SEL-3390T

Time and Ethernet Adapter Card

Instruction Manual

20241105

SCHWEITZER ENGINEERING LABORATORIES

PM3390T-01

Part Number: PM3390T-01

Features, Benefits, and Applications

The SEL-3390T Time and Ethernet Adapter Card is a PCI Express (PCIe) expansion card that adds accurate time synchronization and distribution functionality to the flexible and robust SEL automation controllers. SEL-3390 expansion cards have a standard PCI Express card form factor and are designed and built to be used in harsh industrial and substation environments. They offer a wide operating temperature range; immunity to ESD, shock, and vibration; and conformal coating for corrosion immunity.

The SEL-3390T provides the following:

- **IRIG-B Input/Output.** Synchronize the system time to a satellite clock by using the high-accuracy IRIG-B input. Distribute IRIG-B to downstream devices by using the IRIG-B output.
- **Gigabit Ethernet Ports.** Communicate over Ethernet connections by using the two independent gigabit Ethernet ports, capable of 10, 100, and 1000 Mbps connection speeds. Each port has a unique media access control (MAC) address, allowing connections to as many as two independent Ethernet networks.
- **Precision Time Protocol (PTP).** The SEL-3390T Ethernet ports provide PTP hardware time stamps, enabling PTP client software to achieve high-precision time synchronization over Ethernet.
- **Copper and Fiber-Optic Connections.** Connect to copper 10/100/1000BASE-T, and fiber-optic 100BASE-FX and 1000BASE-X networks. Small form-factor pluggable (SFP) fiber-optic modules enable flexibility and mixed network connections. Three different port configurations are available: two RJ45 copper ports, two LC SFP fiber-optic ports, or one RJ45 and one SFP port.
- **Failover Mode.** Create redundant Ethernet connections for the most reliable communication. Failover Mode combines the two Ethernet ports into a pair with automatic failover based on the link state.
- **Conformal Coating (Optional).** Protect circuitry from hazards such as chemicals, vibration, moisture, salt spray, humidity, fungus, and corrosion with this durable protective coating, extending the working life of the printed circuit board (PCB) and components.
- **Reliability.** Apply in harsh substation environments. The SEL-3390T exceeds IEEE 1613, IEEE C37.90, and IEC 60255 protective relay standards. The card provides reliable operation from –40° to +75°C (–40° to +167°F), and is backed by the SEL worldwide, ten-year product warranty and highly rated technical support.

Product Overview

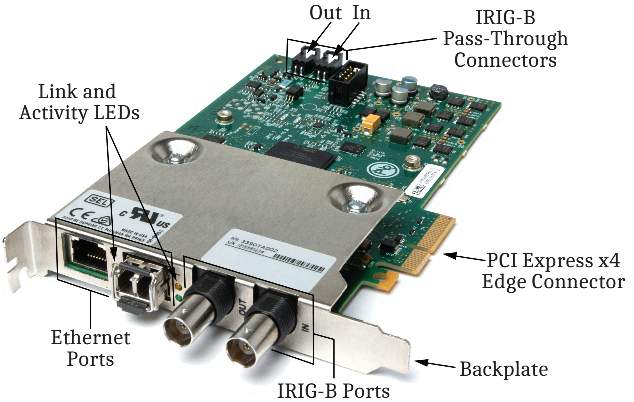

Figure 1 SEL-3390T Functional Overview

Safety Information

Dangers, Warnings, and Cautions

This manual uses three kinds of hazard statements, defined as follows:

⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in serious death or injury.

⚠WARNING
Indicates a potentially hazardous situation that, if not avoided, **could** result in death or serious injury.

⚠CAUTION
Indicates a potentially hazardous situation that, if not avoided, **may** result in minor or moderate injury or equipment damage.

Safety Symbols

The following symbols are often marked on SEL products.

⚠	**⚠CAUTION** Refer to accompanying documents.	**⚠ATTENTION** Se reporter à la documentation.
⏚	Earth (ground)	Terre

	Protective earth (ground)	Terre de protection
	Direct current	Courant continu
	Alternating current	Courant alternatif
	Both direct and alternating current	Courant continu et alternatif
	Instruction manual	Manuel d'instructions

Safety Marks

The following statements apply to this device.

General Safety Marks

For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.

Other Safety Marks (Sheet 1 of 2)

⚠WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	**⚠AVERTISSEMENT** L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.
⚠WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	**⚠AVERTISSEMENT** Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.

Other Safety Marks (Sheet 2 of 2)

⚠CAUTION Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	⚠ATTENTION Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.	⚠ATTENTION L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.

Installation and Maintenance

These instructions can generally be applied to both SEL and other PCIe-compliant systems. For more detailed instructions, refer to the instruction manual for your system.

Begin the installation by following *Hardware Installation on page 4* to install the SEL-3390T into your system chassis. Once the SEL-3390T has been properly installed, turn the system on and proceed with *Software Installation on page 6* to install the device driver software. After installing the device driver, you can configure software settings and connect communications cables to use the SEL-3390T Ethernet and IRIG-B ports.

Hardware Installation

When installing or removing expansion cards, ensure that the system is off and the power supply is disconnected. Be sure to properly ground yourself to the system chassis to avoid ESD damage. Remove any SFP modules from the SEL-3390T to prevent interference with the system chassis during installation.

⚠**CAUTION**

Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

Remove the top or side panel of the system chassis to gain access to the expansion slots. Locate an available PCIe expansion slot in which to install the SEL-3390T. The SEL-3390T uses a PCIe x4 interface, which can be plugged into a PCIe x4 slot, as well as longer PCIe x8 and PCIe x16 slots. See *Figure 2* to help identify the proper type of slot.

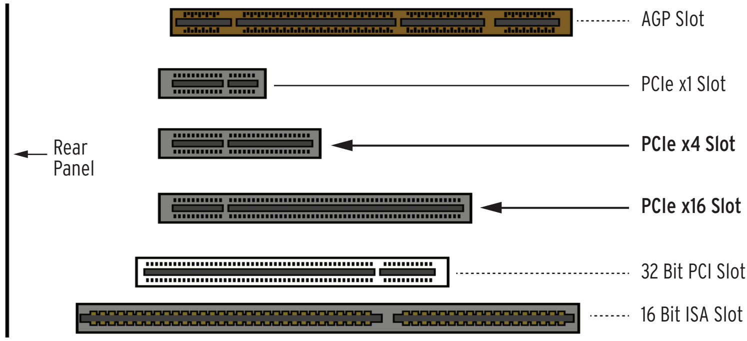

Figure 2 Identifying PCIe Expansion Slots

Expansion cards are typically secured to the chassis by a retention screw at the rear panel of the system. When no card is installed in the expansion slot, a blanker plate is used to cover the rear-panel opening. Remove the retention screw and blanker plate for the expansion slot selected, retaining the screw for later use (see *Figure 3*).

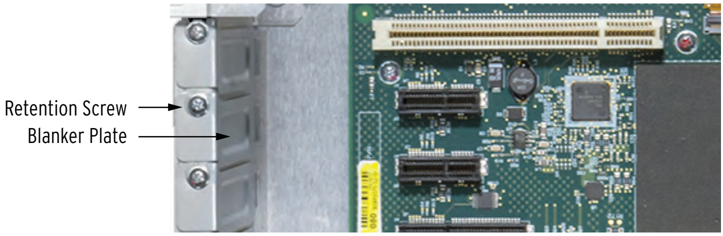

Figure 3 Expansion Slots With Retention Screws and Blanker Plates Installed

Align the PCIe x4 edge connector on the SEL-3390T with the PCIe expansion slot and gently apply pressure to the edge of the SEL-3390T until it seats fully into the slot. Align the slot in the top edge of the SEL-3390T backplate with the screw hole in the system chassis, and reinstall the screw removed earlier. Tighten the screw until it securely clamps the card backplate to the chassis. Be careful not to overtighten the screw because doing so may damage the threads.

If the system contains multiple SEL-3390 PCIe cards, you should install internal IRIG-B pass-through cables to synchronize the IRIG-B outputs of all cards. See *IRIG-B Pass-Through on page 7* for instructions.

Once you have installed the card, secured the backplate to the chassis, and connected the internal cables, reinstall the top or side panel of the system and apply power.

Software Installation

NOTE: When adding an SEL-3390T card to a system that already has the SEL-3300 driver bundle installed, you may need to run the firmware update tool to synchronize all cards to the correct firmware. For more information, see *Device Missing or Unknown on page 41*.

After you have installed the SEL-3390T in the system, apply power and log in to the operating system as a user that has administrative privilege.

Download the driver installation package from the SEL website at selinc.com, and copy it onto your local hard drive. The installation package includes a README.txt file that contains installation instructions and requirements. Follow the steps in the README.txt to complete the installation.

For Red Hat Enterprise Linux (RHEL) or Ubuntu operating systems, you can optionally source the driver package from the SEL repository instead of the SEL website. Instructions for installing the driver package by using the SEL repository are provided at https://cdn.selinc.com/repos/README.txt.

Cleaning

The SEL-3390T typically does not require any cleaning. Dust may accumulate in systems with forced air ventilation. In that case, you may use dry compressed air to blow the dust off. Cleaning with direct contact of liquids or tools is not recommended, because you may damage components or cause corrosion.

IRIG-B Input/Output

The SEL-3390T can receive and distribute IRIG-B time data for accurate time synchronization of connected devices. Use the IRIG-B input to synchronize the computer system clock to a GPS clock or other accurate time source. The SEL-3390T can also generate IRIG-B directly from the computer system clock, enabling all connected devices to be synchronized to the computer system, which may be synchronized to a Network Time Protocol (NTP) or Precision Time Protocol (PTP) server over Ethernet.

NOTE: The IRIG-B features described in this section are not supported on VMware ESXi operating systems.

NOTE: SEL-3390T IRIG-B004 control bits comply with IEEE C37.118.1-2011 (reverse compatible with IRIG-B000 and IEEE C37.118-2005).

IRIG-B Input

The SEL-3390T can receive a single IRIG-B input, either on the IRIG-B input BNC connector or the internal IRIG-B input connector (see *Figure 1*). The SEL-3390T accepts a demodulated (also referred to as unmodulated) IRIG-B004 and IRIG-B002 input with either EVEN or ODD parity. The IRIG-B002 time-code format is binary-coded decimal (BCD) time code (HH,MM,SS,DDD)—this time-code format is “regular” IRIG-B. The IRIG-B004 time-code formats consist of BCD time code (HH,MM,SS,DDD), plus straight binary seconds (SBS) of the day (0–86400 s), and control bits that depend on user applications. The SEL-3390T IRIG-B004 control bits comply with IEEE C37.118.1-2011 (reverse compatible with IRIG-B000 and IEEE C37.118-2005).

IRIG-B Output

The SEL-3390T can provide demodulated IRIG-B output on the IRIG-B output BNC connector and to the internal IRIG-B output connector (see *Figure 1*). The output format is always IRIG-B004 with IEEE C37.118.1-2011 control bits (reverse compatible with IRIG-B000 and IEEE C37.118-2005) and EVEN parity, regardless of the time source format. If a valid IRIG-B input is present, the output will provide time synchronization to the input with very high precision (±100 ns typical, ±1000 ns maximum separation). If no IRIG-B input signal is present, the output will provide time from the computer system clock, which may be synchronized to an NTP or PTP server over Ethernet.

To determine how many devices an IRIG-B output is able to synchronize, you must perform a parallel resistance calculation by using the input resistance of all devices connected to the output (including the termination resistor, if present). *BNC IRIG-B Output* listed in *Specifications* provides the output drive capacity of the SEL-3390T IRIG-B output. For reliable synchronization, the calculated parallel resistance of all connected devices must be greater than the output drive capacity resistance.

For example, many SEL relays have an IRIG-B input resistance of approximately 2,500 ohms. If the BNC IRIG-B output supports an output drive capacity resistance of 25 ohms, this allows approximately 20 SEL relays to be connected in parallel, with a 50-ohm termination resistor on the farthest device.

When connecting devices to the BNC IRIG-B output, install a 50-ohm termination resistor on the farthest device if the calculated parallel resistance is greater than 75 ohms. The maximum total cable length for IRIG-B distribution is 140 m (459.3 ft) for coaxial BNC cables.

