SEL-2414 Transformer Monitor

Complete System for Control and Monitoring

Major Features and Benefits

The SEL-2414 Transformer Monitor provides an exceptional combination of monitoring, control, and communications in a compact package.

- **Thermal Monitoring and Metering Capabilities.** Safeguard transformers from overheating by tracking thermal conditions. Track the minimum and maximum transformer top oil temperature, hot spot temperature, and as many as 10 RTDs or thermocouples.
- **High Reliability, Rugged Design, and Low Price.** Apply the SEL-2414 in harsh physical and electrical environments. The SEL-2414 withstands vibration, electrical surges, fast transients, extreme operating temperatures from –40° to +85°C, and meets stringent utility standards. Compare our superior specification compliance, higher reliability, lower price, and worldwide, ten-year warranty to other transformer monitor alternatives.
- **Flexible I/O for Transformer Status, Alarms, and More.** Input/output options include digital inputs for status such as oil level and sudden pressure; RTD and thermocouple inputs for measurements such as ambient, top-oil, and hot-spot temperatures; digital outputs for control and alarms; analog inputs and outputs; and ac current and voltage inputs. Easily program monitoring and control functions with powerful logic, math, timers, counters, and edge-trigger functions. These features allow easy integration with new and retrofit transformer monitor applications. Monitor critical substation assets with comprehensive transformer thermal and through-fault monitoring.
- **Advanced Asset Monitoring.** Monitor critical substation assets with comprehensive transformer thermal and through-fault monitoring. Calculate top oil, hotspot, insulation aging acceleration factor, and loss of life while generating hourly and daily data about your transformer. Capture the maximum/minimum values of all transformer model quantities. Capture through-fault current data that could lead to increased transformer wear.
- **Critical Reporting and Logging.** Store as many as 512 Sequential Events Recorder (SER) reports of digital input transitions, time-tagged to the nearest millisecond. Analyze SER reports, analog trending and oscillographic event reports for rapid commissioning, testing, and post-event diagnostics. Send the SER data to a communications processor or computer for system analysis.

- **Communications and Integration.** Automate fan bank control with flexible communication options that provide easy integration with SCADA. Choose from single and dual Ethernet, Modbus® TCP, DNP3 LAN/WAN, IEC 61850, Modbus Serial, EIA-232, EIA-485, Telnet, and File Transfer protocols.
- **AC Metering Capabilities.** The SEL-2414 provides extensive ac metering and monitoring capabilities. Voltage, current, power, energy, power factor, frequency; demand/peak demand metering; and maximum/minimum metering are measured and recorded. Values can be used in programmable calculations and triggers within the meter.
- **Simple Commissioning Tools.** Front-panel HMI provides complete configuration access and displays settings, measurements, and calculated values. Easily set with ACSELERATOR QuickSet® SEL-5030 Software.

Product Summary

The SEL-2414 Transformer Monitor withstands harsh physical and electrical environments and is built and tested to meet mission-critical IEEE and IEC protective relay standards. Apply the SEL-2414 to satisfy standalone or distributed monitoring and control of transformers, or choose from the flexible communications options to connect to a substation distributed SCADA or automation system, or a SCADA master. Communications options include serial, fiber-optic, and Ethernet connections and ASCII, SEL Fast Message, MIRRORED BITS® communications, Modbus, and DNP3 protocols. *Figure 1* shows the SEL-2414 functionality.

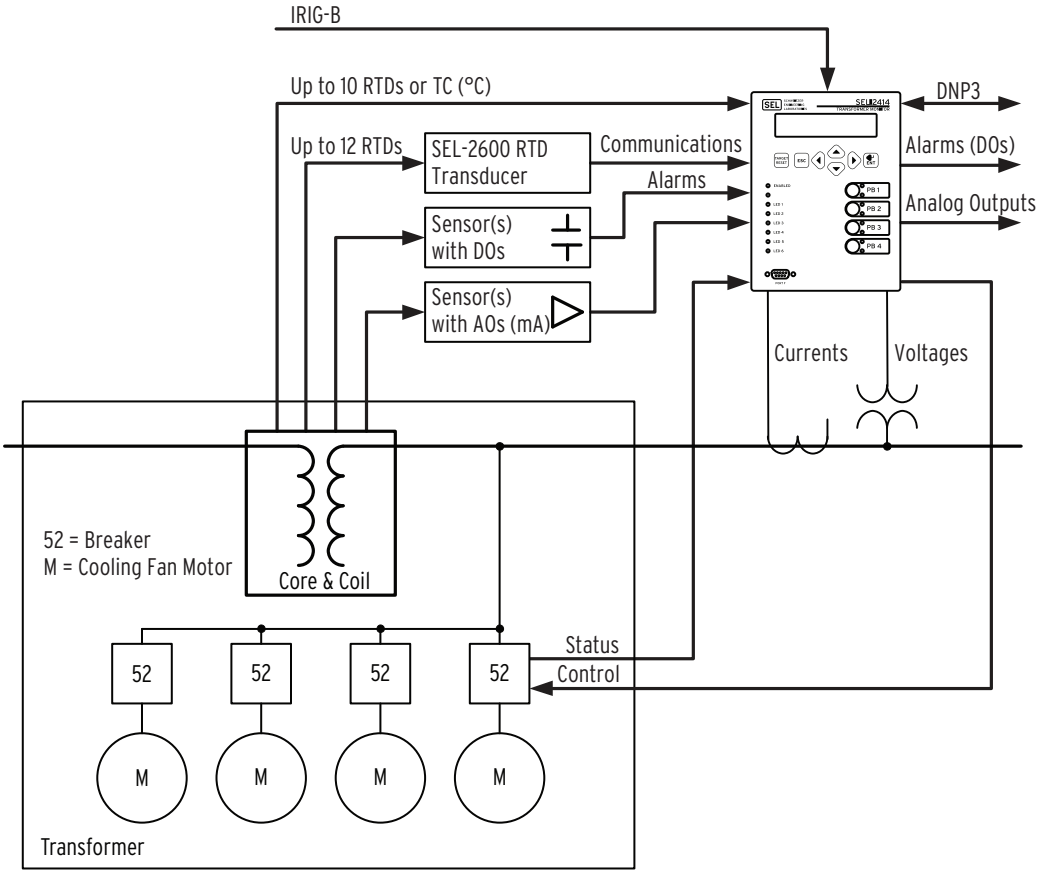


Figure 1 Functional Block Diagram

Monitoring and Control Features

Apply flexible I/O options to meet the many needs of new or retrofit transformer installations. The SEL-2414 includes four slots for plug-in I/O cards. Use digital inputs (DI) to monitor critical transformer alarms and status points. Use analog inputs (AI) to measure pressure, oil level, temperatures, tap positions, and process-level signals (e.g., 4–20 mA, 0–1 mA) from transducers. Operate cooling fans, equipment, alarms, or provide indication with relay-contact or solid-state digital outputs (DO) and analog outputs (AO). Measure ac currents and ac voltage to calculate three-phase power, demand, energy, save in oscillographic reports, and for automatic control processes.

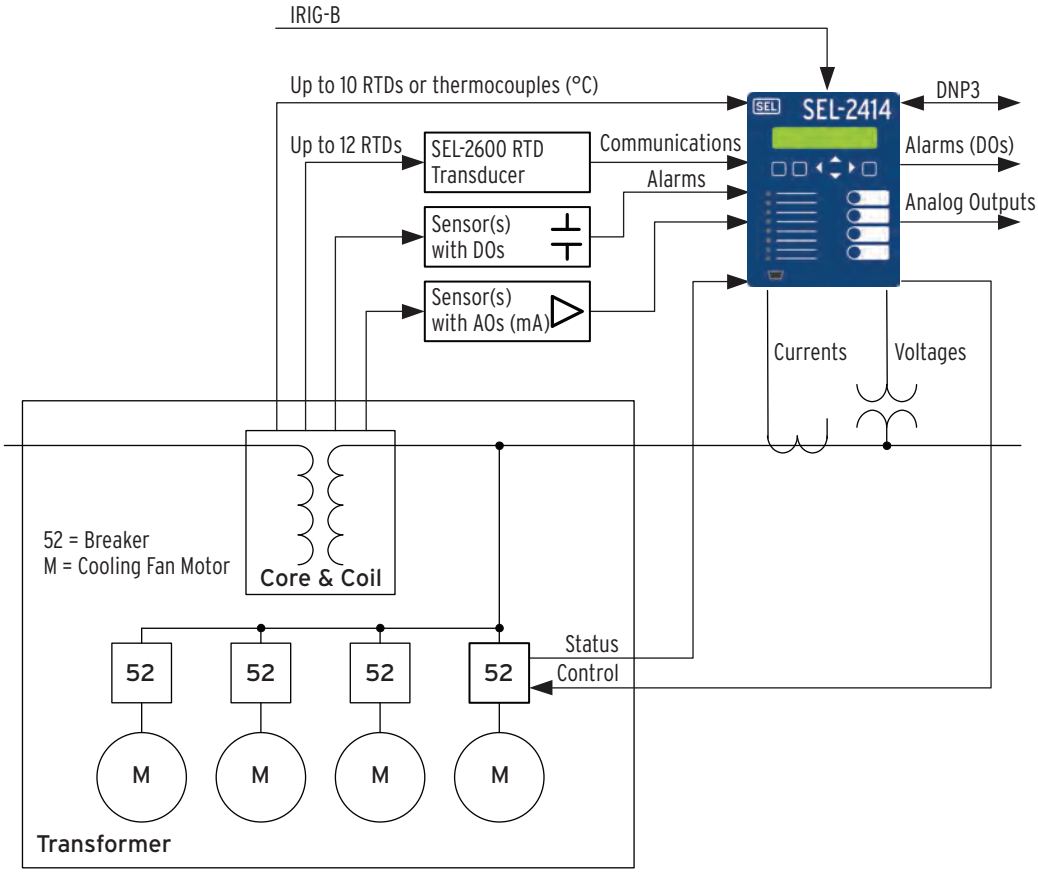


Figure 2 Transformer Monitor and Control System

I/O (Status and Alarms)

Use digital inputs to monitor critical alarms such as oil levels, pressures, gas accumulation; they may also be used for status points such as fans on/off and breakers open/closed, as shown in *Figure 3*.

