# Dependable Communications for Critical Infrastructure®

The versatile SEL Integrated Communications Optical Network (ICON®) is purpose-built for mission-critical communications, providing either SONET, DS1/E1, and/or Ethernet transport. The ICON is a wide-area-networking multiplexer optimized for industrial and utility applications. The deterministic packet transport technology in the ICON preserves the performance characteristics of time-division multiplexing (TDM) with no performance degradation when converting to Ethernet as a transport protocol. By combining TDM and Ethernet transport options with a comprehensive range of data interfaces, the ICON makes it easy to migrate legacy network technologies to a packet-based solution. The ICON interoperates with Multiprotocol Label Switching (MPLS) or Carrier Ethernet-based core networks to provide a hardened edge device for mission-critical applications. The ICON is available in both a full 19" rack-mounted version and a half-width ICON Cube for compact applications.

## Major Features and Benefits

- **Deterministic Packet Transport.** Provides an innovative solution for maintaining the performance of a TDM network for transporting teleprotection traffic over any Ethernet-based core network. ICON Virtual Synchronous Networking (VSN) provides a solution for migrating legacy interfaces to an MPLS or Carrier Ethernet network and enables the performance of critical protection circuits to be maintained.
- **Flexible Transport Bandwidth Options.** The ICON supports DS1/E1, OC-3, OC-12, and OC-48 data rates when configured as SONET and 1 Gbps when operating in Ethernet transport mode. Support for 10 Gbps will be added in a future release. Support for different Ethernet and SONET line rates enables the ICON to address a wide range of network topologies and connectivity requirements.
- **Analog to Ethernet Leased Line Migration.** Combine ICON deterministic transport with dedicated analog drop interfaces that include 2-wire FXO/ FXS, 4-wire analog voice frequency, and DTT to provide a migration solution from analog to Ethernet-based leased line services. Ethernet transport data rates can be reduced to 10 Mbps to support economical leased service rates.
- **Robust Universal Platform.** The ICON platform can operate as a SONET or Ethernet multiplexer with a built-in Ethernet switch. The ICON enables the operator to easily upgrade network backbone bandwidth to support new applications. Because the ICON supports TDM and Ethernet applications, your legacy equipment investments are protected.

- **Reliable and Economical Distribution of Precise Time.** Receive and distribute precise GPS time over the ICON wide-area network with better than 1 µs accuracy. The ICON network also features a robust terrestrial time distribution solution that overcomes vulnerabilities of isolated GPS-only local timing solutions. When operating in Ethernet transport (VSN) mode, the ICON can use the IEEE 1588 PTP telecom profile from a centralized grandmaster timing reference delivered over an MPLS or Carrier Ethernet transport network in addition to local GPS or IRIG-B sources. Time is available at each network node in IRIG-B or IEEE 1588 PTP (power and default profiles) for locally connected devices.
- **Security and Critical Infrastructure Protection.** The ICON helps users achieve NERC-CIP compliance by providing the following:
  - Report generation
  - Logging of all setting changes and firmware and hardware changes
  - Logging of authorized and unauthorized user access and unauthorized access attempts
  - Tools for baselining ICON network configuration
- **Easy and Secure Network Management.** Use SEL-5051 Network Management System (NMS) Client software and SEL-5052 NMS Server software or third-party SNMPv3-based NMS to monitor and manage your network. SEL-5052 provides Lightweight Directory Access Protocol (LDAP) and Single Sign-On (SSO) support to allow use of a centralized corporate directory to manage usernames and passwords to authenticate user access to the ICON network.
- **Channel Latency Monitoring in Real Time.** The ICON can measure and report latency at the individual DS0/E0 level. Mission- and time-critical network traffic can now be monitored, with results reported in real time.
- **TDM Bandwidth ePipes for Mission-Critical Ethernet Traffic.** The SONET payload can be divided into separate TDM pipes to isolate various Ethernet traffic over the wide-area network (WAN). This technology provides guaranteed bandwidth to support high-priority data such as IEC 61850 GOOSE traffic.

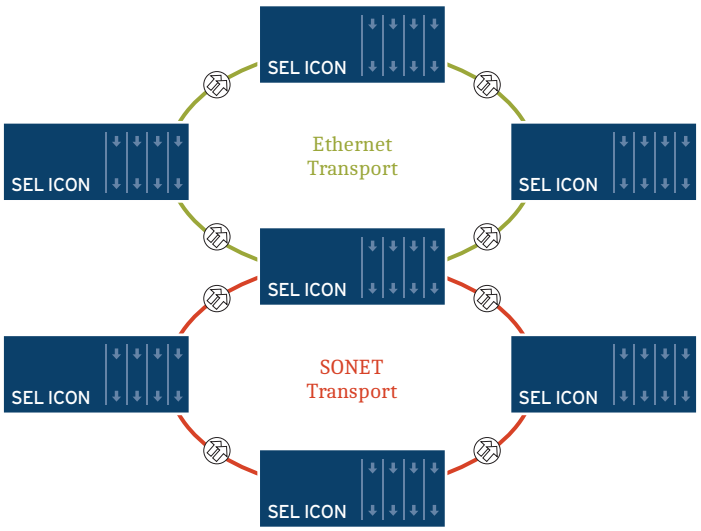


**Figure 1 ICON Mixed SONET and Ethernet Transport**

# Ethernet Transport Features

## VSN Features

- Small form-factor pluggable (SFP) 1 Gbps optical transceivers with a reach as far as 200 km. Support for 10 Gbps will be added in a future release.
- Unidirectional Path Switched Ring for VSN traffic with <5 ms switching time
- Path direction selection and "switch on yellow" to eliminate asymmetrical delays
- User-selectable packetization bandwidths for VSN data. Three, eight, and twenty-five virtual tributaries (VTs) or from 1 to 12 synchronous transport signals (STSs).
- MAC and VLAN filtering
- Packet Delay Variation compensation

- Ethernet packet monitoring
- Support for Ethernet Jumbo frames

## Layer 2 802.1Q Ethernet Features

- Optical transmit and receive level monitors
- Laser current output monitor
- RSTP and MSTP support for Ethernet loop mitigation for non-VSN Ethernet traffic
- Support for the IEEE 1588 PTP telecom profile (ITU-T G.8275.1) for time synchronization from a centralized grandmaster reference over an MPLS or Carrier Ethernet transport network

An ICON network equipped with EPLM line modules and 1 GigE line ports now supports native layer 2 Ethernet traffic. This feature reduces or eliminates the need to install core network switches and routers in the harsh substation environment. An ICON used as an edge device can aggregate the local substation Ethernet traffic and provide it to the core network.

## Managed Layer 2 802.1Q Ethernet and VSN Traffic

An ICON network equipped with EPLM line modules, 1 GigE Ethernet line ports, and an EBAM now supports native layer 2 802.1Q managed Ethernet traffic. This feature reduces or eliminates the need to install core network switches and routers in the harsh substation environment. An ICON used as an edge device can aggregate the local substation Ethernet traffic and provide it to the core network.

### Layer 2 Bridging and VSN Traffic

ICON VSN transport provides a mechanism for encapsulating services within a TDM container for deterministic transport over Ethernet. ICON also supports the capability to transport non-critical Ethernet services outside of the VSN container in regular Ethernet bandwidth.

Layer 2 Bridging (L2B) is a feature of the ICON system that enables ordinary Ethernet traffic to traverse an ICON network. In L2B, the ICON functions as a layer-2 bridge, interoperating with other bridges (including other L2B ICONs) and edge devices.

This enhanced capability allows non-critical services such as video or SCADA to be placed in standard layer 2 802.1Q Ethernet bandwidth outside of VSN. This enables the ICON to more efficiently utilize bandwidth for native Ethernet services and provides a simpler mechanism for the ICON to transport these services across MPLS or Carrier Ethernet transport networks.

Loop mitigation for the VSN traffic is provided by the VSN protocol. Layer 2 Ethernet traffic can use RSTP or MSTP for loop mitigation.

*Figure 2* shows how layer 2 802.1Q traffic is mapped to bandwidth outside of the VSN deterministic traffic.

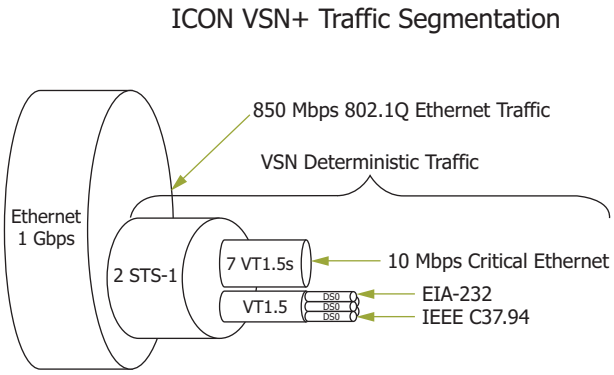


**Figure 2 VSN and Layer 1 802.1Q Ethernet Traffic Segmentation**

### Network Implementation Using VSN With Layer 2 802.1Q Ethernet

VSN traffic can be applied in a ring topology through tunnels configured in the core network. These tunnels are set up to accept only VSN packets. All other Ethernet traffic is passed into the core network where it is managed by the core network.

The ICON is able to use its line ports to carry Ethernet traffic to the core. To increase the amount of bandwidth available to increase the amount of bandwidth available to transport non-critical Ethernet services generated in the substation. Each port is capable of a 1 GigE aggregate allowing, for example, a 1.8 GigE capacity for Ethernet if the VSN bandwidth is set to 1 STS (100 mbps).

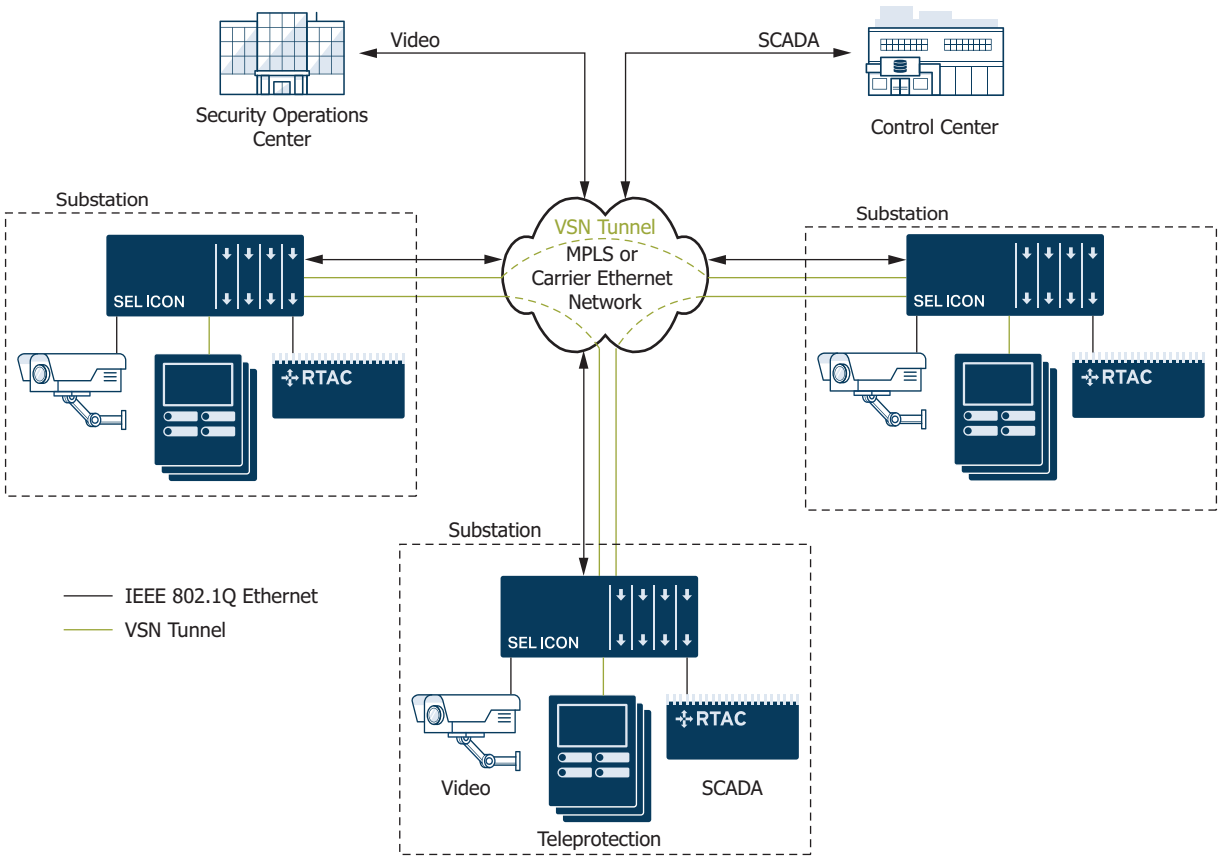


**Figure 3 Network Design Using VSN With Layer 2 802.1Q Ethernet**

## EBAM—Ethernet Bridged Access Module

The ICON offers a dedicated 8 port Ethernet module for LAN facing traffic.