IRIG-B Pass-Through

The internal IRIG-B input and output connectors (see *Figure 1*) can be used to daisy-chain multiple SEL-3390 cards together with SEL-C5865 cables, allowing all cards to provide IRIG-B output synchronized to a single IRIG-B input connection. When using IRIG-B pass-through, make certain that the computer system as a whole only has one external IRIG-B input connected. Optionally, you can connect the output of the last card in the daisy chain to the input of the first card to create a loop, as long as the Source Selection setting for each card is set to Auto or the first card is set to External to prevent a clock runaway condition. See *Time Class on page 28* or *Time Class on page 33* for details on the Source Selection setting. See *Figure 4* for examples.

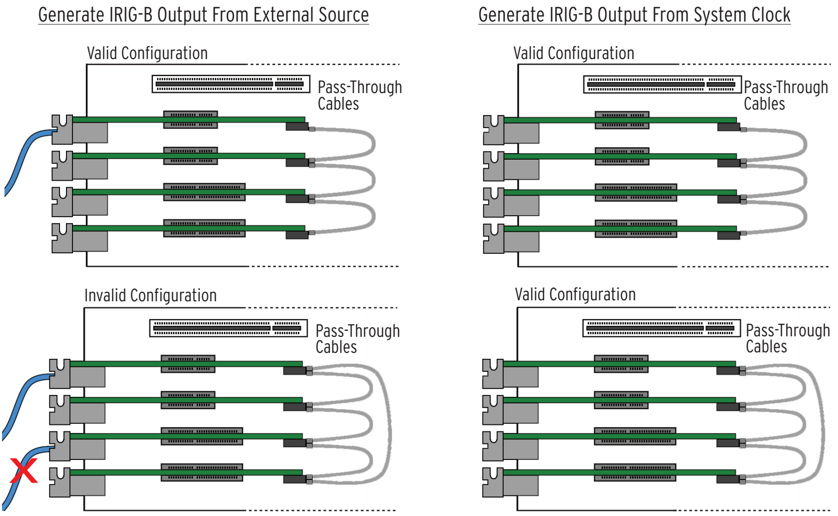

Figure 4 Valid and Invalid IRIG-B Pass-Through Configurations

Ethernet Connections

The SEL-3390T is available in three different port configurations: two RJ45 copper ports, two LC SFP fiber-optic ports, or one RJ45 and one SFP port. Each port operates as an independent network interface, enabling communication with multiple networks as well as redundant network connections for fault tolerance.

RJ45 Copper Connections

The RJ45 Ethernet ports enable communication over copper cable lengths as long as 100 m. The copper Ethernet ports support Auto MDI-X (auto-crossover), allowing you to use a standard Ethernet cable for all connections. When you use copper Ethernet connections, be sure to choose a cable that is rated for the connection speed. SEL recommends you use Cat 5 or higher cable for 10BASE-T connections, and Cat 5e or Cat 6 for 100BASE-TX or 1000BASE-T connections. See *Table 13* for cables available from SEL.

SFP Fiber-Optic Connections

The SEL-3390T uses SFP modules to connect to fiber-optic network connections. The SFP modules have LC-type fiber-optic connectors. See *Figure 5* for the position of the transmit and receive ports. The SEL-3390T auto-detects the type and speed of the SFP module for those provided by SEL. You must manually configure third-party SFP modules through the Ethernet device settings available on Windows and Linux operating systems (see *Ethernet Port Settings on page 10*). On VMware ESXi operating systems you must use SFPs provided by SEL. Third-party SFPs are not supported. See *Table 12* for details on available SFP modules and *Table 13* for cables available from SEL.

NOTE: On VMware ESXi operating systems you must use SFPs provided by SEL. Third-party SFPs are not supported.

SFP modules are hot-pluggable, meaning you can install or remove them while the system is powered on and operational. To install an SFP module, ensure the bail clasp is in the open position (see *Figure 5*) and slide the module rear-first into the SFP socket on the SEL-3390T. Gently apply pressure on the face of the module to seat it into the socket. When fully seated, lift the bail clasp up and lock it into the closed position so that it is nearly flush with the card backplate. If the SFP module will not seat fully, it may be upside down; try installing it in the other direction. To remove the SFP module, simply open the bail clasp and gently pull on it until the module comes out of the socket. To prevent the optics from being contaminated, install the dust plug into the SFP LC port any time a fiber-optic cable is not connected.

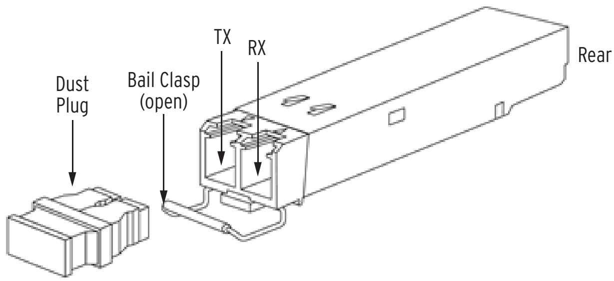

Figure 5 SFP Module Components

NOTE: Although Class 1 lasers and LEDs are considered to be eye safe, avoid staring into the transmitter or fiber-end infrared radiation. Lasers and LEDs do not require maintenance and are not user-serviceable. Return the unit to the factory for repair or replacement.

Status Indicators

Each Ethernet port has two LEDs that indicate network link status and activity and can be used to identify the port. The right (Link) LED illuminates yellow to indicate that a link or connection is present. The left (Activity) LED flashes green during transmit and receive activity.

The Ethernet port Link and Activity LEDs blink in unison when the Identify Port feature is being used. See *Testing and Troubleshooting on page 41* for more details on the Identify Port feature.

If an alarm condition exists in the SEL-3390T, such as a hardware or initialization failure, all Activity LEDs will illuminate green, and all Link LEDs will be extinguished. If the alarm condition clears, the Link and Activity LEDs will return to normal operation.

Failover Mode

Failover Mode combines the two ports on the SEL-3390T into a pair with automatic failover based on the link state. This enables physical port redundancy so that any failure of the port electronics, wire, or fiber-optic connection that causes a loss of link will trigger the SEL-3390T to automatically switch to the other port. The failover operation typically happens a few milliseconds after the link loss and does not require any special programming or features in the connected network.

NOTE: The Failover Mode feature is not supported on VMware ESXi operating systems.

To enable failover mode, you must enable the setting on Port 1 (enabling the feature on Port 2 does nothing). See *Table 1* and *Table 2* for details on enabling Port Redundancy. The link speed, duplex, and type of SFP module do not need to match on port pairs because they will be autonegotiated independently. The Ethernet controller reports the speed and duplex of the currently active port. Port 2 may be reported as present by the operating system but does not function and indicates it has no link.

The SEL-3390T does not give priority to any port. A failover only occurs when the currently active port loses the link, and on initial connection or startup, the first port to get a link becomes the active port. External factors, such as the behavior of the network device the SEL-3390T is connected to, the host OS, and the type of network traffic, will be the largest contributors to failover time. For example, when connected to an unmanaged switch, after failover, the switch may not redirect traffic to the other port until it learns that the MAC address has moved to that port (when the host OS transmits a packet that contains the MAC address).

Precision Time Protocol (PTP)

Use PTP to synchronize client clocks to a master clock over an Ethernet network. It operates similarly to Network Time Protocol (NTP) but can achieve higher precision by using hardware time stamps on the packets as they traverse the network.

The SEL-3390T Ethernet ports provide PTP hardware time stamps, enabling PTP client software that supports hardware time stamps to achieve high-precision time synchronization over Ethernet. See *IRIG-B and Ethernet Time Synchronization on page 14* for more information.

Ethernet Port Settings

Most Ethernet settings are configured on a per-port basis, allowing each Ethernet port to have a unique configuration. The Windows and Linux device drivers provide settings that are unique to the SEL-3390T, and are described in the sections below. The VMware ESXi device drivers only provide the standard network interface settings that are available in the ESXi host management interfaces.

Windows Settings

To access the SEL-3390T Ethernet settings in Windows, open the Windows Device Manager and expand the **Network Adapters** device category. You will see a list of all network adapters in the system. Open the Properties window of the SEL-3390T network adapter being configured by double-clicking on the network adapter. The driver settings are listed in the Properties window on the Advanced tab.

The driver settings available on the Advanced tab are listed in *Table 1*. The settings changes will take effect immediately after you select **OK** to close the Properties window.

Table 1 Windows Settings (Sheet 1 of 2)

Name	Description	Options (Bold = defaults)
Checksum Offload	Enables hardware-accelerated TCP/IP and UDP/IP checksum verification.	**Enabled** Disabled
Interrupt Moderation Rate	Adjusts the relationship between packet latency and CPU burden: ➤ Set to Low for lower packet latency in exchange for higher CPU burden. ➤ Set to Medium to strike a balance between packet latency and CPU burden. ➤ Set to High to have a lower CPU burden in exchange for higher packet latency.	High Low **Medium**
LED Test	Continuously blinks the Link and Activity LEDs on the port, allowing you to identify the physical port for the network adapter.	Enabled **Disabled**
Maximum RBDs	Defines the received packet buffer size: ➤ Smaller buffers use less RAM but have a higher probability of packet loss. ➤ Larger buffers use more RAM but make losing packets less likely.	1024 **2048** 4096
Maximum TBDs	Defines the transmit packet buffer size: ➤ Smaller buffers use less RAM but have a higher probability of packet loss. ➤ Larger buffers use more RAM but make losing packets less likely.	1024 **2048** 4096
Network Address	Sets the MAC address for the network adapter. This is a volatile override; the address entered only takes effect when booted into this operating system. It does not permanently change the MAC address stored in the hardware. Enter the MAC address with no spaces or hyphens (i.e., AABBCCDDEEFF). Leave this value blank to use the hardware MAC address.	Any Valid MAC Address
Port Redundancy	Sets the Failover Mode for the port. If the primary port fails, it will fall back to the secondary port. If the secondary port fails, it falls back to the primary port.[a]	Enabled **Disabled**

Table 1 Windows Settings (Sheet 2 of 2)

Name	Description	Options (Bold = defaults)
Promiscuous Mode	Disables the network adapter MAC filter, enabling it to receive all packets regardless of destination MAC address. This increases CPU burden, but enables monitoring of all network traffic received on the port.	Enabled **Disabled**
SFP Module Configuration	Sets the type of SFP module, speed, and negotiation method. The **Auto** setting is only valid for SFP modules provided by SEL; third-party SFP modules are not compatible with the **Auto** setting.	100 Mbps SERDES 100 Mbps SGMII 1000 Mbps SERDES 1000 Mbps SGMII **Auto**
Speed and Duplex	Sets the link speed and duplex of the port. **Auto** causes the port to autonegotiate the speed and duplex. For 1000 Mbps (gigabit) connections, this must be set to **Auto.** The SEL-3390T ignores this setting for fiber-optic connections because they operate at a fixed speed based on the SFP module used.	10 Mbps Full 10 Mbps Half 100 Mbps Full 100 Mbps Half **Auto**

[a] Port 1 and Port 2 can be set to a failover pair by enabling the setting on Port 1.

Linux Settings

To access the SEL-3390T Ethernet settings in Linux, use the command line syntax shown in *Table 2*. Ethtool is the suggested method for viewing and modifying the network settings in Linux. However, there are a few settings that require modifying specific configuration files.

All setting changes shown in *Table 2* are temporary and will revert to the default values after the device restarts. To make the settings permanent, use a SysVinit init script, systemd service file, or udev rules file, depending on the setting, when you start the device. Some ethtool settings can be made permanent by using Network Manager.

