

# PQube® 3 Power Analyzer

## Installation Manual

Revision 3.1



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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 PQube 3 must only be done by qualified personnel for electrical installations.

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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 <u>not</u> relied on for safety

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# 1 Introduction

## 1.1 What is a PQube® 3?

PQube® 3 is an instrument for both monitoring and diagnosing issues with electric power systems and sensing environmental conditions, helping you to quickly solve problems that impact the quality and reliability of your product or process.

Think of it as a black box for your electric power, environment and process: It is a unique combination of the best features of a power disturbance monitor, a power/energy meter, a process and environment data logger, and a digital fault recorder. It's easy to install, easy use. No special training is required, no software required.

### **What does the PQube 3 record?**

In a few words, your PQube 3 detects and records disturbances on the mains circuit: Sags/dips, swells, interruptions, frequency variations, HF impulses, Rapid voltage changes, waveform changes and more... It also records steady state power quality parameters like flicker, unbalance, THD harmonics and interharmonics. PQube 3 is compliant with the most stringent Power Quality measurement standards: Class A IEC 61000-4-30 Ed3 (2015).

The PQube 3 is one of the few analyzers that measure 2kHz-150kHz conducted emissions.

Your PQube 3 automatically generates daily, weekly, and monthly trends/statistics reports.

When connected to compatible current transformers, your PQube 3 records current waveforms, RMS magnitude, current unbalance and powers (watts, watt-hours, VAR's, power factor, and other power-related parameters). The PQube 3 can monitor power and energy on several circuits.

The PQube 3 when equipped with PSL ultra-precise CTs, is fully compliant with IEC 61000-4-30, edition 3 Class A certified requirements and can be used as a revenue grade Class 0.2 energy meter.

Your PQube 3 includes 4 general purpose channels for interfacing with many type of sensors (RPM, torque, flow, vibration...). It has a digital input, which can be used as an external trigger source, and a relay contact output, used to notify alarms to an external indicator or PLC (the relay opens for at least 3 seconds for any detected event).

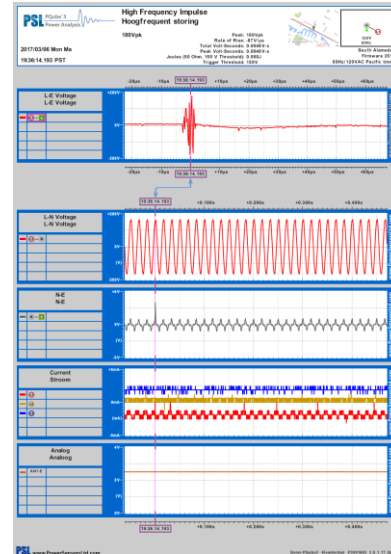
Your PQube 3, with up to 2 optional ENV2 environmental probes, can measure and trigger on temperature, humidity, barometric pressure and mechanical shocks, seismic disturbances and vibration.

## What software do you need?

You don't need special software to use your PQube 3. It records all data on internal memory plus a removable microSD card.

No special software is required – just open the GIF picture files with standard image programs, Microsoft Word® and Microsoft PowerPoint®, or open the CSV files with any spreadsheet program such as Microsoft Excel®.

You configure your PQube 3 with our free PQube 3 Configurator program.



## Which power configurations are supported?

Your PQube 3 can monitor circuits anywhere in the world (from single-phase, split-phase to various types of 3-phase configurations: wye, delta, open delta, corner grounded delta).

It can auto-detect nominal voltages from 57.5VAC up to 600 VAC phase-to-phase, 960VAC phase-to-phase. It can auto-detect mains frequencies of 16.7 Hz, 50 Hz, 60 Hz, and 400 Hz. For medium and high voltage applications, your PQube 3 supports PT ratios (up to 50000:1) and also CT ratios.

Beyond AC voltage, your PQube 3 can be used to monitor DC voltage at up to 60VDC, or up to 1200V DC with an optional interface module (ATT1). For both DC voltage and DC current use the ATT2 interface module. For example, which can be useful for applications such as monitoring photovoltaic generation sites or battery banks of UPS.

Your PQube 3 with an additional module (VAT1) can monitor both the input and output of a 3-phase UPS.

## How do I power my PQube 3?

It can be directly powered from 24V AC or 24~48V DC source.

If a network hub with Power over Ethernet is available, the PQube 3 can power from its Ethernet port (PoE).

If a wall power socket is available, you can power the PQube 3 with a snap-in PM1/PM2 module (range AC 100VAC ~ 240VAC, 50/60Hz, or 120VDC ~ 370VDC)

## Easy operation and communication with PQube 3?

No network is required to retrieve files from your PQube 3. Simply copy the data using a USB thumb drive or microSD card.

If a network connection is available, PQube 3 can automatically send you e-mails whenever it detects an event. You can use emails the PQube 3 to send a new setup file, and update its firmware. It

includes a built-in web server, FTP server, and supports communication protocols including MODBUS TCP/IP, SNMP and DNP3.

## 1.2 How is the PQube 3 Unique?

There are many power quality meters, energy meters, and energy recorders available. What makes the PQube 3 unique?

**No software. Open data.** – No specific software is required. All the data that the PQube 3 records are in standard easy to understand open formats. No need to buy or lease software from PSL, or pay a fee to see or use your data.

**Friendly data.** –Data is organized and presented to you in a format you can understand.

**Works out of the box, or you can customize your configuration** – Auto configuration, enables you to instantly measure and start recording data. You can change almost any setting using the PQube 3 Configurator program.

**Works with or without a network** – Plug the cable into your PQube 3's Ethernet port and get emails when an event occurs, use your Internet browser to navigate through recorded events and trends. Real time measurements are also available via communication protocols such as Modbus/TCP, SNMP (including traps), or DNP3.

Don't have a network? You can extract the data onto a USB thumb drive (or micro SD) and look at all the files on any computer without proprietary software.

**Store years of data in its internal flash memory.** – Your PQube 3 comes with an external microSD card which holds a backup for the internal memory. It automatically deletes the oldest data when it becomes full, so no maintenance is required. You can take this card with you while your PQube3 continues to measure and store recordings.

**Ultra-compact size** – The PQube 3 is tiny, making it easy to integrate into your equipment, enclosure, or electrical panel.

**Great value** – The PQube 3 provides high-end features at an affordable price.

## 1.3 Overview of PQube3 models and modules

PQube 3 comes in four versions:

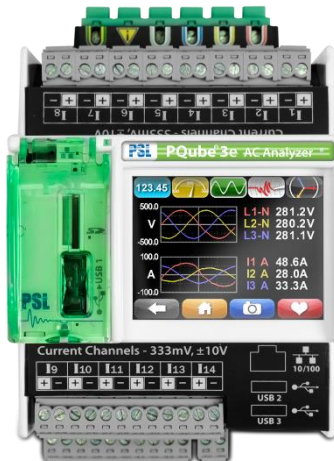
### 1.3.1 PQube 3



The PQube 3 is the most popular model (more details below) in the family. It is easy to setup and comes from the factory with a default setup so you can “plug and go” for most installations. It auto-detects the mains frequency, wiring configuration and nominal voltage. You can connect directly to up to 600 volts (nominal) and the device computes 4-quadrant ANSI Class 0.2 revenue-grade energy on eight single-phase channels and is certified for Class A power quality according to IEC 61000-4-30 Ed3

The PQube 3 holds years of data and thousands of events via 32 GB of internal flash memory.

### 1.3.2 PQube 3e



**PQube 3e** is identical to the PQube 3 and adds more metering channels. You can connect up to 14 energy metering channels – these can be configured in any combination of four three-phase loads or 14 single-phase loads. You can quantify energy costs with revenue-grade-accuracy ANSI Class 0.2 including CTs and simultaneously utilize the PQube 3e’s advanced Class A power quality monitoring.

Setup is identical to the PQube 3: Configure the additional channels at installation using the same Configurator tool as the PQube 3.



### 1.3.3 PQube 3v



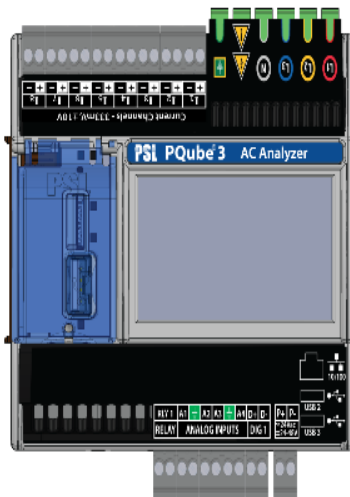
If you are focusing purely on voltage compliance the PQube 3v is the best value: It connects the mains voltage directly at up to 600VAC nominal.

The unit does a great job verifying electricity delivered at the point of common coupling (PCC), as well as diagnosing equipment malfunctions. It monitors AC power (or DC voltage), but you can also monitor process parameters like speed or flow, by attaching sensors to the analog AC/DC channels.

You get the same ultra-precise results delivered immediately to your inbox.

Setup is identical to the PQube 3: You only need configure voltage values and the unit uses the same easy-to-use Configurator tool.

### 1.3.4 PQube 3r



PQube 3r identical to PQube 3 and is your best choice for protecting sensitive processes that require recovery actions because of specific power disturbances. For example, a production line running a sensitive process where tools must be reset to a known state or the line must be properly shut down before the production process is restarted.

It features 3 additional trigger output relays to monitor sag/swells/interruptions, wave shape changes, high frequency impulses, over/inrush current.

Setup is identical to the PQube 3 and uses the same easy-to-use Configurator tool.

## 1.3.5 Modules and Accessories

Each PQube 3 comes standard with the following features:

- Three AC mains voltage channels
- Eight current channels (for CTs with 0.333V secondary), 14 channels for PQube 3e
- Four analog input channels for additional signals (for example, the output of a power supply)
- One digital input channel (monitor the state of an interlock switch)
- One signal output relay (notify your PLC that an event has occurred)
- Power supply input rated for 24VAC or 24-48VDC
- One 10/100 Ethernet port (PoE compatible!)
- One Hi-speed USB 2.0 port (for USB drive or ENV2 environmental probe)
- Two standard USB 1.0 ports (for ENV2 environmental probes)
- Full color touchscreen
- 32GB internal memory
- One 16GB microSD card
- One USB drive included with each PQube 3 (contains manual, quickstart guide, setup file, Configurator program, Report Writer program)

**Several types of modules and accessories are available including:**

- AC/DC Interface: VAT1, ATT1, and ATT2.
- Power Supply and Backup: UPS1, UPS2, and UPS3.
- Time and Synchronization: MPS1 and GPS.
- Relay Extensions: RM8.
- Environment Sensors: ENV 2.
- Current Interface for 1A/5A CT Secondaries: CT-1A and CT-5A.

**To choose modules for your application, you need to ask yourself:**

- Do I need to power my PQube 3 from 100~240Vac (50/60/400 Hz) and if so do I need battery backup in the event of a power outage? **See Power Supply and Backup Modules**
- Do I need current inputs to measure the 1A or 5A secondary of a CT at ANSI Class 0.2 or IEC 62053-22 Class 0.2S revenue energy accuracy? **See CTI Series CT Interface Modules**
- Do I need ultra-precise GPS timestamps on your data? **See Time and Sync Modules**
- Do I want to record the environmental conditions such as temperature, humidity, pressure, or acceleration? **See Environmental Sensor**

Below is an overview of the PQube 3 family and accessories. The left hand connected modules include the GPS, relay module and those for measuring the secondary of current transformers. The right hand modules are power supply and power backup. The accessories include various attenuators, split core CTs and environmental probes.



