

PDC Setup at Machine Learning for Power System Lab

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1. Objective

The objective of this system is to learn synchrophasor system capabilities and analyse the data using a PDC and SEL 351S PMU

2. Introduction

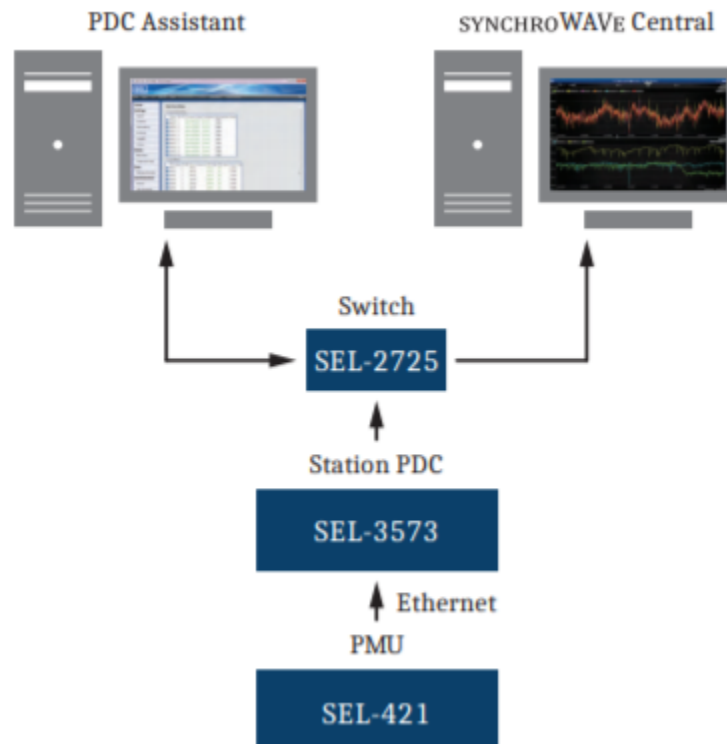
A minimal synchrophasor system consists of phasor measurement units (PMUs) and integrates the collected data into centralized operator displays. A more capable system includes a substation phasor data concentrator (PDC) with archiving capability or a distributed control processor such as a synchrophasor vector processor (SVP). These solutions greatly expand synchrophasor system capabilities.

3. Software Required

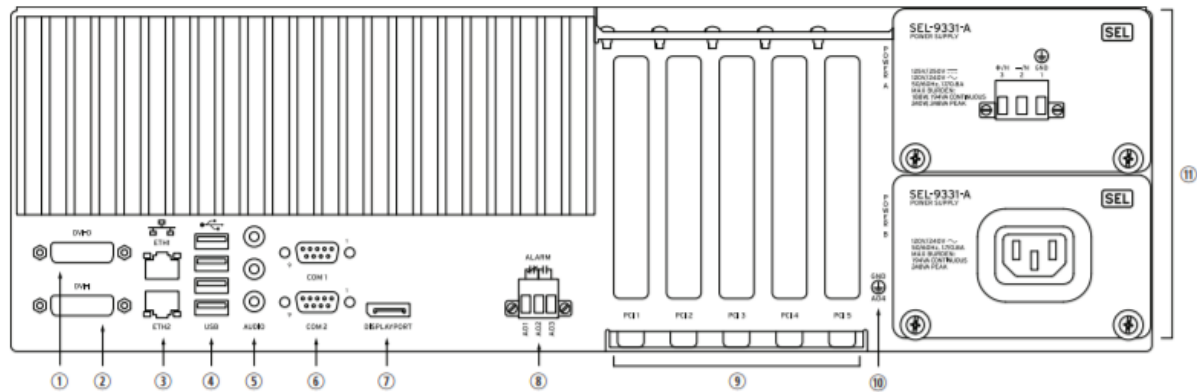
SEL Acselerator Quickset, SEL PDC Assistant

4. Installation

- The first steps in setting up the SEL- 3573 and SEL 351S are installing the software and connecting the devices.



- Provide the appropriate power and ground connections



① DVI-D Port. Not used by the SEL-3573 at this time.

② DVI-I Port. Not used by the SEL-3573 at this time.

③ ETH1 and ETH2 Ports. Onboard independent Gigabit Ethernet interfaces.

④ USB Ports. Not used by the SEL-3573 at this time.

⑤ AUDIO Ports. Not used by the SEL-3573 at this time.

⑥ COM1 and COM2 Ports. Standard EIA-232 serial ports with configurable +5 Vdc power on Pin 1.

⑦ DISPLAYPORT Port. Not used by the SEL-3573 at this time.

⑧ ALARM Contact. The Form C contact output can be wired either normally closed or normally open.

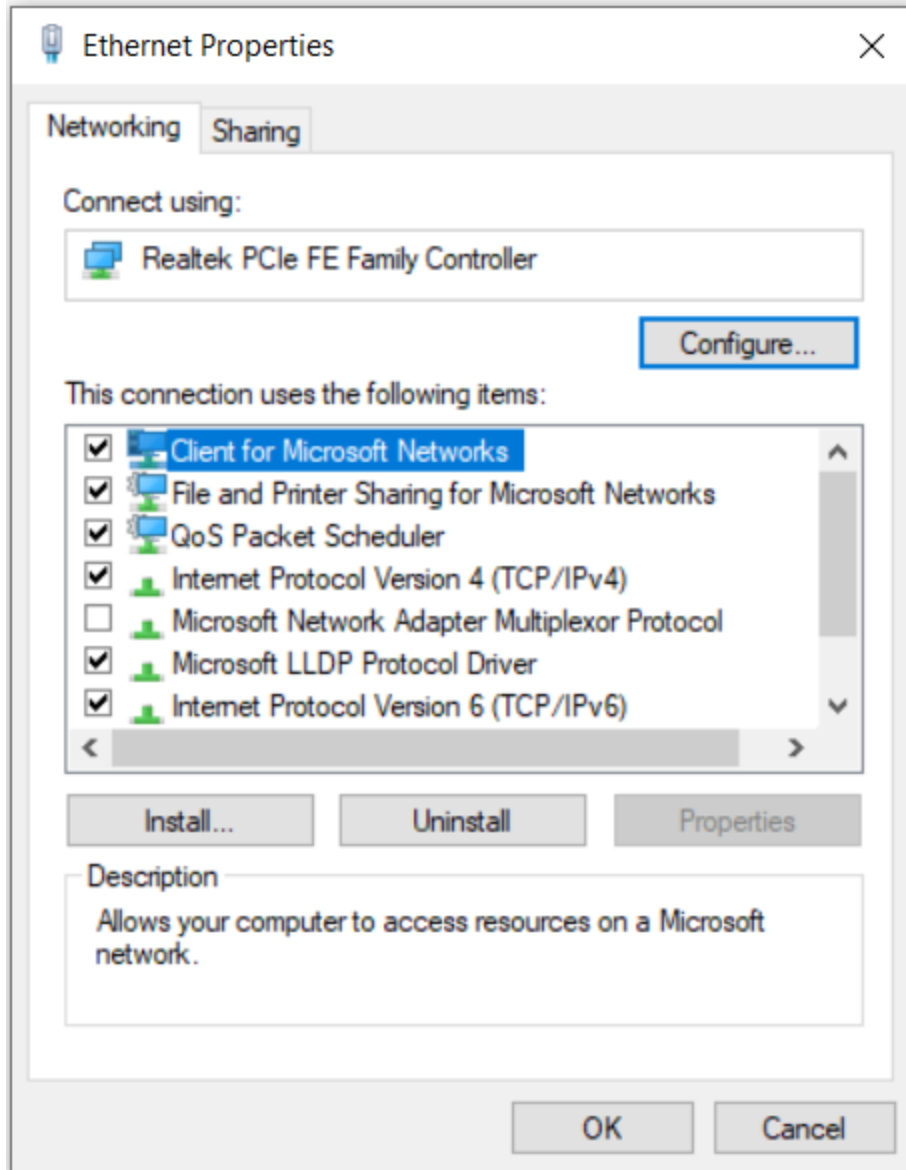
⑨ PCI Expansion Slots. Use SEL rugged PCI Express expansion cards for additional serial inputs.