Table 2 Linux Settings (Sheet 1 of 3)

Name	Description	Options (Bold = defaults)	Command Line Interface[a]
Checksum Offload	Enables hardware-accelerated TCP/IP and UDP/IP checksum verification.	Off **On**	**Ethtool Example** List features supported by the device: ethtool -k <ethX> Set a feature (checksum offload in this case): ethtool -K <ethX> rx off ethtool -K <ethX> tx off

Table 2 Linux Settings (Sheet 2 of 3)

Name	Description	Options (Bold = defaults)	Command Line Interface[a]
Interrupt Moderation Rate	Adjusts the relationship between packet latency and CPU burden: ➤ Set to Low for lower packet latency in exchange for higher CPU burden. ➤ Set to Medium to strike a balance between packet latency and CPU burden. ➤ Set to High to have a lower CPU burden in exchange for higher packet latency.	0 **1** 2	/sys/class/net/<ethX>/sel_port/interrupt_-moderation_file Reading prints the current mode, while writing to the file sets the mode. Modes: 0 = Low 1 = Medium 2 = High
LED Test	Continuously blinks the Link and Activity LEDs on the port, allowing you to identify the physical port for the network adapter.	N/A	**Ethtool Example** Blink <ethX> for 5 s ethtool -p <ethX> 5
Maximum RBDs	Defines the received packet buffer size: ➤ Smaller buffers use less RAM but have a higher probability of packet loss. ➤ Larger buffers use more RAM but make losing packets less likely.	1024 **2048** 4096	**Ethtool Example** View the current settings: ethtool -g <ethX> Set the size: ethtool -G <ethX> rx 1024 tx 1024
Maximum TBDs	Defines the transmit packet buffer size ➤ Smaller buffers use less RAM but have a higher probability of packet loss. ➤ Larger buffers use more RAM but make losing packets less likely.	1024 **2048** 4096	**Ethtool Example** View the current settings: ethtool -g <ethX> Set the size: ethtool -G <ethX> rx 1024 tx 1024
Network Address	Sets the MAC address for the network adapter. This is a volatile override; the address entered only takes effect when booted into this operating system. It does not permanently change the MAC stored in hardware.	Any Valid MAC Address	ip link set <ethX> address 02:01:02:03:04:08[b]
Port Redundancy	Sets the Failover Mode for the port. If the primary port fails it will fall back to the secondary port or if secondary port fails it falls back to the primary port.	**Off** On	**Ethtool Example**[c] To turn it on: ethtool --set-priv-flags <ethX> Failover on To turn it off: ethtool --set-priv-flags <ethX> Failover off **NOTE:** If enabled, this will conflict with bonded interfaces.

Table 2 Linux Settings (Sheet 3 of 3)

Name	Description	Options (Bold = defaults)	Command Line Interface[a]
Promiscuous Mode	Disables the network adapter's MAC filter, enabling it to receive all packets regardless of destination MAC address. This increases CPU burden, but it enables monitoring of all network traffic received on the port.	**<blank>** promisc	To turn on: ip link set <ethX> promisc on[b] To turn off: ip link set <ethX> promisc off[b]
SFP Module Configuration	Sets the type of SFP module, speed, and negotiation method. The **Auto** setting is only valid for SFP modules provided by SEL; third-party SFP modules are not compatible with the **Auto** setting.	**0** 1 2 3 4	/sys/class/net/<ethX>/sel_port/ Reading prints the current mode, while writing to the file sets the mode. sfp_configuration file: Modes: 0 = Auto 1 = 100 Mbps SERDES 2 = 1000 Mbps SERDES 3 = 100 Mbps SGMII 4 = 1000 Mbps SGMII SEL_SFPId file: Read-only—Reading it gives identifying information about an installed SFP module. SEL_SFPDiag file: Read-only—Reading it gives diagnostic information about an installed SFP module if the module supports diagnostics.
Speed and Duplex	Sets the link speed and duplex of the port. **Auto** causes the port to autonegotiate the speed and duplex. For 1000 Mbps (gigabit) connections, this must be set to **Auto**. The SEL-3390T ignores this setting for fiber-optic connections because they operate at a fixed speed based on the SFP module used.	For speed: 10 100 For duplex: half full For autoneg: on off	**Ethtool Example** Set Settings: ethtool -s <ethX> speed 100 duplex half autoneg off ethtool -s <ethX> speed 10 duplex full autoneg off ethtool -s <ethX> autoneg on **NOTE:** When autoneg is set to on, it is possible to negotiate to 1000 Mbps.

[a] This is a generic example using <ethX> port where X can be any available Ethernet port.
[b] This example uses the ip command. Any network configuration application can be used (ifconfig or sysconfig are examples of other applications).
[c] Port 1 and Port 2 can be set to a failover pair by enabling the setting on Port 1.

IRIG-B and Ethernet Time Synchronization

Each SEL-3390T card in the computer system contains an SEL Time Controller that is a dedicated hardware clock that is used for precise time synchronization. This time controller performs decoding and encoding of the IRIG-B input and outputs and enables the SEL-3390T Ethernet ports to provide hardware time stamps to support

PTP. This enables the SEL-3390T to receive high-precision time and distribute it to devices connected to the BNC and internal IRIG-B outputs, as well as synchronize the computer system clock to high-precision time sources.

NOTE: The SEL Time Controller and all related features described in this section are not supported on VMware ESXi operating systems.

The SEL Time Controller is separate from the main computer system clock (referred to as the CMOS clock). System software is responsible for configuring the SEL Time Controller and synchronizing with the CMOS clock. This synchronization can happen in either direction; the SEL Time Controller can be the master when a precise source (IRIG-B or PTP) is available, or the CMOS clock can be the master when no precise source is available.

The block diagram in *Figure 6* provides a high-level picture of the data flow and synchronization between the clocks and different time sources in the system. Although *Figure 6* shows all time sources connected and active simultaneously. In a typical installation, only one source will be active. Regardless of how many time sources are active, you can only synchronize the hardware clock to one source at any given time. By default, the source selection of the SEL Time Controller is automatic, meaning it will select between sources, prioritizing IRIG-B first, then PTP, and lastly the System (CMOS) clock. You can set the source selection to a specific source (manually or via program/scripting) by using the SEL MI Time Class.

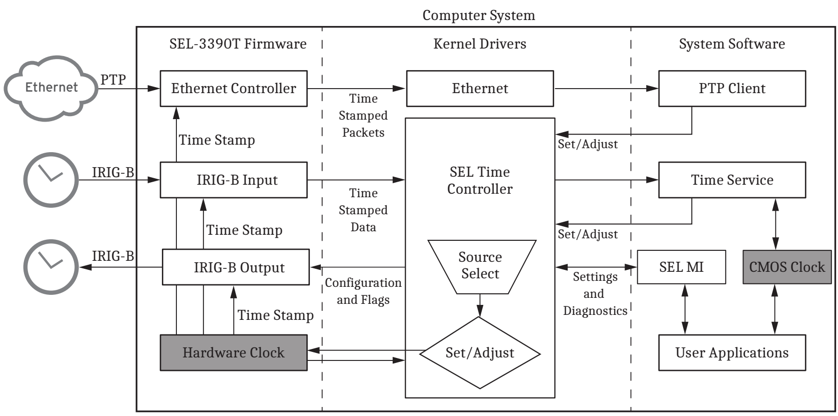

Figure 6 Time Synchronization Data Flow

In a typical configuration, the SEL Time Controller hardware clock is synchronized to a precise time source. The SEL-3390T IRIG-B outputs are generated from that same hardware clock, so they are synchronized to the source with very high precision (±100 ns typical, ±1000 ns maximum separation). The CMOS clock is then synchronized to the SEL Time Controller hardware clock by the system software. If no precise time source is available, the system software synchronizes the SEL Time Controller hardware clock to the CMOS clock and the IRIG-B outputs are then generated from the hardware clock.

The exact behavior and performance of the CMOS clock synchronization depends on the configuration of the SEL Time Controller and the system software. In a typical configuration, the two clocks can be synchronized with lower precision (<10 ms typical, <100 ms maximum separation), but this can be adversely affected by an extremely high CPU workload and/or misconfiguration.

The SEL Time Controller can directly synchronize its hardware clock to IRIG-B sources without the assistance of system software. However, synchronization to PTP sources does require the assistance of system software to align the hardware time stamp with the PTP packet data and adjust the SEL Time Controller hardware clock accordingly. For both IRIG-B and hardware-time-stamped PTP sources, the hardware clock can be synchronized with very high precision (±100 ns typical, ±1000 ns maximum separation).

Some operating systems may not have the system software required for hardware-time-stamped PTP time synchronization but may still support software PTP synchronization of the CMOS clock. In this situation, the system operates as if no precise time source is available, where the system software synchronizes the SEL Time Controller hardware clock to the CMOS clock with lower precision (<10 ms typical, <100 ms maximum separation), and the IRIG-B outputs are then generated from the hardware clock.

NOTE: If the host system enters a low-power state (Sleep or Hibernate state, for example), it will stop servicing the SEL Time devices, causing the HW clocks and IRIG-B outputs to desynchronize (even if an IRIG-B input is connected). Upon coming out of the low-power state, the HW clocks and IRIG-B outputs will re-synchronize.

Windows Configuration

NOTE: At this time, the SEL Time Controller does not support hardware-time-stamped PTP synchronization on Windows operating systems; the IRIG-B input is the only high-precision source available.

The default configuration enables the SEL Time Controller to automatically select the best available time source to synchronize its hardware clock, and the IRIG-B outputs are automatically enabled on system startup. The automatic source selection prioritizes high-precision sources and will fall back on the CMOS clock if none are available. The source selection can be changed from automatic to a specific source (manually or via program/scripting) by using the SEL MI Time Class. See *Time Class on page 28* for a complete list of diagnostics and settings available for the SEL Time Controller.

IRIG-B Time Zone and DST

The SEL Time Controllers hardware clock is always set to UTC time. If the input is IRIG-B004 format, the time zone and DST offset are included in the IRIG-B data, so the SEL Time Controller can calculate UTC time directly from the IRIG data. If the input is IRIG-B002 format and is in local time instead of UTC, the SEL Time Controller must obtain the time zone and DST offset from the Windows Date and Time settings.

The Time class in the SEL MI contains a property named TimeReferenceIsUtc, which specifies if incoming IRIG-B002 is in UTC or local time (see *SEL Management Interface on page 27* for details on the SEL MI). This setting is set to TRUE by default, which indicates the incoming IRIG-B002 is in UTC time, and no time zone or DST offset will be applied when synchronizing the hardware clock. If the incoming IRIG is local time, change the TimeReferenceIsUtc property to **FALSE**. The SEL Time Controller will use the Windows Time Zone and DST settings to calculate the local time offset and adjust the hardware clock to UTC time. The following commands can be run from a Windows Powershell prompt to configure the TimeReferenceIsUtc property:

Incoming IRIG-B002 is UTC:

```
Set-CimInstance -Query 'Select * from SEL_Time where DeviceID like
"Time 0"' -Property @{TimeReferenceIsUtc=$TRUE}
```

Incoming IRIG-B002 is local:

```
Set-CimInstance -Query 'Select * from SEL_Time where DeviceID like
"Time 0"' -Property @{TimeReferenceIsUtc=$FALSE}
```

You can check the TimeReferenceIsUtc property value and other SEL Time Controller settings and diagnostics by running the following command from a Windows Powershell prompt:

Get-CimInstance -ClassName SEL_Time

CMOS Clock Synchronization

The SEL Time Controller relies on the Windows Time service to synchronize the CMOS clock to the hardware clock. The SEL Time Controller registers with the Windows Time service as a time provider, and the Windows Time service synchronizes the CMOS clock by using its own settings and algorithms. This means the Windows Time service must be enabled and running to synchronize the CMOS clock to the SEL Time Controller. The Windows Time service will only source time from the SEL Time Controller if a precise source (IRIG-B) is connected, otherwise it will use other configured sources (NTP or PTP for example) or allow the CMOS clock to free-run. To verify the Windows Time service is being synchronized to the SEL Time Controller, open an administrator command prompt and run the following command:

w32tm /query /status

The response to the previous command should indicate the source is SEL3390TimeProvider if an IRIG-B source is connected.