The EBAM provides four copper ports capable of 10, 100, 1000 Mbps and four SFP drop ports capable of 100 or 1000 Mbps operation.

With the release of the Layer 2 Bridging functionality, the EBAM now supports loop mitigation using RSTP or MSTP.

The ICON network can be used as a PTP grand master and IEEE 1588 power system profile timing can be optionally equipped providing high accuracy time distribution through the drop ports.

# SONET Features

- Small form-factor pluggable (SFP) OC-3, OC-12, and OC-48 optical transceivers with a reach of up to 240 km
- Unidirectional Path Switched Ring with <5 ms switching time
- Path direction selection and “switch on yellow” to eliminate asymmetrical delays
- STS-12c, STS-3c, STS-1 (synchronous transport signal), and VT (virtual tributary) granular internal cross-connect for seamless interring traffic between networks
- Error monitoring for individual STS-1 and VTs at predetermined and user-defined intervals
- Optical transmit and receive level monitors
- Laser current output monitor
- Ethernet mapping using generic framing procedure (GFP-F)
- Built-in test capabilities
  - Force AIS XMT and RCV
  - Line loopback
  - Section trace
  - PRBS/test bytes

- ➢ STS-1 payload monitor
- ➢ VT payload monitor
- ➢ Channel latency

➤ Support for point-to-point, linear, ring, and multiple ring topologies. Internal cross-connect provides seamless operation between rings. Support for single or dual-ring interconnect ties, linear spurs, and subtended rings.

SONET standards supported:

➤ Telcordia GR.253-CORE

➤ ITU-T G.7041

# DS0/E0 and DS1/E1 TDM Features

➤ Connect and synchronize non-ICON DS1 and E1 equipment for system-wide interoperability

➤ Groom incoming DS1/E1 subrate (DS0/E0) signals onto any ICON network-wide DS0/E0 channel

➤ Add/Drop any DS0/E0/DS1/E1 signal from higher-level STS-1 signals

➤ Aggregate DS1/E1 circuits onto the SONET WAN and individually extract them at any node

# Local Area Network Ethernet Features

➤ Port statistics counters for frame length and type (unicast, multicast, broadcast) exiting and entering the Ethernet ports

➤ MAC table key functions and features:

- ➢ "Learn and Lock"—user-configurable capability to learn MAC addresses
- ➢ "No Learn"—user-entered MAC addresses
- ➢ "Aging field"
- ➢ "Learn and Age"
- ➢ Content-addressable RAM (avoids "fail-to-learn" problems when using HASH technology)

➤ Port-based VLANs (transparent traffic transport)

➤ 802.1Q VLANs

➤ Nested VLANs (802.1Q VLANs in port-based VLANs)

➤ Support for eight priority queues per port

➤ VLAN filtering per port—list of allowed or blocked VLANs, ingress and egress (SEL-8036-01/-02 Ethernet Bridging Access Module [EBAM])

➤ BPDU filtering and Ethernet Virtual Wire support to manage how ICON Ethernet LAN ports interact with spanning tree protocols from LAN switches

➤ Loop mitigation using RSTP and MSTP

Ethernet standards supported:

➤ 802.1d Ethernet bridge

➤ 802.1Q VLAN tagging, priority queues

➤ 802.3ab 1000BASE-T (RJ45 Cu)

➤ 802.3ac Frame format extensions for VLAN tagging

➤ 802.3i 10BASE-T (RJ45 Cu)

➤ 802.3u 100BASE-T (RJ45 Cu), 100BASE-BX/EX/FX/LX/ZX

➤ 802.3z 1000BASE-BX/LX/SX/XD/ZX

➤ DSCP DiffServ to 802.1Q priority mapping

## Features Supported on Fiber Ethernet Ports

➤ Remote Fault Indicator

- ➢ 1000 Mbps Ethernet
- ➢ 100 Mbps Ethernet

➤ Monitor of fiber-optic transceiver parameters

- ➢ Optic receive level
- ➢ Optic transmit power
- ➢ Temperature

➤ IEEE 1588 PTP (SEL-8036-02 EBAM)

- ➢ IEEE/IEC 61850-9-3
- ➢ IEEE C37.238-2017
- ➢ IEEE 1588-2008 Annex F

## Features Supported on Copper Ethernet Ports

- Autonegotiation (bit rate mode)
- Auto-MDIX (crossover cables not required)
- Port enabling and disabling
- IEEE 1588 PTP (SEL-8036-02 EBAM)
  - IEEE/IEC 61850-9-3
  - IEEE C37.238-2017
  - IEEE 1588-2008 Annex F

# ICON System Description

The ICON combines both SONET and Ethernet transport technologies on a single platform. To provide the equivalent functionality of the ICON through traditional methods, as many as four discrete pieces of hardware would be necessary. *Figure 4* is a comparison of the ICON functionality to that of traditional methods.

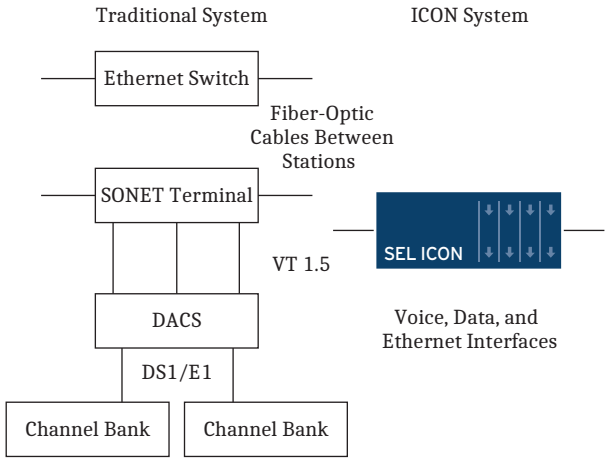


**Figure 4 Traditional Communications System Versus the ICON**

The ICON provides all the functionality of a traditional communications system, including the following components:

- Support for 155 Mbps (OC-3), 622 Mbps (OC-12), and 2.4 Gbps (OC-48) line speeds.
- Support for 1 Gb Ethernet transport with 10 Gbps available in a future release.
- An Ethernet switch module to provide local Ethernet connectivity.
- Drop ports for voice and data circuits. To do this using traditional approaches would require a separate channel bank or E1/T1 terminal.
- Integrated Digital Access Cross-Connect Switch (DACS). This provides the cross-connection between the voice and data circuit traffic on DS0/E0 channels and the SONET multiplexer. DS0/E0 signals from incoming DS1/E1 tributaries can also be individually groomed and routed to any other network-wide DS0/E0 egress location. In legacy systems, this functionality was typically performed using separate hardware.

The ICON combines both TDM and packet technology while offering interfaces to the lowest bandwidth applications, including serial data and voice communication. This consolidation of functionality provides economy of scale, central management of the network, and a versatile system that will provide a communications platform for many years.

# Applications

## Flexible Interoperation With Packet Core Network

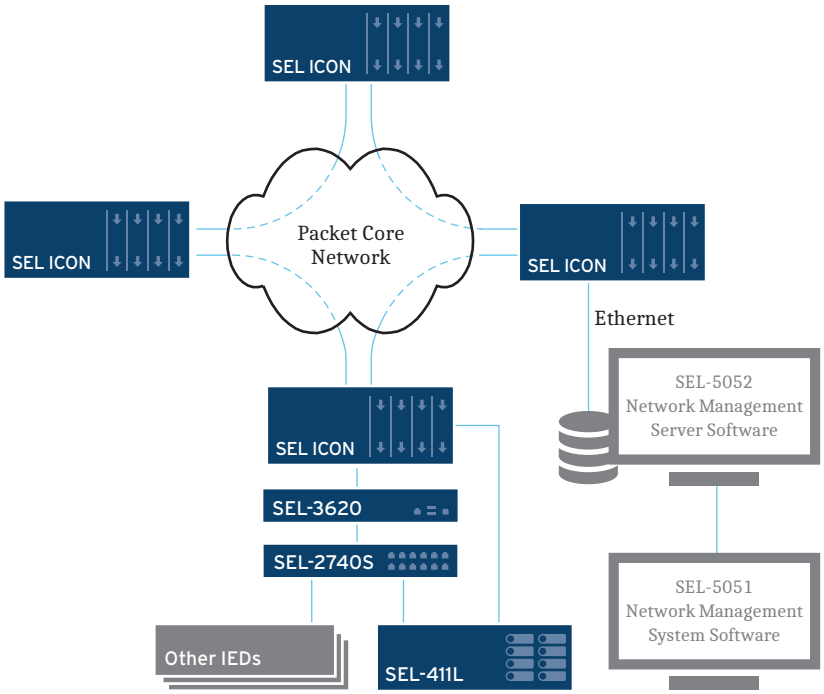


**Figure 5 Packet Core Network**

The SEL ICON is designed to provide low-latency services for substation and operational technology (OT) applications. With the ICON, you can provision time-division multiplexing (TDM) and TDM-encapsulated services across substation facilities while allowing native Ethernet services to transit through core network infrastructure. By complying with Ethernet standards for the Virtual Synchronous Network (VSN) transport technology for the ICON, you can pass Ethernet services across core network infrastructure, enabling the ICON to interoperate with Multiprotocol Label Switching (MPLS) or Carrier Ethernet-based core networks.

ICON VSN technology provides the innovative approach of delivering mission-critical traffic with low and deterministic latency over an Ethernet transport network. The implementation preserves the performance characteristics of TDM with minimal performance degradation when converting to Ethernet as a transport protocol.

