N4L Newtons4th Ltd

PPA3500 Series

Precision Power Analyzer

User manual

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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

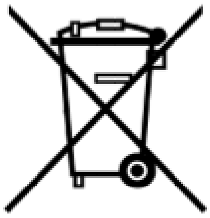
This section provides information about the environmental impact of the product.

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

Declaration of Conformity

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

We declare that the product:

Description: Phase Sensitive Multimeter
Model: PPA35xx 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.)

Preface

This manual covers the Newtons4th Ltd PPA55xx Series Precision Power Analyzers

Models covered

PPA3530 PPA3540 PPA3550 PPA3560	Available in LC 20Arms (Low Current), and Standard 30Arms versions

Key Features

Dual screen display

Wide frequency range DC & 10mHz to 1MHz

0.04%rdg + 0.1% rng 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

3 – 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 PPA3500 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 PPA3500 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.

General Specifications

General Specifications

Frequency Range	
DC & 10mHz to 1MHz	Normal
DC & 10mHz to 100kHz	Range 1+2
Accuracy	0.001%

Voltage Input	
Ranges	100mVpk to 2500Vpk (1000Vrms) in 10 ranges 20% over-range ability maintains 300Vpk range with 240Vrms
Accuracy	1V – 2500Vpk Range: 0.04% Rdg + 0.1% Rng + (0.005% x kHz Rdg) + 5mV * Range 1+2: 0.04%Rdg + 0.1%Rng + (0.01% x kHz Rdg) +1mV*
External sensor input	0 to 3Vpk – BNC connector
Range	1mVpk to 3Vpk in 8 ranges
Accuracy	Accuracy – 0.04% Rdg + 0.1% Rng + (0.005% x kHz Rdg) + 3µV*

Current Input	
The standard PPA is fitted with a 30Arms internal shunt, the -LC models with a 20Arms internal shunts are available.	
20Arms Shunt	
Ranges	10mApk to 300Apk (20Arms) in 10 ranges
Accuracy: Normal Accuracy: Range 1+2	0.04% Rdg + 0.1% Rng + (0.005% x kHz Rdg) + 300µA* 0.04% Rdg + 0.1% Rng + (0.01% x kHz Rdg) + 100µA*
30Arms Shunt	
Ranges	30mApk to 1000Apk (30Arms) in 10 ranges
Accuracy: Normal Accuracy: Range 1+2	0.04% Rdg + 0.1% Rng + (0.005% x kHz Rdg)+ 900µA* 0.04% Rdg + 0.1% Rng + (0.01% x kHz Rdg)+ 300µA*
External sensor input:	1mVpk to 3Vpk in 8 ranges – BNC connector
Accuracy	0.04% Rdg + 0.1% Rng + (0.005 x kHz Rdg) + 3µV
* Measured fundamental value	
Phase Accuracy	
Normal:	5 millidegrees + (10 millidegrees x kHz)
Range 1+2:	5 millidegrees + (20 millidegrees x kHz)

Watts Accuracy	
Normal:	[0.1% +0.1%/pf +(0.01% x kHz)/pf] Rdg +0.05%VA Rng
Range 1+2:	[0.1% +0.1%/pf +(0.02% x kHz)/pf] Rdg +0.05%VA Rng
40Hz-850Hz Watts Accuracy	[0.06% + 0.1%/pf +(0.01% x kHz)/pf] Rdg + 0.03%VA Rng

DC Accuracy	
Voltage	
Normal:	0.1% Rdg + 0.1% Rng + 10mV
Range 1+2:	0.1% Rdg + 0.1% Rng + 2mV
Current	
Internal	
20Arms	
Normal:	0.1% Rdg + 0.1% Rng + 1mA
Range 1+2:	0.1% Rdg + 0.1% Rng + 200µA
30Arms	
Normal:	0.1% Rdg + 0.1% Rng + 3mA
Range 1+2:	0.1% Rdg + 0.1% Rng + 600µA
External Input	0.1% Rdg + 0.1% Rng + 10µV
Watts	
20Arms	
	0.20% Rdg + 0.20% VA Rng + 10µW
Voltage set to Range 1 or 2	0.20% Rdg + 0.20% VA Rng + 2µW
Current set to Range 1 or 2	0.20% Rdg + 0.20% VA Rng + 2µW
Both set to Range 1 or 2	0.20% Rdg + 0.20% VA Rng + 0.4µW
30Arms	
	0.20% Rdg + 0.20% VA Rng + 30µW
Voltage set to Range 1 or 2	0.20% Rdg + 0.20% VA Rng + 6µW
Current set to Range 1 or 2	0.20% Rdg + 0.20% VA Rng + 6µW
Both set to Range 1 or 2	0.20% Rdg + 0.20% VA Rng + 1.2µW

Notes:

Normal: excludes Current and Voltage Range 1 and 2

Voltage Range 1=100mV and Range 2=300mV

Current Ranges:

PPA3500-20A: Range 1=10mA and Range 2=30mA
PPA3500-30A: Range 1=30mA and Range 2=100mA

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 Normal:	0.05% hi rdg + 0.1% rng + 0.005% * KHz + 5mV
Hi error Range 1+2	0.05% hi rdg + 0.1% rng + 0.01% * KHz + 1mV
Current: 20A:	
Hi Error Normal:	0.05% hi rdg + 0.1% rng + 0.005% * KHz + 500uA
Hi Error Range 1+2	0.05% hi rdg + 0.1% rng + 0.01% * KHz + 100uA
Current: 30A:	
Hi Error Normal:	0.05% hi rdg + 0.1% rng + 0.005% * KHz + 1mA
Hi Error Range 1+2	0.05% hi rdg + 0.1% rng + 0.01% * KHz + 300uA
External Sensor Input:	
Hi Error Voltage	0.05% hi rdg + 0.1% rng + 0.005% * KHz + 5uV

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

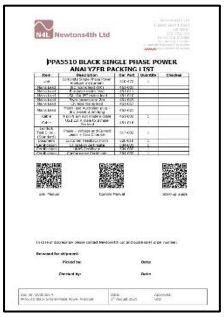
PPA SERIES COMPARISON TABLE	PPA1500/500	**PPA3500**	PPA5500
Phases			
Maximum V & A phases	3	**6**	3
Accuracy			
Basic V & A reading + range	0.05% + 0.1%	**0.04% + 0.1%**	0.01% + 0.038%
Power reading + VA range	0.1% + 0.1%	**0.1% + 0.05%**	0.03% + 0.03%
Voltage Input			
Direct Voltage	2500Vpk	**2500Vpk**	3000Vpk
Ranges	8 (10♦)	**10**	9
Direct current input options			
10Arms			3mA-30Apk
20Arms	10mA - 30Apk♦ 100mA - 300Apk	**10mA-30Apk● 100mA-300Apk**	
30Arms	30mA-100Apk♦ 300mA-1000Apk	**30mA-100Apk● 300mA-1000Apk**	30mA-300Apk
50Arms			100mA-1000Apk
Ranges	8	**10**	9
Bandwidth			
AC+DC coupled	DC to 1MHz	**DC to 1MHz**	DC to 2MHz
Selectable Low BW		✓	✓
General features			
Display	High contrast Colour Graphic	**High contrast colour Graphic**	High contrast Colour Graphic
Processing power - Harmonic computations per second	300	**600**	1,800
Non volatile internal Memory	192kB	**1GB**	1GB
USB port for memory drive	✓	✓	✓
Plug in USB memory drive		**2GB**	2GB
Non-volatile real-time clock	✓	✓	✓
Torque and speed inputs		**Analog & pulsed**	Analog & pulsed
Analogue output			✓
Internal datalog functions	4	**32 (2 x 4 x 4)**	16 (4 x 4)
Datalog record storage capacity	16,000	**10,000,000**	10,000,000
Frequency measurement accuracy	0.02%	**0.02%**	0.001%
Application modes			
PWM		✓	✓
Lighting	✓	✓	✓
Inrush	✓	✓	✓
Transformer		✓	✓
Standby Power	✓	✓	✓
Mechanical			
Handle	Adjustable	**Adjustable**	Adjustable
Tilt	Multiple position	**Multiple position**	Multiple position
19” Rack mounting option		✓	✓

X10 range mode = ♦ Range 1+2 = ●

Installing your PPA3500

Checking the shipped contents

Carefully unpack your PPA3500 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 PPA3500 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	-10 ° C to +60 ° C
Operational Temperature	0 ° C to +50 ° C
Operating Humidity	20% 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: 100mVpk ~ 2500Vpk (1000Vrms) 10 ranges = 100mV, 300mV, 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

nput

Characteristic	Description
Current	
PPA3500-LC 20Arms Shunt, 4mm Safety Connectors	10mApk ~ 300Apk (20Arms) (10 ranges = 10mA, 30mA, 100mA, 300mA, 1A, 3A, 10A, 30A, 100A, 300A)
PPA3500 30Arms Shunt, 4mm Safety Connectors	30mApk ~ 1000Apk (30Arms) (10 ranges = 30mA, 100mA, 300mA, 1A, 3A, 10A, 30A, 100A, 300A, 1000A)
External Current BNC Input Ranges	1mVpk ~ 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 PPA3500 series Carry / Tilt Handle.

The PPA3300 Power Analyzer is supplied with a Carry/Tilt Handle already fitted.

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.

Handle Removal

The following pictures sequence, (Fig1-5) illustrate how to remove and refit the handle if required:

Showing unit as unpacked with handle fitted.

Fig 1

To remove the handle, first position as shown left.

Fig 2

On each boss there is a light grey key, these need to be pressed in.

Fig 3

At the same time pull the boss and arm away from the unit on both sides as shown left.

Fig 4

Lift the handle assembly clear of the unit.

Fig 5

The following picture shows the locking mechanism on each handle boss.

Fig 6

Refitting Handle

To refit the handle, place handle above unit and with the light grey keys depressed pull the arms apart slightly and align with the fittings on the side of the PPA.

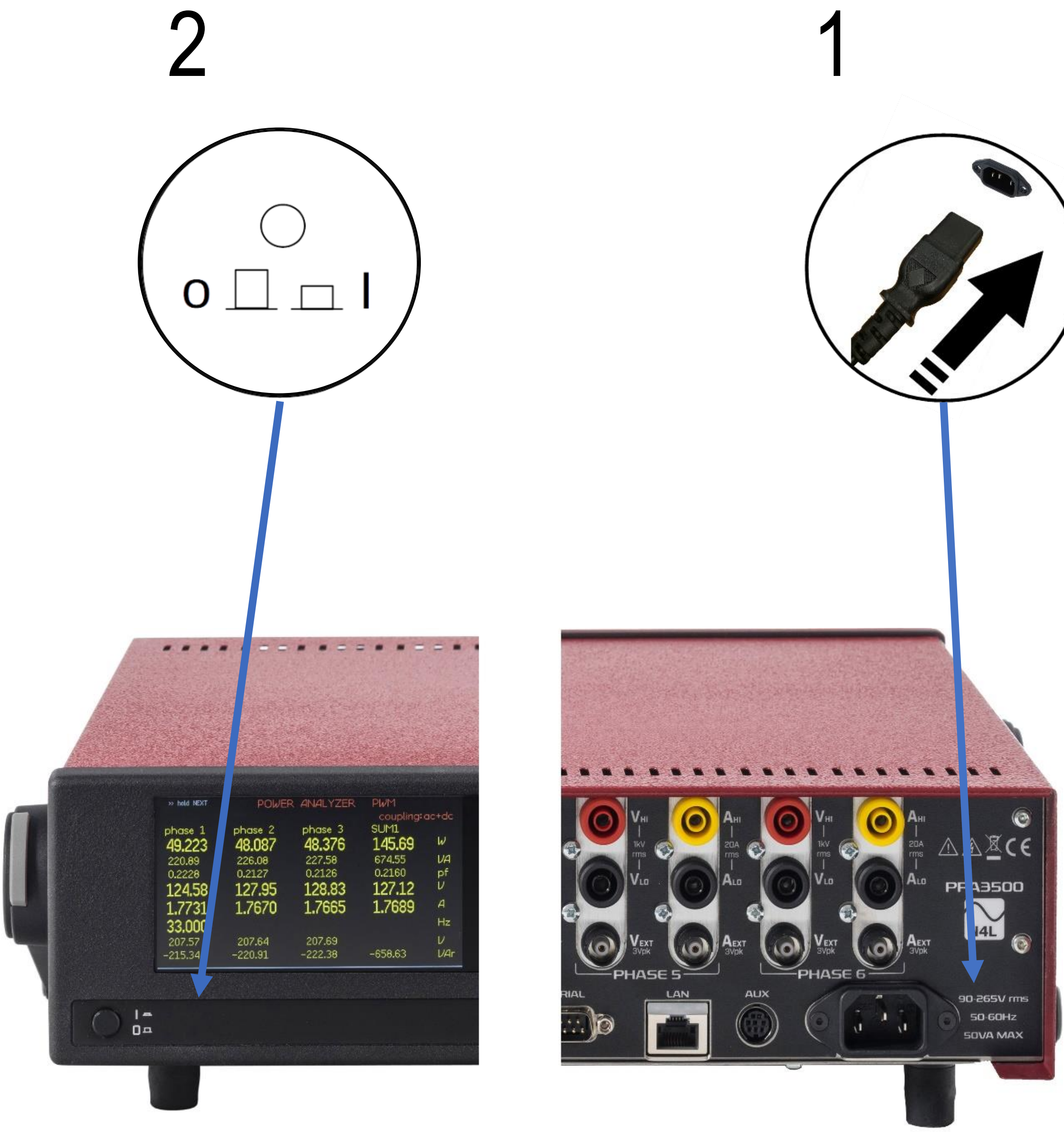
Allow the handles to spring back and click into place.

Check for free movement of handle by depressing the grey keys and move the handle through its whole range of movement.

Powering On your PPA3500 series

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

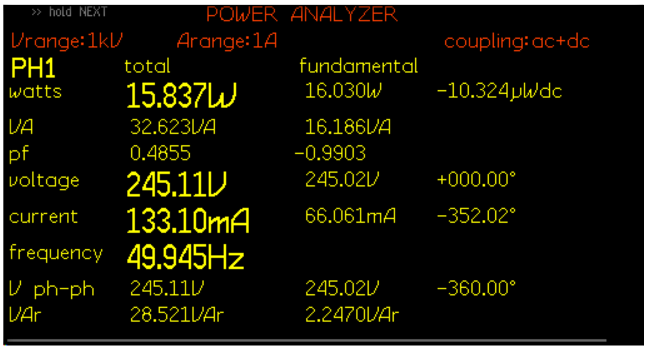


After a few seconds, the following splash screens will be seen on the left and right of the LCD display.

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

The PPA3500 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 PPA3500



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

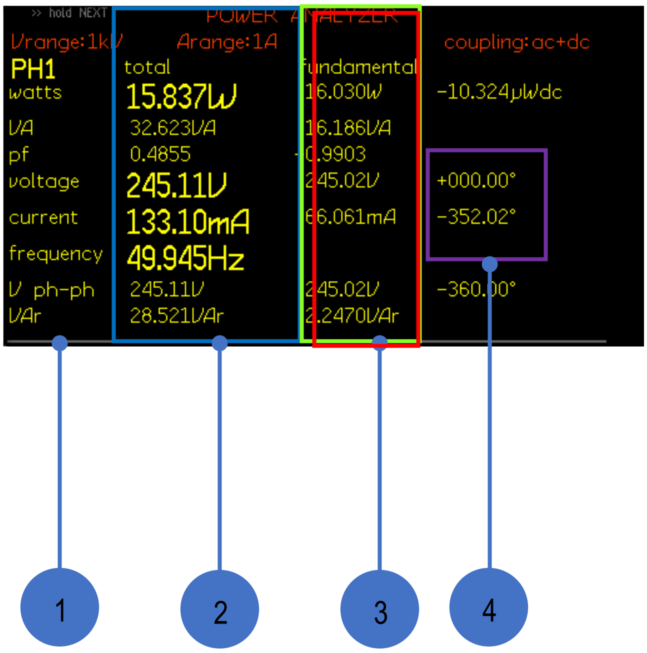
Within the Power Analyzer screen, you will notice several distinct areas: -

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

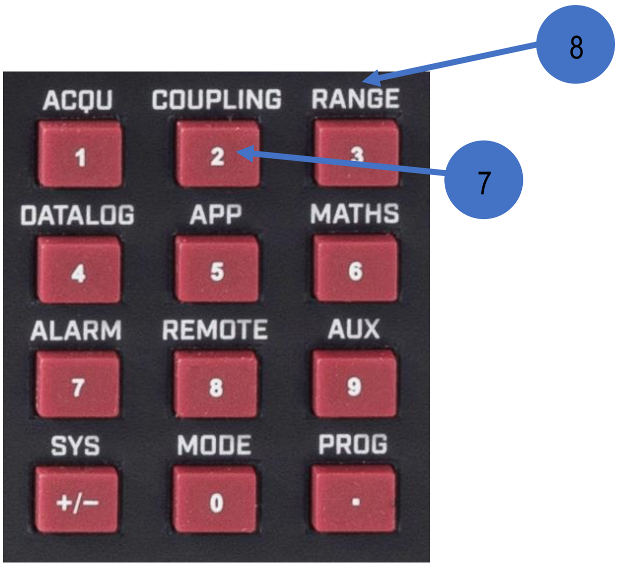
Instrument Layout

Front panel Controls

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

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

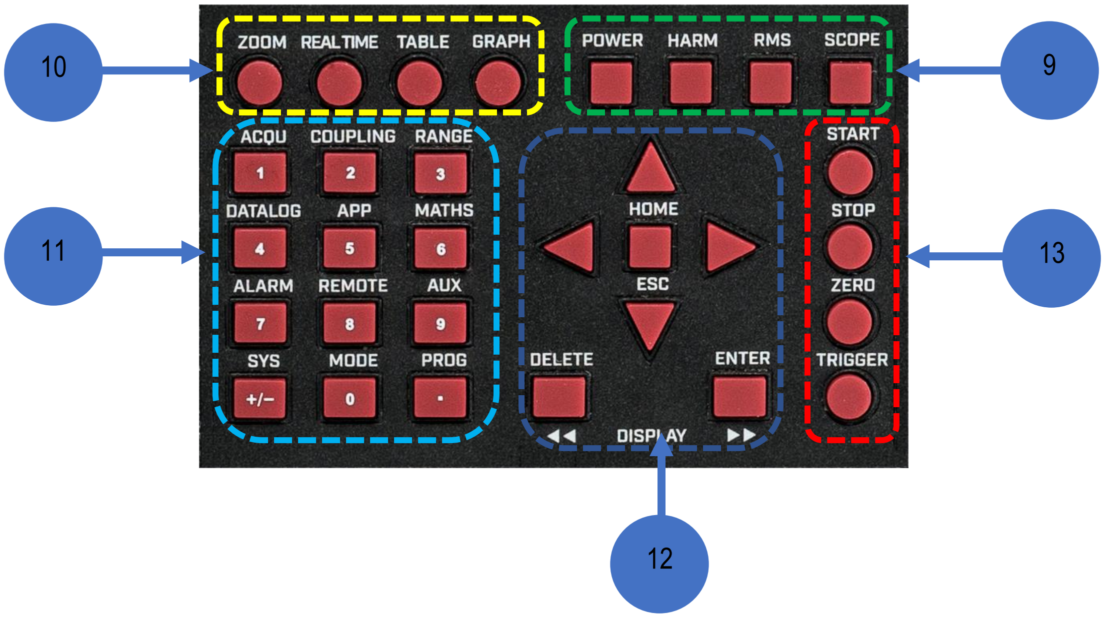
1. Adjustable handle
2. On/Off power switch
3. Left hand LCD screen
4. Right hand LCD screen
5. Front USB port for USB memory drives
6. Main keypad



7.Primary numeric function, the key will display "3" or "D, E, or F" when entering numerals and text in a menu option.

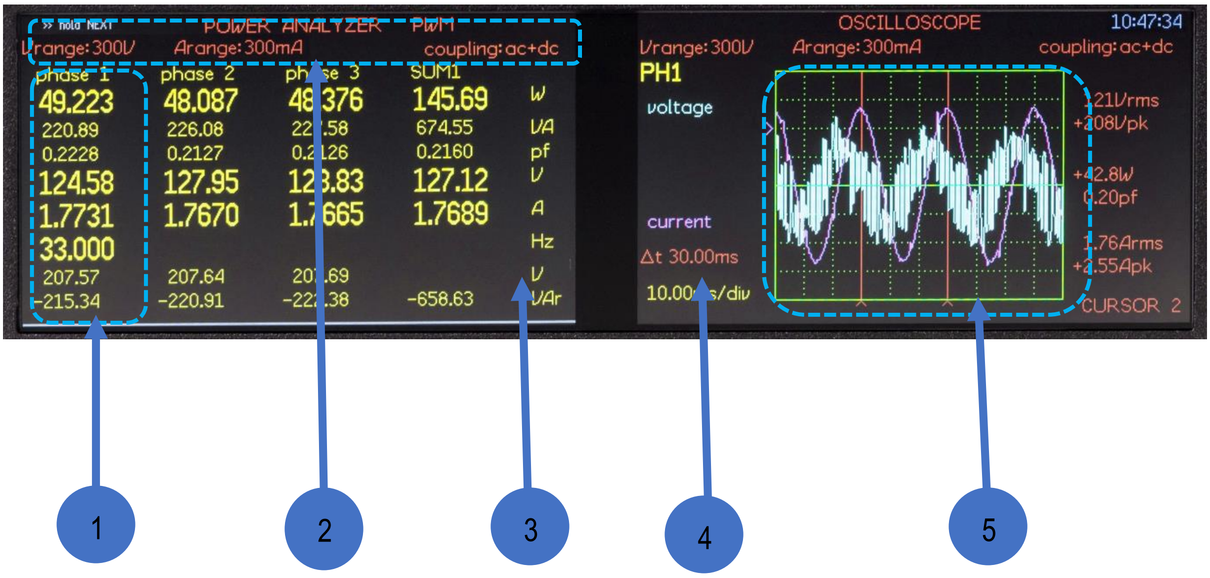
8.Secondary function, the key will open the RANGE menu screen

Keyboard Zones



9. Power Analyzer mode selection keys
10. Screen display function keys
11. Alphanumeric and measurement settings
12. Menu selection and cursor controls
13. Measurement control keys

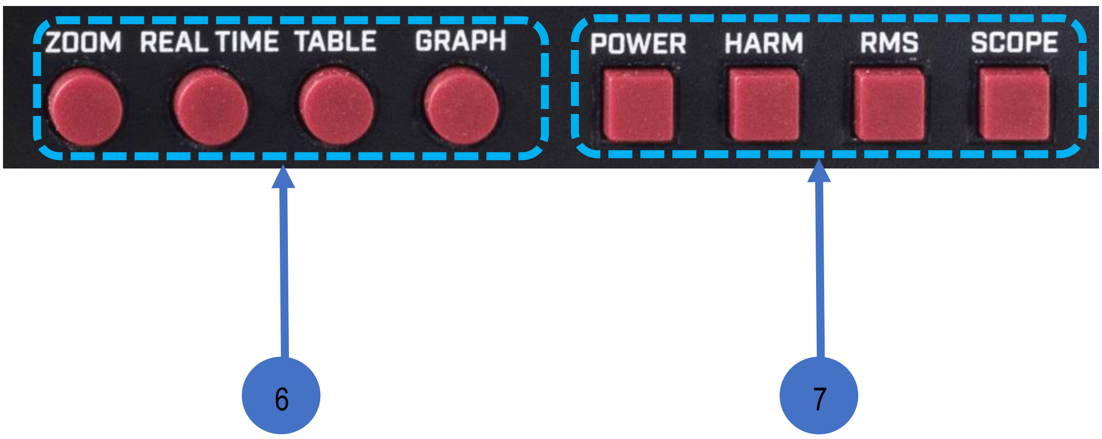
Screen Area



In the screens shown above, each column of results refers to the phase noted at the top of the column, with column 4 showing the SUM of phases 1-3.

1. Main results display, the contents of this area are context sensitive to the type of instrument MODE selected.
2. Settings area, this displays the selected Mode, Application, Coupling and Bandwidth selected.
3. Left hand or No.1 screen
4. Right hand or No.2 screen
5. Oscilloscope display

Top row display & application control keys



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.

Application mode direct access keys, the POWER, HARM, RMS, & 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. (μ, m, k, & M)

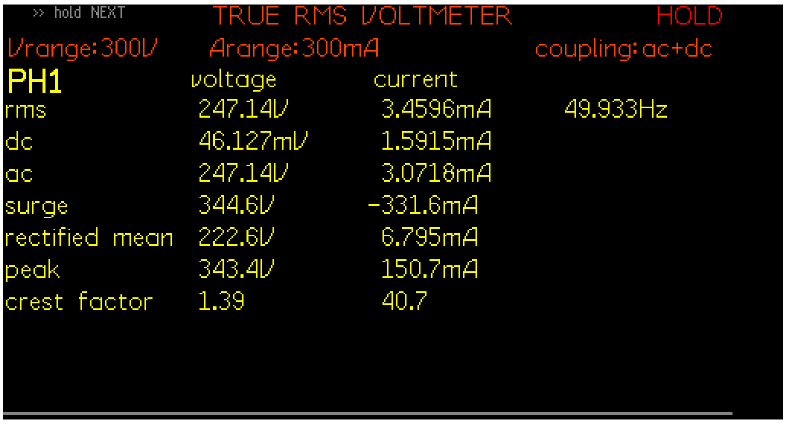
Zoom

The zoom key enables up to 4 parameters on any of the real time displays to be chosen to be magnified to one of three increased sizes to highlight important readings.

Pressing the *zoom* key cycles through the five stages as shown

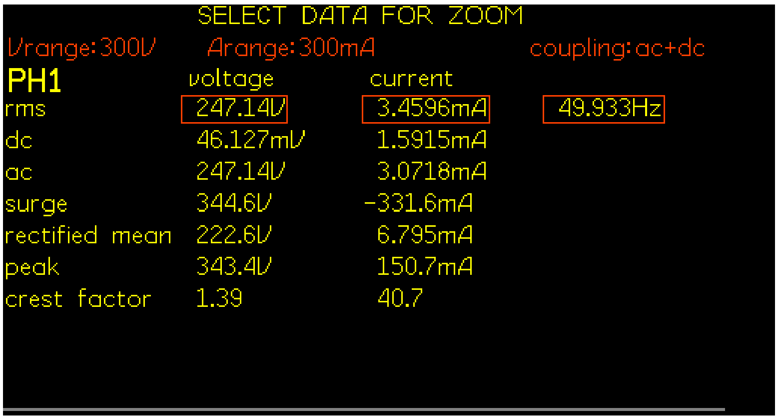
No zoom ➞ Select data for zoom ➞ zoom level 1

No zoom ← zoom level 3 ← zoom level2

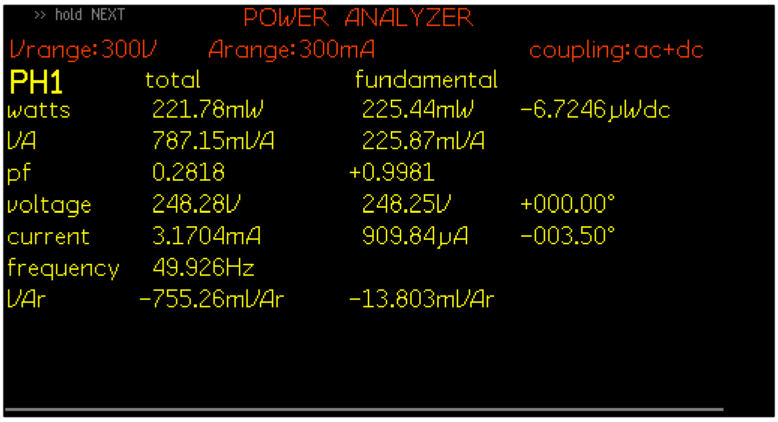


In any Real- Time screen with no zoom applied the results will be displayed as shown here. All the measurement parameters and their values are the same size.

Press the *ZOOM* key to view the presently selected data (solid red non flashing highlight box(s)) as shown below

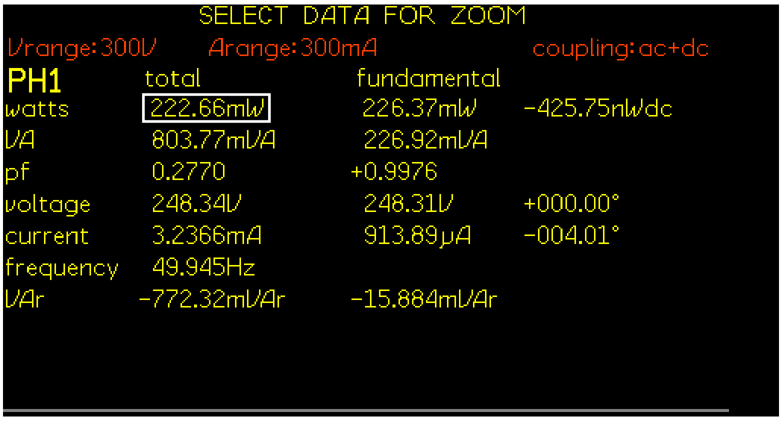


Three of a possible four parameters have been selected.



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 until no parameters are highlighted as above.

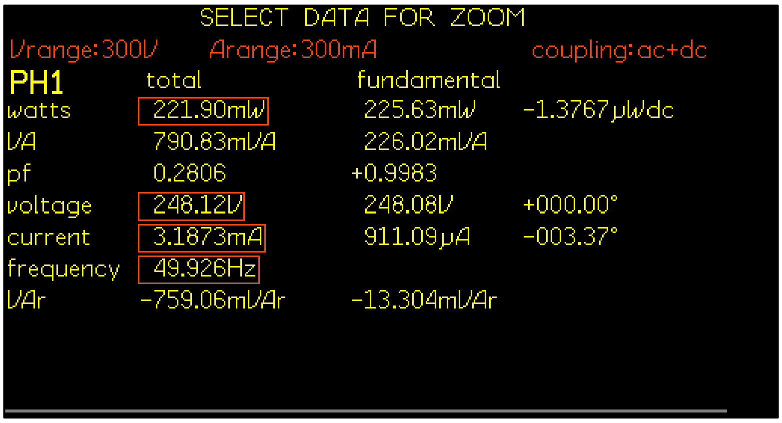
Each parameter that you want to be highlighted for zoom display can be selected by using the ▼, ▲, ►, & ◄ keys. The ▲& ▼ keys allow the selection of the parameters and will if continuously pressed cycle from the top to the bottom and back to the top again. Similarly, the ►& ◄ keys will swap from one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



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, as seen above, 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.

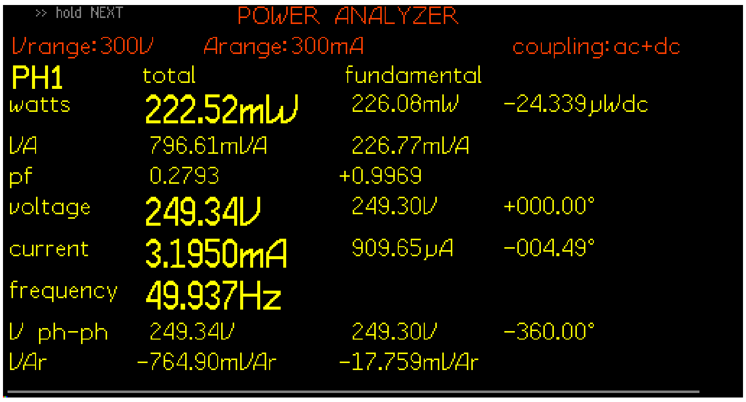
It is not necessary to have to select four parameters. Each solid highlight signifies that the parameter will be zoomed when the ZOOM key is pressed. If a fifth parameter is selected, the first parameter will be deselected.
The PPA3500 supports 1-4 parameters in zoom levels 1 & 2, zoom level 3 only displays the first 3 parameters selected.
By default, each instrument mode has the most useful parameters set for zoom at boot up, these of course can be changed by the user and saved to a particular program location for subsequent recall. Loading program 0 will reload the standard default settings for the zoom selection.

Shown below are examples of each zoom level.



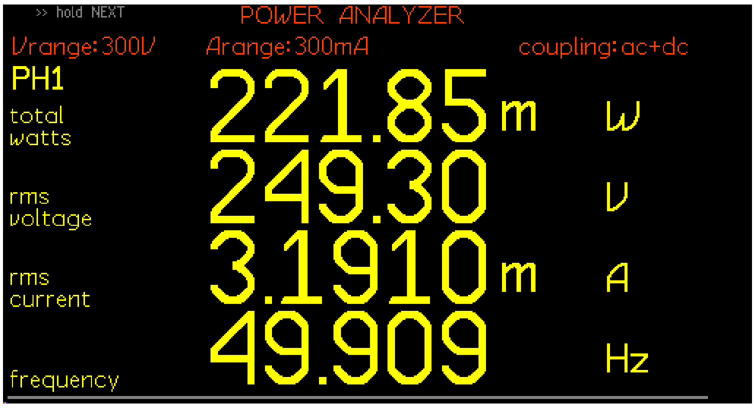
The first zoom level enlarges the parameters selected in the previous view, while leaving the remainder at the original size.

Zoom level 1

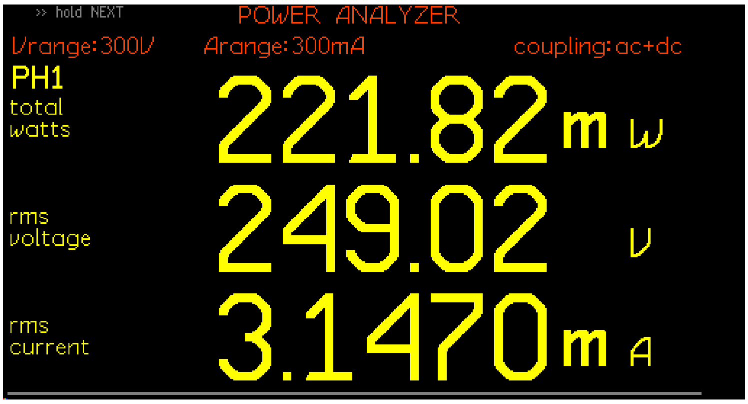


The second level of zoom now only displays the selected parameters to be displayed.

Zoom level 2



Zoom level 3



The third level is now at maximum magnification, another press of the *zoom* key will return to the original display of all the parameters with no zoom selected.

Default zoom selections

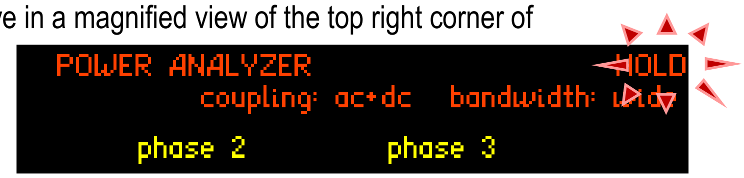
Mode	Selected Defaul Parameters			
Power Analyzer	Total Watts	rms voltage	rms current	Frequency
Impedance Meter	Impedance	or Inductance	or Capacitance	
Power Integrator	Total Wh	Total VAh	Pf Avg.	Total Ah
Harmonic Analyzer	THD voltage	THD current		
Oscilloscope				
True RMS Voltmeter	rms Voltage	rms Current	Frequency	
Phase Meter	Gain dB	Phase °		

The *zoom* key has a secondary function when setting the alarms.

Real Time – Data Hold

The Real Time key has two functions, its primary function is to switch the active screen to a Real Time view from a menu or tabular results screen. The second function is to activate data hold when in a real time display.

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*** replaces the time display and 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.



