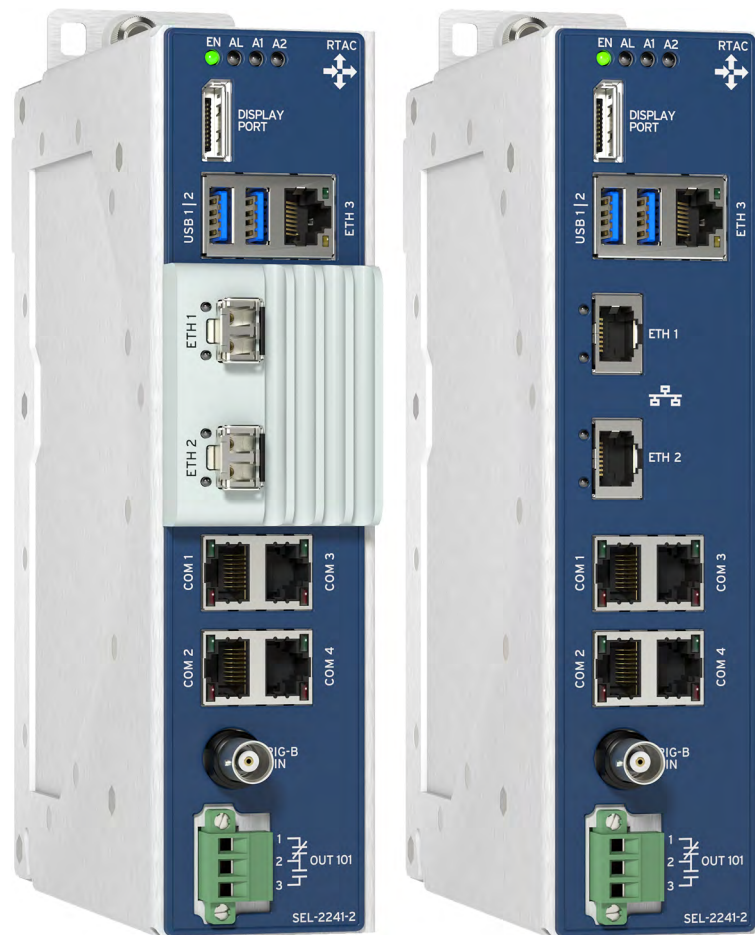




# SEL-2241-2 Real-Time Automation Controller (RTAC)

## 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<sup>®</sup> 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  $-40^{\circ}$  to  $+85^{\circ}\text{C}$  ( $-40^{\circ}$  to  $+185^{\circ}\text{F}$ ) 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.