# Time Distribution

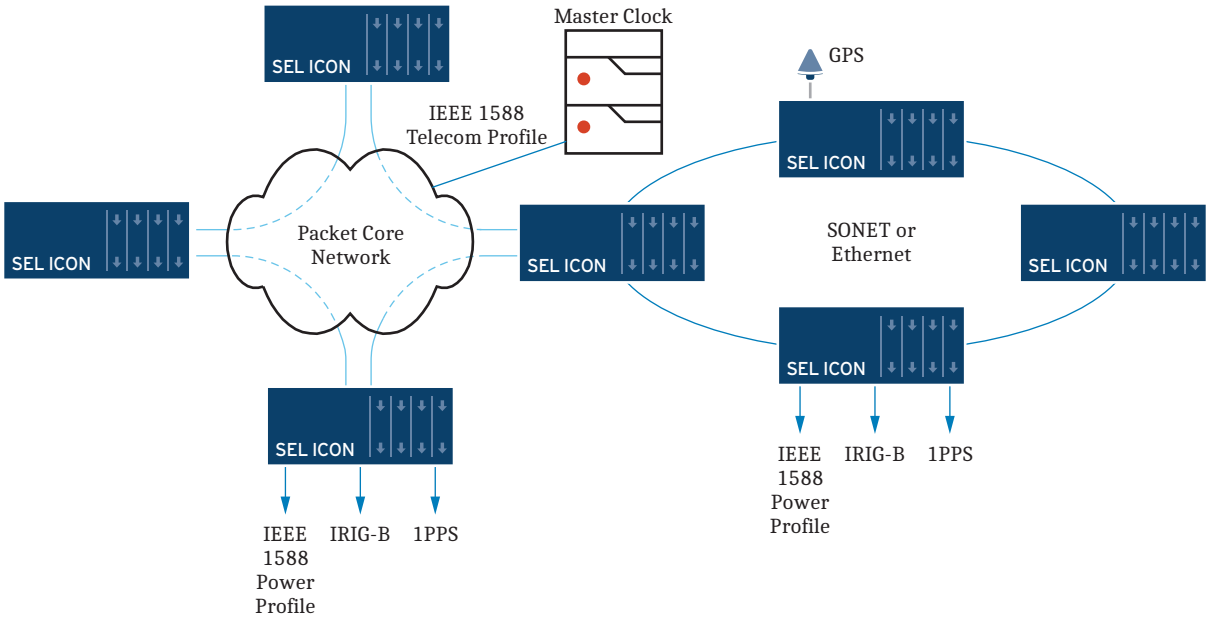


**Figure 6 Time-Distribution Network**

The ICON can distribute time over wide-area networks (WANs) with an accuracy of 1 µs. High-accuracy time is a critical requirement in power utility protection and monitoring schemes for use in applications such as the following:

- Power system disturbance recording devices
- Synchrophasor measurement
- Sequential Events Recorders (SER)
- Line current differential and traveling-wave protection

The ICON has the ability to obtain time using a built-in GPS receiver or via IRIG-B. In addition, when operating in Ethernet transport (VSN) mode, the ICON can use the IEEE 1588 PTP telecom profile from a centralized grandmaster timing reference delivered over an Ethernet transport network (Ethernet, SDN, MPLS, or Carrier Ethernet).

Each ICON node has a built-in GPS receiver. When enabled, the local GPS receiver provides the local real-time clock and network stratum 1 clock. In the event of a local GPS receiver failure, other clock sources in the network will continue to provide high-accuracy timing over the network. In the event that all clock sources in an ICON network are lost, the network will fall back to a holdover oscillator and continue to maintain 1 µs relative accuracy across the network.

Each node also has an IRIG-B input port to allow a collocated high-stability (OCXO, Rubidium, or Cesium) clock, such as the SEL-2488 Satellite-Synchronized Network Clock, to improve the holdover drift.

Mitigation for malicious time spoofing attacks is provided when multiple time sources are enabled on the network. Internode time source comparisons are performed to monitor timing source integrity. GPS antenna location is monitored and alarms are issued for location changes.

Time signals to local intelligent electronic devices (IEDs) (e.g., SEL-411L) are available from two BNC ports on each Enhanced Protected Line Module (EPLM), the EIA-232/EIA-422 ports on the Async Submodule, and the Ethernet drop ports on the SEL-8036-02 Ethernet Bridging Access Module (EBAM).

An EBAM can also provide IEEE 1588 PTP timing over all Ethernet ports via an ordering option.

# Transmission Line Protection

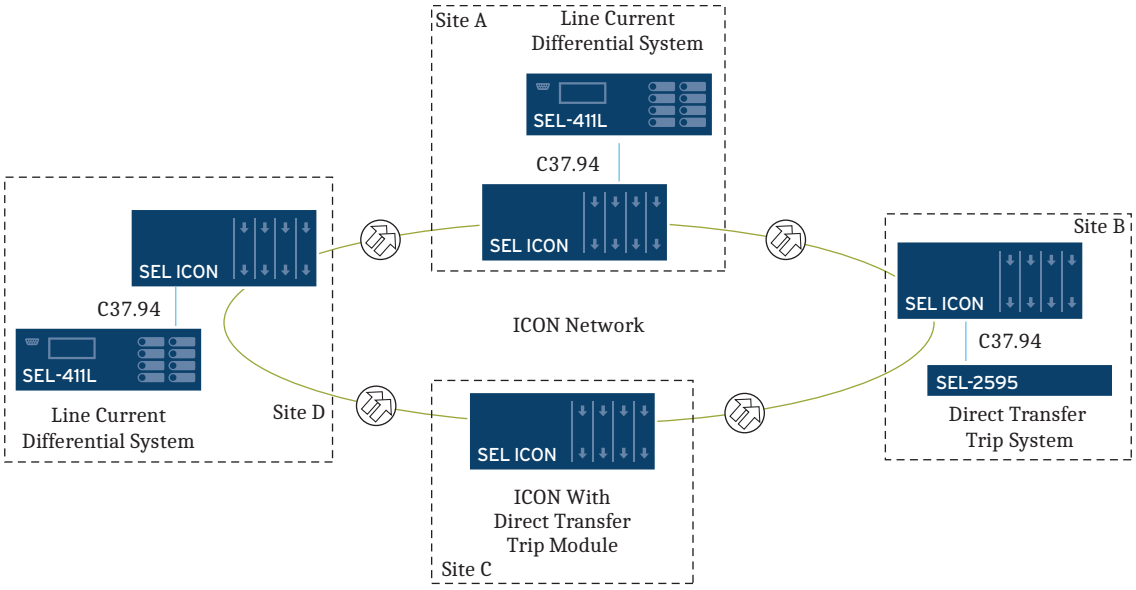


**Figure 7 Teleprotection—Transmission Line Protection**

Transmission line protection is an important application to an electric utility. *Figure 7* shows two types of protection: line current differential protection and direct transfer trip protection.

For line current differential protection, an SEL-411L Relay with an IEEE C37.94 interface connects to an Nx64F Data Submodule on the ICON at Site D. A similar connection is established at Site A. For the SEL-411L Relay with an EIA-422 interface, the 422 Sync Submodule on the ICON can be used at Site D with a similar connection at Site A.

For direct transfer trip protection, an SEL-2595 with an IEEE C37.94 interface connects to an Nx64F data submodule on the ICON at Site B. A similar connection is established at Site C using the Transfer Trip Module (TTM) available on the ICON. The ICON network monitors and reports the channel latency in real time. You can select the shortest path between terminals as the primary path. This ensures that the system always reverts to this configuration in the event of a path failure and subsequent restoration. The ICON TTM is a four-function transfer trip module that can plug into the ICON shelf for an integrated solution. These features combined with robust environmental operating specifications make the ICON ideal for critical power system applications.

# Synchrophasors

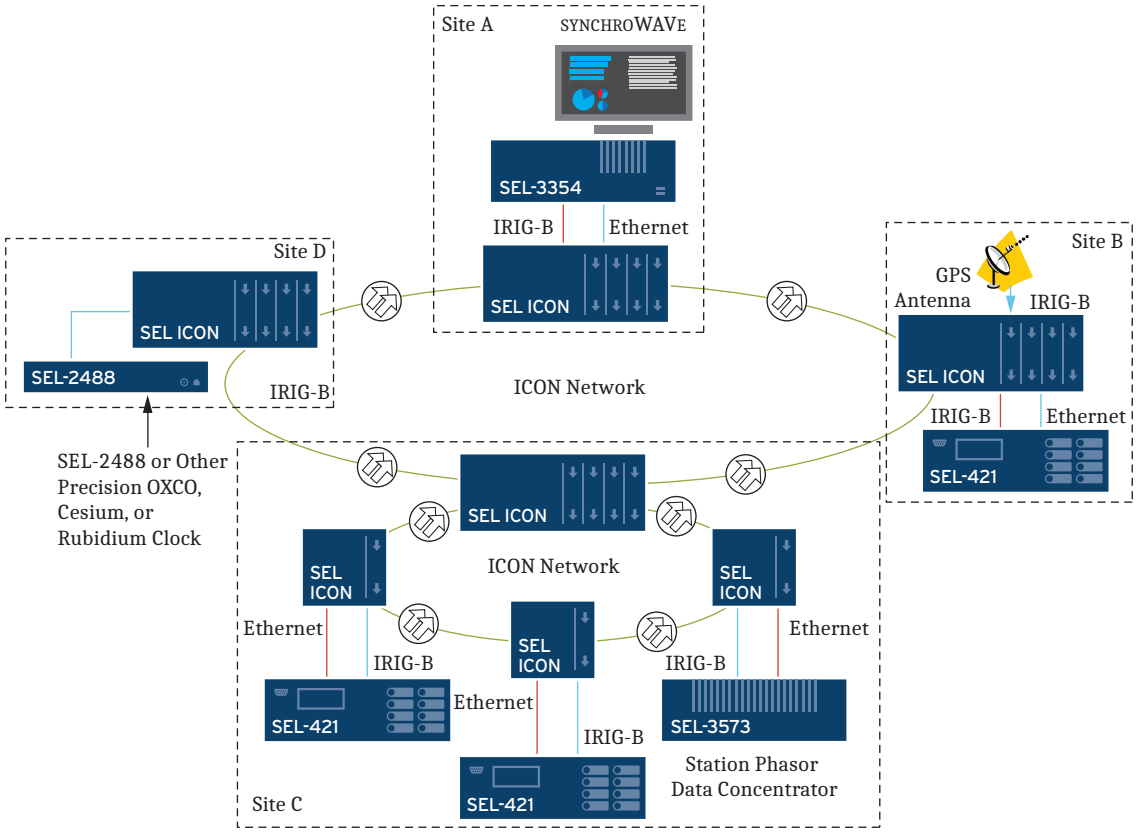


**Figure 8 Wide-Area Control Using Synchrophasors**

Synchronized phasor measurements (synchrophasors) provide a real-time measurement of electrical quantities across a power system. If they are synchronized correctly, you can use these measurements for analysis and control of the power system. The ICON provides communication necessary for synchrophasors. Ethernet is the preferred method to communicate synchrophasor data between power system substations and control locations. A key component of a synchrophasor system is the availability of precise time. The ICON distributes time across the network and can maintain better than 1 µs accuracy among all terminals in the network. This allows synchrophasor systems to continue to operate accurately even in the event of a local or system-wide timing source failure.

# Migrating Analog Leased Services to Ethernet

**Figure 9 Transporting an Analog DTT Circuit Over a Leased Ethernet Network**

With the major carriers announcing the end of service for leased analog services, many utilities are facing a forced migration to leased Ethernet circuits. This creates the challenge of maintaining adequate latency and asymmetry performance for critical analog circuits.

With ICON deterministic packet transport combined with dedicated analog drop interfaces that include 2-wire FXO/FXS, 4-wire analog voice frequency, and DTT, it is possible to migrate from an analog leased service to Ethernet.

These interfaces allow you to preserve existing analog end equipment and create a low-latency circuit through your leased service provider to maintain end-to-end

communications channel performance for critical applications. Using the ICON, you can achieve the same, or better, end-to-end latency.

## DS0/E0 Grooming

Use the DS0/E0 grooming ability (DACS 2016 DS0) of the ICON to route low-speed DS0/E0 circuits from byte synchronous DS1/E1 inputs onto any DS0/E0 drop on the ICON network.

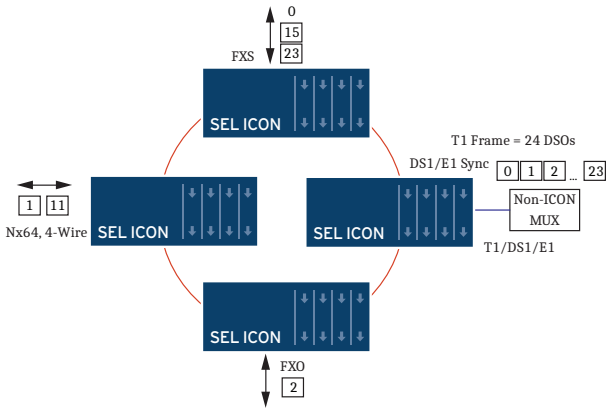


**Figure 10 Route Low-Speed DSO/EO Circuits**

Extend the reach of your corporate PBX into each ICON location by connecting it to the ICON DS1/E1 Sync Submodule. Then use ICON FXS Submodules throughout the network to distribute and terminate two-wire analog circuits for telephones and faxes.

