microPMU Installation and User's Manual

Revision 2.0

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WARNING: Death, serious injury, or fire hazard could result from improper connection or operation of this instrument. Carefully read and understand manual before connecting this instrument.

AVERTISSEMENT: Si l'instrument est mal connecté, la mort, des blessures graves, ou un danger d'incendie peuvent s'en suivre. Lisez attentivement le manuel avant de connecter l'instrument.

WARNUNG: Der falsche Anschluß dieses Gerätes kann Tod, schwere Verletzungen oder Feuer verursachen. Bevor Sie dieses Instrument anschließen, müssen Sie die Anleitung lesen und verstanden haben.

ADVERTENCIA: Una conexión incorrecta de este instrumento puede producir la muerte, lesiones graves y riesgo de incendio. Lea y entienda el manual antes de conectar.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Installation, service, and maintenance of your microPMU must only be done by an expert for electrical installations.

The information contained in this document is subject to change without notice.

PSL MAKES NO WARRANTY OF ANY KIND WITH REGARD TO THIS MATERIAL, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR USE.

PSL shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material. If you do not accept this limitation on liability, please return the product to PSL prior to use.

Produced in the United States of America.

Symbol	Meaning
	Caution. Consult this manual in all cases where this symbol is marked, in order to find out the nature of the potential hazards and any actions which have to be taken to avoid them.
	Caution. Risk of electric shock
	Alternating current
	Alternating current (a.c.) or direct current (d.c.)
	Double or Reinforced insulation
	Functional earth terminal not relied on for safety

Release: October 2016

Table of Contents

Table of Figures

Introduction

What is a microPMU?

Synchrophasor measurements have traditionally been used to observe the flow of power between generators across transmission lines. To do this, Phasor Measurement Units (PMUs) measure the phase angle of the voltage between two locations. PMUs are synchronized to a GPS clock, allowing for measurements that are accurate to the degree, or 1/360th of a cycle. They transmit a constant stream of data to a central computer called a Phasor Data Concentrator (PDC).

But to measure the effects of renewable energy sources, synchrophasor measurements must be made at the distribution level, where changes in phase angle are more on the order of minutes. To effectively measure the effects of renewable energy sources on the distribution lines, a more accurate and precise synchrophasor (microPMU) is required.

The microPMU operated on the same hardware platform as a PQube 3 power quality monitor (www.pqube3.com). The microPMU undergoes a specific calibration process at PSL, and must be equipped with a MS1 module and GPS1 receiver and antenna to operate.

What do I need to operate microPMU?

At the bare minimum, you will need the main microPMU unit (grey lid , model , plus the MS1 synchronization module and GPS1 receiver, with the PSL-provided custom GPS cable (RJ-45 on one end, 8-pin terminal block on the other).

IMPORTANT: Installation, service, and maintenance of your microPMU must only be done by an expert for electrical installations.[1]

Additional optional modules are available. They snap into your microPMU to provide additional features. To choose modules for your application, you'll need to answer a few simple questions:

Figure 1 microPMU

- Do you need to power the instrument from 100~240Vac (50/60Hz)?
- Do you need battery backup in the event of a power outage?
- Do you want to record the environmental conditions in addition to everything about the electric power?

[1] *This is a requirement for Japanese safety standard approvals.*

PM1 Power Manager Module – Power the device from the wall outlet (optional)

Figure 2 microPMU and Power Supply

If you want to power your microPMU from the wall outlet (100~240Vac), you'll need an optional PM1/PM2 Power Manager module.

MS1 synchronization module and GPS1 Receiver (required)

If you need ultra-precise GPS timestamps, or if you want to perform micro-synchrophasor measurements, connect the MS1 Sync module with the GPS1 receiver to the left side of your microPMU.

Figure 3 microPMU and GPS Antenna

The MS1 module interfaces with the GPS1 receiver to provide your microPMU with ultra-precise GPS timing.

Figure 4 GPS Antenna

The GPS1 receiver locks onto GPS satellites in the sky to provide your microPMU with ultra-precise GPS timing. It is designed to be weather-resistant and you can install it outside using optional mounting hardware. It has 600V isolation at both ends of the cable for safety.

UPS1 Module - Backup your microPMU during a power outage (optional)

Figure 5 microPMU and UPS module

Connect the UPS1 Battery Backup module to your microPMU to provide up to 30 minutes of back up power during a power outage. It can be used with or without a PM1 module.
Options for up to 3 hours with a UPS2 module are available.

Installation

Quickstart Guide

1 **Assemble your modules together**

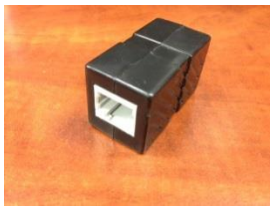
Snap in the MS1 module to the left of your microPMU. If using a PM1 module and/or UPS1 module, snap them into the right side of your microPMU.

Figure 6 Typical micro PMU with GPS, Power Supply and UPS

2 **GPS setup**

Your GPS cable has an 8-pin terminal block on one end and an RJ-45 jack on the other end. The 8-pin terminal block plugs into the back of your MS1 module, the other end plugs into the GPS1 receiver.

Figure 7 GPS Connections



IMPORTANT: Do not plug the RJ-45 end of the GPS cable into a network switch or router.

Place the GPS1 receiver in an area with direct line of sight to the sky. For maximum exposure to satellites, mount it on the roof. If mounting near a window, make sure your microPMU locks onto at least 4 satellites. To view the number of satellites, from the main menu go to System, Advanced, and then GPS.

If necessary, you can extend the GPS cable using a standard RJ-45 coupler and an Ethernet cable.

3 Provide a network connection for your microPMU

Plug in a standard Ethernet cable between your microPMU and a network switch/hub/router, or cellular modem. If you will be archiving the phasor data into a database or PDC (phasor data concentrator), make sure your microPMU is on the same network as your database, or set up a public IP address for your microPMU.

Figure 8 Ethernet Network Connection

By default, your microPMU is configured for DHCP, which means the network is responsible for assigning an IP address to your microPMU.

If necessary, you can set your microPMU to use a Fixed IP address in the Network_Setup section of your Setup.ini file.

```
;-----------------------------------------------------
[Network_Setup]
;-----------------------------------------------------

; ------ Valid Values: Use_DHCP Use_Fixed_IP
IP_Address_Method=Use_DHCP
Publish_IP_Address=ON

;-----------------------------------------------------
[Fixed_IP]
;-----------------------------------------------------

; ------ This section is ignored if the IP_Address_Method is set to
Use_DHCP
IP_Address=172.17.69.20
IP_Gateway=172.17.1.1
```

```
IP_Mask=255.255.255.0
IP_DNS1=8.8.8.8
IP_DNS2=8.8.4.4
```

4 Connect instrument power wires

You have several options for powering your microPMU:

- Low voltage ±24 – 48VDC or 24VAC instrument power terminals on main module

Figure 9 MPU Power Terminals

- PM1 AC Input Terminals 100~240VAC (CAT II)
- Make sure the power is OFF before servicing  these terminals.

Figure 11 PM1 Rear View - 100 - 240VAC Terminals

Figure 10 PM1 Top View - 100-240VAC Terminals

- Connect an ethernet cable to a PoE (Power over Ethernet) port

Figure 12 Power over Ethernet Port

5 Connect wires to mains AC terminals

Make sure the power is OFF before servicing these terminals. Connect the wires to the high voltage terminal block on the rear side of your microPMU. They will be labeled L1, L2, L3, N, and Ground.

IMPORTANT: You **must** ensure that the ground wire is connected to your microPMU. This is critical for accurate phase angle measurements.

Figure 13 Main input monitoring Terminals

Refer to wiring diagrams on following pages for sample single-phase and 3-phase installations.

Wiring Diagrams

Single Phase L-N

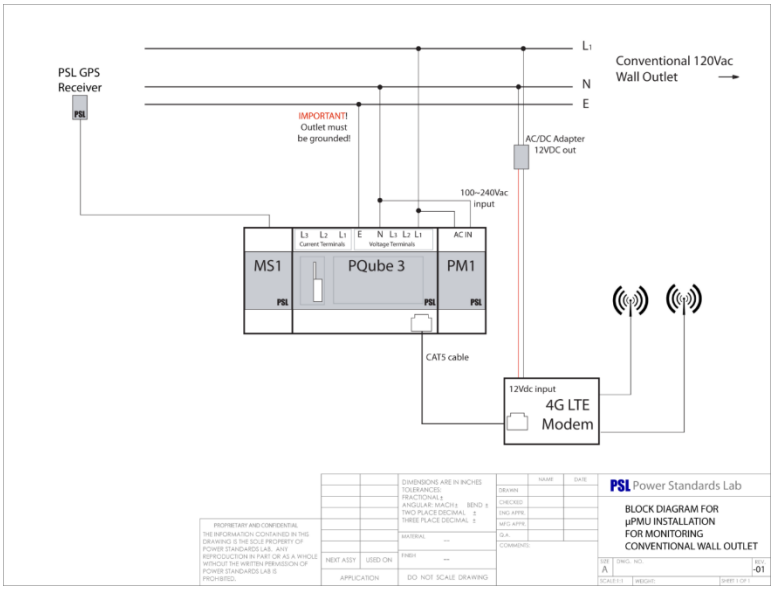


Figure 14 Single Phase Terminations

Delta (3-phase no neutral)

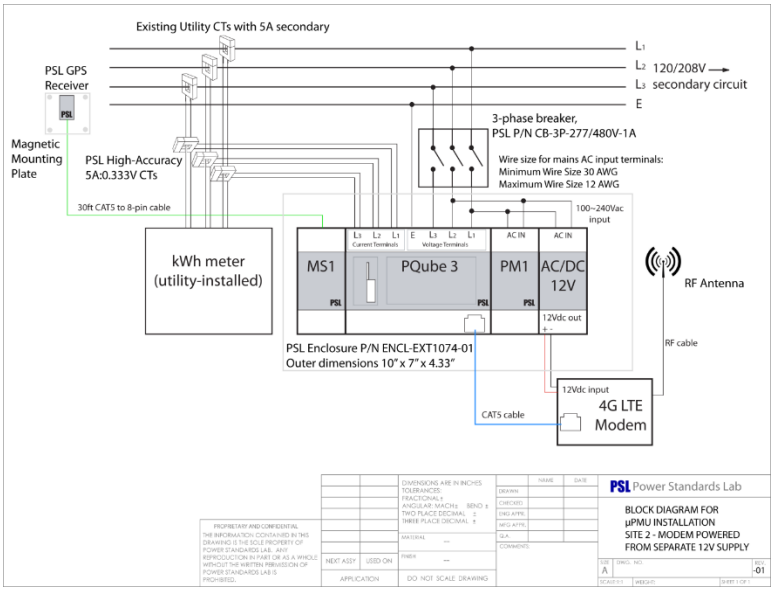


Figure 15 Three Phase Terminations

Overview of connections and controls

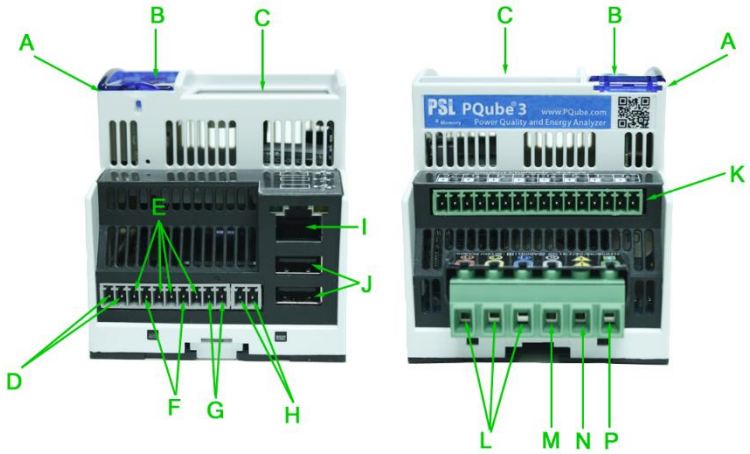


Figure 16 microPMU Connections

A	Coin-cell battery
B	SD memory card and adjacent High-Speed USB 2.0 port
C	Touchscreen display
D	Signal relay outputs. One is standard on all PQube 3's.
E	Analog inputs. Maximum ±60V to earth. Can be used as differential inputs.
F	Earth – functional. Used as the reference voltage.
G	Digital input. 60-volt tolerant. 1.5-volt threshold. Wetted with 2.4V at 3 microamps.
H	Power inputs. 24VAC, or 24VDC to 48VDC (either polarity) nominal. 20VA max.

