

**Powertek**

**USER GUIDE**

**PA2801/PA2802**

**Advanced Single  
and Dual-Channel  
Power Analyzers**



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# Introduction

The purpose of this user guide is to describe the use and capabilities of the PA2801/PA2802 Advanced Single and Dual-Channel Power Analyzers.

## Scope

The PA2801/PA2802 Advanced Single and Dual-Channel Power Analyzers incorporate the ideal combination of precision, speed and ease-of-use in instruments so economical they can be on every bench.

With an extended measurement range from micro-amps to hundreds of amps and millivolts to kilovolts, the PA2801/PA2802 is the ideal analyzer for efficiency, standby power or ENERGY STAR testing. In addition to numerical results, the PA2801/PA2802 analyzer captures waveforms with true 512-point precision. Results and waveforms can be displayed, read via the communication ports, or sent directly at full resolution to a USB printer. Power and amplitude measurements with an accuracy of  $<0.1\%$  are automatically synchronized to the fundamental frequency. Peak, RMS, rectified, and DC measurements of voltage, current and power are provided including continuous, inrush, startup and history modes, plus an integration mode for W-Hr, A-Hr, VA-Hr, as well as integrated average power. The analyzer also provides waveform peak and glitch capture modes.

## Features

The PA2801/PA2802 Power Analyzer's features include the following—

- Highest Performance-to-Cost ratio in the industry
- Up to 2000V peak and 150A peak measurable internally (also external CT capable)
- Base accuracy <0.08%. Current and voltage accuracies specified to less than 1mA<sub>rms</sub> and 1V<sub>rms</sub> respectively (<0.2%)
- Measures and displays volts, current, power, frequency, harmonics, THD, PF, CF, K-Factor, Triplens, inrush, distortion, glitches, and much more.
- Integrated line switch and inrush waveforms
- Source or load measurements with wiring loss and voltage burden compensation
- DC charge and discharge measurements
- Frequency Range: DC and 20mHz – 200kHz
- Graphics display shows numerical results, waveforms, bar graphs, startup & history plots
- 16-bit A/D converters at 235ksps
- 12 User-configurable digital I/O
- USB Flash drive support for data logging\*
- Communications interfaces include GPIB (IEEE488), RS-232, and USB (host and device) all standard.

\* Planned feature

# Functional Description

This chapter describes the circuitry and interfaces of the PA2801/PA2802 Power Analyzer.

## Theory of Operation

### OVERALL BLOCK DIAGRAM

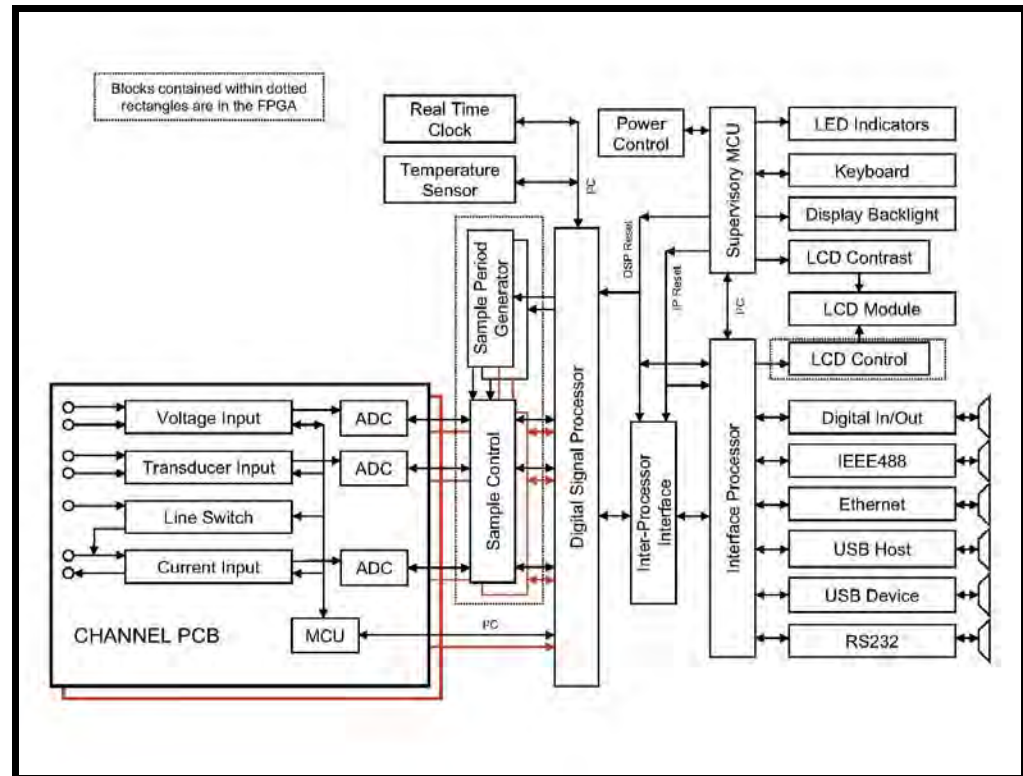


Figure 1. Overall Block Diagram

## Analog Channel Board

The PA2801 is built with one and the PA2802 is built with two Analog Channel Boards fitted. The block diagrams of this circuitry are shown below.

### Voltage Input Attenuator Notes

The primary voltage-reducing element formed by the 1 Mohm portion of the attenuator is comprised of several lesser value resistors in series:

- a) To assure the input remains safe when a single resistor fails to a short circuit;
- b) To reduce the voltage coefficient of the attenuator caused by self heating when high voltages are applied; and
- c) To ensure that the input can withstand high voltages in excess of the maximum specified to the user.

### Transducer Input Attenuator Notes

The Transducer input attenuator is similar to the Voltage input attenuator but with a much lower primary resistance value and a slightly higher output impedance. Since the input voltages specified are low, only a single primary attenuator resistor is used as there are no single fault safety issues with this input.

## Voltage Input Attenuator

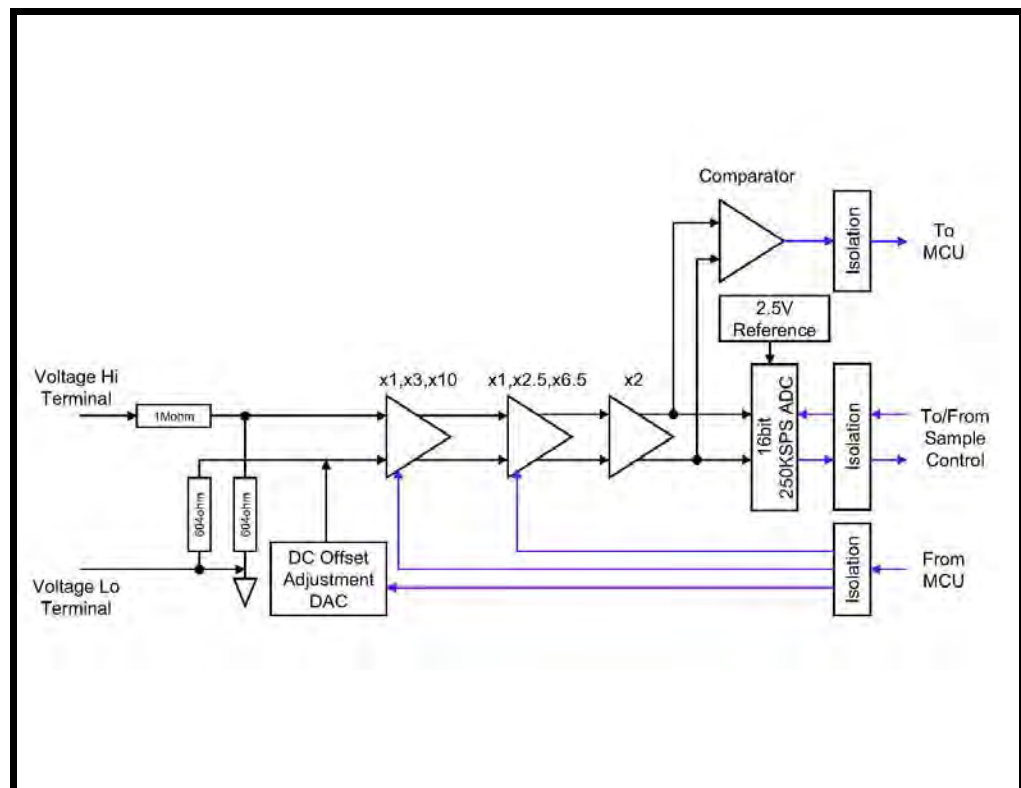


Figure 2. Voltage Input Attenuator Block Diagram

## Transducer Input Attenuator

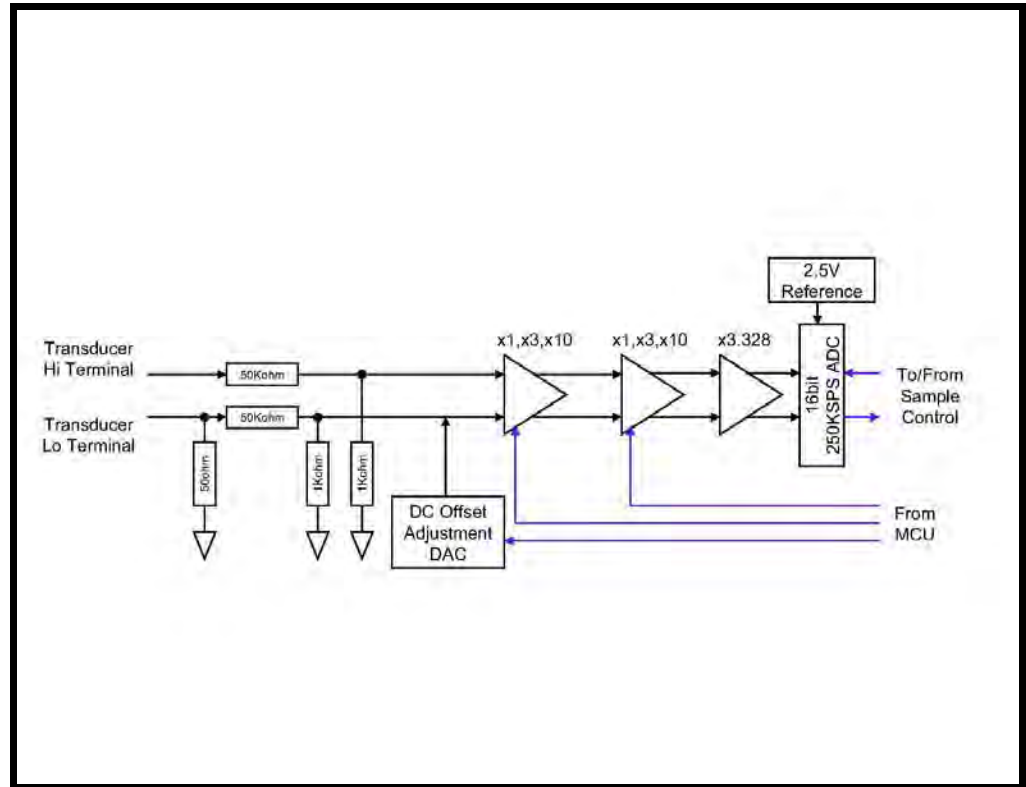


Figure 3. Transducer Input Attenuator Block Diagram



## Current and Line Switch

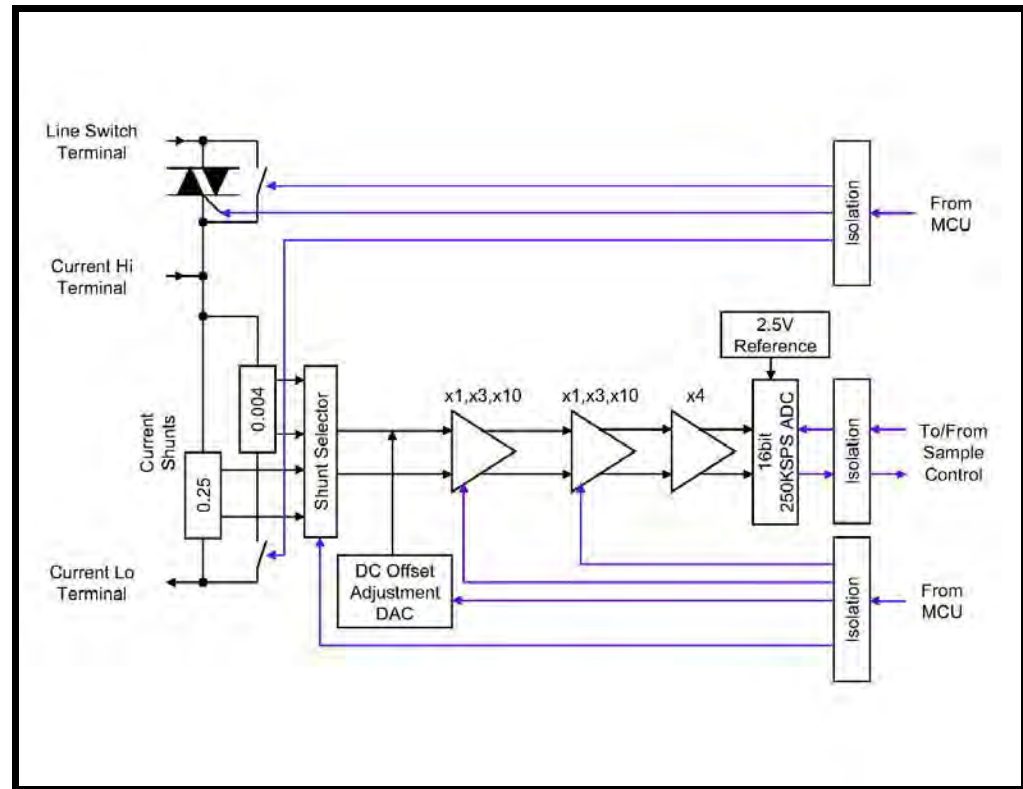


Figure 4. Current and Line Switch Block Diagram

## Line Switch Notes

The TRIAC and relay are controlled directly by the Channel MCU as commanded by the DSP.

The timing of the turn on sequence when operating with AC voltages is accomplished by the MCU delaying turning on the TRIAC (after being commanded to do so by the DSP) by an amount commanded by the DSP from the active edge of the “squared” signal from the comparator in the Voltage Input circuitry. When set for DC voltage operation, the TRIAC is turned on immediately after being commanded to do so without reference to this signal.

Other than the delay noted above, the turn on sequence in either AC or DC voltage modes is the same and is timed by the Channel MCU.

Nominally 50ms after the TRIAC is turned on, the parallel relay is engaged, and then nominally 20ms after that the TRIAC has its control signal removed. Since the relay has a low voltage drop, there is insufficient current flowing through the TRIAC to hold it in the on state, and thus only the relay conducts from this point onwards.

When configured for DC voltage operation, the turn off sequence (controlled by the channel MCU) is simply to turn off the relay immediately after being commanded to do so by the DSP.

When configured for AC voltage operation the timing sequence during turn off is as follows. Immediately after being commanded to turn off the switch, the MCU turns on the control signal to the TRIAC. After nominally 20ms the relay is turned off, and after a further nominally 40ms the TRIAC control signal is removed. In this manner the actual load turn off is controlled by the TRIAC rather than the relay.

If the switch is used in high  $dV/dT$  situations (e.g. inductive loads), then it may be required that the user add an external snubber circuit. This circuitry cannot be included internally, as it is dependent on the actual load characteristics and its presence will directly affect the off characteristics of the switch.

Since the relay is normally the current carrying device, the TRIAC does not limit the continuous current capability of the switch as the thermal issues with the TRIAC are not present. The TRIAC is only used to withstand the turn on surge of the load, and to withstand any reverse “kick” when an AC load is turned off. Similarly, the relay is not required to withstand the surge current of the load during turn on, nor is it required to withstand the turn off surge of an inductive AC load, so the requirements on the relay are reduced.

### **DC Offset Adjustment DACs (all inputs)**

The DC Offset adjustment DACs are adjusted by the DSP (via the Channel MCUs) to produce a zero DC reading when commanded to do so by the user. This is accomplished independently for each input, each range, and each current shunt selection. The DAC settings required to produce each zero DC reading is stored independently for each combination in the Channel MCU in non-volatile memory.

### **Isolation (all inputs except the Transducer input)**

The digital signals are all passed through digital isolation barriers. This provides the required isolation between the measurement circuitry and the chassis ground of the product.

A further area of isolation, not specifically shown on the block diagrams is that of power to the analog circuitry in each input.

## **Interfaces**

**Note:** Specifications are subject to change without notice.

### **Front Panel**

**Liquid Crystal Display**—240 x 64 high-speed graphics LCD with CCFL backlight (5" x 1.35" viewing area)

**Keyboard**—Seven fixed-purpose keys + four softkeys

### **IEEE488**

**Interface**—

IEEE488.1 (Certain commands conform to IEEE488.2)

**Addressing**—

Single address, user selectable via front panel between 0 and 29 inclusive

**Capabilities**—

SH1 AH1 T6 L4 SR1 RL1 PP0 DC1 DT1 C0 E2 (350ns min. T1)

**Max. Talk Data Rate**—

>300,000 bytes per second

**Max. Listen Data Rate**—

>100,000 bytes per second

**Command Set**—

All front panel capabilities are provided via ASCII textual command sequences.

**Results**—

Any results may be obtained at any time from the interface as ASCII textual numerical data. Additionally, status and state interrogatives are provided for on-the-fly determination of product status.

### **USB Device**

USB 2.0 compliant, full-speed, multiple endpoint interface to a host.

Driver provided with instrument is for PC compatible computers running Windows 2000 or later

## **USB Host**

USB 2.0 compliant, low or full-speed (as selected by the device).  
Compatible with all printers supporting either the PCL3 (or higher) language or supporting unformatted text transfers.

Printer must be directly connected to the PA2802 (hubs are not supported).

## **RS-232**

RTS/CTS hardware handshaking. Also supports the DTR and DSR signals.  
Baud rate user selectable as 9600, 19200, 38400, 57600, 115200 or 230400baud.

8 bits per character, no parity, 1 stop bit transmission format.

## **Digital I/O**

The Digital I/O port can be used to control the internal line switch or to control integration..

## **Ethernet**

Not yet available.

# Using the Power Analyzer

The purpose of this chapter is to describe how to set up and use the PA2802. This chapter covers—

- Setting up the analyzer
- Using the front panel interface
- Rear panel connections
- Power testing

## Setting Up

The power analyzer is made to sit on the bench. The viewing angle can be optimized by adjusting the handle and the viewing brightness enhanced by adjusting the DISPLAY CONTRAST. An optional rack adapter is available.



Figure 5. Benchtop Version of PA2801 Power Analyzer



Figure 6. Benchtop Version of PA2802 Power Analyzer

*To adjust the handle—*

Press and hold the buttons located on the rear side where the handle attaches to the case sides. Rotate the handle until it clicks into place.



**WARNING:** IF THE POWER ANALYZER IS USED IN A MANNER NOT SPECIFIED BY POWERTEK, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.

## Using the Front Panel Interface

Use the PA2801/PA2802 front panel interface to select and setup the desired tests and to read the test results. The interface includes a power switch; LCD display; two keys used for scrolling; a shift key to alter the softkey functions; a line switch key; and separate keys used to pull up menus, to make selections, and to print. Additionally, there are four softkeys. The four LEDs function as indicators. Figure 7 shows the front panel interface display, keys and LEDs.

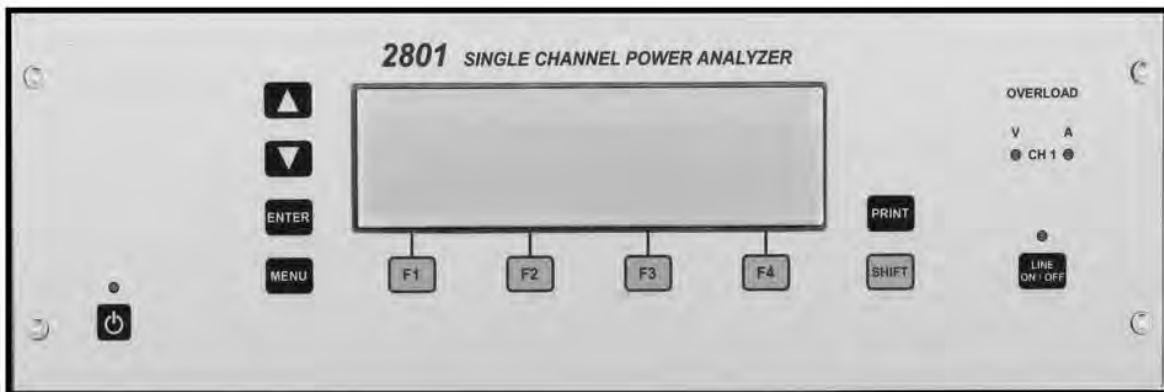


Figure 7. PA2801 Front Panel Interface Detail

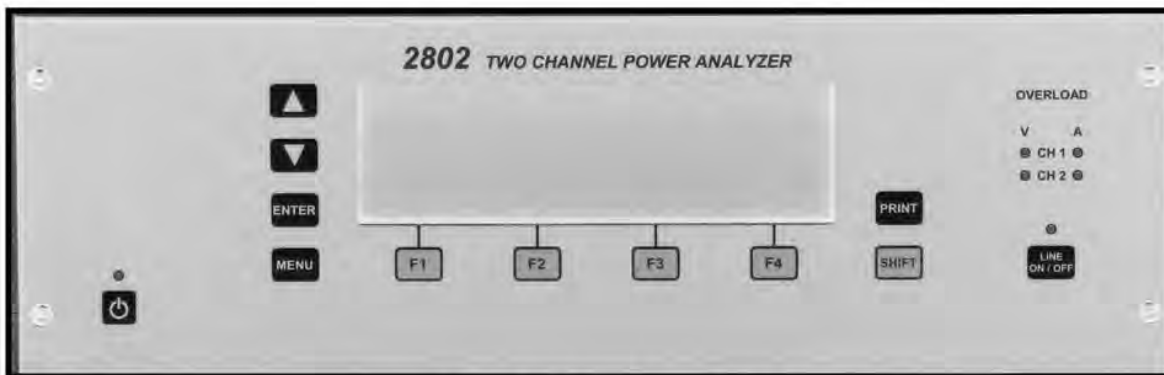


Figure 8. PA2802 Front Panel Interface Detail








The highlighted menu item will be initiated by pressing the ENTER key.



Figure 9. Sample Display

The display is used to view and select the various menu options and to review the power *measurement results* numerically and graphically, as shown in the section on *Viewing Results*.

The display contains helpful navigational symbols, such as, the softkey labels; and on the right there may be an arrow pointing either up or down, if additional line items are available. The F1 through F4 softkey labels correlate with each display and are used to modify setups and to expand on existing numerical and graphical measurement results.

	<p>If the LED above the power key is yellow, it indicates power has been connected. To power up the analyzer, hold the power key until the LED turns green. It requires that the key be pressed for 500 milliseconds. When turning it off the LED turns from green to yellow.</p>
 	<p>Use the ▲ and ▼ (up and down arrow) keys to scroll a highlight bar through options in a menu, to bring up the various measurement results for viewing, and to view additional measurement results. The up arrow key moves the display to the previously viewed screen or item. The down arrow key moves to the next viewable screen or item.</p>
	<p>The SHIFT key provides additional options for softkeys F1 through F4 when applicable. This feature is most valuable when viewing charts.</p>
	<p>Use the ENTER key to make a selection. Press ENTER when the desired menu option or measurement selection is highlighted.</p>
	<p>Use the MENU key to access the MAIN MENU. The MENU key is also used to move from submenus to higher level menus and from the MAIN MENU to Measurement Results.</p>
	<p>The four softkeys, F1 through F4, change functionality within a display and correlate with that specific menu or Measurement Results display.</p>



<p><b>OVERLOAD</b></p> <p><b>V</b>                      <b>A</b></p> <p>○ <b>CH 1</b> ○</p> <p>○ <b>CH 2</b> ○</p>	<p>The LEDs designated OVERLOAD V and A indicate the selected current/voltage threshold has been exceeded, such as, an input signal is greater than the selected range value, above strict ranging or the selected maximum range. Note that when either of these LEDs remains lighted, changes to the test device's signal input or values in the SETUP MEASUREMENTS MENU are required.</p> <p><i>PA2802 is shown, PA2801 only has CH1 Overload LEDs</i></p>
<p>○</p> <p><b>LINE ON / OFF</b></p>	<p>A lighted LED at LINE ON/OFF indicates that power has been turned on to the device connected to the analyzer for testing/measuring.</p> <p>Hold the LINE ON/OFF key for a few milliseconds to power up or power down the test device. Note that this line switch is ENABLED or DISABLED from within the SETUP MEASUREMENTS MENU.</p>
<p><b>PRINT</b></p>	<p>The PRINT key allows the user to print a full page of data reflecting the display results. The formatting of the printout is either graphical or numerical tabulation.</p>
	<p>The F1, F2, F3 and F4 keys are softkeys. They correlate with labels given on the display. The softkey labels indicate other options available or the status of the display. An ellipsis (...) following the label indicates additional choices available. See below.</p>

## Grounding of the Analyzer

There are two distinct grounded areas built into the PA2801/PA2802 Power Analyzer.

### Chassis Ground

This comprises the entire external and internal chassis mechanical components, the outside shells of all interface connectors, and the shield connection in the IEEE488 interface connector. An external protective ground terminal is directly connected to this ground.

### Internal Electronic Ground

This comprises all grounded circuitry within the product and is the reference

for all interface signals within the interface connectors except for the Ethernet connections (which are transformer isolated according to the applicable Ethernet standards). This area is electrically connected to the negative side of the DC power input via an RF pi filter network having a low DC resistance.

***Notes on Grounding:***

Between the two ground areas there is a 50ohm (1%) power resistor in parallel with a 1000pF/50V ceramic capacitor for RF filtering.

The T input connections are isolated from the Internal Electronic Ground via a nominally 50ohm (1%) power resistor. An isolating current transducer having sufficient safety rating for the signals being measured **MUST** be used when using this input.

The A and Line Switch connections are fully isolated from the Internal Electronic Ground using transformer isolation to the requirements of EN61010. This isolation is 100% tested to 4.5kV peak.

The V connections are fully isolated from the Internal Electronic Ground using transformer isolation to the requirements of IEC61010. This isolation is 100% tested to 4.5kV peak.

The V connections are resistively isolated from each other with nominally 1Mohm to the requirements of EN61010 in no fault, single fault and dual fault conditions. This isolation is 100% tested to 2kV peak.

Mechanical isolation is provided between the V connections and the A and Line Switch connections, which is well in excess of the class ratings of either set of terminals, there are no electrical signals between these connections.

Because of the use of transformer isolation, there is very little current flowing between the UUT terminals and the ground of the product. The isolation impedance is  $>10^9$  ohms and the capacitance is typically a few 10s of pF.

The EN61010 ratings in each application category for each terminal are stated on the rear panel of the product next to the terminals.

## Rear Panel Connections - PA2801 and PA2802

### Power Requirements

In order to comply with the safety ratings stated on the rear panel of the product according to the requirements contained in EN61010, these products *must* be provided with an external ground connection in some manner (either through the power source for the product or by connection to the protective ground on the product).

These products *must only* be used with a power supply which contains isolation from the mains supply which meets the requirements of EN61010.

**WARNING:** TO AVOID AN UNSAFE AND POTENTIALLY DAMAGING CONDITION, *NEVER* USE AN EXTERNAL DC POWER SOURCE TO THIS PRODUCT, WHICH IS *NOT ISOLATED* FROM THE MAINS SUPPLY.

When used with the external power supply provided with the product by Powertek, the ground is supplied via the negative DC power input. If the product is powered by any other equivalent grounded output DC power supply, then the ground is supplied via that power supply. In these cases the user *need not* provide any additional ground connection to the product provided that the external DC Supply has a ground connection to it.

In all other cases, e.g. powered from an external battery or any other isolated DC supply, the instrument **MUST** be provided with a ground connection to the protective ground terminal located on the rear panel of the product (this is marked according to the requirements of EN61010.)

*Never* use an external DC power source to the product which is *not isolated* from the mains supply – this is **UNSAFE** and may cause **DAMAGE** to the product.

If at any time there is doubt regarding the continuity of the ground connection to the product, then it is strongly recommended to use the rear panel protective ground terminal.

Operation of the product in the absence of any ground connection does *not* intrinsically render the product unsafe; however the safety ratings for the UUT terminals are significantly reduced in this situation. Safety

ratings for the products have not been formally established when operating without a ground connection.



**WARNING:** To avoid possible electrical shock, do not operate the product without an external ground connection in a manner described herein.



**CAUTION:** The external DC power source for the product **MUST** be rated to meet the voltage range and minimum current requirements stated on the rear panel of the product.

## PA2801 Rear Panel Connections

The PA2801 Power Analyzer rear panel contains a variety of connectors. Refer to Figure 10. The connectors used for testing/measuring functions are along the midline of the instrument. The connectors used for communications and control are along the bottom. The ground terminal is at the lower left corner.



**WARNING:** IF THE POWER ANALYZER IS USED IN A MANNER NOT SPECIFIED BY POWERTEK, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.



**WARNING:** IT IS RECOMMENDED THAT THE PROTECTIVE CONDUCTOR TERMINAL IS CONNECTED TO EARTH GROUND WHEN THE SIGNALS BEING MEASURED ARE REFERENCED TO EARTH GROUND.



**CAUTION:** THE USE OF THE T5 CHARGER FROM POWERTEK OR A POWERTEK RECOMMENDED REPLACEMENT MUST BE USED TO ENSURE THAT THE UNIT GROUND IS NOT COMPROMISED.

**CAUTION:** FOR ALL CONNECTIONS, KEEP INPUT AND OUTPUT WIRING SEPARATED.

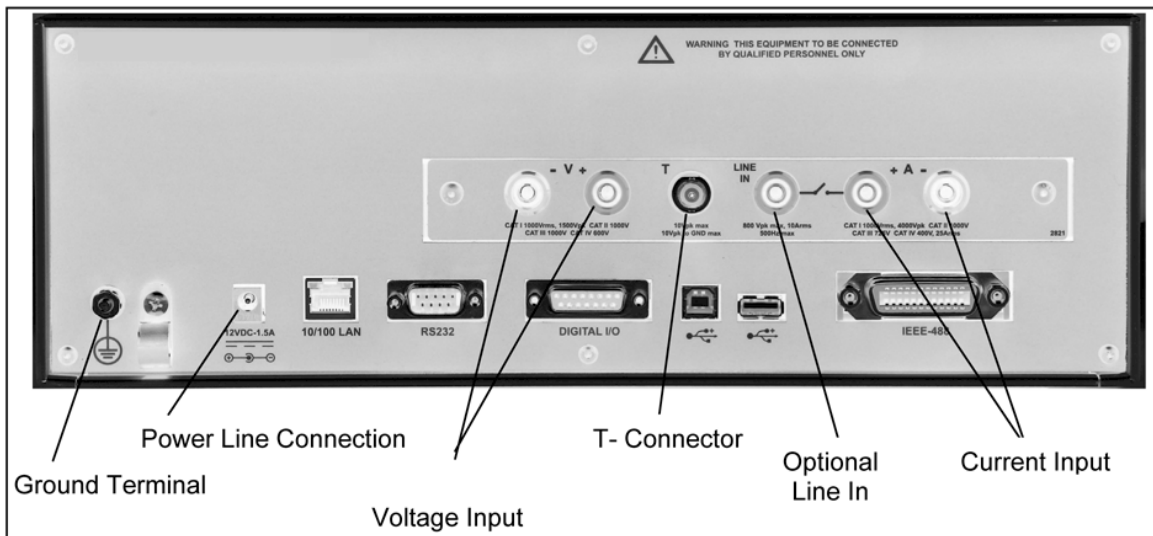


Figure 10. Rear Connection Panel

## Single-Channel Measurements of a Power Source: Connection Method 1

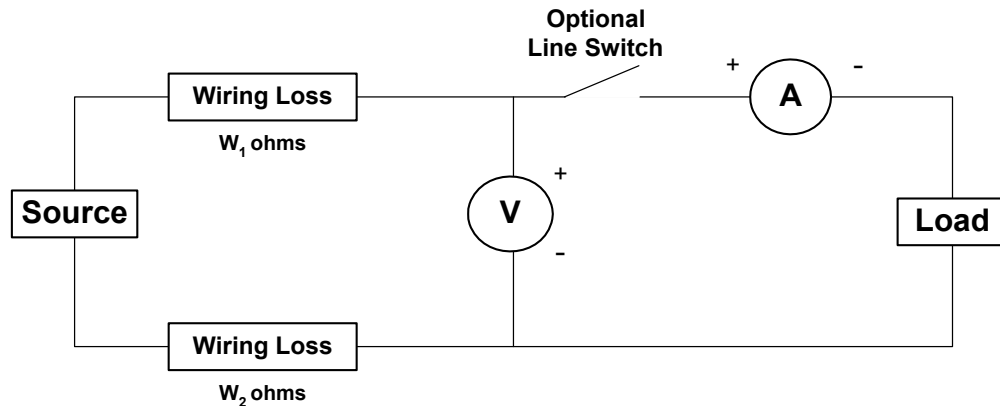


Figure 11. Measuring a Power Source, Method 1

Configure the channel as follows -

- This connection method is suitable for most applications.
- At high frequencies, the wiring length between the source and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W1 + W2)$  ohms. Include all wiring resistances between the source and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to YES.
- If the current measurement terminals are reversed, then set **Reverse Current** to YES, otherwise set to NO.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to YES, otherwise set to NO.

## Single-Channel Measurements of a Power Source: Connection Method 2

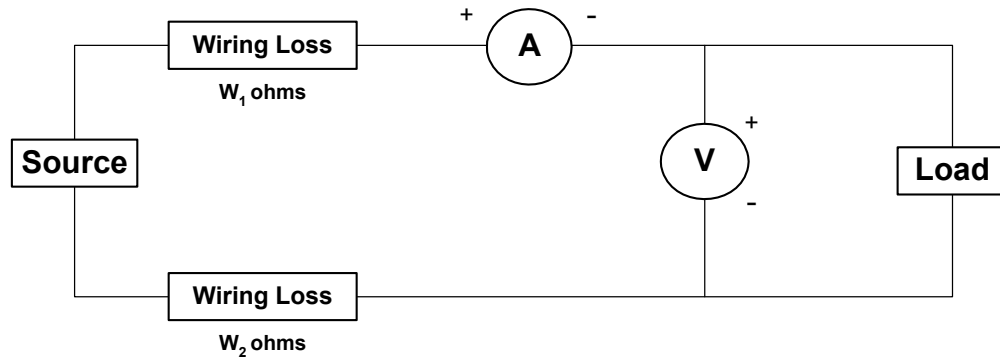


Figure 12. Measuring a Power Source, Method 2

Configure the channel as follows -

- Method 2 may provide improved results for applications with very low voltage and very high current, when using the internal shunt.
- At high frequencies, the wiring length between the source and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W1 + W2)$  ohms. The instrument will always automatically adjust for the internal shunt burden resistance if the channel is set to use the internal shunt. Other than the internal shunt burden, include all wiring resistances between the source and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to *NO*.
- If the current measurement terminals are reversed, then set **Reverse Current** to *YES*, otherwise set to *NO*.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to *YES*, otherwise set to *NO*.