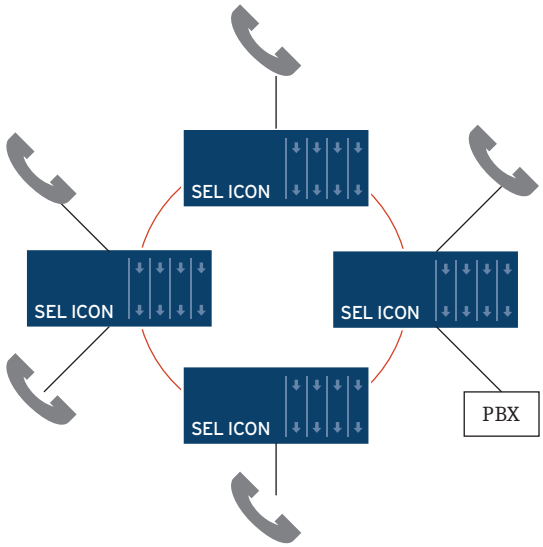


**Figure 11 Distribute and Terminate Two-Wire Analog Circuits**

## DS1 PSync 1x1 Protected DS1

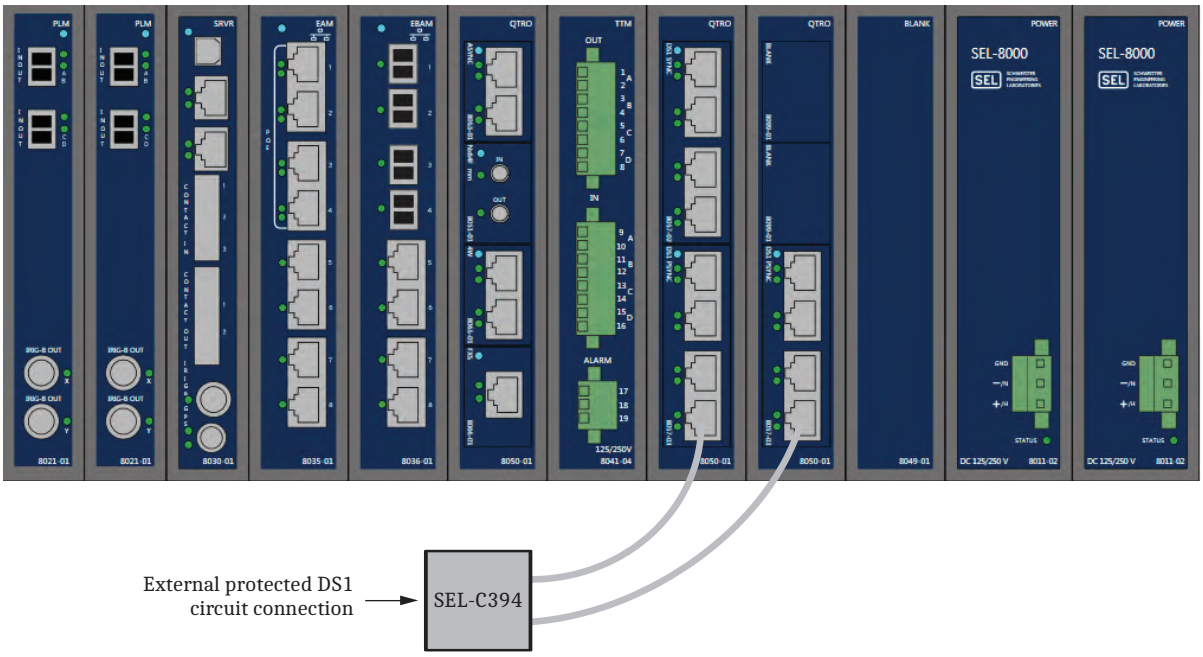


**Figure 12 Redundant DS1 Interface**

The DS1 PSync Submodule provides four 1-by-1 protected DS1 interfaces. The DS1 PSync Submodules are used in pairs, and DS1 connections are made using an SEL-C394 cable as shown in *Figure 12*. The DS1 PSync must be used with the Enhanced Protected Line Module (SEL-8022-01), which supports the ability to groom network traffic at the DS0 level from SONET virtual tributaries (VT1.5). Local TDM drop ports can also be terminated (hairpinned) without requiring a SONET termination.

# Network Management

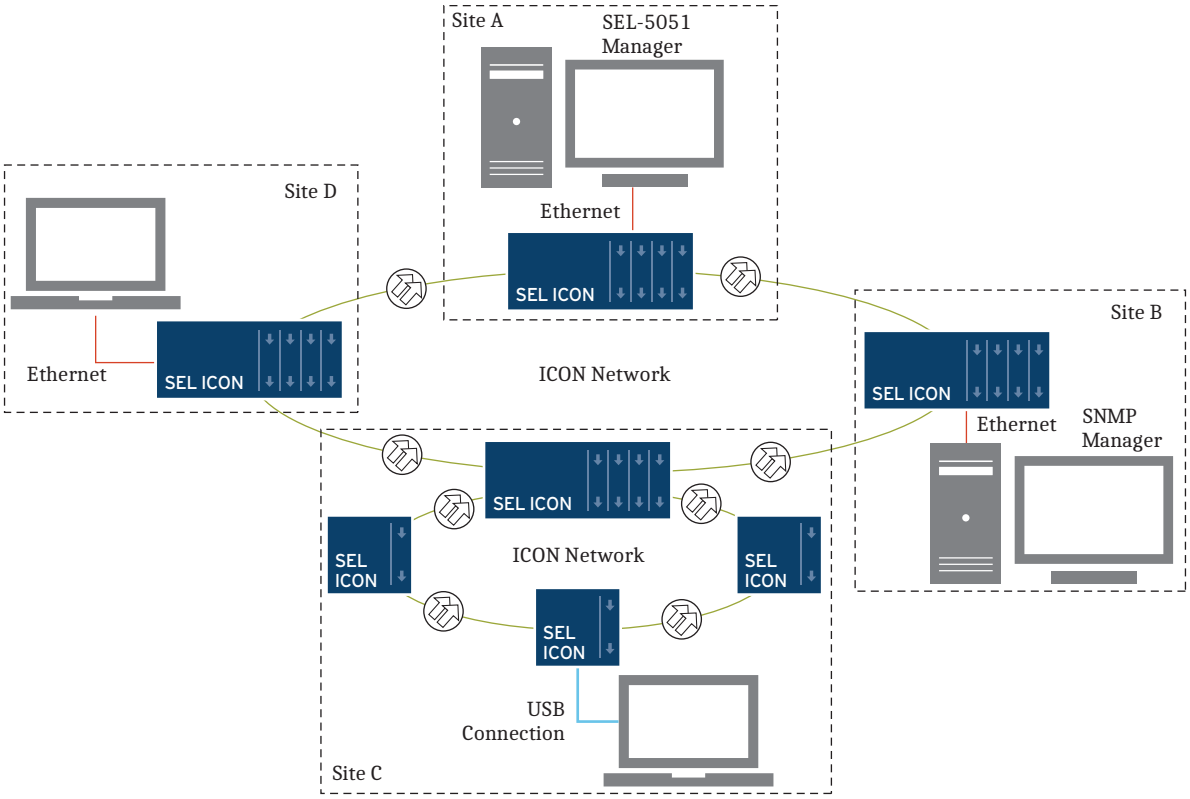


**Figure 13 ICON Integrated Communications Network With Network Management**

Use industry-standard SNMPv3 or SEL-5051 to manage an ICON network. These network management sessions can occur either locally or remotely via Ethernet, or locally via USB. NMS provides:

- Graphical network representation
- Remote provisioning
- Event recording/reporting
- Performance monitoring
- Inventory management
- Remote firmware upgrade
- Email notifications
- Management of multiple role-based users
- Circuit tracing
- Automatic network backups

NMS detects the network and topology, then presents it graphically as shown in *Figure 14*. The configuration of each network element can be viewed and modified as shown in *Figure 15*. The graphical views allow the status of every network element and subnetwork to be verified, with the ability to perform system-wide monitoring and event logging.

ICON also supports a client-server architecture for network management. In the client-server model, the SEL-5051 will connect to SEL-5052, as shown in *Figure 5*. In this network management model, SEL-5052 is responsible for centrally managing user accounts (i.e., multiuser security) and managing the ICON network, and SEL-5051 polls SEL-5052 for user accounts and ICON network information.

