SEL-487B Bus Differential Relay

Busbar and Breaker Failure Protection, Automation, and Control System

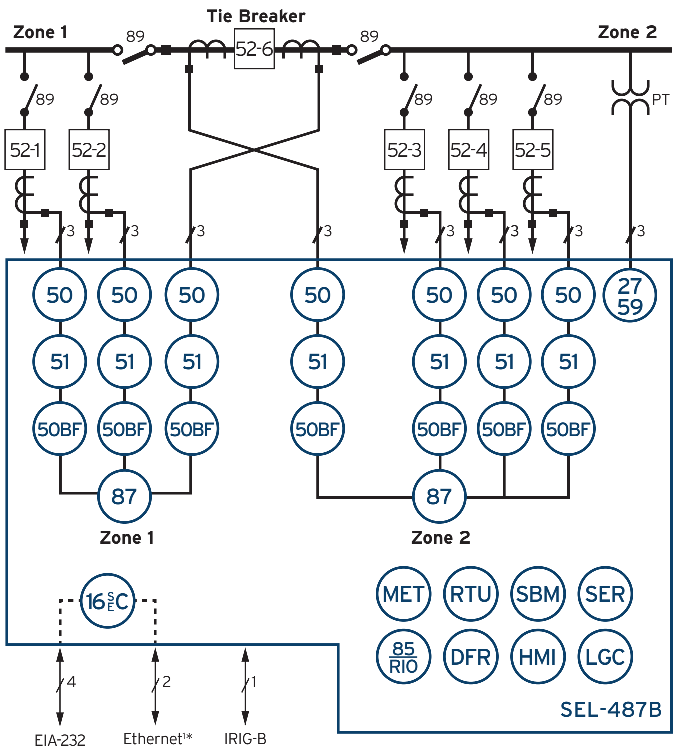
Major Features and Benefits

The SEL-487B Relay provides bus current differential protection, circuit breaker failure protection, and backup overcurrent protection. The relay has 21 analog current inputs and three analog voltage inputs. For buses with no more than seven terminals, use one SEL-487B in a single-relay application. For buses with eight to ten terminals, use two SEL-487B relays. For buses with as many as 21 terminals, use three SEL-487B relays; each relay provides as many as six independent and adaptable zones of protection. Contact SEL Research and Development for methods on protecting larger systems.

- ➤ Busbar differential protection operates in less than one cycle to increase system stability margins and reduce equipment damage.
- ➤ Flexible zone selection and six differential zones provide protection for multiple busbar applications.
- ➤ Failed CT detection elements reliably indicate open and shorted CTs for alarming and/or blocking.
- ➤ Differential protection accommodates as high as 10:1 CT ratio mismatch without auxiliary CTs.
- ➤ Differential protection is secure for external faults with minimal CT requirements.
- ➤ Breaker failure protection for each terminal integrates bus and breaker failure protection.
- ➤ Instantaneous and inverse time-overcurrent elements provide backup protection for each terminal.
- ➤ Negative- and zero-sequence over- and undervoltage elements provide for differential element supervision.
- ➤ Three dedicated check zones are available in each relay to supervise complex bus differential schemes.
- ➤ Interconnection with automation systems uses IEC 61850 or DNP3 protocols directly or DNP3 through a Communications Processor. Use FTP for high-speed data collection.

- ➤ The relay records a wide range of system events with sampling rates as fast as 8 kHz, and as much as 24 seconds of data per COMTRADE compliant event report.
- ➤ Parallel Redundancy Protocol (PRP) provides seamless recovery from any single Ethernet network failure, in accordance with IEC 62439-3. The Ethernet network and all traffic are fully duplicated with both copies operating in parallel.
- ➤ IEEE 1588, Precision Time Protocol version 2 provides high-accuracy timing over an Ethernet network.
- ➤ Time-domain link (TiDL) technology allows for remote data acquisition through use of the SEL-2240 Axion. The Axion provides remote analog and digital data over an IEC 61158 EtherCAT TiDL network. This technology provides very low and deterministic latency over a fiber point-to-point architecture. The SEL-487B-1 Relay can receive fiber links from as many as eight Axion remote data acquisition nodes.

Functional Overview



ANSI NUMBERS/ACRONYMS AND FUNCTIONS	
16 SEC	Access Security (Serial, Ethernet)
27/59	Over- and Undervoltage
50	Overcurrent
50BF	Breaker Failure Overcurrent
51	Time-Overcurrent
85 RIO	SEL MIRRORED BITS Communications
87	Current Differential
DFR	Event Reports
HMI	Operator Interface
LGC	Expanded SELOGIC Control Equations
MET	High-Accuracy Metering
RTU	Remote Terminal Unit
SER	Sequential Events Recorder

ADDITIONAL FUNCTIONS	
SBM	Station Battery Monitor
TiDL	Time-Domain Link Remote Data Acquisition

ADDITIONAL FEATURES
Open CT Detection
Three Independent Check Zones
Disconnect Status and Monitoring Logic for 60 Disconnects
Single-Relay Application: 2 Three-Phase Zones for as many as 7 Terminals
Two-Relay Application: 3 Three-Phase Zones for as many as 10 Terminals
Three-Relay Application: 6 Single-Phase Zones for as many as 21 Terminals

[1] Copper or Fiber Optic   * Optional Feature

Figure 1 SEL-487B Relay Basic Functions in a Double-Bus Application

Protection Features

Order the 9U chassis version of the SEL-487B to equip the relay with a maximum of four interface boards. With four interface boards, the relay has a total of 103 inputs (72 common inputs and 31 independent inputs) and 40 outputs (24 high-speed, high-current interrupting outputs and 16 standard outputs).

Order the 7U chassis version of the SEL-487B to equip the relay with a maximum of two interface boards. With two interface boards, the relay has a total of 55 inputs (36 common inputs and 19 independent inputs) and 24 outputs (12 high-speed, high-current interrupting outputs and 12 standard outputs).

The 7U and 9U chassis options for the SEL-487B both contain 21 current inputs and three voltage inputs.

With the flexibility of the expanded SELOGIC control equations, you need no external auxiliary relays to configure the relay for complex busbar arrangements. The SEL-487B provides station-wide protection through the use of up to six zones of differential protection, advanced zone selection algorithms, and per-terminal breaker failure and overcurrent protection.

Dynamic Zone Configuration

The SEL-487B dynamically assigns the input currents to the correct differential elements without the need for auxiliary relays. Connect the digital inputs from the busbar disconnect auxiliary contacts directly to the relay. SELOGIC control equations and zone selection logic will correctly assign the currents to the differential elements, even for complex bus arrangements such as the one in *Figure 2*.

Busbar configuration information, as a function of the disconnect status, is readily available. *Figure 3* depicts the response of the relay to the **ZONE** command, showing the terminals and bus-zones assigned to each protection zone.

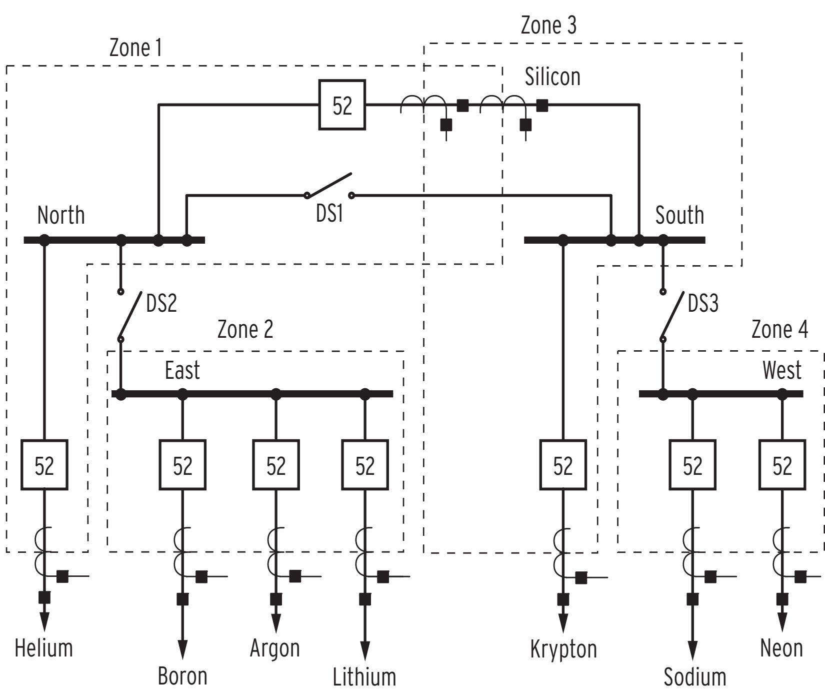


Figure 2 Bus-Zone Protection Based on Disconnect Switch Positions

```
=>>ZONE <Enter>
BUS PROTECTION
Rinadel Station
Terminals in Protection Zone 1
HELIUM         SILICON
Bus-Zones in Protection Zone 1
NORTH
Terminals in Protection Zone 2
BORON        ARGON       LITHIUM
Bus-Zones in Protection Zone 2
EAST
Terminals in Protection Zone 3
SILICON         KRYPTON
Bus-Zones in Protection Zone 3
SOUTH
Terminals in Protection Zone 4
SODIUM         NEON
Bus-Zones in Protection Zone 4
WEST
=>>
```

Figure 3 Result of ZONE Command Indicating the Protection Zone Configuration According to Disconnect Switch Positions

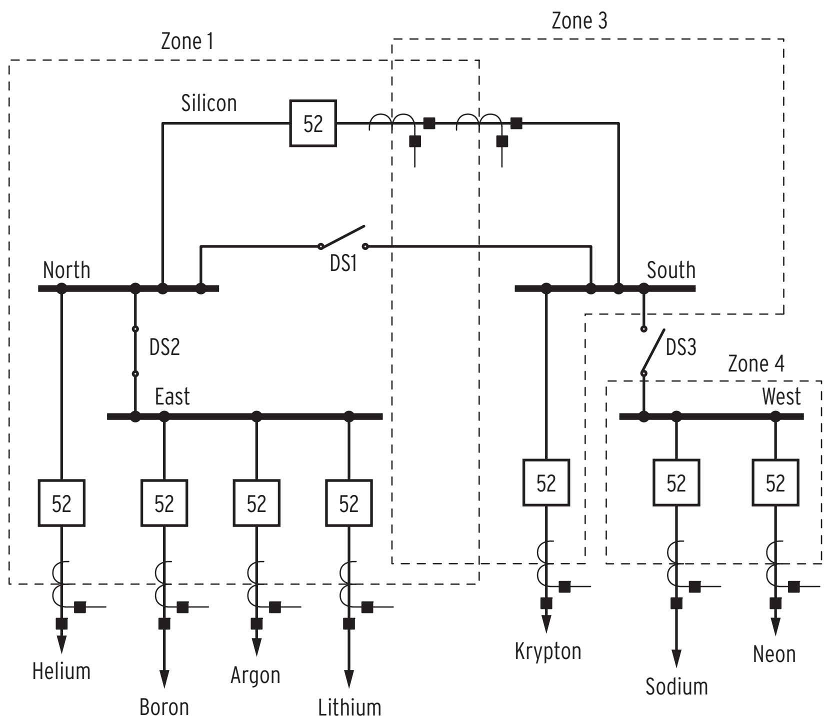


Figure 4 Bus Arrangement With Disconnect DS2 Closed; the New Zone 1 That Includes Bus-Zones North and East

```
=>>ZONE <Enter>
BUS PROTECTION
Rinadel Station
Terminals in Protection Zone 1
HELIUM         SILICON       BORON      ARGON       LITHIUM
Bus-Zones in Protection Zone 1
NORTH          EAST
Terminals in Protection Zone 3
SILICON         KRYPTON
Bus-Zones in Protection Zone 3
SOUTH
Terminals in Protection Zone 4
SODIUM         NEON
Bus-Zones in Protection Zone 4
WEST
=>>
```

Figure 5 Result of ZONE Command, Showing the Protection Zone Configuration After Zone 1 Merges With Zone 2

Closing disconnect DS2 combines Zone 1 and Zone 2, resulting in a single zone. *Figure 4* shows the new protection zone configuration. In this combination, Zone 1 includes North and East bus-zones. *Figure 5* shows the new Zone 1 that includes bus-zones North and East.

Zone Selection Logic

Busbar protection requires assignment of the correct current values to the appropriate differential elements as a function of user-defined conditions. To achieve this, the SEL-487B employs a two-step process:

- ➤ Evaluates the user-defined conditions.
- ➤ Assigns the currents to the differential element of the appropriate zone.

Current assignment conditions vary from simple to complex. A simple condition would be a statement such as "always include this terminal in the differential calculations." A more complex condition statement could be "when Disconnect 2 is closed, and the transfer disconnect is open."

SELOGIC control equations provide the mechanism by which the user enters the conditions for assigning the currents to the differential elements when these conditions are met. When a SELOGIC control equation becomes true (e.g., the disconnect is closed), the relay dynamically assigns the current to the differential elements. Conversely, when the SELOGIC control equation is false (the disconnect is open), the relay dynamically removes the currents from the differential elements. This is also true for the trip output. When the SELOGIC control equation of a terminal is false, the relay issues no trip signal to that terminal. *Table 1* shows a simple case where the disconnect status is the only condition for the relay to consider.

Table 1 Conditions for Automatic Terminal Assignment

Example of Condition	SELOGIC Control Equation Result	Consider Terminal in Protection Calculations?	Issue Trip?
Disconnect is open	False	No	No
Disconnect is closed	True	Yes	Yes

End-Zone Protection

To illustrate the flexibility of use of SELOGIC control equations for user-defined conditions, consider the ease of achieving end-zone protection with the SEL-487B.

Figure 6 shows fault F1 between an open circuit breaker and CT of a feeder at a substation. This area is a "dead" zone because neither busbar protection nor local line protection can clear this fault; the remote end of the feeder must clear this fault. Because the feeder circuit breaker is already open, operation of the busbar protection serves no purpose. The busbar protection must not operate for this fault.

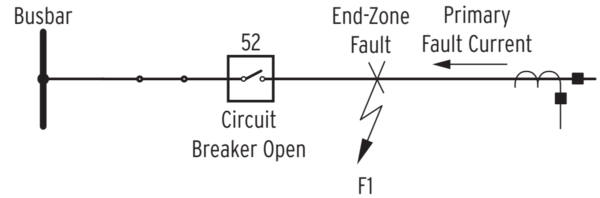


Figure 6 Fault Between Breaker and CT

By including the circuit breaker auxiliary contact in one of the SELOGIC control equations (*Figure 7*), we can cause the value of the SELOGIC control equation to be false when the circuit breaker is open, removing the current from the differential element calculations. This capability ensures stability of the busbar protection. By our use of SELOGIC control equations and normal communications channels to configure the protection system, the relay sends a trip signal to the remote end of the feeder.

