Newtons4th Ltd

PPA4500 Series

Precision Power Analyzer

User manual

Chapter 0 Table of Contents

Chapter 1 Safety

Important safety Information

This manual contains important information that must be followed to ensure the safety of all operatives and both this instrument and any accessories attached.

CAUTION.
Input Connections: It is critical that the 4mm inputs and BNC inputs on each PPA input channel are not connected to any external circuit at the same time.

You MUST only use EITHER the 4mm OR the BNC connection – NOT both, this applies to both Voltage and Current inputs.

General Safety Information

Use the product only as detailed in this manual. Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. Carefully read all instructions. Retain these instructions for future reference.

For correct and safe operation of this instrument, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The product is designed to be used by trained personnel only it is designed to comply with BSEN 61010-1 (Safety requirements for electrical equipment for measurement, control, and laboratory use)

Ensure that the supply voltage agrees with the rating of the instrument printed on the back panel before connecting the mains cord to the supply.

The cover(s) should not be removed to attempt repair, maintenance, or adjustment, as this instrument contains no user serviceable parts. All repairs, maintenance or adjustment should only be caried out by Newtons4th Ltd or our official distributor.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

When incorporating this equipment into a system, the safety of that system is the responsibility of the assembler of the system.

There are no user serviceable parts inside the instrument – do not attempt to open the instrument, refer service to the manufacturer or his appointed agent.

To avoid fire or personal injury

Use the correct mains lead. Use only the mains lead supplied with this product and certified for the country of use.

Ground the instrument. This instrument is grounded through the grounding conductor of the mains lead. To avoid electric shock, the grounding conductor **must** be connected to earth ground. Before making connections to the input or output terminals of the instrument, ensure that the instrument is properly grounded.

Power disconnect. Do not position the instrument so that it is difficult to disconnect the mains lead; it must always remain accessible to the user to allow for quick disconnection if needed in an emergency.

Connect and disconnect properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source. Use only insulated voltage probes, test leads, and accessories supplied with the product, or indicated by Newtons4th Ltd. to be suitable for the product.

Observe all terminal ratings. To avoid fire or shock hazard, observe all rating and markings on the instrument. Consult the specifications in this user manual for further ratings information before making connections to the product. Do not exceed the Measurement Category (CAT) rating and voltage or current rating of the lowest rated individual component of a product, probe, or accessory. Use caution when using 1:1 test leads because the probe tip voltage is directly transmitted to the instrument.
Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Do not operate with suspected failures. If you suspect that there is damage to this instrument, have it inspected by Newtons4th Ltd or our official distributor. Do not use the instrument if it is damaged or operates incorrectly. If in doubt about safety of the instrument, turn it off and disconnect the mains lead. Clearly mark the instrument to prevent its further operation. Before use, inspect voltage probes, test leads, and accessories for mechanical damage and replace when damaged. Do not use probes or test leads if they are damaged.

Use proper fuse. Use only the fuse type and rating specified for this product.

Do not operate in wet/damp conditions. Be aware that condensation may occur if a unit is moved from a cold to a warm environment.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry. Remove the input signals before you clean the product, only use a dry cloth for cleaning. Do not use chemicals or cleaning products on this instrument.

Provide proper ventilation. Refer to the section on rack mounting in this manual's installation instructions for details on installing the instrument so it has proper ventilation. Slots and openings are provided for ventilation and should never be covered or otherwise obstructed. Do not push objects into any of the openings.

Provide a safe working environment. Always place the instrument in a location convenient for viewing the display and indicators. Use care when lifting and carrying the product. This product is provided with handles for lifting and carrying.

Terms in the manual

These terms may appear in this manual:

WARNING. Warning statements identify conditions or practices that could result in injury or loss of life.

CAUTION. Caution statements identify conditions or practices that could result in damage to this product or other property.

INFORMATION. Information statements identify instructions or commands that may save time or provide extra functionality

Terms on the product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

Symbols on the product

When this symbol is marked on the product, be sure to consult the manual to find out the nature of the potential hazards and any actions which must be taken to avoid them.

The following symbol(s) may appear on the instrument.

Instrument GND

Conventions used to signify control keys, screen menu options and remote control commands are differentiated as shown below.

control keys *ACQU* denoted by *italicised font*
menu options ***bandwidth*** denoted by ***bold italicised font***
script commands ****CLS*** denoted by ***grey, bold italicised font***

Environmental compliance

This section provides information about the environmental impact of the product.

Product end-of-life handling
Observe the following guidelines when recycling an instrument or component:

Equipment recycling. Production of this equipment required the extraction and use of natural resources.

The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product’s end of life. To avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

This symbol indicates that this product complies with the applicable European Union requirements according to
Directives 2012/19/EU and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check

Chapter 2 Declaration of Conformity

Manufacturer: Newtons4th Ltd.
Address: 1 Bede Island Road
Leicester
LE2 7EA

We declare that the product:

Description: Precision Power Analyzer
Model: PPA45xx Series

Conforms to the EEC Directives:

2014/30/EU relating to electromagnetic compatibility:
EN 61326-1:2013
EN 55022 class A
EN 61000-3-2:2014
EN 61000-3-3:2013

2014/35/EU relating to Low Voltage Directive:
EN 61010-2-030:2010
EN 61010-1:2010

January 2021

Jigar Patel
(Senior Engineer Newtons4th Ltd.)

Chapter 3 Preface

This manual covers the Newtons4th Ltd PPA45xx Series Precision Power Analyzers

Models covered

PPA4510 PPA4520 PPA4530 PPA4540 PPA4550 PPA4560	Available in LC (Low Current), HC (High Current) and Standard versions

Key Features

Wide frequency range DC & 10mHz to 2MHz

0.03˚ Basic accuracy

5 millidegree phase accuracy for low power factor applications

Up to 50Arms(1000Apk) & 1000Vrms (3000Vpk) direct input

Low, standard, and high current versions 10Arms, 30Arms, & 50Arms versions available

Remote control via RS232, LAN, USB or GPIB (IEEE 488)

Torque & Speed inputs

1 – 6 Phase versions available

Simple BNC connection of N4L shunts for high current applications

Real time Digital, Tabular, Graphic & Oscilloscope displays

Galvanically isolated voltage & current channels

Realtime no gap analysis

Planar shunt technology

Free Microsoft Windows Software for datalogging, graphs, Excel compatible output options, Microsoft, (Excel, Windows, Word, & C++) are trademarks of the Microsoft group of companies.

Pre-programmed application specific modes for -: PWM motor drives, Lighting ballasts, Inrush current measurement, Power Transformers, & Standby power measurement

Warranty

This product is guaranteed to be free from defects in materials and workmanship for a period of 36 months from the date of purchase.

In the unlikely event of any problem within this guarantee period, first contact Newtons4th Ltd. or your local representative, to give a description of the problem. Please have as much relevant information to hand as possible – particularly the serial number and release numbers (press SYSTEM then LEFT).

If the problem cannot be resolved directly then you will need to request an RMA number from the support section of our website. https://resources.newtons4th.com/ and return the unit. The unit will be repaired or replaced at the sole discretion of Newtons4th Ltd.

This guarantee is limited to the cost of the PPA4500 itself and does not extend to any consequential damage or losses whatsoever including, but not limited to, any loss of earnings arising from a failure of the product or software.

In the event of any problem with the instrument outside of the guarantee period, Newtons4th Ltd. offers a full repair and re-calibration service. It is recommended that PPA4500 is re-calibrated annually.

Please contact your local Distributor or the N4L office for further details of N4L's instrument repair and re-calibration service.

Chapter 4 General Specifications

General Specifications

Frequency Range	
DC & 10mHz to 2MHz	10Arms & 30Arms versions
DC & 10mHz to 1MHz §	50Arms version
Accuracy	0.001%

§ Voltage bandwidth unchanged to 2MHz, current readings above 1MHz are for reference only.

Voltage Input	
Ranges	1Vpk to 3000Vpk in 8 ranges 20% over-range ability maintains 300Vpk range with 240Vrms
Accuracy	0.03% Rdg + 0.04% Rng + (0.004% x kHz Rdg) + 5mV *
External sensor input	0 to 3Vpk – BNC connector
Range	1mVpk to 3Vpk in 8 ranges
Accuracy	Accuracy – 0.03% Rdg + 0.04% Rng + (0.004% x kHz Rdg) + 3µV

Current Input	
The standard PPA is fitted with a 30Arms internal shunt, models with 10Arms or 50Arms internal shunts are available.	
10Arms Shunt	
Ranges	10mApk to 30Apk (10Arms) in 8 ranges
Accuracy	0.03% Rdg + 0.04% Rng + (0.004% x kHz Rdg) + 30µA*
30Arms Shunt	
Ranges	100mApk to 300Apk (30Arms) in 8 ranges
Accuracy	0.03% Rdg + 0.04% Rng + (0.004% x kHz Rdg)+ 300µA*
50Arms Shunt	
Ranges	300mApk to 1000Apk (50Arms) in 8 ranges
Accuracy	0.03% Rdg + 0.04% Rng + (0.004 x kHz Rdg) + 3µV
* Measured fundamental value	

Watts Accuracy	
Std (30Arms), & -LC (10Arms) versions	[0.04% + 0.5%/pf +(0.01% x kHz)/pf] Rdg + 0.04%VA Rng
HC (50Arms) version	0.04% + 0.05%/pf +(0.01% x kHz)/pf] Rdg + 0.06%VA Rng
40Hz-850Hz Watts Accuracy	[0.03% + 0.04%/pf +(0.01% x kHz)/pf] Rdg + 0.03%VA Rng

DC Accuracy	
Voltage	
Internal	0.02% Rdg + 0.076% Rng + 10mV
External	0.02% Rdg + 0.076% Rng + 6µV
Current	
Internal	
10Arms	0.02% Rdg + 0.076% Rng + 60µA
30Arms	0.02% Rdg + 0.076% Rng + 600µA
50Arms	0.02% Rdg + 0.076% Rng + 1.8mA
External	
	0.02% Rdg + 0.076% Rng + 6µV
Watts	
10Arms	0.04% Rdg + 0.15% VA Rng + 600nW
30Arms	0.04% Rdg + 0.15% VA Rng + 6µW
50Arms	0.04% Rdg + 0.15% VA Rng + 18µW

Common Mode Rejection	
Total Common Mode and Noise effect on current channels	
Applied 250V @ 50Hz	Typical 1mA (150dB)
Applied 100V @ 100kHz	Typical 3mA (130dB)

Torque and Speed Analogue Accuracy	
Range	±10V Analogue Bipolar
Accuracy	0.05% Rdg + 0.05% Rng

Torque and Speed Pulse Count Accuracy	
Range	± 1Hz to 1MHz
Accuracy	0.01% Rdg

Total Harmonic Distortion (THD) Accuracy	
$$THD + THD\ Error = \left(\frac{1}{h1 + \ h1\ error}\right)\sqrt{\sum_{i=2}^{i=n}(hi + hi\ error)^2}$$	
Voltage:	
Hi error (Voltage)	= 0.03% hi Rdg + 0.04% Rng + 0.004% * KHz + 5mV
Current:	
10A model Hi error (Current)	= 0.03% hi Rdg + 0.04% Rng + 0.004% * KHz + 10μA
30A model Hi error (Current)	= 0.03% hi Rdg + 0.04% Rng + 0.004% * KHz + 300μA
50A model Hi error (Current)	= 0.03% hi Rdg + 0.04% Rng + 0.004% * KHz + 900μA

Datalog	
Functions	Up to 4 measured functions user selectable (30 with free optional PPALog PC software)
Datalog window	From 10ms with no gap between each log
Memory	RAM or non-volatile, up to 10,000,000 records

General	
Crest factor	Voltage and Current - 20
Sample rate	Real time no gap - 2.2Ms/s on all channels
Low power accuracy	Compliant with IEC62301 using internal shunt Refer to low power measurement application note
Remote operation	Full capability, control and data
Application modes	PWM Motor Drive Ballast Inrush Power transformer Standby Power

Ports	
RS232	Baud rate to 38400 – RTS/CTS flow control
LAN	10/100 base-T Ethernet auto sensing RJ45
GPIB	IEEE488.2 compatible
USB	USB device – 2.0 and 1.1 compatible
Analogue	(Maximum memory stick capacity 2GB) Bipolar +/- 10V
Speed	Analogue bipolar +/- 10V or pulse count
Torque	Analogue bipolar +/- 10V or pulse count
Sync	Measurement synchronization for 6 phase mode
Extension	Master slave control and N4L accessory port **

** Master/slave for legacy purposes only

Physical	
Display	320 x 240mm Colour TFT Display
Size	PPA45xx - 130H x 400W x 315D mm – excluding feet
Weight	5.4kg – 1 phase - 6kg 3 phase
Safety isolation	1000V rms or DC – category II
Power supply	90-265 rms 50-60Hz 35VA max

Environmental	
Operational temperature range	0°C to +50°C
Storage temperature range	-10°C to +60°C
Relative Humidity range	20 to 95% non-Condensing
Maximum Altitude.	2,000 Metres

Chapter 5 Installing your PPA4500

Checking the shipped contents

Carefully unpack your PPA4500 and check the packing list that came with your instrument to verify that you have received all standard accessories and ordered items.


Newtons4th Ltd

PPA5510 BLACK SINGLE PHASE POWER ANALYZER PACKING LIST

If any items are missing or damaged, please contact either Newtons4th Head Office or your local Distributor.

Visit http://www.newtons4th.com to find contact details of your nearest distributor.

It is highly advised to retain all the original protective packaging for re-use when you require to return the instrument for calibration or repair purposes to avoid transit damage.

Operational Requirements

The PPA4500 is designed to be used within the required operating environment, power, and signal input voltage ranges to provide the most accurate measurements and safe instrument operation.

Environmental and Power Requirements

Characteristic	Description
Storage Temperature	0 ° C to +50 ° C
Operational Temperature	-10 ° C to +60 ° C
Operating Humidity	5% to 95% relative humidity (% RH), Noncondensing.
Altitude	2,000 metres
Power source	voltage 90 V - 264 VAC rms, single phase 30VA

Input

Characteristic	Description
Voltage	
Voltage Internal Ranges	Normal : 1Vpk ~ 3000Vpk (8 ranges = 1V, 3V, 10V, 30V, 100V, 300V, 1KV, 3KV) (240Vrms within 300Vpk range, using 20% over range)
Internal Voltage Input Impedance	3Mohm in parallel with 5pF, 90pF common mode to chassis
Internal Voltage Connectors	4mm Safety connector
Voltage External Ranges	1mVpk ~ 3Vpk [BNC Connector 3Vpk Max Input] 8 Ranges = 1mV, 3mV, 10mV, 30mV, 100mV, 300mV, 1V, 3V
External Voltage Input Impedance	1Mohm in parallel with 40pF, 90pF common mode to chassis
External Voltage connectors	Single Safety BNC

Input

Characteristic	Description
Current	
PPA4500-LC 10Arms Shunt, 4mm Safety Connectors	10mApk ~ 30Apk (10Arms) (8 ranges = 10mA, 30mA, 100mA, 300mA, 1A, 3A, 10A, 30A)
PPA4500 30Arms Shunt, 4mm Safety Connectors	100mApk ~ 300Apk (30Arms) (ranges = 100mA, 300mA, 1A, 3A, 10A, 30A, 100A, 300A)
PPA4500-HC 50Arms Shunt, 50A Screw Type Safety Terminals	100mApk ~ 1000Apk (50Arms) (8 ranges = 300mA, 1A, 3A, 10A, 30A, 100A, 300A, 1KA)
External Current BNC Input Ranges	1Vpk ~ 3Vpk [BNC Connector 3Vpk Max Input] 8 Ranges = 1mV, 3mV, 10mV, 30mV, 100mV, 300mV, 1V, 3V
External Current connectors	Single Safety BNC

Fitment of the PPA4500 Series Carry/Tilt handle

The PPA4500 Series Phase Sensitive Multimeter is supplied with a Carry / Tilt Handle that is located within the accessory pack.

The handle allows a user to position the instrument upwards at one of two angles for easier viewing when the instrument is positioned below the line of sight.

The design also allows storage under the unit without obstruction of the rubber feet so that instruments can be stacked and is easily removed to allow the connection of rack mounting brackets without the need to remove instrument covers.

Correct installation of the handle is important to ensure the correct operation and long life the handle.

The following pictures illustrate correct and incorrect handle fitment:

Pic 1

Pic 2

Correct fitting is from the top of the unit as shown in pictures 1 & 2 above.

Pic 3

Pic 4

A correctly fitted handle will havetheN4LNewtons4th' wording in the correct reading plane when the handle is to the front of the instrument (Pic. 3) Also, a correctly fitted handle will allow storage under the unit (Pic. 4)

Fitting the handle from the bottom of the unit as shown here is wrong, (Pic. 5)

Incorrect fitting can be seen because the handle does not fit correctly under the unit resulting in a gap under the rear feet, and handle sides do not fit flush with the registration washer (Pic. 6)

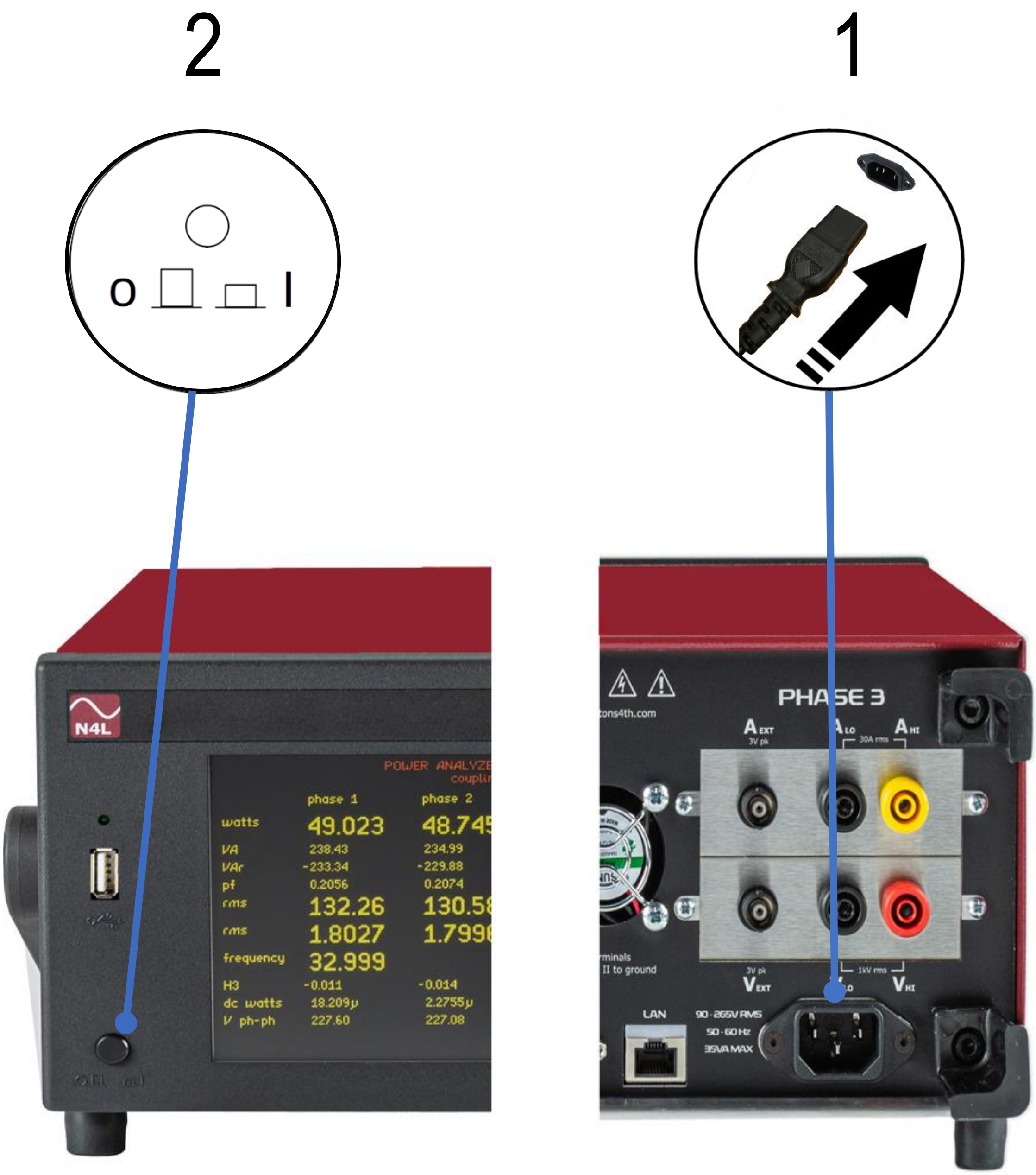
Pic 5

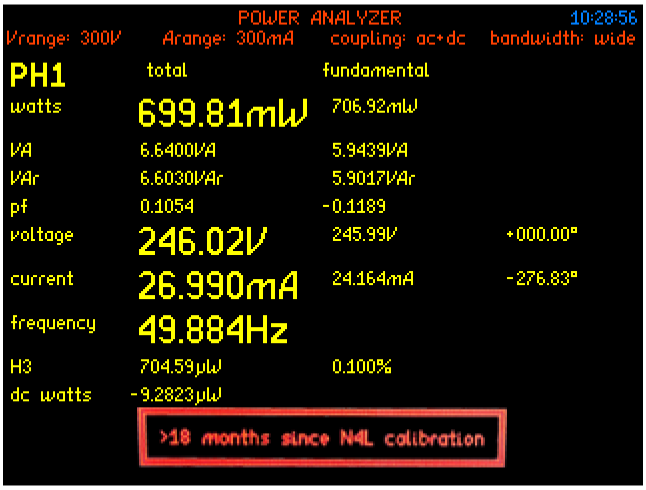
Pic 6

Powering On your PPA4500

Step 1 Attach the supplied IEC power lead to the mains recepticle on the rear of the instrument

Step 2 Turn the instrument on using the On/Off switch on the front lower LH corner

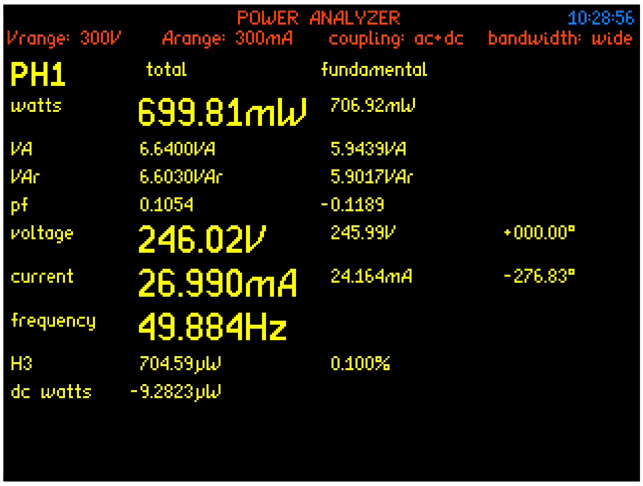




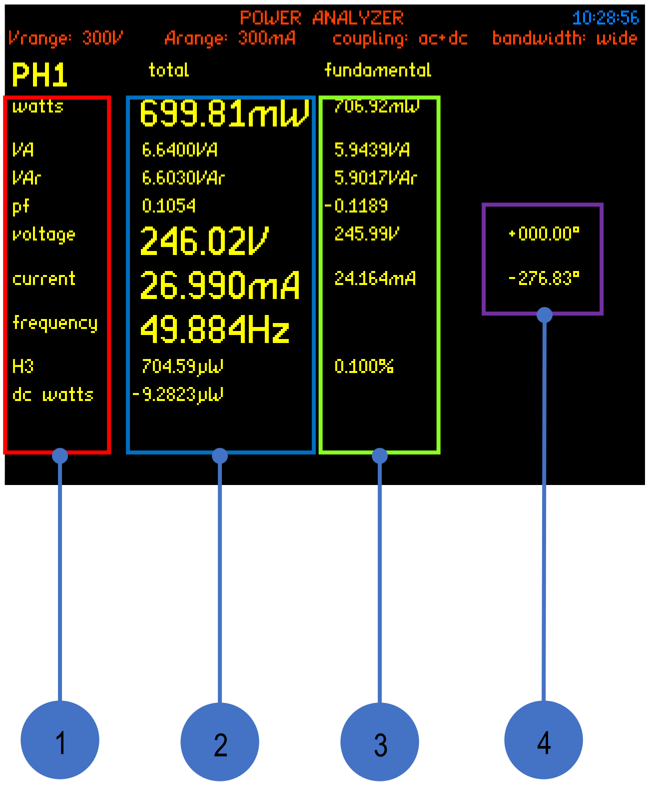
INFORMATION. The message displayed on boot up regarding N4L calibration due date is only accurate if the system clock and date is set correctly, here

The PPA4500 is supplied ready to use – it comes complete with an appropriate power lead and the requisite number of sets of test leads (dependent upon model). It is supplied fully calibrated and does not require anything to be done by the user before it can be put into service.

See Checking your PPA4500 here



Once powered on, the analyser's factory default settings from memory location 0 will be displayed as shown, note these can be altered to your own desired settings here



Within the Power Analyzer screen you will notice several distinct areas: -

1.Unit of measure and phase being monitored
2.Total measurements
3.Fundamental measurements
4.Phase angle

Total Measurements = Fundamental + Harmonics + Noise

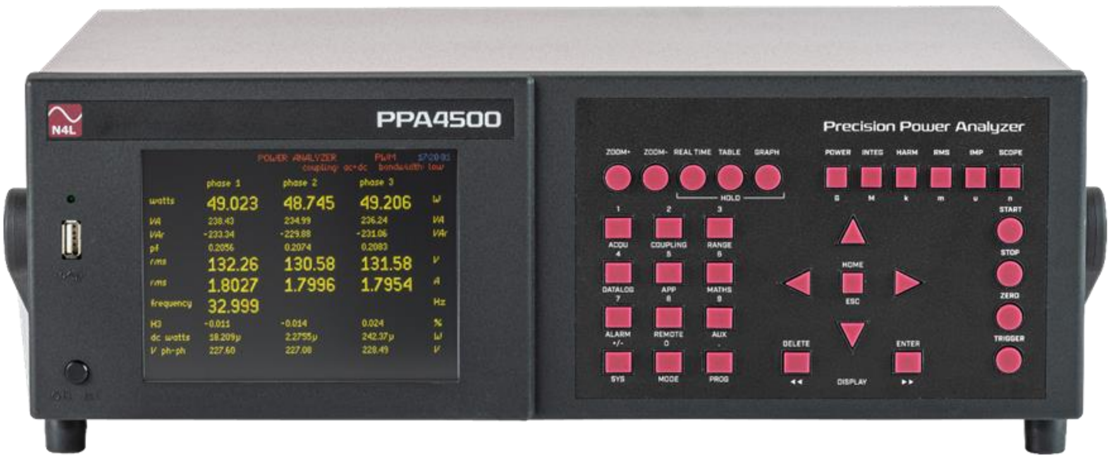
Fundamental = Fundamental Power Measurements (All Distortion Removed)

Each measurement mode is pre-configured to display relevant parameters. Up to 4 measurement functions can be selected and zoomed in so that they are displayed in a larger font size.

These can be viewed within 3 zoom screens; the Zoom function is described in detail here

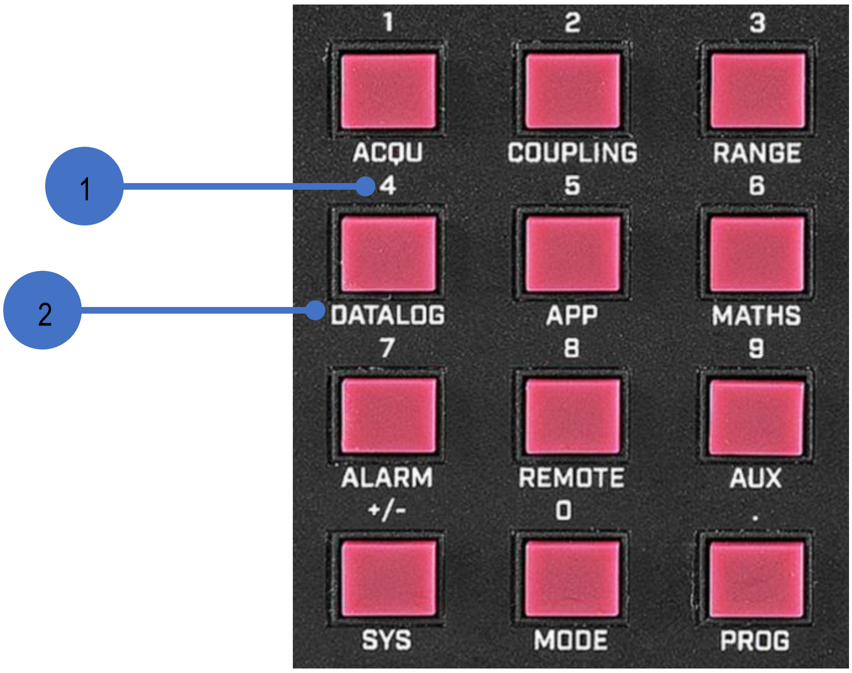
Chapter 6 Instrument Layout

Front panel Controls



The front panel has keys for controlling the instrument, the colour LCD screen, a front USB connector and ON/OFF switch.

The display and controls are arranged into logical groupings, each item/group of controls is explained below.



1. Primary numeric function, the key will display “4” or “G” when entering numerals and text in a menu option.
2. Secondary function, the key will open the DATALOG menu screen

Screen area

3. Settings area, this displays the Mode, Application, Coupling and Bandwidth selected.

4. USB & Power switch. The USB port is used for storing or recalling results, programs, and screen shots to a USB drive. The main push key power switch is below the USB port.
5. Main results display, the contents of this area are context sensitive to the type of instrument MODE selected. In the screen shown above each column of results refers to the phase noted at the top of the column.

Top row display & application control keys

6. Display control keys, this group of keys allows the user to select and highlight up to four parameters, return the screen to real time measurements, switch between tabular and graphical displays, & hold/release the real time readings.

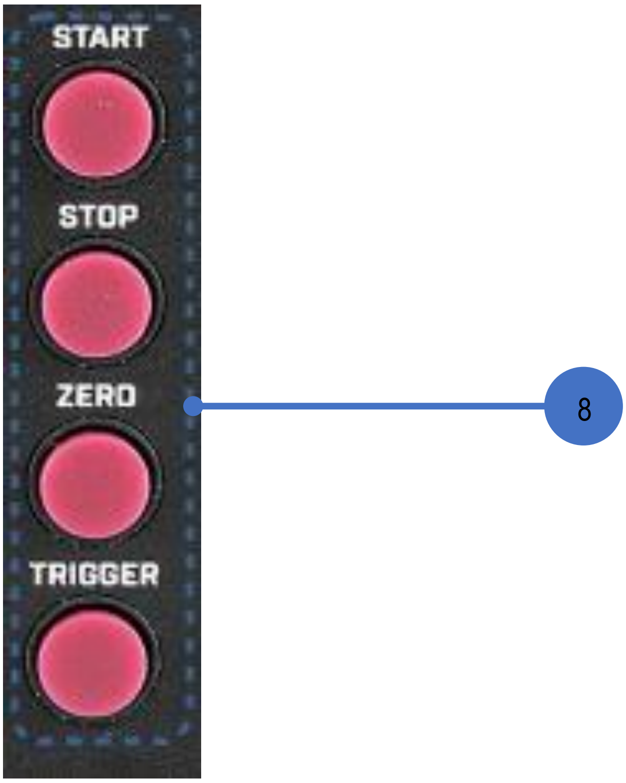
Data Hold

When in real time display mode, the data on the display can be held at any time by pressing the *REAL TIME* key. When *HOLD* is activated the word, ***HOLD*** flashes in the top right hand corner of the display as shown above in a magnified view of the top right corner of the screen.

Press the *REAL TIME* key again or the *HOME* or *START* key to release ***HOLD***; in this case, *HOME* and *START* keys do not have their normal functions. Changing mode also releases the hold function.

When *HOLD* has been activated, the DSP continues to sample, compute, and filter the results but the data is ignored by the CPU. When *HOLD* is released, the display is updated with the next available value from the DSP.

7. Application mode direct access keys, the POWER, INTEG, HARM, RMS, IMP, & SCOPE keys allow direct one key access to the appropriate application menus for setting up the instrument. They also provide the SI unit prefix multipliers when entering numeric values.



8. Action keys, this group of keys are used to start and stop Dataloging, take screen shots to the USB stick, and releases instrument from HOLD.

Zero compensation

There are 2 levels of zero compensation:

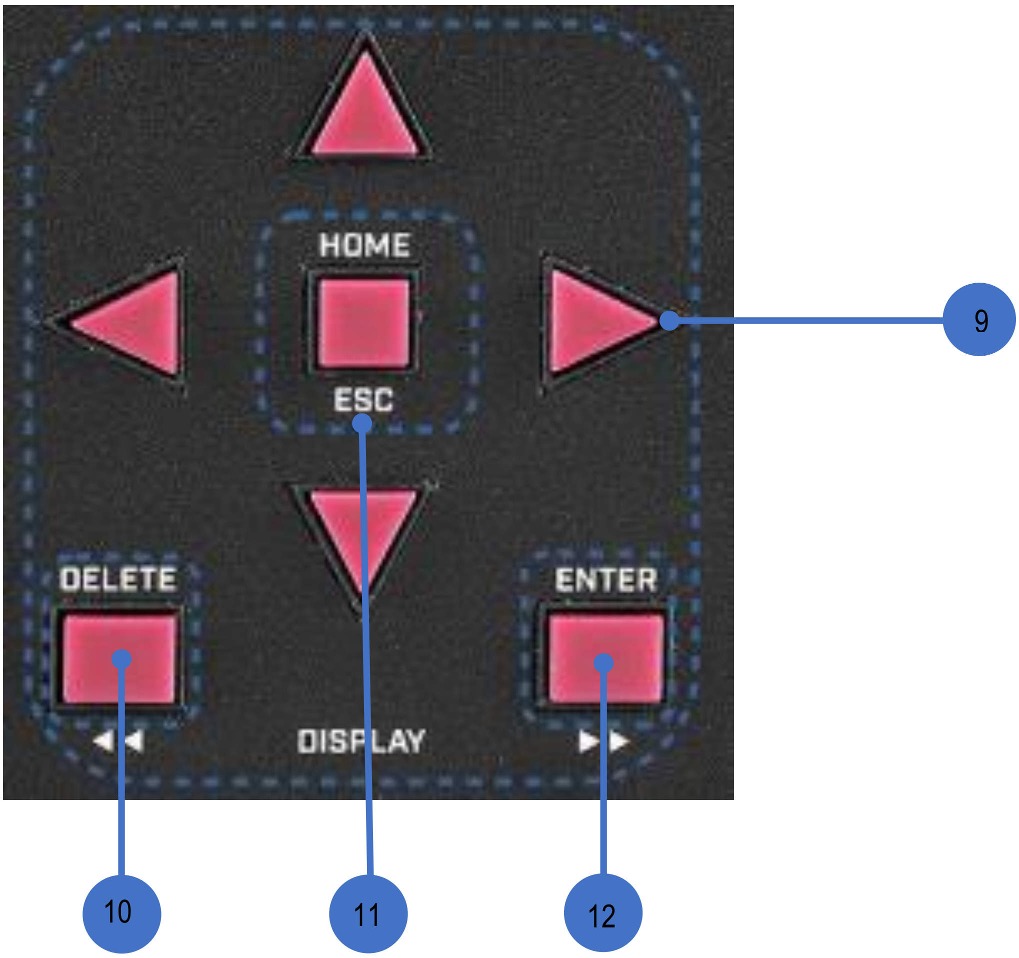
Trim out the DC offset in the input amplifier chain.

Measure any remaining offset and compensate.

The trim of the DC offset in the input amplifier chain can be manually invoked with the *ZERO* key, or over the RS232 with the ***REZERO*** command. This DC offset trim measures the DC present while the autozero switch is active and applies an equal and opposite offset via a D/A converter so that the input range to the A/D is optimised.

The measurement of the remaining offset also happens when the offset is trimmed but is also repeated at regular intervals. This is to compensate for any thermal drift in the amplifier chain. The remaining DC offset is precisely measured and stored so that the measurements can be compensated by an appropriate algorithm in the instrument firmware.

Real time measurement is not possible while the autozero measurement is in progress so this repeated autozero function can be disabled via the SYSTEM OPTIONS menu.



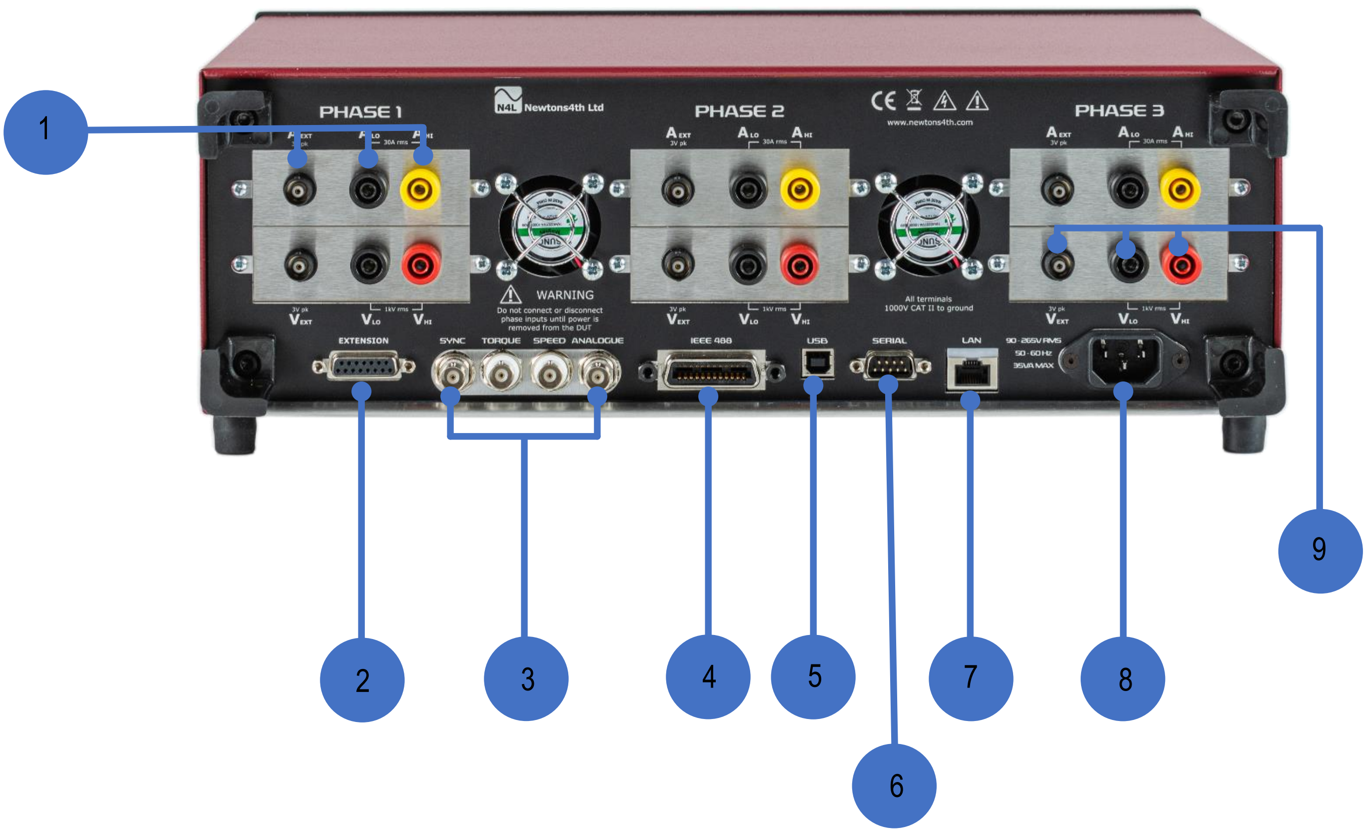
9. Menu navigation keys, the four directional arrow keys are multi-purpose, their main function is to navigate the menu options and drop down choices, in scope mode they are used to control cursors and time-base / measurement per division respectively.

10. Back/Delete key, this dual use key is used to edit alphanumeric entries and also to navigate between screens that have additional sub screens.

11. Home/ESC key, this dual use key will enable the user to return to the selected application start screen once it has been adjusted or will escape from any screen view and return to the selected application home screen.

12. Enter/Next key, this dual use key is used to confirm an entry or selection and to navigate between screens that have additional sub screens.

Rear panel connectors



1. Current input connections 1, 2 or 3 channel dependent on model. Internal connections are via 4mm safety plugs, external connection via safety BNC connector.

2. Extension connection port via 15 way D-Sub connector.

3. Auxiliary connections via BNC connections.

4. IEEE488 (GPIB) port.

5. Female USB 2.0 Type B socket for communication.

6. RS232 communication port, 9 pin D-Sub.

7. LAN/Ethernet port.

8. IEC 60320 C13 mains inlet socket

9. Voltage connections 1, 2 or 3 channel dependent on model. Internal connections are via 4mm safety plugs, external connection via safety BNC connector.

WARNING. The BNC safety connections (Item 1), A_{EXT} & V_{EXT} must be connected with touch proof safety BNC leads as these can carry dangerous levels of current.

Analogue output

The Analogue Output BNC connector is located on the rear of the instrument, see item 3 above. The output voltage (max ±10V) can be controlled using the *ALARM* functions to generate a voltage representative of Zoom 1-4 measurements or a manual level.

The Voltage present at the Analogue Output can be calculated using this formula:

Analogue Output = 10V x (measured – zero) / (full scale – zero)

"Measured" is the value measured on the instrument.

"Zero" and "Full Scale" are user defined values.

In the following example a 2V Peak 50Hz signal will be monitored by the Power Analyzer. The frequency will be adjustable by +/-2Hz. Therefore, in the above formula Zero will be 50 and Full Scale will be 52.

With a Full scale value of +/-2Hz, the Analogue Output will vary between -10V at 48Hz up to +10V at 52Hz. The Analogue Output Voltage will be 0V when the frequency is 50Hz.

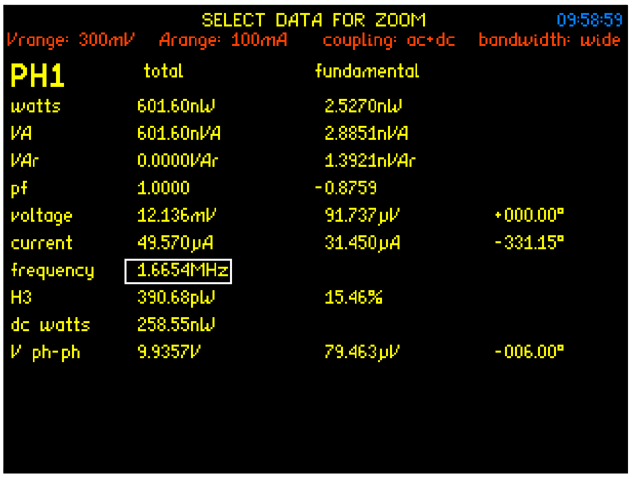
Zoom 1 in the Alarm menus will be used to control the voltage levels on the Analogue Output.

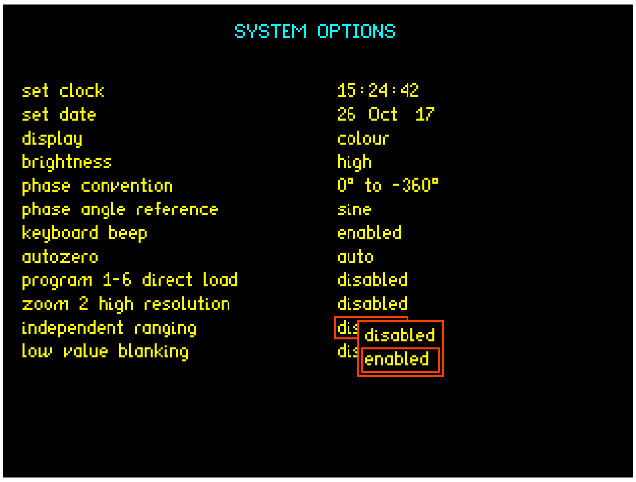
Connections

Connect the input signal to Phase 1 on the PPA and connect the Analogue output to Phase 2. In this example a 2.00V Peak 50Hz input signal was used.

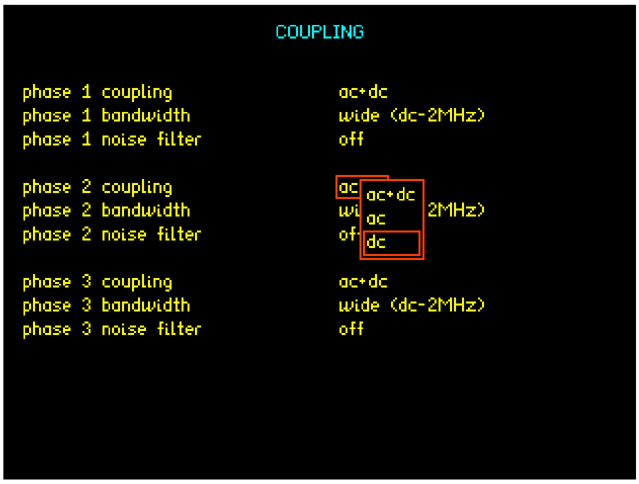
PPA Settings

Using the *ZOOM* key select frequency for ***Zoom 1***. Other parameters can also be selected but for this example ***Zoom 1*** must be set to frequency.

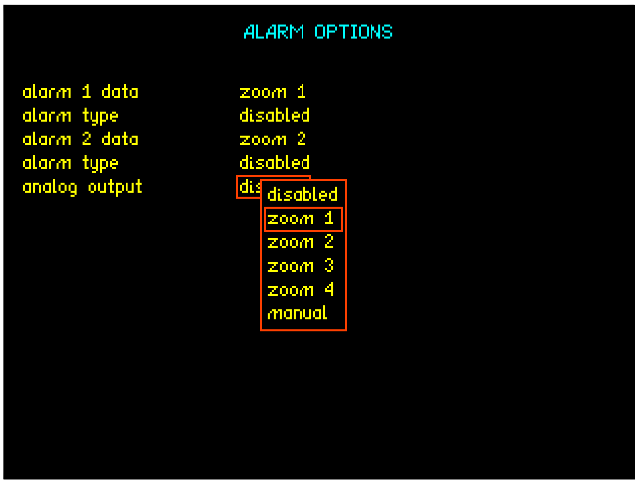




Press the *SYS* key and ***enable Independent Ranging.***



Press the *COUPLING* key and set ***Phase 2 coupling*** to ***DC***.



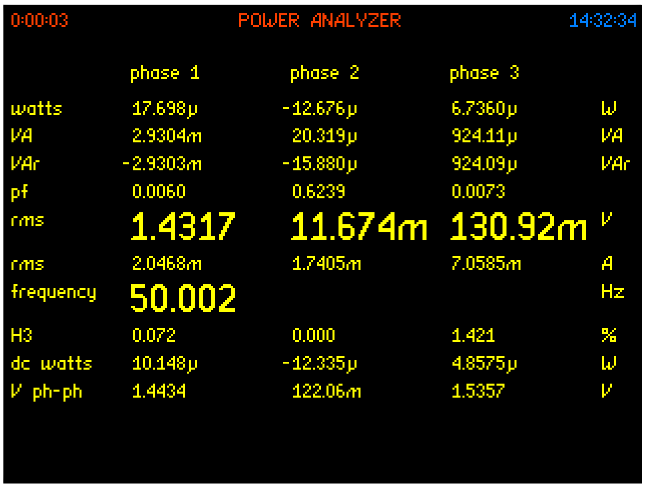
Press the *ALARM* key and set the ***Analog output*** option to ***ZOOM 1***.

This will display the Analogue Output settings.

Enter a value of ***50*** for ***Analogue Zero***.

Enter a value of ***52*** for ***Analogue Full Scale***.

Press the *HOME/ESC* key to return to the Power Analyzer display.



Press the *ENTER* / ►► key 4 times to display all phases at the same time.

Results
Phase 1 on the PPA display indicates the Frequency and RMS voltage levels of the signal being monitored.
Phase 2 indicates the voltage present on the Analogue Output connector on the rear of the PPA.

Phase 3 is not used.

Example 1.

The Input signal frequency was set to 50.5Hz.

The frequency displayed on the PPA was 50.512Hz.

Analogue Output = 10V x (measured— zero) / (full scale – zero)

Analogue Output = 10V x (50.512 – 50) / (52-50) = 2.56V

Example 2.

The Input signal frequency was set to 51.5Hz.

The frequency displayed on the PPA was 51.508Hz.

Analogue Output = 10V x (measured – zero) / (full scale – zero)

Analogue Output = 10V x (51.508 – 50) / (52-50) = 7.54V

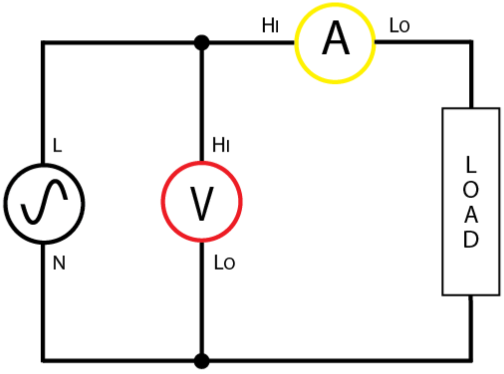
Chapter 7 PPA4500 Numeric key functions

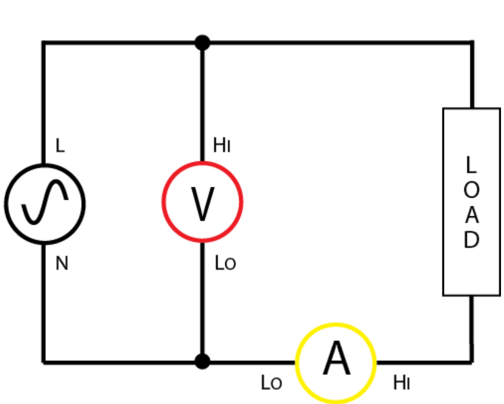
Key & Sub Categories	Description
ACQU **Wiring:**	Acquisition Control: Used for configuring inputs appropriate to source and nature of signals being analyzed
Single Phase 1	In single phase 1 configuration, (phase 2 & phase 3) inputs are disabled and the selected phase acts as a completely independent single phase power analyzer
2 Phase 2 Wattmeter	In the 2 phase 2 wattmeter configuration, the voltages are measured relative to each individual phase input, with a single frequency reference selected within the frequency reference parameter
3 Phase 2 Wattmeter	In the 3 phase 2 wattmeter configurations, the voltages are measured relative to phase 3. Typically, the phase 1 voltage input is connected across phase 1 and phase 3, and phase 2 voltage input is connected across phase 2 and phase 3, thus measuring phase to phase voltage directly. Phase 1 and 2 current inputs are connected normally. There is no need to measure the current in phase 3 as phase 3 has no voltage relative to itself so the power contribution is zero. In this mode, the neutral channel displays the synthesized phase 3 current. The advantage of this connection method is that 3 phase power can be measured with only 2 wattmeters
3 Phase 3 Wattmeter	With the 3 phase 3 wattmeter configuration, each measurement phase is connected to a phase of the load with the voltage low inputs measuring to neutral. In this mode, phase to neutral voltages are measured directly and phase to phase voltages are also computed
Single Phase 2	In single phase 2 mode, (phase 1 & phase 3) inputs are disabled and the selected phase acts as a completely independent single phase power analyzer
Single Phase 3	In single phase 3 mode, (phase 1 & phase 2) inputs are disabled and the selected phase acts as a completely independent single phase power analyzer
3 Phase 2 Wattmeter + PH3	As above (3 phase, 2 wattmeter) but with the option to use PH3 as an independent meter i.e., use PH3 to measure a DC bus plus phase's 2 & 3 to measure a 3 phase inverter output. PH3 can be set as an additional connection for Torque & Speed to supplement the existing "EXT" BNC connections on the rear panel. This mode essentially facilitates independent frequency synchronisation of PH3
Independent	In independent wiring mode each phase can be selected as an individual analyzer enabling the ability to select its own frequency, coupling ranging etc

Speed	In normal acquisition mode the window over which the measurements are computed is adjusted to give an integral number of cycles of the input waveform. The results from each window are passed through a smoothing filter. There are 5 pre-set speed options that adjust the nominal size of the window, and therefore the update rate and time constant of the filter. Greater stability is achieved at a slower speed at the expense of a slower update rate
Very Slow	Update rate = 10s. Results window size will update every 10 seconds
Slow	Update rate = 2.5s. Results window size will update every 2.5 seconds
Medium	Update rate = 1/3s. Results window size will update 3 times per second
Fast	Update rate = 1/20s. Results window size will update 20 times per second
Very Fast	Update rate = 1/80s. Results window size will update 80 times per second
Window	The window application will allow the user to input their own speed settings different to any of the 5 pre-set settings above
Smoothing	Smoothing filter will gather the data and average out over a sliding window time scale. This is very useful when gathering data which could be affected by noise. Each speed above has its own time constant for filtering and data updates
Normal	With Normal smoothing applied the following update windows will apply to the relevant speed selected. V.Fast =0.05s, Fast = 0.2s, Medium = 1.5s, Slow = 12s, V.Slow = 48s
Slow	With Slow smoothing selected all results are X4 greater than in normal smoothing mode
None	With no smoothing to computed results the data update will be dictated by the speed only
Smoothing Response	
Auto Reset	The smoothing response is by default set to “auto reset” where the filtering described in “smoothing” is reset in response to a significant change in data such as frequency, voltage, and current levels. This speeds up the response of the instrument to changing conditions
Fixed Time	Auto reset can be disabled so that the filtering has a fixed time constant, which would have an exponential response to a step change, this is useful for PWM inverter drive evaluation where variable frequency tracking is required

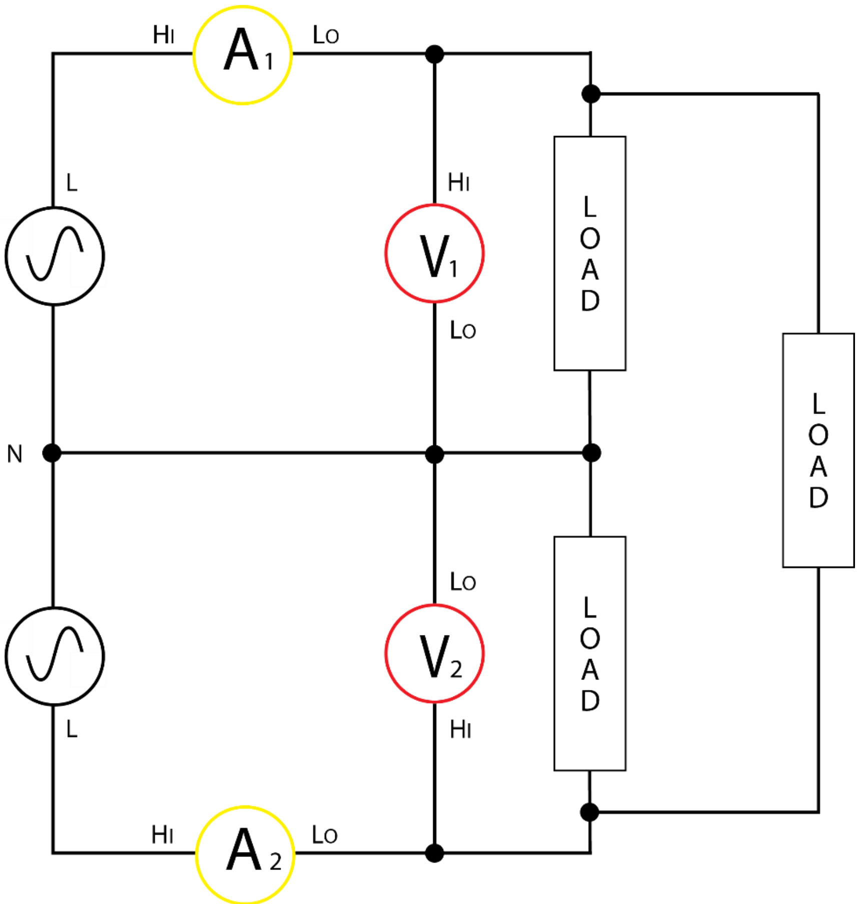
Wiring diagrams

Single Phase

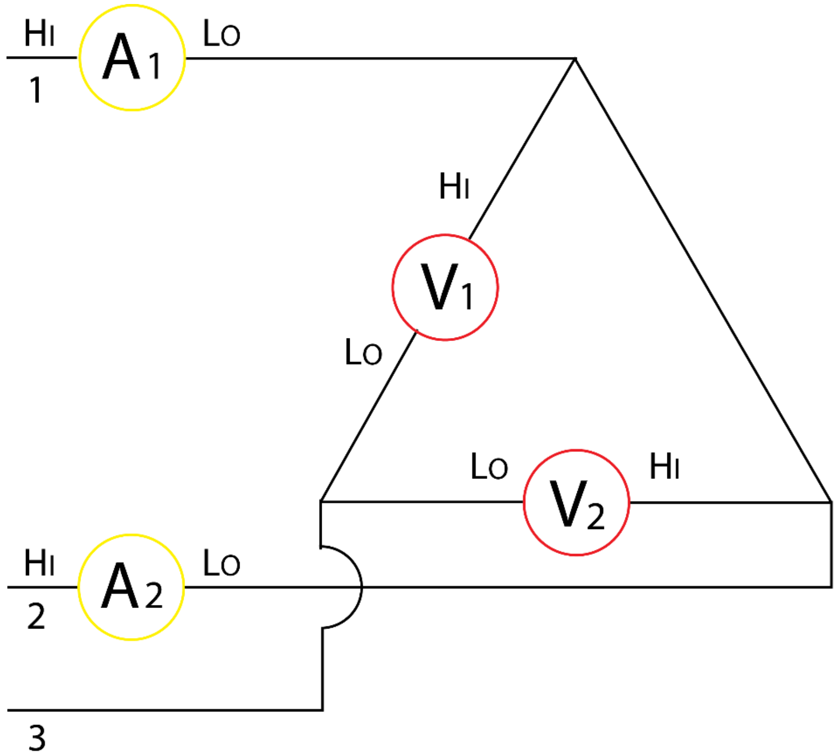




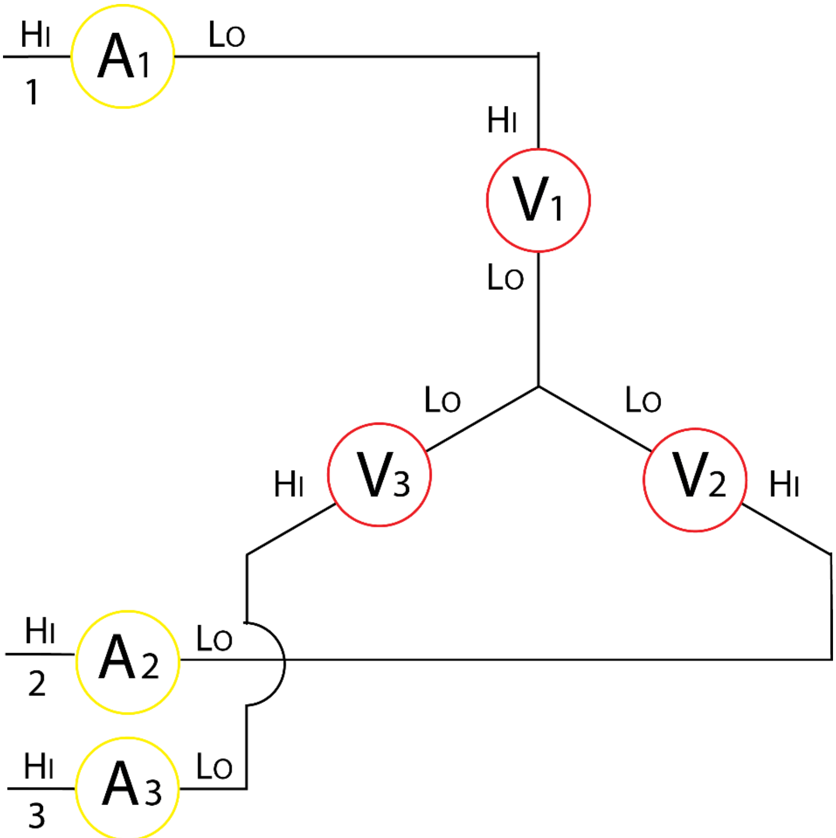
Two Phase Two Wattmeter



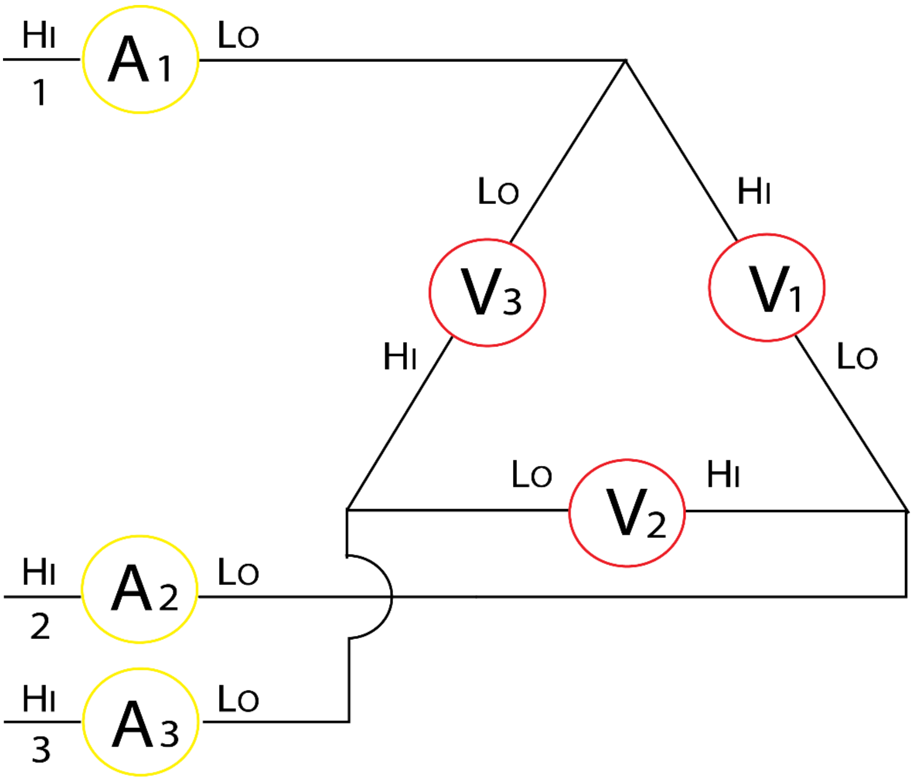
Three Phase Two Wattmeter Delta connection



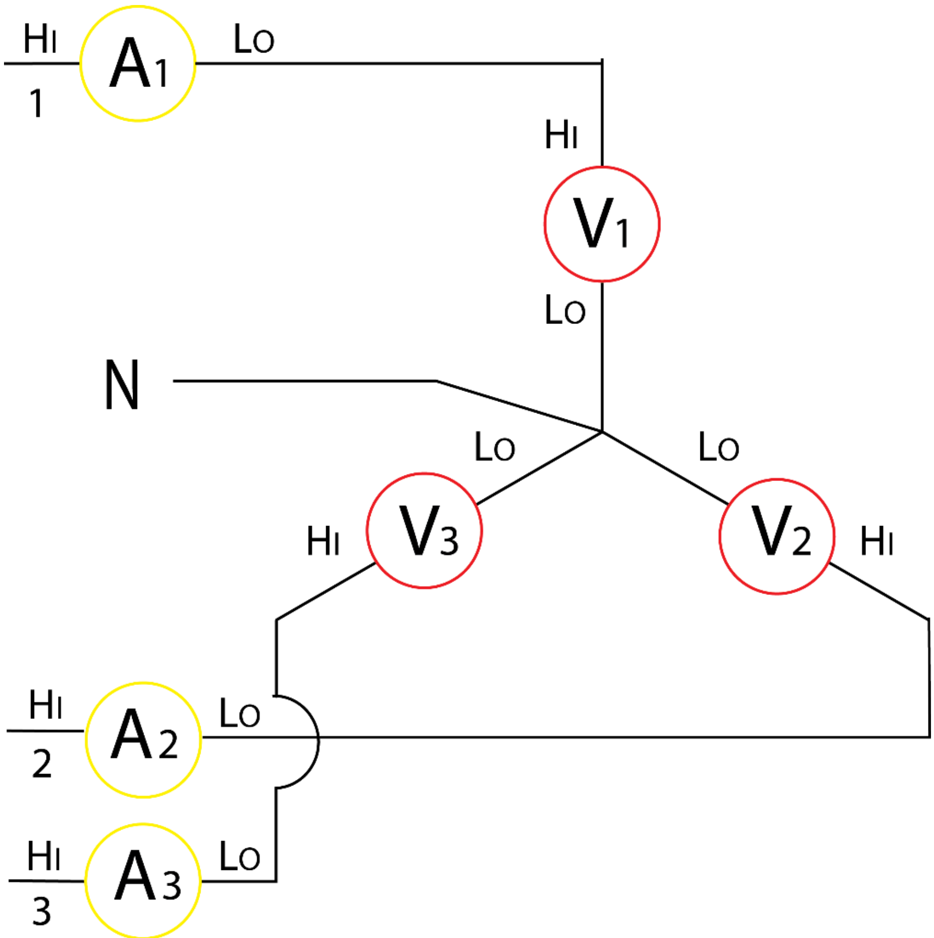
Three Phase Three Wattmeter – Simulated neutral – Star connection



Three Phase Three Wattmeter - Delta connection



Three Phase Three Wattmeter - Star connection



On a multi phase instrument, all the phases usually use the same input control data – internal/external, scaling factor etc. It is possible to select 'independent' so that the phases can be set up differently. This is useful if different scaling factors are required for external shunts or if one phase is using internal shunt when others are external.