I	RJ-45 Ethernet port. 48V PoE compatible.
J	USB ports – For use with PSL accessories including temperature and humidity sensors.
K	Current transformer inputs – 0.333V nominal
L	L1, L2, L3 voltage inputs. 1000Vrms max phase-to-phase (equivalent to 600Vrms phase-to-earth)
M	Neutral terminal – optional connection
N	Not connected
P	Earth – functional. Used as the reference voltage.

Disconnect mains prior to servicing

Always disconnect all mains connections, and verify disconnections, prior to servicing.

Setting Up Your microPMU

Getting Started

1. Update the firmware to the latest version

To check the firmware version on your microPMU, from the main menu go to System, then Info. Download the latest firmware at http://micro-pmu.com/firmware

For links to the latest firmware, contact support@powerstandards.com.

With USB thumb drive

Copy the xxx.PQ3 file onto a USB thumb drive, and then insert it into your microPMU. The update process will begin automatically and the device will reboot within a few minutes.

To confirm successful installation, remove the USB drive after reboot (from Main Menu press Actions, then Eject). The xxx.PQ3 file will be renamed to xxx.PQ3*<install date of update>*

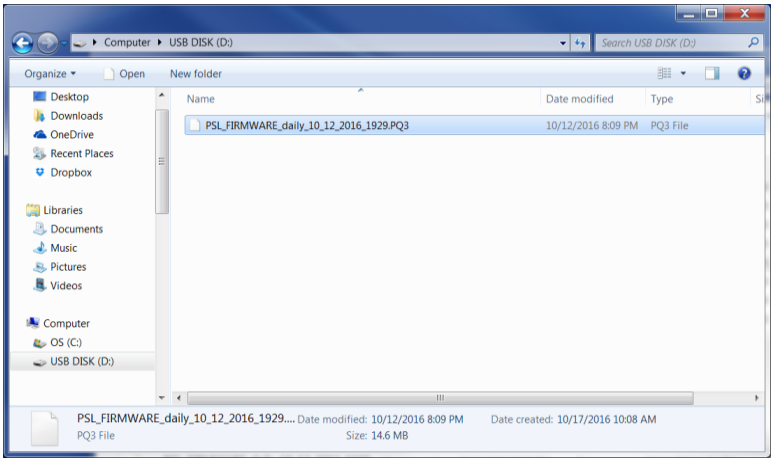


Figure 17 xxx.PQ3 file copied to USB thumb drive

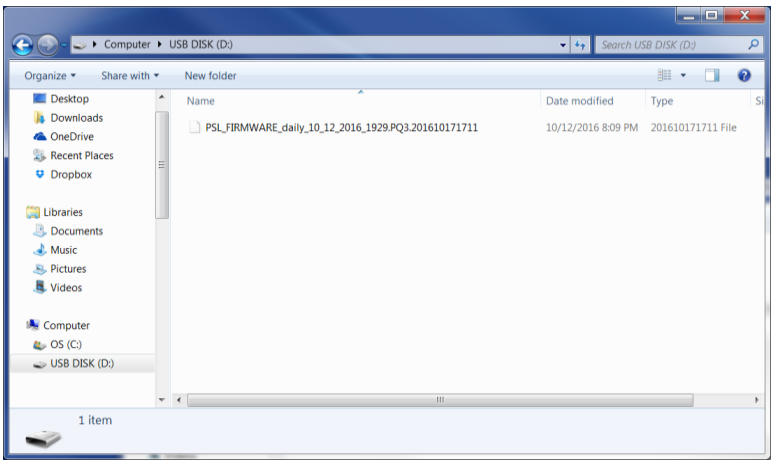


Figure 18 After successful update, the xxx.PQ3 file is renamed with the date/time of installation

Updating microPMU over the web

If you know your microPMU's IP address, enter it into the address bar of your web browser.

Firmware

Go to the Commands page to upload the new firmware. Your microPMU will automatically reset after installing the update.

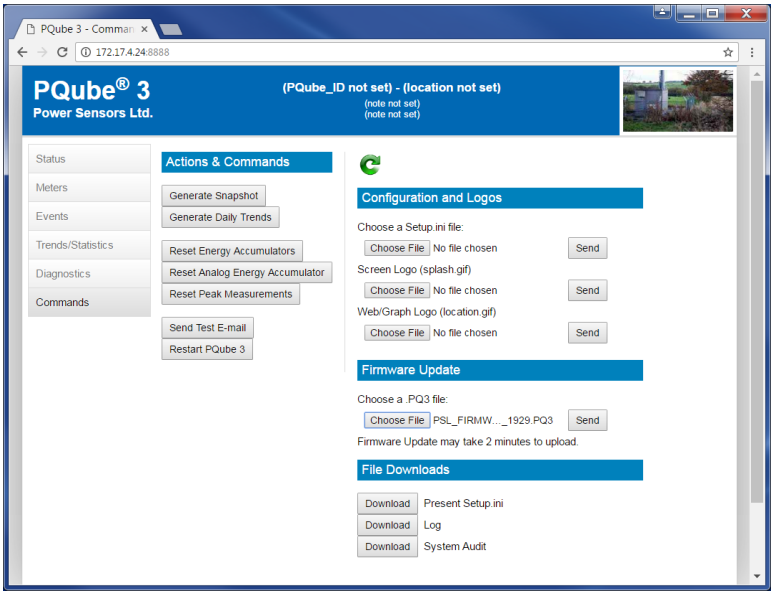


Figure 19 Configuration Web page

Setup.ini

The setup.ini can be down and uploaded via the webpage shown in the figure above. Your microPMU will automatically reset after updating the setup.ini.

uPMU SETUP.INI editor configurator

The link below will download the microPMU configurator.

http://powersensorsltd.com/Download/microPMUConfigurator

Recommended Settings

PSL recommends setting the PQube ID, Location Name, Note 1, and Note 2 in the [PQube_Information] section at the top.

Set the Power_Configuration as necessary for your application.

For single-phase outlets with a Neutral conductor, use Single_Phase_L1_N.

For 3-phase without Neutral use Delta. For 3-phase with Neutral use Wye or Star.

```
; ------ PQube 3 from Power Sensors Ltd.
; ------ www.powersensorsltd.com
; ------ PQube 3 Version 3.5

;-------------------------------------------------
[PQube_Information]
```

```
;-----------------------------------------------------
; ------ Assign a unique identifier for your PQube 3
PQube_ID="P3001697"

; ------ Describe the place where your PQube 3 is installed
Location_Name="PSL Staging Room"

; ------ Optional additional information about your PQube 3
Note_1="PSL Alameda"
Note_2="USA"

; ------ Duration in minutes of battery back up before your PQube 3 automatically shuts down
; ------ This applies only if your PQube has a UPS module
; ------ Valid values: 3 to 30, typical value 5
UPS_Time_In_Minutes=5

; ------ Capacity of the battery pack connected to the UPS2 module. If there are several
battery packs connected,
; ------ the capacity is the total capacity for all packs together
; ------ Note: This parameter is ignored if a UPS1 module is connected to the PQube3.
; ------ Valid values: 2500 to 7500, default is 2500
UPS_Model=None
UPS_Battery_Capacity_In_mAh=

; ------ Your PQube 3's internal fan turns on when the CPU temperature exceeds this threshold.
; ------ Valid values: integer between 40 and 60, typical value 55
Fan_Temperature_Threshold_in_DegC=60

; ------ Choose the language for web pages, screen display, and graphs generated by your PQube
3.
PQube_Primary_Language=English-American
PQube_Secondary_Language=None

;-----------------------------------------------------
[Data_Backup]
;-----------------------------------------------------
; ------ If enabled, your PQube 3 will perform a measurement data backup from its memory
; ------ to either the extractible microSDCard or to the USB thumb drive.
; -----  the copy occurs once a day, if the media is present in its slot.
; ------ Valid Values: OFF, ON. Default is OFF
Enable_Data_Backup=OFF

; ------ Valid Values: No_backup, USB, SDCARD, Default is No_backup
Data_Backup_to=No_backup

;-----------------------------------------------------
[Nominal_Inputs]
;-----------------------------------------------------
; ------ Choose the nominal value of the mains voltage measured in volts, taking into account
transformer ratios if applicable
; ------ Valid Values: AUTO, positive value between 69 and 800000
; ------ AUTO sets the nominal voltage using the actual voltages at the mains AC terminals
during startup and rounds to the nearest standard worldwide voltage.
; ------ Examples of values when using transformer ratios: 11000, 12470, 33000

; ------ Typical values for Phase to Phase voltage are 208, 380, 400, 480
Nominal_Phase_To_Phase_Voltage=AUTO

; ------ Typical values for Phase to Neutral voltage are 100, 120, 230, 277
Nominal_Phase_To_Neutral_Voltage=AUTO

; ------ Valid Values: 50, 60
Nominal_Frequency=60
```

