SEL-3378

Synchrophasor Vector Processor

Instruction Manual

20161214

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM3378-01

Table of Contents

Appendix A: Firmware and Manual Versions

Appendix B: SVP Configurator

Glossary

Index

List of Tables

This page intentionally left blank

List of Figures

Preface

Manual Overview

The SEL-3378 Synchrophasor Vector Processor manual includes necessary information to properly install the product.

The scope of the manual covers specifications, installation, and mechanical information, system configuration, self-monitoring, and alarming.

An overview of each manual section follows:

Preface. Describes the manual organization and conventions used to present information.

Section 1: Introduction and Specifications. Describes the basic features and functions of the SEL-3378; lists the specifications.

Section 2: Installation. Describes how to mount and wire the SEL-3378; illustrates wiring connections for various applications. Describes the communication and configuration features that are used in the SEL-3378.

Section 3: Product Functionality. Describes SEL-3378 functions and function blocks.

Section 4: Product Application Examples. Shows application examples on how to configure the SEL functions and function blocks.

Section 5: Troubleshooting. Lists common operating and troubleshooting questions.

Appendix A: Firmware and Manual Versions. Details differences between firmware and manual versions. Provides a record of changes made to the manual since the initial release.

Appendix B: SVP Configurator. Shows how to create a project in your PC and how to communicate with the SEL-3378.

Safety and General Information

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

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

⚠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.

Symbols

The following symbols from EN 61010-1 are often marked on SEL products.

Symbol 14		Caution, Risk of Danger—Consult Documentation for Additional Information
Symbol 6		Protective (Safety) Ground Conductor Terminal
Symbol 1		Direct Current
Symbol 2		Alternating Current
Symbol 3		Direct and Alternating Current
Symbol 5		Earth (Ground) Terminal

SEL-3378 Cautions, Warnings, and Dangers

The following hazard statements appear in the body of this manual in English. See the following table for the English and French translation of these statements.

English	French
⚠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.	⚠ATTENTION 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 Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	⚠AVERTISSEMENT Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.
⚠WARNING This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.	⚠AVERTISSEMENT Cet appareil est expédié avec des mots de passe par défaut. A l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accés non-autorisé á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accés non-autorisé.
⚠WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	⚠AVERTISSEMENT L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.
⚠WARNING Never use standard null-modem cables with the SEL-3378. Using any non-SEL cable can cause severe power and ground problems involving Pins 1, 4, and 6 on the SEL-3378 communications ports.	⚠AVERTISSEMENT Ne jamais utiliser de cables standards à inversion de signaux ("null-modem") avec le SEL-3378. 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-3378.
⚠WARNING If a modulated IRIG-B input is used, the demodulated IRIG-B output is unsuitable for synchronizing connected PMCUs.	⚠AVERTISSEMENT Si une entrée de type IRIG-B à modulation est utilisée, la sortie correspondante de type IRIG-B démodulé ne peut être utilisée pour synchroniser les autres Unités de Commande et de Mesure de Phaseurs qui sont raccordées.
⚠WARNING Do not operate device unless the device is properly grounded.	⚠AVERTISSEMENT Ne pas mettre l'appareil en marche à moins qu'il ne soit adéquatement mis à la terre.
⚠WARNING Failure to ensure proper voltage levels can cause equipment damage.	⚠AVERTISSEMENT Des dommages peuvent survenir à l' équipement en cas de présence de niveaux de tension inadéquats.
⚠WARNING There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. Dispose of used batteries according to the manufacturer's instructions.	⚠AVERTISSEMENT Il y a un danger d'explosion si la pile électrique n'est pas correctement remplacée. Utiliser exclusivement Ray-O-Vac® No. BR2335 ou un équivalent recommandé par le fabricant. Se débarrasser des piles usagées suivant les instructions du fabricant.

English	French
⚠**CAUTION** Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	⚠**ATTENTION** Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠**CAUTION** Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠**ATTENTION** Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

Section 1
Introduction and Specifications

Overview

The SEL-3378 Synchrophasor Vector Processor allows you to use synchronized phasor measurements (synchrophasors) for real-time power system monitoring, control, and protection. The SEL-3378 acquires and time correlates synchrophasor data from various Phasor Measurement and Control Units (PMCUs), such as the SEL-351, SEL-421, SEL-451, SEL-487E, and SEL-487V relays, and from other devices that support the IEEE C37.118-2005, Standard for Synchrophasors for Power Systems. The SEL-3378 receives synchrophasor messages through serial and Ethernet® communications. The SEL-3378 can process incoming data from as many as 20 PMCUs at a maximum data rate of 60 messages per second with a message size of up to 354 bytes.

The SEL-3378 transmits the time-correlated data over Ethernet to as many as six external C37.118 clients. The SEL-3378 also sends the data to the internal C37.118 client, which makes the data available to SEL predefined functions and to IEC 61131-3 user-programmed functions. You can configure the SEL-3378 to send control commands to external devices. You can also configure one Phasor Measurement Unit (PMU) server (LOCAL_PMCU) based on the derived or calculated outputs of the predefined or user-configurable functions. This section introduces the SEL-3378 and provides information regarding features, SEL libraries, available options, applications, and specifications.

Features

The SEL-3378 provides a mechanism for collecting and time correlating synchrophasor data from as many as 20 PMCUs. The SEL-3378 also collects data from Phasor Data Concentrators (PDCs) such as the SEL-3306. It can then transmit the correlated data to as many as six external and one internal C37.118 clients for synchrophasor applications. SEL-3378 features include the following:

- **Synchrophasor Message Inputs and Outputs**

  Inputs. Reads through serial and Ethernet ports according to IEEE C37.118-2005.

  Outputs. Outputs synchrophasor data through Ethernet according to IEEE C37.118-2005.

- **SEL Preconfigured Function Blocks and Functions**

  The SEL-3378 includes the following functions:

  - Power Calculation Function Block
  - Phase Angle Difference Function Block
  - Modal Analysis Function Block
  - Substation and State Topology Processor Function

- **Control Commands (SEL Fast Operate Commands)**

  Remote Bits. Sets, clears, and pulses as many as 32 remote bits per external device.

  Control Bits. Generates as many as eight open and close breaker commands per external device.

- **User-Defined Synchrophasor Message**

  The SEL-3378 has one programmable server that outputs user-configurable C37.118 messages. You can program as many as 640 phasors, 320 analogs, and 80 digital words at 60 messages per second or less.

- **Communication Ports**

  Serial and Ethernet Ports. Fifteen serial ports and two Ethernet ports can process messages as large as 354 bytes from as many as 20 PMCUs at 60 messages per second. An extra serial port (console port) is dedicated to the support of terminal access configuration. The console port does not support streaming synchrophasor measurement data. The user configures the network settings of the SEL-3378 via the console port.

- **IRIG-B**

  IRIG-B Time-Code Input. The SEL-3378 is configured for demodulated IRIG-B input on the IRIG IN BNC connector. The IRIG-B input updates the operating system clock.

  IRIG-B Time-Code Output. Demodulated IRIG-B is distributed to each serial port and the IRIG OUT BNC connector.

➤ **Watchdog Timer**

A separate system watchdog microcontroller provides an extra level of system reliability. The SEL-3378 provides a user-programmable IEC function to periodically reset the watchdog timer.

SEL Libraries

The SEL-3378 includes the libraries listed in *Table 1.1*.

Table 1.1 SEL-3378 Libraries

Library	Description
SEL_C37_118_Gateway	FAST_OP_BREAKER_CLOSE Function Block FAST_OP_BREAKER_OPEN Function Block FAST_OP_REMOTE_BIT_CLEAR Function Block FAST_OP_REMOTE_BIT_PULSE Function Block FAST_OP_REMOTE_BIT_SET Function Block PMCU_IN Function Block PMCU_OUT Function
SEL _PWRC	PWRC, Power Calculation Function Block
SEL_PADM	PADM, Phase Angle Difference Monitor Function Block
SEL_TCS_CTRL	TCS_CONFIG, Time Alignment Client Server Configuration Function
SEL_Modal_Analysis	MODAL_ANALYSIS, Modal Analysis Function Block
SEL_SSTP	SSTP, Substation and State Topology Function
SEL_Diagnostics_3378	DIAGNOSTICS_STATUS Function Block CLEAR_ALARM Function LATCH_ALARM Function USER_WATCHDOG Function

Models and Options

Models

This manual does not provide complete ordering information. For this information, see the latest SEL-3378 Model Option Table at selinc.com, under **SEL Literature** > **Ordering Information** (Model Option Tables).

Options

The SEL-3378 has the following options:

- Power Supply Ranges
  - 24/48 Vdc
  - 48/125 Vdc or 120 Vac
  - 125/250 Vdc or 120/240 Vac
- Mounting
  - Horizontal panel
  - Horizontal 19-inch rack

Applications

Figure 1.1 shows a system configuration of the SEL-3378 in which it processes synchrophasor data at the substation level and sends the data to remote applications.

Figure 1.2 shows a system configuration of the SEL-3378 for a synchrophasor application that requires synchrophasor measurements from sources at different geographical areas.

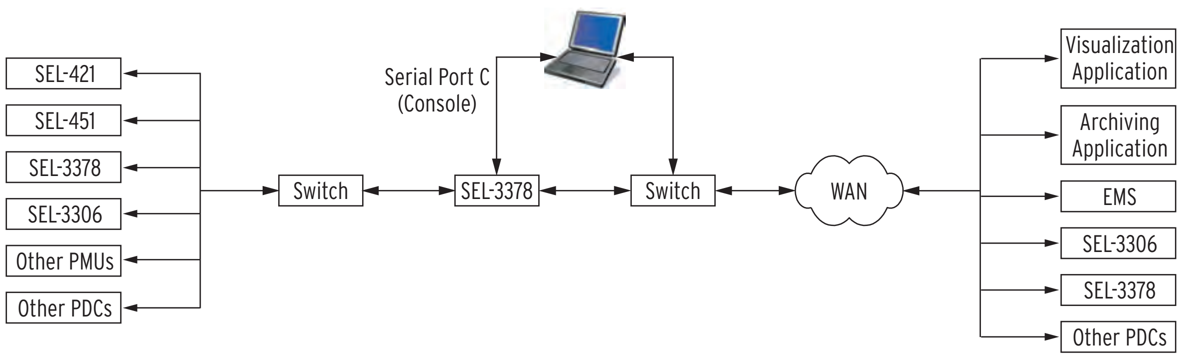


Figure 1.1 System Configuration for SEL-3378 Substation-Level Applications

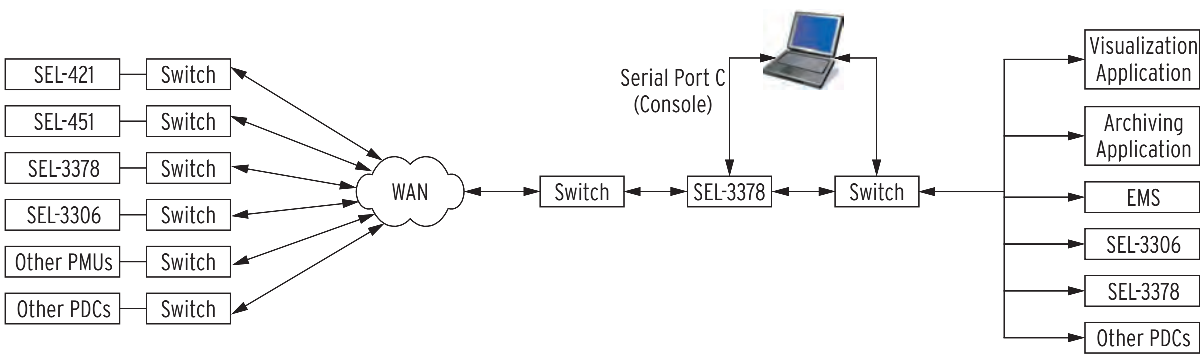


Figure 1.2 System Configuration for SEL-3378 With Remote Synchrophasor Measurement Sources

Figure 1.3 shows a System Integrity Protection Scheme (SIPS) that uses the SEL-3378. The SIPS sheds excess generation if the angle difference between two system buses exceeds a user-defined threshold.

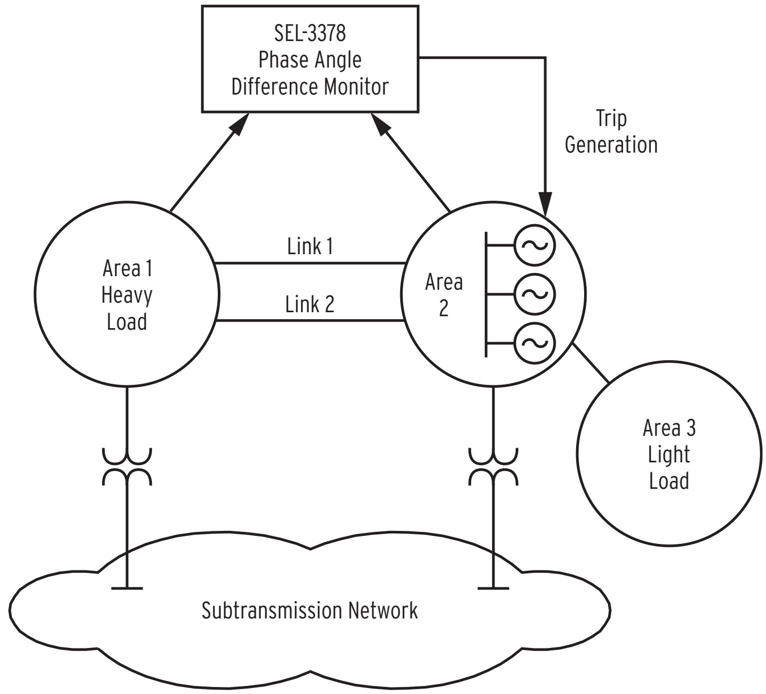


Figure 1.3 Automatic Generation Shedding Scheme for a Three-Area Power System That Uses Bus Voltage Angle Difference Information to Trip Excess Generation

Figure 1.4 shows a power system oscillation detection application that uses the Modal Analysis function block. The monitoring system detects unwanted oscillation, activates the oscillation alarm, and sends the remedial action command.

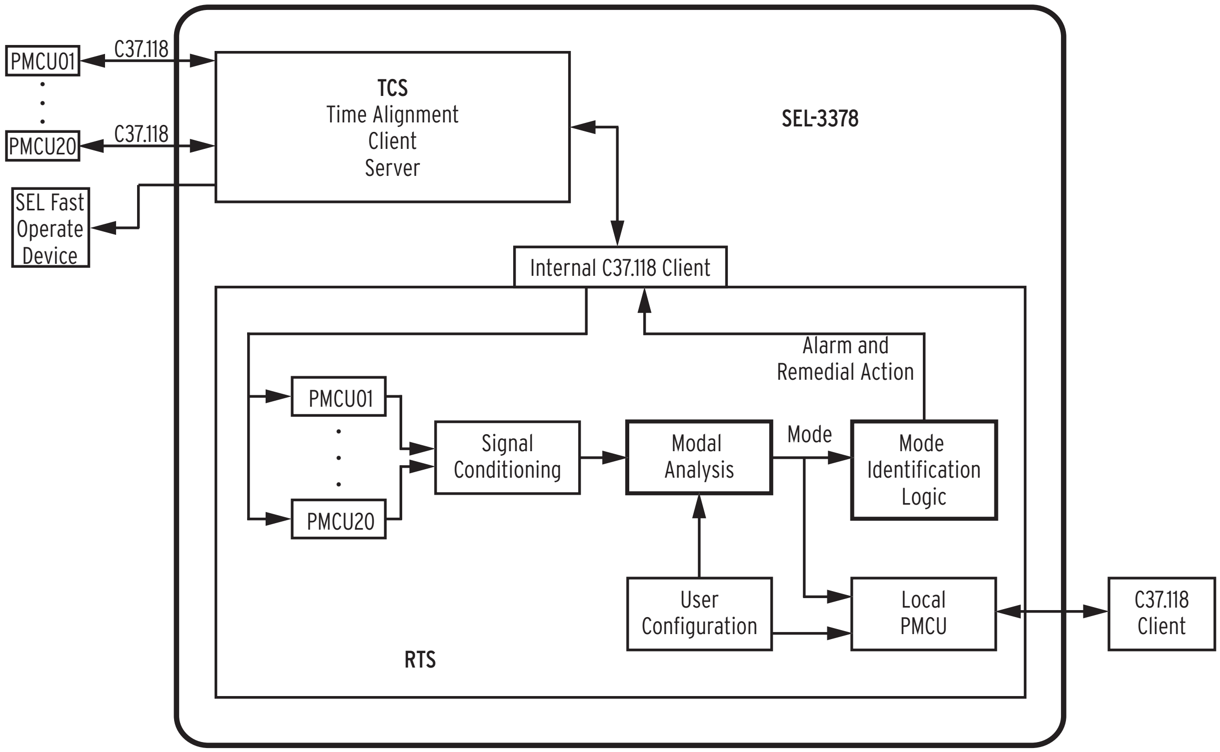


Figure 1.4 Real-Time Modal Analysis-Based Power System Disturbance Detection System

Figure 1.5 shows the one-line diagram that corresponds to a double-bus and transfer bus arrangement with Phasor Measurement and Control Units (PMCUs) and the SEL-3378. In this application, the SEL-3378 identifies voltage and current measurement errors and refines these measurements.

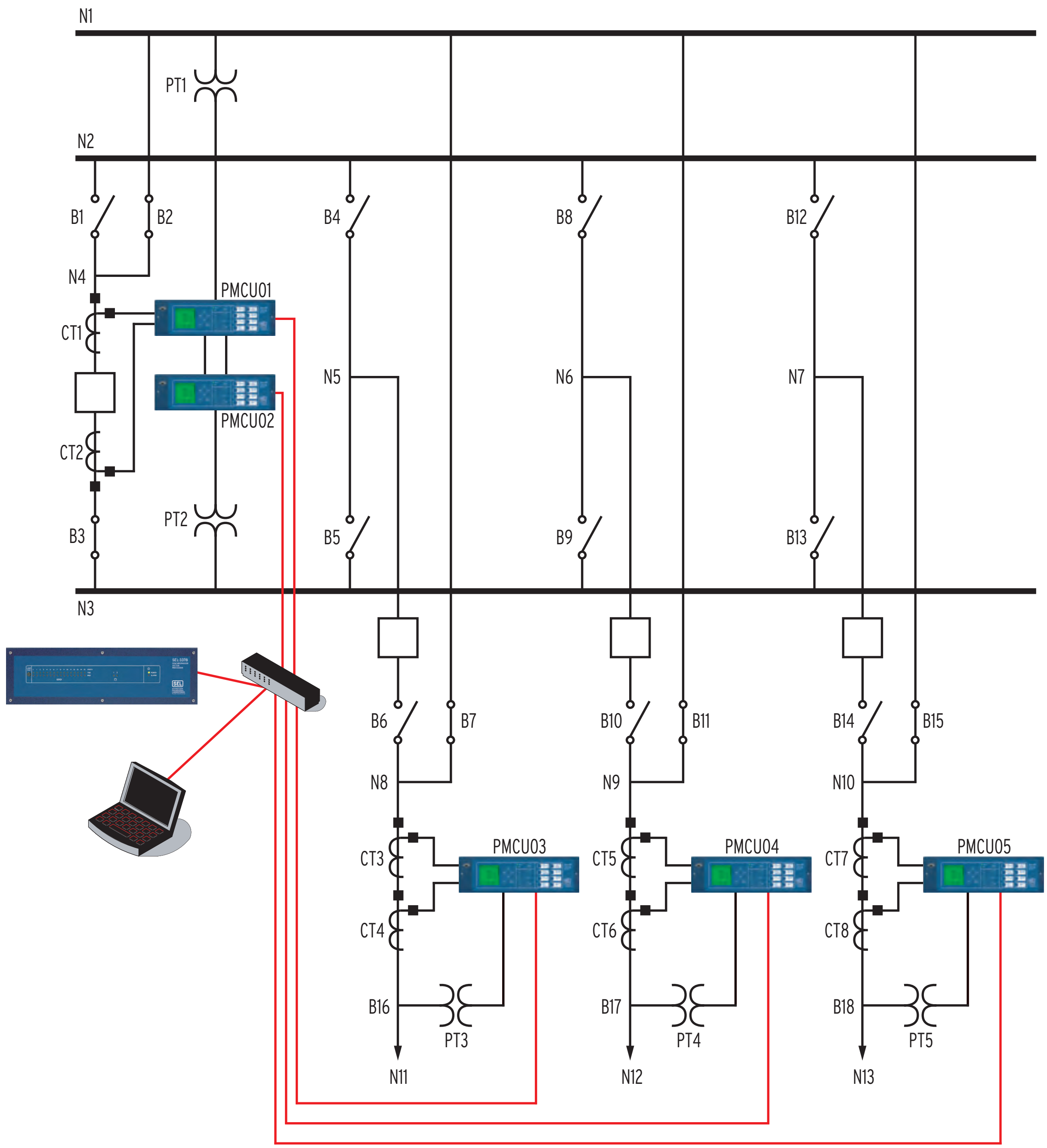


Figure 1.5 Bus Arrangements to Identify Voltage and Current Measurement Errors and to Refine These Measurements

Specifications

General

Operating Temperature

–40° to +75°C (–40° to +167°F)

Storage Temperature

–40° to 85°C (–40° to +185°F)

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. Ring terminals are recommended.

Operating Environment

Pollution Degree:	2 as per IEC 60950
Overvoltage Category:	II as per IEC 60950
Humidity:	5 to 95% without condensing
Altitude:	2000 m maximum
Atmospheric Pressure:	80 to 110 kPa
Unit Weight:	5 kg (11 lbs)

Communications Ports

Serial Ports:	Sixteen serial ports
Console Port:	EIA-232 with DB-9 connectors
Serial Data Speed:	9600 bps
Ports 1–15:	EIA-232 with DB-9 connectors
Serial Data Speed:	9600, 19200, 38400, 57600, 115200 bps
Ethernet Ports:	Two Ethernet ports
Ethernet Port 1:	10/100BASE-T copper or 100BASE-FX fiber-optic ports, jumper selectable.
Ethernet Port 2:	100BASE-FX fiber-optic port

IRIG-B Ports

Time-Code Input

Connector:	Female BNC
Time-Code:	Demodulated IRIG-B TTL compatible

Time-Code Output

Connector:	15 rear DB-9 port connectors Female BNC
Time-Code:	Demodulated IRIG-B TTL compatible
Pinout:	DB-9 port connectors Pin 4 TTL-level signal Pin 6 chassis ground reference Female BNC

Note: IRIG-B output available only when IRIG-B input is present.

Synchrophasor Data Format

Input Data Formats

IEEE C37.118-2005:	Ethernet and serial

Output Data Formats

IEEE C37.118-2005:	Ethernet

Synchrophasor Input/Output Message Rates

60 Hz Nominal Data Rate:	1, 2, 4, 5, 10, 12, 15, 20, 30, 60 messages per second
50 Hz Nominal Data Rate:	1, 2, 5, 10, 25, 50 messages per second

Synchrophasor Data

Servers (PMUs):	20
Clients:	7

Synchrophasor Processing Capacity

Processing Capacity:	20 PMCUs
Processing Interval:	4 ms
Maximum Message Size:	354 bytes
Maximum Data Rate:	60 messages per second
Data Through Latency	
TCS	
Average:	4 ms
Maximum:	8 ms (1–16 inputs) 20 ms (17–20 inputs)
PMCU	
Average:	8 ms
Maximum:	12 ms (1–16 inputs) 30 ms (17–20 inputs)
Command Processing Latency:	8 ms (plus the synchrophasor message time interval)

Fast Operate Commands

Transmitted Remote Bits Per External Device:	32
Transmitted Breaker Control Bits per External Device:	8
Received Remote Bits:	32
Communications Output:	Serial and Ethernet

IEC 61131-3 Programming Languages

Instruction List

Structured Text

Sequential Function Chart

Function Block Diagram

Ladder Diagram

Continuous Function Chart Editor

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:	< 40 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:	< 40 W

24/48 Vdc

DC Range:	20–60 Vdc polarity dependent
Burden:	< 40 W

Main Supply Voltage

Fluctuations:	as much as ±10% of nominal voltage

Type Tests

Environmental

Enclosure Protection Class:	IEC 60529:IP20 UL 50: Enclosure Type 1
Cold:	IEC 60068-2-1:1990 + A1:1993 + A2:1994 Test Ad: 16 hours at –40°C
Dry Heat:	IEC 60068-2-2:1974 + A1:1993 + A2:1994 Test Bd: 16 hours at +75°C
Damp Heat, Cyclic:	IEC 60068-2-30:1980 + A1:1985 Test Db: (12 + 12-hour cycle), 95% r.h. 25° to 55°C, 6 cycles
Vibration Resistance:	IEC 60255-21-1:1988, Endurance Class 1 Response Class 1
Shock Resistance:	IEC 60255-21-2:1988, Shock Withstand, Bump Class 1 Shock Response Class 1 IEC 60255-21-3:1993 Quake Response Class 2
Object Penetration:	IEC 60529:2001 + CRGD:2003, IP30 from front of unit

Electromagnetic Compatibility Immunity

Electrostatic Discharge:	IEC 60255-22-2:1996 IEC 61000-4-2:2001 IEEE C37.90.3-2001 Severity Level: 2, 4, 6, 8 kV contact discharge; 2, 4, 8, 15 kV air discharge
Fast Transient Burst:	IEC 61000-4-4:1995 + A1:2000 + A2:2001 IEC 60255-22-4:2002 Severity Level: Class A 4 kV, 2.5 kHz on power supply; 2 kV, 5 kHz on communication lines, digital inputs, and digital outputs
Radiated Radio Interferences:	IEC 61000-4-3:2002 IEC 60255-22-3:2000 Severity Level: 10 V/m IEEE C37.90.2-2004 Severity Level: 35 V/m
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
Surge Immunity:	IEC 61000-4-5:1995 + A1:2001 IEC 60255-22-5:2002 Severity Level: 0.5, 1.0 kV Line-to-Line; 0.5, 1.0, 2.0 kV Line-to-Earth
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
Voltage Fluctuations and Flicker:	IEC 61000-3-3:2002
Conducted Immunity:	IEC 61000-4-6:2004 IEC 60255-22-6:2001 Severity Level: 10 Vrms
Power Frequency Magnetic Field Immunity:	IEC 61000-4-8:2001 1000 A/m for 3 s 100 A/m for 1 min., Level 5

Safety

Dielectric Strength:	IEC 60255-5:2000, IEEE C37.90-1989, 3100 Vdc for 1 min. on power supply 2500 Vac on contact output Type tested for one minute
Impulse:	IEC 60255-5:2000 IEEE Std 1613-2003 IEEE C37.90-1989 Severity Level: 0.5 Joule, 5 kV
Laser:	IEC 60825-1:1993 + A1:1997 + A2:2001

Certifications

ISO: This product was designed and manufactured using an ISO 9001 certified quality program.

CE: CE Mark
EN 61326: 1997—EMC Directive
EN 50263:1999—EMC Directive
EN 61010-1:2001—Low-Voltage Directive (Safety)
IEC 60255-6:1998—Low-Voltage Directive (Safety)

This page intentionally left blank

Section 2
Installation

Overview

This section describes jumpers, unit placement and maintenance, rear-panel connections, and field serviceability. Also included is an overview of the communication interfaces for configuring the SEL-3378. *Access Control and Security on page 2.19* explains security features that prevent unauthorized access. *Startup Procedure on page 2.20* provides a step-by-step commissioning procedure. A successful installation requires an understanding of both the physical and software functions of the device.

Familiarity with synchrophasor vector processor configuration features and options is critical to safe and effective installation and connection. Carefully plan unit placement, cable connections, and communications during initial design.

This section contains drawings for Ethernet® ports, serial ports, IRIG-B port, alarm contact, and power input. Use these drawings when planning synchrophasor vector processor applications.

Jumpers

The SEL-3378 contains jumpers that configure the processor communication hardware and emergency password reset. Access the jumpers from the main board (the top board).

Main Board Jumpers

The jumpers on the main board perform the following functions:

- Alarm contact function (JMP1)
- Serial port +5 Vdc or Data Carrier Detect (DCD) enable or disable (JMP2)
- Ethernet Port 1, copper or fiber-optic selection (JMP5)
- Password override jumper (J28)

Figure 2.1 shows the location of the main board jumpers JMP2, JMP5, and J28. *Table 2.1* shows jumper positions and whether these jumpers are accessible from the front of the device.

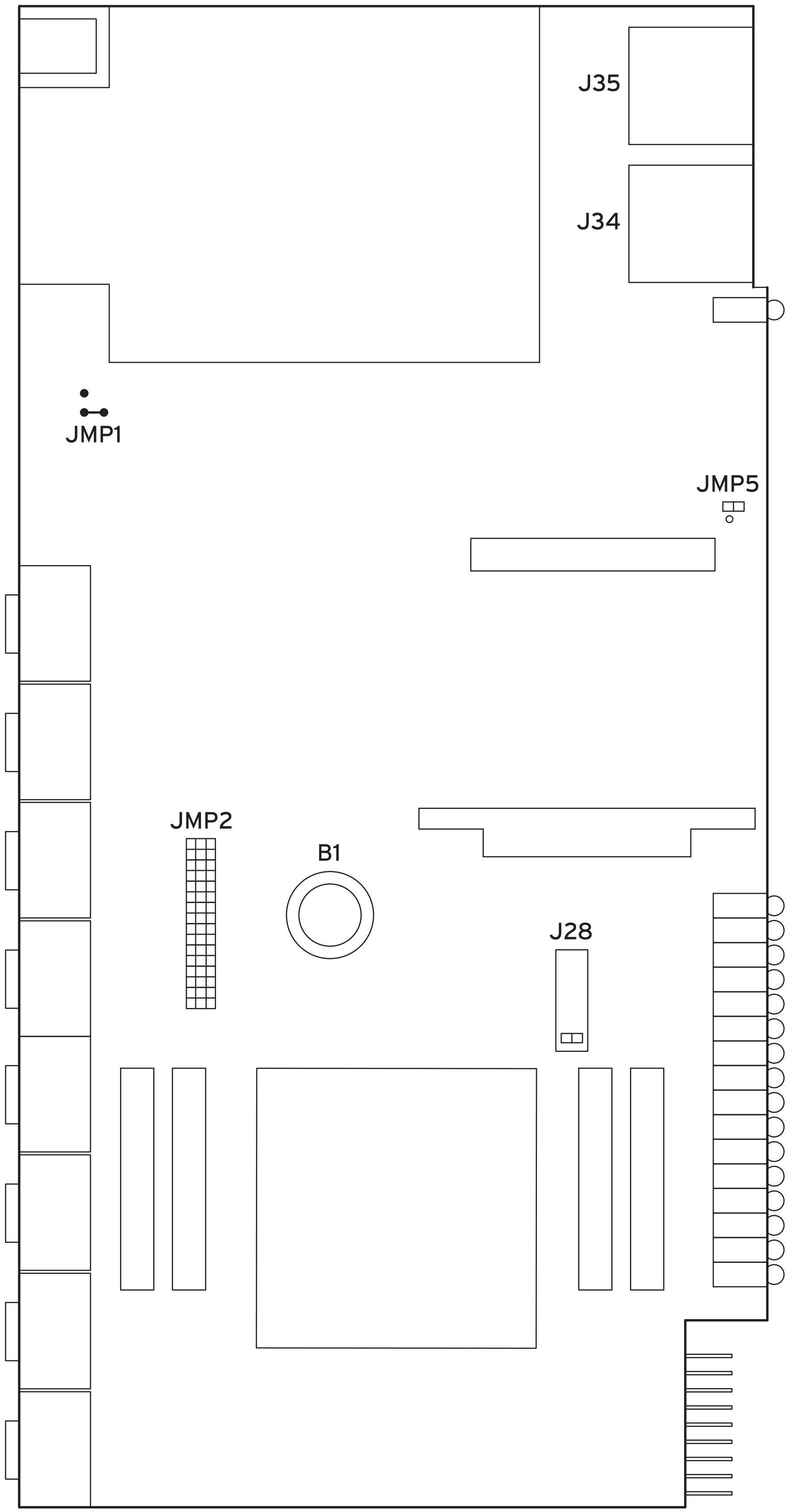
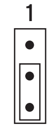
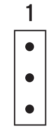
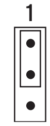
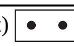
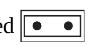
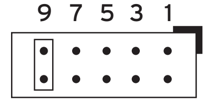
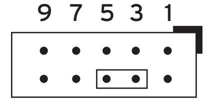


Figure 2.1 Jumper Locations

Table 2.1 Main Board Jumper Positions

Function	Jumper Position	Access From Front
JMP1	Fixed in position B	No
JMP2 Serial Port 1	DCD Connection (Default)  No Connection  +5 Vdc Connection 	No
JMP5 Ethernet Port 1 Fiber-Optic Selection	10/100BASE-T Enabled (Default)  100BASE-FX Enabled 	Yes
J28 Emergency Password Override	Normal Operation (Default)  Emergency Password Override 	Yes

JMP1 is a hard-soldered jumper that modifies the alarm contact function from normally closed to normally open.

