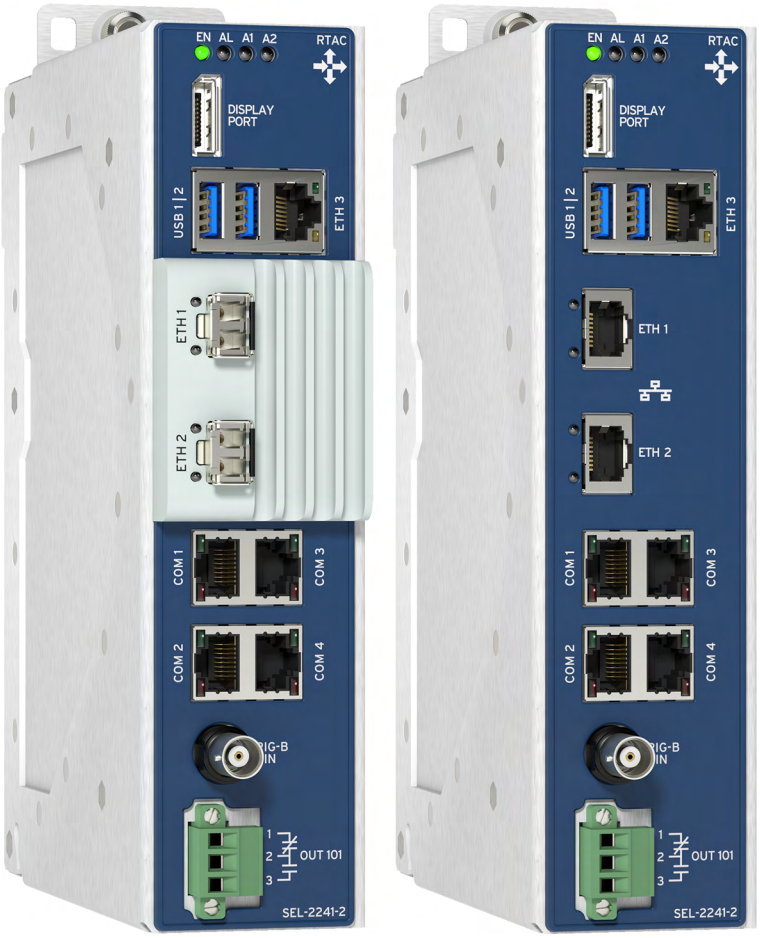
SEL-2241-2 Real-Time Automation Controller (RTAC)

High-Performance RTAC Module for the SEL-2240 Axion



Key Features and Benefits

The SEL-2241-2 is the next generation of automation and control for the SEL-2240 Axion® platform. Its rugged hardware enables you to deploy fully customized automation solutions into industrial environments. This module offers backward-compatibility for direct replacement in the Axion backplane.

- **Maximum Value.** With its Intel Atom quad-core processor and dense communication interfaces, the SEL-2241-2 delivers substantially higher performance and capabilities than a comparably equipped SEL-2241 RTAC.
- **SEL Worldwide, Ten-Year Product Warranty.** Have confidence in your solution and know that SEL will support you through the life of the product.
- **Full Industrial Temperature Range.** With a wide –40° to +85°C (–40° to +185°F) operating temperature range, the SEL-2241-2 will run your applications in harsh environmental conditions.

- **Local HMI.** Connect the DisplayPort and USB interfaces to high-resolution displays, touchscreens, or other HMI devices for local monitoring and control applications.
- **High-Speed Communication.** Go beyond traditional SCADA and phasor measurement unit (PMU) applications by using the Axion industry-exclusive communications, including the 3 kHz Axion Wave Server and energy packet streaming.
- **Flexible and Accurate Time Synchronization.** Synchronize to real time with sub-microsecond accuracy using IRIG-B or Precision Time Protocol (PTP) for PMU applications, IEC 61850 solutions, and more.

Product Overview

Each SEL Axion system requires an RTAC to serve as the system CPU. The SEL-2241-2 is the Axion module variant of the RTAC platform which is mounted in and receives power from the Axion backplane. The SEL-2241-2 provides comparable rugged hardware, communication capabilities, custom logic, and performance to the standalone SEL-3350 Automation and Computing Platform.