By default, your microPMUs are set to DHCP, which relies on the router or modem to assign an IP address. If your network does not support DHCP, you need to set your microPMU to use a fixed IP address. Go to the [Network_Setup] and [Fixed_IP] sections and enter the appropriate settings.

```
;-----------------------------------------------------
[Network_Setup]
;-----------------------------------------------------

; ------ Valid Values: Use_DHCP Use_Fixed_IP
```

```
IP_Address_Method=Use_DHCP
Publish_IP_Address=ON

;-----------------------------------------------------
[Fixed_IP]
;-----------------------------------------------------

; ------ This section is ignored if the IP_Address_Method is set to Use_DHCP
IP_Address=172.17.69.20
IP_Gateway=172.17.1.1
IP_Mask=255.255.255.0
IP_DNS1=8.8.8.8
IP_DNS2=8.8.4.4

 ;-----------------------------------------------------
 [HTTP_Web_Server_Settings]
 ;-----------------------------------------------------
 ; ------ Makes the Command page visible
 ; ------ Valid values ON, OFF
 HTTP_Web_Server_Commands_Page=ON

 ; ------ HTTP port used to access the PQube3 web server pages
 ; ------ Valid values [1-65535], default is 80
 ; ------ make sure that the port chosen does not conflict with
 ; ------ reserved ports and other PQube3 services ports
 ; ------ e.g. FTP, SNMP, SSH, Web Command page...
 HTTP_Web_Server_Port=80

 ; ------ HTTP port used to access the PQube3 web server Command page
 ; ------ Valid values [1-65535], default is 8888
 ; ------ make sure that the port chosen does not conflict with
 ; ------ reserved ports and other PQube3 services ports
 ; ------ e.g. FTP, SNMP, SSH, Web server, HTTP ...
 HTTP_Web_Server_Command_Port=8888

 ; ------ Require password to access the PQube3 web server pages (except command page)
 Require_HTTP_Authorization=OFF
 HTTP_User_Name=
 HTTP_Password=

 ; ------ Require password to access the PQube3 web server command page
 Require_HTTP_Admin_Authorization=OFF
 HTTP_Admin_User_Name=
 HTTP_Admin_Password=

 ;-----------------------------------------------------
 [FTP_Settings]
 ;-----------------------------------------------------
 ; FTP control and Data ports, the default control port is 21, the default data port is 20
 ; ------ Valid values  [1-65535]
 ; ------ make sure that the port chosen does not conflict with
 ; ------ reserved ports and other PQube3 services ports
 ; ------ e.g. SNMP, SSH, Web server, HTTP ...
 FTP_Control_Port=21
 FTP_Data_Port=20

 ; ------ There are 3 user accounts for downloading data : "ftp_user_1" , "ftp_user_2" and
 "ftp_user_3"
 ; ------ Account "ftp_config" - for reading and sending the PQube3 setup.ini files
 ; ------ Account "ftp_updater" - for sending firmware updates
 ; ------ If no password is assigned for a profile, the user does not have access
 ; ------ Password must be at least 8 characters
 ; ------ Password for profile "ftp_user_1"
 FTP_Password_1=
 ; ------ Password for profile "ftp_user_2"
 FTP_Password_2=
 ; ------ Password for profile "ftp_user_3"
 FTP_Password_3=
 ; ------ Password for profile "ftp_config"
 FTP_Password_4=
 ; ------ Password for profile "ftp_updater"
 FTP_Password_5=
```

```
;-----------------------------------------------------
[Security_Settings]
;-----------------------------------------------------
; ------ This enables or disables the embedded PQube3 firewall.
; ------ The firewall will close all ports except the ports being used by the PQube3.
; ------ The firewall will limit the number of external attempts to open ports for a given period
of time,
; ------ therefore protecting against attacks from the Internet.
; ------ Valid values: ON, OFF, default is OFF
Enable_Firewall=ON

; ------ Turning this Security tag ON makes the PQube3 web pages accessible only via secure HTTP
(HTTPS)
; ------ this applies to all pages, including the command page
; ------ Turning this Security tag ON changes the HTTPS port to 443
; ------ If the tag is turned OFF, then the Web pages are accessible via non secure (HTTP)
; ------ Valid values: ON, OFF, default is OFF
Require_WebServer_Security=OFF

; ------ Turning this tag IMPLICIT or EXPLICIT makes the PQube3 FTP server accessible only via
secure FTP (FTPS)
; ------ this applies to all FTP profiles (user, config, and update profiles)
; ------ the FTP ports specified in the FTP section are used
; ------ See the FTP_Settings section for more information about profiles
; ------ If the tag is turned OFF, then the Web pages are accessible via non secure (FTP) or
secure (FTPS)
; ------ Valid values: OFF, IMPLICIT, EXPLICIT, default is OFF
Require_FTP_Security=OFF

;-----------------------------------------------------
[MicroSynchrophasor_Settings]
;-----------------------------------------------------

; ------ Toggle phasor data measurements ON or OFF.
; ------ Valid values: ON, OFF
SynchrophasorMode=ON

; ------ Set the rate at which your µPMU measures and records phasor data.
; ------ Valid values for 50Hz systems: 10, 25, 50, 100
; ------ Valid values for 60Hz systems: 10, 12, 15, 20, 30, 60, 120
Phasor_Measurements_Per_Second=120

; ------ Set the recording period of the binary archive files that are written to disk.
; ------ Valid values: 1, 2, 3, 4, 5, 6, 10, 12, 15
Binary_File_Recording_Period_In_Minutes=1

; ------ Compensate for delays in the data acquisition chain, including all filters and estimation
windows in effect.
; ------ (This is the GRP_DLY field as defined in IEEE C37.118.2-2011 configuration frame 3.)
Phasor_Measurement_Group_Delay_In_Microseconds=0

; ------ Compensate for GPS cable
; ------ Valid values: AUTO, 0-999999, default value: AUTO
; ------ Enter AUTO to have MicroPMU measure the GPS cable delay
PMU_GPS_Cable_Length_In_Meters=AUTO

; ------ Config1 sets voltage measurements to L1, L2, L3, current measurements to I1, I2, I3
; ------ Config2 sets voltage measurements to AN1, AN2, AN3, current measurements to I1, I2, I3
; ------ Config3 sets voltage measurements on L1, AN1, AN2, current measurements on I1, I2, I3
; ------ Config4 sets voltage measurements to L1, L2, L3, current measurements to A1, A2, A3
; ------ Valid values: Config1, Config2, Config3, Config4
PMU_Channel_Configuration=Config1

; ------ Add frequency and total W, VA, VAR, and dPF to microPMU data.
; ------ Valid values: ON, OFF
Enable_Frequency_And_Power_Recording=ON

;-----------------------------------------------------
[C37_Communications_Settings]
;-----------------------------------------------------

; ------ IEEE C37.118.2:2011 Communication Settings
```

```
; ------ Toggle the C37 datastream ON or OFF.
Enable_C37_Datastream=ON

; ------ Assign a unique identifier for your microPMU.
; ------ This name will appear in your phasor data concentrator software.
; ------ Valid values: PQube_ID, "any string"
Station_Name=PSL_UPMU

Device_ID_Code=1
Device_Port=4713

; ------ Set the rate at which the dataframes are transmitted to your PDC.
; ------ Valid values for 50Hz systems: 10, 25, 50, 100
; ------ Valid values for 60Hz systems: 10, 12, 15, 20, 30, 60, 120
C37_Reporting_Rate_In_Frames_Per_Second=60

;-----------------------------------------------------
[microPMU_Database_Server_Settings]
;-----------------------------------------------------
; ------ If you have a microPMU database server, enable this setting
; ------ to automatically push data from your microPMU to the server.
; ------ Valid values: ON, OFF
Enable_Push_Data_to_Database_Server=OFF
Database_Server_IP_Address=

[Demo_Tags]
Display_Web_page=OFF
```

2. Configure your microPMU

As an alternative to the web interface the MicroPMU can be updated via the High-Speed USB 2.0 port on the front on the microPMU as show below;

With USB thumb drive

Use the provided Setup.ini file to make device configuration changes to your microPMU. This file can be modified with a simple text editor and saved onto a USB thumb drive. Make sure this file is named Setup.ini and place it in the root directory of your USB drive. Your microPMU will recognize the file, reboot, and apply the new settings when you plug in the USB thumb drive.

Figure 20 Plug in a USB thumb drive

To verify that your microPMU accepted the new setup file, eject the USB drive after reboot and it will be renamed to SetupYYYYMMDDHHMM to reflect the date/time these settings were applied.

3. Navigating the touchscreen display

Use the touchscreen on your microPMU to navigate through all of the displays. You can view live meters, recent events, system information, and perform actions like ejecting removable media and rebooting the unit.

Figure 21 Home Screen

Use the back button on the lower-left corner of the touchscreen to go back up a level. Use the Home button (2nd from left) to move back to the main screen

Figure 22 Navigation Keys

SYSTEM

Shows details such as Date /Time, network settings, firmware version & GPS status.

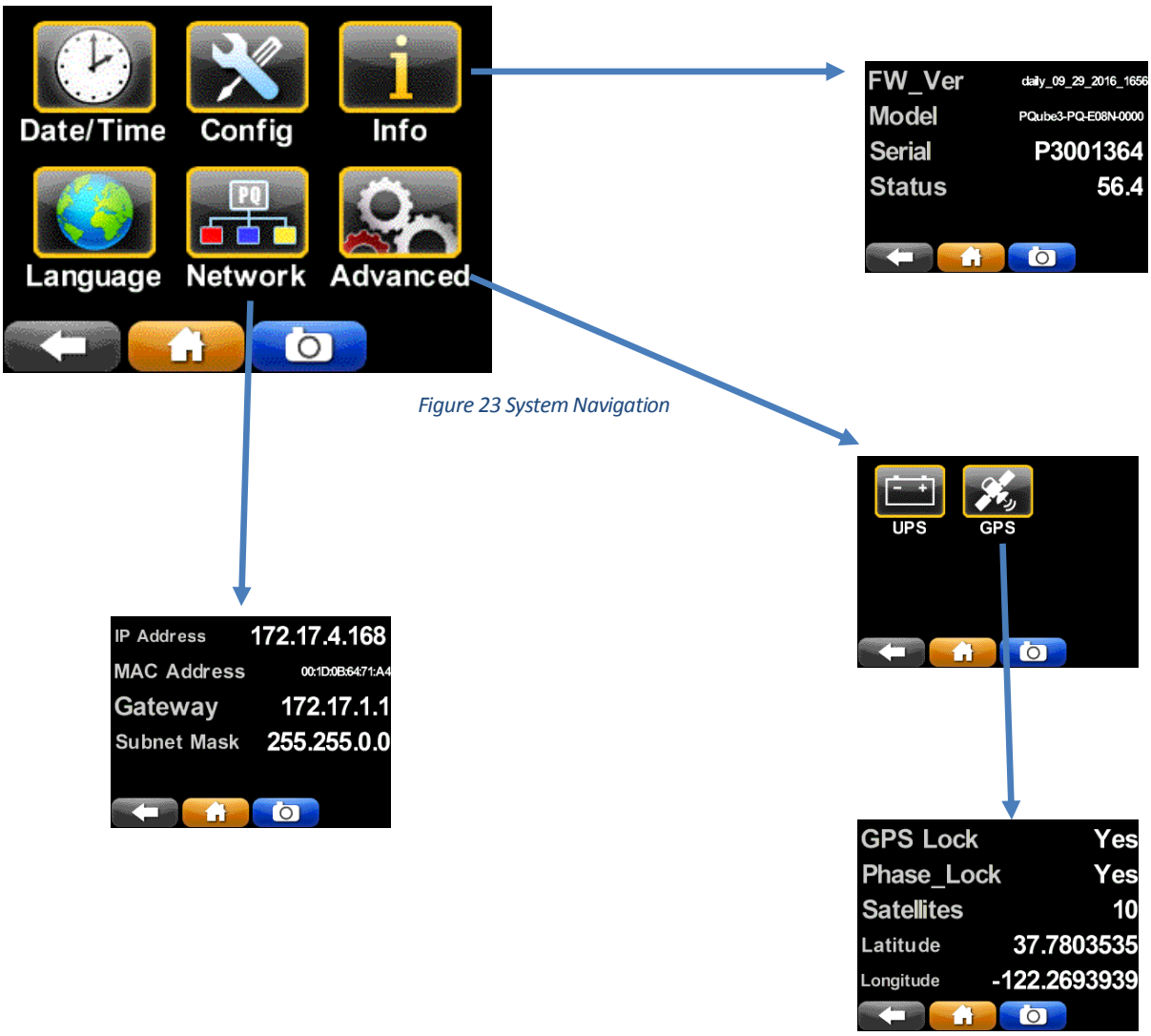


Figure 23 System Navigation

METERS

In this latest new firmware you can view the Voltage and Current magnitudes here.

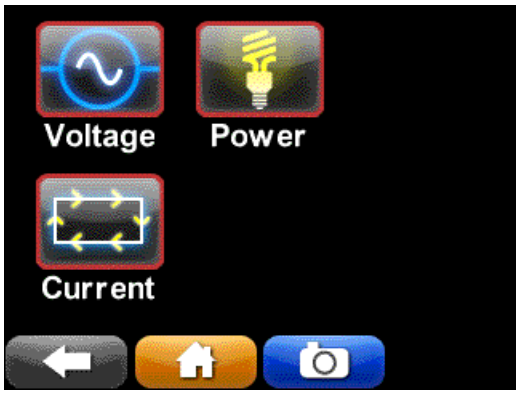


Figure 24 Electrical Metering

Figure 25 Voltage Metering

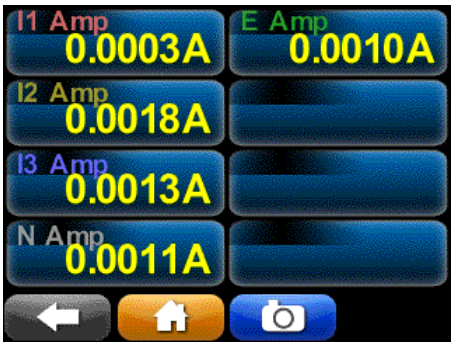


Figure 26 Current Metering

ACTIONS

Go to this screen to reboot the unit or eject USB drives.

