

## 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

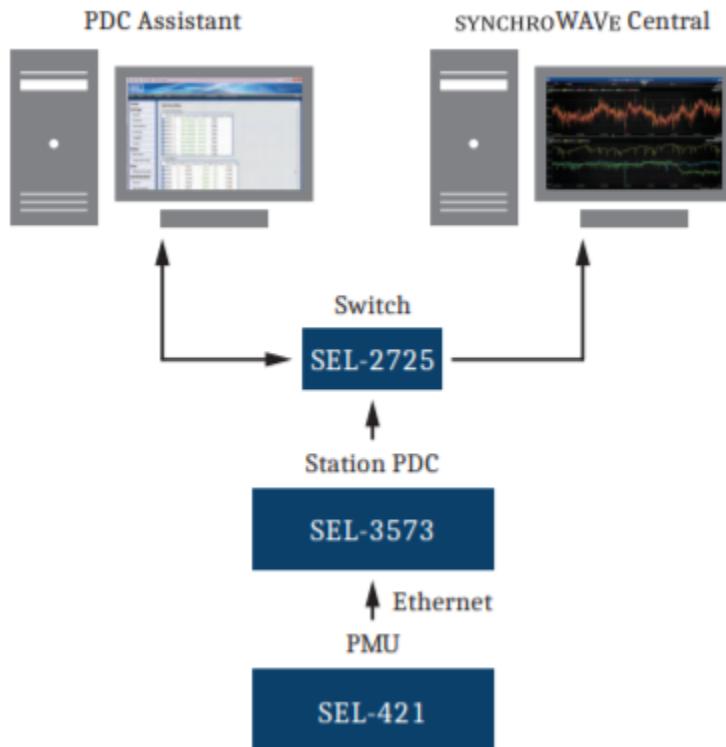
A minimal synchrophasor system consists of phasor measurement units (PMUs) and integrates the collected data into centralized operator displays. A more capable system includes a substation phasor data concentrator (PDC) with archiving capability or a distributed control processor such as a synchrophasor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

### 3. Software Required

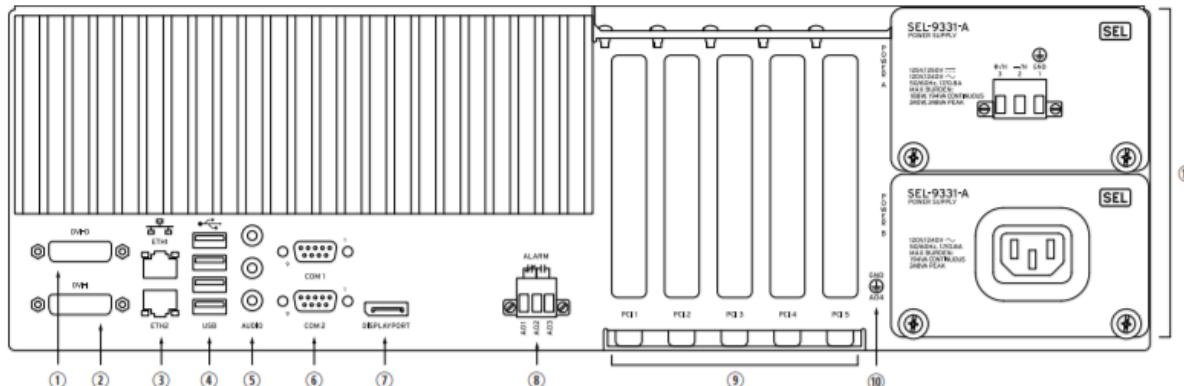
SEL Accelerator Quickset, SEL PDC Assistant

### 4. Installation

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



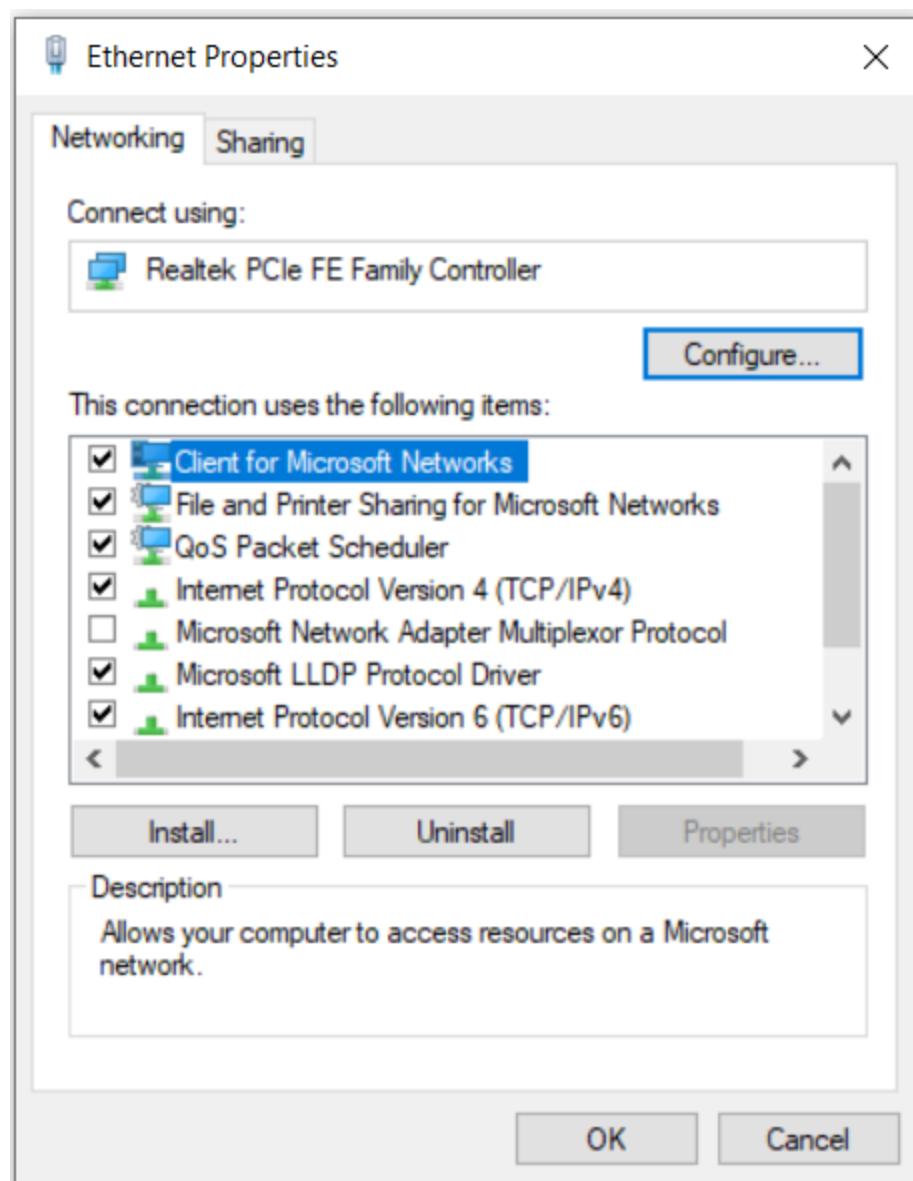
- Provide the appropriate power and ground connections