## Single-Channel Measurements of a Load: Connection Method 1

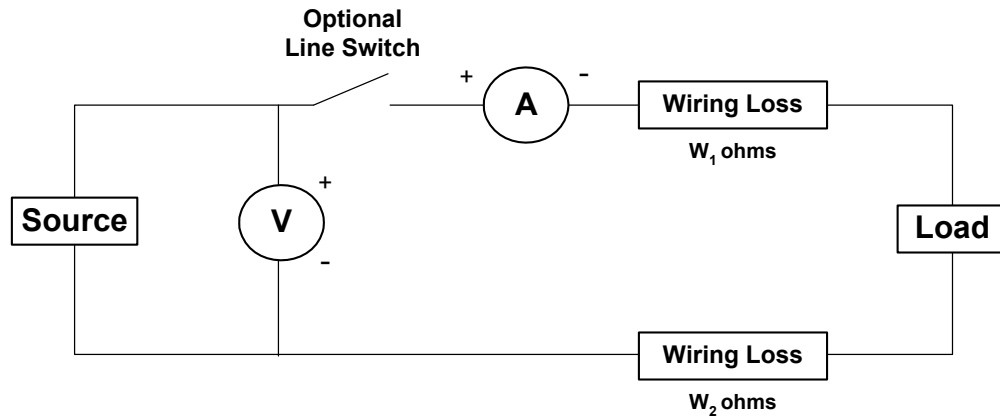


Figure 13. Measuring a Load, Method 1

Configure the channel as follows -

- This connection method is suitable for most applications.
- At high frequencies, the wiring length between the load and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W1 + W2)$  ohms. The instrument will always automatically adjust for the internal shunt burden resistance if the channel is set to use the internal shunt. Other than the internal shunt burden, include all wiring resistances between the load and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to **NO**.
- If the current measurement terminals are reversed, then set **Reverse Current** to **YES**, otherwise set to **NO**.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to **YES**, otherwise set to **NO**.



## Single-Channel Measurements of a Load: Connection Method 2

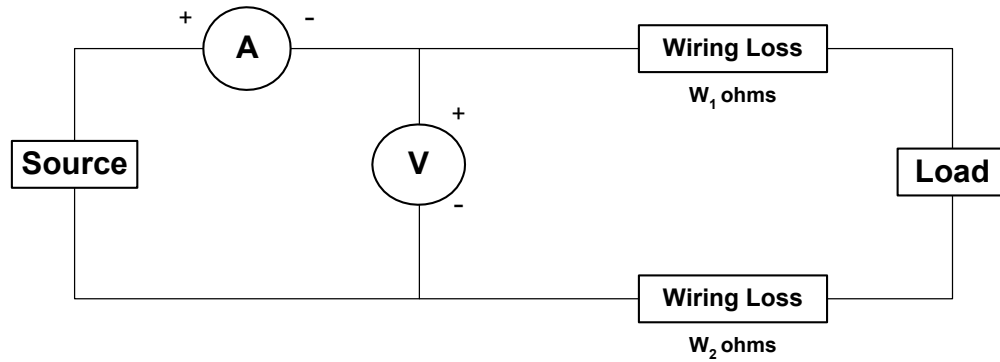


Figure 14. Measuring a Load, Method 2

Configure the channel as follows -

- Method 2 may provide improved results for applications with very low voltage and very high current, when using the internal shunt.
- At high frequencies, the wiring length between the load and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W1 + W2)$  ohms. Include all wiring resistances between the load and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to YES.
- If the current measurement terminals are reversed, then set **Reverse Current** to YES, otherwise set to NO.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to YES, otherwise set to NO.

## Measurements of a Power Source: Connection Method 1 – Ext CT

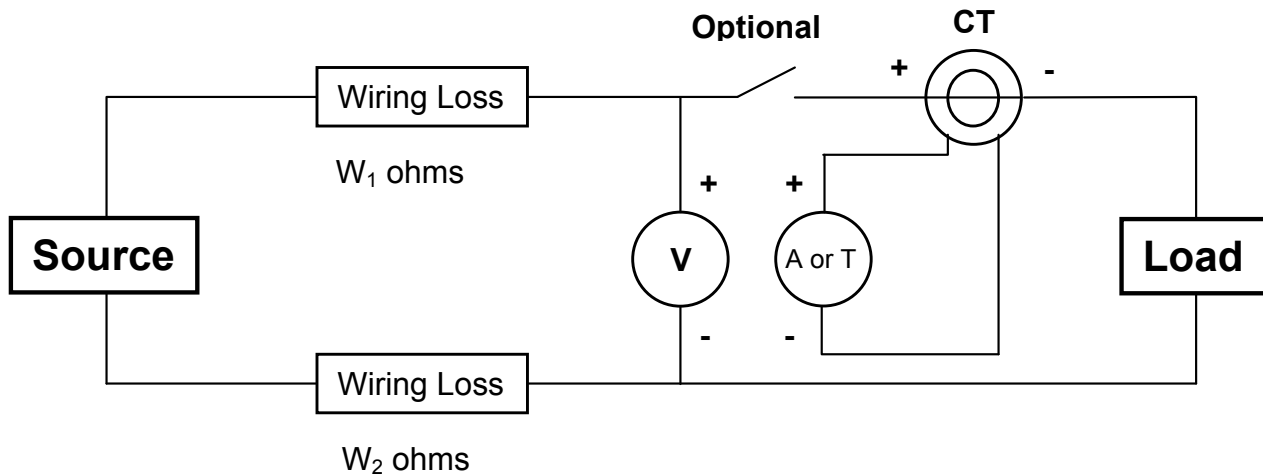


Figure 15. Measuring a Source Using a CT, Method 1

Configure the channel as follows –

- This connection method is suitable for most external transducer applications.
- At high frequencies, the wiring length between the source and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W1 + W2)$  ohms. Include all wiring resistances between the source and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to **YES**.
- If the current measurement terminals of the PA2801 or the wire through the CT (but not both) are reversed then set **Reverse Current** to **YES**, otherwise set to **NO**.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to **YES**, otherwise set to **NO**.
- If using a current output CT then use the A terminals, otherwise use the T connector, of the PA2801. If using a current output CT and using the internal line switch of the PA2801, then take care to reduce the length of the common wiring of the two signals to the A+ terminal of the PA2801.

## PA2802 Rear Panel Connections

The PA2802 Power Analyzer rear panel contains a variety of connectors. Refer to Figure 16. The connectors used for testing/measuring functions are along the midline of the instrument. The connectors used for communications and control are along the bottom. The ground terminal is at the lower left corner.



**WARNING:** IF THE POWER ANALYZER IS USED IN A MANNER NOT SPECIFIED BY POWERTEK, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.



**WARNING:** IT IS RECOMMENDED THAT THE PROTECTIVE CONDUCTOR TERMINAL IS CONNECTED TO EARTH GROUND WHEN THE SIGNALS BEING MEASURED ARE REFERENCED TO EARTH GROUND.



**CAUTION:** THE USE OF THE T5 CHARGER FROM POWERTEK OR A POWERTEK RECOMMENDED REPLACEMENT MUST BE USED TO ENSURE THAT THE UNIT GROUND IS NOT COMPROMISED.

**CAUTION:** FOR ALL CONNECTIONS, KEEP INPUT AND OUTPUT WIRING SEPARATED.

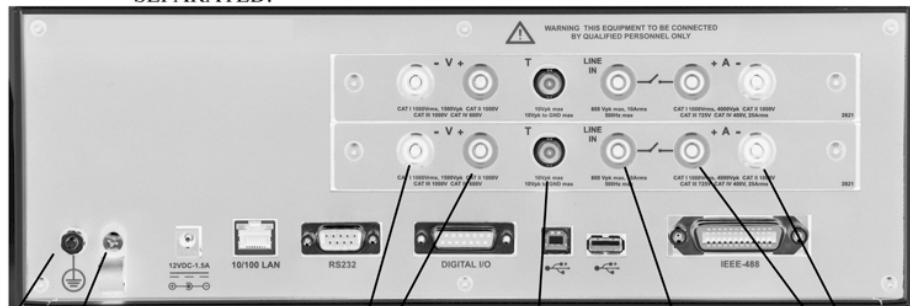


Figure 16. Rear Connection Panel

Ground Terminal      Power Line Connection      Voltage Input      T- Connector      Optional Line In      Current Input

## Measurements of a Power Source: Connection Method 1

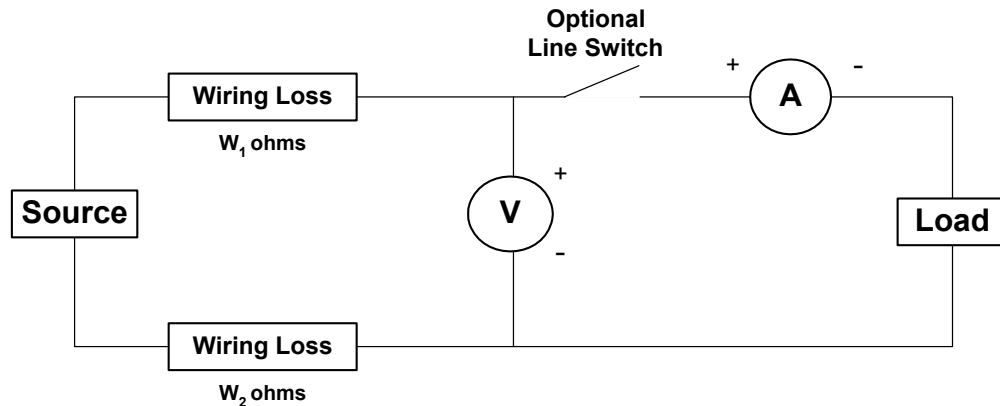


Figure 17. Measuring a Power Source, Method 1

Configure the channel as follows -

- This connection method is suitable for most applications.
- At high frequencies, the wiring length between the source and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W_1 + W_2)$  ohms. Include all wiring resistances between the source and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to YES.
- If the current measurement terminals are reversed, then set **Reverse Current** to YES, otherwise set to NO.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to YES, otherwise set to NO.

## Measurements of a Power Source: Connection Method 2

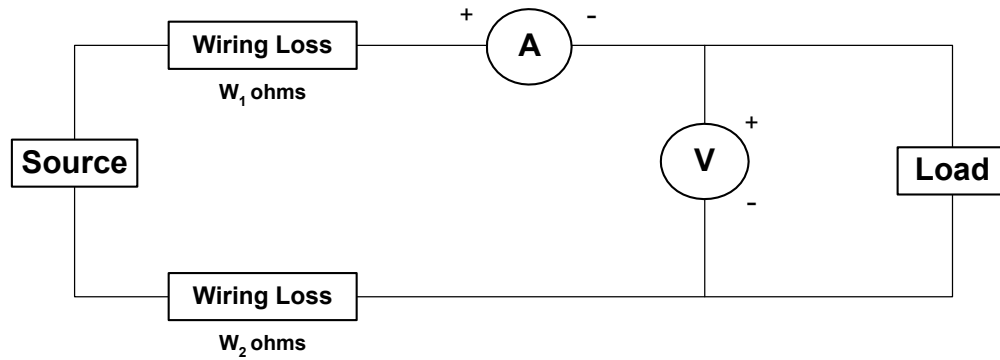


Figure 18. Measuring a Power Source, Method 2

Configure the channel as follows -

- Method 2 may provide improved results for applications with very low voltage and very high current, when using the internal shunt.
- At high frequencies, the wiring length between the source and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W1 + W2)$  ohms. The instrument will always automatically adjust for the internal shunt burden resistance if the channel is set to use the internal shunt. Other than the internal shunt burden, include all wiring resistances between the source and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to *NO*.
- If the current measurement terminals are reversed, then set **Reverse Current** to *YES*, otherwise set to *NO*.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to *YES*, otherwise set to *NO*.

## Measurements of a Load: Connection Method 1

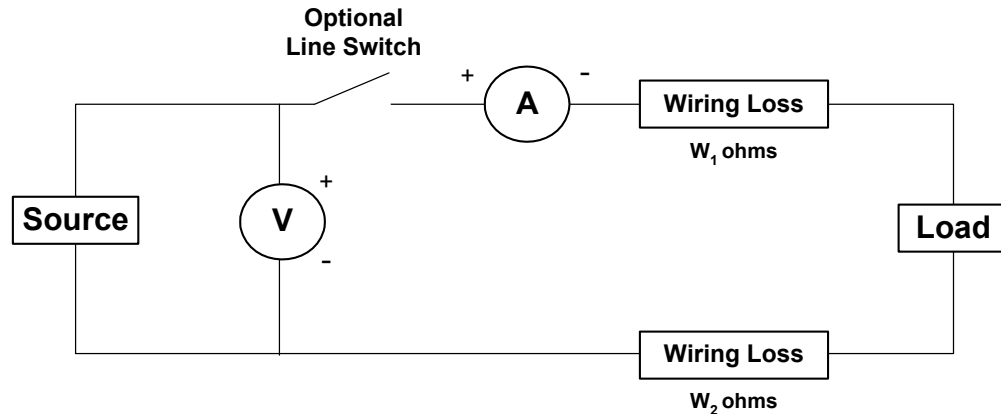


Figure 19. Measuring a Load, Method 1

Configure the channel as follows -

- This connection method is suitable for most applications.
- At high frequencies, the wiring length between the load and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W_1 + W_2)$  ohms. The instrument will always automatically adjust for the internal shunt burden resistance if the channel is set to use the internal shunt. Other than the internal shunt burden, include all wiring resistances between the load and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to **NO**.
- If the current measurement terminals are reversed, then set **Reverse Current** to **YES**, otherwise set to **NO**.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to **YES**, otherwise set to **NO**.

## Measurements of a Load: Connection Method 2

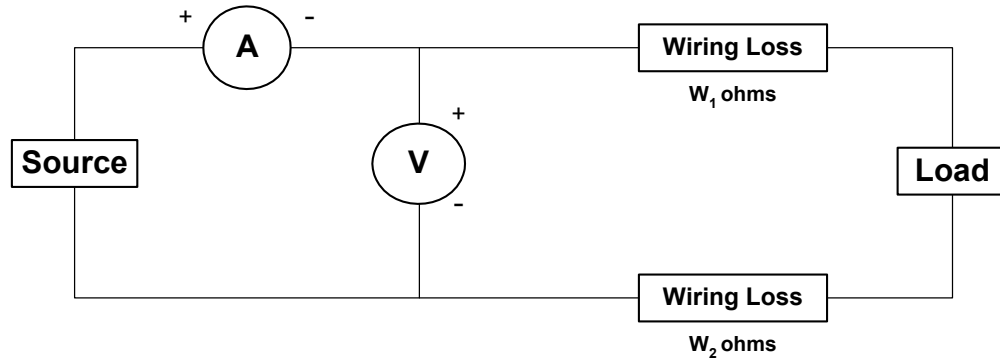


Figure 20. Measuring a Load, Method 2

Configure the channel as follows -

- Method 2 may provide improved results for applications with very low voltage and very high current, when using the internal shunt.
- At high frequencies, the wiring length between the load and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W_1 + W_2)$  ohms. Include all wiring resistances between the load and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to YES.
- If the current measurement terminals are reversed, then set **Reverse Current** to YES, otherwise set to NO.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to YES, otherwise set to NO.

## Measurements of a Power Source and Load: Method 1, Two Ind. Chnls

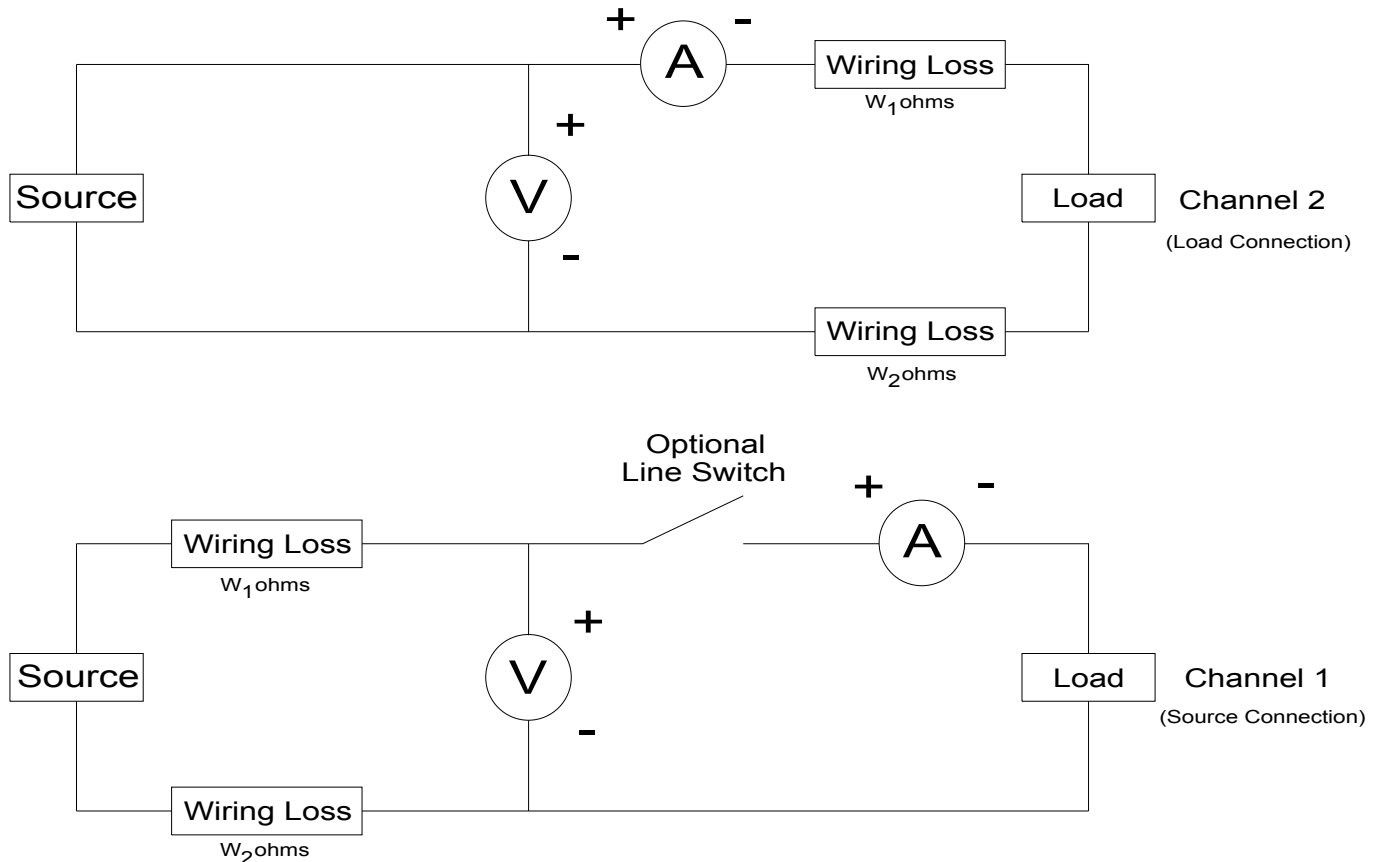


Figure 21. Measuring a Power Source and Load, Method 1, Two Ind. Chnls

Configure the channels as follows -

- This connection method is suitable for most Independent or Input/Output channel applications.
- At high frequencies, the wiring length between the source and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.



- Optionally, set **Wiring Impedance** to  $(W1 + W2)$  ohms. Include all wiring resistances between the source and the points at which the voltage is measured in the entered value for wiring impedance.
- Set V Burden Compensation to YES.
- If the current measurement terminals are reversed, then set **Reverse Current** to YES, otherwise set to NO.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to YES, otherwise set to NO.

### Measurement: 3P-3W 2 Meter Connection, Method 1

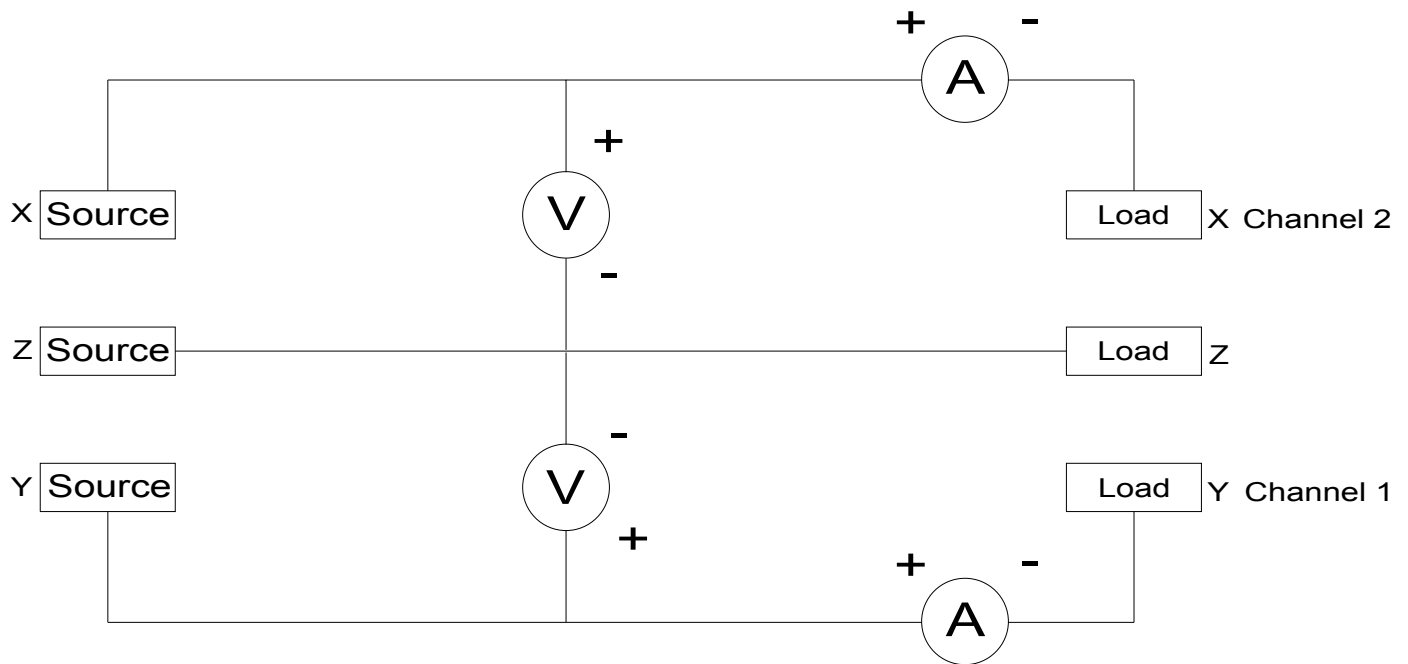


Figure 22. Measure 3P-3W 2 Meter Connection, Method 1

The above diagram is applicable when there are 3 wires connecting to the Load. For ease, we have used X, Y and Z instead of A, B and C. The phase rotation of the Channels must be opposite of each other and the current measurement is made in the line phase connected to the corresponding voltage HI terminal.

Configure the channels as follows -

- Select 3P-3W from the Getting Started Menu.
- The PA2802 will provide the following results
  - Two of the actual measured voltages (X-Z and Y-Z)
  - The Voltage Difference (= Y-X)
  - Two of the actual measured currents (X and Y)
  - The Sum Current (=Z)
  - The individual and totals for VA, W, VAR, PF etc.
- If the current measurement terminals are reversed, then set **Reverse Current** to *YES*, otherwise set to *NO*. (Only if both currents are backwards)
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to *YES*, otherwise set to *NO*. (Only if both Voltages are backwards)

## Measurements of a Power Source: Connection Method 1 – Ext CT

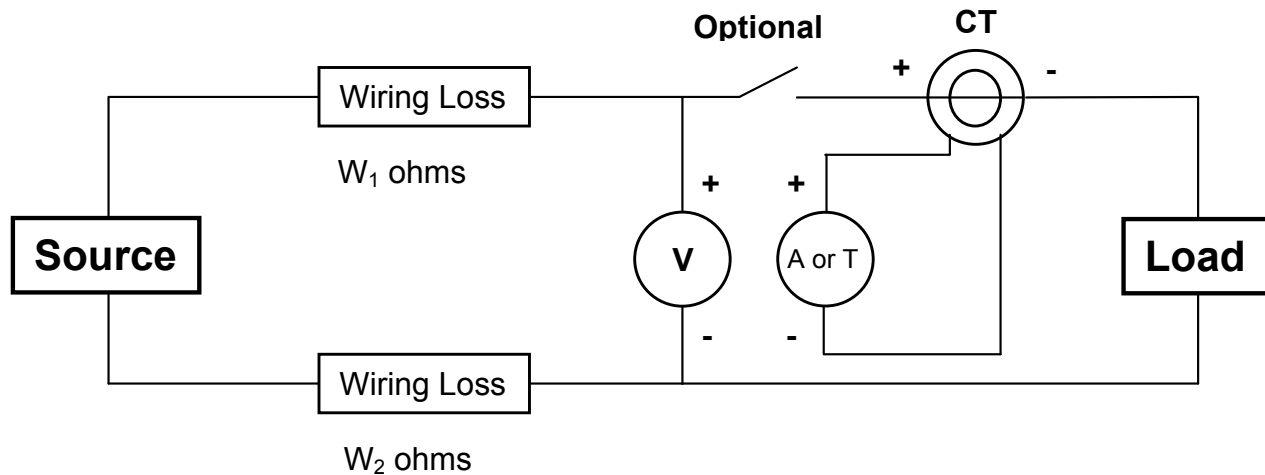


Figure 23. Measuring a Source Using a CT, Method 1

Configure the channel as follows –

- This connection method is suitable for most external transducer applications.
- At high frequencies, the wiring length between the source and the current and voltage measurement points should be kept as short as possible to avoid inductive and capacitive losses causing inaccuracies.
- Optionally, set **Wiring Impedance** to  $(W_1 + W_2)$  ohms. Include all wiring resistances between the source and the points at which the voltage is measured in the entered value for wiring impedance.
- Set **V Burden Compensation** to **YES**.
- If the current measurement terminals of the PA2802 or the wire through the CT (but not both) are reversed then set **Reverse Current** to **YES**, otherwise set to **NO**.
- If the voltage measurement terminals are reversed, then set **Reverse Voltage** to **YES**, otherwise set to **NO**.
- If using a current output CT then use the A terminals, otherwise use the T connector, of the PA2802. If using a current output CT and using the internal line switch of the PA2802, then take care to reduce the length of the common wiring of the two signals to the A+ terminal of the PA2802.

## Using an External Current Transducer

When using the external current transducer, access the **MAIN MENU** by pressing the **MENU** key. The analyzer can be configured for two types of transducers, the Current-to-Current or the Current-to-Voltage type. The Current-to-Current type will be connected to the current input receptacles on the rear panel. The Current-to-Voltage type will be connected to the T input connection on the rear panel which is a BNC-Type connection.

The following diagram shows the recommended method for wiring up an external current transducer to the PA2801 or PA2802.

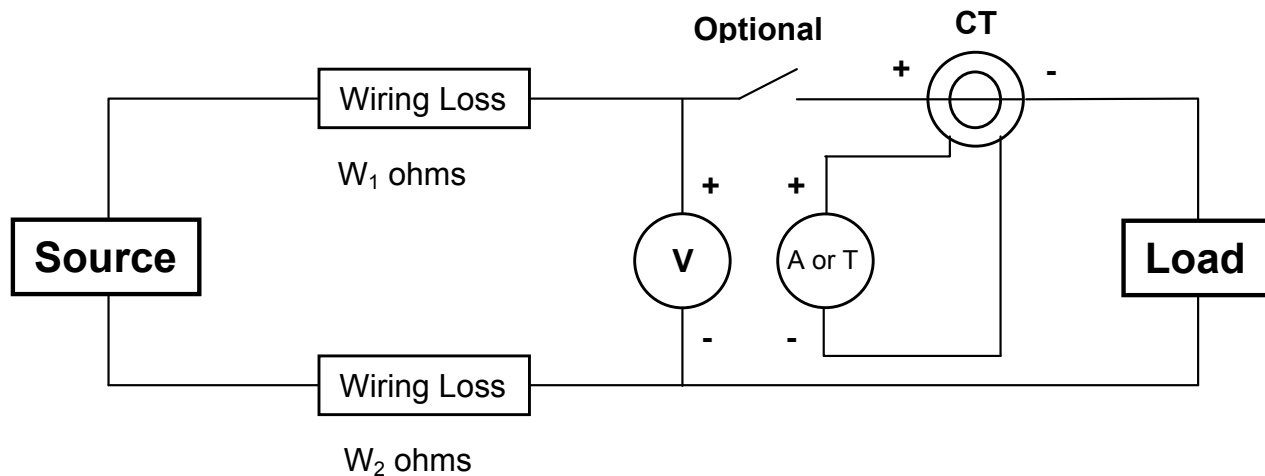


Figure 24. External Transducer Test Connections

To setup the unit for the type of current transducer being used, it is recommended to use the **GETTING STARTED** routine under the **MAIN MENU**. If not, then refer to the **SETUP MEASUREMENTS/ SETUP CHANNEL** menu to configure the **CURRENT INPUT** and the **CURRENT SCALING** for the type of current transducer used.

When the second choice **SELECT CURRENT MEASUREMENT** is displayed, there are 3 choices from which to choose. Select choice 2 or 3

depending on the type of current transducer being used. Use the **ARROW** keys to highlight the choice and press **ENTER** to select

- 1 Internal Shunt (A terminals)
- 2 External CT (Current Out, A Terminals)
- 3 External CT (Voltage Out, T Connector)

The **ENTER CURRENT RATIO 1** will now be displayed. Use the arrow keys to change the highlighted item. Press the F1 or F2 keys to move the highlight left or right. Use the DEL key to delete numbers and use the .X to enter a decimal point. As an example, to set up a ratio of +1000 : 1.005 from the default settings,

PERFORM THE FOLLOWING STEPS:

- Press the F2 key twice
- Press the DEL key once. The decimal point will disappear and the screen will show +10 A.
- Press the F2 key once, the screen will show +100 A.
- Press the F2 key one more time, the screen will show +1000 A.
- Press the ENTER key.

The **ENTER CURRENT RATIO 2** will now be displayed, set this for a setting of 1.005 (as an example).

- Press the F2 key 4 times, the screen will show 1.000 V.
- Press the UP ARROW key 5 times, the screen will show 1.005 V.
- Press the ENTER key.

Complete any additional changes required to configure the analyzer for the desired measurements.

Note the following-

1. If the power analyzer unexpectedly displays negative watts indications, these indications mean that the current flow in the transducer is reversed. Check for one of these conditions:

- the wire is reversed in the transducer;
- the neutral wire was inadvertently routed through the transducer (instead of the live wire), or;
- the transducer output has the incorrect polarity.

The negative watts indication may be resolved by correcting the wiring, or by setting the current input scale factor in the power analyzer to a negative polarity, or by selecting REVERSE CURRENT INPUT from the WIRING ADJUSTMENTS menu.

2. If a transducer is being used which has DC current capability then the user should perform the DC ZERO procedure. This is performed after making the connections and allowing the external transducer to settle after application of its power.
3. Particularly when operating at low current levels, it may be important to ensure that the voltage signals cannot capacitively couple into the current transducer output. The use of flexible coaxial cable is recommended for the current transducer output wiring.

## Starting the Analyzer

The following startup display will show for a few seconds and then return to the measurement display last used.

<b>2801</b>	
SERIAL NUMBER:	
MAIN	v2.12/v1.01
ANALOG	v2.11/v1.02/v1.02
FPGA	v1.02

<b>2802</b>	
SERIAL NUMBER:	
MAIN	v2.12/v1.01
ANALOG	v2.11/v1.02/v1.02
FPGA	v1.02

Figure 25. Startup Screen PA2801 and PA2802

## Configuring the Power Analyzer PA2801/PA2802

The MAIN MENU screen gains access to the areas for setting up the instrument. You will find the menus for the following routines –

### PA2801

GETTING STARTED  
SETUP MEASUREMENTS  
SETUP SYSTEM  
CONFIGURATION STORAGE  
PERFORM DC ZERO  
DIAGNOSTICS  
ABOUT

### PA2802

GETTING STARTED  
CHANNEL CONFIGURATION  
SETUP INPUT MEASUREMENTS  
SETUP OUTPUT MEASUREMENTS  
SETUP SYSTEM  
CONFIGURATION STORAGE  
PERFORM DC ZERO  
DIAGNOSTICS  
ABOUT

To gain access to the Main Menu, press the MENU key. This will bring up the MAIN MENU screen display as shown below.



Figure 26. Main Menu Screen

*Important Note:* **We recommend the GETTING STARTED setup described below when setting up the PA2801/PA2802 Power Analyzer for the first-time.**

## Getting Started

The first item listed is GETTING STARTED. This is a listing of the preset applications and predefined measurement settings that can be selected to configure the PA2801/PA2802. We recommend selecting the appropriate choice that corresponds to your application when using the power analyzer for the first time.

### *To initiate the Getting Started setup:*

1. Press the up or down arrow key to highlight GETTING STARTED, press the **ENTER** key to view the application choices. The application in Bold is the factory default setting

#### PA2801 APPLICATIONS

##### **LINE (40Hz – 1kHz) HF**

(40Hz-80kHz)

HF (10kHz-200kHz) DC

(40Hz-5kHz Ripple) DC

(nx50Hz Ripple) DC

(nx60Hz Ripple) DC

(nx400Hz Ripple) LF

(0.5Hz-20Hz)

LF (0.02Hz-5Hz)



## PA2802 APPLICATIONS

3 $\Phi$ 3w

2 $\Phi$ 3w

1 $\Phi$ 3w

DC:DC

DC:LINE

DC:HF

LINE:DC

LINE:LINE (SYNC)

LINE:LINE (ASYNC)

LINE:HF

**DUAL:LINE (ASYNC)**

DUAL HF (ASYNC)

2. Press the up or down arrow key to highlight the application that best fits your intended use, press the **ENTER** key to select your choice

## **Channel Configuration (PA2802 Only)**

The second item listed is CHANNEL CONFIGURATION, this is used to set how the channels will be used within the application. (**Note. There is no need to select one of these options if you had previously selected one of the quick start choices**)

This is a listing of the preset channel configuration settings that can be selected to configure the PA2802.

### ***To initiate the CHANNEL CONFIGURATION setup:***

1. Press the up or down arrow key to highlight CHANNEL CONFIGURATION, press the **ENTER** key to view the application choices.

### CHANNEL CONFIGURATION

3 $\Phi$ 3w

2 $\Phi$ 3w

1 $\Phi$ 3w

IN:OUT (ASYNC)

IN:OUT (SYNC)

INDEP CHANNELS

2. Press the up or down arrow key to highlight the application that fits your intended use, press the **ENTER** key to select your choice

## **Configuring the Analyzer Measurement Results**

This section gives a brief description of the menu selections from which to define the desired measurements. The SETUP MEASUREMENT choices will vary depending on which GETTING STARTED or CHANNEL CONFIGURATION has been selected. Once in the setup menu the selections are listed in the order that they come up on the analyzer display. Indentation is used to denote submenu position. The application in **BOLD** is the ship from factory default setting for the PA2801/PA2802.

For PA2801 SETUP MEASUREMENTS is your only choice, for the PA2802 and if the application is set for 3 $\Phi$ 3w, 2 $\Phi$ 3w or 1 $\Phi$ 3w then the menu choice is

SETUP MEASUREMENTS

If the application is setup for DC:DC then the menu choice is

SETUP OVERALL MEASUREMENTS

SETUP INPUT MEASUREMENTS

SETUP OUTPUT MEASUREMENTS

If the application is setup for DC:LINE, DC:HF, LINE:DC then the menu choice is

SETUP INPUT MEASUREMENTS  
SETUP OUTPUT MEASUREMENTS

If the application is setup for LINE:LINE (sync) then the menu choice is

SETUP OVERALL MEASUREMENTS  
SETUP INPUT MEASUREMENTS  
SETUP OUTPUT MEASUREMENTS

If the application is setup for LINE:LINE (async), LINE:HF then the menu choice is

SETUP INPUT MEASUREMENTS  
SETUP OUTPUT MEASUREMENTS

**If the application is setup for DUAL:LINE (async), DUAL:HF then the menu choice is (PA2802 Default setting)**

**SETUP Ch1 MEASUREMENTS**  
**SETUP Ch2 MEASUREMENTS**

***To Select SETUP MEASUREMENTS PA2801:***

1. Press the **MENU** key to bring up the MAIN MENU. The second selection is SETUP MEASUREMENTS... Press the down arrow key to highlight SETUP MEASUREMENTS.
2. Press the **ENTER** key to enter into the SETUP MEASUREMENTS, as shown in Figure 26.

