SEL-787-2/-3/-4

Transformer Protection Relay

The only compact platform with REF and up to four-terminal differential protection

- Dual-slope percentage differential protection with harmonic blocking and restraint enhances security.

- User-configurable restricted earth fault (REF) element provides sensitive ground-fault detection in grounded-wye transformers.

- The 5-inch, 800 × 480 color touchscreen display allows direct monitoring and control of your system.

- Optional single-phase voltage input for synchronism check or station battery monitor.

- The Rapid Spanning Tree Protocol (RSTP) provides alternate paths in a network to improve network recovery.

SEL

Key Features

Differential Protection

The SEL-787-2/-3/-4 provides dual-slope differential protection with harmonic blocking and restraint for as many as four terminals and provides as many as three independent REF elements for sensitive ground-fault detection in grounded-wye transformers. Standard overcurrent elements in the SEL-787-2/-3/-4 provide backup protection, including phase, negative-sequence, residual-ground, and neutral-ground elements. You can select breaker failure protection for as many as four three-pole breakers.

Transformer Monitoring

Measure and track accumulated through-fault current levels, and use optional 4 to 20 mA inputs or resistance temperature detector (RTD) thermal inputs to monitor ambient, load tap changer (LTC) tank, or transformer oil temperatures.

Flexible Communications

Advanced protocols support communications using legacy and modern supervisory and control systems. These protocols include IEC 61850 Edition 2, RSTP, EtherNet/IP, the IEEE 1588 Precision Time Protocol (PTP) (firmware-based), IEC 60870-5-103, the Parallel Redundancy Protocol (PRP), Modbus (RTU and TCP/IP), the Simple Network Time Protocol (SNTP), DNP3 (serial and LAN/WAN), ASCII, Telnet, and the File Transfer Protocol (FTP). In addition, the IEC 61850 test mode in the SEL-787-2/-3/-4 enables in-service testing, which reduces commissioning time.

Proven Hardware

The SEL-787-2/-3/-4 operates in extreme conditions, with an operating temperature range of −40° to +85°C (−40° to +185°F). It is designed to work in harsh substation environments and is tested to verify that it exceeds requirements for reliable operation in the presence of vibration, electromagnetic interference, and other adverse environmental conditions. Optional conformal coating provides extra protection in caustic environments. In addition, the SEL-787-2/-3/-4 is ATEX-certified and Underwriters Laboratories (UL) Class I, Division 2-certified for use in hazardous and potentially explosive environments.