JMP2 has a set of jumpers (1 through 16) that correspond to the Console port and Ports 1 through 15. JMP2 connects serial port Pin 1 to a +5 Vdc source, no connection, or DCD. DCD asserts when an external modem establishes a connection to another modem through a telecommunications network. Pin 1 on the ports can provide as much as 0.6 A at 5 V (3 W) total for all 16 ports.

JMP5 position determines the Ethernet Port 1 media. The Off position enables copper, and the On position enables a fiber-optic Ethernet connection. The processor reads the Off or On position during bootup. Reboot the SEL-3378 to acknowledge a change in jumper position.

SEL-3378 ships with the default jumper positions shown in *Table 2.1*. Set the main board jumpers to meet specific requirements.

⚠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.

Perform the following steps to configure the JMP2 jumper to change the serial port function.

Step 1. De-energize the SEL-3378 by disconnecting or removing power.

Be sure that the power source is tagged properly to avoid accidental reenergization.

Step 2. Remove all connections from the rear of the SEL-3378.

Step 3. Remove the SEL-3378 from the panel or 19-inch rack.

Step 4. Remove the front panel.

Step 5. Remove the top cover.

Step 6. Locate jumper JMP2 on the main board as shown in *Figure 2.1*.

Configure the main board JMP2 jumper according to the options given in *Table 2.1*. Note that the **Console** port and Port 1 through Port 15 are mapped to the JMP2 jumpers labeled 1 through 16.

Step 7. After reconfiguring, replace the top cover.

Step 8. Replace the front panel.

Step 9. Reinstall the SEL-3378 into the panel or 19-inch rack.

Step 10. Replace the cable connections in the rear of the SEL-3378.

Step 11. Reapply power to the SEL-3378.

Perform the following steps to configure the JMP5 jumper to change the Ethernet port function.

Step 1. De-energize the SEL-3378 by disconnecting or removing power.

Be sure that the power source is tagged properly to avoid accidental reenergization.

Step 2. Remove the front panel.

Step 3. Locate the jumper JMP5 on the main board as shown in *Figure 2.1*.

Configure the main board JMP5 jumper according to the options in *Table 2.1*.

Step 4. Replace the front panel.

Step 5. Reapply power to the SEL-3378.

Emergency Password Override

⚠WARNING
It is not recommended to operate the device in the Emergency Password Override state, except for short-term configuration or maintenance conditions.

Jumper J28 is provided for emergency password override. Operating the SEL-3378 with jumper J28 installed between Pins 4 and 6 disables all authentication and allows unrestricted access through the device **Console** port.

Perform the following steps to configure jumper J28 for emergency password override.

Step 1. De-energize the SEL-3378 by disconnecting or removing power.

Be sure that the power source is tagged properly to avoid accidental reenergization.

Step 2. Remove the front panel.

Step 3. Locate Jumper J28 on the main board as shown in *Figure 2.1*.

Step 4. Configure Jumper J28 according to *Table 2.1* (J28, Pins 4 and 6).

Step 5. Reapply power to the SEL-3378.

Step 6. Use the **Console** port to access the device and set the new password using the **PASSWORD** (**PAS**) command.

Step 7. De-energize the SEL-3378 by disconnecting or removing power.

Be sure that the source is tagged properly to avoid accidental reenergization.

Step 8. Move the jumper back to its original position (J28, Pins 9 and 10).

Step 9. Replace the front panel.

Step 10. Reapply power to the SEL-3378.

Password Override Jumper J28 must be returned to the default position (Pin 9 and Pin 10) as soon as the maintenance is completed. Failure to return the jumper to its default state compromises the **Console** port security/authentication capability.

Unit Placement and Maintenance

Proper placement and maintenance of the SEL-3378 helps ensure years of trouble-free operation. Use the following guidelines for proper installation of the SEL-3378.

Physical Location

Mount the SEL-3378 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 on page 1.8*). The unit is rated to Overvoltage Category II and Pollution Degree 2 according to IEC 60950. 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.

Unit Mounting

Panel and rack mount options are available. *Figure 2.2* shows dimensions and panel cutout sizes for both options.

Cleaning

Use care when cleaning the SEL-3378. 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.

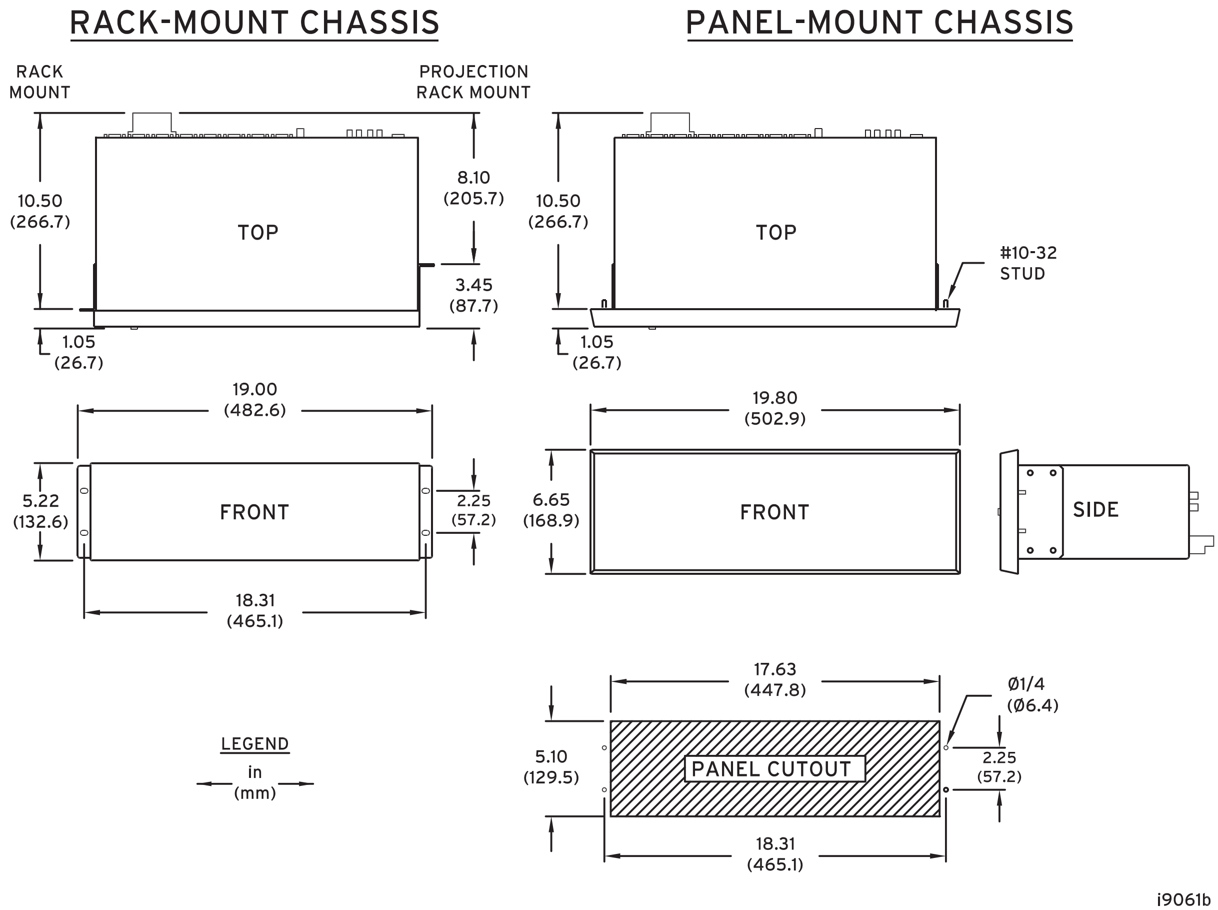
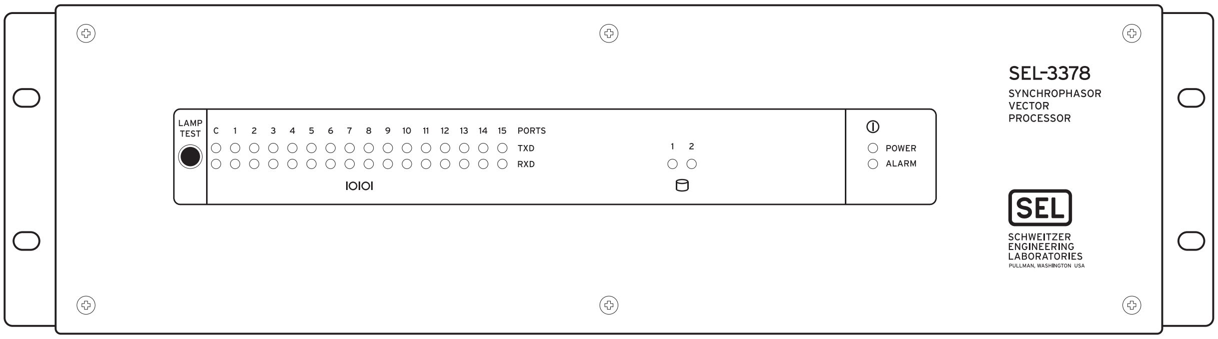
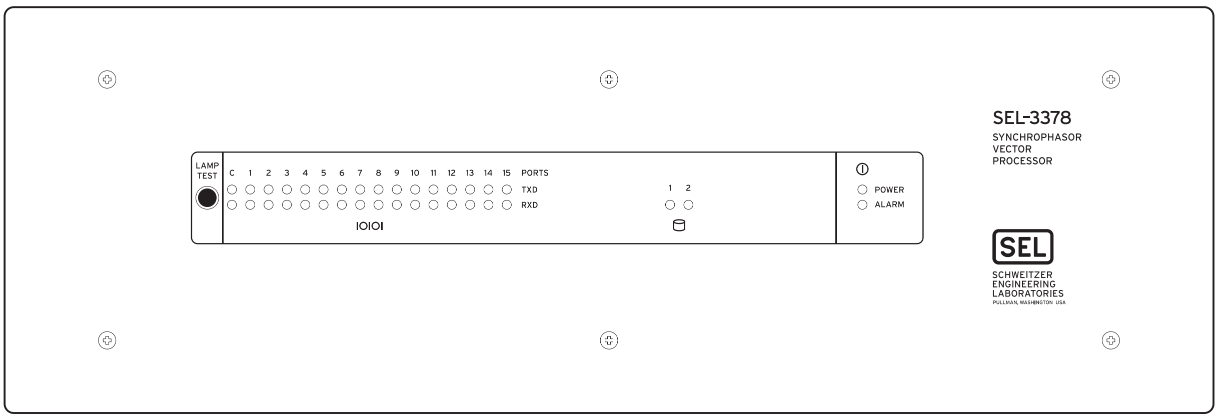


Figure 2.2 Dimensions Diagram



i4207a

Figure 2.3 Front Rack-Mount Diagram

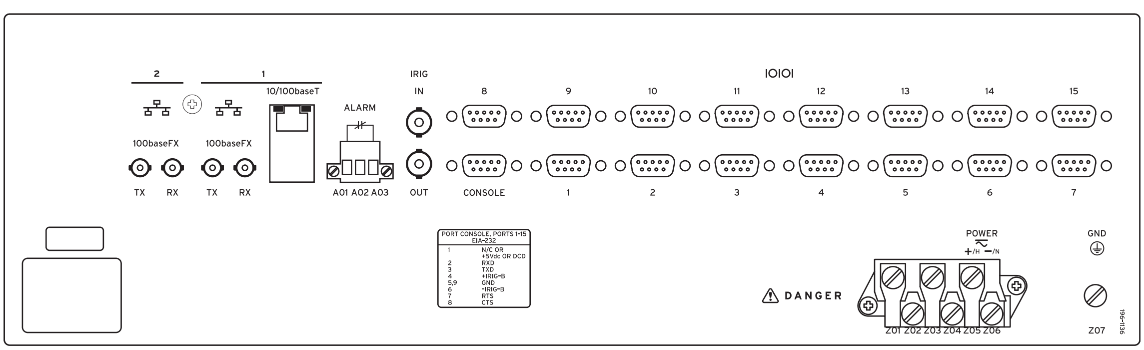


i4193a

Figure 2.4 Front Panel-Mount Diagram

Rear-Panel Connections

The physical layout of the connectors on the rear panel of an SEL-3378 is shown in *Figure 2.5*.



i3896c

Figure 2.5 Rear-Panel Diagram

Ethernet Connection

Use the Ethernet connection to send correlated synchrophasor data to other synchrophasor data processors and for synchrophasor applications. Also use the Ethernet port to read synchrophasor data from other PMCUs and the SEL-3378. Refer to *Figure 1.1 on page 1.4* for application overview.

The SEL-3378 is equipped with dual Ethernet. Ethernet Port **1** is jumper selectable between copper 10/100BASE-T or fiber-optic 100BASE-FX (see *Figure 2.1* and *Table 2.1*). The Ethernet Port **1** copper and fiber interface cannot be used at the same time. Ethernet Port **2** is 100BASE-FX only.

The LEDs on the Ethernet Port **1** jack apply to both copper and fiber connections. The left LED illuminates orange for a 10 Mbps connection and green for a 100 Mbps connection. The LED on the right flashes yellow during data transfer.

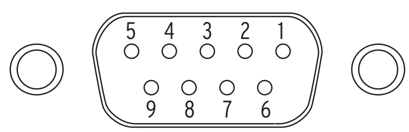
The dual Ethernet function of the SEL-3378 is the same as for a standard dual Ethernet PC compatible computer.

Serial Port Communications

Sixteen serial ports (**Console**, **1–15**) are available on the SEL-3378, as shown in *Figure 2.5*.

The **Console** port is dedicated for interfacing with the SEL-3378. The port has a fixed data rate of 9600 baud (8, N, 1, and no flow control). Ports **1** through **15** have settable data rates. Use these ports to read synchrophasor data from different protective devices (SEL-421 or SEL-451) and other PMCUs.

The serial ports function as standard EIA-232 ports. See *Figure 2.6* for EIA-232 DB-9 female connector pin numbers. See *Table 2.2* for EIA-232 serial port pin functions.



Female chassis connector, as viewed from the outside panel.

Figure 2.6 EIA-232 DB-9 Connector Pin Numbers

The communications circuits have internal surge protection.

NOTE: The SEL-3378 serial ports (Console, 1–15) transmit IRIG-B. Do not connect to another device with a serial port that transmits IRIG-B.

Table 2.2 Serial Port Connector Pin Definition

Pin	Signal Name	Description
1	N/C or +5 Vdc or DCD[a]	Modem power
2	RXD	Receive data
3	TXD	Transmit data
4	+IRIG-B	Time-code signal positive
5	GND	Chassis ground
6	–IRIG-B (GND)	Time-code signal negative
7	RTS	Request to send
8	CTS	Clear to send
9	GND	Chassis ground

[a] Jumper configurable.

The following figures show common serial cable configurations. Refer to SEL-5801 Cable Selector Software for the most recent cable configurations. *Figure 2.7* shows the C234A serial cable for interfacing SEL-3378 (through the **Console** port) with a local computer. *Figure 2.8* shows the C272A serial cable for connecting to PMCUs that do not require RTS/CTS information. Use cable C276 (see *Figure 2.9*) to connect to PMCUs that require RTS/CTS information.

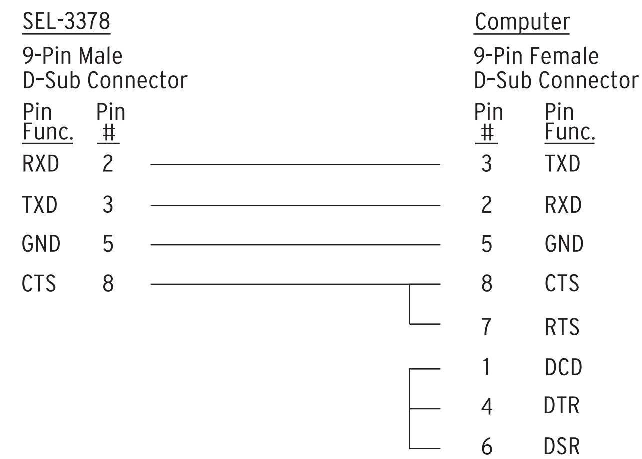


Figure 2.7 SEL Cable C234A

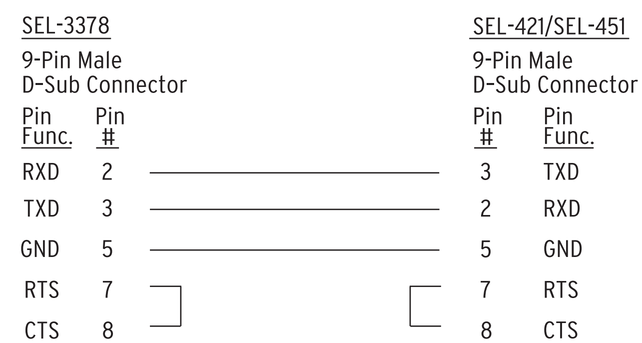


Figure 2.8 SEL Cable C272A

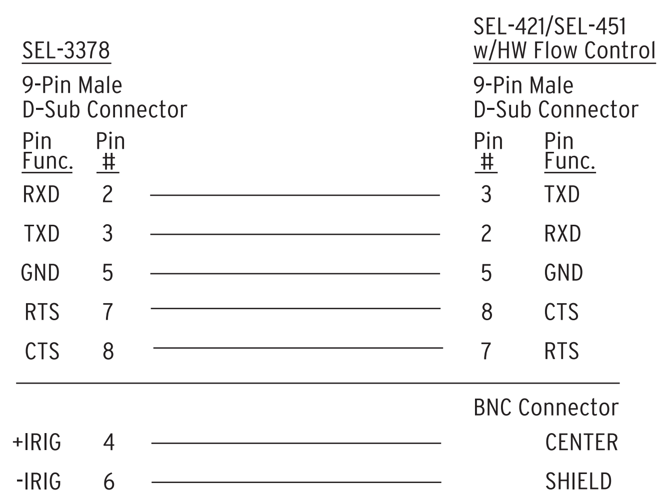


Figure 2.9 SEL Cable C276

⚠WARNING
Never use standard null-modem cables with the SEL-3378. Using any non-SEL cable can cause severe power and ground problems involving Pins 1, 4, and 6 on the SEL-3378 communications ports.

The following list provides additional rules and practices necessary for successful communication with EIA-232 serial communications devices and cables:

- Keep communications cables as short as possible to minimize communications circuit interference and to minimize the magnitude of hazardous ground potential differences that can develop during abnormal power system conditions.
- EIA-232 communications cables should never exceed 50 feet. Always use shielded cables for communications circuits longer than 10 feet.
- Modems or fiber-optic lines are necessary for communication over long distances and to provide isolation from ground potential differences between device locations. Refer to the SEL-2800 series of fiber-optic transceivers.
- Route communications cables away from power and control circuits. Switching spikes and surges in power and control circuits can cause noise in inadequately separated communications circuits.

Overcurrent Status

The SEL-3378 sources power out of the EIA-232 ports. Current limiting on these ports is provided to ensure that there will not be equipment damage in the event of a short circuit on these ports. Shorting the power on these ports will not affect the operation of the SEL-3378. *Table 2.3* shows the current limited sections.

Table 2.3 Current Limited Sections

Port	Limit
EIA-232 ports	0.6 A, 5 Vdc, 3.0 W total for all

Exceeding the limits shown in *Table 2.3* will cause the alarm contact to close.

IRIG-B Connections

NOTE: IRIG-B input is not available on any serial communication ports.

⚠WARNING
If a modulated IRIG-B input is used, the demodulated IRIG-B output is unsuitable for synchronizing connected PMCUs.

The SEL-3378 accepts demodulated (B002) IRIG-B on the BNC IRIG-B input connector. Demodulated IRIG-B is distributed through the BNC IRIG-B output connector and on Pins 4 and 6 of the serial ports.

IRIG-B can be distributed through serial ports and a BNC connector. IRIG propagation delay through SEL-3378 serial outputs is about 350 ns. IRIG propagation delay through BNC output is about 300 ns. To distribute IRIG-B to PMCUs sending C37.118 synchrophasor data, use an IRIG-B input that has C37.118 compliant control bit information.

Use the IRIG-B input to update day-of-the-year and time-of-day but not year. Update the year manually. See *DATE on page 2.17* to change the year. The SEL-3378 stores the year for the set date in nonvolatile memory. Once the date is set properly, the SEL-3378 maintains the proper year even if power cycles off and on.

Alarm Contact Connection

⚠WARNING
Do not operate device unless the device is properly grounded.

The SEL-3378 includes an alarm output contact connected to terminals **A01** and **A03**. Terminal **A02** is not used. By default, the alarm contact is closed for an alarm condition and open for normal operation. To invert the alarm output contact to close under normal conditions (i.e., Form A), contact your local SEL representative for assistance.

The SEL-3378 monitors its critical subsystems and latches or pulses the alarm contact during failure conditions. See *Section 5: Troubleshooting* for a discussion of these failures. The ALARM LED on the front panel illuminates whenever the alarm contact asserts. 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.

Ground Connection

Connect the grounding terminal (#Z07) labeled GND on the rear panel to a rack frame ground or main station ground for proper safety and performance. Use 2.5 mm^2 (14 AWG) wire shorter than 2 m (6.6 ft) for this connection. This terminal connects directly to the internal chassis ground of the SEL-3378.

Power Connection

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

⚠WARNING
Do not operate device unless properly grounded.

Connect the power terminals on the rear panel (Z05(+/H) and Z06(-/N)) to a proper power source that matches the power supply rating listed on the serial number sticker on the rear panel as shown in *Figure 2.10*. Ensure that the connected voltage is within the specified range. Refer to *Section 1: Introduction and Specifications* for power supply specification.

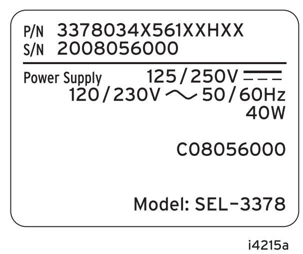


Figure 2.10 Serial Number Sticker

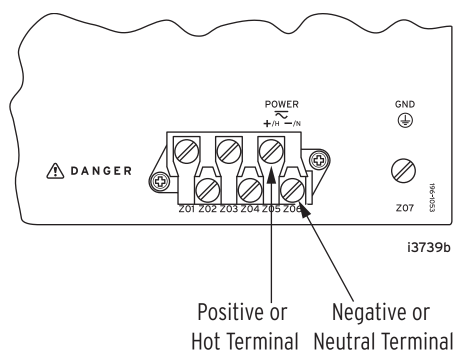


Figure 2.11 Power Connections

The power terminals are isolated from the chassis ground. Use 2.5 mm^2 (14 AWG) to 1.5 mm^2 (16 AWG) 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 ft) of the SEL-3378. Disconnect devices must comply with IEC 60947-1 and IEC 60947-3.1.

Operational power is internally fused on the power supply. See *Field Serviceability on page 2.13* for the fuse replacement procedure. An internal fuse failure indicates possible circuit board or electronic failure that can cause sporadic or incorrect device operation.

Field Serviceability

The SEL-3378 is designed to provide years of trouble-free and maintenance-free operation. Should you need to maintain the device, consult this section for information on field-serviceable items. SEL recommends contacting your local SEL representative before performing any of the service items in this section. By contacting SEL, you provide SEL feedback necessary for determining if a common failure mode is developing. SEL can also provide any recent suggestions or clarifications to the following procedures.

Fuse 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.

To replace the power supply fuse, perform the following steps:

Step 1. De-energize the SEL-3378 by disconnecting or removing power.

Be sure that the power source is tagged properly to avoid accidental reenergization.

Step 2. Remove all connections from the rear of the SEL-3378.

Step 3. Remove the SEL-3378 from the panel or 19-inch rack.

Step 4. Remove the front panel.

Step 5. Remove the top cover.

Step 6. Remove the side and rear screw connections (see *Figure 2.12*) between the heatsink and the case.

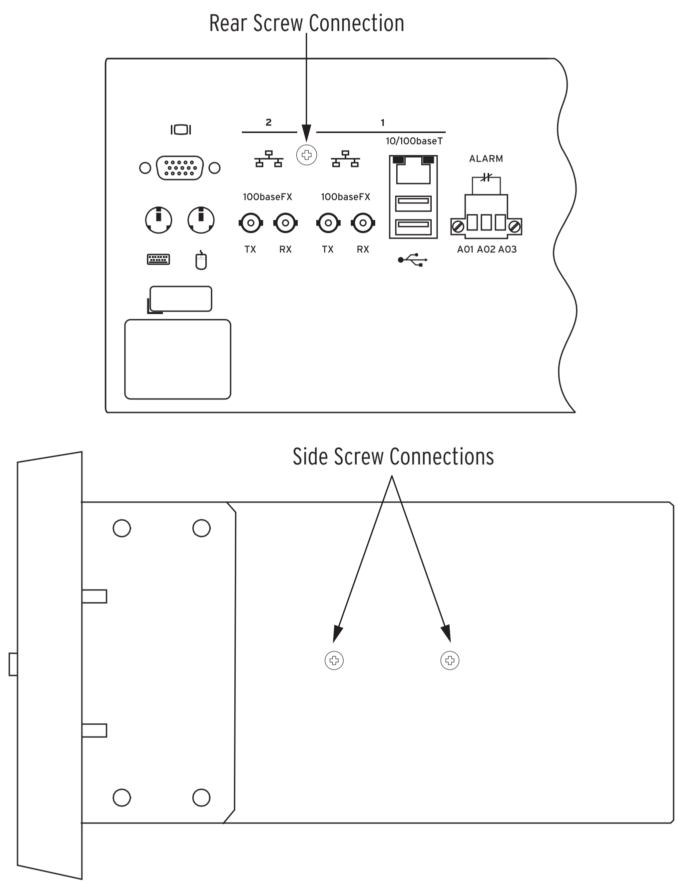


Figure 2.12 Screw Connections

Step 7. Gently slide out the top tray.

Step 8. Locate the power supply mounted on the bottom of the chassis.

Step 9. Locate fuse F1 on the power supply as shown in *Figure 2.13*.

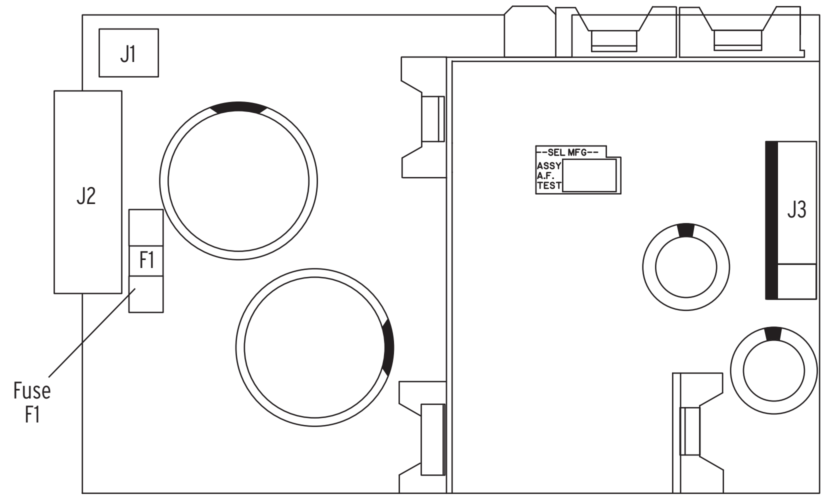


Figure 2.13 Power Supply Fuse Location

Step 10. Replace the fuse with fuse types listed in *Table 2.4*.

Table 2.4 Fuse Requirements for the SEL-3378 Power Supply

Nominal Power Supply Voltage Rating	Fuse F1	Fuse Description
24/48 V	T6.3AH250V	5x20 mm, time-lag, 6.3 A, high break capacity, 250 V
48/125 V 120 V 50/60 Hz	T3.15AH250V	5x20 mm, time-lag, 3.15 A, high break capacity, 250 V
125/250 V 120/230 V 50/60 Hz	T3.15AH250V	5x20 mm, time-lag, 3.15 A, high break capacity, 250 V

Step 11. Gently slide in the top tray.

Step 12. Replace the side and rear screws.

Step 13. Connect the power supply cable.

Step 14. Replace the top cover.

Step 15. Replace the front panel.

Step 16. Replace the device into the panel or 19-inch rack.

Step 17. Replace all connections on the rear of the device.

Step 18. Reapply power to the SEL-3378.

Lithium Battery Replacement

⚠CAUTION
There is danger of explosion if the battery is incorrectly replaced. Replace only with a 3 V lithium coin cell Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. Dispose of used batteries according to the manufacturer's instructions.

A lithium battery powers the clock (supplying date and time) if the external power source is lost or removed. At room temperature, the battery will operate nominally for two years at rated load with no external source present. When an external source powers the SEL-3378, the battery discharges at a low rate and can operate longer than 10 years.

The battery cannot be recharged. To replace the lithium battery, perform the following steps.

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

Be sure that the power source is tagged properly to avoid accidental reenergization.

Step 2. Remove all connections from the rear of the SEL-3378.

Step 3. Remove the SEL-3378 from the panel or 19-inch rack.

Step 4. Remove the front panel.

Step 5. Remove the top cover.

Step 6. Locate battery B1 as shown in *Figure 2.1*.

Step 7. Remove the battery from underneath the retaining clip.

Properly dispose of the battery.

Step 8. Install a new battery with the positive (+) side up.

Step 9. Replace the top cover.

Step 10. Replace the front panel.

Step 11. Reinstall the SEL-3378 into the panel or 19-inch rack.

Step 12. Replace the cable connections in the rear of the SEL-3378.

Step 13. Reapply power to the SEL-3378.

Console Port

The console port provides a serial communication interface with the SEL-3378 for configuring the network settings, for displaying self-test status report information, and for setting date and time. **Console** is dedicated as the console port. The console port is set at a fixed data rate of 9600 (eight bits per byte, no parity, one stop bit, and no flow control).

Issue ASCII commands as needed to change product configuration or to view the status report.

The console port has three access levels (0, 1, 2). Each level has corresponding commands and includes the commands of any lower access level. See *Access Control and Security on page 2.19* for more details on console port access levels and passwords.

The following tables list commands, command descriptions, and command availability.

Console Port Commands

HELP

Use the **HELP** (**HEL**) command to display a list of commands available at the present access level.

Table 2.5 HELP Commands

Command	Description	Access Level
HEL	Display a list of commands	1, 2

QUIT

Use the **QUIT** (**QUI**) command to go to Access Level 0. See *Access Control and Security on page 2.19* for more details on Access Level 0 and this command.

Table 2.6 QUIT Command

Command	Description	Access Level
QUI	Go to Access Level 0	1, 2

ACCESS

Use the **ACCESS** (**ACC**) command to go to Access Level 1. See *Access Control and Security on page 2.19* for more details on Access Level 1 and this command.

Table 2.7 ACCESS Command

Command	Description	Access Level
ACC	Go to Access Level 1	0, 1, 2

2ACCESS

Use the **2ACCESS** (**2AC**) command to go to Access Level 2. See *Access Control and Security on page 2.19* for more details on Access Level 2 and this command.

Table 2.8 2ACCESS Command

Command	Description	Access Level
2AC	Go to Access Level 2	1, 2

PASSWORD

⚠**WARNING**
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Use the **PASSWORD** (**PAS**) command to change the password of the present access level to a new password. All passwords are case sensitive. See *Startup Procedure on page 2.20* for more details on changing passwords. See *Access Control and Security on page 2.19* for more details on password protection for the console port.

Table 2.9 PASSWORD Command

Command	Description	Access Level
PAS	Change passwords	1, 2

DATE

Use the **DATE** (**DAT**) command to display the date of the internal clock. Use the **SET DATE** (**SET DAT**) command to change the date.

If you enter an invalid date or date with invalid format, the SEL-3378 responds `Invalid Entry`. The SEL-3378 overwrites the entered date (except year) if you connect IRIG to the SEL-3378. Regardless of whether IRIG is updating the internal clock, use the **SET DAT** command to change the year of the internal clock.

