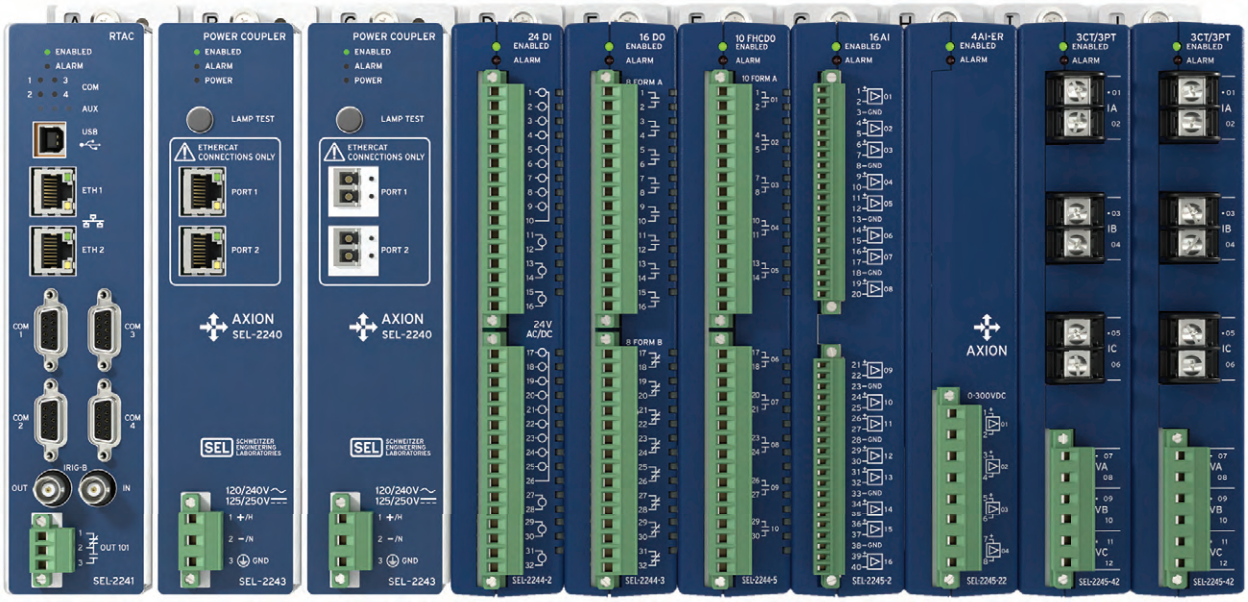
SEL-2240 Axion

Rugged Digital I/O, Analog I/O, Current and Voltage Measurements, and Control for Your Toughest Applications



The SEL Axion® is a fully integrated modular digital I/O, analog I/O, current and voltage measurement, and control solution suitable for many utility and industrial applications. It combines the communications, built-in security, and IEC 61131 logic engine of the SEL Real-Time Automation Controller (RTAC) family with a durable suite of I/O modules that provide high-speed, deterministic, control performance over an EtherCAT® backplane.

Major Features and Benefits

- **High-Speed and High-Accuracy DC Analog Control.** Use the Axion DC Analog Output module to provide high-accuracy current and voltage control signals for low-level self-wetted (sourcing) control applications.
- **Proportional Integral Derivative (PID) Control.** Use the PID function block to provide advanced closed-loop control for analog set points commonly used in generator and process control.
- **Synchronized Current and Voltage Measurements.** Retrieve high-accuracy current and voltage measurements with the advantage of synchronized measurements. Multiple CT/PT modules in an Axion system sample all measurements at the same time to ensure a common reference for all voltages and currents. This enables many time-deterministic control applications without performing additional processing to align the measurements to a reference. Use this capability to accomplish complex control schemes including load shedding, microgrid control, and autosynchronization.
- **Top of Second Synchronized Measurements.** When connected to IRIG, synchronize the measurement of all CT/PT modules to the top of the second. This enables Axions in geographically dispersed locations to run algorithms on voltage and current measurements and provide time-aligned data from all the Axion modules. This expands time-deterministic control capability to wide-area applications because the CT/PT measurements from multiple Axion systems are all synchronized.

- **Protection Against Malware and Other Cybersecurity Threats.** Protect your RTAC system with exe-GUARD®, which uses advanced cryptographic algorithms to authorize the execution of any program or service on the system. Any tasks not approved by the whitelist are blocked from operation.
- **RTU and PLC in a Single System.** Employ the Axion's I/O, SCADA communications, and control logic support in many industrial and utility applications.
- **Simple Setup With ACSELERATOR RTAC® SEL-5033 Software.** Use standard device templates to build a system, including I/O modules, quickly.
- **Flexible I/O Selections.** Choose a custom mix of digital and analog I/O modules that suit the application. Include hundreds of points in a single panel, all connected to a deterministic EtherCAT backplane.
- **Advanced User Authentication and System Security.** Enforce LDAP user accounts to maintain security perimeter integrity. Apply corporate logging and port control policies to comply with NERC/CIP requirements.
- **Integrated Web-Based Human-Machine Interface (HMI).** Integrate the SEL-2241 RTAC module directly into the Axion system. The RTAC, via the embedded web server, includes a flexible graphical HMI system.
- **Deterministic I/O Performance.** Update connected I/O at a deterministic frequency; all inputs provide 1 ms Sequential Events Recorder (SER) time stamps.
- **More than SCADA.** Go beyond SCADA by using the Axion industry-standard communications protocols to enable multiple SCADA connections, as well as distributed control networks, among many stations.
- **Networking Options.** Implement I/O networks that use optional fiber-optic cables to provide outstanding signal isolation and flexibility in module placement.
- **Standard IEC 61131-3 Logic Design.** Create innovative logic solutions directly in ACSELERATOR RTAC by using editor tools such as Ladder Diagram, Tag Processor, Structured Text, or Continuous Function Chart.
- **Redundant Power Supplies.** Install optional dual SEL-2243 power couplers for applications needing redundant power sources.

Product Overview

Functional Diagram

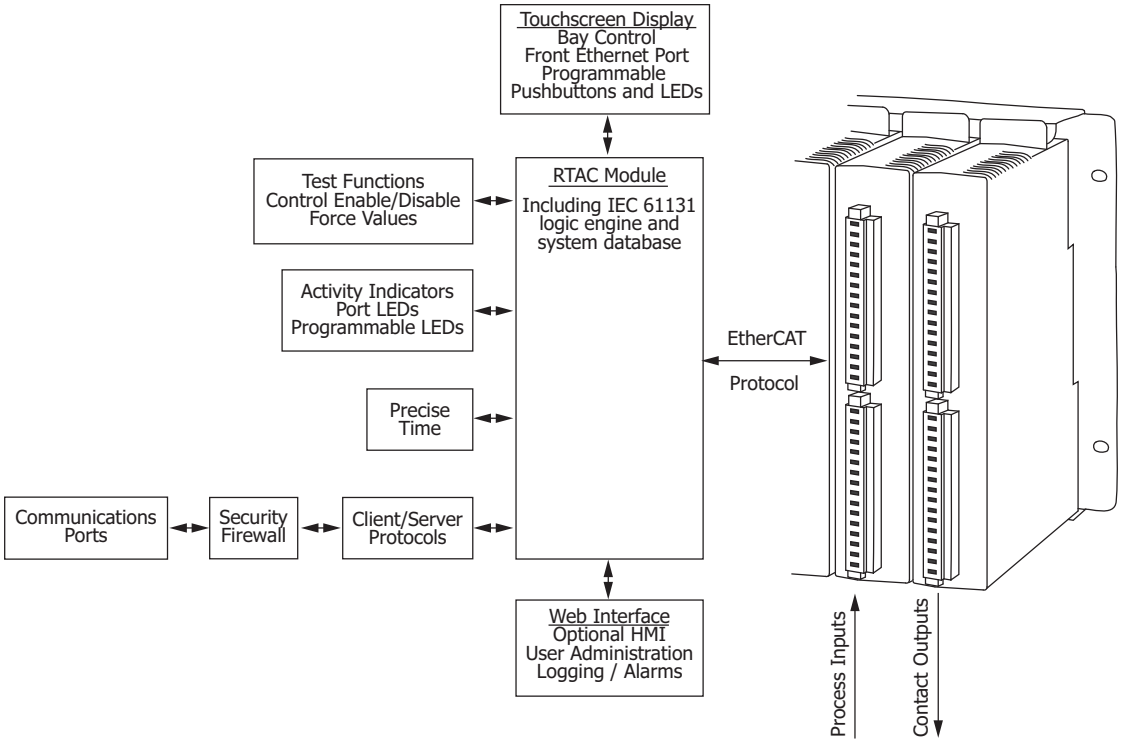


Figure 1 Functional Diagram

Flexible System Architecture

Today's monitoring and control applications need flexible system architectures and integrated security. The Axion meets these needs by using SEL RTAC as the system CPU. Two configurations are possible. There can be an SEL-2241 RTAC module installed directly in the Axion node, or the node can be connected to a standalone RTAC. A standalone SEL RTAC (e.g., SEL-3350) RTAC connects via Ethernet to an SEL-2240 node.

NOTE: The SEL-2242 backplane with 7-inch touchscreen display is only compatible with the SEL-2241 RTAC module in Slot A. See the SEL-2240 Axion Bay Controller data sheet for more details.

SEL designs all Axion hardware to published standards (see *Specifications* on page 25) and performs tests to verify that each component exceeds standards by adequate margins. The Power Coupler module (model SEL-2243) is a highly reliable device that uses the same power supply technology presently in use in SEL protective relays. Configure the SEL Axion to include single or redundant power couplers for critical applications. In redundant configurations, the pair of SEL-2243 modules actively share loads to supply power for the entire node. If one module should become unavailable, the remaining power coupler can accommodate the entire node with no loss of system capability. Employ dual power couplers for installations where you have dual power sources, one that is ac and one that is dc.

Figure 2 Modules Installed in Chassis/Backplane

Each Axion node is mounted in a chassis/backplane (model SEL-2242) that provides a means for each node to include a custom arrangement of modules. A single node can contain as many as nine modules. Use any combination, quantity, and sequence of modules that suits the application.

The node does not need to be entirely full to function properly. Leave empty slots for future expansion as necessary. Many RTU and control systems need more I/O points than will fit in a single Axion node. In those cases, use the EtherCAT protocol to connect multiple nodes together via a real-time Ethernet network. Through use of an Axion system EtherCAT network, you can use as many as 60 modules in a single network with no loss of speed or determinism. *Applications* on page 5 explores several possible network configurations. In each implementation, a single RTAC module provides logic functions and data concentration for the entire network.

RTU and PLC Functionality

The Axion is both a remote terminal unit (RTU) and ultra-rugged programmable logic controller (PLC). All the modules are rated from –40°C to +85°C and can optionally include conformal coating. The system is designed to be flexible; use the right combination of modules and nodes, in almost any arrangement, to suit the job. The SEL-2244 Digital Output Module has trip-rated contacts (30 A make, 6 A carry) to limit the need for interposing relays.

The SEL-2241, SEL-3530, and SEL-3530-4 RTACs all interface seamlessly with the I/O modules and provide easy integration with other serial and Ethernet devices via preinstalled communications protocols. The RTACs also support multiple SCADA/HMI channels. For high-speed communication, use EtherCAT fieldbus connections to I/O modules or optional IEC 61850 GOOSE messaging with station IEDs. Poll data sets and reports from other IEDs with optional IEC 61850 MMS client.

With the Axion, you need no optional hardware or software to have the programmable logic engine required for many applications. Each RTAC includes an IEC 61131 logic engine that ships preconfigured to provide access for all system tags, intelligent electronic device (IED) and I/O data, diagnostics, alarms, security events, and communications statistics. The RTAC provides unified tag mapping between protocols and programmable logic that simplifies developing applications. You simply use any necessary IED and I/O data, calculated values, and system tags in deterministic logic for the control of critical applications.

Management of the task processing sequence and solve rate in the RTAC is similar to that for traditional PACs. Optimize processor use by setting the processing rate no faster than necessary for your application.

Task processing in the logic engine includes protocols, I/O, system management, and any custom logic programs you create using Structured Text (ST), Ladder Logic Diagrams (LD), or Continuous Function Charts (CFC). CFC programs are type of IEC 61131-3 Function Block Diagram (FBD) that provide more programming flexibility than standard FBDs. The ACSELERATOR RTAC software, free of charge with purchase of an SEL RTAC, includes the IEC 61131-3 and Tag Processor editors you will use to manage any protocol information and custom logic necessary for your system.

Secure Operation

You can use the built-in web interface to manage user accounts and system alarms remotely. Each user account has a unique username, password, and assigned role that defines system permissions. You can also configure the system to use LDAP central authentication for user account management. There are webpages for monitoring user logs and maintaining network policies.

By enabling Ethernet and serial ports independently, you can minimize any security threat from unused but enabled ports. Employ SSH encryption for remote engineering access to further protect the system. Combine the Axion with other SEL security solutions to simply deploy a solution that meets your needs for maintaining a secure electronic perimeter for the control system.

Seamless System Configuration

ACSELERATOR RTAC is a Microsoft Windows-compatible configuration software for offline and online use with the SEL-2241, SEL-3530, and SEL-3530-4 RTACs. A project in ACSELERATOR RTAC contains the complete configuration, settings, and logic for an individual RTAC device. Preconfigured device and I/O module templates are available for you to quickly create all device and master connections for the project.

Once you create the settings for a specific device connection, improve engineering efficiency by saving a custom device template for later use with similar projects. Share custom templates via email or network for even greater savings. The application also includes complete project templates for some common project types.

The Tag Processor view facilitates the mapping of operational data between IEDs and SCADA. ACSELERATOR RTAC is compatible with Microsoft Excel and other programs, so you can save time and increase accuracy by copying SCADA maps from the source document.

There is no need to install or learn more than one software interface. Use the included Structured Text, Ladder Diagram, or Continuous Function Chart editors to develop custom IEC 61131 logic.

Enable remote monitoring and control functions by using the optional web-based HMI for any of the RTAC devices. *Figure 3* shows an example of a screen displaying operational data and secure controls from connected I/O and other devices. Every tag in the database is available for use in HMI screens.

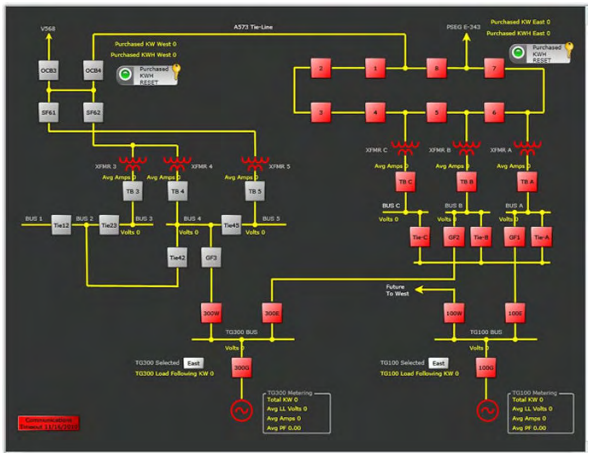


Figure 3 Powerful Monitoring Functions Using the Web-Based HMI

Deterministic System Performance

If your application includes distributed control strategies, sequential logic, or SER reports, the deterministic performance of EtherCAT will meet your needs. The software updates all I/O and time-stamps inputs with 1 ms accuracy. Log any tag values and system events to provide a system-wide SOE report that you can view online. You can also use an ODBC connection to transfer the logs to a central database.

Applications

Load Shedding for Industrial Applications

The Axion system eliminates the need for separate input, output, and control devices for industrial and microgrid load-shedding schemes. Combining system frequency and power measurements with the ability to add hundreds of binary inputs and outputs, the Axion combines the measurement, logic engine, and mitigation equipment into a single unit. Employing the CT/PT module's frequency and power elements, the powerful logic engine in the Axion incorporates system variables into fast-acting control logic for underfrequency or demand control load shedding. Complete with the HMI, the Axion is a standalone control system for many remedial action schemes.

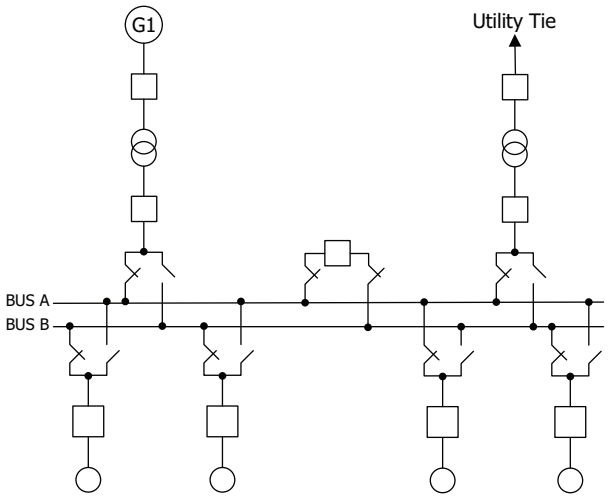


Figure 4 Load-Shedding Topology

Microgrid Control Applications

The SEL-2245-4 adds dozens of voltage and current channels to the hundreds of input, output, and analog channels already available in a single Axion system. With the capability of linking Axion backplanes as far as five kilometers away, the Axion is well suited to monitor and control across distances consistent with many microgrid applications. In an Axion system, all CT/PT modules sample at precisely the same time, ensuring a common reference for all voltages and currents entering the RTAC logic engine. This synchronized sampling enables many unique microgrid applications, including islanding detection, generation restoration, and dispatch algorithms.