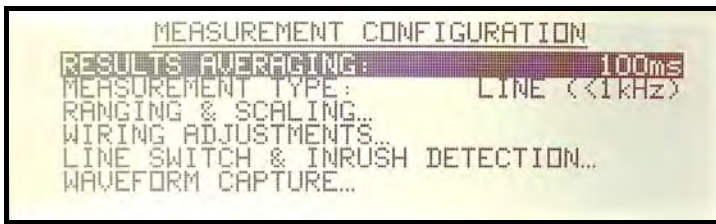


Figure 27. Measurement Configuration Screen

***To Select SETUP MEASUREMENTS PA2802:***

3. Press the **MENU** key to bring up the MAIN MENU. The third selection is SETUP Ch1 MEASUREMENTS... from which Channel One's measurement settings are accessible.
4. Press the down arrow key to highlight SETUP Ch1 MEASUREMENTS.
5. Press the **ENTER** key to enter into the SETUP Ch1 MEASUREMENTS, as shown in Figure 27.

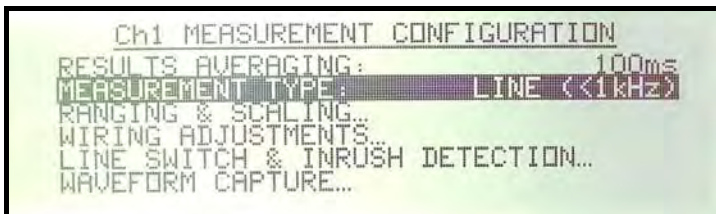


Figure 28. Measurement Configuration Screen

## Setting Up the Measurement Configuration

There are six selections in the MEASUREMENT CONFIGURATION menu. The following section defines each of the selections and the associated submenu options available. Refer to the arrow on the side of this display and scroll this menu down to access each one:

RESULTS AVERAGING:

MEASUREMENT TYPE:

RANGING AND SCALING ...

WIRING ADJUSTMENTS ...

LINE SWITCH & INRUSH DETECTION ...

WAVEFORM CAPTURE ...

### RESULTS AVERAGING

All displayed measurements can be averaged using a two-pole filter having a user-selected time constant. This setting only affects the displayed measurement results, it does not affect any charted measurement results.

- NONE; 10ms; 20ms; 50ms; **100ms**; 200ms; 500ms; 1 Sec; 2 Sec; 5 Sec; 10 Sec; 20 Sec; 1 Min

### MEASUREMENT TYPE

This menu item contains the following seven setup selections –

#### LINE FREQ (<1kHz)

Configures the analyzer to make optimal signal measurements at line frequencies in the 40 to 1000Hz range. To accomplish this, the analyzer –

- 1) Synchronizes on the voltage waveform with frequencies in the range of 40Hz to 1000Hz; and
- 2) Tracks the input signals using a low-pass filter where the filter corner frequency automatically adjusts to maintain better than 5% accuracy at 200 times the fundamental frequency.

**Note:** When you enable autorange and a downrange is required, the analyzer downranges at the rate of 20ms per range. LINE FREQ (40-1000Hz) is the recommended selection when making line measurements.

**HIGH FREQ (>40Hz)**

Configures the analyzer to make the optimal signal measurements at frequencies higher than line frequency, in the range 40Hz to above 100kHz. The analyzer –

- 1) Synchronizes on the voltage waveform with frequencies in the range of 40Hz to above 100kHz; and
- 2) Tracks input signals using no low-pass filtering.

**Note:** When you enable autoranging and a downrange is required, the analyzer downranges at the rate of 20ms per range. HIGH FREQ (>40Hz) is the recommended selection when making high frequency measurements or for line measurements where a large amount of high frequency signal content is present.

**10kHz -200kHz**

Configures the analyzer to make optimal signal measurements at frequencies in the range 10kHz to 200kHz. To accomplish this, the analyzer –

- 1) Synchronizes on the voltage waveform with frequencies in the range of 10kHz to 200kHz; and
- 2) Tracks the input signals using a fixed low-pass filter where the filter corner frequency is set to maintain better than 5% accuracy at 10kHz.

**Note:** When you enable autoranging and a downrange is required, the analyzer downranges at the rate of 10ms per range. The 10kHz-200kHz selection is recommended when making high frequency measurements. The 10kHz -200kHz setting is not recommended for line measurements.

**DC**

Configures the analyzer to make optimal signal measurements at DC. To accomplish this, the analyzer operates as follows.

- 1) When not configured for ripple measurements -

Measurements of DC and AC are made over 50ms periods. No harmonic data is available. Frequency is not measured. Signals have a fixed-corner, 4kHz, low-pass filter applied.

- 2) When configured for ripple measurements –

All DC and non-harmonic AC measurements are made over the longer of 5ms (rounded upwards to the nearest integer number of cycles) or one

cycle of the entered base ripple frequency. All harmonic data is measured over the longer of 5ms (rounded upwards to the nearest integer number of cycles) or four cycles of the entered base ripple frequency. Frequency is not measured. Signals have a fixed-corner, low-pass filter applied with a corner frequency equal to 200 times the entered base ripple frequency

**Note:** When you enable autorange and a downrange is required, the analyzer downranges at the rate of 20ms per range. DC is the recommended selection when making DC measurements.

### **USER SET**

This selection brings up a menu choice in the Ch1 MEASUREMENT CONFIGURATION that allows you to directly select USER SET MEASUREMENT configuration parameters, which are automatically set for the other selections. Refer to USER SET MEASUREMENT below.

**Note:** This USER SET selection is not recommended for inexperienced users.

### **LOW FREQ (0.5-20Hz)**

Configures the analyzer to make optimal signal measurements at frequencies less than line frequency, in the range 0.5 to 20Hz. To accomplish this, the analyzer –

- 1) Synchronizes on the voltage waveform with frequencies in the range of 0.5Hz to 20Hz; and
- 2) Tracks the input signals using a fixed low-pass filter where the filter corner frequency is set to maintain better than 5% accuracy at 10kHz.

**Note:** When you enable autoranging and a downrange is required, the analyzer downranges at the rate of 10s per range. The LOW FREQ (0.1-100Hz) selection is recommended when making low frequency measurements. LOW FREQ is not recommended for line measurements.

### **LOW FREQ (0.02-5Hz)**

Configures the analyzer to make optimal signal measurements at frequencies less than line frequency, in the range 0.02 to 5Hz. To accomplish this, the analyzer –

- 1) Synchronizes on the voltage waveform with frequencies in the range of 0.02Hz to 5Hz; and

2) Tracks the input signals using a fixed low-pass filter where the filter corner frequency is set to maintain better than 5% accuracy at 10kHz.

**Note:** When you enable autoranging and a downrange is required, the analyzer downranges at the rate of 10s per range. The LOW FREQ (0.02 - 5Hz) selection is recommended when making very low frequency measurements. LOW FREQ is not recommended for line measurements.

## USER SET MEASUREMENT...

The Following are the MENU choices for the  
USER SET MEASUREMENT CONFIGURATION menu

HF FILTER TYPE:  
SYNC SOURCE  
MIN FUNDAMENTAL  
MAX FUNDAMENTAL  
MAX HARMONIC  
DOWNRANGE DELAY

The following paragraphs define the above options.

- **HF FILTER TYPE - NONE, ADAPTIVE CUTOFF OR FIXED CUTOFF**
- **NONE:** No HF Filter.
- **Adaptive Cutoff HF Filter:** This is a similar filter to that for the Fixed Cutoff HF Filter, but the cutoff frequency is continuously adjusted to maintain a specific ratio to the measured fundamental frequency. Another name for this (and actually a better name) is a Tracking Filter.
- **Fixed Cutoff HF Filter:** This provides a 4-pole Butterworth LP filter which is 5% down at a defined, fixed, frequency.
- **SYNC SOURCE**  
There are two selections for this entry –  
**FROM VOLTAGE**  
The analyzer measures the fundamental frequency from the



signal content of the applied voltage signal. To measure the fundamental in the applied voltage signal, enter both a maximum fundamental frequency and a trigger level.

#### **FROM CURRENT**

This is similar to the FROM VOLTAGE selection, however, uses the selected current input signal as the source of fundamental frequency measurements. Most effective when used where the voltage signal has complex frequency content. (e.g. Use FROM CURRENT with switch-mode motor drives.)

- **MIN FUNDAMENTAL**

This option sets the lowest frequency to which the analyzer will synchronize and sets the rate at which downranging occurs (if ENABLED). Selecting an extremely low value makes auto-ranging very slow, as the minimum down range interval is one period of this settable frequency.

- **MAX FUNDAMENTAL**

This option sets the highest frequency to which the analyzer will synchronize and determines the number of harmonics measurable.

- **MAX HARMONIC**

This sets the range of Harmonics that will be reported back. There are two choices with in the menu, SET MIN and SET MAX.

- **DOWNRANGE DELAY**

This entry gives you control of the minimum time between successive downranges when using autoranging. Typically set to one period of the expected lowest frequency of any signal content (e.g. 20ms for most measurements). However there may be cases where the applied signal has considerable sub-fundamental signal content (e.g. a computer may draw a varying current with a period of a few hundred milliseconds, or a high frequency signal may have significant line modulation). Note that to stop the analyzer from continuously autoranging to accommodate these fast, regular, changes in signal, the entry for the DOWNRANGE DELAY can be extended.

**Note:** Typically the analyzer can downrange up to two ranges per interval, setting an overly lengthy MIN DOWNRANGE TIME can slow down autoranging when traversing from the highest to the lowest range.

## **RANGING & SCALING**

This menu item contains the following four setup selections –

- **VOLTAGE RANGE**

This option allows the user to select AUTO (ranging) or a fixed range to measure the voltage signal. When auto-range has been selected, the actual range being used is displayed in parentheses after AUTO.

Selections: **AUTO**; 850V; 450V; 135V; 50V; 20V

**Note** : The instrument's ability to safely withstand high voltages is not affected by this selection.

- **CURRENT INPUT**

This option allows the user to select whether the analyzer uses the internal current shunt DIRECT (A INPUT), or an external transducer having a voltage output (the BNC input, T), or an external transducer having a current output (A INPUT) as the current signal.

TERMINALS (CURRENT): or TRANSDUCER (VOLTAGE): or TRANSDUCER (CURRENT)

- **CURRENT RANGE**

This option allows the user to select AUTO or a fixed range to be used for measurements of the selected current signal. When auto-range has been selected the actual selected range being used is displayed in parentheses after AUTO.

**AUTO**; 65A; 20A; 6.5A; 2A; 0.65A; 300mA; 100mA; 30mA; 10mA  
Transducer - **AUTO**; 15V; 5V; 1.5V; 0.5V; 0.15V.

**Note:** When using the internal current shunt and a fixed range of 300mA or lower, the analyzer does NOT have full ability to withstand high current continuous overloads unless the analyzer is enabled to up-range for protection (see the STRICT RANGING selection).

- **STRICT RANGING**

*This selection is only available if either the voltage, or current input, (or both) has a fixed range selected.* Setting this to NO enables the analyzer to auto-range to a higher capability range than that selected in order to protect itself from overloads. Setting this to YES forces the analyzer to select the USER SET range.

NO or YES

- **CT RATIO**

This option is only shown when the CT (A INPUT) or the CT (T INPUT) is configured. This allows the user to apply a fixed scale factor to all current measurements. This is normally used to adjust for

the scale factor of an external current transducer.

### CT RATIO SETTING

Press the DOWN arrow key to highlight CT RATIO, press the ENTER key.

You can move the cursor in the window by using the F1 or F2 keys, these keys will move the cursor left or right.

When the highlighted cursor is in the correct position, use the UP or DOWN ARROW keys to change the highlighted number or symbol

Press the ENTER key when finished.

Note: You can press the CLEAR (F3) key to start over, or clear the screen.

The INPUT scale is set first, when the ENTER key is pushed the CT RATIO OUT screen will then be shown, repeat the above steps to enter in the correct ratio number for the output setting.

Press the ENTER to key to finish entering in the CT RATIO

### WIRING ADJUSTMENTS...

This selection brings up the WIRING ADJUSTMENTS menu –



Figure 29. Wiring Adjustments Menu Screen

#### ○ MEASURE

Select LOAD or SOURCE according to whether the “virtual” voltage measurement point is closer to the load or to the source

from the analyzer.

**LOAD** or **SOURCE**

- **WIRING COMPENSATE:**

Setting this to YES enables the analyzer to adjust for any external or internal wiring losses in the measurement of the voltage signal.

When set to YES an additional option becomes available –

**WIRING LOSS.**

**NO** or **YES**

- **WIRING LOSS**

Enter the estimated or measured external wiring impedance between the point at which the analyzer's actual voltage measurements are being made and the point at which the desired "virtual" voltage measurements should be made.

This is a four position, decimal point, milliohm unit of measure.

- **COMPENSATE V BURDEN**

Although very small, there is a finite current flowing between the voltage terminals of the analyzer. Depending on the wiring method, this current may flow through the current measuring device (internal shunt or external transducer). If it is desired to eliminate error in current measurements caused by this excess signal, set this option to YES, which enables the analyzer to automatically adjust the current signal for the current flowing in the voltage terminals.

**NO** or **YES**

**Note:** When enabled this adjusts for the actual signal flowing in the voltage terminals, in real-time.

- **REVERSE VOLTAGE POLARITIES**

Setting this to YES reverses the polarity of the voltage signal being measured by the analyzer.

**NO** or **YES**

- **REVERSE CURRENT POLARITIES**

Setting this to YES reverses the polarity of the current signal being measured by the analyzer.

**NO** or **YES**

### LINE SWITCH & INRUSH DETECTION

This option allows the user to define what type of signal is being controlled by the internal line switch:

- **NONE**  
If this is selected, the internal line switch is continuously held in the ON state.
- **INTERNAL**  
If this is selected, the internal line switch will turn on (when commanded to do so) at the user-entered line switch phase of the applied voltage signal and will turn off (when commanded to do so) at the zero crossing of the current signal.
- **EXTERNAL**  
If this is selected, an external line switch can be used to switch signals without regard to phase or current state. The Digital I/O can be used to control the external line switch (See SETUP SYSTEM)

**Note:** Selecting DC when using an AC signal at large currents may degrade the reliability of the analyzer.

### TURN ON PHASE (Shows when INTERNAL is selected)

This option allows the user to select a user-defined phase of the input voltage at which the line switch be turned on or a PRESET choice of 0°, 45°, 90°, 135°, 180°, 225°, 270° or 315°.

To set the TURN ON PHASE, press the ENTER key when TURN ON PHASE is highlighted, you have the option to enter your own value by using the F1, F2 keys to scroll the cursor right and left and the use the up and down arrow keys to change the character.

To use one of the PRESET values, press the F4 key to enter the PRESET menu, use the up and down arrow keys to highlight your selection and press the ENTER key to select your choice. You can then edit the number or press ENTER again to save and exit out of the menu.

By pressing the F3 CLEAR key, this will clear your selection.

**INRUSH CURRENT RANGE (Shows when INTERNAL is selected)**

This option allows the user to select a fixed range to be used for measurements of the selected current signal.

**65A; 20A; 6.5A; 2A; 0.65A; 300mA; 100mA; 30mA; 10mA**

**INRUSH CURRENT TRIGGER ENABLE**

- **INRUSH CURRENT TRIGGER ENABLE**

Setting this to YES enables the analyzer to capture INRUSH and STARTUP screen captures based on user-defined current trigger levels.

The Menu choices are **NO** and **YES**. These are set by pressing the ENTER key when the INRUSH CURRENT TRIGGER ENABLE is highlighted, use the up and down arrow keys to select NO or YES, press ENTER to select.

When set to NO, the analyzer will use the line switch as the trigger to capture data for the INRUSH and STARTUP screens.

The following guidelines can be used to setup the appropriate combination for triggering the INRUSH and STARTUP charts.

1. When the LINE SWITCH is set to NONE and the INRUSH CURRENT TRIGGER ENABLE is set to NO. Inrush & startup capture is disabled.
2. When the LINE SWITCH is set to INTERNAL or EXTERNAL and the INRUSH CURRENT TRIGGER ENABLE is set to NO. the Inrush & Startup capture is triggered when the Line Switch is turned on.
3. When the LINE SWITCH is set to NONE and the INRUSH CURRENT TRIGGER ENABLE is set to YES. The user also has to configure the inrush current trigger level (INRUSH DETECT LEVEL). Inrush & Startup capture is triggered by an inrush current detection.
4. When the LINE SWITCH is set to INTERNAL or EXTERNAL and the INRUSH CURRENT TRIGGER ENABLE is set to YES. The

user also has to configure the inrush current trigger level (INRUSH DETECT LEVEL). Inrush & Startup capture is triggered when the Line Switch is turned on and then waits for an inrush current detection.

- **Note:** The inrush waveforms (voltage and current signals) are always captured for a period of approximately 3ms before and 65ms after the trigger event. This data has a time resolution of nominally 4.1us per point.

#### **INRUSH DETECT LEVEL** (Shows when INRUSH CURRENT TRIGGER ENABLE is selected)

This option allows the user to select a user-defined trigger level for the inrush current or PRESET choices of 100mA, 1A, 10A or 100A.

To set the preset INRUSH DETECTION LEVEL, press the ENTER key when INRUSH DETECT LEVEL is highlighted. You have the option to enter your own value by using the F1, F2 keys to scroll the cursor right and left and the use the up and down arrow keys to change the character.

To use one of the PRESET values, press the F4 key to enter the PRESET menu, use the up and down arrow keys to highlight your selection and press the ENTER key to select your choice. You can then edit the number or press ENTER again to save and exit out of the menu.

By pressing the F3 CLEAR key, this will clear your selection.

#### **CAPTURE FILTERED WAVEFORM** (Shows when INRUSH CURRENT TRIGGER ENABLE is selected)

This option allows the user to configure the waveform capture system in the analyzer. Waveforms are captured by the analyzer when an “event” occurs on either the voltage or current signal. This event can be either a peak in the actual signal or a peak in the “virtual” signal created by removing the

fundamental component.

The CAPTURE FILTERED WAVEFORM setting selects whether the captured waveform is to be filtered or not -

The Menu choices are NO and YES. These are set by pressing the ENTER key when the CAPTURE FILTERED WAVEFORM is highlighted, use the up and down arrow keys to select NO or YES, press ENTER to select.

- YES : the captured inrush waveform is filtered according to the filtering selected by the measurement type (see below).
- NO : the captured inrush waveform is totally unfiltered (i.e. full bandwidth of the product).

The filtering that is used for each measurement type is as follows, this filtering applies to all measurements,

- MEASUREMENT TYPE = LINE : Uses an Adaptive HF Cutoff filter with an upper cutoff (5% down) of the lower of 60kHz or twice the maximum measured harmonic frequency.
- MEASUREMENT TYPE = HF : Uses a Fixed HF Cutoff filter with an upper cutoff (5% down) at 200kHz.
- MEASUREMENT TYPE = 10kHz-200kHz : Uses no HF filtering.
- MEASUREMENT TYPE = USER SET : Filtering is set by the user.
- MEASUREMENT TYPE = DC : If uses a fixed frequency ripple measurement - Uses a Fixed HF Cutoff filter with an upper cutoff (5% down) at 200 times the user entered fixed ripple frequency, otherwise – uses a Fixed HF Cutoff filter with an upper cutoff (5% down) at 4kHz.
- MEASUREMENT TYPE = 0.5-20Hz : Uses an Adaptive HF Cutoff filter with an upper cutoff (5% down) of the lower of 14kHz or 100 times the measured fundamental frequency.



- MEASUREMENT TYPE = 0.02-5Hz : Uses an Adaptive HF Cutoff filter with an upper cutoff (5% down) of the lower of 4kHz or 100 times the measured fundamental frequency.

### **STARTUP (NOT SHOWN in the menus, this is for information only)**

To enable the STARTUP graph you must enable either the Line Switch or turn on INRUSH CURRENT TRIGGER ENABLE to YES and set the appropriate trigger level under the INRUSH DETECT LEVEL. This is found under the MAIN MENU, SETUP MEASUREMENTS, LINE SWITCH & INRUSH DETECTION.

**Note:** To get data on the INRUSH or STARTUP screen the unit must be configured and set properly or the system will not trigger or show results on the INRUSH and STARTUP graph screens.

The Startup Chart is not user settable. The STARTUP chart runs until the first of the following occurs –

1. The chart is full (typically about 4 minutes)
2. The user turns off the Line Switch. The chart will run for about 350ms afterwards to ensure that the user can also see the “power down” data.

STARTUP data is collected similarly to a history chart, so you can “inspect” using the cursors to “zoom in” on a particular time span. To do this when looking at the STARTUP graph, perform the following steps.

- Press the CURSOR (F2) key, this will bring up the cursors.
- Use the right or left arrow key to move the active cursor in the display window, the CURSOR with the TRIANGLE on the top and bottom of the cursor is the active cursor.
- Press the CURSOR (F2) to toggle to the other cursor

- Press ENTER to zoom into the data. The data that is between the two cursors will fill the screen. This can be repeated to zoom in further by repeating the above steps. Note: that the cursors will be at the edge of the display windows each time you enter back into the cursor window.
- Press the ZOOM OUT (F3) key to zoom back out or you can press the FULL SPAN (F4) key to exit back to the STARTUP screen.

## WAVEFORM CAPTURE

This menu item contains the following setup selections –

The WAVEFORM CAPTURE setting selects the signal on which the unit will trigger when enabled.

The Menu choices are as follows.

NONE: Trigger is disabled

Vpeak: Unit will trigger on the voltage peak.

Vglitch: Unit will trigger on a voltage glitch or anomaly.

Apeak: Unit will trigger on a current peak.

Aglitch: Unit will trigger on a current glitch or anomaly.

These are set by pressing the ENTER key when the WAVEFORM CAPTURE is highlighted. Then, press the ENTER key again to enter into the menu choices. Use the up and down arrow keys to highlight, then press ENTER to select.

Set the TRIGGER LEVEL.

Press the DOWN arrow key to highlight TRIGGER LEVEL, press the ENTER key.

You can move the cursor in the window by using the F1 or F2 keys, these keys will move the cursor left or right.

When the highlighted cursor is in the correct position, use the UP or DOWN ARROW keys to change the highlighted number or symbol

Press the ENTER key when finished.

Note: You can press the CLEAR (F3) key to start over, or clear the screen.

Press the MENU key to exit back to the MEASUREMENT CONFIGURATION menu, or keep pressing the MENU key to exit back to the main display screens.

## **Setting Up the Ch2 Measurement Configuration (PA2802 Only)**

There are four selections in the Ch2 MEASUREMENT CONFIGURATION menu. The following section defines each of the selections and the associated submenu options available. Refer to the arrow on the side of this display and scroll this menu down to access each one:

RESULTS AVERAGING:

MEASUREMENT TYPE:

RANGING AND SCALING...

WIRING ADJUSTMENTS...

The configuration of these menus are identical to the methods described in the section for Configuring the Analyzer's Measurement Results.

## **Setup System**

Access the SETUP SYSTEM MENU from the MAIN MENU. Press ENTER at highlighted item to access.

The initial setup includes setting the correct date and time in the desired format; adjusting the contrast and turning on the backlight, if necessary. Also use this menu to configure the IEEE488 address, RS232 baud rate and configure the DIGITAL I/O ports.

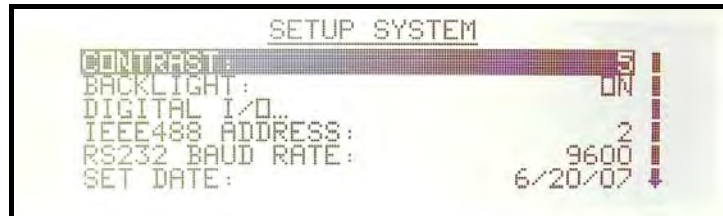


Figure 30. System Menu Screen

### Setting Contrast and Backlight

Scroll through the 10 available contrast settings to determine the best one; mid point is 5, 6, or 7. Select OFF for the backlight only if there is sufficient external light to read the display.

### DIGITAL I/O

The following are the available configurations for the DIGITAL I/O:

- LINE ON INPUT
- INTEGRATE INPUT
- CLR INTEGRATE INPUT
- LINE ON OUTPUT
- INTEGRATE INPUT (CH2)
- CLR INTEGRATION INPUT (CH2)
- MEASUREMENT HOLD INPUT

Each of the above choices can be configured individually by highlighting your selection, press ENTER, and use the UP or DOWN arrow key to select the setting for this DIGITAL I/O port. The choices are

- DISABLED
- ACTIVE HIGH
- ACTIVE LOW

## IEEE488 Address Setting

Select the appropriate IEEE-488 (GPIB) address from zero to 31 in accordance with IEEE-488. The factory default setting is address **2**.

## RS232 Baud Rate Setting

Select the appropriate baud rate (RS-232). The choices that are available are 9600, 19200, 38400, 57600, 115200 and 230400. The factory default setting is **115200**.

## Setting Date and Time

### DATE

Select the correct date from a calendar format. Use the arrow keys to scroll the highlight up and down. Use the F1 and F2 softkeys to scroll left and right. The F3 softkey moves back one month and F4 moves forward one month. Press ENTER when done.

### TIME

Select the correct time in the default format. Use the arrow keys to increase or decrease the number value. Use the F1 and F2 softkeys to move to a new position. The factory default settings are in **bold**.

### DATE FORMAT

Select the desired date format from the following choices:

<b>MM/DD/YY</b>	11/24/06
DD/MM/YY	24/11/06
MONTH DATE, YEAR	November 24 2006
DATE MONTH YEAR	24 November 2006

### TIME FORMAT

Select the desired time format from the following choices:

<b>12 HOUR AM/PM</b>	6:30:04PM
24 HOUR	18:30:04

### LANGUAGE

Only ENGLISH is supported at this time.

## Configuration Storage

Access the LOAD/SAVE CONFIGURATION from the MAIN MENU. Press ENTER at highlighted item to access. There are 6 storage locations available. They are numbered 1 through 6.

### SAVE

To save configuration changes, highlight SAVE, press ENTER, scroll to the configuration location in which you want to save your configuration and press ENTER.

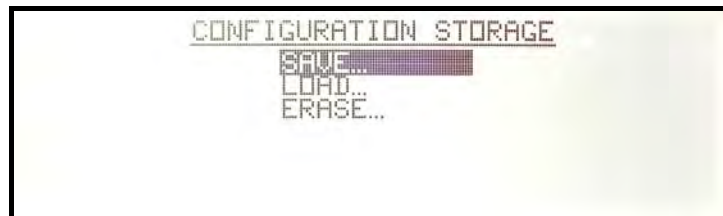


Figure 31. LOAD/SAVE Main Menu Screen

### LOAD

To LOAD a previously saved configuration, press the ARROW key to select LOAD and then press the ENTER key. The screen will change to LOAD CONFIGURATION as shown below. Press the ARROW keys to scroll up or down the choices.

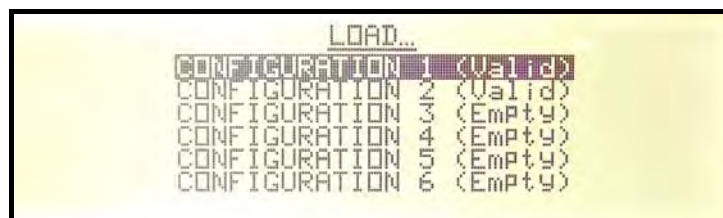


Figure 32. Load Configuration Selection Screen

## ERASE

To ERASE a previously saved configuration, press the ARROW key to select ERASE and then press the ENTER key. The screen will change to ERASE as shown below. Press the ARROW keys to scroll up or down the choices.

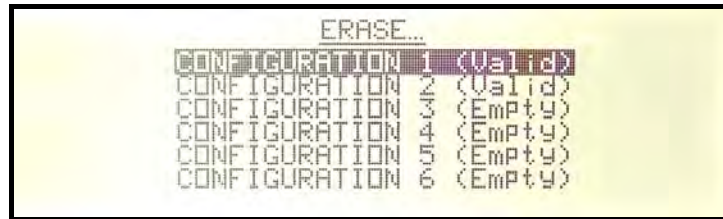


Figure 33 Erase Configuration Selection Screen

## Perform DC Zero

To initiate a DC ZERO, press the MENU key. Use the arrow keys up or down to highlight PERFORM DC ZERO. Press the ENTER key and follow the prompts.

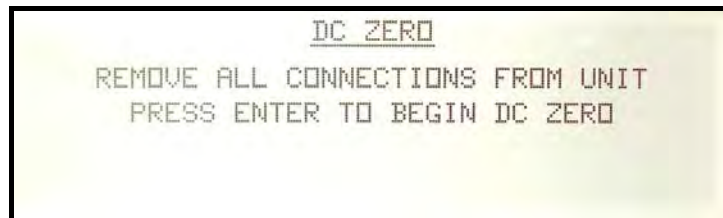


Figure 34. DC Zero Screen

**NOTE: The T input BNC connector on the rear panel (external transducer input) MUST be shorted using a 50 ohm BNC plug when performing a DC ZERO.**

## Diagnostics

To perform DIAGNOSTICS, press the MENU key. Use the arrow keys to highlight DIAGNOSTICS, press the ENTER key. Press the up or down arrow

key to select from the choices LCD TEST; LED TEST; KEYPAD TEST; PERFORMANCE.

The LCD TEST scans the pixels. This will continue until any one of the keys is pressed, with exception of the LINE SWITCH key which is disabled while in this menu.

The LED TEST will turn on and off the OVERLOAD LEDs and the LINE SWITCH LEDs in a round robin format. This will continue until any one of the keys is pressed, with exception of the LINE SWITCH key which is disabled while in this menu.

The KEYPAD TEST is used to verify that the front panel keys are operational. When a key is pressed, the key name will appear on the screen. When the MENU key is pressed the name will flash on the screen and then the screen will exit to the DIAGNOSTIC MENU.

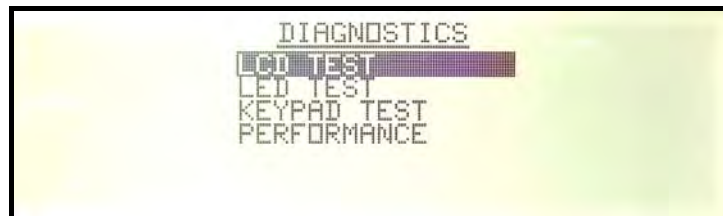
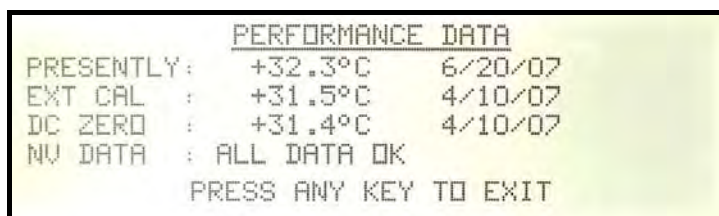


Figure 35. Diagnostic Menu Screen

The PERFORMANCE screen provides the user with the present internal instrument temperature and the temperature for which the EXT CALIBRATION and DC ZERO were performed. If the internal temperature has changed by more than +/- 5 Deg C, then it is recommended that the DC ZERO procedure be followed.



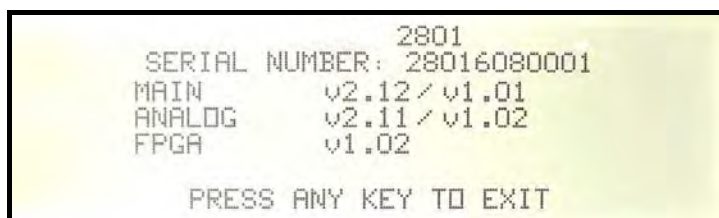
A screenshot of a device's performance screen. The screen has a light green background and a black border. At the top, the text 'PERFORMANCE DATA' is centered. Below it, there are four lines of data: 'PRESENTLY: +32.3°C 6/20/07', 'EXT CAL : +31.5°C 4/10/07', 'DC ZERO : +31.4°C 4/10/07', and 'NV DATA : ALL DATA OK'. At the bottom, the text 'PRESS ANY KEY TO EXIT' is centered.

```
PERFORMANCE DATA
PRESENTLY: +32.3°C 6/20/07
EXT CAL : +31.5°C 4/10/07
DC ZERO : +31.4°C 4/10/07
NV DATA : ALL DATA OK
PRESS ANY KEY TO EXIT
```

Figure 36. Performance Screen

## About

The ABOUT screen displays the current firmware revisions and the serial number of the unit.

A screenshot of a device's about screen. The screen has a light green background and a black border. At the top, the text '2801' is centered. Below it, the text 'SERIAL NUMBER: 28016080001' is centered. Then, there are three lines of data: 'MAIN v2.12 / v1.01', 'ANALOG v2.11 / v1.02', and 'FPGA v1.02'. At the bottom, the text 'PRESS ANY KEY TO EXIT' is centered.

```
2801
SERIAL NUMBER: 28016080001
MAIN v2.12 / v1.01
ANALOG v2.11 / v1.02
FPGA v1.02
PRESS ANY KEY TO EXIT
```

Figure 37. About Screen

## Default Settings

The following default settings for the PA2801/PA2802 analyzer support the rear panel's wiring connection Method 1. Access the **SETUP MEASUREMENTS MENU** from the **MAIN MENU**.

### SETUP CHANNEL

MEASUREMENT TYPE	LINE FREQ (<1kHz)
VOLTAGE INPUT	AUTO
CURRENT INPUT	DIRECT (A INPUT)
CURRENT RANGE	AUTO
STRICT RANGING	NO
CURRENT SCALING	DISABLED
MEASURE	LOAD
WIRING COMPENSATION	NO
COMPENSATE V BURDEN	NO
REVERSE VOLTAGE	NO
REVERSE CURRENT	NO
<b>Note:</b> Above 1kHz select HIGH FREQ; below 40Hz select LOW FREQ	
SETUP WAVEFORM CAPTURE	
TRIGGER ON	VOLTS PEAK
TRIGGER LEVEL	500.00VPK
RESULTS AVERAGING	100mS
LINE SWITCH	NONE
INRUSH CURRENT TRIGGER ENABLE	NO

## SETUP SYSTEM MENU

CONTRAST	5
BACKLIGHT	ON
DIGITAL I/O	
IEEE-488 ADDRESS	2
RS-232 BAUD RATE	115200
SET DATE	8/1/06
SET TIME	09:01:36AM
DATE FORMAT	MM/DD/YY
TIME FORMAT	12 HOUR AM/PM
LANGUAGE	ENGLISH

## Using the Line Switch and Inrush Capabilities

The following *terms* describe available settings for the Line Switch (Channel 1 only) and commands that can be initiated. All settings and commands can be made from the front panel interface or by way of a control interface. Most settings take affect on the next communication with the device-under-test.

### Line On

A command initiated by pressing the front panel LINE ON/OFF key when the LED is extinguished, or by means of a command issued via a control interface. Note that this is not necessarily the state of the internal line switch.

### Line Off

A command initiated by pressing the front panel LINE ON/OFF key when the LED is illuminated, or by means of a command issued via a control interface. Note that this is not necessarily the state of the internal line switch.

### Rearm

A command initiated by pressing one of the front panel, F1 through F4 keys, available when the LINE ON/OFF LED is illuminated, or by means of a command issued via a control interface

### Using the Line Switch

Make a signal connection to the device-under-test by pressing the front panel LINE ON/OFF key with the internal line switch set to ENABLE. Its lighted LED indicates connection.