Table 2.10 DATE Commands

Command	Description	Access Level
DAT	Display the internal clock date	1, 2
SET DAT	Change the internal clock date	2

TIME

Use the **TIME** (**TIM**) command to display the time of the internal clock. Use the **SET TIME** (**SET TIM**) command to change the time. If you enter an invalid time, the SEL-3378 responds `Invalid Entry`. The SEL-3378 overwrites the entered time if an IRIG source is updating the internal clock.

Table 2.11 TIME Commands

Command	Description	Access Level
TIM	Display the internal clock time	1, 2
SET TIM	Change the internal clock time	2

SHOW

Use the **SHOW** (**SHO**) command to display SEL-3378 setting labels and present values.

Table 2.12 SHOW Command

Command	Description	Access Level
SHO	Show settings	1, 2

SET

Use the **SET** command to configure SEL-3378 network settings.

Table 2.13 SET Command

Command	Description	Access Level
SET	Change current setting configuration	2

When you change settings, the SEL-3378 displays the setting label, prompt, and present value. *Table 2.14* lists the possible keyboard operations from a setting prompt.

Table 2.14 Possible Keyboard Operations

Press Key(s)	Response
<Enter>	Accept setting and move to next setting
value <Enter>	Enter the given value and move to the next setting if valid

The SEL-3378 checks each setting to ensure that it is within the allowed range. If the setting is not within the allowed range, the SEL-3378 responds `Invalid Entry` and prompts you for the setting again.

When you have entered all settings, the SEL-3378 prompts you for approval. Answer **Y <Enter>** to enable the new settings. Upon successful completion of the **SET** command session, the SEL-3378 becomes disabled for about 10 seconds while it saves the setting values in nonvolatile memory.

STATUS

Use the **STATUS** (**STA**) command to display the SEL-3378 network status report. See *Section 5: Troubleshooting* for more details.

Table 2.15 STATUS Command

Command	Description	Access Level
STA	Display the self-test status report information	1, 2

REBOOT

Use the **REBOOT** (**REB**) command to initiate a reboot of the SEL-3378.

Table 2.16 REBOOT Command

Command	Description	Access Level
REBOOT	Reboots the SEL-3378	2

Access Control and Security

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Controlled access levels and multilevel passwords for the console port prevent unauthorized access. The SEL-3378 comes with default passwords. It is extremely important that you change the factory default passwords. Setting unique passwords for the product access levels increases security. This subsection provides information on access control and security for the console port.

The console port has three access levels: 0, 1, and 2. *Figure 2.14* shows the general access level structure for the console port.

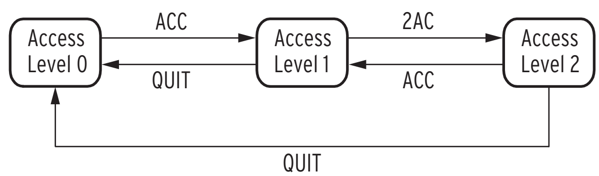


Figure 2.14 Console Port Access Level Structure

Access Level 0 provides very limited access. Access Level 1 provides access only for viewing settings. Access Level 2 provides full access for viewing and modifying settings. Each access level has an associated prompt that indicates the active level. Moving from lower to higher security levels is sequential and requires correct passwords. *Table 2.17* lists the access levels, prompts, ASCII commands, and corresponding factory default passwords.

Table 2.17 Console Port Access Levels, Prompts, ASCII Commands, and Passwords

Access Level	Prompt	ASCII Command	Factory Default Password
0	=	QUIt	(none)
1	=>	ACCess	OTTER-3378
2	=>>	2ACess	TAIL-3378

You must first enter a correct password to move from Access Level 0 to Access Level 1. To enter Access Level 2, you must enter a correct password from Access Level 1. For example, to go to the Access Level 2 from Access Level 1, type **2AC <Enter>**. At the `Password: ?` prompt, type your Access Level 2 password.

If you are unable to enter the correct password after the third failed attempt, the SEL-3378 displays the following error message: `Bad password. Console is now locked`. In addition, you cannot make further access level entry attempts for 30 seconds.

Passwords can contain no fewer than 6 characters and no more than 256 characters. The SEL-3378 treats upper- and lowercase letters as different characters. Strong passwords consist of at least the allowed number of characters, with at least one special character, number and mixed case sensitivity but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Table 2.18 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ' { | } ~

See *Startup Procedure on page 2.20* for details on changing passwords.

Use the **QUI** command from any access level to return to Access Level 0.

When the console session times out, the access level resets to Access Level 0.

Startup Procedure

The following is a step-by-step procedure for SEL-3378 commissioning, which includes initial checkout and console port password change.

Initial Checkout

Perform the following steps for initial checkout.

Step 1. Visually inspect the SEL-3378 for any loose or damaged parts.

Step 2. Use the information provided in *Unit Placement and Maintenance on page 2.6* to properly mount the SEL-3378.

Step 3. Use an SEL-C234A cable or equivalent to connect a computer equipped with terminal emulation software to the console port (Console) of the SEL-3378.

When using Microsoft® HyperTerminal, set **Backspace key sends** to **Del**.

If your computer only has a USB port, use C662 USB to EIA-232 cable.

Step 4. Connect any PMCUs sending synchrophasor data through serial cable to SEL-3378 serial ports. See *Serial Port Communications on page 2.9* for details.

Step 5. Use a BNC cable to connect any GPS clock with IRIG-B output to the SEL-3378 IRIG IN input. See *IRIG-B Connections on page 2.11* for more details on the IRIG-B connection.

Step 6. Connect and apply power to the SEL-3378. Wait at least five minutes for the device to boot.

Step 7. Press and hold the LAMP TEST button and confirm that all LEDs illuminate.

Step 8. Set the computer terminal emulation software to operate at the following settings:

- 9600 bits per second (sometimes called baud)
- 8 data bits
- No parity
- 1 stop bit
- No hardware flow control

Step 9. Press **<Enter>**.

Step 10. Verify that the SEL-3378 returns the = prompt.

Completion of this procedure should have successfully established console port communication.

Console Port Password Change

⚠WARNING
This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

Perform the following steps to change access level passwords on the console port.

Step 1. Type **ACC** and press **<Enter>** at the = prompt to go to Access Level 1.

If you have not yet changed the password, enter the factory default password (**OTTER-3378**) and press **<Enter>**. The password is case sensitive. The SEL-3378 returns the `=>` prompt.

Step 2. Type **2AC** and press **<Enter>** at the `=>` prompt to change to Access Level 2.

If you have not yet changed the password, enter the factory default password (**TAIL-3378**) and press **<Enter>** (the SEL-3378 returns the `=>>` prompt).

Step 3. Type **PAS** and press **<Enter>** at the `=>>` prompt to change the Access Level 2 password from the default.

Step 4. Verify that the SEL-3378 returns the `Old Password: ?` prompt. Enter the Access Level 2 password (**TAIL-3378**) and press **<Enter>**.

Step 5. Verify that the SEL-3378 returns the `New Password: ?` prompt.

Step 6. Enter the new password (for example, **ot7S#Er**) and press **<Enter>**.

See *Access Control and Security on page 2.19* for more details on using strong passwords. Verify that the SEL-3378 returns the `Verify New Password: ?` prompt.

Step 7. Enter the new password (for example, **ot7S#Er**) again and press **<Enter>**.

If the new passwords do not match, the SEL-3378 issues a `New passwords do not match` response. Otherwise, the SEL-3378 issues a `Password for Access Level 2 changed` response.

Step 8. Similarly, use the **PAS** command at Access Level 1 to change the Access Level 1 password.

Network Configuration Settings

The console port is used mainly to configure network configuration settings for Ethernet Port 1 and 2 during product installation. See *Ethernet Connection on page 2.9* for more details regarding the Ethernet port and connections. *Table 2.19* shows the network configuration settings and default values that you can modify or display at the console port through the use of the **SET** or **SHO** commands.

Table 2.19 Network Configuration Settings

Label	Prompt	Default Value
01ETHEN	Enable network interface 01	Y
01ETDHCP[a]	Enable DHCP on network interface 01	Y
01ETIPAD[a,b]	Network interface 01 IP address	0.0.0.0
01ETSNMK[a,b]	Network interface 01 subnet mask	0.0.0.0
01ETGTWY[a,b]	Network interface 01 gateway	0.0.0.0
02ETHEN	Enable network interface 02	Y
02ETDHCP[c]	Enable DHCP on network interface 02	Y
02ETIPAD[c,d]	Network interface 02 IP address	0.0.0.0
02ETSNMK[c,d]	Network interface 02 subnet mask	0.0.0.0
02ETGTWY[c,d]	Network interface 02 gateway	0.0.0.0
ETHOST[e]	Network hostname	NA

[a] Setting is hidden when 01ETHEN = N.
[b] Setting shows only when 01ETDHCP = N.
[c] Setting is hidden when 02ETHEN = N.
[d] Setting shows only when 02ETDHCP = N.
[e] Setting is hidden when 01ETHEN = N and 02ETHEN = N.

The SEL-3378 default network configuration settings assume that the two Ethernet ports are enabled and that the network has a DHCP (Dynamic Host Configuration Protocol) server. The DHCP server dynamically assigns IP configuration (i.e., IP address, Subnet Mask, and Gateway address) to the Ethernet port. Use the 01ETHEN and 02ETHEN settings to enable Ethernet Ports **1** and **2**. If you have a DHCP server in the network, use the 01ETDHCP and 02ETDHCP settings to enable the DHCP server to provide IP configuration automatically. Contact your network administrator for the network configuration.

The following is an example of how to configure SEL-3378 network settings. Ethernet Port 1 on SEL-3378 is connected to the utility network, which has a DHCP server. Ethernet Port 2 on SEL-3378 is connected to a different network that has no DHCP server.

Step 1. Gain access to Access Level 2 on the console port.

Step 2. Each Ethernet port has a unique MAC address. MAC addresses for Ethernet ports can be found by using the **STA** command.

Step 3. Provide the MAC addresses to the network administrator for reserving static IP configuration for the SEL-3378 Ethernet ports.

Step 4. Use the **SET** command to enter the new settings according to *Table 2.20*.

Table 2.20 New Settings

Prompt	Action
Enable network interface 01	**Y <Enter>**
Enable DHCP on network interface 01	**Y <Enter>**
Enable network interface 02	**Y <Enter>**
Enable DHCP on network interface 02	**N <Enter>**
Network interface 02 IP address	**123.123.123.123 <Enter>**
Network interface 02 subnet mask	**255.255.0.0 <Enter>**
Network interface 02 gateway	**231.211.212.1 <Enter>**
Network hostname	**HOSTNAME <Enter>**
Are you sure you want to change settings?	**Y <Enter>**

Step 5. Connect SEL-3378 Ethernet ports to the network.

Step 6. Issue the **SHO** command again at the =>> prompt and press **<Enter>**.

Step 7. SEL-3378 responds as follows:

```
=>>SHO <Enter>

Network Configuration
01ETHEN  : Y
01ETDHCP : Y
02ETHEN  : Y
02ETDHCP : N
02ETIPAD : 123.123.123.123
02ETSNMK : 255.255.0.0
02ETGTWY : 231.211.212.1
ETHOST   : HOSTNAME
```

This page intentionally left blank

Section 3
Product Functionality

Overview

This section describes the basic functionality of the SEL-3378 Synchrophasor Vector Processor. It includes descriptions of the following functions and function blocks:

- ➤ Time Alignment Client Server (TCS)
- ➤ Fast Operate (FO) Command Function Blocks
- ➤ Power Calculation (PWRC) Function Block
- ➤ Phase Angle Difference Monitor (PADM) Function Block
- ➤ Modal Analysis (MA) Function Block
- ➤ Substation State and Topology Processor (SSTP)
- ➤ Local PMCU (user-configurable synchrophasor message) Function Block

Basic Functionality

The SEL-3378 Synchrophasor Vector Processor (SVP) includes Time Alignment Client Server (TCS) software with the functionality included in *Table 3.1* and shown in *Figure 3.1*.

Table 3.1 TCS Functionality

Modules	Description
Time Alignment (TA)	TA aligns incoming C37.118 messages from external C37.118 servers.
Client	The TCS client performs the following tasks: Sends commands to external C37.118 servers. Receives synchrophasor data and configuration messages from external C37.118 servers and sends these messages to TA. Sends SEL Fast Operate (FO) commands to external devices (e.g., SEL-421, SEL-2515, SEL-2411).
Server	The TCS server performs the following tasks: Receives commands from external and internal C37.118 clients. Sends time-aligned data to the internal C37.118 client. Sends time-aligned data to as many as six external C37.118 clients.

The TCS server sends the time-aligned data to an internal C37.118 client that makes the data available to the SEL-3378 Run Time System (RTS). With the SVP Configurator, you can develop monitoring and control applications that use the C37.118 information (phasors, real values, and Boolean values) that external C37.118 servers publish. This environment includes a programming system that uses the IEC-61131-3 programming language for programmable logic controllers (PLCs). The SEL-3378 runs the program, built in the SVP Configurator, that includes the user applications. In addition to PLC functionality, the SEL-3378 includes the function blocks and functions included in *Table 3.2*.

Table 3.2 SEL-3378 Function Blocks and Functions

Function Blocks and Functions	Description
Power Calculation Function Block (PWRC)	PWRC calculates the real and reactive power from a user-selected set of voltage and current phasors.
Phase Angle Difference Monitor Function Block (PADM)	PADM calculates the angle difference between two user-selected angles and provides two angle difference alarms based on user-defined thresholds.
Modal Analysis Function Block (MA)	MA calculates the modes of a user-selected signal.
Substation State and Topology Processor (SSTP)	The SSTP identifies measurement errors, calculates current unbalance and symmetrical components, and refines voltage and current measurements.
Fast Operate Command (FO)	FO commands activate remote bits and breaker control bits.
Local PMCU	The Local PMCU is a user-configurable C37.118 server that supports one external C37.118 client.

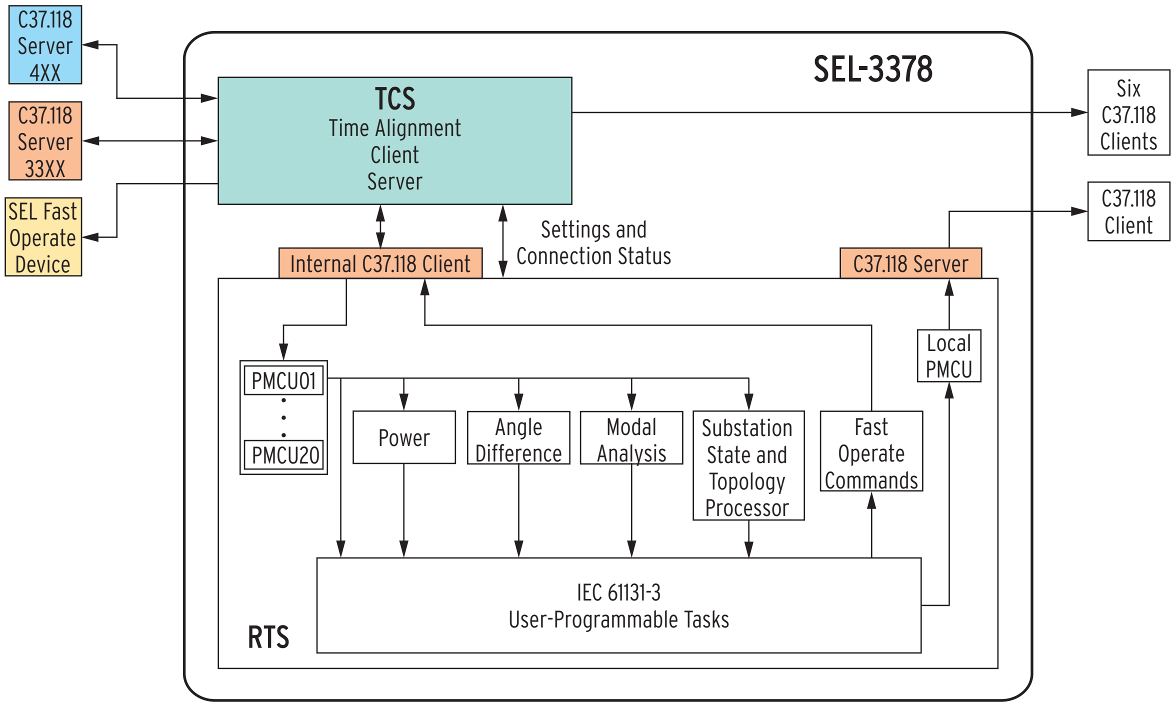


Figure 3.1 Synchrophasor Vector Processor Functionality

Time Alignment Client Server (TCS)

The TCS time correlates IEEE C37.118-2005, Standard for Synchrophasors for Power Systems, data frames from as many as 20 PMCUs (serial and Ethernet® connections) and generates a single C37.118 data frame that contains the time-aligned data from all the incoming PMCUs (similar to a Phasor Data Concentrator). The time-aligned data are available to the internal C37.118 client and six external C37.118 clients (e.g., SYNCHROWAVE® Console SEL-5078 Software). The TCS can also receive Fast Operate commands from external C37.118 clients and the RTS. The TCS client transmits these commands to the appropriate external device to perform the requested action.

Power Calculation (PWRC)

PWRC calculates real and reactive power based on user-selected voltage and current phasors. PWRC outputs the instantaneous values of the real power (kW) and reactive power (kVAR) with their corresponding timestamps. *Equation 3.1* and *Equation 3.2* show this implementation of the function block.

$$P = (RE\_V \cdot RE\_I + IM\_V \cdot IM\_I)/1000 \qquad \textbf{Equation 3.1}$$

where:

P is the real power in kW.

$$Q = (IM\_V \cdot RE\_I - RE\_V \cdot IM\_I)/1000 \qquad \textbf{Equation 3.2}$$

where:

Q is the reactive power in kVAR.

Phase Angle Difference Monitor (PADM)

The PADM Function Block calculates the angle difference between two phasors and asserts alarms based on user-defined thresholds. You can assign the two phasor angles, the two angular thresholds in degrees, and the corresponding pickup timers for each threshold. PADM outputs the instantaneous value of the phase angle difference in degrees and the status of the two alarms with the corresponding time stamp. The angle difference output range is ±180°.

Modal Analysis (MA)

The SEL-3378 supports as many as six MA instances. From among such signals as frequency, phasor magnitude, phasor angle, analog value, power, angle difference, etc., you select one input signal to MA per instance. You also define the input signal message rate, the observation time, the sliding window percentage, the required number of modes, the input signal time stamp, and the input signal quality status. The MA output includes the following information per mode: frequency, damping constant, damping ratio, amplitude, and phase. The MA results are available for System Integrity Protection Schemes or for power system monitoring. You can configure the Local PMCU to send the MA results to an external C37.118 client (for example, the SYNCHROWAVE Console software).

Signal Modal Representation

The MA Function Block captures a set of contiguous time-synchronized samples of a user-selected signal and calculates the signal modes. You can use these calculation results to reconstruct the signal y[n] according to *Equation 3.3* for $1 \le n \le N$. The value N is the number of samples in the observation window (observation time multiplied by the message rate).

$$\hat{y}[n] = \sum_{m=1}^{M} A_m \bullet e^{\sigma_m \bullet n \bullet T} \cos(2\pi \bullet f_m \bullet n \bullet T + \phi_m)$$

Equation 3.3

where:

M is the number of modes
m is the signal mode
A_m is the amplitude of mode m
σ_m is the damping constant of mode m
f_m is the frequency of mode m in Hz
ϕ_m is the phase of mode m in degrees
T is the sample interval in seconds

Damping Ratio

NOTE: Negative damping ratio indicates an increasing oscillation.

MA uses *Equation 3.4* to calculate the damping ratio, ζ_m, and to determine the rate of decay in the oscillation amplitude.

$$\zeta_m = -\frac{\sigma_m}{\sqrt{\sigma_m^2 + (2\pi \bullet f_m)^2}}$$

Equation 3.4

Signal-to-Noise Ratio

Additionally, MA compares the estimated signal against the original signal. MA uses *Equation 3.5* to calculate the signal-to-noise-ratio (SNR) in dBs, quantifying the quality of the fit:

$$\mathrm{SNR} = 20 \cdot \log\left(\frac{\|y[n]\|}{\|\hat{y}[n] - y[n]\|}\right) \qquad \textbf{Equation 3.5}$$

where:

$y[n]$ is the original signal

$\hat{y}[n]$ is the estimated signal

$\|y[n]\|$ is the norm of $y[n]$

Substation State and Topology Processor (SSTP)

The SSTP is part of the system shown in *Figure 3.1*. SSTP gathers time-aligned synchrophasor data, along with the status of breakers and disconnect switches from PMUs and PMCUs, for substation state and topology assessment. SSTP uses these data to identify measurement errors and improve measurement accuracy. The SSTP module is organized into three main processors (see *Figure 3.2*): the Topology Processor (TP), the Current Processor (CP), and the Voltage Processor (VP). TP processes breaker and disconnect switch status to obtain the substation topology and then makes this information available to CP and VP. The current and voltage processors use the substation topology and the synchrophasor data to detect measurement errors and improve the accuracy of current and voltage measurements in real time.

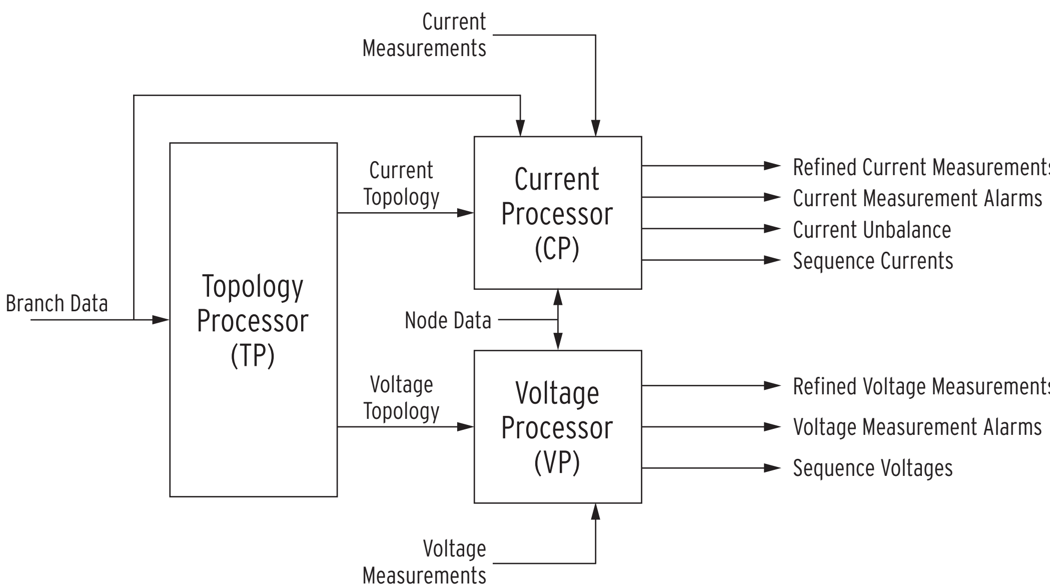


Figure 3.2 Substation State and Topology Processor Includes Topology, Current, and Voltage Processors to Refine Measurements and to Identify Measurement Errors

Topology Processor (TP)

TP uses branch status information to provide topology information for the current and voltage processors. TP determines the current topology and the voltage topology by merging busbar nodes to create node groups according to the closed status of the branches in the busbar arrangement. TP identifies the branches with current measurements. To create the current topology, TP merges nodes when the non-metered branches are closed or when the branch close status quality of the non-metered branch is FALSE. To create the voltage topology, TP merges nodes when branches are closed. CP uses the current topology for current measurement checks and refinement. VP uses the voltage topology for voltage measurement checks and refinement.

Current Processor (CP)

CP identifies current measurement errors, refines current measurements, calculates current unbalance, and calculates symmetrical component currents. It also provides user-defined alarms for current unbalance and symmetrical component currents.

Current Measurement Normalization and Consistency Check

CP applies correction factors to scale each current measurement and computes the median of all the measurements associated with each branch on a per-phase basis. You enter the correction factor angles in degrees. The current angle measurements are in radians. CP compares the median value with the individual measurements and sets the corresponding alarms if the differences exceed a user-provided current consistency threshold, i_cons_thre. CP outputs the scaled measurements and the measurement consistency alarms in the branch_output_data structure.

Kirchhoff's Current Law (KCL) Check and Current Measurement Refinement

The current processor computes the sum of currents (KCL) reaching every current node group on a per-phase basis. When all currents reaching a group of nodes are available for KCL check, CP compares the sum of the currents against the user-supplied KCL threshold, KCL_thre. If the magnitude of the sum of the measurements is less than the user-supplied KCL threshold, CP sets the KCL_OK flag for all the involved phase currents and refines the measurement values. Otherwise, at least one of the measurements is bad and no refinement occurs. Consider *Figure 3.3*, where A_1, A_2, and A_3 are the A-phase scaled current measurements on the three branches reaching Node 1.

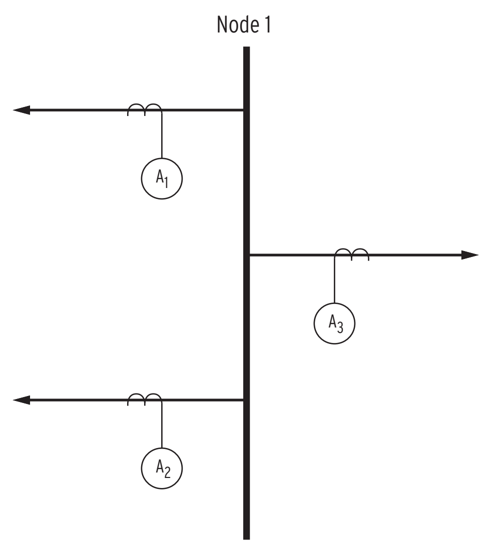


Figure 3.3 Current Measurements for Current Measurement Refinement

Equation 3.6 presents the sum condition for the node in *Figure 3.3*. To refine the measurements, we find I_1, I_2, and I_3 minimizing the overall error ε defined in *Equation 3.7*. The I_1, I_2, and I_3 currents correspond to the refined current measurements.

$$\left|\sum_{i=1}^{3} A_i\right| < KCL\_thre$$

Equation 3.6

$$\varepsilon = \left|\sum_{i=1}^{3} I_i\right| + |I_1 - A_1| + |I_2 - A_2| + |I_3 - A_3| \quad \textbf{Equation 3.7}$$

Current Unbalances and Alarms

The current unbalance logic processes the three-phase currents according to the logic in *Figure 3.4* to find current unbalances on metered branches. When the median of the phase current magnitudes exceeds the current unbalance enable threshold, i_unb_en_thre, the current unbalance logic calculates the current unbalance percentage for each phase. The logic also compares the computed phase current unbalance percentages to the corresponding user-defined current unbalance threshold, i_unb_thre, and sets the current unbalance alarm when any of the phase unbalance percentages exceeds this threshold. The calculation repeats for each measurement.

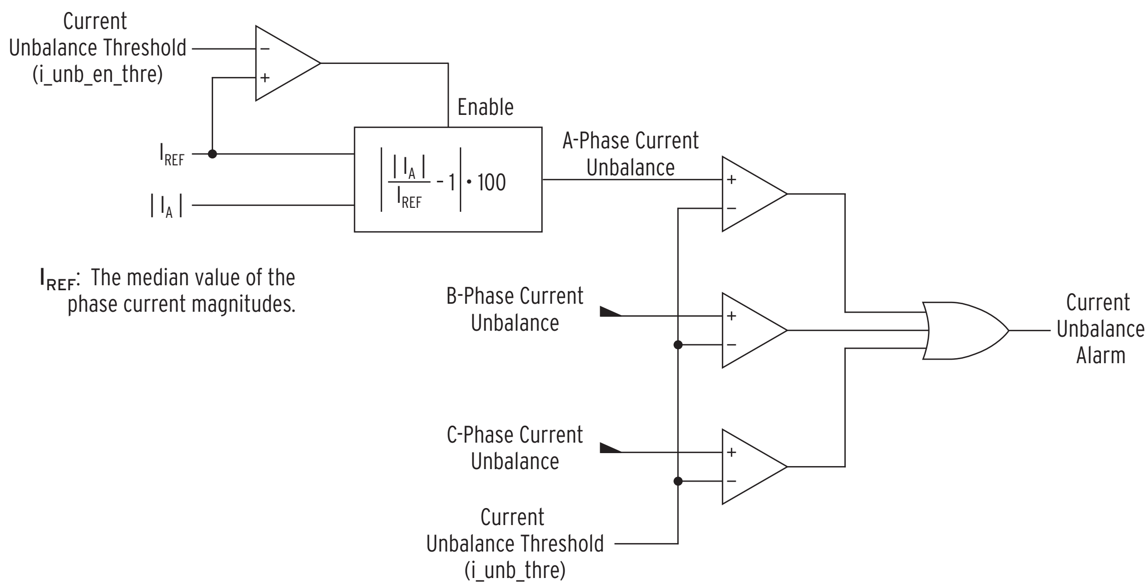


Figure 3.4 Current Unbalance Logic

Symmetrical Component Currents and Alarms

CP also computes symmetrical component currents (positive, negative, and zero) for each branch, and asserts alarms for symmetrical component currents in excess of their corresponding symmetrical component current thresholds.

Voltage Processor

The voltage processor (VP) identifies measurement errors, refines voltage measurements, and calculates symmetrical component voltages. It also provides user-defined thresholds for symmetrical component voltage alarms.

Voltage Measurement Normalization

VP applies user-provided correction factors to each voltage measurement on a per-node and per-phase basis. The scaled voltage measurement variables store the results of these multiplications.

Voltage Measurement Refinement and Consistency Check

VP computes the median of the scaled voltage of every group of nodes on a per-phase basis and then uses this value as the refined voltage for the group of nodes. VP compares the refined voltage in each group of nodes to each individual scaled voltage measurement in every node. If the difference between the scaled voltage and the refined voltage exceeds the user-defined voltage consistency threshold, v_cons_thre, the voltage consistency alarm associated with the scaled voltage asserts to identify the measurement error.

Symmetrical Component Voltages and Alarms

VP computes the symmetrical components of the refined voltage measurements and sets symmetrical component alarms for symmetrical component voltages that violate their corresponding symmetrical component voltage thresholds.

The node_output_data structure includes the scaled voltage measurements, voltage consistency alarms, symmetrical component voltages, and symmetrical component alarms.

Node Merging Process Example

Figure 3.5 shows a simple bus arrangement to illustrate the node merging process. The bus arrangement has 11 nodes and 11 branches. There are four nodes suitable for KCL checks (N1, N2, N3, and N4), seven terminal nodes (N5, N6, …, N11), eight metered branches (BR1, BR2, …, BR8), and three non-metered branches (BR9, BR10, BR11). *Table 3.3* shows the branch-to-node data array for the current processor when all the non-metered branches are open. The array shows the FROM and TO node identification for each branch.

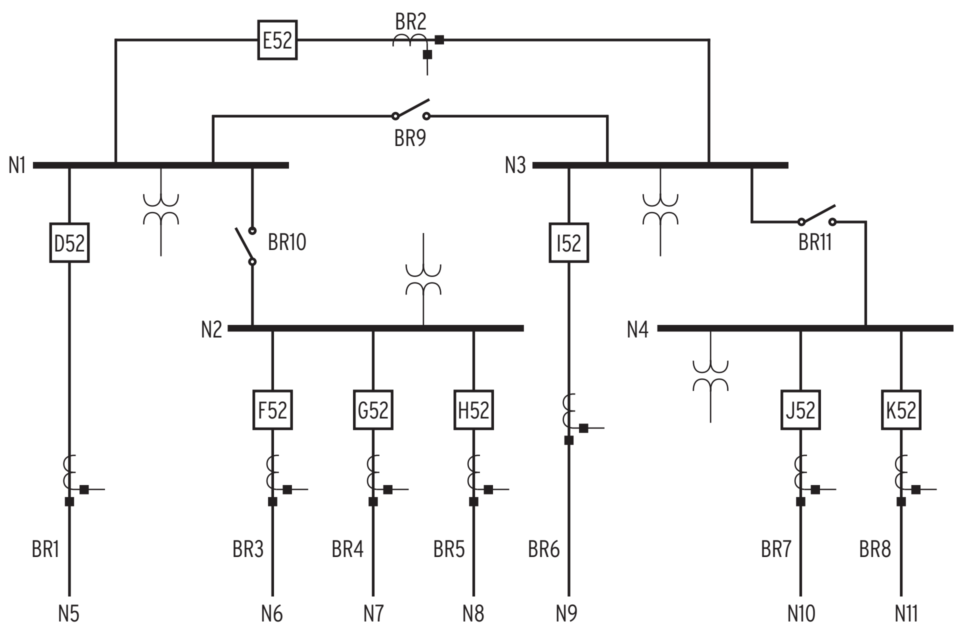


Figure 3.5 Bus Arrangement With Four KCL Nodes, Seven Terminal Nodes, Eight Metered Branches, and Three Non-Metered Branches

Table 3.3 Branch-to-Node Data Array for the Current Processor When All Non-Metered Branches Are Open

	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8	BR9	BR10	BR11
FROM Node ID	1	1	2	2	2	3	4	4	1	1	3
TO Node ID	5	3	6	7	8	9	10	11	3	2	4

After a non-metered branch closes, TP replaces all instances of the non-metered branch TO Node ID with the FROM Node ID in the branch-to-node data array. For example, *Table 3.4* shows the new array after Branch 10 merges Nodes 1 and 2. In this case, the TO Node ID is 2 and the FROM Node ID is 1.