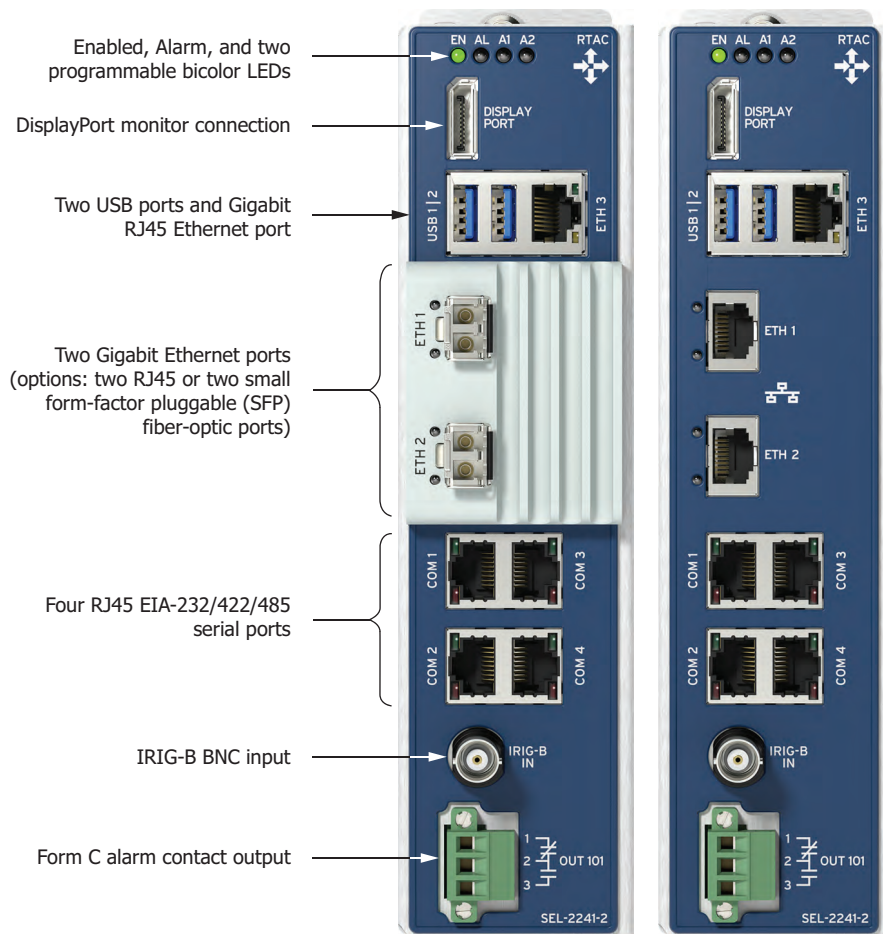


Figure 1 Product Overview

# Features

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**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

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## 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, SEL-2245-43 12 Channel AC Input, 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 kps, 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.
- ▶ Configure DFR systems easily with the SEL-5033 DFR Extension.

- ▶ Use SEL-2245-43 modules paired with non-intrusive split-core CTs to eliminate the need to modify secondary CT wiring and support high-density current-input measurements.
- ▶ Apply field calibration to compensate for gain and phase errors introduced by the split-core CT connections.

## 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 kps to SEL Synchronwave 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 Synchronwave<sup>®</sup> Operations and SEL-5703 Synchronwave Monitoring.

## Diagrams and Dimensions

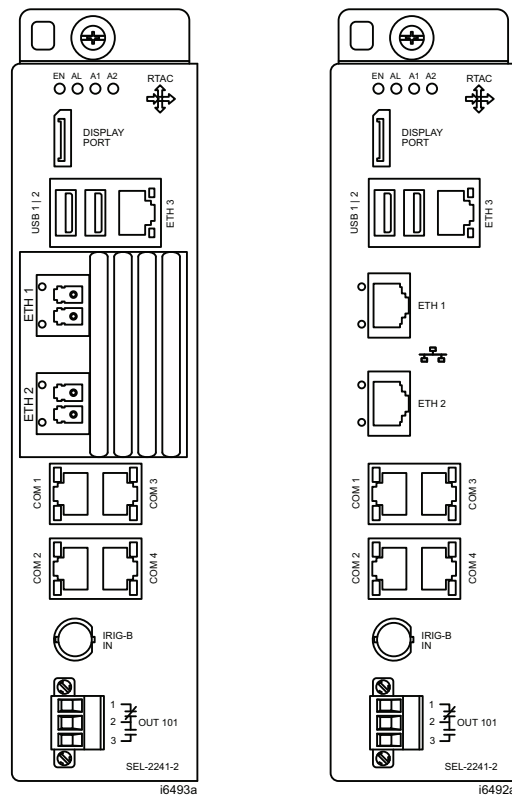


Figure 2 SEL-2241-2 Connections Diagram

# 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:  $V_{ih} \geq 2.2 \text{ V}$   
Off (0) State:  $V_{il} \leq 0.8 \text{ V}$   
Input Impedance:  $\geq 1.2 \text{ k}\Omega$  at 5 V Signal Level  
Constant Load:  $\leq 4 \text{ mA}$

50  $\Omega$  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:  $V_{oh} \geq 2.4 \text{ V}$   
 Off (0) State:  $V_{ol} \leq 0.8 \text{ V}$

Output Drive Capacity

Each Serial Port: TTL 6 mA (>400  $\Omega$ )

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†:  $\leq 6 \text{ ms}$  (resistive load)

Power Supply Burden†:  $\leq 1 \text{ W}$

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 60255-21-3:1993  
 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 192 analog inputs\* (SEL-2245-42 or SEL-2245-43)†. More channels may be supported depending on EtherCAT® bandwidth limitations‡.

Digital Input Count: Supports as many as 1,728 digital inputs (SEL-2244-2 or SEL-2244-4)†

\* An SEL-3555 RTAC is required for systems with more than 96 analog channels

† 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\*

\* A maximum of 12 seconds is required for systems with more than 96 channels.

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

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

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