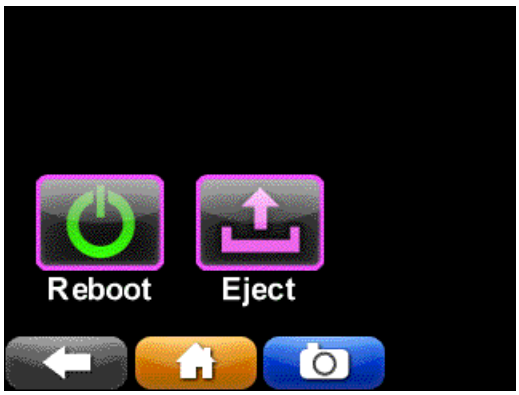


Figure 27 Actions Screen

4. Verify IP address

After updating the firmware and setup file, the first thing you should verify is that the IP address is correct. From the main menu, go to System, then Network.

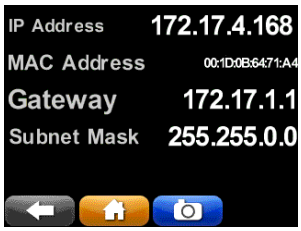


Figure 28 Network Address Screen

5. Verify GPS lock status

If this is your first time turning on your microPMU, it may take up to 1 hour for it to obtain GPS and phase lock. From the main menu, go to System, Advanced, then GPS.

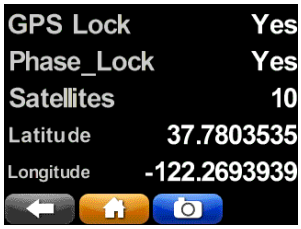


Figure 29 GPS tracking details

You need to wait until both the GPS Lock and Phase Lock fields read Yes. At this moment your microPMU has synchronized its internal timing mechanisms to GPS and it will automatically begin generating phasor data.

Accessing Data From Your microPMU

Access the web interface

Type in the IP address of your microPMU in the web browser, and the main Status page will be displayed. The PQube ID, Location Name, Note 1, and Note 2 values that you entered in your setup file will appear on the main status page. Figure 19 Configuration Web page.

The magnitudes of your voltages and currents, as well as the mains frequency are available from the Meters page shown below in Figure 30 Web Metering page.

From the Commands page you can perform system tasks including system reset, uploading a new setup file, and updating the firmware.

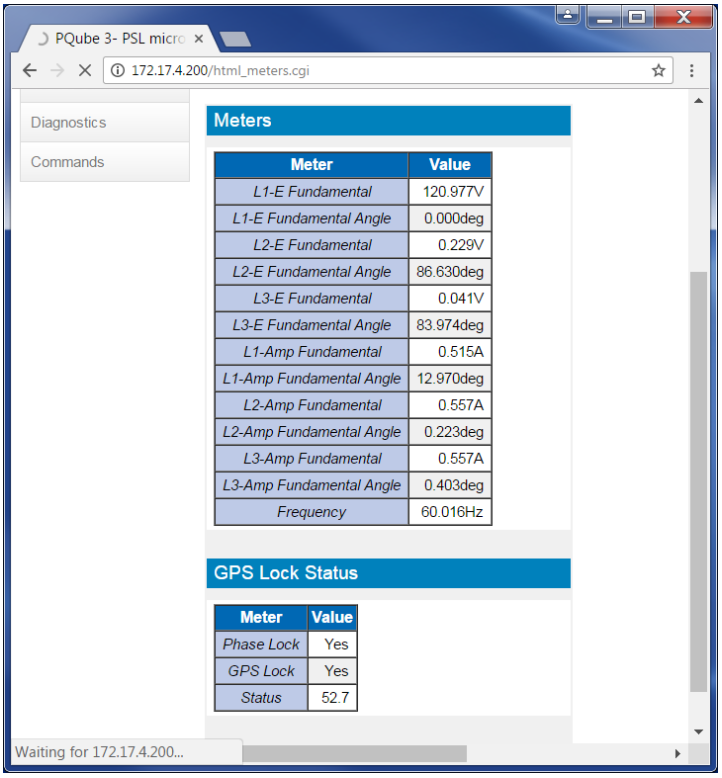


Figure 30 Web Metering page

Binary files

Your microPMU automatically saves phasor data to disk as binary files. These binary .dat files are stored in folders that are sorted by Year, Month, Day, and Hour. You can access these files via FTP.

By default, each binary file contains 5 minutes of data. You can change the interval in the MicroSynchrophasor_Settings section of your setup file.

Your microPMU has a built-in FTP server which you can access using an FTP client. PSL recommends FileZilla, available as a free download from https://filezilla-project.org/ .

Your microPMU has a built-in plain FTP server which you can access using any standard FTP client.

There are 5 different FTP accounts available.

1. ftp_user_1, ftp_user_2, ftp_user_3
Use these accounts to access events, trends, and logs.

2. ftp_config
Use this account to upload a new setup file. After the upload is complete, your microPMU will automatically reboot and load your new settings. You can also retrieve your microPMU's existing setup file using this account.

3. ftp_updater
You can upload new firmware to your microPMU using this account. After the upload is complete, your microPMU will automatically reboot and install the new firmware.

By default, each FTP account is disabled. To enable access for a particular account, you will need to specify a password for that account.

In the microPMU Configurator program, go to the Network Setup tab and locate the FTP Profiles section.

Select the FTP account you would like to use, and hit the Enable button. Specify a password (at least 8 characters long) and save your Setup file. After uploading your setup file, that FTP account will be available for you to use.

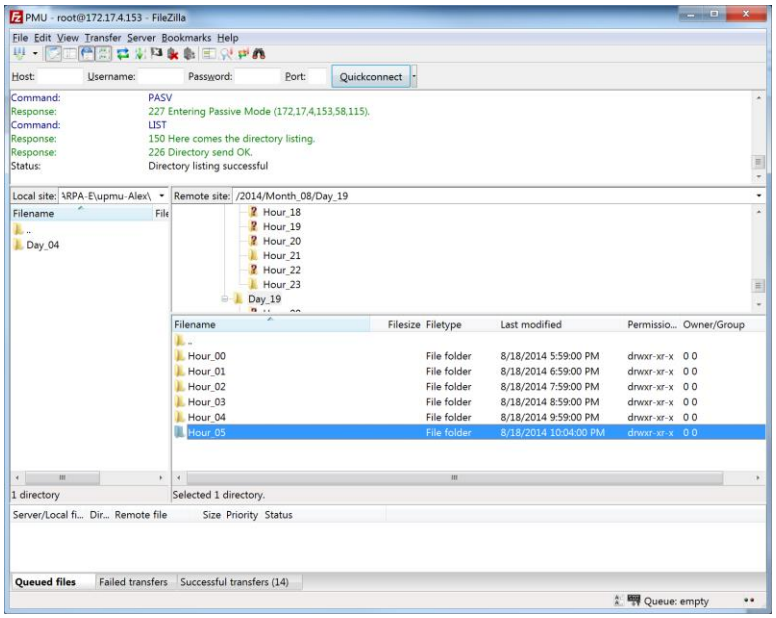


Figure 31 Location of binary .dat files

Converting the binary data to CSV

Ultimately, the binary data will be directly imported into a database. In the meantime, we have prepared a simple conversion program that will transform the binary files into CSV format, which you can open in Microsoft Excel.

Download **Binary .dat to .csv file converter.exe** from the provided link below.

http://www.powersensorsltd.com/outputs/PSL%20microPMU%20Binary%20File%20Conversion%20Utility%20v0.1.exe

1. Enter the serial number of your microPMU in the first field
2. Choose the folder on your PC where the binary files are stored
3. Choose a destination folder for your CSVs
4. Press the **Convert .dat files to .csv files** button

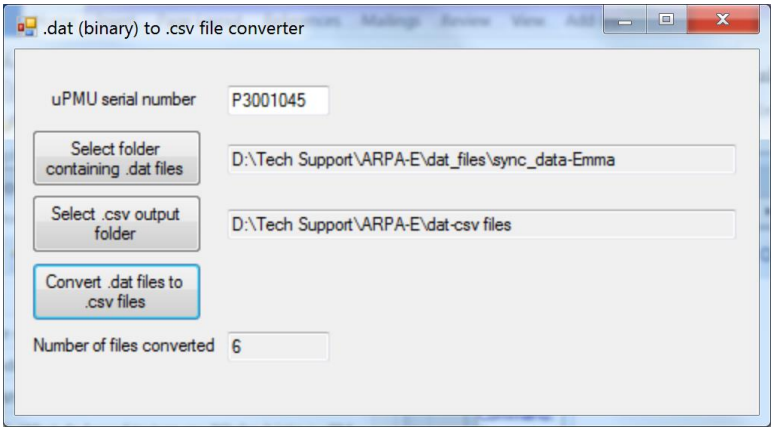


Figure 32 Binary to csv converter

In the destination folder, you will find CSV files each spanning 5 seconds. The file-naming convention is YYYYMMDDHHMMSS-P300xxxx.

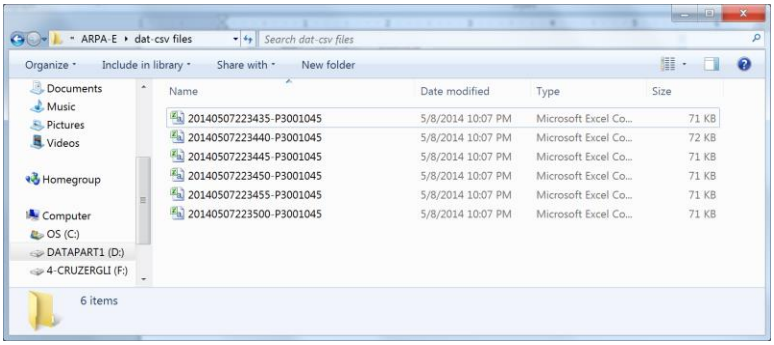
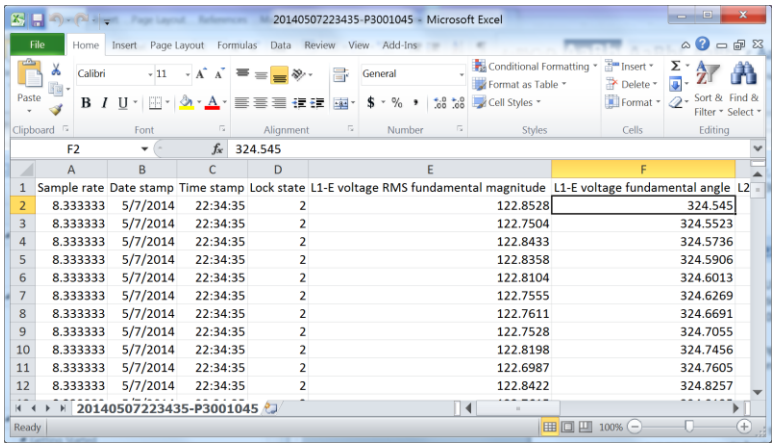


Figure 33 Converted csv files

Description of binary files

As soon as the microPMU begins running, it will start generating the binary .dat files. The file-naming convention is sync_data_sec_#.dat. Each file spans 5 seconds at the absolute time clock (12:00:00, 12:00:05, 12:00:10, and so on).

We record 120 phase angle measurements per second, so each file should contain 600 measurements, assuming data was recorded for the entire time period.