Functional Overview
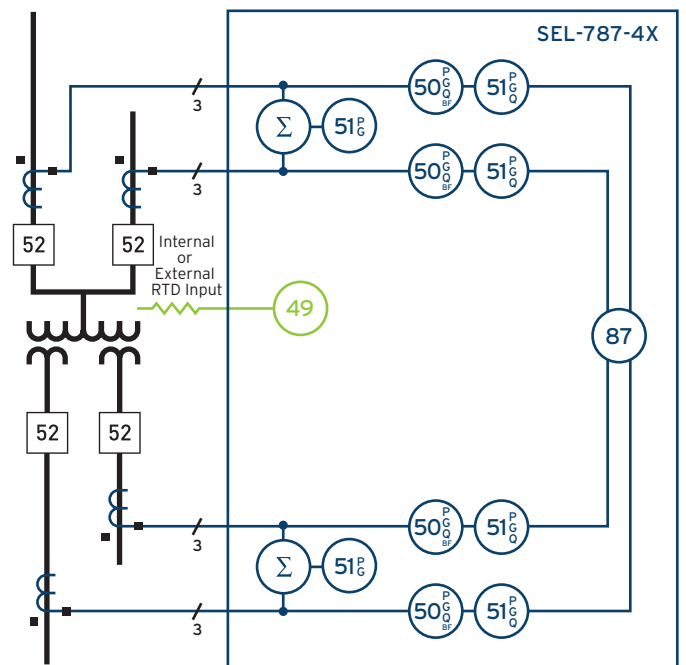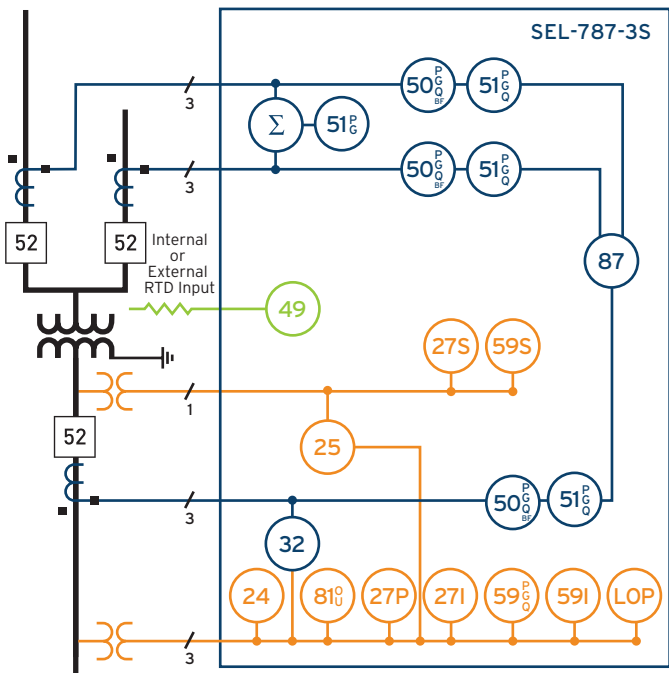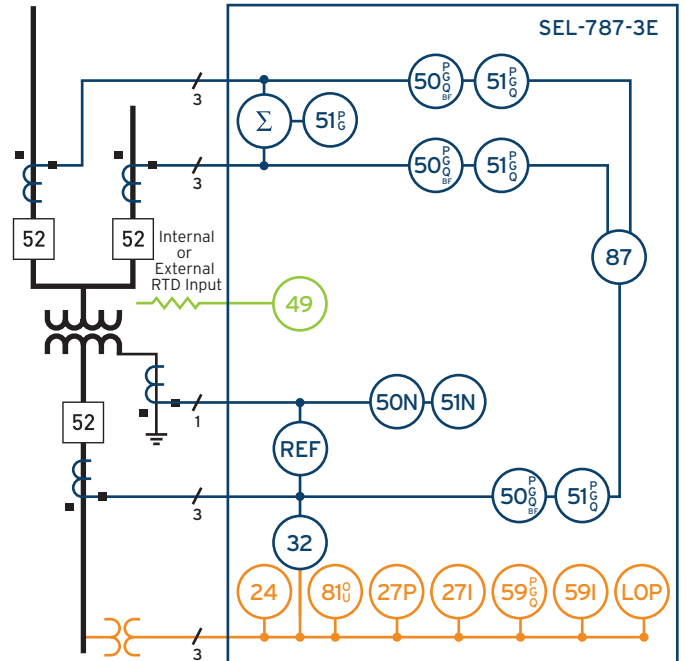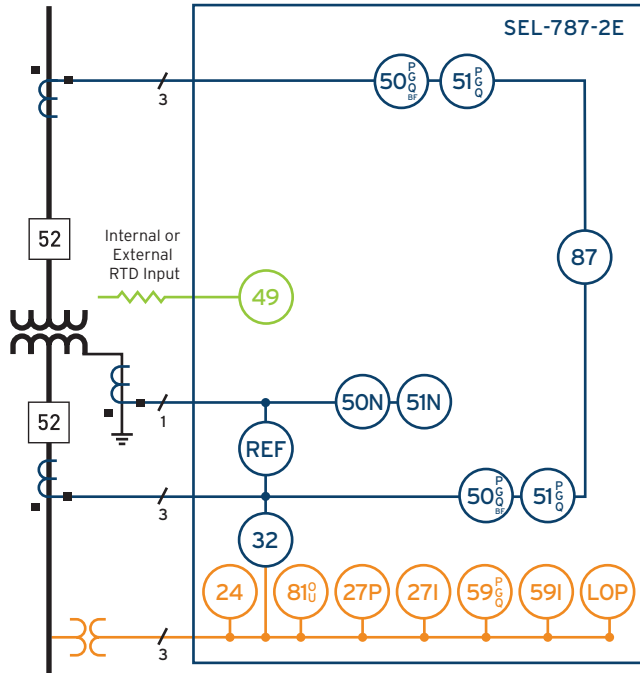
Model Features		SEL-787-2X	SEL-787-21	SEL-787-2E	SEL-787-3E	SEL-787-3S	SEL-787-4X
Windings Protected		2	2	2	3	3	4
CT/PT Inputs							
Phase Voltage Inputs		0	0	3	3	3	0
Differential Current Inputs		6	6	6	9	9	12
Neutral Current		0	1	1	1	0	0
VS/VBAT Channel		0	0	0	0	1	0
Protection Elements							
24	Volts/Hertz			•	•	•	
25	Synchronism Check					•	
27I	Inverse Time Undervoltage (Phase, Phase-to-Phase, Sequential, Vsync)			•	•	•	
27P	Undervoltage (Phase) With Inverse Characteristic			•	•	•	
27PP	Phase-to-Phase Undervoltage			•	•	•	
27S	VS Channel Undervoltage					•	
32	Directional Power			•	•	•	
49	RTDs	•	•	•	•	•	•
50N	Neutral Overcurrent		•	•	•		
50 (P,G,Q, BF)	Overcurrent (Phase, Ground, Neg. Seq, Breaker Failure)	•	•	•	•	•	•
51 (P,G,Q)	Time-Overcurrent (Phase, Ground, Neg. Seq.)	•	•	•	•	•	•
51N	Neutral Time-Overcurrent		•	•	•		
51PC	Combined Winding Phase Time-Overcurrent				•	•	•
51GC	Combined Winding Ground Time-Overcurrent				•	•	•
59 (P,G,Q)	Overvoltage (Phase, Ground, Neg. Seq.)			•	•	•	
59I	Inverse Time Overvoltage (Phase, Phase-to-Phase, Sequential, Vsync)			•	•	•	
59S	Overvoltage (Synchronism or Battery Voltage)					•	
81 (O,U)	Over-/Underfrequency			•	•	•	
87	Phase Differential	•	•	•	•	•	•