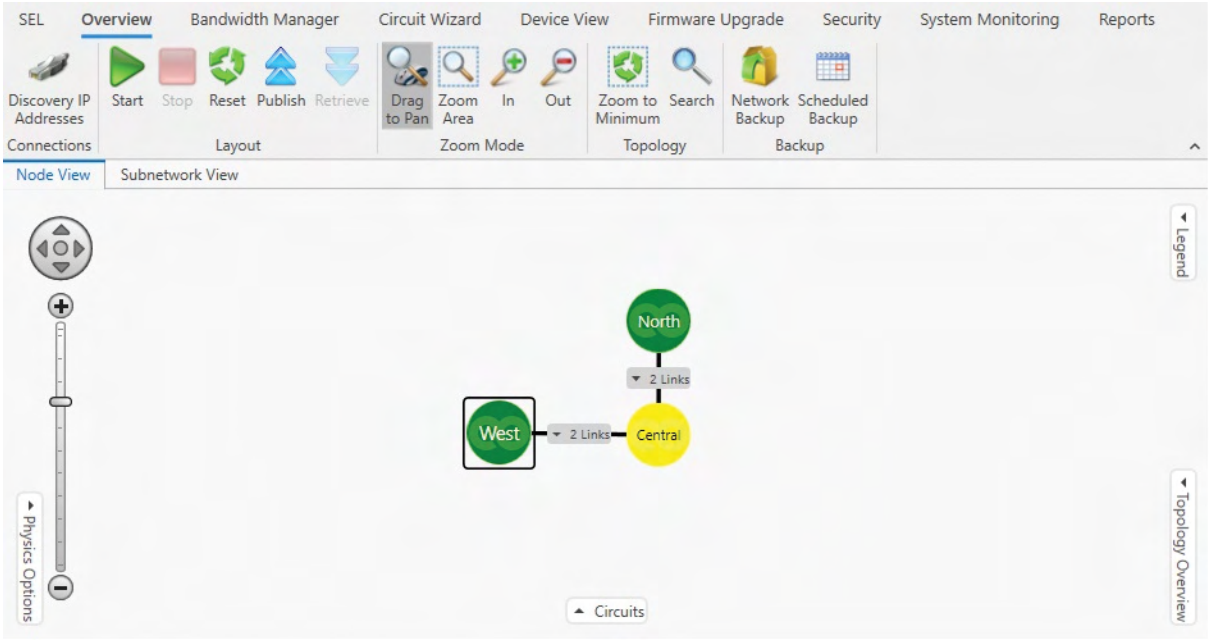


**Figure 14 SEL-5051 Network and Topology (Overview Tab)**

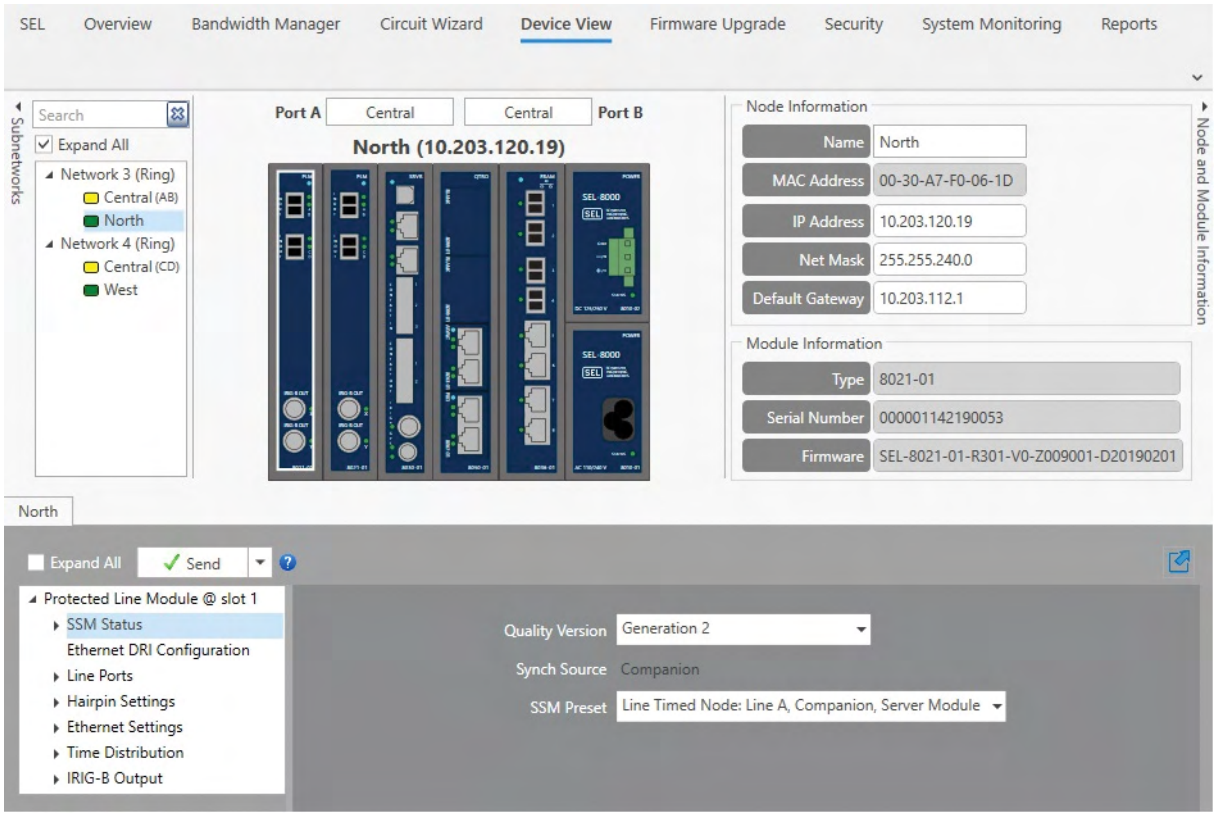


**Figure 15 SEL-5051 Device View Tab (For Configuring and Monitoring Modules)**

**Table 1 Network Management Features (Sheet 1 of 2)**

| Feature | Description |
|---|---|
| Graphical Network Representation | ➤ Represent ICON network element with a node icon<br>➤ Organize and arrange node icons<br>➤ Distribute common view to multiple users<br>➤ Display type and status of internode line links |
| Event Management | ➤ Track user access at each node<br>➤ Monitor valid and invalid login attempts<br>➤ Session statistics—login and logout times<br>➤ Configuration history<br>➤ Filtering and sorting of event log parameters/columns<br>➤ Event log electronic file storage or paper record<br>➤ Alarms for users exceeding allowable invalid counts for specific events |
| Alarm Management | ➤ Alarms are recorded in an alarm engine that supports three views<br>➢ Current alarms<br>➢ New alarms<br>➢ Acknowledged alarms<br>➤ Alarms are time-stamped and stored on the local node<br>➤ An alarm log file is stored on the host computer<br>➤ Alarms are filtered and sorted<br>➤ SNMP traps are available |
| Inventory Management | ➤ Inventory by network, ring, node<br>➢ Total number of modules<br>➢ Number of specific modules<br>➤ Inventory information<br>➢ Module serial numbers<br>➢ Module firmware<br>➢ Specific parameters<br>➤ Remote firmware upgrade of all units |
| Configuration Management | ➤ Circuit provisioning wizards (Pipes, STS-1, VT)<br>➤ Circuit trace<br>➤ Circuit report<br>➤ System health check<br>➤ Settings backup and restore<br>➤ Circuit aliases<br>➤ Node aliases<br>➤ Ring aliases<br>➤ Port aliases |
| Performance Management | ➤ Analytics<br>➤ SONET performance monitoring<br>➢ Section<br>➢ Line<br>➢ Path<br>➢ VT: Code violations<br>➢ Errored seconds<br>➢ Severely errored seconds<br>➤ Ethernet frame counters<br>➢ Input and output frame counters<br>➢ Error frame counters |

**Table 1 Network Management Features (Sheet 2 of 2)**

| Feature | Description |
|---|---|
| Cybersecurity—Systems Security Management | ➤ Capable of enabling NERC-CIP compliance<br>➤ Generates network topology maps and configuration<br>➤ Role-based user access controls, reports, and file encryption<br>➤ LDAP and SSO support<br>➤ Centralized user account and password management<br>➤ Event reporting<br>➤ GPS spoofing detection and mitigation<br>➤ Logs all changes to system settings, firmware, and hardware modules<br>➤ Communications ports disabled by default<br>➤ Authenticates and monitors all user access<br>➤ Logs all authorized and unauthorized access attempts<br>➤ Alarm management<br>➤ Logs physical removal of hardware modules and attempts to access disabled Ethernet ports<br>➤ Configure and forward event data to target Syslog servers or as email notifications |

# ICON Architecture

## Chassis Options

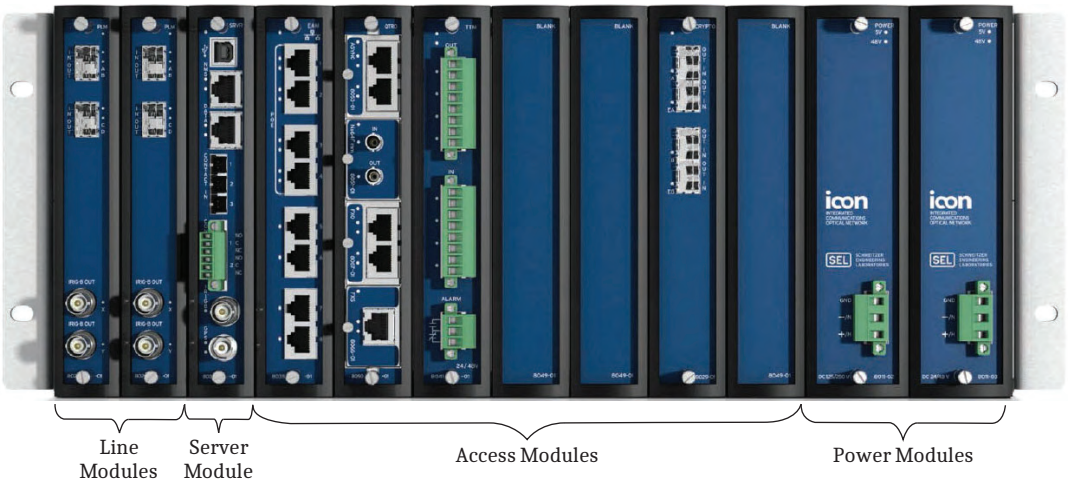


**Figure 16 19-Inch Rack-Mount Chassis (Front Cable Access Shown)**

The ICON is available in a 19-inch rack-mount chassis as shown in *Figure 16*. The 19-inch rack-mount chassis has seven access module slots, which are available for the various interfaces.

For installations in which space may be limited, the ICON is available in the ICON Cube chassis shown in *Figure 17*. The ICON Cube has two access module slots.

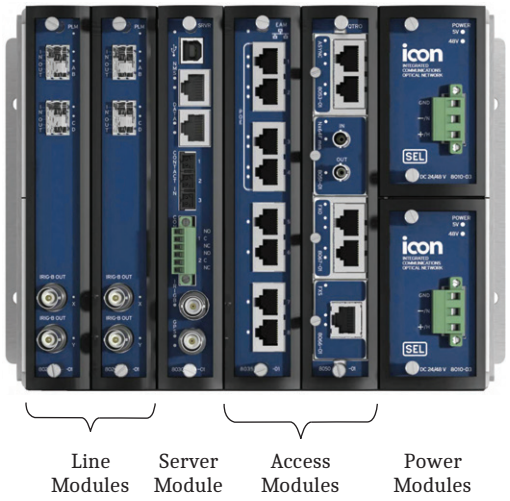


**Figure 17 ICON Cube Chassis (Front Cable Access Shown)**

Access module slots are the physical locations for the various accessory drop interfaces chosen by the user. Each ICON slot can accommodate one full-height module or a Quattro adapter that can support four Quattro access submodules. The full-height and the Quattro submodules are shown in *Figure 17*. Use the Quattro Module to divide the access module slot into four parts called submodule slots. The Quattro Module concept allows more efficient use of an access module slot. For example, if only one voice or data circuit is necessary, the Quattro Module can support various combinations of data and voice submodules in the four available submodule slots.

## Enhanced Protected Line Module

The Enhanced Protected Line Module (EPLM) provides a redundant SONET or Gigabit Ethernet line interface. The Enhanced Protected Line Module provides added reliability by ensuring that line communications are maintained in the event of a module failure or replacement. The Enhanced Protected Line Module provides the following functionality:

- Internode communications links using SONET OC-3/OC-12/OC-48/1 Gigabit Ethernet line ports. Any combination of transport line rates are available on any port pair.
- Cross-connect with STS-1, VT, DS0, or E0 granularity.
- Timing output (IRIG-B) signals
- LAN Ethernet support provided by a separate Ethernet Bridging Access Module
- IEEE 1588 PTP telecom profile support when operating in Ethernet transport mode

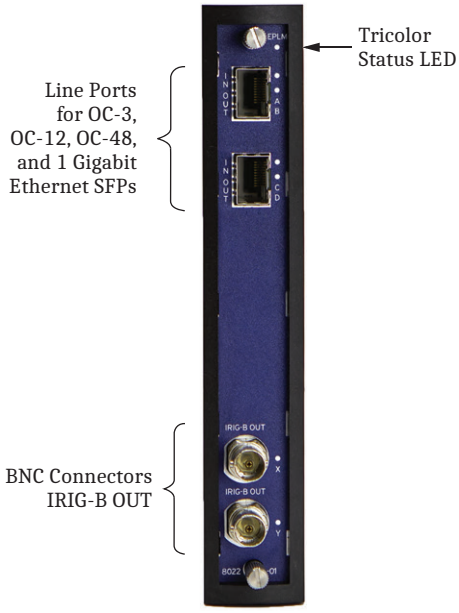


**Figure 18 Enhanced Protected Line Module**

## Server Module

The Server Module provides the following functionality:

- Timing input (GPS and IRIG-B) signals
- RJ45 connector supporting 100 Mbps Ethernet for NMS local or remote connection
- USB management port
- Three internally wetted contact inputs for network management system (NMS) alarm information
- Two Form C Solid State Relay contact outputs for major and minor alarms

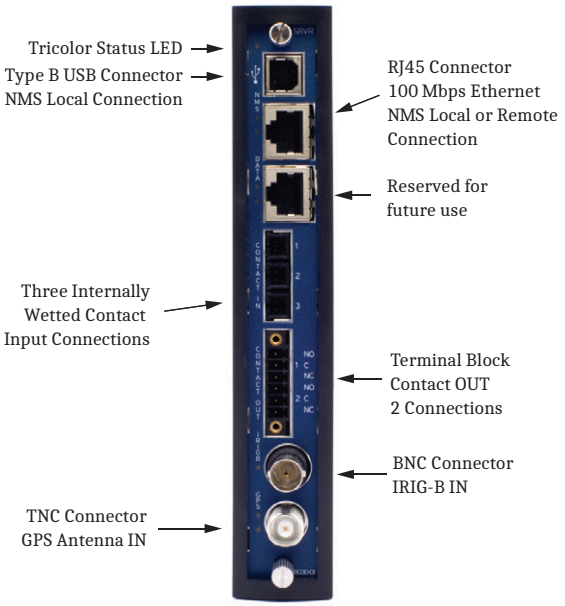


**Figure 19 Server Module**

# Access Modules

Access modules are the full height of the chassis. The 19-inch rack-mount chassis has seven access module slots. The ICON Cube has two access module slots available.

