SEL-3373

Station Phasor Data Concentrator

Instruction Manual

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SCHWEITZER ENGINEERING LABORATORIES, INC.

PM3373-01

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PM3373-01

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Preface

Overview

The SEL-3373 Station Phasor Data Concentrator (PDC) allows you to use synchronized phasor measurements (synchrophasors) for real-time power system monitoring, control, archiving, and protection. The SEL-3373 acquires and time correlates synchrophasor data from various Phasor Measurement Units (PMUs), Phasor Data Concentrators (PDCs), Synchrophasor Vector Processors (SVPs), and other devices that support the IEEE C37.118-2005, Standard for Synchrophasors for Power Systems. The SEL-3373 receives synchrophasor messages using Ethernet communications and EIA-232. The SEL-3373 transmits the time-correlated data over Ethernet to external C37.118 clients. The SEL-3373 also sends the data to the internal archiver, which saves data in a relational database.

The PDC Assistant software is a non-licensed settings configuration tool that is included with the SEL-3373 and is free to download from selinc.com. This Windows®-based software provides the ability to configure the SEL-3373. The PDC Assistant is a user-friendly interface where inputs, outputs, calculations, and archives are set with the aid of a real-time status display. In addition, the following features are available: logged results of unusual activity, retrieval of archives based on time and date, manually or with the Archive Collection Service (ACS), and the management of user accounts and SEL-3373 firmware versions.

Section 1: Introduction and Features. Introduces and lists features for the SEL-3373 Station PDC and PDC Assistant software.

Section 2: Installation. Provides information on the installation of the SEL-3373 Station PDC and PDC Assistant software.

Section 3: SYNCHROWAVE PDC Assistant. Explains in detail how to set up your system, view real-time status, collect archived synchrophasor data, create new user accounts, and view system logs.

Section 4: Troubleshooting. Offers insight about symptoms, causes, and debugging methods for commonly encountered issues.

Appendix A: Software/Firmware and Manual Versions. Lists revisions to the software and instruction manual.

Appendix B: Detailed Diagnostic Logs. Contains a list of all diagnostic logs and details regarding the cause of the log, as well as tips for resolving the log item.

Appendix C: Network Ports and Services. Provides information to help security auditors verify that the network hosts and open ports on a control network are what is expected.

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 death or serious 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.

Other Safety Marks (Sheet 1 of 2)

DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	**DANGER** Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
WARNING Do not operate device unless properly grounded.	**AVERTISSEMENT** Ne pas faire fonctionner ce dispositif s'I n'est pas adéquatement mis à la terre.
WARNING Failure to ensure proper voltage levels can cause equipment damage.	**AVERTISSEMENT** A défaut d'appliquer les bons niveaux de tension, l'équipement peut être endommagé.

Other Safety Marks (Sheet 2 of 2)

⚠WARNING Never use standard null-modem cables with the SEL-3373. Using any non-SEL cable can cause severe power and ground problems involving Pins 1, 4, and 6 on the SEL-3373 communications ports.	**⚠AVERTISSEMENT** Ne jamais utiliser de cables standards à inversion de signaux (“null-modem”) avec le SEL-3373. L’utilisation d’un cable d’une autre provenance que SEL peut causer de sérieux problèmes de neutre et d’alimentation impliquant les fiches 1, 4 et 6 sur les ports de communication du SEL-3373.
⚠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.

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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Section 1

Introduction and Features

Overview

The SEL-3373 Station Phasor Data Concentrator (PDC) is a hardware device that allows you to use synchronized phasor measurements (synchrophasors) for real-time power system monitoring, control, archiving, and protection. The SEL-3373 acquires and time correlates synchrophasor data from various Phasor Measurement Units (PMUs), such as the SEL-351, SEL-421, SEL-451, SEL-487E, SEL-487V, SEL-411L, SEL-311C, SEL-787, SEL-751, SEL-751A, SEL-700G relays, SEL-651R-2 and SEL-351RS recloser controls, SEL-2431 voltage regulator controls, and from other devices that support IEEE C37.118-2005, Standard for Synchrophasors for Power Systems. The SEL-3373 receives synchrophasor messages using Ethernet communications and EIA-232. The SEL-3373 can process incoming data from up to 40 PMUs. The maximum data rate is 240 messages per second. The SEL-3373 transmits the time-correlated data over Ethernet to as many as six external C37.118 clients. The SEL-3373 also sends the data to the internal archiver, which saves data in a relational database.

The PDC Assistant software is included with the SEL-3373. This Windows®-based software provides the ability to configure the SEL-3373. The PDC Assistant is a user-friendly interface where inputs, outputs, calculations, and archives are set with the aid of a real-time status display. In addition, the following features are available:

- Logged results of unusual activity.
- Retrieval of archives based on time and date, manually or automatic.
- Management of user accounts and SEL-3373 firmware versions.

Figure 1.1 shows the internal architecture of the SEL-3373, along with connectivity of PDC Assistant.

Figure 1.1 SEL-3373 Station PDC Internal Architecture

Figure 1.2 shows a simple system configuration. The SEL-3373 Station PDC is receiving synchrophasor data from an SEL-421 relay. The SEL-421 includes PMU functionality as a standard feature. Synchrophasor data is processed and then communicated to SYNCHROWAVE® Central for visualization. The PDC Assistant software is shown running on a separate computer, although it can also run with SYNCHROWAVE Central on the same computer.

Figure 1.2 Small-Scale System Architecture

Figure 1.3 shows a large-scale synchrophasor system, with data shared between substations, utilities, and regional coordinating centers.

Figure 1.3 Large-Scale System Architecture Regional Control Centers

Features

The SEL-3373 collects and time correlates synchrophasor data from PMUs such as those listed previously and also PDCs such as the SEL-3378 Synchrophasor Vector Processor, SEL-3306 Synchrophasor Processor, SEL-5073 SYNCHROWAVE PDCs, SEL-3373 Station PDCs, and SEL relays with real-time control (RTC) capability.

The SEL-3373 can then transmit correlated data to external IEEE C37.118 clients for synchrophasor applications. The following features are included.

- **High Performance.** Connect PMUs at message rates from 1–240 messages per second. Configure as many as six separate outputs.
- **Low Latency.** Specified to be less than 20 ms, typically less than 10 ms.
- **Easy to Configure and Commission.** Quickly set up or add PMUs, outputs, internal archives, and more, without interrupting existing ones, using the PDC Assistant.
- **Synchrophasor Message Inputs and Outputs.** Read inputs through Ethernet ports and EIA-232 according to IEEE C37.118-2005. Outputs send synchrophasor data through Ethernet according to IEEE C37.118-2005. Individually configure message rates and content for outputs.
- **Archiving.** Select from several options for capturing data: continuous or triggered archives, pre- and post-disturbance data capture. Retrieve data in binary and ASCII COMTRADE, .csv, and compressed .csv formats. The Archive Collection Service (ACS) enables the automatic collection and storage of phasor archive data on local or network drives.
- **Calculations.** Several calculations are available, including power, sequence, algebraic, scaling, dx/dt, and latency. All calculations can be saved in archives and output to upstream PDCs.

Table 1.1 shows the performance for various configurations using 20 and 40 PMUs.

Table 1.1 Performance of Configurations for 40 and 20 PMU Inputs

Number of PMUs	Input Message Rate	Number of Archives	Number of Outputs	Average Latency
40[a]	30	2	2	<10 ms
20[a]	60	1	3	<10 ms
40[b,c]	60	4	1	<15 ms
20[b,d]	30	2	6	<30 ms

[a] Each PMU input included 8 phasors, 2 analogs, 1 digital word, status, frequency, and df/dt.
[b] Each PMU input included 12 phasors, 8 analogs, 2 digital words, status, frequency, and df/dt.
[c] Included 40 calculations.
[d] Included 20 calculations.

Security

Malware Protection

SEL Whitelist technology protects the SEL-3373 by allowing only authorized tasks to run on the system.

There is no need for virus definition files because only whitelisted or preapproved tasks are allowed to run on the SEL-3373. SEL Whitelist operates at the core of the SEL-3373 operating system, where it intercepts every program before it is executed. Using advanced cryptographic algorithms, Whitelist inspects a program's binary image before allowing the program to execute, verifying its legitimacy and integrity against a known digital signature. Unauthorized changes to the system will generate corresponding diagnostic logs.

User Authentication and Security Auditing

The SEL-3373 authenticates individual user- and role-based accounts, requiring strong passwords, and supports centralized user account management using LDAP. Audit logs are generated for user activity.

Models and Options

Models

Complete ordering information is not provided in this instruction manual. See the latest SEL-3373 Model Option Table at selinc.com.

SEL-3373 Station Phasor Data Concentrator (PDC)

- Base Product Includes:
  - 16 DB9 Serial Ports
  - 2 Rear, 1 Front Ethernet ports
  - Firmware licensing that allows connection up to 8 PMUs

Options

Consider the following options when ordering and configuring the SEL-3373.

- Add archiving capability to the Phasor Data Concentrator
- Add capability for 40 PMU inputs
- 60 GB Solid-State Drive
- 120 GB Solid-State Drive

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

General

Terminal Connections

Rear Screw-Terminal Tightening Torque

Minimum:	0.8 Nm (7 in-lb)
Maximum:	1.4 Nm (12 in-lb)

User terminals and stranded copper wire should have a minimum temperature rating of 105°C and a minimum insulation thickness of 0.4 mm. Ring terminals are recommended.

Power Supply

125/250 Vdc or 120/230 Vac; 50/60 Hz

DC Range:	85–300 Vdc
AC Range:	85–264 Vac
Frequency Range:	30–120 Hz
Burden:	<50 W

48/125 Vdc or 120 Vac; 50/60 Hz

DC Range:	38–140 Vdc
AC Range:	85–140 Vac
Frequency Range:	30–120 Hz
Burden:	<50 W
Main Supply Voltage Fluctuations:	up to ±10% of nominal voltage

Operating Temperature

Performance

–20° to +60°C (–4° to +140°F)

Safety

–20° to +60°C (–4° to +140°F)

Storage Temperature

–40° to +85°C (–40° to +185°F)

Relative Humidity

5% to 95% non-condensing

Maximum Altitude

2000 m

Atmospheric Pressure

80–110 kPa

Overvoltage Category

Category II

Pollution Degree

2

Weight

3.17 kg (7 lbs)

Serial Ports

16 rear-panel ports, DB-9 connectors

Serial Data Speed

9600, 19200, 38400, 57600, 115200 bps (meets EIA/TIA 562 specifications)

Ethernet Ports

Ethernet 1: Fiber Optic or Copper
Ethernet 2: Fiber Optic or Copper
Ethernet F: Copper

Fiber Optic

Maximum TX Power:	–14 dBm
Minimum TX Power:	–19 dBm
RX Sensitivity:	–32 dBm
System Gain:	13 dB
Wavelength:	1300 nm
Source:	LED
Connector Type:	LC (IEC 61754-20)

Time-Code Input

Connector:	Female BNC
Time Code:	Demodulated (B000 or B002) IRIG-B TTL compatible

Time-Code Output

Pinout:	DB-9 port connectors Pin 4 TTL-level signal Pin 6 chassis ground reference Female BNC
Connectors:	16 rear DB-9 port connectors Female BNC

Note: Outputs are generated from IRIG-B input (when present).

PDC Assistant Configuration Software Requirements

Required to configure and view real-time status of the SEL-3373 Station PDC.

Supported Operating System	Windows XP SP3 Windows Server 2008 32/64 Bit SP2 Windows Server 2012 R2 Windows Server 64 Bit R2 SP1 Windows Vista 32/64 Bit SP2 Windows 7 32/64 Bit SP1 Windows 8 32/64 Bit Windows 8.1 32/64 Bit Windows 10 32/64 Bit
Supported File System	NTFS
Supported Architectures	x86, x86_64
RAM	1 GB Minimum, 2 GB Recommended
Installation Space Required	200 MB
.NET 4.0 Framework	Included on CD
Monitor	SVGA (1024 x 768 or higher resolution monitor)

Synchrophasor Performance

Synchrophasor Data Format

Input Data Formats

IEEE C37.118-2005:	Serial and Ethernet

Output Data Formats

IEEE C37.118-2005:	Ethernet

Synchrophasor Message Rates

Input/Output Message Rates

60 Hz Nominal System Frequency: 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, and 240 messages per second

50 Hz Nominal System Frequency: 1, 2, 5, 10, 25, 50, 100, and 200 messages per second

Synchrophasor Data Ports

Input Data Ports

Individually configurable for message rate and data to be sent.

Input alignment waiting time: User settable between 0–120 seconds

8 PMU inputs standard, 40 PMU inputs optional.

Connection ports for 16 serial EIA-232 inputs and Ethernet standard.

Simultaneous serial and Ethernet input allowed.

Support for redundant inputs.

Output Data Ports

Individually configurable for message rate, data to be sent, and location to send data.

Phasors can be sent in rectangular or polar format.

Up to six fully configurable Ethernet output data ports.

Support for redundant outputs.

Synchrophasor Processing

Processing Time (latency through PDC); see the following table.

Performance of Configurations for 20 and 40 PMU Inputs

Number of PMUs	Input Message Rate	Number of Archives	Number of Outputs	Average Latency
40[a]	30	2	2	<10 ms
20[a]	60	1	3	<10 ms
40[b,c]	60	4	1	<15 ms
20[b,d]	30	2	6	<30 ms

[a] Each PMU input included 8 phasors, 2 analogs, 1 digital word, status, frequency, and df/dt.
[b] Each PMU input included 12 phasors, 8 analogs, 2 digital words, status, frequency, and df/dt.
[c] Included 40 calculations.
[d] Included 20 calculations.

Security

Firewall

All input and output ports must be enabled before they are used. By default all ports are disabled except for those required by the PDC Assistant.

Alarm Contact and Alarm LED

Contacts close and LED lights for any of the following conditions:
- Unit failure.
- Failed internal diagnostic.
- User-settable limit for available space on SSD exceeded.
- Connection to SEL-3373 from the PDC Assistant attempted with incorrect PW (1 second momentary close).
- Settings change sent to SEL-3373 from the PDC Assistant (1 second momentary close).
- When password jumper is installed (opens once the jumper is removed).
- CPU processor overburden.

Account Management

Centralized user management via Lightweight Directory Access Protocol (LDAP).

User and role-based account authentication requires use of strong passwords.

User-settable parameters for login/logout:
- Allowed unsuccessful login attempts
  - setting range: 0 to 10
- Unsuccessful login lockout time
  - setting range: 1 to 60 mins
- Session Idle time out
  - setting range: 0 to 60 mins

Security Audit Features

Access Logs—All user access to the PDC is saved to archive.

User activity that is logged in the access log:
- User logins to the PDC.
- User access to the diagnostic logs.
- User clearing of the diagnostic logs.
- Software/firmware change.
- Time/date of settings changes and user notes.
- PDC starting or stopping.
- User logging out, including a user session time-out.
- User account that has been locked out.
- User account that is unlocked.

Diagnostic Logs—All diagnostic logs are saved to archive.

Audit Facility—Information provided for ports and services:
- PDC firmware version.
- PDC Assistant version.
- PDC serial number.
- Current date.
- CPU usage, memory usage, processes running.
- Solid state drive (SSD) usage.
- Network connections and ports.
- Network card status.
- Host-to-IP mappings.
- Domain name servers.
- Routing table information.
- Firewall rules.
- IRIG and HW status.

Supported Communications Protocols

Inputs: TCP, UDP, UDP_U, UDP_T, UDP_S, and EIA-232.
Outputs: TCP, UDP_U, UDP_T, UDP_S.
IP multicast inputs/outputs.

Archiving

Conforms to IEEE C37.232 naming practice for time-sequence file names.

Secure ODBC Interface (Open Database Connectivity software API) for interfacing with database management systems.

Archive collection service automatically collects data from 1 or more SEL-3373 local archives and saves data to a user-defined central archive drive.

Data Retrievable In:
- Binary or ASCII COMTRADE format
- CSV format
- Compressed CSV format

Selectable Archiving Modes:
- Continuous Archiving
- Triggered Archiving
  - Up to 90 minutes of pretrigger
  - Up to 90 minutes of post-trigger

Storage Options for Archiving

60 GB solid-state drive

120 GB solid-state drive

Calculations

Mathematical

Power calculations: single- or three-phase in watts and VARs

Sequence components: positive, negative, and zero

Phasor and analog algebra: addition, subtraction, multiplication, and division

Phasor and analog value scaling: magnitude or angle using a constant

Derivative: calculates the rate of change in analog values

Utility

Network Latency: instantaneous, average, and maximum latency measurements

Inter-packet Delay: instantaneous, average, and maximum packet-to-packet delay

Component: separates a phasor into its components

Diagnostics and Status

Up to 10 Syslog outputs (RFC 3164)

Queried Logs

Type Tests

Electromagnetic Compatibility Immunity

Electrostatic Discharge:	IEC 60255-22-2:2008 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 Disturbance:	IEC 61000-4-4:2004 IEC 60255-22-4:2008 Severity Level: Class A 4 kV, 5 kHz on power supply and outputs; 2 kV, 5 kHz on communication lines
Radiated Radio Frequency:	IEC 61000-4-3:2006 IEC 60255-22-3:2007 Severity Level: 10 V/m IEEE C37.90.2-2004 Severity Level: 20 V/m
Conducted Emissions:	EN 55011:1998 + A1:1999 + A2:2002 Level: Class A IEC 60255-25:2000
Radiated Emissions:	EN 55011:1998 + A1:1999 + A2:2002 Level: Class A IEC 60255-25:2000
Surge Withstand Capability Immunity:	IEC 60255-22-1:2005 Severity Level: Power supply and outputs 2.5 kV peak common mode 1.0 kV peak differential mode Communications ports 1.0 kV peak common mode IEEE C37.90.1-2002 Severity Level: 2.5 kV oscillatory 4 kV fast transient
Conducted Immunity:	IEC-61000-4-6:2006 IEC-60255-22-6:2001 Severity Level: 10 Vemf
Power Frequency Magnetic Field Immunity:	IEC-61000-4-8:2001 Severity Level: 1000 A/m for 1 s 100 A/m for 1 min.
Power Supply Variation and Interruption:	IEC 61000-4-11:2004 IEC 60255-11:1979

Environmental Tests

Cold:	IEC 60068-2-1:1990 + A1:1993 + A2:1994 Test Ad: 16 hours at –20°C
Dry Heat:	IEC 60068-2-2:1974 + A1:1993 + A2:1994 Test Bd: 16 hours at +600°C
Damp Heat Cycle:	IEC 60068-2-30:1980 + A1:1985 Test Db: (12 + 12 hour cycle), 95% r.h. 25° to 55°C, 6 cycles
Object Penetration:	IEC 60529:2001 + CRGD:2003, from front of unit.
Vibration:	IEC 60255-21-1:1988, Endurance Class 1 Response Class 1 IEC 60255-21-2:1988, Shock Withstand, Bump Class 1 Shock Response Class 1 IEC 60255-21-3:1993 Quake Response Class 2

Safety

Dielectric Strength:	IEC 60255-5:2000, 3100 Vdc on power supply 2500 Vac on contact output Type tested for one minute IEEE C37.90-1989 3100 Vdc for 1 min. on power supply 2500 Vac on contact output Type tested for one minute IEEE 1613-2003
Impulse:	IEC 60255-5:2000 IEEE 1613-2003 IEEE C37.90-1989 Severity Level: 0.5 Joule, 5 kV

Real-Time Clock/Calendar

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

Section 2

Installation

Overview

The first steps in applying the SEL-3373 Station Phasor Data Concentrator (PDC) are installing and connecting the unit. This section describes common installation features and requirements. A successful installation requires an understanding of both the hardware and software functions.

To install and connect the SEL-3373 safely and effectively, you must be familiar with the device configuration features and options. Carefully plan unit placement, cable connections, and communications during initial design.

This section contains connection drawings for Ethernet ports, DB-9, IRIG-B, and power. Use these drawings as a starting point for planning your particular application.

Unit Placement and Maintenance

Proper placement of the SEL-3373 helps make certain that you receive years of trouble-free operation. Use the following guidelines for proper installation of the SEL-3373.

Physical Location

Mount the SEL-3373 in a sheltered indoor environment (a building or an enclosed cabinet) that does not exceed the temperature and humidity ratings for the unit (see *Specifications*). The unit is rated Installation/ Overvoltage Category II and Pollution Degree 2. This rating allows mounting of the unit indoors or in an outdoor (extended) enclosure where the unit is protected against exposure to direct sunlight, precipitation, and full wind pressure, but temperature and humidity are not controlled.

Unit Mounting

Panel-mount and 19-inch rack-mount options are available. The following diagrams show dimensions and panel cutout size for the unit.

Cleaning

Use care when cleaning the SEL-3373. Use a mild soap or detergent solution and a damp cloth to clean the unit chassis. Allow the unit to air dry, or wipe dry with a soft, dry cloth. Do not use abrasive materials or polishing compounds on any unit surface. Be careful cleaning the front and rear panels because a permanent plastic sheet covers each panel; do not use harsh chemical solvents such as xylene or acetone on these surfaces.

Figure 2.1 Dimensions Diagram

① LEDs indicate transmitted and received activity on each port for easy checkout.

② Rugged enclosure withstands EMI, RFI, shock, and vibration. Clock battery lasts 10 years. No other maintenance is required.

Figure 2.2 Front Rack-Mount Diagram

Figure 2.3 Front Panel-Mount Diagram

Rear-Panel Connections

The physical layout of the connectors on the rear panel of an SEL-3373 is shown in *Figure 2.4*.