	A	B	C	D	E	F	
1	Sample rate	Date stamp	Time stamp	Lock state	L1-E voltage RMS fundamental magnitude	L1-E voltage fundamental angle	L2
2	8.333333	5/7/2014	22:34:35	2	122.8528	324.545	
3	8.333333	5/7/2014	22:34:35	2	122.7504	324.5523	
4	8.333333	5/7/2014	22:34:35	2	122.8433	324.5736	
5	8.333333	5/7/2014	22:34:35	2	122.8358	324.5906	
6	8.333333	5/7/2014	22:34:35	2	122.8104	324.6013	
7	8.333333	5/7/2014	22:34:35	2	122.7555	324.6269	
8	8.333333	5/7/2014	22:34:35	2	122.7611	324.6691	
9	8.333333	5/7/2014	22:34:35	2	122.7528	324.7055	
10	8.333333	5/7/2014	22:34:35	2	122.8198	324.7456	
11	8.333333	5/7/2014	22:34:35	2	122.6987	324.7605	
12	8.333333	5/7/2014	22:34:35	2	122.8422	324.8257	

Figure 34 microPMU converted data

Using PMU Connection Tester

The connection tester can be downloaded from the link below;

https://pmuconnectiontester.codeplex.com/

1. Configure PMU Connection Tester

From the Settings tab, set the following options:

'Force IPv4' to True and 'SkipDisableRealTime' to True as shown below

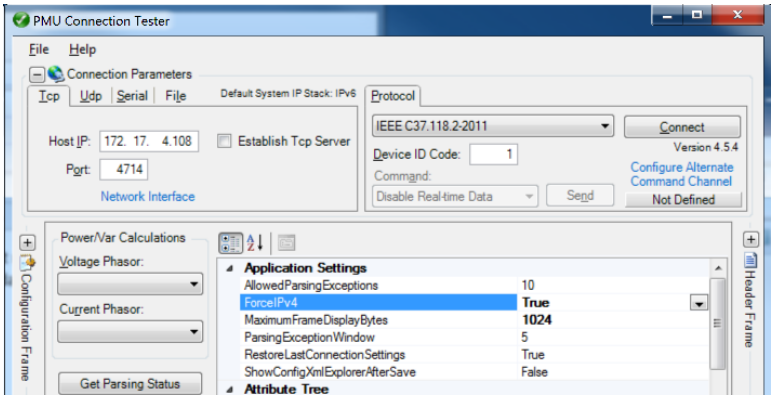


Figure 35 microPMU Connection Test (settings A)

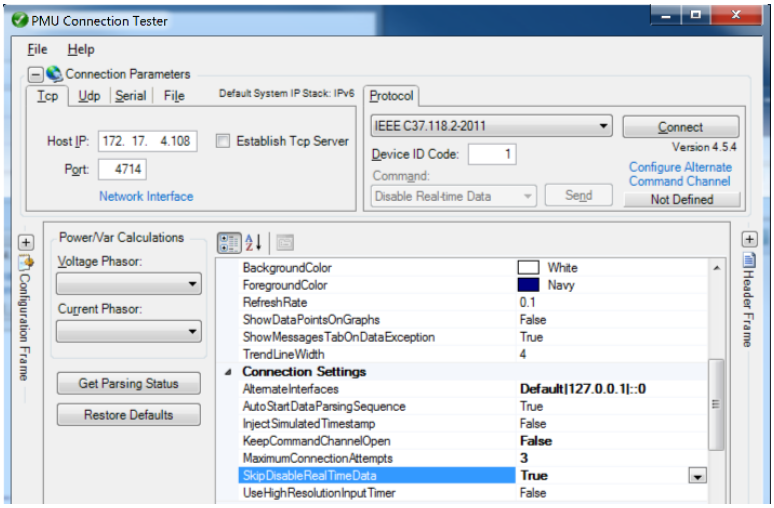


Figure 36 microPMU Connection Test (settings B)

2. Set the Connection Parameters

At the main window, enter the IP address, Port, and Device ID Code of your microPMU. Select IEEE C37.118.2-2011 protocol from the dropdown.

If you don't know your IP address, go to System, then Network. Device Port and Device ID Code are defined in the C37_Communications_Settings section at the bottom of your Setup.ini file.

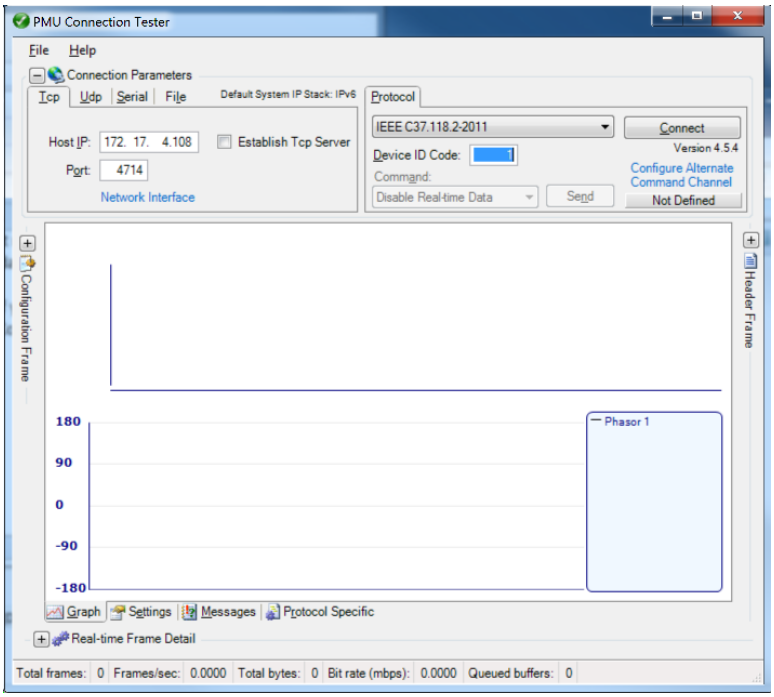


Figure 37 microPMU server connection settings

Underneath Port, click Network Interface and make sure the proper network adapter is selected.

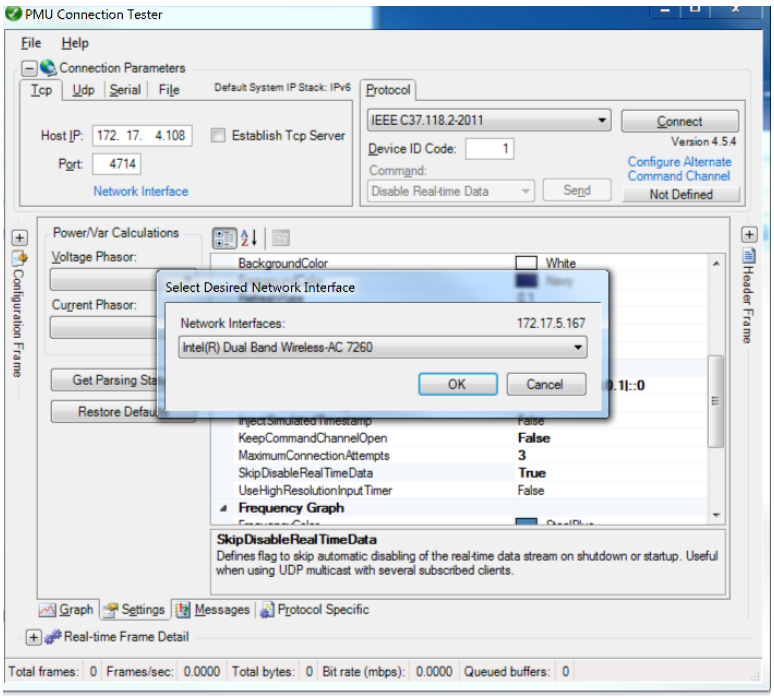


Figure 38 Network Adaptor Settings

3. Turn on the datastream

Press Connect to watch the dataframes begin streaming into the program.

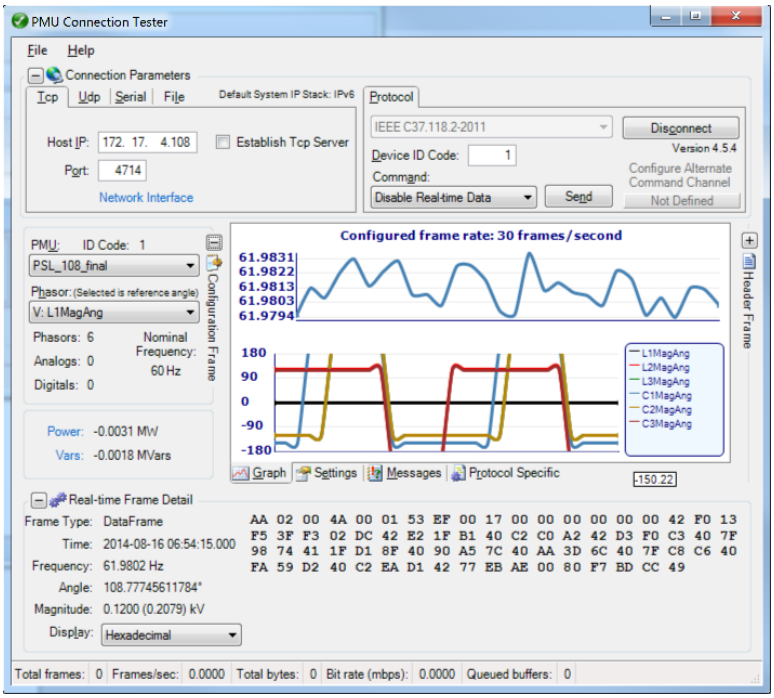


Figure 39 Datastream

Setting Up OpenPDC

1. Wait for Meters to appear on web page

After you have uploaded the latest firmware and setup file, launch the webpage and go to Meters. Assuming you have voltage connected to the mains AC terminals, you'll see some values appear after several minutes.

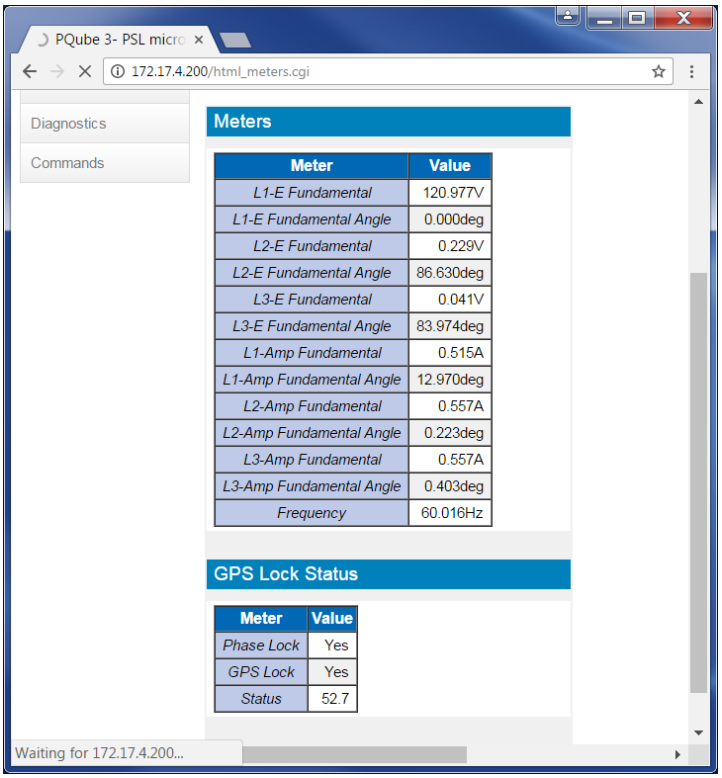


Figure 40 Metering page

When values appear in the Meters page, this means your microPMU has synchronized to a sufficient number of GPS satellites and the various internal processes have synchronized enough to the point where you can start viewing phasor data.

2. Add a new input device to OpenPDC

Launch OpenPDC Manager. From the main menu, go to Inputs, Input Device Wizard.