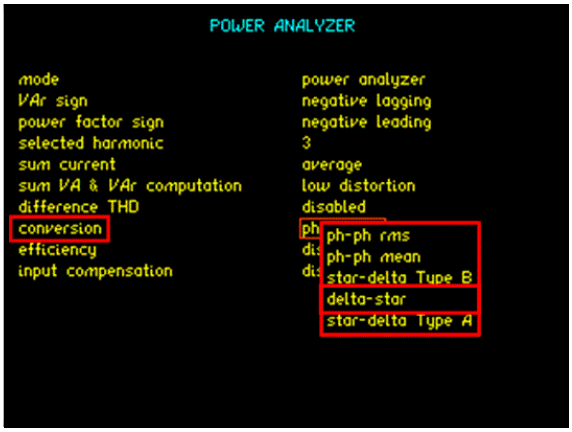
Instrument wiring

Please refer to Appendix C for physical PPA connection diagrams.

Conversion Settings

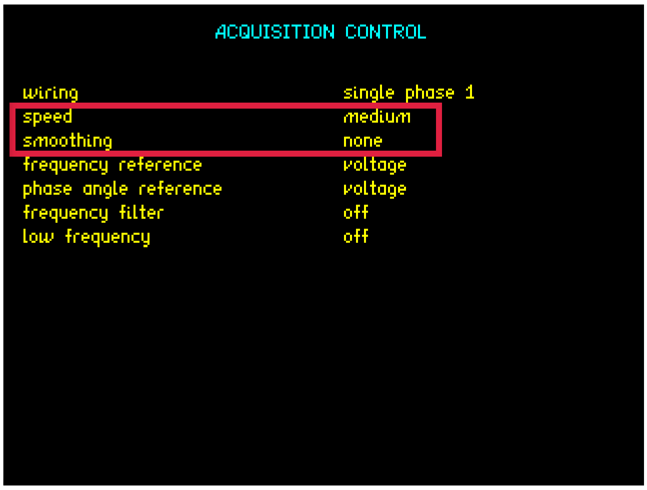
To obtain correct measurements it is essential to select the correct Configuration option for the selected wiring option and measurements that are to be performed.

The Conversion can be chosen from the drop down menu in the Power analyzer menu:



It is not possible for the instrument to detect the wiring configuration used to connect the instrument to the motor / DUT. All "conversion" options have to be available with the User ensuring the correct option is selected from the menu.

Speed and Smoothing



Within this section we look at how the speed and smoothing parameters are set within the Acquisition menu affect the measurement results

NOTE: All measurement windows must have an integral number of cycles within them to calculate correct RMS and Harmonics

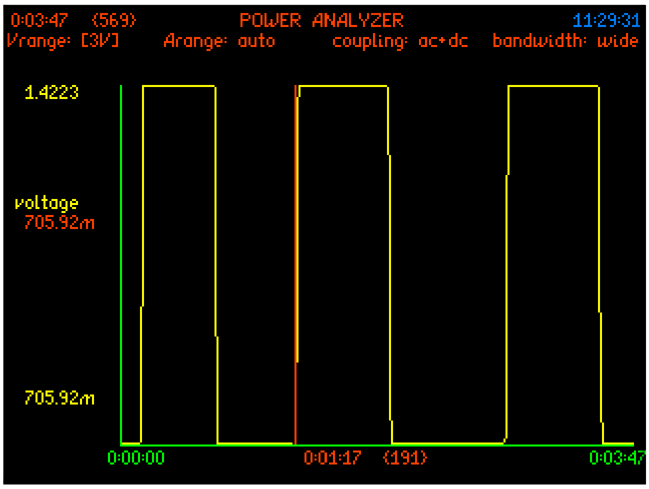
Input = 50Hz Sine Wave

Amplitude = 1Vpk & 2Vpk range

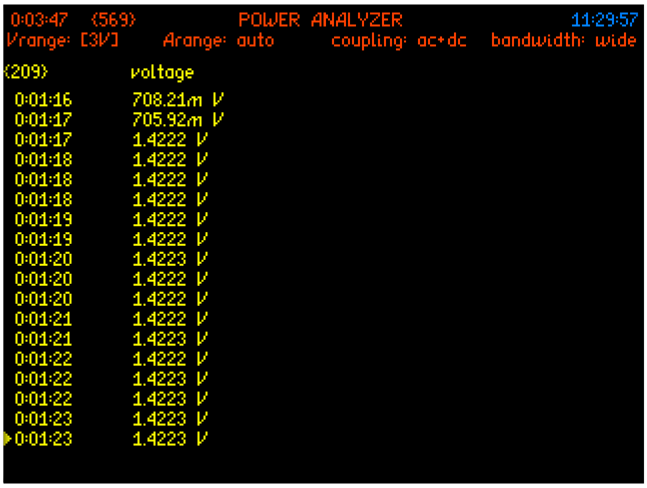
The first sets of results are from a Datalog conducted with NO smoothing selected, therefore the data update will be dictated by the speed parameter only

Speed set to medium = 3 updates per second

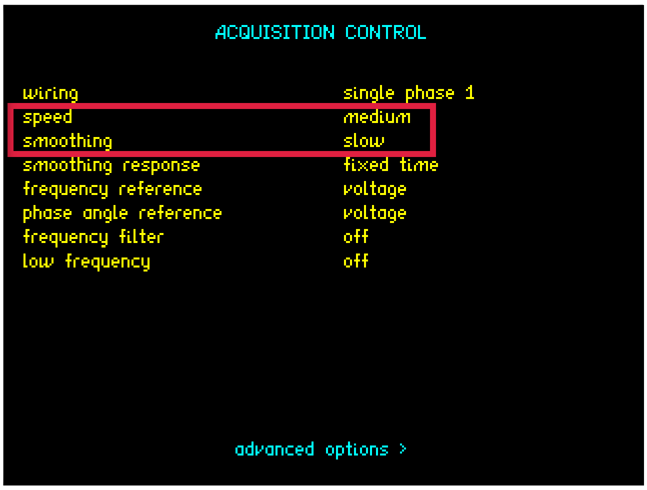
50Hz input signal = 50 cycles worth of data points per second recorded, analyzed, adjusted and displayed within 3 update windows



Displayed left is the graph showing the Datalog results with no smoothing present and the input amplitude switching between 1Vpk and 2Vpk from this graph as soon as the amplitude is increased or decreased then the next available update will show this change



The table of results displayed are in relation to the previous graph; and we can see that the voltage step is immediately recorded after 0:01:17



This next sets of screenshots are for the same set up, but with smoothing activated

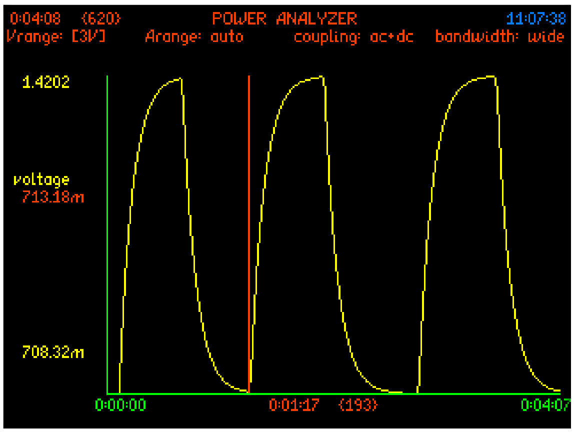
Selecting smoothing will take the data and apply the equivalent of a single pole low pass filter with an RC time constant relative to the selection mode dependent upon the speed selected

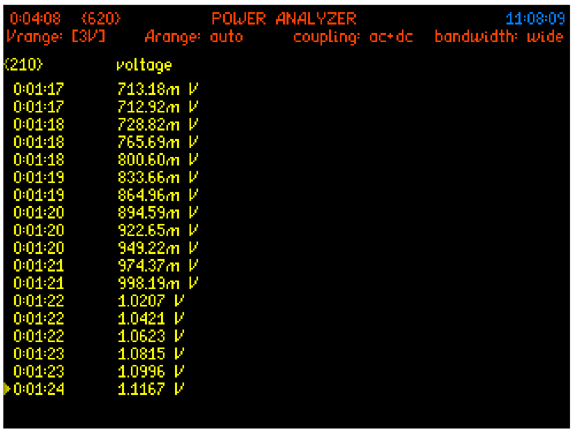
We have selected ***slow smoothing*** with a medium speed giving us a sliding window of 48 seconds

Smoothing response can be set to ***Auto Reset*** where the instrument will reset the filtering in response to any significant change in data

Fixed Time can be selected to correspond with the speed and smoothing parameters and will override ***auto-reset*** so that the smoothing is not reset when the frequency changes etc

The resulting graph and results table with smoothing applied are displayed above.





The displays above show how with smoothing applied, the data is smoothed out over the resultant timescale and displaying an intermediate value for every update window during the step between the two peak voltage values

Note: each speed parameter has its own time constant for smoothing and data updates as shown in the table below

Speed	**Update Rate: (speed only)**	**Normal Smoothing: applicable to relevant speed**	**Slow Smoothing: applicable to relevant speed**
Very Slow	10s	48s	196s
Slow	2.5s	12s	48s
Medium	0.333s	1.5s	6s
Fast	0.05s	0.2s	0.8s
Very Fast	0.0125s	0.05s	0.2s
Window	Manually Input speed setting different to 5 pre-selected one’s above		

Frequency Reference	The frequency may be measured from any of the following inputs:
Voltage	Select Voltage to detect frequency from the input voltage
Current	Select Current to detect frequency from the input current
Speed Input	Select speed input to frequency detection to set frequency via “speed input” BNC
AC line	Select ac line to read frequency from the ac line input, measured from power inlet to PPA
Frequency Reference	On a multi-phase instrument, any Phase may be selected for the frequency measurement
Phase 1	Select this option to detect frequency from phase 1
Phase 2	Select this option to detect frequency from phase 2
Phase 3	Select this option to detect frequency from phase 3
Phase Angle Reference	Phase angle measurements must be made with reference to a specific input
Voltage	Phase 1 voltage is by default set as the input reference
Current	The phase angle reference can be set to current which is useful if operating the instrument with only current inputs, or with low level voltage inputs

Frequency Filter	A parallel digital frequency filter of low-pass may be selected to filter out the HF carrier component of a PWM waveform ensuring measurements are carried out on the fundamental frequency, further filter settings for PWM waveforms can be found within the APP/PWM section
Off	No frequency filter selected
On	Switches On frequency filter (4kHz)
Low Frequency	Normal frequency measurement is from 5Hz upwards so that there is not a very long delay if measuring dc. There is a low frequency option that extends the frequency measurement down to 20mHz. This low frequency option also applies a digital filter, which can be useful when measuring in a low frequency, noisy environment
Off	Select to switch this mode off
On	Select to switch this mode on

ADVANCED OPTIONS	
DFT Selectivity	Analysis of the fundamental component uses a DFT (Discrete Fourier Transform) algorithm. The selectivity of the DFT analysis is a compromise between noise rejection of frequencies close to the frequency of the fundamental component and the required stability of the frequency component
Normal	Default settings for the fundamental calculations
Narrow	Selecting "narrow" increases the selectivity of the DFT analysis (reducing the effective bandwidth at each component) which has the effect of improving the noise rejection. It does however require that the frequency of the fundamental component is more stable
Ignore Overload	In a noisy application any spikes present on the signal may push the instrument onto a higher range than is necessary for the signal being measured. If the nature of the spurious spikes is such that they do not contribute to the measurement and can safely be ignored, then the range can be manually set to the appropriate range for the signal to be measured and the instrument can be told to ignore any overload. If using this mode, it is wise to check the signal on the oscilloscope to be sure that the signal being measured is not genuinely over range
Off	Select to switch this mode off
On	Select to switch this mode on
Frequency Lock	In a very noisy application, where the frequency of the signal is known but the instrument is unable to measure the frequency even with PWM filters or low frequency mode filters applied, it is possible to manually enter the frequency to be used for analysis
Normal	Utilises N4L unique signal processing techniques for fundamental frequency synchronisation including hysteresis to increase frequency noise immunity
Constant	Constant selection will allow the user to overwrite the present measured frequency with the known frequency. This entered frequency is then used for all the analysis and the frequency of the input signal is not measured
Dynamic	As per "Normal" without hysteresis. This option should not be used when DC only coupling is selected in the Coupling menu.
Minimum Frequency	
High Speed	High speed mode can be selected for data log speeds less than 100ms
Disabled	Disable high speed function
Enabled	Activate high speed data log function
Watts	
Signed	Result assigned as +ve or -ve
Absolute	Magnitude of result only

Normalise Reference	Selecting the Normalise Reference function adjusts the scale factors on each current channel so that they read the same as phase 1. The reference can be either the current measured on phase 1 or if there is a reference CT it can be

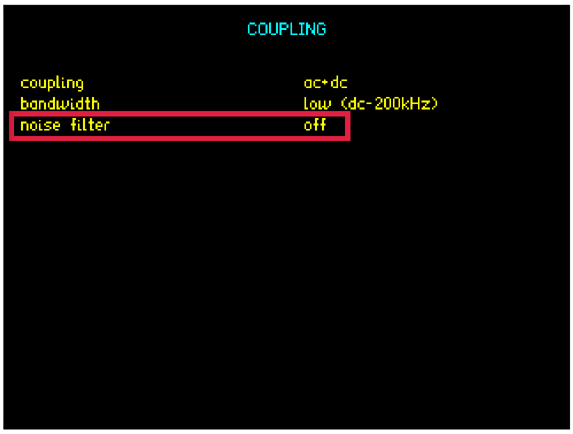
	connected to the external input of phase 1 voltage and used as a reference.
Disabled	Normalise function is disabled
Voltage	Selecting the Normalise voltage reference function adjusts the scale factors on each voltage channel so that they read the same as phase 1.
Current	Selecting the Normalise current reference function adjusts the scale factors on each current channel so that they read the same as phase 1. The reference can be either the current measured on phase 1 or if there is a reference CT it can be connected to the external input of phase 1 voltage and used as a reference.
Phase Offset	

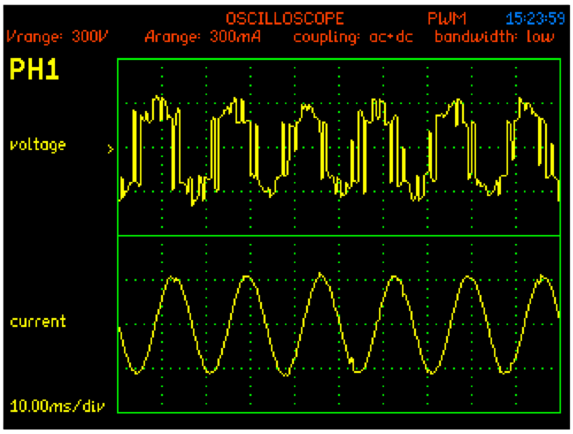
COUPLING

Coupling	There are three coupling options - AC only, AC+DC, or DC only. AC+DC coupling is the default option and should be used where possible. AC coupling should be used for measuring signals that are biased on a DC level (such as an amplifier operating on a single supply or the output of a DC PSU). DC coupling should be selected when making DC measurements as it prevents noise from resetting the frequency measurement algorithm. The coupling option does not affect the bandwidth of the instrument only the frequency detection.
ac + dc	Will allow both AC and DC signals to be calculated in all measurements
ac	AC Coupling only allows AC signals to be measured and will filter out all AC components
dc	DC coupling should be selected when making DC measurements as it prevents noise from resetting the frequency measurement algorithm, the bandwidth of the instrument is not affected. When DC coupling is selected “Dynamic” Frequency lock has no meaning and so should not be used.
Bandwidth	The bandwidth setting dictates the frequency range of the instrument. This selection sets an inline analogue filter as per the selection
Wide (DC - 2MHz)	Wide bandwidth will offer the full range of frequency components available for analysis
Low (DC- 200KHz)	Low bandwidth may be useful in noisy applications for example where there are switching spikes superimposed on the waveform of interest. The switching spikes may push the input channels onto a higher range than is necessary for the measurement. Selecting low bandwidth puts a hardware filter in the analogue input path to eliminate unwanted high frequency components
DC (DC – 5Hz)	The DC only bandwidth option applies a DC-accurate low pass filter of around 10Hz to reduce the ac signal. This is particularly useful when accurately measuring the dc content of an ac waveform such as the output of a UPS (Uninterruptible Power Supply). A 50Hz or 60Hz ac signal would not be removed entirely so that the measurement may still be synchronised to the waveform, but the amplitude would be greatly reduced so that the instrument would be on a more appropriate range for the DC component

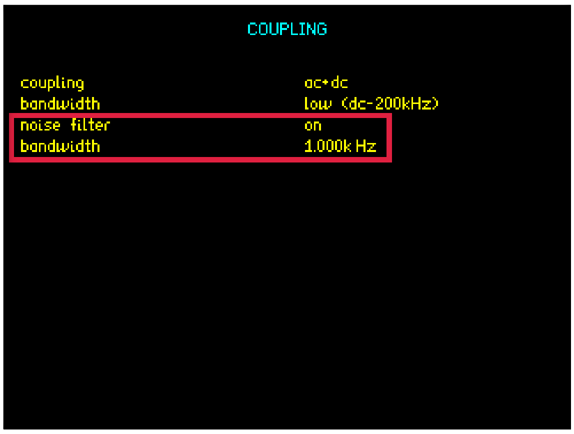
Noise Filter	In signal processing, a “FILTER” is a device or process that removes from a signal some unwanted component or feature. The noise filter is a digitally selectable in line filter which will alter the bandwidth of the processed signal
Off	Select to switch this mode off
On	Select to switch this mode on

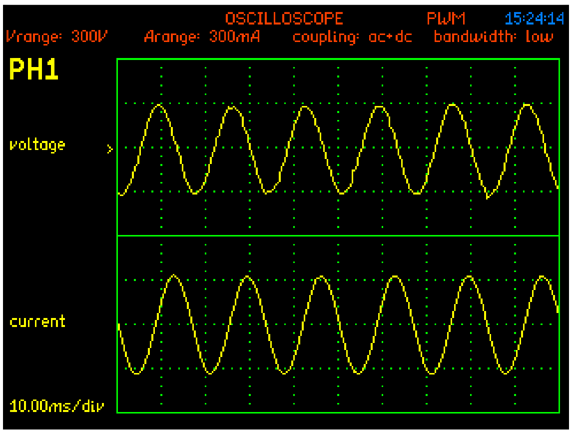
The following screenshots are taken from the *Scope* display with the PPA set in PWM application mode





Noise filter set to ***OFF*** the scope display shows a PWM switching Voltage waveform with noise distortion





Noise filter activated and bandwidth set to 1KHz the Voltage waveform is now displayed and is smoother and more sinusoidal

RANGE	Input channel options
Voltage Input	
Internal	The internal voltage attenuator selects the 4mm connections on the rear of the instrument and has a max input of 3000Vpk
External Attenuator (For connection to a HF shunt etc.)	An External Sensor / Shunt can be connected to the instrument which will give the operator more versatility in selecting the Input range required. Note: if this option is selected then the resulting data is scaled by the appropriate value within the attenuator and scale factor sub section. Max input of 3Vpk

CAUTION.
Input Connections: It is critical that the 4mm inputs and BNC inputs on each PPA input channel are not connected to any external circuit at the same time.

You **MUST** only use **EITHER** the 4mm **OR** the **BNC** connection – **NOT** both, this applies to both Voltage and Current inputs.

Autoranging	
Full Autorange	Default setting. Full autoranging will be selected and implemented within the instrument
Range up only	Selecting this option will allow the test being carried out to find the highest range via peak detection and hold on this range. Once this value has been found another test can be carried out by pressing the "Trigger" button which will restart from the minimum value for the set parameter used for "Low" Frequency measurements
Manual	Selecting this option will allow the user to set up the range from the configured measurements available, this is useful for inrush testing when a mid-analysis range change is not desirable
Minimum Range	Pre-set Input Voltage minimum range
1V	Minimum Input Voltage range will not be below 1v
3V	Minimum Input Voltage range will not be below 3v
10V	Minimum Input Voltage range will not be below 10v
30V	Minimum Input Voltage range will not be below 30v
100V	Minimum Input Voltage range will not be below 100v
300V	Minimum Input Voltage range will not be below 300v
1kV	Minimum Input Voltage range will not be below 1Kv
3kV	Minimum Input Voltage range will not be below 3Kv
Scale Factor	Manually set the scale factor required, normally used in conjunction with current transformers

Current Input	
Internal	The internal current shunt selects the 4mm connections on the rear of the instrument. Max Apk is dependent upon model type; LC (10A rms), Standard (30A rms) or HC (50Arms)
External Shunt	An External Shunt can be connected to the instrument which will give the operator more versatility in selecting the Input range required. Note: if this option is selected then the resulting data is scaled by the appropriate value within the scale factor and shunt value sub section

Autoranging	
Full Autorange	Default setting. Full autoranging will be selected and implemented within the instrument
Range up only	Selecting this option will allow the test being carried out to find the highest range via peak detection and hold on this range. Once this value has been found another test can be carried out by pressing the *TRIGGER* key which will restart from the minimum value set parameter
Manual	Selecting this option will allow the user to set up the minimum range from the configured measurements available
Minimum Range	Pre-set current input minimum range
10mA LC Version Only	Minimum Input Current range will not be below 10mA
30mA LC, SC Versions	Minimum Input Current range will not be below 30mA
100mA LC, SC Versions	Minimum Input Current range will not be below 100mA
300mA LC, SC, HC	Minimum Input Current range will not be below 300mA
1A LC, SC, HC	Minimum Input Current range will not be below 1A
3A LC, SC, HC	Minimum Input Current range will not be below 3A
10A LC, SC, HC	Minimum Input Current range will not be below 10A
30A LC, SC, HC	Minimum Input Current range will not be below 30A
100A SC, HC Versions	Minimum Input Current range will not be below 100A
300A SC, HC Versions	Minimum Input Current range will not be below 300A
1000A HC Version Only	Minimum Input Current range will not be below 1000A
Scale Factor	Manually set the scale factor required
DC offset	Used to trim out DC offset commonly found on external current transducers

Range Specifications
All the input channels are fully isolated from each other and from earth with very high CMRR (common mode rejection ratio). They are controlled independently but sampled synchronously.

Each input channel has an external input as well as an internal shunt or high voltage attenuator. The external input gives versatility in the input ranging by using external shunts or attenuators. If the external shunt or external attenuator option is selected, the data is scaled by the appropriate value (entered under the relevant channel menu).

Precision low inductance current shunts or current transformers may be used with the current channels; high voltage attenuators or oscilloscope probe may be used with the voltage channels.

CAUTION. Note that when using external shunts or attenuators on high voltage signals, the inputs must not exceed 1000V rms cat II, or 600V cat III, to ground.

There are 8 input ranges with nominal full scale values set with a 1:3:1 ratio. For convenience, the peak range system has been converted to the equivalent rms ranges this gives the following range system:

10Arms Model

Peak Ranges				RMS Ranges – Sinusoid	
Range	internal current	internal voltage	external input	Internal current	Internal voltage
1	10mA	1V	1mV	8.48mArms	848mVrms
2	30mA	3V	3mV	25.4mArms	2.54Vrms
3	100mA	10V	10mV	84.8mArms	8.48Vrms
4	300mA	30V	30mV	254mArms	25.4Vrms
5	1A	100V	100mV	848mArms	84.8Vrms
6	3A	300V	300mV	2.54Arms	254Vrms
7	10A	1kV	1V	8.48Arms	848Vrms
8	30A	3kV	3V	10.0Arms	1000Vrms

30Arms Model

Peak Ranges				RMS Ranges – Sinusoid	
Range	internal current	internal voltage	external input	Internal current	Internal voltage
1	100mA	1V	1mV	84.8mArms	848mVrms
2	300mA	3V	3mV	254mArms	2.54Vrms
3	1A	10V	10mV	848mArms	8.48Vrms
4	3A	30V	30mV	2.54Arms	25.4Vrms
5	10A	100V	100mV	8.48Arms	84.8Vrms
6	30A	300V	300mV	25.4Arms	254Vrms
7	100A	1kV	1V	30Arms	848Vrms
8	300A	3kV	3V	30Arms	1000Vrms

50Arms Model

Peak Ranges				RMS Ranges – Sinusoid	
Range	internal current	internal voltage	external input	Internal current	Internal voltage
1	300mA	1V	1mV	254mArms	848mVrms
2	1A	3V	3mV	848mArms	2.54Vrms
3	3A	10V	10mV	2.54Arms	8.48Vrms
4	10A	30V	30mV	8.48Arms	25.4Vrms
5	30A	100V	100mV	25.4Arms	84.8Vrms
6	100A	300V	300mV	50Arms	254Vrms
7	300A	1kV	1V	50Arms	848Vrms
8	1000A	3kV	3V	50Arms	1000Vrms

The actual ranges have approximately 20% overload (subject to noise) headroom so, for example, the 300Vpk range has an actual peak input value of 360Vpk allowing for the 20% headroom.

All N4L analyzers auto-range to the waveform peak, this is vitally important as it ensures that the waveform is not clipped unlike within traditional rms ranging power analyzers.

The ranges may be selected manually, or by autoranging (default). To speed up the autoranging, the start range for autoranging may be selected if it is known that the signal will not be below a certain level.

There is also an option to autorange 'up only' so that a test may be carried out to find the highest range. Once the highest range has been determined, the range can be set to manual and the test carried out without losing any data due to range changing. Pressing the *TRIGGER* key (or sending ***TRG**) restarts the autoranging from the selected minimum range.

In multi-phase applications, it is usual to allow the phases to independently range but there is an option to lock the ranges across the phases. When enabled, this means that all the voltage channels will be on the same range, and all the current channels will be on the same range.

When in an input channel menu, the *ZERO* key provides a quick way to lock and unlock the range. When no flashing box is visible in the input channel menu and autoranging is selected, pressing the *ZERO* key selects the range that the instrument is currently using and sets the autoranging to manual, thus locking the range and preventing further autoranging. Pressing the *ZERO* key again returns to full autoranging from the bottom range.

For most measurement functions full autoranging is the most suitable option but some applications, such as where transient events are occurring, are more reliable with manual ranging. Manual ranging (or up-only autoranging) is essential for low frequency measurements.

Separately from the current shunt and attenuator value, a scaling factor can be entered for each channel.

In multi-phase applications, if independent input control has been set (see system options) then the ranging options may be independently set on each phase. Press the ► and ◄ keys to step between the phases.

DATALOG	
Datalog	Interrogation and extraction of information resulting from a test log in a specified time scale and at a set speed
Disabled	No memory selected
RAM	Instruments internal memory selected for data storage; this offers the fastest performance
Internal Flash	Utilises 1GB internal memory
USB memory stick	External USB memory stick selected for data storage

APP	
Mode	Application function to be selected
Normal	Using the Normal Application, the default settings within the instrument will be applied to all measurements, useful for general measurements
Default Settings	All default parameters will be selected when *ENTER* is pressed
PWM Motor Drive	The nature of the waveforms in a PWM motor drive application makes measurement of the fundamental frequency difficult. The application mode for PWM motor drives applies a selectable filter which is a parallel digital filter and will not affect the bandwidth of the instrument; it is only used for frequency detection. The best filter to use for a given application should be selected by experiment. The filter does not change the measured data at all. PWM application mode also allows torque and speed to be simultaneously measured so that efficiency can be computed
Default Settings	All default parameters will be selected when *ENTER* is pressed
Frequency Filter	Pre selectable filter options 64Hz, 250Hz, 1KHz, 4KHz, 16KHz, 64KHz, 250KHz
Frequency Reference	Select which parameter frequency reference will be detected from input signal (voltage, current, or speed input)
Low Frequency	Can be selected as On or Off if “On” is selected manually enter the minimum frequency required which will then be displayed
Torque + Speed	Power Measurement function can be set to disabled or enable to measure the desired function from analogue, pulsed speed, pulsed torque, or pulsed. (Pulsed infers that both speed and torque are pulsed inputs) Once enabled a scale factor / offset will require setting in relation to either Voltage or Frequency
Efficiency	(Not applicable to the PPA4510) Efficiency can be measured between selected channels from the drop down menu. disabled, phase/next phase, next phase/phase, slave/master, master/slave, mechanical/sum, sum/mechanical, phase 3/sum, & sum/phase 3

Lighting Ballast	Electronic lighting ballast waveforms consist of a high frequency carrier signal modulated by the line frequency. The instrument measures the line frequency independently of the input waveform frequency and synchronises the measurement period to the line frequency. The carrier frequency measurement ignores any "dead band" around the zero crossing of the ac line to compute the actual switching frequency of the ballast. Both the frequency measured on the input waveform and the frequency of the line input are displayed, the output of the ballast should always be connected to Phase 1
Default Settings	All default parameters will be selected when *ENTER* is pressed
Frequency Tracking	Selectable tracking speed from drop down menu
Efficiency	(Not applicable to the PPA4510) Efficiency can be measured between selected channels from the drop down menu. disabled, phase/next phase, next phase/phase, slave/master, master/slave, mechanical/sum, sum/mechanical, phase 3/sum, & sum/phase 3
Inrush Current	Inrush current (surge) requires very fast sampling to catch the highest instantaneous value. Measurements must be made under conditions of manual ranging and with the voltage applied to the instrument. Then when the load is switched on the highest peak value can be detected. If the peak current is unknown then a minimum of two tests should be performed, one to set the range and a second test to capture the inrush current
Default Settings	All default parameters will be selected when *ENTER* is pressed
Minimum Range	Select the minimum current range applicable from the drop down menu
Auxiliary Device	Allows PCIS inrush switch to be used for measurement of Inrush Current. If selected phase offset and waveform cycle for results will require setting Swich phase offset is 0º to 315º in 45º steps and the switch on cycle is selectable from continuous, half cycle & full cycle. Alternatively, one of the ADI40 analogue I/O units can be chosen.
Transformer Mode	Large power transformers operate at very low power factor (<0.01) and the phase accuracy is critical to measure the losses. Power transformer application mode sets the configuration options to the optimum for phase accuracy e.g., AC+DC coupling range lock across phases. The temperature can be monitored at the same time by connecting a suitable temperature sensor to the “torque” BNC input on the rear.
Default Settings	All default parameters will be selected when *ENTER* is pressed
Temperature	Temperature mode can be disabled or selected to measure ºC or ºF via a suitable temperature sensor connected to the “Torque” BNC input

Standby Power	To minimise standby power, some devices operate in a “dormant” mode whereby power is only drawn from the supply when needed. These devices draw very little current for most of the time and then draw a larger current for a single cycle to charge a reservoir capacitor. This pattern is repeated on an irregular basis. Most of the power consumed by devices in this mode is taken in the periodic higher current cycles so to accurately measure the power drawn by these devices, the instrument synchronises to the power frequency for the analysis but extends the measurement window to the irregular period of higher energy pulses. Because the instrument samples in true real time without any gaps, no data is missed, and every power cycle is captured. It is important that ranging is set to manual or up only autoranging so that the power cycles are not missed while ranging
Default Settings	All default parameters will be selected when “ENTER” is pressed
Low Frequency	Select “On” or “Off” if low frequency filter is required
Calibration	This mode is used when calibrating the instrument with N4L software
Default AC Settings	Select to calibrate AC
Default DC Settings	Select to calibrate DC
Frequency Filter	Frequency synchronisation for calibration gives more accuracy at low levels, applies to AC only

MATHS	
Formula	
Disabled	No maths formula is selected
(term1 + term2) / (term3 + term4)	Sum of (term1 + term2) divided by sum of (term3 + term4)
(term1 + term2) x (term3 / term4)	Sum of (term1 + term2) multiplied by sum of (term3 ÷ term4)
(term1 x term2) / (term3 + term4)	Sum of (term1 x term2) divided by sum of (term3 + term4)
(term1 + term2 + term3) / term4	Sum of (term1 + term2 + term3) divided by term4

Note: Selection of “TERMS” is via the zoom order selections here

ALARM	
Alarm 1 Data	Alarm on selected parameter and thresholds
Zoom 1	Zoom 1 parameter selected for alarm threshold
Zoom 2	Zoom 2 parameter selected for alarm threshold
Zoom 3	Zoom 3 parameter selected for alarm threshold
Zoom 4	Zoom 4 parameter selected for alarm threshold
Alarm Type (Alarm 1)	
Disabled	No alarm
Linear	Frequency of beep increases linearly as value reaches its limit
Alarm if high	Alarm will sound if values exceed a threshold
Alarm if low	Alarm will sound if values fall below a threshold
Outside window	Alarm will sound if values are outside a permitted window setting

Inside window	Alarm will sound if values are within a permitted window setting
Alarm 2 Data	Alarm on selected parameter and thresholds
Zoom 1	Zoom 1 parameter selected for alarm threshold
Zoom 2	Zoom 2 parameter selected for alarm threshold
Zoom 3	Zoom 3 parameter selected for alarm threshold
Zoom 4	Zoom 4 parameter selected for alarm threshold
Alarm Type (Alarm 2)	
Disabled	No alarm
Alarm if high	Alarm will sound if values exceed a threshold
Alarm if low	Alarm will sound if values fall below a threshold
Outside window	Alarm will sound if values are outside a permitted window setting
Inside window	Alarm will sound if values are within a permitted window setting
Analogue Output	
Disabled	No analogue output
Zoom 1	Set an analogue output voltage representative of zoom 1
Zoom 2	Set an analogue output voltage representative of zoom 2
Zoom 3	Set an analogue output voltage representative of zoom 3
Zoom 4	Set an analogue output voltage representative of zoom 4
Manual	Set a constant analogue output voltage

Alarm Function

The PPA4500 has two independent alarms that can be read remotely or can generate an audible sound. Each of the alarms can be triggered by comparison to one or two thresholds:

sound the alarm if the value exceeds a threshold

sound the alarm if the value is below a threshold

sound the alarm if the value is outside a threshold window

sound the alarm if the value is inside a threshold window

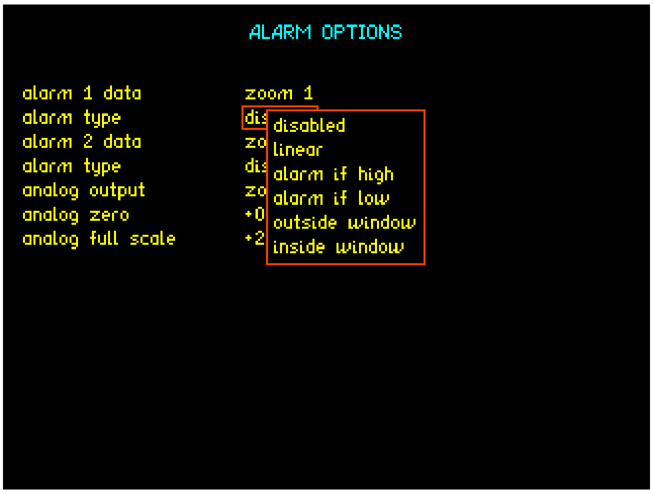
Additionally, one of the alarms (alarm 1) can be used to generate a sound which varies linearly between two user defined thresholds.

The value to which each alarm is applied can be any of the measurement parameters selected for zoom here

The *ALARM* menu screen shown below

alarm 1 data - is the first alarm, this can be linked to any of the measured parameters that have been defined by the zoom function, designated zoom 1 → zoom 4

To program an alarm, first select the functions for the zoom; up to four measurements can be selected for the display, the alarm can be applied to any of them; then press *ALARM* to invoke the ***alarm options*** menu

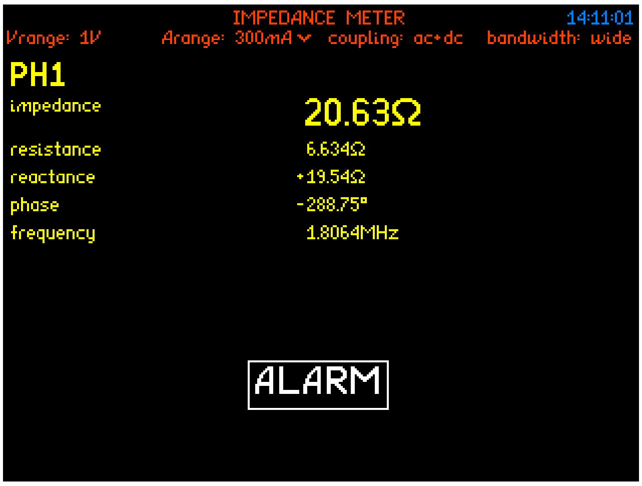


Select which of the zoom functions is to be used, then select the type of alarm from the five choices displayed in the drop down list

The **alarm type** sets up the way the thresholds are treated, enabling the user to set the upper and lower thresholds, both when set to one of the windows or to the linear option. Depending on the selection either one or two thresholds will be displayed for setting to the desired value.

i.e., if ***alarm if high*** is chosen then the high threshold is displayed, conversely when ***alarm if low*** is chosen then the low threshold is displayed. If a ***linear, inside window*** or ***outside window*** option is chosen, then both the high and low thresholds will be displayed.

In this case ***outside window*** has been selected which then displays additional fields to be edited that are appropriate for the choice made. With both this and ***inside window*** the high and low threshold limits are displayed and editable rather than just the high or low threshold when ***alarm if high*** or ***alarm if low*** are chosen.
If ***alarm latch*** is set to ***ON*** the alarm will continue to sound even if the value being monitored returns to a value outside the set threshold(s).



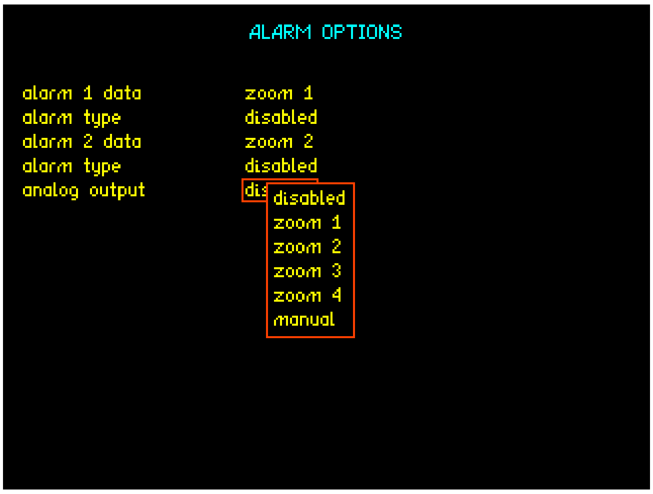
If ***alarm sounder*** is ***enabled***, when triggered the alarm causes both an audible bleep and displays a message at the bottom of the screen.

To clear the alarm, press *HOME*.

If the alarm latch is selected, then both alarms will continue to sound even if the value returns to within the normal boundaries. To clear the alarm, press *HOME*.

The alarm latch can also be set to *HOLD* the data so that an event can be captured. The data on the screen will be the measurement that first triggered the alarm condition.

The ***linear alarm*** option allows tests to be carried out even if it is not possible to see the display. Pressing *ZERO* in the alarm menu sets the upper and lower threshold to 4/3 and and 1/3 of the measured value respectively. The repetition rate of the sounder then varies linearly as the value changes between these thresholds.



analog output – The Analog Output BNC connector is located on the rear of the instrument.
The output voltage (0 to 10V DC) can be controlled using the ALARM functions to generate a voltage representative of Zoom 1→4 measurements or a manual level.

The Voltage present at the Analog Output can be calculated using the following formula:
Analog Output = 10 x (measured - zero) / (full scale - zero)
"Measured" is the value measured on the instrument and defined by one of the zoomed parameters.
analog zero and ***analog scale*** are user defined values set in the menu.
The ***analog output*** menu option can be set to ***disabled, zoom 1 → zoom 4*** or ***manual***, with manual representing a fixed value with just the analog output set by the user.

The output is updated whenever new data is available.
A 2V Peak 50Hz signal is monitored by the Power Analyzer. The frequency is adjustable by +/-2Hz.
Therefore using the above formula, “Zero” will be 50 and “Full Scale” will be 52. With a Full scale value of +/-2Hz, the Analog Output will vary between -10V at 48Hz up to +10V at 52Hz. The
Analog Output Voltage will be 0V when the frequency is 50Hz.
Zoom 1 in the Alarm menus is used to control the voltage levels on the Analog Output

alarm 2 data, behaves and is set up in the same way as ***alarm 1*** with the following exception that the linear alarm is only available on ***alarm 1***.
In both cases the alarm sound can be disabled, and the alarm can be latched so that it stays on even if the monitored parameter is now outside the set alarm conditions. If using a latched alarm which is continuing to sound, press the *HOME* key to clear the alarm.

REMOTE	
Resolution	Press to set the data resolution and change the format to which the instrument responds to future commands, via Comms interface
Normal	Data Resolution set to 5 decimal points
High	Data Resolution set to 6 decimal points
Binary	Data transmitted in Binary Format
Interface	Communications type between instrument and pc
RS232	RS232 Comms interface
USB	USB Comms interface
LAN	LAN Comms interface
GPIB	GPIB Comms interface
Recall with Program	When enabled recalls communication port settings from any stored memory location
Off	Turn OFF this option
On	Turn ON this option
Screen Print	
Disabled	No Screen print option selected
RS232	Print screen via RS232 Cable i.e., to printer
USB Memory Stick	Print screen directly onto USB memory stick

INFORMATION. It is advisable to only use USB sticks of 2Gb or smaller capacity.

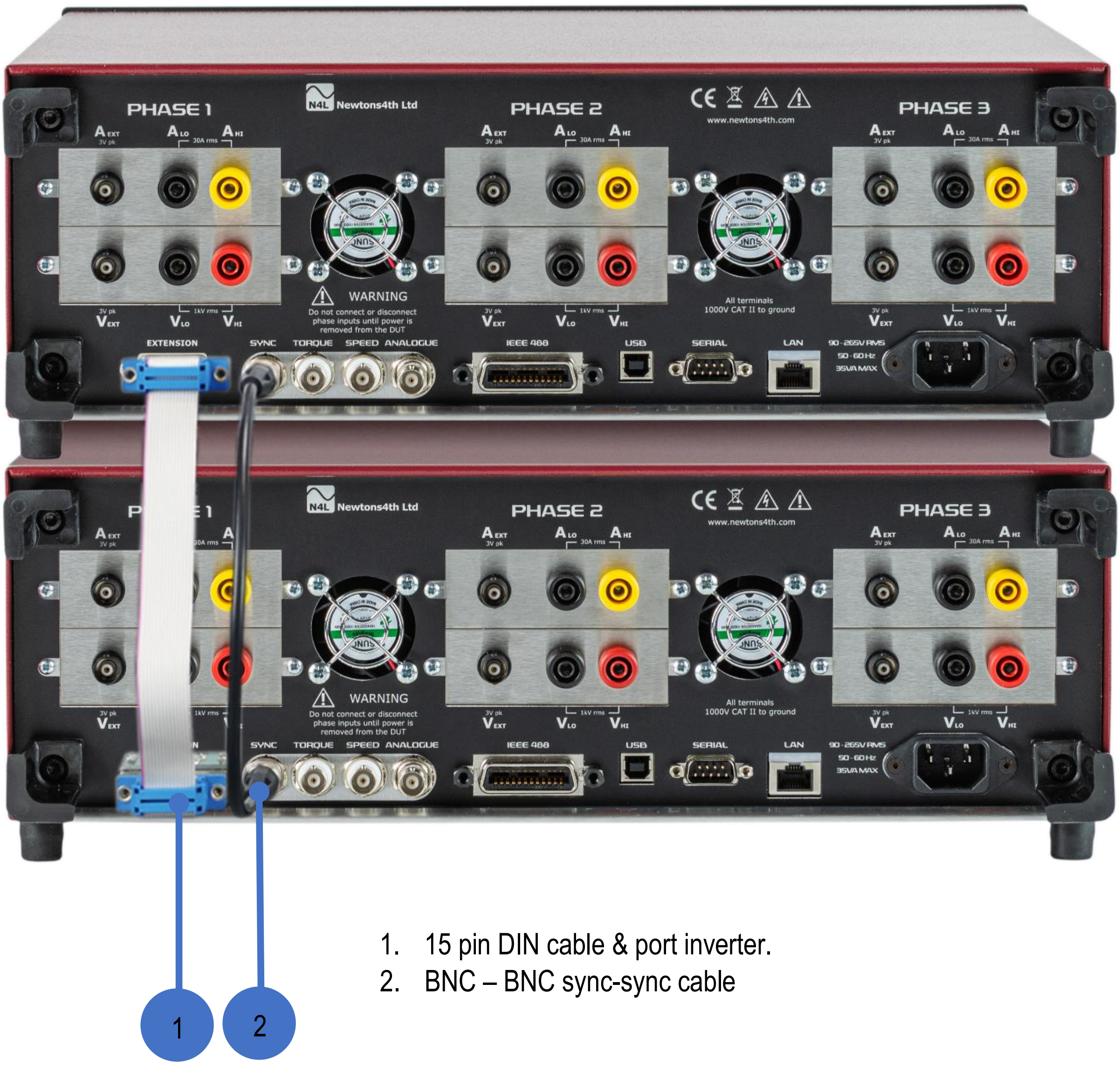
AUX	Superseded see note
Master / Slave	Select if 2 x PPA45xx units are to be used as a PPA4540/50/60
Disabled	Master / Slave configuration disabled
Master	Select to set PPA45xx as master unit within 4 -6 phase configuration
Slave	Select to set PPA45xx as slave unit within 4 - 6 phase configuration

Master/slave operation (Included for legacy purposes only)

Two instruments can be connected to make synchronised measurements with up to 6 phases. The unit assigned as 'master' controls the measurements so both instruments are taking data at the same time.

When in POWER or INTG modes, the SUM power from the slave instrument is read by the master instrument to compute the overall efficiency.

To operate in master/slave mode, connect the extension ports on the back of the instrument with the 15-way ribbon cable and the 15 pin D type port inverter. Also connect the SYNC BNC connectors on the back of the instruments with a BNC cable. Press the AUX key on each instrument to set master/slave to master and slave respectively. The master/slave selection is shown in the top left hand corner of the display.



1. 15 pin DIN cable & port inverter.
2. BNC – BNC sync-sync cable

Because the measurement window is set by the master instrument, if the slave instrument is measuring a different frequency (for example when measuring the efficiency of a 3 phase inverter) then the measurements on the slave will not be exactly synchronised to its frequency and may take a little longer to settle than usual.

In the event that either instrument changes range or detects a significant change in frequency then both instruments will resynchronise and "waiting for data" will be shown on the display.

To synchronise data read over the communications ports, first send 'HOLD,ON' to the master (which puts both instruments in hold mode) read the data from the master and slave, then release HOLD on the master 'HOLD,OFF'.

INFORMATION. Please note Master /Slave is redundant and is only included for legacy compatibility, it has been superseded by our PPADatalogger software which allows up to 4 PPA's to be connected simultaneously and should be used instead of Master/Slave

Auxiliary Device	
None	No Auxiliary device connected
PCIS Inrush Switch	Phase Controlled Inrush Switch – is an active device which is controlled over the extension port within the instrument See APP section here
ADI40-4 Analogue I/O	Enable the ADI40 Analogue–Digital Interface unit with 4 thermocouple inputs
ADI40-8 Analogue I/O	Enable the ADI40 Analogue–Digital Interface unit with 8 thermocouple inputs
ADI40-12 Analogue I/O	Enable the ADI40 Analogue–Digital Interface unit with 12 thermocouple inputs
ADI40-16 Analogue I/O	Enable the ADI40 Analogue–Digital Interface unit with 16 thermocouple inputs
External System Scaling	
Disabled	External System Scaling is not selected
Enabled	Enable External System Scaling and recall calibration Adjustment settings etc

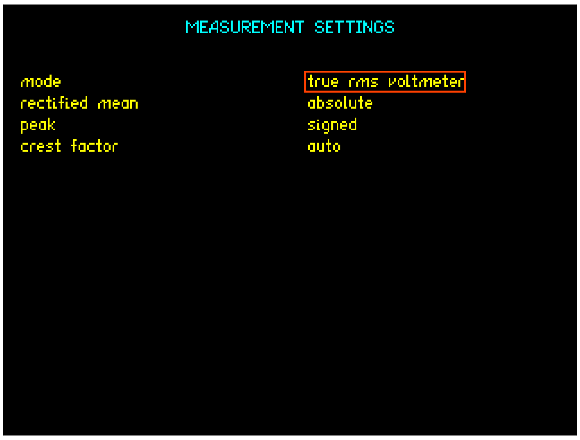
SYS	
Set Clock	Manual Setting Required. Use Numerical Keys
Set Date	Manual Setting of Date and Year, Month settings are pre-set
Display	
Colour	Display data will be in colour
White on Black	Display data will be displayed as white font on black background
Black on White	Display data will be displayed as black font on white background
Brightness	
Low	Screen brightness set to Low
High	Screen brightness set to High
Phase Convention	Measurements of Phase can be expressed in one of three formats:
-180º to +180º	Commonly used in circuit analysis
0º to -360º	Commonly used in power applications
0º to +360º	Select as required
Keyboard Beep	Audible sound when keys are pressed
Disabled	Audible sound disabled
Enabled	Audible sound activated
Autozero	
Autozero	Periodically re-zero's input to prevent drift, useful for long periods of DC analysis
Manual	Unit will only zero inputs if "Zero" is pressed by user
Program 1-6 Direct Load	Program 1-6 may be recalled with a direct press of the function keys (POWER, INTEG etc)
Disabled	Function will be disabled
Enabled	Function will be enabled
Zoom 2 High Resolution	The data displayed in zoom 2 may be displayed to one digit greater resolution than normal, this is particularly useful when measuring phase at power line frequencies
Disabled	Function will be disabled
Enabled	Function will be enabled

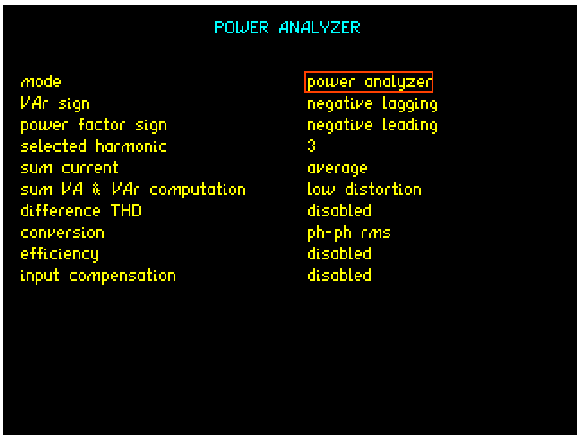
Independent Ranging	This allows the user to set different scale factors and select independently internal / external shunts separately on each phase
Disabled	Function will be disabled
Enabled	Function will be enabled
Low Value Blanking	Low value blanking will zero to display values under the following conditions Input Signal Peak < 45% of RNG 1 < 25% of RNG 2 < 15% of all other ranges
Disabled	Function will be disabled
Enabled	Function will be enabled

◄ **System Information**	The information given in this section cannot be changed by the user
Serial Number	Instruments unique serial number
Manufacturing Code	Code attributed to build date of instrument
Main Release	Current firmware release installed in instrument
DSP Release	Digital Signal Processing release version
FPGA Release	Field Programmable Gate Array release version
Boot Release	Release version of Instruments boot up firmware
Last N4L Calibration	Instruments last calibration date

► **User Data**	
Supervisor Access	Enable or Disable (not currently supported)
User Data	Manually enter company name
User Data	Manually enter individual or company
User Data	Manually enter unique ID for instrument
Save	Save all above settings

MODE	Each mode selection reveals a subset of settings appropriate to the selected mode
True RMS Voltmeter	The RMS voltmeter displays the additional secondary parameters of ac, crest factor, surge, mean and form factor
Phase meter	The phase meter mode is a secondary function which does not have a separate key. The phase meter uses the terminology of channel 1 for voltage and channel 2 for current as it is normal to use a phase meter to compare voltages directly. The phase meter measures the phase and gain of channel 2 relative to channel 1 using a Discrete Fourier Transform (DFT) algorithm at the fundamental frequency





The parameters displayed alter dependent on the selected mode.

Power Analyzer	In the POWER mode, the analyzer measures power values for each phase
Impedance Meter	The IMP mode on the PPA uses the real and imaginary components at the fundamental frequency using DFT analysis to compute the impedance of the load and associated parameters
Power Integrator	In the INTEG mode, the PPA will compute additional power values within a Datalog and display them relative to time (total power)
Harmonic Analyzer	The HARM mode of the PPA computes multiple DFTs on the input waveforms in real time. There are two modes of operation: difference THD, and series harmonics. Series harmonic mode includes options for THD, TIF, THF, TRD, TDD and phase. There is also an option of a series harmonic bar graph display which shows both the voltage and current harmonics simultaneously. In difference THD mode, the THD (Total Harmonic Distortion) is computed from the rms and fundamental: In series THD mode, the THD is computed from a series of up to 125 harmonics (100 Harmonics for TDD, THF, TIF, TRD, Harmonic RMS and Harmonic Factor options).
Oscilloscope	The PPA provides a storage oscilloscope function to view the waveforms being measured

PROG	
Memory	Program Store / Recall Options
Internal Flash	Instruments internal memory utilised to store or recall data to/from
USB Memory Stick	External USB memory stick utilised to store or recall data to/from
Data	
Program	Upload or download a program
Results	Upload or download results
Datalog	Upload or download Datalog
Action	
Recall	Recall any Data selections from above
Store	Store any Data selections from above
Delete	Delete any Data selections from above
Location	999 selectable locations for data to be stored to, & recalled, or deleted from
Name	Allows user to name data within location
Execute	Using the ▲ & ▼ keys to highlight ***EXECUTE*** Press the *ENTER* key to execute any change(s) made to any parameter within "PROG" mode screen
Memory Status	Status of memory in either Internal or USB configuration

Program store and recall

There are 999 non-volatile program locations where the settings for the entire instrument can be saved for future recall later. An associated name of up to 24 characters can be entered by the user to aid identification, (see Text Entry)

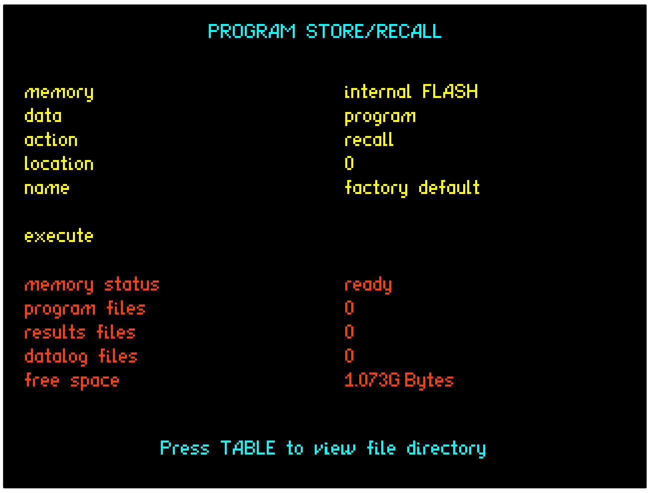
Program number 1 (if not empty) is loaded when the instrument is powered on so that the PPA4500 can be set to a user defined state whenever it is switched on. This is particularly useful to set system options such as phase convention, GPIB address etc. If no settings have been stored in program 1 then the factory default settings are loaded (program number 0).