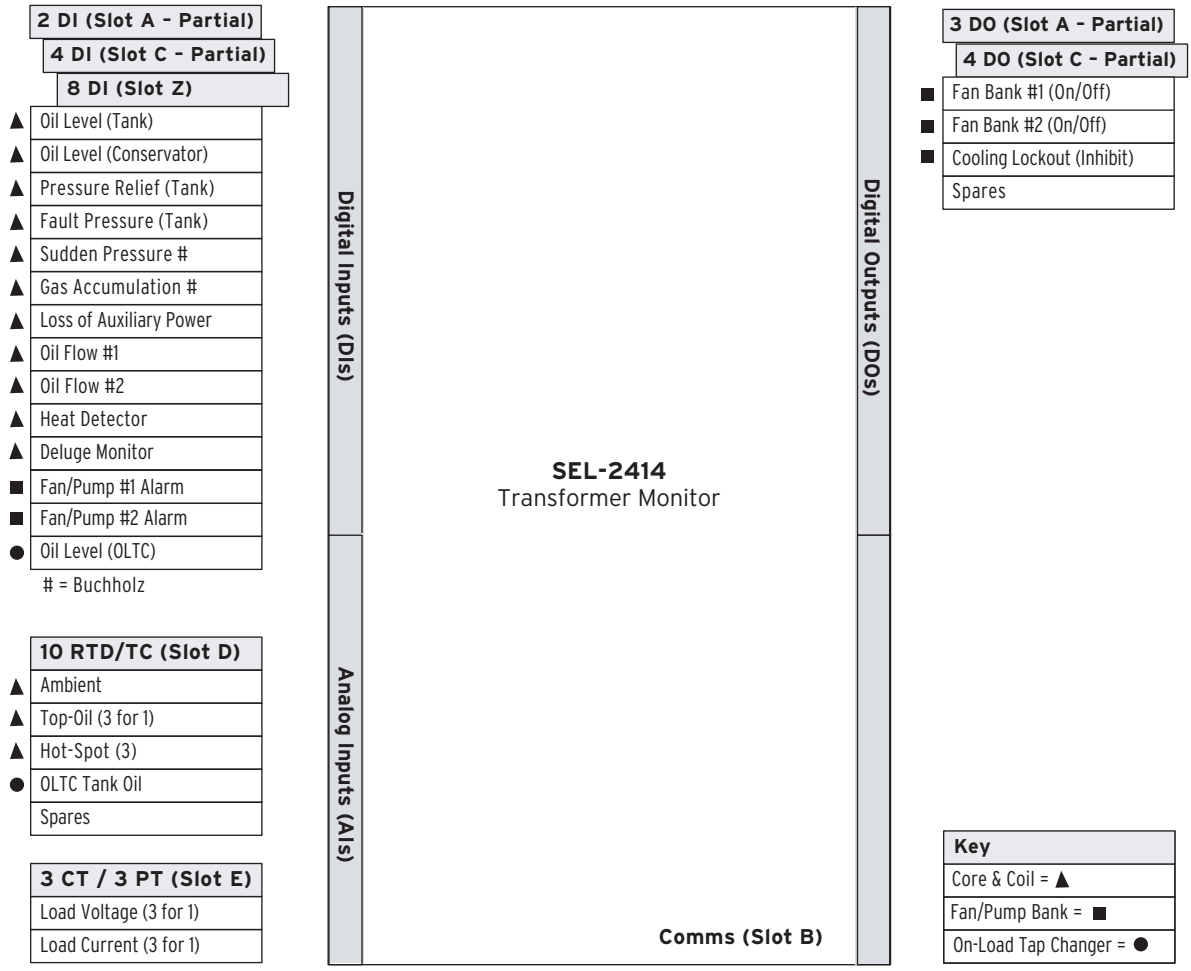


Figure 3 Monitoring Inputs and Control Outputs

Analyze Transformer Sequence-of-Events

Record sequence-of-events related to transformer events or operations with the Sequential Events Recorder (SER) function. With this function, you can analyze assertions and deassertions of digital inputs and outputs; as many as 512 state changes to the millisecond for as many as 96 different digital points. The function also captures when the device powers up and a settings change occurs.

```
SEL-2414                                    Date: 04/03/2005 Time: 07:21:19
DEVICE

#      DATE         TIME             ELEMENT                 STATE
17  04/03/2005  06:25:51.120  RB01                        Deasserted
16  04/03/2005  06:25:51.125  OUT102                      Deasserted
15  04/03/2005  06:26:03.049  RB01                        Asserted
14  04/03/2005  06:26:03.053  OUT102                      Asserted
13  04/03/2005  06:51:17.748  Device Powered Up
12  04/03/2005  06:51:20.361  OUT101                      Asserted
11  04/03/2005  06:51:21.366  OUT101                      Deasserted
10  04/03/2005  06:54:10.753  Device Settings Changed
9   04/03/2005  06:54:10.762  FAN BANK #2 OFF             Asserted
8   04/03/2005  06:54:11.737  OUT101                      Deasserted
7   04/03/2005  07:06:01.739  FAN BANK #2 ON              Asserted
6   04/03/2005  07:06:02.744  OUT101                      Deasserted
5   04/03/2005  07:06:14.993  Device Settings Changed
4   04/03/2005  07:06:15.002  OUT101                      Asserted
3   04/03/2005  07:06:15.977  FAN BANK #1 ON              Deasserted
2   04/03/2005  07:13:22.947  OUT101                      Asserted
1   04/03/2005  07:13:23.951  OUT101                      Deasserted

        SER                  Element or                  Element
       Number                Condition                   State
```

Figure 4 Example SER Report

Combine SER data from individual SEL-2414 Transformer Monitors into a system-wide log. Synchronize the system with IRIG-B time code and the report data will align perfectly.

Figure 5 Combine SER Data From Multiple SEL-2414 Transformer Monitors for a System-Wide Log and Display

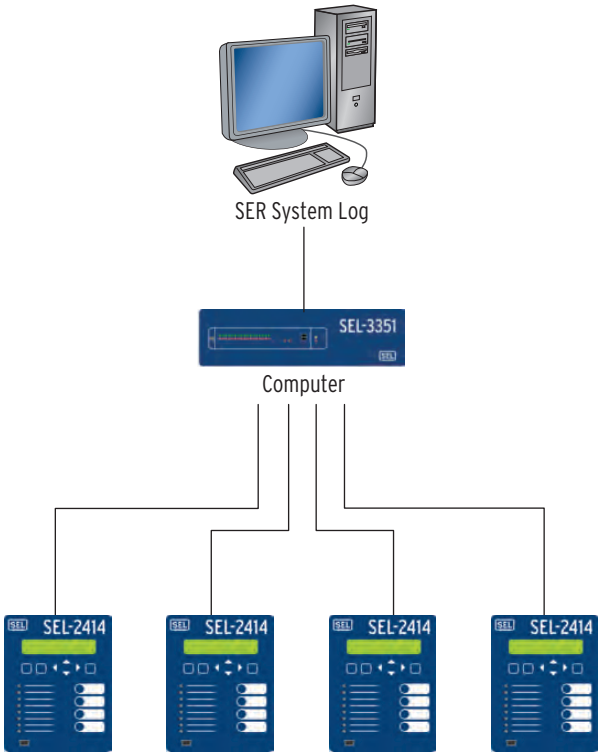


Figure 6 Example SER Collection Architecture

Analyze Transformer Event Waveforms

Record analog and digital waveforms at 32 samples/cycle for as many as 64 power system cycles, approximately 1 s. Use the event report to move the oscillographic data to your PC. You can plot your event report data with the SEL-5601 Analytic Assistant software or with Microsoft® Excel®.

Event reports contain ac currents, ac voltages, and digital inputs and outputs. The report automatically adjusts content to the I/O cards you use. Reports are stored in nonvolatile memory to protect your data even if power is lost. Event reports are optimized for recording power disturbances and relating them to your process.

