User's Guide *PQPro™* & *PQPro-HA™*

8 Channel Power Quality Analyzer - PQ Firmware and optional XCW Firmware

CANDURA
instruments

PQPro™ & *PQPro-HA*™ User's Guide

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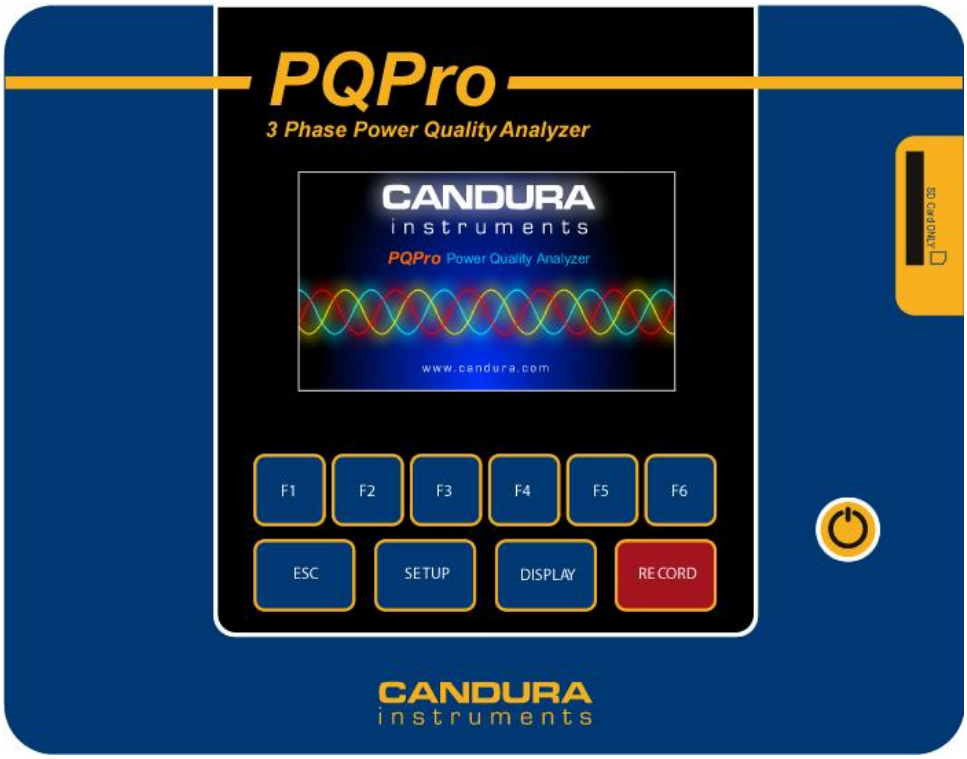
1. Introduction

The ***PQPro***™ is the third generation of power quality analyzers developed by CANDURA Instruments for the measurement of power quality and for power system diagnostics. From the front panel of the instrument, the user can configure the ***PQPro***™, start and stop recording, and view real time data such as: voltage and current RMS, real power, voltage and current waveforms, harmonics and phasors.

CANDURA Instrument's ***PV II***™ software can be used to process the recorded data and view:

- AC and DC Voltage, Current, Power and Frequency graphs
- Waveforms, harmonics and vector diagrams for both voltage and current
- Three phase voltage and current unbalance
- Voltage sags and swells
- High speed voltage transients
- Current inrush
- Flicker (IEC 61000-4-15)
- Power Quality Measurements in accordance with the IEC 61000-4-30 standard. The ***PQPro***™ is a Class A instrument.



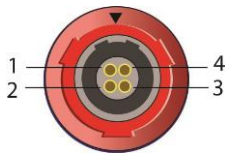
The ***PQPro***™ is an 8-channel power quality analyzer / data recorder. It monitors three phases of voltage and current as well as a fourth channel of voltage and current. Measured parameters are updated every ½ cycle to ensure that nothing is missed. Most measurements can be viewed on the front panel LCD in the field and recorded data can be transferred to a computer using the removable memory card or wirelessly if the option is installed. The instrument is powered from the V1 voltage measurement input or, if V1 is a weak source, an auxiliary power supply may be used. The ***PQPro***™ has an internal rechargeable battery that can power the instrument for up to 4 hours in the event of a power outage. The entire unit is enclosed in a rugged case for use in harsh environments.

2. Safety

Although this instrument is designed to be as safe as possible, safety is ultimately the responsibility of the operator. This instrument should only be operated as specified by the manufacturer and by authorized personnel.

Please read and UNDERSTAND the following information before operating this instrument

- The ***PQPro™*** uses a membrane keypad that could be damaged if a sharp object is brought into contact with it.
- Frequently inspect the test leads and the instrument for damage. If the instrument shows any signs of physical damage or functions improperly, it should not be used.
- Never work alone. Ensure that a qualified observer is mindful of your activities.
- When performing any measurements, all connections should be made to the circuits while the power is off. To ensure personnel safety, the test leads and related connectors should not be handled while the circuit is energized.
- Do not attempt to measure any voltage higher than the maximum rating of 600 VAC RMS / 850 VDC. Failure to observe the maximum rating could result in damage to the equipment or personnel injury.
- Refer servicing of this instrument to qualified personnel only. Disconnect supply power before servicing. Potentially lethal voltages may be present inside the case. If any of the protective circuitry is improperly repaired, the safety of this product could be compromised.
- Do not expose the ***PQPro™*** directly to outdoor elements.
- See explanation in manual to find out the nature of the potential HAZARD and any actions to be taken.
- On / Standby
- If the ***PQPro™*** is used in a manner not specified by the manufacturer the provided protection of the instrument may be diminished.
- Clean with damp cloth only.
- Measurement Category IV (CAT IV) refers to the overhead or underground utility service of an installation. Measurement Category III (CAT III) refers to distribution level and fixed installation circuits inside a building.
- The measurement category of a combination of the instrument and an accessory is the lower of the two measurement categories.
- CT inputs are voltage only. CTs must have an integrated burden resistor with 1VRMS output corresponding to rated current. CT connection is to pins 1 (+) and 2 (-).

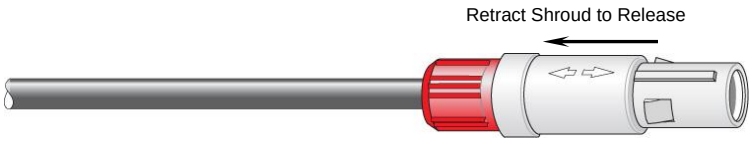


3. Quick Start

Connecting the ***PQPro™*** to a power circuit is a straightforward process.

1. Connect the voltage leads for each phase to be measured. For proper operation V1 must always be used. Three phase circuits can be connected in either a 'wye' or 'delta' configuration. Refer to the 'Hookup Configurations' section for the various methods of connecting the voltage leads. You can view the different 'Hookup Configurations' diagrams by pressing the SETUP button and clicking on CONFIGURATION or by looking on the inside of the ***PQPro™*** lid.

2. Connect the clamp CTs or flex CTs. Channels 1, 2 and 3 must use the same type and rating of CT, channel 4 may use a different type and/or rating CT (Ensure that the correct CTs have been selected in the SETUP menu).



3. Turn the instrument on by pressing the On/Standby button.

4. Ensure a memory card is installed.

5. Use the 'SETUP' key and function keys to check and modify any of the setup parameters.

6. Press the 'Record' key and then F1 to start recording synchronized to the real time clock or, if recording continuous waveforms, press F2 to start recording immediately.