① Dual Ethernet connection.

②All rear serial ports provide communication and time code. Internal clock generates time code and synchronizes to modulated or demodulated time-code input.

③Wide-range power supply and alarm contact connections.

④VGA ports are for SEL internal testing purposes only and provide no functionality once the SEL-3373 has shipped.

Figure 2.4 Rear-Panel Diagram

Ethernet Connection

The SEL-3373 is equipped with three Ethernet ports. Two Ethernet ports (ETH 1 and ETH 2) are on the rear and one Ethernet port (ETH F) is on the front. Ethernet 1 and 2 may be ordered as either copper 10/100BASE-T or fiber-optic 100BASE-FX. Ethernet F is a standard 10/100BASE-T copper port.

All three Ethernet ports may be used at the same time and have unique MAC addresses. A full discussion of MAC addresses is beyond the scope of this manual. See your network administrator for questions or concerns.

The LEDs for the Ethernet ports apply to both copper and fiber connections. The left LED illuminates orange for a 10 Mbps connection and green for a 100 Mbps connect. The LED on the right flashes yellow during data transfer.

The multiple Ethernet function of the SEL-3373 is the same as a standard multiple Ethernet PC-AT compatible computer.

Alarm Contact Connection

The SEL-3373 provides a Form C, dry alarm contact that closes under the following conditions:

- The SEL-3373 is not running after power on
- The SEL-3373 failed an internal diagnostic
- Less than the user-set amount of the available space for archiving remains on the internal drive
- Closes for one second when a connection to the SEL-3373 is attempted from a PDC Assistant after the allowed number of unsuccessful log-in attempts has been exceeded
- Closes for one second each time settings are sent to the SEL-3373 from a PDC Assistant
- Closes and latches closed when the password jumper is installed. The alarm opens when the jumper is removed.

The SEL-3373 automatically restarts on a device failure. The device does not restart when the archive is full. Please see *Archives on page 3.29* for more details on the archiving function and disk space guidelines.

Ratings for the contact are 30 A make, 6 A continuous, and 0.5 A or less break (depending on circuit voltage). The alarm contact has a maximum safety rating of 250 Vac/330 Vdc.

IRIG-B Connections

NOTE: The SEL-3373 cannot be used to distribute IRIG-B to PMUs. It does not provide the high accuracy time needed for phasor measurements.

The SEL-3373 accepts demodulated (B000 or B002) IRIG-B input. Demodulated IRIG-B is provided on the BNC IRIG-B output connector and on Pins 4 and 6 of all serial communication ports except Port 1.

The IRIG-B signal preference is given to the BNC connector, IRIG-B input. When this signal is not present, then IRIG-B is generated from the system computer clock and distributed to the IRIG-B output connections.

IRIG-B input is *not* available on any serial communications ports. The IRIG-B signal includes code for day-of-the-year and time-of-day. It does not include a code to identify the year. To set the device calendar to the proper year, you need to set the date on each device receiving an IRIG-B signal.

The IRIG-B signal input is used to set and maintain the time in the SEL-3373. It is not used to time-align data. Data are time-aligned using the time stamps sent with the data.

Serial Port Communication

Sixteen serial ports are available on the SEL-3373. Each serial port has a communications port number assigned.

The serial communications ports can function as standard EIA-232.

Table 2.1 EIA-232 Serial Port Connector Pin Definition

Pin	Ports 1–16
1	N/C
2	RXD
3	TXD
4	+IRIG-B
5, 9	GND
6	–IRIG-B (GND)
7	RTS
8	CTS

Female chassis connector, as viewed from outside panel.

Figure 2.5 EIA-232 DB-9 Connector Pin Numbers

The communications circuits have internal surge protection.

Common serial cable configurations are shown in the following figures. Refer to SEL-5801 Cable Selector Software for the most recent cable configurations. Please refer to individual device manual and Cable Selector Software prior to selecting a proper cable.

Figure 2.6 SEL-C235 Cable

SEL-3373 9-Pin Male D-Sub Connector Pin Func.	Pin #		300/400/500/700 Series Relays except SEL-321 9-Pin Male D-Sub Connector Pin #	Pin Func.
RXD	2	———	3	TXD
TXD	3	———	2	RXD
+IRIG	4	———	4	+IRIG
GND	5	———	5	GND
-IRIG	6	———	6	-IRIG
RTS	7	———	8	CTS
CTS	8	———	7	RTS

Figure 2.7 SEL-C273A Cable

⚠WARNING
Never use standard null-modem cables with the SEL-3373. Using any non-SEL cable can cause severe power and ground problems involving Pins 1, 4, and 6 on the SEL-3373 communications ports.

The following list provides additional rules and practices you should follow for successful communication using EIA-232 serial communications devices and cables:

- Keep the length of the communications cables as short as possible to minimize communications circuit interference and also to minimize the magnitude of hazardous ground potential differences that can develop during abnormal power system conditions.
- EIA-232 communications cable lengths should never exceed 50 feet, and you should always use shielded cables for communications circuit lengths greater than 10 feet.
- Modems or fiber optics are required for communication over long distances and to provide isolation from ground potential differences between device locations.
- Route communications cables away from power and control circuits. Switching spikes and surges in power and control circuits can cause noise in the communications circuits if not adequately separated.
- Lower data rate communication is less susceptible to interference and will transmit greater distances over the same medium than with higher data rates. Use the lowest data rate that provides adequate data transfer speed.

Port Isolators

SEL offers a data-line-powered isolator for use with EIA-232 ports and metallic communications cables. The SEL-2910 Port Isolator isolates IRIG-B time-code inputs on the same communications port. These isolators break cable ground loops and are useful in existing applications of metallic cables in switchgear. SEL does not recommend using port isolators for circuits outside the control house. Fiber should be used in such applications. Refer to SEL Application Guide AG2001-06, *Avoiding Magnetic Induction Issues in Communication Cabling*, for detailed information.

Fiber-Optic Cables

One benefit of applying the SEL-3373 as the hub of a star topology is that it enables low-cost, point-to-point fiber-optic connections. The SEL-2800 family of fiber-optic transceivers connects directly to the serial port connectors on the rear of the SEL-3373. Fiber-optic links improve safety by isolating the equipment from hazardous and damaging ground-potential rise, eliminate instrumentation system ground-loop problems, reduce susceptibility to RFI and EMI, and allow longer signal paths than metallic EIA-232 connections.

Main Board Jumpers

Set the main board jumpers to meet your requirements. See *Table 2.2* for jumper functions and positions. See *Figure 2.8* for jumper location on the main board.

Table 2.2 Main Board Jumper Positions

Function	Jumper Position(s) to Bridge	Default
Watchdog Jumper	JMP5 A	OFF
IRIG demodulated pass through	JMP5 B	OFF
Password Jumper	JMP5 C	OFF
Reserved	JMP5 D	OFF
Reserved	JMP5 E	OFF
COM16 IRIG-B Output[a]	JMP1 A, C	ON
COM1 DSR/DTR[a]	JMP1 B, D	OFF

[a] Either IRIG Output or DSR/DTR must be chosen, not both.

Figure 2.8 Jumper Locations (JMP1 and JMP5) on the Main Board

Grounding

Connect the grounding terminal (see **A09** on *Figure 2.9*) labeled **GND** on the rear panel to a rack frame ground or main station ground for proper safety and performance. Use 12 AWG (4 mm^2) or heavier wire less than 2 m (6.6 feet) in length for this connection. This terminal connects directly to the internal chassis ground of the SEL-3373.

Power Connections

Connect the power terminals on the rear panel (**A07(+/H)** and **A08(-/N)**) to the proper ac or dc power source. Ensure the connected voltage is with the rated range for the power supply ordered. Routed voltages are indicated on the serial number label.

Figure 2.9 Power Connections

WARNING
Do not operate device unless properly grounded.

WARNING
Failure to ensure proper voltage levels can cause equipment damage.

The power terminals are isolated from the chassis ground. Use 16 AWG (1.5 mm^2) size or larger wire to connect to the power terminals.

Place an external switch, circuit breaker, or other overcurrent protection device in the power leads. The overcurrent protection device must interrupt both the hot and neutral power leads if dc powered. The maximum current rating for the overcurrent protection device must be no greater than 20 A. Be sure to locate this device within 3.0 m (9.8 feet) of the SEL-3373. Disconnect devices must comply with IEC 60947-1 and IEC 60947-3-1.

Operational power is internally fused on the power supply. Replacing the internal power supply fuse is not recommended unless indicated otherwise by your local SEL representative. An internal fuse failure indicates possible circuit board or electronic failure that may cause sporadic or incorrect device operation.

Initial Connection to the SEL-3373

For the initial connection to an SEL-3373, you need the following:

- A computer with a wired Ethernet port
- An uncommissioned SEL-3373
- One RJ45 Ethernet cable

The Physical Network

NOTE: The SEL-3373 is capable of autocrossover. This means that neither a hub nor a crossover cable is required.

Connect the SEL-3373 to your computer as shown in *Figure 2.10*. Using a standard RJ45 Ethernet cable, connect the Ethernet port of your computer directly to the **ETH F** port of the SEL-3373. The uncommissioned SEL-3373 only has the **ETH F** port enabled. By default the IP address on this port is 192.168.1.2.

Figure 2.10 Commissioning Network

Configuring Microsoft Windows Networking

NOTE: Depending on your company's computer use policies and your user privileges, you may need the assistance of your IT department to configure networking on your workstation.

Confirm that your computer is configured to communicate on the 192.168.1.0/255.255.255.0 subnet.

Step 1. Start the Microsoft® Windows® Command Terminal. The Command Terminal can typically be found under the Accessories folder of the Windows Start menu.

Figure 2.11 Open Terminal With Run Command

Step 2. In the command terminal, type **ipconfig <Enter>** as shown in *Figure 2.12*. This will show you the IP address and subnet mask that your Ethernet connection is configured for. The IP address must match 192.168.1.1 and the subnet mask must match 255.255.255.0. If these values are correct, please skip to *Commissioning the SEL-3373*.

Figure 2.12 Windows IP Configuration

NOTE: Any IP address in the 192.168.1.0/255.255.255.0 subnet is acceptable except for 192.168.1.2 which is taken by the SEL-3373.

Step 3. If you need to configure your computer to communicate on the 192.168.1.0/255.255.255.0 subnet, then open Microsoft Windows Network Connections. Do this by typing **ncpa.cpl** in the Windows Run dialog box, as shown in *Figure 2.13*. Clicking **OK** will open the Network Connections window, which contains a list of the network devices available on your computer.

Figure 2.13 Open Network Connections With Run Command

Step 4. Right-click on the connection you will be using to communicate with the SEL-3373 and select the **Properties** option. This connection may be labeled Local Area Connection.

Figure 2.14 Open Connection Properties

Step 5. Select the **Internet Protocol (TCP/IP)** entry from the list in the **This connection uses the following items** area (this entry is usually located last in the list). Click the **Properties** button.

Figure 2.15 Local Area Connection Properties

Step 6. Select the radio button labeled **Use the following IP address**. Enter **192.168.1.1** as the IP address and **255.255.255.0** as the subnet mask as shown in *Figure 2.16*. Click the **OK** button.

Figure 2.16 Internet Protocol (TCP/IP) Properties

Step 7. Click the **OK** button in the **Local Area Connection Properties** dialog box. The new settings will not take effect until this is done.

Commissioning the SEL-3373

The SEL-3373 has a default IP address of 192.168.1.2 assigned to the ETH F port. The SEL-3373 uses port number 26272 for PDC Assistant access. To initially connect to the SEL-3373, open PDC Assistant (see *Installation on page 3.7*) and click **Connect**. In the **Connections** dialog, enter **192.168.1.2** as the server, **26272** as the port number, and leave the **User name** and **Password**

blank, as shown in *Figure 2.17*. Connecting without a username and password is only allowed with the initial connection to the PDC, or if the password jumper is installed.

Figure 2.17 Connection Dialog Box

Upon connection, PDC Assistant will prompt for an administrator account name and password, as shown in *Figure 2.18*. Enter an account name and password to be used when configuring the SEL-3373 and click **OK**.

Figure 2.18 Initial Account Setup

The next step in commissioning is to setup the network settings for each Ethernet port on the device. Refer to *Network on page 3.55* to complete this process.

Connect IRIG-B

SEL-3373 internal time must be within 30 minutes of time values the device receives from external PMUs to which it is connected. PDC Assistant provides a means for synchronizing SEL-3373 internal time to the local computer time (see *Device on page 3.51*), which typically is within 30 minutes of the GPS time values that the PMUs receive. In this case, however, natural drift of SEL-3373 internal time could cause shifting of this time outside of the 30-minute synchronization requirement.

SEL therefore recommends connecting a GPS time source to the SEL-3373 through its IRIG-B connection. This ensures synchronization of SEL-3373 internal time to GPS time.

Synchronizing through PDC Assistant is beneficial when the internal SEL-3373 time is significantly different from the IRIG-B time. This could occur when initially connecting the SEL-3373 to IRIG-B. In this case there will be a delay while the SEL-3373 slowly synchronizes its internal time to the IRIG-B time. Using the PDC Assistant synchronization function forces the

SEL-3373 internal time to match the connected computer time and therefore accelerates the IRIG-B synchronization time. Please see *Device on page 3.51* for instructions on synchronizing the SEL-3373 internal time.

Password and Networking Reset

If the administrator username or password are forgotten, or if the network settings are configured such that PDC Assistant cannot connect to it, the SEL-3373 has a password jumper that can be installed to temporarily correct the situation. The password jumper location is identified in *Table 2.2*.

After installing the password jumper, turn on the device. When the device is turned on with the password jumper installed, the device:

- Temporarily allows the PDC Assistant to log in with no username or password.
- Temporarily overrides the networking configuration, restoring it to the factory default (ETH F = 192.168.1.2/255.255.255.0, ETH 1 and ETH 2 disabled).

If you have forgotten the administrator username or password, follow these steps.

Step 1. Turn off the SEL-3373 and install password jumper.

Step 2. Turn on the SEL-3373.

Step 3. With PDC Assistant, connect to the SEL-3373 via the front port, with the remote computer configured as described in *Initial Connection to the SEL-3373*. Use an empty username and password.

Step 4. PDC Assistant will prompt for a new administrator username and password. You may create a new account or overwrite an existing account. After creating this account, you may view the existing accounts by clicking on **User Accounts**.

Step 5. Turn off the SEL-3373 and remove the password jumper.

If the SEL-3373 network configuration is incorrect (making it impossible for PDC Assistant to connect), follow these steps to correct it.

Step 1. Turn off the SEL-3373 and install the password jumper.

Step 2. Turn on the SEL-3373.

Step 3. Connect a PC to the SEL-3373 via the front port, with the PC configured as described in *Initial Connection to the SEL-3373*. Open PDC Assistant and connect to the SEL-3373 using server 192.168.1.2, port 26272, and your existing administrator username and password.

Step 4. Click on **Network Settings**. The incorrectly configured network settings will be displayed. Modify this configuration as necessary and click **Apply Changes**.

Step 5. Reconnect to the PDC Assistant with the new network settings to verify you have corrected the problem. If not, turn off the SEL-3373 and repeat *Step 3* through *Step 5*.

Step 6. When the network settings are corrected, turn off the SEL-3373 and remove the password jumper.

Real-Time Clock and BIOS Battery Replacement

⚠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.

⚠DANGER
Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

A lithium battery powers the clock (date and time) if the external power source is lost or removed. The battery also maintains the configured system computer BIOS settings. The battery is a 3 V lithium coin cell, Ray-O-Vac® BR2335 or equivalent. At room temperature, the battery will operate nominally for 2 years at rated load with no external source present. When the device is powered from an external power source, the battery experiences a low self-discharging rate. Thus, battery life may extend well beyond 10 years. The battery cannot be recharged.

Step 1. De-energize the device by disconnecting or removing power.

Be sure proper tagging is applied to the power source to avoid accidental re-energization.

Step 2. Remove all connections from the rear of the device.

Step 3. Remove the device from the panel or 19-inch rack.

Step 4. Remove the top/rear panel.

To remove the top/rear panel, you will need to remove the two side, two top, and three rear screws.

Step 5. Locate the battery.

Step 6. Carefully remove the battery from underneath the retaining clip.

Properly dispose of the battery.

Step 7. Install a new battery with the positive (+) side up.

Step 8. Replace the top/rear panel.

Step 9. Replace the side, top, and rear screws for the top/rear panel.

Step 10. Reinstall the device into the panel or 19-inch rack.

Step 11. Replace all connections to the rear of the device.

Step 12. Reapply power to the device.

Firmware Upgrades

You can update the firmware version of SEL-3373 remotely using the PDC Assistant software. Before attempting a firmware upgrade, make sure you have installed the latest version of PDC Assistant software. You can check the version of PDC Assistant from the help menu on the PDC Assistant window. The latest PDC Assistant version can be downloaded from selinc.com/products/3373/ or selinc.com/products/5073/. When a new version of the SEL-3373 firmware is available, SEL will provide a firmware file which you can upload to the SEL-3373 using the following instructions.

NOTE: It is recommended to back up existing settings and data before each firmware upgrade.

Step 1. Connect to the SEL-3373 using PDC Assistant software.

Step 2. Go to the Administration Device screen as shown in *Figure 2.19*.

Figure 2.19 Administration Device Screen

Step 3. Click on the **Upgrade Firmware** button.

Step 4. Browse to the firmware file.

Figure 2.20 Firmware File Browser Window

Step 5. SEL-3373 will process the firmware upgrade and notify you when the upgrade has been completed. Please wait until the SEL-3373 is fully rebooted (**ENABLED** LED on the front panel is on) before connecting with PDC Assistant.

Figure 2.21 Upgrade Progress Dialog Box

Figure 2.22 Upgrade Complete Dialog Box

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Section 3

SYNCHROWAVE PDC Assistant

Overview

This section describes the SEL PDC Assistant software application. Use the PDC Assistant to configure the SEL-5073 SYNCHROWAVE® PDC or the SEL-3373 Station PDC, retrieve archived data, view the PDC real-time status, view PDC logs, set up user accounts, and update the PDC firmware and maintain the PDC.

Figure 3.1 PDC Assistant Homepage

Figure 3.1 shows the initial screen after launching the PDC Assistant. From the PDC Assistant **Home** view, the user can see different categories of tasks. The list of tasks is accessible from the left pane shown in *Figure 3.1*.

Figure 3.2 Example PDC Assistant Settings Page

Project Files

The PDC configuration information is stored in a project file. When saving a project file, two options are available:

- Store the project file on a computer via the **Save** or **Save As** buttons.

  In this case the file is available for future edits with the PDC Assistant.

- Store the project file on an SEL-5073 or the SEL-3373 using the **Send Settings** or **Connect** buttons.

  In this case the file is also used by the SEL-5073 or SEL-3373 as its internal source of configuration information.

The PDC Assistant caches a local project file when changes have been made to settings, but these changes have not yet been saved to either a computer or an SEL-5073 or SEL-3373. Changes to a document are not permanent until saved. Files are retrieved either from a computer or from the SEL-5073 or SEL-3373 storage.

Figure 3.3 Various SEL-5073 or SEL-3373 Storage Locations for Project Files

Online vs. Offline Modes

Configuration of the SEL-5073 SYNCHROWAVE® PDC or the SEL-3373 Station PDC is possible without a connection to either PDC. This allows setting the SEL-5073 or SEL-3373 from a local computer and then saving the settings information later to the SEL-5073 or SEL-3373. Accessing real-time status, diagnostic logs, retrieving archives, and general PDC administration are not available offline. For these tasks an active connection with the PDC is required.

File and Connection Management Menu Bar

Figure 3.4 shows the file and connection management menu bar. Use it for managing project files and connecting to the SEL-5073 or SEL-3373.

Figure 3.4 File and Connection Management Menu Bar

Each option is defined as follows:

➤ **New:** Start a new project file.

When adding a new project file, the settings version dialog box appears, as shown in *Figure 3.5*.

Figure 3.5 Device Setting Version Number

Select the device type, either SEL-3373 or SEL-5073. The Settings Version Number (SVN) corresponds with the version of PDC being used. *Table 3.1* shows the mapping between SVN, PDC version and the PDC Assistant version in which the given SVN was introduced.

Table 3.1 Settings Version Map

SVN	SEL-3373	SEL-5073	PDC Assistant[a]
Z001	NA	R100	1.1.0.0
Z002	R100	NA	1.2.0.0
Z003	R101	R101	1.3.0.0
Z004	R108	R108	1.4.0.0
Z005	R110	R110	1.5.0.0
Z006	R111	R111	1.7.0.0
Z007	R112, R113, R114, R115	R112, R113	1.9.0.0
Z008	NA	R115, R116	2.0.0.0
Z008	R116	NA	2.1.0.0
Z008	R116-V6	NA	2.3.0.0
Z008	R116-V7	R116-V1	2.5.0.0

[a] Each PDC Assistant version provides backward compatibility with all previous SVN settings.

- **Open:** Open an existing project file from a local computer.
- **Save:** Save the settings to a local computer project file. You can select the **Save As** button or use the **Ctrl-s** key combination. An asterisk will appear in the PDC Assistant window heading when the project file contains unsaved settings.

Figure 3.6 Unsaved Settings Indicator

- **Close:** Close the project file.
- **Send Settings:** Send settings to the PDC. This stores the presently open project file to the PDC. This option is useful after connecting to a PDC and when changes have been made to the settings.