⑩ Earth Ground (GND) Terminal Screw. The earth ground connection for the SEL-3573.

⑪ Power Supply Modules. The rated input voltage is marked on the chassis near the terminals.

5. Ethernet Port Configuration

Use the Ethernet port on the SEL-3573 to connect to the laptop. In order to configure the PDC's ethernet settings the following changes need to be done to the user's laptop/desktop. Go to Control Panel > Network and Sharing > Change Adapter Settings > Ethernet Properties.



Then double click on Internet Protocol Version 4 (TCP/IPv4)

Internet Protocol Version 4 (TCP/IPv4) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

☐ Obtain an IP address automatically

☒ Use the following IP address:

IP address: 192 . 168 . 1 . 1

Subnet mask: 255 . 255 . 255 . 0

Default gateway: | . . .

☐ Obtain DNS server address automatically

☒ Use the following DNS server addresses:

Preferred DNS server: . . .

Alternate DNS server: . . .

☐ Validate settings upon exit

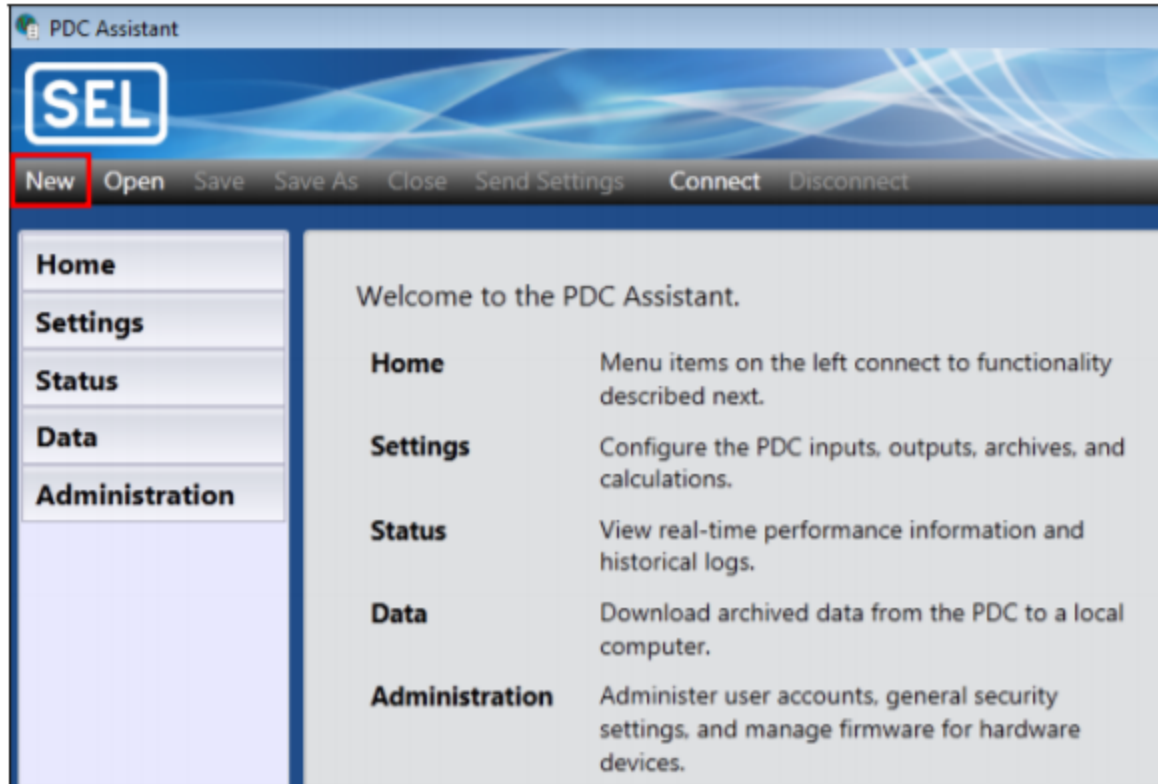
Advanced...

OK Cancel

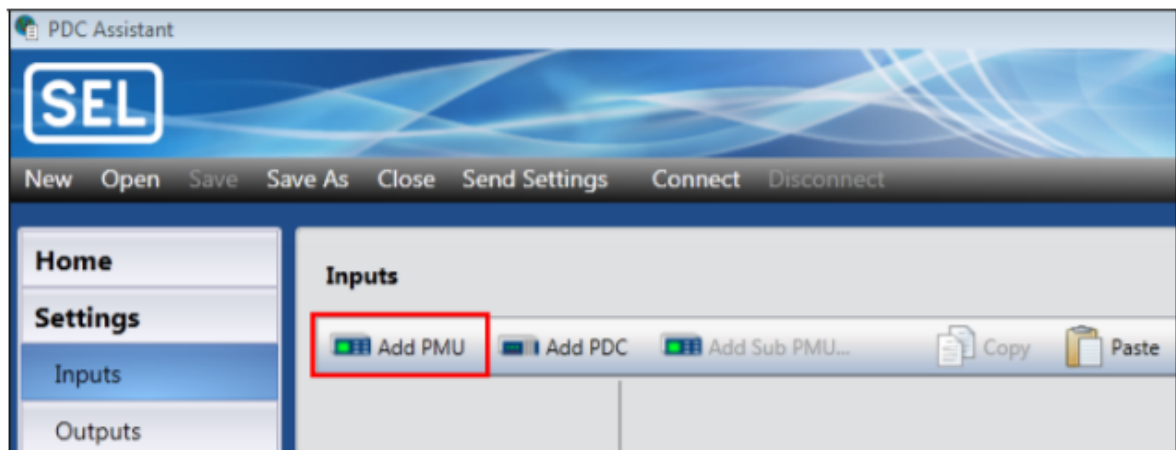
Make sure that the IP address, Subnet mask and Default gateway are set to the values shown above.

