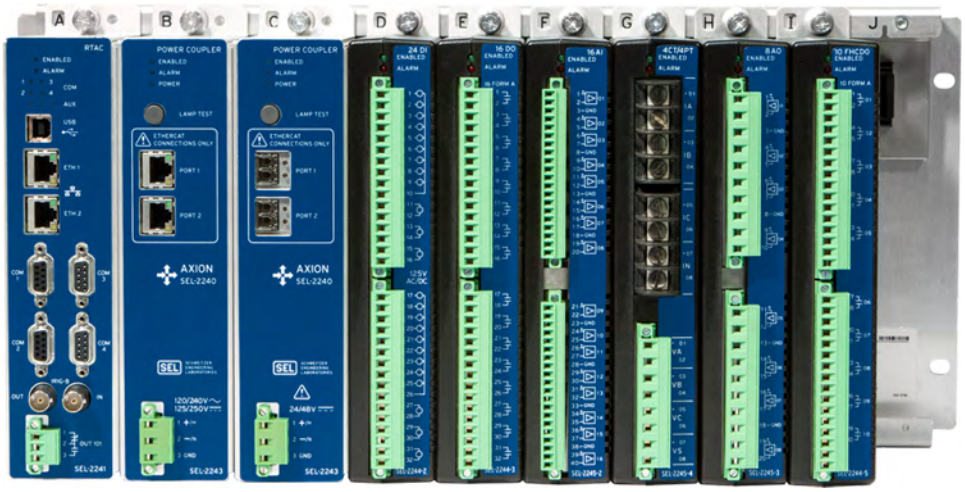
SEL-2240 Axion

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



The SEL Axion® is a fully integrated modular digital I/O, analog input, 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 network.

Major Features and Benefits

- **Synchronized Current and Voltage Measurements.** The Axion CT/PT module provides 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. Utilize this capability to accomplish complex control schemes including load shedding, microgrid control, and autosynchronization.
- **Top of Second Synchronized Measurements.** When connected to IRIG, the Axion synchronizes 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 of the Axion modules. This expands time-deterministic control capability to wide-area applications since the CT/PT measurements from multiple Axion systems are all synchronized.
- **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® network.
- **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) timestamps.
- **More than SCADA**. Go beyond SCADA using the Axion's 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

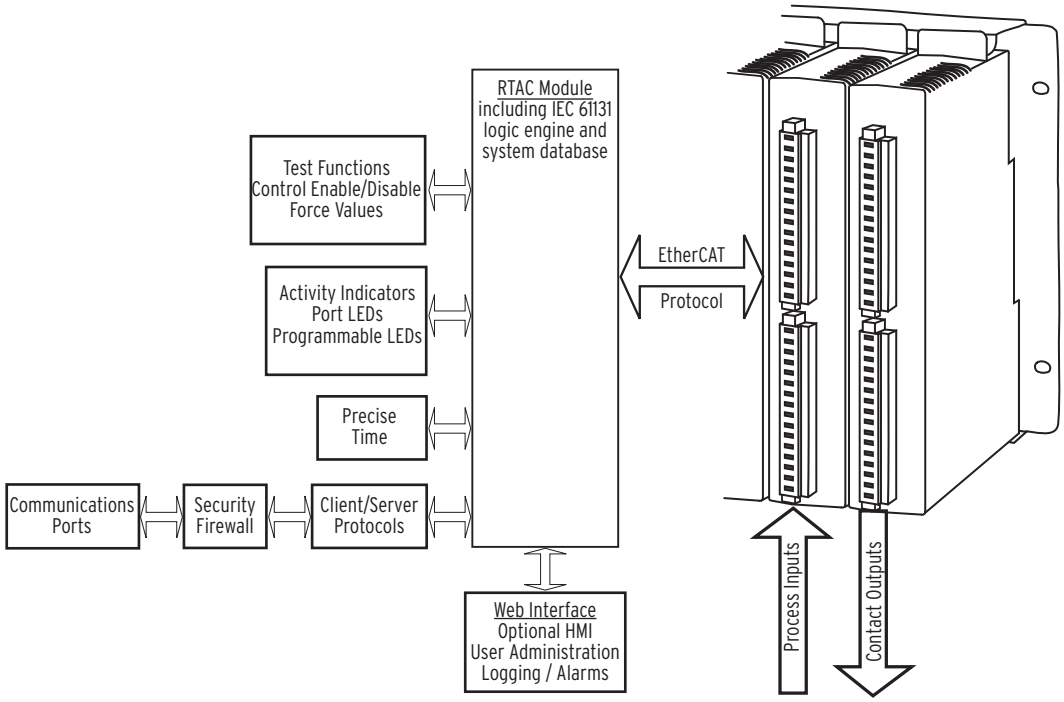


Figure 1 Functional Diagram

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 modules 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 stand-alone RTAC module. SEL-3530 RTAC connects via Ethernet to an SEL-2240 node. SEL designs all Axion hardware to published standards (see *Specifications*) 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.

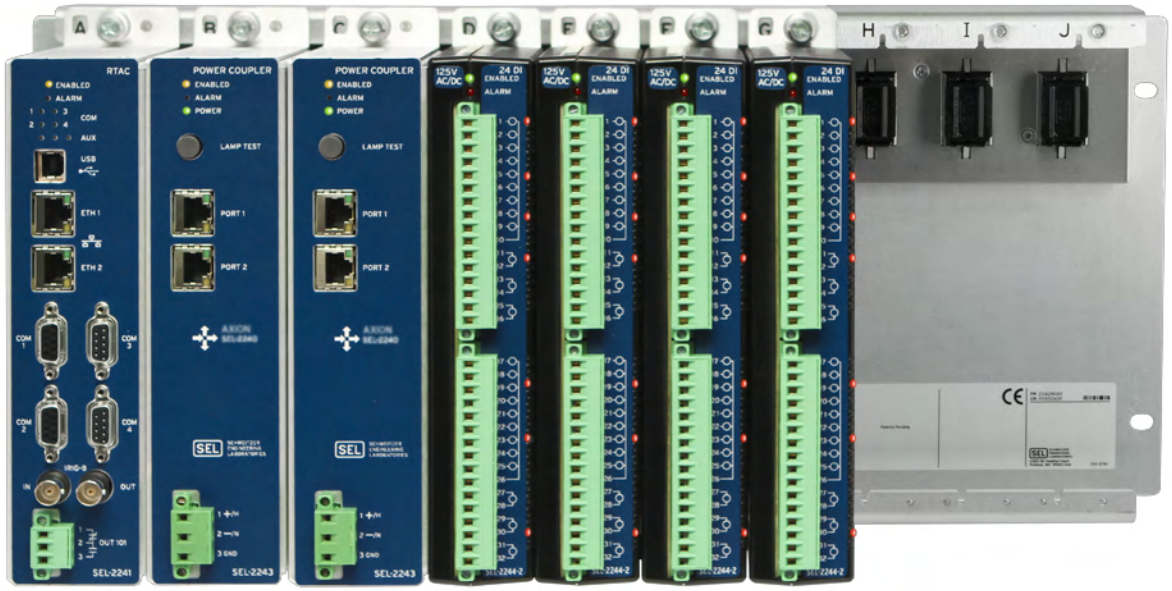


Figure 2 Modules Installed in Chassis/Backplane With Spare Slots

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. The *Applications* section explores a number of 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 of 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 pre-installed 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 which 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 user name, 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 web pages 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.

Use the intuitive ribbon interface, as shown in *Figure 3*, to configure all of the I/O modules and device connections for the project. The Project View in the left pane lets you organize and quickly see everything in the project.

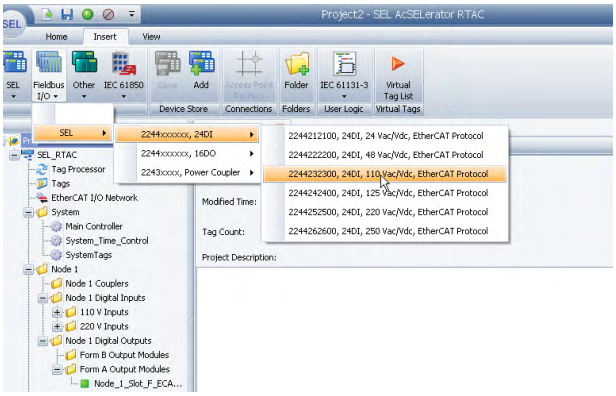


Figure 3 Adding SEL-2240 I/O Modules to a Project

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 4* 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.

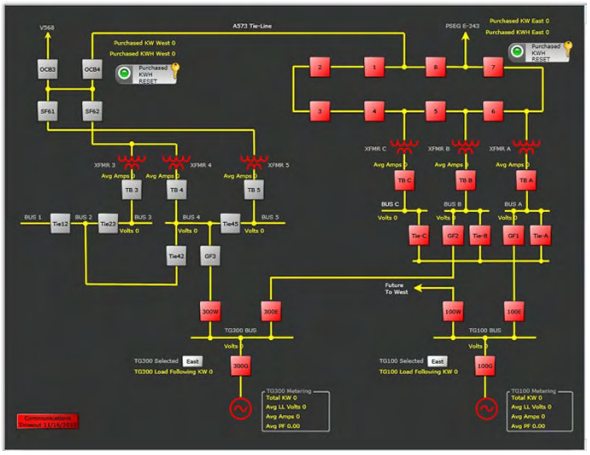


Figure 4 Powerful Monitoring Functions Using the Web-Based HMI

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.

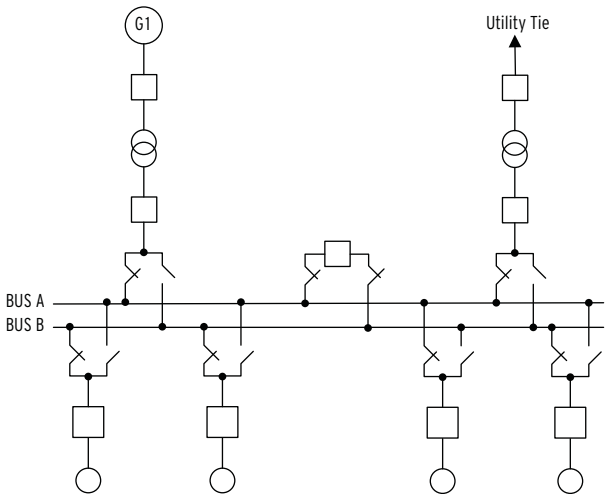


Figure 5 Load-Shedding Topology

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 many 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 6 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.

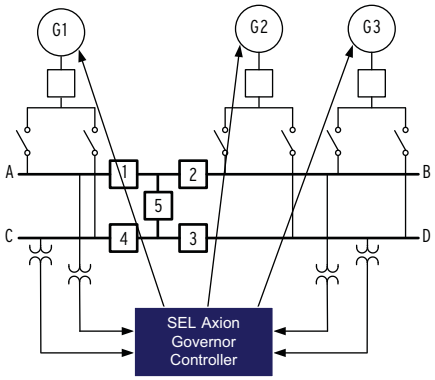


Figure 7 SEL Axion Autosynchronization System

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 (DNP, 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 DNP, Modbus, LG 8979, IEC 61850, or SEL Fast Message. The following diagram illustrates use of the Axion as a distributed RTU communicating over DNP to a SCADA master.

