Manual Version 1.2.2-e

PQube®

Installation & User's Manual

Firmware Rev 1.2.2

PSL
Power Standards Lab
1201 Marina Village Pkwy #101
Alameda CA 94501 USA
www.PowerStandards.com

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.

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Produced in the United States of America.

Symbol	Meaning
	Caution. Consult this manual in all cases where this symbol is used.
	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

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Introduction

What Can Your PQube Do?

Your PQube® is an instrument for monitoring electric power systems.

It is convenient to think of it as a combination of a power disturbance monitor, a power meter, a power recorder, and a digital camera – it combines the best features of all four.

Your PQube records disturbances on the mains circuit: sags/dips, swells, interruptions, frequency variations, and disturbances on two analog input channels. It also records impulses, waveform snapshots, unbalance, RMS flicker, and THD, and trend data (strip charts and cumulative statistics).

When equipped with an optional current sensing module, your PQube also records current waveforms, RMS amps, power and carbon. It measures watts, watt-hours, VAR's, power factor, and other power-related parameters.

You don't need any software from PSL to use your PQube. It records all data on a SD memory card, which can be read by any computer. No special software is required – just open the GIF picture files with standard image programs, or even Microsoft Word® and Microsoft PowerPoint®, or open the CSV files with any spreadsheet program such as Microsoft Excel® (or OpenOffice.org Calc if you prefer something free). Configure your PQube by editing a text file on the SD card.

It can monitor single-phase or three-phase circuits, at up to 690 VAC phase-to-phase (400 VAC phase-to-earth), at 50 Hz, 60 Hz, and 400 Hz.

It includes channels for measuring auxiliary voltages – typically 24V AC or 48V DC.

It also has a general-purpose digital input, which you can control with switch contacts or a logic signal, and a relay contact output, which opens for at least 3 seconds whenever your PQube detects an event.

It can be directly powered from 24V AC or 24~48V DC, or it can be equipped with an optional PS1 power supply that operates from 100V ~ 240V, 50/60 Hz.

Your PQube also measures temperature and humidity at up to two locations, using optional TH1 temperature-humidity probes.

When equipped with an optional ETH1 Ethernet module, your PQube can automatically send you e-mails whenever it detects an event. You can send your PQube a new setup file, or even update its firmware via e-mail. The Ethernet module also includes a web server, an FTP server, and MODBUS over TCP, giving you even more ways to communicate with your PQube.

How Is The PQube Different?

There are many power quality meters, energy meters, and energy recorders available. What makes the PQube stand out from other products?

- **No software. No rental fees. Open data.** -- You don't need any software from PSL to use the PQube. Do you have a web browser? A text editor? A spreadsheet program like Microsoft Excel®? That's all you need! All the data that the PQube records are in open formats that are easy to understand. You don't have to buy or lease software from Power Standards Lab, you don't have to pay us to see your data, and the files are easy to pass on to third parties.
- **Friendly data.** – When you look at information about your electric power, you don't want to spend a lot of time learning to use software to get the view that you want. You simply want your data organized and presented to your in a format you can understand. Your PQube presents power quality events, trends, and statistics in formats you can easily use and lays the data out in a way that's understandable. Your PQube knows what's important.
- **Free firmware updates** – From time to time, we offer firmware updates to add new features to your PQube. Other instrument manufacturers charge for firmware updates, we don't.
- **Works out of the box, or configure everything to work for you** – With our patent-pending auto configuration, you can connect your PQube to the power that you want to measure and the PQube will immediately start recording data. If you don't like the default settings you can change almost anything by editing a text file on the SD card.
- **Works with or without a network** – Do you have an Ethernet network? Use an optional ETH1 module and get emails when an event occurs, browse the recorded events and trends with your web browser, or integrate it into your Modbus system. Don't have a network? No problem, just walk up to the PQube and take the SD card. You can look at all the files on any computer (you don't need software). You don't need a sophisticated centralized data collection system to get started. Just connect a PQube and start getting data right away.
- **Store years of data on standard SD cards.** – Your PQube comes with a 2GB SD card which will store about 2 years worth of data. Need more storage? Go to www.powerstandards.com and buy a 4GB or 8GB card.
- **Small size** – The PQube is tiny (a little bit bigger than your fist), and that makes it easier to integrate into your product.
- **Low cost** – At Power Standards Lab, we're experts at building power sensor electronics. We know how to do it right, and we know how to do it inexpensively. The PQube costs far less than comparable instruments.
- **It's everything you need.** – Power quality data: dips, swells, frequency variation, and high-frequency impulses. Energy data: kWh, kVAh, and carbon. Trend data: daily, weekly, and monthly strip charts, cumulative probability and load duration. Why buy multiple meters when the PQube can do it all?

Applications

Your PQube is ideal for reducing your service costs on sensitive equipment, such as semiconductor manufacturing equipment and sophisticated medical scanners. By detecting and recording power disturbances, you can easily and quickly separate intermittent power problems from other intermittent problems: software bugs, user errors, supply stock problems, etc.

And your PQube is an excellent choice for monitoring the power that feeds industrial controls, such as automated machinery, robotics, and elevator/lift controls.

You can use your PQube in dozens of other applications: monitoring the power quality at key accounts, doing national surveys of power quality, safely recording power data for research projects, understanding why your wind turbine drops off line unexpectedly, and many other purposes.

Choosing Modules

Your PQube records events, trends, and statistics by monitoring the line voltage. It also includes two analog input channels that you can use to measure any additional signals (for example, the output of a power supply), a digital input channel, an output relay, and a full color display. Your PQube records all information to a standard SD card.

You can combine your PQube with several optional modules to provide extra features. These modules snap into your PQube; just click them together. To choose modules for your application, you'll need to answer four simple questions:

- Are you interested in measuring current, power, or energy?

- Do you want to power your PQube from 100~240Vac (50/60Hz)?
- Are you interested in any of the following: email, a web server, an FTP server, or Modbus over TCP?
- Do you want to record the temperature and humidity in addition to everything about the electric power?

Measure Current, Power, and Energy

Are you interested in measuring current, power, or energy? If so, you'll need one of our current modules. There are four versions; you can pick the one that is best for you.

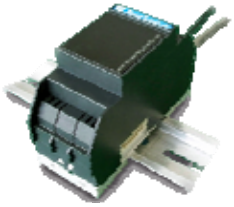
XCT4

If you already have CTs (Current Transformers) or purchase CTs from Power Standards Lab, you can use a XCT4. This module comes accepts 1-Amp, 5-Amp, 0.333-Volt, 1-Volt, 5-Volt, or 10-Volt secondaries. For more information, see the *XCT4 Current Module section (page 18)*.

CT4

If you don't want to use CTs, the CT4 current module might be right for you. This module comes in 20Amp and 100Amp versions and has the CTs built in already. Just pass the conductors through. For more information, see the *CT4 Current Module section (page 18)*.

Power Your PQube From 100~240Vac



Do you want to power your PQube from 100~240Vac (50/60Hz)? If you have 24~48Vdc or 24Vac, you can use your PQube's internal power supply (just connect to the power supply screw terminals). If you want to use 100~240Vac, you'll need an optional PS1 Power supply module.

Remote Communication

Are you interested in any of the following: email, a web server, an FTP server, or Modbus over TCP? If you need any of these features, you need an ETH1 Ethernet module. For more information, see the *ETH1 Ethernet Module section (page 42)*.

Measure Temperature and Humidity

Do you want to record the temperature and humidity in addition to everything about the electric power? You can use up to two TH1 Temperature/Humidity sensors. Measure the local environment or connect a second sensor with an extension cable and measure the temperature and humidity at two locations simultaneously. Just

plug them into your PQube and it will start recording data immediately.

Installation

Quickstart

1. Snap your PQube (and any plug-in modules) on to your DIN rail.

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2. Don't have an ETH1, XCT4 or CT4 plug-in module? Go to step 3.
   a) ETH1 module? Connect your Ethernet cable.
   b) XCT4 current interface module? Connect your current transformer to the screw terminals of your XCT4.
   c) CT4 current sense module? Pass your current carrying conductors through the CT openings.

(a)

(b)

(c)

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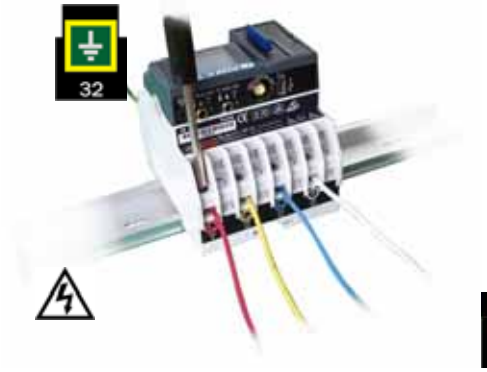
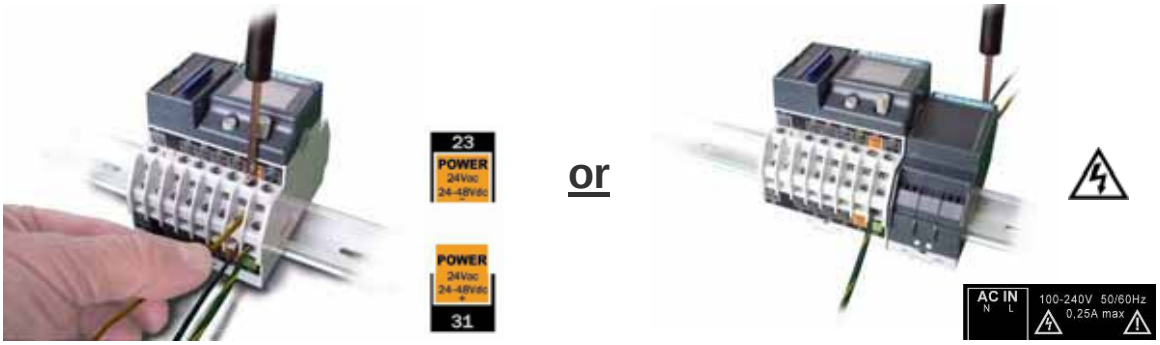
3. Connect Earth and Mains wires to your PQube.



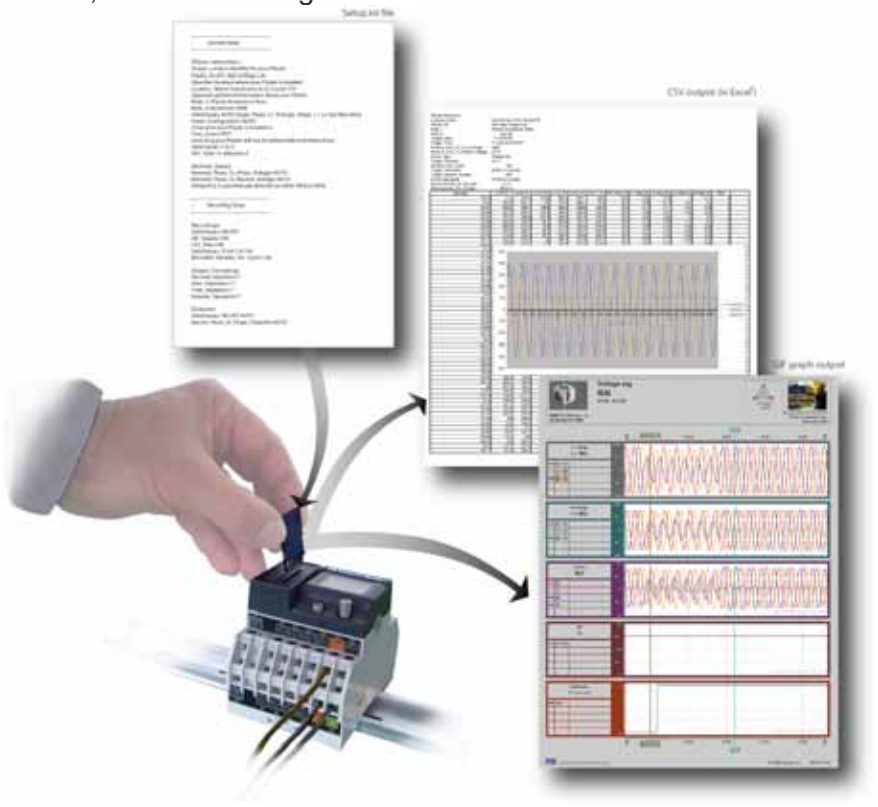
4 Connect 24VAC or 24-48VDC POWER to your PQube,
or plug in a PS1 Power Supply module and connect 100~240VAC to it.



5 Use the joystick and pushbutton to change settings ….

… and check that your PQube has correctly determined your mains voltage

6 Your PQube is recording power quality events on its SD card. If you have an XCT or a CT4, your PQube is also measuring energy.
Edit the Setup.ini file on your SD card to set location, thresholds, transformer ratios, email access, and other settings.



General Installation

Mount your PQube securely

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

The optional PS1 Power Supply module connects to the right side of your PQube. The optional ETH1 Ethernet module and current sensing modules connect to the left side of your PQube. Connect them to your PQube in any order that is convenient. Do not connect multiple current sensing modules. Only connect one current sensing module, either a CT4 or XCT4.

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.

Your PQube's "enclosure", as defined in UL/IEC 61010-1, is provided by the installation, and must be evaluated in the end product.

Your PQube must be installed only by an expert for electrical installations[1]. The instrument power screw terminals must be connected to no more than 24Vac +/- 20%, or 24Vdc~48Vdc +/- 20%, supplied by a certified isolating power supply.