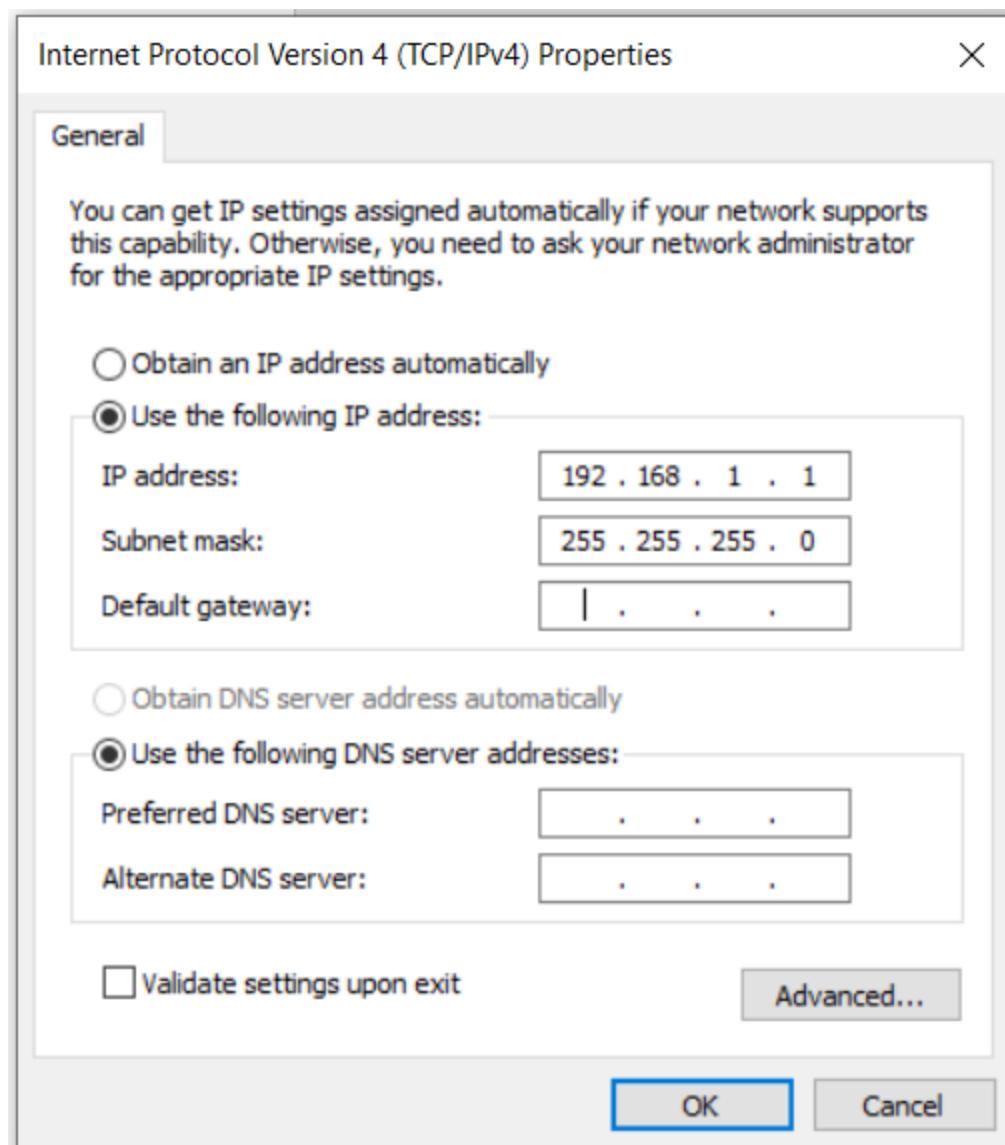
- ① DVI-D Port. Not used by the SEL-3573 at this time.
- ② DVI-I Port. Not used by the SEL-3573 at this time.
- ③ ETH1 and ETH2 Ports. Onboard independent Gigabit Ethernet interfaces.
- ④ USB Ports. Not used by the SEL-3573 at this time.
- ⑤ AUDIO Ports. Not used by the SEL-3573 at this time.
- ⑥ COM1 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.



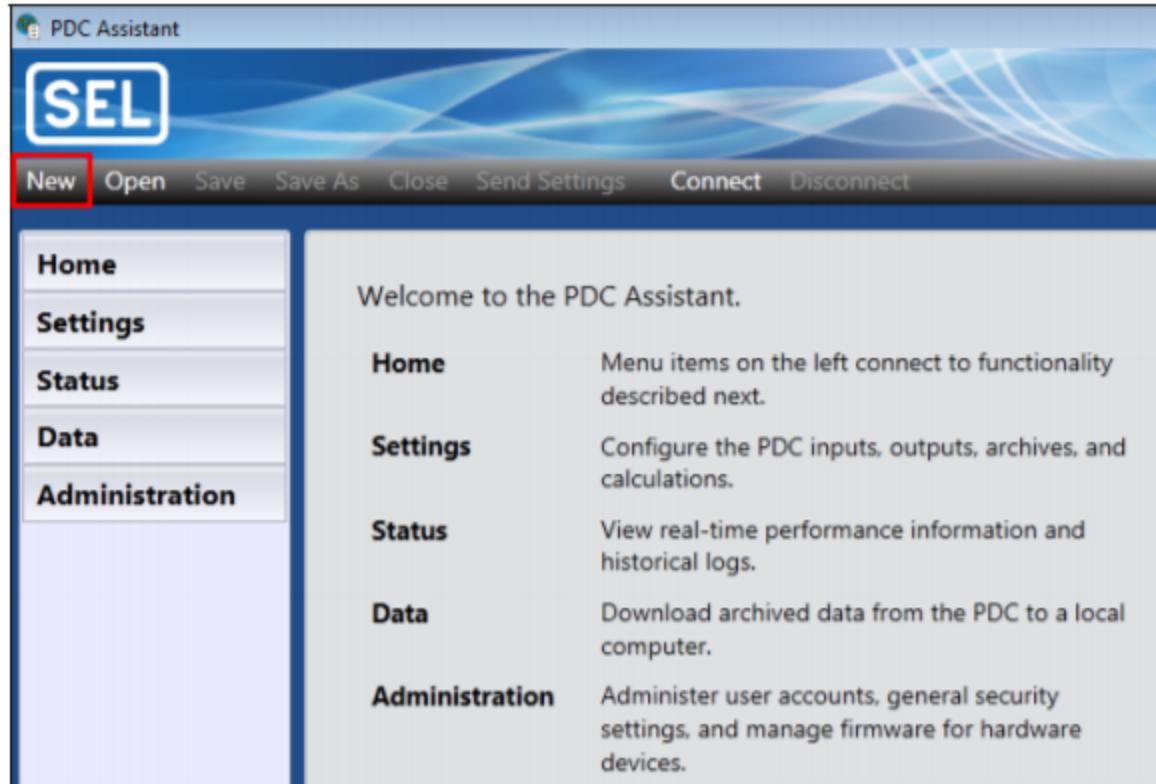
Then double click on Internet Protocol Version 4 (TCP/IPv4)



