PA900

PRECISION MULTI-CHANNEL HARMONIC POWER ANALYZER

OPERATING MANUAL

ABOUT THIS MANUAL

This document is formatted to be best viewed on a computer using a suitable reader application rather than being printed on paper and then read. If printed, then it should be printed using color.

The table of contents is "clickable". You may click on any of the entries to go to that section. The table of contents is also made available as Bookmarks for Adobe Reader or Acrobat, allowing you to permanently display the table of contents alongside the document and navigate by clicking on each section as needed.

The typical user does not need to read the entire manual, it is recommended that you look through the table of contents and read those sections which are applicable to your intended application.

This document applies to the PA900 having a main firmware revision of 1.0.19, there may be differences if the PA900 has a different main firmware version.

Throughout this document images of actual PA900 screens are shown. The actual screen displayed may be slightly different from that shown in this document because of changes to firmware, differences in PA900 option content and configuration settings in the PA900.

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PRODUCT FEATURES

- Low cost of ownership with 2 year parts and labor warranty; 2 year accuracy specs and recommended calibration cycle
- Reliable state of the art fully solid-state design with 2.9GIPs RISC processing and FPGA based sampling control
- Large, high-resolution color display shows all the data you want with an easy-to-use touchscreen user interface to get you up and testing in no time
- Highest precision measurements with industry-leading noise floor and linearity
- Extremely wide dynamic range allows signals with crest factors to over 30:1 to be measured with full accuracy without having to reconfigure, and allows range-less operation (within each shunt) providing truly gapless measurements with varying signals and is one less thing for you to configure and worry about
- All configured measurements are always performed, no need to reconfigure for specific results
- Up to 100 readings per second with no reduction in accuracy
- Measurement of up to 500 harmonics and harmonics frequencies up to over 300kHz exceeding avionics power measurement requirements (with option H500 and W type channels)
- Measurements of low power meeting the requirements of EN50564:2011 are built into the PA900 as standard. A computer is not needed
- Front Panel USB Drive Interface for portable flash drives or hard disc drives –
    - Data log to a file (up to 100 per second) in text or binary formats
    - Save an image of the screen – great for engineering record keeping
    - Import and export screen and measurement configurations – great for sharing a configuration between units or just having your very own configuration handy
    - Import and export harmonics limits – makes it easy to switch between different harmonics requirements
    - Export textual harmonics listings, complete measurement results, or scope capture listings – makes generating your own reports easy without mistakes
- Not a "one size fits all" with the extra cost and reduction in performance that entails – you only have to pay for of the capabilities and performance you want -
    - Up to four power measurement channel cards in any combination, each of three different channel card types -

      S - Provides 0.1% accuracy, 1MHz class bandwidth and 22bit sampling
      A - Provides world class 0.03% accuracy, 1MHz class bandwidth and 24bit sampling
      W - Provides 0.1% accuracy, 5MHz class bandwidth and 22bit sampling
    - Each channel card type is available with one of three current input options -

      D – Dual Shunt (up to 20Arms continuous and 150Apk inrush) in a single input terminal pair with resolution down to 0.1uA – no need to change terminals
      H - High Current (up to 30Arms continuous and 200Apk inrush) with resolution down to 10uA
      X – External Current Transducer or Shunt Input (20uV to 15Vrms) with resolution down to 0.1uV
- Up to three different Virtual Power Analyzers™ (VPAs) may be configured in the one unit for input/mid-point/output power and efficiency tests - there is no need to interconnect separate units in order to make synchronous or non-synchronous group power measurements.
- Measurements in each VPA are fully configured in a single screen at the touch of the screen, no hunting around for the configuration setting you need. Each may be configured as Nx1ø (1 to 4ch), 2ø3w (2ch), 3ø3w (2ch), 3ø3w (3ch) or 3ø4w (3ch) and each VPA has totally independent measurement configuration.
- A choice of screens to view the measurements, just one touch to change between any screens -
    - Power Data Screen - display V, A, W, VA, VAR and PF data for any single channel or for a group of channels, or display loading (impedance, resistance and capacitance/inductance), or display power loss and efficiency.
    - Custom Power Data Screen - lets you choose the data you want displayed in the color, font size and location you want, along with text you define
    - Harmonic Bar Chart Screen - displays harmonics with flexibly scaled bar charts and also a scrollable textual listing of both amplitude and phase results and harmonics can be checked against user supplied limits for each harmonic with individual harmonic and overall pass/fail indications
    - Vector Screen - displays fundamental voltage and current vectors with user defined coloring
    - History Screen – the unit automatically maintains a continuous historical recording of measurement data – no configuration needed. Any data from this record may be viewed with user defined scaling, offset and color
    - Scope View Screen - an extreme resolution digital scope to capture events such as in-rush current without interfering with other measurements
    - Cycle View Screen - represents a single cycle of the voltage and current periodic waveforms, jitter sampled over multiple cycles within each measurement period giving time resolution down to 2.6ns – no configuration needed
    - Standby Power Screen – allows EN50564 compliant low power measurements without the need for a computer.
- Connectivity - Ethernet, High Speed Serial and USB (client) control interfaces
- CE mark certified to EN61010

SAFETY

The user should be aware of these safety warnings at all times while using the PA900.

WARNING - THE PA900 MEASURES VOLTAGES AND CURRENTS WHICH MAY BE LETHAL; UNSAFE OPERATION MAY RESULT IN SEVERE INJURY OR DEATH.

WARNING - IF THE PA900 IS USED IN A MANNER NOT SPECIFIED BY VITREK THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED AND SAFETY MAY BE COMPROMISED.

POWER AND GROUNDING

WARNING - THE PA900 IS INTENDED TO BE POWERED FROM A POWER CORD HAVING A PROTECTIVE GROUND WIRE WHICH MUST BE INSERTED INTO A POWER OUTLET HAVING A PROTECTIVE GROUND TERMINAL. IF THE PA900 IS NOT POWERED FROM A SUITABLE POWER SOURCE THEN THE CHASSIS GROUND TERMINAL LOCATED NEAR THE POWER ENTRY CONNECTOR ON THE REAR PANEL MUST BE PROTECTIVE GROUNDED.

WARNING - DO NOT REMOVE THE POWER CORD FROM THE PA900 OR FROM THE SOURCE OF POWER WHILE IT IS MEASURING HIGH VOLTAGES. THIS WILL REMOVE THE PROTECTIVE GROUND FROM THE CHASSIS OF THE PA900 WHICH MAY RESULT IN HAZARDOUS VOLTAGES BEING ACCESSIBLE TO THE USER.

TERMINALS AND WIRING

WARNING - THE PA900 MEASURES VOLTAGES AND CURRENTS WHICH MAY BE LETHAL, ENSURE NO VOLTAGE OR CURRENT IS PRESENT WHEN CONNECTING TO OR DISCONNECTING FROM THE TERMINALS.

CAUTION – THE USER MUST USE WIRE WHICH IS RATED FOR THE HIGHEST EXPECTED VOLTAGE AND CURRENT FOR ALL CONNECTIONS TO THE PA900.

PHYSICAL SPECIFICATIONS AND INSPECTION

DIMENSIONAL

Nominal Dimensions	137mmH x 248mmW x 284mmD (5.4” x 9.75” x 11.2”) with feet not extended
Nominal Weight	3.2kg (7lb) net, 5kg (11lb) shipping

ENVIRONMENTAL

Storage Environment	-20 to 75C (-4 to 167F) (non-condensing)
Operating Environment	0 to 40C (32 to 104F), <85% RH (non-condensing), Pollution Degree 2
Operating Altitude	0 to 2000m (6560ft) ASL

POWER SUPPLY

Line Power	Installation Category II; 85-264Vrms, 45 to 65Hz, 40VA max. Internally fused with a non-user serviceable fuse

SAFETY

General Safety	Conforms to the requirements of EN61010-1
Measurement Safety	EN61010-1 CAT I 1000V; CAT II 1000V; CAT III 600V; CAT IV 300V

CAUTION – THE PA900 SHOULD NOT BE USED IN AN ENVIRONMENT WHERE CONDUCTIVE POLLUTION CAN OCCUR, E.G. IN AN OUTDOOR ENVIRONMENT.

CAUTION – IF THE PA900 IS TRANSPORTED BETWEEN DIFFERING ENVIRONMENTS AND CONDENSATION IS SUSPECTED, THE UNIT SHOULD REMAIN UNPOWERED FOR SUFFICIENT TIME FOR CONDENSATION TO HAVE DISSIPATED. IF THERE IS ANY DOUBT THEN CONTACT VITREK FOR ADVICE.

WARNING - IF FLUIDS OR OTHER CONDUCTIVE MATERIALS ARE ALLOWED TO ENTER THE PA900 ENCLOSURE, EVEN IF NOT POWERED, THEN THE PA900 SHOULD BE IMMEDIATELY TAKEN OUT OF OPERATION AND SERVICED AS SAFETY MAY HAVE BEEN COMPROMISED.

INSPECTION

After the PA900 has been shipped or otherwise handled in an unknown manner, you should visually inspect the PA900 for damage before attempting to operate it. Particular attention should be taken to ensure that there are no significant dents or cracks in any outer surfaces, there are no marks or scratches on the front panel LCD touchscreen, and that all terminals are securely mounted to the unit and are not cracked or significantly dirty. If any abnormality is noted then it is recommended that the PA900 be serviced prior to being placed into use, as safety may have been compromised.

OPTIONS AND ACCESSORIES

OPTION H500

This option extends the standard harmonic capability of a maximum of 100 harmonics to a maximum of 500 harmonics. This option is field installable, does not require removal of the PA900 covers, and does not affect calibration of the PA900; contact Vitrek for details.

ACCESSORY LPA-1

The accessory provides the connections necessary for you to connect a mains plug for a unit under test to a mains supply, with one channel of the PA900 analyzing the power drawn by the unit under test.

Note: this accessory is limited to a maximum of 300Vrms and 10Arms.

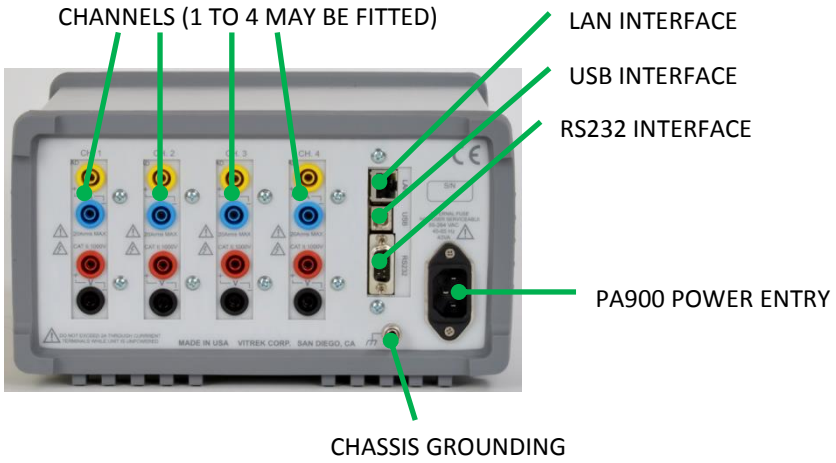
CD CONTENTS

To be determined.

FRONT AND REAR PANEL LAYOUT

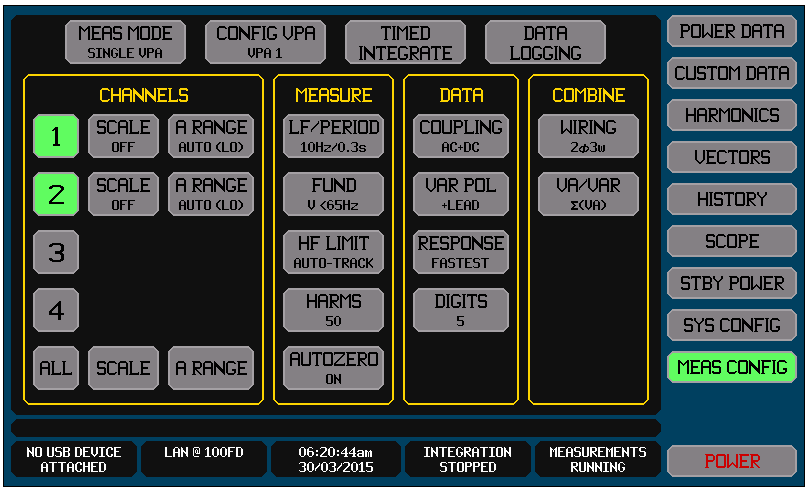
FRONT PANEL LAYOUT

REAR PANEL LAYOUT



GETTING STARTED

1) **Apply power to the PA900**.
    a) Attach a three wire power cord to the power entry connector on the rear panel of the PA900 and attach the other end to a suitable source of mains.
2) **Turn ON the PA900** (depending on how the PA900 has previously been configured this step might not be needed).
    a) Press and hold anywhere on the front panel screen for at least ½ a second. Use your finger tip or a stylus; do not use a pen or pencil.
3) **Decide what you need to measure**.
    a) Read the Applications section. For now, just look at the single VPA applications and tackle the more complex applications later.
4) **Wire your application to the PA900**.
    a) Ensure there are no voltages present while performing this.
    b) Read the relevant part of the Wiring to Channels section for details.
5) **Configure the PA900**.
    a) Press the MEAS CONFIG button on the PA900 screen.
        i) Full details are in the Configuring Measurements section, but for now just follow the steps below.
        ii) Initially we'll start with settings which are usable for just about any application; you can always come back and change these later if you want to optimize them for your specific application.
        iii) Everything is visible on the one screen which is shown by pressing the one button, so it's easy to remember how to change settings later but what you are now seeing is all you'll ever need to configure for many applications.



    b) MEAS MODE: Change this to SINGLE VPA if needed by pressing this button and then pressing the SINGLE VPA button on the choice screen.
    c) In the CHANNELS area of this screen -
        i) Select the channels you are using and deselect those you are not. Press each numeric channel button as needed to toggle the selection.
        ii) SCALE: If you are using PTs or CTs then setup the scaling for each channel, or turn off scaling if not using them. Press the SCALE button for each channel to change whether scaling is being applied or not and what scaling to apply as needed.
        iii) A RANGE: Not all channels have this button. Start with the HI range. Press the A RANGE button for each channel to change it if needed.
    d) In the MEASURE area of this screen, just four settings configures measurements –
        i) LF/PERIOD: Select 10Hz/0.3s. Press the LF/PERIOD button to change it if needed.
        ii) FUND: In most applications select for the fundamental to be measured from the voltage, and set the maximum fundamental frequency to just a bit higher than you expect. Press the FUND button, select VOLTAGE, and then set the maximum fundamental frequency -
            - For 50/60Hz applications set this to 65Hz
            - For 400Hz applications set this to 850Hz
            - For other applications set this to a high value above what you're expecting
            - If you're totally unsure then set it to 500kHz; when you start making measurements you'll see the frequency.
        iii) HF LIMIT: Select AUTO-TRACK to allow the PA900 to automatically configure itself for filtering. Press the HF LIMIT button to change it if needed.

iv) HARMS: Start with a setting of 50 unless you know you need other than this. Press the HARMS button to change it if needed.

e) In the DATA area of this screen, set up how you want to see the results –

i) COUPLING: Select AC+DC. If you know that you only want the DC values then select DC. Press the COUPLING button to change it if needed.

ii) VAR POL: Select +LEAD unless you prefer to display a positive VAR for a lagging PF (the +LAG setting). Press the VAR POL button to change it if needed.

iii) RESPONSE: Select MEDIUM. Press the RESPONSE button to change it if needed.

iv) DIGITS: Select 5. Press the DIGITS button to change it if needed.

f) In the COMBINE area of this screen (only shown if you're making multi-channel measurements) –

i) WIRING: Set this to the wiring configuration which you used to wire to the PA900. Press the WIRING button to change it if needed.

ii) VA/VAR: Select Σ(VA). Press the VA/VAR button to change it if needed.

g) That's it for configuration, you have just completely configured measurements in the PA900 and we didn't leave anything out. Press the POWER DATA button to save the configuration and to start seeing the measurements.

6) **You can apply voltage to your application now.**

7) **Select what results to look at**.

a) Viewing results is just a single press on one of the upper 7 buttons down the right side of the screen to view that screen. On each of these screens you can select several different ways of looking at the measurements. In all cases the buttons across the top of each screen allows you to select what you're looking at. A brief summary of each screen is as follows –

POWER DATA: enables you to view numerical results for –

All voltage, current, and power (W, VA, VAR and PF) measurements; in peak, RMS, fundamental only, or rectified forms.

Inrush.

Resistive, inductive and capacitive loading.

Integrated and long-term average measurements (e.g. Watt-Hours).

Efficiency and power loss.

CUSTOM DATA: enables you to view just about any numerical data you wish, along with descriptive text. You can configure a wide variety of formats for this screen.

HARMONICS: enables you to view voltage and current harmonics in both graphical and numerical formats.

VECTORS: enables you to view single or multi-channel voltage and current graphically as vectors on a polar chart.

HISTORY: enables you to see what's happened in the past without needing configuration beforehand. Gives a graphical chart of most measurement results with powerful zooming capabilities.

SCOPE: enables you to view the voltage, current and power waveforms without needing configuration (CYCLE VIEW), or to use the PA900 as a powerful oscilloscope (SCOPE VIEW).

STBY POWER: enables you to configure, run and view the results of EN50564 low power measurements in both numerical and graphical formats.

b) The PA900 always measures everything configured to be measured; measurements are not dependent on which screen you're looking at. So, for example, you can configure an oscilloscope capture on the SCOPE screen, change to another screen and then come back to the SCOPE screen later to see what's been captured.

c) Simply exporting a screen image to a USB drive file enables you to document your results for any screen.

d) If your signals have instability then the results displayed by the PA900 will respond to that instability and so the numerical results may be difficult to read. In those situations you should go back to the MEAS CONFIG for that VPA and adjust one or more of the following settings–

(1) Set the RESPONSE setting to a slower response. This averages all results over a number of measurement periods.

(2) Set the LF/PERIOD setting to a longer measurement period. This slows down the changes in the results.

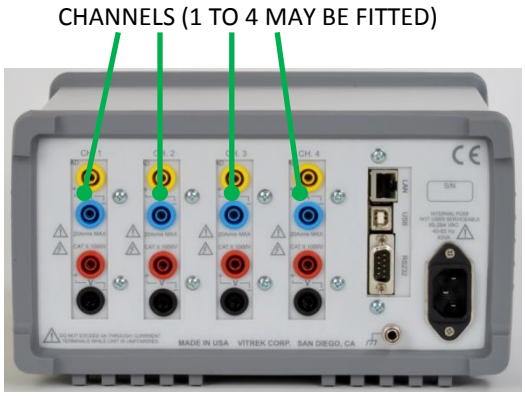
(3) Set the DIGITS setting to less displayed digits. This reduces the resolution on most numerical results.

The PA900 remembers what you have configured, which results screen you are looking at and how you have setup that screen. If you turn off the PA900, when you turn it back on it will come back configured just like you left it. But remember, it's best to remove power from your application when turning off the PA900. You can also export and import configurations to/from files on a USB drive, giving you the freedom to experiment with configuration settings without worrying about being able to return to a prior known configuration.

APPLICATIONS

This section discusses in general terms the use of PA900 channels and virtual power analyzers (VPAs) in typical applications and should be used to decide which channels and VPAs will be used and what purpose each VPA performs in a user application. Details regarding connecting the signals to the channels, and configuring the channels and VPAs are given in later sections.

CHANNELS



Channels are numbered CH1, CH2, CH3 and CH4 from left to right when looking at the PA900 rear panel.

Each channel provides the PA900 with one voltage and one current measurement which are always simultaneously sampled to provide the best power accuracy.

Each channel can be one of three types and each with one of three current input options. Which channel type and current input option is installed in each position is indicated by a two letter code labelled in the upper left corner of each channel sub-panel.

The channel type is denoted by the first letter of the two letter code –

S - Provides 0.1% accuracy, 1MHz class bandwidth, 22bit sampling and a 1000Vrms maximum continuous voltage input

A - Provides 0.03% accuracy, 1MHz class bandwidth, 24bit sampling and a 1000Vrms maximum continuous voltage input

W - Provides 0.1% accuracy, 5MHz class bandwidth, 22bit sampling and a 600Vrms maximum continuous voltage input

The current input option is denoted by the second letter of the two letter code –

D – Dual Shunt (up to 20Arms continuous and 150Apk inrush) in a single input terminal pair with resolution down to 0.1uA

H - High Current (up to 30Arms continuous and 200Apk inrush) with resolution down to 10uA

X – External Current Transducer (voltage output type) or Shunt Input (20uV to 15Vrms) with resolution down to 0.1uV

Each channel can be independently configured for voltage scaling (when using an external PT) and/or current offset and scaling (when using an external CT or shunt).

VIRTUAL POWER ANALYZERS (OR VPA)

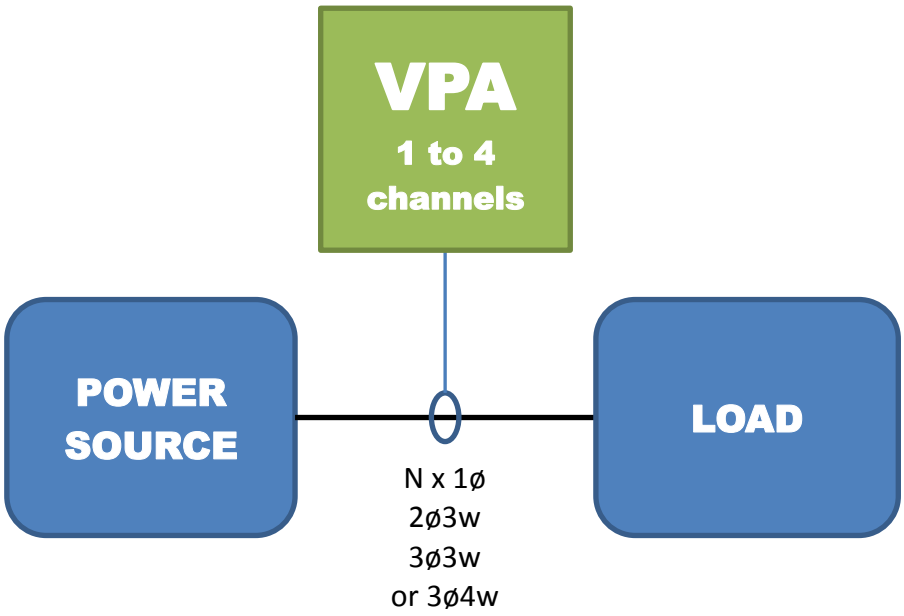
The PA900 is actually three power analyzers in a single chassis with a single user interface. These are called Virtual Power Analyzers (or VPA) and are numbered VPA1, VPA2 and VPA3. The numbers are solely descriptive and otherwise serve no function. You may use any one, any two, or all three of the VPAs depending on the specific application.

The installed channels may be configured in any one (or none) of the VPAs. Each VPA may be configured for up to all channels installed (however W type channels may not be mixed with other types in the same VPA). The channels do not have to be physically adjacent when configuring them in a VPA, for example it is OK to configure CH1 and CH4 in one VPA and CH2 and CH3 in another.

If a VPA is configured to actively synchronize to the fundamental component of an applied voltage or current then this is always performed in the lowest numbered channel configured in the VPA, otherwise there is no special relationship involving the channel numbers.

Each VPA can be independently configured for measurement period, LF and HF filtering, harmonic analysis, signal filtering, default measurement coupling, results smoothing and displayed significant digits, multi-channel wiring configuration, VA/VAR combine method, and efficiency grouping. VPAs may optionally be configured to be synchronized to each other (see later regarding configuring VPAs).

TYPICAL SINGLE VPA APPLICATIONS



- DC and 0.01Hz to over 1MHz (W channels) or 100kHz (A or S channels) supply frequencies
- N x 1ø can be up to 4 AC or DC supplies
- 2ø3w and 3ø4w measures neutral current from phase currents
- 3ø3w can use either 2 or 3-wattmeter methods
- 2ø3w, 3ø3w (3ch) and 3ø4w measures phase-to-phase voltages in addition to the individual phase voltages
- Wye (3ø4w) and Delta (3ø3w) voltage conversions for 3ø3w and 3ø4w resp.
- Power can flow in either direction, separately integrates power in each direction (per phase and total) as well as the total
- Total power (W, VA, VAR and PF) measured in addition to the individual phases
- Max. hold maintained for voltage, current and power measurements
- Harmonic analysis of every signal up to the 500th (option H500) or 100th (standard) harmonic <305kHz (W channels) or <80kHz (A or S channels)
- Built-in oscilloscope capturing every signal, triggering on any selected signal for waveform or transient analysis without interfering with the power or harmonic measurements
- Each channel individually configurable for PT and/or CT use

TYPICAL DUAL VPA APPLICATIONS

Examples of dual VPA applications as shown in the diagram below include –

AC to DC Power Supplies (single or multiple outputs)

DC to DC Power Supplies (single or multiple outputs)

DC or fixed frequency AC supplied variable or fixed speed motor drives

Power Transformers (single or multi-phase)

Lighting Ballasts (most types)

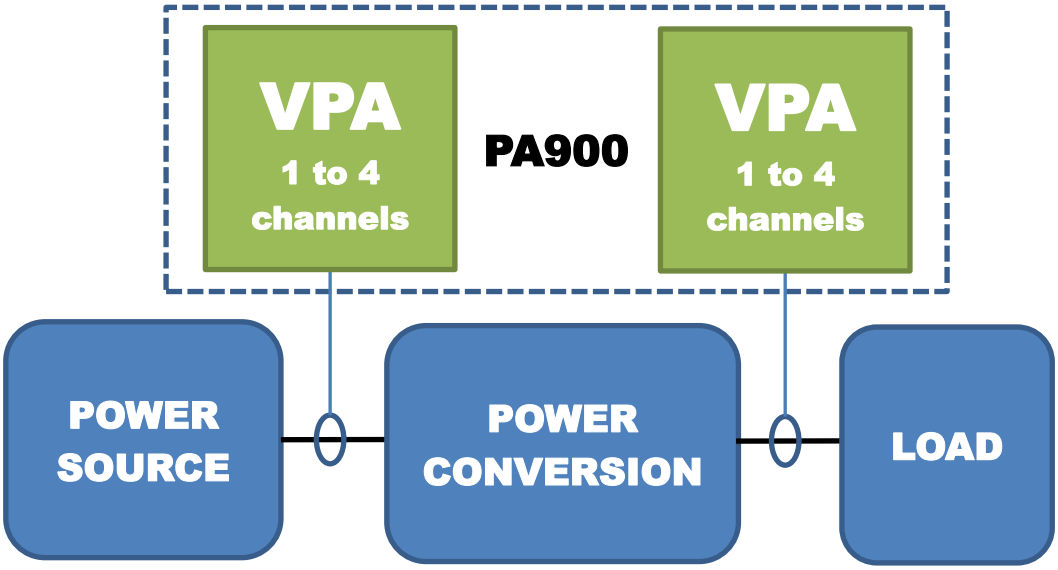
Standby or Backup Power Supplies (AC or DC)

Photovoltaic Power Generators (DC in; DC or AC out)

There are also other dual VPA configurations which are not shown here. As examples –

If the neutral current is to be actually measured rather than computed from the other phases for a 2ø3w or 3ø4w supply or load then that is accomplished by using a second VPA for just the neutral current measuring channel and setting that VPA to be fully synchronous with the main VPA.

If a load has both AC and DC supply inputs (or vice versa), or two different frequency AC supplies, then each supply can be measured in separate VPAs and an efficiency group used to produce the total input (or output) power from both VPAs.



- Each VPA is independently configured and has the same capabilities as previously described for single VPA applications (except only a single oscilloscope in one VPA is allowed).
- Each VPA can be configured as N x 1ø, 2ø3w, 3ø3w(2ch), 3ø3w(3ch) or 3ø4w limited by the total number of channels installed.
- Overall efficiency and power loss can be measured.
- The two VPAs may be configured as either –
    - Totally independent and having totally different frequency content signals to each other.
    - Or, have totally different frequency content signals but make measurements over times which are synchronized to each other.
    - Or, have the same frequency content signals and make measurements over exactly the same periods of time (the oscilloscope captures the signals in both VPAs in this case).

TYPICAL TRIPLE VPA APPLICATIONS

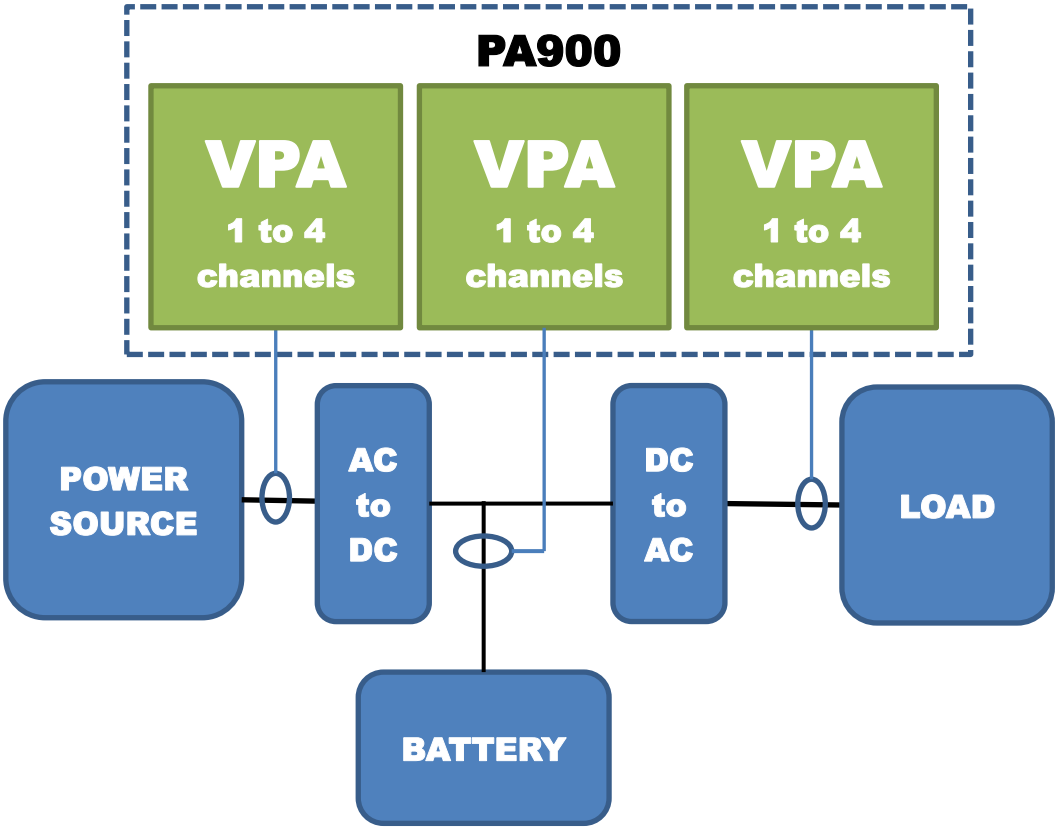
Examples of triple VPA applications as shown in the diagram below include –

Emergency Lighting Ballasts (most types)

Standby or Backup Power Supplies (AC or DC)

There are also other triple VPA configurations which are not shown here. As example –

If a facility has a backup or PV source of power, an internal power distribution, and also access to a network supply then three VPAs can be used, one measuring each of these. In this case you should note that the PA900 can also separately integrate the bought and sold power for the network power source.

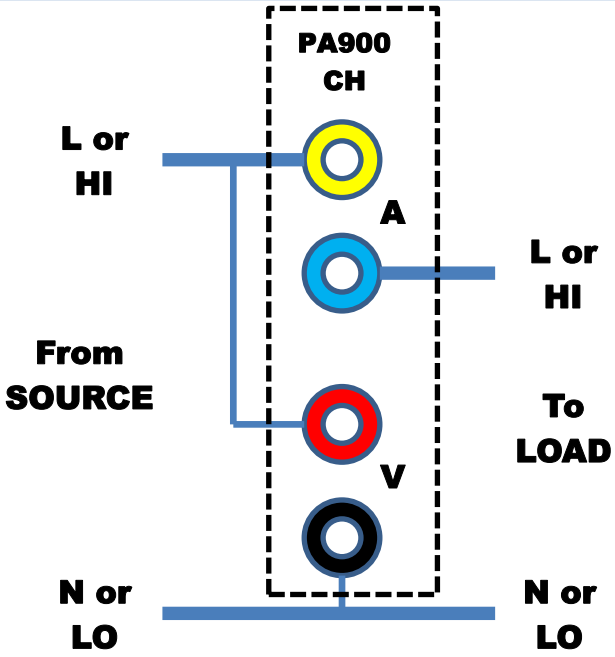


- Each VPA has the same capabilities and are independently configured as for single VPA applications (except only a single oscilloscope in one VPA is allowed).
- Each VPA can be configured as N x 1ø, 2ø3w, 3ø3w(2ch), 3ø3w(3ch) or 3ø4w limited by the total number of channels installed.
- Efficiency and power loss can be measured, overall and for each intermediate stage.
- For the example shown above, the total charge and discharge AHr for the battery can be measured.
- The VPAs may be configured as either –
    - Totally independent and having totally different frequency content signals to each other.
    - Or, have totally different frequency content signals but make measurements over times which are synchronized to each other.
    - Or, have the same frequency content signals and make measurements over exactly the same periods of time (the oscilloscope captures the signals in both VPAs in this case).

WIRING TO CHANNELS

This section shows typical wiring to each channel in each VPA matching the configuration WIRING setting for that VPA in the PA900 MEAS CONFIG menu.

1Ø WIRING USING INTERNAL CURRENT MEASUREMENT



CAUTION:

- **FOR USE WITH SH, SD, AH, AD, WH OR WD CHANNELS ONLY**
- **DO NOT CONNECT WIRING WHILE VOLTAGE PRESENT.**
- **ENSURE WIRING IS CORRECT BEFORE APPLYING VOLTAGE.**
- **DO NOT PASS LOAD CURRENT >2Arms WITH THE PA900 TURNED OFF.**

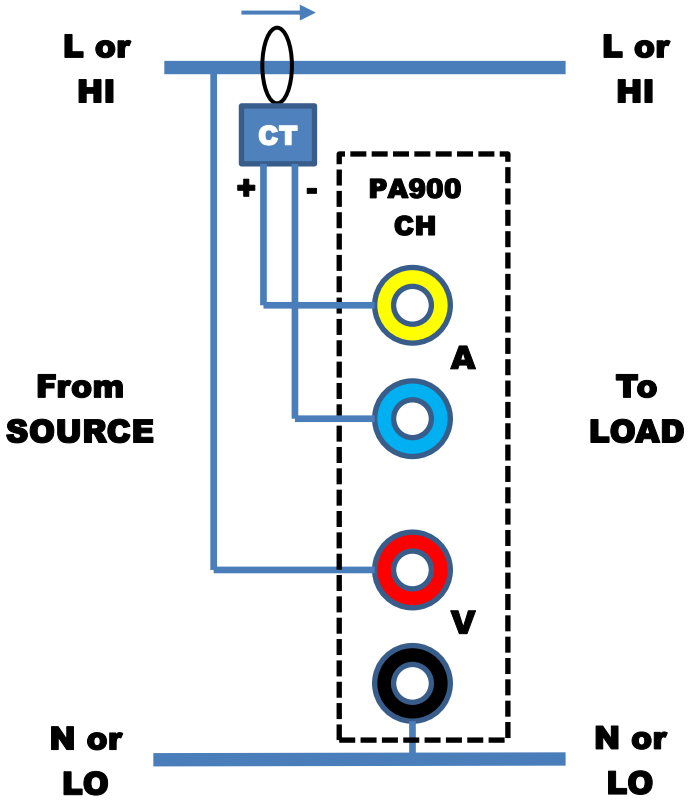
WIRING:

- Thicker connections are current carrying. Ensure wire used is rated for the maximum voltage and current to be encountered.
- Thinner connections are not current carrying. Ensure wire used is rated for the maximum voltage to be encountered.
- The wiring connections shown above ensure the best overall system accuracy in most circumstances. For applications requiring the best accuracy for the power to the load and using low voltages (<50V) and high currents (>1A) change the RED V+ terminal connection to that of the BLUE A- terminal instead of the YELLOW A+ terminal shown above. This ensures that the voltage drop across the A terminals does not affect the V measurement, at the expense of the current and power measurements including the current and power drawn by the V input.

PA900 CONFIGURATION:

- In the PA900 MEAS CONFIG menu you should set SCALE for the channel to OFF.

1Ø WIRING USING EXTERNAL CURRENT MEASUREMENT



CAUTION:

- **FOR AN A:A TYPE CT : USE WITH SH, SD, AH, AD, WH OR WD CHANNELS ONLY**
- **FOR AN A:V TYPE CT OR A SHUNT : USE WITH SX, AX OR WX CHANNELS ONLY**
- **DO NOT CONNECT WIRING WHILE VOLTAGE PRESENT.**
- **ENSURE WIRING IS CORRECT BEFORE APPLYING VOLTAGE.**

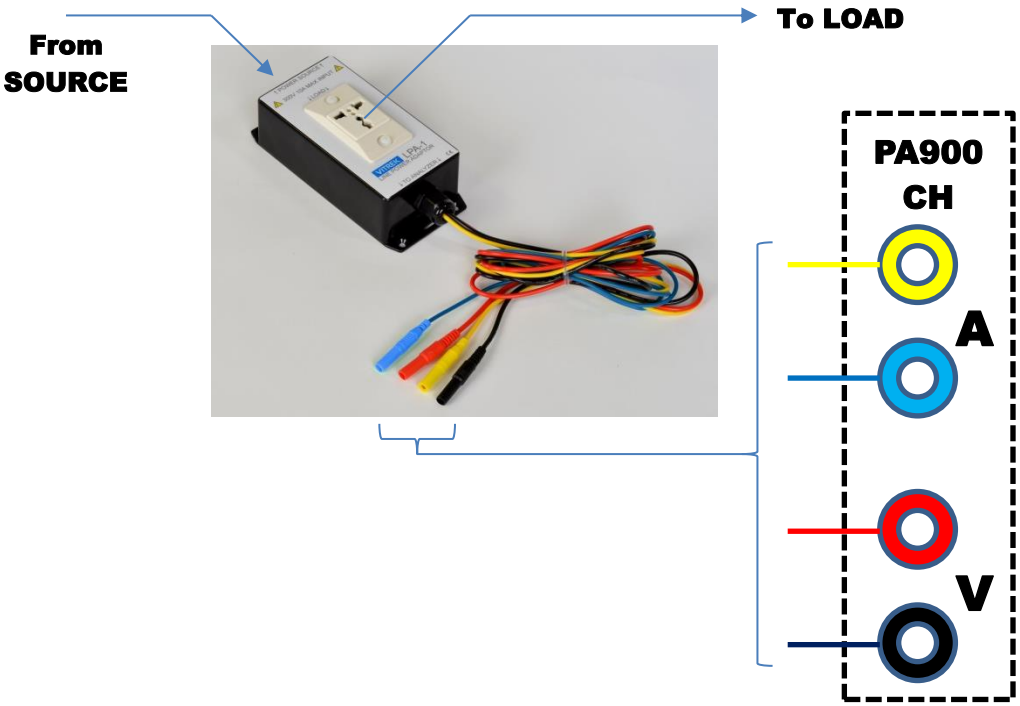
WIRING:

- Thicker connections are current carrying. Ensure wire used is rated for the maximum voltage and current to be encountered.
- Thinner connections are not current carrying. Ensure wire used is rated for the maximum voltage to be encountered.
- Many CT devices are isolating, in those cases you should ground the A- (BLUE) terminal of the channel if the CT does not ground it.

PA900 CONFIGURATION:

- In the PA900 MEAS CONFIG menu you should appropriately set SCALE for the channel to suit the CT or shunt being used (both a scale factor and an offset are available).

1Ø WIRING USING LPA-1 ADAPTOR



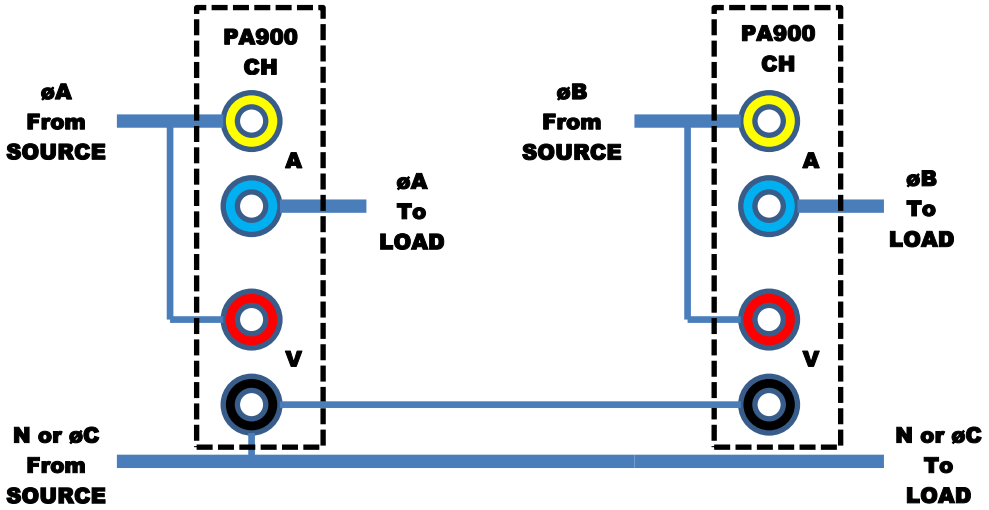
CAUTION:

- **FOR USE WITH SH, SD, AH, AD, WH OR WD CHANNELS ONLY**
- **DO NOT CONNECT WIRING WHILE VOLTAGE PRESENT.**
- **ENSURE THAT EACH PA900 TERMINAL COLOR MATCHES THE WIRE CONNECTOR COLOR BEFORE APPLYING THE SOURCE VOLTAGE.**
- **DO NOT PASS LOAD CURRENT >2Arms WITH THE PA900 TURNED OFF.**

PA900 CONFIGURATION:

- In the PA900 MEAS CONFIG menu you should set SCALE for the channel to OFF.

2Ø3W OR 3Ø3W(2CH) WIRING USING INTERNAL CURRENT MEASUREMENT



CAUTION:

- **FOR USE WITH SH, SD, AH, AD, WH OR WD CHANNELS ONLY**
- **DO NOT CONNECT WIRING WHILE VOLTAGE PRESENT.**
- **ENSURE WIRING IS CORRECT BEFORE APPLYING VOLTAGE.**
- **DO NOT PASS LOAD CURRENT >2Arms WITH THE PA900 TURNED OFF.**

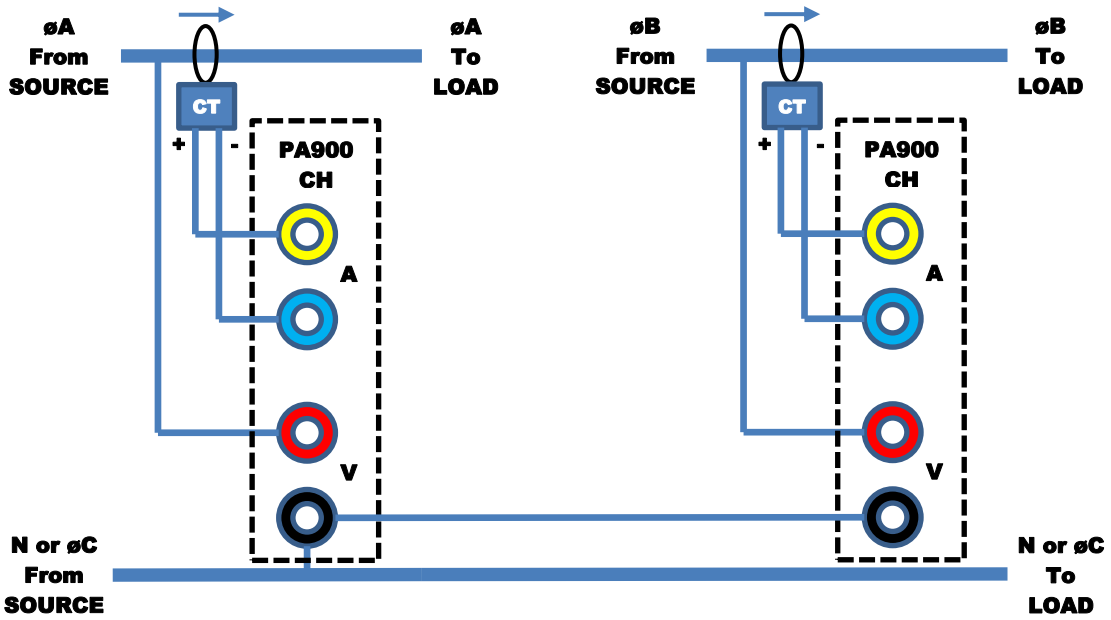
WIRING:

- Thicker connections are current carrying. Ensure wire used is rated for the maximum voltage and current to be encountered.
- Thinner connections are not current carrying. Ensure wire used is rated for the maximum voltage to be encountered.
- Phases are shown for descriptive purposes, the PA900 places no reliance on the actual phasing however using those shown ensures that the PA900 display matches the actual phasing if the channels have increasing channel numbers from left to right in the diagram above.
- The wiring connections shown above ensure the best overall system accuracy in most circumstances. For applications requiring accurate measurements of the power to the load and using low voltages (<50V) and high currents (>1A) change the RED V+ terminal connections to that of the respective BLUE A- terminal instead of the YELLOW A+ terminal shown above. This ensures that the voltage drop across the A terminals does not affect the V measurement, at the expense of the current and power measurements including the current and power drawn by the V input.

PA900 CONFIGURATION:

- In the PA900 MEAS CONFIG menu you should set SCALE for the channels to OFF.