PQube power

Your PQube can take its operating power from three different sources: its Power screw terminals [23][31], its internal Lithium Polymer rechargeable battery, or an optional PS1 Power Supply module.

Power screw terminals

Your PQube's Power screw terminals [23][31] accept 24VAC nominal, or 24Vdc~48Vdc nominal. They are most commonly connected to 24Vdc, 24VAC, or -48Vdc.

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

Internal Li-Polymer battery

Your PQube's internal Li-Polymer battery is automatically charged from all the other power sources. An application-specific chip manages the charging process, paying attention to voltage, current, and temperature. The battery itself is equipped with an internal high-temperature shut-down circuit.

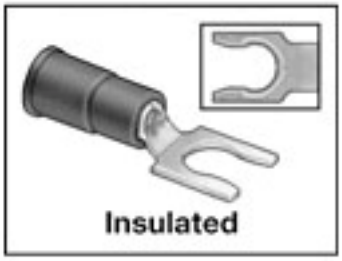
The battery operating capability depends on the options installed in your PQube, and on the ambient temperature. In typical tests, the battery can operate your PQube for about one hour. However, you can choose the operating duration by writing a value in your **Setup.ini** file. The value can be set from 1 to 9 minutes (the default is 3 minutes). This guarantees that there will be enough charge in the battery to record several successive power interruptions.

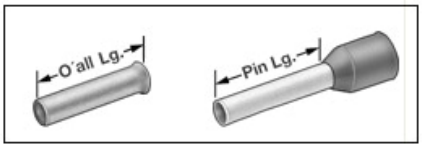
As the battery ages, its capacity will decline. For maximum performance, it may be necessary to replace the battery in 5 years. Some normal swelling of the battery may result from high temperature operation, but this does not interfere with battery performance.

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, or crimped snap-on forked lugs. Tighten the screw terminals to 0,8 newton-meters (7 inch-pounds) of torque. Observe all voltage ratings and limits.

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





For mains connections and current connections, PSL recommends snap-on forked terminals, such as 3M Scotchlok® P/N MU18-6FL or MU14-6FL, or Panduit P10-6lF. For other 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 PS1 Power Supply module, optionally use a shielded power conductor.

Conductor characteristics

Connection	**Minimum wire size**	**Maximum wire size**	**Limitations and remarks** Comply with all local safety and installation requirements and regulations.
PQube terminals L1, L2, L3, N [9] [11] [13] [15]	20AWG (0,52 mm^2)	14 AWG (2.1mm^2)	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 Earth terminal [32]	Wire size used for L1,L2,L3,N terminals	14 AWG (2.1mm^2)	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 RLY4 terminals [25] [26]	20AWG (0,52 mm^2)	14 AWG (2.1mm^2)	Min 600V UL-recognized insulation system required. Wire size must be adequate for relay contact load. These terminals are rated at 30 VAC max, 60 Vdc max, 2 amps max.
All other PQube terminals	20AWG (0,52 mm^2)	14 AWG (2.1mm^2)	Min 600V UL-recognized insulation system required.
Optional PS1 terminals	20AWG (0,52 mm^2)	14 AWG (2.1mm^2)	Min 600V UL-recognized insulation system required. Shielded cable recommended for minimizing emissions.
Optional XCT4 terminals	20AWG (0,52 mm^2)	14 AWG (2.1mm^2)	Ring lugs or snap-on forked terminals are recommended for CT connections. Self-retaining screws in terminals may make ring lugs challenging to install. Wire size must be adequate for 1-amp or 5-amp currents. Min 600V UL-recognized insulation system required
Optional CT4 pass-through inputs	20AWG (0,52 mm^2)	Limited by physical dimension of pass-through locations: 8.5 mm (0.34") dia.	Min 600V UL-recognized insulation system required. ⚠Insulated wire is required!⚠

Maximum voltages

Connection	Maximum voltage with respect to Earth	Maximum current	Limitations and remarks
PQube terminals L1, L2, L3, N [9] [11] [13] [15]	400 Vrms, CAT III up to 300Vrms, CAT IV		Corresponds to 690 Vrms phase-to-phase on centered-neutral mains systems. Corresponds to 480Vrms phase-to-phase on centered-neutral mains systems.
PQube Earth terminal [32]	N/A		
Optional PQube RLY4 terminals [25] [26]	30 Vrms or 60 Vdc		
All other PQube terminals	30 Vrms or 60 Vdc		
Optional PS1 terminals	240 Vrms, CAT III		
Optional XCT4 terminals	400 Vrms, CAT III	1 amp for XCT4-1A 5 amps for XCT4-5A	Usually connected to external current transformer secondaries, which provide insulation from mains. Corresponds to 690 Vrms phase-to-phase on centered neutral mains systems.
	up to 300Vrms, CAT IV		Usually connected to external current transformer secondaries, which provide insulation from mains. Corresponds to 480Vrms phase-to-phase on centered neutral mains systems.
Optional CT4 pass-through inputs ⚠Insulated wire is required!⚠	400 Vrms, CAT III	20 amps for CT4-20 100 amps for CT4-100	Corresponds to 480Vrms phase-to-phase on centered neutral mains systems.
	up to 300Vrms, CAT IV		Corresponds to 690 Vrms phase-to-phase on centered neutral mains systems.

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."

Using your PQube with external Potential Transformers

If you want to measure nominal voltages higher than 690 volts, you can connect your PQube voltage inputs to the secondary windings (low voltage windings) of any standard Potential Transformer.

In general, the accuracy of your PQube's voltage measurements are so precise (roughly ±0.1%) that any accuracy specification will be determined almost entirely by the potential transformer that you select.

For information on configuring your PQube to read correct voltages when using a potential transformer, see *Setting Your Potential Transformer Ratio (page 20)*.

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 meet the relevant requirements of IEC 60974-1 and IEC 60947-3, and be suitable for the application.

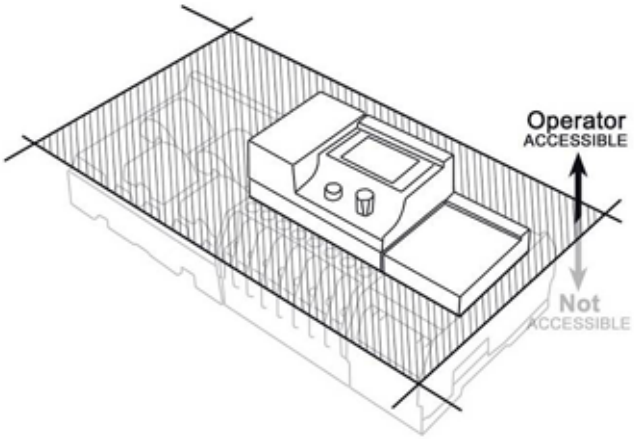
The overcurrent protection device must be rated between 1 amp (minimum) and 20 amps (maximum).

Your PQube 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, and must be marked to indicate the disconnection function. Do not install your PQube 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, within easy reach of the operator.

Protect the operator from the hazardous terminals

Install your PQube so that all of the screw terminals are not ACCESSIBLE[2] to the operator. Your PQube can also be installed without a cover if installed in a lockable IUL 508 control panel.



The operator must be protected from the hazardous screw terminals by a barrier. The screw terminals 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 in an enclosure, select a UL-listed enclosure that is appropriate for the purpose, such as the Altech EK series (www.AltechCorp.com). If you plan to use an enclosure of this type, you should review its mechanical compatibility with any optional features of your PQube that you plan to use: optional USB connections, optional temperature-humidity probes, etc.

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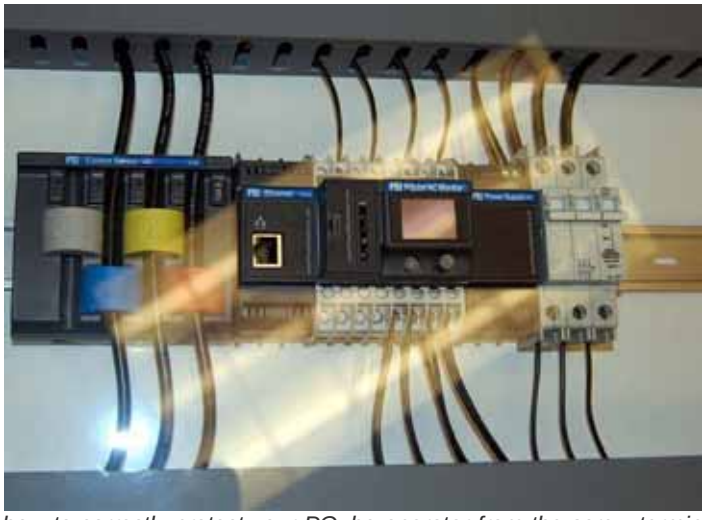
[2] *Accessible, as defined in UL 61010-1, means able to be touched with a standard test finger or test pin, when used as specified in UL61010-1 6.2.*



A different example of how to correctly protect your PQube operator from the screw terminals. A 6,35mm (0.25 in) clear Plexiglass® sheet, which requires a tool to remove, protects the operator. A rectangular cutout in the Plexiglass gives the operator access to your PQube controls, the Ethernet connection, etc. Note the 1-amp, 3-phase circuit breaker, at far right, used both as external overcurrent protection and disconnecting device, near your PQube. The rectangular opening in the Plexiglass should be 74mm x 47mm (for your PQube alone), or 110mm x 47mm (for your PQube and the ETH1 module, or your PQube and the PS1 module), or 146mm x 47mm (for your PQube and both the ETH1 and PS1 modules).

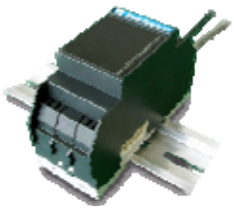
Protect antenna terminals from lightning

If you install a PQube antenna (GPS, Zigbee, etc.) 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. Follow all local installation safety requirements and regulations.

Installing Your ETH1 Ethernet Module

The optional ETH1 Ethernet module connects to the left side of your PQube; just snap it in. Connect the module before supplying power to your PQube. The ETH1 Ethernet module contains a standard RJ-45 Ethernet port. The module uses 10BaseT Ethernet with built-in crossover detection. You can connect your ETH1 Ethernet module to any standard Ethernet network using a standard Ethernet cable. For information on configuring your ETH1 module see *Setting up Your Optional ETH1 Ethernet Module (page 22)*.

Installing Your PS1 Power Supply Module



The optional PS1 Power Supply Module connects to the right side of your PQube; just snap it in. It accepts any 50/60 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. The PS1 Power Supply module contains an internal fuse.

Installing Current Modules

If you want to measure current with your PQube you can install an optional module. Simply plug the module into the side of your PQube.

PQube current modules provide transformer-based electrical isolation, except for the XCT4-0.333V, XCT4-01V, XCT4-05V, and XCT4-10V, which take low-voltage inputs.

Note that your PQube makes current measurements with a Crest Factor of 3.5. This means that your PQube can measure instantaneous currents up to 350% of the nominal rated current (for example, if you have selected a 300-amp current transformer with a 5-amp secondary, your PQube will accurately measure up to ±1050 amps instantaneous). This is a very useful feature when dealing with inrush currents, and currents with high harmonic contents.

When connecting a Current Module, 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 important for correct power and energy calculations.

There are two main types of current module, the XCT4 and the CT4. You only need one current module to measure current, power, and energy. Pick the version that works best for you.

XCT4 Current Module

You can connect external current transformers to your PQube. There are five version of the XCT4 module: each will work with a different type of CT. Make sure you carefully read all safety information provided by the manufacturer before installing CTs.

If you are using a CT with a current secondary, you can use the XCT4-1A-00 or the XCT4-5A-00 which have 1 and 5 Amp inputs, respectively. Your PQube places almost zero burden on the current transformer (less than 0.1 VA), so you can select almost any current transformer.

If you are using a current sensor that has a voltage output, you can choose between the XCT4-0.333V-00, XCT4-01V-00, XCT4-05V-00, and XCT4-10V-00 which have 0.333, 1, 5, and 10 Volt inputs, respectively.

You can use either standard current transformers, or split-core current transformers. Standard current transformers are generally less expensive, and are often more accurate. Split-core transformers are much easier to install.

In general, the accuracy of your PQube's current measurements are so precise (roughly ±0.1%) that the accuracy of your current measurements will be determined almost entirely by the current transformer that you select.

CT4 Current Module

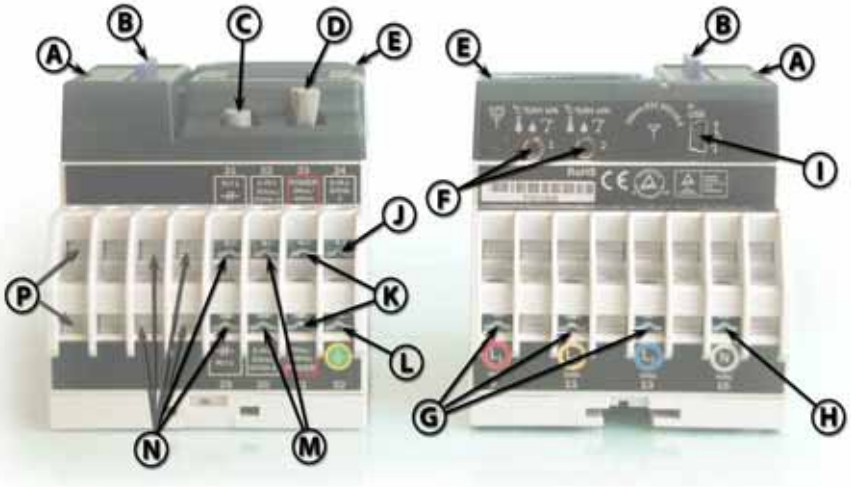
If you don't already have CTs, but you want to measure current, you can use the optional CT4 module. It has the CTs already built in and ready to use.