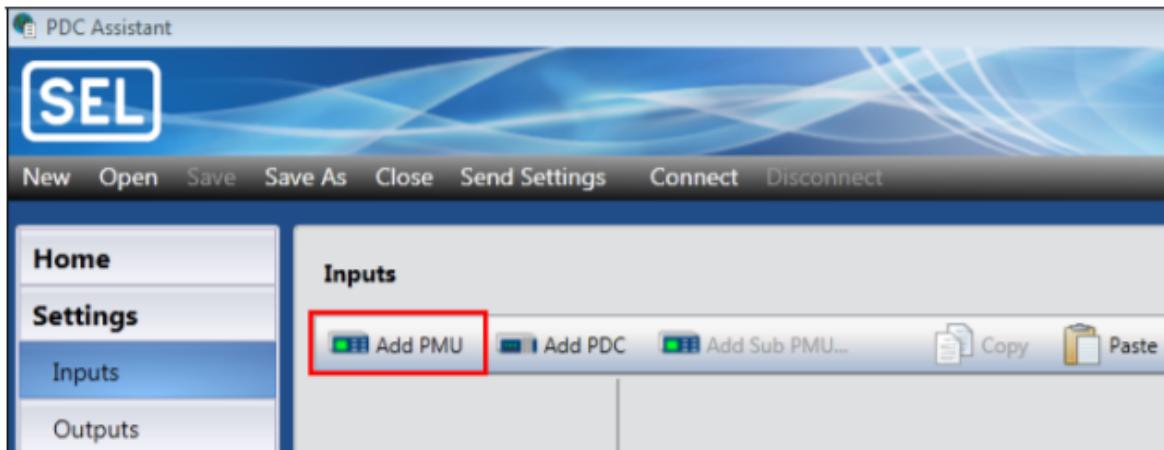
Make sure that the IP address, Subnet mask and Default gateway are set to the values shown above.

#### 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**

**TEST STATION**

Enabled	<input checked="" type="checkbox"/>	
Station Name	TEST STATION	
Station Name Alias		
PMU ID	1	
PMU ID Alias		
Data Rate	10	Msg per sec

**Primary Connection**

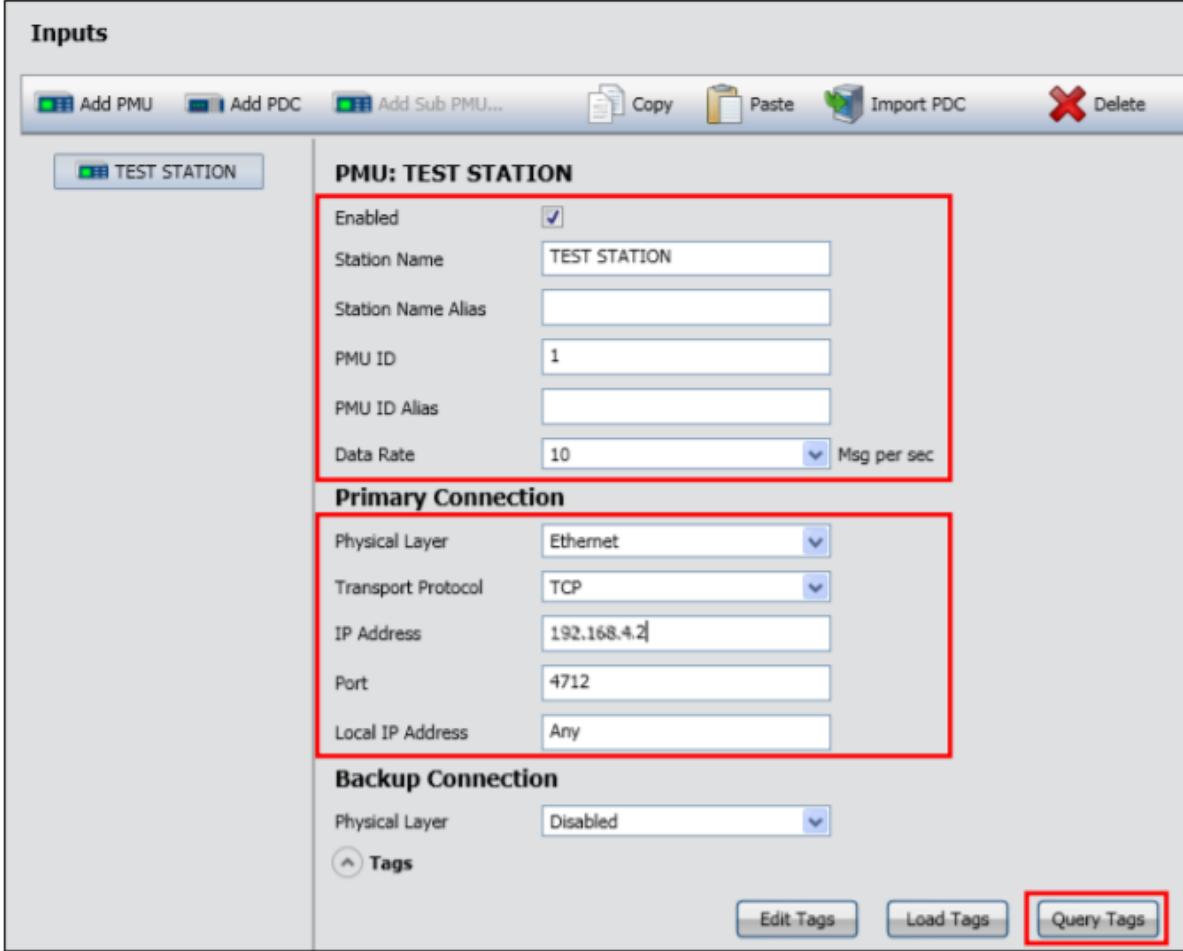
Physical Layer	Ethernet
Transport Protocol	TCP
IP Address	192.168.4.2
Port	4712
Local IP Address	Any

**Backup Connection**

Physical Layer	Disabled
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**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.

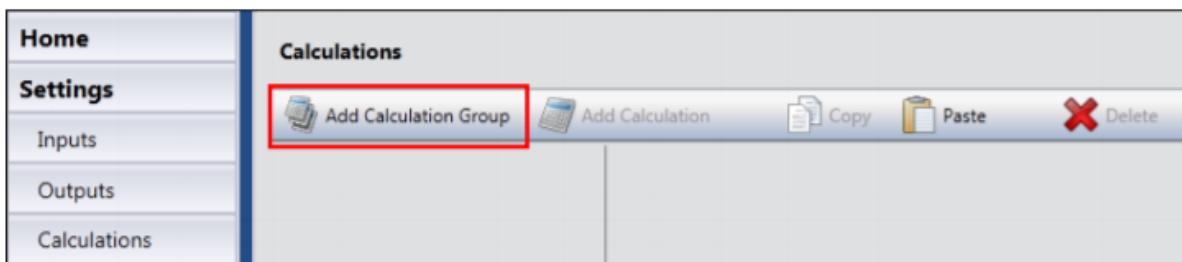
Edit Tags

Expected Input Tags				Save Tags	Load Tags	Query 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