Ethernet (PTP and NTP) Synchronization

Precision Time Protocol (PTP) and Network Time Protocol (NTP) are both handled directly by the Windows Time service. As of Windows 10 1809 and Server 2019, the Windows Time service supports PTP by using any Ethernet adapter (regardless of hardware time-stamp support); previous versions of Windows do not support PTP. At this time, the SEL Time Controller does not support hardware time-stamped PTP synchronization on Windows operating systems. When using the Windows Time service to synchronize to a PTP or NTP source, the SEL Time Controller operates as if no precise time source is available, where the SEL Time Controller hardware clock is synchronized to the CMOS clock with lower precision (<10 ms typical, <100 ms maximum separation) and the IRIG-B outputs are then generated from the hardware clock.

To configure the Windows NTP Client, follow these steps:

Step 1. Open Windows Settings and select **Time & Language**.

Step 2. On the left, select **Region**, then under Related settings, select **Additional date, time, & regional settings**.

Step 3. In the Clock and Region control panel, select **Date and Time**.

Step 4. In the Date and Time window, select the **Internet Time** tab, then select the **Change Settings** button.

Step 5. Check the box to synchronize with an internet time server, and type in the NTP server name or IP address.

Step 6. Select the **Update Now** button to test the connection to the NTP server.

To configure the Windows PTP Client, follow these steps to configure the Windows registry keys and values shown in *Table 3*:

Step 1. Select the Windows Start button, type **regedit**, then select **Registry Editor**.

Step 2. Navigate to the root key specified in *Table 3*. If the PTPClient key does not exist, right-click the **TimeProviders** key and select **New > Key** then type **PTPClient**.

Step 3. Set the registry values shown in *Table 3* by double-clicking the matching name and typing in the data specified. If the values do not exist, right-click in the white space in the right pane and select **New > [Type]**, where [Type] matches the type shown for that value in *Table 3*. Then type the value name for the new value, and set the value data.

Step 4. Once the values have been configured, restart the Windows Time service for the settings to take effect.

Table 3 Windows PTP Registry Configuration (Sheet 1 of 2)

Root Key	**HKLM\SYSTEM\CurrentControlSet\Services\W32Time\TimeProviders\PtpClient**	
Value Name	**Type**	**Data**
PtpMasters	REG_SZ (String Value)	[PTP server IP address]
Enabled	REG_DWORD	1
InputProvider	REG_DWORD	1

Table 3 Windows PTP Registry Configuration (Sheet 2 of 2)

Root Key	**HKLM\SYSTEM\CurrentControlSet\Services\W32Time\TimeProviders\PtpClient**	
Value Name	**Type**	**Data**
DllName	REG_SZ (String Value)	"c:\windows\system32\ptpprov.dll"
DelayPollInterval	REG_DWORD	0x3e80 (hexadecimal)
AnnounceInterval	REG_DWORD	0x0fa0 (hexadecimal)
EnableMulticastRx	REG_DWORD	0

The PtpMasters value can contain a comma-separated list of IP addresses for multiple PTP Masters. To use multicast (off by default), change the EnableMulticastRx value to 1.

To avoid conflicts, you may need to disable the NTP Client and VMIC Time Provider. To disable these, from the root key in *Table 3*, navigate to the TimeProviders key to find the NTPClient and VMICTimeProvider keys. For both keys, set their Enabled values to 0.

If the Windows Firewall is enabled, create new rules to allow the PTP client to communicate with the server by using the following steps:

Step 1. Select the **Windows Start** button, type **firewall**, then select **Windows Defender Firewall**.

Step 2. On the left, select **Advanced Settings**.

Step 3. On the left, right-click **Inbound Rules** and select **New Rule**.

Step 4. In the Rule Type wizard, select **Port** for the type of rule, then select **Next**.

Step 5. Select **UDP** and specify the ports **319** and **320**, then select **Next**.

Step 6. Select **Allow the connection**, then select **Next**.

Step 7. Select where you want the rule to apply, then select **Next**.

Step 8. Type a name for the rule, for example PTP Client Inbound, then select **Finish**.

Step 9. On the left, right-click **Outbound Rules** and select **New Rule**, then repeat *Step 4–Step 8* to create the outbound rule for the same UDP ports.

To verify the Windows Time service is being synchronized to the PTP server, open an administrator command prompt and run the following command:

w32tm /query /status

The response to the previous command should indicate the source is the IP address of the PTP server.

Linux Configuration

The SEL Time Controller is presented to Linux-based operating systems as a PTP device for easy integration. PTP devices are found in the /dev directory and are named /dev/ptp#, where # is a unique number for each device. To configure the SEL Time Controller of the SEL-3390T, determine which ptp# is the SEL-3390T card by examining the PTP devices listed in /sys/class/ptp through the use of the following command:

ls -l /sys/class/ptp/ptp*

Figure 7 provides an example of the output of this command when run on an SEL-3355 with SEL-3390S8 serial, SEL-3390E4 Ethernet, and SEL-3390T time adapter cards installed. The PTP devices that have seltime in the address are the SEL adapter cards, in this case ptp2–4.

```
[root@sel-3355-2 ~]# ls -l /sys/class/ptp/ptp*
lrwxrwxrwx. 1 root root 0 Feb 22 17:01 /sys/class/ptp/ptp0 -> ../../devices/pci0000:00/0000:00:01.0/0000:01:00.0/ptp/ptp0
lrwxrwxrwx. 1 root root 0 Feb 22 17:01 /sys/class/ptp/ptp1 -> ../../devices/pci0000:00/0000:00:1f.6/ptp/ptp1
lrwxrwxrwx. 1 root root 0 Feb 22 17:01 /sys/class/ptp/ptp2 -> ../../devices/pci0000:00/0000:00:01.1/0000:02:00.0/seltime.2.aut
o/ptp/ptp2
lrwxrwxrwx. 1 root root 0 Feb 22 17:01 /sys/class/ptp/ptp3 -> ../../devices/pci0000:00/0000:00:1c.4/0000:04:00.0/seltime.9.aut
o/ptp/ptp3
lrwxrwxrwx. 1 root root 0 Feb 22 17:01 /sys/class/ptp/ptp4 -> ../../devices/pci0000:00/0000:00:1d.0/0000:05:00.0/seltime.17.au
to/ptp/ptp4
```

Figure 7 Example Linux PTP Device List

To determine which seltime device is the SEL-3390T card, match the PCI address of the PTP device with one of the devices listed by the **lspci** command. In the **lspci** command output shown in *Figure 8* is a communication synchronizer, which is the device class of the SEL-3390T card, that has a PCI address 02:00.0. *Figure 7* shows that the PCI address 02:00.0 is seltime.2 and /dev/ptp2, which are therefore the designations for the SEL-3390T card.

```
[root@sel-3355-2 ~]# lspci
00:00.0 Host bridge: Intel Corporation Xeon E3-1200 v5/E3-1500 v5/6th Gen Core Processor Host Bridge/DRAM Registers (rev 07)
00:01.0 PCI bridge: Intel Corporation 6th-10th Gen Core Processor PCIe Controller (x16) (rev 07)
00:01.1 PCI bridge: Intel Corporation Xeon E3-1200 v5/E3-1500 v5/6th Gen Core Processor PCIe Controller (x8) (rev 07)
00:02.0 VGA compatible controller: Intel Corporation HD Graphics P530 (rev 06)
00:08.0 System peripheral: Intel Corporation Xeon E3-1200 v5/v6 / E3-1500 v5 / 6th/7th/8th Gen Core Processor Gaussian Mixture
 Model
00:14.0 USB controller: Intel Corporation 100 Series/C230 Series Chipset Family USB 3.0 xHCI Controller (rev 31)
00:14.2 Signal processing controller: Intel Corporation 100 Series/C230 Series Chipset Family Thermal Subsystem (rev 31)
00:16.0 Communication controller: Intel Corporation 100 Series/C230 Series Chipset Family MEI Controller #1 (rev 31)
00:16.3 Serial controller: Intel Corporation 100 Series/C230 Series Chipset Family KT Redirection (rev 31)
00:17.0 RAID bus controller: Intel Corporation SATA Controller [RAID mode] (rev 31)
00:1c.0 PCI bridge: Intel Corporation 100 Series/C230 Series Chipset Family PCI Express Root Port #1 (rev f1)
00:1c.4 PCI bridge: Intel Corporation 100 Series/C230 Series Chipset Family PCI Express Root Port #5 (rev f1)
00:1d.0 PCI bridge: Intel Corporation 100 Series/C230 Series Chipset Family PCI Express Root Port #9 (rev f1)
00:1d.1 PCI bridge: Intel Corporation 100 Series/C230 Series Chipset Family PCI Express Root Port #10 (rev f1)
00:1d.3 PCI bridge: Intel Corporation 100 Series/C230 Series Chipset Family PCI Express Root Port #12 (rev f1)
00:1f.0 ISA bridge: Intel Corporation CM236 Chipset LPC/eSPI Controller (rev 31)
00:1f.2 Memory controller: Intel Corporation 100 Series/C230 Series Chipset Family Power Management Controller (rev 31)
00:1f.3 Audio device: Intel Corporation 100 Series/C230 Series Chipset Family HD Audio Controller (rev 31)
00:1f.4 SMBus: Intel Corporation 100 Series/C230 Series Chipset Family SMBus (rev 31)
00:1f.6 Ethernet controller: Intel Corporation Ethernet Connection (2) I219-LM (rev 31)
01:00.0 Ethernet controller: Intel Corporation I210 Gigabit Network Connection (rev 03)
02:00.0 Communication synchronizer: Device 1aa9:0014 (rev 01)
04:00.0 Ethernet controller: Device 1aa9:0018 (rev 01)
05:00.0 Multiport serial controller: Device 1aa9:000d (rev 01)
07:00.0 PCI bridge: Texas Instruments XIO2001 PCI Express-to-PCI Bridge
[root@sel-3355-2 ~]#
```

Figure 8 Example Linux PCI Device List

If more than one SEL-3390T card is installed, connect an external IRIG source to one of the cards and use the SEL MI Time class diagnostics to determine which device has an IRIG signal on the external input (see *SEL Management Interface on page 27*).

Once you have determined the designations of the SEL-3390T card, use the SEL MI Time Class (see *SEL Management Interface on page 27*) to configure the source selection, IRIG-B DST and Time Zone, and other settings.

In installations where no external IRIG-B or PTP source is available, if the source_selection property in the SEL MI Time class is set to auto, set the auto_uses_system property to **1** to allow the SEL Time Controller to synchronize the hardware clock to the CMOS clock. In this configuration, ensure the CMOS clock is *not* being synchronized to the SEL Time Controller. Otherwise, a loop is created that causes the clocks to drift rapidly.

CMOS Clock Synchronization

NOTE: When the CMOS clock is being synchronized to the SEL Time Controller, ensure the auto_uses_system property in the SEL MI Time Class is set to **0** to prevent a loop that will cause the clocks to drift rapidly.

The SEL Time Controller requires a Linux time service to synchronize the CMOS clock to the hardware clock. The recommend time service is Chrony, which is available in all the supported releases of RHEL, RHEL derivatives, and Ubuntu. Follow these steps to configure Chrony to synchronize the CMOS clock to the SEL Time Controller:

Step 1. Install the Chrony package.

Step 2. Find the **chrony.conf** file. In most installations, it is located at /etc/chrony.conf.

Step 3. Edit the **chrony.conf** (require root privileges) with a text editor and add the following line to the end if the document:

```
refclock PHC /dev/ptp# trust
```

Where ptp# is the PTP device ID associated with the SEL-3390T card. The trust directive is optional. It instructs chrony to trust this source over all other sources that are not likewise marked trusted. It is useful if you have less accurate sources being used as backup and you do not want chrony averaging them into the system time (see *Time Class on page 33*).

Step 4. Save changes to **chrony.conf** and restart the Chrony service (requires root privileges).

On RHEL 7 or newer and Ubuntu:

systemctl restart chronyd

On RHEL 6:

service chronyd restart

In the earlier example, the SEL-3390T time device was /dev/ptp2, so add **refclock PHC /dev/ptp2** to the chrony.conf file. Other parameters can be added to control the polling interval, etc. See the Chrony man page for more details.