2Ø3W OR 3Ø3W(2CH) WIRING USING EXTERNAL CURRENT MEASUREMENT



CAUTION:

- **FOR AN A:A TYPE CT : USE WITH SH, SD, AH, AD, WH OR WD CHANNELS ONLY**
- **FOR AN A:V TYPE CT OR A SHUNT : USE WITH SX, AX OR WX CHANNELS ONLY**
- **DO NOT CONNECT WIRING WHILE VOLTAGE PRESENT.**
- **ENSURE WIRING IS CORRECT BEFORE APPLYING VOLTAGE.**

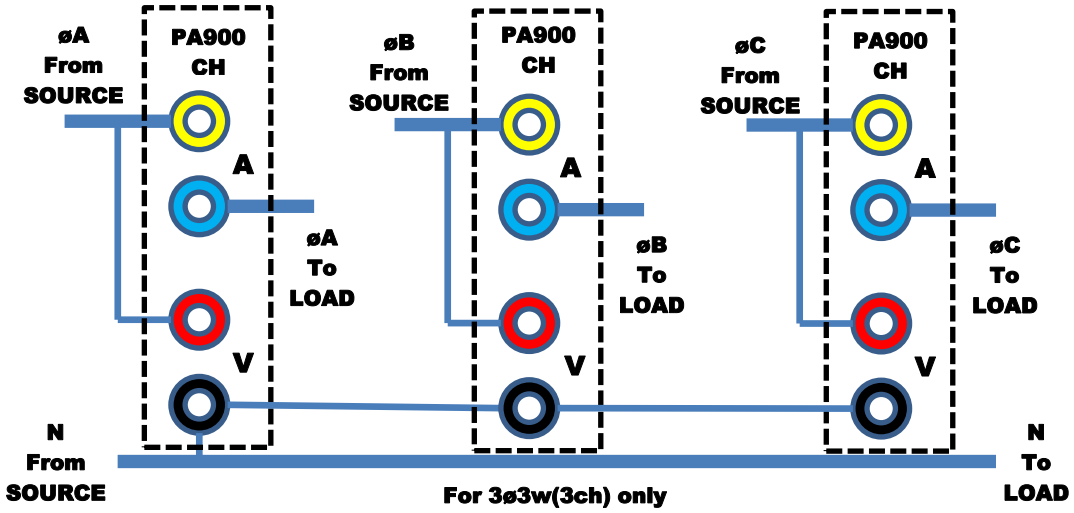
WIRING:

- Thicker connections are current carrying. Ensure wire used is rated for the maximum voltage and current to be encountered.
- Thinner connections are not current carrying. Ensure wire used is rated for the maximum voltage to be encountered.
- Phases are shown for descriptive purposes, the PA900 places no reliance on the actual phasing however using those shown ensures that the PA900 display matches the actual phasing if the channels have increasing channel numbers from left to right in the diagram above.
- Many CT devices are isolating, in those cases you should ground the A- (BLUE) terminal of the channel if the CT does not ground it.

PA900 CONFIGURATION:

- In the PA900 MEAS CONFIG menu you should appropriately set SCALE for each channel to suit the CT or shunt being used (both a scale factor and an offset are available).

3Ø3W(3CH) OR 3Ø4W WIRING USING INTERNAL CURRENT MEASUREMENT



CAUTION:

- **FOR USE WITH SH, SD, AH, AD, WH OR WD CHANNELS ONLY**
- **DO NOT CONNECT WIRING WHILE VOLTAGE PRESENT.**
- **ENSURE WIRING IS CORRECT BEFORE APPLYING VOLTAGE.**
- **DO NOT PASS LOAD CURRENT >2Arms WITH THE PA900 TURNED OFF.**

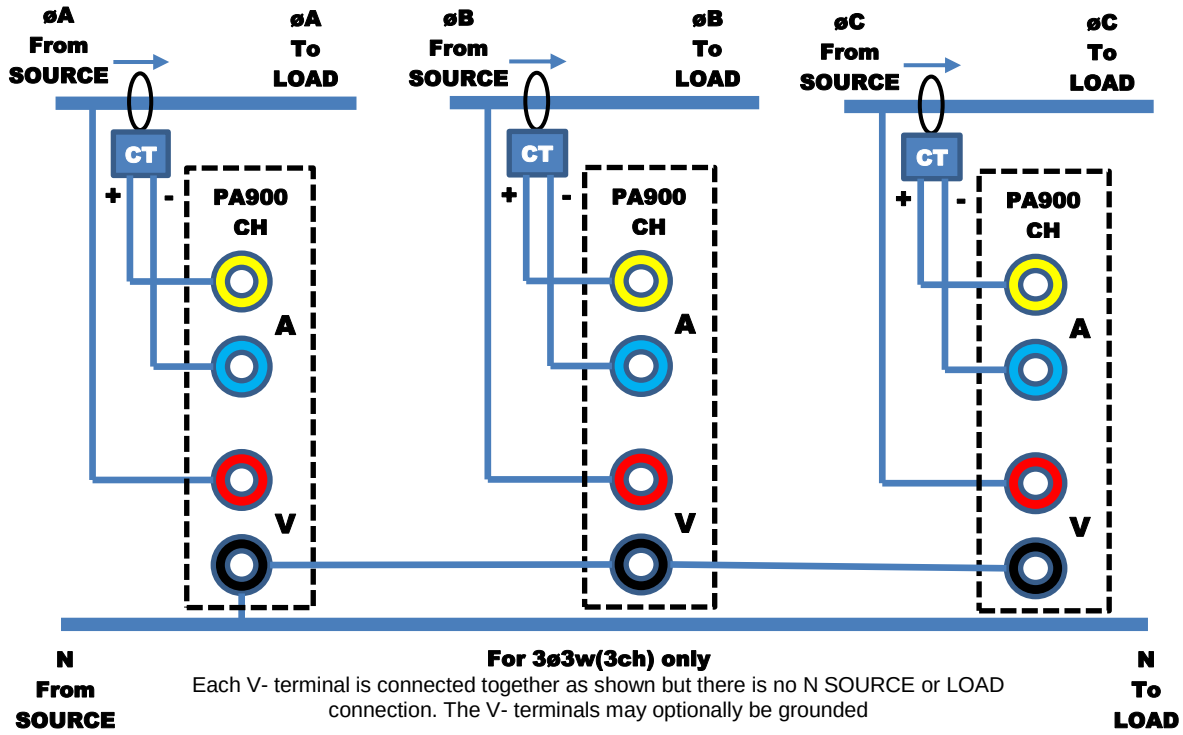
WIRING:

- Thicker connections are current carrying. Ensure wire used is rated for the maximum voltage and current to be encountered.
- Thinner connections are not current carrying. Ensure wire used is rated for the maximum voltage to be encountered.
- Phases are shown for descriptive purposes, the PA900 places no reliance on the actual phasing however using those shown ensures that the PA900 display matches the actual phasing if the channels have increasing channel numbers from left to right in the diagram above.
- The wiring connections shown above ensure the best overall system accuracy in most circumstances. For applications requiring accurate measurements of the power to the load and using low voltages (<50V) and high currents (>1A) change the RED V+ terminal connections to that of the respective BLUE A- terminal instead of the YELLOW A+ terminal shown above. This ensures that the voltage drop across the A terminals does not affect the V measurement, at the expense of the current and power measurements including the current and power drawn by the V input.

PA900 CONFIGURATION:

- In the PA900 MEAS CONFIG menu you should set SCALE for the channels to OFF.

3Ø3W(3CH) OR 3Ø4W WIRING USING EXTERNAL CURRENT MEASUREMENT



CAUTION:

- **FOR AN A:A TYPE CT : USE WITH SH, SD, AH, AD, WH OR WD CHANNELS ONLY**
- **FOR AN A:V TYPE CT OR A SHUNT : USE WITH SX, AX OR WX CHANNELS ONLY**
- **DO NOT CONNECT WIRING WHILE VOLTAGE PRESENT.**
- **ENSURE WIRING IS CORRECT BEFORE APPLYING VOLTAGE.**

WIRING:

- Thicker connections are current carrying. Ensure wire used is rated for the maximum voltage and current to be encountered.
- Thinner connections are not current carrying. Ensure wire used is rated for the maximum voltage to be encountered.
- Phases are shown for descriptive purposes, the PA900 places no reliance on the actual phasing however using those shown ensures that the PA900 display matches the actual phasing if the channels have increasing channel numbers from left to right in the diagram above.
- Many CT devices are isolating, in those cases you should ground the A- (BLUE) terminal of the channel if the CT does not ground it.

PA900 CONFIGURATION:

- In the PA900 MEAS CONFIG menu you should appropriately set SCALE for each channel to suit the CT or shunt being used (both a scale factor and an offset are available).

POWERING THE PA900

TURNING POWER ON

The PA900 is configurable regarding when it powers on; when initially shipped from Vitrek the PA900 is configured for power on/off to be solely controlled by the touch panel. If this configuration setting has been changed then the PA900 may power on almost immediately when mains is initially applied without any other user action.

1. Connect the power entry connector on the rear panel of the PA900 to a suitable source of AC mains power within the specifications of the PA900. **This must be connected using a power cable with a continuous ground connection and must be plugged into a source of power which provides a safety ground. If a safety ground is not present in the power cable then the PA900 chassis must be safety grounded by you prior to applying mains or signals to the PA900 using the rear panel chassis ground connector.**
2. When initially powered the front panel POWER indicator LED will be illuminated RED.
3. Either using the tip of a finger, or using a stylus designed for use with a touch panel, press and hold anywhere on the touch panel for at least ½ second. Do not use excessive force, the POWER indicator LED brightens when the panel is detected as being touched. DO NOT USE A PEN OR A SCREWDRIVER OR A SIMILAR IMPLEMENT WITH SHARP CORNERS AS IT MAY DAMAGE THE TOUCH PANEL.
4. The PA900 will now power on and you may release the touch panel –

   a. The front panel POWER indicator LED will change to GREEN.
   b. The LCD screen will show an initial welcoming graphic for about 2 seconds and then the PA900 will start normal operation.

TURNING POWER OFF

1. Unless it is unavoidable, do not power down the PA900 by removing the source of mains power to it.
2. It is recommended that all signals be removed from the PA900 prior to powering down.
3. Press and hold the POWER button in the lower right corner of the PA900 screen. This button must be pressed for at least ¾ second to power down the unit. If any channel has current flowing which is over its capability to withstand when powered down then the PA900 will not power down and the POWER button will be colored red while it is pressed.
4. The PA900 may delay powering down if it still has unsaved data, during this delay a message is displayed on the screen, this typically is less than a second.
5. If the PA900 has been configured to be always powered then the PA900 will almost immediately power back on.

MEASUREMENT RESULT TERMINOLOGY

HARMONICS

PHASE MEASUREMENT RESULTS

All phase results are given in degrees using a ±180° format.

Fundamental Voltage	relative to the V fundamental in the lowest numbered channel of the VPA
Non-fundamental Voltage	relative to the V fundamental in the selected channel
Fundamental Current	relative to the V fundamental in the selected channel
Non-fundamental Current	relative to the A fundamental in the selected channel

RELATIVE INDIVIDUAL HARMONICS

Individual harmonics given as a percentage are the percentage relative to the fundamental of that signal unless otherwise stated.

PERCENTAGE DISTORTION

Percentage harmonic distortion is given relative to fundamental as THDf, or relative to total signal as THDsig, or relative to the AC signal as THDac.

LEADING/LAGGING

Whether the current is leading or lagging the voltage for an individual channel or for a VPA total is shown by the direction of an arrow shown immediately after any PF data shown. If the arrow is pointing upwards then it is leading, if downwards then it is lagging.

For an individual channel this is obtained from the phase of the fundamental current (if available) or by analysis of the waveforms by computing the power result obtained by using a delayed current waveform (if no fundamental is available).

For a VPA total this is obtained from the polarity of the total VAR result.

INDIVIDUAL CHANNEL RESULTS

All results given for an individual channel are the results for that channel without regard to the WIRING configuration of the VPA in which the channel is configured.

WIRING PHASE INDICATIONS

All results given for an individual wiring phase are as follows-

øA, øB, øC, øD	Data obtained from the 1st, 2nd, 3rd and 4th channels in a VPA respectively.
A, B, C, D	Data obtained from the 1st, 2nd, 3rd and 4th channels in a VPA respectively (when a VPA is configured for N x 1ø WIRING).
øAC	Data obtained for signals between øA and øC; for 3p3w(2ch) WIRING this is the data from the 1st channel in the VPA, otherwise between the 1st and 3rd channels in a VPA.
øBC	Data obtained for signals between øB and øC; for 3p3w(2ch) WIRING this is the data from the 2nd channel in the VPA, otherwise between the 2nd and 3rd channels in a VPA.
øAB	Data obtained for signals between øA and øB (i.e. the 1st and 2nd channels in a VPA).
N	Data computed for Neutral current as measured from the combination of the channels in a VPA (when a VPA is configured for 2p3w and 3p4w WIRING).

INDIVIDUAL VPA TOTAL RESULTS

VOLTAGES

VPA total results given for voltage is the average phase voltage for the VPA depending on the WIRING setting for the VPA-

Other than 3p3w(2ch)	The mean of all channel voltages
3p3w(2ch)	The mean of the øAC, øBC and øAB voltages.

INRUSH VOLTAGES

VPA total results given for voltage inrush is the highest recorded voltage of any phase in the VPA depending on the WIRING setting for the VPA-

Other than 3p3w(2ch)	Any channel voltage
3p3w(2ch)	øAC, øBC and øAB voltages.

WYE VOLTAGE

This is only available for a VPA configured as 3p3w(2ch) or 3p3w(3ch) and is (mean of the øAC, øBC and øAB voltages)/√3.

DELTA VOLTAGE

This is only available for a VPA configured as 3p4w and is the mean of the øAC, øBC and øAB voltages.

CURRENTS

VPA total results given for current is the average phase current for the VPA depending on the WIRING setting for the VPA-

Other than 3p3w(2ch)	The mean of all channel currents
3p3w(2ch)	The mean of the øA, øB and øC currents.

INRUSH CURRENTS

VPA total results given for current inrush is the highest recorded current of any phase in the VPA depending on the WIRING setting for the VPA-

Other than 3p3w(2ch)	Any channel current
3p3w(2ch)	øA, øB and øC currents.

WATTS

VPA total results given for Watts are the total power computed for the entire VPA. This is always the sum of the Watts for each channel in the VPA.

VAR AND VA

VPA total results given for VAR and VA are the total power computed for the entire VPA. Depending on the VA/VAR configuration setting for the VPA this is one of the following-

Σ(VAR) setting	VAR is the sum of the VAR for the channels and VA is computed directly from the W and VAR using (total VA)^2 = (Σ(W))^2 + (Σ(VAR))^2
Σ(VA) setting	VA is dependent on the WIRING setting– 3ø3w(2ch) setting: total VA = (Σ(VA)) * (√3) / 2 Other settings: total VA = Σ(VA) VAR is computed directly from the W and VA using (total VAR)^2 = (Σ(VA))^2 - (Σ(W))^2

POWER FACTOR

VPA total results given for PF are always computed from the total Watts and VA for the VPA.

OPERATING FROM THE FRONT PANEL

This section gives information regarding using the front panel and its' menus.

TOUCH PANEL

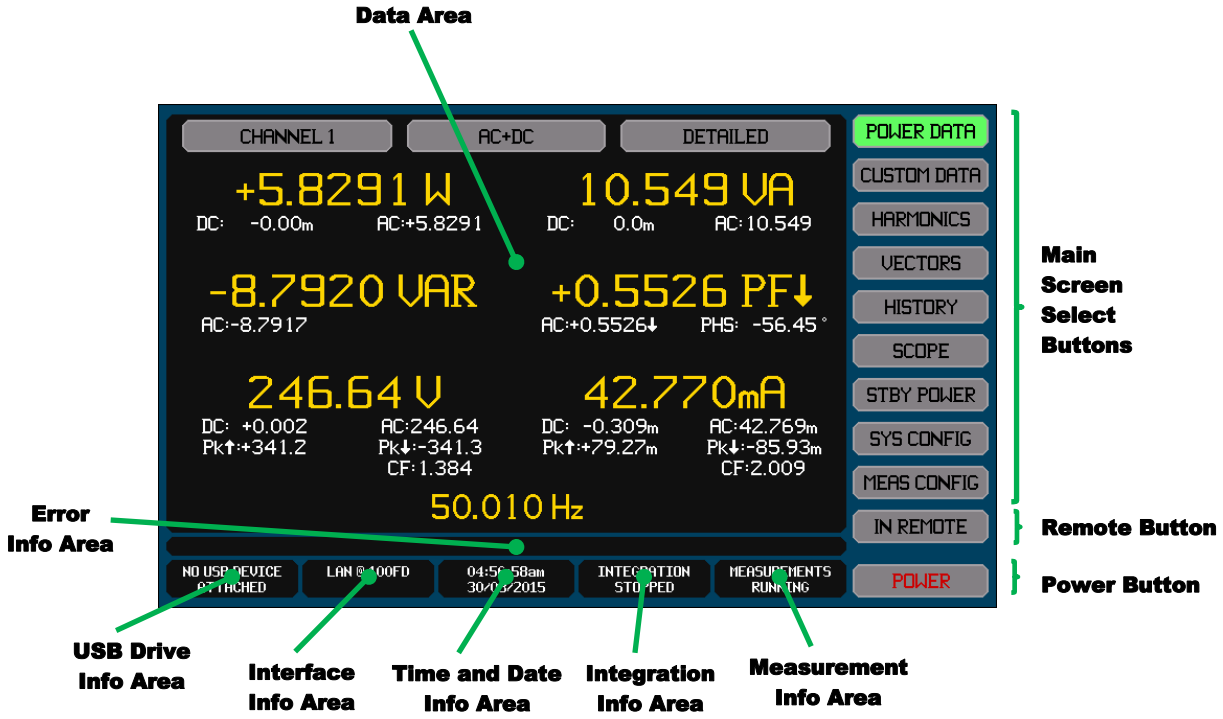
You interact with the PA900 entirely through the use of the touch panel. A user may either use the tip of a finger, or may use a stylus designed for use with a pressure type touch panel. DO NOT USE A PEN OR A SCREWDRIVER OR SIMILAR IMPLEMENT WITH SHARP CORNERS AS IT MAY DAMAGE THE TOUCH PANEL. Do not apply excessive force to the touch panel, typically only a gentle touch is required. While any touch is detected the POWER LED is intensified.

A described later in this section, the PA900 has buttons on its' screens which allow you to interact and configure the unit. Pressing a button other than the POWER button almost immediately causes the desired activity for that button, if the button colors red while pressed then that button is disabled typically because there is only one choice regarding the selectable data, or the unit is in the remote state and preventing that configuration setting from being altered.

In many cases a button has two lines of text shown within it and the upper line is of a larger font size than the lower one. In these cases the lower line of text shows the present setting, which can be changed by pressing this button.

MAIN SCREEN LAYOUT

There are nine main screens, of which the POWER DATA screen shown below is an example. All the main screens have the same basic layout.



MAIN SCREEN SELECT BUTTONS

These nine buttons allow you to choose which main screen is being shown. The upper seven select one of the measurement data screens and the PA900 will always power on displaying the last one of these selected. Which main screen is presently selected is shown by the respective button being highlighted with a green color.

REMOTE BUTTON

This button is only present if you have placed the PA900 into the remote state via an interface. If you press this button it returns the PA900 to the local state if it is able (the interface can also set the remote with lockout state which disables this button).

POWER BUTTON

If you press this button it will turn off the PA900. If configured for the PA900 to be continuously powered then the PA900 will immediately power back on again, so performing a reboot action.

If this button is colored red when pressed then this indicates that there is too much current flowing through the PA900 and the user should remove this current prior to turning off the PA900.

This button must be pressed continuously for at least ¾ second for it to take effect.

DATA AREA

The selected main screen data is shown in this area. The content of this area depends on which main screen is presently selected. Following this section are sections detailing each main screen.

ERROR INFO AREA

An applicable error message may be shown in this area, if any text being shown in this area is colored red then it of high importance, if orange then it is of medium importance, and if white then it is for informative purposes only.

USB DRIVE INFO AREA

While not data logging –

- The area shows the connection and error status of the drive attached to the front panel USB port.
- If an error is being shown then you should re-attempt connection to the device, if the error persists then the drive is either faulty or is not compatible with the PA900.
- If you press this area it initiates the File Import/Export Screen.

While data logging –

- The area shows the present status of data logging.
- While performing the delay prior to starting the actual data logging, the area shows a progress bar which grows from the left as the delay progresses, reaching the right end when the delay expires.
- While actually data logging the area shows a buffer status bar which indicates the amount of the PA900 drive buffer which is being used, 0% at the left end, 100% at the right end. The highest used is indicated by a vertical line within the bar area. If this indicates that a significant amount of the buffer has been used then you should consider using a faster drive, logging less data, or using a longer data logging interval.
- If you press this area it initiates the Data Logging Configuration and Status Screen.

INTERFACE INFO AREA

This area shows the present status of the configured interface of the PA900 (if any). The upper portion shows the presently configured interface and the connection status of it. The lower area shows if any transmit or receive data activity is occurring. For the LAN interface, if the text in this area is colored red then it indicates that the PA900 does not have a valid IP address, if colored orange then it indicates that the PA900 is in the process of obtaining a valid IP address.

If you press this area it initiates the Interface Configuration Screen.

TIME AND DATE INFO AREA

This area shows the present time and date.

If you press this area it initiates the Adjust Time and Date Screen.

INTEGRATION INFO AREA

This area shows the present status of integration.

If you press this area it starts or stops integration depending on the present integration state.

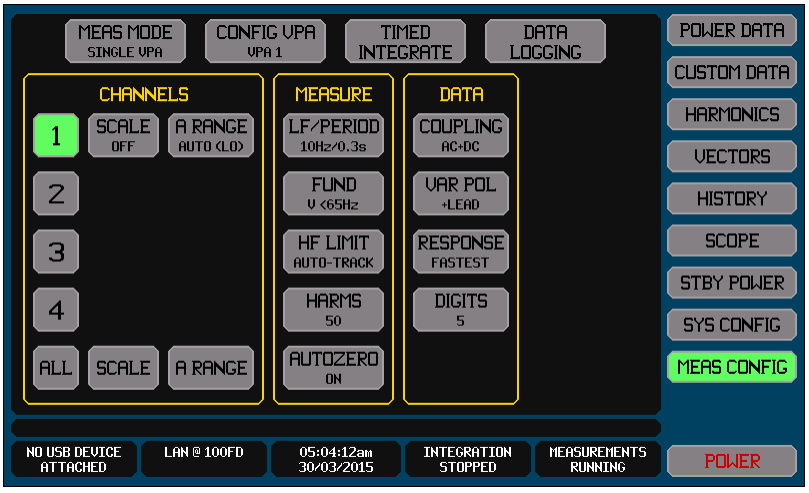
MEASUREMENT INFO AREA

This area shows the present status of measurements.

If you press this area it releases or holds all measurements depending on the present measurement state.

CONFIGURING MEASUREMENTS

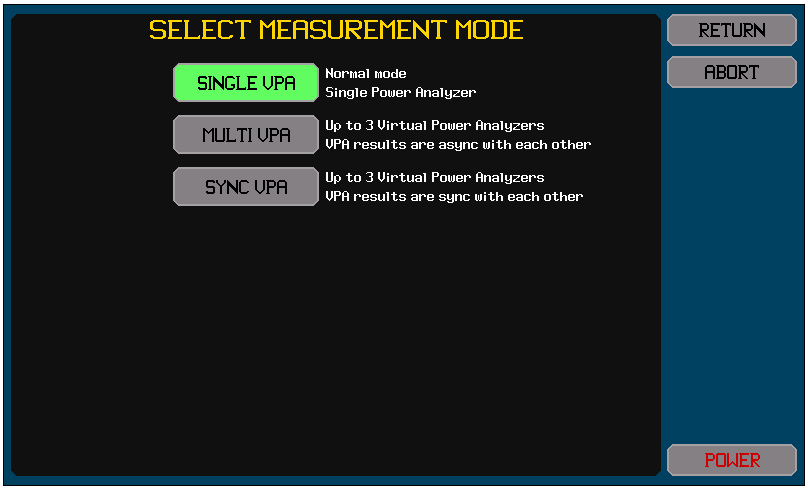
All measurement configuration of the PA900 is performed in the MEAS CONFIG Screen accessed by pressing the MEAS CONFIG button.



- Changes made to the configuration do not become active until this screen is navigated away from, i.e. one of the other Main Screen Select Buttons is pressed.
- If you press the MEAS CONFIG button while showing the MEAS CONFIG Screen then any changes which have been made will be discarded and the screen will return to showing the presently used configuration.

SELECTING THE OVERALL MEASUREMENT MODE

If you press the MEAS MODE button it starts a screen which allows you to select the measurement mode the PA900 is to operate in. This screen shows a list of buttons, one for each available mode, next to each is a basic description of the action of each mode.



- To change the mode, press the button for the mode required.
- If the presently selected mode (as indicated by the button highlighted in green) is OK, press either the RETURN or the ABORT button in the upper right corner of the screen.

After the mode is selected the screen returns to the Measurement Configuration Screen.

CONFIGURING A VPA

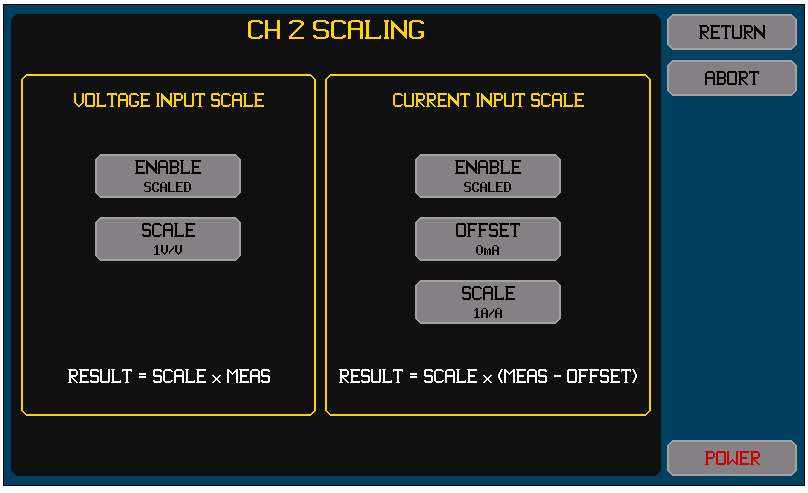
If you press the CONFIG VPA Button it starts a screen which allows you to select one of the three VPAs to configure. If the SINGLE VPA mode is selected then only VPA1 can be selected and the CONFIG VPA Button is inactive.

The configuration shown on the screen shows the configuration for the selected VPA, the selected VPA is shown in the lower half of the CONFIG VPA button.

SELECTING AND CONFIGURING THE CHANNELS IN THE SELECTED VPA

This is performed by using the buttons in the CHANNELS area.

1. If you press any of the available numeric buttons, then that numbered channel is toggled between selected (button highlighted green) or unselected (not highlighted and colored grey). Only channels which are fitted are displayed; in the example above channel 3 is not installed, channels 1 and 2 are not used in the selected VPA, only channel 4 is being used in the selected VPA.
   - Pressing the ALL button selects all available channels in the selected VPA.
   - A channel can only be selected in a single VPA, selecting a channel in the selected VPA deselects it in other VPAs automatically.
   - W type channels cannot be selected along with S or A type channels in the same VPA, but S and A type channels can be selected in the same VPA. If any A or S type channels are selected in a VPA and you need to change to selecting a W type channel then you must deselect the A or S type channels before you can select a W channel in that VPA. Similarly, if any W type channels are selected in a VPA and you need to change to selecting a S or A type channel then you must deselect the W type channels before you can select a S or A type channel in that VPA.
   - Deselecting all channels from the selected VPA disables the selected VPA.
2. If you press any of the SCALE buttons then it initiates a screen allowing you to configure that channel for voltage scaling, current scaling and/or current offset. Pressing the SCALE button next to the ALL button sets all selected channels to the same scaling and offset settings. An example of the screen used to setup scaling is shown below.



- If you press the ABORT button then changes made on this screen are discarded and you are returned to the MEAS CONFIG screen.
- If you press the RETURN button then changes made on this screen are retained and you are returned to the MEAS CONFIG screen. Changes made in this screen are not used for measurements until the underlying MEAS CONFIG screen is navigated away from.
- If scaling is disabled for voltage and/or current, the scale factors and offset remain saved in the PA900 for later reuse.
- If the channel is subsequently moved from one VPA to another (or disabled by not selecting it in any VPA) then the channel scaling and offset settings stay with the channel.
- Voltage scale factors between 0.001 and 1000000 may be entered.
- Current scale factors between 0.000001 and 1000000 may be entered.
- Current offsets may be entered up to the maximum measurable for the current input option and are the offset at the output of the transducer (as shown on the screen).
    - NOTE: the current offset is applied as a DC offset to current measurements. You should not attempt to use it as a method to offset an unwanted AC signal content.
- The present scale factor and offset displayed in the button may be shown with less resolution than that actually entered. The full resolution of the entered data is actually used for scaling (within nominally ±0.1ppm).

3. If you press any of the A RANGE buttons then it initiates a menu screen allowing you to configure that channel for the desired current range selection. Pressing the A RANGE button next to the ALL button sets all selected channels to the same current range selection.
    - The text in the lower half of the A RANGE button for each channel shows the presently selected range setting and if set for AUTO also indicates the present range being used (LO or HI).
    - Channels having the H current input option have no A RANGE button.
    - Channels having the X current input option do not allow an AUTO range selection.
    - RECOMMENDATION: In most applications you should select the same current range for all channels in a VPA.
    - RECOMMENDATION: When configuring a channel with the D current input option the use of the AUTO setting is recommended for most applications, however if the load has rapidly changing current or if the user is going to trigger on an inrush current, then the HI range should be selected.
    - RECOMMENDATION: When configuring a channel with the X current input option you should choose the range giving the best compatibility with the type of transducer being used. Generally, for A:V type transducers this will be the HI range and for external shunts this will be the LO range.

CONFIGURING THE MEASUREMENTS MADE IN THE SELECTED VPA

This is performed by using the buttons in the MEASURE area. Some of the settings in this area are interdependent, you should start with the uppermost setting and work downwards on the screen (all lower settings are forced to be consistent with higher settings as needed). Depending on configuration and the installed channels some buttons may not be present or may not allow modification of the setting.

1. The LF/PERIOD button allows you to select the low frequency limit and measurement period for the selected VPA. If you press the LF/PERIOD button it initiates a screen which allows you to choose from a list of available choices for this setting.
    - The present selection is shown in the lower half of the LF/PERIOD button.
    - The selection is the nominal measurement period; it is automatically adjusted during operation to be an integer number of fundamental signal cycles as needed.
    - You may configure this setting to a lower numbered VPA instead of a low frequency and measurement period selection. This configures the VPA being configured to use the same measurement period and fundamental frequency of the VPA selected in the LF/PERIOD setting, forcing all measurements in both VPAs to be exactly synchronous. Note that if the VPA being configured contains W type channels then the lower numbered VPA selected here must also contain W type channels.
    - RECOMMENDATION: For typical use, the 10Hz/0.3s or 20Hz/0.1s settings are recommended.
2. The FUND button allows you to select the source of fundamental frequency for the selected VPA. If you press the FUND button it initiates a screen which allows you to choose from a list of available choices for this setting.
    - The present selection is shown in the lower half of the FUND button.
    - If you select a FIXED fundamental frequency then a further screen allows you to enter the frequency to use.
    - If you select a measured fundamental frequency (from either VOLTAGE or CURRENT signals) then a further screen allows you to enter the highest frequency to measure.
        - RECOMMENDATION: Generally the VOLTAGE setting should be selected, however if the signals are a pulse width modulated waveform (e.g. a motor drive) then the CURRENT setting should be selected. The fundamental frequency is measured from the lowest numbered selected channel in the VPA being configured.
        - RECOMMENDATION: Generally the maximum frequency should be set as low as possible but high enough to allow the full range of expected signal frequencies.
        - For future compatibility the user may enter up to 5MHz as the maximum frequency, however the maximum measurable frequency is limited to 80kHz for A or S channel types and 305kHz for W channel types and may be further limited by the HF LIMIT setting (see below).
    - If you select another VPA as the source of the fundamental frequency then the fundamental frequency used is automatically obtained from that VPA in real time.

- RECOMMENDATION: If the VPA being configured is making DC measurements but the signals have significant ripple at a frequency related to that being measured by another VPA, then this ability to obtain a fundamental from that other VPA may be used to reduce the effects of that ripple. If configured in this manner then you can use harmonic analysis in the VPA being configured to measure the ripple content of the DC signal.

3. The HF LIMIT button allows you to select the HF filtering to use within the VPA being configured. If you press the HF LIMIT button it initiates a screen which allows you to choose from a list of available choices for this setting.
   - The present selection is shown in the lower half of the FUND button.
   - If you select AUTO-TRACK then the PA900 will automatically provide just enough HF filtering to have an insignificant effect on the measurements, as determined from the fundamental frequency and the HARMS settings in real time.
   - The fixed HF filter frequency settings are the frequencies for -1dB error and are 2-pole Butterworth IIR type filters.
   - RECOMMENDATION: The AUTO-TRACK selection is recommended for most applications unless a set bandwidth or no filtering at all is specifically required by the application.
   - RECOMMENDATION: In some applications it may be necessary to select a -3dB filter frequency, in those applications select a filter with ½ of the required -3dB frequency (e.g. if the requirement is for a 100kHz -3dB filter, then select the 50kHz filter).
4. The HARMS button allows you to select the maximum number of harmonics to analyze within the VPA being configured. If you press the HARMS button it initiates a screen which allows you to enter the integer number for this setting.
   - The present selection is shown in the lower half of the HARMS button.
   - If this is set to 0 then no harmonics will be analyzed in the VPA being configured.
   - This setting limits the maximum number of harmonics which will be analyzed; the actual number of harmonics may be further limited by other settings and/or by the measured fundamental frequency.
   - RECOMMENDATION: for most applications this should be set to 50. Only if the specific application requires more harmonics is it recommended to set this higher. In modulated signal applications (such as motor drives) this should be lowered and often a figure of 5 is used.
5. The AUTOZERO button allows you to select whether the PA900 is enabled to track changes to the environment and adjust its DC zeroes, or is disabled from doing so. If you press the AUTOZERO button it initiates a screen which allows you to select if this is enabled or disabled.
   - The present selection is shown in the lower half of the AUTOZERO button.
   - If set to ON then the PA900 will occasionally (every few minutes in a typical environment) adjust its' DC zeroes to track any changes to the environment. This incurs a 20ms gap between measurements once every few minutes in a typical environment (a 99.99% transient signal capture probability).
   - If set to OFF then the DC zeroes will slightly change if the environment changes, however the transient signal capture probability is 100%.
   - RECOMMENDATION: in almost all applications this will be set to ON. Only select OFF if you are concerned about a nominally 0.01% probability of not capturing transient signal events lasting less than 20ms.

CONFIGURING HOW MEASUREMENT RESULTS ARE DISPLAYED

This is performed by using the buttons in the DATA area.

1. The COUPLING button allows you to select whether DC, AC or AC+DC results will be shown as the primary data in data screens, and used for the calculation of integrated data, and used for obtaining total values for the selected VPA. If you press the COUPLING button it initiates a screen which allows you to choose from a list of available choices for this setting.
   - The present selection is shown in the lower half of the COUPLING button.
   - This does not restrict channel measurement data to the selected coupling; the measurement results within a channel are available for all couplings.
   - RECOMMENDATION: Unless it is known that only the DC results are required then the AC+DC setting is recommended.
2. The VAR POL button allows you to select the polarity of the displayed VAR results. If you press the VAR POL button it initiates a screen which allows you to choose from a list of available choices for this setting.
   - The present selection is shown in the lower half of the VAR POL button.
   - Note – by convention lead/lag is indicated by the polarity of VAR and not by any other measurement result. Showing lead/lag by the polarity of PF is incorrect but has historically been done as a result of limitations in simpler VAW meters.
   - Mathematically VAR has usually been described as the 'sine' relationship to the phase shift of the current relative to the voltage, resulting in a positive VAR indicating a leading current and in most applications this is the recommended selection, but in certain industries the opposite convention is used where a positive VAR indicates a lagging current.
   - RECOMMENDATION: For most applications the use of the +LEAD setting is recommended.
3. The RESPONSE button allows you to select that measurement results will be averaged over time. If you press the RESPONSE button it initiates a screen which allows you to choose from a list of available choices for this setting.
   - The present selection is shown in the lower half of the RESPONSE button.
   - This setting can be used in combination with the DIGITS setting (see below) to reduce the jitter in readings from unstable signals.
   - RECOMMENDATION: The performance and specifications of the PA900 are not reliant on the use of this capability; it should only be used when needed and otherwise set to FASTEST.

4. The DIGITS button allows you to select that all available measurement results will be displayed with limited resolution if desired. If you press the DIGITS button it initiates a screen which allows you to choose from a list of available choices for this setting.
    - The present selection is shown in the lower half of the DIGITS button.
    - This only affects displayed numerical results; it does not affect any measurements obtained via an interface or via a historically saved record or via data logging.
    - RECOMMENDATION: In most applications this should be set to 5, only if there is significant instability in the signals should this be set to 3 or 4.

CONFIGURING HOW RESULTS ARE COMBINED

This is performed by using the buttons in the COMBINE area. Depending on configuration and the installed channels not all buttons may be present.

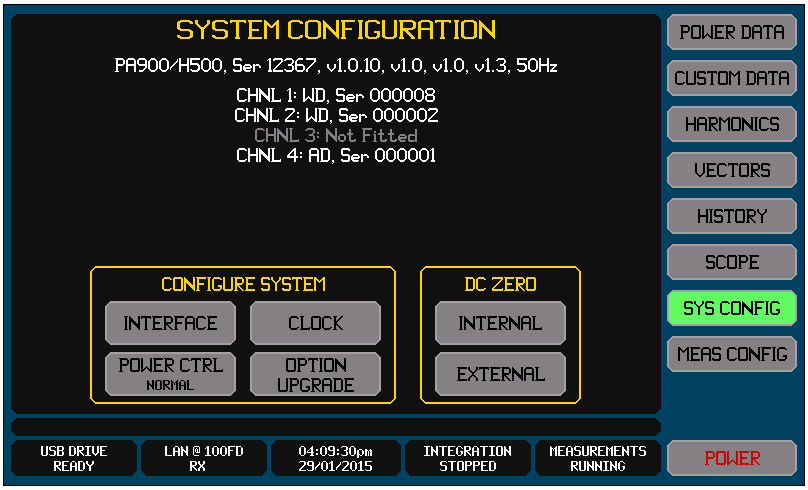
1. The WIRING button allows you to select how measurements are combined to produce total results for the selected VPA. If you press the WIRING button it initiates a screen which allows you to choose from a list of available choices for this setting.
    - The present selection is shown in the lower half of the WIRING button.
    - The available selections are determined from the number of channels selected in the VPA being configured. If the number of channels is altered then this setting will be reset to the N x 1ø setting which is valid for any number of channels.
    - This selection must match the method used to wire the application to the PA900 channels in this VPA.
2. The VA/VAR button allows you to select how measurements are combined to produce total VA and VAR result for the selected VPA. If you press the VA/VAR button it initiates a screen which allows you to choose from a list of available choices for this setting.
    - The present selection is shown in the lower half of the VA/VAR button.
    - If the Σ(VAR) choice is made then the total VAR for this VPA will be the sum of the VAR for the channels selected in this VPA and the total VA will be computed directly from the W and VAR totals for this VPA using $(\text{total VA})^2 = (\Sigma(W))^2 + (\Sigma(VAR))^2$
    - If the Σ(VA) choice is made then the total VA for this VPA will depend on the WIRING selection –
        - 3ø3w(2ch): total VA = $(\Sigma(VA)) * (\sqrt{3}) / 2$
        - Others: total VA = Σ(VA)
    - You should note that since this selection affects the total VA results, this selection also affects the total PF results.
    - RECOMMENDATION: if you have previously used the Σ(VA) method (which is commonly used by some other manufacturers of Power Analyzers) then it is recommended to use that setting. Otherwise the Σ(VAR) should be selected as it matches the mathematical approach. For pure sinewave voltages and currents, and the expected phase shift between the voltages, and a perfectly balanced load, there is no difference in the results between these selections.
3. The EFF/LOSS button allows you to select how the total power of this VPA is included in efficiency and power loss data. If you press the EFF/LOSS button it initiates a screen which allows you to choose from a list of available choices for this setting.
    - The present selection is shown in the lower half of the EFF/LOSS button.
    - The PA900 allows the total watts of a VPA to be included in one of three available data, IN, MIDDLE and OUT power. Alternately the total power of a VPA can be excluded from all three of these.

SYSTEM CONFIGURATION AND VIEWING THE PA900 BUILD INFORMATION

Pressing the SYS CONFIG button from any Main Screen initiates the SYS CONFIG Screen.

This screen has the following areas –

1. The uppermost information line shows (in order) –
    a. Model number and option content
    b. Unit serial number
    c. Main Firmware version
    d. FPGA Version
    e. Boot Firmware version
    f. Power Management MCU Firmware version
    g. The present mains supply frequency to the PA900
2. For each channel it lists the type and current option installed and the channel serial number.
3. It has a group of buttons in a CONFIGURE SYSTEM area allowing you to set system configuration settings.
4. It has a group of buttons in a DC ZERO area allowing you to ensure that the circuitry DC zeroes are set properly (INTERNAL) or that any external CT has its DC zero set correctly. The actions of these buttons are described the Optimizing Low-Level DC Performance section.

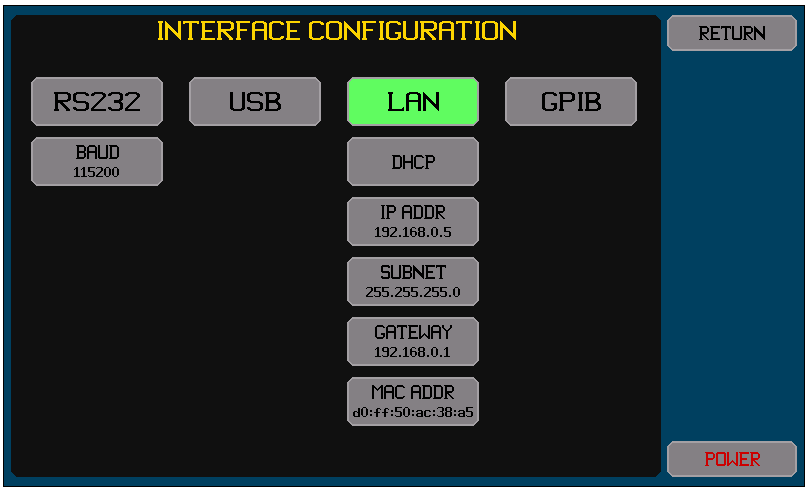


CONFIGURING THE INTERFACE

You may initiate the Interface Configure Screen by either –

1. Pressing the Interface Info area while on any main screen.
2. Or, pressing the SYS CONFIG button and then pressing the INTERFACE button on that screen.

Changes to the interfaces can only be made while not in remote.



The presently selected interface (if any) is shown highlighted in green. Pressing any of the top interface buttons toggles the selection active or inactive (only one interface can be active at any time).

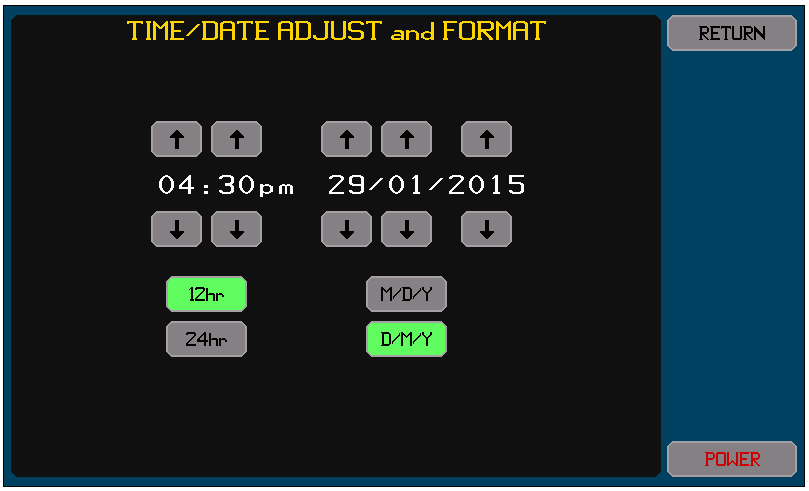
Below each interface button are the buttons allowing that interface to be configured, it is not necessary to enable an interface in order to configure it. Any changes made have an immediate effect.

1. For the RS232 interface the only setting is for the baud rate, which may be selected from those available by pressing the BAUD button.
2. There are no configuration settings for the USB interface.
3. For the LAN (Ethernet) interface there are two types of configuration selectable –
   - Using DHCP to obtain the LAN configuration.
     - In this case you press the DHCP/STATIC IP button and selects DHCP. In this case there is no other configuration required and if the LAN interface is enabled the remaining buttons show the configuration obtained (while obtaining the configuration the text in the buttons is colored orange).
   - Using manually set static IP information.
     - In this case you press the DHCP/STATIC IP button and select STATIC IP, and then manually enter the IP ADDR, SUBNET and GATEWAY addresses. You should consult your IT department to obtain the correct settings for these.
     - If the configured IP address is colored red, then this indicates that the PA900 has detected another device on the network which is using that IP address.
     - It is possible to use the LAN interface as a peer-to-peer interface to a computer using the STATIC IP method. The computer Ethernet interface being used must also be set to use a static IP and must have the same subnet and gateway settings as those of the PA900 for this to function correctly. The computer may need other configuration changes. The method of configuring a computer for this is beyond the scope of this document and you should consult your IT department regarding how to configure a computer Ethernet port for peer-to-peer (off network) operation.
4. For the GPIB interface you must set the GPIB address of the PA900.

SETTING THE CLOCK AND TIME/DATE FORMATS

You may initiate the Time and Date Configure Screen by either –

1. Pressing the time and date Info area while on any main screen.
2. Or, pressing the SYS CONFIG button and then pressing the CLOCK button on that screen.