Program numbers 1-6 may be recalled with a single press of the Application Direct Access keys, (item 7) if the direct load option is selected in the system menu (see system options).

The instrument can be restored to the factory default settings at any time by recalling program number 0.

The program menu is accessed using the *PROG* key. The program location can be selected either by stepping through the program locations in turn using the ►&◄ keys to see the name or by entering the program number directly.

The default condition when in the Program Store/Recall menu is as shown below.



To store a configuration in any of the locations 2-999, press the ▼ key twice to highlight ***action***, then press the ► key once to select ***store***.

Now using the ▼ key highlight the program number and either step through the numbers with the ►&◄ keys or directly enter the number from the numeric keys, then press *HOME*.

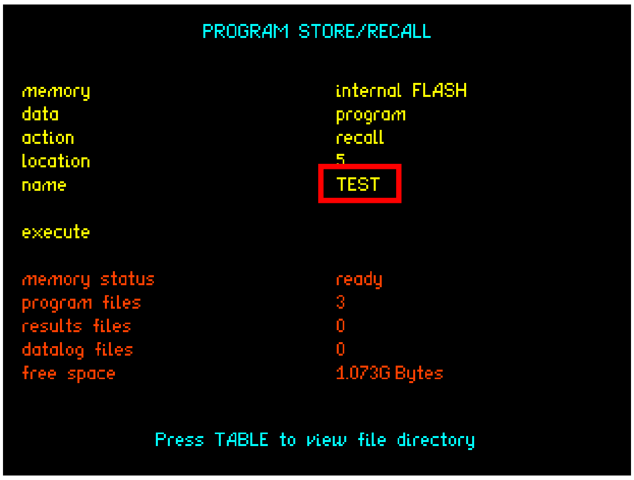
Using the ▼ key, highlight ***execute***, and press *ENTER*.

When storing a configuration in a program, there will be a slight pause (of about 1 second) if the program has previously been written or deleted. The process will be very quick if the location has not been used.

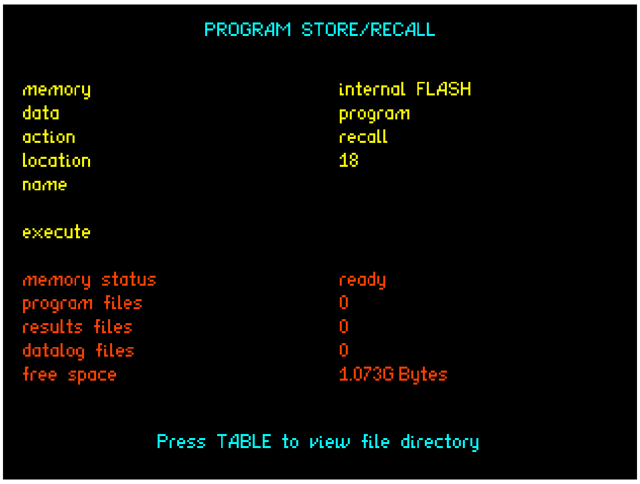
When supervisor mode is disabled (see system options), programs can only be recalled, not stored nor deleted, to avoid accidental modification.

Scrolling through the numerical memory locations using the ► & ◄ keys it will be observed that against the field called ***name*** there can be 3 options., either ***empty*** which means that there is nothing stored in that location , or a name such as ***PWM TEST*** which shows that the location has a program stored at that location number which has been named PWM TEST, lastly it can be completely blank, this does not mean the memory slot is empty, but rather settings were stored without saving their name to identify them. This is poor practice and should be avoided if possible as it is bad housekeeping.

In this screenshot location 12 is shown as empty and can be used to store program settings.



In this case location 5 has a program stored called TEST, this location can be used for storage, but it will be overwritten by the new saved program.

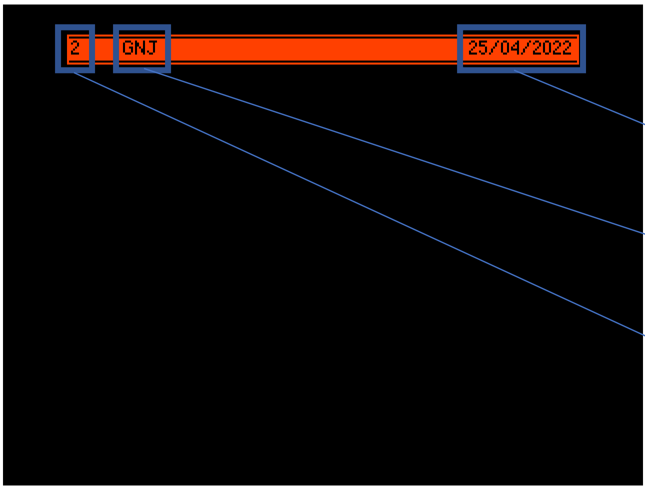


In this last instance, location 18 is not showing either the word empty or a program name. This infers that there is a program stored in this location, but it was saved without a name. As previously it can be overwritten with a new program.

CAUTION. Of the 3 cases shown above the memory slot in the first one is empty, however in the second and third cases they both have something stored in them and to use these slots will overwrite the contents already there without any warning.

When recalling a program, it may be desirable for the program to recall the selected communications interface that was in use when the program was stored (RS232, LAN, or USB). Alternatively, it is more common for the communications interface to be associated with the instrument rather than a stored program. There is a selectable option in the *REMOTE* menu to enable "***recall with program***". If this is "***off***" then recalling the program will not change the communications interface.

All file directory information can be displayed by pressing the "*PROG*" key and then the "TABLE" key. This will allow all the information to be displayed as a table and show what the internal file directory contains. (Pressing the "*TABLE*" key again exits the directory screen).



This screen shot shows the file table, there is only one entry in this instance.

The date the program or results were saved.

The program or results name (up to 24 characters)

The memory position or “slot” number 2-999

Results store and recall

Each of the 999 locations can store either real-time results, datalogs or instrument settings / programs, as described in the previous paragraphs.

Measurement results can be stored in one of 20 locations. Press *HOLD* to hold the results, press *PROG* and select ***memory*** = ***results***. Each location holds the entire set of computed results for all the phases no matter what phase is on the display. Oscilloscope and harmonic series data can also be stored but these take 3 contiguous locations each because of a large amount of data. In each case, the full instrument set up is stored with the data and recalled so that measurements may easily be repeated and verified.

Datalog store and recall

Datalog can be stored directly into non-volatile memory or can be logged to RAM and stored subsequently. The data then can be recalled for viewing or to download to a PC for further analysis. There is a single non-volatile location for holding the datalog.

Saving data & files to USB Memory Stick

Data and files can also be stored and downloaded via a USB memory device. When using a large capacity or slow device all the data may not be transferred within the transfer time window. If this happens it will be recognised, and a display caption appears to prompt the user to press “any Key” to terminate the transfer when completed.

You can use larger USB sticks such as a 4GB or 8GB if they are not full of files, if they are, the time taken reading the file directory will cause a time out error.

The best way to ensure that a 4GB or 8GB USB stick will function correctly is as follows: -

1. Format a 4GB or 8GB USB drive. Both FAT16 and FAT 32 formats will work.

2. When you put the stick in, it will start flashing and there will be a message saying “press any key” – ignore this and any further error messages, typically “Error 4”

3. After a period of time, you will see that the USB stick stops flashing the activity LED, once this has gone out the stick is ready to use for screen shots, program saving etc.

ZOOM +	Increase font size on selected parameters on display screen
ZOOM -	Decrease font size on selected parameters on display screen

REAL TIME	Press *REAL TIME* to return to the display screen and see all data in real time. Pressing the *REAL TIME* key will toggle between HOLD and REAL TIME modes
TABLE	Press *TABLE* to view results either during or at the completion of a Datalog in tabular format, this is also the default screen whilst Datalog is running
GRAPH	Press *GRAPH* during Datalog to view plotted data points whilst log is in process, or view graph plots once Datalog is complete. Press *GRAPH* to move through screen display options
POWER	Direct key to Power Analyzer mode functions
INTEG	Direct key to Power Integrator mode functions
HARM	Direct key to Harmonic Analyzer mode functions
RMS	Direct key to True RMS Voltmeter mode functions
IMP	Direct key to Impedance Analyzer mode functions
SCOPE	Direct key to Scope mode where waveforms can be viewed from measurements being taken. The ◄ & ►directional arrows will allow the time base to be changed and the ▲ & ▼arrows will allow the trigger level to be set
START	*START* key will start any Datalog. Is also the key used to initialise a screen dump of any data displayed onto a USB memory stick
STOP	*STOP* key will stop any Datalog
ZERO	*ZERO* key will reset the inputs to zero
TRIGGER	*TRIGGER* returns display screen back to real time from a hold command. Also triggers a single shot in SCOPE mode, all trigger settings can be found by pressing the *SCOPE* key whilst in SCOPE mode

ENTER / ►► (Dual use key)	*ENTER* / ►► will enable the user to confirm any configurations they have set within the menus and will scroll through the display screen to view all individual phase screens or all phases together

DELETE / ◄◄ (Dual use key)	*DELETE* / ◄◄ will enable the user to delete any inputted data or scroll back through any results screens

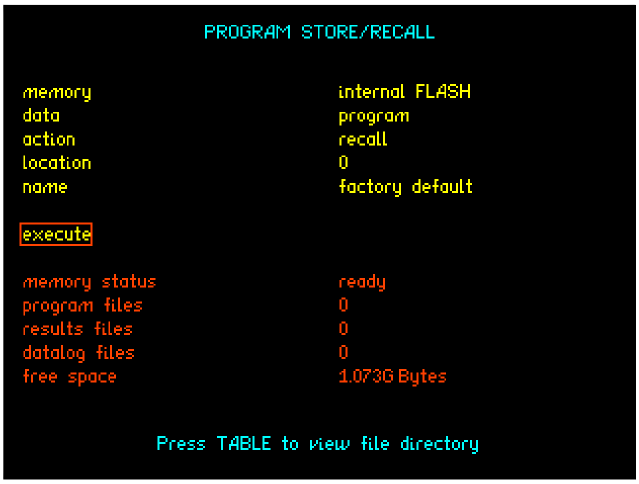
HOME / ESC (Dual use key)	*HOME / ESC* will enable the user to return to the home page once data within parameters has been adjusted and entered, or will escape from any screen view and return to the selected mode's home screen

Chapter 8 Guide for testing the basic functionality of the instrument.

This section of the manual provides instructions on how to test the basic functionality of your Precision Power Analyzer to ensure it has a basic level of functionality; this should be used as a pre cursor to any further fault investigations. Details are provided of the instrument setup, the required connections between the PPA and other basic test equipment commonly available in a laboratory. Furthermore, screen shots of the expected results are displayed on the PPA.

Testing of the external inputs of the PPA is performed by monitoring the output of a signal generator. To test the internal inputs of the PPA a breakout box with a load connected is used, the PPA monitoring the AC mains supply with the current shunts in series with the load and the voltage attenuators in parallel.

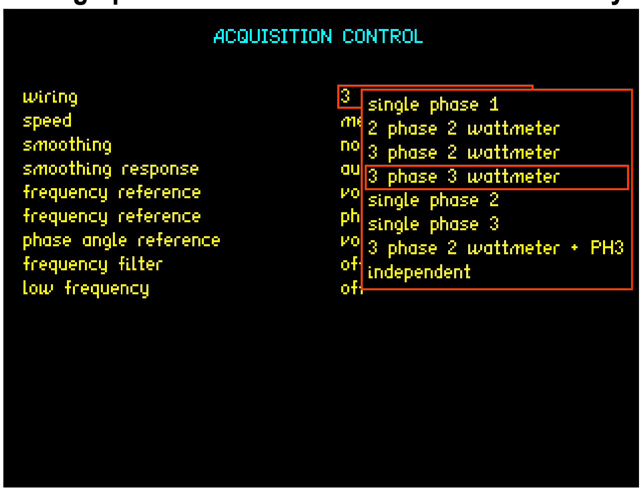
RESETTING THE PPA TO FACTORY DEFAULT MODE.
This will clear any user defined programs that might be stored in the PPA and recalled when the instrument is switched on. Program 1 is recalled when the PPA is restarted.



To access Program Store / Recall mode:

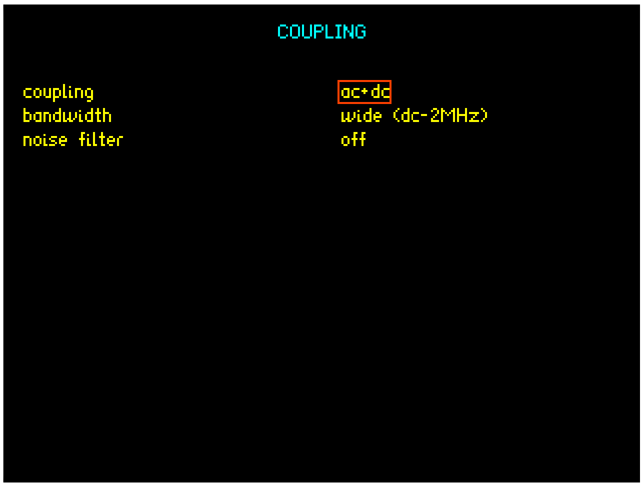
Press the *PROG* key, then press the ▼ Key until the Red Box surrounds the number adjacent to ***Location.***
Press “0” & then press the ▼ Key until the Red Box surrounds ***Execute,*** press *ENTER* - This will now reset the instrument to factory default mode.

Setting up PPA4500 for external BNC functionality Check.



Acquisition control.

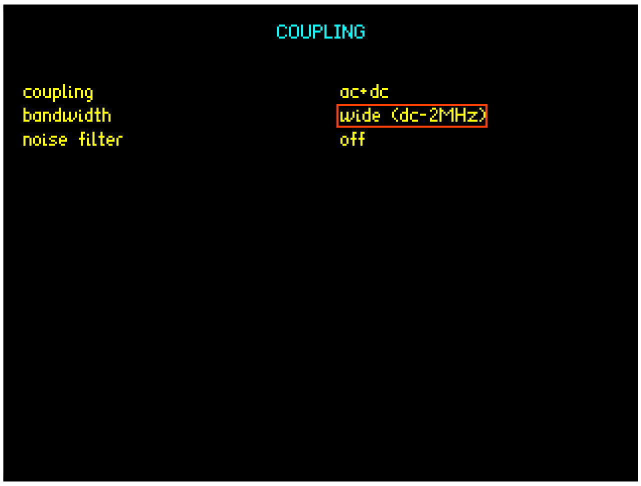
Press *ACQU* key, then press the ▼ key until the Red Box surrounds the ***wiring*** options. Use the ▼&▲ keys to select ***3 phase 3 wattmeter*** from the list, then press *Enter*.



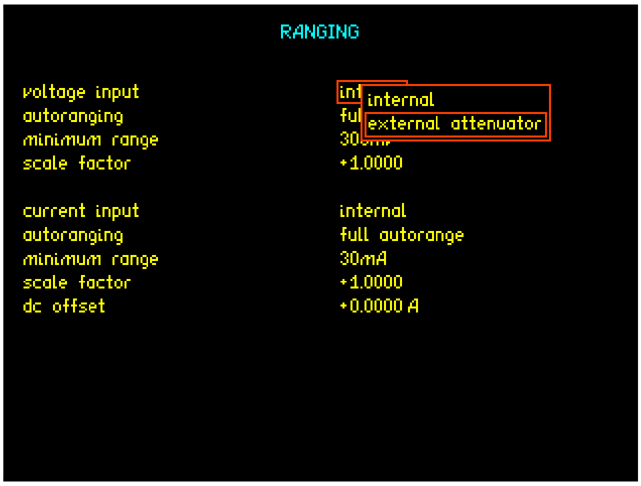
Coupling

Press COUPLING key

Press the ▼ key until the Red Box surrounds the “Coupling” options. Use the ▼& ▲ keys to select ***ac+dc*** from the drop down list.



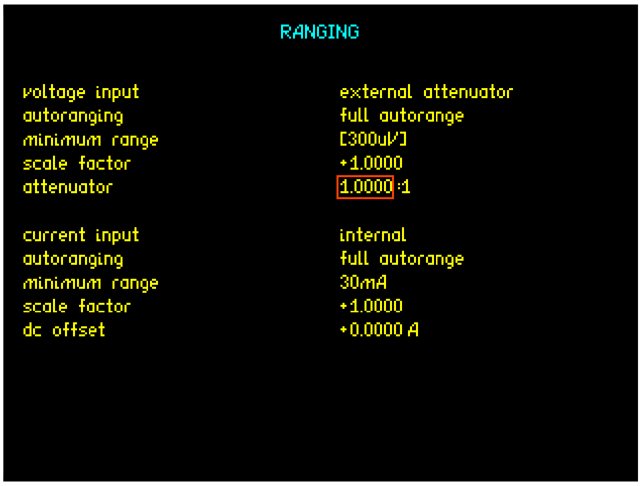
Press the ▼ key until the Red Box surrounds the ***bandwidth*** options. Use the ▼& ▲ keys to select ***wide (DC-2MHz)*** from the list.



Ranging.

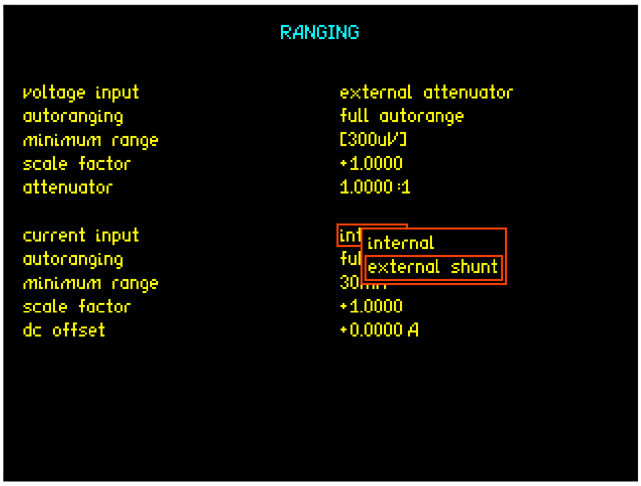
Press *RANGE* key press the ▼key until the Red Box surrounds the ***Voltage input*** options.

Use the ▼& ▲ keys to select ***external attenuator*** from the list.



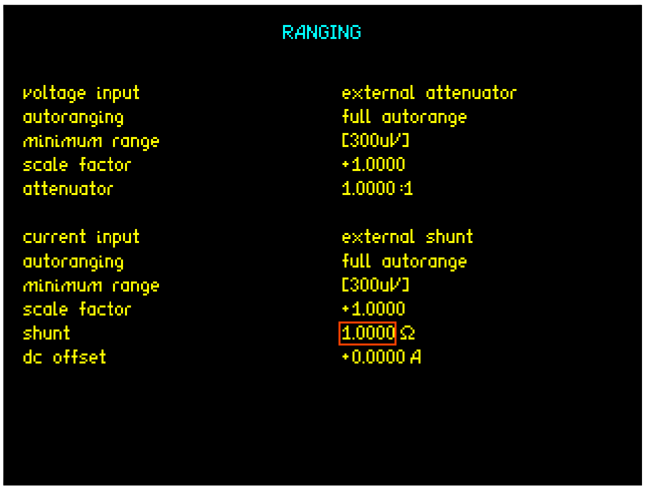
Press the ▼key until the Red Box surrounds the ***attenuator*** options

Type in an attenuator setting of ***1.0000:1***



Press the ▼key until the Red Box surrounds the ***current input*** options

Use the ▼&▲ keys to select ***external shunt*** from the list.



Press the ▼key until the Red Box surrounds the ***shunt*** options

Type in an attenuator setting of ***1.0000Ω***

Connecting the PPA to a signal Generator
A signal generator is required to provide a 1.41V PK (1.00Vrms) 50Hz sine wave, if the signal generator expects a 50Ohm load impedance then an output voltage of 0.707V (0.5Vrms) should be used. This signal is used for checking the integrity of the external voltage and external current inputs; these are 3Vpk Max Isolated Differential Voltage inputs.

The PPA is connected to the signal as shown in the drawing. The various modes on the instrument can then be selected. The following section provides screenshots of the PPA display for each of these modes.

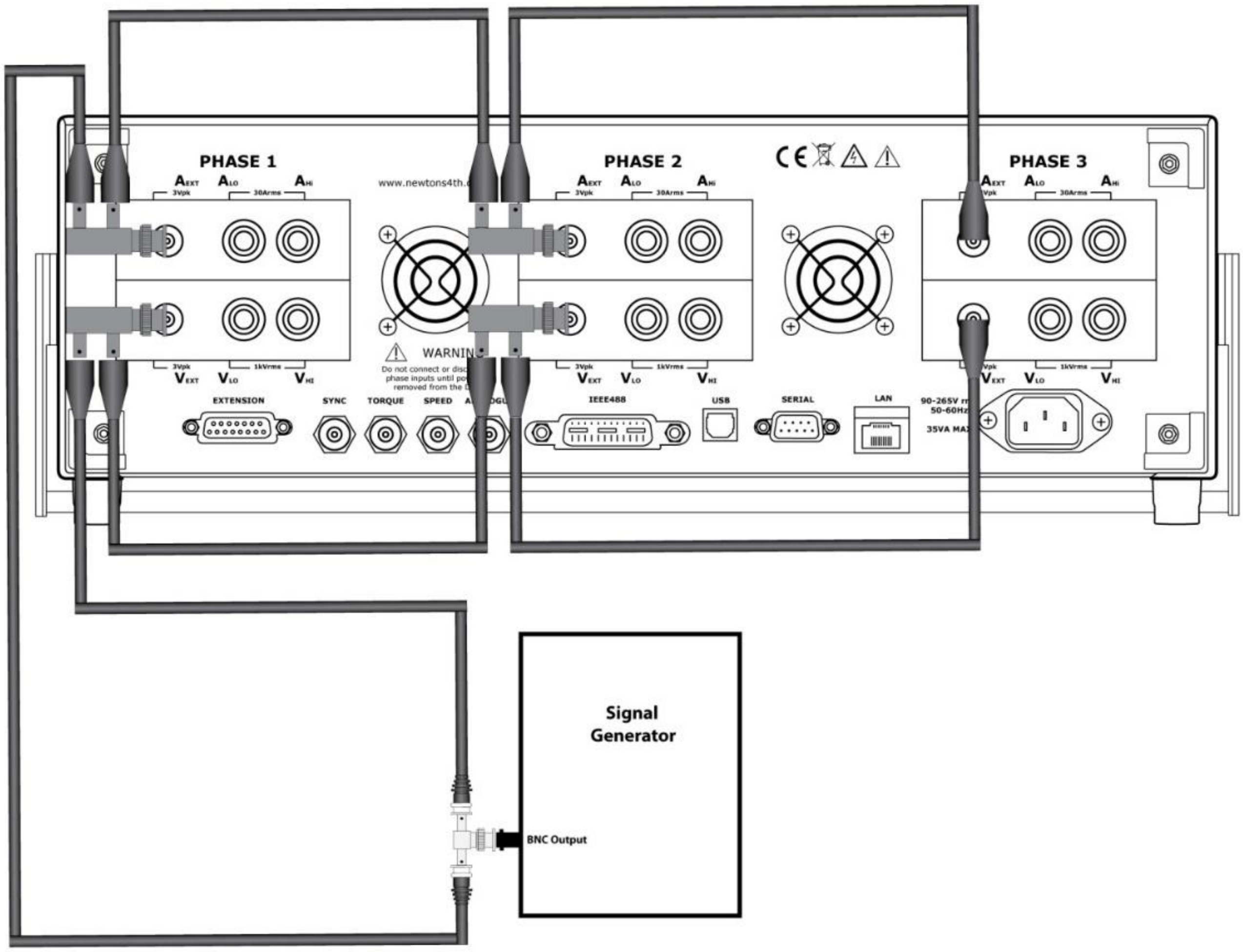
To make the connections shown in the diagram you will need the following accessories that are not supplied with the PPA.

4 x BNC cables for connections on the rear of the PPA.

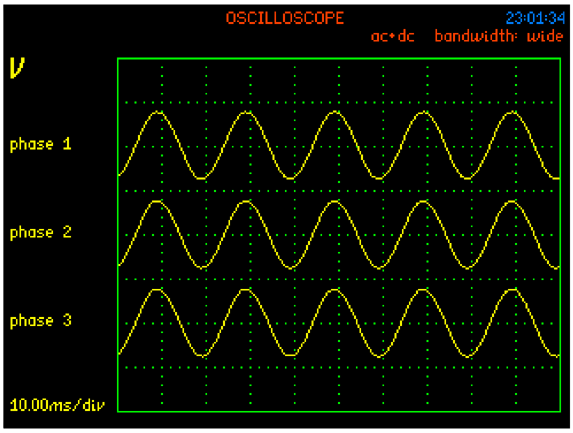
2 x BNC cables to connect between the PPA and the signal generator.

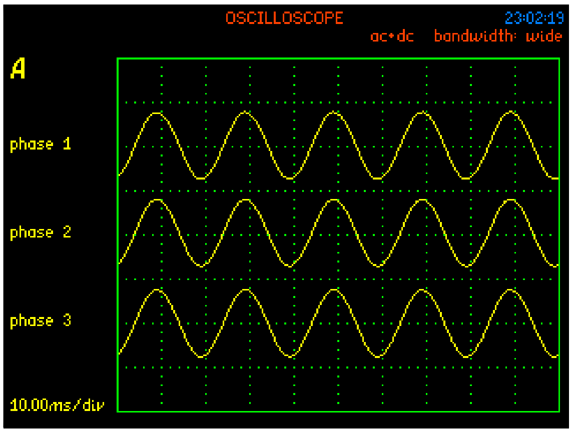
5 x BNC “T” piece connectors.

Connection diagram for the functionality checks of the External BNC inputs

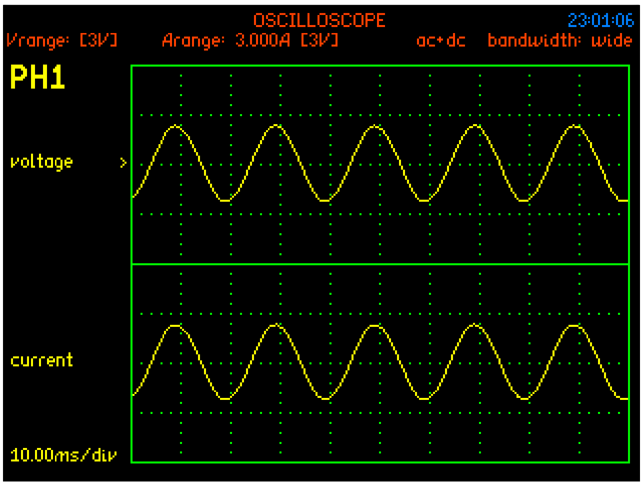


Screenshots of PPA Display when making "external" measurements.
Oscilloscope Mode

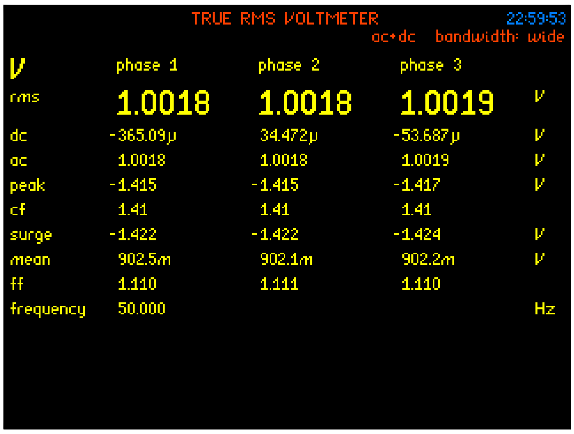


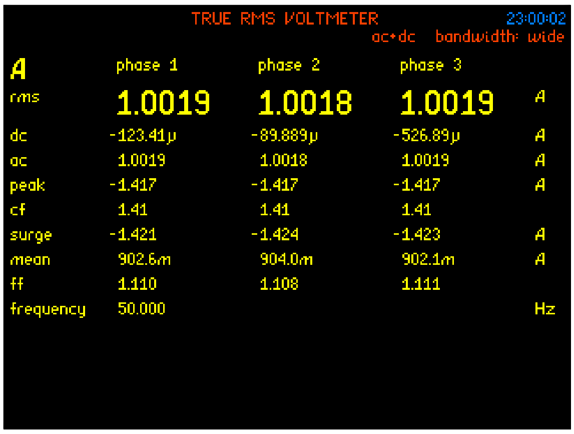


The above screenshots of the scope mode display current and voltage for all 3 phase inputs. Use the *ENTER/*►► key to scroll through the various oscilloscope displays. The screenshot below shows current and voltage for phase 1 only. Comparisons can be made of current and voltage on all 3 phase inputs. There should be zero phase shift and equal magnitude on both traces.

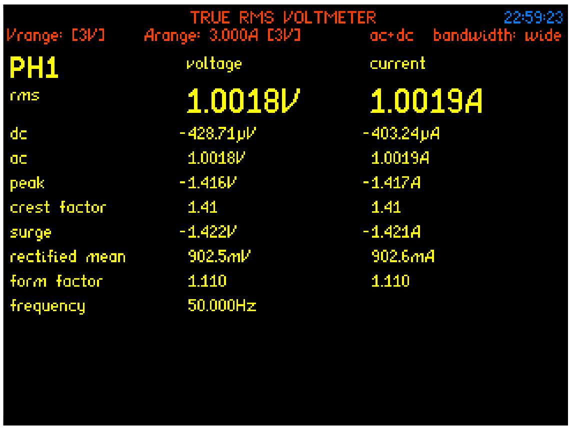


True RMS Voltmeter Mode



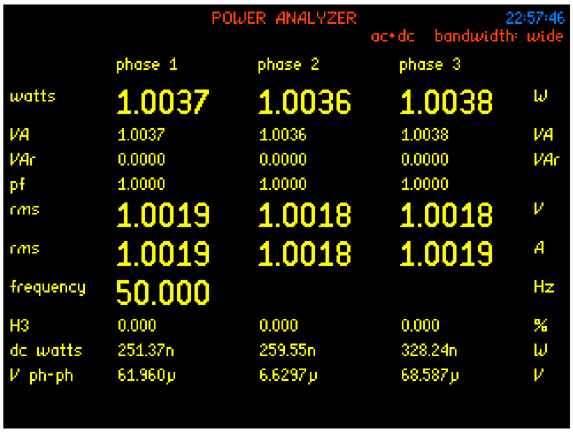


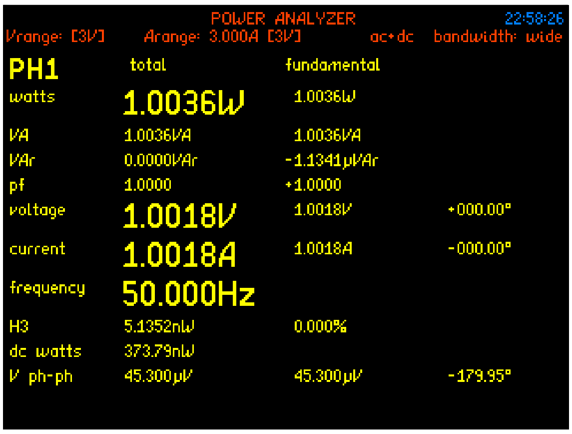
These screenshots are of the instrument in True RMS Voltmeter mode. The one on the left is displaying the voltage results for all 3 phases whilst the one on the right is displaying current for all 3 phase inputs. These allow comparisons of current and voltage readings between the 3 phases. It is also possible to check that the instrument has detected the correct frequency.



In this screenshot we are looking at just one phase, in this example phase 1. The instrument is displaying both the voltage and current readings for the one phase only. It is also possible to scroll through the various true RMS voltmeter displays to view similar results for phases 2 or 3.

Power Analyzer Mode

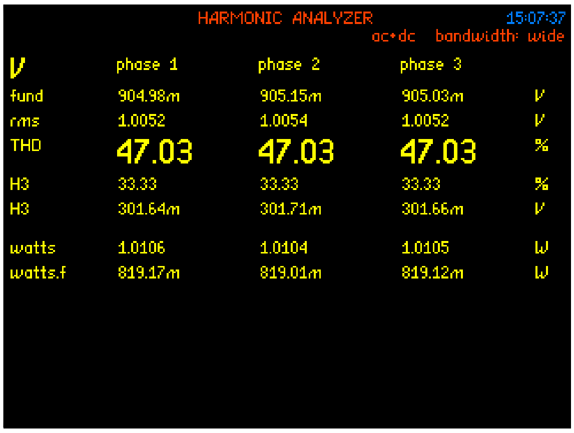


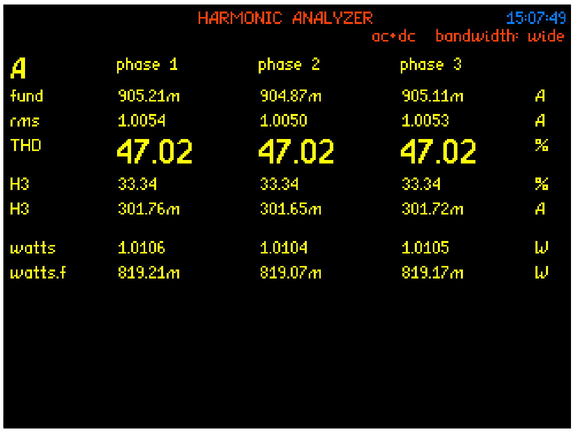


The above screenshots are of the instrument in Power Analyzer mode. The screenshot on the left is displaying the results for all 3 phase inputs. The screenshot on the right is the results for phase 1 only. Comparison of current, power and voltage can be made on all 3 phases, and it is also possible to check that the instrument has detected the correct frequency.

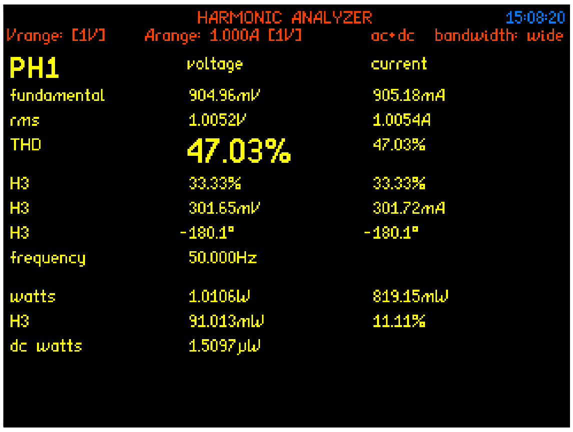
Harmonic Analyzer Mode

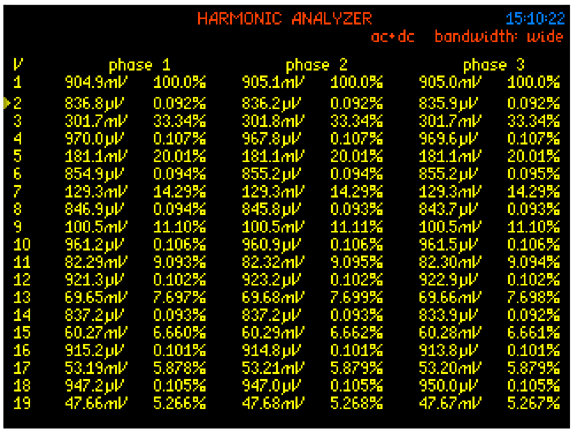
The signal generator is adjusted to provide a 1.00V PK, 50Hz square wave to check the frequency detection function of the PPA. Harmonic Analyzer mode is utilised, and correct harmonic magnitudes are displayed providing the fundamental frequency of the waveform is correctly detected.





The screenshots above show the instrument in Harmonic Analyzer mode with a square wave input. Comparisons can be made of Current, Power, Voltage and Total Harmonic Distortion on all 3 phases. When looking at a single channel it is also possible to check the frequency of the signal. The final screenshot shows that it is also possible to look at the harmonics in table form so that it is possible to look at all the individual harmonics at once. This example was for the voltage harmonics, but it is also possible to get the same table format for current harmonics.





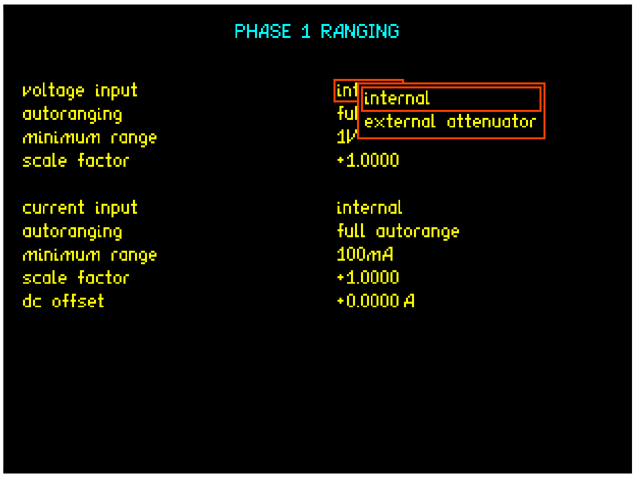
We have used a square wave as the harmonics of this waveform are well known, it is advisable to compare the harmonic values in the displayed table and ensure they are nominally the same as the table below.

Harmonic Content of a Square Wave

Harmonic Number	Frequency	Relative Magnitude
Fundamental	50 Hz	100 %
3rd harmonic	150 Hz	33 %
5th harmonic	250 Hz	20 %
7th harmonic	350 Hz	14 %
9th harmonic	450 Hz	11 %

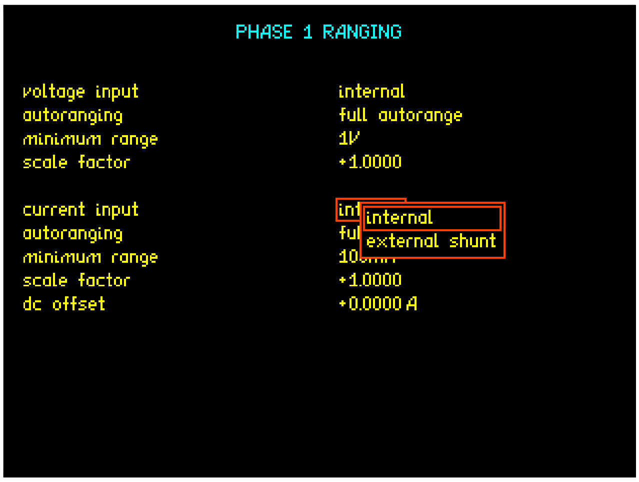
Setting up PPA for “internal” measurements.

The set up procedure for internal measurements is very similar to that above for external measurements. The only difference is in the configuration of the Ranging settings.



Ranging should be set up as follows:

Press the *RANGE* key
Press the ▼ key until the Red Box surrounds the ***Voltage input*** options
Use the ▼ & ▲ keys to select ***internal*** from the list.



Press the ▼ key until the Red Box surrounds the ***current input*** options Use the ▼ & ▲ keys to select ***internal*** from the list.

Connecting the PPA for "internal" measurements.

The breakout box (see Appendix A for further details of this accessory) is connected to a mains supply. A load is connected to the breakout box to produce a current for the PPA to monitor. The PPA is used to monitor the voltage and current on the connections of the breakout box. The same voltage and current levels are applied to the 3 phase inputs of the PPA. Therefore, the display should indicate the nominally same values for all 3 phases. For the tests illustrated in this manual a 230V 50Hz mains supply was used, the load used was sinking a current of 3.00A.

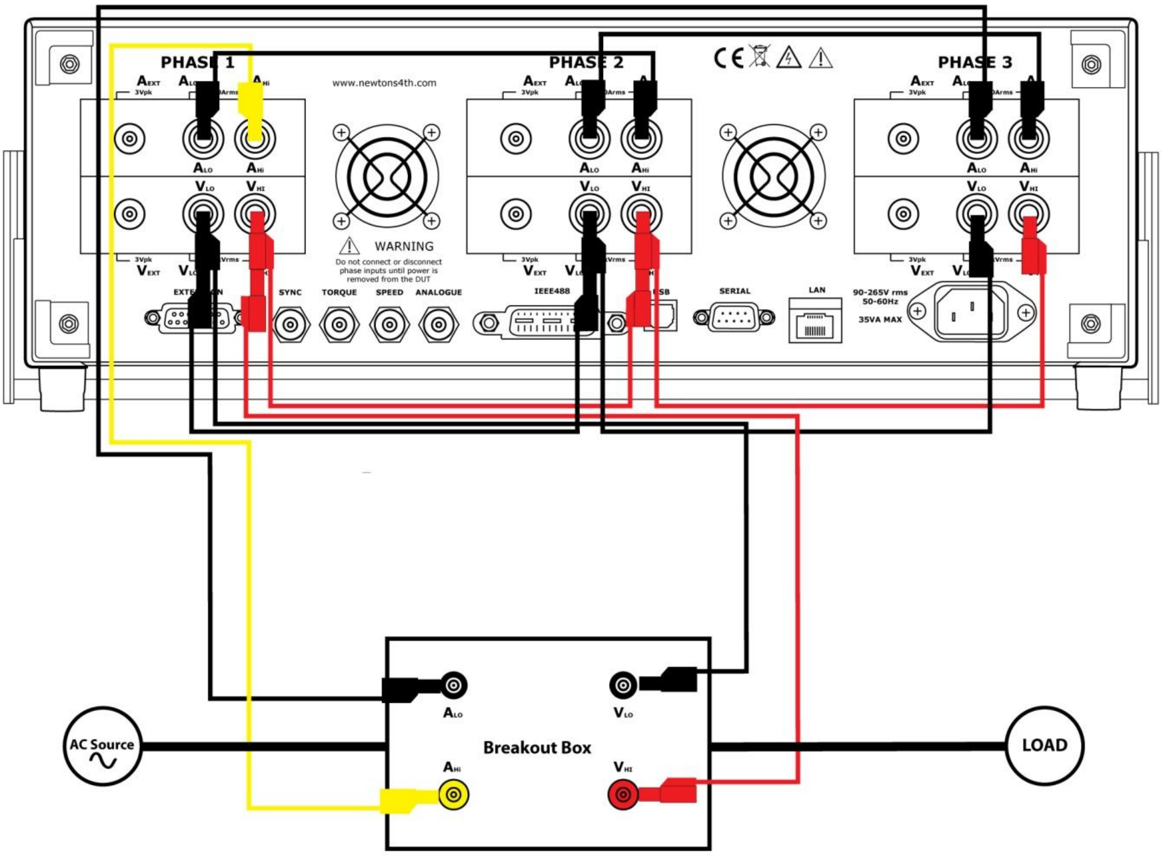
To make the connections shown in the diagram you will need the following accessories that are not supplied with the PPA.

1 x breakout box.

1 x Load that will be connected to the breakout box.

All other connections can be made using the 4mm safety leads supplied with the PPA.

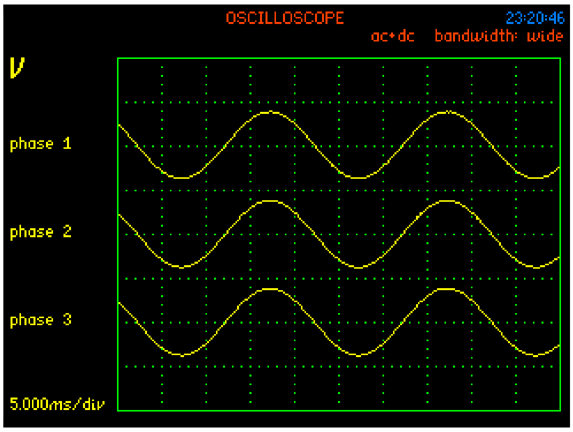
Connection diagram for the functionality checks of the Internal 4mm sockets inputs.

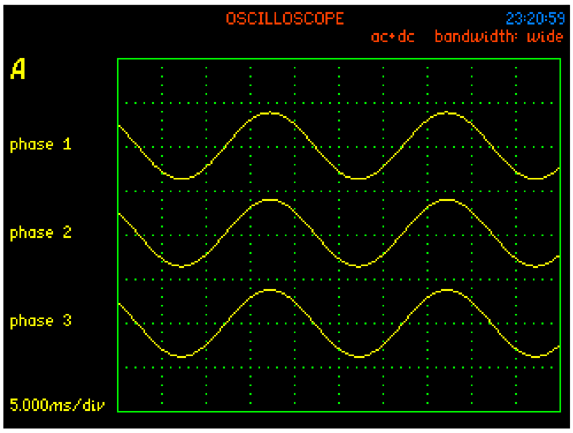


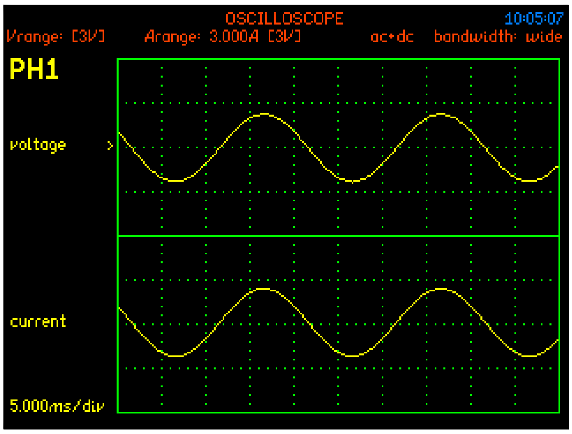
Screenshots of PPA Display when making "internal" measurements.

The following screenshot examples were taken with the PPA set up for internal measurements. For full descriptions for each of the PPA modes please refer to the "external" measurements

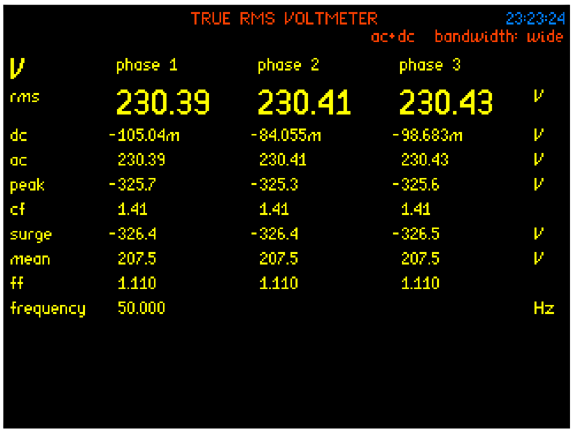
Oscilloscope Mode

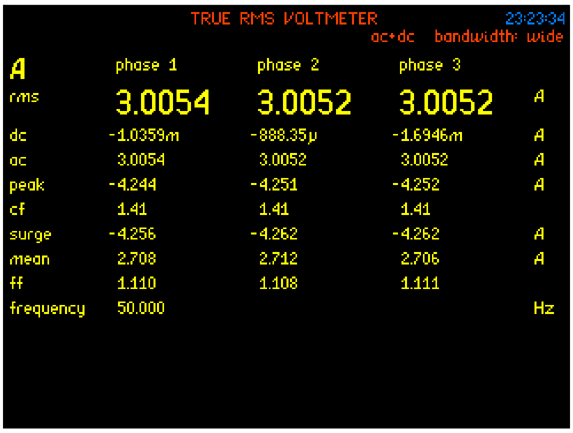


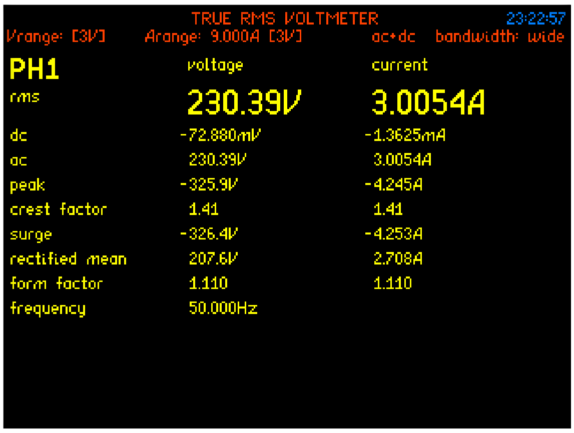




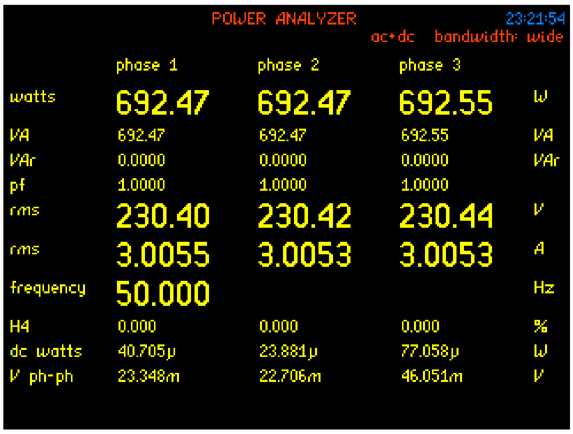
True RMS Voltmeter Mode

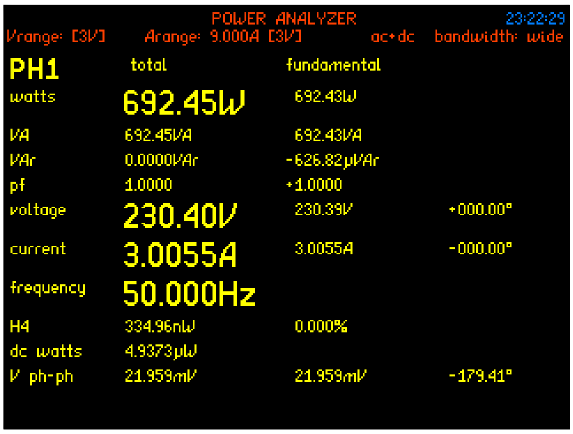




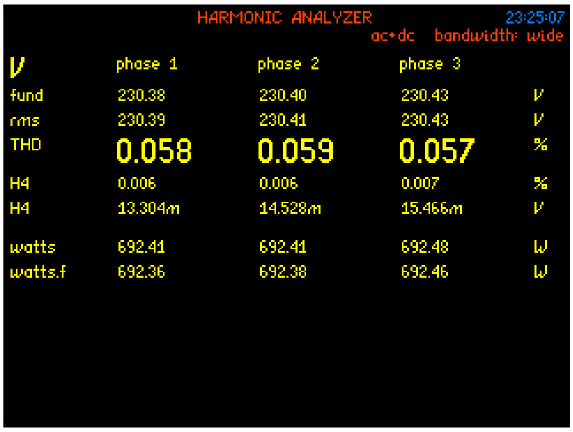


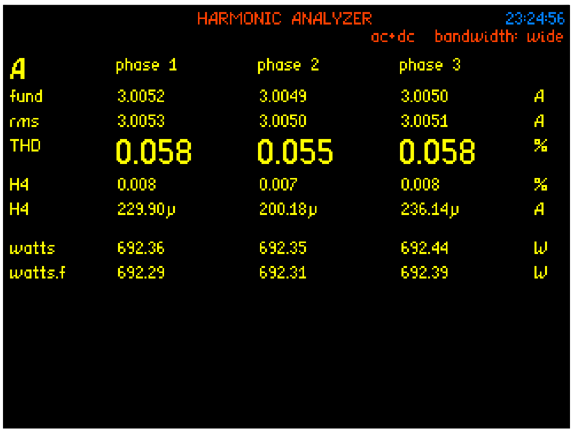
Power Analyzer Mode

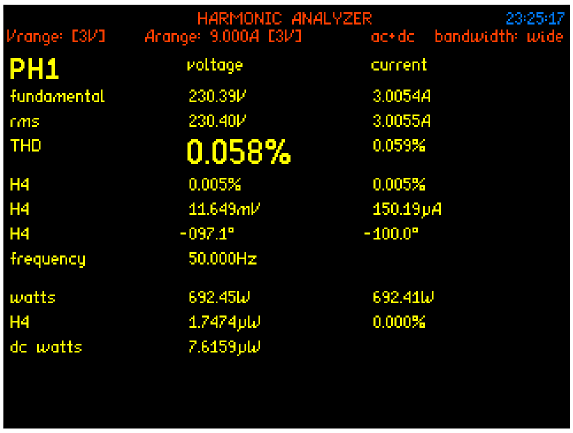




Harmonic Analyzer Mode







Harmonic verification

Verify that Vthd is nominally the same across all phases inputs, as a reference signal (such as a square wave) is not being used we cannot verify individual harmonic magnitudes. This is not a problem as we have already verified this with the external inputs.

Basic Fault Symptoms and Causes

Symptom	Cause
Noisy trace on external voltage input	Possible damage to analogue front end circuitry caused by excessive voltage
Noisy trace on external current input	Possible damage to analogue front end circuitry caused by excessive current
Flat trace on external voltage input	Possible damage to digital circuitry in voltage card
Flat trace on external current input	Possible damage to digital circuitry in voltage card
Incorrect Voltage reading on External Input	Possible damage to input attenuator caused by excessive voltage
Incorrect Current reading on External Input	Possible damage to input attenuator caused by excessive voltage.
Incorrect Voltage reading on Internal Input	Possible damage to input attenuator caused by excessive voltage
Incorrect Current reading on Internal Input	Possible damage to current shunt caused by excessive current
Incorrect Harmonic magnitude on external input	Possible damage to analogue input circuitry / Incorrect frequency detection
Incorrect Harmonic magnitude on internal input	Possible damage to analogue input circuitry / Incorrect frequency detection

Chapter 9 Menus-how to use and navigate them

Main menus There are twelve main menu options available, these are labelled under each of the twelve numeric keys and are accessed by a single keypress.

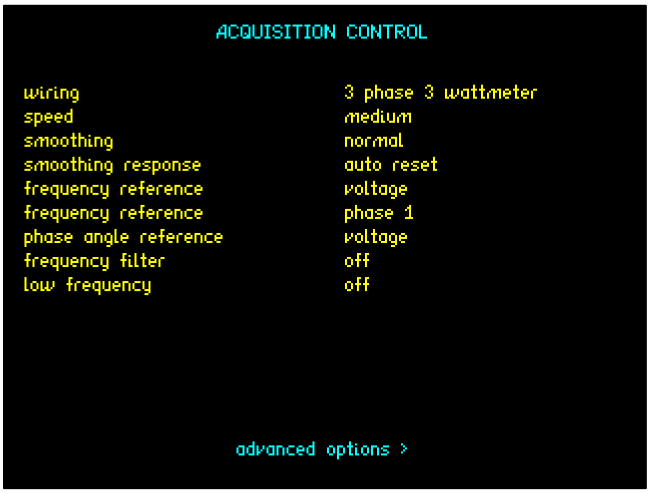
The PPA4500 Series can be configured for a wide range of application disciplines. Keys 1-9 on the alphanumeric keyboard, +/- and decimal point are used to access the menus to set up the PPA4500 Series to suit the intended measurement application.

ACQC	Press key 1
Acquisition Control: Used for configuring inputs appropriate to source and nature of signals being analysed	
COUPLING	Press key 2
There are three coupling options - AC only, AC+DC, or DC only. AC+DC coupling is the default option and should be used where possible. The coupling option does not affect the bandwidth of the instrument only the frequency detection	
RANGE	Press key 3
Input channel options	
DATALOG	Press key 4
Interrogation and extraction of information resulting from a test log in a specified time scale and at a set speed	
APP	Press key 5
Application function to be selected	
MATHS	Press key 6
Used to select appropriate formulae for derived units not directly measured	
ALARM	Press key 7
Used to select the alarm types and options	
REMOTE	Press key 8
Press to set the data resolution and change the format to which the instrument responds to future commands, via Comms interface	
AUX	Press key 9
Used to select and setup specific parameters for any optional accessories connected to the PPA	
SYS	Press key ±
Used to set general system wide controls	
MODE	Press key 0
Used to select pre-programmed instrument functions	
PROG	Press the decimal point **.** key
Recall/Store/Delete of non-volatile programs	

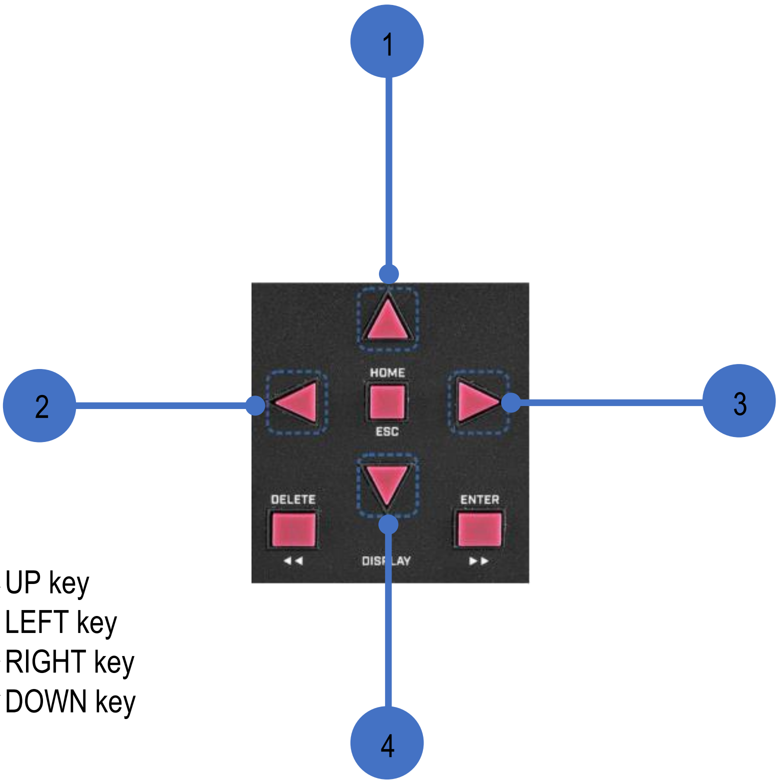
Selection from a list

This data type is used where there are only predefined options available such as the output may be 'on' or 'off', or the bandwidth may be low, wide, or auto.