Model Features		SEL-787-2X	SEL-787-21	SEL-787-2E	SEL-787-3E	SEL-787-3S	SEL-787-4X
Differential and REF Elements							
Differential Protection Windings (Standard)		2	2	2	3	3	4
REF Elements (Standard)		0	1	1	1	0	0
Differential Protection Windings (Winding 3 Configured for REF)					2	2	3
REF Elements (Winding 3 Configured for REF)					2	2	2
Additional Functions							
85RIO	SEL MIRRORED BITS® Communications	•	•	•	•	•	•
BF	Breaker Failure	•	•	•	•	•	•
BW	Breaker Wear Monitoring	•	•	•	•	•	•
DFR	Event Reports	•	•	•	•	•	•
ENV	SEL-2600 RTD Module Support*	•	•	•	•	•	•
LDP	Load Data Profiling	•	•	•	•	•	•
LGC	SELOGIC® Control Equations	•	•	•	•	•	•
LOP	Loss of Potential			•	•	•	
MET	High-Accuracy Metering	•	•	•	•	•	•
RTD	10 Internal or 12 External (see ENV) RTD Inputs*	•	•	•	•	•	•
REF	Restricted Earth Fault		•	•	•	•	•
RTU	Remote Terminal Unit	•	•	•	•	•	•
SER	Sequential Events Recorder	•	•	•	•	•	•
TFE	Through-Fault Event Monitor	•	•	•	•	•	•
PMU	Synchronized Phasor Measurement	•	•	•	•	•	•
WEB	Web Server	•	•	•	•	•	•

*Optional feature

Product Overview

Large 2 × 16 character LCD.

Default messages or up to 32 customizable display labels notify personnel of power system events or the relay status.

SCHWEITZER ENGINEERING LABORATORIES

SEL

SEL-787
TRANSFORMER PROTECTION RELAY

SEL-787
TRANSFRMR RELAY

TARGET RESET

ESC

ENT

Customizable push-buttons and labels.

ENABLED

TRIP

DIFFERENTIAL

INST OC

TOC

O/U VOLT

O/U FREQ

V/Hz

SELECTED
BRKR1
CLOSED/OPEN

ENABLED
LOCK
DISABLED

SELECTED
BRKR2
CLOSED/OPEN

BREAKER CLOSING
CLOSE

SELECTED
BRKR3
CLOSED/OPEN

BREAKER OPENING
TRIP

AUX 2

AUX 1

Programmable front-panel tricolor LEDs.

Two programmable tricolor LEDs per pushbutton.

PORT F

User-configurable label kit.

Power supply options include 24—48 Vdc or 110—250 Vdc/110—240 Vac.

2 digital inputs (DI) and 3 digital outputs (DO).

A wide variety of communications protocols and media provide flexibility to communicate with other devices and control systems.

EIA-232 serial port (P3) and fiber-optic EIA-232 serial port (P2) with IRIG-B input.

Accelerate firmware downloads via the Ethernet port.