The access modules and submodules all support the following test and monitoring features:

- Circuit addressing
- Real-time latency monitoring
- PRBS generation and monitoring
- Local and line loopback

This feature set consumes an additional 64 kbps time slot per module.

## Ethernet Bridging Access Module

The Ethernet Bridging Access Module (EBAM) is an eight-port, full-height module providing four RJ45 copper ports for 10/100/1000 Mbps links, and four SFP-based fiber-optic links at 100/1000 Mbps.

All eight ports can also provide time as a PTP Master-Only Clock (via an ordering option). This supports IEDs and LANs with the following IEEE 1588 profiles:

- IEEE/IEC 61850-9-3 Base Power Profile
- IEEE C37.238-2017 Extended Power Profile
- IEEE 1588-2008 Annex F (default profile for transport of PTP over IEEE 802.2/Ethernet)

## Transfer Trip Module

### Inputs

Number of command inputs: 4
Input voltage options: 24, 48, 125, 250 Vdc
Connector: Terminal block

### Outputs

Number of command outputs: 4
Output type: SEL Fast Hybrid
Output ratings
Make: 30 A per IEEE C37.90
Interrupting: 48 Vdc 10 A L/R = 40 ms
125 Vdc 10 A L/R = 40 ms
250 Vdc 10 A L/R = 20 ms
Pickup time: 10 µs
Dropout time: 8 ms
Connector type: Terminal block

## Quattro Module

The Quattro Module provides the interface for as many as four access submodules. The various submodules available are described in *Access Submodules* on page 17.

# Access Submodules

## Data

### Nx64F

Number of ports: 1
Interface: IEEE C37.94
Data rate: 64 kbps to 768 kbps
Connector: ST fiber-optic
Wavelength: 850 nm multimode or 1310 nm single-mode (ordering option)

### Async

Number of ports: 2

**Note**: As many as six EIA-232 circuits can be supplied if handshake signals are not necessary.

Interface:

- EIA-232
- EIA-422
- EIA-485

Data rate: 110 bps to 115.2 kbps
Connector: Two RJ45
Time output: IRIG-B

### Async-CB

The Async Data Channel Bank Submodule is intended for operation with a DS1 Sync or E1 Sync Submodule to support transport of EIA-232, EIA-422, and EIA-485 circuits over the DS1/E1 interface between ICONs.

Number of ports: 2

**Note**: As many as six EIA-232 circuits can be supplied if handshake signals are not necessary.

Interface:

- ➤ EIA-232
- ➤ EIA-422
- ➤ EIA-485

Data rate: 110 bps to 115.2 kbps
Connector: Two RJ45

### 422 Sync

Number of ports: 1
Connector: RJ45
Nominal data rate: 64 kbps

### G.703

Number of ports: 1
Connector: One RJ48C
Data rate: 64 kbps

### DS1 Async

Number of ports: 4
Connector: Four RJ48C
Line coding schemes: AMI, B8ZS
Nominal data rate: 1.544 Mbps

### DS1 Sync

Number of ports: 4
Connector: Four RJ48C
Line coding schemes: AMI, B8ZS
Nominal data rate: 1.544 Mbps

### DS1 PSync

Number of ports: 4 (1x1 protected)
Connector: Four RJ48C
Line coding schemes: AMI, B8ZS
Nominal data rate: 1.544 Mbps

### E1 Async

Number of ports: 4
Connector: Four RJ48C
Line coding schemes: AMI, HDB3
Nominal data rate: 2.048 Mbps

### E1 Sync

Number of ports: 4
Connector: Four RJ48C
Line coding schemes: AMI, HDB3
Nominal data rate: 2.048 Mbps

## Voice

### Voice 4-Wire

Number of circuits: 2
Signaling: Type I, II, III, V, or Transmission Only (TO)
Connector: Two RJ45

### Voice 4-Wire Bridging

Number of circuits: 1
Connector: Two RJ45 (duplicate)

### Voice 2-Wire FXS

Number of circuits: 1
Signaling: Loop start, PLAR
Connector: One RJ11

### Voice 2-Wire FXO

Number of circuits: 2
Signaling: Loop start
Connector: Two RJ11

# Network Management System PC Requirements

SEL-5051 requires a computer and operating system which meet the specifications listed in *Table 2*.

**Table 2 Network Management System Requirements (Sheet 1 of 2)**

| | |
|---|---|
| **Processor Speed:** | 2 GHz or faster |
| **Operating System:** | Microsoft Windows 10 with 4 GB RAM<br>Microsoft Windows 11 with 4 GB RAM |

**Table 2 Network Management System Requirements (Sheet 2 of 2)**

| | |
|---|---|
| **Disk Space:** | 1 GB |
| **Monitor:** | 1280 x 1024 or higher resolution |
| **Input Device:** | Mouse or other pointing device |
| **Networking:** | Ethernet adapter |

SEL-5052 requires a computer and operating system that meets the specifications listed in *Table 3*.

**Table 3 SEL-5052 Network Management System Server Minimum Requirements**

| | |
|---|---|
| **Processor:** | Intel Core i3 or later |
| **Operating System:** | Microsoft Windows Server 2019 with 2 GB RAM<br>Microsoft Windows Server 2022 with 2 GB RAM<br>Microsoft Windows 10 64-bit with 2 GB RAM<br>Microsoft Windows 11 64-bit with 2 GB RAM |
| **Disk Space:** | 128 GB |

**Table 4 SEL-5052 NMS Server Host Recommendations for ICON Network Size**

| Number of ICONs | Processor Speed (GHz) | Number of Processor Cores | RAM (GB) | Storage Space (GB) |
|---|---|---|---|---|
| <25 | 2.4 | 1 | 4 | 1 |
| 26–75 | 3.0 | 2 | 4 | 2[a] |
| 76–250 | 3.4 | 4 | 8 | 4[a] |
| >250 | 3.7 | 6+ | 16 | 6[a] |

[a] A solid-state hard drive (SSD) is highly recommended to improve storage access speed when managing more than 25 ICONs.

# ICON Dimensions

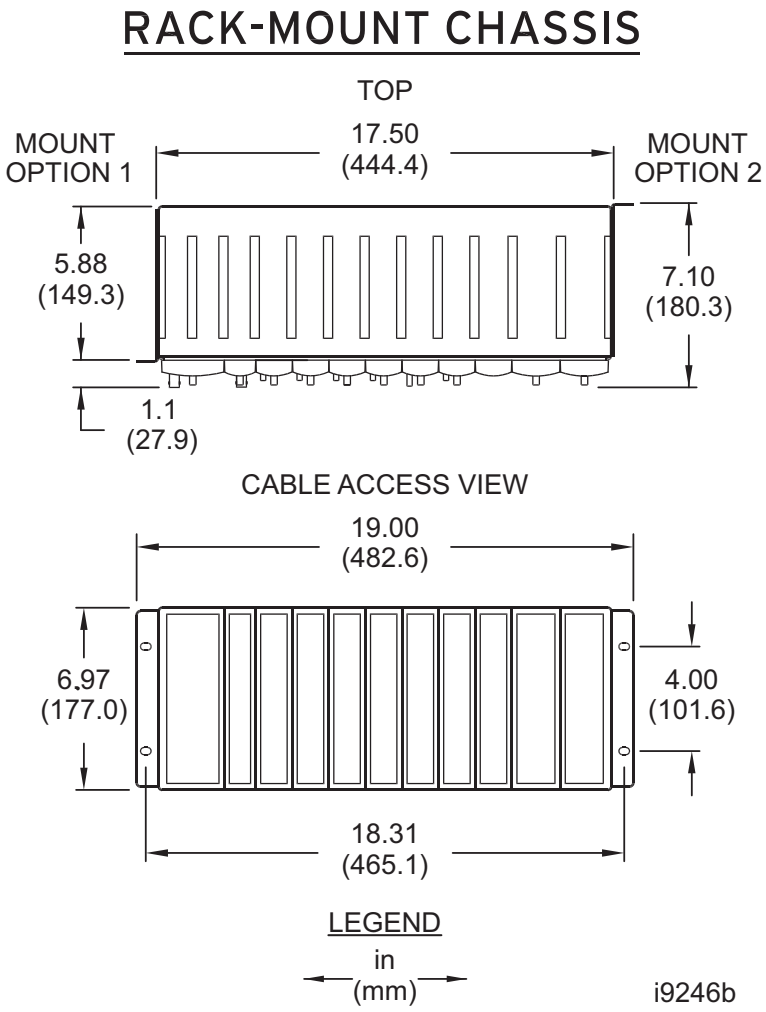


**Figure 20 19-Inch ICON Dimension Diagram**

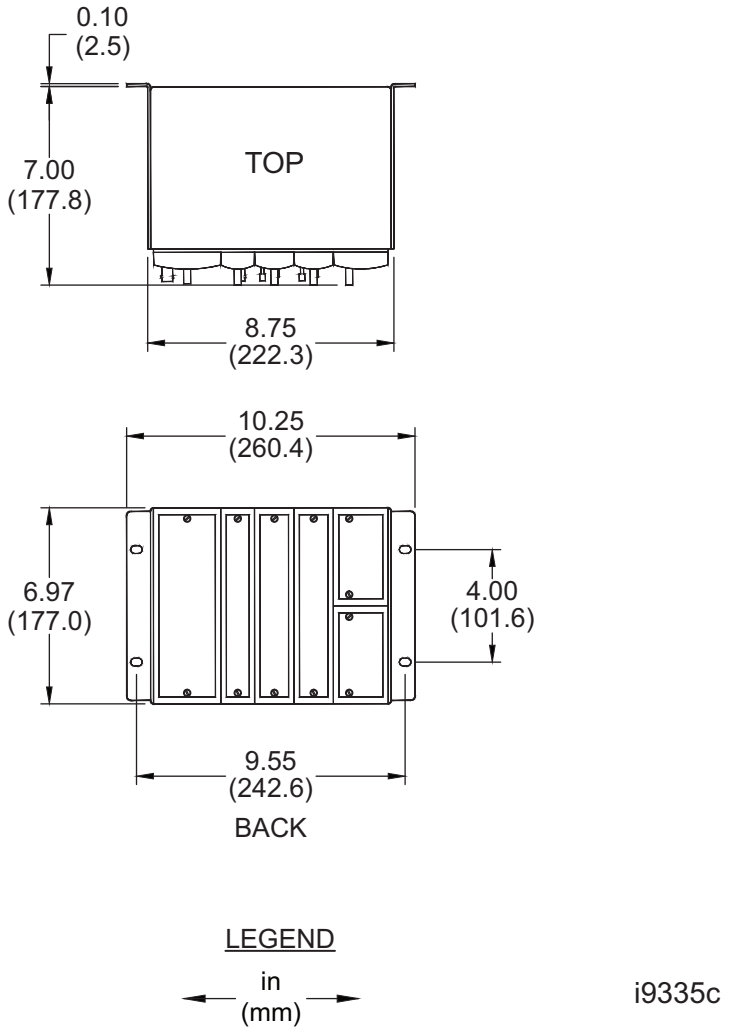


**Figure 21 Half-Width ICON Cube Dimension Diagram**

# Specifications

## Enhanced Protected Line Module (SEL-8022-01)

### Line Ports

| | |
|---|---|
| A/B: | OC-3, OC-12, OC-48, or 1 GigE |
| C/D: | OC-3, OC-12, OC-48, or 1 GigE |

### Small Form-Factor Pluggables (SFPs)

See selinc.com/products/sfp.