7. The measured values can be viewed from the instrument using the 'DISPLAY' key and function keys.

8. To stop recording press the 'RECORD' key and then F2 followed by F1 to confirm the stop command.

Note: Static discharges may occur when connecting leads or the memory card, depending on environmental conditions. This is not hazardous and will not damage the instrument. However it may affect the integrity of the data if the instrument is recording. Connection and disconnection of leads etc. should be done while the instrument is not recording. Before handling an instrument that is recording the operator should discharge any potential static by touching a grounded object.

9. Data is transferred to a computer using the memory card or wirelessly if the option is installed. When recording has been stopped the memory card can be removed from the instrument. The memory card can be inserted directly into the card reader. Run ***PV II™*** and select 'File', 'Open' and then go to the drive that has been configured for the memory card. If there is data on the card you will then see a file that can be opened. After opening the file on the data card the file is processed and stored on the computer's hard drive.

Note: Do not remove the memory card before you stop the recording. Improper removal of the card may lead to corrupt or unusable data.

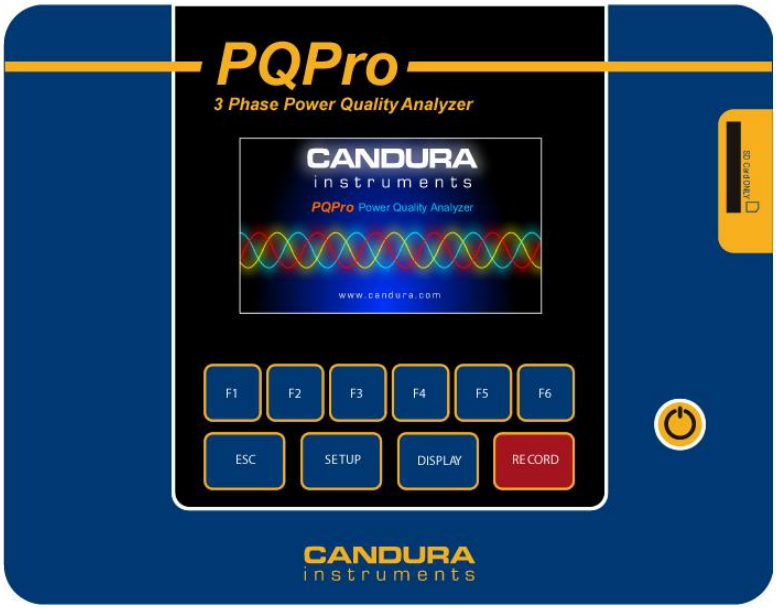
4. PQPro™ Operation

4.1 Front Panel

The front panel of the ***PQPro™*** has a colour graphics display, a 10-button keypad and a memory card interface.

The colour graphics display is 270x480 pixels.

The keypad has two types of buttons. The bottom row of 4 keys are fixed function buttons and the top row of 6 keys are function keys that change function depending on the active screen on the display. In most screens the bottom line of the display is used to describe the functions associated with the six function keys.

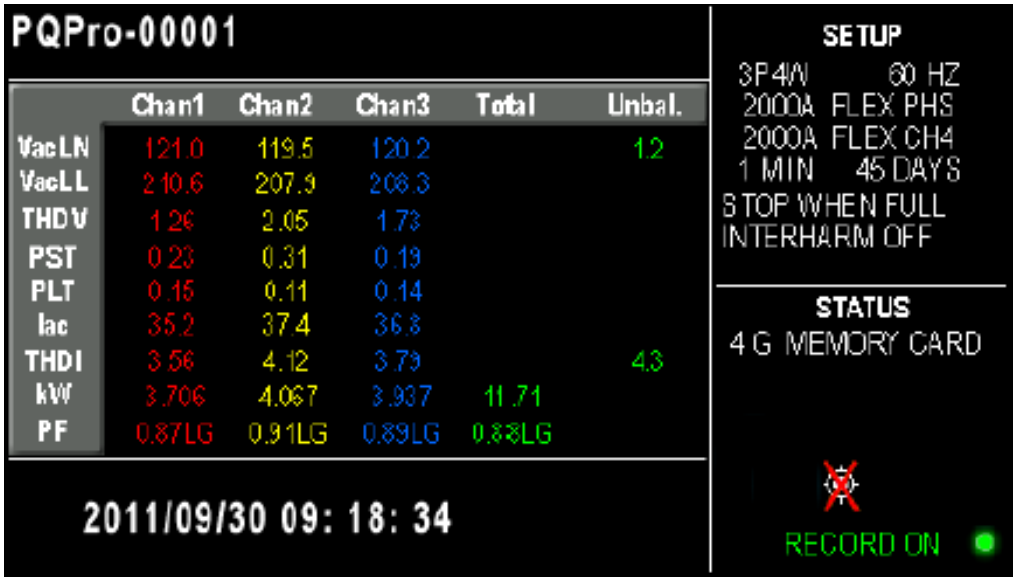


The memory card interface is used to store recorded data on a memory card and also to load new firmware. The ***PQPro™*** will not begin a survey without a memory card installed. Once a survey has been started the memory card may not be removed until the survey has been stopped.

Once the instrument is turned on, the opening screen will appear on the LCD screen, as shown in the figure above. The opening screen is customizable and can be changed based on the user's request. Please contact info@candura.com for further details.

4.2 Main Screen

Once start-up is complete, the main screen will appear on the LCD. This screen will look similar to the figure shown below. You can reach the main screen from any other screen or menu by pressing the 'ESC' button once to three times (depending in which menu you are located).



The main screen is divided into five separate sections:

- Top left section has the ***PQPro™*** serial number.
- The middle left section contains the RMS values of the measured voltages and currents, as well as a series of power measurements (total harmonic distortion, short and long term flicker, real power, true power factor, and voltage/current unbalance). These measurements are displayed and updated in real time.
- The bottom left section displays the date and time.
- The top right section displays the ***PQPro™*** setup. Specifically, the 'SETUP' section shows the circuit configuration (in this example it is a 3 Phase 4 Wire configuration), the system frequency, the setup of the current clamps or flexes, the type and length of recording, and whether interharmonics are computed.
- The bottom right section is called 'STATUS' and it displays information regarding the current ***PQPro™*** operation such as the size of the inserted memory card installed and if you are currently recording. At the bottom of the STATUS section, the user can see the GPS icon (if installed). The icons will indicate the status of the Wireless comm or GPS (in the figure below wireless comm is enabled and there is an active connection, while GPS is not installed). The 'STATUS' section will also display warning messages (in capital red letters) if there are any issues detected with the current setup (voltage too low, battery not charging).

4.3 Back Panel

The voltage and current connections are colour coded according to phase and polarity (for voltage).

Channel 1 or Phase A	Red
Channel 2 or Phase B	Yellow
Channel 3 or Phase C	Blue
Channel 4 Current	Grey
Channel 4 Voltage	White

Note: The four voltage connectors are **differential** input, both the positive and the negative (neutral) terminals must be connected!

An auxiliary 12Vdc connector (lower left in the figure below) is used to connect to an external DC power supply and power the unit. Connection to the DC power adapter is only required when V1 is connected to a weak source, otherwise the ***PQPro™*** will draw its necessary power from the V1 connection.

Note: When measuring less than 4 voltages, V1 must always be used. V1 zero crossing is used to synchronize the data sampling and measure frequency. In the event of an outage on V1, the PQPro™ has an internal digital PLL that simulates the zero crossing until V1 is restored.

4.4 Turning On and Off

The ***PQPro™*** has a dedicated On/Standby button . If the instrument is running on battery power without recording, and there has been no key pressed or wireless activity for five minutes the instrument will automatically turn off in order to conserve battery capacity. If the instrument is running on battery power and recording the instrument will not turn off until the battery capacity is below 15%. At that time the data file will be closed and the instrument will automatically turn off – no data will be lost.