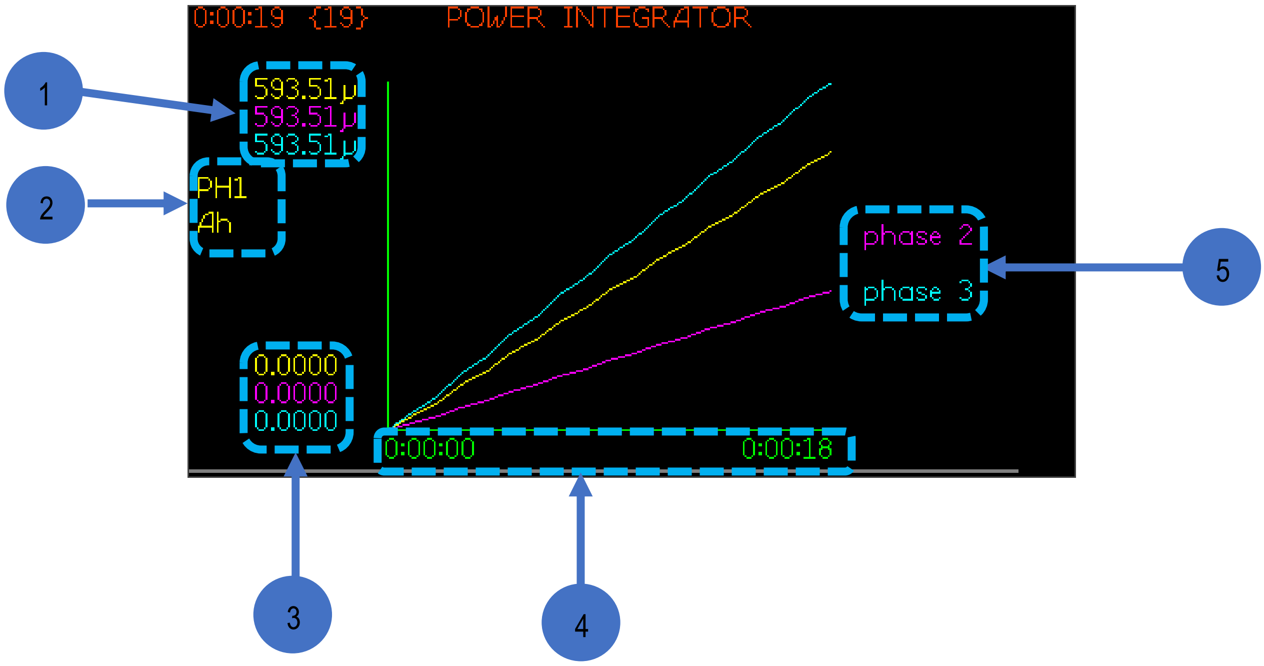
Press the *REAL TIME* key again or the *HOME* or *START* key to release ***HOLD***; in this case, *HOME* and *START* keys do not have their normal functions. Changing mode also releases the hold function.

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.

Table & Graph keys

The *TABLE* & *GRAPH* keys are used to display tabular and graphical results from datalogging of the Power Integrator or the harmonic analyzer modes.

Each successive press of either key will cycle through the parameters being logged either in the tabular format with the *Table* key or the graph will change with each press of the *Graph* key.



Main features of the graph display

1. Y-axis label. This shows the upper value for the chosen parameter, the value displayed is auto ranged. Each of the three phases which are colour coded, yellow=ph1, Purple=ph2, and Cyan=ph3

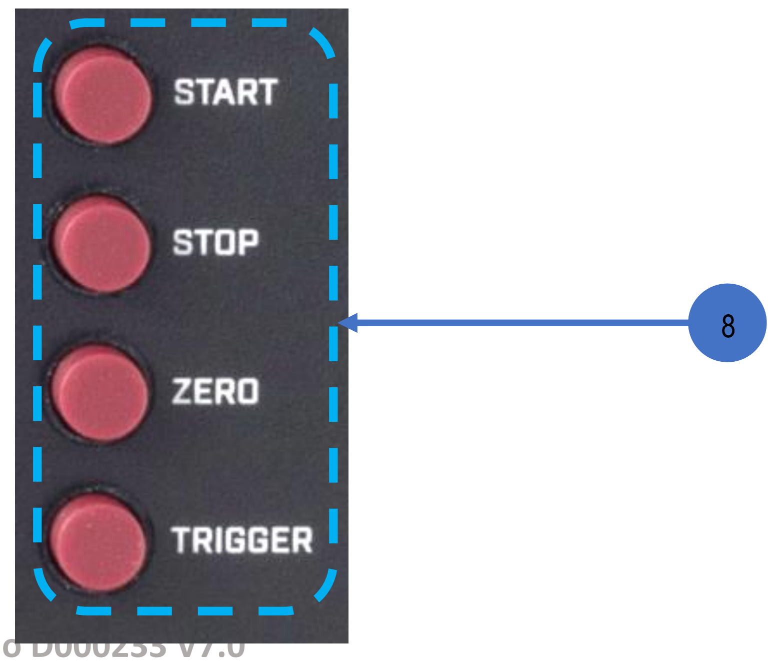
2. Parameter being measured, this cycles through the available parameter dependent on the mode selected at each press of the *GRAPH* key.

3. Y-axis lower value label

4. X-axis label displays elapsed time of integration in the following format HH:MM:SS

5. Trace/graph key colour coded per phase.

Measurement Control Keys



Start key This key has many functions that are context sensitive.

The *START* key assumes the following functions.

Mode	Settings	Action
	Datalogging Disabled	
Any	Screen print in *REMOTE* menu set to ***USB memory stick***	Hold start key in for approx. 0.5 s then release- Screen shot saved to USB stick
Power Integrator	None	Starts power integration
Any Real Time Display active	HOLD selected by pressing *REAL TIME* key	Releases Real Time display from Hold
Scope	None	Initiates Single Shot Trigger
	Datalogging Enabled	
Datalogging	None	Initiates Datalogging

Stop key This key is dual use only.

It is used to halt logging in Power Integrator mode or if datalogging is enabled, it will stop the logging until the *START* key is pressed again.

Zero key This key is dual use only.

It is used to reset any currently running power integration, when not in power integrator mode it is used for manual zero compensation as described below.

Zero compensation

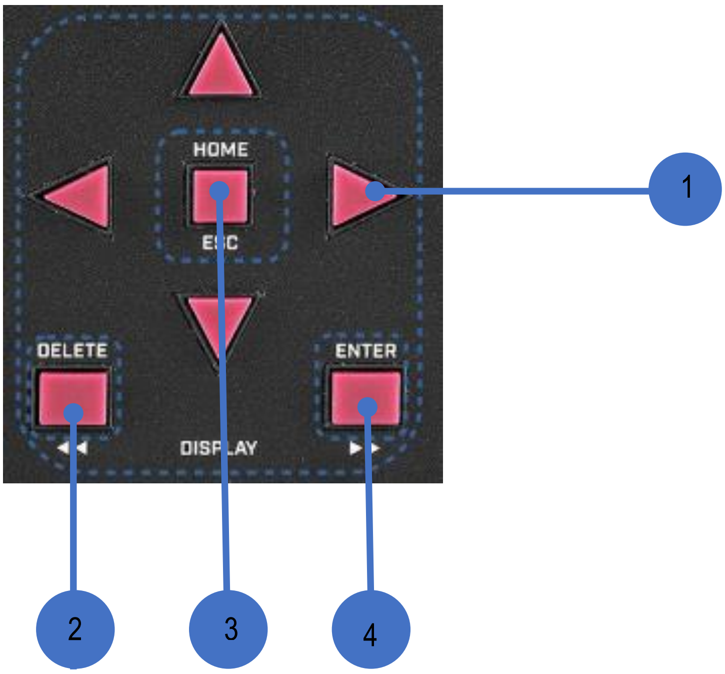
There are 2 levels of zero compensation:

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.



1. 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.
2. Back/Delete key, this dual use key is used to edit alphanumeric entries and also to navigate between screens that have additional sub screens.
3. 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.
4. 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.

Dual Display Screens

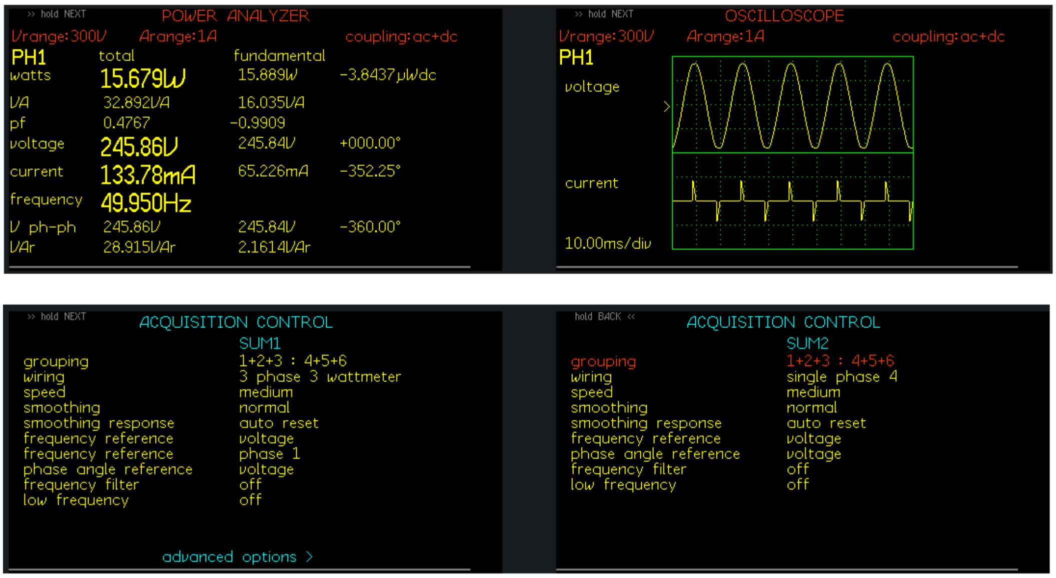
The PPA3500 range of power analyzers is unique amongst the whole range of N4L power analyzers, in that all PPA3500 models have dual side by side LCD screens.

The PPA3500 series of power analysers covers 1 to 6 phase applications in both low current (10Arms) and standard models(30Arms), (Available in 3 to 6 phase configurations only) The phase inputs are associated with two groups which may be independently configured for different wiring modes or may be synchronised together into a single wiring mode. Each screen is dedicated to a single group.

Group 1 is controlled via the left hand screen and Group 2 the right.

For example, some combinations available on a 4 phase model are:

Group 1	Group 2
4 phase	n/a
3 phase 3 wattmeter	Single phase
3 phase 2 wattmeter	3 phase 2 wattmeter



For each group, the voltage and current inputs are simultaneously sampled, and the data is analysed in real-time by a high-speed DSP (digital signal processor). A separate CPU (central processing unit) takes the results from the two DSPs for display and communications. At the heart of the system is an FPGA (field-programmable gate array) that interfaces the various elements.

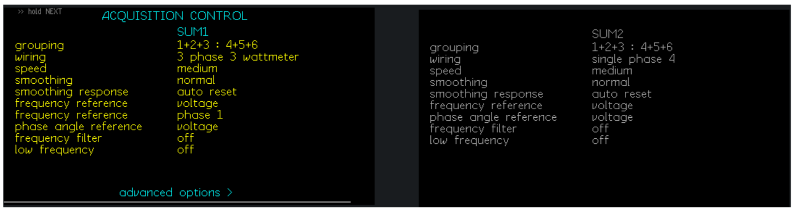
The dual screen functionality of the PPA35xx gives the user the capability to display the same measurement data in two different formats at the same time. The screenshot above is taken from a 6 phase PPA3540, the screen on the top left is displaying real time power measurements, whereas the top right hand screen is displaying the scope trace of the rms Voltage and Current.

The bottom pair of screens shows the ACQU settings for the displays on the top row.

N.B. Both the screens on the bottom row are shown as “live”, this is depicted for this manual to make the settings clearer, in reality only one screen can be “live” and able to be edited at a time. The live screen is designated by the thin grey line at the bottom of the screen. The second screen is “greyed out” *The ►► / Enter* & ◄◄ */ Delete* keys are held down for approx. 1.5 seconds to switch between the first and the second screen.

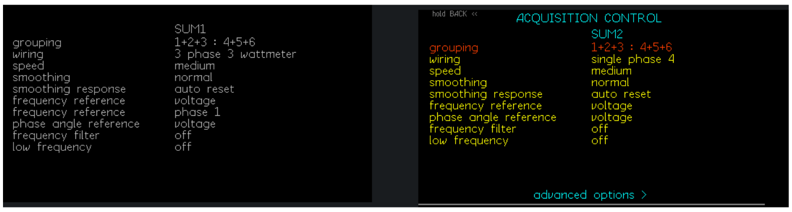
In the example below screen 1 is active and the second, right hand screen is “greyed out” and cannot be edited. A long press of the *Next / Enter* key will change the live screen to the right hand side, as can be seen in the lower screenshot.

1



2

3



4

In addition to show the changing status of each screen, text colours are used to signify further information and activity status.

Screen colour coding

The menu screens use a colour code to convey the status in a convenient and simple manner.

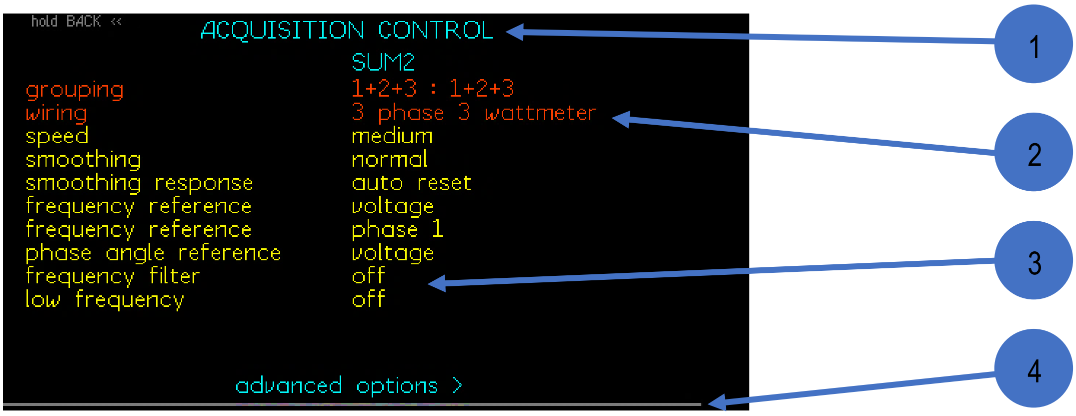
Yellow text signifies normal menu parameters that can be edited and set to specific values, either by direct entry of a value or selection from a drop down menu. Changing a yellow parameter in the left hand screen has no effect on the corresponding parameter on the right hand screen and vice versa.

Conversely if a parameter is changed in the live screen and then the focus is swapped to the other screen and any text is showing in red, this signifies that the parameter is common across both screens.

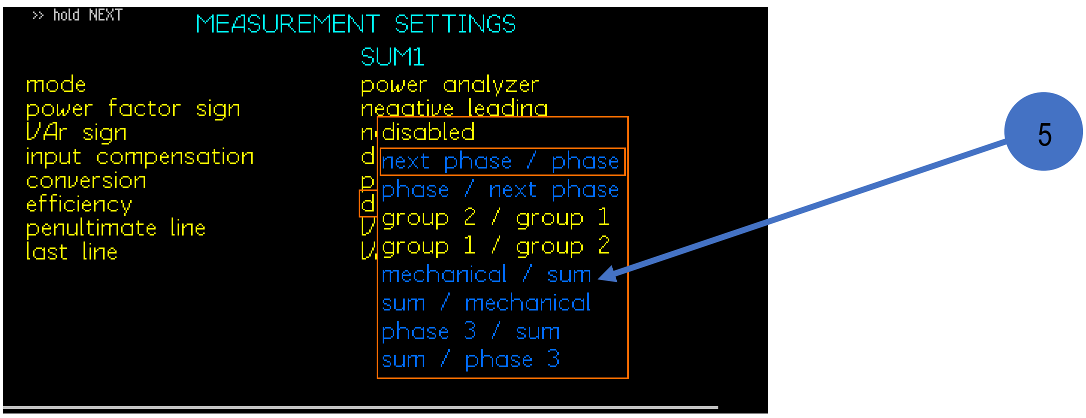
Blue is used to signify that a parameter selection is invalid with the current settings applied.

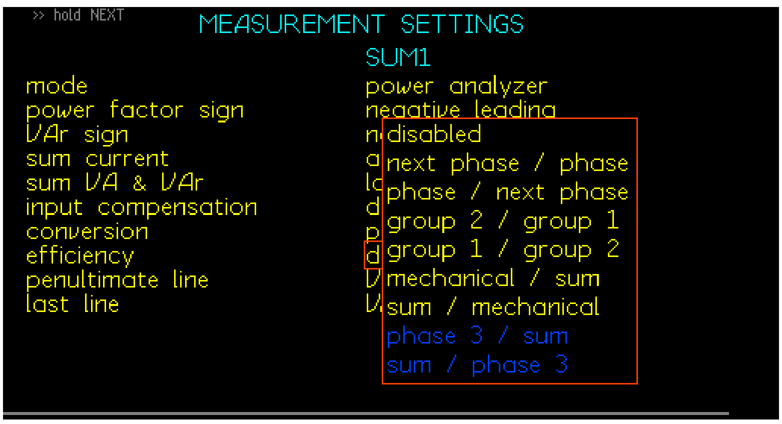
Turquoise signifies a label or instruction.

Grey is used to denote the status of the screen. The grey line at the base of either of the screen signifies that the screen is currently active, and parameters can be edited. Whereas grey text signifies that the screen is inactive, and parameters cannot be edited.

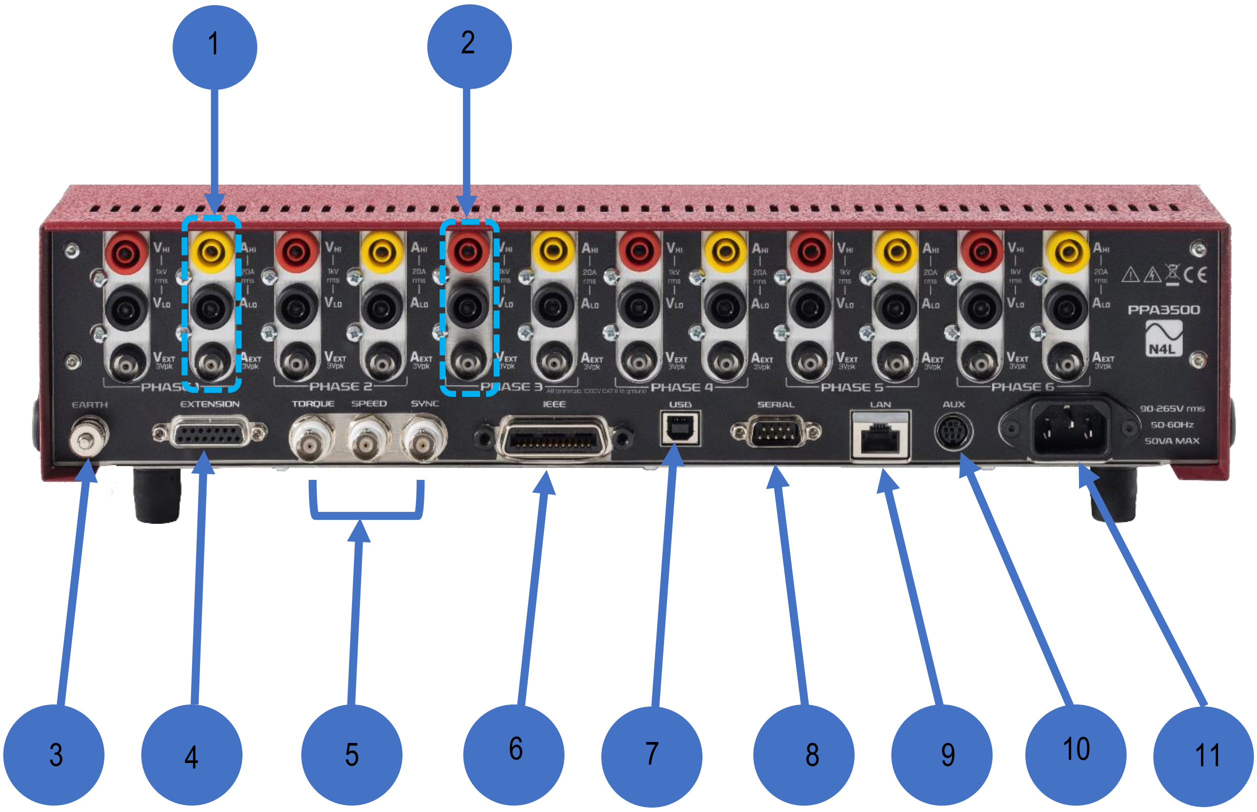


1. Turquoise text for the menu title and the screen label
2. Red text for parameters that change in both groups when changed in the other
3. Yellow text for normal parameter descriptions and editable values
4. Grey text and line for live screen designation and screen navigation labels
5. Blue text for options that are not available due to current settings, by changing the grouping in the ACQU menu the allowable options shown in the second screen shot below have changed.





Rear panel connectors



1. Current input connections 3-6 channel dependent on model. Internal connections are via 4mm safety plugs, external connection via safety BNC connector.
2. Voltage input connections 3-6 channel dependent on model. Internal connections are via 4mm safety plugs, external connection via safety BNC connector.
3. Chassis ground terminal.
4. Extension connection port via 15 way D-Sub connector.
5. Torque, Speed & Sync connections via BNC connections.
6. IEEE488 (GPIB) port.
7. Female USB 2.0 Type B socket for communication.
8. RS232 communication port, 9 pin D-Sub.
9. LAN/Ethernet port.
10. Auxillary DIN connector
11. IEC 60320 C13 mains inlet socket.

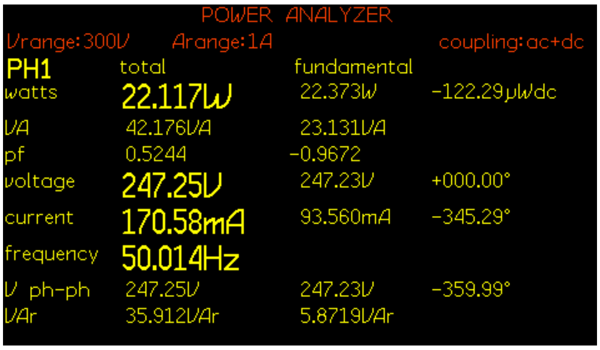
⚠ **WARNING.** The BNC safety connections (Item 1), A_{EXT} & V_{EXT} must be connected with touch proof safety BNC leads as these can carry dangerous levels of current.

PPA3500 Numeric key functions

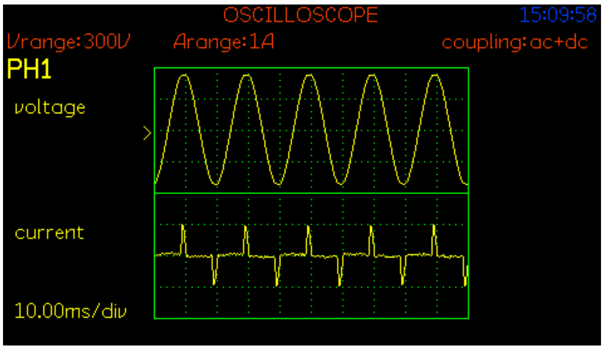
Key & Sub Categories	Description
ACQU	Acquisition Control: Used for configuring inputs appropriate to source and nature of signals being analyzed
Grouping:	Select appropriate Phase Grouping configuration for measurement analysis to be displayed
1+2+3 : 4+5+6	Selecting this grouping allows the user to configure the PPA3560 as 2 x 3 Phase Power Analyzers with complete configuration separate to each other
1+2+3+4	4 Phase Power Analyzer Mode. Configuration of instruments parameters will affect all 4 phases simultaneously. Independent ranging can be "enabled" which will allow the range configuration of each Phase individually
1+2+3+4+5	5 Phase Power Analyzer Mode. Configuration of instruments parameters will affect all 5 phases simultaneously. Independent ranging can be "enabled" which will allow the range configuration of each Phase individually
1+2+3+4+5+6	6 Phase Power Analyzer Mode. Configuration of instruments parameters will affect all 6 phases simultaneously. Independent ranging can be "enabled" which will allow the configuration of each Phase individually
1+2+3 : 1+2+3	Selecting this grouping allows the user to configure the PPA3560 as 2 x 3 Phase Power Analyzers, allowing different functions to be viewed on any phase simultaneously.
Wiring:	Select appropriate wiring configuration for measurement analysis to be displayed. Wiring is only available for two groupings:- 1+2+3:4+5+6 & 1+2+3:1+2+3
Display Screen 1	**Grouping set to 1+2+3 : 4+5+6**
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
Display Screen 2	**Grouping set to 1+2+3 : 4+5+6**
Single Phase 4	In single phase 4 configuration, (phase 5 & phase 6) 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 5	In single phase 5 mode, (phase 4 & phase 6) inputs are disabled and the selected phase acts as a completely independent single phase power analyzer
Single Phase 6	In single phase 6 mode, (phase 4 & phase 5) inputs are disabled and the selected phase acts as a completely independent single phase power analyzer
3 Phase 2 Wattmeter + PH6	As above (3 phase, 2 wattmeter) but with the option to use PH6 as an independent meter i.e., use PH6 to measure a DC bus plus Phase's 4 & 5 to measure a 3 phase inverter output. PH6 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 PH6

Group 1	Selecting Group 1 will allow the user to display a secondary set of measurements or scope screen from any phase configured within display screen 1, for example screen 1 can display all power measurements for PH1 whilst screen 2 displays the input signal of the same phase via the scope menu, as shown within the screenshots below.



Display Screen 1



Display Screen 2

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 selected then any computed results of 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

Frequency Reference	The frequency may be measured from either of the inputs:
Voltage	Select Voltage to detect frequency from the input voltage
Current	Select Current to detect frequency from the input current

Frequency Reference	This second frequency reference is only applicable for two groupings:- 1+2+3:4+5+6 & 1+2+3:1+2+3 On a multi-phase instrument, any channel may be selected for the frequency measurement
Display Screen 1	
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
Display Screen 2	
Phase 4	Select this option to detect frequency from phase 4
Phase 5	Select this option to detect frequency from phase 5
Phase 6	Select this option to detect frequency from phase 6

Phase Angle Reference	Phase angle measurements must be made with reference to a specific input
Voltage	For display screen 1, Phase 1 voltage is by default set as the input reference channel. For display screen 2, Phase 4 voltage is by default set as the input reference channel.
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 low pass filter 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
Fundamental >1kHz	Select for Fundamental Frequencies above 1kHz
Fundamental <1kHz	Select for Fundamental Frequencies below 1kHz

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

Wiring configuration

In the single phase modes the other phase inputs are completely ignored and the selected phase acts as a completely independent single phase power analyser.

In the 3 phase 2 wattmeter configuration, the voltages are measured relative to phase 3. 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 synthesised phase 3 current.

The advantage of this connection method is that 3 phase power can be measured with only 2 wattmeters. This frees up phase 3 of a 3 phase instrument to simultaneously measure the power of a single phase input (3 phase 2 wattmeter + phase 3 configuration). This allows direct measurement of efficiency in a 3 phase motor drive or 3 phase inverter application. The frequency reference for the independent phase 3 may be selected to be voltage or current. In this mode, frequencies up to 1kHz can be measured with phase 3.

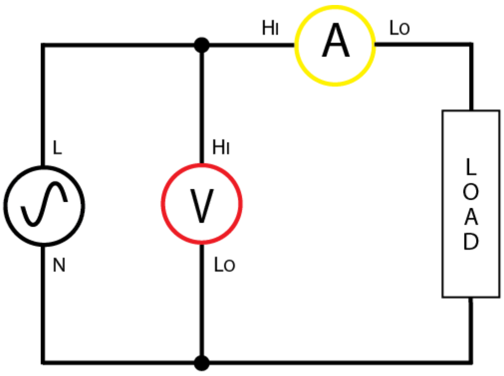
With the 3 phase 3 wattmeter configuration, each measurement phase is connected to a phase of the load with the voltage inputs measuring to neutral. In this mode, phase to neutral voltages are measured directly and phase to phase voltages are also computed.

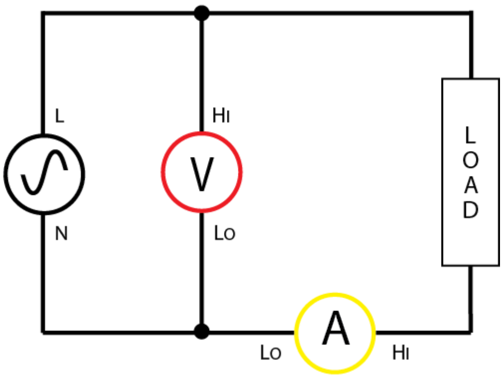
The instrument includes Star–Delta Type A and Star–Delta Type B options in the Power Analyzer mode menu options.

The wiring configuration is the first item to be selected under the ACQU menu.

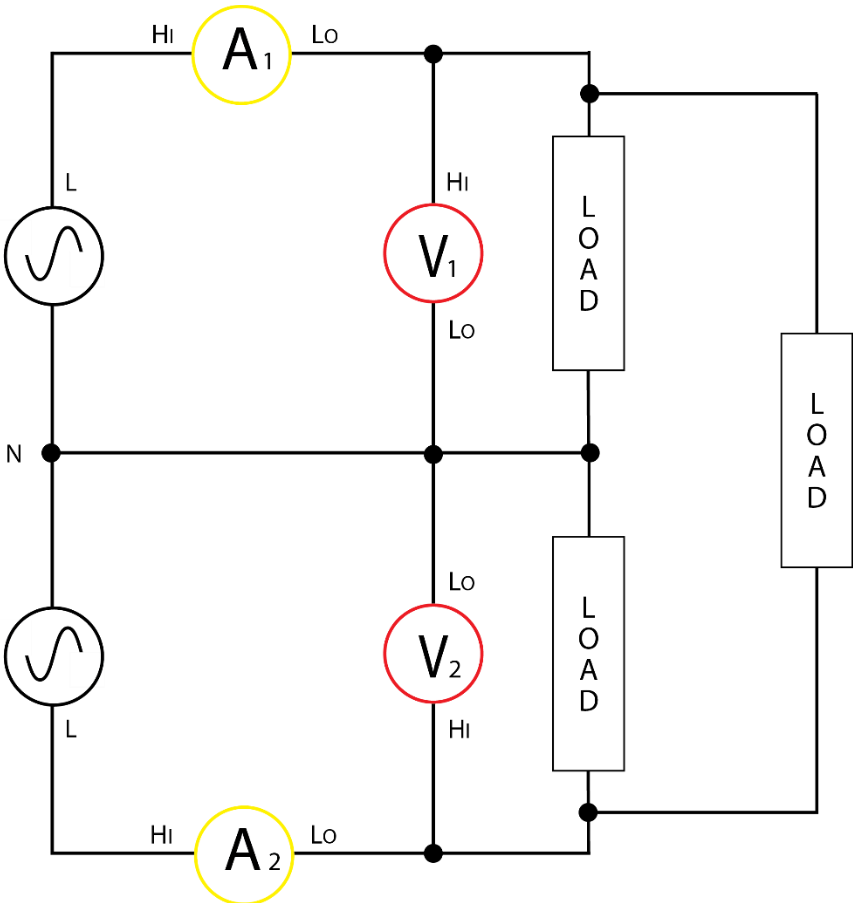
Wiring diagrams

Single Phase

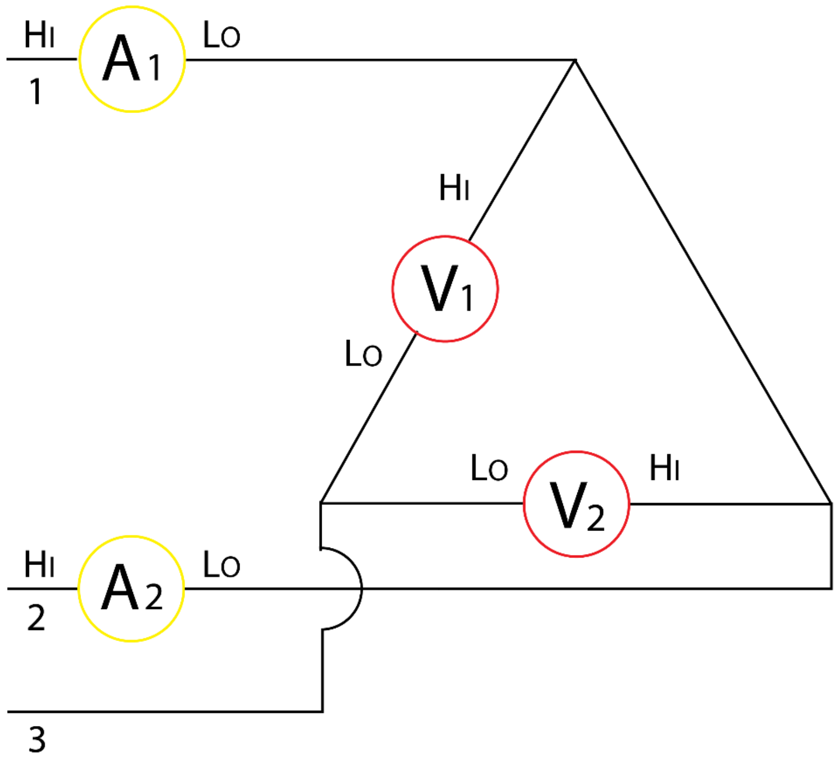




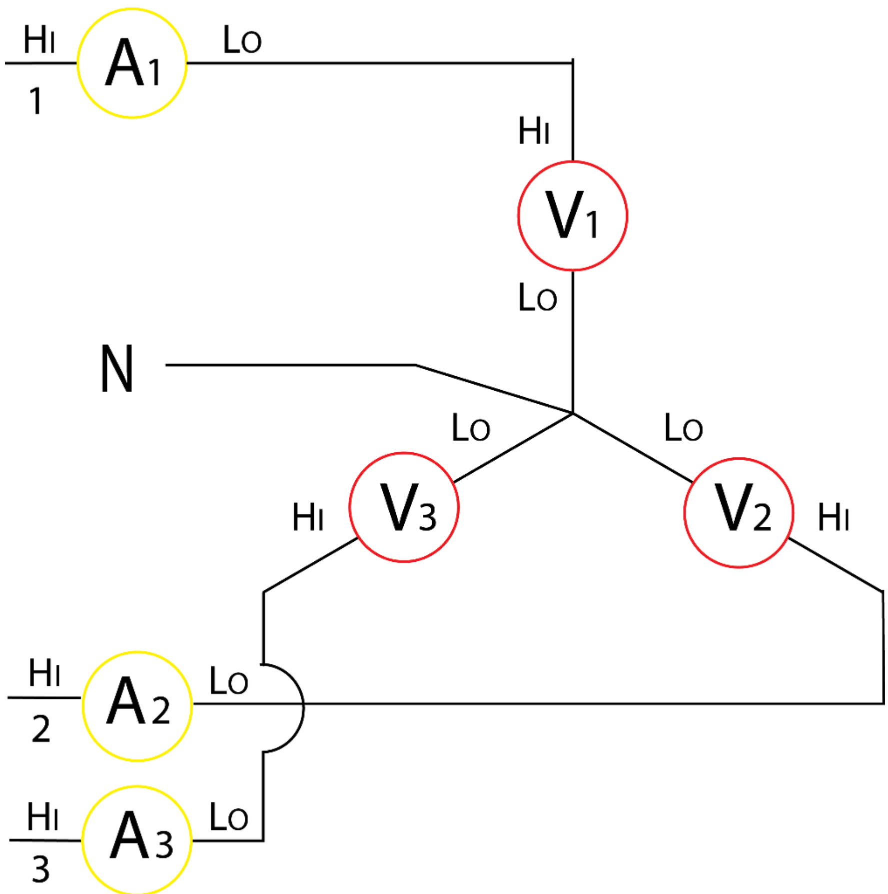
Two Phase Two Wattmeter



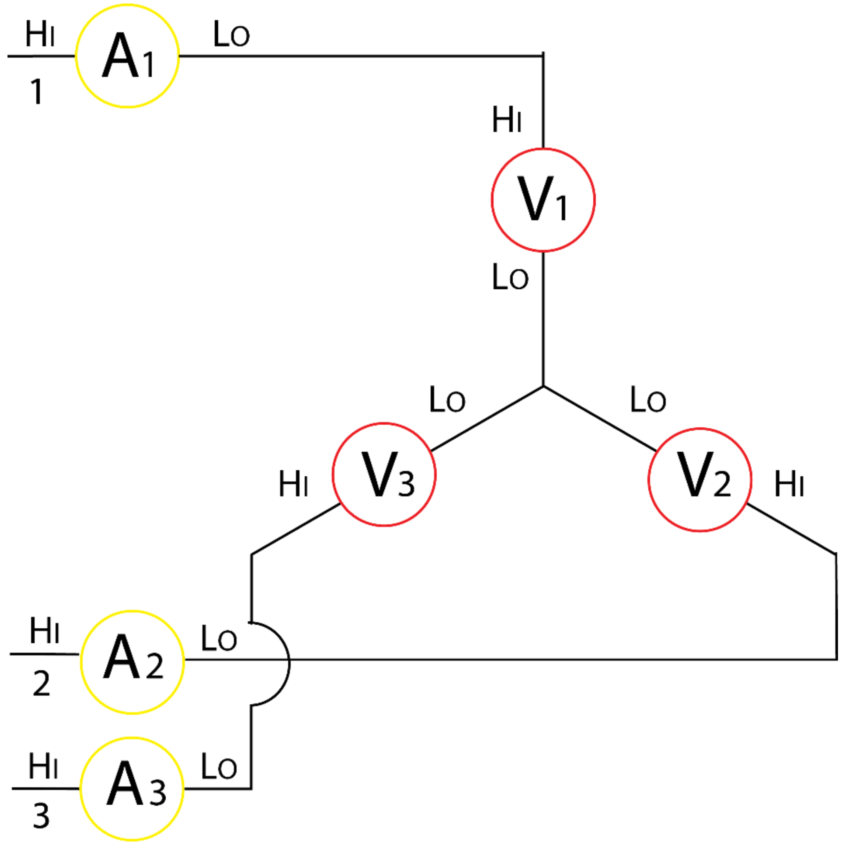
Three Phase Two Wattmeter Delta connection



Three Phase Three Wattmeter - Star connection



Three Phase Three Wattmeter – Simulated neutral – 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.