Positions for optional I/O cards.

Positions for current and voltage options.

+/H −/N

GND

A01 A02 A03 A04 A05 A06

A07 A08 A09 A10 A11 A12

PORT 1A   PORT 1B   TX   RX   PORT 3
                      PORT 2

1   2   3   4   5
PORT 4A

PORT 4C

D01   D08   D09   D16

E01 E02 E03 E04 E05 E06   E07 E08 E09 E10 E11 E12

Z01 Z02 Z03 Z04 Z05 Z06   Z07 Z08 Z09 Z10 Z11 Z12
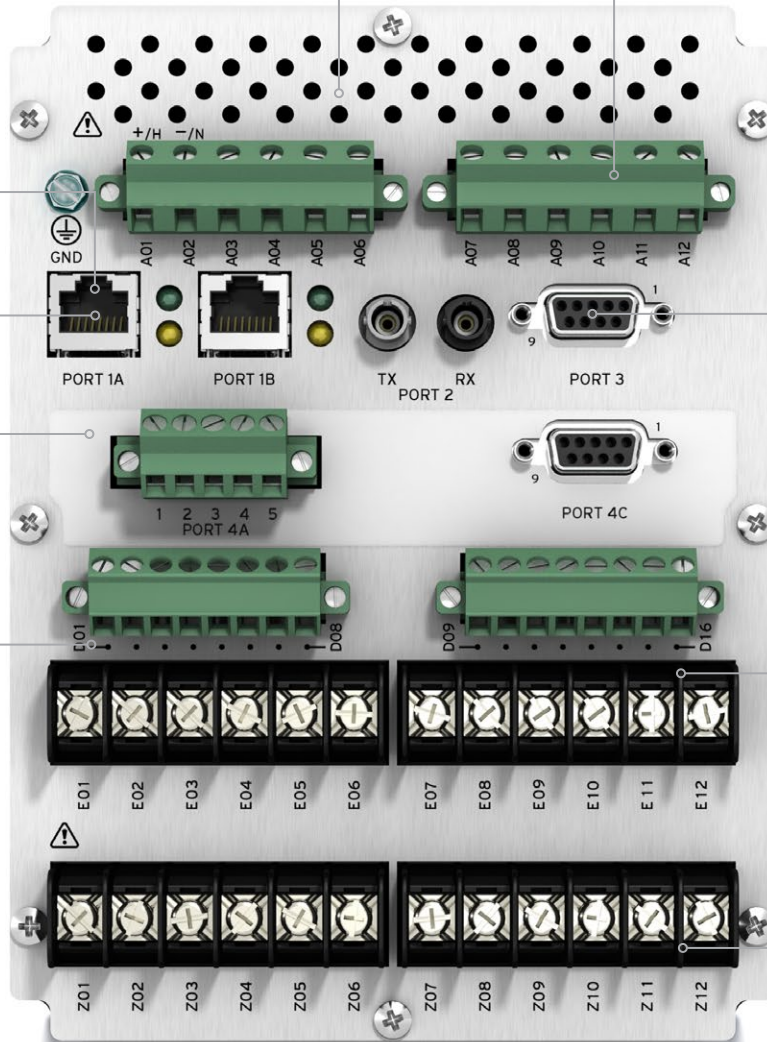
Touchscreen Overview

The 5-inch diagonal color display with a resolution of 800 × 480 pixels offers direct navigation via a capacitive touchscreen.

Folders and applications provide quick access to bay screens, metering and monitoring data, reports, settings, and more.

Full keyboard facilitates easy adjustment of settings.

The home pushbutton allows users to easily return to the default home screen.

The front panel is available in English or Spanish.

Touchscreen Display Features and Functions

The SEL-787-2/-3/-4 5-inch, 800 × 480 color touchscreen display provides a one-line diagram mimic display for bay control and monitoring. You can view metered quantities, phasor diagrams, relay settings, event summaries, target statuses, and SER data.

Bay Screens and Bay Control

Select from predefined bay screens, or configure as many as five custom bay screens using ᴀᴄSELᴇʀᴀᴛᴏʀ® Bay Screen Builder SEL-5036 Software and ᴀᴄSELᴇʀᴀᴛᴏʀ QuickSet® SEL-5030 Software. With the bay screen, you can control as many as 4 breakers, 16 two-position disconnects, and 2 three-position disconnects and can view analog and digital data in a contextual display.