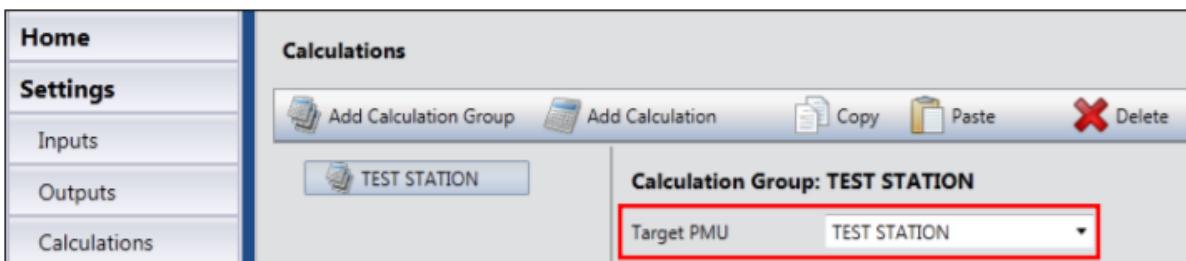
Select All   Remove   New Tag   OK   Cancel

- Real and Reactive Three-Phase Power Calculation Setup

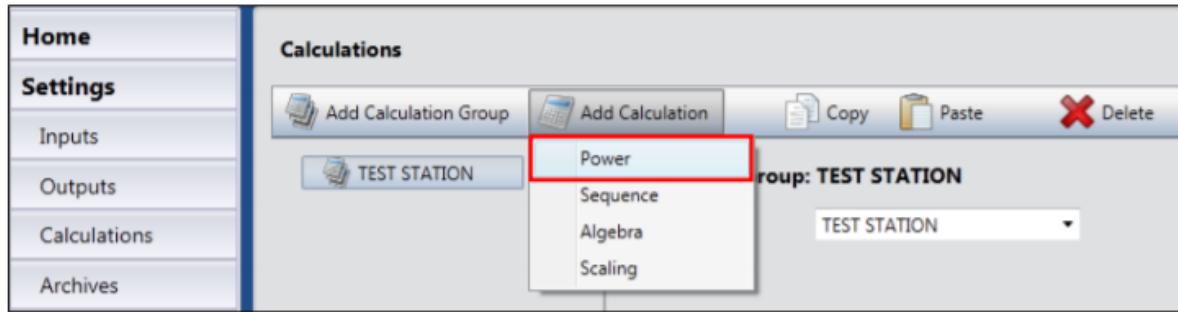
Click Settings > Calculations on the menu to configure SYNCHROWAVE PDC for the necessary power calculations. Then click the Add Calculation Group button, as shown.



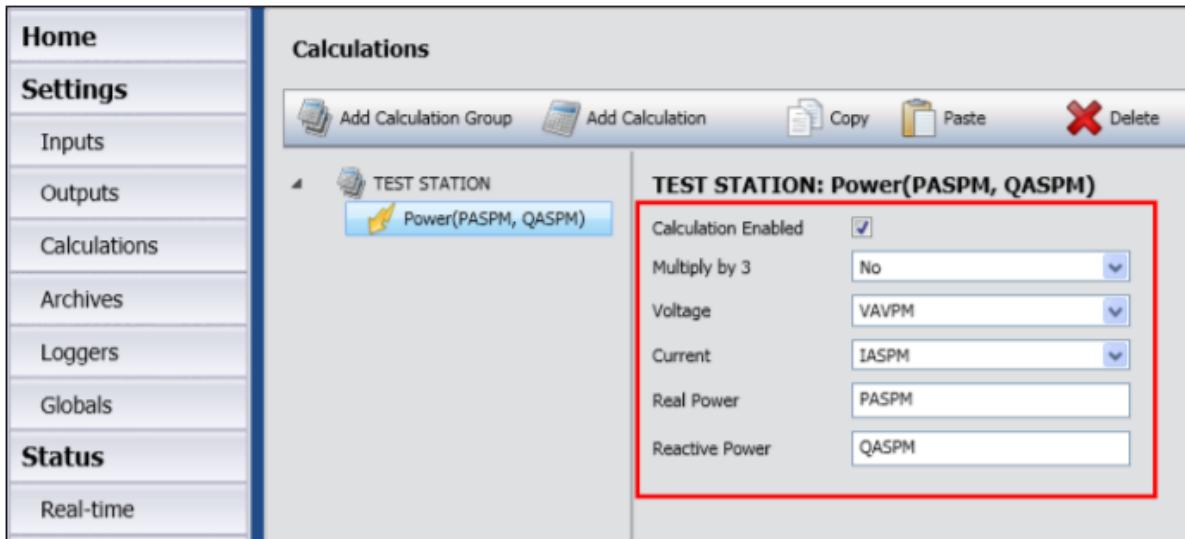
- Select the Target PMU to use for the power calculations



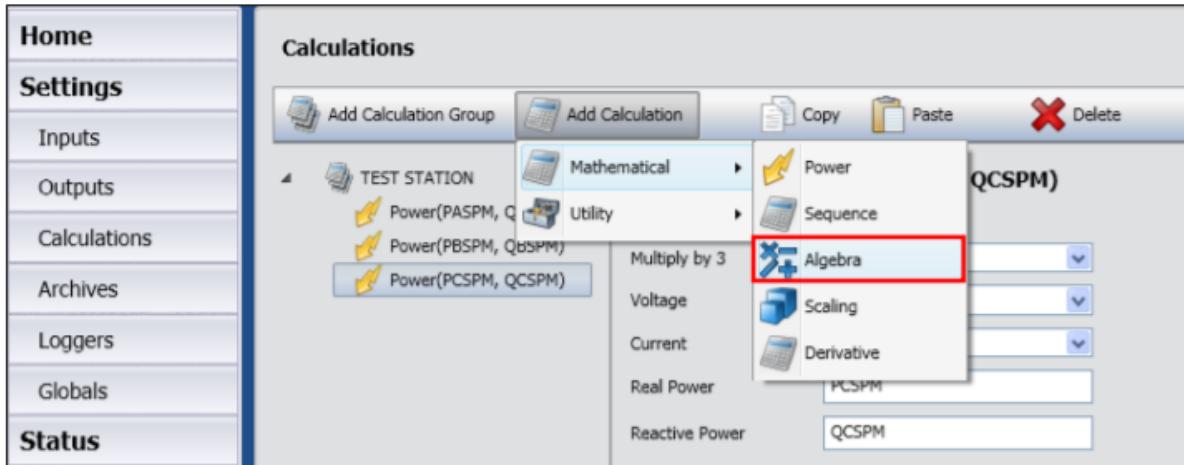
- Click the Add Calculation button, and then click Power on the drop-down menu