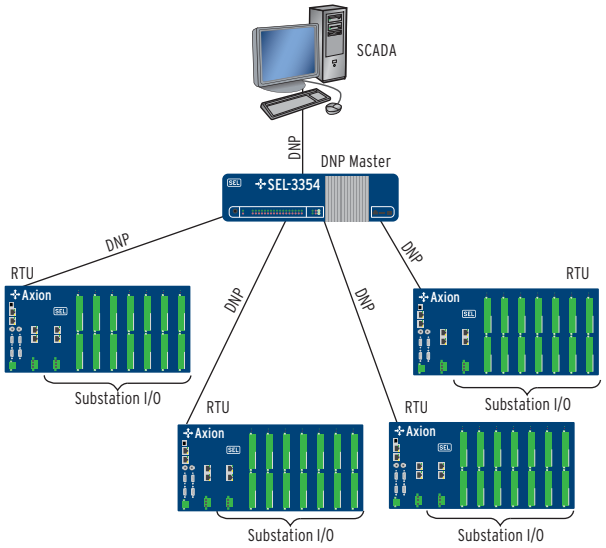


Figure 8 RTACs Distributed With RTUs

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 DNP and interface directly with the SCADA system. The master Axion in *Figure 9* 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 9* 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.

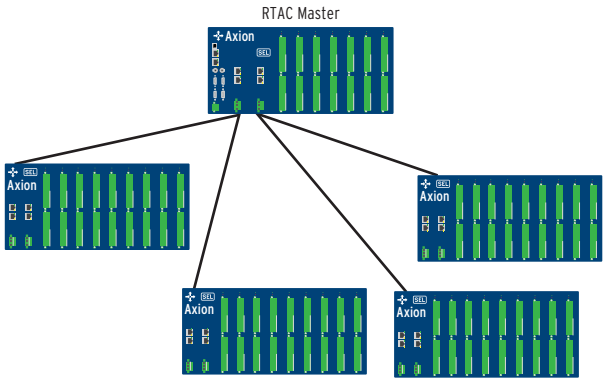


Figure 9 EtherCAT Star Network Topology

Figure 10 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.

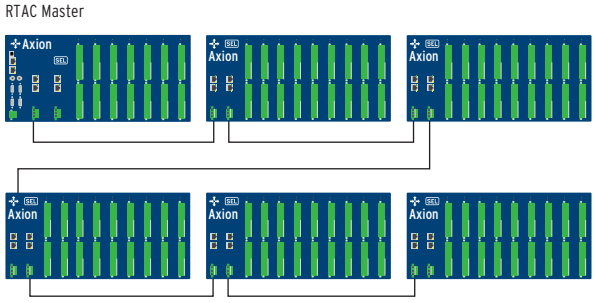


Figure 10 EtherCAT Sequential Network Topology

Figure 11 illustrates a combination of star and sequential connections with six Axion nodes.

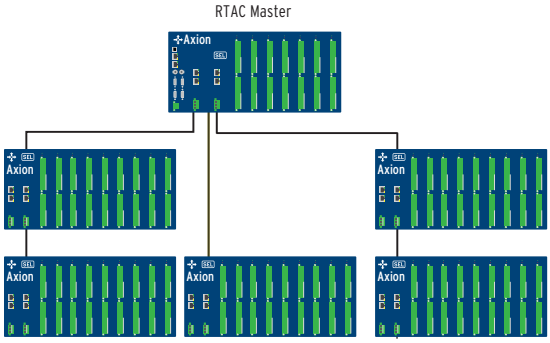


Figure 11 EtherCAT Hybrid Network Topology

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.

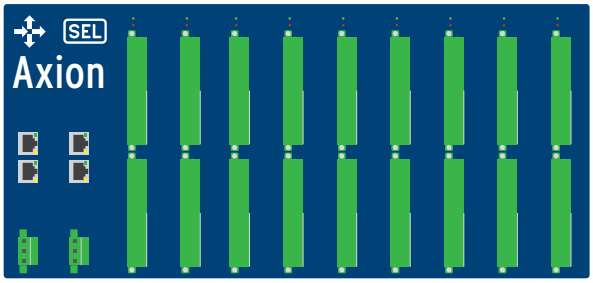


Figure 12 Remote I/O Configuration

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.

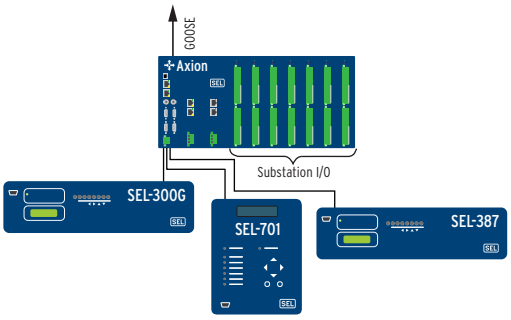


Figure 13 IEC 61850 Goose Concentrator

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.

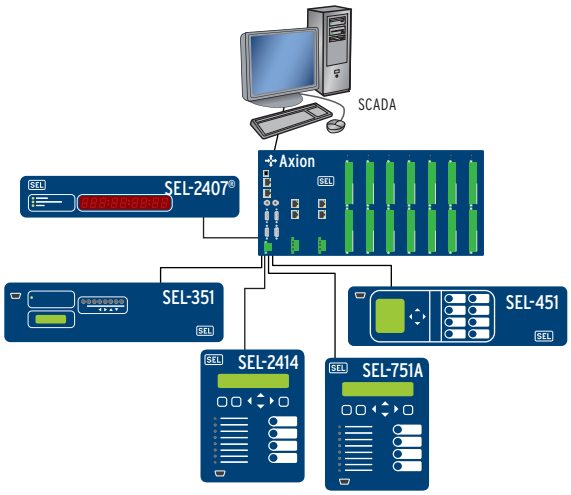


Figure 14 Synchrophasor Concentrator

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.

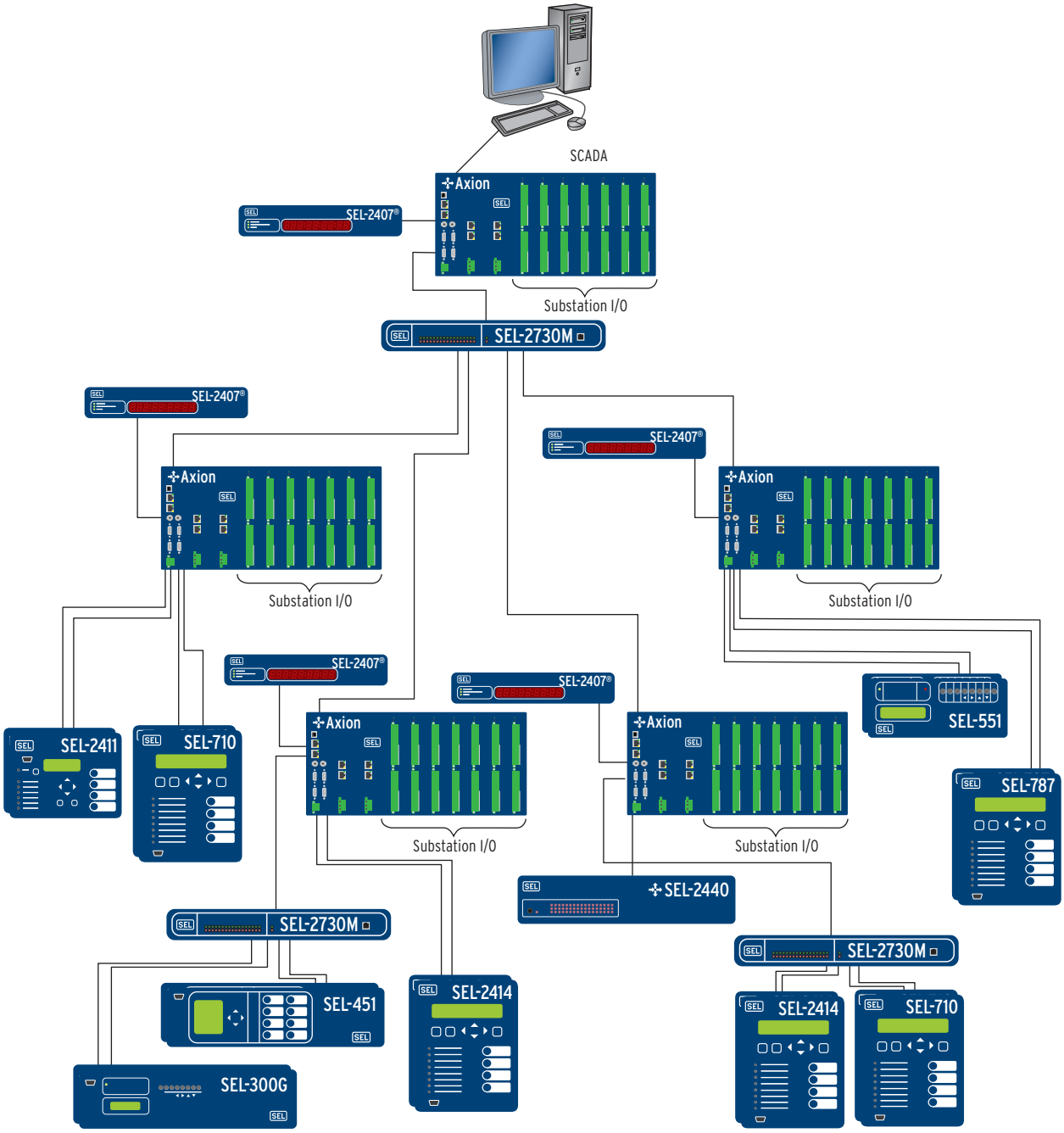


Figure 15 SCADA Data Concentrator and HMI

Human-Machine Interface

Use the built-in web human-machine interface (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. Since the HMI application is web-based, multiple users can view the HMI screens simultaneously.

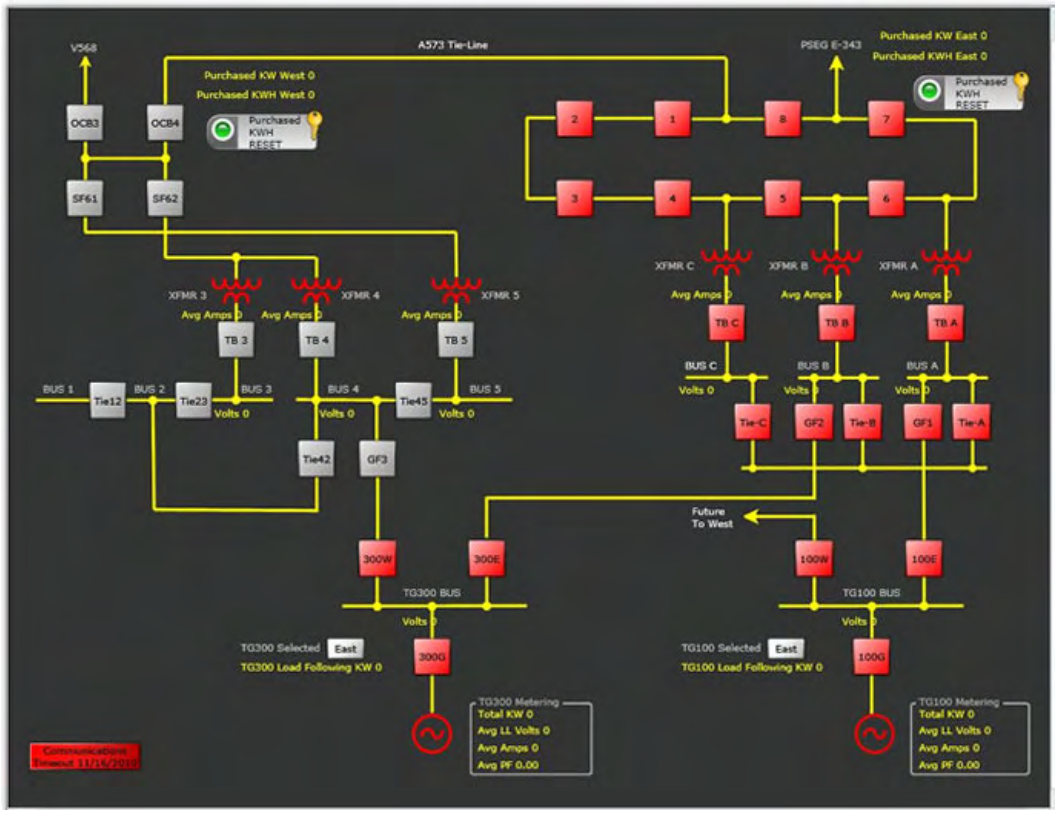


Figure 16 HMI Oneline

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.