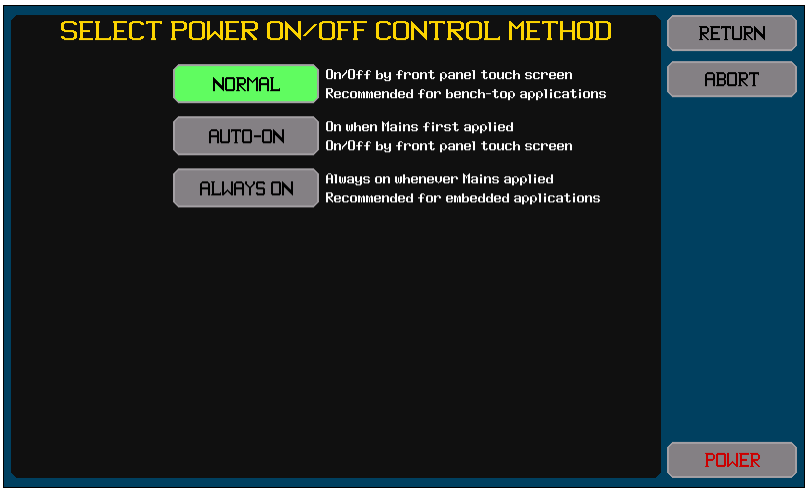
The presently selected formats are shown by the highlighted buttons.

You may adjust the time and/or date by using the respective up and down arrow buttons (these buttons auto-repeat if maintained pressed).

When changing the time the seconds data is always set to zero.

SELECTING THE POWER CONTROL SETTING

The POWER CTRL button on the SYS CONFIG screen enables you to select from the three power control methods for the PA900. The actions of each method are described on the screen allowing the selection and the setting takes an immediate effect when changed.



UPGRADING THE PA900 OPTION CONTENT

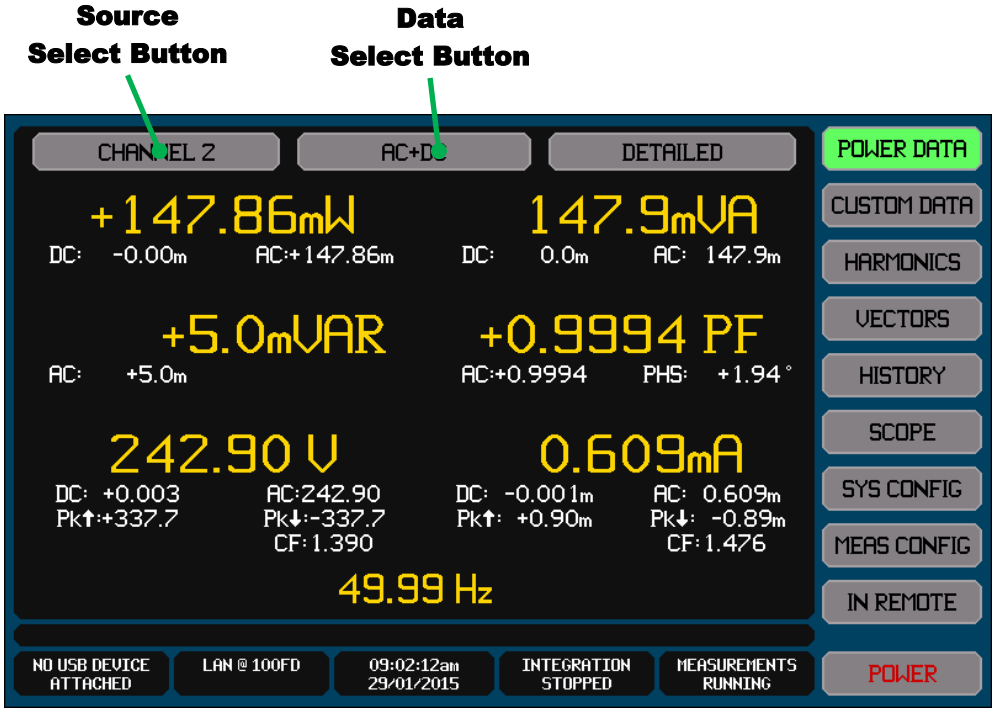
Certain PA900 options are field upgradable by the purchase of an upgrade code and entry of that code into the PA900. The upgrade is accomplished by pressing the OPTION UPGRADE button and entering the code.

USING THE POWER DATA SCREEN

The POWER DATA Screen can be selected for view from any of the Main Data Screens by pressing the POWER DATA button.

The POWER DATA Screen gives you access to pre-formatted numeric measurement results for individual channels or VPAs, or to overall power loss and efficiency results.

There are several formats available as described in the following sections.

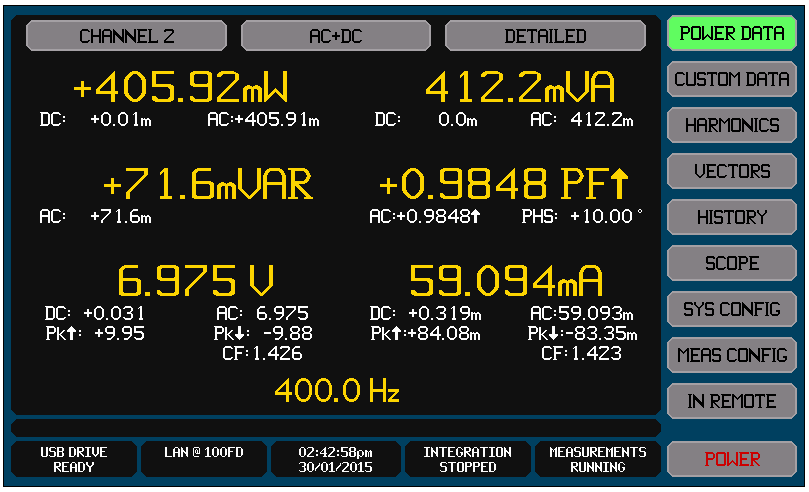


VIEWING MEASUREMENT RESULTS FOR AN INDIVIDUAL CHANNEL

The results for an individual channel can be selected on the POWER DATA screen by pressing the Source Select Button and selecting the desired channel. Only channels configured for measurement, i.e. selected in a VPA, can be selected.

For an individual channel, the Data Select Button allows the selection of a variety of data, each having a slightly different layout.

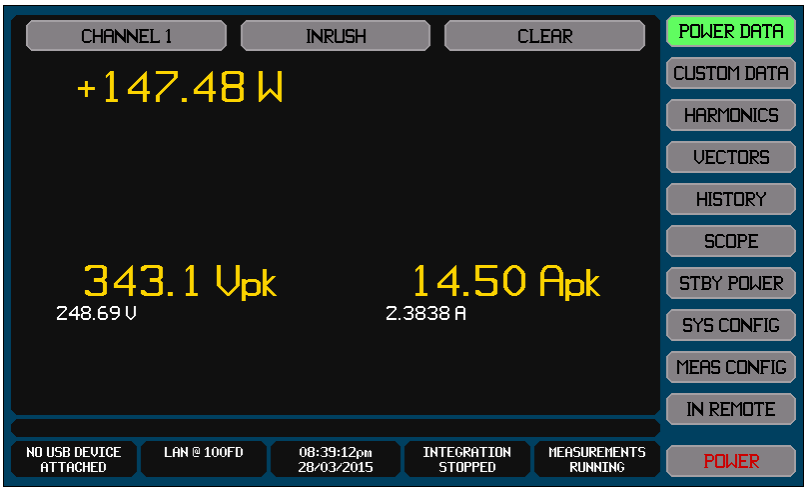
COUPLED, RECTIFIED AND FUNDAMENTAL DATA



This is viewed by selecting the COUPLED, RECTIFIED or FUNDAMENTAL selection in the Data Select Button. If the COUPLED selection is chosen then the button shows the configured COUPLING selection for this channel (i.e. DC, AC or AC+DC).

- The primary measurement results are shown using a large font and colored yellow-gold. The secondary results are shown in a smaller font and are colored white and these may be disabled or enabled by pressing the DETAILED/BASIC Button.
- The Watts, VA, VAR, PF, Volts and Amps results are grouped with their respective secondary results.
- For all data the secondary results include the results for couplings other than that configured (for the example above, AC+DC is configured as the COUPLING so the secondary results show the DC and AC data). Note that DC PF is not shown.
- Whether the current is leading or lagging the voltage can be determined by the direction of an arrow shown immediately after any PF data shown. If the arrow is pointing upwards then the current is leading, if downwards then it is lagging.
- The PHS data in the PF group is the inverse cosine of the PF data with the polarity set from the lead/lag determination.
- For COUPLED Data: the voltage and current group secondary data also shows the most positive and most negative peak excursions and the crest factors.
- For RECTIFIED Data: the voltage and current group secondary data also shows the most positive and most negative peak excursions and the form factors.
- For FUNDAMENTAL Data: the voltage and current group secondary data also shows the distortion percentage relative to the fundamental.

INRUSH DATA

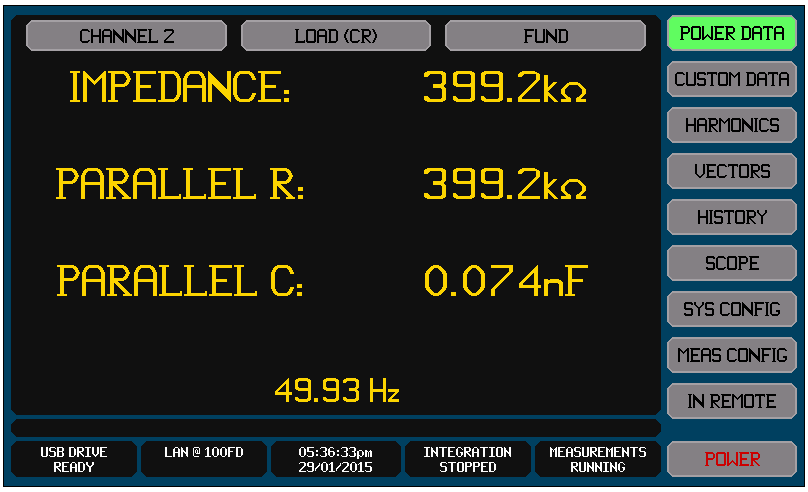


This is viewed by selecting the INRUSH selection in the Data Select Button and shows the highest recorded Watts, Volts, Peak Volts (largest excursion from zero), Amps, and Peak Amps (largest excursion from zero).

Inrush data is an alternative name for Max. Hold data and may be reset by pressing the CLEAR button.

RECOMMENDATION: when using channel(s) with the D current input option the user should select the HI A RANGE setting to properly measure the inrush current. This avoids a range change being required during the inrush event.

LOAD DATA



This is viewed by selecting the LOAD, LOAD (LR) or LOAD (CR) selections in the Data Select Button and shows the load impedance for LOAD, best fit series resistance/inductance for LOAD (LR), or the best fit parallel resistance/capacitance for LOAD (CR).

If the COUPLING configuration setting for the VPA containing this channel is set to DC then only the LOAD selection is available, otherwise only the LOAD (CR) and LOAD (LR) selections are available.

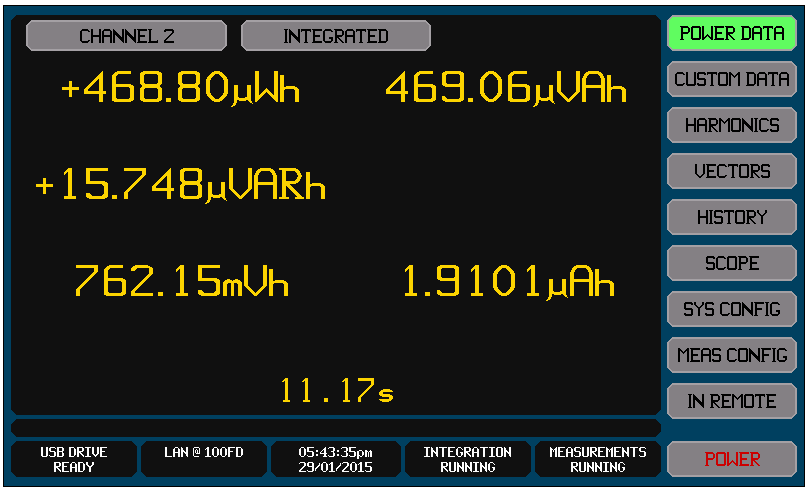
If LOAD is selected –

- Only the IMPEDANCE data is shown

If LOAD (CR) or LOAD (LR) is selected –

- If harmonic data is available then pressing the AC/FUND button toggles between showing the AC coupled or fundamental data respectively.
- If a fit could not be obtained for the selected load then the parallel C or series L data is blank (you typically should select the other type of loading indication) but the IMPEDANCE data is always shown (and is the same data in either screen).

INTEGRATED DATA



This is viewed by selecting the INTEGRATED, INTEG AVG, BOUGHT POWER, SOLD POWER, CHARGE or DISCHARGE selections in the Data Select Button and shows the selected integrated data. If no integration has been performed then NO DATA is displayed.

- BOUGHT POWER is data integrated only while the Watts reading is positive.
- SOLD POWER is data integrated only while the Watts reading is negative.
- CHARGE is data integrated only while the DC Amps reading is positive.
- DISCHARGE is data integrated only while the DC Amps reading is negative.
- INTEG AVG is the INTEGRATED data divided by the integration time, so yields the average data over the entire integration period.

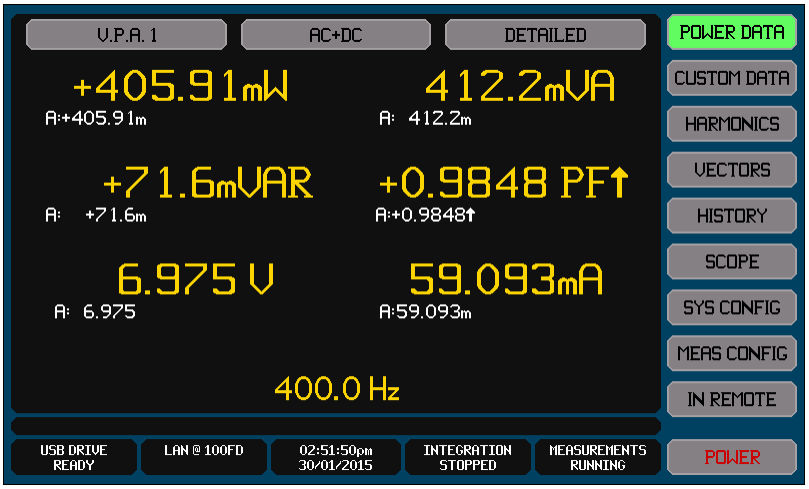
Integration can be started or stopped either from within the Integration Configure Screen (from the MEAS CONFIG menu) or by pressing the Integrate Info area in the bottom of any main data screen. Integration results are always cleared when integration is started. See the Integrating Data section of this document for details regarding configuring, starting and stopping integration.

VIEWING MEASUREMENT RESULTS FOR A VPA

The results for a VPA can be selected on the POWER DATA screen by pressing the Source Select Button and then selecting the desired VPA. Only VPAs configured for measurement, i.e. containing at least one channel, can be selected.

For a VPA the Data Select Button allows the selection of a variety of data, each having a slightly different layout. The layout also slightly varies with the WIRING configuration setting for the selected VPA.

COUPLED, RECTIFIED AND FUNDAMENTAL DATA

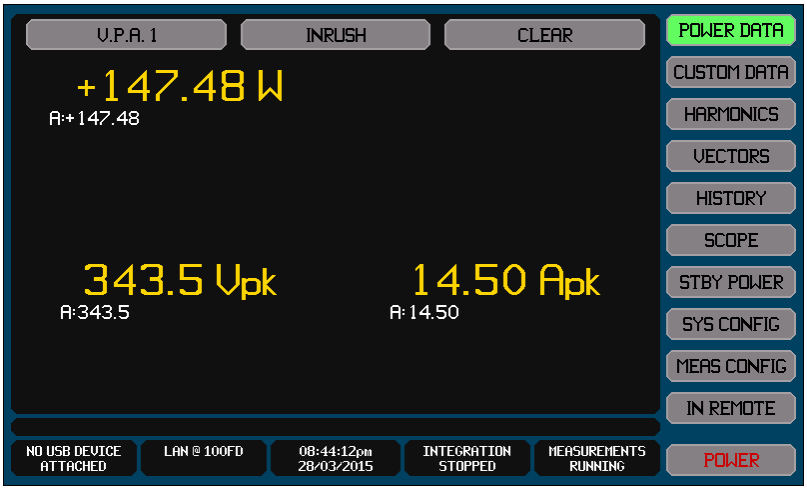


This is viewed by selecting the COUPLED, RECTIFIED or FUNDAMENTAL selection respectively in the Data Select Button. If the COUPLED selection is chosen then the button shows the configured COUPLING selection for this VPA (i.e. DC, AC or AC + DC).

- The primary measurement results are shown using a large font and colored yellow-gold. The secondary results are shown in a smaller font and are colored white and these may be disabled or enabled by pressing the DETAILED/BASIC Button.
- The Watts, VA, VAR, PF, Volts and Amps results are grouped with their respective secondary results.
- The primary Watts, VA, VAR and PF data is the total data for the VPA.
- The primary Volts and Amps data is the average for all phases/channels in the VPA.
- For all data the secondary results show the individual channel results for each channel in the VPA.
- For 3ø3w(2ch) and 3ø3w(3ch) WIRING settings the secondary voltages are the phase-to-phase voltages and the primary voltage is the average of the three phase-to-phase voltages.
- For 3ø3w(2ch) and 3ø3w(3ch) WIRING settings the Wye voltage conversion is also shown.

- For 3ø4w WIRING setting the Delta voltage conversion is also shown.
- Whether the current is leading or lagging the voltage can be determined by the direction of an arrow shown immediately after any PF data shown. If the arrow is pointing upwards then the current is leading, otherwise it is lagging.

INRUSH DATA

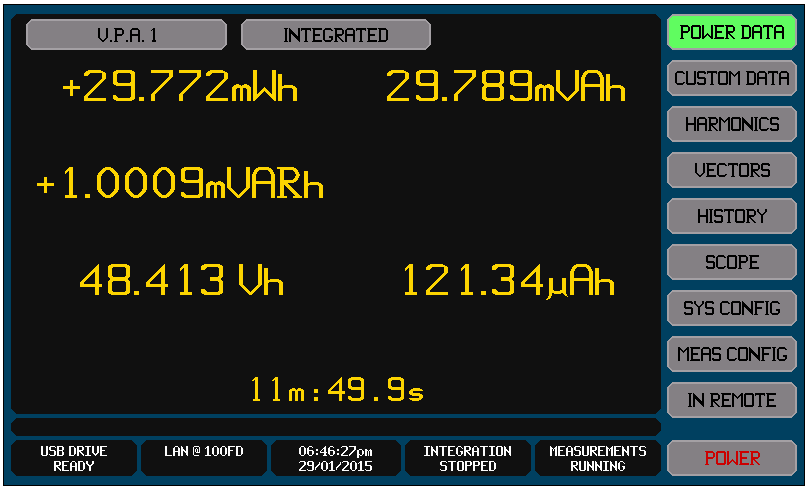


This is viewed by selecting the INRUSH selection in the Data Select Button and shows the highest recorded Total and Channel/Phase Watts, Channel/Phase Peak Volts, and Channel/Phase Peak Amps.

Inrush data is an alternative name for Max. Hold data and may be reset by pressing the CLEAR button.

RECOMMENDATION: when using channel(s) with the D current input option the user should select the HI A RANGE setting to properly measure the inrush current. This avoids a range change being required during the inrush event.

INTEGRATED DATA

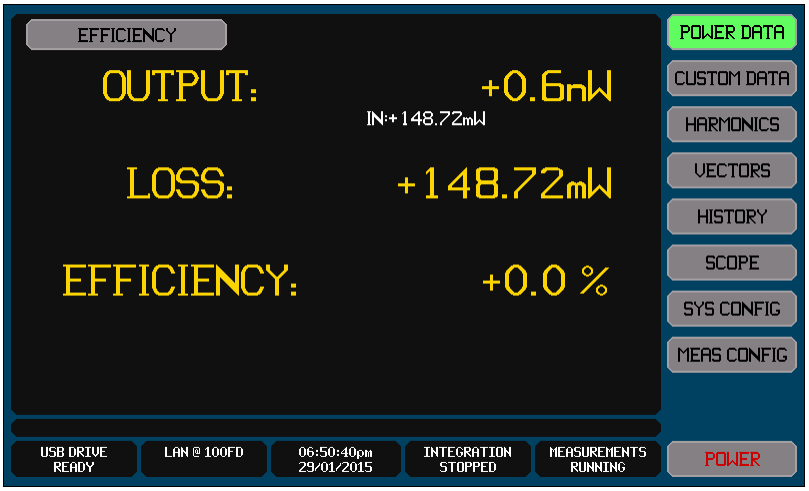


This is viewed by selecting the INTEGRATED, INTEG AVG, BOUGHT POWER, SOLD POWER, CHARGE or DISCHARGE selections in the Data Select Button and shows the selected integrated data. If no integration has been performed then NO DATA is displayed.

- BOUGHT POWER is data integrated only while the Watts reading is positive.
- SOLD POWER is data integrated only while the Watts reading is negative.
- CHARGE is data integrated only while the DC Amps reading is positive.
- DISCHARGE is data integrated only while the DC Amps reading is negative.
- INTEG AVG is the INTEGRATED data divided by the integration time, so yields the average data over the entire integration period.

Integration can be started or stopped either from within the Integration Configure Screen (from the MEAS CONFIG menu) or by pressing the Integrate Info area in the bottom of any main data screen. Integration results are always cleared when integration is started. See the Integrating Data section of this document for details regarding configuring, starting and stopping integration.

VIEWING EFFICIENCY AND POWER LOSS MEASUREMENT RESULTS



The results for efficiency and power loss can be selected on the POWER DATA screen by pressing the Source Select Button and then selecting EFFICIENCY. This selection is only available if at least one channel is configured to be included in the IN, MIDDLE or OUT groups.

- The Watts for the IN and MIDDLE groups are shown as secondary data under the OUTPUT Power result (which is the OUT group Watts). Each is only shown if any VPA is configured in that group.
- The IN:MIDDLE and MIDDLE:OUT power loss is shown as secondary data under the LOSS result (which is the IN:OUT power loss). Each is only shown if VPAs are configured in both groups.
- The IN:MIDDLE and MIDDLE:OUT efficiency is shown as secondary data under the EFFICIENCY result (which is the IN:OUT efficiency). Each is only shown if VPAs are configured in both groups.

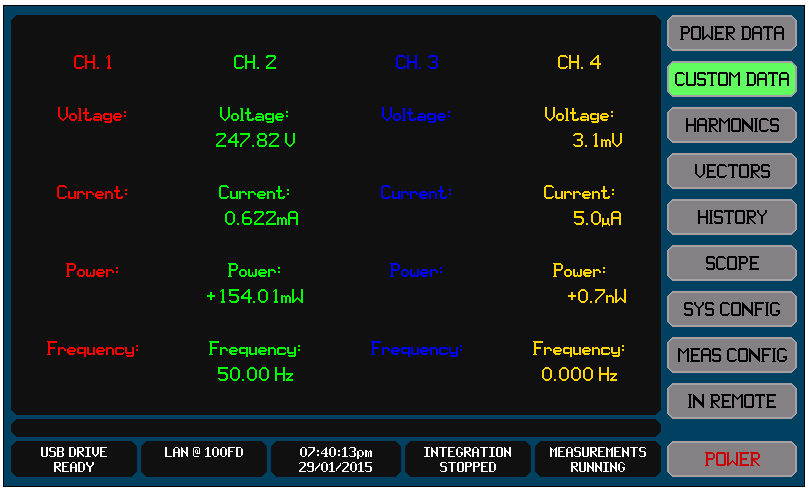
USING THE CUSTOM DATA SCREEN

The CUSTOM DATA Screen gives you access to user-formatted numeric measurement results which are entirely selected and configured by you.

Any numeric measurement result obtainable within the PA900 can be displayed in a variety of screen positions with a variety of font sizes, colors and optionally with text associated with it.

The CUSTOM DATA Screen can be selected for view from any of the Main Data Screens by pressing the CUSTOM DATA button.

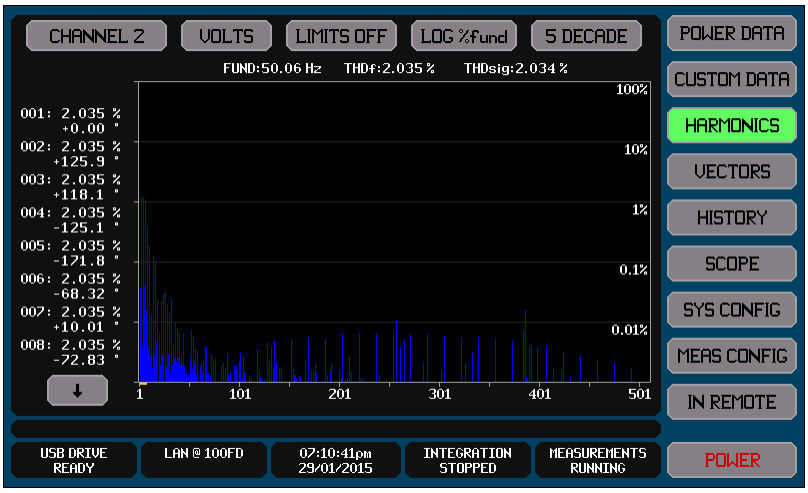
A simple example custom data screen is shown below.



Configuring the CUSTOM DATA screen requires –

1. Either –
    a. Using the supplied application to create the desired screen and then sending the created custom screen definition to the PA900 via an interface.
    b. Or, exporting the definition from a PA900 which already has the desired custom screen definition and then importing this file into another PA900 using a USB drive.
    c. Or, importing from an ASCII file on a USB drive which has been generated by you. See Creating and Importing an ASCII Custom Screen Definition File for details regarding this.
2. You can have many binary custom screen definitions on a single USB drive. In this case you can switch between custom screens by simply importing the desired custom screen. The imported custom screen is available as soon as it is imported and is stored inside the PA900 automatically, the USB drive does not need to remain in place.

USING THE HARMONICS SCREEN



The HARMONICS Screen can be selected for view from any of the Main Data Screens by pressing the HARMONICS button.

The HARMONICS Screen gives you access to graphically formatted bar charts of channel voltage and current harmonics and a scrollable numerical listing of that data. The number of bars shown is selected depending on the number of harmonics configured.

If no harmonics are available then the bar chart is blank and there are no numerical listings on the left side.

The displayed data is controlled by the 4 or 5 buttons across the top of the screen (in order from left to right) -

1. Select which channel is shown by using the leftmost button.
2. Select whether voltage or current harmonics are shown by using the VOLTS/AMPS button.
3. Select whether the selected channel voltage or current harmonics are to be compared against limits by the LIMITS button. See below for details regarding applying harmonics limits.
4. Select the format of the bar chart by using the fourth button. You may select linearly or logarithmically scaled bar charts, either for the absolute data, or relative to the fundamental, or relative to the total signal.
5. If a logarithmic format bar chart is selected then the fifth button allows you to select how many decades are shown.

USING THE NUMERIC LISTING

The numerical listing down the left side shows the amplitude and phase for up to 8 selected harmonics.

Each harmonic is listed with the harmonic number, and also there is a gold colored bar under the horizontal axis of the bar chart showing where the listed harmonics are located on the bar chart.

There are two methods which can be used to scroll the numerical listing –

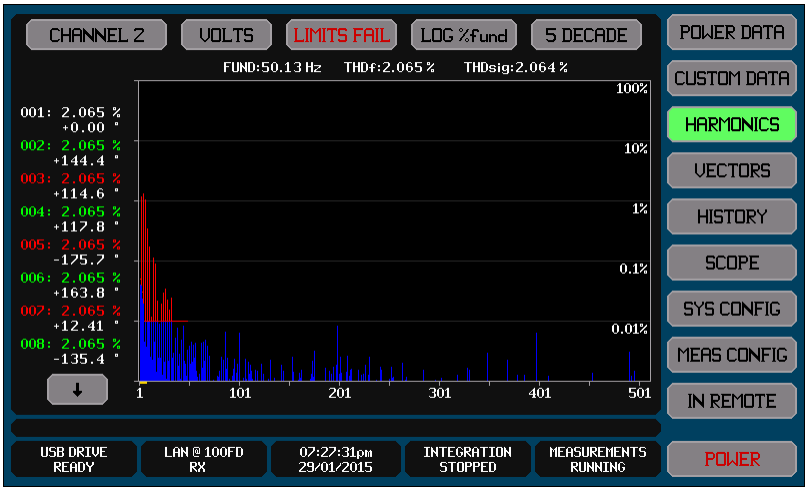
1. Using the scroll up/down buttons above and below the listing (these buttons repeat if held pressed).
2. Pressing anywhere in the bar chart. This positions the listing in the harmonics shown at that position on the bar chart. You may also drag the listing as required in this manner.

The amplitude data is in Volts or Amps or % units as set by the type of bar chart selected.

The phase data is in degree units with ±180° range as follows –

- Fundamental Voltage : relative to the V fundamental in the lowest numbered channel of the VPA
- Non-fundamental Voltage : relative to the V fundamental in this channel
- Fundamental Current : relative to the V fundamental in this channel
- Non-fundamental Current : relative to the A fundamental in this channel

COMPARING HARMONICS AGAINST LIMITS



The PA900 has the ability to compare voltage and current harmonics against limits set for each harmonic independently for voltage and current.

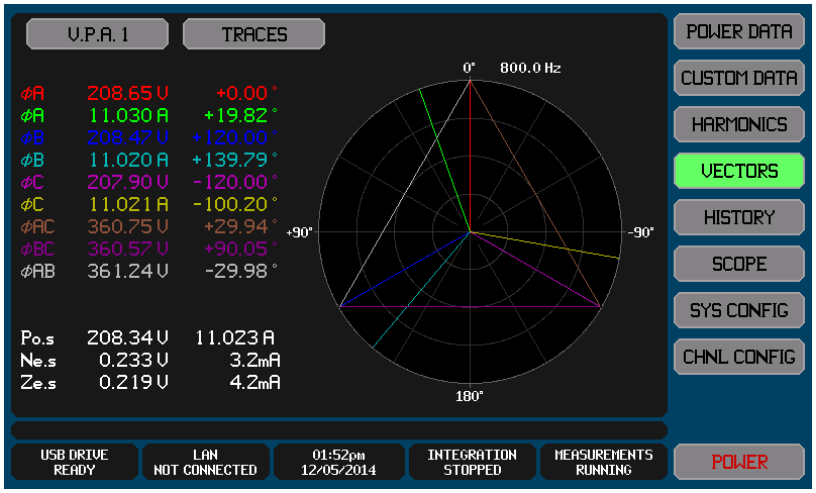
In order to compare harmonics against limits you must perform the following –

1. Create the harmonic limit for each required harmonic.
    a. This can be achieved by using the interface to command the limits directly into the PA900,
    b. Or, they can be exported from a PA900 which already has the harmonics limits defined and then importing that file into this PA900 using a USB drive.
    c. Or, they can be imported from an ASCII file on a USB drive which has been generated by you. See the Creating and Importing an ASCII Harmonics Limits File section of this document for details regarding this.
2. Once limits have been set the PA900 always compares the measured harmonics against these limits, but you may select whether the bar chart and numeric listing in the HARMONICS screen includes the results of those comparisons or not by pressing the LIMIT button on the HARMONICS screen.

If limits are enabled to be shown then-

- The bar chart includes a red line indicating the limit for each checked harmonic
- Colors any harmonic bar above the limit as red
- Colors the numerical listing for each compared harmonic as either green (pass) or red (fail)
- Shows the overall pass/fail status in the LIMIT button (colored red or green).
- Harmonics which have no limit set have their bars and numeric listing colored normally.

USING THE VECTORS SCREEN



The VECTORS Screen can be selected for view from any of the Main Data Screens by pressing the VECTORS button.

The VECTORS Screen gives you access to polar charts of voltage and current fundamental vectors and a numerical listing of that data which includes sequence data if showing a VPA which is configured for 3ø4w WIRING.

If no harmonics are available then the vector chart is blank and there are no numerical results on the left side.

You should note the following –

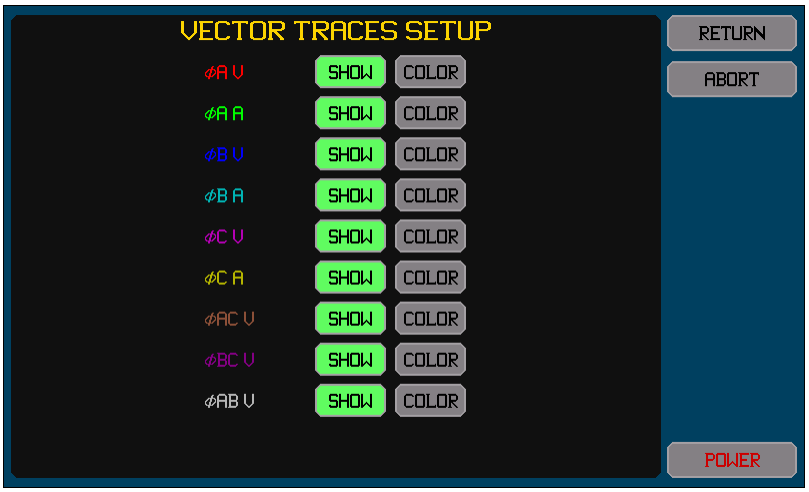
- The length of all voltage vectors are scaled such the longest vector just touches the outer boundary of the chart and the other voltage vectors are scaled relative to this.

- The length of all current vectors are scaled such the longest vector just touches the outer boundary of the chart and the other current vectors are scaled relative to this.
- If showing a VPA and that VPA is configured for 3ø3w(2ch) WIRING then the voltage vectors are constructed as follows –
    - A 'delta' is formed from the two measured inter-phase voltage vectors and the vector between the ends of those vectors.
    - The size and position of that constructed delta is such that the apex between the two measured vectors is at 0° and all apexes either just touch the outer boundary of the chart or are inside it, with at least one touching it.
- Otherwise, 0° is the phase of the voltage in the lowest numbered channel in the VPA (if a VPA is selected) or the voltage signal of the selected channel (if a channel is selected).
- For convenience the polar chart is drawn with circular gridlines at 25% intervals, and angular gridlines at 30° intervals.
- In the numerical listing on the left side, the angles shown are the angles of each corresponding vector as shown on the chart. The voltage or current shown is effectively the length of each corresponding vector but in absolute units rather than ratiometric as they are drawn.
- For the sequence data (if any) to have the normal significance, the wiring phasing must be phase A to the lowest numbered channel in the VPA, phase B to the middle, and phase C to the highest. If the wiring is not as described then the three sequence data will have different meanings to those shown.

The displayed vectors and the corresponding numerical data are controlled by the 2 buttons across the top of the screen (in order from left to right) –

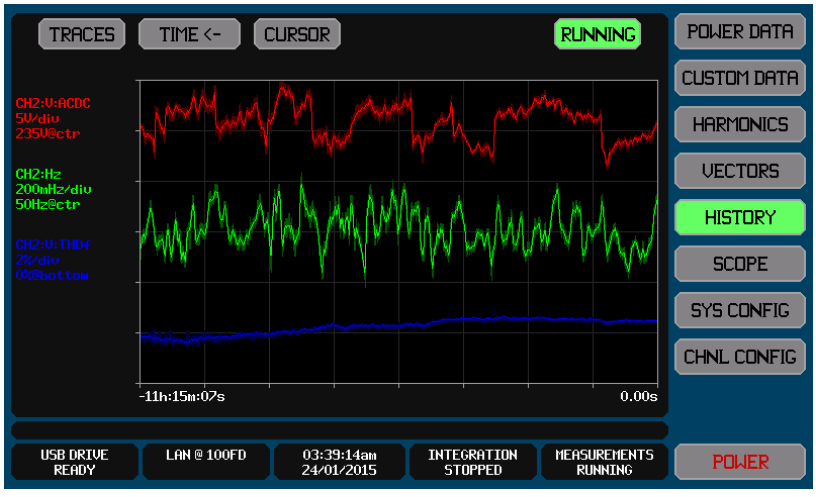
1. Selection of the channel or VPA for which to display the vectors. Pressing this button initiates a screen which allows you to select the channel or VPA from those configured.
2. Selection of the vector traces to show. Pressing this button initiates a screen which allows you to select which signal traces will be shown and which color will be used for each enabled trace. The available selections are dependent on whether a channel or a VPA is selected and if a VPA is selected then also the WIRING configuration of that VPA.

   The screen shown below shows an example of the trace selection screen for a VPA configured for 3ø3w(2ch). All possible traces are shown as selected in this example; with each trace set for a different color (9 colors are available for selection).



- A trace is enabled if the SHOW button is highlighted colored green. Pressing the SHOW button toggles whether the trace is selected or not.
- Pressing the COLOR button changes the color of that trace to the next available color, the name of the trace being changed shows which color will be used for that trace and the numerical data for it.

USING THE HISTORY SCREEN



The HISTORY Screen can be selected for view from any of the Main Data Screens by pressing the HISTORY button.

The HISTORY Screen gives you access to charts of up to four measured results vs elapsed time. All available data is always recorded without you having to make configuration settings. The only configuration needed is that needed to select the data to display and to format the display of those selected data. You may select to display the same data on more than one trace, each with different scaling and offset as desired.

Each trace is drawn showing the average and the extents of the data within each pixel. The average is drawn with full brightness, while the extents are shown colored between the lowest and highest extents using a lower brightness. The traces in the example screen shown above demonstrate this.

To the left of the chart there is textual information indicating the data selection, color, scaling and offset settings for each enabled trace in a brief format.

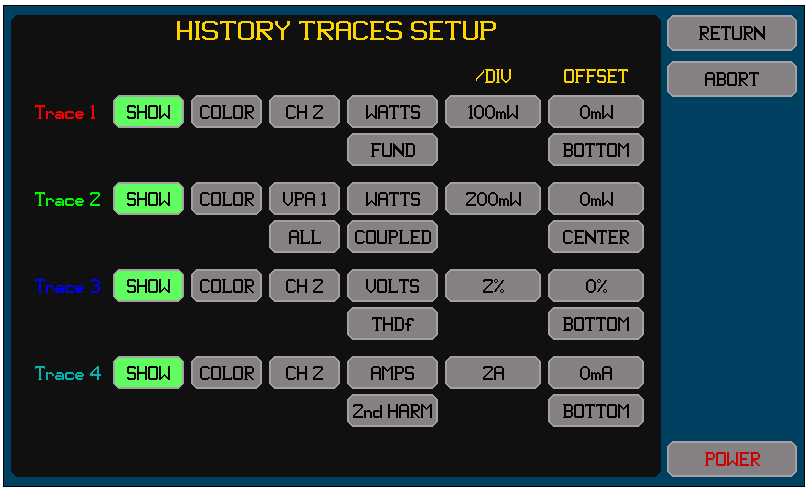
Since all available historical data are always saved while the HISTORY is RUNNING, you are free to change traces at will without needing to retake data.

Unless you have zoomed the chart, the right end of the chart is 'now' and the left end is when the chart was started.

SELECTING AND CONFIGURING THE TRACES SHOWN ON THE CHART

The HISTORY screen traces are selected and configured by using the TRACES button at the top of the screen. If you press this button it initiates a screen which allows you to select up to four traces. An example of that screen is shown below.

Traces are drawn in numerical order, trace 1 first, and then trace 2, and so on. So the highest numbered enabled trace is the uppermost trace if traces overlap.



For each trace you may configure –

1. If the trace is shown or not. Pressing the SHOW button toggles the trace on/off. The button is highlighted colored green when enabled.
2. The color of the trace. Change the color by repeatedly pressing the COLOR button until the adjacent trace number shows the desired color.
3. The measurement result to trace. There are two, three or four buttons to the right of the COLOR button which allows you to set the desired measurement data to trace. The measurement data selected is the combination of these settings.
4. The scaling (per division) for this trace. The button in the /DIV column allows you to set the scaling in the units of the selected measurement data. Note that this is entered per division and there are a total of six vertical divisions in the chart.
5. The offset on the chart for the trace. The buttons in the OFFSET column allows you to set the measurement data value and the place on the chart to position that value.
    a. For example if a voltage trace was set for a 0.5A offset value and the offset set to CENTER, then the resulting trace will be in the center of the chart vertically when it has the 0.5A value, if higher than 0.5A then it will be higher (by an amount set by the scaling required) and will be lower if below 0.5A.
    b. Usually if you are plotting data that can be positive or negative and it is wished to set the chart to cover the entire range of possible values, then you should set an offset of 0 at the CENTER, and set the scaling to ensure the trace stays within the 3 divisions on either side of the center.
    c. Usually if you are plotting data which is always positive (such as THD or CF for example) and it is wished to set the chart to cover the entire range of possible values, then you should set an offset of 0 at the BOTTOM, and set the scaling to ensure the trace stays within the 6 divisions of the chart.
    d. Usually if you wish to plot the deviation of data from some nominal expected value then you should set that expected nominal value as the offset and set for the offset CENTER location, and set the scaling as desired to make any deviations easily visible.

CHANGING THE WAY IN WHICH TIME IS DISPLAYED ON THE CHART

The TIME button (second from the left across the top of the screen) toggles between showing TIME<- and TIME->.

When TIME<- is selected then time is shown below the horizontal axis of the chart with 0 at the right (corresponding to 'now') and the time at which the chart was last started at the left with a negative time shown (indicating time before now).

When TIME-> is selected then time is shown below the horizontal axis of the chart with 0 at the left (corresponding to when the chart was last started) and 'now' at the right with a positive time shown (indicating time after the start).

STARTING, STOPPING, AND RESTARTING THE CHART

Normally the chart is always collecting results. You may stop result collection by pressing the RUNNING button, and then may start the chart from the beginning by pressing it again (now labelled STOPPED). When starting, all previous historical data is erased from memory. This button is highlighted colored green when the chart is running.

A typical use of stopping and starting the chart is when it is required to chart the stability of certain measurements. In this case you would typically start making the measurements and then stop and restart the history chart. In this manner the chart only contains the time period of interest.

PROHIBITING DATA COLLECTION TEMPORARILY

While running a chart you can temporarily disable data collection by pressing the Measurement State Info area below the chart (normally showing MEASUREMENTS RUNNING). This holds all measurement results in the PA900 and also has the effect of prohibiting data collection into the historical record. The historical record still runs however, but the traces are blanked during this time.

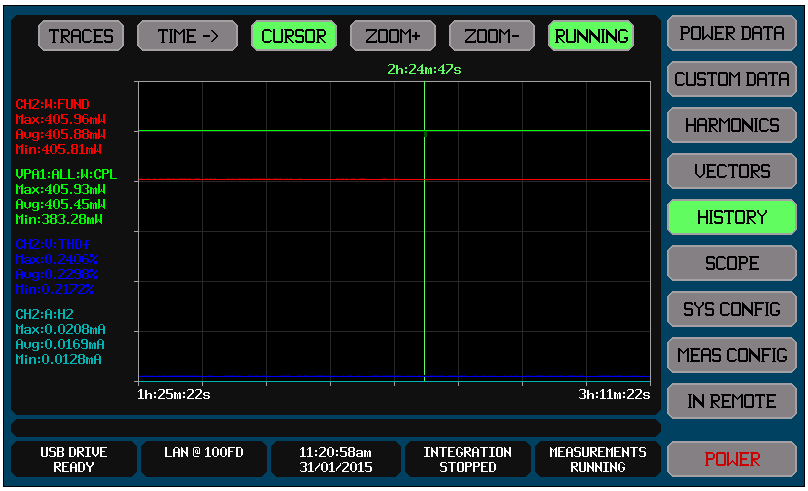
Data collection can be restarted by pressing the Measurement State Info area again (while showing MEASUREMENTS HELD).

USING THE CURSOR AND ZOOMING THE CHART

A vertically drawn cursor may be placed on to the chart by you. There are two ways of achieving this –

1. Press the CURSOR button at the top of the screen, this places a cursor at the last used position of the cursor, or at the left end of the screen if the cursor has not been used before.
2. Press anywhere on the chart, this places a cursor at the horizontal position pressed. You may drag the cursor in this manner, or you may reposition the cursor by pressing somewhere else on the chart.

The screen below shows an example of a HISTORY data screen with the cursor shown and zoomed in slightly.



When the cursor is shown –

- The CURSOR button is highlighted colored green
- The time position of the cursor is shown above the cursor line
- The cursor remains at the same position in time relative to the start of the data collection.
- The textual data in the left side of the screen changes to show the maximum, average and minimum data recorded for each trace in the time increment corresponding to the width of one pixel at the present cursor position.
- You may zoom the chart horizontally by pressing the ZOOM+ button (next to the CURSOR button). While zoomed –
    - You may zoom in further by pressing the ZOOM+ again, or may zoom back by pressing the ZOOM- button.
    - The cursor remains set to the same time as it was prior to zooming, but it may still be moved within the timespan of the zoomed chart by pressing at the desired location within the chart.
    - Each ZOOM+ press changes the horizontal timing by a factor of 2:1 and a maximum of 6 zoom levels are allowed (i.e. the maximum zoom is 64:1).
- Any zoom can be cancelled and the screen returned to the non-zoomed state without a cursor at any time by pressing the CURSOR button while it is highlighted.

SPECIFICATIONS FOR HISTORICAL DATA COLLECTION

The historical data collection automatically stops after approximately 397 days of data collection.

The minimum time resolution is the greater of-

- 1 pixel of the display
- 1 measurement period of the data being recorded
- A maximum of 1/2048th of the elapsed historical data collection time (typically 1/4096th).

Every data from every measurement period covered by each time resolution period is included in the maximum, average and minimum data regardless of the time resolution.