Figure 5 Offshore Microgrid

Autosynchronization Systems

Use multiple CT/PT and I/O modules to create advanced and highly scalable autosynchronization systems. Automatically adjust the governor exciter controls as necessary to provide safe, secure, and unattended synchronization of generation onto the power system. With synchronized sampling from multiple CT/PT modules, the control algorithm for multiple governor exciters all have access to all necessary PT measurements in the same Axion system. Additionally, the measurements are already time-aligned, eliminating the need to adjust to a common reference. An added bonus is that the CT/PT modules can be located remotely across the system and provide the synchronized measurements through the Axion's deterministic EtherCAT network.

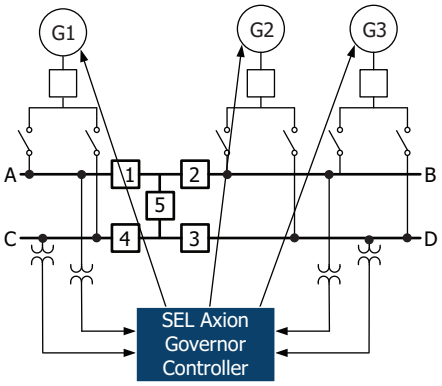


Figure 6 SEL Axion Autosynchronization System

Remote Terminal Unit (RTU)

Remote terminal units gather digital and analog signals at remote sites and supply these data over a variety of industry-standard protocols (DNP3, Modbus®, LG 8979, or IEC 61850) to a central supervisory control and data acquisition (SCADA) center or HMI. A master controller in the SCADA center can perform all logic or distribute logic to the RTU. The SEL-2244 I/O modules are available in a variety of types to gather many types of I/O at RTU locations. The SEL-2241 RTAC module has a variety of industry-standard protocols by which it can integrate seamlessly with any SCADA system. Additionally, the versatile IEC 61131 logic engine in the RTAC can meet the majority of logic requirements for small to large automation projects. The modular design of the Axion provides it the ability to perform as an RTU in two ways: as a centralized master RTU or as distributed logic in each substation.

Systems using distributed logic at the RTU use an SEL-2241 RTAC in each Axion node, thus providing all automation capabilities of the RTAC in each RTU. This architecture allows each RTU to function autonomously even if the central SCADA system is offline. Each RTAC can communicate with the SCADA master over DNP3, Modbus, LG 8979, IEC 61850, or SEL Fast Message. The following diagram illustrates use of the Axion as a distributed RTU communicating over DNP3 to a SCADA master.

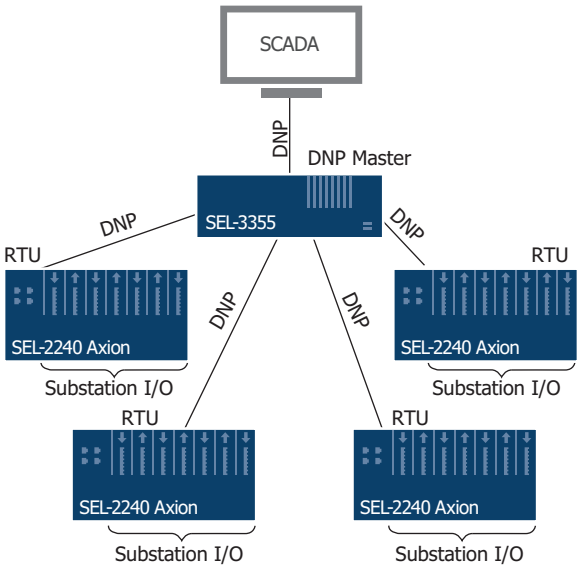


Figure 7 RTACs Distributed With RTUs

Systems that do not need autonomous operation at each RTU can use a central SEL-2241 and communicate to the remote nodes through the SEL-2243 Power Couplers. This architecture offers an economical solution to distributed I/O over EtherCAT at an extremely fast acquisition rate. The master SEL-2241 can host all data from remote nodes over DNP3 and interface directly with the SCADA system. The master Axion in *Figure 7* illustrates this functionality.

EtherCAT Network Topologies

The SEL-2243 Power Couplers provide not only hot-pluggable power supplies, but also fast EtherCAT connections to remote SEL-2240 nodes. The power couplers create EtherCAT links in star network topology, sequential network topology, or a combination of both. Star-configured topologies still use the sequential message format inherent to EtherCAT design and offer greater flexibility than wired sequential network topologies in creating a network to match your physical system. Refer to *Appendix C* in the *ACSELERATOR RTAC SEL-5033 Software Instruction Manual* for detailed information on EtherCAT.

Apply single or dual power couplers in each Axion node based on connection or redundancy requirements. *Figure 8* illustrates a star topology for four remote SEL-2240 nodes with single power couplers in the remote nodes and dual couplers in the RTAC master.

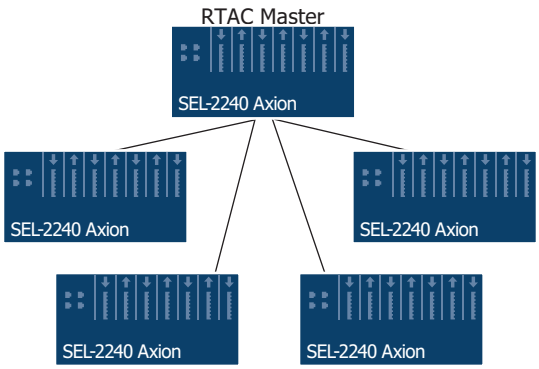


Figure 8 EtherCAT Star Network Topology

Figure 9 illustrates connections for an EtherCAT sequential topology with six Axion nodes. Each node uses a single SEL-2243 Power Coupler to provide connections to the previous and next node in the EtherCAT network.

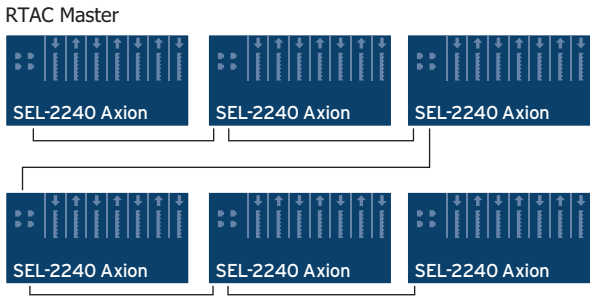


Figure 9 EtherCAT Sequential Network Topology

Figure 10 illustrates a combination of star and sequential connections with six Axion nodes.

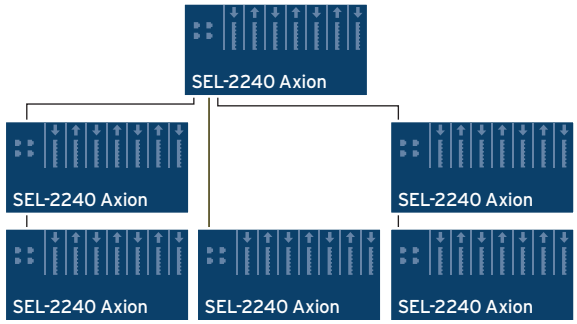


Figure 10 EtherCAT Hybrid Network Topology

Remote I/O

When you use single or dual power couplers, the Axion serves as a low-cost remote I/O module. As many as 60 modules or six nodes can connect to one resident SEL-2241 RTAC or to a separate SEL-3530 RTAC. The Axion is an excellent teleprotection device that provides through EtherCAT a simple means for expanding the number of I/O points available in an automation system at rapid data acquisition rates.

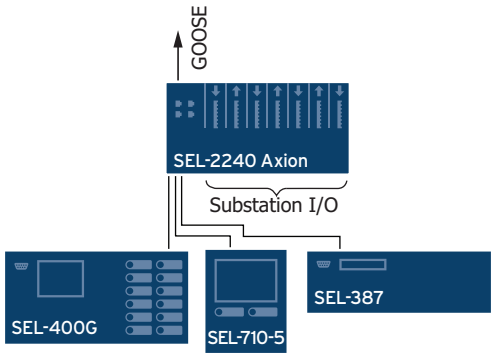


Figure 11 IEC 61850 GOOSE Concentrator

IEC 61850 GOOSE Concentrator

Gather a variety of substation I/O with the SEL-2244 modules and share the data with IEC 61850 Generic Object-Oriented Substation Event (GOOSE) messages. Use the protocol flexibility of the RTAC to concentrate data from non-IEC 61850 relays and convert these data to GOOSE messages.

Synchrophasor Concentrator

Use standard protocols, such as DNP3, to move synchrophasor data to SCADA operation centers. Include time stamps and time quality in the SCADA message to allow for system-wide usage of synchrophasor data. Within the RTAC logic engine, you can perform complex math and logic calculations on synchrophasor data you collect from SEL relays and other IEEE C37.118-compliant devices.

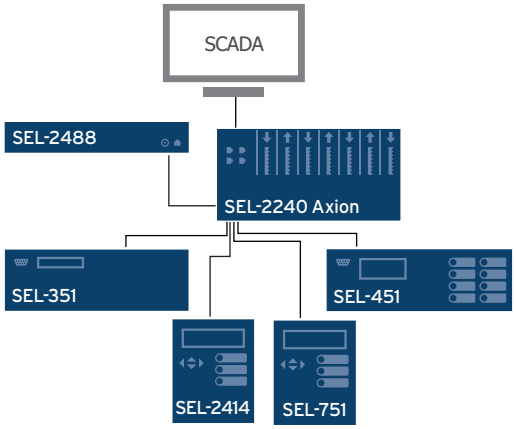


Figure 12 Synchrophasor Concentrator

SCADA Data Concentrator

Use the RTAC with your protective relays and other IEDs as the substation SCADA data concentrator. You can configure the RTAC to collect and view station-wide SER and event reports. Use MIRRORED BITS® protocol to ensure compatibility with any SEL device. Retrieve asset optimization data from SEL or other IEDs to maintain

the best possible system reliability. Take advantage of multiprotocol support to collect SCADA information, process control commands, and obtain SNTP/NTP time synchronization through a single communications link to each Ethernet device. Scale values and calculate logic in a familiar IEC 61131 configuration environment. Enjoy secure, encrypted communications to any device on the substation network or serial channel.

Remotely access the RTAC through the Ethernet connection, and use any web browser to manage users, view diagnostics, and access logs. Establish a remote connection with any IED connected to the RTAC through engineering access communications channels. Use the SEL Fast Message protocol to maintain SCADA control and metering updates throughout the engineering access connection. Use ACSELERATOR QuickSet® SEL-5030 Software to remotely manage protection and control settings in attached relays.

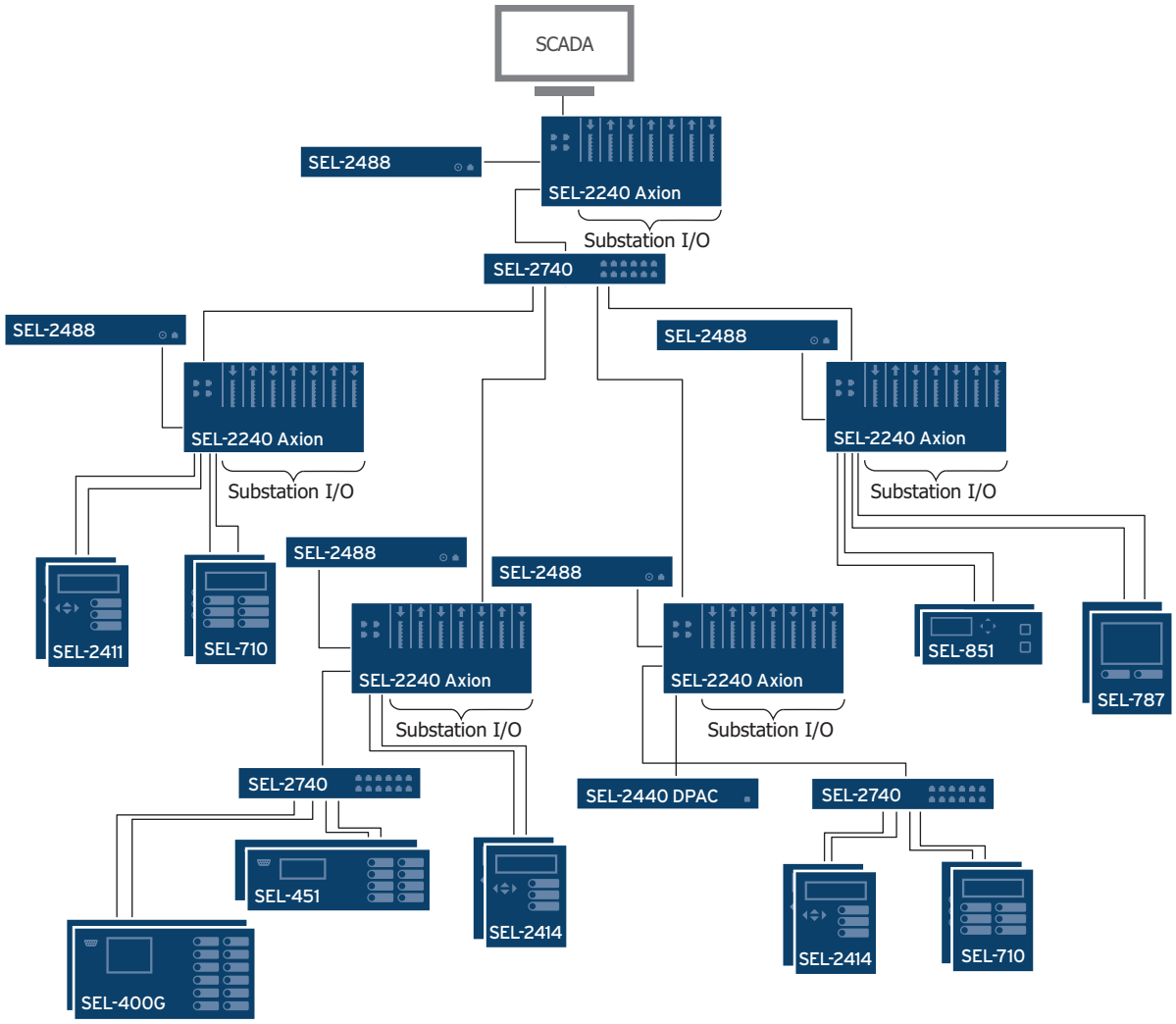


Figure 13 SCADA Data Concentrator and HMI

Human-Machine Interface

Use the built-in web HMI in the RTAC for viewing and controlling any tags you configured in the RTAC. Use ACSELERATOR Diagram Builder to develop custom HMI screens and load them into the RTAC. You can include one-line diagrams, annunciators, and graphical representations that contain control buttons, and you can then display any data in the RTAC. Once you have loaded the screens into the RTAC, you can view the screens in the RTAC web interface. Because the HMI application is web-based, multiple users can view the HMI screens simultaneously.

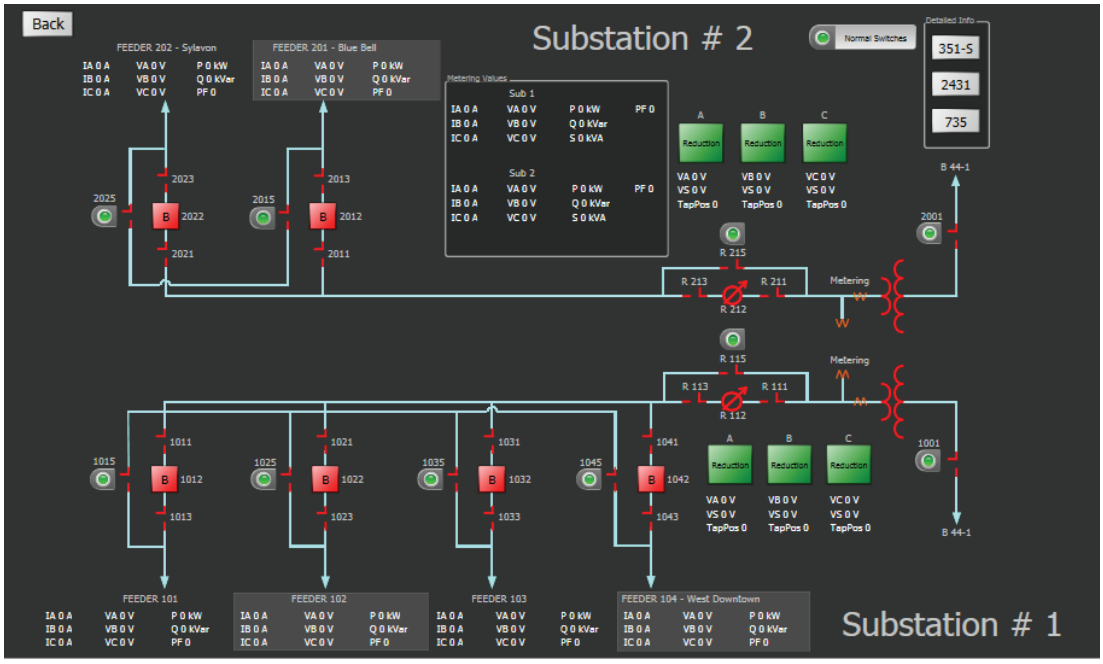


Figure 14 HMI One-Line Diagram

The logging system in the RTAC provides comprehensive logging for all variables in the RTAC, including those that connected IEDs provide. The logging system compensates for time-stamp differential among data from different IEDS, so all data are in sequence and on the same time-stamp reference. The RTAC can log data for changes in the state of Boolean values, changes in string values, and changes in Boolean, analog, or string time stamps. The RTAC can also alarm for analog values that cross defined thresholds. Assign variables for logging in the Tag Processor, or use one of the logger function blocks in IEC 61131 custom programs.