6. Configuring the PDC Assistant Software

- Install and Open the SYNCHROWAVE PDC Assistant Software, and select New, as shown in Figure



- Select the appropriate PDC model (SEL 3573) and the version number
- Select the Settings > Inputs tab, and click Add PMU, as shown in Figure



- Set up the added PMU by entering a Station Name, PMU ID, and Data Rate. Ensure that the Enabled box is checked. The Station Name, PMU ID, and Data Rate must exactly match what was set in the relay.

Inputs

Add PMU Add PDC Add Sub PMU... Copy Paste Import PDC Delete

TEST STATION

PMU: TEST STATION

Enabled ☒

Station Name TEST STATION

Station Name Alias

PMU ID 1

PMU ID Alias

Data Rate 10 Msg per sec

Primary Connection

Physical Layer Ethernet

Transport Protocol TCP

IP Address 192.168.4.2

Port 4712

Local IP Address Any

Backup Connection

Physical Layer Disabled

Tags

Edit Tags Load Tags Query Tags

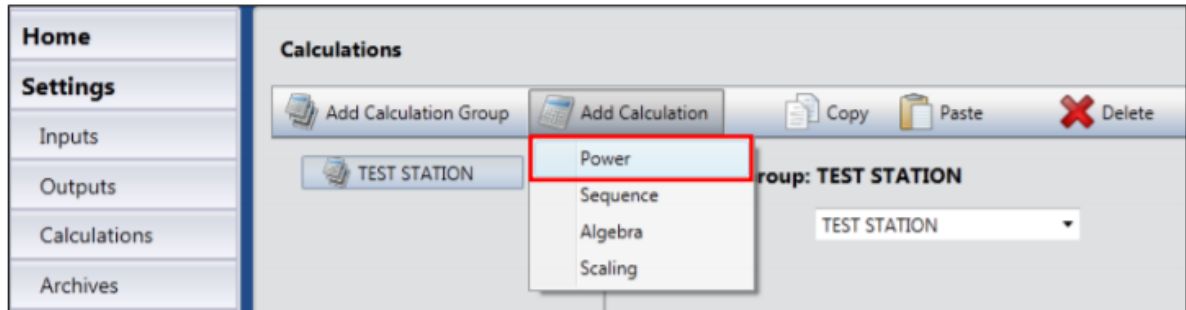
- Under Primary Connection, select TCP for the transport protocol. Input the IP address (IPADDR) and command port number (PMOTCP1) of the SEL-351S, as shown in Figure 43. This protocol and the port number need to match the PMU synchrophasor output settings.
- Click the Query Tags button
- All of the possible measurement tags load. Click on the Edit Tags button to add or remove any of the measurement tags. Figure below shows the interface used to add new tags or to remove tags.

Tag	Alias	Description	Units	Type	Quantity Type	Phase
V1VPM		Positive Sequence Voltage, V Terminals	V	Phasor	Voltage	1
V1ZPM		Positive Sequence Voltage, Z Terminals	V	Phasor	Voltage	1
VAVPM		A Phase Voltage, V Terminals	V	Phasor	Voltage	A
VBVPM		B Phase Voltage, V Terminals	V	Phasor	Voltage	B
VCVPM		C Phase Voltage, V Terminals	V	Phasor	Voltage	C
VAZPM		A Phase Voltage, Z Terminals	V	Phasor	Voltage	A
VBZPM		B Phase Voltage, Z Terminals	V	Phasor	Voltage	B
VCZPM		C Phase Voltage, Z Terminals	V	Phasor	Voltage	C
I1SPM		Positive Sequence Current, S Terminals	A	Phasor	Current	1
I1TPM		Positive Sequence Current, T Terminals	A	Phasor	Current	1
I1UPM		Positive Sequence Current, U Terminals	A	Phasor	Current	1

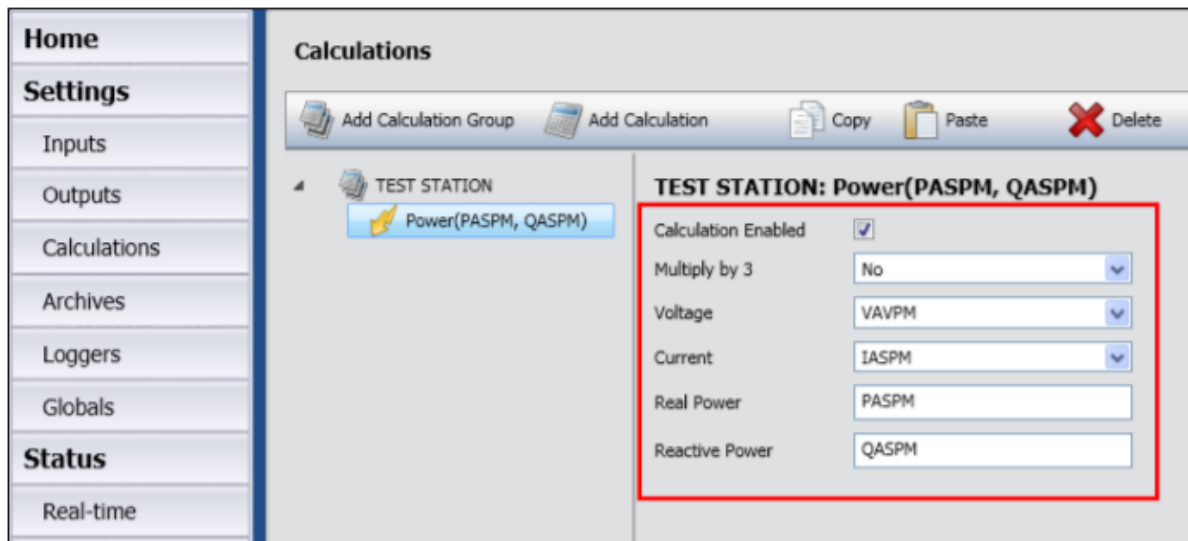
- Real and Reactive Three-Phase Power Calculation Setup
Click Settings > Calculations on the menu to configure SYNCHROWAVE PDC for the necessary power calculations. Then click the Add Calculation Group button, as shown.