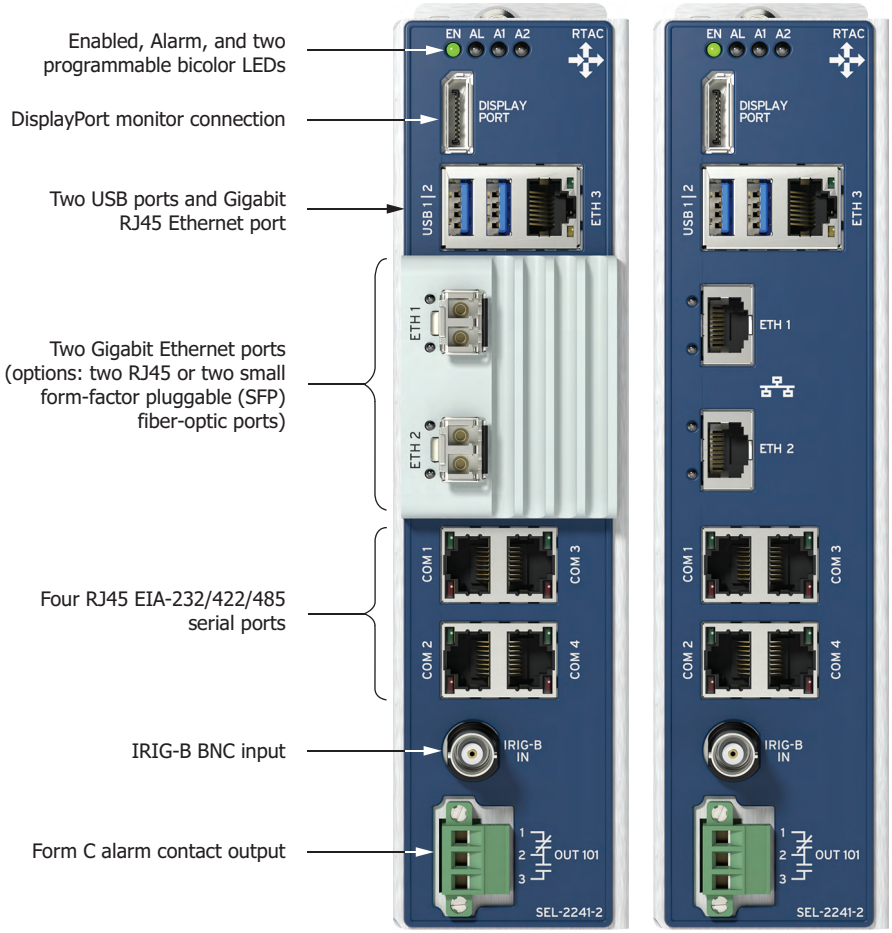


Figure 1 Product Overview

Features

X86-64 Architecture. The Intel Atom microprocessor architecture delivers high performance.

Form Factor. The SEL-2241-2 is designed for the Axion backplane. Mounting instructions are in the Mechanical Installation section of the *SEL-2240 Instruction Manual*.

Display Interface. A single DisplayPort interface enables connecting a high-definition display.

USB Connectivity. The USB ports provide connections to keyboards, mice, and touchscreen control interfaces. The current limiter of each port protects the system from external short circuits.

Ethernet. Three Ethernet ports provide high-speed, gigabit network connectivity through three independent Ethernet controllers, enabling connections to independent networks or redundant paired network connections. Options include two RJ45 or two SFP fiber-optic Ethernet ports.

Serial I/O. The SEL-2241-2 has 4 EIA-232/422/485 serial ports to communicate with electronic devices, such as automation controllers, protective relays, communication radios, and modems. Each port provides IRIG-B time distribution to the connected devices.

Contact Output. The SEL-2241-2 includes one Form C contact output (OUT101). The SEL-2241-2 system alarm normally controls the OUT101 output to notify external devices when the SEL-2241-2 or Axion system is experiencing abnormal operating conditions. Automation logic can also be used to control the OUT101 contact.

IRIG-B Input. Synchronize the system time to a satellite clock using the high-precision IRIG-B input. Distribute IRIG-B to downstream devices using the IRIG-B serial ports.

Watchdog. In the event of a system lockup, the watchdog can trigger a system reboot to attempt returning the system to a normal operating state.

Remote Management. The SEL-2241-2 supports remote access over Ethernet.