There are two user interfaces for viewing logged data. These include a secure HTML interface and an open database connectivity (ODBC) connection. Access the HTML interface through a web browser connection. Use the ODBC connection for standard data transfer between the logged data and database or spreadsheet software.

Programmable Logic/Automation Controller

Use the Axion as a programmable logic/automation controller (PLC/PAC) to automate your real-time tasks based on a variety of input conditions and diagnostic information. Use the powerful IEC 61131 logic engine to write programs in Structured Text, Function Block, or Ladder Logic. Schedule periodic tasks, or drive event-driven tasks with multiple preconditions. Create function blocks of complex tasks for simple configuration. Easily replace aging PLCs implemented in Ladder Logic by replicating the same logic or by using a conversion tool to translate logic to Structured Text.

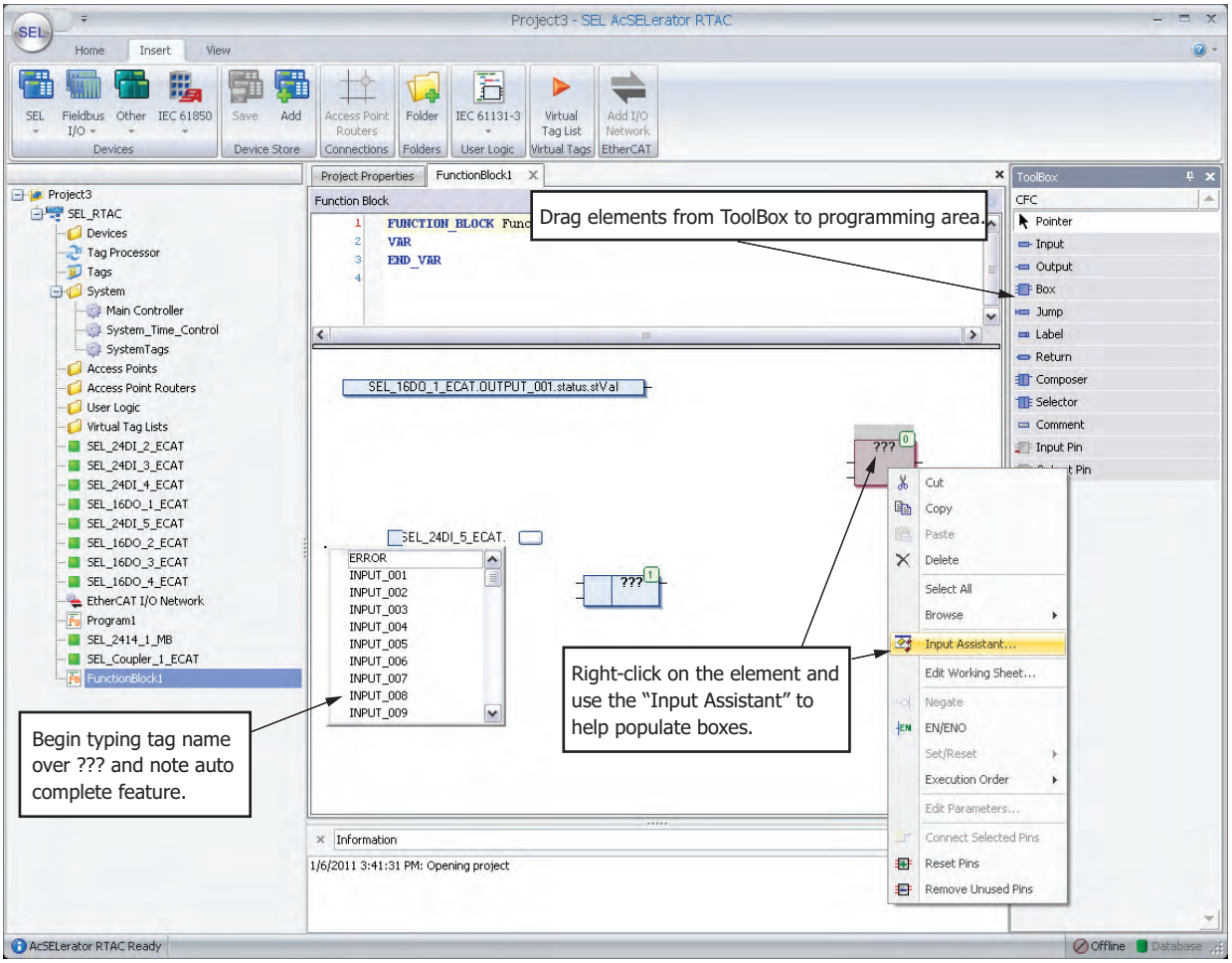


Figure 15 IEC 61131 Logic Example

Intelligent Port Switch

Flexible communications parameters make the RTAC a great choice for almost any port-switching application. Although RTAC multitasking/multiuser and data handling capabilities make it a very powerful remote automation platform, it is still an economical choice for port-switching applications. The time-synchronization capabilities of the RTAC add to its value in this application.

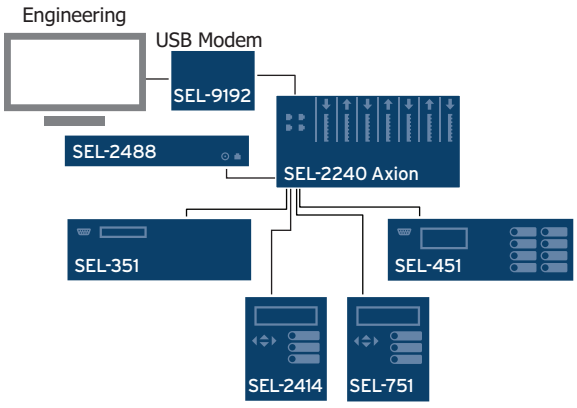


Figure 16 Intelligent Port Switch

Network Gateway

The SEL-2241 RTAC has two Ethernet ports through which it can make serially connected devices available to high-speed networks. The RTAC supports virtual terminal connections through the Ethernet ports. For example, Ethernet users can establish secure Telnet sessions and communicate with an IED connected to the RTAC.

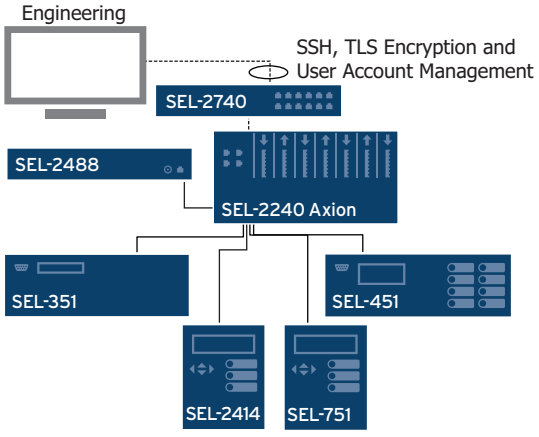


Figure 17 Network Gateway

Protocol Gateway

Collect downstream data with client protocols. Then send these data to your upstream HMI, RTU, or SCADA master with server protocols, converting the data from one protocol to another in the process. RTAC multitasking/multiuser and data handling capabilities make it a great choice for data concentration.

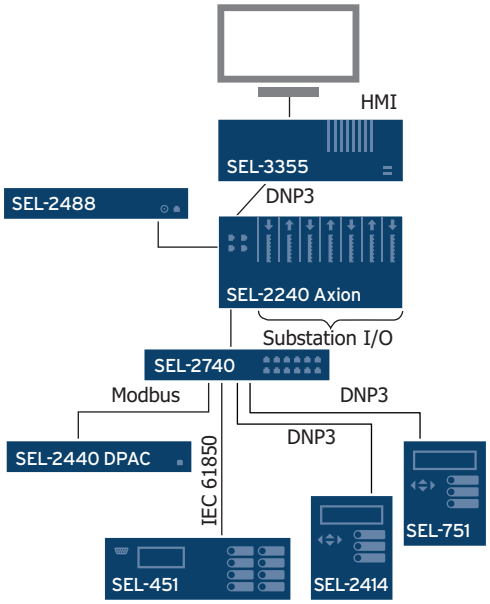


Figure 18 Protocol Converter

Time-Synchronization Source

Synchronize the time clocks in attached devices that accept a demodulated IRIG-B time signal. The SEL-2241 RTAC regenerates the demodulated IRIG-B signal from an external modulated or demodulated source, such as a GPS satellite clock receiver, SNTP/NTP source, or serial or Ethernet protocol such as DNP3. If an external clock source is unavailable, the RTAC generates an IRIG-B signal from its internal clock, providing device synchronization to a common clock for improved SER data analysis.

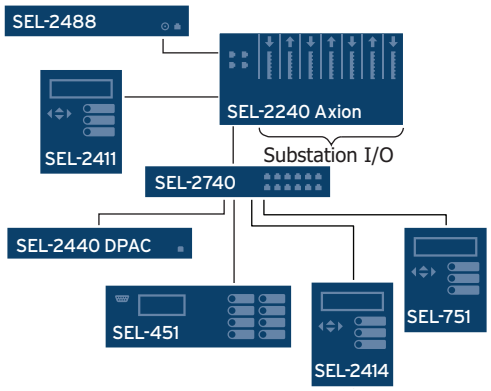


Figure 19 Time Synchronization

Security Gateway

Secure the automation network with the Axion. Enable encryption for any engineering access channel or SCADA link. Implement system security auditing, logging, and password restrictions to enforce NERC standards. Comply with role-based requirements by implementing per-user security profiles. Optionally, incorporate serial and wireless encrypting devices to further secure communications to any device

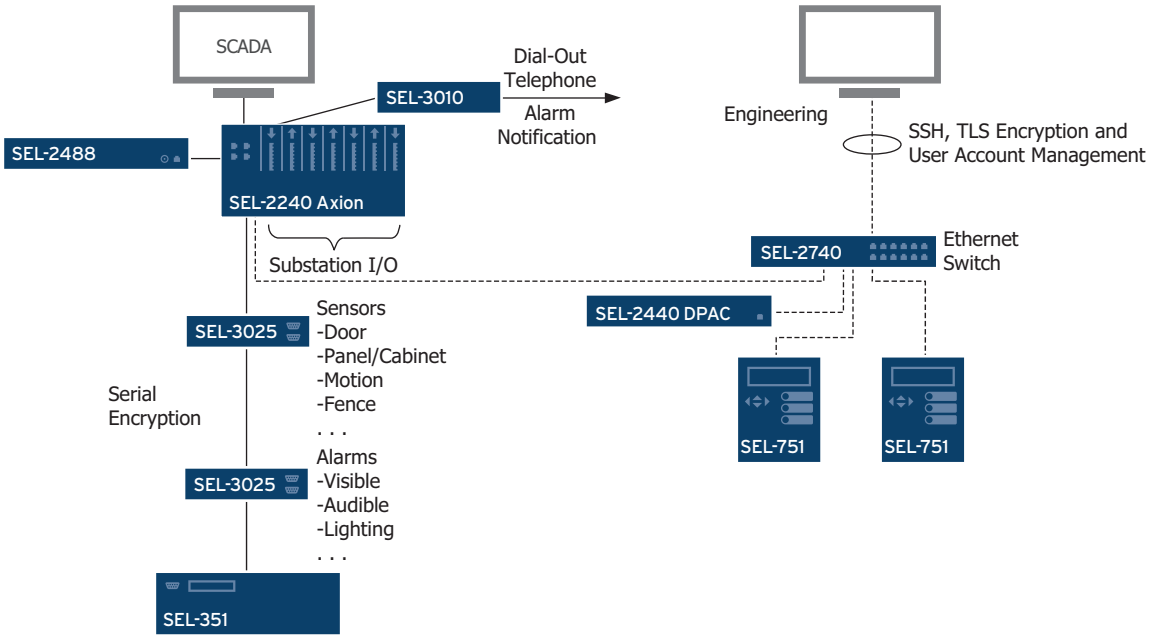


Figure 20 Security Gateway

Ordering Options

Table 1 SEL-2241 RTAC Module

Ethernet Communication	Two Ethernet ports: 10/100BASE-T copper (standard) 100BASE-FX fiber-optic (optional) 100BASE-LX single-mode fiber-optic (optional)
Web-Based HMI	Basic runtime license and Diagram Builder software
Peer-to-Peer Protocols	IEC 61850 GOOSE
Client Protocols	IEC 61850 MMS
Server Protocols	IEC 61850 MMS
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 2 SEL-2242 Chassis/Backplane

Slot Configuration	10-Slot, 4-Slot, or Dual 4-Slot
Mounting	Horizontal Surface Mount, 5U[a] Horizontal Rack Mount, 5U Horizontal Panel Mount, 5U (10-Slot or Dual 4-Slot)
Environment	Conformal coating for chemically harsh and high-moisture environments

[a] For applications compliant with IEC 60255-27, surface-mount units must be installed in IP4X enclosures.

Table 3 SEL-2243 Power Coupler

Voltage Range	24/48 Vdc or 120/250 Vac/Vdc
EtherCAT Communication	Two ports: RJ45 Ethernet (standard) LC fiber-optic multimode or single-mode (optional)
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 4 SEL-2244-2 Digital Input Module

Input Ratings	24 Vac/Vdc 48 Vac/Vdc 110 Vac/Vdc	125 Vac/Vdc 220 Vac/Vdc 250 Vac/Vdc
Environment	Conformal coating for chemically harsh and high-moisture environments	

Table 5 SEL-2244-3 Standard Current Digital Output Module

Output Types	16 Form A Control Outputs 8 Form A, 8 Form B Control Outputs 16 Form B Control Outputs
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 6 SEL-2244-5 Fast High-Current Digital Output Module

Output Types	10 Form A Control Outputs 5 Form A, 5 Form B Control Outputs 10 Form B Control Outputs
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 7 SEL-2245-2 DC Analog Input Module

Input Types	±20 mA, ±2 mA, ±10 V
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 8 SEL-2245-22 DC Analog Input Extended Range Module

Input Types	0–300 V
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 9 SEL-2245-221 Low-Voltage (LEA) Monitoring Module

Input Types	0–30 V peak
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 10 SEL-2245-3 DC Analog Output Module

Output Types	±20 mA, ±10 V
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 11 SEL-2245-4 AC Metering Module

Input Types	0–22 A, 5–400 V
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 12 SEL-2245-42 AC Protection Module

Input Types	0–20 A, 6–300 V
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 13 SEL-2245-411 Standard Current and Low-Voltage (LEA) Monitoring Module

Input Types	0–22 A, 0–30 V peak
Environment	Conformal coating for chemically harsh and high-moisture environments