Table 3.4 Branch-to-Node Data Array for the Current Processor After Branch 10 Merges Nodes 1 and 2

	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8	BR9	BR10	BR11
FROM Node ID	1	1	1	1	1	3	4	4	1	1	3
TO Node ID	5	3	6	7	8	9	10	11	3	1	4

Table 3.5 shows the current topology that includes the groups of nodes for KCL checks and the list of branches for each node group after the merging process. Note that Branch 10 is not in the branch list, because the FROM Node ID and the TO Node ID are the same. Also note that Branches 9 and 11 are non-metering branches.

Table 3.5 Group of Nodes and Branch List for Current Topology When Branch 10 Is Closed

Group of Nodes for Current Topology	Branch List
Node 1, Node 2	BR1, BR2, BR3, BR4, BR5
Node 3	BR2, BR6
Node 4	BR7, BR8

Next, we show how the topology processor creates the groups of nodes for the voltage processor when Branch 2 closes. Only nodes 1, 2, 3, and 4 include voltage measurements. TP considers all branches as merging branches to create the voltage node groups. After Branch 2 closes, nodes 1 and 3 merge, and TP replaces all instances of the branch TO Node ID (3) with the FROM Node ID (1) in the branch-to-node data array. *Table 3.6* shows the new array after Branch 2 merges Nodes 1 and 3.

Table 3.6 Branch-to-Node Data Array for the Voltage Processor When Branch 2 Merges Node 1 and Node 3

	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8	BR9	BR10	BR11
FROM Node ID	1	1	2	2	2	1	4	4	1	1	1
TO Node ID	5	1	6	7	8	9	10	11	1	2	4

Table 3.7 shows the voltage topology that includes the groups of nodes for voltage measurement checks and refinement when Branch 2 is closed.

Table 3.7 Group of Nodes for Voltage Topology When Branch 2 Is Closed

Group of Nodes for Voltage Topology
Node 1, Node 3
Node 2
Node 4

Local PMCU

The SEL-3378 has one programmable synchrophasor server, referred to as the Local PMCU, that outputs user-configurable C37.118 messages. The Local PMCU supports 640 phasors, 320 analogs, and 80 digital words. The inputs to the Local PMCU can be programmed to the outputs of the available function blocks or to any appropriate signal. *Section 4* provides description of the inputs and outputs of the Local PMCU (PMCU_OUT) function.

Section 4
Product Application Examples

Overview

Use the SVP Configurator to create project files based on your application. Project files include programs based on the available functions in the SEL-3378 and your programmed functions. Before running a project, you must compile the project and download it to the SEL-3378 for execution.

This section provides instructions for creating project files and for configuring functions in the SEL-3378. Following are the available functions:

➤ **Time Alignment Client Server (TCS)**

Provides time-aligned IEEE C37.118-2005, Standard for Synchrophasors for Power Systems, synchrophasor messages to internal and external clients and provides an interface for transmitting control commands.

➤ **Phasor Measurement and Control Unit Input (PMCU_IN)**

Provides interface for accessing PMCU data for user applications.

➤ **Power Calculation (PWRC)**

Calculates real and reactive power based on user-assigned phasors.

➤ **Phase Angle Difference Monitor (PADM)**

Calculates angle difference between user-assigned phasor angles and asserts alarms based on user-defined thresholds.

➤ **Modal Analysis (MA)**

Calculates modal parameters of the user-selected signal.

➤ **Substation State and Topology Processor (SSTP)**

Refines measurements and asserts alarms based on user-defined thresholds.

The SEL-3378 CD-ROM includes the project examples listed in *Table 4.1*.

Table 4.1 SEL-3378 Project Examples

Project Name	Description
my_project.pro	Project to add two numbers
project1.pro	Project includes tasks to execute TCS, PMCU_IN, PWRC, PADM, and MA functions and function blocks
project2.pro	Project includes tasks to execute TCS, PMCU_IN, and SSTP functions
SVPTemplate.pro	Project includes TCS, PMCU_IN, PWRC, PADM, and MA functions and function blocks with 32 TCS clients and 6 TCS servers

Create a New Project

This subsection provides instructions for creating a new project in the SVP Configurator using IEC 61131-3. It also discusses how to create a new task, set required task configuration attributes, and download the project to the SEL-3378. *Figure 4.1* shows your PC running the SVP Configurator software connected to the SEL-3378, your target device to run your compiled project. If you are not familiar with the SVP Configurator, read *Appendix B: SVP Configurator* before you continue.

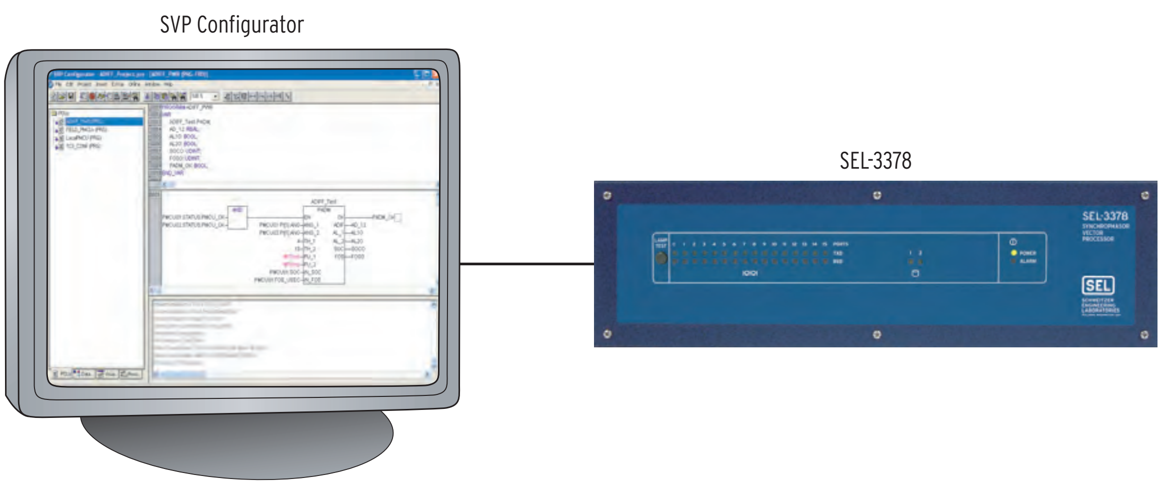


Figure 4.1 PC Running SVP Configurator and Communicating With SEL-3378

Figure 4.2 shows the steps necessary for creating and running a project. Perform the following steps to create a new POU and associate it to a task:

Step 1. Launch the SVP Configurator.

Step 2. Choose **File > New**.

Step 3. Select SEL-3378 **RTS V2.4 for Linux Helens V.1.0** under target settings.

Step 4. Click **OK**.

Step 5. In the **New POU** window, select **Program** (type of POU) and **ST** (structured text option).

Step 6. Assign **EXAMPLE** as the name of the new object (POU).

Step 7. Click **OK**.

Step 8. Set **Task Configuration** as follows:

a. Click on the **Resources** tab (see *Figure 4.3*).

b. Double-click on **Task Configuration**.

Step 9. Select **Append task** from the **Insert** menu.

Step 10. Change the task name to **EXAMPLE_TASK**.

Step 11. Set the **Priority** of the added task to 2.

Priority 0 indicates the highest priority.

Step 12. Set **Type** to Cyclic.

Step 13. Set **Interval** to 16 ms.

For example, **t#16ms**, defines a 16 ms processing interval.

Step 14. From the **Insert** menu perform the following steps:

a. Select **Append Program Call**.

b. Click on the **Browse** button.

c. Assign **EXAMPLE()** to the program call.

For each new POU, you must assign a program call that can be under a new task or an existing task.

Step 15. Select **File > Save** to save your new project.

Step 16. Save the file with the filename **my_project**.

Step 17. Establish communications with the SEL-3378.

a. Choose **Online > Communication Parameters.**

b. Select **New**.

c. Select **TCP/IP Device Name** and name the channel appropriately.

d. Click **OK**.

e. Replace the address from the local host with the SEL-3378 address.

f. Click **OK**.

Step 18. In the programming space insert the sample code shown in *Figure 4.3* to add two numbers.

Step 19. Choose **Project > Clean All**.

Step 20. Choose **Project > Rebuild All**.

Step 21. Choose **Online > Login**.

Step 22. Choose **Online > Run**.

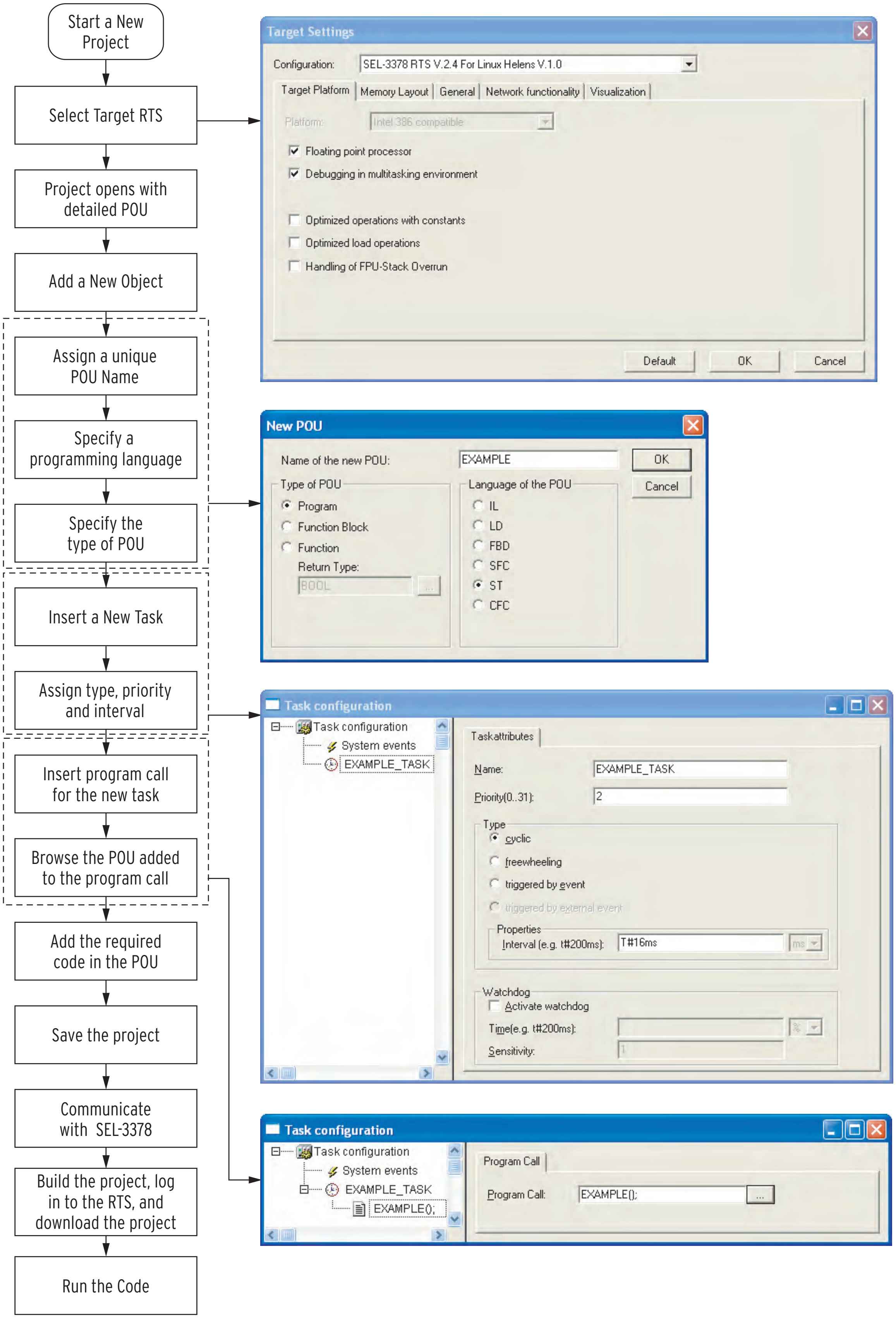


Figure 4.2 Steps to Create and Execute a New Project

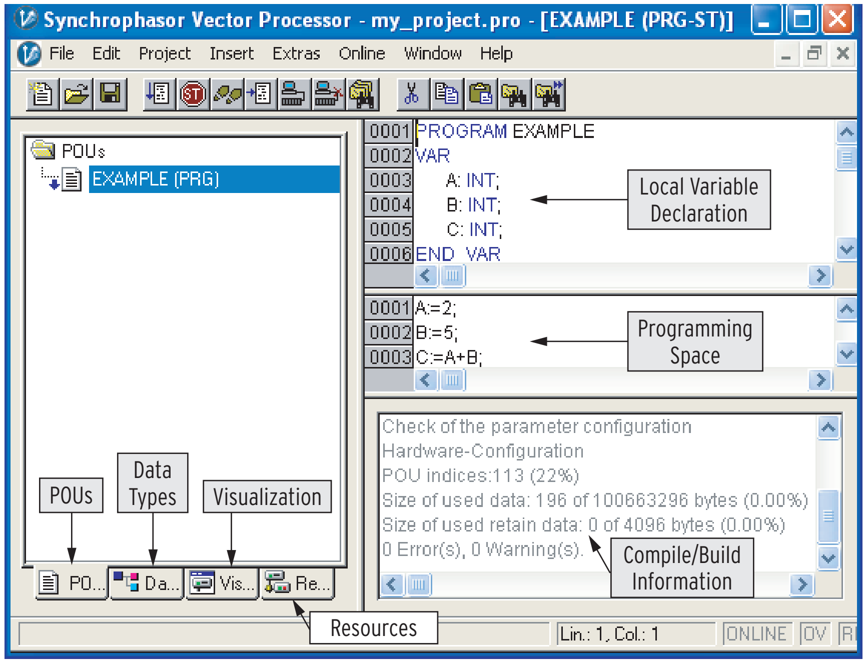


Figure 4.3 Sample Project to Add Two Numbers

Task Organization Guidelines

To run a program/POU you need to assign it to a user configurable process/task (except for the default POU, PLC_PRG). A task groups POUs to run at a certain processing rate with a certain priority. To configure a task you need to enter its priority and processing interval. You can enter priorities from 0 to 31 (0 is the highest real-time priority). Priorities 0 to 15 are for real-time tasks, while priorities 16 to 31 are for nonreal-time tasks.

Non-Speed Critical Tasks

The POUs in this task initialize, configure, and provide information to POUs running in the real-time task. This task has no strict real-time constraints, so it can run at a slow rate with nonreal-time task priority. For example, set the task priority to 30 and the processing interval to 2 seconds. Use nonreal-time tasks for applications such as TCS configuration.

High-Speed Real-Time Tasks

These tasks meet strict time constraints. All high-speed POUs must be placed in a single task, and the task priority must be set to 0 (the highest priority) with a 4 ms processing interval. Use high-speed real-time tasks for speed-critical applications like System Integrity Protection Schemes (SIPS).

Low-Speed Real-Time or Snapshot Tasks

The POUs in these tasks acquire data from the high-speed POUs. Then the POU in the low-speed task can operate on these data. The POU in the low-speed task first sets a synchronization lock variable to control data acquisition and guarantee data coherency. This POU clears the synchronization lock variable at the end of the processing interval. The POU in the high-speed task first checks if the synchronization lock variable is not set. If the variable is not set, the POU in the high-speed task updates the required input data. If the variable is set, the high-speed task does not update these data. The synchronization lock variable guarantees that the low-speed task uses the latest available data.

You can have multiple low-speed tasks with different priorities and processing rates. Each POU in the low-speed task must provide its own synchronization lock variable to the data source in the high-speed task. Set the processing rate of the low-speed task according to the requirements of your application. The priority of the snapshot task must be ≥2 and ≤15. Priority 1 is reserved for future applications. For example, a low-speed application can operate on data once per second with priority set to 2.

Time Alignment Client Server (TCS)

To receive from external servers and send to external clients synchrophasor messages and commands, you need to configure the TCS. This subsection describes how to configure the TCS. *Figure 4.4* shows the inputs and output of the TCS_CONFIG function. Use this function to configure all TCS clients and servers. A TCS_CONFIG output value equal to or greater than zero indicates no TCS configuration errors.

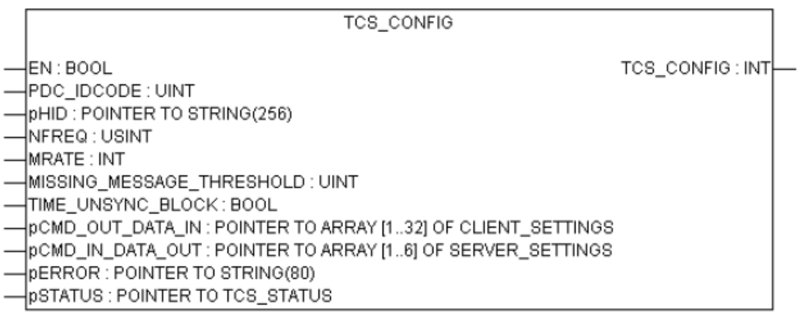


Figure 4.4 TCS Configuration Function

TCS Configuration

For TCS configuration, you must enter global, client, and server settings.

TCS Global Settings

Table 4.2 shows the TCS global settings and their corresponding descriptions.

Table 4.2 TCS Global Settings (Sheet 1 of 2)

Setting	Description
EN	Enables TCS functionality.
PDC_IDCODE	PDC hardware identification of the SEL-3378 (1, 2, …, 65534).
pHID	Pointer to C37.118 header information for external C37.118 clients (256 characters).
NFREQ	Nominal system frequency (50 or 60 Hz).
MRATE	Message rate (1, 2, 4, 5, 10, 12, 15, 20, 30, 60 for NFREQ := 60 Hz. 1, 2, 5, 10, 25, 50 for NFREQ := 50 Hz). MRATE must be the same for all incoming messages.
MISSING_MESSAGE_THRESHOLD	Number of missing messages before resumption of TCS transmission (2, 3, …, 30). When a message does not arrive within this period, TCS creates a message with zero filled data.

Table 4.2 TCS Global Settings (Sheet 2 of 2)

Setting	Description
TIME_UNSYNC_BLOCK	The TCS processes data frames that have PMU-Sync (Bit 13) deasserted in the STAT field if TRUE.
pCMD_OUT_DATA_IN	Pointer to array of TCS client settings (see *Table 4.3*). RTS uses this pointer to pass client settings to TCS. The client array size must be set to 32.
pCMD_IN_DATA_OUT	Pointer to array of TCS server settings (see *Table 4.4*). RTS uses this pointer to pass server settings to TCS. The server array size must be set to 6.
pERROR	Pointer to error description.
pSTATUS	Pointer to TCS status.

TCS Client Settings

The TCS includes as many as 32 clients. TCS clients can be C37.118, Fast Operate (FO), or C37.118 and FO. With the FO option, TCS can send control commands to external devices with FO capability. The number of C37.118 clients should not exceed 20. *Table 4.3* shows the TCS client settings.

Table 4.3 TCS Client Settings (Sheet 1 of 2)

Setting	Description
EN	Enables client settings instance.
IDCODE	Server (external device PMCU, PMU, PDC) IDCODE (1, 2, …, 65534). All devices must have unique IDCODEs.
C37_118_CLIENT	TRUE indicates C37_118 Client. FALSE indicates Fast Operate Client.
FASTOP	0 for no FO command, 1 for SEL FO command, and 2 for FO command embedded in the C37.118 Extended Frame Command.
CONNECTION	S for Serial connection E for Ethernet® connection.
SPORT	Serial port settings:
PORT_NUMBER	Serial port number (1, 2, …,15).
CONNECTION_SPEED	Connection baud rate (9600, 19200, 38400, 57600, 115200).[a]
RTS_CTS	Enables hardware flow control.
EPORT	Ethernet port settings:
SERVER_IP	Server (external device PMCU, PMU, PDC) IPv4 address.
SERVER_CMD_PORT	Server command port (23,2000,2001,…,65515).
TRANSPORT_SCHEME	Transport layer protocol (UDP, UDP_F, UDP_T, TCP).[b]
CLIENT_IP	SEL-3378 network interface (TCS client) IPv4 address.
CLIENT_DATA_PORT	Client UDP data port (2000, 2001...65515) if TRANSPORT_SCHEME := UDP_T, UDP_F.

Table 4.3 TCS Client Settings (Sheet 2 of 2)

Setting	Description
CONF_FILE	Name of the file containing the PMU configuration. Download this file to the SEL-3378 when TRANSPORT_SCHEME := UDP_F.
FASTOP_PORT	TCP FO Port (0, 23, 2000, 2001...65515), set to 0 to use SERVER_CMD_PORT.
FASTOP_PORT_TELNET_EN	Enables Telnet protocol for FASTOP_PORT.

[a] The connection uses eight data bits, no parity check, and one stop bit.
[b] Select TRANSPORT_SCHEME := UDP_T for synchrophasor applications that require solicited messages according to C37.118. With this option, the TCS sends data over UDP, sends configuration over TCP, and receives commands over TCP.
Select TRANSPORT_SCHEME := TCP for data, command, and configuration traffic over TCP.
Select TRANSPORT_SCHEME := UDP for data, command, and configuration traffic over UDP.
Select TRANSPORT_SCHEME := UDP_F when the PMU does not respond to the configuration command.

TCS Server Settings

The TCS supports synchrophasor message outputs to as many as six C37.118 external clients. *Table 4.4* shows the TCS server settings.

Table 4.4 TCS Server Settings

Setting	Description
EN	Enables server settings instance.
MRATE	Output message rate. Must be equal to or submultiple of input message rate. For NFREQ := 60 (see *Table 4.2*), allowable selections are: 1, 2, 4, 5, 10, 12, 15, 20, 30, 60. For NFREQ := 50, allowable selections are: 1, 2, 5, 10, 25, 50.
CLIENT_IP	Client (external device) IPv4 address.
CLIENT_DATA_PORT	Client (external device) UDP data port (2000, 2001, …,65515).
TRANSPORT_SCHEME[a]	Transport layer protocol (UDP_T, UDP_S). UDP_T uses SERVER_CMD_PORT to exchange configuration and commands over TCP and uses CLIENT_DATA_PORT to send data over UDP. UDP_S uses CLIENT_DATA_PORT to send configuration and data over UDP.
SERVER_IP	TCS Server IPv4 address.
SERVER_CMD_PORT	Server TCP configuration and command port (2000, 2001, … , 65515).

[a] Select TRANSPORT_SCHEME := UDP_T for synchrophasor applications that require solicited messages according to C37.118. With this option, the TCS sends data over UDP, sends configuration over TCP, and receives commands over TCP. With the second option, TRANSPORT_SCHEME := UDP_S, the TCS outputs unsolicited C37.118 data over UDP and sends configuration at the top of the minute.

TCS Remote Bits

The SEL-3378 can decode SEL Fast Operate commands embedded in the C37.118 command frame from external C37.118 clients and route these commands according to the IDCODE of the device. The TCS includes 32 remote bits that operate according to the external C37.118 request when the IDCODE corresponds to the PDC_IDCODE (SEL-3378 IDCODE). The TCS external devices can set, clear, and pulse these remote bits. When TCS receives a pulse command, TCS asserts the specified remote bit for one second. Status information for the PDC remote bit is available to the RTS in the PMCU instance with IDCODE := PDC_IDCODE. The TCS maps the TCS remote bits to the PMCU digital word as follows:

RB01 ⇨ DWI[1].BIT01
•
•
•
RB16 ⇨ DWI[1].BIT16
RB17 ⇨ DWI[2].BIT01
•
•
•
RB32 ⇨ DWI[2].BIT16

TCS Application Example

For this example, we program a nonreal-time task to configure TCS to receive synchrophasors from two PMCUs, send control commands to the PMCUs, and send a time-aligned synchrophasor message (super packet) to an external C37.118 client. *Figure 4.5* shows two PMCUs (C37.118 servers) connected to the SEL-3378. The incoming synchrophasor message rate is 60 messages per second.

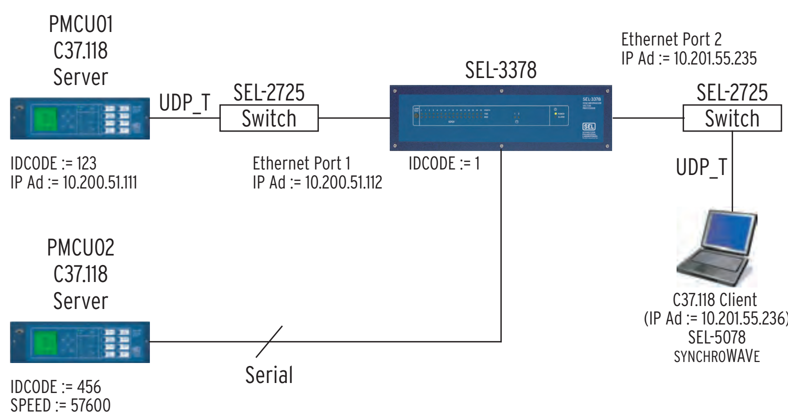


Figure 4.5 Synchrophasor Acquisition and Data Concentration Example

Perform the following steps to create the **TCS** POU and the **TCSConfiguration** task:

Step 1. Launch the SVP Configurator.

Step 2. Choose **File > New**.

Step 3. Select SEL-3378 **RTS V2.4 For Linux Helens V.1.0** under target settings.

Step 4. Click **OK**.

Step 5. In the **New POU** window, select **ST** (structured text option).

Step 6. Assign **TCS** as the name of the new object (POU).

Step 7. Click **OK**.

Step 8. Set **Task Configuration** as follows:

a. Click on the **Resources** tab (see *Figure 4.3*).

b. Double-click on **Task Configuration**.

Step 9. Select **Append Task** from the **Insert** menu.

Step 10. Change the task name to **TCSConfiguration**.

Step 11. Set the **Priority** of the added task to 30.

Priority 0 indicates the highest priority.

Step 12. Set **Type** to Cyclic.

Step 13. Set **Interval** to 2 seconds.

For example, **t#2s**, defines a 2 second processing interval.

Step 14. From the **Insert** menu perform the following steps:

a. Select **Append Program Call**.

b. Click on the **Browse** button.

c. Assign **TCS()** to the program call.

For each new POU, you must assign a program call that can be under a new task or an existing task.

Step 15. Select **File > Sav**e to save your new project.

Step 16. Name the project **project1.pro**.

TCS Configuration

The TCS_CONFIG function, in *Figure 4.4*, uses pointers that allow the RTS to send client and server settings to the TCS. In this example, we define the **PMCU_INPUT** variable as an ARRAY[1..32] of CLIENT_SETTINGS and the **PMCU_OUTPUT** variable as an ARRAY[1..6] of SERVER_SETTINGS.

Local Variables

Declare the following variables in the local variable space of the task POU, TCS:

```
PMCU_INPUT:ARRAY[1..32] OF CLIENT_SETTINGS;
PMCU_OUTPUT:ARRAY[1..6] OF SERVER_SETTINGS;
TCS_STATUS_OUT:TCS_STATUS;
TCS_ERROR_OUT:STRING(256);
HEADER_118:STRING(256):='SVP_SEL_3378';
TCSconfigOK:INT;
```

Client Settings

In the programming space of the POU (TCS), add the following settings:

```
(* Client 1 connected via Ethernet Port 1*)
PMCU_INPUT[1].EN:=TRUE;
PMCU_INPUT[1].IDCODE:=123;
PMCU_INPUT[1].C37_118_CLIENT:=TRUE;(* C37.118 Client *)
PMCU_INPUT[1].FASTOP:=1; (* Use SEL-Fast Operate command *)
PMCU_INPUT[1].CONNECTION:='E';
PMCU_INPUT[1].EPORT.SERVER_IP:='10.200.51.111';(* PMCU address *)
PMCU_INPUT[1].EPORT.SERVER_CMD_PORT:=4712;
PMCU_INPUT[1].EPORT.TRANSPORT_SCHEME:='UDP_T';
PMCU_INPUT[1].EPORT.CLIENT_IP:='10.200.51.112';(* Ethernet Port 1 SEL-3378 address *)
PMCU_INPUT[1].EPORT.CLIENT_DATA_PORT:=5111;
PMCU_INPUT[1].EPORT.FASTOP_PORT:=23; (* Sends FO commands to Port 23 on the SEL-421 *)
PMCU_INPUT[1].EPORT.FASTOP_PORT_TELNET_EN:=TRUE;

(* Client 2 connected via Serial Port 1 *)
PMCU_INPUT[2].EN:=TRUE;
PMCU_INPUT[2].IDCODE:=456;
PMCU_INPUT[2].C37_118_CLIENT:=TRUE;(* C37.118 Client *)
PMCU_INPUT[2].FASTOP:=1; (* Use SEL-Fast Operate command *)
PMCU_INPUT[2].CONNECTION:='S';
PMCU_INPUT[2].SPORT.PORT_NUMBER:=1;
PMCU_INPUT[2].SPORT.CONNECTION_SPEED:=57600;
PMCU_INPUT[2].SPORT.RTS_CTS:=TRUE;
```

Synchrophasor Message Output Settings

Add the following settings in the programming space of the POU (TCS):

```
 (* Client 1 connected via Ethernet Port 1*)
PMCU_OUTPUT[1].EN:=TRUE;
PMCU_OUTPUT[1].MRATE:=60;
PMCU_OUTPUT[1].CLIENT_IP:='10.201.55.236';(* SEL-5078 external C37.118 Client *)
PMCU_OUTPUT[1].CLIENT_DATA_PORT:=2078;
PMCU_OUTPUT[1].TRANSPORT_SCHEME:='UDP_T';
PMCU_OUTPUT[1].SERVER_IP:='10.201.55.235';(* Ethernet Port 2 SEL-3378 address *)
PMCU_OUTPUT[1].SERVER_CMD_PORT:=2079;
```

TCS Function Activation

The TCS function shown in *Figure 4.4* uses global, client, and server settings. Activate the TCS function with the following information:

```
TCSconfigOK:=TCS_CONFIG(EN := TRUE,
PDC_IDCODE:= 1,
pHID := ADR(HEADER_118),
NFREQ := 60,
MRATE := 60,
MISSING_MESSAGE_THRESHOLD := 6,
TIME_UNSYNC_BLOCK := TRUE,
pCMD_OUT_DATA_IN := ADR(PMCU_INPUT),
pCMD_IN_DATA_OUT := ADR(PMCU_OUTPUT),
pERROR := ADR(TCS_ERROR_OUT),
pSTATUS := ADR(TCS_STATUS_OUT));
```

To enter the information shown above, **Right Click** on the programming space and use the Input Assistant (see *Appendix B: SVP Configurator*). The Input Assistant includes the inputs that TCS requires under Standards Functions\TCS_CTRL.LIB.

TCS Outputs

The TCS_CONFIG output **TCSconfigOK** returns 0 if the configuration is valid. If the configuration is not valid, the output returns a negative number (See *Section 5 Troubleshooting* for details). The pERROR string output describes the type of error. The pSTATUS output structure of TCS_STATUS type provides TCS status information associated with each input client and output server.

Phasor Measurement and Control Unit (PMCU_IN)

This subsection describes how to program a POU to access the PMCU data from the TCS. This POU is part of **project1.pro**. In this subsection you create the **PMCU_Assign** POU (FBD type). *Figure 4.6* shows the function block corresponding to PMCU_IN.

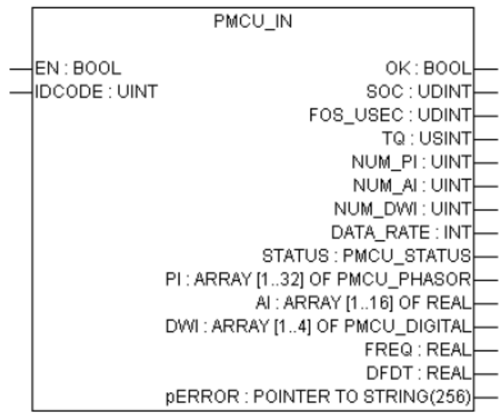


Figure 4.6 PMCU_IN Function Block

Table 4.5 describes the input configuration settings, and *Table 4.6* describes the outputs of the PMCU_IN Function Block.