- Select the Target PMU to use for the power calculations

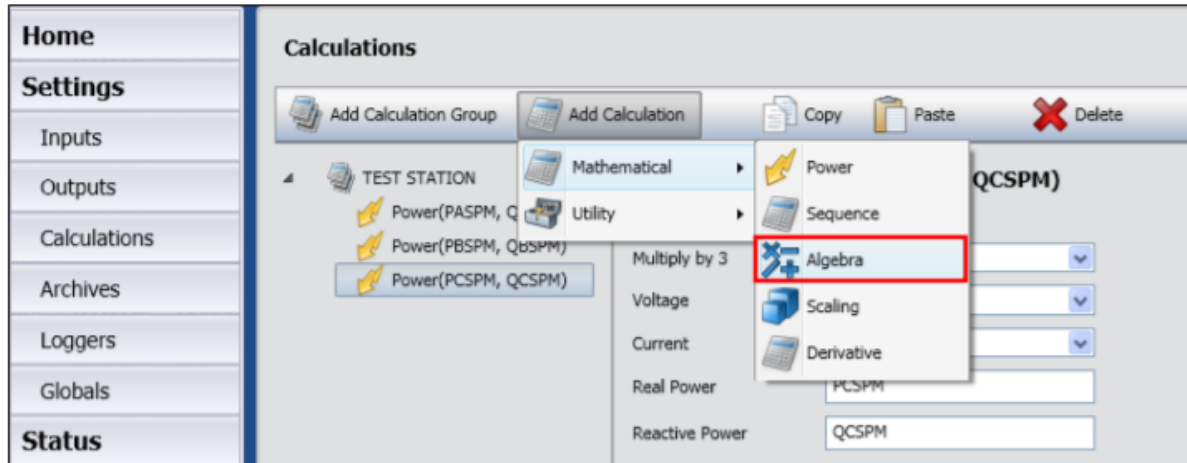
- Click the Add Calculation button, and then click Power on the drop-down menu



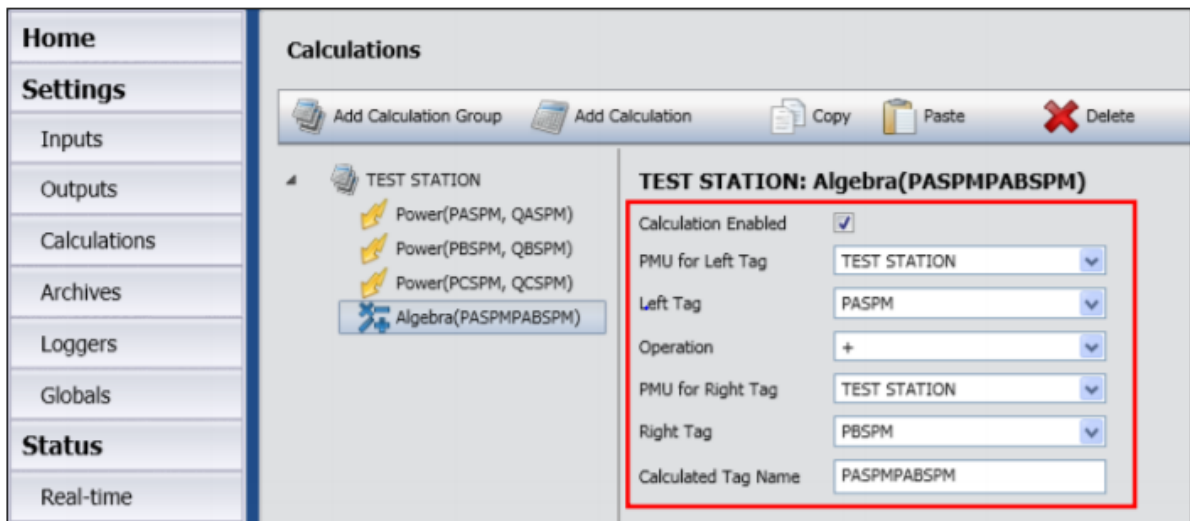
- Set up the A-phase power calculation by selecting the corresponding voltages and currents, as shown in Figure 48. Complete the procedure in Steps 1 through 4 for each of the three phases.



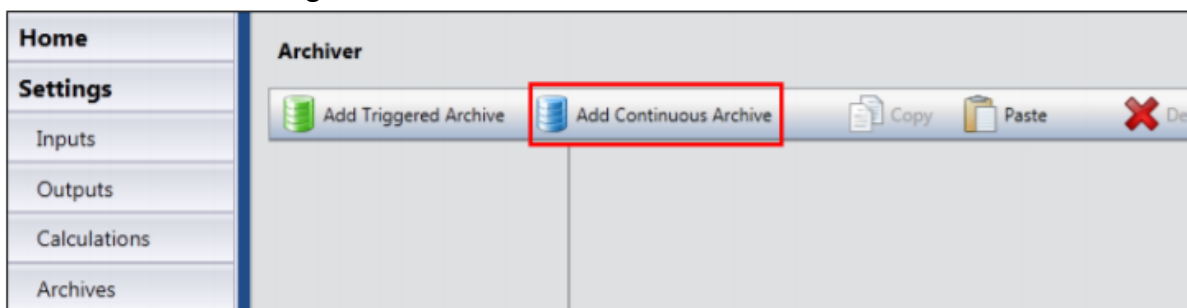
- Click the Add Calculation button, and then click Algebra on the drop-down menu, as shown in Figure 49. Summing the individual phase power is required to meet the PRC-002-2 three-phase power requirements.



- Add the A- and B-phase real powers together



- Add the C-phase real power to the previous A- and B-phase real power summation
7. Archiving the setup
- Click Archives on the menu to configure SYNCHROWAVE PDC for archiving data using continuous recording. Then click the Add Continuous Archive button