Set the report to capture either 15 or 64 power system cycles of data around the trigger event. For a 60 Hz system, the event report lengths are 0.25 seconds and 1.07 seconds. For a 50 Hz system, the report lengths are 0.30 seconds and 1.28 seconds.

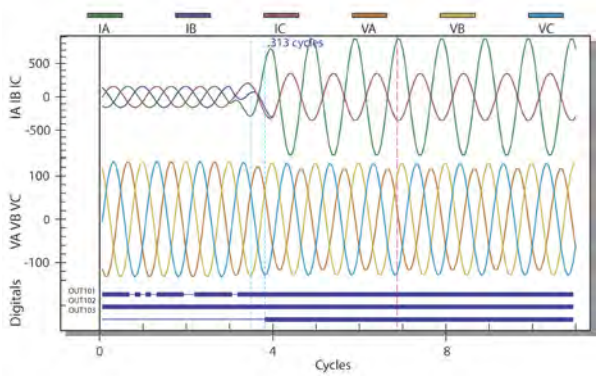


Figure 7 Example SEL-5601 Waveform Plot

Trend Transformer Temperatures and Other Analog Inputs

Record measured ambient, transformer top-oil, transformer hot-spot and other analog data (measured or calculated) for trending with the Analog Signal Profile function. This profile (trending) function can track as many as 32 analog channels. The function records the magnitude and time of acquisition of each analog channel. Use the profile report to move trend records to your PC and quickly plot the data with Microsoft Excel or any other spreadsheet application.

```
=>>CPR <Enter>
"REC_NUM","YEAR","MONTH","DAY","HOUR","MIN","SEC","MSEC","VA_MAG","VB_M
AG","VC_M
AG","AI301","AI302","AI303","AI304","AI305","AI306","1D7A"
14,2005,9,1,12,10,4,261,2092.127,2099.499,2089.107,-0.001,-0.000,
-0.001,-0.001,-
0.001,-0.001,"1190"
13,2005,9,1,12,15,3,982,2093.966,2099.176,2088.974,-0.001,-0.001,
-0.001,-0.000,-
0.001,-0.001,"11AC"
12,2005,9,1,12,20,4,82,2091.636,2099.117,2089.346,-0.001,-0.000,
-0.001,-0.001,-0
.001,-0.001,"115C"
11,2005,9,1,12,25,4,332,2092.435,2098.398,2088.487,-0.001,-0.001,
-0.001,-0.001,-
0.001,-0.001,"119C"
10,2005,9,1,12,30,4,36,2092.907,2098.208,2089.058,-0.001,-0.001,
-0.000,-0.001,-0
.001,-0.001,"115C"
9,2005,9,1,12,35,4,186,2093.153,2098.865,2089.091,-0.001,-0.000,
-0.001,-0.001,-0
.001,-0.001,"116F"
8,2005,9,1,12,40,3,978,2094.284,2098.926,2089.732,-0.001,-0.001,
-0.001,-0.001,-0
.001,-0.001,"1179"
```

Figure 8 Comma-Separated File Format for Easy Display, Analysis, and Archiving

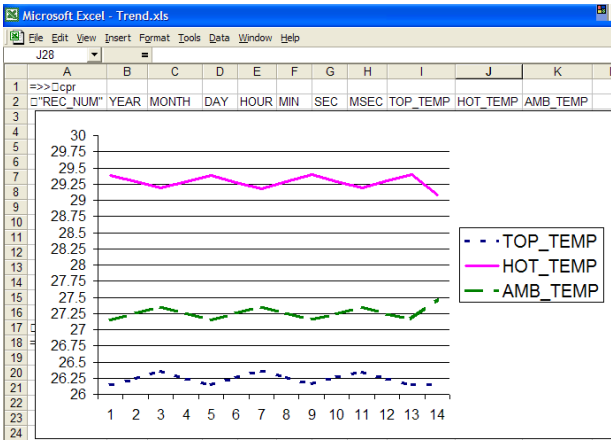


Figure 9 Excel Graph of Trend Data

Transformer Thermal Monitoring

Transformer thermal modeling per IEEE C57.91-1995 for mineral-oil immersed transformers is a standard feature in the SEL-2414. Specify the SEL-2414 to provide this capability for monitoring and protection of a single three-phase transformer, a three-phase transformer with tertiary windings (three-winding mode with separate CT ratios), or three independent single-phase units. Use the thermal element to activate a control action or issue a warning or alarm when your transformer overheats or is in danger of excessive insulation aging or loss-of-life.

Use the thermal event report to capture current hourly and daily data about your transformer. Operating temperature calculations are based on load currents, type of cooling system, and actual temperature inputs (ambient and top-oil). Use as many as four thermal sensor inputs: a single ambient temperature transducer and one transducer for top-oil temperature from each of three single-phase transformers. Temperature data are obtained via an internal RTD/thermocouple card or from an external SEL-2600A RTD Module. While the SEL-2414 can receive temperature data at any rate, the thermal element uses the temperature data once per minute.

The thermal element operates in one of three modes, depending upon the presence or lack of measured temperature inputs: 1) measured ambient and top-oil temperature inputs, 2) measured ambient temperature only, and 3) no measured temperature inputs. If the device receives measured ambient and top-oil temperatures, the thermal element calculates hot-spot temperature. When the device receives a measurement of ambient temperature without top-oil temperature, the thermal element calculates the top-oil temperature and hot-spot temperature. In the absence of any measured ambient or top-oil temperatures, the thermal element uses a default ambient temperature setting that you select and calculates the top-oil and hot-spot temperatures. The device uses hot-spot temperature as a basis for calculating the insulation aging acceleration factor (FAA) and loss-of-life quantities. Use the thermal element to indicate alarm conditions and/or activate control actions when one or more of the following exceed settable limits:

- Top-oil temperature
- Winding hot-spot temperature
- Insulation aging acceleration factor (FAA)
- Daily loss-of-life
- Total loss-of-life

Generate a thermal monitor report that indicates the present thermal status of the transformer. Historical thermal event reports and profile data are stored in the device in hourly format for the previous 24 hours and in daily format for the previous 31 days.

The thermal model can be used even if a current card is not installed. Current magnitude data can be received by IEC 61850 or other communications protocols.

Through-Fault Event Monitor

A through fault is an overcurrent event external to the differential protection zone. Though a through fault is not an in-zone event, the currents required to feed this external fault can cause great stress on the apparatus inside the differential protection zone. Through-fault currents can cause transformer winding displacement leading to mechanical damage and increased transformer thermal wear because of mechanical stress of insulation components in the transformer. The SEL-2414 through-fault event monitor gathers current level, duration, and date/time for each through fault. The monitor also calculates a I^2t and cumulatively stores these data per-phase. The SEL-2414 through-fault report also provides percent of total through-fault accumulated according to the *IEEE Guide for Liquid-Immersed Transformer Through-Fault-Current Duration, C57.109-1993*. Use through-fault event data to schedule proactive transformer bank maintenance and help justify through-fault mitigation efforts. Apply the accumulated I^2t alarm capability of the device to indicate excess through-fault current over time.

Simplify Your Transformer Commissioning

The SEL-2414 front panel simplifies commissioning and troubleshooting:

- View field data and calculated values
- Diagnose data flow problems in seconds instead of hours
- Dramatically reduce troubleshooting time
- Eliminate the need for out-of-service time