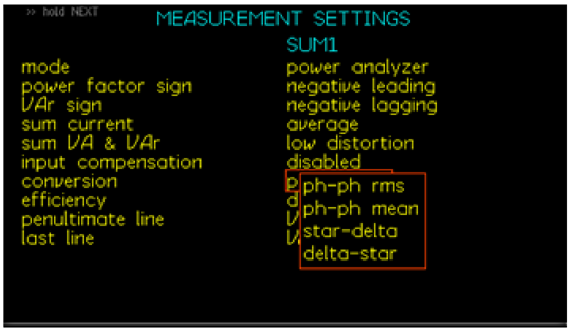
Instrument wiring

Please refer to Appendix F 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.

Selecting an incorrect conversion option with respect to the actual wiring configuration used will result in incorrect computations being performed. Negative values can be expected in 3 phase 2 Wattmeter mode but can be displayed in other wiring modes should an incorrect conversion option be selected.

INFORMATION. Select Delta-Star for Delta wiring configurations and select Star-Delta for Star wiring configurations.

ADVANCED OPTIONS	
Name	This is user editable in the same way as User Data, the default is SUM1
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	Manually set a minimum frequency for analysis detection. Default setting is 500mHz (Range =10mHz – 500Hz)
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	Signed parameter
Absolute	Watts magnitude typically used for power integration
Synchronise Window	
Enabled	Updates at fastest of the two window speeds
Disabled	Updates at slowest of the two window speeds
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.

COUPLING

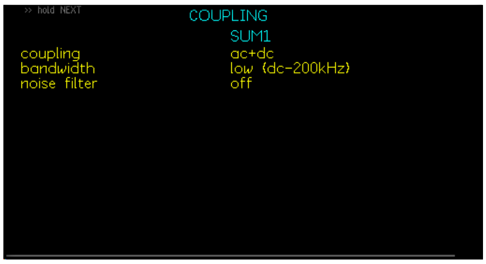
Coupling	There are three coupling options - AC only, AC+DC, or DC only. AC+DC coupling is the default option and should be used where possible. AC coupling should be used for measuring signals that are biased on a DC level (such as an amplifier operating on a single supply or the output of a DC PSU). 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 DC 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.

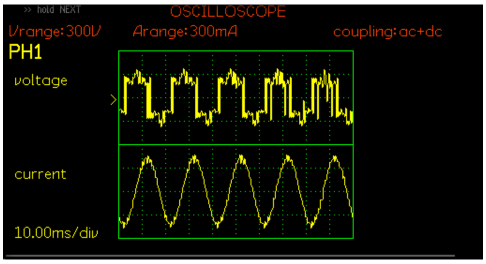
Bandwidth	The bandwidth setting dictates the frequency range of the instrument. This selection sets an inline analogue filter as per the selection

Coupling set to: ac+dc	
Wide (DC – 1MHz)	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
Coupling set to: ac	
Wide (5Hz - 1MHz)	See previous sub-section
Low (5Hz - 200KHz)	See previous sub-section
Coupling set to: dc	
Wide (DC - 1MHz)	See previous sub-section
Low (DC - 200KHz)	See previous sub-section

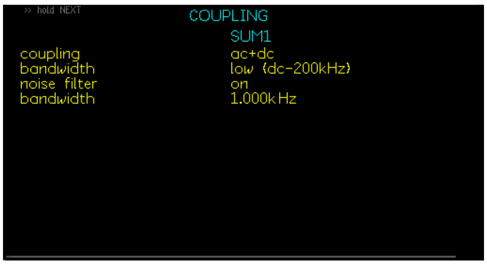
Noise Filter	In signal processing, a “FILTER” is a device or process that removes from a signal some unwanted component or feature. The noise filter is a digitally selectable in line filter which will alter the bandwidth of the processed signal
Off	Select to switch this mode off
On	Select to switch this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

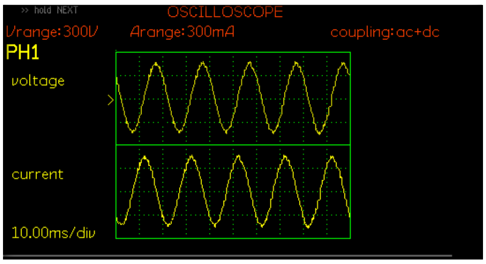
The following screenshots are taken from the “Scope” display with the PPA set in PWM application mode.





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" key 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
100mV	Minimum Input Voltage range will not be below 100mV
300mV	Minimum Input Voltage range will not be below 300mV
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 (20A rms) or Standard (30A rms)
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

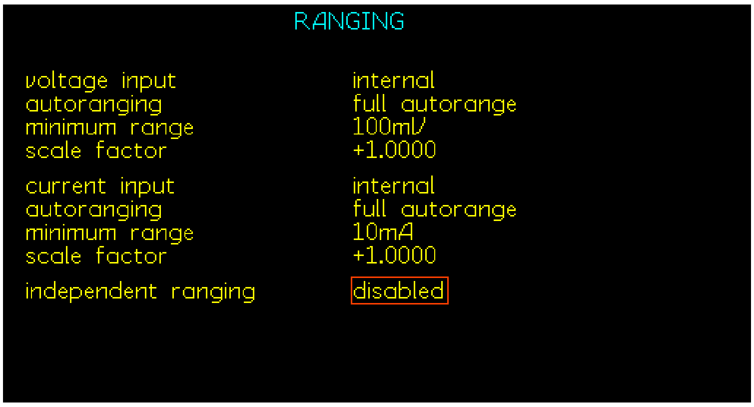
Autoranging	
Full Autorange	Default setting. Full autoranging will be selected and implemented within the instrument
Range up only	Selecting this option will allow the test being carried out to find the highest range via peak detection and hold on this range. Once this value has been found another test can be carried out by pressing the "Trigger" key which will restart from the minimum value for the 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

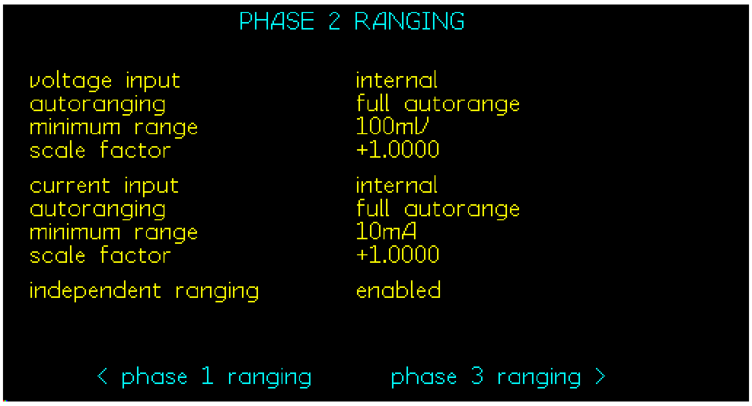
30mA LC, Std	Minimum Input Current range will not be below 30mA
100mA LC, Std	Minimum Input Current range will not be below 100mA
300mA LC, Std	Minimum Input Current range will not be below 300mA
1A LC, Std	Minimum Input Current range will not be below 1A
3A LC, Std	Minimum Input Current range will not be below 3A
10A LC, Std	Minimum Input Current range will not be below 10A
30A LC, Std	Minimum Input Current range will not be below 30A
100A LC, Std	Minimum Input Current range will not be below 100A
300A LC, Std	Minimum Input Current range will not be below 300A
1000A Std Version Only	Minimum Input Current range will not be below 1000A

Scale Factor	Manually set the scale factor as required

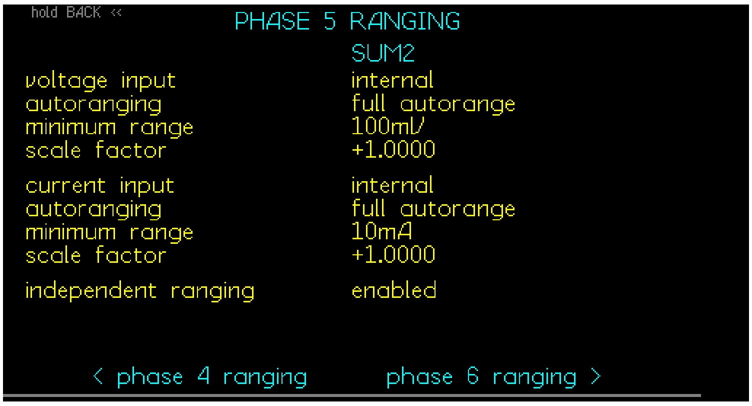
Independent Ranging	Enabling this parameter allows the user to select a different range menu for each individual Phase



Once independent ranging has been enabled, the display will change from Ranging to Phase 2 Ranging.



By using the ◄ & ► keys, the menu can be switched between phases in any single group.



Similarly, by changing the active screen to screen 2 (RHS) and enabling independent ranging, the
◄ & ► keys will switch between phases 4, 5, & 6 as shown here.

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	Utilises 500MB internal Flash 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 the 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

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. Default setting is 500mHz

Torque + Speed	Power Measurement function can be set to disabled or enable to measure the desired function from analogue torque & speed, pulsed speed & analogue torque, pulsed torque & analogue speed, or pulsed torque and speed. Once enabled, a scale factor and offset will require setting in relation to either Voltage or Frequency
Efficiency	Efficiency can be measured between selected channels from the drop down menu choices.

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 is 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
AC Line	Manually set the AC input line for frequency detection
Frequency Tracking	Selectable tracking speed from drop down menu
Efficiency (Only available with the following wiring choices: 1+2+3:4+5+6 or 1+2+3:1+2+3)	Efficiency can be measured between selected channels from the drop down menu Disabled, next phase / phase, phase / next phase, group 2 / group 1, group 1 / group 2, 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
Default Settings	All default parameters will be selected when *ENTER* is pressed
Rectified Mean	This can be set to absolute or normalised

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 occurs
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 by highlighting and pressing *ENTER*
Default DC Settings	Select to calibrate DC by highlighting and pressing *ENTER*

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

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

Alarm Function

The PPA3500 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.

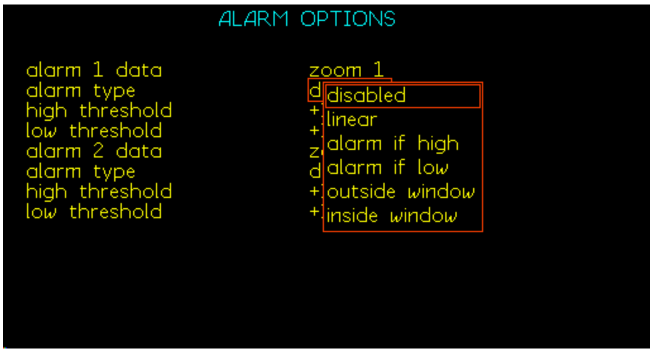
Additionally, one of the alarms (alarm 1) can be used to generate a sound which varies linearly between two user defined thresholds.

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

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

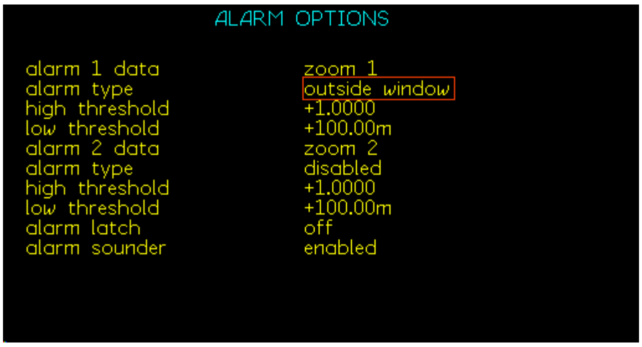
To program an alarm, first select the functions for the zoom; up to four measurements can be selected for the display, the alarm can be applied to any of them; then press *ALARM* to invoke the ***alarm options*** menu



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 displays the 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 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, set alarm type to ***disabled***.

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.

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 (Baud rate set to 19200)
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
USB Memory Stick	Print display screen directly onto USB memory stick
RS232 (DPU-414)	Print screen via RS232 Cable to dpu-414 thermal printer
RS232 (DPU-D2)	Print screen via RS232 Cable to DPU-D2 thermal printer

AUX	
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. It accurately synchronises to the line input, measures the frequency and switches on the output at a precise phase angle selected from the instruments front panel. Useful for testing inrush current of ballasts
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
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
Phase angle Reference	
Cosine	
Sine	

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 1-4 Direct Load	Program 1-4 may be recalled with a direct press of the function keys (POWER, HARM 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
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 Calibration	Instruments last calibration date

► User Data	
Supervisor Access	Enable or Disable
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	
True RMS Voltmeter	The RMS voltmeter displays the additional secondary parameters of AC, crest factor, surge, rectified mean and peak
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
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	In the HARM mode the PPA will compute multiple DFT's on the Input waveform in real time
Oscilloscope	The PPA provides a storage oscilloscope function in order to view the waveforms being measured

PROG	
Memory	Program Store / Recall Options of the different data types
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 (instrument settings)
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	99 selectable locations for data to be stored, recalled, or deleted from

Name	Allows user to name data within location

Execute	Press to execute any change made to any parameter within "PROG" mode

Memory Status	Status of memory in either Internal or USB configuration

Program Files	Number of stored program files in each type of memory

Results files	Number of stored results files in each type of memory

Datalog files	Status of memory in either Internal or USB configuration

Free space	Status of memory in either Internal or USB configuration

Program store and recall

There are 99 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.

Program number 1 (if not empty) is loaded when the instrument is powered on so that the PPA3500 can be set to a user defined state whenever it is switched on.

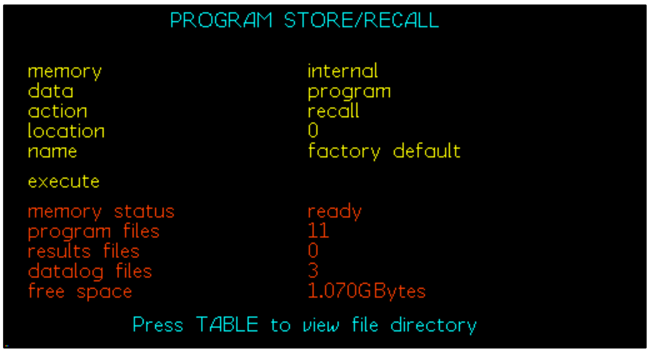
This is particularly useful to set system options such as phase convention, GPIB address etc. If no settings have been stored in program 1 then the factory default settings are loaded (program number 0).

Program numbers 1-4 may be recalled with a single press of the Application Direct Access keys, if the direct load option is selected in the system

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 2-99, press the ▼ key twice to highlight ***action***, then press the ► key once to select ***store***.

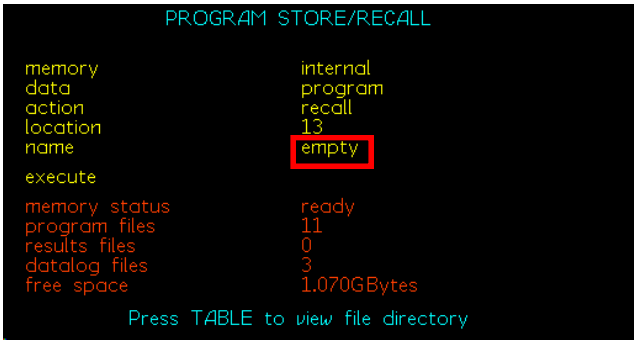
Now using the ▼ key highlight the program number and either step through the numbers with the ►&◄ keys or directly enter the number from the numeric keys, then press *HOME*.

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

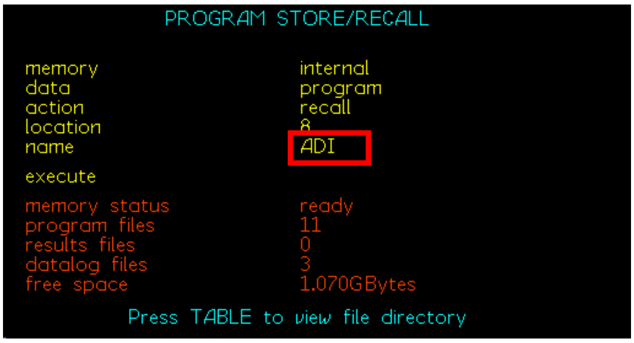
When storing a configuration in a program, there will be a slight pause (of about 1 second) if the program has previously been written or deleted. The process will be very quick if the location has not been used.

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

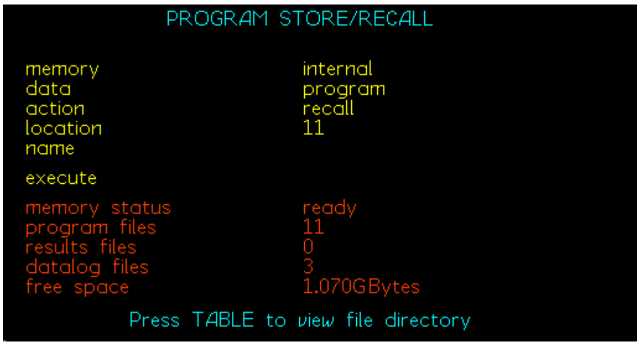
Scrolling through the numerical memory locations using the ► & ◄ keys it will be observed that against the field called ***name*** there can be 3 options., either ***empty*** *w*hich means that there is nothing stored in that location , or a name such as ***PWM TEST*** which shows that the location has 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 13is shown empty and can be used to store program settings.



In this case location 8 has a program stored called ADI this location can be used for storage, but it will be overwritten by the new saved program.

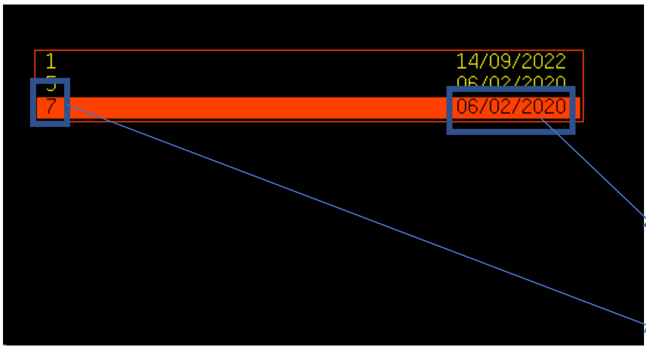


In this last instance, location 11 is not showing either the word empty or a program name. This infers that there is a program stored in this location, but it was saved without a name. As previously it can be overwritten with a new program.

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 are three entries in this instance.

The date the program / results / or datalog were saved.

The memory position or "slot" number 2-999

Results store and recall

Each of the 99 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: -

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

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”

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 or 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 also put the display screen into hold mode
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

HARM	Direct key to Harmonic Analyzer mode functions

RMS	Direct key to True RMS Voltmeter 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

Guide for testing the basic functionality of the instrument.

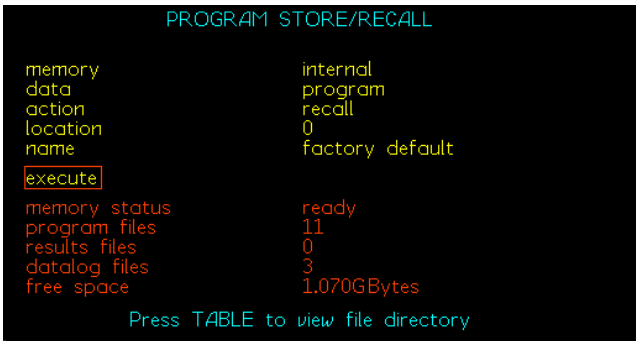
This section of the manual provides instructions on how to test the basic functionality of your Precision Power Analyzer to ensure it has a basic level of functionality; this should be used as a pre cursor to any further fault investigations. Details are provided of the instrument setup, the required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

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.

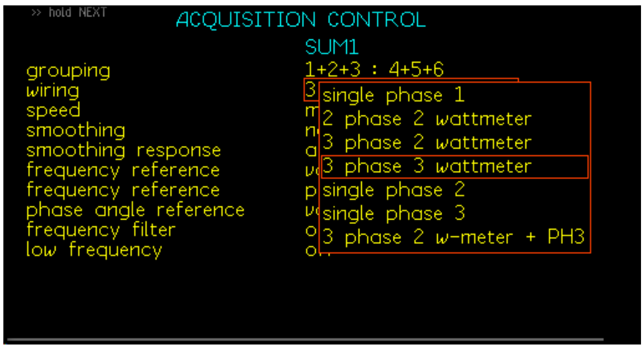
To access Program Store / Recall mode:



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.

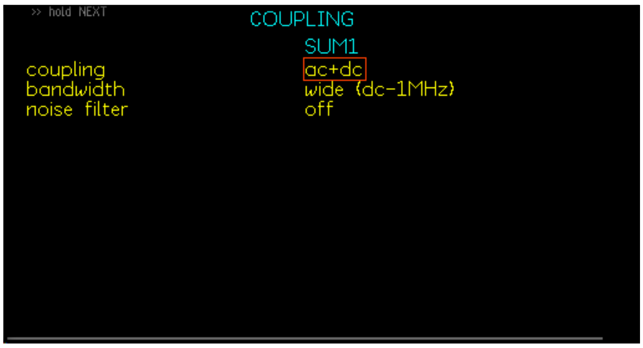
Setting up PPA3500 for external BNC functionality Check.

Acquisition control.



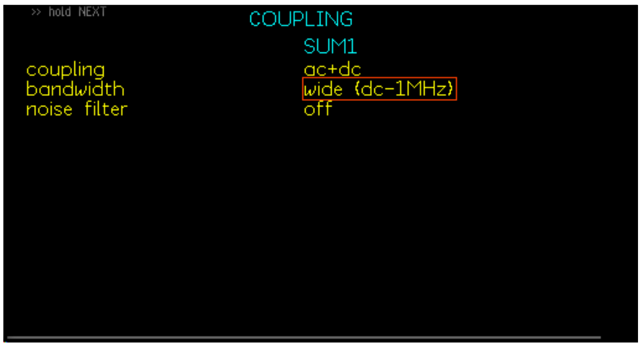
Press *ACQU* key, then press the ▼ key until the Red Box surrounds the ***wiring*** options. Use the ▼&▲ keys to select ***3 phase 3 wattmeter*** from the list, then press *Enter*.

Coupling



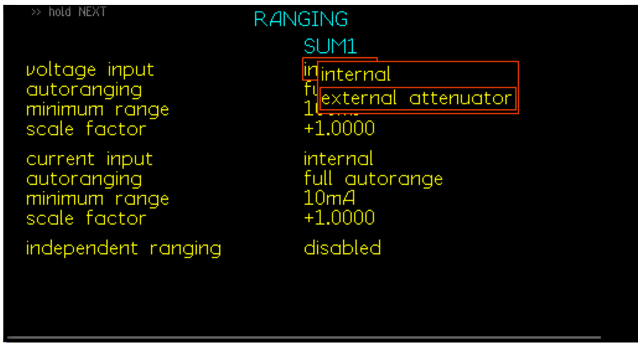
Press *COUPLING* key

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



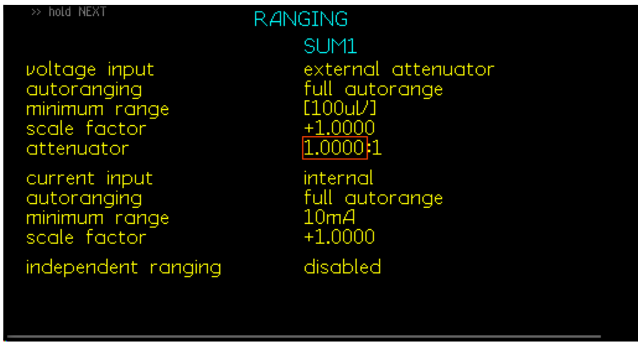
Press the ▼ key until the Red Box surrounds the ***bandwidth*** options. Use the ▼&▲ keys to select ***wide (DC-1MHz)*** from the list.

Ranging



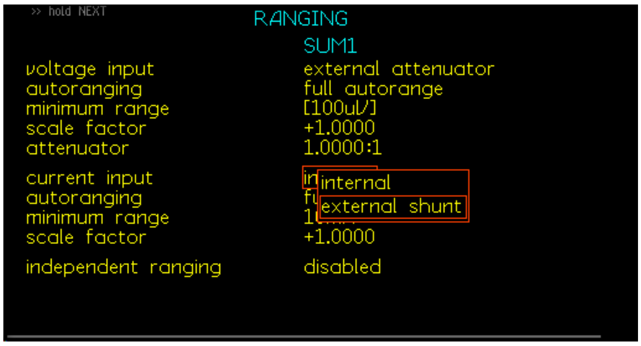
Press *RANGE* key press the ▼key until the Red Box surrounds the *Voltage input* options.

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



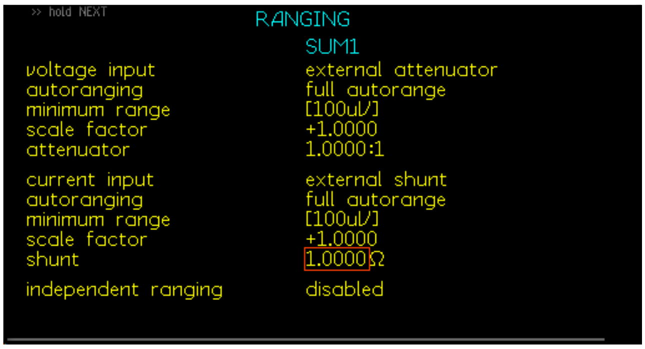
Press the ▼key until the Red Box surrounds the *attenuator* options.

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.

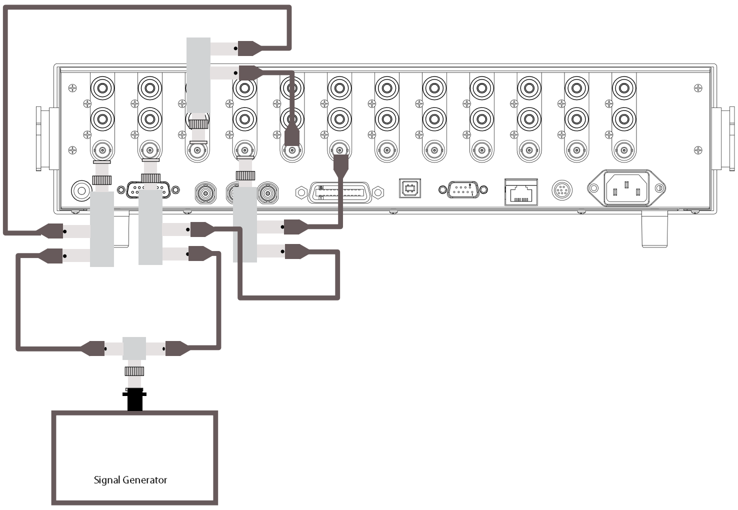
To make the connections shown in the diagram you will need the following accessories that are not supplied with the PPA.

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

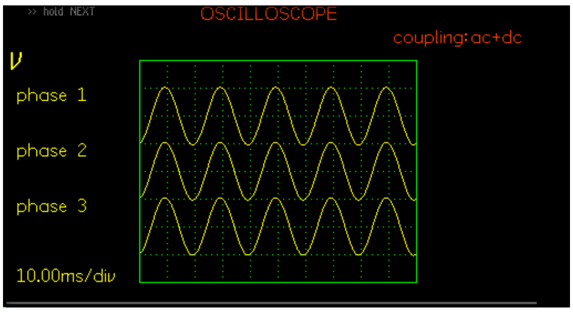
x BNC cables to connect between the PPA and the signal generator.

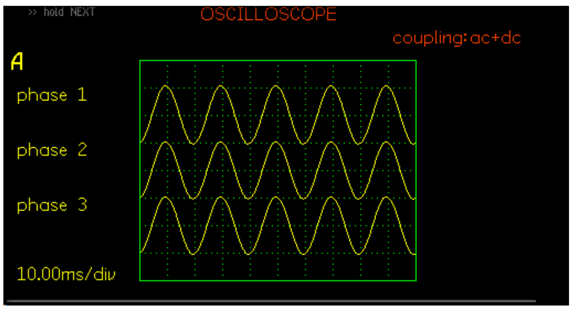
5 x BNC “T” or “F” piece connectors.

Connection diagram for the functionality checks of the External BNC inputs



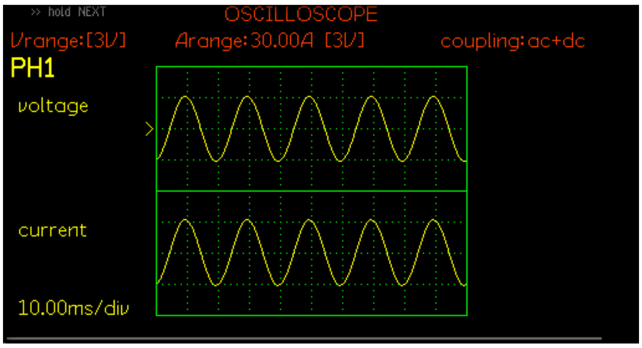
Screenshots of PPA Display when making “external” measurements.
Oscilloscope Mode





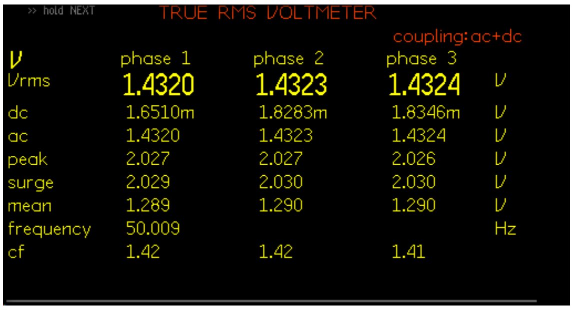
The above screenshots of the scope mode display current and voltage for all 3 phase inputs. Use the *ENTER/►►* key to scroll through the various oscilloscope displays.

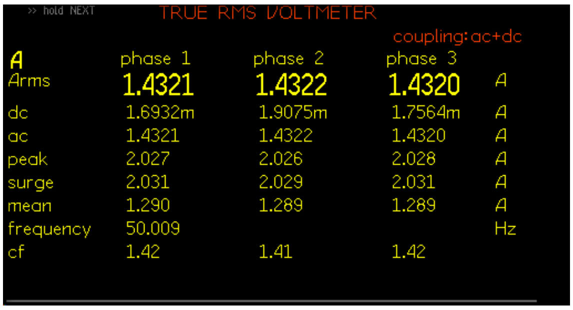
The screenshot below shows current and voltage for phase 1 only. Comparisons can be made of current and voltage on all 3 phase inputs. There should be zero phase shift and equal magnitude on both traces.

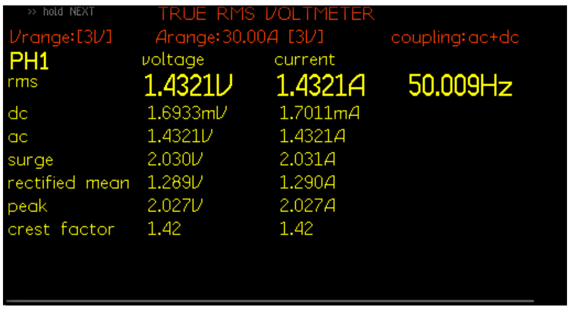


True RMS Voltmeter Mode

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.



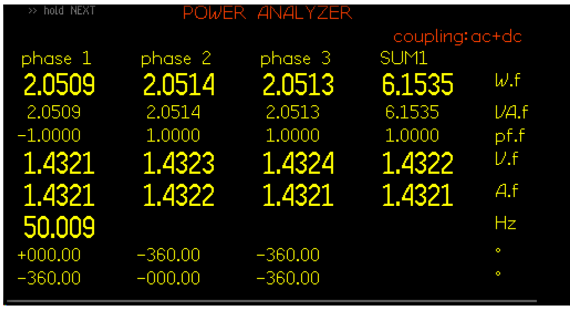


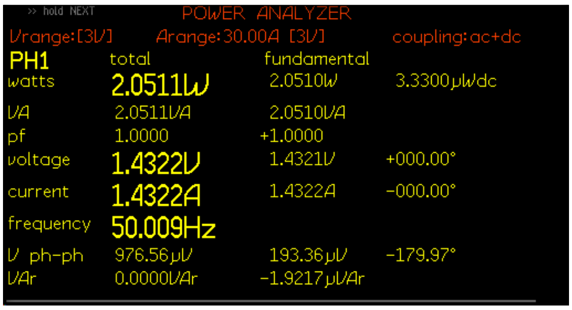


In this screenshot we are looking at just one phase, in this example phase 1. The instrument is displaying both the voltage and current readings for the one phase only. It is also possible to scroll through the various true RMS voltmeter displays to view similar results for phases 2 or 3.

Power Analyzer Mode

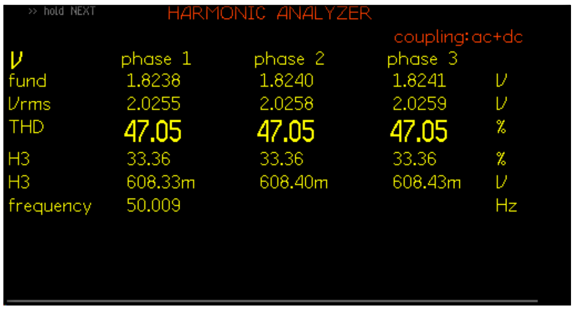
The screenshots below are of the instrument in Power Analyzer mode. The screenshot on the left is displaying the results for all 3 phase inputs. The screenshot on the right is the results for phase 1 only. Comparison of current, power and voltage can be made on all 3 phases, and it is also possible to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

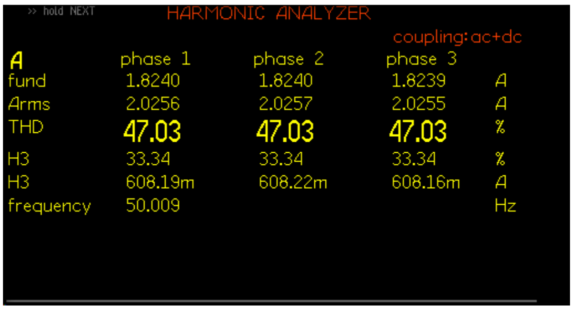




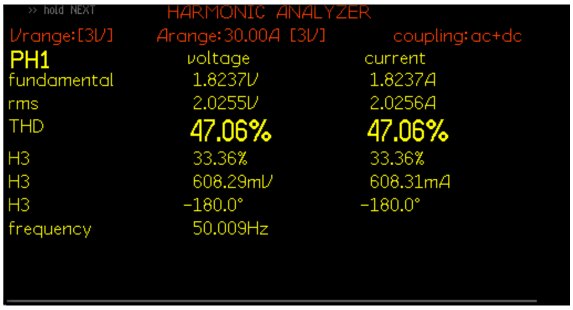
Harmonic Analyzer Mode

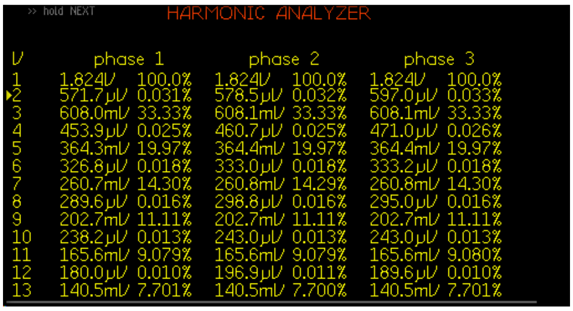
The signal generator is adjusted to provide a 1.00V PK, 50Hz square wave to check the frequency detection function of the PPA. Harmonic Analyzer mode is utilised, and correct harmonic magnitudes are displayed providing the fundamental frequency of the waveform is correctly detected.





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.





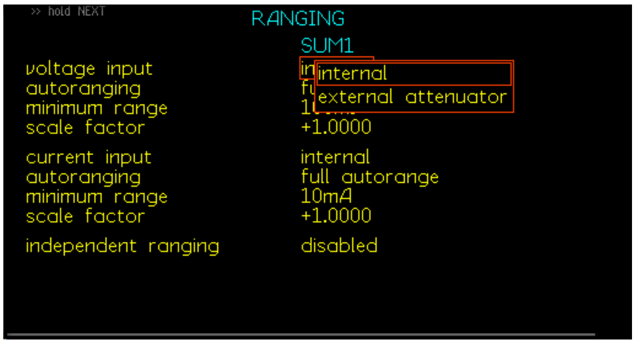
We have used a square wave as the harmonics of this waveform are well known, it is advisable to compare the harmonic values in the displayed table and ensure they are nominally the same as the table below.