To control a breaker, simply tap the Bay Screens application on the home screen and then the breaker you want to control.
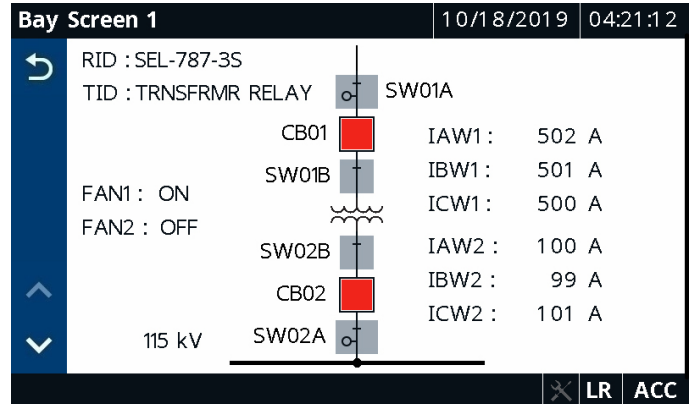
Next, enter your Level 2 password and tap Submit. The onscreen keyboard allows you to quickly and easily enter passwords.
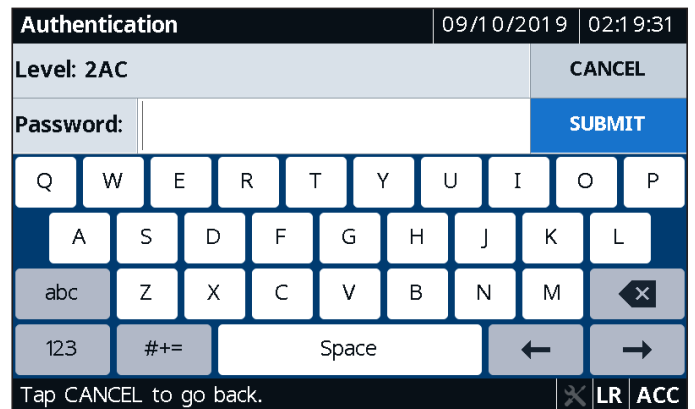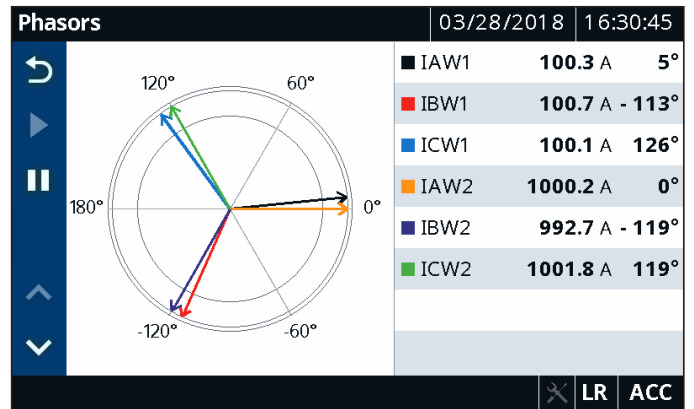

Finally, tap Trip or Close to control the breaker. When asked to confirm the action before the operation is completed, choose Yes or No.
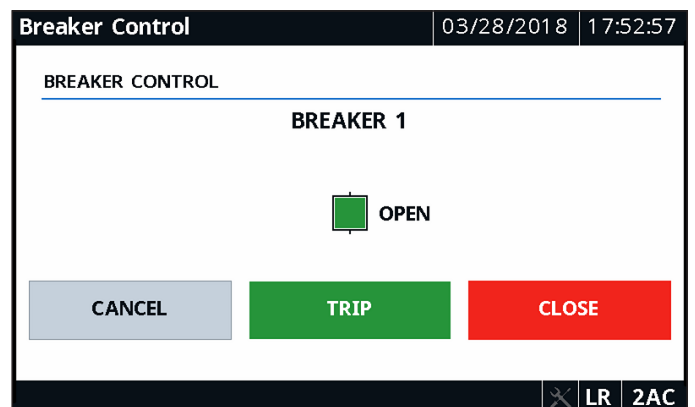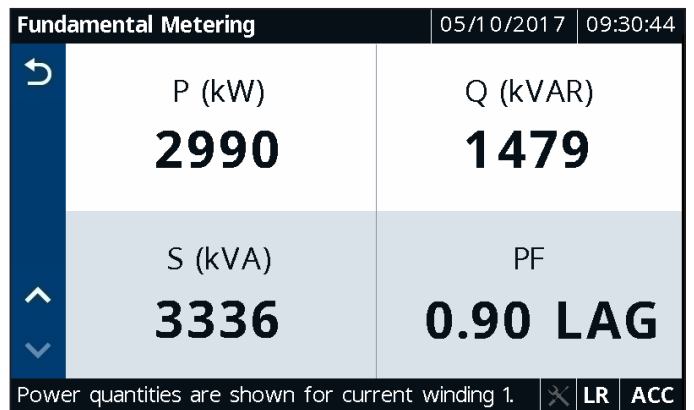
Meter Phasors