### Other Ports

| | |
|---|---|
| IRIG-B Out Connector: | BNC |

## Server Module (SEL-8030-01)

| | |
|---|---|
| GPS Antenna Connector: | TNC |
| Supply for GPS Antenna: | 5 V or 3 V |
| GPS Cable: | SEL-C965 |
| IRIG-B In Connectors: | BNC |
| IRIG-B Cable: | SEL-C953 (<10 m) |
| IRIG-B Format: | IRIG-B00X signal format, DCLS equivalent TTL<br>IEEE C37.118 extended IRIG-B format |

Network Management Ports

| | |
|---|---|
| Connector: | B-type USB or RJ45 Ethernet |
| Quantity: | 3 (2 USB, 1 Ethernet) |
| Cable: | <3 m for USB<br>SEL-CA605R Ethernet |
| Data Ports Connector: | RJ45 reserved for future use |

Contact In

| | |
|---|---|
| Connector: | Molex 70551 connector |
| Quantity: | 3 |
| Cable: | SEL-C575 only (<3 m) |
| Burden Per Input: | 0.0 W (internally wetted) |

Contact Out

| | |
|---|---|
| Connector: | Terminal block |
| Quantity: | 2 |

| | |
|---|---|
| Cable: | Insulated 24 AWG, 0.6 A long-distance (3.5 A short <0.9 m) |
| Type: | Form C Solid State Relay |
| Rated Voltage Range: | <50 V |
| Open Contact Voltage Withstand: | 50 V |
| Total Burden: | 1.5 W @ 50 V |
| Limited Making Capacity (Off Current): | 1 µA |
| Contact Current: | 150 mA (continuous); 350 mA (max) |
| Limited Breaking Capacity (On Resistance): | 35 Ω |
| Endurance: | >10,000 cycles for make or break unloaded |

## Power Modules

### Half-Height Power Module for ICON Cube Chassis

SEL-8010-01

| | |
|---|---|
| Rated Voltage Range: | 120–240 Vac, 50/60 Hz |
| Min/Max Voltage: | 102–264 Vac, 50/60 Hz |
| Wiring Interface: | IEC C6 Connector |
| Cable: | SEL 030-1002 |
| Minimum Wire Gauge: | 16 AWG (10 A) |
| Maximum Burden: | 163 VA (65 W) |
| Fuse Rating: | 2.0 A, Time-lag T, 60 A @ 250 Vac, 24 $I^2t$ |

**Note**: Fuses are not user-serviceable. Return units to manufacturer for servicing.

SEL-8010-02

| | |
|---|---|
| Rated Voltage Range: | 125–250 Vdc<br>120–240 Vac, 50/60 Hz |
| Min/Max Voltage: | 88–300 Vdc; 102–264 Vac |
| Wiring Interface: | Terminal Block Connector |
| Cable: | SEL-C5006 |
| Minimum Wire Gauge: | 16 AWG (10 A) |
| Maximum Burden | |
| AC: | 163 VA |
| DC: | 65 W |
| Fuse Rating: | 2.0 A, Time-lag T, 60 A @ 250 Vac, 24 $I^2t$<br>2.0 A, Time-lag T, 50 A @ 250 Vdc, 24 $I^2t$<br>2.0 A, Time-lag T, 100 A @ 125 Vdc, 24 $I^2t$ |

**Note**: Fuses are not user-serviceable. Return units to manufacturer for servicing.

SEL-8010-13

| | |
|---|---|
| Rated Voltage Range: | 24–48 Vdc |
| Min/Max Voltage: | 19.2–60.0 Vdc |
| Wiring Interface: | Terminal Block Connector |
| Minimum Wire Gauge: | 16 AWG (10 A) |
| Maximum Burden: | 78 W |
| Fuse Rating: | 10.0 A, Time-lag T |

**Note**: Fuses are not user-serviceable. Return units to manufacturer for servicing.

### Full-Height Power Module for 19" Chassis

SEL-8011-01

| | |
|---|---|
| Rated Voltage Range: | 120–240 Vac, 50/60 Hz |
| Min/Max Voltage: | 102–264 Vac, 50/60 Hz |
| Wiring Interface: | IEC C6 Connector |
| Cable: | SEL 030-1002 |
| Maximum Burden: | 92 W |

SEL-8011-02

| | |
|---|---|
| Rated Voltage Range: | 125–250 Vdc<br>120–240 Vac, 50/60 Hz |
| Min/Max Voltage: | 88–300 Vdc; 102–264 Vac |
| Wiring Interface: | Terminal Block Connector |
| Cable: | SEL-C5006 |
| Maximum Burden: | 92 W |

SEL-8011-03

| | |
|---|---|
| Rated Voltage Range: | 24–48 Vdc |
| Min/Max Voltage: | 19–58 Vdc |
| Wiring Interface: | Terminal Block Connector |
| Maximum Burden: | 92 W |

## Access Modules

### Ethernet Bridging Access Module (SEL-8036-01, SEL-8036-02)

| | |
|---|---|
| Connector: | RJ45 and SFP |
| 10/100/1000 Copper Ethernet Ports: | 4 |
| 100/1000 Fiber-Optic Ports: | 4 |
| Precision Time Protocol Support: | IEEE 1588pp (SEL-8036-02 only) |

### Transfer Trip Module (SEL-8041-01, SEL-8041-04)

| | |
|---|---|
| Rated Voltages (SEL-8041-01): | 24 Vdc, 48 Vdc |
| Rated Voltages (SEL-8041-04): | 125 Vdc, 250 Vdc |
| Connector: | Terminal Block |
| Conductor Size: | 12–28 AWG |
| Maximum Carrying Current: | 5 A |
| Number of Commands: | 4 |
| Channel Bandwidth: | 64 kbps |

### Nx64F Submodule (Multimode) (SEL-8051-21)

| | |
|---|---|
| Data Standard: | C37.94 |
| Fiber: | Multimode |
| Connector: | ST |
| Quantity: | 1 Rx, 1 Tx |
| Data Rate: | 64 kbps–768 kbps |

### Nx64F Submodule (Single-Mode) (SEL-8051-22)

| | |
|---|---|
| Data Standard: | C37.94 |
| Fiber: | Single-mode |
| Connector: | ST |
| Quantity: | 1 Rx, 1 Tx |
| Data Rate: | 64 kbps–768 kbps |

### Async Data Submodule (SEL-8053-11)

| | |
|---|---|
| Connector: | RJ45 |
| Quantity: | 2 ports supporting as many as 6 circuits |
| Data Standards: | EIA-232, EIA-422, EIA-485 with IRIG support |
| Data Rates: | 110 bps–115.2 kbps |

### Async Data CB Submodule (SEL-8053-12)

| | |
|---|---|
| Connector: | RJ45 |
| Quantity: | 2 ports supporting as many as 6 circuits |
| Data Standards: | EIA-232, EIA-422, EIA-485 |
| Data Rates: | 110 bps–115.2 kbps |

### 422 Sync Submodule (SEL-8055-01)

| | |
|---|---|
| Connector: | RJ45 |
| Quantity: | 1 |
| Data Standard: | EIA-422 |
| Data Rate: | 64 kbps |

### G.703 Submodule (SEL-8056-01)

| | |
|---|---|
| Connector: | RJ48C |
| Quantity: | 1 |
| Data Rate: | 64 kbps |

### DS1 Async Submodule (SEL-8057-11)

| | |
|---|---|
| Connector: | RJ48C |
| Quantity: | 4 |

### DS1 Sync Submodule (SEL-8057-12)

| | |
|---|---|
| Connector: | RJ48C |
| Quantity: | 4 |

### DS1 PSync Submodule (SEL-8057-03)

| | |
|---|---|
| Connector: | RJ48C |
| Quantity: | 4 (1x1 protected) |

### E1 Async Submodule (SEL-8057-14)

| | |
|---|---|
| Connector: | RJ48C |
| Quantity: | 4 |

### E1 Sync Submodule (SEL-8057-15)

| | |
|---|---|
| Connector: | RJ48C |
| Quantity: | 4 |

### 4W VF Submodule (SEL-8065-11)

| | |
|---|---|
| Connector: | RJ45 |
| Quantity: | 2 |

### 4W Bridging VF Submodule (SEL-8065-12)

| | |
|---|---|
| Connector: | RJ45 |
| Quantity: | 2 |
| Circuits: | 1 |

### 2W FXS Submodule (SEL-8066-01)

| | |
|---|---|
| Connector: | RJ11 |
| Quantity: | 1 |

### 2W FXO Submodule (SEL-8067-01)

| | |
|---|---|
| Connector: | RJ11 |
| Quantity: | 2 |

## System Specifications

| | |
|---|---|
| Network Topologies: | Point-to-point, linear, ring, multiple rings with single or dual interconnected nodes |
| Path Switching Time: | <5 ms per ring for Ethernet; <5 ms end-to-end for TDM |
| Convection Cooled: | No fans |

## Environmental Requirements

**Note**: To meet published IEEE 1613 vibration specifications, all ICON full-height modules should be firmly secured in the chassis by tightening the captive screws to a torque of 14 in-lb (1.6 Nm). All submodules should be firmly secured in the chassis by tightening the captive screws to a torque of 6 in-lb (0.7 Nm).

### Operating Requirements

| | |
|---|---|
| Operating Temperature: | –20° to +65°C (–4° to +149°F) ambient[a] |
| Storage Temperature: | –40° to +85°C (–40° to +185°F) |
| Relative Humidity: | 5%–95%, noncondensing |
| Operating Environment | |
| Enclosure Type: | NEMA Type 1 (indoor) |
| Pollution Degree: | 2 |
| Overvoltage Category: | II |
| Insulation Class: | I |
| Maximum Altitude: | 2000 m |
| Atmospheric Pressure: | 80–110 kPa |
| Enclosure Protection | |
| Terminal Blocks (Contact Out, Power, and TTM): | IP2X |
| All Other Locations: | IP4X |

[a] ICONs equipped with CWDM SFPs are rated –20°C to +50°C (–4° to +122°F).

# Compliance and Type Tests

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B Class A
This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference in which case the user will be required to correct the interference at his own expense.

Emissions for Canada ICES-001 (A) / NMB-001 (A)
This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to ICES-001, Issue 5.

Class 1 Laser
Modules and SFPs comply with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3, as described in Laser Notice No. 56, dated May 8, 2019.

Refer to the following matrix for module-specific FCC, CAN ICES-001, CE, RCM, RoHS, and UKCA compliance information:

| Compliance Specs | ICON Models | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8001 | 8002 | 8010 | 8011 | 8022 | 8030 | 8036 | 8041 | 8050 | 8051 | 8053 | 8055 | 8056 | 8057 | 8065 | 8066 | 8067 |
| FCC PART 15 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| CAN ICES-001 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| CE | | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| RCM | | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| RoHS | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| UKCA | | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |

## Communications Product Testing

**NOTE:** These standards apply to SEL-8002-01, SEL-8010-01, SEL-8010-02, SEL-8010-13, SEL-8022-01, SEL-8030-01, SEL-8036-01, SEL-8036-02, SEL-8050-01, SEL-8051-21, SEL-8051-22, SEL-8053-11, SEL-8053-12, SEL-8055-01, SEL-8056-01, SEL-8057-03, SEL-8057-11, SEL-8057-12, SEL-8057-14, SEL-8057-15, and SEL-8065-11 when tested at Communication Profile 3 (IEEE 1613)/Profile 2 (IEC 61850-3) with double-shielded cables.