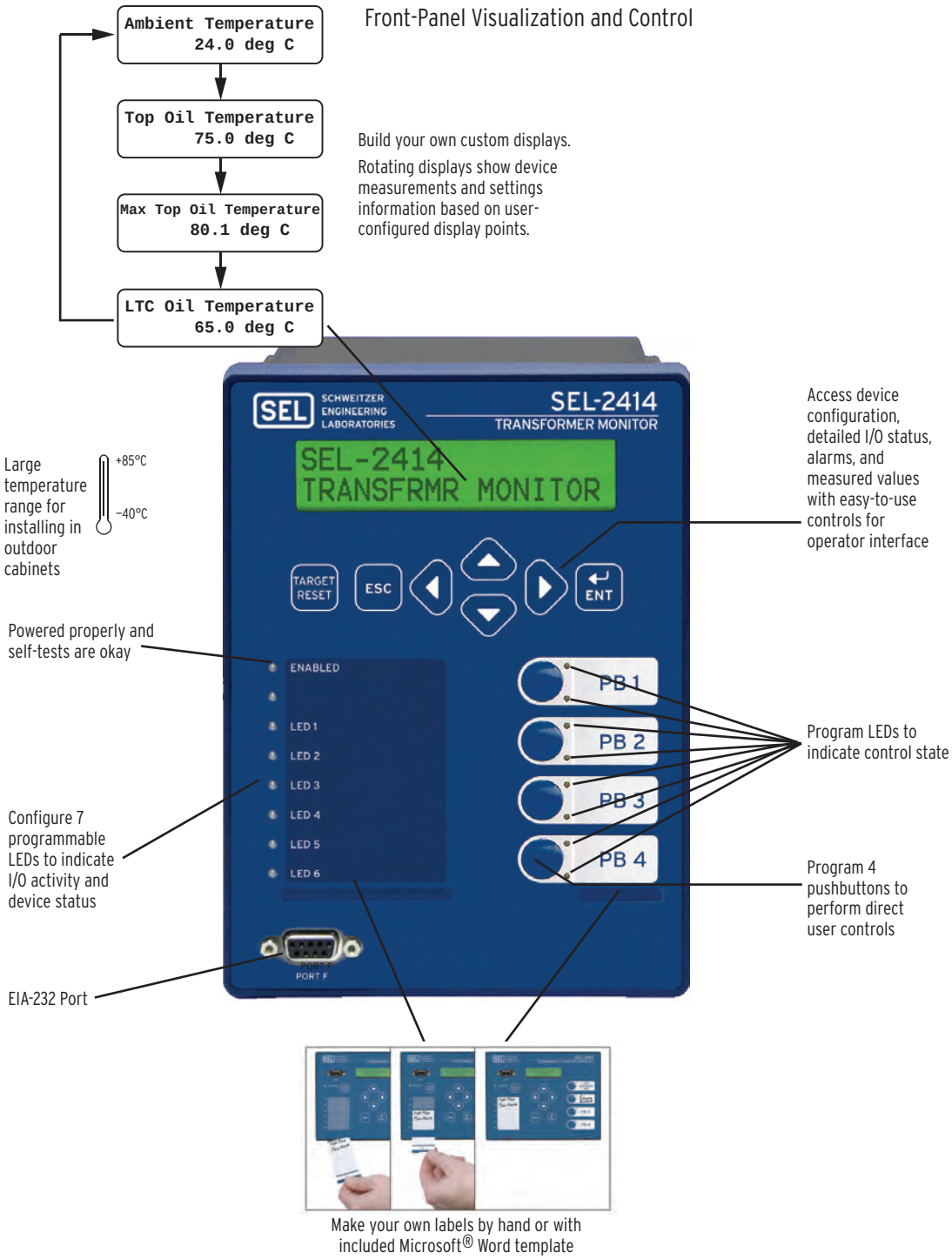


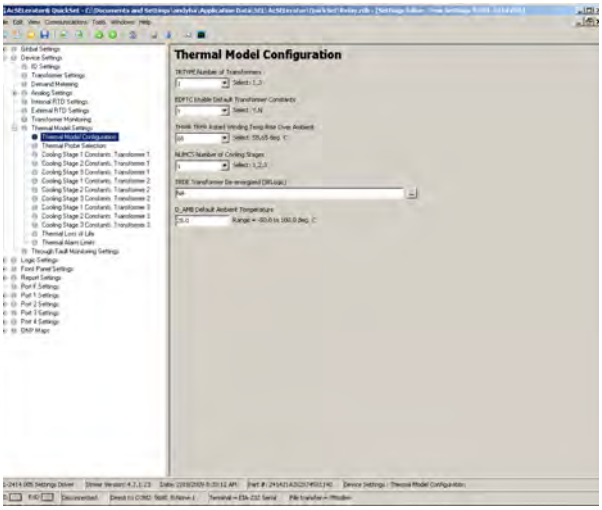
Figure 10 Simplify Your Commissioning

Configuration and Commissioning Software

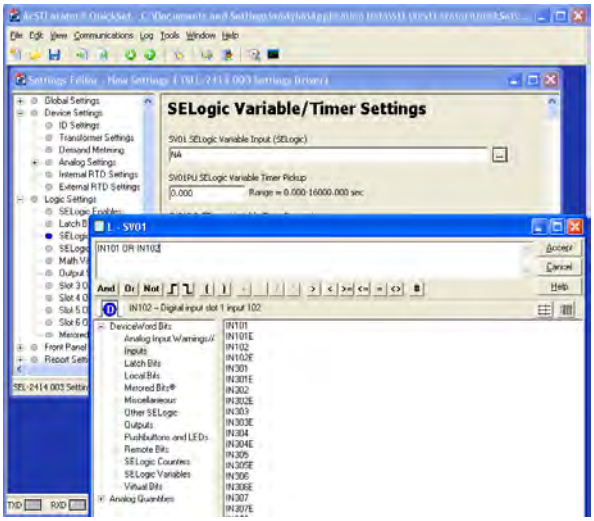
The included ACSELERATOR QuickSet software program simplifies device configuration in addition to providing commissioning and analysis support for the SEL-2414.

- ➤ Access settings creation help online.
- ➤ Organize settings with the device database manager.
- ➤ Load and retrieve settings using a simple PC communications link.
- ➤ Analyze event records with the integrated waveform and harmonic analysis tool.
- ➤ Use the PC interface to remotely retrieve reports and other system data.
- ➤ Monitor analog data, device I/O, and logic point status during commissioning tests.
- ➤ Remotely operate and monitor using the device overview as a virtual front panel.

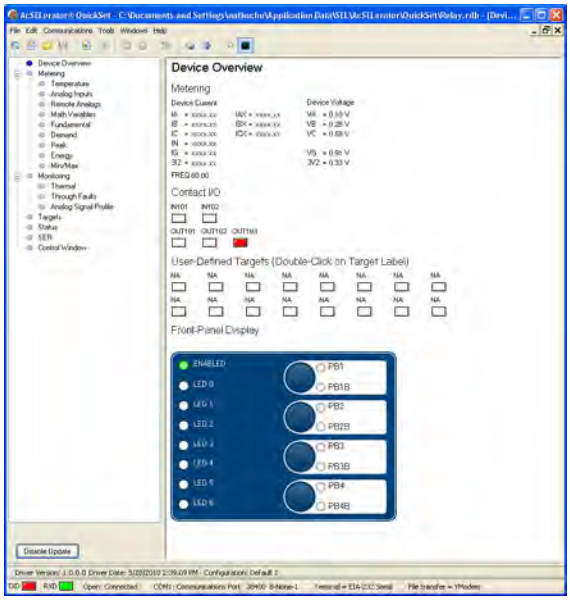
Settings–Develop Settings Off-Line With an Intelligent Settings Editor That Only Allows Valid Settings.



Settings–Create SELOGIC Control Equations With a Drag and Drop Editor and/or Text Editor.



HMI–Device Overview.



Metering

The SEL-2414 provides extensive metering capabilities. See *Specifications* for metering and power measurement accuracies. As shown in *Table 1*, metering includes current and voltage based metering and analog input, math variable and remote analog metering. Fundamental, maximum and minimum, and demand metering typically includes phase voltages and currents; sequence voltages and currents; and power, frequency, and energy.

Table 1 Metering Types

Standard	
Fundamental	IA, IB, IC, VA, VB, VC
Energy	Real, Reactive, Apparent (In and Out)
Maximum and Minimum	Frequency, Voltages (VA, VB, VC), Currents (IA, IB, IC, 3I2), Apparent, Reactive, and Real Power
Demand and Peak Demand	IA, IB, IC, IG, 3I2
Analog Input	AIx01–AIx08
Math Variable	MV01–MV32
Remote Analog	RA001–RA128
Analog Signal Profiling	
Optional	
➤ Temperature and thermal (with the external SEL-2600 RTD Module, internal RTD option, or internal RTD/TC option)	
➤ Maximum and Minimum Temperatures	

Additional Ordering Options

The following options can be ordered for any SEL-2414 model (see the SEL-2414 Model Option Table for details):

Digital I/O[a]	8 DI (PN 9760), 8 DO (PN9761), 4 DI/4 DO (PN 9764), 4 DI/3 DO with 2 Form C and 1 Form B (PN 9773)
Analog I/O	8 AI (PN9762), 4 AI/4 AO (PN 9763)
Temperatures	10 RTDs (PN 9772)
CTs and PTs	3 ACI/3 AVI (PN 9771), 4CT (PN 9770), 3 AVI (PN 9769)
Port 1	Single/Dual 10/100BASE-T copper (RJ45 connector) Single/Dual 100BASE FX (LC connector)
Port 2	Fiber-Optic Port (62.5 µm core fiber, ST connectors, SEL-2812 compatible)
Port 4	EIA-232 or EIA-485 (PN 9751)
Protocols	Serial: DNP3; Ethernet: Modbus TCP, DNP3 LAN/WAN, FTP, Telnet, IEC 61850
Mounting	Surface Mounting kit for in-cabinet installation (PN 915900204)
Environment	Conformal coating for chemically harsh and high-moisture environments

[a] Unless otherwise specified, all digital outputs are Form A.

Automation

Flexible Control Logic and Integration Features

The SEL-2414 is equipped with as many as four independently operated serial ports: one EIA-232 port on the front, one EIA-232 or EIA-485 port on the rear, one fiber-optic port, and one EIA-232 or EIA-485 port option card. The device does not require special communications software. Use any system that emulates a standard terminal system for engineering access to the device. Establish communication by connecting computers, modems, protocol converters, printers, an SEL Communications Processor, SCADA serial port, and an RTU for local or remote communication. Apply an SEL communications processor as the hub of a star network, with point-to-point fiber or copper connection between the hub and the SEL-2414. Included communications protocols are listed below.