  The real-time status, diagnostic logs, retrieving archives, and general PDC administration are not available offline. Furthermore, changes in these functions through PDC Assistant are applied immediately to the connected PDC. Therefore, there is no Send Settings functionality associated with them.
- **Connect:** Connect to the PDC. The connection dialog box requires the username and password. For the Server, type in the IP address of the PDC. The SEL-5073 port is the value selected during installation. The SEL-3373 port is 26272.

  The PDC Assistant uses Secure Socket Layer (SSL) encryption for communications with the SEL-5073 and SEL-3373 by default. Refer to *Section 4: Troubleshooting* for additional information.

  Connecting automatically opens the project file presently stored in the PDC. There are a couple of cases to consider when connecting the PDC Assistant to the SEL-5073 or SEL-3373. First, when settings edits have been made in PDC Assistant, and then a connection is established to the SEL-5073 or SEL-3373, the correct project file needs to be determined. The menu shown in *Figure 3.7* will appear.

Figure 3.7 Connection Dialog Box Login Information

Referring to *Figure 3.8*, select **Read Project from PDC** to reject the present cached project file in the PDC Assistant and use the Project File #1 (see *Figure 3.3*) that is presently stored in the PDC. In this case all existing settings changes that have been made in PDC Assistant are rejected and the new settings information is read from the PDC.

Select **Send** to send the present cached project file to the PDC. This overwrites the existing Project File #1 in the PDC.

Select **Disconnect** to cancel the operation. This option avoids any changes to either the Project File #1 in the PDC or the present cached project file in PDC Assistant.

Figure 3.8 Menu for Selecting Project File

➤ **Disconnect:** Disconnect from the PDC.

This allows using a different project file than the one stored in the PDC.

When terminating the PDC Assistant program while connected to the PDC, or when attempting to open a new project file, the existing configuration edits must be saved. The menu shown in *Figure 3.9* will appear. Referring to *Figure 3.9*, select **Send** to send the present cached project file to the PDC. This overwrites the existing Project File #1 in the PDC.

Select **Discard** to continue with the present operation, and reject any changes to the cached project file in PDC Assistant. Finally, select **Cancel** to cancel the attempted PDC Assistant closing or opening a new project file.

Figure 3.9 Menu to Determine Storage Location for Present Settings Edits

The dialog box in *Figure 3.10* appears when exiting the PDC Assistant while not presently connected to the PDC and the settings information has been changed since last being saved. The options are identical to the case of *Figure 3.9* except an option to save the cached configuration data to Project File #2 (a file on a local computer) is available.

You can think of the **Send** button in *Figure 3.9* as saving the configuration information to the PDCs internal storage and the **Save to File** button in *Figure 3.10* as saving the configuration to the local computer's internal storage.

Figure 3.10 Menu for Terminating PDC Assistant

Local Services

Local services are only available if SEL-5073 or Archive Collection Service is installed on the same computer as PDC Assistant. The **Local Services** menu bar selection allows the user to start and stop the SEL-5073 service and/or the ACS or launch the Microsoft service manager.

Figure 3.11 Local Services Menu

The **Local Services** options are defined as follows:

- **SEL-5073 PDC:** Allows the user to Start or Stop the SEL-5073 service. The present status of the service is displayed in parentheses next to heading, (Stopped) or (Running).
- **Archive Collection Service:** Allows the user to start, stop, or configure the ACS. Refer to *Archive Collection Service* for details. The present status of the service is displayed in parentheses next to heading, (Stopped) or (Running).
- **Manage Service Startup:** Allows the user to launch the Microsoft Service Manager. Once initiated the Service Manager, the user is able to start, stop, or edit all services on the machine.

Status Bar

The **Status** bar includes four status elements.

Figure 3.12 Program Status Indication

Each option is defined as follows:

- **Project Status**
  - No project is defined.
  - Active project with no errors.
  - Current project has settings errors.
- **PDC Sync**
  - Unable to determine if local settings are synchronized with the SEL-5073 or SEL-3373.
  - Local settings are synchronized with the SEL-5073 or SEL-3373.
  - Local settings have been modified and may be different than those stored in the SEL-5073 or SEL-3373.
- **PDC Connection**
  - Disconnected from the SEL-5073 or SEL-3373.
  - Active connection to the SEL-5073 or SEL-3373.
  - The SEL-5073 service is not running.
- **User Domain**
  - Indicates user authentication is performed remotely via LDAP.
  - Indicates user authentication is performed by the PDC.

Installation

System Requirements

SEL PDC Assistant can be installed on the following operating systems. Note that the system disk must be partitioned as an NTFS drive.

- Windows XP SP3
- Windows Server 2008 32/64 Bit SP2
- Windows Server 2008 R2 SP1 (64 Bit)
- Windows Vista 32/64 Bit
- Windows 7 SP1 32/64 Bit
- Windows 8 32/64 Bit
- Windows Server 2012 R2

Installation

Use the SEL PDC Assistant install file to begin installation of the PDC Assistant software. Follow the onscreen instructions as shown in *Figure 3.13*.

Figure 3.13 PDC Assistant Software Installation

Settings

The **Settings Navigation** menu items are organized into six categories:

- **Inputs:** Add a PMU, a PDC, or a sub PMU. The sub PMU is a PMU that has previously been concentrated with other PMUs in a PDC. For each input, tags define data names. When defining inputs, tags are loaded from PDC Assistant device definition files, created in the tag editor, or populated automatically using the **Query Tags** button or the automatic Sub PMU menu item.
- **Outputs:** Each output combines a set of time-aligned PMU data into a concentrated data packet. The tag editor included with the output settings enables combining individual PMU data values into a single output.
- **Calculations:** The PDC includes an engine for high-speed calculations. The results are available as tags, which can be used in outputs or archives.
- **Archives:** A real-time database stores triggered or continuous archives. The archive settings provide a way to configure how data are stored and to select individual tags for storage.
- **Loggers:** Select the severity level, Syslog output, and storage amount for the PDC log capture.
- **Globals:** These settings are for general PDC configuration.

After changing any settings value the settings must be resent to the PDC in order for the new values to take effect. The PDC Sync field will be marked with a green check when the settings seen in the PDC Assistant view have been sent to the PDC.

Inputs

Selecting the inputs option for the PDC Assistant will display the screen shown in *Figure 3.16*. Add in input by selecting options across the top menu bar.

Figure 3.14 Inputs Menu Bar

Each option is defined as follows:

- **Add PMU:** Adds a new PMU to the left column of the device hierarchy region.
- **Add PDC:** Adds a new PDC to the left column of the device hierarchy region.
- **Add Sub PMU:** Adds a new PMU under the currently selected PDC.

  Use this option to configure a system with multiple PMUs included in a PDC. This can be done using **Manually** or **Automatically**. Using **Automatically** will query the available PMUs and enter the name, ID, and tags available. This requires that the PDC input is communicating successfully with the PDC. Verify this on the Real-Time Status page.
- **Copy/Paste:** Copy and Paste PMUs and PDCs that have been created or imported. To simplify configuring a PDC input coming from an SEL-5073 or SEL-3373 and going to a cascaded SEL-5073 or SEL-3373, PDC Assistant supports copying the output configuration

from the upstream project and pasting into the input configuration of the downstream project. During the paste operation, PDC Assistant will map the appropriate settings from the output to an input (of type PDC).

- **Import:** This feature allows the importing of .pdcx files exported from PDC Assistant. Outputs created in PDC Assistant can be exported to a .pdcx, where the file can then be imported as an Input PDC or PMU.
- **Delete:** Remove a PDC or a PMU.

The settings for each PMU are defined in the settings pane:

- **Enabled:** Check this box to enable the input.

  Inputs not enabled reject all inbound connection attempts for security.
- **Station Name:** Input the Station Name for the incoming PMU.

  This must match the station name of the external PMU settings.
- **Station Name Alias:** Allows the user to change the station name of the PMU in the PDC and the PDC output.
- **PMU ID:** Input the PMU ID for the incoming PMU.

  This must match the PMU ID of the external PMU settings.
- **PMU ID Alias:** Allows the user to change the ID of the PMU in the PDC and the PDC output.
- **Data Rate:** Select the data rate of received data from the external PMU.
- **Physical Layer:** Select Ethernet or Serial.

For Ethernet connection, the SEL-5073 and SEL-3373 support TCP, UDP, UDP_T, UDP_U, and UDP_S Transport Protocols. For TCP, the IP address is the address of the external device. For UDP, the IP address is the address of the external device. The command port is the port on the external device that will receive commands, and the data and configuration port is the port on the PDC that will receive data and configuration frames. For UDP_S, the Port setting refers to the port number on the SEL-3373 to which C37.118 data are sent. For UDP_T and UDP_U a command port on the external device and data port on the PDC are required.

Figure 3.15 Supported Protocols

This is some general guidance on using the various protocols. Use TCP to ensure that all data are received (e.g., for archiving). TCP uses handshaking that allows data to be retransmitted if lost in transit. TCP should not be used in high latency (>5 s) situations because disconnects and drops may occur. Use UDP, UDP_T, or UDP_S for applications where it is OK if some data are lost (e.g., visualization). UDP_S is used in applications where users want to ignore all incoming communications (e.g., used on the output of a substation PDC). UDP_S also enables the use of IP multicast. Use UDP_T or UDP_U in applications where you want TCP handshaking for the commands, and want minimal latency added to the data stream.

For serial connection, the baud rate, parity, stop bits, and flow control can be specified.

Figure 3.16 Input Settings Screen—Add PMU

Under Ethernet Configuration, the following settings apply:

- **Transport Protocol:** Select UDP_T, UDP_U, UDP_S, UDP, or TCP.
- **IP Address:** Enter the IP address of the external device to which the PDC will be connecting.
- **Port:** Specify the port the communication will be using. When the transport protocol is set to UDP, UDP_T, or UDP_U, the following settings appear:
  - **Command Port:** Specify the port the PDC will use for communicating commands.
  - **Data Port:** Specify the port the PDC will use for communicating data.
- **Local IP Address:** The IP Address must be an address of one of the interfaces configured on the device (see *Network*). This address is used for all communication to and from this input. Use **Any** to allow the SEL-3373 or SEL-5073 to automatically choose the address to use, or enter the desired IP address. When you are using IP multicasting with UDP_S, you cannot use the **Any** setting.

Discarding Invalid Time-Stamped Data

The PDC uses the time stamps sent in the data stream for time aligning data received. Thus all data received with a common time stamp will be concentrated together and sent out in a superpacket message with that same time stamp.

To increase the robustness of the PDC in accurately concentrating data, the PDC uses a majority voting scheme to discard data with unusual time stamps. The algorithm looks at the time stamps of all the inputs and performs a simple majority vote (each input comprises a single vote) to determine time stamps

that are earlier or later that the other time stamps received. This ensures that data coming in with an erroneous time stamp does not corrupt data with valid time stamps. This algorithm orders time stamps with the earliest being first, thus handling out of order data packets that arrive within the **Waiting Period** specified by the user for each output. This allows the PDC to eliminate PMU data that has an incorrect time stamp (either a time stamp value that is in the future or past—beyond the specified waiting period) due to an error with the PMU clock.

When this condition does occur, the PMU data packet will be zero filled and the PDC will set bits 15, 14, 13, 5, and 4 in the STAT field of the data message to indicate that an incorrect time stamp was received.

PDC Input Redundancy

The PDC supports redundant inputs and output to increase the availability of streaming synchrophasor data for downstream applications. This allows the user to set up redundant PMUs and/or PDCs to improve data availability in cases where one of the inputs is impacted by network outage, clock failure or status irregularities such as invalid data or time quality.

Figure 3.17 System Architecture Showing Redundant PMUs to Improve Data Availability

Figure 3.18 System Architecture Showing Redundant PMUs and PDCs to Improve Data Availability

Input redundancy is configured using the **Inputs** selection located below the Settings tab.

By configuring the **Backup Connection** you can enable redundant inputs. Note that the default setting for the **Backup Connection** is "Disabled." Redundant inputs require that the data stream be identical from both servers, including the same station name, ID code, and data set.

Configuring the Backup Connection

Settings for the **Backup Connection** are identical to the **Primary Connection**, however, there is an additional setting **Fail-Over Period** that allows the user to specify the time to wait before failing over to the backup input. The **Fail-Over Period** can be set from 1 ms to 1 second. Additionally, the user can configure a different physical layer (serial or Ethernet) and a different transport protocol for the backup connection.

The PDC always uses the primary connection unless the quality of the primary connection is less than the backup connection. The PDC uses the following information from the C37.118 message stream to evaluate each data stream and select the best quality data stream:

- Time Quality bits that are part of the FRACSEC field in the data frame
- PMU Data Valid bit (bit 15 of the STAT field in the data frame)
- PMU Error bit (bit 14 of the STAT field in the data frame)
- PMU Sync bit (bit 13 of the STAT field in the data frame)
- Unlocked Time bits (bits 5 and 4 of the STAT field in the data frame)

Figure 3.19 Configuring the Backup Input Connections

Configuring Multicast Inputs

The SEL-3373 and the SEL-5073 support multicast inputs and outputs. Allowable multicast addresses include 224.0.0.0 through 239.255.255.255.

Configuring the PDC for multicast inputs:

- Select UDP_S for the transport protocol.
- Specify which local IP address to use.
- Check the **Enable Multicast** box.
- Enter the desired Multicast Group IP address.

Figure 3.20 Configuring Multicast Inputs

Loading Data Tags

For PMU inputs, use the **Tags** section to select the incoming PMU data. A tag is the name of a data value. For each PMU, select the available tags from the **Edit Tags** button.

The **Edit Tags** dialog button allows loading predefined sets of tag names for each PMU. These names are stored in a device definition file. Several prebuilt device definition files are included with the PDC Assistant software. These files are for IEEE C37.118-2005 compliant devices only.

The device definitions are stored in text files using XML syntax. Device definition files are not required for phasor data concentrators unless they create new tag values (i.e., when cascading multiple SEL-5073 or SEL-3373 PDCs). If a PDC creates a new power calculation result, and this value is used by a subsequent PDC, then a device definition file provides a way to access the new tag value.

Table 3.2 PMU Device Definition Files (Non-SEL PMUs Are Also Included) (Sheet 1 of 2)

PMU	Name of File
ABB-RES521	ABB-RES521.devx
GE-N60	GE-N60.devx
SEL-311C	SEL-311C_1_2_3.devx
SEL-351	SEL-351.devx
SEL-351A	SEL-351A.devx
SEL-351RS	SEL-351RS.devx
SEL-351S	SEL-351S.devx
SEL-411L	SEL-411L.devx
SEL-421-0, SEL-421-1, SEL-421-2, SEL-421-3	SEL-421.devx
SEL-421-4, SEL-421-5	SEL-421_4_5.devx
SEL-451-0, SEL-451-1, SEL-451-2, SEL-451-3	SEL-451.devx
SEL-451-5	SEL-451_5.devx
SEL-487E	SEL-487E.devx
SEL-487V	SEL-487V.devx
SEL-651R-2	SEL-651R-2.devx
SEL-700G	SEL-700G.devx
SEL-751	SEL-751.devx

Table 3.2 PMU Device Definition Files (Non-SEL PMUs Are Also Included) (Sheet 2 of 2)

PMU	Name of File
SEL-751A	SEL-751A.devx
SEL-787	SEL-787.devx
SEL-2431	SEL-2431.devx

Query Button

NOTE: The C37.118 standard requires that printable ASCII characters be used. If the PDC receives tags with non-printable ASCII characters, the characters will be replaced with spaces in the tag name. Additionally, if there are leading and lagging spaces in the name, the PDC will strip them off.

To automatically discover the tags that are available from a PMU, enter the PMU settings of Station Name, PMU ID, Data Rate, and the communications settings of the PMU. Send the settings to the PDC and check the Real-Time page to confirm that the SEL-3373 or SEL-5073 is receiving data from the PMU. Then select the **Query Tags** button. The list of tags will be automatically filled in.

You can also add a new tag using the **New Tag** button (see *Figure 3.21*). By incrementally adding new tags a complete PMU is defined and can be saved. Note that the initial **Validation Error** message that pops up when the **New Tag** button is pressed will go away when the new tag information (e.g., tag type, name) is entered.

Also, after loading the tags, the user can remove the unwanted tags or the tags that are not present in the input stream by simply selecting them and selecting the **Remove** button. Finally the user can also save the selected tags with the **Save Tags** button. See *Figure 3.21* for editing and saving tags. Leaving tags defined that are present in the input stream, but that are not used, has little impact on the PDC's performance.

Figure 3.21 Edit Tags Screen

Figure 3.22 shows the already available tag definition files for SEL PMUs that can be readily used.

Selecting tags that are not present in the input data stream will result in an error message when the tag is used in an output, calculator, or archive.

Figure 3.22 Prebuilt Device Definition Files

Data Tag Aliasing

The PDC allows the user to change the tag name on any input. The new tag name will be used on all downstream data streams and tags that are saved in the local archive or used for calculations in the PDC.

To change a tag name use the **Inputs** selection located below the Settings tab. Then select the **Edit Tags** button. In the **Edit Tags** pop-up window enter the desired tag alias under the column titled Alias for each tag in the table. Remember that all tag references will use these new tag names, thus any downstream PDC will need to be configured to use these tag names. If you do not want to alias a tag, you can leave the alias column empty, and the PDC will output the same tag name that it receives.

Tag	Alias	Description	Units	Type	Quantity Type	Phase
V1LPM	Sullivan_V1	Positive Sequence Voltage	V	Phasor	Voltage	1
VALPM		A Phase Voltage	V	Phasor	Voltage	A
VBLPM		B Phase Voltage	V	Phasor	Voltage	B
VCLPM		C Phase Voltage	V	Phasor	Voltage	C
I1WPM		Positive Sequence Current, W Terminals	A	Phasor	Current	1
IAWPM		A Phase Current, W Terminals	A	Phasor	Current	A
IBWPM		B Phase Current, W Terminals	A	Phasor	Current	B
ICWPM		C Phase Current, W Terminals	A	Phasor	Current	C

Figure 3.23 Enter Tag Alias Names for Each Tag Under the Alias Column

Alias names must conform to the same validation rules that apply to the original tag names, namely:

- Must be printable ASCII
- Must be 16 characters or less
- Must not conflict with other existing tag or alias names in the same PMU
- Must not conflict with built-in tag names **Frequency** or **Dfrequency**

NOTE: The C37.118 standard requires that printable ASCII characters be used. If the PDC receives tags with non-printable ASCII characters, the characters will be replaced with spaces in the tag name. Additionally, if there are leading and lagging spaces in the name, the PDC will strip them off.

Adding a PDC Input

The settings for PDC input are nearly identical to the PMU input. Here the source name can be user-defined and does not need to match the incoming PDC name. But the PDC ID and data rate must match the external PDC settings. Although there is no incoming tag selection for a PDC input, the Inputs page tool bar provides an **Add Sub PMU...** function which provides an option to automatically discover PMUs and associated data tags that are available from a connected PDC. Check the Real-Time page to confirm that the SEL-3373 or SEL-5073 is receiving data from the input PDC before selecting the **Add Sub PMU-->Automatically** option. *Figure 3.24* shows an example PDC input settings.

Figure 3.24 Input Settings Screen—Add PDC

Outputs

Add an output by selecting the **Add Output** option across the top menu bar.

Figure 3.25 Top Menu Bar

Each option is defined as follows:

- **Add Output:** Adds an Output PDC that is user configurable.
- **Copy/Paste:** Copy and paste a PDC Output.
- **Export:** Export a PDC Output that can be imported as a PDC Input into PDC Assistant.

Exporting PDC Output Configuration for Importing to a Downstream PDC

When the output of an SEL-5073 or SEL-3373 is sent to another SEL-5073 or SEL-3373, PDC Assistant provides a feature to simplify the configuration of the downstream PDC. The Output configuration can be exported as an XML file. This file can be transferred (emailed to another site, for example) to the location of the downstream PDC, where it is imported as a PDC Input. Use the following steps for this process:

1. Open the upstream PDC configuration in PDC Assistant.
2. Select **Outputs** on the navigation menu and select the Output to be transferred.
3. Select the **Export** button and supply a filename for the exported file. The extension for PDC export files is .pdcx.
4. Open the downstream PDC configuration in PDC Assistant.
5. Select **Inputs** on the navigation menu.
6. Select the **Import PDC** button and select the exported file.

Note that the IP Address information is purposely stripped from the exported configuration file for security purposes. It will have to be manually entered in the downstream project.

For each output the following settings apply:

- **Enabled:** Check this box to enable the output.

  Outputs that are not enabled will reject any connection attempts and will not send any packets.

- **Output Name:** Select the name that will associate with this set of concentrated data.

  This should be unique for each output.

- **PDC ID:** The ID of the SEL-5073 or SEL-3373.

  This can be the same for more than one output.

- **Data Rate:** Select the data rate of transmitted data from the SEL-5073 SYNCHROWAVE PDC or the SEL-3373 Station PDC for this output.
- **Waiting Period:** The time alignment functionality of the SEL-5073 or SEL-3373 will wait up to this amount of time for all inputs concentrated into this specific output.
- **Phasor Domain:** Select either polar or rectangular.
- **Transport Protocol:** Select TCP, UDP_S, UDP_T, or UDP_U protocol.
- **Port:** For TCP the port number selects the value of the listening port. For details on UDP_S, UDP_T, and UDP_U see *Figure 3.26*.
- **Local IP Address:** This address is used for all communication to and from this output. Use **Any** to allow the SEL-3373 or SEL-5073 to automatically choose the address to use, or enter the desired IP address. When you are using IP multicasting with UDP_S, you cannot use the **Any** setting.

