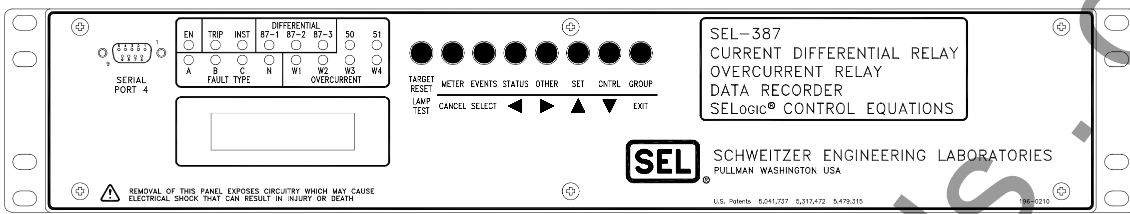
SEL-387 Current Differential and Overcurrent Relay



Data Sheet

- Protects transformers, buses, generators, reactors, and other devices requiring differential protection.
- Four groups of three-phase current inputs can be independently enabled for overcurrent protection, differential protection, or combined differential and overcurrent protection.
- Restrained differential protection can be fixed percentage or variable percentage, using one or two settable slopes with adjustable intersection point and minimum pickup values.
- Second- and fifth-harmonic blocking prevents restrained differential element operation during inrush or overexcitation conditions; independent fifth-harmonic alarm element warns user of overexcitation condition.
- Unrestrained differential protection produces rapid tripping for severe internal faults.
- Full "around-the-clock" current compensation, in 30-degree increments, accommodates virtually any type of transformer and CT winding connections.
- Eleven overcurrent elements per terminal provide phase, negative-sequence, and residual overcurrent protection, via torque-controlled instantaneous, definite-time and inverse-time elements; two special per-phase instantaneous elements for each terminal provide phase identification for protection, control, or display functions.
- For ring bus and breaker-and-a-half applications, two special combined overcurrent elements provide inverse-time phase and residual overcurrent protection based on summation of currents from Windings 1 and 2, and Windings 3 and 4.
- Restricted Earth Fault (REF) protection feature permits sensitive detection of internal ground faults.
- Three EIA-232 and one EIA-485 serial ports provide flexible communications to external computers and control systems; communication speed from 300 to 19200 baud; three-level password protection increases security of remote communications.
- Extensive use of enhanced SELOGIC® control equations in the relay settings increases flexibility of control and protection logic.

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- Three additional sets of enhanced SELOGIC control equation timed variables and latch bits permit further user customization of control schemes.
- Fully programmable optoisolated inputs and contact outputs optimize user application choices.
- Relay version with additional Input/Output (I/O) board greatly increases control scheme options.
- Five trip variables and four close variables permit separate control of up to four breakers and a separate lockout device.
- Six selectable setting groups permit easier adaptation to changes in application.
- Extensive metering capabilities allow user to see real-time phase and differential quantities, as well as phase demand and peak demand values. Harmonic content from dc to fifteenth harmonic for all 12 phase currents can also be displayed.
- Programmable-length event reports, stored in nonvolatile memory, optimize data retrieval for different event types; report length can be 15, 30, or 60 cycles, with settable prefault duration and user-defined triggering.
- Four breaker monitors with user-definable wear curves, operation counters, and accumulated interrupted currents per phase allow for optimal breaker maintenance scheduling.
- DC battery voltage monitor with four settable voltage thresholds can warn user of impending station battery failure.
- Programmable Sequential Events Recorder (SER) displays 512 time-tagged events for better data analysis; element alias names make SER reports more user-friendly.
- Programmable analog input quantity labels allow user to define current names for reporting purposes.
- Sixteen remote bits permit control scheme activation from a remote location, using a serial port; remote bits can be set, cleared, or pulsed.
- Sixteen LEDs, eight pushbuttons, and a backlit LCD display permit setting, data retrieval, and relay testing assistance at the front panel; two-level password protection limits function access.
- Sixteen programmable display points and three programmable LEDs allow customization of relay front-panel displays.
- Battery backed-up real-time clock, synchronizable to demodulated IRIG-B input, provides accurate time stamps for event records.
- Patented Low-Level Test Interface permits relay testing with low energy test equipment.
- Program storage in Flash memory permits easier periodic firmware upgrading via a serial communications port.
- Integration Package available, providing system-wide SER capabilities, 16 front-panel control functions, and expanded control logic.

HARDWARE OVERVIEW

Rear-Panel Connections

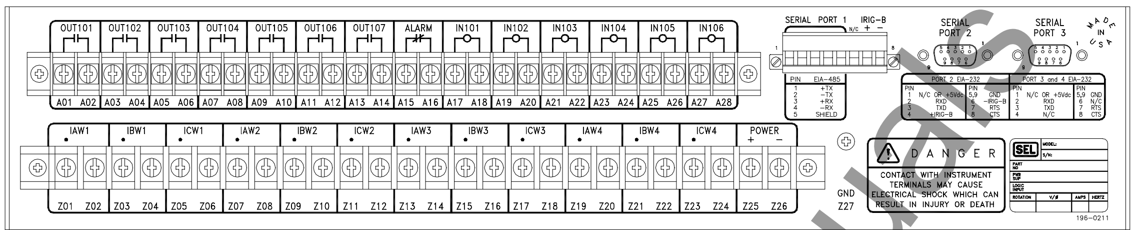


Figure 1: SEL-387 Relay Rear Panel, Basic Version

The basic version of the SEL-387 Relay (Figure 1) has eight output contacts and six optoisolated level-sensitive inputs. A version with one I/O board, providing an additional eight inputs and 12 outputs, greatly increases the number of control functions that can be undertaken by the relay. (Case height increases for additional I/O board).