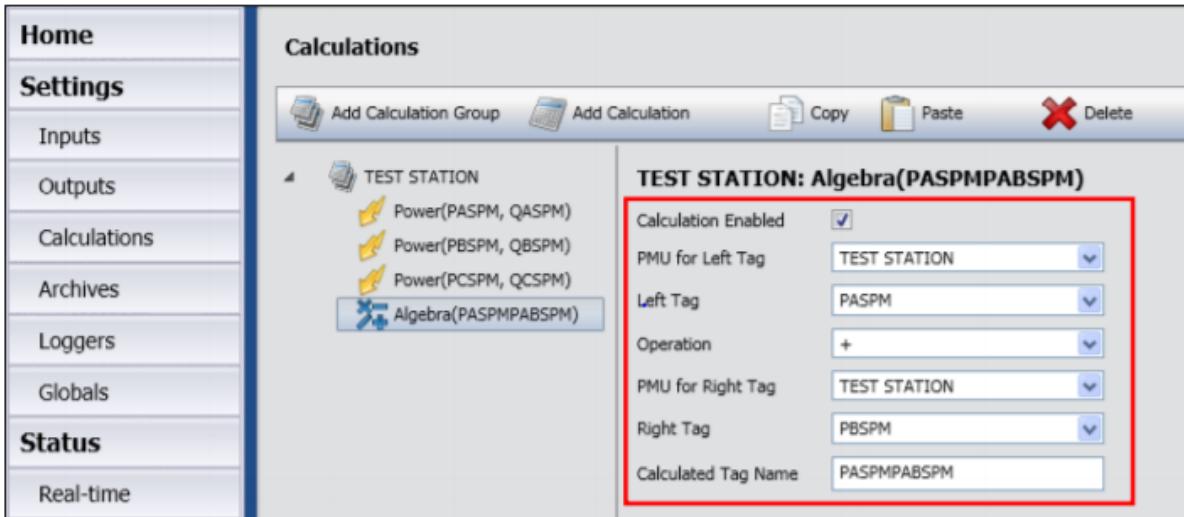
- Set up the A-phase power calculation by selecting the corresponding voltages and currents, as shown in Figure 48. Complete the procedure in Steps 1 through 4 for each of the three phases.



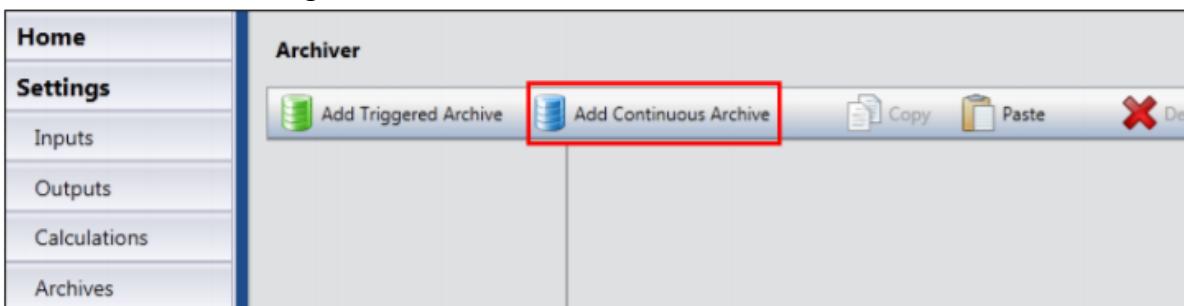
- Click the Add Calculation button, and then click Algebra on the drop-down menu, as shown in Figure 49. Summing the individual phase power is required to meet the PRC-002-2 three-phase power requirements.



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

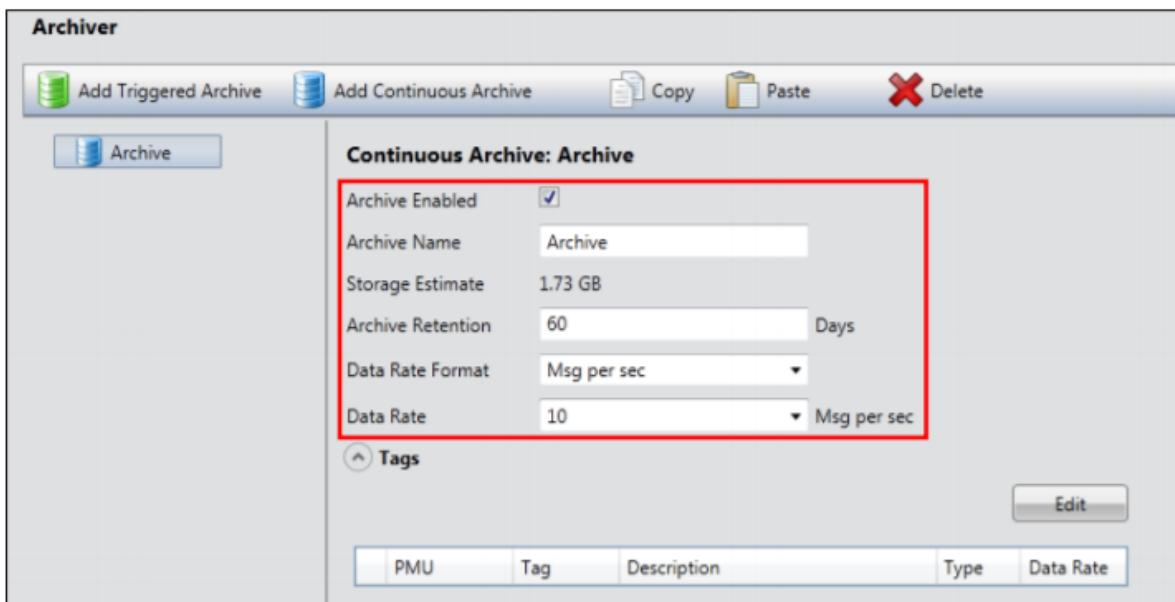


- Add the C-phase real power to the previous A- and B-phase real power summation
7. Archiving the setup
    - Click Archives on the menu to configure SYNCHROWAVE PDC for archiving data using continuous recording. Then click the Add Continuous Archive button