Figure 3.26 Output Settings Screen

Choose **Tags** to select the tags to output. Selecting the **Edit** button will display the **Available Tags** dialog with a list of the available input tags from all of the inputs and calculations. The **Data Rate** setting is constrained to be a common divisor of the data rates of the input data selected. For example, if V1ZPM is received from PMU #1 at a rate of 60 messages per second and VAPM is received from PMU #2 at a rate of 20 messages per second, then the output rate can be set to 20, 10, 5, 2, or 1 messages per second.

The IEEE C37.118-2005 standard allows a maximum configuration frame size of 65536 bytes. This will limit the maximum number of tags available for sending in a single output. If this limit is exceeded, a message is displayed indicating that fewer tags should be selected.

Figure 3.27 shows the tag selection window for an output.

Figure 3.27 Tag Selection Window for an Output

Configuring the Redundant Output Data Stream

The PDC allows the user to configure identical output data streams to be sent to two different downstream PDCs.

Figure 3.28 Configuring the Redundant Output Connection Settings

By configuring the **Redundant Connection Settings** you can enable redundant outputs. Note that the default setting for the **Redundant Connection Settings** is **Disabled**. Additionally, the user can configure a different transport protocol for the backup output.

Configuring Multicast Outputs

The SEL-3373 and the SEL-5073 support multicast inputs and outputs. Allowable multicast addresses include 224.0.0.0 through 239.255.255.255.

NOTE: Data output from the PDC uses IEEE 754 floating point format.

Configuring the PDC for multicast outputs:

- Select UDP_S for the transport protocol.
- Specify which local IP address to use.
- Enable Multicast by checking the **Enable Multicast** check box.
- Enter the desired Multicast Group IP address (224.0.0.0 through 239.255.255.255).

Figure 3.29 Configuring Multicast Outputs

Calculations

The PDC is capable of performing various phasor and analog calculations, including sequence component calculations, phasor and analog value math, phasor and analog value scaling, derivative (dx/dt) calculations, PMU latency measurement, inter-packet latency measurement and separation of phasors into their respective components. To set up these calculations, the first step is to add a calculation group.

Adding a Calculation Group

To add a calculation group, select **Calculations** on the left menu bar, and **Add Calculation Group** on the Calculations menu bar. For each Calculation group, the following settings apply:

- **Target PMU:** Calculation results are included in archives and outputs as additional data tags of the PMU selected as the “Target PMU”.

Figure 3.30 Calculations Screen

Calculation Details

Once the calculation group is added, selecting **Add Calculation** displays a drop-down menu of the calculations available on the PDC. Calculations are split into two categories: mathematical and utility. Select the type of calculation desired.

Mathematical options available include:

- **Power:** Calculates real and reactive power output.
- **Sequence:** Calculates positive-, negative-, and zero-sequence components.
- **Algebra:** Performs addition, subtraction, multiplication and division of phasor or analog values. Phasor value math follows the rules of complex operations.
- **Scaling:** Scales magnitude and angle values by a user-defined constant value.
- **Derivative:** Calculates the rate of change in the analog value between subsequent measured values.

The utility options available include:

- **Network Latency:** Estimates the latency between when the PMU time stamps the data and when the data are received at the PDC. The network latency calculation also supports instantaneous, average, and maximum results.
- **Inter-packet Delay:** Calculates the data packet to data packet delay and provides instantaneous, average, and maximum results.
- **Component:** Separates a phasor into its magnitude and angle components. The component calculator provides magnitude and angle, and real and imaginary values.

Mathematical Calculations

Power Calculations. For each power calculation the following settings apply:

- **Calculation Enabled:** Check box to enable the power calculation.
- **Voltage:** Select the voltage phasor to be used in the power calculation.
- **Current:** Select the current phasor to be used in the calculation.
- **Real Power:** This is the tag name that the PDC will use for the real power calculated.
- **Reactive Power:** This is the tag name that the PDC will use for the reactive power calculated.

Figure 3.31 Power Calculation Example

Sequence Calculations. For each sequence calculation the following settings apply:

- **Calculation Enabled:** Check box to enable the sequence calculation.
- **Quantity:** Select either Voltage or Current for the sequence quantity.
- **Phase A:** This value is automatically populated by the Phase A phasor, if there is only one Phase A voltage or current tag in the Target PMU. If there are multiple Phase A values, select the appropriate phasor from the drop-down.
- **Phase B:** This value is automatically populated by the Phase B phasor, if there is only one Phase B voltage or current tag in the Target PMU. If there are multiple Phase B values, select the appropriate phasor from the drop-down.

- **Phase C:** This value is automatically populated by the Phase C phasor, if there is only one Phase C voltage or current tag in the Target PMU. If there are multiple Phase C values, select the appropriate phasor from the drop-down.
- **Positive Sequence:** Select this to enable the positive-sequence calculation.
- **Positive-Sequence Tag:** The user-defined tag name for the calculated positive-sequence value.
- **Negative Sequence:** Select this to enable the negative-sequence calculation.
- **Negative-Sequence Tag:** The user-defined tag name for the calculated negative-sequence value.
- **Zero Sequence:** Select this to enable the zero-sequence calculation.
- **Zero-Sequence Tag:** The user-defined tag name for the calculated zero sequence value.

Figure 3.32 Sequence Component Calculation Example

Algebraic Calculations. For each algebraic calculation the following settings apply:

- **Calculation Enabled:** Check box to enable the algebraic calculation.
- **PMU for Left Tag:** Select the PMU where the desired tag resides for the operation intended.
- **Left Tag:** Select the phasor tag needed for the desired operation.
- **Operation:** Select the desired operator.
- **PMU for Right Tag:** Select the PMU where the desired tag resides for the operation intended.

- **Right Tag:** Select the phasor tag needed for the desired operation.
- **Calculated Tag Name:** The user-defined tag name to the resulting calculation.

Figure 3.33 Algebraic Calculation Example

Scaling Calculations. For each scaling calculation the following settings apply:

NOTE: The scaling Calculator can be used to alias the frequency and df/dt and convert them into Analogs.

- **Calculation Enabled:** Check box to enable the algebra calculation.
- **Input Tag:** Select the tag desired to be scaled.
- **Magnitude Scale Factor:** The desired factor by which to scale the phasor magnitude.
- **Angle Rotation:** The number of degrees by which to rotate the phasor angle.
- **Calculated Tag Name:** The user-defined tag name to the resulting calculation.

Figure 3.34 Scaling Calculation Example

Derivative Calculations. For each derivative calculation, the following settings apply:

- **Calculation Enabled:** Check box to enable the algebra calculation.
- **Noise Reduction:** Specifies which previous measured value to perform the calculation against.
- **Calculated Tag Name:** Enter the desired tag name for the calculation.

Figure 3.35 Derivative Calculation Example

Utility Calculations

Network Latency. Select the network latency measurements desired. Selections include Instantaneous, Average, and Maximum.

Figure 3.36 Network Latency Example

Inter-Packet Delay. Select the inter-packet delay measurements desired. Selections include Instantaneous, Average, and Maximum.

Figure 3.37 Inter-Packet Delay Example

Component. For each Component calculation, the following settings apply:

- **Calculation Enabled:** Check box to enable the algebra calculation.
- **Phasor:** Select the phasor desired to be separated into its components.
- **Domain:** Specify the domain (polar or rectangular) for the separated components. If **Polar** is selected, the **Angle Format** will be displayed with selections of "–180 to 180 degrees", "0 to 360 degrees", and "–pi to pi radians."

Figure 3.38 Component Separation Example

Archives

The SEL-5073 and SEL-3373 include built-in internal archiving with a high-speed relational database. The SEL-5073 also supports external archiving to local directories, external drives, or other computers on the network.

- Internal archiving maintains a circular buffer of synchrophasor data in a relational database format within the PDC database. These data can later be extracted onto a network storage location in .csv or COMTRADE formats as desired.
- External archiving publishes synchrophasor data directly to a local directory or network storage location at a specified rate and in the desired format.

When the available storage space on the SEL-3373 decreases to a user-specified limit, the alarm contact asserts and remains asserted until more storage space is available. For both SEL-5073 and SEL-3373, archiving stops when the drive is full. Use the archive information on the real-time status display to monitor available local storage space.

To approximate the disk space required for archiving, use the following equation.

Peak Bytes of Archive = [32 + 8 • (number of phasors) + 4 • (number of analogs) + 4 • (digital words) + 4 • (number of frequencies) + 4 • (number of df/dt) + 2 • (number of status tags)] • (86400 seconds/day) • (data rate of archive) • (retention duration of archive in days)

where:

digital words = 0 for no digitals
= 1 for 1 to 16 digitals
= 2 for 17 to 32 digitals

To make more disk space available, decrease the archive retention. The settings for archive retention differ between internal and external archives and are explained in detail in this section.

Set up the database using options from the top menu. Add a triggered archive, a continuous archive, or delete an archive. The archive data remain until they are deleted either manually or by the data retention setting. Multiple archives can be set up and run simultaneously (e.g., continuous and triggered).

Figure 3.39 Archive Menu Bar

Triggered Archive

NOTE: Triggered archives are available for internal archiving.

Data archiving can be done based on an event. The triggered archive starts archiving whenever any one of the trigger bits in any of the PMUs with a tag in the archive is asserted. The PMU settings determine the conditions for setting trigger bits.

Figure 3.40 Triggered Archive—Pre- and Post-Trigger Times

The triggered archive options are as follows:

- **Archive Enabled:** Select to enable storing data into the archive.
- **Archive Name:** Use the archive name to refer to all data from the archive.
- **Waiting Period:** Maximum amount of time to wait for all inputs to be received before archiving a set of time-aligned data.
- **Pre-trigger Duration:** Determine the amount of data to save prior to the trigger condition in units of minutes.
- **Post-trigger Duration:** Determine the amount of data to save after the trigger condition in units of minutes.
- **Archive Retention:** Determine the duration of the archive in days. Data after this time interval is deleted.

➤ **Ridethrough:** This must be less than or equal to the post-trigger duration.

Use this to determine if you want to archive consecutive triggers in a single archive or separately, if a second trigger occurs within the post-trigger duration of the first trigger.

For example, assume that the pre-trigger and post-trigger duration of a triggered archive is 2 minutes and 5 minutes, respectively. Its **Ridethrough** duration is 3. Now if a second trigger occurs within the post-trigger duration of the first trigger then the **Ridethrough** time determines whether the first trigger and second trigger should be archived together or archived separately. If the second trigger occurs within 3 minutes of the first trigger occurrence, then both of the triggers will share a common archive. If the second trigger occurs after 3 minutes of first trigger occurrence, both of the triggers will be archived separately.

Select the archive tags in a manner identical to selecting the output tags.

Figure 3.41 Triggered Archive Settings Screen

Use the **Tags** section for selecting the tags to archive. Selecting the **Edit** button will display the **Available Tags** dialog with a list of the available input tags from all the inputs. Select all of the input tags or a set of tags from this list to archive into the database. A maximum of 800 tags can be stored in a single archive.

Note that for triggered archives the user will not be able to combine data from two or more PMUs that have different message rates. Use **Continuous Archive** to archive data from two or more PMUs that have different rates.

Figure 3.42 Tag Selection Window for Archives

Continuous Archive

The continuous archive starts archiving data when enabled and continues until disabled. The continuous archive options are as follows:

- **Archive Enabled:** Select to enable storing data into the archive.
- **Archive Name:** Use the archive name to refer to all data from the archive.
- **Waiting Period:** Maximum amount of time to wait for all inputs to be received before processing a set of time-aligned data.
- **Data Rate Format:** Messages per minute or Messages per second.
- **Data Rate:** Rate at which the data needs to be archived.
- **Archive Location:** Archive data within the PDC's internal relational database or directly to an external storage location (SEL-5073 only).

Use the **Tag** section for selecting the tags to archive. Selecting the **Edit** button will display the **Available Tags** dialog with a list of the available tags from all the inputs and calculations. From this list select a set of tags to archive into the database.

The **Data Rate** setting is constrained to be less than or equal to the largest common multiple of the data rates of the input data selected. For example, if V1ZPM is received from PMU#1 at a rate of 60 messages per second and VAZPM is received from PMU#2 at a rate of 20 messages per second, then the archive rate cannot be set larger than 20 messages per second.

External Archiving (SEL-5073 Only)

When the **Archive Location** setting is set to **External Archiving**, additional settings are displayed which govern the formatting and collection of the data files.

- **Authentication:** Use the optional authentication settings when specific permission is required to write files to the desired local folder or network storage location. By default, the SEL-5073 will attempt to write to the folder as the default SEL-5073 service user: LocalSystem. The LocalSystem account has limited access to local folders, and no permissions for network locations.
- **User Name:** Specify a user that has the **Modify** permission enabled for the desired target directory.
- **Password:** Specify the password for the specified user.
- **Domain:** Specify a domain to authenticate the specified user against. Leave empty to authenticate locally.

For example, an SEL-5073 residing on Cindy's computer can externally archive to Jim's computer by using Jim's credentials. Or Jim can enable the guest account on his computer and modify the security settings of the folder to grant **Modify** permissions to **Everyone**.

- **File Path:** Specify the path of the local or remote target directory. Use the full UNC path instead of a mapped network drive as part of the Output Path Template. For example, instead of T:\Archives, use \\server\share\Archives.
- **Filename Template:** Configure a file naming scheme from built-in macros and custom text.
- **File Format:** Choose between .CSV or COMTRADE file format.
- **Phasor Format:** Choose between polar, rectangular, or both.
- **Angle Format:** Choose between degree and radian formats.
- **Minutes per file:** Enter the number of minutes of data to be stored in each individual archive file.
- **Number of Files:** Specify the maximum number of files to be stored in the target directory. Once the target directory contains the specified number of files, the External Archive function manages the number of files in the target directory by deleting and replacing the oldest file with the most recent file.

Select the **Unlimited** option to disable External Archive file management.

Figure 3.43 shows an example of continuous external archive settings with some example tags selected.

Figure 3.43 Continuous External Archive Settings

Internal Archiving

When the **Archive Location** setting is set to **Internal**, the **Archive Retention** setting is made available for specifying the duration of the archived data in terms of days. Data after this time interval is deleted. The **Storage Estimate** is also displayed which indicates the amount of estimated space required for the archive. The storage estimate is automatically calculated based on the current settings.

Figure 3.44 shows an example of continuous internal archive settings with some example tags selected.

Figure 3.44 Continuous Internal Archive Settings

Archive Collection Service

NOTE: SEL recommends using the archive collection service to back up the archived data in the PDC. Configure the service so that archived data are saved to a long-term storage location.

The Archive Collection Service (ACS) allows the user to automate the process of collecting archived phasor data from internal archives and storing the collected data on a local or network storage drive. ACS is a separate service running on the host computer and is launched through PDC Assistant. When ACS is running, it periodically (with a period determined by the "Minutes Per File" setting described later) connects to the configured PDC devices and exports archives to the specified location. The ACS logs errors, warnings, and information to the Windows Application Log under the Source "SEL PDC Archive Collection Service". To access the Windows Application Log from the start menu, right-click on (My) Computer, select **Manage**, then select **Event Viewer** and find the Application log.

It is recommended that a specific account be set up on the PDC for the ACS (Archive Collection Service). Set the role for this account to Technician, which is a read-only account on the device. This account should be used only by the ACS, easily allowing any account activity reported in the logs to be traced to the ACS service.

Figure 3.45 Archive Collection Service Menu Option

ACS Options

The following options are available for the ACS:

- **Start Collection Service:** Begin collection of archived phasor data
- **Stop Collection Service:** End collection or archived phasor data
- **Configure Collection Service:** Configure the archive collection parameters

Configure Collection Service

Selecting **Configure Collection Service** displays the following screen:

Figure 3.46 Archive Collection Service Configuration Screen

Under the "PDCs to Collect Archives From" section, the following options are available:

- **Add:** Add a PDC from which to collect archived phasor data. It is recommended that when adding archive collection, the user specifies a different network port than the port that is currently being used for PMU data collection. Using the same port may result in increased data latency.
- **Edit:** Edit the PDC data sources that have been added
- **Remove:** Remove the selected PDC data source
- **Set Collection Time:** Identifies the data time stamp in the archive at which to begin the collection of archived phasor data. Leaving this setting blank initiates the collection of all archived data on the PDC.

Under the "Collection Options" section, the following options are available:

- **Output Path and Suffix Template:** Specify the output path and file name of the archive using a path name template. The Output file can be stored locally, or on a network drive using the following steps:
  - Use the full UNC path instead of a mapped drive letter as part of the Output Path Template. For example, instead of T:\Archives\<DATE>,<TIME> use \\server\share\Archives\<DATE>,<TIME>.

- Set the service up to log in as a network account with appropriate privileges to access the output folder, as follows:

  In PDC Assistant, select the **Manage Service Startup** item under the **Local Services** menu.

  In the Services window that appears, locate the service SEL **PDC Archive Collection Service**. Right-click and select **Properties**.

  Select the Log On tab.

  Select the **This account** radio button and enter the network account name and password.

  Restart the service by right-clicking on the service and selecting Restart.

  Select OK.

- **File Format:** Choose between *.CSV or COMTRADE file format
- **Phasor Format:** Choose between polar, rectangular, or both
- **Angle Format:** Choose between degrees or radians format
- **Minutes Per File:** Enter the number of minutes of data to be stored in each individual archive. The ACS creates individual archive files of the length specified. The initial archive file created will only store data to nearest even increment of the time specified to ensure that the subsequent files created are done so starting at whole number increments on the minute. This is only valid for Continuous archive triggers.

Loggers

Define severity and length of the Internal Log as well as add Syslog destinations by selecting options from the top menu bar.

Figure 3.47 Logger Menu Bar

NOTE: The PDC will store the most recent 50,000 diagnostic logs.

SEL recommends setting **Minimum Severity** to **Error** for normal operation. The internal logger options are as follows:

- **Minimum Severity:** Select the severity level of logs which are displayed. Use this to limit receiving too many less important logs, which could obscure the more important error cases.
- **Maximum Length:** The length in time to save log data.

Figure 3.48 shows an example of internal log settings.

Figure 3.48 Loggers Setting Screen

The settings options to add a Syslog destination are as follows:

- **Name of Destination:** Select a unique name for the destination.
- **IP Address:** The IP address of the log location.
- **Port:** The port of the log location.
- **Minimum Severity:** Select the severity level of logs which are recorded. Use this to limit the receipt of less important logs, which could obscure the more important error cases.

Figure 3.49 shows an example of Syslog destination log settings.

Figure 3.49 Settings for Addition of Syslog Destination

Global Settings

Global settings affect all aspects of the PDC. Any changes to the global settings will restart all inputs, archives, and outputs. Global settings include:

- **Frequency:** This is nominal frequency of the power system to which the input PMUs are connected.
- **Free Disk Space Warning Threshold:** This lets the user set the threshold for available disk space for archiving data. Exceeding this threshold causes a PDC alarm.
- **Maximum Waiting Period:** This sets the maximum waiting period allowed by the PDC. It also is used to limit how long the calculations wait for data.

Figure 3.50 Global Settings Screen

Status

The **Status** menu provides real-time information on the state of the synchrophasor system. The PDC Assistant must be connected to an SEL-5073 SYNCHROWAVE PDC or SEL-3373 Station PDC to receive status information. The connection between PDC Assistant and an SEL-3373 is secured by encryption. The real-time information is displayed for PMU inputs, PDC inputs, outputs, and the archiver.

PDC status provides real-time information and diagnostic logs:

- **Real-Time:** The real-time status is updated every few seconds. Information shown includes input/output connectivity states, PDC/PMU data status, and archive utilization.
- **Diagnostic Logs:** The log status keeps a running history of all PDC initiated diagnostic logs. This information can be sorted by sequence, severity, event, source, data time stamp, event source instance, or log time.

All data being displayed in the status panel (including logs) is updated at least every two seconds. The real-time status definitions follow.

Real-Time

Input Connections

- **Name:** Source Name from the PMU or PDC input settings.
- **PMU or PDC ID:** PDC ID number from the input settings.
- **Connection State: Receiving Data** if connected, **Not Connected** if not connected. See *Section 4: Troubleshooting* for additional information related to the connection state.
- **Time Quality:** Shows the maximum time error as determined by the PMU clock function.
- **Received Data Frames:** Number of data frames received.

Select the + button to the left of the PDC name to access the following real-time information.

- **Latency:** Provides the maximum and average time latency (one minute average) of the data being received on this input. Latency is measured using the local time of the PDC and comparing it with the time-stamped data received.

Other information provided includes the number of data frames, missed data frames, duplicate data frames, past data frames, configuration frames received, and command frames sent.

- **Reset:** The left **Reset** button allows the latency maximum and average values to be reset. The right **Reset** button resets the frame counters.

Figure 3.51 Input Connections Real-Time Status Detail

Input PMUs

- **PMU Name:** Station Name or the PMU Station Name alias from the PMU input settings.
- **PMU ID:** PMU ID number or the PMU ID alias from the PMU input settings.
- **Input Connection:** The input connection which includes this PMU.
- **PMU State: Found** if the PMU is contained in the input connection. **Not Found** if it is not contained in the input connection. See *Section 4: Troubleshooting* for tips associated with a PMU state of **Not Found**.
- **PMU Status:** Indicates if there is invalid PMU data, a PMU error, or PMU synchronization error as per the STAT field of the IEEE C37.118-2005 standard.
- **Unlock Time:** Indicates a range of seconds since loss of synchronization was detected.