Module Features

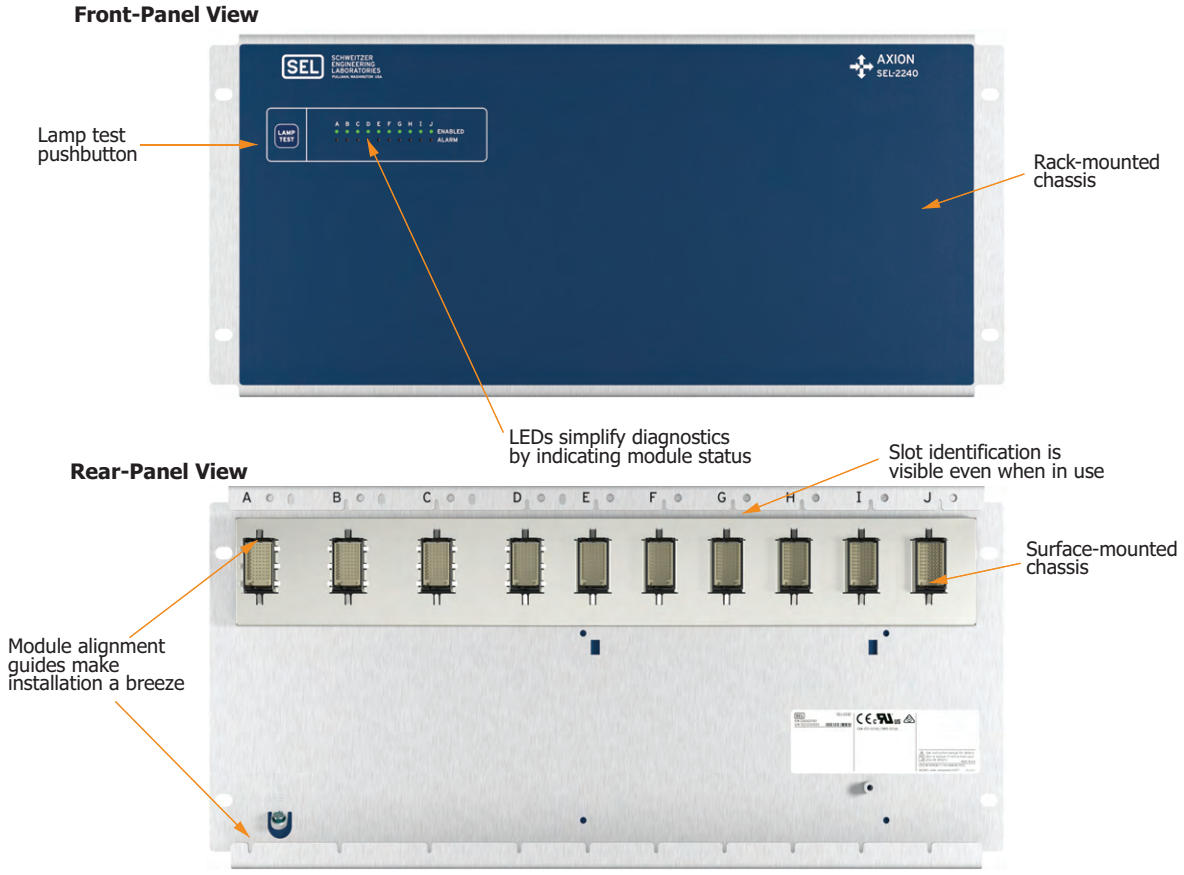


Figure 21 SEL-2242 10-Slot Chassis/Backplane

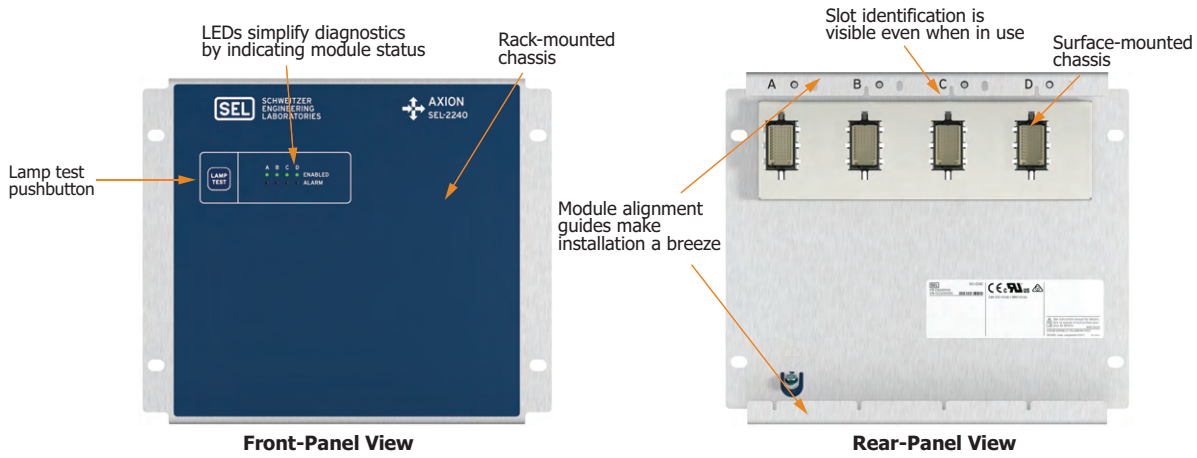


Figure 22 SEL-2242 4-Slot Chassis/Backplane

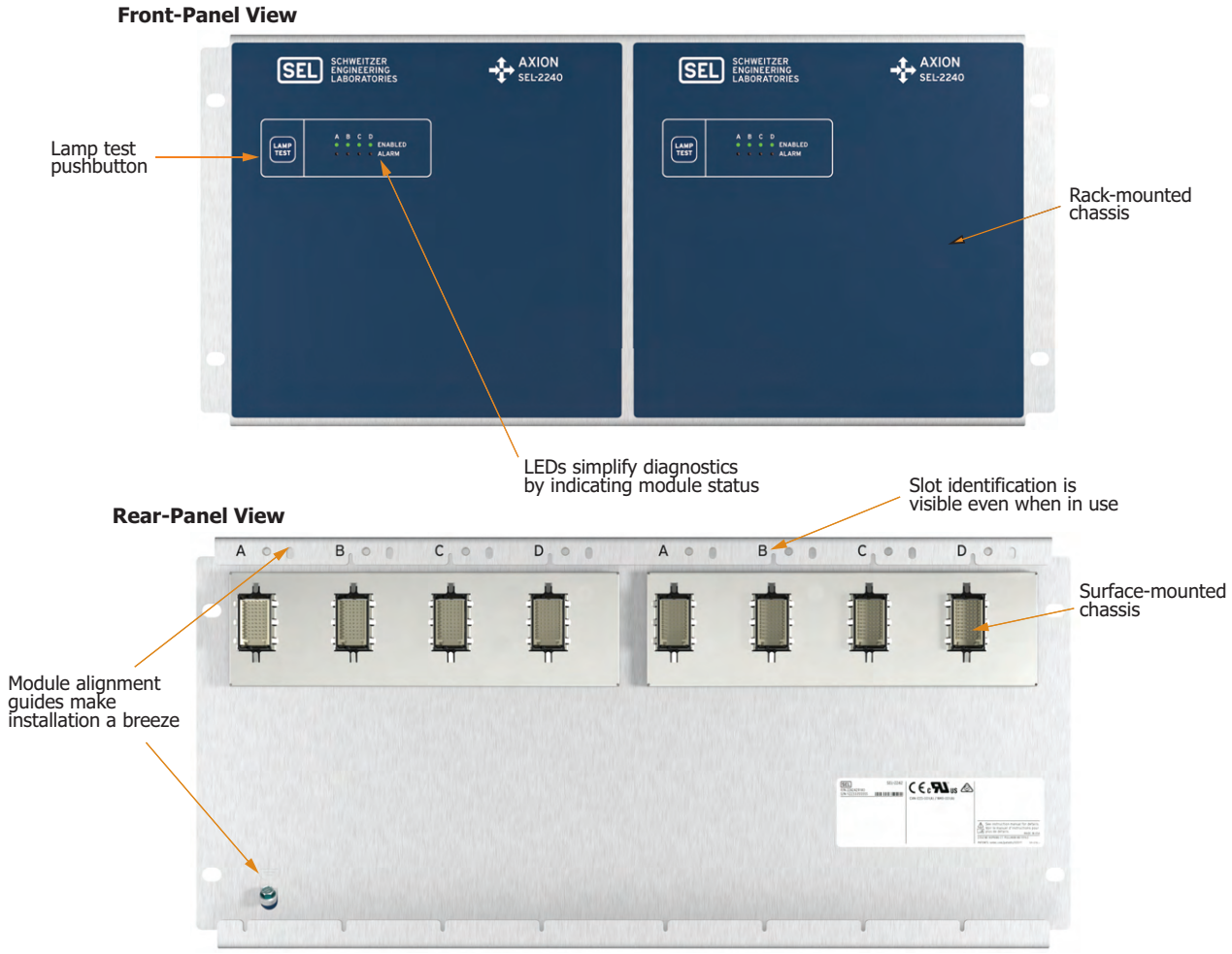


Figure 23 SEL-2242 Dual 4-Slot Chassis/Backplane

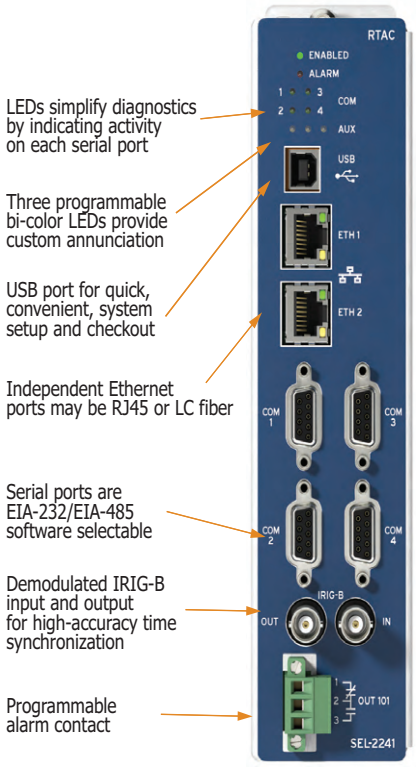


Figure 24 SEL-2241 RTAC Terminal-Side View

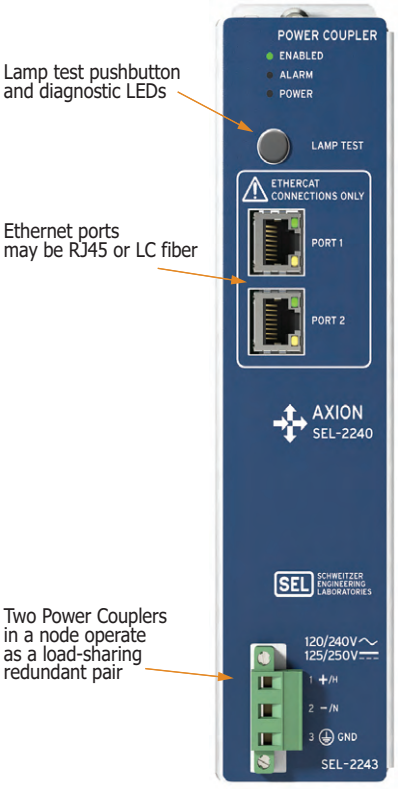


Figure 25 SEL-2243 Power Coupler Terminal-Side View

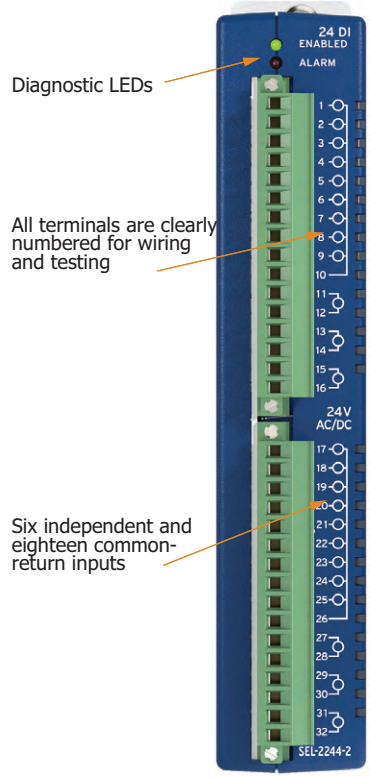


Figure 26 SEL-2244-2 Digital Input Module Terminal-Side View

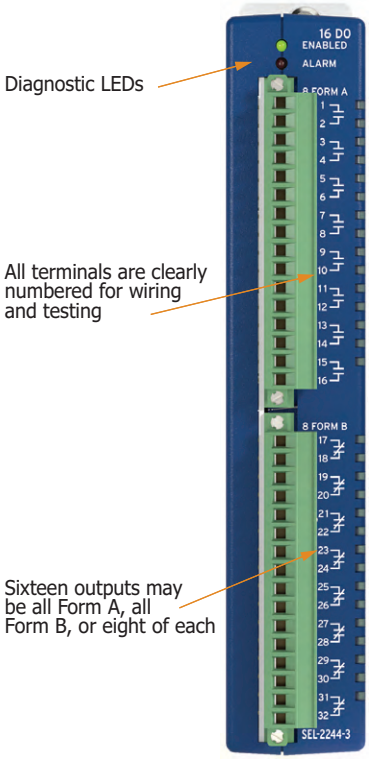


Figure 27 SEL-2244-3 Standard Current Digital Output Module Terminal-Side View

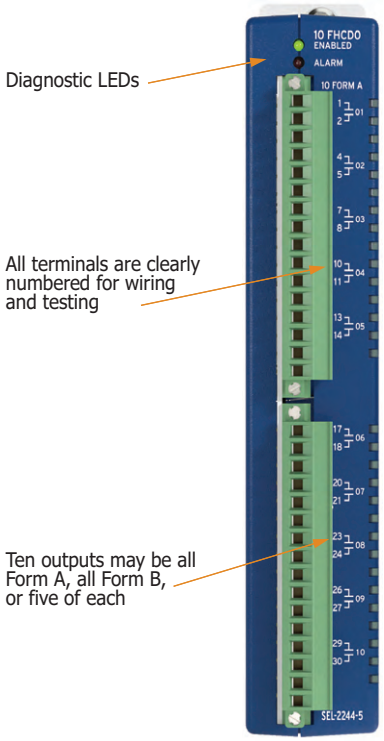


Figure 28 SEL-2244-5 Fast High-Current Digital Output Module Terminal-Side View

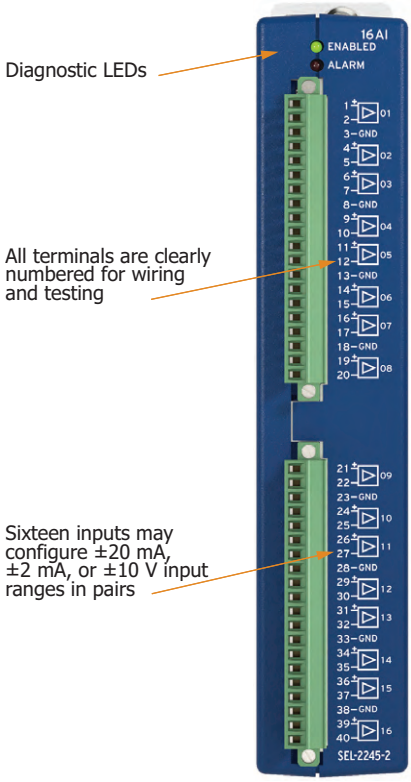


Figure 29 SEL-2245-2 DC Analog Input Module Terminal-Side View

Figure 30 SEL-2245-22 Analog Input Extended Range Module Terminal-Side View