Not all data are available, the available data are shown in the list provided below which has been shortened by the use of the following–

CHn	Any of CH1, CH2, CH3 or CH4
An	Any of VPA1, VPA2 or VPA3
pX	Any of øA, øB, øC or øD
Hn	Any of H1 … 3

FREQ:CHn
FREQ:An
VOLTS:CHn:DC
VOLTS:CHn:AC
VOLTS:CHn:ACDC
VOLTS:CHn
VOLTS:CHn:CF
VOLTS:CHn:PK
VOLTS:CHn:HIPK
VOLTS:CHn:LOPK
VOLTS:CHn:Hn
VOLTS:CHn:P1
VOLTS:CHn:THDf
VOLTS:CHn:THDsig
VOLTS:An:pX:DC
VOLTS:An:pX:AC
VOLTS:An:pX:ACDC
VOLTS:An:pX
VOLTS:An:pX:CF
VOLTS:An:pX:PK
VOLTS:An:pX:HIPK
VOLTS:An:pX:LOPK
VOLTS:An:pX:Hn
VOLTS:An:pX:P1
VOLTS:An:pX:THDf
VOLTS:An:pX:THDsig
VOLTS:An:øAC:AC
VOLTS:An:øAC:ACDC
VOLTS:An:øAC
VOLTS:An:øAC:CF
VOLTS:An:øAC:PK
VOLTS:An:øAC:HIPK
VOLTS:An:øAC:LOPK
VOLTS:An:øAC:Hn
VOLTS:An:øAC:P1
VOLTS:An:øAC:THDf
VOLTS:An:øAC:THDsig
VOLTS:An:øBC:AC
VOLTS:An:øBC:ACDC
VOLTS:An:øBC
VOLTS:An:øBC:CF
VOLTS:An:øBC:PK
VOLTS:An:øBC:HIPK
VOLTS:An:øBC:LOPK
VOLTS:An:øBC:Hn
VOLTS:An:øBC:P1
VOLTS:An:øBC:THDf
VOLTS:An:øBC:THDsig
VOLTS:An:øAB:AC
VOLTS:An:øAB:ACDC
VOLTS:An:øAB
VOLTS:An:øAB:CF
VOLTS:An:øAB:PK
VOLTS:An:øAB:Hn
VOLTS:An:øAB:P1
VOLTS:An:øAB:THDf
VOLTS:An:øAB:THDsig
VOLTS:An
VOLTS:An:PK
VOLTS:An:H1
AMPS:CHn:DC
AMPS:CHn:AC
AMPS:CHn:ACDC
AMPS:CHn
AMPS:CHn:CF
AMPS:CHn:PK
AMPS:CHn:HIPK
AMPS:CHn:LOPK
AMPS:CHn:Hn
AMPS:CHn:P1
AMPS:CHn:THDf
AMPS:CHn:THDsig
AMPS:An:pX:DC
AMPS:An:pX:AC
AMPS:An:pX:ACDC
AMPS:An:pX
AMPS:An:pX:CF
AMPS:An:pX:PK
AMPS:An:pX:HIPK
AMPS:An:pX:LOPK
AMPS:An:pX:Hn
AMPS:An:pX:P1
AMPS:An:pX:THDf
AMPS:An:pX:THDsig
AMPS:An:N:DC
AMPS:An:N:AC
AMPS:An:N:ACDC
AMPS:An:N
AMPS:An:N:CF
AMPS:An:N:PK
AMPS:An:N:H1
AMPS:An
AMPS:An:PK
AMPS:An:H1
WATTS:CHn:DC
WATTS:CHn:AC
WATTS:CHn:ACDC
WATTS:CHn
WATTS:CHn:H1
WATTS:An:pX:DC
WATTS:An:pX:AC
WATTS:An:pX:ACDC
WATTS:An:pX
WATTS:An:pX:H1
WATTS:An:øAC:DC
WATTS:An:øAC:AC
WATTS:An:øAC:ACDC
WATTS:An:øAC
WATTS:An:øAC:H1
WATTS:An:øBC:DC
WATTS:An:øBC:AC
WATTS:An:øBC:ACDC
WATTS:An:øBC
WATTS:An:øBC:H1
WATTS:An
WATTS:An:H1
WATTS:IN
WATTS:MIDDLE
WATTS:OUT
LOSS:IN-MID
LOSS:IN-OUT
LOSS:MID-OUT
EFFICIENCY:IN-MID
EFFICIENCY:IN-OUT
EFFICIENCY:MID-OUT
VAR:CHn:AC
VAR:CHn:ACDC
VAR:CHn
VAR:CHn:H1
VAR:An:pX:AC
VAR:An:pX:ACDC
VAR:An:pX
VAR:An:pX:H1
VAR:An:øAC:AC
VAR:An:øAC:ACDC
VAR:An:øAC
VAR:An:øAC:H1
VAR:An:øBC:AC
VAR:An:øBC:ACDC
VAR:An:øBC
VAR:An:øBC:H1
VAR:An
VAR:An:H1
VA:CHn:DC
VA:CHn:AC
VA:CHn:ACDC
VA:CHn
VA:CHn:H1
VA:An:pX:DC
VA:An:pX:AC
VA:An:pX:ACDC
VA:An:pX
VA:An:pX:H1
VA:An:øAC:DC
VA:An:øAC:AC
VA:An:øAC:ACDC
VA:An:øAC
VA:An:øAC:H1
VA:An:øBC:DC
VA:An:øBC:AC
VA:An:øBC:ACDC
VA:An:øBC
VA:An:øBC:H1
VA:An
VA:An:H1
PF:CHn:AC
PF:CHn:ACDC
PF:CHn
PF:CHn:H1
PF:An:pX:AC
PF:An:pX:ACDC
PF:An:pX
PF:An:pX:H1
PF:An:øAC:AC
PF:An:øAC:ACDC
PF:An:øAC
PF:An:øAC:H1
PF:An:øBC:AC
PF:An:øBC:ACDC
PF:An:øBC
PF:An:øBC:H1
PF:An
PF:An:H1
LOADZ:CHn:DC
LOADZ:CHn:AC
LOADZ:CHn:ACDC
LOADZ:CHn
LOADZ:CH

USING THE SCOPE SCREEN

The SCOPE Screen can be selected for view from any of the Main Data Screens by pressing the SCOPE button.

There are two SCOPE screens –

CYCLE VIEW –

- Always shows a single fundamental cycle of waveforms.
- Requires no specific configuration.
- Time resolution of the greater of 2.6ns or 1/512th of a cycle.
- Can show the volts, amps and/or watts signals.
- Can trace the same signal multiple times with different vertical scaling and offsets.
- Allows up to 6 traces to be simultaneously viewed.
- Perfect for the inspection of periodic waveforms with extreme amplitude and time detail available.

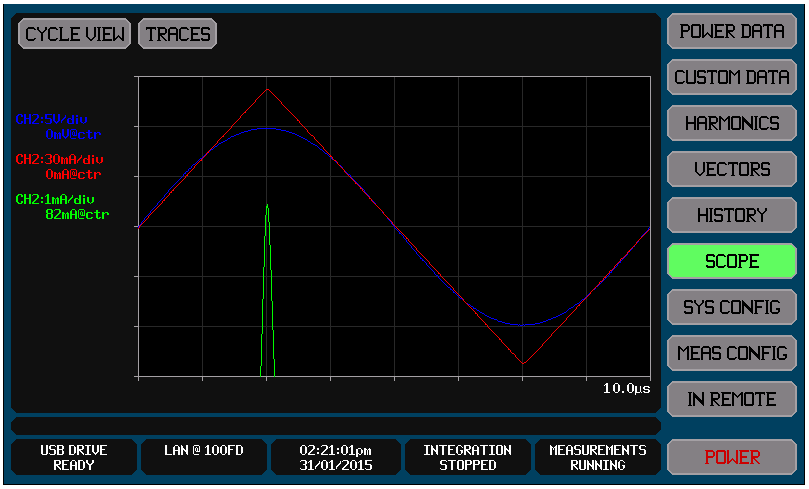
SCOPE VIEW –

- A multi-channel digital oscilloscope with many enhancements
    - Can change traces and/or trace scaling without having to retrigger
    - All data within the selected VPA is captured and with full 22/24 bit resolution so can change traces and/or trace scaling without having to retrigger
    - Can show the volts, amps and/or watts signals.
    - Can show the same signal in multiple traces, each with different vertical scaling and offsets.
- User configurable trigger and timebase.
- Continuous or single trigger.
- Allows up to 6 traces to be simultaneously viewed.
- Perfect for capturing non-periodic waveforms and transients (such as inrush current for example).

Which screen is viewed is selected by the upper left button of the SCOPE screen. The presently selected view name is displayed in the button, which toggles every time it is pressed.

The trace selections for each of these screens are independent of each other.

USING THE CYCLE VIEW SCREEN

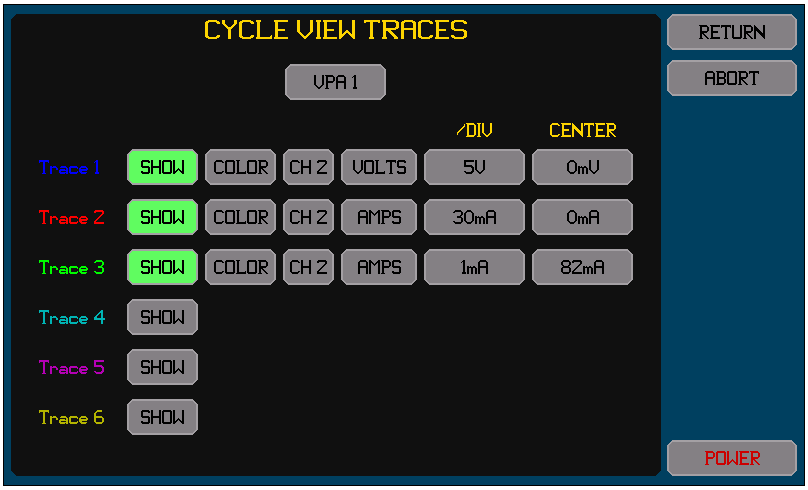


The above example shows the voltage (in blue) and current (in red) waveforms of a 100kHz signal (with 20ns time resolution) and includes a third trace (in green) which is also of the current waveform, but scaled and offset for close inspection of the peak of the triangle wave.

Cycle view places every sample from each measurement period at the correct phase to build a single cycle formed from all cycles present during the measurement period. To do this it needs the results of the harmonic analysis to position the samples correctly and it needs to know the fundamental frequency. Cycle view is NOT an inverse Fourier transform.

If no harmonics are available then the chart is blank.

The only configuration needed is to select the traces and to set the trace color, scaling and offset for each. This is performed by pressing the TRACES button which initiates a screen allowing this to be achieved. An example of this screen is shown below.



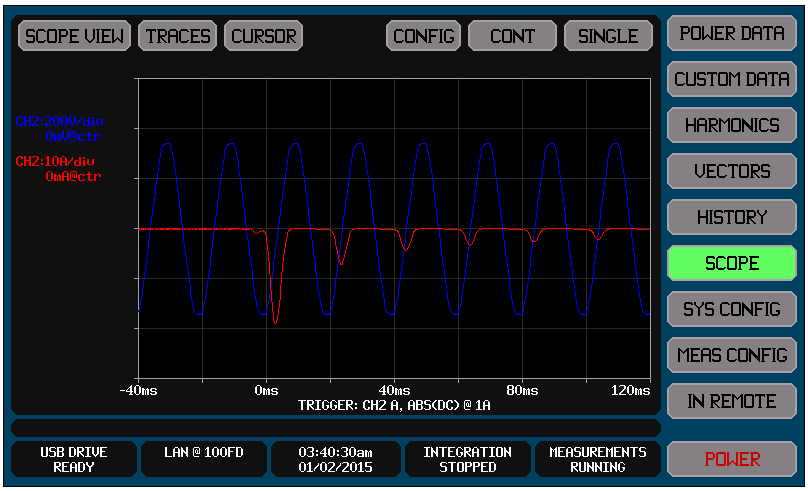
All traces must be from the same VPA, so this must be set prior to selecting any traces so that the correct signals may be selected for each trace.

For each trace you may configure –

1. If the trace is shown or not. Pressing the SHOW button toggles the trace on/off. The button is highlighted colored green when enabled.
2. The color of the trace. Change the color by pressing the COLOR button until the adjacent trace number shows the desired color.
3. The signal to trace. There are two buttons to the right of the COLOR button which allows you to select the channel and signal to trace. Either the voltage or current or watts signals may be traced. The watts signal is the result of multiplying the voltage and current signals.
4. The scaling (per division) for this trace. The button in the /DIV column allows you to set the scaling in the units of the selected signal. Note that this is entered per division and there are a total of 6 vertical divisions in the chart (3 above and 3 below the centerline).
5. The offset on the chart for the trace. The button in the OFFSET column allows you to set the signal level which will correspond to the centerline of the chart.

Traces are drawn in numerical order, trace 1 first, and then trace 2, and so on. So the highest numbered enabled trace is the uppermost trace if traces overlap.

USING THE SCOPE VIEW SCREEN

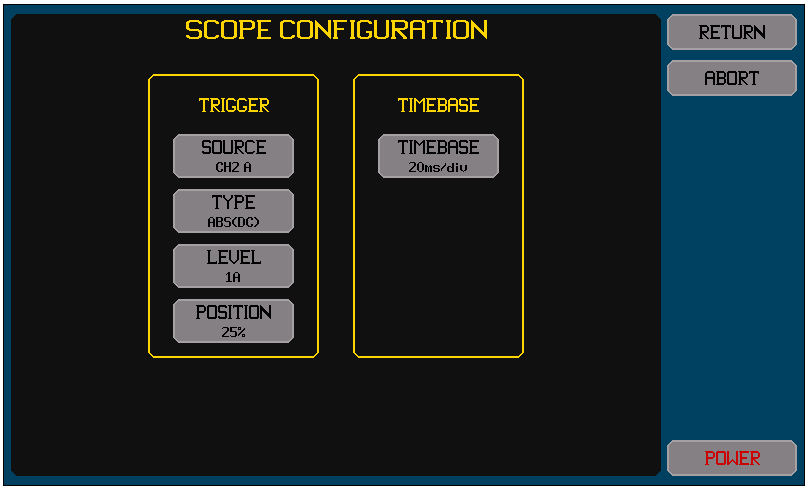


The above example shows the voltage (in blue) and current (in red) waveforms of an inrush current.

CONFIGURING THE TRIGGER AND TIMEBASE

Pressing the CONFIG button initiates a screen allowing the configuration of the trigger and the timebase.

While in remote you can only view the trigger and timebase settings but cannot change them.



Pressing the SOURCE button allows you to select the trigger source from the available signals. Note that the scope always captures all signals in the channels which are configured in the same VPA as that of the trigger source.

- If a VPA is configured with its LF/PERIOD setting selecting as another VPA and the trigger source channel is in either of these VPAs, then channels may be in either of these two VPAs.

Pressing the TYPE button allows you to select the trigger detection type. The available selections are-

- DC (rising edge). This selects that the scope is triggered when the selected signal changes from below the trigger level to above the trigger level. HF filtering is provided to reduce the possibility of small glitches causing a trigger.
- DC (falling edge). This selects that the scope is triggered when the selected signal changes from above the trigger level to below the trigger level. HF filtering is provided to reduce the possibility of small glitches causing a trigger.
- ABS(DC). This selects that the scope is triggered when the selected signal is above the trigger level or below the negative of the trigger level. This setting is particularly useful when triggering on inrush currents or voltage transients because you do not know which polarity the transient will be. HF filtering is provided to reduce the possibility of small glitches causing a trigger.
- HF. This selects that the scope is triggered when the result of HP filtering the selected signal is above the trigger level or below the negative of the trigger level. This setting is useful when it is required to trigger on fast glitches. The HP filter employed corresponds to a time of nominally 10% of the timebase setting.

Pressing the LEVEL button allows you to select the trigger detection level in the units of the signal.

- For the ABS(DC) or HF trigger types only positive values can be used.
- For the ABS(DC) or HF types you should not enter a trigger level of zero, as the signal will always trigger.

Pressing the POSITION button allows you to set where the trigger position is located on the unzoomed chart.

- You may select 0%, 25%, 50% or 75%.

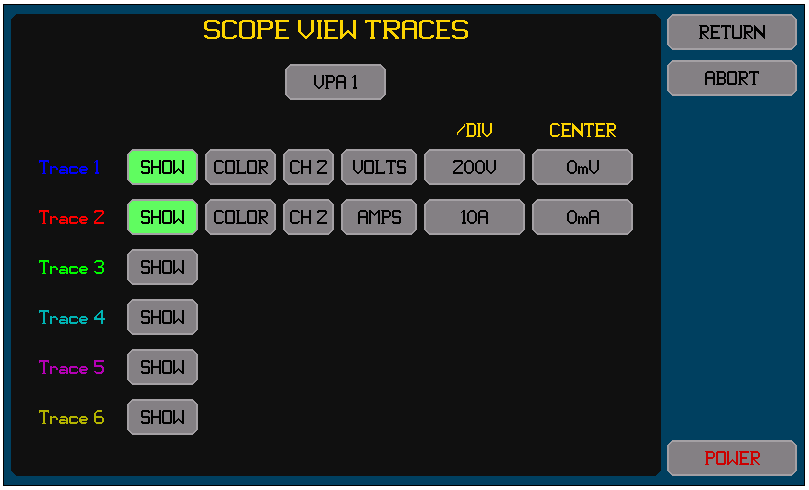
Pressing the TIMEBASE button allows you to select the timebase in units of time per division similarly to an oscilloscope.

- Timebase settings between 5us and 20s per division are available.

When all settings have been made correctly, you should press the RETURN button to return to the SCOPE VIEW screen, or the ABORT button may be pressed to return to the SCOPE VIEW screen discarding any changes made. When changes have been made any previously captured traces are cleared.

CONFIGURING TRACES

This is achieved by pressing the TRACES button on the SCOPE VIEW screen.



For each trace you may configure –

1. If the trace is shown or not. Pressing the SHOW button toggles the trace on/off. The button is highlighted colored green when enabled.

2. The color of the trace. Change the color by pressing the COLOR button until the adjacent trace number shows the desired color.
3. The signal to trace. There are two buttons to the right of the COLOR button which allows you to select the channel and signal to trace. Either the voltage or current or watts signals may be traced. The watts signal is the result of multiplying the voltage and current signals. All traces must be in channels configured in the same VPA as that in which the trigger source channel is configured.
4. The scaling (per division) for this trace. The button in the /DIV column allows you to set the scaling in the units of the selected signal. Note that this is entered per division and there are a total of 6 vertical divisions in the chart (3 above and 3 below the centerline).
5. The offset on the chart for the trace. The button in the OFFSET column allows you to set the signal level which will correspond to the centerline of the chart.

Traces are drawn in numerical order, trace 1 first, and then trace 2, and so on. So the highest numbered enabled trace is the uppermost trace if traces overlap.

Changing traces does not clear any previously made scope capture; it only affects how it is displayed.

RUNNING A SCOPE CAPTURE

The oscilloscope may be run in either SINGLE or CONT modes similarly to a normal oscilloscope.

While capturing in SINGLE or CONT modes the SINGLE button is highlighted colored green and is labelled with the status of the scope-

- PRETRIG. Indicates that the scope is collecting sufficient signal to accommodate the configured trigger position.
- WAITING. Indicates that the scope is waiting for a trigger event.
- TRIG'D. Indicates that the scope is collecting the signals after a trigger event has been detected but there is not enough signal to fill the screen yet.

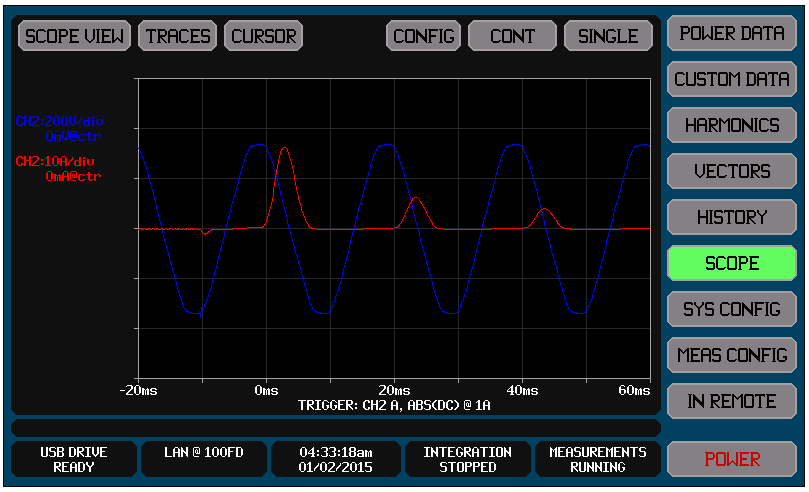
Pressing the CONT button starts continuous oscilloscope captures. Shortly after triggering and capturing all signals, the scope will wait for another trigger event. While capturing in CONT mode you may press the CONT button to stop capturing signals, or may press the button to its right to make a SINGLE mode capture instead.

Pressing the SINGLE button starts a single oscilloscope capture. After triggering and capturing all signals, the scope will stop. While capturing in SINGLE mode you may press the SINGLE button to abort the capture, or may press the CONT button to initiate CONT mode instead.

Note the following recommendations regarding running scope capture –

- Channels with the D current option should not be set for AUTO-RANGE unless it is known ahead of time that an auto-range change will not occur during the capture. If a range change occurs during a capture then the capture is abandoned and a new one is started, this may lead to data being lost.
- The HF LIMIT setting for the VPA also bandwidth limits all signals for the scope. This can limit your ability to use the HF trigger type if set for a fast timebase. If you intend to use the HF trigger type to detect very fast glitches on a much lower frequency signal then it is recommended to configure the VPA measurements for an HF LIMIT setting of UNFILTERED.
- Since the scope view capture is intended for the capture of non-repetitive signals it gains no advantage from the advanced sampling system in the PA900 and scope view data has the time resolution of individual samples of the signals. For W channel types this is just over 1us, otherwise it is just over 4us.
- Just as for all digital sampling oscilloscopes, setting the timebase to a very long value and attempting to capture a higher frequency signal will cause aliasing in the captured data making the captured signal look like it has a much lower frequency than it actually has. The PA900 has an internal scope capture time resolution down to $1/256^{th}$ of the configured timebase, but the screen has a time resolution of $1/64^{th}$ of the timebase when not zoomed. You should always set an appropriate timebase considering the frequency of the signal expected.
- If the intention is to trigger on an inrush event, then the use of the ABS(DC) trigger type is recommended, using the current signal as the trigger source and setting the trigger level to a suitable current level which you expect the inrush current to exceed. Typically SINGLE mode is used for inrush capture.
- If the intention is to trigger on a mains supply surge then the ABS(DC) trigger type is recommended, using the voltage signal as the trigger source and setting the trigger level to a suitable voltage level just above the peak level of the highest expected normal mains voltage. Typically CONT mode is used for mains supply surge capture as this enables the PA900 to detect another surge without user intervention.
- If the intention is to trigger on mains supply 'glitches' then the HF trigger type is recommended, using the voltage signal as the trigger source and setting the trigger level to a voltage level just high enough to not trigger on whatever glitches are normally present. Typically CONT mode is used for mains supply glitch capture as this enables the PA900 to detect another glitch without user intervention.
- For capturing repetitive signals then the use of the DC(rising) or DC(falling) trigger types is recommended, however you should also consider using CYCLE VIEW as this provides better trace resolution in time and requires no configuration.

VIEWING A SCOPE CAPTURE



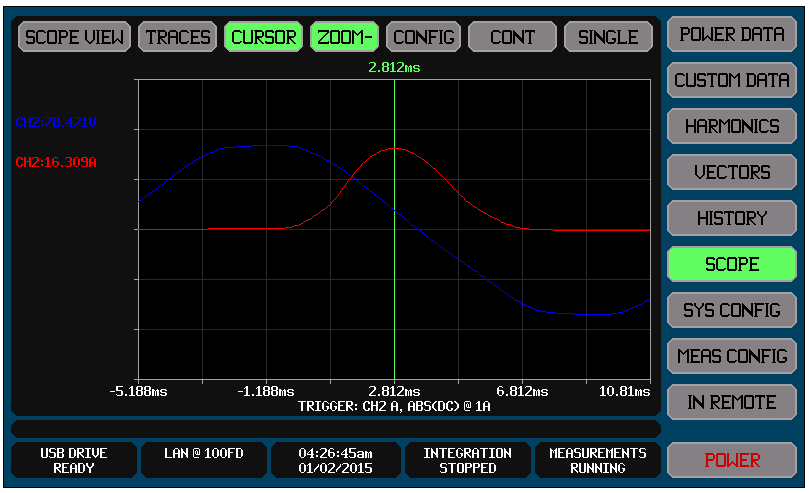
The last taken scope capture is shown with the traces selected and configured as described above. To the left of the chart is a listing of the configured traces. Below the chart is a textual description of the trigger configuration.

You may change the trace selections as required without having to capture further data. All signals within the VPA are always captured and have full resolution, allowing the trace colors, the trace signals, or the trace scaling and offset to be altered at will after the capture.

A vertically drawn cursor may be placed on to the chart by you. There are two ways of achieving this –

1. Pressing the CURSOR button at the top of the screen, this places a cursor at the last used position of the cursor or at the trigger position if the cursor has not been used before.
2. Pressing anywhere on the chart, this places a cursor at the position pressed. You may drag the cursor in this manner, or may reposition the cursor by pressing somewhere else on the chart.

The screen below shows the same SCOPE VIEW screen data shown above, but with the cursor shown and zoomed in on the initial inrush peak.



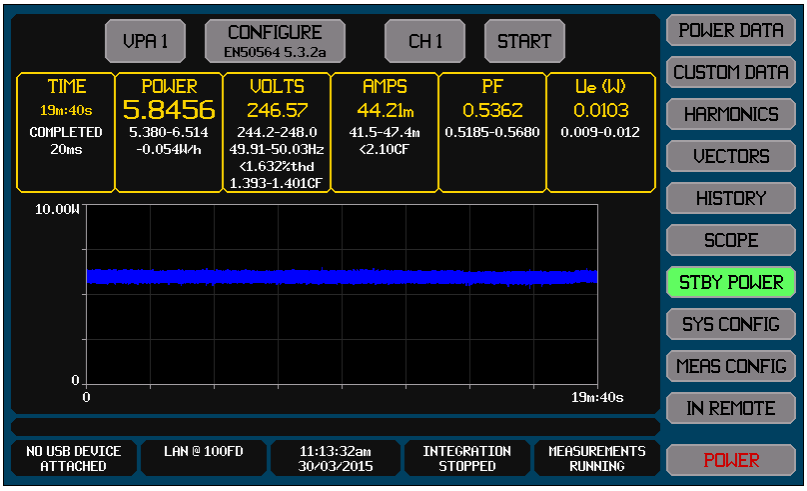
When the cursor is shown –

- The CURSOR button is highlighted colored green
- The time position of the cursor is shown above the cursor line
- The textual data in the left side of the screen changes to show the signal level captured for each trace at the time of the present cursor position.
- You may zoom the chart horizontally by pressing the ZOOM+ button; this zooms by between 4:1 and 5:1 depending on the timebase setting. While zoomed –
    - When the ZOOM+ button is pressed the traces are positioned so that the cursor position is centered in the screen.
    - The ZOOM button shows ZOOM- and will return the screen to the un-zoomed state but with the cursor still shown.
    - The ZOOM button is highlighted colored green.
    - The cursor remains set to the same time as it was prior to zooming, but it may still be moved within the timespan of the zoomed chart by pressing at the desired location within the chart.
- Any zoom can be cancelled and the screen returned to the non-zoomed state without a cursor at any time by pressing the CURSOR button while it is highlighted.

USING THE STBY POWER SCREEN

The STBY POWER Screen can be selected for view from any of the Main Data Screens by pressing the STBY POWER button.

The STBY POWER Screen gives you the ability to configure, start/stop, and view the results of low power measurements in accordance with EN50564:2011. The PA900 has the ability to perform these measurements independently in each VPA.



PERFORMING MEASUREMENTS IN ACCORDANCE TO EN50564:2011

The PA900 can be configured to perform low power measurements in strict accordance with EN50564:2011 but it does not restrict the user to doing so.

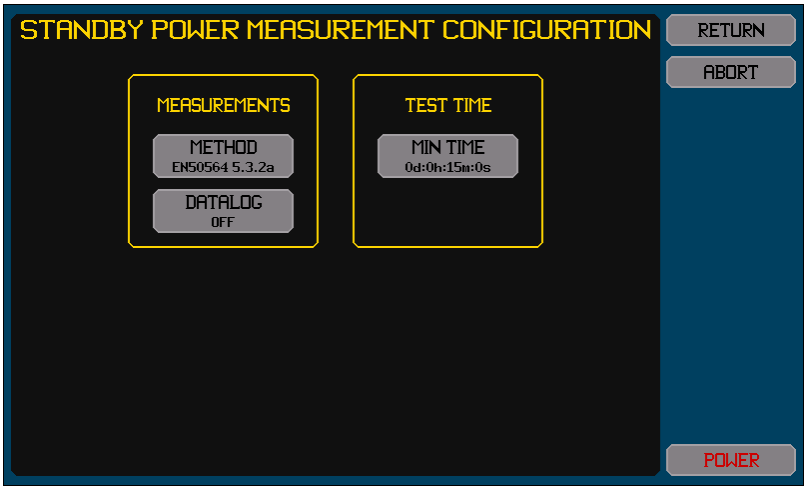
- For strict accordance with EN50564:2011 para. 4.3 the voltage source to the device being measured may need to be a regulated power source with limits on the voltage level and stability, frequency value and stability, voltage crest factor and voltage distortion. It is possible that the local mains supply meets these requirements, but this is often not the case. Also, the EN50564:2011 requirements for voltage level and frequency are often overridden by other standards, usually calling for this measurement but imposing limits on the measurement result, but which are specific to local supply voltages or frequencies different to those in EN50564:2011. The PA900 maintains a record of the voltage level, frequency, voltage crest factor and voltage THD during a low power measurement and reports the range of these measurements encountered during the measurement, and also reports if any of the crest factor or THD requirements are exceeded by coloring the data red if those EN50564:2011 requirements are exceeded, but the PA900 does not stop a low power measurement nor otherwise prevent the user from recording the final measurement result.
- To ensure strict accordance with EN50564:2011 para. 4.4 during the measurement the PA900 maintains a record of the Ue (power measurement accuracy) as defined by EN50564:2011 para. 4.4.1. The measurements are maintained in real-time during the measurement, dynamically applying the MCR correction on the limit as required by EN50564:2011 para. 4.4.1. The mean value and the range of values are reported by the PA900 and also reports if the requirement is exceeded by coloring the data red, but the PA900 does not stop a low power measurement nor otherwise prevent the user from recording the final measurement result.
- The PA900 always corrects the indicated low power measurement to accommodate any power loss in the internal current shunt. Generally this is a very small correction and is performed very accurately and the inaccuracy of doing so is included in the reported Ue measurement. The user should always use the connection methods shown in the Wiring to Channels section of this document, which is the method described in EN50564:2011 para B.4.2.
- EN50564:2011 para. 4.4.2 requires that the power measurement be made with a frequency response exceeding 2KHz. It is recommended that the PA900 VPA be configured for a fixed 6kHz filter to correspond to this requirement (this yields a 12kHz bandwidth) but the PA900 does not enforce this setting.
- EN50564:2011 para. 4.3.2 requires limits on the THD of the voltage source and requires that this THD shall be computed using up to and including the 13th harmonic. It is recommended that the PA900 VPA be configured for a HARMS setting of at least 13 to correspond to this requirement but the PA900 does not enforce this setting. The reported voltage THD on the STBY POWER screen only includes up to the 13th harmonic no matter what HARMS is set to as long as it is at least 13.
- The PA900 performs the low power measurement in accordance with EN50564:2011 para. 5.3.2, which is the recommended method for all low power measurements. You should note that the word “sampling” in the standard relates to sampling of the individual measurement period results of the PA900, not to the “sampling” of the signals used to perform each such measurement. The PA900 performs one “sample” every measurement period, so to strictly accommodate the requirement of EN50564:2011 para. 5.3.2 the VPA must be configured for a LF/PERIOD setting of either 10Hz/0.3s, 20Hz/0.1s or 45Hz/20ms but to allow the PA900 to be used at different supply frequencies this is not enforced by the PA900. Generally, the 20Hz/0.1s setting is recommended which exceeds the requirement by a factor of over 10:1; however for shorter low power measurements, or where the load is known to have fast excursions in power, the 45Hz/20ms setting can be used if desired.
- The PA900 can perform two types of measurement as defined by EN50564:2011 para. 5.3.2. These are shown as EN50564 5.3.2a and 5.3.2d and relate to the first and fourth methods described in EN50564:2011 para. 5.3.2, i.e. the methods for measuring “power consumption within a mode is not cyclic…” (5.3.2a) and “Modes that are known (based on instructions for use, specifications or measurements) to be of limited duration…” (5.3.2d). In almost all circumstances the 5.3.2a setting should be used.
- For strict compliance to EN50564:2011 para. 5.3.2 the low power measurement should be performed for a minimum of 15 minutes and should not be completed until the linear regression of the power during the final 2/3rd of the total period is less than that allowed by EN50564:2011. For convenience where strict adherence to the standard is not required, the PA900 allows the user to configure a total period of other than 15 minutes. The PA900 will (as required by EN50564:2011) automatically

extend the total period if the slope during the final 2/3rd of the elapsed time does not achieve the maximum required and will not automatically stop the measurement until this is achieved and the minimum period has also been achieved, but you may manually stop the measurement at any time. If the measurement is stopped by the user rather than automatically stopped to the requirements of EN50564:2011 this is shown by denoting that the measurement was "STOPPED" rather than "COMPLETED" on the PA900 screen.

- If you prefer a measurement according to EN50564:2011 para. 5.3.3 ("Average reading method") or 5.3.4 ("Direct meter reading method") then these can be accommodated using the POWER DATA with the VPA properly configured and (as needed) using the Integration capabilities of the PA900 described elsewhere in this document. The STBY POWER screen should generally not be used for these methods, but you should note that the method employed in the STBY POWER screen to EN50564:2011 5.3.2 is "the recommended approach" and "should always be used if there is any doubt regarding the behavior of the product or stability of the mode".
- If generating a report which is in strict conformance to the requirements of EN50564:2011 para. 6 then this can be achieved by simply exporting an image of the STBY POWER screen after the completion of the measurement and including it in a report along with the additional (non-measurement related) requirements of EN50564:2011. This exceeds the requirements of EN50564:2011 and includes many of the additional recommended features.

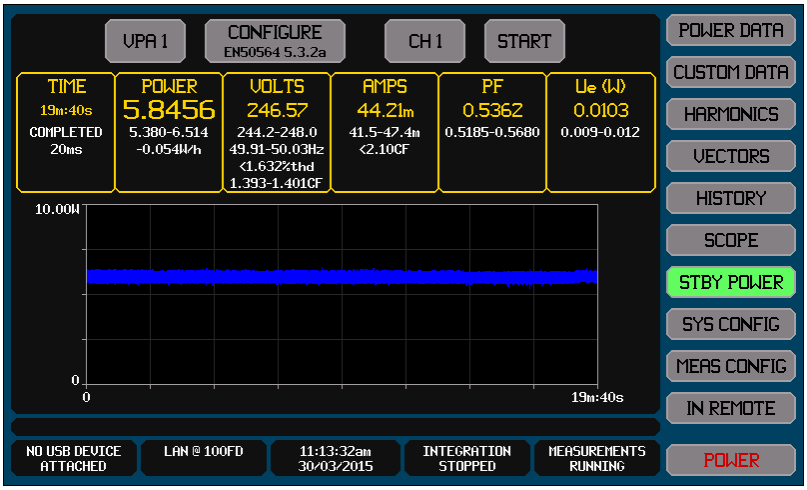
CONFIGURING A LOW POWER MEASUREMENT

The low power measurement itself is configured by pressing the CONFIGURE button on the STBY POWER screen. The present method selection is shown in a smaller font size on this button.



- The METHOD is selectable as EN50564 5.3.2a or 5.3.2d as described above. Pressing the METHOD button initiates a screen which allows you select which of these methods to use.
- The DATALOG button is for future expansion. If you desire to data log measurements during a standby power measurement then this can be accommodated by using the standard data logging capabilities of the PA900 as described in the Data Logging section of this document.
- If the user selected the EN50564 5.3.2a method then the TEST TIME section is shown on the screen with a button which allows you to set the minimum test time for the measurement (for strict accordance with EN50564:2011 para. 5.3.2 this must be at least 15 minutes, but the PA900 does not enforce this). In the data entry screens for the TEST TIME setting there are four entries, one for each unit of days, hours, minutes and seconds.
    - The screen always starts with the days data selected; you can jump to any of the four time units directly by pressing the respective time entry area.
    - You can enter a numeric between 0 and 99 into any of the four screens. The actual time used is the total time created by combining all four data with their respective units.
    - When the ENT button is pressed the selected time unit area automatically changes to next area to the right, unless the seconds data is selected when the action is same as pressing the overall RETURN button.
    - After configuring the desired minimum test time press the RETURN button to return to the previous screen.
- If the user selected the EN50564 5.3.2d method then the MODE DETECT section is shown on the screen with two buttons which allows you to set the power levels at which the specific product mode will be detected as starting and ending. These levels are in Watts and the PA900 will detect the start condition as soon as the measured power level exceeds the START setting, and will automatically stop the measurement when measured power level drops below the END setting. Note that you may also manually stop the measurement, and by setting an END level of 0.0W and a START level of 0.0W then effectively the measurement period will be totally manually controlled.

PERFORMING A LOW POWER MEASUREMENT AND VIEWING THE RESULTS



You can select which VPA is being configured, controlled and viewed by using the VPA button (the leftmost across the top of the screen).

You can select which channel within the selected VPA is being viewed by using the CH n button (which is labelled according to the presently selected channel).

You can START and manually stop a low power measurement by pressing the START button (which is labelled STOP while a measurement is being performed). This controls low power measurements in all channels within the selected VPA.

You should note the following points-

- You do have to remain on the STBY POWER screen during the measurement. The measurement will automatically progress whether this screen is being displayed or not.
- The RESPONSE configuration setting for the VPA is not applied to the STBY POWER results.
- The measurement hold capability of the PA900 is not applied to the STBY POWER results.
- Although allowed by the PA900, it is not recommended to reconfigure a VPA during a low power measurement.

The following data is shown on this screen. Except for the total measurement time all data is for the last 2/3rd of the measurement time if configured for EN50564 5.3.2a method or for the entire measurement time if configured for the 5.3.2d method-

- TIME shows (from top to bottom of that area)-
    - The elapsed total time of the low power measurement.
    - "WAITING" (if waiting for the configured START power level to be exceeded when configured for the 5.3.2d method), "RUNNING" (when less than the minimum test time), "EXTENDING" (if beyond the minimum test time), if manually stopped then it shows "STOPPED", and if automatically completed it shows "COMPLETED".
    - The average measurement sampling period.
- POWER shows (from top to bottom of that area)-
    - The average power (in Watts).
    - The range of power encountered.
    - The slope of the linear regression in W/hour (only if configured for the 5.3.2a method).
- VOLTS shows (from top to bottom of that area)-
    - The average AC+DC RMS supply voltage.
    - The range of AC+DC RMS supply voltage encountered.
    - The range of AC+DC RMS supply frequency encountered.
    - The highest supply voltage THD (measured over the 2nd through 13th harmonics) encountered. This is colored RED if this exceeds the requirements of EN50564:2011.
    - The range of supply voltage crest factor (CF) encountered. This is colored RED if this exceeds the requirements of EN50564:2011.
- AMPS shows (from top to bottom of that area)-
    - The average AC+DC RMS load current.
    - The range of AC+DC RMS load current encountered. This is colored RED if this exceeds the capabilities of the PA900 during the last 2/3rd of the measurement time.
    - The highest load current crest factor (CF) encountered.
    - This data is not required by EN50564:2011 but is included for informative purposes.
- PF shows (from top to bottom of that area)-
    - The average AC+DC PF.
    - The range of AC+DC PF encountered.
    - This data is not required by EN50564:2011 but is included for informative purposes.

- Ue shows (from top to bottom of that area)-
    - The average Ue (PA900 watts measurement error).
    - The range of Ue (PA900 watts measurement error) encountered. This is colored RED if this exceeds the requirements of EN50564:2011.
- Below the numerical data a chart graphically shows the power (in watts) vs. time during the entire measurement.

INTEGRATING DATA

The PA900 can provide integrated results, for example AHr, WHr, VAHr etc.. This section describes how to configure integration and how to start and stop integration.

When starting integration, any previous integration results are always cleared and a new integration is started.

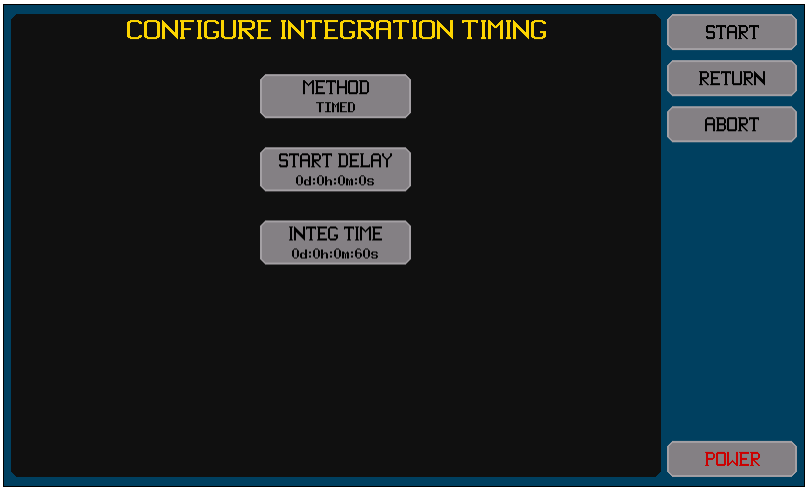
Integrated results do not only provide the total integrated data but also can provide you with bought, sold, charge and discharge integrated data as follows-

- Bought integrated data includes only data while the channel or VPA has positive Watts and is only available in VPAs which are not configured for DC ONLY COUPLING.
- Sold integrated data includes only data while the channel or VPA has negative Watts and is only available in VPAs which are not configured for DC ONLY COUPLING.
- Charge integrated data includes only data while the channel or VPA has positive DC Amps and is only available in VPAs which are configured for DC ONLY COUPLING.
- Discharge integrated data includes only data while the channel or VPA has negative DC Amps and is only available in VPAs which are configured for DC ONLY COUPLING.

CONFIGURING INTEGRATION

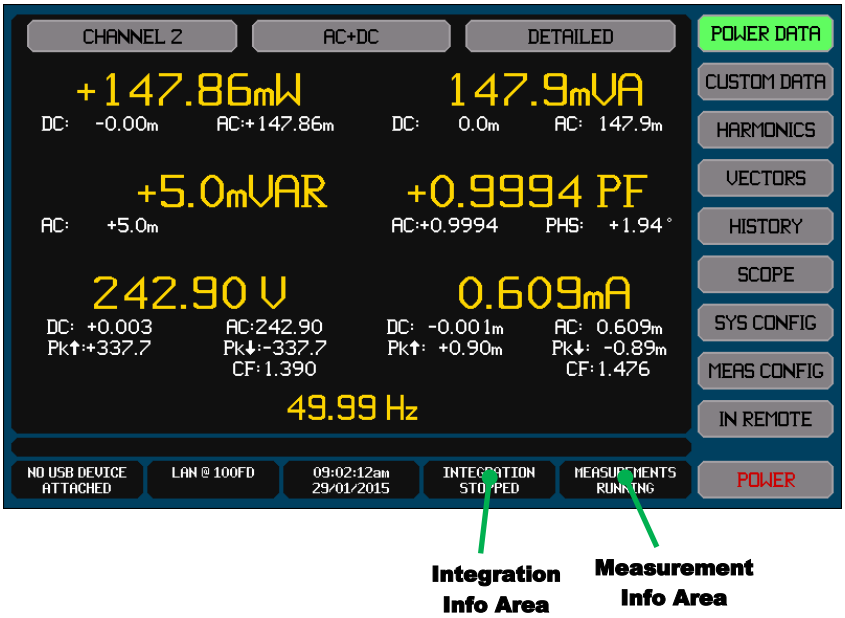
You may configure for manually controlled integration or for automatically time controlled integration by pressing the MEAS CONFIG button on any main screen and then pressing the TIMED INTEGRATE button. This starts a screen which allows you to configure integration for all VPAs.

Note that it is possible to reconfigure integration while it is running.



- The METHOD button allows you to select if integration is to be fully manually controlled (the MANUAL selection) or have a timed delay and a timed run time (the TIMED selection).
    - If set for TIMED you can still stop integration manually at any time.
- You can start or stop an integration using the START/STOP button while on this screen or by pressing the Integration Info Area at the bottom of any main screen.
- If the TIMED selection is selected in METHOD then you can configure the desired delay time using the START DELAY button and the desired run time using the INTEG TIME button.
- In the data entry screens for the START DELAY and INTEG TIME settings there are four entries, one for each unit of days, hours, minutes and seconds.
    - The screen always starts with the days data selected; you can jump to any of the four time units directly by pressing the respective time entry area.
    - You can enter a numeric between 0 and 99 into any of the four screens. The actual time used is the total time created by combining all four data with their respective units.
    - When the ENT button is pressed the selected time unit area automatically changes to next area to the right, unless the seconds data is selected when the action is same as pressing the overall RETURN button.
    - After configuring the desired integration method press the RETURN button to return to the MEAS CONFIG screen, then press any of the main screen selection buttons to view whichever data screen is required – the configured integration is not active until this is done. Pressing the ABORT button returns to the MEAS CONFIG screen and discards any changes made to the integration configuration. The START button makes any changes made immediately active and starts integration, if integration was already running then it is cleared and restarted.

INTEGRATION INFO AREA



All main screens have an integration info area as shown on the example screen above. This shows the present status of integration as follows –

- STOPPED. Indicates that no integration is presently being performed.
- RUNNING. Indicates that a manually controlled integration is being performed. Integration will continue until manually stopped.
- PAUSED. Indicates that a manually controlled integration is being performed but has been paused by you pressing the Measurement Info area to hold it. Integration will continue when the measurement hold is released or integration is manually stopped.
- DELAY. Indicates that a timed integration is being performed and is delaying prior to collecting integrated data. The progress bar to the right shows how much of the delay has expired.
- RUN. Indicates that a timed integration is being performed and is collecting integrated data. The progress bar to the right shows how much of the configured run time has expired.
- PAUSE. Indicates that a timed integration is being performed, the delay time has expired, but the PA900 is not collecting integrated data because you have held measurement results. The progress bar to the right shows how much of the configured run time has expired.