Table 4.5 PMCU Function Block Configuration

Settings	Description
EN	Enables the PMCU instance
IDCODE	PMCU IDCODE (1,2,...,65534)

Table 4.6 PMCU Function Block Outputs (Sheet 1 of 2)

Outputs	Description
OK	Valid output
SOC	Second-of-century for the PMCU data
FOS_USEC	Fraction-of-second for the PMCU data in microseconds
TQ	Time quality
NUM_PI	Number of phasors
NUM_AI	Number of analogs
NUM_DWI	Number of digital words
DATA_RATE	Synchrophasor message rate (1, 2, 4, 5, 10, 12, 15, 20, 30, 60 for NFREQ := 60 Hz. 1, 2, 5, 10, 25, 50 for NFREQ := 50 Hz).
STATUS	PMCU status
PMCU_OK	Based on DATA_VALID, PMCU_ERROR, and PMCU_SYNC
VALUE	Status word from C37.118 standard
DATA_VALID	Status Bit 15[a] negated
PMCU_ERROR	Status Bit 14[a] negated
PMCU_SYNC	Status Bit 13[a] negated

Table 4.6 PMCU Function Block Outputs (Sheet 2 of 2)

Outputs	Description
DATA_SORTING	Status Bit 12[a]
UNLOCK_TIME	Status Bit 5[a] and Status Bit 4[a]
PI	Array of 32 phasors. When the PMCU is an SEL-421/ SEL-451 with PHDATAV and PHDATAI set to ALL, the PI array of incoming phasors includes the following voltage and current phasors: V1, VA, VB, VC, I1W, IAW, IBW, ICW, I1X, IAX, IBX, and ICX. V1 is the first phasor of the array, and ICX is the last phasor of the array. If PHDATAV and PHDATAI are set to V1 and I1, the first phasor of the array corresponds to V1 and the second phasor corresponds to I1. Phasors are available as outputs in polar and rectangular formats.[b]
AI	Array of 16 analogs. When the PMCU is an SEL-421/ SEL-451, the AI array of incoming analogs includes the following values: PMV64 (AI[1]), •••, PMV57 (AI[8]).[b]
DWI	Array of 4 digital words. When the PMCU is an SEL-421/ SEL-451, the DWI array of incoming digital words includes the following values: PSV49 (DW[1].BIT01), •••, PSV64 (DW[1].BIT16), PSV33 (DW[2].BIT01), •••, PSV48 (DW[2].BIT16).[b]
FREQ	Frequency in Hz
DFDT	Rate-of-change of frequency in Hz/s
pERROR	Pointer to error description

[a] Bits specified according to IEEE C37.118-2005, Standard for Synchrophasors for Power Systems.
[b] See the Synchrophasor Order in Data Stream table in the SEL-421, SEL-451, SEL-487E, and SEL-487V Instruction Manuals.

PMCU Application Example

The system in *Figure 4.7* includes the SEL-421 Relays at the terminals of Line 2. One relay is located at Station SKA, and the other relay is located at Station TKW. Both relays feed synchrophasor messages to a remote SEL-3378. The TCS within the SEL-3378 generates a time-correlated synchrophasor message that includes all incoming synchrophasor messages from the external C37.118 servers (relays at the Line 2 terminals). This application shows how to make the PMCU data available to the SVP Configurator. In this example, we program a POU to obtain PMCU data with IDCODE := 123.

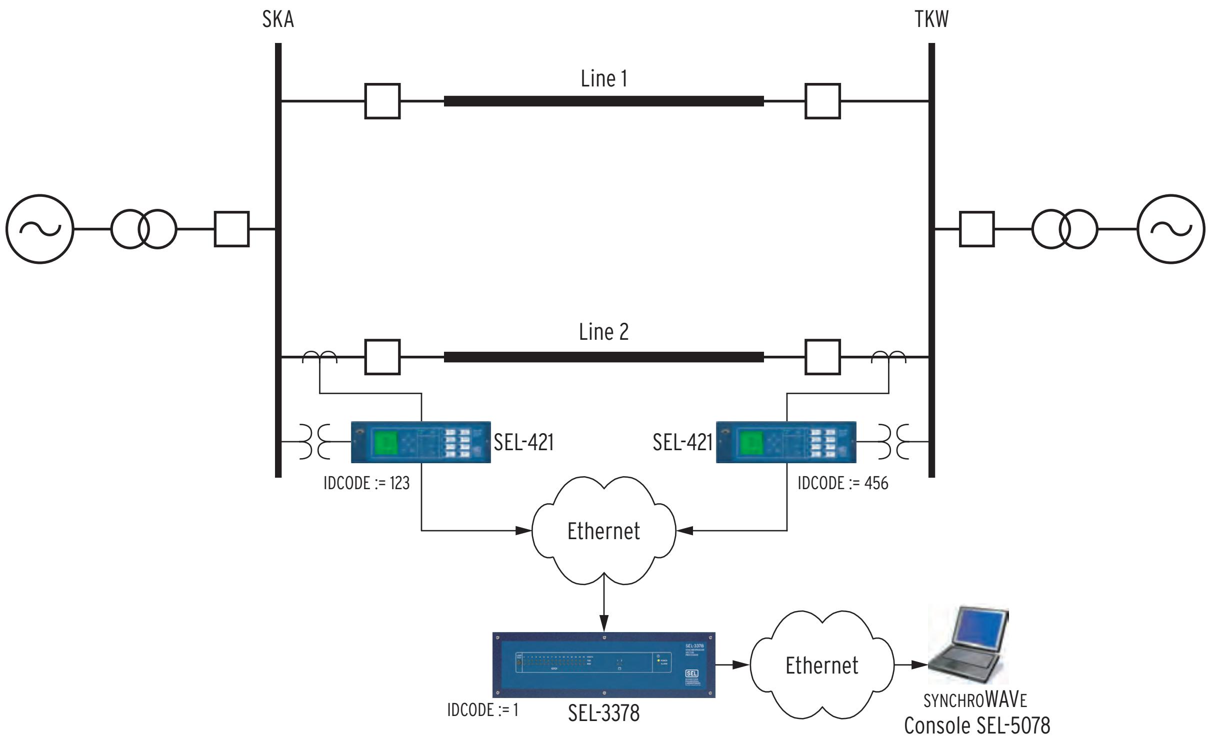


Figure 4.7 SEL-421 Relays Feed Synchrophasor Messages to a Remote SEL-3378

Create the PMCU_Assign and assign it to the high-speed task using the following steps:

Step 1. Select **Project > Object > Add...** while in the POU tab.

Step 2. Change the name of the new POU to **PMCU_ASSIGN**.

Step 3. Click **OK**.

Step 4. Set **Task Configuration** as follows:

a. Click on the **Resources** tab (see *Figure 4.3*).

b. Double-click **Task Configuration**.

Step 5. Select **Insert > Append Task**.

Step 6. Change the task name to **HighSpeed_Applications**.

Step 7. Set the **Priority** of the added task to **0**.

Step 8. Set **Type** to **cyclic**.

Step 9. Set **Interval** to 4 ms (**t#4ms**).

This processing interval guarantees data reception and allows 6 ms latency between two consecutive messages from the same external C37.118 server.

Step 10. Select **Insert > Append Program Call**.

NOTE: All PMCU_IN function blocks must be part of the same POU.

Step 11. Click on the **Browse** button and assign **PMCU_Assign()** to the program call.

Perform the following steps to access the programming space of the **PMCU_Assign POU** and add the PMCU_IN Function Block:

Step 1. Click the **POU** tab, double-click **PMCU_Assign**, then click in the programming space.

Step 2. Add a box by clicking the icon found on the menu bar, , or by right-clicking within the programming space.

NOTE: The inputs and outputs associated with the PMCU_IN function block will display automatically. The required inputs for the function block display with question marks (**???**).

Step 3. Replace the default name (AND) with PMCU_IN, and click outside the box. *Figure 4.8* shows the PMCU_IN function block assigned to PMCU with IDCODE 123.

Step 4. Program **EN** input to **TRUE**, or assign this input to a variable of Boolean type.

Step 5. Program **IDCODE** input to **123.**

This IDCODE should match the PMCU_ID of the target PMCU. Each PMCU_IN should be associated with a unique instance name.

Step 6. Replace the instance name (**???**) with **SKA** and declare the variable as PMCU_IN type under VAR_GLOBAL class. Declaring SKA in the VAR_GLOBAL class allows other POUs in the project to access SKA.

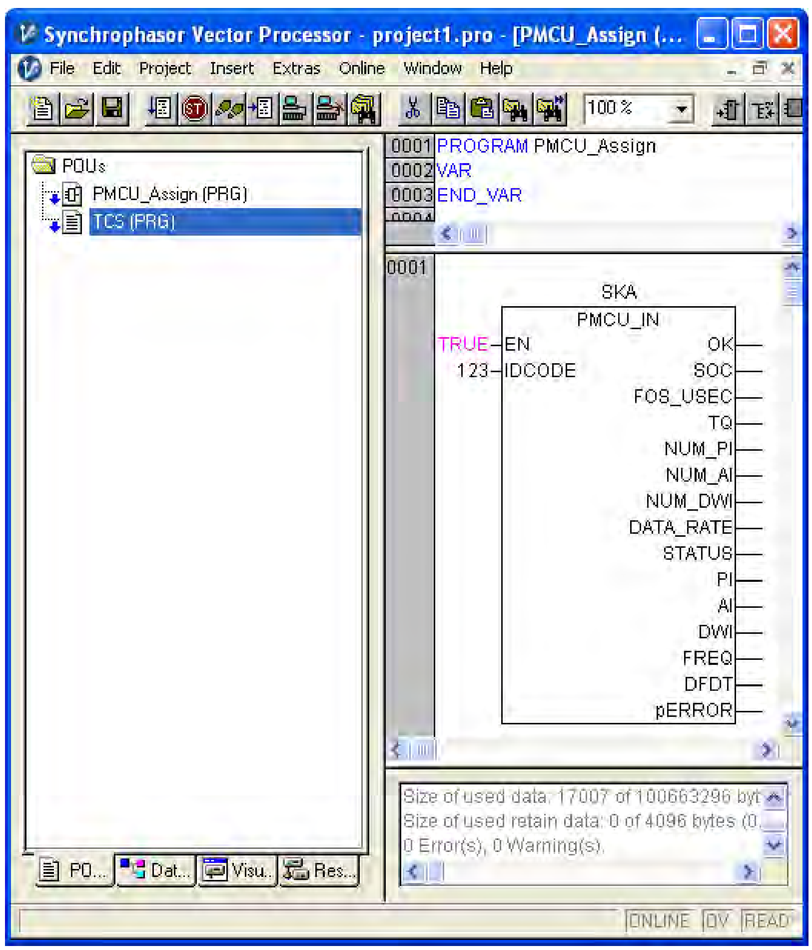


Figure 4.8 PMCU_IN Configuration

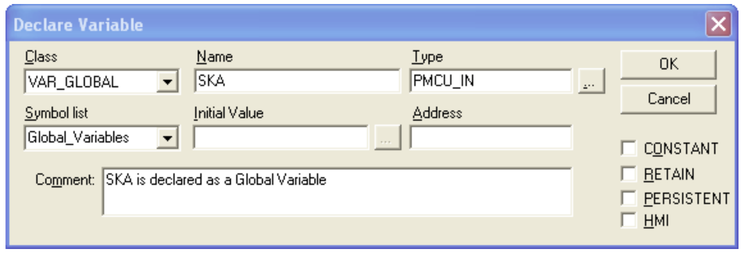


Figure 4.9 Global Variable Assignment

Figure 4.9 shows variable SKA of PMCU_IN type assigned as a global variable. The outputs of PMCU_IN will be associated with the created instance name (see *Figure 4.8*). You can add other PMCUs similarly by right clicking on the programming space, selecting **Network (after)**, and configuring the additional PMCUs.

Power Calculation (PWRC)

This subsection describes how to program a task to configure the Power Calculation (PWRC) Function Block. In this subsection you create the **SYNCPWR** POU (FBD type). The **SYNCPWR** POU is part of **project1.pro**. This POU must be part of the **HighSpeed_Applications** task described earlier. *Figure 4.10* shows the PWRC function block. Following are the input configuration settings and outputs of the PWRC function block.

PWRC Configuration

Table 4.7 shows the PWRC settings with their corresponding descriptions.

Table 4.7 PWRC Configuration

Settings	Description
EN	Enables PWRC function block
RE_V	Real part of voltage phasor
IM_V	Imaginary part of voltage phasor
RE_I	Real part of current phasor
IM_I	Imaginary part of current phasor
IN_SOC	Second-of-century of phasors
IN_FOS	Fraction-of-second of phasors

PWRC Outputs

Table 4.8 shows the PWRC outputs with their corresponding descriptions.

Table 4.8 PWRC Outputs

Outputs	Description
OK	Valid output
P	Real power in kW
Q	Reactive power in kVAR
SOC	Second-of-century corresponding to the output
FOS	Fraction-of-second corresponding to the output

PWRC Application Example

Now, we set the SEL-3378 to calculate Line 2 power at Station SKA. Use positive-sequence voltage and current phasors from the PMCU with IDCODE := 123 to program a task to calculate real and reactive power. In the programming space corresponding to object **SYNCPWR**, add a box, replace the default name with **PWRC**, and click outside the box. The inputs and outputs associated with the PWRC function block will display automatically. The inputs necessary for the function block display with **???**. Program the inputs as follows.

EN := SKA.STATUS.PMCU_OK

RE_V := SKA.PI[1].RE

IM_V := SKA.PI[1].IM

RE_I := SKA.PI[5].RE

IM_I := SKA.PI[5].IM

IN_SOC := SKA.SOC

IN_FOS := SKA.FOS_USEC

This program uses positive-sequence voltage and current phasors to calculate power. Each PWRC function block should be associated with a unique instance name. Program the instance name to be **SKA_PQ**. Assign outputs of interest to variables SKA_kW and SKA_kVAR, so that these variables can be visualized in the SVP Configurator.

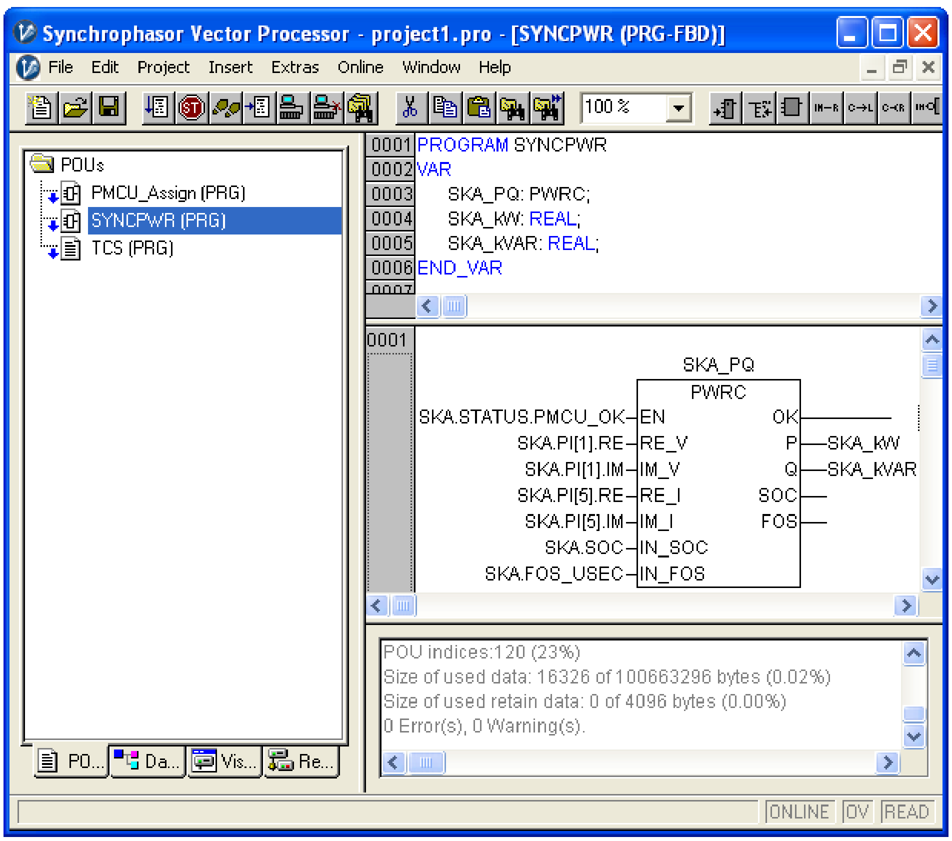


Figure 4.10 Power Calculation Function Block Configuration

You can add multiple instances of the PWRC function block according to your application.

Phase Angle Difference Monitor (PADM)

This subsection describes configuration of the Phase Angle Difference Monitor (PADM). In this subsection you create the **AngDiff** POU (CFC type). The **AngDiff** POU is part of **project1.pro**. This POU must be part of the **HighSpeed_Applications** task described earlier. *Figure 4.11* shows the PADM function block.

PADM Function Block Configuration

Table 4.9 shows the PADM function block settings with their corresponding descriptions.

Table 4.9 PADM Function Block Configuration

Setting	Description
EN	Enables the PADM function block
ANG_1	Angle 1 input in radians
ANG_2	Angle 2 input in radians
TH_1	Threshold 1 in degrees
TH_2	Threshold 2 in degrees
PU_1	Pickup timer 1
PU_2	Pickup timer 2
IN_SOC	Second-of-century of the incoming data
IN_FOS	Fraction-of-second of the incoming data

PADM Function Block Outputs

Table 4.10 shows the PADM function block outputs with their corresponding descriptions.

Table 4.10 PADM Function Block Outputs

Outputs	Description
OK	Indicates valid PADM output
ADIF	Angle difference in degrees
AL_1	Threshold 1 exceeded
AL_2	Threshold 2 exceeded
IN_SOC	Fraction-of-second for the output
FOS	Fraction-of-second for the output

PADM Application Example

Program a POU to compute the difference between positive-sequence voltage angles at Stations SKA and TKW and assert the corresponding alarms based on thresholds set at 12 degrees (32 ms pickup timer) for Level 1 and 18 degrees (16 ms pickup timer) for Level 2.

In the programming space corresponding to the new object **AngDiff**, add a box, and replace the default name **AND** with **PADM**. The inputs and outputs associated with the PADM function block will display automatically. Program the inputs as shown in *Figure 4.11*:

Each PADM function block should be associated with a unique instance name. Program the instance name to **PADM_ST**. Assign outputs in which you are interested as variables, which you can then visualize in the run time environment.

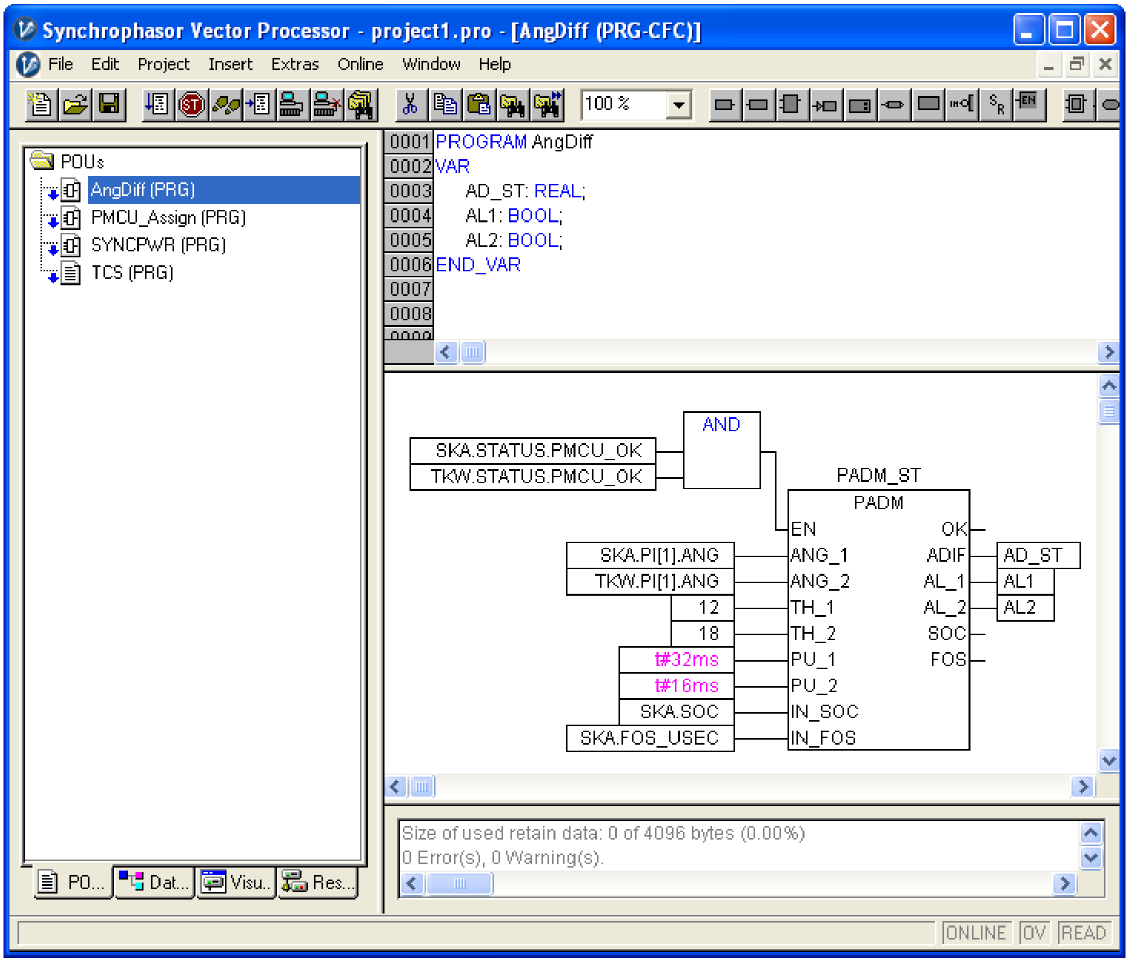


Figure 4.11 Configuring Phase Angle Difference Module

You could add multiple instances of the PADM function block according to your application.

Fast Operate Commands

You can operate 32 remote bits and eight breaker control Fast Operate commands per external device from the RTS. *Figure 4.12* shows the available Fast Operate function blocks within the SVP Configurator to activate these commands. Each Fast Operate function block sends the corresponding Fast Operate command to the external device (e.g., PMCU) with the assigned IDCODE when the Enable (EN) input is TRUE.

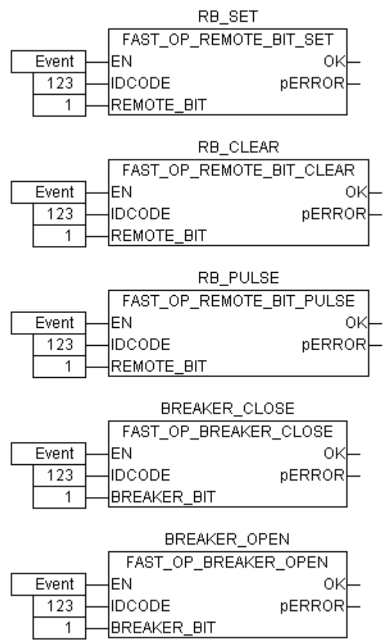


Figure 4.12 Fast Operate Command Function Blocks

Fast Operate Command Application Example

This example uses the FAST_OPERATE_REMOTE_BIT_SET Function Block to send a command to an external device with IDCODE := 123 based on the rising edge of the Alarm 1 output from the Phase Angle Difference Monitor (PADM). This example uses the POU configured in *Phase Angle Difference Monitor (PADM) on page 4.18*. Add a box in the programming space and replace the default name **AND** with R_TRIG, provide a unique instance name **RT**, and connect the **CLK** input to the Alarm 1 output AL1 of the PADM. Add one more box, replace the default name with **FAST_OP_REMOTE_BIT_SET**, and provide a unique instance name **FOS**. Connect the **EN** input to the **Q** output of the R_TRIG function block. Assign IDCODE input to **123** and REMOTE_BIT input to **1**. The configuration will assert remote Bit RB01 of PMCU (IDCODE := 123) when the **EN** input asserts. *Figure 4.13* shows the configuration.

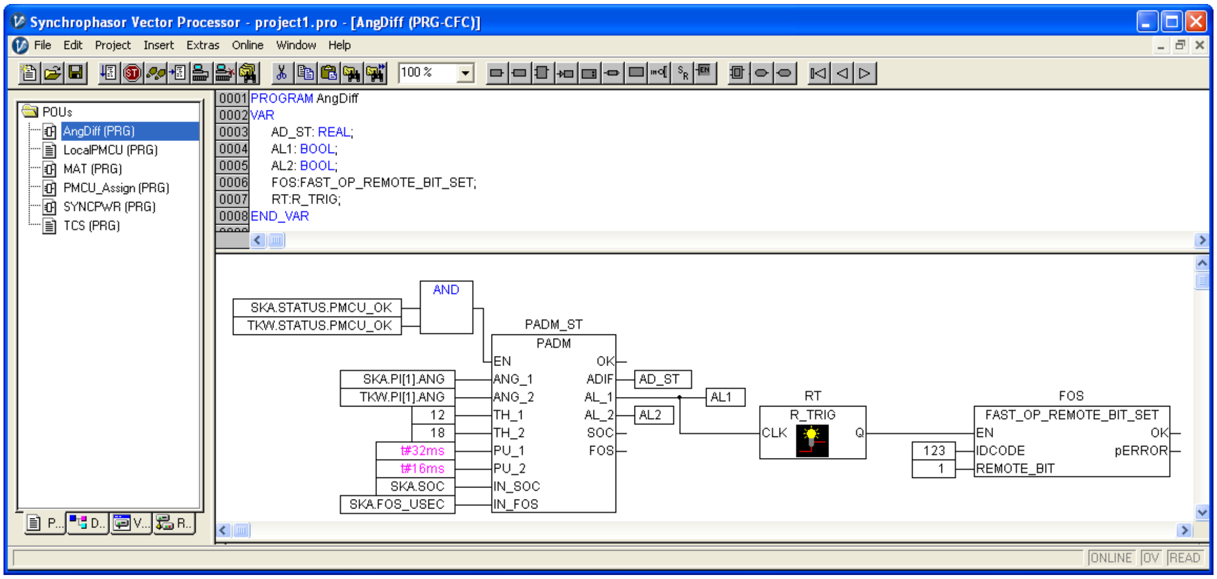


Figure 4.13 Configuring Fast Operate Command Module

You could add multiple instances of the Fast Operate function block according to your application.

Local PMCU (PMCU_OUT)

This subsection describes how to program the SEL-3378 to configure the **PMCU_OUT** function (Local PMCU) to send C37.118 messages to an external client. In this subsection you create the **LocalPMCU** POU (ST type) to configure the output, to acquire data from the SVP Configurator, and to activate the PMCU_OUT function. The **LocalPMCU** POU is part of **project1.pro** and the **HighSpeed_Applications** task. The PMCU_OUT function needs configuration and data to perform its task. *Figure 4.14* shows the PMCU_OUT function. A PMCU_OUT output value equal to zero indicates no Local PMCU configuration errors. The PMCU_OUT function only supports the UDP_T Transport Scheme.

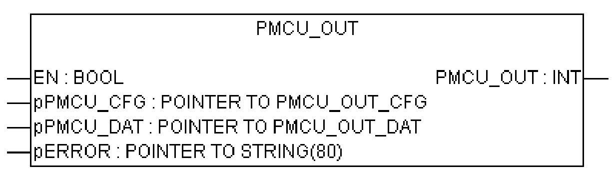


Figure 4.14 PMCU_OUT Function Block

Variables pPMCU_CFG and pPMCU_DAT are pointers to PMCU_OUT_CFG and PMCU_OUT_DAT. The variable pERROR is the pointer to the error string. *Table 4.11* shows the output configuration settings.

Table 4.11 Local PMCU Output Configuration

Setting	Description
PDC_IDCODE	PDC (3378) hardware identification (1, 2, …, 65534)
PMCU_IDCODE	PMCU_OUT hardware identification (0,1, 2, …, 65534) Default setting is 0 to indicate that PMCU_IDCODE := PDC_IDCODE
STN_NAME	Station name (As many as 16 ASCII character)
CLIENT_IP	Client (external device) IPv4 address
CLIENT_DATA_PORT	Client (external device) UDP data port (2000, 2001, …,65515)
SERVER_IP	Server IPv4 address
SERVER_CMD_PORT	Server TCP configuration and command port (2000, 2001, …,65515)
MRATE	Message rate (1, 2, 4, 5, 10, 12, 15, 20, 30, 60 for 60 Hz. 1, 2, 5, 10, 25, 50 for 50 Hz)
NFREQ	Nominal frequency (50 or 60 Hz)
NUM_PO_V	Number of voltage phasors (0, 1, …, 640)[a]
NUM_PO_I	Number of current phasors (0, 1, …, 640)
NUM_AO	Number of analog quantities (0, 1, …, 320)
NUM_DWO	Number of digital words (0, 1, …, 80)
PH_RECT_FMT	Phasor format. TRUE = rectangular, FALSE = polar
CFG_CNT	Configuration count (0,1,..,65535)

[a] The total number of voltage and current phasors must be ≤640.

Local PMCU Application Example

In this example, the SEL-3378 outputs two phasors, three analog quantities, and one digital word to an external C37.118 client at 60 messages per second. The two phasors are the positive-sequence voltages of station SKA and TKW. The three analog quantities are the positive-sequence voltage angle at station SKA, the positive-sequence voltage angle at station TKW, and the angle difference between the two stations (PADM angle difference calculation result). The digital word includes the two PADM alarms. The output message also includes the frequency and the derivative of the frequency with respect to time from station SKA.

In the variable space of the POU, define variable **out_cfg_pmcu** of PMCU_OUT_CFG type and **out_dat_pmcu** of PMCU_OUT_DAT type. Also define a variable **pmcu_error** of STRING (256) type to point to the error string pERROR shown in *Figure 4.14*. Following are the local variables that PMCU_OUT requires:

```
out_cfg_pmcu: PMCU_OUT_CFG;
out_dat_pmcu: PMCU_OUT_DAT;
pmcu_error: STRING (256);
```

In the programming space, define the information necessary for configuration and output data.

Output Configuration

Following are the instructions to configure the PMCU_OUT. These instructions are part of the LocalPMCU POU:

```
out_cfg_pmcu.PDC_IDCODE:=1;
out_cfg_pmcu.STN_NAME:='SVP';
out_cfg_pmcu.CLIENT_IP:='10.4.12.13';
out_cfg_pmcu.CLIENT_DATA_PORT:=2234;
out_cfg_pmcu.SERVER_IP:='10.4.12.12';
out_cfg_pmcu.SERVER_CMD_PORT:=5678;
out_cfg_pmcu.MRATE:=60;
out_cfg_pmcu.NFREQ:=60;
out_cfg_pmcu.NUM_PO_V:=2;(*Two phasors*)
out_cfg_pmcu.NUM_AO:=3;(*Three analogs*)
out_cfg_pmcu.NUM_DWO:=1; (*One digital word)
out_cfg_pmcu.PH_RECT_FMT:=TRUE;
out_cfg_pmcu.CFG_CNT:=1;
```

Output Data

Following are the instructions to update the PMCU_OUT data. These instructions are part of the LocalPMCU POU.

```
out_dat_pmcu.SOC:=SKA.SOC;
out_dat_pmcu.FOS_USEC:=SKA.FOS_USEC;
out_dat_pmcu.PO_V[1].RE:=SKA.PI[1].RE; (*Phasor V1 @SKA*)
out_dat_pmcu.PO_V[1].IM:=SKA.PI[1].IM;
out_dat_pmcu.PO_V[2].RE:=TKW.PI[1].RE; (*Phasor V1 @TKW*)
out_dat_pmcu.PO_V[2].IM:=TKW.PI[1].IM;
out_dat_pmcu.AO[1]:=PADM_ST.ANG_1; (*V1 angle @SKA*)
out_dat_pmcu.AO[2]:=PADM_ST.ANG_2; (*V1 angle @TKW*)
out_dat_pmcu.AO[3]:=PADM_ST.ADIF; (*Angle Difference between SKA and TKW*)
out_dat_pmcu.DWO[1].BIT01:=PADM_ST.AL_1; (*Alarm 1 output*)
out_dat_pmcu.DWO[1].BIT02:=PADM_ST.AL_2; (*Alarm 2 output*)
out_dat_pmcu.FREQ:=SKA.FREQ;
out_dat_pmcu.DFDT:=SKA.DFDT;
out_dat_pmcu.TQ:=0;
out_dat_pmcu.STATUS:=0;
```

Local PMCU Function Activation

The PMCU_OUT function, in *Figure 4.14*, includes the enable input (EN) and pointers to output configuration, output data, and error. The function also includes an integer output that is zero if PMCU_OUT finds no errors. The output configuration (out_cfg_pmcu) and output_data (out_dat_pmcu) are predefined. Following are the instructions (in the programming space) to activate the PMCU_OUT function when new PMCU_IN data arrive:

```
IF (SKA.OK OR TKW.OK) AND (SKA.FOS_USEC = TKW.FOS_USEC) THEN
PMCU_OUT(TRUE, ADR(out_cfg_pmcu), ADR(out_dat_pmcu), ADR(pmcu_error));
END_IF
```

Program an external C37.118 client (e.g., SYNCHROWAVE® Console SEL-5078 Software) to receive the data.

