SEL-3573 Station Phasor Data Concentrator (PDC)

Substation-Hardened, Real-Time Performance PDC With Archiving

The SEL-3573 Station Phasor Data Concentrator (PDC) is a rugged, high-performance, purpose-built synchrophasor processor that enables local archiving, data aggregation and routing, secure operation and user access, and user-defined calculations.

Major Features and Benefits

- **Exceptional Performance.** The SEL-3573 concentrates as many as 120 phasor measurement unit (PMU) inputs at rates as fast as 240 messages per second, exceeding the IEEE C37.118-2011 requirement of 60 messages per second.
- **Powerful Archiving.** The SEL-3573 includes a built-in archiving feature that can be used as part of a NERC PRC-002-2 disturbance recording system. Local archiving of data at each substation protects against loss of data, even in the event of a communications outage. The SEL-3573 offers archiving for both continuous and predefined trigger conditions, so it never misses capturing data necessary for post-disturbance analysis.
- **Proven SEL Reliability.** The SEL-3573 operates reliably in harsh environments, conforming to IEEE C37.90 and IEC 60255 Protective Relay Standards and IEEE 1613, Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations.
- **High Availability.** Allows configuration of redundant inputs and redundant outputs to increase the availability of streaming synchrophasor data to applications.
- **Intuitive Configuration and Commissioning.** The included PDC Assistant software provides the means to set up, configure, and manage PDC operation. The user interface saves you time by making it easy to add a PMU, configure an output stream, set up an archive, review logs, and see real-time operational status.
- **Secure.** Designed with Critical Infrastructure Protection (CIP) security requirements in mind, the SEL-3573 provides features that make it fit easily into CIP-compliant systems. Security features include SEL exe-GUARD® whitelist antivirus technology and mandatory access control, individual user- and role-based account authentication, LDAP for centralized device and user management, strong passwords, access logs, a firewall, and an audit functionality.
- **Redundant Power Supply.** Supports a redundant power configuration with two load-sharing, hot-swappable power supply modules, enabling you to power the SEL-3573 from two independent power sources for maximum availability and without inverters.

Functional Overview

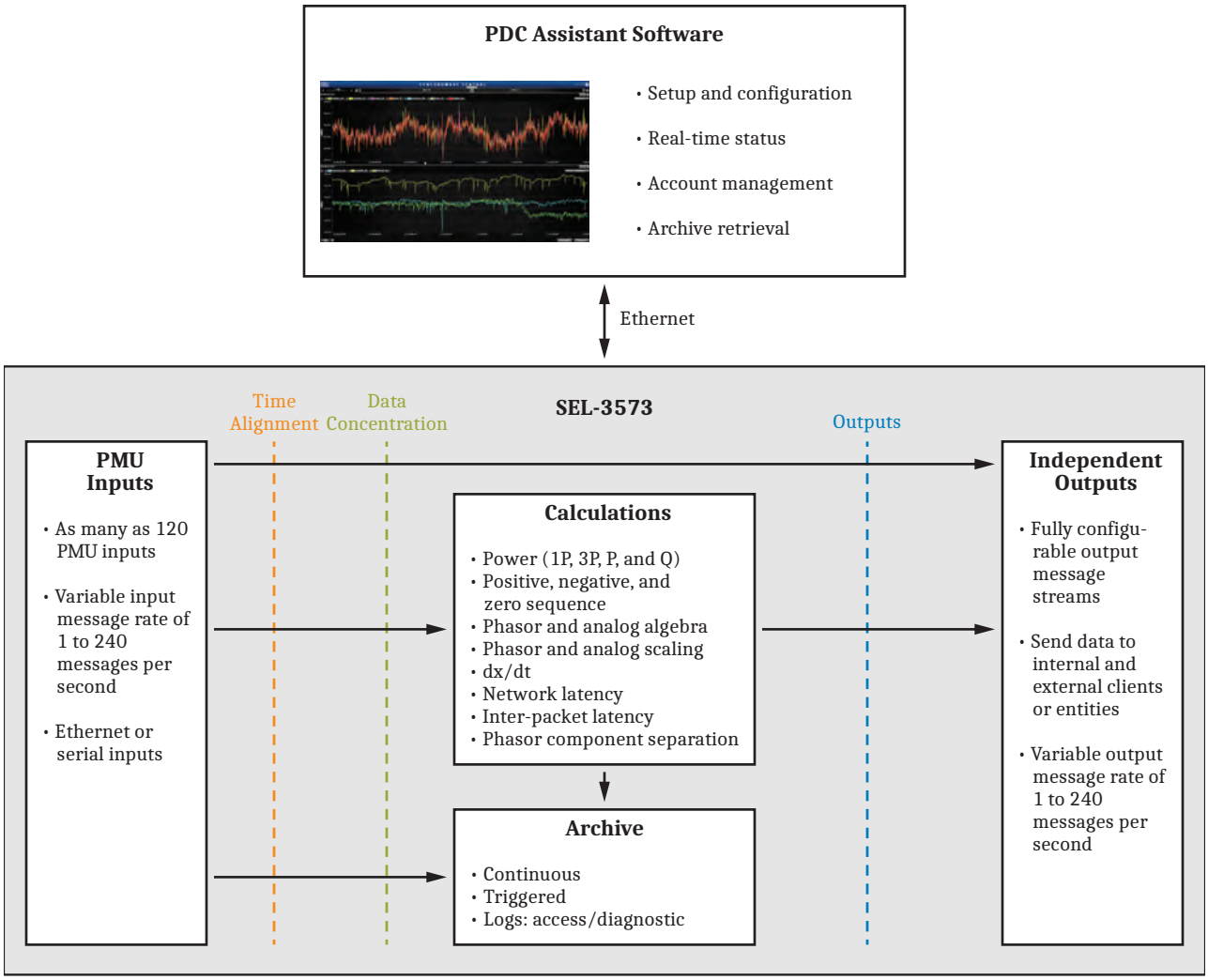


Figure 1 Functional Diagram

Phasor Data Concentration

The SEL-3573 allows you to time-align and concentrate IEEE C37.118-compliant phasor data from PMU or PDC inputs. You can select message rates independently from 1 to 240 messages per second for each input. The SEL-3573 supports data rates as fast as 240 messages per second with a reduced number of inputs and outputs.

Data Archiving

With the optional integrated archiving capability, you can archive all PMU data, or only the PMU information you specify, to the solid-state drive (SSD). Archiving can be continuous or include preset triggers; through the use of these triggers, you can set the PDC to capture pre- and post-disturbance data. Archives also store all calculations and logs.

Interconnections

A variety of serial and Ethernet input connections provide flexibility for connecting PMUs. The following table lists port types and the number available of each.