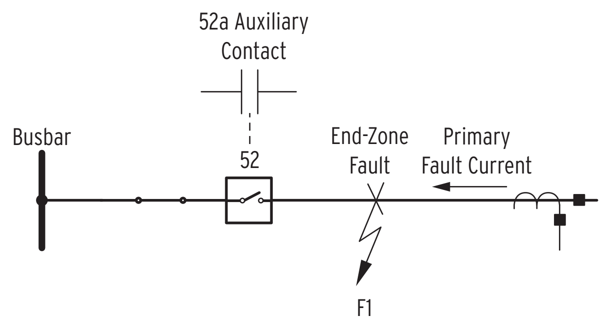


Figure 7 Bus Protection Is Not Affected by Fault, F1; Use Transfer Trip to Clear the Fault

Check Zones

The SEL-487B provides three completely independent check zones, each with its own adaptive differential element. Supervise zone differential elements by using the independent check zones to monitor all incoming sources and outgoing feeders on a per-phase basis. During an internal fault, the check zone differential element will assert. During an external fault, the check zone element will remain deasserted.

Differential Protection

The SEL-487B includes six independent current differential elements. Operating time for internal faults, including high-speed output contact closure, is less than one cycle. *Figure 8* shows an example of an internal fault and differential element operation.

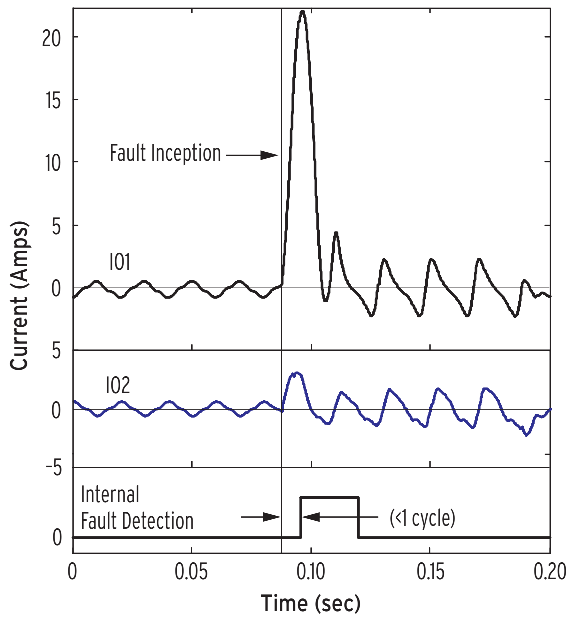


Figure 8 Differential Element Operation in Less Than One Cycle for Internal Faults

Each of the differential elements provides the following:

- ➤ Fast operating times for all busbar faults
- ➤ Security for external faults with heavy CT saturation
- ➤ Security with subsidence current present
- ➤ High sensitivity for busbar faults
- ➤ Minimum delay for faults evolving from external to internal faults

Figure 9 shows a block diagram of one of the six differential protection elements.

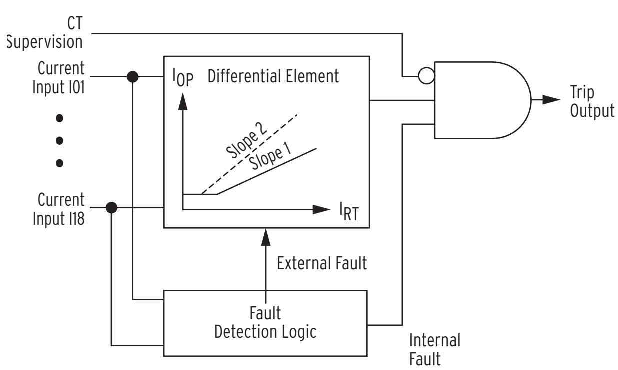


Figure 9 External Fault Detection Logic Increases Differential Element Security

CT saturation is one of the main factors to address when considering relay security. Because of the high sampling rate, the fault detection logic detects external faults in less than 2 ms by comparing the rate of change of the restraint and operating currents. Following the detection of an external fault, the relay enters a high-security mode, during which it dynamically selects a higher slope for the differential elements (see *Figure 9*). *Figure 10* shows an external fault with heavy CT saturation, without differential element operation.

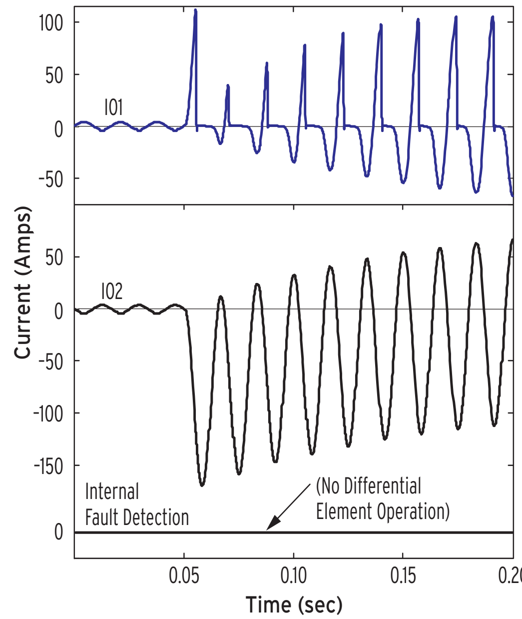


Figure 10 Differential Element Does Not Operate for External Fault With Heavy CT Saturation

CT Supervision

Open or shorted current transformers produce equal and opposite changes in restraint and operate current. The advanced CT supervision in the SEL-487B monitors differential zone restraint and operating current for these changes, to provide rapid and dependable detection of open or shorted CT conditions. Use the CT supervision logic in zone trip equations.

Voltage Elements

Voltage elements consist of two levels of phase under- (27) and overvoltage (59) elements and two levels of negative- (59Q) and zero-sequence (59N) overvoltage elements, based on one set of three analog voltage quantities. *Table 2* provides a summary of the voltage elements.

Table 2 Voltage Elements

Element	Quantity	Levels
Undervoltage	Phase	Two levels
Overvoltage	Phase, negative-, and zero-sequence	Two levels

Breaker Failure Protection

The SEL-487B includes complete breaker failure protection, including retrip, for each of the 21 terminals. Because some applications require external breaker failure protection, set the SEL-487B to external breaker fail and connect the input from any external breaker failure relay to the SEL-487B; you can set any terminal to either internal or external breaker failure protection.

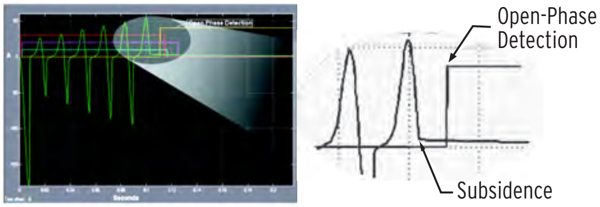


Figure 11 Open-Phase Detection Reduces Breaker Failure Coordination Time

High-speed, open-pole detection logic detects open-pole conditions in less than 0.75 cycle, reducing breaker failure coordination times as in *Figure 11*.

Overcurrent Elements

Choose from 10 time-overcurrent curves (*Table 3*) for each of the 21 current inputs. Each torque-controlled time-overcurrent element has two reset characteristics. One choice resets the elements if current drops below pickup for one cycle, while the other choice emulates the reset characteristic of an electromechanical induction disk relay.

Each terminal also includes instantaneous and definite-time overcurrent elements. These overcurrent elements are summarized in *Table 4*.

Table 3 Time-Overcurrent Curves

US	IEC
Moderately Inverse	Standard Inverse
Inverse	Very Inverse
Very Inverse	Extremely Inverse
Extremely Inverse	Long-Time Inverse
Short-Time Inverse	Short-Time Inverse

Table 4 Overcurrent Elements per Terminal

Element	Quantity	Levels
Instantaneous Overcurrent	Phase	One level
Definite-Time Overcurrent	Phase	One level

Disconnect Status Monitor

Figure 12 shows the disconnect open and close contact relationship. During the open-to-close operation, the 89b contact must open (disconnect is CLOSED) during the transition zone before the main contact arcing starts. The 89a contact must close in this transition zone.

During the close-to-open operation, the 89b contact must close during the transition zone after the main contact arcing is extinguished (disconnect is OPEN), as shown in *Figure 12*. The 89a contact must open in this transition zone.

Table 5 shows the four possible disconnect auxiliary contact combinations and how the relay interprets each combination.

Table 5 Disconnect Status as a Function of the Auxiliary Contacts

89a	89b	Relay 89 Status Interpretation
0	0	closed
0	1	open
1	0	closed
1	1	closed

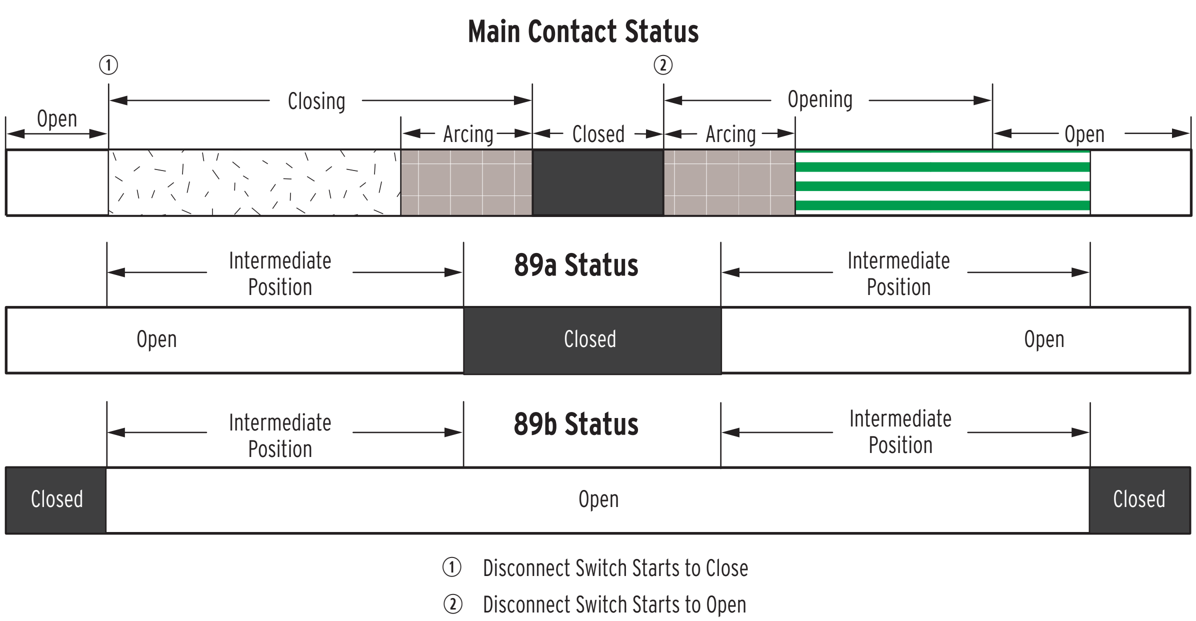


Figure 12 Disconnect Switch Auxiliary Contact Requirements for the Zone Selection Logic; No CT Switching Required

Tie-Breaker Configurations

Figure 13, *Figure 14*, and *Figure 15* show three tie-breaker schemes:

- ➤ Two CTs configured in overlap (*Figure 13*)
- ➤ A single CT with two cores configured in overlap (*Figure 14*)
- ➤ Two CTs configured with a differential element across the breaker (*Figure 15*)

Configure any one of these schemes without using external auxiliary relays. *Figure 13* and *Figure 14* also show the tie breaker closing onto an existing fault, F1. The SEL-487B includes tie-breaker logic to prevent the loss of both zones for this fault.

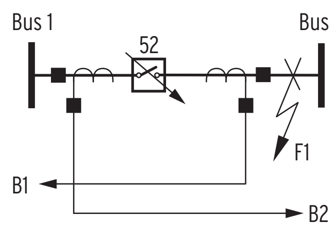


Figure 13 Two CTs Configured in Overlap

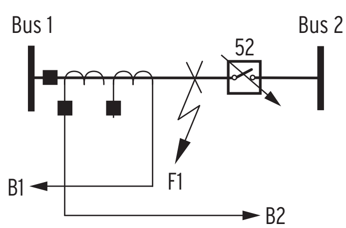


Figure 14 A Single CT With Two CT Cores Configured in Overlap

Configure one of the differential zones as a differential across the tie breaker. This arrangement has the following advantages:

- ➤ Both main zones are secure for a fault between the tie breaker and the CT.
- ➤ Only one main zone is tripped for a fault between the tie breaker and the CT (as opposed to both main zones with an overlapping tie-breaker arrangement).

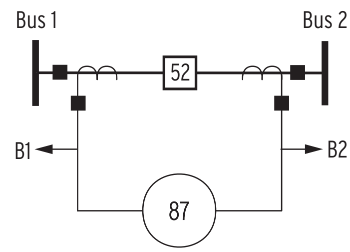


Figure 15 Two CTs Configured With a Differential Element Across the Breaker

Six Independent Settings Groups Increase Operation Flexibility

The relay stores six settings groups. Select the active settings group by control input, command, or other programmable conditions. Use these settings groups to cover a wide range of protection and control contingencies.

Selectable settings groups make the SEL-487B ideal for applications requiring frequent settings changes and for adapting the protection to changing system conditions. Selecting a group also selects logic settings. Program group logic to adjust settings for different operating conditions, such as station maintenance, seasonal operations, and emergency contingencies.

Applications

Figure 16 shows a station with double bus sections and a bus tie breaker. Use a single SEL-487B for this application.

For stations with breaker-and-a-half busbar configuration and seven or fewer connections to either busbar, use an SEL-487B for each busbar, as in *Figure 17*.