**CAUTION:** When the line switch is set to DISABLED, it is actually held in the ON (shorted) state. Do not connect the A+ and LINE terminals to different

circuits. It is best to use the A+ terminal only. The bolded items are default settings.

Table 1 Line Switch Options

On/Off Key	Line Switch		Inrush	
	LED	Menu Control	Trigger	Detection
On	Lighted	<b>Disabled</b>	<b>Line Switch</b>	Enabled
<b>Off</b>	<b>Off</b>	AC (Phase Programmable)	PRESET 100mApk  PRESET 1.0Apk; PRESET 10Apk; PRESET 100Apk; User Set	<b>Disabled</b>

**Notes:**

1) If the user is operating using the internal current terminals (A) and is either using voltages above 500Vrms, or frequencies above 1kHz, then the Line Switch *must* be set to the DISABLED state, otherwise damage could be caused to the line switch in the long term.

2) Only use the Line Switch for switching DC, or AC with frequencies between 40Hz and 600Hz. If the frequency being switched is outside of this range then the switch will not reliably operate.

**Inrush Detection**

Detection of Inrush starts when the channel's current waveform exceeds the set level. Examples:

a): Detection occurs immediately, if the set level is zero and the internal line switch is disabled

b): Detection occurs as soon as the LINE ON/OFF key is pressed, if the set level is zero (or <Line Switch>) and the internal line switch is enabled.

**Inrush Enable**

A setting that allows for the collection of Inrush waveforms and Startup data. This setting can be disabled.

**Inrush Period**

Covers the first 65ms (nominally) after Inrush detection.

**Inrush Range**

A setting that allows the user to set a different current input range during the Inrush Period than the one used when not in the Inrush Period.

**Inrush Waveform**

The voltage and current waveforms collected during the entire Inrush Period. These waveforms are always collected during the Inrush Period when enabled. The collected Inrush waveforms can be shown on the display, printed, or retrieved from a control interface, at any time.

**Startup Data**

The measurements (e.g. Vrms, Arms, Watts etc.) collected during the Startup Period. The collected Startup data can be shown on the display, printed, or retrieved from a control interface, at any time.

# Display Screens

## Viewing Measurement Results

This section describes the various Measurement Results display screens available on the PA2801/PA2802 Power Analyzer.

### Numeric Display Screens

In a numeric display the labels for F1 (starting left) and F2 show the measurement selection. As shown in Figure 37, the data displayed correlates with ACDC and Normal. The F4 label showing “RUN” is an option. Shown below is a display on “HOLD” where pressing F4 will continue updating the data displayed.

a) Display Screens

In the Numerics screens, F1 allows selection of the desired measurement to be displayed. All measurements are always available all the time, the user simply selects the one to display. F2 allows for the selection, from the list of parameters available, for the type of measurement chosen.

i) Numerics

(1) ACDC (Total AC+DC signal, fundamental plus harmonics)

(a) Normal



Figure 38. ACDC Normal

## (b) Inrush



Figure 39. ACDC Inrush

## (c) Integrated



Figure 40. ACDC Integrated

- (d) Integrated Average
  - (e) Integrated Maximum
  - (f) Integrated Minimum
- (2) AC(rms)
- (a) Normal
  - (b) Inrush
  - (c) Integrated
  - (d) Integrated Average
  - (e) Integrated Maximum
  - (f) Integrated Minimum

- (3) DC
  - (a) Normal



Figure 41. DC Normal

- (b) Inrush
  - (c) Integrated
  - (d) Integrated Average
  - (e) Integrated Maximum
  - (f) Integrated Minimum
- (4) Rectified
  - (a) Normal



Figure 42. Rectified Normal

- (b) Inrush
  - (c) Integrated
  - (d) Integrated Average
  - (e) Integrated Maximum
  - (f) Integrated Minimum



- (5) Fundamental  
(a) Normal



Figure 43. Fundamental Normal

- (b) Integrated  
(c) Integrated Average  
(d) Integrated Maximum  
(e) Integrated Minimum  
(f) Load
- (6) ΣHarmonics  
(a) Normal



Figure 44. ΣHarmonics Normal

- (7) DC Charge & Discharge  
(a) Integrated

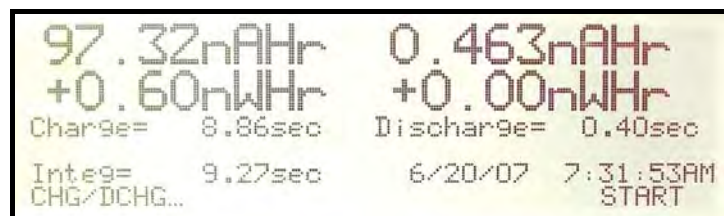
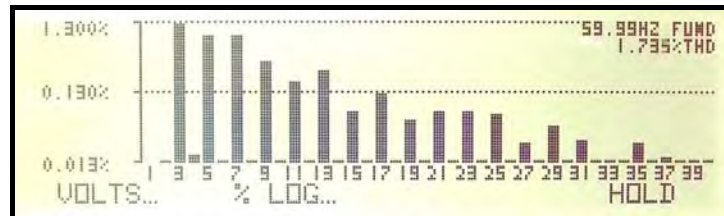


Figure 45. DC Charge & Discharge

$Z = 5708.1 \Omega$        $R = 469.4 \Omega$   
 $X = -5689 \Omega$   
 Parallel 0.463uF      69.43k $\Omega$       60.009Hz  
 LOAD...      6/20/07      7:33:06AM  
    RUN

- ii) Harmonics Bar Charts
  - (1) Volts
    - (a) Percent Log
    - (b) Percent Linear
    - (c) Absolute Log
    - (d) Absolute Linear
  - (2) Amps
    - (a) Percent Log
    - (b) Percent Linear
    - (c) Absolute Log
    - (d) Absolute Linear



(3) Watts

- (a) Percent Log
- (b) Percent Linear
- (c) Absolute Log
- (d) Absolute Linear

## iii) Harmonics Listing

## (1) Absolute

Use F2 and F3 to scroll from the Fundamental Harmonic to the 100<sup>th</sup>.



Figure 48. Harmonics Absolute in List Form

## (2) Percent

## (3) Phase

## iv) Waveforms

## (1) Real-time

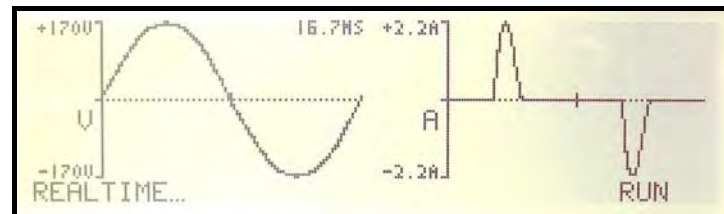


Figure 49. Real-time Waveform

## (2) Distortion

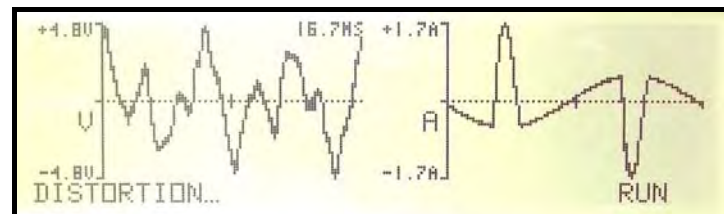


Figure 50. Distortion Waveform

## (3) Captured

## (4) Glitch

## Chart Displays

### Starting Startup and Inrush Charts

As previously described, the Startup and Inrush charts are initiated by the detection of an Inrush current and/or the turning on of the internal line switch. Note that the reported Inrush Numeric Measurement results are the maximal results collected during the period defined by the Startup chart.

The internal line switch can be disabled or enabled (for either DC or AC operation) as configured by the user in the MEASUREMENT SETUP menu.

The user can set the Inrush Detection Level in the MEASUREMENT SETUP menu, or it can be disabled by setting the detection level to zero.

The method used is dependent on the specific configuration chosen by the user as follows.

#### Line Switch Disabled and Inrush Detection Disabled

In this case the Startup and Inrush Charts are disabled. Any data previously captured is maintained in the PA2801/PA2802 as long as power is turned on and the user does not clear the chart.

#### Line Switch Disabled and Inrush Detection Enabled

In this case the Startup and Inrush charts are started whenever the actual peak current waveform changes from having been continuously below the Inrush Detection Level for at least 20ms to being above the Inrush Detection Level for at least 4us. This is accomplished in a manner such that the Startup chart cannot restart mid-way through a data collection (i.e. once the Startup and Inrush charts have been started they will always run to completion while in this mode).

#### Line Switch Enabled and Inrush Detection Disabled

In this case, the Startup and Inrush charts are started concurrently with the line switch being turned on by the user. If using the Internal Line Switch (either DC or AC mode), then the charts are started at the time that the line switch actually turns on. Once started, the user can turn

off the line switch at any time; this has no affect on the collection of data for the Startup and Inrush Charts. In this mode, if the user has selected to use the Internal Line Switch (either DC or AC mode), and the user has enabled auto-range on the current input, then the PA2801/PA2802 automatically selects the uppermost range of the selected current input just before it actually turns on the line switch. It then returns the range to that selected by the user when either the inrush chart has been fully collected or the line switch is turned off by the user, whichever occurs first. The operation is the same when a range is fixed, but the user has disabled strict ranging,

### **Line Switch Enabled and Inrush Detection Enabled**

This is similar to the case with the Line Switch Enabled and the Inrush Detection disabled, described above, the only difference being the addition of not starting data collection until the Inrush detection level has been exceeded after the line switch has been turned on by the user. Note that the current must be below the Inrush detection level for at least 20ms before the PA2802 will allow a new chart to be started. If the current is not below this level prior to turning on the line switch, no Startup or Inrush data collection will occur (the line switch will operate, however).

## **Chart Formats**

There are Chart display screens for History, Startup and Inrush data. The chart screens include a labeled axis, the actual chart data plotted graphically, and descriptive information regarding the chart. Optional chart data is available through using the softkeys, which are labeled at the bottom.

The chart gives a graphical representation of the selected measurement results plotted over time. The charts use time as the x-axis, with earlier time being to the left and later to the right. The y-axis automatically scales to give the fullest resolution for that measurement, with both the upper and lower limits adjusted dynamically. In all cases, the upper limit is greater than the lower limit.

### **Viewing Modes**

There are two x-axis modes of viewing the chart data, *Normal* and *Inspect*. These two viewing modes are accessed using the CURSOR F2 softkey.

Pressing F2 when viewing a chart display will enter you into the Inspect Mode and enable the cursors for inspecting the data..

Normal viewing mode: In this mode the selected data covers a time span equal to the extent of the data collected. The reference date/time and the total time span being shown are included on the chart screen. While in this mode the viewed chart is continuously updated with the latest available data.

Inspect viewing mode: In this mode the user is able to view a portion of the data shown in Normal viewing mode. It enables the user to zoom in using the cursors to select the portion of the history data to inspect. The cursors can be used to zoom in to a particular area or can be moved within the display screen by using the Left (F3) softkey or the RIGHT (F4) softkey. To ZOOM into the selected area press the ENTER key,. The displayed data is the data between the two cursor settings. The user can zoom in further by using the cursors again to select the area to be inspected and pressing ENTER to zoom into this section, this can be done until the unit reaches its resolution point.

When in the inspect mode the user can use the ZOOM OUT (F3) softkey to ZOOM back out a level at a time or can use the FULL-SPAN (F4) key to exit back to the normal viewing screen.

The reference date/time, the time offset to the leftmost data displayed and the time span being displayed are all included on the chart. The data viewed in this mode is only computed when the scroll offset or the zoom level is changed, thus any changes to the chart occurring (e.g. a new startup and inrush chart being started) may not become evident until one of these is changed.

Data is unavailable whenever no measurements are being made, whether due to ranging operation or due to user hold of measurements. Note that a user hold of measurements is different from a user hold of the chart. The y-axis is drawn as a vertical solid line at the leftmost end of the chart, with tick marks extending left from the axis and with the associated y scale values next to the tick marks. These tick marks are at the lowermost, center and uppermost pixels, with the actual value corresponding to the center point of each pixel row in the displayed chart. The chart extends to an odd number of pixels in both X and Y directions.

For the STARTUP and HISTORY screens the data that is displayed can be shown in the EXTENTS or the TRENDS mode. EXTENTS is the maximum

and minimum for each measurement period and the TREND is the averaged or smoothed data. This is selected by pressing the F1 key and moving the cursor to EXTENTS OR TREND. Press the ENTER key and use the UP or DOWN arrow key to select EXTENTS or TREND. Press the ENTER key when finished.

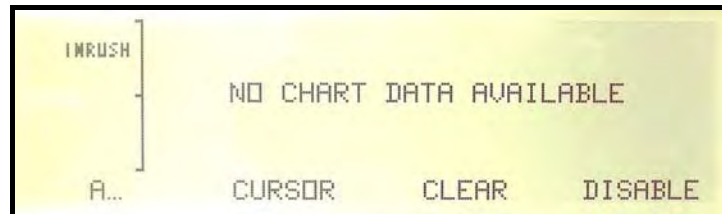


Figure 51. No Inrush Detected

## History Charts

The History chart is always running and does not need configuring by the user. The data collected by the History chart is all of the basic measurement results (e.g. Vrms, Vac, Vdc, Arms, Watts) including fundamental, percent THD, and internal temperature results. Data is collected as new results become available, any data that is unknown, whether because of the lack of a reference signal (e.g. for frequency or harmonic data), or due to range changing, or after pressing the HOLD softkey the measurements, are not charted. Unknown data is shown as a “blank” spot in the chart, the relative timing of all data is always accurate within the resolution limits of the chart. The date and time at which the chart was last started is saved as the chart reference date/time. This date is made available (i.e. the chart is manually cleared or the PA2801/PA2802 power was turned on), as is the total time span covered by the chart (always the difference between the reference date/time and the present date/time). Data is viewable with a typical time resolution of 1 cycle or 0.1% of the age of the data (whichever is larger).

As data becomes limited in time resolution due to age, the data is set to the average (except peak results) or the highest (peak results) measurement in the resolution limited period. This action tends to “smooth” the chart for non-peak results as the time span covered becomes longer because the history chart is always plotted with the time resolution determined by the oldest displayed data. If the user zooms in to only show more recent data (using the inspect mode), then the time resolution can be regained.

For the History chart in Normal viewing mode, all of the available history data is shown. Note that the right end of the scale shows the most recent data and the left end value of the x-axis is fixed at the time at which the data collection was started.

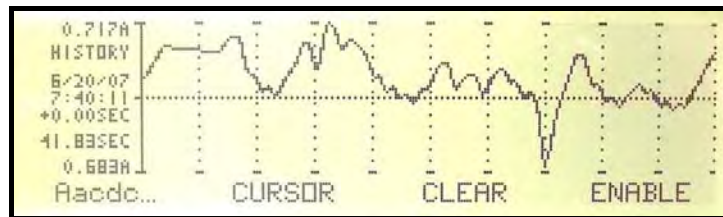


Figure 52. History of Amps ACDC, Trend in Full View

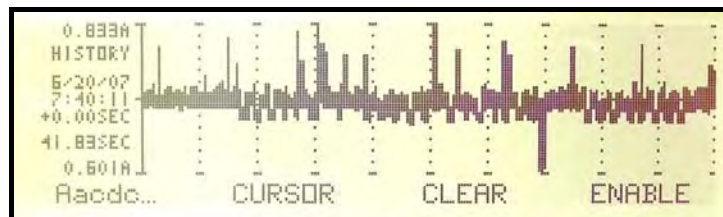


Figure 53. History of Amps ACDC, Extents in Full View

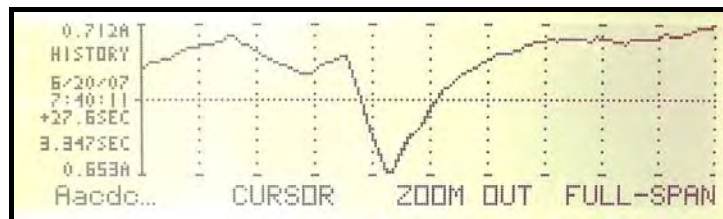


Figure 54. History of Amps ACDC, Trend in Zoom Mode



Figure 55. History of Amps ACDC, Trend; Scrolled



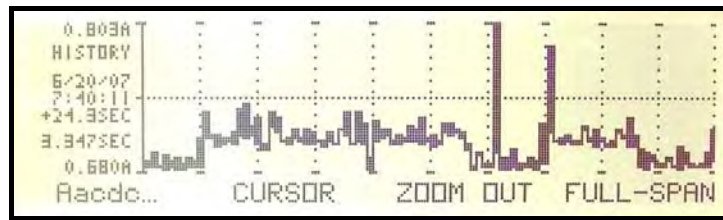


Figure 56. History of Amps ACDC, Extents in Zoom Mode

The following is a list of available data for the History charts. The data to be displayed is selected by pressing the F1 key which will enter you into the HISTORY CHART DATA menu.

Use the UP or DOWN arrow key to highlight MEASUREMENT if it is not highlighted, press the ENTER key to view the available display types, use the UP or DOWN arrow keys to scroll through the choices and press the ENTER key to select, the following are the available choices.

VOLTS  
AMPS  
WATTS  
VA  
VAR  
PF  
FREQUENCY  
TEMPERATURE

The TYPE of data to be displayed can be set in the HISTORY CHART DATA. The TYPE can be found by pressing the F1 key which will enter into the HISTORY CHART DATA menu.

Use the UP or DOWN arrow key to highlight TYPE if it is not highlighted, press the ENTER key to view the available display types, use the UP or DOWN arrow keys to scroll through the choices and press the ENTER key to select, the following are the available choices.

ACDC  
AC  
DC  
FUNDAMENTAL  
PERCENT THD  
PEAK  
PEAK AC

### **Startup Charts**

The Startup chart maintains a record of the same set of measurement results as the History chart, but is started and stopped depending on the detection of an Inrush current and/or by turning on the internal Line Switch (depending on configuration). The date/time at which the chart was started is saved as the reference date/time for startup charts. Data is viewable with a typical time resolution of 1 cycle or 0.1% of the pre-configured startup chart period (whichever is larger).

The Startup period is factory set to approximately 4 minutes. Data is collected over this time at full resolution.

In the case of the Startup and Inrush charts the operation is fundamentally the same as that for the History chart, however the left and right end values of the x-axis are set by scroll and zoom. When plotting the measured data, there may be periods of time for which the data was unavailable. In those cases, no data is charted for the affected period(s) of time.

In the Startup chart format, the x-axis in Normal viewing mode is sufficient to cover the startup period.

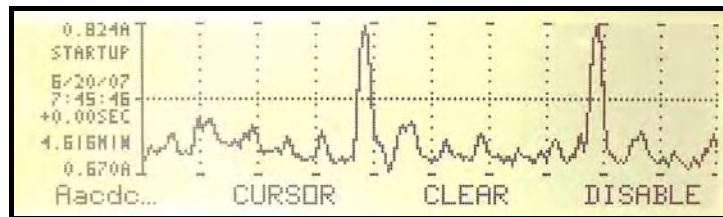


Figure 57. Startup in Full View, Trend

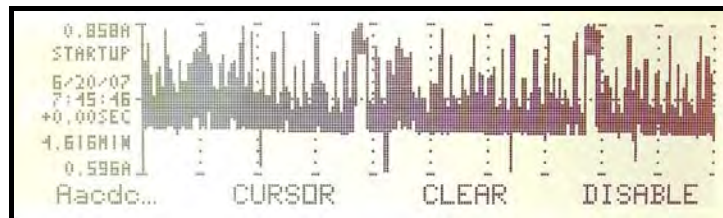


Figure 58. Startup in Full View, Extents

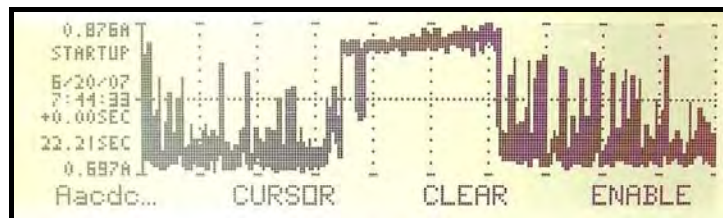


Figure 59. Startup, Partial, Extents

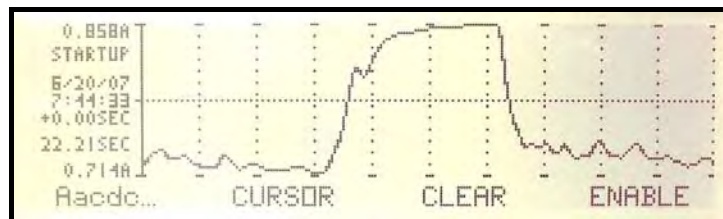


Figure 60. Startup, Partial, Extents

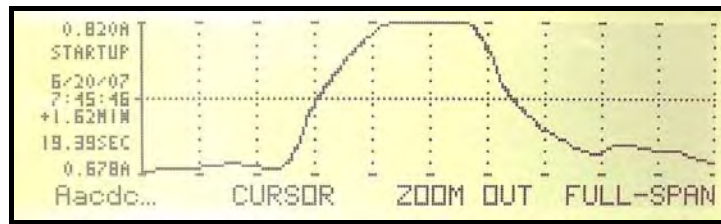


Figure 61. Startup in Zoom Mode

The following is a list of available data for the STARTUP charts. The data to be displayed is selected by pressing the F1 key which will enter you into the HISTORY CHART DATA menu.

Use the UP or DOWN arrow key to highlight MEASUREMENT if it is not highlighted, press the ENTER key to view the available display types, use the UP or DOWN arrow keys to scroll through the choices and press the ENTER key to select, the following are the available choices.

VOLTS  
AMPS  
WATTS  
VA  
VAR  
PF  
FREQUENCY

The TYPE of data to be displayed can be set in the STARTUP CHART DATA. The TYPE can be found by pressing the F1 key which will enter into the HISTORY CHART DATA menu.

Use the UP or DOWN arrow key to highlight TYPE if it is not highlighted, press the ENTER key to view the available display types, use the UP or DOWN arrow keys to scroll through the choices and press the ENTER key to select, the following are the available choices.

ACDC  
AC

DC  
FUNDAMENTAL  
PERCENT THD  
PEAK  
PEAK AC

### Inrush Charts

The Inrush chart maintains a record of the actual current and voltage waveforms from a time nominally 3ms prior to the detection of an Inrush current and/or by the turning on of the internal line switch (depending on configuration) to nominally 65ms afterwards. Data is viewable with a typical time resolution of 4.1 microseconds.

The Inrush chart is not capable of capturing data during a change in range. In order for an Inrush chart to be produced, the user must ensure that no ranges occur during this period of time.

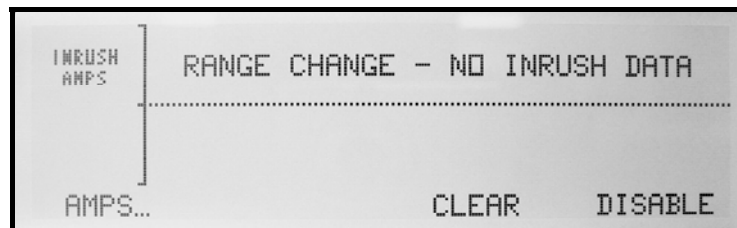


Figure 62. Range Change

The date/time at which the chart was started is saved as the reference date/time for Inrush charts (note that this is the same reference date/time as for the startup chart).

The Inrush chart format, the x-axis in Normal viewing mode is sufficient to cover the nominal 68ms inrush event, which cannot change while data is being collected. Note that the left end of the scale is fixed in time relative to the time of the inrush event and all data is placed in accordance with age relative to that time. For the Inrush chart Y-axis, the center value will always be zero, and thus the upper and lower data will always be of the same value but with opposite polarities.

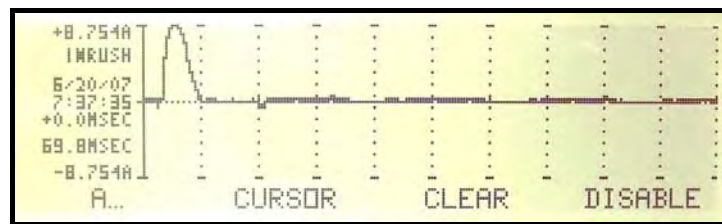


Figure 63. Amps Inrush in Normal Mode

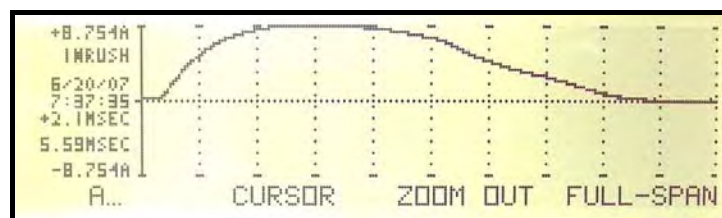


Figure 64. Inrush in Zoom Mode



Figure 65. Inrush in Zoom Mode, Additional Zoom Level

The following is a list of available data for the INRUSH charts. The data to be displayed is selected by pressing the F1 key which will enter you into the INRUSH CHART DATA menu.

Press the ENTER key to view the available display types, use the UP or DOWN arrow keys to scroll through the choices and press the ENTER key to select. the following are the available choices.

VOLTS  
AMPS

# Printing Results

This chapter illustrates some of the various printouts available using the PA2801/PA2802. Each printout reflects the data from the display group presently viewed.

## Sample Printouts

A text or graphic print is immediately initiated when the PRINT key is pressed for each of the results display screens.

Every printout includes—

- Descriptive title of the data
- Configuration selections
- Current date (month, day, year)
- Calibrated date
- Time in hours : minutes : seconds
- Elapsed time
- Powertek PA2801 or PA2802 model number
- Firmware Version number

The samples provided have been printed from each of the display groups **Basics**, **Harmonics**, **Waveforms**, and **History**.

- All the data viewed in the **Basics** group of displays will print on one page.
- The **Harmonics** LISTING data, including ABS, PCT, and PHASE will print on one page. .

- The **Harmonics** BARGRAPH data will print separate bar charts for ABS, %, Lin or Log for current or voltage.
- For the **Waveforms** group, volts, amps and power waveforms will print together if a graphical print is selected. If a text only printer is selected, then volts and amps will print together.
- Voltage and current **Waveforms** for PEAK, DIST and GLITCH captures will print separately.
- Each **History** display will print a full page of graphically formatted data. .

The following pages illustrate the sample printouts.



2802		CONFIGURATION	PAGE 1 OF 1
MAIN v2.00, ANALOG v2.00		12/13/06 14:55:49	
<u>FACTORY SETTINGS</u>	: DISPLAY CONTRAST : 155 to 255		
	: SERIAL NUMBER : 28026021001		
	: FACTORY OPTIONS : 0000000000		
<u>INTERFACE SETTINGS</u>	: LANGUAGE : ENGLISH		
	: BACKLIGHT : ON		
	: DISPLAY CONTRAST : 6		
	: DATE FORMAT : MM/DD/YY		
	: TIME FORMAT : 24 HOUR		
	: IEEE488 ADDRESS : 02		
	: RS232 BAUD RATE : 9600		
<u>DIGITAL I/O SETTINGS</u>	: LINE ON INPUT : DISABLED		
	: INTEGRATE INPUT : DISABLED		
	: CLR INTEGRATION INPUT : DISABLED		
	: LINE ON OUTPUT : DISABLED		
	: INTEGRATE INPUT(CH2) : DISABLED		
	: CLR INTEGRATION INPUT(CH2) : DISABLED		
<u>SCREEN SETTINGS</u>	: NUMERICS SCREEN : ACDCrms NORMAL Ch1		
	: BARCHART SCREEN : VOLTS PERCENT LINEAR Ch1		
	: HARMONICS LISTING SCREEN : PHASE Ch1		
	: WAVEFORMS SCREEN : REALTIME Ch1		
	: HISTORY CHART SCREEN : VOLTS ACDC Ch1 EXTENTS		
	: STARTUP CHART SCREEN : VOLTS ACDC Ch1 TREND		
	: INRUSH WAVEFORM SCREEN : VOLTS Ch1		
<u>MEASUREMENT SETTINGS</u>	: APPLICATION : 2ch (async)		
	: RESULT AVERAGING : Ch1: 100ms		Ch2: 100ms
	: MEASUREMENT TYPE : Ch1: HF		Ch2: HF
	: VOLTAGE RANGES : Ch1: AUTO		Ch2: AUTO
	: CURRENT INPUT TYPE : Ch1: DIRECT(A INPUT)		Ch2: DIRECT(A INPUT)
	: CURRENT RANGES : Ch1: AUTO		Ch2: AUTO
	: STRICT RANGING : Ch1: NO		Ch2: NO
	: MEASURE SOURCE : Ch1: LOAD		Ch2: LOAD
	: WIRING COMPENSATE : Ch1: NO		Ch2: NO
	: V BURDEN COMPENSATE : Ch1: NO		Ch2: NO
	: REVERSE V TERMINALS : Ch1: NO		Ch2: NO
	: REVERSE A & T TERMINALS : Ch1: NO		Ch2: NO
	: LINE SWITCH : NONE		
	: CURRENT TRIGGERS INRUSH : NO		
	: WAVEFORM CAPTURE TRIGGER : NONE		