Port Type	Number
DB-9 serial	2
RJ45 EIA-232 serial	6[a]
10/100/1000 Mbps copper Ethernet rear panel	2

[a] Optional: Add as many as 18 additional ports, for a total of 24.

Alarm Contacts

To assist in the prompt resolution of problems, the rear-panel connections include an alarm contact that alerts service personnel to SEL-3573 internal failures or malfunctions. Alarm contacts also close when the PDC exceeds its disk space limit and when a user exceeds the allowed number of unsuccessful login attempts.

Calculations

You can perform different calculations on streaming phasor data, including the following:

- Single- and three-phase real and reactive power
- Positive-, negative-, and zero-sequence components
- Phasor and analog algebra
- Phasor and analog value scaling
- dx/dt
- Network latency
- Inter-packet latency
- Phasor component separation

Calculations are available for archiving and for sending in the real-time output super data packet.

Configuring Outputs

The SEL-3573 provides ten fully configurable output data streams. For example, you can send individual phase voltages and currents at a rate of 60 messages per second to your control centers, send positive-sequence voltage at a rate of 30 messages per second to the independent system operator, and send all data to the SEL-5078-2 SYNCHROWAVE® Central Software at a rate of 60 messages per second. You can choose the output content, where to send it, and at what message rate.

PDC Assistant Software

The PDC Assistant software allows you to set up and configure the PDC. This software runs on a Windows® PC and connects via an Ethernet connection to the SEL-3573. You can use the PDC Assistant locally or remotely from the control center, and you can use the software to view real-time PDC status and to export archived data.

You can configure the SEL-3573 with or without PMUs connected. This gives you the ability to configure your system offline in your office and then download the configuration information when you connect to the SEL-3573 in a substation.

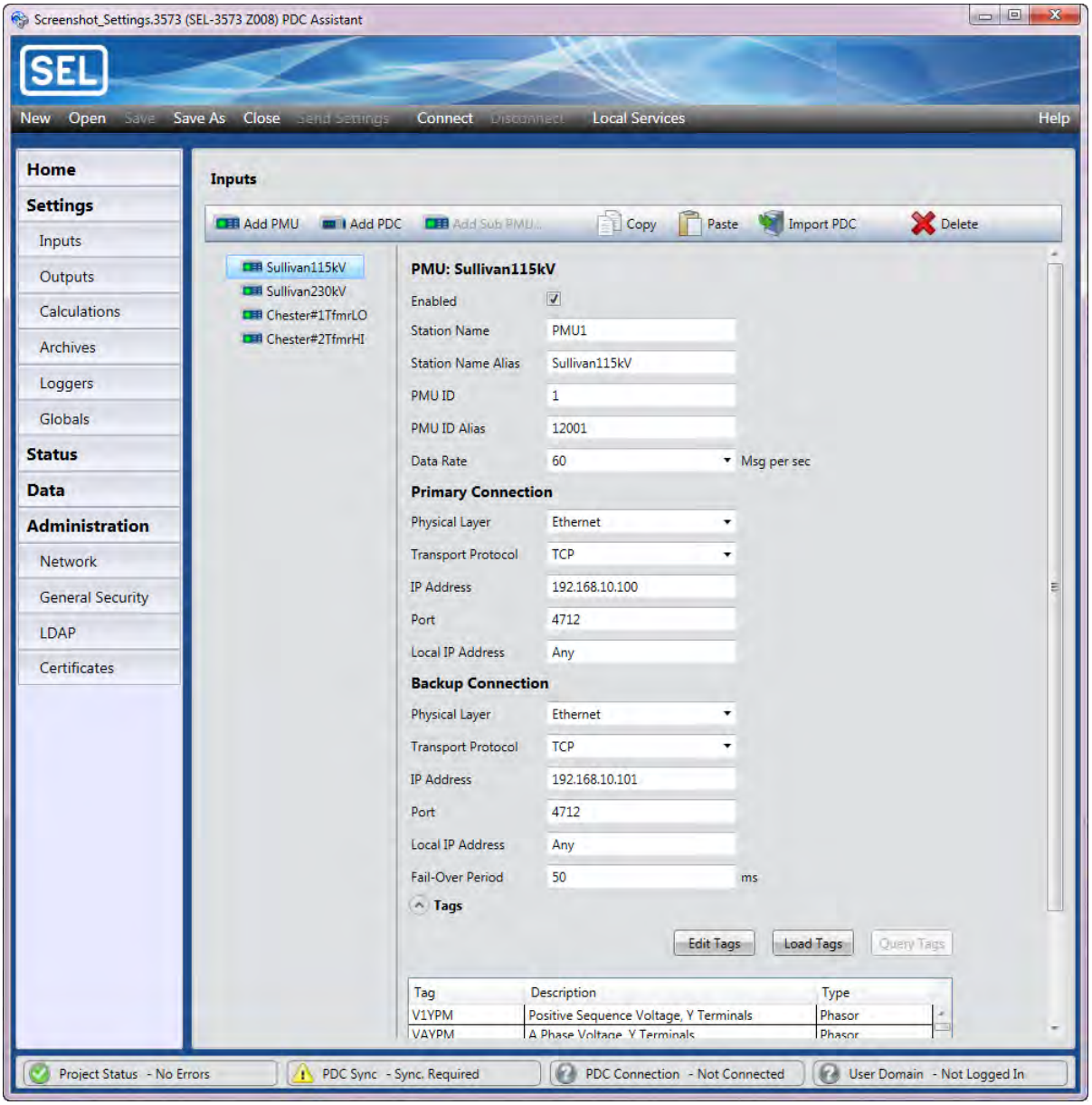


Figure 2 Inputs Configuration Screen

You can filter the phasor data that you send downstream by using independent and fully configurable outputs. For each stream, you can set the message rate, the selected information, and the location to which you want to send the data.