IEC 61850-3 Performance Class 1
IEEE 1613-2009 + A1:2011 Performance Class 1

## Electromagnetic Compatibility (EMC)

**NOTE:** These standards apply to SEL-8002-01, SEL-8010-01, SEL-8010-02, SEL-8010-13, SEL-8022-01, SEL-8030-01, SEL-8036-01, SEL-8036-02, SEL-8050-01, SEL-8051-21, SEL-8051-22, SEL-8053-11, SEL-8053-12, SEL-8055-01, SEL-8056-01, SEL-8057-03, SEL-8057-11, SEL-8057-12, SEL-8057-14, SEL-8057-15, and SEL-8065-11 when tested at Communication Profile 3 (IEEE 1613)/Profile 2 (IEC 61850-3) with double-shielded cables.

| **Product Standards** | **ETSI EN 303 413<br>ETSI EN 301 489-1 V2.2.0: 2017-03<br>ETSI EN 301 489-19 V2.1.0: 2017-03<br>ICES-001, Issue 5<br>IEC 60255-26:2013<br>IEC 61850-3:2013<br>IEEE 1613-2009<br>IEEE C37.90-2005** | | | |
|---|---|---|---|---|
| **Test** | **Methodology** | **Level** | | |
| Emissions | ANSI C63.4<br>CISPR 11/22/32<br>EN 55011<br>EN 55022<br>EN 55032<br>KN 32 | Class A | | |
| Harmonics | IEC 61000-3-2 | Class A | | |
| Flicker | IEC 61000-3-3 | Class A | | |
| Radiated RF Immunity | ETSI 301 489-19<br>IEC 61000-4-3 | **Frequency (MHz)** | **Field Strength** | **Modulation** |
| | | 80–6000 | 3 V/m | AM 80% 1 kHz sine |
| | | 80–6000 | 20 V/m | AM 80% 1 kHz sine |
| Conducted RF Immunity | IEC 61000-4-6 | 150 kHz–80 MHz, 1 kHz 80% AM 10 Vrms<br>Spot Frequencies: 27 MHz and 68 MHz | | |
| Electrostatic Discharge | IEC 61000-4-2 | Contact Discharge: ±2, 4, 6, 8 kV<br>Indirect Discharge: ±2, 4, 6, 8 kV<br>Air Discharge: ±2, 4, 8, 15 kV | | |

<table>
<tr><th>Product Standards</th><td colspan="3">ETSI EN 303 413<br>ETSI EN 301 489-1 V2.2.0: 2017-03<br>ETSI EN 301 489-19 V2.1.0: 2017-03<br>ICES-001, Issue 5<br>IEC 60255-26:2013<br>IEC 61850-3:2013<br>IEEE 1613-2009<br>IEEE C37.90-2005</td></tr>
<tr><th>Test</th><th>Methodology</th><th colspan="2">Level</th></tr>
<tr><td rowspan="4">Electrical Fast Transient Burst</td><td rowspan="4">IEC 61000-4-4</td><td colspan="2"><table><tr><th>Port Type</th><th>Level</th></tr><tr><td>Power, Input/Output</td><td>±4 kV @ 5 kHz (Zone A)</td></tr><tr><td>Communication Ports</td><td>±4 kV @ 5 kHz (Zone A)</td></tr></table></td></tr>
<tr><td colspan="2">Note: For USB ports, use cable lengths ≤3 m.</td></tr>
<tr><td rowspan="4">Surge Immunity</td><td rowspan="4">IEC 61000-4-5</td><td colspan="2"><table><tr><th>Port Type</th><th>Level</th></tr><tr><td>Power</td><td>±0.5, 1 kV line-to-line (Zone B)<br>±0.5, 1, 2 kV line-to-earth (Zone B)</td></tr><tr><td>Communication Ports</td><td>±0.5, 1, 2 kV line-to-earth (Zone B)</td></tr></table></td></tr>
<tr><td colspan="2">Note: For USB ports, use cable lengths ≤3 m. For Server IRIG-B port, use cable lengths ≤10 m.</td></tr>
<tr><td rowspan="7">Damped Oscillatory Wave Immunity</td><td rowspan="7">IEC 61000-4-18</td><td colspan="2"><table><tr><th>Port Type</th><th>Level</th></tr><tr><td>Power</td><td>±2.5 kV Common<br>±1 kV Differential</td></tr><tr><td>Contact I/O</td><td>±2.5 kV Common<br>±1 kV Differential</td></tr><tr><td>Communication Ports</td><td>±1 kV Common</td></tr><tr><td>GPS</td><td>±1 kV Common</td></tr><tr><td>IRIG-B</td><td>±1 kV Common</td></tr></table></td></tr>
<tr><td colspan="2">Note: For USB ports, use cable lengths ≤3 m.</td></tr>
<tr><td>Power Frequency Immunity/Conducted Common Mode Disturbances</td><td>IEC 60255-26<br>IEC 61000-4-16</td><td colspan="2">Exempt. For binary input ports, use cable lengths ≤10 m.</td></tr>
<tr><td>Power Frequency Magnetic Field Immunity</td><td>IEC 61000-4-8</td><td colspan="2">100 A/m for 60 Seconds<br>1000 A/m for 1–3 Seconds</td></tr>
<tr><td>Pulse Magnetic Field Immunity</td><td>IEC 61000-4-9</td><td colspan="2">1000 A/m, Level 5</td></tr>
<tr><td>Damped Oscillatory Magnetic Field Immunity</td><td>IEC 61000-4-10</td><td colspan="2">100 A/m, Level 5</td></tr>
<tr><td>AC Dips and Interruptions</td><td>IEC 61000-4-11</td><td colspan="2">10 Cycles</td></tr>
<tr><td>Ripple on DC Power Input</td><td>IEC 61000-4-17</td><td colspan="2">15% of Rated DC Value</td></tr>
<tr><td>DC Dips and Interruptions</td><td>IEC 61000-4-29</td><td colspan="2">200 ms</td></tr>
<tr><td>Burden</td><td>IEC 60255-1</td><td colspan="2">Meets applicable requirements</td></tr>
<tr><td rowspan="5">Surge Withstand Capability</td><td rowspan="5">IEEE C37.90.1</td><td colspan="2">Damped Oscillatory (1 MHz)<table><tr><th>Port Type</th><th>Level</th></tr><tr><td>Power, Input/Output</td><td>±2.5 kV Common<br>±2.5 kV Differential</td></tr><tr><td>Communication Ports</td><td>±2.5 kV Common</td></tr></table></td></tr>
<tr><td colspan="2">Fast Transient (5 kHz)<table><tr><th>Port Type</th><th>Level</th></tr><tr><td>Power, Input/Output</td><td>±4.0 kV Common<br>±4.0 kV Differential</td></tr><tr><td>Communication Ports</td><td>±4.0 kV Common</td></tr></table></td></tr>
<tr><td colspan="2">Note: For USB ports, use cable lengths ≤3 m.</td></tr>
<tr><td rowspan="2">Radiated Immunity</td><td rowspan="2">IEEE C37.90.2</td><td colspan="2"><table><tr><th>Frequency (MHz)</th><th>Field Strength</th><th>Modulation</th></tr><tr><td>80–6000</td><td>20 V/m</td><td>AM 80% 1 kHz sine</td></tr></table></td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Electrostatic Discharge</td><td>IEEE C37.90.3</td><td colspan="2">Contact Discharge: ±2, 4, 6, 8 kV<br>Indirect Discharge: ±2, 4, 6, 8 kV<br>Air Discharge: ±2, 4, 8, 15 kV</td></tr>
</table>

## Environmental

NOTE: These standards apply to SEL-8002-01, SEL-8010-01, SEL-8010-02, SEL-8010-13, SEL-8022-01, SEL-8030-01, SEL-8036-01, SEL-8036-02, SEL-8050-01, SEL-8051-21, SEL-8051-22, SEL-8053-11, SEL-8053-12, SEL-8055-01, SEL-8056-01, SEL-8057-03, SEL-8057-11, SEL-8057-12, SEL-8057-14, SEL-8057-15, and SEL-8065-11 when tested at Communication Profile 3 (IEEE 1613)/Profile 2 (IEC 61850-3) with double-shielded cables.

| **Product Standards** | **IEC 60255-27:2014<br>IEC 61850-3:2013<br>IEEE 1613-2009** | | |
|---|---|---|---|
| **Test** | **Methodology** | **Level** | |
| Cold | IEC 60255-1<br>IEC 60068-2-1 | **Test Type** | **Level** |
| | | Operational | Test Ad: 16 hours at –20°C |
| | | Storage | Test Ab: 16 hours at –40°C |
| Dry Heat | IEC 60255-1<br>IEC 60068-2-2 | **Test Type** | **Level** |
| | | Operational | Test Bd: 16 hours at +65°C |
| | | Storage | Test Bb: 16 hours at +85°C |
| Cyclic Temperature | IEC 60255-1<br>IEC 60068-2-14 | Test Db: –20°C to +65°C, 5 cycles | |
| Damp Heat | IEC 60255-1<br>IEC 60068-2-78<br>IEC 60068-2-30 | **Test Type** | **Level** |
| | | Steady State | Test Cab: 93% RH, +40°C, 10 days |
| | | Cyclic | Test Db: +25°C to +55°C, 6 cycles, (12+12-hour cycle), 95% RH |
| Vibration | IEC 60255-21-1 | Class 2 Endurance, Class 2 Response | |
| Shock/Bump | IEC 60255-21-2 | **Test Type** | **Level** |
| | | Shock | Class 1 Withstand, Class 2 Response |
| | | Bump | Class 1 Withstand |
| Seismic | IEC 60255-21-3 | Class 2 Quake Response | |
| Shock Phenomena | IEEE 1613 | **Test Type** | **Level** |
| | | Normal Handling | 100 mm Drop |
| | | **Note:** Excluding cable access face. | |

## Safety

**NOTE:** These standards apply to SEL-8002-01, SEL-8010-01, SEL-8010-02, SEL-8010-13, SEL-8022-01, SEL-8030-01, SEL-8036-01, SEL-8036-02, SEL-8050-01, SEL-8051-21, SEL-8051-22, SEL-8053-11, SEL-8053-12, SEL-8055-01, SEL-8056-01, SEL-8057-03, SEL-8057-11, SEL-8057-12, SEL-8057-14, SEL-8057-15, and SEL-8065-11 when tested at Communication Profile 3 (IEEE 1613)/Profile 2 (IEC 61850-3) with double-shielded cables.

| **Product Standards** | **IEC 60255-27:2013<br>IEC 61850-3:2013<br>IEEE 1613-2009<br>IEEE C37.90-2005** | | |
|---|---|---|---|
| **Test** | **Methodology** | **Level** | |
| Dielectric Strength | IEC 60255-27 | **Port Type** | **Level** |
| | | Power | ±3.6 kVdc |
| | | Alarm Contacts | ±2.5 kVac |
| | | Ethernet Ports | ±1.5 kVac |
| | | Other Communication Ports | ±500 Vac |
| Impulse | IEC 60255-27 | **Port Type** | **Level** |
| | | Power | ±5 kV |
| | | All Other Ports | ±1 kV |
| Insulation Resistance | IEC 60255-27 | Meets applicable levels | |
| Flammability of Insulating Materials | IEC 60255-27 | Meets applicable levels | |
| Maximum Temperature of Parts and Materials | IEC 60255-27 | Meets applicable levels, Normal use | |
| Protective Bonding/Continuity | IEC 60255-27 | Meets applicable levels | |
| Object Penetration | IEC 60529 | **Location** | **Level** |
| | | Terminal Blocks | IP2X |
| | | All Other Locations | IP4X |
| Laser Safety | IEC 60825-1<br>IEC 60825-2<br>21 CFR 1040.10 and 1040.11 | Class 1 | |
| Line Leakage | IEC 60255-27<br>IEC 60990 | Meets applicable levels | |
| Insulation Coordination | IEEE C37.90 | **Dielectric Strength** | |
| | | **Port Type** | **Level** |
| | | Power | ±3.6 kVdc |
| | | Alarm Contacts | ±2.5 kVac |
| | | Ethernet Ports | ±1.5 kVac |
| | | Other Communication Ports | ±500 Vac |
| | | **Impulse** | |
| | | **Port Type** | **Level** |
| | | Power | ±5.0 kV |
| | | All Other Ports | ±1.0 kV |
| | | **Insulation Resistance**<br>Meets applicable levels | |

# 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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