Modal Analysis (MA)

This subsection describes configuration of the Modal Analysis (MA) Function Block and use of SYNCHROWAVE Console software to display MA outputs. In this subsection you create the **MAT** POU (CFC type). The **MAT** POU is part of **project1.pro** and the **HighSpeed_Applications** task. The system, in *Figure 4.15*, can use voltage magnitude, voltage angle, current magnitude, current angle, power, or frequency measurements as inputs to the MA function block. You can create a signal conditioning function block that, when necessary, modifies the PMCU signals to obtain the required MA input signal. The outputs of the MA function block are available to the Local PMCU and for custom logic.

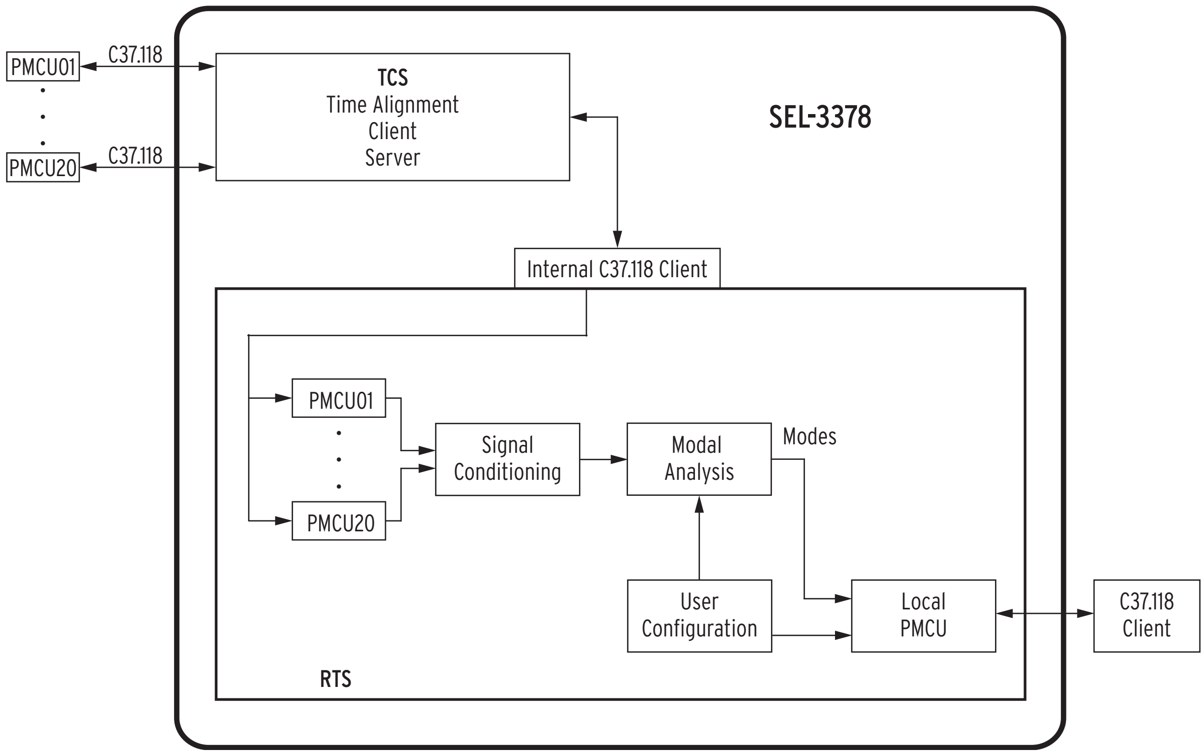


Figure 4.15 Real Time Modal Analysis-Based Power System Disturbance Monitoring System

MA Function Block Configuration

Figure 4.16 shows the MA function block inputs and outputs.

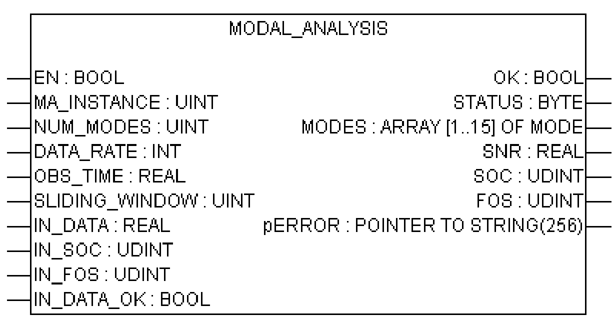


Figure 4.16 Modal Analysis Function Block Inputs and Outputs

Table 4.12 shows the MA function block settings and their corresponding descriptions.

Table 4.12 MA Function Block Settings

Setting	Description
EN	Enables the MA function block
MA_INSTANCE	Modal analysis instance (1,2,..,6)
NUM_MODES	Number of modes (1,2, .., 15)
DATA_RATE	Input signal data rate: 10, 12, 15, 20, 30, 60 for NFREQ := 60 Hz 10, 25, 50 for NFREQ := 50 Hz This rate must be equal to or a submultiple of PMCU_IN DATA_RATE
OBS_TIME	Observation time in seconds Less than or equal to 1800/DATA_RATE. Greater than or equal to 4 • NUM_MODES/DATA_RATE
SLIDING_WINDOW	Sliding window in percent of OBS_TIME (10,11,..,100) OBS_TIME • SLIDING WINDOW/100 must be ≥ 10 s
IN_DATA	Input signal
IN_SOC	Second-of-century of IN_DATA
IN_FOS	Fraction-of-second of IN_DATA in microseconds
IN_DATA_OK	TRUE indicates valid incoming signal

The observation time, OBS_TIME, and the sliding window percentage, SLIDING_WINDOW, define the MA calculation update. *Figure 4.17* shows the observation window with SLIDING_WINDOW := 60 and OBS_TIME := 20. MA updates calculations every twelve seconds with this observation time and sliding window percentage setting.

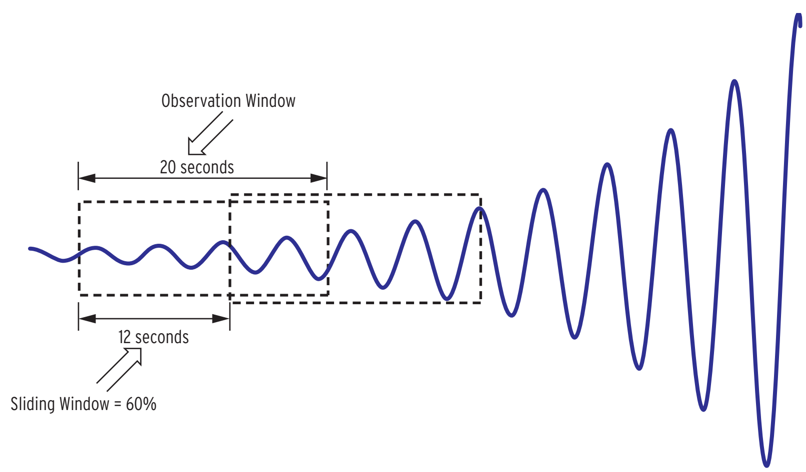


Figure 4.17 Signal With 20-Second Observation Time Window and 12-Second Calculation Update

MA Function Block Outputs

Table 4.13 shows the MA function block outputs.

Table 4.13 MA Function Block Outputs

Outputs	Description
OK	Indicates valid MA output refresh.
STATUS	0 indicates valid configuration.
MODES:ARRAY[1..15] OF MODE.	Amplitude Frequency (Hz) Phase (Degrees) Damping constant Damping ratio
SNR	Signal-to-noise ratio in dB.
SOC	Second-of-century for the MA calculation data.[a]
FOS	Fraction-of-second for the MA calculation data in microseconds.[a]
pERROR	Pointer to error description.

[a] The timestamp corresponds to the timestamp of the last sample in the observation window.

Modal Analysis Application Example

This example shows how to perform modal analysis on a real power signal. *Figure 4.18* shows a power system model in which an SEL-421 monitors one of the transmission lines. The SEL-421 generates the positive-sequence voltage and positive-sequence current synchrophasor measurements and sends the measurements to an SEL-3378.

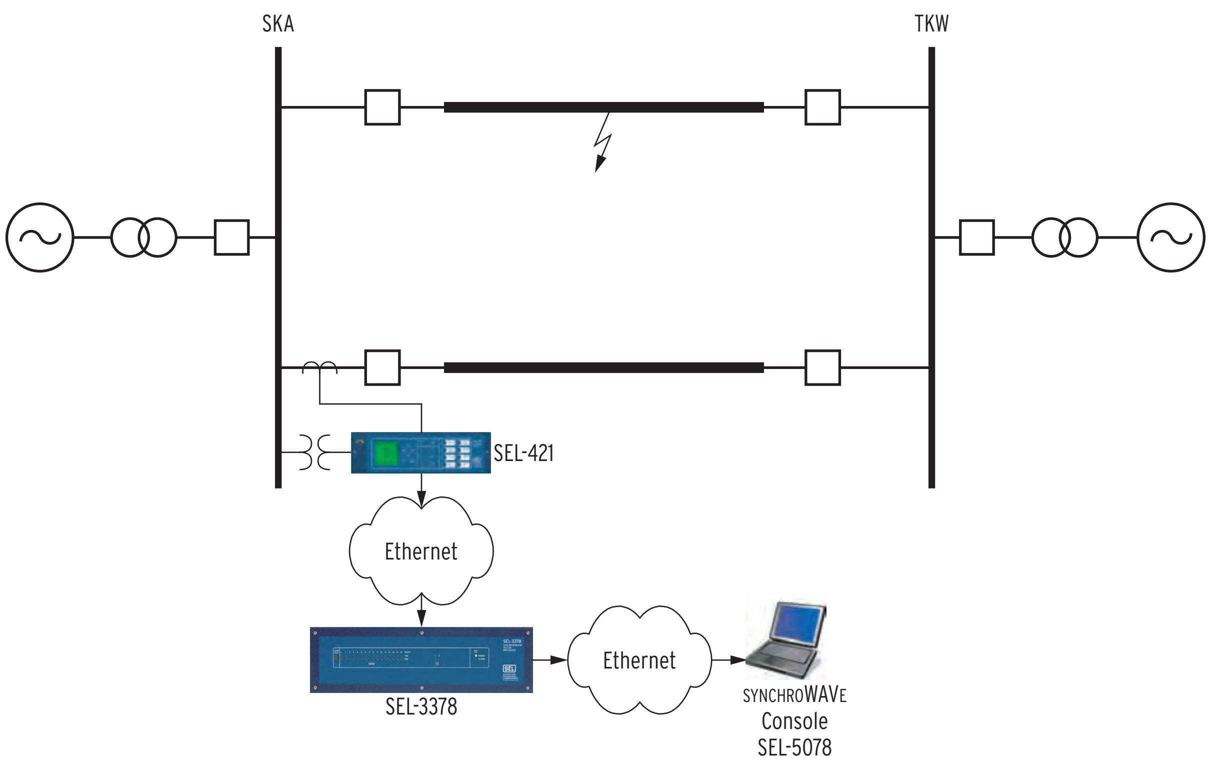


Figure 4.18 Power System Model Using Modal Analysis for Real Power Signal Monitoring

We use the real power, P, output of the PWRC function block (multiplied by 3 and divided by 1000 to obtain three-phase power in MW) as the input signal to the MA function block (see *Figure 4.19*). Parallel line open detection enables the MA calculation function, 2 seconds after the line opens, for 300 seconds.

MA Function Block Settings

Table 4.14 shows the MA function block settings with their corresponding descriptions.

Table 4.14 MA Function Block Application Example Settings

Settings	Description
EN := MA_EN	Enables MA function block when the parallel line opens.
MA_INSTANCE_ID := 1	MA supports as many as six instances.
NUM_MODES := 15	MA calculates as many as 15 modes.
DATA_RATE := 60	Input signal rate: 60 samples per second.
OBS_TIME := 30	Observation time in seconds. MA supports as many as 1800 samples.
SLIDING_WINDOW := 40	Sliding window in percent of OBS_TIME.
IN_DATA := SKA_3P_MW	Input signal (3P in this example).
IN_SOC := P1.SOC	Second-of-century of PWRC.
IN_FOC := P1.FOC	Fraction-of-second of PWRC.
IN_DATA_OK := P1.OK	P1 data OK.

With OBS_TIME := 30 seconds and SLIDING_WINDOW := 40 percent, MA provides calculation outputs every 12 seconds. *Figure 4.19* shows the diagram that includes the PWRC function block, the open-line detection logic, and MA function block with their corresponding settings. This POU is a high-speed POU that must be part of the high-speed task described earlier. Refer to **project1.pro** project in your SEL-3378 CD-ROM.

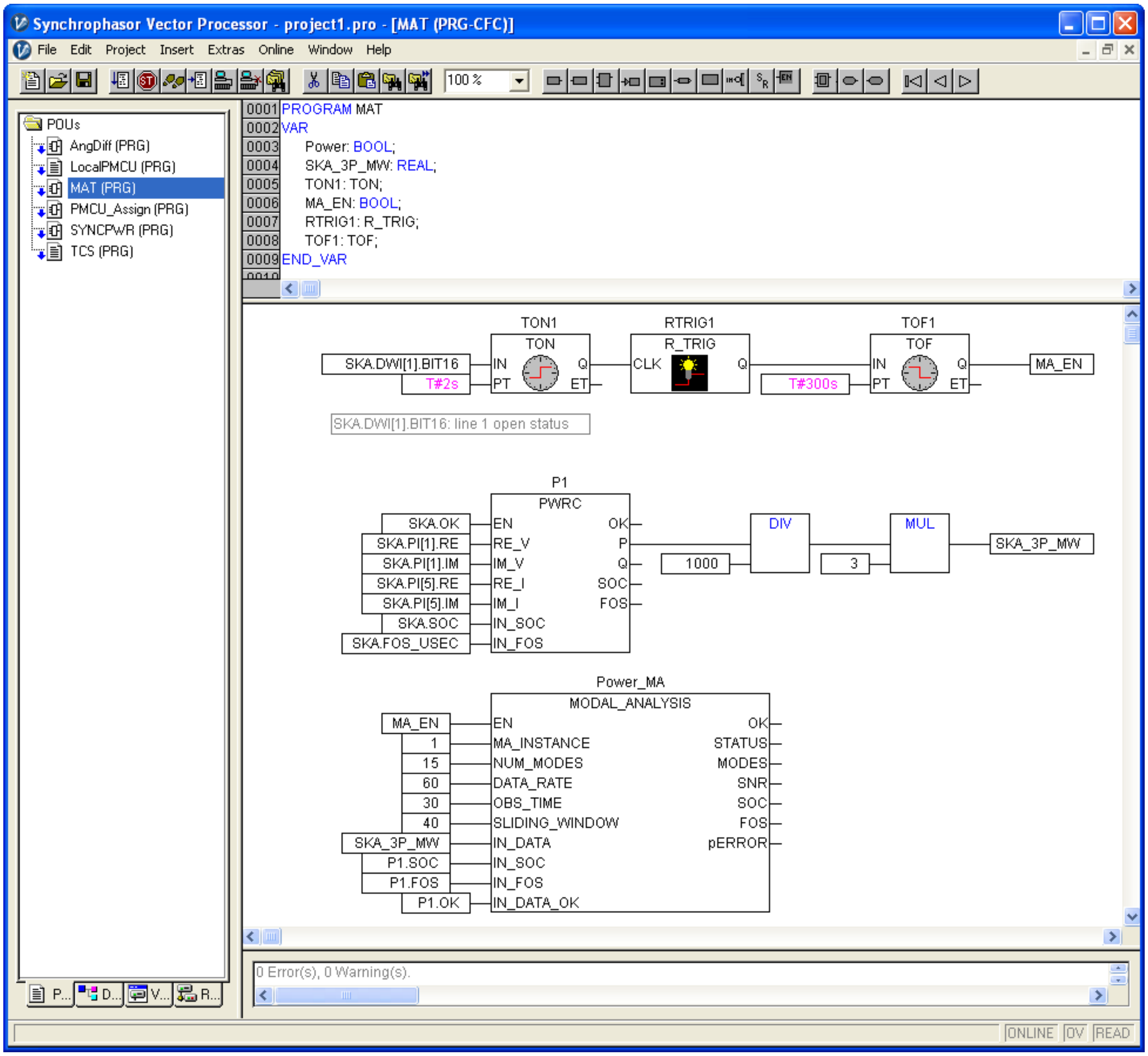


Figure 4.19 Power Calculation Function Block, Open-Line Detection Logic, and Modal Analysis Function Block Configuration

Local PMCU Configuration to Output MA Results

We use the SYNCHROWAVE Console software for visualization of MA outputs. In this example, we want to display the amplitude, frequency, and damping ratio of Mode 2, the SNR of the input signal, and the real power. Mode 1 includes the signal dc component, which is the signal with the greatest amplitude. We use the same configuration as that shown in the Local PMCU section, with the following modifications:

Output Configuration

```
out_cfg_pmcu.NUM_AO:=8
```

Output Data

```
out_dat_pmcu.AO[4]:=Power_MA.MODES[2].AMP;
out_dat_pmcu.AO[5]:=Power_MA.MODES[2].FREQ;
out_dat_pmcu.AO[6]:=Power_MA.MODES[2].DAMP_RATIO;
out_dat_pmcu.AO[7]:=Power_MA.SNR;
out_dat_pmcu.AO[8]:=SKA_3P_MW;
```

Figure 4.20 shows the MA calculation for a sudden change in real power in the monitored transmission line. MA identifies the signal mode with frequency equal to 0.56 Hz. This oscillating frequency matches the real power oscillation period shown in *Figure 4.20*.

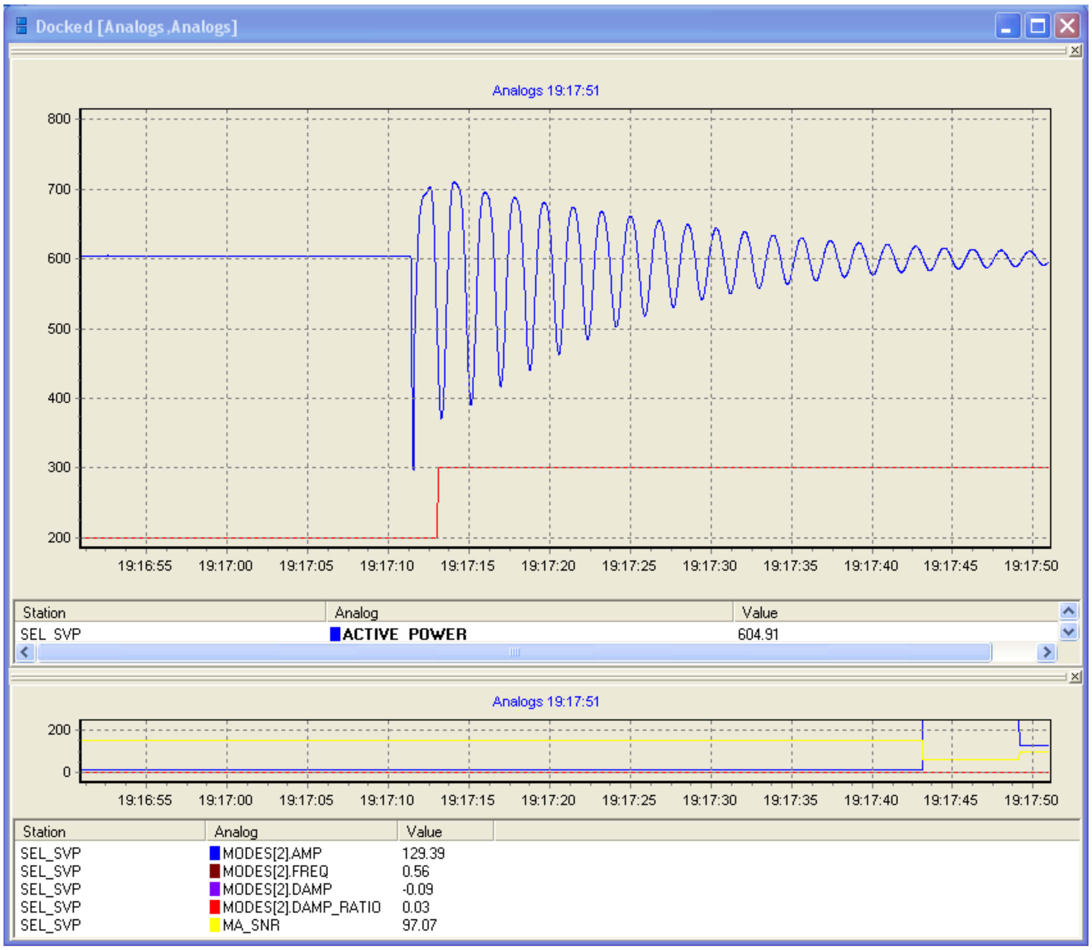


Figure 4.20 Mode 2 Amplitude, Frequency, and Damping Ratio for a Sudden Change in Power After the Parallel Line Opens

This last application example completes project **project1.pro**. *Figure 4.21* shows the project task configuration.

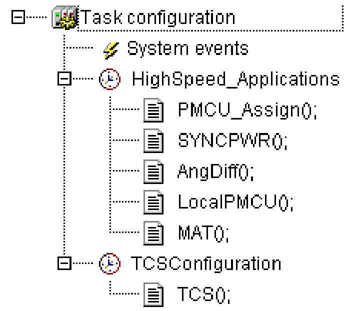


Figure 4.21 project1.pro Task Configuration

Substation State and Topology Processor (SSTP)

This application example describes how to configure the SEL-3378 for voltage and current measurement error identification and refinement of voltage and current measurements. This example is part of **project2.pro**. In this subsection you create the POUs **SSTP_DOUBLE_BUS_XFR** (ST type) and **SSTP_DOUBLE_BUS_XFR _EN** (ST type) to run the SSTP function. *Figure 4.22* shows the one-line diagram that corresponds to a double-bus and transfer bus arrangement. We will use this bus arrangement in our example.

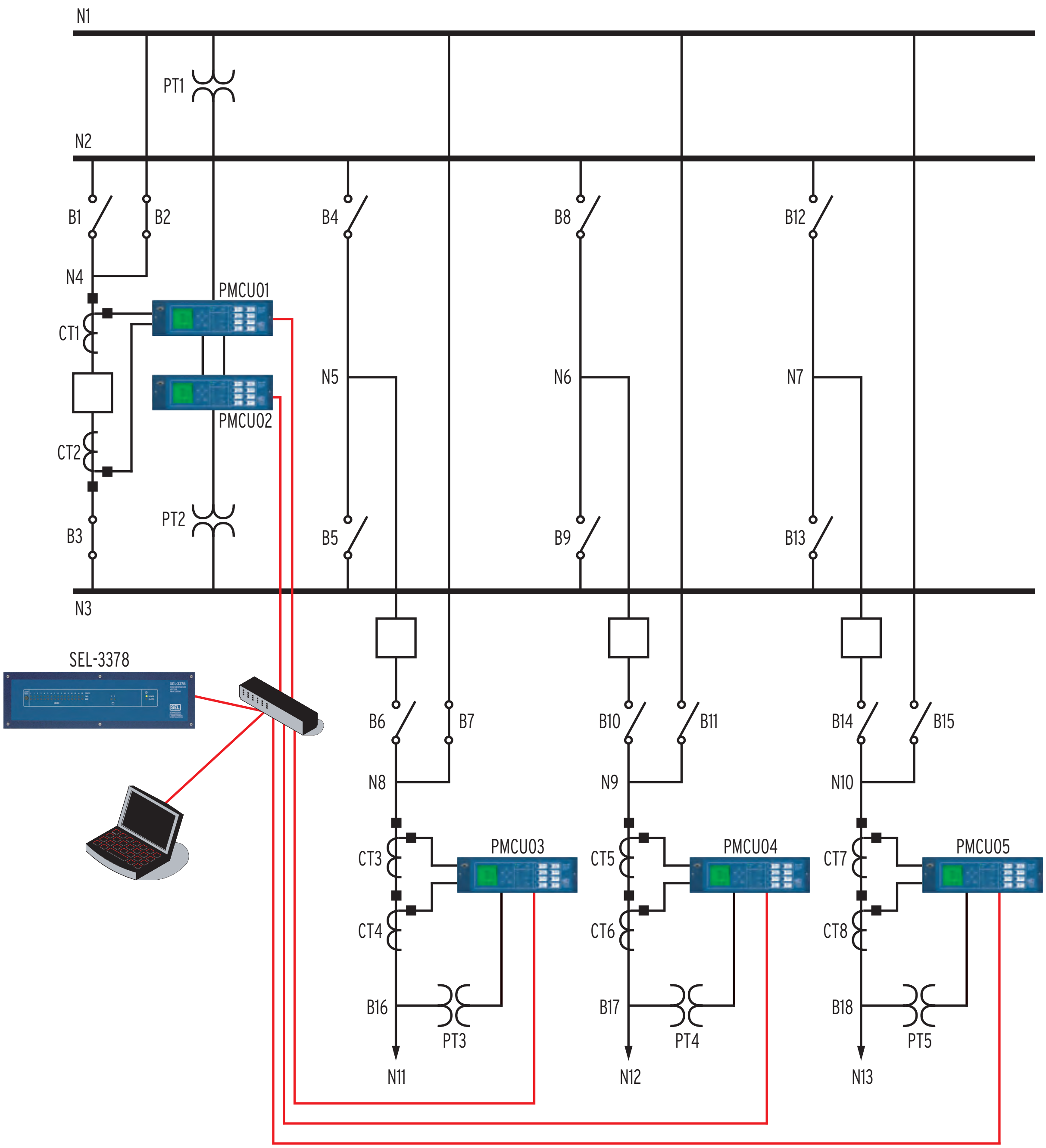


Figure 4.22 Bus Arrangement to Identify Voltage and Current Measurement Errors and to Refine These Measurements

The PMCUs (SEL-421 Relays in this application) use C37.118 protocol over Ethernet to send synchrophasor messages to the SEL-3378 at a rate of one message per second. The messages from the SEL-421 relays include data relevant to SSTP (see *Table 4.15*):

Table 4.15 SEL-421 Message Data Relevant to SSTP

Message	Description
PMCU Status	Variables that indicate if the PMCU data and time synchronization are OK.
Twelve phasors V1, VA, VB, VC, I1W, IAW, IBW, ICW, I1X, IAX, IBX, and ICX	Phasors are floating point numbers in rectangular numeric representation.
Branch Closed Status and Branch Closed Status Quality	Boolean variables that indicate if the branch is closed and if the closed status information is OK.
IDCODEs	1, 2, 3, 4, and 5 for PMCU01, PMCU02, PMCU03, PMCU04, and PMCU05, respectively.

Polarity Mark Convention and Correction Factors

The SSTP uses correction factors to normalize current measurements associated with a branch. For example, two relays, R1 and R2, are connected to the branch shown in *Figure 4.23*.

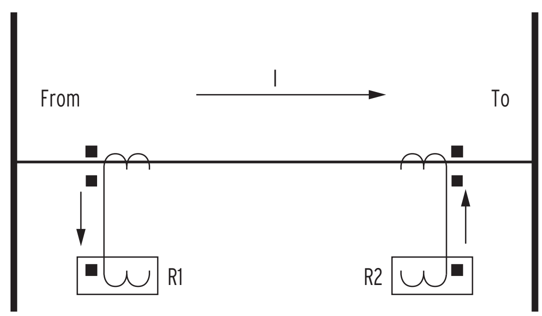


Figure 4.23 Current Measurement Polarity Convention and Correction Factors

With the given CT and relay polarities and assuming no measurement errors, the currents measured by R1, I_{R1}, and by R2, I_{R2}, will satisfy the following equation.

$$I_{R1} = -I_{R2} = I$$

We choose the first measurement correction factor k1 = 1 at 0 degrees, because the primary current flowing from the FROM Node to the TO Node causes the secondary current to enter the relay at the polarity mark. Similarly, we choose k2 = 1 at 180 degrees, because the primary current flowing from the FROM Node to the TO Node causes the secondary current to leave the relay at the polarity mark. With these correction factors, we obtain the following.

$$k_1 \bullet I_{R1} = k_2 \bullet I_{R2}$$

We can compare $k_1 \bullet I_{R1}$ and $k_2 \bullet I_{R2}$ directly.

SSTP Input Data

First create a new project titled **project2.pro**. For SSTP, you must enter data acquisition and substation configuration information based on the bus arrangement, such as that shown in *Figure 4.22*. The topology, current, and voltage processors use this information to perform their corresponding tasks.

The SSTP has two input data structures: the first is the branch_input_list, and the second is the node_input_list. In this example, the SSTP Input Data structure name is SSTP_IN (declare SSTP_IN as global variable).

Branch Input List

The branch_input_list includes the following information:

- Number of branches in the station (1 to 100)
- One branch_input_data structure per branch that includes the following:
  - FROM Node ID
  - TO Node ID
  - Branch Closed Status

    Indicates if the branch is closed.
  - Branch Closed Status Quality

    Indicates if the branch closed status is valid. If the closed status quality is bad, the topology processor assumes that the branch is closed to determine the current topology or open to determine the voltage topology.
  - Number of three-phase current measurements (1 to 10)
  - A-Phase measurements
    - Current measurements (magnitude and angle)
    - Current correction factors (magnitude and angle)
  - B-Phase measurements
    - Current measurements
    - Current correction factors
  - C-Phase measurements
    - Current measurements
    - Current correction factors
  - Current consistency threshold, i_cons_thre
  - Current unbalance enable threshold, i_unb_en_thre
  - Current unbalance threshold, i_unb_thre
  - Positive-sequence overcurrent threshold, i1_thre
  - Negative-sequence overcurrent threshold, 3i2_thre
  - Zero-sequence overcurrent threshold, 3i0_thre
- KCL threshold, KCL_thre

  This is a threshold that applies to all groups of nodes defined in the topology processor.

Number of Branches

According to the one-line diagram of *Figure 4.22*, the substation bus arrangement has 18 branches. The structured text to set the number of branches is as follows:

```
(*________Branch Data Begins_______________*)
SSTP_IN.list_of_branches.number_of_branches: =18;
```

Branch Input Data

Next, we show Branch 1 and Branch 3 configuration settings. Branch 1 is a merging branch without current measurements, and Branch 3 is a metered branch with four sets of current measurements. We only show Measurement Set 1 configuration; configurations of the remaining sets are similar to Measurement Set 1.