By selecting the + button to the left of the PMU Name, the following additional real-time information is available to the user.

- **Timestamp:** Displays the time stamp of the last data received.
- **Frequency:** Displays the measured frequency.
- **df/dt:** Displays the measured change of frequency with respect to time.
- **Phasors:** Displays measured phasor values, both magnitude and angle.
- **Analogs:** Displays measured analog values.
- **Digitals:** Displays measured digital status bits 0 or 1. Nominal is always 0 after the data enters the PDC.

Figure 3.52 Input PMUs Real-Time Status Details

Outputs

- **Server:** Server Name from the PDC output settings.
- **Connection State: Sending Data** if connected, **Not Connected** if not connected.
- **Missing Data:** Indicates whether any data are missing from the output data stream.
- **Sent Data Frames:** Number of data frames sent from that output.

Select the + button to the left of the Server name to access the following real-time information.

- **Network Latency:** Provides the maximum and the average time latency of the data being received on each input. Latency is measured using the local time of the PDC and comparing it with the time-stamped data received. The **Differences** row takes the maximum–minimum of all the inputs. This can be used to set the waiting period setting on the output.
- **Frames:** Provides a count of sent data frames, capability frames (CFG 1 frames), configuration frames (CFG 2 frames) sent, and command frames received. Next to each count is the time stamp of the most recent associated message.

- **Missing Tags:** Provides a per-tag count of missing tags.
- **Reset:** Allows associated statistics and counts to be manually reset to zero.

Figure 3.53 Output Real-Time Status Details

Internal Archives

- **Archive:** Archive Name from the PDC settings.
- **Space Currently Used (MByte):** Approximate amount of space currently used by this Archiver in megabytes.
- **Input Rate (MByte/Hour):** The amount of data received by this Archiver in megabytes per hour. Note that this value is a running average and may not precisely match the instantaneous archive update rate.
- **Space Available:** The amount of space available for archiving data.

External Archives

- **Archive:** Archive Name from the PDC settings.
- **Files:** The estimated number of files currently in the target directory vs the **Number of Files** setting from the PDC settings. A tally of the files written and deleted is shown in parentheses.
- **Operations Backlog:** Total number of pending operations in the external archive process. The operations backlog is sensitive to network and local computer activity. During nominal conditions, this number will not increase over time.

Figure 3.54 Archives Real-Time Status Details

Figure 3.55 Real-Time Status Screen

When initially acquiring the real-time status, it might take a few seconds to initialize the collection.

Figure 3.56 Real-Time Status Screen—Updating Status

Diagnostic Logs

The **Log** menu enables selection of diagnostic information from the SEL-5073 SYNCHROWAVE PDC or the SEL-3373 Station PDC. The diagnostic logs can be exported to a user-defined location using the **Export** button.

Figure 3.57 Diagnostic Logs Tool Bar

NOTE: The PDC will store the most recent 50,000 diagnostic logs.

The log definitions are as follows:

- **Log Time:** Time of the event.
- **Severity**
  - **Debug:** Detailed diagnostic information. This information is not relevant for normal PDC operation.
  - **Informational:** Helpful information regarding the state of the PDC. Logs of informational nature do not indicate a problem.
  - **Warning:** Logs an event that is abnormal in nature but presents no problem for system performance.
  - **Error:** Informs of a problem that must be resolved. The PDC is designed for an embedded environment and therefore automatically recovers from most error cases.
- **Event Source:** Indication of the subsystem (e.g., C37.118 Client, C37.118 Server, Calculator, Communications, Historian, Logging, Security, Settings, or System) related to the log.
- **Event Source Instance:** Instance of the subsystem.
- **Description:** Detailed information regarding the log.
- **Data Timestamp (UTC):** Time stamp of the most recent data received packet related to the log.
- **Event Code:** Coded values of the description for convenient sorting.

Figure 3.58 Diagnostic Log Screen

The diagnostic log includes user activity and error logs seen by the PDC. This user activity is saved in the archive of the PDC (note that to see these logs the user must set the log Minimum Severity to **Informational**).

User activity that is logged in the diagnostic log:

- Logging of user logins to the PDC.
- Logging of user access to the diagnostic logs.
- Logging of a user that clears the diagnostic logs.
- Logging of a software/firmware change.
- Logging of the time/date of settings changes, along with user-defined notes pertaining to the settings change.
- Logging of the PDC starting and stopping. (e.g., PDC initialization complete or PDC shutdown).
- Logging of a user logging out, including a user session time-out.
- Logging of a user account that has been locked out.
- Logging of a user account that is unlocked.

A complete list of all diagnostic logs and details regarding the cause of the log, as well as tips for resolving the log item, is provided in *Appendix B: Detailed Diagnostic Logs*.

Data

The PDC keeps a synchrophasor data history in its internal database. Use the archiver settings to configure the stored data. Then, these data are retrieved and stored on a local computer by the following menu category.

Retrieve Archives: Select the retrieved archive file name, format, and location. Both the archive time range and individual tag names are options for selecting data.

After the SEL-5073 SYNCHROWAVE PDC or the SEL-3373 Station PDC has collected synchrophasor data into its internal relational database, use this menu item to retrieve the archived information. Select an archive by its name from the archive configuration section. The data are available in binary COMTRADE, ASCII COMTRADE, or .csv format.

Figure 3.59 Retrieve Archive Menu Bar

Selecting the archive name provides the user with an archive summary along with the file settings. File settings options are as follows:

- **Filename Template:** User can input the desired name for the file. Also, the file can be named according to the IEEE C37.232 file naming standard. This can be selected by selecting the **IEEE** button.
- **Phasor Format:** Defines the phasor format of the data in the retrieved file. Can be **Polar** or **Rectangular** or **Both**.
- **Angle Format:** Defines the angle format of the data in the retrieved file. Can be **–180° to 180°** or **0° to 360°** or **Radians**.
- **Multiple Files:** Check this box to retrieve the data in multiple files.
- **Minutes per File:** Defines the number of minutes per file when retrieving the data in multiple files.

- **File Format:** Retrieve the data in either **ASCII COMTRADE** or **Binary COMTRADE** or **CSV** formats. Selecting the **Zipped CSV** will zip the .csv file.
- **Output Directory:** The user can specify the destination folder for all the retrieved archive files. By default all the recordings are stored in **C:\Documents and Settings\User\My Documents\PDC Assistant**.

Figure 3.60 Archive Retrieval Screen—File Settings

Archive Filename Templates

When archives are exported to files from the PDC (either manually, using external archiving, or the ACS), it uses filename templates to determine what to name the export files. The template includes user-defined text intermixed with fields. The fields are replaced with actual values at the time the file is written. A field is a text string surrounded by < and >. The allowed fields are:

<DATE> is replaced with the start date of the data.

<DATE4> is replaced with the start date of the data using a 4 digit year.

<TIME> is replaced with the start time of the data.

<TC> is replaced with the "time code" which represents the time-zone as an offset from Universal Time (UT).

<ARCH> is replaced with the archive name.

<DUR> is replaced with the file duration.

<REASON> is replaced with the trigger reason (triggered archives only).

The format (date format, for example) of the field replacement values matches the IEEE C37.232-2007 Standard. The default template matches the file naming recommended in the standard:

<DATE>,<TIME>,<TC>,device,company (where device and company are manually replaced with user-defined text).

It is up to the user to ensure that the names of generated files are unique. This is usually accomplished by including <DATE>, <TIME>, and <ARCH> fields in the template.

The Archive Collection Service allows placing fields as part of the directory name. This allows the user to configure the ACS to create directories based on archive names, dates, times, etc. For example, the following template will create a directory for each archive containing a subdirectory for each date, and place all archive files for that date within the subdirectory:

c:\Archives\<ARCH>\<DATE>\<TIME>

Figure 3.61 Archive Retrieval Screen—Segment Summaries

For each segment under the archive name, the user is provided with the segment summary along with the export file filter options. Export filter options are as follows:

- **Begin:** Defines the begin time for the retrieved data file. By default this is autofilled with the start time of the archive segment shown in the segment summary. The user can also edit this to apply a time filter.
- **End:** Defines the end time for the retrieved data file. By default this is autofilled with the end time of the archive segment shown in the segment summary. The user can also edit this to apply a time filter.

Example: Assume that the begin time and the end time of an archive segment are as shown in *Figure 3.62*.

Figure 3.62 Date Filter Settings for Archive Retrieval

Now, changing the begin time and the end time as shown in *Figure 3.63* will retrieve the data packets archived only in that 1 minute period of time.

Figure 3.63 Date Filter Settings for Archive Retrieval—One Minute Filter

Use the **Tag Selection** menu for selecting the tags to retrieve. The **Available Tags** section shows the list of available tags selected in the archiver settings. Select a set of tags from this list to retrieve them in a file.

If the retrieved archive file appears to be missing some data, here are possible causes:

1. For COMTRADE files, if there are no data for the archive (for example, a trigger has not occurred), a file is still exported but it will be empty.
2. If a tag is selected for the archive that is not being sent by a PMU, then that tag will appear in the archive file but no data will be shown.
3. During a network interrupt, data are not received by the PDC. In this case the data in the archive will depend on the archive file type.
    a. For a .csv file the entire row will be missing, including the time stamp.
    b. For a COMTRADE file, a row is present with proper time stamp, but no data will be shown.
4. The internal message waiting period for the archive is settable. Once this period expires no other data arriving with that time stamp are included in the database. The initial connecting negotiation to a PMU, after settings are changed, could exceed this waiting period and a few values could be missing from the archive at startup.

Administration

- **Device:** Manage firmware updates and other maintenance services when PDC Assistant is connected to a hardware phasor data concentrator. Device administration is not required when connected to a software phasor data concentrator.
- **User Accounts:** Maintain user accounts.
- **Network:** Lets the user set up various network settings for the SEL-3373.

- **General Security:** Lets the user set up various security parameters.
- **LDAP:** Provides the settings needed to configure the PDC for centralized user authentication using LDAP.
- **Certificates:** Lets the user configure the PDC's local certificate chain.

Device

Software version numbers are available here. Use the **Synchronize PDC Date/Time** button shown in *Figure 3.64* to set the date, year, and time of the SEL-3373 to match the local computer time. This option is not available when using SEL-5073 software. When using the external IRIG connection to the SEL-3373, the **Synchronize PDC Date/Time** button sets the year during the commissioning process described under *Commissioning the SEL-3373* in *Section 2*.

Figure 3.64 Device Information Screen

Audit Facility for Ports and Services (SEL-3373 Only)

The SEL-3373 Station PDC allows users to see detailed diagnostic information that includes the status of system performance, network settings, and firewall rules. This is not available to users in the Technician role.

Information provided about the SEL-3373 includes the following:

- PDC firmware version
- PDC Assistant version
- The PDC serial number
- Current date

- CPU usage, memory usage, processes running
- Solid state drive (SSD) usage
- Network connections and ports
- Network card statuses including IP address, netmask, bytes sent and received and other information about the network cards
- Host-to-IP mappings
- Domain name servers
- Routing table information
- Firewall rules used
- SEL SysMon information
- Whitelist antivirus information

Whitelist (SEL-3373 and SEL-3573 Only)

The whitelisting function used by the SEL-3373 and SEL-3573 allows only a preapproved set of tasks to run. This function generates diagnostic logs to indicate object integrity verification failures (whitelist blocking actions). The whitelisting function provides additional status information within the **Detailed Diagnostics** window on the **Device** page.

- Enabled (True(1)/False(0)): Whether whitelisting is enabled. This should always be True. A False indicates a major failure.
- Enforcing (True(1)/False(0)): Whether whitelisting is enforcing. This should always be True. A False indicates a major failure.
- Signature Count (number): This is a static count of the number of objects (executables, libraries, scripts, etc.) that are whitelisted. This only changes between firmware upgrades.
- Files Verified (number): This is a count of the number of objects (executables, libraries, scripts, etc.) that have been whitelisted (processed by SEL Whitelist cryptographic functions) since the last restart. This will increment at various times (when objects are executed, loaded, etc.).
- Cache Hits (number): For use by SEL.
- Cache Success (number): For use by SEL.
- Cache Invalidates (number): For use by SEL.
- Integrity Failures (number): This is a count of the number of objects (executables, libraries, scripts, etc.) that have failed whitelist validation because they were modified. If this number is greater than zero, one or more corresponding diagnostic logs will have been generated, and the PDC should be removed from service and returned to SEL for investigation and restoration.
- Unknown Files (number): This is a count of the number of objects (executables, libraries, scripts, etc.) that have failed whitelist validation because they do not have a signature. If this number is greater than zero, one more or more corresponding diagnostic logs will have been generated, and the PDC should be removed from service and returned to SEL for investigation and restoration.

Firewall (SEL-3573 and SEL-3373 Only)

The SEL-3373 has a built-in firewall that automatically enables only the ports configured by the user. By default, all ports are disabled except for those required by PDC Assistant (TCP 26272). This minimizes the possible ports that can be accessed by unauthorized users, thus improving security. Disabled ports will not respond in any to data sent to them.

Ports are automatically enabled as part of setting up the PDC inputs and outputs. The firewall cannot be manually configured. Specifying the Local IP Address setting in inputs and outputs increases the firewall security by limiting which network interface is allowed through the firewall.

Firewall Configuration

Input connection type:

- TCP: User specifies a remote IP address, and a remote port. Thus, no ports are enabled because only an outbound connection is established.
- UDP: User specifies a remote IP address, the remote device port to receive command frames, and the local port to receive data and configuration frames. Thus, a UDP port now accepts data on the local port that are from the remote IP address. If the **Local IP Address** setting is set to anything except **Any**, then data are only accepted on the set IP address.
- UDP_T and UDP_U: User specifies a remote IP address, a remote port, and a local port. Thus, a UDP port now accepts data on the local port that are from the remote IP address. If the **Local IP Address** setting is set to anything except **Any**, then data are only accepted on the set IP address.
- UDP_S: User specifies a local port. Thus, a UDP port now accepts data on the local port. If the **Local IP Address** setting is set to anything except **Any**, then data are only accepted on the set IP address.

Output connection type:

- TCP: User specifies a local port. Thus, a TCP port now accepts connections to the local port. If the **Local IP Address** setting is set to anything except **Any**, then data are only accepted on the set IP address.
- UDP_T and UDP_U: User specifies a local port, a remote IP address, and a remote port. Thus, a TCP port now accepts connections to the local port from the remote IP address. If the **Local IP Address** setting is set to anything except **Any**, then data are only accepted on the set IP address.
- UDP_S: User specifies a remote IP address, and remote port. Thus, no ports are enabled because there are only outbound data.

NOTE: The firewall is disabled if the password jumper is installed in the SEL–3373.

By default, the firewall will also disable responses to ping requests. This can be configured on a per-interface basis on the **Network Settings** tab. Ping responses are limited to once per second to avoid ping flood security issues.

User Accounts

User Accounts and Passwords

The PDC has user-based accounts to increase the authentication, authorization, and accountability functions of the system. User-based accounts provide the ability to authenticate a user to their identity rather than

to their role. This means that the system knows the identity of the person performing any action on the system, rather than to only which group they belong. Knowing the identity of a user makes event tracking and forensics more accurate. User-based accounts also make password management easier because passwords can be set and changed by individual users or the administrator.

User Accounts Password Requirements

- **Password Length:** Minimum of 8 characters and a maximum of 64 characters.
- **Password Set:** Only ASCII characters allowed. A valid password must have at least one uppercase, one lowercase, one number, and one punctuation/special character.

User Account Rolls

Figure 3.65 User Account Tool Bar

There are three predefined roles for any given user: Administrator, Engineer, and Technician.

- **Administrator:** The Administrator has full permissions including the following:
  Permission to add/edit/remove other users.
  Permission to create/edit/view settings.
  Permission to create/edit/retrieve/delete archives.
  Permission to view status and diagnostics.
  Permission to synchronize PDC time.
  Permission to update firmware.
- **Engineer:** The Engineer has the following permissions:
  Permission to change their own password.
  Permission to create/edit/view settings.
  Permission to create/edit/retrieve/delete archives.
  Permission to view status and diagnostics.
- **Technician:** The Technician has the following permissions:
  Permission to change their own password.
  Permission to view settings.
  Permission to retrieve archives.
  Permission to view status and diagnostics.

  The Technician is allowed to change local settings and save configuration files, however he/she will not be able to send any settings files to the PDC.

Figure 3.66 User Accounts Screen

Multiple Users Logging Into the PDC Assistant

Since the PDC Assistant can be loaded onto multiple computers, it is possible that more than one user can be logged into the PDC simultaneously. The PDC Assistant allows this, but SEL does not recommend this because changes made by one user will not be seen by another user until they log off and log back on.

Resetting Passwords (SEL-5073 Only)

If you are set up as an administrator and forget your password you have two options: contact SEL for help in resetting the password or reload the PDC software.

Network

When PDC Assistant is connected to an SEL-3373, the **Network** button is available on the navigation menu. The **Network** button is not available when using the SEL-5073 software. Selecting this button shows the Network Settings configuration page, as shown in *Figure 3.67*. Incorrectly configuring network settings can cause the SEL-3373 to not be able to communicate with PDC Assistant. If this happens, refer to Password and Networking Reset to reset the network settings.

Figure 3.67 Network Settings Configuration Screen

The SEL-3373 has three Ethernet ports. Each may be configured with one of these options: **Disabled** or **Static**. A disabled port will not allow incoming or outgoing network traffic.

When a port is set to Static, as shown in *Figure 3.67*, the IP address and netmask are set to fixed values. These values are entered on the Network Configuration page. Consult your IT department to determine the appropriate network settings for your network.

You can configure various network settings for the PDC using this page:

- **Gateway:** Specify the IP address of the gateway to use when accessing IP addresses outside the local networks.
- **Primary DNS IP Address:** Specify the IP address of the domain name server to use when resolving the hostname for the LDAP server. If you are not using centralized authentication through LDAP, this setting is not used.
- **Secondary DNS IP Address:** Specify a backup to the primary domain name server. If the primary one fails to resolve the hostname for whatever reason, the secondary one will be used.
- **Hosts:** Explicitly map an IP address of a centralized authentication server to a hostname. See *LDAP on page 3.58* for more details.

General Security

- **Allowed Unsuccessful Login Attempts:** This sets the number of unsuccessful login attempts with an incorrect password that are allowed before the Unsuccessful Login Lockout Timer starts. This locks out the user that has exceeded the number of unsuccessful logins. The default setting is 3. Settable range is 0 to 10. A setting of 0 disables this feature.

- **Unsuccessful Login Lockout Time:** This sets the length of lockout time before a user is allowed to try to log in after exceeding the number of unsuccessful login attempts. The default setting is 10 minutes. Settable range is 1 to 60 minutes.
- **Session Idle Timeout:** This is the amount of idle time with no input activity from a user logged on using the PDC Assistant before the PDC Assistant automatically logs the user out. The default setting is 10 minutes. Settable range is 0 to 60 minutes. A setting of 0 disables this feature.
- **Refresh Period:** This is the time period used to refresh the user credentials with the central server.

  The Refresh Period setting exists to reduce the overhead associated with pulling account information from an LDAP server. The PDC caches this information locally, improving access times. The Refresh Period at which the PDC synchronizes this information can be set from 0 to 24 hours. If the Refresh Period is set to 0, then the PDC synchronizes every time someone logs on. A successful LDAP bind is necessary every time someone logs on, even if the account information is cached locally. The PDC only synchronizes when someone logs on. Thus, a user who stays logged on for longer than the Refresh Period is not affected until they log off and on again.

Figure 3.68 General Security Configuration Screen

LDAP

Centralized User Accounts With LDAP

Many IT departments use Lightweight Directory Access Protocol (LDAP) to manage the users and devices on their corporate networks. LDAP is a powerful and flexible protocol that allows fast information lookups from servers that are optimized for read access. The information stored on LDAP servers can be any type of record-based information that is stored in a directory structure. Examples include user and device lists, phone books, and recipes. The PDC includes LDAP as a mechanism for centralized user management. With LDAP, you can manage users at a central server. When a user who does not have a local account requests access to the PDC, the PDC will poll the central directory to verify that the user is authorized to access the unit (see *Figure 3.69*).

Figure 3.69 Centralized User Authentication Using LDAP

For the PDC to support this behavior, you must configure certain parameters in the PDC to allow it to communicate with your LDAP server. All of these parameters are configurable through the PDC Assistant (SEL-3373 only). To configure LDAP on your PDC, connect to your PDC with the PDC Assistant and use an account with administrative privileges to log on.

To begin, the PDC needs to know how to communicate with your LDAP server. Because this is done using a hostname, you need a method to resolve this hostname to an IP address.

SEL-5073 Only . Generally, this method uses a domain name server (DNS). You can configure a primary and secondary DNS for each network interface card (NIC) on the machine. If an NIC is configured by dynamic host configuration protocol (DHCP), then the DNSs for that NIC may be automatically configured for you.

You can check your DNS setup by opening a command prompt and running:

nslookup <hostname of LDAP server>

This will either return the IP address of your LDAP server, or it will fail. If it fails, the PDC will be unable to communicate with your LDAP server. You need to reconfigure your DNS correctly as described in the preceding paragraphs.

SEL-3373 Only. You can either use a domain name server (DNS) to automatically resolve the hostname to an IP address, or you can explicitly define a mapping from the hostname to the IP address.