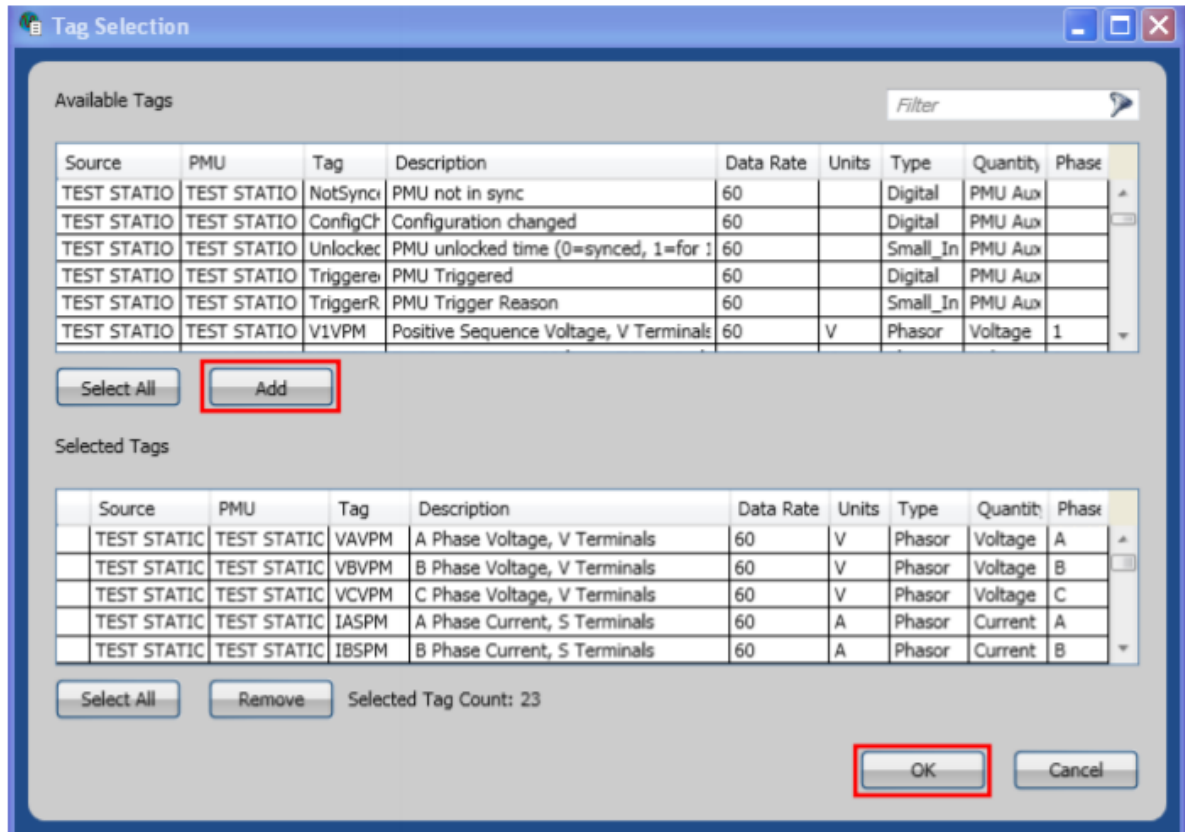


- Set up the added archive by entering the Archive Name, Archive Retention, and Data Rate.

Check the Archive Enabled box

The screenshot shows the 'Archiver' application window. On the left is a sidebar with an 'Archive' button. The main area is titled 'Continuous Archive: Archive'. A red rectangular box highlights the 'Archive Enabled' checkbox, which is checked. Below this are several fields: 'Archive Name' with the value 'Archive', 'Storage Estimate' showing '1.73 GB', 'Archive Retention' set to '60' with a 'Days' unit selector, 'Data Rate Format' set to 'Msg per sec' via a dropdown, and 'Data Rate' set to '10' with a 'Msg per sec' unit selector. At the bottom right of the configuration area is an 'Edit' button. Below the configuration fields is a 'Tags' section with a plus icon and a table with columns: PMU, Tag, Description, Type, and Data Rate.

- Click the Edit button in order to select which tags are archived.
- Select the measurement tags to be archived, click Add, and then click OK. PRC-002-2 requires measurements for all phase voltages, phase currents, frequency, and three-phase real and reactive power.

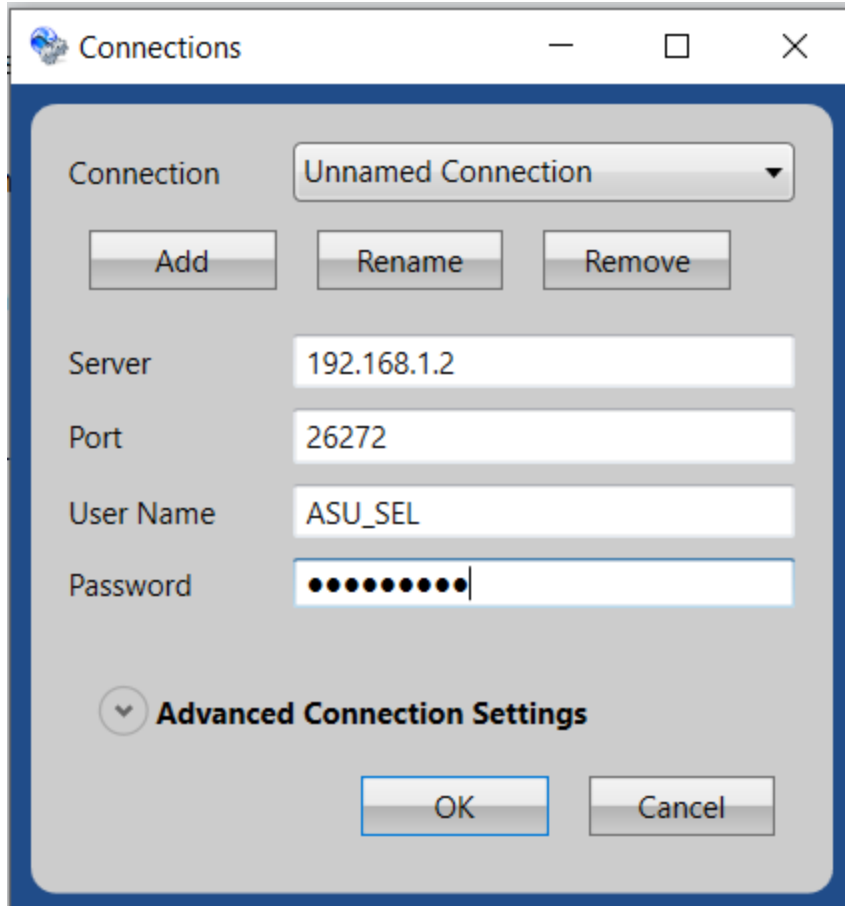


8. Sending settings to PDC and Data Collection from 351S

- Click the Send Settings button. This will establish a connection with the PDC. If the settings have already been sent to the PDC, the Connect button can be clicked instead.
- Click on Connect and enter the following details:

Username: ASU_SEL

Password: Asu12345@



Connections

Connection: Unnamed Connection

Add Rename Remove

Server: 192.168.1.2

Port: 26272

User Name: ASU_SEL

Password: ●●●●●●●●

Advanced Connection Settings

OK Cancel

- Select Status > Real-time. This window shows the connection status with the relay and archive status of the PDC.

Unnamed Connection (SEL-3573 2008) - PDC Assistant

SEL

New Open Save Save As Close Send Settings Connect Disconnect Local Services Help

Home

Settings

Inputs

Outputs

Calculations

Archives

Loggers

Globals

Status

Real-time

Diagnostic Logs

Data

Retrieve Archives

Administration

Device

User Accounts

Network

General Security

LDAP

Certificates

Real-time Status

Input Connections

Name	PDC ID	Connection State	Time Quality	Received Data Frames
TEST STATION 1	1	Receiving Data	Normal	12750

Input PMUs

PMU Name	PMU ID	Input Connection	PMU State	PMU Status	Unlock Time
TEST STATION 1	1	TEST STATION	Found	OK	Locked

Outputs

Server Connection State Missing Data Sent Data Frames

Archivers

Archive	Missing Data	Space Currently Used (MByte)	Input Rate (MByte/Hour)
Archive No		117.6225	6.769442
Totals		117.6225	6.769442

Space Available (MByte) 112736.4

Project Status - No Errors PDC Sync - Synchronized PDC Connection - Connected User Domain - Local