Upon entry to any of the twelve main menus, no options are highlighted (ACQU menu screen shown below)

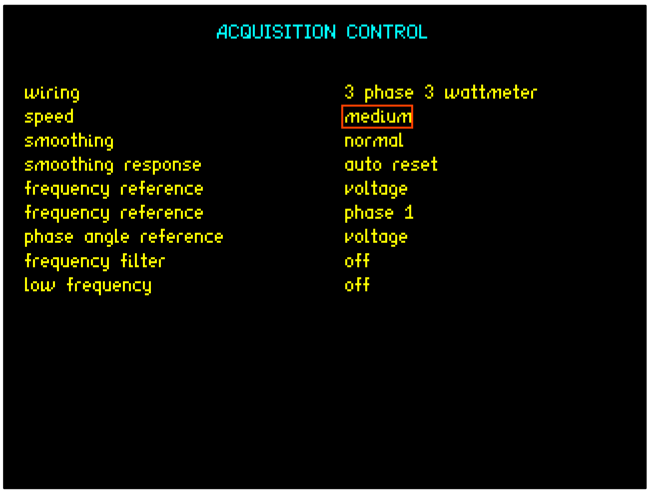


If the ▼ key is then pressed the first option will be highlighted by a flashing box



1 ▲UP key
2 ◄LEFT key
3 ►RIGHT key
4 ▼DOWN key

4 way navigation keys for the menus and data entry



Press the ▼ a second time then the flashing cursor will highlight the second parameter, ***speed***. The ► key steps forward through the list, & the ◄ key steps backwards through the list. When the correct option has been highlighted by use of the ►&◄ keys, then *Enter* must be selected to choose that parameter.

The number keys, 0-9, depending on the number of options available, jump directly to the appropriate position in the list, this provides a quick way to jump through long lists. Again, *Enter* will need to be pressed to select the desired choice.

For example, if the speed selection list comprises the options:

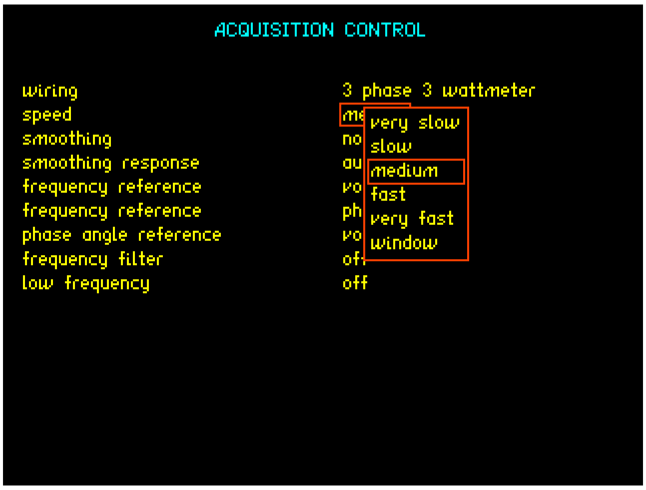
very slow	(item 0)
slow	(item 1)
medium	(item 2)
fast	(item 3)
very fast	(item 4)
window	(item 5)

and the presently selected option is ***medium***, there are 3 ways to select ***window***:

press ► twice followed by *Enter*

press ◄ three times followed by *Enter*

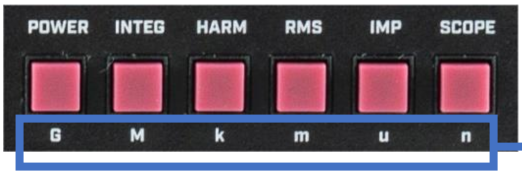
or press number *5* key followed by *Enter*



Direct numeric entry

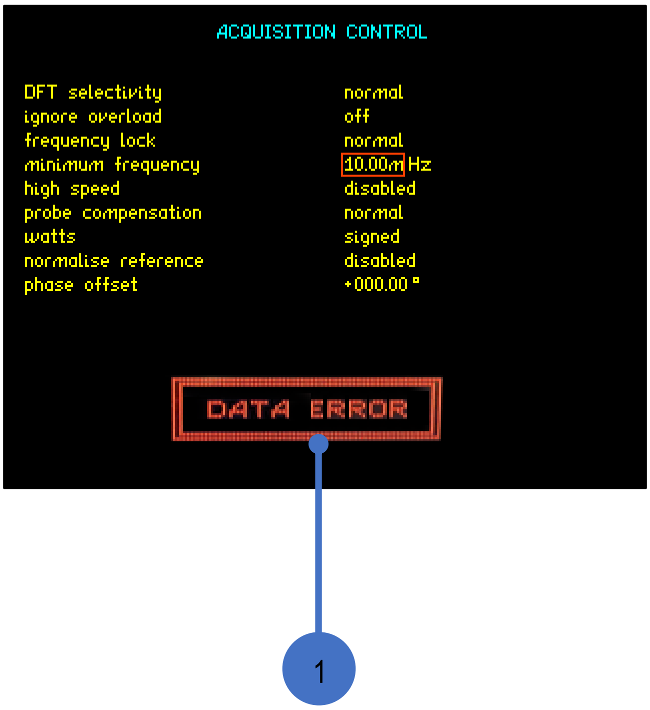
Parameters such as frequency and phase offset are entered as numeric characters; frequency is an example of an unsigned parameter; phase offset is an example of a signed parameter.

Numbers are entered using the number keys, decimal point key, and +/- key (if a signed value is permitted), & if required, the SI unit prefix multiplier keys (G, M, k, m, µ, & n) will add the associated prefix.



When the numeric character string has been entered, pressing the *ENTER* key (item 12) sets the parameter to the new value. Until the *ENTER* key is pressed, pressing the *HOME* key (item 11) aborts the data entry and restores the original number.

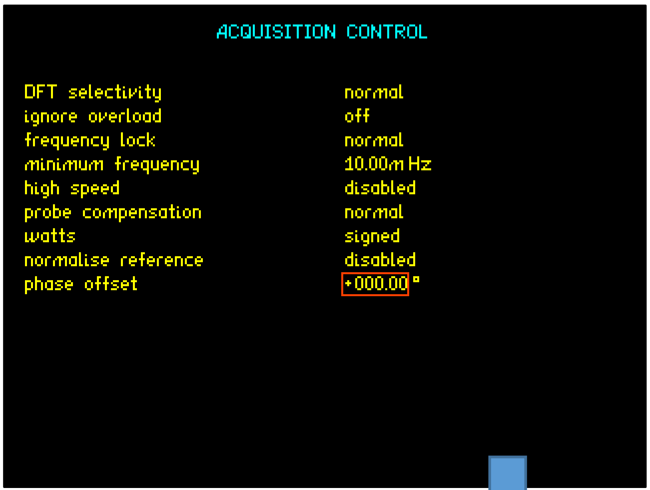
If the numeric data value is entered that is outside the valid limits for that parameter, then a warning beep is heard, a message is displayed on the screen showing ***DATA ERROR*** and the parameter is re-set as close to the requested value as possible. For example, the minimum frequency; if a value under 10mHz is entered, a warning beep together with a message will be given, and the value set to the minimum of 10mHz as shown below.



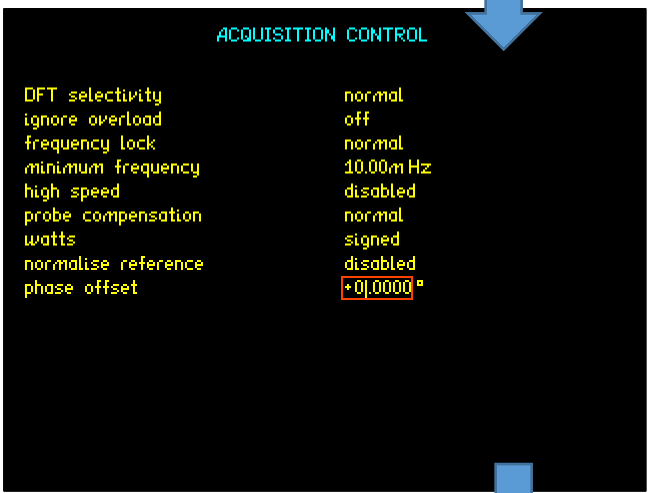
When any menu is first displayed the numeric parameters will have no cursor “□” visible.

There are two types of numeric variables, those showing an integer value and those showing a decimal value.

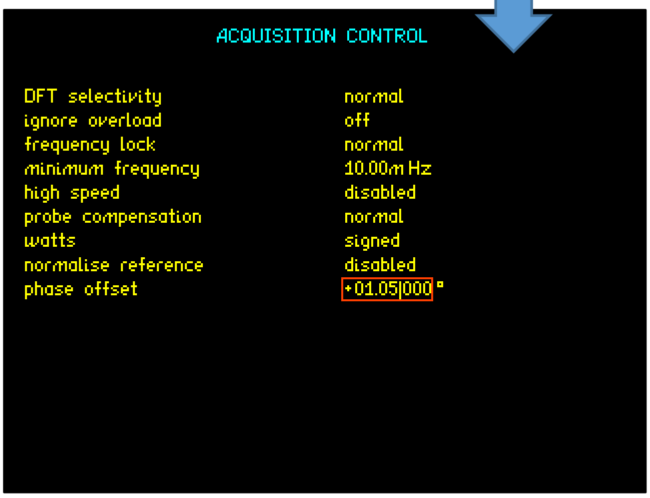
To edit a decimal numeric value such as ***phase offset*** in the screen shot below, use the ▼key to highlight the numeric value, in this case you would need to press the ▼key nine times to highlight the ***phase offset*** numeric value. Once highlighted a new number will overwrite the existing value if any numeric key(s) are pressed.



1. If you wanted to edit the value to be 1.05˚ for example
2. Press ► x1 to display the cursor | as shown in the second screen shot



3. Press ► x2 to insert & move the cursor 2 places to the right
4. Press 1 once, to insert a 1 to the left of the cursor |



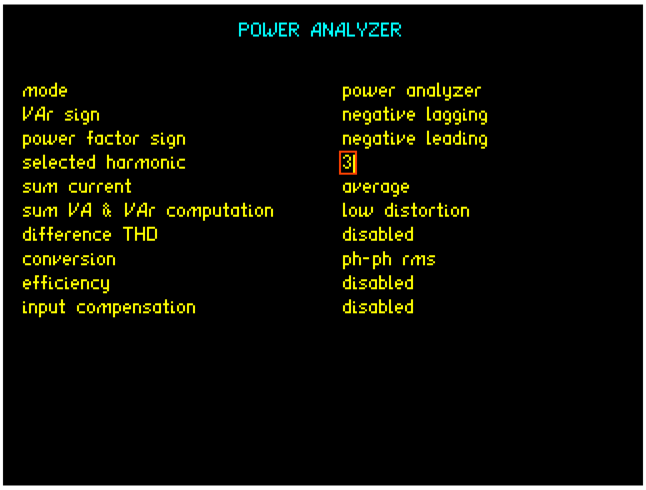
5. Press► x2 to move the cursor 2 further places to the right.
6. Now press 5
7. Press *ENTER* and now the value is saved for that parameter.

If you want to correct a mistake, then pressing *DELETE* will delete the character to the left of the current cursor position.

If you need to change a value after pressing *ENTER,* then use the ▼ key to position the cursor against the correct parameter and use the ► key to move the cursor to the right of the character you want to delete.

REMEMBER the numeric keys and the *DETETE* key always affect the character to the left of the cursor

To edit an integer numeric value such as ***selected harmonic*** in the *POWER ANALYZER* menu shown below, figure 23



Using the ▲ & ▼ keys move the highlight to the desired line.

Use of the ◄ & ► keys to increase or decrease the selected value.

Alternatively use the numeric keys to enter the value directly. If a multiple digit value is entered, then the ◄ & ► keys can be used to position the cursor for editing as above.

INFORMATION. Data values are always shown in engineering notation to at least 5 digits (1.0000-999.99 and a multiplier).

Text Entry

There are occasions where it is useful to enter a text string; for example, a non-volatile program may have some text as a title.

Text is entered by selecting one of 6 starting characters using the main function keys on the top right hand side of the keyboard (item 7), then stepping forwards or backwards through the alphabet with the ▲and ▼ keys.

The starting letters are A (*POWER*), E (*ITEG*), I (*HARM*), O (*RMS*), U (*IMP*), or space (*SCOPE*). You can continue from any one of the starting letters backwards and forwards using the ▲and ▼ keys step forward and backwards using the ASCII character definitions – other printable characters such as # or ! can be obtained by stepping on from the space. The available character set is given in the Appendix. Numbers can also be inserted using the number keys.

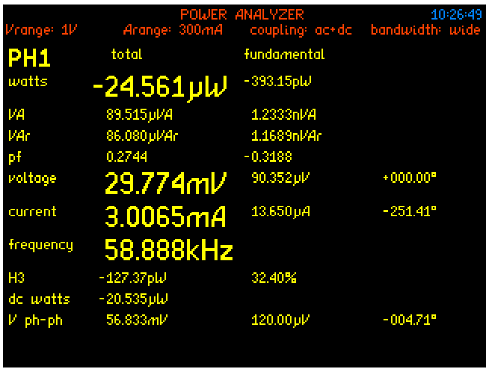
When entering alphabetic characters, the *ZOOM+* and *ZOOM-* keys select upper and lower case respectively for the character to the left of the cursor and the next characters to be entered.

The editing keys, ►◄, *DELETE* and *ENTER* operate in the same way as for numeric entry.

User Data

When the PPA4500 is first powered on, for approx. 4 seconds a splash screen is shown, by default, the instrument model, firmware version and Newtons4th Ltd. will be displayed. This splash screen can be edited and personalised to your company details.

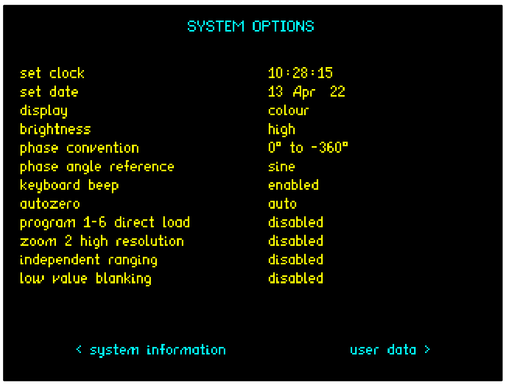
(N.B. The screen shot shown is of a PPA5530, however a PPA4500 series is identical except for the model number)



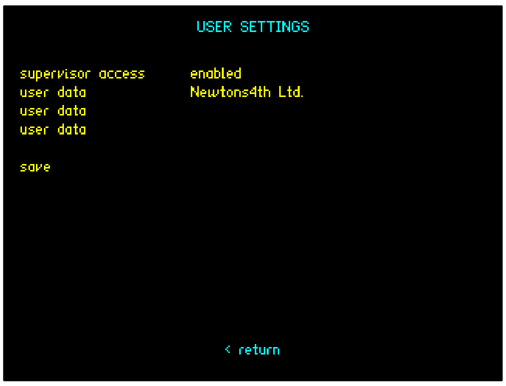
The splash screen then changes to the default real time Power Analyzer screen

Editing the User Data

To do so, press the *SYS* key followed by the ► key which will then display the following screens: -

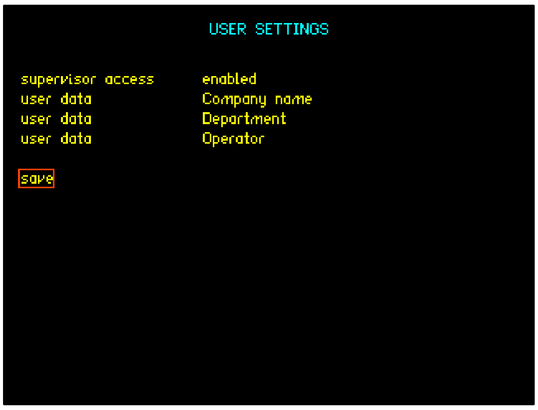


then



There are 3 lines of ***user data*** that can be edited to suit the user, (see section preceding section, Text Entry)

A sample of edited ***user data*** is shown here



As can be seen in this screen, the 3 lines of user data have been set to “Company name”, “Department”, and “Operator”, however these can be edited by the user to read appropriately to your usage, i.e., “operator could be “Asset No.” or similar.

Supervisor Mode

For use in a production environment where it is desirable that the operator cannot be able to change and save the settings, the PPA4500 offers supervisor mode. When supervisor mode is enabled, the stored programs can only be recalled, and not changed.

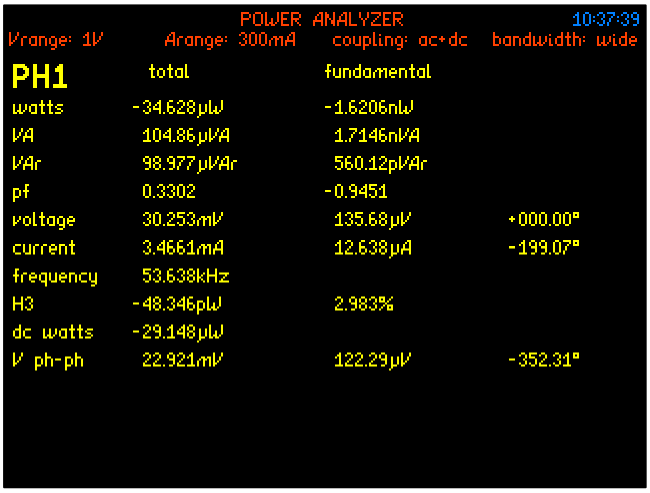
After changing the user data or supervisor status, execute ***save*** by highlighting the command with the use of the ▲ & ▼ keys and then pressing *ENTER* to save the data in non-volatile memory.

The next time the instrument is switched on, the splash screen will show the three lines of ***user data*** and the ***supervisor*** status will be that last saved.

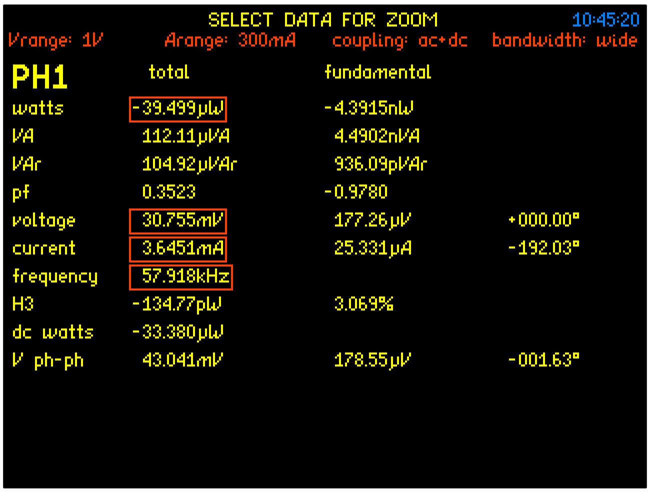
Special Functions

Display Zoom

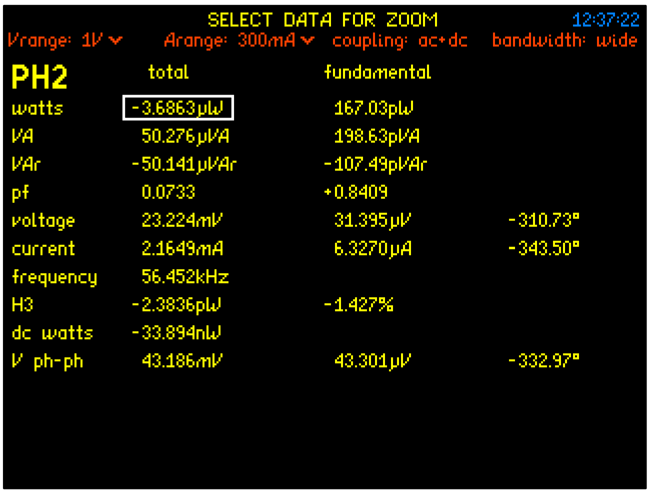
The PPA4500 normally displays multiple results on the screen in a small font size. The zoom function enables the PPA4500 to display a mixture of up to 4 user selected parameters in a larger font size along with the remainder in the standard size, alternatively the four selected parameters only can be shown by themselves in an extra-large font size.



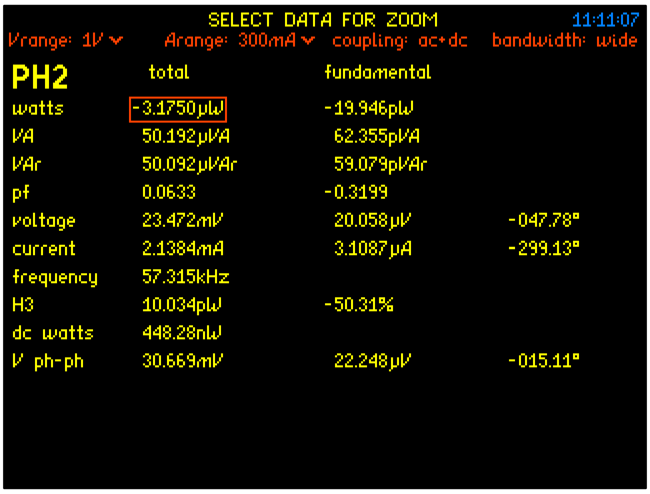
To set which parameters are to be displayed in the larger font size, first return to a no zoom condition by pressing the *ZOOM-* key twice, if necessary, as each press of *ZOOM-* will reduce the font zoom.



Press the *ZOOM+* key to view the presently selected data (solid red non flashing highlight box(s)), and press *DELETE* to clear the whole selection.

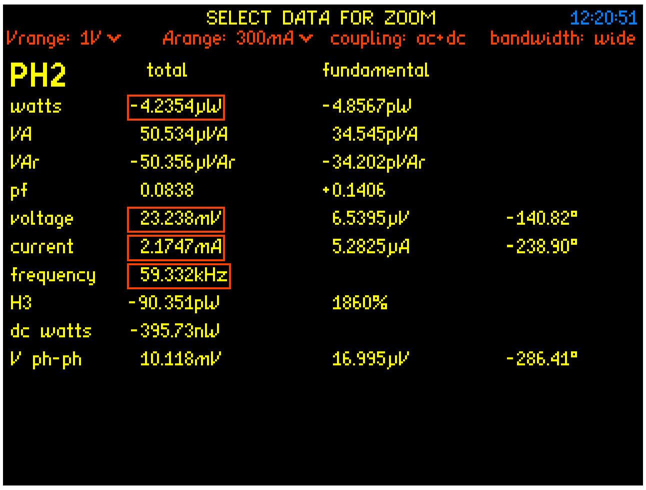


In the example shown here, if the *DELETE* key is pressed all the selected parameters will be deleted for the zoom functions. The topmost left parameter is then highlighted by a flashing white box, but it has not been selected for zoom until the *ENTER* key is pressed and the highlight box stops flashing and turns solid red as the cursor moves to the next parameter.

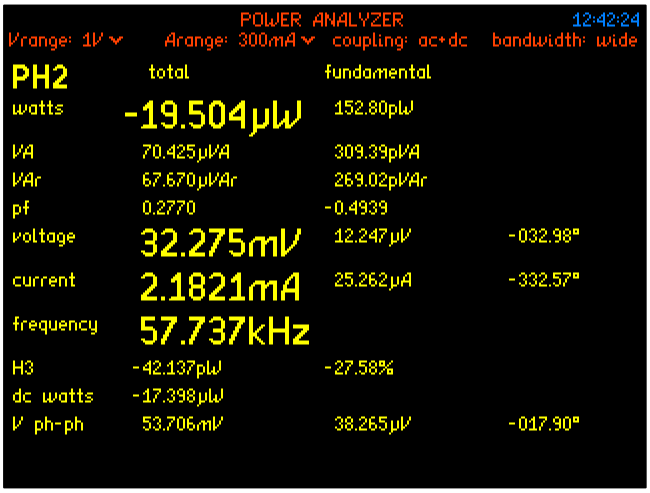


Each parameter that you want to select for zoom display can be selected by using the ▼, ▲, ►, & ◄ keys. The ▲ & ▼ keys allow the selection of the parameters and will if continuously pressed cycle from the top to the bottom and back to the top again. Similarly, the ► & ◄ keys will swap from one column to the other, Total and Fundamental in this case.

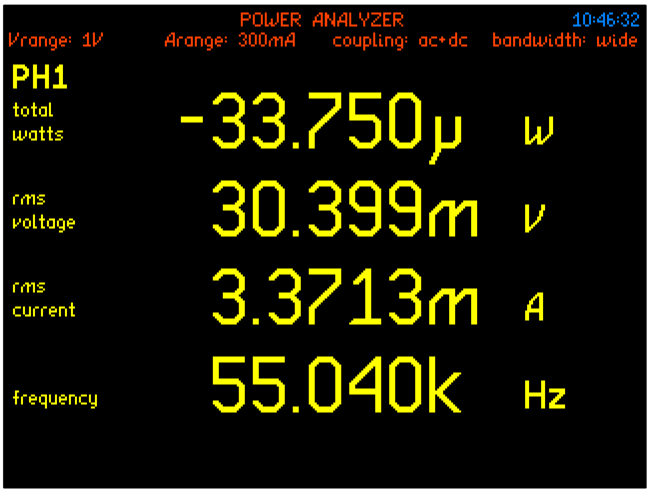
The PPA4500 supports 1-4 parameters in both zoom modes, it is not necessary to have to select four parameters. Each solid highlight signifies that the parameter will be zoomed when the *ZOOM+* key is pressed. If a fifth parameter is selected, the first parameter will be deselected.



Having selected the chosen parameters for zooming, pressing the *ZOOM+* key will display the first level of zoom.

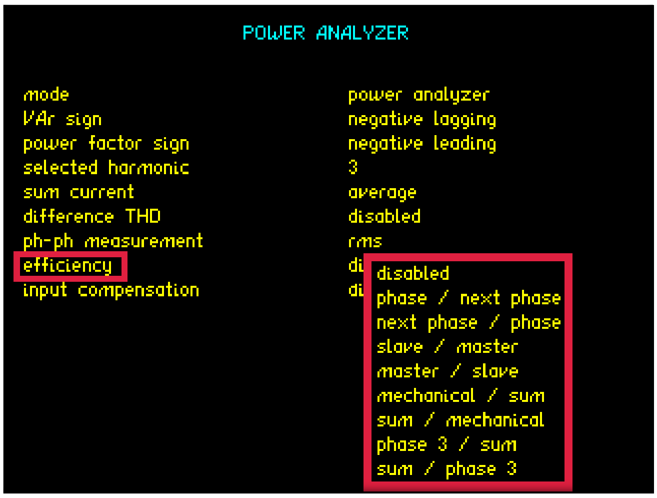


The next press of the *ZOOM+* key will increase the zooming effect and only show the selected parameters on the screen as shown in the screen shot below.



EFFICIENCY

The “Efficiency” mode will compute and compare the data results from any of the configurations shown within the screenshot below



To select the “Efficiency” parameter from any application mode.

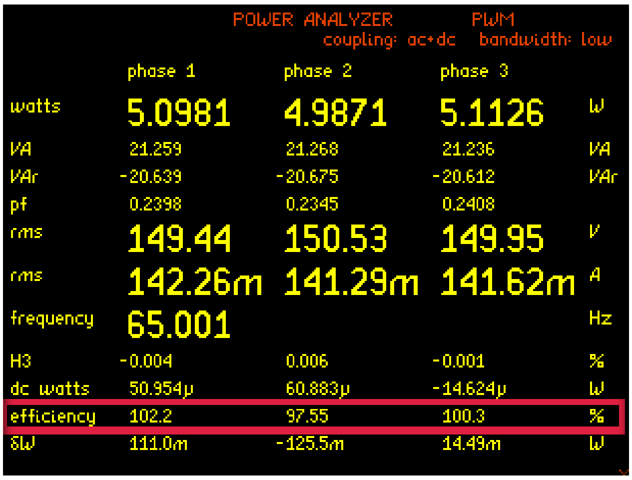
Access the Power Analyzer home screen and press *POWER* this will take you into a sub menu.

Scroll down to the ***efficiency*** parameter and press ► key, this will open the dropdown menu with all available configurations as shown

Use the ▲ & ▼ keys to move through the configurations and press *ENTER* to select and confirm

Press *HOME* to return to the Power Analyzer display screen

The results will then be displayed at the end of the Power Analyzer home screen as shown



Chapter 10 Instrument modes

The PPA4500 Series has nine different modes, these are selected via the Mode menu, six of them are also accessible from the direct selection keys (see item 7)

In this section each mode will be described with examples and help on the best configurations to select for different DUT's.

The modes are:-

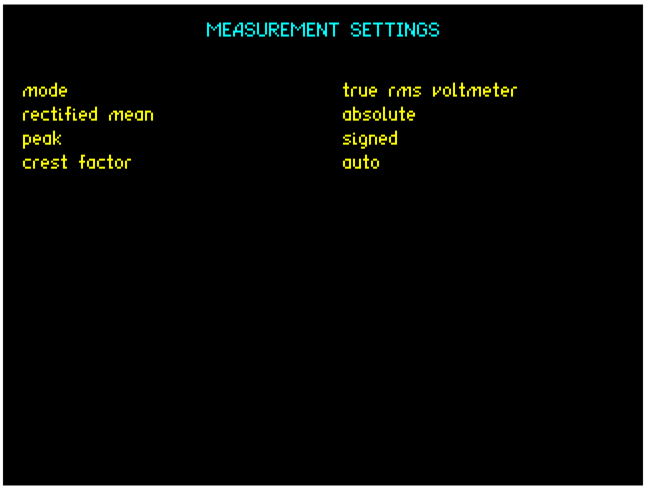
True RMS Voltmeter *
Phase Meter
Power Analyzer *
Impedance Meter *
Power Integrator *
Harmonic Analyzer
Oscilloscope *

The entries above designated with an asterisk are also available directly from the keys at the top right side of the keyboard, labelled POWER, INTEG, HARM, RMS, IMP, and SCOPE. (See item 7)

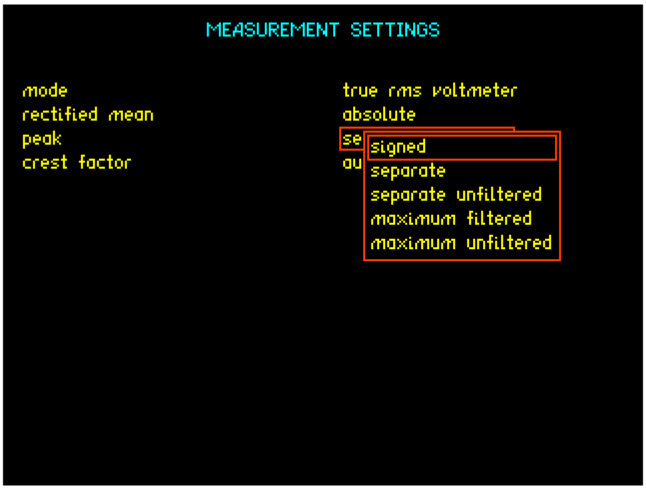
True RMS Voltmeter

Atypical application that would utilise True RMS Voltmeter would be for measuring the inrush current of a DUT with the aid of our PCIS accessory (see Appendix A)

When selecting True RMS Voltmeter from the Mode menu, the default measurement settings screen is displayed as shown below.



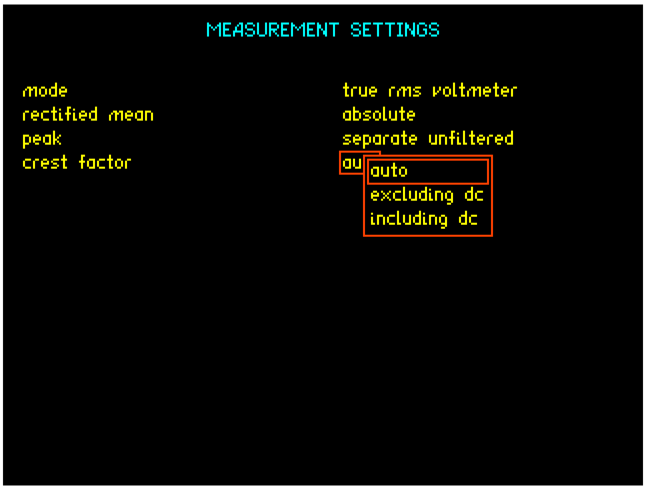
Rectified mean can be set to either ***normalised*** or ***absolute***



The ***Peak*** parameter can be set to the options shown below.

Signed, separate & ***separate unfiltered*** are updated on a per window bases. Whereas ***maximum filtered*** and ***maximum unfiltered*** are parameters that are updated when the value is higher than the existing displayed value, and not refreshed for each window.

In all cases unfiltered ignores the effect of the smoothing filter if that has been selected.



The option selected for the crest factor parameter alter the way in which the crest factor is calculated.

Auto – If the DC component is < 2% of the rms value then: -
cf =(positive peak - negative peak) / 2 * rms
otherwise it is calculated as including DC

Including DC
cf= abs(peak) / RMS

Excluding DC
cf== (positive peak - negative peak) / 2 * ac

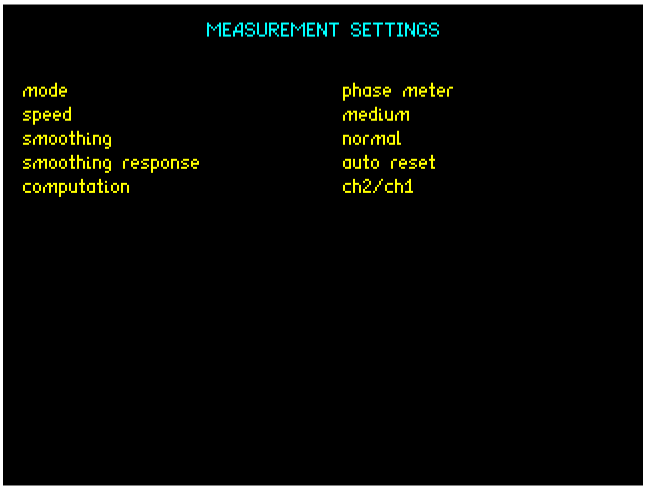
Phase Meter

The phase meter mode is a secondary function which does not have a separate direct access key. It is only selected by stepping through the operating mode via the *MODE* menu. The phase meter uses the terminology of channel 1 for voltage and channel 2 for current as it is normal to use a phase meter to compare voltages directly. In this case, the current input is set to external attenuator in the *RANGE* menu, and a voltage probe (oscilloscope probe) can be used. For optimum phase accuracy, the same type of voltage probe should be used for the voltage input which can also be set to external attenuator in the *RANGE* menu.
Remember to trim the oscilloscope probes, if necessary, by connecting them to a 1kHz square wave and adjusting them for 33.3% 3rd harmonic in the ***harmonic analyser*** mode.

The phase meter measures the phase and gain of channel 2 relative to channel 1 using a discrete Fourier transform (DFT) algorithm at the fundamental frequency. Relative gain is given as an absolute value and in dB. The ratio can be inverted to give the gain of channel 1 relative to channel 2.

To look at differences in gain from a nominal value, an offset gain can be applied either manually or by pressing ZERO.
offset gain = measured dB – offset dB

The screen below is displayed on first selecting ***phase meter*** in the *mode* menu.



Speed – This is the same control parameter as is accessed in the *ACQU* menu see here for full details.

Smoothing and ***smoothing response*** are also the same parameters that are available in the *ACQU* menu.

Computation- The default is ch2/ch1, however ch1/ch2 can be set if required.

Speed	Update Rate	Normal Time Constant	Slow Time Constant
Very Fast	1/80s	0.05s	0.2s
Fast	1/20s	0.2s	0.8s
Medium	1/3s	1.5s	6s
Slow	2.5s	12s	48s
Very Slow	10s	48s	192s

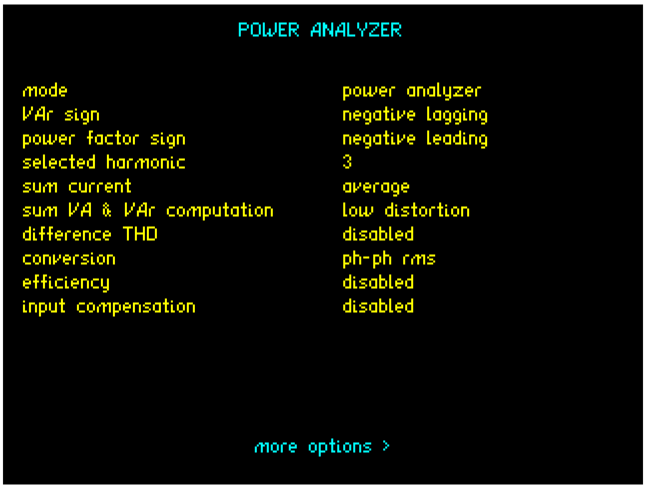
Power Analyzer

In the POWER Analyzer mode, the PPA4500 series measures the following values for each phase:

Parameter	Type	Units
Frequency	elementary	Hz
True power	elementary	W
Apparent power	secondary	VA
Reactive power	secondary	VAr
Power factor	secondary	Unitless
RMS voltage	elementary	V
RMS current	elementary	A
Fundamental power	secondary	W
Fundamental VA	secondary	VA
Fundamental VAr	secondary	VAr
Fundamental power factor	secondary	Unitless
Voltage fundamental	elementary	V
Current fundamental	elementary	A
Voltage magnitude	secondary	V
Current magnitude	secondary	A
phase	secondary	degrees
Voltage harmonic	elementary	V
Current harmonic	elementary	A
Voltage harmonic magnitude	secondary	V
Current harmonic magnitude	secondary	A
DC voltage	elementary	V
DC current	elementary	A
DC power	secondary	W
Peak voltage	elementary	V
Peak current	elementary	A
Rectified mean voltage	elementary	V
Rectified mean current	elementary	A

All elementary parameters (e.g., Watts) are computed from their true definitions in real time so the measurements are valid for all waveshapes. Secondary parameters are computed from one or more of the elementary parameters (e.g., VA = Vrms x Arms).

Not all the parameters listed are displayed in POWER mode, but they are all computed, these can be accessed via the remote control commands. (See Appendix B)



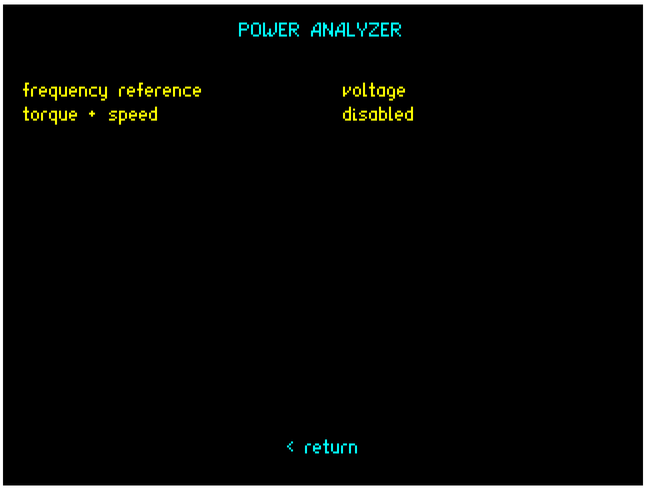
On entering the Power Analyzer mode either by 2 presses of the direct access key labelled *POWER*, or via the drop down menu found on the *MODE* key, the first settings screen is displayed.

Pressing the ▶ key displays the more options screen as shown below.

Both ***VAr*** and ***power factor*** can be switched between negative leading or lagging.

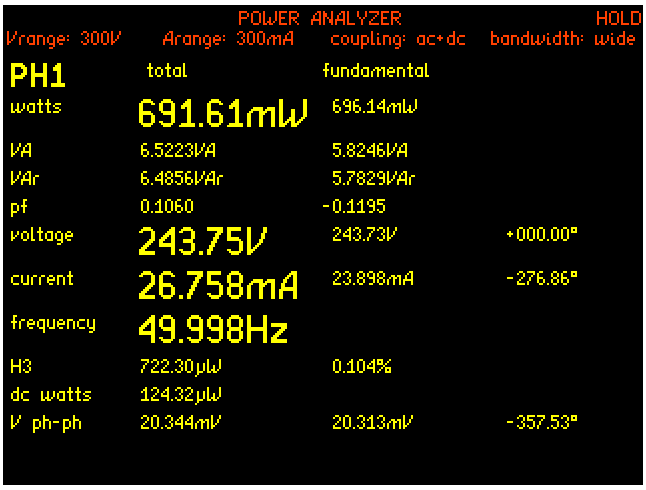
Selective harmonic can be set between 2 and 40

Sum VA & VAr computation, select according to signal type being measured.



Difference THD can be disabled or set to include or exclude DC in its computations.

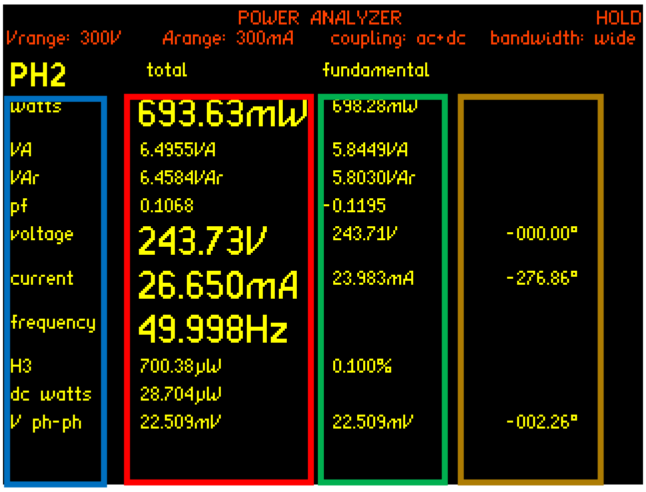
A multi phase instrument also computes the equivalent values for total power (SUM channel) and the values for the NEUTRAL current. Neutral currents are synthesised from the phase measurements and are accurate for low distortion waveform. Step through the phase values with the *DELETE*/◄◄ & *ENTER*/►► keys, as shown below. Ph1→ Ph2→ Ph3→ SUM→ Ph1,2, & 3 total values→ Ph1,2, & 3 fundamental values→ Neu "*then back to the beginning of the cycle"*



Each press of the ENTER/►► key will progress through the phases.

The number of phases that can be displayed, will depend on the settings chosen in the *ACQU* menu for the ***wiring*** parameter.

It is quite possible to have a 3 phase PPA4530 but if wiring is set to single phase 1 or 2 etc, then only that phase will be shown when using the keys to step back and forth.

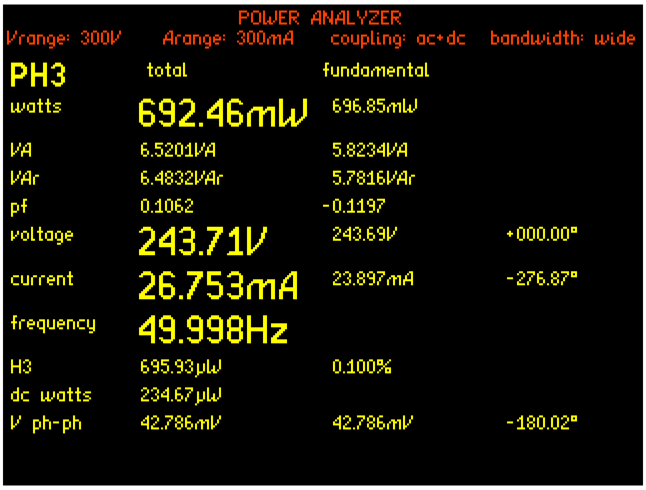


In the single phase screen, there are four columns.

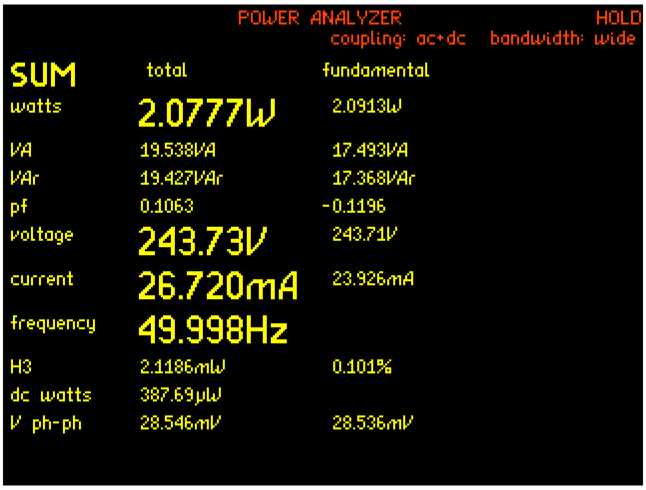
The first column shown in blue is headed by the phase being displayed, in this case phase 2, and then lists the parameters that are being displayed, voltage, current, frequency etc.

Column 2, in Red displays the total values, column 3, in green displays the same parameters as column 2 but for the fundamental frequency.

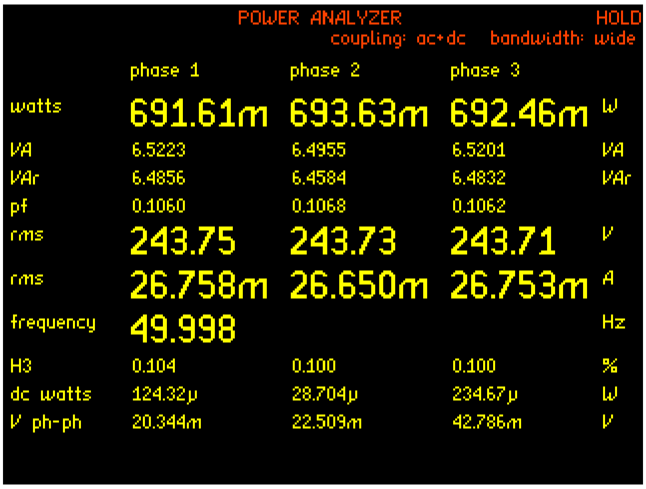
Lastly the fourth column displays the phase angle of the voltage and the current with respect to the reference set in the *ACQU* menu.



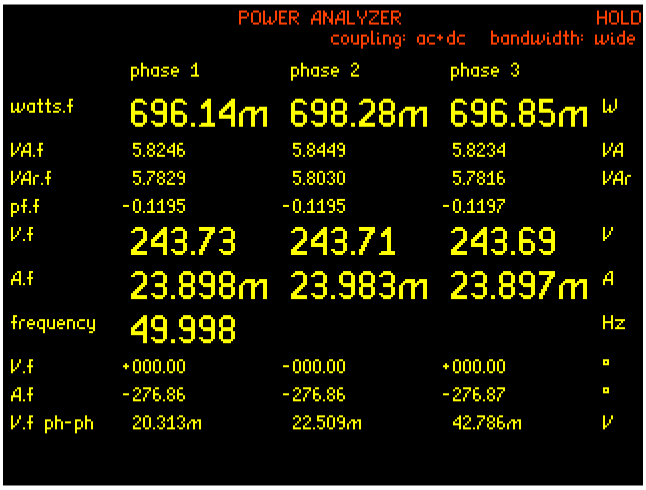
Phase 3 is shown here for clarity of the totals shown on the Sum screen below.



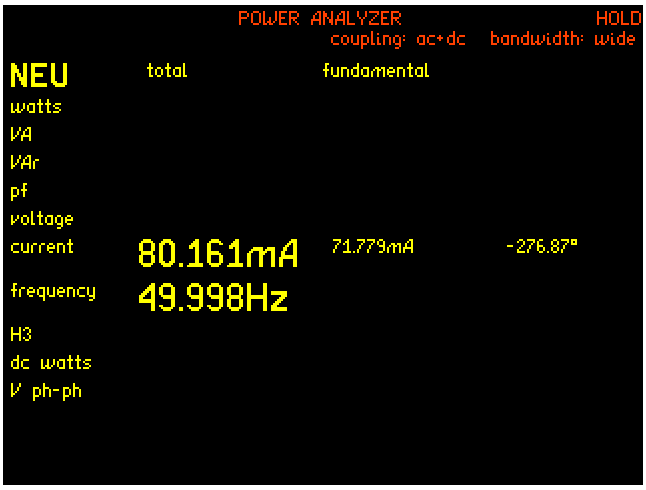
The SUM results screen displays the arithmetic sum of the three phases for Watts, VA, VAr, H3 & DC Watts, while Voltage, Current, V ph-ph & pf are the average value of the phases.



This view shows each of the phases results for Total values of each parameter.



The next view shows the same multi-phase view as previously but in this case, it is for the fundamental values rather than the total.



The final display available shows the neutral current values the derivation of these is via Kirchhoff's Law and explained in more detail along with the other derivations of the secondary values on the following pages.

The measurements are computed over rectangular windows with no gaps. The processing power of the DSPs allows the measurements to be made in true real time without missing any samples. In this way, the measured power is a true value even if the signal is fluctuating. The only occasion when data is missed is when an autozero measurement is requested – this can be disabled in the *SYSTEM OPTIONS* menu.

The elementary values are individually filtered before being used for secondary computations.

Individual phase computations

The power dissipated in a load subjected to a periodic voltage, $v(\phi)$, with a current flowing $a(\phi)$, is given by:

$$w = 1/2\pi \int_{0}^{2\pi} v(\phi).a(\phi)\, d\phi$$

For a sampled signal, the formula becomes:

$$w = 1/n \sum_{i=0}^{i=n-1} v[i].a[i]$$

Where n is the number of samples for an integral number of complete cycles of the input waveform.

The rms value of a periodic waveform, $v(\phi)$, is given by:

$$rms = \sqrt{\left[1/2\pi \int_{0}^{2\pi} v^2(\phi)\, d\phi \right]}$$

For a sampled signal, the formula becomes:

$$rms = \sqrt{\left[1/n \sum_{i=0}^{i=n-1} v^2[i] \right]}$$

Where n is the number of samples for an integral number of complete cycles of the input waveform.

The DC present is given by:

$$DC = 1/2\pi \int_{0}^{2\pi} v(\phi)\, d\phi$$

For a sampled signal, the formula becomes:

$$DC = 1/n \sum_{i=0}^{i=n-1} v[i]$$

Where n is the number of samples for an integral number of complete cycles of the input waveform.

From these elementary values of W, rms and DC, the following secondary values can be derived:

VA	$= V_{rms} \times A_{rms}$
VAr	$= \sqrt{(VA^2 - W^2)}$
power factor	= W/VA
W_{DC}	$= V_{DC} \times A_{DC}$

The fundamental in-phase and quadrature values of a periodic waveform, $v(\phi)$, are given by:

$$a_1 = \sqrt{2}/2\pi \int_0^{2\pi} v(\phi).\cos(\phi)\, d\phi$$

$$b_1 = \sqrt{2}/2\pi \int_0^{2\pi} v(\phi).\sin(\phi)\, d\phi$$

For a sampled signal, the formulae become:

$$a_1 = 1/n \sum_{i=0}^{i=n-1} v[i].\cos(2\pi ci/n)$$

$$b_1 = 1/n \sum_{i=0}^{i=n-1} v[i].\sin(2\pi ci/n)$$

Where n is the number of samples for an integral number of complete cycles of the input waveform, and c is the number of cycles.

These ‘a’ and ‘b’ values yield the further elementary parameters:

magnitude = $\sqrt{(a^2 + b^2)}$

phase angle = $\tan^{-1}(b/a)$

From these elementary ‘a’ and ‘b’ values of voltage and current, the following secondary values can be derived:

fundamental Watts	$= V_a \times A_a + V_b \times A_b$
fundamental VA	$= V_{mag} \times A_{mag}$
fund power factor	$= W_{fund} / VA_{fund}$
fundamental VAr	$= V_a \times A_b - V_b \times A_a$

The signs of Watts and VAr are a direct result of the computation (watts has the sign of cos (phase angle), VAr has the sign of sin(phase angle)). The sign of fundamental power factor is determined by convention such that a lagging current (inductive load) is shown as a positive power factor and a leading current (capacitive load) is shown as a negative power factor; this is effectively the sign of sin (-phase angle). Optionally the signs of fundamental VAr and power factor can be independently inverted.

Sum computations

When the PPA4500 is set in either of the 3 phase wiring modes, (2 Wattmeter or 3 Wattmeter), the values for the total load are computed from the data for each individual channel.

W, VA, VAr, W.f, VA.f , VAr.f, W.DC, and W.h are computed as the sum of the individual phase data.

V.rms, V.mag, V.pprms and V.ppmag are computed as the average of the individual phase data.

A.rms and A.mag are computed from sum VA / sum V and sum VA.f / sum V.f

Sum power factor is computed as sum W / sum VA and the fundamental power factor is computed as fundamental sum W / fundamental sum VA with the sign derived from the sign of sum VAr.

When calculating 3 phase 2 wattmeter Sum:VA and VAr, options are as follows:

For low distortion signals:

$$sum.VAr = ph1.VAr + ph2.VAr$$

$$sum.VA = \sqrt{}(sum.W^2 + sum.VAr^2)$$

For High distortion signals:

$$sum.VA = \frac{\sqrt{3}}{2}\,(ph1.VA + ph2.VA)$$

$$sum.VAr = \sqrt{}(sum.VA^2 - sum.W^2)$$

Negative Reading?

In 3ph 2w mode, Phase 3 is used as the reference point.

In certain conditions, the combination of power factor values below 0.5 and Phase Angle can result in leading and lagging Power vectors. These can cause negative watts values to be displayed particularly for Phase 2.

Application Note **APP014** describes 3 Phase 2 Wattmeter Power Measurements in more detail. Vector diagrams and example calculations are used to explain how the measurements are computed.

Neutral synthesis

In 3 phase 3 wattmeter configuration, the values for the neutral current are synthesised from the measured values of the three phases. By Kirchhoff's law, the sum of the instantaneous currents flowing into a node must be zero. By convention neutral current is regarded as flowing out of the load so the neutral current can be derived from the sum of the three phase currents.

In 3 phase 2 wattmeter configuration, the "neutral current" values are synthesised from the 2 phase currents and represent the third phase current.

Values available are rms, fundamental magnitude and phase. Additional values for DC, AC, peak and crest factor are displayed in RMS mode.

Phase to phase computations

In 3 phase 3 wattmeter configuration, the voltmeters are connected across each individual phase and neutral. The phase to phase voltages are synthesised from the individual phase data:

display phase	computation
phase 1	phase 1 – phase 2
phase 2	phase 2 – phase 3
phase 3	phase 3 – phase 1

Phase to phase values are computed for rms, fundamental magnitude and phase.

Consider the fundamental component:

$$V_{12}(t) = V_1(t) - V_2(t)$$

$$= V_1 \sin(\omega t) - V_2 \sin(\omega t + \varphi_{12})$$

$$= V_1 \sin(\omega t) - V_2 [\sin(\omega t).\cos(\varphi_{12}) + \cos(\omega t).\sin(\varphi_{12})]$$

$$= \sin(\omega t) [V_1 - V_2 \cos(\varphi_{12})] - V_2 \cos(\omega t).\sin(\varphi_{12})$$

In a balanced system:

$$V_1 = V,\ V_2 = V \text{ and } \varphi_{12} = 120^\circ$$

$$V_{12} = \sin(\omega t) [V - V \cos(120^\circ)] + V \cos(\omega t).\sin(120^\circ)$$

$$= 1.5\ V \sin(\omega t) - \sqrt{3}/2\ V \cos(\omega t)$$

$$= \sqrt{3}\ V \sin(\omega t - 30^\circ)$$

So the phase to phase voltage would have a magnitude √3 times larger than the phase to neutral voltage at a phase displacement of -30˚.

The PPA4500 series applies the computations in a general way without any assumptions about the system. It, therefore, computes the correct values whatever the waveform.

The phase to phase values may also be displayed as a rectified mean measurement.

Mechanical power

The PPA4500 series has 2 extra inputs to measure the mechanical power of motors or generators. Torque is measured in Nm with a +/-10V analogue input scaled in Nm/V or as a pulse count input scaled in pulses/Nm. Speed is measured in rpm either with a +/-10V analogue input scaled in rpm/V or as a pulse input which can be scaled with pulses/revolution.

An offset can be entered to allow for DC offset within the torque and speed sensors. The scaled value is derived as:

Torque or speed = (measured value – offset) x scale

The speed offset only applies to analogue speed, not pulsed. The offset values can be entered directly in the *APP* menu or by pressing *ZERO* when 'home' in the *APP* menu i.e., no menu items are highlighted. To use the *ZERO* function press *APP*, move down to enable the torque and speed, press HOME to return the cursor to the 'home' position then press *ZERO*. The presently measured values will be entered automatically as the offsets.

The mechanical power is given by:

$$W_{mech} = \text{torque x angular velocity (rad/s)}$$

$$= \text{torque x speed (rpm) x } 60 \text{ x } 2\pi$$

The mechanical power can then be used to compute efficiency as:

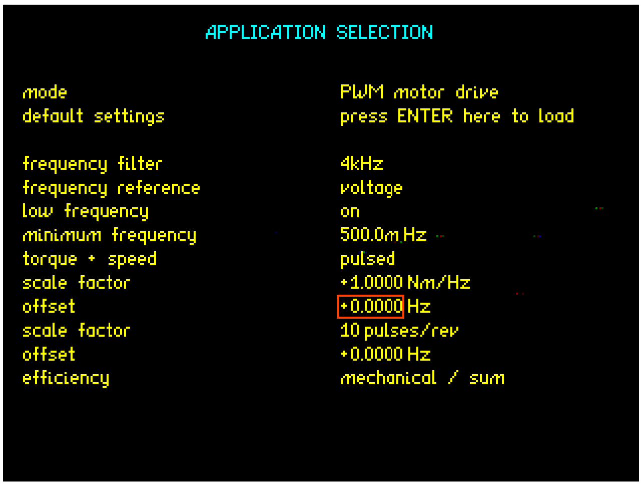
efficiency = mechanical power / sum power (motor)

or

efficiency = sum / mechanical power (generator)

The measurement of mechanical power is made simultaneously with the electrical measurements over the same window.

The frequency offset can be set in pulsed mode for both speed & torque within the APP menu as shown below



Efficiency

Efficiency may be computed as a ratio of any of the following:

phase 1 / phase 2 power,
master / slave power,
mechanical / sum power, or
phase 3 and sum power

In all cases, either term may be input power or output power.

Total efficiency is computed from the total power, fundamental efficiency is computed from the fundamental power. In the case of mechanical power, there is only the one measured power which is used both for total and fundamental.

Torque & Speed

Should a second input for mechanical power measurements is required, the phase 3 external inputs for voltage and current can be utilised.

Torque & Speed can be set for power measurement mode by independently using Phase 3 within the 3 Phase 2 Wattmeter + Phase 3 wiring configuration.

Channel 3 Voltage Input BNC = Torque
Channel 3 Current Input BNC = Speed

If using Multilog software:
PH3 Watts = Power
PH3 voltage DC = Torque
PH3 current DC = Speed

Input compensation

This compensation option subtracts the power absorbed by the voltage input.

When measuring low power with the voltage input wired after the current input the Power measurement would include the power absorbed by the voltage attenuator.

For example, at 230V a 1MΩ voltage attenuator would absorb a power of 0.0529W ($230V^2$/1MΩ). Enabling Input compensation subtracts this power and the corresponding currents from the measured values.

Star - Delta conversion

Deriving delta (phase to phase) voltages from star (phase) values is usually recommended because the PPA's inputs will be subject to less noise and a lower common mode signal.

In Star-Delta conversion mode the PPA derives the delta voltages using the directly measured phase-star voltages. Two types of Conversion are available:

	Type A	**Type B**
Displayed Delta voltage	Derived from Phase measurements	
Displayed Phase voltage	Direct measurement	Back calculated using the Delta voltage[1] $Vrms_{phase} = \frac{Vdelta}{\sqrt{3}}$

[1] This assumes a balanced system.

In both cases the Delta voltage is derived from the directly measured phase voltages. The difference is that Type B then uses the derived Delta value to back calculate the RMS phase voltage.

It may be beneficial to use Type B to remove common mode voltages/triplens[1] or to provide a stable value when using a floating star-point.

[1] The odd multiples of third harmonics, 3,9,15,21……

Impedance meter

The *IMP* mode on the PPA4500 uses the real and imaginary components at the fundamental frequency together with DFT analysis as described previously to compute the impedance of the load and associated parameters.

From the fundamental components of voltage, (a + jb), and those of the current, (c + jd), the PPA4500 computes the complex impedance given by:

$$\mathbf{z} = v / \mathbf{i}$$

$$= (a + jb) / (c + jd)$$

The components of the complex impedance are filtered independently to minimise the effects of noise, which would have random phase and would therefore be filtered out.