The CT4 comes in two models: the CT4-20A (for nominal currents up to 20 amps) and the CT4-100A (for nominal currents up to 100A). Both versions can accept conductors up to 0.34 inches (8,6mm) in diameter. 600V, UL-recognized insulation is required.

Disconnect mains prior to servicing

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

Overview of connections and controls



A	Battery compartment latch
B	SD memory card and adjacent LED
C	Select button
D	Joystick. Click like a button to return to main menu.
E	Heartbeat LED
F	Temperature/humidity probe inputs. Optically isolated from local earth.
G	L1, L2, L3 voltage inputs. 690Vrms max phase-to-phase (equivalent to 400Vrms phase-to-earth)
H	Neutral terminal – optional connection

I	USB port. Optically isolated from local earth. Factory use for Rev 1.2 firmware; user access in free future firmware upgrades.
J	Digital input. 60-volt tolerant. 1.5-volt threshold. Wetted with 5.4V at 3 microamps.
K	Power inputs. 24VAC, or 24VDC to 48VDC (either polarity) nominal. 15VA max.
L	Earth – functional. Used as the reference voltage.
M	Analog inputs. Maximum ±60V to earth. Can be used as differential inputs.
N	Signal relay outputs. One is standard, two more are optional (not yet available).
P	Optional relay contact output rated at 30VAC, 60VDC, 2 amps (not yet available).

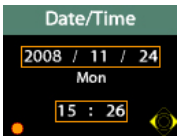
Calibration Information for Your PQube

Every PQube 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 by entering your PQube's serial number at www.powerstandards.com/CalibCerts.htm.

Setting up your PQube

Your PQube will work right out of the box. Simply follow the *Quickstart Guide (page 10)* and your PQube will begin recording data immediately. The default settings will work for most applications, but if you have special requirements you may need to change a few settings. Don't worry, it's an easy process.

Setting the Date and Time



You can set the time and date via your PQube's display. For information on how to use your PQube's display, see *Your PQube's Display and User Interface (page 27)*. Go to the configuration menu and scroll to the Date/Time screen. Press the select button and then use the joystick to change each field to the present date and time.

Setting the date and time is important because all of the output files your PQube produces include a time stamp.

Note that if you have an ETH1 Ethernet module and you are using the SNTP feature (off by default), your PQube will set its own time to UTC and will override any changes you make to the date and time.

Setting Your Languages

Changing the language setting on your PQube will change your PQube display and the GIF graphs produced by your PQube. You can set up to two different languages for your PQube. If you set two languages, both languages will apear on the GIF graphs. This can be useful if you are discussing graphs with someone who is more comfortable in another language.

To change the language settings for your PQube, use the display and joystick. The Language settings are in the configuration menu.

Setting Your Potential Transformer Ratio

If you are using Potential Transformers (PT) to monitor voltages above 690Vac Phase-to-Phase (400Vac Phase-to-Earth) you can tell your PQube about the ratio to use to calculate the measured voltage. For example, to use your PQube on a 24 kilovolt distribution system, you might use a 100:1 potential transformer to reduce the 24 kilovolts to 240 volts. In your PQube's **Setup.ini** file, you would set

```
Potential_Transformer_Ratio=24000:240
```

Or, if you prefer, you could set

```
Potential_Transformer_Ratio=100:1
```

Note that, if you choose to set the nominal voltage in your PQube's **Setup.ini** file, you would set

```
Nominal_Phase_To_Neutral_Voltage=24000
```

even though the voltage at your PQube's terminals is 240 volts nominal.

Setting up Your Optional Current Module

Setting Current Transformer Ratio

If you are using a CT4 current sensing module, you don't need to set a CT ratio – your PQube will set it automatically.

If you are using an XCT4 current sensing module, you will need to set the CT ratio so that your PQube can correctly display the amount of current, as well as correctly calculate power and energy usage. For example, to use your PQube on a system with 200 amps flowing in the power conductors, you might choose current transformers rated at 300 amps, with a 5-amp secondary. In your PQube's **Setup.ini** file, you would set

```
Current_Transformer_Ratio=300:5
```

Inverting Current Channels

During installation, it is easy to make a mistake in your current transformer connections, either by reversing the secondary connections (when using an XCT4) or by feeding the main power conductor through your current transformer backwards (when using a CT4 or XCT4). Of course, you can always correct your wiring; but an easier alternative is to use your PQube's **Setup.ini** file to invert one or more of your current channels. If you realize that you have installed your L2 current transformer backwards, you can fix this easily:

```
Invert_L1_Current_Channel=OFF
Invert_L2_Current_Channel=ON
Invert_L3_Current_Channel=OFF
Invert_N_Current_Channel=OFF
```

Why Bother?

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.

Calculating Current With a Missing CT

You do not need to connect CTs to all of the conductors that you want to monitor. When current flows through a system, the net current is always zero. Because of this, you can connect one fewer CT than you have conductors (for a delta system, you only need two CTs, for a wye/star system you only need 3 CTs). Your PQube can calculate the current in the missing CT. Note that if you calculate the current in a missing CT, your PQube will incorrectly show any earth current as flowing in the calculated phase.

If you want to use this feature, change the `Calculate_Current_Channel` setting in the **setup.ini** file on your SD card.

Setting up Your Optional ETH1 Ethernet Module

Your ETH1 module requires some configuration before you can begin using it. To configure your ETH1 module, you need to make a few changes to the **setup.ini** file on your SD card. Network Setup is required to use your ETH1 Ethernet Module. The other sections are optional.

Network Setup

To set up your network connection, you may need to change the `IP_Address_Method` setting in the **setup.ini** file

Your PQube supports two different methods to get network information. DHCP is the automatic method used on most modern networks and the default for your PQube. If your network supports DHCP and you use the `Use_DHCP` setting, simply plug in your PQube and it will get the network configuration automatically. If your network doesn't support DHCP, change this setting to `Use_Fixed_IP` and fill out the `[Fixed_IP]` section.

Email Setup

You must set up an e-mail account for your PQube before it can send email. This is because your PQube is an email client, just like your computer. You will need to give your email system administrator some information, have him or her set up an account for your PQube, and then fill in the [Email_Server_Settings] section of the setup.ini file on your SD card.

> **SMTP vs. POP**
>
> Simple Mail Transfer Protocol (SMTP) is the standard protocol for sending email while Post Office Protocol (POP) is the standard protocol for receiving email.

Setup Configuration

Please tell your System Administrator that:

- Your PQube is a standard e-mail client.
- For outgoing mail, your PQube supports plain-text authentication, Cram-MD5, or MD5-Digest login.
- For incoming mail, your PQube supports plain-text authentication, Cram-MD5, MD5-Digest, USER-PASS, or APOP login.
- Ask your System Administrator to set up an e-mail account, and get the following information from them:

  SMTP Server: _____ Port: _____

  POP Server: _____ Port: _____

  PQube e-mail address: _____

  PQube e-mail user name: _____

  PQube e-mail password: _____

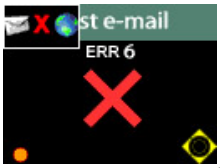
- Use this information to fill in your **Setup.ini** file.

Sending a test e-mail from your PQube

After you have set up your PQube to use email, it is a good idea to send a test e-mail from your PQube. Use the joystick to go to the "Send test e-mail" screen, just to the left of your "Configuration" menu, and select it. If your PQube sends an e-mail successfully, you will see a green check mark.

Click the button to send a test email

The email was sent successfully



There was an error sending the email

If your PQube could not send an e-mail, you will see an ERR number on the screen. The error number corresponds to one of the following problems:

ERR 1: You don't have an Ethernet Module with compatible firmware, or it's not attached to your PQube properly.

ERR 4: PQube sending e-mail: Your PQube had a problem opening the e-mail body file.

ERR 6: PQube sending e-mail: No network connection is available. Check your Ethernet cable and router, and check your network settings in your Setup.ini file.

ERR 7: PQube sending e-mail: Problem connecting to your e-mail SMTP server. Check that you have the correct SMTP server name in your Setup.ini file.

ERR 8: PQube sending e-mail: Your PQube successfully connected to your e-mail SMTP server, but the authentication process failed. Check that you have the correct password, and e-mail address, and that your SMTP e-mail server supports one of the following authentication methods: plain text, CRAM MD5, MD5 Digest.

ERR 9: PQube sending e-mail: Your PQube had a problem opening an attachment file.

ERR 10: PQube sending e-mail: Error while receiving a reply from your e-mail SMTP server (Your PQube was expecting data from your SMTP server, but PQube never received the data.)

ERR 11: PQube sending e-mail: E-mail rejected by your SMTP server (Your PQube transmitted the email, and the SMTP server got the email, but the SMTP server rejected the email for some reason.)

ERR 12: PQube sending e-mail: response error while transmitting to your e-mail SNTP server (Your PQube connected to your SMTP server, but there was an error sending data to your server).

ERR 13: Domain Name Server error (Your PQube couldn't connect to the Domain Name Server you specified, or there was an error during DNS transmission, or a bad response from DNS.)

ERR 14: The Domain Name Server says that the domain name does not exist. Check the POP and SMTP and SNTP servers that you specified in your Setup.ini file.

ERR 15: Your PQube recognizes that an ETH1 Ethernet module is connected, but it is unable to communicate with it. Your ETH1 may be starting up, and may not be ready yet – try again in a few seconds. If the problem persists, you may have a mis-match between your PQube firmware and your ETH1 firmware. Upgrade your PQube firmware.

ERR 16: PQube sending e-mail: the "To:" field is blank in the e-mail.

ERR 17: PQube receiving e-mail: your POP server caused a Domain Name Server error. Check the POP server that you specified in your Setup.ini file.

ERR 18: PQube receiving e-mail: Unable to connect to your POP server. Check the POP server that you specified in your Setup.ini file.

ERR 19: PQube receiving e-mail: POP server authentication failed. Check the POP server that you specified in your Setup.ini file. Check that you have the correct password, and e-mail address, and that the e-mail server supports one of the following authentication methods: plain text, CRAM MD5, MD5 Digest.

ERR 20: PQube receiving e-mail: Checking POP server inbox failed. Your PQube connected to your POP server, and your POP server accepted your PQube's authentication, but for some reason refused to disclose the inbox contents.

ERR 21: PQube receiving e-mail: Error retrieving a message from your POP server inbox. Your PQube connected to your POP server, and your POP server accepted your PQube's authentication, and your POP server provide the list of inbox contents, but for some reason the transfer of a message from your POP server to your PQube failed.

ERR 254: Unknown e-mail error.

Web Server Setup

Your option ETH1 module includes a web server. When you can type the IP address of your PQube into your web browser, you will see a web site that contains all of the information that your PQube has recorded, as well as real-time meters and status information.

The web server is enabled by default and uses the default HTTP port 80. This means that you shouldn't need to change any settings to use the web server. If you need to use a different port, you can change the `Web_Server_port` setting in the **setup.ini** file on your SD card.

For information on using your PQube's web server, see the *Web section (page 43)*.

FTP Setup

Your PQube contains a FTP server that you can use to get files from your SD card. FTP (File Transfer Protocol) is a simple system used for transferring files between two computers that are connected by a network. The FTP server is disabled by default, you can enable it by changing the `FTP_Server` setting the **setup.ini** file to `ON`. You can also change the login and password for your FTP server by changing the `FTP_User_Name` and `FTP_Password` settings. For information on connecting to the FTP server see the *FTP section (page 44)*.

Modbus Setup

Your ETH1 Ethernet module contains a Modbus-over-TCP slave device that you can use to read meters and determine when new event or trend recordings are available. This feature is in beta for firmware version 1.2. You can set the Modbus TCP port by changing the `Modbus_TCP_port` setting in the **setup.ini** file on the SD card of your PQube. You can also set the base address of the registers by changing the `Modbus_Register_Start_Address` setting.

Please configure your Modbus client using the following settings:

Mode = TCP
"2 byte ID" disabled
Function code = 4
Minus offset = 0
Registers should be represented as 32 bit float except where noted

For a description of the available registers, see the *Modbus section (page 44)*.

The Setup.ini File

Configure your PQube by editing the **Setup.ini** file on its SD card.

This is a simple text file. You can edit it with any text editor, such as Notepad.

Your PQube uses the standard INI file format. All you have to do is change the text after the equals signs (=).

When you plug an SD card into your PQube, your PQube will automatically reset itself, and then read your **Setup.ini** file. As it reads your **Setup.ini** file, your PQube will store your settings into its flash memory.

If you plug in an SD card that does not include a **Setup.ini** file, your PQube will use the Setup that it previously stored in its flash memory. So you can easily configure your PQube once, then use blank SD cards from then on. Note that you may want to copy the setup.ini file and the language packs from the old SD card to make it easier to make changes to your PQube setup and make it possible to change the language settings.

Location.gif

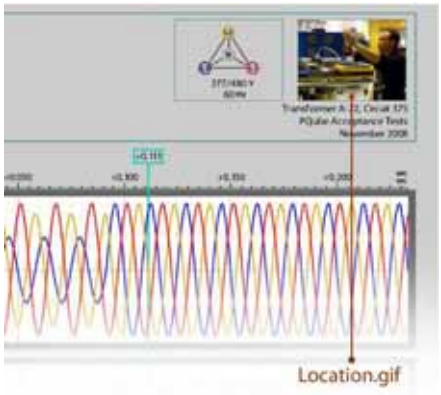
Location.gif is a photograph (usually) of where your PQube is installed. Your PQube automatically inserts it at the top right corner of your PQube's graphic output files.