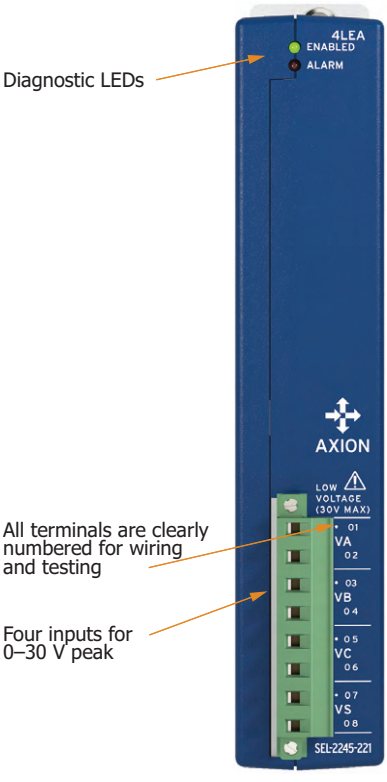


Figure 31 SEL-2245-221 Low-Voltage (LEA) Monitoring Module

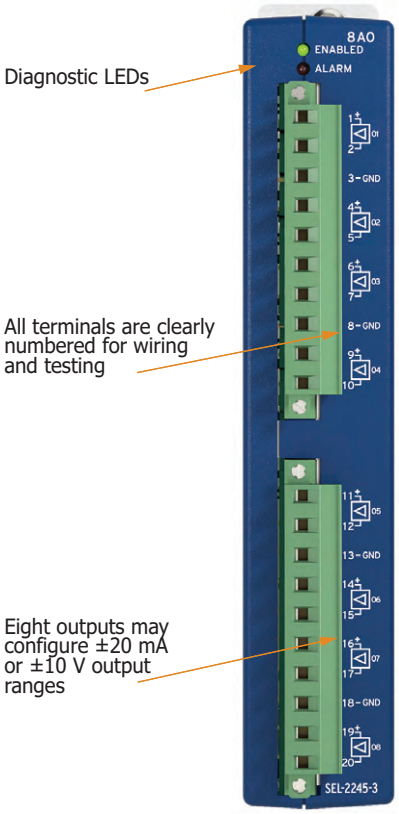


Figure 32 SEL-2245-3 DC Analog Output Module Terminal-Side View

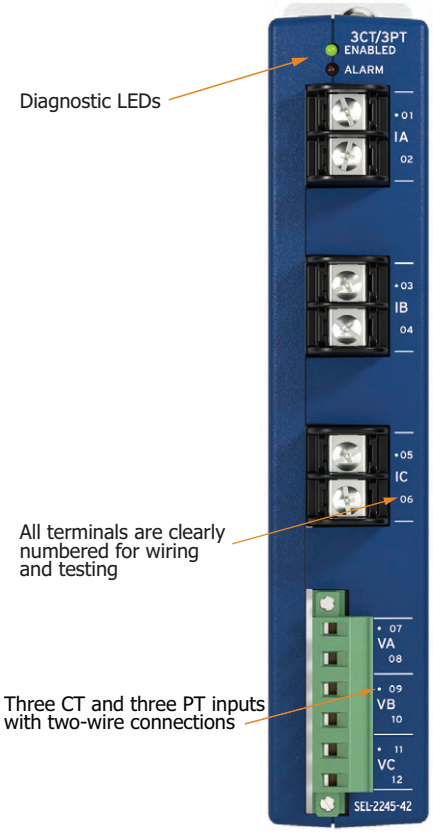


Figure 34 SEL-2245-42 AC Protection Module Terminal-Side View

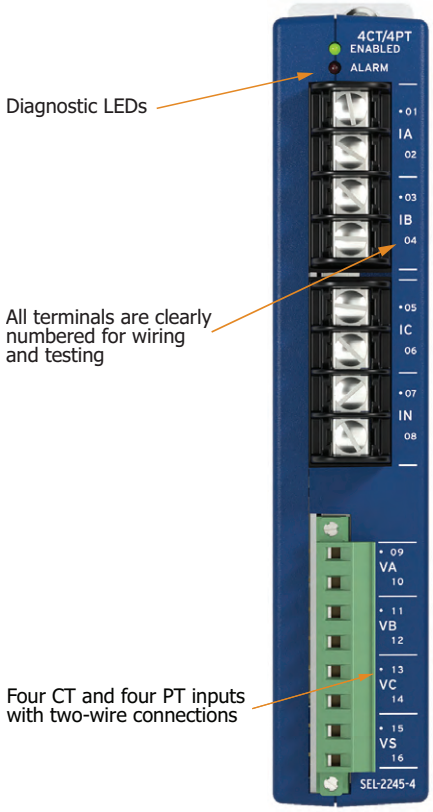


Figure 33 SEL-2245-4 AC Metering Module Terminal-Side View

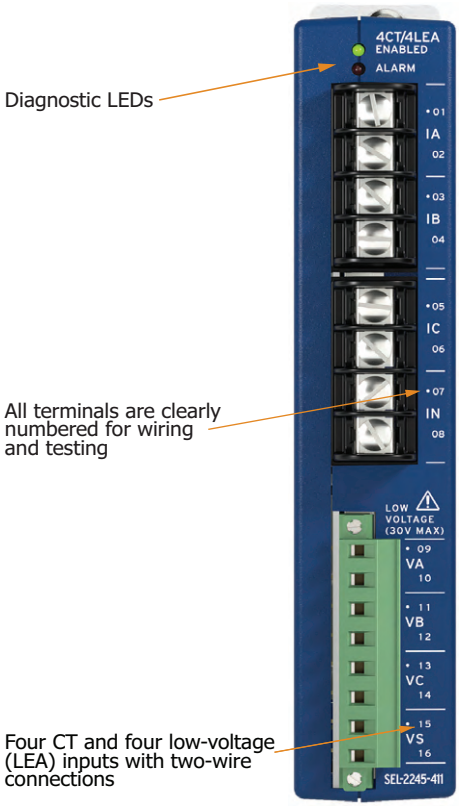


Figure 35 SEL-2245-411 Standard Current and Low-Voltage (LEA) Monitoring Module

Diagrams and Dimensions

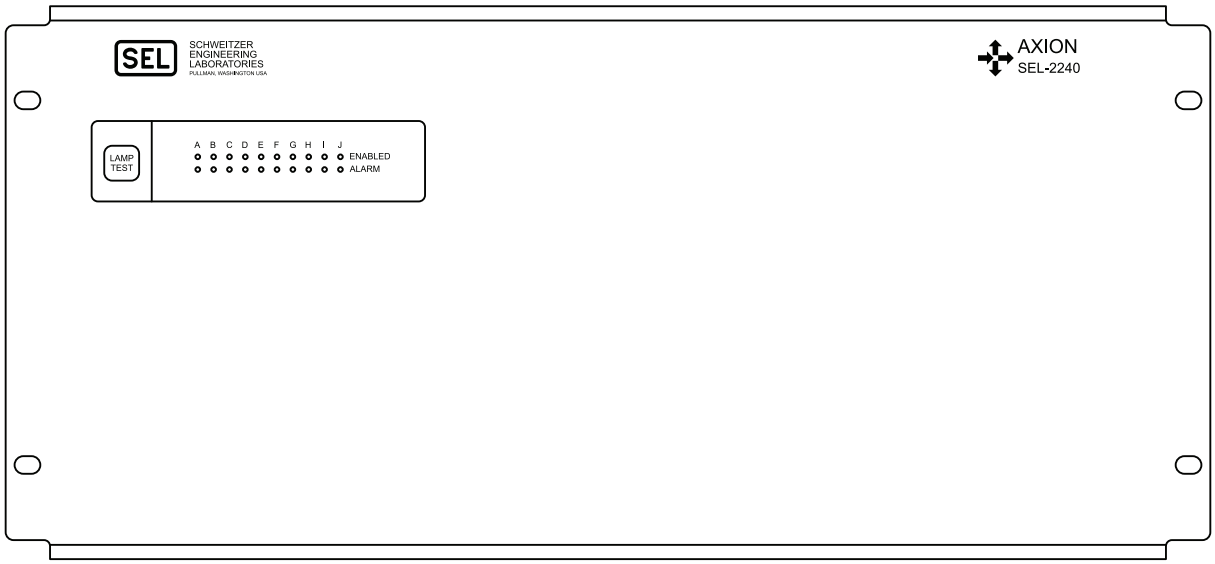


Figure 36 SEL-2240 10-Slot Front Panel (Rack Mount)

Figure 37 Figure 38 SEL-2240 10-Slot Front Panel (Panel Mount)

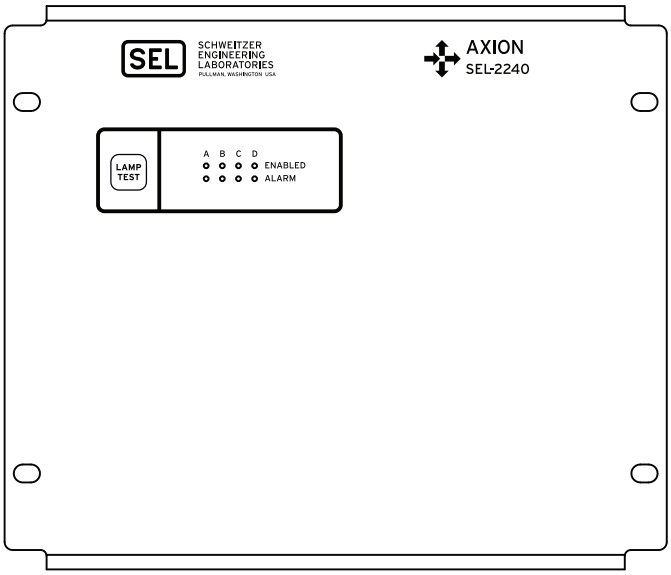


Figure 38 SEL-2240 4-Slot Front Panel

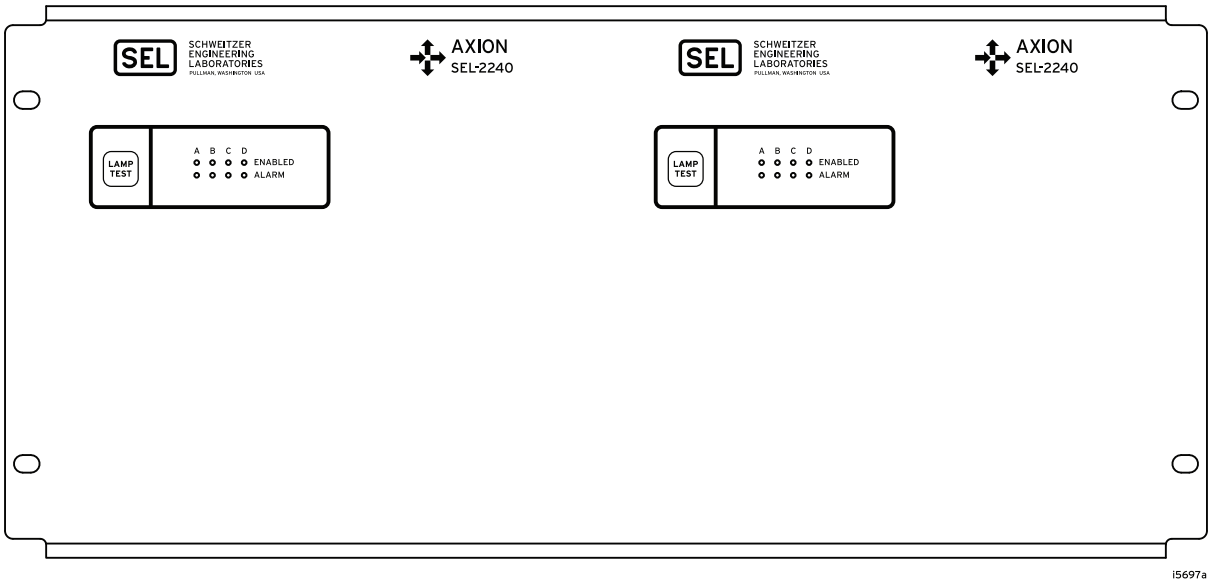


Figure 39 SEL-2240 Dual 4-Slot Front Panel (Rack Mount)

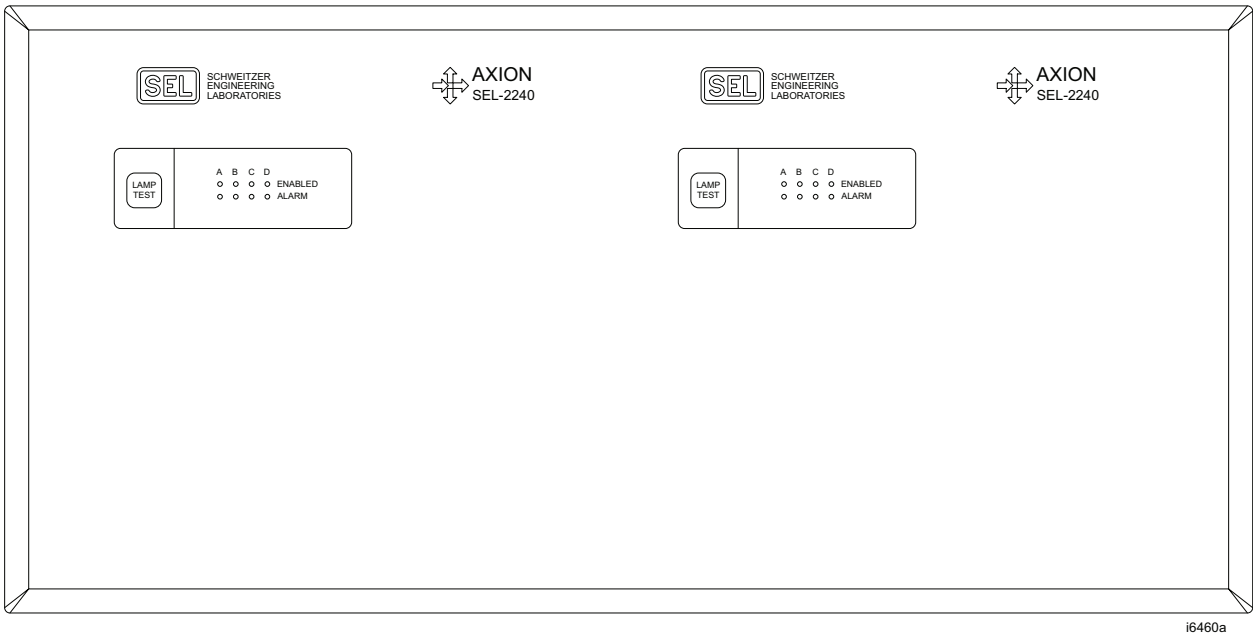


Figure 40 SEL-2240 Dual 4-Slot Front Panel (Panel Mount)