#### Left Hand Modules



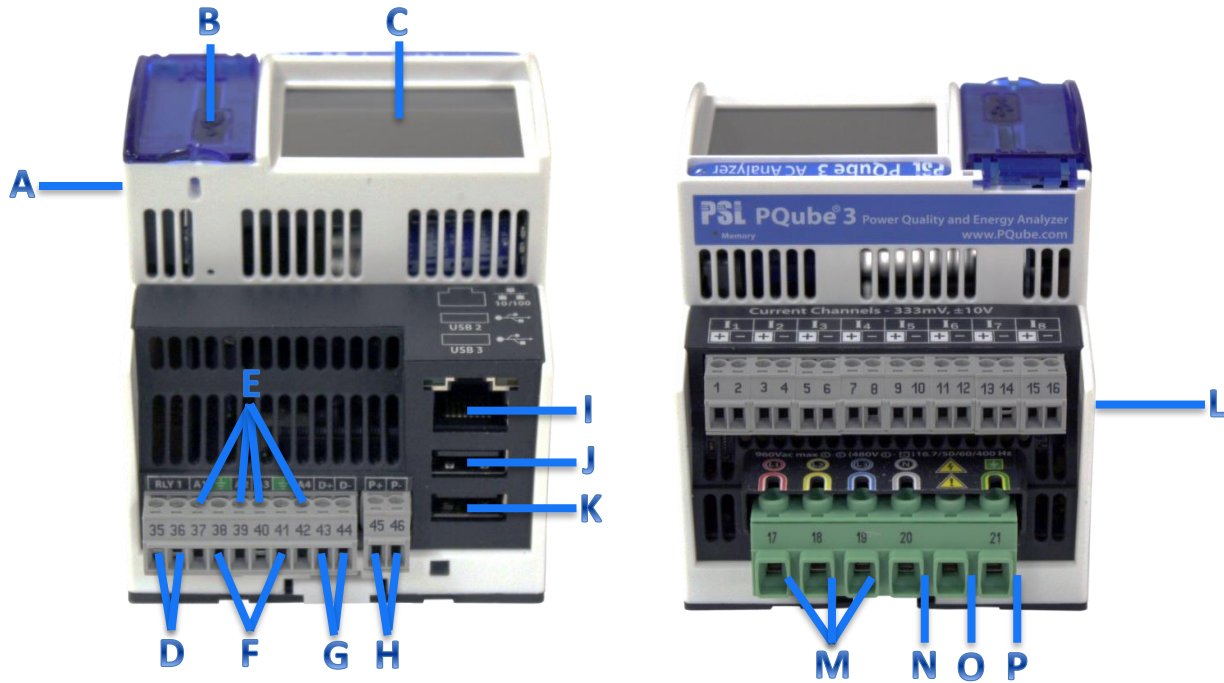
#### Right Hand Modules






#### Accessories



## 1.4 Overview of PQube 3 Ports, Connections and Controls



A	Coin-cell battery (keeps real time clock alive when instrument power is lost)
B	<b>USB-1</b> High-Speed USB 2.0 port for USB hard drives and adjacent microSD card slot (format using FAT32 filesystem)
C	Touchscreen display
D	Signal relay output. Normally closed during recording mode. Opens ½ cycle after event or device shutdown.
E	Analog inputs. Maximum ±60VDC or 33VAC to earth. Can be used as differential inputs.
F	Earth – functional. Use as a reference point for analog inputs (not needed if using analog channels in differential mode).
G	Digital input. Wetted with 2.4V at 3 microamps. 1.5-volt threshold. 60-volt tolerant.
H	Power supply input. 24VAC, or 24VDC to 48VDC (either polarity) nominal. 20VA max.

I	10/100 Ethernet RJ-45 port. 48V PoE compatible.
J	<b>USB-2</b> Standard USB 1.0 port for use ONLY with ENV2 environmental probes.
K	<b>USB-3</b> Standard USB 1.0 port for use ONLY with ENV2 environmental probes.
L	Current transformer inputs – nominal 0.333V RMS (LOW range) or ±10V <sub>pk</sub> (HIGH range)
M	 L1, L2, L3 voltage inputs. See page 23 for maximum voltage ratings.
N	 Neutral terminal – optional depending on your power configuration
O	Not connected.
P	 Earth – functional. Used as the reference point for voltage measurements. <b>IMPORTANT:</b> this terminal must be properly connected to ground for safety, accuracy, and reliability.

## 1.5 Choosing Modules

### 1.5.1 Power your PQube 3 from 100~240Vac (PM1/PM2)



If you have 24~48Vdc or 24Vac, you can use your PQube 3's internal power supply (just connect the voltage to the power supply screw terminal blocks).

If you need to power your PQube 3 from 100~240Vac, you'll need the plug-in PM1 or PM2 Power Manager module.

The PM2 module also includes a 24VDC auxiliary output so you can power small accessories (up to 5W) like LEDs or fans.

### 1.5.2 Backup your PQube 3 during a power outage (UPS1/UPS2/UPS3)

#### UPS1



Connect the UPS1 Battery Backup module to your PQube 3 to provide up to 30 minutes of backup power during a power outage. It can be used with or without a PM1 or PM2 module.

#### UPS2 and UPS3

Extended autonomy models are available: The UPS2 backup module provides extended power backup (up to three hours) controlling up to three PSL XB1 lead acid battery packs (60 min/pack). The UPS3 is identical and also includes outputs to backup 5 watts of accessories. Both units offer a wide temperature range (25°C~60°C) for severe environments such as shipboard.



### **1.5.3 Measure currents from secondary of current transformers (CTI-1A/CTI-5A)**



Your PQube 3 comes standard with 8 current channels which are compatible with CTs with 0.333V secondary.

But if you need to measure CTs with 1A or 5A secondary wires for your application, use the CTI Current Transformer Input module.

There are two versions; one with 1A input and one with 5A input. Use the CTI module that matches the secondary rating of your external CTs.

There are four current inputs per module. Your PQube 3 can accommodate up to two CTI modules.

Use this module if your application requires ANSI C12.20 Class 0.2 or IEC 62052-22 Class 0.2S revenue grade accuracy.

### **1.5.4 Three Phase AC/Dual DC Voltage Attenuator**



The perfect solution for monitoring two sets of three-phase AC voltages such as the primary and secondary side of transformers or the input and output of a three-phase UPS. The unit could be used in a data center to monitor two HVDC channels like the input and output of 480VAC to 380 VDC rectifiers.

### 1.5.5 Relay Extension Module for load shedding (RM8)



You can now turn your PQube 3 into a powerful controller, and command the shedding of loads to protect your main distribution circuit from tripping.

The RM8 extension relay module snaps easily to your PQube3 (also PQube 3e) and its 8 relays are fully programmable.

This allows you to customize your load shedding scheme by assigning incremental thresholds, or by applying the scheme to protect up to 4 circuits. And the PQube3 power Analyzer measures, reports in real time and records the power, VA, VARs and Power Factor of all the circuits monitored

### 1.5.6 Measure Environmental Conditions (ENV2)



The ENV2 environmental probe allows your PQube 3 to measure ambient temperature, humidity, pressure.

It also includes an accelerometer to measure shock and vibration, a thermocouple input for wide temperature ranges, and a solar irradiation input.

Connect up to 2 probes to your PQube 3 using a microUSB to USB cable.

You can use a USB cable with a length of up to 15ft /5 meters.

## **1.5.7 Synchronize your PQube 3 clock to GPS time**

Your PQube 3 can synchronize its time clock to GPS, which provides better than 1 microsecond accuracy. This is useful for Class A measurements, or if you need to make phasor measurements with a microPMU.

### **MS1-GPS1**



The MS1 module interfaces with the GPS1 receiver to provide your PQube 3 with ultra-precise time, (no drift) time stamping for power quality events.

The GPS1 receiver locks onto GPS satellites in the sky to provide your PQube 3 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 functional isolation at both ends of the cable for safety.

Connect the GPS1 receiver to your MS1 module using the included cable. You can extend the cable up to 25 meters using a female-female RJ-45 coupler and standard CAT5E cable.



## 2 Installing Your PQube 3

### 2.1 Unpacking your PQube 3



Verify that your package contents are complete:

- 1 PQube 3
- 1 USB thumb drive (contains manual, quickstart guide, setup file, Configurator program, Report Writer program)
- 1 six pole Voltage connector (mains voltage)
- 8 two pole connectors (current inputs)
- 1 two pole connector (power supply)
- 1 ten pole connector (for analog channels, digital input, relay output)

**Note:**

- PQube 3e comes with an additional 6 two pole connectors (additional current inputs)
- PQube 3v is not equipped with current input connectors
- PQube 3r comes with an additional set of 3 three pole connectors (additional 3 relays)

### 2.2 Installation

#### 2.2.1 Disconnect mains prior to servicing

**IMPORTANT:** Your PQube 3 must be installed only by qualified personnel for electrical installations.

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

In the United States and Canada, the equipment installation shall meet ANSI/NFPA 70, NEC, with CSA C22.1, CEC, Part I or with both as appropriate. In other countries, follow all local installation requirements and regulations.

#### 2.2.2 Mount your PQube 3 properly and securely

Your PQube 3, and its optional modules, are designed to be mounted on an industry-standard 35mm DIN rail as rack- or panel-mounted equipment.

Example installation:



MS1 module on left side of PQube 3

PQube 3 (main module)

PM1/PM2 Module on right side of PQube 3

UPS1 Module on far right side

### 2.2.3 Include overcurrent protection and a disconnecting device

An external overcurrent protection device, such as a fuse or a circuit breaker, must be installed on each mains connection. **The device shall be UL Listed, branch circuit type overcurrent protector. You should consult a qualified electrician to determine the overcurrent protection installation.**

Your PQube 3 can share the overcurrent protection device with other loads.

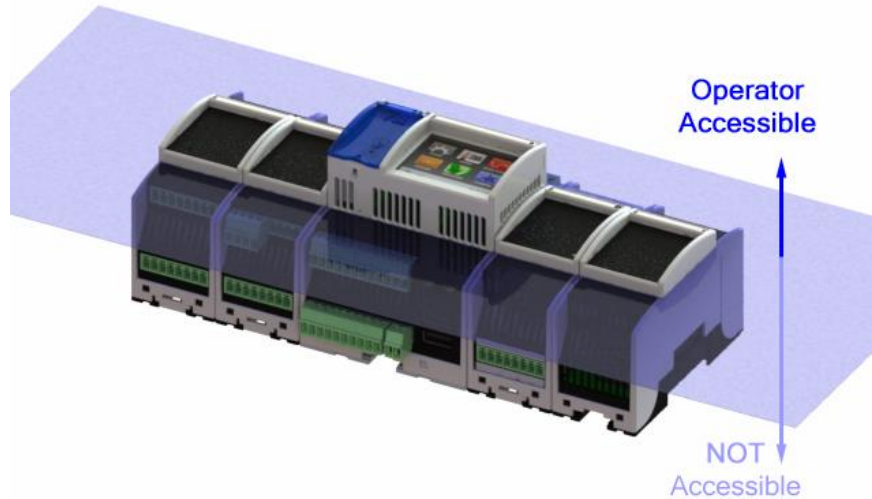
An operator-activated disconnecting device, such as a switch or a circuit breaker, must be installed on the mains connections. This device must be clearly marked as the disconnecting device for your PQube 3, and must be marked to indicate the disconnection function. Do not install your PQube 3 in such a way that it becomes difficult to operate this disconnecting device. The disconnecting device must not disconnect the earth connection. The disconnecting device should be installed near your PQube 3, within easy reach of the operator.