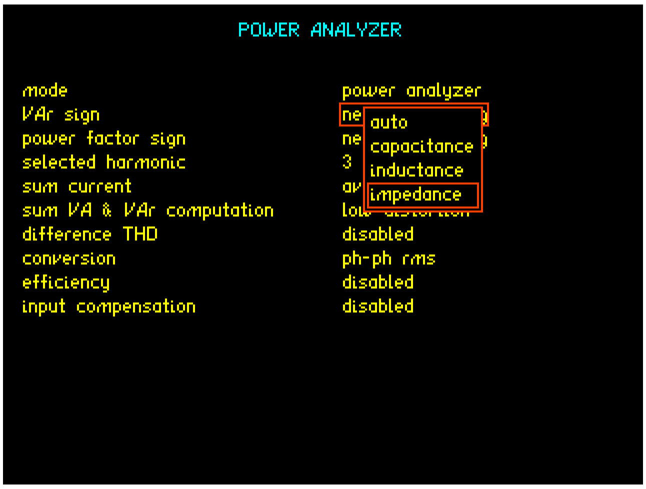
The magnitude of the voltage and current are also computed.

From the complex impedance the following parameters can be derived:

Resistance
inductance
capacitance
impedance
phase
tanδ (= real/imaginary)
Q factor (= imaginary/real)

Values can be displayed for either series or parallel models.

If the parameter option in LCR menu is set to ***auto***, the PPA4500 will display capacitance or inductance according to the phase of the measurement. Alternatively, the display can be forced to capacitance, inductance, or impedance as shown here.



Capacitance is displayed with tanδ, inductance is displayed with Q factor, and impedance is displayed in its resistive + reactive form and as magnitude. The phase of the impedance is displayed with all options.

For phase critical impedance measurements, is it possible to offset the phase measurement to allow for phase shift within the connection leads

Note that the phase of the impedance is the opposite to the phase of the current in POWER mode. This is because the impedance is defined as voltage/current which, considering the magnitude and phase of Z (impedance), V (voltage) and A (current), gives:

Zmagnitude = Vmagnitude / Amagnitude

Zphase = Vphase – Aphase

As the phase is referred to the voltage:

Zphase = - Aphase

Therefore, using the phase convention from -180° to +180°, an inductive load which has an impedance with positive phase would cause a current with negative phase.

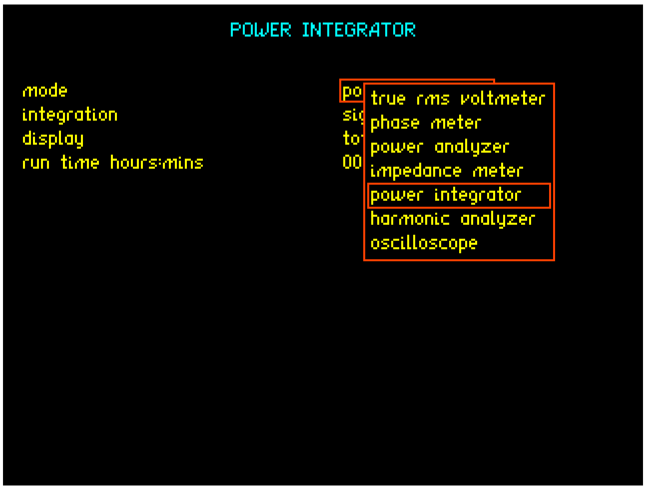
Power Integrator

In the INTEG mode, the PPA4500 computes the following additional values:

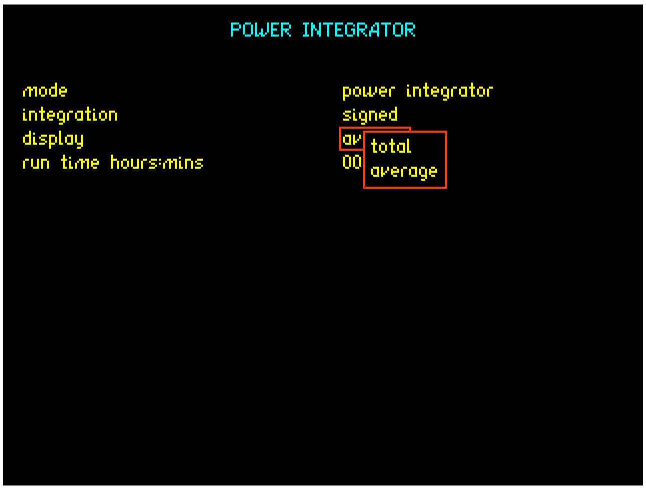
Parameter	Units
Watt hours	Wh
VA hours	VAh
VAr hours	VArh
Average power factor	
Average rms voltage	V
Ampere hours	Ah
Fundamental watt hours	Wh
Fundamental VA hours	VAh
Fundamental VAr hours	VArh
Average fundamental power factor	
Average fundamental voltage	V
Fundamental ampere hours	Ah

Setting up and running the Integrator function

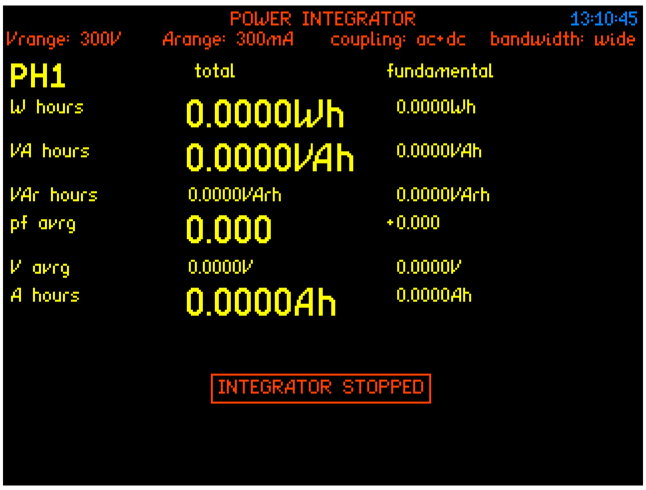
The setup menu options can be accessed either via 2 presses of the *INTEG* key or the *MODE* key and using the ▼, ▶, ▼, ▼ combination of direction key presses to highlight ***power integrator*** then press *ENTER*.



The Watt hour integration and the Ampere hour integration can be selected to be signed or magnitude. To integrate the total power in terms of heating effect, choose magnitude. If signed integration is selected, then the rms current is given the sign of the power before integration. The Ampere hours and Watt hours then reflect the power taken by the load, less any power generated by the load, such as during regenerative braking in battery systems.



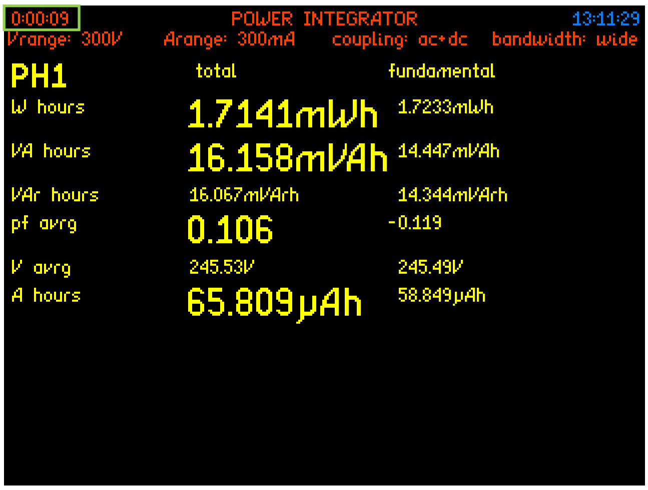
The integration results can be set to be ***Total*** accumulated values or as the ***average*** over the integration period, depending on the ***display*** parameter settings, as shown left. Lastly a countdown ***run time*** timer can be set for the desired length of time that the integration needs, up to a maximum of 99 hours and 59 minutes. Setting the timer to zero, disables the timer. Alternatively, if a longer integration time is required, the time can be controlled manually via the *START* and *STOP* keys or remotely via the command set.



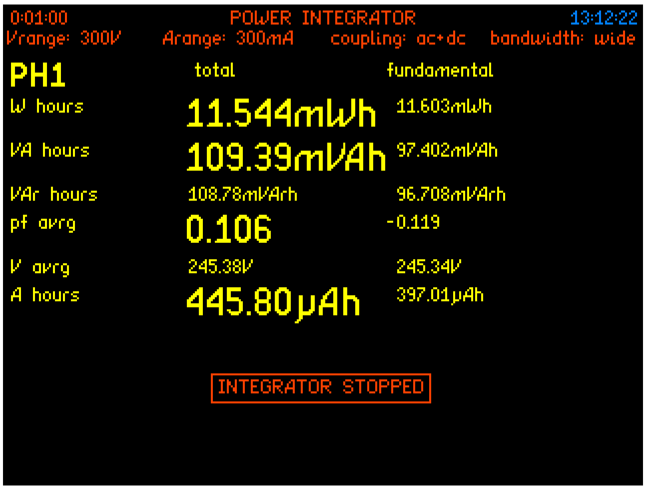
Once all the parameters have been set, press the *HOME* key twice and the integrator will display the starting zeroed integration screen. the elapsed time is displayed in the upper left corner of the display as soon as the integration starts.

The integration can be stopped by pressing the *STOP* key then restarted by pressing the *START* key again. To reset the accumulated values and time press the *ZERO* key. While the integration is running, pressing the *REAL TIME* key holds the displayed values but accumulation continues in the background.

Once started, the integration continues to accumulate in the background even if the *MODE* is changed to *POWER* or *RMS*. This allows the real time values to be displayed without disturbing the integration.



The running integration shows the timer in the top right hand corner, highlighted in green.



When either the timer reaches zero or the *STOP* key is pressed then the screen displays INTEGRATOR STOPPED at the bottom of the screen.

Harmonic analyser

The *HARM* mode of the PPA4500 computes multiple DFTs on the input waveforms in real time.

Each mode of operation displays a context sensitive option settings screen relevant to the type of harmonics analysis being performed.

There are two modes of operation: difference THD, and series harmonics.

Series harmonic mode includes options for THD, TIF, THF, TRD, TDD and phase. There is also an option of a series harmonic sweep, inter harmonics sweep, harmonic rms and harmonic factor.

The results are available in real time, tabular or bar graph format.

Not all analyses are displayed in all formats.

Analysis Type	Real Time	Tabular	Bar graph
THD	✓	✗	✗
Series THD	✓	✓	✓
Series TIF	✓	✓	✓
Series THF	✓	✓	✓
Series TRD	✓	✓	✓
Series TDD	✓	✓	✓
Series Harmonics phase	✓	✓	✓
Inter-Harmonic Sweep	✓	✓	✗
Harmonic rms	✓	✓	✓
Harmonic Factor	✓	✓	✓

Analyses Formulae

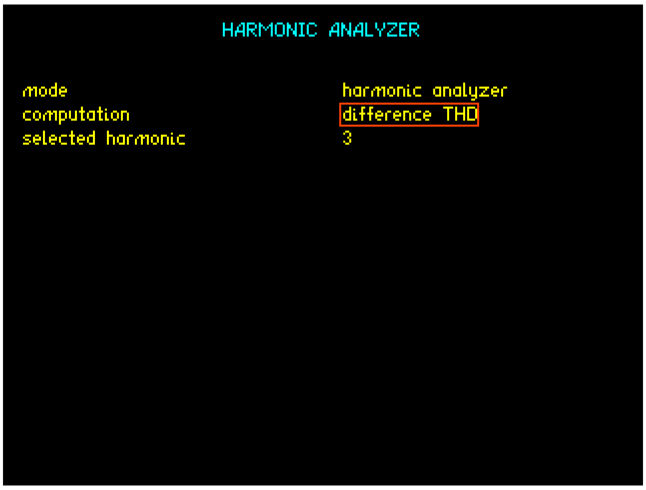
In difference THD mode, the THD (Total Harmonic Distortion) is computed from the rms and fundamental:

$$THD = 1/h_1 \sqrt{(rms^2 - h_1^2)}$$

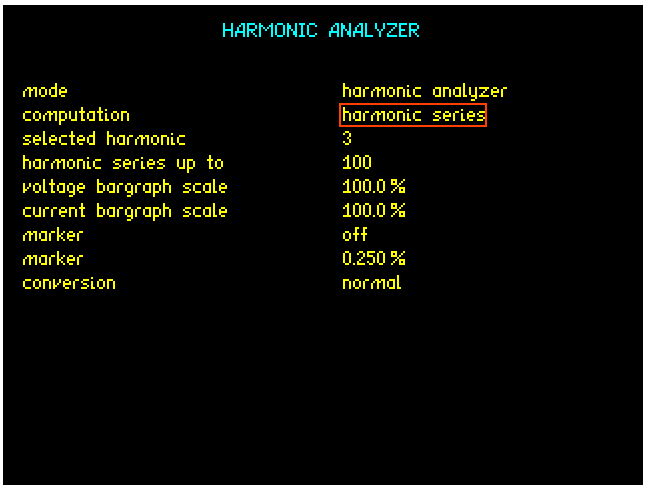
In series THD mode, the THD is computed from a series of up to 125 harmonics.

$$THD = 1/h_1 \sqrt{\sum_{i=2}^{i=n} h_i^2}$$

where h_i is the i^{th} harmonic



Difference THD parameter settings default screen



Series harmonic THD, TIF, & THF all share the same setup parameter options

TIF (Telephone Influence Factor) is similar to THD, but each harmonic has a weighting factor applied to reflect the severity of the potential interference of that harmonic on telephone communication.

$$\text{TIF} = 1/\text{rms} \sqrt{\sum_{i=1}^{i=n} (h_i \times t_i)^2}$$

where h_i is the i^{th} harmonic

and t_i is the i^{th} weighting factor

TIF is defined by IEEE standard 115 and the weighting factors are given in ANSI standard C50-13. The harmonic factors for TIF are specified for harmonics of 60Hz.

THF (Telephone Harmonic Factor) is a similar computation to TIF but uses different weighting factors and is expressed as a percentage.

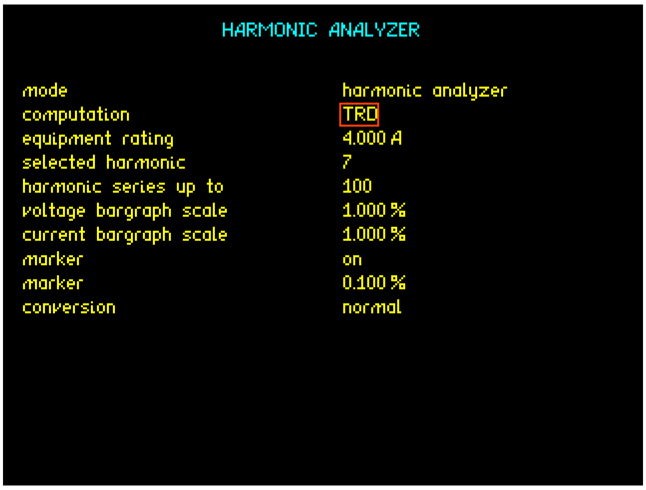
$$THF = 1/rms \sqrt{\sum_{i=1}^{i=n} (h_i \times t_i)^2}$$

where h_i is the i^{th} harmonic

and t_i is the i^{th} weighting factor

The THF computation and weighting factors have been implemented according to IEC standard 60034 part 1 (1996) with amendments A1 (1997) and A2 (1999). The harmonic factors are specified for harmonics of 50Hz.

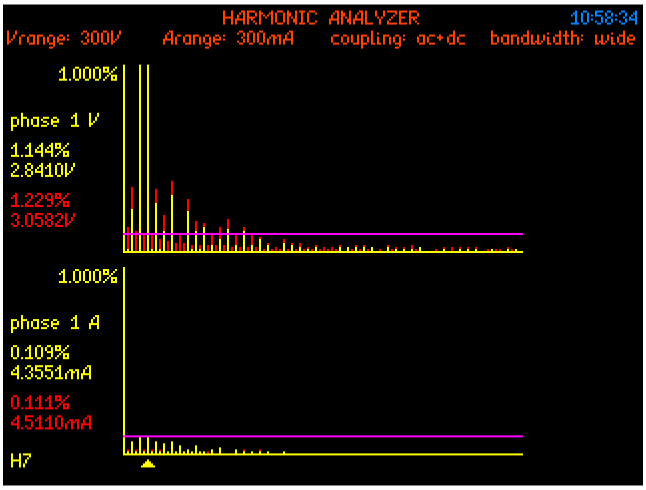
TRD (Total Rated Distortion) uses a different reference to scale the harmonic percentages instead of the fundamental. The voltage harmonics are scaled by the rms voltage, and the current harmonics are scaled by the larger of the rms current or the rated current entered by the HARM menu. The rms is computed from the series of harmonics.



$$TRD = 1/ref \sqrt{\sum_{i=2}^{i=n} h_i^2}$$

where h_i is the i^{th} harmonic

and ref is rms or rated current



The features on the bar graph display are common to all the different analyses formats.

The values shown in yellow are the current measured values for each parameter.

The red figures and the small red areas on the bar graph represent the peak value since the last triggering.

Similarly, TDD (Total Demand Distortion) scales the computed harmonic distortion by the measured rms. For voltage, TDD is the same as TRD; for current, TRD is less than TDD unless the measured rms current is greater than the entered rated current.

The value for TRD and TDD will always be lower than the computed THD as rms is always greater than the fundamental.

$$TDD = 1/rms \sqrt{\sum_{i=2}^{i=n} h_i^2}$$

where h_i is the i^{th} harmonic

Harmonic phase can be selected instead of a thd computation and each harmonic in the series is computed as a magnitude and phase angle.

The number of harmonics used for THF, TIF, TRD, TDD (max 100) and series harmonic phase computation (max 125) is selectable in the same way as for THD.

Harmonics can be measured from Phase to Neutral or Phase to Phase, this option is selected in the HARM menu

In all cases, the harmonics are phase referred to Phase 1 voltage fundamental so that their in-phase and quadrature components may be separately filtered to minimise noise.

Accurate frequency synchronisation is essential for reliable harmonic measurement. Good results can be obtained in a reasonable time using the medium speed setting (which runs a little slower than other modes) but for the best results, use the slow speed setting.

Harmonic phase angle reference
As phase angle is a measurement of the relative difference between the computed harmonic and the zero phase angle reference, it is important to understand what the harmonic is being referred to.

Single phase
The default phase angle reference is voltage fundamental but can be set by menu option to current fundamental.

As all harmonics are referred to the same measurement, the harmonics can be combined to recreate the original waveform by adding the components:

$$V(t) \approx \sum_{i=1}^{i=n} A_i \cos(i\,\omega t + \varphi_i)$$

where:

ω = angular frequency

i = harmonic number

n = maximum harmonic

A_i = amplitude of harmonic i

φ_i = phase angle of harmonic i

Note that computed phase angles are quoted according to the cosine formula above not a sine formula.

Multi phase

In a multi-phase measurement, the fundamental phase angle of each phase is expressed relative to a common reference, normally phase 1 voltage; while the harmonic phase angles of each phase are expressed relative to their own phase, normally voltage as with single phase. So, on a three phase system with the same waveform on each phase displaced by 120 degrees at the fundamental, the harmonic measurements would show the same phase angle on each phase (because they are referred to their own phase) while the fundamentals would show the 120 degree phase displacement.

Therefore, to recreate the original waveform, apply the same formula as for single phase but first refer the phase angle of the fundamentals to the same reference as that of the harmonics. If the reference is voltage, subtract the voltage phase angle from the current angle and set the voltage to zero; if the reference is current, subtract the current phase angle from the voltage phase angle and set the current phase angle to zero.

Phase to phase harmonics

When the instrument is wired phase to neutral, but the option is selected to display phase to phase harmonics, the phase angle reference for all the harmonics, including the fundamentals, is the same. The common phase angle reference is the original phase to neutral signal on phase 1 so the formula for single phase can be applied without changing the phase reference for the fundamentals.

Inter-harmonic Sweeps

Inter-harmonic Sweep Mode measures the Inter-harmonic voltage and Inter-harmonic current on each phase over a range of harmonics.

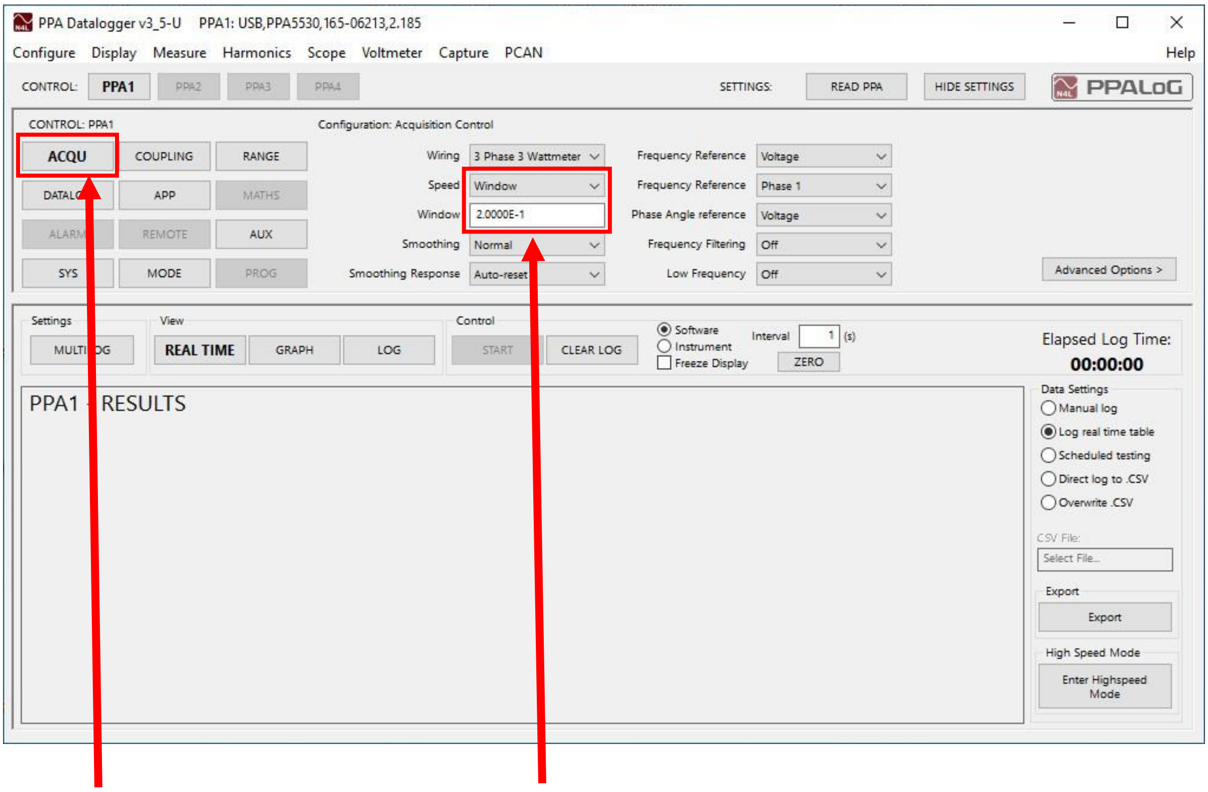
The results are displayed on the PPA and can be exported to an Excel document using our free PPA Datalogger software.

The following parameters can be selected:

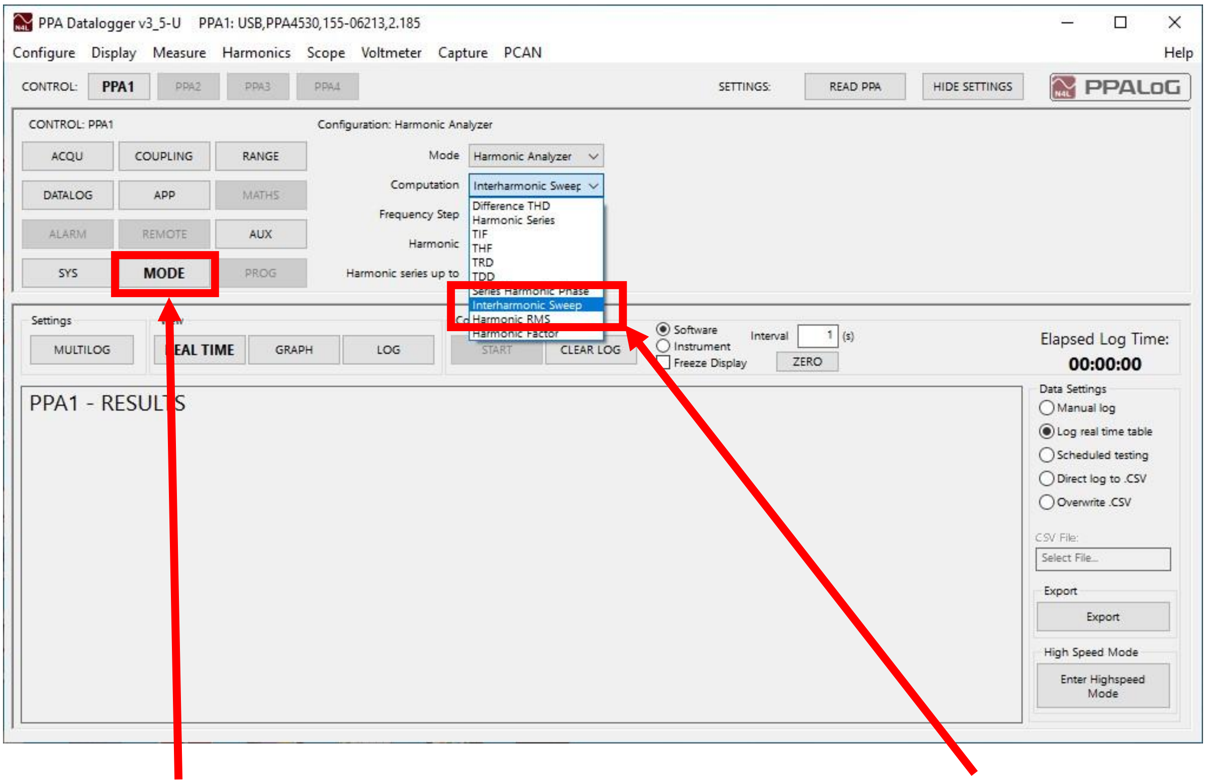
Frequency step size: selectable from 500mHz to 100Hz (Frequency step between each harmonic)
Selected Harmonic: selectable from 2 to 1000 (Individual harmonic)
Harmonic Series up to selectable from 2 to 9999 (Number of harmonics included in the sweep)

To export the sweep data using

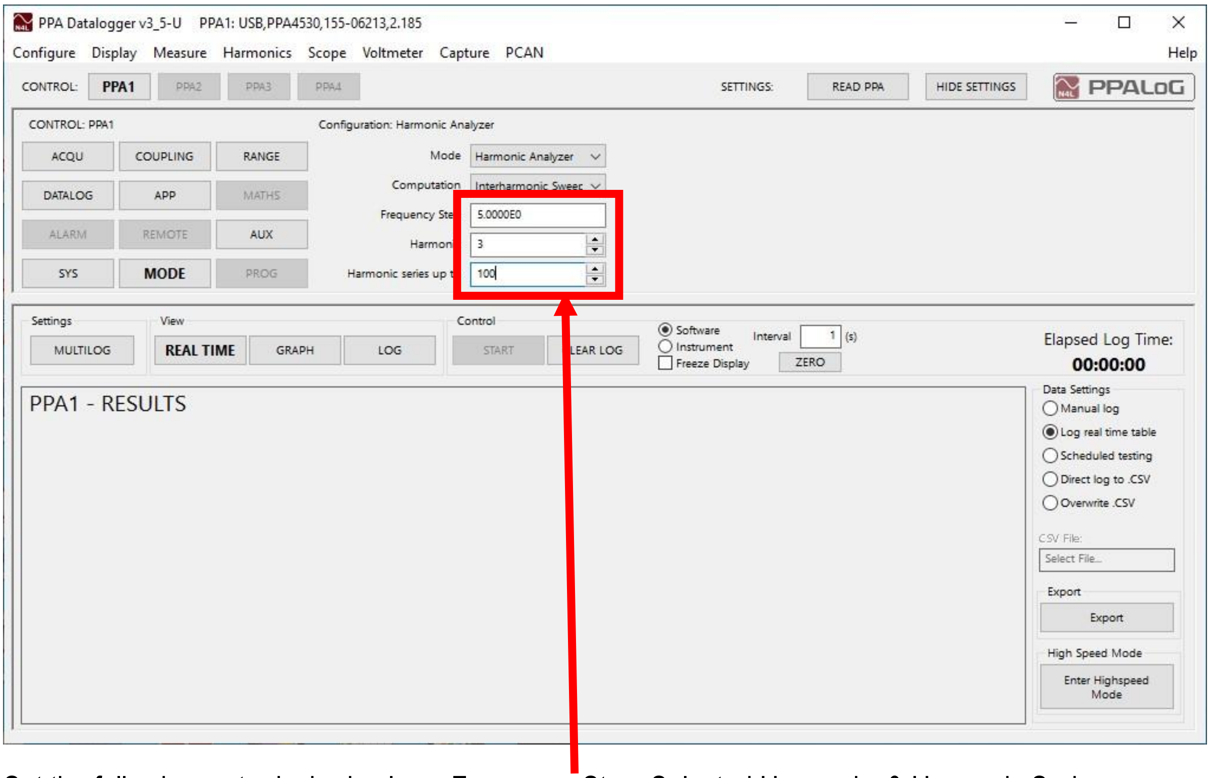
Connect the PPA4500 to the PPA Datalogger/PPALoG software. Version v3.1b and above can be used but **v3.5** is recommended.



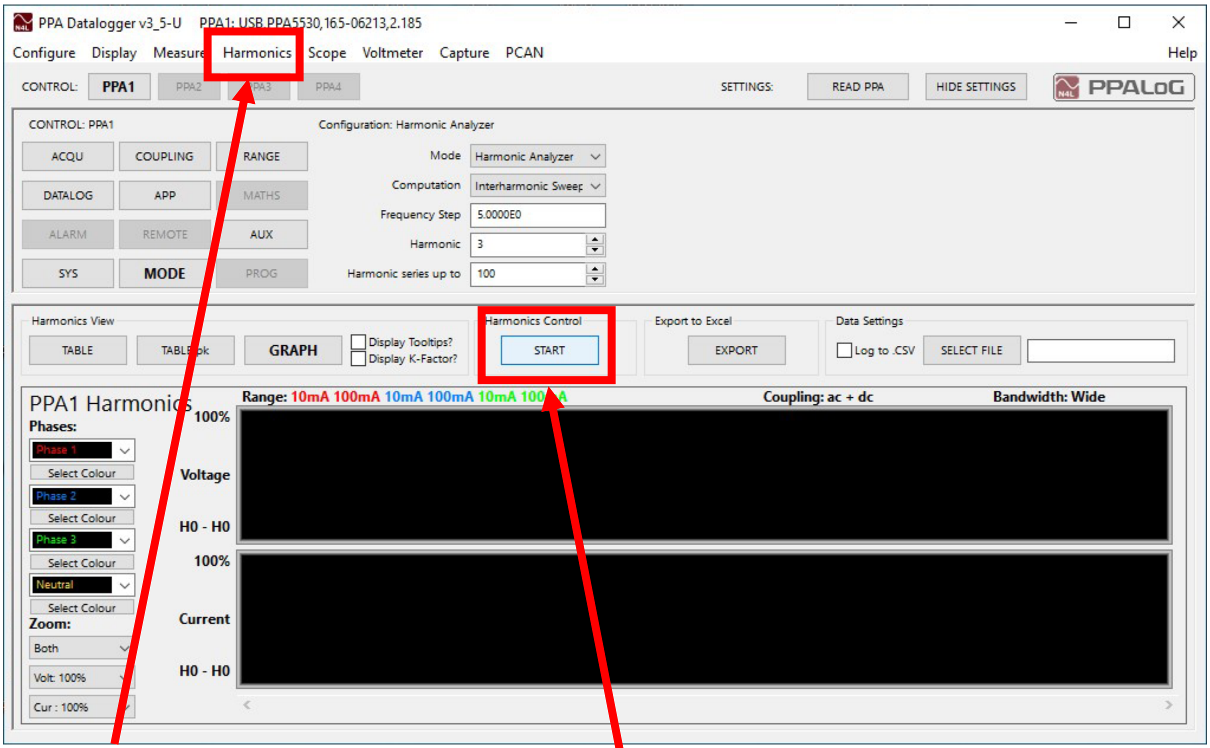
Click on ACQU, then set the speed to a window of 200ms



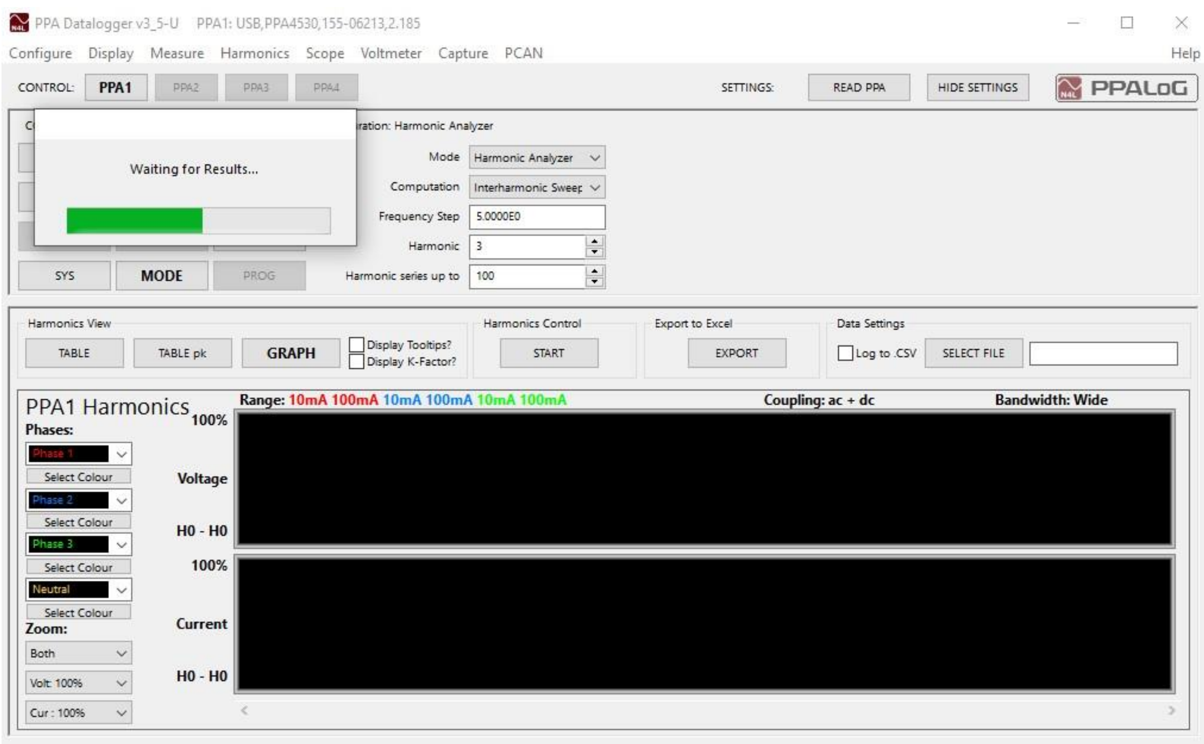
Enter the Harmonics mode, and select the computation drop down to be Interharmonic Sweep



Set the following se to desired values, Frequency Step, Selected Harmonic, & Harmonic Series Up To, (in this example they are set to 5, 3, & 100 respectively)

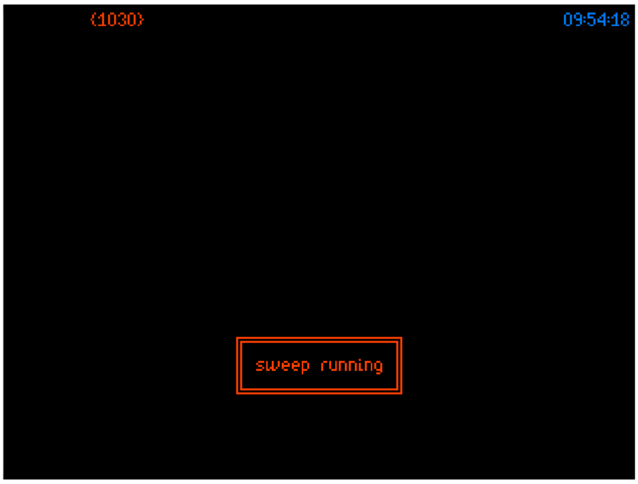


Click Harmonics in the top menu bar, followed by Start.

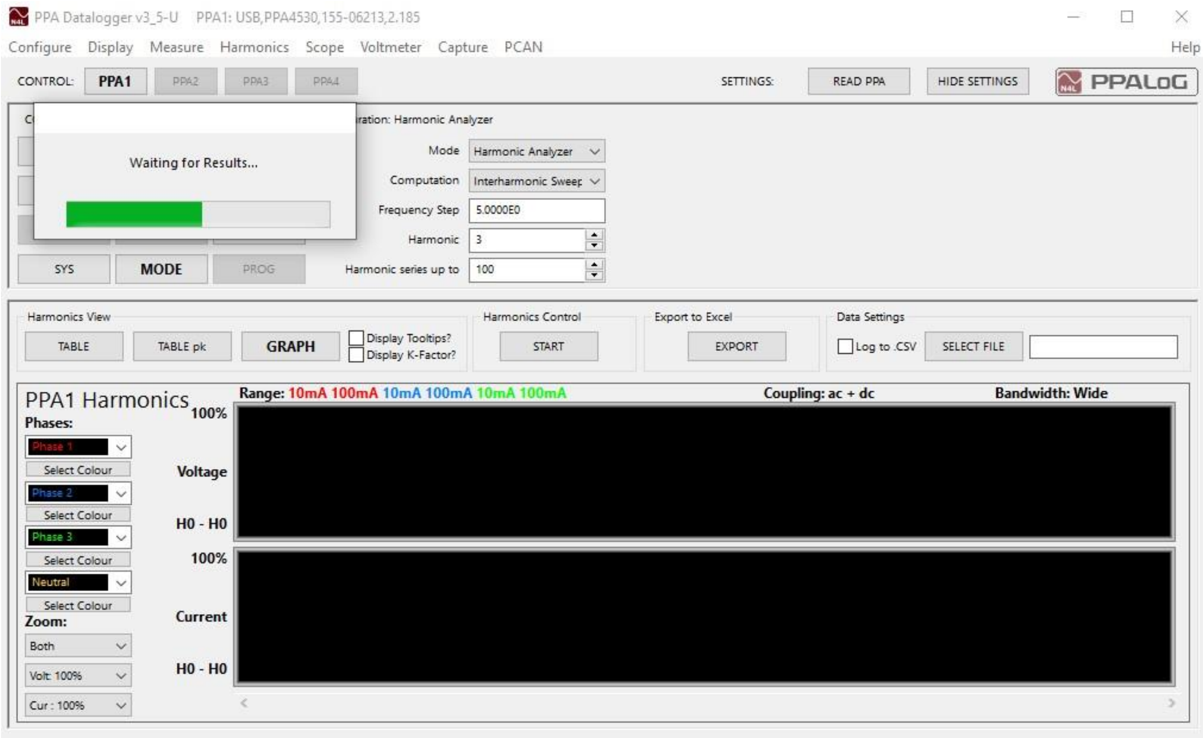


Wait for test to complete this will depend on the PPA speed setting and the number of harmonics included in the sweep. The software will display a message: “Waiting for Results”

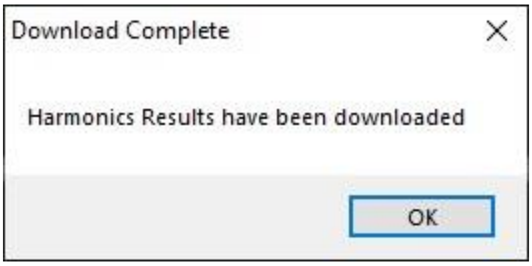
Depending on the settings selected, a flashing message may be displayed on the PPA: “Sweep Running”

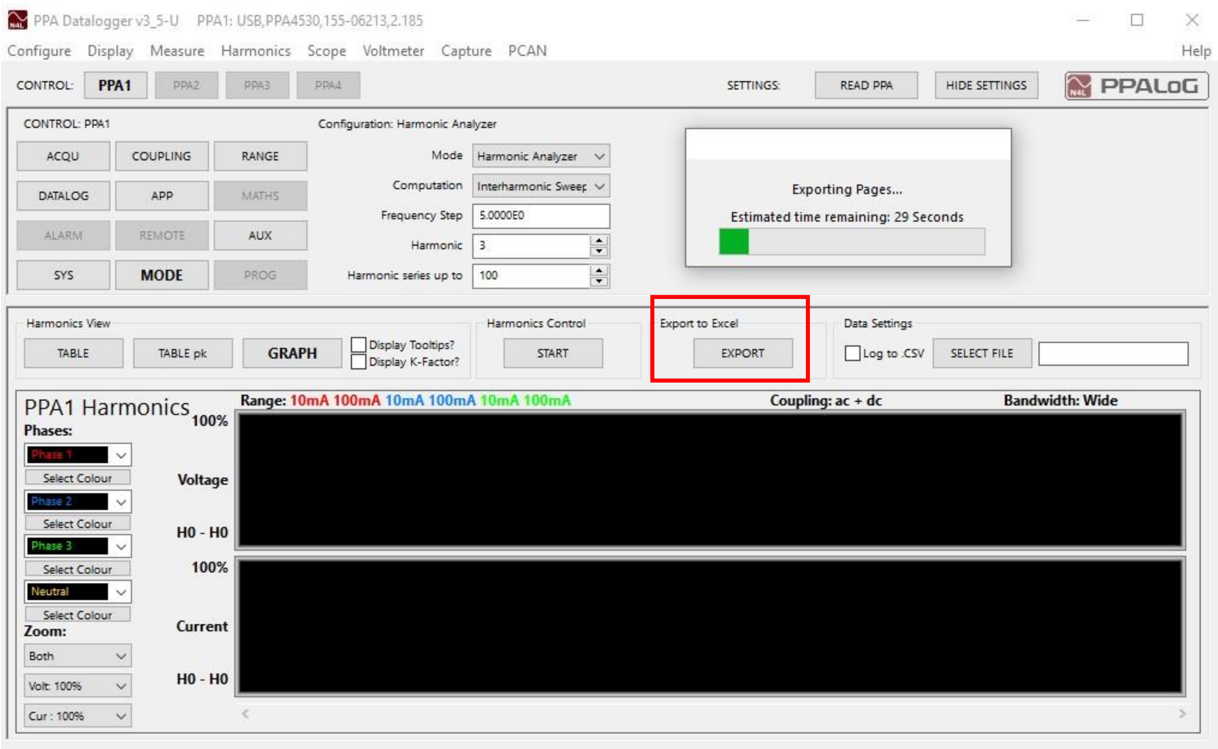


The red test number will be seen to be incrementing in the top left hand corner of the display.



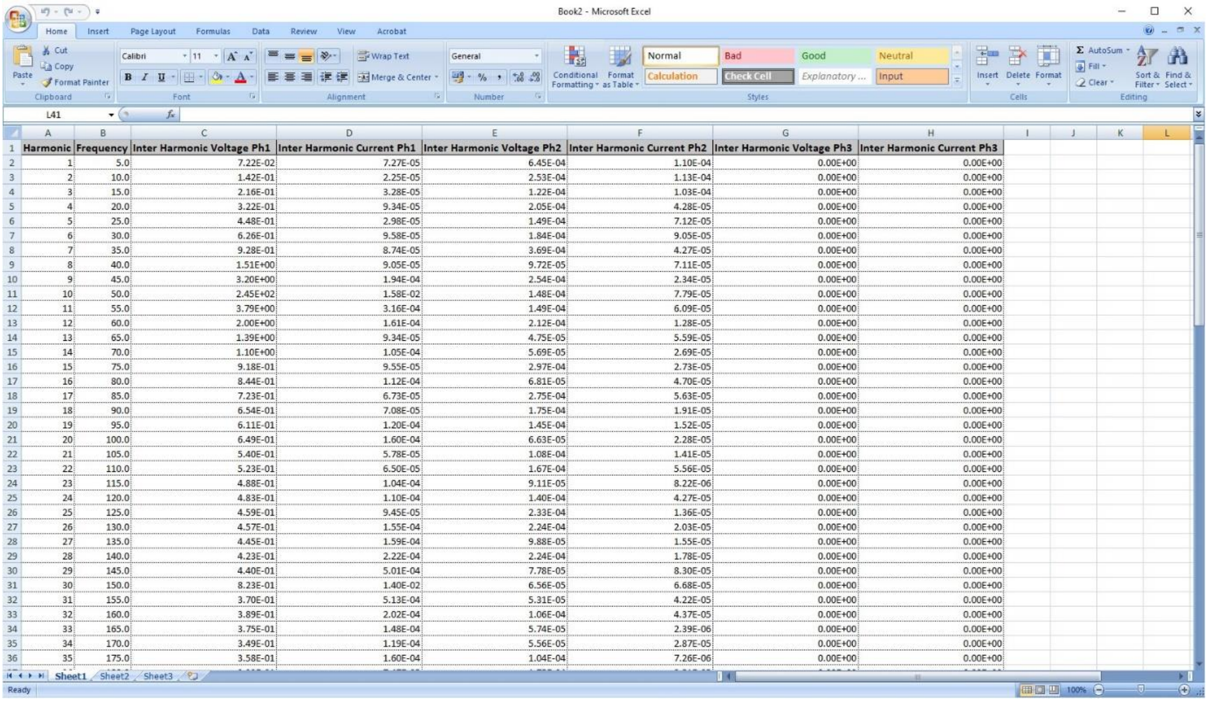
On completion of the tests the software will start to download the results from the instrument, and the message is updated once the results have been downloaded to read





Note that the results are only visible on the PPA's LCD display, they are not able to be viewed in the Datalogger software. An Excel results file can be created by clicking on the Export button in the software. (Highlighted in RED)

A message box will appear showing an estimate of the time to prepare and open the Excel file, this will disappear and then a new Excel worksheet will open with the results as seen on the next page.



Harmonic	Frequency	Inter Harmonic Voltage Ph1	Inter Harmonic Current Ph1	Inter Harmonic Voltage Ph2	Inter Harmonic Current Ph2	Inter Harmonic Voltage Ph3	Inter Harmonic Current Ph3
1	5.0	7.22E-02	7.27E-05	6.45E-04	1.10E-04	0.00E+00	0.00E+00
2	10.0	1.42E-01	2.25E-05	2.53E-04	1.13E-04	0.00E+00	0.00E+00
3	15.0	2.16E-01	3.28E-05	1.22E-04	1.03E-04	0.00E+00	0.00E+00
4	20.0	3.22E-01	9.34E-05	2.05E-04	4.28E-05	0.00E+00	0.00E+00
5	25.0	4.48E-01	2.98E-05	1.49E-04	7.12E-05	0.00E+00	0.00E+00
6	30.0	6.26E-01	9.58E-05	1.84E-04	9.05E-05	0.00E+00	0.00E+00
7	35.0	9.28E-01	8.74E-05	3.69E-04	4.27E-05	0.00E+00	0.00E+00
8	40.0	1.51E+00	9.05E-05	9.72E-05	7.11E-05	0.00E+00	0.00E+00
9	45.0	3.20E+00	1.94E-04	2.54E-04	2.34E-05	0.00E+00	0.00E+00
10	50.0	2.45E+02	1.58E-02	1.48E-04	7.79E-05	0.00E+00	0.00E+00
11	55.0	3.79E+00	3.16E-04	1.49E-04	6.09E-05	0.00E+00	0.00E+00
12	60.0	2.00E+00	1.61E-04	2.12E-04	1.28E-05	0.00E+00	0.00E+00
13	65.0	1.39E+00	9.34E-05	4.75E-05	5.59E-05	0.00E+00	0.00E+00
14	70.0	1.10E+00	1.05E-04	5.69E-05	2.69E-05	0.00E+00	0.00E+00
15	75.0	9.18E-01	9.55E-05	2.97E-04	2.73E-05	0.00E+00	0.00E+00
16	80.0	8.44E-01	1.12E-04	6.81E-05	4.70E-05	0.00E+00	0.00E+00
17	85.0	7.23E-01	6.73E-05	2.75E-04	5.63E-05	0.00E+00	0.00E+00
18	90.0	6.54E-01	7.08E-05	1.75E-04	1.91E-05	0.00E+00	0.00E+00
19	95.0	6.11E-01	1.20E-04	1.45E-04	1.52E-05	0.00E+00	0.00E+00
20	100.0	6.49E-01	1.60E-04	6.63E-05	2.28E-05	0.00E+00	0.00E+00
21	105.0	5.40E-01	5.78E-05	1.08E-04	1.41E-05	0.00E+00	0.00E+00
22	110.0	5.23E-01	6.50E-05	1.67E-04	5.56E-05	0.00E+00	0.00E+00
23	115.0	4.88E-01	1.04E-04	9.11E-05	8.22E-06	0.00E+00	0.00E+00
24	120.0	4.83E-01	1.10E-04	1.40E-04	4.27E-05	0.00E+00	0.00E+00
25	125.0	4.59E-01	9.45E-05	2.33E-04	1.36E-05	0.00E+00	0.00E+00
26	130.0	4.57E-01	1.55E-04	2.24E-04	2.03E-05	0.00E+00	0.00E+00
27	135.0	4.45E-01	1.59E-04	9.88E-05	1.55E-05	0.00E+00	0.00E+00
28	140.0	4.23E-01	2.22E-04	2.24E-04	1.78E-05	0.00E+00	0.00E+00
29	145.0	4.40E-01	5.01E-04	7.78E-05	8.30E-05	0.00E+00	0.00E+00
30	150.0	8.23E-01	1.40E-02	6.56E-05	6.68E-05	0.00E+00	0.00E+00
31	155.0	3.70E-01	5.13E-04	5.31E-05	4.22E-05	0.00E+00	0.00E+00
32	160.0	3.89E-01	2.02E-04	1.06E-04	4.37E-05	0.00E+00	0.00E+00
33	165.0	3.75E-01	1.48E-04	5.74E-05	2.39E-06	0.00E+00	0.00E+00
34	170.0	3.49E-01	1.19E-04	5.56E-05	2.87E-05	0.00E+00	0.00E+00
35	175.0	3.58E-01	1.60E-04	1.04E-04	7.26E-06	0.00E+00	0.00E+00

INFORMATION. Note: Rather than performing the initial steps above, the settings can instead be entered on the PPA. Press the *ACQU* key on the instrument keypad and entered the required speed setting.

Press the *MODE* key and select ***Harmonic Analyzer*** mode and ***Interharmonic sweep***. Enter the required values for "***Frequency step size***", "***Selected harmonic***" and "***Harmonic series up to***". Finally click on the "Read PPA" button in the software to transfer the settings from the PPA into the software. Ensure the software is displaying the Harmonic test window and then proceed from the step shown above

INFORMATION. Note: When selecting an Inter-harmonic Sweep the Speed setting in the ACQU menu is automatically set to a default window of **200mS**. It is recommended to use this setting to ensure the highest accuracy of Harmonic data displayed on the instrument & when using PPADatalogger software.

Harmonic Factor
The Harmonic Voltage Factor and Harmonic Current Factor are defined in section 7.2.1.1 of EN60034-1:2010.

Harmonic Voltage Factor
HVF is the square root of the sum of the squared voltage harmonics divided by their harmonic number, for harmonics 2 to 13 excluding those divisible by 3.

INFORMATION. Note: we do not limit the upper harmonic to 13 to allow the user to enter the upper harmonic of their choice (max 100). However, this should be set to 13 for the test to be compliant to the standard.

The HVF is computed using the following formula:

$$HVF = \sqrt{\sum_{n=2}^{k} \frac{u_n^2}{n}}$$

Where:

k = 13
n = the order of harmonic (not divisible by three)
u_n = is the ratio of the harmonic voltage U_n to the rated voltage U_N.

Harmonic Current Factor
The HCF is the square root of the sum of the squared current harmonics for Harmonics 2 to 13.

Note: the harmonics are not divided by the harmonic number, nor are those divisible by 3 excluded. It is effectively the same as THD with the maximum harmonic set to 13.

The HCF is computed using the following formula:

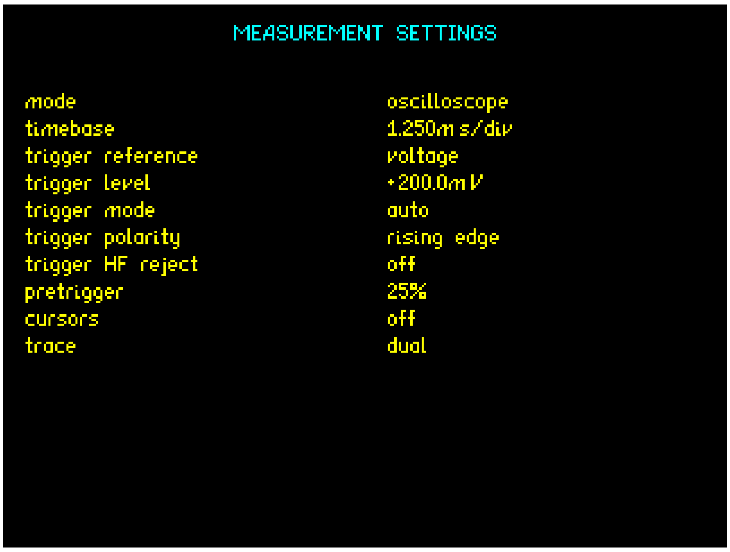
$$HCF = \sqrt{\sum_{n=2}^{k} i_n^2}$$

Where:

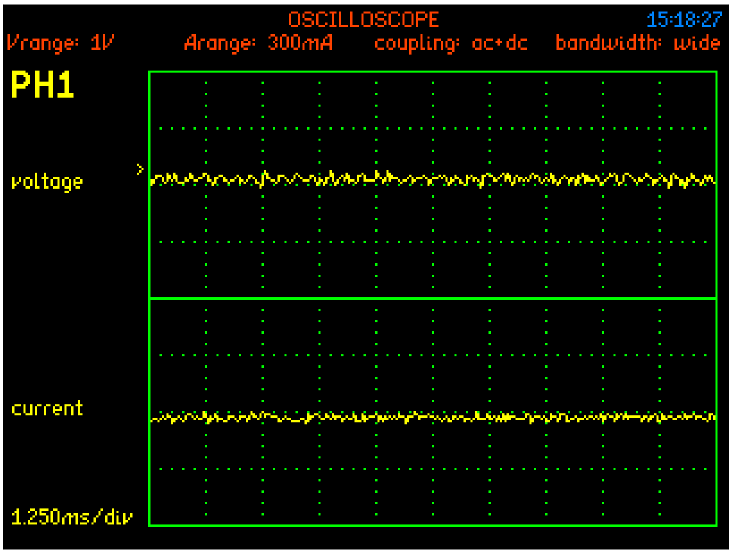
k = 13
n = the order of harmonic
i_n = is the ratio of harmonic current I_n to the rated current I_N.

Scope Mode

The PPA4500 series provides a digital storage oscilloscope function to view the waveforms being measured. The settings for the oscilloscope are configured by pressing the *SCOPE* key twice. Upon entering the *SCOPE* menu, the following screenshot will be displayed.



Selecting *SCOPE* mode from the operating mode keys (Item 7 page 24), or by cycling through the operating modes in any of the Operating Mode Select Options, displays voltage and current waveforms as a conventional oscilloscope – the screenshot below shows the default display with no inputs connected.



Time Base: The display for the oscilloscope is divided into 10 divisions along the time axis with the selected time base displayed in the bottom left hand corner of the display. The time base may be set to any real value between 15µs/div to 5s/div. Pressing the ►◄ arrows on the main panel will adjust the time base by a factor of 2

Trigger Reference: The data source for the trigger can be selected to be either Voltage or Current. On a multiphase instrument, any of the phases may be selected for the trigger source.

Trigger Level: The trigger level is set directly in Volts or Amps in relation to the trigger reference settings and does not change if the range is changed. The trigger level is displayed by a small **>** on the extreme left hand edge of the display. If the trigger is set to a value above or below the range of the input channel, then a small carat **^** is shown at the top or inverted at the bottom of the display as appropriate

Trigger Mode: The trigger mode may be set to be.

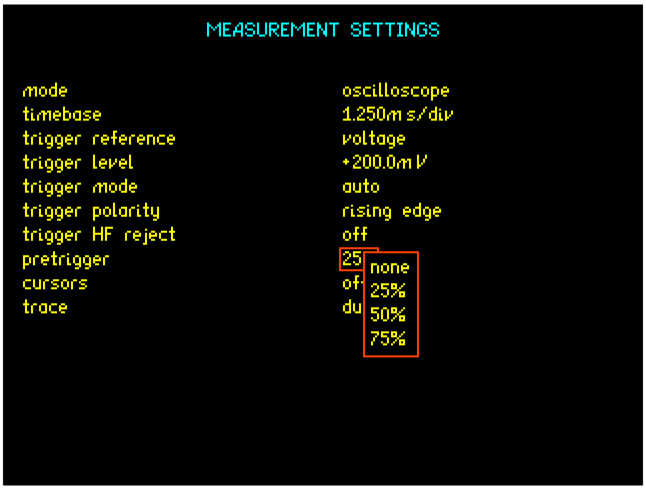
Auto	(trigger if possible but do not wait)
Normal	(wait indefinitely for trigger)
Single shot	(wait for trigger then hold)

The single shot option is reset using the *TRIGGER* key

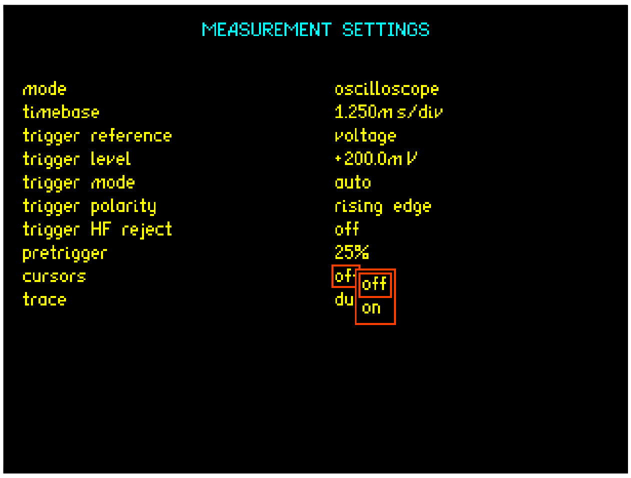
Trigger Polarity: The trigger polarity may be set to rising edge or falling edge

Trigger HF Reject: Select to be either ***ON*** or ***OFF***. When set to ***ON*** a low pass filter is applied to the trigger data to stabilise the trace with noisy signals. The filter only influences the trigger detection and does not change the data displayed.

Pretrigger: This may be set to none, 25%, 50% or 75% using the drop down menu as shown below



Cursors: Two cursors can be enabled on the display as per the screenshot below



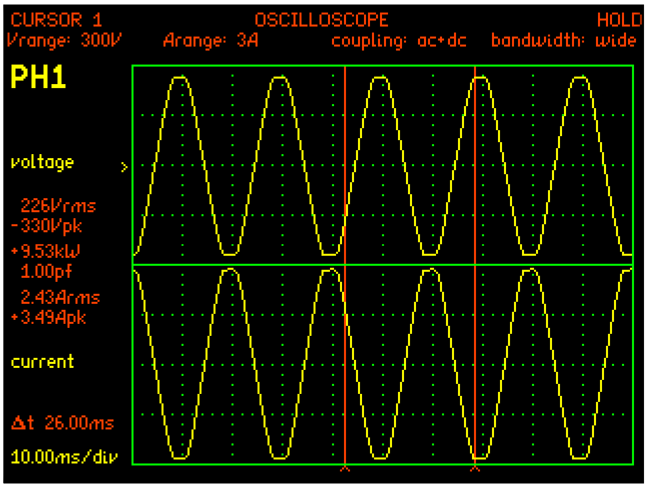
When enabled use the ▲&▼ keys to enable and switch between Cursor 1 and Cursor 2.