Figure 66. Configuration Printout

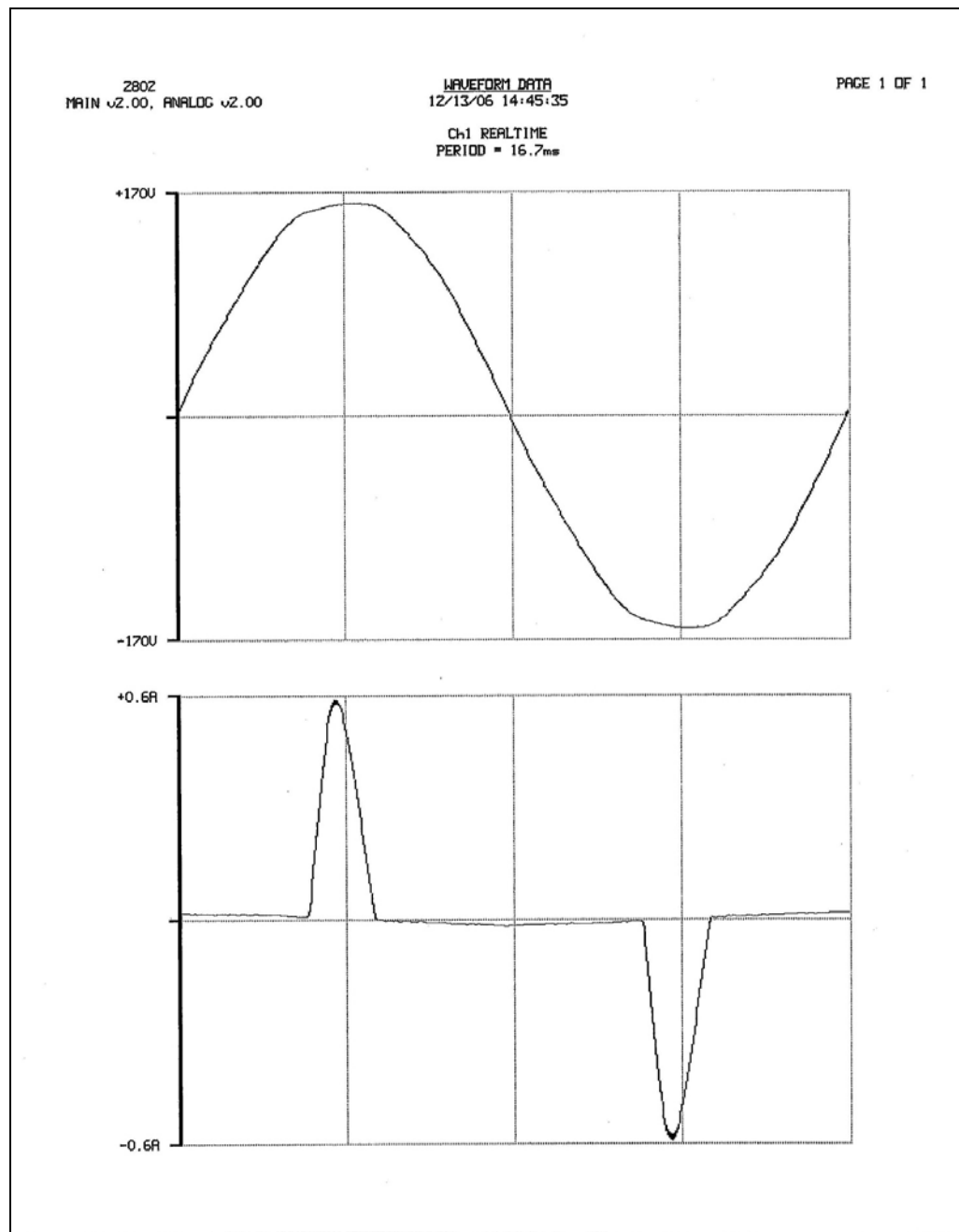


Figure 67. Waveform Channel 1 Real-time

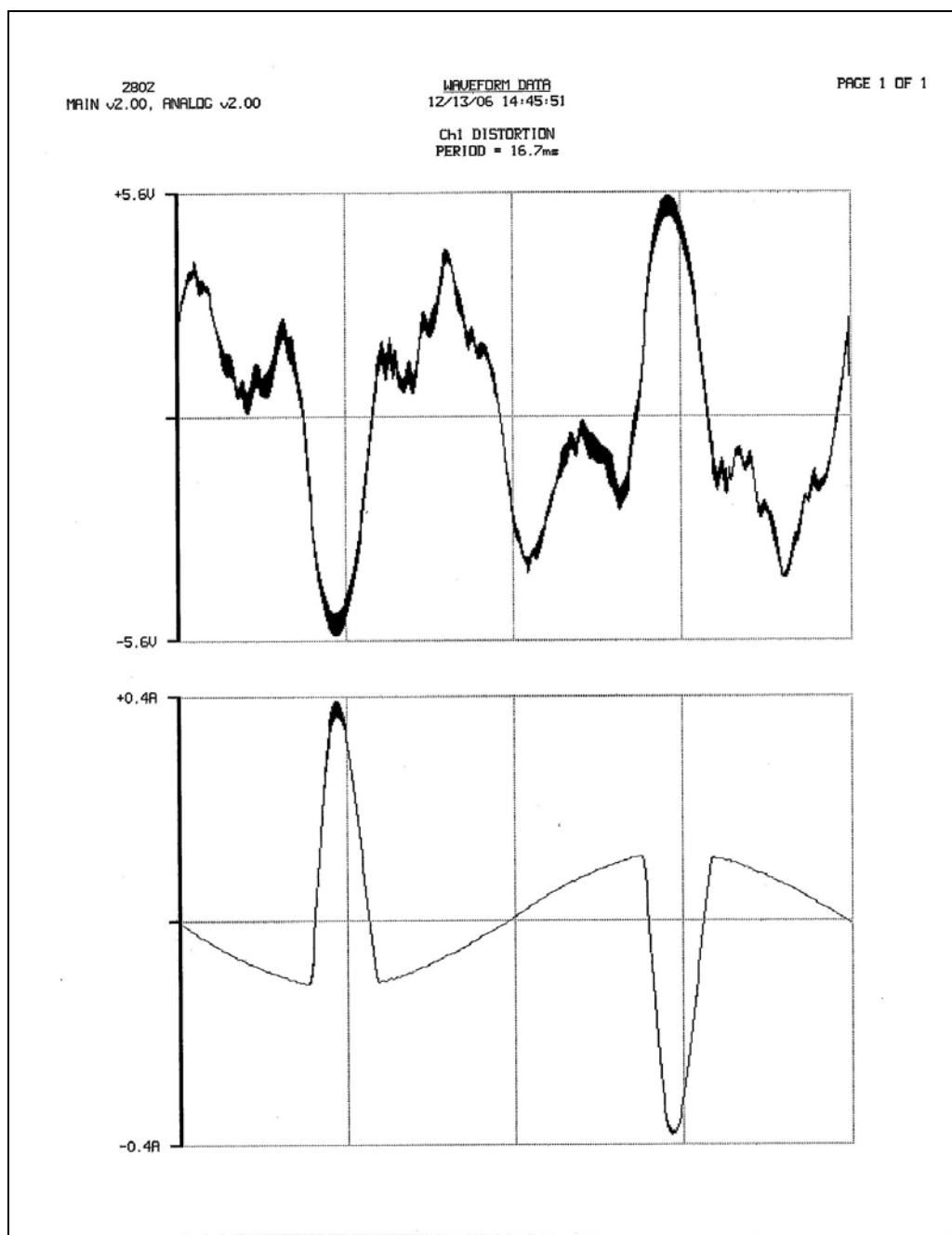


Figure 68. Waveform Channel1 Distortion

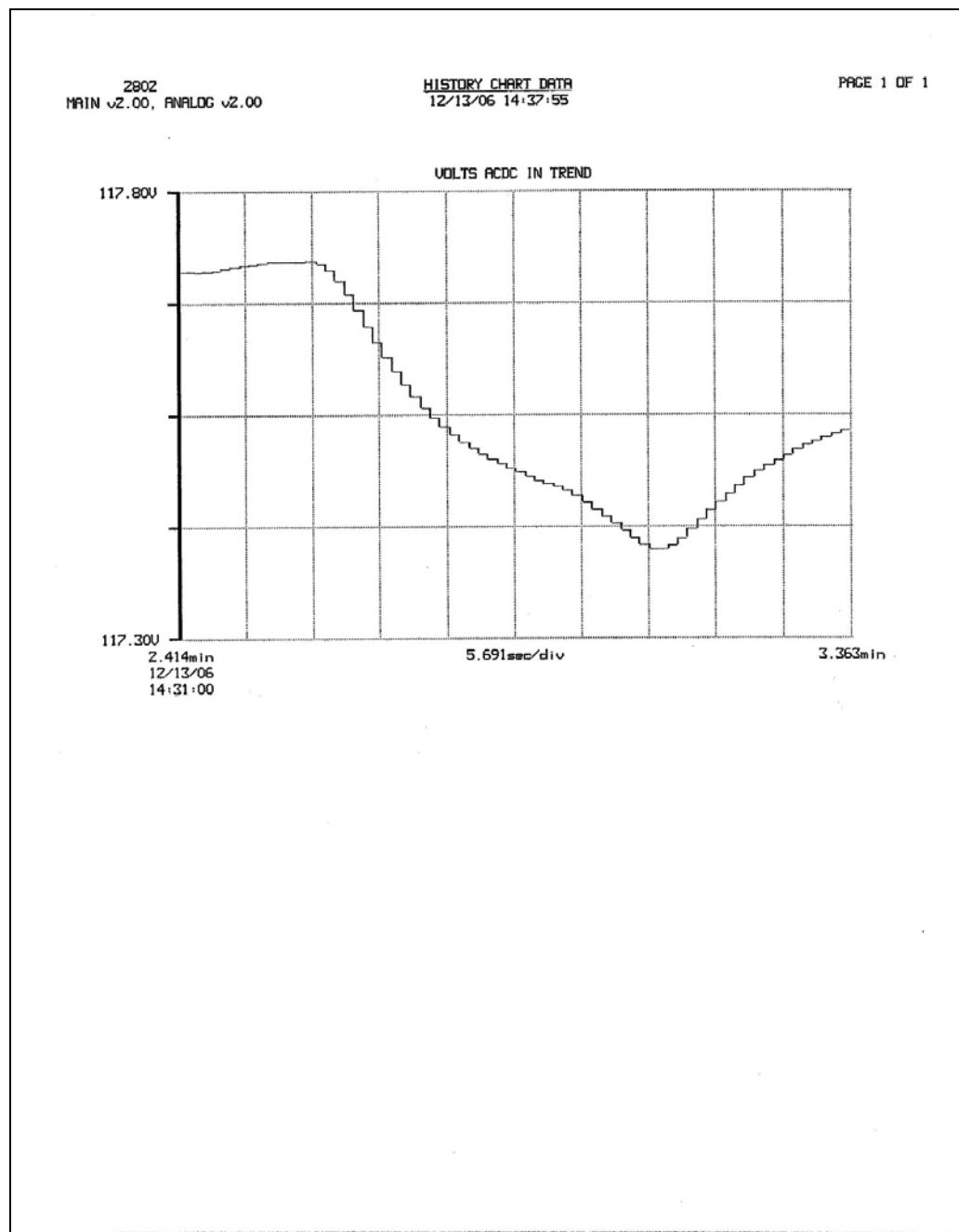


Figure 69. History Chart VOLTS ACDC, Trends View

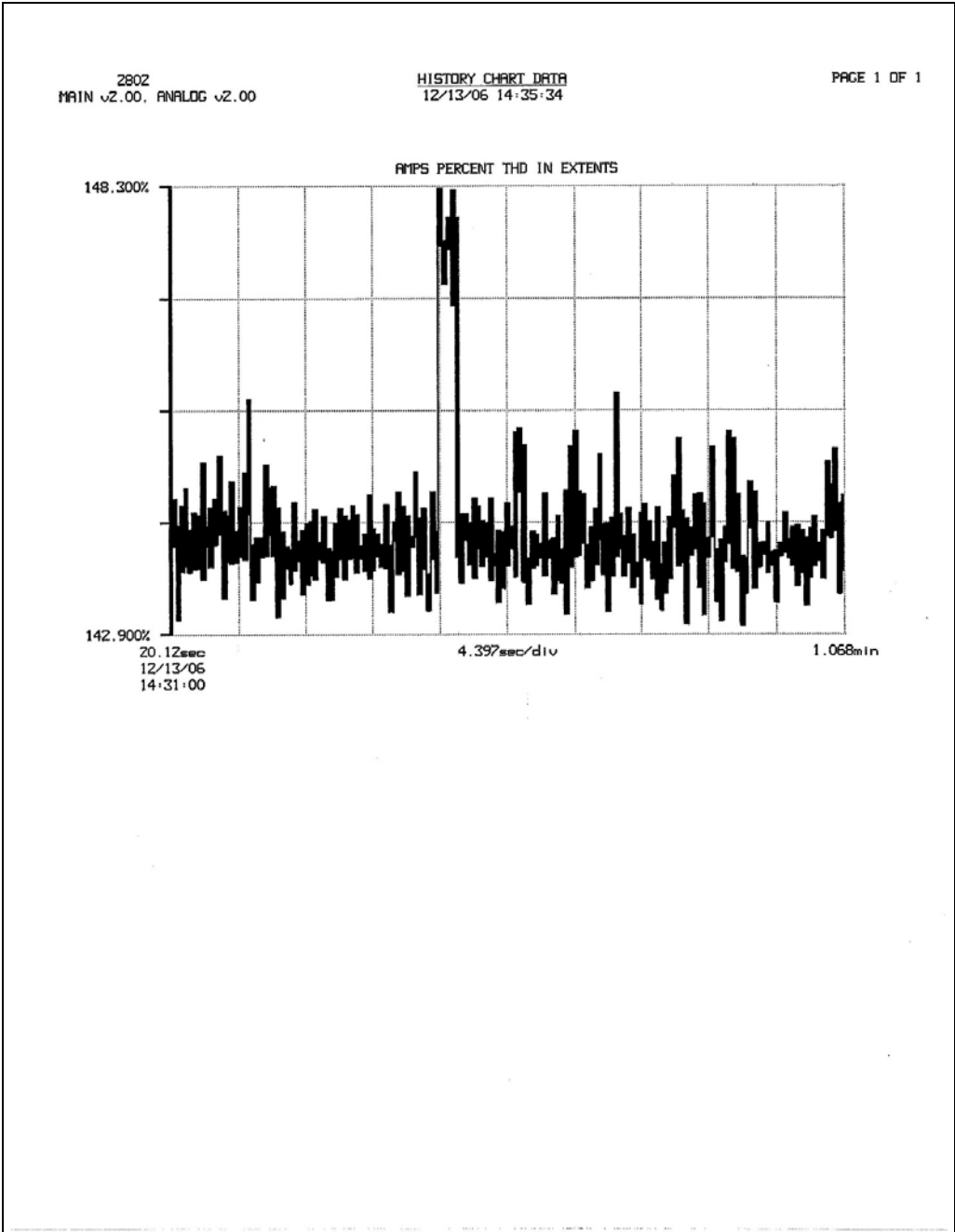


Figure 70. History Chart AMPS PERCENT THD Extents View

2802 MAIN v2.00, ANALOG v2.00				HARMONICS LISTING 12/13/06 14:58:28			PAGE 1 OF 2	
HARMONIC	LEVEL	VOLTAGE %FUND	PHASE	LEVEL	CURRENT %FUND	PHASE	WATTAGE LEVEL	
Fund:	117.339V		-0.01°	95.490mA		+9.34°	+11.056W	
2nd:	0.007V	0.006%	+46.48°	0.215mA	0.225%	+168.78°	-0.000W	
3rd:	2.229V	1.900%	+17.98°	86.513mA	90.599%	-171.10°	-0.190W	
4th:	0.007V	0.006%	-110.59°	0.525mA	0.549%	-56.65°	+0.000W	
5th:	0.422V	0.360%	+146.83°	73.731mA	77.213%	+15.75°	-0.020W	
6th:	0.006V	0.005%	+2.16°	0.303mA	0.317%	+170.73°	-0.000W	
7th:	1.176V	1.002%	+34.39°	57.895mA	60.629%	-157.69°	-0.067W	
8th:	0.002V	0.002%	+85.56°	0.235mA	0.247%	+31.15°	+0.000W	
9th:	0.406V	0.346%	-117.66°	40.567mA	42.482%	+31.17°	-0.014W	
10th:	0.007V	0.006%	-118.95°	0.280mA	0.293%	-92.34°	+0.000W	
11th:	0.240V	0.205%	-1.18°	24.245mA	25.390%	-137.14°	-0.004W	
12th:	0.003V	0.002%	+153.20°	0.299mA	0.313%	+121.17°	+0.000W	
13th:	0.265V	0.226%	+28.08°	12.074mA	12.644%	+65.78°	+0.003W	
14th:	0.002V	0.002%	+103.66°	0.307mA	0.321%	-30.10°	-0.000W	
15th:	0.069V	0.059%	-134.66°	5.625mA	5.890%	-60.24°	+0.000W	
16th:	0.002V	0.002%	+95.84°	0.276mA	0.289%	-179.30°	+0.000W	
17th:	0.160V	0.137%	+70.18°	6.278mA	6.574%	+177.19°	-0.000W	
18th:	0.002V	0.002%	+25.93°	0.229mA	0.240%	+34.45°	+0.000W	
19th:	0.060V	0.051%	+156.98°	6.293mA	6.590%	+20.85°	-0.000W	
20th:	0.002V	0.002%	-29.66°	0.202mA	0.211%	-105.45°	+0.000W	
21st:	0.037V	0.031%	-114.02°	4.821mA	5.049%	-142.82°	+0.000W	
22nd:	0.005V	0.004%	+47.61°	0.210mA	0.220%	+114.03°	+0.000W	
23rd:	0.015V	0.013%	-46.58°	2.449mA	2.565%	+54.86°	-0.000W	
24th:	0.005V	0.004%	+22.54°	0.197mA	0.206%	-28.59°	+0.000W	
25th:	0.016V	0.014%	+115.03°	0.769mA	0.805%	-41.40°	-0.000W	
26th:	0.005V	0.005%	-111.02°	0.172mA	0.180%	+179.65°	+0.000W	
27th:	0.047V	0.040%	+67.96°	1.896mA	1.985%	-155.85°	-0.000W	
28th:	0.006V	0.005%	-179.75°	0.163mA	0.170%	+38.83°	-0.000W	
29th:	0.036V	0.030%	-125.27°	2.250mA	2.357%	+38.13°	-0.000W	
30th:	0.004V	0.003%	-117.67°	0.154mA	0.161%	-97.26°	+0.000W	
31st:	0.026V	0.022%	-88.35°	1.690mA	1.770%	-131.28°	+0.000W	
32nd:	0.002V	0.002%	-52.79°	0.162mA	0.170%	+116.48°	-0.000W	
33rd:	0.021V	0.018%	+23.61°	0.772mA	0.808%	+50.88°	+0.000W	
34th:	0.002V	0.002%	-42.52°	0.154mA	0.162%	-32.31°	+0.000W	
35th:	0.028V	0.024%	+128.24°	0.285mA	0.299%	+101.79°	+0.000W	
36th:	0.003V	0.002%	-88.89°	0.131mA	0.137%	-178.99°	+0.000W	
37th:	0.017V	0.015%	+167.81°	1.053mA	1.102%	-104.68°	+0.000W	
38th:	0.003V	0.002%	+105.41°	0.105mA	0.110%	+42.62°	+0.000W	
39th:	0.022V	0.019%	-120.04°	1.134mA	1.188%	+74.17°	-0.000W	
40th:	0.003V	0.003%	+21.49°	0.096mA	0.100%	-106.52°	-0.000W	
41st:	0.027V	0.023%	+94.98°	0.862mA	0.903%	-104.38°	-0.000W	
42nd:	0.003V	0.002%	-45.26°	0.092mA	0.097%	+114.63°	-0.000W	
43rd:	0.011V	0.009%	+103.96°	0.246mA	0.258%	+97.41°	+0.000W	
44th:	0.003V	0.002%	-90.00°	0.096mA	0.100%	-22.42°	+0.000W	
45th:	0.023V	0.020%	-75.46°	0.380mA	0.398%	+74.01°	-0.000W	
46th:	0.002V	0.002%	-167.09°	0.081mA	0.084%	-157.71°	+0.000W	
47th:	0.015V	0.013%	+69.91°	0.699mA	0.732%	-91.78°	-0.000W	
48th:	0.002V	0.002%	+116.85°	0.057mA	0.060%	+43.51°	+0.000W	
49th:	0.026V	0.022%	+167.43°	0.674mA	0.706%	+100.56°	+0.000W	
50th:	0.002V	0.002%	+96.90°	0.051mA	0.054%	-113.08°	-0.000W	

Figure 71. Harmonics Listing page 1

2802 MAIN v2.00, ANALOG v2.00				HARMONICS LISTING 12/13/06 14:58:28			PAGE 2 OF 2
HARMONIC	LEVEL	VOLTAGE %FUND	PHASE	LEVEL	CURRENT %FUND	PHASE	WATTAGE LEVEL
51st:	0.009U	0.007%	-79.09°	0.553mA	0.579%	-74.32°	+0.000W
52nd:	0.002U	0.002%	+61.09°	0.053mA	0.055%	+149.28°	+0.000W
53rd:	0.035U	0.030%	+7.08°	0.324mA	0.339%	+101.73°	-0.000W
54th:	0.002U	0.002%	+171.80°	0.048mA	0.050%	-3.89°	-0.000W
55th:	0.014U	0.012%	-47.30°	0.269mA	0.282%	+92.09°	-0.000W
56th:	0.002U	0.002%	+174.14°	0.051mA	0.053%	-126.86°	+0.000W
57th:	0.010U	0.009%	-48.89°	0.461mA	0.482%	-62.85°	+0.000W
58th:	0.003U	0.003%	+110.40°	0.029mA	0.030%	+112.14°	+0.000W
59th:	0.005U	0.004%	+17.27°	0.530mA	0.555%	+113.88°	-0.000W
60th:	0.001U	0.001%	-81.15°	0.034mA	0.035%	-49.67°	+0.000W
61st:	0.011U	0.009%	+160.30°	0.385mA	0.403%	-69.96°	-0.000W
62nd:	0.004U	0.003%	-84.34°	0.021mA	0.022%	-174.44°	-0.000W
63rd:	0.012U	0.010%	+78.51°	0.136mA	0.143%	+134.04°	+0.000W
64th:	0.002U	0.001%	-124.30°	0.033mA	0.034%	+4.19°	-0.000W
65th:	0.016U	0.014%	-103.66°	0.115mA	0.120%	+106.29°	-0.000W
66th:	0.002U	0.001%	+10.63°	0.019mA	0.020%	-101.75°	-0.000W
67th:	0.027U	0.023%	-103.07°	0.481mA	0.503%	-37.85°	+0.000W
68th:	0.002U	0.002%	+20.81°	0.034mA	0.036%	+129.72°	+0.000W
69th:	0.010U	0.008%	-10.44°	0.396mA	0.415%	+124.50°	-0.000W
70th:	0.003U	0.002%	+39.77°	0.022mA	0.023%	+49.96°	+0.000W
71st:	0.008U	0.007%	-77.15°	0.280mA	0.293%	-41.30°	+0.000W
72nd:	0.002U	0.001%	-154.85°	0.033mA	0.035%	-135.37°	+0.000W
73rd:	0.004U	0.003%	+59.04°	0.112mA	0.117%	+119.25°	+0.000W
74th:	0.004U	0.004%	+150.92°	0.027mA	0.028%	+53.81°	-0.000W
75th:	0.019U	0.016%	+71.52°	0.224mA	0.235%	+162.28°	-0.000W
76th:	0.001U	0.001%	+129.22°	0.024mA	0.026%	-139.75°	-0.000W
77th:	0.006U	0.005%	-106.42°	0.229mA	0.240%	-27.03°	+0.000W
78th:	0.002U	0.002%	-117.03°	0.012mA	0.012%	-11.52°	-0.000W
79th:	0.004U	0.003%	+100.12°	0.213mA	0.224%	+148.17°	+0.000W
80th:	0.002U	0.001%	-75.94°	0.018mA	0.019%	+27.88°	+0.000W
81st:	0.008U	0.007%	+165.33°	0.171mA	0.179%	-69.23°	-0.000W
82nd:	0.001U	0.001%	+6.95°	0.019mA	0.020%	-114.37°	+0.000W
83rd:	0.014U	0.012%	-71.44°	0.170mA	0.178%	+37.72°	-0.000W
84th:	0.002U	0.001%	-79.70°	0.027mA	0.028%	+61.38°	-0.000W
85th:	0.016U	0.014%	+43.90°	0.217mA	0.227%	+166.07°	-0.000W
86th:	0.002U	0.002%	+49.81°	0.020mA	0.021%	-170.29°	-0.000W
87th:	0.003U	0.002%	-27.21°	0.170mA	0.179%	+6.53°	+0.000W
88th:	0.002U	0.002%	+67.19°	0.028mA	0.029%	+171.12°	-0.000W
89th:	0.021U	0.018%	-36.51°	0.166mA	0.174%	+103.11°	-0.000W
90th:	0.001U	0.001%	-104.88°	0.020mA	0.021%	+64.08°	-0.000W
91st:	0.009U	0.007%	+72.90°	0.038mA	0.040%	-88.73°	-0.000W
92nd:	0.002U	0.002%	+128.43°	0.032mA	0.034%	-104.87°	-0.000W
93rd:	0.013U	0.011%	-133.12°	0.107mA	0.113%	-1.31°	-0.000W
94th:	0.002U	0.002%	-168.35°	0.017mA	0.018%	-137.85°	+0.000W
95th:	0.011U	0.009%	-28.25°	0.056mA	0.058%	+171.80°	-0.000W
96th:	0.001U	0.001%	-78.66°	0.029mA	0.031%	+2.11°	+0.000W
97th:	0.012U	0.010%	+145.59°	0.072mA	0.076%	-22.64°	-0.000W
98th:	0.001U	0.001%	+16.01°	0.021mA	0.022%	-176.25°	-0.000W
99th:	0.018U	0.015%	-100.38°	0.076mA	0.079%	-47.77°	+0.000W
100th:	0.002U	0.001%	-97.40°	0.022mA	0.023%	+28.60°	-0.000W

Figure 72. Harmonics Listing page 2

## **Sending Commands and Interrogatives**

All commands are sent to the PA2801/2 using standard ASCII characters. In general, the user may freely use upper- or lower-case characters within commands. A command is actioned when the Line Feed ASCII character is received (or when a character is received with EOI asserted over the IEEE488 interface).

Multiple commands can be included in the same “line”, in this case each command should be separated from the next by the semi-colon ASCII character.

For RS-232 after sending the READ = command, you must send the character “ ? ” to the unit or you will not get a reply

### **Operating using Multiple Interfaces**

All three interfaces, IEEE488, USB and RS232 operate in an independent manner. They each have their own remote/local state, their own measurement result response requests, and their own interrogative responses. If the user sends commands over multiple interfaces then these are executed on a first-come first-served command-by-command basis.

### **Interrogatives**

There are many settings which can be queried by the user via an interface. This action is called an “interrogative” command. Generally an interrogative is formed by the command keyword followed by the question mark ASCII character.

The action of an interrogative command is slightly dependent on the interface being used.



## USB

The user should read the reply to an interrogative from the “interrogative” response linkage to the driver DLL. See the driver DLL documentation for details regarding this.

## RS232

The PA2801/2 automatically transmits the response over the RS232

Note: For RS232 after sending the READ = command, you must send the character “ ? ” to the unit or you will not get a reply

## IEEE488

Any interrogative responses become the highest priority data for the next read of the PA2801/2 which the user performs. If the user sends another command without reading any pending interrogative responses, then they are discarded. Once the user has read any pending interrogative response, then the PA2801/2 will revert to sending the measurement result response data when next read via the IEEE488 interface.

## Remote / Local Operation

Any interface can command that the front panel user be locked out from making changes. This does not lock out the user from viewing menus, it only locks out the user from making changes within them. When any command is received over any interface any menu open by the front panel user will be closed.

If any interface has commanded remote, then the first level menu (accessed by the MENU key) has an entry on the first line entitled RETURN TO LOCAL MODE. If the front panel user highlights this entry and presses ENTER then all interfaces will be returned to the LOCAL state if they are able.

Any interface can command the instrument at any time, whether in the local or remote state.

To command the remote or local state via any interface the REMOTE command is used.

REMOTE=0 – places the unit in the local state.

REMOTE=1 – places the unit in the remote state.

The user can interrogate the unit regarding the remote state of that particular interface by using the REMOTE? interrogative, the response will be 0 if in local, or 1 if in remote.

## Resetting the Instrument

The entire instrument can be reset, as if the power was cycled at the front panel, by using the \*RST command.

## Initializing an Interface

A specific interface can be initialized (clear any pending interrogative, clear any defined measurement result responses etc.) by sending the \*CLS command. The IEEE488 interface user can also use the DCL or SDC bus commands to perform this. The IEEE488 IFC bus command also performs this but without clearing the measurement result responses.

## Identifying the Instrument

The user can send the \*IDN? interrogative via any interface. The response to this is of the following format –

2801,0,v2.00,v2.00,v1.01,v1.02,v1.02  
Or

2802,0,v2.00,v2.00,v1.01,v1.02,v1.02,v1.02

Similarly the user can send \*OPT? or the PRODUCT? Interrogative command from any interface, either of which simply returns “2801” or “2802” as applicable.

The VER? Interrogative is also available on any interface, returning a string such as –

## Querying the Date or Time

The date and/or time can be read from the PA2801/2 by the normal measurement result process using the READ command, or the user can interrogate the PA2801. The TIME? and/or DATE? Interrogatives can be used for this purpose.

The format of the responses to these are as defined by the prevailing date and time format configurations in the SETUP SYSTEM menu.

## Setting the Date or Time

DATEFORMAT=0 – sets that all dates will use the MM/DD/YY format over the interfaces and on the display

DATEFORMAT=1 – sets that all dates will use the DD/MM/YY format over the interfaces and on the display

DATEFORMAT=2 – sets that all dates will use the Month, Date, Year format over the interfaces and the MM/DD/YY format on the display

DATEFORMAT=3 – sets that all dates will use the Date, Month, Year format over the interfaces and the DD/MM/YY format on the display

DATEFORMAT? – queries the present state of the date format. Returns the digit corresponding to the format, as used in the commands above.

TIMEFORMAT=0 – sets that all times are in 12 hour format.

TIMEFORMAT=1 – sets that all times are in 24 hour format.

TIMEFORMAT? – queries the present state of the time format. Returns the digit corresponding to the format, as used in the commands above.

DATE=date – where date is of the same format as set by DATEFORMAT.

TIME=time – where time is of the same format as set by TIMEFORMAT.

## Setting the Interface & Front Panel Language

LANGUAGE=0 – sets the English language. This is presently the only available option.

## Storing and Recalling Configurations

Complete configurations of the unit can be stored and later recalled from internal non-volatile stores numbered 1 through 6.

STORE=value – stores the present configuration into the store # set by value

RECALL=value – recalls and executes the configuration from store # set by value

ERASE=value – erases any configuration stored in the store # set by value

## IEEE488 Status Byte Commands

The IEEE488 interface has an SRQ capability which is controlled by a status byte internal to the PA2801/2.

The STATUS, \*SRE and \*STB commands are provided with the standard IEEE488.2 syntax to control the use of the IEEE488 status byte.

## Commands which affect the measurement process

MEASUREMENT? – this interrogative queries the state of the RUN/HOLD front panel control. 0 is returned if the PA2801/2 is presently in HOLD, 1 is returned if it is presently in RUN.

MEASUREMENT(CH2)? – this interrogative queries the state of the RUN/HOLD front panel control. 0 is returned if the PA2801/2 is presently in HOLD, 1 is returned if it is presently in RUN. This is for the state of channel 2 integration when the PA2802 is configured for 2ch (Async) applications.

MEASUREMENT=0 – disables measurements. Disables both channels (i.e. all measurements) if not configured for 2ch (Async) applications, otherwise disables only channel 1.

MEASUREMENT(CH2)=0 – disables measurements on channel 2 only (only when configured for 2ch (Async) applications).

MEASUREMENT=1 – enables measurements. Enables both channels (i.e. all measurements) if not configured for 2ch (Async) applications, otherwise enables only channel 1.

MEASUREMENT(CH2)=1 – enables measurements on channel 2 only (only when configured for 2ch (Async) applications).

CLR-WAVECAPTURE – this command resets and clears the waveform capture system

WAVECAPTURE=0 – disables waveform capture

WAVECAPTURE=1 – enables waveform capture (if otherwise enabled by configuration and signal input).

WAVECAPTURE? – queries the present WAVECAPTURE setting

CLR-HISTORY – this command clears the history collection process and restarts it.

HISTORY=0 – disables history chart collection

HISTORY=1 – enables history chart collection

HISTORY? – queries the present HISTORY setting

CLR-INRUSH – this command clears the inrush waveform, inrush results and startup chart collection results.

INRUSH=0 – disables inrush & startup capture

INRUSH=1 – enables inrush & startup capture (if otherwise enabled by configuration).

INRUSH? – queries the present INRUSH setting

CLR-INTEGRATION – this command clears any integration data collected. If an integration is running, it continues to run after this command. If an integration is not running, it continues to not run after this command.

CLR-INTEGRATION(CH2) – this command clears any integration data collected for channel 2 (when configured for 2ch (Async) applications only). If an integration is running, it continues to run after this command. If an integration is not running, it continues to not run after this command.

START-INTEGRATION – this command clears any previously obtained integrated measurement results and (re)starts the integration of measurement results.

START-INTEGRATION(CH2) – this command clears any previously obtained integrated measurement results and (re)starts the integration of

measurement results for channel 2 (when configured for 2ch (Async) applications only)

STOP-INTEGRATION - this command stops the integration of measurement results. If the PA2801/2 was already not integrating then this command has no affect. This command does not affect any integrated measurement results.

STOP-INTEGRATION(CH2) - this command stops the integration of measurement results for channel 2 (when configured for 2ch (Async) applications only). If the PA2801/2 was already not integrating then this command has no affect. This command does not affect any integrated measurement results.

CONT-INTEGRATION – this command continues the integration of measurement results. If the PA2801/2 was already integrating measurement results then this command has no affect. Other than possibly starting collection, this command does not affect any integrated measurement results.

CONT-INTEGRATION(CH2) – this command continues the integration of measurement results for channel 2 (when configured for 2ch (Async) applications only). If the PA2801/2 was already integrating measurement results then this command has no affect. Other than possibly starting collection, this command does not affect any integrated measurement results.

INTEGRATION=0 –the same as the STOP-INTEGRATION command

INTEGRATION=1 –the same as the CONT-INTEGRATION command

INTEGRATION(CH2)=0 –the same as the STOP-INTEGRATION(CH2) command

INTEGRATION(CH2)=1 –the same as the CONT-INTEGRATION(CH2) command

INTEGRATION? – this interrogative queries the present integration state. 0 is returned if the PA2801/2 is not presently integrating, 1 is returned if it is integrating.

INTEGRATION(CH2)? – this interrogative queries the present integration state. 0 is returned if the PA2801/2 is not presently integrating, 1 is returned if it

is integrating. This is for the state of channel 2 integration when the PA2802 is configured for 2ch (Async) applications.

Note : When the PA2802 is configured for 2ch (Async) applications the commands without the (CH2) portion only affect channel 1, in all other applications they affect both channels results. When configured for 2ch (Async) applications the user may wish to use an alternate syntax which includes (CH1) at the end of the keyword (i.e. syntactically the same as the CH2 variants, but more obviously specific to CH1 than not including it).

## **Commanding and Controlling a DC Zero**

START-DC-ZERO – commands the PA2801/2 to start performing a DC Zero operation

CANCEL-DC-ZERO – commands the PA2801/2 to abort any DC Zero operation in progress.

DC-ZERO-STATUS? – queries the PA2801/2 regarding the status of any DC Zero in progress. A zero response indicates that no DC zero is in progress, either because of completion, or because one has not started yet, or because none was commanded.

DC-ZERO-COMPLETE? – queries the PA2801/2 as to whether a DC Zero was successfully completed. Returns 0 if a DC Zero is in progress, returns 1 if the last one was successfully completed.

## **Controlling the Line Switch**

LINESWITCH=0 – commands the Line Switch to the OFF state (if enabled)

LINESWITCH=1 – commands the Line Switch to the ON state (if enabled)

LINESWITCH? – queries the present state of the line switch, returns 1 if the line switch is presently in the ON state, 0 if presently in the OFF state.

## **Controlling the Display Backlight & Contrast**

BACKLIGHT=0 – turns off the backlight

BACKLIGHT=1 – turns on the backlight

BACKLIGHT? – queries the present BACKLIGHT setting.

CONTRAST=value – sets the display contrast to ‘value’ which must be an integer in the range 1 to 10.

CONTRAST? – queries the present CONTRAST setting.

## Configuring Measurements

Many commands can have either (CH1) or (CH2) added to the keyword to allow for control and queries of channel 1 and 2 settings independently, when allowed by the overall configuration of the PA2802. (CH1) may be added in any configuration, or for a PA2801, but the (CH2) is only effective when the unit is a PA2802 and it is configured to allow for separate channel control of the command. For improved readability of commands, (IN) or (A) may be used in place of (CH1), and (OUT) or (B) may be used in place of (CH2).

Setting channel 2 data when configured for synchronous channel operation is allowed, but has no affect until configured for asynchronous operation.

Setting values which are only effective when other configurations have specific settings are allowed (and can be queried) but will only take effect when the enabling configuration setting(s) is/are set accordingly.

### **APPLICATION – Application**

APPLICATION=0 – (PA2802 only) sets the configured application type selection to 3p3w

APPLICATION=1 – (PA2802 only) sets the configured application type selection to 2p3w

APPLICATION=2 – (PA2802 only) sets the configured application type selection to 1p3w

APPLICATION=3 – (PA2802 only) sets the configured application type selection to IN:OUT (Async)

APPLICATION=4 – (PA2802 only) sets the configured application type selection to IN:OUT (Sync)



APPLICATION=5 – (PA2802 only) sets the configured application type selection to 2ch (Async)

APPLICATION? – (PA2802 only) queries the present APPLICATION setting

## **RESULTAVG – Result Averaging Period**

RESULTAVG=n – sets the result averaging period (see the table below for the values of n)

0	no result averaging
1	10ms result averaging
2	20ms result averaging
3	50ms result averaging
4	100ms result averaging
5	250ms result averaging
6	500ms result averaging
7	1 second result averaging
8	2.5 second result averaging
9	5 second result averaging
10	10 second result averaging
11	20 second result averaging
12	1 minute result averaging

RESULTAVG? – queries the present result averaging period (see the table below for the responses)

## **MSRTYPE – Measurement Type**

MSRTYPE=0 – sets the measurement type to the LINE (<1kHz) selection

MSRTYPE=1 – sets the measurement type to the HF selection

MSRTYPE=2 – sets the measurement type to the VHF selection (10kHz to 200kHz)

MSRTYPE=3 – sets the measurement type to the DC selection

MSRTYPE=4 – sets the measurement type to the USER SET selection

MSRTYPE=5 – sets the measurement type to the LF selection (0.5Hz to 20Hz)

MSRTYPE=6 – sets the measurement type to the VLF selection (0.02Hz to 5Hz)

MSRTYPE? – queries the present MSRTYPE setting

### **FILTERTYPE – HF Cutoff Filter**

This is only effective when MSRTYPE=4.

FILTERTYPE=0 – sets for no HF filter cutoff

FILTERTYPE=1 – sets for adaptive (or tracking) HF filtering with a cutoff at nominally 200x the measured fundamental frequency.

FILTERTYPE=2 – sets for a fixed HF filter cutoff frequency (see FILTERFREQ below)

FILTERTYPE? – queries the present FILTERTYPE setting

### **FILTERFREQ – HF Filter Cutoff Frequency**

This is only effective when MSRTYPE=4 and FILTERTYPE=2

FILTERFREQ=value – sets the fixed HF filter cutoff frequency to value (in Hz).

FILTERFREQ? – queries the present FILTERFREQ setting

### **CURRENTSYNC – Use current synchronization**

This is only effective when MSRTYPE=4

CURRENTSYNC=0 – sets that the voltage signal is used for fundamental frequency measurement and synchronization

CURRENTSYNC=1 – sets that the current signal is used for fundamental frequency measurement and synchronization

CURRENTSYNC? – queries the present CURRENTSYNC setting

### **MINFUND – Minimum Fundamental Frequency**

This is only effective when MSRTYPE=4

MINFUND=value – sets that the highest fundamental frequency to which the PA2801/2 will synchronize is that given by value (in Hz).

MINFUND? – queries the present MINFUND setting

### **MAXFUND – Maximum Fundamental Frequency**

This is only effective when MSRTYPE=4

MAXFUND=value – sets that the lowest fundamental frequency to which the PA2801/2 will synchronize is that given by value (in Hz).

MAXFUND? – queries the present MAXFUND setting

### **MAXHARMS – Maximum Number of Measured Harmonics**

This is only effective when MSRTYPE=4

MAXHARMS=value – sets that harmonics up to that set by value (integer) will be measured. MAXHARMS=0 disables harmonics measurements (and waveform collection and capture).

MAXHARMS? – queries the present MAXHARMS setting

### **GENDNRANGEDLY – User Set Minimum Downrange Delay**

This is only effective when MSRTYPE=4

GENDNRANGEDLY=value – sets that the minimum delay before downranging is set by value (in seconds)..

GENDNRANGEDLY? – queries the present GENDNRANGEDLY setting

### **MSRDCRIPPLE – DC Ripple Measurement Method**

This is only effective when MSRTYPE=3

MSRDCRIPPLE=0 – sets that DC ripple measurements will be wideband AC measurements (i.e. non-frequency specific).

MSRDCRIPPLE=1 – sets that DC ripple measurements will be made at integer multiples of a user specified frequency (see RIPPLEFREQ below).

MSRDCRIPPLE? – queries the present MSRDCRIPPLE settings.

**RIPPLEFREQ – DC Ripple Base Frequency**

This is only effective when MSRTYPE=3 and MSRDCRIPPLE=1

RIPPLEFREQ=value – sets that the base frequency for “harmonic” DC ripple measurement should be value (in Hz).