Standard Protocols

- Modbus RTU
- SEL ASCII
- SEL Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message
- SEL MIRRORED BITS

SEL-2414 logic improves integration in the following ways.

Replaces Traditional Panel Control Switches

Eliminate traditional panel control switches with operator control pushbuttons or the 32 local bits, available through the menu system. Program the four conveniently sized operator pushbuttons to control fan banks and fan lockout. Set, clear, or pulse local bits with the front-panel pushbuttons and display. Program the local bits into your control scheme with SELOGIC control equations. Use the local bits to perform functions such as breaker trip/close.

Replaces Traditional Indicating Panel Lights

Replace traditional indicating panel lights with 32 programmable displays. Define custom messages (e.g., Fan On, Fan Off) to report transformer or device conditions on the front-panel display. Use advanced SELOGIC control equations to control which messages the device displays. *Figure 11* shows an example.

Replaces Traditional Temperature Gauges

Replace traditional temperature gauges that show the temperature, and the maximum and minimum temperature since last reset. The SEL-2414 Max/Min metering records and time stamps the maximum and minimum temperatures and transformer thermal model quantities.

Replaces Traditional Latching Relays

Replace as many as 32 traditional latching relays for such functions as “remote control enable” with latch bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the device loses power.

Eliminates External Timers

Eliminate external timers for custom protection or control schemes with 32 general purpose SELOGIC control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to control scheme logic.

Eliminates RTU-to-Device Wiring

Eliminate RTU-to-Device wiring with 32 remote bits. Set, clear, or pulse remote bits using serial port commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip and close.

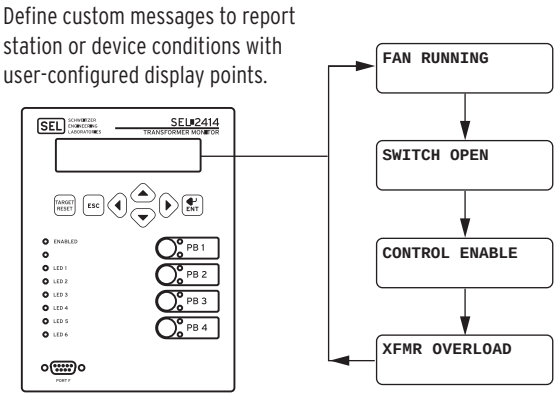


Figure 11 Define Custom Messages to Report Station or Device Conditions

Communications Architectures

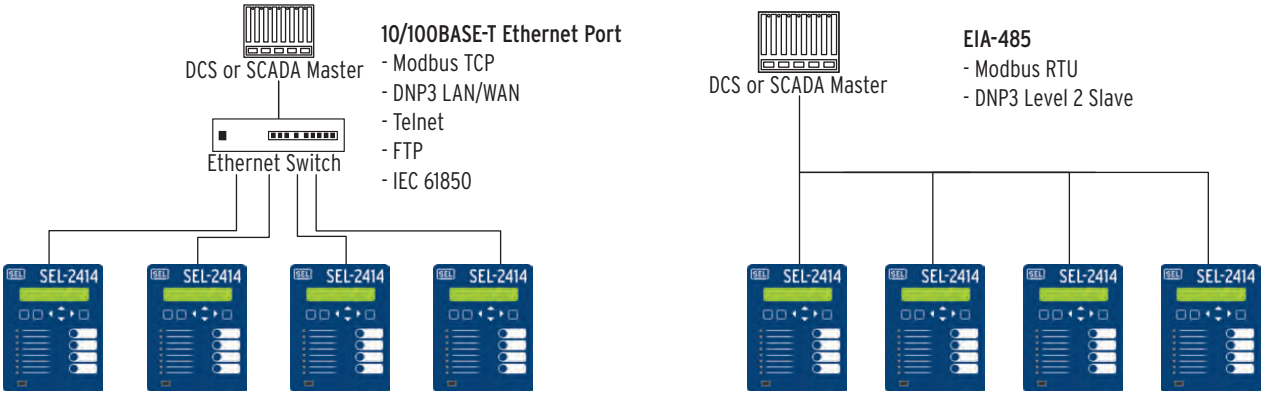


Figure 12 Typical Ethernet and EIA-485 Communications Architectures

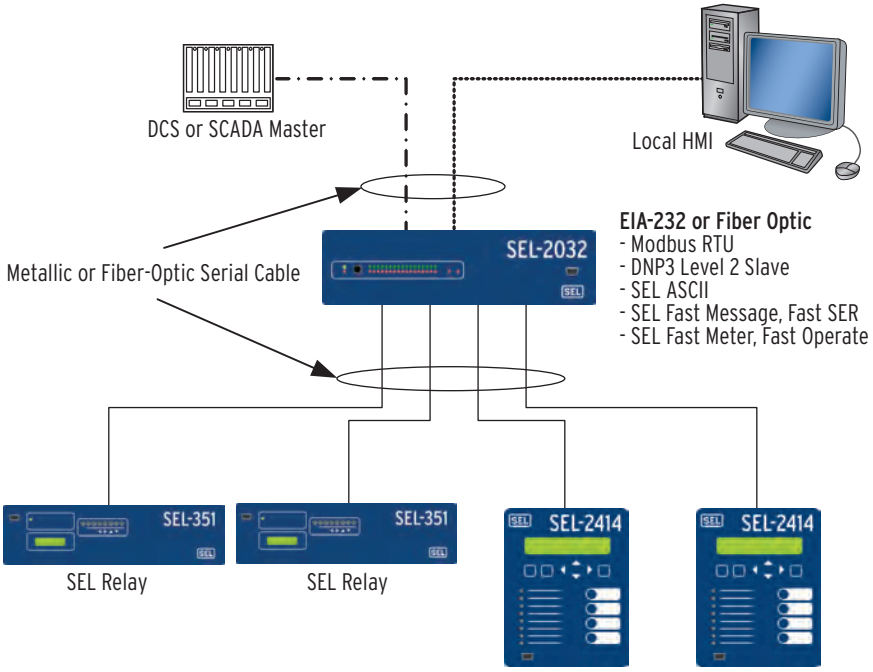


Figure 13 Typical EIA-232 and Fiber-Optic Communications Architecture

Guideform Specification

The microprocessor-based device shall provide monitoring, control, and automation. Self-checking functions shall be included. Specific requirements are as follows:

- **Front-Panel Visualization.** The transformer monitor shall be capable of displaying measured values, calculated values, I/O statuses, device status, and configuration parameters on a front-panel LCD display. The display shall have a rotating capability to display custom messages and data. Thirty-two display messages shall be provided. The front panel shall also have a minimum of 14 user-programmable LEDs and four user-programmable pushbutton controls.
- **SELOGIC Programming Language.** The transformer monitor shall be capable of implementing a wide variety of logic and control functions using the tools available in the SELOGIC Programming Language. Logic shall have the ability to use math functions, comparison functions, and Boolean logic functions. Boolean logic loop execution time shall be ≤ 5 ms.
- **Automation.** The transformer monitor shall include 32 local control logic points, 32 remote control logic points, 32 latching logic points, 32 counters, 32 math variables, 64 logic variables, and 64 timers.
- **Small Form Factor.** The transformer monitor shall have a compact case with quick-disconnect connectors for analog and digital I/O to simplify installation.
- **Digital I/O.** The transformer monitor shall be configurable based upon end-user application requirements.
- **Analog Inputs.** As an option, the transformer monitor shall have the ability to support 32 current or voltage (jumper selectable) analog inputs. The allowed signal input range is ±20 mA, ±10 volts, or ±300 volts.
- **Analog Outputs.** As an option, the transformer monitor shall have the ability to support eight current or voltage (jumper selectable) analog outputs. The allowed signal output range is ±20 mA or ±10 volts.
- **IRIG-B Synchronized, Timestamped Events.** The transformer monitor shall store as many as 512 event records with IRIG-B synchronized timestamps. An internal real time clock shall be used for time stamping if an IRIG-B signal is not available.
- **Sequential Event Recorder.** A chronological report shall be provided by the transformer monitor to help determine the order and cause of events and assist in troubleshooting. The last 512 input, output, and element events shall be recorded with 1 ms accuracy.
- **Metering.** The transformer monitor shall include metering capabilities for real-time current, voltage, power, and energy qualities, as well as phase demand and peak demand current values for all ac current and voltage inputs.
- **Max/Min Metering.** The transformer monitor shall support Max/Min metering. Max/Min metering shall record and timestamp the maximum and minimum of ac measured quantities (current, voltage, power, etc.) and thermal quantities (RTD measurements and transformer thermal model values).
- **Transformer Thermal Monitor.** The transformer monitor shall incorporate a transformer thermal monitor based on IEEE C57.91-1995. The model shall include capability for entering known transformer thermal constants as well as default constants. Three loss-of-insulation-life alarms shall be provided. These include loss-of-life per day, total loss-of-life, and insulation aging factor. As many as four temperature inputs shall be accommodated by the device.
- **Through-Fault Event Monitor.** The transformer monitor shall provide for the capability of reporting fault current level, duration, and date/time for overcurrent events through the differential protection zone. Through-fault monitoring shall provide accumulated through-fault levels, number of through-faults, and the total consumed through-fault capacity of the transformer (based on the *IEEE Guide for Liquid-Immersed Transformer Through-Fault-Current Duration, C57.109-1993*).
- **RTD.** As an option, the transformer monitor shall have the ability to support as many as 10 RTD inputs with an internal SELECT I/O card or 12 RTD inputs in an external module (SEL-2600 series) for temperature measurements.
- **TC.** As an option, the transformer monitor shall have the ability to support as many as 10 thermocouple inputs with an internal general purpose RTD/TC select I/O card for temperature measurements.
- **Event Record.** The transformer monitor shall store as many as 15 cycles of raw data with 16-sample/cycle resolution. As many as 17 most recent events are time-stamped and stored in nonvolatile memory.
- **Voltage Inputs.** Optional voltage inputs shall accept 0–300 Vac.
- **Current Inputs.** Optional current inputs shall accept 0–5 A or, optionally, 0–1 A nominal current inputs.
- **Digital Relay-to-Relay Communications.** The transformer monitor shall have eight transmit and eight receive logic elements in each of two communications ports for dedicated relay-to-relay communications. These elements shall be available for use in control logic.
- **DNP3.** The transformer monitor shall be capable of operating as a DNP3 Level 2 Outstation, either serial or LAN/WAN. The device shall allow configuration of any incoming data or data calculated within the device to be available through any of three custom DNP data maps. All control points within the transformer monitor shall be available as DNP3 control points, using latch on/latch off, pulse on/pulse off, or trip/close control functions. SER data shall be available as time-stamped DNP event data.