### 2.2.4 Protect the operator from the hazardous terminals

**IMPORTANT:** All high voltage parts must be covered, including the AC power to your PQube 3. Install your PQube 3 so that all of the screw terminal blocks are not ACCESSIBLE<sup>1</sup> to the operator. Your PQube 3 can also be installed without a cover if installed in a lockable IUL 508 control panel.

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<sup>1</sup> Accessible, as defined in UL 61010-1, means able to be touched with a standard test finger or test pin, when used as specified in UL61010-1 6.2.



*The operator must be protected from the hazardous screw terminal blocks by a barrier. The screw terminal blocks must be made "not ACCESSIBLE", as defined in UL /IEC 61010-1 6.2, using an enclosure or barrier that meets the rigidity requirements of UL /IEC 61010-1 8.1 and that requires a tool to remove.*

*If you choose to install your PQube 3 in an enclosure, select a UL-listed enclosure that is appropriate for the purpose. If you plan to use an enclosure of this type, you should review its mechanical compatibility with any optional features of your PQube 3 that you plan to use: optional USB connections, optional temperature-humidity probes, etc.*



## **2.2.5 Connect your PQube 3 to the power supply**

Your PQube 3 can take its operating power from four different sources:

- 24VAC or  $\pm 24$ –48VDC power supply terminals on PQube 3
- Power over Ethernet (PoE)
- Optional PM1/PM2 Power Supply module
- Rechargeable UPS module (automatically provides up to 30 minutes of battery backup when the main power supply source drops out)

## PQube 3 power supply terminals

The instrument power terminals (45 and 46) on the front of your PQube 3 must be connected to 24VAC ( $\pm 20\%$ ) or 24–48VDC ( $\pm 20\%$ ), supplied by a certified isolating power supply.

**WARNING:** Applying voltages outside of this range can cause permanent damage to your PQube 3.

Polarity does not matter. Also, your PQube 3 provides a minimum of 150V of transformer-based isolation between these terminals and all other terminals, eliminating any problems with ground loops.



## Power over Ethernet (PoE)

Plug in an Ethernet cable leading to a 48V PoE source (PoE switch/hub/router or PoE injector).

If no other power sources are available, your PQube 3 will request power from the PoE switch.

If your PQube 3 is already powered from another source (24V power supply or PM1/PM2 power supply module, for example) then it will not request power from the PoE switch when you plug it in.

## PM1 or PM2 Power Supply Module

The PM1 or PM2 module accepts a range of 100~240VAC, 50/60/400Hz. It snaps into the right side of your PQube 3. This module is ideal for applications where 24-48VDC, 24VAC, and PoE are not available. Make sure your AC source can supply at least 20W.



PM2 front view –  
24VDC output terminals



PM1/PM2 rear view -  
100~240VAC input terminals



PM1 top view -  
100~240VAC input terminals

On the PM2 module, 24VDC outputs are available on the 8-pin terminal block for powering external accessories including DC Hall Effect sensors and indication LEDs. The first pair of terminals labeled “Switched 24Vdc” can be toggled on and off in software. The other three pairs are tied together internally. The total combined power output is 5W. This is enough to power one additional PQube 3.

## UPS1 Module

Plug the UPS1 module on the right side of your PQube 3 or PM1/PM2 module. This module is always the outermost module on the right side.

By default, the UPS timer interval is 5 minutes. However, you can choose the operating duration by writing a value in your **Setup.ini** file. The value can be set from 3 to 30 minutes. This guarantees that there will be enough charge in the battery to record several successive power interruptions.

As the lithium ion battery inside the module ages, its capacity will decline. Depending on operating conditions and requirements, it may be necessary to replace your UPS1 Module every 3 to 5 years or 500 cycles, whichever comes first.

UPS 2 and UPS 3 allow for the addition of external batteries for up to 3 hours of battery life.

### Maximum Load and Temperature Ratings

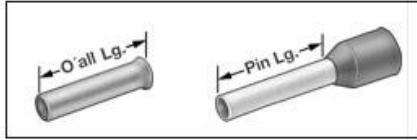
Your PQube 3 is rated for 65°C maximum ambient temperature under normal conditions when installed according to the procedures set forth in this manual.

However, when loading the PM2 module’s 24V auxiliary circuit with 5W, the maximum ambient temperature is derated to 55°C.

Power Source	Product Configuration	Auxiliary 24VDC load	Maximum USB Load	Maximum Load on Relay Outputs	Maximum Ambient Temperature
Instrument Power Terminals	PQube 3, MS1, GPS1	No load	USB1 1.5W USB2 0.5W USB3 0.5W	RLY1, RLY2, RLY3, RLY4 loaded with 30VDC/30VAC, 300mA max	65°C
PM1 AC Input Terminals	PQube 3, PM1, UPS1	5.15W max	USB1 0.3W USB2 0.1W USB3 0.1W	RLY1 loaded with 30VDC/30VAC, 300mA max	55°C
PM1 AC Input Terminals	PQube 3, PM1, UPS1, MS1, GPS1	No load	USB1 0.3W USB2 0.1W USB3 0.1W	RLY1 loaded with 30VDC/30VAC, 300mA max	65°C

## 2.2.6 Connecting the wires

Observe the wire size specifications and limitations. All conductors must be stranded copper. All conductors and insulation systems and crimped devices must be appropriate for the application. PSL recommends crimped ferrules on stranded wire. Tighten the screws on the high voltage terminal block to 0,5 newton-meters (5 inch-pounds) of torque. Observe all voltage ratings and limits.



For connections, PSL recommends wire ferrules for stranded wire, such as Panduit F77 series, for example Panduit F77-6-M.



Figure 1: Your PQube meets all IEC requirements for high-frequency emissions and susceptibility, both conducted and radiated. For further protection, you can use clamp-on ferrites on signal cables to minimize radio-frequency emissions. For example, these are Panasonic KRCBC160928B and KRCBC130714B.








Figure 2: To minimize emissions with the optional PM1 Power Supply module, optionally use a shielded power conductor.

### Conductor characteristics

Connection	Minimum wire size	Maximum wire size	Limitations and remarks <b>Comply with all local safety and installation requirements and regulations.</b>
PQube 3 terminals L1, L2, L3, N	20AWG (0,52 mm <sup>2</sup> )	14 AWG (2.1mm <sup>2</sup> )	Min 600V UL-recognized insulation system required. These terminals require less than 0,01 amps. Connection to N (15) is optional. For single phase monitoring, connect either L1-N or L1-L2 as appropriate for the mains configuration.
PQube 3 Earth terminal	20AWG (0,52 mm <sup>2</sup> )	14 AWG (2.1mm <sup>2</sup> )	Connect this terminal to a suitable earth connection. For proper PQube operation, you must connect this terminal to earth. It is used as a measurement reference, and as a reference for your PQube's low voltage circuits.
Optional PQube 3 terminals	20AWG (0,52 mm <sup>2</sup> )	14 AWG (2.1mm <sup>2</sup> )	Min 600V UL-recognized insulation system required. Wire size must be adequate for relay contact load. These terminals rated at 30 VAC max, 60 Vdc max, 2 amps max.
All other terminals	20AWG (0,52 mm <sup>2</sup> )	14 AWG (2.1mm <sup>2</sup> )	Min 600V UL-recognized insulation system required.
PM1 AC Input terminals	20AWG (0,52 mm <sup>2</sup> )	14 AWG (2.1mm <sup>2</sup> )	Min 600V UL-recognized insulation system required. Shielded cable recommended for minimizing emissions.
PM1 DC Output terminals	20AWG (0,52 mm <sup>2</sup> )	14 AWG (2.1mm <sup>2</sup> )	Min 600V UL-recognized insulation system required

## Maximum voltages

Connection	Measurement Category	Maximum current	Limitations and remarks
PQube 3 terminals L1, L2, L3, N 	600 Vrms, CAT III		 Corresponds to 480V L-N / 830V L-L max for 3-phase, 4-wire Wye/Star systems.  Corresponds to 600V L-L max for 3-phase, 3-wire Delta systems.  Corresponds to 480V L-L max for 1-phase, 2-wire Single Phase systems.  Corresponds to 480V L-N / 960V L-L max for Split-Single-Phase, 3-wire systems.  All voltage channels must be covered after installation.
	300 Vrms, CAT IV		Corresponds to 277 L-N / 480V L-L max for 3-phase, 4-wire Wye/Star systems.  Corresponds to 480V L-L max for 3-phase, 3-wire Delta systems.  Corresponds to 240V L-L max for 1-phase, 2-wire Single Phase systems.  Corresponds to 240V L-N / 480V L-L max for Split-Single-Phase, 3-wire systems.  All voltage channels must be covered after installation.
PQube 3 Earth terminal 	N/A		
Optional PQube 3 RLY terminals	30 Vrms or 60 Vdc	0.3A	
All other PQube 3 terminals	30 Vrms or 60 Vdc		
PM1 AC input terminals 	240 Vrms, CAT II		 Rated for Single-Phase 100~240VAC max. AC voltage input terminal must be covered after installation.
PM1 DC output terminals	24 VDC	0.42A	10W maximum output
USB1 Input	5VDC	0.2A	
USB2 and USB3	5VDC	0.1A	

Note: "CAT III" means Measurement Category III as defined in UL / IEC 61010-1: "Measurement category III is for measurements performed in the building installation.... Examples are measurements on distribution boards, circuit-breakers, wiring, including cables, bus-bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industrial use..."

"CAT IV" means Measurement Category IV as defined in UL / IEC 61010-1: "measurements performed at the source of the low-voltage installation.... Examples are electricity meters and measurements on primary overcurrent protection devices and ripple control units."

## 2.2.7 Connect mains AC voltage wires

The large high voltage terminal block on the back of your PQube 3 is removable. Refer to the wiring diagrams on page 32 and use the appropriate wiring scheme for your power configuration.

**IMPORTANT:** Don't forget to install the Earth conductor. Your PQube 3 relies on the Earth conductor for safety, reliability, and accuracy.



You must apply at least 30VAC to these terminals before your PQube 3 will begin recording.



## 2.2.8 Protect antenna terminals from lightning

If you install an antenna in an outdoor location where it may be exposed to lightning, you must include a properly installed UL-497C-listed lightning protection device on the antenna cable and the antenna must be reliably earthed. Follow all local installation safety requirements and regulations.

## 2.2.9 Installing Your PM1 Power Supply Module



The optional PM2 Power Supply Module connects to the right side of your PQube 3; just snap it in. It accepts any 50/60/400 Hz single-phase input between 100Vac and 240Vac nominal. Verify that you are connecting the line and neutral wires to the correct terminals on the module.

## 2.2.10 Installing Your UPS Module



The UPS1 Module provides backup power to your PQube 3 in the event of complete loss of instrument power. Plug it into the right-side of your PQube 3. If using a PM1 Power Supply Module, plug the UPS module into the right side of the PM1/PM2 module. The lithium-ion battery pack can provide power between 3 and 30 minutes (user-configurable).

If more power duration is required UPS 2 and 3 with optional battery packs can be used.

## 2.2.11 Installing Split Core Current Transformers (CTs)

*Note: you can skip this chapter if you are installing a PQube 3v (voltage monitor)*

Your PQube 3 records AC current by measuring the secondary circuit of a current transformer (CT).