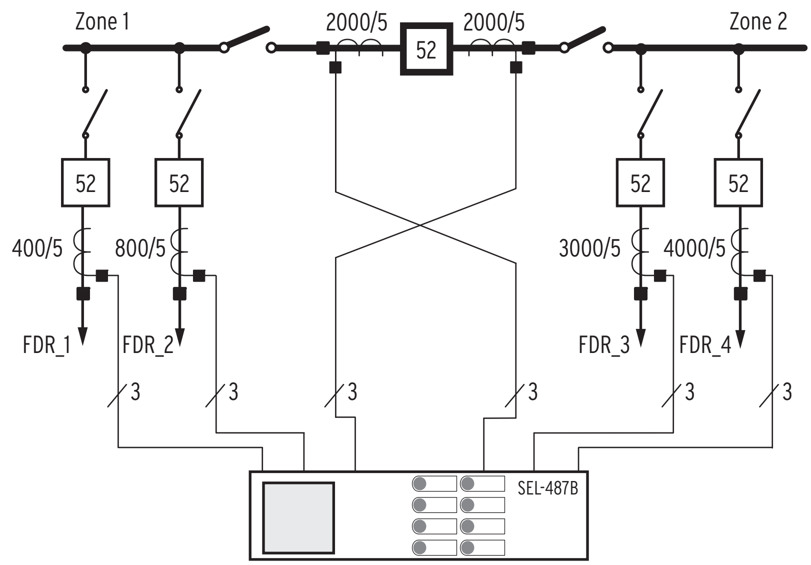


Figure 16 Single SEL-487B Protecting Double Bus Sections With Bus Tie Breaker

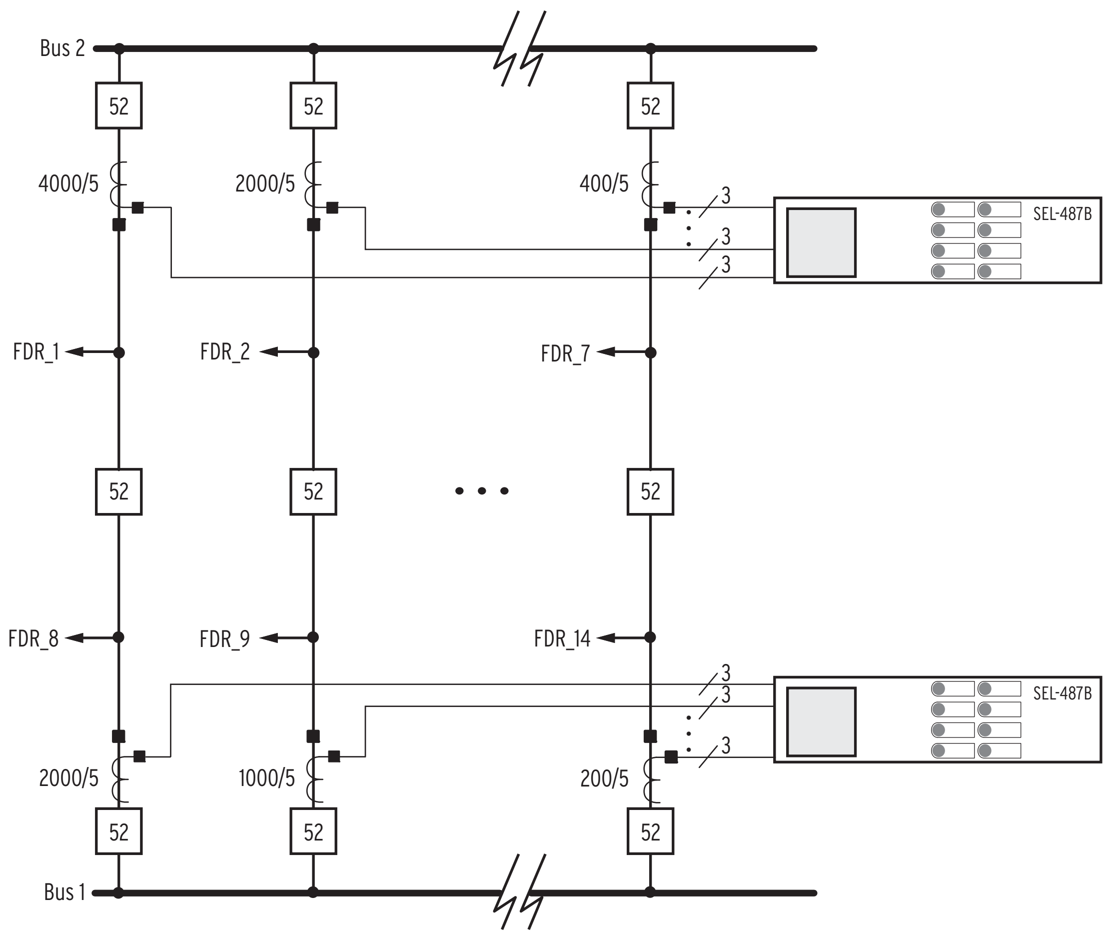


Figure 17 Two Single SEL-487B Relays Protecting the Two Busbars in a Breaker-and-a-Half Busbar Configuration

For stations with 10 to 21 terminals (*Figure 18*), use three separate SEL-487B relays and wire analog current inputs from A-, B-, and C-phases separately into each relay. This way, each of the 21 analog current inputs in each relay measures only one phase, with six dedicated zones of protection available. Each relay operates independently; the only communication among relays is MIRRORED BITS® communication and IRIG-B. In this application, operators have complete flexibility because they can close any disconnect at any time without compromising the busbar protection. This is possible because the relay dynamically computes the station connection replica by using the patented zone-selection algorithm.

Figure 18 shows a busbar layout consisting of two main busbars and a transfer bus, one busbar coupler, and 20 terminals.

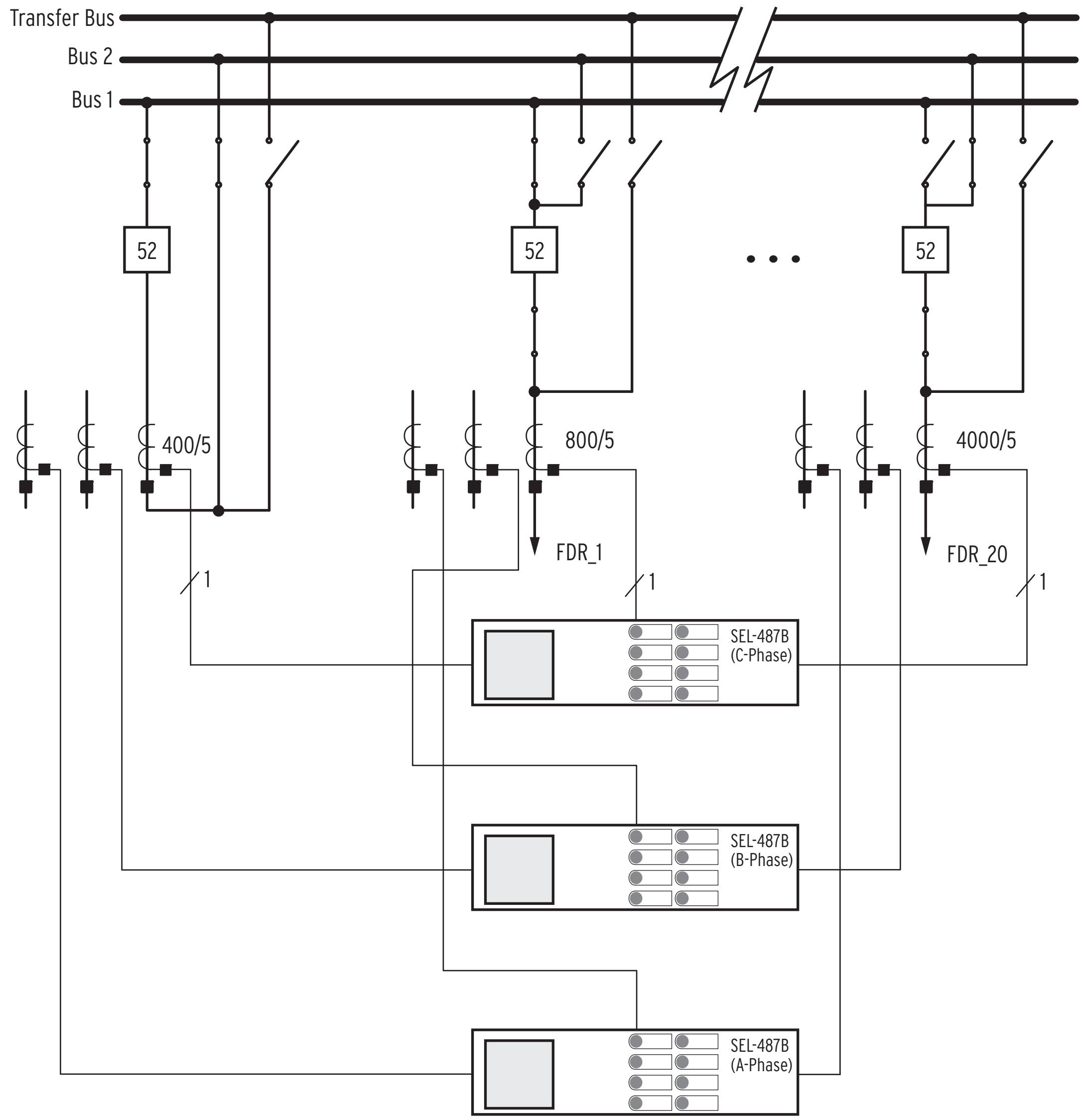


Figure 18 Three SEL-487B Relays Protect Two Main Busbars and a Transfer Busbar, Bus Coupler, and 20 Terminals

Optimize your SEL-487B by protecting both HV and LV busbars with three relays. *Figure 19* shows two HV busbars and two LV busbars. Use of four zones for the four busbars (two HV and two LV) still leaves two zones available in each relay. We can configure independent check zones for HV and LV bus protection supervision.

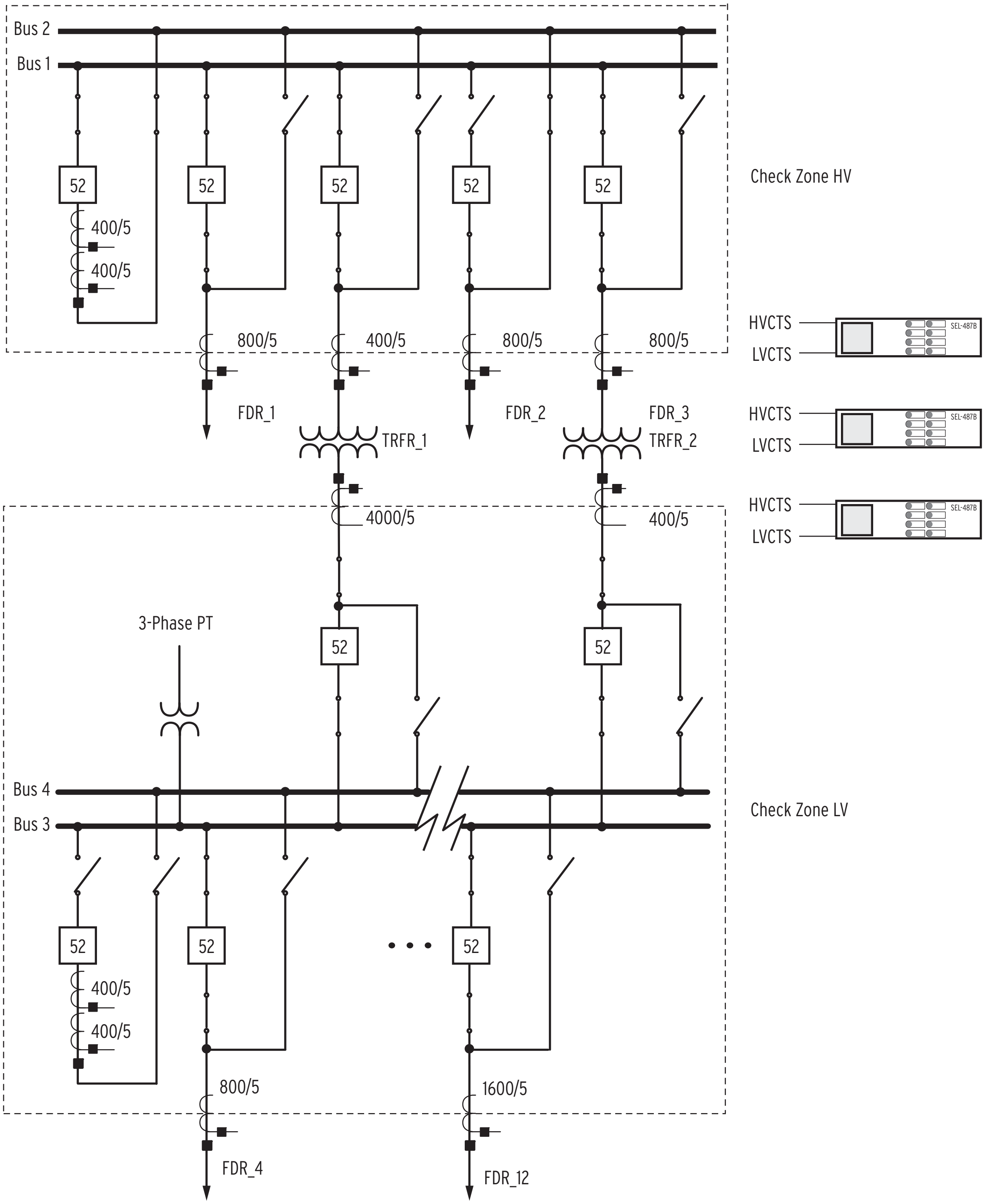


Figure 19 Three SEL-487B Relays Protect Both HV and LV Busbars

Time Synchronization, Automation, and Communication

Time Synchronization

To synchronize the relays in a three-relay application, use the unique **IN** and **OUT** IRIG-B connectors installed on each relay for the IRIG-B signal. Referring to the External Source connections in *Figure 20*, connect the IRIG-B signal to the **IN** connector of Relay A to update the time. Connect the **OUT** connector of Relay A to the IN connector of Relay B to update the time in Relay B. Use a similar connection between Relay B and Relay C to update the time in Relay C. In the absence of an external IRIG-B signal, connect the relays as shown by the Internal Source connections in *Figure 20*. Connected this way, Relay B and Relay C synchronize to the internal clock of Relay A. The event reports the different relays generate are time-stamped to within 10 µs of each other.