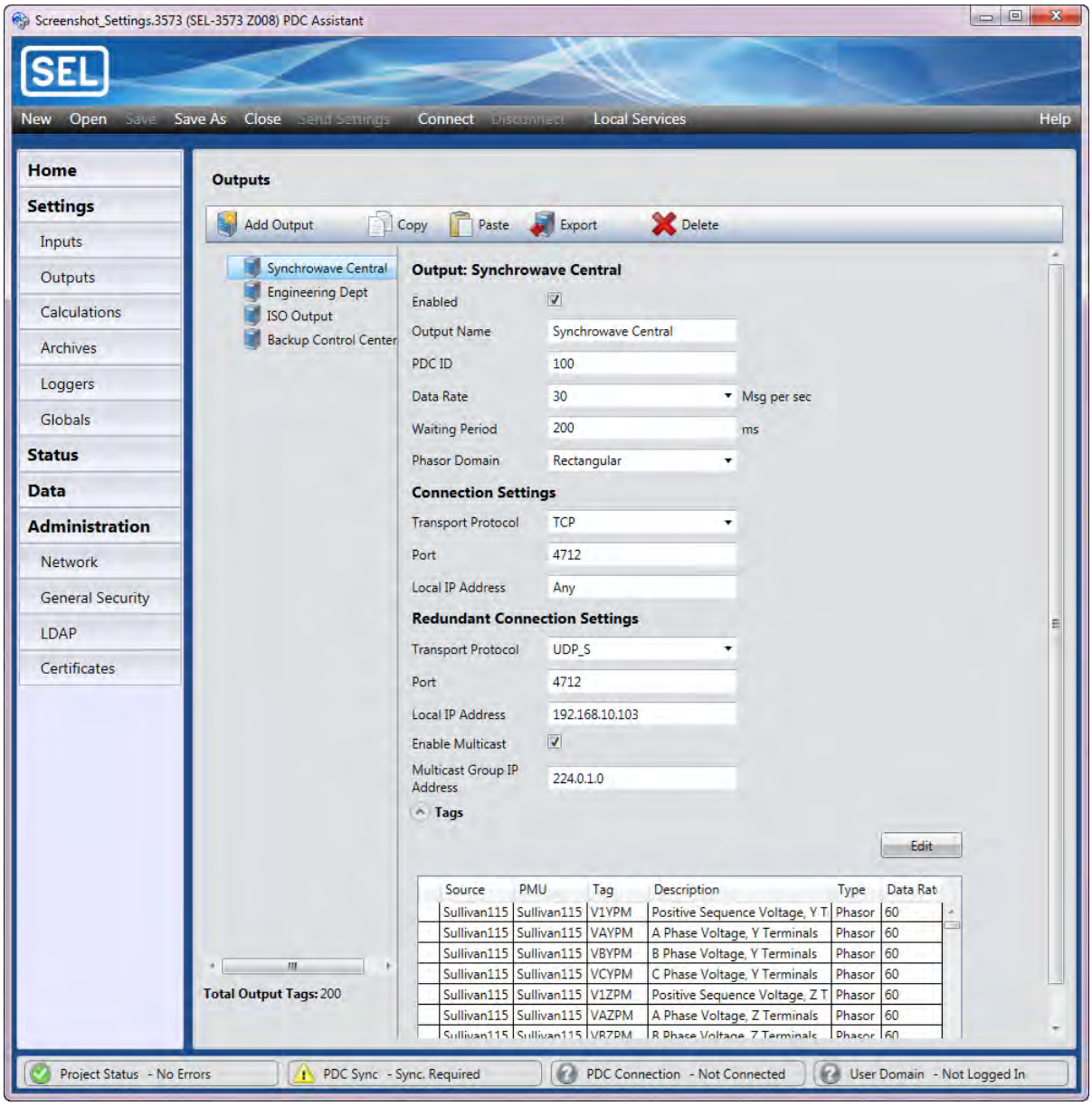


Figure 3 Outputs Configuration Screen

You can set up continuous and triggered archives as part of your disturbance monitoring system. You can use all triggers available in the PMUs to trigger archives in the SEL-3573.

Figure 4 Archives Configuration Screen

A real-time status display provides a comprehensive summary of the SEL-3573 operational status. The simple user interface allows you to check the status of inputs, outputs, and the archives: green indicates the device is operating as expected, red indicates a problem. Clicking the plus (+) button expands the row to provide additional details for the selected input or output. See *Figure 6* for an example of PMU input details and network latency information.