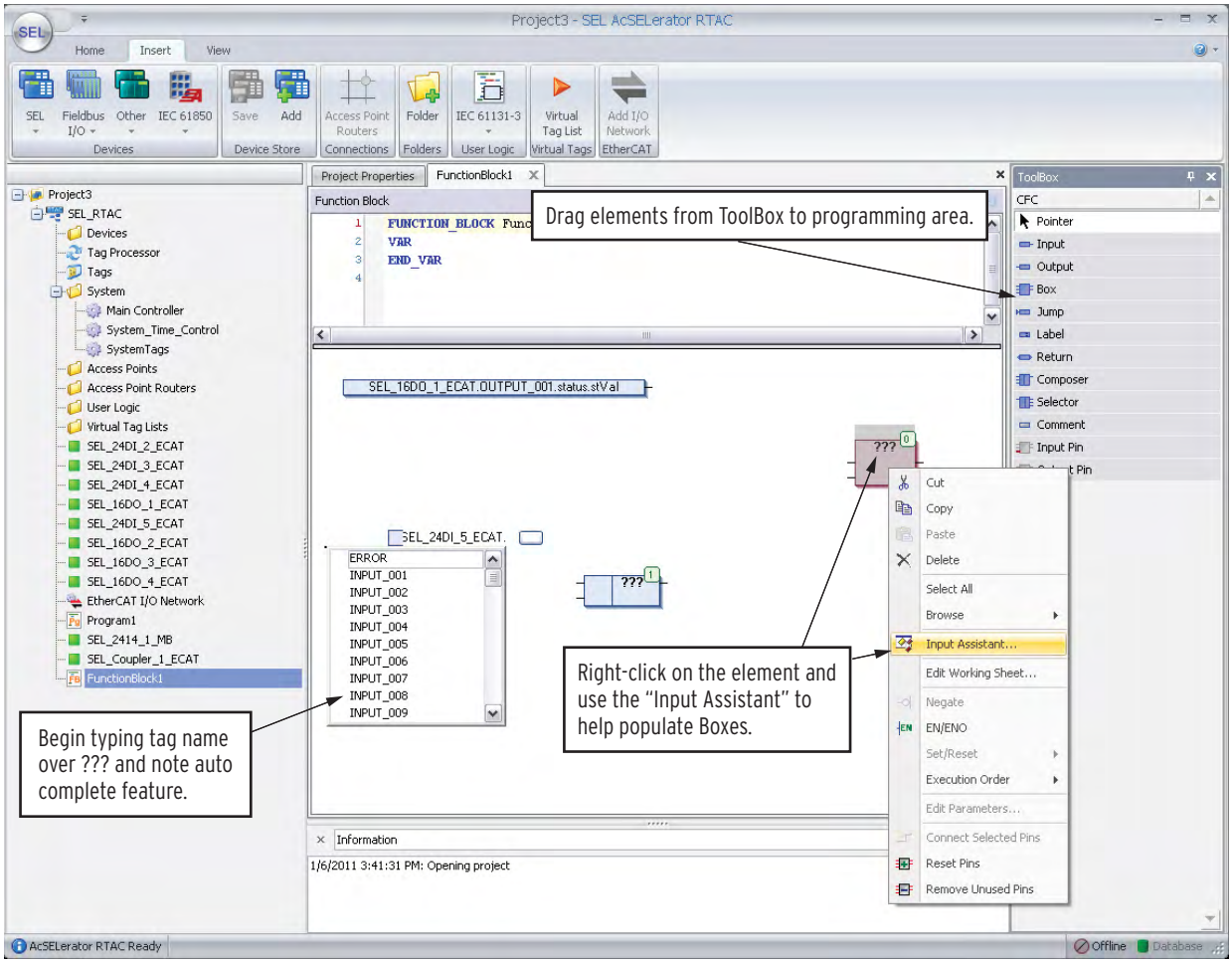


Figure 17 IEC 61131 Logic Example

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.

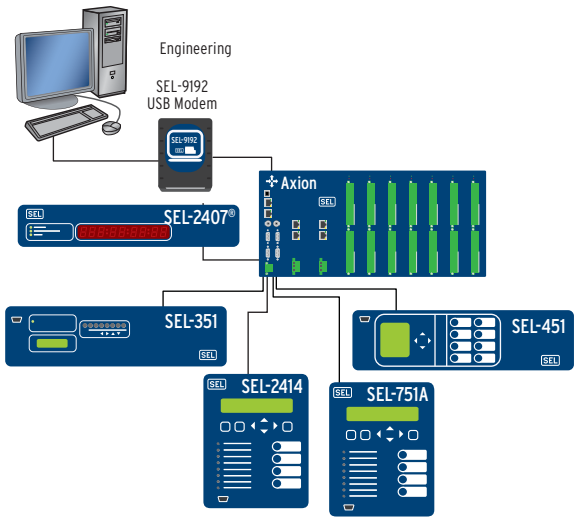


Figure 18 Intelligent Port Switch

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.

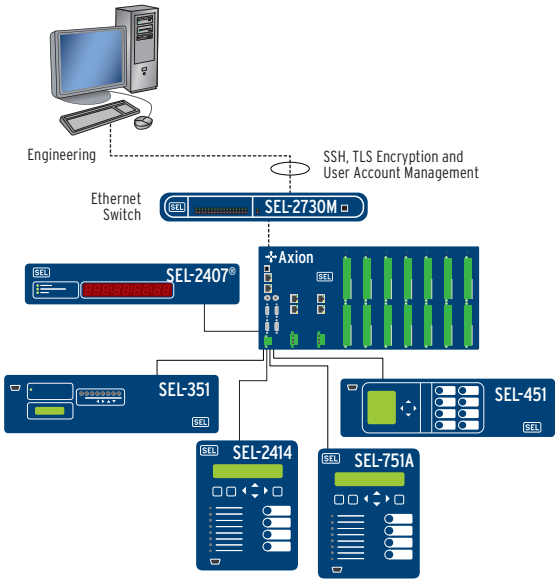


Figure 19 Network Gateway

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.

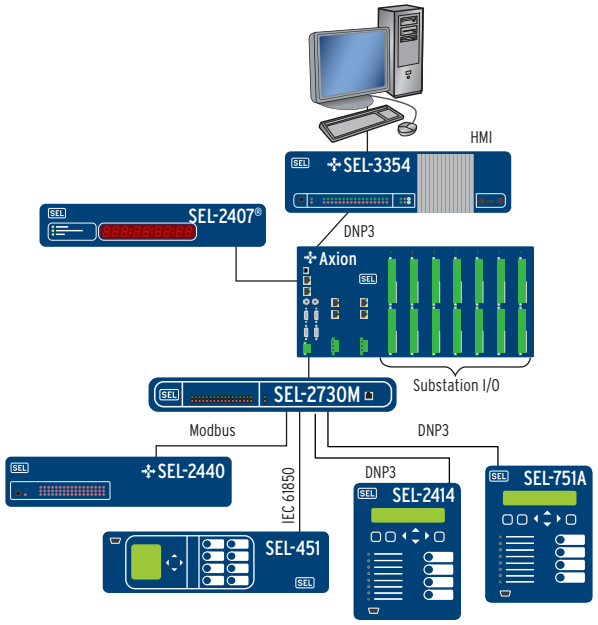


Figure 20 Protocol Converter

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.

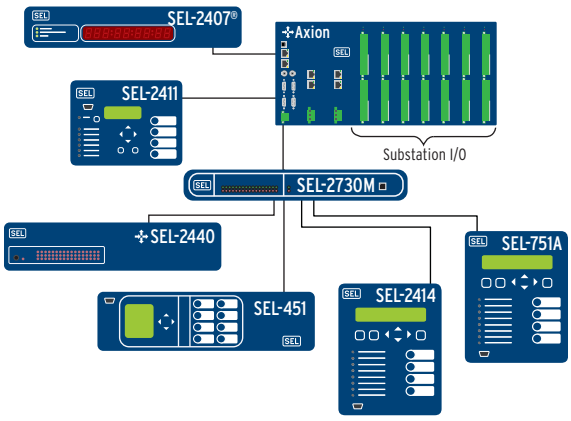


Figure 21 Time Synchronization

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.

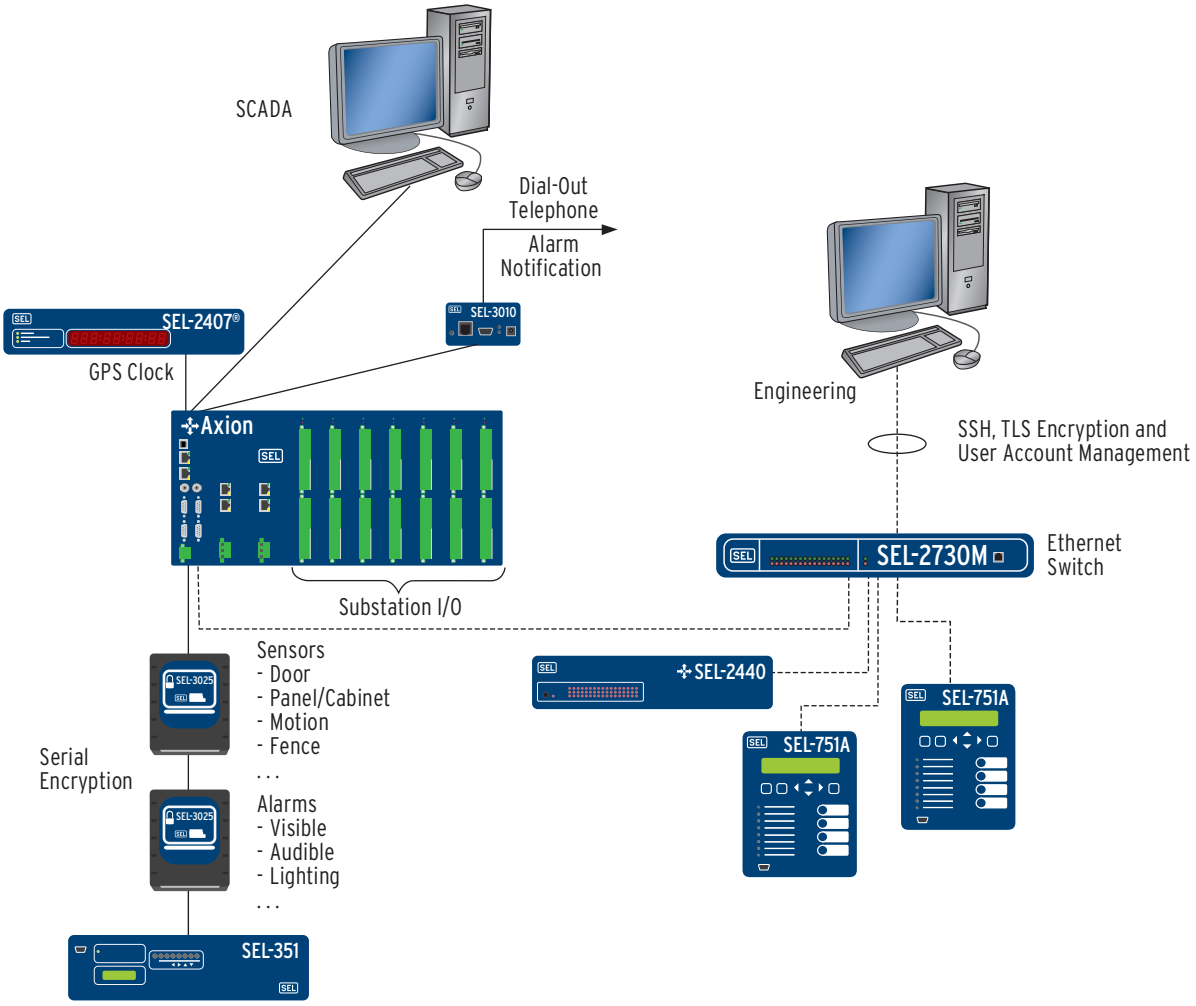


Figure 22 Security Gateway

Ordering Options

Table 1 SEL-2241 RTAC Module

Ethernet Communication	2 Ethernet ports: 10/100BASE-T copper (standard) or 100BASE-FX fiber optic (optional)
Web-based Human-Machine Interface (HMI)	Basic runtime license and Diagram Builder software
Peer-to-Peer Protocols	IEC 61850 GOOSE
Client 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 Horizontal Rack Mount, 5U
Environment	Conformal coating for chemically harsh and high-moisture environments