RIPPLEFREQ? – queries the present RIPPLEFREQ setting.

**DCDNRANGEDLY – User Set Minimum Downrange Delay**

This is only effective when MSRTYPE=3

DCDNRANGEDLY=value – sets that the minimum delay before downranging is set by value (in seconds)..

DCDNRANGEDLY? – queries the present DCDNRANGEDLY setting

**VRANGE – Select a Voltage Input Range**

VRANGE=value – sets the V input range to be used to that associated with the value as shown below –

0	Autorange
1	850V
2	450V
3	135V
4	50V
5	20V

VRANGE? – queries the present actual range selection.

**AINPUT – Select the Current Input Mode**

AINPUT=0 – sets that the internal shunt current input of the unit shall be used without scaling (i.e. no external CT)

AINPUT=1 – sets that the internal shunt current input of the unit shall be used with user set scaling (i.e. with an external CT, see SHUNTRATIO1 and SHUNTRATIO2 commands below)

AINPUT=2 – sets that the internal T (BNC connector) current input of the unit shall be used with user set scaling (i.e. with an external CT with voltage output, see TRANSRATIO1 and TRANSRATIO2 commands below)

AINPUT? – queries the present AINPUT settings

**ARANGE – Select a Current Input Range (Shunt Input Only)**

This is only effective when AINPUT=0 or AINPUT=1

ARANGE=value – sets the A input range to be used to that associated with the value as shown below –

0	Autorange
1	65A
2	20A
3	6.5A
4	2A
5	0.65A
6	300mA
7	100mA
8	30mA
9	10mA

ARANGE? – queries the present actual range selection.

**TRANGE – Select a Current Input Range (Transducer Input Only)**

This is only effective when AINPUT=2

TRANGE=value – sets the T input range to be used to that associated with the value as shown below –

0	Autorange
1	15V
2	5V
3	1.5V
4	0.5V
5	0.15V

TRANGE? – queries the present actual range selection.

**STRICTRANGING – Forces the App. of the Requested Fixed Range**

This is only effective if VRANGE is not 0, ARANGE is not 0 or TRANGE is not 0

STRICTRANGING=0 – enables the PA2801/2 to select a higher full-scale range than set by the VRANGE, ARANGE or TRANGE command if needed to correctly measure the actual input signal.

STRICTRANGING=1 – forces the PA2801/2 to select the range selected by the VRANGE, ARANGE or TRANGE setting under all circumstances.

STRICTRANGING? – queries the present STRICTRANGING setting

### **SHUNTRATIO1 and SHUNTRATIO2 – Sets A input CT Ratio**

This is only effective if AINPUT=1

SHUNTRATIO1=value

SHUNTRATIO2=value

The actual scale factor is set to the division of the SHUNTRATIO1= value by the SHUNTRATIO2= value. Effectively the SHUNTRATIO1 value is the input current level to the external CT which corresponds to an output current level from that CT given by the SHUNTRATIO2 value.

SHUNTRATIO1? – queries the present SHUNTRATIO1 setting

SHUNTRATIO2? – queries the present SHUNTRATIO2 setting

### **TRANSRATIO1 and TRANSRATIO2 –sets T input CT Ratio**

This is only effective if AINPUT=2

TRANSRATIO1=value

TRANSRATIO2=value

The actual scale factor is set to the division of the TRANSRATIO1= value by the TRANSRATIO2= value. Effectively the TRANSRATIO1 value is the input current level to the external CT which corresponds to an output voltage level from that CT given by the TRANSRATIO2 value.

TRANSRATIO1? – queries the present TRANSRATIO1 setting

TRANSRATIO2? – queries the present TRANSRATIO2 setting

**MSRSOURCE – Sets Whether the Pwr Source / Load is to be Meas.**

MSRSOURCE=0 – sets that the Load is to be measured (i.e. the measurement is downstream from the PA2801/2).

MSRSOURCE=1 – sets that the Source is to be measured (i.e. the measurement is upstream from the PA2801/2).

MSRSOURCE? – queries the present MSRSOURCE setting

**WIRINGCOMP – Enables Wiring Impedance Compensations**

WIRINGCOMP=0 – disables all wiring impedance compensations

WIRINGCOMP=1 – enables all wiring impedance compensations

WIRINGCOMP? – queries the present WIRINGCOMP setting

**WIRINGLOSS – Sets the Wiring Loss Impedance Value**

(Effects Channel 1 or None Only)

This is only effective when WIRINGCOMP=1

WIRINGLOSS=value – sets the wire impedance level to value in ohms.

WIRINGLOSS? – queries the present WIRINGLOSS value

**WIRINGLOSSN – Neutral Wiring Loss (PA2802 only)**

This is only effective when WIRINGCOMP=1 and APPLICATION=1 or 2

WIRINGLOSSN=value – (PA2802 only) sets the Neutral wire impedance level to value in ohms.

WIRINGLOSSN? – queries the present WIRINGLOSSN setting

**WIRINGLOSSG – Ground Wiring Loss (PA2802 only)**

This is only effective when WIRINGCOMP=1 and APPLICATION=2

WIRINGLOSSG=value – (PA2802 only) sets the Ground wire impedance level to value in ohms.

WIRINGLOSSG? – queries the present WIRINGLOSSG setting

**VBURDENCOMP** – Enables Voltage Burden Compensation

(Effects Channel 1 or None Only)

VBURDENCOMP=0 – disables V input burden compensation

VBURDENCOMP=1 – enables V input burden compensation

VBURDENCOMP? – queries the present VBURDENCOMP setting

**REVERSEV** – Enables Reversal of Voltage Measurement Polarities

REVERSEV=0 – Voltages (V input) do not have their polarity reversed

REVERSEV=1 – All Voltage (V input) Measurements have their polarity reversed

REVERSEV? – queries the present REVERSEV setting

**REVERSEA** – Enables Reversal of Current Measurement Polarities

REVERSEA=0 – Currents (A or T input) do not have their polarity reversed

REVERSEA=1 – All Current (A or T input) Measurements have their polarity reversed

REVERSEA? – queries the present REVERSEA setting

**LINECONTROL** – Configures the Line Switch

(Effects Channel 1 Only)

LINECONTROL=0 – disables the line switch

LINECONTROL=1 – enables the internal line switch

LINECONTROL=2 – enables the line switch in external mode

LINECONTROL? – queries the present LINECONTROL setting.

**LINEPHASE** – Internal Line Switch Turn On Phase

(Effects Channel 1 Only)

This is only effective if LINECONTROL=1 and MSRTYPE=0, 1 or 4

LINEPHASE=n – sets the line switch turn ON phase to n (in degrees) when configured for AC mode operation. N must be an integer in the range 0 to 359°



LINEPHASE? – queries the present LINEPHASE setting

### **INRUSHARNG – Sets the A input Inrush Range**

This is only effective if LINECONTROL=1 and AINPUT=0 or 1

INRUSHARNG=value – sets the A input range to select immediately prior to and for 150ms following turning on the internal line switch. The same values as used for ARANGE are used, with the exception of the 0 value, which is not allowed.

INRUSHARNG? – queries the present INRUSHARNG settings

### **INRUSHTRNG – Sets the T input Inrush Range**

This is only effective if LINECONTROL=1 and AINPUT=2

INRUSHTRNG=value – sets the A input range to select immediately prior to and for 150ms following turning on the internal line switch. The same values as used for TRANGE are used, with the exception of the 0 value, which is not allowed.

INRUSHTRNG? – queries the present INRUSHTRNG settings

### **FILTEREDINRUSH – Filtered or Unfilt. Signal is Captured During Inrush**

This is only effective if LINECONTROL=1 or 2 or TRIGGERINRUSH=1

FILTEREDINRUSH=0 – selects that the unfiltered voltage & current signals are captured as the inrush waveforms.

FILTEREDINRUSH=1 – selects that the filtered (as selected by the measurement type, or by the HFFILTER and FILTERFREQ commands) voltage & current signals are captured as the inrush waveforms.

FILTEREDINRUSH? – queries the present FILTEREDINRUSH setting

### **WAVETRIG – Sets the Method of Triggering Waveform Capture**

This is ineffective if harmonics are not being measured for any reason.

WAVETRIG=0 – disables waveform capture

WAVETRIG=1 – enables detection of peak voltages to trigger a waveform capture

WAVETRIG=2 – enables detection of glitch voltages to trigger a waveform capture

WAVETRIG=3 – enables detection of peak currents to trigger a waveform capture

WAVETRIG=4 – enables detection of glitch currents to trigger a waveform capture

WAVETRIG? – queries the present WAVETRIG setting

### **TRIGVOLTS – Sets the Voltage for Waveform Capture Triggering**

This is ineffective if harmonics are not being measured for any reason or if WAVETRIG=0, 3 or 4

TRIGVOLTS=value – sets the peak/glitch voltage level at which waveform capture is triggered

TRIGVOLTS? – queries the present TRIGVOLTS setting

### **TRIGAMPS – Sets the Current for Waveform Capture Triggering**

This is ineffective if harmonics are not being measured for any reason or if WAVETRIG=0, 1 or 2

TRIGAMPS=value – sets the peak/glitch current level at which waveform capture is triggered

TRIGAMPS? – queries the present TRIGVOLTS setting

## READ and UPDATE commands

These commands are used to control obtaining measurement data from the PA2801/2 in the normal manner.

UPDATE=value – sets the rate at which new measurement data becomes available to this interface to ‘value’ milliseconds. If UPDATE=0 is specified then the measurement results are only updated each time that a new READ=data command is received, but not at any other time.

READ=data – specifies the data which is to be read by the interface.

Data is a set of one or more data request definitions, each separated from any others by the comma character. Each data request definition follows a common general format –

Note: For RS232 after sending the READ = command, you must send the character “ ? ” to the unit or you will not get a reply

Keyword[Fields]

Where –

Keyword	defines the general data being requested
Fields	contains none to many additional specifications which serve to exactly define the data being requested. Each field specification is separated from any others by the comma character. If no fields are specified then the square braces may be omitted.

In general the ‘fields’ portion is made up of none, one or more than one textual specification, followed by either a) none or three integer specifications or b) a single integer specification followed by none or two floating point specifications.

The available textual specifications are selected as none or one from each of the following groups, these may be specified in any order, but must always be before any numeric specifications –

**Channel Specification (defaults to CH1)**

CH1	Channel 1 data
CH2	Channel 2 data
A	Channel 1 data
B	Channel 2 data
IN	Channel 1 data
OUT	Channel 2 data
TOTAL	Combined Channel 1 & 2 data
AB	Combined Channel 1 & 2 data

**Measurement Collection Type Specification (defaults to normal)**

INRUSH  
INTEG  
CHARGE  
DISCHARGE  
INTEG-AVG or AVERAGE  
INTEG-MAX or HIGHEST  
INTEG-MIN or LOWEST

**Logarithmically Scaled (default is linear)**

DB

**Extents or Median Value within a chart or waveform point (defaults to EXTENTS)**

EXTENTS  
MEDIAN

**Measurement Bandwidth (defaults to ACDC in most cases)**

ACDC  
AC  
DC  
FUND

**Extent Limits or Trend Value from a Chart (defaults to LIMITS)**

LIMITS  
TRENDS

A partial list of the available combinations are –

## Normal Results –

These return a single floating point value.

AMPS[chnl] or AMPS[chnl,ACDC]  
AMPS[chnl,AC]  
AMPS[chnl,DC]  
AMPS[chnl,FUND]  
A-CF[chnl] or A-CF[chnl,ACDC]  
A-CF[chnl,AC]  
A-FF[chnl]  
A-PK[chnl] or A-PK[chnl,ACDC]  
A-PK[chnl,AC]  
A-HIPK[chnl] or A-HIPK[chnl,ACDC]  
A-HIPK[chnl,AC]  
A-LOPK[chnl] or A-LOPK[chnl,ACDC]  
A-LOPK[chnl,AC]  
A-PKPK[chnl]  
A-RECT[chnl]  
FREQ[chnl]  
LOADR[chnl,FUND]  
LOADR[chnl,DC]  
LOADZ[chnl,FUND]  
LOADZ[chnl,DC]  
LOADX[chnl] or LOADX[chnl,FUND]  
PF[chnl] or PF[chnl,ACDC]  
PF[chnl,AC]  
PF[chnl,FUND]  
DPF[chnl]  
VA[chnl] or VA[chnl,ACDC]  
VA[chnl,AC]  
VA[chnl,DC]  
VA[chnl,FUND]  
VAR[chnl] or VAR[chnl,AC]  
VAR[chnl,FUND]  
VOLTS[chnl] or VOLTS[chnl,ACDC]  
VOLTS[chnl,AC]  
VOLTS[chnl,DC]  
VOLTS[chnl,FUND]  
V-CF[chnl] or V-CF[chnl,ACDC]

V-CF[chnl,AC]  
V-FF[chnl]  
V-PK[chnl] or V-PK[chnl,ACDC]  
V-PK[chnl,AC]  
V-HIPK[chnl] or V-HIPK[chnl,ACDC]  
V-HIPK[chnl,AC]  
V-LOPK[chnl] or V-LOPK[chnl,ACDC]  
V-LOPK[chnl,AC]  
V-PKPK[chnl]  
V-RECT[chnl]  
V-WYE  
WATTS[chnl] or WATTS[chnl,ACDC]  
WATTS[chnl,AC]  
WATTS[chnl,DC]  
WATTS[chnl,FUND]  
LOSS  
EFFY  
TEMPERATURE

The following all return a single floating point, computed as a total over all harmonics between harmonic # 'start' thru' harmonic # 'end' (inclusive) using a step value of 'step'.

A-HRNG[chnl,start,end,step]  
A-THD[chnl,start,end,step]  
A-KFACT[chnl,start,end]  
TRIPLENS[start,end]  
EVEN-TRIPLENS[start,end]  
ODD-TRIPLENS[start,end]  
V-HRNG[chnl,start,end,step]  
V-THD[chnl,start,end,step]  
W-HRNG[chnl,start,end,step]  
PF-HRNG[chnl,start,end,step]  
VA-HRNG[chnl,start,end,step]  
VAR-HRNG[chnl,start,end,step]

The following all return one value per each harmonic in the range harmonic # 'start', thru' harmonic # 'end' (inclusive) using a step value of 'step'.

V-PHASE[chnl,start,end,step]  
A-PHASE[chnl,start,end,step]

V-HARMS[chnl,start,end,step]  
 V-THD-HARMS[chnl,start,end,step]  
 A-HARMS[chnl,start,end,step]  
 A-THD-HARMS[chnl,start,end,step]  
 W-HARMS[chnl,start,end,step]  
 PF-HARMS[chnl,start,end,step]  
 VA-HARMS[chnl,start,end,step]  
 VAR-HARMS[chnl,start,end,step]

The following return 'npoints' pairs of values (max followed by min) if EXTENTS is included, or a single value if MEDIAN is included. The points are equally spread over the inclusive phase range 0 thru 360° of a single cycle.

V-WAVE[chnl,npoints,EXTENTS]  
 V-WAVE[chnl,npoints,MEDIAN]  
 V-DIST[chnl,npoints,EXTENTS]  
 V-DIST[chnl,npoints,MEDIAN]  
 V-CAP[chnl,npoints,EXTENTS]  
 V-CAP[chnl,npoints,MEDIAN]  
 V-CAP-GLITCH[chnl,npoints,EXTENTS]  
 V-CAP-GLITCH[chnl,npoints,MEDIAN]  
 A-WAVE[chnl,npoints,EXTENTS]  
 A-WAVE[chnl,npoints,MEDIAN]  
 A-DIST[chnl,npoints,EXTENTS]  
 A-DIST[chnl,npoints,MEDIAN]  
 A-CAP[chnl,npoints,EXTENTS]  
 A-CAP[chnl,npoints,MEDIAN]  
 A-CAP-GLITCH[chnl,npoints,EXTENTS]  
 A-CAP-GLITCH[chnl,npoints,MEDIAN]

The following return 'npoints' pairs of values (max followed by min) if EXTENTS is included, or a single value if MEDIAN is included. The charted values are given in equally spaced intervals over the time span 't\_span' (in floating point seconds), starting at offset 't\_start' (in floating point seconds) from the chart start date & time. If t\_span and t\_offset are both zero (or not specified) then the full span of the charted data is given.

A-HIST[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
 A-HIST[chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
 A-HIST[chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]

A-HIST[chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-HIST[chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-HIST[chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-HIST[chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-HIST[chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-HIST[chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-HIST[chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-HIST[chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-HIST[chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-PK-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-THD-HIST[chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-THD-HIST[chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-THD-HIST[chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-THD-HIST[chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
FREQ-HIST[chnl,,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
FREQ-HIST[chnl,,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
FREQ-HIST[chnl,,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
FREQ-HIST[chnl,,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
PF-HIST[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
PF-HIST[chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
PF-HIST[chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
PF-HIST[chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
PF-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
PF-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
PF-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
PF-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
PF-HIST[chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
PF-HIST[chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
PF-HIST[chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
PF-HIST[chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]



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VA-HIST[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA-HIST[chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VA-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VA-HIST[chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA-HIST[chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VA-HIST[chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA-HIST[chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA-HIST[chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VAR-HIST[chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-HIST[chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-HIST[chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-PK-HIST[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]

V-PK-HIST[chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-PK-HIST[chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-PK-HIST[chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-PK-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-PK-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-PK-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-PK-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-THD-HIST[chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-THD-HIST[chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-THD-HIST[chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-THD-HIST[chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-WYE-HIST[chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-WYE-HIST[chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-WYE-HIST[chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-WYE-HIST[chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W-HIST[chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W-HIST[chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
TEMP-HIST[chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
TEMP-HIST[chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
TEMP-HIST[chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
TEMP-HIST[chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
LOSS-HIST[chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
LOSS-HIST[chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
LOSS-HIST[chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
LOSS-HIST[chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
EFFY-HIST[chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
EFFY-HIST[chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]

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EFFY-HIST[chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
EFFY-HIST[chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-STARTUP[chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A- STARTUP [chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-PK- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
A-THD- STARTUP [chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
A-THD- STARTUP [chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
A-THD- STARTUP [chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
A-THD- STARTUP [chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
FREQ- STARTUP [chnl,,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
FREQ- STARTUP [chnl,,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
FREQ- STARTUP [chnl,,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
FREQ- STARTUP [chnl,,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]

PF- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
PF- STARTUP [chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VA- STARTUP [chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
VAR- STARTUP [chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]

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V- STARTUP [chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V- STARTUP [chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-PK- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-THD- STARTUP [chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-THD- STARTUP [chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-THD- STARTUP [chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-THD- STARTUP [chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
V-WYE- STARTUP [chnl,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
V-WYE- STARTUP [chnl,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
V-WYE- STARTUP [chnl,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
V-WYE- STARTUP [chnl,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,ACDC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,ACDC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,ACDC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,ACDC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,AC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,AC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,AC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,AC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,DC,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,DC,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,DC,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,DC,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,FUND,EXTENTS,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,FUND,MEDIAN,LIMITS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,FUND,EXTENTS,TRENDS,npoints,t\_start,t\_span]  
W- STARTUP [chnl,FUND,MEDIAN,TRENDS,npoints,t\_start,t\_span]  
AMPS-INRUSH[chnl,npoints,t\_start,t\_span]  
VOLTS-INRUSH[chnl,npoints,t\_start,t\_span]

## Highest Measurement During an Inrush & Startup

These all return a single floating point value.

AMPS[chnl,INRUSH] or AMPS[chnl,ACDC,INRUSH]  
AMPS[chnl,AC,INRUSH]  
AMPS[chnl,DC,INRUSH]  
AMPS[chnl,FUND,INRUSH]  
A-CF[chnl,INRUSH] or A-CF[chnl,ACDC,INRUSH]  
A-CF[chnl,AC,INRUSH]  
A-FF[chnl,INRUSH]  
A-PK[chnl,INRUSH] or A-PK[chnl,ACDC,INRUSH]  
A-PK[chnl,AC,INRUSH]  
A-HIPK[chnl,INRUSH] or A-HIPK[chnl,ACDC,INRUSH]  
A-HIPK[chnl,AC,INRUSH]  
A-LOPK[chnl,INRUSH] or A-LOPK[chnl,ACDC,INRUSH]  
A-LOPK[chnl,AC,INRUSH]  
A-PKPK[chnl,INRUSH]  
A-RECT[chnl,INRUSH]  
FREQ[chnl,INRUSH]  
PF[chnl,INRUSH] or PF[chnl,ACDC,INRUSH]  
PF[chnl,AC,INRUSH]  
PF[chnl,FUND,INRUSH]  
DPF[chnl,INRUSH]  
VA[chnl,INRUSH] or VA[chnl,ACDC,INRUSH]  
VA[chnl,AC,INRUSH]  
VA[chnl,DC,INRUSH]  
VA[chnl,FUND,INRUSH]  
VAR[chnl,INRUSH] or VAR[chnl,AC,INRUSH]  
VAR[chnl,FUND,INRUSH]  
VOLTS[chnl,INRUSH] or VOLTS[chnl,ACDC,INRUSH]  
VOLTS[chnl,AC,INRUSH]  
VOLTS[chnl,DC,INRUSH]  
VOLTS[chnl,FUND,INRUSH]  
V-CF[chnl,INRUSH] or V-CF[chnl,ACDC,INRUSH]  
V-CF[chnl,AC,INRUSH]  
V-FF[chnl,INRUSH]  
V-PK[chnl,INRUSH] or V-PK[chnl,ACDC,INRUSH]  
V-PK[chnl,AC,INRUSH]  
V-HIPK[chnl,INRUSH] or V-HIPK[chnl,ACDC,INRUSH]  
V-HIPK[chnl,AC,INRUSH]

V-LOPK[chnl,INRUSH] or V-LOPK[chnl,ACDC,INRUSH]  
V-LOPK[chnl,AC,INRUSH]  
V-PKPK[chnl,INRUSH]  
V-RECT[chnl,INRUSH]  
V-WYE[INRUSH]  
WATTS[chnl,INRUSH] or WATTS[chnl,ACDC,INRUSH]  
WATTS[chnl,AC,INRUSH]  
WATTS[chnl,DC,INRUSH]  
WATTS[chnl,FUND,INRUSH]

## **Integrated Results (scaling in unit.Hours)**

These all return a single floating point value.

AMPS[chnl,INTEG] or AMPS[chnl,ACDC,INTEG]  
AMPS[chnl,AC,INTEG]  
AMPS[chnl,DC,INTEG]  
AMPS[chnl,FUND,INTEG]  
A-RECT[chnl,INTEG]  
VA[chnl,INTEG] or VA[chnl,ACDC,INTEG]  
VA[chnl,AC,INTEG]  
VA[chnl,DC,INTEG]  
VA[chnl,FUND,INTEG]  
VAR[chnl,INTEG] or VAR[chnl,AC,INTEG]  
VAR[chnl,FUND,INTEG]  
VOLTS[chnl,INTEG] or VOLTS[chnl,ACDC,INTEG]  
VOLTS[chnl,AC,INTEG]  
VOLTS[chnl,DC,INTEG]  
VOLTS[chnl,FUND,INTEG]  
WATTS[chnl,INTEG] or WATTS[chnl,ACDC,INTEG]  
WATTS[chnl,AC,INTEG]  
WATTS[chnl,DC,INTEG]  
WATTS[chnl,FUND,INTEG]

## **Integrated Average Results**

These all return a single floating point value.

AMPS[chnl,INTEG-AVG] or AMPS[chnl,ACDC,INTEG-AVG]

AMPS[chnl,AC,INTEG-AVG]  
AMPS[chnl,DC,INTEG-AVG]  
AMPS[chnl,FUND,INTEG-AVG]  
A-RECT[chnl,INTEG-AVG]  
VA[chnl,INTEG-AVG] or VA[chnl,ACDC,INTEG-AVG]  
VA[chnl,AC,INTEG-AVG]  
VA[chnl,DC,INTEG-AVG]  
VA[chnl,FUND,INTEG-AVG]  
PF[chnl,INTEG-AVG] or VA[chnl,ACDC,INTEG-AVG]  
PF[chnl,AC,INTEG-AVG]  
PF[chnl,FUND,INTEG-AVG]  
VAR[chnl,INTEG-AVG] or VAR[chnl,AC,INTEG-AVG]  
VAR[chnl,FUND,INTEG-AVG]  
VOLTS[chnl,INTEG-AVG] or VOLTS[chnl,ACDC,INTEG-AVG]  
VOLTS[chnl,AC,INTEG-AVG]  
VOLTS[chnl,DC,INTEG-AVG]  
VOLTS[chnl,FUND,INTEG-AVG]  
WATTS[chnl,INTEG-AVG] or WATTS[chnl,ACDC,INTEG-AVG]  
WATTS[chnl,AC,INTEG-AVG]  
WATTS[chnl,DC,INTEG-AVG]  
WATTS[chnl,FUND,INTEG-AVG]

## Measurement Extents during Integration

These all return a single floating point value.

AMPS[chnl,INTEG-MAX] or AMPS[chnl,ACDC,INTEG-MAX]  
AMPS[chnl,AC,INTEG-MAX]  
AMPS[chnl,DC,INTEG-MAX]  
AMPS[chnl,FUND,INTEG-MAX]  
A-CF[chnl,INTEG-MAX] or A-CF[chnl,ACDC,INTEG-MAX]  
A-CF[chnl,AC,INTEG-MAX]  
A-FF[chnl,INTEG-MAX]  
A-PK[chnl,INTEG-MAX] or A-PK[chnl,ACDC,INTEG-MAX]  
A-PK[chnl,AC,INTEG-MAX]  
A-HIPK[chnl,INTEG-MAX] or A-HIPK[chnl,ACDC,INTEG-MAX]  
A-HIPK[chnl,AC,INTEG-MAX]  
A-LOPK[chnl,INTEG-MAX] or A-LOPK[chnl,ACDC,INTEG-MAX]  
A-LOPK[chnl,AC,INTEG-MAX]  
A-PKPK[chnl,INTEG-MAX]



A-RECT[chnl,INTEG-MAX]  
FREQ[chnl,INTEG-MAX]  
PF[chnl,INTEG-MAX] or PF[chnl,ACDC,INTEG-MAX]  
PF[chnl,AC,INTEG-MAX]  
PF[chnl,FUND,INTEG-MAX]  
DPF[chnl,INTEG-MAX]  
VA[chnl,INTEG-MAX] or VA[chnl,ACDC,INTEG-MAX]  
VA[chnl,AC,INTEG-MAX]  
VA[chnl,DC,INTEG-MAX]  
VA[chnl,FUND,INTEG-MAX]  
VAR[chnl,INTEG-MAX] or VAR[chnl,AC,INTEG-MAX]  
VAR[chnl,FUND,INTEG-MAX]  
VOLTS[chnl,INTEG-MAX] or VOLTS[chnl,ACDC,INTEG-MAX]  
VOLTS[chnl,AC,INTEG-MAX]  
VOLTS[chnl,DC,INTEG-MAX]  
VOLTS[chnl,FUND,INTEG-MAX]  
V-CF[chnl,INTEG-MAX] or V-CF[chnl,ACDC,INTEG-MAX]  
V-CF[chnl,AC,INTEG-MAX]  
V-FF[chnl,INTEG-MAX]  
V-PK[chnl,INTEG-MAX] or V-PK[chnl,ACDC,INTEG-MAX]  
V-PK[chnl,AC,INTEG-MAX]  
V-HIPK[chnl,INTEG-MAX] or V-HIPK[chnl,ACDC,INTEG-MAX]  
V-HIPK[chnl,AC,INTEG-MAX]  
V-LOPK[chnl,INTEG-MAX] or V-LOPK[chnl,ACDC,INTEG-MAX]  
V-LOPK[chnl,AC,INTEG-MAX]  
V-PKPK[chnl,INTEG-MAX]  
V-RECT[chnl,INTEG-MAX]  
V-WYE[INTEG-MAX]  
WATTS[chnl,INTEG-MAX] or WATTS[chnl,ACDC,INTEG-MAX]  
WATTS[chnl,AC,INTEG-MAX]  
WATTS[chnl,DC,INTEG-MAX]  
WATTS[chnl,FUND,INTEG-MAX]

AMPS[chnl,INTEG-MIN] or AMPS[chnl,ACDC,INTEG-MIN]  
AMPS[chnl,AC,INTEG-MIN]  
AMPS[chnl,DC,INTEG-MIN]  
AMPS[chnl,FUND,INTEG-MIN]  
A-CF[chnl,INTEG-MIN] or A-CF[chnl,ACDC,INTEG-MIN]  
A-CF[chnl,AC,INTEG-MIN]  
A-FF[chnl,INTEG-MIN]  
A-PK[chnl,INTEG-MIN] or A-PK[chnl,ACDC,INTEG-MIN]

A-PK[chnl,AC,INTEG- MIN]  
A-HIPK[chnl,INTEG- MIN] or A-HIPK[chnl,ACDC,INTEG- MIN]  
A-HIPK[chnl,AC,INTEG- MIN]  
A-LOPK[chnl,INTEG- MIN] or A-LOPK[chnl,ACDC,INTEG- MIN]  
A-LOPK[chnl,AC,INTEG- MIN]  
A-PKPK[chnl,INTEG- MIN]  
A-RECT[chnl,INTEG- MIN]  
FREQ[chnl,INTEG- MIN]  
PF[chnl,INTEG- MIN] or PF[chnl,ACDC,INTEG- MIN]  
PF[chnl,AC,INTEG- MIN]  
PF[chnl,FUND,INTEG- MIN]  
DPF[chnl,INTEG- MIN]  
VA[chnl,INTEG- MIN] or VA[chnl,ACDC,INTEG- MIN]  
VA[chnl,AC,INTEG- MIN]  
VA[chnl,DC,INTEG- MIN]  
VA[chnl,FUND,INTEG- MIN]  
VAR[chnl,INTEG- MIN] or VAR[chnl,AC,INTEG- MIN]  
VAR[chnl,FUND,INTEG- MIN]  
VOLTS[chnl,INTEG- MIN] or VOLTS[chnl,ACDC,INTEG- MIN]  
VOLTS[chnl,AC,INTEG- MIN]  
VOLTS[chnl,DC,INTEG- MIN]  
VOLTS[chnl,FUND,INTEG- MIN]  
V-CF[chnl,INTEG- MIN] or V-CF[chnl,ACDC,INTEG- MIN]  
V-CF[chnl,AC,INTEG- MIN]  
V-FF[chnl,INTEG- MIN]  
V-PK[chnl,INTEG- MIN] or V-PK[chnl,ACDC,INTEG- MIN]  
V-PK[chnl,AC,INTEG- MIN]  
V-HIPK[chnl,INTEG- MIN] or V-HIPK[chnl,ACDC,INTEG- MIN]  
V-HIPK[chnl,AC,INTEG- MIN]  
V-LOPK[chnl,INTEG- MIN] or V-LOPK[chnl,ACDC,INTEG- MIN]  
V-LOPK[chnl,AC,INTEG- MIN]  
V-PKPK[chnl,INTEG- MIN]  
V-RECT[chnl,INTEG- MIN]  
V-WYE[INTEG- MIN]  
WATTS[chnl,INTEG- MIN] or WATTS[chnl,ACDC,INTEG- MIN]  
WATTS[chnl,AC,INTEG- MIN]  
WATTS[chnl,DC,INTEG- MIN]  
WATTS[chnl,FUND,INTEG- MIN]

## Charge & Discharge data (scaled in unit.Hours)

These all return a single floating point value.

AMPS[chnl,DC,CHARGE]  
 AMPS[chnl,DC,DISCHARGE]  
 VA[chnl,DC,CHARGE]  
 VA[chnl,DC,DISCHARGE]  
 VOLTS[chnl,DC,CHARGE]  
 VOLTS[chnl,DC,DISCHARGE]  
 WATTS[chnl,DC,CHARGE]  
 WATTS[chnl,DC,DISCHARGE]

## Special Data

The following all return a special format data, specific to each keyword.

TIME	Returns the present time of day
DATE	Returns the present date
INT-TIME[chnl]	Returns the integration time (in hours)
CHARGE-TIME[chnl]	Returns the charge time (in floating point hours)
DISCHARGE-TIME[chnl]	Returns the discharge time (in floating point hours)
CAP-TIME	Returns the waveform capture time of day
CAP-DATE	Returns the waveform capture date
HISTORY-TIME	Returns the start time of day for the history chart
HISTORY-DATE	Returns the start date of the history chart
HISTORY-SPAN	Returns the time span of the full history chart (in floating point seconds)
STARTUP-SPAN	Returns the time span of the full startup chart (in floating point seconds)

INRUSH-SPAN	Returns the time span of the full inrush waveform chart (in floating point seconds)
INRUSH-TIME	Returns the start time of day for the inrush waveform chart
INRUSH-DATE	Returns the start date for the inrush waveform chart
NHARMS[chnl]	Returns the integer number of valid harmonics measured



# Appendix A - Physical Specifications

## General

**Note:** Specifications subject to change without notice.

## Environment

Operating:	0°C to 55°C, <95% RH non-condensing
Storage:	-20°C to 70°C, non-condensing.

## Altitude Equivalent

Atmospheric pressures and air densities from 1000ft below sea level to 15000ft above sea level.

## Warm Up

Specifications valid within 30 minutes after application of power.

## Accuracy

Valid for 1 year for ambient temperatures within 5°C of the calibration temperature (for all parameters).



## Appendix B - Measurement Specifications

### Autorange

When enabled, continuously automatically selects the best range to produce the highest accuracy results for the applied signal on each input independently. Changes to a higher range take <10ms per range, changes to a lower range take less than 1 cycle of the minimum frequency per range. The PA2801/PA2802 can change to a lower range up to 2 ranges each cycle.

### Ranging

Commanded range changes take less than 5ms.

### Input Filtering

When user-set for low pass filtering, the user entered frequency is that for 5% attenuation, otherwise accuracy is valid for frequencies up to 100kHz. When unfiltered, the typical 3dB bandwidth is 5MHz. An adaptive filtering mode is also provided, when selected the upper frequency (5% attenuation) is nominally 200x the fundamental frequency or 150kHz (whichever is lower).

### Low Frequencies

User selectable low frequency limit (does not affect measurement accuracy).

### Measurement Rate Frequency

Made over the greater of 10ms or 2 cycles of input signal.



## **Non-Harmonics**

Made over the greater of 5ms or 1 cycle of input signal. Measurements are made without intervening non-measurement periods of time between measurements (except when making a range change or when making a significant change to the sampling rate).

## **Harmonics**

Made over the greater of 5ms or 4 cycles of input signal (2 cycles for fundamental frequencies less than 5Hz).

All measurements are always measured, except for the harmonics results, which are not measured when no fundamental component can be established in the selected input signal and the user has selected no default frequency.

## **DC Input Offset Compensation**

The user may select to use the present DC signals as compensation for future DC measurements. This compensates for both internally and externally generated DC offsets. This procedure typically takes less than 5 seconds.

## **Frequency Measurements**

Made after applying an adaptive 6-pole bandpass filter to the selected signal. A minimum input level of 5% of range is required. The accuracy of frequency measurements is 0.005%.

## **Harmonic Analysis**

A variable length DFT is performed on the input samples with a length of between 768 and 2048 samples per DFT period. Input samples are decimated and anti-aliased as needed. Each harmonic from the fundamental up to the lower of the 100<sup>th</sup> or having a frequency of 70kHz is measured.

## Result Averaging

All final results may be averaged using a 2-pole filter with a user selectable time constant of between 10ms and 5s.

## Input Sampling

All inputs within same channel are always sampled simultaneously. Sampling is short-term quasi-randomly dithered by up to 0.5% and long-term synchronized to the selected input signal to within 0.001%. Nominal sampling rate is 235kSPS.