Application Examples

Remote Terminal Unit (RTU) and SCADA Data Concentrator

Use the SEL-2241-2 and Axion platform to effectively control and monitor digital and analog signals from station equipment. Collect SCADA information, process control commands, and achieve SNTP/NTP/PTP time synchronization through a single Ethernet link. Concentrate data from protective relays and other IEDs seamlessly, and configure the SEL-2241-2 to collect and view station-wide Sequential Events Recorder (SER) and event reports and then report these data to SCADA systems using a wide variety of industry-standard protocols. Remotely access the RTAC to monitor logs and diagnostics, and establish terminal sessions with any IED through Engineering Access communication channels. Ensure data safety with secure, encrypted communications across the substation network or serial channels.

Bay Control Unit (BCU)

Develop Bay Control applications with the SEL-2241-2 and the Axion Bay Controller backplane featuring a 7-inch color touchscreen display. This combination provides advanced automation, a powerful logic engine with preconfigured libraries, current and voltage measurement, and advanced communication protocols for comprehensive monitoring and reliably bay control. Choose from a variety of digital I/O and analog I/O modules to meet your bay control and monitoring requirements. The Axion Bay Controller's advanced automation and flexible I/O modules support any blocking or interlocking scheme required by substation switching devices, making it a cost-effective solution for monitoring and controlling substation bays at the transmission or distribution level.

Enhance Existing Axion Installations

Easily upgrade your Axion systems by using the SEL-2241-2 as a direct replacement for legacy SEL-2241 devices. The SEL-2241-2 delivers five times the performance of its predecessor and includes support for a local HMI via DisplayPort and USB connections. Connect to more devices with the increased server and client limitations. Develop advanced custom logic applications. Combine BCU applications with Axion Wave Server processing or streaming to get more value out of your existing Axion system.

Digital Fault Recorder

Use the SEL-2241-2 with Axion modules, including the SEL-2245-42 AC Protection and Digital Input modules, to implement DFR solutions.

- Record triggered oscillography records at 24 kilosamples per second (ksps) with Recording Group configuration for combining multiple module event reports, including digital values, into a single COMTRADE file.
- Stream PMU data (as fast as 120 messages per second (mps)) and oscillography at 3 ksps, providing significantly more visibility into power system behavior than intermittent event reports.

- Record as many as 500,000 millisecond-accurate substation Sequence of Events logs.
- Monitor fault locations on transmission line assets.

Axion Wave Server Streaming

The time-synchronized waveform streaming system includes SEL-2240 Axion devices with SEL-2245-42 AC Protection Modules. These modules provide three current and three voltage measurements at 3 ksps to SEL Synchrowave software via the Axion Wave Server protocol in the SEL-2241-2 RTAC. This protocol is based on IEEE C37.118, but the packet consists of time-domain sampled data rather than calculated phasor data. The waveform streaming system supports as many as 96 channels per SEL RTAC and works with both SEL-5702 Synchrowave® Operations and SEL-5703 Synchrowave Monitoring.

Diagrams and Dimensions

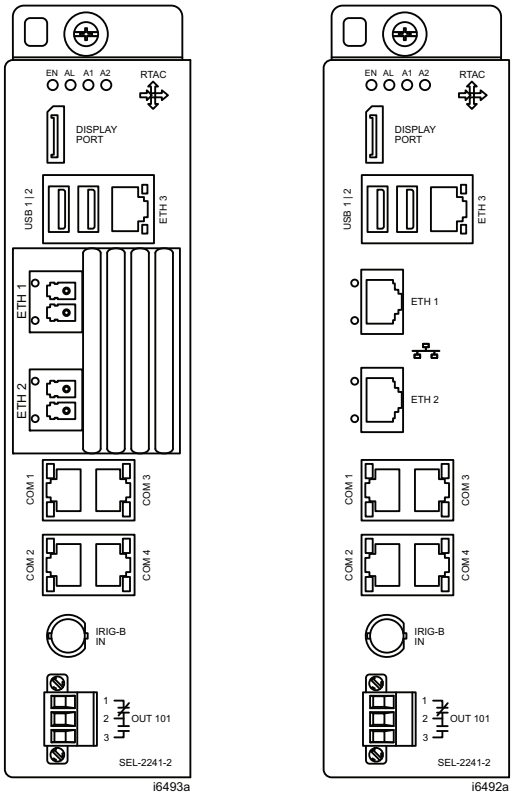


Figure 2 SEL-2241-2 Connections Diagram

Specifications

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 E220228; NRAQ)

CE Mark

UKCA Mark

General

SEL Operating System

SEL Real-Time Automation Controller (RTAC)