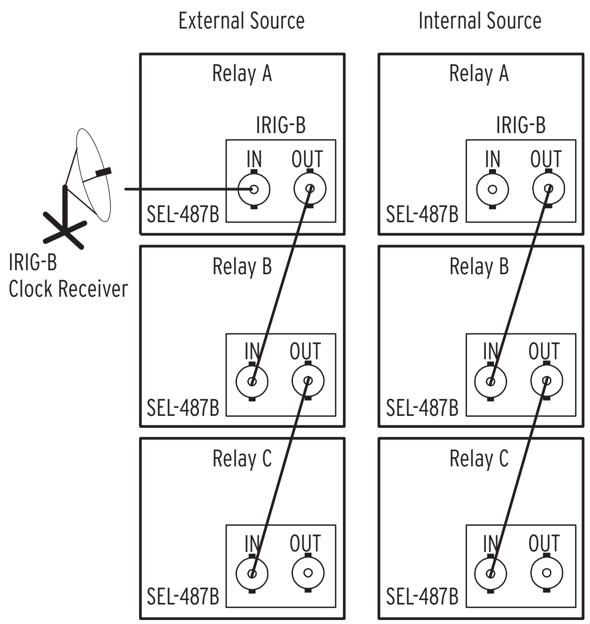


Figure 20 Time Synchronize SEL-487B Relays With or Without External Clock Source

Precision Time Protocol (PTP) Time Synchronization

In addition to IRIG-B, the relay can be time synchronized through the Ethernet network using IEEE 1588 Precision Time Protocol, version 2 (PTPv2). When connected directly to a grandmaster clock providing PTP at 1-second sync intervals, the relay can be synchronized to an accuracy of ±100 ns. The relay is capable of receiving as many as 32 sync messages per second.

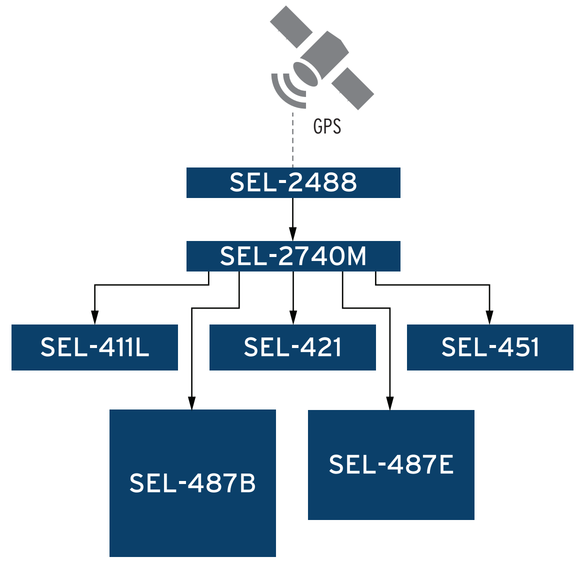


Figure 21 Example PTP Network

SNTP Time Synchronization

Use simple network time protocol (SNTP) to cost-effectively synchronize SEL-487B relays equipped with Ethernet communication to within ±1 ms with no time source delay. Use SNTP as a primary time source, or as a backup to a higher accuracy IRIG-B time input to the relay.

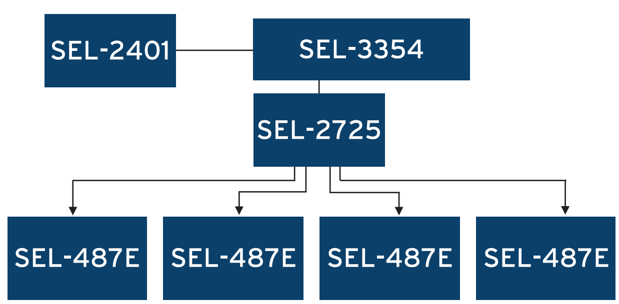


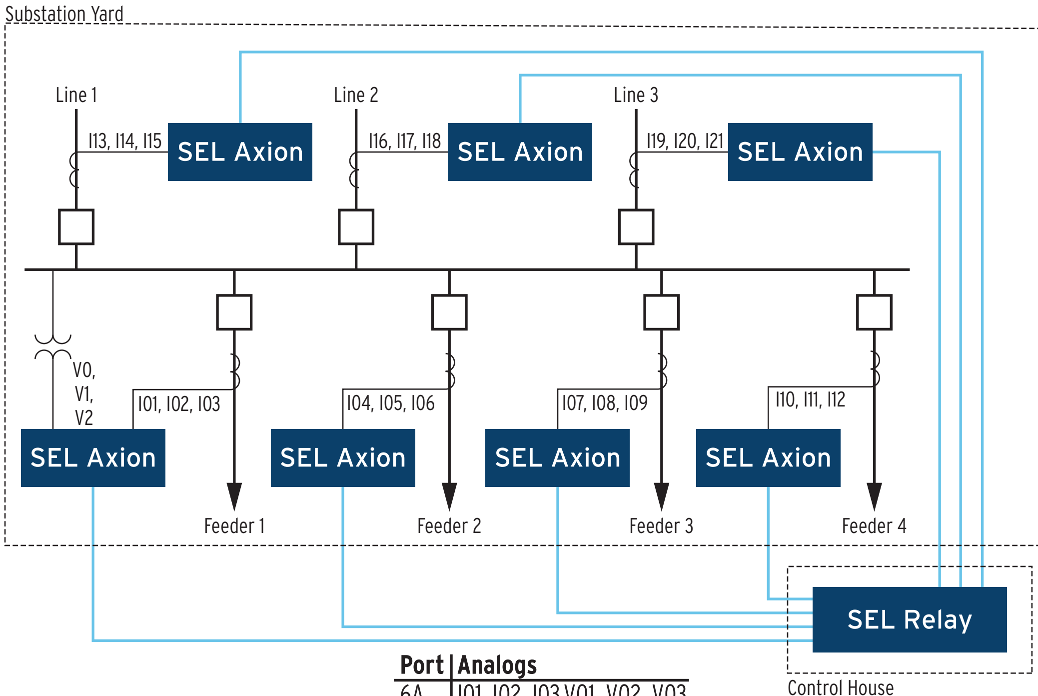
Figure 22 SNTP Diagram

Automation

Time-Domain Link (TiDL) Technology

The SEL-487B supports remote data acquisition through use of an Axion with a technology known as TiDL. The Axion provides remote analog and digital data over an IEC 61158 EtherCAT TiDL network. This technology provides very low and deterministic 1.5 ms latency over a point-to-point architecture. The SEL-487B Relay can receive as many as eight fiber links from as many as eight Axion remote data acquisition nodes.

The relay supports a number of fixed topologies. The relay maps the voltage and current inputs from the Axion to existing analog quantities in the SEL-487B Relay based on the connected topology. This limits the number of settings and makes converting an existing system to TiDL easy. *Figure 23* shows a sample TiDL topology. The SEL-487B Instruction Manual shows all supported topologies.



Port	Analogs
6A	I01, I02, I03,V01, V02, V03
6B	I04, I05, I06
6C	I07, I08, I09
6D	I10, I11, I12 (optional)
6E	I13, I14, I15 (optional)
6F	I16, I17, I18 (optional)
6G	I19, I20, I21 (optional)

Figure 23 Sample Topology

Flexible Control Logic and Integration Features

Use the SEL-487B control logic to replace the following:

- ➤ Traditional panel control switches
- ➤ RTU-to-relay wiring
- ➤ Traditional latching relays
- ➤ Traditional indicating panel lights

Eliminate traditional panel control switches with 32 local control points. Set, clear, or pulse local control points with the front-panel pushbuttons and display. Program the local control points to implement your control scheme via SELOGIC control equations. Use the same local control points for functions such as taking a terminal out of service for testing.

Eliminate RTU-to-relay wiring with 96 remote control points. Set, clear, or pulse remote control points via serial port commands. Incorporate the remote control points into your control scheme via SELOGIC control equations. Use remote control points for SCADA-type control operations (e.g., trip, settings group selection).

Replace traditional latching relays for such functions as remote control enable with 32 latching control points. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the latch control points via control inputs, remote control points, local control points, or any programmable logic condition. The relay retains the states of the latch control points after powering up following a power interruption.

Replace traditional indicating panel lights and switches with either of these HMIs:

- ➤ Standard HMI: 16 latching target LEDs and 8 programmable pushbuttons with LEDs.
- ➤ Expanded HMI option: 24 tricolor latching target LEDs and 12 programmable pushbuttons.

Define custom messages to report analog and Boolean power system or relay conditions on the large format LCD. Control displayed messages via SELOGIC control equations by driving the LCD display via any logic point in the relay. Use any of the dozens of measured or calculated analog values in the relay to create display messages for system metering on the front-panel LCD.

SELOGIC Control Equations With Expanded Capabilities and Aliases

Expanded SELOGIC control equations (*Table 6*) put relay logic in the hands of the protection engineer. Assign the relay inputs to suit your application, logically combine selected relay elements for various control functions, and assign outputs to your logic functions. Programming SELOGIC control equations consists of combining relay elements, inputs, and outputs with SELOGIC control equation operators. You can use any of the relay internal variables (Relay Word bits) in these equations. For complex or unique applications, these expanded SELOGIC control equation functions allow superior flexibility. Add programmable control functions to your protection and automation systems. New functions and capabilities enable you to use analog values in conditional logic statements. Use the new alias capability to assign more meaningful relay variable names. This improves the readability of customized programming. Use as many as 200 aliases to rename any digital or analog quantity. The following is an example of possible applications of SELOGIC control equations using aliases:

=>>**SET T <Enter>**
1: **PMV01,THETA**
(assign the alias "THETA" to math variable PMV01)
2: **PMV02,TAN**
(assign the alias "TAN" to math variable PMV02)
=>>**SET L <Enter>**
1: **# CALCULATE THE TANGENT OF THETA**
2: **TAN:=SIN(THETA)/COS(THETA)**
(use the aliases in an equation)

ACSELERATOR QuickSet SEL-5030 Software

Use the ACSELERATOR QuickSet® SEL-5030 Software to develop settings and busbar configurations offline. The system automatically checks interrelated settings and highlights out-of-range settings. You can transfer settings you create offline by using a PC communications link with the SEL-487B. The relay converts event reports to oscillograms with time-coordinated element assertion and phasor diagrams. The ACSELERATOR QuickSet interface supports Server 2008, Windows® 7 and Windows 8 operating systems, and can be used to open COMTRADE files from SEL and other products. You can also use ACSELERATOR QuickSet to design application-specific settings templates and then store the templates in non-volatile memory within the relay for trouble-free retrieval.

Figure 24 Settings Templates

MIRRORED BITS Communications

The SEL patented MIRRORED BITS technology provides bidirectional relay-to-relay digital communication. *Figure 25* shows two SEL-487B relays with MIRRORED BITS communications using SEL-2815 Fiber-Optic Transceivers. In the SEL-487B, MIRRORED BITS communications can operate simultaneously on any two serial ports. This bidirectional digital communication creates additional outputs (transmitted MIRRORED BITS) and additional inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS communications mode.

Communicated information can include digital, analog, and virtual terminal data. Virtual terminal allows operator access to remote relays through the local relay. You can use this MIRRORED BITS protocol to transfer information between stations to enhance coordination and achieve faster tripping.

Table 6 Expanded SELOGIC Control Equation Operators (Sheet 1 of 2)

Operator Type	Operators	Comments
Edge Trigger	R_TRIG, F_TRIG	Operates at the change of state of an internal function.
Math Functions	SQRT, LN, EXP, COS, SIN, ABS, ACOS, ASIN, CEIL, FLOOR, LOG	Combine these to calculate other trigonometric functions, i.e., TAN: = SIN(THETA)/COS(THETA).
Arithmetic	*, /, +, -	Uses traditional math functions for analog quantities in an easily programmable equation.
Comparison	<, >, <=, >=,=, <>	Compares the values of analog quantities against predefined thresholds or against each other.
Boolean	AND, OR, NOT	Combines variables, and inverts the status of variables.

Table 6 Expanded SELogic Control Equation Operators (Sheet 2 of 2)

Operator Type	Operators	Comments
Precedence Control	( )	Allows up to 14 sets of parentheses.
Comment	#	Provides for easy documentation of control and protection logic.

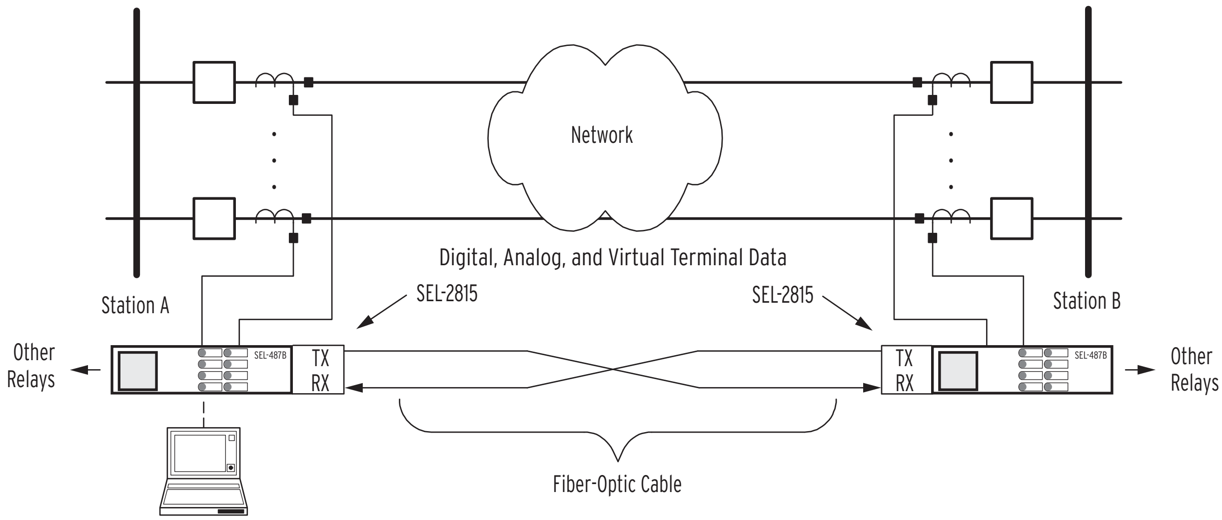


Figure 25 Integral Communication Provides Secure Protection, Monitoring, and Control as Well as Terminal Access to Both Relays Through One Connection

Communications Features

The SEL-487B offers the following communications features:

- Four independent EIA-232 serial ports
- Full access to event history, relay status, and meter information from the communications ports
- Settings and group switching password control
- SCADA interface capability including FTP, IEC 61850, and DNP3 LAN/WAN (via optional internally mounted Ethernet card), and DNP3 Level 2 Slave (via serial port)

The relay does not require special communications software. You need only ASCII terminals, printing terminals, or a computer supplied with terminal emulation and a serial communications port. *Table 7* provides a synopsis of the communications protocols in the SEL-487B.