Real-time Status

Input Connections

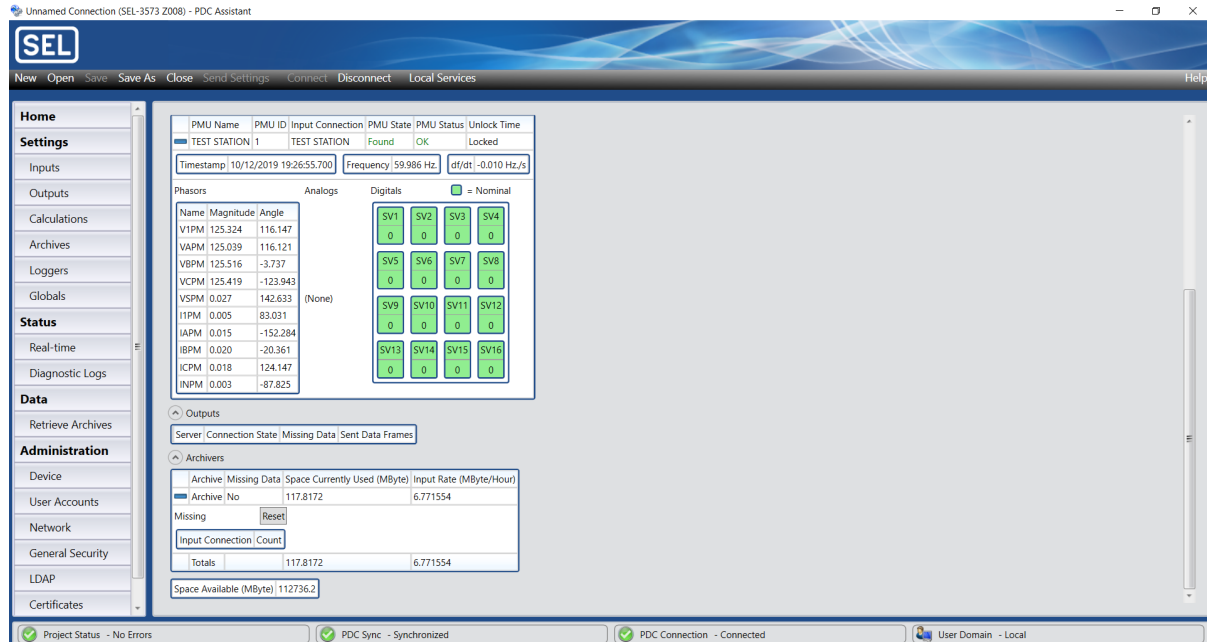
Name	PDC ID	Connection State	Time Quality	Received Data Frames
TEST STATION 1	1	Receiving Data	Normal	13590

Network Latency

	Latency	
Maximum	~ -1 minute(s) (00:01:03.5252630)	Reset
Average	~ -1 minute(s) (00:01:03.5432730)	

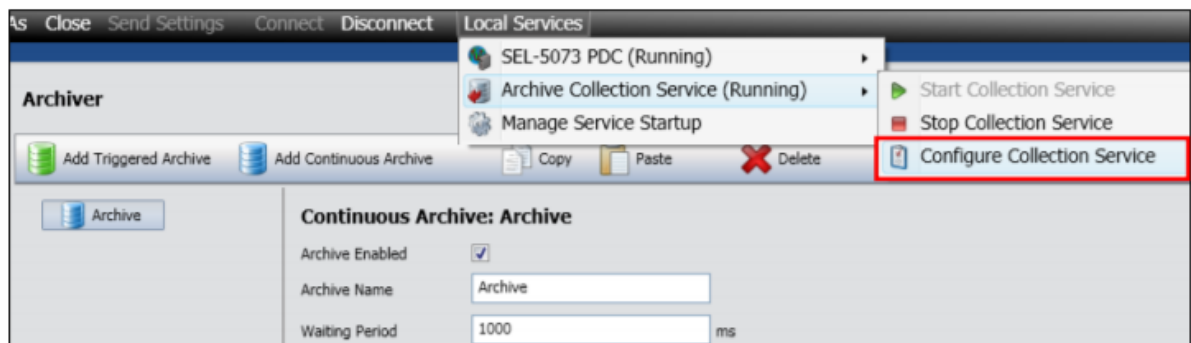
Frames

	# Frames	Timestamp	
Data	13590	10/12/2019 19:26:21.700	Reset
Missed Data	252276	10/12/2019 19:13:05.000	
Duplicate Data	0		
Past Data	0		
Configuration	1	10/12/2019 19:02:39.220	
Command	3		



9. Set Up File Archive for DDR

- To configure a collection of the archived data into the same folder as the fault recording and SOE report files, select Local Services > Archive Collection Service > Configure Collection Service



- Set up the name, location, and format of the archive

Archive Collection Service

Archive Collection Service Configuration

PDCs to Collect Archives From

PDC	Next Collection Time (UTC)
Unnamed Connection	09/16/2011 19:46

Collection Options

Output Path: C:\PRC_002-2 Events\SEL-487E

Suffix Template: <ARCH>\<DATE>,<TIME>,<TC>,device,company

Example: C:\PRC_002-2 Events\SEL-487E\ExampleArchive
 \110929,111638150,0,device,company