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 %

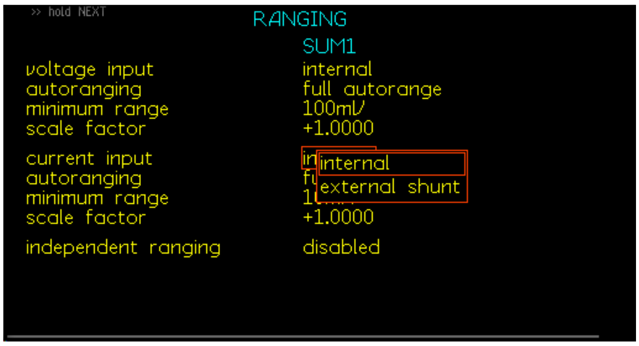
Setting up PPA for “internal” measurements.

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 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.

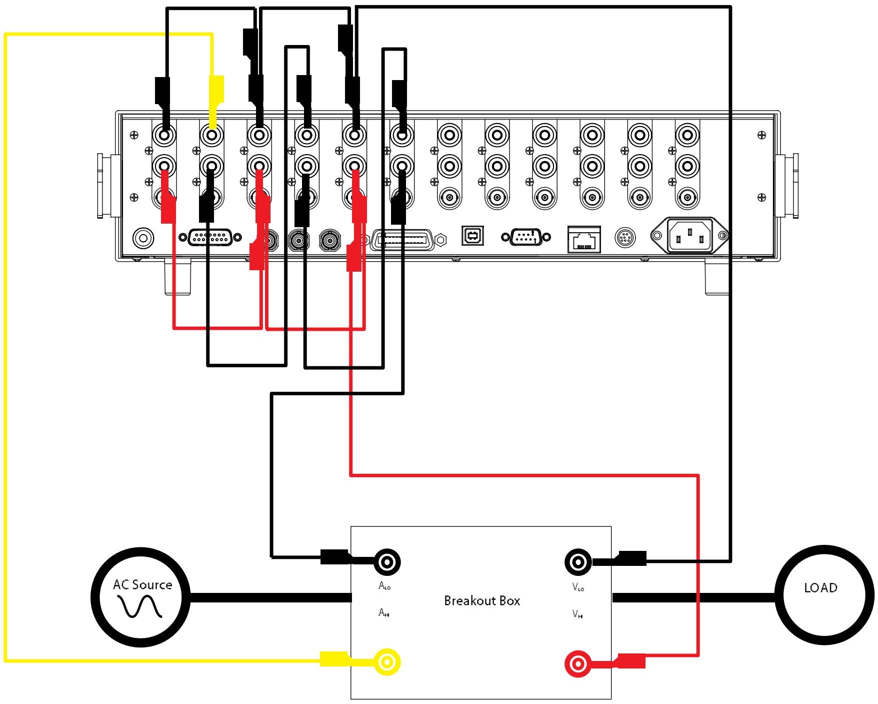
To make the connections shown in the diagram you will need the following accessories that are not supplied with the PPA.

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.

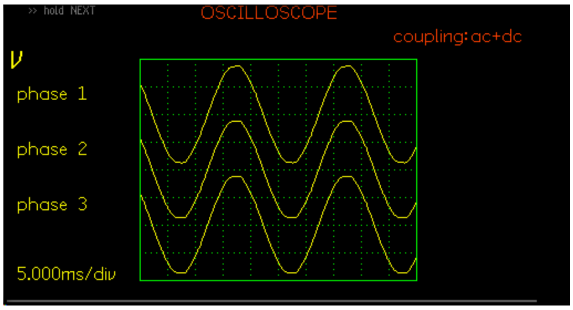
Connection diagram for the functionality checks of the Internal 4mm sockets inputs.

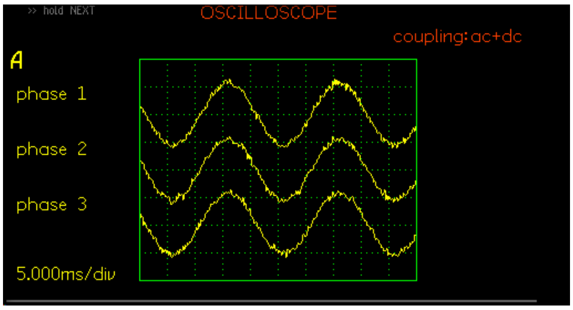


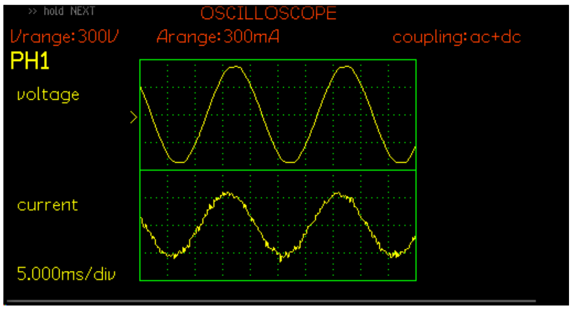
Screenshots of PPA Display when making “internal” measurements.

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.

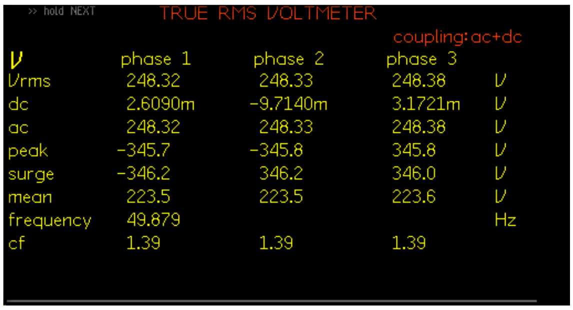
Oscilloscope Mode

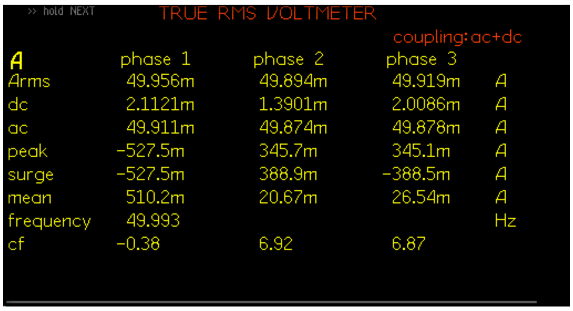


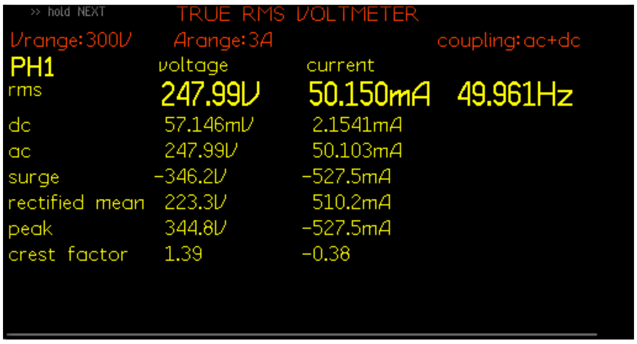




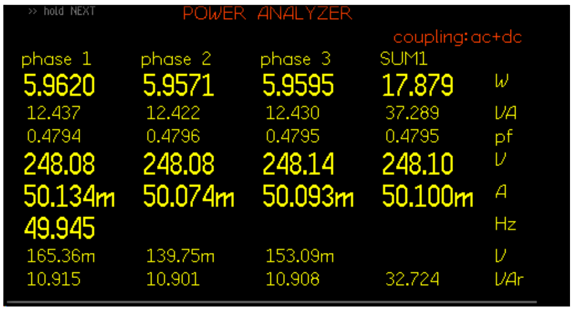
True RMS Voltmeter Mode

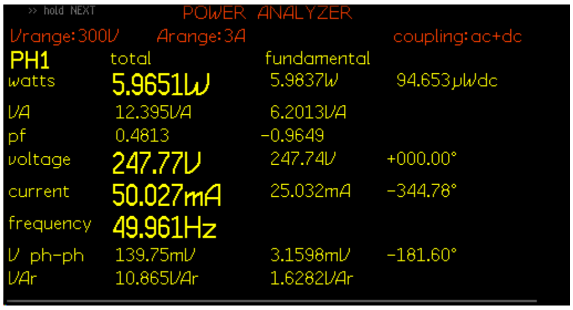




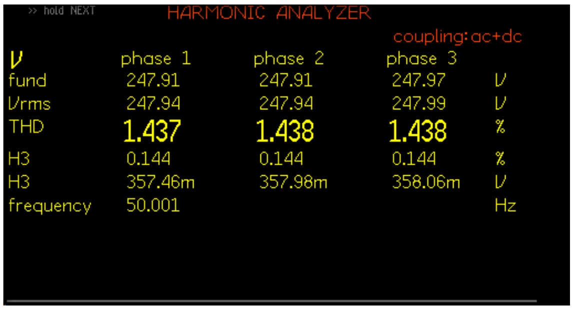


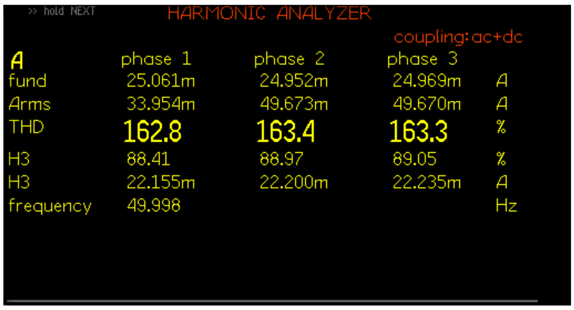
Power Analyzer Mode

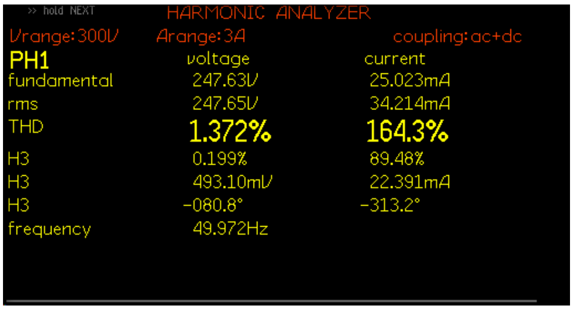




Harmonic Analyzer Mode







Harmonic verification

Verify that V_{thd} 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

Menus-how to use and navigate them.

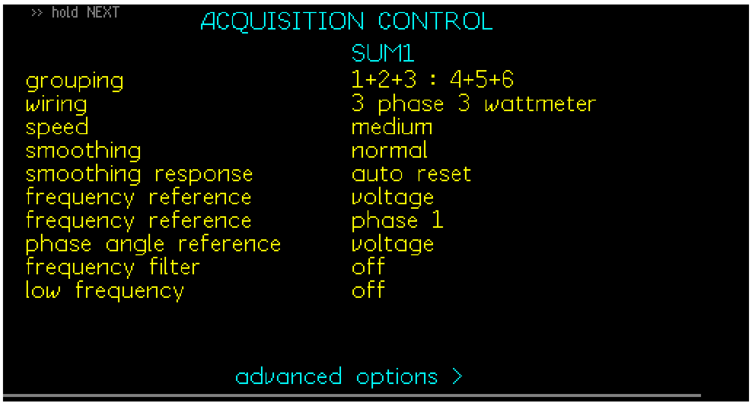
Main menus There are twelve main menu options available, these are labelled under each of the twelve numeric keys and are accessed by a single keypress. The PPA3500 Series can be configured for a wide range of application disciplines. Keys 1-9 on the alphanumeric keyboard, +/- and decimal point are used to access the menus to set up the PPA3500 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	

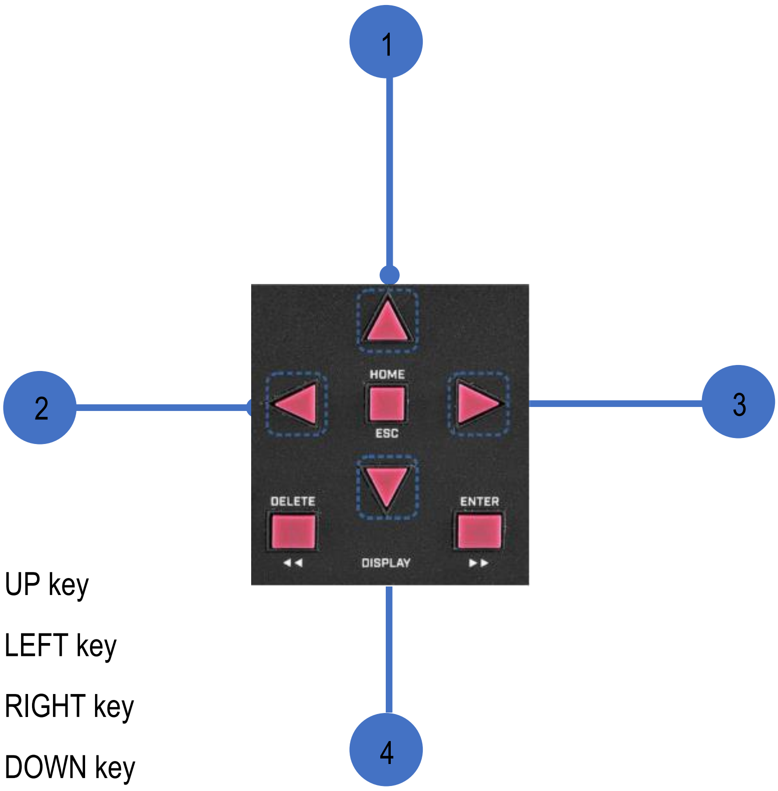
Selection from a list

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 red box



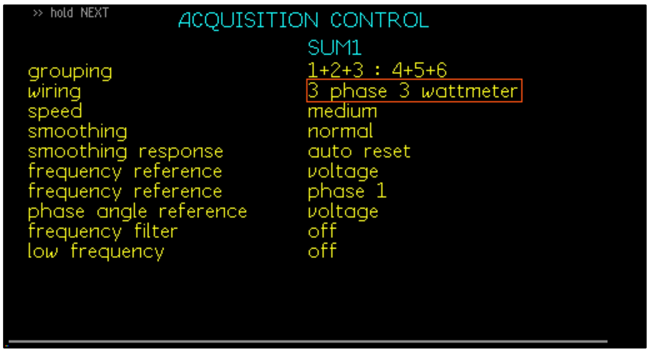
1 ▲UP key

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, ***wiring*** 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 ▲&▼ or ►&◄ 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 wiring selection list comprises the options:

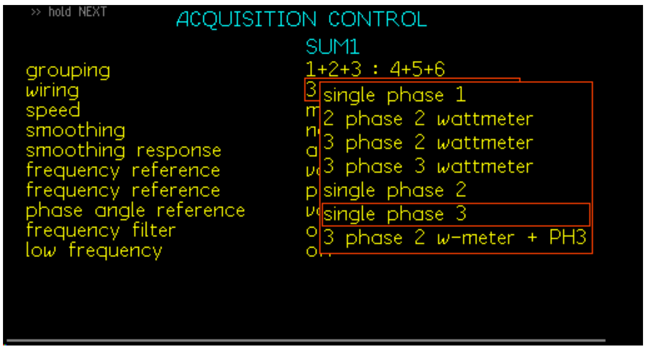
single phase 1	(item 0)
2 phase 2 wattmeter	(item 1)
3 phase 2 wattmeter	(item 2)
3 phase 3 wattmeter	(item 3)
single phase 2	(item 4)
single phase 3	(item 5)
3 phase 2 w-meter + PH3	(item 6)

and the presently selected option is ***3 phase 3 wattmeter***, there are 3 ways to select ***single phase 3***:

press ▼ twice followed by *Enter*

press ▲ five times followed by *Enter*

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



Direct numeric entry

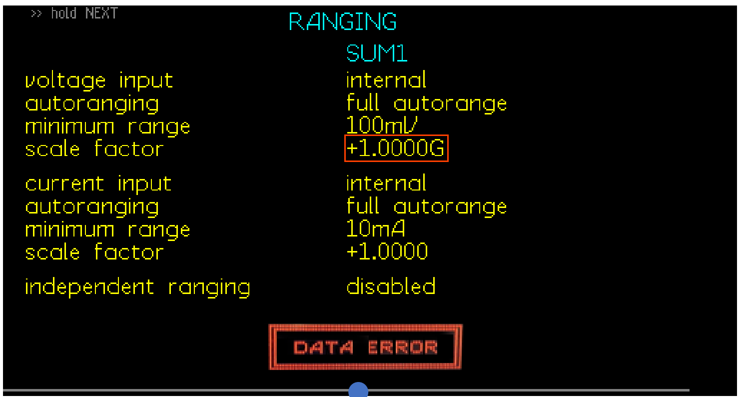
Parameters such as frequency and phase offset are entered as numeric characters; frequency is an example of an unsigned parameter; phase offset is an example of a signed parameter.

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

M, k, m, & µ) 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 scale factor; if a value over 1.0G is entered, a warning beep together with a message will be given, and the value set to the maximum of +1.000G as shown below.

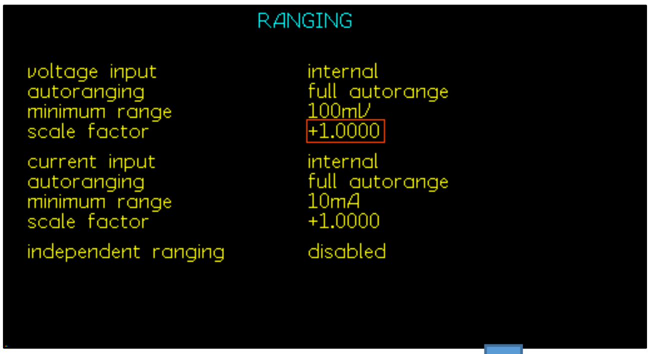


Data Error message is shown on screen for ≈ 3 seconds

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

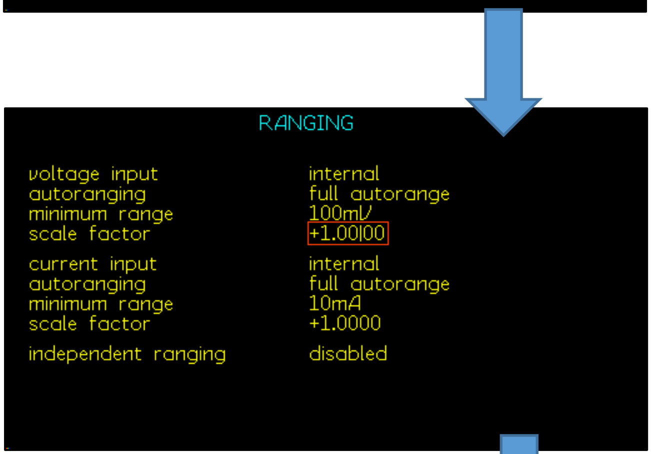
There are two types of numeric variables, those showing an integer value and those showing a decimal value.

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



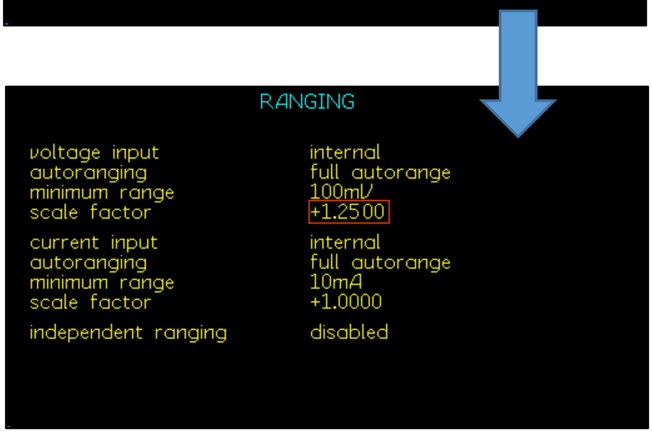
If you wanted to edit the value to be 1.2500 for example

Press ▶ x5 to display the cursor | as shown in the second screen shot



Press *DELETE* x2 to delete 2 numerals

Press 2 once, to insert a to the left of the cursor |



Press 5 to insert a 5 to the

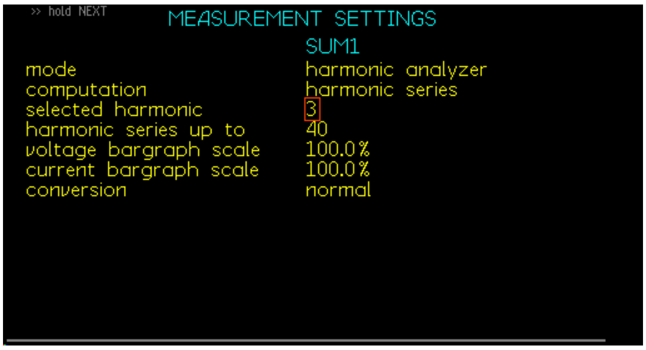
left of the cursor | Now press *ENTER* and now the value is saved for that parameter.

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 Harmonic mode *measurement settings* menu shown below



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.

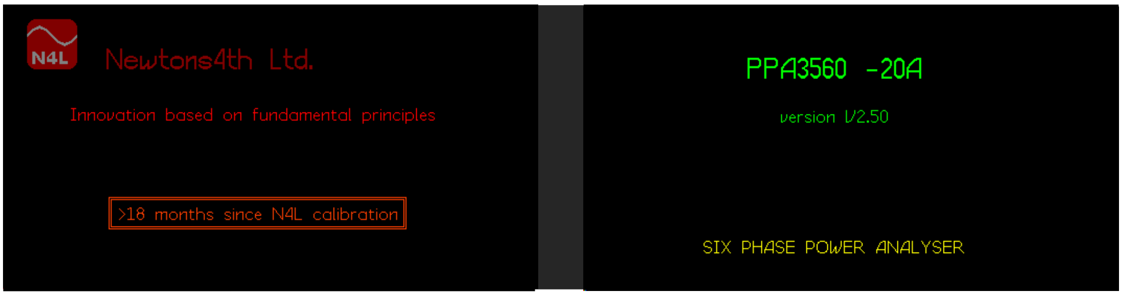
Text is entered by selecting one of 4 starting characters using the main function keys on the top right hand side of the keyboard (item 7), then stepping forwards or backwards through the alphabet with the ▲and ▼ keys.

The starting letters are A (*POWER*), I (*HARM*), O (*RMS*), or space (*SCOPE*). You can continue from any one of the starting letters backwards and forwards using the ▲and▼ keys to 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.

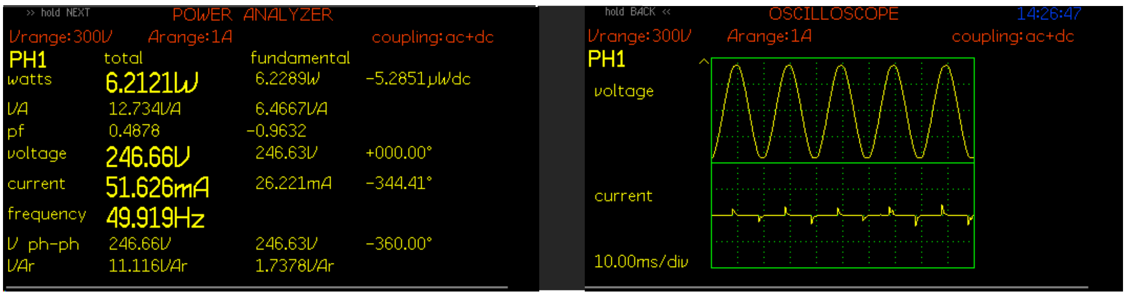
The editing keys, ►◄, *DELETE* and *ENTER* operate in the same way as for numeric entry.

User Data

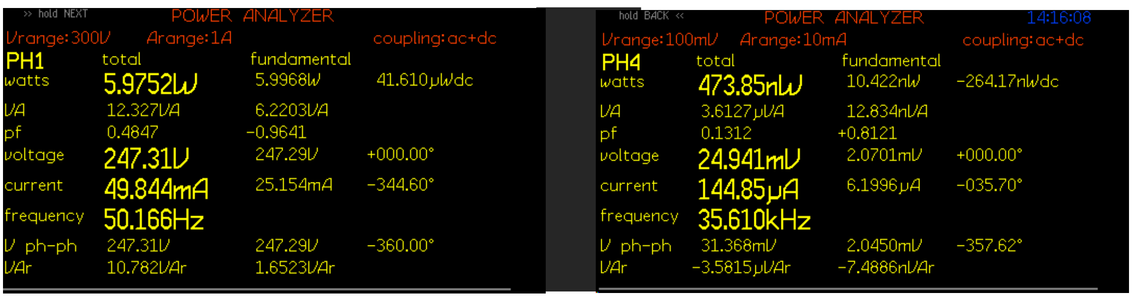
When the PPA3500 is first powered on, for approx. 4 seconds splash screens are shown, by default, Newtons4th Ltd. and Logo are displayed on the left screen, the instrument model, & firmware version will be displayed on the right screen. The left hand splash screen can be edited and personalised to your company details.



The splash screens then change to the default, real time Power Analyzer screens. By default the left hand screen is displaying phase 1 and the right hand screen phase 4, except on a PPA3530 which displays phase 1 real time, and the right hand screen displays the oscilloscope plot of phase 1 as shown below.

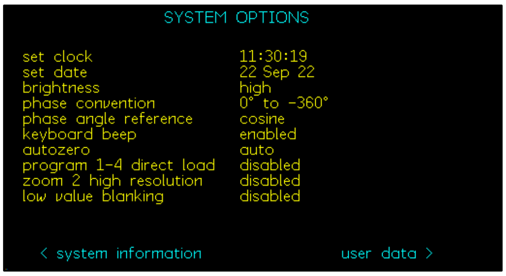


If other program settings have been saved into location 1 which loads on boot up, then the screens displayed after the splash screens may well be different to that shown above.

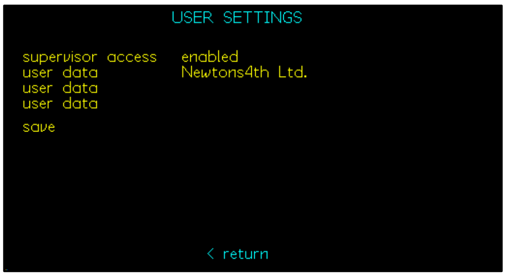


Editing the User Data

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

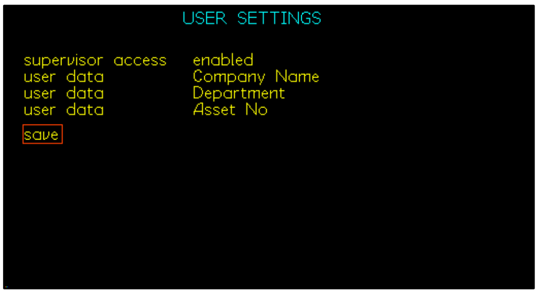


then



There are 3 lines of ***user data*** that can be edited to suit the user.

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 “Asset No”, however these can be edited by the user to read appropriately to your usage, i.e., “Asset No.” could be “operator” or similar.

Supervisor Mode

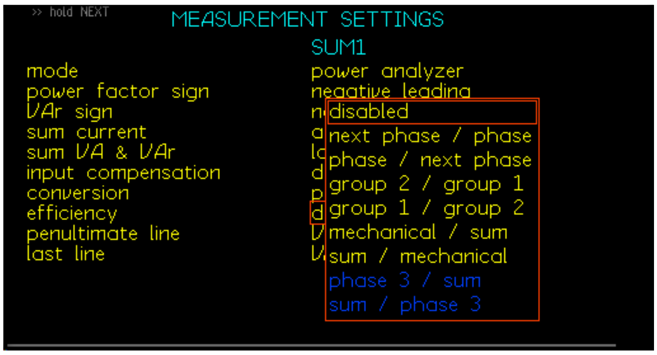
For use in a production environment where it is desirable that the operator cannot be able to change and save the settings, the PPA3500 offers supervisor mode. When supervisor mode is enabled, the stored programs can only be recalled, and not changed.

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.***

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.

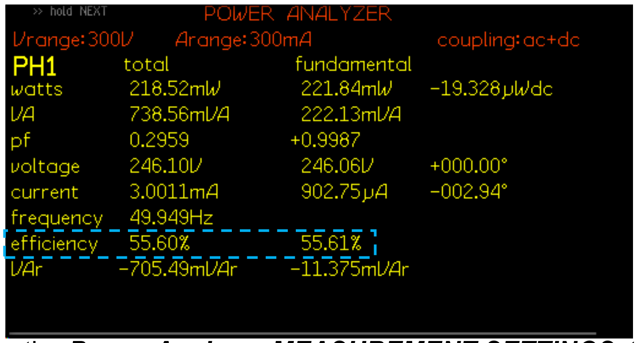
Access the Power Analyzer home screen and press *POWER* this will take you into a sub menu.

Scroll down to the ***efficiency*** parameter and press ► key, this will open the dropdown menu with all available configurations (yellow entries, blue signifies not available) as shown.

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

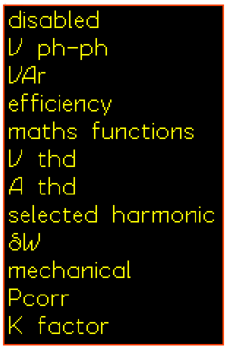
Press *HOME* to return to the Power Analyzer display screen.

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



Due to the number of parameters that need to be displayed in the power analyzer screen, the two bottom lines can be changed to display different parameters to the default Frequency and VAr.

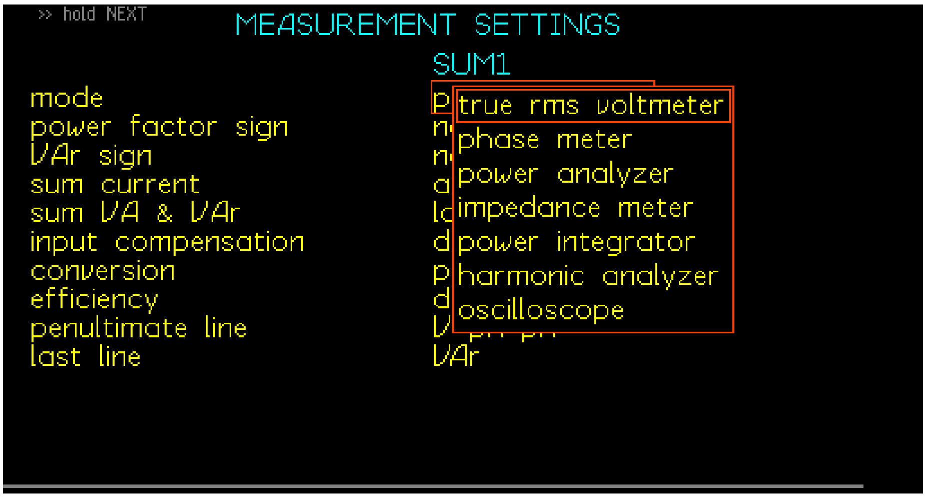
In the ***Power Analyzer MEASUREMENT SETTINGS*** the last two parameters are ***penultimate line*** and ***last line*** both of these lines can be changed to any of the following options.



Instrument modes

The PPA3500 Series has seven different modes available, these can be selected either via the Mode menu, or four of them are also accessible from the direct selection keys (see item 7) negating several key presses.

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:-

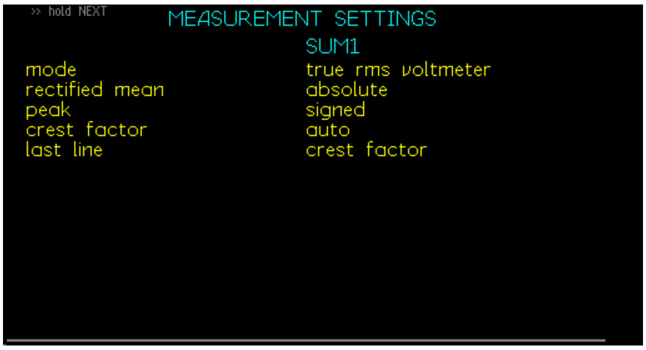
True RMS Voltmeter *
Phase Meter
Power Analyzer *
Impedance Meter
Power Integrator
Harmonic Analyzer*
Oscilloscope *

The entries above designated with an asterisk* are also available directly from the keys at the top right side of the keyboard, labelled POWER, HARM, RMS, and SCOPE.

True RMS Voltmeter

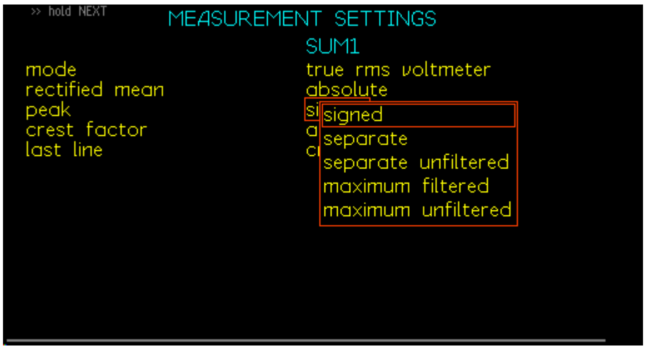
A typical application that would utilise True RMS Voltmeter would be for measuring the inrush current of a DUT with the aid of our PCIS accessory (see Appendix A)

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

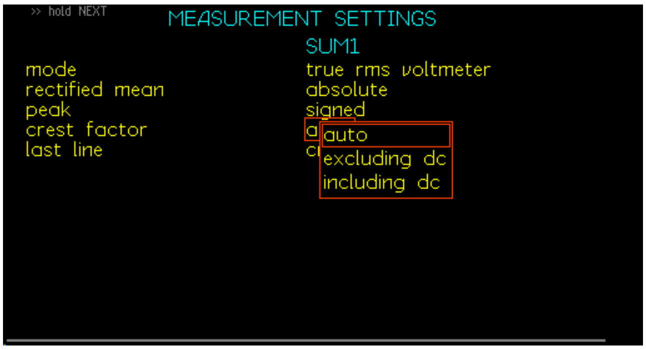


Rectified mean can be set to either ***normalised*** or ***absolute***

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 alters 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

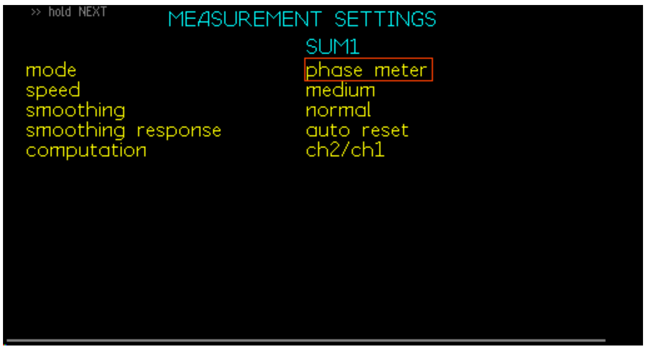
Excluding DC
cf= (positive peak - negative peak) / 2 * ac

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 left 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. ***Smoothing*** and ***smoothing response*** are also the same parameters that are available in the *ACQU* menu, & can be set from either 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

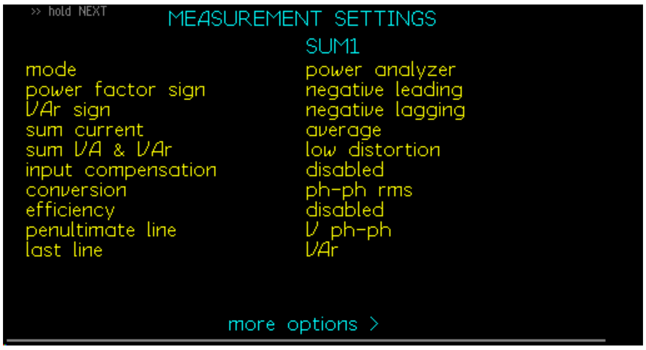
Power Analyzer

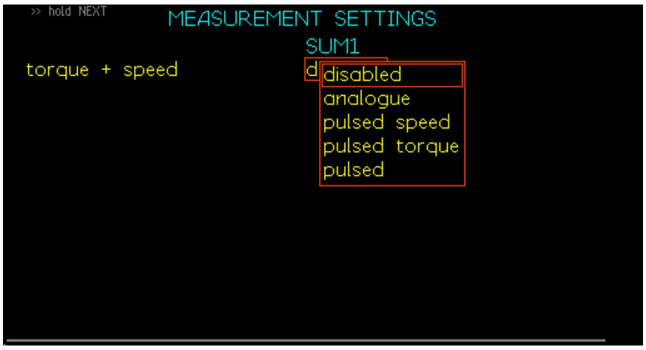
In the POWER Analyzer mode, the PPA3500 series measures the following values for each phase:

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) and via multilog in the PPAdatalogger software.