STARTING AND STOPPING INTEGRATION

Either-

1. You may press the START button from within the TIMED INTEGRATION screen as described above.
2. You may press the Integration Info area described above. This will either start integration (if it is presently stopped) or will stop integration (if it is not presently stopped).

INTEGRATION SPECIFICATIONS

Integrated Result accuracy is within 0.02% + 1ms (in addition to the accuracy of the underlying result).

Timed Integration Delay Time may be between 0 and 99 days, 99 hours, 99 minutes, 99 seconds with 1 second resolution and is accurate to within 0.02% + 8ms.

Timed Integration Run Time may be between 1 second and 99 days, 99 hours, 99 minutes, 99 seconds with 1 second resolution and is accurate to within 0.02% + 1ms.

Manual Integration may be for an unrestricted period of time; however results typically will become impaired regarding accuracy after 400days.

IMPORTING AND EXPORTING DATA, CONFIGURATIONS AND UPDATES

You can import configuration or update files from, or can export data or configuration files to, an external USB drive using the front panel USB drive port of the PA900.

DRIVE COMPATIBILITY

A wide variety of drives are compatible with the PA900. These must meet the following requirements-

- Meet USB2.0 or higher using full-speed.
- Meet the requirements of the USB Mass Storage Class specification and be a single physical drive (multi-drive convertors cannot be used with the PA900).
- Require less than 500mA of power from the USB port (some USB3.0 drives do not meet this requirement).
- The drive must use 512bytes per sector (this is a requirement of the Mass Storage Class, but there are drives which claim compatibility with this but do not use this sector size).
- Be formatted using the MBR with BPB method (some drives are not formatted in this way but are formatted as if a floppy drive).
- The drive may be partitioned, but only the first FAT32 partition will be used.
- The drive must be formatted using the FAT32 format as defined by Microsoft.
- The partition must be <4Tb in size.
- The drive must be directly connected to the PA900, a hub must not be used and an extension cable is not recommended.

CHECKING DRIVE COMPATIBILITY

If a drive is compatible with a computer that does not necessarily mean it is compatible with the PA900. Vendors of operating systems such as Windows and Linux have many years of data regarding drives which do not meet standards and have built-in patches in them to work around these non-standard drives. The PA900 requires the drive to meet the standards (however only a small sub-set of the requirements are required by the PA900 so even drives that do not fully meet the standards are often compatible).

The best method to check if a drive is compatible with the PA900 is to insert it into the front panel USB drive port. The USB Drive Info area on any main screen of the PA900 shows the connection status.

USB Drive Info Area

The indications are as follows (assuming no data logging is active) –

- NO DEVICE ATTACHED. The PA900 has not detected that any device is attached, typically the PA900 will detect a device is attached within <1 second, if the drive is attached but the PA900 remains showing this for an extended period of time then the drive is not compatible with USB2.0 full-speed operation and should be removed.
- USB DEVICE ATTACHING. This indicates that the PA900 has detected the device as being attached and is performing the initial USB enumeration of the device. This typically takes <1 second, but on some drives may take a little longer.
- USB DEVICE FAULT. This indicates that the PA900 has detected the device as being attached but the device failed to enumerate properly. This may indicate that the device draws more than 500mA of power or that the drive is not compatible with the USB2.0 specification. The drive should be removed and after waiting a few seconds it should be reinserted, if the message returns then the drive is not compatible with the PA900 (this can sometimes be caused by a partial or intermittent insertion of the drive into the PA900).
- USB DEVICE INCOMPATIBLE. This indicates that the drive has enumerated correctly, but that the drive is either not detected as a Mass Storage Class device or has multiple drives and should be removed.

- USB DRIVE MOUNTING. This indicates that the PA900 has detected the drive and is attempting to mount the drive. For some drives this can take several seconds, portable hard drives can take even longer as the drive must achieve the correct rotation speed before it will mount.
- USB DRIVE INCOMPATIBLE. This indicates that the drive has been correctly detected and has been correctly mounted, but inspection of the drive has not found a valid FAT32 partition for the PA900 to use and should be removed. The drive may need to be formatted. Not all drives are formatted with FAT32 when purchased (but most are) so require formatting on a computer before they can be used with a PA900. If using a computer running Windows to format a drive please note the following-
    - Depending on the size of the drive, the default for Windows may not be the FAT32 format. In those cases you should ensure that the FAT32 format is selected before starting to format the drive.
    - For best performance, the Allocation Unit Size (or cluster size) should either be set to "Default Allocation Size" or to a setting of 8192 bytes or higher.
    - Do not select "Quick Format" as this will not actually format the drive.
    - For reasons unknown to Vitrek, some drives cannot be formatted by Windows to the FAT32 format. In those cases you may need to obtain a third party drive format application to format the drive. There are several available on the internet which are free of charge.
- USB DRIVE READY. This indicates that the drive has been successfully enumerated and mounted and is compatible with the PA900. There is the possibility that the drive may fail compatibility at some later point in time, such as when reading or writing files, but this has never been seen and is very unlikely.

Note that while data is actually transferring between the drive and the PA900 the background of the USB Drive Info area flashes a dark maroon color. Do not remove a drive while this is flashing. Many drives have an LED (or similar), on many drives this indicates activity but on some drives this indicates connection state.

FILES

The PA900 only operates on files in the root directory of the drive and only uses the 8.3 filename format.

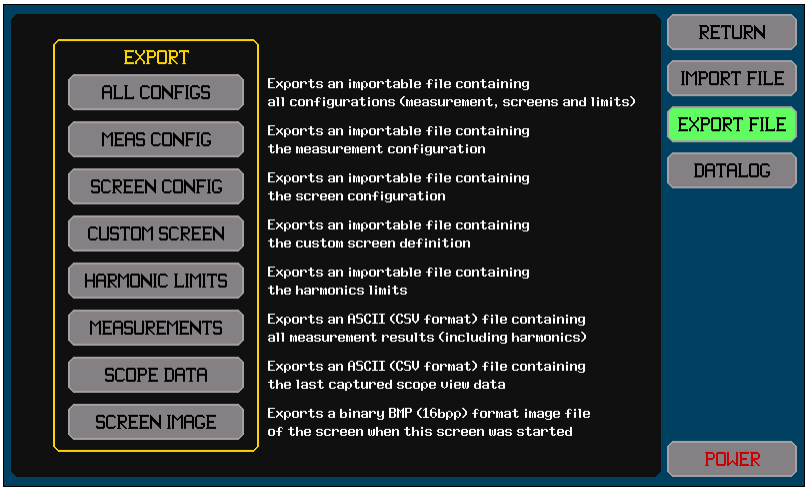
The PA900 does not include the ability to format a drive nor for file management. These actions should be performed using a computer if required.

CHECKING THE DRIVE FILE STRUCTURE

If a drive is accidently removed while activity is in progress then it is possible that the file structure of the drive has been damaged. It is recommended to use a utility program on a computer to check for and repair any file structure damage which may have occurred if this is suspected.

EXPORTING FILES TO A DRIVE

The PA900 can export configuration or measurement data or screen image files to a drive. This is achieved by pressing the USB Drive Info area while a drive is correctly attached. This initiates a screen which allows you to export files from the PA900.



Next to each button are descriptions of the file which will be exported from the PA900 and written to the drive.

After pressing the button for the type of file to export, a screen is initiated which allows you to set the filename of the file to be exported, the extension is automatically provided by the PA900. After entering the filename the PA900 writes the file, showing a progress bar on the right side of the screen. When completed the right side of the screen shows the completion status and you may press another button for a further USB drive activity or press the RETURN button to return to the screen which was being viewed when the USB Drive Info area was initially pressed.

EXPORTING CONFIGURATION, CUSTOM SCREEN AND HARMONIC LIMITS FILES

These are exported in a proprietary binary format suitable for import into a PA900.

When exporting these files, the PA900 automatically saves them with a .CFG extension to the filename, but this is not necessary for importing them into a PA900. You may rename these files using a computer to any valid 8.3 format filename. You should note that 8.3 filenames are not case sensitive, so the use of uppercase letters is recommended in filenames to avoid confusion.

The following file names may not be used –

MLO
PA900.S19
PA900.HEX
WELCOME.IMG
VHLIMIT.CSV
AHLIMIT.CSV
CUSTOM.CSV

If the ALL CONFIGS selection is made then the file contains –

- All screen configurations.
- Any custom screen definition.
- The measurement configuration.
- Any voltage and current harmonics limits defined.

It does not contain the interface configuration or the time and date format configuration settings.

MEASUREMENT DATA FILE FORMAT

When MEASUREMENTS is selected for file export the resulting file is a CSV (comma separated variable) format ASCII file which is able to be opened by many spreadsheet or database programs (such as Excel for example).

This file contains every data measured by the PA900 along with a description of the data. The first column of every line contains the description, following that are columns for each channel or each VPA as appropriate. There are separate sections of the file for channel based and VPA based data and at the top of each section are headers describing each column.

All fields are always present even if the channel or VPA is not configured or otherwise no data is available for the specific data field. In these cases the field is blank.

The first section is the data for each VPA, below is an example of the first few lines of the VPA data section.

```
DATA,VPA1,VPA2,VPA3
Frequency,+49.9916E+0,,
V13(pk),+0.00000E-9,,
V13(dc),+0.00000E-9,,
V13(ac),+0.00000E-9,,
V13(acdc),+0.00000E-9,,
V13(rect),+0.00000E-9,,
V13(CF),+0.00000E-9,,
V13(FF),+0.00000E-9,,
V23(pk),+0.00000E-9,,
V23(dc),+0.00000E-9,,
V23(ac),+0.00000E-9,,
```

As shown above, some of this data is labelled V13 or similar, V13 indicates that the voltage is that measured on the 1st channel in the VPA, relative to that of the 3rd channel in the VPA and similarly for the others.

The second section is the data for each channel and there is a blank line between the sections, below is an example of the first few lines of the channel data section.

```
DATA,CH1,CH2,CH3,CH4
Frequency,,+49.9916E+0,,
Voverload,,0,,
Aoverload,,0,,
V(hipk),,+337.888E+0,,
V(lopk),,-337.987E+0,,
V(pk),,+337.987E+0,,
V(dc),,-9.84504E-3,,
V(ac),,+244.650E+0,,
V(acdc),,+244.650E+0,,
V(rect),,+219.508E+0,,
V(CF),,+1.38151E+0,,
V(FF),,+1.11454E+0,,
A(hipk),,+8.60092E-3,,
A(lopk),,-7.13595E-3,,
A(pk),,+8.60092E-3,,
A(dc),,+71.3018E-6,,
A(ac),,+2.85873E-3,,
A(acdc),,+2.85962E-3,,
A(rect),,+2.38726E-3,,
```

At the end of the channel section are the harmonics results, these are listed for the highest number of harmonics measured in any channel. All phase data is in degree units.

SCOPE DATA FILE FORMAT

When SCOPE DATA is selected for file export the resulting file is a CSV (comma separated variable) format ASCII file which is able to be opened by many spreadsheet or database programs (such as Excel for example).

This file contains every data captured by the latest completed scope capture. All possible data columns are included; data which is not captured has a blank field. The file always contains 2048 records (plus the header record) and is always ordered in increasing time.

Below is an example of the first few lines of this file. All voltages are in volts units, all currents are in amps units, and the time column is the time in seconds units relative to the trigger point.

```
TIME,CH1V,CH1A,CH2V,CH2A,CH3V,CH3A,CH4V,CH4A
-37.3109E-3,,,+99.4792E+0,-4.54687E-3,,,,
-37.2380E-3,,,+91.7955E+0,-2.06459E-3,,,,
-37.1651E-3,,,+84.0672E+0,+2.82051E-3,,,,
-37.0923E-3,,,+76.3141E+0,+3.01298E-3,,,,
-37.0194E-3,,,+68.5283E+0,+4.84707E-3,,,,
-36.9465E-3,,,+60.4204E+0,+2.24682E-3,,,,
-36.8736E-3,,,+52.3775E+0,-1.87460E-3,,,,
-36.8008E-3,,,+44.4456E+0,-107.568E-6,,,,
-36.7279E-3,,,+36.6903E+0,-5.38010E-3,,,,
-36.6550E-3,,,+29.1832E+0,-3.80430E-3,,,,
-36.5821E-3,,,+21.8476E+0,-3.35975E-3,,,,
-36.5093E-3,,,+14.7098E+0,-178.348E-6,,,,
-36.4364E-3,,,+7.48967E+0,+1.59737E-3,,,,
-36.3635E-3,,,+120.091E-3,+2.75470E-3,,,,
-36.2906E-3,,,-7.38952E+0,+3.04030E-3,,,,
-36.2178E-3,,,-14.9958E+0,-318.668E-6,,,,
```

SCREEN IMAGE FILE FORMAT

The PA900 write an image file equivalent to the screen which was being viewed when the USB Drive Info area was pressed. This is a standard 16bpp BMP format file. Most image processing and viewing programs can open this file format, but it has been found that some photo editing software cannot as the 16bbp format is not commonly used for photographs (but is commonly used for graphics images).

Gimp, Adobe Photoshop, Windows Photo Viewer, Paint, and Word are just a few examples of programs which can open these files.

These files are quite large (751Kbytes) and are uncompressed images for maximum quality. If you wish, there are many programs available on the internet that can either convert these images to a compressed image or to just compress the file.

IMPORTING FILES FROM A DRIVE

The PA900 can import configuration or update files from a drive. This is achieved by pressing the USB Drive Info area while a drive is correctly attached. This initiates a screen in which you should press the IMPORT FILE button to initiate the import file screen.

The right side area of the screen shows a listing of the files which may be imported for the file type selected by the buttons on the left side (the IMPORT area). Which file type is being shown is indicated by the respective button in the IMPORT area being highlighted colored green. To change the type of file listed press the desired IMPORT area file type button.

The files (if any) are listed as buttons in the right side area, with each button showing the filename and file date, if a large number of files are available then there are scroll buttons shown to allow you to scroll through the list. To import a file press the button for that specific file in the file listing area. The right side area of the screen then changes to indicate the progress of the import. After completion you may press any of the IMPORT area buttons to repeat this, or may press the EXPORT DATA button to export a file, or press the RETURN button to return to the screen which was being viewed when the USB Drive Info area was initially pressed.

IMPORTING CONFIGURATION, CUSTOM SCREEN AND HARMONIC LIMITS FILES

These are files which have been previously exported by a PA900. The PA900 automatically recognizes these files by their contents and no specific filenames or extensions are assumed by the PA900. You may rename these files using a computer to any valid 8.3 format filename. You should note that 8.3 filenames are not case sensitive, so the use of uppercase letters is recommended in filenames to avoid confusion.

CREATING AND IMPORTING AN ASCII HARMONICS LIMITS FILE

You can create an ASCII format harmonics file for either voltage or current limits on a computer using a plain text editor such as Windows Notepad, save the ASCII file to the drive, insert the drive into the PA900, and then import the file into a PA900.

The file must be named VHLIMIT.CSV to define the voltage harmonics limits, or AHLIMIT.CSV to define the current harmonics limits. These files (if present on the drive) are automatically included in the listing of available HARMONIC LIMITS type files.

Each line of the file must contain in the order shown with the comma character separating each item –

1. The letter H.
2. A number of characters forming an integer between 1 and 500 inclusive which sets which harmonic is being set by this line.
    a. If more than one line sets the limit for a harmonic, the last one is used.
    b. The file does not need to define every harmonic; harmonics not included in the file are not checked against a limit.
3. Either the character 1 if the limit is to be the highest of the percentage and level limits, or 2 if the limit is to be the addition of the percentage and level limits.
4. Either the character 0 if the percentage is to be of the fundamental amplitude or 1 if it is to be the percentage of the total signal.
5. A number of characters forming a floating number which is the percentage limit (in percent).
6. A number of characters forming a floating number which is the level limit (in Volts or Amps).

The file may contain blank lines if desired.

A simple example of the contents of such a file is-

```
H,2,1,0,0.1,1
H,3,2,1,0.2,2
```

This sets limits as follows –

- For harmonic 2, the higher of 0.1% of fundamental or 1V or A
- For harmonic 3, the addition of 0.2% of signal and 2V or A

CREATING AND IMPORTING AN ASCII CUSTOM SCREEN DEFINITION FILE

You can create an ASCII format custom screen definition on a computer using a plain text editor such as Windows Notepad, save the ASCII file to the drive, insert the drive into the PA900, and then import the file into a PA900.

The file must be named CUSTOM.CSV. This file (if present on the drive) is automatically included in the listing of available CUSTOM SCREEN type files.

A custom screen is composed of 57 cells arranged in 15 rows with row 0 (the topmost row) only having a single column (column 0) and rows 1 through 14 having 4 columns (the leftmost column is 0, the rightmost is 3). For cells other than the row 0 cell, for text sizes other than 12pix or 16pix the target cell is expanded to include surrounding cells as follows –

22pix text size: includes the cell to the right of the target cell.

28pix and 36pix text sizes: includes the cell to the right of the target cell and also the cells immediately below both the target cell and that to the right of it.

Note that the length of the text in a cell might cause the cell to be overrun into adjacent cells for any text height defined. The user may need to adjust their definition to obtain the desired format.

Each line of the file defines one cell in the custom screen and may be defined in any order in one of the following formats –

DEFINING A BLANK CELL

Note that lines to define a blank cell are not needed as the custom screen definition always starts blank, however you may wish to include blank cell definitions for readability of the file.

The fields shown below with the comma character separating each item –

1. The letter C.
2. A number of characters forming an integer between 0 and 14 inclusive which sets which row the cell is in which this line defines.
3. A numeric character between 0 and 3 inclusive which sets which column the cell is in which this line defines.

DEFINING A CELL WHICH IS TEXT ONLY

The fields shown below with the comma character separating each item –

1. The letter C.
2. A number of characters forming an integer between 0 and 14 inclusive which sets which row the cell is in which this line defines.
3. A numeric character between 0 and 3 inclusive which sets which column the cell is in which this line defines.
4. A numeric character which defines the character font size for this cell as follows –
    - 0: Text which is 12pix high
    - 1: Text which is 16pix high
    - 2: Text which is 22pix high
    - 3: Text which is 28pix high
    - 4: Text which is 36pix high
5. A numeric character which defines the text horizontal justification for this cell as follows –
    - 0: Text is left justified
    - 1: Text is centre justified
    - 2: Text is right justified

6. Three sets of characters separated by the colon character each of which forms an integer between 0 and 255 inclusive, setting the intensity for the red, green and blue colors respectively.
7. A blank field (no characters)
8. A blank field (no characters)
9. Up to 60 characters which defines the text to be shown in this cell.

DEFINING A CELL WHICH IS A MEASUREMENT RESULT

The fields shown below with the comma character separating each item –

1. The letter C.
2. A number of characters forming an integer between 0 and 14 inclusive which sets which row the cell is in which this line defines.
3. A numeric character between 0 and 3 inclusive which sets which column the cell is in which this line defines.
4. A numeric character which defines the character font size for this cell as follows –
   - 0: Text which is 12pix high
   - 1: Text which is 16pix high
   - 2: Text which is 22pix high
   - 3: Text which is 28pix high
   - 4: Text which is 36pix high
5. A numeric character which defines the text horizontal justification for this cell as follows –
   - 0: The entire text is left justified
   - 1: The entire text is centre justified
   - 2: The entire text is right justified
6. Three sets of characters separated by the colon character each of which forms an integer between 0 and 255 inclusive, setting the intensity for the red, green and blue colors respectively.
7. A definition of the measurement result to show (see RDEF Measurement Definition Field Sub-Fields for the allowed formats of this field).
8. A numeric character which sets which defines if the measurement result is to be followed by the applicable units character(s) as follows –
   - 0: No units character(s) will be included.
   - 1: Units character(s) will be included.

DEFINING A CELL WHICH IS A MEASUREMENT RESULT WITH LEADING TEXT

The fields shown below with the comma character separating each item –

1. The letter C.
2. A number of characters forming an integer between 0 and 14 inclusive which sets which row the cell is in which this line defines.
3. A numeric character between 0 and 3 inclusive which sets which column the cell is in which this line defines.
4. A numeric character which defines the character font size for this cell as follows –
   - 0: Text which is 12pix high
   - 1: Text which is 16pix high
   - 2: Text which is 22pix high
   - 3: Text which is 28pix high
   - 4: Text which is 36pix high
5. A numeric character which defines the text horizontal justification for this cell as follows –
   - 0: The entire text is left justified
   - 1: The entire text is centre justified
   - 2: The entire text is right justified
6. Three sets of characters separated by the colon character each of which forms an integer between 0 and 255 inclusive, setting the intensity for the red, green and blue colors respectively.
7. A definition of the measurement result to show (see RDEF Measurement Definition Field Sub-Fields for the allowed formats of this field).
8. A numeric character which defines if the measurement result is to be followed by the applicable units character(s) as follows –
   - 0: No units character(s) will be included.
   - 1: Units character(s) will be included.
9. Up to 5 characters which define the text to be shown before the measurement result in this cell (this may be blank which has the same resultant cell as if the previous format was used).

EXAMPLE CUSTOM SCREEN ASCII FILE

A simple example of the contents of such a file is-

```
C,0,0,3,1,255:255:255,,,MEASUREMENTS
C,2,0,1,1,255:255:255,,,Ch2
C,3,0,1,1,255:255:255,V:CH2,1
C,4,0,1,1,255:255:255,A:CH2,1
C,5,0,1,1,255:255:255,W:CH2,1
C,6,0,1,1,255:255:255,VA:CH2,1
C,7,0,1,1,255:255:255,PF:CH2,1
C,8,0,1,1,255:255:255,FREQ:CH2,1
```

This sets the screen to be similar to that shown below.

UPDATING THE FIRMWARE OR THE FPGA

These files must have a specific filename.

There are several types of update files; most of these are associated with updating the firmware or the FPGA to a newly released update from Vitrek. Follow the instructions provided with the firmware or FPGA release to import and use these files.

CHANGING THE WELCOMING SCREEN

This file must have a specific filename of WELCOME.IMG and is in a proprietary binary format.

One of the file selection possibilities in the UPDATE type of file import is to change the welcoming screen shown on the PA900 when it is turned on. An application is provided with the PA900 allowing you to convert a standard image file into the format needed for this file. The image must be exactly 800 pixels wide by 480 pixels high to be used by this utility.

DATA LOGGING

The PA900 has the capability of data logging up to 16 user defined measurements (or sets of harmonics measurements) at a user defined interval to a file on the front panel USB drive. Each set of data recorded at each data log interval is called a data log record.

Data logging is not synchronous to any measurement period, but logs the data at each respective time interval. It is guaranteed that within a single data log record that all data from the same VPA is from the same measurement period.

The PA900 uses a large internal FIFO buffer to prevent inconsistencies in the write speed of the drive from disrupting data logging. If this buffer is overrun then data logging continues, but some data log records may be lost. This buffer also allows you to initiate data logging before inserting a drive into the front panel USB drive port of the PA900, but once a drive has been inserted it must remain in place until data logging is stopped.

CAUTION: removing the drive while data logging may damage the file system on the drive and may render the drive and the data on it unusable.

Note that while data is actually transferring between the drive and the PA900 the background of the USB Drive Info area flashes a dark maroon color. Do not remove a drive while this is flashing. Many drives have an LED (or similar), on many drives this indicates activity but on some drives this indicates connection state.

Data logging can create files up to 4Gbytes in size; you should ensure that the drive has sufficient room available prior to starting data logging. If the maximum file size for FAT32 (4Gbytes) is reached, or the drive becomes full, prior to you stopping data logging then data logging is automatically stopped by the PA900 and a data logging error status is set.

DRIVE COMPATIBILITY

A wide variety of drives are compatible with the PA900. These must meet the following requirements-

- Meet USB2.0 or higher using full-speed.
- Meet the requirements of the USB Mass Storage Class specification and be a single physical drive (multi-drive convertors cannot be used with the PA900).
- Require less than 500mA of power from the USB port (some USB3.0 drives do not meet this requirement).
- The drive must use 512bytes per sector (this is a requirement of the Mass Storage Class, but there are drives which claim compatibility with this but do not use this sector size).
- Be formatted using the MBR with BPB method (some drives are not formatted in this way but are formatted as if a floppy drive).
- The drive may be partitioned, but only the first FAT32 partition will be used.
- The drive must be formatted using the FAT32 format as defined by Microsoft.
- The partition must be <4Tb in size.
- The drive must be directly connected to the PA900, a hub must not be used and an extension cable is not recommended.

The PA900 only operates on files in the root directory of the drive and only uses the 8.3 filename format.

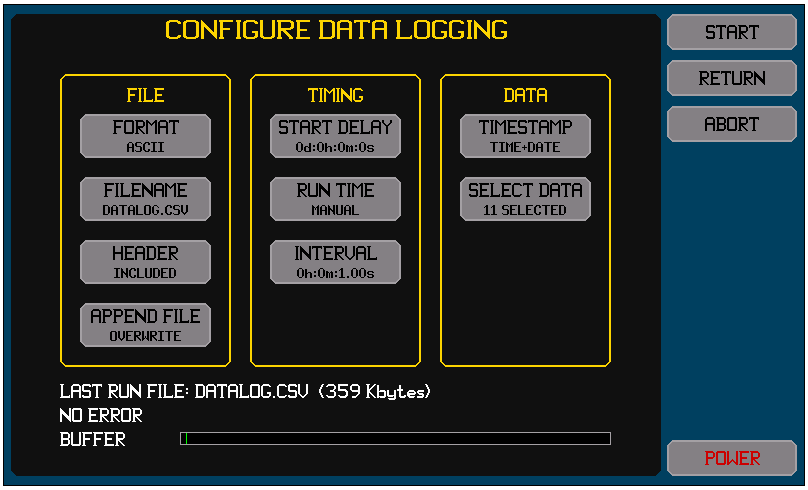
If a drive is compatible with a computer that does not necessarily mean it is compatible with the PA900. Vendors of operating systems such as Windows and Linux have many years of data regarding drives which do not meet standards and have built-in patches in them to work around these non-standard drives. The PA900 requires the drive to meet the standards (however only a small sub-set of the requirements are required by the PA900 so even drives that do not fully meet the standards are often compatible).

The best method to check if a drive is compatible with the PA900 is to insert it into the front panel USB drive port. The USB Drive Info area on any main screen of the PA900 shows the connection status.

CONFIGURING, STARTING, STOPPING AND VIEWING THE STATUS OF DATA LOGGING

Prior to performing data logging you must configure the file details, data logging timing, and the file contents.

This is achieved by pressing the MEAS CONFIG button and then pressing the DATA LOGGING button. A screen is then initiated which allows you to configure data logging (if a drive is present then this can also be reached by pressing the USB Drive Info area and then pressing the DATALOG button). Data logging can also be started from this screen following configuration or may be manually stopped from this screen if required.



There are four areas on this screen, the lower area showing the status is only shown if either a data logging activity is presently taking place or a previously run data log has been completed and a drive has not been removed and inserted since then.

You can return to this screen while performing data logging. In that case the configuration can only be viewed but cannot be changed, and the status information shows the progress of data logging in more detail than that shown in the USB Drive Info area.

This status information is –

1. The filename of the data log file and the size of it.
2. A description of any errors which occurred.
3. A bar which shows the amount of the buffer which is presently used (a green bar growing from the left as more buffer is used), and also shows the maximum amount of the buffer which has been used (a vertical line within the bar area).
    a. Because of the buffering, after the data log has completed there is a "finishing" time while the remaining data in this buffer is written to the drive.
    b. If this indicates that a significant amount of the buffer has been used (>50%) then you should consider either using a faster drive, logging less data, or using a longer data logging interval.
    c. Drives are not consistent in their timing; a typical drive will occasionally pause while writing data which will cause this buffer bar to move in an inconsistent manner. It is recommended to perform a test data log to a drive before attempting to create a substantial data log file to ensure that the drive can support the required average data write rate. This test run should be for at least a few minutes.
    d. A drive is fastest if there are no other files on it; this ensures that the PA900 can write the file into consecutive areas of the drive.
    e. For best speeds, use a portable hard drive not a flash drive. Hard drives have far more consistent write speeds and are significantly faster typically.
    f. Generally the PA900 is not the limitation to the maximum achievable data logging rate. The drive average write speed and the USB speed itself are typically the main limitations.

CONFIGURING THE DATA LOG FILE

This is performed by using the buttons in the FILE Area.

1. The FORMAT button allows you to select if the file is to be written with ASCII or BINARY data formats.
    - If data is written in ASCII format then it is written as one record per line, with each data within the record being comma separated.
        - This is often called the CSV format and files generated in this format can usually be opened with commercially available spreadsheet programs (such as Excel) and with many data base programs.
        - You should first confirm that the application is able to open the size of file likely to be generated while data logging, for example earlier versions of Excel could only open a file with less than 65536 records.
    - If data is written in binary format then it can only be read using an application provided with the PA900, which converts the file to ASCII format.
        - A binary file is nominally 3x smaller than the equivalent ASCII file so more data can be written into the maximum allowed data log file size of 4Gbytes.
        - A binary file typically has a 2 or 3:1 faster writing speed than the equivalent ASCII file, allowing shorter intervals to be used when logging to a slower drive and/or logging large amounts of data.
2. The FILENAME button allows you to set the name of the file which will be written.
    - Only filenames using the 8.3 form are allowed.
    - The extension is automatically provided (either .CSV or .BIN depending on the FORMAT setting).
    - The following file names may not be used –

        VHLIMIT.CSV
        AHLIMIT.CSV
        CUSTOM.CSV

3. The HEADER button allows you to select if the file will start with a header record or not (this is only available for the ASCII FORMAT setting).
   - If a header is set to be included, then the first file record will contain a textual description of each column of data.
4. The APPEND FILE button allows you to select what will happen if the specified file already exists on the drive when data logging is started (or the drive is subsequently inserted after starting it).
   - WARNING: If set to append to an existing file then the existing contents of the file may not be of the correct format to allow the file to be opened on a computer after completing the data log. APPEND should only be selected when it is definitely known that the existing data has the same format.

CONFIGURING DATA LOGGING TIMING

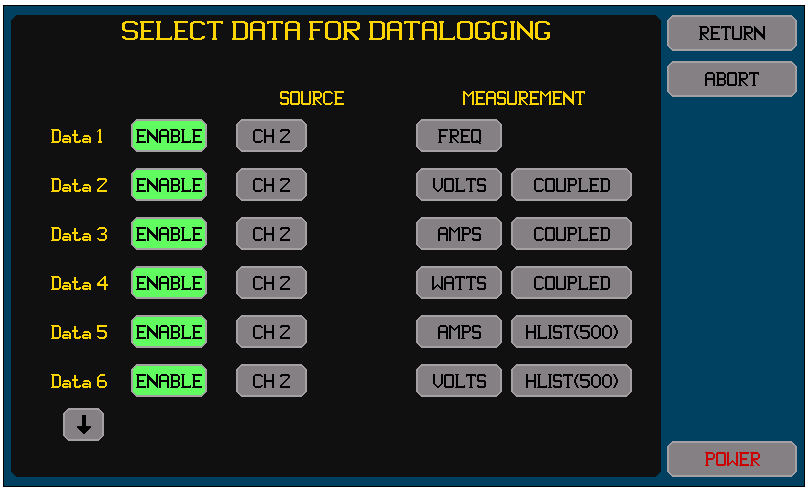
This is performed by using the buttons in the TIMING Area.

1. The START DELAY button allows you to select if actual data logging is to start after a delay has expired following pressing the START button.
   - In the data entry screens for START DELAY there are four entries, one for each unit of days, hours, minutes and seconds.
   - The screen always starts with the days data selected; you can jump to any of the four time units directly by pressing the respective time entry area.
   - You can enter a numeric between 0 and 99 into any of the four screens. The actual time used is the total time created by combining all four data with their respective units.
   - When the ENT button is pressed the selected time unit area automatically changes to next area to the right, unless the seconds data is selected when the action is same as pressing the overall RETURN button.
   - Pressing the RETURN button returns to the Data Logging Configure Screen and saves the configured time, whereas pressing the ABORT returns to the Data Logging Configure Screen without saving any changed data.
2. The RUN TIME button allows you to select if data logging is to run until manually stopped (MANUAL) or to run for a specific period of time.
   - If set to run for a specific time then the entry of that time follows the same procedure as setting the START DELAY (above).
3. The INTERVAL button allows you to set the data logging interval.
   - The entry of the interval follows the same procedure as that for the START DELAY and the RUN TIME (above), but uses a different set of four units (hours, minutes, seconds, and 1/100th seconds). The minimum interval is 1/100th of a second.

CONFIGURING DATA LOGGING RECORD CONTENTS

This is performed by using the buttons in the DATA Area.

1. The TIMESTAMP button allows you to select if each record is to contain the time of day and date information, or not.
   - The first field of every record is always the record number which continuously increments.
   - If enabled, the time of day is the second field of every record and in ASCII format it is formatted as the prevalent time format setting for the PA900 (i.e. 12 or 24 hour format).
   - If enabled, the date is the third field of every record and in ASCII format it is formatted as the prevalent date format setting for the PA900 (i.e. DD:MM:YYYY or MM:DD:YYYY).
2. The SELECT DATA button allows you to select each of the 16 data selections which will be logged. The lower half of the button shows how many of the 16 entries are being used presently.
   - Pressing the SELECT DATA button starts a screen which allows you to enable or disable each of the 16 entries and, if enabled, to select what data to log for each entry. The screen shown below is an example of this screen.



   - Only measurements which are presently configured to be measured can be selected while in this screen. It is generally not recommended to both configure VPAs and configure data logging in the same visit to the MEAS CONFIG screen.
   - Each ENABLE button is highlighted (green) if the data is enabled; otherwise the ENABLE button is not highlighted and is colored grey.

- If the SOURCE is selected to be from a VPA then there is a second SOURCE button which selects whether the total for the VPA or that from a specific phase of the VPA is to be used.
- If a harmonic list is selected as the MEASUREMENT then you must also enter the number of harmonics to be listed. The listing always includes the fundamental up to and including this entered harmonic. If a harmonic is not being measured at the data log time then the respective data recorded is zero.
- Typically each enabled entry is one field in the data log; however if a harmonic listing is selected the entry will create the same number of fields as the number of harmonics set to be listed.
- You do not need to enable consecutive entries; the file will only contain fields for enabled entries in the order defined and skip over entries which are not enabled.
- If an entry is not enabled, any prior selection of the source and measurement data is still saved. In this manner you may have several different data logging data sets and change between them by changing which entries are enabled.
- Pressing the RETURN button returns to the Data Logging Configure Screen and saves the configured data entries, whereas pressing the ABORT returns to the Data Logging Configure Screen without saving any changes.

OPTIMIZING LOW-LEVEL DC PERFORMANCE

If you are only using measurements configured as AC (i.e. not DC or AC+DC) or the AC levels are significantly higher than any expected DC levels (e.g. more than 30:1 higher) then low level DC performance is not required and this section of the manual can be ignored.

INTERNAL DC ZERO ADJUSTMENT

The PA900 automatically checks the internal DC zeroes if the environment has significantly changed and then applies any changes as needed. The automatic tracking of environmental changes can be disabled for any VPA by selecting OFF for the AUTOZERO setting in a VPA on the MEAS CONFIG screen, in which case the user should occasionally perform this Internal DC Zero operation manually.

RECOMMENDATION:

- If AUTOZERO has been set to OFF for any VPA then it is recommended to perform this Internal DC Zero operation at least daily, or whenever the environment has changed by more than 2C from that in which it was last performed.
- If AUTOZERO has been set to ON but the PA900 is a significantly different environment that in which it was calibrated then there will be a few minutes after turning on the PA900 while the DC zeroes are tracking that change in environment. To reduce this small shift during the first few minutes of operation you should perform an Internal DC Zero operation in the normally used environment, otherwise there is no need to perform this operation.

This operation takes a few seconds and does not require that signals be removed from the PA900 terminals. Note that this operation only affects channels which are configured for use.

This is achieved by pressing the SYS CONFIG button from any main screen and then pressing the INTERNAL button in the DC ZERO area. The PA900 will then perform an Internal DC Zero operation and save the adjustments recorded. A screen will show the progress of the operation and will wait for you to press the RETURN button on that screen when the action has been successfully completed.

While performing the Internal DC Zero you should not send any configuration interface commands to the PA900.

EXTERNAL DC ZERO ADJUSTMENT

If you are using external current transducers or shunts which may have a significant DC offset in their output you can perform an External DC Zero operation to set those offsets to the presently measured values. This external DC zero operation can also be used to account for any external DC offsets (leakage currents or thermally induced voltages) or to adjust any remaining offsets in the PA900 caused by adverse environments (e.g. nearby heat sources and/or unusual orientation of the PA900).

This differs from the Internal DC Zero described above because it corrects for any externally applied DC offset, so you must ensure that there are no DC signals present on the terminals of the PA900 which are not wished to be adjusted for.

This takes very little time and has an immediate effect. Channels which are not configured are not affected by this action.

This is achieved by pressing the SYS CONFIG button from any main screen and then pressing the EXTERNAL button in the DC ZERO area. You are then shown a screen which requests that you select whether to adjust the DC offset for all channels (ALL), or only those configured for scaling (ONLY SCALED), or to abort the action (NO). After you select the desired choice the PA900 will immediately use the latest obtained DC measurements and apply them as DC offsets. If no channels were affected by this operation then a message is displayed for a short time. If the measured DC values were too large to be adjusted then a message is displayed for a short time and no adjustments are made.

RECOMMENDATION: If it is desired to use this external DC zero ability when AUTOZERO is set to OFF for any channels then it is recommended to perform an internal DC zero operation and ensure that valid measurement results are available by returning to any of the measurement results screens and checking that the readings being indicated are those expected before returning to the SYS CONFIG screen and performing the external DC zero operation.

USING AN X CURRENT OPTION INPUT AT LOW LEVELS

X option current inputs have a resolution of 1uV or lower when used with an external current shunt. To achieve this level of performance the user must be aware of thermally induced DC voltages which can occur both within the shunt itself and in the wiring between the shunt and the terminals of the PA900. The user can reduce these effects by using high quality wiring and connectors, and by balancing the two sense wires by using the same gages and lengths, using the same connector types, and routing the two wires together. In severe circumstances this can also be affected by air currents passing over the shunt or the wiring, so you may need to take precautions to prevent unwanted airflow over them.

In practice twisting together the two sense wires from the shunt to the PA900 terminals both reduces these thermal voltage affects and also reduces the inductive pick-up of AC current in these wires, so is highly recommended. The use of coaxial cable is not recommended as often the two conductors are not of the same material. You should also note that the use of thinner gage wiring (e.g. 26awg or thinner) will produce the best thermal voltage performance as thinner wiring does not allow significant heat transfer through it.

Even when all precautions are taken, there will typically be several micro-volts of thermally induced offset voltages. The regular use of the External DC Zero capability described above is highly recommended when using shunts.

COMPUTER CONTROL OF THE PA900

There are a great many software languages, compilers and development platforms. It is beyond the scope of this document to attempt to provide you with complete assistance regarding writing software to control the PA900, so it is described in general form. Examples, where given, use the Microsoft Visual Studio Express 2010 development platform and the VB.NET language. In practice you may need to provide handlers for recovering from timeout errors in the examples shown.

RS232 (SERIAL) INTERFACE

Baud Rate	9600, 19200, 57600 or 115200
Handshake	Bi-directional, hardware (RTS/CTS)
Data Bits	8
Parity	None
Start/Stop Bits	1
Connector	9-pin Male Dsub
Interface Pinout Type	DTE (same as PC computer)
Cable required	9-wire female-female null modem cable, fully wired
Cable Length	<50ft (per standard)

CONNECTING TO THE RS232 INTERFACE

The RS232 connector located on the rear panel of the PA900 must be connected to the computer. For a standard PC type computer this requires a 9-pin female-female null modem cable, the pinout on the PA900 connector is identical to that on a standard PC, so the data and handshake lines must cross-over in the cable. Suitable cables are available from Vitrek in a selection of lengths.

USING A USB-TO_RS232 CONVERTOR

Many computers do not have a RS232 interface available; in these cases you may need to use a USB-to-RS232 convertor (sometimes called a 'dongle') to provide the RS232 interface. Many such convertors are available but many do not have adequate performance; Vitrek offers a fully tested convertor which is recommended.

Although the use of a convertor may not appear to alter the software written by you, the majority of USB-to-RS232 convertors have a fairly severe latency delay for each transmitted and received string of characters, typically this is 10ms or more. In high speed applications this may severely restrict the overall speed.

Many convertors have buffers for transmitted and received characters within the convertor itself. Experience has shown that the state of the buffer for characters transmitted from the computer to the PA900 is not properly managed in some convertors which can result in buffer overrun. This can cause character loss when performing high-speed transfers of commands to the PA900. If using such a convertor and the user is experiencing data loss (usually seen as randomly occurring command errors at the PA900) then the following is recommended based on past experiences–

- Use a different convertor. Vitrek offers a fully tested convertor.
- Ensure you are using the latest driver for the convertor in your computer. If changing between convertors then it is recommended to uninstall all previous USB-to-RS232 convertor drivers after removing the present USB-to_RS232 convertor and reboot the computer prior to installing a different convertor. Many different manufacturers of convertors use a similar chip set and are detected as compatible devices and may re-use the existing driver.
- Limit all transmitted data to a maximum of 64 characters and rate limit each packet transmitted by using pauses in your software. In extreme cases this 64 character limit may need to be lowered. Experience has shown that some convertors are only reliable when single characters are transmitted. The rate limiting time delay between packets should be greater than the USB frame rate of 1ms.
- Some convertors rely on the mechanical ground connection from the RS232 end to the convertor. Although a convertor may appear to be operating correctly, if the screws mounting a RS232 cable to the convertor are not installed then the convertor becomes very sensitive to interference. This typically gives a similar issue to the buffer management issue noted above, but often yields character loss in both transmitted and received data.

WRITING SOFTWARE TO CONTROL THE PA900 VIA RS232

Before your software can communicate with the PA900 it generally must create an object for the specific serial port and configure it.

As an example the following lines of code configure and open the port for communications (SerialPort1 is defined as a System.IO.Ports.SerialPort object)-

```
SerialPort1.BaudRate = 115200
SerialPort1.PortName = "COM1"
SerialPort1.Handshake = IO.Ports.Handshake.RequestToSend
SerialPort1.ReadTimeout = 100
SerialPort1.WriteTimeout = 100
SerialPort1.DtrEnable = True
SerialPort1.Open()
```

Since the PA900 communicates entirely using the standard ASCII character set, methods for sending and receiving character strings must be used, remembering to always terminate both transmitted and received strings with the <CR> and/or <LF> characters.

To transmit a command string (TransmitString) to the PA900 the following is an example –

```
SerialPort1.WriteLine(TransmitString)
```

To receive a response string (ReceiveString) from the PA900 the following is an example –

```
Dim ReceiveString as String = SerialPort1.ReadLine()
```

LAN (ETHERNET) INTERFACE

Speed	10baseT or 100baseTX, auto-selected
Duplex	Half or full-duplex, auto-selected
MDI/MDIX	Auto-selected
Protocols	ICMP, ARP, DHCP (DHCPv4 only), TCP/IP (IPv4 only)
TCP Port	10733
Remote Connections	Only one remote connection is allowed at any given time
Connector	RJ45
Cable required	CAT5 or CAT5e, UTP or STP
Cable Length	<100m (per standard)

CONNECTING TO THE LAN INTERFACE

The LAN connector located on the rear panel of the PA900 must be connected to your network, or can be directly connected to a computer if the computer is configured to operate that NIC as a 'peer-to-peer' (off network) port.

Standard CAT5e UTP cable is sufficient for the majority of applications and the PA900 has an auto MDI/MDIX so the use of a crossover cable is not necessary.

WRITING SOFTWARE TO CONTROL THE PA900 VIA LAN

Communication with the PA900 uses TCP/IP using port 10733 in the PA900. The PA900 only allows one active socket at any given time, so you must close the TCP/IP socket when finished using it. To avoid unnecessary lockouts, the PA900 will allow a replacement socket if the previously active socket is still open but has not been active for >1 minute, in which case it will close the expired socket (this only occurs if a new socket is attempted, otherwise the PA900 will keep a socket open even if it is not active). TCP/IP has CRC error checking, packet loss detection, and automatic retransmission of lost or corrupted data. This means that the user need not perform error checking using commands such as *ERR? when using the LAN interface except for testing your software, as each command is guaranteed to reach the PA900 without error.

Before your software can communicate with the PA900 it generally must create an object for the socket and then configure and open it.

```
Dim enet socket As System.Net.Sockets.TcpClient
enet socket.Connect(System.Net.IPAddress.Parse(EnetIPAddrBox.Text), 10733)
enet_socket.ReceiveTimeout = 1000
```

To close the socket the following is an example.

```
enet_socket.Close()
```

Since the PA900 communicates entirely using the standard ASCII character set, methods for sending and receiving character strings must be used, remembering to always terminate both transmitted and received strings with the <CR> and/or <LF> characters.

To transmit a command string (TransmitString) to the PA900 the following is an example –

```
Dim send data As Byte() = System.Text.Encoding.ASCII.GetBytes(TransmitString + Chr(10))
Dim send_len As Integer = cmd_string.Length
enet_socket.GetStream.Write(send_data, 0, send_len + 1)
```

To receive a response string (ReceiveString) from the PA900 the following is an example –

```
Dim sr As New System.IO.StreamReader(enet_socket.GetStream())
Dim ReceiveString as String = sr.ReadLine()
```

USB INTERFACE

Connector	USB B connector
Cable required	USB 2.0 A-B Cable
Compatibility	Compatible with Windows XP and later operating systems
USB Speed	Full-speed
USB Device	Enumerates as a Human Interface Device (HID) of the Vendor-specific type
Driver	None required

CONNECTING TO THE USB INTERFACE

The USB connector located on the rear panel of the PA900 must be connected to the computer or a hub using a standard USB AB type cable. The use of a quality cable is recommended particularly if interference is likely, as lower quality cables have poor shielding (if any) and have a high RF impedance in the ground connection.