CPU

Processor:	Intel Atom x5-E3940
Core/Threads:	4/4
Frequency:	1.6 GHz
Cache:	2 MB L2

RAM

4 GB ECC SDRAM

Mass Storage

8 GB eMMC

BIOS

AMI UEFI

Real-Time Clock/Calendar

Battery Type:	IEC No. BR-1632A Lithium
Battery Life:	10 years with power 2 years without power
Drift:	200 ppm

Trusted Platform Module

Infineon SLM 9670AQ TPM 2.0

Network Time Protocol (NTP) Modes

NTP Client (synchronize to as many as three NTP servers)

NTP Server

Simple Network Time Protocol (SNTP) Accuracy

±1 ms (excludes external factors such as network switches and topologies)

Precision Time Protocol (PTP)

PTP Client:	Peer delay request and end-to-end path delay supported

Operating Environment

Operating Temperature Range:	–40° to +85°C (–40° to +185°F)

Note: UL maximum ambient 40°C. See the SEL-2240 instruction manual safety information for additional restrictions.

Storage Temperature Range:	–40° to +85°C (–40° to +185°F)
Relative Humidity:	5%–95%, noncondensing
Insulation Class:	1
Pollution Degree:	2

Overvoltage Category

Category	Maximum Altitude	Atmospheric Pressure
Category III	2000 m	54–110 kPa

Peripheral Connections

Video and Audio

Intel HD Graphics 500 Controller

DisplayPort 2.1 output

Intel Display Audio digital audio output

Maximum Resolution*: 4096 x 2160 @ 60 Hz

Use DisplayPort cables that have ferrite chokes and are less than 2 m (6 ft) in length for Electromagnetic Compatibility Immunity compliance.

* Note: High-resolution displays require high-quality cables. Ensure your display cables are as short as possible and rated for the required screen resolution.

USB

2 USB A ports

200 mA maximum combined current

Use USB cables that have ferrite chokes and are less than 2 m (6 ft) in length for Electromagnetic Compatibility Immunity compliance.

Communications Ports

Ethernet

SEL Gigabit Ethernet controllers

One 10/100/1000 Mbps port, RJ45 copper

Configurations: 2 RJ45 copper ports
2 SFP fiber-optic ports

Use RJ45 Ethernet cables that are less than 10 m (33 ft) in length for protection-level performance and for Surge Immunity Zone A compliance.

Serial

SEL multiport serial controller

EIA-232/422/485 Ports: 4 ports

RJ45 connectors

300–115,200 bps

256 byte TX and RX FIFOs each port

+5 Vdc port power

COM 1–4: 200 mA maximum combined current

IRIG-B output

Use serial cables less than 10 m (33 ft) for Electromagnetic Compatibility Immunity compliance.

Time-Code Inputs and Outputs

Time-Code Inputs

One BNC IRIG-B input

Format:	IRIG-B002 or -B004 (demodulated)
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	≥1.2 kΩ at 5 V Signal Level
Constant Load:	≤4 mA

50 Ω termination recommended at furthest device from signal driver.

Note: IRIG-B004 control bits comply with IEEE C37.118.1-2011 (backward-compatible with IRIG-B000 and IEEE C37.118-2005).

Time-Code Outputs

All RJ45 Serial Ports

Format:	IRIG-B004 (demodulated)
On (1) State:	$V_{oh} \geq 2.4$ V
Off (0) State:	$V_{ol} \leq 0.8$ V
Output Drive Capacity	
Each Serial Port:	TTL 6 mA (>400 Ω)

Note: IRIG-B004 control bits comply with IEEE C37.118.1-2011 (backward-compatible with IRIG-B000 and IEEE C37.118-2005).

Standard Output Contact OUT101/Alarm

Output Type:	Relay Form C Break Before Make
Pilot Duty Ratings*:	B300 (UL), AC-15 (IEC) R300 (UL), DC-13 (IEC)
Rated Voltage†:	24–250 Vdc 110–240 Vrms

Note: The voltage across the contact output terminals must not exceed the operational voltage.

Operational Voltage†:	0–300 Vdc 0–264 Vrms
Contact Protection:	MOV protection across open contact 264 Vrms continuous voltage 300 Vdc continuous voltage
Continuous Carry†:	6 A @ 70°C, 4 A @ 85°C
Pickup/Dropout Time†:	≤6 ms (resistive load)
Power Supply Burden†:	≤1 W
Mechanical Endurance†:	10,000 no-load operations
Make (Short-Duration Contact Current)†:	30 Adc 1,000 operations @ 250 Vdc 2,000 operations @ 125 Vdc

Note: 200 ms on, 15 ms off, current interrupted by independent means.