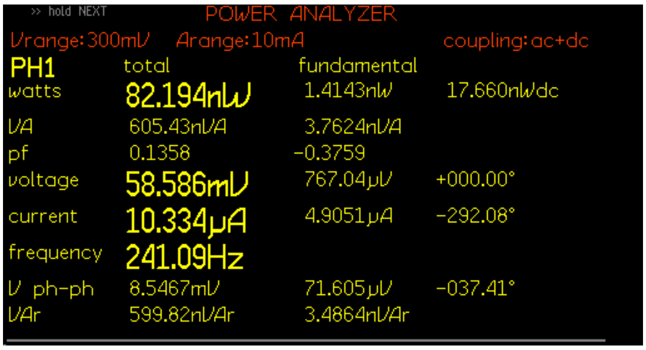
On entering the Power Analyzer mode either by 2 presses of the direct access key labelled *POWER*, or via the drop down menu found on the *MODE* key, the first settings screen is displayed. Pressing the ► key displays the more options screen as shown below. Both ***VAr*** and ***power factor*** can be switched between negative leading or lagging.

Pressing the ► key gives access to further options in the same manner as the System screen.

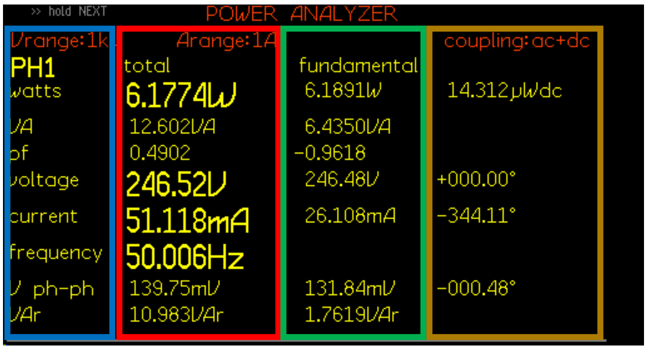
In this case just torque and speed settings allow for different sensor inputs, either analogue voltage signals or pulsed signals.

Check the accompanying information that was supplied with the torque and speed sensor to select the correct settings.

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 PPA3540 but if wiring is set to single phase 1 or 2 etc, then only that phase will be shown when using the ►►*/ENTER* & ◄◄*/DELETE* keys to step back and forth.

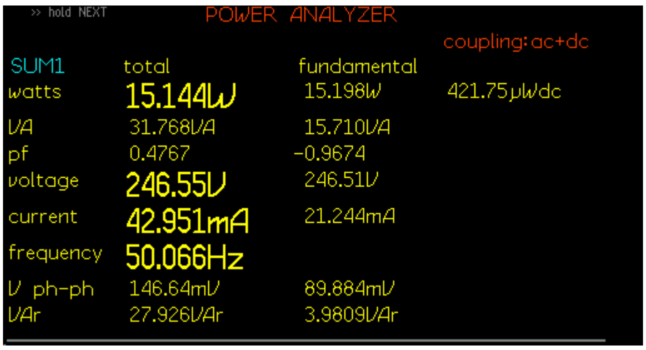


In the single phase screen, there are four columns.

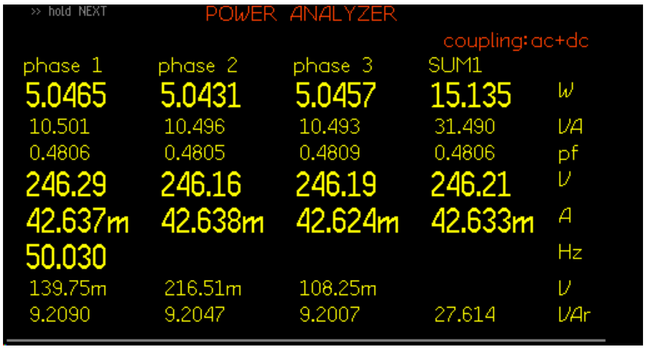
The first column shown in blue is headed by the phase being displayed, in this case phase 2, and then lists the parameters that are being displayed, voltage, current, frequency etc.

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

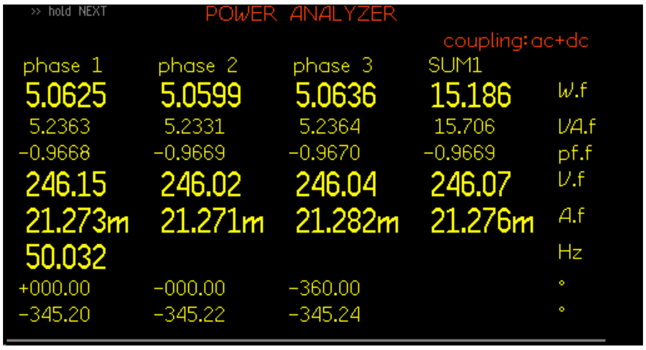
Lastly the fourth column displays the phase angle of the voltage and the current with respect to the reference set in the *ACQU* menu.



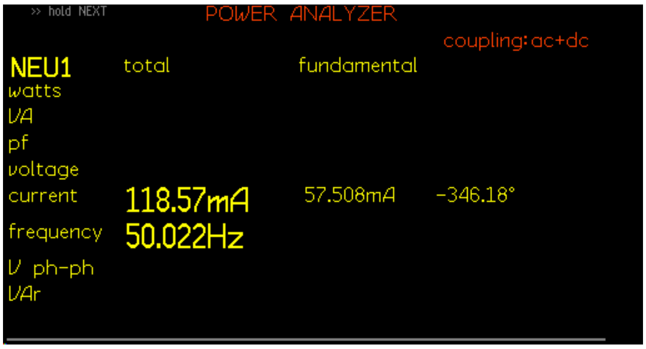
The SUM results screen displays the arithmetic sum of the three phases for Watts, VA, VAr, H3 & DC Watts, while Voltage, Current, V ph-ph & pf are the average value of the phases.



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, as designated by the lower case ***f*** to the right of the units.



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(ϕ), 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:

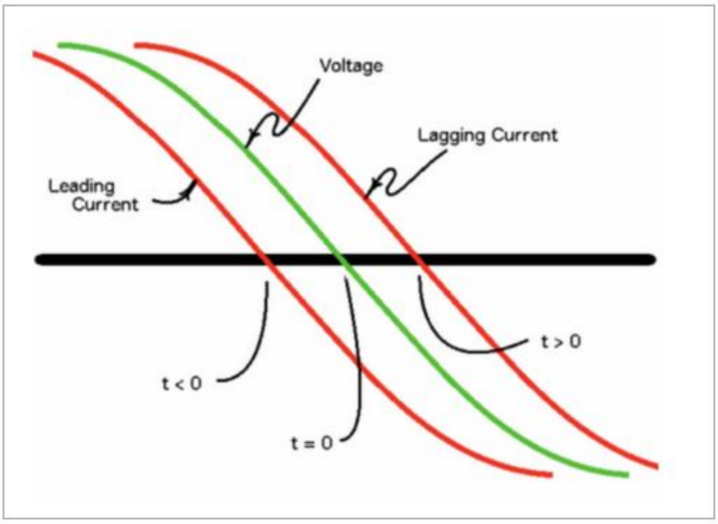
fundamental Watts $= V_a \times A_a + V_b \times A_b$

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 PPA3500 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:

$V_1 = V$, $V_2 = V$ 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 $\sqrt{3}$ times larger than the phase to neutral voltage at a phase displacement of -30˚.

The PPA3500 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 PPA3500 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} = torque x angular velocity (rad/s)

= torque x speed (rpm) x 60 x 2π

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

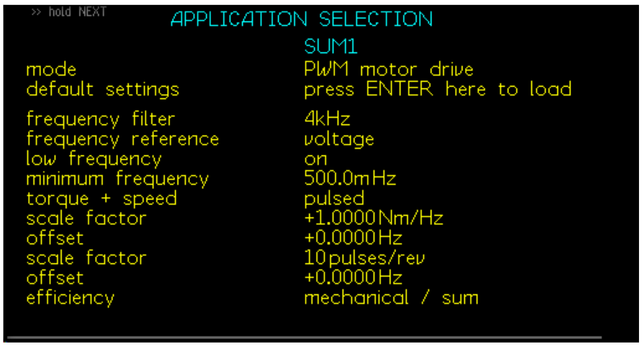
efficiency = mechanical power / sum power (motor)

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, then 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 ($230V^2/1M\Omega$). 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] $Vrms_{phase} = \frac{Vdelta}{\sqrt{3}}$

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 PPA3500 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 PPA3500 computes the complex impedance given by:

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

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

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.

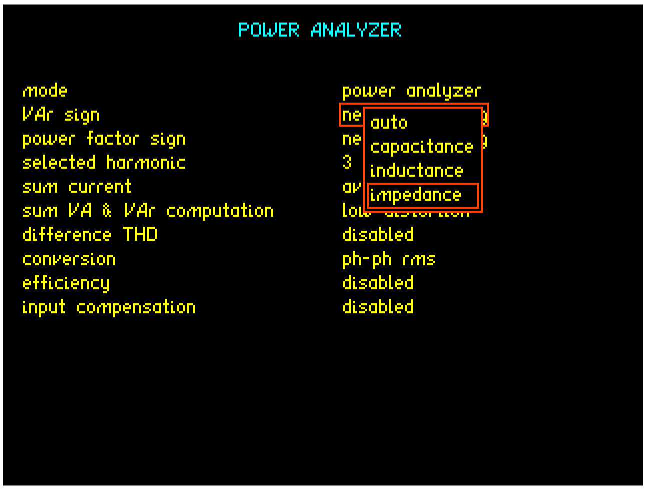
The magnitude of the voltage and current are also computed.

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 PPA3500 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:

$Z_{magnitude} = V_{magnitude} / A_{magnitude}$

$Z_{phase} = V_{phase} – A_{phase}$

As the phase is referred to the voltage:

$Z_{phase} = - A_{phase}$

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.

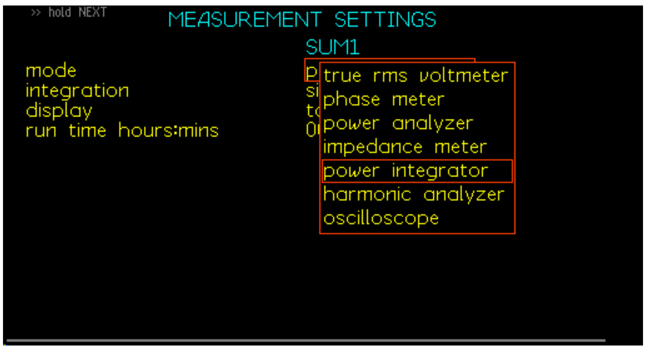
Power Integrator

In the INTEG mode, the PPA3500 computes the following additional values:

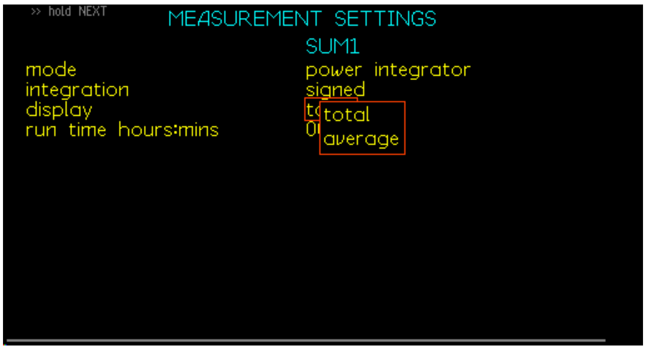
Parameter	Units
Watt hours	Wh
VA hours	VAh
VAr hours	VArh
Average power factor	Unitless
Average rms voltage	V
Ampere hours	Ah
Fundamental watt hours	Wh
Fundamental VA hours	VAh
Fundamental VAr hours	VArh
Average fundamental power factor	Unitless
Average fundamental voltage	V
Fundamental ampere hours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

Setting up and running the Integrator function

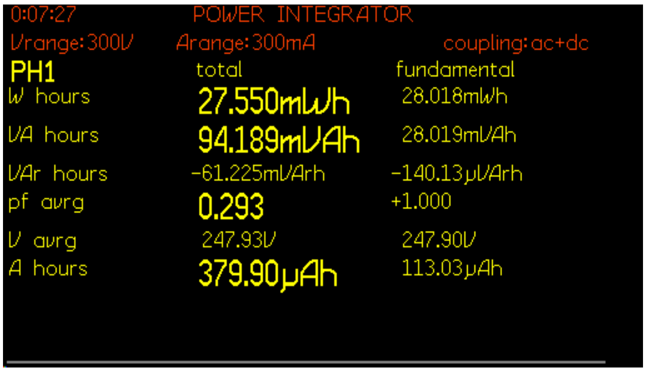
The setup menu options can be accessed via the *MODE* key and using the ▼, ►, ▼, ▼ combination of direction key presses to highlight ***power integrator*** then press *ENTER*.



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.



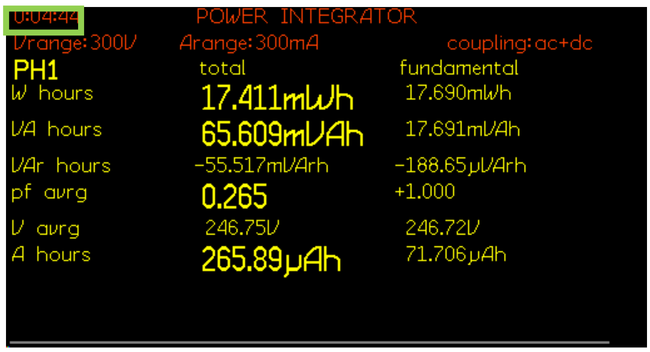
The integration results can be set to be ***Total*** accumulated values or as the ***average*** over the integration period, depending on the ***display*** parameter settings, as shown left. Lastly a countdown ***run time*** timer can be set for the desired length of time that the integration needs to be recorded, 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.



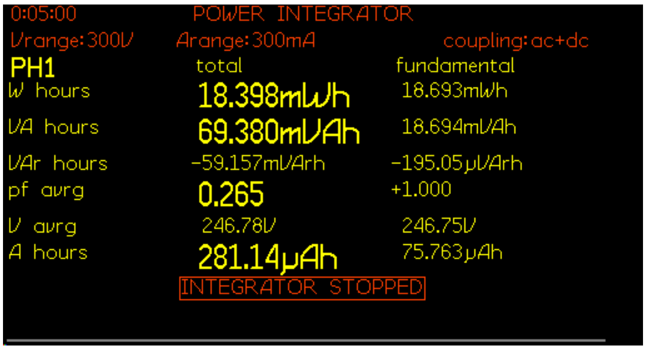
Once all the parameters have been set, press the *HOME* key twice and the integrator will display the starting zeroed integration screen. the elapsed time is displayed in the upper left corner of the display as soon as the integration starts. Pressing the *START* key will initiate the integration.

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 the time set, (5 minutes in this case) 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 PPA3500 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	✓	✓	✓
Harmonic rms	✓	✓	✓
Harmonic Factor	✓	✓	✓

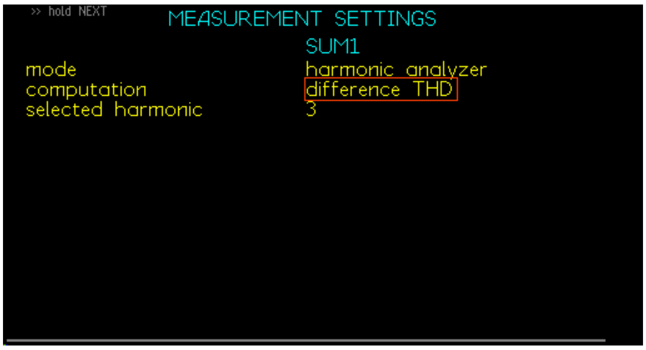
Analyses Formulae

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

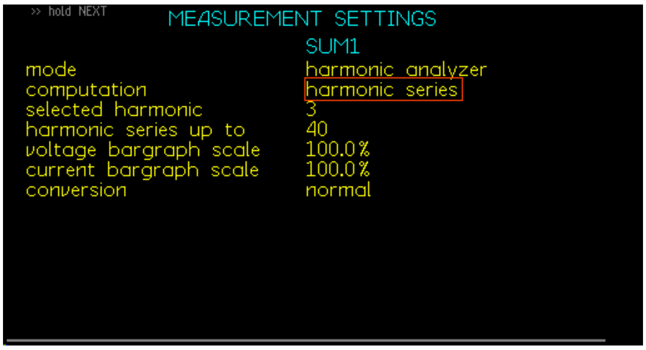
$$THD = 1/h_1 \sqrt{(rms^2 - h_1^2)}$$

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.

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

where h_i is the i^{th} harmonic

and t_i is the i^{th} weighting factor

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.

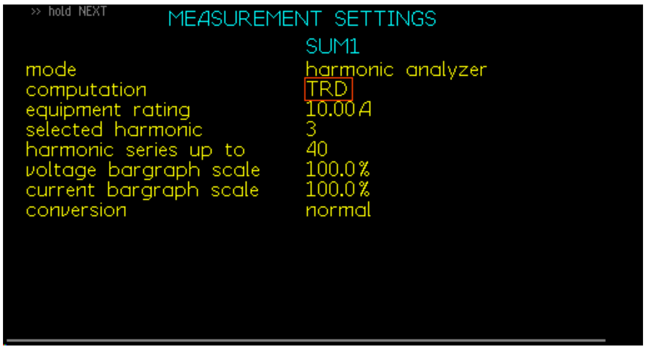
$$THF = 1/rms \sqrt{\sum_{i=1}^{i=n} (h_i \times t_i)^2}$$

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.

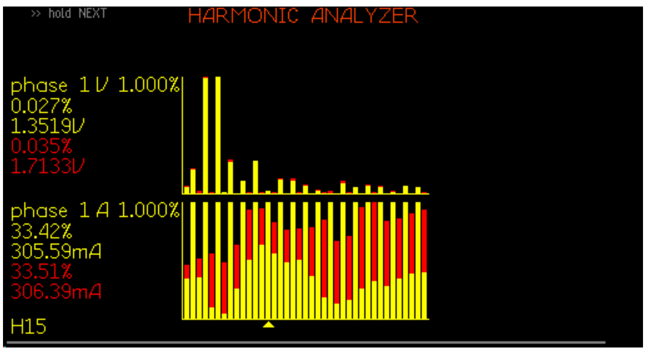
TRD (Total Rated Distortion) uses a different reference to scale the harmonic percentages instead of the fundamental. The voltage harmonics are scaled by the rms voltage, and the current harmonics are scaled by the larger of the rms current or the rated current entered by the HARM menu. The rms is computed 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, and series harmonic phase computation (max 100) 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, labelled as ***conversion***

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.

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:

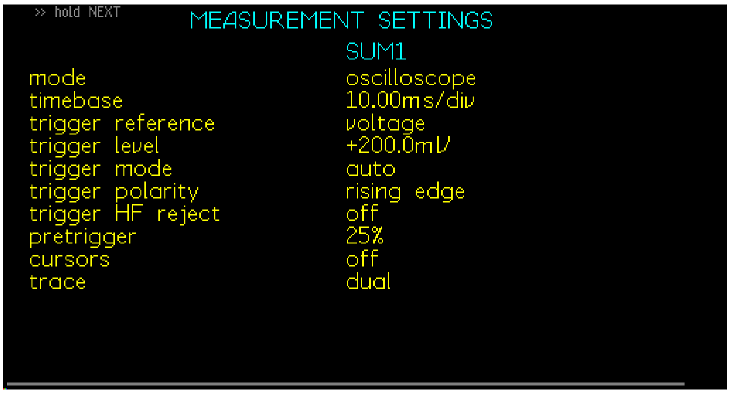
$$HCF = \sqrt{\sum_{n=2}^{k} i_n^2}$$

Where:

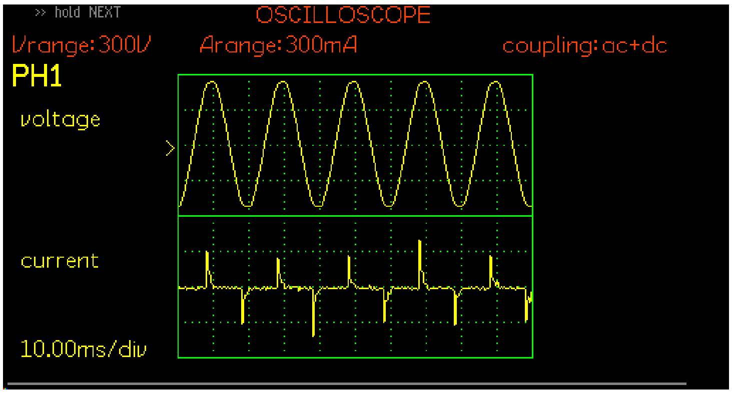
k = 13
n = the order of harmonic
i_n = is the ratio of harmonic current I_n to the rated current I_N.

Scope Mode

The PPA3500 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, 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 display with inputs connected to a small SMPS mobile phone charger.



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.

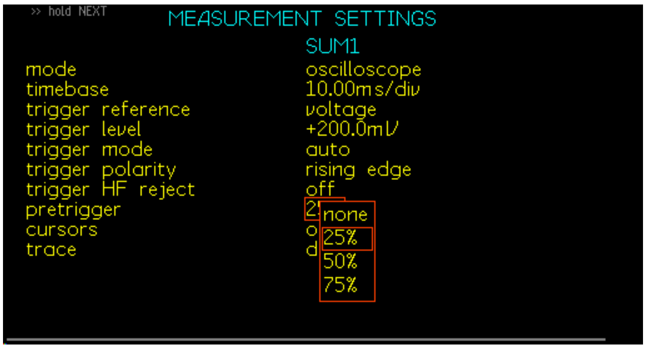
Auto	(trigger if possible but do not wait)
Normal	(wait indefinitely for trigger)
Single shot	(wait for trigger then hold)

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

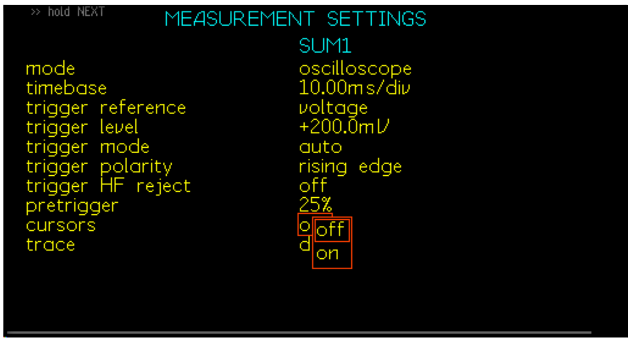
Trigger Polarity: The trigger polarity may be set to rising edge or falling edge.

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.

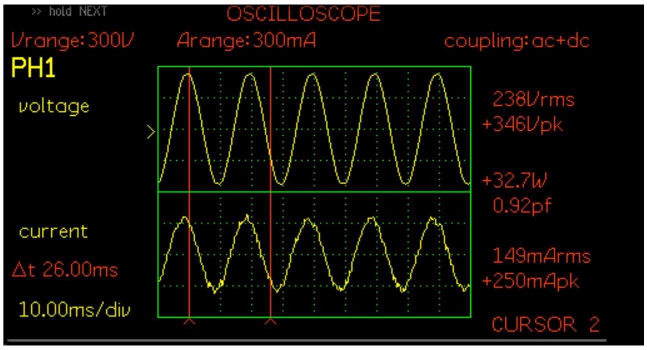
Use the ◄&► keys to move the selected cursor along the timescale.

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

With the ***cursor*** option ***off*** (default); the ▲&▼keys change the time-base.

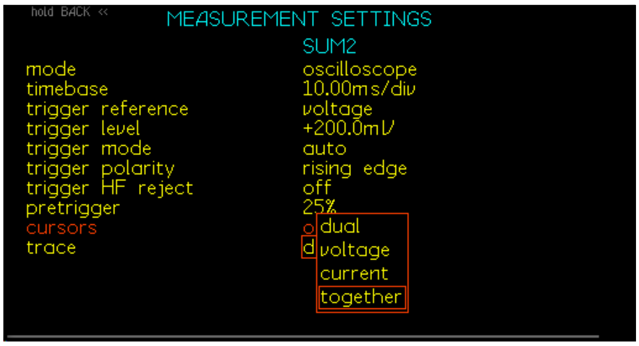
With the ***cursor*** option ***on*** the ◄&► keys change the cursor position and the ▲&▼ keys toggle between cursor 1 control and cursor 2 control.

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



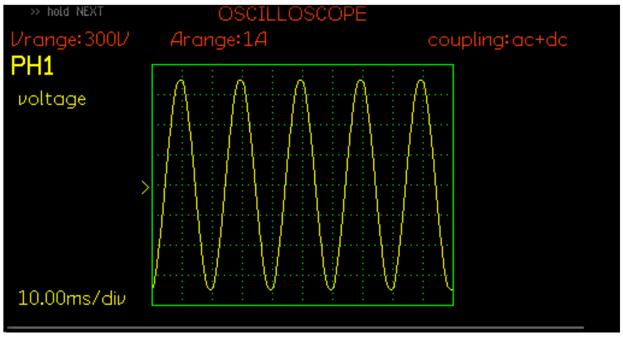
Screenshot from Scope display with ***Trace*** set to ***Dual*** & cursors enabled, showing all fundamental measurements from the position of cursor 1. Also the time difference between the cursors, "Δ t" = 26.00ms with the time base set to 10ms/div

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.

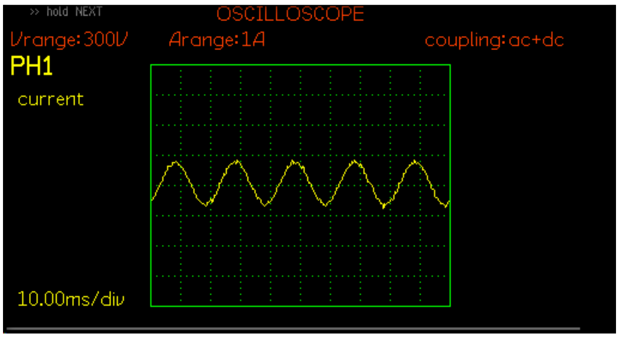


The following four screen shots show the display when set to ***Voltage***, ***Current***, ***Dual***, & ***Together***.

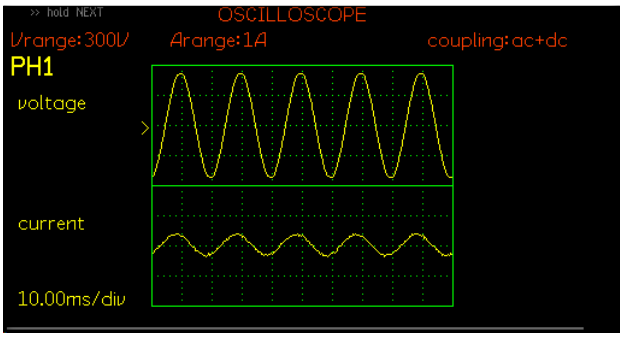
Trace set to Voltage:



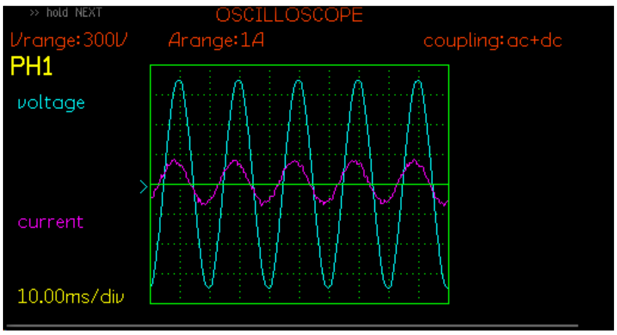
Trace set to Current:



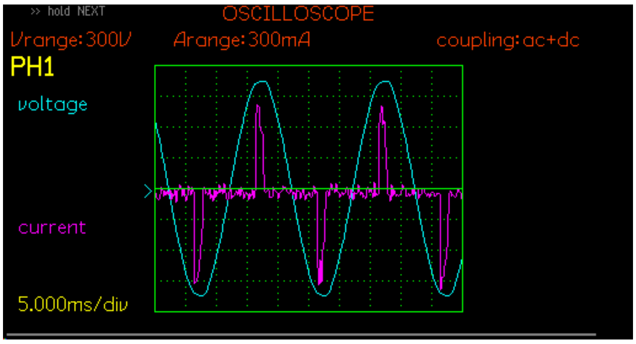
Trace set to Dual



Trace set to Together



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



Application Modes

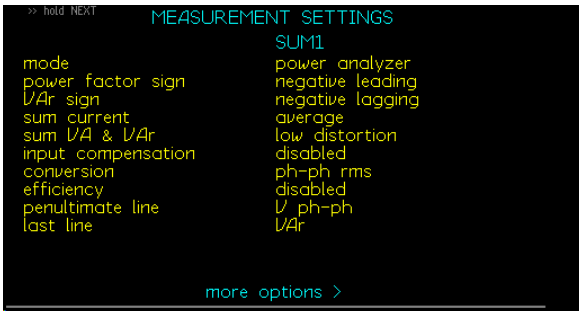
Within this section we will look at all the different application modes selectable from within the PPA3500 Series *APP* menu, with the aid of screenshots and instructions.

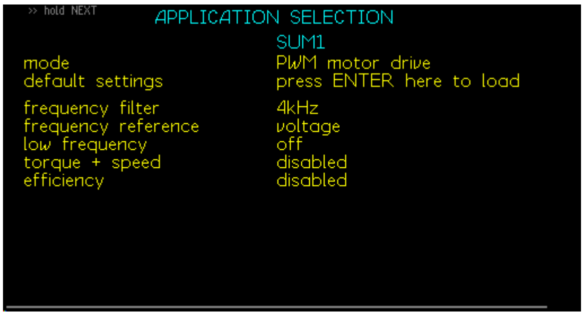
Each of the *APP* selections will load and adjust settings as a suitable starting point for the application appropriate to the DUT or system that is to be analysed.

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

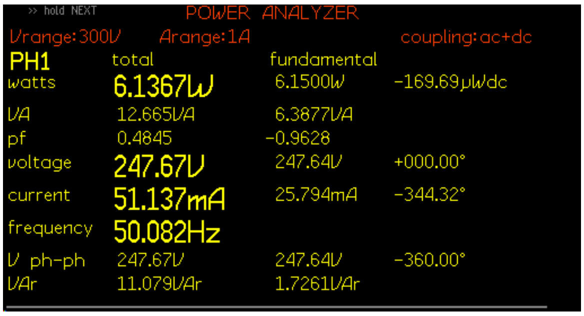


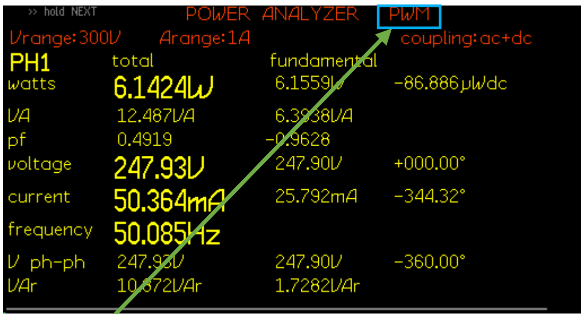


screen

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 any 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 PPA3500 Series instruments.

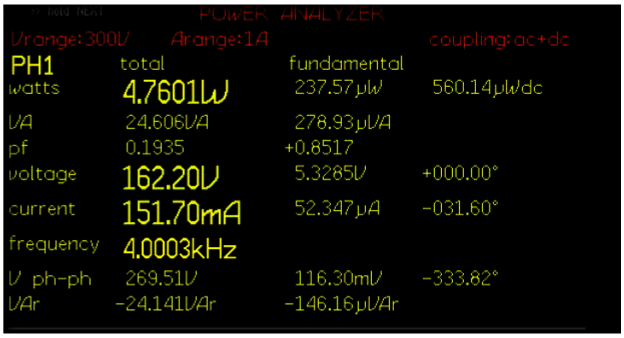
PWM Motor Drive

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 PPA3500 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.

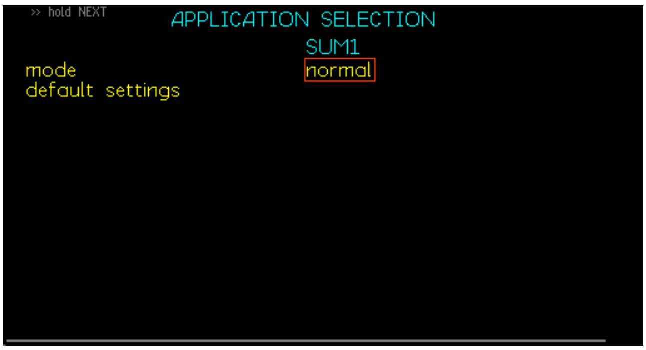
The nature of the waveforms produced in a PWM motor drive application makes measurement of the fundamental frequency difficult. In this section we will look at the switching and fundamental frequencies and how frequency lock and filters will allow the correct measurements to be displayed on such a complex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

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

Leaving the PPA3500 in the ***normal*** *APP* mode record the frequency measurement, 4.0638kHz in this instance.

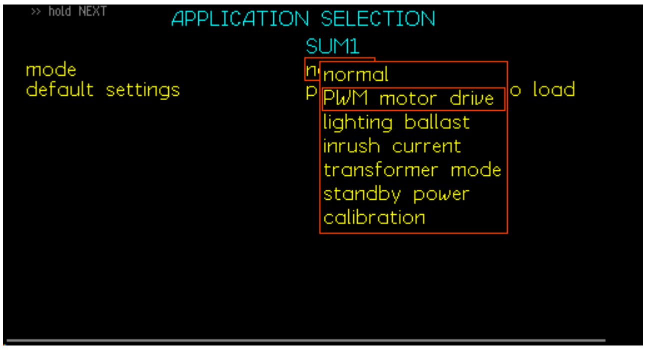


In the ***normal*** *APP* mode, the PPA3500 is locking onto a switching frequency / high frequency noise of 4 KHz with no filtering applied. This can be used as a guide when selecting a frequency filter from within the PWM motor drive application parameters screen.

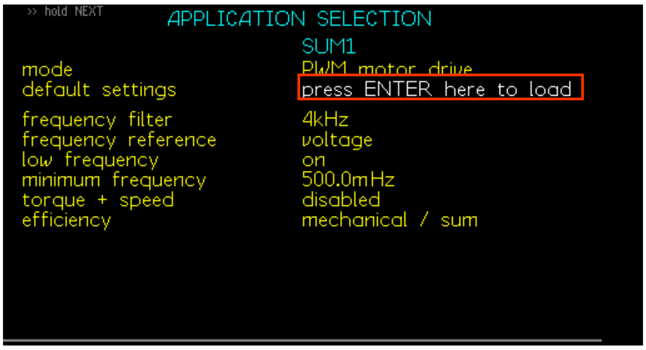


To access PWM motor drive mode:

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.



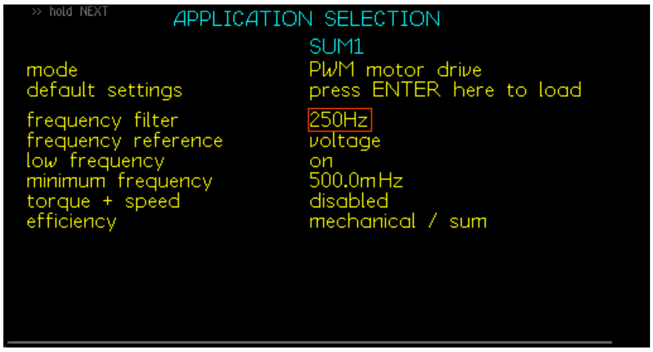
However untill the default settings have been confirmed , the instrument is not set for PWM mode.

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



From the drop down menu. Select a frequency range in 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 64Hz 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

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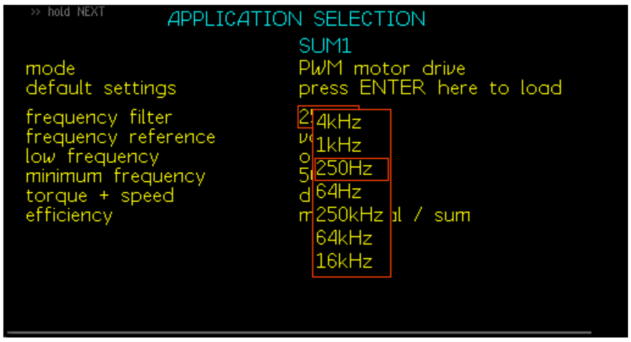
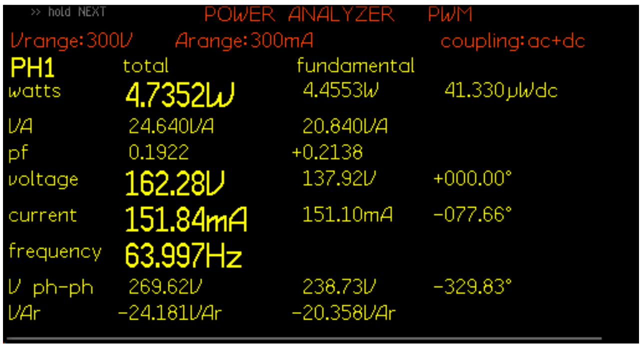
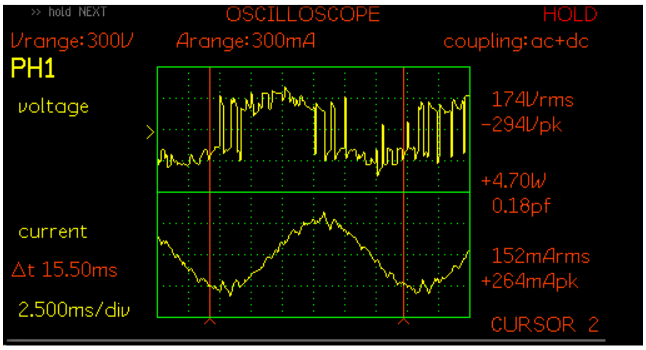


Setting the frequency filter: Press the ▼ key to highlight the ***frequency filter*** values. Press the ▶ key to open the frequency ranges dropdown menu. Press the ▼ key 2x to highlight 250Hz, press *ENTER* to confirm selection.