DNS (SEL-3373 Only)

You can configure a primary and secondary DNS on the Network settings page in the Administration section.

Figure 3.70 Configuring Primary and Secondary DNS

Explicit Hosts (SEL-3373 Only)

You can configure explicit mappings from hostnames to IP addresses on the Network settings page in the Administration section. Select **Add Host** and fill in the **Host Name** and **IP Address** fields.

Figure 3.71 Configuring an Explicit Host Mapping to IP Address

Now that your PDC can communicate with your LDAP servers, you can configure the PDC to access those servers. Navigate to the LDAP settings page in the Administration section to configure the PDC to access the servers.

Figure 3.72 Configuring the PDC to Access the LDAP Server

To simplify configuration, we have included a form for your LDAP administrators to complete. You can then use the information from that form to populate all the LDAP settings.

LDAP Settings Form

Print the LDAP Settings Form (the form is located at the end of this manual and is also included on the product CD) and give it to your Information Services department. Having this information ahead of time will make setting up the PDC much easier.

LDAP Settings Form

Print the LDAP Settings Form below and give to your Information Services department. Having this information ahead of time will make setting up the PDC much easier.

LDAP Hosts (For the SEL-3373 only) Input these settings on the Network settings page (need at least one):	
Host Name:	IP Address(SEL-3373 only):
Host Name:	IP Address(SEL-3373 only):
LDAP Servers (Input these settings on the LDAP settings page, need at least one):	
Host Name:	Port Number:
Host Name:	Port Number:
LDAP Settings (Input these settings on the LDAP settings page):	
Search Base DN:	
Bind DN (optional, if left blank will use anonymous binds):	
Bind Password (optional, required only if not using anonymous binds):	
User Filter:	
Group Attribute:	
Group To Role Mappings (Required to map users to roles, input these settings on the LDAP settings page, need at least one):	
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:

Figure 3.73 LDAP Settings Form

Enable the LDAP settings by checking the **Enable LDAP** check box. Then, fill out the Primary Host Name and Primary Port. If there are two LDAP servers, configure the Secondary Host Name and Secondary Port to point to the second one.

Use the LDAP Search Base as the root directory from which to begin your user search. Form the search by listing all of the components of the search base separated by commas and going from the most specific component to the broadest component. In *Figure 3.72* the Search Base DN setting is “dc=ldap,dc=local”. In this search base, dc refers to domain component. The domain components combine with “.” to create the search domain. In this case, the search domain is “ldap.local”. Interpret this search base as, “Start the search from the root directory residing on an LDAP server in the ldap.local domain.”

Other common LDAP components are ou and cn. The abbreviation ou is short for organization unit, or directory. cn stands for common name, and is a name that refers to a specific object that may or may not be unique. Examples of common names are groups and usernames.

The PDC supports both authenticated and anonymous binds to your LDAP servers. Authenticated binds use a service account (Bind DN and Bind Password) to access the LDAP server. If the LDAP service account is revoked, or if the password expires, the PDC will be unable to access the LDAP server, and centralized users will be unable to access the PDC. Anonymous binds forgo the use of service accounts. Determine which method your LDAP administrator prefers.

The **User Filter** and **Group Attribute** settings identify the usernames and groups of users. If entered incorrectly, the PDC will be unable to determine which LDAP fields to search for usernames or group membership.

The PDC has specific roles that can be mapped to LDAP group memberships. Select the **Add Mapping** button create a new mapping from an LDAP group DN to a PDC role. It is possible to map more than one LDAP group DN to the same PDC role. It is also possible to map the same LDAP group DN to more than one PDC role; however, only the most permissive PDC role will have an effect. Your server administrator may need to create new groups and assign members appropriate for these mappings. Work with your LDAP administrator to determine group-to-role mappings.

Certificates

For security when transmitting authentication information, such as usernames and passwords, the PDC only supports SSL communication with LDAP servers. The PDC confirms the identity of your LDAP server using the certificate the LDAP server provides and the certificate chain stored locally. The certificate chain, also known as the certification path, is a list of certificates used to authenticate the LDAP server. The chain, or path, begins with the certificate of the LDAP server (the one it provided to the PDC), and each certificate in the chain is signed by the CA identified by the next certificate in the chain. The chain terminates with a root CA certificate, which is always signed by the CA itself. The signatures of all certificates in the chain must be verified by the PDC. The certificate provided by your LDAP server must contain the same hostname used to communicate with your LDAP server. Work with your LDAP administrator to acquire the certificates in the certificate chain.

SEL-3373 Only. You can configure the PDC's local certificate chain by navigating to the Certificate setting page in the Administration section.

Figure 3.74 Configuring the Certificate Chain (SEL-3373 Only)

SEL-5073 Only. The easiest way to add a certificate chain that the PDC can use to verify the certificate the LDAP server provided is by double-clicking on the certificate, selecting **Install Certificate**, and telling the Certificate Import

Wizard to place the certificate in the Trusted Root Certification Authorities certificate store. The PDC's local certificate chain can also be configured through Microsoft's Management Console.

Section 4

Troubleshooting

Overview

If you have trouble getting the SEL-3373 Station PDC or the SEL-5073 SYNCHROWAVE PDC to work, look through this section for a possible solution.

One tool that is very helpful in determining a possible issue is the diagnostic log. Using the **Loggers** tab, set the internal logger event severity to Debug, Send Settings, then go to the **Diagnostic Log** tab and review the logs listed. A detailed listing of the diagnostic logs, causes, causes, and resolution, can be found in *Appendix B: Detailed Diagnostic Logs*.

Not able to ping the SEL-3373:

- The default firewall settings prevent the SEL-3373 from responding to a ping. Using the Network Settings tab, pinging can be enabled on a per-interface basis.
- Check to see if a corporate or local firewall is blocking the ping attempts.

The PDC Assistant will not connect to the PDC (e.g., `Failed to establish a connection`.):

- Check to see if the PDC is running before trying to connect the PDC Assistant.
- Check to see if a corporate or local firewall is blocking the connection attempts.

Real-time status screen says it cannot connect to the PDC and remains grayed out:

- Check to see if the PDC is running.
- Check to see if a corporate or local firewall is preventing the PDC Assistant from connecting with the PDC.

Real-Time status screen shows that an input is `Not Connected`:

- Check to see if the IP address and port number of the input PMU/PDC match those entered into the PDC.
- Check to see if a corporate or local firewall is blocking the connection attempts.

Real-Time status screen shows that an input is `Waiting for Silence`:

- Check to see if the input PMU station name and PMU ID exactly match the station name and PMU ID in the PDC. Common errors include not matching upper and lower case, or not accounting for spaces in the name or after the name. Spaces after the name are not supported.
- Check to see that the message rate of the input PMU matches the receiving rate of the PDC. The diagnostic log will show this information.

Real-Time status screen shows that an input is `Configuring` or toggles between `Configuring` and `Not Connected`:

- Check to see if the input PMU/PDC ID, and/or the transport protocol exactly match between the sending PMU/PDC and the receiving PDC.
- If using the UDP_T or UDP_U transport protocol, make sure that the data port is set correctly.
- If using the UDP_S transport protocol, make sure the port is set correctly.

Real-Time status screen shows that an output is `Missing Data`:

- Check to see if the tag names in the PDC input match the tags sent from the PMU. Looking at the diagnostic log will provide details of missing particular tags. Any missing tags will also be listed in the detailed output status, along with the number of times they have been missed. This can be easily fixed by using the **Query** button to get exactly which tags the PMU is sending.
- This problem can also be caused by late data. If the PMU data arrives too late (exceeds the waiting period set in Outputs) to be time aligned with other PMUs in that output, its tags will be zero filled and considered missing.

Real-Time status screen indicates that a triggered archive is currently using hard drive space even though no event has been triggered.

- This is normal behavior. A triggered archive will use a portion of hard drive space to maintain its pre trigger data buffer.

Real-Time status screen indicates that the Operational Backlog is increasing steadily for a given external archive.

- Check the PDC host machine resource usage from the Performance tab of Windows Task Manager. SEL recommends that the average CPU usage is kept below 50%.
- This problem can also be caused by network congestion or mis-configuration between the PDC host machine and the network storage device.

The PDC is not sending data frames momentarily and then resumes sending data:

- Check the incoming data path. The PDC will not output data if there are no data coming in.

Creating a positive-sequence calculation generates an error:

- Check to see if positive-sequence data tags are being sent from the PMU. Many PMUs provide positive-sequence data tags as part of their output. The SEL-3373 does not allow duplicate tag names. Simply specify a nonconflicting name for the calculated positive-sequence tag, or remove the positive-sequence calculation altogether.

The Archive does not start or data are not being archived:

- Check diagnostic logs to see if there is a large time-stamp (>1 hour) difference between input sources.
- Check to see if the clock in the PDC is within one hour of actual time (corrected from UTC time). The archiver will not archive if the time difference is greater than 1 hour.
- Ensure that the PDC clock time is not set in advance of the time-stamped data (corrected from UTC time).

Archiving stops archiving data for some time:

- Check to see if the disk space is full beyond the set limit. Verify disk space via the diagnostic logs.

The Archive Collection Service is not archiving data to the specified drive/location:

- Check to see that the ACS has been started. Check the PC that is archiving the data. It's time cannot be set in advance of the time-stamped data.

The PDC unexpectedly stops running:

- This is associated with the processor being overburdened during some operation. Probable causes include exporting a large archive or running the ACS service. SEL recommends that the nominal processor loading be kept to 50% to provide adequate overhead for events that can significantly increase the processor burden.

An unexpected communications error in the TCP connection keeps the PMU from reconnecting to the PDC once communication is reestablished:

- Enable the TCP Keep Alive (ETCPKA) setting in the relay or PMU. Using TCP Keep Alive allows the PMU to determine that the connection was interrupted and enable the PDC to reconnect. The only other way to reestablish a connection between the PMU and the PDC is to restart the PMU or make a change in the settings.

When trying to log into the PDC, the PDC Assistant gives the user log-in error `FATAL: 28000: "xxxxxx" account is locked or expired`:

- If your account is locked, but you have not failed to log in, then someone may be trying to log in using your account. Or you may have inappropriately used your account with the ACS and given it a bad password. This can occur if running ACS on the same machine as the PDC Assistant. To remedy the situation, select **Local Services** and turn off ACS service. Wait 10 minutes (default setting for "Unsuccessful Login Lockout Time" or whatever time that this field has been set to) and log in again. It is recommended that the ACS service be set up as a separate user with a "technician" role in user accounts.

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Appendix A

Software/Firmware and Manual Versions

Software/Firmware

Table A.1 lists the software and firmware versions, a description of modifications, and the instruction manual date code that corresponds to these versions. The most recent version is listed first.

Table A.1 Software/Firmware Revision History (Sheet 1 of 4)

Identification Numbers	Summary of Revisions	Manual Date Code
PDC SEL-3373-R116-V7-Z008006-D20191101	➤ Addressed an issue that could prevent connection to servers that use the UDP transport protocol.	20191101
PDC Assistant Software Revision 2.5.0.0	➤ Updated archive file name macro for stricter compliance with IEEE C37.232. ➤ Resolved an issue that could cause a time-out while exporting archived data.	
PDC SEL-3373-R116-V6-Z008006-D20170711	➤ Addressed an issue where the PDC diagnostic log function may exhaust remaining storage space, leading to adverse behavior and a failure to re-enable after a reboot. ➤ Addressed an issue where the PDC could use more than the available storage, leading to adverse behavior and a failure to re-enable after a reboot. ➤ Addressed an issue where previously the PDC would not create a diagnostic log for a firmware upgrade.	20170711
PDC Assistant Software Revision 2.3.0.0	➤ Updated for compatibility with R116-V6 PDC firmware.	
PDC SEL-3373-R116-V5-Z008006-D20160411	➤ Resolved an issue that could cause a time-out during an upgrade.	20160411

Table A.1 Software/Firmware Revision History (Sheet 2 of 4)

Identification Numbers	Summary of Revisions	Manual Date Code
PDC SEL-3373-R116-V4-Z008006-D20151229	➤ Added SEL Whitelisting Antivirus support. ➤ Resolved an issue that could inhibit the calculation of latency and delay calculations. ➤ Resolved an issue that could cause the PDC to restart unexpectedly. ➤ Updated and streamlined the operating system.	20151229
PDC Assistant Software Revision 2.1.0.0	➤ Resolved an issue that inhibited the Device page from displaying the full PDC serial number. ➤ Resolved an issue that disabled a user account if the account password contained a semicolon.	
PDC Assistant Software Revision 2.0.0.0	➤ Enabled device specific settings files. ➤ Integrated LDAP, General Security, and Network settings into the settings file. ➤ Updated file and function icons. ➤ Added an option to disable SSL when connecting to the PDC.	
PDC SEL-3373-R115-V4-Z007005-D20141031	➤ Updated operating system packages. ➤ Disabled SSL versions 2 and 3. ➤ Resolved an issue that prevents the detailed diagnostics window from updating. ➤ Resolved an issue that disables the Real Time status page. ➤ Resolved an issue that disables the PDC when the password jumper is applied. ➤ Resolved an issue that can momentarily block real-time processing, the severity of which can worsen over time.	20141031
PDC SEL-3373-R114-V4-Z007005-D20130920	➤ Added support for IRIG-B000 even-parity format per IEEE-1344 and IEEE C37.118-2005. ➤ Updated operating system packages.	20130920
PDC SEL-3373-R113-V4-Z007005-D20130311	➤ Resolved an issue that prevented anonymous binding when using LDAP centralized authentication. ➤ Resolved an issue in R108 that causes the PDC to stop working when station name aliasing is used and the inputs are intermittent. ➤ Resolved an issue in R112 that can cause the PDC to stop working, exacerbated by an increased number of missing tags in the output. ➤ Resolved an issue that disables the Detailed Diagnostics report after several days of operation.	20130311

Table A.1 Software/Firmware Revision History (Sheet 3 of 4)

Identification Numbers	Summary of Revisions	Manual Date Code
PDC SEL-3373-R112-V4-Z007005-D20121029	➤ Added selectable phasor output format (polar or rectangular). ➤ Added additional calculations, network latency, inter-packet delay, derivatives, and a way to separate the magnitude and angle of a phasor into the two components. ➤ Added the ability to archive latency measurements. ➤ Added UDP transport protocol for input devices. ➤ Improved handling of characters not allowed in the C37.118 message stream (non-printable ASCII characters). ➤ Improved robustness of the PDC Assistant's real-time interface connection to the PDC. ➤ Upon export of COMTRADE files, the PDC differentiates phasor names for magnitude from those for angle. These files now work with ACSELERATOR Analytic Assistant® SEL-5601 Software.	20121029
PDC Assistant Software Revision 1.9.0.0	➤ Enhanced user interface for the new features in the PDC.	
PDC SEL-3373-R111-V4-Z006004-D20120730	➤ Resolved a data loss and compatibility issue caused by the fiber-optic ports attempting to autonegotiate (optional update for units with rear, fiber-optic Ethernet ports).	20120730
PDC SEL-3373-R111-V3-Z006004-D20120217	➤ Added LDAP centralized authentication. ➤ Added Station Name and PMU ID aliasing. ➤ Added network latency measurements and data tag measurements to the real-time status screen. ➤ Added the ability to query data tags for input PMUs or PDCs.	20120217
PDC Assistant Software Revision 1.7.0.0	➤ Enhanced user interface for the new features in the PDC. ➤ Resolved an issue that prevented ACS from archiving COMTRADE data files.	
PDC SEL-3373-R110-V3-Z005003-D20110831	➤ Resolved an issue that allowed the initial administrator account creation to be repeated. ➤ Added setting to allow disabling the Session Idle Timeout feature.	20110831
PDC Assistant Software Revision 1.5.0.0	➤ Enhanced user interface for the new features in the PDC.	

Table A.1 Software/Firmware Revision History (Sheet 4 of 4)

Identification Numbers	Summary of Revisions	Manual Date Code
PDC SEL-3373-R108-V3-Z004003-D20110715	➤ Added input and output redundancy data streams. ➤ Added multicast input and output data stream capability. ➤ Added a majority voting scheme to discard data with unusual timestamps. ➤ Added the ability to alias tag names. ➤ Added several log-in/log-out features to improve security. ➤ Added several user activity items to the diagnostic logs. ➤ Enabled TCP keep alive to assist with detecting unexpected TCP disconnections. ➤ Improved handling of bursts or batches of data packets. ➤ Added firewall capability. ➤ Added audit facility.	20110715
PDC Assistant Software Revision 1.4.0.0	➤ Enhanced user interface for the new features in the PDC.	
PDC SEL-3373-R101-V2-Z003002-D20110114	➤ Added Archive Collection Service. ➤ Added UDP_S protocol for inputs and outputs. ➤ Expanded calculations to include sequence components, phasor and analog algebra, phasor and analog scaling. ➤ Improved latency through PDC.	20110114
PDC Assistant Software Revision 1.3.0.0	➤ Enhanced user interface for the new features in the PDC. ➤ Added “cut and paste” and import of PDC files for faster setup/configuration of PDC.	
PDC SEL-3373-R100-V2-Z002002-D20101201	➤ Additional enhancement to hardware for operating in cold environments.	20101201
PDC SEL-3373-R100-V1-Z002002-D20100929	➤ Improved hardware for operating in cold environments.	20100929
PDC SEL-3373-R100-V0-Z002002-D20100817	➤ Initial version.	20100817
PDC Assistant Software Revision 1.2.0.0	➤ Initial version.	

Instruction Manual

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

Table A.2 lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

Table A.2 Instruction Manual Revision History (Sheet 1 of 3)

Revision Date	Summary of Revisions
20191101	Section 3 ➤ Added notes about diagnostic log retention. ➤ Updated *Table 3.1: Settings Version Map*. Appendix A ➤ Updated for PDC firmware version R116-V7. ➤ Updated for PDC Assistant version 2.5.0.0. Appendix B ➤ Updated entire appendix.
20170711	Section 1 ➤ Added an updated security statement. Section 3 ➤ Updated *Table 3.1: Settings Version Map*. Section 4 ➤ Added additional details on Whitelist function status indicators. Appendix A ➤ Updated for PDC firmware version R116-V6. Appendix C ➤ Added *Appendix C: Network Ports and Services*.
20160411	Appendix A ➤ Updated for PDC software version R116-V5.
20151229	➤ Updated all figures. Section 1 ➤ Updated *Specifications*. Section 3 ➤ Added new *Table 3.1: Settings Version Number mapping*. ➤ Added settings description for the External Archive function. ➤ Added *Figure 3.43: Continuous External Archive Settings* and F*igure 3.44: Continuous Internal Archive Settings*. ➤ Created Section 4 as a dedicated Troubleshooting section. Appendix A ➤ Updated for PDC software version R116. ➤ Updated for PDC Assistant software version 2.1.0.0.
20141031	Appendix A ➤ Updated for PDC software version R115.
20130920	Appendix A ➤ Updated for PDC software version R114.
20130311	Appendix A ➤ Updated for PDC software version R113.

Table A.2 Instruction Manual Revision History (Sheet 2 of 3)

Revision Date	Summary of Revisions
20121029	Section 1 ➤ Added Calculations to the list in *Features*. ➤ Added *PDC Assistant Configuration Software Requirements* in *Specifications*. ➤ Updated *Output Data Ports* and *Calculations* in *Specifications*. Section 2 ➤ Updated *Figure 2.1: Dimensions Diagram*. Section 3 ➤ Updated to reflect new capability added in this release. ➤ Added new project file information in *File and Connection Management Menu Bar*. ➤ Added *Figure 3.5: Device Setting Version Number*. ➤ Changed the caption for *Figure 3.6* to *Connection Dialog Box Information*. ➤ Added User Domain icons and their descriptions in *Status Bar*. ➤ Added references to UDP in *Inputs*. ➤ Updated the UDP_S portion of *Figure 3.14: Supported Protocols*. ➤ Added Note in *Query Button* and *Data Tag Aliasing*. ➤ Added Phasor Domain setting description in *Exporting PDC Output Configuration for Importing to a Downstream PDC*. ➤ Updated *Figure 3.25: Output Settings Screen*. ➤ Updated *Figure 3.26: Tag Selection Window for an Output*. ➤ Updated *Calculations*. ➤ Added the following figures in *Calculations*: *Figure 3.34: Derivative Calculation Example*, *Figure 3.35: Network Latency Example*, *Figure 3.36: Inter-Packet Delay Example*, and *Figure 3.37: Component Separation Example*. ➤ Added Maximum Waiting Period description and updated *Figure 3.48: Global Settings Screen* in *Global Settings*. ➤ Updated *Figure 3.49: Input Connections RT Status Detail* and *Figure 3.51: Output Real-Time Status Details* in *Status*. ➤ Added UDP input connection type in Firewall Configuration. ➤ Added Network, General Security, LDAP, and Certificates in Administration. ➤ Updated Troubleshooting. Appendix A ➤ Updated for PDC software version R112. ➤ Updated for PDC Assistant software revision 1.9.0.0. Appendix B ➤ Added this appendix, which includes a list of diagnostic logs.
20120730	Appendix A ➤ Updated for PDC software version R111-V4.
20120217	Section 1 ➤ Updated to include LDAP information. ➤ Updated *Figure 1.3: Large-Scale System Architecture Regional Control Centers*. ➤ Updated *Specifications*. Section 2 ➤ Updated IRIG-B input support and alarm threshold for archives. Section 3 ➤ Updated to reflect new capability added in this release. ➤ Added *Troubleshooting* section. Appendix A ➤ Updated for PDC software version R111. ➤ Updated for PDC Assistant software revision 1.7.0.0.