## Integration

Most results are available as integrated, maximum value, minimum value and average values over a user defined integration period (between user start and stop actions).

The DC voltage and current measurement results are also integrated separately depending on the polarity of the DC current and are made available as the Charge and Discharge integrated results.

## History Charts

Most results are available as a history chart. The chart data is stored every measurement period. The last 512 measurements are always available, the prior 2,048 are stored as the average or the maximum value (as applicable) over sets of 4 measurements. The prior 8,192 are stored as the average or the maximum value (as applicable) over sets of 16 measurements. The prior 32,768 are stored as the average or the maximum value (as applicable) over sets of 64 measurements, and so on until a maximum of 89,478,144 total measurements have been collected. When full, the oldest data point is discarded.

## Startup Charts

Most results are available as a startup chart. The chart data is collected at intervals of  $1/1024^{\text{th}}$  of the user set overall startup period. Data is combined into the startup chart as the average or the maximum value (as applicable) between each collection interval.

## Waveform Data

The present voltage, current and power waveforms are stored in the instrument. These are available plotted as measured, or with the fundamental component removed, and/or with the DC component removed.

## Captured Waveforms

The voltage, current and power waveforms are captured when a waveform with a peak value, or with a non-fundamental component, is found which is higher than a user set trigger level or that previously encountered (as specified by the user).

## Inrush Waveforms

The voltage and current waveforms are captured over a period of nominally 3ms before, and 65ms after, the detection of inrush.

## Line Switch

The internal line switch can be turned on and off by user controls. When supplied with an AC voltage signal, the line switch can be programmed to turn on at a specific phase (with  $1^\circ$  resolution) of the voltage signal. Turn off is always at nominally zero current signal when an AC voltage is supplied, otherwise the turn off is as commanded by the user. The line switch has the following nominal characteristics -

Max. Open Voltage : 480Vrms (720Vpk)

Max. Surge Current : TBD

Max. On Current : 10Arms

Turn On Phase :	Within $1^\circ + 20\mu\text{s}$ of the commanded turn on phase (if applicable).
On Voltage Loss :	$<0.1\Omega$ after the defined inrush period, $<3V_{pk}$ during the defined inrush period.
Off Leakage :	TBD



## Appendix C-Input & Target Specifications

### Voltage Input Specifications

Input Burden	1M $\Omega$    10pF between terminals, >10 <sup>12</sup> $\Omega$    25pF Voltage Lo terminal to ground
Ranges	850V (2000Vpk) 450V (675Vpk) 135V (200Vpk) 50V (80Vpk) 20V (30Vpk)
Max. Input	850Vrms, 2000Vpk max. continuous (any range), between terminals, or either terminal to ground.
Max. External DC Offset	Offsets of up to 20V may be compensated for on any range, compensation is performed at the input prior to range selection.
Compensation	When enabled, the input may be polarity reversed and/or adjusted to compensate for the measured current flowing through a user entered wiring impedance (includes the internal shunt automatically as applicable).
RMS Accuracy	As shown in the charts for AC, AC+DC and DC only parameters, filtered (20kHz) and unfiltered.
Rectified Accuracy	1.5x RMS accuracy
Form Factor Accuracy	0.5x RMS accuracy, as a percentage of 1.0

Peak Accuracy	Filtered (20kHz) : RMS accuracy + 50mV + 0.01% of peak range Unfiltered : RMS accuracy + 200mV + 0.02% of peak range.
Crest Factor Accuracy	Filtered (20kHz) : (50mV + 0.01% of peak range) /RMS value. Unfiltered : (200mV + 0.02% of peak range) /RMS value.
Harmonics Accuracy	Absolute : (RMS accuracy) * (1 + (h/100)) Relative: (RMS accuracy) * (h/100) Floor : <0.02% of range (any single harmonic), <0.035% of range (all harmonics).
Common Mode Effects	Less than (0.2V + 0.1V * F(kHz)) per 500V applied to Voltage Lo terminal relative to ground.
Temperature Effects	Add 0.007% of reading per °C when operating more than 5°C from the calibration temperature (no effect on relative harmonics, Crest Factor or Form Factor).

### ***Current Input Specifications***

Input Burden	650mA - 65A Ranges : <0.015Ω. 10mA - 300mA Ranges : <0.3Ω.
Ranges	65A (150Apk) 20A (50Apk) 6.5A (15Apk) 2A (5Apk) 0.65A (1.5Apk) 300mA (800mApk) 100mA (250mApk) 30mA (80mApk) 10mA (25mApk)
Max. Input	30Arms, 300Apk continuous (any range) 50Arms <1 second non-repetitive (any range) 150Arms <100ms non-repetitive (any range) 300Arms <10ms non-repetitive (any range)
Isolation	Up to 2000Vpk, less than 50pF to ground

Scaling	Measurements may be scaled by a user-entered factor of between 0.001 and 10000.
Max. External DC Offset	Offsets of up to 1A may be compensated for on the 1A - 100A ranges, 20mA on the 15mA - 500mA ranges, compensation is performed at the input prior to range selection.
Compensation	When enabled, the input may be polarity reversed and/or adjusted to compensate for the current caused by the measured voltage across the Voltage Input Burden.
RMS Accuracy	As shown in the charts for AC, AC+DC and DC only parameters, filtered (20kHz) and unfiltered.
Rectified Accuracy	1.5x RMS accuracy
Form Factor Accuracy	0.5x RMS accuracy, as a percentage of 1.0
Peak Accuracy	Filtered (20kHz) : RMS accuracy + 50uA + 0.01% of peak range. Unfiltered : RMS accuracy + 200uA + 0.02% of peak range.
Crest Factor Accuracy	Filtered (20kHz) : (50uA + 0.01% of peak range) /RMS value. Unfiltered : (200uA + 0.02% of peak range)/RMS value.
Harmonics Accuracy	Absolute: (RMS accuracy) * (1 + (h/100)) Relative: (RMS accuracy) * (h/100) Floor : <0.02% of range (any single harmonic), <0.035% of range (all harmonics).
Common Mode Rejection	1A - 100A Ranges : <(0.001% Range + 50uA) per kHz per 500V 15mA - 500mA Ranges : <(0.0015% Range + 0.5uA) per kHz per 500V
Temperature Effects	Add 0.008% of reading per °C when operating more than 5°C from the calibration temperature (no effect on relative harmonics).



## Transducer (15V) Input Specifications

Input Burden	50k $\Omega$    10pF, shield grounded via 50 $\Omega$
Ranges	15V (35Vpk) 5V (12.5Vpk) 1.5V (3.5Vpk) 0.5V (1.25Vpk) 0.15V (0.35Vpk)
Max. Input	70Vrms, 200Vpk continuous (any range)
Scaling	Measurements may be scaled by a user entered factor of between 0.001 and 10000. The result is scaled into the units of Amps.
Max. External DC Offset	Offsets of up to 6V may be compensated for any range, compensation is performed at the input prior to range selection.
Compensation	When enabled, the input may be polarity reversed and/or adjusted to compensate for the current caused by the measured voltage across the Voltage Input Burden.
RMS Accuracy	As shown in the charts for AC, AC+DC and DC only parameters, filtered (20kHz) and unfiltered.
Rectified Accuracy	1.5x RMS accuracy
Form Factor Accuracy	0.5x RMS accuracy, as a percentage of 1.0
Peak Accuracy	Filtered (20kHz) : RMS accuracy + 2mV + 0.01% of peak range. Unfiltered : RMS accuracy + 10mV + 0.02% of peak range.
Crest Factor Accuracy	Filtered (20kHz) : (2mV + 0.01% of peak range) /RMS value Unfiltered : (10mV + 0.02% of peak range)/RMS value.
Harmonics Accuracy	Absolute: (RMS accuracy) * (1 + (h/100)) Relative: (RMS accuracy) * (h/100) Floor : <0.02% of range (any single harmonic), <0.035% of range (all harmonics).

Temperature Effects	Add 0.0065% of reading per °C when operating more than 5°C from the calibration temperature (no effect on relative harmonics).
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## Power Factor Specifications

Non-Harmonic Accuracy	$(\text{Watts Error}) + 0.01\% + (\text{Voltage Accuracy}) + (\text{Current Accuracy}) - (\text{Power Accuracy})$ . Result is a percentage of 1.0. See charts for Watts Error and Power Accuracy for each current input method.
Harmonic Accuracy	$(\text{Watts Error}) + 0.01\%$ . Result is a percentage of 1.0. See chart for Watts Error.
Temperature Effects	There are no temperature effects on Power Factor.

## VA Specifications

Accuracy	$(\text{Voltage Accuracy}) + (\text{Current Accuracy})$ . See charts for Current Accuracy for each current input method.
Temperature Effects	Add the Voltage temperature effects and the current temperature effects for the required input method (see above).

## Watts Specifications

DC Accuracy	$(\text{DC Voltage Accuracy}) + (\text{DC Current Accuracy})$ . See charts for Current Accuracy for each current input method.
AC Accuracy	Add Power Accuracy (% of Watts) and Watts Error (% of VA) and 0.01% (% of VA). See charts for Watts Error and for Power Accuracy for each current input method. When combining % of Watts and % of VA, use $(\% \text{ of Watts}) = (\% \text{ of VA}) / \text{DPF}$ or $(\% \text{ of VA}) = (\% \text{ of Watts}) * \text{DPF}$ . DPF is Dissipation Power Factor, i.e. the Power Factor at the fundamental frequency. Note that reduction of Power

	Factor caused by distortion and noise has negligible affect on the accuracy of Watts.
Temperature Effects	Add the Voltage temperature effects and the current temperature effects for the required input method (see above). Use as a percentage of Watts.

### ***VAR Specifications***

Accuracy	Add Power Accuracy (% of VAR) and VAR Error (% of VA) and 0.01% (% of VA). See charts for VAR error and for Power Accuracy for each current input method. When combining % of VAR and % of VA, use $(\% \text{ of VAR}) = (\% \text{ of VA}) / \sqrt{1 - \text{DPF}^2}$ or $(\% \text{ of VA}) = (\% \text{ of VAR}) * \sqrt{1 - \text{DPF}^2}$ . DPF is Dissipation Power Factor, i.e. the Power Factor at the fundamental frequency. Note that reduction of Power Factor caused by distortion and noise has negligible affect on the accuracy of VAR.
Temperature Effects	Add the Voltage temperature effects and the current temperature effects for the required input method (see above). Use as a percentage of VAR.