After turning off due to low battery voltage the battery will have enough capacity to keep the real time clock functioning for over a month.

4.5 Memory Card

The ***PQPro™*** continually checks the memory card interface to see if a card has been inserted or removed. When it detects a card being inserted, or a card in the socket immediately after power up, the instrument checks the card size and the number of files on the card. The ***PQPro™*** PQ Firmware supports from 4GB to 32GB memory cards. The optional XCW firmware supports 64GB and 128GB memory cards. Each file is allocated approximately 0.5GB on the card so that a 4GB card can hold up to 8 data files and a 32GB card can hold up to 64 data files.

When the instrument detects a card being removed, the display screen reverts to the main display screen. If the instrument was recording when the memory card is removed, recording is stopped and the following error message is displayed:

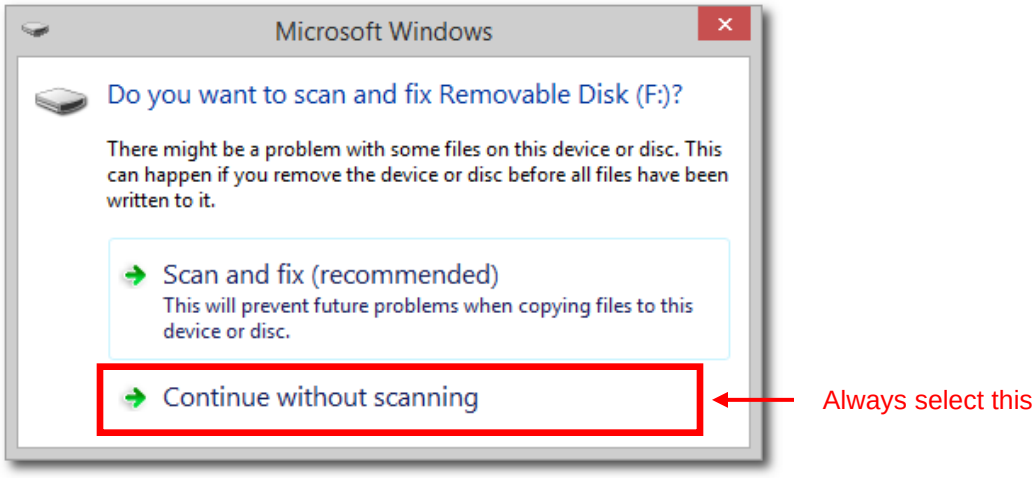
MEMORY CARD REMOVED WHILE RECORDING
RECORDING STOPPED
RE-INSERT CARD TO CLOSE FILE PROPERLY

If the memory card is not re-inserted the data file on the card will have the name Q999xxxx.TSQ and ***PV II™*** software ***may*** be able recover the trend and event data.

Note: The memory card should NEVER be removed while recording is on. ALWAYS stop recording before removing the memory card.

In order to record and store a large amount of data continuously, ***PQPro™*** uses a custom FAT32 File System to handle reading & writing data to the memory cards. Because of this reason, Windows sometimes might mistakenly identify the card as problematic and ask for 'Scan and Fix'. ***Always select 'Continue without scanning'***, as Windows' own 'Scan and Fix' might ruin the custom File System header and render the recorded file un-readable.

Note: ***Always select 'Continue without scanning'***, as 'Scan and Fix' might ruin the custom File System header and render the recorded file un-readable.



If 'Scan and Fix' is applied and the file become unreadable, please contact info@candura.com for further assistance.

Firmware is loaded into the ***PQPro™*** by inserting a specially created memory card into the card slot when the ***PQPro™*** is turned off. The ***PQPro™*** is then turned on to start the firmware load process. Once the firmware is loaded it will stay in the ***PQPro™*** until other firmware is loaded.

If optional firmware is loaded into a ***PQPro™*** without the proper activation, the screen will display a message telling the user to install the PQ firmware and then it will turn off.

The Memory card offers a fast and convenient method to transfer recorded data to a computer. To transfer data from the memory card to a computer, remove the card from the logger and insert it into a card reader. Run ***PV II™*** and select 'File' -> 'Open' and then go to the drive that has been configured for the memory card. If there is data on the card you will then see a file that can be opened. After opening the file, the processed file can be saved on the computer's hard drive. If the wireless option has been installed recorded data can be downloaded wirelessly.

4.6 Setup

Pressing the 'SETUP' button calls up the main setup screen. The main screen displayed on the LCD screen is shown in the figure below.

From the main setup screen you can select the following:

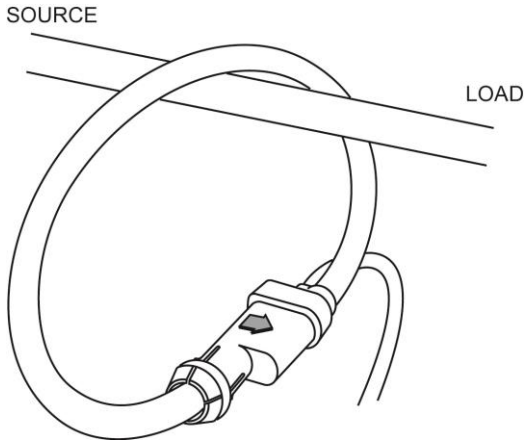
PHASE CT RANGE
CH 4 CT RANGE
CONNECTION
DATA STORAGE
TRIGGER LEVELS
EXT PT/CT
SYSTEM FREQ
CLOCK
WIRELESS TECH
CALIBRATE
LANGUAGE
SETUP LOCK

Each of these options will be further detailed in the following subsections.

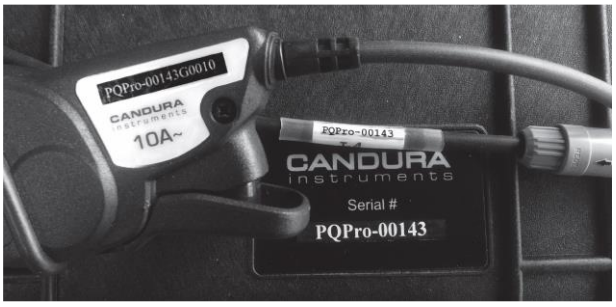
4.6.1 Phase CT Range

User selects the clamp CT or flex CT that is being used on channels 1, 2 and 3. The same type and rating is used for all three channels.

For correct polarity the arrow on the Clamp CT or the Flex CT connector should be pointing towards the load. The Flex CTs are slightly position dependent (up to +/- 1% of reading). For best results the Flex plane should be perpendicular to the current carrying cable and the Flex connector should be on the opposite side of the loop with respect to the current carrying cable:



Clamp and Flex CTs are calibrated for specific ***PQPro™*** units, therefore they should always be used as a matching set. Clamp CT serial numbers are found on the clamp handles, and Flex CT serial numbers are found under clear heat shrink near the Flex connector. The CTs are calibrated to have an error of less than 0.2% of full scale. If CTs from a different ***PQPro™*** are used, the Clamp CT error could be ±1.0% of full scale and the Flex CT error could be ±10% of full scale!



Note: Please keep the CTs with the PQPro they belong to!

4.6.2 CT4 Ch Range

User selects the clamp CT or flex CT that is being used on Ch 4. The type and rating can be different from the phase CT.