Short-Time Thermal Withstand†:	50 A for 1 s
Limiting Making Capacity†:	1,000 W @ 250 Vdc (L/R = 40 ms)
Limiting Breaking Capacity/ Electrical Endurance†:	10,000 operations 10 operations in 4 s, followed by 2 min idle

Rated Voltage	Resistive Break	Inductive Break L/R = 40 ms (DC) PF = 0.4 (AC)
24 Vdc	1.25 Adc	1.25 Adc
48 Vdc	0.63 Adc	0.63 Adc
125 Vdc	0.30 Adc	0.30 Adc
250 Vdc	0.20 Adc	0.20 Adc
110 Vrms	0.30 Arms	0.30 Arms
240 Vrms	0.20 Arms	0.30 Arms

* Per UL 508 and IEC 60947-5-1 for IEC 61010-2-201 compliance.
† Parameters verified by SEL per IEC 60255-1:2009 and IEEE C37.90-2005.

Product Standards

Communications Equipment in Utility Substations:	IEC 61850-3:2013 Performance Class 1
Electrical Equipment for Measurement, Control, and Laboratory Use:	UL 61010-1:2019, CAN/CSA-C22.2 No. 61010-1-12 (R2022) UL 61010-2-201:2018, CAN/CSA-C22.2 No. 61010-2-201:18 (R2023)
Measuring Relays and Protection Equipment:	IEC 60255-26:2013 IEC 60255-27:2013
Safety of Laser Products:	EN 60825-1:2014 EN 60825-2:2004 + A1:2007 + A2:2010

Type Tests

Note: To ensure protection-level EMI and EMC performance, type tests were performed using shielded Ethernet and serial cables with the shield grounded at both ends of the cable and using USB and video cables with ferrite chokes.

Environmental Tests

Enclosure Protection:	IEC 60255-27:2013 IEC 60255-27:2023 IEC 60529:1989 + A1:1999 IEC 60529:1989 + A1:1999 + A2:2013
As Installed (IEC 60529):	Top/Bottom Ventilation Holes: IP3X Elsewhere: IP2X
Vibration Resistance:	IEC 60255-21-1:1988 Vibration Endurance, Severity: Class 2 Vibration Response, Severity: Class 2
Shock Resistance:	IEC 60255-21-2:1988 Bump Withstand, Severity: Class 1 Shock Withstand, Severity: Class 1 Shock Response, Severity: Class 2
Seismic:	IEC 60255-21-2:1988 Seismic Response, Severity: Class 2
Cold, Operational and Cold, Storage:	IEC 60068-2-1:2007 –40°C, 16 hours
Dry Heat, Operational and Dry Heat, Cyclic:	IEC 60068-2-2:2007 +85°C, 16 hours
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25°C to 55°C, 6 cycles, 95% relative humidity
Damp Heat, Steady State:	IEC 60068-2-78:2001 93% relative humidity and 55°C for 10 days
Change of Temperature:	IEC 60068-2-14:2009 1 deg. per minute, –40°C and +85°C, 5 cycles

Dielectric Strength and Impulse Tests

Impulse:	IEC 60255-27:2013 IEC 61850-3:2013 Severity Level: 0.5 J, 5 kV digital I/O, IRIG 0.5 J, 1.5 kV Ethernet IEEE C37.90:2005 Severity Level: 0.5 J, 5 kV digital I/O, IRIG 0.5 J, 1.5 kV Ethernet
Dielectric (HiPot):	IEC 60255-27:2013 IEC 61850-3:2013 Severity Level: 2.5 kVac on digital I/O, IRIG-IN 1.5 kVac on Ethernet IEEE C37.90:2005 Severity Level: 2.5 kVac on digital I/O, IRIG-IN 1.5 kVac on Ethernet

RFI and Interference Tests

Slow Damped Oscillatory Waves*:	IEC 61000-4-18:2006 + A1:2010 Severity Level: 2.5 kV differential/common mode for digital I/O 1 kV common mode for Ethernet, serial, IRIG

* Ports or applications with cable lengths limited to <2 m (<6 ft) are excluded from the Damped Oscillatory Wave test.