Branch 1. Branch 1 connects Node 2 and Node 4 and does not include current measurements. For this branch, you only need to assign the FROM and TO node IDs, the branch closed status, and the branch closed_status_quality. The bits 01 and 02 of the first digital word of the PMCU01 synchrophasor message correspond to the branch closed status and the branch closed_status_quality, respectively. The Branch 1 configuration is as follows:

```
(* Branch 01 *)
SSTP_IN.list_of_branches.branch[1].from_node:=2;
SSTP_IN.list_of_branches.branch[1].to_node:=4;
SSTP_IN.list_of_branches.branch[1].closed:=PMCU01.DWI[1].BIT01;
SSTP_IN.list_of_branches.branch[1].closed_status_quality:=PMCU01.DWI[1].BIT02;
```

Branch 3. Branch 3 connects Node 3 and Node 4. The Bits 05 and 06 of the first digital word of the PMCU01 synchrophasor message correspond to the branch closed status and the branch closed_status_quality, respectively. Measurement Set 1 corresponds to the IW currents of PMCU01, Measurement Set 2 corresponds to the IX currents of PMCU01, Measurement Set 3 corresponds to the IW currents of PMCU02, and Measurement Set 4 corresponds to the IX currents of PMCU02. CT1 secondary is connected in series to the IW terminals of PMCU01 and PMCU02; CT2 secondary is connected in series to the IX terminals of PMCU01 and PMCU02. In this example, all CT secondary polarity marks are connected to relay polarity. Note that current leaves CT1 polarity when the current flows from Node 3 to Node 4. For this reason, the current_correction_factor is set to 1 at 180° for Measurement 1. The Branch 3 configuration is as follows:

```
(* Branch 03 *)
SSTP_IN.list_of_branches.branch[3].from_node:=3;
SSTP_IN.list_of_branches.branch[3].to_node:=4;
SSTP_IN.list_of_branches.branch[3].closed:=PMCU01.DWI[1].BIT05;
SSTP_IN.list_of_branches.branch[3].closed_status_quality:=PMCU01.DWI[1].BIT06;
SSTP_IN.list_of_branches.branch[3].number_of_current_measurements:=4;
(* Measurement Set 1 *)
(* A-Phase *)
SSTP_IN.list_of_branches.branch[3].A_phase.current_measurement[1].mag:=PMCU01.PI[6].MAG;
SSTP_IN.list_of_branches.branch[3].A_phase.current_measurement[1].ang:=PMCU01.PI[6].ANG;
SSTP_IN.list_of_branches.branch[3].A_phase.current_correction_factor[1].mag:=1;
SSTP_IN.list_of_branches.branch[3].A_phase.current_correction_factor[1].ang:=180;
(* B-Phase *)
SSTP_IN.list_of_branches.branch[3].B_phase.current_measurement[1].mag:=PMCU01.PI[7].MAG;
SSTP_IN.list_of_branches.branch[3].B_phase.current_measurement[1].ang:=PMCU01.PI[7].ANG;
SSTP_IN.list_of_branches.branch[3].B_phase.current_correction_factor[1].mag:=1;
SSTP_IN.list_of_branches.branch[3].B_phase.current_correction_factor[1].ang:=180;
(* C-Phase *)
SSTP_IN.list_of_branches.branch[3].C_phase.current_measurement[1].mag:=PMCU01.PI[8].MAG;
SSTP_IN.list_of_branches.branch[3].C_phase.current_measurement[1].ang:=PMCU01.PI[8].ANG;
SSTP_IN.list_of_branches.branch[3].C_phase.current_correction_factor[1].mag:=1;
SSTP_IN.list_of_branches.branch[3].C_phase.current_correction_factor[1].ang:=180;
(* Measurement Set 2 *)
(* Measurement Set 3 *)
(* Measurement Set 4 *)
(* Thresholds *)
SSTP_IN.list_of_branches.branch[3].i_cons_thre:=20;
SSTP_IN.list_of_branches.branch[3].i_unb_en_thre:=60;
SSTP_IN.list_of_branches.branch[3].i_unb_thre:=60;
SSTP_IN.list_of_branches.branch[3].i1_thre:=1000;
SSTP_IN.list_of_branches.branch[3]._3i2_thre:=60;
SSTP_IN.list_of_branches.branch[3]._3i0_thre:=60;
```

KCL Threshold. The KCL threshold for this example is KCL_thre := 60.

```
(* KCL Threshold *)
SSTP_IN.list_of_branches.KCL_thre:=60;
(*________Branch Data Ends_________*)
```

Node Input List

The node_input_list includes the following information:

- Number of nodes in the station (1 to 100)
- One node_input_data structure per node that includes the following:
    - KCL node information that indicates if CP can process KCL on this node
    - A-Phase measurements
        - Number of voltage measurements (1 to 10)
        - Voltage measurements (magnitude and angle)
        - Voltage correction factors (magnitude and angle)
    - B-Phase measurements
        - Number of voltage measurements (1 to 10)
        - Voltage measurements
        - Voltage correction factors
    - C-Phase measurements
        - Number of voltage measurements (1 to 10)
        - Voltage measurements
        - Voltage correction factors
    - Positive-sequence undervoltage threshold, v1_thre
    - Negative-sequence overvoltage threshold, _3v2_thre
    - Zero-sequence overvoltage threshold, _3v0_thre
- Voltage consistency threshold, v_cons_thre

  This is a setting that applies to all node measurements.

Number of Nodes

According to the one-line diagram of *Figure 4.22*, the substation bus arrangement has 13 nodes.

```
*__________Node Data Begins_______________*)
SSTP_IN.list_of_nodes.number_of_nodes: =13;
```

Node Input Data

Next, we show Node 1, Node 2, and Node 11 configuration settings. Node 1 is a KCL node with one set of voltage measurements, Node 2 is a KCL node without voltage measurements, and Node 11 is a non-KCL node with one set of voltage measurements. The current processor can perform KCL in all nodes except in nodes 11, 12, and 13. Nodes 1, 3, 11, 12, and 13 include one voltage measurement for each phase.

Node 1. Node 1 includes one voltage measurement on each phase and is suitable for KCL check. PT1 is connected in parallel to the VY terminals of PMCU01. In this example, all PT secondary polarity marks are connected to relay polarity. The voltage_correction_factors are set to 1 at 0 degrees. The Node 1 configuration is as follows:

```
(* Node 01 *)
SSTP_IN.list_of_nodes.node[1].KCL:=TRUE;
(* A-Phase *)
SSTP_IN.list_of_nodes.node[1].A_phase.number_of_voltage_measurements:=1;
SSTP_IN.list_of_nodes.node[1].A_phase.voltage_measurement[1].mag:=PMCU01.PI[2].MAG;
SSTP_IN.list_of_nodes.node[1].A_phase.voltage_measurement[1].ang:=PMCU01.PI[2].ANG;
SSTP_IN.list_of_nodes.node[1].A_phase.voltage_correction_factor[1].mag:=1;
SSTP_IN.list_of_nodes.node[1].A_phase.voltage_correction_factor[1].ang:=0;
(* B-Phase *)
SSTP_IN.list_of_nodes.node[1].B_phase.number_of_voltage_measurements:=1;
SSTP_IN.list_of_nodes.node[1].B_phase.voltage_measurement[1].mag:=PMCU01.PI[3].MAG;
SSTP_IN.list_of_nodes.node[1].B_phase.voltage_measurement[1].ang:=PMCU01.PI[3].ANG;
SSTP_IN.list_of_nodes.node[1].B_phase.voltage_correction_factor[1].mag:=1;
SSTP_IN.list_of_nodes.node[1].B_phase.voltage_correction_factor[1].ang:=0;
(* C-Phase *)
SSTP_IN.list_of_nodes.node[1].C_phase.number_of_voltage_measurements:=1;
SSTP_IN.list_of_nodes.node[1].C_phase.voltage_measurement[1].mag:=PMCU01.PI[4].MAG;
SSTP_IN.list_of_nodes.node[1].C_phase.voltage_measurement[1].ang:=PMCU01.PI[4].ANG;
SSTP_IN.list_of_nodes.node[1].C_phase.voltage_correction_factor[1].mag:=1;
SSTP_IN.list_of_nodes.node[1].C_phase.voltage_correction_factor[1].ang:=0;
(* Thresholds *)
SSTP_IN.list_of_nodes.node[1].v1_thre:=106000;
SSTP_IN.list_of_nodes.node[1]._3v2_thre:=6600;
SSTP_IN.list_of_nodes.node[1]._3v0_thre:=6600;
```

Node 2. Node 2 does not include voltage measurements and is suitable for KCL check. The Node 2 configuration is as follows:

```
(* Node 02 *)
SSTP_IN.list_of_nodes.node[2].KCL:=TRUE;
```

Node 11. Node 11 includes one voltage measurement on each phase and is not suitable for KCL check. PT3 is connected in parallel to the VY terminals of PMCU03. The voltage_correction_factors are set to 1 at 0 degrees. The Node 11 configuration is as follows:

```
(* Node 11 *)
SSTP_IN.list_of_nodes.node[11].KCL:=FALSE;
SSTP_IN.list_of_nodes.node[11].A_phase.number_of_voltage_measurements:=1;
(* A-Phase *)
SSTP_IN.list_of_nodes.node[11].A_phase.voltage_measurement[1].mag:=PMCU03.PI[2].MAG;
SSTP_IN.list_of_nodes.node[11].A_phase.voltage_measurement[1].ang:=PMCU03.PI[2].ANG;
SSTP_IN.list_of_nodes.node[11].A_phase.voltage_correction_factor[1].mag:=1;
SSTP_IN.list_of_nodes.node[11].A_phase.voltage_correction_factor[1].ang:=0;
(* B-Phase *)
SSTP_IN.list_of_nodes.node[11].B_phase.number_of_voltage_measurements:=1;
SSTP_IN.list_of_nodes.node[11].B_phase.voltage_measurement[1].mag:=PMCU03.PI[3].MAG;
SSTP_IN.list_of_nodes.node[11].B_phase.voltage_measurement[1].ang:=PMCU03.PI[3].ANG;
SSTP_IN.list_of_nodes.node[11].B_phase.voltage_correction_factor[1].mag:=1;
SSTP_IN.list_of_nodes.node[11].B_phase.voltage_correction_factor[1].ang:=0;
(* C-Phase *)
SSTP_IN.list_of_nodes.node[11].C_phase.number_of_voltage_measurements:=1;
SSTP_IN.list_of_nodes.node[11].C_phase.voltage_measurement[1].mag:=PMCU03.PI[4].MAG;
SSTP_IN.list_of_nodes.node[11].C_phase.voltage_measurement[1].ang:=PMCU03.PI[4].ANG;
SSTP_IN.list_of_nodes.node[11].C_phase.voltage_correction_factor[1].mag:=1;
SSTP_IN.list_of_nodes.node[11].C_phase.voltage_correction_factor[1].ang:=0;
(* Thresholds *)
SSTP_IN.list_of_nodes.node[11].v1_thre:=106000;
SSTP_IN.list_of_nodes.node[11]._3v2_thre:=6600;
SSTP_IN.list_of_nodes.node[11]._3v0_thre:=6600;
```

Voltage Consistency Threshold

The global voltage consistency threshold for this example is: v_cons_thre := 1300. The voltage processor uses this threshold to determine the adequacy of the scaled measurements.

```
*Global_Voltage_Consistency_ Threshold_*)
SSTP_IN.list_of_nodes.v_cons_thre:=1300;
(*__________Node Data Ends______________*)
```

SSTP Output Data

SSTP has two output data structures: the first is the branch_output_list, and the second is the node_output_list. In this example, the SSTP Output Data structure name is SSTP_OUT (declare SSTP_OUT as global variable).

Branch Output List

The branch_output_list includes one branch_output_data structure per branch with the following information:

- A-Phase current measurements and alarms
  - Scaled measurement (magnitude and angle)
  - Measurement consistency alarm
  - Refined measurement (magnitude and angle)
  - KCL check status
- B-Phase current measurements and alarms
  - Scaled measurement (magnitude and angle)
  - Measurement consistency alarm
  - Refined measurement (magnitude and angle)
  - KCL check status
- C-Phase current measurements and alarms
  - Scaled measurement (magnitude and angle)
  - Measurement consistency alarm
  - Refined measurement (magnitude and angle)
  - KCL check status
- Current unbalance percentage
- Current unbalance alarm
- Positive-sequence current (magnitude and angle)
- Positive-sequence current alarm
- Negative-sequence current (magnitude and angle)
- Negative-sequence current alarm
- Zero-sequence current (magnitude and angle)
- Zero-sequence current alarm

Node Output List

The node_output_list includes one node_output_data structure per node with the following information:

- A-Phase voltage measurements and alarm
  - Scaled measurement (magnitude and angle)
  - Measurement consistency alarm
  - Refined measurement (magnitude and angle)
- B-Phase voltage measurements and alarm
  - Scaled measurement (magnitude and angle)
  - Measurement consistency alarm
  - Refined measurement (magnitude and angle)
- C-Phase voltage measurements and alarm
  - Scaled measurement (magnitude and angle)
  - Measurement consistency alarm
  - Refined measurement (magnitude and angle)
- Positive-sequence voltage (magnitude and angle)
- Positive-sequence voltage alarm
- Negative-sequence voltage (magnitude and angle)
- Negative-sequence voltage alarm
- Zero-sequence voltage (magnitude and angle)
- Zero-sequence voltage alarm

Error Messages

The SSTP output data structure provides SSTP error information to help you configure SSTP. *Figure 4.24* shows the error message when there are no errors, and *Figure 4.25* gives an error example when a branch threshold is set to zero.

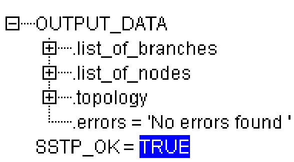


Figure 4.24 No Errors Message

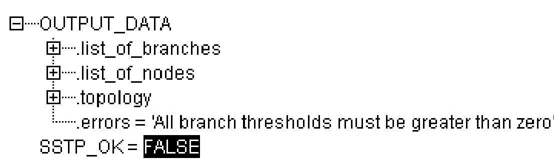


Figure 4.25 One of the Branch Thresholds is Set to Zero

SSTP Function Activation

The SSTP function, in *Figure 4.26*, includes the SSTP enable input (EN) and pointers to sstp_input_data and sstp_output_data structures. The function also includes a Boolean output (SSTP) that is TRUE if SSTP finds no errors in the input data.

Figure 4.26 SSTP Function Definition

The input and output data are predefined as pointers, so you must provide addresses for the sstp_input_data and sstp_output_data structures. The following structured text sets three inputs: EN := SSTP_EN, POINTER TO sstp_input_data := ADR(SSTP_IN), and POINTER TO sstp_ouput_data := ADR(SSTP_OUT) to run the SSTP function.

```
SSTP_OK:=SSTP(SSTP_EN, ADR(SSTP_IN), ADR(SSTP_OUT)); (*Function Call*)
```

Running The SSTP

To achieve input data coherency, use two POUs when running the SSTP. One POU acquires the input data, sstp_data_in, and runs in the same task as the PMCU_IN. This task is a high priority and executes once every four milliseconds. A second POU locks the input data, runs the SSTP, and clears the lock. In contrast to the first POU, the second POU runs at the priority of the snapshot task and should be set to run no more frequently than once a second. This locking scheme requires definition of the following variables in the VAR_GLOBAL section of the project:

```
VAR_GLOBAL
    SSTP_IN:sstp_input_data;
    SSTP_OUT:sstp_output_data;
    SSTP_OK:BOOL;
    SSTP_EN:BOOL;
    SSTP_LOCK:BOOL;
    (*Other global variables*)
          .
          .
          .
END_VAR
```

The first POU (**SSTP_DOUBLE_BUS_XFR**) acquires the data that the SSTP requires from the PMCU_IN instances. The structure of this POU is as follows:

```
IF NOT SSTP_LOCK THEN
(*Set input data in the SSTP_IN structure
as described in the sstp Input Data section*)

SSTP_EN:=PMCU01.STATUS.PMCU_OK AND PMCU02.STATUS.PMCU_OK AND PMCU03.STATUS.PMCU_OK
    AND PMCU04.STATUS.PMCU_OK AND PMCU05.STATUS.PMCU_OK;
          .
          .
          .
END_IF
```

Note that SSTP acquires data only when the global variable SSTP_LOCK is FALSE. The structure of the second POU (**SSTP_DOUBLE_BUS_XFR _EN**) is as follows:

```
SSTP_LOCK:=TRUE;  (*Set Lock*)
SSTP_OK:=SSTP(SSTP_EN, ADR(SSTP_IN), ADR(SSTP_OUT)); (*Function call*)
SSTP_LOCK:=FALSE;  (*Clear Lock*)
```

Note that the first POU cannot acquire new input data while SSTP is running, because the SSTP_LOCK is set.

Station HMI

The Station HMI, in *Figure 4.27*, is an example of how you can show the refined measurements and measurement alarms for the configured substation. This visualization tool, part of the SVP Configurator, provides graphic elements and can be associated with the project variables. The user could add a new visualization object in the project file with the available graphic elements and build custom HMI screens based on the application. In run mode, the HMI screens respond to the assigned variables (Refer to the *CoDeSys Visualization Manual* available on the SEL-3378 CD-ROM for more information). *Figure 4.27* shows the configured 230 kV substation layout with refined measurements at branches 3, 6, 10, and 14. The HMI could be programmed to signal any alarm conditions. In this example, Node **N1** and Branch **B3** turned RED. *Figure 4.28* and *Figure 4.29* show the corresponding refined measurements and associated alarms.

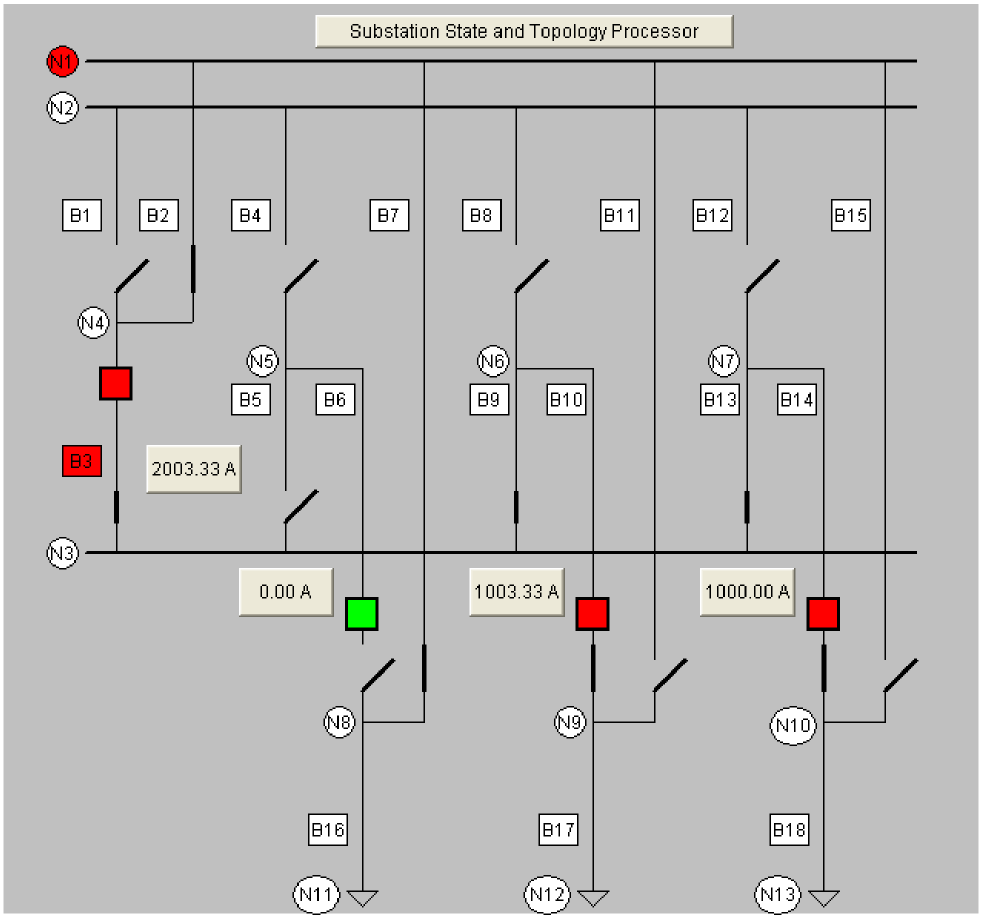


Figure 4.27 Station HMI Showing Refined Measurement Values

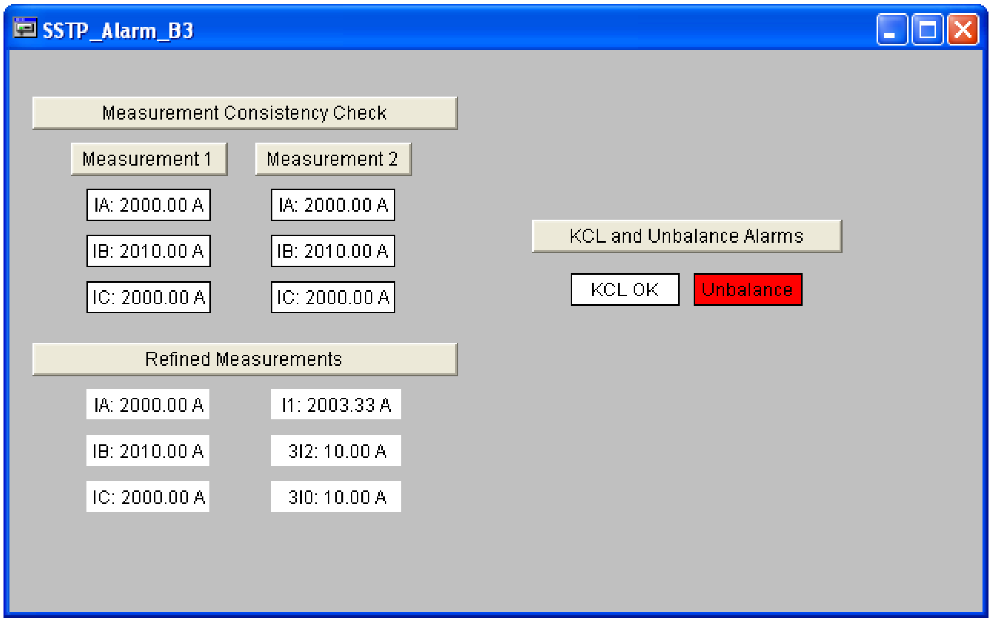


Figure 4.28 Branch 3 Refined Measurements and Alarms

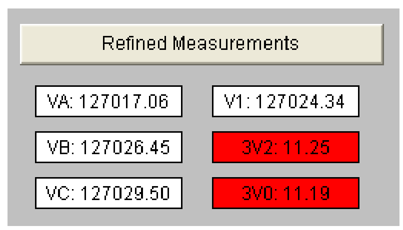


Figure 4.29 Node 1 Refined Measurements and Alarms

This page intentionally left blank

Section 5
Troubleshooting

Overview

The SEL-3378 runs continuous self-tests to detect out-of-tolerance conditions. While these tests run at the same time as the rest of the system functions, there is no degradation of SEL-3378 performance.

Status Report

The SEL-3378 reports out-of-tolerance conditions as a status failure. A severe out-of-tolerance condition causes the processor to declare a status failure. During status failure, the SEL-3378 continues operation but displays a status byte in the data frame that indicates data invalidity. Upon status failure, the processor asserts the alarm contact and illuminates the front-panel red LED **ALARM**.

```
=>>STATUS <Enter>

                 Date/Time : Tue Mar 18 15:43:05 UTC 2008
                  Hostname : sel-3378
                       FID : SEL-3378-R101-V0-Z001001-D20080317
             Serial Number : 0000000001
               IRIG Status : Absent
   Available System Memory : 448 MB OK
      Available Disk Space : 861 MB OK
   Serial Port Overcurrent : OK
                 CPU Usage : 0 % OK
           CPU Temperature : 45 C OK
             Alarm Contact : DEASSERTED                          MAC Addresses

eth0      Link encap:Ethernet  HWaddr 00:30:A7:00:5A:E6
          inet addr:10.200.45.213  Bcast:10.200.255.255  Mask:255.255.0.0
          inet6 addr: fe80::230:a7ff:fe00:5ae6/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:2687 errors:0 dropped:0 overruns:0 frame:0
          TX packets:82 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:447614 (437.1 KiB)  TX bytes:25340 (24.7 KiB)
          Interrupt:11 Base address:0xdc00

eth1      Link encap:Ethernet  HWaddr 00:30:A7:00:5A:E7
          inet addr:10.200.1.15  Bcast:10.200.255.255  Mask:255.255.0.0
          inet6 addr: fe80::230:a7ff:fe00:5ae7/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:688 errors:0 dropped:0 overruns:0 frame:0
          TX packets:7 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:122757 (119.8 KiB)  TX bytes:510 (510.0 B)
          Interrupt:9 Base address:0xd880
```

Figure 5.1 Sample STATUS Screen

The SEL-3378 displays the following:

- SEL-3378 Date and Time
- Host name
- Firmware ID (see *Firmware on page A.1*)
- Serial number

Additionally, the SEL-3378 displays the following:

- IRIG Status
- Available system memory
- Available disk space
- Serial port overcurrent status
- CPU usage percentage
- CPU temperature (°C)
- Alarm contact status
- Network 1 Settings
- Network 2 Settings

Troubleshooting Procedures

Table 5.1 lists troubleshooting procedures for common problems. The table lists each symptom, possible causes, and corresponding diagnoses/solutions.

Table 5.1 Troubleshooting Procedures (Sheet 1 of 2)

Symptom and Possible Cause	Diagnosis/Solution
Dark Front Panel	
Power is off.	Verify that substation battery power is operational.
Input power is not present.	Verify that power is present at the rear-panel terminal strip.
Blown power supply fuse.	Replace the fuse.
LED Alarm On	
Self-test failure.	See STATUS at the Console Port, and then contact the SEL factory or your Technical Service Center.
Alarm Output Asserts	
Power is off.	Restore power.
Blown power supply fuse.	Replace the fuse.
Power supply failure.	LED alarm is on.
Pin 1 communications serial port shorted to ground.	Remove short from Pin 1.
RTS issued Alarm Latch command.	Issue Alarm Clear command.

Table 5.1 Troubleshooting Procedures (Sheet 2 of 2)

Symptom and Possible Cause	Diagnosis/Solution
System Resets Every 5 Minutes	
No program is executing on the SEL-3378 logic engine.	Verify that a program is being executed.
IEC function USER_WATCHDOG is not being executed.	Verify that the USER_WATCHDOG function is being executed.
System failure is preventing Logic Engine from running.	Contact the SEL factory for assistance.
System Does Not Respond to Console Port Commands	
Communications device is not connected to the system.	Connect a communications device.
Incorrect data speed (baud rate) or other communications parameters.	Configure your terminal port parameters to the particular relay port settings.
Incorrect communications cables.	Use SEL communications cables, or use cables you build according to SEL specifications.
Communications cabling error.	Check cable connections.
Handshake line conflict; system is attempting to transmit information, but it cannot do so.	Check communications cabling. Use SEL communications cables, or use cables you build according to SEL specifications.
System is in the XOFF state, halting communications.	Type **<Ctrl+Q>** to put the system in the XON state.
Terminal Displays Meaningless Characters	
Data speed (baud rate) is set incorrectly.	Check the terminal parameters configuration.
Terminal emulation is not optimal.	Try other terminal types, including VT-100 and VT-52 terminal emulations.
Missing C37.118 Data Frames	
No data are received.	Check the status for each input. You can view status from the TCS_CONFIG function block STATUS.INPUT array. The OK status message should be TRUE if data are being received. If the OK status message is FALSE then check the individual status messages for details.
The STATUS.INPUT.CONNECTED value is FALSE.	Check that all cables are connected properly. Check that all network devices have power and are connected properly. Check the keep alive setting in the sending device (the remote C37.118 server). This setting should be enabled.
Received data frames are occasionally not received.	Check that the TCS_CONFIG MISSING_MESSAGE_THRESHOLD setting is set large enough to exceed the worst-case relative network delay between any two inputs. Check that the IEC Task of the PMCU_IN function block is set to be priority zero and with an interval of 4 ms.

Diagnostic Status and Alarm Function Blocks

The SVP Configurator includes Diagnostic Status Function Block and Latch Alarm, Clear Alarm, and User Watchdog Functions.

Diagnostic Status

Upon the rising edge of the EN input, the SEL-3378 updates diagnostic status information including the following (see *Figure 5.2*):

- System status
- Alarm contact status
- IRIG presence indication
- CPU temperature and CPU temperature violation indication
- CPU usage and CPU usage violation indication

  CPU usage refers to real-time processing tasks only
- Free disk space and free disk space violation indication
- Free memory and free memory violation indication
- Timestamp

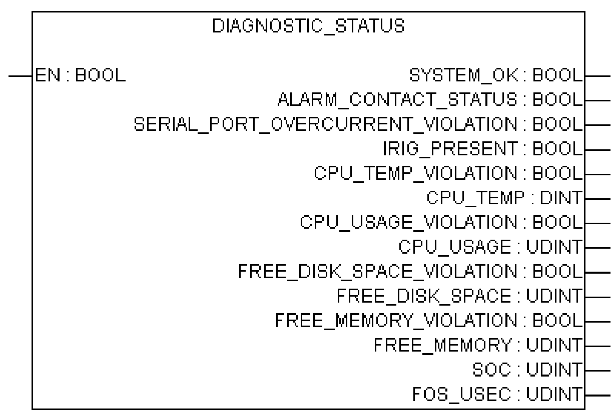


Figure 5.2 Diagnostic Status Function Block

Alarm Contact

You can latch and clear the alarm contact within the SVP Configurator. Upon rising edge of the TRIGGER input of the function blocks shown in *Figure 5.3*, the alarm contact latches or clears depending on the function block in use.

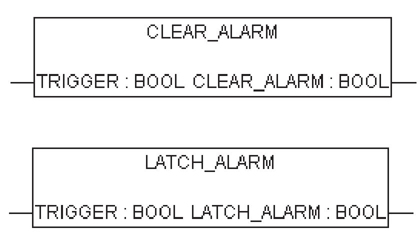


Figure 5.3 Alarm Latch and Clear Function Blocks

User Watchdog

Each time this function block is run, the watchdog is reset. You must program the USER_WATCHDOG function shown in *Figure 5.4* to run in a low priority IEC task (priority 16 through 31 are acceptable) cyclically with an interval of between 1 second to 4 minutes. If the watchdog does not reset within the watchdog’s five-minute time-out period, the watchdog will cause the SEL-3378 to reset and the alarm contact to assert to notify an operator that there is a problem within the SEL-3378.

Figure 5.4 User Watchdog Function

TCS Error Messages

Table 5.2 lists TCS_CONFIG output numbers with their corresponding error messages.

Table 5.2 TCS Error Messages (Sheet 1 of 2)

TCS_Config Output Number	Error Message Description
≤ 0	No error found.
–2	TCS settings manager server not reporting status.
–3	Input pCMD_OUT_DATA_IN not defined.
–4	Input pCMD_IN_DATA_OUT not defined.
–101	CRC error on tcs_settings_xfer_frame.
–102	Framing error on tcs_settings_xfer_frame.
–104	PDC_IDCODE setting is out of range. Allowable values are 1 to 65534.
–105	NFREQ setting is out of range. Allowable options are 50 or 60.
–106	MRATE setting is out of range.
–107	MISSING_MESSAGE_THRESHOLD setting is out of range. Allowable values are 2 to 30.
–108	CLIENT_SETTINGS->IDCODE setting is out of range. Allowable values are 1 to 65534.
–109	CLIENT_SETTINGS->EN = TRUE. Either C37_118 CLIENT or FASTOP needs to be enabled.
–110	CLIENT_SETTINGS->FASTOP setting is out of range. Allowable options are 0 (no fastop), 1 (SEL fastop), and 2 (118 fastop).
–111	CLIENT_SETTINGS->EPORT.SERVER_IP setting is out of range.
–112	CLIENT_SETTINGS->EPORT.CLIENT_DATA_PORT setting is out of range. Allowable values are 2000 to 65515.
–113	CLIENT_SETTINGS->EPORT.TRANSPORT_SCHEME setting is out of range. Allowable options are TCP, UDP, UDP_T, or UDP_F.
–114	CLIENT_SETTINGS->EPORT.SERVER_CMD_PORT setting is out of range. Allowable values are 23, 2000 to 65515.
–115	CLIENT_SETTINGS->EPORT.FASTOP_PORT setting is out of range. Allowable values are 0, 23, 2000 to 65515.
–116	CLIENT_SETTINGS->SPORT.PORT_NUMBER setting is out of range. Allowable values are 1 to 15.
–117	CLIENT_SETTINGS->SPORT.CONNECTION_SPEED setting is out of range.
–118	CLIENT_SETTINGS->CONNECTION setting is out of range. Allowable options are E (Ethernet) or S (serial).
–119	SERVER_SETTINGS->MRATE setting is out of range.
–121	SERVER_SETTINGS->CLIENT_IP setting is out of range.

Table 5.2 TCS Error Messages (Sheet 2 of 2)

TCS_Config Output Number	Error Message Description
–122	SERVER_SETTINGS->SERVER_CMD_PORT setting is out of range. Allowable values are 2000 to 65515.
–123	SERVER_SETTINGS->TRANSPORT_SCHEME setting is out of range. Allowable options are UDP_T or UDP_S.
–124	SERVER_SETTINGS->CLIENT_DATA_PORT setting is out of range. Allowable values are 2000 to 65515.
–125	CLIENT_SETTINGS->EPORT.CLIENT_IP setting is out of range.
–126	SERVER_SETTINGS->SERVER_IP setting is out of range.
–128	CLIENT_SETTINGS->EPORT.FASTOP_PORT setting is out of range. Allowable values are 23, 2000 to 65515.
–201	TCS settings manager client not connected.
–252	TCS settings manager client not connected.
–253	TCS settings manager client not connected.