Ethernet (PTP) Synchronization

In Linux operating systems, you can synchronize the SEL Time Controller hardware clock to a PTP source by using the LinuxPTP package. This package includes multiple components; the primary component used for synchronizing the hardware clock is ptp4l. When using the ptp4l to synchronize with a PTP source, you can synchronize the SEL Time Controller hardware clock with the PTP source with very high precision (±100 ns typical, ±1000 ns maximum separation), and the IRIG-B outputs are then generated from the hardware clock, providing high precision PTP to IRIG-B conversion.

While ptp4l can be run in many different configurations, the examples provided in this section describe running ptp4l as an ordinary clock (a device that synchronizes with the PTP source and does not repeat or pass through the PTP data). In this mode, ptp4l synchronizes the SEL Time Controller hardware clock to the PTP source. To synchronize the CMOS clock to the SEL Time Controller, an additional application such as chrony is required (see *CMOS Clock Synchronization on page 21*).

Follow these steps to install the LinuxPTP package and configure ptp4l to synchronize the SEL Time Controller to a PTP source:

Step 1. Install the LinuxPTP package by using the command:

On Ubuntu:

sudo apt-get install linuxptp

On RHEL:

sudo dnf install linuxptp

Step 2. Find the ptp4l.conf configuration file:

On Ubuntu:

/etc/**linuxptp/ptp4l.conf**

On RHEL:

/etc/**ptp4l.conf**

Step 3. Edit **ptp4l.conf** with a text editor as described in *Setting Up ptp4l.conf on page 24*.

Step 4. Edit the service startup file if needed. In many versions of Ubuntu and Red Hat the Network interface used by ptp4l is hard coded at run time using the ‘-i’ command line option in the system startup file. In later versions of Ubuntu, the network interface was made dynamic by making it a Systemd template variable that can be specified when the service is enabled. Specifying the network interface on the command line like this overrides any network interface configuration in the ptp4l.conf file. If your distribution uses an interface different than the one you want to use or if you require a multi-interface configuration, then you will have to edit the service startup configuration. The following instructions assume that you are doing this on a distribution using Systemd as the services manager.

On Ubuntu:

The ptp4l service file will likely be in **/usr/lib/systemd/system/**, but this may change in future revisions. The file will likely be named either ptp4l.service or ptp4l@.service. The ptp4l.service version will have a hard coded interface. The ptp4l@.service version is a template that allows you to specify the interface when enabling the service (see *Step 5*). Depending on the setup desired, do one of the following:

a. Single network interface setup, non-template file.

Copy /usr/lib/systemd/system/ptp4l.service to /etc/systemd/system/

Edit /etc/systemd/system/ptp4l.service, change "-i eth0" to "-i <your NIC>" at the end of the line that starts with **ExecStart=**.

b. Single network interface setup, template file.

Specify network interface when enabling in *Step 5*.

c. Multi-interface setup. The following removes the interface setup from the service startup file, which assumes that you are specifying the interfaces in your ptp4l.conf file as described in *Setting Up ptp4l.conf on page 24*.

Copy /usr/lib/systemd/system/ptp4l.service (or ptp4l@.service) to /etc/systemd/system/. If copying ptp4l@.service rename the file to ptp4l.service.

Edit /etc/systemd/system/ptp4l.service, removing "-i eth0" (or "-i %I") from the end of the line that starts with **ExecStart=**.

On RHEL:

a. Single network interface setup.

Edit /etc/sysconfig/ptp4l/ptp4l, change "-i eth0" to "-i <your NIC>" at the end of the line that starts with **OPTIONS=**.

b. Multi-interface setup. The following removes the interface setup from the service startup file, which assumes that you are specifying the interfaces in your ptp4l.conf file as described in *Setting Up ptp4l.conf* on page 11.24.

Edit /etc/sysconfig/ptp4l/ptp4l, removing "-i eth0" from the end of the line that starts with **OPTIONS=**.

Step 5. Configure ptp4l to run automatically on startup by using the relevant command.

For non-template startup:

sudo systemctl enable ptp4l.service

For template startup:

sudo systemctl enable ptp4l@<your NIC>.service

For example:

sudo systemctl enable ptp4l@eth4.service

Step 6. Restart the ptp4l service by using the relevant command:

sudo systemctl daemon-reload ptp4l.service

For non-template restarts:

sudo systemctl restart ptp4l.service

For template restarts:

sudo systemctl restart ptp4l@<your NIC>.service

For example:

sudo systemctl restart ptp4l@eth4.service

Setting Up ptp4l.conf

Table 4 lists the settings that are typically used in the ptp4l.conf configuration file for PTP synchronization of the SEL Time Controller. If you need additional information, refer to the online documentation for ptp4l and any documentation for the PTP source (master clock) device.

Table 4 ptp4l Configuration File Common Settings

Name	Description	Options (Bold=defaults)
boundary_-clock_jbod	Allows ptp4l to run as a boundary clock (act as both a PTP client and server) that uses multiple network interfaces that are not synchronized to each other.	**0 (disabled)** 1 (enabled)
delay_mechanism	Selects the message propagation delay mechanism, which should be set to match the PTP source. Auto starts as E2E, then switches to P2P if available. Note for sources like the SEL-2488 serving c37.238 compatible PTP, set this to P2P.	Auto **E2E** P2P
network_transport	Selects type of network transport, which should be set to match the PTP source. UDPv4 is UDP over IPv4, UDPv6 is over IPv6, and L2 is IEEE 802.3 Layer 2 transport (not routable, local network only).	**UDPv4** UDPv6 L2
slaveOnly	Prevents ptp4l from running as a PTP master (source) clock.	**0 (disabled)** 1 (enabled)
time_stamping	Select the time stamping method to be used by ptp4l.	**hardware** software legacy
utc_offset	Sets the current offset between TAI and UTC, in seconds. This value is the total sum of all UTC leap seconds that occurred and must be updated for new leap seconds. This value must also match the utc_offset setting for the SEL Time Controller; see *Time Class on page 28*.	Any integer; **37** (as of March 2022)

The ptp4l.conf file contains a global section for settings that are to be applied to all network interfaces. This section is prefaced by the [global] section header. All settings immediately following the header, which are not included in an interface settings section, are considered global. A default set of global settings will be included with each ptp4l package.

Settings can be made specific to an individual interface by creating an interface settings section. Creating an interface settings section can also be a way of specifying the interfaces where ptp4l will receive time synchronization data. Interfaces specified on the command line (see *Step 4* of *Ethernet (PTP) Synchronization on page 21*), will be chosen as the time-synchronization data source over interfaces specified by creating an interface settings section in ptp4l.conf. Settings in an interface settings section will be applied to the interface overriding the same setting in the global section for the specified interface.

An interface settings section is started by creating a new interface section header. Do this by entering the interface name in square brackets (for example [eth4]) on a new, blank line. All settings immediately below this section header will be applied to the interface named in the section header. For single-interface setups it is easiest to specify the interface on the command line and omit it in the ptp4l.conf file. For multi-interface setups, remove the interface from the command line (see *Step 4* of *Ethernet (PTP) Synchronization on page 21*) and add the desired interfaces as described in the relevant examples below.

The following examples describe some common ptp4l configurations and the relevant ptp4l.conf file contents. Note that these examples show only the settings that commonly need to be changed from the list in *Table 4*. ptp4l has more settings than are shown in *Table 4*. For a description of these settings, see the ptp4l or ptp4l.conf manual (man) pages included with your Linux distribution.

➤ **Default Profile, Single Interface**: The network interface eth0 is configured for the default PTP profile (using UDP packets and the P2P delay mechanism):

```
[global]
delay_mechanism Auto
network_transport UDPv4
utc_offset 37

[eth0]
```

➤ **Default Profile, Multiple Interfaces on One Multi-Port Ethernet Device**: The interfaces eth0 and eth1 are both on a single SEL multi-port Ethernet device. The default ptp4l behavior with multiple interfaces is to act as a boundary clock (receive PTP one interface and serve PTP on the other), so the slaveOnly setting is used to receive PTP on both interfaces, allowing for automated failover. The boundary_clock_jbod setting is not used because both eth0 and eth1 are on the same device and therefore both use the same SEL Time Provider hardware clock.

```
[global]
delay_mechanism Auto
```

```
network_transport UDPv4
utc_offset 37
slaveOnly 1

[eth0]

[eth1]
```

- **Default Profile, Multiple Interfaces on Separate Ethernet Devices**: This example is identical to the previous one except the interfaces eth0 and eth5 are on two separate SEL multi-port Ethernet devices. The boundary_clock_jbod setting has been added because each SEL Ethernet device has its own SEL Time Provider hardware clock, which would normally cause ptp4l to generate an error.

```
[global]
delay_mechanism Auto
network_transport UDPv4
utc_offset 37
slaveOnly 1
boundary_clock_jbod 1

[eth0]

[eth5]
```

- **Power Profile on one interface, Default Profile on the other**: To set the interface eth0 to the default profile and the interface eth5 to the IEEE C37.238-2017 power profile, set the network_transport setting to **L2** under the [eth5] group. Note that the L2 transport is not routable, so this configuration requires the PTP source to be on the same local network as eth5.

```
[global]
delay_mechanism Auto
network_transport UDPv4
utc_offset 37
slaveOnly 1
boundary_clock_jbod 1


[eth0]

[eth5]
network_transport L2
```

To quickly test the ptp4l.conf file, follow these steps:

Step 1. Stop ptp4l using the command:

sudo systemctl stop ptp4l.service

Step 2. Run ptp4l from the command line, specifying the configuration file and using the -m flag to print output to the console:

sudo ptp4l -f /etc/ptp4l.conf -m

Step 3. Press **Ctrl+C** to stop ptp4l.

Step 4. Make any additional configuration file changes necessary, repeating *Step 2* and *Step 3* to test the changes.

Step 5. Once you are satisfied with the configuration file, start the ptp4l service using the command:

For non-template restarts:

sudo systemctl restart ptp4l.service

For template restarts:

sudo systemctl restart ptp4l@<your NIC>.service

For example:

sudo systemctl restart ptp4l@eth4.service

SEL Management Interface

The SEL MI provides a simple standardized method for custom applications and scripts to monitor and control the SEL-3390T hardware. On Microsoft Windows operating systems, the SEL MI is accessible through Windows WMI, while on Linux operating systems, the SEL MI is accessible through SysFS.

NOTE: The SEL MI is not supported on VMware ESXi operating systems.

Commonly used scripting languages, such as PowerShell or VBScript on Windows or Python on Linux, provide quick and simple methods to access WMI and SysFS, in addition to most compiled languages if that level of application complexity is required. While explaining how to write scripts and programs to access Windows WMI and Linux SysFS is outside the scope of this manual, some examples are given for Windows in *Examples on page 32* and Linux in *Examples on page 38*, and a wealth of knowledge and examples can be found on the internet.

The SEL MI groups the SEL-3390T components into classes. Each SEL MI class contains a set of properties that are either read-only (status information) or read/write (settings and controls). The organization of these classes and properties differs between the Windows and Linux versions of the SEL MI.

SEL MI Classes in Windows WMI

Each individual SEL-3390T card exposed through the SEL MI is accessed as an instance of a Windows WMI class. *Table 5* provides a list of properties that are present in most of the SEL MI classes in Windows WMI.

Table 5 Common Class Properties

Property Name	Read/Write Access	Description
Caption	read	A short textual description of the instance
Description	read	A detailed textual description of the instance
DeviceID	read	An address or other identifying information to uniquely name the instance
ErrorDescription	read	A string supplying information about any errors
SystemName	read	The computer system's name

Time Class

The Time class provides access to the SEL-3390T to monitor the status of IRIG-B inputs and the hardware clock synchronization, configure the synchronization source, and enable or disable the IRIG-B outputs. Status indicators for IRIG-B inputs are separated into External, Internal, and Decoded groups. The External and Internal groups provide a PulseCounter property to indicate the presence of an electrical signal on the input, and Good and ParityGood properties to indicate the signal is a valid IRIG-B data stream. The Decoded group provides additional status indicators decoded from the selected source. The TimeQuality and ContinuousTimeQuality properties indicate the accuracy of time synchronization as reported by the source. The Time class includes all common properties listed in *Table 5* and the additional properties listed in *Table 6*.