4.6.3 Connection

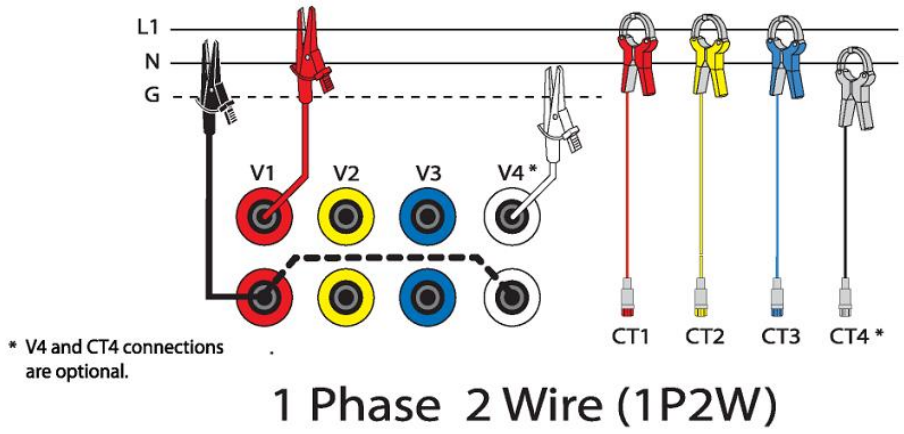
User selects the type of phase connection. If the Storage Rate is set to 0.2 seconds, then the ***PQPro™*** will record in Continuous Waveform mode.

Note: Only 3P3W and 3P4W configurations are available if the Storage Rate is set to 0.2 seconds (Continuous Waveform). If another configuration is selected while setting the Storage Rate to 0.2 seconds, the PQPro™ will automatically change the configuration to 3P4W.

The available configurations are detailed next.

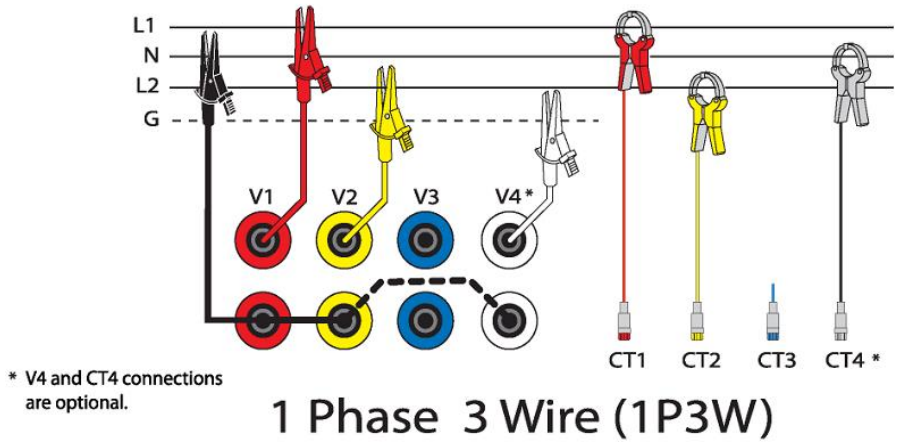
1P2W - 1 Phase 2 Wire

The three phase CTs are associated with V1 so that three individual loads can be monitored in this configuration. Channel 4 voltage and current is **NOT** recorded. However, channel 4 voltage and current will be displayed on the LCD screen is you press the DISPLAY button, followed by F1.



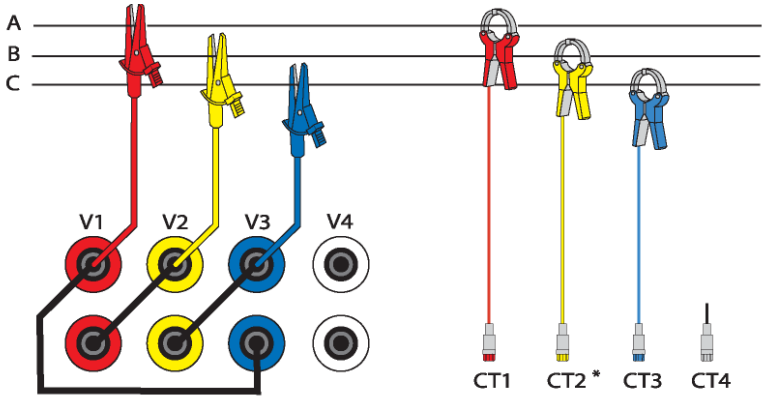
1P3W - 1 Phase 3 Wire (Edison circuit)

Channels 1 and 2 for voltage and current are used for monitoring a residential type split phase service. Channel 4 voltage is **NOT** recorded. Channel 4 current is recorded.



3P3W - 3 Phase 3 Wire (Delta circuit)

Line to line voltages (V_{ab}, V_{bc} and V_{ca}) and line currents (I_a, I_b and I_c) are measured directly. Only I_a and I_c are required for three phase power calculations. Channel 4 voltage and current are recorded for all storage rates **except** 0.2 seconds (Continuous Waveform).

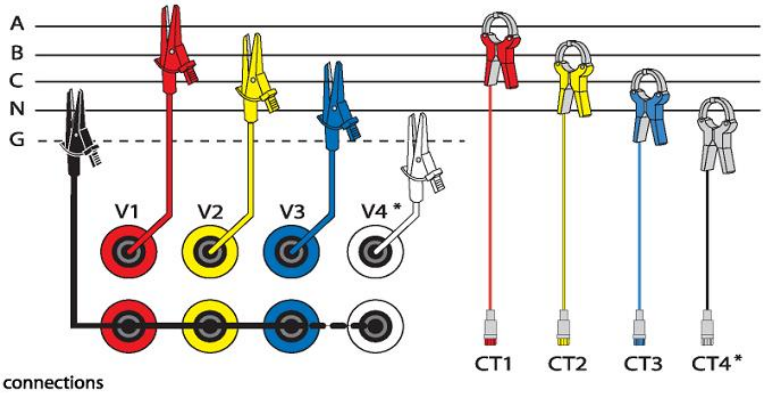


3 Phase 3 Wire (3P3W)

* Optional: CT2 not used in Total Power Calculation

3P4W - 3 Phase 4 Wire (Wye circuit)

Line to neutral voltages (V_{an}, V_{bn} and V_{cn}) and line currents (I_a, I_b and I_c) are measured directly. Channel 4 voltage and current are recorded for all storage rates **except** 0.2 seconds (Continuous Waveform).

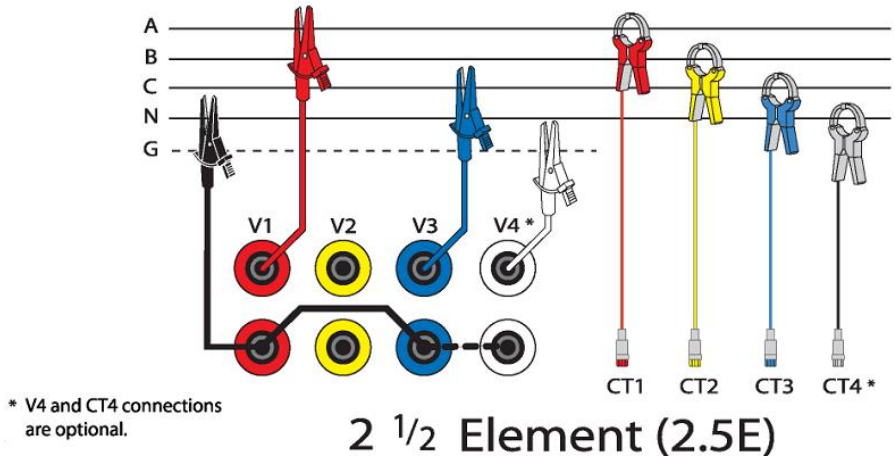


* V4 and CT4 connections are optional.