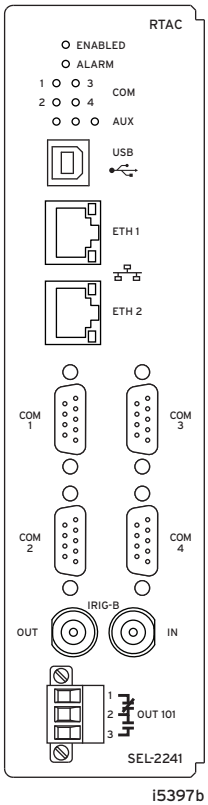


Figure 41 SEL-2241 Connections Diagram

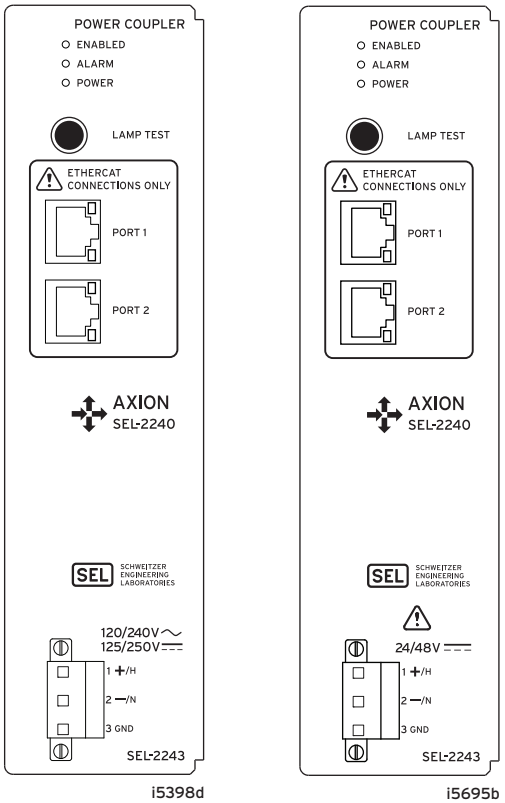


Figure 42 SEL-2243 Connections Diagrams

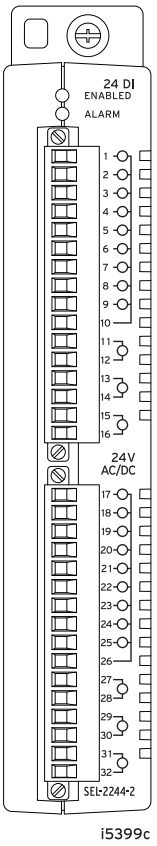


Figure 43 SEL-2244-2 Connections Diagram

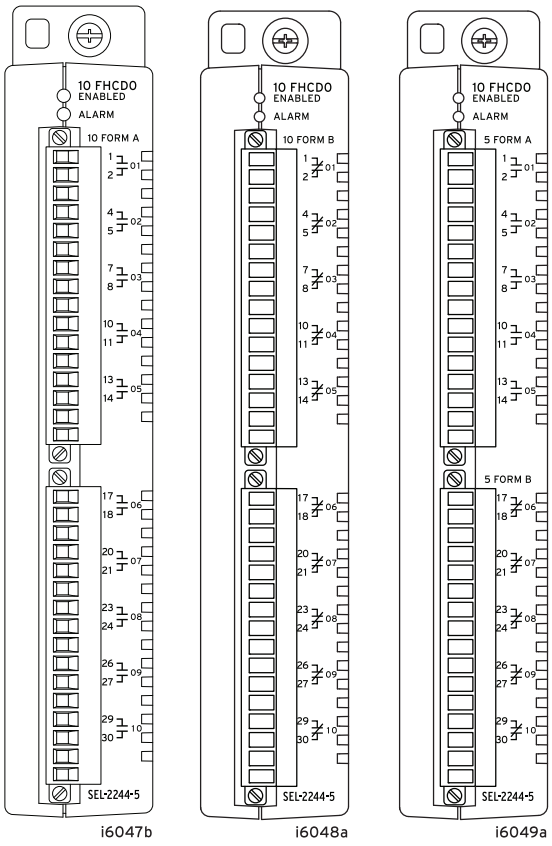


Figure 45 SEL-2244-5 Connections Diagrams

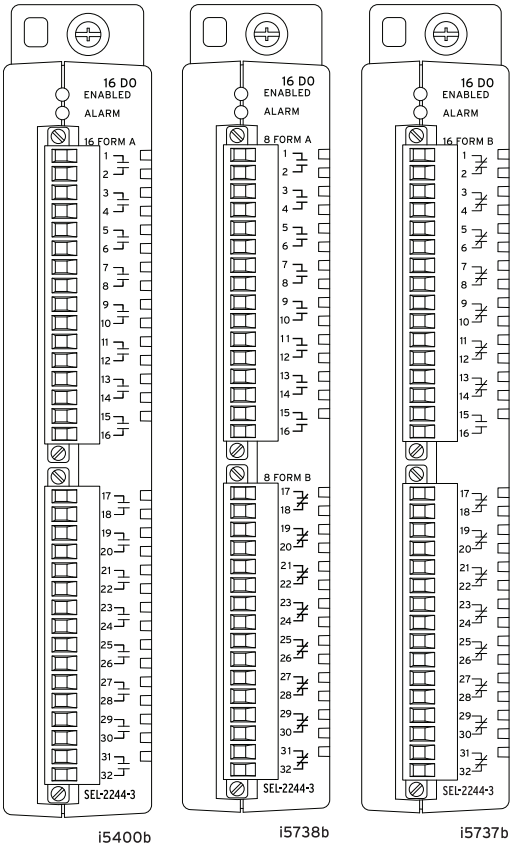


Figure 44 SEL-2244-3 Connections Diagrams

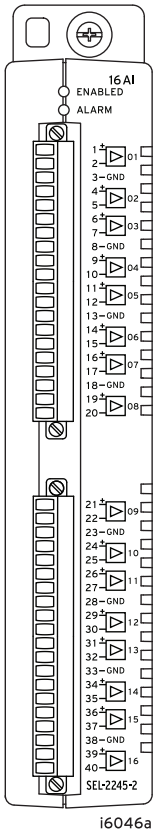


Figure 46 SEL-2245-2 Connections Diagram

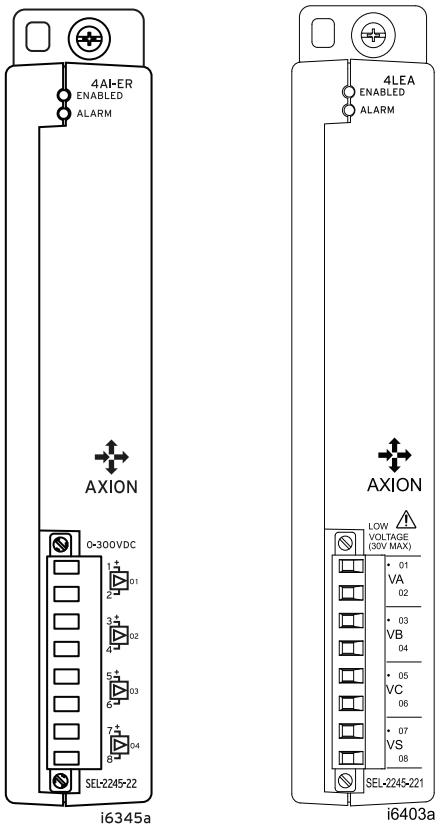


Figure 47 SEL-2245-22 and SEL-2245-221 Connections Diagrams

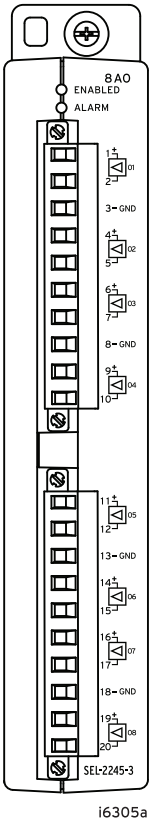


Figure 48 SEL-2245-3 Connections Diagram

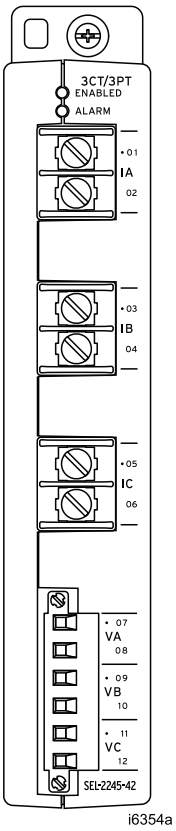


Figure 49 SEL-2245-42 Connections Diagram

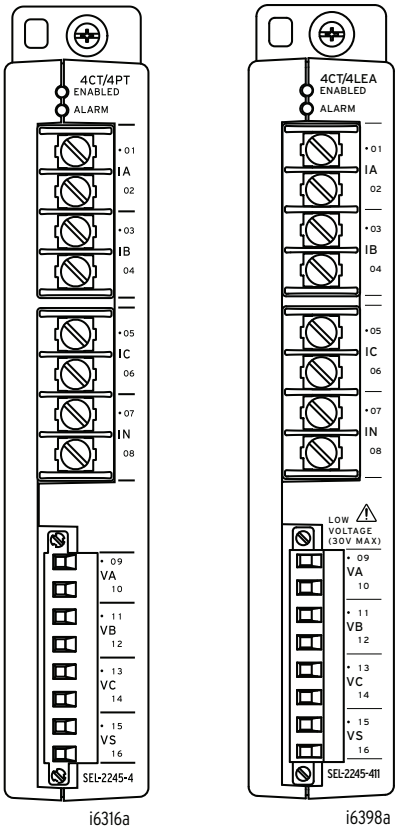


Figure 50 SEL-2245-4 and SEL-2245-411 Connections Diagrams

RACK-/SURFACE-MOUNT CHASSIS

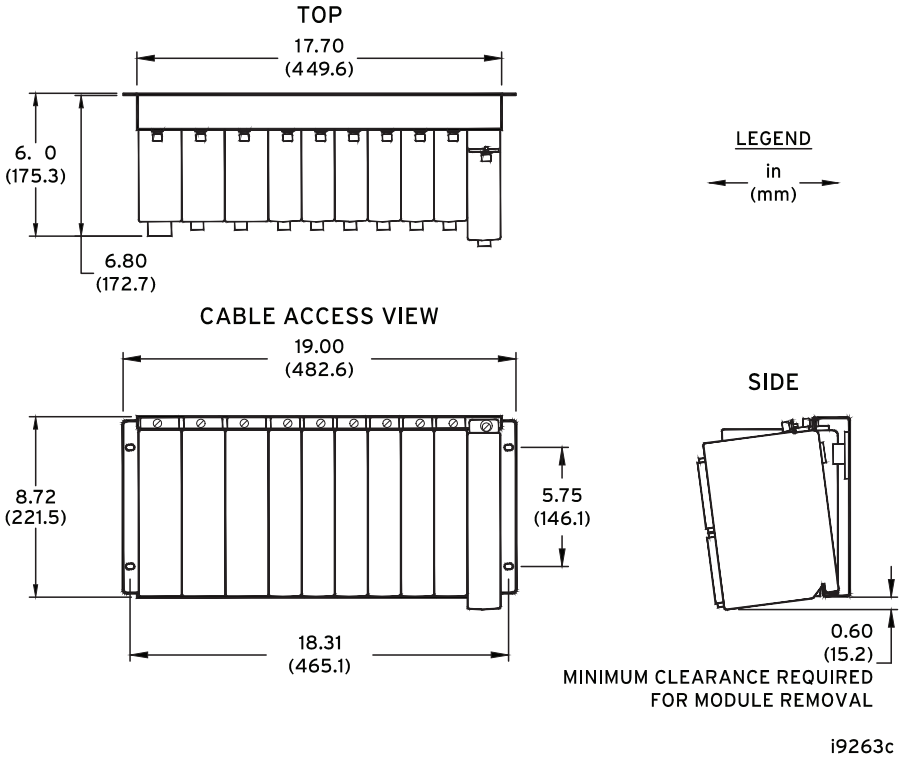


Figure 51 SEL-2240 Dimensions for 10-Slot Rack- and Surface-Mount Chassis

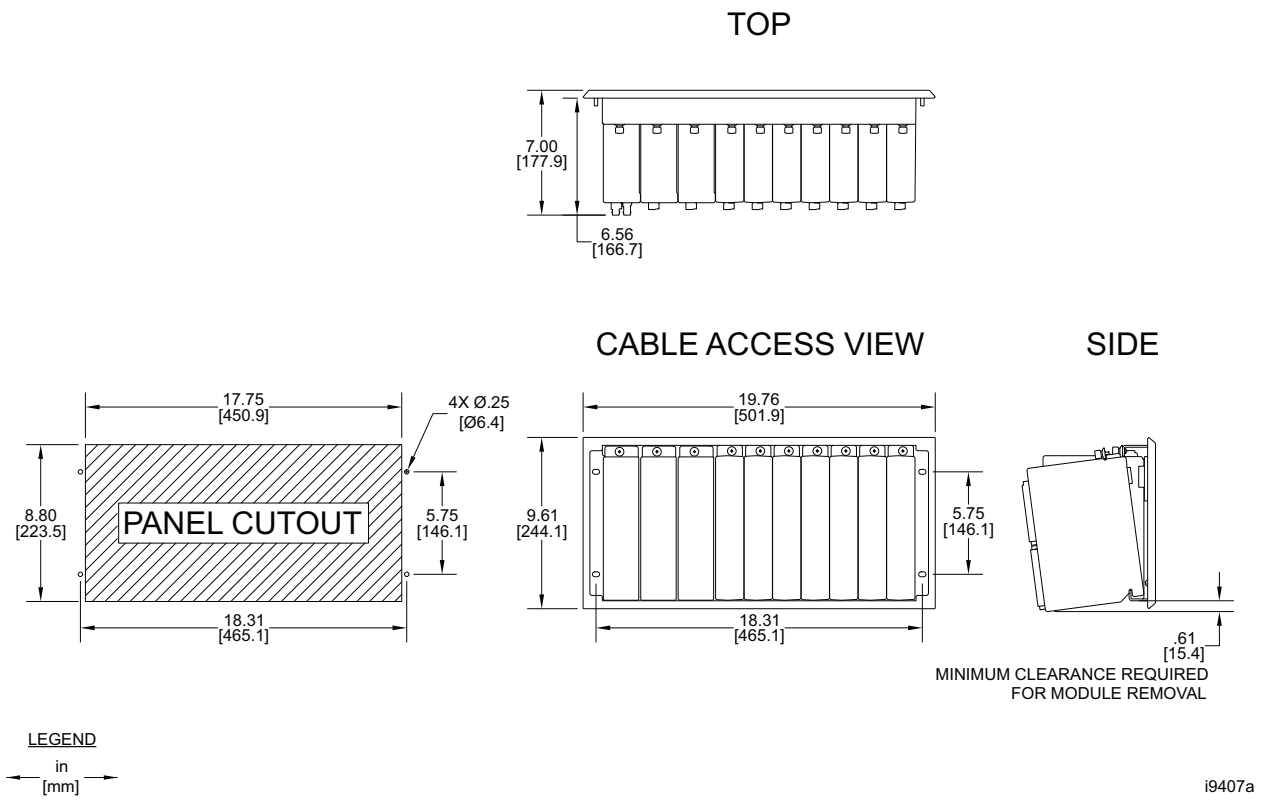


Figure 52 SEL-2240 Dimensions for 10-Slot Panel-Mount Chassis

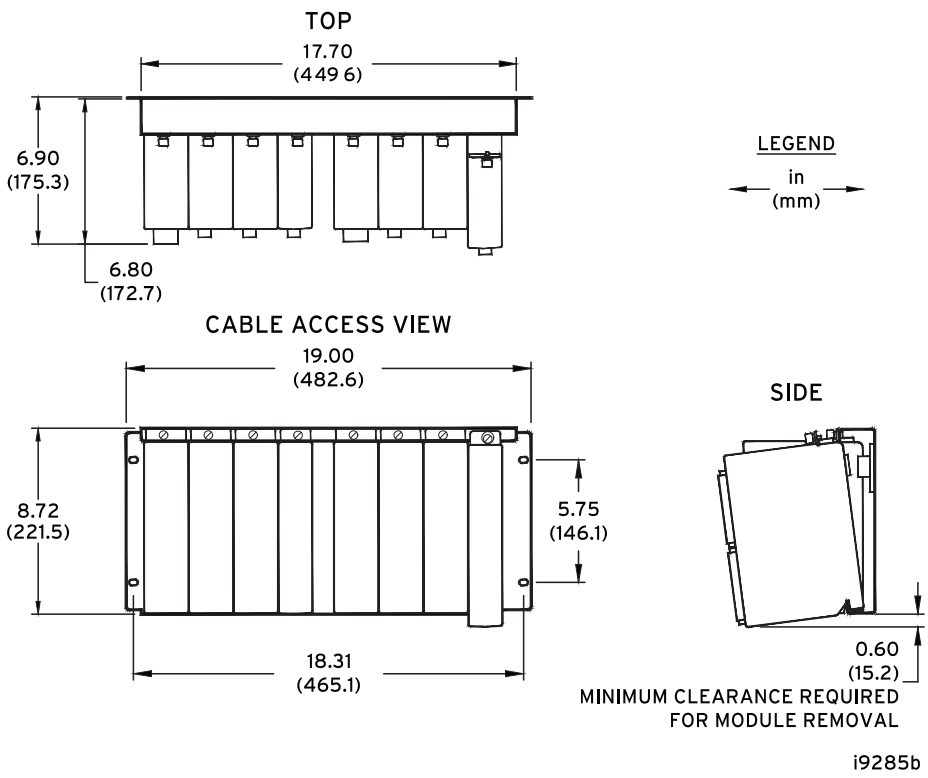


Figure 53 SEL-2240 Dimensions for Dual 4-Slot Rack- and Surface-Mount Chassis

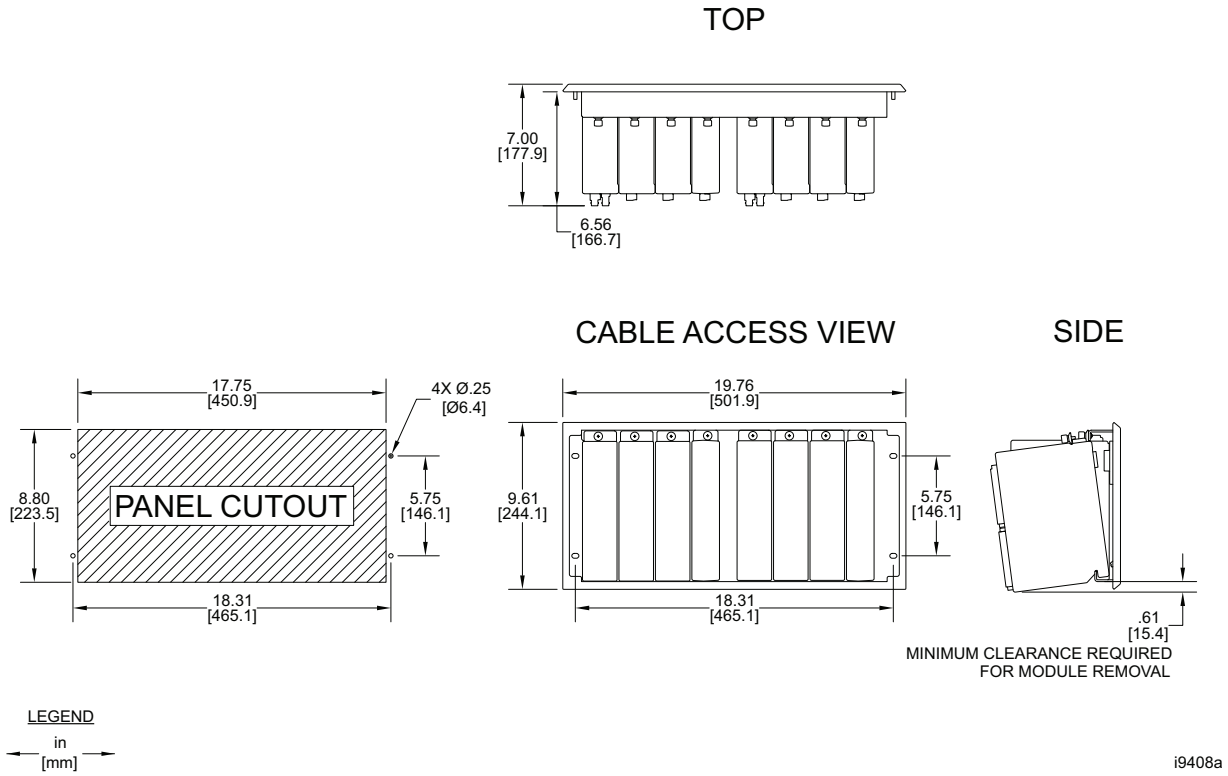


Figure 54 SEL-2240 Dimensions for Dual 4-Slot Panel-Mount Chassis

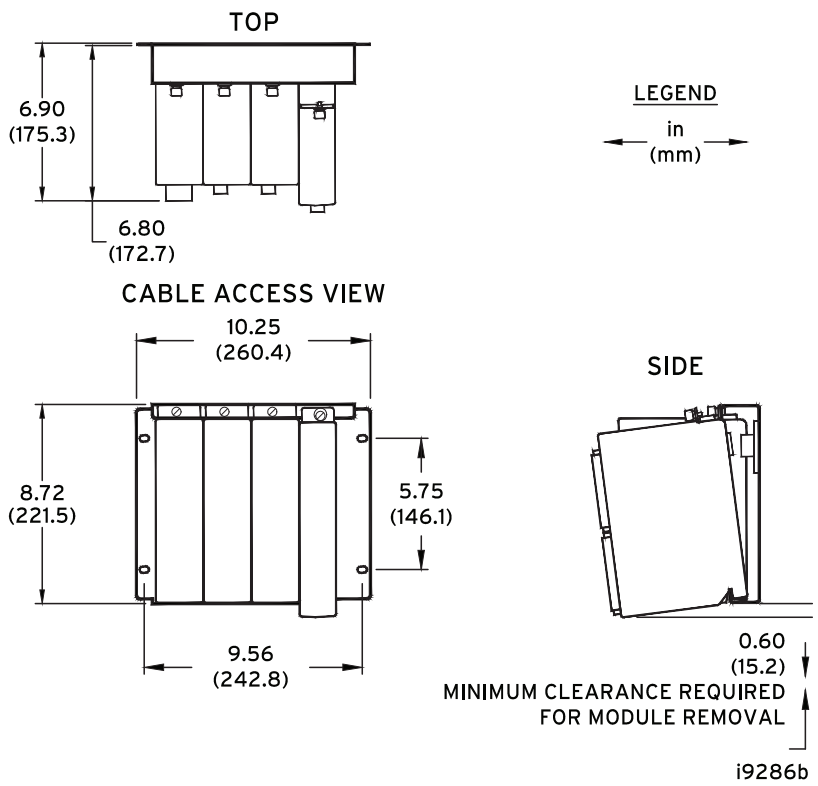


Figure 55 SEL-2240 Dimensions for 4-Slot Rack- and Surface-Mount Chassis

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

SEL Axion operates at the specified limits on power up as soon as the device enables. Refer to the individual SEL Axion module datasheets for compliance and type test specifications.