Local PMCU Error Messages

Table 5.3 lists PMCU_OUT numbers with their corresponding error messages.

Table 5.3 Local PMCU Error Messages

PMCU_OUT Number	Error Message Description
0	No error found.
–1	CLIENT_DATA_PORT is invalid. Allowable range is 2000 to 65515.
–2	SERVER_CMD_PORT is invalid. Allowable range is 2000 to 65515.
–3	PDC_IDCODE is invalid. Allowable range is 1 to 65534.
–4	PMCU_IDCODE is invalid. Allowable range is 0 to 65534.
–5	NUM_PO_V is invalid. Allowable range is 0 to 640.
–6	NUM_PO_I is invalid. Allowable range is 0 to 640.
–7	The sum of NUM_PO_V and NUM_PO_I cannot exceed 640.
–8	NUM_AO is invalid. Allowable range is 0 to 320.
–9	NUM_DWO is invalid. Allowable range is 0 to 80.
–10	NFREQ is invalid. Allowable values are 50 or 60.
–11	CLIENT_IP is invalid.
–12	SERVER_IP is invalid.

SSTP Error Messages

When an error occurs while SSTP is running, SSTP halts execution and provides an error message describing the problem in the output data structure **sstp_output_data.errors** and the SSTP function returns `FALSE`. *Table 5.4* lists SSTP error messages and corresponding errors.

Table 5.4 SSTP Error Messages

Error Message	Error
`Maximum number of branches exceeded.`	NUMBER_OF_BRANCHES > MAX_NUMBER_OF_BRANCHES
`Number of branches must be greater than zero.`	NUMBER_OF_BRANCHES == 0
`Maximum number of nodes exceeded.`	NUMBER_OF_NODES > MAX_NUMBER_OF_NODES
`Number of nodes must be greater than zero.`	NUMBER_OF_NODES < 1
`Maximum number of voltage measurements exceeded.`	NODE[node].A_PHASE.NUMBER_OF_VOLTAGE_MEASURE-MENTS > MAX_NUMBER_OF_VOLTAGE_MEASURE-MENTS_PER_NODE
`Maximum number of voltage measurements exceeded.`	NODE[node].B_PHASE.NUMBER_OF_VOLTAGE_MEASURE-MENTS > MAX_NUMBER_OF_VOLTAGE_MEASURE-MENTS_PER_NODE
`Maximum number of voltage measurements exceeded.`	NODE[node].C_PHASE.NUMBER_OF_VOLTAGE_MEASURE-MENTS > MAX_NUMBER_OF_VOLTAGE_MEASURE-MENTS_PER_NODE
`Maximum number of current measurements exceeded.`	BRANCH[branch].NUMBER_OF_CURRENT_MEASUREMENTS > MAX_NUMBER_OF_CURRENT_MEASUREMENTS_PER_BRANCH
`input_data—> LIST_OF_BRANCHES.BRANCH[branch].FROM_NODE or TO_NODE must not be greater than LIST_OF_NODES.NUMBER_OF_NODES.`	All the FROM and TO IDs in the branches must be smaller or equal to the number of nodes in the list of nodes.
`input_data-> LIST_OF_BRANCHES.BRANCH[branch].FROM_NODE or TO_NODE must be greater than zero.`	The FROM and TO IDs in every branch must be greater than zero.
`LIST_OF_BRANCHES.KCL_THRE must be greater than zero.`	input_data->LIST_OF_BRANCHES.KCL_THRE ≤ 0
`Current element thresholds in metered branches must be greater than zero.`	LIST_OF_BRANCHES.BRANCH[branch]._3I0_THRE ≤ 0.0 LIST_OF_BRANCHES.BRANCH[branch]._3I2_THRE ≤ 0.0 LIST_OF_BRANCHES.BRANCH[branch].I1_THRE ≤ 0.0 LIST_OF_BRANCHES.BRANCH[branch].I_CONS_THRE ≤ 0.0 LIST_OF_BRANCHES.BRANCH[branch].I_UNB_THRE ≤ 0.0 LIST_OF_BRANCHES.BRANCH[branch].I_UNB_EN_THRE ≤ 0.0
`LIST_OF_NODES.V_CONS_THRE must be greater than zero.`	V_CONS_THRE ≤ 0
`Voltage element thresholds in nodes with three-phase measurements must be greater than zero`	input_data-> LIST_OF_NODES.NODE[node]._3V0_THRE ≤ 0.0 input_data->LIST_OF_NODES.NODE[node]._3V2_THRE ≤ 0.0 input_data->LIST_OF_NODES.NODE[node].V1_THRE ≤ 0.0

Factory Assistance

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 USA
Tel: +1.509.332.1890
Fax: +1.509.332.7990
Internet: selinc.com
Email: info@selinc.com

Appendix A
Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your SEL-3378

To find the firmware revision number in your SEL-3378, use the serial port **STATUS** command or the front panel to view the status report. The firmware revision number is after the R, and the release date is after the D. For example, the following is firmware revision number Rxxx, release date Dxxxxxxxx.

FID=SEL-3378-Rxxx-V0-Z001001-Dxxxxxxxx

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

Table A.1 Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-3378-R104-V0-Z002002-D20161214	➤ Resolved an issue that could inhibit the transmission of Fast Operate commands.	20161214
SEL-3378-R103-V0-Z002002-D20110401	➤ Manual update only (see *Table A.2).*	20140307
SEL-3378-R103-V0-Z002002-D20110401	➤ Manual update only (see *Table A.2).*	20111005
SEL-3378-R103-V0-Z002002-D20110401	➤ Extended the frame wait time to two seconds to accommodate frames that take longer than 200 ms to arrive.	20110401
SEL-3378-R102-V0-Z002002-D20100127	➤ Made improvements for manufacturability.	20100127
SEL-3378-R101-V0-Z002002-D20090929	➤ Increased the number of input PMUs to 20. ➤ Increased message size to accommodate 32 phasors, 16 analogs, and 4 digital words. ➤ Increased FRACSEC jitter tolerance to ±1 ms. ➤ Added a setting to allow processing of messages even when messages are not time synchronized. ➤ Added UDP and UDP_F TRANSPORT_SCHEME options. ➤ Added user-programmable watchdog reset.	20090929
SEL-3378-R100-V0-Z001001-D20080404	➤ Initial version.	20080404

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

Revision Date	Summary of Revisions
20161214	Appendix A Updated for firmware version R104.
20140307	Section 1 ➤ Updated *Certifications* in *Specifications*.
20111005	Section 1 ➤ Updated *Data Through Latency* in *Specifications*. ➤ Updated *Figure 2.2: Dimensions Diagram*.
20110401	Appendix A ➤ Updated for firmware version R103.
20100127	Appendix A ➤ Updated for firmware version R102.
20090929	General ➤ Increased number of PMCUs from 16 to 20. ➤ Increased maximum size of synchrophasor messages from 154 bytes to 354 bytes. ➤ Increased Local PMCU support to 640 phasors and 80 digital words. Section 1 ➤ Updated *Table 1.1: SEL-3378 Libraries*. Section 4 ➤ Updated *Figure 4.4: TCS Configuration Function*. ➤ Added TIME_UNSYNC_Block information to *Table 4.2: TCS Global Settings*. ➤ Added CONF_FILE information to *Table 4.3: TCS Client Settings*. ➤ Updated *Figure 4.6: PMCU_IN Function Block*. ➤ Added NUM_PO_V and NUM_PO_I to *Table 4.11: Local PMCU Output Configuration*. Section 5 ➤ Updated *Table 5.1: Troubleshooting Procedures*. ➤ Added *User Watchdog*. ➤ Added NUM_PO_V and NUM_PO_I to *Table 5.3: Local PMCU Error Messages*. Appendix A ➤ Updated for firmware version R101.
20080404	➤ Initial version.

Appendix B
SVP Configurator

Introduction

The SVP Configurator allows you to build projects based on your required applications. The Run Time System (RTS) turns the SEL-3378 into an IEC 61131-3 programmable logic controller (PLC). The programming languages that the SVP Configurator offers conform to the requirements of IEC 61131-3, an international standard for programming languages of PLCs. The SEL-3378 uses this environment to configure the Time Alignment Client Server, the Local PMCU, the Fast Operate Command functions, PWRC, PADM, MA, and SSTP in the SEL-3378. In addition, you could program custom logic based on your applications.

Project Layout

The project layout, in *Figure B.1*, has four different objects: Program Organization Units (POU), Data Types, Visualization, and Resources. Save the working project with the extension **.pro** within the SVP Configurator.

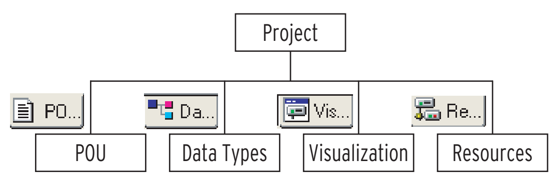


Figure B.1 Project Layout

Program Organization Unit (POU)

POU can be a simple program, function, or a function block that you define based on your application. Each POU consists of a local variable declaration part and a programming space. Programs are written in one of the IEC 61131-3 programming languages (e.g., Function Block Diagram, Structured Text). POUs can call up other POUs. However, recursions are not allowed.

Data Types

You can define new data types in addition to those that are standard (e.g., REAL, INT). For example, you can create data structures and references (aliases).

Visualization

The SVP Configurator contains an integrated visualization editor that allows you to create visualization objects or HMI screens. The visualization objects can directly access the variables in the project. You can create visualization objects in the project and add visualization elements like Meter, Trend, Alarm

Table, Bar display, etc. based on the application. For more details see the *CoDeSys Visualization Manual* (CoDeSys instruction manuals are available on the SEL-3378 CD-ROM).

Resources

Tools for configuring and organizing your project are available in the Resources object. Some of the available tools include the following:

- Global variables that you can use throughout the project
- Library manager for addition and deletion of project libraries
- Log for recording actions during an online session
- Task Configuration to specify POU execution attributes (processing interval, priority, etc.)
- Watch and Receipt Manager for displaying variable values and for setting default variable values
- Alarm Configuration for managing project alarms

Figure B.2 shows a project example in which we add two numbers and identifies the object tabs (POU, Data types, Visualization, Resources), local variable declaration, programming space, and the compile information window.

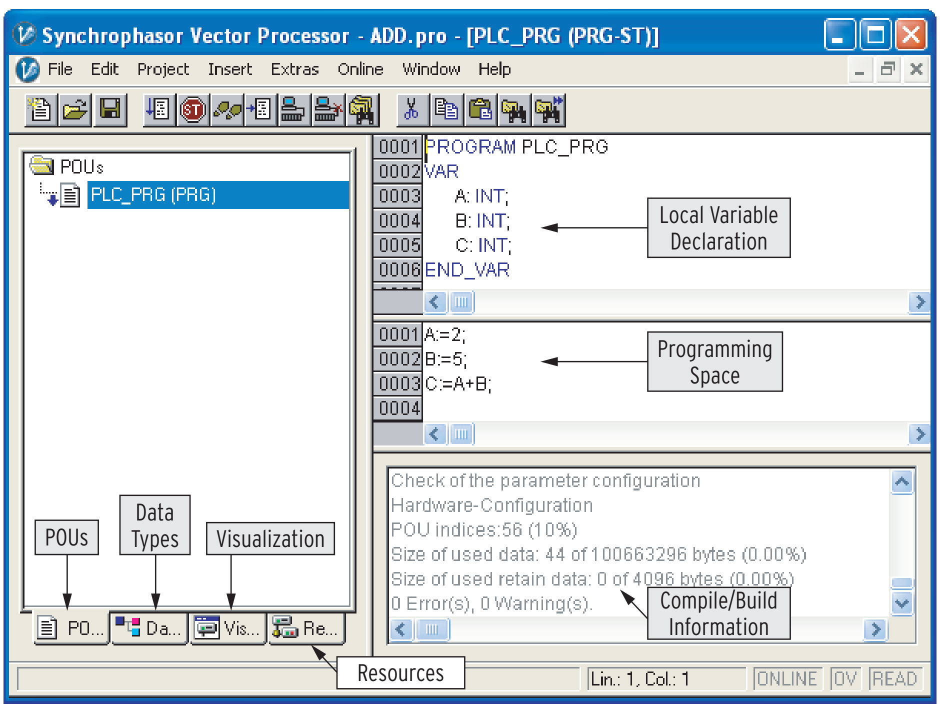


Figure B.2 Project Example

Programming Languages

The SVP Configurator supports all the languages that the IEC 61131-3 standard describes. These languages can be characterized as textual and graphical languages.

Textual Languages:

- ➤ Instruction List (IL)
- ➤ Structured Text (ST)

Graphical Languages:

- ➤ Sequential Function Chart (SFC)
- ➤ Function Block Diagram (FBD)
- ➤ Ladder Diagram (LD)
- ➤ Continuous Function Chart Editor (CFC)

See the *CoDeSys User's Manual* for more details.

Creating a Project

Use the following path to begin work in the SVP Configurator:

Start > Programs > SEL Applications > SVP Configurator

To create a new project, click **File > New**.

Creating a New POU

To create a new POU within a project, select **Project > Object > Add...** while in the POU tab.

Assigning a POU to a Task

Step 1. Click on the **Resources** tab (see *Figure 4.3*).

Step 2. Double-click **Task Configuration**.

Step 3. Select **Insert > Append Task**.

Step 4. Change the task name.

Step 5. Set the **Priority, Type, and Interval** for the added task.

Step 6. Select **Insert > Append Program Call**.

Step 7. Click on the **Browse** button <icon> and assign the new POU to the program call.

Target Settings

Double-click **Target Settings** in the resources tab and select SEL-3378 **RTS V2.4 For Linux Helens V.1.0**.

Communication to the Run Time System (RTS)

The SVP Configurator uses a gateway server to communicate with the RTS. Configure the communication parameters by selecting **Online** > **Communication Parameters**. *Figure B.3* shows the architecture specific to SEL-3378.

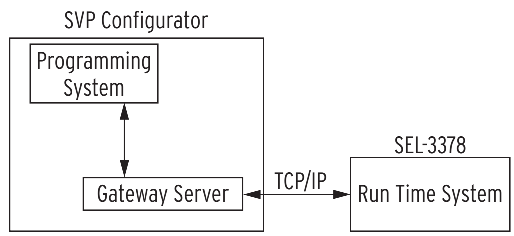


Figure B.3 SEL-3378 Architecture

Set up a new communications channel between the PC (running the SVP Configurator) and the SEL-3378 as follows:

Step 1. Click on the **New** button in the **Communication Parameters** dialog.

Step 2. Assign a name specific to the channel with TCP/IP as the device option.

Step 3. Double-click on the value associated with the address.

Step 4. Enter the IP address of the SEL-3378.

Step 5. Click **OK**.

Figure B.4 shows the example settings for the channel configuration.

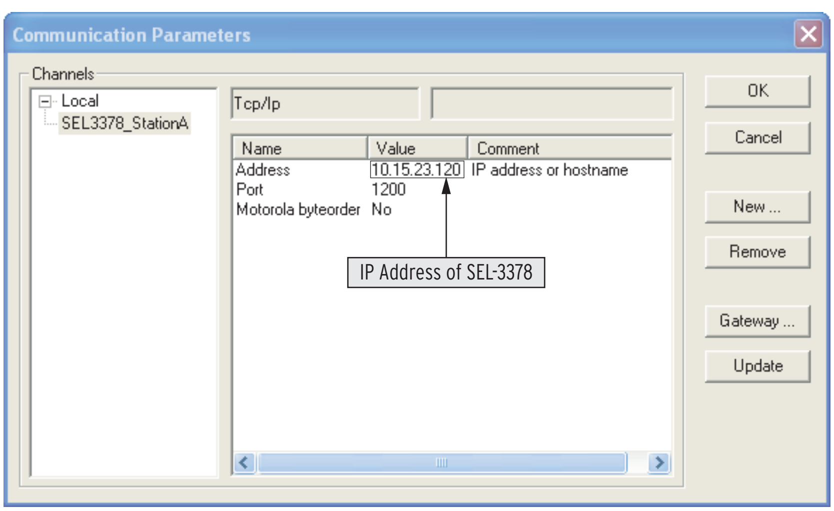


Figure B.4 Communication Parameters Setup

Running a Project

Click **Project** > **Build** to compile the project. The compilation process is incremental; the SVP Configurator only recompiles the modified POUs. It compiles all the POUs when you execute the command **Project** > **Clean all**. During compilation, a message window (see *Figure B.2*) shows compilation progress.

Table B.1 shows some of the commands available in the **Online** menu from which you connect to the RTS and run the project:

Table B.1 Online Menu Commands

Command	Description
Login	Switches the programming system into online mode.
Logout	Terminates the online mode.
Download	Loads the compiled project into the SEL-3378.
Run	Starts user program in the SEL-3378.
Stop	Halts user program execution in the SEL-3378.
Simulation Mode	Switches to Simulation Mode, which allows the user program to run on the same PC under Microsoft® Windows®.
Create Boot Project	Sets up the compiled project on the SEL-3378 in such a way that the SEL-3378 can load the compiled project automatically upon restart.

Following are the steps to set up a boot project.

Step 1. In the **Resources** tab, double-click on the **Target Settings**.

Step 2. Enable the **Load bootproject automatically** option in the **General** tab (see *Figure B.5*).

Step 3. Click **OK**.

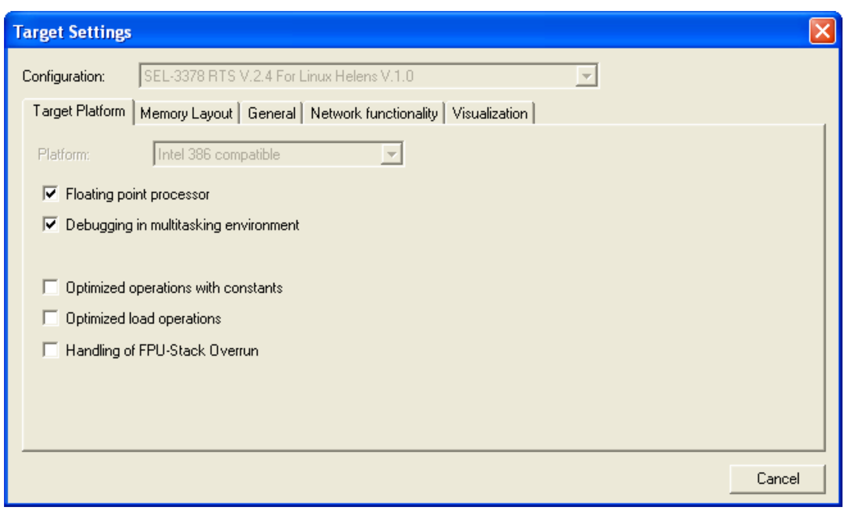


Figure B.5 Project Build Information

Step 4. Click **Project** > **Options**.

Step 5. Enable the **Implicit on create boot project** option in the **Source download** category (see *Figure B.6*).

Step 6. Enable the **Remind of boot project on exit** option in the **Load & Save** category.

Step 7. Click **OK**.

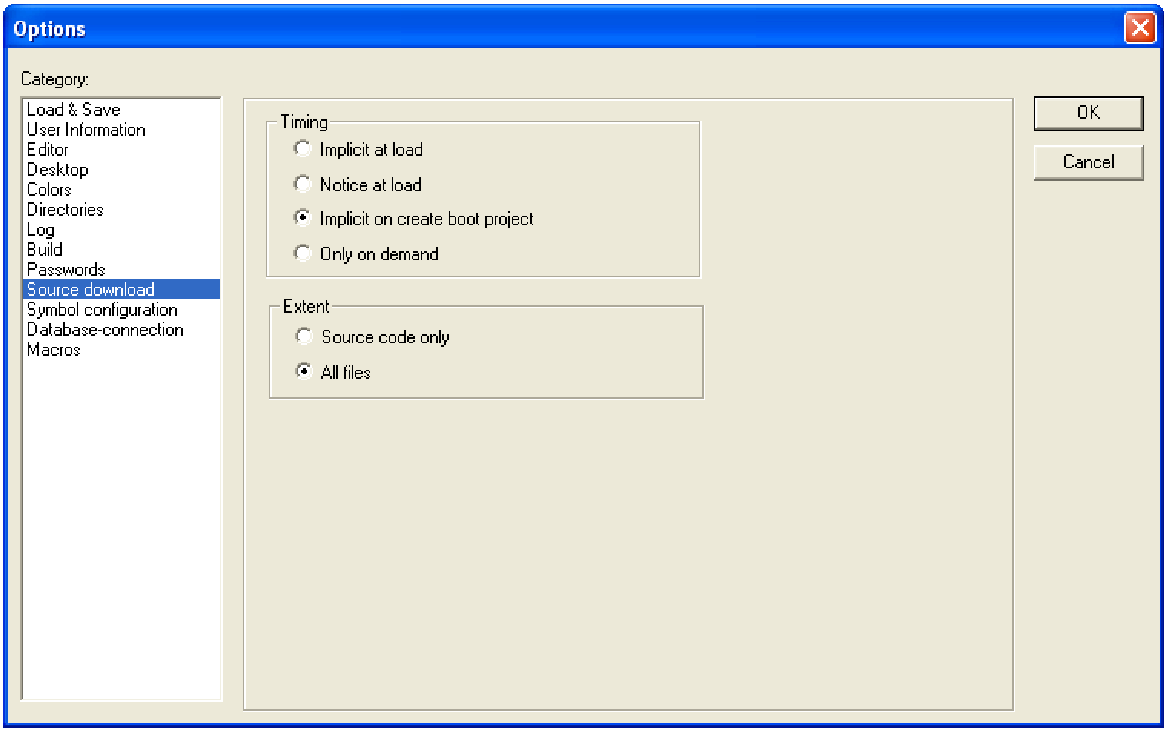


Figure B.6 Source Download Options

Step 8. Click **Online** > **Login**.

This starts the program and switches the programming system into online mode.

Step 9. Click **Online** > **Create boot project**.

Library Manager

The Library Manager shows all libraries included with the project. You can add or delete libraries associated with the project according to your application. Open the Library Manager by navigating to the **Window** menu and selecting **Library Manager** in the project. The library titled **standard.lib** is available as a default library in a new project; this library consists of all the functions and function blocks that the IEC 61131-3 standard requires for an IEC programming system.

Figure B.7 shows the Library Manager associated with the project **project1.pro**. The **SEL_PWRC.lib** file is highlighted; the right side of the figure shows the data types associated with the PWRC function block parameters. Navigate to **Insert**, select **Additional Library**, and browse to the appropriate folder to add a new library to the project. To delete a library from the project, select the library and click on the **Delete** button.

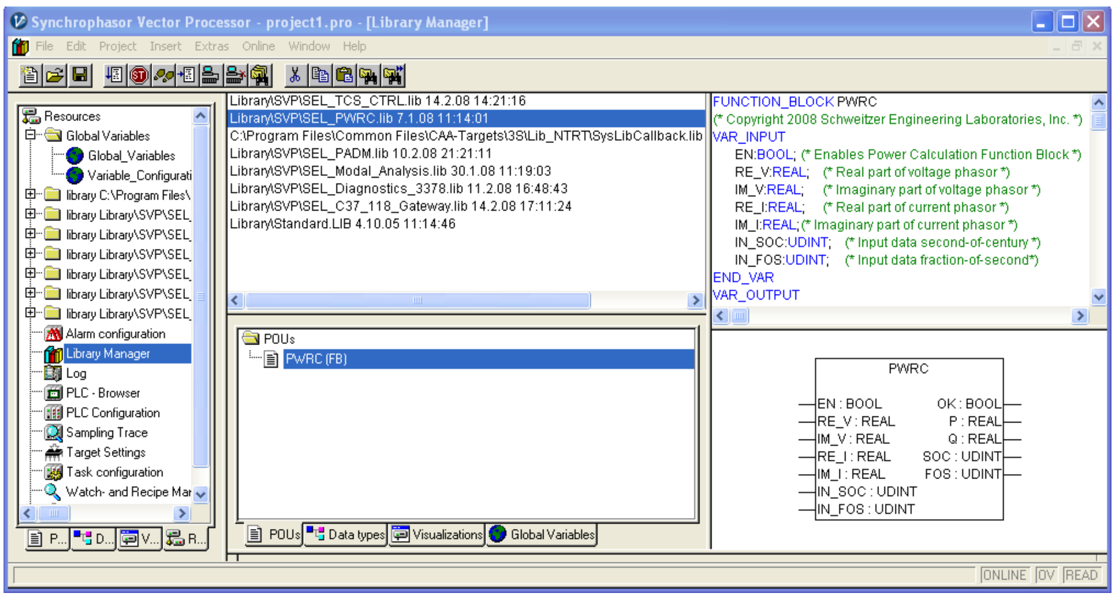


Figure B.7 Library Manager and Project Libraries

Input Assistant

The Input Assistant (shortcut key = **F2**) helps you to select available operators, variables, functions, and function blocks. *Figure B.8* shows the **Input Assistant** dialog box.

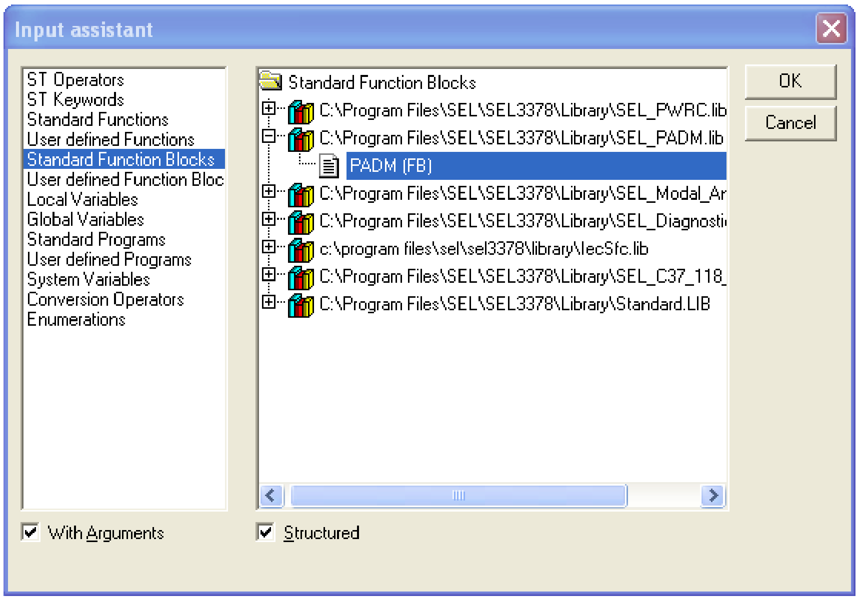


Figure B.8 Input Assistant

Perform the following steps to insert a function block (PADM) into the programming space of the POU:

Step 1. Press **F2**.

Step 2. Select **Standard Function Blocks.**

Step 3. Select the required library.

Step 4. Select the function block.

Step 5. Click **OK**.

Figure B.9 shows the text inserted with the associated attributes in the programming space. You then must assign the required inputs and the instance name. The inputs of the function block are shown with := next to the variable name, and the outputs are shown with =>.

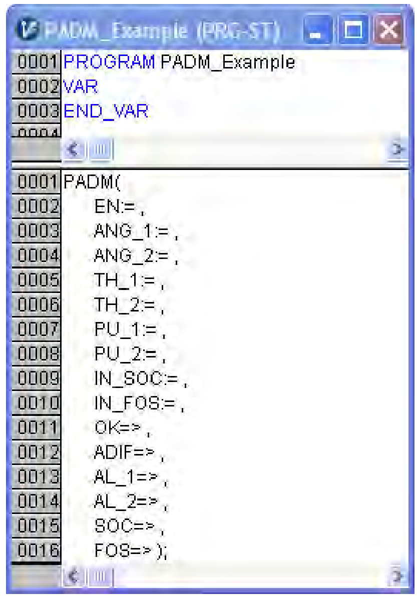


Figure B.9 PADM Inputs and Outputs Input Assistant

This page intentionally left blank

Glossary

10/100BASE-T 10BASE-T is a variant of Ethernet that allows devices to be connected via twisted-pair cable. 100BASE-T incorporates any of several Fast Ethernet standards (under IEEE 802.3) or planned standards for twisted-pair cables. Fast Ethernet is a version of Ethernet capable of 100 Mbps, instead of the 10 Mbps data transfer speed for standard Ethernet.

100BASE-FX Fast Ethernet over optical fiber. Fast Ethernet is a version of Ethernet capable of 100 Mbps, instead of the 10 Mbps data transfer speed for standard Ethernet.

3U The designation of the vertical height of a device in rack units. One rack unit, U, is approximately 1.75 inches or 44.45 mm.

A Abbreviation for amps or amperes; unit of electrical current.

ac Abbreviation for alternating current.

ASCII Abbreviation for American Standard Code for Information Interchange. Defines a standard set of text characters.

Baud A unit of speed in data transmission equal to 1 bit per second (1 bps).

Burden Percentage of time during which the CPU is working.

CP Current Processor.

CPU Central processing unit.

CTS Clear to send.

dc Abbreviation for direct current.

Dry Contact An initially available contact that is neither connected to nor energized by voltage (such voltage is usually supplied externally).

DTR Data Terminal Ready. A wire in an EIA-232 connection that tells data communications equipment (typically a modem) that the computer or terminal is ready to transmit and receive data.

EIA-232 Electrical definition for point-to-point serial data communications interfaces based on the standard EIA/TIA-232. Formerly known as RS-232.

EMI Electromagnetic Interference.

ESD Electrostatic discharge. The sudden transfer of charge between objects at different potentials caused by direct contact or induced by an electrostatic field.

Ethernet A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

ETX End of Text.

FBD Function Block Diagram.

Firmware The nonvolatile program stored in the unit that defines its operation.

FO Fast Operate.

FOS Fraction-of-second.

GND Ground.

GPS Global Positioning System. Source of position and high-accuracy time information.

GUI Graphical user interface.

HMI Human machine interface.

IDCODE Hardware Identification Code.

IEC 61131-3 International Standard for programmable controllers, Part3: Programming Languages.

IEEE C37.118 IEEE Standard for Synchrophasors for Power Systems.

IEEE Floating-Point A 32-bit representation of a real number in accordance with IEEE 754-1985.

IRIG-B A time-code input that the unit can use to set the internal unit clock.

KCL Kirchhoff Current Law.

LCD Liquid Crystal Display.

LED Light-Emitting Diode.

MA Modal Analysis.

MAC Address The hardware address of a device connected to a shared network medium.

MOV Metal-Oxide Varistor.

P Real Power.

PADM Phase Angle Difference Monitor.

PC Personal Computer.

PDC Phasor Data Concentrator. A data concentrator used in phasor measurement systems.

Phasor A complex equivalent of a simple cosine wave quantity such that the complex modulus is the cosine wave amplitude and the complex angle (in polar form) is the cosine wave phase angle.

PLC Programmable Logic Controller.

PMCU Phasor Measurement and Control Unit. A PMU with additional features allowing further controlling/protection/automation functions.

PMCU_IN Phasor Measurement and Control Unit Input.

PMCU_OUT Phasor Measurement and Control Unit Output.

PMU Phasor Measurement Unit. A generic device that produces synchronized phasors from voltage and/or current inputs and synchronizing signal.

POU Program Organization Unit.

Protocol A language for communication between devices.

PWRC Power Calculation.

Q Reactive Power.

RAM Random-Access Memory.

RFI Radio-Frequency Interference.

RTS Run Time System.

RXD Received data.

SNR Signal-to-Noise Ratio.

SOC Second Of Century, as measured from the epoch (00:00:00 January 1, 1970).

SSTP Substation State and Topology Processor.

ST Structured Text.

SVP Synchrophasor Vector Processor.

SVP Configurator Controlled Development System, PLC Development Environment.

Synchronism The state where connected alternating-current systems, machines, or a combination operate at the same frequency and where the phase angle displacements between voltages in these systems and machines either remain constant or vary about a steady and stable average value.

Synchronized Phasor A phasor calculated from data samples that uses a standard time signal as the reference for the measurement. In this case, the phasors from remote sites have a defined common phase relationship. Syn: synchrophasor.

TA Time Alignment.

TCP Transmission Control Protocol.

TCS Time Alignment Client Server.

TP Topology Processor.

TXD Transmitted data.

UDP User Datagram Protocol.

UTC Coordinated Universal Time calculated by BIH in Paris, France. It is distributed by various media, including the GPS system.

V Abbreviation for volts; unit of electromotive force.

VP Voltage Processor.

W Abbreviation for watts; unit of electrical power.

Index

Page numbers appearing in bold mark the location of the topic's primary discussion.

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 USA
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
www.selinc.com • info@selinc.com