- Your **Location.gif** file must be exactly 128 x 96 pixels;
- it *must* be normal row order (not interlaced);
- it *must* use the Web palette.

When you insert an SD card that contains a **Location.gif** file, your PQube will automatically reset itself, then store the **Location.gif** into its flash memory. It will permanently remember this picture until you replace it. (The storing process takes a few seconds, so you may want to delete the **Location.gif** file from your SD card after you have inserted it once.)

You can see your Location.gif on your PQube's display, one joystick click down from the bottom of the main menu.

Need help creating a Location.gif file? Send us an e-mail at Support@PowerStandards.com .



The locaton.gif picture appears in GIF graph output files.

User Guide

Using Your PQube

Your PQube's Display and User Interface

Joystick and button

Use the joystick (B) on the front of your PQube to navigate through the displays.

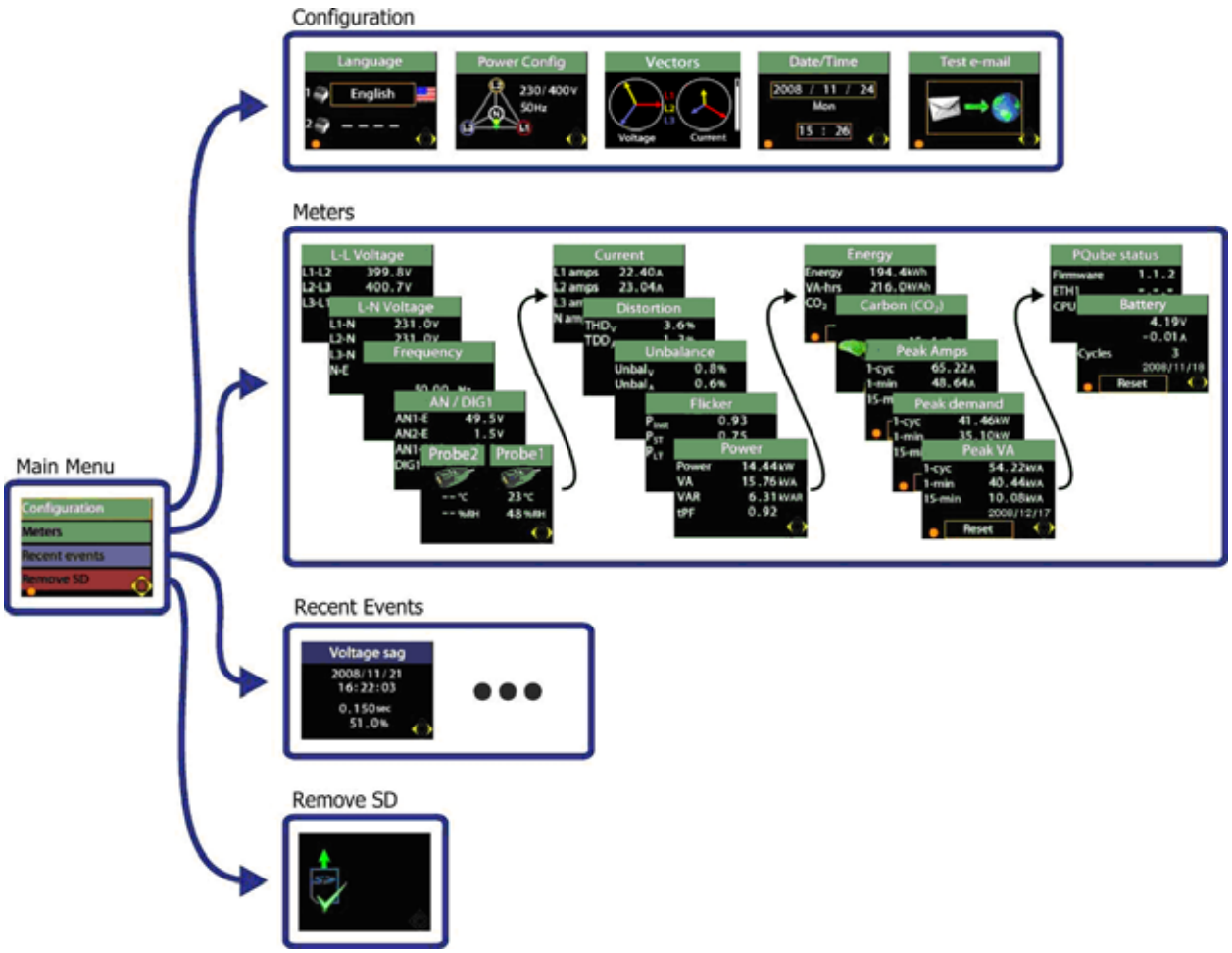
Gently push down on the joystick (B) like a button to return to the Main Menu. Click the button (A) to make a selection.

To force your PQube to reset, hold the button (A) down for 10 seconds.

The PQube Display

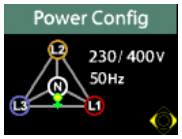
Use the joystick on the front of your PQube to navigate through these screens. Use the select button to choose an item outlined by an 

orange box.

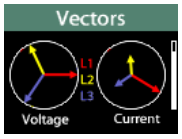


Configuration

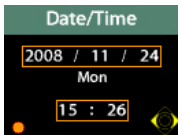
Language: Language 1 sets your PQube's main language, which is used for all of these screens and the GIF output graphs. Language 2, if you choose one, sets the second language on GIF output graphs. This can be useful if you expect to discuss these graphs with an engineer who reads another language.



Power configuration: This screen shows you the power configuration that your PQube is using. If your PQube is hunting for the correct power configuration, this screen will cycle through the various possible configurations until your PQube locks onto the correct configuration. Your PQube knows roughly 1,000 different possible power configurations used around the world, and can identify the correct configuration approximately 10 seconds after power has been applied to the terminals.



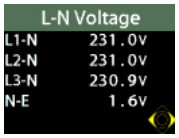
Vectors: Use this screen to verify that your voltage and current inputs are wired up correctly. Full scale voltage is determined by the nominal voltage found when the PQube locks onto the power configuration. The vertical bar on the right represents the largest phase magnitude of current. Its range is from zero amps to the value specified by the Max_Current_of_Interest_in_Amps tag in the setup.ini file. (By default, it is set to the value shown on your current module, multiplied by the current transformer ratio specified in the setup.ini tag Current_Transformer_Ratio).

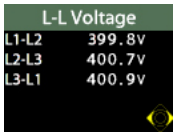


Date/time: Set your PQube's internal clock-calendar. Your PQube will automatically set the correct day of week. If you have an ETH1 Ethernet Module, and you have enabled SNTP in your **Setup.ini** file, your PQube will automatically set its clock-calendar to UTC.

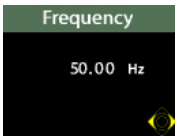
Test e-mail: Press the select button to send a test e-mail. If your e-mail succeeds, you will get a green check mark. If your e-mail does not go through, you will see a red X with an error message. See *Sending a test e-mail from your PQube (page 23)* for more information.

Meters

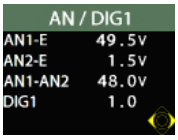




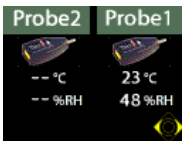
L-L voltage meters, L-N voltage meters: These are line-to-line, line-to-neutral, and neutral-to-earth true-RMS voltmeters. Different meters will show on these screens, depending on your power configuration. (For example, if the power configuration is "delta", there will not be any L-N meters, because there is no neutral conductor.) If you have set a potential transformer ratio in your **Setup.ini** file, then these meters will use that ratio, so these meters will sometimes show their values in kilovolts or even megavolts.



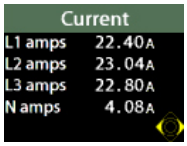
Frequency: This is a frequency meter. It is phase-locked to either L1-E or L2-E, depending on which channel has the best signal. It measures frequency by timing the zero-crossings, with a 5-pole analog low-pass filter and a 64-cycle digital low-pass filter.



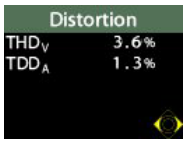
AN/DIG1: The AN meters show the RMS voltage (equivalent to DC voltage for DC signals) for the AN1 screw terminal to earth, AN2 screw terminal to earth, and AN1-to-AN2 differential voltage. The DIG1 meter shows the average value of the DIG1 digital input screw terminal with respect to earth, averaged over one cycle – useful when the DIG1 signal is changing rapidly, because it will show the duty cycle of the DIG1 signal.



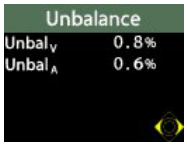
Probe2 / Probe 1: These meters show the temperature and humidity of the two TH1 temperature-humidity probes. If one or both probes are not plugged in, the meters will show "--".



Current: These meters show the true-RMS current. They only appear if you have plugged in an optional XCT4 current transformer interface module, or a CT4 current sensing module. If you have set a current transformer ratio in your **Setup.ini** file, then these meters will use that ratio, so these meters will sometimes show their values in kilo-amps or even mega-amps. Different meters will show on this screen, depending on your power configuration. (For example, if the power configuration is "delta", this screen will not show a neutral current meter, because there is no neutral conductor in delta power.)

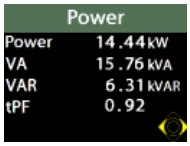


Distortion: These meters show the Total Harmonic Distortion (THD) of the voltage and Total Demand Distortion (TDD) of the current (if you have an optional current sensing module installed).

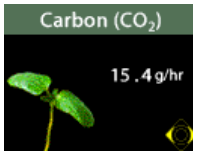


Unbalance: These meters show the voltage unbalance and the current unbalance (if you have an optional current sensing module installed). Your PQube calculates unbalance using the ANSI C84.1 method.

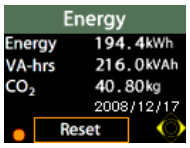
Flicker: These meters show you RMS flicker. P_{inst} is the average absolute difference between $U_{RMS½}$ and 1-second RMS, in percent of nominal, multiplied by scaling factor for improved compatibility with Incandescent Flicker in IEC 61000-4-15. P_{ST} is the mean value of P_{inst} over previous 10 minutes, synchronized to real-time clock. P_{LT} is the mean value of P_{inst} over previous 2 hours, synchronized to real-time clock.



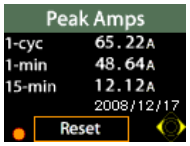
Power: These are the true power readings, and they correctly handle harmonics (distorted voltages and distorted currents). If you have set a current transformer ratio and/or potential transformer ratio in your **Setup.ini** file, then these meters will use those ratios, so these meters can show their values in kilowatts, megawatts, or even gigawatts.



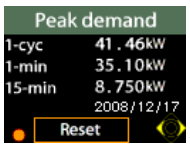
Carbon: This meter shows the intensity of carbon dioxide output, based roughly from the EPA's measurements for typical California, USA values. You may edit these values in the **Setup.ini** file as necessary.



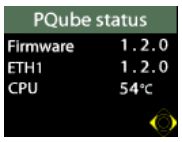
Energy: These three meters show the total energy, apparent energy, and carbon since the last reset of these meters. You can reset these meters by holding down the select button for 3 seconds. The date of the last reset will appear on the screen. You can reset these meters by holding down the select button for 3 seconds. The date of the last reset will appear on the screen.



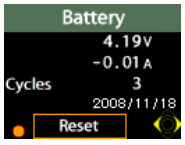
Peak amps: These three meters show the cycle-by-cycle highest RMS amps; the 1-minute interval with the highest RMS amps; and the N-minute interval with the highest RMS amps. (The highest RMS amps value is determined by looking at the highest among all of the active phase conductors. It excludes the neutral conductor.) The N-minute reading is usually set to 15 minutes, but you can set it to a value between 3 minutes and 60 minutes in your **Setup.ini** file. The 1-minute and N-minute readings are automatically synchronized to your PQube's real time clock. These readings can be useful for evaluating inrush current and circuit breaker settings, and for sizing power conditioning devices such as UPS and voltage regulating transformers. You can reset these meters by holding down the select button for 3 seconds. The date of the last reset will appear on the screen.



Peak demand: These three meters show the cycle-by-cycle highest kilowatt reading; the 1-minute interval with the highest RMS kilowatt reading; and the N-minute interval with the highest kilowatt reading. The N-minute reading is usually set to 15 minutes, but you can set it to a value between 3 minutes and 60 minutes in your **Setup.ini** file. The 1-minute and N-minute readings are automatically synchronized to your PQube's real time clock. You can reset these meters by holding down the select button for 3 seconds. The date of the last reset will appear on the screen.

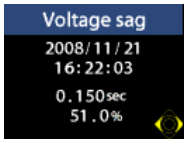


PQube Status: This screen shows you the release version of your PQube's firmware and the release version of your ETH1 Ethernet Module's firmware if it is installed. It also shows you the temperature of the hottest CPU inside your PQube. A temperature lower than 80°C is typical.



Battery: Your PQube's battery voltage will typically be between 3.3V and 4.2 volts. Positive current shows that your PQube is charging its battery; negative current shows that your PQube is taking power from its battery. Cycle count shows the number of times your PQube has taken power from this battery. You can reset the cycle count by holding down the select button for 3 seconds. The date shows the last time the cycle count was reset.