The PA900 does not require a vendor supplied driver, so no installation is required. When the PA900 is first connected to a computer (sometimes to each specific USB port of a computer) the operating system of the computer must load the native HID device driver, this may take a short while. During that time the PA900 cannot be communicated with via the USB. The PA900 appears as a standard HID Input Device with Vendor-specific properties, it is shown in the Windows Device Manager as a Human Interface Device -> USB Input Device.

WRITING SOFTWARE TO CONTROL THE PA900 VIA USB

Since the PA900 appears as a standard HID Device with Vendor-specific properties, you must communicate through the standard Windows® interface for such devices. This can be a difficult task, so Vitrek includes a pair of DLL files to ease this communication (SLABHIDtoUART.dll and SLABHIDDevice.dll, both of which must be accessible to your program). All attempts to open the port, transmit strings through the port, receive strings through the port and close the port should be directly made through simple calls to these DLL files. Header files defining these calls for VB.NET, for C# and for C/C++ are also provided (SLABCP2110.vb, SLABCP2110.cs and SLABCP2110.h respectively).

When compiling applications using the Visual Studio development platform you should compile for x86 processors otherwise there may be conflicts with the supplied DLL files.

Note that most communications require knowledge of the USB VID (Vendor ID) and PID (Product ID) numbers used by the PA900. These are 4292 and 34869 respectively for all PA900 units.

Before your software can communicate with the PA900 it generally must create an object for the socket and then configure and open it.

```
Dim num_devices As Integer
Dim usbdevice As System.IntPtr
HidUart GetNumDevices(num devices, 4292, 34869)
If (num devices > 0 And HidUart Open(usbdevice, 0, 4292, 34869) = HID UART SUCCESS) Then
HidUart_SetUartConfig(usbdevice, 115200, HID_UART_EIGHT_DATA_BITS, HID_UART_NO_PARITY, /
        ID_UART_SHORT_STOP_BIT, HID_UART_RTS_CTS_FLOW_CONTROL)
HidUart_SetTimeouts(usbdevice, 0, 1000)
End If
```

To close the connection the following is an example.

```
HidUart_Close(usbdevice)
```

Since the PA900 communicates entirely using the standard ASCII character set, methods for sending and receiving character strings must be used, remembering to always terminate both transmitted and received strings with the <CR> and/or <LF> characters.

Although not shown here, it is recommended that you should check if the device handle is active by using the *HidUart_IsOpened* function call prior making calls for transmitting or receiving data. If this call indicates an invalid handle then you should repeat the process of opening a socket and obtaining a new device handle. This is only needed when significant interference is present and is necessary because some operating systems (e.g. Windows) disconnect a USB device which has interference.

To transmit a command string (TransmitString) to the PA900 the following is an example –

```
Dim send_data As Byte() = System.Text.Encoding.ASCII.GetBytes(cmd_string + Chr(10))
Dim send_len As Integer = cmd_string.Length
Dim written As Integer
HidUart_Write(usbdevice, send_data, send_len + 1, written)
```

To receive a response string (ReceiveString) from the PA900 the following is an example –

```
' The USB only operates with byte arrays - so must handle each byte and detect the LF
' terminator
' Although usually all characters in a response are received in a single array, this cannot be
' relied upon
' Uses a 2 second timeout to receive a complete line (far longer than needed)
Dim Timer As Stopwatch = Stopwatch.StartNew()
Dim rx_lf As Boolean = False
ReceiveString = “”
While (Not (rx lf))
        Dim rx data(1024) As Byte
        Dim rx index As Integer = 0
        Dim bytes As Integer = 0
        HidUart_Read(usbdevice, rx_data, 1024, bytes)
        ' Because we configured a 0 read timeout this will return immediately if there’s no
        ' characters
        While (bytes)
                If (rx_data(rx_index) = 10) Then
                        rx_lf = True
                        Exit While
                End If
                rx index += 1
                bytes -= 1
        End While
        ReceiveString += System.Text.Encoding.ASCII.GetString(rx_data, 0, rx_index)
        If (Timer.ElapsedMilliseconds > 2000) Then
                ' Timeout occurred – need to take some action here
                Timer.Stop()
                Exit Function
        End If
End While
```

SUMMARY OF PROVIDED DLL FUNCTIONS

In all function calls requiring a PID and/or VID, you must use the values noted above for the PA900.

The definitions for the function shown below use a C language form for clarity; do not use the calls exactly as shown instead use the header provided for the specific language being used.

CAUTION – the provided DLL files also contain other functions, you must not call these other functions otherwise it may render the PA900 permanently inoperative.

HidUart_GetNumDevices

This function returns the number of devices connected to the host with matching vendor and product ID (VID, PID).

```
HID_UART_STATUS HidUart_GetNumDevices (DWORD* numDevices, WORD vid, WORD pid)
```

numDevices—Returns the number of devices connected on return.

vid—Filter device results by vendor ID.

pid—Filter device results by product ID.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_PARAMETER

HidUart_GetString

This function returns a null-terminated vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string for the device specified by an index passed in *deviceNum*. The index for the first device is 0 and the last device is the value returned by *HidUart_GetNumDevices()* – 1.

```
HID_UART_STATUS HidUart_GetString (DWORD deviceNum, WORD vid, WORD pid, char*
deviceString, DWORD options)
```

deviceNum—Index of the device for which the string is desired.

vid—Filter device results by vendor ID.

pid—Filter device results by product ID.

deviceString—Variable of type `HID_UART_DEVICE_STRING` which will contain a NULL terminated ASCII device string on return. The string is 260 bytes.

options—Determines if *deviceString* contains a vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_DEVICE_NOT_FOUND, HID_UART_INVALID_PARAMETER, HID_UART_DEVICE_ACCESS_ERROR

HidUart_GetOpenedString

This function returns a null-terminated vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string for the device specified by *device*.

```
HID_UART_STATUS HidUart_GetOpenedString (HID_UART_DEVICE device, char* deviceString,
DWORD options)
```

device—Device object pointer as returned by *HidUart_Open()*.

deviceString—Variable of type HID_UART_DEVICE_STRING which will contain a NULL terminated ASCII device string on return. The string is 260 bytes.

options—Determines if *deviceString* contains a vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_INVALID_PARAMETER, HID_UART_DEVICE_ACCESS_ERROR

HidUart_Open

Opens a device using a device number between 0 and *HidUart_GetNumDevices()–1* and returns a device object pointer which will be used for subsequent accesses.

```
HID_UART_STATUS HidUart_Open (HID_UART_DEVICE* device, DWORD deviceNum, WORD vid, WORD
pid)
```

device—Returns a pointer to a PA900 device object. This pointer will be used by all subsequent accesses to the device.

deviceNum —Zero-based device index, between 0 and *(HidUart_GetNumDevices()* – 1).

vid—Filter device results by vendor ID.

pid—Filter device results by product ID.

Return Value: HID_UART_STATUS= HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_DEVICE_NOT_FOUND, HID_UART_INVALID_PARAMETER, HID_UART_DEVICE_IO_FAILED, HID_UART_DEVICE_ACCESS_ERROR, HID_UART_DEVICE_NOT_SUPPORTED

Note - Be careful when opening a device. Any HID device may be opened by this library. However, if the device is not actually a PA900, use of this library will cause undesirable results. The PA900 PID and VID must always be used.

HidUart_Close

Closes an opened device using the device object pointer provided by *HidUart_Open()*.

```
HID_UART_STATUS HidUart_Close (HID_UART_DEVICE device)
```

device—Device object pointer as returned by *HidUart_Open()*.

Return Value: HID_UART_STATUS= HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_INVALID_HANDLE, HID_UART_DEVICE_ACCESS_ERROR

Note - *device* is invalid after calling *HidUart_Close()*. It is recommended to set *device* to NULL after this call.

HidUart_IsOpened

Returns the device opened status.

```
HID_UART_STATUS HidUart_IsOpened (HID_UART_DEVICE device, BOOL* opened)
```

device—Device object pointer as returned by *HidUart_Open()*.

opened—Returns *TRUE* if the device object pointer is valid and the device has been opened using HidUart_Open().

Return Value: HID_UART_STATUS= HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_INVALID_PARAMETER

HidUart_Read

Reads the available number of bytes into the supplied buffer and returns the number of bytes read which can be less than the number of bytes requested. This function returns synchronously after reading the requested number of bytes or after the timeout duration has elapsed. Read and write timeouts can be set using *HidUart_SetTimeouts()*.

```
HID_UART_STATUS HidUart_Read (HID_UART_DEVICE device, BYTE* buffer, DWORD
numBytesToRead, DWORD* numBytesRead)
```

device—Device object pointer as returned by *HidUart_Open()*.

buffer—Address of a buffer to be filled with read data.

numBytesToRead—Number of bytes to read from the device into the buffer (1–32768). This value must be less than or equal to the size of *buffer.*

numBytesRead—Returns the number of bytes actually read into the buffer on completion.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_READ_ERROR, HID_UART_INVALID_PARAMETER, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_READ_TIMED_OUT, HID_UART_INVALID_REQUEST_LENGTH

Note - *HidUart_Read()* returns HID_UART_READ_TIMED_OUT if the number of bytes read is less than the number of bytes requested. This will only occur after the read timeout has elapsed. If the number of bytes read matches the number of bytes requested, this function will return HID_UART_SUCCESS.

HidUart_Write

Write the specified number of bytes from the supplied buffer to the device. This function returns synchronously after writing the requested number of bytes or after the timeout duration has elapsed. Read and write timeouts can be set using *HidUart_SetTimeouts()*.

```
HID_UART_STATUS HidUart_Write (HID_UART_DEVICE device, BYTE* buffer, DWORD
numBytesToWrite, DWORD* numBytesWritten)
```

device—Device object pointer as returned by *HidUart_Open()*.

buffer—Address of a buffer to be sent to the device.

numBytesToWrite—Number of bytes to write to the device (1–4096 bytes). *This value must be less than or equal to the size of buffer.*

numBytesWritten—Returns the number of bytes actually written to the device.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_WRITE_ERROR, HID_UART_INVALID_PARAMETER, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_WRITE_TIMED_OUT, HID_UART_INVALID_REQUEST_LENGTH

Note - *HidUart_Write()* returns HID_UART_WRITE_TIMED_OUT if the number of bytes written is less than the number of bytes requested.

HidUart_FlushBuffers

This function flushes the receive buffer in the PA900 and the HID driver.

```
HID_UART_STATUS HidUart_FlushBuffers (HID_UART_DEVICE device, BOOL flushTransmit, BOOL
flushReceive)
```

device—Device object pointer as returned by *HidUart_Open()*.

flushTransmit —Set to *TRUE* to flush the device transmit buffer.

flushReceive —Set to *TRUE* to flush the device receive buffer and HID receive buffer.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_DEVICE_IO_FAILED

HidUart_Cancello

This function cancels any pending HID reads and writes.

```
HID_UART_STATUS HidUart_CancelIo (HID_UART_DEVICE device)
```

device—Device object pointer as returned by *HidUart_Open()*.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_DEVICE_IO_FAILED

HidUart_SetTimeouts

Sets the read and write timeouts. Timeouts are used for *HidUart_Read()* and *HidUart_Write()*. The default value for timeouts is 1000 ms, but timeouts can be set to wait for any number of milliseconds between 0 and 0xFFFFFFFF.

```
HID_UART_STATUS HidUart_SetTimeouts (HID_UART_DEVICE device, DWORD readTimeout, DWORD
writeTimeout)
```

device—Device object pointer as returned by *HidUart_Open()*.

readTimeout—HidUart_Read() operation timeout in milliseconds.

writeTimeout—HidUart_Write() operation timeout in milliseconds.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT

Note - If read timeouts are set to a large value and no data is received, then the application may appear unresponsive. It is recommended to set timeouts appropriately before using the device.

HidUart_SetUartConfig

Sets the baud rate, data bits, parity, stop bits, and flow control. Caution, this sets parameters within the PA900 – do NOT alter these settings from those shown below.

HidUart_SetUartConfig(device, 115200, HID_UART_EIGHT_DATA_BITS, HID_UART_NO_PARITY, HID_UART_SHORT_STOP_BIT, HID_UART_RTS_CTS_FLOW_CONTROL)

device—Device object pointer as returned by *HidUart_Open()*.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_PARAMETER, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_DEVICE_IO_FAILED

COMMAND SYNTAX

All commands use the standard 7-bit ASCII character set using 8-bit encoding (the 8th bit is zero) independent of the actual interface being used. A command is a stream of characters, the unit storing received characters until a command terminator character is received and only then is action taken on the commands. Further characters may be received while the unit is taking the actions needed for a preceding command but no action will be taken on them until all pending command decode activity is completed.

Each command is a KEYWORD field defining the command possibly followed by further fields which refine the action of the command. The available command keywords and the fields required for each are described in tables later in this section.

More than one command can be present in a single command set, in which case each command is separated from the previous by a command separator character. If an error is found in a command within a command set then that command and any remaining commands in the command set will not be actioned.

Since the interface is based on streaming ASCII characters the use of separator and terminator characters is required to ensure that the extents of each field can be established. To improve the readability of commands you may also wish to employ whitespace characters to spread apart fields.

SPECIAL CHARACTERS

Certain ASCII characters serve a special purpose.

COMMAND TERMINATOR CHARACTERS

The end of a command set is determined by the presence of a command terminator which may be the line-feed, carriage return, form feed or NULL (0 value) ASCII characters.

Everything between successive command terminators is a command set. A command set is limited to a maximum of 2047 characters in total. There is no action taken or error generated if a command terminator is immediately followed by another command terminator.

COMMAND SEPARATOR CHARACTER

If more than one command is in a command set then each successive command is separated from the previous by a command separator which is the semi-colon ASCII character.

Everything between successive command separators or command terminators is a command. There is no action taken or error generated if a command separator is immediately followed by another command separator or a command terminator.

FIELD SEPARATOR CHARACTER

Most commands require command fields which refine the action of the command; each field is separated from the previous by a field separator which is the comma ASCII character.

Everything between successive field separators, command separators or command terminators is a field.

SUB-FIELD SEPARATOR CHARACTER

In some cases a single command field is made up of several sub-fields; each sub-field is separated from a previous sub-field by a sub-field separator which is the colon ASCII character.

Everything between successive sub-field separators, field separators, command separators or command terminators is a sub-field.

WHITESPACE CHARACTERS

Most fields and sub-fields can have one or more whitespace characters at the beginning and/or end. The space, tab and underscore ASCII characters are considered as whitespace characters.

FIELDS WITHIN A COMMAND

Command fields are one of the types described below. In certain cases a single field may be formed by multiple sub-fields, in which case each successive sub-field (each having one of the field types described below) is separated from the previous by a preceding sub-field separator character.

KEYWORD COMMAND FIELD SYNTAX

A KEYWORD field is a combination of printable ASCII characters which match the corresponding allowable keywords as described later. A KEYWORD field is not case-sensitive (e.g. the letters V and v are equivalent) and may be preceded and/or followed by one or more whitespace characters but may not contain any whitespace characters within it.

Examples of valid KEYWORD fields are –

*CLS
*cls
*Cls

ARANGE
Arange
CH1
Ch1
ch1

STRING COMMAND FIELD SYNTAX

A STRING field is any combination of any printable ASCII characters in the range 'space' through 'z'. A STRING field is literal, containing the exact definition of the required string; however certain characters have special meaning –

!	The Ω character
\	The ø character
$	The µ character
^	The Σ character
[	The up arrow character
`	The down arrow character
]	The ° character
‘	The centre dot character

Note that STRING fields are only terminated by a command terminator or separator character and may contain what would normally be any other separator character (if printable).

Examples of valid STRING fields are –

This is a string field
Volts:

NR1 COMMAND FIELD SYNTAX

A NR1 field is any combination of ASCII numeric (0 through 9) characters which form an integer value. A NR1 command field must not include a polarity character. A NR1 field may be preceded and/or followed by one or more whitespace characters but may not contain any whitespace characters within it.

All NR1 fields must be in the range 0 to 4294967295 and will cause a syntax error if outside of this range and in most commands this range is further limited and will cause a data range error if that range is exceeded.

Examples of valid NR1 fields are –

10
153465782

NR3 COMMAND FIELD SYNTAX

A NR3 field is any combination of ASCII characters which form a floating point value. A NR3 field may be preceded and/or followed by one or more whitespace characters but may not contain any whitespace characters within it.

All NR3 fields are decoded and used within the PA900 with approximately 1 in 10^7 resolution and may be in the range -10^{+99} to 10^{+99} and may contain a number of characters which is only limited by the maximum length of a command set.

Examples of valid NR3 fields are –

10
10.0
+10.0
1e1
-10.0
+1.2345678E+6
+1.2345678e+6
+1.2345678e-6
+1.2345678e6
153465782.34

VDEF COMMAND FIELD SYNTAX

This field type allows you to define a VPA using any of the following syntaxes-

- 1 to 3 (in NR1 format)
- A1 to A3 (in KEYWORD format)
- VPA1 to VPA3 (in KEYWORD format)
- CH1 to CH4 (in KEYWORD format) (defines the VPA which is presently configured to use the channel identified by CH1 to CH4)

CDEF COMMAND FIELD SYNTAX

This field type allows you to define a channel using any of the following syntaxes-

- 1 to 4 (in NR1 format)
- CH1 to CH4 (in KEYWORD format)

RDEF COMMAND FIELD SYNTAX

This field type contains 1 to 5 sub-fields which define a measurement result to be used. See a later section for details regarding the sub-fields of the RDEF command field type.

DDEF COMMAND FIELD SYNTAX

This field type contains 1 to 5 sub-fields which define a measurement result to be used. See a later section for details regarding the sub-fields of the DDEF command field type.

COLOR COMMAND FIELD SYNTAX

A COLOR command field contains three NR1 type sub-fields defining the level of the red, green and blue color components respectively. Each value is a maximum of 255 corresponding to full brightness of the respective color.

BLANK COMMAND FIELD SYNTAX

In some cases it is allowed to have a blank command field. This is a field which has a preceding field separator character but is immediately followed by another separator or terminator character. Except for a STRING command field, a blank field may contain one or more whitespace characters but no other characters.

RESPONSES TO COMMANDS

Some commands cause the PA900 to respond with a requested data response or set of data responses. The response is formed by a set of fields, similar to those for commands described above. Note that all command keywords which end with the ? character cause a response, while all command keywords which do not end with the ? character do not cause a response.

All responses from the PA900 use the standard 7-bit ASCII character set using 8-bit encoding (the 8th bit is zero) independent of the actual interface being used.

You may request more than one response in a set of commands, in which case each response (or set of responses) is separated from the previous by a comma separator and the responses are included in the same order as they were requested. A complete response is always terminated by a carriage return followed by a line feed ASCII character and may contain up to 65535 characters in total.

It is expected that after a command is given to the unit to produce a response that the originator will not issue further commands requesting a response until that prior response has been fully received. If the unit receives a command which requests a response but the prior response has not been fully transmitted then this raises a Tx Overrun error.

RESPONSE FIELDS

As defined for each such command a response is one or more fields, each of which is of the following types.

STRING RESPONSE FIELD SYNTAX

A STRING response is a set of ASCII characters forming the response. Only printable ASCII characters are used and the length of a STRING response is variable, the terminating comma (if more response fields follow it) or the terminating carriage return and line feed characters should be used to determine the end of a STRING field.

NR1 RESPONSE FIELD SYNTAX

A NR1 response is a set of ASCII numeric characters defining an integer value. The length of a NR1 response is variable, the terminating comma (if more response fields follow it) or the terminating carriage return and line feed characters should be used to determine the end of a NR1 field. A NR1 response never includes a polarity symbol as all such responses are positive.

NR3 RESPONSE FIELD SYNTAX

A NR3 response is a set of ASCII characters defining a floating point numeric value. The length of a NR3 response is fixed at 11 characters however it is recommended that the terminating comma (if more response fields follow it) or the terminating carriage return and line feed characters be used to determine the end of a NR3 field.

A NR3 response always has the following parts in the order shown –

A polarity character, defining the polarity of the numeric
6 digit characters with an embedded decimal point character, defining the mantissa portion of the numeric
The letter E character (upper case)
A polarity character, defining the polarity of the exponent
A single digit character defining the exponent (which is always a multiple of 3)

There is a special case of a NR3 response which is used to indicate that the data is not available. Normally a zero value uses a +0.00000E-9 response; a response of +0.00000E+0 indicates that the value is unavailable.

COMMAND KEYWORDS AND FIELDS

In the tables below, the specified command KEYWORD should be followed by each field (if any) in the order described in the table with each field separated from the previous by a field separator character. E.g. VSCALE,1,0 – turns off voltage scaling for channel 1.

INTERFACE CLEAR COMMANDS

Both of these commands perform the same function. The use of either of these commands is recommended when starting a session with the PA900 to ensure that any incomplete activities performed in a prior session are properly discarded.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
*CLS	-	-	-	Clears all interface registers and flushes any unsent Tx data, selects the LOCAL state, and abandons any unsaved measurement configuration changes from the interface
*RST				

LOCAL/REMOTE STATE CONTROL COMMANDS

The PA900 automatically enters the REMOTE state when any command is received via an interface. While in the REMOTE state a front panel user cannot change the measurement or interface configuration without first selecting to return to the LOCAL state. Interface commands are always actioned independent of the LOCAL/REMOTE state.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
LOCAL	-	-	-	Enters the LOCAL state (front panel measurement configuration changes enabled)
LOCKOUT	-	-	-	Enters the LOCKOUT state (front panel measurement configuration changes disabled and you cannot unlock from the front panel)

ERROR REGISTER QUERY COMMANDS

Each register accumulates interface command errors and is cleared when read. The use of the ERR register is recommended, the OPC and ESR registers are included for legacy purposes.

It is not recommended to include an error register query command with any other commands in a set of commands; any syntax error in those other commands may cause the error register query command to not be actioned.

These commands should be used following commands during testing of your software; they may be removed later if desired. For the LAN interface it is highly unlikely that a command will be corrupted, so the regular use of this type of error checking is not necessary; however for the USB and RS232 interfaces it is possible for commands to become corrupted during transmission to the PA900 so the use of the *ERR? command is recommended in high interference environments.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
*ERR?	-	-	-	Responds with the NR1 ERR register contents and clears the register Response is the highest error encountered since cleared and has the following possible values - 0: No error has occurred 1: The command cannot not be executed at this time 2: The content or configuration of the PA900 was not compatible with a command 3: An interface command field was syntactically valid but the data was out of the valid range 4: An interface command field was syntactically invalid 5: An interface command field was expected but not found 6: An interface command field was found but not expected 7: An invalid interface command was found 8: The requested response data contains too many characters 9: A response was requested but the previous response has not been read 10: A Rx overrun occurred
*ESR?	-	-	-	Responds with the NR1 ESR register contents and clears the register The response forms a single byte quantity with the following logical bit meanings (b0 is the LS bit) - b0: Set if an interface command error occurred b1: Set if a Tx overrun occurred
*OPC?	-	-	-	Responds with the NR1 OPC register contents and clears the register The response forms a single byte quantity with the following logical bit meanings (b0 is the LS bit) - b0: Set if an interface command error did not occur b1: Set if an interface command had too many or too few fields b2: Set if an interface command field syntax or data range error occurred b3: Set if an interface command field was not compatible with the content or configuration b4: Set if a Tx overrun occurred b5: Set if a Rx overrun occurred b6: Set if an unknown command was received

UNIT AND CHANNEL IDENTIFICATION QUERY COMMANDS

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
CHNL?	*c*	CDEF	-	Responds with two fields describing channel *c* - 1st field: (STRING) Two letter channel type (or NF if not fitted, or NI if fitted but has invalid data) 2nd field: (NR1) Serial Number
*IDN?	-	-	-	Responds with six fields describing the PA900 as follows - 1st field: (STRING) Manufacturer 2nd field: (STRING) Model (with /H500/EN appended if the respective option is installed) 3rd field: (STRING) Unit serial number 4th field: (NR1) Firmware major version number 5th field: (NR1) Firmware minor version number 6th field: (NR1) Firmware build number

DATE AND TIME CONTROL AND QUERY COMMANDS

It may take up to 500ms for a change in date and/or time to become apparent in the display or in interface query commands.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
DATE	*d*	NR1	1 to 31	Sets the date (*d*), month (*m*) and year (*y*)
	m	NR1	1 to 12	
	y	NR1	0 to 99	
DATEFMT	*f*	NR1	0 or 1	Sets MDY (*f*=0) or DMY (*f*=1) displayed date format
DATE?	-	-	-	Responds with the STRING format present date (as selected format) E.g. DD/MM/YYYY
TIME	*h*	NR1	0 to 23	Sets the hour (*h*, 24 hour format), minute (*m*) and second (*s*). The *s* field is optional.
	m	NR1	0 to 59	
	s	NR1	0 to 59	
TIMEFMT	*f*	NR1	0 or 1	Sets 24 hour (*f*=0) or 12 hour (*f*=1) displayed time format
TIME?	-	-	-	Responds with the STRING format present time (as selected format) E.g. HH:MM:SSam

MEASUREMENT STATE CONTROL AND QUERY COMMANDS

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
CLRINRUSH	-	-	-	Clears all inrush (max. hold) measurement results Inrush results are invalid until the next measurement period completion
DATALOG	*s*	NR1	0 or 1	Sets whether data logging is to be started (*s*=1) or stopped (*s*=0)
DATALOG?	-	-	-	Responds with two fields indicating the present state of data logging – 1st field (NR1) - 0: no data logging activity is presently being performed 1: delaying prior to starting actual data logging 2: starting data logging (finished delay but not fetched the first data yet) 3: performing data logging 4: not data logging, but finishing writing data to the drive 2nd field (NR1) – This field is maintained after a data log is terminated and is cleared when a data log is started. 0: There has been no data logging error 1: Data logging data loss occurred because of buffer overrun 2: Data logging was terminated because of file size limitation (approx. 4Gbytes) 3: Data logging was terminated because the drive became full 4: Data logging was terminated because of a drive write error 5: Data logging has terminated because the drive was removed
HISTORY	*s*	NR1	0 or 1	Stops (*s*=0) or (re)starts (*s*=1) historical data collection, data is cleared on (re)starting
HISTORY?	-	-	-	Responds with NR1 whether historical data collection is being performed (1) or not (0)
HOLD	*s*	NR1	0 or 1	Sets whether measurements are held (*s*=1) or not (*s*=0)
HOLD?	-	-	-	Responds with NR1 whether measurements are held (1) or not (0)
INTEG	*s*	NR1	0 or 1	Stops (*s*=0) or (re)starts (*s*=1) integrated data collection, data is cleared and the configured delay is initiated on (re)starting as applicable
INTEG?	-	-	-	Responds with NR1 – 0: integrated results are not being updated 1: integrated results are going to be updated after the configured delay has expired 2: integrated results are held because of measurement hold 3: integrated results are being updated
MCR?	-	-	-	Responds with the NR1 MCR (Measurement Completion) Register and clears it The NR1 is a 16-bit word formed by the following logically 'or-ed' bits (b0 is the LS bit) - b0 through 2: set if VPA 1 through 3 resp. have completed a non-harmonic measurement b8 through 10: set if VPA 1 through 3 resp. have completed a harmonic measurement Note: this register is also cleared when any measurement configuration change is made with the SAVECONFIG command.
SCOPE	*s*	NR1	0 to 2	Stops (*s*=0), starts a single (*s*=1) or starts a continuous (*s*=2) scope view capture If starting (*s* =1 or *s* =2) then any previously captured scope view data is cleared.
SCOPE?	-	-	-	Returns the present status of scope view capture as a NR1 as follows – 0: Scope view capture is stopped (no data has been collected) 1: Scope view capture is stopped (data has been collected) 2: A single scope view capture is in progress (no data has been collected) 3: Continuous scope view capture is in progress (no data has been collected) 4: Continuous scope view capture is in progress (data has been collected)
STBYRUN	*v*	VDEF	-	Stops (*s*=0) or starts (*s*=1) a standby power measurement in VPA *v*
	s	NR1	0 or 1	
STBYSTATE?	*v*	VDEF	-	Returns the present state of standby power measurement in VPA *v* as a NR1 as

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
				follows- 0: No standby measurement in progress and no data available (none has been previously run) 1: The last standby measurement was stopped by the operator. 2: The last standby measurement was stopped normally. 3: A EN50564 5.3.2d measurement is in progress but is waiting for the start detection level (no data is available). 4: A EN50564 5.3.2a measurement is in progress and is within the specified minimum time period. 5: A EN50564 5.3.2a measurement is in progress and has been extended beyond the specified minimum time period. 6: A EN50564 5.3.2d measurement is in progress.

MEASUREMENT CONFIGURATION EDIT COMMANDS

The Measurement Configuration Edit commands shown below have been split into separate sections for clarity; all of the commands described in these sections are controlled by the EDITCONFIG and SAVECONFIG commands.

These commands are only checked for syntax and compatibility with the installed hardware (if applicable) when each command is received and are not executed and the consistency of setting combinations are not checked until the SAVECONFIG command is used. In this manner you may configure measurements using these commands in any order without the need to consider intermediate potentially incompatible setting combinations. For this reason, the CH1 to CH4 variants of the VDEF format are not allowed for these commands.

The EDITCONFIG command may be used to discard any previous measurement configuration commands which have not been executed, ensuring that the configuration being edited by the interface is that presently being used in the PA900. If you are unsure if there are any pending commands from these sections (e.g. from a prior session where the SAVECONFIG command was not used) then you should use the EDITCONFIG command to ensure that there are none.

A typical command flow is-

Send the EDITCONFIG command (to ensure there are no previously unsaved measurement configuration changes)

Send the required measurement configuration commands (in any order)

Send the SAVECONFIG command (to execute the prior measurement configuration commands)

The above command flow can be sent in any number of sets of commands, including all in the same set of commands.

While performing an internal DC zero you should not send any of these commands to the PA900.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
EDITCONFIG	-	-	-	Sets the configuration to be edited by the interface to that presently being used in the PA900.
SAVECONFIG	-	-	-	Sets the presently used configuration within the PA900 to include all changes made via the interface since the prior EDITCONFIG or SAVECONFIG command. When this command is executed all measurements in progress may be abandoned and restarted with the changed configuration (depending on the changes made)

MEASUREMENT MODE CONFIGURATION COMMAND

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
MODE	*m*	NR1	0 to 5	Sets the overall operating mode for the PA900 - *m*=0: Single VPA mode *m*=1: Multi-VPA mode (only valid if more than one channel fitted) *m*=2: Sync-VPA mode (only valid if more than one channel fitted) *m*=3: EN61000-3-2 mode (only valid if at least one A channel option is fitted and option EN is installed). *m*=4: EN61000-3-3 mode (only valid if at least one A channel option is fitted and option EN is installed). *m*=5: EN61000-3-4 mode (only valid if at least one A channel option is fitted and option EN is installed). *m*=6: EN61000-3-11 mode (only valid if at least one A channel option is fitted and option EN is installed)

CHANNEL CONFIGURATION COMMANDS

An error is raised if the *c* field selects a channel which is not installed.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
ARANGE	*c*	CDEF	-	Sets the current input range for channel *c* – *r*=0: Selects the HI range *r*=1: selects the LO range *r*=2: selects for auto-range (only valid for a D current input channel)
	r	NR1	H input : 0 only D input : 0 to 2 X input : 0 to 1	
ASCALE	*c*	CDEF	-	Sets the current scaling and offset for channel *c*

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
	s	NR3	0.0, or +1e-6 to +1e6	If *s*=zero then turns off scaling and offset (*o* is ignored), otherwise turns on scaling and offset using *s* and *o* respectively Field o is optional, zero is used if not present
	o	NR3	Within the measurable range of the channel current option	
VSCALE	*c*	CDEF	-	Sets voltage scaling for channel *c* If *s*=zero then turns off scaling Otherwise turns on voltage scaling using *s*
	s	NR3	0.0, or +1e-3 to +1e6	

VPA CONFIGURATION COMMANDS

These commands are only valid while operating with a MODE setting of 0 or 1 or 2. If operating with a MODE setting of 0 then the *v* field must select VPA1.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
AUTOZERO	*v*	VDEF	-	Sets that environmental tracking of DC zeroes is enabled (*s*=1) or disabled (*s*=0)
	s	NR1	0 or 1	
CHANNELS	*v*	VDEF	-	Sets the channels included in VPA *v* to *c* = additive channel selection, CH1=1, CH2=2, CH3=4, CH4=8
	c	NR1	0 to 15	
COUPLE	*v*	VDEF	-	Sets the default measurement result coupling for VPA *v* to AC+DC (*c*=0), AC (*c*=1) or DC (*c*=2)
	c	NR1	0 to 2	
DIGITS	*v*	VDEF	-	Sets the number of displayed digits for VPA *v* results to *d*
	d	NR1	3 to 5	
EFFGROUP	*v*	VDEF	-	Sets the efficiency group for VPA *v* to None (*e*=0), IN (*e*=1), MIDDLE (*e*=2) or OUT (*e*=3)
	e	NR1	0 to 3	
FUND	*v*	VDEF	-	Sets the fundamental frequency for VPA *v* *f*=0: No fundamental (*freq* ignored) *f*=1: Fixed fundamental (*freq* sets the frequency) *f*=2: V input measurement (*freq* sets the maximum allowed frequency) *f*=3: A input measurement (*freq* sets the maximum allowed frequency) *f*=4 through 6: Use VPA1 through 3 resp. as the fundamental frequency (*freq* ignored) – cannot use VPA *v* The *freq* field need not be present if not needed
	f	NR1	0 to 6	
	freq	NR3	Set by PERIOD command selection	
HARMS	*v*	VDEF	-	Sets the maximum number of harmonics for VPA *v* to *h*
	h	NR1	0 to 100 (0 to 500 if H500 installed)	
HF	*v*	VDEF	-	Sets the HF Filter Limit for VPA *v* *h*=0: Auto-Track HF Filter *h*=1: 6kHz HF Filter *h*=2: 25kHz HF Filter *h*=3: 50kHz HF Filter *h*=4: 100kHz HF Filter (only valid if VPA contains W channels) *h*=5: 150kHz HF Filter (only valid if VPA contains W channels) *h*=6: 250kHz HF Filter (only valid if VPA contains W channels) *h*=7: None
	h	NR1	0 to 7	
LEADLAG	*v*	VDEF	-	Sets the VAR polarity for VPA *v* *m*=1: VAR is +ve for leading. *m*=2: VAR is -ve for leading.
	m	NR1	1 or 2	
PERIOD	*v*	VDEF	-	Sets the measurement period for VPA *v* *p*=0: VLF *p*=1: LF *p*=2: 10Hz/0.3s *p*=3: 20Hz/0.1s *p*=4: 45Hz/20ms *p*=5: 150Hz/10ms *p*=6: Full synchronization with VPA1 *p*=7: Full synchronization with VPA2
	p	NR1	*v* = 1 : 0 to 5 *v* = 2 : 0 to 6 *v* = 3 : 0 to 7	
RESPONSE	*v*	VDEF	-	Sets the measurement response for VPA *v* to Fastest (*r*=0), Medium (*r*=1), Slow (*r*=2) or Slowest (*r*=3)
	r	NR1	0 to 3	
STBYA	*v*	VDEF	-	Sets VPA *v* for EN50564 5.3.2 method A standby power measurements *d* is the minimum number of days for the measurement. *h* is the minimum number of hours for the measurement. *m* is the minimum number of minutes for the measurement. *s* is the minimum number of seconds for the measurement.
	d	NR1	0 to 99	
	h	NR1	0 to 99	
	m	NR1	0 to 99	
	s	NR1	0 to 99	
STBYD	*v*	VDEF	-	Sets VPA *v* for EN50564 5.3.2 method D standby power measurements *s* is the starting power detection level. *e* is the ending power detection level.
	s	NR3	≥0.0	
	e	NR3	≥0.0 and ≤*s*	
SUMVA	*v*	VDEF	-	Sets the VA/VAR total method for VPA *v* *m*=0: VAR is summed, VA is calculated. *m*=1: VA is summed, VAR is calculated
	m	NR1	0 or 1	
WIRING	*v*	VDEF	-	Sets the wiring method for VPA *v*

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
	w	NR1	0 to 4	*w*=0: N x 1ø method. *w*=1: 2ø3w method. *w*=2: 3ø3w (2 channel) method. *w*=3: 3ø3w (3 channel) method. *w*=4: 3ø4w method

SCOPE VIEW CONFIGURATION COMMANDS

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
TIMEBASE	*b*	NR1	0 to 20	Sets the scope data capture timebase to 5µs (*b*=0), 10µs (*b*=1), 20µs (*b*=2), 50µs (*b*=3), 100µs (*b*=4), 200µs (*b*=5), 500µs (*b*=6), 1ms (*b*=7), 2ms (*b*=8), 5ms (*b*=9), 10ms (*b*=10), 20ms (*b*=11), 50ms (*b*=12), 100ms (*b*=13), 200ms (*b*=14), 500ms (*b*=15), 1s (*b*=16), 2s (*b*=17), 5s (*b*=18), 10s (*b*=19) or 20s (*b*=20)
TRIGGER	*i*	NR1	0 to 7	Configures scope data capture triggering Trigger Input (*i*) : *i*=0: Trigger using CH 1 V input signal *i*=1: Trigger using CH 1 A input signal *i*=2: Trigger using CH 2 V input signal *i*=3: Trigger using CH 2 A input signal *i*=4: Trigger using CH 3 V input signal *i*=5: Trigger using CH 3 A input signal *i*=6: Trigger using CH 4 V input signal *i*=7: Trigger using CH 4 A input signal Trigger Detection Method (*t*) : *t*=0: DC rising edge *t*=1: DC falling edge *t*=2: Rectified signal (rising edge) *t*=3: High Frequency Trigger Position (*p*) : *p*=0: Trigger is at 0% of the captured time span *p*=1: Trigger is at 25% of the captured time span *p*=2: Trigger is at 50% of the captured time span *p*=3: Trigger is at 75% of the captured time span Trigger Level (*l*) in V or A units as applicable
	t	NR1	0 to 3	
	p	NR1	0 to 3	
	l	NR3	Any	

INTEGRATION CONFIGURATION COMMANDS

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
INTEGAUTO	*i*	NR1	0 or 1	Sets that integration will be automatically timed (*i*=1) or manually stopped and started (*i*=0)
INTEGDELAY	*d*	NR1	0 to 99	Sets the automatically timed integration start delay time to *d* days, *h* hours, *m* minutes plus *s* seconds.
	h	NR1	0 to 99	
	m	NR1	0 to 99	
	s	NR1	0 to 99	
INTEGRUN	*d*	NR1	0 to 99	Sets the automatically timed integration run time to *d* days, *h* hours, *m* minutes plus *s* seconds.
	h	NR1	0 to 99	
	m	NR1	0 to 99	
	s	NR1	0 to 99	

DATA LOGGING CONFIGURATION COMMANDS

These commands will return an error if used while data logging is running.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
LOGDATA	*t*	NR1	0 or 1	Sets the data to be saved in each data logging record – Each record includes a time/date field (*t*=1) or not (*t*=0) and data for each DDEF field (in order)
	0 to 16 fields	DDEF	-	
LOGDELAY	*d*	NR1	0 to 99	Sets the data logging start delay time to *d* days, *h* hours, *m* minutes plus *s* seconds
	h	NR1	0 to 99	
	m	NR1	0 to 99	
	s	NR1	0 to 99	
LOGFILE	*f*	NR1	0 or 1	Configures the file used for data logging – File Format – *f*=0: ASCII
	h	NR1	0 or 1	
	a	NR1	0 or 1	

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
	name	STRING	1 to 8 characters	*f*=1: Binary Header – *h*=0: No header (not valid for binary format) *h*=1: Header included File append – *a*=0: File (if exists) will be overwritten *a*=1: File (if exists) will be appended File Name (*name*) (excluding extension, first eight characters only) – this is case insensitive and may only contain valid file name characters for the 8.3 filename format (long file names are not supported).
LOGINTERVAL	*h*	NR1	0 to 99	Sets the data logging interval time to *h* hours, *m* minutes, *s* seconds plus *f* 1/100th seconds (all fields cannot be zero)
	m	NR1	0 to 99	
	s	NR1	0 to 99	
	f	NR1	0 to 99	
LOGRUN	*d*	NR1	0 to 99	Sets the data logging run time to *d* days, *h* hours, *m* minutes plus *s* seconds (if all fields are 0 then selects manually timed)
	h	NR1	0 to 99	
	m	NR1	0 to 99	
	s	NR1	0 to 99	

MEASUREMENT CONFIGURATION QUERY COMMANDS

These commands respond with the requested configuration being used at the time of the command, not including any unsaved changes.

An error is raised if the *c* field defines a channel which is not installed, or if the *v* field is not 1 when MODE is not 1 or 2.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
ARANGE?	*c*	CDEF	-	Responds with the NR1 current input range setting for channel *c* – 0: Set for the HI range 1: Set for the LO range 2: Set for auto-range, using the HI range 3: Set for auto-range, using the LO range
ASCALE?	*c*	CDEF	-	Responds with the current scaling and offset settings for channel *c* in two fields – 1st NR3 : current scaling setting (0.0 if not configured for scaling and offset) 2nd NR3 : current offset setting (0.0 if not configured for scaling and offset)
AUTOZERO?	*v*	VDEF	-	Responds with the NR1 DC zero environment tracking setting for VPA *v* – 0: Environment tracking is disabled 1: Environment tracking is enabled
CHANNELS?	*v*	VDEF	-	Responds with the NR1 channel inclusion setting for VPA *v* – 0: none 1 through 15: additive channel selection, CH1=1, CH2=2,CH3=4,CH4=8
COUPLE?	*v*	VDEF	-	Responds with the NR1 default measurement result coupling setting for VPA *v* – 0: AC+DC 1: AC Only 2: DC Only
DIGITS?	*v*	VDEF	-	Responds with the NR1 displayed digits setting for VPA *v*
EFFGROUP?	*v*	VDEF	-	Responds with the NR1 efficiency group setting for VPA *v* – 0: None 1: IN 2: MIDDLE 3: OUT
FUND?	*v*	VDEF	-	Responds with the fundamental frequency setting for VPA *v* as two fields, the 1st field is a NR1 and the 2nd is a NR3 – NR1 value - 0: No fundamental, NR3 is 0.0 1: Fixed fundamental, NR3 is the fixed value 2: V input measurement, NR3 is the maximum limit 3: A input measurement, NR3 is the maximum limit 4 through 6: Use VPA1 through 3 resp. as the fundamental frequency, NR3 is 0.0
HARMS?	*v*	VDEF	-	Responds with the NR1 maximum number of harmonics setting for VPA *v*
HF?	*v*	VDEF	-	Responds with the NR1 HF Filter Limit setting for VPA *v* – 0: Auto-Track HF Filter 1: 6kHz HF Filter 2: 25kHz HF Filter 3: 50kHz HF Filter 4: 100kHz HF Filter 5: 150kHz HF Filter 6: 250kHz HF Filter 7: None
INTEGAUTO?	-	-	-	Responds with a NR1 if integration is automatically controlled (1) or manually controlled (0)
INTEGDELAY?	-	-	-	Responds with four NR1 values for the automatically controlled integration delay time (days, hours, minutes and seconds respectively).

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
INTEGRUN?	-	-	-	Responds with four NR1 values for the automatically controlled integration run time (days, hours, minutes and seconds respectively).
LEADLAG?	*v*	VDEF	-	Responds with the NR1 VAR polarity setting for VPA *v* – 1: VAR is +ve for leading. 2: VAR is -ve for leading.
LOGDATA?	-	-	-	Responds with the presently defined data content in each data logging record – 1st field (NR1) indicates if time and date is included (1) or not (0) 2nd through 17th fields (STRING) indicate the definition for each data field in the record (a blank field in the response indicates that the field is not included in the record)
LOGDELAY?	-	-	-	Responds with the present delay time for data logging as four NR1 fields indicating the days, hours, minutes and seconds respectively.
LOGFILE?	-	-	-	Responds with the present file settings for data logging – 1st field (NR1) indicates if the file is in binary (1) or ASCII (0) format 2nd field (NR1) indicates if a header record will be included (1) or not (0) 3rd field (NR1) indicates if an existing file will be append to (1) or overwritten (0) 4th field (STRING) is the file name (including extension)
LOGINTERVAL?	-	-	-	Responds with the present interval for data logging as four NR1 fields indicating the hours, minutes, seconds and 0.01seconds respectively.
LOGRUN?	-	-	-	Responds with the present run time for data logging as four NR1 fields indicating the days, hours, minutes and seconds respectively (manually controlled if all fields are 0)
MODE?	-	-	-	Responds with a NR1 showing the present overall operating mode for the PA900. 0: Single VPA mode 1: Multi-VPA mode 2: Sync-VPA mode 3: EN61000-3-2 mode 4: EN61000-3-3 mode 5: EN61000-3-4 mode 6: EN61000-3-11 mode
PERIOD?	*v*	VDEF	-	Responds with the NR1 measurement period setting for VPA *v* – 0: VLF 1: LF 2: 10Hz/0.3s 3: 20Hz/0.1s 4: 45Hz/20ms 5: 150Hz/10ms 6: Full synchronization with VPA1 7: Full synchronization with VPA2
RESPONSE?	*v*	VDEF	-	Responds with the NR1 measurement response setting for VPA *v* – 0: Fastest 1: Medium 2: Slow 3: Slowest
STBY?	*v*	VDEF	-	Responds with the standby power measurement settings for VPA *v* – If the configured method is EN50564 5.3.2a: 1st field is a STRING of value A 2nd field is a NR1 with the days minimum measurement time setting 3rd field is a NR1 with the days minimum measurement time setting 4th field is a NR1 with the days minimum measurement time setting 5th field is a NR1 with the days minimum measurement time setting If the configured method is EN50564 5.3.2d: 1st field is a STRING of value D 2nd field is a NR3 with the starting power detection level setting 3rd field is a NR3 with the ending power detection level setting
SUMVA?	*v*	VDEF	-	Responds with the NR1 VA/VAR total method setting for VPA *v* – 0: VAR is summed, VA is calculated. 1: VA is summed, VAR is calculated
TIMEBASE?	-	-	-	Responds with the NR1 scope data capture timebase setting as 5µs (0), 10µs (1), 20µs (2), 50µs (3), 100µs (4), 200µs (5), 500µs (6), 1ms (7), 2ms (8), 5ms (9), 10ms (10), 20ms (11), 50ms (12), 100ms (13), 200ms (14), 500ms (15), 1s (16), 2s (17), 5s (18), 10s (19) or 20s (20)
TRIGGER?	-	-	-	Responds with the scope data capture triggers settings as the following four fields – 1st field (NR1) is the trigger input selection - 0: Trigger using CH 1 V input signal 1: Trigger using CH 1 A input signal 2: Trigger using CH 2 V input signal 3: Trigger using CH 2 A input signal 4: Trigger using CH 3 V input signal 5: Trigger using CH 3 A input signal 6: Trigger using CH 4 V input signal 7: Trigger using CH 4 A input signal 2nd field (NR1) is the trigger method selection – 0: DC rising edge 1: DC falling edge 2: Rectified signal (rising edge)

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
				3: High Frequency 3rd field (NR1) is the trigger position selection - 0: trigger is at 0% of the captured time span 1: trigger is at 25% of the captured time span 2: trigger is at 50% of the captured time span 3: trigger is at 75% of the captured time span 4th field (NR3) is the configured trigger level in V or A units as applicable
VSCALE?	*c*	CDEF	-	Responds with the NR3 voltage scaling setting (0.0 if not configured for scaling) for channel *c*
VPA?	*c*	CDEF	-	Responds with the NR1 indicating which VPA channel *c* is configured in (1 through 3) or if not configured or not installed (0)
WIRING?	*v*	VDEF	-	Responds with the NR1 wiring method setting for VPA *v* – 0: N x 1ø method. 1: 2ø3w method. 2: 3ø3w (2 channel) method. 3: 3ø3w (3 channel) method. 4: 3ø4w method

CONFIGURATION SAVE AND LOAD COMMANDS

These commands allow the user to temporarily save and reload the complete configuration of the PA900 (the saved configuration is volatile, i.e. it is not retained after a power cycle).