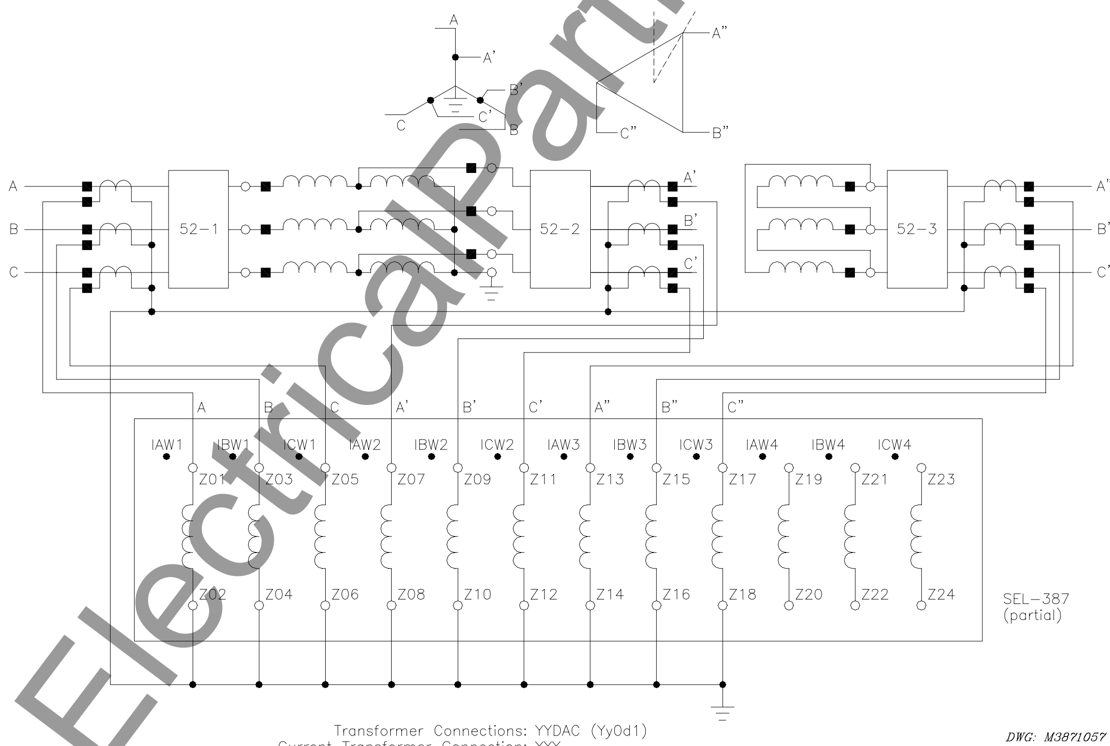


Figure 2: Typical AC Connection Diagram, Three-Winding Transformer

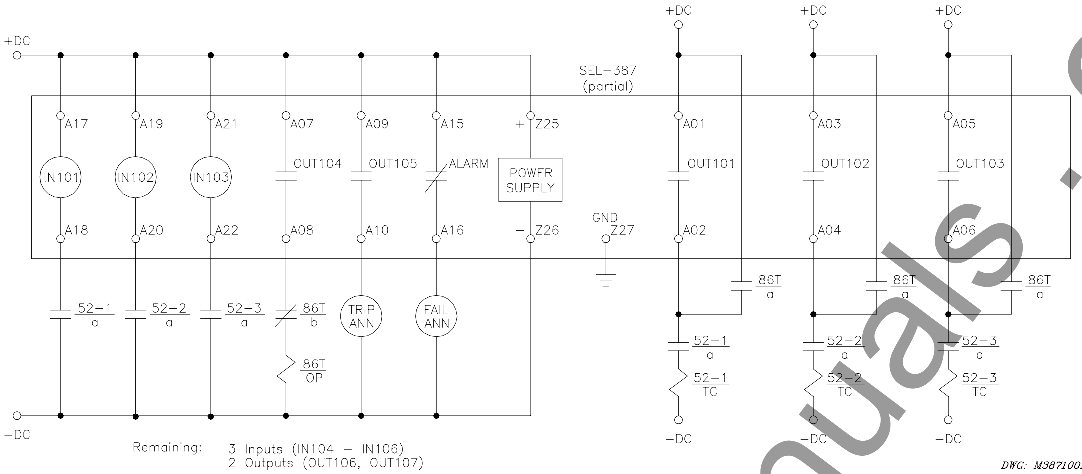


Figure 3: Typical DC Connection Diagram

Figure 2 and Figure 3 represent typical ac and dc connections for a three-winding transformer application. The transformer is a 230 kV to 115 kV autotransformer, with a tertiary where the terminals have been brought out to a breaker. The unused fourth set of current inputs on the relay could be used for:

- Separate overcurrent protection for some other circuit.
- Additional input if another primary or secondary breaker were added to the transformer due to conversion of the substation to a ring bus or breaker-and-a-half configuration.
- Neutral CT input for the REF protection function.

Hardware Block Diagram

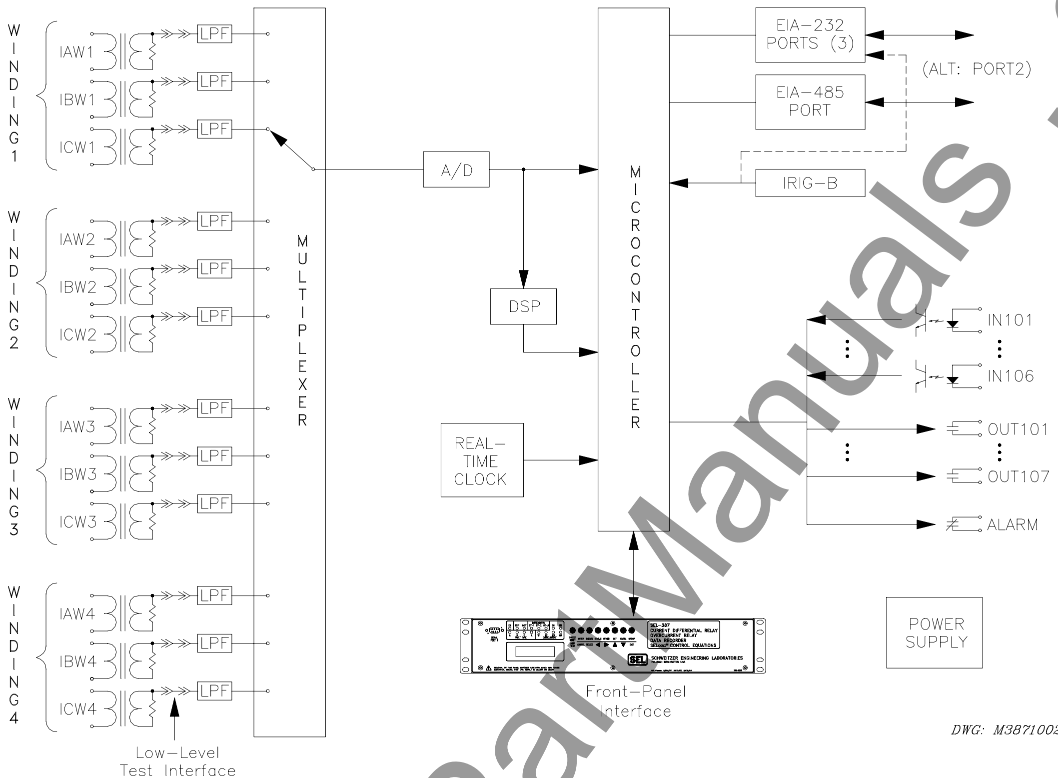
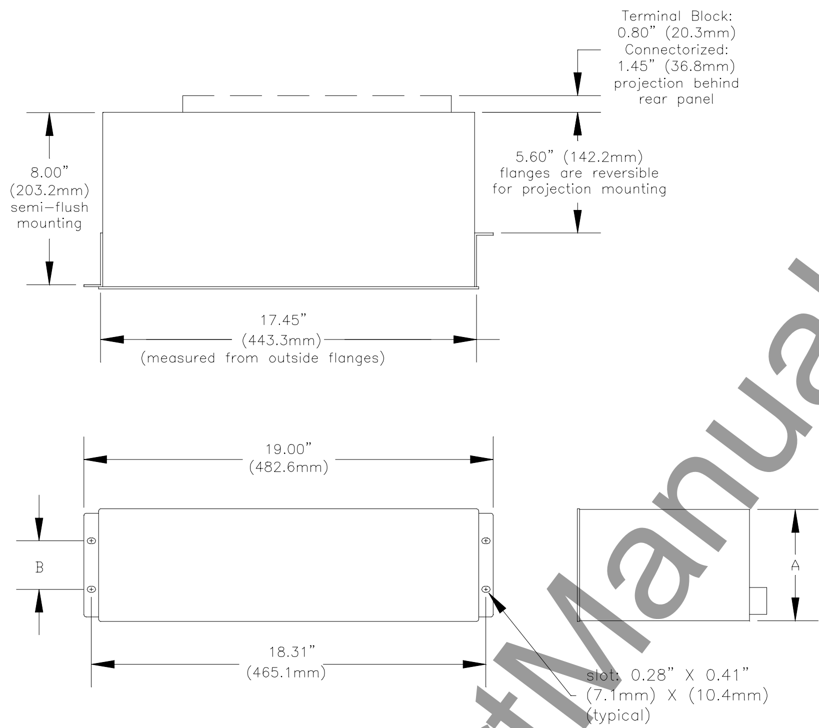