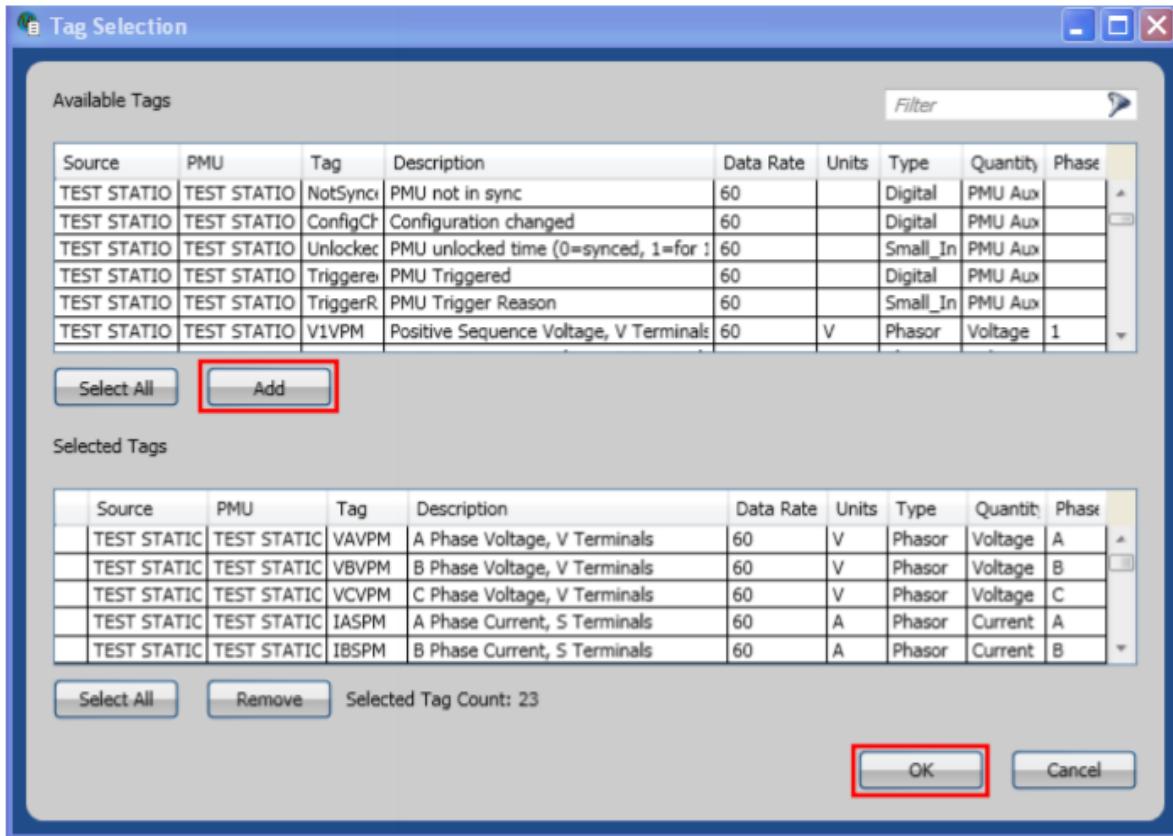


- Set up the added archive by entering the Archive Name, Archive Retention, and Data Rate.

Check the Archive Enabled box

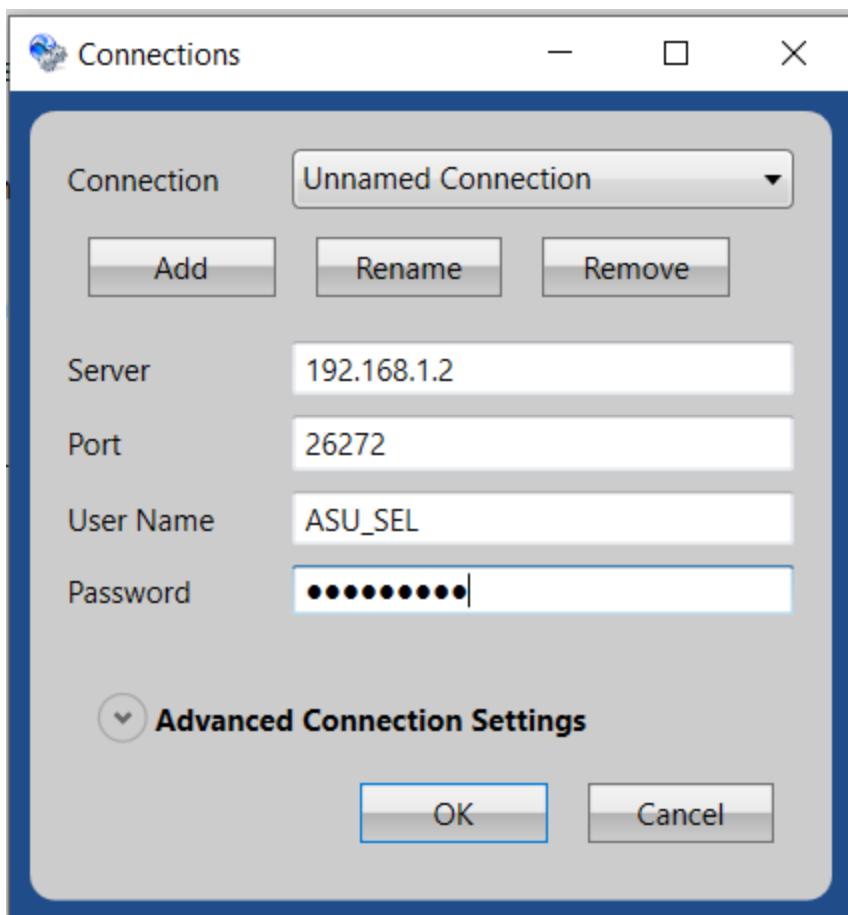


- Click the Edit button in order to select which tags are archived.
- Select the measurement tags to be archived, click Add, and then click OK. PRC-002-2 requires measurements for all phase voltages, phase currents, frequency, and three-phase real and reactive power.



#### 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@



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

Unnamed Connection (SEL-3573 Z008) - PDC Assistant

**SEL**

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

**Real-time Status**

**Input Connections**

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

**Input PMUs**

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

**Outputs**

Server	Connection State	Missing Data	Sent Data Frames
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**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**

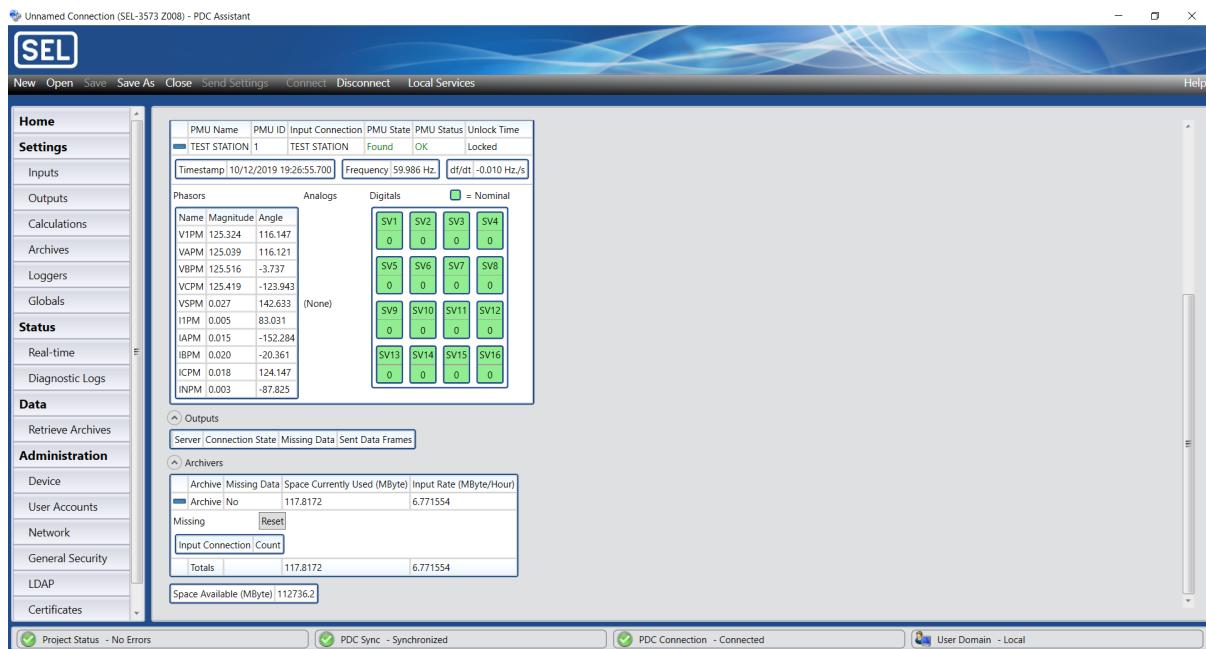
Name	PDC ID	Connection State	Time Quality	Received Data Frames
TEST STATION 1		Receiving Data	Normal	13590