Ethernet Card

The SEL-487B provides Ethernet communications capabilities with the optional Ethernet card. This card mounts directly in the relay. Use Telnet applications for easy terminal communication with SEL relays and other devices. Transfer data at high speeds (10 Mbps or 100 Mbps) for fast file uploads. The Ethernet card communicates using FTP applications for easy and fast file transfers. Choose Ethernet connection media options for primary and stand-by connections:

- 10/100BASE-T Twisted Pair Network
- 100BASE-FX Fiber-Optic Network

Communicate using IEC 61850 Logical Nodes and GOOSE Messages, or DNP3 LAN/WAN.

Telnet and FTP

Order the SEL-487B with Ethernet communications and use the built-in Telnet and File Transfer Protocol (FTP) that come standard with Ethernet to enhance relay communications sessions. Use Telnet with the ASCII interface to access relay settings, and metering and event reports remotely. Use FTP to transfer settings files to and from the relay via the high-speed Ethernet port.

DNP3 LAN/WAN

The DNP3 LAN/WAN option provides the SEL-487B with DNP3 Level 2 slave functionality over Ethernet. You can configure custom DNP3 data maps for use with specific DNP3 masters.

Precision Time Protocol (PTP)

An Ethernet card option with Ports 5A and 5B populated provides the ability to accept IEEE 1588 Precision Time Protocol, version 2 (PTPv2) for data time synchronization. Optional PTP support includes both the Default and Power System (C37.238-2011) PTP Profiles.

Parallel Redundancy Protocol (PRP)

This protocol is used to provide seamless recovery from any single Ethernet network failure, in accordance with IEC 62439-3. The Ethernet network and all traffic are fully duplicated with both copies operating in parallel.

HTTP Web Server

When equipped with Ethernet communications, the relay can serve read-only web pages displaying certain settings, metering, and status reports. As many as four users can access the embedded HTTP server simultaneously.

IEC 61850 Ethernet Communications

IEC 61850 Ethernet-based communications provide interoperability among intelligent devices within the substation. Logical nodes using IEC 61850 allow standardized interconnection of intelligent devices from different manufacturers for monitoring and control of the substation. Reduce wiring among various manufacturers' devices and simplify operating logic with IEC 61850.

Eliminate system RTUs by streaming monitoring and control information from the intelligent devices directly to remote SCADA client devices.

You can order the SEL-487B with embedded IEC 61850 protocol operating on 10/100 Mbps Ethernet. EC 61850 Ethernet protocol provides relay monitoring and control functions including:

- ➤ As many as 128 incoming GOOSE messages. The incoming GOOSE messages can be used to control up to 256 control bits in the relay with <3 ms latency from device to device. These messages provide binary control inputs and analog values to the relay for high-speed control functions and monitoring.
- ➤ As many as eight outgoing GOOSE messages. You can configure outgoing GOOSE messages for Boolean or analog data. Boolean data and designated remote analog outputs are provided with <3 ms latency from device to device. Apply outgoing GOOSE messages for high-speed control and monitoring of external breakers, switches, and other devices.
- ➤ IEC 61850 Data Server. The SEL-487B, equipped with embedded IEC 61850 Ethernet protocol, provides data according to predefined logical node objects. Each relay supports as many as seven simultaneous client associations. Relevant Relay Word bits are available within the logical node data, so you can use the IEC 61850 data server in the relay to monitor the status of relay elements, inputs, outputs, or SELOGIC control equations.
- ➤ Configuration of up to 256 Virtual Bits within GOOSE messaging to represent a variety of Boolean values available within the relay. The Virtual Bits the relay receives are available for use in SELOGIC control equations.
- ➤ As many as 64 Remote analog outputs that you can assign to virtually any analog quantity available in the relay. You can also use SELOGIC math variables to develop custom analog quantities for assignment as remote analog outputs. Remote analog outputs using IEC 61850 provide peer-to-peer transmission of analog data. Each relay can receive up to 256 remote analog inputs and use those inputs as analog quantities within SELOGIC control equations.

MMS File Services

This service of IEC 61850 MMS provides support for file transfers completely within an MMS session. All relay files that can be transferred via FTP can also be transferred via MMS file services.

MMS Authentication

When enabled via a setting in the CID file, the relay will require authentication from any client requesting to initiate an MMS session. The client request must be accompanied by the 2AC level password.

ACSELERATOR Architect

USE ACSELERATOR Architect® SEL-5032 Software to manage the logical node data for all IEC 68150 devices on the network. This Microsoft® Windows®-based software provides easy-to-use displays for identifying and binding IEC 61850 network data among logical nodes using IEC 61850-compliant Configured IED Description (CID) files. ACSELERATOR Architect uses CID files to describe the data the IEC 61850 logical node will provide within each relay.

Table 7 Open Communications Protocol (Sheet 1 of 2)

Type	Description
ASCII	Plain-language commands for human and simple machine communication. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports allow external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.

Table 7 Open Communications Protocol (Sheet 2 of 2)

Type	Description
Extended SEL Fast Meter, SEL Fast Operate, and SEL Fast SER	Binary protocol for machine-to-machine communication. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected.
Ymodem	Support for reading event, settings, and oscillography files.
Optional DNP3 Level 2 Slave	Distributed Network Protocol with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and settings groups.
MIRRORED BITS	SEL protocol for exchanging digital and analog information among SEL relays and for use as low-speed terminal connection.
Optional FTP and Telnet	Available with the optional Ethernet card. Use Telnet to establish a terminal-to-relay connection over Ethernet. Use FTP to move files in and out of the relay over Ethernet.
IEC 61850	Ethernet-based international standard for interoperability among intelligent devices in a substation.
SNTP	Ethernet-based simple network time protocol for Ethernet-based time synchronization among relays.

Additional Features

Front-Panel Display

Figure 26 and *Figure 27* show close-up views of the standard SEL-487B front panel. The standard front panel includes a 128 x 128 pixel (76.2 mm x 76.2 mm or 3 in x 3 in) LCD screen; 18 LED target indicators; and eight direct-action control pushbuttons with indicating LEDs for local control functions. You can use easily changed slide-in labels to custom configure target and pushbutton identification. *Figure 28* shows the expanded SEL-487B front panel. The optional expanded SEL-487B front panel provides the same LCD screen with more latching target LEDs and programmable pushbuttons. When you order the optional front panel, the SEL-487B provides 24 tricolor LEDs and 12 programmable pushbuttons with indicating LEDs. Use the capabilities of the expanded SEL-487B front panel to integrate a wide range of control and system annunciation functions.

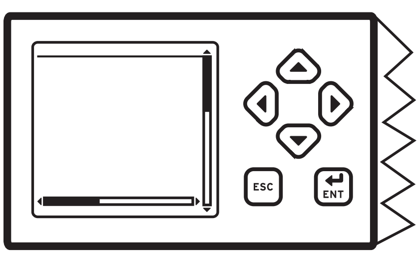


Figure 26 Front-Panel Display and Pushbuttons

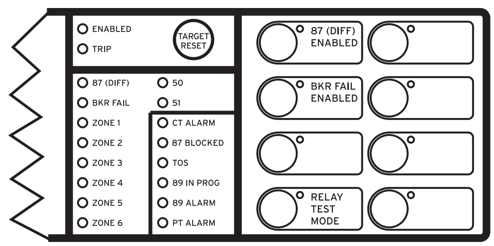


Figure 27 Standard Front-Panel Configurable Labels, Programmable Targets and Controls for Customized Applications

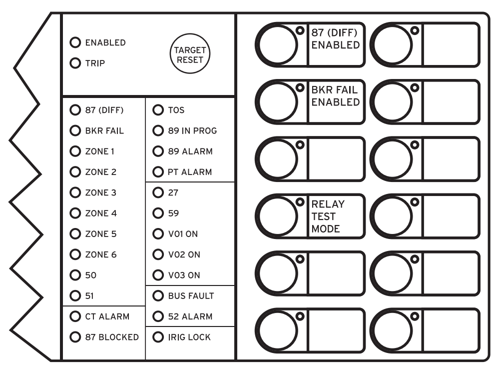


Figure 28 Optional Front Panel With 24 Tricolor Target LEDs and 12 Pushbuttons

The LCD shows event, metering, setting, and relay self-test status information. Control the LCD through the navigation pushbuttons (*Figure 26*), automatic messages the relay generates, and user-programmable display points. The rotating display scrolls through any active, nonblank display points. If none are active, the relay scrolls through displays of the differential operating and restraint quantities, the terminals in each enabled zone, and the primary current and voltage values. Each display remains for five seconds before the display continues scrolling. Any message the relay generates because of an alarm condition takes precedence over the rotating display.

Status and Trip Target LEDs

The SEL-487B standard front panel includes 16 programmable status and trip target LEDs as well as eight programmable direct-action control pushbuttons on the front panel. The optional SEL-487B expanded front panel provides 24 programmable tricolor LED indicators and 12 direct action control pushbuttons. These targets are shown in *Figure 27* and *Figure 28* and explained in *Table 8*.

Table 8 Description of Factory Default Target LEDs

Target LED	Function
87 (DIFF)	Differential element trip
BKR FAIL	Breaker failure protection trip
ZONE 1	Fault was in Zone 1
ZONE 2	Fault was in Zone 2
ZONE 3	Fault was in Zone 3
ZONE 4	Fault was in Zone 4
ZONE 5	Fault was in Zone 5
Standard Front-Panel LED Functions	
ZONE 6	Fault was in Zone 6
50	Instantaneous overcurrent element trip
51	Time-overcurrent element trip
CT ALARM	Current transformer alarm
87 BLOCKED	Differential element blocked
TOS	Any terminal out of service
89 IN PROG	Disconnect operation in progress
89 ALARM	Disconnect failed to complete operation
PT ALARM	Potential transformer alarm
Expanded Front-Panel LED Functions	
27	Phase Undervoltage
59	Phase Overvoltage
V01 ON	Phase Voltage V01 Present
V02 ON	Phase Voltage V02 Present
V03 ON	Phase Voltage V03 Present
BUS FAULT	Any Bus Zone Internal Fault
52 ALARM	Any System Breaker Failure Alarm
IRIG LOCK	IRIG Clock Input Lock

Configurable Front-Panel Labels

Customize the SEL-487B front panel to fit your needs. Use SELOGIC control equations and slide-in configurable front-panel labels to change the function and identification of target LEDs, operator control pushbuttons, and pushbutton LEDs. The blank slide-in label set is included with the SEL-487B. Functions are simple to configure using ACSELERATOR QuickSet.

You can use templates supplied with the relay or handwritten on blank labels supplied with the relay to print labels.

Control Inputs and Outputs

The basic SEL-487B (main board only) includes five independent and two common inputs, and two standard Form A, three high-current interrupting Form A, and three Form C standard outputs, as in *Figure 29*.

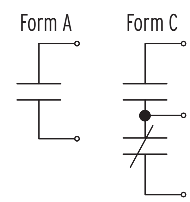


Figure 29 Form A and Form C Output Contacts

Add as many as four interface boards with the following additional input/output (I/O) per interface board:

- ➤ six independent inputs
- ➤ eighteen common inputs (in two groups of nine)
- ➤ six high-speed, high-interrupting Form A outputs
- ➤ two standard Form A output contacts

The relay is available in either 9U or 7U chassis heights. The 9U chassis supports as many as four INT4 interface boards, while the 7U chassis option supports as many as two INT4 interface boards. Assign the control inputs for disconnect auxiliary contact status and breaker auxiliary contact status. Set the input debounce time independently for each input or as a group. You can use SELOGIC control equations to program each control output.

Monitoring and Metering

Access a range of useful information in the relay with the metering function. Metered quantities include fundamental primary and secondary current and voltage magnitudes and angles for each terminal. Secondary quantities also include the PT ratio and CT ratio of each terminal. Zone information displays primary current and voltage magnitudes and angles for each terminal and also includes the polarity of each CT and the bus-zones in each of the protective zones at the station. The same information is available in secondary quantities and includes both the CT ratio and polarity. Differential metering shows the operating and restraint currents, as well as the reference current, for each zone.

Table 9 Flexible Metering Capabilities and Large Screen Display Eliminate Need for Panel Instruments

Capabilities	Description
V01, V02, V03	Fundamental phase voltage magnitude and angle in primary and secondary values
I01, I02, . . ., I21	Fundamental phase current magnitude and angle in primary and secondary values
IOP, IRT, IREF	Operating and restraint currents for each zone, check zone, and the reference current
Bus Zones in Protection Zone *n*	Names of the bus-zones in Protection Zone *n* (where *n* = 1 to 6)
PTR, CTR	PT ratio and CT ratio for each terminal
POL	Polarity of each CT

Event Reporting and Sequential Events Recorder (SER)

Event Reports and Sequential Events Recorder features simplify post-fault analysis and help improve your understanding of both simple and complex protective scheme operations. These features also aid in testing and troubleshooting relay settings and protection schemes.

Oscillography and Event Reporting

In response to a user-selected internal or external trigger, the voltage, current, and element status information contained in each event report confirms relay, scheme, and system performance for every fault. The SEL-487B provides sampling rates as fast as 8 kHz for analog quantities in a COMTRADE file format. It also provides 12 sample-per cycle and 4 sample-per-cycle event reports that sample filtered analog quantities. The relay stores in nonvolatile memory as much as 5 seconds of 8 kHz event data and as much as 24 seconds of 1 kHz event data. Relay settings operational in the relay at the time of the event display at the end of each filtered event report.

Use event report settings in the relay to assign up to 20 analog quantities for inclusion in the filtered event reports. Use relay-calculated values such as check zone operate and restraint current, or use SELOGIC automation or protection math variables.

Each SEL-487B provides event reports for analysis with software such as the ACSELERATOR Analytic Assistant® SEL-5601 Software. With ACSELERATOR Analytic Assistant, you can display events within the same time-stamp range from as many as three different relays in one window to make fault analysis easier and more meaningful. Because different relays time-stamp events with values from their individual clocks, be sure to time synchronize the SEL-487B with an IRIG-B clock input before using this feature (see *Figure 20*). *Figure 30* shows the SEL-5601 software screen with three events selected.

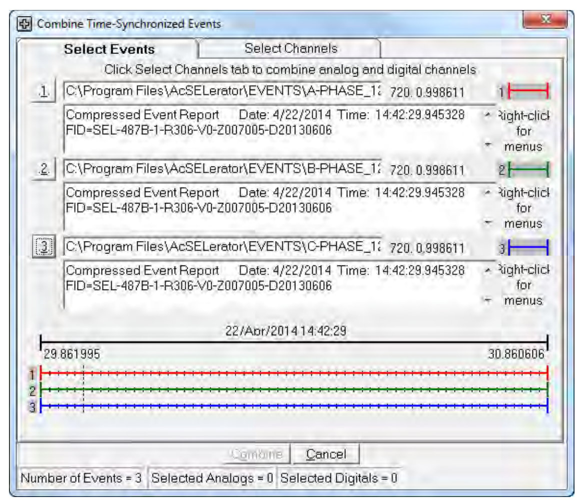


Figure 30 Software Screen After Reading an Event From Three Different Relays

Select from each event the information of interest, and combine this selection into a single window. *Figure 31* shows the combination of the tie-breaker A-phase current (Relay 1), B-phase current (Relay 2), and C-phase current (Relay 3) in one window.