When installing current transformers, it is important to match the phases to the voltage inputs and current input (connect the L1 voltage input and the L1 current sensor to the same conductor). This is necessary for correct power and energy calculations.

Instructions for setting your CT ratio can be found on page [41](#).

**IMPORTANT:** You must only use UL listed energy monitoring current transformers with your PQube 3.

### **A note on choosing the appropriate range of CT's for your application:**

If the PQube 3 is installed to monitor power and load, the nominal rated current of the CT should be the most common load current throughout the consumption period (e.g. work days). Your PQube 3 makes current measurements with a Crest Factor of 3.5. This means that your PQube 3 can measure instantaneous currents up to 350% of the nominal rated current (for example, if you have selected a 300-amp current transformer, your PQube 3 will accurately measure up to  $\pm 1050$  amps instantaneous). This is a very useful feature when dealing with inrush currents, and currents with high harmonic contents.

If the PQube 3 is installed to troubleshoot circuit breaker trip operation, the nominal rated current should be selected closer to the trip settings. In all cases the PQube crest factor of 3.5 provides a margin to capture properly the peak currents.

**Note: PSL Ultra-Precise CTs:**

PSL Ultra-Precise CTs are specifically designed for your PQube 3. Ultra-Precise calibrated shielded split-core CT are specifically designed to meet demanding accuracy application with accuracy on both current amplitude AND current angle accuracy.

The PSL Ultra-Precise CT's exceed the most demand standard: ANSI C12.20 Class 0.2 revenue grade \*

This is important if you need to measure high-order current harmonics or if you need revenue-grade accuracy for your application.



*Note:*

*Calibrated to match the input impedance of your PQube 3's current input channels, and each CT comes with its own NIST-Traceable calibration certificate and table which you can upload to your PQube 3.*

*PSL Ultra-Precise CTs are UL listed and utilize a 0.333V secondary to match your PQube 3's current input terminals. A burden resistor is built into the CT so you do not need to worry about hazardous open circuit voltages.*

*You can see the list of available PSL Ultra-Precise CTs for your PQube 3 here:*

<https://www.powerstandards.com/?product=kits-modules-accessories/current-sensors>

*You can look up the calibration certificate for your CTs here:*

<https://www.powerstandards.com/?product=pqube-3/certificates>

## Installing Split Core CTs with 0.333V secondary

Your PQube 3 comes standard with 8 current input channels, which are typically used to measure L1, L2, L3, N, E, plus 3 additional single-phase channels. The current channels on your PQube 3 are rated for 0.333V nominal input, and they are designed to be used with CTs with 0.333V secondary.

For PSL CTs, white wires are positive and black wires are negative.

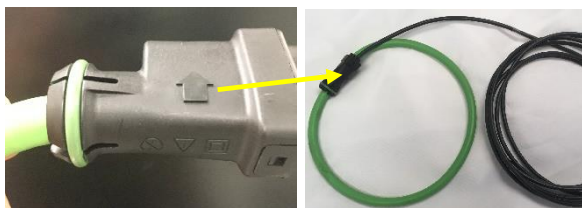
If using PSL Ultra-Precise CTs with the shielded secondary wires, red is positive and black is negative. Connect the shield conductor to ground. If using another manufacturer's CTs, verify which wires are positive and negative before installing them.



Clamp the CT around the conductor. For all PSL CTs, the label faces towards the source.



## FCT-XX-3000A Flexible Current Sensor Installing Split Core CTs with 0.333V secondary



The arrow must face the source

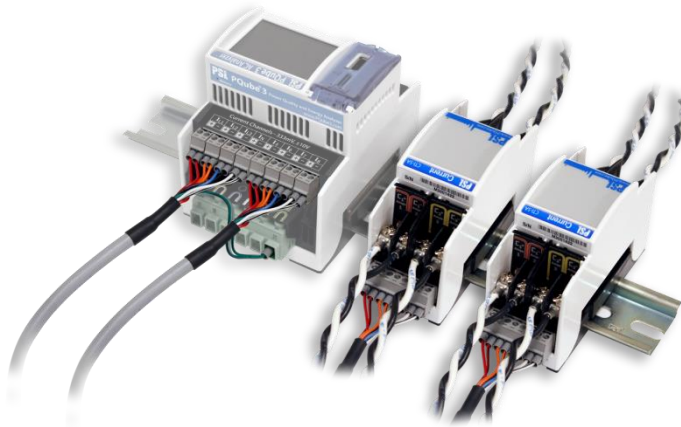
The flexible AC current sensors (Rogowski coils) are perfect for applications where limited space makes installation of traditional current transformers difficult or impossible. Their pliable split-core design allows you to easily clamp around cables or bus bars

- Plugs directly into your PQube 3 – built-in integration, but must be configured in setup.ini.
- Flexible, IP 65 weather resistant loop
- Four-meter cable, shielded for noise immunity
- UL approved, RoHS, and WEEE compliant

- Nominal 30 A to 3000 A measurement range
- Typical amplitude accuracy:  $\pm 0.5\%$  rdg
- Typical angle accuracy:  $\pm 1$  deg
- No magnetic hysteresis (saturation or non-linearity)
- Calibrated to match PQube 3 impedance

## Installing CTs at the secondary of measuring current transformers (1A or 5A secondary)

If you will be monitoring the 1A or 5A secondary of existing metering CTs, you will need to use the CTI-1A or the CTI-5A module. They have 1A and 5A nominal inputs, respectively.



The CTI module inputs are installed in series with your 1A or 5A secondary circuit. The terminal block on your CTI module is connected to the 0.333V current input channels on your PQube 3. Each CTI module includes 4 current channels, so you can use up to 2 CTI modules per PQube 3.



**WARNING:** When installing CTs with 1A or 5A secondaries, take extra precautions to ensure that an open circuit does not develop on the secondary wires. Shorting blocks are typically used to avoid the possibility of an open circuit during installation. CTs must be installed only by qualified personnel for electrical installations.

### **1A or 5A vs. 0.333V secondary, what's the difference?**

Most current transformers are designed to have 1A or 5A of current flowing through the secondary circuit while full rated current is flowing through the primary circuit.

While installing CTs with 1A or 5A secondary, it is imperative that an open circuit does not develop in the secondary. If an open circuit develops while current is flowing through the primary of the CT, a very hazardous open circuit voltage (OCV) will develop across the opening. In this condition, typical OCV values can range from hundreds to thousands of volts.

For this reason, PSL offers CTs exclusively with 0.333V secondary. Our CTs include a built-in burden resistor in the secondary circuit so that the current always has a path to flow through. The resistor value is calibrated and tuned to achieve a 0.333V drop across the resistor at full rated current. This 0.333V signal can then be measured using the 2 wires coming out of the CT.

## **2.2.12 Connecting the ENV2 environmental probes**

ENV2 probes are interfaced through a USB cable. Insert the USB connector into the USB-2 and USB-3 slots of the PQube 3. You can connect up to 2 probes to your PQube 3.

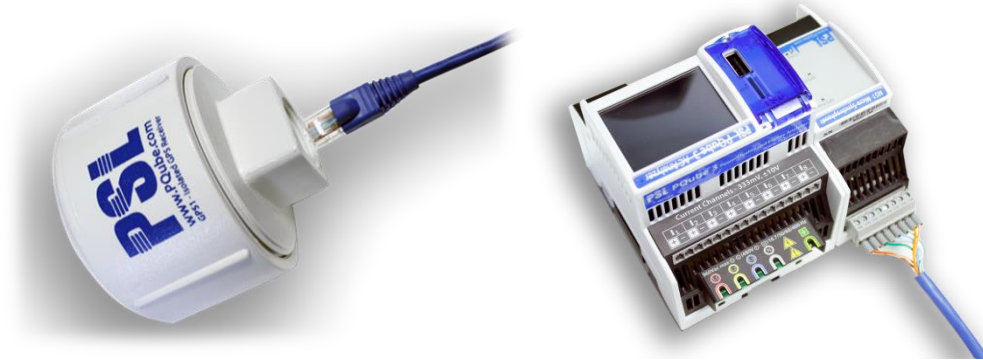
Note: if necessary, the probe can be connected to the front USB-1 slot, but you cannot extract data over USB while the probe is occupying this port.

You can verify the proper operation of the environmental probe by checking the meter on the screen (see Chapter "Operation" - touch screen - meters).



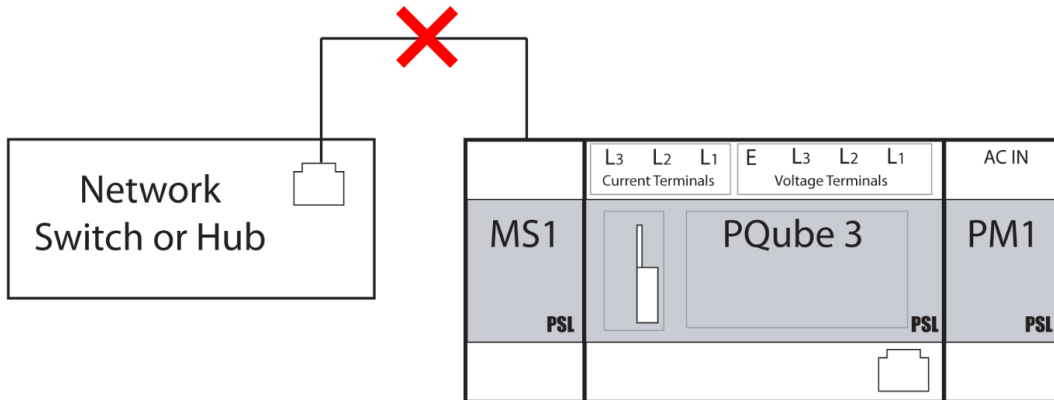
### 2.2.13 Installing Your MS1 Sync Module (if GPS synchronization needed)

The optional MS1 Sync Module connects to the left side of your PQube 3; just snap it in. Connect the module before supplying power to your PQube 3. The MS1 Sync Module interfaces with the PSL GPS1 module using a special 8-pin cable at the MS1 module and an RJ45 connection at the GPS1 receiver.