WMI NameSpace: **root\CIMV2**

WMI Class Name: **SEL_Time**

Table 6 Time Class Additional Properties (Sheet 1 of 3)

Property Name	Read/Write Access	Description
DecodedContinuous-TimeQuality	read	Continuous Time Quality indicator from the selected IRIG source's control flags, if present: Q = 0...7, inaccuracy < 10^(Q+1) nanoseconds (ns).
DecodedDST Active	read	Daylight Saving Time Active indicator from the selected IRIG source's control flags, if present: TRUE = DST active.
DecodedDST Pending	read	Daylight Saving Time Pending indicator from the selected IRIG source's control flags, if present: TRUE = DST pending.

Table 6 Time Class Additional Properties (Sheet 2 of 3)

Property Name	Read/Write Access	Description
Decoded-LeapSecondInsert	read	Leap Second direction indicator from the selected IRIG source's control flags, if present: TRUE = insert second, FALSE = delete second.
Decoded-LeapSecond-Pending	read	Leap Second Pending indicator from the selected IRIG source's control flags, if present: TRUE = leap second pending.
DecodedLocaltimeOffset	read	Local Time Zone Offset value from the selected IRIG source's control flags, if present, in hours and minutes ([–]HH:MM).
Decoded-TimeQuality	read	Time Quality indicator from the selected IRIG source's control flags, if present: Q = 0...15, deviation from UTC < 10^(Q–1) nanoseconds (ns).
External0-Continuous-TimeQuality	read	Continuous Time Quality indicator from the external IRIG input's control flags, if present: Q = 0...7, inaccuracy < 10^(Q+1) nanoseconds (ns).
External0-Good	read	Overall status indicator for the external IRIG input: TRUE = healthy.
External0ParityGood	read	Parity status indicator for the external IRIG input: TRUE = good parity.
External0-PulseCounter	read	Signal presence indicator for the external IRIG input: 32-bit counter that increments on each voltage pulse on the IRIG input.
External0-TimeQuality	read	Time Quality indicator from the external IRIG input's control flags, if present: Q = 0.15, deviation from UTC < 10^(Q–1) nanoseconds (ns).
Hardware-Time	read	The current time from the hardware clock, ISO-8601 format: YYYY-MM-DDTHH:MM:SSZ.
InternalContinuous-TimeQuality	read	Continuous Time Quality indicator from the internal IRIG input's control flags, if present: Q = 0...7, inaccuracy < 10^(Q+1) nanoseconds (ns).
InternalGood	read	Overall status indicator for the internal IRIG input: TRUE = healthy.
InternalParity-Good	read	Parity status indicator for the internal IRIG input: TRUE = good parity.
InternalPulse-Counter	read	Signal presence indicator for internal IRIG input: 32-bit counter that increments on each voltage pulse on the IRIG input.
Internal-TimeQuality	read	Time Quality indicator from internal IRIG input's control flags, if present: Q = 0.15, deviation from UTC < 10^(Q–1) nanoseconds (ns).
NumSecondsSince-LastJump	read	Elapsed time since the last time jump in seconds.
NumTime-Jumps	read	Count of times the hardware clock was adjusted by a significant time jump.

Table 6 Time Class Additional Properties (Sheet 3 of 3)

Property Name	Read/Write Access	Description
OutputEn-abled	read/write	The IRIG Output state, default is **TRUE**: TRUE = enabled.
Source	read	Indicates which source the hardware clock is presently synchroniz-ing to. See SourceSelection.
SourceSelec-tion	read/write	Configures the source that the hardware clock should synchronize to. The default is **AUTO**: AUTO = automatically select source based on priority EXTERNAL-0 = external IRIG-B input (AUTO priority 1) INTERNAL = internal IRIG-B input (AUTO priority 2) SYSTEM = system (CMOS) clock (AUTO priority 3) Check SupportedSourceSelection for valid source names at runtime.
Supported-SourceSelec-tion	read	Provides a comma-separated list of source names that are valid to use for SourceSelection, e.g., AUTO, EXTERNAL-0, INERNAL, SYSTEM.
SyncError	read	The current synchronization error between the hardware clock and source in nanoseconds (ns).
Termination	read/write	Configures the termination impedance for the external IRIG-B input, default is **FALSE**: TRUE = low impedance, FALSE = high impedance.
TimeReferen-ceIsUtc	read/write	If IRIG-B input is B002 (no extensions), this setting specifies if incoming IRIG-B is UTC or local time, default is **TRUE**: TRUE = UTC, FALSE = local.

SFP Module Diagnostics Class

The SFP Module Diagnostics class provides access to the diagnostic data from any of the SFP modules plugged into the Ethernet ports. Some properties are not supported on some SFP modules. The SFP Module Diagnostics class includes the Caption, Description, and DeviceID properties listed in *Table 5* and the additional properties listed in *Table 7*.

WMI Namespace: **root\WMI**

WMI Class Name: **SEL_SFPDiag**

Table 7 SFP Module Diagnostics Class Additional Properties (Sheet 1 of 2)

Property Name	Read/Write Access	Description
Active	read	Device operational status; this value will always be TRUE
InstanceName	read	Hardware ID from the operating system
RxPower	read	Receiver optical power in nanowatts (nW)

Table 7 SFP Module Diagnostics Class Additional Properties (Sheet 2 of 2)

Property Name	Read/Write Access	Description
SupplyVoltage	read	SFP module supply voltage in microvolts (µV)
Temperature	read	SFP module temperature in degrees Celsius (°C)
TxBiasCurrent	read	Transmit laser bias current in microamperes (µA)
TxPower	read	Transmit laser optical power in nanowatts (nW)

SFP Module Identification Class

The SFP Module Identification class provides access to the identification data from any SFP modules plugged into the Ethernet ports. Some properties are not supported on some SFP modules. The SFP Module Identification class includes the Caption, Description, and DeviceID properties listed in *Table 5* and the additional properties listed in *Table 8*.

WMI Namespace: **root\WMI**

WMI Class Name: **SEL_SFPId**

Table 8 SFP Module Identification Class Additional Properties (Sheet 1 of 2)

Property Name	Read/Write Access	Description
Active	read	Device operational status; this value will always be TRUE
DateCode	read	Manufacturer’s SFP module build date
InstanceName	read	Hardware ID from the operating system
Length50umOM2	read	Max length with 50 µ multimode OM2 fiber in meters (m)
Length50umOM3	read	Max length with 50 µ multimode OM3 fiber in meters (m)
Length62p5umOM1	read	Max length with 62.5 µ multimode OM1 fiber in meters (m)
LengthCopper	read	Max length with copper cable in meters (m)
LengthSingle-Mode	read	Max length with single-mode fiber in meters (m)
Manufacturer	read	Manufacturer’s name
Part Number	read	Manufacturer’s part number
SELPartNumber	read	SEL part number
SELSerialNumber	read	SEL serial number

Table 8 SFP Module Identification Class Additional Properties (Sheet 2 of 2)

Property Name	Read/Write Access	Description
SerialNumber	read	Manufacturer's serial number
Version	read	Manufacturer's version ID
Wavelength	read	Laser wavelength in nanometers (nm)

Examples

You can access windows WMI from most programming environments and scripting languages. The following examples can be run in Windows Powershell, by either typing the command into a Windows Powershell window or incorporating the commands into a Powershell script file. Note that you may have to run Powershell as an Administrator to access some classes or properties.

Display all property values for all instances of a class:

Get-CimInstance -NameSpace [namespace] -ClassName [class]

Example for Time class:

Get-CimInstance -NameSpace root\CIMV2 -ClassName SEL_Time

Display only specific property values for all instances of a class:

Get-CimInstance -NameSpace [namespace] -ClassName [class] | Select-Object -Property [property1], [property2], ...

Example for Time class Source and SyncError values:

Get-CimInstance -NameSpace root\CIMV2 -ClassName SEL_Time | Select-Object -Property DeviceID, Source, SyncError

Display all property values for a specific instance of a class:

Get-CimInstance -NameSpace [namespace] -Query "Select * from [class] where [Property] like '[value]'"

Example for Time class Time 0 instance all diagnostics:

Get-CimInstance -NameSpace root\CIMV2 -Query "Select * from SEL_Time where DeviceID like 'Time 0'"

Set a property value for a specific instance of a class:

Set-CimInstance -NameSpace [namespace] -Query "Select * from [class] where [Property] like '[value]'" -Property @{[Property1]=[value1];[Property2]=[value2]...}

Example for Time class Time 0 instance set SourceSelection to 'EXTERNAL-0':

Set-CimInstance -NameSpace root\CIMV2 -Query "Select * from SEL_Time where DeviceID like 'Time 0'" -Property @{SourceSelection='EXTERNAL-0'}

Example for Time class Time 0 instance set TimeReferenceIsUtc for local time:

Set-CimInstance -NameSpace root\CIMV2 -Query "Select * from SEL_Time where DeviceID like 'Time 0'" -Property @{TimeReferenceIsUtc=$FALSE}

SEL MI Classes in Linux SysFS

In the Linux SEL MI, each SEL-3390T card exposed through the SEL MI is accessed through Linux SysFS. Each SEL MI class consists of one or many SysFS files, allowing read and write access to status data and settings by using the same methods that are used to access plain text files. Details for each class and their associated properties are provided in the following sections.

Changes to SysFS file contents/settings will take effect immediately but are not persistent; all SysFS files will revert to default values on each startup. For settings to persist through a restart, a configuration script must be run on each startup. See *Examples on page 38* for assistance modifying SysFS files and configuring startup scripts.

Time Class

The Time class provides access to the SEL-3390T to monitor the status of IRIG-B inputs, the hardware clock synchronization, configure the synchronization source, configure time-zone offsets when necessary, and enable or disable the IRIG-B outputs.

Status indicators for IRIG-B inputs are separated into External, Internal, and Decoded groups. The External and Internal groups provide a _pulse_counter property to indicate the presence of an electrical signal on the input, and _good and _parity_good properties to indicate the signal is a valid IRIG-B data stream. The Decoded group provides additional status indicators decoded from the selected source. The _time_quality and _continuous_time_quality properties indicate the accuracy of time synchronization as reported by the source.

Settings for daylight-saving time (DST) and time zone offsets are provided for when this information cannot be decoded from the IRIG-B input, for example if the incoming signal is IRIG-B002 (no IEEE C37.118 extension data) or there is no IRIG-B input available. The DST settings are separated into input_dst_ and output_dst_ property groups, and time zone offset is configured through the _localtime properties.

The Time class for each SEL-3390 card is the directory at the path listed below, where seltime.# is in the PTP device description associated with each card (see *Linux Configuration on page 20*). Each property listed in *Table 9* is a plain text file in that directory that contains the property value.

Linux SysFS Path: **/sys/class/sel_time/seltime.#**

Table 9 Time Class Properties (Sheet 1 of 4)

Property Name	Read/Write Access	Description
auto_uses_system	read/write	Allow the auto source_selection to select the system (CMOS) clock as a source. Only change the default value if the system (CMOS) clock is not configured to receive time from the SEL Time Controller. The default is **0**: 1 = allow auto to use system (CMOS) source, 0 = do not allow auto to use system (CMOS) source.
decoded_continuous_time_quality	read	Continuous Time Quality indicator from the selected IRIG source's control flags, if present: Q = 0...7, inaccuracy < 10^(Q + 1) nanoseconds (ns).
decoded_dst_active	read	Daylight Saving Time Active indicator from the selected IRIG source's control flags, if present: 1 = DST active.
decoded_dst_pending	read	Daylight Saving Time Pending indicator from the selected IRIG source's control flags, if present: 1 = DST pending.
decoded_leap_second_insert	read	Leap Second Direction indicator from the selected IRIG source's control flags, if present: 1 = insert second, 0 = delete second.
decoded_leap_second_pending	read	Leap Second Pending indicator from the selected IRIG source's control flags, if present: 1 = leap second pending.
decoded_localtime_offset	read	Local Time Zone Offset value from the selected IRIG source's control flags, if present, in hours and minutes ([–]HH:MM).
decoded_time_quality	read	Time Quality indicator from the selected IRIG source's control flags, if present: Q = 0...15, deviation from UTC < 10^(Q – 1) nanoseconds (ns).
external0_continuous_time_quality	read	Continuous Time Quality indicator from the external IRIG input's control flags, if present: Q = 0...7, inaccuracy < 10^(Q + 1) nanoseconds (ns).
external0_good	read	Overall status indicator for the external IRIG input: 1 = healthy.
external0_parity_good	read	Parity status indicator for the external IRIG input: 1 = good parity.
external0_pulse_counter	read	Signal presence indicator for the external IRIG input: 32-bit counter that increments on each voltage pulse on the IRIG input.
external0_time_quality	read	Time Quality indicator from the external IRIG input's control flags, if present: Q = 0...15, deviation from UTC < 10^(Q – 1) nanoseconds (ns).
hardware_time	read	Current time from the hardware clock, ISO-8601 format: YYYY-MM-DDTHH:MM:SSZ.
input_dst_auto	read/write	When receiving IRIG-B002, enable the IRIG input to automatically adjust the incoming time for DST using the input_dst property values. The default is **0**: 0 = do not apply DST adjustment, 1 = apply DST adjustments.