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.



Viewing the waveforms in the Oscilloscope mode, we can see the switching frequency of the Voltage and a smoother Current waveform. By use of the two cursors, the Current waveform shows the time for 1 cycle to be approximately 15.50ms

Therefore 1s ÷ (15.50x10^{-3}) = 64.5161Hz 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.

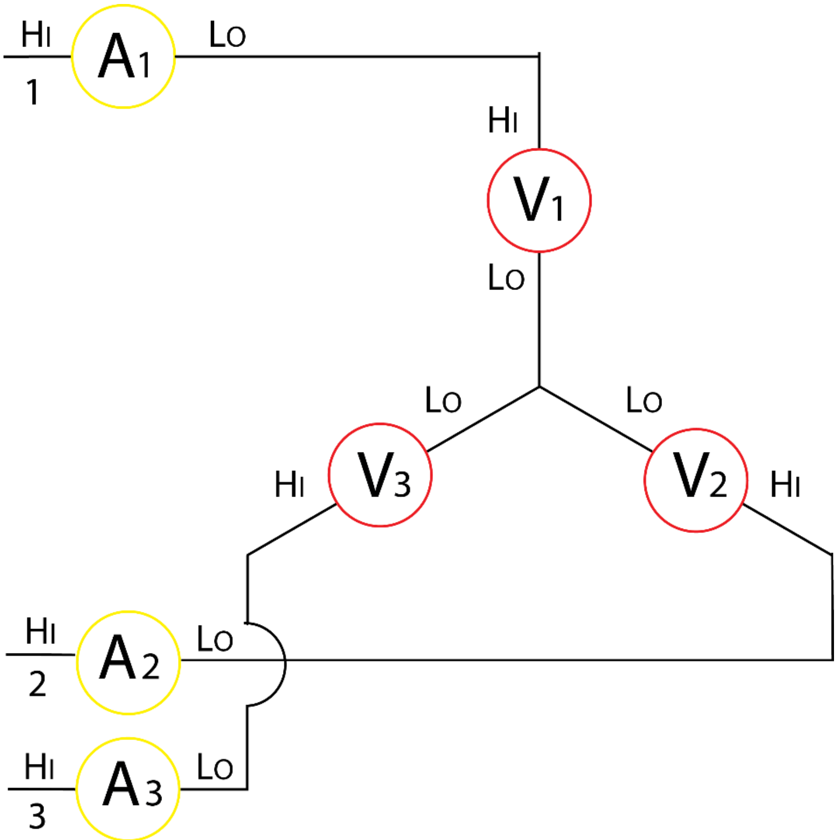
Using the PPA3500 to measure 3 phase power with PWM drives

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:

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”).

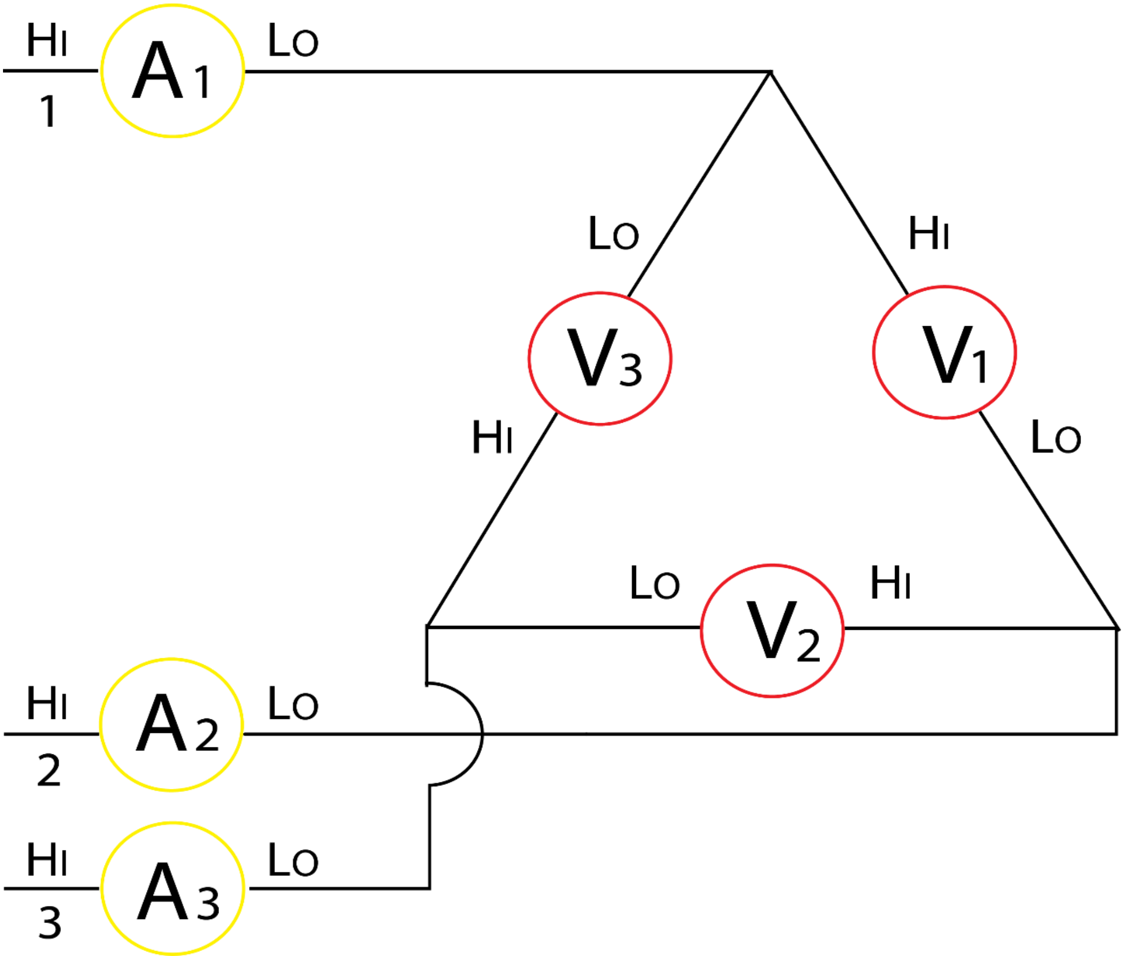
If, however, the neutral point is not available, then the measurement of the voltage rms is more difficult. The options are to use a synthesised neutral or to connect in delta configuration and derive the phase measurements.

Three Phase Three Wattmeter – Simulated neutral – Star connection



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.

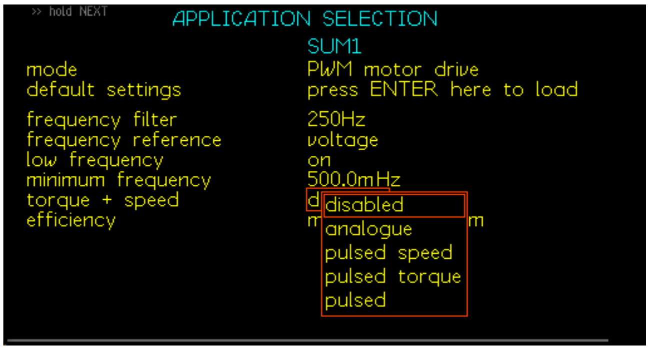
Wiring	Conversion	Phase rms voltage	Phase power
Star with neutral	Phase to phase rms	Measured	Measured
Star without neutral	Phase to phase rms	Slightly high	Measured
	Star to delta type A	Derived	Measured
	Star to delta type B	Derived	Calculated
Delta	Delta to star	Derived	Derived

Instrument wiring

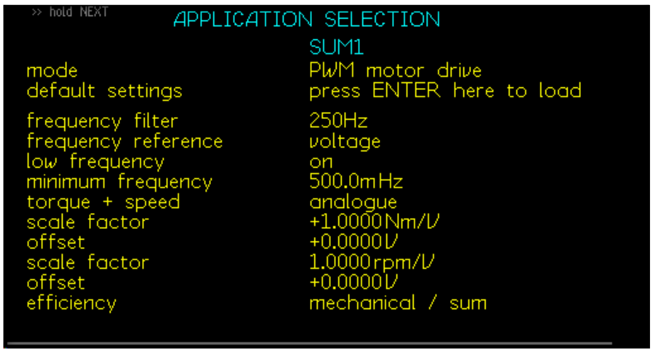
Please refer to Appendix F for physical PPA connection diagrams.

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 & 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.



Once a configuration has been selected you will need 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 PPA3500 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.

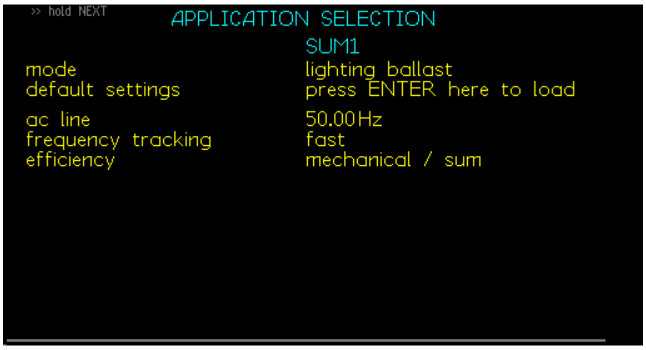
Both the frequency measured on the input waveform and the frequency of the line input are displayed.

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.

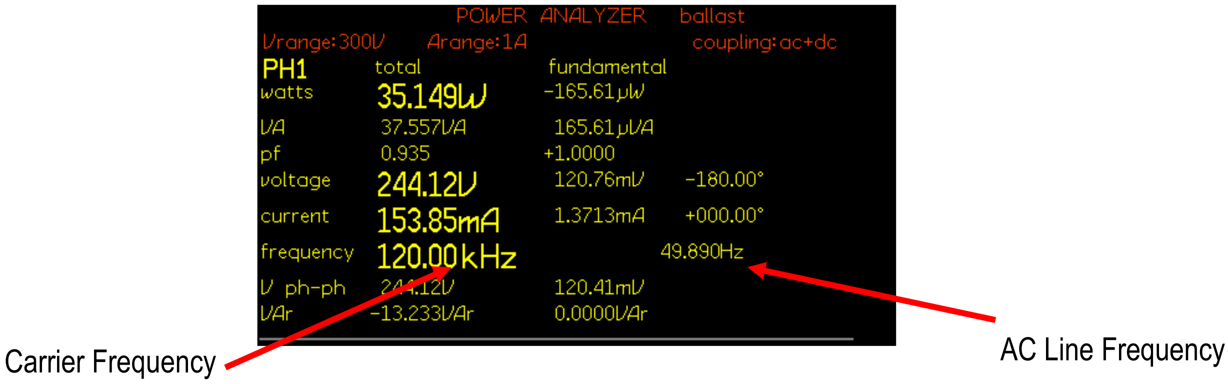
Ballast mode quick start guide



Select ***lighting ballast*** in the APP menu, then 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.

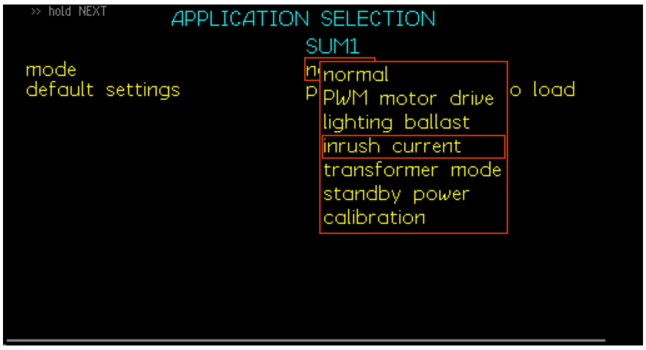
INFORMATION. The default setting for efficiency measurements is Phase 1/Phase 2, as displayed on the bottom line of the display.

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 PPA3500 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 PPA3500.

The PPA3500 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

Inrush measurement without a PCIS accessory.



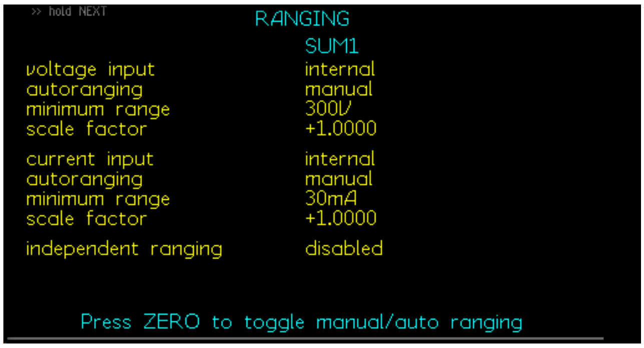
In the *APP* menu, select ***inrush current*** and then press *ENTER* to load the default settings.

The default settings are shown in the screen shot below.

The 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 PPA3500 samples and analyses every sample at the full sample rate >1Msamples/s to catch even very fast peaks.

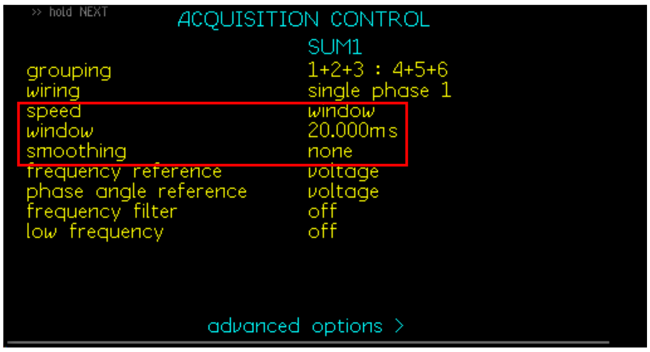
Setting the range parameter

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.

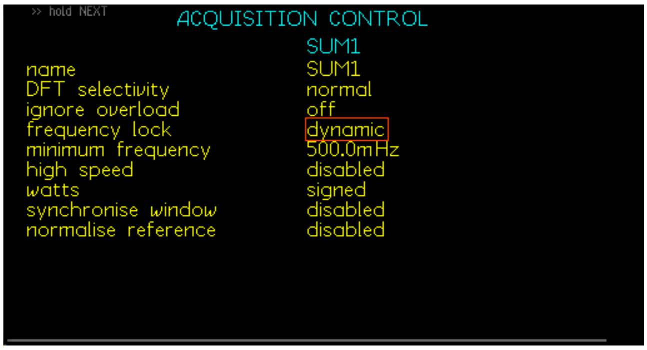


Set the ***autoranging*** parameter to ***range up only*** and the minimum range to the 30mA range this will allow the test being carried out to find the highest range via peak detection and hold on this range.

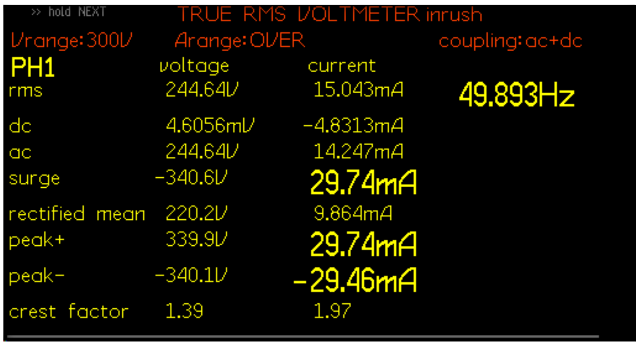
Setting the Speed and Smoothing



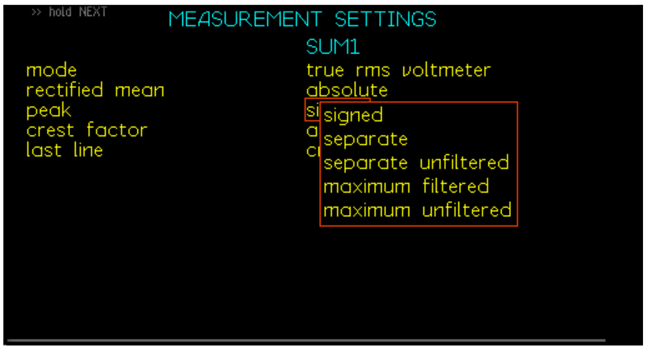
For this application a mains input signal of 50Hz was used, therefore we can set the ***speed*** to ***window*** and ***20.00ms*** this will enable us to capture cycle by cycle data over the whole waveform, to get the instantaneous cycle by cycle power the ***smoothing*** parameter is best set to ***none***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



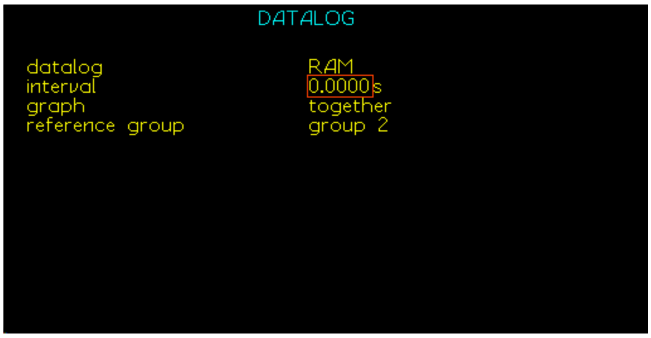
Upon completion of the speed and smoothing settings press the ► key to take you to the advanced settings screen. If undertaking cycle by cycle measurements on the input signal, then set the ***frequency lock*** to ***Dynamic.***



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.



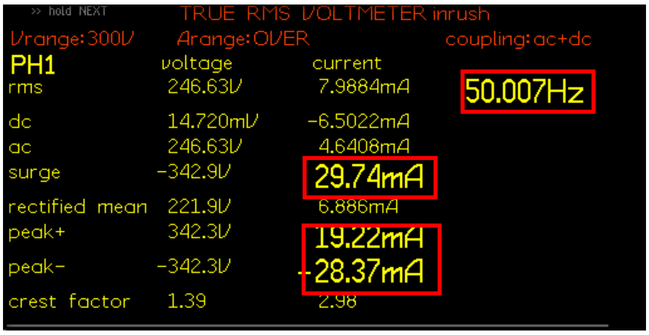
For this demonstration we selected ***separate unfiltered*** this then gave us the unfiltered ***Peak +*** and ***Peak*** – measurement parameters as displayed earlier for both Voltage and Current



Data logging to Internal Memory

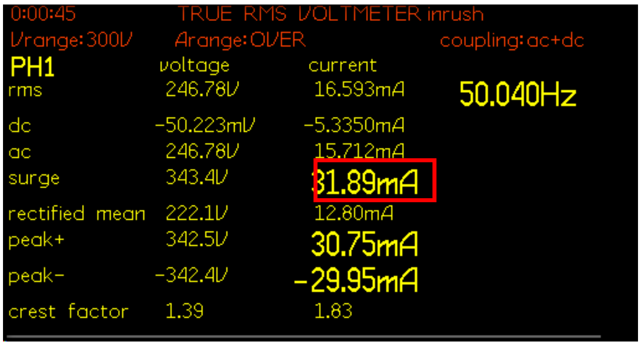
Set the ***Datalog*** parameter to the internal ***RAM*** memory this will offer the user the fastest performance.

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

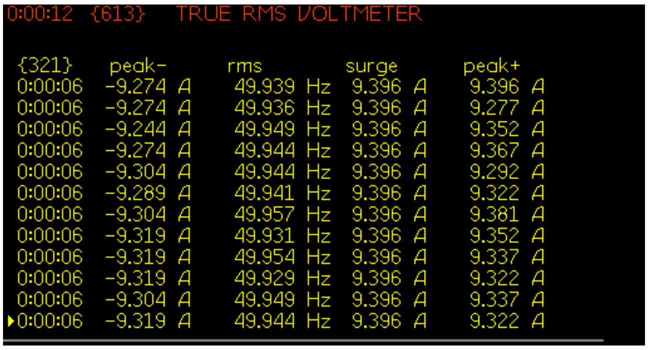


Reconfigure zoom parameters within real time display

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



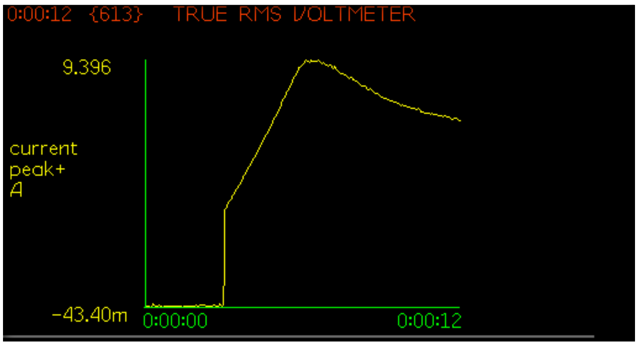
DataLog Results From the Real Time display the surge measurement at the moment the DUT was switched on is recorded as 31.89mA



0:00:12 {613} TRUE RMS VOLTMETER

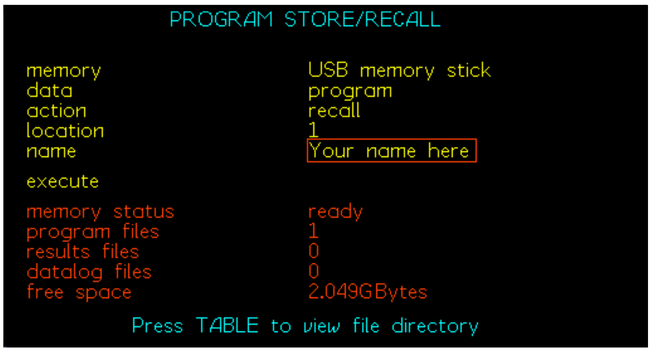
{321}	peak-	rms	surge	peak+
0:00:06	-9.274 A	49.939 Hz	9.396 A	9.396 A
0:00:06	-9.274 A	49.936 Hz	9.396 A	9.277 A
0:00:06	-9.244 A	49.949 Hz	9.396 A	9.352 A
0:00:06	-9.274 A	49.944 Hz	9.396 A	9.367 A
0:00:06	-9.304 A	49.944 Hz	9.396 A	9.292 A
0:00:06	-9.289 A	49.941 Hz	9.396 A	9.322 A
0:00:06	-9.304 A	49.957 Hz	9.396 A	9.381 A
0:00:06	-9.319 A	49.931 Hz	9.396 A	9.352 A
0:00:06	-9.319 A	49.954 Hz	9.396 A	9.337 A
0:00:06	-9.319 A	49.929 Hz	9.396 A	9.322 A
0:00:06	-9.304 A	49.949 Hz	9.396 A	9.337 A
0:00:06	-9.319 A	49.944 Hz	9.396 A	9.322 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 9.396A



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.

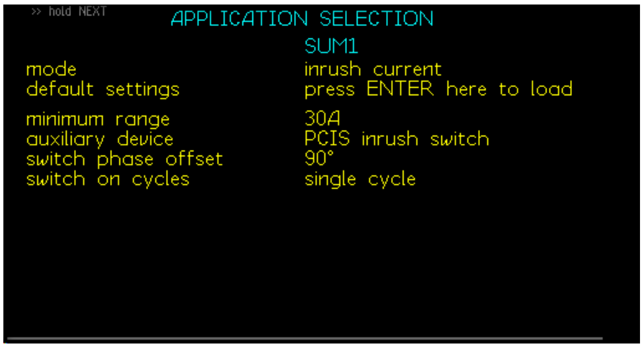
Upon completion you are now able to save / recall or delete your test results taken from your DataLog within the PROG mode key



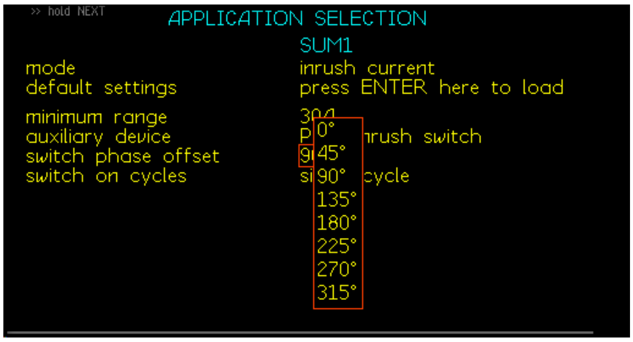
Transferring the Datalog from the RAM memory onto a USB memory stick will allow the user to export the .txt file which can be imported into an Excel file if desired.

Inrush Current Mode using the N4L PCIS accessory.

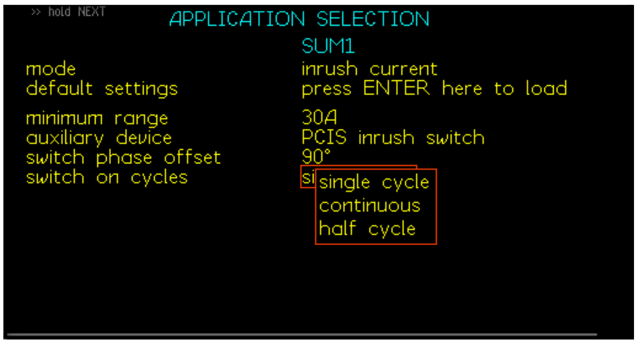
The Phase Controlled Inrush Switch, or PCIS, available as an accessory for the PPA3500, controls the switch on of the power to the DUT from 0˚to 315˚ in steps of 45˚ from the Instruments front panel.



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).



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.

Speed, medium

Smoothing, fixed time

Low frequency mode, ON

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 PPA35xx 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 PPA3500 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.

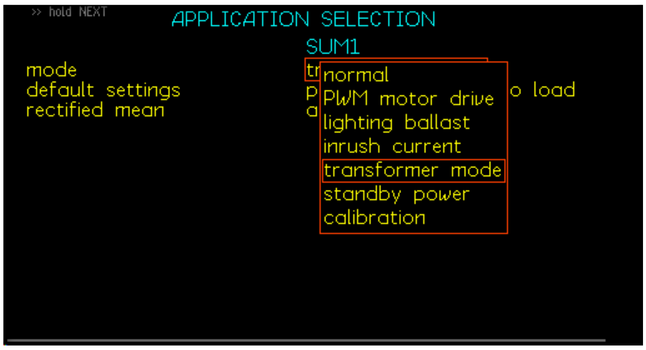
When testing a three phase transformer, the multiple phase display is changed to show imbalance across the phases. Phase 1 appears with the normal measurements but the voltage and current measurements for phase 2 and phase 3 are expressed as a percentage of the corresponding values from phase 1. The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

Single phase testing

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

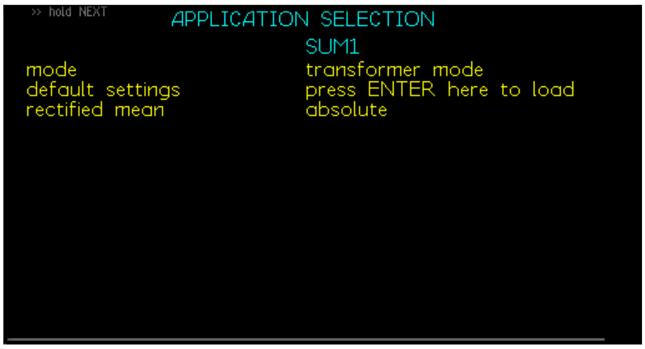
Accessories: 1 x Break out Box

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

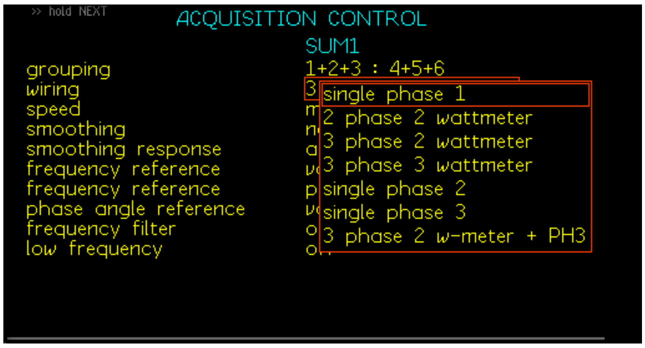


To access transformer mode from the drop down menu, press the ▼ key 4 times and press *ENTER* as displayed, transformer mode will now be selected.

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



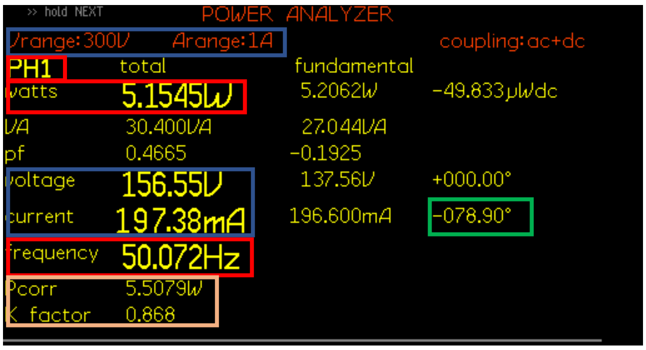
Pressing the *HOME* key twice will take you back to the power analyzer home screen.



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 lower Blue Box in the above screen shot 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 78.90º. A perfect transformer would display a phase angle of 90º. 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

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

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

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

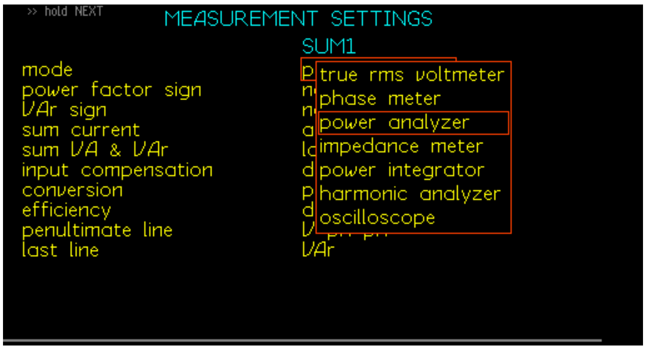
$$d = \frac{U' - U}{U'} \quad (\text{usually negative})$$

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 on the previous page, 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.

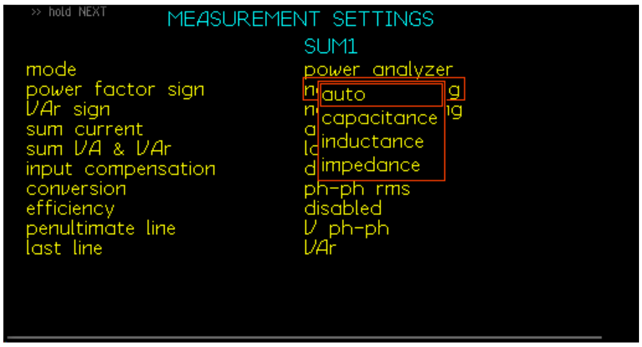


Press the *MODE* key to enter the ***Measurement Settings*** screen

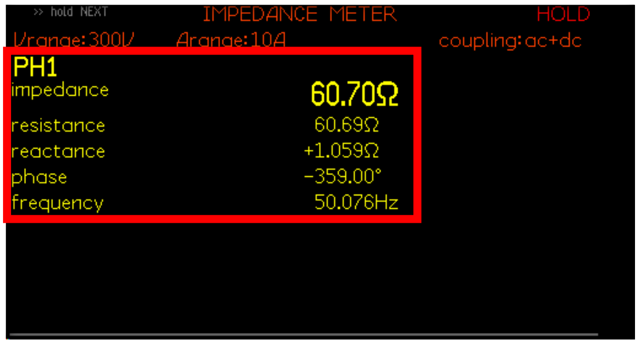
Press the ▼ key, a red box surrounds ***mode*** parameters

Press the ▶ key to open the drop down menu

Press the ▼ key once followed by the *ENTER* key to select ***Impedance meter.***



Next press the ▼ key once, followed by the ► key. 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.



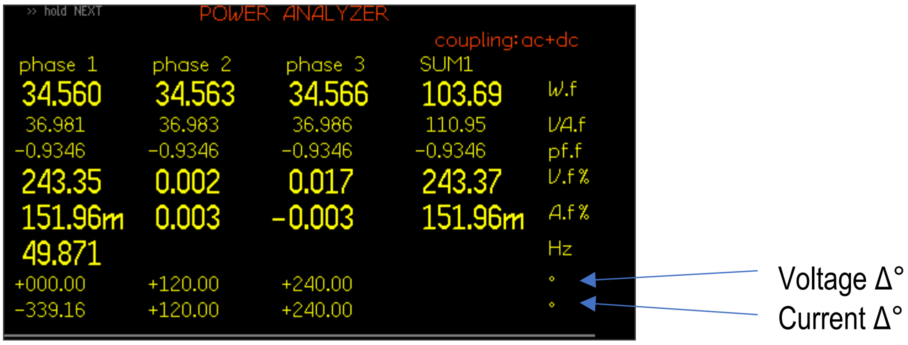
Press *ENTER* to return to home screen and view measurements. From the "auto" screen you can now see that we have a Resistive component affecting the purity of the transformer

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)

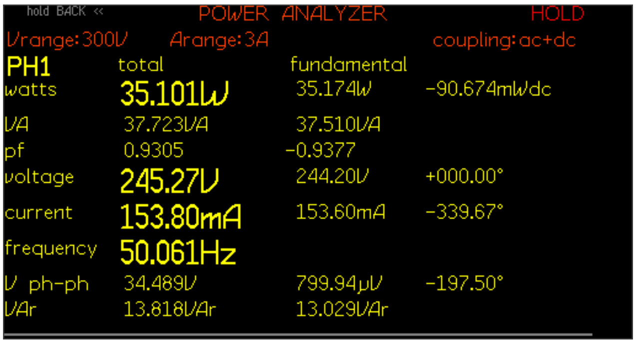
When performing analysis of a 3 Phase load, transformer mode is extremely useful. The PPA will display phase balance information in an intuitive manner without the requirement for a vector display, this has the advantage of maintaining 5 digit resolution which is not possible whilst attempting to visually 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 deg and 240 deg respectively.

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.

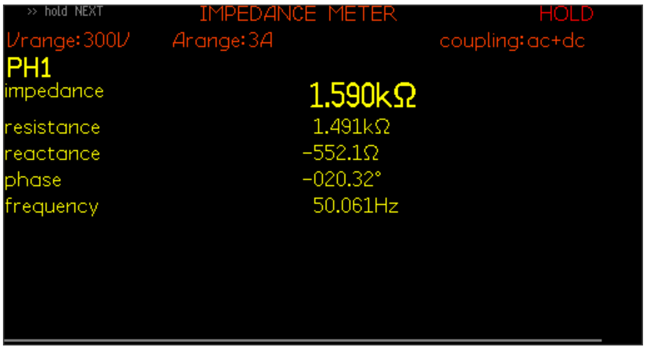


At a mains voltage of 244.20V (fundamental 50.061Hz) and 35.174 watts the transformer has a primary off load phase angle of -339.67 degrees. This is the phase angle between V_1 and I_0

The calculated impedance at the fundamental frequency of 50.061Hz is as follows.

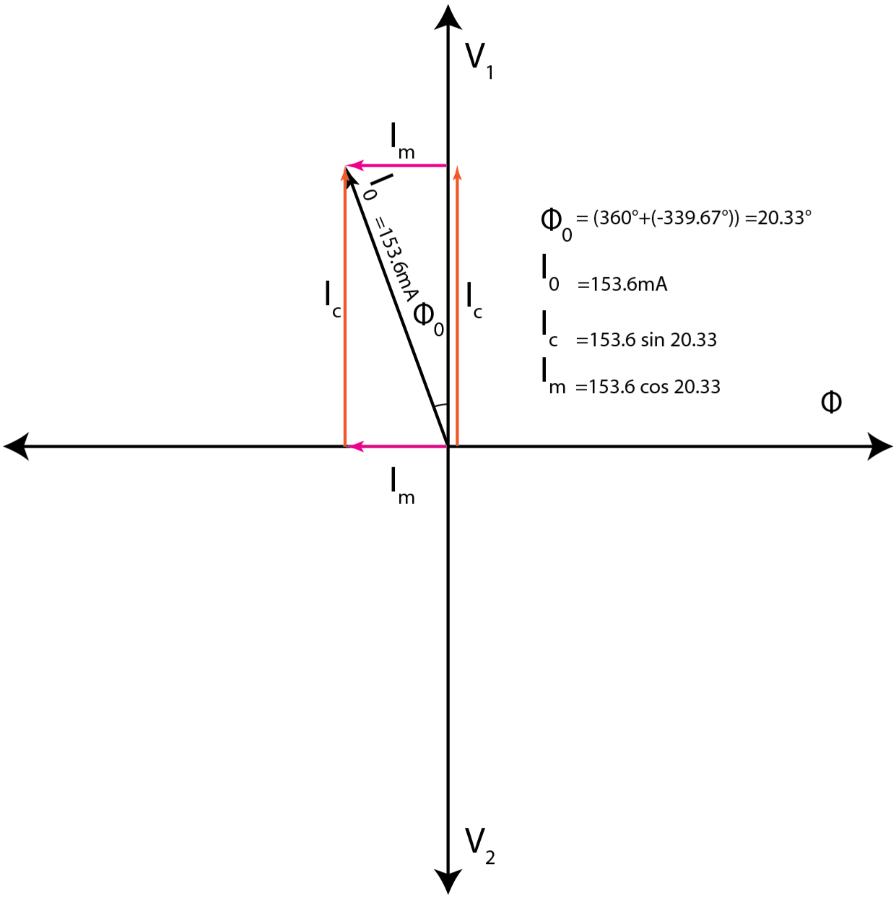
244.20V / 153.60mA = 1.589kΩ

This is confirmed in the Impedance Analyzer mode on the PPA3500.