3 Phase 4 Wire (3P4W)

2.5E - 2½ Element

Line to neutral voltages (V_{an} and V_{cn}) and line currents (I_a, I_b and I_c) are measured directly. Line to neutral voltage V_{bn} is calculated from V_{an} and V_{cn}. Channel 4 voltage and current are recorded.



4.6.4 Data Storage

User can configure various data store parameters:

STORAGE RATE
RECORDING MODE
INTERHARMONICS
VOLT SPIKE WVFRM (Voltage Spike Event Waveforms)
VOLT U/O WVFRM (Under/Over Voltage Event Waveforms)
CURR INRSH WVFRM (Current Inrush Event Waveforms)
RMS CAPTURE (RMS Event Capture)

Storage Rate

The storage rate has the following settings:

0.2, 1, 5, 10, 15, 30 seconds
1, 5, 10, 15, 30 minutes

RMS calculations are updated every ½ cycle using a sliding one cycle window. At each storage interval the minimum, maximum and average RMS values based on the ½ cycle updates are stored.

For 0.2 second storage rate, 10 cycles (50 Hz systems) or 12 cycles (60 Hz systems) of waveforms are stored every 200 milliseconds. This results in continuous waveform storage – ***with no gaps*** in the waveform record. The RMS values are stored every 200 milliseconds. Event capture is disabled and wireless communication is limited.

For 1 second and higher storage rates with interharmonics turned off, one waveform cycle for each channel is recorded every interval. If interharmonics are on, the ***PQPro™*** will store 10 cycles (50 Hz systems) or 12 cycles (60 Hz systems) per interval.

Recording Mode

There are two different recording modes: *Stop When Full* and *Restart When Full*

Stop When Full
When a data file is full* the file is closed and a new file is automatically started.
If an Event data buffer is full before the RMS data buffer, then Event Capture for that type of event will be suspended until a new file is started. For storage rates 1 second or longer the file will start on an even minute boundary so there could be a gap of up to a minute between the end of one data file and the start of the next one. For 0.2 second storage rate the new file will start immediately with no gap between the end of one data file and the start of the next one.

When the memory card is full recording will automatically stop.

Restart When Full
When a data file is full* the file is closed and a new file is automatically started. For storage rates of 1 second or longer the new file will start on an even minute boundary so there could be a gap of up to a minute between the end of one data file and the start of the next one. For 0.2 second storage the new file will start immediately with no gap between the end of one data file and the start of the next one.

When the memory card is full the oldest file will be deleted and a new one will be started. Recording will continue until the user stops recording.

** A data file is determined to be full when the RMS Trend data buffer is full. There are separate buffers for Event data. If an Event data buffer is full before the RMS Trend data buffer then that type of Event capture will be suspended until a new file is started.*

Interharmonics

Interharmonics are calculated by the software from the waveform snapshots that are stored every storage interval. If Interharmonics are turned off, one cycle of waveforms are stored every storage interval and the software can only calculate Harmonics. If Interharmonics are turned on, then multiple cycles of waveforms are stored every storage interval, 10 cycles for 50 Hz systems, or 12 cycles for 60 Hz systems. The Interharmonic resolution is 5 Hz.

Interharmonics use a lot of memory and should only be used if required. For example, in a 60 Hz system at 1 minute storage, it will take 45 days to fill one data file with Interharmonics OFF and only 5.0 days with Interharmonics ON. On power up of the ***PQPro™,*** Interharmonics are OFF and the user must turn this feature ON manually if desired.

Voltage Spike Waveforms

For high speed voltage transients (>20 microseconds for 50 Hz systems or >16 microseconds for 60 Hz systems) user can adjust the number of waveform cycles stored from 2 to 10 cycles. There will be a ½ cycle of pre-trigger data.

Under/Over Voltage Waveforms

For Under/Over Voltage transients that are ½ cycle or longer, the user can adjust the number of waveform cycles stored from 4 to 100. Pre-trigger data is 25% of the waveform buffer. Both Under/Over Voltage and Current Inrush waveform buffers will be set to the same length.

Current Inrush Waveforms

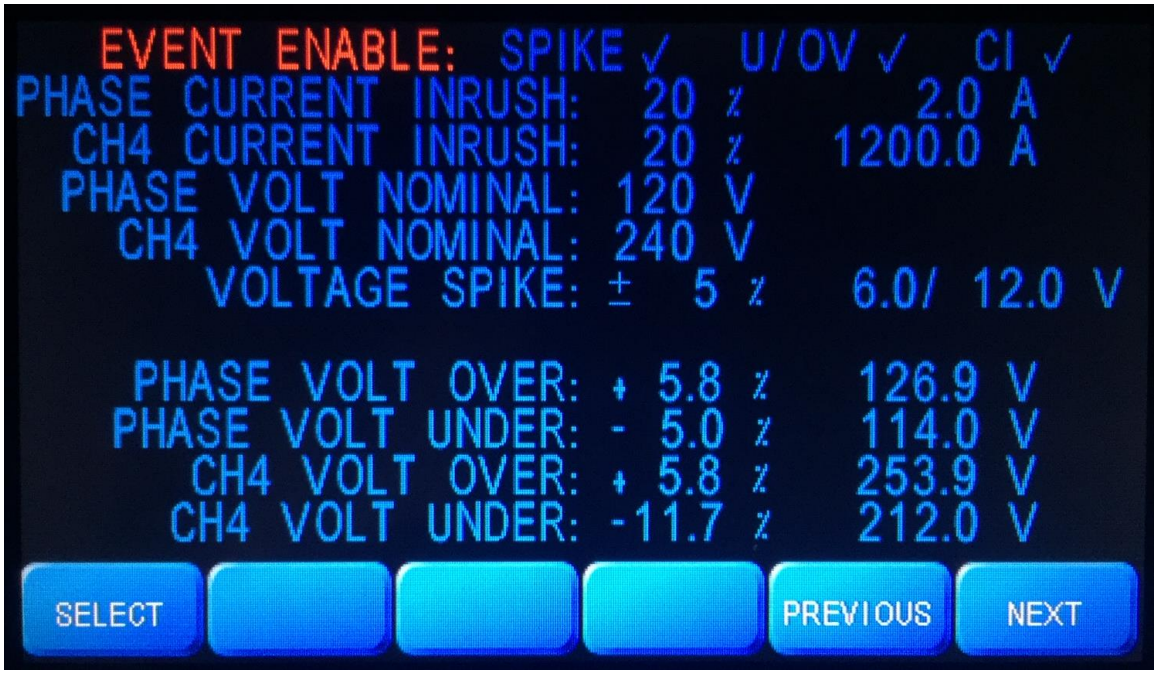
For Current Inrush transients that are ½ cycle or longer the user can adjust the number of waveforms cycles stored from 4 to 100 cycles. Pre-trigger data is 25% of the waveform buffer. Both Under/Over Voltage and Current Inrush waveform buffers will be set to the same length.

RMS Capture

This setting affects the RMS transient data stored for both under/over voltage transients and current inrush. The pre-trigger buffer size is fixed at 64 cycles. User can adjust the total length of the RMS storage from 120 to 3600 cycles. The resolution of the RMS data is ½ cycle.

4.6.5 Trigger Levels

The event trigger levels are set here. The figure below shows the menu seen on the LCD screen once the 'TRIGGER LEVELS' option is selected from the 'SETUP' menu.