Recent Events



Your PQube displays the 6 most recent events. (Your PQube stores up to 40,000 events on its SD card, depending on the size of the SD card and the type of events.)

Remove SD Card

You can safely remove the SD memory card from your PQube when you see this screen with a green check mark. Remove the SD card by pressing it down gently, then let it pop up. Your PQube will automatically reset when you re-insert a SD card.

Inserting and Removing Your SD Card

To insert the SD card, push it gently into the slot until it clicks. Your PQube will automatically reset itself.

To remove the SD card, go to the menu screen and select "Remove SD Card". Wait until you see a green check mark, then push the SD card in gently, then release. Removing the SD card before you see the green check mark may corrupt the data on the SD card.

There is a light next to the SD card.

SD card light	Meaning
Flashing Red	SD card is missing
Green	Normal
Orange or intermittent red	PQube is writing to SD card – do not remove it. Wait until light is green.

Different brands of SD cards have substantially different speeds. Your PQube requires Sandisk® brand SD cards, purchased directly from Power Standards Lab. Your PQube supports SD cards with capacities of up to 8 Gigabytes.

What Channels Does My PQube Measure?

Standard PQube Channels

Mains AC voltage measurements

Nominal voltages

All PQubes measure single-phase and three-phase voltages.

All PQubes can be connected to single-phase, split-single-phase, delta, wye or star. In addition, all PQubes can be connected to any standard earthing system: corner earth, center earth, or single-phase end earth.

All PQubes can measure power systems with the following nominal voltages: 69V, 100V, 120V, 200V, 208V, 230V, 240V, 277V, 350V, 400V, 480V, 600V, and 690V (maximum 400V with respect to Earth).

All PQubes can measure power systems with nominal frequencies of 50 Hz, 60 Hz, and 400 Hz.

Sampling and accuracy

RMS measurements are better than ±0,1% of nominal voltage, and sampled at 256 samples per cycle to ensure full accuracy for all measurements.

Your PQube's sampling rate is automatically locked to the frequency, and tracks the frequency as it changes at a rate of up to ±3 Hz per second.

In a free future firmware upgrade, you will be able to select up to 1024 samples per cycle for snapshots.

Frequency

Voltage frequency measurements are phase-locked to either L1-E or L2-E, depending on which channel has the best signal. It measures frequency by timing the zero-crossings, with a 5-pole analog low-pass filter and a 64-cycle digital low-pass filter.

Voltage Distortion (THD)

THD is a measurement of the amount of voltage harmonics present in the voltage waveform. Your PQube uses a Discrete Fourier Transform of phase-locked 256-samples-per cycle to calculate total harmonic distortion.

Voltage Unbalance

Voltage unbalance is a measurement of the difference in the magnitude voltages in a three-phase system. Your PQube measures the unbalance of the voltage waveform using the definition from ANSI C84.1. This measurement is disabled if the power system being monitored is not three-phase.

RMS Flicker

RMS Flicker is an expression of how much the line voltage is varying up and down over several different time scales. RMS Flicker has three components: P_{inst}, P_{ST}, and P_{LT}. P_{inst} is the average absolute difference between $U_{RMS½}$ and 1-second RMS, in percent of nominal, multiplied by scaling factor for improved compatibility with Incandescent Flicker in IEC 61000-4-15. P_{ST} is the mean value of P_{inst} over previous 10 minutes, synchronized to real-time clock. P_{LT} is the mean value of P_{inst} over previous 2 hours, synchronized to a real-time clock.

Auxiliary Analog Measurements

Your PQube has two auxiliary analog input screw terminals labeled **AN1** and **AN2**. They are scaled at ±100V with respect to your PQube's Earth terminal, and are rated at 60VDC with respect to earth, or 30VAC with respect to earth.

One common use for these screw terminals is to monitor a -48VDC system, or to monitor a 24VAC or 24VDC system. For example, you might connect these AN monitoring terminals to your PQube's **POWER** terminals.

Your PQube can monitor the voltages between each of these terminals and the earth connection, and/or the voltage between these two terminals.

It monitors these terminals for voltage dips and swells. An event on these terminals can be used to trigger a waveform recording on all channels. And events on the mains terminals can include the waveforms on these auxiliary analog measurements, too.

If you wish to use these channels, you will want to enable the channel so that it is recorded in event files. Enable the appropriate channels in the [Channels] section of the **setup.ini** file on your PQube's SD card.

Digital Input

Your PQube has a single digital input called DIG1. It is a voltage input with respect to your PQube's Earth terminal.

It is rated at 60VDC or 30VAC, maximum, with respect to earth. The digital input is wetted with +5.4Vdc at 3µA, and has a logic threshold of approximately +1.5V with respect to your PQube's earth terminal. The digital input can be connected to dry contacts, TTL or open-collector outputs, or logic signals that are 5Vdc, 12Vdc, 24Vdc, or any other signal less than 60Vdc or 30VAC.

There is an inherent digital-filter time constant of approximately 1 millisecond on this DIG1 input.

Recordings of events on the mains terminals include state of the digital input if you turn the channel on in the Setup.ini file.

You can use your PQube's digital input to monitor the state of a switch, or the state of a logic signal.

Additional Channels Available With Optional Current Module

Mains Current Measurements

There are two optional types of current inputs into your PQube.

The optional CT4-100A current sense module allows you to measure up to 100 amps directly (limited by insulated conductor diameter). Simply pass the mains conductors through the CT4 module. The CT4-20A current sense module is identical, but rated at 20A.

The optional XCT4-1A and XCT4-5A current transformer interface modules work with external current transformers, with 1-amp or 5-amp secondaries.

The optional XCT4-0.333V, XCT4-01V, XCT4-05V, and XCT-10V current transformer interface modules work with external current sensors, with 0.333-volt, 1-volt, 5-volt, or 10-volt outputs.

The crest factor for all PQube current modules is 3.5 (in other words, a PQube current module that is rated at 100 amps can measure instantaneous current up to ±350 amps).

CT4 Module (attached to a PQube)

XCT4 Module (attached to a PQube)

Current Distortion (TDD)

Total Demand Distortion (TDD) is a measure of the harmonic distortion of the current your PQube is monitoring. Instead of comparing the amount of harmonics to the amount of the fundamental (the method used in THD), TDD compares the amount of current harmonics to the total available current. You can change the total current used for the calculation by changing the `Max_Current_of_Interest_in_Amps` setting in your **setup.ini** file on your SD card. See Standard IEEE 519 for a full explanation of TDD.

Current Unbalance

Current unbalance is a measurement of the difference in the magnitude voltages in a three-phase system. Your PQube measures the unbalance of the current waveform using the definition from ANSI C84.1. This measurement is disabled if the power system being monitored is not three-phase.

Power

Your PQube makes true power readings, correctly handling harmonics (distorted voltages and distorted currents). Your PQube measures watts, VA, and tPF. "VA" is apparent power, the product of the RMS voltage times the RMS current. Your PQube correctly calculates VA and Power for all power configurations, including delta configurations, for which it creates a digital metering neutral. "tPF" is true power factor, the ratio of watts to volt-amps. (This is different from dPF, which is the cosine of the angle between the voltage fundamental and the current fundamental.) VAR's are calculated using the Budeanu algorithm.

Energy

Your PQube measures the amount of energy you have used (both energy - Wh, and apparent energy - VAh). Your PQube will accumulate energy until you reset the counter. You can reset the energy reading using the display on your PQube (go to the Energy screen in the Meter section and hold down the action button for 3 seconds).

Carbon

Your PQube uses a patent pending method to calculate the amount of CO_2 produced by the energy consumption monitored. In order to use this feature you will need to determine the amount of carbon produced by the different type of power your local utility uses, as well as the mixture of the different types. Once you have this information, you can configure the `[Carbon_Intensity]` and `[Power_Generation_Breakdown]` sections of the **setup.ini** file on your SD card.

Temperature and Humidity

Optionally, you can plug one or two TH1 temperature-humidity probes into your PQube. The probes may be located at your PQube, or they may be extended up to 20 meters from your PQube with any 2.5mm stereo audio cable.

All data flow to and from the temperature-humidity probe is digital, which reduces noise issues. The temperature-humidity probes are electrically isolated from your PQube. This arrangement eliminates ground loop issues.

PQube Recordings

Event and Snapshot Recordings

When your PQube detects an event, it records information about the event to its SD card. You can remove the SD card to look at this data, look at the recent events screen of the display, or (if you have an optional ETH1 Ethernet module) you can get emails about the event or even look at the event using your web browser. However you look at the event, the data is always the same.

Interpreting Event and Snapshot Recordings

PQube Event and Snapshot recordings contain the details of the event recorded (for example, Voltage Dip recordings include the precise start time of the event, the duration of the event, and the magnitude of the event)

Most events also include the waveforms for the beginning and end of the event, as well as the RMS measurements for the beginning and end of the event. If multiple events occur very close together (within about 30 seconds of each other) your PQube will record all events, but will only store waveform and RMS data for the first event. This is because your PQube is still clearing the space that it requires to record the information. It is important to note that, as long as your PQube is running, it is almost impossible for it to miss an event (your PQube can miss an event if more than 4 events of any one type occur within 4 seconds of each other).

During an event, your PQube will always be sampling the voltage at 256 samples per cycle. You can change the number of samples per cycle written to an event recording (256, 128, 64, or 32 samples per cycle) by changing the `Recorded_Samples_Per_Cycle` setting in the **setup.ini** file on your SD card.

Why would I want fewer samples per cycle in my recordings?

Your PQube Records 1024 samples at the beginning of an event and 1024 sample at the end of an event. If your PQube is configured to record at 256 samples per

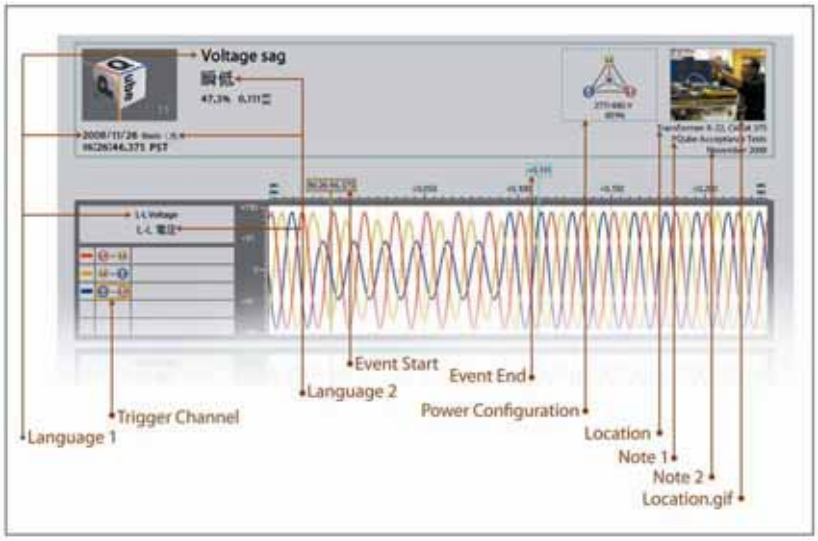
cycle, it will record 4 cycles at the beginning and 4 cycles at the end of the event (1024/256=4). If you set the recording rate lower, you get a longer recording (with fewer points per cycle).

For example, if you choose 64 samples per cycle, your PQube will continue to sample at 256 samples per cycle, but the output recording will be written at 64 samples per cycle. Your Event recordings will have 16 cycles at the beginning and 16 cycles at the end of the event (1024/64=16).

Of course, you always get many cycles of RMS values: 10 seconds of data at 50Hz or 8.5 seconds of data at 60Hz, regardless of the number of samples per cycle you choose to record.

Event Graph Headers

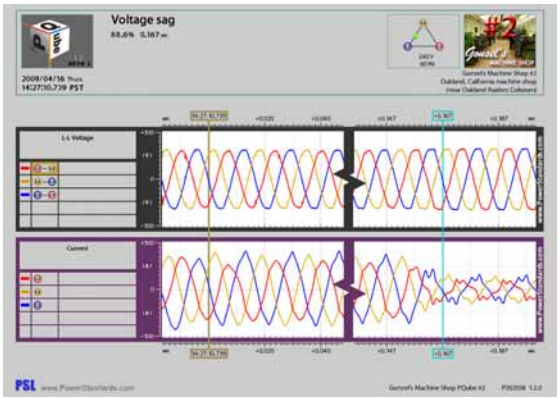
Every event graph has information in the header that tells you details about the event recorded and information about your PQube that recorded the event. This makes it easy to send a graph file to another person without having to explain the context of the recording. You can set the location name, your PQube ID, and the notes by editing the **setup.ini** file on your SD card.



Graph headers – many of these parameters can be set in your Setup.ini file.

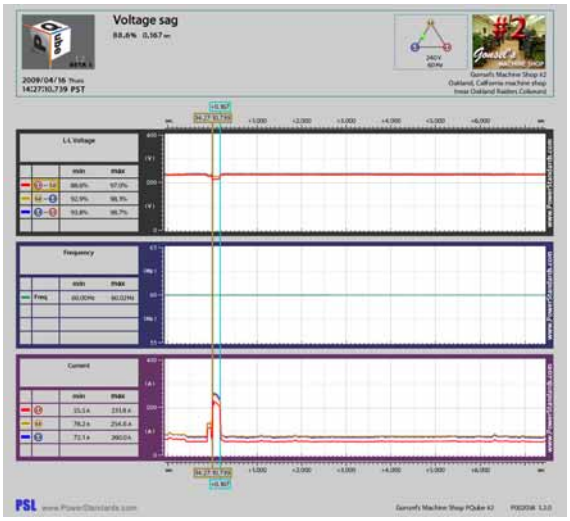
Waveform Recordings

Events that include waveform recording will include the exact same data in both a GIF graph file and a CSV spreadsheet file. Waveform recordings are useful for looking at the fine details of what happened when an event began and ended. If you prefer an overview of the event, consider using the RMS recording.