See the PQube 3 reference manual for the description of the MS1- GPS1-cable

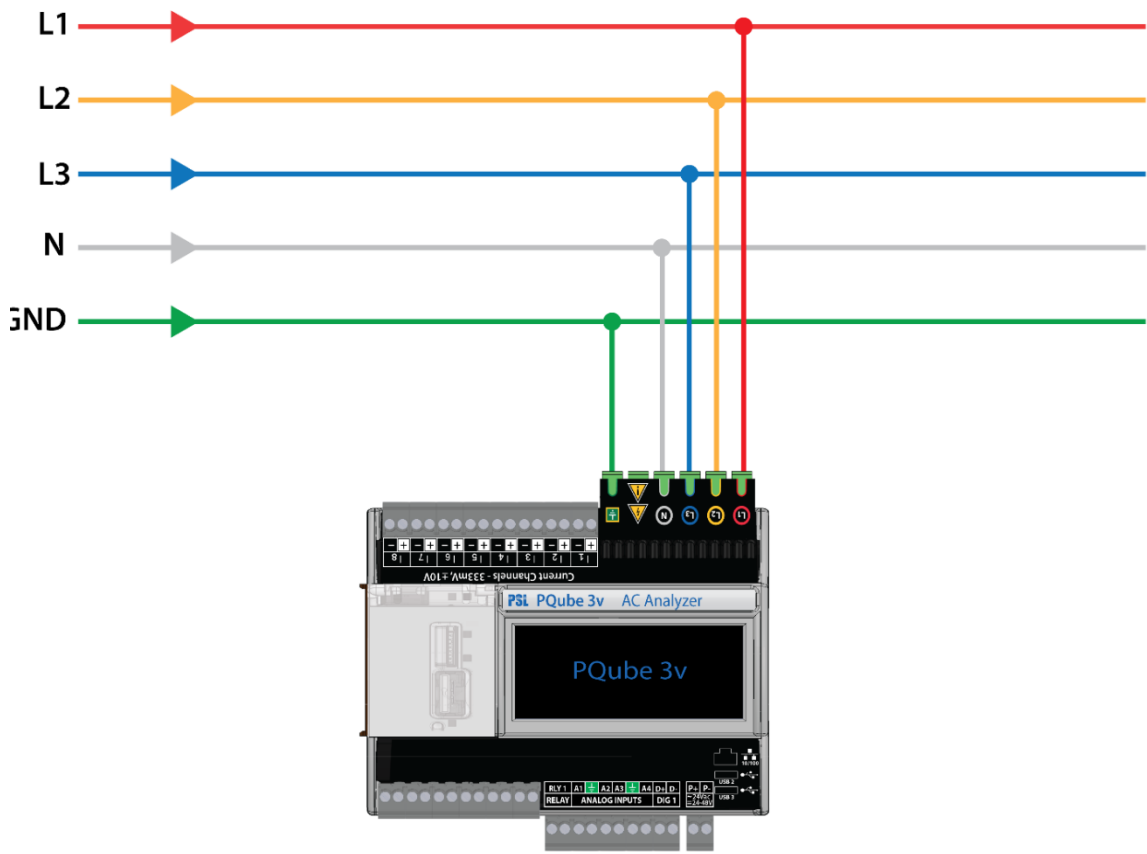
**IMPORTANT:** Do not connect the RJ-45 plug of your GPS cable into a network switch or router. It will damage your networking equipment.



# 3 Wiring Diagrams

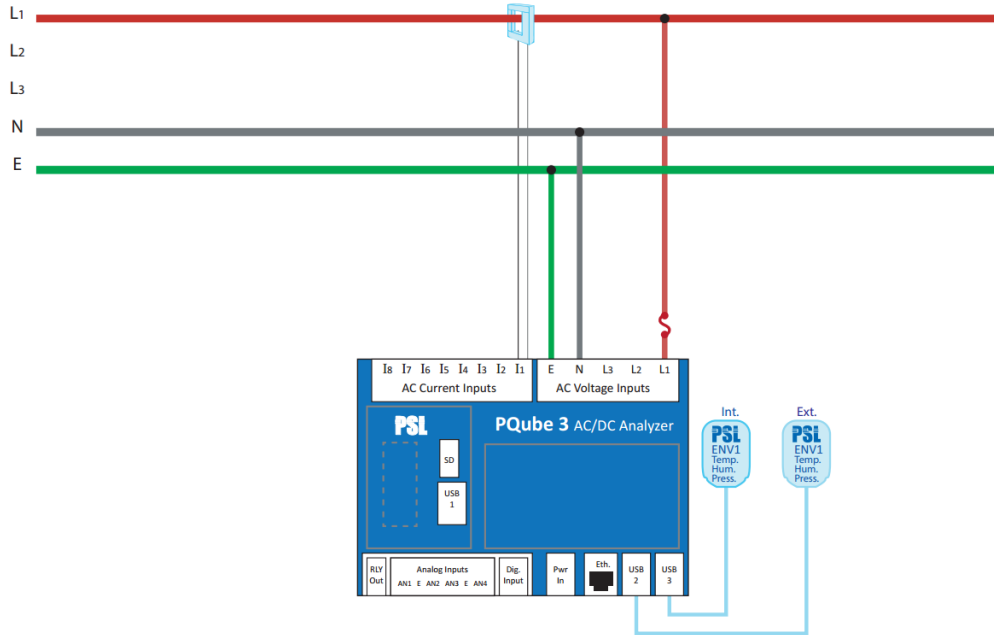
## 3.1 Wiring diagram for PQube 3v

*PQube 3v measures voltage only so connections DO NOT include CTs*

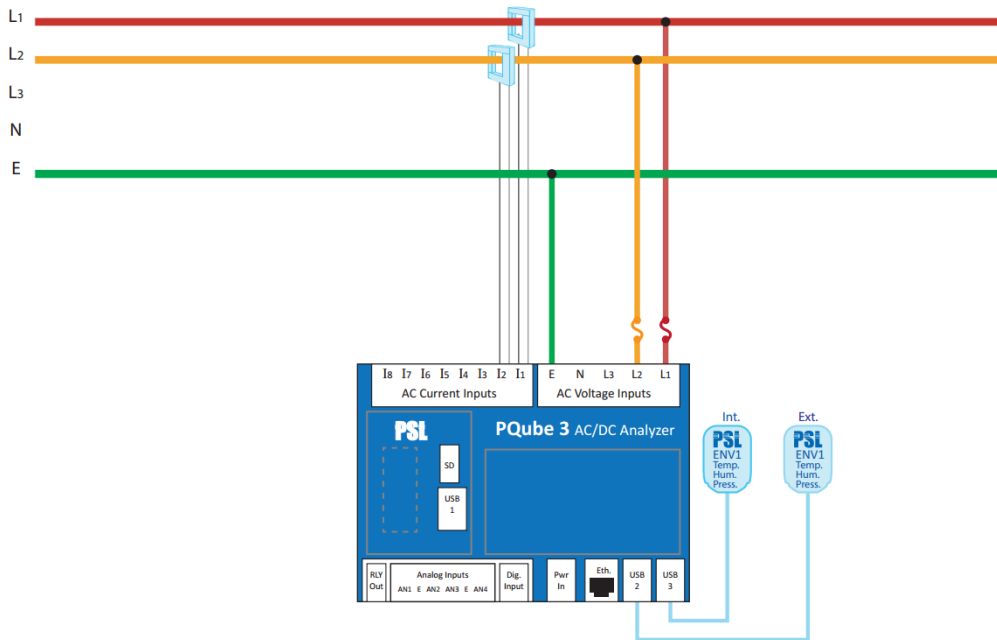




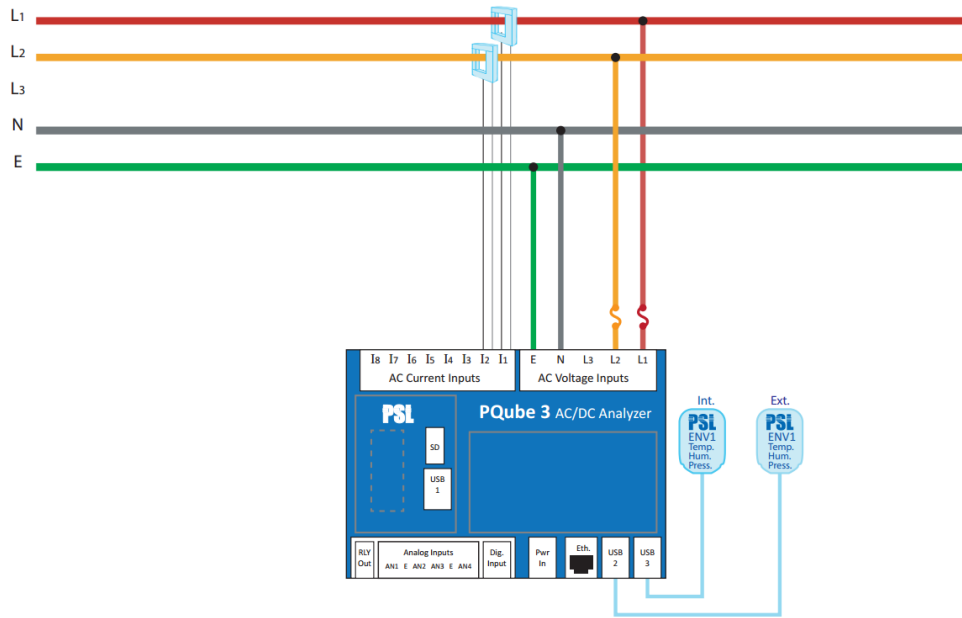
## 3.2 Wiring Diagrams (PQube 3, PQube 3e, PQube 3r)