**Network Latency**

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

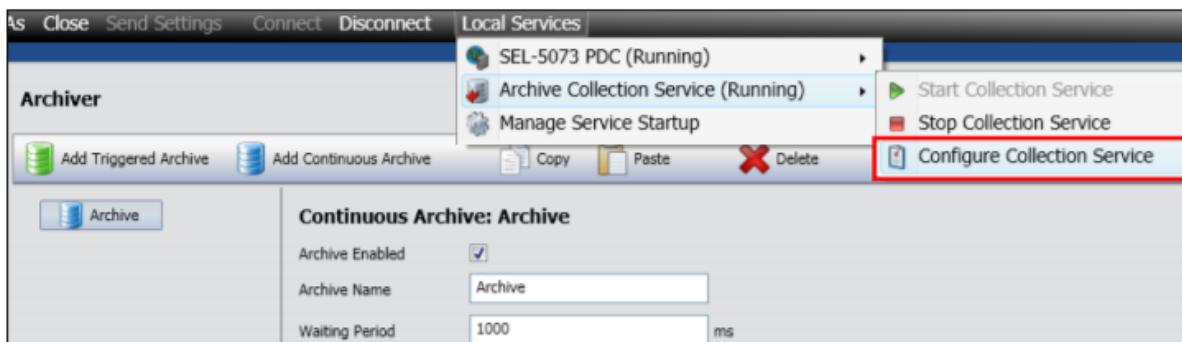
**Frames**

	# Frames	Timestamp
Data	13590	10/12/2019 19:26:21.700
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

Add Edit Remove Set Collection Time

Collection Options

Output Path C:\PRC\_002-2 Events\SEL-487E Browse

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

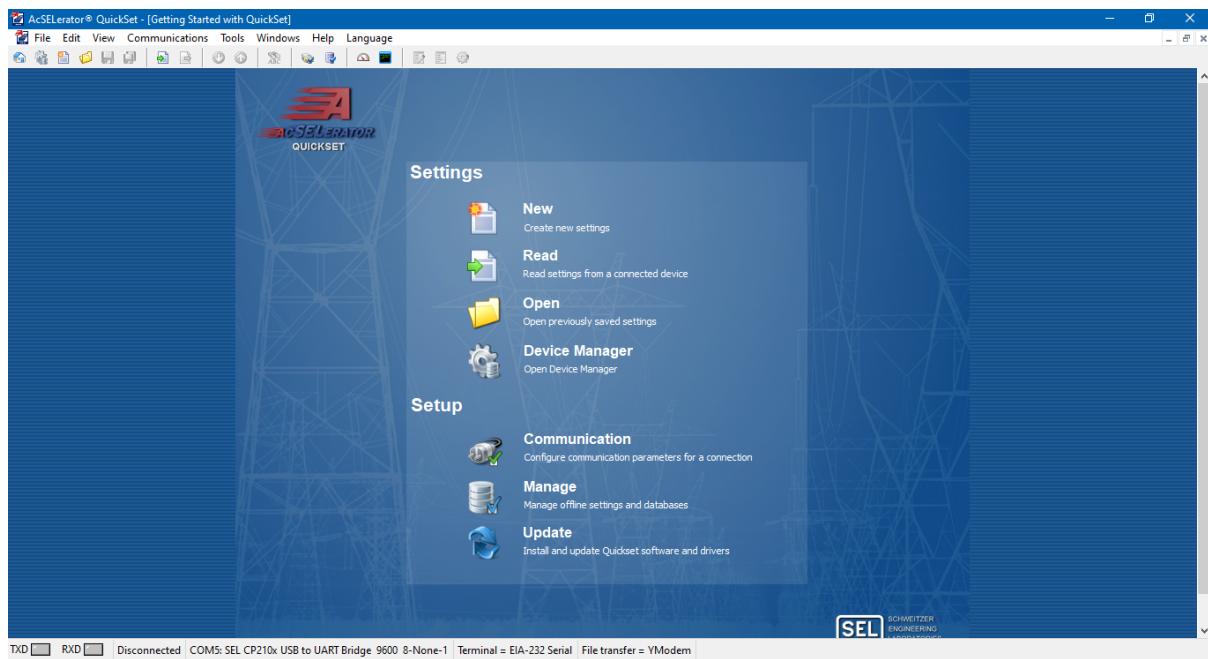
Angle Format -180 to 180 degrees

Minutes Per File 60

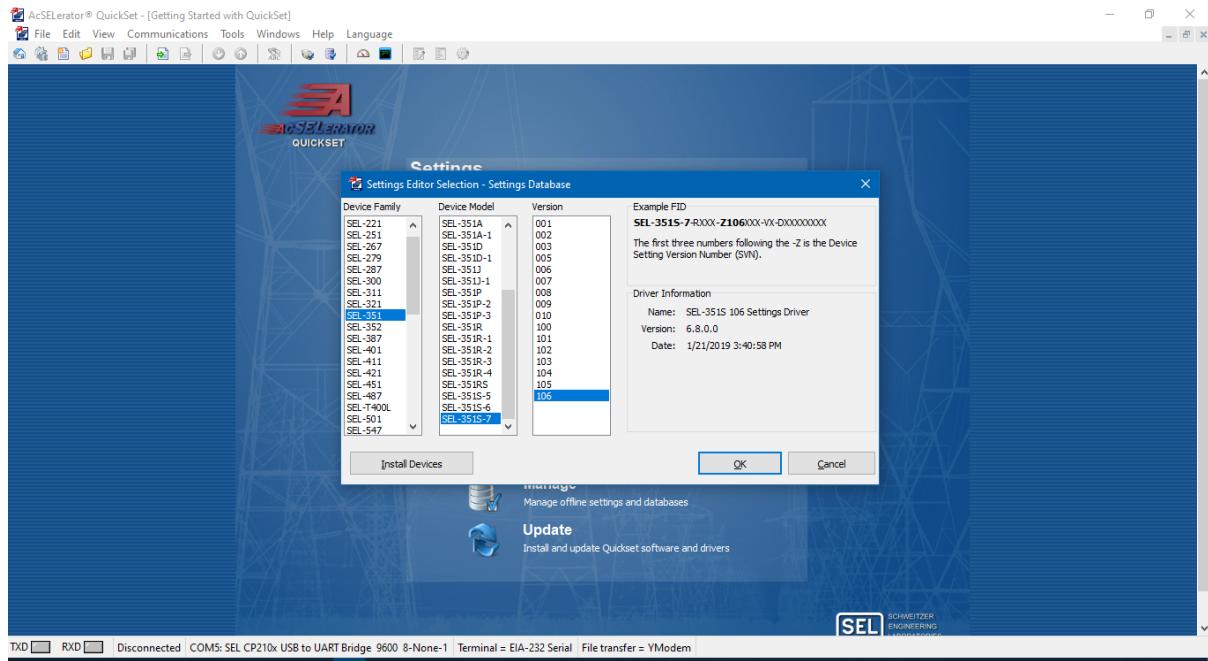
Apply Cancel

## 10. Relay and Clock Settings

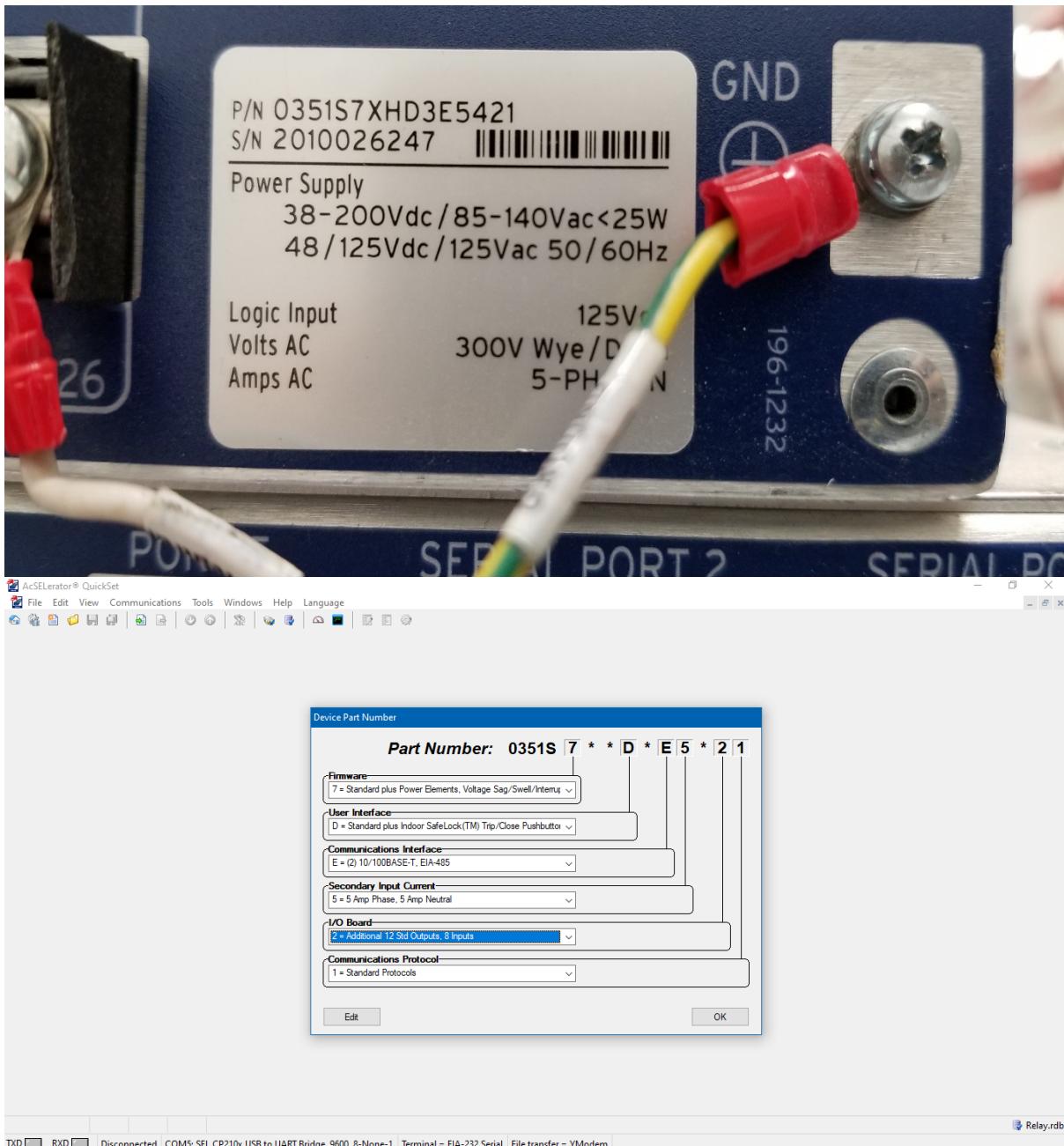
1. Install and Open SEL AcSElerator QuickSet.



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



- 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 show 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          TID      =STATION A  
CTR      = 2                 CTRN     = 1           PTR      = 1.00        PTRS     = 1.00  
VNOM     = 67.00  
Z1MAG    = 2.14              Z1ANG    = 68.86       Z0MAG    = 6.38        Z0ANG    = 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           EIOP     = 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

Y Select: Y, N

MFRMT Messages Format

C37.118 Select: C37.118, FM

MRATE Messages per Second

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

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

F Select: F, N

PHCOMP Freq. Based Phasor Compensation

Y Select: Y, N

PMSNTN Station Name

TEST STATION Range = ASCII string with a maximum length of 16.

PMID PMU Hardware ID

1 Range = 1 to 65534

PHDATAV Phasor Data Set, Voltages

ALL Select: V1, PH, ALL, NA

VPCOMP Phase Volt. Angle Comp.

0.00 Range = -179.99 to 180.00

VSCOMP VS Volt. Angle Comp.

0.00 Range = -179.99 to 180.00

VCOMP Voltage Angle Comp. Factor

0.00 Range = -179.99 to 180.00

PHDATAI Phasor Data Set, Currents

ALL Select: I1, PH, ALL, NA

IPCOMP Phase Current Angle Comp.