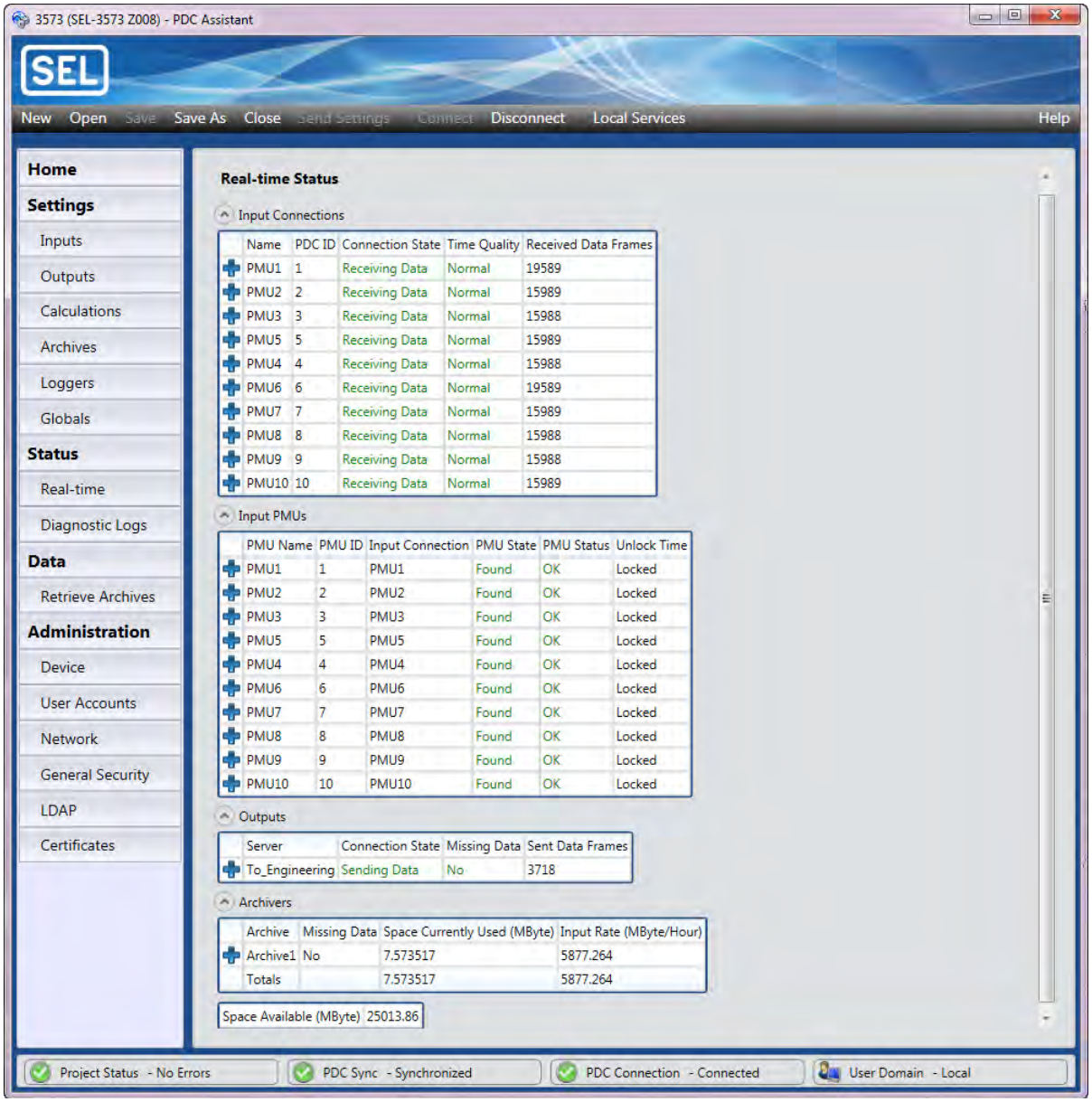


Figure 5 Real-Time Status Screen

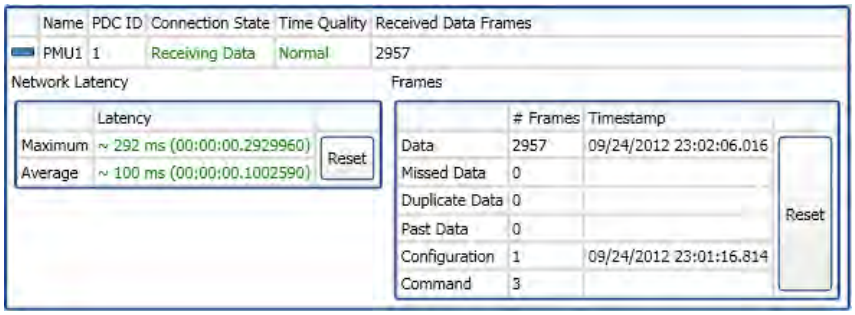


Figure 6 PMU Input Details and Network Latency Measurement

Applications

Wide-Area Situational Awareness

The SEL-3573 is a core component in a Wide-Area Situational Awareness (WASA) system. It gives operators the ability to concentrate PMU inputs at the substation and PDC inputs at the control centers, and the ability to forward utility-wide synchrophasor data to the independent system operator (ISO) or the regional coordinating council (RCC). By collecting information from all member utilities, the ISO or RCC can improve their situational awareness of the system by observing frequency and voltage angles throughout the entire network. This awareness allows them to identify weak points in the system and be able to detect warnings of possibly catastrophic system events. By understanding how system performance is affected when large amounts of load or generation are added to or removed from a system, engineers can develop more robust special protection or remedial action schemes to improve overall system reliability.

Wide-Area Disturbance Recording

You can quickly analyze system disturbances by using system-wide phasor data to simplify the gathering of system-wide, time-synchronized disturbance data from all PMU locations. Installing station PDCs at each substation and using the PDC data archiving feature protects against loss of data, even if there is a temporary communications outage to the substation during the event. The data is available locally on the SEL-3573. You can pull time-synchronized event data from all substations in a few hours instead of spending weeks or months trying to time-align event data from across the system. If the control center uses ACSELERATOR TEAM® SEL-5045 Software to automate event collection, your system can collect data from all substations when an event occurs. TEAM detects, gathers, and summarizes event details automatically. The result is that you can easily put together event reports in only a few minutes.

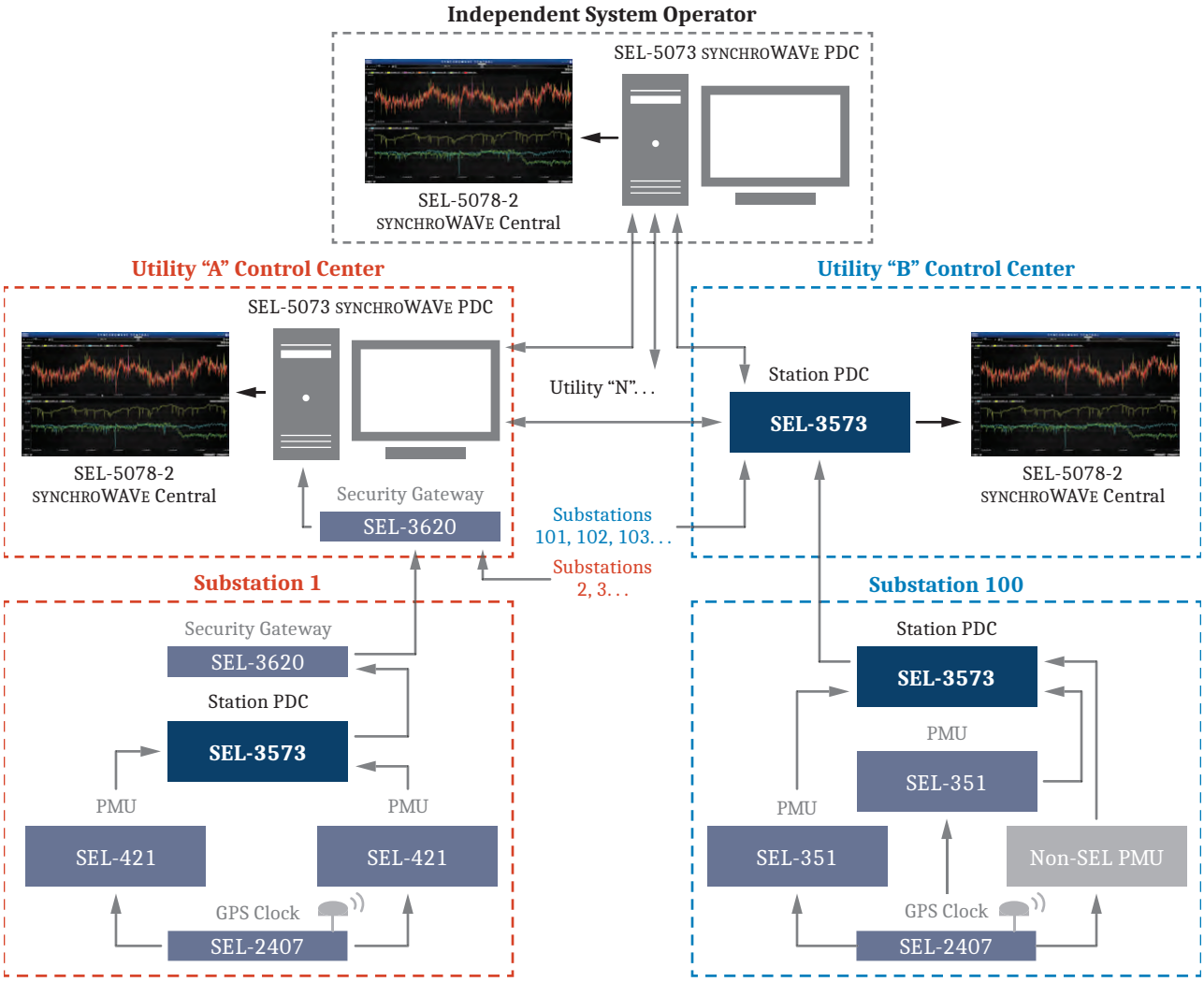


Figure 7 Typical Wide-Area Synchrophasor System Architecture Using SEL-3573 PDCs and SEL-5073 SYNCHROWAVE PDC Software