To obtain a visual representation of the PPA3500 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 PPA3500 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 50.061Hz.



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 PPA3500, 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

$$Im = 0.15360sin20.33$$

$$Im = 0.05336A$$

Core loss component

$$Ic = 0.15360cos20.33$$

$$Ic = 0.14403A$$

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

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

$$Loss = 244.20 \times 0.14403 = 35.172W$$

Although there is a small rounding error in comparison with the correct figure shown on the PPA3500, you can see the figure does correlate with the watts measurement.

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.

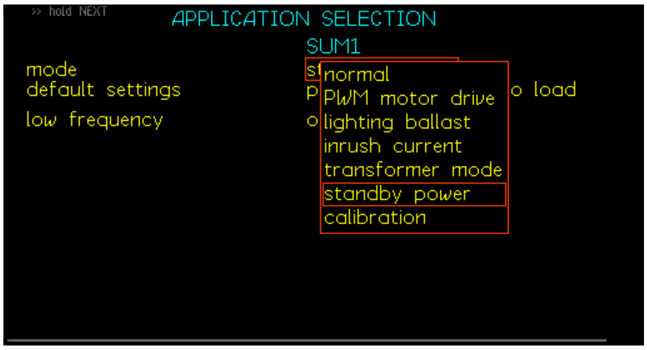
In the past, standby power was largely a non-issue for users, electricity providers, manufacturers, and government regulators. However, as climate change awareness has grown it has become an important consideration for all parties. Up to the middle of the 2000’s, standby power was often several watts 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 PPA3500 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 PPA3500 synchronises to the power frequency for the analysis but extends the measurement window to the irregular period of higher energy pulses. Because the PPA3500 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, then 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 PROGRAM LOADED message will be displayed & the instrument will now set the voltage and current measurement parameters. Press the ▼ key to move the cursor to low frequency mode.

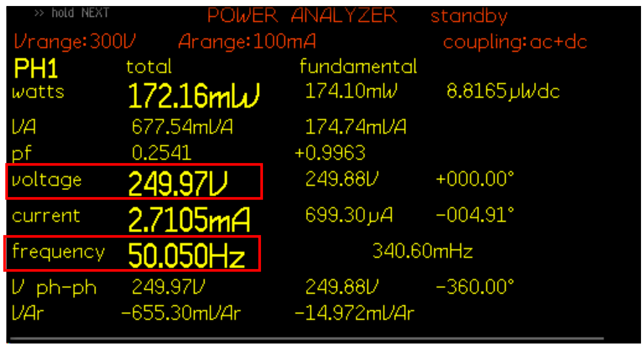
INFORMATION. Note that Pressing ENTER to load the applications default settings will automatically set the low frequency parameter to OFF

You can now return to the Power Analyzer screen

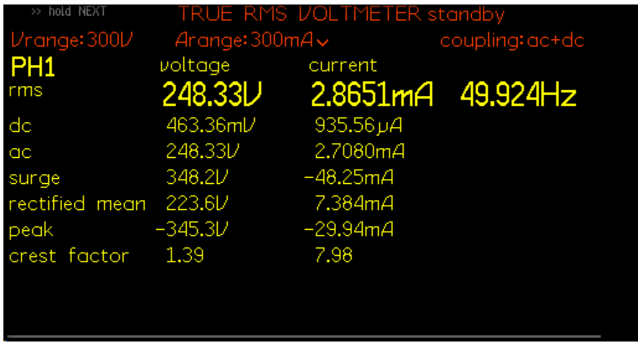
Test device: 1 x Stand-alone Heater

Accessories: 1 x Break Out Box

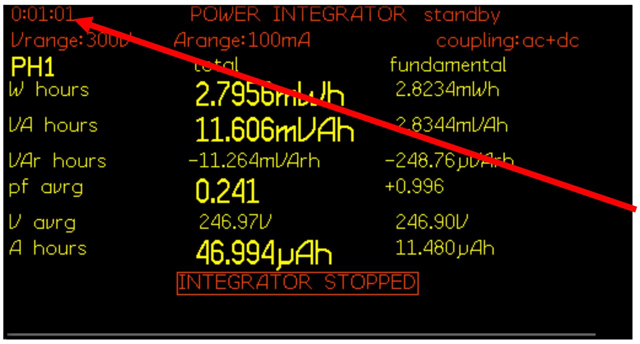
It is important that ranging is set to manual or up only auto ranging so that the power cycles are not missed while ranging.



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



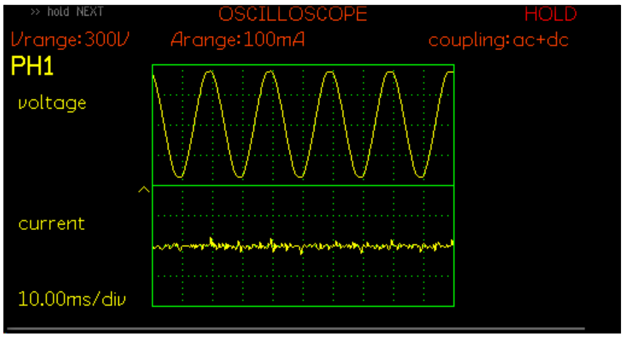
Reverting to the "RMS" screen you can see all the subsequent voltage measurements from each phase associated with the test unit in Standby Mode



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

Setting up and using remote control

The PPA3500 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 PPA3500 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 PPA3500 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 PPA3500 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 PPA3500 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?***

The PPA3500 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.

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

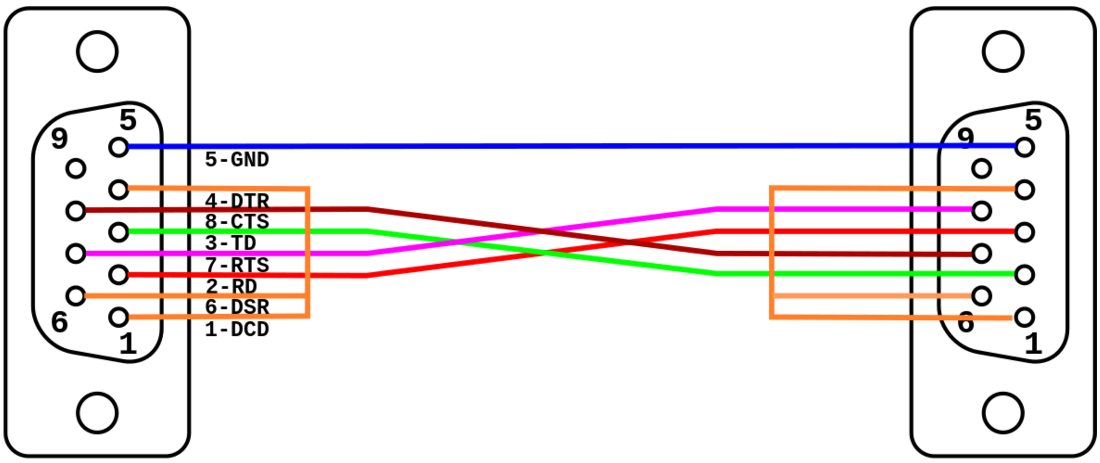
The RS232 port on the PPA3500 SERIES uses the same pinout as a standard 9 pin serial port on a PC or laptop (9-pin male 'D' type).

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 PPA3500 SERIES will only transmit when CTS (pin 8) is asserted and can only receive if DCD (pin 1) is asserted. The PPA3500 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 PPA3500 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 PPA3500 SERIES to a PC, use a 9 pin female to 9 pin female null modem cable:

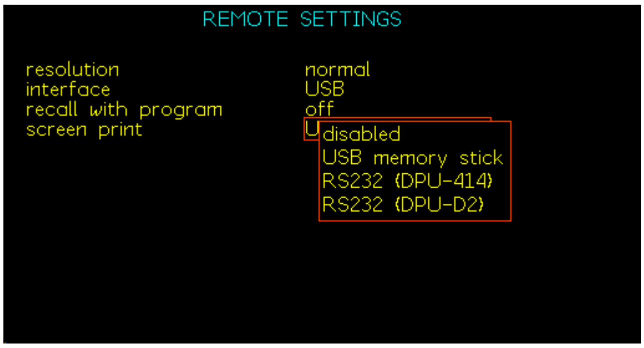
Pin(s)	Conect to	Pin(s)
1 & 6	⇆	4
2	⇆	3
3	⇆	2
4	⇆	1 & 6
5	⇆	5
7	⇆	8
8	⇆	7



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.

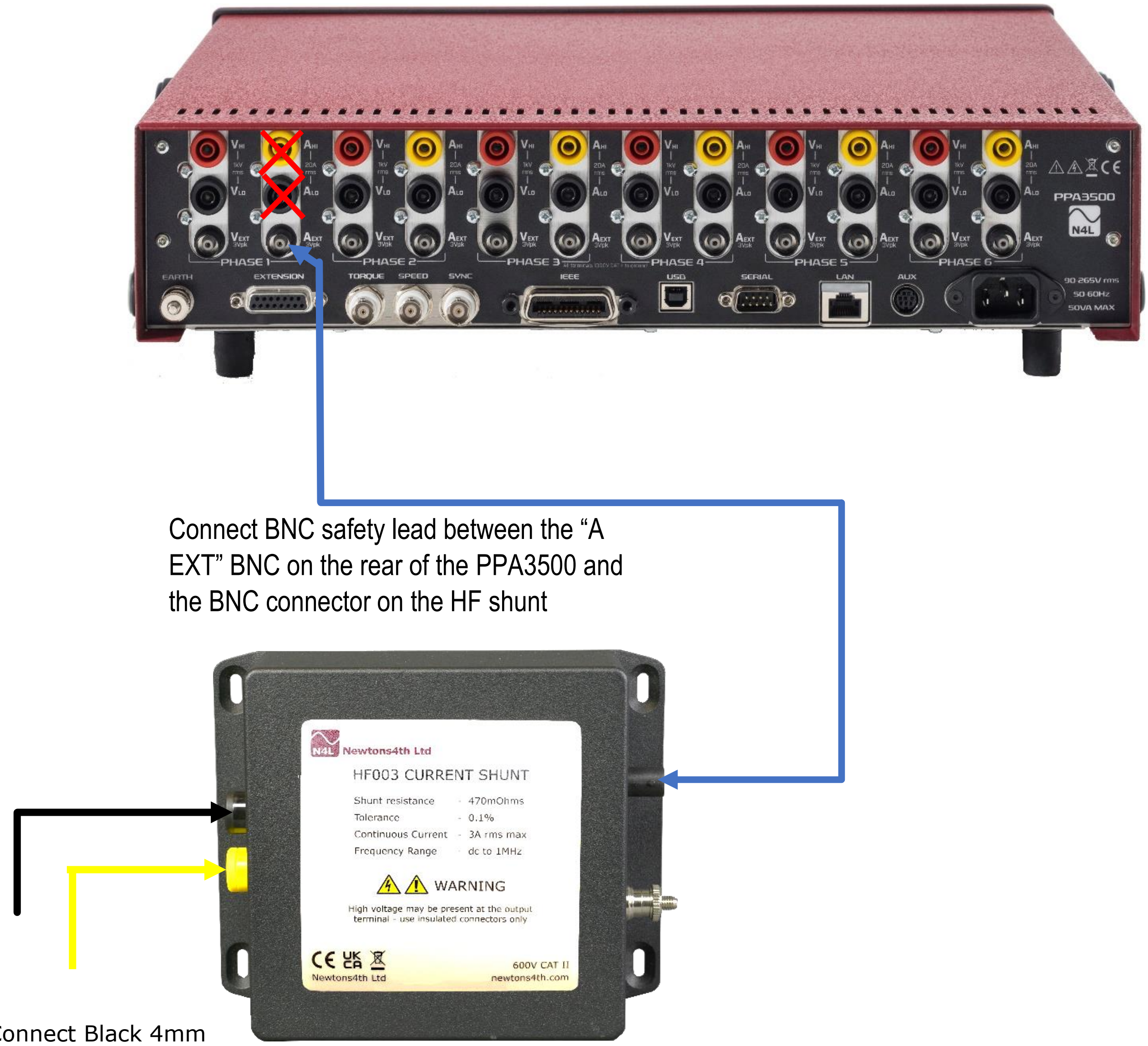
External shunts and transducers

A variety of peripherals can be connected to the PPA3500 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

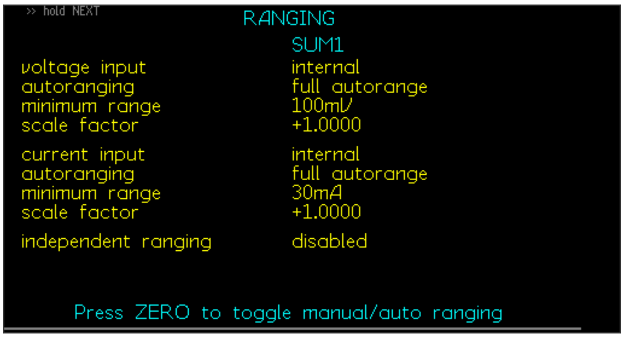
Test equipment for demonstration:
1 x Inverter/Motor test unit (single phase)
1 x HF 003 Current Shunt (shunt resistance = 470mΩ)
Wiring Configuration:



Connect Black 4mm lead from Load & Yellow 4mm from source

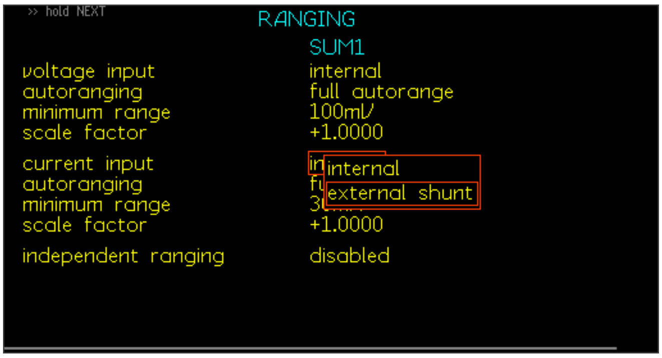
Setting the PPA

Press the *RANGE* button



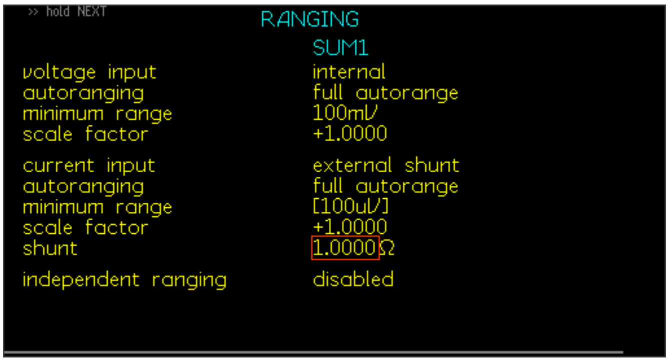
Press the ▼ key 5x until the flashing red highlight surrounds the ***current*** input parameter

Press the ► key and select ***external shunt*** by use of the ▼ key.

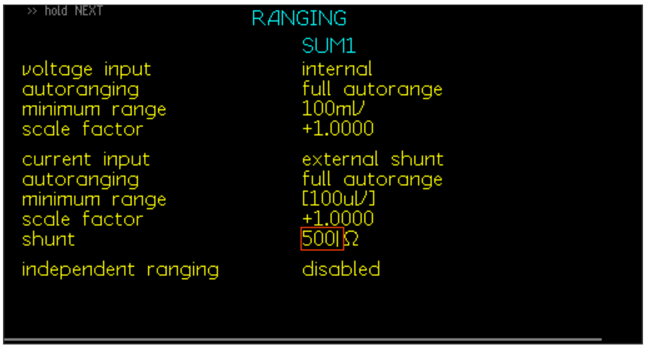


Press *ENTER*, to select the external shunt.

Press the ▼ key 4x until the flashing red highlight surrounds the ***shunt*** parameter.

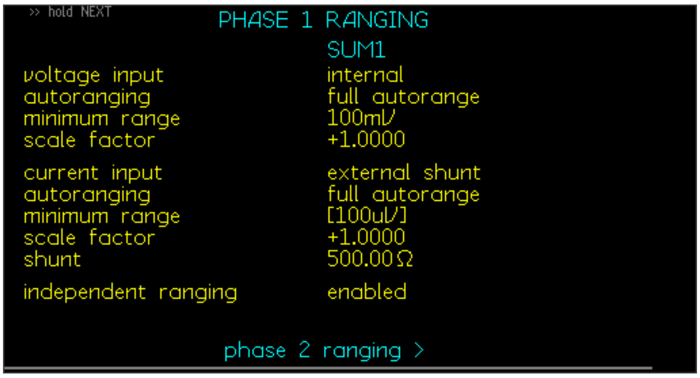


Manually input the shunt resistance value using the numeric keypad



Press *ENTER*, external shunt value will now be selected, in this instance the value has been set to 500Ω

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*** at the bottom of the ranging menu.



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.

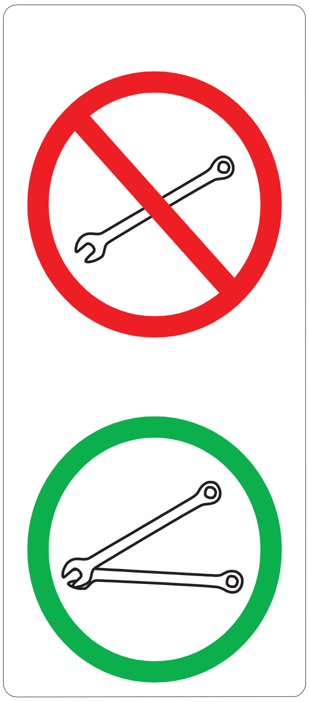
Remember to disconnect all leads to appropriate channels internal current shunts

CAUTION. Connection to some models of HF shunt are 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

Current Shunt Model	Spanner Size
HF100 + HF200	17mm
HF500	24mm



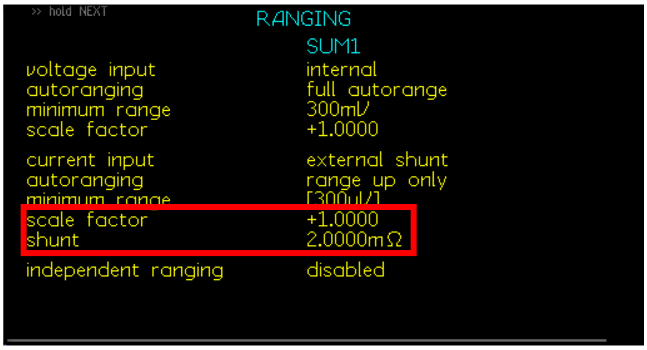
Damage to the shunt will occur when using only 1 spanner

Always use 2 spanners to limit torque stress on the shunt stud

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

---

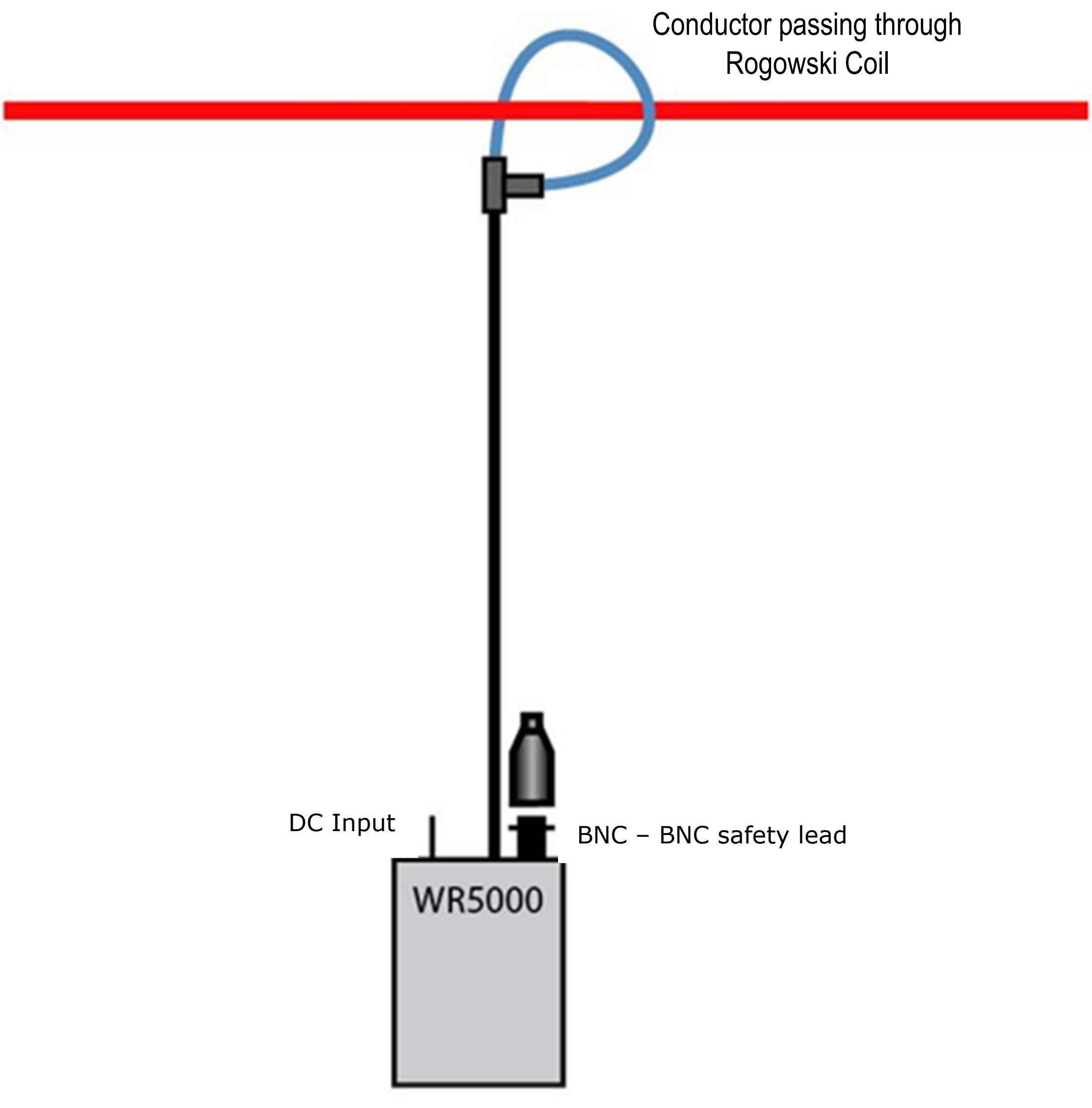
⚠ **IMPORTANT.** Multiple turns around the conductor:
If the coil is wrapped twice around the conductor set the shunt value to 4mΩ If the coil is wrapped 3 times around the conductor set the shunt value to 6mΩ etc.

Connection should be made as per the following diagrams:

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

CAUTION. Remember to connect either the Internal or External shunt only to the PPA3500



Zero Flux Current Transformers (CT)

For measuring currents exceeding the internal current shunts fitted to the PPA3500 series

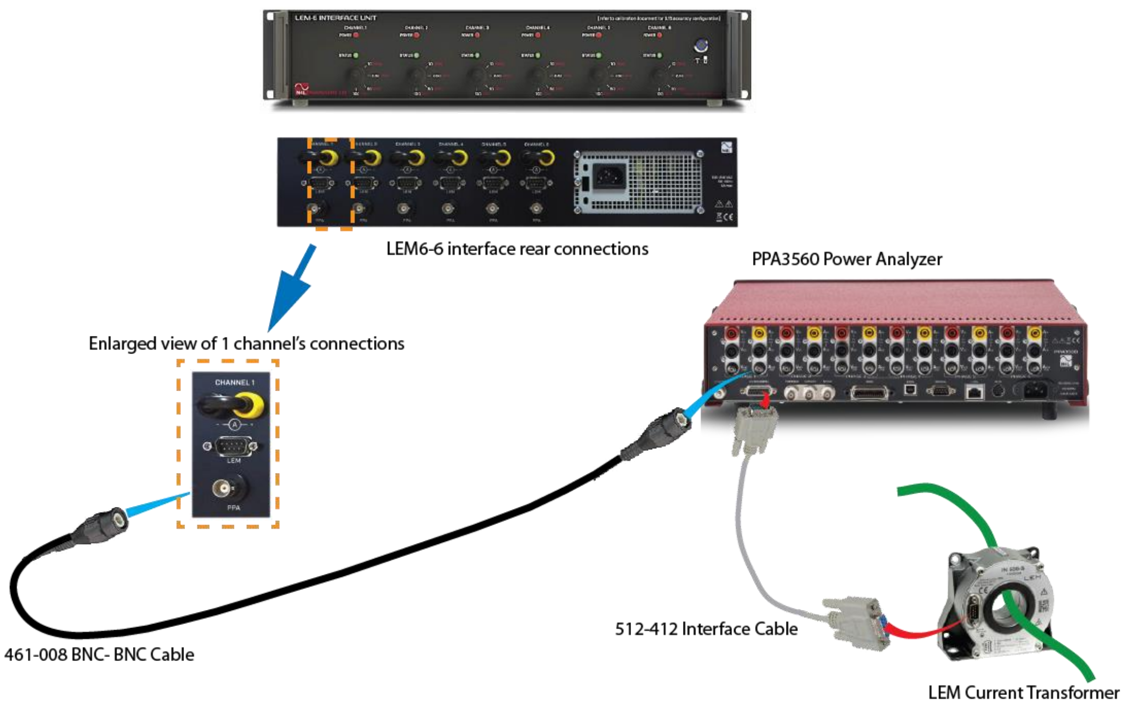
PPA3500-LC	10Arms
PPA3500	30Arms
PPA3500-HC	50Arms

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 - 6 phase 19" rack mountable interface for current transformers



Connection diagram

The N4L LEM-6 Interface serves as a high accuracy, highly stable interfacing unit allowing simple "plug and play" connection of the PPA3500 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.

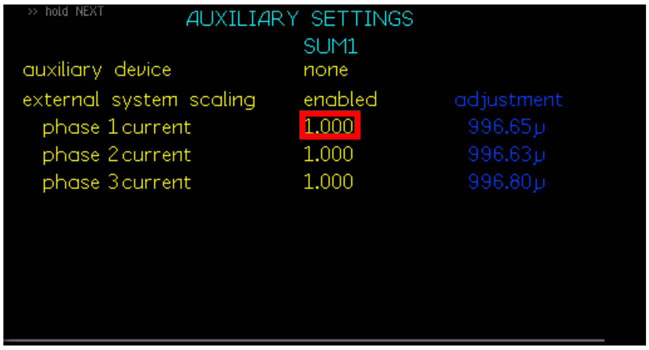
Model Number	Current Rating		Conversion Factor
IT60-S	60Apk	42Arms	600
IN100-S	150Apk	100Arms	500
IT200-S	200Apk	141Arms	1000
IN200-S	200Apk	300Arms	1000
IT400-S	400Apk	282Arms	2000
IN400-S	400Apk	600Arms	1500
IT700-S	700Apk	495Arms	1750
ITN600-S	600Apk	424Arms	1500
IN500-S	500Apk	800Arms	750
DS50ID	150Apk	50Arms	500
DS200ID	370Apk	200Arms	500
DS300ID	500Apk	300Arms	1000
DS400ID	600Apk	300Arms	1000
DS600ID	1000Apk	600Arms	1500
DM1200ID	1800Apk	1200Arms	1500

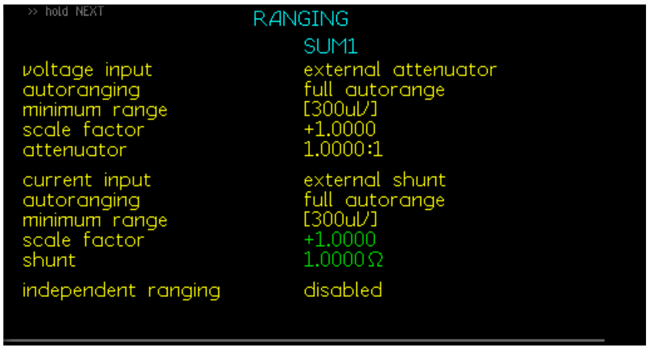
INFORMATION. N4L supply a wider range of current transformers than listed above, however the other models are not suitable to be used with the LEM 6-X interface as the power requirements are above that of the LEM 6 PSU. In this case then we offer a LEM-1 interface

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.

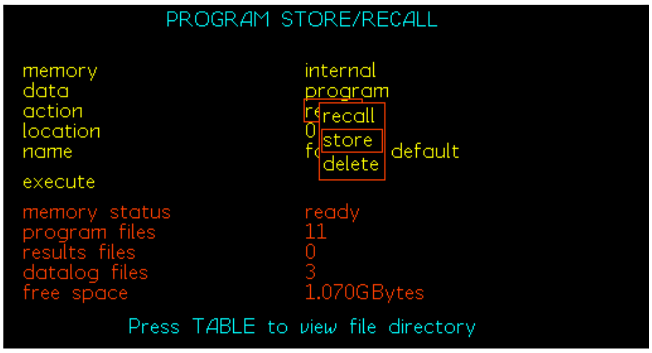
Following System Calibration, the Calibration Adjustment figures for the 4 current shunts on the LEM6 are stored in program location 1 on the instrument. They are then automatically recalled each the instrument is switched on.

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.

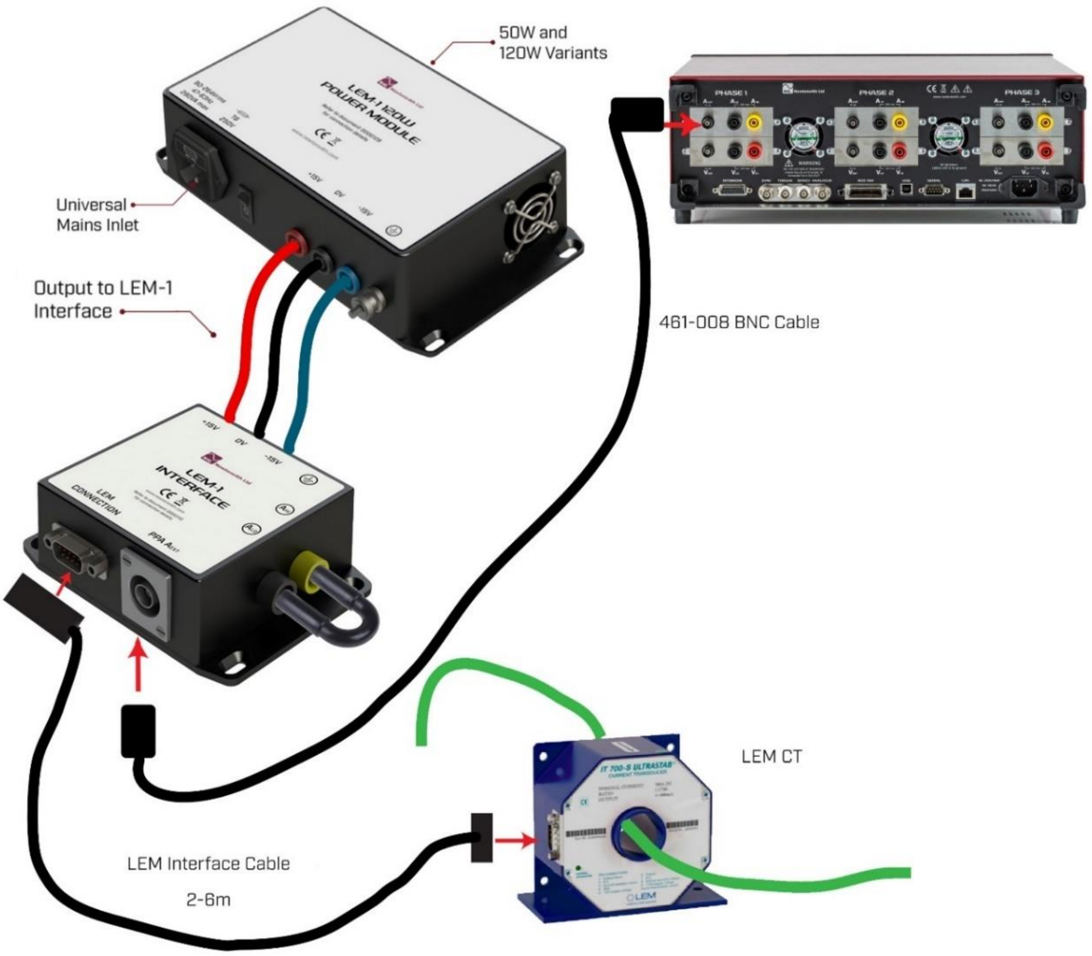


Only the settings stored in program location 1 are automatically recalled each time the instrument is switched on. Should it be preferred to not have them automatically recalled they can instead by saved to an alternative memory location and then deleted from location 1. The User can then recall the 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, which can be downloaded from our web site.

The LEM 1 interface system is suitable with the complete range of LEM and Danisense CT models that N4L supply.

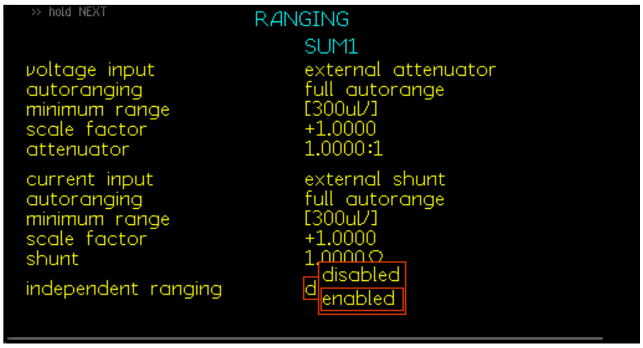


For multi-phase systems, each phase requires a separate LEM 1 interface, the number and wattage of the LEM 1 PSU's is dependent on which CT model and the number of phases required.

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

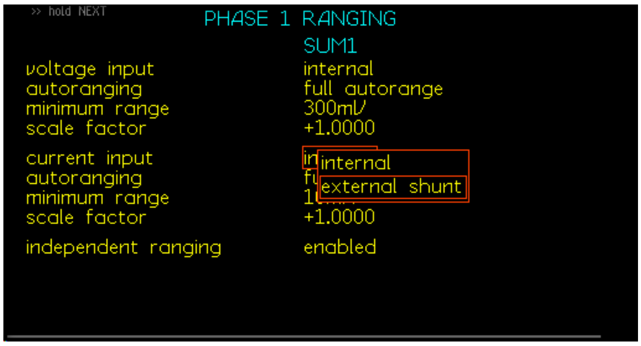
Press the *RANGE* key



Press the ▼ key 10x until ***independent ranging*** is highlighted red

Press the ▶ key, select ***Enabled*** with the ▼key.

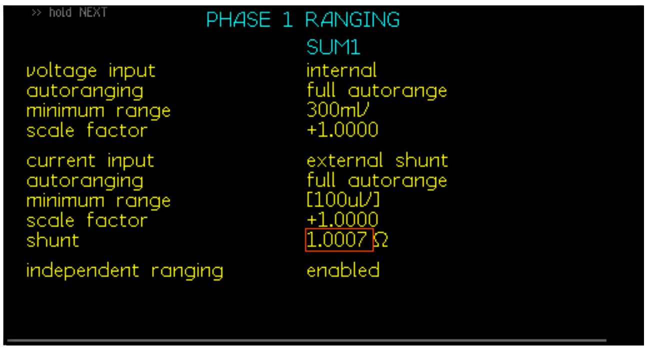
Press the ENTER key twice to return to the power analyser screen.



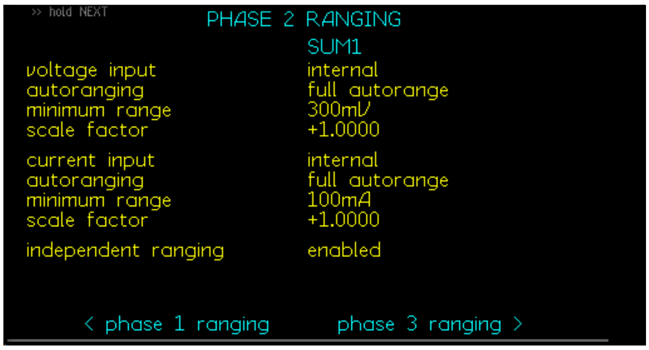
Press the ▲ key five times until Current Input is highlighted.