RMS Recordings

Events that include RMS recording will include the exact same data in both a GIF graph file and a CSV spreadsheet file. Voltage RMS recordings give you a good overview of what happened before, during, and after the event. RMS recordings use the $RMS_{1/2}$ reading to get the average reading over the course of a cycle. Because your PQube records the average reading per cycle, RMS recording cover more time than waveform recordings.



Voltage Dips

A voltage dip is a brief decrease in the line voltage. Dips are most typically caused by large loads starting nearby or by faults elsewhere on the power system. Your PQube records voltage dips according to IEC 61000-4-30 class A. A dip begins when the 1-cycle RMS of any voltage goes below the threshold (90% of nominal by default) and ends when all voltages are above the threshold, plus the hysteresis setting (90% threshold + 2% hysteresis = 92% by default). You can change the threshold for voltage swells by changing the settings in the `[Phase_To_Neutral_Events]` and `[Phase_To_Phase_Events]` sections of the **setup.ini** file on your SD card.

Voltage Swells

A voltage swell is a brief increase in the line voltage. Your PQube records voltage swells according to IEC 61000-4-30 class A. A swell begins when the 1-cycle RMS of any voltage goes above the threshold (110% of nominal by default) and ends when all voltages are beneath the threshold, minus the hysteresis setting (110% threshold – 2% hysteresis = 108% by default). You can change the threshold for voltage swells by changing the settings in the `[Phase_To_Neutral_Events]` and `[Phase_To_Phase_Events]` sections of the **setup.ini** file on your SD card.

Voltage Interruptions

A voltage interruption occurs when all the line voltage goes away (such as when a breaker trips). Your PQube records voltage interruptions according to IEC 61000-4-30 class A. An interruption begins when the 1-cycle RMS of all voltage channels go below the threshold (10% of nominal by default) and ends when any voltage is above the threshold, plus the hysteresis setting (10% threshold + 2% hysteresis = 12% by default). You can change the threshold for voltage interruptions by changing the settings in the `[Phase_To_Neutral_Events]` and `[Phase_To_Phase_Events]` sections of the **setup.ini** file on your SD card. Note that by definition, any voltage interruption is also a voltage dip, so your PQube will record each voltage interruption as two overlapping events (a dip and an interruption).

Frequency Variations

Your PQube records underfrequency and overfrequency events. Each type of event is triggered when the frequency goes under a threshold (99.5% by default) or over a

threshold (100.5% by default), respectively. Underfrequency and overfrequency events end when the voltage frequency approaches the nominal again. You can change the threshold for underfrequency and overfrequency events by changing the settings in the `[Frequency_Events]` section of the **setup.ini** file on your SD card.

High Frequency Impulses

Your PQube includes special hardware used to detect high frequency impulses. These sensors monitor L1-E, L2-E, L3-E and filter out everything but high frequency events. Your PQube will detect an impulse with a ±450V (or more) peak that lasts for as little as 1 microsecond.

When your PQube detects a high frequency impulse it will make a standard event recording. Note that the sampling rate of your PQube is 256 samples per cycle, so you may not see the impulse in the recording, but the exact time of the impulse is marked and recorded.

Analog Dips and Swells

Your PQube includes two analog input channels called AN1 and AN2. You can set up a trigger to record an event when your PQube detects a dip or a swell on AN1-Earth, AN2-Earth, or AN1-AN2. You can enable these events and set the thresholds in the `[AN1_E_Events]`, `[AN2_E_Events]`, and `[AN1_AN2_Events]` sections of the **setup.ini** file on your PQube's SD card.

If you enable these events, you will also want to enable the channel so that it is recorded in event files. Enable the appropriate channels in the [Channels] section of the **setup.ini** file on your PQube's SD card.

If you enable these events, be sure to set the dip and swell voltages carefully. It is important that you not be "stuck" in an event, as this will prevent your PQube from writing updates about new events. For example, if you connect AN1-Earth to a 24V nominal signal, but you set the swell threshold to 20 volts, your PQube will start recording a swell immediately, but it will never finish that event.

Snapshots

Your PQube records events when it senses a problem with the electric power. This information about problems is useful, but sometimes it can also be helpful to see what your electric power looks like when there isn't a problem. Snapshots show you what your PQube is monitoring and are trigger by an internal timer in your PQube (instead of a power quality event). Snapshots record all of the same information that any other event recording includes.

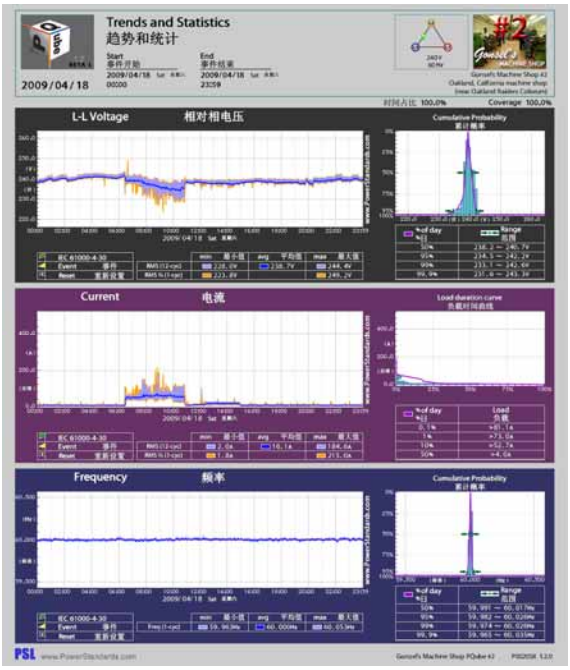
To configure this feature, you can change the `Waveform_Snapshot_Interval_In_Hours` setting in the **setup.ini** file on your PQube's SD card. Valid settings are OFF, 1, 6, or 24.

Trends and Statistics Recordings

Your PQube records minimum/ average/ maximum strip charts, cumulative probability statistics, and load duration statistics. By default, your PQube will record all of this information over the course of each day, week, and month.

Trends and statistics recordings give you information about what happened on the systems that your PQube is monitoring, even if there weren't any events.

These recordings include readings every minute (for daily recordings) or every 5 minutes (for weekly and monthly recordings). Your PQube contains the average reading every one or five minutes as well as the minimum and maximum updated five times a second.



Times and Dates

Your PQube uses ISO 8601 methods for representing times and dates in Trends and Statistics Recordings.

Days begin at 00:00 Midnight, and end at 11:59pm. Days are displayed as [YYYY]/[MM]/[DD].

Weeks begin at the midnight between Sunday and Monday, and end at 11:59pm of the next Sunday. Weeks are displayed as [YYYY]-CW[WW]. (CW = Calendar Week)

Months begin at 00:00 Midnight of the 1st day of the month, and end at 11:59 of the last day of the month. Months are displayed as [YYYY]-[MM].

Minimum/Average/Maximum Values

For polyphase systems, your PQube displays voltage and current trends as single values where applicable:

The minimum value is the lowest $U_{RMS½}$ value out of all the channels.

The average value is the voltage or current of all channels averaged together over the entire measurement interval.

The maximum value is the highest $U_{RMS½}$ value out of all the channels.

Flags

Whenever an event occurs during a measurement, your PQube will flag the measurement at the appropriate time interval.

For GIF Trends and Statistics:

This is a voltage dip/swell/interruption as defined by IEC 61000-4-30.

This is a non-IEC 61000-4-30 event. These include frequency changes, high frequency impulses, and analog dips and swells.

This indicates that the PQube reset during the indicated time interval.

For CSV Trends and Statistics:

U = Start Up

D = Shut Down

P = Partial Minute

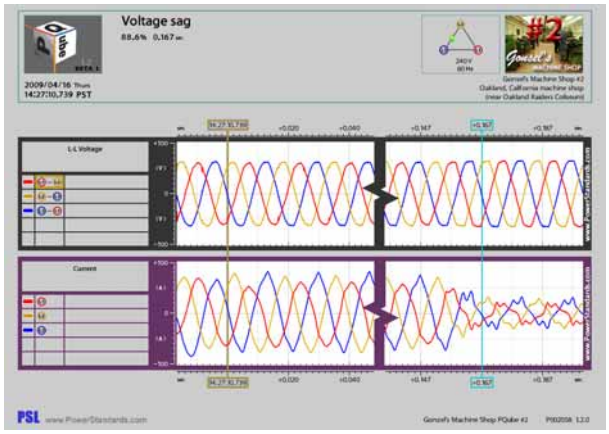
F = 4-30 Event

O = Other Event

File Formats

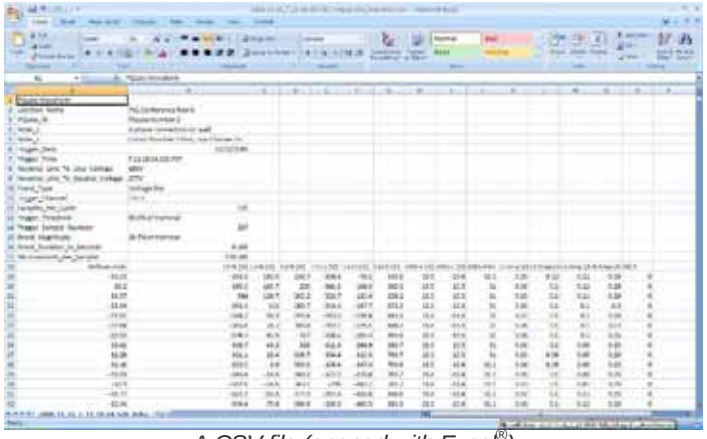
Picture Graphs (GIF)

GIF picture files can be opened by any image program. You don't need any special software. You can also embed GIF picture files directly in Microsoft PowerPoint® presentations, Microsoft Word® reports, and so on.



Spreadsheet (CSV)

CSV files can be opened with Excel® or almost any spreadsheet program. These files are useful if you want more detailed data, and the ability to sort individual recordings and customize your own graphs. The CSV files cover the same recording period as the GIF files, and therefore both formats contain the same information, the CSV files are more detailed, while the GIF files are easier to work with.



A CSV file (opened with Excel®)

Web Pages (HTML)


Event

Event Type:	Voltage Dip
Event Magnitude:	88.64%
Event Duration in Seconds:	0.167
Trigger Date:	2009/04/16
Trigger Day of Week:	Thursday
Trigger Time:	T 14:27:10.739 PST
Trigger Channel:	L1-L2
Trigger Threshold:	90.0% of nominal

Min Max Readings

Channel	Min	Max	Min	Max
L1-L2	212.7V	232.7V	212.7V	235.7V
L2-L3	223.0V	235.5V	223.0V	238.7V
L3-L1	225.2V	237.0V	225.2V	239.0V
L1 Amp	55.5A	231.8A	91.5A	231.8A
L2 Amp	78.2A	254.6A	136.9A	254.6A
L3 Amp	72.1A	260.0A	222.4A	260.0A
Frequency	60.004Hz	60.016Hz	60.009Hz	60.012Hz
Power	23.88kW	68.29kW	58.19kW	68.29kW

Your PQube produces HTML files that can be opened with any web browser (such as Internet Explorer). Even if you don't have an ETH1 Ethernet module, your PQube will produce HTML files and store them on your SD card.

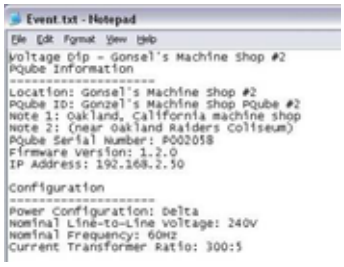
HTML files are useful because they are easy to read and the data is well formatted for a human to read. Use these files for preparing presentation or for sharing data with other users. If you want to write a program to extract data automatically, XML format may be a better choice. If you are having trouble changing the format you may want to use a simpler format, like text.

PQDIF (Power Quality Data Interchange Format)

Your PQube will produce PQDIF files that you can use with most PQDIF viewers. These files are useful if you use PQDIF files already or if you want to use standard files that utilities and other power quality experts understand.

PQDIF files are in beta for firmware version 1.2 and therefore are not produced by default. To enable this option, change the `PQDIF_Files` setting to `ON` in the setup.ini file on your SD card.