Disturbance Recording

The SEL-3573 can help you meet the PRC-002-2 Disturbance Recording specification. PRC-002-2 establishes the requirements for analyzing disturbances on the power system. This standard outlines recording and reporting standards for sequence of events (SOE) recording, fault recording, and dynamic disturbance recording (DDR) data. You can use the SEL-3573 in conjunction with SEL relays and TEAM to capture the data to meet these requirements.

Improve System Models

You can use synchrophasor data to improve your system models and understanding of system performance. With time-synchronized voltage and current quantities that include magnitude and angle measurements across the system, you can accurately determine the impedance or admittance of your system under any load condition. Accurate system models allow you to use your system capacity to its optimum extent and to know system limitations.

Identify Issues in Substations

You can easily identify voltage and current phasing issues in new substations or after significant modifications or repairs. By using the PMU functionality in the relays and by comparing angle measurements for each phase of a line at the substation with an adjacent substation, you can readily identify rolled or transposed phases. Additionally, you can identify CT or PT issues by comparing the current and voltage values across phases and at various points on the bus.

Improve State Estimation

Current state estimators use nonlinear, iterative algorithms to calculate system phase angles. Typical update rates for these systems are once every few seconds because of the complex nature of these calculations. Synchrophasors, on the other hand, provide direct angle measurement, which significantly improves the state-estimation process. PMUs measure the actual angles, and PDCs concentrate and send these measurements to the state estimator; the result is that state estimation is a linear calculation and can provide updates of system operating conditions in near real-time. This synchrophasor-based state-estimation system provides operators with time-varying, real-time system state information, even during disturbance events when this information is critical to understanding system operating conditions.

High-Availability System Architecture

The SEL-3573 supports improved availability of synchrophasor data by providing redundant data stream inputs and outputs. The PDC chooses the data stream with the highest quality data based on status bits included in the C37.118 message. When one of the data streams encounters an error or failure, the PDC switches to using the other data stream with no loss of data at the output of the PDC or in the archive. With this configuration, a component can be taken out of the system for service with no interruption of data to the end application.

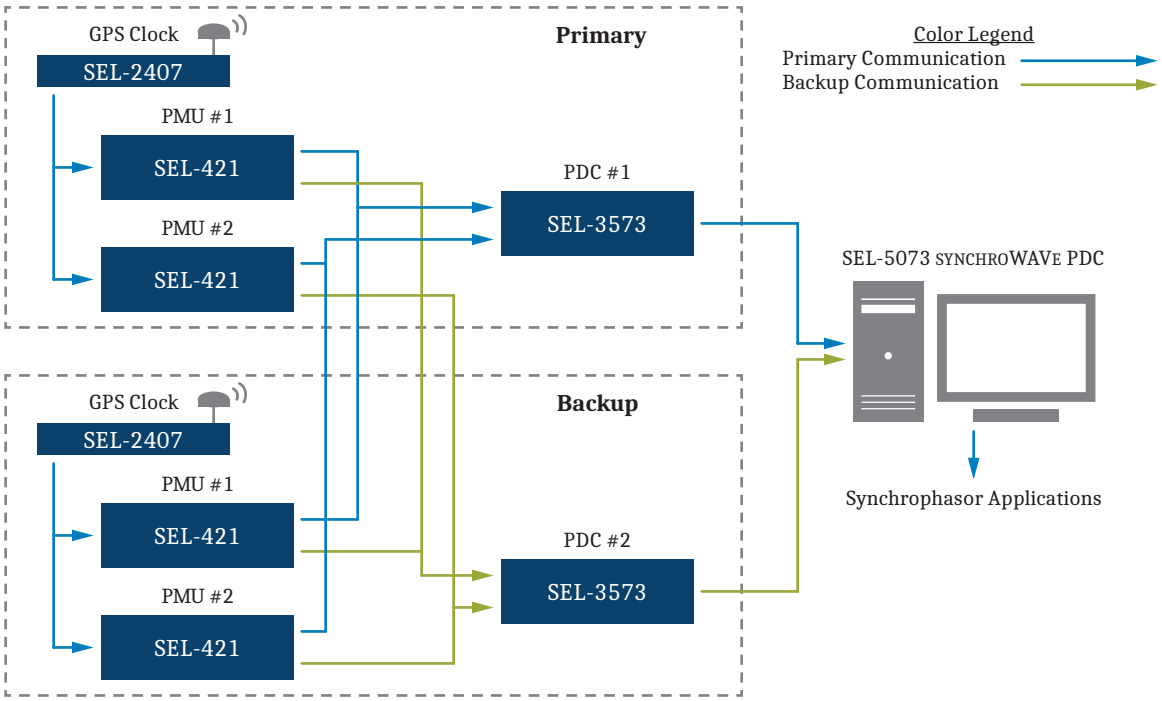


Figure 8 High Availability or Redundant System Architecture

Integrating Distributed Generation (DG)

One of the challenges facing utilities today is finding a reliable approach for integrating distributed generation (DG) into the system. Synchrophasors are ideally suited for improving anti-islanding detection. One approach is to measure the change in phase angle with respect to time (i.e., the slip frequency) and the change in slip frequency with respect to time (i.e., acceleration) between the point of common coupling and the DG system. You can determine islanding conditions with an algorithm that uses these inputs and has defined regions of island operation staying connected to, or disconnecting from, the bulk power system. You can easily measure the angle information, regardless of load-generation match, system disturbance, or system configuration. Additionally, if the island is stable, you can decide whether to let it operate and not shut it down. As more renewable energy sources connect to the power grid, synchrophasors provide a reliable, robust, and smart approach to integrating and using DG.

Figure 9 illustrates a smart anti-islanding scheme for photovoltaic (PV) distributed generation that uses both local- and wide-area phasor data and the SEL-3555 Real-Time Automation Controller.