UKCA Mark

Enclosure Protection

IP4X Front
IP2X Product Without SEL-2245-4, SEL-2245-411, and SEL-2245-42
IP1X Product With SEL-2245-4, SEL-2245-411, or SEL-2245-42
Note: If rear terminals are accessible during normal use, the product must be mounted in a locked enclosure or restricted area accessible by trained maintenance or operation personnel only.

Product Standards

IEC 60255-26:2013 - Relays and Protection Equipment: EMC
IEC 60255-27:2014 - Relays and Protection Equipment: Safety
IEC 60825-2:2004 +A1:2007 +A2:2010 for fiber-optic communications
IEC 61850-3:2013 - Comm Systems for Power Utility Automation

General

Operating System

SEL Linux® Yellowstone running Linux kernel 3.x with real-time preemption patches

Operating and Storage Temperature Range

–40° to +85°C (–40° to +185°F)
Units should be stored and transported in their original packaging.

Note: Operating temperature evaluated for UL ambient 0° to 40°C.
Note: The optional front-panel LCD is impaired for temperatures below –20°C and above +70°C.

Operating Environment

Pollution Degree:	2
Overvoltage Category:	II
Insulation Class:	1
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude:	2000 m
Vibration, Earth Tremors:	Class 1

Dimensions

Refer to *Section 2: Installation* for dimensions.

Weight

SEL-2241 RTAC:	0.670 kg (1.47 lb)
SEL-2242 19 in Backplane:	3.24 kg (7.13 lb)
Panel Mount Bezel:	0.283 kg (0.625 lb)
SEL-2242 10-Slot (19 in Rack Width) With 7 in Touchscreen Display:	3.999 kg (8.80 lb)
SEL-2243-1 HV Coupler:	0.85 kg (1.87 lb)
SEL-2243-2 LV Coupler:	0.89 kg (1.97 lb)

SEL-2244-2 24 DI:	0.45 kg (1.00 lb)
SEL-2244-3 16 DO:	0.59 kg (1.30 lb)
SEL-2244-5 10 FHCDO:	0.57 kg (1.26 lb)
SEL-2245-2 16 AI:	0.51 kg (1.12 lb)
SEL-2245-22 4 AI-ER:	0.42 kg (0.92 lb)
SEL-2245-221 4 LEA:	0.42 kg (0.92 lb)
SEL-2245-3 8 AO:	0.46 kg (1.01 lb)
SEL-2245-4 4 CT/4 PT:	0.54 kg (1.18 lb)
SEL-2245-411 4 CT/4 LEA:	0.54 kg (1.18 lb)
SEL-2245-42 3 CT/3 PT:	0.73 kg (1.60 lb)

Module Burden

Table 14 Maximum Burden Per Module for Each Node

Module	Maximum Added Burden (W)[a]
SEL-2241 RTAC (Copper Ethernet)	12.5
SEL-2241 RTAC (Fiber Ethernet)	15
SEL-2242R Standard Rack-Mount Backplanes	1
SEL-2242 With Touchscreen Display	4
SEL-2243 Power Coupler (Fiber Ethernet)	5[b]
SEL-2243 Power Coupler (Copper Ethernet)	2.5[b]
SEL-2244-2 24 DI	2
SEL-2244-3 16 DO	8[c]
SEL-2244-5 10 FHCDO	6[c]
SEL-2245-2 16 AI	3
SEL-2245-22 4 AI-ER	2
SEL-2245-221 4 LEA	2
SEL-2245-3 8 AO	13
SEL-2245-4 4 CT/4 PT	3
SEL-2245-411 4 CT/4 LEA	3
SEL-2245-42 3 CT/3 PT	6
Feature Selections	**Typical Burden (W)**
No use of SEL-2241 Serial Port +5 Vdc	–3
Each DO port not energized (SEL-2241, SEL-2244-3, or SEL-2244-5 relay coil)	–0.3
Each AO port not energized (SEL-2245-2)	–0.7

[a] Values include worst-case real power consumption and do not include worst-case ac power factor correction (0.4). If the unit will not be used in wide temperature extremes, reduce power by up to 6%.

[b] Each SEL-2243 will draw a minimum of 11 W (quiescent) when the total burden of all other modules in the node is less than 11 W.

[c] All DO relay coils may be energized simultaneously and still meet specifications.

CPU Processing and Memory

Processor Speed:	533 MHz
Memory:	1024 MB DDR2 ECC RAM
Storage:	4 GB (2 GB reserved)

Security Features

Account Management:	User Accounts User Roles LDAP Central Authentication RADIUS Central Authentication Strong Passwords Inactive Account Logouts
Intrusion Detection:	Access/Audit Logs Alarm LED Alarm Contact
Encrypted Communication:	SSL/TLS, SSH, HTTPS

Automation Features (Protocols)

Client:	DNP3 Serial, DNP3 LAN/WAN, Modbus RTU, Modbus TCP, SEL ASCII, SEL Fast Messaging, LG 8979, IEEE C37.118, IEC 61850 MMS, CP2179, IEC 60870-5-101/104, SNMP, SES-92, CDC Type II, Courier, IEC 60870-5-103, Ethernet/IP Explicit Message Client
Server:	DNP3 Serial, DNP3 LAN/WAN, Modbus RTU, Modbus TCP, SEL Fast Messaging, LG 8979, SES-92, IEEE C37.118, IEC 61850 MMS, IEC 60870-5-101/104, FTP, SFTP, CDC Type II, Ethernet/IP Implicit Message Adapter
Peer-to-Peer:	SEL MIRRORED BITS Communications, IEC 61850 GOOSE, Network Global Variables (NGVL), Parallel Redundancy Protocol
Fieldbus:	EtherCAT Client (in RTAC), EtherCAT Server (I/O modules)
Engineering Access	
Modes:	SEL Interleaved, Direct
Port Server:	Map Serial Ports to IP Ports
Secure Web Server:	Diagnostic and Communications Data

Time-Code Input (Modulated IRIG-B)

Input Impedance:	2 kΩ
Accuracy:	500 µs

Time-Code Input (Demodulated IRIG-B)

On (1) State:	$V_{ih} > 2.2$ V
Off (0) State:	$V_{il} < 0.8$ V
Input Impedance:	2 kΩ
Accuracy:	500 ns

Time-Code Output (IRIG-B)

On (1) State:	$V_{oh} > 2.4$ V
Off (0) State:	$V_{ol} < 0.8$ V
Load:	50 Ω

Network Time Protocol (NTP) Modes

NTP Client:	As many as three configurable servers
NTP Server	

Simple Network Time Protocol (SNTP) Accuracy

±1 ms:	This does not take into account external factors such as network switches and topologies

Precise Time Protocol (PTP)

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

Communications Ports (SEL-2241 RTAC)

Ethernet Ports (To Backplane)

Ports:	1
Data Rate:	Automatic
Protocols:	Dedicated EtherCAT port

Ethernet Ports (Terminal Side)

Ports:	2
Data Rate:	10 or 100 Mbps
Connector:	RJ45 Female or LC Fiber (Multimode or Single-Mode 100 Mbps only)

Fiber-Optic Ports (Class 1 LASER/LED)

Wavelength

1300 nm

Optical Connector Type

LC

Multimode Option

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

Single-Mode Option

Link Budget:	10 dB
Min. TX Power:	–15 dBm
Min. RX Sensitivity:	–25 dBm
Fiber Size:	9 µm
Approximate Range:	15 km
Data Rate:	100 Mbps
Typical Fiber Attenuation:	–0.4 dB/km

Serial Ports

Ports:	4
Types:	EIA-232/EIA-485 (software selectable)
Data Rate:	300 to 115,200 bps
Connector:	DB-9 Female
Time Synchronization:	IRIG-B
Power:	+5 Vdc power on Pin 1 (500 mA maximum per SEL-2241)

USB Device Ports

1 Type B

Output (SEL-2241 RTAC)

Mechanical Durability

10 M no-load operations

DC Output Ratings

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
Thermal:	50 A for 1 s
Contact Protection:	360 Vdc, 40 J MOV

Operating Time (Coil Energization to Contact Closure, Resistive Load):	Pickup/Dropout time ≤8 ms typical		
Breaking Capacity (10,000 Operations) Per IEC 60255-0-20:1974:	24 Vdc 48 Vdc 125 Vdc 250 Vdc	0.75 A 0.50 A 0.30 A 0.20 A	L/R = 40 ms L/R = 40 ms L/R = 40 ms L/R = 40 ms
Cyclic Capacity (2.5 Cycles/Second) Per IEC 60255-0-20:1974:	24 Vdc 48 Vdc 125 Vdc 250 Vdc	0.75 A 0.50 A 0.30 A 0.20 A	L/R = 40 ms L/R = 40 ms L/R = 40 ms L/R = 40 ms

AC Output Ratings

Rated Operational Voltage:	240 Vac
Rated Insulation Voltage:	300 Vac
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Contact Protection:	270 Vac, 40 J
Continuous Carry:	3 A @ 120 Vac 1.5 A @ 240 Vac
Conventional Enclosed Thermal Current (I_{the}) Rating:	5 A
Rated Frequency:	50/60 ± 5 Hz
Operating Time (Coil Energization to Contact Closure, Resistive Load):	Pickup/Dropout time <8 ms typical
Electrical Durability Make VA Rating:	3600 VA, cosø = 0.3
Electrical Durability Break VA Rating:	360 VA, cosø = 0.3

Backplane (SEL-2242)

Ethernet Port

Port:	1
Data Rate:	10/100 Mbps
Connector:	RJ45 Female
Protocol:	Engineering Access

Note: SEL-2242 Ethernet port is included with the optional touchscreen, 10-slot model only.

Fuse Rating

Non-Serviceable:	2.5 A, 125 V, time lag T

Power Coupler (SEL-2243)

EtherCAT Ports

Ports:	2
Data Rate:	Automatic
Connector:	RJ45 Female or LC Fiber
Protocols:	Dedicated EtherCAT

RJ45 Ports

Cable Length:	<3 m

Fiber-Optic Ports (Class 1 LASER/LED)

Wavelength

1300 nm

Optical Connector Type

LC

Multimode Option

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

Single-Mode Option

Link Budget:	10 dB
Min. TX Power:	–15 dBm
Min. RX Sensitivity:	–25 dBm
Fiber Size:	9 µm
Approximate Range:	15 km
Data Rate:	100 Mbps
Typical Fiber Attenuation:	–0.4 dB/km

Power Supply

AC Input Voltage (High-Voltage Model)

Note: Single phase.

Nominal Supply Voltage:	120–240 Vac, 50–60 Hz
Operational Voltage Range:	85–264 Vac, 40–70 Hz

DC Input Voltage (High-Voltage Model)

Nominal Supply Voltage:	125–250 Vdc
Operational Voltage Range:	85–300 Vdc

DC Input Voltage (Low-Voltage Model)

Nominal Supply Voltage:	24–48 Vdc
Operational Voltage Range:	19.1–57.6 Vdc polarity-dependent

Note: UL operational voltage range is equal to the nominal voltage range ±10 percent.

Fuse Rating

High-Voltage Model, F1:	3.15 A, high breaking capacity, time lag T, 250 V (5x20 mm, T3.15AH 250 V)
High-Voltage Model, F2 (Non-Serviceable):	8 A, high breaking capacity, time lag T, 60 Vdc (2.7x6.1 mm, T8A 60 Vdc)
Low-Voltage Model:	6.30 A, high breaking capacity, time lag T, 250 V (5x20 mm, T6.3AH 250 V)

Power Consumption: See *Table 14* for power per module.

Maximum AC Burden:	160 VA
Maximum DC Burden:	75 W
Interruptions:	30 ms @ 24 Vdc 130 ms @ 48 Vdc 50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

The following exceptions for the IEC 61850-3 acceptance criteria for normal equipment functioning regarding ac power dips and interruptions and dc voltage dips are applicable (refer to IEC 61850-3 subclause 7.5.5, Equipment functioning, and 7.5.6, Exceptions).

Power Supply	Requirement	Exception[a]
125 Vac	5 cycles (83,33 ms @ 60 Hz, 100 ms @ 50 Hz)	50 ms
	50 cycles	Not applicable[b]

[a] Voltage interruptions that are longer than the specified interruption duration result in a device restart.

[b] Equipment is not intended to be connected to power supply ports that are directly connected to a public low-voltage power supply network.

Max Inrush:	17 A
Isolation:	3100 Vdc
Redundant Installation:	Each node may have one or two SEL-2243 modules installed. When two are used, they operate in load-sharing mode.

Recommended External Overcurrent Protection

Breaker Type:	Standard
Breaker Rating:	15 A or 20 A at 250 Vdc
Current Breaking Capacity:	10 kA
Grounded Neutral System:	Device in series with the HOT or energized conductor
DC and Isolated Systems:	Device in series with both conductors

Optoisolated Control Inputs (SEL-2244-2)

When Used With DC Control Signals:

250 Vdc	ON for 200–275 Vdc	OFF below 150 Vdc
220 Vdc	ON for 176–242 Vdc	OFF below 132 Vdc
125 Vdc	ON for 100–135.5 Vdc	OFF below 75 Vdc
110 Vdc	ON for 88–121 Vdc	OFF below 66 Vdc
48 Vdc	ON for 38.4–52.8 Vdc	OFF below 28.8 Vdc
24 Vdc	ON for 15–30 Vdc	OFF for < 10 Vdc

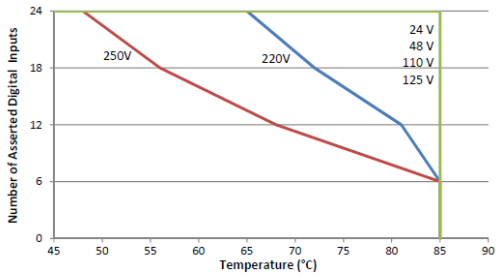
When Used With AC Control Signals:

250 Vdc	ON for 170.6–300 Vac	OFF below 106 Vac
220 Vdc	ON for 150.3–264 Vac	OFF below 93.2 Vac
125 Vdc	ON for 85–150 Vac	OFF below 53 Vac
110 Vdc	ON for 75.1–132 Vac	OFF below 46.6 Vac
48 Vdc	ON for 32.8–60 Vac	OFF below 20.3 Vac
24 Vdc	ON for 14–27 Vac	OFF for < 5 Vac

Burden/Current Draw at Nominal DC Voltage:	2–6 mA (Except for 24 V, 8 mA)
Rated Insulation Voltage:	300 Vac
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

Input Thermal Derating

SEL-2244-2 Digital Input Derating Curve



Control Outputs (SEL-2244-3 Standard Contacts)

Mechanical Durability

10 M no-load operations

DC Output Ratings

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:	350 Vdc, 145 J MOV protection across open contacts		
Operating Time (Coil Energization to Contact Closure, Resistive Load):	Pickup/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

AC Output Ratings

Rated Operational Voltage:	240 Vac
Rated Insulation Voltage (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)
Contact Protection:	250 Vac, 145 J
Continuous Carry:	3 A @ 120 Vac 1.5 A @ 240 Vac
Conventional Enclosed Thermal Current (I_{the}) Rating:	5 A
Rated Frequency:	50/60 ±5 Hz
Operating Time (Coil Energization to Contact Closure, Resistive Load):	Pickup/Dropout time <8 ms typical
Electrical Durability Make VA Rating:	3600 VA, cosø = 0.3
Electrical Durability Break VA Rating:	360 VA, cosø = 0.3

Control Outputs (SEL-2244-5 Fast High-Current Contacts)

Mechanical Durability

10 M no-load operations

DC Output Ratings

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:	330 Vdc, 145 J MOV protection across open contacts
Operating Time (Coil Energization to Contact Closure, Resistive Load)	
Pickup Time:	≤12 µs at 250 Vdc, 16 µs at 125 Vdc, 65 µs at 19.2 Vdc typical (results with 100 kΩ resistive load)
Dropout Time:	≤8 ms typical