The options are:

EVENT ENABLE
PHASE CURRENT INRUSH
CH4 CURRENT INRUSH
PHASE VOLT NOMINAL
CH4 VOLT NOMINAL
VOLTAGE SPIKE
PHASE VOLT OVER
PHASE VOLT UNDER
CH4 VOLT OVER
CH4 VOLT UNDER

Note: This menu is not accessible if the storage rate is set to 0.2 seconds (Continuous Waveform storage).

Event Enable

The three events types (Voltage Spike, Under/Over Voltage and Current Inrush) can be individually disabled. On power up all events are automatically enabled. All events are disabled if the storage Interval is set to 0.2 seconds.

Phase Current Inrush

This trigger level is an RMS value. If any of the three phase currents (channels 1, 2 or 3) exceeds this level then a Current Inrush Event is triggered.

Channel 4 Current Inrush

This trigger level is an RMS value. If the current on channel 4 exceeds this level then a Current Inrush Event is triggered.

Phase Voltage Nominal

This is the expected nominal voltage for channels 1, 2 and 3. If measuring Line – Neutral this is the line to neutral nominal voltage, If measuring Line – Line this is the line to line nominal voltage. This is used as a reference for channels 1, 2 and 3 voltage event trigger levels.

Channel 4 Voltage Nominal

This is the expected nominal voltage for channel 4. This is used as a reference for channel 4 voltage event trigger levels.

Voltage Spike

Trigger setting for the high speed voltage transient capture function.

Phase Voltage Over

The RMS over voltage trigger level for channels 1, 2 and 3.

Phase Voltage Under

The RMS under voltage trigger level for channels 1, 2 and 3.

Channel 4 Voltage Over

The RMS over voltage trigger level for channel 4.

Channel 4 Voltage Under

The RMS under voltage trigger level for channel 4.

4.6.6 Ext PT/CT

For use when measuring on the secondary sides of external PTs and CTs. Entering these values enables user to view voltage, current and power as they are on the primary side of the external PTs and CTs. With the ratios set 1:1 user would see them as they are on the secondary side. The maximum voltage ratio that can be entered is 999,999:1. The maximum current ratio that can be entered is 99,999:1. These ratios can also be modified later when viewing the data in software.

4.6.7 System Freq

User can select either 50 Hz or 60 Hz. Different nominal frequencies (such as 400 Hz) can be customized at the user's request.

The frequency setting will affect the operation of some of the instrument functions. These functions are:

i) Flicker calculation. The ***PQPro™*** calculates flicker according to the IEC 61000-4-15 standard which has different requirements for 50 Hz and 60 Hz systems. For frequencies other than 50 Hz and 60 Hz, flicker is not calculated.

ii) Interharmonic calculation. ***PV II™*** calculates Interharmonics according to the IEC 61000-4-30 standard which has different requirements for 50 Hz and 60 Hz systems. For both frequencies a 200 millisecond window is used which corresponds to 10 cycles at 50 Hz and 12 cycles at 60 Hz resulting in an Interharmonic resolution of 5 Hz.

iii) 0.2 second storage rate, for 50 and 60 Hz systems the *PQPro™* stores RMS data every 200 milliseconds and waveforms, with 256 samples/cycle, continuously.

4.6.8 Clock

This enables the user to set the ***PQPro™*** internal clock from the front panel. The internal clock can also be set from a computer using ***PV II™*** software and a wireless interface. The clock resolution is 0.01 seconds.

4.6.9 Wireless

User can turn off the internal wireless radio transmitter. Wireless communication is an optional feature and if installed, communication is automatically enabled on power up.

4.6.10 Calibrate

Calibration factors are stored internally in the ***PQPro™***. Any user can view the calibration factors without the ability to modify them. Qualified personnel can modify the calibration factors by first entering a six-digit password. Please contact CANDURA Instruments at info@candura.com to receive the password.

4.6.11 Language

User can change the language used by the ***PQPro™*** display. English and Spanish are currently supported.

4.6.12 Setup Lock

When the Setup Lock is ON, the setup parameters cannot be changed from the front panel. The password '4123' is used to turn the lock ON and OFF.

4.7 Display

Pressing the 'DISPLAY' button calls up the main display screen. The main display shows the real time values of AC voltage, current and power. The main display is formatted depending on the connection configuration. The following figure shows the display screen for a 3P4W configuration.

From the main display screen, you can select the following options:

AC/DC Voltage, Current and Frequency

AC and DC voltage and current are displayed. For a 1 phase 2 wire connection (1P2W), the power shown is for the channel current referenced to the channel 1 voltage.

Waveforms

Voltage and current waveforms can be viewed in real time.

Harmonic Bar Chart

Voltage and current harmonic magnitudes up to the 41st harmonic can be viewed in real time. When data is recorded and viewed with ***PV II***™ software harmonic magnitudes up to the 128th can be viewed.

Vector Diagram

Voltage and current vectors can be viewed in real time. The ***PQPro***™ has a digital PLL which synchronizes the channel 1 voltage vector to zero degrees. This synchronization attempts to maintain the same waveform position (phase) for all waveform records.

System Information

User can view the ***PQPro***™ serial number, the firmware revision, installed options, the recording status (on or off), the battery status (charging or discharging and capacity) and memory card usage. The options that may be installed are as follows:
Wireless Technology
GPS (GPS)
Meter Installation Verification (MIV)
eXtended Continuous Waveform (XCW)

4.8 Record

Pressing the 'RECORD' button calls up the recording screen. From this screen user can:

i) (F3) Run a system check that checks over range voltage and current, reverse CT connections, reverse phase sequence and voltage and current outside trigger levels. Please see section 4.8 Hookup Diagnostic Warning for more details.

ii) (F2) Start recording immediately. This is only available if recording continuous waveforms.

iii) (F1) Start recording synchronized to the internal clock. Recording starts on an even minute. User can adjust the start time to be the next even minute or delayed as much as 24 hours. When delayed start is initiated the display will show 'RECORD DELAY'. When the delay is over this will change to 'RECORD ON' and the first record will be written to the data file.

The Record screen also shows the memory usage in terms of number of records available/used in the current file and the number of files available/used on the card.

When recording is started 'F2' becomes the stop recording button.

If events are active messages in red will be printed above the function keys.

4.9 Hookup Diagnostic Warning

From the 'RECORD' screen the operator can select 'SYSTEM CHECK'. The instrument does a number of checks on the connected signals, if it detects a potential problem a message will be displayed in the RECORD screen. The operator can elect to ignore these messages and start anyway in which case these messages will not appear while the instrument is recording. If the operator makes changes to the instrument setup or the connections to the power system and the condition clears then the messages will clear when the operator selects 'SYSTEM CHECK' again.

Possible messages and descriptions are presented below:

'CH1 VOLTAGE TOO LOW'
'CH2 VOLTAGE TOO LOW'
'CH3 VOLTAGE TOO LOW'

Voltage being measured is less than 10V

'CH1 VOLTAGE TOO HIGH'
'CH2 VOLTAGE TOO HIGH'
'CH3 VOLTAGE TOO HIGH'
'CH4 VOLTAGE TOO HIGH'

Voltage being measured is greater than 120% of rated value.

'CH1 CURRENT TOO HIGH'
'CH2 CURRENT TOO HIGH'
'CH3 CURRENT TOO HIGH'
'CH4 CURRENT TOO HIGH'

Current being measured is greater than 120% of the CT rating.

‘-VE POWER CHECK CT1’
‘-VE POWER CHECK CT2’
‘-VE POWER CHECK CT3’
‘-VE POWER CHECK CT4’

This usually means that the relevant CT has been connected in reverse. To fix the problem remove the CT, rotate it 180 degrees, reconnect it and then press ‘SYSTEM CHECK’ again. In some cases this is not an error (i.e. when measuring a generator output).