Figure 4: SEL-387 Relay Hardware Block Diagram, Basic Version

Relay Installation Dimensions

Figure 5 shows dimensions for all hardware options of several relays using the same hardware platform as the SEL-387 Relay. Not all options may apply to a given relay type. Please contact your SEL representative for information on currently available styles of the SEL-387 Relay.



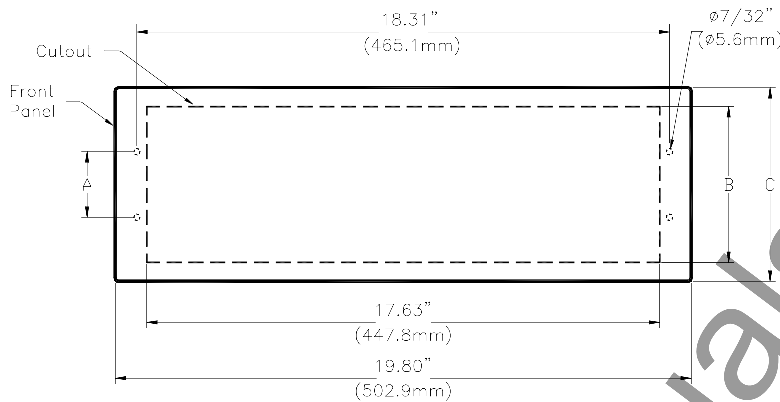
DIMENSION	MAIN BOARD ONLY (2U)	ONE I/O BOARD (3U)
A	3.47" (88.1mm)	5.22" (132.6mm)
B	3.00" (76.2mm) 1.75" (44.5mm) optional	2.25" (57.2mm)

NOTE:

1. ALL TOLERANCES ARE ± 0.020" (0.51mm)
2. TO DETERMINE THE CUTOUT DIMENSIONS CONSIDER BOTH SEL'S SPECIFIED TOLERANCE AND THE CUSTOMER'S ALLOWED TOLERANCE
3. DRAWING NOT TO SCALE

DWG. 387–rackmount

Figure 5: SEL-387 Relay Dimensions and Drill Plan for Rack-Mount Models



RELAY	DIM A	DIM B	DIM C
2U HIGH	3.00" (76.2mm)	3.60" (91.4mm)	4.90" (124.5mm)
3U HIGH	2.25" (57.2mm)	5.35" (135.9mm)	6.65" (168.9mm)

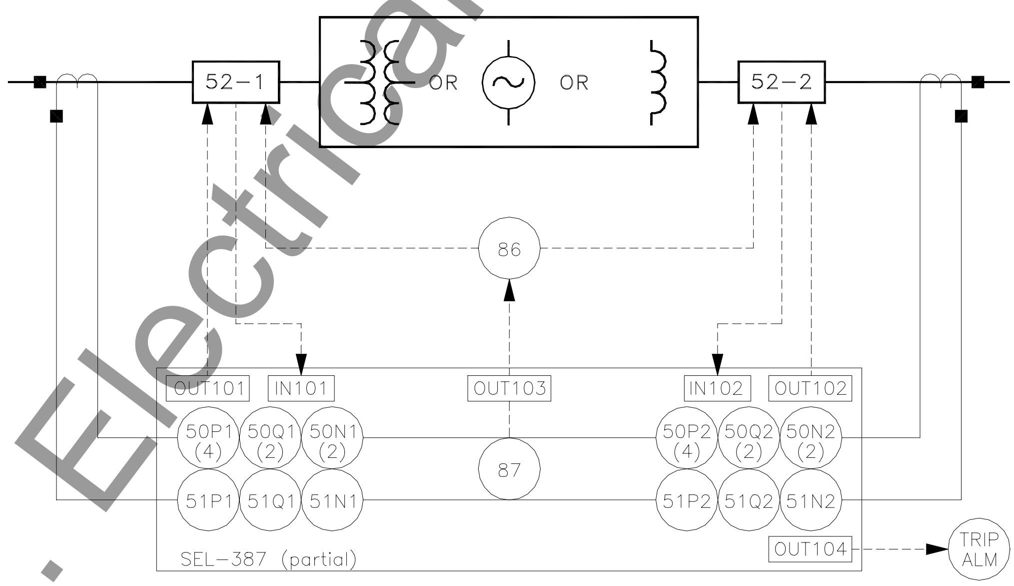
NOTE:

1. ALL TOLERANCES ARE ± 0.020" (0.51mm)
2. TO DETERMINE THE CUTOUT DIMENSIONS CONSIDER BOTH SEL'S SPECIFIED TOLERANCE AND THE CUSTOMER'S ALLOWED TOLERANCE
3. DRAWING NOT TO SCALE

DWG: 387–panelmount

Figure 6: SEL-387 Relay Dimensions and Drill Plan for Panel-Mount Models

Relay Functional Diagram



DWG: M3871004

Figure 7: SEL-387 Relay Protection Functions (two-winding application shown for simplicity)

GENERAL SPECIFICATIONS

AC Input Currents

I_N: 1 A or 5 A nominal; $3 \bullet I_N$ continuous; $100 \bullet I_N$ for 1 second; measurement linear to $31 \bullet I_N$, symmetrical.
Burden: Less than $0.1 \bullet I_N$ VA at I_N A secondary.
Four three-phase inputs total.