View a graphical and textual representation of the real-time voltages and currents in a power system during balanced and unbalanced conditions. By analyzing the phasors, you can determine power system conditions.

Phasors		03/28/2018	16:30:45
■ IAW1	100.3 A	5°	
■ IBW1	100.7 A	-113°	
■ ICW1	100.1 A	126°	
■ IAW2	1000.2 A	0°	
■ IBW2	992.7 A	-119°	
■ ICW2	1001.8 A	119°	

Meter Fundamentals

View the real, reactive, and apparent power of each phase in your system, and monitor the power factor information to determine if the phase current leads or lags the phase voltage.

Fundamental Metering — 05/10/2017 09:30:44

P (kW)	Q (kVAR)
2990	**1479**
S (kVA)	PF
3336	**0.90 LAG**

Power quantities are shown for current winding 1.

Meter Differential

View the operate and restraint currents for each differential element (87) of your transformer in multiples of TAP. You can use these quantities in conjunction with the phasors or fundamental metering screen to visualize the differential protection of your transformer and for commissioning exercises.

Differential Metering — 05/10/2017 09:31:15

	87-1	87-2	87-3
Operate (pu)	0.03	0.02	0.03
Restraint (pu)	2.02	2.03	2.00
2nd Harmonic (%)	0.00	0.00	0.00
4th Harmonic (%)	0.00	0.00	0.00
5th Harmonic (%)	0.00	0.00	0.00

SEL-787-2/-3/-4 Options

Optional Communications and I/O Cards
Serial communications card (EIA-232/-485)
3 DI, 4 DO, 1 4–20 mA analog output (AO)
4 DI, 4 DO
8 DO
8 DI
14 DI
4 DI, 3 DO (2 Form C, 1 Form B)
4 analog inputs (AI), 4 AO
10 RTD inputs

| Current and Voltage Input Cards	Model
6 currents (Slot Z)	SEL-787-2X
6 currents (Slot Z) and 1 neutral current (Slot E)	SEL-787-21
6 currents (Slot Z) and 1 neutral current, 3 voltages (Slot E)	SEL-787-2E
6 currents (Slot Z) and 3 currents, 1 neutral current, 3 voltages (Slot E)	SEL-787-3E
6 currents (Slot Z) and 3 currents, 3 voltages, 1 voltage (battery or synchronism check) (Slot E)	SEL-787-3S
6 currents (Slot Z) and 6 currents (Slot E)	SEL-787-4X

Applications

Multiwinding Differential Transformer Protection

Provide dual-slope differential protection with harmonic blocking and restraint for transformers with as many as four three-phase terminals at power plants, transmission substations, distribution substations, and industrial plants. The relay allows you to choose harmonic blocking, harmonic restraint, or both, providing stability during transformer inrush conditions. Even-numbered harmonics (second and fourth) provide security during energization, while fifth-harmonic blocking provides security for overexcitation conditions.
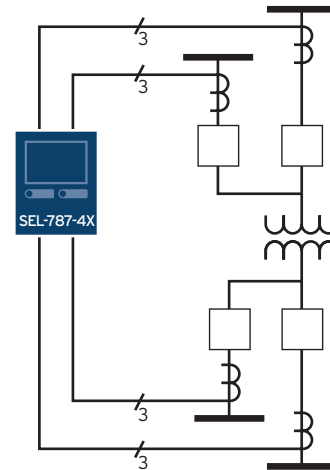
REF Protection

Provide sensitive detection of internal ground faults on grounded wye-connected transformer windings and autotransformers using the REF element. The number of REF elements available is model-dependent.