Text


Event.txt - Notepad

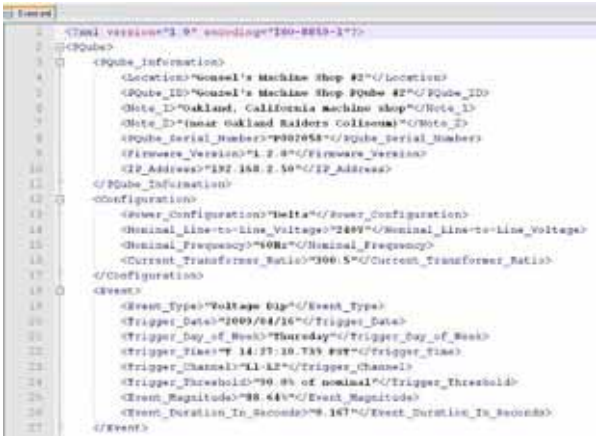
File Edit Format View Help

```
Voltage Dip - Gonsel's Machine Shop #2
PQube Information
--------------------
Location: Gonsel's Machine Shop #2
PQube ID: Gonzel's Machine Shop PQube #2
Note 1: Oakland, California machine shop
Note 2: (near Oakland Raiders Coliseum)
PQube Serial Number: P002058
Firmware version: 1.2.0
IP Address: 192.168.2.50

Configuration
--------------------
Power Configuration: Delta
Nominal Line-to-Line voltage: 240V
Nominal Frequency: 60HZ
Current Transformer Ratio: 300:5
```

Text files are the simplest PQube output file. Almost any program can open a text file. The default Windows program is Notepad, shown here. Text files are useful when you want to make sure that everyone can read the file that you have produced. Text files are still better suited for showing to people, if you want a data format that is easy for a computer to automatically process, try XML. If you want a format that looks better, try HTML.

XML



```
<?xml version="1.0" encoding="ISO-8859-1"?>
<PQube>
    <PQube_Information>
        <Location>"Gonsel's Machine Shop #2"</Location>
        <PQube_ID>"Gonsel's Machine Shop PQube #2"</PQube_ID>
        <Note_1>"Oakland, California machine shop"</Note_1>
        <Note_2>"(near Oakland Raiders Coliseum)"</Note_2>
        <PQube_Serial_Number>"P002058"</PQube_Serial_Number>
        <Firmware_Version>"1.2.0"</Firmware_Version>
        <IP_Address>"192.168.2.50"</IP_Address>
    </PQube_Information>
    <Configuration>
        <Power_Configuration>"Delta"</Power_Configuration>
        <Nominal_Line-to-Line_Voltage>"240V"</Nominal_Line-to-Line_Voltage>
        <Nominal_Frequency>"60Hz"</Nominal_Frequency>
        <Current_Transformer_Ratio>"300:5"</Current_Transformer_Ratio>
    </Configuration>
    <Event>
        <Event_Type>"Voltage Dip"</Event_Type>
        <Trigger_Date>"2009/04/16"</Trigger_Date>
        <Trigger_Day_of_Week>"Thursday"</Trigger_Day_of_Week>
        <Trigger_Time>"T 14:27:10.739 PST"</Trigger_Time>
        <Trigger_Channel>"L1-L2"</Trigger_Channel>
        <Trigger_Threshold>"90.0% of nominal"</Trigger_Threshold>
        <Event_Magnitude>"88.64%"</Event_Magnitude>
        <Event_Duration_In_Seconds>"0.167"</Event_Duration_In_Seconds>
    </Event>
```


XML format is more dificult for people to read, but there are many software packages that understand XML. If you are building a monitoring system that will automatically process data from your PQube, consider using XML as your data format. Your PQube's XML files are standard XML and can be opened with any program that understand that file format. On most computers the default program is Internet Explorer. If you want make it eady to share your data directly with other people (and not through a computer program), consider HTML or text format files.

Getting Data Into and Out of Your PQube

SD Card

Your PQube records all data to its SD card. At any time you can follow the directions in for *Inserting and Removing Your SD Card (page 31)* and look at the files using any computer. Recorded data is stored in folders with the name of the year that the data was recorded, log files and other useful diagnostics are stored in the Log folder. Your PQube gets all of its setup information from the **setup.ini** file found in the root directory of the SD card.

ETH1 Ethernet Module

For information on how to set up your ETH1 Ethernet Module see *Setting up Your Optional ETH1 Ethernet Module (page 22)*.

Email

PQube sending emails

Your PQube will send an email every time it records an event or snapshot, and every time it records daily, weekly, and monthly trends and statistics. The email will contain all of the details about the recording and it will attach any related files (such as spreadsheets or graphs).

Sending emails to your PQube

Your PQube can respond to emails that you send it. See the Setup.ini file for information on configuring the ETH1 email settings.

Whenever your PQube receives an e-mail, it will automatically respond with its present meter readings (unless the email does not match the incoming email filters, see the Ethernet Setup section of the **Setup.ini** documentation).

Sending your PQube a new Setup file

You can send your PQube a new **Setup.ini** file via e-mail. Your e-mail must meet all of the filter requirements in your existing **Setup.ini** file, and must have "New Setup File", without the quotation marks, in the subject of your e-mail. For example, if `Subject_Must_Begin_With` is set to "PQube" in your existing setup file, then your PQube will be watching for an e-mail with the subject "PQube New Setup File", without the quotes.

Your new setup file must be named **Setup.ini**, and must be attached to the e-mail.

Your PQube will send you two reply e-mails: one when it receives the new setup file, and another when the new setup file has been successfully installed after your PQube automatically resets itself.

Sending your PQube new firmware via email

You can update your PQube's firmware via e-mail.

Your firmware update e-mail must meet all of the filter requirements in your existing **Setup.ini** file, and must have "Firmware Update", without the quotation marks, in the subject of your e-mail. For example, if `Subject_Must_Begin_With` is set to “PQube” in your existing setup file, then your PQube will be watching for an e-mail with the subject “PQube Firmware Update”, without the quotes.

You must attach a file called **PQube_Firmware_XX_YY_ZZ_FFFFFFFF.pqf** which you can obtain from www.PowerStandards.com. The XX, YY, and ZZ are digits that identify the type of firmware update, and FFFFFFFF is a checksum. Do not re-name this file. If your PQube receives a valid firmware update, it will reset itself and perform the update.

Resetting your PQube via e-mail

You can reset your PQube via e-mail.

Your reset e-mail must meet all of the filter requirements in your existing **Setup.ini** file, and must have "Reset PQube", without the quotation marks, in the subject of your e-mail. For example, if `Subject_Must_Begin_With` is set to “PQube” in your existing setup file, then your PQube will be watching for an e-mail with the subject “PQube Reset PQube”, without the quotes.

Tickling your PQube’s e-mail watchdog

You can set a watchdog that will automatically reset your PQube if it fails to receive an e-mail periodically. See the Setup File section. Your PQube’s e-mail watchdog can be useful if you want to be certain that your PQube will automatically reset if it fails to hear from you.

Your watchdog e-mail must meet all of the filter requirements in your existing **Setup.ini** file, and must have "Watchdog", without the quotation marks, in the subject of your e-mail. For example, if `Subject_Must_Begin_With` is set to “PQube” in your existing setup file, then your PQube will be watching for an e-mail with the subject “PQube Watchdog”, without the quotes.

Requesting your PQube’s log files via e-mail

You can ask your PQube to send you its log files via e-mail. The log files can help diagnose PQube setup problems, and they show the complete history of your PQube.

Your log file request e-mail must meet all of the filter requirements in your existing **Setup.ini** file, and must have "Send Logs", without the quotation marks, in the subject of your e-mail. For example, if `Subject_Must_Begin_With` is set to “PQube” in your existing setup file, then your PQube will be watching for an e-mail with the subject “PQube Send Logs”, without the quotes.

Web

In order to access your PQube’s web site, you will need set up the web server (see *Web Server Setup on page 24*) and determine the IP address of your PQube. If you are using fixed IP, you already know the IP address, but if you are using DHCP you will need to send a test email from your PQube (*see Sending a test e-mail from your PQube, page 23*), which will include the IP

address of your PQube. Simply type this IP address into any web browser (such as Internet Explorer).

You will be able to see the present status of your PQube, real-time meters, and all event, trend, and statistics recordings stored on your PQube's SD card.

FTP

Before using your PQube's FTP server, you will need to set it up (see *FTP Setup on page 24*). Once you have configured the server, you can access your PQube using any standard FTP client, with the following restrictions:

- you must restrict your client to 1 simultaneous connection (consult your client's documentation for details on how to do this)
- you may need to enable FTP keep-alive on your client (your PQube will disconnect automatically after 5 minutes of inactivity, turning on keep-alive in your client will prevent the disconnection)
- ask your system administrator if there are firewalls or other protection systems in place that might affect your ability to connect to your PQube via FTP.

In order to access your PQubes FTP server, you will need to determine the IP address of your PQube. If you are using fixed IP, you already know the IP address, but if you are using DHCP you will need to send a test email from your PQube (*see Sending a test e-mail from your PQube, page 23*), which will include the IP address of your PQube.

Modbus

Your ETH1 Ethernet module contains a Modbus-over-TCP slave device that you can use to read meters and determine when new event or trend recordings are available. The update rate for the registers is approximately one second in most circumstances. For information on how to set up the Modbus feature, see the *Modbus Setup section (page 24)*. Once you have set up the feature, you can connect to the device with a Modbus controller and read registers. The meters consist of two registers that represent a 32-bit floating point number (the two "new recordings" registers are both 16-bit unsigned integers). The register addresses are expressed as an offset from the base register (7000 by default). The Modbus feature is in beta for firmware version 1.2. There is a known limitation in this version: your PQube will update the registers approximately once per second, unless it is busy (such as when your PQube is generating an output file for an event or for daily trends and statistics). When your PQube is busy, register updates can be as far apart as 120 seconds. Note that for the majority of the time, the update rate is once per second.

Offset	Register
0~1	L1-E
2~3	L2-E
4~5	L3-E
6~7	N-E
8~9	L1-N
10~11	L2-N
12~13	L3-N
14~15	L1-L2
16~17	L2-L3
18~19	L3-L1
20~21	AN1-E
22~23	AN2-E
24~25	AN1-AN2

26~27	Frequency
28~29	L1 Current
30~31	L2 Current
32~33	L3 Current
34~35	N Current
36~37	Power (W)
38~39	Apparent Power (VA)
40~41	Digital Input
42~43	Peak Current (1-cycle)
44~45	Peak Current (1-minute)
46~47	Peak Current (N-minute*)
48~49	Peak Power (1-cycle)
50~51	Peak Power (1-minute)
52~53	Peak Power (N-minute*)
54~55	Peak VA (1-cycle)
56~57	Peak VA (1-minute)
58~59	Peak VA (N-minute*)
60~61	Energy (Wh)
62~63	Apparent Energy (VAh)
64~65	Voltage THD
66~67	Current TDD
68~69	Voltage Unbalance
70~71	Current Unbalance
72~73	RMS Flicker P(inst)
74~75	RMS Flicker P(ST)
76~77	RMS Flicker P(LT)
78	New Event Recordings**
79	New Trend Recordings**

* -- you can set this demand interval by changing the Peak_Demand_Interval_In_Minutes setting in the **setup.ini** file on your SD card. The default is 15 minutes, but you can change it to 3, 5, 10, 15, 20, 30, or 60 minutes.

** -- These two registers tell you how many new recordings are available since you last read the register (reading the register clears it). You can use this information to determine when to use a web browser or FTP client to get new event or trend recordings from the SD card.

The PQube Relay

In Firmware Revision 1.2, your PQube's RLY1 contacts are closed when there is no event, and will open for at least 3 seconds (or the duration of the event, whichever is longer) when any event occurs. When your PQube is reset, these relay contacts are open for several seconds, until your PQube determines the power configuration and decides that the voltages are correct.

Maintenance

Upgrading Your PQube's Firmware

Power Standards Lab offers free firmware updates to add new features to your PQube and to fix bugs. You can check www.PQube.com from time to time to see if there is a new version of firmware available. Every firmware upgrade comes with a guide with detailed instructions on how to perform the update.

Turning Off Your PQube

Your PQube 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, turn off your PQube's instrument power (either the power screw terminals on your PQube, the optional PS1 Power Supply Module, or both), once your PQube is running from battery, reset your PQube by removing and re-inserting your PQube's SD card. This will cause your PQube to reset and power down (as there is no power available). If your PQube resets and begins to start up again, you have not removed all instrument power.

Replacing your PQube's battery

The battery is PSL type "340-000080" followed by a 2-digit revision level. This part must be supplied only by the PSL or PSL agents. It contains built-in protection.

PSL recommends replacing your PQube's battery after 5 years, or 1000 uses, whichever comes first. You can find the battery installation date and the number of times the battery has been used on your PQube's battery status screen, in the Meters menu.

To replace the battery, use a small flat-blade screwdriver to open the battery compartment. Pull on the tab to slide the battery out, then slide in the new battery in the correct orientation. Seat the new battery gently, then close the battery compartment. Go to the battery status screen, and hold down the Select button for 3 seconds – this will reset the installation date and the battery use counter.

It is not necessary to remove power while replacing the battery. Follow local regulations when disposing of the used battery.

Cleaning Instructions

If necessary, wipe the accessible parts of your PQube with a cloth, slightly moistened with clear water. Do not use abrasives or chemical cleaners.