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
TEMPSAVECFG	-	-	-	Saves the present complete configuration of the PA900 into an internal temporary storage.
TEMPLOADCFG	-	-	-	Reloads the previously saved configuration from a TEMPSAVECFG command. If there was no previous TEMPSAVECFG command then this command raises an error. This command can only be used once for each TEMPSAVECFG command.

HARMONICS LIMITS CONFIGURATION AND CONFIGURATION QUERY COMMANDS

Any changes made to harmonics limits take an immediate effect but are volatile until the SAVEHLIMITS command is used (i.e. will not be retained when power is turned off).

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
CLRHLIMITS	*i*	KEYWORD	V or A	Removes all voltage (*i*=V) or current (*i*=A) harmonic limits
HLIMIT	*i*	KEYWORD	V or A	Sets voltage (*i*=V) or current (*i*=A) limit for harmonic *h* according to the remaining fields as follows – *t* sets the type of limit (if any) to apply - *t*=0: no limit applied (further fields are optional and are ignored if present) *t*=1: the limit is the highest of the percentage and level limits *t*=2: the limit is the addition of the percentage and level limits *p* sets whether the percentage limit is a percentage of the fundamental (*p*=0) or of the total signal (*p*=1) *plimit* and *llimit* are the percentage and level limits respectively Note : setting a limit with both *plimit* and *llimit* =0.0 will never pass
	h	NR1	1 to 500	
	t	NR1	0 to 2	
	p	NR1	0 or 1	
	plimit	NR3	≥0.0	
	llimit	NR3	≥0.0	
HLIMIT?	*i*	KEYWORD	V or A	Responds with the HLIMIT command STRING needed to reproduce the voltage (*i*=V) or current (*i*=A) limit for harmonic *h*
	h	NR1	1 to 500	
SAVEHLIMITS	*i*	KEYWORD	V or A	Saves all voltage (*i*=V) or current (*i*=A) harmonic limits

DC ZERO CONTROL AND QUERY COMMANDS

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
DCZERO	-	-	-	Initiates an INT DC ZERO activity on all configured channels (same as the SYS CONFIG -> INT DC ZERO button) Sets DCZ register as needed and clears DCZERR register Suspends normal measurement actions of the PA900 until ENDDCZERO is received
DCZ?	-	-	-	Responds with the NR1 DCZ register b0 through 3: set if CH 1 through 4 resp. are performing an INT DC Zero activity Each bit clears when the activity is successfully completed or ENDDCZERO commanded
DCZERR?	-	-	-	Responds with the NR1 DCZERR register b0 through 3: set if CH 1 through 4 resp. have found an error during an INT DC Zero activity
ENDDCZERO	-	-	-	Terminates an INT DC ZERO activity on all channels (aborts if still in progress) Clears DCZ and DCZERR registers Returns to normal measurement actions of the PA900
EXTDCZERO	*o*	NR1	0 or 1	Performs an external DC Zero. If *o* is 0 then all channels have their DC zeroes adjusted to the present DC measurements, otherwise if *o* is 1 then only those channels which are scaled have their DC zeroes adjusted to the present DC measurements.

CUSTOM SCREEN CONFIGURATION AND CONFIGURATION QUERY COMMANDS

The actual custom screen is not updated with the results of any changes until the SAVECUSTOM command is actioned. The use of the CLRCUSTOM command is recommended prior to starting to generate a custom screen via the interface to ensure that no existing contents of a custom screen are included in a newly generated screen. Following a SAVECUSTOM command no further custom screen commands can be executed for up to 300ms and attempting to do so raises an error.

Note that the CUSTOM command must either be the only command or the last command in a set of commands (i.e. it must be terminated by a command terminator character).

A custom screen is composed of 57 cells arranged in 15 rows with row 0 (the topmost row) only having a single column and rows 1 through 14 having 4 columns (the leftmost column is 0). For cells other than the row 0 cell, for text sizes other than 12pix or 16pix then the target cell is expanded to include surrounding cells as follows –

22pix text size: includes the cell to the right of the target cell.
28pix and 36pix text sizes: includes the cell to the right of the target cell and also the cells immediately below both the target cell and that to the right of it.

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
CLRCUSTOM	-	-	-	Sets the custom screen totally blank
CUSTOM	*r*	NR1	0 to 14	Set custom screen cell row (*r*), column (*c*) according to the remaining fields - *size* sets the text size to 12pix (*size*=0), 16pix (*size*=1), 22pix (*size*=2), 28pix (*size*=3) or 36pix (*size*=4) *just* sets the horizontal text justification to left (*just*=0), centered (*just*=1) or right (*just*=2) *colour* sets the text colour (R:G:B values) *def* sets the measurement result to be shown (blank if none required) *units* selects whether to include the measurement results units (*units*=1) or not (*units*=0) *text* sets the text to include. If *def* is defined then up to the first 5 characters of *text* are included to the left of the measurement result otherwise the cell contains up to the first 60 characters of *text*; if no characters are to be included in the cell then the *text* field need not be present If both *def* and *text* fields are blank (or not included) then only the *r* and *c* fields are used
	c	NR1	0 to 3	
	size	NR1	0 to 4	
	just	NR1	0 to 2	
	colour	COLOR	-	
	def	RDEF	-	
	units	NR1	0 or 1	
	text	STRING	Up to 60 characters	
CUSTOM?	*r*	NR1	0 to 14	Responds with the CUSTOM command string to recreate custom screen row *r* and column *c*
	c	NR1	0 to 3	
SAVECUSTOM	-	-	-	Saves the present custom screen internally and makes any changes active

MEASUREMENT RESULTS QUERY COMMANDS

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
CYCLEVIEW?	*c*	CDEF	-	Responds with the 512 data points of cycle view data for channel *c* voltage (*s*=V), current (*s*=A) or power (*s*=W) waveforms The data points correspond to phases of the fundamental starting at 0° and then at successive (360/512)° increments. Each data point contains two fields as follows – 1st field : NR1 indicating if this data point has a valid data (1) or not (0) 2nd field : NR3 indicating the level at this data point Note – the response is a large number of characters (approximately 7K) and is a total of 1024 fields. Not all data points may be valid, interpolate between valid data points as appropriate.
	s	KEYWORD	V or A or W	
HARMLIST?	*i*	KEYWORD	V or A or W	Responds with one NR3 harmonic amplitude for the voltage input (*i*=V) or current input (*i*=A) or power (*i*=W) of channel *c* for each harmonic starting with the *start* harmonic up to and including the *end* harmonic (the fundamental is harmonic 1).
	c	CDEF	-	
	start	NR1	1 to 500	
	end	NR1	*start* to 500	
HISTORYDATA?	*n*	NR1	2 to 1024	Responds with *n* data points of historical data defined by *def*, starting at historical data collection time *start* and ending at *end* (both in seconds relative to the time at which historical data collection was last started) Each data point is four fields as follows – 1st field: NR1 indicating if this data point contains data (1) or not (0) 2nd field: NR3 indicating the maximum data recorded 3rd field: NR3 indicating the average data recorded 4th field: NR3 indicating the minimum data recorded Note – the response can be a very large number of characters (up to 38.9K) and fields (up to 4096).
	start	NR3	≥0.0	
	end	NR3	>*start*	
	def	DDEF	-	
HISTORYTIME?	-	-	-	Responds with an NR3 indicating the length of time covered by the present historical data (in seconds)
HLIMITFAIL?	*c*	CDEF	-	Responds with a NR1 indicating if harmonic *h* (*h*>0) or all harmonics (*h*=0) for the voltage (*i*=V) or current (*i*=A) of channel *c* is passing (responds with 0) or failing (responds with 1) Note – a harmonic which has no limit or is not being measured is considered as passing
	i	KEYWORD	V or A	
	h	NR1	0 to 500	

COMMAND KEYWORD	FIELD(s)	FIELD FORMAT	FIELD DATA RANGE	DESCRIPTION
LEADING?	*srce*	KEYWORD	CH1, CH2, CH3, CH4, A1, A2, A3, VPA1, VPA2, or VPA3	Responds with a NR1 indicating if the selected data source (*srce*) has a leading PF (responds with 1) or lagging PF (responds with 0) *srce* is either- A1 to A3: selects VPA1 to 3 as the data source VPA1 to VPA3: selects VPA1 to 3 as the data source CH1 to CH4: selects channel 1 to channel 4 as the data source
MAXHARMS?	*v*	VDEF	-	Responds with a NR1 indicating the number of harmonics being measured in VPA *v*
READ?	*1 to 50 fields*	RDEF	-	Responds with the requested measurement result(s). You may specify up to 50 results to be obtained in a single READ? command.
REREAD?	-	-	-	Responds with the measurement results defined by the last received READ? Command. Note – this is typically used when a large number of results are to be repeatedly requested and a slow interface (e.g. USB or RS232) is being used. Sending the READ? command once and then repeating by using the REREAD? command achieves higher throughput because of the reduction in characters required. When using the LAN interface there is typically very little difference if the REREAD? command is used.
SCOPEVIEW?	*c*	CDEF	-	Responds with the 2048 data points of scope view data for channel *c* voltage (*s*=V), current (*s*=A) or power (*s*=W) waveforms Each data point contains two fields as follows – 1st field: NR3 indicating the time of the point (relative to the trigger point, in seconds, the first data point is the earliest and the last is the latest) 2nd field: NR3 indicating the level at this data point Note – the response is a very large number of characters (approximately 49.2K) and is a total of 4096 fields.
	s	KEYWORD	V or A or W	
STBYERR?	*c*	CDEF	-	Responds with a NR1 indicating if the PA900 measurement error was outside of the requirements of EN50564 at any time during the measurement (responds with 1) or not (responds with 0)
STBYHISTORY?	*c*	CDEF	-	Responds with *n* data points of standby historical data defined by *def*, ending at relative time *end* (in seconds relative to the time at which the standby measurement was started) The *def* field is- W: responds with the Watts data V: responds with the Volts data VCF: responds with the Volts Crest Factor data VTHD: responds with the Volts Distortion data (in percent) FREQ: responds with the Frequency data A: responds with the Amps data ACF: responds with the Amps Crest Factor data PF: responds with the Power Factor data ERR: responds with the PA900 Measurement Error data (in Watts) Each data point is three fields as follows – 1st field: NR1 indicating if this data point contains data (1) or not (0) 2nd field: NR3 indicating the maximum data recorded 3rd field: NR3 indicating the minimum data recorded Note – the response can be a very large number of characters (up to 24.6K) and fields (up to 3072).
	n	NR1	2 to 1024	
	end	NR3	*>0.0*	
	def	STRING	W, V, VCF, VTHD, FREQ, A, ACF, PF or ERR	
STBYVCF?	*c*	CDEF	-	Responds with a NR1 indicating if the voltage crest factor was outside of the requirements of EN50564 at any time during the measurement (responds with 1) or not (responds with 0)
STBYVTHD?	*c*	CDEF	-	Responds with a NR1 indicating if the voltage distortion was outside of the requirements of EN50564 at any time during the measurement (responds with 1) or not (responds with 0)

RDEF MEASUREMENT DEFINITION FIELD SUB-FIELDS

This field is made up of one to five sub-fields, each separated by the sub-field separator (colon character). The sub-fields may be specified in any order and may optionally be omitted (a default value being used as needed).

Sub-Field	Sub-field Format	Value	Description
Measurement Data	KEYWORD	FREQ	Responds with a signal frequency (in Hz)
		PERIOD	Responds with a signal period (in seconds)
		INTEGTIME	Responds with the integration time (in Hours)
		VOLTS or V	Responds with a voltage (in V)
		AMPS or A	Responds with a current (in A)
		WATTS or W	DEFAULT if no other Measurement Data sub-field found Responds with a real power (in W)
		LOSS	Responds with a real power loss (in W)
		EFFICIENCY or EFF	Responds with a real power efficiency (in %)
		VAR	Responds with an imaginary power (in W)
		VA	Responds with an apparent power (in VA)
		PF	Responds with power factor
		PHASE	Responds with apparent phase (in degrees)

Sub-Field	Sub-field Format	Value	Description
		LOADZ	Responds with load impedance (in ohms)
		SERIESR	Responds with load series resistance (in ohms)
		SERIESL	Responds with load series inductance (in henries)
		PARALLELR	Responds with load parallel resistance (in ohms)
		PARALLELC	Responds with load parallel capacitance (in farads)
		STBYTIME	Responds with elapsed standby power measurement time (in hours)
		STBYERR	Responds with standby power measurement error (in W)
Measurement Source	KEYWORD	CH1, CH2, CH3 or CH4	CH1 is DEFAULT if no other Measurement Source sub-field found Data is from the selected channel
		A1, A2, A3, VPA1, VPA2 or VPA3	Data is from the selected VPA
		IN	Data is from the IN efficiency group (or starts at this group if 2nd Measurement Source is MIDDLE or OUT)
		MIDDLE	Data is from the MIDDLE efficiency group (or starts at this group if 2nd Measurement Source is OUT)
		OUT	Data is from the OUT efficiency group
2nd Measurement Source (ignored if Measurement Source is a single channel)	KEYWORD	MIDDLE	Data is to the MIDDLE efficiency group (only valid if Measurement Source is IN)
		OUT	Data is to the OUT efficiency group (only valid if Measurement Source is IN or MIDDLE)
		pA … D	Data is from the 1st through 4th (resp.) channel of the selected VPA
		pAC	Data is the voltage measured between phases A and C of the selected VPA
		pAB	Data is the voltage measured between phases A and B of the selected VPA
		pBC	Data is the voltage measured between phases B and C of the selected VPA
		pN	Data is the neutral current of the selected VPA
		WYE	Data is the 'Wye' voltage of the selected VPA
		DELTA	Data is the 'Delta' voltage of the selected VPA
		SEQZERO	Data is the zero sequence data of the selected VPA
		SEQPOS	Data is the positive sequence data of the selected VPA
		SEQNEG	Data is the negative sequence data of the selected VPA
		TOTAL or AVERAGE	DEFAULT if no other 2nd Measurement Source sub-field found Data is the total for the selected VPA, except for VOLTS and AMPS data which is the average of all channels/phases
Measurement Type	KEYWORD	DC	Data is the DC component
		AC	Data is the AC component
		ACDC or RMS	Data is the ACDC component
		COUPLED	DEFAULT if no other Measurement Type sub-field found Data is the DC, AC or ACDC component as configured for the VPA
		RECTIFIED	Data is the average rectified
		STBY	Data is the average standby power measurement
		STBYMIN	Data is the minimum standby power measurement
		STBYMAX	Data is the maximum standby power measurement
		STBYCFMIN	Data is the minimum crest factor standby power measurement
		STBYCFMAX	Data is the maximum crest factor standby power measurement
		STBYTHDMAX	Data is the maximum THD standby power measurement (as the percentage of the fundamental)
		FF	Data is the form factor
		CF	Data is the crest factor
		PK	Data is peak
		HIPK	Data is the highest peak (including polarity)
		LOPK	Data is the lowest peak (including polarity)
		THDF	Data is THD relative to fundamental amplitude (in %)
		THDSIG	Data is THD relative to COUPLED amplitude (in %)
		H1 … 500	Data is harmonic amplitude data for the specified harmonic
		P1 … 500	Data is harmonic phase data for the specified harmonic (in degrees with ±180° range)
		INRUSH	Data is the inrush data (max hold)
		INRUSHPK	Data is the peak inrush data (max hold)
		INTEG	Data is the integrated data
		INTAVG	Data is the average integrated data
		CHARGE	Data is the integrated charge data
		DISCHARGE	Data is the integrated discharge data
		BOUGHT	Data is the integrated bought data
		SOLD	Data is the integrated sold data
		%2 … 500	Data is as Hn but expressed as a percentage of the fundamental
		%S2 … 500	Data is as Hn but expressed as a percentage of the COUPLED amplitude
Ending Harmonic (only used if Measurement Type is H1 … 500 or %2 … 500)	NR1	1 to 500	Data includes harmonics up to and including this number (if this sub-field is not specified then data only includes the single harmonic specified in the Measurement Type sub-field)

A list of allowed combinations is provided below. In this list the following codes are used to reduce the length of the list –

CHn	Any of CH1, CH2, CH3 or CH4
An	Any of A1, A2 or A3
pX	Any of pA, pB, pC or pD
Hn	Any of H1 … 500
n	Any of 1 … 500
Pn	Any of P1 … 500
%n	Any of %2 … 500 or %S2 … 500

Not all combinations shown may be allowed in all circumstances; channels might not be installed or the configuration may not provide valid results for a specific combination. Not all valid combinations may be shown below and where a default sub-field value may be used the combination is only shown without defining that specific sub-field.

FREQ:CHn
FREQ:CHn:STBYMIN
FREQ:CHn:STBYMAX
FREQ:An
INTEGTIME:CHn:INTEG
INTEGTIME:CHn:CHARGE
INTEGTIME:CHn:DISCHARGE
INTEGTIME:CHn:BOUGHT
INTEGTIME:CHn:SOLD
INTEGTIME:An:INTEG
INTEGTIME:An:CHARGE
INTEGTIME:An:DISCHARGE
INTEGTIME:An:BOUGHT
INTEGTIME:An:SOLD
STBYTIME:CHn
STBYTIME:An
VOLTS:CHn:DC
VOLTS:CHn:AC
VOLTS:CHn:ACDC
VOLTS:CHn
VOLTS:CHn:RECTIFIED
VOLTS:CHn:FF
VOLTS:CHn:CF
VOLTS:CHn:PK
VOLTS:CHn:HIPK
VOLTS:CHn:LOPK
VOLTS:CHn:INRUSH
VOLTS:CHn:INRUSHPK
VOLTS:CHn:INTEG
VOLTS:CHn:INTAVG
VOLTS:CHn:CHARGE
VOLTS:CHn:DISCHARGE
VOLTS:CHn:BOUGHT
VOLTS:CHn:SOLD
VOLTS:CHn:Hn
VOLTS:CHn:Hn:n
VOLTS:CHn:Pn
VOLTS:CHn:THDf
VOLTS:CHn:THDsig
VOLTS:CHn:%n
VOLTS:CHn:%n:n
VOLTS:CHn:STBY
VOLTS:CHn:STBYMIN
VOLTS:CHn:STBYMAX
VOLTS:CHn:STBYCFMIN
VOLTS:CHn:STBYCFMAX
VOLTS:CHn:STBYTHDMAX
VOLTS:An:pX:DC
VOLTS:An:pX:AC
VOLTS:An:pX:ACDC
VOLTS:An:pX
VOLTS:An:pX:RECTIFIED
VOLTS:An:pX:FF
VOLTS:An:pX:CF
VOLTS:An:pX:PK
VOLTS:An:pX:HIPK
VOLTS:An:pX:LOPK
VOLTS:An:pX:INRUSH
VOLTS:An:pX:INRUSHPK
VOLTS:An:pX:INTEG
VOLTS:An:pX:INTAVG
VOLTS:An:pX:CHARGE
VOLTS:An:pX:DISCHARGE
VOLTS:An:pX:BOUGHT
VOLTS:An:pX:SOLD
VOLTS:An:pX:Hn
VOLTS:An:pX:Hn:n
VOLTS:An:pX:Pn
VOLTS:An:pX:THDf
VOLTS:An:pX:THDsig
VOLTS:An:pX:%n
VOLTS:An:pX:%n:n
VOLTS:An:pAC:AC
VOLTS:An:pAC:ACDC
VOLTS:An:pAC
VOLTS:An:pAC:RECTIFIED
VOLTS:An:pAC:FF
VOLTS:An:pAC:CF
VOLTS:An:pAC:PK
VOLTS:An:pAC:HIPK
VOLTS:An:pAC:LOPK
VOLTS:An:pAC:INRUSH
VOLTS:An:pAC:INRUSHPK
VOLTS:An:pAC:INTEG
VOLTS:An:pAC:INTAVG
VOLTS:An:pAC:BOUGHT
VOLTS:An:pAC:SOLD
VOLTS:An:pAC:Hn
VOLTS:An:pAC:Hn:n
VOLTS:An:pAC:Pn
VOLTS:An:pAC:THDf
VOLTS:An:pAC:THDsig
VOLTS:An:pAC:%n
VOLTS:An:pAC:%n:n
VOLTS:An:pBC:AC
VOLTS:An:pBC:ACDC
VOLTS:An:pBC
VOLTS:An:pBC:RECTIFIED
VOLTS:An:pBC:FF
VOLTS:An:pBC:CF
VOLTS:An:pBC:PK
VOLTS:An:pBC:HIPK
VOLTS:An:pBC:LOPK
VOLTS:An:pBC:INRUSH
VOLTS:An:pBC:INRUSHPK
VOLTS:An:pBC:INTEG
VOLTS:An:pBC:INTAVG
VOLTS:An:pBC:BOUGHT
VOLTS:An:pBC:SOLD
VOLTS:An:pBC:Hn
VOLTS:An:pBC:Hn:n
VOLTS:An:pBC:Pn
VOLTS:An:pBC:THDf
VOLTS:An:pBC:THDsig
VOLTS:An:pBC:%n
VOLTS:An:pBC:%n:n
VOLTS:An:pAB:AC
VOLTS:An:pAB:ACDC
VOLTS:An:pAB
VOLTS:An:pAB:RECTIFIED
VOLTS:An:pAB:FF
VOLTS:An:pAB:CF
VOLTS:An:pAB:PK
VOLTS:An:pAB:INRUSH
VOLTS:An:pAB:INRUSHPK
VOLTS:An:pAB:Hn
VOLTS:An:pAB:Hn:n
VOLTS:An:pAB:Pn
VOLTS:An:pAB:THDf
VOLTS:An:pAB:THDsig
VOLTS:An:pAB:%n
VOLTS:An:pAB:%n:n
VOLTS:An:SEQZERO
VOLTS:An:SEQPOS
VOLTS:An:SEQNEG
VOLTS:An:WYE
VOLTS:An:DELTA
VOLTS:An
VOLTS:An:RECTIFIED
VOLTS:An:PK
VOLTS:An:INRUSH
VOLTS:An:INRUSHPK
VOLTS:An:INTEG
VOLTS:An:INTAVG
VOLTS:An:CHARGE
VOLTS:An:DISCHARGE
VOLTS:An:BOUGHT
VOLTS:An:SOLD
VOLTS:An:H1
AMPS:CHn:DC
AMPS:CHn:AC
AMPS:CHn:ACDC
AMPS:CHn
AMPS:CHn:RECTIFIED
AMPS:CHn:FF
AMPS:CHn:CF
AMPS:CHn:PK
AMPS:CHn:HIPK
AMPS:CHn:LOPK
AMPS:CHn:INRUSH
AMPS:CHn:INRUSHPK
AMPS:CHn:INTEG
AMPS:CHn:INTAVG
AMPS:CHn:CHARGE
AMPS:CHn:DISCHARGE
AMPS:CHn:BOUGHT
AMPS:CHn:SOLD
AMPS:CHn:Hn
AMPS:CHn:Hn:n
AMPS:CHn:Pn
AMPS:CHn:THDf
AMPS:CHn:THDsig
AMPS:CHn:%n
AMPS:CHn:%n:n
AMPS:CHn:STBY
AMPS:CHn:STBYMIN
AMPS:CHn:STBYMAX
AMPS:CHn:STBYCFMAX
AMPS:An:pX:DC
AMPS:An:pX:AC
AMPS:An:pX:ACDC
AMPS:An:pX
AMPS:An:pX:RECTIFIED
AMPS:An:pX:FF
AMPS:An:pX:CF
AMPS:An:pX:PK
AMPS:An:pX:HIPK
AMPS:An:pX:LOPK
AMPS:An:pX:INRUSH
AMPS:An:pX:INRUSHPK
AMPS:An:pX:INTEG
AMPS:An:pX:INTAVG
AMPS:An:pX:CHARGE
AMPS:An:pX:DISCHARGE
AMPS:An:pX:BOUGHT
AMPS:An:pX:SOLD
AMPS:An:pX:Hn
AMPS:An:pX:Hn:n
AMPS:An:pX:Pn
AMPS:An:pX:THDf
AMPS:An:pX:THDsig
AMPS:An:pX:%n
AMPS:An:pX:%n:n
AMPS:An:pN:DC
AMPS:An:pN:AC
AMPS:An:pN:ACDC
AMPS:An:pN
AMPS:An:pN:RECTIFIED
AMPS:An:pN:FF
AMPS:An:pN:CF
AMPS:An:pN:PK
AMPS:An:pN:INRUSH
AMPS:An:pN:INRUSHPK
AMPS:An:pN:Hn
AMPS:An:pN:Hn:n
AMPS:An:pN:Pn
AMPS:An
AMPS:An:RECTIFIED
AMPS:An:PK
AMPS:An:INRUSH
AMPS:An:INRUSHPK
AMPS:An:INTEG
AMPS:An:INTAVG
AMPS:An:CHARGE
AMPS:An:DISCHARGE
AMPS:An:SEQZERO
AMPS:An:SEQPOS
AMPS:An:SEQNEG
AMPS:An:BOUGHT
AMPS:An:SOLD
AMPS:An:H1
WATTS:CHn:DC
WATTS:CHn:AC
WATTS:CHn:ACDC
WATTS:CHn
WATTS:CHn:H1
WATTS:CHn:INRUSH
WATTS:CHn:INTEG
WATTS:CHn:INTAVG
WATTS:CHn:CHARGE
WATTS:CHn:DISCHARGE
WATTS:CHn:BOUGHT
WATTS:CHn:SOLD
WATTS:CHn:STBY
WATTS:CHn:STBYMIN
WATTS:CHn:STBYMAX
WATTS:CHn:STBYSLOPE
WATTS:An:pX:DC
WATTS:An:pX:AC
WATTS:An:pX:ACDC
WATTS:An:pX
WATTS:An:pX:H1
WATTS:An:pX:INRUSH
WATTS:An:pX:INTEG
WATTS:An:pX:INTAVG
WATTS:An:pX:CHARGE
WATTS:An:pX:DISCHARGE
WATTS:An:pX:BOUGHT
WATTS:An:pX:SOLD
WATTS:An:pAC:DC
WATTS:An:pAC:AC
WATTS:An:pAC:ACDC
WATTS:An:pAC
WATTS:An:pAC:H1

WATTS:An:pAC:INRUSH
WATTS:An:pAC:INTEG
WATTS:An:pAC:INTAVG
WATTS:An:pAC:CHARGE
WATTS:An:pAC:DISCHARGE
WATTS:An:pAC:BOUGHT
WATTS:An:pAC:SOLD
WATTS:An:pBC:DC
WATTS:An:pBC:AC
WATTS:An:pBC:ACDC
WATTS:An:pBC
WATTS:An:pBC:H1
WATTS:An:pBC:INRUSH
WATTS:An:pBC:INTEG
WATTS:An:pBC:INTAVG
WATTS:An:pBC:CHARGE
WATTS:An:pBC:DISCHARGE
WATTS:An:pBC:BOUGHT
WATTS:An:pBC:SOLD
WATTS:An
WATTS:An:H1
WATTS:An:INRUSH
WATTS:An:INTEG
WATTS:An:INTAVG
WATTS:An:CHARGE
WATTS:An:DISCHARGE
WATTS:An:BOUGHT
WATTS:An:SOLD
WATTS:IN
WATTS:MIDDLE
WATTS:OUT
LOSS:IN:MIDDLE
LOSS:IN:OUT
LOSS:MIDDLE:OUT
EFFICIENCY:IN:MIDDLE
EFFICIENCY:IN:OUT
EFFICIENCY:MIDDLE:OUT
VAR:CHn:AC
VAR:CHn:ACDC
VAR:CHn
VAR:CHn:H1
VAR:CHn:INTEG
VAR:CHn:INTAVG
VAR:CHn:BOUGHT
VAR:CHn:SOLD
VAR:An:pX:AC
VAR:An:pX:ACDC
VAR:An:pX
VAR:An:pX:H1
VAR:An:pX:INTEG
VAR:An:pX:INTAVG
VAR:An:pX:BOUGHT
VAR:An:pX:SOLD
VAR:An:pAC:AC
VAR:An:pAC:ACDC
VAR:An:pAC
VAR:An:pAC:H1
VAR:An:pAC:INTEG
VAR:An:pAC:INTAVG
VAR:An:pAC:BOUGHT
VAR:An:pAC:SOLD
VAR:An:pBC:AC
VAR:An:pBC:ACDC
VAR:An:pBC
VAR:An:pBC:H1
VAR:An:pBC:INTEG
VAR:An:pBC:INTAVG
VAR:An:pBC:BOUGHT
VAR:An:pBC:SOLD
VAR:An
VAR:An:H1
VAR:An:INTEG
VAR:An:INTAVG
VAR:An:BOUGHT
VAR:An:SOLD
VA:CHn:DC
VA:CHn:AC
VA:CHn:ACDC
VA:CHn
VA:CHn:H1
VA:CHn:INTEG
VA:CHn:INTAVG
VA:CHn:CHARGE
VA:CHn:DISCHARGE
VA:CHn:BOUGHT
VA:CHn:SOLD
VA:An:pX:DC
VA:An:pX:AC
VA:An:pX:ACDC
VA:An:pX
VA:An:pX:H1
VA:An:pX:INTEG
VA:An:pX:INTAVG
VA:An:pX:CHARGE
VA:An:pX:DISCHARGE
VA:An:pX:BOUGHT
VA:An:pX:SOLD
VA:An:pAC:DC
VA:An:pAC:AC
VA:An:pAC:ACDC
VA:An:pAC
VA:An:pAC:H1
VA:An:pAC:INTEG
VA:An:pAC:INTAVG
VA:An:pAC:CHARGE
VA:An:pAC:DISCHARGE
VA:An:pAC:BOUGHT
VA:An:pAC:SOLD
VA:An:pBC:DC
VA:An:pBC:AC
VA:An:pBC:ACDC
VA:An:pBC
VA:An:pBC:H1
VA:An:pBC:INTEG
VA:An:pBC:INTAVG
VA:An:pBC:CHARGE
VA:An:pBC:DISCHARGE
VA:An:pBC:BOUGHT
VA:An:pBC:SOLD
VA:An
VA:An:H1
VA:An:INTEG
VA:An:INTAVG
VA:An:CHARGE
VA:An:DISCHARGE
VA:An:BOUGHT
VA:An:SOLD
PF:CHn:AC
PF:CHn:ACDC
PF:CHn
PF:CHn:H1
PF:CHn:STBY
PF:CHn:STBYMIN
PF:CHn:STBYMAX
PF:An:pX:AC
PF:An:pX:ACDC
PF:An:pX
PF:An:pX:H1
PF:An:pAC:AC
PF:An:pAC:ACDC
PF:An:pAC
PF:An:pAC:H1
PF:An:pBC:AC
PF:An:pBC:ACDC
PF:An:pBC
PF:An:pBC:H1
PF:An
PF:An:H1
PHASE:CHn:AC
PHASE:CHn:H1
PHASE:An:pX:AC
PHASE:An:pX:H1
PHASE:An:pAC:AC
PHASE:An:pAC:H1
PHASE:An:pBC:AC
PHASE:An:pBC:H1
PHASE:An:AC
PHASE:An:H1
LOADZ:CHn:DC
LOADZ:CHn:AC
LOADZ:CHn:ACDC
LOADZ:CHn
LOADZ:CHn:H1
SERIESR:CHn:AC
SERIESR:CHn:H1
SERIESL:CHn:AC
SERIESL:CHn:H1
PARALLELR:CHn:AC
PARALLELR:CHn:H1
PARALLELC:CHn:AC
PARALLELC:CHn:H1
STBYERR:CHn:STBY
STBYERR:CHn:STBYMIN
STBYERR:CHn:STBYMAX

DDEF MEASUREMENT DEFINITION FIELD SUB-FIELDS

This field is made up of one to five sub-fields, each separated by the sub-field separator (colon character). The sub-fields may be specified in any order and may optionally be omitted (a default value being used as needed).

Sub-Field	Sub-field Format	Value	Description
Measurement Data	KEYWORD	FREQ	Signal frequency (in Hz)
		VOLTS or V	Voltage (in V)
		AMPS or A	Current (in A)
		WATTS or W	DEFAULT if no other Measurement Data sub-field found Real power (in W)
		LOSS	Real power loss (in W)
		EFFICIENCY or EFF	Real power efficiency (in %)
		VAR	Imaginary power (in W)
		VA	Apparent power (in VA)
		PF	Power factor
		LOADZ	Load impedance (in ohms)
Measurement Source	KEYWORD	CH1, CH2, CH3 or CH4	CH1 is DEFAULT if no other Measurement Source sub-field found Data is from the selected channel
		A1, A2, A3, VPA1, VPA2 or VPA3	Data is from the selected VPA
		IN	Data is from the IN efficiency group
		MIDDLE	Data is from the MIDDLE efficiency group
		OUT	Data is from the OUT efficiency group
		IN-MID	Data is from the IN efficiency group to the MIDDLE efficiency group
		IN-OUT	Data is from the IN efficiency group to the OUT efficiency group
		MID-OUT	Data is from the MIDDLE efficiency group to the OUT efficiency group
2nd Measurement Source (ignored if Measurement Source is not a VPA)	KEYWORD	pA … D	Data is from the 1st through 4th (resp.) channel of the selected VPA
		pAC	Data is the voltage measured between phases A and C of the selected VPA
		pAB	Data is the voltage measured between phases A and B of the selected VPA

Sub-Field	Sub-field Format	Value	Description
		pBC	Data is the voltage measured between phases B and C of the selected VPA
		pN	Data is the neutral current of the selected VPA
		TOTAL or AVERAGE	DEFAULT if no other 2nd Measurement Source sub-field found Data is the total for the selected VPA, except for VOLTS and AMPS data which is the average of all channels/phases in the selected VPA
Measurement Type	KEYWORD	DC	Data is the DC component
		AC	Data is the AC component
		ACDC or RMS	Data is the ACDC component
		COUPLED	DEFAULT if no other Measurement Type sub-field found Data is the DC, AC or ACDC component as configured for the VPA
		CF	Data is the crest factor
		PK	Data is peak
		HIPK	Data is the highest peak (including polarity)
		LOPK	Data is the lowest peak (including polarity)
		THDF	Data is THD relative to fundamental amplitude (in %)
		THDSIG	Data is THD relative to COUPLED amplitude (in %)
		H1 or H2 or H3	Data is harmonic amplitude data for the 1st, 2nd or 3rd harmonic respectively
		P1	Data is harmonic phase data for the fundamental (in degrees with ±180° range)
		HLIST	Data is a list of the harmonic amplitudes for each harmonic. This may only be used with the LOGDATA command, and only with a channel Measurement Source, and only with voltage or current Measurement Data.
Ending Harmonic (only used if Measurement Type is HLIST)	NR1	1 to 500	This sub-field is only used with a Measurement Type of HLIST; if present it is ignored for other measurement types. Data includes harmonics up to and including this number (if this sub-field is not specified then the data includes all allowable harmonics, i.e. either 100 or 500 depending on if H500 is installed)

A list of allowed combinations is provided below. In this list the following codes are used to reduce the length of the list –

CHn Any of CH1, CH2, CH3 or CH4
An Any of A1, A2 or A3
pX Any of pA, pB, pC or pD
Hn Any of H1 … 3

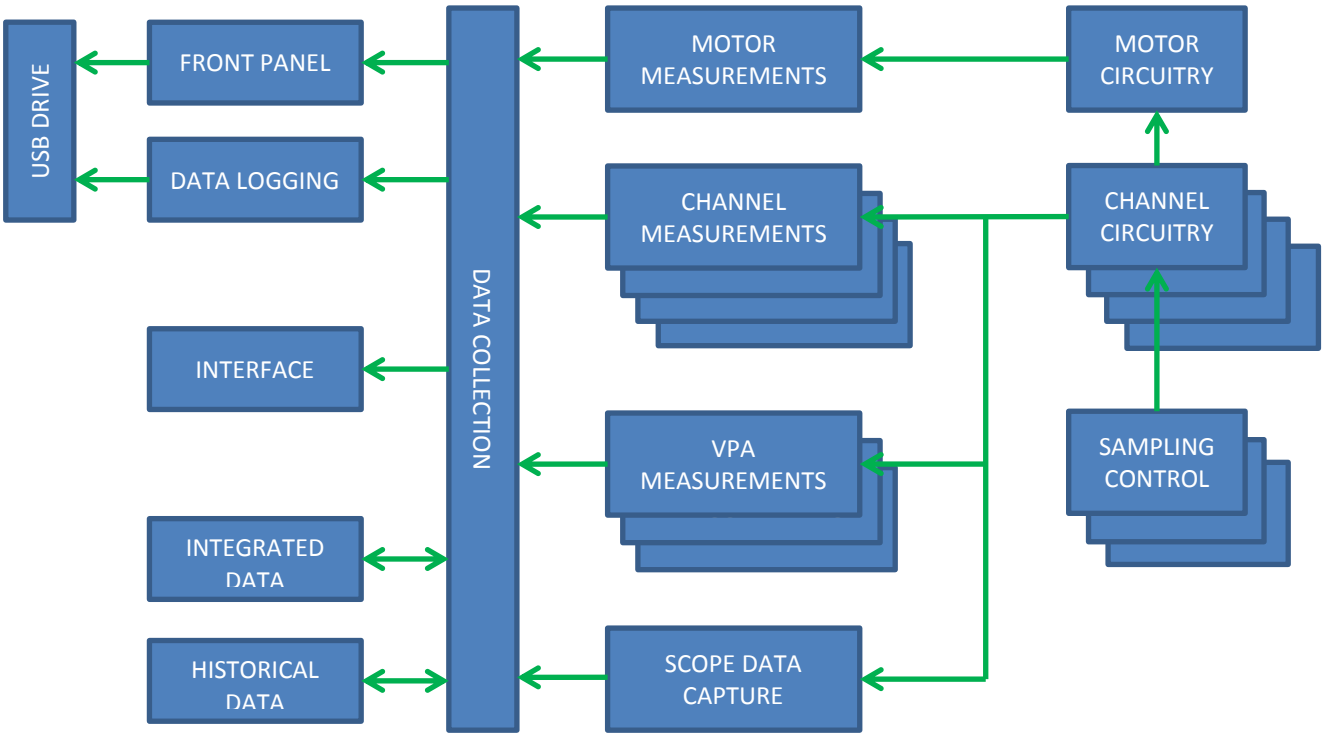
Not all combinations shown may be allowed in all circumstances; channels might not be installed or the configuration may not provide valid results for a specific combination. Not all valid combinations may be shown below and where a default sub-field value may be used the combination is only shown without defining that specific sub-field.

FREQ:CHn
FREQ:An
VOLTS:CHn:DC
VOLTS:CHn:AC
VOLTS:CHn:ACDC
VOLTS:CHn
VOLTS:CHn:CF
VOLTS:CHn:PK
VOLTS:CHn:HIPK
VOLTS:CHn:LOPK
VOLTS:CHn:Hn
VOLTS:CHn:P1
VOLTS:CHn:THDf
VOLTS:CHn:THDsig
VOLTS:CHn:HLIST
VOLTS:CHn:HLIST:n
VOLTS:An:pX:DC
VOLTS:An:pX:AC
VOLTS:An:pX:ACDC
VOLTS:An:pX
VOLTS:An:pX:CF
VOLTS:An:pX:PK
VOLTS:An:pX:HIPK
VOLTS:An:pX:LOPK
VOLTS:An:pX:Hn
VOLTS:An:pX:P1
VOLTS:An:pX:THDf
VOLTS:An:pX:THDsig
VOLTS:An:pAC:AC
VOLTS:An:pAC:ACDC
VOLTS:An:pAC
VOLTS:An:pAC:CF
VOLTS:An:pAC:PK
VOLTS:An:pAC:HIPK
VOLTS:An:pAC:LOPK
VOLTS:An:pAC:Hn
VOLTS:An:pAC:P1
VOLTS:An:pAC:THDf
VOLTS:An:pAC:THDsig
VOLTS:An:pBC:AC
VOLTS:An:pBC:ACDC
VOLTS:An:pBC
VOLTS:An:pBC:CF
VOLTS:An:pBC:PK
VOLTS:An:pBC:HIPK
VOLTS:An:pBC:LOPK
VOLTS:An:pBC:Hn
VOLTS:An:pBC:P1
VOLTS:An:pBC:THDf
VOLTS:An:pBC:THDsig
VOLTS:An:pAB:AC
VOLTS:An:pAB:ACDC
VOLTS:An:pAB
VOLTS:An:pAB:CF
VOLTS:An:pAB:PK
VOLTS:An:pAB:Hn
VOLTS:An:pAB:P1
VOLTS:An:pAB:THDf
VOLTS:An:pAB:THDsig
VOLTS:An
VOLTS:An:PK
VOLTS:An:H1
AMPS:CHn:DC
AMPS:CHn:AC
AMPS:CHn:ACDC
AMPS:CHn
AMPS:CHn:CF
AMPS:CHn:PK
AMPS:CHn:HIPK
AMPS:CHn:LOPK
AMPS:CHn:Hn
AMPS:CHn:P1
AMPS:CHn:THDf
AMPS:CHn:THDsig
AMPS:CHn:HLIST
AMPS:CHn:HLIST:n
AMPS:An:pX:DC
AMPS:An:pX:AC
AMPS:An:pX:ACDC
AMPS:An:pX
AMPS:An:pX:CF
AMPS:An:pX:PK
AMPS:An:pX:HIPK
AMPS:An:pX:LOPK
AMPS:An:pX:Hn
AMPS:An:pX:P1
AMPS:An:pX:THDf
AMPS:An:pX:THDsig
AMPS:An:pN:DC
AMPS:An:pN:AC
AMPS:An:pN:ACDC
AMPS:An:pN
AMPS:An:pN:CF
AMPS:An:pN:PK
AMPS:An:pN:H1
AMPS:An
AMPS:An:PK
AMPS:An:H1
WATTS:CHn:DC
WATTS:CHn:AC
WATTS:CHn:ACDC
WATTS:CHn
WATTS:CHn:H1
WATTS:An:pX:DC
WATTS:An:pX:AC
WATTS:An:pX:ACDC
WATTS:An:pX
WATTS:An:pX:H1
WATTS:An:pAC:DC
WATTS:An:pAC:AC
WATTS:An:pAC:ACDC
WATTS:An:pAC
WATTS:An:pAC:H1
WATTS:An:pBC:DC
WATTS:An:pBC:AC
WATTS:An:pBC:ACDC
WATTS:An:pBC
WATTS:An:pBC:H1
WATTS:An
WATTS:An:H1
WATTS:IN
WATTS:MIDDLE
WATTS:OUT
LOSS:IN-MID
LOSS:IN-OUT
LOSS:MID-OUT
EFFICIENCY:IN-MID
EFFICIENCY:IN-OUT
EFFICIENCY:MID-OUT
VAR:CHn:AC
VAR:CHn:ACDC
VAR:CHn
VAR:CHn:H1
VAR:An:pX:AC
VAR:An:pX:ACDC
VAR:An:pX

VAR:An:pX:H1
VAR:An:pAC:AC
VAR:An:pAC:ACDC
VAR:An:pAC
VAR:An:pAC:H1
VAR:An:pBC:AC
VAR:An:pBC:ACDC
VAR:An:pBC
VAR:An:pBC:H1
VAR:An
VAR:An:H1
VA:CHn:DC
VA:CHn:AC
VA:CHn:ACDC
VA:CHn
VA:CHn:H1
VA:An:pX:DC
VA:An:pX:AC
VA:An:pX:ACDC
VA:An:pX
VA:An:pX:H1
VA:An:pAC:DC
VA:An:pAC:AC
VA:An:pAC:ACDC
VA:An:pAC
VA:An:pAC:H1
VA:An:pBC:DC
VA:An:pBC:AC
VA:An:pBC:ACDC
VA:An:pBC
VA:An:pBC:H1
VA:An
VA:An:H1
PF:CHn:AC
PF:CHn:ACDC
PF:CHn
PF:CHn:H1
PF:An:pX:AC
PF:An:pX:ACDC
PF:An:pX
PF:An:pX:H1
PF:An:pAC:AC
PF:An:pAC:ACDC
PF:An:pAC
PF:An:pAC:H1
PF:An:pBC:AC
PF:An:pBC:ACDC
PF:An:pBC
PF:An:pBC:H1
PF:An
PF:An:H1
LOADZ:CHn:DC
LOADZ:CHn:AC
LOADZ:CHn:ACDC
LOADZ:CHn
LOADZ:CHn:H

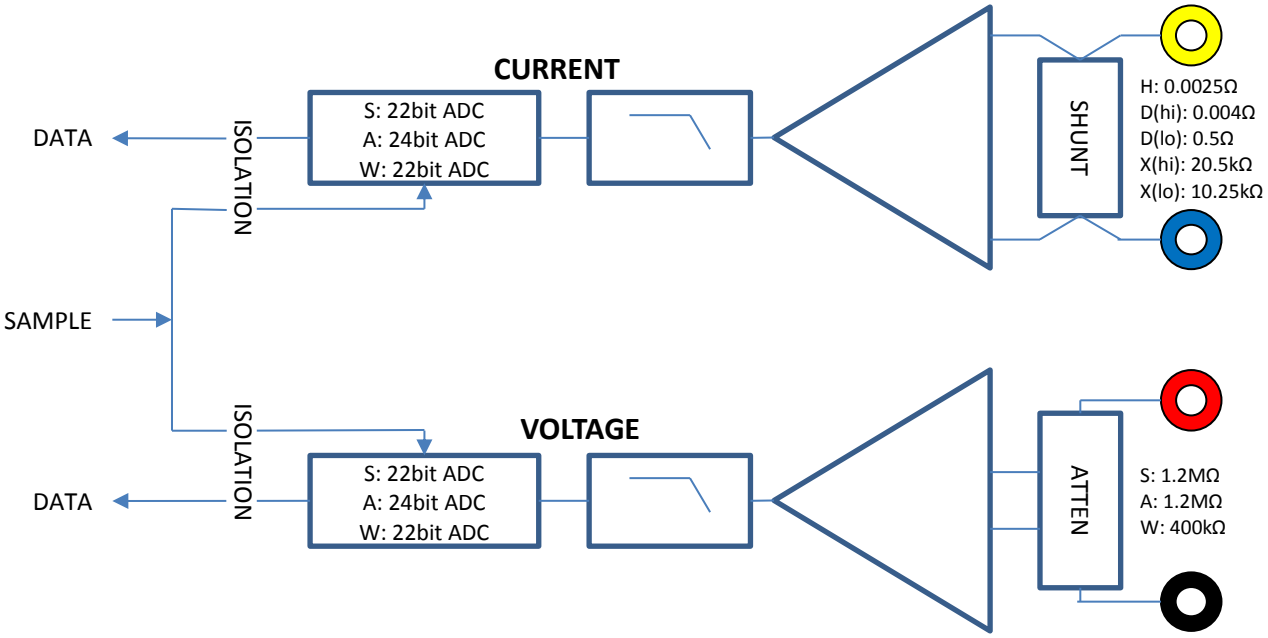
INSIDE THE PA900

This appendix is intended to give you an insight into the internal structure of the PA900. In order to use the PA900 knowledge of the internal operation of the PA900 is not necessary. In many places a full description is not provided to protect IP rights. The diagram below is a simplified block diagram of the measurement flow inside a PA900.