Table A.2 Instruction Manual Revision History (Sheet 3 of 3)

Revision Date	Summary of Revisions
20110831	Section 3 ➤ Updated Session Idle Timeout information in *Global Settings*. Appendix A ➤ Updated for PDC software version R110. ➤ Updated for PDC Assistant software revision 1.5.0.0.
20110715	➤ Updated for PDC software version R108. ➤ Updated for PDC Assistant software revision 1.4.0.0.
20110114	➤ Updated for PDC software version R101. ➤ Updated for PDC Assistant software revision 1.3.0.0.
20101201	➤ Updated for hardware version V2.
20100929	➤ Updated for hardware version V1.
20100817	➤ Initial version.

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Appendix B

Detailed Diagnostic Logs

This section provides additional details on each diagnostic log that may appear on the Diagnostic Logs page of PDC Assistant.

Note that in the **Message** column in *Table B.1*, italicized variables, such as *xx*, indicate specific text that varies depending on what the situation is that prompts the message. Different variables in the same message, such as *xx* and *xy*, indicate different text within the same message.

Table B.1 Detailed Diagnostic Logs (Sheet 1 of 18)

Event	Source	Severity	Message	Cause	Resolution
100	Logging	ERROR	Communications Failure: Message=*xx*	Internal error.	Contact SEL.
101	Logging	ERROR	Deserialization Failure: Message=*xx*	Internal error.	Contact SEL.
102	Logging	ERROR	Standard exception occurred. Error message: *xx*	Internal error.	Contact SEL.
103	Logging	ERROR	Unhandled exception occurred.	Internal error.	Contact SEL.
120	Logging	ERROR	*xx*	An executable has failed its whitelist antivirus verification.	Contact SEL.
121	Logging	ERROR	Exception: *xx*	Internal error.	Contact SEL.
122	Logging	ERROR	Mandatory Access Control Violation: raw=*xx*	An executable has attempted to do something it is not allowed to do and has violated its mandatory access controls.	Contact SEL.
190	Logging	ERROR	Failed to Format: Event Code=*xx* Message=*yy*	Internal error.	Contact SEL.
191	Logging	ERROR	Failed to Emit: Event Code=*xx* Message=*yy*	Internal error.	Contact SEL.
200	Logging	ERROR	Database Error: State=*xx* Message=*yy*	Internal error.	Contact SEL.
201	Logging	ERROR	Error: Message=*xx*	Internal error.	Contact SEL.
202	Logging	ERROR	Error: Message=Unknown	Internal error.	Contact SEL.
203	Logging	WARNING	Logs Deleted: Reason=Retention period expired. Logs Deleted=*xx*	Old logs have been deleted.	No resolution is required. (*Optional*) Increase maximum length of the internal log on the Loggers page.

Table B.1 Detailed Diagnostic Logs (Sheet 2 of 18)

Event	Source	Severity	Message	Cause	Resolution
204	Logging	WARNING	Logs Deleted: Reason=Maximum total log size exceeded. Current Size (bytes)=*xx* Maximum Size (bytes)=*yy* Logs Deleted=*zz*	Old logs have been deleted.	No resolution is required.
220	Logging	ERROR	Communications Failure: Message=*xx*	Internal error.	Contact SEL.
221	Logging	ERROR	Serialization Failure: Message=*xx*	Internal error.	Contact SEL.
222	Logging	ERROR	Standard exception occurred. Error message: *xx*	Internal error.	Contact SEL.
223	Logging	ERROR	Unhandled exception occurred.	Internal error.	Contact SEL.
230	Logging	ERROR	Communication Failure: Message=*xx*	The syslog destination was not reachable.	Check if the syslog destination is up and running.
					Check the network between the PDC and the syslog destination for disruptions or connectivity issues.
400	System	DEBUG	Exception: *xx*	Internal error.	Contact SEL.
401	System	DEBUG	Exception: Unknown	Internal error.	Contact SEL.
402	System	WARNING	Invalid tag: Tag=*xx*	The diagnostic requested does not exist in the PDC.	Check the name of the diagnostic requested to make sure it matches a diagnostic provided by the PDC.
				Internal error.	Contact SEL.
1000	System	ERROR	Unhandled exception occurred.	Internal error.	Contact SEL.
1001	System	INFORMATIONAL	Upgraded to PDC Firmware Version: *xx*	The firmware was upgraded.	No resolution is required.
1200	PDC	INFORMATIONAL	The PDC is initializing...	The PDC is initializing.	No resolution is required.
1201	PDC	INFORMATIONAL	PDC Information: Version=*xx*	The PDC is initializing.	No resolution is required.
1202	PDC	INFORMATIONAL	The PDC initialization is complete.	The PDC is running.	No resolution is required.
1203	PDC	INFORMATIONAL	The PDC is shutting down...	The PDC is turning off.	No resolution is required.
1204	PDC	INFORMATIONAL	The PDC shutdown is complete.	The PDC is off.	No resolution is required.
1205	PDC	ERROR	Fatal error exception occurred in *xx*: *yy*	Internal error.	Contact SEL.
1206	PDC	ERROR	Nonfatal error exception occurred in *xx*: *yy*	Internal error.	Contact SEL.
1207	PDC	ERROR	Exception: *xx*	Internal error.	Contact SEL.
1250	Logging	INFORMATIONAL	The Log System is initializing...	Logging is initializing.	No resolution is required.

Table B.1 Detailed Diagnostic Logs (Sheet 3 of 18)

Event	Source	Severity	Message	Cause	Resolution
1251	Logging	INFORMATIONAL	The Log System initialization is complete.	Logging is running.	No resolution is required.
1252	Logging	INFORMATIONAL	The Log System is shutting down...	Logging is turning off.	No resolution is required.
1253	Logging	INFORMATIONAL	The Log System shutdown is complete.	Logging is off.	No resolution is required.
1254	Logging	ERROR	Fatal error exception occurred in *xx*: *yy*	Internal error.	Contact SEL.
1255	Logging	ERROR	Nonfatal error exception occurred in *xx*: *yy*	Internal error.	Contact SEL.
1300	Monitors	INFORMATIONAL	Version=*xx*	Monitoring has started.	No resolution is required.
1301	Monitors	ERROR	Exception: *xx*	Internal error.	Contact SEL.
1302	Monitors	ERROR	Temperature *yy*: Where=*xx* Value=*zz* Nominal=[*xxy*,*xxz*]	The PDC is too hot.	Provide proper spacing around the PDC for air flow.
				The PDC is too cold.	Provide heating to meet the minimum temperature requirements of the PDC (see *Operating Temperature on page 1.6*).
				The PDC is no longer too hot or too cold.	No resolution is required.
1400	System	DEBUG	Caught an exception: *xx*	Internal error.	Contact SEL.
1401	System	ERROR	Shutting down the PDC do to overburden. Please modify settings to reduce burden.	The PDC was overburdened. This can occur when too many inputs, outputs, calculations, archives, etc. are specified in the settings.	Reduce the number of inputs, outputs, calculations, archives, etc.
1402	System	WARNING	CPU burden is high. Please modify settings to reduce burden.	The PDC is nearly overburdened. This can occur when too many inputs, outputs, calculations, archives, etc. are specified in the settings.	Reduce the number of inputs, outputs, calculations, archives, etc.
1500	System	INFORMATIONAL	Updating firewall rules and exceptions.	The firewall settings have changed.	No resolution is required.
1501	System	DEBUG	Caught an exception: *xx*	Internal error.	Contact SEL.
1502	System	INFORMATIONAL	Initialized firewall.	The firewall has established a baseline set of rules.	No resolution is required.
1503	System	ERROR	Initialization Failure: Reason=*xx*	Internal error.	Contact SEL.
1504	System	WARNING	Default initialized firewall.	The password jumper is set, and the firewall is essentially disabled.	No resolution is required.
					(*Optional*) Remove the password jumper and turn the PDC off and then back on.
1505	System	ERROR	Default Initialization Failure: Reason=*xx*	Internal error.	Contact SEL.

Table B.1 Detailed Diagnostic Logs (Sheet 4 of 18)

Event	Source	Severity	Message	Cause	Resolution
1506	System	DEBUG	Allowing pings on interface *xx*.	The network settings allow for pings on the network interface.	No resolution is required. (*Optional*) Uncheck the **Allow Ping** setting on the network interface on the Network Settings page.
1507	System	ERROR	ICMP (Ping) Exception Failure: Interface=*xx* Reason=*yy*	Internal error.	Contact SEL.
1508	System	DEBUG	No longer allowing pings on interface *xx*.	The network settings no longer allow for pings on the network interface.	No resolution is required. (*Optional*) Check the **Allow Ping** setting on the network interface on the Network Settings page.
1509	System	ERROR	ICMP (Ping) Disallow Failure: Interface=*xx* Reason=*yy*	Internal error.	Contact SEL.
1510	System	WARNING	No network interface could be associated with *xx*. Defaulting to any interface.	The IP address specified did not match any of the IP addresses bound to any of the network interfaces.	Check the input or output settings to make sure the IP addresses are correct. Check the IP addresses assigned to the network interfaces to make sure they are correct.
1511	System	ERROR	Calculated interface *xx* for local address *yy* and interface *zz* for address *xxy*. These should be the same. Defaulting to any interface.	The local IP address specified in either an input or an output did not match any of the IP addresses bound to any of the network interfaces.	Change the **Local IP Address** setting of the input or output. Change the IP address of a network interface to match the **Local IP Address** setting of the input or output.
1512	System	DEBUG	Added a firewall exception for: Protocol: *xx* Local IP: *yy* Local Port: *zz* Remote IP: *xxy* Interface: *xxz*	A new firewall rule was created allowing network traffic into the PDC.	No resolution is required.
1513	System	ERROR	Exception Failure: Protocol=*xx* Local IP=*yy* Local Port=*zz* Remote IP=*xxy* Interface=*xxz* Reason=*yyy*	Internal error.	Contact SEL.
1514	System	DEBUG	Deleted a firewall exception for: Protocol: *xx* Local IP: *yy* Local Port: *zz* Remote IP: *xxy* Interface: *xxz*	A firewall rule was removed, disallowing network traffic into the PDC.	No resolution is required.

Table B.1 Detailed Diagnostic Logs (Sheet 5 of 18)

Event	Source	Severity	Message	Cause	Resolution
1515	System	ERROR	Disallow Failure: Protocol=*xx* Local IP=*yy* Local Port=*zz* Remote IP=*xxy* Interface=*xxz* Reason=*yyy*	Internal error.	Contact SEL.
1600	System	INFORMATIONAL	Setting change detected.	Settings were changed.	No resolution is required.
1601	System	WARNING	Password jumper is installed.	The password jumper is installed.	Remove the password jumper and turn the PDC off and then back on.
1602	System	DEBUG	Caught an exception: *xx*	Internal error.	Contact SEL.
1603	System	WARNING	The initial setup user account is enabled.	The password jumper is installed.	Remove the password jumper and turn the PDC off and then back on.
				The PDC has not been commissioned (no administrator account created).	Create an administrator account.
1604	System	INFORMATIONAL	Updated the device time to *xx*.	The PDC was time-synced by PDC Assistant.	No resolution is required.
1605	System	WARNING	Enabling SSH access.	The firmware was upgraded, which requires the use of SSH access.	No resolution is required.
1606	System	INFORMATIONAL	Disabling SSH access.	The firmware was upgraded, which requires the use of SSH access.	No resolution is required.
1607	System	ERROR	Time Update Failure: Requested Time=*xx* Reason=*yy*	Internal error.	Contact SEL.
1609	System	ERROR	Starting upgrade process.	The firmware was upgraded.	No resolution is required.
1700	System	INFORMATIONAL	Updating network settings.	The network settings changed.	No resolution is required.
1701	System	DEBUG	Caught an exception: *xx*	Internal error.	Contact SEL.
1702	System	ERROR	Failed to set the default gateway: Gateway=*xx* Reason=*yy*	Internal error.	Contact SEL.
1703	System	DEBUG	*xx* has been disabled.	A network interface was disabled.	No resolution is required.
1704	System	ERROR	Failed to disable *xx*: Reason=*yy*	Internal error.	Contact SEL.
1705	System	DEBUG	*xx* set to ip=*yy*, netmask=*zz*.	A network interface was configured.	No resolution is required.
1706	System	ERROR	Failed to configure interface: Interface=*xx* IP=*yy* Netmask=*zz* Reason=*xxy*	Internal error.	Contact SEL.

Table B.1 Detailed Diagnostic Logs (Sheet 6 of 18)

Event	Source	Severity	Message	Cause	Resolution
1707	System	DEBUG	Added a mapping from host name *xx* to IP address *yy*.	A host mapping was configured.	No resolution is required.
1708	System	DEBUG	Added domain name server at IP address *xx*.	A domain name lookup server was configured.	No resolution is required.
1709	System	ERROR	Failed to update the domain name servers: Reason=*xx*	Internal error.	Contact SEL.
1710	System	ERROR	Failed to add the hostname to the hosts file: Reason=*xx*	Internal error.	Contact SEL.
1711	System	DEBUG	Default gateway has been disabled.	The default gateway was removed.	No resolution is required.
1712	System	ERROR	Failed to disable default gateway: Reason=*xx*	Internal error.	Contact SEL.
1713	System	DEBUG	Default gateway set to *xx*.	The default gateway was configured.	No resolution is required.
1714	System	INFORMATIONAL	Updating network settings to their defaults.	The password jumper is installed, and the network interfaces are configured with their default factory settings.	Remove the password jumper and turn the PDC off and then back on.
1715	System	ERROR	Failed to clear domain name servers: Reason=*xx*	Internal error.	Contact SEL.
1716	System	ERROR	Failed to clear hosts: Reason=*xx*	Internal error.	Contact SEL.
1800	System	INFORMATIONAL	Updating certificates.	The certificate settings have been changed.	No resolution is required.
1801	System	DEBUG	Caught an exception: *xx*	Internal error.	Contact SEL.
1802	System	DEBUG	Added the *xx* certificate.	A certificate has been added to settings.	No resolution is required.
1803	System	ERROR	Failed to open the certificate file for writing.	Internal error.	Contact SEL.
2000	Communications	DEBUG	Failed to set send buffer size, *xx*, *yy*	Internal error.	Contact SEL.
2001	Communications	DEBUG	Failed to set receive buffer size, *xx*, *yy*	Internal error.	Contact SEL.
2002	Communications	DEBUG	Failed to disable the Nagle algorithm, *xx*, *yy*	Internal error.	Contact SEL.
2003	Communications	DEBUG	CRC failed on C37.118 frame	Data were corrupted by the network equipment, cables, or software.	Identify what is causing the issue and address. This is not caused by the PDC but is a symptom of an external problem.
				The upstream device did not correctly calculate the CRC.	This indicates a bug in, or an incompatibility with, the upstream device.

Table B.1 Detailed Diagnostic Logs (Sheet 7 of 18)

Event	Source	Severity	Message	Cause	Resolution
2004	Communications	DEBUG	Invalid C37.118 frame data detected	The wrong version of IEEE C37.118 was used. The PDC only supports the 2005 version.	Use only IEEE C37.118-2005-compatible upstream and downstream devices.
				The IEEE C37.118 message type was not valid. The PDC only supports data, header, CFG1, CFG2, and command messages.	Check with the manufacturer of the upstream or downstream device for known issues or incompatibilities.
2005	Communications	WARNING	Not connected	An upstream or downstream device disconnected on purpose.	Reconnect the upstream or downstream device.
				An upstream or downstream device disconnected unexpectedly.	Check for network equipment issues such as cables, switches, routers, etc.
					Check for network software issues such as firewall or packet shaping.
					Check the downstream device for any failures.
				The PDC is unable to connect to either the upstream or downstream device.	Check for network equipment issues such as cables, switches, routers, etc.
					Check for network software issues such as firewall or packet shaping.
2006	Communications	ERROR	Failed to Open: What=*xx* Code=*yy* Category=*zz* Message=*xxy*	Internal error.	Contact SEL.
2007	Communications	ERROR	Failed to Bind: Address=*xx*:*yy* What=*zz* Code=*xxy* Category=*xxz* Message=*yyy* Note=Make sure the local address is valid and the port is not in use by another program.	Internal error.	Contact SEL.
2008	Communications	ERROR	Failed to Listen: What=*xx* Code=*yy* Category=*zz* Message=*xxy*	Internal error.	Contact SEL.
2009	Communications	ERROR	Failed to Close: What=*xx* Code=*yy* Category=*zz* Message=*xxy*	Internal error.	Contact SEL.

Table B.1 Detailed Diagnostic Logs (Sheet 8 of 18)

Event	Source	Severity	Message	Cause	Resolution
2010	Communications	ERROR	Failed to bind to *xx*. Make sure the local address is valid.	The local IP address specified in either an input or an output did not match any of the IP addresses bound to any of the network interfaces.	Change the **Local IP Address** setting of the input or output. Change the IP address of a network interface to match the **Local IP Address** setting of the input or output.
2011	Communications	ERROR	Failed to set keep alive, *xx*, *yy*	Internal error.	Contact SEL.
2012	Communications	ERROR	Failed to set keep alive parameters	Internal error.	Contact SEL.
2013	Communications	ERROR	Failed to set keep alive parameters: *xx* – *yy*	Internal error.	Contact SEL.
2014	Communications	ERROR	Failed to join the multicast group. Make sure the local IP address (*xx*) is one of *yy*.	The local IP address specified in the input did not match any of the IP addresses bound to any of the network interfaces.	Change the **Local IP Address** setting of the input. Change the IP address of a network interface to match the **Local IP Address** setting of the input.
2015	Communications	ERROR	Failed to join the multicast group.	The local IP address specified in the output did not match any of the IP addresses bound to any of the network interfaces.	Change the **Local IP Address** setting of the output. Change the IP address of a network interface to match the **Local IP Address** setting of the output.
2016	Communications	ERROR	Failed to open socket: *xx*	Internal error.	Contact SEL.
2100	C37.118	WARNING	A *xx* overflow occurred while converting *yy* into an integer. Value (Before Scaling): *zz* Scaling: *xxy* Value (After Scaling): *xxz yyy yyz*: *yyz zzy*: *zzz*	The phasor being converted into Polar format was too close to the extremes (min. or max.) to fit into the new format.	Specify **Rectangular** as the phasor domain in the output. The Rectangular domain is larger than the Polar domain.
2101	C37.118	DEBUG	*xx* output as an irregular floating point number: *yy*	Converting the phasor into Polar format exceeded what can normally be expressed in a floating-point number.	Specify **Rectangular** as the phasor domain in the output. This will result in skipping the conversion to polar.
2102	C37.118	ERROR	Failed to convert the fractional seconds to a new time base: Fractional Second: *xx* Original Time Base: *yy* New Time base: *zz*	Converting the fractional seconds into SI units failed because the upstream device sent a CFG2 with an invalid time base.	This indicates a bug in, or an incompatibility with, the upstream device.
2200	C37.118 Server	WARNING	A C37.118 frame was received, but it wasn't a C37.118 command frame It was a C37.118 *xx* frame. This is unexpected and could mean the remote client is not properly configured.	The downstream device is not a valid IEEE C37.118 client or is incompatible.	Check with the manufacturer of the downstream device for known bugs or incompatibilities.

Table B.1 Detailed Diagnostic Logs (Sheet 9 of 18)

Event	Source	Severity	Message	Cause	Resolution
2201	C37.118 Server	WARNING	A C37.118 command frame was received, but it was too small to be valid. It was *xx* bytes in length. This is unexpected and could point to an issue with the remote client.	The downstream device is not a valid IEEE C37.118 client or is incompatible.	Check with the manufacturer of the downstream device for known bugs or incompatibilities.
2202	C37.118 Server	WARNING	A C37.118 command frame was received, but it contained an un-expected Id code. It was *xx*. The expected Id code is *yy*. Check the settings of the remote client and make sure it is using *yy* as its Id code. Or change the expected Id code of this output.	The downstream device sent a command to the output that had an ID code different from the ID code specified in the output settings.	Change the ID code of the downstream device to match the ID code of the output. Change the ID code setting of the output to match the ID code expected of the downstream device.
2203	C37.118 Server	INFORMATIONAL	A C37.118 command frame was received, but it contained a command that is not supported. It was *xx*.	The PDC only supports the stop, start, capability request, and configuration request commands.	Check the downstream device to see why it is sending that command and whether it is needed.
2204	C37.118 Server	ERROR	Connect Failed: Code=*xx* Category=*yy* Message=*zz*	The downstream device disconnected either on purpose or accidentally.	Check the downstream device to see why it disconnected. Check the network between the PDC and the downstream device for disruptions or connectivity issues.
2205	C37.118 Server	DEBUG	Waiting for reconnect.	The PDC is waiting for the downstream device to connect.	Check the downstream device to see why it is not connecting. Check the network between the PDC and the downstream device for disruptions or connectivity issues.
2206	C37.118 Server	ERROR	Attempted to send a frame that was too big for the C37.118 protocol. Adjust the settings of this server to reduce the frame size.	The total frame size for any IEEE C37.118 message is limited to 65,536 bytes, but the specified settings would require a larger frame than that.	Reduce the number of PMUs or tags in the output.