File Format: ASCII Comtrade

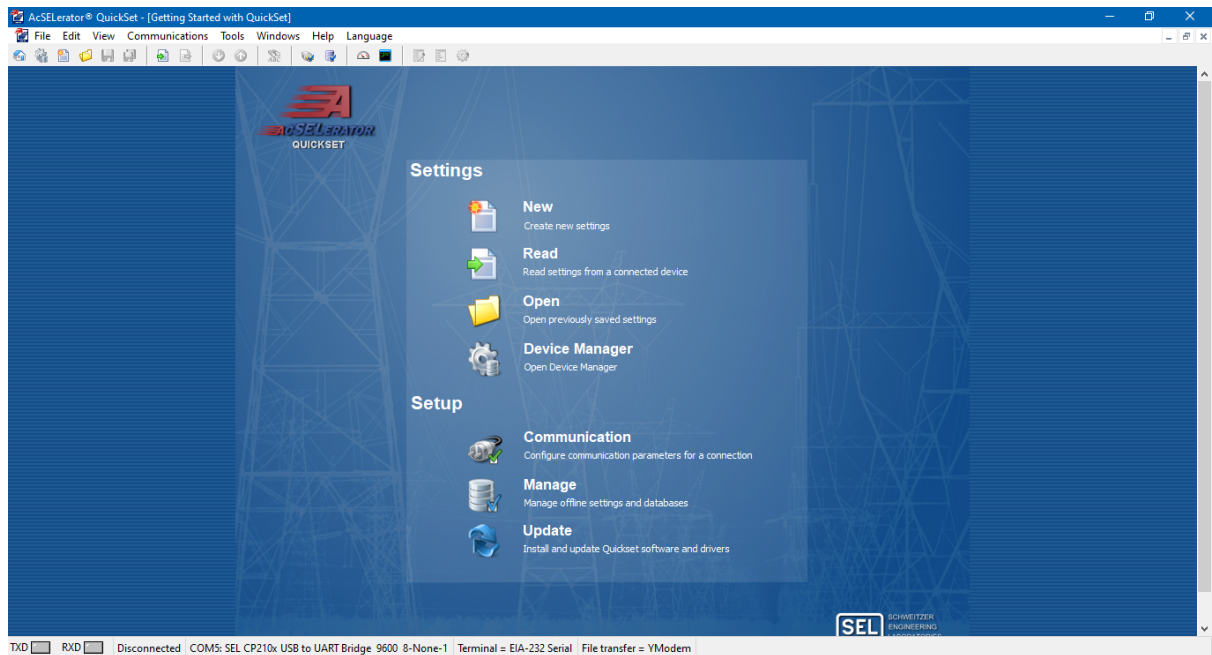
Phasor Format: Polar

Angle Format: -180 to 180 degrees

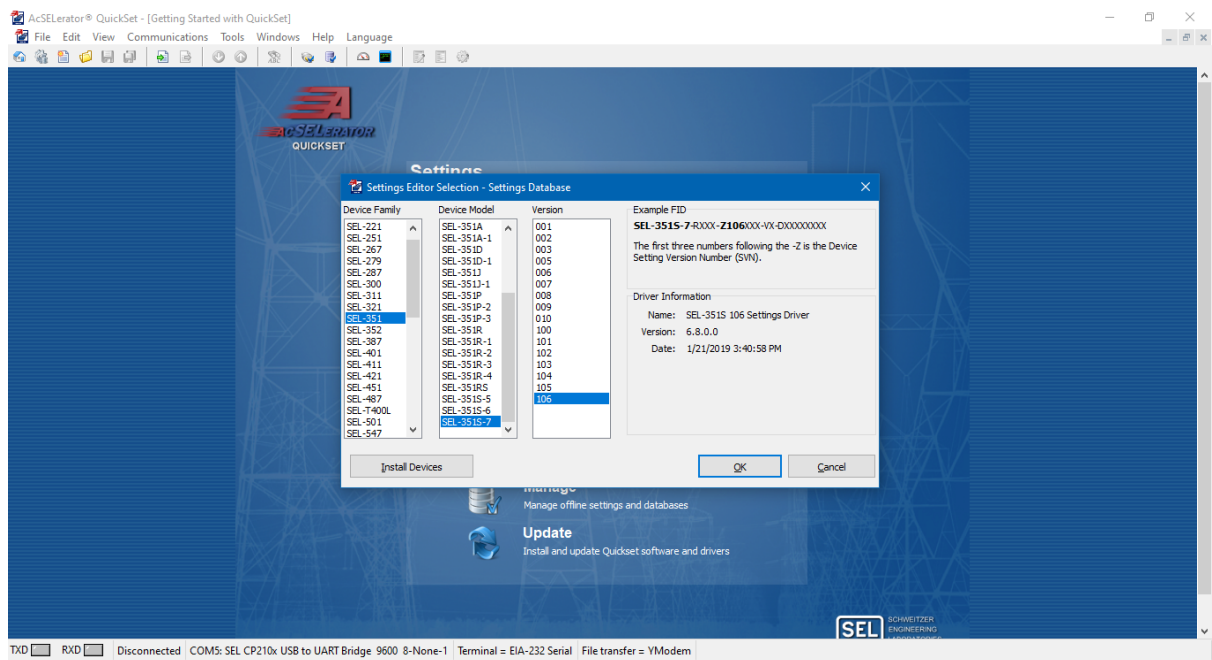
Minutes Per File: 60

10. Relay and Clock Settings

1. Install and Open SEL AcSElerator QuickSet.



2. Create new Project and Select Device family, model, and version from device Part No (P/N).

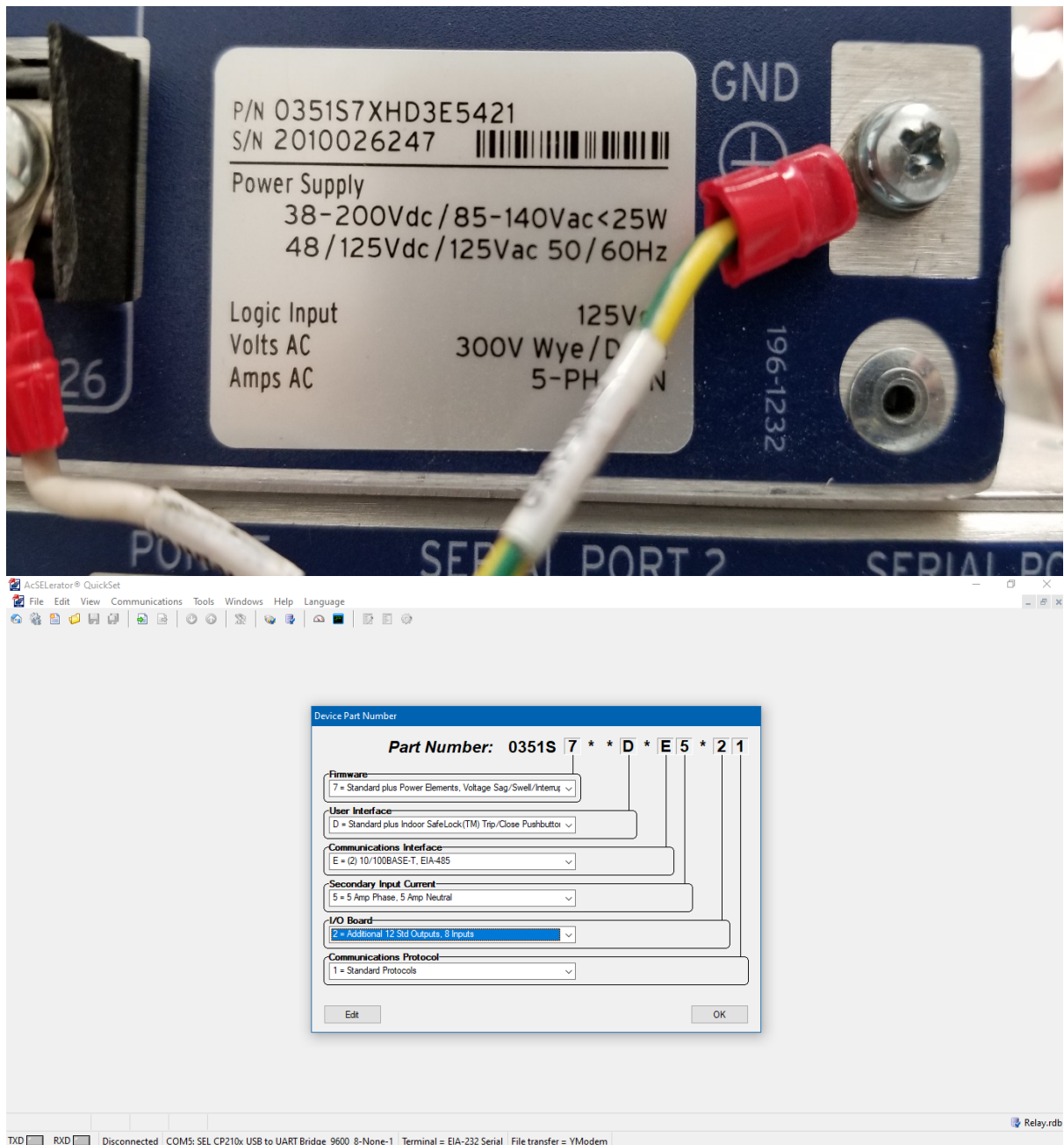


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- Enter Device Part No. as per given Part no. (P/N) make sure serial no. as well.