Protection Using Different Combinations of Nominal CT Inputs

For each transformer winding, you can order a 5 A or 1 A nominal CT input to match your application.
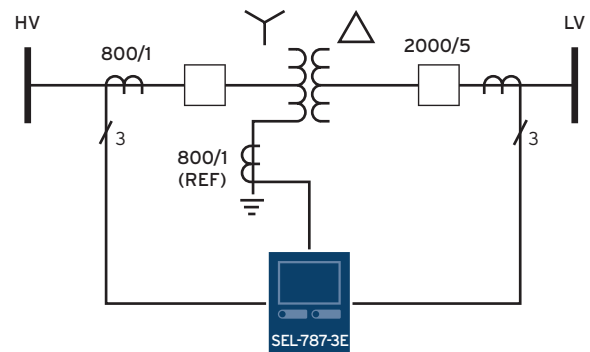
Standard Time-Overcurrent Protection

Standard overcurrent elements, including phase, negative-sequence, residual-ground, and neutral-ground elements, provide backup protection.

Through-Fault Monitoring

Track transformer wear with through-fault monitoring. Transformer through-fault monitoring lets you gather the current levels, through-fault duration, and date/time of each through fault. Through-fault currents can cause transformer winding displacement, leading to mechanical damage and increased transformer thermal wear. By monitoring through faults, you can schedule proactive maintenance based on the cumulative through-fault duty.
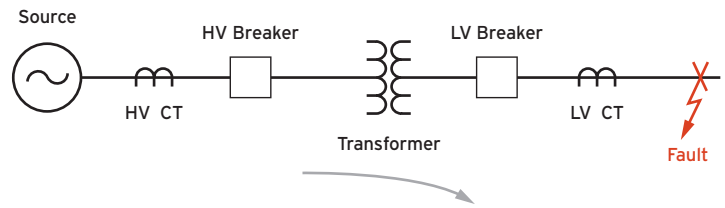
Circuit Breaker Monitor

The SEL-787-2/-3/-4 circuit breaker monitor feature compares the breaker manufacturer's maintenance curve to the measured (unfiltered) ac current at the time of trip and the number of close-to-open operations. The circuit breaker monitor feature helps in scheduling circuit breaker maintenance.
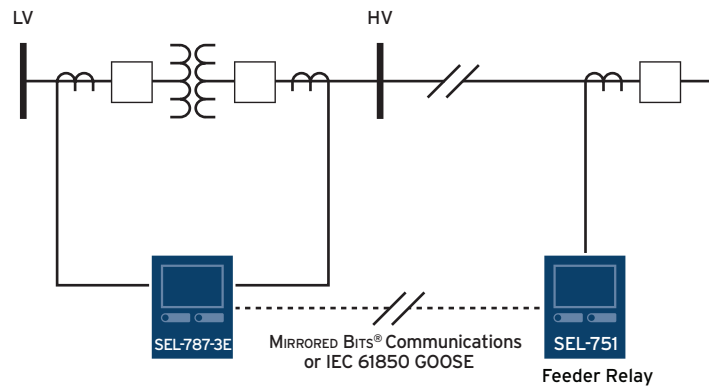
Protection Coordination

Use SEL MIRRORED BITS or IEC 61850 GOOSE communications to coordinate with upstream protection.

Easy Information Access With the Integrated Web Server

Access basic SEL-787-2/-3/-4 information on a standard Ethernet network with the built-in web server. You can view the relay status, SER data, metering information, and settings with easy access within a local network. For increased security, web server access requires a relay password and the information is limited to a read-only view. You can also upgrade the relay firmware through the web server.
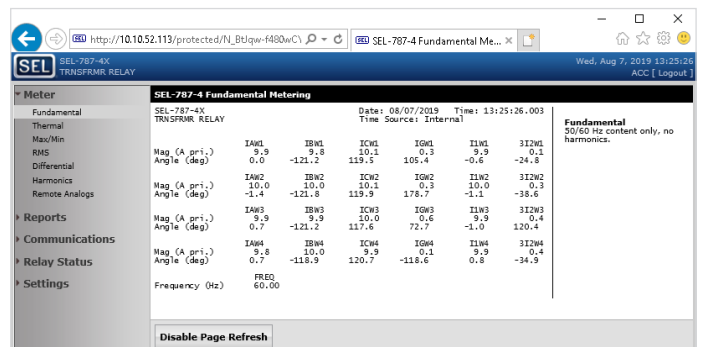
Integration and Language Support

Integrate relays using multiple protocol options, and securely manage local and remote access for protection, monitoring, and control. Through a secure serial or Ethernet network, you can centrally monitor and manage transformers, share data between substations, and integrate relays inside the control house. The relay is available with either Spanish or English interface options.