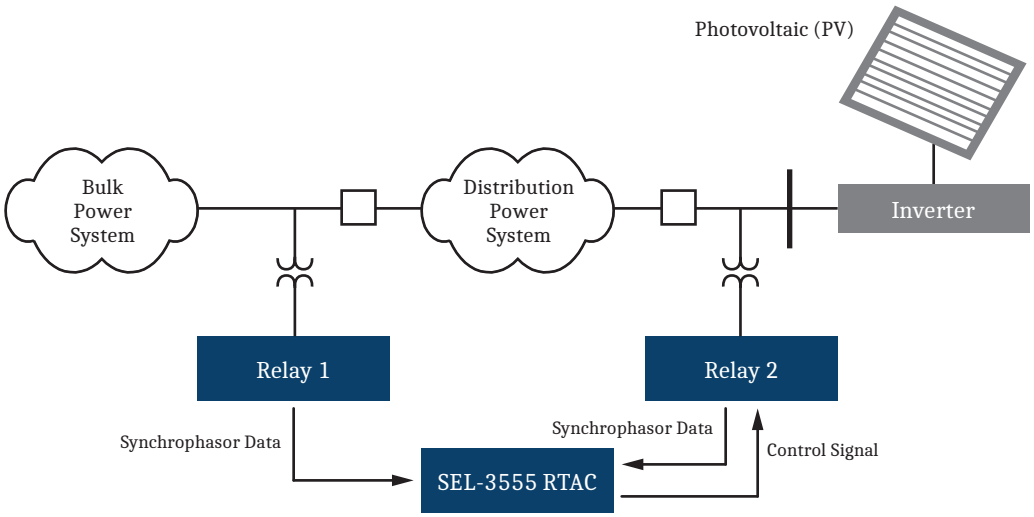
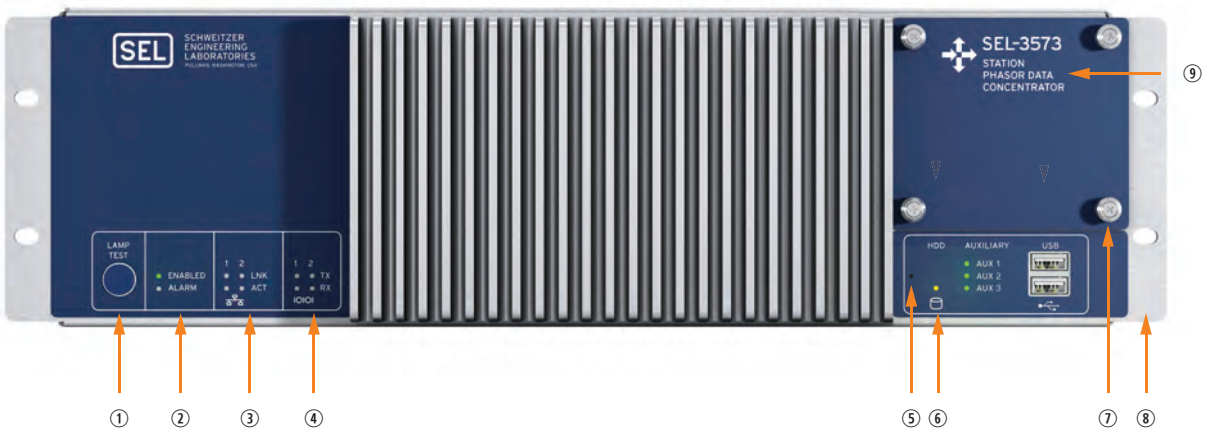


Figure 9 Example Anti-Islanding Scheme that Uses the SEL-3555 RTAC

Front- and Rear-Panel Diagrams



① **LAMP TEST** Button. Press and hold to test the front-panel LEDs.

② **ENABLED** and **ALARM** LEDs. The **ENABLED** LED indicates operational status. Green indicates normal operation, and red indicates that the system is stopped, booting, or that an alarm condition has occurred. The **ALARM** LED indicates that a non-optimal system condition exists. The **ALARM** LED illuminates red whenever the alarm contact operates.

③ **LNK** and **ACT** LEDs. Indicate link status and network activity for each Ethernet port.

④ **TX** and **RX** LEDs. The Transmit (**TX**) and Receive (**RX**) LEDs indicate activity on serial ports.

⑤ Pinhole Button. Provides reset and power functions; requires a pin to prevent accidental use.

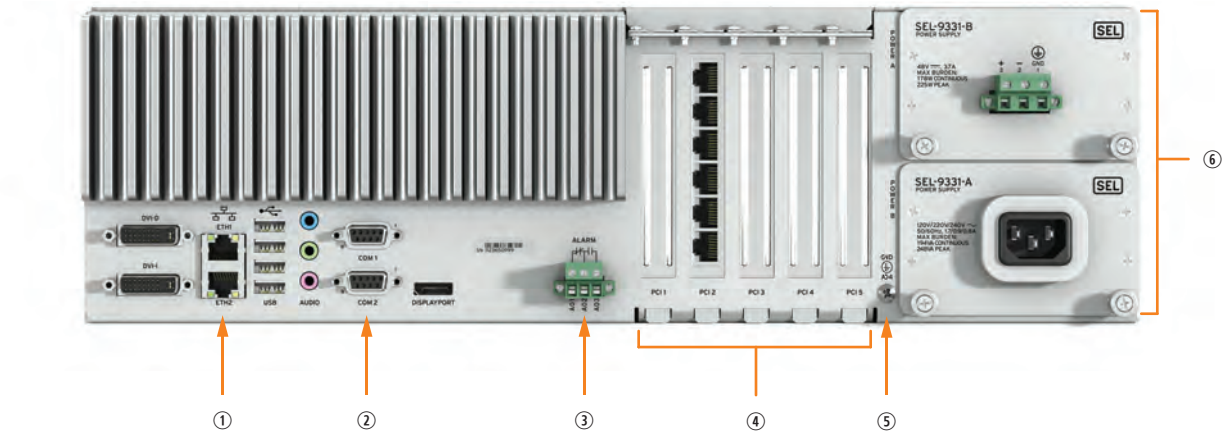
⑥ **HDD** LED. Indicates SATA drive activity.

⑦ Removable Drive Bay Panel. Allows access to the solid-state drive (SSD) and control (DIP) switches.

⑧ Device Enclosure. The rugged enclosure withstands EMI, RFI, shock, and vibration.

⑨ Device Label. The high contrast, white-on-blue lettering is highly legible even in dark areas.

Figure 10 SEL-3573 Front Panel



① Ethernet Ports. Two high-speed Gigabit Ethernet ports.

② EIA-232 Ports. BIOS configurable for +5 Vdc port power.