Use the ◄&► keys to move the selected cursor along the timescale

When operating in the oscilloscope mode, the ▲&▼keys operate in one of two modes:

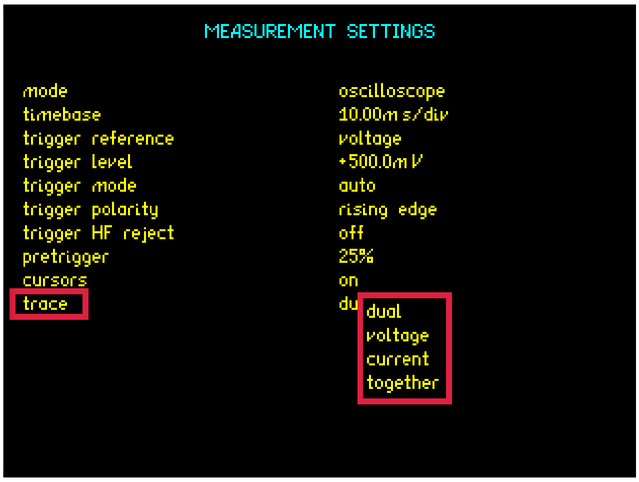
A. With the ***cursor*** option ***off*** (default); the ▲&▼keys change the time-base
B. With the ***cursor*** option ***on*** the ▲&▼keys change the cursor position and the ◄&►keys toggle between cursor 1 control and cursor 2 control.

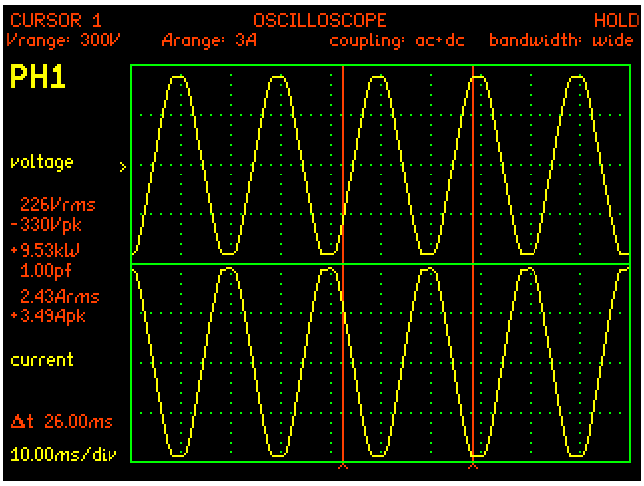
INFORMATION. When the cursors are enabled then the ◄&►arrow keys no longer adjust the time-base, and the ▲&▼ don't affect the trigger level.



From the screenshot left, the display shows all fundamental measurements from the position of cursor 1. Also displayed is the time difference between the 2 cursors, Δt= 26.00ms with the time-base set to 10ms/div

Trace: Used to set which waveform the user wishes to be displayed at any one time from the 4 options within the drop down menu



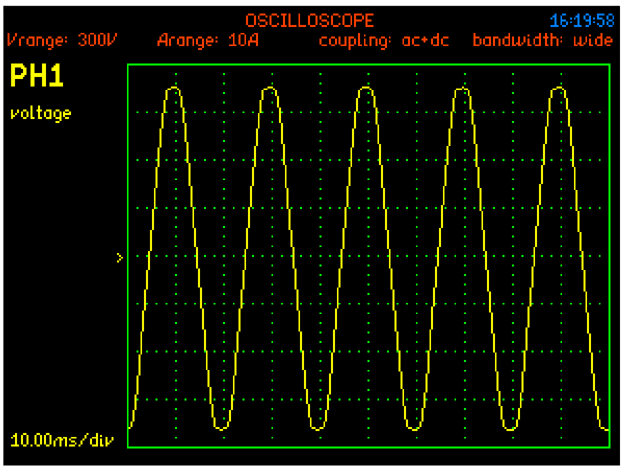


Screenshot from Scope display with ***Trace*** set to ***Dual*** & the cursors are enabled

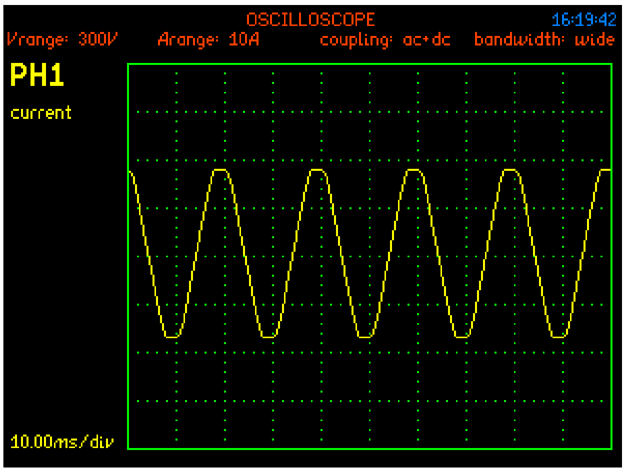
This screenshot shows all fundamental measurements from the position of cursor 1. Also displayed is the time difference between the 2 cursors, "delta t" = 26.00ms with the time base set to 10ms/div

The following four screen shots show the display when set to Voltage, Current, Dual, & Together.

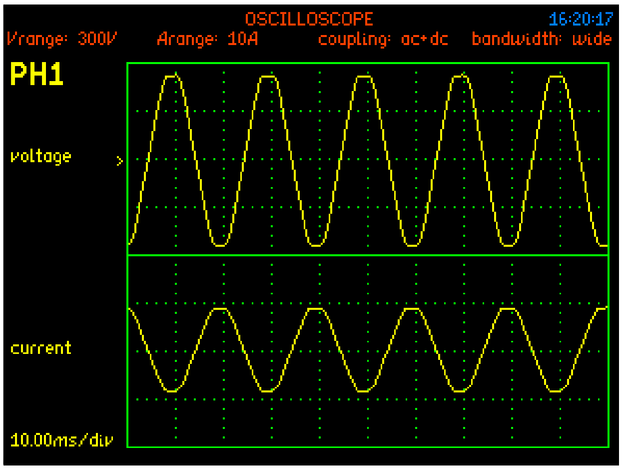
Trace set to Voltage:



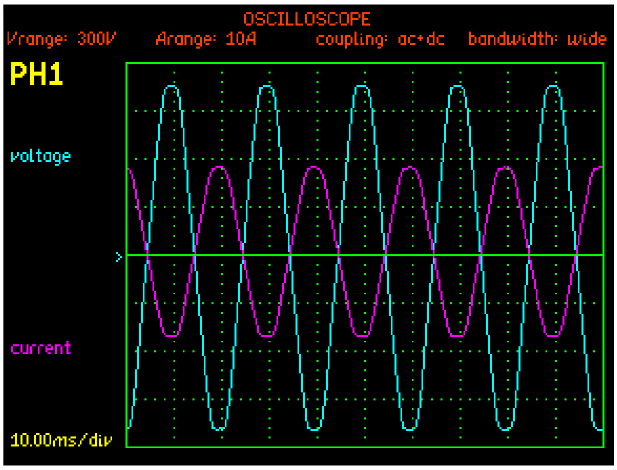
Trace set to Current:



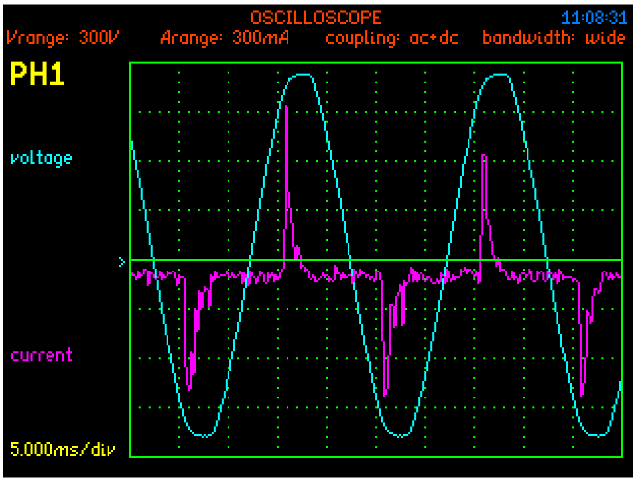
Trace set to Dual



Trace set to Together



A typical display of voltage and current waveforms for a switched mode power supply is shown below:



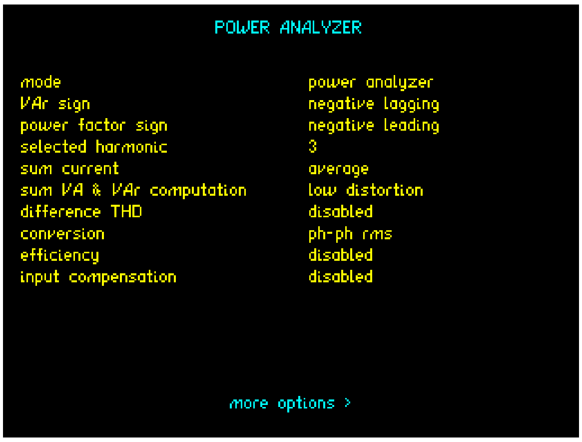
Chapter 11 Application Modes

Within this section we will look at all the different application modes selectable from within the PPA4500 Series *APP* menu, with the aid of screenshots and instructions.

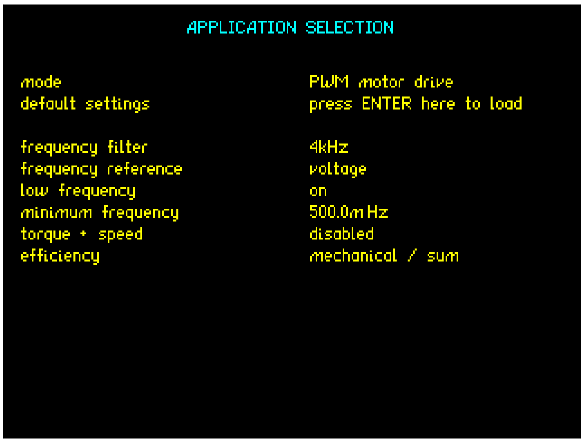
Each of the *APP* selections will load and adjust settings as a suitable starting point for the application appropriate to the DUT or system that is to be analysed.

While the top of the display screen will still show for example, ***Power Analyzer*** when the ***PWM*** *APP* has been selected, the instruments settings will not be the same as when it is set to ***Power Analyzer*** in ***normal*** mode. In fact, some of the settings are only available in a particular mode compared to the standard mode of the same name.

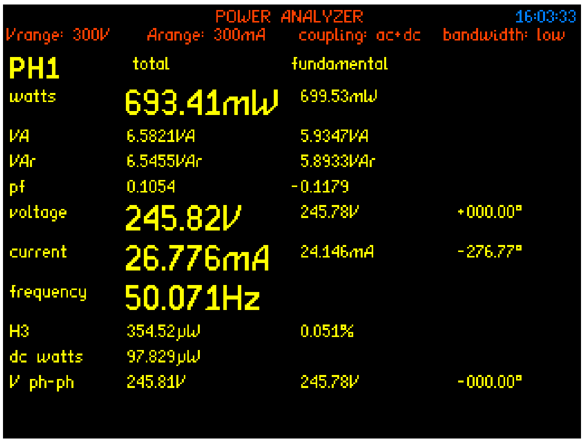
Normal default screen



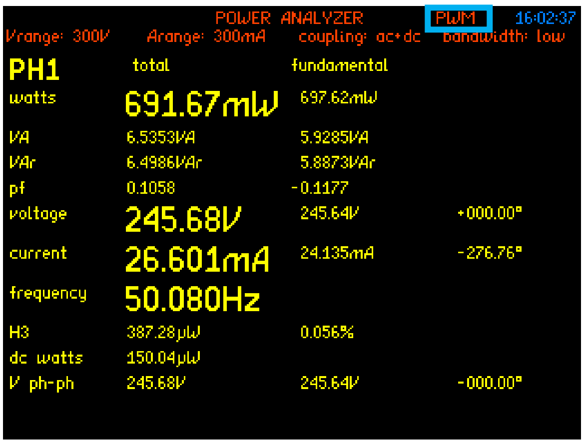
PWM Mode default screen



Normal Power Analyzer screen



Power Analyzer PWM screen



In the PWM Real Time screen the tell tail difference is highlighted in a light blue box, upper right where it shows PWM

On inspection of the PWM mode screen, top right, except for efficiency, all the other settings now loaded are not those shown in the normal Power Analyzer default screen. In the case of efficiency and values set in the App screen that are also in the normal settings will overwrite the normal settings. i.e., the App mode settings take precedence.

To reset to the normal Power Analyzer mode, chose ***Normal*** in the *APP* selection screen and load the default settings by highlighting Press ENTER here to load Followed by *ENTER*

To select your chosen measurement application, you will need to activate the *APP* key. Use the ▼ key to select mode / function then press the ► key to open the drop down menu.

In the following sections, each App mode setup and configuration will be illustrated to enable the maximum use and benefit from the PPA4500 Series instruments.

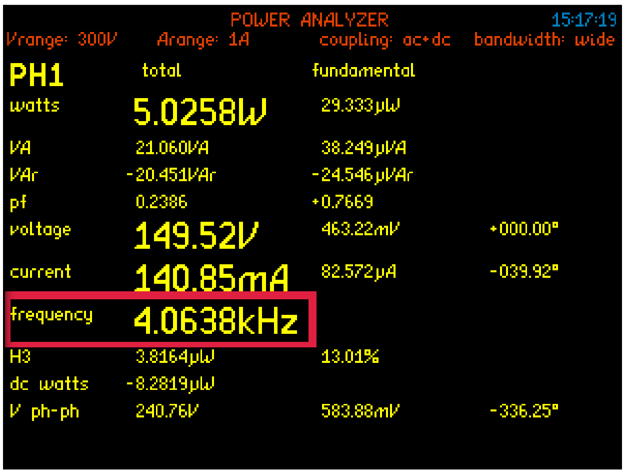
PWM Motor Drive

With the ever increasing pace that EV's are being developed, associated Pulse Width Modulated (PWM) power electronic techniques have become an ever growing share of the analyses that Newtons4th PPA4500 series are called upon to perform.
Given the crucial need to meet tight performance limits and increased efficiencies, accurate measurements are required. This is not a simple given the complexity of waveforms associated with PWM applications.

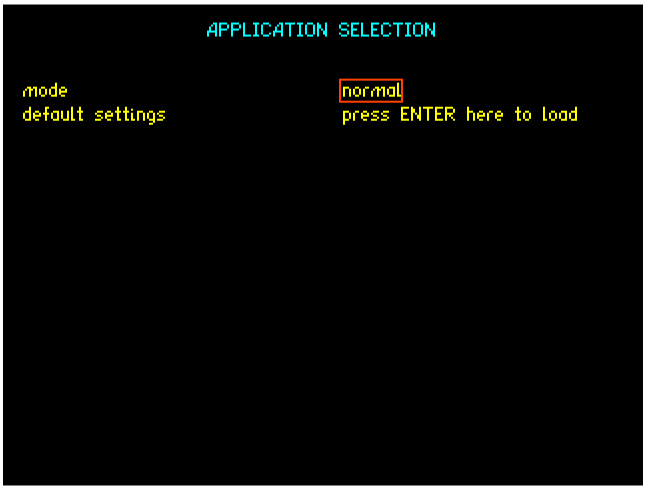
The nature of the waveforms produced in a PWM motor drive application makes measurement of the fundamental frequency difficult. In this section we will look at the switching and fundamental frequencies and how frequency lock and filters will allow the correct measurements to be displayed on such a complex waveform

Test device: 1 x Inverter/Motor test unit (set at 65Hz)

Leaving the PPA4500 in the ***normal** APP* mode record the frequency measurement, 4.0638kHz in this instance.

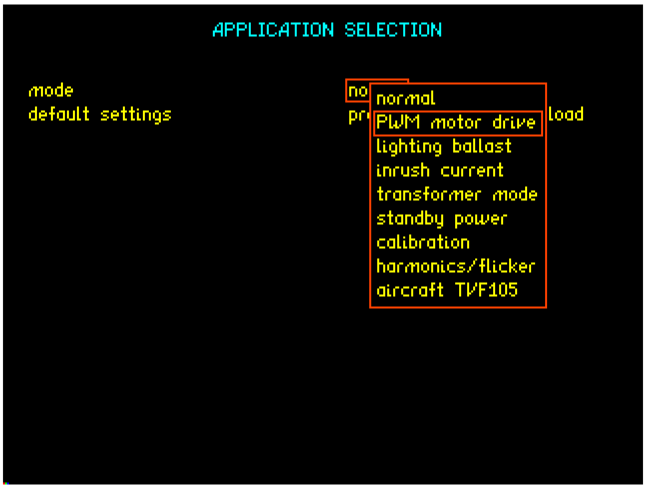


In the ***normal** APP* mode, the PPA4500 is locking onto a switching frequency / high frequency noise of 4 KHz with no filtering applied. This can be used as a guide when selecting a frequency filter from within the PWM motor drive application parameters screen.

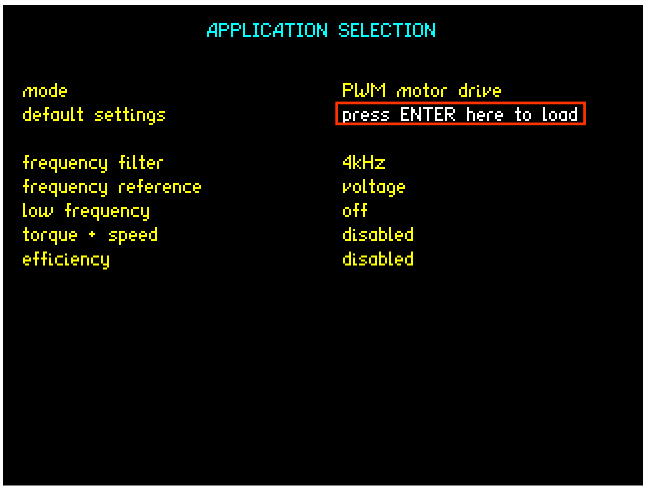


To access PWM motor drive mode:

Press the APP key, press the ▼ Key and a red Box will surround the ***mode*** parameter ***normal,*** press the ► key, followed by the ▼ Key, the display will now show a drop down menu with the PWM motor drive option highlighted and flashing, as shown in the next screenshot.

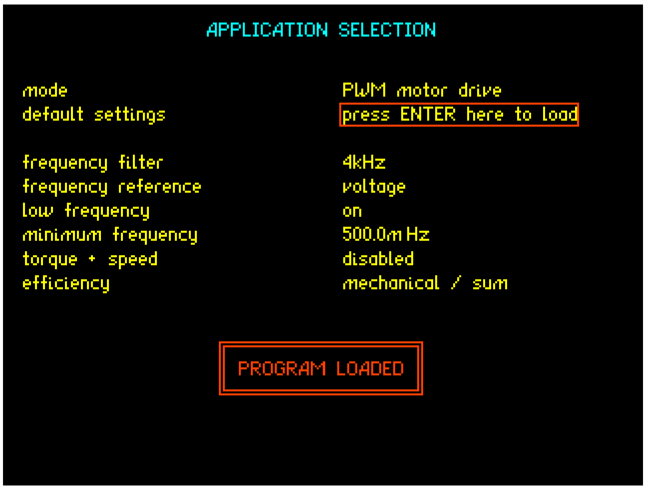


At this stage, press the *ENTER* key, the screen will change the colour of the ***press ENTER here to load*** message to white and display five additional parameters as shown in the next screen shot below.



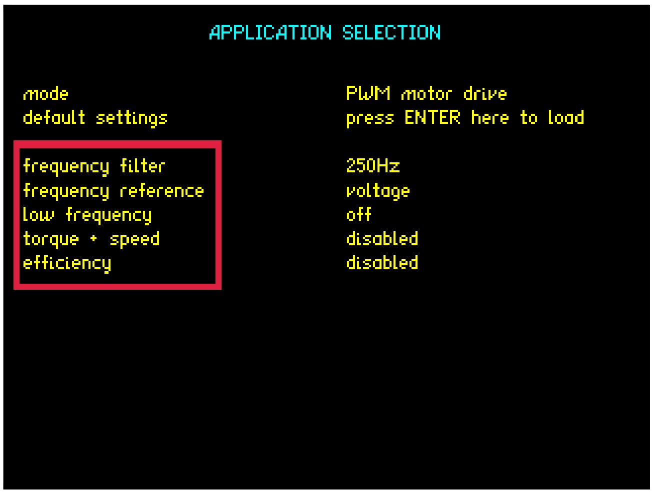
However untill the default settings have been confirmed , the instrument is not set for PWM mode.

Press the ▼ key untill ***the press ENTER here to load*** is highlighted with a red box and then press the *ENTER* key.



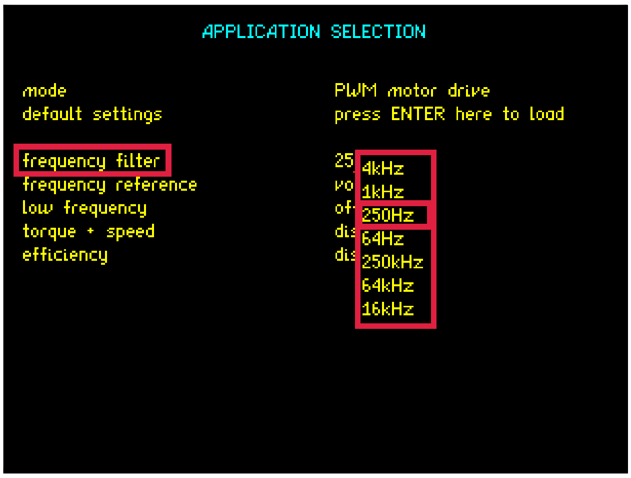
The white text will turn yellow and a message box stating PROGRAM LOADED will be briefly displayed at the base of the screen.

The PWM mode is now loaded, and the extra six default settings are now activated as low frequency has been turned on and set to 500mHz.



Frequency filter: Selectable filter from drop down menu. Select a frequency whose range is between the Fundamental Frequency and the Switching Frequency but closer to the fundamental. In this test we have set the inverter to a fundamental frequency of 65Hz so we will select a frequency filter of 250Hz

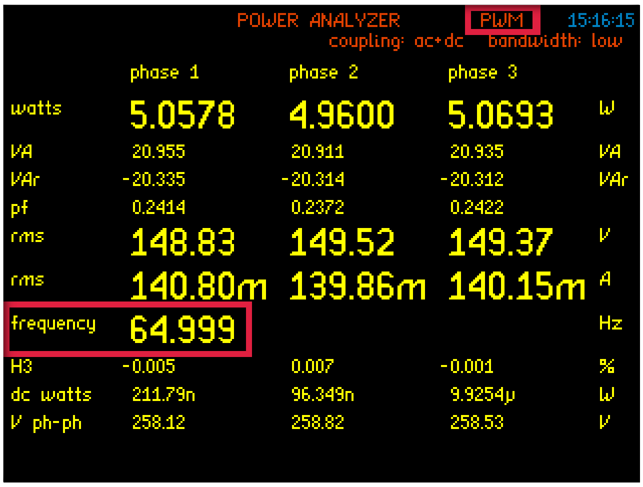
INFORMATION. Do not select a filter too close to the fundamental frequency this may result in the frequency measurement reading 0Hz



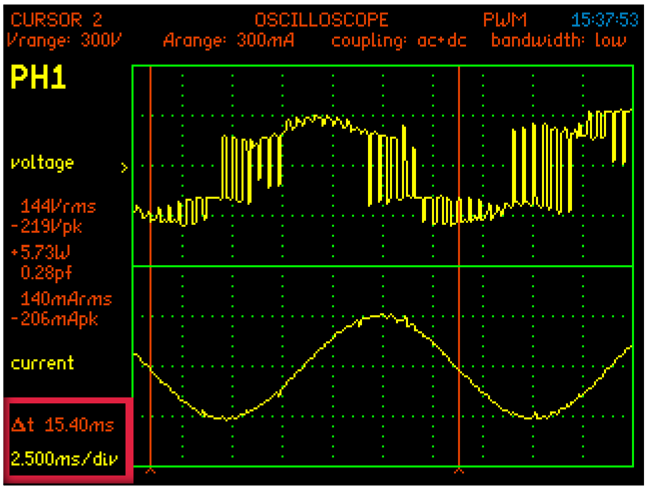
Setting the frequency filter:

Press the ▼ key to highlight the ***frequency filter*** values. Press the ►key to open the frequency ranges dropdown menu.

Press the ▼ key 2x to highlight 250Hz, press *ENTER* to confirm selection.



By applying a 250Hz filter within PWM mode we can now see that the instrument is locking onto the fundamental frequency, this is required for correct signal processing of the waveform.



By viewing the waveforms in the Oscilloscope mode, we can see the switching frequency of the Voltage and a smoother sine wave Current waveform

By use of the two cursors, the Current waveform shows the time for 1 cycle to be approximately 15.40ms

Therefore 1s ÷ ($15.40\text{x}10^{-3}$) = 64.9Hz the Fundamental Frequency

Frequency reference:

Select from the drop down menu which waveform the fundamental frequency is to be synchronised with Voltage or Current

Low Frequency:

Set this parameter to ***ON*** *if not already set*, switching on will then present the minimum frequency parameter

Minimum Frequency:

Manually input a value to allow the results window to extend automatically if the fundamental frequency time-period is longer than the time period of the data window. This is recommended

Torque & Speed:

The options available are disabled, analogue, pulsed speed, pulsed torque, and pulsed.
Analogue sets both the torque and speed inputs to analogue
Pulsed speed sets torque to an analogue input and speed to pulsed input
Pulsed Torque sets speed to an analogue input and torque to pulsed input
Pulsed sets both torque and speed to pulsed inputs

For all the above settings other than disabled, once selected, two additional pairs of menu options will appear, scale factor, and offset for both the torque and speed parameters. Consult the torque and speed transducer's specifications to make the appropriate correct settings.

Efficiency

When enabled, efficiency provides four different sets of parameters

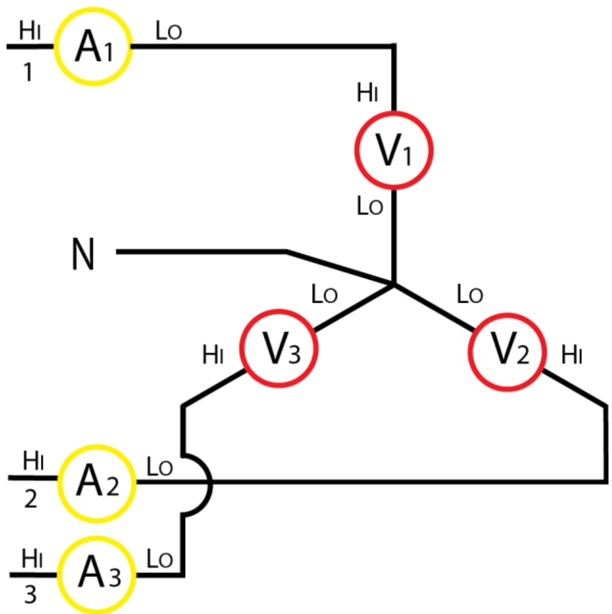
Phase/next phase
Master/slave
Mechanical/sum
Phase 3/sum

In each case above the reciprocal ratio is also offered.

Using the PPA4530 to measure 3 phase power with PWM drives

If there is access to the neutral point (star point) of a star wired load, then accurate measurements can easily be made by connecting the measurement channels in star configuration:

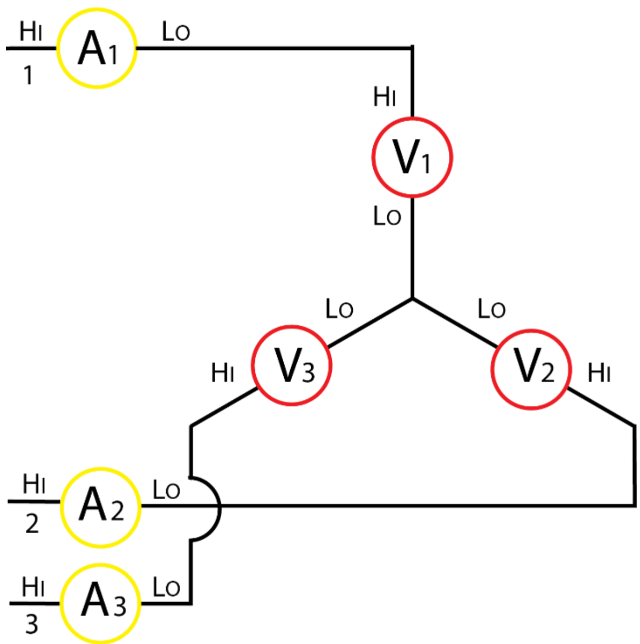
Three Phase Star 3P3W



In this configuration, the data including rms voltage will be correct for each phase, and the phase to phase voltage rms can be derived (set conversion to “phase to phase rms”).

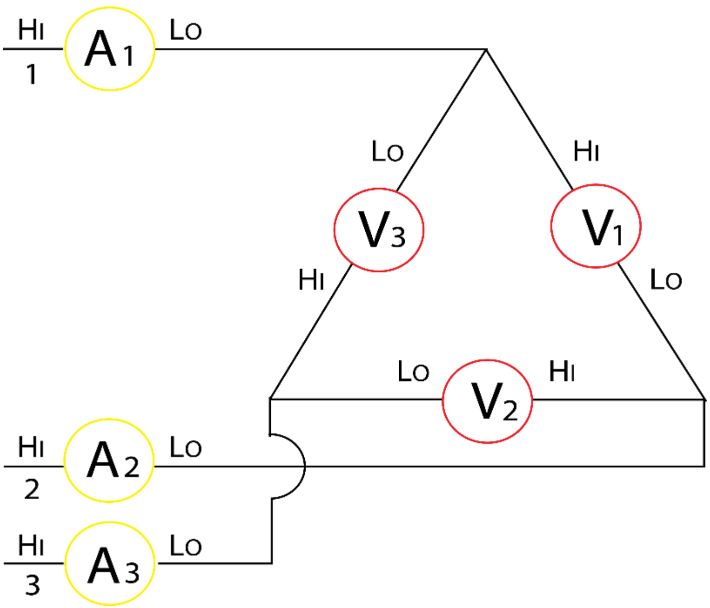
If, however, the neutral point is not available, then the measurement of the voltage rms is more difficult. The options are to use a synthesised neutral or to connect in delta configuration and derive the phase measurements.

Consider the synthesised neutral configuration:



When using synthesised neutral, the elementary measurement of the voltage rms will usually be higher than that measured with a true neutral. For this case, there is a conversion option “star to delta” which accurately computes the phase to phase voltages, then derives a phase to neutral value from the computed phase to phase values. This gives a phase to neutral value which is much closer to that measured with a real neutral. The phase to phase (or “delta”) value, Vd(t) is derived from the instantaneous “star” voltage values, Vs(t) (eg. Vd1(t) = Vs1(t) – Vs3(t)) so the voltage present on the synthesised neutral has no effect.

Consider the delta wired configuration:

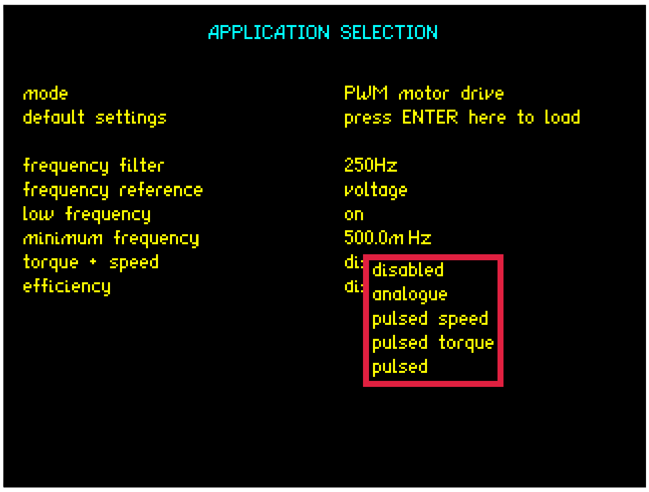


In this case the phase to phase voltages are measured directly and the phase to neutral values are derived (set conversion to “delta to star”). The power measurements are also adjusted to show the individual “star” phase powers. The delta/star conversion assumes that the impedance of the load is equal on all three phases.

Wiring	Conversion	Phase rms voltage	Phase power
Star with neutral	Phase to phase rms	Measured	Measured
Star without neutral	Phase to phase rms	Slightly high	Measured
	Star to delta type A	Derived	Measured
	Star to delta type B	Derived	Calculated
Delta	Delta to star	Derived	Derived

Torque & Speed:

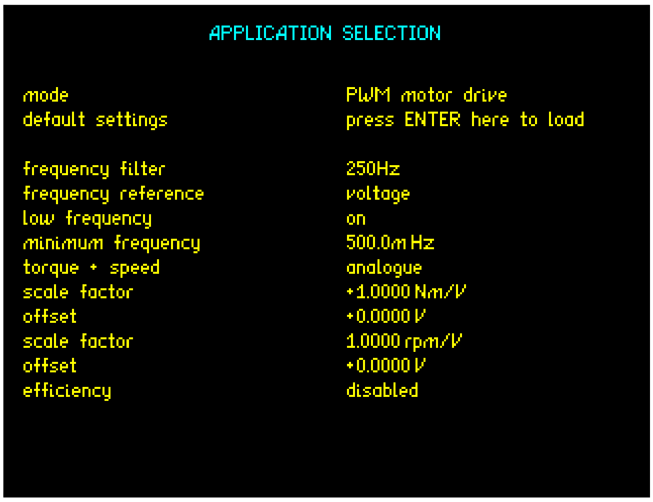
Set the Torque and Speed parameters to measure the Mechanical Power (Nm) and Speed (RPM) via the Torque and Speed BNC connectors on the rear of the instrument, situated below the cooling fan between Phase 1 and Phase 2 connections, shown highlighted in blue.



Open the torque and speed drop down box to select which type of transducer output is to be connected to each BNC connector.

See here for description of each selection.

Once a configuration has been selected you will be required to input a scale factor relating to both the Mechanical Power (Nm) and Speed (RPM), both parameters will then be calculated against the selected source.



Consult the transducer manufacturer's documentation for scale factor and offset settings.

Lighting Ballast

Electronic lighting ballast waveforms consist of a high frequency carrier signal modulated by the line frequency. The PPA4500 measures the line frequency independently of the input waveform frequency and synchronises the measurement period to the line frequency.

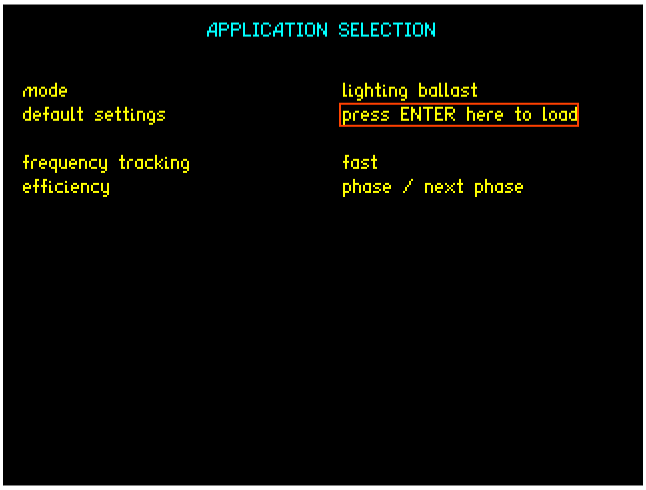
The carrier frequency measurement ignores any “dead band” around the zero crossing of the AC line to compute the actual switching frequency of the ballast.

Both the frequency measured on the input waveform and the frequency of the line input are displayed.

As the switching frequency can vary over the cycle, the analysis frequency of the DFT measurement is continually adjusted to give an optimum measurement of the fundamental and harmonics. The response of the tracking algorithm can be adjusted to suit the ballast being measured:

Fixed time (no adjustment)
Fast
Medium
Slow

To select lighting ballast mode, press the *APP* key, select the mode with the cursor keys, move down to the ***default settings*** option and press *ENTER*. The defaults are loaded, and the particularly important parameters can then be changed.



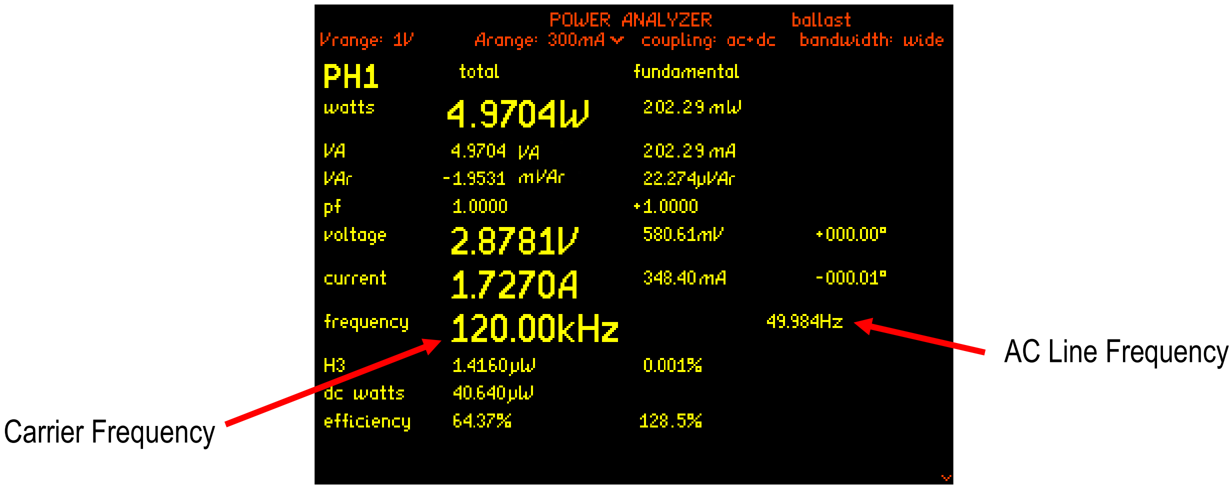
Ballast mode quick start guide

After selecting ***lighting ballast*** in the APP menu, the next step is to connect the ballast input and output (if required) to the Power Analyzer.

Connect the OUTPUT of the ballast to PHASE 1 of the PPA, this is important as detection of the modulation signal is on PHASE 1.
Connect the input (50/60Hz line etc) of the ballast to PHASE 2 of the PPA.

With connections to the PPA made, we are ready to commence measurements.

Example measurements



Phase 2 will also display the same two frequency components for the user's reference.

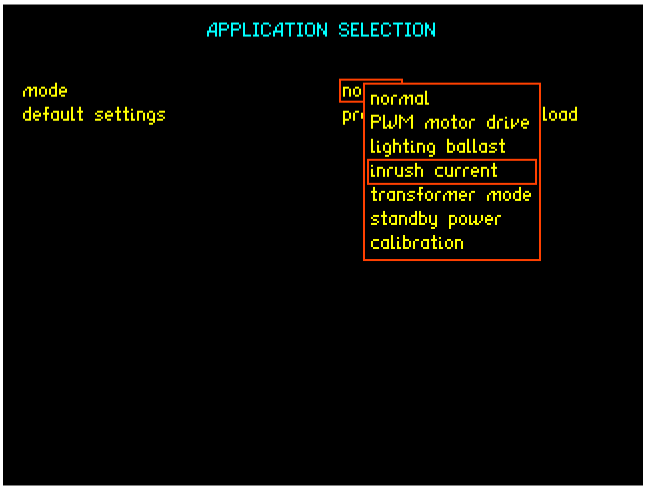
INFORMATION. The default setting for efficiency measurements is Phase 1/Phase 2, as displayed on the bottom line of the display.

Inrush Current

Measurement of inrush current (surge) requires very fast gapless sampling to catch the highest instantaneous transient typical of this type of behaviour. By default, the PPA4500 series will be set to auto ranging, while in most cases this is a positive advantage, for determining inrush current measurements, it can work against the PPA4500.

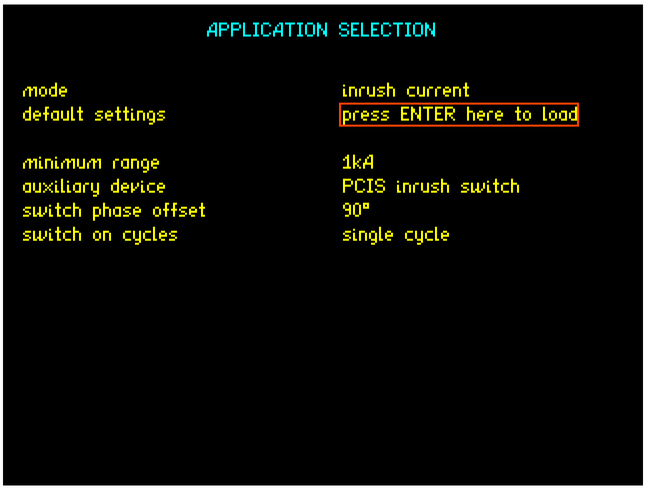
The PPA4500 series can be used in two ways to measure the inrush current, firstly as a standalone instrument, and secondly with the use of the PCIS accessory (See Appendix A)

Inrush measurement without a PCIS accessory.



In the *APP* menu, select ***inrush current*** and then press *ENTER* to load the default settings

The default settings are shown in the screen shot below



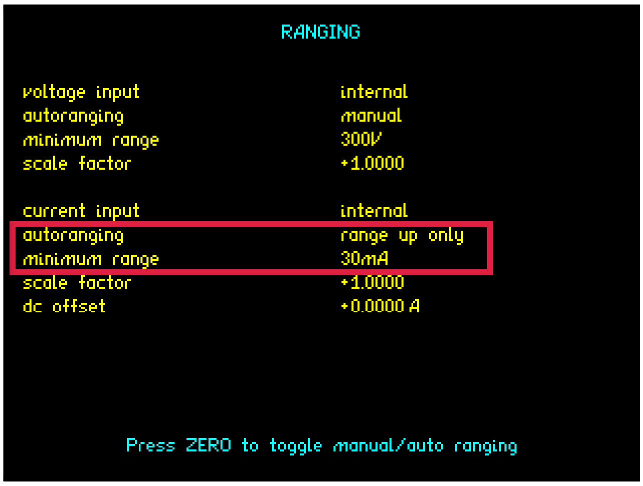
The default settings expect the PCIS to be used, by pressing the ▼ twice, the auxiliary device parameter is highlighted, use the ► and ▲ key to highlight ***none*** followed by *ENTER*

The last two parameters, ***switch phase offset*** and ***switch on cycles*** will be removed from the screen and measurements can commence.

The measurements must be made under conditions of manual ranging and with the voltage applied to the instrument. Then when the load is switched on the highest peak value can be detected. In inrush mode, the PPA4500 samples and analyses every sample at the full sample rate >2Msamples/s to catch even very fast peaks.

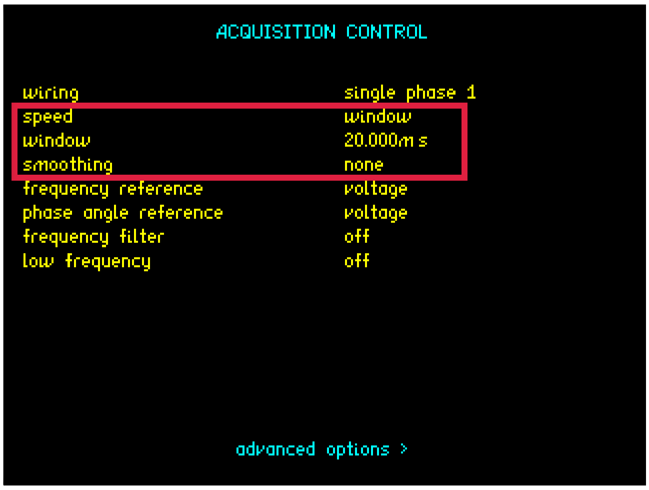
Setting the range parameter

This is best configured if the user has prior knowledge of the peak current measurement expected from the DUT. If this is not available, then the user should set the current settings as follows.

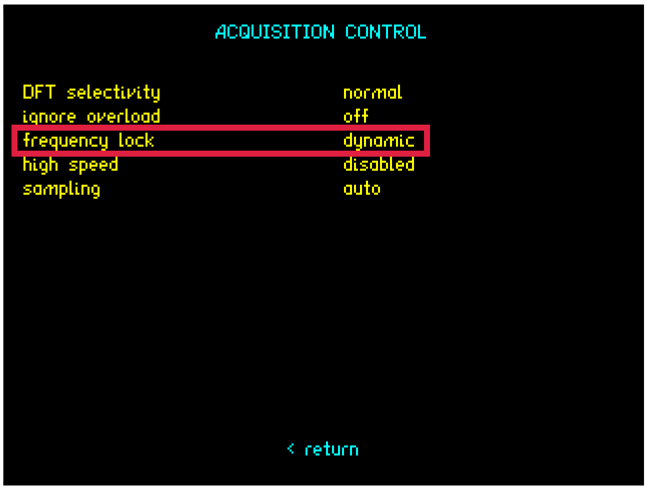


Set the ***autoranging*** parameter to ***range up only*** and the minimum range to the 30mA range this will allow the test being carried out to find the highest range via peak detection and hold on this range

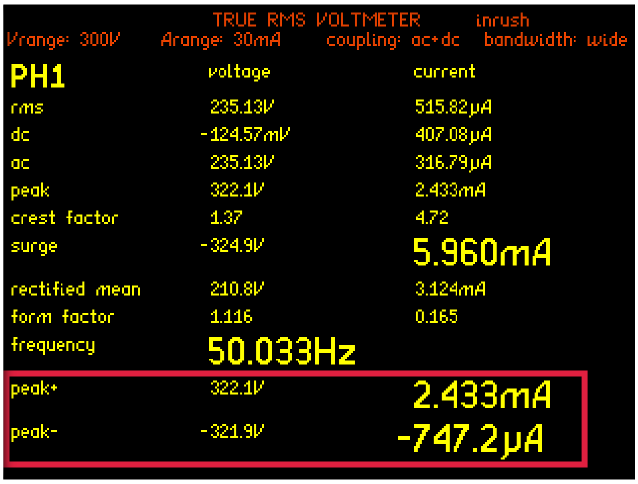
Setting the Speed and Smoothing



For this application a mains input signal of 50Hz was used, therefore we can set the ***speed*** to ***window*** and ***20.00ms*** this will enable us to capture cycle by cycle data over the whole waveform, to get the instantaneous cycle by cycle power the ***smoothing*** parameter is best set to ***none*** as shown



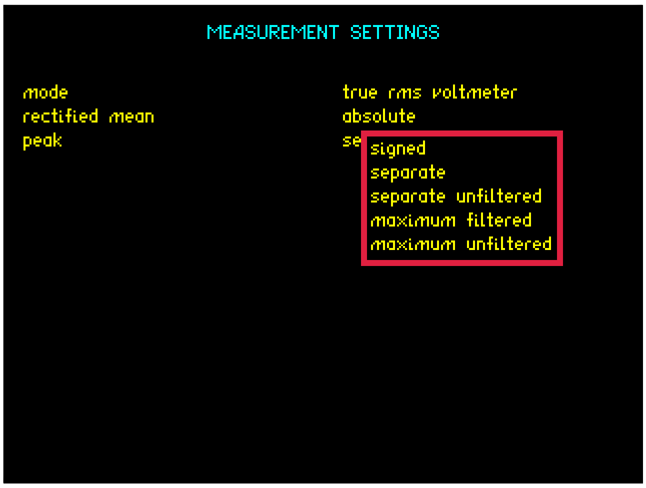
Upon completion of the speed and smoothing settings press the ► key to take you to the advanced settings screen. If undertaking cycle by cycle measurements on the input signal, then set the ***frequency lock*** to ***Dynamic***



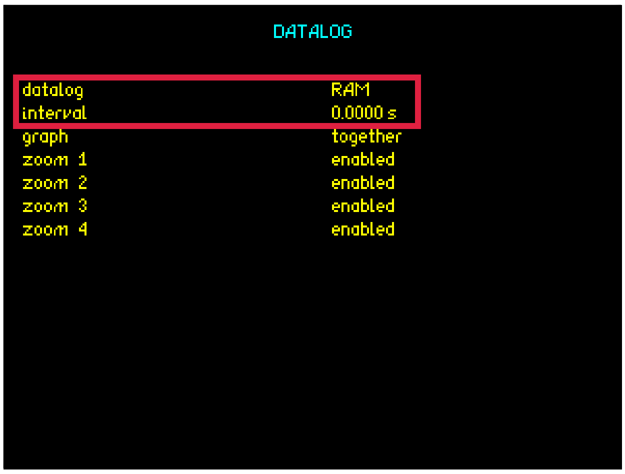
Setting Peak Measurement Parameters, if required, you can display the ***Peak+*** and ***Peak-*** measurements within the RMS Voltmeter mode screen

These parameters can be configured within the True RMS Voltmeter mode key

Press the *RMS* mode key until the measurement settings screen is displayed



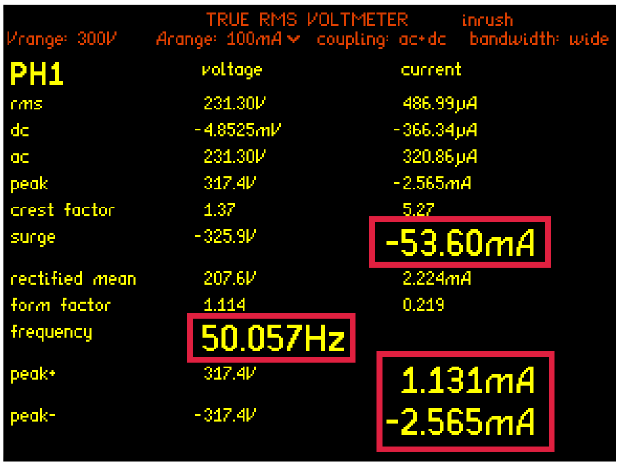
For this demonstration we selected ***separate unfiltered*** this then gave us the unfiltered ***Peak +*** and ***Peak –*** measurement parameters as displayed earlier for both Voltage and Current



Data logging to Internal Memory

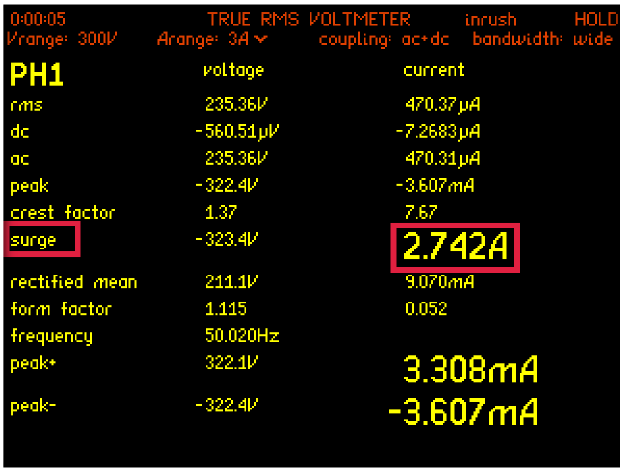
Set the ***Datalog*** parameter to the internal ***RAM*** memory this will offer the user the fastest performance

Set the ***interval*** time to ***0.00s*** to enable the Datalog to capture every cycle of the fundamental frequency

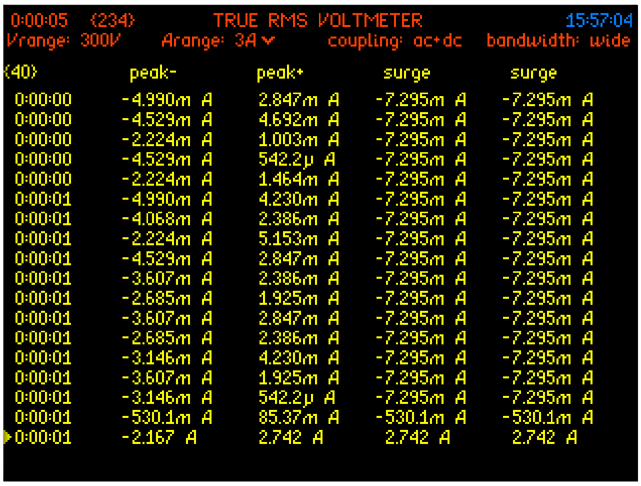


Reconfigure zoom parameters within real time display as described here

Zoomed parameters can now be used to capture the Inrush Current (Surge) data within a Datalog

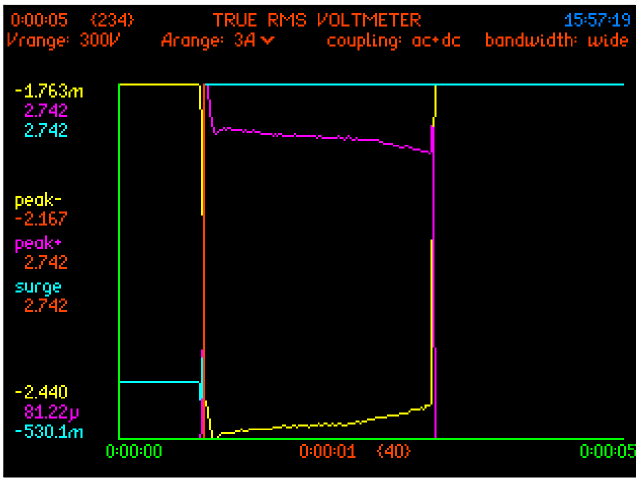


DataLog Results
From the Real Time display the surge measurement at the moment the DUT was switched on is recorded as 2.742A



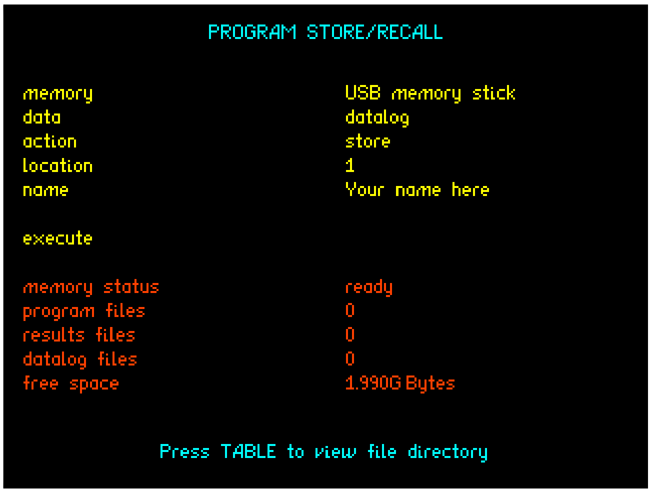
(40)	peak-	peak+	surge	surge
0:00:00	-4.990m A	2.847m A	-7.295m A	-7.295m A
0:00:00	-4.529m A	4.692m A	-7.295m A	-7.295m A
0:00:00	-2.224m A	1.003m A	-7.295m A	-7.295m A
0:00:00	-4.529m A	542.2μ A	-7.295m A	-7.295m A
0:00:00	-2.224m A	1.464m A	-7.295m A	-7.295m A
0:00:01	-4.990m A	4.230m A	-7.295m A	-7.295m A
0:00:01	-4.068m A	2.386m A	-7.295m A	-7.295m A
0:00:01	-2.224m A	5.153m A	-7.295m A	-7.295m A
0:00:01	-4.529m A	2.847m A	-7.295m A	-7.295m A
0:00:01	-3.607m A	2.386m A	-7.295m A	-7.295m A
0:00:01	-2.685m A	1.925m A	-7.295m A	-7.295m A
0:00:01	-3.607m A	2.847m A	-7.295m A	-7.295m A
0:00:01	-2.685m A	2.386m A	-7.295m A	-7.295m A
0:00:01	-3.146m A	4.230m A	-7.295m A	-7.295m A
0:00:01	-3.607m A	1.925m A	-7.295m A	-7.295m A
0:00:01	-3.146m A	542.2μ A	-7.295m A	-7.295m A
0:00:01	-530.1m A	85.37m A	-530.1m A	-530.1m A
0:00:01	-2.167 A	2.742 A	2.742 A	2.742 A

Pressing the *TABLE* key will now display all the data points taken from the associated DataLog and you will notice that the Inrush Current (Surge) is displayed as being 2.742A

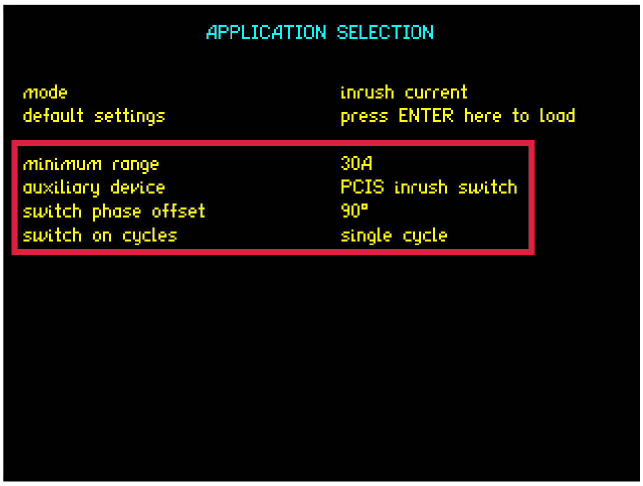


Pressing the *GRAPH* key will display in a graphical format all the data points from the associated DataLog displayed within the previous screenshot the surge displayed within the tabular display corresponds with the graphical display

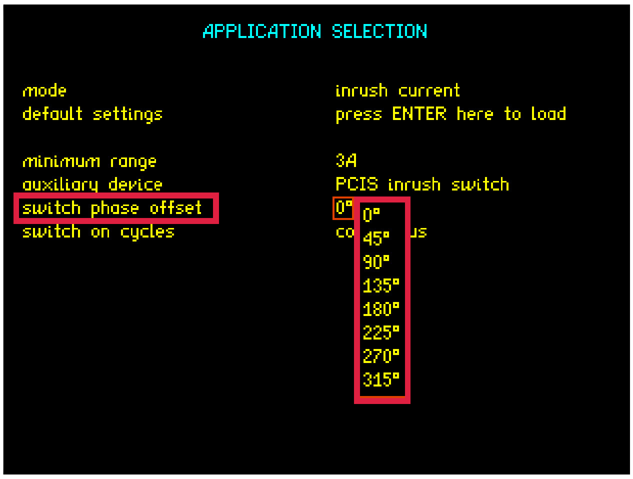
Upon completion you are now able to save / recall or delete your test results taken from your DataLog within the *PROG* mode key



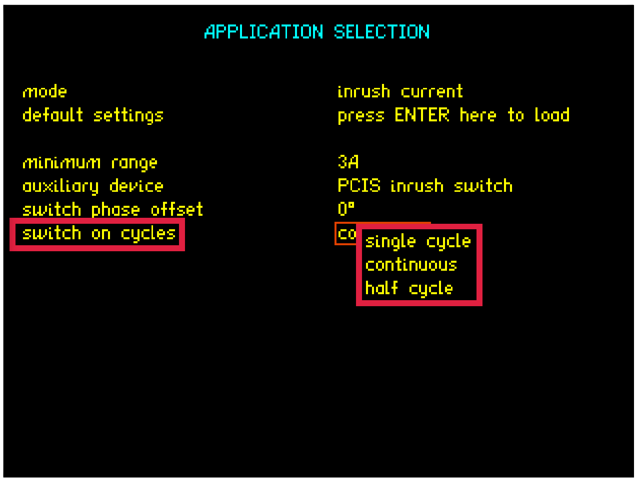
Transferring the Datalog from the RAM memory onto a USB memory stick will allow the user to export the .txt file which can be imported into an Excel file if desired, more details can be found relating to the transfer of data here



Inrush Current Mode using the N4L PCIS Switch.
For the worst case inrush current the input to the device under test must be switched on at the worst point in the cycle (90˚ or 270˚ for a capacitive load, 0˚ or 180˚ for an inductive load). The Phase Controlled Inrush Switch, or PCIS, available as an accessory for the PPA4500, controls the switch on of the power to the DUT from 0˚to 315˚ in steps of 45˚ from the Instruments front panel.