Table 3 SEL-2243 Power Coupler

Voltage Range	24/48Vdc or 120/250 Vac/Vdc
EtherCAT Communication	2 ports: RJ45 Ethernet (standard) or LC Fiber Optic (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-2245-4 AC Metering Module

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

Module Features

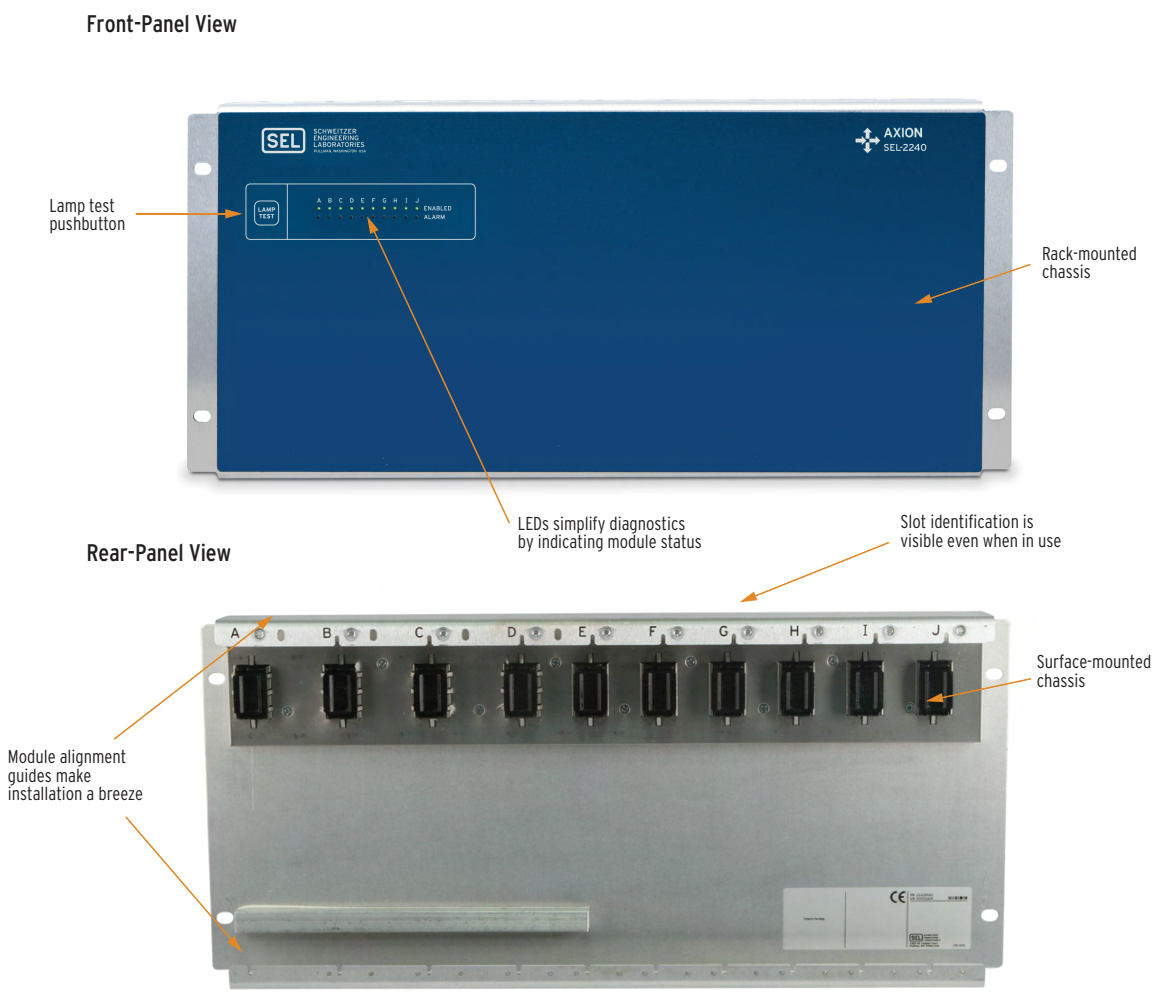


Figure 23 SEL-2242 10-Slot Chassis/Backplane

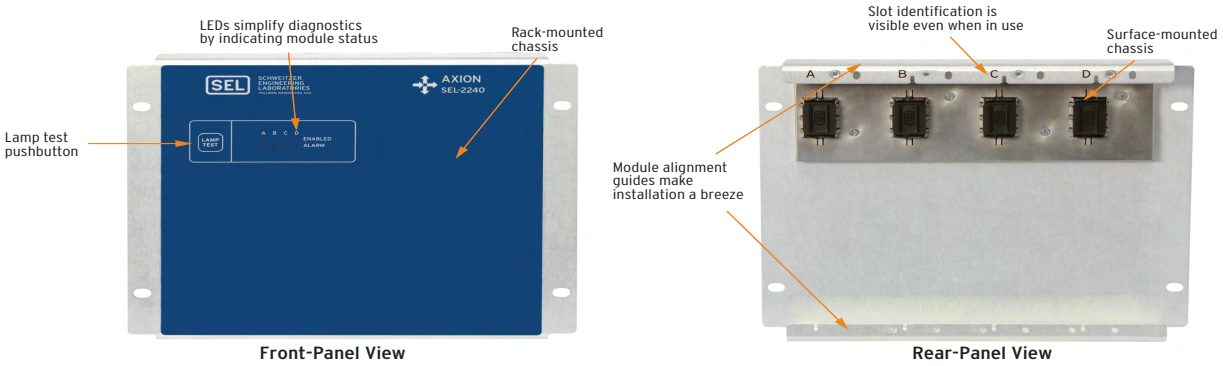


Figure 24 SEL-2242 4-Slot Chassis/Backplane

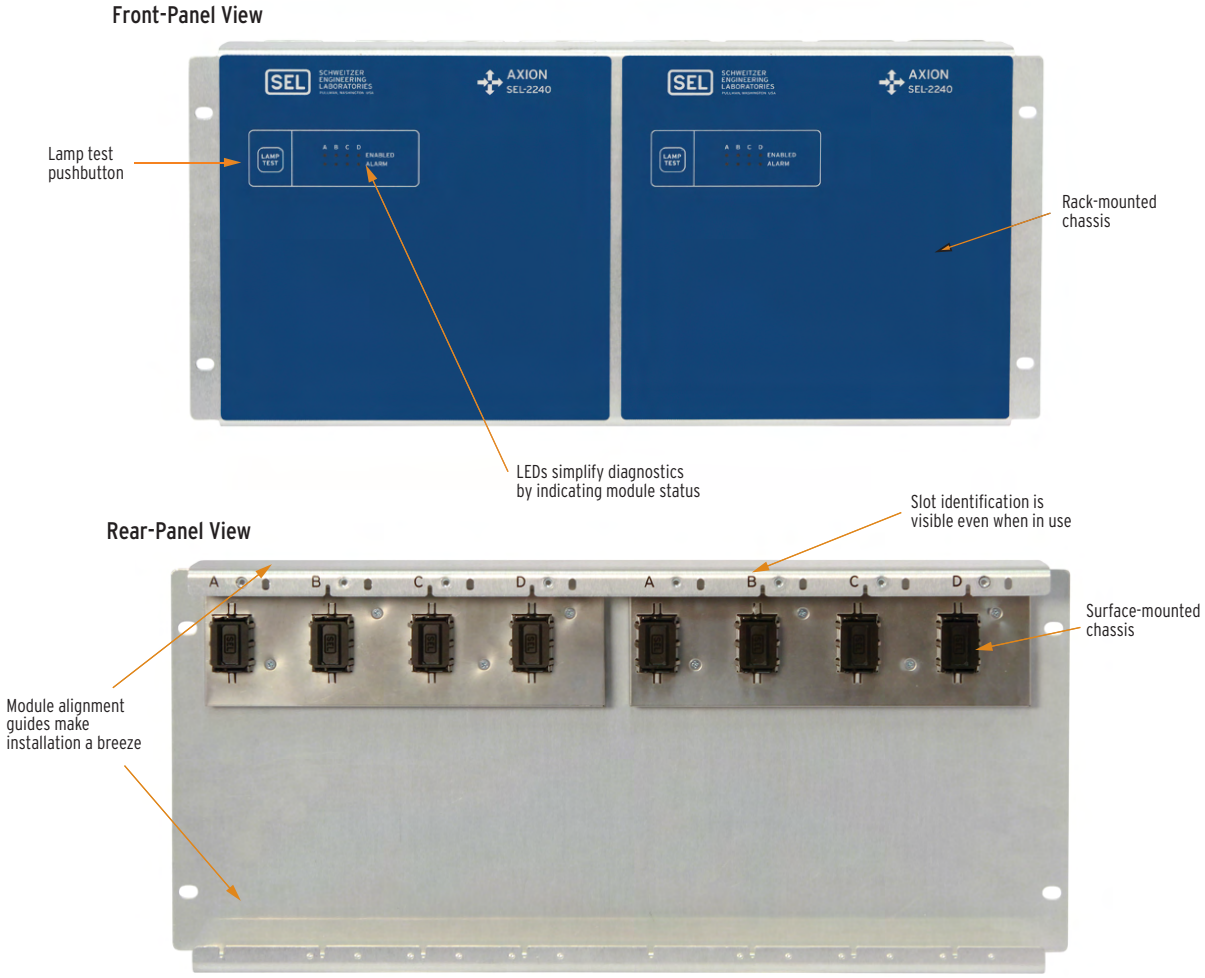


Figure 25 SEL-2242 Dual 4-Slot Chassis/Backplane

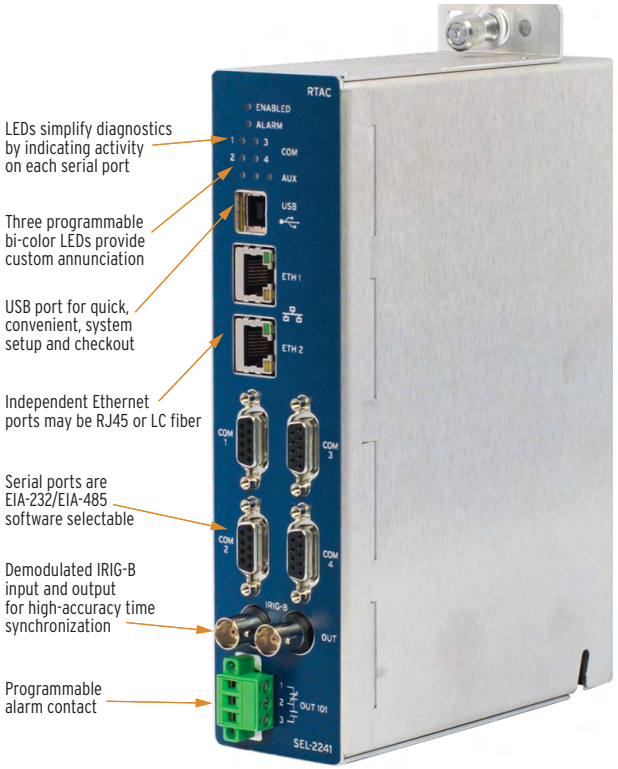


Figure 26 SEL-2241 RTAC Terminal-Side View

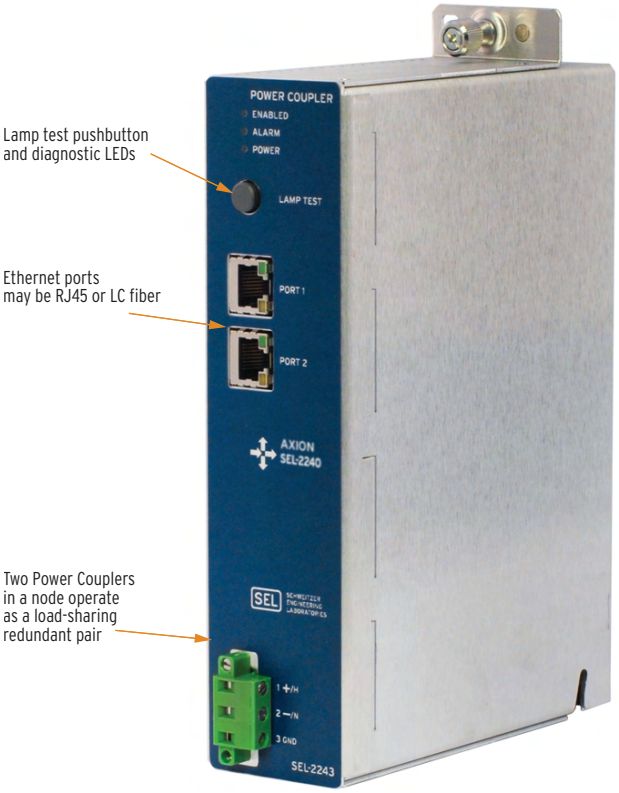


Figure 27 SEL-2243 Power Coupler Terminal-Side View

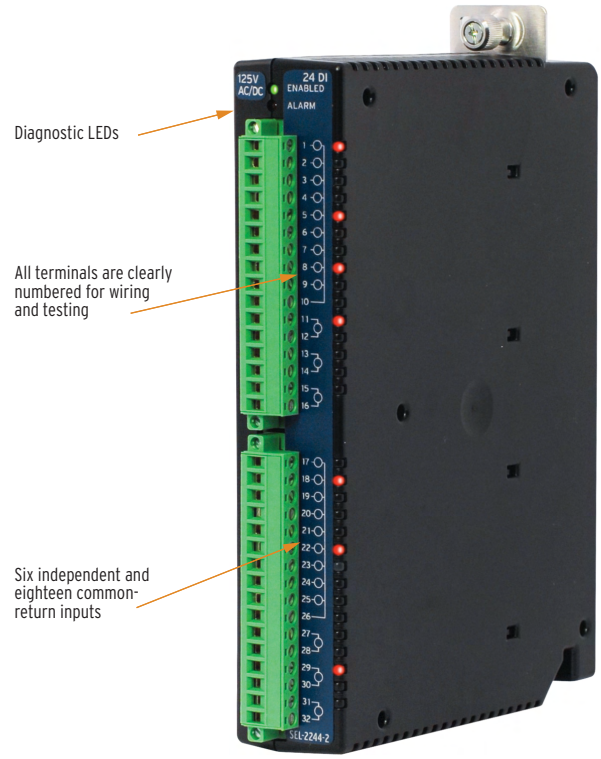


Figure 28 SEL-2244-2 Digital Input Module Terminal-Side View

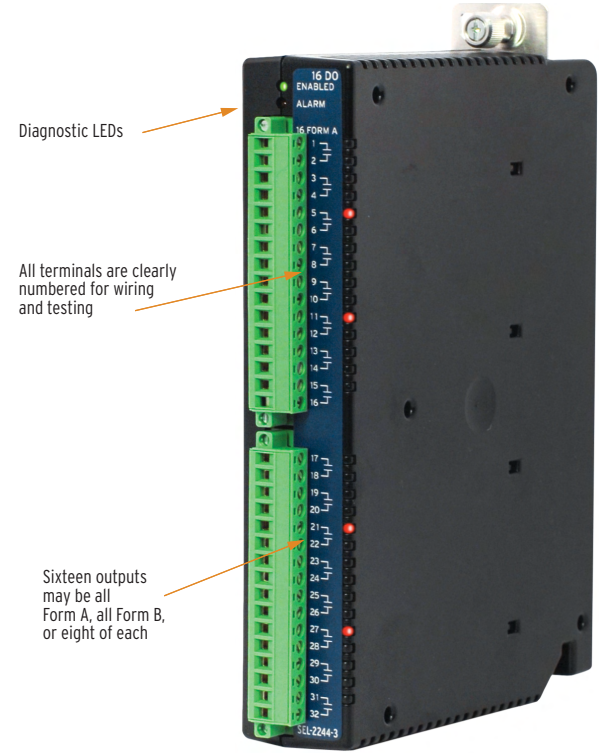


Figure 29 SEL-2244-3 Standard Current Digital Output Module Terminal-Side View

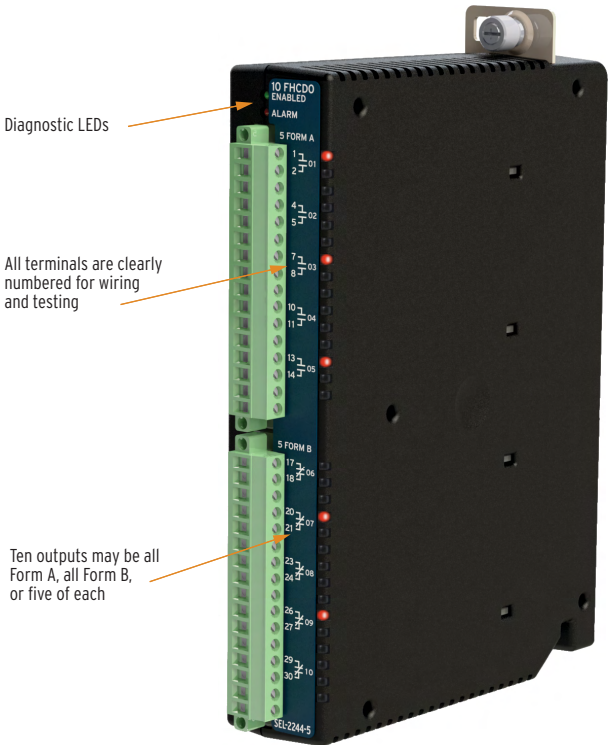