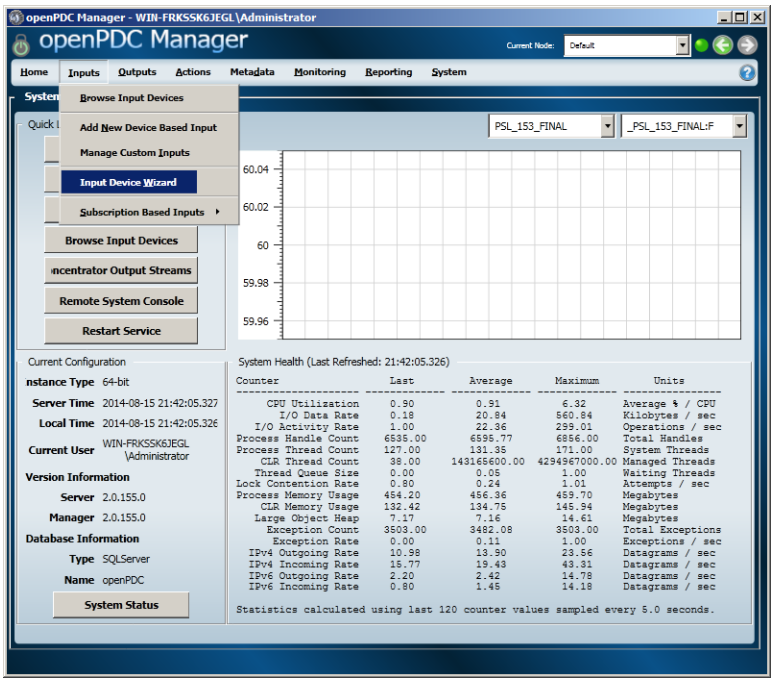


Figure 41 Open PDC manager

3. Set the network connection string

Click on the Connection String icon.

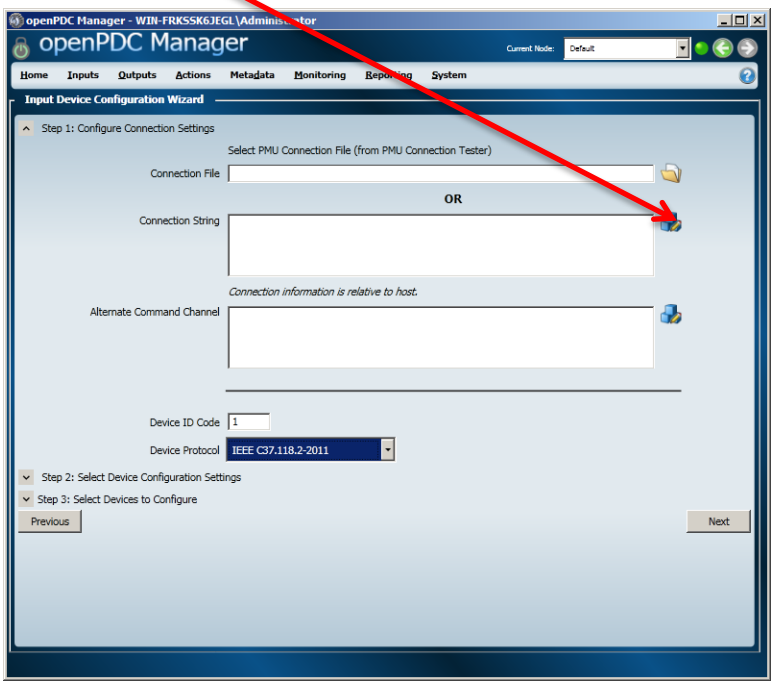


Figure 42 Network Connection String

Enter all of the network parameters for your microPMU and hit Save. Make sure Force IPv4 is checked.

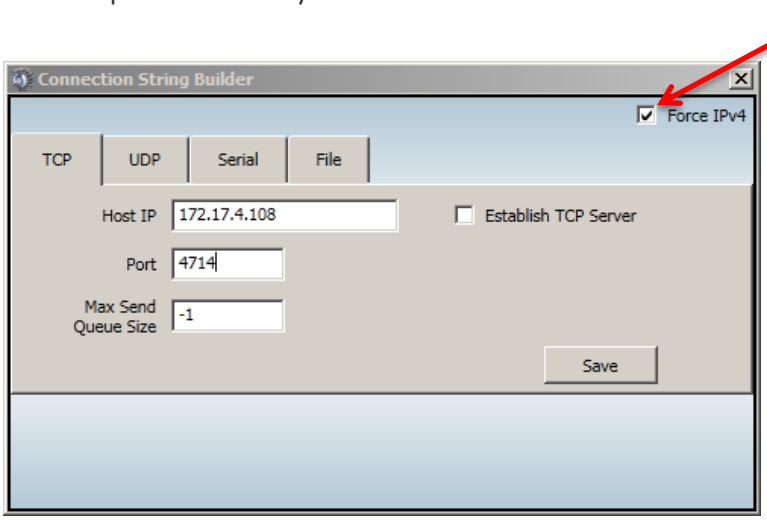


Figure 43 IPv4 settings

4. Set ID Code and Protocol

Back at the Input Device Wizard window, set the Device ID Code and choose IEEE C37.118.2-2011 as the Device Protocol. Then click Next;

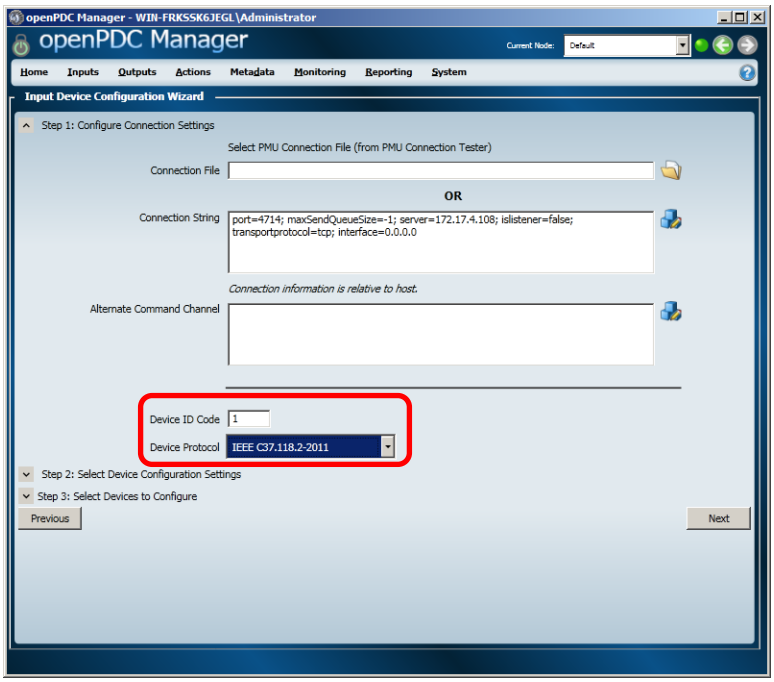


Figure 44 Device ID Code and IEEE C37 settings

5. Request Configuration from your microPMU

At Step 2, click Request Configuration and you should see a successful confirmation window.

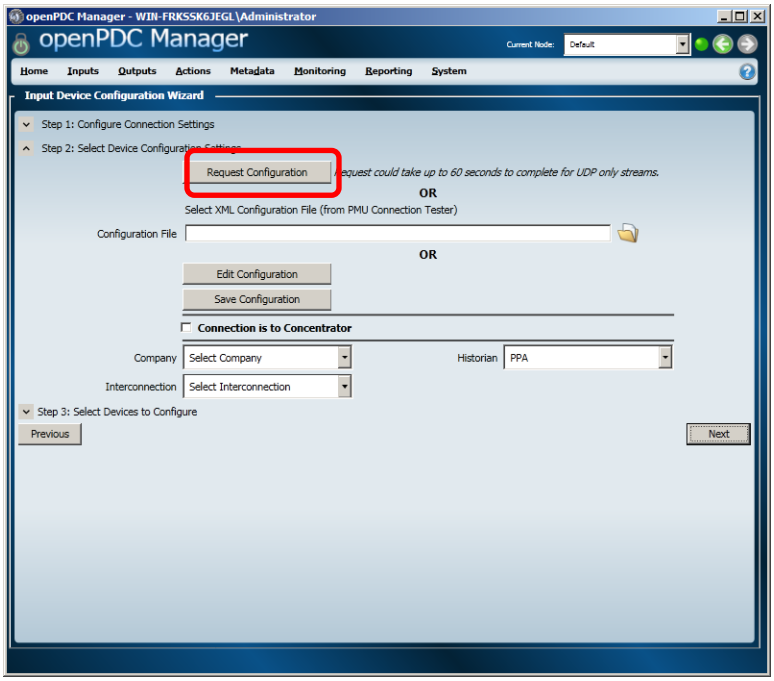


Figure 45 Configuration Request

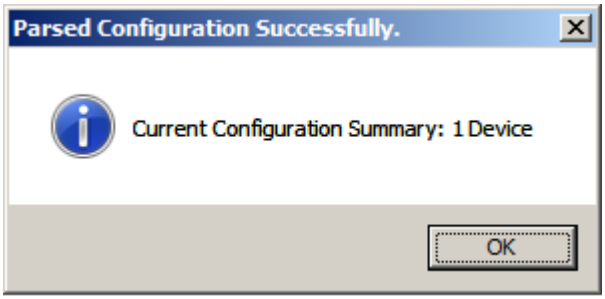


Figure 46 Configuration Summary

Hit Next after receiving the configuration from your microPMU.

6. Finalize Configuration

OpenPDC will automatically import the name specified in the Station_Name tag from your setup file, but you can change it here if necessary.

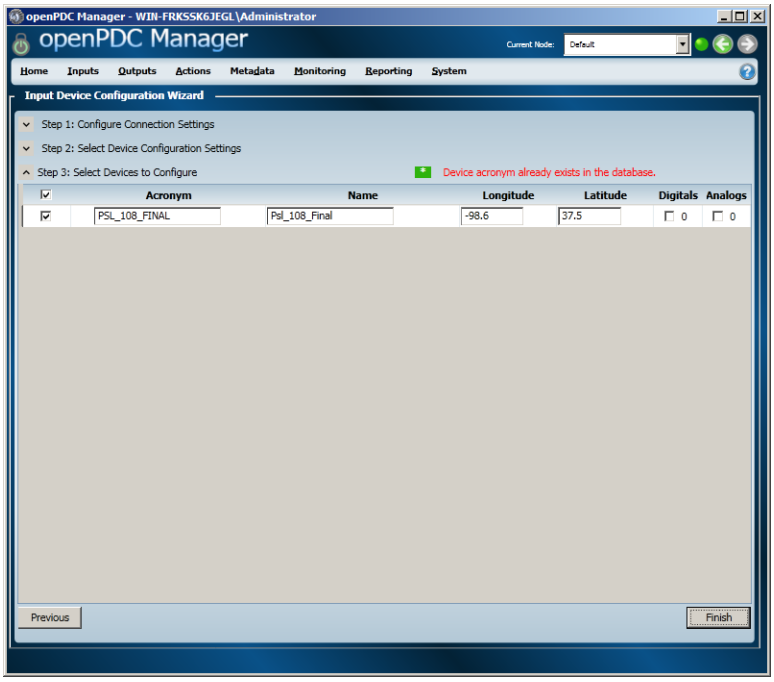


Figure 47 Finalizing Configuration

When you are done, hit Finish to save the device configuration.