PQube Specifications

PQube Specifications Version 1.2.2(e)

Reference conditions for factory tests: 19~25°C, 15%~50% RH, steady-state 10/12 cycle signals. ±1/2 display count on all accuracies

Inputs	
Mains Voltage Measuring Channels	
Connection	L1, L2, L3, N PQube screw terminals [9], [11], [13], [15]
Frequency Range	40Hz~70Hz and 320Hz ~ 560Hz. Nominal 50Hz, 60Hz, or 400 Hz auto, 320-560Hz manually selected
Mains Configuration	Single-phase, delta, wye or star. User selected or auto-selected
Range of Nominal Input Voltage	100VAC~690VAC L-L (69VAC~400VAC L-N) User selected or auto-selected
Measurement Channels	Line-to-Neutral, Line-to-Line, Neutral-to-Earth
Sampling Rate	256 samples per cycle, phase-locked to input frequency
Measurement range	0 VAC ~ 900 VAC L-L (520 VAC L-N)
Accuracy	±0.05% rdg ±0.05% FS typical (10% ~ 150% of nominal). Every PQube factory tested at better than ±0.04%rdg ±0.04%FS. Note: FS is based on measurement range.
RMS measurement method	True single-cycle RMS, phase-locked to each channel, updated every 1/2 cycle. $U_{RMS½}$ per IEC 61000-4-30 Class A. Also 10/12 cycle true-RMS per IEC 61000-4-30 Class.
HF Impulse detection	L1-E, L2-E, L3-E. ±450V_{pk} nominal threshold detected through 2-pole high-pass 4.8 kHz nominal filter. Every PQube factory tested with 1-µsecond 10%-to-90% impulses; trigger required at ±650V_{pk}, must not trigger ±250V_{pk}.
Unbalance - voltage	Measurement method ANSI C84.1. Range: 0.0% - 100.0% Accuracy equivalent to rms voltage specification applied to measurement method.
THD - voltage	Measurement method: Discrete Fourier Transform of phase-locked 256-samples-per cycle. Range: 0.0% - 100.0% Accuracy: ±0.2% at test waveform having typical harmonic content (5% 5th, 2.5 7th, 1.5 9th, and 1% 11th). Samples measured through 6-pole low-pass analog anti-alias filter, 3 dB frequency 4.7 kHz.
RMS Flicker	P_{inst} – average absolute difference between $U_{RMS½}$ and 1-second RMS, in percent of nominal, multiplied by scaling factor for improved compatibility with Incandescent Flicker in IEC 61000-4-15. P_{ST} – mean value of P_{inst} over previous 10 minutes, synchronized to real-time clock. P_{LT} – mean value of P_{inst} over previous 2 hours, synchronized to real-time clock. Range 0.0 ~ 20.0 . Accuracy ±0.1.
Isolation	PQube provides more than 7500 VDC isolation to Earth. UL/IEC 61010 reinforced insulation.
PT Input Ratio Range	1:1 to 10000:1
Installation category	CAT IV UL/IEC 61010 for voltages up to 300VAC L-N (equivalent to 480VAC L-L), CAT III for higher voltages. Pollution Degree 2
Analog Input Channels	
Connection	AN1, AN2 PQube screw terminals [22], [30]
Nominal Input	0~30VAC or ±60VDC (to Earth) max
Full Scale	70VAC, ±100VDC
Measurement Channels	AN1-Earth, AN2-Earth, AN1-AN2
User-specified Input Ratio	1:1 to 10000:1
Sampling Rate	12.8kHz or 15.4kHz (measured at same rate as mains voltage measuring channels)
Accuracy	±0.2% rdg ±0.2% FS typical (10% ~ 100% FS). Every PQube factory tested at better than ±0.1% rdg ±0.1% FS AC.
Digital Input	
Connection	DIG1 PQube screw terminal [24]
Rating	60VDC to Earth
Wetting	5.4VDC at 3µA
Threshold	1.5V±0.2V with respect to PQube's Earth terminal, with 0.3V hysteresis typical
Sampling Rate	12.8kHz or 15.4kHz (sampled at same rate as mains voltage measuring channels)
Frequency Measurement	
Range	40Hz to 70Hz and 320Hz to 560Hz
Accuracy	±0.01Hz, steady state
Method	Cycle-by-cycle zero-crossing detection on L1-E or L2-E (auto-selected). Firmware phase-locked for frequency slew rate up to 5 Hz/sec. For 50/60 Hz, measured through an 9-pole low-pass analog filter, 3 dB frequency 76 Hz. For 400 Hz, measured through 7-pole low-pass filter, 3 dB frequency 1 kHz. Poles and 3 dB frequency are auto-selected based on nominal frequency.

Optional Temperature/Humidity Probes	
Connection	2.5mm stereo jack. Functional electrical isolation from PQube
Location	Optional probes plug into the PQube directly or through PSL-provided extension cables
Scan Time	5 seconds max
Temperature Accuracy	Typical: ± 0.5ºC. Max: ± 2ºC (-20~+80ºC)
Humidity Accuracy	Typical: ± 4.5%RH (20~80% R.H), Max:± 7.5% (0~100% R.H)
	Note: For optimal ambient temperature and humidity accuracy, use extension cable to avoid self-heating of probe by PQube
Optional Current Measuring Modules	
CT4-20A-00	
Measurement Type	Pass-through (built-in current transformers)
Nominal	20 amps RMS
Crest Factor	3.5 (± 70 amps instantaneous)
Sampling Rate	12.8kHz or 15.4kHz (sampled at same rate as mains voltage measuring channels)
Accuracy	±0.2% rdg ±0.2% FS typical (10% ~ 120% FS). Every PQube factory tested at better than ±0.15% rdg ±0.15% FS.
Burden	less than 0.1VA
Conductors	0.34 inches (8,6mm) max. diameter, 600V UL-recognized insulation required
CT4-100A-00	
Measurement Type	Pass-through (built-in current transformers)
Nominal	100 amps RMS
Crest Factor	3.5 (± 350 amps instantaneous)
Sampling Rate	12.8kHz or 15.4kHz (measured at same rate as mains voltage measuring channels)
Accuracy	±0.2% rdg ±0.2% FS typical (10% ~ 120% FS). Every PQube factory tested at better than ±0.15% rdg ±0.15% FS.
Burden	less than 0.1VA
Conductors	0.34 inches (8,6mm) max. diameter. 600V UL-recognized insulation required
XCT4-1A-00 and XCT4-5A-00	
Measurement Type	External current transformer
CT input ratio range	1:1 to 10000:1
Nominal	1 amp RMS for XCT4-1A, 5 amps RMS for XCT4-5A
Crest Factor	3.5 (± 3.5 amps instantaneous for XCT4-1A and ±17.5 amps instantaneous for XCT4-5A)
Sampling Rate	12.8kHz or 15.4kHz (measured at same rate as mains voltage measuring channels)
Accuracy - excluding external CT's	±0.2% rdg ±0.2% FS typical (10% ~ 120% FS). Every PQube factory tested at better than ±0.15% rdg ±0.15% FS.
Burden	Less than 0.1VA
Wire connection	Min. 20AWG (0,52 mm2), Max. 14AWG (2.1mm2). 600V UL- recognized insulation required
Max screw torque	7 inch-pounds (0,8Nm)
XCT4-0.333V-00, XCT4-1V-00, XCT4-5V-00, and XCT4-10V-00	
Measurement Type	External current transformer
CT input ratio range	1:1 to 10000:1
Nominal	0.333V RMS, 1V RMS, 5V RMS, and 10V RMS
Crest Factor	3.5 (± 1.17V peak, 3.5V peak, 17.5V peak, and 35V peak)
Sampling Rate	12.8kHz or 15.4kHz (measured at same rate as mains voltage measuring channels)
Accuracy - excluding external CT's	±0.2% rdg ±0.2% FS typical (10% ~ 120% FS). Every PQube factory tested at better than ±0.1% rdg ±0.1% FS.
Wire connection	Min. 20AWG (0,52 mm2), Max. 14AWG (2,1mm2). 600V UL- recognized insulation required
Max screw torque	5 inch-pounds (0,6Nm)

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 (tPF)	True power factor – ratio of Watts to Volt-Amps.
VAR's (volt-amps reactive)	Budeanu definition
Carbon (CO_2 rate and accumulated)	Based on patent-pending algorithm using watts and user-selected proportions of generator sources, and user-supplied carbon generation rates for each source.
Current unbalance	Measurement method ANSI C84.1.
Inputs	
Voltages	L-N, or L-N_m for delta configurations. N_m defined as measurement neutral, the instantaneous average L-E voltage. All voltages scaled up to 10000:1 for potential transformers.
Currents	L1, L2, L3 currents. Optional user-selected calculated current on one channel for installations with N-1 current transformers. All voltages scaled up to 10000:1 for current transformers.
Accuracy excluding external CT's	
Watts (power)	±0.2% at unity power factor, nominal voltage, 20% ~ 100% FS current. Class 0.5 ANSI C12.20-1998. Better than ±0.25% rdg ±0.25% FS (10% ~ 120% FS), for phase angle $\Theta_{fundamental} = \pm 30°$ (angle between fundamental voltage and fundamental current). Accuracy calculation: sum of voltage accuracy, plus current accuracy, plus phase angle correction which is guaranteed less than ±0.025% x (1 / cos($\Theta_{fundamental}$)).
Volt-Amps (apparent power)	Better than ±0.25% rdg ±0.25% FS typical (10% ~ 120% FS)
Measurement interval	
Measurement interval	Phase-locked, 10-cycles (50 Hz nominal) or 12-cycles (60 Hz nominal). Approximately 5 readings per second. Actual readings per second dependent on actual frequency.
Instrument Power	
Screw Terminals	(AC or DC) PQube POWER screw terminals [23], [31]
AC Input	24VAC ± 20% 50/60 Hz
DC Input	24-48VDC ± 20% (polarity independent)
Power Required	5VA max
Isolation	PQube provides more than 150VDC isolation to all other circuits
Internal UPS	
Type	Lithium Polymer Battery (replacement batteries available from PSL)
Capacity	600mAH. 30 minutes typical with new, fully-charged battery.
Backup period	User controlled. 1 to 10 minutes, 3 minute default.
Storage & Discharge Temperature	-20ºC to +60ºC
Charge Temperature	0ºC to +45ºC
Charging Cycles	>500 full cycles
Lifetime	Estimated 5+ years, depending on operating and environmental conditions
Replacement Method	User replaceable while PQube is operating (tool required)
Optional PS1 Plug-in Module	
AC Input	100~240VAC ± 10%. 50/60 Hz
Power Required	25VA max
Isolation	Module provides more than 3200VDC isolation to all other circuits
Outputs	
Signal Relay	
Connection	RLY1 PQube screw terminals [19], [27]
Rating	30VAC/60VDC, 300mA max
Function	Normally closed. Contacts open for duration of event or 3 seconds (whichever is longer)
Sense & Operate time	20 milliseconds

Communications	
USB	
Connection	Mini-B USB socket
Future Applications	Future: USB mass storage device, and USB-based serial COM port.
Isolation	PQube provides at least 150VDC isolation to Earth (eliminates ground loops)
Optional Plug-in Ethernet Module	
Connection	Standard RJ-45 socket (wired Ethernet)
Email	Sends emails after every event with data attached; user request real-time meters via e-mail, PQube firmware upgrade via email, change PQube setup via email, incoming e-mail filters. Includes GIF graphs, CSV spreadsheet files, PQDIF, HTML and XML summaries
Web Server	Real-time meters. All event recordings, trends and statistics recordings. Includes GIF graphs, CSV spreadsheet files, PQDIF, HTML and XML summaries
Modbus over TCP	Real-time meters with update rate of approximately 1 second. Event/trend-statistics counters can be used for triggering downloads via FTP or web server.
FTP Server	File Transfer Protocol. Transfers files from PQube SD card to and from any computer. Limit to one simultaneous connection.
SNTP	Simple Network Time Protocol for synchronizing PQube real-time clock to UTC. (2 second absolute - UTC referenced)
Clock Timing	
Internal Real-Time Clock	
Accuracy	Typical ± 30 seconds/yr. Temperature compensated. ±120 seconds/yr max drift
Optional SNTP (Requires ETH1)	
Accuracy	± 2 seconds absolute, UTC time
Operating Environment	
Ambient Conditions – Operating	-20°C ~ 50°C, 10%RH ~ 90%RH non-condensing
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
Physical	
PQube	
Dimensions	2.8in x 3.5in x 3.2in (72mm x 90mm x 80mm)
Weight	8.7oz (247g)
Mounting	Standard 35mm DIN rail. Optional panel mounting clips available.
Screw Terminal Torque	7inch-pounds (0,8Nm)
PS1 Power Supply	
Dimensions	1.7in x 3.5in x 2.4in (43mm x 90mm x 61mm)
Weight	4.0oz (113g)
Mounting	Standard 35mm DIN rail. Optional panel mounting clips available.
Screw Terminal Torque	7inch-pounds (0,8Nm)
ETH1 Ethernet	
Dimensions	1.7in x 3.5in x 2.4in (43mm x 90mm x 61mm)
Weight	2.1oz (60g)
Mounting	Standard 35mm DIN rail. Optional panel mounting clips available.
XCT4 Current	
Dimensions	1.7in x 3.5in x 2.4in (43mm x 90mm x 61mm)
Weight	3.5oz (99g)
Mounting	Standard 35mm DIN rail. Optional panel mounting clips available.
Screw Terminal Torque	7inch-pounds (0,8Nm)
CT4	
Dimensions	4.4in x 3.5in x 1.6in (112mm x 90mm x 41mm)

Weight	8.1oz (230g)
Mounting	Standard 35mm DIN rail. Optional panel mounting clips available.
TH1	
Dimensions	1.8in x 0.7in x 0.4in (46mm x 18mm x 10mm)
Weight	0.2oz (6g)
Connection	2.5mm stereo jack

Agency Approvals and Listings

UL (Underwriters Laboratories)	UL-recognized, cULus – File Number E220936
RoHS	Certified – PSL Construction File PQube-001
CE	Certified – PSL Construction File PQube-001, TUV CB Test Certificate US-TUVR-4368-A2
ITC	Certified – 20080102-01-CE, 20080326-01-RI
TUV Bauart-mark	Certified – TUV Report 30880881.009