Table 9 Time Class Properties (Sheet 2 of 4)

Property Name	Read/Write Access	Description
input_dst_offset	read/write	Offset to apply to the incoming time when DST is active, in minutes. The default is **0**: range is –120 to 120.
input_dst_start_dow	read/write	Day of the week when DST starts. The default is **sunday**: range is sunday–saturday.
input_dst_start_month	read/write	Month when DST starts. The default is **march**: range is january–december.
input_dst_start_time	read/write	Time of day when DST starts (HH:MM). The default is **02:00**: range is 00:00–23:59.
input_dst_start_week	read/write	Week of the month when DST starts. The default is **second**: range is first–fourth, last.
input_dst_stop_dow	read/write	Day of the week when DST stops. The default is **sunday**: range is sunday–saturday.
input_dst_stop_month	read/write	Month when DST stops. The default is **november**: range is january–december.
input_dst_stop_time	read/write	Time of day when DST stops (HH:MM). The default is **02:00**: range is 00:00–23:59.
input_dst_stop_week	read/write	Week of the month when DST stops. The default is **first**: range is first–fourth, last.
input_localtime_offset	read/write	When receiving IRIG-B002, configure the local time zone offset for the IRIG-B input, in hours and minutes ([–]HH:MM). The default is **00:00**: range is –12:00 to 14:00.
internal_continuous_time_quality	read	Continuous Time Quality indicator from the internal IRIG input's control flags, if present: Q = 0...7, inaccuracy < 10^(Q + 1) nanoseconds (ns).
internal_good	read	Overall status indicator for the internal IRIG input: 1 = healthy.
internal_parity_good	read	Parity status indicator for the internal IRIG input: 1 = good parity.
internal_pulse_counter	read	Signal presence indicator for internal IRIG input: 32-bit counter that increments on each voltage pulse on the IRIG input.
internal_time_quality	read	Time Quality indicator from internal IRIG input's control flags, if present: Q = 0...15, deviation from UTC < 10^(Q – 1) nanoseconds (ns).
num_seconds_since_last_jump	read	Elapsed time since the last time jump in seconds.
num_time_jumps	read	Count of times the hardware clock was adjusted by a significant time jump.

Table 9 Time Class Properties (Sheet 3 of 4)

Property Name	Read/Write Access	Description
output_dst_auto	read/write	When the time source is IRIG-B002 or the system (CMOS) clock, enable the IRIG output to automatically adjust the outgoing IRIG-B004 control flags for DST by using the output_dst property values. The default is **0**: 0 = do not adjust DST control flags, 1 = adjust DST control flags.
output_dst_offset	read/write	DST offset value in the outgoing IRIG-B004 control flags when DST is active, in minutes. The default is **0**: range is –120 to 120.
output_dst_start_dow	read/write	Day of the week when DST starts. The default is **sunday**: range is sunday–saturday.
output_dst_start_month	read/write	Month when DST starts. The default is **march**: range is january–december.
output_dst_start_time	read/write	Time of day when DST starts (HH:MM). The default is **02:00**: range is 00:00–23:59.
output_dst_start_week	read/write	Week of the month when DST starts. The default is **second**: range is first–fourth, last.
output_dst_stop_dow	read/write	Day of the week when DST stops. The default is **sunday**: range is sunday–saturday.
output_dst_stop_month	read/write	Month when DST stops. The default is **november**: range is january–december.
output_dst_stop_time	read/write	Time of day when DST stops (HH:MM). The default is **02:00**: range is 00:00–23:59.
output_dst_stop_week	read/write	Week of the month when DST stops. The default is **first**: range is first–fourth, last.
output_enabled	read/write	The IRIG output state, default is **1**: 1 = enabled, 0 = disabled.
output_localtime	read/write	Configures the IRIG output to adjust the outgoing time by the output_localtime_offset value. The default is **0**: 1 = apply localtime offset, 0 = do not apply localtime offset.
output_localtime_offset	read/write	Configures the local time zone offset for the IRIG-B output, in hours and minutes ([–]HH:MM). The default is **00:00**: range is –12:00 to 14:00.
source	read	Indicates which source the hardware clock is presently synchronizing to. See source_selection.
source_selection	read/write	Configures the source that the hardware clock should synchronize to, default is **auto**: auto = automatically select source based on priority External0 = external IRIG-B input (AUTO priority 1) internal = internal IRIG-B input (AUTO priority 2) ptp = precision time protocol (AUTO priority 3) system = system (CMOS) clock (AUTO priority 4)

Table 9 Time Class Properties (Sheet 4 of 4)

Property Name	Read/Write Access	Description
sync_error	read	The current synchronization error between the hardware clock and source in nanoseconds (ns).
termination	read/write	Configures the termination impedance for the external IRIG-B input, default is **0**: 1 = low impedance, 0 = high impedance.
utc_offset	read/write	If the time source is in TAI (for example a PTP source), set this property to the offset between TAI time and UTC time. This offset is the total cumulative sum of UTC leap seconds that have occurred. The default is **0**.

SFP Module Diagnostics Class

The SFP Module Diagnostics class provides access to the diagnostic data from any SFP modules plugged into the Ethernet ports. Some properties are not supported on some SFP modules. The SFP Module Diagnostics class is the file at the path listed below, and each property listed in *Table 7* is a name-value pair in the rows of text in that file.

Linux SysFS Path:

/sys/class/net/eth[n]/sel_port/SEL_SFPDiag

Table 10 SFP Module Diagnostics Class Properties

Property Name	Read/Write Access	Description
RxPower	read	Receiver optical power in nanowatts (nW)
SupplyVoltage	read	SFP module supply voltage in microvolts (µV)
Temperature	read	SFP module temperature in degrees Celsius (°C)
TxBiasCurrent	read	Transmit laser bias current in microamperes (µA)
TxPower	read	Transmit laser optical power in nanowatts (nW)

SFP Module Identification Class

The SFP Module Identification class provides access to the identification data from any SFP modules plugged into the Ethernet ports. Some properties are not supported on some SFP modules. The SFP Module Identification class is the file at the path listed below, and each property listed in *Table 8* is a name-value pair in the rows of text in that file.

Linux SysFS Path:

/sys/class/net/eth[n]/sel_port/SEL_SFPId

Table 11 SFP Module Identification Class Properties

Property Name	Read/Write Access	Description
DateCode	read	Manufacturer's SFP module build date
Length50umOM2	read	Max length with 50 µ multimode OM2 fiber in meters (m)
Length50umOM3	read	Max length with 50 µ multimode OM3 fiber in meters (m)
Length62p5umOM1	read	Max length with 62.5 µ multimode OM1 fiber in meters (m)
LengthCopper	read	Max length with copper cable in meters (m)
LengthSingleMode	read	Max length with single-mode fiber in meters (m)
Manufacturer	read	Manufacturer's name
Part Number	read	Manufacturer's part number
SELPartNumber	read	SEL part number
SELSerialNumber	read	SEL serial number
SerialNumber	read	Manufacturer's serial number
Version	read	Manufacturer's version ID
Wavelength	read	Laser wavelength in nanometers (nm)

Examples

To view the contents of a file in SysFS use the **cat** command. For example, the following command displays the time synchronizatoin source for the seltime.7 device:

```
cat /sys/class/sel_time/seltime.7/source
```

You can change settings by using the **echo** command to write the setting values in the file. Root privilege is required to write to these files. An example of changing the source_selection setting in the Time class for seltime.7 is as follows:

```
echo ptp > /sys/class/sel_time/seltime.7/source_selection
```

The methods available to set the SysFS file contents at start time depends on the device and application initialization services available. On systems with udev installed, you can create a custom rule file to configure the settings when the devices like the seltime.# are added. For example, on a RHEL or Ubuntu installation, creating a file with a .rules file name extension in the /etc/udev/rules.d/ directory that contains the following text sets seltime.7 Time class instance to use ptp for the source_selection:

```
ACTION=="add", KERNEL=="seltime.7", GOTO="seltime.7_setup"

ACTION=="change", KERNEL=="seltime.7", GOTO="seltime.7_setup"


GOTO="setltime.7_end"

LABEL="seltime.7_setup"
```

ATTR{source_selection}="ptp"

LABEL="seltime.7_end"

Note that the attribute names, for example ATTR{source_selection}, correspond to the class setting file names in *Table 9*.

An alternative to the udev method to set the SysFS file contents at start time is to create a Systemd or SysV init script. For example, you can create a bash script in /usr/local/sbin/ that writes the desired changes to each SysFS file, and then configure either Systemd or SysV run the script during startup.

Accessories

Fiber-Optic SFP Modules

The SEL-3390T accepts both SFP modules provided by SEL and third-party SFP modules (third-party SFP modules are not supported on VMware ESXi operating systems). SEL SFP modules are temperature tested and automatically configure the settings. Third-party SFP module settings must be manually configured and are not tested by SEL. Ensure that third-party SFP modules support the required temperature range of –40° to +85°C (–40° to +185°F). When you use fiber-optic connections, be sure to select SFP modules that are compatible with the Ethernet devices you are connecting to. Important considerations are the type, cable diameter, wavelength, and cable length. For example, using an SFP module that is too powerful (rated for a long cable length) can cause communication failures because of the receiver being over-driven.

Table 12 shows compatible SFP modules available from SEL. All listed modules use an LC connector (IEC 61754-20). Additional SFP modules may be available. Contact SEL for assistance with selecting the proper SFP modules for your application.

NOTE: Although Class 1 lasers and LEDs are considered to be eye safe, avoid staring into the transmitter or fiber-end infrared radiation. Lasers and LEDs do not require maintenance and are not user-serviceable. Return to the factory for repair or replacement.