③ Alarm Contact Output. Wire with a Form C alarm contact output either normally closed or normally open. The **ALARM** LED on the front panel indicates the alarm contact state.

④ Expansion Card Slots. SEL rugged PCI Express expansion cards provide additional serial and IRIG-B inputs[a]. One six-port serial expansion card is included standard.

⑤ Chassis Ground Connection.

⑥ Power Supplies. Single or dual power supply options available. Connect power supplies to independent sources for higher availability. Load-sharing, hot-swappable supplies provide maximum uptime and serviceability.

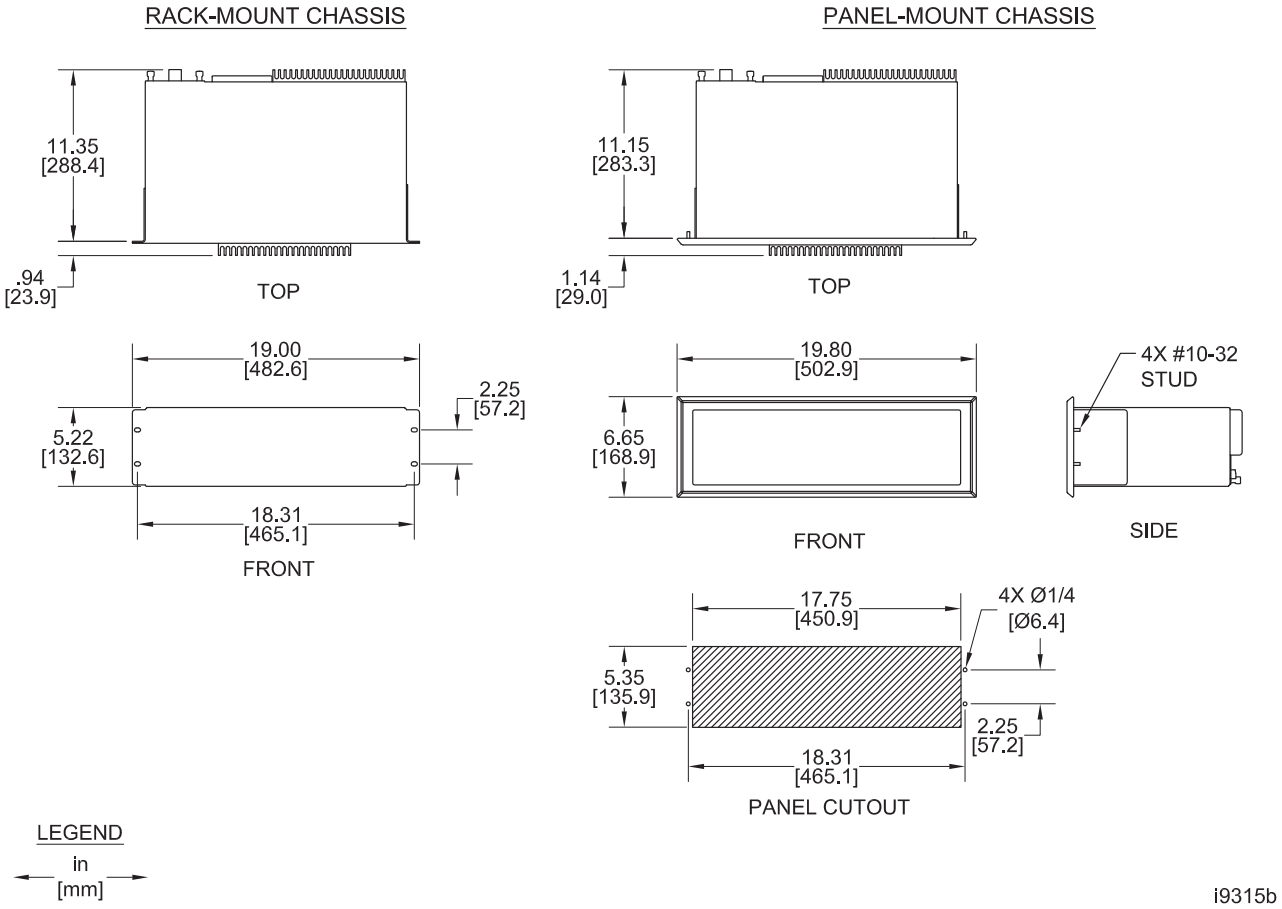
[a] IRIG-B input only available through PCI expansion cards.

Figure 11 SEL-3573 Rear Panel

Ordering Options

SEL-3573 Product Option	Standard	Option
Primary power supply	SEL-9331 With Euro Style Terminal Block	SEL-9331 With IEC 60320 C14 Coupler
Secondary power supply	None	SEL-9331 With Euro Style Terminal Block SEL-9331 With IEC 60320 C14 Coupler
Environmental protection	No conformal coating	Conformal coating
PCI Expansion Slot 1	None	NA
PCI Expansion Slot 2	SEL-3390S8 Serial Expansion Card	NA
PCI Expansion Slot 3	None	SEL-3390S8
PCI Expansion Slot 4	None	SEL-3390S8
PCI Expansion Slot 5	None	SEL-3390S8
Solid-state drive (SSD) storage	30 GB Industrial Grade SLC SSD	60 GB Industrial Grade SLC SSD 120 GB Industrial Grade SLC SSD 250 GB Industrial Grade SLC SSD
Mounting	Horizontal rack mount	Panel mount

Dimensions



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 E231500; NWGQ2, NWGQ8)

CE Mark

General

Operating System

SEL Linux® Krakatoa

CPU

Intel Core i7-3612QE Quad-Core

Speed:	2.1 GHz base, 3.1 GHz turbo
Cache:	4 x 256 KB L2, 6 MB L3

RAM

8 GB DDR3 ECC PC3-10600 (1333 MHz)

Chipset

Intel QM77 Express Chipset

Mass Storage

Internal Drive Bay:	One 2.5" SSD SATA II 3.0 Gb/s

Ethernet

Two Rear-Panel 1 Gbps Copper RJ45 Ports

ETH1:	Intel 82579LM, 10/100/1000 Mbps RJ45 copper
ETH2:	Intel 82574L, 10/100/1000 Mbps RJ45 copper

Serial Ports

Standard Ports:	2 EIA-232 ports, DB-9 connectors, 300 to 115,200 bps Included SEL-3390S8 PCIe expansion card provides six additional EIA-232 ports, RJ45 connectors, 9600 to 115,200 bps
Optional SEL-3390S8 PCIe x1 Expansion Cards:	As many as 18 additional EIA-232 ports, RJ45 connectors, 9600 to 115,200 bps

Note: On-board and SEL-3390S8 serial ports meet EIA/TIA-562 specifications.