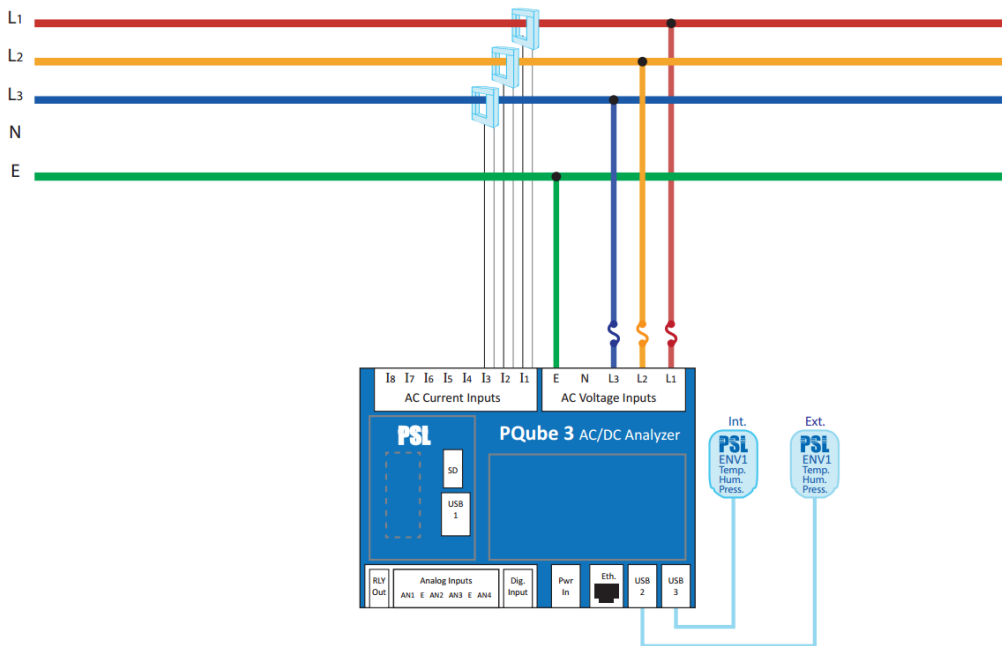
### 3.2.1 Single Phase L1-L2



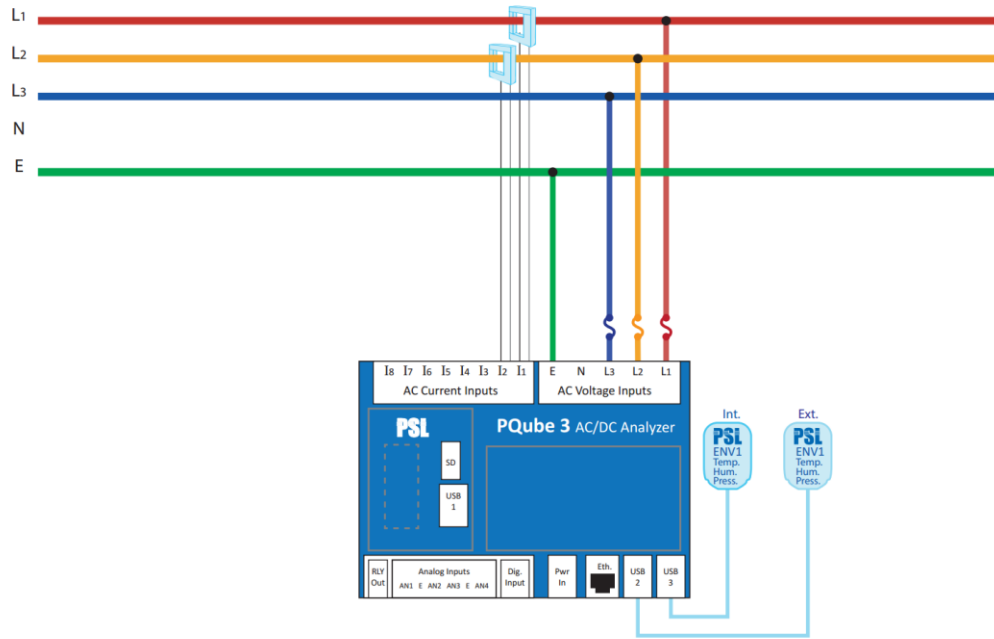
### 3.2.2 Single Split Phase



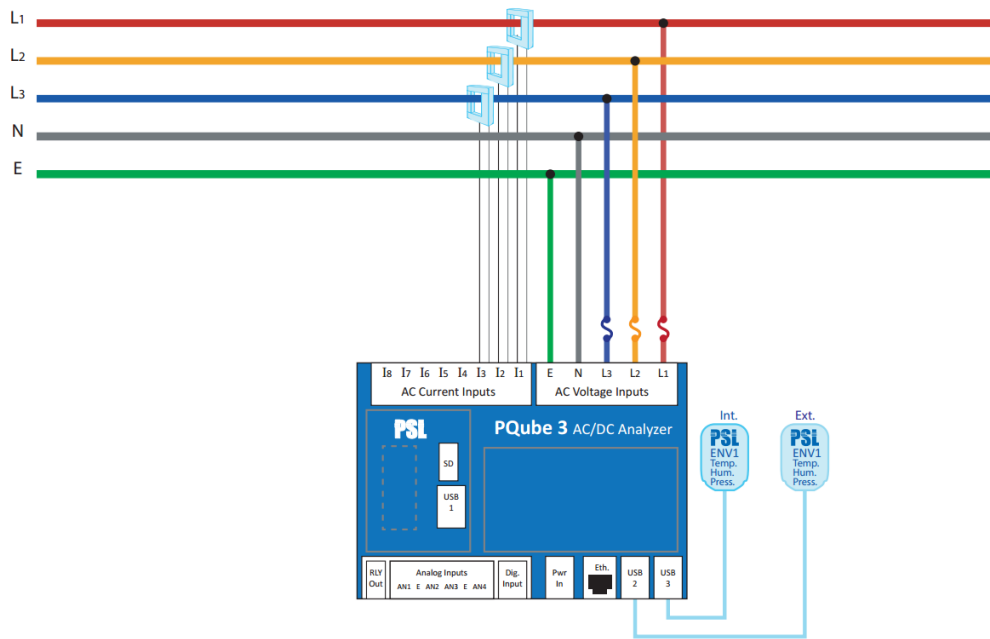
### 3.2.3 Delta – 3 CTs



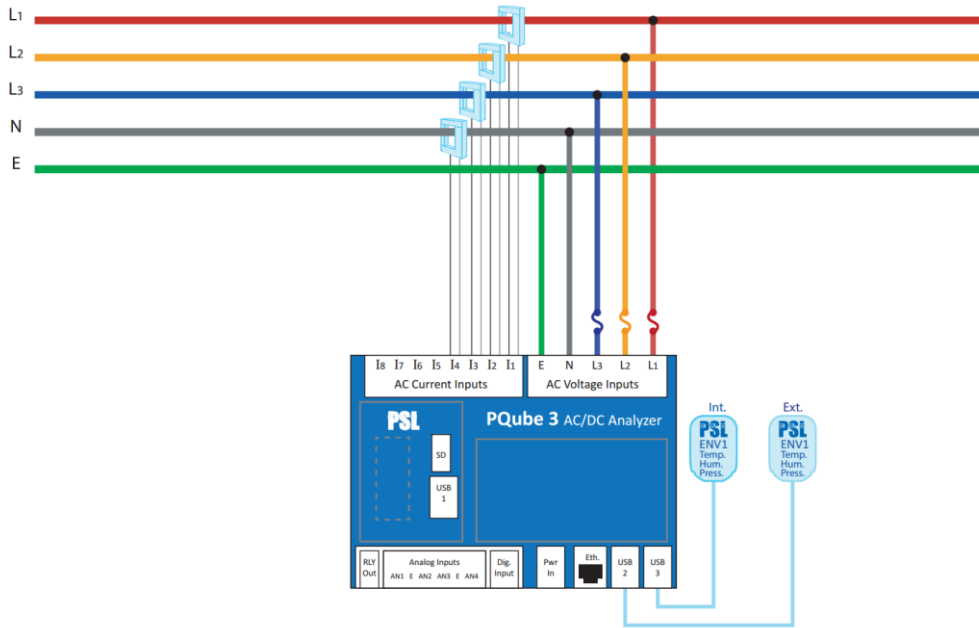
### 3.2.4 Delta – 2 CTs (PQube 3 calculates current on remaining channel)



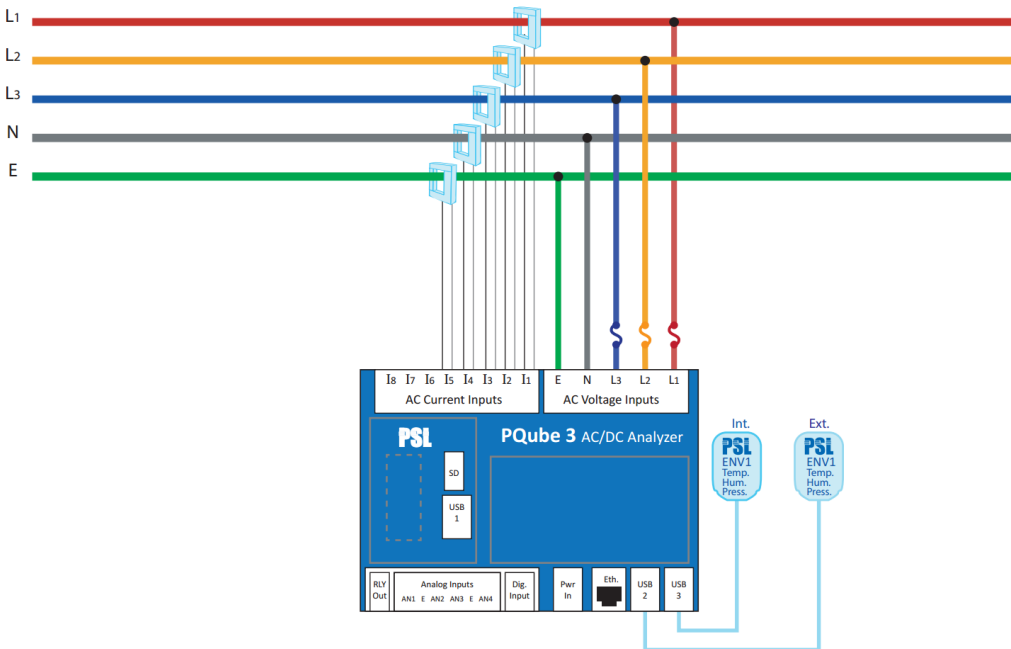
### 3.2.5 Wye/Star



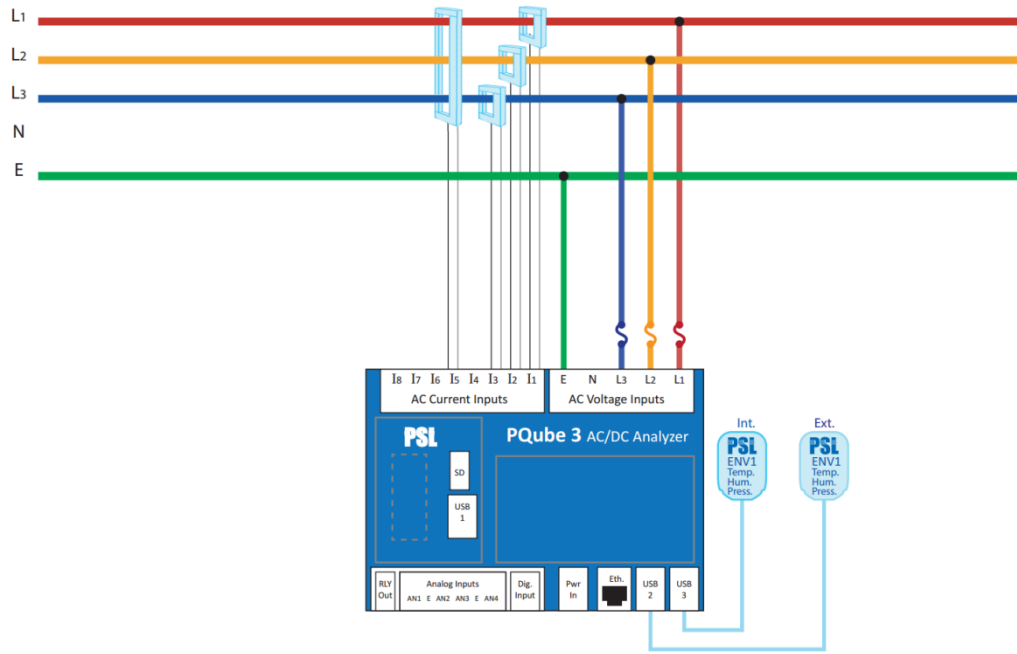
### 3.2.6 Measuring Neutral Current (applies to any power configuration with Neutral)



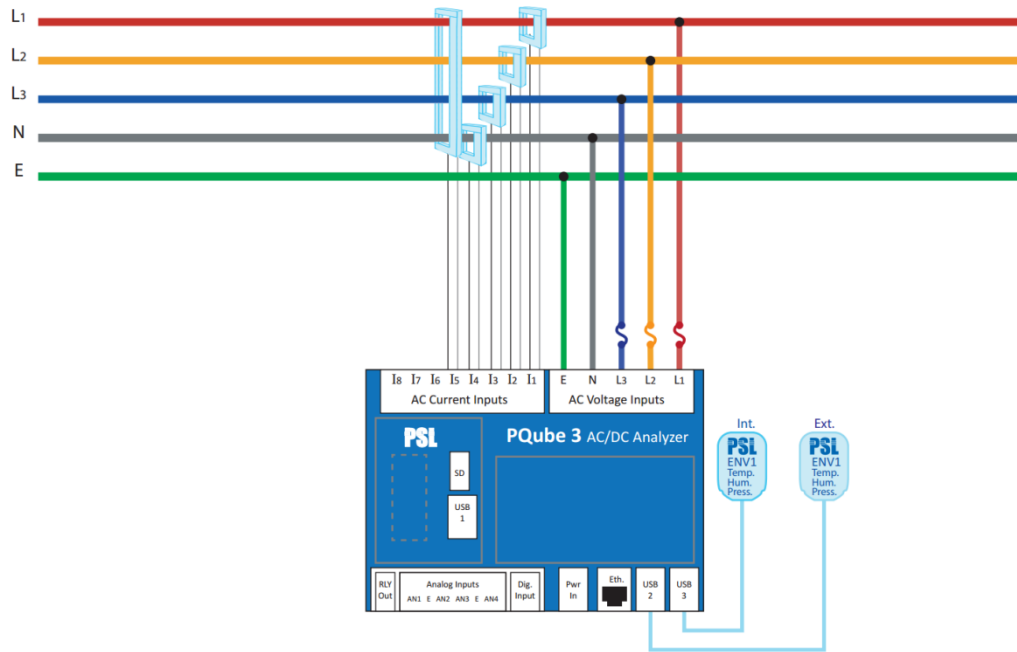
### 3.2.7 Measuring Earth Current (applies to any power configuration)