- **Modbus.** The transformer monitor shall be capable of operating as a Modbus slave either through a serial connection or Modbus TCP via Ethernet. The Modbus slave implementation shall allow direct access to any register within the device. The Modbus implementation shall allow control of any control point within the I/O processor and controller.
- **IEC 61850 Ethernet Communications.** The device shall provide IEC 61850 compliant communications. The IEC 61850 capability shall include GOOSE messaging and defined logical node data points.
- **PC Software.** The transformer monitor shall include compatibility with a PC software program for use in programming control settings and logic functions, and retrieving event data. The PC software is available, but is not required to use the transformer monitor.
- **Operating Temperature.** The transformer monitor shall have an operating temperature range of –40° to +85°C (–40° to +185°F) and a power supply input operating voltage range of 85–264 Vac/85–275 Vdc.
- **Specification Compliance.** The transformer monitor front panel shall meet NEMA 12/IP54. The programmable automation controller shall be type tested to sections of C37.90, IEC 60255, IEC 60068, and IEC 61000 standards.
- **Reliability.** The vendor shall supply the actual measured Mean-Time Between Failures (MTBF) for the device upon request.
- **Service.** The device shall include no-charge technical support for the life of the product.
- **Manufacturer.** The manufacturer shall design and assemble all components including the printed-circuit boards in a wholly owned manufacturing facility within the United States.
- **Conformal Coating.** The device shall have optional conformal coating to protect the circuit boards from harsh environments.
- **Warranty Return.** The vendor shall support a 72-hour turn-around on all warranty repairs.
- **Warranty.** The device shall include a ten-year, no-questions-asked warranty for all material and workmanship defects. In addition, the warranty shall cover accidental customer-induced damage.

Front- and Rear-Panel Diagrams

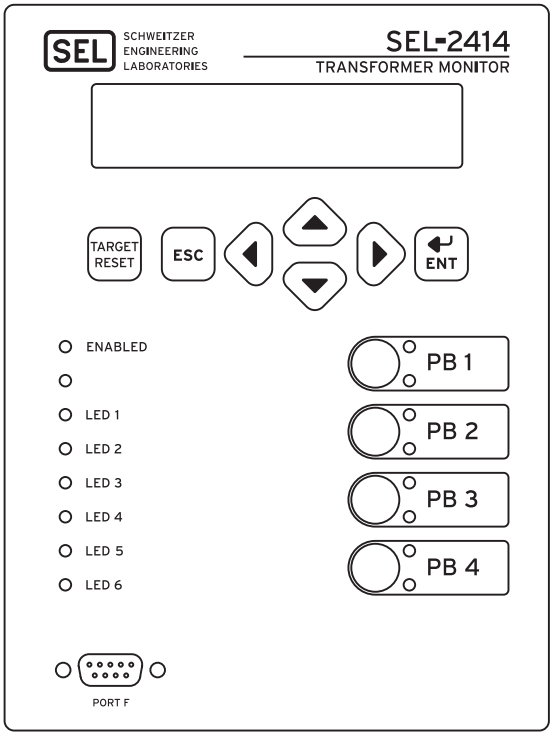
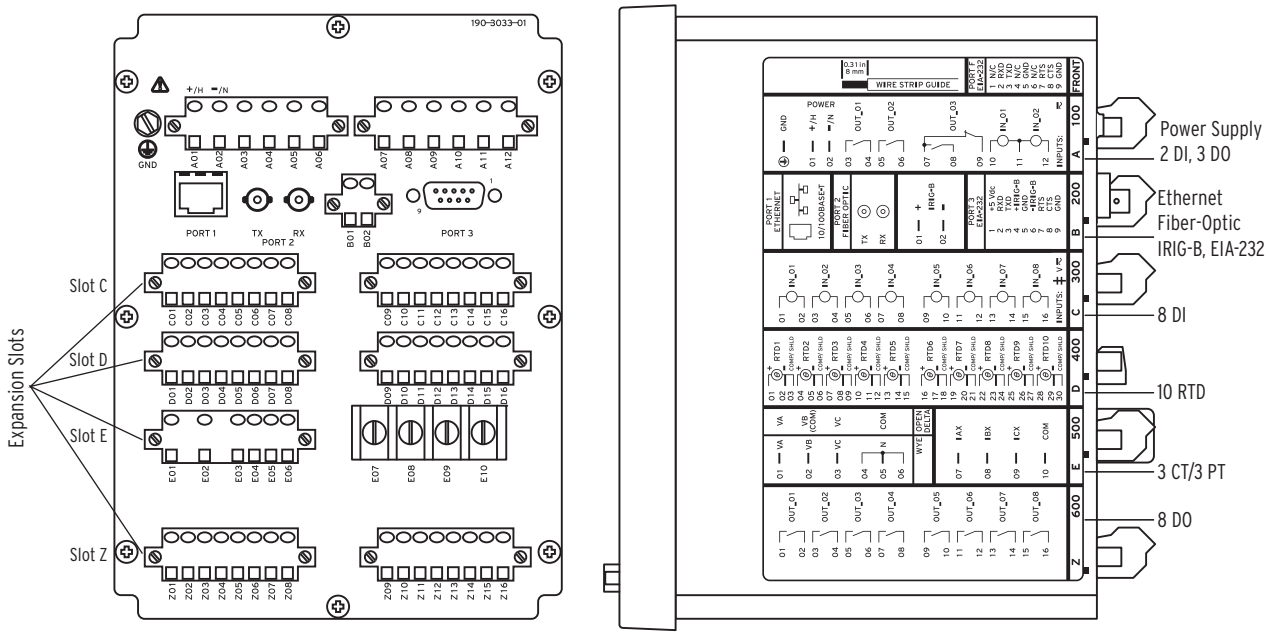