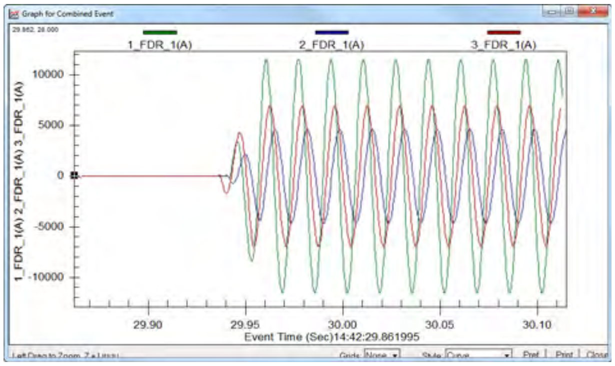


Figure 31 Information From Three Relays Combined Into a Single Window

Event Summary

Each time the relay generates a standard event report, it also generates a corresponding Event Summary. This is a concise description of an event that includes the following information:

- ➤ Relay/terminal identification
- ➤ Event date and time
- ➤ Event type
- ➤ Event number
- ➤ Time source
- ➤ Active settings group
- ➤ Targets asserted during the fault
- ➤ Current magnitudes and angles for each terminal
- ➤ Voltage magnitudes and angles
- ➤ Terminals tripped for this fault
- ➤ Bus-zones in Protection Zone *n* (*n* = 1–6)

With an appropriate setting, the relay will send an Event Summary in ASCII text automatically to one or more serial ports for each triggering of an event report.

Sequential Events Recorder (SER)

Use this feature to gain a broad perspective of relay element operation. Items that trigger an SER entry are selectable and can include as many as 250 monitoring points such as input/output change of state and element pickup/dropout. The relay SER stores the latest 1000 events.

Substation Battery Monitor for DC Quality Assurance

The SEL-487B measures and reports the substation battery voltage for one battery system. The relay provides alarm, control, and dual ground detection for one battery and charger. The battery monitor includes warning and alarm thresholds that you can monitor with the SEL-3530 Real-Time Automation Controller (RTAC) and use to trigger messages, telephone calls, or other actions. The relay reports measured dc voltage in the `METER` display via serial or Ethernet port communications, on the LCD, and in the Event Report. Use the event report data to see an oscillographic display of the battery voltage. Monitor the substation battery voltage drops during trip, close, and other control operations.

Front- and Rear-Panel Diagrams

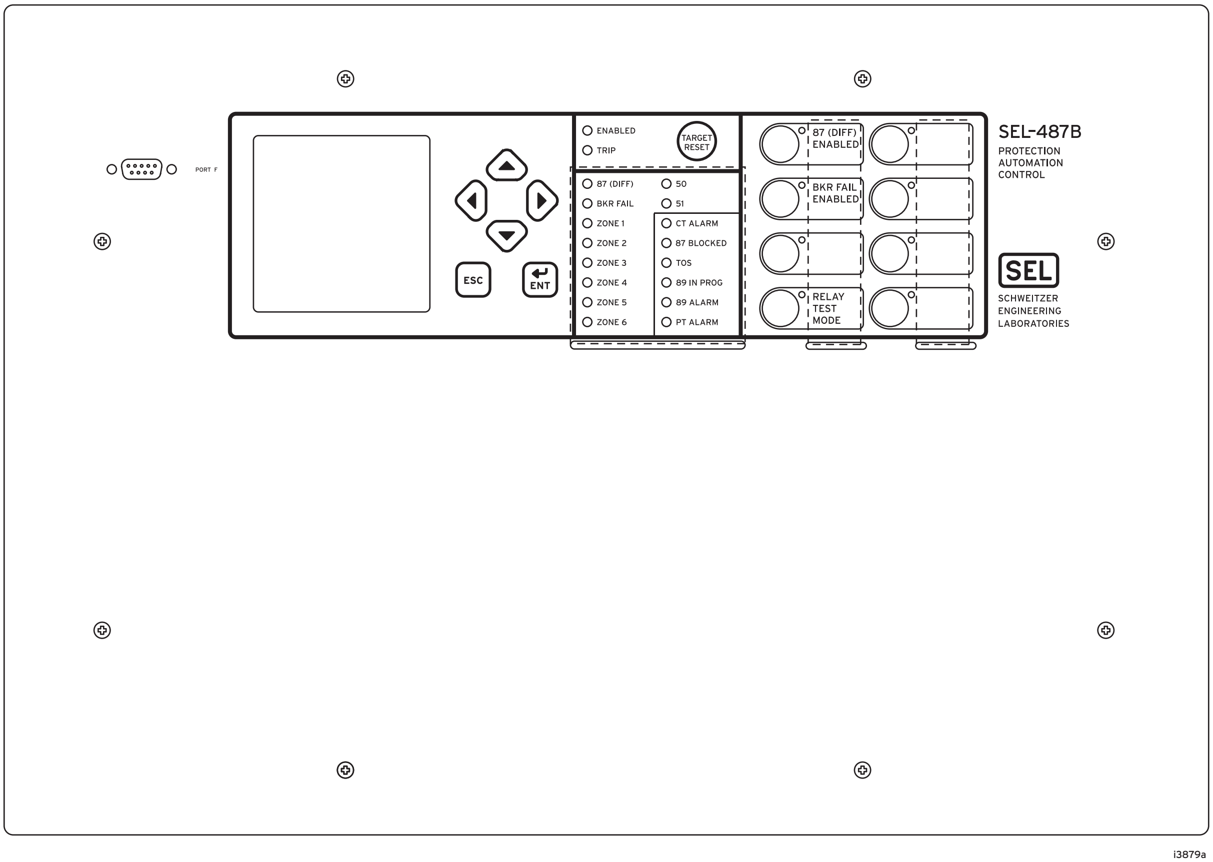


Figure 32 Standard Front-Panel Diagram, 9U Chassis Size, Panel-Mount Option, Showing the Front Panel With LCD, Navigation Pushbuttons, 16 Target LEDs, Reset, and Eight Programmable Pushbuttons

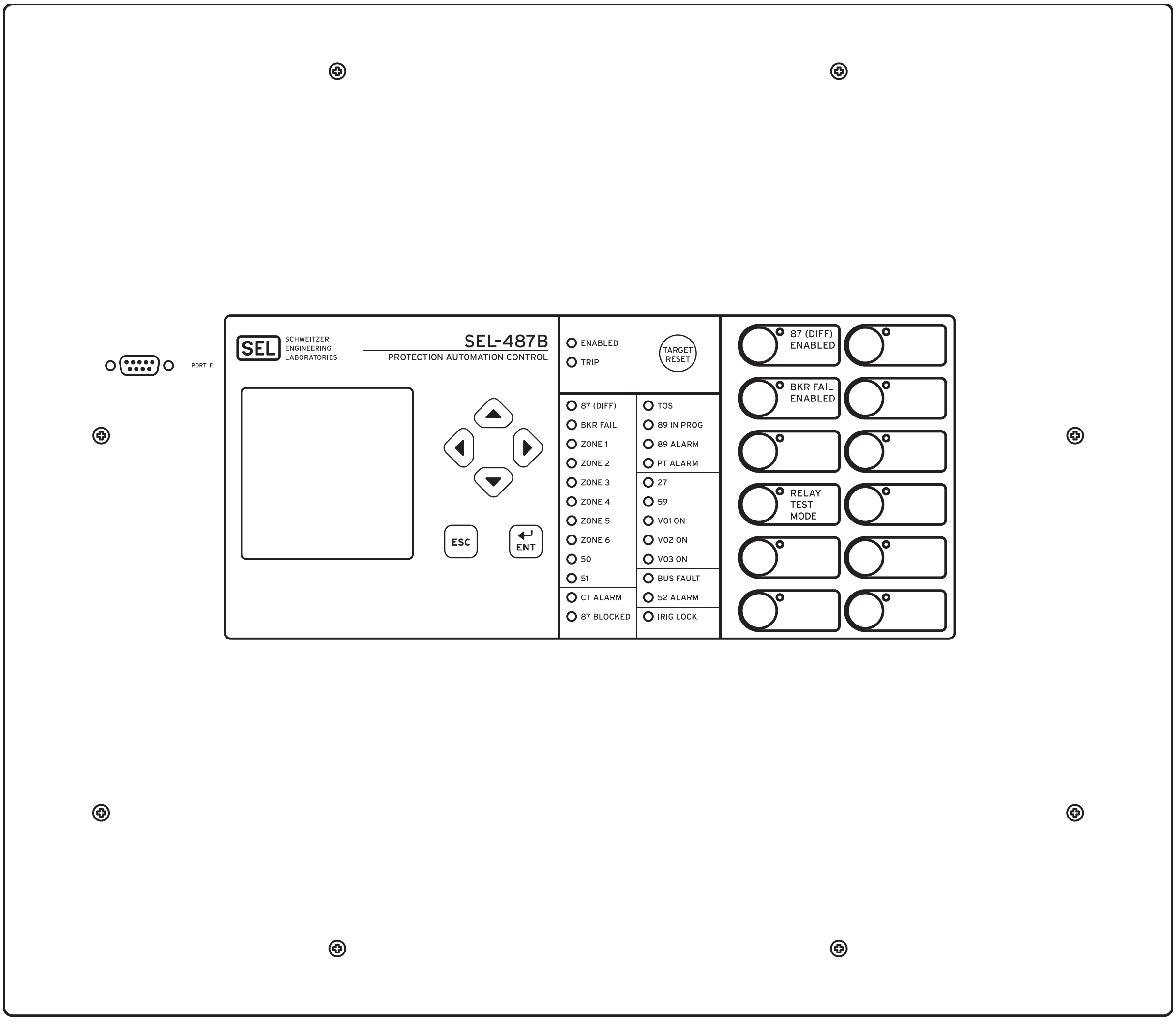


Figure 33 Expanded Front-Panel Diagram, 9U Chassis Size, Panel-Mount Option, Showing Extended Front-Panel HMI With LCD, Navigation Pushbuttons, 24 Tricolor LEDs, Reset, and 12 Programmable Pushbuttons