Inductive Breaking Capacity (10,000 Operations) Per IEC 60255-0-20:1974:	24 Vdc	10 A	L/R = 40 ms
	48 Vdc	10 A	L/R = 40 ms
	125 Vdc	10 A	L/R = 40 ms
	250 Vdc	10 A	L/R = 20 ms
Cyclic Capacity (4 Cycles/Second Followed by 2 Min Idle Thermal Dissipation) Per IEC 60255-0-20:1974:	24 Vdc	10 A	L/R = 40 ms
	48 Vdc	10 A	L/R = 40 ms
	125 Vdc	10 A	L/R = 40 ms
	250 Vdc	10 A	L/R = 20 ms

AC Output Ratings

Rated Operational Voltage:	110/120/220/240 Vac
Voltage Range:	19.2–250 Vac
Rated Insulation Voltage:	250 Vac
Make:	30 A @ 240 Vac
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:	250 Vac, 145 J MOV protection across open contacts
Operating Time (Coil Energization to Contact Closure, Resistive Load)	
Pickup Time:	≤12 µs at 250 Vac, 16 µs at 125 Vac, 65 µs at 19.2 Vac typical (results with 100 kΩ resistive load)
Dropout Time:	≤8 ms typical

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

Fuse Rating	
Non-Serviceable:	4 A, 450 V, medium time lag M

DC Transducer (Analog) Inputs (SEL-2245-2)

Input Impedance

Current Mode:	200 Ω for ±20 mA 5000 Ω for ±2 mA
Voltage Mode:	10 MΩ

Input Range (Maximum)

±20 mA (transducers: 4–20 mA or 0–20 mA typical)
±2 mA (transducers: 0–1 mA or 0–2 mA typical)
±10 V (transducers: 0–5 V or 0–10 V typical)

Sampling Rate

1 ksps

Anti-Alias Filter

Corner Frequency:	330 Hz
Rolloff:	20 dBV per decade

Digital Filter

Corner Frequency:	Filter A: 16 Hz Filter B: 10 Hz Filter C: 0.2 Hz
50 Hz Rejection:	Filter A: > 30 dB Filter B: > 50 dB Filter C: > 70 dB
60 Hz Rejection:	Filter A: > 60 dB Filter B: > 70 dB Filter C: > 70 dB

Step Response

No Filter:	3 ms (10%–90% response)
Filter A:	23 ms (10%–90% response)
Filter B:	35 ms (10%–90% response)
Filter C:	700 ms (10%–90% response)

Common Mode Range

±35 Vdc between separate inputs
±250 Vdc all inputs to chassis

Isolation

500 Vac between inputs
2000 Vac all inputs to chassis

Accuracy at 25°C

ADC:	16 bit
Voltage Inputs (±10 V):	0.25% of full-scale typical 0.05% with field calibration 2% of full-scale maximum
High Current Inputs (±20 mA):	0.5% of full-scale typical 0.1% with field calibration 2% of full-scale maximum
Low Current Inputs (±2 mA):	0.5% of full-scale typical 0.1% with field calibration 4% of full-scale maximum

Accuracy Variation With Temperature

Inputs:	±0.015% per °C of full scale (±20 mA, ±2 mA, or ±10 V)
ADC:	±0.004% per °C

Triggered Waveform Recording

Sampling Rate:	1 kHz
Record Duration:	0.1 second increments from 0.5 s to 144 s
Record Pre-Trigger:	0.05 s minimum to a maximum of (record length minus 0.05 s)
Waveform File Format:	COMTRADE (IEEE C37.111-1999 compliant)

DC Analog Inputs Extended Range (SEL-2245-22 in DC Mode)

Input Impedance

>7 MΩ

Input Range (Maximum)

0–300 V

Sampling Rate

24 ksps

Anti-Alias Filter

Corner Frequency:	5 kHz
Rolloff:	20 dB per decade

Digital Filter

Corner Frequency:	Filter A: 16 Hz Filter B: 10 Hz Filter C: 0.2 Hz
50 Hz Rejection:	Filter A: > 30 dB Filter B: > 50 dB Filter C: > 70 dB
60 Hz Rejection:	Filter A: > 60 dB Filter B: > 70 dB Filter C: > 70 dB

Step Response

Group Delay (Pre-Filter):	5.3 ms
No Filter:	3 ms (10%–90% response)
Filter A:	23 ms (10%–90% response)
Filter B:	35 ms (10%–90% response)
Filter C:	700 ms (10%–90% response)

Common Mode Range

±250 Vdc between separate inputs
±250 Vac all inputs to chassis

Isolation

2500 Vrms between separate inputs
2500 Vrms all inputs to chassis

Accuracy at 25°C

ADC:	16 bit
Inputs:	0.25% of full scale typical 3% of full scale worst case

Accuracy Variation With Temperature (Inputs)

±0.015% per °C of full scale

Triggered Waveform Recording

Sampling Rate:	1, 2, 4, 8, 24 kHz
Record Duration:	0.1 second increments from 0.5 s to 144 s
Record Pre-Trigger:	0.05 s minimum to a maximum of (record length minus 0.05 s)
Waveform File Format:	COMTRADE (IEEE C37.111-1999 compliant)

DC Analog Outputs (SEL-2245-3)

Current Mode

Output Range:	–20.48 to +20.48 mA
Load Impedance:	0–750 Ω @ 20 mA, 100 µH

Voltage Mode

Output Range:	–10.24 to +10.24 volts
Load Impedance:	>2000 Ω, 1 µF

Step Response

1 ms (10%–90% response typical)

Isolation

2000 Vdc between outputs or ground

Accuracy at 25°C (Outputs)

Current Mode:	±0.3% of full-scale typical ±3% of full-scale worst case (average during an EMI event over a 1-second period)
Voltage Mode:	±0.2% of full-scale typical ±2% of full-scale worst case (average during an EMI event over a 1-second period)

Accuracy Variation With Temperature (Outputs)

±0.01% of full-scale/°K (current or voltage mode)

AC Metering Inputs (SEL-2245-4, SEL-2245-411, SEL-2245-221, and SEL-2245-22 Voltage Inputs in AC Mode)

Frequency:	50/60 Hz
Range:	45–65 Hz
Typical Accuracy	
SEL-2245-4 and SEL-2245-22:	±0.005 Hz above 20 V
SEL-2245-411 and SEL-2245-221:	±0.005 Hz above 500 mV
Worst-Case Accuracy	
SEL-2245-4 and SEL-2245-22:	±0.01 Hz above 20 V
SEL-2245-411 and SEL-2245-221:	±0.01 Hz above 500 mV
Phase Rotation:	ABC, ACB
Input Configuration:	3-Wire Delta, 4-Wire Wye
Update Interval	
Fundamental Metering:	200 Hz
RMS Metering:	5 Hz

Current Inputs Phase and Neutral

I_{NOM}:	1 A or 5 A (no setting required)
Measurement Range:	0.050–22 A Continuous 22–100 A Symmetrical for 25 s
Thermal Withstand Limit:	500 A for 1 s
Typical Accuracy:	±0.1% Fundamental @ f_{NOM} and > 0.6 A ±0.1% RMS @ f_{NOM} and > 0.6 A
Worst-Case Accuracy:	±2% ± 0.005 A Fundamental ±1% ± 0.005 A RMS
Angle	
Range:	±180°
Typical Accuracy:	±0.1° Fundamental @ f_{NOM} and > 0.6 A
Worst-Case Accuracy:	±2° @ f_{NOM}
Burden:	<0.1 VA @ I_{NOM}

Voltage Inputs (SEL-2245-4 and SEL-2245-22 in AC Mode)

V_{NOM}:	300 V
Measurement Range:	5–400 L-N, 9–693 L-L Vac Fundamental/RMS 5–300 L-N, 9–520 L-L Vac Fundamental/RMS (UL)
Maximum:	600 L-N, 1039 L-L Vac Fundamental/RMS for 10 s
Typical Accuracy:	±0.1% Fundamental @ f_{NOM} and > 20 V ±0.1% RMS@ f_{NOM}
Worst-Case Accuracy:	±2% Fundamental @ f_{NOM} ±1% RMS plus ±0.05 V
Angle	
Range:	±180°
Typical Accuracy:	±0.1° @ f_{NOM} and >20 V
Worst-Case Accuracy:	±2° @ f_{NOM}
Burden:	<0.1 VA

LEA Voltage Inputs (SEL-2245-411 and SEL-2245-221)

V_{NOM}:	1.5 V
Measurement Range:	30 Vac peak 0.05–22 Vac RMS
Maximum:	300 V_{L-N} RMS for 10 s (surge)
Typical Accuracy:	±0.1% RMS@ f_{NOM} and >50 mV ±0.1% Fundamental @ f_{NOM} and >50 mV
Worst-Case Accuracy:	±3% ±1 mV @ f_{NOM} Fundamental/RMS
Angle	
Range:	±180°
Typical Accuracy:	±0.1° @ f_{NOM} and > 50 mV
Worst-Case Accuracy:	±2° @ f_{NOM}
Burden:	<0.1 VA

Sequence Components (SEL-2245-4)

Values:	I0, I1, I2, V0, V1, V2
Typical Accuracy	
Magnitude:	±0.2% @ f_{NOM} and V > 6.7 V, I > 0.6 A
Angle:	±0.2° @ f_{NOM} and V > 6.7 V, I > 0.6 A
Worst-Case Accuracy	
Magnitude:	±3% @ f_{NOM} and V > 6.7 V, I > 0.6 A
Angle:	±0.2° @ f_{NOM} and V > 6.7 V, I > 0.6 A

Power and Power Factor Per Phase and Three-Phase (SEL-2245-4)

PA, PB, PC, 3P	
Typical Accuracy:	0.1% @ PF > 0.1
Worst-Case Accuracy:	2%
QA, QB, QC, 3Q	
Typical Accuracy:	0.1% @ PF < 0.9
Worst-Case Accuracy:	2%
SA, SB, SC, 3S	
Typical Accuracy:	0.1%
Worst-Case Accuracy:	2%
PFA, PFB, PFC, 3PF	
Typical Accuracy:	0.1% @ PF > 0.1
Worst-Case Accuracy:	2%

Power and Power Factor Per Phase and Three-Phase (SEL-2245-411)

PA, PB, PC, 3P	
Typical Accuracy:	0.1% @ PF ≥ 0.5
Worst-Case Accuracy:	2%
QA, QB, QC, 3Q	
Typical Accuracy:	0.1% @ PF ≤ 0.98
Worst-Case Accuracy:	2%
SA, SB, SC, 3S	
Typical Accuracy:	0.1%
Worst-Case Accuracy:	2%
PFA, PFB, PFC, 3PF	
Typical Accuracy:	0.1% @ Unity PF
Worst-Case Accuracy:	2%

Synchrophasor

Conformance:	IEEE C37.118.1-2011 as amended by IEEE C37.118.1a-2014 IEEE C37.118.2-2011
Accuracy:	Level 1 as specified by IEEE C37.118
Measurements:	Software selectable (P or M class)
Voltage:	VA, VB, VC, VS
Current:	IA, IB, IC, IN
Positive-Sequence:	V1, I1
Periodic:	Frequency and df/dt
Processing Rate:	120 Hz
Frequency Resolution:	±1.25 mHz*
Calculated Power Resolution:	±0.1%*

* Resolution values tested on SEL-2245-4 with 69 V voltage inputs, 0.6 A to 1 A current inputs, and 49.5 to 50.5 Hz frequency range.

Message Rates (60 Hz nominal):	1, 2, 4, 5, 10, 12, 15, 20, 30, 60, and 120* (messages/second)
Message Rates (50 Hz nominal):	1, 2, 5, 10, 25, 50, and 100* (messages/second)

* This message rate is only supported on the SEL-2245-4 and SEL-2245-411 Axion modules. Message rates are supported on the SEL-3350, SEL-3555, and SEL-3560.

Triggered Waveform Recording (SEL-2245-4, SEL-2245-411, SEL-2245-22, and SEL-2245-221)

Sampling Rates:	1, 2, 4, 8, 24 kHz software selectable
Record Duration:	0.1 second increments from 0.5 s to specified maximum for each sample rate.
Maximum Record Duration:	6 s @ 24 kHz 18 s @ 8 kHz 36 s @ 4 kHz 72 s @ 2 kHz 144 s @ 1 kHz
Record Pre-Trigger:	0.05 s minimum to a maximum of (record length minus 0.05 s)
Waveform File Format:	COMTRADE (IEEE C37.111-1999 compliant)

AC Protection Inputs (SEL-2245-42)

Frequency

Rated:	50/60 Hz
Range:	40–90 Hz
Typical Accuracy:	±0.005 Hz above 20 V
Worst-Case Accuracy:	±0.01 Hz above 20 V (±0.1 Hz for < 2.5 cycles during transients)

Phase Rotation

ABC, ACB

Input Configuration

3-Wire Delta, 4-Wire Wye

Update Interval

Fundamental Metering:	250 Hz
RMS Metering:	250 Hz
RMS Window Size:	1 cycle

AC Current Channels

Nominal Current:	1 A_{RMS} or 5 A_{RMS} (no setting required)
Current Range Rating (With DC Offset at X/R = 10, 1.5 Cycles):	0.1–91 A
Operational Range:	0.1–300 A_{RMS}
Measurement Range:	0.1–20 A_{RMS}
Thermal Withstand Limit:	15 A_{RMS} continuous 500 A_{RMS} for one second

Fundamental Measurement Accuracy

Magnitude:	±0.1%, typical, ±0.001 A ±2%, worst case, ±0.001 A
Phase:	±0.1°, typical at f_{NOM} and current > 0.4 A ±1°, over full rated temperature range ±2°, worst case

RMS Measurement Accuracy

Magnitude:	±0.1%, typical, ±0.001 A ±2%, worst case, ±0.001 A
Burden:	<0.1 VA

AC Voltage Channels

Rated Range:	67–240 V_{L-N}

Note: Rated Range refers to the IEEE C37.118 rating system.

Operational Range:	0–300 V_{L-N}
Accuracy Range:	6.7–300 V_{L-N}
Rated Insulation Voltage:	300 V_{L-N} continuous 600 V_{L-N} for ten seconds

Isolation (Galvanic Isolated Channels)

Channel-to-Ground:	2.5 kV_{RMS} for one minute
Channel-to-Channel:	2.5 kV_{RMS} for one minute

Fundamental Measurement Accuracy

Magnitude:	±0.1%, typical, plus ±0.05 V ±3%, worst case, plus ±0.05 V
Phase:	±0.1° @ f_{NOM}, typical ±1° @ f_{NOM}, over full rated temperature range ±2° @ f_{NOM}, worst case

RMS Measurement Accuracy

Magnitude:	±0.1%, typical, plus ±0.05 V ±3%, worst case, plus ±0.05 V
Burden:	<0.01 VA @ 67 V Impedance >500 kΩ

Sequence Components

Values:	I0, I1, I2, V0, V1, V2

Note: Sequence components are of the fundamental frequency.

Accuracy

Magnitude:	±1%, typical
Angle:	±0.5°, typical

Power and Power Factor (Per-Phase and Three-Phase)

Values:	PA, PB, PC, PAB, PBC, PCA QA, QB, QC, QAB, QAC, QCA SA, SB, SC, SAB, SBC, SCA PFA, PFB, PFC, P3, Q3, S3, PF3
Accuracy:	±1%, typical

THD and Noise (Accuracy)

±5% of measurement plus ±0.25%

Synchrophasors

Conformance:	IEEE C37.118.1-2011 as amended by IEEE C37.118.1a-2014 IEEE C37.118.2-2011
Accuracy:	Level 1 as specified by IEEE C37.118
Measurements:	Software selectable (P or M Class)
Voltage:	VA, VB, VC
Current:	IA, IB, IC
Positive-Sequence:	V1, I1
Periodic:	Frequency and df/dt
Processing Rate:	120 Hz
Frequency Resolution:	±1.25 mHz*
Calculated Power Resolution:	±0.1%*

* Resolution values tested with 69 V voltage inputs, 0.6 A to 1 A current inputs, and 49.5 to 50.5 Hz frequency range.

Message Rates (60 Hz nominal):	1, 2, 4, 5, 10, 12, 15, 20, 30, 60, and 120* (messages/second)
Message Rates (50 Hz nominal):	1, 2, 5, 10, 25, 50, and 100* (messages/second)

* Message rates are supported on the SEL-3350, SEL-3555, and SEL-3560.

Triggered Waveform Recording

Sampling Rates:	1, 2, 4, 8, 24 kHz software selectable

Transient Fault Record Length

Individual Records as Long as:	24 s for 24 kHz 72 s for 8 kHz 144 s for 4 kHz 288 s for 2 kHz 576 s for 1 kHz
Pre-Fault Time:	0.05 s to (max. event length – 0.05 s)
Data Format:	IEEE C37.111-2013 COMTRADE
File Naming:	IEEE C37.232 COMNAME

Fuse Rating

Non-Serviceable:	2.5 A, 125 V, time lag T

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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Notes

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