3.50 Range = -179.99 to 180.00

INCOMP Neut. Current Angle Comp.

5.50 Range = -179.99 to 180.00

ICOMP Current Angle Comp. Factor

3.50 Range = -179.99 to 180.00

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

F Select: I, F

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

P Select: R, P

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

I Select: I, F

NUMDSW Number of 16-bit Digital Status Words

1 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

Select: NONE, C37.118

UTC\_OFFSET Offset from UTC

Range = -24.00 to 24.00

DST\_BEGM Month to Begin DST

Range = 1 to 12, NA

DST\_BEGW Week Of The Month to Begin DST

Range = 1 to 3, L

DST\_BEGD Day Of The Week To Begin DST

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

DST\_BEGH Local Hour To Begin DST

Range = 0 to 23

DST\_ENDM Month To End DST

Range = 1 to 12

DST\_ENDW Week Of The Month to End DST

Range = 1 to 3, L

DST\_ENDD Day Of The Week To End DST

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

DST\_ENDH Local Hour To End DST

Range = 0 to 23

- Global > Port 5 > Ethernet Synchrophasor Settings.

## Ethernet Synchrophasor Settings

EPMIP Enable PMU Processing

Y Select: Y, N

PMOTS1 PMU Output 1 Transport Scheme

TCP 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])

192.168.4.3 Range = ASCII string with a maximum length of 19.

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

4712 Range = 1 to 65534

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

4713 Range = 1 to 65534

PMOTS2 PMU Output 2 Transport Scheme

OFF 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])

192.168.2.10 Range = ASCII string with a maximum length of 19.

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

4723 Range = 1 to 65534

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

4713 Range = 1 to 65534

6. Connect SEL-2401 Satellite-Synchronized clock with the SEI 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  
=>>|
```