Switch Phase Offset:
Press the ▼ Key followed by the ▶ key to reveal the drop down menu to select switch on phase angle. Select the desired angle by use of the ▲ & ▼ keys, followed by *ENTER* to confirm the selection.



Switch on Cycles:
Press the ▼ Key, the ***Switch on Cycles*** parameter will be selected. Press the ► key, the drop down box will open with all available waveform cycle ranges.

Select the desired waveform cycles value by use of the ▲ & ▼ keys, followed by *ENTER* to confirm the selection

The testing, datalogging etc can now be performed in the same manner as in the previous section without the PCIS

When performing analysis of inrush current of a product such as a transformer or the input stage of a switched mode power supply, "range up only" (found in the *RANGE* menu) can provide a useful method for determining an appropriate range for the inrush tests if the current consumption of the product during an inrush event is unknown.

However, precautions should be taken regarding the range-up only function as this functionality is generally intended for use when monitoring gradual load current changes, such as when a motor load is gradually increased over time.

Ideally, before performing an inrush test the range setting in the PPA would be manually selected and fixed using the ***manual*** setting in the *RANGE* menu. This setting will reflect the maximum peak current you expect the device under test to draw from the voltage supply.

INFORMATION. It is important that the voltage supply signal is always present at the voltage input terminals of the PPA, do not turn the source on and off to perform inrush current tests. The voltage source should be disconnected and reconnected to the device under test using safe working practices.

To utilise "range up only" to determine an appropriate range, it is advisable to make the following settings

1. ***Speed, medium***
2. ***Smoothing, fixed time***
3. ***Low frequency mode, ON***
4. ***RANGE, current, range up only***

After these settings are made, the device under test should be connected to the voltage source repeatedly until the range up only function no longer "ranges up".

If at any time you observe the range briefly ranging up and then ranging back down, you should revert to manual ranging and perform the tests manually until a suitable range is found.

After these tests are made, the appropriate range should be set to ***manual*** and ***smoothing*** and ***low frequency*** mode ***disabled***

If you wish to analyse the peak current (this is the highest single sample point detected) within any cycle, then a slower speed can be selected and the ***surge*** parameter in ***RMS*** mode will provide this value***.***

INFORMATION. Entering the default settings in inrush mode in the application menu selects the PCIS and sets the PPA45xx to manual ranging. If PCIS is not being used, then it can be deselected in the AUX menu. Having selected the default settings, the current range should be set to an appropriate range for the DUT. The oscilloscope mode is also useful for qualitatively evaluating the inrush current.

Transformer

Power transformers

Large power transformers operate at very low power factor (<0.01) and the phase accuracy is critical to measure the losses. Power transformer application mode sets the configuration options to the optimum for phase accuracy e.g., AC+DC coupling, range lock across phases.

The Transformer mode in the PPA4500 series is ideal for both single phase and three phase transformer analysis, we will first describe general operation with a single phase device and then move on to describe three phase measurements. For both single and three phase tests the Corrected power (Pcorr) and K-factor values are displayed in the results window.

When testing a three phase transformer, the multiple phase display is changed to show imbalance across the phases. Phase 1 appears with the normal measurements but the voltage and current measurements for phase 2 and phase 3 are expressed as a percentage of the corresponding values from phase 1. The phase angle measurements are expressed as a deviation from the expected values of -120° and -240°.

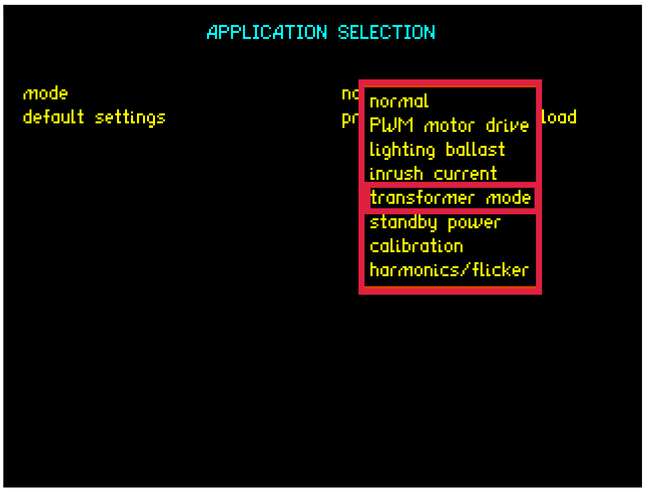
Additionally, the temperature can be monitored at the same time by connecting a suitable temperature sensor to the “torque” BNC input (see here). The input accepts an analogue voltage from -10V to +10V which can be scaled by an offset and a factor in degrees per Volt. The offset is entered as the zero degree voltage so for a sensor with an output range of 5° / Volt and 0V = 10 degrees, the offset to be entered would be -2V.

Single phase testing

Test device: 1 x Single Phase Transformer, ratio (1:1)

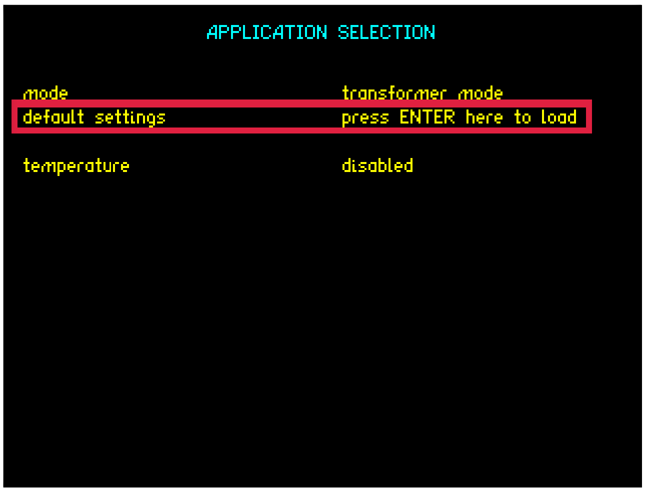
Accessories: 1 x Break out Box

Transformer Mode will allow the user to assess and view characteristics applicable to the transformer field under test conditions



To access transformer mode from the drop down menu, press the ▼ key 4 times and press *ENTER* as displayed, transformer mode will now be selected

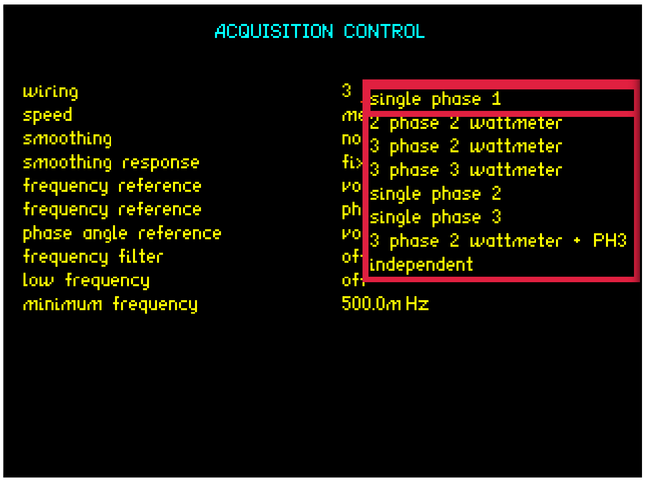
Press the down arrow 1 more time to highlight default settings mode and press *ENTER,* this will set the instrument into its default settings for transformer mode



Pressing the *HOME* key twice will take you back to the power analyzer home screen

You are now required to set the wiring configuration for the transformer.

Press *ACQU* key which will bring up the ***ACQUISITION CONTROL*** screen. Press the ▼ key once so the red box flashes around the wiring selection; press the ▶ key to open up the drop down menu as seen within the screenshot below



Use the ▲ & ▼keys to select which wiring configuration you require. For this example, ***single phase 1*** was selected to reflect the transformer being used. Press *ENTER* to confirm selection then *HOME* twice to return to the power analyzer home screen

The “Power Analyzer” home screen will now display the data measurements collected from your transformer under test

With the transformer plugged into a Breakout Box and no load attached, the following measurements are displayed

The Voltage and Current measurements displayed within the upper Blue Box above reflect the auto ranging configured by selecting the default settings within the instruments application home set up screen

Viewing the data (Green Box) the phase angle of the fundamental is shown as 78.90°. A perfect transformer would display a phase angle of 90°. From this data we can confirm that there must be parasitic elements within the makeup of the transformer causing these results, such as a series resistance.

The Pcorr (Corrected Power) and K factor values displayed within the Orange Box (see above) are computed in transformer mode. In transformer mode there is usually very little distortion. The equations used to calculate these values are:

The Corrected power (P_0) equation is the top one in the right hand column.

The K factor equation is the lower one in the left hand column.

IEC 6007 6-1 :2011

$$P = P_m \frac{P_m}{P_1 + k \,.\, P_2}$$

$$\boxed{k = \left[\frac{U}{U'}\right]^2}$$

$$\boxed{P_0 = P_m\,(1 + d)}$$

$$d = \frac{U' - U}{U'} \quad (\text{usually negative})$$

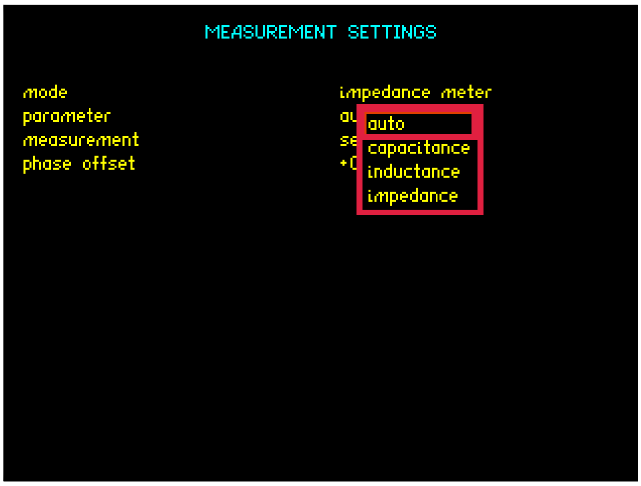
Where

P or P_0 = corrected power	P_2 = ratio of eddy current losses to total iron losses
P_m = measured power	U’ = Normalised mean value of voltage
P_1 = ratio of hysteresis loss to total iron losses	U = rms value of voltage

Within the measurement screen the display shows that with “NO” load connected the transformer is consuming 5.1545W of power at a Frequency of 50Hz. If you now press the *IMP* key you will enter the Impedance Meter screen, within this application mode you will be able to view all the individual data values collected that make up the total Impedance measurement attributed to the DUT. (Both real and imaginary)

In the next set of screen shots, we will be able to view this data

Press IMP key to enter the Impedance Meter screen
Press IMP key again to enter Measurement Settings screen
Press the ▼ key 2 times, a red box surrounds parameter settings
Press the ▶ key to open the drop down menu



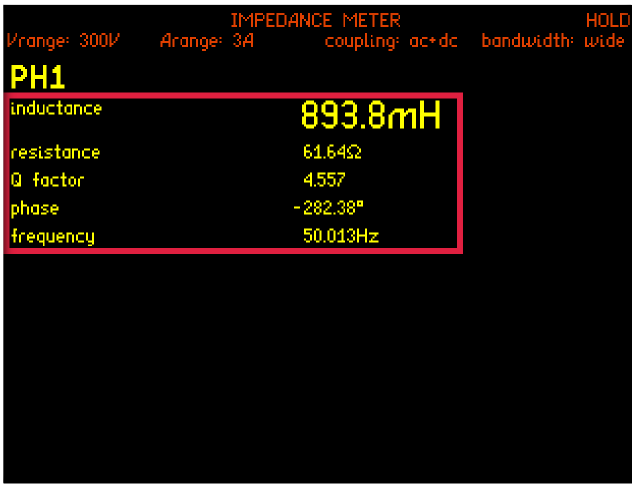
From the drop down menu you will now be able to view all parameters as shown or alternatively by selecting "auto" the display will show the appropriate parameters values attributed to the DUT

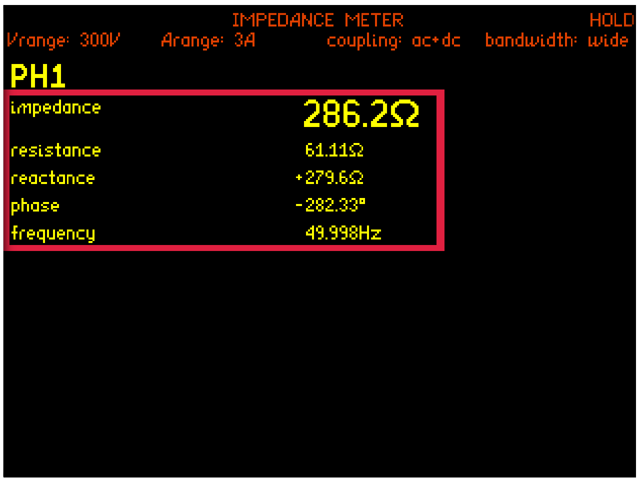
Press *ENTER* to confirm selection

Press *ENTER* to return to home screen and view measurements

From the "auto" screen you can now see that we have a Resistive component affecting the purity of the transformer

From the Inductance and Resistance readings the instrument will calculate the total impedance of the transformer winding at the selected frequency

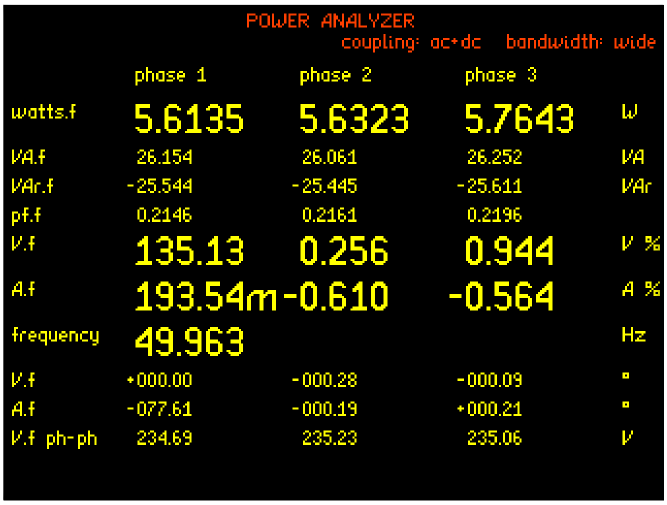




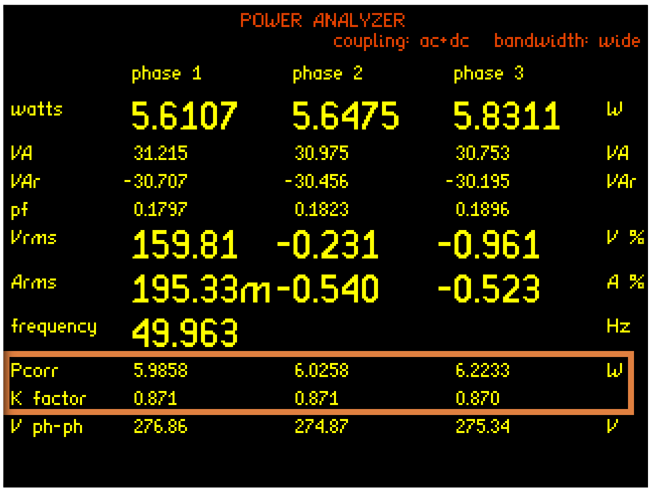
To view the total Impedance calculated you will need to change the display screen back from ***Auto*** to ***Impedance*** as shown

Transformer Mode (Three Phase)

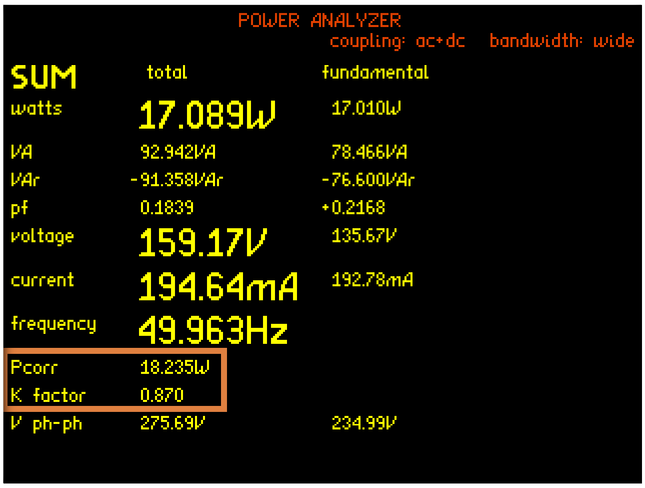
When performing analysis of a 3 Phase load, transformer mode is extremely useful. The PPA will display phase balance information in an intuitive manner without the requirement for a vector display, this has the advantage of maintaining 5 digit resolution which is not possible whilst attempting to visually interpret phase balance on a conventional vector display.



As illustrated, the PPA can display 3 phase power simultaneously, along with this the Voltage % and Current % deviation from the phase 1 readings displayed. The phase reference is taken from phase 1 Voltage, and we can see that phases 2 and 3 are (120-0.28) deg and (240-0.09) deg respectively.



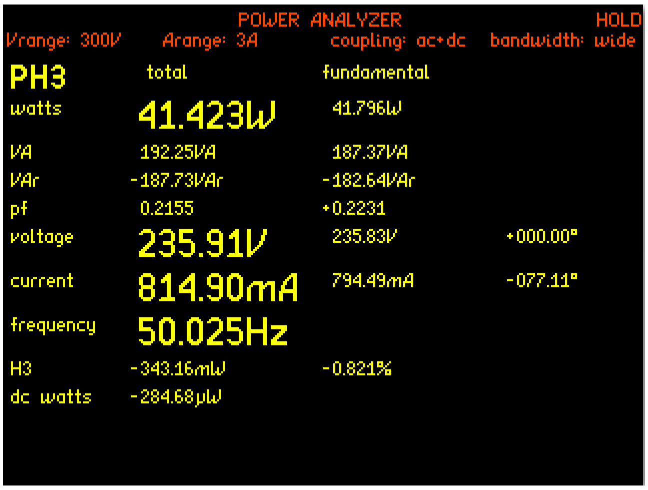
Pcorr (Corrected Power) and K factor values are also displayed in Three Phase Transformer mode. The calculated values for Pcorr and K factor are displayed for each phase, this can be seen in the orange box below:



On the SUM screen the displayed Pcorr value is the sum of the Pcorr values for each of the three phases. The K factor displayed on the Sum screen is the average of the K factor values for each of the three phases.

Transformer power factor and efficiency testing

A 1:1 isolation transformer was tested, and the results are shown in the following text, no load and max load tests were performed, short circuit tests were not carried out at this time.

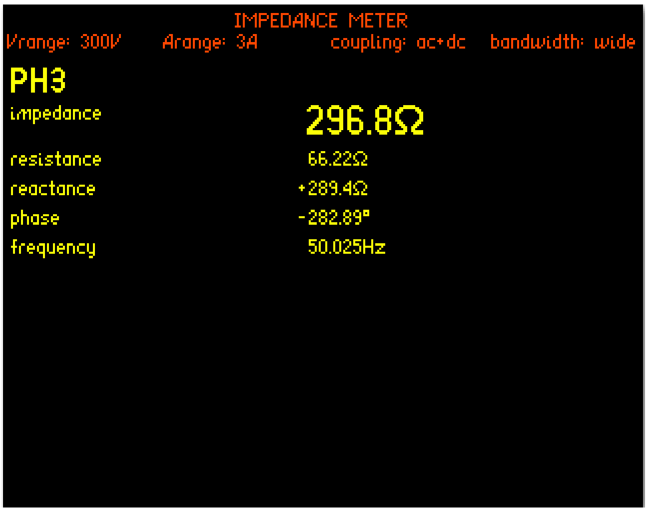


At a mains voltage of 235.83V (fundamental 50.025Hz) and 41.796 watts the transformer has a primary off load phase angle of -77.11 degrees. This is the phase angle between V_1 and I_0

The calculated impedance at the fundamental frequency of 50.025Hz is as follows

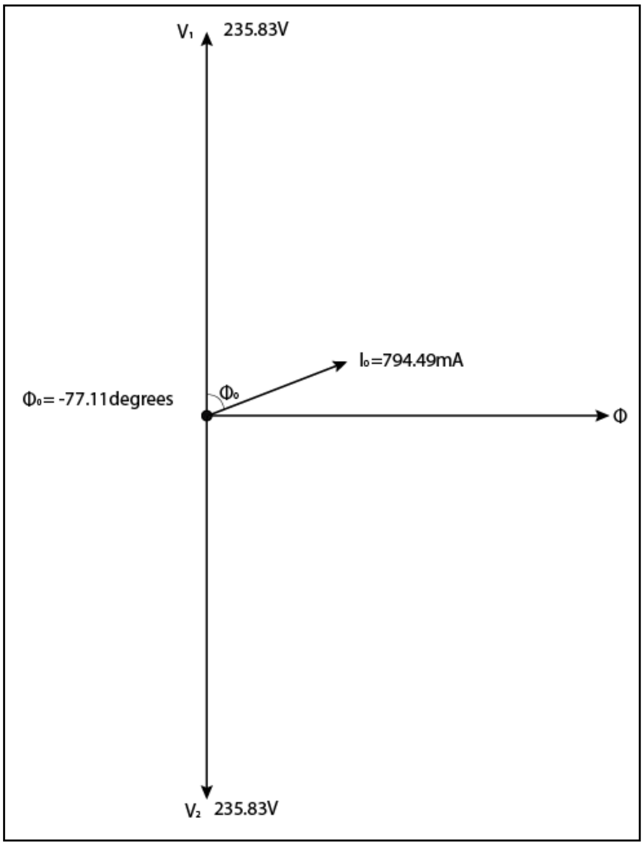
235.83V / 794.49mA = 296.83Ω

This is confirmed in the Impedance Analyzer mode on the PPA4500.



To obtain a visual representation of the PPA4500 results, especially for those who are unfamiliar with power analyzer numerical displays, which offer far more resolution than a vector display. We will convert the figures into a vector diagram to help with interpretation of the results. It must be noted that trying to read such phase angle critical measurements from a vector diagram is the incorrect approach and the PPA4500 offers a numeric representation of the phase angles.

INFORMATION. Note that the display will show the "fundamental impedance" This is the impedance of the transformer winding at the fundamental frequency of 50.025Hz.

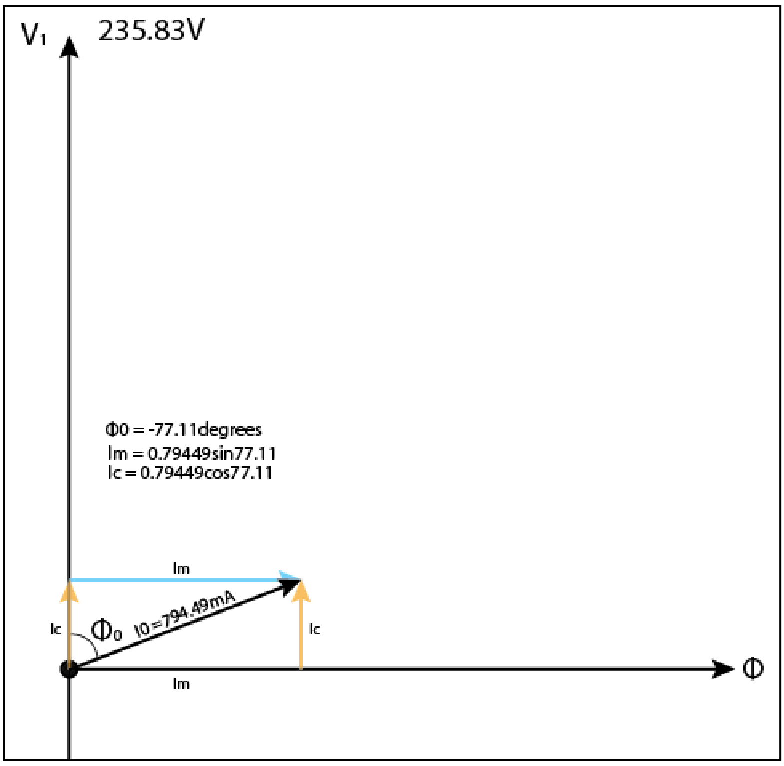


Here we can see V_1 the primary voltage from the grid, I_0 is the off-load current. This includes the magnetizing current and Core losses.

We can calculate the losses with just the primary voltage, off load current magnitude and the phase angle between the two.

We then use trigonometry to calculate the in phase current component (the losses) and multiply this by the Voltage which will give us the power in Watts. Using a PPA4500, all these calculations are performed within the instrument.

This provides a good understanding of what power really is; it is the "in phase" current component providing "real" power i.e., Heat Loss.



As you will now be able to see, the more Hysteresis and Eddy Current loss that exists in the core, the greater the in-phase component will be.

Magnetizing Current

$$Im = 0.79449sin77.11$$

$$Im = 0.774A$$

Core loss component

$$Ic = 0.79449cos77.11$$

$$Ic = 0.177A$$

If we multiply the “In phase” core loss component with the fundamental voltage, we have the power

$$Loss\ (Watts) = \ V\ x\ Im$$

$$Loss = 235.83\ x\ 0.177 = 41.74W$$

Although there is a small rounding error in comparison with the correct figure shown on the PPA4530, you can see the figure does correlate with the watts measurement in the screen shot here

Standby Power

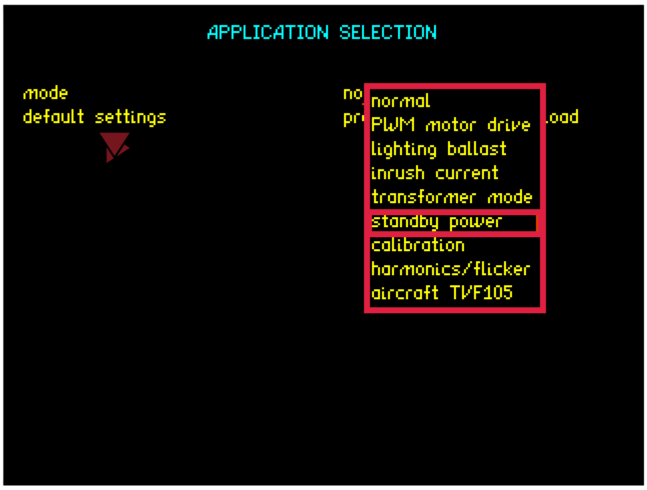
Standby power, also sometimes referred to as vampire power, vampire draw, phantom load or ghost load refers to the way electric power is consumed by electronic and electrical appliances while they are seemingly “switched off” or in a dormant or “standby state. This occurs when devices claimed to be "switched off" on their control interface are in fact drawing small amounts of power to enable rapid switch on, or to maintain timer functions and the like. Some devices, such as power adapters for disconnected electronic devices, consume power without offering any features (sometimes called no-load power). All the above examples, such as the remote control, digital clock functions and—in the case of adapters, no-load power—are completely switched off just by switching off at the power point. However, for some devices with built-in internal battery, such as a phone, the standby functions can be stopped by removing the battery instead where this is feasible.

In the past, standby power was largely a non-issue for users, electricity providers, manufacturers, and government regulators. However, as climate change awareness has grown it has become an important consideration for all parties. Up to the middle of the 2000’s, standby power was often several watts or even tens of watts per appliance. By 2010, regulations were in place in most developed countries restricting standby power of devices sold to one watt (and half that from 2013).

IEC 62301:2011 - Household electrical appliances - Measurement of standby power is the standard used to measure against. The unrivalled dynamic range of the PPA4500 series enables the user to comply with IEC62301 and Energy Star testing standards. Utilising "Standby Power Mode" the PPA employs proprietary standby power signal processing algorithms to provide accurate no gap analysis of high crest factor (CF) signals.

Most of the power consumed by devices in standby mode is taken in the periodic higher current cycles, so to accurately measure the power drawn by these devices, the PPA4500 synchronises to the power frequency for the analysis but extends the measurement window to the irregular period of higher energy pulses. Because the PPA4500 samples in true real time without any gaps, no data is missed, and every power cycle is captured.

The Standby Power settings are accessed in the same way as the other application modes, i.e., via the *APP* menu key, and the default settings are enabled via the use of the *ENTER* key as previously.



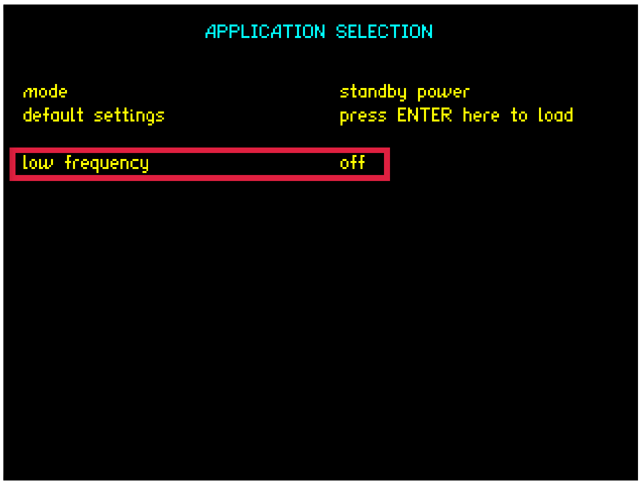
To access standby mode:

Press the *APP* key

Press the ▼ key and then the ► key. This will open the drop down menu selections.
Press the ▼ key 5 times until the red box surrounds standby power.
Press *ENTER*, this will now set the mode

Press the ▼ key to move to default settings and press *ENTER*. The instrument will now set the voltage and current measurement parameters

Press the ▼ key to move the cursor to low frequency mode



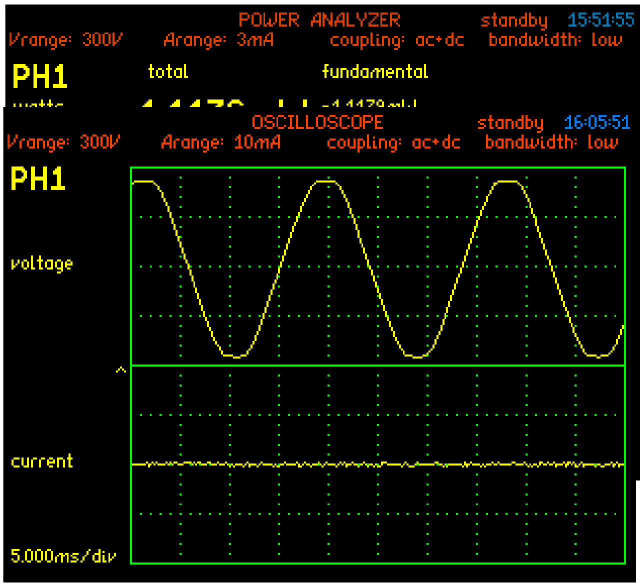
Pressing *ENTER* to load the applications default settings will automatically set the ***low frequency*** parameter to ***OFF***

You can now return to the Power Analyzer screen

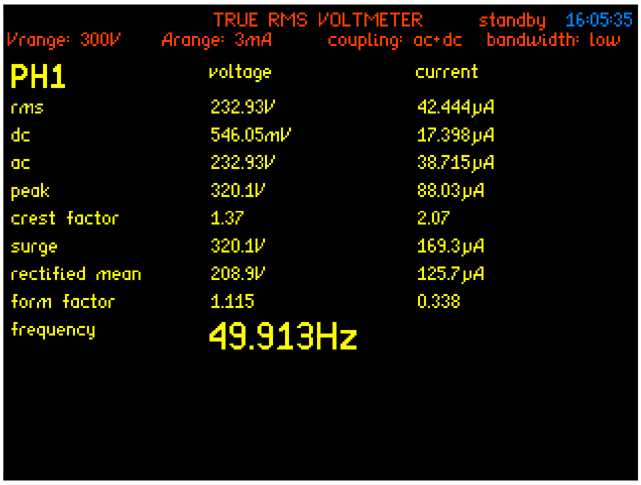
Test device: 1 x Stand-alone Heater

Accessories: 1 x Break Out Box

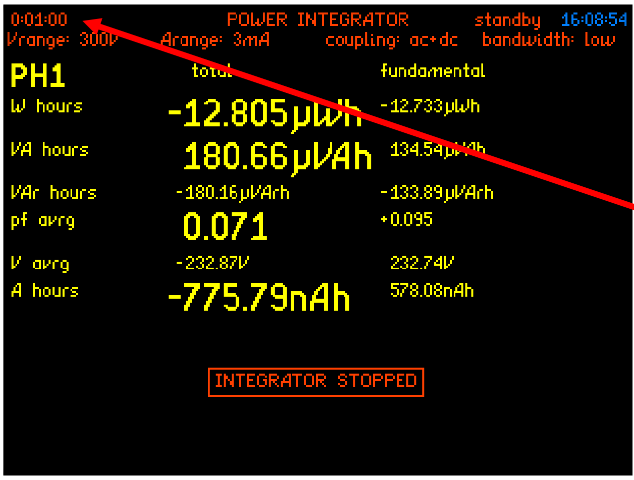
It is important that ranging is set to manual or up only auto ranging so that the power cycles are not missed while ranging.



The real time display shows a screenshot from the Power Analyzer home screen with the test device in standby mode



Reverting to the “RMS” screen you can see all the subsequent voltage measurements from each phase associated with the test unit in Standby Mode



Left is a display taken from the power integrator screen *INTEG*, displaying a 1 minute integration of the power being consumed

(The timer is in the top left hand corner)

Press the *SCOPE* button to view the Voltage and Current waveforms being produced by the device under test.

Calibration

Calibration Mode is to be used in combination with N4LCal (N4L Calibration software) which facilitates performing manual calibration with an external source. This software is supplied with a detailed manual describing the calibration process, for more information contact N4L on the following email.

support@newtons4th.com

Chapter 12 Setting up and using remote control

The PPA4500 SERIES is fitted with an RS232 serial communications port, USB port, IEEE488 (GPIB) interface and LAN interface fitted as standard, (Port No 10001). All the interfaces use the same ASCII protocol except for the end of line terminators:

Interface	Rx expects	Tx sends
RS232 USB LAN	Carriage return (line feed ignored)	carriage return and line feed
IEEE488	Carriage return or line feed or EOI	carriage return with EOI

All the functions of the PPA4500 SERIES can be programmed via any of the interfaces, and the results read back. When the IEEE488 interface is set to ***remote*** the RS232 port is ignored.

The commands are not case sensitive and white space characters are ignored (e.g., tabs and spaces). Replies from PPA4500 SERIES are always upper case, delimited by commas, without spaces.

Only the first six characters only of any command are significant – any further characters will be ignored. For example, the command to set the generator frequency is ***FREQUE*** but the full word ***FREQUENCY*** may be sent as the redundant ***NCY*** at the end will be ignored.

Fields within a command are delimited by a comma, multiple commands can be sent on one line delimited with a semi-colon e.g.

BANDWI,LOW;SPEED,SLOW

Mandatory commands specified in the IEEE488.2 protocol have been implemented, (e.g. ****IDN?, *RST***) and all commands that expect a reply are terminated with a question mark.

Data values returned by the PPA4500 SERIES are in scientific notation, with a 5 digit mantissa by default. For extra resolution, this can be increased to 6 digits by setting the resolution to ***high*** in the *REMOTE* menu.

There is also an option for higher speed data transfer by selecting ***resolution*** = ***binary*** where each value is returned in 4 bytes, each of which has the msb set so that it will not be interpreted as an ASCII character.

byte 1	2's complement signed exponent
byte 2	Bit 6 = mantissa sign bit 5:0 = mantissa bits 19:14
byte 3	mantissa bits 13:7
byte 4	mantissa bits 6:0

When the msbs are stripped off and the bytes put together, there is 6 bit signed exponent, a mantissa sign bit and a 20 bit mantissa magnitude. The value then is given by:

Value = +/- $2^{exponent}$ x mantissa / 2^{20}

The PPA4500 SERIES maintains an error status byte consistent with the requirements of the IEEE488.2 protocol (called the standard event status register) that can be read by the mandatory command ***ESR?** (See here)

The PPA4500 SERIES also maintains a status byte consistent with the requirements of the IEEE488.2 protocol, that can be read either with the IEEE488 serial poll function or by the mandatory command ***STB?** over RS232 or USB or IEEE or LAN. (See here)

The IEEE address defaults to 23 and can be changed via the *REMOTE* menu. Setting the LAN IP address to 0.0.0.0 will enable the DHCP and the unit will obtain its IP-Address from the DHCP server. The DHCP server must be present on the network for this to work. The LAN will not start normal operation until it receives an IP address from the server.

Setting the LAN IP manually will disable the DHCP and the unit will use a fixed IP address, defined by the IP Address setting in the *REMOTE* menu.

The keyboard is disabled when the instrument is set to "remote" using the IEEE interface or if the command ***KEYBOA,DISABL*** is sent via RS232 or LAN. Press *HOME* to return to Local operation.

RS232 data format

The RS232 format is: start bit, 8 data bits (no parity), 1 stop bit. Flow control is ***RTS/CTS***, baud rate is selectable via the *REMOTE* menu.

A summary of the available commands is given in the Appendix. Details of each command are given in the communication command section of the manual.

Commands are executed in sequence except for two special characters that are immediately obeyed:

Control T (20) – reset interface (device clear)
Control U (21) – warm restart

To maintain compatibility with some communication systems, there is an optional "protocol 2" which requires a space between the command and any arguments.

Standard event status register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PON		CME	EXE	DDE	QYE		OPC

Bit 0	OPC	(operation complete) cleared by most commands set when data available or sweep complete
Bit 2	QYE	(unterminated query error) set if no message ready when data read
Bit 3	DDE	(device dependent error) set when the instrument has an error
Bit 4	EXE	(execution error) set when the command cannot be executed
Bit 5	CME	(command interpretation error) set when a command has not been recognised
Bit 7	PON	(power on event) set when power first applied, or unit has reset

The bits in the standard event status register except for OPC are set by the relevant event and cleared by specific command (***ESR?, *CLS, *RST***). OPC is also cleared by most commands that change any part of the configuration of the instrument (such as ***MODE*** or ***START***).

Serial Poll status byte

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
		ESB	MAV	ALA	FDV		RDV

Bit 0 RDV	(result data available) set when results are available to be read as enabled by ***DAVER***
Bit 2 FDV	(fast data available (streaming)) set when data streaming results are available to be read as enabled by ***DAVER***
Bit 3 ALA	(alarm active) set when an alarm becomes active as enabled by ***ALARMER***
Bit 4 MAV	(message available) set when a message reply is waiting to be read
Bit 5 ESB	(standard event summary bit) set if any bit in the standard event status register is set as well as the corresponding bit in the standard event status enable register (set by ****ESE***).

RS232 connections

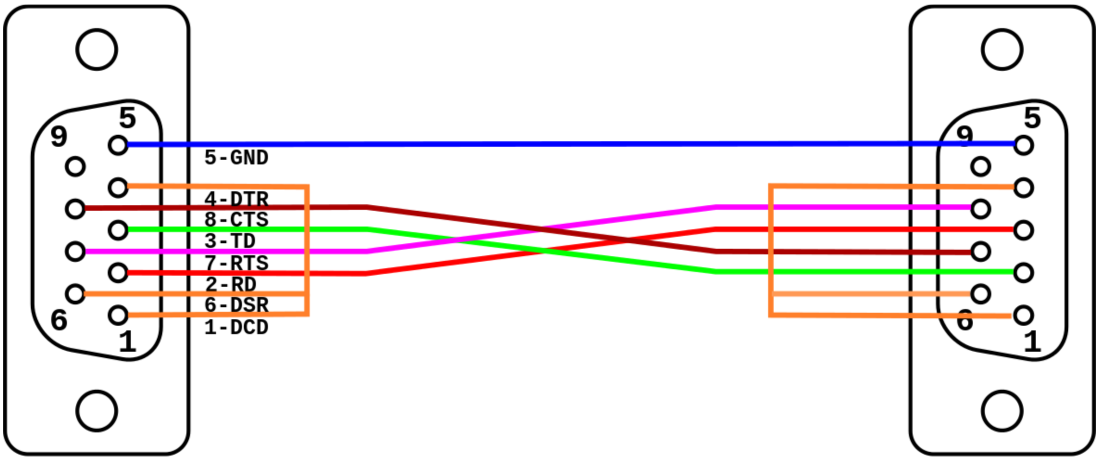
The RS232 port on the PPA4500 SERIES uses the same pinout as a standard 9 pin serial port on a PC or laptop (9-pin male 'D' type).

Pin	Function	Direction
1	DCD	in (+ weak pull up)
2	RX data	in
3	TX data	out
4	DTR	out
5	GND	
6	DSR	not used
7	RTS	out
8	CTS	in
9	RI	Not used

The PPA4500 SERIES will only transmit when CTS (pin 8) is asserted and can only receive if DCD (pin 1) is asserted. The PPA4500 SERIES constantly asserts (+12V) DTR (pin 4) so this pin can be connected to any unwanted modem control inputs to force operation without handshaking. The PPA4500 SERIES has a weak pull up on pin 1 as many null modem cables leave it open circuit. In electrically noisy environments, this pin should be driven or connected to pin 4.

To connect the PPA4500 SERIES to a PC, use a 9 pin female to 9 pin female null modem cable:

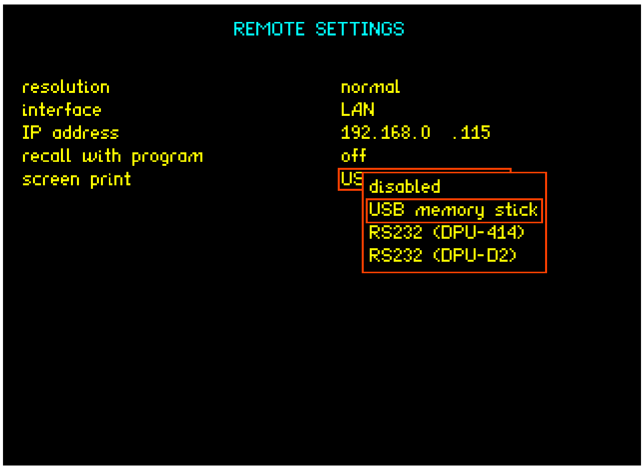
Pin(s)	Conect to	Pin(s)
1 & 6	⇆	4
2	⇆	3
3	⇆	2
4	⇆	1 & 6
5	⇆	5
7	⇆	8
8	⇆	7



Null modem serial cable pin-out

Screen Shot

If required, you can take a screenshot of what is currently displayed on the screen. To do this, insert a USB memory stick into the USB slot on the front of the device and then hold the 'START' key for roughly 2 seconds. This will capture what is currently on the screen and save it as a bitmap image on the memory stick.



By default, the save location for the screen shot will be the USB memory stick; this can be changed in the *REMOTE* menu. You can change it to print to the RS232 port, that is used to print to an attached printer to print a physical copy of what is shown on the screen.

RS232 printer

Alternatively, the RS232 port can also be connected to a serial printer for making a hard copy of any screen. When printing is enabled in the REMOTE menu, then pressing START will commence a screen dump to the printer. The graphic protocol used is the ESC/P so any printer which supports this protocol should work such as the Seiko DPU-414.

The other communication options, USB, LAN or GPIB, can still be used while the RS232 printer is enabled.

For full details of all the available commands and configurable parameters, please refer to the PPA4500 Comms Manual, available on the N4L website https://resources.newtons4th.com/

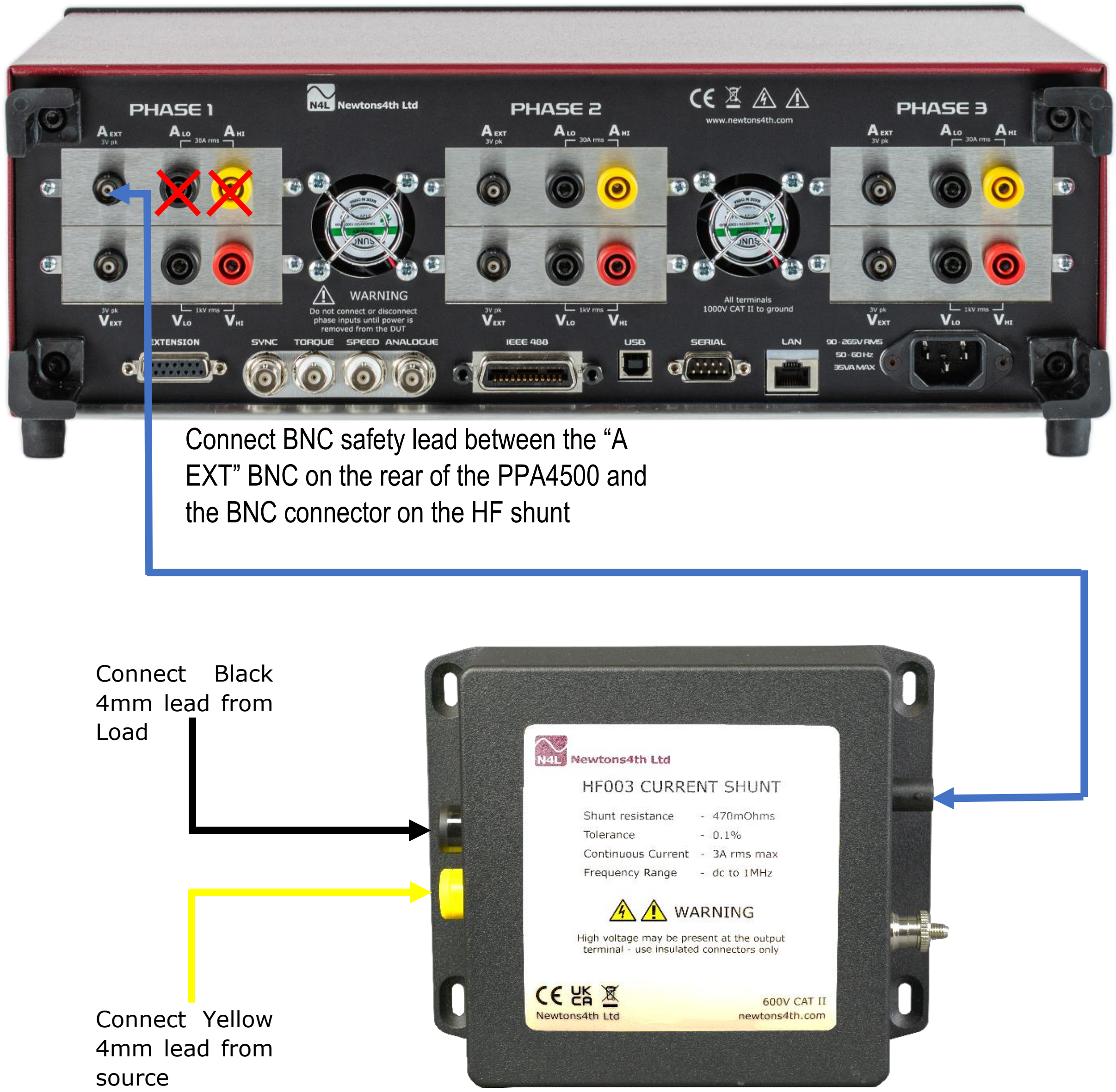
Chapter 13 External shunts and transducers

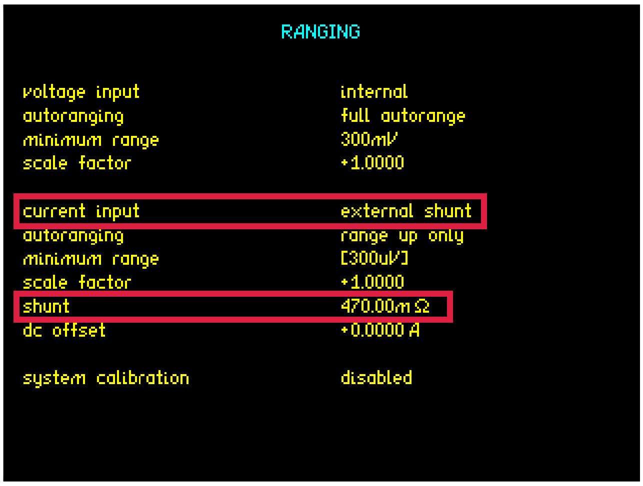
A variety of peripherals can be connected to the PPA4500 range of instruments, to enhance and adapt the measuring capability to suit most scenarios.

Refer to Appendix for full range of accessories and transducers. This section explains how to connect and set up the most often used types of transducers

External current shunts can be used as an alternative to the instruments internal shunt as a fixed value Impedance circuit. Note do not use both shunts together

Test equipment for demonstration:
1 x Inverter/Motor test unit (single phase)
1 x HF 003 Current Shunt (shunt resistance = 470mΩ)
Wiring Configuration:





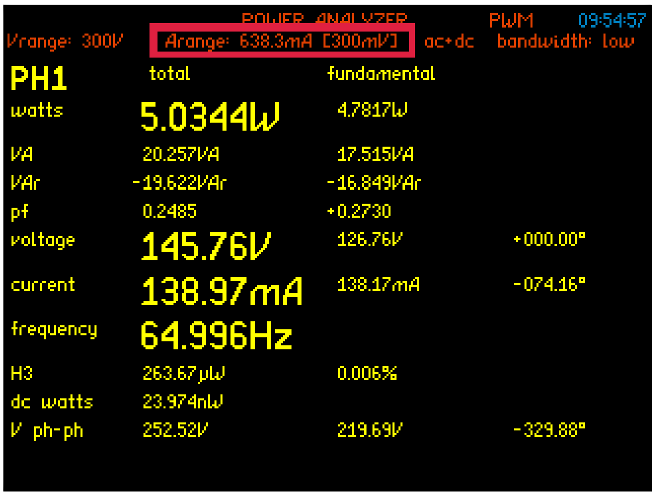
Set up PPA to read the external current shunt:

Press the *RANGE* button
Press the ▼ key until the flashing red highlight surrounds the ***current*** input parameter
Press the ► key and select ***external shunt***

Press *ENTER*, to select the external shunt

Press the ▼ key until the flashing red highlight surrounds the ***shunt*** parameter. Manually input the shunt resistance value
Press *ENTER*, external shunt value will now be selected

If connecting the external shunt to a different channel, then use the ► key to select the correct channel configurations screen as prompted at the bottom of the *RANGE* home screen, this is only available if ***independent ranging*** has been set to ***enabled*** in the System Options menu (*SYS*)



Now going back to the real time display screen, the range selected by the analyzer is the (300mV) range. This range is a peak range, and the analyzer will convert this voltage to the equivalent current range, dependent upon the shunt value entered in the *RANGE* menu.

In this case the shunt value is 470mΩ; therefore, the analyzer will display 638.3mA for the 300mV range

$$I = \frac{300mV}{470m\Omega}$$

As the instrument ranges up and down the ***Arange*** value will change accordingly

---

CAUTION.
Input Connections: It is critical that the 4mm inputs and BNC inputs on each PPA input channel are not connected to any external circuit at the same time.

You MUST only use EITHER the 4mm OR the BNC
connection – NOT both, this applies to both Voltage and Current inputs.

Remember to disconnect all leads to appropriate channels internal current shunts

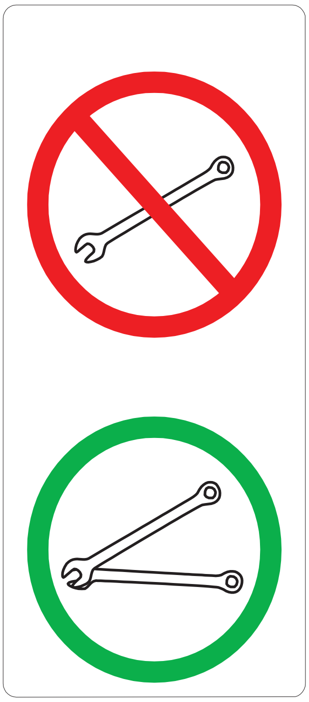
---

CAUTION. Connection to these instruments is made via a stud and bolt, great care must be taken when connecting heavy duty ring terminals to the appropriately sized stud or alternatively, to an "L" bracket on the HF500 shunt.

It is essential that 2 correctly sized spanners are **ALWAYS** used (see table below) so that adequate torque can be applied to the bolt without transferring any excessive turning force to the stud

Any damage caused to the fixing stud **WILL** be irreparable

Damage to the shunt will occur when using only 1 spanner

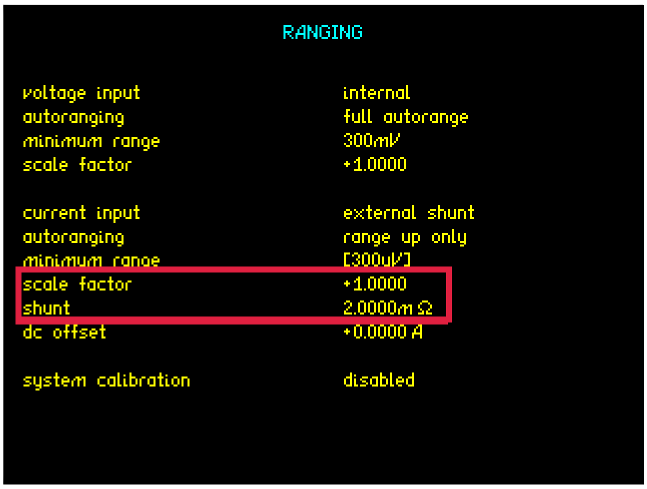


Always use 2 spanners to limit torque stress on the shunt stud

Current Shunt Model	Spanner Size
HF100 + HF200	**17mm**
HF500	**24mm**

Rogowski Coil

The Rogowski coil offers an alternative means of measuring high current DUT's with the advantage that they can be used in situations where it is not possible to break the current path or that the conductor in question is of such a size that the more widely used zero flux current transformers are unable to accommodate.



A Rogowski coil consists of the measuring coil itself, attached to an integrator box.

Input the correct shunt value corresponding to the switch value on the Rogowski Transducer

The shunt value is set to 2mΩ to reflect the switch position being set to 1KA (2mV per A) and a scale factor of 1:1

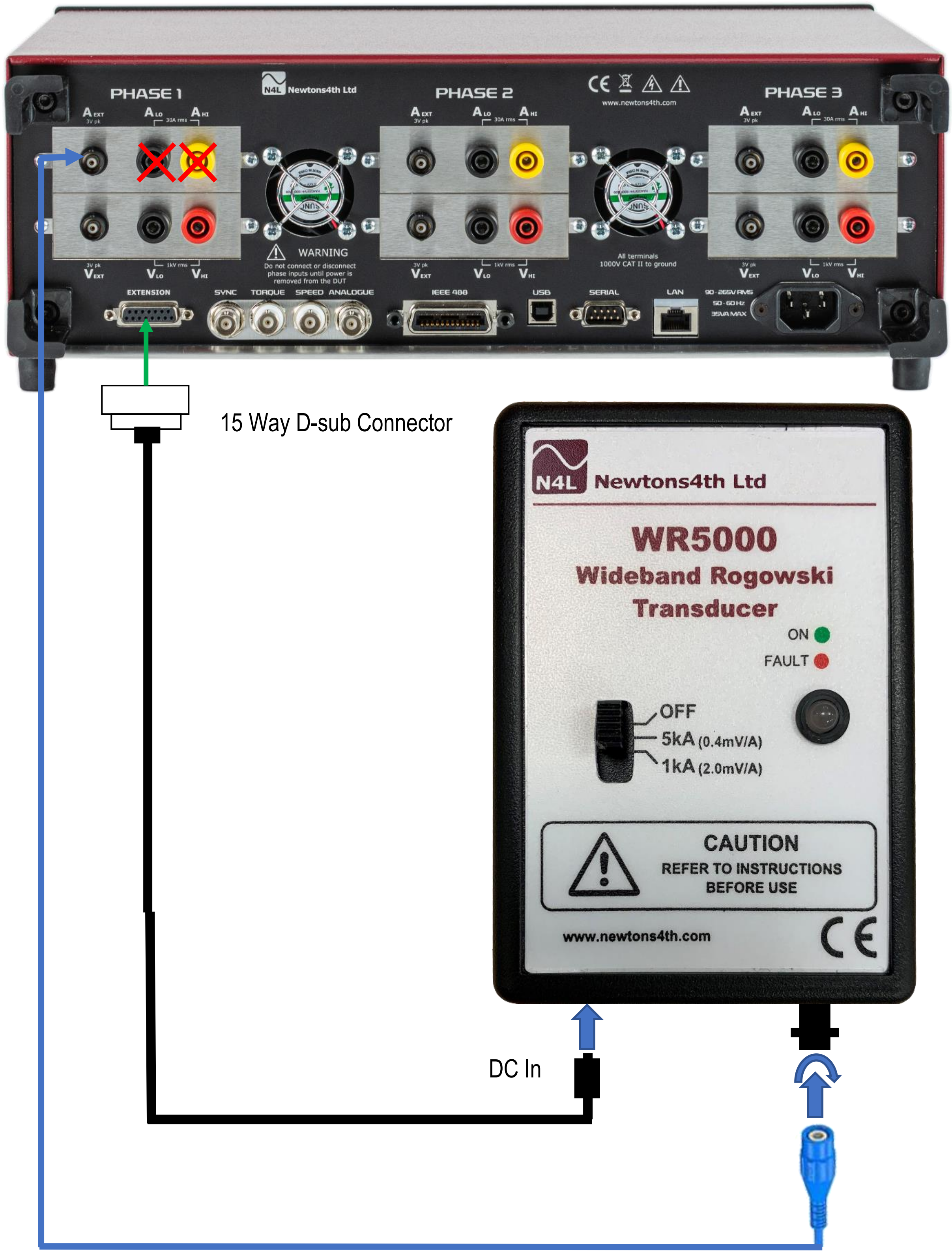
The shunt is set to 2mΩ as a 2mΩ shunt would also produce the same 2mV/A output as the coil

Multiple turns around the conductor:

If the coil is wrapped twice around the conductor set the shunt value to 4mΩ

If the coil is wrapped 3 times around the conductor set the shunt value to 6mΩ etc.