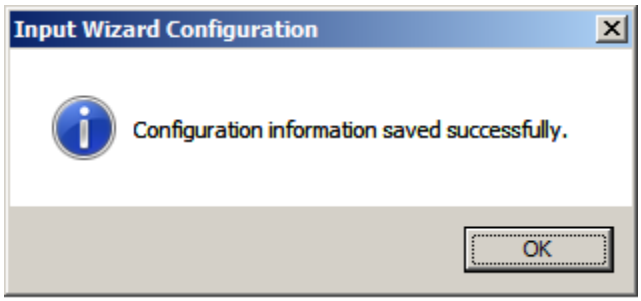


Figure 48 Successful Configuration

7. Edit Device Configuration

From the main menu, go to Inputs, then Browse Input Devices. You will see the microPMU that you just added in the previous step. Click on the Station Name of your microPMU.

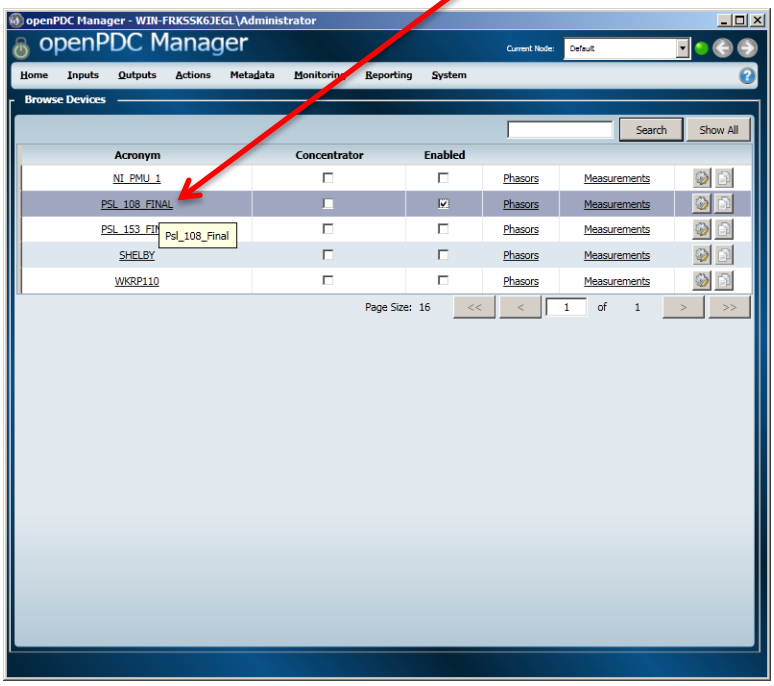


Figure 49 Editing Device Configuration

Make sure Skip Disable Real-time Data is checked. Hit Save when completed.

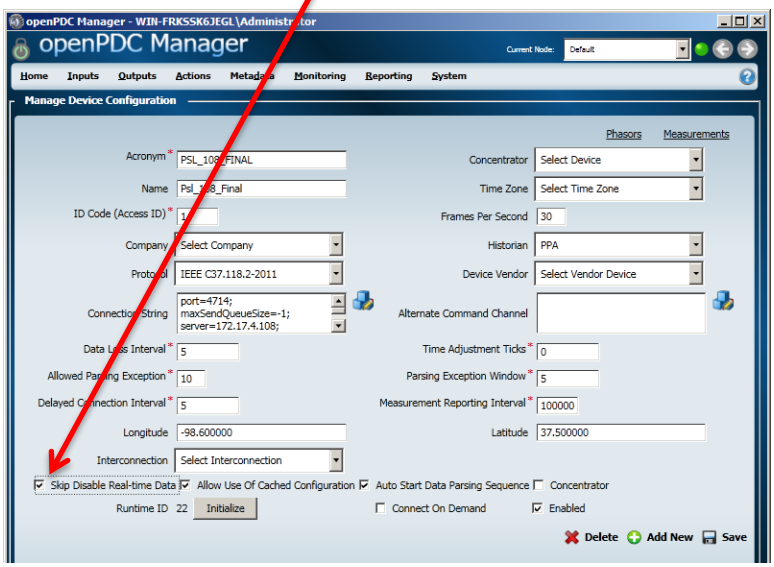


Figure 50 Open PDC 'skip disable real-time data

Check the Enabled box to begin streaming data from your microPMU to OpenPDC.

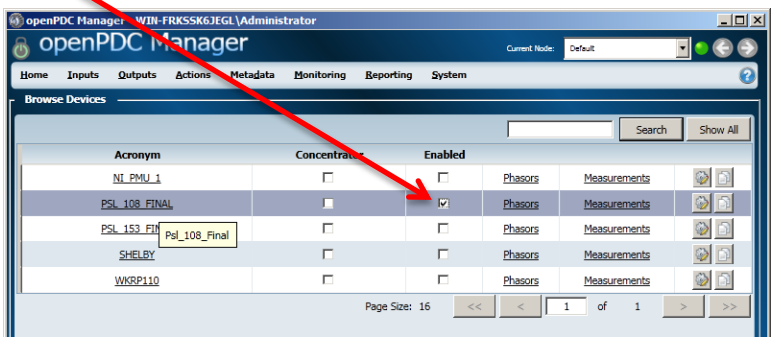


Figure 51 Data streaming

IMPORTANT! If you wish to stop the datastream, you will have to come back to this window and uncheck the Enabled box. Simply closing the OpenPDC Manager will not stop the datastream.

8. Verify the data coming in from your microPMU

From the main menu, go to Monitoring, then Monitor Device Outputs. After 5 seconds you will see some values coming in from your microPMU.

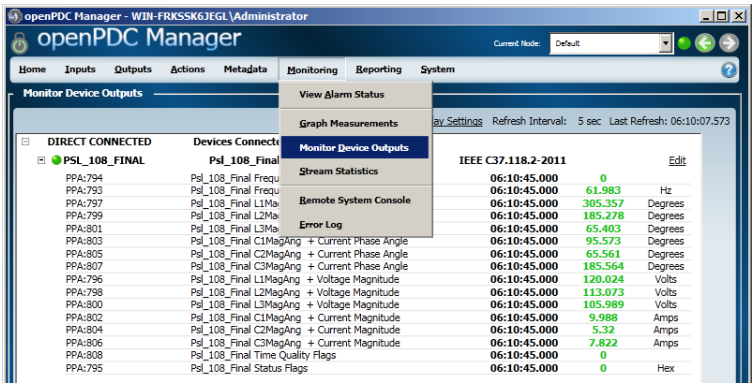


Figure 52 Monitor Device Outputs

Then go to Monitoring, and Graph Measurements. Check the desired parameters in the left frame and you will automatically see the graph update with the selected parameters.

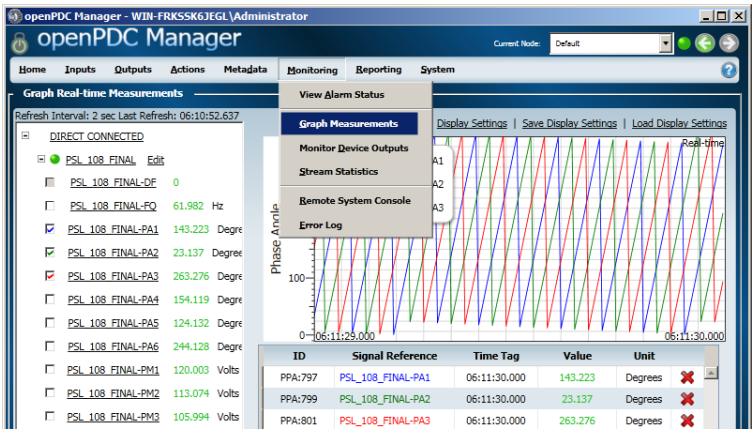


Figure 53 Graphical measurements

Questions? Contact us at support@powerstandards.com.

Maintenance

Turning Off Your microPMU

Your microPMU is designed to be a permanently installed monitor. It does not have an on/off switch because it is designed to run continuously. If you need to turn off your microPMU, remove instrument power (either the power screw terminals on your microPMU, the optional PM1 Power Supply Module, or both). Your microPMU will automatically initiate graceful shutdown to prevent any write damage to flash. If you have a UPS module installed, your microPMU will continue to run for the allotted amount of time (30 minutes by default). To immediately power down your microPMU while on backup power from the UPS module, go to the Actions screen and press Reboot.

Replacing Your microPMU's Battery

Your microPMU uses a user-replaceable, non-rechargeable lithium-manganese coin cell battery to back up the system clock in the event of instrument power loss. PSL recommends replacing this battery every 10 years. Before replacing the lithium battery, always remember to power off the device first, disconnect mains connections, and verify disconnections.

To replace the battery, insert a small flat-head screwdriver to pry up the label near the USB port and microSD card slot. Remove the old battery and install the new one. It is not possible to install the battery with the wrong polarity.

Follow all applicable federal, state, and local regulations when disposing of the used battery.

Disconnect power to the device before replacing the battery.

Replace battery with Renata, Type CR2477N only. Use of another battery may present a risk of fire or explosion. This part must be supplied only by PSL or PSL agents.

Cleaning Instructions

If necessary, wipe the accessible parts of your microPMU with a slightly damp cloth. Do not use abrasives or chemical cleaners.

Micro-PMU Specifications

Reference conditions for factory tests: 19~25°C, 10%~60% RH, steady-state 10/12 cycle signals. ±1/2 display count on all accuracies

MAINS VOLTAGE MEASURING CHANNELS	
Connection	L1, L2, L3, N PQube3 screw terminals (max torque 5 inch-pounds (0,6Nm))
Frequency Range	Nominal 50 Hz, 60 Hz.
Mains Configuration	Single-phase, split-single-phase, delta, wye/star. User selected or auto-selected.
Range of Nominal Input Voltage	100 VAC ~ 960 VAC L-L (69 VAC ~ 480 VAC L-N). User selected or auto-selected.
Measurement Channels	Line-to-Earth, Neutral-to-Earth
Sampling Rate	25,600 s/s @ 50Hz and 30,720 s/s @ 60Hz
Measurement Range	0 VAC ~ 750VAC L-N (0 VAC ~ 1300 VAC L-L)
Isolation	PQube3 tested up to 5100VAC isolation to Earth. UL/IEC 61010 test pending.
Installation Category	CAT IV UL/IEC 61010 for voltages up to 300 VAC L-N (equivalent to 480 VAC L-L), CAT III for voltages up to 600VAC L-N. Pollution degree 2. UL/IEC 61010 test pending.

CURRENT INPUT CHANNELS	
Measurement Type	External current transformer, voltage-type secondary – Screw terminal (Max torque 2 inch-pounds (0,25Nm))
CT Input Ratio Range	1:1 to 50000:1
Nominal Input	0.333 V RMS
Input Impedance	33.3kΩ
Crest Factor	3.5 (±1.17 Vpk)
Sampling Rate	Same rate as mains voltage measuring channels
Wire Connection	Min. 28AWG (0,8 mm²), Max. 16AWG (1,31mm²). 600V UL- recognized insulation required

POWER MEASUREMENTS	
Definitions	
Watts (power)	Sum of true instantaneous per-phase power.
Volt-Amps (apparent power)	Sum of per-phase product of RMS voltage and RMS current, taken over the measurement interval.
Power Factor	True power factor—ratio of Watts to Volt-Amps
VARs (volt-amps reactive)	Fundamental VARs
INSTRUMENT POWER SUPPLY	
PQube 3 main power supply (Screw Terminals)	(AC or DC) PQube3 POWER screw terminals
AC Input Voltage Range	24VAC ± 10% 50/60 Hz
AC Input Current Rating	1.5A

DC Input Voltage Range	±24-48VDC ±10% (polarity independent)
DC Input Current Rating	1A
Power Consumption	20W max
Isolation	>150VDC isolation to all other circuits
PQube 3 – POE - Power Over Ethernet	
Input Voltage Range	37-57VDC
Power Consumption	15W max
PM1 Power Manager Module (optional)	
AC Input Range	100~240VAC ± 10%. 50/60 Hz
AC Input Current Rating	400mA
Auxiliary DC Power Output	24VDC isolated, up to 5.15W max
Power Consumption	20W max

COMMUNICATIONS

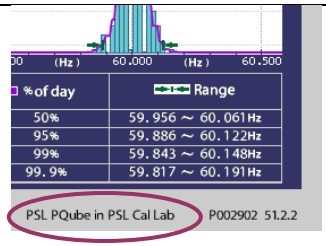
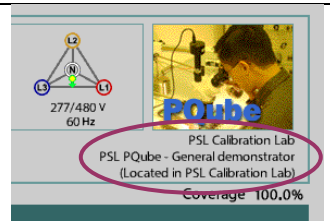
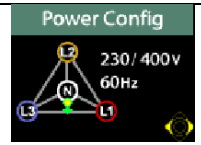
RJ-45 Ethernet	
Connection	Standard RJ-45 socket (wired Ethernet).
Protocols	.
Web Server	Real-time meters. All events, trends and statistics recordings. Includes GIF graphs, CSV spreadsheet files, PQDIF, HTML and XML summaries.
FTP Server	File Transfer Protocol. Transfers files from PQube3 SD card to and from any computer.