Output Contact Ratings

IEEE C37.90 : Tripping Output Performance Requirements.
Standard: 30 A make, 6 A carry. (Eight contacts total, Basic Version).
MOV protected: 250 Vac, 330 Vdc, 40 J.
Closing time: 4 ms, typical.
High Current Interrupting (I/O Board Option): Ratings as above, plus 10 A break for L/R = 40 ms at 125 Vdc, L/R = 20 ms at 250 Vdc.

Optoisolated Input Ratings

250 Vdc:	on for 200	–	300 Vdc;	off below 150 Vdc.
125 Vdc:	on for 105	–	150 Vdc;	off below 75 Vdc.
110 Vdc:	on for 88	–	132 Vdc;	off below 66 Vdc.
48 Vdc:	on for 38.4	–	60 Vdc;	off below 28.8 Vdc.
24 Vdc:	on for 15.0	–	30 Vdc.	

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

Power Supply Ratings

125/250 V: 85 – 350 Vdc or 85 – 264 Vac, less than 15 Watts.
24/48 Vdc: 20 – 60 Vdc, less than 15 Watts.

Serial Communications

One front-panel and two rear-panel EIA-232 9-pin sub-D connectors.
One rear-panel EIA-485 port with 2,100 Vdc isolation.
Baud Selection (per port): 300, 1200, 2400, 4800, 9600, and 19200.

Metering Functions

Instantaneous and Demand Ammetering functions. Phase, Residual, Positive-Sequence, Negative-Sequence. Measurement Accuracy: ±3% ±0.02 • I_N ±1°.

Operate and Restraint Quantities, Second- and Fifth-Harmonics.
Measurement Accuracy: ±5% ±0.02 • I_N.

Dielectric Strength

Current inputs: 2500 Vac for 10 seconds.
Power supply, logic inputs, and contact outputs: 3000 Vdc for 10 seconds.

Operating Temp.

-40° to +85°C (-40° to +185°F).

Dimensions

See Figure 5 and Figure 6.

Weight

6.8 kg (15 lbs) (Basic Version).

Shipping Weight

Approximately 9.1 kg (20 lbs) (Basic Version).

Type Tests and Standards

IEEE C37.90.1 : 1989 IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems. (3 kV oscillatory, 5 kV fast transient).

IEEE C37.90.2 : 1987 IEEE Trial-Use Standard, Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers. 10 V/m.

Exceptions

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

IEC 68-2-1 : 1990 Basic environmental testing procedure, Part 2: Tests - Test Ad: Cold.

IEC 68-2-2 : 1974 Basic environmental testing procedure, Part 2: Tests - Test Bd: Dry heat.

IEC 68-2-3 : 1969 Basic environmental testing procedure, Part 2: Tests - Test Cd: Damp heat, steady state.

IEC 68-2-30 : 1980 Basic environmental testing procedures, Part 2: Tests - Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle).
Humidity, 95% between 25°C and 55°C.

IEC 255-5 : 1977 Electrical relays, Part 5: Insulation tests for electrical relays:
Section 6: Dielectric Tests, Series C (2500 Vac on analog inputs; 3100 Vdc on power supply, contact inputs and contact outputs).
Section 8: Impulse Voltage Tests, 0.5 J, 5 kV.

IEC 255-21-1 : 1988 Electrical relays, Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment, Section One - Vibration tests (sinusoidal), Class 1.

IEC 255-21-2 : 1988 Electrical relays, Part 21: Vibration, shock, bump, and seismic tests on measuring relays and protection equipment, Section Two - Shock and bump tests, Class 1.

IEC 255-22-1 : 1988 Electrical disturbance tests for measuring relays and protection equipment, Part 1: 1 MHz burst disturbance tests. Class III (2.5 kV common mode, 1.0 kV differential).

IEC 801-2 : 1991 Electromagnetic compatibility for industrial-process measurement and control equipment, Part 2: Electrostatic discharge requirements. Severity Level: 4.

IEC 801-3 : 1984 Electromagnetic compatibility for industrial process measurement and control equipment, Part 3: Radiated electromagnetic field requirements. Severity Level: III (10 V/m).

Exceptions:

9.1 Frequency sweep approximated with 200 frequency steps per octave.

IEC 801-4 : 1988 Electromagnetic compatibility for industrial-process measurement and control equipment, Part 4: Electrical fast transient/burst requirements. Severity Level: IV (4 kV on power supply, 2 kV on inputs and outputs).

ORDERING OPTIONS

The SEL-387 Relay can be ordered with several different options, including:

- Integration Package
- Choice of optoisolated input voltage
- Additional Input/Output board
- High-Current Interrupting Outputs on additional I/O board
- Plug-in connectors (Connectorized®) or conventional terminal blocks on rear panel
- 1 A or 5 A nominal current inputs
- 24/48 Vdc or 125/250 Vac or Vdc power supply

Contact your SEL Representative for ordering assistance.

PROTECTION OVERVIEW

Differential Protection

Differential Element Operation

The SEL-387 Relay has three differential elements (87R-1, 87R-2, and 87R-3). These elements employ operate (IOP) and restraint (IRT) quantities calculated from the winding input currents. The characteristic used is shown in Figure 8. The characteristic can be set as either a single-slope, percentage differential characteristic, or as a dual-slope, variable percentage differential characteristic. Tripping occurs if the operate quantity is greater than the curve value for the particular restraint quantity. A minimum pickup level for the operate quantity must also be satisfied. The four settings that define the characteristic are:

O87P = minimum IOP level required for operation

SLP1 = initial slope, beginning at origin and intersecting O87P at IRT=O87P•100/SLP1