Connection should be made as per the following diagrams:

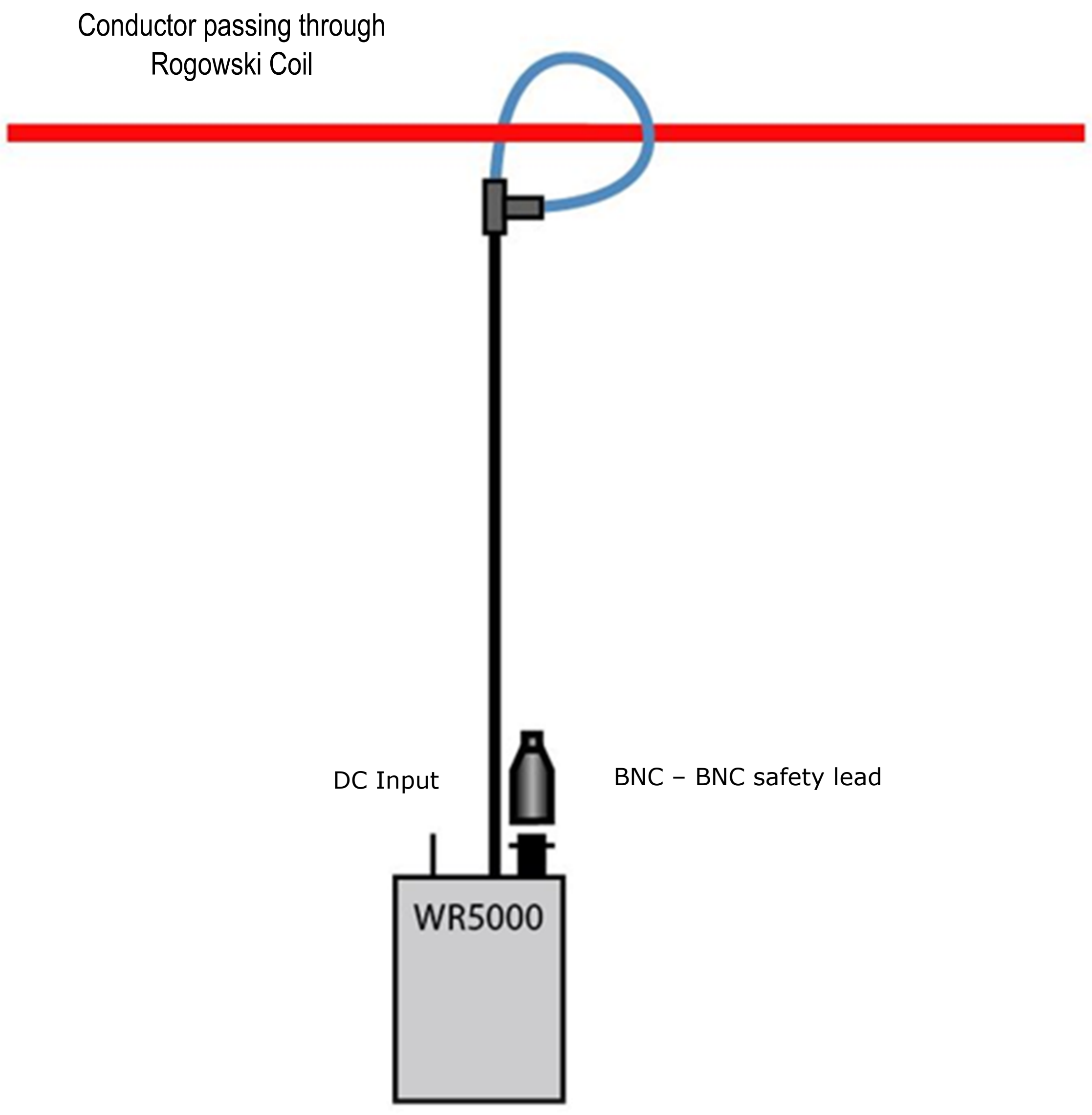


CAUTION. Remember to connect either the Internal or External shunt only to the PPA4500

Connect up the Rogowski Coil as shown, wrap the clear plastic tube around the conductor and slot into the “T”piece connector, tighten the connector nut to secure the lead into position

A single coil wrapped around the conductor will result in voltage measurement equal to the 2mV/A detail on the WR5000 as set on previous page

If the coil is double wrapped around the conductor, then the voltage value will double accordingly



Zero Flux Current Transformers (CT)

For measuring currents exceeding the internal current shunts fitted to the PPA4500 series

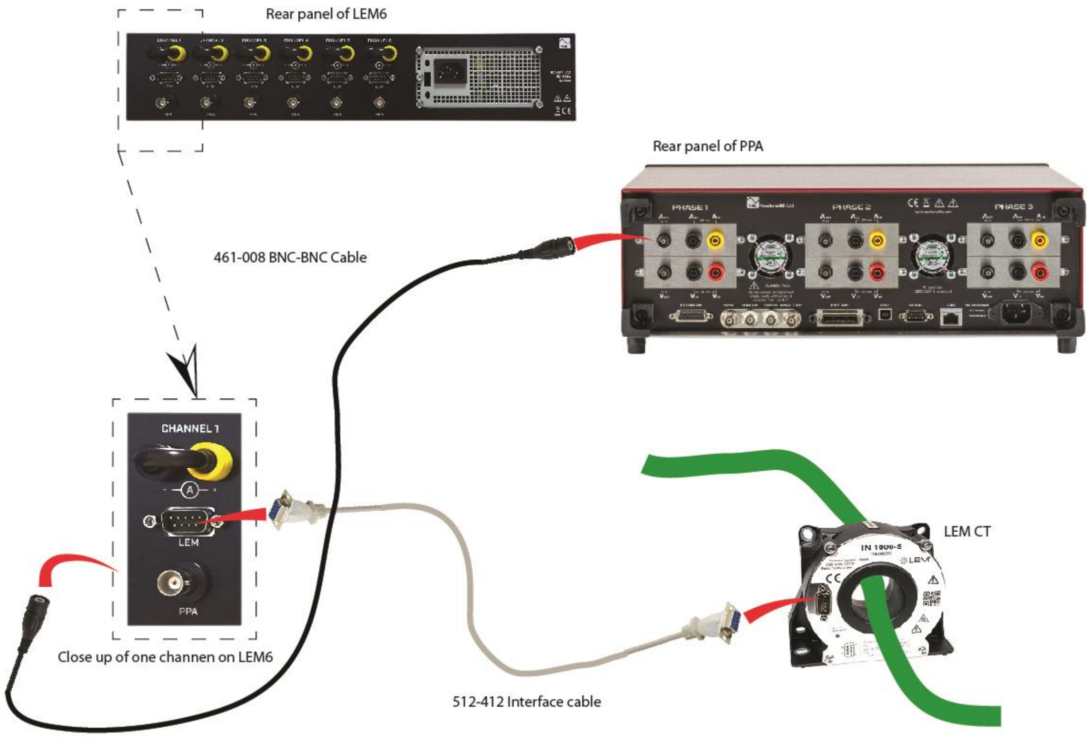
PPA4500-LC	10Arms
PPA4500	30Arms
PPA4500-HC	50Arms

Zero Flux Current Transducers are often utilised, combined with N4L interfaces a flexible multiphase system is achievable.

Dependent on the exact model of CT used, there are two ranges of interface available.

Here we examine the LEM 6-X series of interface which are available in 3 - 6 phase configurations.

LEM 6-6 A 6 phase 19" rack mountable interface for CT's



Connection diagram

The N4L LEM-6 Interface serves as a high accuracy, highly stable interfacing unit allowing simple "plug and play" connection of the PPA4500 series to the LEM or Danisense current transducers listed in table 1.

The LEM-6 supplies the LEM or Danisense transducer with a highly stable isolated supply voltage; each channel is isolated from the next providing excellent cross channel coupling immunity. There are 4x current shunts per channel, 1Ω, 2.5Ω, 5Ω & 10Ω; this ensures the transducer can be utilized accurately throughout its dynamic range without the introduction of noise into the measurement.

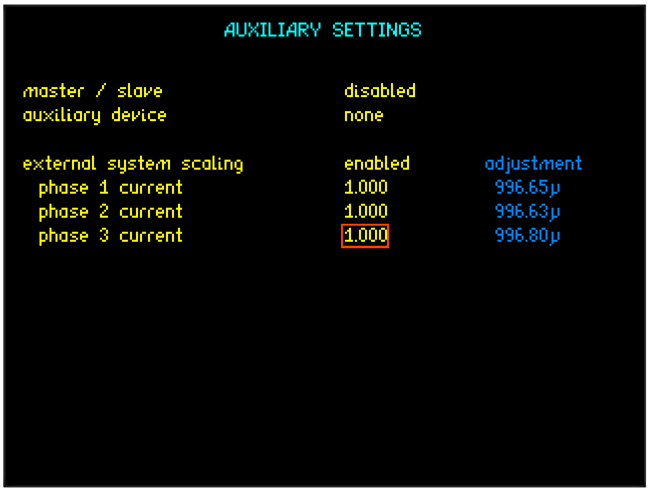
Model Number	Current Rating		Conversion Factor
IT60-S	60Apk	42Arms	600
IN100-S	150Apk	100Arms	500
IT200-S	200Apk	141Arms	1000
IN200-S	200Apk	300Arms	1000
IT400-S	400Apk	282Arms	2000
IN400-S	400Apk	600Arms	1500
IT700-S	700Apk	495Arms	1750
ITN600-S	600Apk	424Arms	1500
IN500-S	500Apk	800Arms	750
DS50ID	150Apk	50Arms	500
DS200ID	370Apk	200Arms	500
DS300ID	500Apk	300Arms	1000
DS400ID	600Apk	300Arms	1000
DS600ID	1000Apk	600Arms	1500
DM1200ID	1800Apk	1200Arms	1500

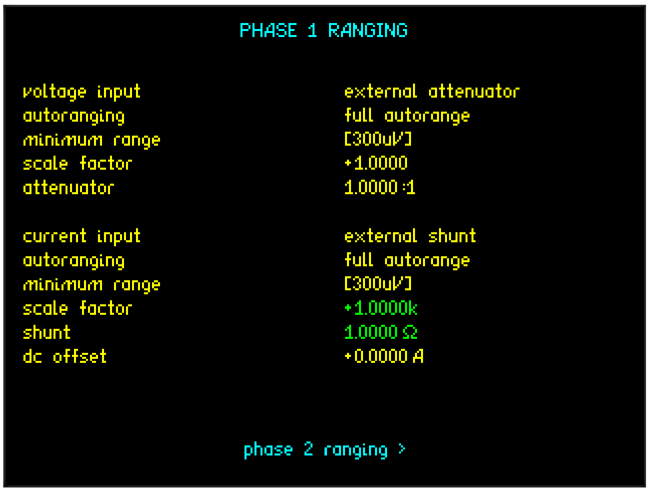
INFORMATION. N4L supply a wider range of current transformers than listed above, however the other models are not suitable to be used with the LEM 6-X interface as the power requirements are more than the LEM 6 PSU. In this case then we offer a LEM-1 interface

If the LEM-6 is purchased with an N4L power analyzer and LEM transducers, the LEM-6 Interface can be "system calibrated" within N4L's ISO17025 UKAS laboratory. This provides the operator with a single uncertainty figure and improved accuracy performance.

Following System Calibration, the Calibration Adjustment figures for the 4 current shunts on the LEM6 are stored in program location 1 on the instrument. They are then automatically recalled each the instrument is switched on.

These values can be viewed by pressing the *AUX* button and referring to the ***External system Scaling*** option. The screenshot below shows the adjustment figures for the 1Ω current shunt shown in blue.





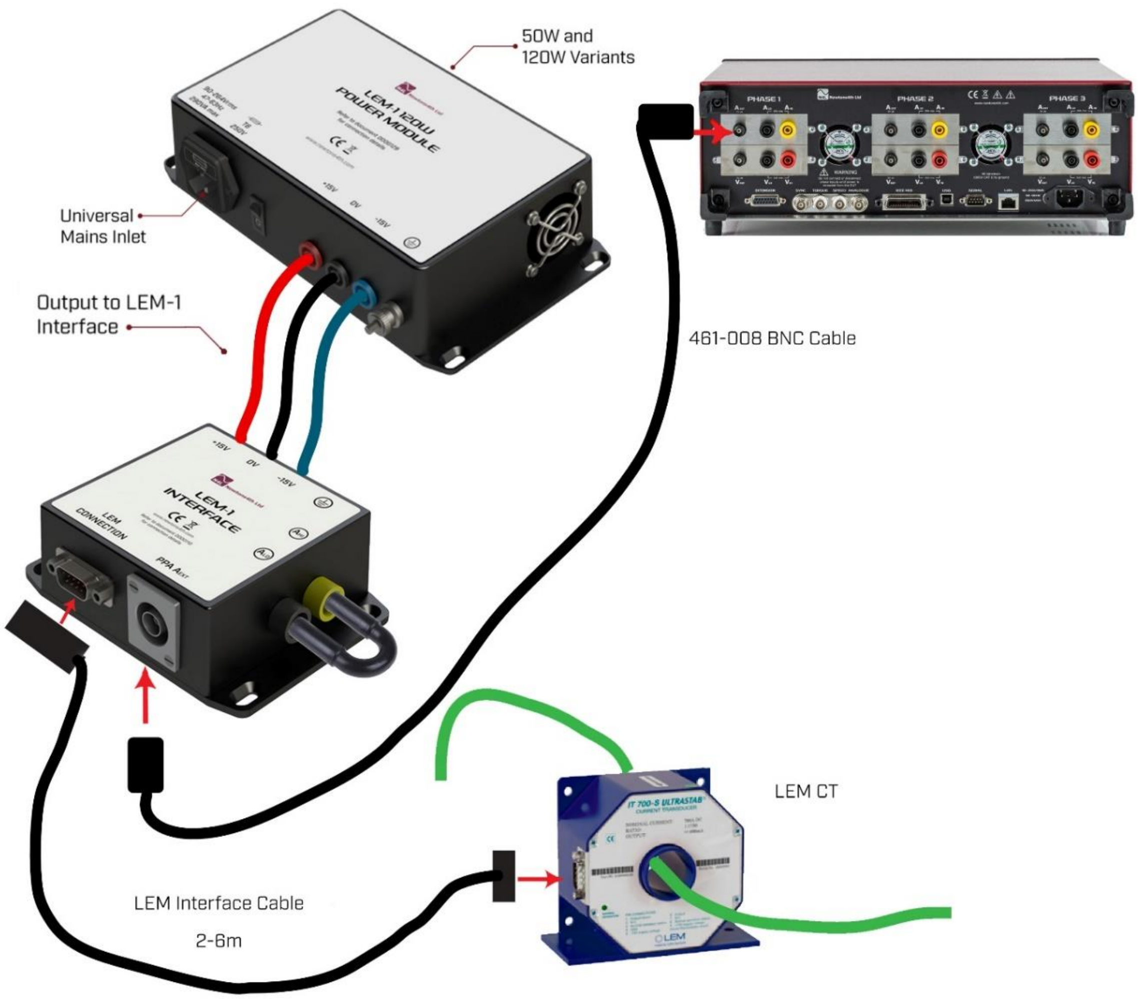
Pressing the *RANGE* key to display the ***RANGING*** menu will confirm that the external system scaling has been selected in the *AUX* menu, as the Scale factor and the nominal shunt value will be displayed in green text. The screenshot left shows the settings for Phase 1.

Only the settings stored in program location 1 are automatically recalled each time the instrument is switched on. Should it be preferred to not have them automatically recalled they can instead by saved to an alternative memory location and then deleted from location 1. The User can then recall the System Calibration data when required. The Program Store/Recall/Delete menu should be used to make the changes:

The LEM6 can also be used with non-system calibrated CT's.

Full details of the LEM6 features, Specification, and setup procedure for use with System Calibrated and Non-System Calibrated CT's can be found in the LEM6 User Manual.

The LEM 1 interface system is suitable with the complete range of LEM and Danisense CT models that N4L supply.

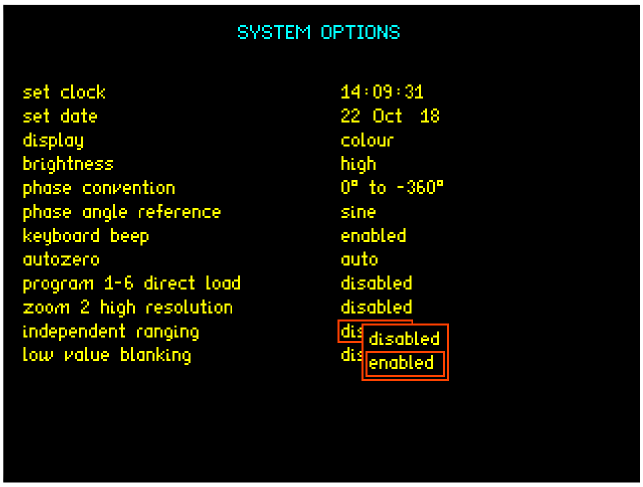


For multi-phase systems, each phase requires a separate LEM 1 interface, the number and wattage of the LEM 1 PSU's is dependent on which CT model and the number of phases required.

There is a guide to compatibility and supply requirements that can be downloaded from our website, here: https://www.newtons4th.com/wp-content/uploads/2021/03/D000132_5-Current-Transformer-Interface-Options.pdf

As with the LEM6 interface, the LEM 1 interface can be set up with system calibrated CT's or non-system calibrated CT's

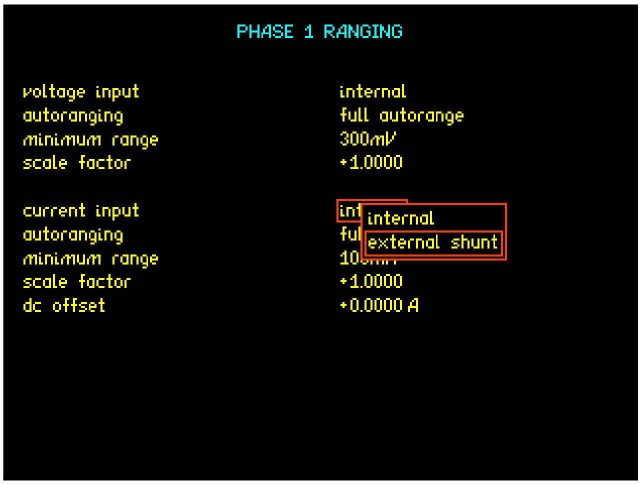
Use with non-system calibrated CT's



Press the *SYS* key

Press the ▼ key until ***independent ranging*** is highlighted red
Press the ► key, select ***Enabled*** with the ▼key.

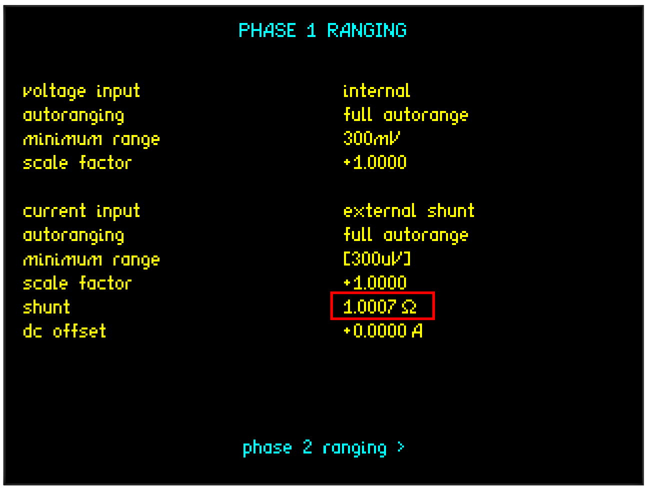
Press the ENTER key twice to return to the power analyser screen.



Press the *RANGE* key followed by the ▼ key five times until Current Input is highlighted.

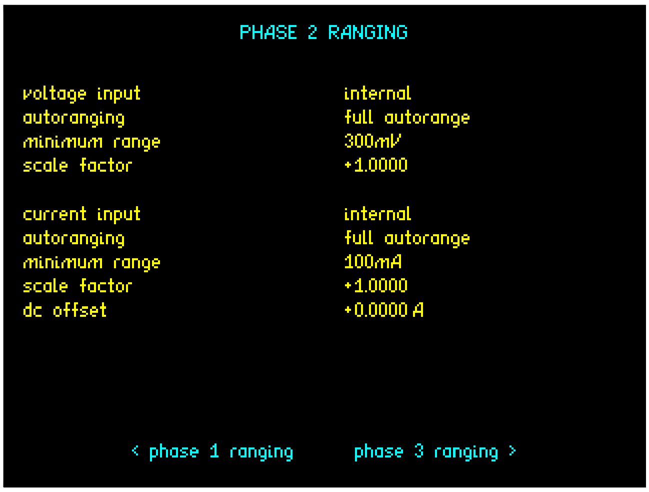
Press the ► key, then the ▼ key to select ***External shunt***.

Press the ENTER key followed by the ▼key 3 times and set the ***Scale factor*** to suit the CT in use.



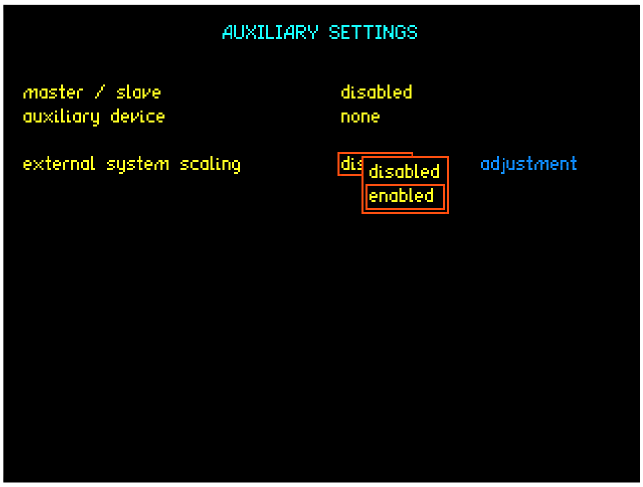
Press the ▼ key and set the ***shunt*** value to the actual value from calibration certificate. 1.0007Ω in this instance.

Press *HOME* key then using ► key go to the next phase.



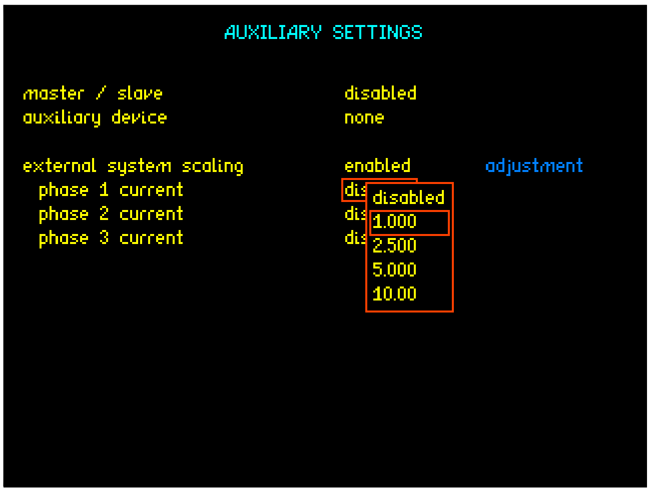
connected to the PPA.

Use with system calibrated CT's

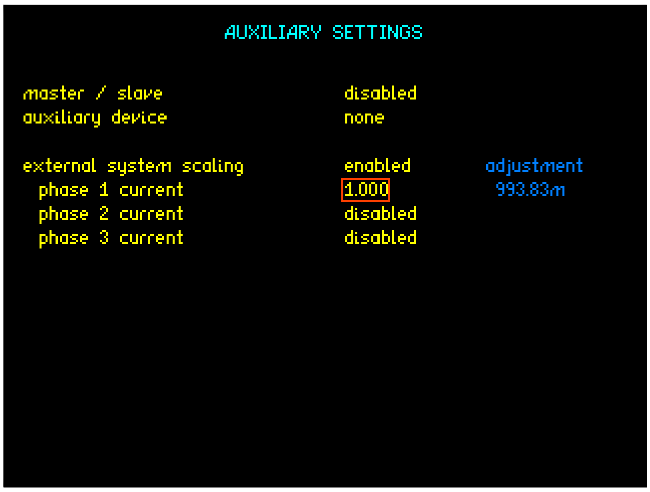


Press the *AUX* key
Press the ▼ 3 times to highlight ***External system scaling***.

Press the ► key followed by the ▼key to select ***enabled***.



Press the *ENTER* key
Press the ▼ key to highlight ***Phase 1 current***
Press the ► key, this now displays menu showing shunts.



Using the ▼ key to select the 1Ω shunt value, press the *ENTER* key, then to the right the adjustment value is shown in blue, then press *ENTER*.

Repeat for each connected LEM-1

Chapter 14 Additional I/O interfaces

The use of the ADI40, enables the PPA500 series to become a multi-channel measurement system, allowing integration between the PPA4500, multiple analogue inputs/outputs and software.

There are 4 model variants available each one with a total of 20 inputs, split between ± 10VDC and thermocouple inputs.

The outputs can be interfaced with chart recorders that can be mapped to any of the measurements recorded by the PPA4500

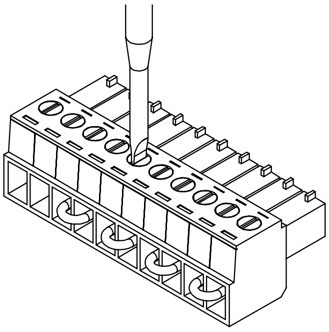
The thermocouple inputs are differential with a range of ± 20mVDC and is suitable for both J and K type thermocouples.

Auxiliary cable - 25 way ribbon

Switch on the ADI40 and the PPA4500. The POWER led should illuminate and the AUX led will flash, indicating that the auxiliary cable is connected but communication has not yet been established. Press the *AUX* key on the instrument, ensure that ***master/slave*** is disabled and then select ***ADI40*** from the auxiliary device menu. Press the *HOME* key twice for the change to take effect. The AUX led should stop flashing and the OUT and IN leds will begin to flash sequentially.

INFORMATION. If the LEDs do not flash, then check that the extension port cable has not been damaged and has been correctly fitted between the instrument and the ADI40

It is a good idea to use a shorting link wire between each unused + and – thermocouple pair to eliminate noise pickup.



Getting data in and out

Continuous measurements are made by the ADI40 inputs whenever it is connected to a PPA4500 with the correct AUX menu setup. Measurement data can be accessed in the following ways:

- Using the ANALOG,channel? command to monitor the inputs in CommView2
- Assigning inputs to MULTIL,1-60 and reading back with MULTIL? or MULTIL,lines?, in CommView2
- Using the N4L PPALoG software to log and export measurement data.

The ADI40 inputs can be used with a wide variety of sensors and components such as Airflow rate sensors, pressure sensors and DC fans.

The ADI40 outputs are also updated whenever it is connected to a PPA3500, PPA4500 or PPA4500 with the correct AUX menu setup. Outputs can be accessed in the followings ways:

- Using the ANALOG,channel,value command to manually set the output voltage to a DC value between +/-10.
- Using the ADIMAP command to map a PPA parameter or ADI40 input back onto one of the outputs.

A detailed example of using the MULTIL and ADIMAP commands are given in the PPA4500 Communications Manual which is available as a free download from the Newtons4th website along with full operating instructions are provided in the ADI40 User Manual which is also available to download.

https://resources.newtons4th.com/wp-content/uploads/2021/05/D000227_PPA4500-Comms_Manual-v4.0.pdf

https://resources.newtons4th.com/wp-content/uploads/2021/08/D000187_ADI40-Start-up-Guide-v2.0.pdf

Chapter 15 Trouble shooting – FAQ

Q. The PPA will not connect to the Datalogger software.

A. There are several points to check depending on the connection method used.
Firstly whether RS232, USB or LAN is being used to make the connection, the method chosen in the software must match that selected via the *REMOTE* menu on the PPA itself, additionally if using RS232, the connection cable must be a Null modem cable, and the Baud rate must be set to 19200 in both the software and the PPA.

Q. Error messages pop up when trying to connect.

A. If an error message other than failed to connect appears, then the most likely cause is that there is an incompatibility between the software and firmware versions. We always advise that the latest versions of software and firmware are used. These are available as free downloads from https://resources.newtons4th.com/

Q. Unexpected readings when the DUT is a motor/inverter drive.

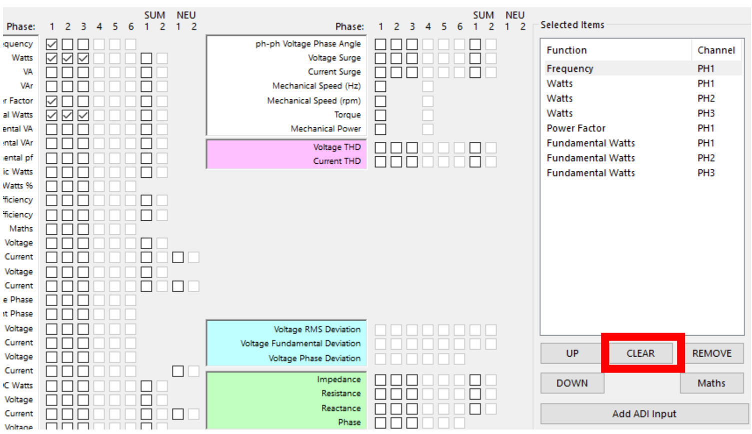
A. Within the *APP* menu, the first special mode available is ***PWM motor drive*** this should be chosen to enable other specific settings such as the frequency filter (See PWM_mode)

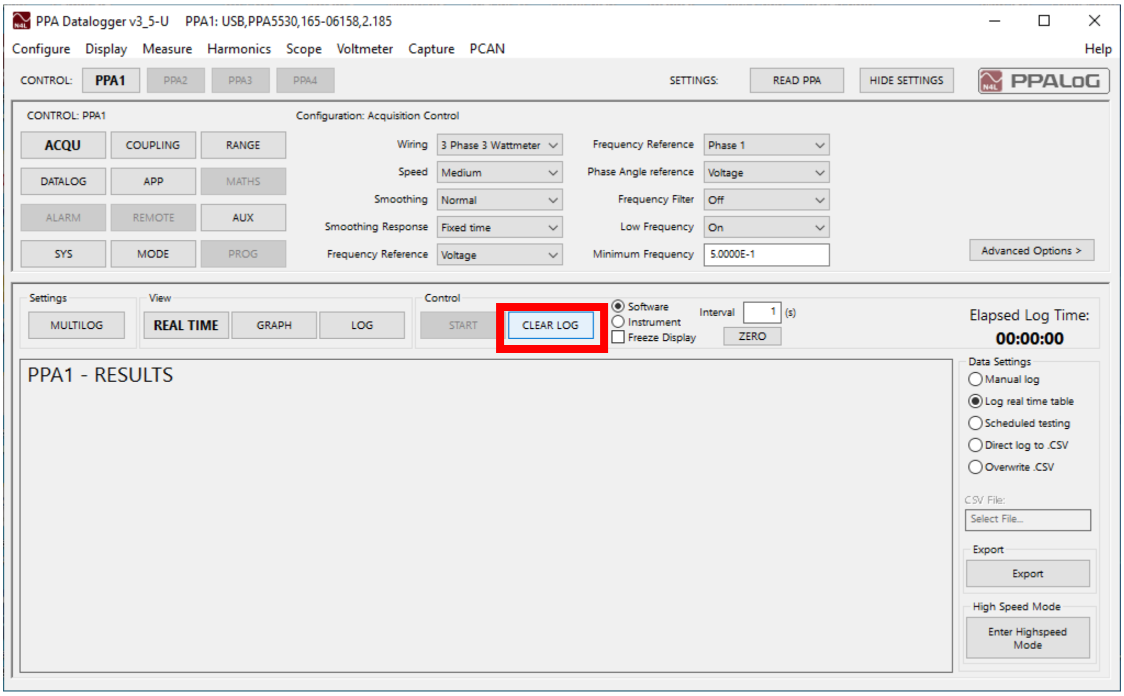
Q. Can't lock on to the fundamental frequency

A. Normally in most cases voltage on phase 1 should be used as the frequency reference, however, should current or a different phase be required, these parameters can be set from the *ACQU* menu.

Q. When in Datalogger the modes cannot be changed.

A. If data has already been recorded, it is important to clear the log before trying to change the mode. The Clear Log button is shown highlighted in red below. Additionally, it is important to clear the selections made in the multilog window. This is accomplished by clicking the CLEAR button





Q. How do you set up the PPA for different current capacity Current Transformers.

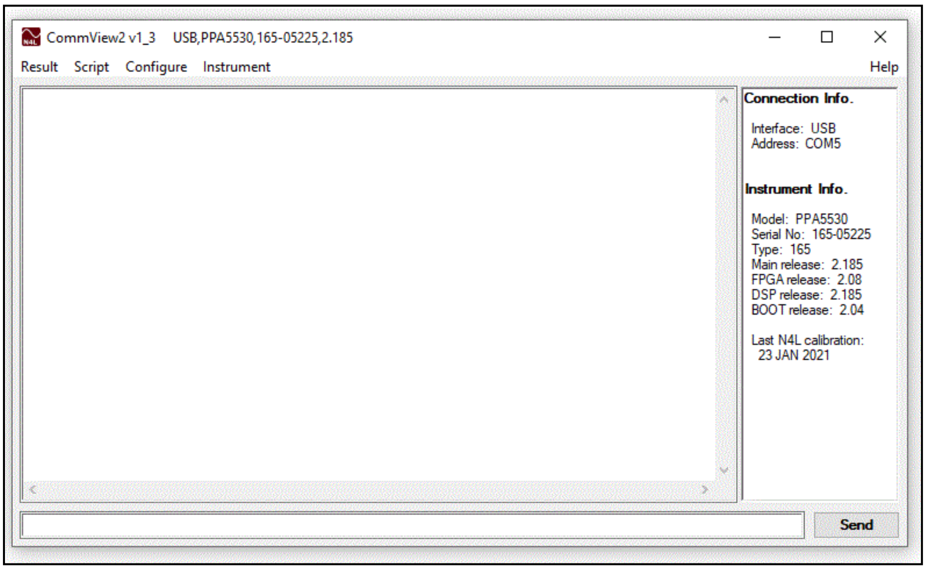
A. To take best advantage of each CT, it is necessary to enable ***independent ranging*** from the *SYS* menu. After this has been enabled within the *RANGE* menu there will be the opportunity to switch between each phase by use of the ► & ◄ keys

Chapter 16 Appendix A- Accessories and software

Supplied Standard Accessories

Leads	Power, RS232, USB
Connection cables	36Arms rated 1.5 meter long leads with 4mm – stackable terminals 1x Yellow, 1 x Red and 2x Black per phase Note 1: LC version instruments (rated at 10Arms) are supplied with 20Arms connection cables Note 2: HC version instruments (rated at 50Arms) are not supplied with connection cables or connection clips.
Connection clips	4mm terminated alligator clips – 1x Yellow, 1 x Red and 2x Black per phase
Documentation	Calibration Certificate, Both the User manual (this manual) & Communications manual are free downloads from www.newtons4th.com

Firmware Upgrade & CommView2 PC software



N4L CommView2 is a self-contained executable software program written in C++ using the Microsoft win32 graphics set.

CommView2 can connect to the PSMPPA4500 via Serial/RS232, USB, or LAN.

INFORMATION. Dependant on the version of Windows loaded on the connected PC, the USB drivers may need updating. These are available from our website.
https://resources.newtons4th.com/software/

CommView2 allows strings to be sent and received between a PC and the PPA4500. The strings can be viewed in a window and optionally stored in a file. Data received from the instrument may be displayed in normal scientific notation with an identifying label.

CommView2 may be used interactively or may execute a series of commands automatically from a prepared text tile.

CommView2 may be used to upgrade the firmware in the instrument when new firmware is released.

The script file is created with any text editor and includes three types of lines (interpreted by the first character on each line):

lines beginning with " are sent to the PPA4500

lines beginning with # are commands for CommView2

any other line is a comment.

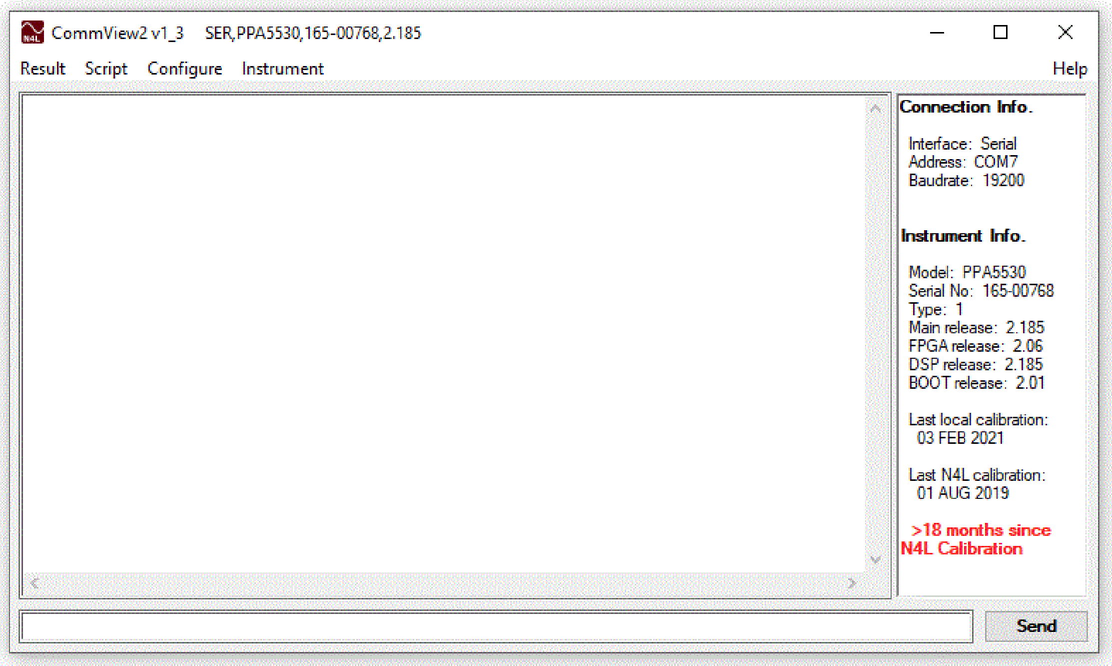
The # commands that are recognised:

format	arguments	effect
"text	string	send text to instrument
#label,i,name	i = result index name = string	overwrites label associated with results value [n]
#pause,t	t = delay in s	delay by real number seconds
#wait,text		display text string and wait for a key press (discard key press)
#beep		sound beeper on PC
#reply,t	t = timeout in s	wait for a reply using a specified timeout
#flush		discard any received characters.
;text		comment

Other functions in CommView2:	Found within
save results	***results menu***
set COM port parameters	***configure menu***
firmware upgrade	***instrument menu***
read/store user programs	***instrument menu***

As with all N4L Software, it is available for free download along with a full User manual from our website. See www.newtons4th.com/support for more details.

Once registered and your account has been activated you will have access to the software and manuals download sections.



When connecting to the instrument the panel to the right hand side of the software window will display details about the instrument.

This includes:

Connection Information: Details of the interface used to connect the instrument to the PC.

Instrument Information: Instrument Model, Serial number along with firmware details.

Calibration information: Details of when the instrument was last calibrated*

*From firmware version v2.185 onwards details of the last N4L Calibration procedure are displayed along with details of any later calibration performed by a locally based Calibration Laboratory.

At boot up an advisory message is displayed if the N4L Calibration & Adjustment was last performed more than 18 months ago.

PPA Datalogger/PPALoG PC software

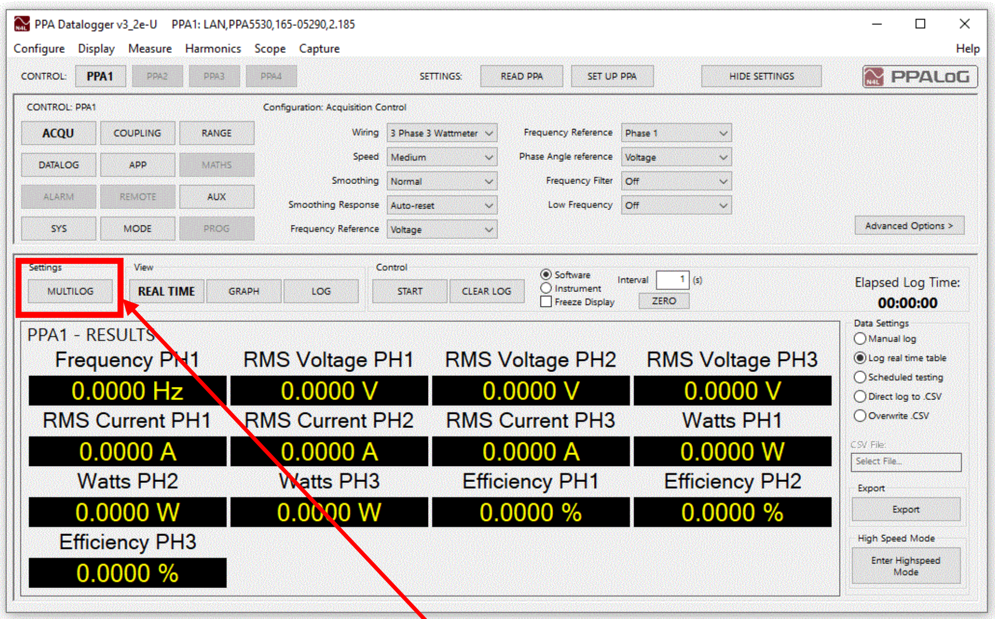
PPA Datalogger is a self-contained executable software program written in C++ using the Microsoft win32 graphics set.

PPA Datalogger has the ability to connect to the PPA series of instruments via RS232, USB and LAN. The software includes all measurement modes to reflect instrument operation.

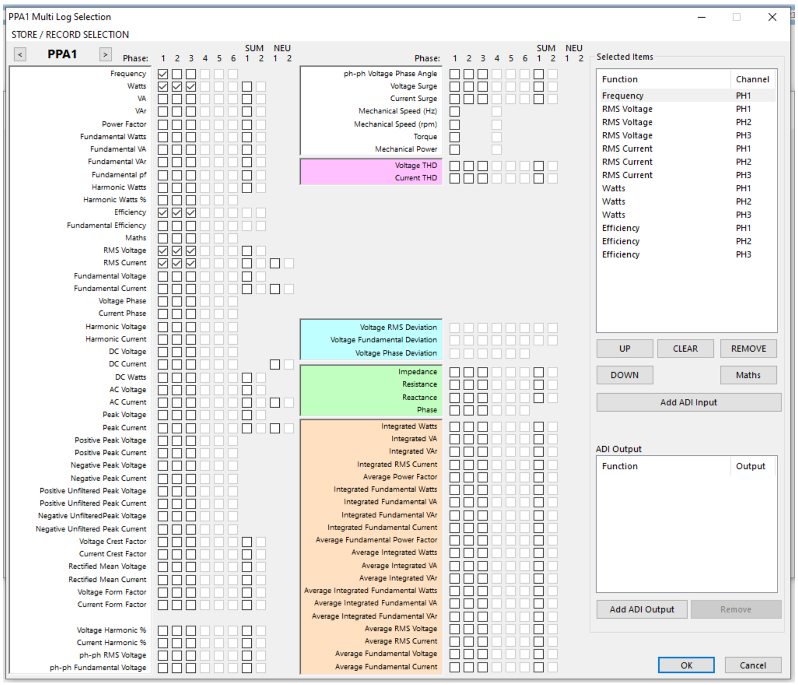
PPA Datalogger has the capability to communicate with up to 4 different PPA Instruments at the same time.

PPA Datalogger supports the ability to export text files in CSV format as well as export directly to Microsoft Excel ™

Measure Mode is PPA Datalogger's all-purpose measurement mode. Measure mode is an intuitive way to log a wide range of parameters using Real Time, Graph and Log datalogging methods. A few simple steps will see PPA Datalogger ready to record up to 60 of the PPAs wide range of multilog parameters, on up to 4 PPAs synchronised by PPA Datalogger, with speeds up to 200 results a second.



Measure mode is a truly flexible measuring system which will fulfil most needs. The Parameters to be datalogged are selected using the Multilog selection window:



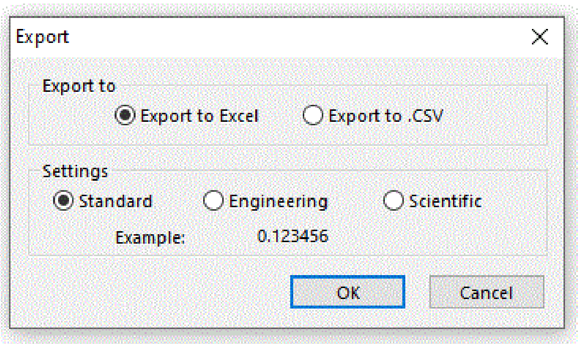
There are several measuring modes including:

Real Time: the default mode which records each result read from the connected Instrument to the Data Log.

Scheduled Testing Mode: The Start Time and Date and End Time and Date for the test are pre-selected.

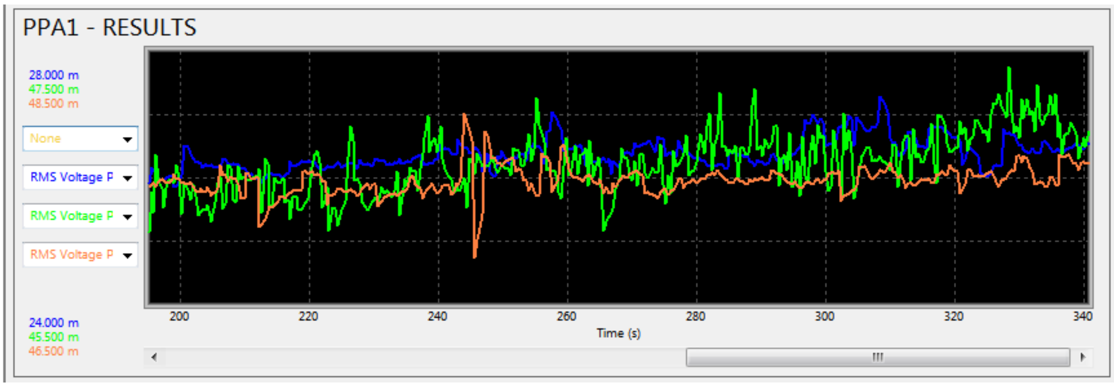
Direct Log to CSV Mode: The data is recorded from the instruments straight to a CSV file.

On completion of the test the results can be exported to Excel™ of CSV in several formats using the Export function:



Other PPA Datalogger Features:

Customisable Graph mode allowing up to 4 parameters to be selected:



Harmonics Mode: Harmonic data can be displayed in graph or table format.

Scope Mode: Allows up to 4 parameters to be displayed in Scope format, either in single step or continuous mode.

Capture Mode: Allows screenshots to be taken of the PPA display.

Display mode: Allows the displayed software screen to be saved to the clipboard, a Bitmap file or a Word document.

Equations Mode: Measure Mode's Multilog Parameters can be used to create custom equations. The equations can be added to Multilog Setups and logged alongside other Multilog Parameters, as well as exported.

The PPA Datalogger User Manual provides a full description of the various datalogging modes and functionality. There are full setup instructions for the software and connecting to the instruments.

Chapter 17 Appendix B- Available character set

The following characters can be selected in text entry mode.

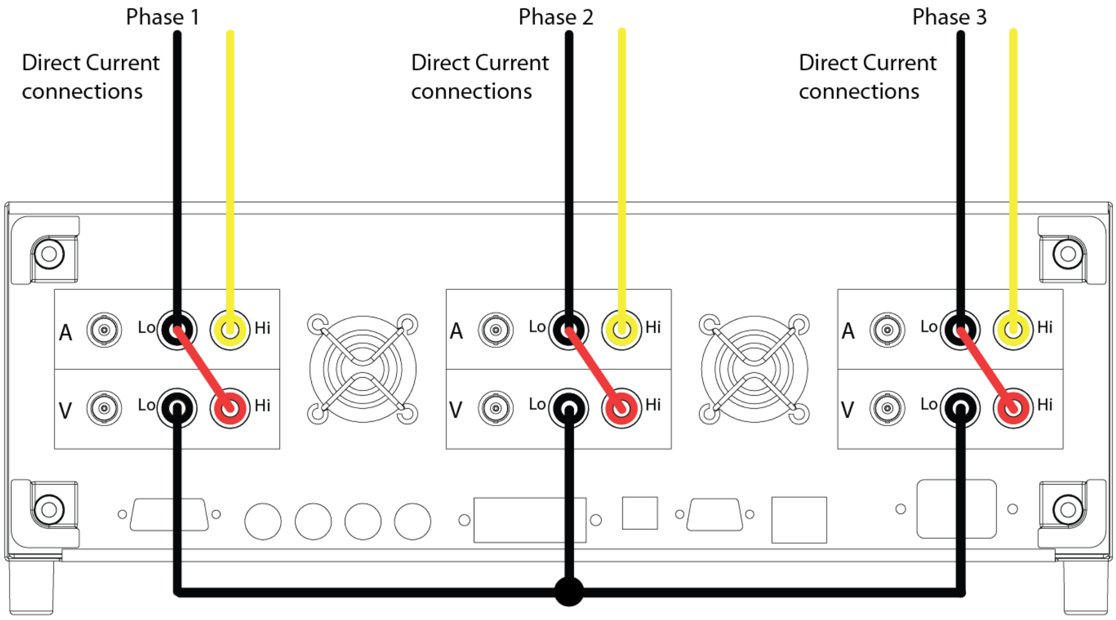
The table is to be read across then down (e.g. starting at space and repeatedly pressing NEXT gives ! “ # $ % & ‘ ( ) * etc.)

	!	“	#	$	%	&	‘
(	)	*	+	,	-	.	/
0	1	2	3	4	5	6	7
8	9	:	;	<	=	>	?
@	A	B	C	D	E	F	G
H	I	J	K	L	M	N	O
P	Q	R	S	T	U	V	W
X	Y	Z	[	\	]	^	_
‘	a	b	c	d	e	f	g
h	i	j	k	l	m	n	o
p	q	r	s	t	u	v	w
x	y	z	{	|	}		

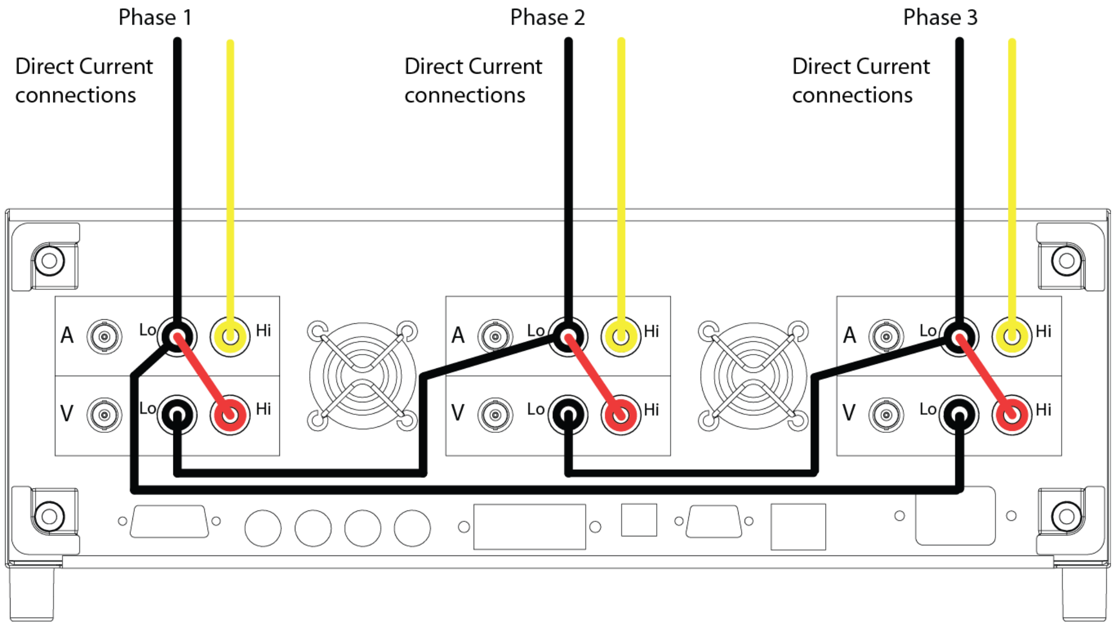
Chapter 18 Appendix C- Physical connection diagrams

Internal connections only

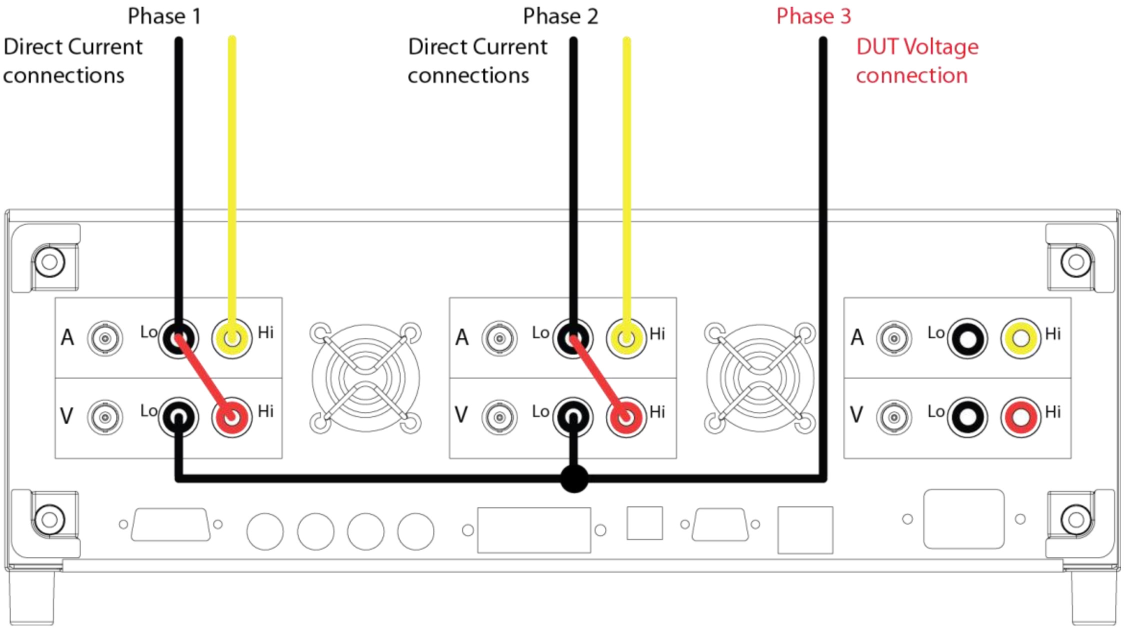
3P3W Star Connection



3P3W Delta Connection



3P2W Delta Connection



Chapter 19 Appendix D- Default Menu settings

The tables show the default menu settings at bootup from Prog 0 (factory default reset)

The table header shows both the short name below the key along with the title displayed on the LCD for each menu. Below the header the parameters and their values are listed.

Menu name below key	Title displayed on LCD
parameter	value

ACQU	ACQUISITION CONTROL
wiring	3 phase 3 wattmeter
speed	medium
smoothing	normal
Smoothing response	Auto reset
frequency reference	voltage
frequency reference	Phase 1
phase angle reference	voltage
frequency filter	off
low frequency	off
advanced options >	
DFT selectivity	normal
ignore overload	off
frequency lock	normal
minimum frequency	500.0mHz
high speed	disabled
probe compensation	normal
watts	signed
normalise reference	disabled
phase offset	+000.00˚
<return	

COUPLING	COUPLING
coupling	ac+dc
bandwidth	wide (dc-2mhz)
noise filter	off

RANGE	RANGING
voltage input	internal
autoranging	full autorange
minimum range	300mv
scale factor	+1.0000
current input	internal
autoranging	full autorange
minimum range	100ma
scale factor	+1.0000
dc offset	+0.0000a

DATALOG	DATALOG
datalog	disabled

APP	APPLICATION SELECTION
mode	normal
default settings	press ENTER here to load

APP	APPLICATION SELECTION
mode	PWM motor drive
default settings	press ENTER here to load
frequency filter	4kHz
frequency reference	voltage
low frequency	Off
torque + speed	Disabled
efficiency	disabled

APP	APPLICATION SELECTION
mode	Inrush current
default settings	press ENTER here to load
Minimum range	100mA
Auxiliary device	none

APP	APPLICATION SELECTION
mode	Lighting ballast
default settings	press ENTER here to load
frequency tracking	fast
efficiency	disabled

APP	APPLICATION SELECTION
mode	transformer mode
default settings	press ENTER here to load
temperature	disabled

APP	APPLICATION SELECTION
mode	standby power
default settings	press ENTER here to load
low frequency	off

APP	APPLICATION SELECTION
mode	calibration
default ac settings	press ENTER here to load
default dc settings	press ENTER here to load
Frequency filter	off

APP	APPLICATION SELECTION
mode	Harmonics/flicker
Harmonics/flicker	IEC61000-3-2(harmonics)
default settings	press ENTER here to load
Minimum range	100mA
autoranging	Full autorange
Verify source harmonics	BSEN61000
standards	A

APP	APPLICATION SELECTION
mode	Aircraft TVF105
default settings	press ENTER here to load
frequency step size	5.0000 Hz
selected harmonic	3
harmonic series up to	40
autoranging	full autorange
minimum range	300mV
autoranging	Full autorange
minimum range	100mA

MATHS	MATHS FUNCTIONS
formula	disabled

ALARM	ALARM OPTIONS
alarm 1 data	zoom 1
alarm type	disabled
alarm 2 data	zoom 2
alarm type	disabled
analog output	disabled

REMOTE	REMOTE SETTINGS
resolution	normal
interface	RS232
baud rate	19200
recall with program	off
screen print	USB memory stick

AUX	AUXILARY SETTINGS
master/slave	disabled
auxiliary device	none
external system scaling	disabled

SYS	SYSTEM OPTIONS
Set clock	10:32:59
Set date	28 Jun 22
display	colour
brightness	high
phase convention	0° to -360°
Phase angle reference	sine
Keyboard beep	enabled
autozero	auto
program 1-6 direct load	disabled
Zoom 2 high resolution	disabled
Independent ranging	enabled
Low value blanking	disabled
< system information	User data>

SYS	SYSTEM INFORMATION
serial number	xxx-xxxxx
manufacturing code	xxxxxx
main release	x.xxx.xx
DSP release	x.xxx.xx
FPGA release	x.xx.xx
boot release	x.xx
last N4L calibration	Day Month Year Time Initials
return >	

SYS	USER SETTINGS
Supervisor access	10:32:59
User data	28 Jun 22
User data	colour
User data	high
	0° to -360°
save	sine
< return	

The MODE menu is context dependent, and selection of the *MODE* key will display the relevant menu for the currently selected mode from the Function Keys, (see here) and allow the mode to be changed.

MODE	Power analyzer
VAr sign	negative lagging
power factor sign	negative leading
selected harmonic	3
sum current	average
sum VA & VAr computation	low distortion
difference THD	disabled
conversion	ph-ph rms
efficiency	disabled
input compensation	disabled

MODE	Impedance meter
parameter	impedance
measurement	series
Phase offset	+000.00˚

MODE	Power integrator
integration	signed
display	total
run time hours:mins	00:00

MODE	harmonic analyzer
computation	harmonic series
mode	normal
selected harmonic	3
harmonic series up to	40
voltage bargraph scale	100.0%
current bargraph scale	100.0%
marker	Off
marker	0.250%
conversion	normal
HARM key function	harmonic analyzer

MODE	oscilloscope
timebase	10.00ms/div
trigger reference	voltage
trigger level	+22.0mV
trigger mode	auto
trigger polarity	rising edge
trigger hf reject	off
pretrigger	25%
cursors	off
trace	dual

MODE	Fluctuating harmonics
HARM key function	harmonic analyzer
selected harmonic	3
current bargraph scale	100.0A

MODE	flickermeter
measurement	voltage
Impedance scaling	1.000
Tshort duration	10 minutes
Tlong duration	12
d(t) tet	none

MODE	rue rms voltmeter
rectified mean	absolute
peak	signed
crest factor	auto

MODE	Phase meter
speed	medium
smoothing	normal
smoothing response	auto reset
computation	ch2/ch1

PROG	Program Store/Recall
memory	Internal FLASH
data	program
action	recall
location	0
name	factory default
execute	

Chapter 20 Appendix E- Contact Details

Please direct all queries or comments regarding the PSM1735 instrument or manual to:

Newtons4th Ltd.

1 Bede Island Road

Leicester

LE2 7EA

United Kingdom

Tel: (0116) 230 1066 international +44 116 230 1066

E-mail address: sales@newtons4th.com

office@newtons4th.com

web site: www.newtons4th.com

At Newtons4th Ltd. we have a policy of continuous product improvement and are always keen to hear comments, whether favourable or unfavourable, from users of our products.

An example comment form can be found at the end of this manual – if you have any comments or observations on the product, please fill a copy of this form with as much detail as possible then fax or post it to us.

Alternatively send an e-mail with your comments.

PPA4500 comments

serial number:	main release: dsp release: fpga release: boot release: (press SYS then LEFT)	date:

your contact details:

comments:

detailed description of application or circumstances:

Please post or fax to Newtons4th Ltd.