Figure 14 Front Panel With Default Configurable Labels



(A) Rear-Panel Layout (B) Side-Panel Input and Output Designations

Figure 15 Rear-Panel Connections and Labels

Dimensions

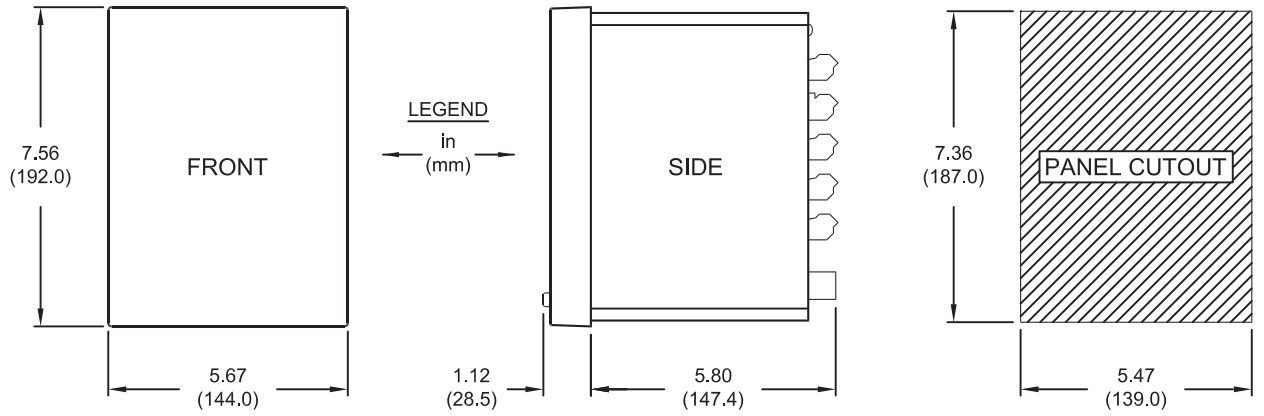


Figure 16 SEL-2414 Panel-Mount

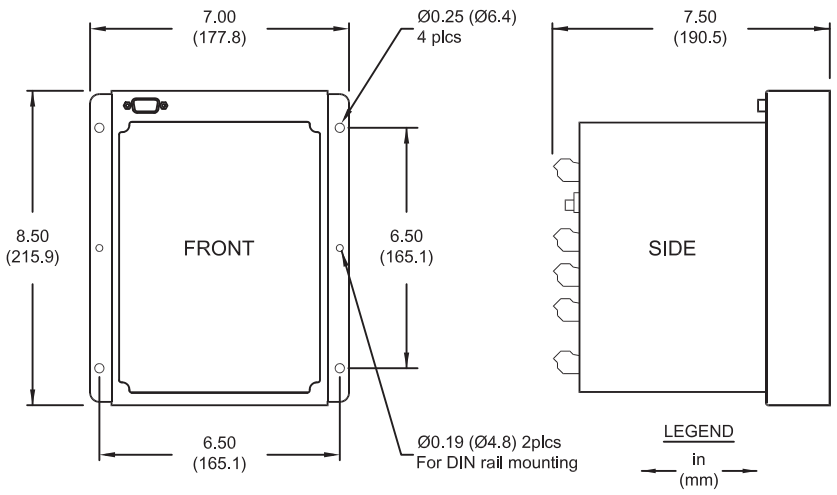


Figure 17 SEL-2414 Surface-Mount Dimensions

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL, cUL:	UL 508, CSA C22.2 No. 142
CSA:	CSA C22.2 No. 61010-1
CE Mark:	EMC Directive Low Voltage Directive
Hazardous Locations Approvals:	Complies with UL 1604, CSA 22.2 No. 213, and EN 60079-15.

General

Operating Temperature Range

–40° to +85°C (–40° to +185°F), per IEC 60068-2-1 and 60068-2-2.
Note: LCD contrast impaired for temperatures below –20°C and above +70°C (–4°F and +158°F, respectively).

UL/CSA Conformal Coated:	–40° to +75°C (–40° to +167°F)

Operating Environment

Pollution Degree:	2
Overvoltage Category:	II
Relative Humidity:	5–95%, noncondensing
Maximum Altitude:	2000 m

Dimensions

See *Figure 16* and *Figure 17*.

Weight

2.0 kg (4.4 lbs)

Frequency

System Frequency:	50, 60 Hz

Inputs

AC Current Input Phase

I_{NOM}	I_{NOM} = 5 A	I_{NOM} = 1 A
Rated Range:	0.1–96.0 A (according to IEC 60255-5, 60664-1)	0.02–19.20 A

Note: This is a linearity specification and is not meant to imply continuous operation.

Continuous Thermal Rating:	15 A (according to IEC 60255-6, IEEE C37.90-1989)	3 A
1 Second Thermal:	500 A (according to IEC 60255-6)	100 A
Rated Frequency:	50/60 ±5 Hz	50/60 ±5 Hz
Burden (per phase):	< 0.050 VA	< 0 .002 VA
Measurement Category:	II	

AC Current Input Neutral

I_{NOM}	I_{NOM} = 5 A	I_{NOM} = 1 A
Rated Range:	0.05–10.00 A (according to IEC 60255-5, 60664-1)	0.01–2.00 A

Note: This is a linearity specification and is not meant to imply continuous operation.

Continuous Thermal Rating:	15 A (according to IEC 60255-6, IEEE C37.90-1989)	3 A
1 Second Thermal:	500 A (according to IEC 60255-6)	100 A
Rated Frequency:	50/60 ±5 Hz	50/60 ±5 Hz
Burden (per phase):	< 0.1 VA	< 0 .01 VA
Measurement Category:	II	

AC Voltage Input (300 V)

Rated Operating Voltage (U_e):	100 –250 Vac
Rated Insulation Voltage:	300 Vac
10-Second Thermal:	600 Vac
Rated Frequency:	50/60 ±5 Hz
Burden:	< 0.1 W

DC Transducer (Analog) Inputs

Input Impedance:	
Current Mode:	200 Ω
Voltage Mode:	>10 kΩ
Input Range (Maximum):	
Current Mode:	±20 mA
Voltage Mode:	±10 V
Sampling Rate:	At least 5 ms
Step Response:	1 s

Accuracy at 25°C:

ADC:	16 bit
With user calibration:	0.05% of full scale (current mode) 0.025% of full scale (voltage mode)
Without calibration:	Better than 0.5% of full scale at 25°C

Accuracy Variation With Temperature:

± 0.015% per °C of full scale (± 20 mA or ±10 V)

DC Transducer (Analog) Inputs Extended Range Option

Input Impedance:	
Voltage Mode:	>10 kΩ
Input Range (Maximum):	
Voltage Mode:	±300 V
Sampling Rate:	At least 5 ms
Step Response:	1 s
Accuracy at 25°C:	
ADC:	16 bit
With user calibration:	0.025% of full scale (voltage mode)
Without calibration:	Better than 0.5% of full scale at 25°C
Accuracy Variation With Temperature:	
± 0.015% per °C of full scale (±10 V)	
CMRR Typical:	65 db at 60 Hz

Optoisolated Control Inputs

When Used With DC Control Signals:

250 V	ON for 200–275 Vdc	OFF below 150 Vdc
220 V	ON for 176–242 Vdc	OFF below 132 Vdc
125 V	ON for 100–135.5 Vdc	OFF below 75 Vdc
110 V	ON for 88–121 Vdc	OFF below 66 Vdc
48 V	ON for 38.4–52.8 Vdc	OFF below 28.8 Vdc
24 V	ON for 15–30 Vdc	OFF for < 5 Vdc

When Used With AC Control Signals:

250 V	ON for 170.6–275 Vac	OFF below 106 Vac
220 V	ON for 150.3–264 Vac	OFF below 93.2 Vac
125 V	ON for 85–150 Vac	OFF below 53 Vac
110 V	ON for 75.1–132 Vac	OFF below 46.6 Vac
48 V	ON for 32.8–60 Vac	OFF below 20.3 Vac
24 V	ON for 14–27 Vac	OFF below 5 Vac

Current Draw at Nominal DC Voltage:	2–4 mA (Except for 240 V, 8 mA)
Rated Insulation Voltage:	300 Vac
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

RTD Input Card

Number of Channels:	Ten 3-wire RTDs
Input Type: Supports the following RTD types on each independent input.	100 Ω platinum (PT100) 100 Ω nickel (NI100) 120 Ω nickel (NI120) 10 Ω copper (CU10)
Measuring Range:	–50°C to 250°C
ADC Resolution:	24 bit
Accuracy:	
CU10:	±1°C typical at 25°C
PT100, NI100, NI120:	±1°C typical at 25°C
CU10, PT100, NI100, NI120:	±2°C worst case
Resolution:	±1°C
Update Rate:	<3 s
CMRR (typical):	100 dBv
Noise Rejection:	Up to 1 Vrms 50/60 Hz

Universal Temperature Input Card

Number of Channels:	Ten (thermocouples or 3-wire RTDs)
Input Type: Supports the following RTD or TC types on each independent input.	100 Ω platinum (PT100) 100 Ω nickel (NI100) 120 Ω nickel (NI120) 10 Ω copper (CU10) J, K, T, E
Measuring Range	
RTDs:	–50° to 250°C
Thermocouples (TCs)	
J:	–200° to 1200°C
K:	–200° to 1370°C
T:	–200° to 400°C
E:	–200° to 950°C
ADC Resolution:	24 bit
Accuracy	
RTDs	
CU10:	±1°C typical at 25°C
PT100, NI100, NI120, CU10:	±0.1°C typical at 25°C
CU10, PT100, NI100, NI120:	±2°C worst case
TCs	
J, K, T, E:	±1°C with field calibration ±3°C without field calibration
Resolution:	±0.1°C
Update Rate:	< 3 s
CMRR (typical):	100 dBv
Noise Rejection:	Up to 1 Vrms 50/60 Hz
Isolation	
Number of Banks:	Two Banks (5 channels each)
Max. Working Common Mode:	250 Vdc
Cold Junction Compensation:	Automatic

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ
Accuracy:	±3 milliseconds

Outputs

General

OUT103 is Form C Trip Output, all other outputs are Form A.

Dielectric Test Voltage:	2000 Vac
Impulse Withstand Voltage (U_{imp}):	4000 V
Mechanical Durability:	10M no load operations

DC Output Ratings

Electromechanical

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C; 4 A @ 85°C
Continuous Carry (UL/CSA Derating with All Outputs Asserted):	5 A @ < 60°C; 2.5 A 60 to 70°C

Thermal: 50 A for 1 s

Contact Protection: 360 Vdc, 40 J MOV protection across open contacts

Operating Time (coil energization to contact closure, resistive load): Pickup or Dropout time ≤ 8 ms typical

Breaking Capacity (10,000 operations) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycles/second) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Fast Hybrid (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: < 50 µs, resistive load

Dropout Time: 8 ms, resistive load

Update Rate: 1/8 cycle

Breaking 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: Per IEC 60255-23:1994, using the simplified method of assessment.
Note: Make rating per IEEE C37.90-1989.