IRS1 = limit of IRT for SLP1 operation; intersection where SLP2 begins

SLP2 = second slope, if used; must be greater than or equal to SLP1

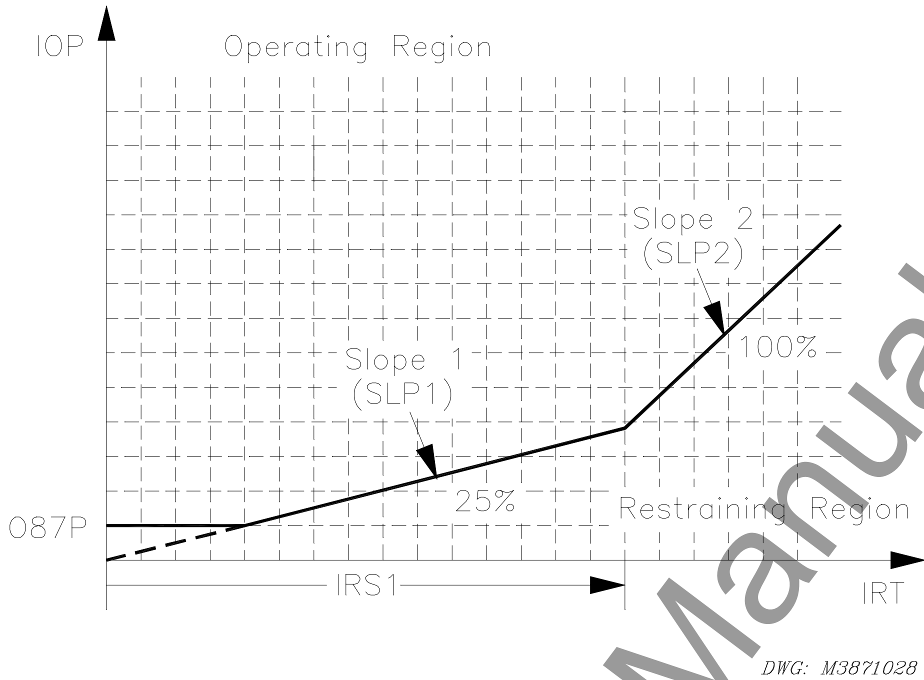


Figure 8: Percentage Restraint Differential Characteristic

By careful selection of these settings, the user can duplicate fairly closely the characteristics of existing differential relays that have been in use for many years.

Figure 9 illustrates the manner in which the operate and restraint quantities are obtained for use in the characteristic. The sets of three-phase currents are compensated for the phase angle and phase interaction effects introduced by the winding connection of the transformer and CTs. The currents are then divided by a TAP value, determined on the same MVA basis for each winding, to reduce the currents to dimensionless multiples of TAP.

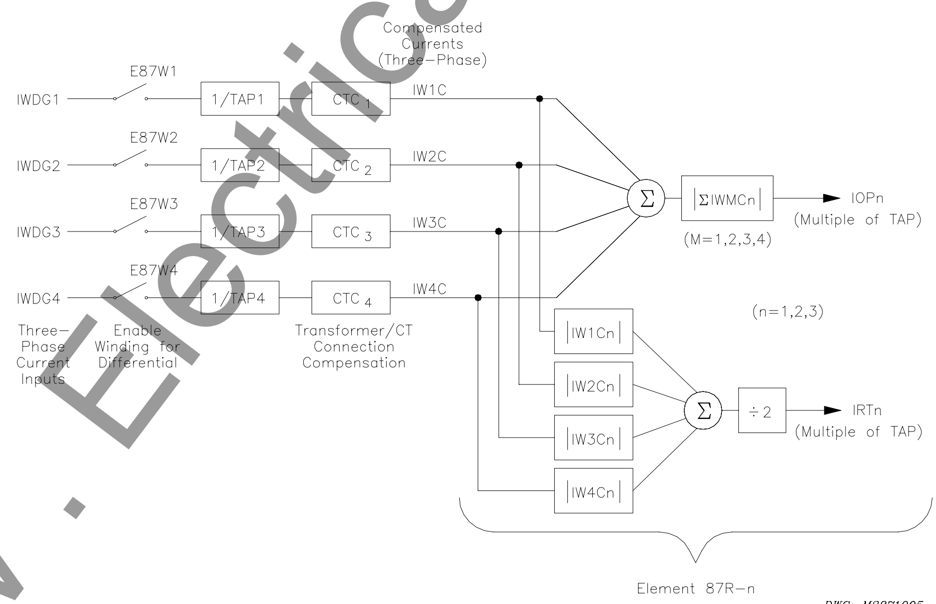


Figure 9: Differential Element Operate and Restraint Quantities

The resulting phase A, phase B, and phase C currents from each winding are then introduced to the differential elements 87R-1, -2, and -3, respectively. In each element, the winding currents are summed in a phasor addition. The magnitude of this result is IOP. The magnitudes of the winding currents are then summed in a simple scalar addition, and divided by two. This result is IRT. For balanced through-load current, these calculations produce ideal results of IOP = 0 and IRT = 1.

The restrained differential elements are supervised by second- and fifth-harmonic elements, which block tripping if the specific harmonic content, as a percent of fundamental operating current, is above a specified threshold. This prevents improper tripping during transformer inrush (second) or allowable overexcitation conditions (fifth). The two thresholds, PCT2 and PCT5, are independently settable. The user also can specify whether the harmonic blocking of any element is to disable all elements, or just the affected element. This setting, IHBL, stands for Independent Harmonic Blocking. If set to N (No) and any of the harmonic blocking elements assert, then all restrained differential elements are blocked.

There is also a set of unrestrained differential elements, 87U-1, -2, and -3. These elements simply compare the IOP quantity to a setting value (U87P), typically about ten times TAP, and trip if this level is exceeded. The 87U function is essentially an instantaneous unit set high enough that the pickup level could only mean that an internal fault has occurred.

An additional element measures the fifth-harmonic content of the differential current to detect overexcitation conditions. The element has a separate threshold (TH5P) and an adjustable timer (TH5D). These may be useful for transformer applications in or near generating stations.

Differential Element Performance

Pickup Accuracy:
- 5 A Model ±5% ±0.10 A secondary
- 1 A Model ±5% ±0.02 A secondary

Unrestrained Element Pickup Time (Min/Typ/Max): 0.8/1.0/1.9 cycles
Restrained Element Pickup Time (Min/Typ/Max): 1.5/1.6/2.2 cycles

Harmonic Measurement Element Performance

Pickup Accuracy:

5 A Model	±5% ±0.10 A secondary	Time-Delay Accuracy: ±0.1% ±0.25 cycle
1 A Model	±5% ±0.02 A secondary	Time-Delay Accuracy: ±0.1% ±0.25 cycle

<u>Differential Element Setting Ranges</u>

Winding n Current TAP (5 A model)	TAPn	0.5 – 155
Winding n Current TAP (1 A model)	TAPn	0.1 – 31
Maximum Allowable TAP Ratio	TAP_{MAX}/TAP_{MIN}	≤ 7.5
Restrained Element Operating Current PU	O87P	0.1 – 1.0
Restraint Slope 1 Percentage	SLP1	5 – 100
Restraint Slope 2 Percentage	SLP2	OFF, 25 – 200
Restrained Current Slope Limit	IRS1	1 – 20
Unrestrained Element Operating Current PU	U87P	1 – 20
Second-Harmonic Blocking Percentage	PCT2	OFF, 5 – 100
Fifth-Harmonic Blocking Percentage	PCT5	OFF, 5 – 100
Fifth-Harmonic Alarm Threshold	TH5P	OFF, 0.02 – 3.2
Fifth-Harmonic Alarm Time-Delay PU	TH5D	0 – 8000 cycles
Independent Harmonic Blocking	IHBL	Y, N

Overcurrent Protection

The SEL-387 Relay has 11 overcurrent elements for each of the four three-phase current inputs. There are nine torque-controlled elements that encompass one instantaneous, one definite-time, and one inverse-time element each, for phase, negative-sequence, and residual currents. The phase elements operate on the maximum of the A-, B-, or C-phase currents at any time. The remaining two elements, 50Pn3 and 50Pn4, are phase-segregated to assist in phase identification for targeting purposes or for level-sensing type functions. These are not torque-controlled.