Time-Code Input/Output

Available With SEL-3390S8 Expansion Card

Connector:	RJ45
Time-Code:	Compatible with demodulated IRIG-B TTL

Note: Output generated from either IRIG-B input or SEL-3573 clock.

Real-Time Clock/Calendar

Battery Type:	IEC No. BR2335 Lithium
Battery Life:	10 years with power 2 years without power

Power Supply

125–250 Vdc or 120–240 Vac

Rated Voltage:	125–250 Vdc, 120–240 Vac
Operational Voltage Range:	100–300 Vdc, 85–264 Vac
Rated Frequency:	50/60 Hz
Operational Frequency Range:	45–65 Hz
Typical Burden:	50 W
Max. Burden:	300 W, 310 VA
DC Ripple:	<15% rated voltage
Peak Inrush:	20 A
Insulation:	3100 Vdc

Recommended External Overcurrent Protection

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

Power Consumption (in Watts)

Component	Min.	Typical	Max.
Base System (Quad-Core CPU, 1 PSU, 8 GB RAM, 30 GB SSD, and 1 SEL-3390S8 Serial Card)	31	45	70
Additional Consumption From Optional Components			
2nd Power Supply	+10	+10	+13
SEL-3390S8 Serial Card	+4	+5	+7
Chipset Heater Consumption			
Cold startup (<5°C [41°F])	NA	NA	+90
Continuous operation (0°C [32°F])	0	+5	+10
Continuous operation (–40°C [–40°F])	0	+20	+40

Fuse Ratings

HV Power Supply Fuse:	5 A, 250 Vdc/277 Vac Time-lag T 277 Vac/1500 A break rating
Heater Fuses F2, F3:	5 A, 125 V slow blow 125 Vdc/50 A break rating

Note: Fuses are not user-serviceable.

Alarm Output Contact

Per IEC 60255-0-20:1974, using the simplified method of assessment.

Output Type:	Relay, Form C, break-before-make
Power Supply Burden:	<1 W maximum
Mechanical Life:	2,000,000 operations
Operational Voltage:	250 Vac/Vdc
Make:	30 A at 250 Vdc
Carry:	6 A continuous at 70°C
1 s Rating:	50 A
MOV Protection:	270 Vac/360 Vdc, 75 J
Insulation Voltage:	300 Vac/Vdc
Pickup Time:	<8 ms
Dropout Time:	<8 ms

Breaking Capacity (10,000 Operations):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 Cycles/Second):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Terminal Connections

Compression Screw Terminal

Power Wiring

Insulation:	300 V min.
Size:	12–18 AWG

Alarm Wiring

Insulation:	300 V min.
Size:	12–18 AWG

Tightening Torque

Minimum:	0.6 Nm (5 in-lb)
Maximum:	0.8 Nm (7 in-lb)

Crimp Ferrule Recommended

Mounting Ear Tightening Torque

Minimum:	0.18 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

Grounding Screw

Ground Wiring

Insulation:	300 V min.
Size:	12 AWG, length <3 m

Tightening Torque

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Ring Terminal Recommended

Serial Port

Tightening Torque

Minimum:	0.6 Nm (5 in-lb)
Maximum:	0.8 Nm (7 in-lb)

Operating Temperature Range

i7-3612QE CPU: –40° to +60°C (–40° to +140°F)

Note: Not applicable to UL applications.

Storage Temperature

–40° to +85°C (–40° to +185°F)

Relative Humidity

5 to 95% noncondensing

Maximum Altitude

2000 m

Atmospheric Pressure

80–110 kPa

Overvoltage Category

Category II

Pollution Degree

2

Insulation Class

1

Weight (Maximum)

9.072 kg (20 lb)

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
Information Technology Equipment:	CISPR 22:2008 CISPR 24:2010 IEC 60950-1:2005+A1:2009 +A2:2013 UL UL 60950-1, C22.2 No. 60950-1
Measuring Relays and Protection Equipment:	IEC 60255-26:2013 IEC 60255-27:2013

Type Tests

Electromagnetic Compatibility Emissions

Conducted and Radiated Emissions:	CISPR 11:2009+A1:2010 CISPR 22:2008 ANSI C63.4-2014 Class A
Harmonic Current:	IEC 61000-3-2:2014 Severity Level: Class A
Voltage Flicker:	IEC 61000-3-3:2013

Electromagnetic Compatibility Immunity

Conducted RF:	IEC 61000-4-6:2008 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 4 kV, 5 kHz on power supply and outputs; 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 IEC 61000-4-9:2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m
Power Supply:	IEC 61000-4-11:2004 IEC 61000-4-17:1999+A1:2001 +A2:2008 IEC 61000-4-29:2000
Radiated Radio Frequency:	IEC 61000-4-3:2006+A1:2007 +A2:2010 Severity Level: 10 V/m IEEE C37.90.2-2004 Severity Level: 35 V/m
Surge Withstand Capability:	IEC 61000-4-18:2006+A1:2010 Severity Level (power supply and outputs): 2.5 kV peak common mode 1.0 kV peak differential mode Severity Level (communications ports): 1.0 kV peak common mode IEEE C37.90.1-2002 Severity Level: 2.5 kV oscillatory 4 kV fast transient
Surge Immunity:	IEC 61000-4-5:2005 1 kV line-to-line 2 kV line-to-earth 2 kV communications ports

Environmental

Change of Temperature:	IEC 60068-2-14:2009 Severity Level: 5 cycles, 1°C per minute ramp –40°C to +60°C (i7-3612QE CPU)
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
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Severity Level: 12 + 12-hour cycle 25° to 55°C, 6 cycles, >93% r.h.
Damp Heat, Steady:	IEC 60068-2-78:2001 Severity Level: 40°C, 240 hours, >93% r.h.
Dry Heat, Operational:	IEC 60068-2-2:2007 Severity Level: 16 hours at 60°C (i7-3612QE CPU)
Dry Heat, Storage:	IEC 60068-2-2:2007 Severity Level: 16 hours at 85°C
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 IEEE 1613-2009 Severity Level: V.S.4

Safety

Enclosure Protection:	IEC 60529:2001 + CRGD:2003 Severity Level: IP30
Dielectric Strength:	IEC 60255-27:2013 IEEE C37.90-2005 Severity Level: 3100 Vdc on power supply 2500 Vac on contact output 1500 Vac Ethernet ports Type tested for one minute
Impulse:	IEC 60255-27:2013 IEEE C37.90-2005 Severity Level: 5 kV power supply, contact outputs 1.5 kV Ethernet ports

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