Table B.1 Detailed Diagnostic Logs (Sheet 10 of 18)

Event	Source	Severity	Message	Cause	Resolution
2207	C37.118 Server	ERROR	Missing data.	The upstream device and the input settings do not agree on what PMUs or tags should be included in the data.	Check the settings of the upstream device to make sure it is sending all the expected data.
					Change the PMU or tag names in the input settings to be identical to what the upstream device is providing, or you can use the **Query Tags** button and the **Add Sub-PMU > Automatically** button to direct the PDC to fill out the names exactly as it reads them.
				A whole PMU or an individual tag arrived too late to be included in an output.	Increase the output waiting period to allow for late arriving PMUs and tags, or investigate the cause of the latency.
				Due to the asynchronous nature of settings changes, it is possible for parts of the system to start in the middle of a data set and miss the data that came before.	No resolution is required. This issue should only occur briefly at startup or when settings are changed.
2300	C37.118 Client	ERROR	Data Rate Mismatch: Encountered=*xx* Expected=*yy*	The upstream device is providing data at a faster rate than specified in the input settings.	Change the data rate of the upstream device or the data rate setting in the input to be the same.
2301	C37.118 Client	ERROR	Configuration PDC Id Code Mismatch: Encountered=xx Expected=*yy*	The upstream device sent a CFG2 to the input that had an ID code different from the ID code specified in the input settings.	Change the ID code of the upstream device or the ID code setting of the input to the same ID.
2302	C37.118 Client	ERROR	Nominal Frequency Mismatch: Encountered=*xx* Expected=*yy*	The upstream device sent a CFG2 to the input that had a nominal frequency that was different than the global nominal frequency setting.	The nominal frequency is a global setting and must be the same for all inputs and the upstream device.
2303	C37.118 Client	ERROR	Data PDC Id Code Mismatch: Encountered=*xx* Expected=*yy*	The upstream device sent data to the input that had an ID code different from the ID code specified in the input settings.	Change the ID code of the upstream device or the ID code setting of the input to the same ID.
2304	C37.118 Client	ERROR	Configuration PMU Id Code Mismatch: PMU=*xx* Encountered=*yy* Expected=*zz*	The upstream device sent a CFG2 to the input that had a PMU with a different ID code than the ID code specified in the PMU in the input settings.	Change the ID code of the PMU in the upstream device or the ID code setting of the PMU in the input to the same ID.

Table B.1 Detailed Diagnostic Logs (Sheet 11 of 18)

Event	Source	Severity	Message	Cause	Resolution
2305	C37.118 Client	WARNING	Unexpected Timestamp: Reason=Gap in the data stream. Current Timestamp=*xx* Last Timestamp=*yy* Data Messages Missed=*zz*	Data were dropped by the network equipment or software.	Identify what is causing the issue and fix it. This is not caused by the PDC but is a symptom of an external problem.
				Data were corrupted by the network equipment or software.	
				The upstream device did not send the data.	No resolution is required.
				The PDC is overburdened.	Reduce the number of inputs and outputs to and from the PDC.
2306	C37.118 Client	WARNING	Unexpected Timestamp: Reason=Duplicate: Timestamp=*xx*	The network duplicated some number of UDP packets.	No resolution is required. If this occurs frequently, identify what network equipment or software is causing the duplication, or switch to a TCP transport scheme.
2307	C37.118 Client	WARNING	Unexpected Past Timestamp: Current Timestamp=*xx* Last Timestamp=*yy*	The network reordered UDP packets.	No resolution is required. If this occurs frequently, identify what network equipment or software is causing the duplication, or switch to a TCP transport scheme.
				The timing signal for the upstream device jumped backwards in time.	No resolution is required. If this occurs frequently, address the issue of the timing signal in the upstream device.
2308	C37.118 Client	WARNING	PMU Station Name Not Found: Station name=*xx*	The upstream device and the input settings do not agree on what PMUs should be included in the data.	Check the settings of the upstream source to make sure it is sending data to all the expected PMUs.
					Change the PMU names in the input settings to be identical to what the upstream device is providing. Use the **Add Sub-PMU > Automatically** button to direct the PDC to fill out the names exactly as it reads them.
2309	C37.118 Client	INFORMATIONAL	Config Change Detected: Reason=Unexpected data frame size. Encountered Data Frame Size=*xx* Expected Data Frame Size=*yy*	The upstream device changed configuration without setting the configuration changed bit.	This indicates a bug in, or an incompatibility with, the upstream device.
2310	C37.118 Client	INFORMATIONAL	Config Change Detected: Reason=PMU is missing. PMU=*xx*	The upstream device changed configuration by removing a PMU and the configuration changed bit associated with it.	No resolution is required.

Table B.1 Detailed Diagnostic Logs (Sheet 12 of 18)

Event	Source	Severity	Message	Cause	Resolution
2311	C37.118 Client	INFORMATIONAL	Config Change Detected: Reason=Configuration change bit asserted in PMU. PMU=*xx*	The settings where changed in the upstream device.	No resolution is required.
2312	C37.118 Client	INFORMATIONAL	Trigger Detected: PMU=*xx* Trigger Reason=*yy* (*zz*)	The trigger bit of the status word for the PMU was asserted.	No resolution is required.
4000	Historian	ERROR	Unable to connect to database. *xx*	Internal error.	Contact SEL.
4001	Historian	ERROR	Failed to copy data into database.	Internal error.	Contact SEL.
4002	Historian	DEBUG	Failed to copy data into database. *xx*	Internal error.	Contact SEL.
4003	Historian	INFORMATIONAL	Bad database connection deleted. Attempting reconnect.	Internal error.	Contact SEL.
4004	Historian	INFORMATIONAL	Database re-connection attempt succeeded.	A connection to the database was recreated successfully.	No resolution is required.
4005	Historian	ERROR	Database re-connection attempt failed. *xx*	Internal error.	Contact SEL.
4006	Historian	ERROR	Unable to save trigger event information to database. *xx*	Internal error.	Contact SEL.
4007	Historian	ERROR	Data timestamp out of range. Data timestamp=[*xx*] System timestamp=[*yy*]. The difference between the data timestamp and the current timestamp is *zz*. Please ensure that your GPS clock has IEEE C37.118 extensions enabled. *xxy*	The PDC system clock is not accurate enough for archiving.	Connect an IRIG-B time source to the PDC. Enable IEEE C37.118 extensions in the IRIG-B signal. Use the clock sync function on the Device page.
4008	Historian	ERROR	Data timestamp out of range. Data timestamp=[*xx*] System timestamp=[*yy*]. The difference between the data timestamp and the current timestamp is *zz*. *xxy*	The PDC system clock is not accurate enough for archiving.	Connect an IRIG-B cable to the PDC. Enable IEEE C37.118 extensions in the IRIG-B signal. Use the clock sync function on the Device page.
4009	Historian	DEBUG	Entering triggered archive Mode	Rising edge of one of the PMUs triggered bit.	No resolution is required.
4010	Historian	DEBUG	Exiting triggered archive Mode	Falling edge of one of the PMUs triggered bit.	No resolution is required.
4011	Historian	ERROR	Failed managing archive partition tables. Internal error, contact SEL for assistance. *xx*	Internal error.	Contact SEL.

Table B.1 Detailed Diagnostic Logs (Sheet 13 of 18)

Event	Source	Severity	Message	Cause	Resolution
4012	Historian	ERROR	Failed getting archive space used from the database. Internal error, if this message occurs frequently contact SEL for assistance. *xx*	Internal error.	Contact SEL.
4013	Historian	ERROR	The maximum number of bytes per timeslice in the archive has been exceeded. Try reducing the number of tags being archived. size *xx*, maximum size *yy*. Internal error, contact SEL for assistance.	The archive has too many tags.	Reduce the number of tags in the archive.
4014	Historian	ERROR	Failed getting database data directory. Internal error, contact SEL for assistance. *xx*	Internal error.	Contact SEL.
4015	Historian	ERROR	Stopping archiving, available disk space is less than or equal to *xx* MB.	The PDC has run out of available archive space.	Reduce the archive retention period, or manually delete archives.
4016	Historian	WARNING	Available disk space is less than *xx* MB. Archiving will stop when available disk space is less than or equal to *yy* MB.	The PDC has nearly run out of available archive space.	Reduce the archive retention period.
					Decrease the number of tags archived.
					Decrease the data rate of the archive.
4017	Historian	ERROR	Failed to flush archive data to the database. *xx*	Internal error.	Contact SEL.
4018	Historian	ERROR	Missing data.	The upstream device and the input settings do not agree on what PMUs or tags should be included in the data.	Check the settings of the upstream device to make sure it is sending all the expected data.
					Change the PMU or tag names in the input settings to be identical to what the upstream device is providing, or use the **Query Tags** button and the **Add Sub-PMU > Automatically** button to direct the PDC to fill out the names exactly as it reads them.
				A whole PMU or an individual tag arrived too late to be included in an archive.	Increase the archive waiting period to allow for the late arriving PMUs and tags, or investigate the cause of the latency.
				Due to the asynchronous nature of settings changes, it is possible for parts of the system to start up in the middle of a data set and miss the data that came before.	No resolution is required. This issue should only occur briefly at startup or when settings changes occur.

Table B.1 Detailed Diagnostic Logs (Sheet 14 of 18)

Event	Source	Severity	Message	Cause	Resolution
4019	Historian	ERROR	Failed getting the free disk space warning threshold setting. Internal error, contact SEL for assistance. *xx*	Internal error.	Contact SEL.
4020	Historian	INFORMATIONAL	Switching to New File: Old File=*xx* New File=*yy* Reason=A jump backwards in time within the current file has been detected in the data stream. In order to prevent file corruption, a new file was created.	The SEL-5073 External Archive file writer is switching to a new file because the time stamps on the incoming data have jumped backwards in time.	No resolution is required.
4021	Historian	DEBUG	Switching to New File: Old File=*xx* New File=*yy* Reason=The data does not fit within the current file, and so a new file was created. This is normal.	The SEL-5073 External Archive file writer is switching to a new file because the current file as reached its size limit.	No resolution is required.
4022	Historian	ERROR	Disposal Failure: File=*xx* Reason=*yy*	Internal error.	Contact SEL.
4023	Historian	ERROR	Failed checking free disk space. *xx*	Internal error.	Contact SEL.
4100	Security	ERROR	Unable to add user *xx*.	The user already existed.	Pick a different user.
				You do not have permission to add new users.	You must be an administrator to add users.
4101	Security	INFORMATIONAL	New User Created: User=*xx* (*zz*) Creator=*yy*	A new user was created.	No resolution is required.
4102	Security	ERROR	Unable to change password.	The user does not exist.	Specify a user that exists.
				The new password did not satisfy the complexity requirements.	Specify a password that is at least 8 characters, no more than 63 characters, and contains only printable ASCII characters, including an uppercase character, a lowercase character, a number, and a symbol or punctuation mark.
				You do not have permission to change the user's password.	You can change your own password. Administrators can change any user's password.
4103	Security	INFORMATIONAL	Password Changed: User=*xx* Changer=*yy*	The password for the specified user was changed.	No resolution is required.
4104	Security	INFORMATIONAL	*xx* users session has timed out. Please logout and log back in.	The user remained logged in without any activity for too long.	No resolution is required.
					Disable session timeout by setting **Session Idle Timeout** to **0** on the General Security Settings page.

Table B.1 Detailed Diagnostic Logs (Sheet 15 of 18)

Event	Source	Severity	Message	Cause	Resolution
4105	Security	ERROR	Dangling transaction detected. Transaction will be forcibly closed.	Internal error.	Contact SEL.
4106	Security	ERROR	*xx* reached the maximum number of allowed failed login attempts. This account will be locked for *yy* minutes.	The user failed to log in too many times.	No resolution is required.
					Increase the Allowed Unsuccessful Login Attempts setting on the General Security Settings page.
4107	Security	INFORMATIONAL	*xx* has logged in to the PDC from *yy*.	The user logged in.	No resolution is required.
4108	Security	INFORMATIONAL	*xx* has logged out of the PDC from *yy*.	The user has logged out.	No resolution is required.
4109	Security	ERROR	Unable to change user password expiration.	The user does not exist.	Specify a user that exists.
				You do not have permission to change password expirations.	Only administrators can change password expiration.
4110	Security	ERROR	Unable to change user role.	The user does not exist.	Specify a user that exists.
				The new role was not valid.	Only **administrator**, **engineer**, and **technician** are valid roles.
				You tried to change your own role.	You can only change other users' roles.
				You do not have permission to change user roles.	Only administrators can change user roles.
4111	Security	INFORMATIONAL	user: *xx* role changed by: *yy*. old role: *zz* new role: *xxy*	The user's role was changed.	No resolution is required.
4112	Security	ERROR	Unable to remove user.	The user does not exist.	Specify a user that exists.
				You do not have permission to remove users.	Only administrators can remove users.
4113	Security	INFORMATIONAL	The user: *xx* was removed by: *yy*	The user was removed.	No resolution is required.
4114	Security	ERROR	Unable to remove last administrator.	You tried to remove the last administrator.	The last administrator cannot be removed. This prevents a situation where no one can administer the PDC.
				You do not have permission to remove users.	Only administrators can remove users.
4115	Security	INFORMATIONAL	Database Process Id: *xx* was manually terminated by user: *yy*	A database connection was forcibly terminated by the user.	No resolution is required.
4116	Security	INFORMATIONAL	Restored to factory settings by user: *xx*	The PDC was restored to factory settings by the user.	No resolution is required.
4117	Security	ERROR	Failed Login Attempt by *xx*	The user failed to login.	No resolution is required.
4118	Security	INFORMATIONAL	Diagnostic logs were cleared by *xx*.	The diagnostic logs were cleared by the user.	No resolution is required.

Table B.1 Detailed Diagnostic Logs (Sheet 16 of 18)

Event	Source	Severity	Message	Cause	Resolution
4119	Security	INFORMATIONAL	*xx* accessed the diagnostic logs.	The user accessed the diagnostic logs for reading.	No resolution is required.
4120	Security	INFORMATIONAL	New settings uploaded: User=*xx* Comments=*yy*	New settings were uploaded by the user.	No resolution is required.
4121	Security	ERROR	*xx* attempted to *yy*, but lacked permission.	The user attempted to do something not permitted by his role.	No resolution is required.
4122	Security	WARNING	Failed to pulse alarm. Check previous logs for error that caused the alarm pulse.	Internal error.	Contact SEL.
4200	Security	ERROR	*xx* user failed to login. *yy*	Internal error.	Contact SEL.
4201	Security	ERROR	*xx* user failed to logout. *yy*	Internal error.	Contact SEL.
4204	Security	ERROR	Failed to update failed login attempts. *xx*	Internal error.	Contact SEL.
4205	Security	ERROR	Authentication Error. *xx*	Incorrect password for user.	Use the correct password.
				Internal Error.	Contact SEL.
4206	Security	ERROR	Account Management Error. *xx*	The user's account is locked.	Wait for the lock to timeout. The amount of time depends on the Unsuccessful Login Lockout Time setting on the General Security page.
				Internal Error.	Contact SEL.
4240	System	WARNING	Diagnostics *xx* failure: Message=*yy*	The diagnostic requested does not exist in the PDC.	Check the name of the diagnostic requested to make sure it matches a diagnostic provided by the PDC.
				Internal error.	Contact SEL.
4241	System	WARNING	Detailed Diagnostics failure: Message=*xx*	Internal error.	Contact SEL.
6000	Settings	DEBUG	Terminating the *xx* process.	The input, output, calculation, logger, or historian was removed from settings and must be turned off.	No resolution is required.
6001	Settings	DEBUG	Waiting for the *xx* process to terminate.	The PDC is waiting for a process to terminate.	No resolution is required.
6002	Settings	DEBUG	Deleting the *xx* process.	The input, output, calculation, logger, or historian was terminated successfully and cleaned up.	No resolution is required.
6003	Settings	DEBUG	Created the *xx* process.	A new input, output, calculation, logger, or historian was created based on settings.	No resolution is required.

Table B.1 Detailed Diagnostic Logs (Sheet 17 of 18)

Event	Source	Severity	Message	Cause	Resolution
6004	Settings	ERROR	An error occurred in the *xx* process (*yy*). It will be restarted. If this problem persists, please contact SEL for assistance.	Internal error.	Contact SEL.
6005	Settings	DEBUG	Created a placeholder for the disabled *xx* process.	An input, output, calculation, logger, or historian was disabled in settings.	No resolution is required.
					Re-enable the process.
6006	Settings	INFORMATIONAL	Starting the *xx* process.	A new input, output, calculation, logger, or historian was created and can now be started.	No resolution is required.
6007	Settings	DEBUG	Created a disabled process because of an error: Process Name=*xx* Error=*yy*	Internal error.	Contact SEL.
6008	Settings	ERROR	Standard exception (*xx*). If this problem persists, please contact SEL for assistance.	Internal error.	Contact SEL.
6009	Settings	ERROR	Unknown exception. If this problem persists, please contact SEL for assistance.	Internal error.	Contact SEL.
7000	Calculator	ERROR	*xxy* needed for the *xx* input to the *yy* calculation could not be found. Check the source (*zz*) of *xxy* for errors, either in the logs or settings.	The upstream device and the input settings do not agree on what PMUs or tags should be included in the data.	Check the settings of the upstream device to make sure it is sending all the expected data.
					Change the PMU or tag names in the input settings to be identical to what the upstream device is providing, or you can use the **Query Tags** button and the **Add Sub-PMU > Automatically** button to direct the PDC fill out the names exactly as it reads them.
				A whole PMU or an individual tag arrived too late to be used in the calculation.	Identify the cause of the latency and correct it.
				Due to the asynchronous nature of settings changes, it is possible for parts of the system to start up in the middle of a data set and miss the data that came before.	No resolution needed. This issue should only occur briefly at startup or upon settings changes.
7001	Calculator	INFORMATIONAL	Using Primary Input: Data Timestamp=*xx*	A redundant input is using the primary channel.	No resolution is required.

Table B.1 Detailed Diagnostic Logs (Sheet 18 of 18)

Event	Source	Severity	Message	Cause	Resolution
7002	Calculator	WARNING	Using Secondary Input: Data Timestamp=*xx* Reason=Availability	A redundant input switched to the secondary channel because the primary channel is missing.	Identify and fix the reason that the primary input is missing.
					No resolution is required, as the input will continue to function and will switch back to the primary channel when it becomes available.
7003	Calculator	WARNING	Using Secondary Input: Data Timestamp=*xx* Reason=Status	A redundant input switched to the secondary channel because the primary channel has a lower quality.	Identify and correct the problem causing the primary input to have lower quality.
					No resolution is required; the input will continue to function and will switch back to the primary channel when its quality improves.

Appendix C

Network Ports and Services

The following information is intended to help security auditors verify that the network hosts and open ports on a control network are what is expected.

The following table lists the network ports that may be presented by the device. Configuring IEEE C37.118 inputs/outputs or syslog connections will open additional ports.

Physical Port	# Ports	Default State				Disableable
Serial Ports	16	Disabled				Yes
Ethernet Ports	3	Eth F Enabled Eth 1 and 2 Disabled				Yes (all but one)

Device Function	Protocol	Transport Protocol	Local Port	Listening	Default State	Disableable
C37.118 Server	IEEE C37.118 Synchrophasors	TCP	Settable	Yes	Disabled	Yes
C37.118 Server	IEEE C37.118 Synchrophasors	UDP	Ephemeral	No	Disabled	Yes
C37.118 Client	IEEE C37.118 Synchrophasors	TCP	Ephemeral	No	Disabled	Yes
C37.118 Client	IEEE C37.118 Synchrophasors	UDP	Ephemeral or Settable[a]	No	Disabled	Yes
Real-Time Diagnostics (R111 and earlier)	Web Services	TLS / TCP	26273	Yes	Enabled	No
Real-Time Diagnostics (R112 and later)	Open Database Connectivity (ODBC)	TLS / TCP	26272	Yes	Enabled	No
Settings Transfer Archive Retrieval	Open Database Connectivity (ODBC)	TLS / TCP	26272	Yes	Enabled	No
Centralized Authentication/Authorization	Light Weight Directory Access Protocol (LDAP)	TLS / TCP	Ephemeral	No	Disabled	Yes
Audit Trails	Syslog	UDP	Ephemeral	No	Disabled	Yes
Firmware Upgrades	Secure Shell (SSH) server	TCP	22	Yes	Disabled	Yes SSH is only enabled in the following cases: 1. Firmware upgrades 2. When the password jumper is ON (R115 and earlier)

[a] The UDP transport scheme allows the specification of a local UDP port.

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LDAP Settings Form

Print the LDAP Settings Form below and give to your Information Services department. Having this information ahead of time will make setting up the PDC much easier.

LDAP Hosts (For the SEL-3373 only) Input these settings on the Network settings page (need at least one):	
Host Name:	IP Address(SEL-3373 only):
Host Name:	IP Address(SEL-3373 only):
LDAP Servers (Input these settings on the LDAP settings page, need at least one):	
Host Name:	Port Number:
Host Name:	Port Number:
LDAP Settings (Input these settings on the LDAP settings page):	
Search Base DN:	
Bind DN (optional, if left blank will use anonymous binds):	
Bind Password (optional, required only if not using anonymous binds):	
User Filter:	
Group Attribute:	
Group To Role Mappings (Required to map users to roles, input these settings on the LDAP settings page, need at least one):	
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:

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Search Base DN:	
Bind DN (optional, if left blank will use anonymous binds):	
Bind Password (optional, required only if not using anonymous binds):	
User Filter:	
Group Attribute:	
Group To Role Mappings (Required to map users to roles, input these settings on the LDAP settings page, need at least one):	
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:
Administrator / Engineer / Technician	Group DN:

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