4. Use Terminal function to read or change the setting as per requirement.

Example: use of sho command

- To open the Terminal window, Click terminal function or press Ctrl-T.



- Now press enter and if you get same reply that means now relay is connected and communicating.
- To read and change the settings, we need user name and password

First level (to read): **Username: acc (acc is just a command)**

Password: OTTER (Capital)

Second level (to change or write): **Username: 2ac (2ac is just a command)**

Password: TAIL (Capital)

```
=
=acc
Password: ? *****
Invalid Password
Password: ? *****

FEEDER 1                               Date: 10/12/19    Time: 21:11:08.718
STATION A

Level 1

=>2ac
Password: ? *****
Invalid Password
Password: ? *****

FEEDER 1                               Date: 10/12/19    Time: 21:13:03.904
STATION A

Level 2

=>>
=>>|
```

- Now type **sho** to read and change the settings. And for additional command, please read the SEL-351s instruction manual from page 565.

```
=>>
=>>sho ip
Group 1
Invalid Command
=>>sho

Group 1
Group Settings:
RID      =FEEDER 1
CTR      = 2          CTRN      = 1          TID      =STATION A
VNOM     = 67.00      PTR       = 1.00      PTRS     = 1.00
Z1MAG    = 2.14      Z1ANG    = 68.86      ZOMAG    = 6.38      ZOANG    = 72.47
LL       = 4.84
E50P     = 1          E50N     = N          E50G     = N          E50Q     = N
E51P     = N          E51N     = N          E51G     = N          E51Q     = N
E32      = N          ELOAD   = N          ESOTF    = N          EVOLT    = Y
E25      = N          EFLOC   = Y          ELOP     = N          ECOMM    = N
E81      = N          E79     = 3          ESV       = 1          EDEM     = THM
EPWR     = N          ESSI    = N
50P1P    = 2.70
67P1D    = 100.00
50PP1P   = OFF
27P1P    = OFF      27P2P   = OFF      59P1P    = OFF      59P2P    = OFF
59N1P    = 0.20      59N2P   = 0.20      59QP     = 0.50      59V1P    = OFF
27SP     = OFF      59S1P   = OFF      59S2P    = OFF      27PP     = OFF
59PP     = OFF

Press RETURN to continue
```

5. Define Synchronized Phasor Measurement Unit as per following.

Example:

- Global > Synchronized Phasor Measurement Setting.

Synchronized Phasor Measurement

Synchronized Phasor Measurement Settings

EPMU Synchronized Phasor Measurement

Select: Y, N

MFRMT Messages Format

Select: C37.118, FM

MRATE Messages per Second

Select: 1, 2, 4, 5, 10, 12, 15, 20, 30, 60

PMAPP PMU Application(F=Fast Response, N=Narrow BW)

Select: F, N

PHCOMP Freq. Based Phasor Compensation

Select: Y, N

PMSTN Station Name

Range = ASCII string with a maximum length of 16.

PMID PMU Hardware ID

Range = 1 to 65534

PHDATAV Phasor Data Set, Voltages

Select: V1, PH, ALL, NA

VPCOMP Phase Volt. Angle Comp.

Range = -179.99 to 180.00

VSCOMP VS Volt. Angle Comp.

Range = -179.99 to 180.00

VCOMP Voltage Angle Comp. Factor

Range = -179.99 to 180.00

PHDATAI Phasor Data Set, Currents

Select: I1, PH, ALL, NA

IPCOMP Phase Current Angle Comp.

Range = -179.99 to 180.00

INCOMP Neut. Current Angle Comp.

Range = -179.99 to 180.00

ICOMP Current Angle Comp. Factor

Range = -179.99 to 180.00

PHNR Phasor Num. Representation (I=Integer,F=Float)

Select: I, F

PHFMT Phasor Format (R = Rectangular,P = Polar)

Select: R, P

FNR Freq. Num. Representation (I=Integer,F=Float)

Select: I, F

NUMDSW Number of 16-bit Digital Status Words

Select: 0, 1

- Global > Time and Date Management Setting.

Time And Date Management Settings

Time And Date Management Settings

IRIGC IRIG-B Control Bits Definition

C37.118 Select: NONE, C37.118

UTC_OFF Offset from UTC

-7.00 Range = -24.00 to 24.00

DST_BEGM Month to Begin DST

NA Range = 1 to 12, NA

DST_BEGW Week Of The Month to Begin DST

2 Range = 1 to 3, L

DST_BEGD Day Of The Week To Begin DST

SUN Select: SUN, MON, TUE, WED, THU, FRI, SAT

DST_BEGH Local Hour To Begin DST

2 Range = 0 to 23

DST_ENDM Month To End DST

11 Range = 1 to 12

DST_ENDW Week Of The Month to End DST

1 Range = 1 to 3, L

DST_ENDD Day Of The Week To End DST

SUN Select: SUN, MON, TUE, WED, THU, FRI, SAT

DST_ENDH Local Hour To End DST

2 Range = 0 to 23

- Global > Port 5 > Ethernet Synchrophasor Settings.

Ethernet Synchrophasor Settings

EPMIP Enable PMU Processing

Select: Y, N

PMOTS1 PMU Output 1 Transport Scheme

Select: OFF, TCP, UDP_S, UDP_T, UDP_U

PMOIPA1 PMU Output 1 Client IP (Remote) Address (www[h].xxx[h].yyy[h].zzz[h].

Range = ASCII string with a maximum length of 19.

PMOTCP1 PMU Output 1 TCP/IP (Local) Port Number

Range = 1 to 65534

PMOUDP1 PMU Output 1 UDP/IP Data (Remote) Port Number

Range = 1 to 65534

PMOTS2 PMU Output 2 Transport Scheme

Select: OFF, TCP, UDP_S, UDP_T, UDP_U

PMOIPA2 PMU Output 2 Client IP (Remote) Address (www[h].xxx[h].yyy[h].zzz[h].

Range = ASCII string with a maximum length of 19.

PMOTCP2 PMU Output 2 TCP/IP (Local) Port Number

Range = 1 to 65534

PMOUDP2 PMU Output 2 UDP/IP Data (Remote) Port Number

Range = 1 to 65534

6. Connect SEL-2401 Satellite-Synchronized clock with the SEL 531s.
7. Open terminal window and type **time** command to check to ensure correct time and date.

```
=  
=acc  
Password: ? *****  
  
FEEDER 1                               Date: 10/12/19   Time: 15:45:27.712  
STATION A  
  
Level 1  
  
=>  
=>2ac  
Password: ? ****  
  
FEEDER 1                               Date: 10/12/19   Time: 15:45:39.459  
STATION A  
  
Level 2  
  
=>>clock  
  
Close Breaker (Y/N)?  
  
Command Aborted  
=>>  
  
=>>  
  
=>>  
  
=>>time  
  
15:46:03  
=>>|
```