Figure 30 SEL-2244-5 Fast High-Current Digital output module Terminal-Side View

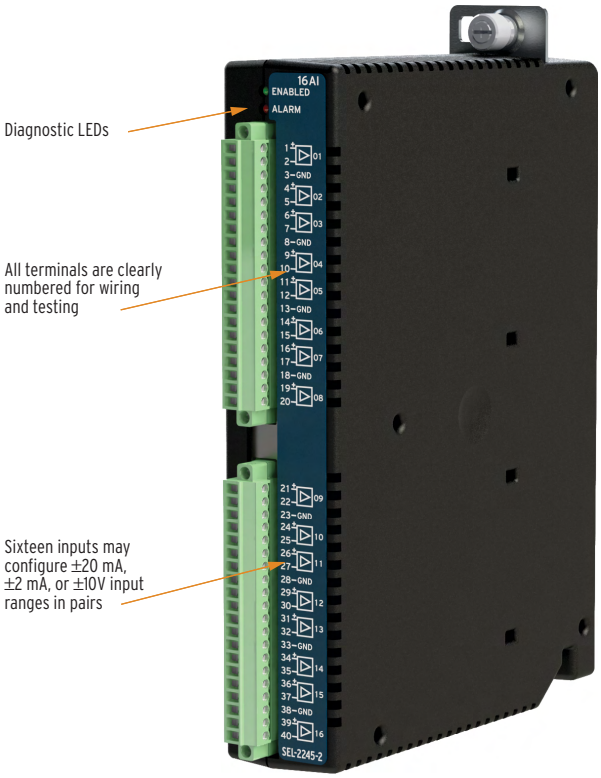


Figure 31 SEL-2245-2 DC Analog Input Module Terminal-Side View

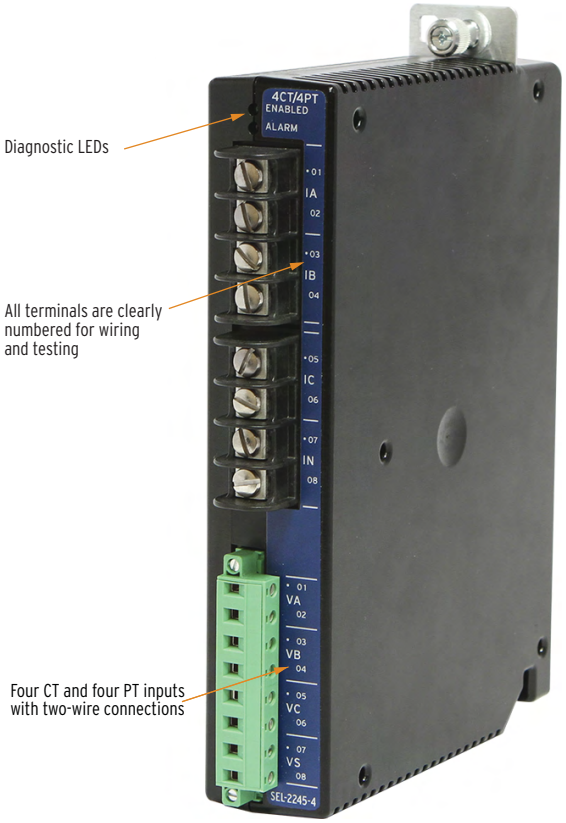


Figure 32 SEL-2245-4 AC Metering Module Terminal-Side View

Guideform Specification

The microprocessor-based system shall operate simultaneously on multiple serial and Ethernet communications networks. It shall provide a combination of functions that include digital input and digital output support, deterministic logic processing, automatic transmission of outgoing messages and processing of responses, data scaling, data aggregation, simultaneous collection of data from multiple server devices, and simultaneous data access for multiple client (master) devices. The system shall provide IEC 61850 GOOSE, EtherCAT, Modbus RTU and Modbus TCP client/server, LG 8979 client/server, SES-92 server, IEC 60870-5 101/104 server, DNP3 Level 3 serial, and DNP3 Level 3 LAN/WAN client/server protocols. Specific operational and functional requirements are as follows:

- **Digital Inputs Sequential Events.** The system shall maintain a user-configurable record of digital input operations on the EtherCAT network that is accurate to 1 ms.
- **DC Analog Inputs.** The system can include as many as sixteen DC analog input modules. Input ranges are ±20 mA, ±2 mA, and ±10 V.
- **AC Analog Inputs.** The system can include as many as 16 CT/PT analog input modules. Input ranges are 0–22 A for CT inputs and 5–400 V for PT inputs.
- **Intelligent and Secure Components.** All electronic equipment shall continuously self-test and report internal errors. The system shall have a hardwire contact indicating system health.
- **IEC 61131-3 Programming.** The system shall include an integrated IEC 61131-3 programming environment, with the ability to monitor and control every connected EtherCAT I/O module, protective relay, and other serial or Ethernet-based intelligent electronic devices (IED) continuously. The IEC 61131-3 programming environment shall be integrated in one software package with the communications protocol mapping environment.
- **Role-Based Security**. The system shall incorporate independent user-based security with strong passwords, role-based accounts, and settable account expirations dates. The system shall provide a mechanism to map security related system tags into SCADA reports.
- **Central Authentication.** The system shall use Lightweight Directory Access Protocol (LDAP) to provide central user account authentication.
- **Selectable Processing Interval and Solve Order.** The system shall include a method to configure the deterministic processing interval for protocol communications and custom logic. The system shall also include a method to configure the processing sequence of software tasks.
- **Redundant Power Supply Operation.** The system shall allow the use of two power supply modules that continuously share load. If the incoming power for one module becomes unavailable, the remaining power supply shall have sufficient capacity to accommodate an entire node.
- **High-Speed Peer-to-Peer Communication.** The system shall use MIRRORED BITS® communications and IEC 61850 GOOSE protocol to transmit and receive high-speed digital data to/from IEDs to create custom protection and control schemes. IEC 61850 GOOSE shall be an available option for the system.
- **IEC 61850.** The information processor shall have an option to support IEC 61850 GOOSE transmit and receive messaging. There shall also be an option to support IEC 61850 MMS client for polling data sets and reports from IEDs.
- **Deterministic Ethernet Fieldbus.** The system shall use EtherCAT protocol to operate a deterministic, Ethernet-based fieldbus network for connected I/O modules.
- **Web-Based HMI.** The system shall have an optional web-based HMI that has complete access to all system tags available.
- **Serial Communications Ports.** The system shall have four serial ports that shall be software configurable for EIA-232 or EIA-485 communications modes. Each serial port connector shall have an available demodulated IRIG-B time-synchronization signal.
- **Ethernet Communications Ports.** The CPU module for the system shall have two Ethernet ports that can operate simultaneously on different networks through independent MAC addresses.
- **Alarm Output.** There shall be an alarm contact output to signal internal errors and malfunctions. The alarm contact shall be programmable so that the alarm conditions that activate the output can include additional conditions.
- **Environmental Testing.** All system modules shall be tested to IEEE 1613-2003 for communications and networking equipment in electric power substations. The system modules shall also be tested to the same standards as those used for protective relays.
- **Synchrophasors.** The system CPU shall be capable of receiving synchronized phasor measurement data via the IEEE C37.118 protocol on all serial and Ethernet ports at rates as fast as 60 messages per second. Additionally, as many as 14 phasor measurements may be served to a master at rates as fast as 60 messages per second.
- **Retained Memory.** The system CPU shall have nonvolatile memory available for user-programmable retained variables.

- **Engineering Access.** The system CPU shall have methods to create transparent connections between any two serial or Ethernet communications ports for engineering access.
- **Reliability.** The vendor shall supply the actual measured Mean Time Between Failures (MTBF) for the device upon request.
- **Service.** The device shall include no-charge technical support for the life of the product.
- **Manufacturer.** The manufacturer shall design and assemble all components, including the printed circuit boards in a wholly owned manufacturing facility within the United States.
- **Conformal Coating.** The device shall have optional conformal coating for each module to protect the circuit boards from harsh environments.
- **Warranty Return.** The vendor shall support a 72-hour turnaround on all warranty repairs.
- **Warranty.** The device shall include a ten-year, no-questions-asked warranty for all material and workmanship defects. In addition, the warranty shall cover accidental customer-induced damage.