Supported protocols include:

- IEC 61850 Edition 2
- EtherNet/IP
- MIRRORED BITS communications
- IEC 60870-5-103
- Firmware-based PTP
- PRP
- SNTP
- DNP3
- Telnet
- Modbus
- FTP
- ASCII
- RSTP

```
=>>aju r

Reporte Ajustes de

Criterio Activacion SER

Activar Auto Eliminacion (Y,N)                ESERDEL := N        ?

Listas Arranques SER
SERn = Hasta 24 elementos Relay-Word separados por espacios o comas.
Use NA para dehabilitar el ajuste. SP


SER1     := 87R 87R1
?
SER2     := TRIP
?
SER3     := TRIPXFMR
?
SER4     := SALARM
?

Aliases Relay-Word Bit
ALIASn = 'RW Bit'(espacio)Alias(espacio)'Texto Activado'(espacio)'Texto Desactiv
ado'.
Texto Alias, Activado, Desactivado puede tenet hasta 15 caracteres.
Use NA para desactivar ajuste.


Enable ALIAS (N,1-20)                EALIAS := 3        ?
ALIAS1  := PB01 FP_LOCK PICKUP DROPOUT
?
ALIAS2  := PB02 FP_CLOSE PICKUP DROPOUT
?
ALIAS3  := PB03 FP_TRIP PICKUP DROPOUT
?

Ajustes Reporte Eventos

ARRANCAR EVENTO (SELogic)
ER       := 0
?
LONGITUD EVENTO (15,64,180 cic)           LER      := 15       ?
LONGITUD PREFALLA (1-10 cic)              PRE      := 1        ?

Activar Fst Msg R
FMRnNAM = Caracteres validos.
FMRN = Hasta 24 Cantidades Analogicas separadas por espacios o comas.
Use NA para desactivar ajuste.


Nombre FMR1 (9 caracteres)               FMR1NAM := FMR1      ?
Leer Fast Message FMR1 (24 cantidades analogicas)
FMR1     := NA
?
Nombre FMR2 (9 caracteres)               FMR2NAM := FMR2      ?
Leer Fast Message FMR2 (24 cantidades analogicas)
FMR2     := NA
?
Nombre FMR3 (9 caracteres)               FMR3NAM := FMR3      ?
Leer Fast Message FMR3 (24 cantidades analogicas)
FMR3     := NA
?
```

SEL-787-2/-3/-4 Specifications

General	
AC Current Inputs	5 A or 1 A nominal
AC Voltage Inputs	300 Vac continuous, 600 Vac for 10 seconds
Output Contacts	The relay supports Form A, B, and C outputs.
Optoisolated Control Inputs	DC/AC control signals: 250, 220, 125, 110, 48, and 24 V
Frequency and Phase Rotation	System frequency: 50, 60 Hz Phase rotation: ABC, ACB Frequency tracking: 15—70 Hz (requires ac voltage inputs)

Communications Ports	Standard EIA-232 (2 ports)
	    Location: front panel, rear panel
	    Data speed: 300—38,400 bps
	
	EIA-485 port (optional)
	    Location: rear panel
	    Data speed: 300—19,200 bps
	
	Standard multimode fiber-optic serial port
	    Location: rear panel
	    Data speed: 300—38,400 bps
	
	Ethernet port (optional)
	    Single/dual 10/100BASE-T copper (RJ45 connector)
	    Single/dual 100BASE-FX (LC connector)

Communications Protocols	SEL (Fast Meter, Fast Operate, and Fast SER), Modbus TCP/IP, Modbus RTU, DNP3, FTP, IRIG-B, Telnet, SNTP, EtherNet/IP, firmware-based IEEE 1588 PTP, IEC 61850 Edition 2, IEC 60870-5-103, PRP, RSTP, MIRRORED BITS communications, and IEEE C37.118-2005 (synchrophasors).
Processing Specification	AC voltage and current inputs: 32 samples per power system cycle Protection and control processing: 4 times per power system cycle

Power Supply	110—250 Vdc or 110—240 Vac
	    Input voltage range: 85—264 Vac or 85—300 Vdc
	
	24—48 Vdc
	    Input voltage range: 19.2—60.0 Vdc

Operating Temperature	−40° to +85°C (−40° to +185°F) Note: Front-panel display contrast is impaired for temperatures below −20°C (−4°F) and above +70°C (+158°F).
Certifications	To view certifications for the SEL-787-2/-3/-4, please visit selinc.com/company/certifications.