OPERATING ENVIRONMENT

Ambient Conditions - Operating	Minimum -20°C, Maximum 45°C at 9W power draw, derate to 40°C at 15W power draw, 5% RH ~ 95% RH non-condensing, indoor use
Altitude	Maximum 2000 meters above sea level
Overvoltage Category	For mains measuring terminals, Overvoltage Category III. For PM1 input terminals, Overvoltage Category II.
Pollution Degree	2
Transient Voltages	100kHz ring wave, 6 kV pk, IEC 61180, IEC 61000-4-5. Applied to voltage measuring terminals with Performance Evaluation Class 1. (When applied to optional power supply mains terminal, supply's fuse may operate in PE Class 3 at test levels greater than 4 kV.)
EFT Burst Immunity	4 kV pk, IEC 61000-4-4, Performance Evaluation Class 1. Applied to power measuring terminals and optional PS1 power supply mains terminals.
RF Field Strength Immunity	3V / m, IEC 61000-4-3 Test Level 2.
Magnetic Field Strength Immunity	30A / m, IEC 61000-4-8 Test Level 4.
Ingress Protection Rating (IP Rating)	IP20H, IEC 60529.

Appendix 1: Setup File Guide

Device Setup

Setup.ini Tags	Comments	Valid Values	Example
[PQube_Information]	General Information about your PQube		
PQube_ID="PSL PQube in PSL Cal Lab"	The unique identifier will appear on all output information. Quotation marks (") are required.	Any combination of letters, numbers, spaces and special characters up to 63 characters	
Location_Name="PSL Calibration Lab" Note_1="PSL PQube – General Demonstrator" Note_2="(Located in PSL Calibration Lab)"	Appears on all Event/Snapshot and Trends and Statistics recordings. Quotation marks (") are required.	Any combination of letters, numbers, spaces and special characters up to 63 characters	
Power_Configuration=AUTO* *AUTO not yet available for this tag	Set this tag to AUTO if you want your PQube to automatically choose its Power Configuration based on the voltage it finds on its input terminals when it starts up. Alternatively, you can specify exactly which power configuration you would like your PQube to lock onto.	AUTO* Single_Phase_L1_N Single_Phase_L1_L2 Split_Phase Star Wye Delta	
Time_Zone=PST	Enter the time zone where your PQube is located. UTC sometimes called Greenwich Mean Time (GMT)	Any combination of 3 or 4 capital letters	

Offset_From_UTC_In_Hours=	Choose the number of hours your PQube should add or subtract from UTC to calculate your local time, if you are using SNTP protocol to set your PQube's time. For example, the offset from UTC in Pacific Standard Time is -8.	-12 to +13	
[Nominal_Inputs]			
Nominal_Phase_To_Phase_Voltage=AUTO* Nominal_Phase_To_Neutral_Voltage=AUTO*	By default, your PQube will automatically detect your nominal voltage if it is one of the following: Phase-Neutral 69V, 120V, 230V, 277V, 350V, or 400V Phase-Phase 69V, 100V, 200V, 208V, 240V, 400V, 480V, 600V, or 690V If using Potential Transformers, you will need to enter the nominal voltage multiplied by the ratio. *AUTO not yet available for this tag	AUTO* Any number between 50 to 400 for Phase-Neutral Any number between 50 to 690 for Phase-Phase	Nominal_Phase_To_Phase_ Voltage=**110** If using a 1000:1 Potential Transformer: Nominal_Phase_To_Phase_Voltage= **110000**
Nominal_Frequency=60*	Set your nominal frequency if it is 50, 60Hz.	50 60	
[Channels]			
Record_Phase_To_Phase_Channels=AUTO Record_Phase_To_Neutral_Channels=AUTO	If your Power Configuration includes a neutral conductor, your PQube will automatically be set to record Phase-Neutral channels. If your Power Configuration includes multiple phases, it will automatically record Phase-Phase channels in the Meters (on display, webpage, and Modbus), GIFs, and CSV files.	AUTO ON OFF	
[Measurement_Setup]			
Current_Range="HIGH"	By default, ranges are set to HIGH..	HIGH LOW	

	For current, HIGH range = ±10V peak. LOW range = 0.333Vrms.		
[Potential_Transformers]	This allows you to express amplitudes measured at the primary of the transformer.		
Potential_Transformer_Ratio=1:1	You can use fractional values such as 1250.5:120. The PT ratio will appear on the display, webpage, and the CSV header. If the PT ratio is high enough, your PQube will automatically switch the units to kV or MV.	From 1:1 to 50000:1	
[Current_Transformers]	Allows you to express the amplitude of currents measured at the primary of the current transformer.		
Current_I1_Transformer_Type=CT Current_I2_Transformer_Type=CT Current_I3_Transformer_Type=CT Current_Transformer_Ratio=1:1	When using PSL CTs with 0.333V secondary rating, the second number is the voltage. You can use fractional values such as 100.35:0.333 If the CT ratio is high enough, your PQube will automatically switch the units to kA.	From 1:1 to 50000:1	

Network Configuration

Setup.ini Tags	Comments	Valid Values	Example
[Network_Setup]			
IP_Address_Method=Use_DHCP	If you are automatically assigned an IP address by your network, use DHCP. If you are using a static IP, use Fixed IP.	Use_DHCP Use_Fixed_IP	
[Fixed_IP]			
IP_Address= IP_Mask= IP_Gateway= IP_DNS1= IP_DNS2=	Enter your IP address information here. This information is ignored if DHCP is selected.		
[HTTP_Web_Server_Settings]			
HTTP_Web_Server_Commands_Page=ON	Enable your microPMU's HTTP Web Server command page	ON OFF	
Web_Server_port=DEFAULT			
Require_HTTP_Authorization=OFF HTTP_User_Name= HTTP_Password=	Restrict general access to your microPMU's Web Server		
Require_HTTP_Admin_Authorization=ON HTTP_Admin_User_Name=admin HTTP_Admin_Password=admin	Restrict access to the Commands section of your microPMU's Web Server.		
[FTP_Settings]			
FTP_Control_Port=21 FTP_Data_Port=20	FTP control and Data ports, the default control port is 21, the default data port is 20	Valid values [1-65535]	

FTP_Password_1= FTP_Password_2= FTP_Password_3= FTP_Password_4= FTP_Password_5=	------ make sure that the port chosen does not conflict with reserved ports and other services ports; e.g.Web server, HTTP … ; ------ Password for profile "ftp_user_1" ; ------ Password for profile "ftp_user_2" ; ------ Password for profile "ftp_user_3" ; ------ Password for profile "ftp_config" ; ------ Password for profile "ftp_updater" There are 3 user accounts for downloading data : "ftp_user_1" , "ftp_user_2" and "ftp_user_3" Account "ftp_config" - for reading and sending the PQube3 setup.ini files Account "ftp_updater" - for sending firmware updates	If no password is assigned for a profile, the user does not have access - Password must be at least 8 characters	
[Security_Settings]			
Enable_Firewall=ON	This enables or disables the embedded PQube3 firewall. The firewall will close all ports except the ports being used by the PQube3. The firewall will limit the number of external attempts to open ports for a given period of time, therefore protecting against attacks from the Internet.	Valid values: ON, OFF, default is ON	
Require_WebServer_Security=OFF	Turning this Security tag ON makes the microPMU's web pages accessible only via secure HTTP (HTTPS) this applies to all pages, including the command page. Turning this Security tag ON changes the HTTPS port to 443 If the tag is turned OFF, then the Web pages are accessible via non secure (HTTP)	Valid values: ON, OFF, default is OFF	

Require_FTP_Security=OFF	; ------ Turning this tag IMPLICIT or EXPLICIT makes the microPMU's FTP server accessible only via secure FTP (FTPS). This applies to all FTP profiles (user, config, and update profiles). The FTP ports specified in the FTP section are used See the FTP_Settings section for more information about profiles If the tag is turned OFF, then the Web pages are accessible via non secure (FTP) or secure (FTPS)	Valid values: OFF, IMPLICIT, EXPLICIT, default is OFF	

Micro Synchrophasor Measurement Configuration

[MicroSynchrophasor_Settings]			
SynchrophasorMode=ON	Toggle phasor data measurements ON or OFF.	Valid values: ON, OFF	
Phasor_Measurements_Per_Second=120	Set the rate at which your µPMU measures and records phasor data.	Valid values for 50Hz systems: 10, 25, 50, 100 Valid values for 60Hz systems: 10, 12, 15, 20, 30, 60, 120	
Binary_File_Recording_Period_In_Minutes=1	Set the recording period of the binary archive files that are written to disk.	Valid values: 1, 2, 3, 4, 5, 6, 10, 12, 15;	
Phasor_Measurement_Group_Delay_In_Microseconds=0	Compensate for delays in the data acquisition chain, including all filters and estimation windows in effect.. (This is the GRP_DLY field as defined in IEEE C37.118.2-2011 configuration frame 3.)	Enter AUTO to have MicroPMU measure the GPS cable delay	
PMU_GPS_Cable_Length_In_Meters=AUTO	Compensate for GPS cable.	Valid values: AUTO, 0-999999, default value: AUTO	
PMU_Channel_Configuration=Config1	-- Config1 sets voltage measurements to L1, L2, L3, current measurements to I1, I2, I3 -- Config2 sets voltage measurements to AN1, AN2, AN3, current measurements to I1, I2, I3	Valid values: Config1, Config2, Config3, Config4-	

	-- Config3 sets voltage measurements on L1, AN1, AN2, current measurements on I1, I2, I3 -- Config4 sets voltage measurements to L1, L2, L3, current measurements to A1, A2, A3		
Enable_Frequency_And_Power_Recording=ON	-- Add frequency and total W, VA, VAR, and dPF to microPMU data.	Valid values: ON, OFF	

C37 Protocol configuration

[C37_Communications_Settings]			
Enable_C37_Datastream=ON	Enables the C37.118 protocol	Valid values: ON, OFF	
Station_Name=PSL_UPMU	Assign a unique identifier for your microPMU. This name will appear in your phasor data concentrator software.	Valid values: PQube_ID, "any string"	
Device_ID_Code=1	Device ID as per C37.118	Valid values >0	
Device_Port=4713	Device ID as per C37.118		
C37_Reporting_Rate_In_Frames_Per_Second=60	Sets the rate at which the dataframes are transmitted to your PDC.	Valid values for 50Hz systems: 10, 25, 50, 100 Valid values for 60Hz systems: 10, 12, 15, 20, 30, 60, 120	

Communication with PSL microPMU Plotter Application

[microPMU_Database_Server_Settings]			
Enable_Push_Data_to_Database_Server=OFF	If you have a microPMU database server, enable this setting to automatically push data from your microPMU to the server	Valid values: ON, OFF	
Database_Server_IP_Address=	IP address of the		