Front- and Rear-Panel Diagrams

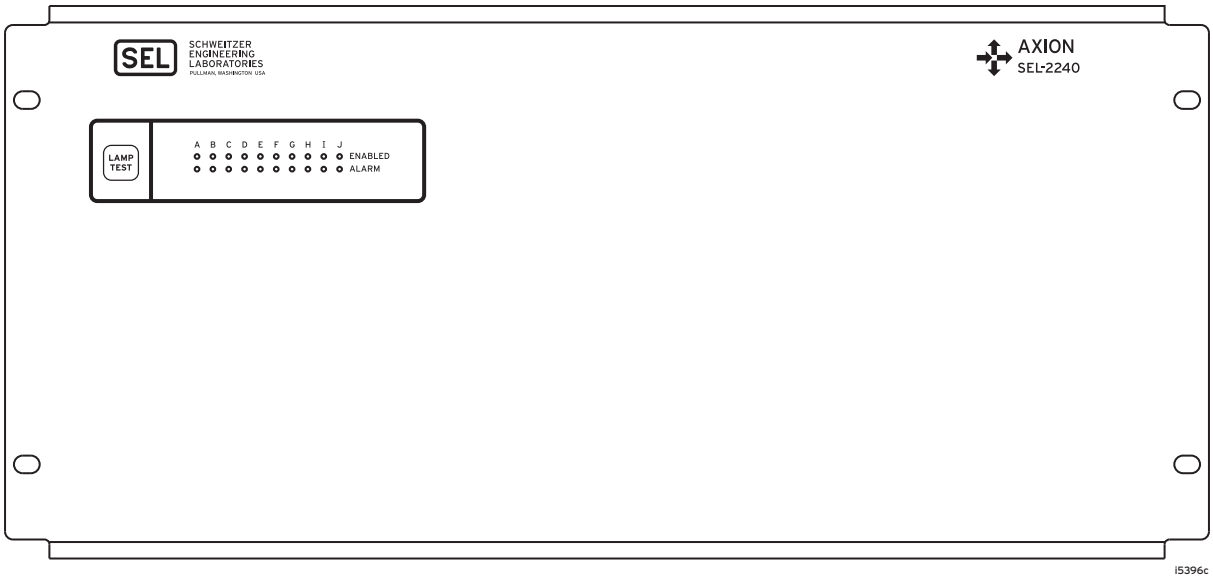


Figure 33 SEL-2240 10-Slot Front Panel

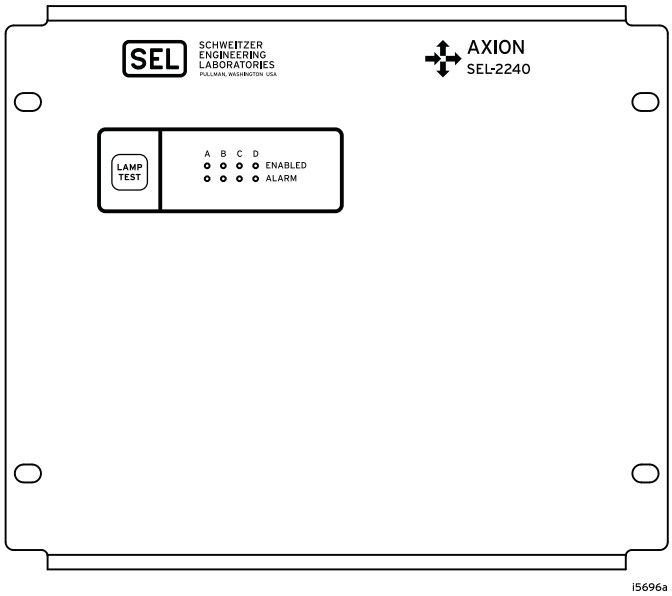


Figure 34 SEL-2240 4-Slot Front Panel

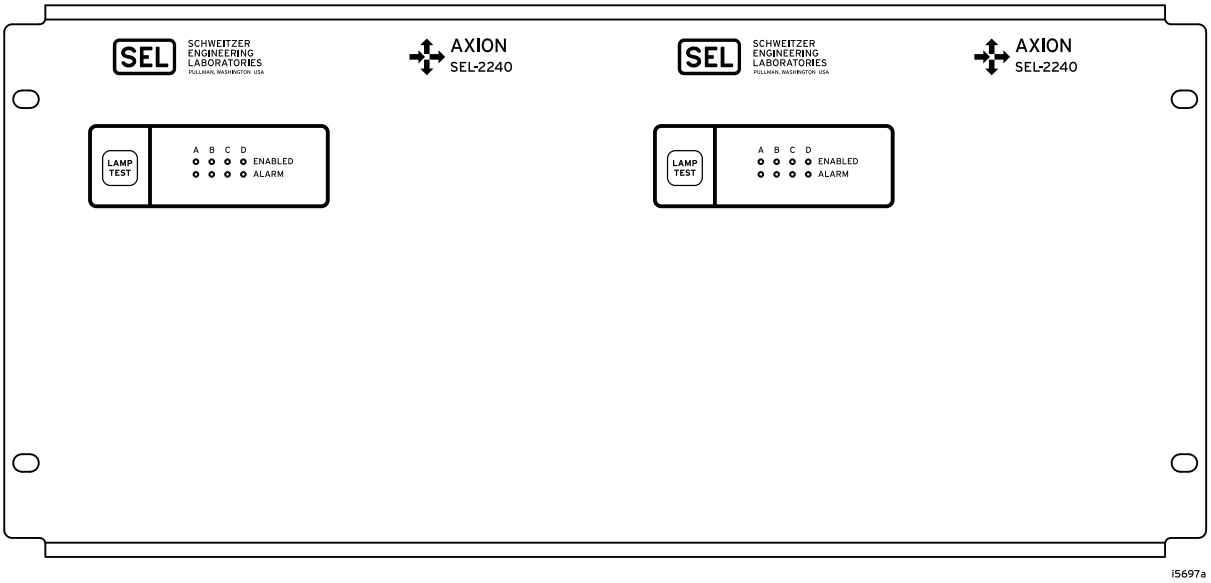


Figure 35 SEL-2240 Dual 4-Slot Front Panel

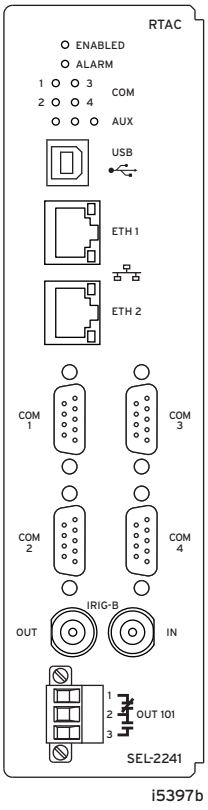


Figure 36 SEL-2241 Connections Diagram

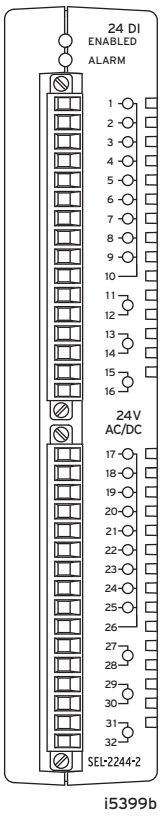


Figure 38 SEL-2244-2 Connections Diagram

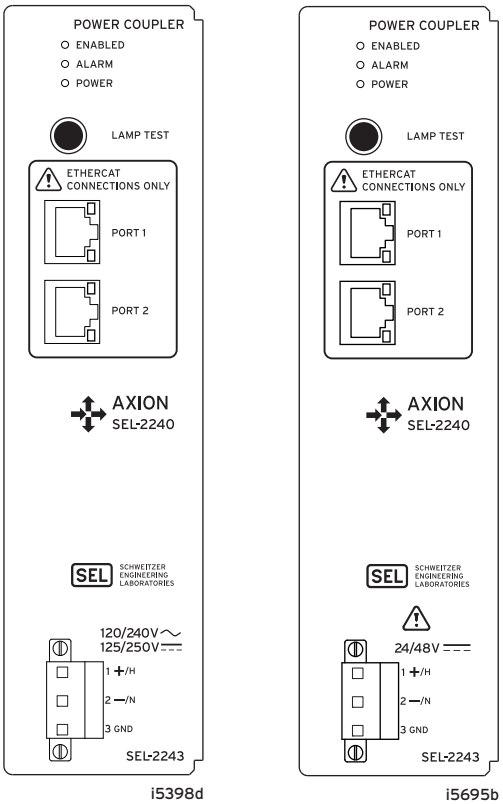


Figure 37 SEL-2243 Connections Diagram

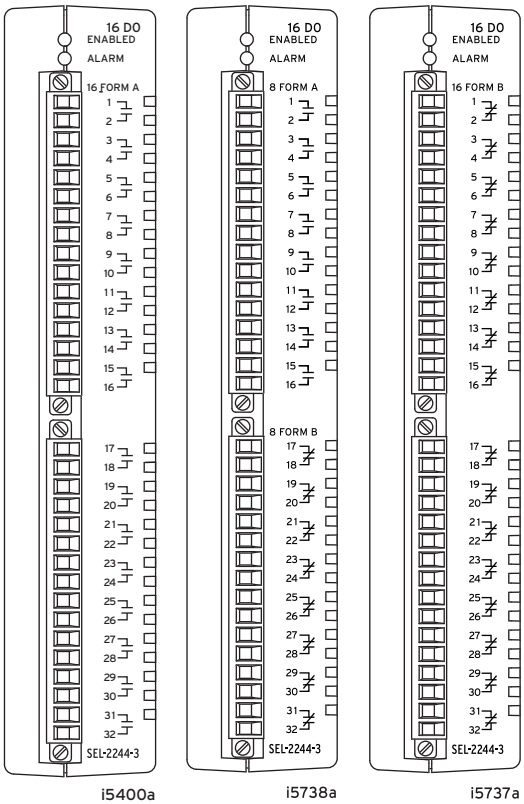


Figure 39 SEL-2244-3 Connections Diagram

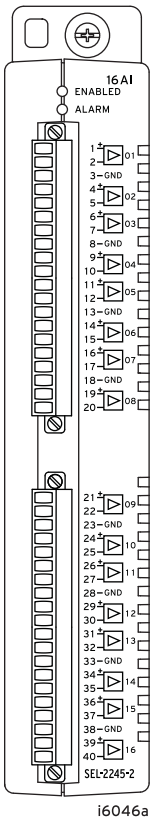


Figure 40 SEL-2245-2 Connections Diagram

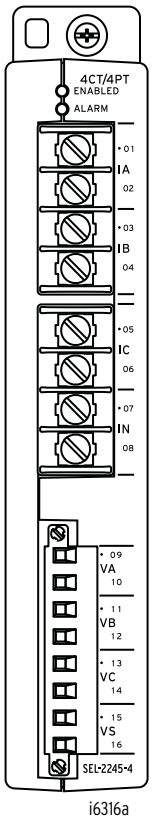


Figure 41 SEL-2245-4 Connections Diagram

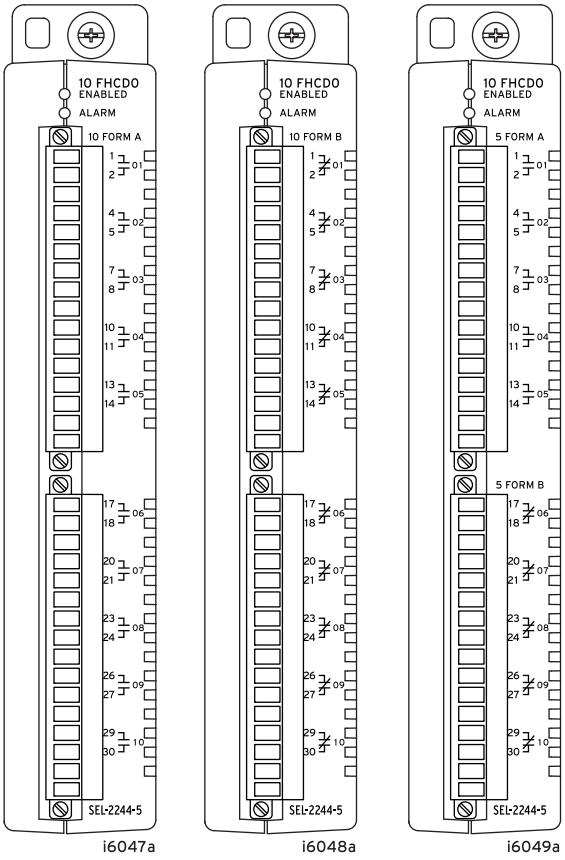


Figure 42 SEL-2244-5 Connections Diagram

Dimensions

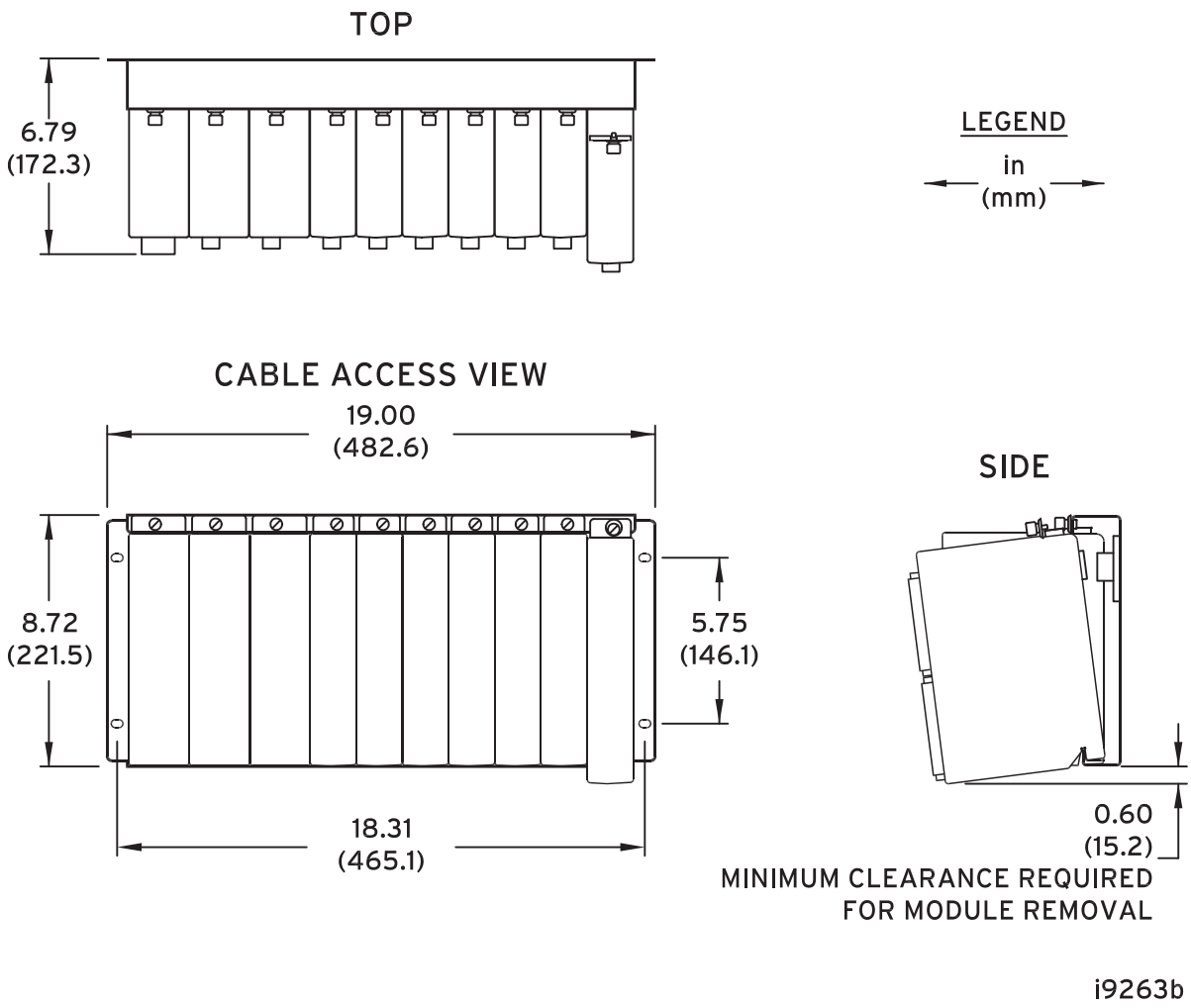


Figure 43 SEL-2240 Dimensions for 10-Slot Rack- and Surface-Mount

RACK-/SURFACE-MOUNT CHASSIS

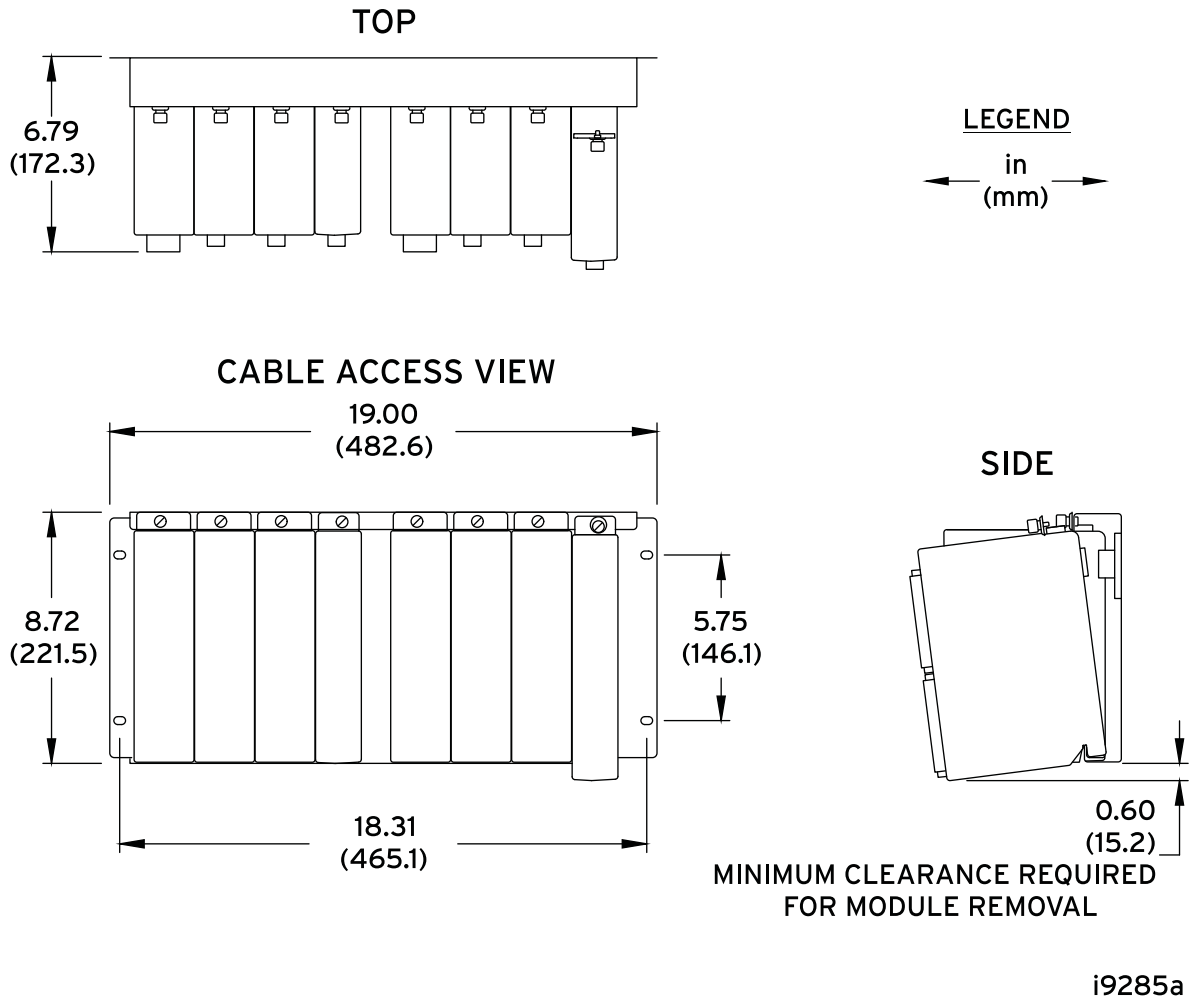


Figure 44 SEL-2240 Dimensions for Dual 4-Slot Rack- and Surface-Mount

RACK-/SURFACE-MOUNT CHASSIS

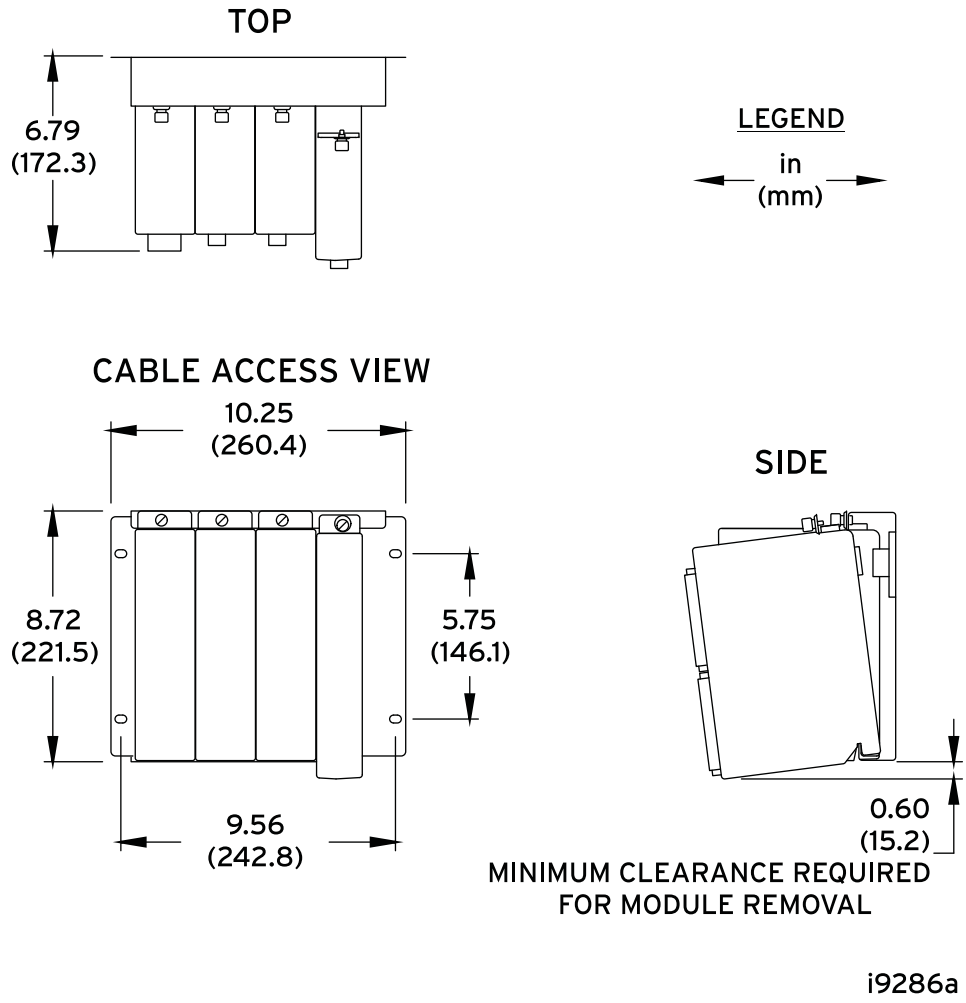


Figure 45 SEL-2240 Dimensions for 4-Slot Rack- and Surface-Mount

Specifications

General

Operating Temperature Range

–40° to +85°C (–40° to +185°F)
Note: Not applicable to UL applications.

Operating Environment

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

Dimensions

Refer to *Section 2: Installation* in the *SEL-2240 Instruction Manual* for dimensions.

Weight (Fully Populated Node)

16 lbs

CPU

Processing and Memory

Processor Speed:	533 MHz
Memory:	512 MB DDR2 ECC RAM
Storage:	4 GB (2 GB reserved)

Security Features

Account Management:	User Accounts User Roles LDAP 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 37.118, IEC 61850 MMS
Server:	DNP3 Serial, DNP3 LAN/WAN, Modbus RTU, Modbus TCP, SEL Fast Messaging, LG 8979, SES-92, IEC 60870-5 101/104
Peer-to-Peer:	SEL MIRRORED BITS Communications, IEC 61850 GOOSE, Network Global Variables (NGVL)
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:	Up to three configurable servers
NTP Server	

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 (100 Mbps only)

Fiber-Optic Ports

Class 1 LASER/LED

Wavelength:	1300 nm
Optical Connector Type:	LC
Fiber Type:	Multimode
Link Budget:	11 dB
Min. TX Power:	–20 dBm
Min. RX Sensitivity:	–31 dBm
Fiber Size:	50–200 µm
Approximate Range:	5 Km
Data Rate:	100 Mb
Typical Fiber Attenuation:	–2 dB/Km

Serial Ports

Ports:	4
Types:	EIA-232/EIA-485 (software selectable)
Data Rate:	300 to 115200 bps
Connector:	DB-9 Female
Time Synchronization:	IRIG-B
Power:	+5 Vdc power on Pin 1 (500 mA maximum)

USB Ports

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	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: 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

Power Coupler (SEL-2243)

EtherCAT Ports

Ports: 2

Data Rate: Automatic

Connector: RJ45 Female or LC Fiber

Protocols: Dedicated EtherCAT

Fiber-Optic Ports

Class 1 LASER/LED

Wavelength: 1300 nm

Optical Connector Type: LC

Fiber Type: Multimode

Link Budget: 11 dB

Min. TX Power: –20 dBm

Min. RX Sensitivity: –31 dBm

Fiber Size: 50–200 µm

Approximate Range: 5 Km

Data Rate: 100 Mb

Typical Fiber Attenuation: –2 dB/Km

Power Supply

AC Input Voltage (High-Voltage Model)

Rated Supply Voltage: 120/240 Vac, 50/60 Hz

Input Voltage Range: 85–264 Vac, 40–70 Hz

DC Input Voltage (High-Voltage Model)