‘VOLTAGE PHASE SEQ ERROR’

Voltage phase sequence is checked when voltage on channels 1, 2 and 3 are greater than 30V and error occurs when phase sequence is not A B C. To fix this problem, swap the voltage connections to channels 2 and 3 and then press ‘SYSTEM CHECK’ again.

‘CURRENT PHASE SEQ ERROR’

Current phase sequence is checked when currents on channels 1, 2 and 3 are greater than 5% of range and error occurs when phase sequence is not A B C. To fix this problem exchange CT’s for channels 2 and 3 and then press ‘SYSTEM CHECK’ again.

‘VOLTAGE OUTSIDE TRIG WINDOW’

This indicates that at least one of the four measured voltages is above the over voltage trigger level or at least one of channels 1, 2 or 3 voltage is below the under voltage trigger level. **Note: Channel 4 under voltage is not included in the system check.**

‘CURRENT GREATER THAN TRIG LEVEL’

This indicates that one or more currents are greater than the current inrush threshold.

‘CT TYPE ERROR - PHASE’

The type of CT(Flex or Clamp) connected to the phase CT inputs is not the same as selected.

‘CT TYPE ERROR - CHANNEL 4’

The type of CT(Flex or Clamp) connected to channel 4 inputs is not the same as selected.

5. *PQPro*™ Firmware Features

5.1 Supported Firmware

There are three different firmware applications that can be loaded into the ***PQPro***™:

The PQ firmware is standard for all ***PQPro***™'s and does not require a license. The XCM firmware is only for continuous waveform recording. See the section XCW Optional Firmware for more information. The MIV firmware is for in service monitoring and documenting revenue meters and uses a software packaged called 'MIV Application for the ***PQPro***™'. XCW and MIV are firmware options that require activation. If optional firmware is loaded into a ***PQPro***™ without the proper activation the screen will display a message telling the user to install the PQ firmware and then it will turn off.

5.2 RMS and Waveform Data Storage

The ***PQPro***™ stores RMS data at set intervals which can be adjusted from 0.2 (Continuous Waveform recording) to 30 seconds or 1 to 30 minutes. The minimum, maximum and average values are stored at the end of each storage interval. The average values are calculated from the sum of the RMS values (updated every ½ cycle) over the preceding storage interval. The minimum and maximum values are updated every ½ cycle over the preceding storage interval.

Data is stored in files with a maximum size of 458MB. For PQ firmware, data cards from 4GB to 32GB are supported. For XCW firmware, 64GB and 128GB data cards are supported.

There are two Storage modes that the user can select: *Stop When Full* and *Restart When Full*. Both modes refer to the space on the memory card. A 4G card will hold a maximum of eight 458M files and if configured for Stop When Full recording will automatically stop when there are eight files on the memory card (unless the user stops recording first). When configured for Restart When Full and there are eight files on a 4G card the oldest file will be overwritten and recording will not stop until the user stops recording.

5.3 IEC 61000-4-30 Class-A Data Storage

IEC 61000-4-30 Class A compliance is achieved by ***PV II***™ software which can process continuous waveform data to produce IEC 61000-4-30 graphs and reports. For more information on this please refer to the '***PV II***™ for the ***PQPro***™' User's Guide.

The PQ firmware records continuous waveform data when storage rate is set to 0.2 seconds. Six channels (V1, V2, V3, I1, I2 and I3) are recorded with a resolution of 256 samples per cycle. During Continuous Waveform storage, event capture functions are disabled, and wireless communication is limited. Maximum recording duration in a 60Hz system with a 32GB memory card is 44 hours.

For continuous recording with configurable sample rate and number of channels, use the XCW Optional Firmware.

5.4 Harmonics

The ***PQPro***™ displays up to the 41st harmonic on its display while the software displays up to the 128th harmonic. Total Harmonic Distortion (THD) is calculated as the ratio between the square root of the squared sum of the harmonic magnitudes (for harmonics 2…128) divided by the fundamental value. THD is calculated over a 0.2 second window.

5.5 Interharmonics

Interharmonics are calculated by the software from waveform snapshots that are stored every storage interval. The Interharmonic calculation requires multiple cycles of waveforms. If Interharmonics are turned off, only one cycle of waveforms is captured and the software can only calculate Harmonics. If Interharmonics are turned on, 10 cycles (for 50 Hz systems) or 12 cycles (for 60 Hz systems) are stored every storage interval. Interharmonics can be resolved to 5 Hz resolution.

Continuous waveform storage stores 10 or 12 cycles of waveforms per record continuously with no missing cycles. This enables the software to be able to calculate Interharmonics over an extended period. For example, the software could use 120 cycles resulting in a resolution of 0.5 Hz (in 60 Hz systems) for Interharmonics. Note that in Continuous Waveform storage (0.2 seconds), there is no option to turn Interharmonics ON or OFF.

5.6 Power Calculations

Power calculations are updated every cycle. Average values of power are recorded every storage interval. The Power Factor displayed is the true power factor, not the displacement power factor which is determined from the phase angle shift between fundamental values of voltage and current. The true power factor is calculated as the ratio of real power (kW) to apparent power (kVA).

5.7 Frequency

System frequency is measured from the V1 input signal and is updated once per cycle. Frequency will not be measured if the voltage input on channel 1 is below 10V.

5.8 Event Capture

Under/over voltage events, high speed voltage transients and current inrush events are stored when they occur. Trigger levels are set in the Setup menu under 'TRIGGER LEVELS'. When an event is triggered data for all four voltage and current channels is stored, if configured for a 3 phase system, irrespective of which channel triggered the event.

Under/Over Voltage Events (U/OV)

Under/over voltage events are tagged as sags/swells if they are under 2 seconds in duration and under/over if they are longer. ***PV II***™ software reports their duration in number of cycles, with ½ cycle resolution, for events less than 2 seconds and in seconds for longer events. The ***PQPro***™ uses a hysteresis value of 0.1% of full scale to determine when the event has finished. For example if the under voltage trigger level is set at 228.0 volts the instrument will start recording an event when the voltage goes under 228.0 volts and will stop recording the event when the voltage goes over 228.8 volts. For under/over voltage events both event waveforms and RMS data, with ½ cycle resolution, are recorded. Pre-trigger data is 25% of the event buffer for waveforms and 64 cycles for RMS data. The Event Waveform buffer is user adjustable between 4 and 100 cycles. The Event RMS buffer is user adjustable between 120 and 3600 cycles. Under/Over Voltage and Current Inrush events have the same Waveform and RMS buffer lengths.

High Speed Voltage Transients (SPIKE)

The ***PQPro***™ captures high speed voltage transients that are 20 microseconds (50Hz) / 16 microseconds (60Hz) or longer. When a transient is detected on any of the four

voltages, high resolution (1024 samples/cycle for 50 and 60 Hz systems) waveform data is stored. Waveform data for all voltage and current channels is stored with a user adjustable buffer of between 2 and 10 cycles. Pre-trigger recording is fixed to ½ cycle.

Current Inrush (CI)

Current inrush data for all voltage and current channels is stored when the current on any of the four channels exceeds the threshold setting. The trigger level setting for channel 4 can be set independently from channels 1, 2 and 3. Both event waveforms (256 samples/cycle for 50 and 60 Hz systems) and RMS data (½ cycle resolution) are recorded. Pre-trigger data is 25% of the event buffer for waveforms and 64 cycles for RMS data. The Event Waveform buffer is user adjustable between 4 and 100 cycles. The Event RMS buffer is user adjustable between 120 and 3600 cycles. Under/Over Voltage and Current Inrush events have the same Waveform and RMS buffer lengths.