AC Output Ratings

Electromechanical

Maximum Operational Voltage (U_e) Rating: 240 Vac

Insulation Voltage (U_i) Rating (excluding EN 61010-1): 300 Vac

Utilization Category: AC-15 (control of electromagnetic loads > 72 VA)

Contact Rating Designation: B300 (B = 5 A, 300 = rated insulation voltage)

Voltage Protection Across Open Contacts: 270 Vac, 40 J

Rated Operational Current (I_e): 3 A @ 120 Vac
1.5 A @ 240 Vac

Conventional Enclosed Thermal Current (I_{the}) Rating: 5 A

Rated Frequency: 50/60 ±5 Hz

Pickup/Dropout Time: ≤ 8 ms (coil energization to contact closure)

Electrical Durability Make VA Rating: 3600 VA, cosϕ = 0.3

Electrical Durability Break VA Rating: 360 VA, cosϕ = 0.3

Fast Hybrid (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: < 50 µs, resistive load

Dropout Time: 8 ms, resistive load

Update Rate: 1/8 cycle

Breaking Capacity (10000 operations):

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

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

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

Note: Per IEC 60255-23:1994, using the simplified method of assessment.
Note: Make rating per IEEE C37.90-1989.

Analog Outputs

Current Ranges (Max): ±20 mA

Voltage Ranges (Max): ±10 V

Output Impedance For Current Outputs: ≥100 kΩ

Output Impedance For Voltage Outputs: ≤ 20 Ω

Maximum Load: 0–750 Ω current mode
> 2 kΩ voltage mode

Accuracy: ±0.55% of full-scale at 25°C

Step Response: 100 ms

Communications

Communications Ports

Standard EIA-232 (2 ports)

Location (fixed): Front Panel
Rear Panel

Data Speed: 300–38400 bps

Optional Ethernet port:

Single/Dual 10/100BASE-T copper (RJ45 connector)
Single/Dual 100BASE FX Multimode (LC connector)

Optional multimode fiber-optic serial port:

Class 1 LED product
Complies with IEC 60825-1:1993 + A1:1997 + A2:2001

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength: 1300 nm

Optical Connector Type: LC

Fiber Type: Multimode

Link Budget: 16.1 dB

Typical TX Power: –15.7 dBm

RX Min. Sensitivity: –31.8 dBm

Fiber Size: 50–200 µm

Approximate Range: ~6.4 Km

Data Rate: 100 Mb

Typical Fiber Attenuation: –2 dB/Km

Port 2 Serial

Wavelength: 850 nm

Optical Connector Type: ST

Fiber Type: Multimode

Link Budget: 8 dB

Typical TX Power: –16 dBm

RX Min. Sensitivity: –24 dBm

Fiber Size: 50–200 µm

Approximate Range:	~4 Km with 62.5 µm, ~1 Km with 200 µm
Data Rate:	5 Mb
Typical Fiber Attenuation:	–4 dB/Km

Optional Communications Card

Standard EIA-232 or EIA-485 (ordering option)

Data Speed:	300–38400 bps

Communications Protocols

Modbus® RTU slave or Modbus TCP
DNP3 Level 2 Outstation (LAN/WAN and Serial)
IEC 61850 Communications
Ethernet FTP
Telnet
SEL MIRRORED BITS (MBA, MBB, MB8A, MB8B, MBTB)
Ymodem file transfer on the front and rear port
Xmodem file transfer on the front port
SEL ASCII and Compressed ASCII
SEL Fast Meter
SEL Fast Operate
SEL Fast SER
SEL Fast Message unsolicited write
SEL Fast Message read request
SEL Event Messenger Points

Maximum Concurrent Connections

Modbus Slave:	1
DNP3 Level 2 Outstation:	3[a]
Ethernet FTP:	2
Telnet:	2

[a] Maximum in any combination of serial and/or LAN/WAN links.

Power Supply

Rated Supply Voltage

Low-Voltage Model:	24/48 Vdc
High-Voltage Model:	110/250 Vdc 110/230 Vac, 50/60 Hz

Input Voltage Range

Low-Voltage Model:	18–60 Vdc
High-Voltage Model:	85–275 Vdc 85–264 Vac

Power Consumption

AC:	< 40 VA
DC:	<15 W

Interruptions

Low-Voltage Model:	10 ms @ 24 Vdc 50 ms @ 48 Vdc
High-Voltage Model:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

AC Metering Accuracies

Current

Phase Current:	±0.5% typical, 25°C, 60 Hz, nominal current
Neutral Current:	±0.5% typical, 25°C, 60 Hz, nominal current
Negative Sequence (3I2):	±0.5% typical, 25°C, 60 Hz, nominal current (calculated)
Residual Ground Current:	±0.5% typical, 25°C, 60 Hz, nominal current (calculated)

Voltage

Line-Neutral Voltage:	±0.08% typical, 25°C, 60 Hz, nominal voltage
Line-Line Voltage:	±0.08% typical, 25°C, 60 Hz, nominal voltage
Negative-Sequence (3V2):	±0.5% typical, 25°C, 60 Hz, nominal voltage (calculated)

Power

Three-Phase Real Power (kW):	±1% typical, 25°C, 60 Hz, nominal voltage and current with 0.10 to 1.00 power factor
Three-Phase Reactive Power (kVAR):	±1% typical, 25°C, 60 Hz, nominal voltage and current with 0.00 to 0.90 power factor
Three-Phase Apparent Power (kVA):	±1% typical, 25°C, 60 Hz, nominal voltage and current

Power Factor

Three-Phase (wye connected):	±1% typical, 25°C, 60 Hz, nominal voltage and current (between 0.97 and 1)

Sampling and Processing Specifications

Without Voltage Card or Current Card

Analog Inputs	
Sampling Rate:	Every 4 ms
Digital Inputs	
Sampling Rate:	2 kHz
Contact Outputs	
Refresh Rate:	2 kHz
Logic Update:	Every 4 ms
Analog Outputs	
Refresh Rate:	Every 4 ms
New Value:	Every 100 ms
Timer Accuracy:	± 0.5% of settings and ±4 ms

With Either Voltage Card, Current Card, or Both Voltage and Current Cards

Analog Inputs	
Sampling Rate:	4 times/cycle
Digital Inputs	
Sampling Rate:	32 times/cycle
Contact Outputs	
Refresh Rate:	32 times/cycle
Logic Update:	4 times/cycle
Analog Outputs	
Refresh Rate:	4 times/cycle
New Value:	Every 100 ms
Timer Accuracy:	±0.5% of settings and ±1/4 cycle

Processing Specifications

AC Voltage and Current Inputs:	16 samples per power system cycle
Frequency Tracking Range:	44–66 Hz
Digital Filtering:	Cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Control Processing:	4 times per power system cycle or 4 ms if no current or voltage card (except for math variables and analog signals used in logic, which are processed every 100 ms)

Type Tests

Environmental Tests

IP Code:	IEC 60529:2001 IP34
Vibration:	IEC 60255-21-1:1988, Class 1 IEC 60255-21-3:1993, Class 2 IEC 60255-21-2:1988, Class 1
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 85°C, 16 hours

Dielectric Strength and Impulse Tests

Dielectric Strength:	IEC 60255-5:2000 IEEE C37.90-2005 2.5 kVac on analog inputs, contact I/O 3.1 kVdc on power supply and analog outputs
Impulse:	IEC 60255-5:2000 0.5 J, 5.0 kV

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 60255-22-2:2008 IEC 61000-4-2:2008 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 60255-22-3: 2007 IEC 61000-4-3:2010 10 V/m IEEE C37.90.2-2004, 35 V/m
Fast Transient, Burst Immunity:	IEC 60255-22-4:2008 IEC 61000-4-4:2011 4 kV @ 5 kHz 2 kV @ 5 kHz for comm. ports
Surge Immunity:	IEC 60255-22-5:2008 IEC 61000-4-5:2005 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 2.5 kV common-mode 1.0 kV differential-mode IEEE C37.90.1-2002, 2.5 kV oscillatory, 4 kV fast transient
Conducted RF Immunity:	IEC 60255-22-6:2001, 10 Vrms IEC 61000-4-6:2006, 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 1000 A/m for 3 seconds 100 A/m for 1 minute

EMC Emissions

Conducted Emissions:	IEC 60255-25:2000, Class A
Radiated Emissions:	IEC 60255-25:2000, Class A

SCHWEITZER ENGINEERING LABORATORIES
2350 NE Hopkins Court • Pullman, WA 99163-5603 USA
Phone: +1.509.332.1890 • Fax: +1.509.332.7990
Internet: www.selinc.com • E-mail: info@selinc.com

PDS2414-01