### 3.2.8 Measuring Net Earth Current – Delta



### 3.2.9 Measuring Net Earth Current – Wye/Star



## 4 Configuring Your PQube 3

### 4.1 Using the Configurator

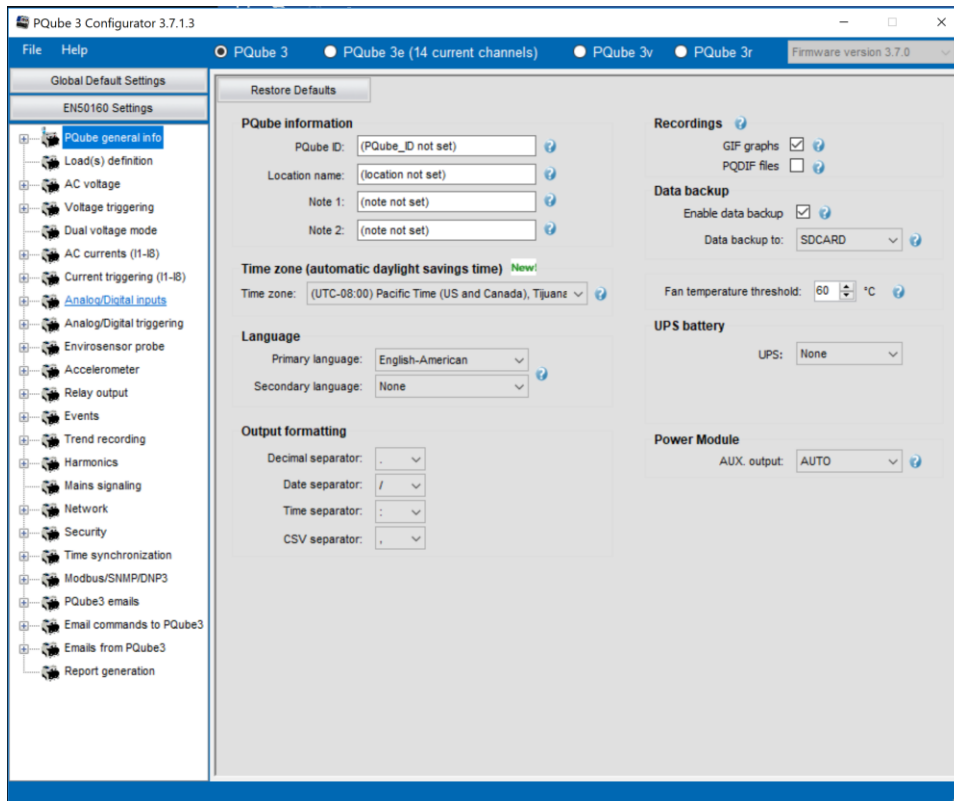
Your PQube 3 comes with a factory default configuration. This configuration is an ASCII file (**setup.ini**).

To customize your individual configuration, you can edit it using the PQube 3 Configurator program. This graphical editing utility is simple to use and will help avoid mistakes and possible conflicts across various dependent parameters.

You could use (but not recommended) a text editor like Notepad to edit the setup.in.

You can download the PQube 3 Configurator program for free here:

<https://www.powerstandards.com/download-center/pqube-3-3e/#5>



After you've made your changes, save the file as **Setup.ini** and upload it back to your PQube 3 via email, web, FTP, and it will automatically reboot and load the new settings on startup. You can also copy your new Setup file onto a USB drive or microSD card and insert it directly into your PQube 3. After detecting the new Setup file, your PQube 3 will ask you to reboot so it can load the new settings.

#### Notes:

- The factory-default setup file is identical to the USB drive that shipped with your PQube 3.

- If you are installing a PQube 3 which has been used previously, you may want to use a copy of that configuration, and then edit it with the Configurator.
- You can retrieve your PQube 3's existing setup file via USB stick locally, or remotely via email, web pages, or FTP.

## 4.2 Initial Device Setup

Your PQube 3 will work right out of the box. Once your PQube 3 has been installed, connected to the monitoring circuit, and powered on, it will begin recording data immediately. The default settings will work for most applications. Note: For Delta Configuration (3 phases, no neutral)

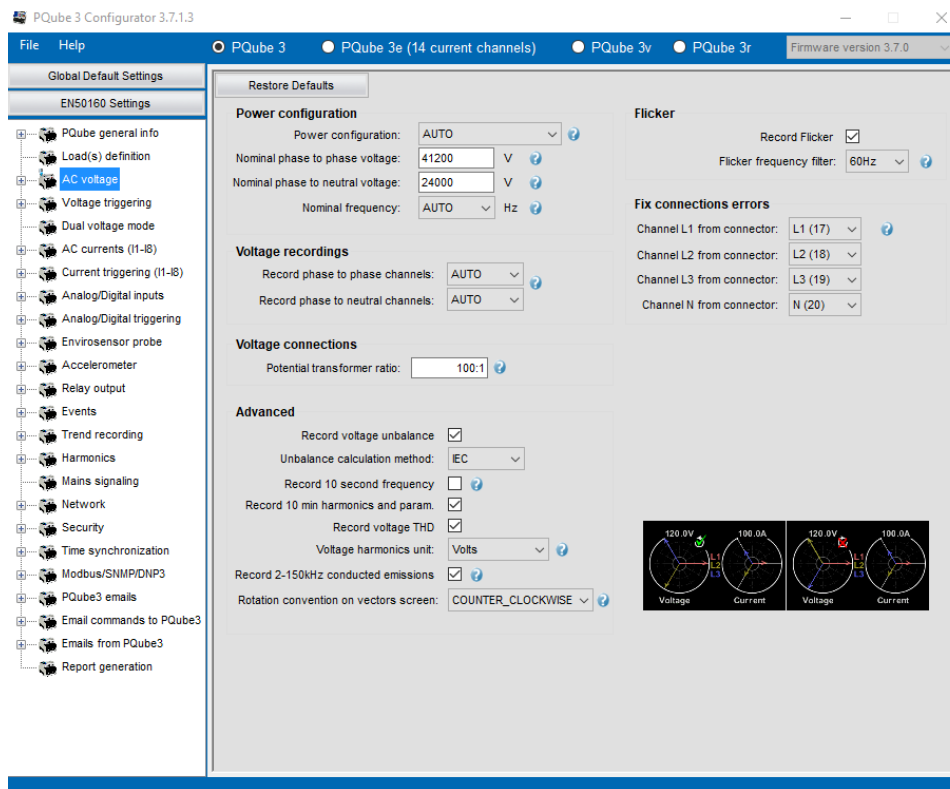
### 4.2.1 Set Your Potential Transformer (PT) Ratio

If you monitor voltages above 960Vac Phase-to-Phase (480Vac Phase-to-Earth), you need to interface to the secondary of a potential transformer (which steps down the voltage to a level compatible with your PQube 3 ).

You then need to define the PT ratio in the configuration, so that your PQube 3 reports the actual primary voltage.

For example, to use your PQube 3 on a 24 kV distribution system, and use a secondary voltage of 240V, you need to set a 100:1 PT ratio.

In the Configurator, set the PT ratio to 24000:240 or 100:1. You will also need to set your nominal voltage using the primary voltage of your PT. Even though your PQube 3 has 240V applied to its mains AC voltage terminals, you need to set the nominal voltage to 24000.



For the PQube 3v ONLY the voltage settings are set, there are no current inputs.

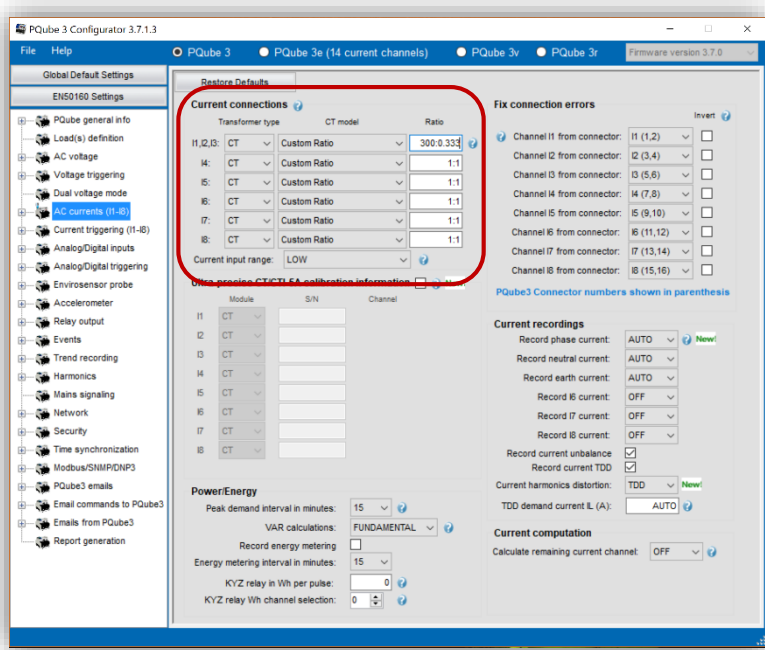


## 4.2.2 Set Your Current Transformer (CT) Ratio

*Note: you can skip this chapter if you are installing a PQube 3v (voltage monitor)*

### 4.2.2.1 If you are using CTs with 0.333V secondary

To set the CT ratio, simply enter the primary current and secondary voltage into your CT ratio. For example, if you have a current transformer rated at 300 amps, with 0.333V secondary, then you would set your CT ratio to 300:0.333. The value in the **Current Transformer Ratio** field is applied to the L1, L2, and L3 current channels.



### 4.2.2.2 If you are using CTs with 1A or 5A secondary

Use the CTI-1A or CTI-5A modules are designed to accept the 1A or 5A secondary of metering CTs.

The CTI-1A module has a ratio of 1A:0.333V. The CTI-5A module has a ratio of 5A:0.333V.

To calculate your CT ratio, multiply the ratio of your metering CT by the ratio of your CTI module.

	CT Ratio	CTI Module	CT Ratio Calculation	CT Ratio in Setup File
<b>Example 1</b>	300A:5A	CTI-5A module	$\frac{300A}{5A} \times \frac{5A}{0.333V} = \frac{300A}{0.333V}$	300:0.333
<b>Example 2</b>	300A:5A	CTI-1A module	$\frac{300A}{5A} \times \frac{1A}{0.333V} = \frac{300A}{1.666V}$	300:1.666

<b>Example 3</b>	300A:1A	CTI-5A module	$\frac{300A}{1A} \times \frac{5A}{0.333V} = \frac{1500A}{0.333V}$	1500:0.333
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Verify your PQube 3 has been configured properly

### 4.2.2.3 Verify the PQube 3 blinks in Green



The first step of the verification is to make sure that the main LED of the PQube 3 blinks in GREEN.