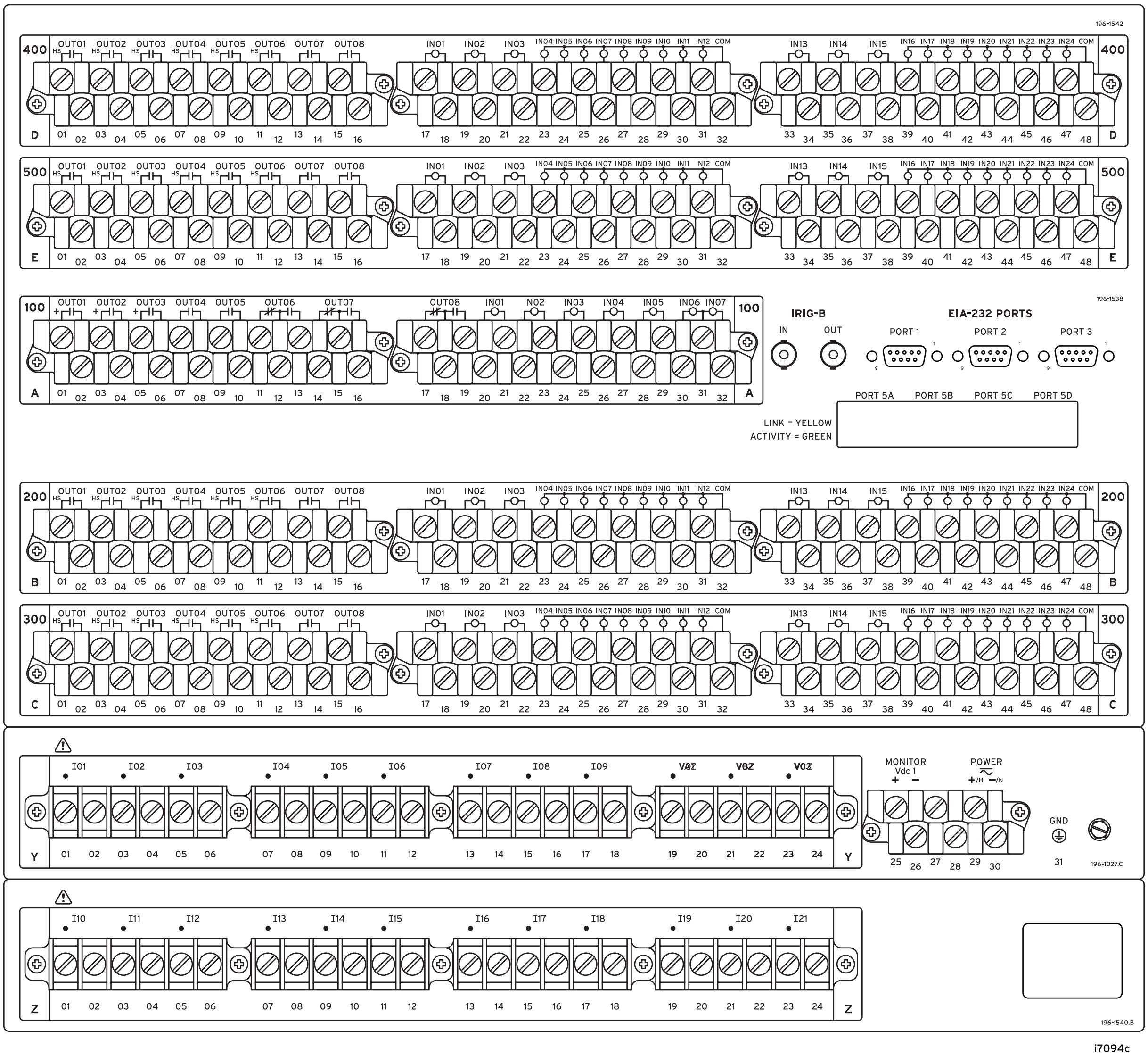


Figure 34 Rear-Panel Diagram of the 9U Chassis With Four INT4 Interface Boards

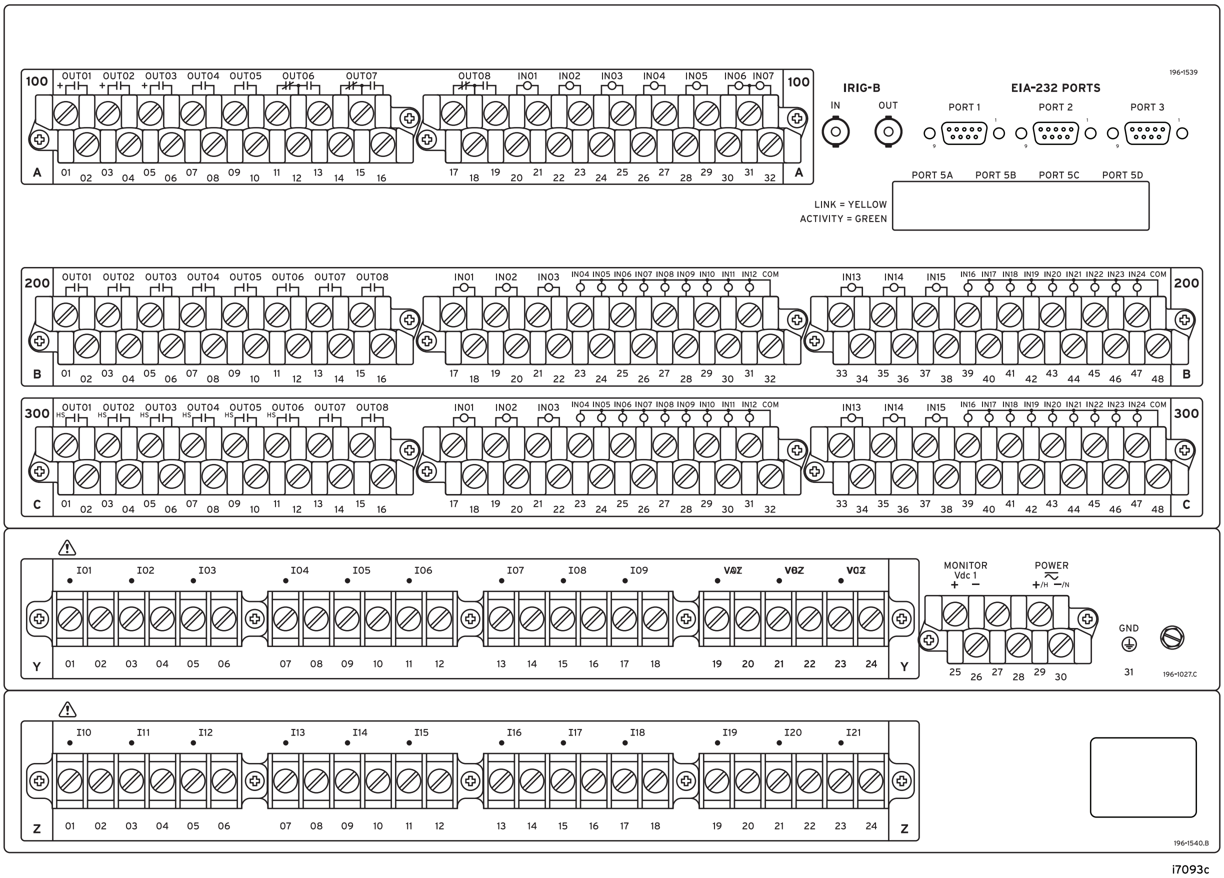


Figure 35 Rear-Panel Diagram of the 7U Chassis With Two INT4 Interface Boards

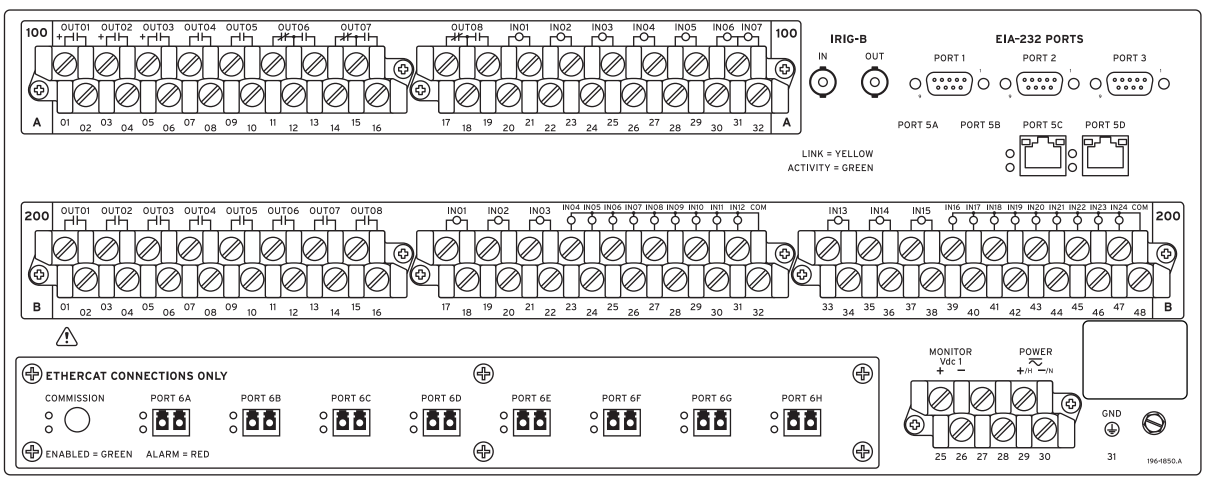
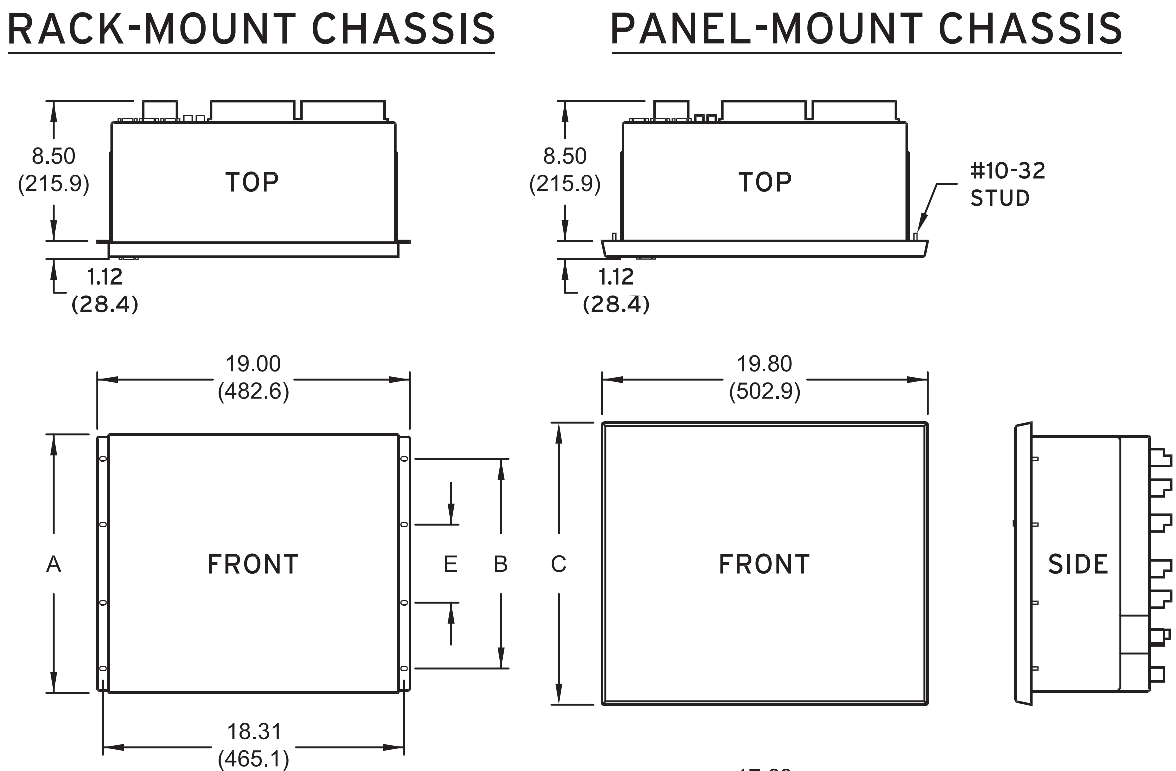


Figure 36 Rear Panel With EtherCAT Board

Relay Dimensions



DIMENSION	TiDL (4U)	TWO I/O BOARD (7U)	FOUR I/O BOARD (9U)
A	6.97 (177.0)	12.22 (310.4)	15.72 (399.3)
B	4.00 (101.6)	9.25 (235.0)	12.75 (323.9)
C	8.40 (213.4)	13.65 (346.7)	17.15 (435.6)
D	6.85 (174.0)	12.10 (307.3)	15.60 (396.2)
E	N/A	2.25 (57.2)	4.75 (120.6)

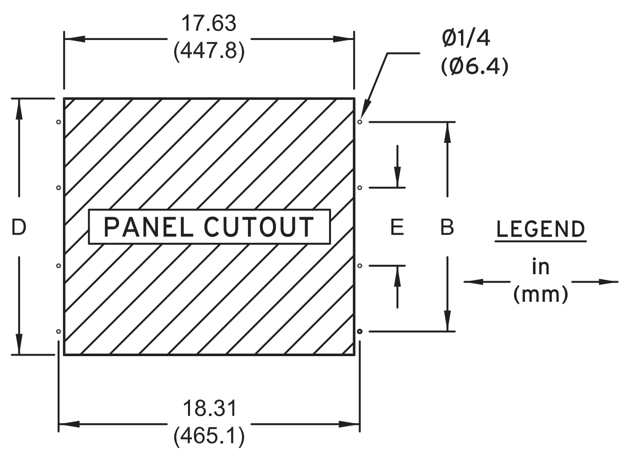


Figure 37 Dimensions for Rack- and Panel-Mount Models

Specifications

Note: If the relay is using a remote data acquisition system such as TiDL, the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay. Element operate times will also have this small added delay.

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

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

UL Listed to U.S. and Canadian safety standards (File E212775; NRGU, NRGU7)

CE Mark

General

AC Current Inputs (Secondary Circuits)

Note: Current transformers are Measurement Category II.

Current Rating (With DC Offset at X/R = 10, 1.5 cycles)

1 A Nominal:	18.2 A
5 A Nominal:	91 A

Continuous Thermal Rating

1 A Nominal:	3 A 4 A (+55°C)
5 A Nominal:	15 A 20 A (+55°C)

Saturation Current (Linear) Rating

1 A Nominal:	20 A
5 A Nominal:	100 A

A/D Current Limit (Peak)

Note: Signal clipping may occur beyond this limit.

1 A Nominal:	49.5 A
5 A Nominal:	247.5 A

One-Second Thermal Rating

1 A Nominal:	100 A
5 A Nominal:	500 A

One-Cycle Thermal Rating (Peak)

1 A Nominal:	250 A
5 A Nominal:	1250 A

Burden Rating

1 A Nominal:	≤0.1 VA @ 1 A
5 A Nominal:	≤0.5 VA @ 5 A

AC Voltage Inputs

Rated Voltage Range:	0–300 V_{LN}
Ten-Second Thermal Rating:	600 Vac
Burden:	≤0.1 VA @ 125 V

Frequency and Rotation

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

Power Supply

24–48 Vdc

Rated Voltage:	24–48 Vdc
Operational Voltage Range:	18–60 Vdc
Vdc Input Ripple:	15% per IEC 60255-26:2013
Interruption:	20 ms at 24 Vdc, 100 ms at 48 Vdc per IEC 60255-26:2013
Burden:	<35 W

48–125 Vdc or 110–120 Vac

Rated Voltage:	48–125 Vdc, 110–120 Vac
Operational Voltage Range:	38–140 Vdc 85–140 Vac
Rated Frequency:	50/60 Hz
Operational Frequency Range:	30–120 Hz
Vdc Input Ripple:	15% per IEC 60255-26:2013
Interruption:	14 ms at 48 Vdc, 160 ms at 125 Vdc per IEC 60255-26:2013
Burden:	<35 W, <90 VA

125–250 Vdc or 110–240 Vac

Rated Voltage:	125–250 Vdc, 110–240 Vac
Operational Voltage Range:	85–300 Vdc 85–264 Vac
Rated Frequency:	50/60 Hz
Operational Frequency Range:	30–120 Hz
Vdc Input Ripple:	15% per IEC 60255-26:2013
Interruption:	46 ms at 125 Vdc, 250 ms at 250 Vdc per IEC 60255-26:2013
Burden:	<35 W, <90 VA

Control Outputs

Standard

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection (maximum voltage):	250 Vac, 330 Vdc
Pickup/Dropout Time:	≤6 ms, resistive load
Update Rate:	1/12 cycle

Break Capacity (10000 operations):

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

Cyclic Capacity (2.5 cycle/second):

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

Hybrid (High-Current Interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection (maximum voltage):	330 Vdc

Pickup/Dropout Time: ≤6 ms, resistive load

Break Capacity (10000 operations):

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

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

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

Note: Do not use hybrid control outputs to switch ac control signals. These outputs are polarity dependent.

High-Speed, High-Current Interrupting

Make: 30 A

Carry: 6 A continuous carry at 70°C
4 A continuous carry at 85°C

1 s Rating: 50 A

MOV Protection (maximum voltage): 250 Vac, 330 Vdc

Pickup Time: ≤10 µs, resistive load

Dropout Time: ≤8 ms, resistive load

Update Rate: 1/12 cycle

Break Capacity (10000 operations):

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

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

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

Note: Per IEC 60255-23:1994, using the simplified method of assessment.

Note: Make rating per IEEE C37.90-2005

Note: Per IEC 61810-2:2005.