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEEE C37.90-3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEEE C37.80.2:2004 Severity Level: 20 V/m IEC 61000-4-3:2006 + A1:2007 + A2:2010 Severity Level: 10 V/m
Conducted RF Immunity:	IEC 61000-4-6:2014 Severity Level: 10 Vrms

Surge Immunity*: IEC 61000-4-5:2005
IEC 61000-4-5:2014 + A1:2017
Severity Level:
Zone A:
2 kV line-to-line
4 kV line-to-earth
Zone B:
2 kV line-to-earth

Surge Immunity Cable Length Requirements

IEC 60255-26 Port Classification	Ethernet Length Restrictions
Zone A Protection	<10 m (<33 ft)
Zone A Communication	<10 m (<33 ft)
Zone B Protection	<10 m (<33 ft)
Zone B Communication	None

Surge Immunity Port Classifications

SEL-2240 Port	IEC 60255-26 Port Classification
IRIG-B In	Zone B
Serial*	Zone A
DisplayPort*	Zone A
USB*	Zone A
Digital I/O	Zone A

* Ports or applications with cable lengths limited to <10 m (<33 ft) are excluded from the Surge test.

Fast Transient, Burst Immunity*: IEC 61000-4-4:2012
Severity Level: 4 kV, 5 kHz

* Ports or applications with cable lengths limited to <2 m (<6 ft) are excluded from the Fast Transient, Burst Immunity test.

Magnetic Field Immunity: IEC 61000-4-9:2016
Severity Level: 1,000 A/m pulsed
IEC 61000-4-8:2009
IEC 61000-4-8:1993
Severity Level:
1,000 A/m for 3 seconds
100 A/m for 1 minute
IEC 61000-4-10:2016
IEC 61000-4-10:1993 + A1:2000
Severity Level: 100 A/m

Surge Withstand Capability Immunity*: IEEE C37.90.1:2012 + ERTA:2013
2.5 kV oscillatory, 4 kV fast transient

* Ports or applications with cable lengths limited to <2 m (<6 ft) are excluded from the Surge Withstand Capability test.

Markings: IEC 60255-27:2013
IEC 60255-27:2023
IEC 61850-3:2013
IEC 61010-1:2010 + A1:2016
UL 61010-1 Third Edition

Radiated and Conducted Emissions: EN 55011:2009 + A1:2010
EN 55022:2010 + AC:2011
EN 55032:2015 + A11:2020
CISPR 11:2009 + A1:2010
CISPR 22:2008
CISPR 32:2015 + A1:2019
CSA CISPR 11:19
ANSI C63.4:2014 + a:2017KS C 9832:2015
47 CFR Part 15.109
47 CFR Part 15.107
Severity Level: Class A

SEL-2240 DFR Specifications

Channel Counts

Analog Input Count: Supports as many as 96 analog channels from SEL-2245-42 module(s)* (more channels may be supported depending on EtherCAT® bandwidth limitations)

Digital Input Count: Supports as many as 54 Digital Input modules (SEL-2244-2 or SEL-2244-4)†

* For capabilities and specifications of the analog input and digital input modules, see the SEL-2240 Data Sheet, available at selinc.com.

† Axion I/O supports as many as 60 modules across 6 Axion nodes. The "as many as" denotes the maximum; this value decreases as other Axion I/O modules are added to the project.

Triggered Fault Recording

Recording Rates: 1, 2, 4, 8, 24

Maximum Individual Recording Lengths in Seconds (for above rates, respectively): 576, 288, 144, 72, 24

Trigger Parameters: Over- and Undercurrent
Over- and Undervoltage
Real, Reactive, and Apparent Power
Sequence Component Currents and Voltages
THD
Harmonics and Interharmonics (up to 63rd)

Cross-trigger DFR records via Digital Input modules or via Ethernet communications links between devices.

Record Count: as many as 1,024

COMTRADE formatted records (COMNAME standard)

Sequence of Event (SOE) Storage

Maximum of 500,000 SOE records with 1 ms accuracy

Phasor Measurement Data Streaming

C37.118 Stream Synchrophasor quantities to SEL-5073 Synchrowave® Monitoring or external PDC.

Stream 3,000 sample per second oscillography data to Synchrowave Monitoring.

Time Synchronization (1 ms Accuracy)

PTP with optional redundant sources

IRIG-B

Fault Location

Single-ended, impedance-based

Requires 24 kHz event recording from SEL-2245-42 AC Protection Modules

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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