5.9 Voltage and Current Unbalance

Voltage and current unbalance is only computed for three phase system configurations (3P3W, 3P4W, 2.5E). Unbalance is calculated as the ratio of the negative sequence component divided by the positive sequence component. Unbalance is calculated over a 0.2 second window.

6. Wireless Option

The wireless option is for communications between a PC running ***PV II***™ software and the ***PQPro***™. ***PV II***™ software can start and stop recording, format a data card, download data (while recording is off) and change setup parameters (while recording is off). While recording is on status information is updated.

Please refer to the '***PV II***™ for the ***PQPro***™' User's Guide for more details.

7. GPS Option

A GPS receiver can be added to the ***PQPro***™***.*** This will give the ***PQPro***™ the capability of time stamping data to an accuracy, relative to UTC time, of ± 1 microsecond. This involves hardware changes that must be done at the factory. For the GPS receiver to function properly it will need to be connected to an antenna that has a view of the sky (it can be through a window) so that it can receive satellite signals. The larger the view of the sky the better. The base GPS option comes with a small magnetically mounted antenna with a 5 meter cable. CANDURA can also supply a high gain antenna with a cable up to 50 meters in length.

If a GPS receiver is installed the "Clock" selection in the Setup menu will be changed to "GPS". The GPS screen will show if the GPS receiver clock is properly synchronized to the satellites, the GPS receiver clock time, the ***PQPro***™ location in Latitude and Longitude and the number of connected satellites.

On power up if an antenna is connected with a view of the sky it should take about a minute and no more than 10 minutes to synchronize the GPS time with the satellite signals. If this does not happen within 10 minutes press 'F6' in the GPS status screen to reinitialize the GPS receiver. This is often required when the PQPro is moved to a new location.

With the GPS option installed there will be two separate clocks in the PQPro. The standard internal clock and the GPS clock. The time displayed in the PQPro main menu is from the standard internal clock. Both clock times are stored in the data records. PVII software will automatically use the GPS time stamps if the GPS time is synchronized to the satellites when recording is started. If the GPS time is not synchronized when recording is started PVII software

will give the user the option of using the PQPro internal clock or the GPS clock. The GPS clock is battery backed up and has a lower drift than the PQPro internal clock so in most cases it is better to use the GPS clock, even when not synchronized to the satellites.

The PQPro internal clock can be set from the GPS clock by pressing F2 (PQPRO CLK SET) to access a 2nd clock menu. In this menu the time zone offset can be adjusted and the PQPro internal clock setting updated from the GPS clock.

The GPS time synchronization can also be seen from the GPS symbol on the main screen. If the center dot in the symbol is flashing then the GPS time is synchronized to the satellites. If the GPS symbol has a red X over it then the GPS option is not installed.

8. XCW Optional Firmware

The eXtended Continuous Waveform (XCW) firmware extends the capabilities of the PQPro for continuous or "gapless" waveform recording. The number of channels recorded and the samples per cycle can be adjusted. Data is stored to either a 64GB or 128GB memory card.

The different channel combinations that can be recorded are:

1 channel:	V1
2 channels:	V1, I1
3 channels:	V1, V2, V3
4 channels:	V1, V2, I1, I3
6 channels:	V1, V2, V3, I1, I2, I3
8 channels:	V1, V2, V3, V4, I1, I2, I3, I4

Note: due to bandwidth limitations at 1024 samples per cycle the maximum number of channels recorded is 6.

The different samples rates that can be selected are:

1024 samples per cycle
512 samples per cycle
256 samples per cycle
128 samples per cycle
64 samples per cycle

For all sample rates RMS calculations are updated every ½ cycle. For 1024, 512 and 256 samples per cycle minimum, maximum and average RMS values are stored every 12 cycles. For 128 samples per cycle RMS values are stored every 24 cycles and for 64 samples per cycle RMS values are stored every 48 cycles.

Before recording can be started the removable memory card must be blank and recently formatted by the PQPro (note that the PQPro will reformat any memory card that has been formatted by a computer). If the number of channels or the sample rate is changed then the memory card must be reformatted by the PQPro.

Recording time for Continuous Waveform storage.
Duration in days (60 Hz systems)

		Duration		
Sample Rate	**Channels**	**64G**	**128G**	**Frequency Range**
1024/cycle	8	na	na	2-75 Hz
	6	0.9	1.8	
	4	1.4	2.8	
	3	1.8	3.7	
	2	2.8	5.5	
	1	5.0	11	
512/cycle	8	1.4	2.8	4-90 Hz
	6	1.8	3.7	
	4	2.8	5.0	
	3	3.7	7.0	
	2	5.0	10	
	1	10	21	
256/cycle	8	2.8	5.0	8-120 Hz
	6	3.7	7.0	
	4	5.0	11	
	3	7.0	15	
	2	10	21	
	1	21	42	
128/cycle	8	5.0	11	16-300 Hz
	6	7.0	15	
	4	11	22	
	3	14	29	
	2	21	42	
	1	42	83	
64/cycle	8	11	22	32-500 Hz
	6	14	29	
	4	22	44	
	3	29	58	
	2	42	83	
	1	83	167	

9. Specifications

		Specifications	Comment
Measurement	V1, V2, V3, V4 0 – 600 VAC RMS / 850VDC 16 - 450Hz	0.005% of range + 0.075% of reading	-
	I1, I2, I3, I4 0 - 1VAC/DC (CLAMP) 0 - 100mVAC (FLEX)	CLAMP: 0.05% of range + 0.15% of reading	CT's are voltage output
		FLEX: 0.05% of range + 0.5% of reading + Flex position error	
	Sampling	1024 samples/cycle every cycle	16 - 75Hz
		64 samples/cycle every cycle	16 - 450Hz
Internal Clock	Initial Accuracy	±0.05 seconds	-
	Drift	±0.5 sec/day	-
Recording	Storage Rate	0.2 seconds (CW recording) 1, 5, 10, 15, 30 sec 1, 5, 10, 15, 30 min	-
	Memory	4G- 128G removable memory card	-
Power Supply and Battery Charger	Internal Power Supply	50VA 100 - 600VAC ± 10% 50 - 400 Hz	Operated from voltage on V1 measuring channel.
	External Power Supply For PQPro	Input: 100-240 VAC ± 10% 47-63Hz, 400mA Output: 12VDC, 1.25A	PHIHONG PSA15R-120P6
	Battery Run Time	4 hours	-
Communication	Wireless	Wireless 2.0	Optional add-on
	GPS	Timing GNSS – 1PPS Time Pulse <100 nsec @130 dBm	Optional add-on
Environmental	Operating Temperature	-20°C to 60°C	-
	Battery Charging Temperature	0°C to 45°C	-
	Humidity	Max 80% relative non condensing	-
	Altitude	Max 2000m	PQPro
		Max 5000m	PQPro-HA
Safety	CSA Certified CAN/CSA-C22.2 No. 61010-1-12 (R2017)	Pollution Degree 2	Normally only non-conductive pollution occurs. However, temporary conductivity caused by occasional condensation must be expected.
		600Vac, 850Vdc CAT IV	PQPro
		300Vac, 425Vdc CAT IV 600Vac, 850Vdc CAT III	PQPro-HA

*Specifications may change without notice.

Abbreviations

- Iac – AC current
- kW – Kilowatts
- PF – Power Factor
- PLT – Flicker Perception Long Term
- PST – Flicker Perception Short Term
- THDI – Total Harmonic Distortion Current
- THDV – Total Harmonics Distortion Voltage
- VacLL – AC Voltage Line to Line
- VacLN – AC Voltage Line to Neutral