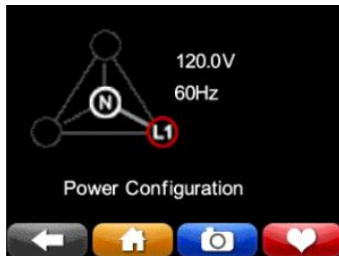
Your PQube will not begin recording until it has locked onto the power configuration. The minimum lock-on voltage is 30VAC applied between L1 and N, or between L1 and L2.

If not blinking green, go to the troubleshooting chapter.

### 4.2.2.4 Check Power Configuration

From the main menu on the touchscreen display, go to System, Config, Power Config. Verify that the power configuration, nominal voltage, and nominal frequency look correct. This is important for proper event detection and data recording.

If you are using your PQube for DC monitoring only, and do not wish to record AC voltage, you can set your Power Configuration to “NO\_MAINS” in your setup file.

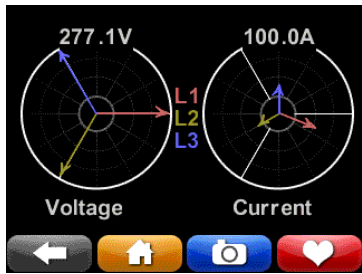


### 4.2.2.5 Verify meter readings



From the display, press the Meters button and check that everything looks correct. If you entered PT and CT ratios into your setup file, verify that your voltage and current values look appropriate. Also make sure that your values for power (watts) and power factor look appropriate. If you have inverted your CTs or installed the CTs on the wrong phases, your power readings will be inaccurate.

### 4.2.2.6 Verify voltage and current vectors



You will also want to verify that your voltage and current vectors look appropriate. Our vector convention for a balanced 3-phase system is L1 voltage at  $0^\circ$ , with L2 voltage at  $-120^\circ$  and L3 voltage at  $+120^\circ$ .

## 4.2.3 Troubleshooting: Common Installation Errors

### Negative Sequence Unbalance Excessively High

If your PQube 3 reports an excessively high negative sequence unbalance ratio, this means your phase rotation is reversed. If you were connecting a 3-phase motor using this sequence, it would begin rotating in the opposite direction as intended. To change your phase rotation, swap any 2 phases.

### Power Readings Lower Than Expected

If your watts and power factor readings are much lower than expected, double check that your CTs are installed on the correct conductors. For example if your L1 current sensor is installed on the L2 conductor, your L1 power will be much lower than expected, and possibly negative.

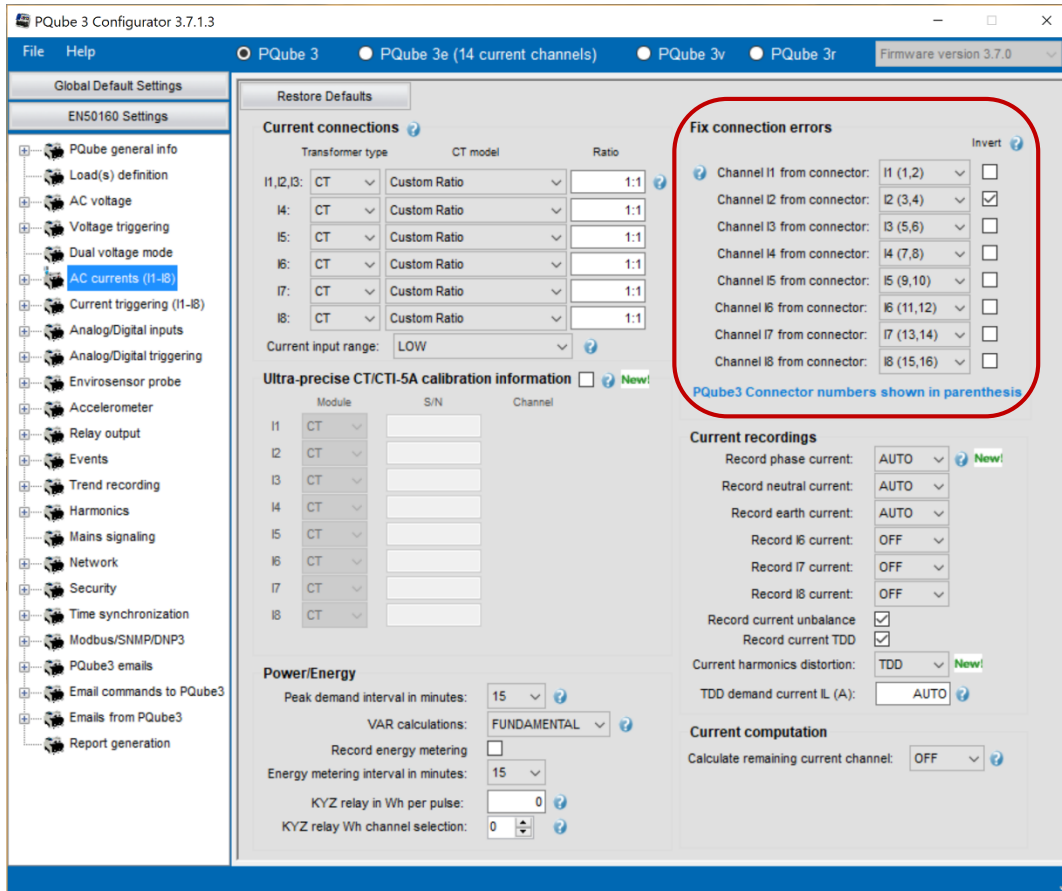
### Unexpected Negative Power Readings

During installation, it is easy to make a mistake in your current transformer connections, either by reversing the secondary connections or by feeding the main power conductor through your current transformer backwards.

It is important to correctly connect your CTs (or use the method above to correct a wiring error). Power (watt) calculations are made by multiplying the instantaneous current by the instantaneous voltage. If one or more of your current transformers is incorrectly set up, your PQube will calculate negative power for that phase.

You can always shut the power down and open up the cabinet to fix your wiring; but an easier way is to invert your CT polarity in your setup file.

For example, if you realize that you have installed your L2 current transformer backwards, just invert the L2 current channel in your setup file.



## PQube 3 Not Locking Onto Power Configuration

Your PQube 3 does not have an ON/OFF switch for recording data. It is designed to automatically begin recording data as soon as it has locked onto the power configuration. If it cannot lock onto a power configuration, it cannot record data and will blink orange.

If your PQube 3 is having trouble locking on, check the following:

You need to have at least 30VAC applied between the L1 and N terminals or the L1 and L2 terminals.

Next, verify that you've connected the Earth conductor to your PQube 3. If you forget to install the Earth conductor to your PQube 3, your PQube 3 may have problems locking onto the power configuration. Connecting the Earth conductor is required to ensure the safety, reliability, and accuracy of your PQube 3.

Still need help? Contact us at [support@powerstandards.com](mailto:support@powerstandards.com).

## 5 Maintenance

### 5.1.1 Turning Off Your PQube 3

Your PQube 3 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 PQube 3, remove your PQube 3's instrument power (either the power screw terminal block on your PQube 3, the optional PM1 Power Supply Module, or PoE). Your PQube 3 will automatically initiate graceful shutdown to prevent any write damage to flash.

If you have a UPS module installed, your PQube 3 will continue to run for the allotted amount of time. To immediately power down the device while on backup power from the UPS module, go to the Actions screen and press Reboot. With no permanent power source available, your PQube 3 will simply turn off.

### 5.1.2 Replacing Your PQube 3's Clock Battery

Your PQube 3 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. When you order a replacement battery, always remember to power off the device first, disconnect mains connections, and verify disconnections.



To remove and 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 a PSL-supplied battery only. Use of another battery may present a risk of fire or explosion. This part must be supplied only by PSL or PSL agents.

### 5.1.3 Life Expectancy of the PQube 3 and the PM1/PM2 module

The estimated life expectancy of a PQube 3 and its PM1 module is 10 years (estimation based on operating temperature at 20-30degC).

### 5.1.4 UPS1 Life Expectancy and Long Term Storage Instructions

The lithium ion batteries in your UPS1 module are rated for 5 years or 500 cycles, whichever comes first. Contact PSL to replace the batteries. Do not attempt to replace the batteries yourself.

If you need to store your PQube 3 and modules on the shelf for 3 months or longer, remember to fully charge the batteries in your UPS1 module before placing them in storage. To fully charge the batteries, turn on your PQube 3 with the UPS1 module plugged in, and let it run for at least 1 day.

PSL recommends charging your UPS1 modules every 6 months while they are in storage. You must store your UPS1 modules at an ambient temperature between -20 – 35°C.

### 5.1.5 Cleaning Instructions

If necessary, wipe the accessible parts of your PQube 3 with a slightly damp cloth while it is powered off. Do not use abrasives or chemical cleaners and do not clean your PQube 3 while it is powered on.

### 5.1.6 Reasons for reset

If your PQube 3 is configured to email you whenever system activity occurs, it will notify you whenever it has reset.

Reset reasons	Description
System Timeout reached	One of the processes of the PQube is stuck or takes too much time to complete compared to expected
Setup File Sent	A new setup.ini file has been sent
Update Required Restart	A firmware update was sent and PQube3 restarted
User Triggered Display Reboot	The touch screen <Action> <reboot> has been used
Web Command Reboot	A reset has been requested from the web command page
Battery Timeout Reached. Battery Percentage: XX%	The PQube has shut down after reaching the configured autonomy of battery (see PQube configuration).
Unspecified Reason	No reason identified (default)

### 5.1.7 Calibration Information for Your PQube 3

Every PQube 3 is calibrated and traced to NIST at the factory. You can download a free NIST trace certificate that contains the specific calibration information for your PQube 3 by entering your PQube 3's serial number at <https://www.powerstandards.com/?product=pqube-3/certificates>

# 6 PQube 3 Technical Specifications

The **PQube 3 Technical specifications** are available for download at:

<https://www.powerstandards.com/?product=pqube-3/specifications>

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Reference conditions for factory tests: 19-25°C, 10%-70% RH

MAIN VOLTAGE MEASURING CHANNELS			
Mains Voltage Channels	3* Line-to-Neutral, 3* Line-to-Line, 3* Line-to-Earth, 1* Neutral-to-Earth		
Power Configuration / Range of Nominal Input Voltage	Single-phase – 69 VAC – 480 VAC (L-N) Split-single-phase – 50 VAC – 480 VAC (L-N) and 100 VAC – 960 VAC (L-L) 3 phase wye/star – 50 VAC – 480 VAC (L-N) and 100 VAC – 830 VAC (L-L) 3 phase delta – 100 VAC – 600 VAC Power configuration and nominal voltages can be user-selected or auto-selected.		
Voltage Measurement Range	0 VAC – 750 VAC (L-N) and 0 VAC – 1300 VAC (L-L)		
Magnitude accuracy (% rdg ±% FS)	Typical	100% Factory Test Pass/Fail Limit	Specification
	±0.01%	±0.025%	±0.05%
10VAC-750VAC L-N, 50/60 Hz			
Voltage fundamental angle accuracy (relative to L1-E channel)	Typical	100% Factory Test Pass/Fail Limit	Specification
	±0.002°	±0.002°	±0.01°
Sub-sample analog angle calibration Calibrated ±0.01 sample resolution 50/60 Hz. All specifications relative to L1-E angle, at nominal voltage. Typical and factory specifications are limited by system resolution.			
Range of Nominal Frequencies	16.67 Hz, 50 Hz, 60 Hz, or 400 Hz auto-selected		
		Sampling Rate	Notes