Four additional combined overcurrent elements are designed to operate on the sum of phase currents from two relay terminals. Two inverse-time elements, one for phase current and one for residual, operate with summed currents from Windings 1 and 2. Two more such elements operate with summed currents from Windings 3 and 4. These elements operate on total transformer input or output current when CTs from two breakers in a ring bus or breaker-and-a-half configuration are used, eliminating the effect of circulating bus current flowing through both breakers.

Winding "n" Overcurrent Elements (n = 1, 2, 3, 4)	**Instantaneous Elements**	**Definite-Time Elements**	**Inverse-Time Elements**
Phase (Ia, Ib, and Ic)	50Pn2, n3*, n4*	50Pn1	51Pn
Negative-Sequence (IQ = 3•I_2)	50Qn2	50Qn1	51Qn
Residual (IR = Ia + Ib + Ic)	50Nn2	50Nn1	51Nn
Pickup Ranges (A secondary)			
5 A Model	0.25 – 100 A	0.25 – 100 A	0.5 – 16 A
1 A Model	0.05 – 20 A	0.05 – 20 A	0.1 – 3.2 A
Definite-Time Delay		0 – 16,000 cycles	

* 50Pn3 and 50Pn4 consist of separate phase elements, e.g., 50An3, 50Bn3, 50Cn3. Any 50A or 50B or 50C element pickup asserts the corresponding 50P element.

Winding Instantaneous/Definite-Time Element Performance

Pickup Accuracy:

5 A Model	±3% ±0.10 A secondary (steady state)	Time-Delay Accuracy: ±0.1% ±0.25 cycle
	±5% ±0.10 A secondary (transient)*	Time-Delay Accuracy: ±0.1% ±0.25 cycle
1 A Model	±3% ±0.02 A secondary (steady state)	Time-Delay Accuracy: ±0.1% ±0.25 cycle
	±5% ±0.02 A secondary (transient)*	Time-Delay Accuracy: ±0.1% ±0.25 cycle
Pickup Time (Typ/Max):	0.75/1.2 cycles	

* ±6% for negative-sequence elements

Winding Inverse-Time Overcurrent Elements (Phase, Neg.-Seq., and Residual)

Ten Curve Shapes:

Time-O/C Curve Setting	Time-Curve Shape
U1	U.S. Moderately Inverse
U2	U.S. Inverse
U3	U.S. Very Inverse
U4	U.S. Extremely Inverse
U5	U.S. Short-Time Inverse
C1	IEC Class A (Standard Inverse)
C2	IEC Class B (Very Inverse)
C3	IEC Class C (Extremely Inverse)
C4	IEC Long-Time Inverse
C5	IEC Short-Time Inverse

Time-Dial Setting Ranges: 0.5 - 15, 0.01 Step; US Curves
0.05 - 1.0, 0.01 Step; IEC Curves

Timing Accuracy: ±4% ±1.5 cycles for $2 \le M \le 30$; (M = multiple of pickup value)
Curves operate on definite-time for M > 30.

Reset Characteristics: (51PnRS, 51QnRS, 51NnRS)
Y = Enable induction-disk reset emulation
N = Reset element if current drops below pickup for 1 cycle
n = Winding Number

Combined Inverse-Time Overcurrent Elements (Phase, Residual)

51PC1 and 51NC1 inputs: IAW1+IAW2, IBW1+IBW2, ICW1+ICW2
51PC2 and 51NC2 inputs: IAW3+IAW4, IBW3+IBW4, ICW3+ICW4
Performance: As for ***Winding Inverse-Time Overcurrent Elements***, listed above.

Restricted Earth Fault Protection

The SEL-387 Relay can provide sensitive detection of internal ground faults, via the REF protection feature. The Winding 4 inputs are used for introduction of neutral CT polarizing current. Operating current is derived from the residual current calculated for the protected winding. A directional element determines whether the fault is internal or external. Tripping is supervised by zero-sequence current thresholds and a positive-sequence current restraint setting. The REF function is applicable to a single grounded wye winding, or an autotransformer with one breaker and set of CTs at one terminal and either one or two breakers and sets of CTs at the other terminal. Since the Winding 4 inputs are used for the neutral CT, only three of the winding inputs may be used for normal differential or overcurrent protection purposes.

Overview of Other Relay Features

Enhanced SELogic Control Equations

A feature that makes the SEL-387 Relay very flexible and powerful is the use of SELogic control equations. This feature permits the user to create Boolean-like logic equations for describing customized logic schemes that the user may wish to implement, but which are not embedded within the relay's own operating code. This feature is a recognition that different users may have different views on how best to have the relay operate within the system.

The basic building blocks of the SELogic control equation are Relay Word bits. These are logical 1 or 0 bits, with specific names, that exist within the relay's embedded elements and logic schemes. They provide useful digital information to the outside world and to other embedded or user-defined logic schemes within the relay. Several hundred such Relay Word bits are available to the user.

In the SEL-387 Relay, there are six logical operators that can be used in SELogic control equations. These operators exist in a hierarchy from the highest level operator to be processed to the lowest level operator. The following table lists these operators in their order of processing.

Table 1: SELogic Control Equation Operators

Operator	Logic Function
( )	parentheses
!	NOT (negation, or inversion)
/	rising edge detect (transition from 0 to 1)
\	falling edge detect (transition from 1 to 0)
*	AND
+	OR

An example of a SELogic control equation is ER, one of the many relay settings which take the form of SELogic control equations and which are used to define conditions for triggering an event report.

ER = /50P11 + /51P1 + /51Q1 + /51P2 + /51Q2 + /51P3

In this example, ER triggers a report when it detects the rising edge (transition from 0 to 1) of any one of the six overcurrent elements defined by the Relay Word bits beginning with 50 or 51.

Additional SELogic Control Equation Sets

The SEL-387 Relay is made even more powerful by the inclusion of three sets of additional variables that can be used for creating more complicated control logic. These sets have two types of variables: timed variables and latch bits. Figure 10 and Figure 11 illustrate the two variables.