Rated Supply Voltage: 125/250 Vdc

Input Voltage Range: 85–300 Vdc

DC Input Voltage (Low-Voltage Model)

Rated Supply Voltage: 24/48 Vdc

Input Voltage Range: 19.1–57.6 Vdc polarity dependent

Power Consumption

Maximum AC Burden: 160 VA

Maximum DC Burden: 80 W

Interruptions: 30 ms @ 24 Vdc
130 ms @ 48 Vdc
50 ms @ 125 Vac/Vdc
100 ms @ 250 Vac/Vdc

Max Inrush: 15 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.

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:

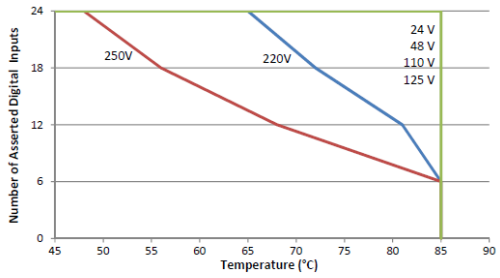
250 Vdc	ON for 170.6–300 Vac	OFF below 106 Vac
220 Vdc	ON for 150.3–264 Vac	OFF below 93.2 Vac
125 Vdc	ON for 85–150 Vac	OFF below 53 Vac
110 Vdc	ON for 75.1–132 Vac	OFF below 46.6 Vac
48 Vdc	ON for 32.8–60 Vac	OFF below 20.3 Vac
24 Vdc	ON for 14–27 Vac	OFF for < 5 Vac

Current Draw at Nominal DC Voltage: 2–4 mA (Except for 24 V, 8 mA)

Rated Insulation Voltage: 300 Vac

Rated Impulse Withstand Voltage (U_{imp}): 4000 V

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

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 mins 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.

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:	300–400 Hz, 330 Hz Typical
Rolloff:	20 dBV per decade

Digital Filter

Corner Frequency:	Filter A: < 20 Hz, 16 Hz typical Filter B: < 20 Hz, 10 Hz typical
50 Hz Rejection:	Filter A: > 30 dBV, 31 dBV typical Filter B: > 50 dBV, 54 dBV typical
60 Hz Rejection:	Filter A: > 30 dBV, 68 dBV typical Filter B: > 50 dBV, 76 dBV typical

Step Response

No Filter:	< 3 ms (10–90% response typical)
Filter A:	< 50 ms (10–90% response)
Filter B:	< 200 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 0.05% of full scale
Inputs:	0.25% of full scale (voltage mode) 0.5% of full scale (current mode)

Accuracy Variation With Temperature

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

AC Metering Inputs (SEL-2245-4)

Frequency:	50/60 Hz
Range:	45–65 Hz
Typical Accuracy:	±0.005 Hz above 20 V
Worst Case Accuracy:	±0.01 Hz above 20 V
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}:	5 A
Measurement Range:	0.050–22 A Continuous 22–100 A Symmetrical for 25 s
Thermal Withstand Limit:	500 A for 1 s
Typical Accuracy:	±1% Fundamental@ f_{NOM} ±0.1% RMS@ f_{NOM}
Worst Case Accuracy:	±2% ± 0.005 A Fundamental/RMS

Angle

Range:	±180°
Typical Accuracy:	±0.5° Fundamental @ f_{NOM}
Worst Case Accuracy:	±2% @ f_{NOM}
Burden:	< 0.1 VA @ I_{NOM}

Voltage Inputs

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:	±1% Fundamental@ f_{NOM} ±0.1% RMS@ f_{NOM}
Worst Case Accuracy:	±3% Fundamental@ f_{NOM} ±3% RMS plus ±0.05 V

Angle

Range:	±180°
Typical Accuracy:	±0.3° @ f_{NOM}
Worst Case Accuracy:	±2° @ f_{NOM}
Burden:	< 0.1 VA

Sequence Components

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

Typical Accuracy

Magnitude:	±5% @ f_{NOM}
Angle:	±2° @ f_{NOM}

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

Typical Accuracy:	±0.1% @ f_{NOM}

Synchrophasor

Accuracy:	Level 1 as specified by IEEE C37.118
Measurements:	Software selectable
Voltage:	VA, VB, VC, VS
Current:	IA, IB, IC, IN
Positive-Sequence:	V1, I1
Periodic:	Frequency and df/dt
Processing Rate:	120 Hz

Triggered Waveform Recording

Sampling Rates:	1, 2, 3, 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 at 24 kHz 18 s at 8 kHz 36 s at 4 kHz 72 s at 2 kHz 144 s at 1 kHz
Record Pretrigger:	0.05 s minimum up to a maximum of (record length –0.05) s
Waveform File Format:	COMTRADE (IEEE C37.111-1999 compliant)

Notes

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