⚠CAUTION

Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

Table 12 SEL-3390T SFP Modules

Part Number	Type	Cabling	Power
8109-01	100BASE-FX	Cable: 62.5/125 µm multimode Wavelength: 1310 nm Max. cable length: 2 km	Max. TX Power: –14 dBm Min. TX Power: –20 dBm RX Sensitivity: –31 dBm
8104-01	100BASE-LX10	Cable: 9/125 µm single-mode Wavelength: 1310 nm Max. cable length: 20 km	Max. TX Power: –8 dBm Min. TX Power: –14 dBm RX Sensitivity: –31 dBm
8104-02	100BASE-LX10	Cable: 9/125 µm single-mode Wavelength: 1310 nm Max. cable length: 50 km	Max. TX Power: 0 dBm Min. TX Power: –5 dBm RX Sensitivity: –34 dBm
8104-03	100BASE-ZX	Cable: 9/125 µm single-mode Wavelength: 1550 nm Max. cable length: 80 km	Max. TX Power: 0 dBm Min. TX Power: –5 dBm RX Sensitivity: –34 dBm
8104-04	100BASE-ZX	Cable: 9/125 µm single-mode Wavelength: 1550 nm Max. cable length: 120 km	Max. TX Power: 5 dBm Min. TX Power: 0 dBm RX Sensitivity: –34 dBm
8104-05	100BASE-ZX	Cable: 9/125 µm single-mode Wavelength: 1550 nm Max. cable length: 160 km	Max. TX Power: 5 dBm Min. TX Power: 2 dBm RX Sensitivity: –35 dBm
8131-01	1000BASE-SX	Cable: 62.5/125 µm multimode Wavelength: 850 nm Max. cable length: 300 m	Max. TX Power: –2.5 dBm Min. TX Power: –9 dBm RX Sensitivity: –18 dBm
8130-01	1000BASE-LX	Cable: 9/125 µm single-mode Wavelength: 1310 nm Max. cable length: 10 km	Max. TX Power: –3 dBm Min. TX Power: –9.5 dBm RX Sensitivity: –21 dBm
8130-02	1000BASE-LX	Cable: 9/125 µm single-mode Wavelength: 1310 nm Max. cable length: 20 km	Max. TX Power: –1 dBm Min. TX Power: –6 dBm RX Sensitivity: –22 dBm
8130-03	1000BASE-LX	Cable: 9/125 µm single-mode Wavelength: 1310 nm Max. cable length: 30 km	Max. TX Power: 0 dBm Min. TX Power: –5 dBm RX Sensitivity: –24 dBm
8130-04	1000BASE-LX	Cable: 9/125 µm single-mode Wavelength: 1310 nm Max. cable length: 40 km	Max. TX Power: 3 dBm Min. TX Power: –2 dBm RX Sensitivity: –24 dBm
8130-05	1000BASE-XD	Cable: 9/125 µm single-mode Wavelength: 1550 nm Max. cable length: 50 km	Max. TX Power: 0 dBm Min. TX Power: –5 dBm RX Sensitivity: –24 dBm
8130-06	1000BASE-ZX	Cable: 9/125 µm single-mode Wavelength: 1550 nm Max. cable length: 80 km	Max. TX Power: 5 dBm Min. TX Power: 0 dBm RX Sensitivity: –24 dBm

Cables

SEL offers a selection of cables to connect the SEL-3390T to other devices. *Table 13* shows available cable configurations. Additional configurations may be available. Contact SEL for assistance with selecting the proper cable for your application.

Table 13 SEL-3390T Cables

Part Number	Termination	Notes
SEL-CA605C	RJ45	Cat 5e Ethernet
SEL-CA605M	RJ45	Cat 5e Ethernet[a]
SEL-C808	LC	Multimode fiber
SEL-C809	LC	Single-mode fiber
SEL-C953	BNC	IRIG-B cable

[a] This cable is double-shielded (contains both foil and braid shields) with the shield connected to the shell at both ends of the cable, for improved immunity to electrical disturbances that can cause data loss.

Testing and Troubleshooting

Identify Port

The Identify Port feature allows you to verify the association of the logical Ethernet device to the physical Ethernet connector on the SEL-3390T. See *Ethernet Port Settings on page 10* for assistance with locating the **LED Test** setting in Windows and Linux.

Device Missing or Unknown

If the device driver does not match the device firmware, the driver may not load properly, causing the device to be marked as missing or unknown. The device driver and software installation package automatically installs the correct firmware into the supported devices during installation. If the hardware is changed or new hardware is installed after the driver package was installed, you may need to manually run the firmware update tool.

On Windows systems, run the firmware update tool at the following location:

C:\Program Files\SEL\Drivers\SEL-Device-Management\device_firmware_update.exe

On Linux systems, run the firmware update tool at the following location:

CentOS/Redhat:

/sbin/sel_device_firmware_update

Ubuntu:

/usr/sbin/sel_device_firmware_update

On VMware ESXi the firmware is automatically checked and updated if necessary on each bootup. When firmware is updated an event will be written to the ESXi system log indicating the update took place and that the system must be rebooted in order for the device(s) to function.

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

Note: 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 to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

UL Recognized to U.S. and Canadian safety standards (File E220228; NRAQ2, NRAQ8)

CE Mark

UKCA Mark

RoHS Compliant

System Requirements

Operating System

Microsoft Windows 10 (64-bit)
Microsoft Windows Server 2016/2019/2022
Red Hat Enterprise Linux* 6/7/8/9
Ubuntu Linux* 16.04/18.04/20.04/22.04 LTS
VMware ESXi** 7/8
OpenSUSE: 15
SUSE Enterprise Linux: 15

*Derivatives with same kernel versions also supported
**IRIG-B is not supported on VMware ESXi

Expansion Slot

PCI Express 1.1 x4 or higher expansion card slot accommodates a full-height, half-length expansion card.

Card Dimensions:	111 mm (4.37") height, 168 mm (6.60") length, backplate not included
Maximum Power Consumption:	5 W (400 mA @ 12 Vdc)

Storage

100 MB free drive space

Ethernet Ports

Connectors

Three Configurations:	2 RJ45 connectors 2 SFP sockets 1 RJ45 and 1 SFP

Network Speeds

10/100/1000 Mbps

Chipset

SEL Gigabit Ethernet controllers

Medium Detection

Auto MDI-X

Jumbo Frame MTU

9000 bytes (Linux and VMware ESXi only)

Time-Code Inputs and Outputs

BNC IRIG-B Input

Format:	IRIG-B002 or -B004 (demodulated)
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Nominal Input Impedance:	3.3 k Ω
Accuracy:	100 ns

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

BNC IRIG-B Output

Format:	IRIG-B004 (demodulated)
On (1) State:	$V_{oh} \geq 2.4$ V
Off (0) State:	$V_{ol} \leq 0.8$ V
Output Drive Capacity:	TTL 240 mA (>20 Ω)

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

Environmental

Operating Temperature Range

–40° to +75°C (–40° to +167°F)

Storage Temperature Range

–40° to +85°C (–40° to +185°F)

Relative Humidity

5% to 95% noncondensing

Maximum Altitude

5000 m

Atmospheric Pressure

80–110 kPa

Pollution Degree

2

Product Standards

Communications Equipment in Utility Substations:	IEC 61850-3:2013 IEEE 1613-2009 Severity Level: Class 1
Industrial Environment:	IEC 61000-6-2:2005 IEC 61000-6-4:2006
Electrical Equipment for Measurement, Control, and Laboratory Use:	IEC 61010-1:2010 UL 61010-1:2016, C22.2 No. 61010-1-12 IEC 61010-2-201:2013
Measuring Relays and Protection Equipment:	IEC 60255-26:2013 (Zone B) IEC 60255-27:2013
EMC Immunity for Industrial Environments:	IEC 61000-6-2:2005 + AC:2005
EMC Emissions for Industrial Environments:	IEC 61000-6-4:2006 + A1:2010
FDA Laser:	21 CFR Part 1040:2017 Subchapter J FDA Notice 42
Safety of Laser Products:	EN 60825-1:2014 EN 60825-2:2004 + A1:2007 + A2:2010

Type Tests

Note: All tests performed while installed in an SEL-3355 Automation Controller.

To ensure good EMI and EMC performance, type tests were performed using shielded Ethernet cables with the shell grounded at both ends of the cable. Double-shielded cables are recommended for best EMI and EMC performance.

Electromagnetic Compatibility Emissions

Conducted and Radiated Emissions (Class A):	CISPR 11:2009 + A1:2010 CISPR 22:2008 CISPR 32:2015 IEC 61000-6-4:2006 IEC 61850-3:2013 FCC 15.107:2014 FCC 15.109:2014 47 CFR Part 15.109 47 CFR Part 15.107 Canada ICES-001 / NMB-001

Electromagnetic Compatibility Immunity

Conducted RF:	IEC 61000-4-6:2013 Severity Level: 10 Vrms
Electrostatic Discharge:	IEC 61000-4-2:2008 IEEE C37.90.3-2001 Severity Level: 2, 4, 6, 8 kV contact discharge; 2, 4, 8, 15 kV air discharge
Fast Transient/Burst:	IEC 61000-4-4:2012 Severity Level: Class A 2 kV, 5 kHz on communications lines
Magnetic Field:	IEC 61000-4-8:2009 Severity Level: 1000 A/m for 3 s 100 A/m for 1 m
Radiated Radio Frequency:	IEC 61000-4-3:2006 + A1:2007 + A2:2010 Severity Level: 10 V/m IEEE C37.90.2-2004 Severity Level: 20 V/m
Slow Damped Oscillatory Waves:	IEC 61000-4-18:2006 + A1:2010 Severity Level: Communications ports 1.0 kV peak common mode

Surge Withstand Capability: IEEE C37.90.1-2012
Severity Level:
2.5 kV oscillatory
4 kV fast transient

Surge Immunity: IEC 61000-4-5:2005
0.5, 1, 2 kV
communications ports

Environmental

Change of Temperature: IEC 60068-2-14:2009
Severity Level:
5 cycles, 1°C per minute ramp
–40° to +75°C

Cold, Operational: IEC 60068-2-1:2007
Severity Level: 16 hours at –40°C

Cold, Storage: IEC 60068-2-1:2007
Severity Level: 16 hours at –40°C
IEC 60255-1:2009
IEC 61850-3:2013

Damp Heat, Cyclic: IEC 60068-2-30:2005
Severity Level:
12 + 12-hour cycle
+25° to +55°C, 6 cycles, >93% RH

Damp Heat, Steady: IEC 60068-2-78:2012
Severity Level:
+40°C, 240 hours, >93% RH

Dry Heat, Operational: IEC 60068-2-2:2007
Severity Level:
16 hours at +75°C

Dry Heat, Storage: IEC 60068-2-2:2007
Severity Level:
16 hours at +85°C

Free Fall: IEEE 1613-2009
Severity Level: 100 mm

Vibration: IEC 60255-21-1:1988
Severity Level:
Endurance Class 2
Response Class 2
IEC 60255-21-2:1988
Severity Level:
Shock Withstand, Bump Class 1
Shock Response, Class 2
IEC 60255-21-3:1993
Severity Level:
Quake Response, Class 2

Safety

Enclosure Protection: IEC 60529:1989 + A1:1999
Severity Level: IP30

Dielectric Strength: IEC 60255-27:2013
IEEE C37.90-2005
Severity Level:
2200 Vdc BNC IRIG-B IN
1500 Vac Ethernet ports
Type tested for one minute

Impulse: IEC 60255-27:2013
IEEE C37.90-2005
Severity Level:
2.5 kV BNC IRIG-B IN
1.5 kV Ethernet ports

Instruction Manual Versions

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table 14 lists the instruction manual versions and revision descriptions. The most recent instruction manual version is listed first.

Table 14 Instruction Manual Revision History (Sheet 1 of 2)

Date Code	Summary of Revisions
20241105	Ethernet Port Settings ➤ Updated *Linux Settings*. IRIG-B and Ethernet Time Synchronization ➤ Added note in *IRIG-B and Ethernet Time Synchronization.*
20240321	Specifications ➤ Updated *Operating System*.
20240227	IRIG-B Input/Output ➤ Added note regarding VMware ESXi. Ethernet Connections ➤ Updated *SFP Fiber-Optic Connections* and *Failover Mode* for VMware ESXi. Ethernet Port Settings ➤ Updated *Ethernet Port Settings* for VMware ESXi. IRIG-B and Ethernet Time Synchronization ➤ Added note regarding VMware ESXi. SEL Management Interface ➤ Added note regarding VMware ESXi. Accessories ➤ Updated *Fiber-Optic SFP Modules* for VMware ESXi. Testing and Troubleshooting ➤ Updated *Device Missing or Unknown* for VMware ESXi. Specifications ➤ Updated *System Requirements* and *Ethernet Ports* for VMware ESXi.
20231013	Specifications ➤ Updated *Operating Systems*.
20221221	Specifications ➤ Added UKCA Mark.
20220324	Installation and Maintenance ➤ Updated *Software Installation*.

Table 14 Instruction Manual Revision History (Sheet 2 of 2)

Date Code	Summary of Revisions
	Ethernet Connections ➤ Added *Precision Time Protocol (PTP)*. Ethernet Port Settings ➤ Updated *Ethernet Port Settings*. IRIG-B and Ethernet Time Synchronization ➤ Added *IRIG-B and Ethernet Time Synchronization*. SEL Management Interface ➤ Added *SEL Management Interface*. Testing and Trouble Shooting ➤ Updated *Testing and Trouble Shooting*. Specifications ➤ Updated *Specifications*.
20210709	➤ Initial version.

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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