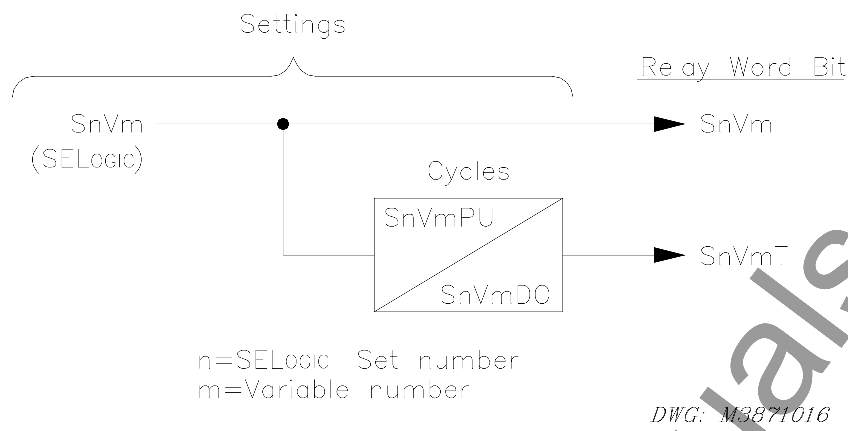


Figure 10: Timed Variables in SELOGIC Control Equation Sets

Timed variables are SELOGIC control equations. When the particular equation is asserted, it asserts the corresponding Relay Word bit, as shown in Figure 10, as well as initiating the timer with pickup and dropout time settings. When the timer pickup is reached, a second Relay Word bit is asserted.

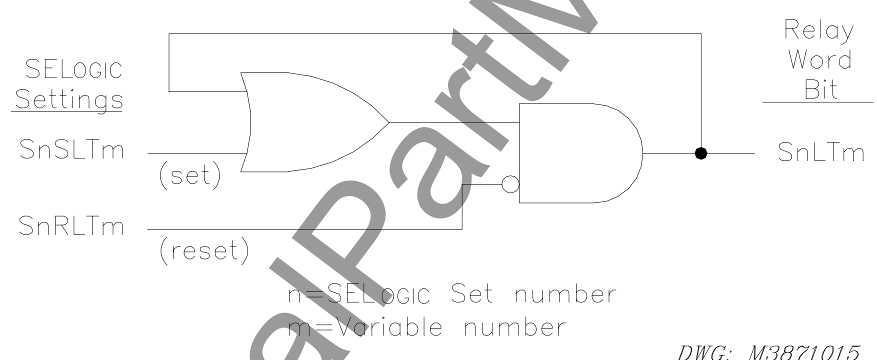


Figure 11: Latch Bits in SELOGIC Control Equation Sets

Latch bits work in a manner similar to a standard latching auxiliary relay. When the set SELOGIC control equation is true, the output Relay Word bit asserts and remains asserted until the reset SELOGIC control equation is true. If both the set and reset equations are true at the same time, the reset equation takes precedence.

Programmable Display Points and LEDs

The user can program specific displays to appear on the two-line front-panel LCD display in response to the logical state (0 or 1) of the SELOGIC control equation setting for a given display point. An example is shown below:

DP1 = IN101

DP1_1 = BREAKER 1 CLOSED

DP1_0 = BREAKER 1 OPEN

IN101 is one of the optoisolated inputs that is connected to a dc source through the 52a auxiliary contact of Breaker 1 (see Figure 3 example). Display Point DP1 is assigned to follow the position of the breaker by reading the state of IN101. If IN101 is asserted, meaning the 52a contact is closed, the relay will display the message defined by DP1_1, that is "BREAKER 1 CLOSED." Conversely, should the breaker open and the 52a contact open along with it, IN101 will deassert and the message for DP1_0 will be displayed, that is "BREAKER 1 OPEN."

Three of the 16 LEDs on the front panel, "A", "B", and "C", can be similarly programmed. They have SELOGIC control equation settings LEDA, LEDB and LEDC, which will light or turn off the LED in response to the logical state of the setting equation.

With these two features, the user can customize the messages that appear on the relay front panel to suit any particular need.

Remote Control Switches (Remote Bits)

The SEL-387 Relay also has 16 remote bits, which are elements of the Relay Word that can be controlled by command over a serial port. These bits can be inserted into SELOGIC control equations, like any other Relay Word bit, for purposes of enabling or disabling logic schemes by remote command from a computer. The user issues the command CON 1, for example, meaning "Control Remote Bit 1". When the relay responds, the user then tells the relay either to set the bit (SRB 1), clear the bit (CRB 1), or to pulse the bit (PRB 1) for one processing interval. This last command might be used, for example, to set or reset a latch bit by using RB1 in the set or reset equation for the latch bit. These remote bits permit the user to interact with the relay control logic from a distance, selectively changing which logic is to be used without the necessity to reprogram the logic itself.

Breaker Monitor

Each of the four winding inputs of the relay has a separate breaker monitor function to record the number of times the breaker associated with that terminal has tripped and the total accumulated asymmetrical RMS amperes that the breaker has interrupted. This information is available via a serial port reporting command or from the front-panel LCD display. The trips are segregated into internal trips (initiated by elements of that particular winding) or external trips (initiated by any other source).

This information is further used with programmable breaker wear curves (Figure 12) based on manufacturer-supplied information to help determine when the breaker has experienced sufficient contact degradation to warrant inspection or major maintenance. The relay can be set to alarm for user-specified conditions. This feature greatly enhances the user's ability to determine the state of the breakers and to schedule maintenance at proper intervals.

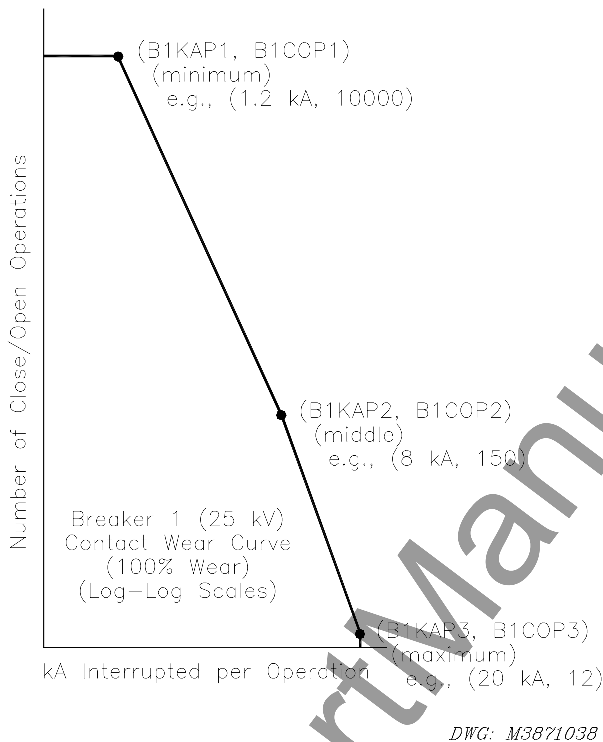


Figure 12: Breaker Monitor Wear Curve

Reporting Functions

As with other SEL relays, the SEL-387 Relay has extensive reporting capabilities.

Metering Reports

The metering reports available are the following:

- Instantaneous phase current, in primary amps, for all four windings, including the positive, negative, and residual components for each.
- Demand current, in primary amps, based on user-settable thermal demand metering time constants and thresholds, for phase, negative-sequence, and residual currents.
- Peak demand, indicating the value, date, and time of occurrence.
- Phasor secondary phase current, showing magnitude and phase angle.
- Differential quantities including: operate, restraint, and second-harmonic and fifth-harmonic currents, for each differential element, in multiples of TAP.
- Harmonic spectrum metering, displaying magnitudes of current from dc to fifteenth harmonic, for all 12 phase currents.