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.

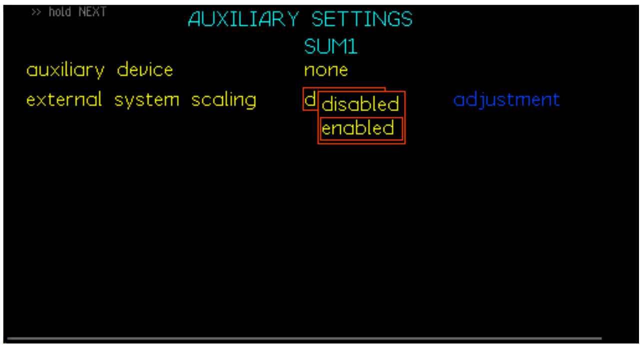


Press the ▼ key and set the ***shunt*** value to the actual value from calibration certificate. 1.0007Ω in this instance. Press the



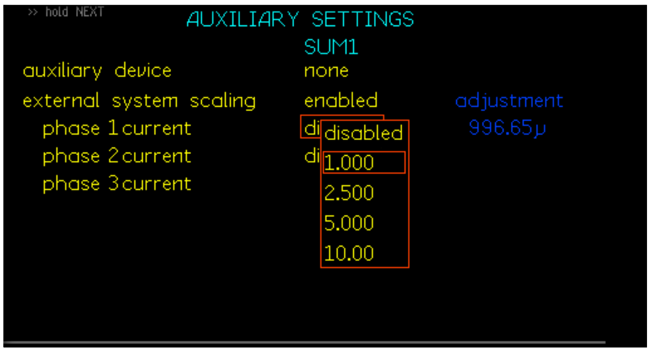
Press *ENTER* followed by the *HOME* key then using the ▶ key go to the next phase connected to the PPA.

Use with system calibrated CT's

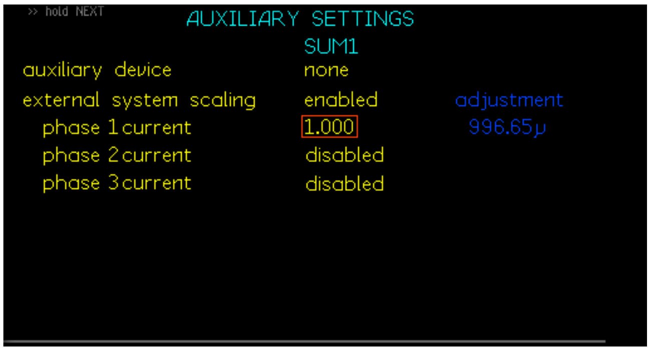


Press the *AUX* key
Press the ▼ twice to highlight ***External system scaling***.

Press the ▶ key followed by the ▼key to highlight ***enabled***, then press the *ENTER* key twice to select enabled and return to the Power Analyzer screen.



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

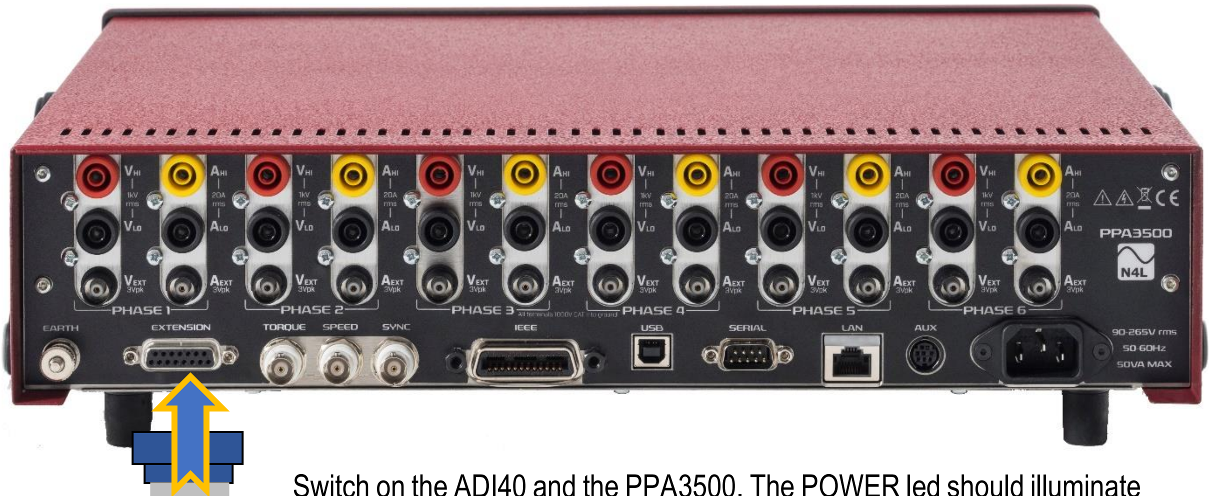
Additional I/O interfaces

The use of the ADI40, enables the PPA3500 series to become a multi-channel measurement system, allowing integration between the PPA3500, 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 PPA3500

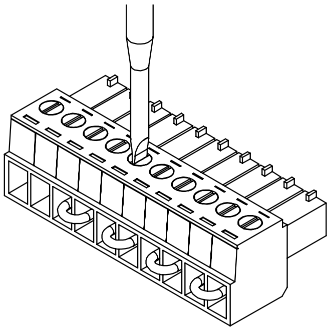
The thermocouple inputs are differential with a range of ± 20mVDC and is suitable for both J and K type thermocouples.



Switch on the ADI40 and the PPA3500. 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, 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 PPA3500 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 PPA5500 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 PPA3500 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 from our website.

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. 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 *RANGE* menu there will be the opportunity to switch between each phase by use of the ► & ◄ keys

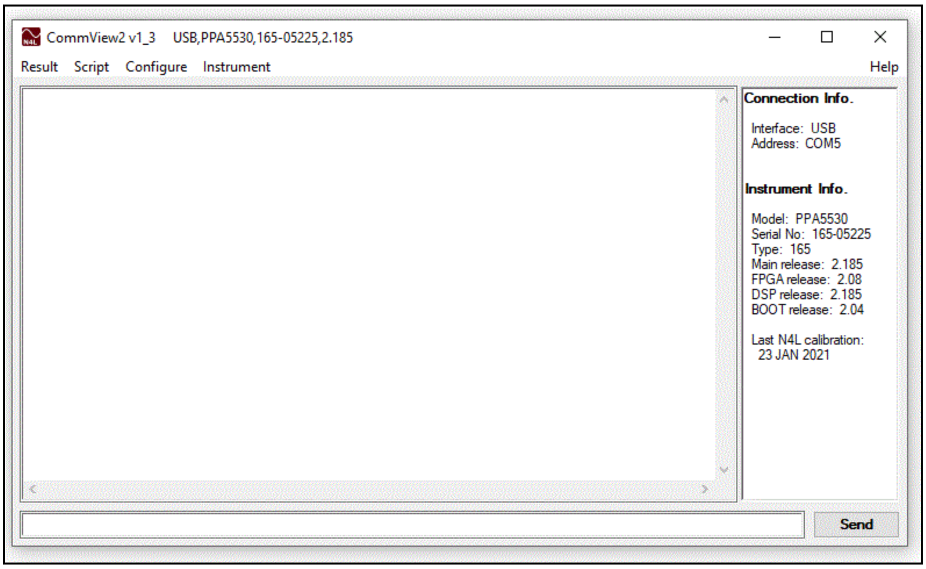
Appendix A- Accessories and software

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
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 https://resources.newtons4th.com/

A full range of PPA accessories can be found on our website.

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 PSMPPA3500 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 PPA3500. 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 PPA3500

lines beginning with # are commands for CommView2

any other line is a comment.

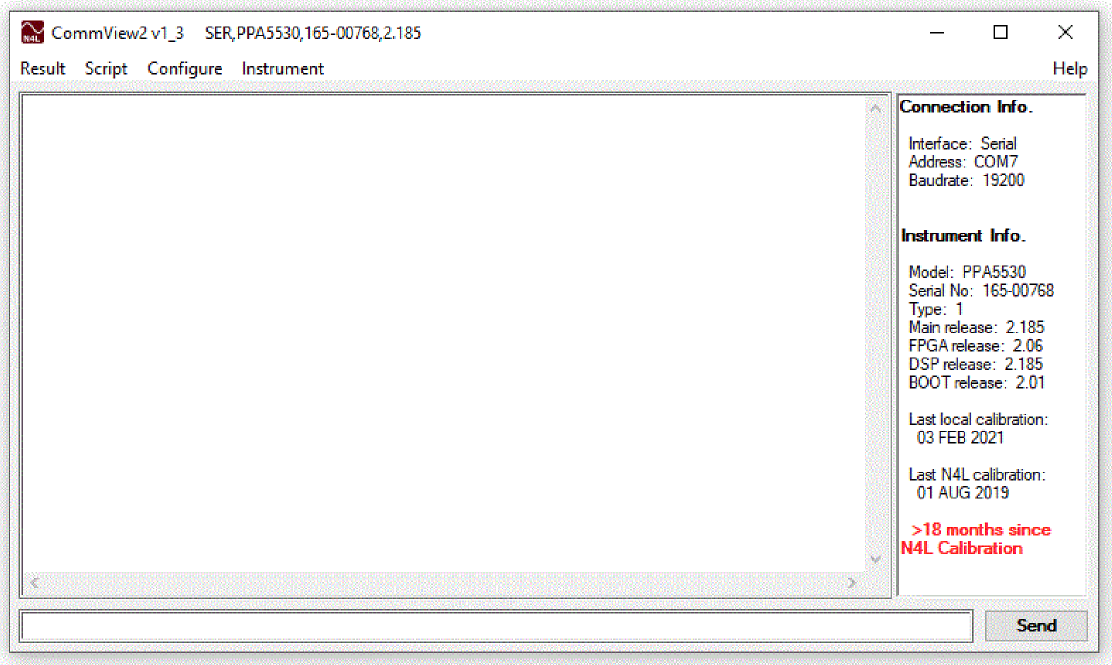
The # commands that are recognised:

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 https://resources.newtons4th.com/ 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.

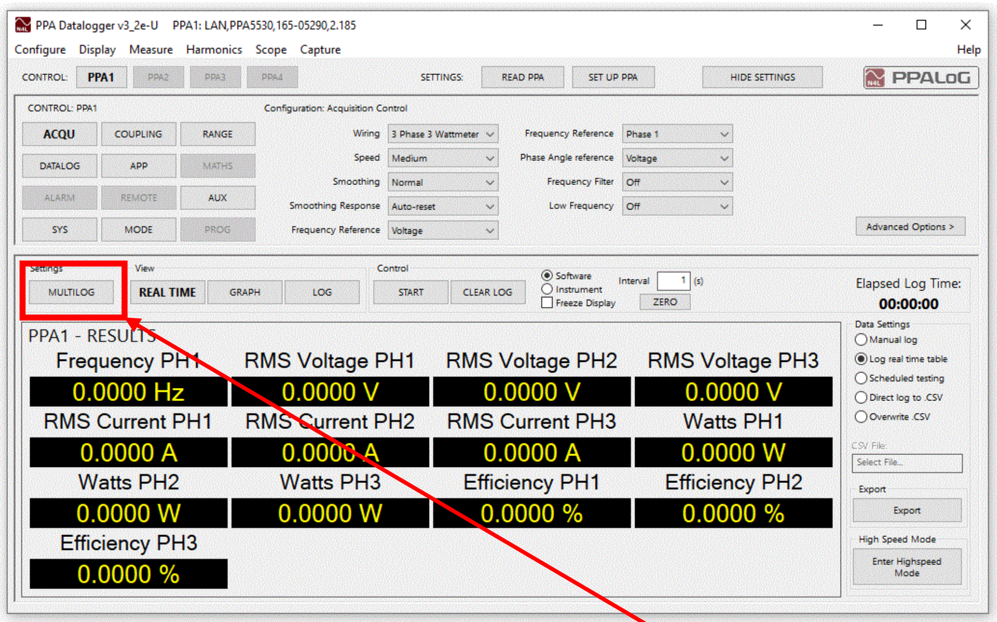
PPA Datalogger is a self-contained executable software program written in C++ using the Microsoft win32 graphics set.

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.

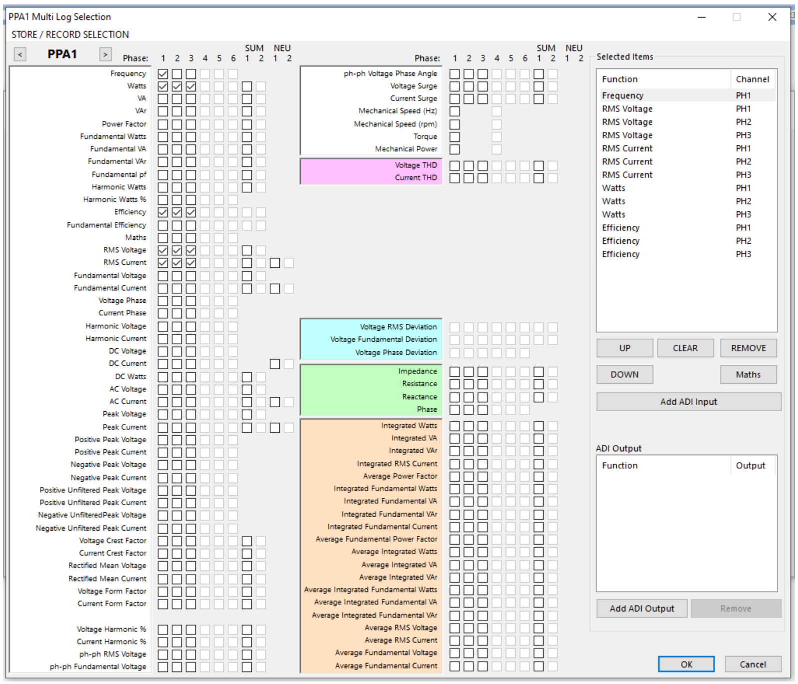
PPA Datalogger has the capability to communicate with up to 4 different PPA Instruments at the same time.

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:



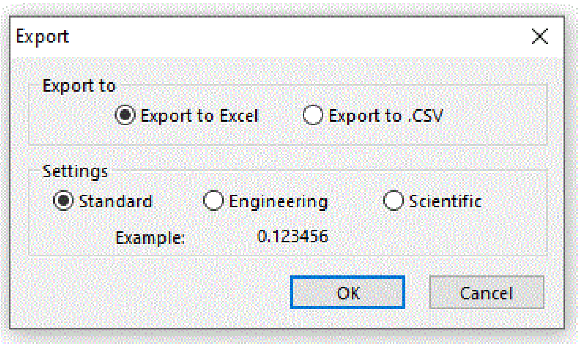
There are several measuring modes including:

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.

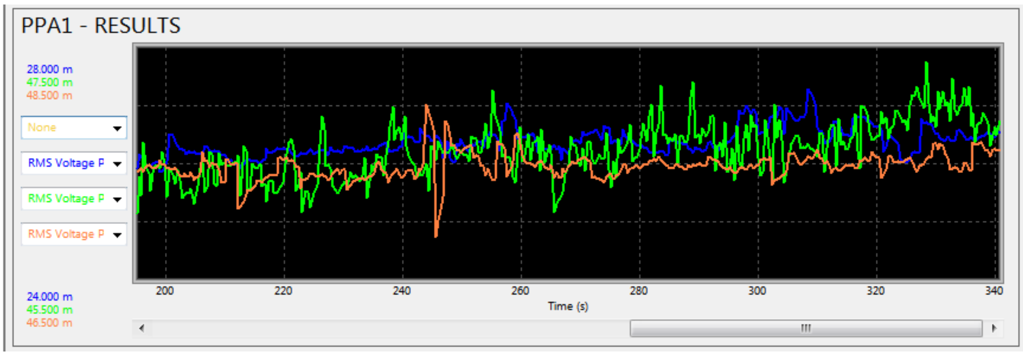
Direct Log to CSV Mode: The data is recorded from the instruments straight to a CSV file.

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.

Appendix B-Serial Command Summary

command format	reply format
*CLS	
*ESE,value	
*ESE?	single integer data value
*ESR?	single integer data value
*IDN?	company,product,serial no,version
*OPC?	0 or 1
*RST	
*SRE,value	single integer data value
*SRE?	
*STB?	single integer data value
*TRG	
*TST?	single integer data value
*WAI	
ABORT	
ADIMAP,output,multilog, offset,scale	
ALARM,latch,sounder	
ALARM?	single integer data value
ALARME,value	
ALARME?	decimal equivalent of alarm bits
ALARM1,type,data,hi,lo	
ALARM2,type,data,hi,lo	
APPLIC,type,setting	

BANDWI,phase,type	
BEEP	
BLANKI,on/off,threshold	
CALVER,string	
CALVER? CAPTUR?	string
CONFIG,parameter,data	
CONFIG,parameter?	single integer or real data value
COUPLI,phase,coupling	
DATALO,function,interval	
DATALO,LINES?	single integer data value
DATALO,0?	index,time,data… one record per line
DATALO,start,records?	index,time,data… one record per line
DAV?	single integer data value
DAVER,value	
DAVER?	single integer data value
DISPLAY,phase	
DISPLAY?	multiple real data values
EFFICI,type	
EFFICI?	total efficiency, fundamental efficiency
FAST on/off	
FQLOCK,on/off	
FQREF,phase,channel	
FREQUE,frequency	
HARMON,para,h,hmax	

HARMON,phase? or	freq,mag1,mag2,hmag1,hmag2, h1,h2, thd1,thd2,hphase1,hphase2
HARMON,phase,SERIES? or	mag,%, x n harmonics mag,phase, x n harmonics
HOLD,on/off	
INPUT,channel,type	
INTEGR,type,display INTEGR,RUNTIM,hours,mins	
INTEGR,phase?	time,Wh,Wh.f, VArh,VArh.f,VAh,VAh.f, pf,pf.f,Vav,Vav.fAh,Ah.f
KEYBOA,value	
LCR,conditions,param,head	
LCR,phase?	freq,Vmag,Amag,impedance,phase,R, L,C,tanδ,Qf,reactance
LOWFRE,on/off	
MODE,type	
MSLAVE,type	
MULTILOG,index,phase,func	
MULTILOG? NORMALISE,current NORMALISE,voltage	1-30 floats as selected
PFCONV,convention PHANGREF,reference	Current or Voltage
PHASEM,ratio	
PHASEM,phase?	Freq,mag1,mag2,dB,phase
PHCONV,convention	
POWER,sum A	

POWER,PHASE,WATTS?	Freq,W,W.f, VA,VA.f,Var,Var.f,pf,pf.f, Wdc,W.h
POWER,PHASE,VOLTAGE?	Freq,rms,mag,dc,ϕ,peak,cf,mean,ff, harmonic
POWER,PHASE,CURRENT?	Freq,rms,mag,dc,ϕ,peak,cf,mean,ff, harmonic
POWER,PH-PH?	Freq,rms1,mag1,ϕ1,rms2,mag2, ϕ2, rms3,mag3,ϕ3
POWER,RMS?	Freq,vrms1,vdc1,arms1,adc1,vrms2, vdc2,arms2,adc2,vrms3,vdc3, arms3, adc3
POWER,VECTORS?	Freq,mag1,ϕ1,mag2,ϕ2,mag3,ϕ3, mag4,ϕ4,mag5,ϕ5,mag6,ϕ6
POWER,WVA?	Freq,w1,vrms1,arms1,w2,vrms2, arms2,w3,vrms3,arms3
PROGRAM,function,number	
PROGRAM,files? PROGRAM,name?	Lists all program files Name of selected program
RANGE,ch,ranging,range	
RESOLU.format	
RESULT,function,number	
RESULT	multiple integers
REZERO	
SCALE,channel,factor	
SCALE,channel?	Single real data value
SCOPE,phase,v/a?	range, trigger, 250 signed integer data values
SHUNT,channel,resistance	
SHUNT,channel?	Single real data value
SMOOTH,type,dynamics	

SPEED,value,window	
START	
STATUS,channel?	Range number,range text,over/low/ok
STOP	
STREAM,enable,window	
STREAM,disable	
STREAM?	Data, data, data, data, data, …..
SUSPEN,on/off	
TEMPER,type,scale,offset	
TEMPER?	single real data value
TORQSP,type,tscale,sscale	
TORQSP,OFFSET,toff,soff	
TORQSP?	Mechanical power, torque, speed
USER?	3 CR terminated text strings
VARCON,convention	
VERSION?	Datecode,cpu,dsp,fpga,boot
VRMS	
VRMS,PHASE,RMS?	Rms1,rms2,dc1,dc2,ac1,ac2
VRMS,PHASE,MEAN?	Rms1,rms2,mean1,mean2,ff1,ff2
VRMS,PHASE,SURGE?	Pk1,pk2,cf1,cf2,surge1,surge2
WIRING,configuration	
ZERO	
ZERO,DELETE	
ZOOM,level,d1,d2,d3,d4	
ZOOM?	Level,d1,d2,d3,d4

Appendix C- 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	{	|	}		

Appendix D- Configurable parameters

All parameters can be accessed using the CONFIG command:

CONFIG,*parameter*?

CONFIG,*parameter,data*

Number	Function
	System parameters
1	operating mode
2	digital resolution
3	master/slave
4	autozero manual or auto
6	phase convention
7	Frequency lock constant / dynamic / normal
8	graph
9	keyboard beep on/off
10	ignore overload
11	low frequency mode
12	window size
13	speed
14	Smoothing
15	Smoothing response
16	baud rate
18	LAN IP address nibble 3
19	LAN IP address nibble 2
20	LAN IP address nibble 1
21	LAN IP address nibble 0
22	Independent ranging

	Input parameters (phase 1)
24	enable channel 1
25	enable channel 2
26	input range channel 1
27	input range channel 2
28	input ranging channel 1
29	input ranging channel 2
30	coupling
31	bandwidth
32	scale factor channel 1 voltage
33	scale factor channel 2 current
34	external shunt channel 1
35	external shunt channel 2
	General parameters
38	Remote resolution
40	voltage or current frequency reference
	Display parameters
41	display page
42	zoom level
43	function zoomed on 1
44	function zoomed on 2
45	function zoomed on 3
46	function zoomed on 4
47	datalog display type

	Advance parameters
48	manual frequency
49	DFT selectivity

50	program 1-6 direct load
51	language (if installed)
52	frequency filter
53	phase reference current / voltage
	Datalog parameters
54	datalog zoom 1
55	datalog zoom 2
56	datalog zoom 3
57 58 59	datalog zoom 4 datalog memory type datalog interval
60	datalog graph
	Maths parameters
61	formula
62	argument 1
63	sub argument 1
64	coefficient 1
65	argument 2
66	sub argument 2
67	coefficient 2
 69	**Application mode parameters** minimum frequency (dynamic)
70	application mode
71	PWM frequency filter
72	ballast frequency tracking speed
73	PWM low frequency mode
	More maths parameters
74	argument 3
75	sub argument 3

76	coefficient 3
77	argument 4
78	sub argument 4
79	coefficient 4
	Power meter parameters
80	temperature
81	sum watts
82	wiring configuration
83	integration type
84	torque and speed enable
85	torque scaling Nm/V
86	speed scaling Hz/V
87	pulses per revolution
88	integration display
89	sum current average
90	phase 3 frequency reference
91	power factor sign convention
92	VAr sign convention
93	efficiency computation
94	range lock
95	mechanical torque offset
96	mechanical speed offset
	Harmonic analyser parameters
99	computation mode
100	selected harmonic
101	maximum harmonic
	More maths parameters
102	harmonic bargraph voltage
103	rated current for TRD
104	harmonic bargraph current
105	Extended harmonic frequency range

	Oscilloscope parameters
106	time-based
107	trigger level
108	Pre-trigger
109	trigger polarity
110	trigger mode
111	trigger reference
112	trigger phase
113	cursors enable
114	trigger HF reject
115	traces
	System parameters
119	zoom 2 high resolution
120	brightness
121	display
	Auxiliary parameters
122	Auxiliary drive
128	PICS phase offset
129	PICS cycles
	Other power parameters
130 131	speed input gear ratio 2 wattmeter sum computation
132	integrator run time
133 134	phase to phase mean phase to phase measurement
135	Difference THD

	LCR meter parameters
137	parameter
138	measurement
139	offset
	Phase meter parameters
140	rms voltage peak
143	sampling rate/compensation
144	rectified mean
148	dB offset
150	computation
	System parameters
152	RS232 printer enable
153	IEEE address
154	interface
155	recall with program
	Alarm functions
156	alarm 1 data
157	alarm 1 type
158	alarm 1 high threshold
159	alarm 1 low threshold
160	alarm latch
161	alarm sounder
162	analogue output
164	analogue zero
165	analogue full scale
167	alarm 2 data
168	alarm 2 type
169	alarm 2 high threshold
170	alarm 2 low threshold
171	sync on alarm

	Input parameters (phase 2)
176	enable channel 3
177	enable channel 4
178	input range channel 3
179	input range channel 4
180	input ranging channel 3
181	input ranging channel 4
182	acdc coupling phase 2
183	bandwidth phase 2
184	scale factor channel 3 voltage
185	scale factor channel 4 current
186	external attenuator channel 3
187	external shunt channel 4
	Input parameters (phase 3)
200	enable channel 5
201	enable channel 6
202	input range channel 5
203	input range channel 6
204	input ranging channel 5
205	input ranging channel 6
206	coupling phase 3
207	bandwidth phase 3
208	scale factor channel 5 voltage
209	scale factor channel 6 current
210	external attenuator channel 5
211	external shunt channel 6
	Program storage
217	memory
218	data
219	action
220	location

	System clock
240	set clock (hrs)
241	set clock (mins)
242	set clock (secs)
243	set date (day)
244	set date (month)
245	set clock (year)

Appendix E- 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 SUM1
grouping	
PPA3530	1+2+3 : 1+2+3
PPA3540	1+2+3 : 4
PPA3550	1+2+3 : 4+5
PPA3560	1+2+3 : 4+5+6
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 >	
name	SUM1
DFT selectivity	normal
ignore overload	off
frequency lock	normal

minimum frequency	500.0mHz
high speed	disabled
watts	signed
synchronise window	disabled
normalise reference	disabled
<return	

COUPLING	COUPLING
coupling	ac+dc
bandwidth	wide (dc-1mhz)
noise filter	off

RANGE	RANGING
voltage input	internal
autoranging	full autorange
minimum range	1300mv
scale factor	+1.0000
current input	internal
autoranging	full autorange
minimum range	10ma
scale factor	+1.0000
Independent ranging	disabled

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	on
Minimum frequency	500.0mHz
torque + speed	disabled
efficiency	mechanical / sum

APP	APPLICATION SELECTION
mode	Inrush current
default settings	press ENTER here to load
minimum range	100A
auxiliary device	PCIS inrush switch
switch phase offset	90˚
switch on cycles	Single cycle

APP	APPLICATION SELECTION
mode	Lighting ballast
default settings	press ENTER here to load
ac line	50.00Hz
frequency tracking	fast
efficiency	next phase / phase

APP	APPLICATION SELECTION
mode	transformer mode
default settings	press ENTER here to load
rectified mean	absolute

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
disconnect all measurement inputs for manual zero	
press ENTER here to execute	
press ENTER here to save	

MATHS	MATHS FUNCTIONS
formula	disabled

ALARM	ALARM OPTIONS
alarm 1 data	zoom 1
alarm type	disabled
high threshold	+1.0000
low threshold	+100.00m
alarm 2 data	zoom 2
alarm type	disabled
high threshold	+1.0000
low threshold	+100.00m

REMOTE	REMOTE SETTINGS
resolution	normal
interface	USB
recall with program	off
screen print	USB memory stick

AUX	AUXILARY SETTINGS
auxiliary device	none
external system scaling	disabled

SYS	SYSTEM OPTIONS
Set clock	10:32:59
Set date	28 Jun 22
brightness	high
phase convention	0° to -360°
Phase angle reference	cosine
Keyboard beep	enabled
autozero	auto
program 1-4 direct load	disabled
Zoom 2 high resolution	disabled
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	enabled
User data	Newtons4th Ltd
User data	
User data	
save	
< 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, and allow the mode to be changed.

MODE	Power analyzer
power factor sign	negative leading
VAr sign	negative lagging
sum current	average
sum VA & VAr	low distortion
input compensation	disabled
conversion	ph-ph rms
efficiency	disabled
penultimate line	V ph-ph
last line	VAr
More options >	
torque + speed	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
selected harmonic	3
harmonic series up to	40
voltage bargraph scale	100.0%
current bargraph scale	100.0%
conversion	normal

MODE	oscilloscope
timebase	10.00ms/div
trigger reference	voltage
trigger level	+200.0mV
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	rue rms voltmeter
rectified mean	absolute
peak	signed
crest factor	auto
Last line	Crest factor

MODE	Phase meter
speed	medium
smoothing	normal
smoothing response	auto reset
computation	ch2/ch1

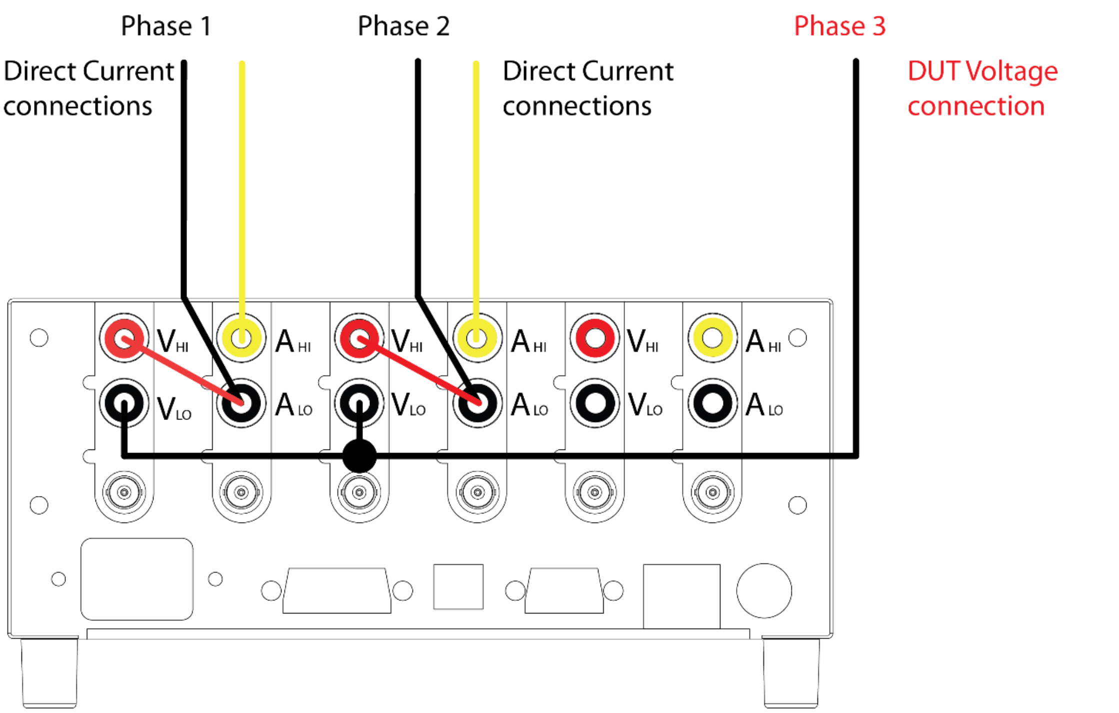
PROG	Program Store/Recall
memory	Internal
data	program
action	recall
location	0
name	factory default
execute	

Appendix F- Physical connection diagrams

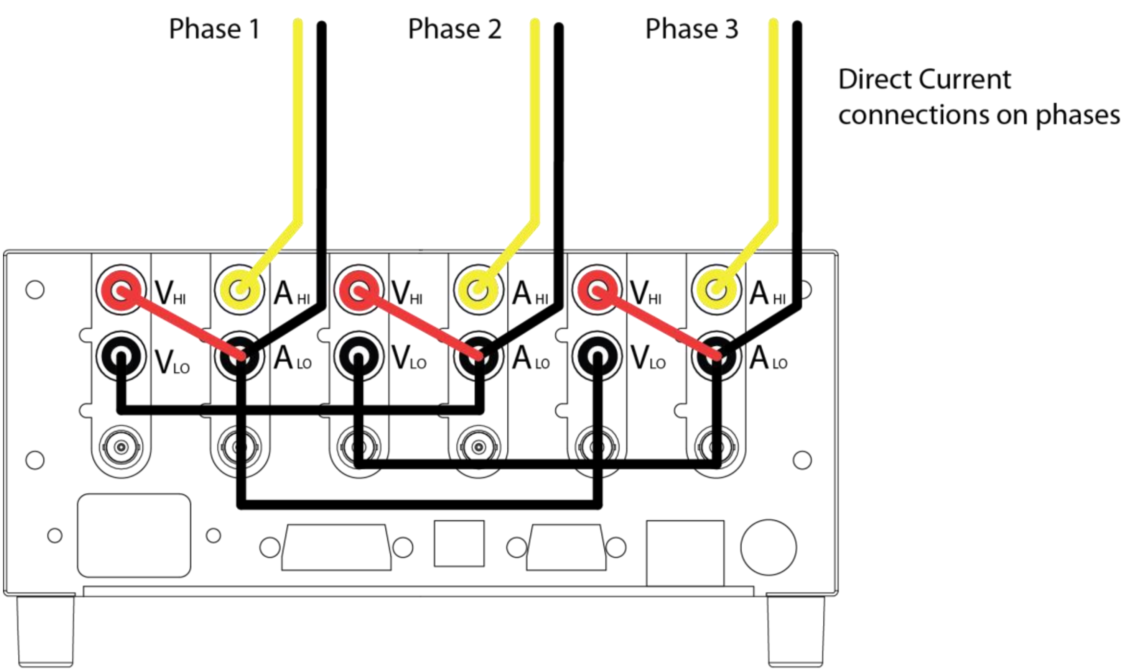
Although the following diagrams show a PPA 500/1500 rear panel, the connector configuration is the same on the PPA3500 range

Internal connections only

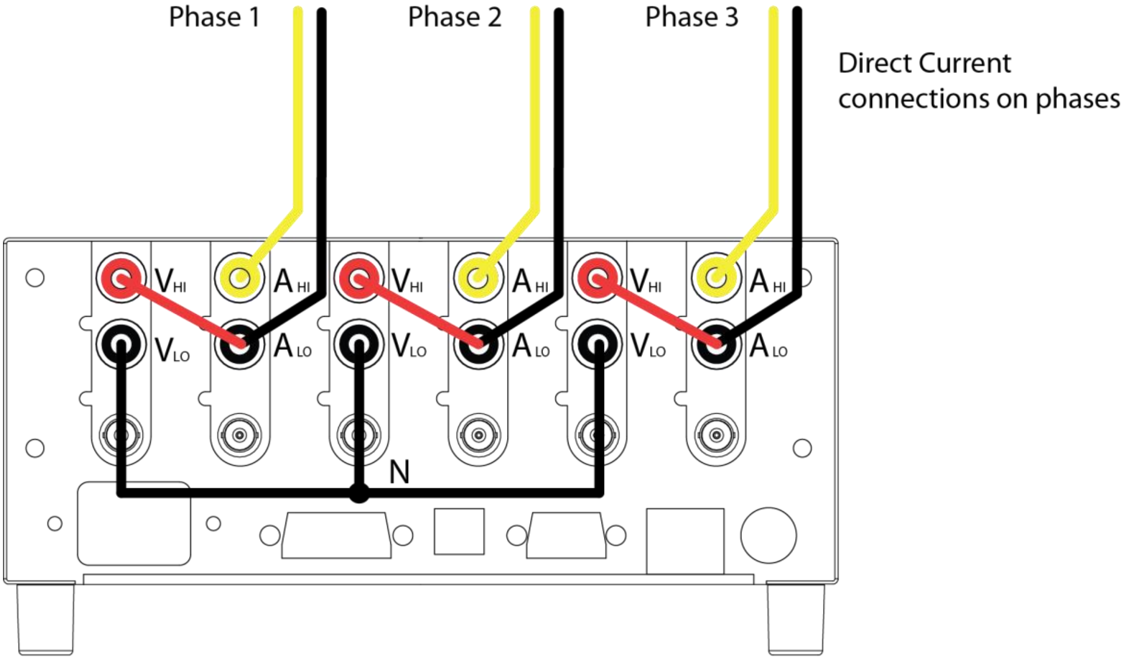
3P2W - Delta



3P3W - Delta



3P3W - Star



Phase 1
Phase 2
Phase 3
Direct Current
connections on phases
VHI
AHI
VLO
ALO
N

Appendix G- Contact Details

Please direct all queries or comments regarding the PPA3500 instrument or manual to:

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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.

PPA3500 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.		