrent Element

Setting range	0.005–2.000 • I_{NOM}
Time delays	0.00–400.00 s
Transient overreach	<5% of pickup

Current Unbalance Element

Alarm and trip elements setting range	2%–80%
Time delays	0.00–400.00 s
Error	<±1%, ±0.01• I_{NOM}

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} = Average 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	0.10–1.00 • FLA
Load-jam trip setting range	0.5–6.0 • FLA
Time delays	0.40–400.00 s

Starts Per Hour, Time Between Starts

Max. starts/hour	1–15 starts
Min. time between 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	<±1.5%
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
Maximum load	8 k or 400 ohms
Error	±0.5%, full scale

Select from % FLA, % thermal cap., hottest RTD, average phase current, maximum phase current

Contact Inputs

6 self-wetted contact inputs, programmable function

Contact Outputs

1 trip contact, 3 programmable contacts, 1 relay self-test alarm

Form C contacts

Make/carry/interrupt ratings

Make	30 A
Carry	6 A
Interrupt	250 Vac 8 A resistive 24 Vdc 0.75 A, L/R = 40 ms 48 Vdc 0.50 A, L/R = 40 ms 125 Vdc 0.30 A, L/R = 40 ms 250 Vdc 0.20 A, L/R = 40 ms

Serial Ports

Front Panel	
EIA-232 port	300–19200 bps
ASCII text communication	
Rear Panel	
ASCII EIA-232 port	300–19200 bps
Or Modbus EIA-485 port	300–19200 bps
EIA-485 port isolation	500 V

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, and Certifications

Operating Temperature Range

–40° to +85°C (–40° to +185°F)

Power Supply Voltage Range

20–250 ±20% Vdc

95–240 ±10% Vac 50/60 Hz

<15 VA total burden

Holdup time	50 ms @ 125 Vdc 150 ms @ 120 Vac

Elevation

Up to 2000 m above mean sea level

Dimensions

177.8 mm W x 243.8 mm H x 113.5 mm D
(7.00 in x 9.60 in x 4.47 in)

Weight

2.7 kg (6 lb)

Terminal Connections

Current, Voltage, and Power Inputs Terminal Block Tightening Torque

Minimum	0.9 Nm (8 in-lb)
Maximum	1.4 Nm (12 in-lb)

Compression Plug Tightening Torque

Minimum	0.4 Nm (3.5 in-lb)
Maximum	0.6 Nm (5.3 in-lb)

Type Tests

Front panel	NEMA 12/IP54
Dielectric	IEC 255-5:1977; IEEE C37.90:1989, 2500 Vac on analogs, contact inputs, and contact outputs; 3100 Vdc on power supply, 2200 Vdc on EIA-485 communications port
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	EN 61000-4-2:1995, Level 4 IEC 255-22-2:1996, Level 4
Radio frequency immunity	IEC 801-3:1984 IEC 255-22-3:1989 ENV 50140:1994 IEEE C37.90.2:1987, 10 V/m
Fast transient burst	EN 61000-4-4:1995, Level 4 IEC 255-22-4:1992, Level 4
1 MHz burst	IEC 255-22-1:1988
Surge withstand	IEEE C37.90.1:1989
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

SEL-701 Motor Protection Relay

General Specifications

Optional Features and 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	<±1.5%

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	0.40–400.00 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

Conformal Coating

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	
Measuring range	–50° to +250°C

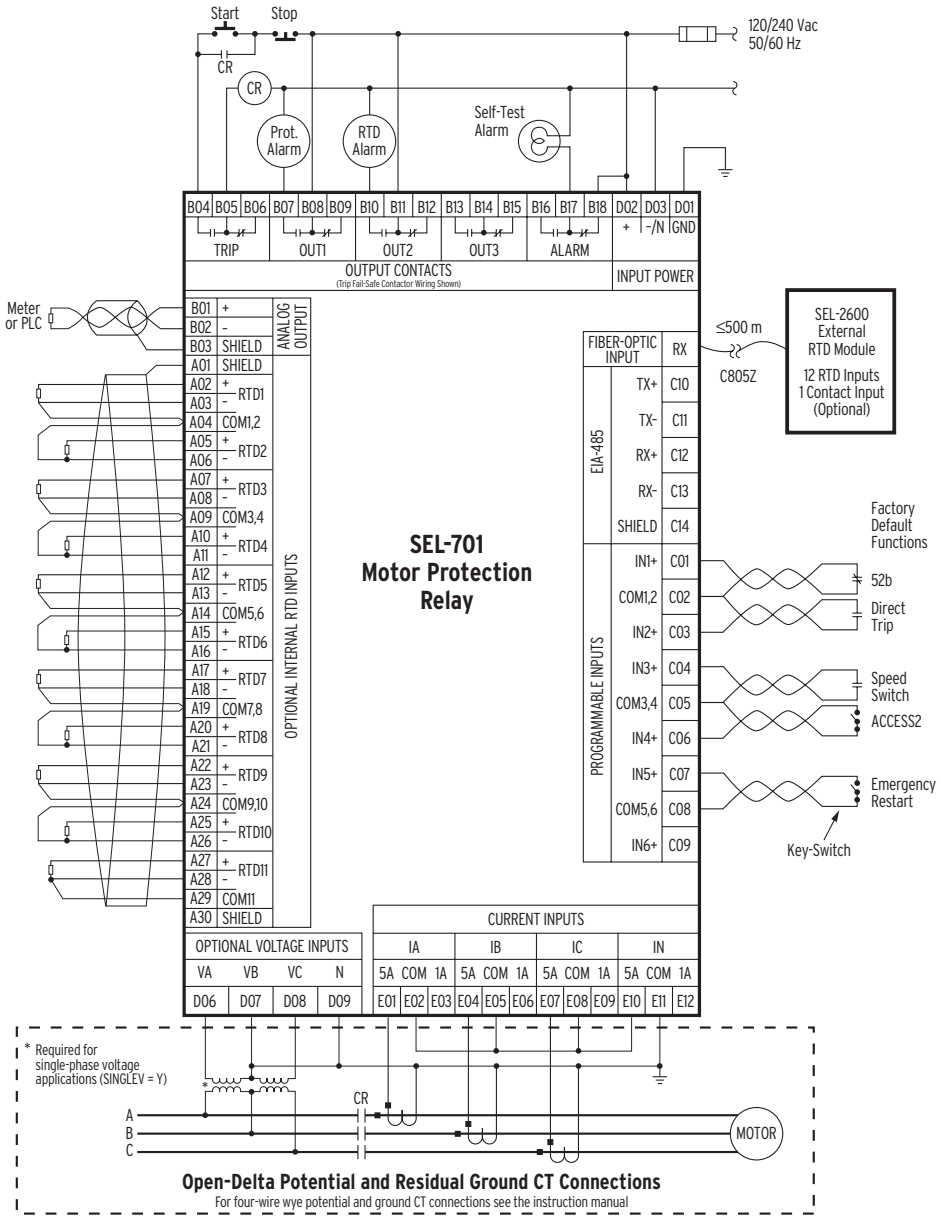
Trip and Alarm Temperatures

Setting range	0° to +250°C
Error	<±2°C
Open and short-circuit detection	
Trip voting	
Thermal model biasing	
Motor cooling time learning	

Optional External RTD Module

SEL-2600A or SEL-2600D RTD Module

Wiring Diagram



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