Event Reports

Event reports are stored in nonvolatile memory, and are available in lengths of 15, 30, or 60 cycles, based on a user setting (LER). The user also defines how much of this length is to be pre-event information, via another setting (PRE). The LER setting determines how many full reports can be stored in the relay at any time. At least 18 of the 15-cycle reports can be stored, while only 7 of the 60-cycle reports can be stored. The following types of reports are available:

- Winding event reports, using filtered data, showing all 12 currents at four or eight samples-per-cycle, as well as the status of digital INputs and OUTputs.
- Digital event reports, showing pickup of overcurrent elements and demand elements, at four or eight samples-per-cycle.
- Differential event reports, showing differential quantities, element pickup, SELOGIC control equation set variables, inputs, and outputs, at four or eight samples-per-cycle.
- Raw winding event reports, using unfiltered data, available at 4, 8, 16, 32, or 64 samples-per-cycle.

Event report information can be used in conjunction with the SEL-5601 Analytic Assistant software, to produce oscillographic-type reports suitable for inclusion in analysis documents, etc. An example of a transformer inrush current is shown in Figure 13.

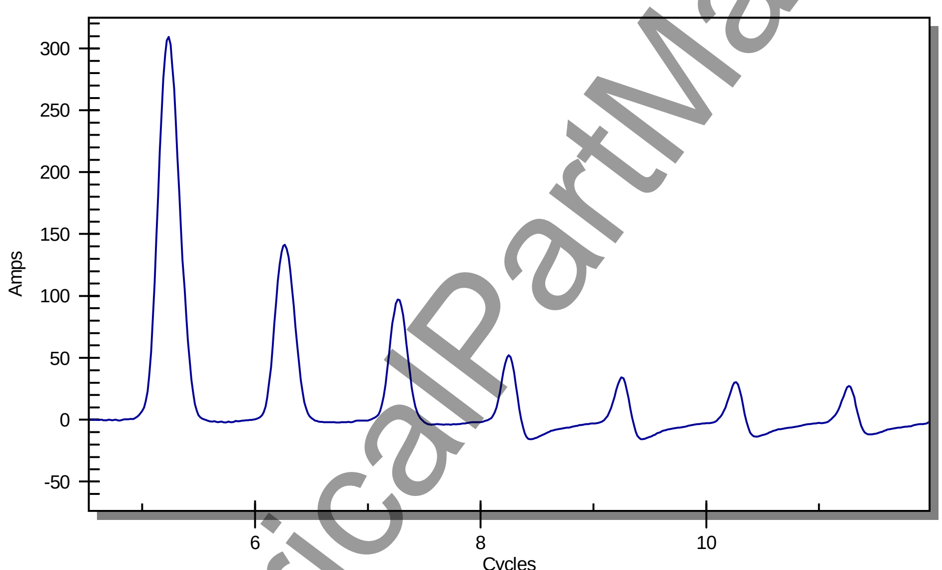


Figure 13: Transformer Inrush Current Plotted from Event Report

In addition to the full-length reports, standard report summaries for the last 99 events are retained in nonvolatile memory. These reports give the event type, the targets generated, and RMS currents in each phase of each winding.

Sequence of Events Reports

The Sequential Events Recorder (SER) is triggered by Relay Word bits determined by the user. The SER stores the most recent 512 events, with time and date stamps. These records show when a trigger was asserted or deasserted. The triggers can be given ALIAS names so that, for example, a certain input can be given a user-friendly label to assist in event analysis. The lengthy store of SER events can be reported in smaller pieces by issuing serial port commands with parameters that define particular time windows or event number windows to display, making the analysis of the records easier.

Integration Package (option)

This package adds system-wide SER capabilities to the SEL-387 Relay. A similar Integration Package available for the SEL-351 Relay works with an SER-capable version of the SEL-2030 Communications Processor to allow for station-wide SER data collection and reporting to your host computer system.

The addition of 16 "Local Bits" to the SEL-387 Relay can eliminate the need for external control switches and associated wiring. Up to 16 local control functions with text prompts are available, and the "positions" of these switches are retained through loss of relay power and settings group changes, just like traditional mechanical switches. The SEL-351 Relay with Integration Package also features these Local Bits, 16 Remote Bits, 16 Display Points, and 16 Latch Bits in SELOGIC control equations so system design is simpler and more consistent.

Serial Port Communications

The SEL-387 Relay is equipped with four serial ports: one EIA-232 port on the front, two EIA-232 ports on the rear, and one EIA-485 port on the rear. Communications may be established by connecting a terminal to one of the serial ports with the appropriate cable. Connect computers, modems, protocol converters, printers, an SEL-PRTU, an SEL-2020 or SEL-2030, an SEL-2885, a SCADA serial port, and/or RTUs for local or remote communications.

Figure 14 shows a closer view of the three rear-panel ports.

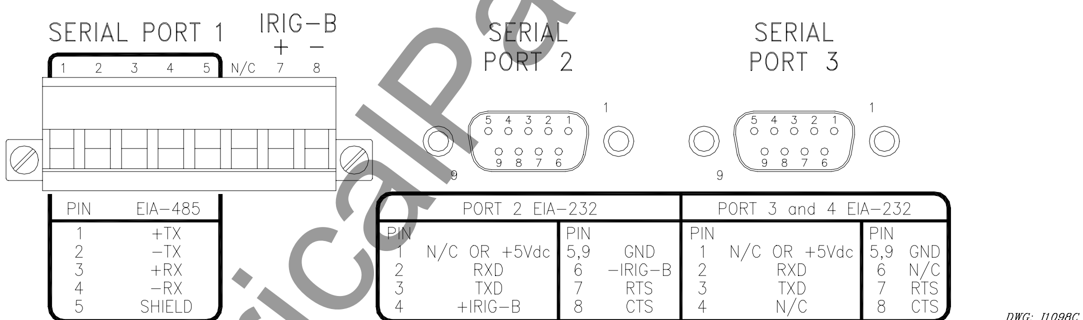


Figure 14: SEL-387 Relay Rear-Panel Serial Port Connectors (female chassis connectors as viewed from outside panel)

At the left, an eight-position plug-in connector serves for connection to the EIA-485 multidrop Port 1, which requires five conductors, and provides two terminals for external connection of a demodulated IRIG-B time code signal. The two EIA-232 ports at center and right use standard 9-pin D-subminiature connectors. Internal jumpers allow the user to connect an internal +5 Vdc source to Pin 1, for powering external devices that must take their power from the port itself. Pins 4 and 6 allow alternate introduction of IRIG-B through the Port 2 cable.

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

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