Control Inputs

Main Board: 5 inputs with no shared terminals
2 inputs with shared terminals

INT4 Interface Board: 6 inputs with no shared terminals
18 inputs with shared terminals (2 groups of 9 inputs, with each group sharing one terminal)

Voltage Options: 24, 48, 110, 125, 220, 250 V

DC Thresholds (Dropout thresholds indicate level-sensitive option)

24 Vdc: Pickup 19.2–30.0 Vdc

48 Vdc: Pickup 38.4–60.0 Vdc; Dropout < 28.8 Vdc

110 Vdc: Pickup 88.0–132.0 Vdc; Dropout < 66.0 Vdc

125 Vdc: Pickup 105–150 Vdc; Dropout < 75 Vdc

220 Vdc: Pickup 176–264 Vdc; Dropout < 132 Vdc

250 Vdc: Pickup 200–300 Vdc; Dropout < 150 Vdc

AC Thresholds (Ratings met only when recommended control input settings are used—see *Table 2.1*)

24 Vac: Pickup 16.4–30.0 Vac

48 Vac: Pickup 32.8–60.0 Vac; Dropout < 20.3 Vac

110 Vac: Pickup 75.1–132.0 Vac; Dropout < 46.6 Vac

125 Vac: Pickup 89.6–150.0 Vac; Dropout < 53.0 Vac

220 Vac: Pickup 150.3–264 Vac; Dropout <93.2 Vac

250 Vac: Pickup 170.6–300 Vac; Dropout <106 Vac

Current Drawn: <5 mA at nominal voltage
<8 mA for 110 V option

Sampling Rate: 2 kHz

Communications Ports

EIA-232: 1 Front and 3 Rear

Serial Data Speed: 300–57600 bps

Communications Card Slot for Optional Ethernet Card

Ordering Options: 100BASE-FX Fiber-Optic Ethernet

Fiber Type: Multimode

Wavelength: 1300 nm

Source: LED

Connector Type: LC fiber

Min. TX Power: –19 dBm

Max. TX Power: –14 dBm

RX Sensitivity: –32 dBm

Sys. Gain: 13 dB

Communications Ports for Optional TiDL Interface

EtherCAT Fiber-Optic Ports: 8

Data Rate: Automatic

Connector Type: LC fiber

Protocols: Dedicated EtherCAT

Class 1 LASER/LED

Wavelength: 1300 nm

Fiber Type: Multimode

Link Budget: 11 dB

Min. TX Power: –20 dBm

Min. RX Sensitivity: –31 dBm

Fiber Size: 50–200 µm

Approximate Range: 2 km

Data Rate: 100 Mbps

Typical Fiber Attenuation: –2 dB/km

Time Inputs

IRIG-B Input—Serial Port 1

Input: Demodulated IRIG-B

Rated I/O Voltage: 5 Vdc

Operating Voltage Range: 0–8 Vdc

Logic High Threshold: ≤2.8 Vdc

Logic Low Threshold: ≥ 0.8 Vdc

Input Impedance: 2.5 kΩ

IRIG-B Input—BNC Connector

Input: Demodulated IRIG-B

Rated I/O Voltage: 5 Vdc

Operating Voltage Range: 0–8 Vdc

Logic High Threshold: ≤2.2 Vdc

Logic Low Threshold: ≥ 0.8 Vdc

Input Impedance: 50 Ω or > 1 kΩ

Dielectric Test Voltage: 0.5 kVac

PTP—Ethernet Port 5A, 5B

Input: IEEE 1588 PTPv2

Profiles: Default, C37.238-2011 (Power Profile)

Synchronization Accuracy: ±100 ns @ 1-second Sync Intervals when communicating directly with master clock

IRIG Time Output

Capable of driving 300 ohm termination with <200 ns propagation delay

The IRIG time output does not support high-accuracy IRIG-B timekeeping.

Operating Temperature

–40° to +85°C (–40° to +185°F)

Note: LCD contrast impaired for temperatures below –20° and above +70°C.

Humidity

5% to 95% without condensation

Weight (Maximum)

4U Rack Unit (TiDL only): 6.4 kg (14.1 lb)

7U Rack Unit: 16.8 kg (36.9 lb)

9U Rack Unit: 20.8 kg (45.9 lb)

Terminal Connections

Rear Screw-Terminal Tightening Torque, #8 Ring Lug

Minimum: 1.0 Nm (9 in-lb)

Maximum: 2.0 Nm (18 in-lb)

User terminals and stranded copper wire should have a minimum temperature rating of 105°C. Ring terminals are recommended.

Wire Sizes and Insulation

Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes. The grounding conductor should be as short as possible and sized equal to or greater than any other conductor connected to the device, unless otherwise required by local or national wiring regulations.

Connection Type	Min. Wire Size	Max. Wire Size
Grounding (Earthing) Connection	14 AWG (2.5 mm^2)	N/A
Current Connection	16 AWG (1.5 mm^2)	10 AWG (5.3 mm^2)
Potential (Voltage) Connection	18 AWG (0.8 mm^2)	14 AWG (2.5 mm^2)
Contact I/O	18 AWG (0.8 mm^2)	10 AWG (5.3 mm^2)
Other Connection	18 AWG (0.8 mm^2)	10 AWG (5.3 mm^2)

Type Tests

Note: These tests do not apply to optoisolated control inputs rated for 24 V.

Electromagnetic Compatibility (EMC)

Electromagnetic Emissions: IEC 60255-25:2000

Electromagnetic Compatibility Immunity

Conducted RF Immunity: IEC 60255-22-6:2001
Severity Level: 10 V rms
IEC 61000-4-6:2008
Severity Level: 10 V rms

Electrostatic Discharge Immunity: IEC 60255-22-2:2008
Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air
IEC 61000-4-2:2008
Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air
IEEE C37.90.3-2001
Severity Level: 2, 4, 8 kV contact; 4, 8, 15 kV air

Fast Transient/Burst Immunity: IEC 60255-22-4:2008, Class A
Severity Level: 4 kV, 5 kHz; 2 kV 5 kHz on communication ports
IEC 61000-4-4:2011
Severity Level: 4 kV, 5 kHz

Magnetic Field Immunity: IEC 61000-4-8:2009
Severity Level: 900 A/m for 3 s, 100 A/m for 1 min.
IEC 61000-4-9:2001
Severity Level: 1000 A/m

Power Supply Immunity: IEC 60255-11:2008
IEC 61000-4-11:2004
IEC 61000-4-29:2000

Radiated Digital Radio Telephone RF Immunity: ENV 50204:1995
Severity Level: 10 V/m at 900 MHz and 1.89 GHz

Radiated Radio Frequency Immunity: IEC 60255-22-3:2007
Severity Level: 10 V/m
IEC 61000-4-3:2010
Severity Level: 10 V/m
IEEE C37.90.2-2004
Severity Level: 35 V/m

Surge Immunity: IEC 60255-22-5:2008
Severity Level: 1 kV line-to-line, 2 kV line-to-earth
IEC 61000-4-5:2005
Severity Level: 1 kV line-to-line, 2 kV line-to-earth

Damped Oscillatory Magnetic Field: IEC 61000-4-10:2001
Severity Level: 100 A/m

Surge Withstand Capability: IEC 60255-22-1:2007
Severity Level: 2.5 kV peak common mode,
1.0 kV peak differential mode
IEEE C37.90.1-2002
Severity Level: 2.5 kV oscillatory, 4 kV fast transient waveform

Environmental

Cold: IEC 60068-2-1:2007
Severity Level: 16 hours at –40°C

Damp Heat, Cyclic: IEC 60068-2-30:2005
Severity Level: 25°C to 55°C, 6 cycles, Relative Humidity: 95%

Dry Heat: IEC 60068-2-2:2007
Severity Level: 16 hours at +85°C

Vibration: IEC 60255-21-1:1988
Severity Level: Class 2 (endurance); Class 2 (response)
IEC 60255-21-2:1988
Severity Level: Class 1 (shock withstand, bump); Class 2 (shock response)
IEC 60255-21-3:1993
Severity Level: Class 2 (quake response)

Object Penetration: IEC 60529:2001 + CRGD:2003
Protection Class: IP30

Safety

Dielectric Strength:	IEC 60255-5:2000 IEEE C37.90-2005 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs; 3100 Vdc on power supply; type tested for 1 minute
Impulse:	IEC 60255-5:2000 IEEE C37.90-2005 Severity Level: 0.5 J, 5 kV

Reporting Functions

High-Resolution Data

Rate:	8000 samples/second 4000 samples/second 2000 samples/second 1000 samples/second
Output Format:	Binary COMTRADE

Note: Per IEEE C37.111-1999, *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems*.

Event Reports

Length:	0.25–24 seconds (depending on LER setting)
Resolution:	4 and 12 samples/cycle
Volatile Memory:	3 seconds of back-to-back event reports sampled at 8 kHz
Nonvolatile Memory:	At least 4 event reports of a 3-second duration sampled at 8 kHz

Oscillography

Volatile Memory:	3 seconds of back-to-back event reports sampled at 8 kHz
Nonvolatile Memory:	At least 5 event reports of a 3-second duration sampled at 8 kHz

Event Summary

Storage:	100 summaries

Sequential Events Recorder

Storage:	1000 entries
Trigger Elements:	250 relay elements
Resolution:	0.5 ms for contact inputs
Resolution:	1/12 cycle for all elements

Processing Specifications

AC Voltage and Current Inputs

12 samples per cycle, 3 dB low-pass analog filter cut-off frequency of 646 Hz, ±5%

Digital Filtering

Full-cycle cosine after low-pass analog filtering

Protection and Control Processing

12 times per power system cycle

Control Points

32 each remote bits, local control bits, latch bits in protection logic, and latch bits in automation logic

Relay Element Pickup Ranges and Accuracies

Differential Elements

Number of Zones:	6
Number of Check Zones:	3
Number of Terminals:	
Three-Relay Application:	21
Single-Relay Application:	7
Slope 1	
Setting Range:	15–90%
Accuracy:	±5% ± 0.02 • I_{NOM}
Slope 2	
Setting Range:	50–90%
Accuracy:	±5% ± 0.02 • I_{NOM}

Supervising Differential Element

Quantity:	9 total, 1 per zone (6 standard zones, 3 check zones)
Setting Range:	0.10–4.00 pu
Accuracy:	±5% ± 0.02 • I_{NOM}

Incremental Restraint and Operating Threshold Current Supervision

Setting Range:	0.1–10.0 pu
Accuracy:	±5% ± 0.02 • I_{NOM}

Sensitive Differential Current Alarm

Quantity:	9 total, 1 per zone (6 standard zones, 3 check zones)
Setting Range:	0.05–1.00 pu
Accuracy:	±5% ± 0.02 • I_{NOM}
Timer Setting Range:	50–6000 cycles

Instantaneous/Definite-Time Overcurrent Elements

Phase Current Setting Range	
5 A Model:	OFF, 0.25–100.00 A secondary, 0.01 A steps
1 A Model:	OFF, 0.05–20.00 A secondary, 0.01 A steps
Accuracy (Steady State)	
5 A Model:	±0.05 A, ±3% of setting
1 A Model:	±0.01 A, ±3% of setting
Transient Overreach:	<5% of setting
Timer Setting Range:	0.00–99999.00 cycles, 1/6-cycle steps
Timer Accuracy:	±0.1% of settings ±1/6 cycle
Maximum Operating Time:	1.5 cycles

Time-Overcurrent Elements

Pickup Range	
5 A Model:	0.50–16.00 A secondary, 0.01 A steps
1 A Model:	0.10–3.20 A secondary, 0.01 A steps
Accuracy (Steady State)	
5 A Model:	±0.05 A, ±3% of setting
1 A Model:	±0.01 A, ±3% of setting
Time Dial Range	
US:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Curve Timing Accuracy:	±1.50 cycles, ±4% of curve time (for current between 2 and 30 multiples of pickup)
Reset:	1 power cycle or Electromechanical Reset Emulation time

Under- and Overvoltage Elements (27, 59)

Processing Rate:	1/6 cycle
Phase Under- and Overvoltage (2 Level/Phase)	
Setting Range:	2.00–200 V_{LN} in 0.01 steps
Accuracy:	±5% of setting, ±0.5 V
Transient Overreach:	<5% of pickup
Maximum Delay:	1.5 cycles
Zero- and Negative-Sequence Overvoltage Elements	
Setting Range:	1.0–200 V in 0.1 steps
Accuracy:	±5% of setting, ±1 V
Transient Overreach:	<5% of setting
Maximum Delay:	1.5 cycles

Breaker Failure Instantaneous Overcurrent

Setting Range	
5 A Model:	0.50–50 A, 0.01 A steps
1 A Model:	0.10–10.0 A, 0.01 A steps
Accuracy	
5 A Model:	±0.05 A, ±3% of setting
1 A Model:	±0.01 A, ±3% of setting
Transient Overreach:	<5% of setting
Maximum Pickup Time:	1.5 cycles
Maximum Reset Time:	<1 cycle
Timers Setting Range:	0–6000 cycles, 1/12-cycle steps (BFPU*nn*, RTPU*nn*) 0–1000 cycles, 1/12-cycle steps (BFISP*nn*, BFIDO*nn*)
Time Delay Accuracy:	1/12 cycle, ±0.1% of setting

Disconnect Monitor

Number:	60
Timer Setting Range:	0–99999 cycles, 1 cycle step

Breaker Status Monitor

Number:	21

Coupler Security Logic

Number:	4
Timer Setting Range:	0–1000 cycles, 1/12 cycle step

Control Input Timers

Setting Range	
Pickup:	0.00–30 ms
Dropout:	0.00–30 ms

Station DC Battery System Monitor Specifications

Rated Voltage:	15–300 Vdc
Operational Voltage Range:	0–350 Vdc
Input Sampling Rate:	2 kHz
Processing Rate:	1/6 cycle
Operating Time:	≤1.5 seconds (element DC1R) ≤1.5 cycles (all elements but DC1R)
Setting Range	
DC Settings:	1 Vdc Steps (OFF, 15–300 Vdc)
AC Ripple Setting:	1 Vac Steps (1–300 Vac)
Pickup Accuracy:	±10% ±2 Vdc (DC1RP) ±3% ±2 Vdc (all elements but DC1RP)

Metering Accuracy

All metering accuracies are based on an ambient temperature of 20°C and nominal frequency.

Currents

Phase Current Magnitude

5 A Model:	±0.2% plus ± 4 mA (2.5–15 A sec)
1 A Model:	±0.2% plus ± 0.8 mA (0.5–3.0 A sec)

Phase Current Angle

All Models:	±0.2° in the current range (0.5–3.0) • I_{NOM}

Differential Currents per Zone (Steady State)

IOP, IRT:	±5.0% ±0.02 • I_{NOM}
IOPCZ, IRTCA:	±5.0% ± 0.02 • I_{NOM}

Voltages

Phase Voltage Magnitude

300 V Maximum Inputs:	±2.5% ±1 V (5–33.5 V) ±0.1% (33.5–300 V)

Phase Angle

300 V Maximum Inputs:	±1.0° (5–33.5 V) ±0.5° (33.5–300 V)

Notes

This product is covered by the standard SEL 10-year warranty. For warranty details, visit selinc.com or contact your customer service representative.

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
selinc.com • info@selinc.com

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