CHANNEL CIRCUITRY

The diagram below is a simplified block diagram of the circuitry for each channel. Up to 4 channels can be installed in a PA900. Although not shown in this diagram, there is digital filtering on the sample data for both voltage and current as required for the HF LIMIT configuration of the controlling VPA and the data is scaled and offset according to the channel calibration data and to user set scale and offset factors. The analog filtering shown in the diagram is simply to reduce sampling artifacts.



SAMPLING CONTROL

There are 3 sampling controls in a PA900. Typically each is associated with a VPA, however if you configure the LF/PERIOD setting in a VPA to synchronize that VPA to a lower numbered VPA then the sampling control of that VPA is used for the channels in the VPA so configured.

The third sampling control is slightly different to the other two, if you have a Motor channel installed then the third sampling control is used to control that Motor channel exclusively thus preventing the use of VPA3 which otherwise would have used this sampling control.

Sampling control performs the following–

1. Calculation of the measurement period for measurement results.
    a. The measurement period is adjusted to be an integer number of fundamental cycles which is the closest to the configured measurement period for the controlling VPA.
2. Calculation and control of the sampling period of channels.
    a. The required sampling period is calculated to yield an integer number of samples in a measurement period which gives the closest sampling period to the nominal sampling period for the channels being controlled. The sampling period is also adjusted to NOT yield an integer number of samples in any harmonic (including the fundamental) over 500Hz. The nominal sampling period for the channel types are as follows (this does NOT limit the HF amplitude performance of the PA900) –
        i. S or A types: 245KSPS
        ii. W type: 910KSPS
    b. Each actual sampling period is controlled with 2.5ps average resolution and 2.6ns incremental resolution with a quasi-random distribution of incremental sample periods within a range sufficient to avoid Nyquist sampling limits.
    c. This yields an effective sampling rate of 384MSPS and synchronization to the measured fundamental to within <1ppm.
3. Starting and stopping measurement periods.
    a. If the PA900 measurement mode is configured to anything other than SYNC-VPA then each sampling control always immediately starts a measurement period when the previous one ends. In this manner all channel and VPA measurements are totally 'gapless'.
    b. If the PA900 measurement mode is configured to SYNC-VPA then each sampling control will start <u>all</u> measurement periods if <u>all</u> measurement periods have ended. In this manner all channel and VPA measurements are synchronized, but only the longest one is 'gapless'.

CHANNEL MEASUREMENTS

For each of the channels the following measurements are performed –

1. Voltage and current DC (the average of the samples in the measurement period).
2. Voltage and current maximum peak (the highest sample in the measurement period).
3. Voltage and current minimum peak (the lowest sample in the measurement period).
4. Voltage and current rectified (the average modulus sample in the measurement period).
5. Voltage and current RMS (the square root of the average squared sample in the measurement period).
6. Watts (the average of the voltage and current samples multiplied together in the measurement period)
7. Harmonic amplitude and phase analysis of the voltage and current samples (using Fourier Transforms). This analysis is only performed if a) the fundamental frequency is known, and b) you have configured for at least 1 harmonic to be analyzed.
8. Formulation of the Cycle View data from all samples in the measurement period. Cycle view places every sample from the measurement period at the correct phase to build a single cycle formed from all cycles present during the measurement period. To do this it needs the results of the harmonic analysis to position the samples correctly and needs to know the fundamental frequency. Cycle view is NOT an inverse Fourier transform.
9. D current option only (if configured for auto-range):
    a. At any time during a measurement period if the range is presently the LO range and the current is at least close to overload then the HI range is immediately commanded in this channel and the relevant sampling control is commanded to start a new measurement period however all channels in the affected VPA are commanded to not discard the existing peak results when starting this measurement period.
    b. If at the end of the measurement period the range is presently the HI range but all samples within the measurement were below a level indicating that the LO range may be used, then the LO range is commanded prior to starting the next measurement period.

VPA MEASUREMENTS

VPA FUNDAMENTAL FREQUENCY

Each VPA provides a fundamental frequency to its associated sampling control as determined by the FUND configuration setting in the VPA; this may be by measurement, by configuration, or from another VPA.

If the fundamental frequency is measured then this is from the voltage or current in the lowest numbered channel in the VPA and uses the following method-

1. This is performed by measurement of the period between zero crossings of the output of a digital band-pass filter which uses the configured samples from the channel.
    a. Hysteresis is employed on the zero crossing detection to prevent near fundamental signal components from creating false zero crossing detections.
    b. Because the filtering is band-pass the frequency is established regardless of any DC signal content.
    c. The low frequency corner of the band-pass filter is set by the LF/PERIOD setting for the VPA.
    d. The high frequency corner of the band-pass filter is continuously adjusted to match the measured frequency. The maximum corner frequency of this filter is limited by the FUND setting of the VPA.

2. To correctly detect the edges of the waveform there must be at least 3 samples in each cycle, thus the maximum measurable frequency is just over 80kHz for A and S channel types, or just over 305kHz for W channel types.

VPA AMPLITUDE MEASUREMENTS

For each of the VPAs the following measurements are performed depending on the WIRING configuration of the VPA.

N x 1ø	There are no VPA measurements performed.
2ø3w	Measurements of the difference between the two channel voltages (this produces the results for øAB data) and measurements of the sum of the two channel currents (this produces the results for N data).
3ø3w(2ch)	Measurements of the difference between the two channel voltages (this produces the results for øAB data) and measurements of the sum of the two channel currents (this produces the results for øC data).
3ø3w(3ch)	Measurements of the difference between every pair of channel voltages (this produces the results for øAB, øAC and øBC data).
3ø4w	Measurements of the difference between every pair of channel voltages (this produces the results for øAB, øAC and øBC data) and measurements of the sum of the three channel currents (this produces the results for N data).

VPA measurements are a sub-set of the channel voltage/current measurements –

1. DC (the average of the samples in the measurement period).
2. Peak (the highest modulus sample in the measurement period).
3. Rectified (the average modulus sample in the measurement period).
4. RMS (the square root of the average squared sample in the measurement period).

DATA COLLECTION

This collects together the measurement results from the Channel and VPA Measurements to provide all final measurement results. In many cases this involves more than one actual measurement result with calculations performed to produce each final result. All final measurement results are continuously calculated and have the configured response filtering imposed, those results are then held as required if you have commanded to hold measurements. In this manner all response filtered results have the correct and linear response filtering characteristics.

Examples of final results computations include –

- AC voltages and currents are computed from the DC and AC+DC RMS measurement results using the fact that $(AC+DC)^2 = (AC)^2 + (DC)^2$
- DC Watts for a channel is computed from the multiplication of the DC voltage and current (and is identical to DC VA).
- AC Watts for a channel is computed using the fact that W(AC+DC) = W(DC) + W(AC)
- VA for a channel is computed from the multiplication of the appropriate voltage and current data.
- PF (for a channel or for a VPA) is computed using the fact that PF = W / VA.
- VAR for a channel is computed using the fact that $VA^2 = W^2 + VAR^2$ with the polarity of the resultant VAR set according to the configured lead/lag information.
- VPA total Watts is computed from the sum of the Watts for the channels in the VPA
- VPA total VAR and VA is computed according the method selected in the configuration for that VPA.
- VPA overall lead/lag is taken from the polarity of the sum of the channel VAR for the VPA.
- The total Watts for an efficiency group is the sum of the VPA total Watts for each VPA configured by the EFF/LOSS setting to be in the requested group.

INTEGRATED DATA

At the end of every measurement period in any VPA, all integrated results are accumulated with the product of the result and the entire measurement period time (if integration was neither started nor stopped during it) or a partial measurement period time (if integration was started and/or stopped during it).

DATA LOGGING

While data logging is running the configured data is obtained from the 'data collection' block and is saved into a large buffer FIFO. The output of this FIFO is formatted as needed and written to the USB Drive if possible.

PERFORMANCE SPECIFICATIONS

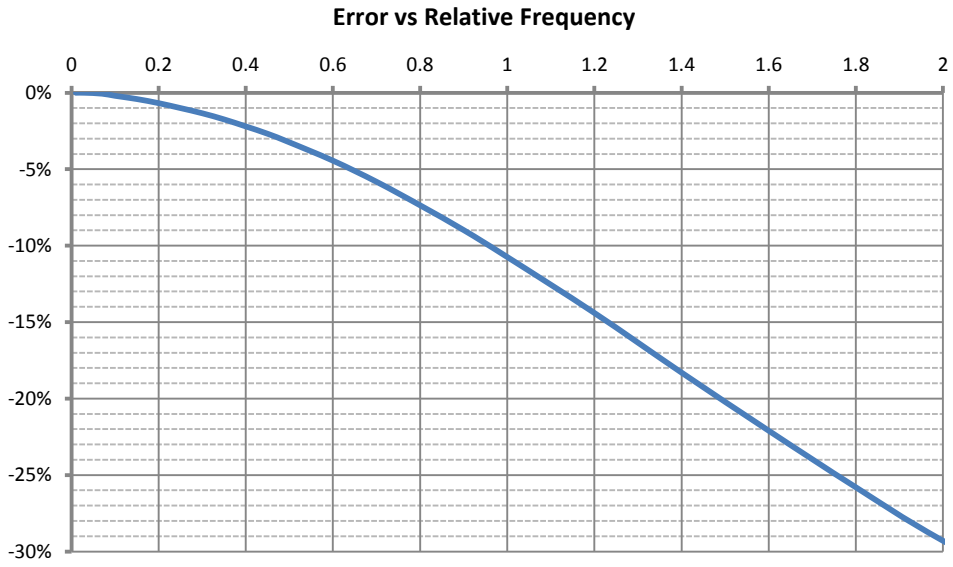
Accuracy specifications are valid under the following conditions-

- Following a 15 minute warm-up period after turning power ON in the PA900.
- For a period of 2 years after calibration in normal use. Continuous use at >75% maximum Specified Input Range levels reduces this to 6 months.
- For ambient temperatures ±5C from calibration temperature. Add 0.005%rdg per C outside of ±5C from the calibration temperature.
- For voltages and currents at the PA900 terminals with crest factors <30:1 and within the Specified Input Range applicable for the channel type, current option and (if applicable) current range selection.
- DC floor specifications assume AUTOZERO is ON, and that an EXT DC ZERO adjustment has been performed following any significant change in the local environment or channel configuration. Add the relevant DC floor specification per C outside of ±1C from the calibration temperature if AUTOZERO is OFF.
- AC <100Hz accuracy and floor specifications are valid using Auto-Track HF limiting to 50 harmonics; for specifications when operating unfiltered with signals <100Hz use the <40kHz figures.
- Where accuracy is shown as %rdg then that is the percentage of the relevant AC+DC reading.

COMMON INPUT SPECIFICATIONS

Isolation	From any V or A terminal to PA900 chassis ground Impedance: >1GΩ||<30pF 4500Vpk max without damage 2500Vrms max for <1s without damage 1000Vrms max continuous rated working voltage (CAT I/II) 600Vrms max continuous rated working voltage (CAT III) 300Vrms max continuous rated working voltage (CAT IV)
Display Resolution	As specified below and also limited by displayed number of digits (add ±½ digit to accuracy specifications).
Interface Resolution	As specified below and also limited to 6 significant digits (add ±½ digit to accuracy specifications)
HF Filtering	Fixed frequency low-pass filtering of 6kHz, 25kHz, 50kHz, 100kHz, 150kHz and 250kHz are available (100kHz and above are only available in W type channels).

The response of the HF Filters is typically as shown in the chart below.



VOLTAGE SPECIFICATIONS

Accuracy is given by the addition of-

Base Accuracy
Relevant Frequency Adder (if applicable)
Relevant Floor Adder (use both DC and relevant AC floor adders for AC+DC measurements)
Self-Heating Adder
Relevant Harmonic Adder (if applicable).

For peak measurements accuracy is same but using 10* relevant Floor Adder.

In specifications below F is frequency in kHz. Self-heating has a nominal 1 minute time constant.

		S Channel Type	A Channel Type	W Channel Type
No Damage Input Range	**<1ms**	2500Vrms (<3000Vpk)		2000Vrms (<3000Vpk)
	<100ms	2000Vrms (<3000Vpk)		1500Vrms (<3000Vpk)
	<5s	1500Vrms (<2500Vpk)		1000Vrms (<2500Vpk)
	Continuous	1000Vrms (<1800Vpk)		700Vrms (<1800Vpk)
Specified Input Range	**DC**	0 to ±1000V		0 to ±700V
	AC	0.1 to 1000Vrms		0.1 to 700Vrms
	Peak	<1800V		<1800V
Impedance		1.2MΩ ± 1%		400KΩ ± 1%
Resolution		0.001V	0.1mV	0.001V
Base Accuracy		0.1%rdg	0.03%rdg	0.1%rdg
Frequency Adder		0.01-1Hz: 0.05%rdg <10kHz: (0.005*F)%rdg 10-40kHz: (0.05+(0.012*(F-10)))%rdg 40-100kHz: (0.41+(0.025*(F-40)))%rdg		0.01-1Hz: 0.1%rdg <40kHz: (0.002*F)%rdg 40-100kHz: (0.08+(0.004*(F-40)))%rdg 100-1000kHz: (0.32+(0.013*(F-100)))%rdg
Bandwidth (-3dB)		>700KHz		>2.5MHz
Floor Adder		DC: 0.003V AC<100Hz: 0.003V AC>100Hz: 0.005V	DC: 0.001V AC<100Hz: 0.002V AC>100Hz: 0.005V	DC: 0.004V AC<100Hz: 0.004V AC>100Hz: 0.007V
Self-Heating Adder		0.0005ppm rdg per $Vrms^2$		0.0015ppm rdg per $Vrms^2$
Single Harmonic Adder		<10kHz: 0.01%fund + 0.001V <80kHz: 0.05%fund + 0.005V	<10kHz: 0.005%fund + 0.0005V <80kHz: 0.05%fund + 0.005V	<10kHz: 0.015%fund + 0.0015V <100kHz: 0.03%fund + 0.005V <305kHz: 0.08%fund + 0.01V
ΣHarmonic Adder		<10kHz: 0.02%fund + 0.002V <80kHz: 0.1%fund + 0.01V	<10kHz: 0.015%fund + 0.001V <80kHz: 0.15%fund + 0.01V	<10kHz: 0.03%fund + 0.003V <100kHz: 0.06%fund + 0.007V <305kHz: 0.15%fund + 0.015V
CMRR		1uV per V.Hz		0.7uV per V.Hz
Inter-Channel Phase		(0.02° + 0.15°*F)		(0.02° + 0.07°*F)

CURRENT INPUT SPECIFICATIONS (ALL OPTIONS)

		H option	D option			X option	
			AUTO range	HI range	LO range	HI range	LO range
No Damage Input Range	**<1ms**	200Arms (<300Apk)	30Arms (<50Apk)	150Arms (<250Apk)	30Arms (<50Apk)	200Vrms (300Vpk)	20Vrms (30Vpk)
	<20ms	75Arms (<300Apk)	20Arms (<50Apk)	50Arms (<200Apk)	20Arms (<50Apk)	50Vrms (300Vpk)	10Vrms (20Vpk)
	<1s	50Arms (<200Apk)	20Arms (<50Apk)	30Arms (<150Apk)	5Arms (<25Apk)	30Vrms (300Vpk)	5Vrms (10Vpk)
	Continuous	30Arms	20Arms (<50Apk)	20Arms (<150Apk)	2Arms (<5Apk)	20Vrms (300Vpk)	2Vrms (10Vpk)
	Power Off	As Above	As LO Range			As Above	As HI Range
Specified Input Range	**DC**	0 to ±30A	0 to ±20A	0 to ±20A	0 to ±1A	0 to ±15V	0 to ±0.5V
	<100Hz	3mA to 30Arms	10uA to 20Arms	2mA to 20Arms	10uA to 1Arms	800uV to 15Vrms	20uV to 0.5Vrms
	>100Hz	20mA to 30Arms	150uA to 20Arms	15mA to 20Arms	150uA to 1Arms	2mV to 15Vrms	150uV to 0.5Vrms
	Peak	<200A	<50A	<150A	<1A	<18V	<0.5V
Impedance		<10mΩ	As HI/LO range	<20mΩ	0.57Ω ± 10%	20.5KΩ ± 1%	10.25KΩ ± 1%

CURRENT OPTION H ACCURACY SPECIFICATIONS

Accuracy is given by the addition of-

Base Accuracy
Relevant Frequency Adder (if applicable)
Relevant Floor Adder (use both DC and relevant AC floor adders for AC+DC measurements)
Self-Heating Adder
Relevant Harmonic Adder (if applicable).

For peak measurements accuracy is same but using 10* relevant Floor Adder.

In specifications below F is frequency in kHz. Self-heating has a nominal 3 minute time constant.

	S Channel Type	A Channel Type	W Channel Type
Resolution	100uA	10uA	100uA
Base Accuracy	0.1%rdg	0.03%rdg	0.1%rdg
Frequency Adder	0.01-1Hz: 0.05%rdg <10kHz: (0.003*F)%rdg 10-40kHz: (0.03+(0.007*(F-10)))%rdg 40-100kHz: (0.24+(0.02*(F-40)))%rdg		0.01-1Hz: 0.1%rdg <40kHz: (0.0015*F)%rdg 40-100kHz: (0.06+(0.003*(F-40)))%rdg 100-1000kHz: (0.24+(0.012*(F-100)))%rdg
Bandwidth (-3dB)	>1.25MHz		>5MHz

Floor Adder	DC: 300uA AC<100Hz: 800uA AC>100Hz: 3mA	DC: 100uA AC<100Hz: 500uA AC>100Hz: 2mA	DC: 400uA AC<100Hz: 1mA AC>100Hz: 4mA
Self-Heating Adder	1.5ppm reading per Arms²		
Single Harmonic Adder	<10kHz: 0.01%fund + 100uA <80kHz: 0.05%fund + 5mA	<10kHz: 0.005%fund + 80uA <80kHz: 0.03%fund + 5mA	<10kHz: 0.015%fund + 150uA <100kHz: 0.03%fund + 5mA <305kHz: 0.08%fund + 5mA
ΣHarmonic Adder	<10kHz: 0.02%fund + 200uA <80kHz: 0.1%fund + 7mA	<10KHz: 0.015%fund + 150uA <80kHz: 0.15%fund + 7mA	<10kHz: 0.03%fund + 300uA <100kHz: 0.06%fund + 7mA <305kHz: 0.15%fund + 10mA
CMRR	500pA per V.Hz		
V:A Phase	(0.01° + 0.015°*F)		(0.01° + 0.007°*F)
Inter-Channel Phase	(0.02° + 0.15°*F)		(0.02° + 0.07°*F)

CURRENT OPTION D ACCURACY SPECIFICATIONS

Current option D has two ranges (HI and LO). Where the specification varies between ranges there are separate specifications for each range denoted (HI) or (LO) as applicable, otherwise the specification applies to both ranges.

Accuracy is given by the addition of-

Base Accuracy
Relevant Frequency Adder (if applicable)
Relevant Floor Adder (use both DC and relevant AC floor adders for AC+DC measurements)
Self-Heating Adder
Relevant Harmonic Adder (if applicable).

For peak measurements accuracy is same but using 10* relevant Floor Adder.

In specifications below F is frequency in kHz. Self-heating has a nominal 3 minute time constant.

	S Channel Type	**A Channel Type**	**W Channel Type**
Resolution (HI)	100uA	10uA	100uA
Resolution (LO)	1uA	0.1uA	1uA
Base Accuracy	0.1%rdg	0.03%rdg	0.1%rdg
Frequency Adder	0.01-1Hz: 0.05%rdg <10kHz: (0.003*F)%rdg 10-40kHz: (0.03+(0.007*(F-10)))%rdg 40-100kHz: (0.24+(0.02*(F-40)))%rdg		0.01-1Hz: 0.1%rdg <40kHz: (0.0015*F)%rdg 40-100kHz: (0.06+(0.003*(F-40)))%rdg 100-1000kHz: (0.24+(0.012*(F-100)))%rdg
Bandwidth (-3dB)	>1.25MHz		>5MHz
Floor Adder (HI)	DC: 300uA AC<100Hz: 500uA AC>100Hz: 2mA	DC: 100uA AC<100Hz: 300uA AC>100Hz: 1.5mA	DC: 400uA AC<100Hz: 700uA AC>100Hz: 3mA
Floor Adder (LO)	DC: 2uA AC<100Hz: 3uA AC>100Hz: 10uA	DC: 1uA AC<100Hz: 1.5uA AC>100Hz: 8uA	DC: 3uA AC<100Hz: 4uA AC>100Hz: 15uA
Self-Heating Adder	2ppm reading per Arms²		
Single Harmonic Adder (HI)	<10kHz: 0.01%fund + 70uA <80kHz: 0.05%fund + 3.5mA	<10kHz: 0.005%fund + 50uA <80kHz: 0.03%fund + 3.5mA	<10kHz: 0.015%fund + 100uA <100kHz: 0.03%fund + 3.5mA <305kHz: 0.08%fund + 4mA
Single Harmonic Adder (LO)	<10kHz: 0.01%fund + 0.4uA <80kHz: 0.05%fund + 20uA	<10kHz: 0.005%fund + 0.3uA <80kHz: 0.03%fund + 20uA	<10kHz: 0.015%fund + 0.5uA <100kHz: 0.03%fund + 20uA <305kHz: 0.08%fund + 30uA
ΣHarmonic Adder (HI)	<10kHz: 0.02%fund + 150uA <80kHz: 0.1%fund + 5mA	<10kHz: 0.015%fund + 120uA <80kHz: 0.15%fund + 5mA	<10kHz: 0.03%fund + 200uA <100kHz: 0.06%fund + 5mA <305kHz: 0.15%fund + 7mA
ΣHarmonic Adder (LO)	<10kHz: 0.02%fund + 1uA <80kHz: 0.1%fund + 30uA	<10kHz: 0.015%fund + 0.7uA <80kHz: 0.15%fund + 30uA	<10kHz: 0.03%fund + 1uA <100kHz: 0.06%fund + 30uA <305kHz: 0.15%fund + 40uA
CMRR (HI)	400pA per V.Hz		
CMRR (LO)	20pA per V.Hz		
V:A Phase	(0.01° + 0.015°*F)		(0.01° + 0.007°*F)
Inter-Channel Phase	(0.02° + 0.15°*F)		(0.02° + 0.07°*F)

CURRENT OPTION X ACCURACY SPECIFICATIONS

Current option X has two ranges (HI and LO). Where the specification varies between ranges there are separate specifications for each range denoted (HI) or (LO) as applicable, otherwise the specification applies to both ranges.

Accuracy is given by the addition of-

Base Accuracy
Relevant Frequency Adder (if applicable)
Relevant Floor Adder (use both DC and relevant AC floor adders for AC+DC measurements)
Relevant Harmonic Adder (if applicable).

For peak measurements accuracy is same but using 10* relevant Floor Adder.

In specifications below F is frequency in kHz.

	S Channel Type	A Channel Type	W Channel Type
Resolution (HI)	10uV	1uV	10uV
Resolution (LO)	1uV	0.1uV	1uV
Base Accuracy	0.1%rdg	0.03%rdg	0.1%rdg
Frequency Adder	0.01-1Hz: 0.05%rdg <10kHz: (0.003*F)%rdg 10-40kHz: (0.03+(0.007*(F-10)))%rdg 40-100kHz: (0.24+(0.02*(F-40)))%rdg		0.01-1Hz: 0.1%rdg <40kHz: (0.0015*F)%rdg 40-100kHz: (0.068+(0.004*(F-40)))%rdg 100-1000kHz: (0.308+(0.015*(F-100)))%rdg
Bandwidth (-3dB)	>1.25MHz		>3MHz
Floor Adder (HI)	DC: 100uV AC<100Hz: 50uV AC>100Hz: 300uV	DC: 75uV AC<100Hz: 30uV AC>100Hz: 250uV	DC: 300uV AC<100Hz: 70uV AC>100Hz: 500uV
Floor Adder (LO)	DC: 20uV AC<100Hz: 3.5uV AC>100Hz: 30uV	DC: 15uV AC<100Hz: 2.5uV AC>100Hz: 30uV	DC: 25uV AC<100Hz: 5uV AC>100Hz: 50uV
Single Harmonic Adder (HI)	<10kHz: 0.01%fund + 7uV <80kHz: 0.05%fund + 350uV	<10kHz: 0.005%fund + 5uV <80kHz: 0.03%fund + 350uV	<10kHz: 0.015%fund + 10uV <100kHz: 0.03%fund + 350uV <305kHz: 0.08%fund + 400uV
Single Harmonic Adder (LO)	<10kHz: 0.01%fund + 0.3uV <80kHz: 0.05%fund + 10uV	<10kHz: 0.005%fund + 0.1uV <80kHz: 0.03%fund + 10uV	<10kHz: 0.015%fund + 0.3uV <100kHz: 0.03%fund + 10uV <305kHz: 0.08%fund + 15uV
ΣHarmonic Adder (HI)	<10kHz: 0.02%fund + 15uV <80kHz: 0.1%fund + 500uV	<10kHz: 0.015%fund + 12uV <80kHz: 0.15%fund + 500uV	<10kHz: 0.03%fund + 20uV <100kHz: 0.06%fund + 500uV <305kHz: 0.15%fund + 700uV
ΣHarmonic Adder (LO)	<10kHz: 0.02%fund + 0.5uV <80kHz: 0.1%fund + 15uV	<10kHz: 0.015%fund + 0.3uV <80kHz: 0.15%fund + 15uV	<10kHz: 0.03%fund + 0.5uV <100kHz: 0.06%fund + 15uV <305kHz: 0.15%fund + 20uV
CMRR (HI)	15nV per V.Hz		
CMRR (LO)	1nV per V.Hz		
V:A Phase	(0.01° + 0.015°*F)		(0.01° + 0.007°*F)
Inter-Channel Phase	(0.02° + 0.15°*F)		(0.02° + 0.07°*F)

WATTS, VAR AND VA MEASUREMENT ACCURACY SPECIFICATIONS

Accuracy is given by the addition of-

Base Accuracy from table below
Floor Adder from table below (use both DC and AC floor adders for AC+DC measurements)
Fundamental Phase Adder from table below (for W or VAR only)
Frequency Adders from both Voltage and Current tables (if applicable)
Self-Heating Adders from both Voltage and Current tables
Relevant Harmonic Adders from both Voltage and Current tables (if applicable)

In the table below the following terms are used-

Vdc is the DC voltage applied to the V terminals
Adc is the DC current (voltage for the X option) applied to the A terminals
Vac is the ACrms voltage applied to the V terminals
Aac is the ACrms current (voltage for the X option) applied to the A terminals
VAfund is the fundamental VA
PFfund is the fundamental power factor (without regard to polarity)
K is 0.3 for Watts, harmonic VAR and harmonic VA otherwise 1.0

	S Channel Type	A Channel Type	W Channel Type
Base Accuracy	0.17%rdg	0.05%rdg	0.17%
Floor Adder	DC: Vdc*(DC Current Floor Adder) + Adc*(DC Voltage Floor Adder) + (DC Voltage Floor Adder)*(DC Current Floor Adder) AC: Vac*K*(AC Current Floor Adder) + Aac*K*(AC Voltage Floor Adder)		
Fundamental Phase Adder	Watts: VAfund*(PFfund - cos(cos^{-1}(PFfund) + V:A phase for current input)) VAR: VAfund*((1-PFfund) - cos(cos^{-1}(1-PFfund) + V:A phase for current input))		

POWER FACTOR MEASUREMENT ACCURACY SPECIFICATIONS

For a non-unity power factor primarily caused by non-linearity in the load (i.e. distortion of the current signal) or by significant non-fundamental components in the source–

Max. Error = PF - ((W + the AC Floor Adder portion with K = 0.3) / (VA + the AC Floor Adder portion with K = 1.0))

Note – this error is biased and is guaranteed to always result in a lower PF reading within the max. error stated

For a non-unity power factor primarily caused by phase shift in the load (i.e. a reactive load)–

Max. Error = ((VA + the AC Floor Adder portion with K = 0.3) / (VA + the AC Floor Adder portion with K = 1.0)) + (PF - cos(cos^{-1}(PF) + V:A phase for current input))

For fundamental power factor-

Max. Error = (PF - cos(cos^{-1}(PF) + V:A phase for current input))

PF = power factor reading, W = Watts reading, and VA = VA reading

FREQUENCY MEASUREMENT ACCURACY SPECIFICATIONS

Frequency Range	10ms period: 145Hz to 80kHz (S or A channel type) or 305kHz (W channel type) 20ms period: 44Hz to 80kHz (S or A channel type) or 305kHz (W channel type) 100ms period: 19Hz to 80kHz (S or A channel type) or 305kHz (W channel type) 300ms period: 9Hz to 80kHz (S or A channel type) or 305kHz (W channel type) LF: 0.19Hz to 1kHz VLF: 0.0099Hz to 65Hz
Min. Input (typ)	Voltage: 1Vpkpk Current, H option: 0.1Apkpk Current, D option: 0.1Apkpk (HI range) or 0.5mApkpk (LO range) Current, X option: 10mVpkpk (HI range) or 200uVpkpk (LO range)
Pulse Input	Minimum Pulse Width: 5us (S or A channel type) or 1.25us (W channel type) Duty Cycle: 10% to 90%
Measurement Period	Greater of 1 cycle or 100ms
Settling Time	Minimal DC content: greater of 3 cycles or 300ms Significant DC content: add 2 amplitude measurement periods
Accuracy and Resolution	<0.02% of reading

HARMONIC ANALYSIS

The voltage and current samples are analyzed by means of DFT analysis performed with 48 bit precision and 64 bit accumulation.

Window	Rectangular
Harmonic Bandwidth	LF and VLF measurement periods: the smallest of (F/2) or 1Hz Other measurement periods: the smallest of (F/2) or 100Hz Where F is the fundamental frequency
Maximum Harmonic	The smallest of - 500th (harmonics over the 100th requires option H500) A frequency of 80kHz (S or A channel type) or 305kHz (W channel type) User configured lower limit

CALIBRATION ADJUSTMENT

Typically calibration adjustment should be rarely needed; however you may wish to perform it at periodic intervals to ensure optimal performance.

- The PA900 employs internal software calibration adjustments, there are no physical adjustments required. These adjustments are needed to correct for manufacturing tolerances in the components used in the PA900.
- It is important to note that there is no calibration of electro-mechanical performance (e.g. high frequency response) or design defects, giving you a high degree of certainty that the PA900 maintains its' specifications.
- Calibration adjustment can only be performed via an interface using an application provided on the CD with the PA900. This application does not control the source of the voltage or current being used for adjustment, it only controls the PA900. You should ensure -
    - The computer being used has a suitable interface installed.
    - The computer being used has the supplied PA900 calibration adjustment application installed.
    - The PA900 has been properly configured for the interface chosen.
- Calibration adjustment should only be performed after the PA900 has been continuously powered in a stable environment for at least 1 hour. If the PA900 has been moved between differing environments, then at least 3 hours should be allowed.
- In the procedure below, each installed channel is calibrated separately and the procedure varies automatically depending on the channel type (the 1st letter of the channel code) and the channel current option (the 2nd letter of the channel code).
- The supplied application automatically saves the measurement configuration of the PA900 prior to reconfiguring it for calibration adjustments and restores the saved configuration after calibration adjustment has been completed.
- The PA900 may be adjusted at any frequency between 45 and 450Hz. It normally produces the optimum results to calibrate the PA900 at 50, 55 or 60Hz. At these frequencies the specifications of the source are typically the most accurate. When calibrating at very low signal levels you may experience interference from the local mains supply, in these cases it is recommended to adjust the PA900 at a frequency of other than the local mains supply. The accuracy difference in the PA900 between 50, 55 or 60Hz is extremely small and may be ignored, and the difference between performing the adjustments at near mains frequency vs. 400Hz for aerospace applications may also be disregarded as the difference in the PA900 accuracy is negligible at the adjustment levels.

EQUIPMENT REQUIRED

The following equipment will be required during calibration adjustment-

1. A short circuit capable of being attached between the V or A terminals of the PA900 channels (standard 4mm banana terminals using ¾ inch spacing) and a method of grounding the short circuit. This short circuit should be constructed to minimize thermally induced EMFs.
2. A source of AC voltages into a 1.2Mohm load (S or A channel types) or 400Kohm load (W channel types) of 10V, 20V, and 200Vrms at a frequency of between 45 and 450Hz (the use of 50Hz or 60Hz is recommended) with sufficient amplitude accuracy to ensure the desired ratio between the specified PA900 accuracy and that of the applied voltage. For a 4:1 TUR (typically used) the voltage source should have an accuracy of <0.025%+0.75mV (S or W channel types) or <0.0075%+0.5mV (A channel types) at these levels.
3. (Only required for channels having the H current option) A source of AC current into a 0.01ohm load (plus the impedance of the wiring between the PA900 and the source) at 1A, 2A and 10Arms at a frequency of between 45 and 450Hz (the use of 50Hz or 60Hz is recommended) with sufficient amplitude accuracy to ensure the desired ratio between the specified PA900 accuracy and that of the applied current. For a 4:1 TUR (typically used) the current source should have an accuracy of <0.025%+200uA (S or W channel types) or <0.0075%+125uA (A channel types) at these levels.
4. (Only required for channels having the D current option) A source of AC current into a 0.02ohm load (plus the impedance of the wiring between the PA900 and the source) at 1A, 2A and 10Arms at a frequency of between 45 and 450Hz (the use of 50Hz or 60Hz is recommended) with sufficient amplitude accuracy to ensure the desired ratio between the specified PA900 accuracy and that of the applied current. For a 4:1 TUR (typically used) the current source should have an accuracy of <0.025%+125uA (S or W channel types) or <0.0075%+75uA (A channel types) at these levels.
5. (Only required for channels having the D current option) A source of AC current into a 0.57ohm load (plus the impedance of the wiring between the PA900 and the source) at 100mArms at a frequency of between 45 and 450Hz (the use of 50Hz or 60Hz is recommended) with sufficient amplitude accuracy to ensure the desired ratio between the specified PA900 accuracy and that of the applied current. For a 4:1 TUR (typically used) the current source should have an accuracy of <0.02575% (S or W channel types) or <0.007875% (A channel types) at these levels.
6. (Only required for channels having the X current option) A source of AC voltage into a 20.5Kohm load at 0.1V, 0.5V, 2V and 10Vrms at a frequency of between 45 and 450Hz (the use of 50Hz or 60Hz is recommended) with sufficient amplitude accuracy to ensure the desired ratio between the specified PA900 accuracy and that of the applied voltage. For a 4:1 TUR (typically used) the voltage source should have an accuracy of <0.025%+12.5uV (S or W channel types) or <0.0075%+7.5uV (A channel types) at these levels. Note that some sources may require that you adjust the voltage setting to achieve the correct voltage into a 20.5Kohm load.
7. (Only required for channels having the X current option) A source of AC voltage into a 10.25Kohm load at 200mVrms at a frequency of between 45 and 450Hz (the use of 50Hz or 60Hz is recommended) with sufficient amplitude accuracy to ensure the desired ratio between the specified PA900 accuracy and that of the applied voltage. For a 4:1 TUR (typically used) the voltage source should have an accuracy of <0.02544% (S or W channel types) or <0.007815% (A channel types) at these levels. Note that some sources may require that you adjust the voltage setting to achieve the correct voltage into a 10.25Kohm load.

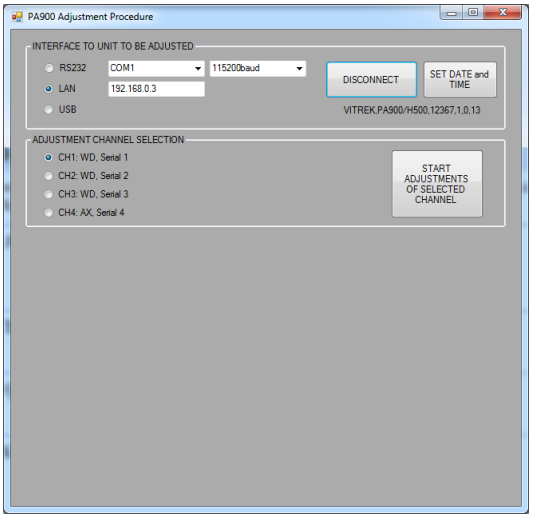
ADJUSTMENT PROCEDURE

After first running the software application provided and connecting the chosen interface between the computer and the PA900 you should perform the actions of each of the following sections.

STARTING THE INTERFACE TO THE PA900

In the INTERFACE TO UNIT TO BE ADJUSTED area of the application-

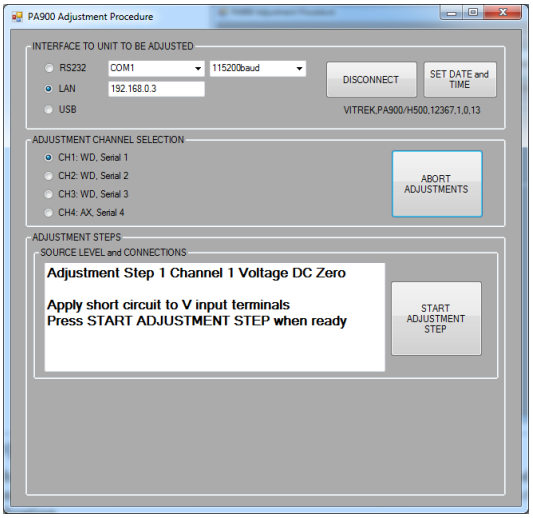
1. Using the radio buttons, select the chosen interface to the PA900.
2. If using the RS232 interface select the baud rate for the RS232 interface.
3. If using the LAN interface type in the IP address of the PA900. This can be seen by pressing the LAN info area on the PA900 screen.
4. Press the CONNECT button, this will then be relabeled DISCONNECT and the identification of the PA900 will be shown underneath the button after the application has correctly established communications with the PA900. This shows the model number, any installed option contents, the serial number and the main firmware version. The installed channels, along with their type and option and serial numbers will be listed with radio buttons in the ADJUSTMENT CHANNEL SELECTION area of the application.
5. Check that you have connected to the correct PA900 and that it has expected serial number and channel content.
6. (If required) Press the SET DATE and TIME button. This will set the date and time of the PA900 to that of the computer.



ADJUSTING EACH CHANNEL IN THE PA900

Each channel is adjusted separately, so the procedure below should be performed for each channel installed in the PA900. After a channel has been adjusted "- ADJUSTED" is shown following its serial number in the ADJUSTMENT CHANNEL SELECTION area of the application.

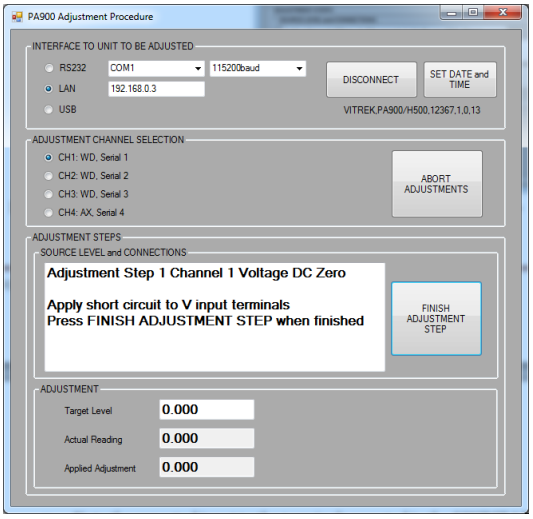
1. Using the radio buttons in the ADJUSTMENT CHANNEL SELECTION area, select the channel to be adjusted.
2. Ensure that there are no connections to any channel terminals of the PA900.
3. Press the START ADJUSTMENTS OF SELECTED CHANNEL button.



4. During each step in the adjustment procedure the same actions are needed (not all steps may be present and the source required in each step varies depending on the channel type and option being adjusted)-

a. Note the expected input to the terminals as noted in the SOURCE LEVEL and CONNECTIONS window and apply the source as requested. Ensure that only the expected connections are made to the PA900, there should be no other connections during any step in the procedure.

b. When the requested input has been provided, press the START ADJUSTMENT STEP button.



c. For the zero adjustment steps (steps 1, 2 and 3): the ADJUSTMENT area shows the target level (always zero), the actual PA900 reading, and the applied adjustment. These are each in volts or amps units depending on the zero being adjusted. Adjustment is automatic for these steps, so you should just press the FINISH ADJUSTMENT STEP button for each when you are satisfied that the zero has been fully adjusted.

   i. Where a short circuit is requested to be applied, you should also ground the short circuit.

   ii. Where an open circuit is requested to be applied, all terminals should have no connections.

   iii. Particularly for the LO range X option DC zero adjustment (step 3 for the X option) there may be thermally induced voltages on the short circuit being used. For step 3 of the X current option adjustment it is recommended to wait at least 1 minute for any thermals to have dissipated before pressing the FINISH ADJUSTMENT STEP button.

   iv. You should be aware of the PA900 specifications for the channel and step being adjusted. Using this will assist you in determining if you are satisfied with the adjustment or not. In some steps the last digit is not trimmed to be exactly correct.

d. For the scaling adjustment steps (steps 4 onwards): the ADJUSTMENT area shows the target level (which may be overwritten if desired), the actual PA900 reading (both in Volts or Amps as applicable), the applied adjustment (in percent) and allows you to either adjust the PA900 manually or automatically. If applying the adjustment manually then you can change the size of each step with the COARSE, MEDIUM and FINE radio buttons and the target value is not used. If applying the adjustment automatically then the user must ensure that the correct target value is entered and the source is fully settled before checking the AUTO ADJUST checkbox. When you are satisfied with the adjustment press the FINISH ADJUSTMENT STEP button to proceed to the next step.

   i. You should be aware of the PA900 specifications for the channel and step being adjusted. Using this will assist you in determining if you are satisfied with the adjustment or not. If you adjust the reading down to the last digit then in some circumstances this will yield unnecessarily long adjustment times and in some steps the last digit cannot be trimmed to be exactly correct.

e. After the last step has been completed for this channel (there are up to 12 steps for each channel) press the SAVE ADJUSTMENTS button to save the adjustments to the channel and return to selecting the next channel to adjust.

f. NOTE: pressing the ABORT ADJUSTMENTS button at any time during the adjustment of a channel will discard any adjustments made to that channel until the SAVE ADJUSTMENTS button is pressed.

FINISHING THE PROCEDURE

When all adjustments have been performed on all channels requiring adjustment, the user may press the DISCONNECT button to disconnect the application from the PA900. The adjustments were saved when each channel adjustment was completed.

WARNING: Do not remove power from the PA900 during or until at least 10 seconds after completing adjustments.

CALIBRATION VERIFICATION

To be determined