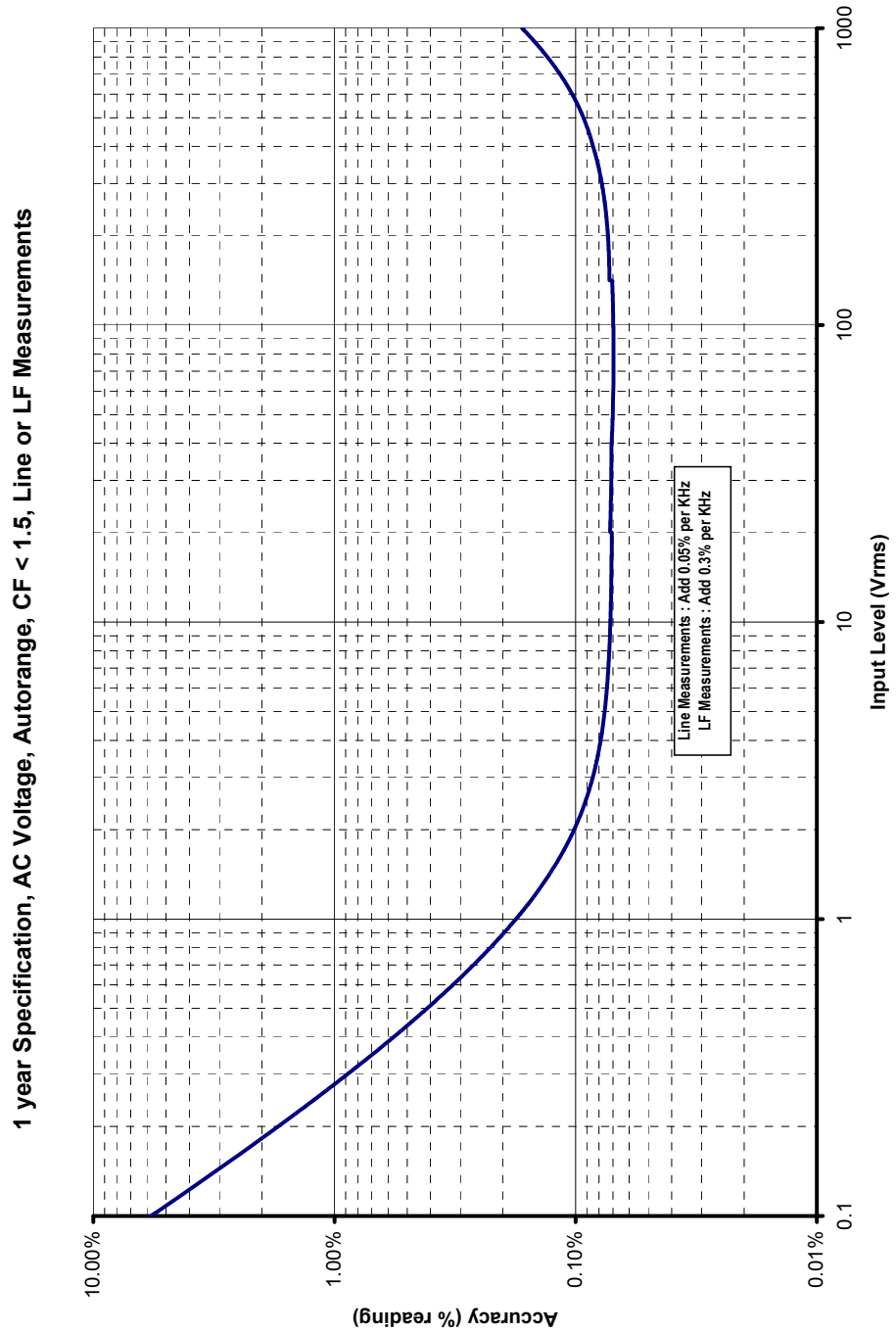


Figure 73. AC Voltage, Autorange

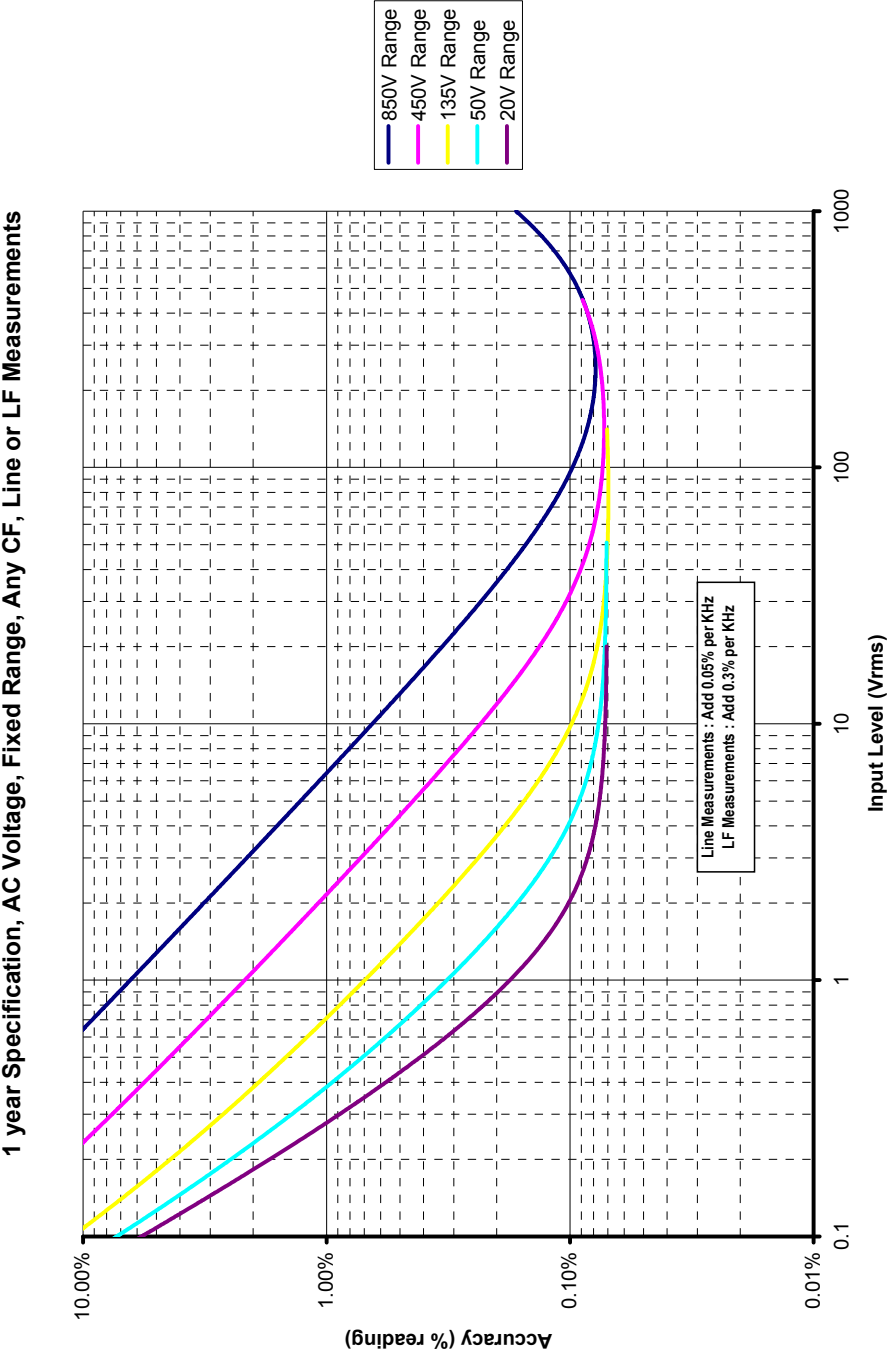


Figure 74. AC Voltage, Fixed Range, Low Frequency

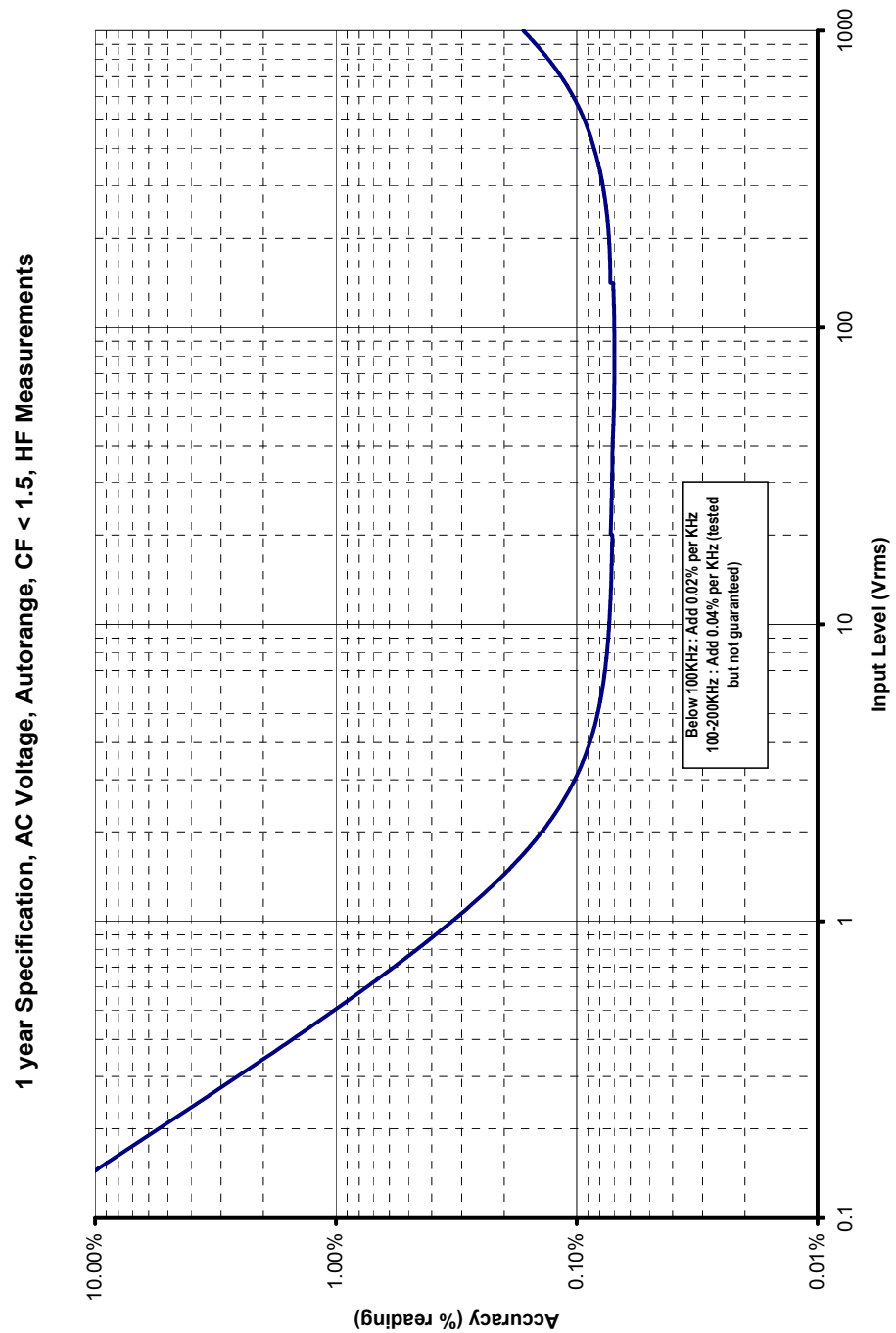


Figure 75. AC Voltage, Autorange, High Frequency

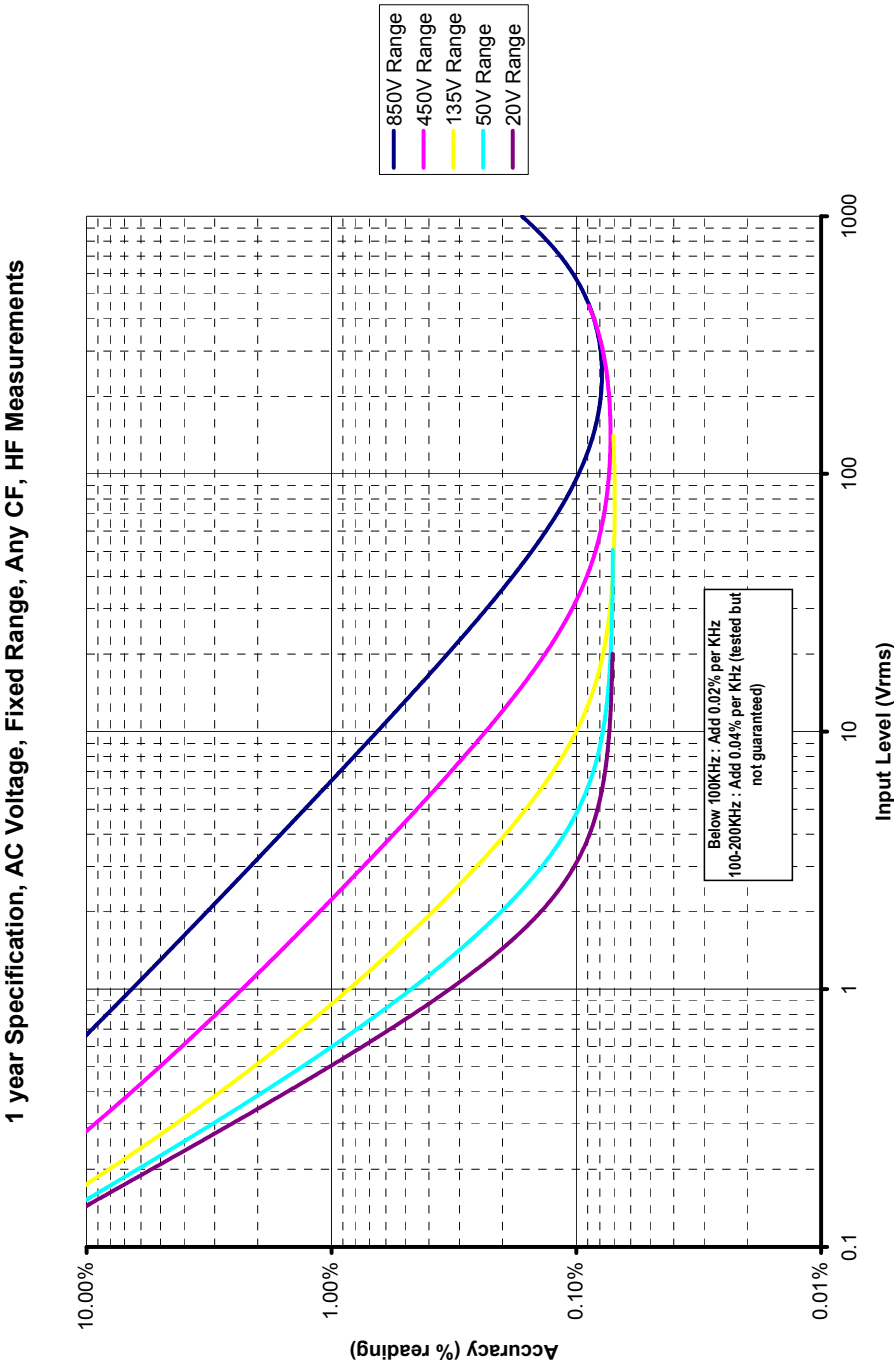


Figure 76. AC Voltage, Fixed Range, High Frequency

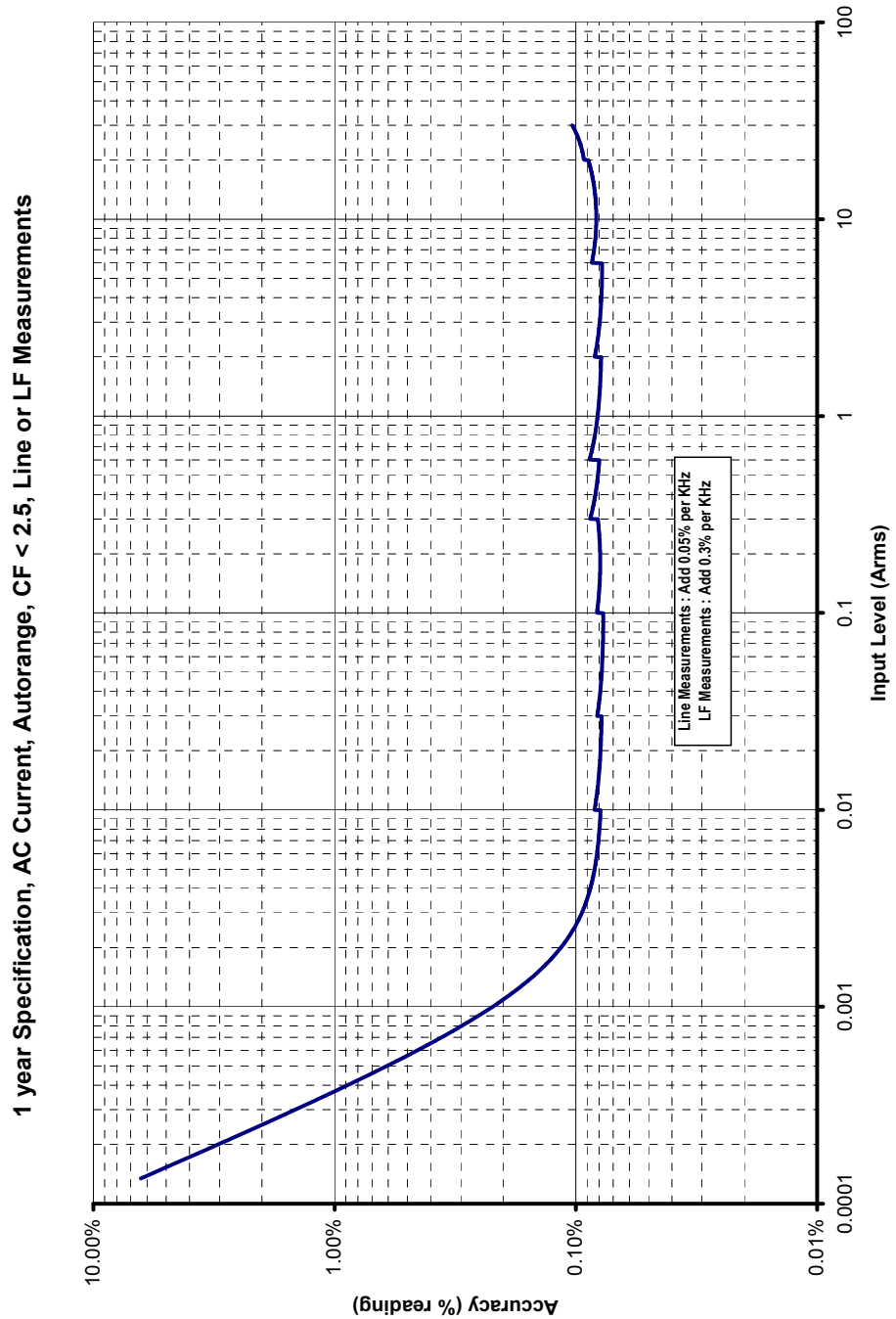


Figure 77. AC Current, Autorange, Low Frequency



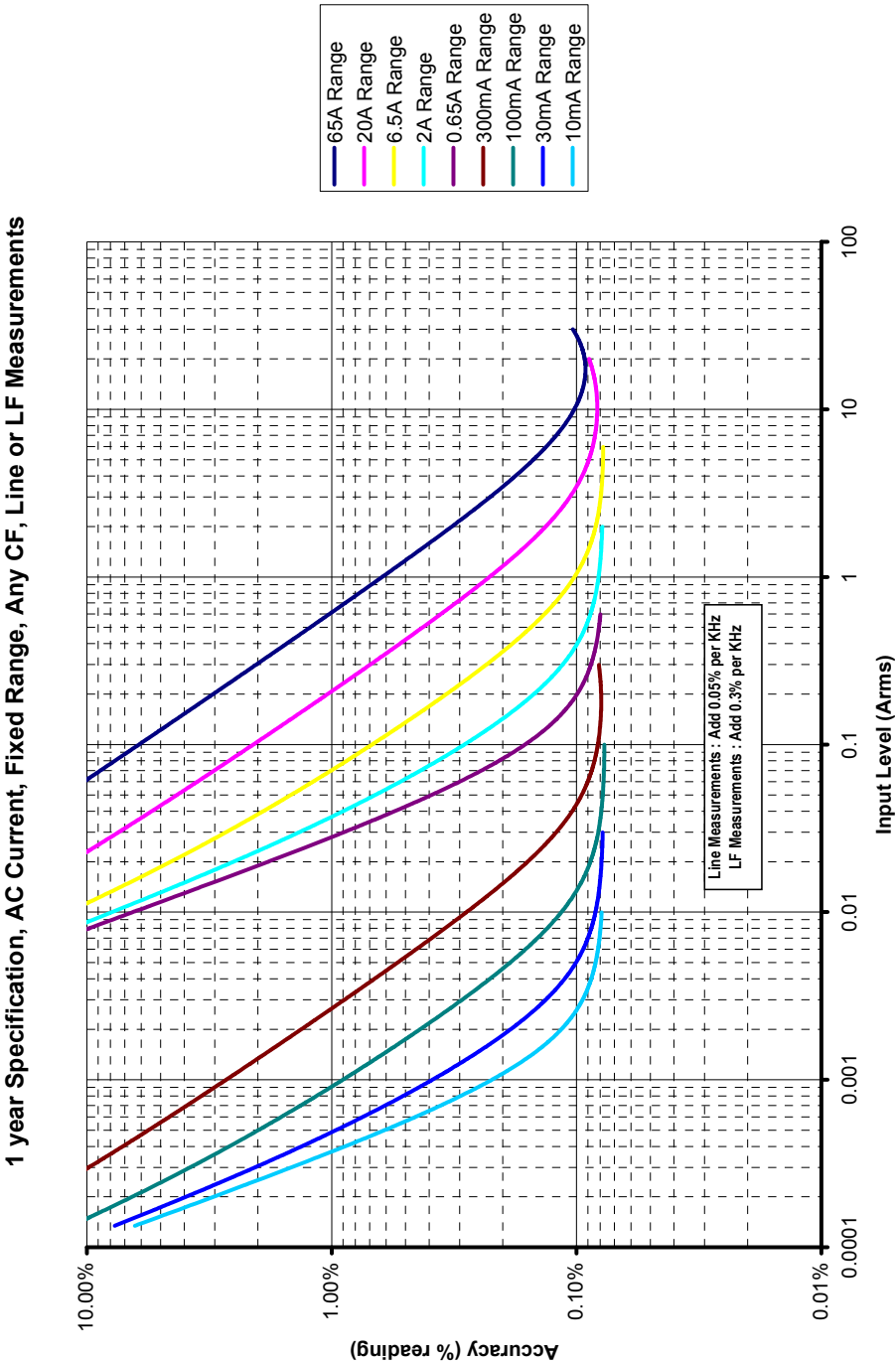


Figure 78. AC Current, Fixed Range, Low Frequency

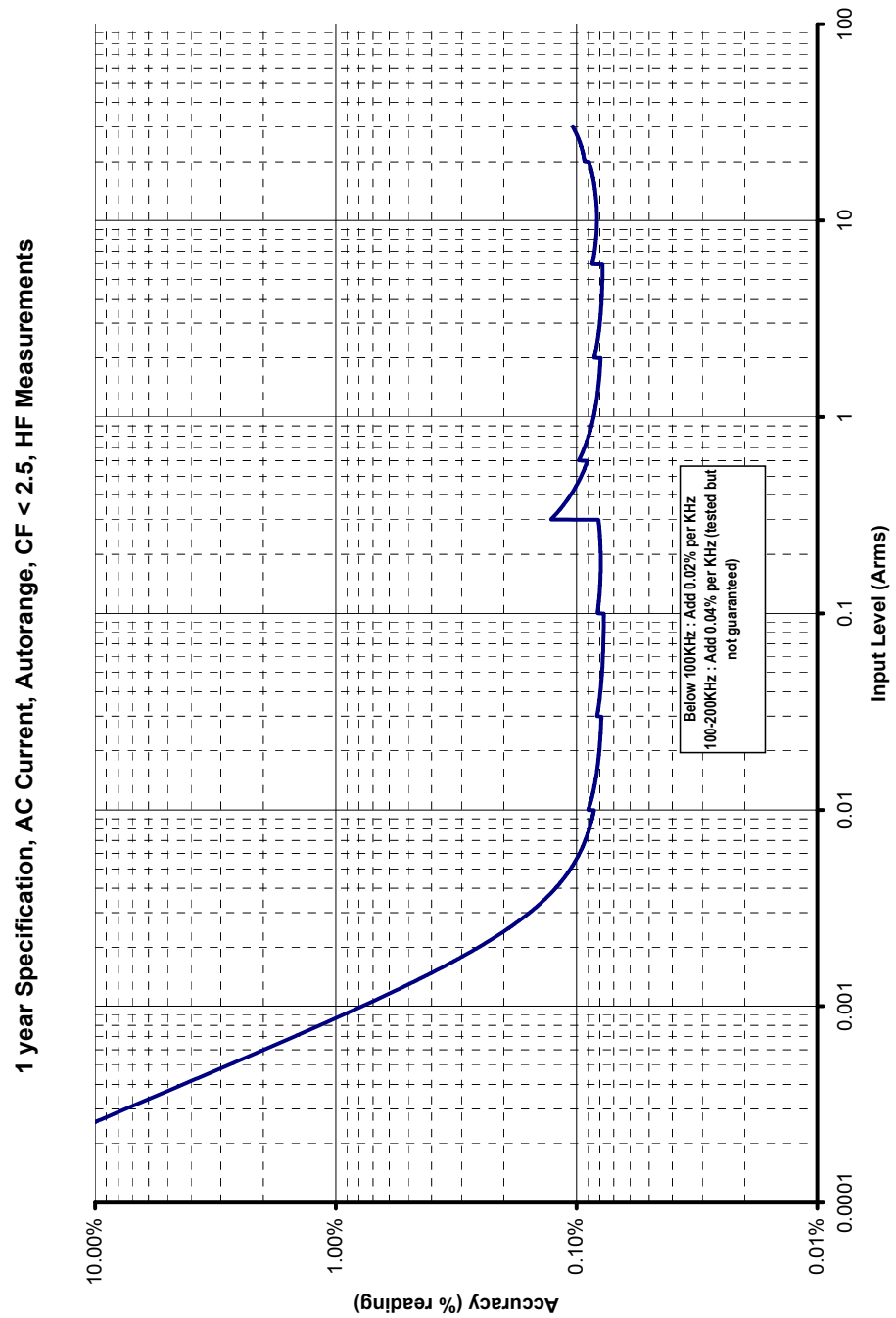


Figure 79. AC Current, Autorange, High Frequency

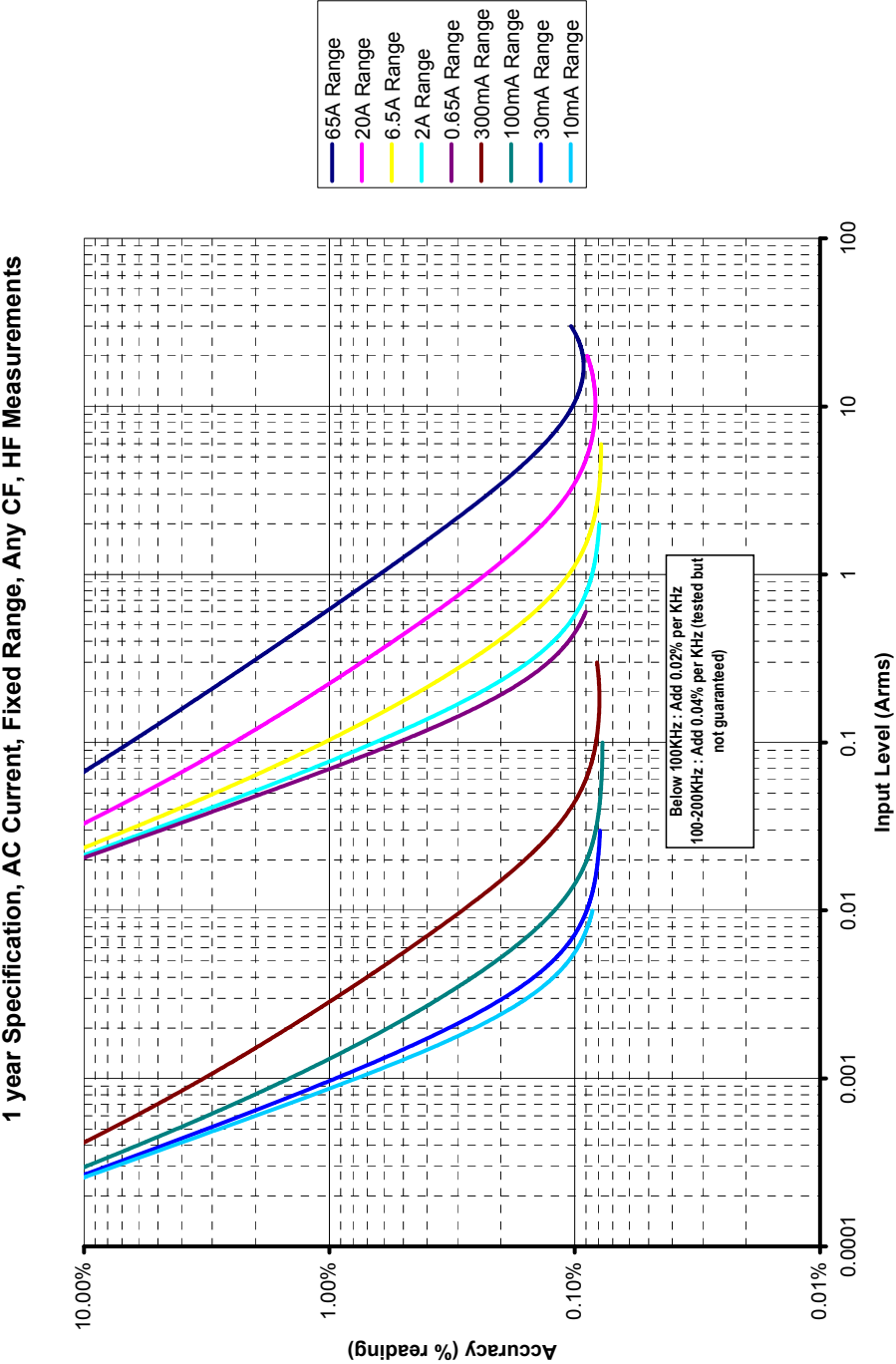


Figure 80. AC Current, Fixed Range, High Frequency

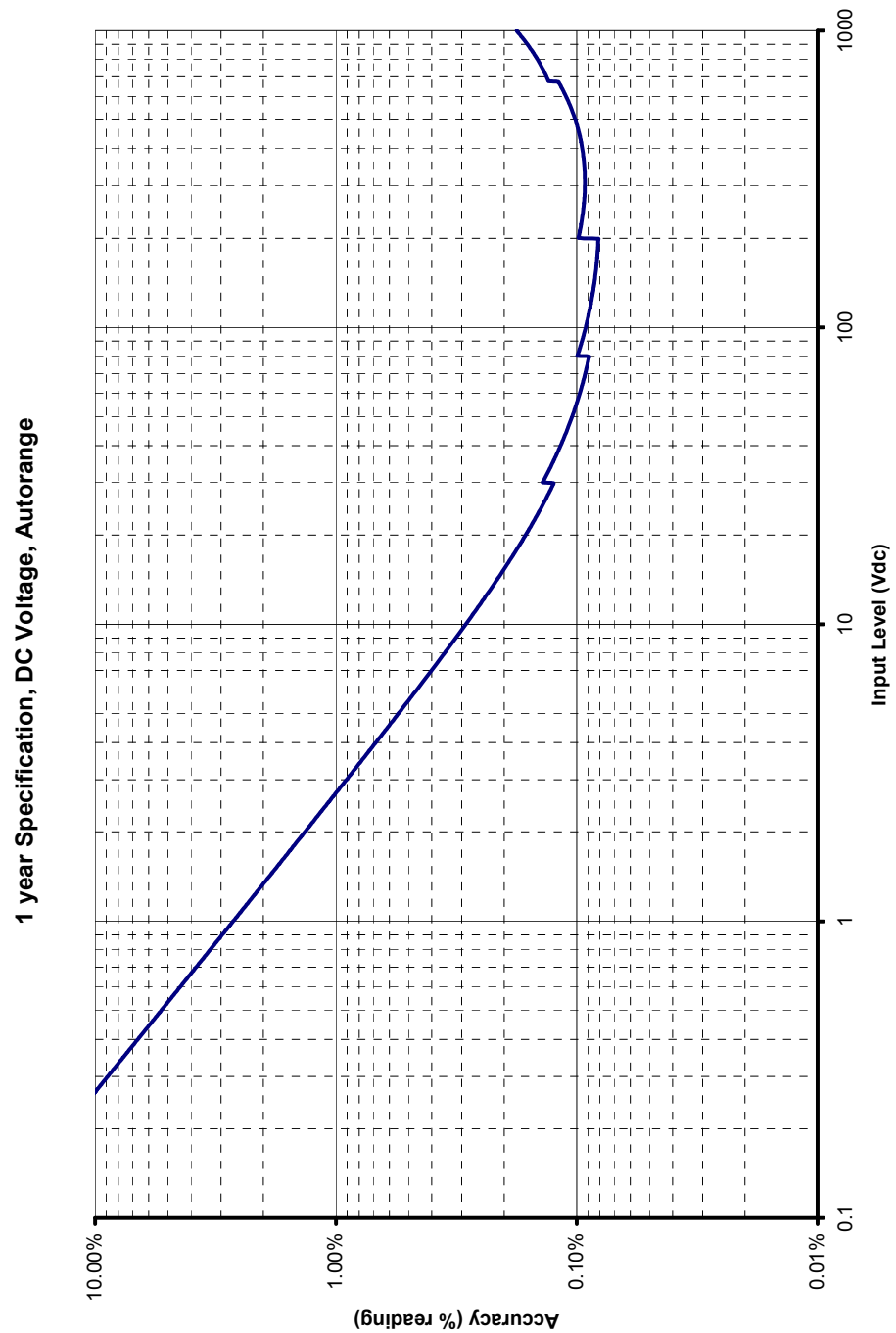


Figure 81. DC Voltage, Autorange

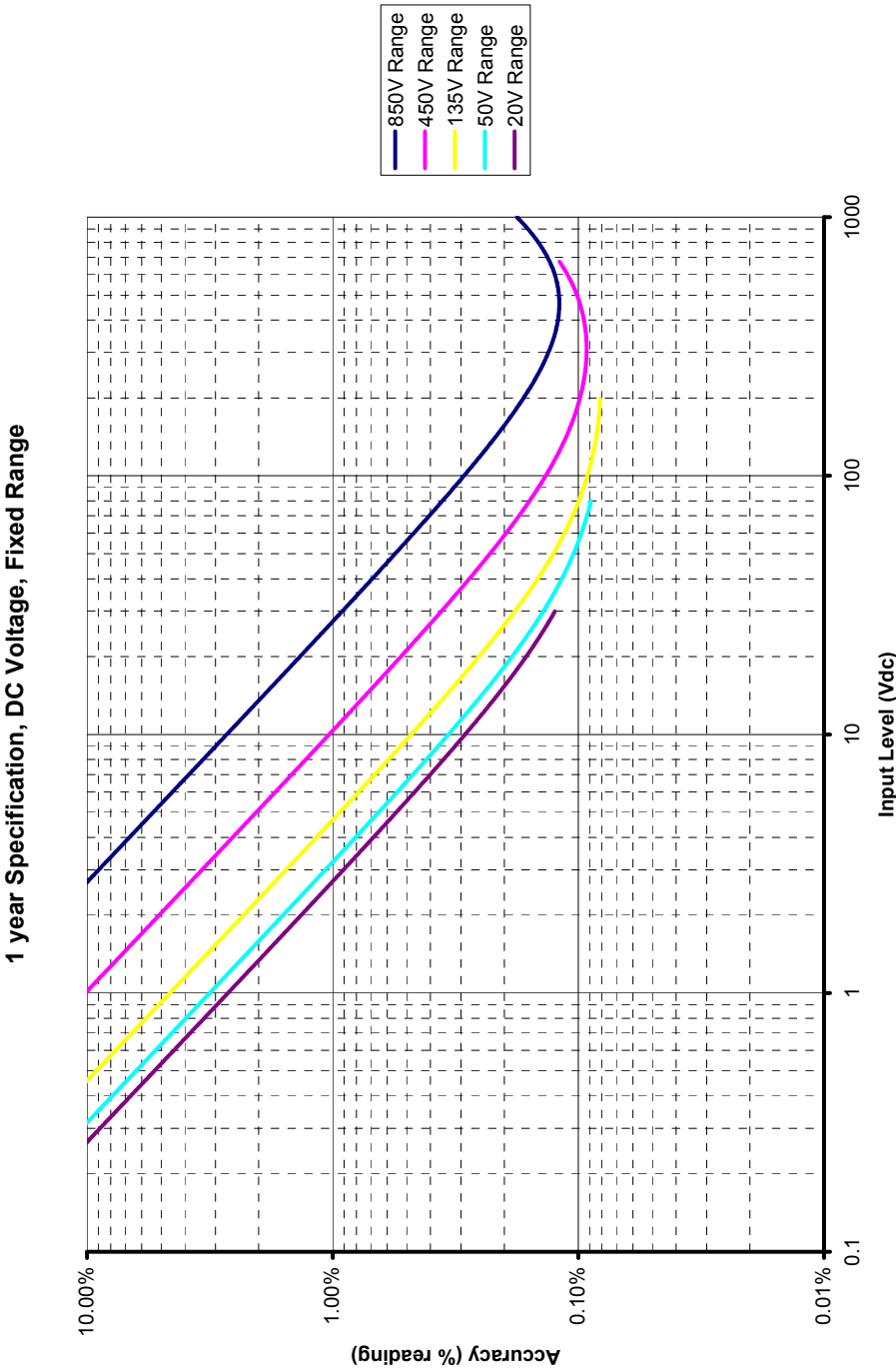


Figure 82. DC Voltage, Fixed Range

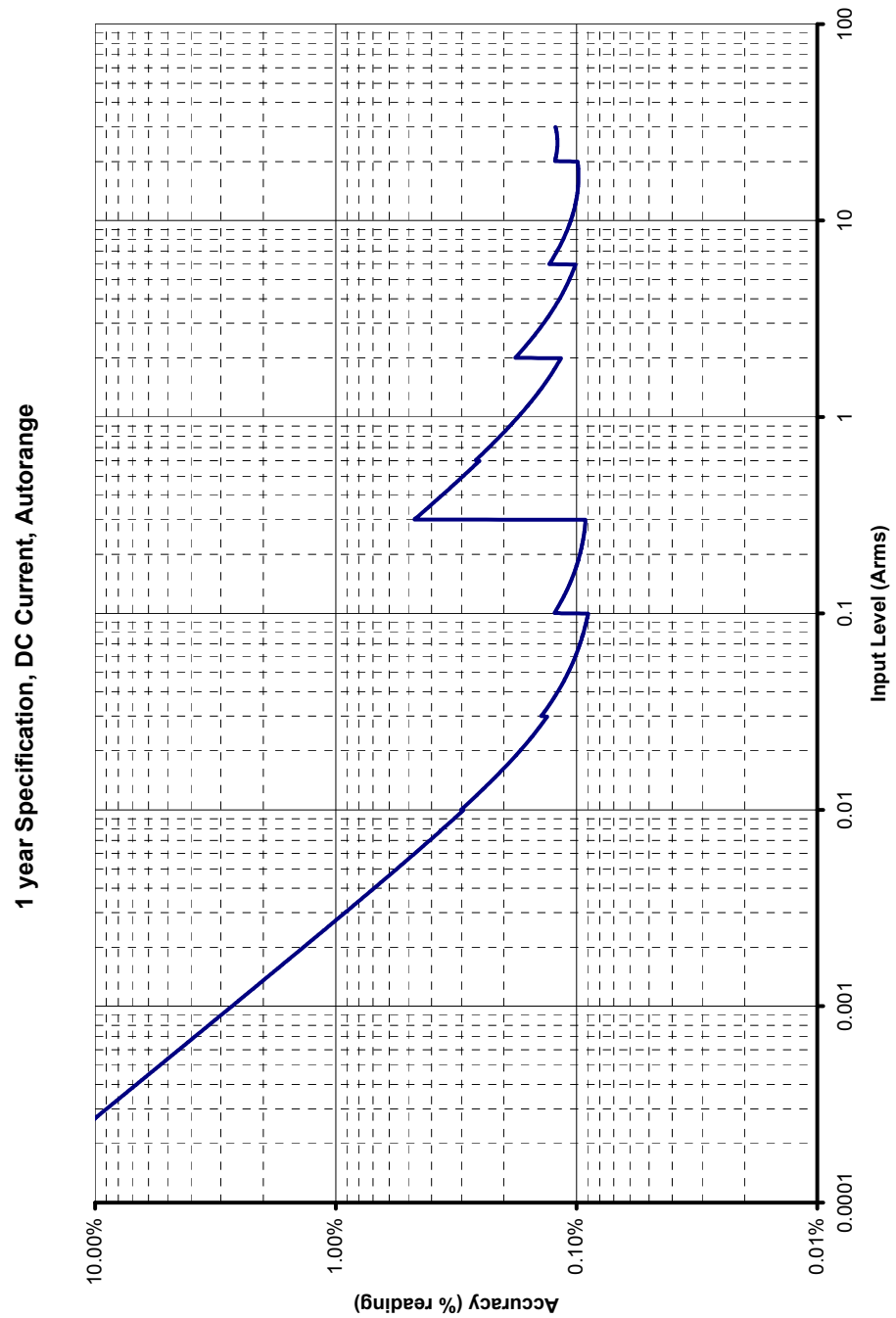


Figure 83. DC Current, Autorange

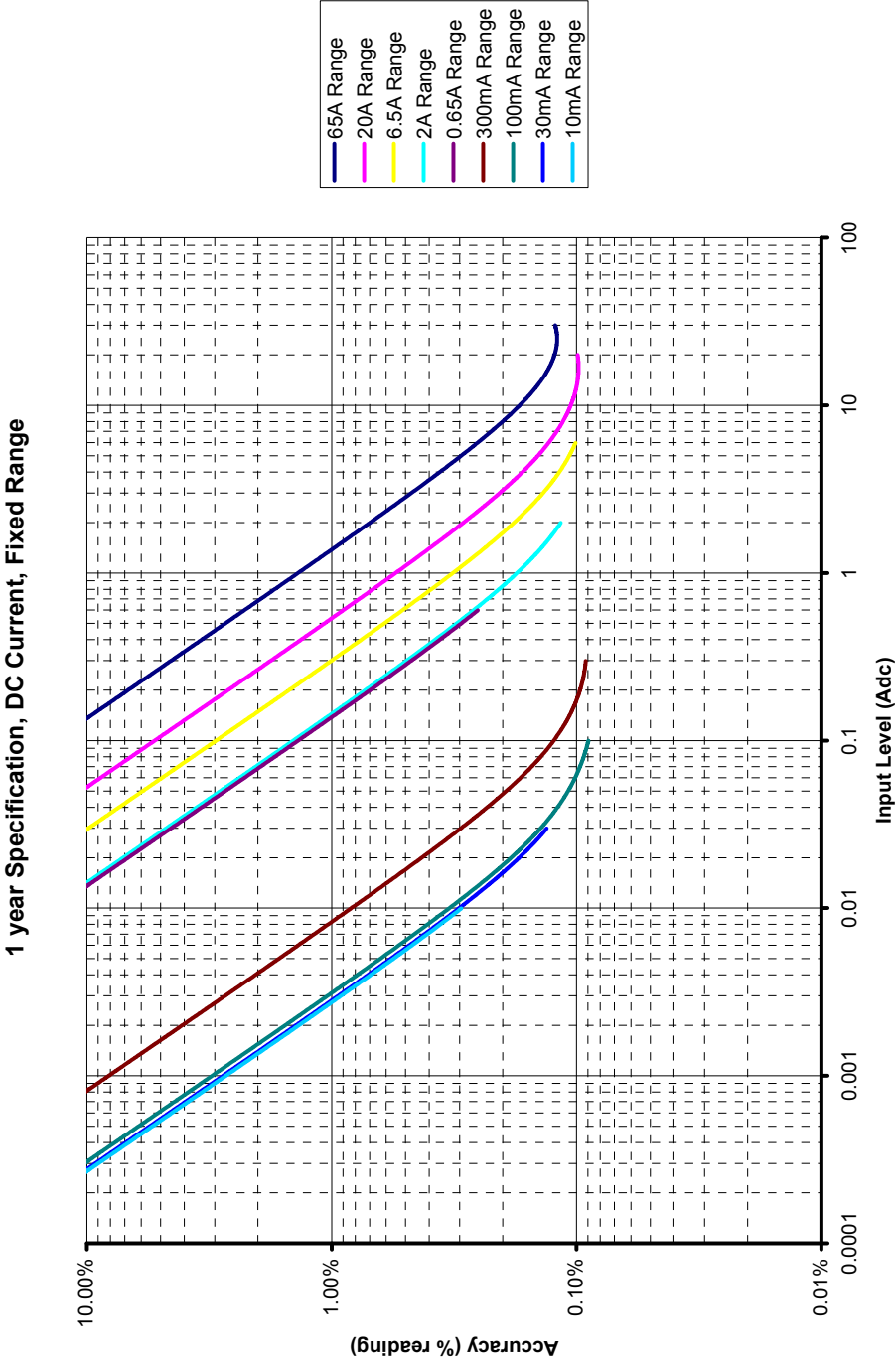


Figure 84. DC Current, Fixed Range

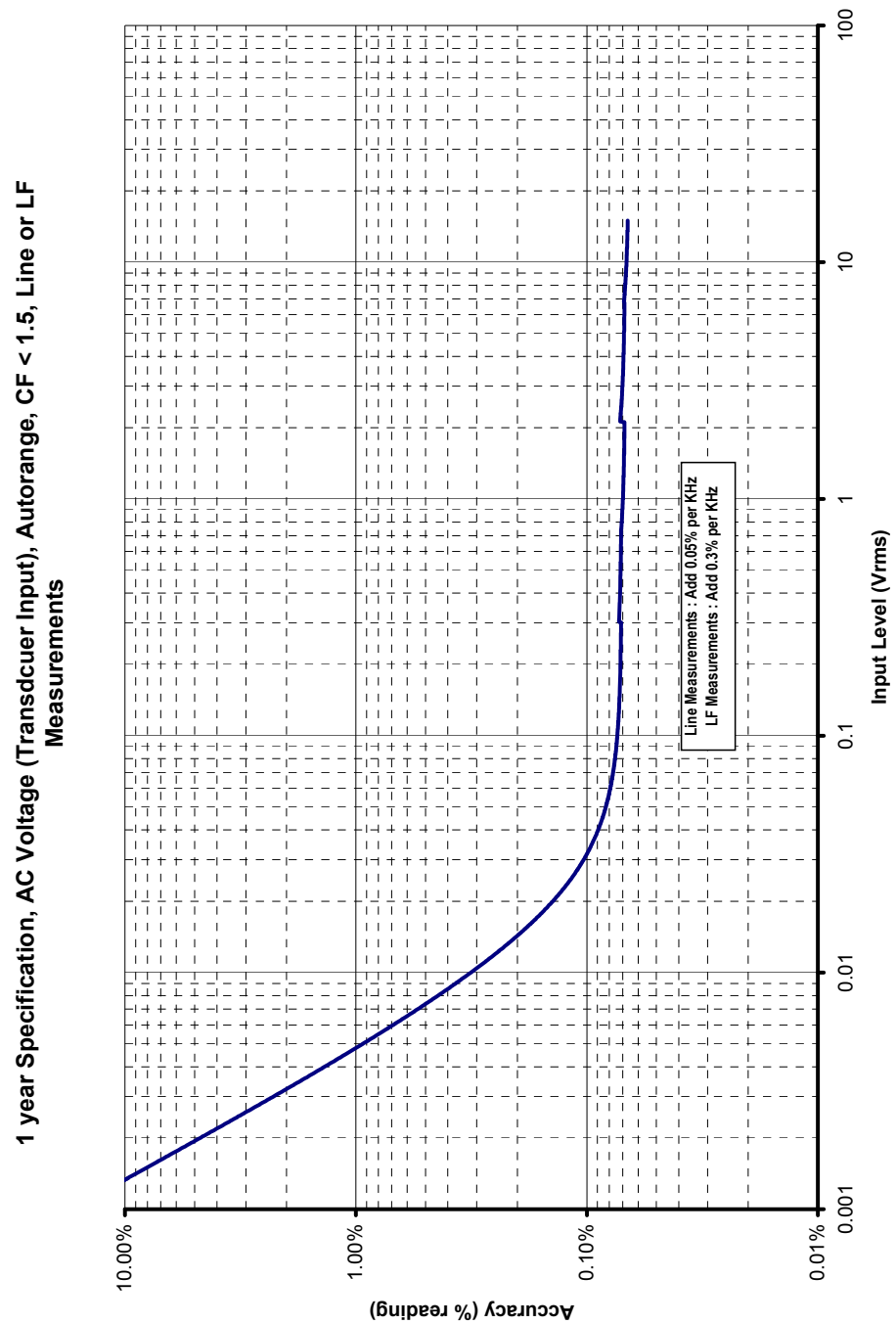


Figure 85. AC Voltage (Transducer), Autorange, Line or LF Measurements



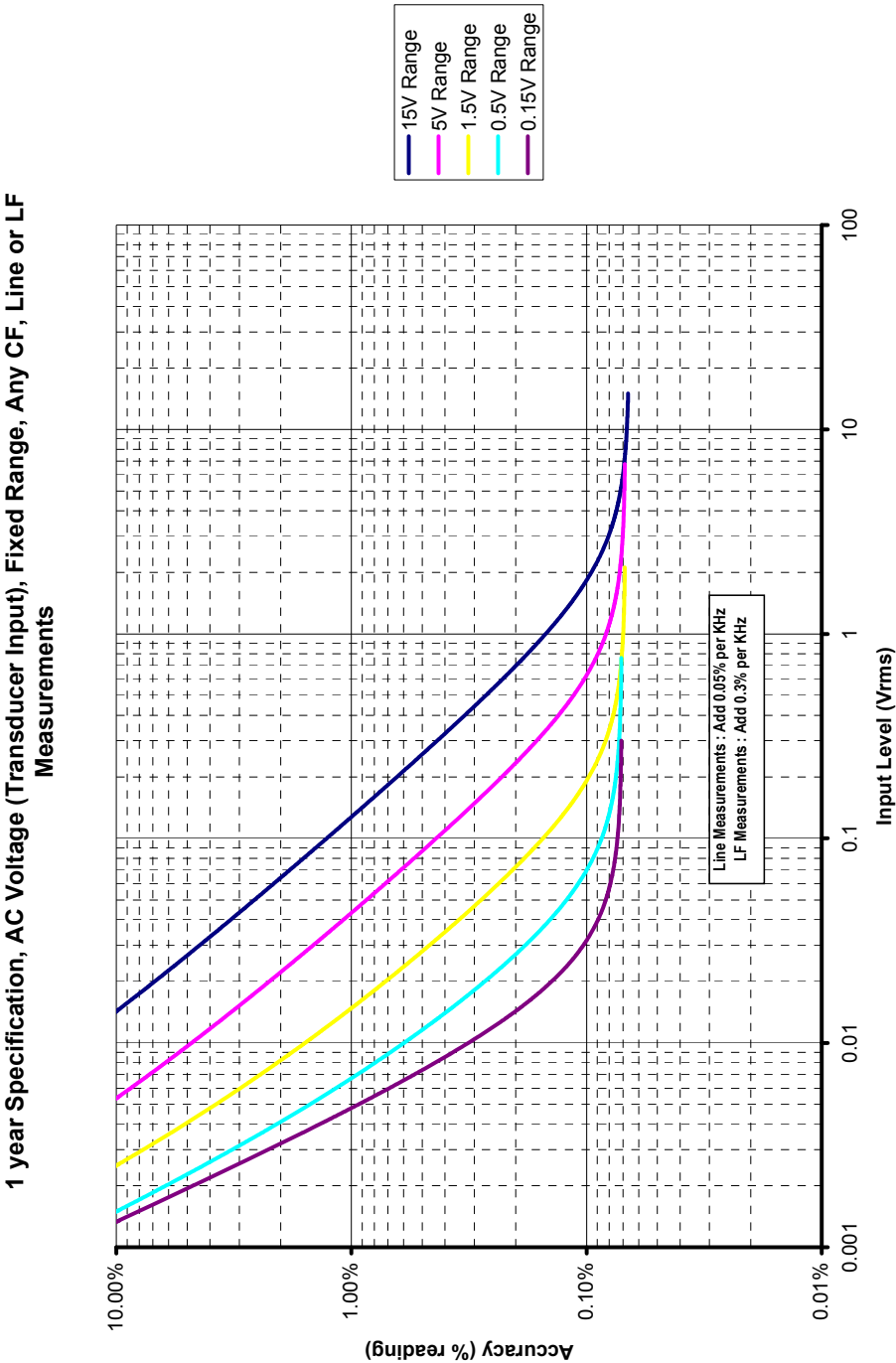


Figure 86. AC Voltage, (Transducer), Fixed Range, Line or LF Measurements

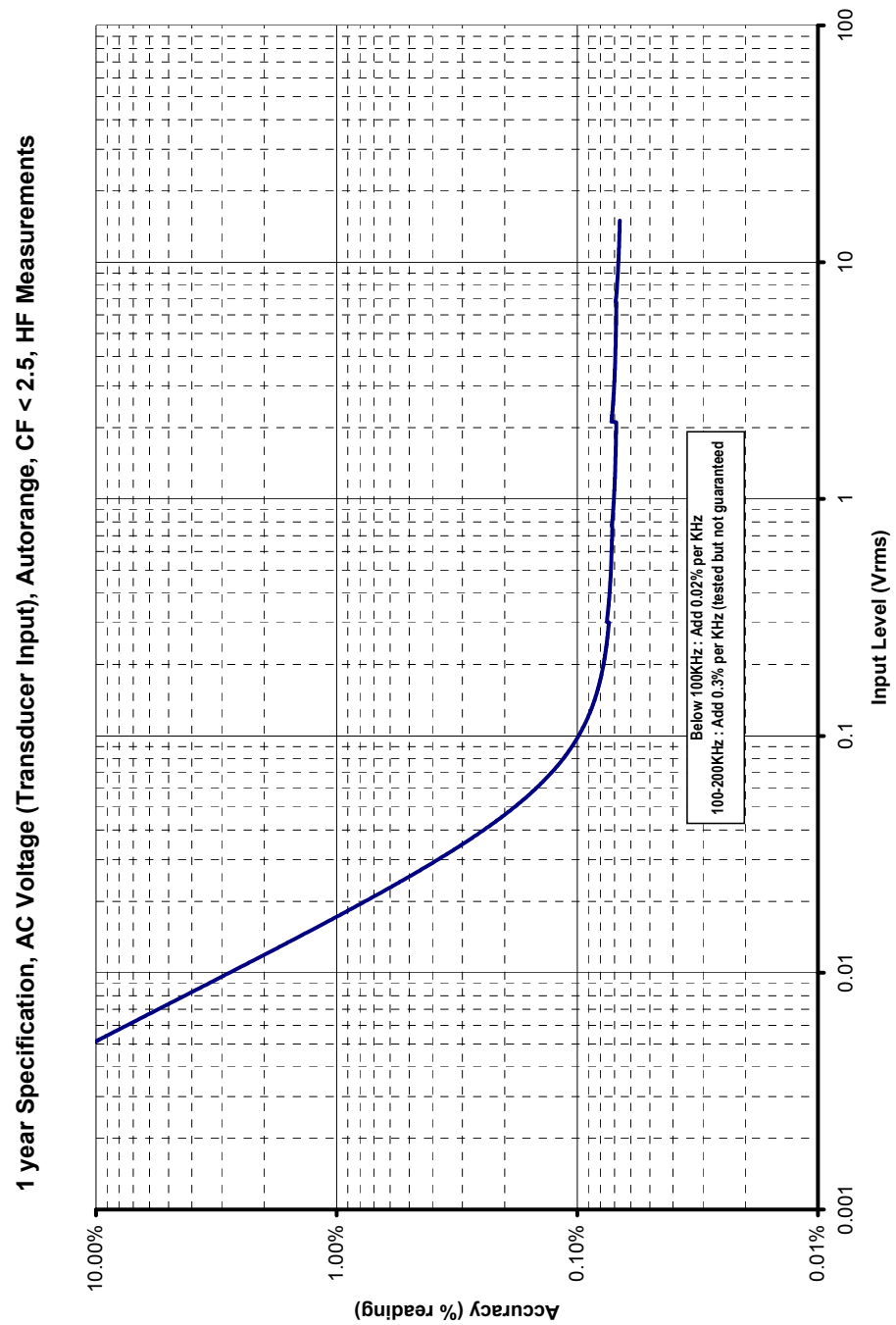


Figure 87. AC Voltage, (Transducer), Autorange, HF Measurements

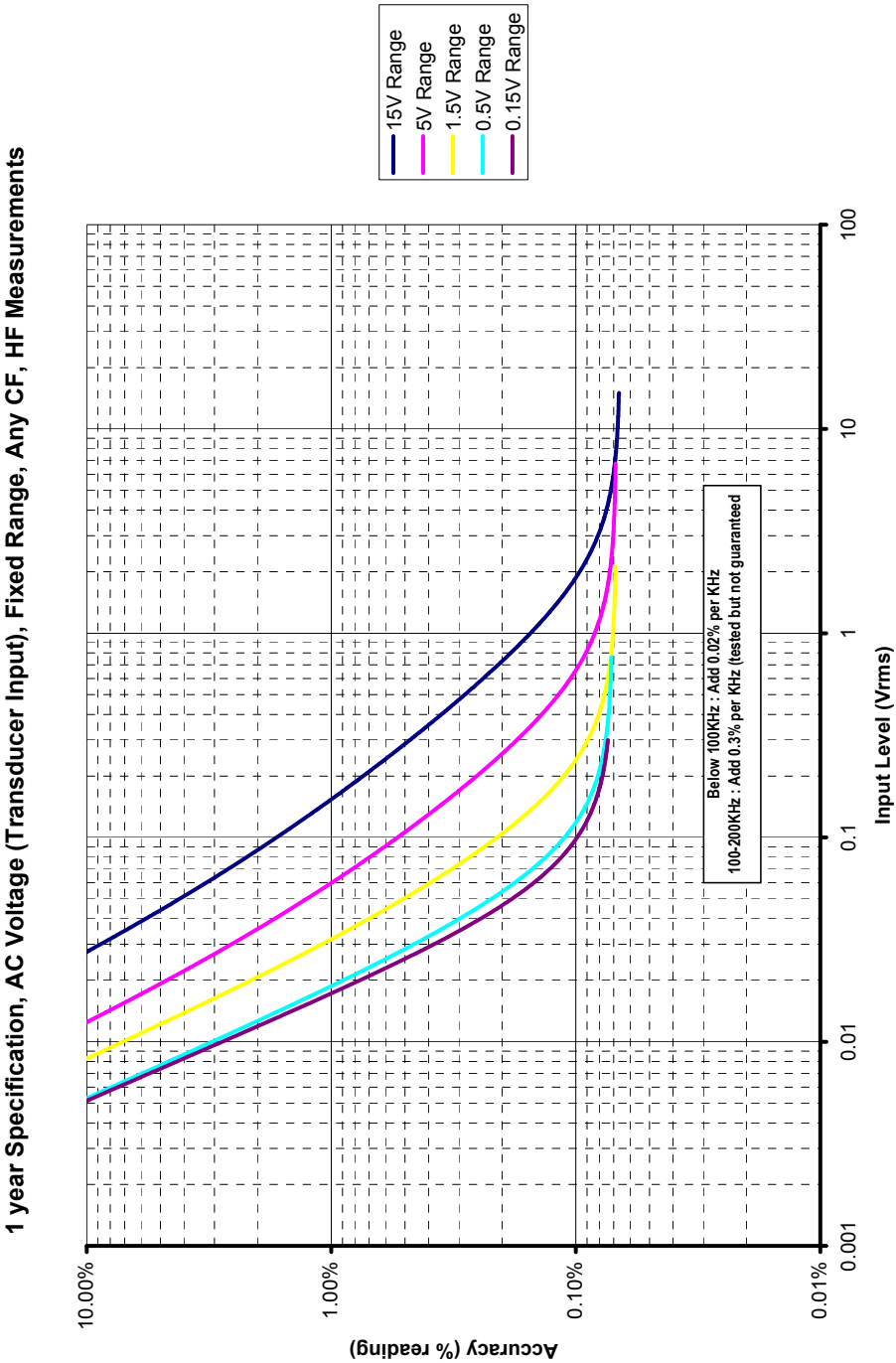


Figure 88. AC Voltage, (Transducer), Fixed Range, HF Measurements

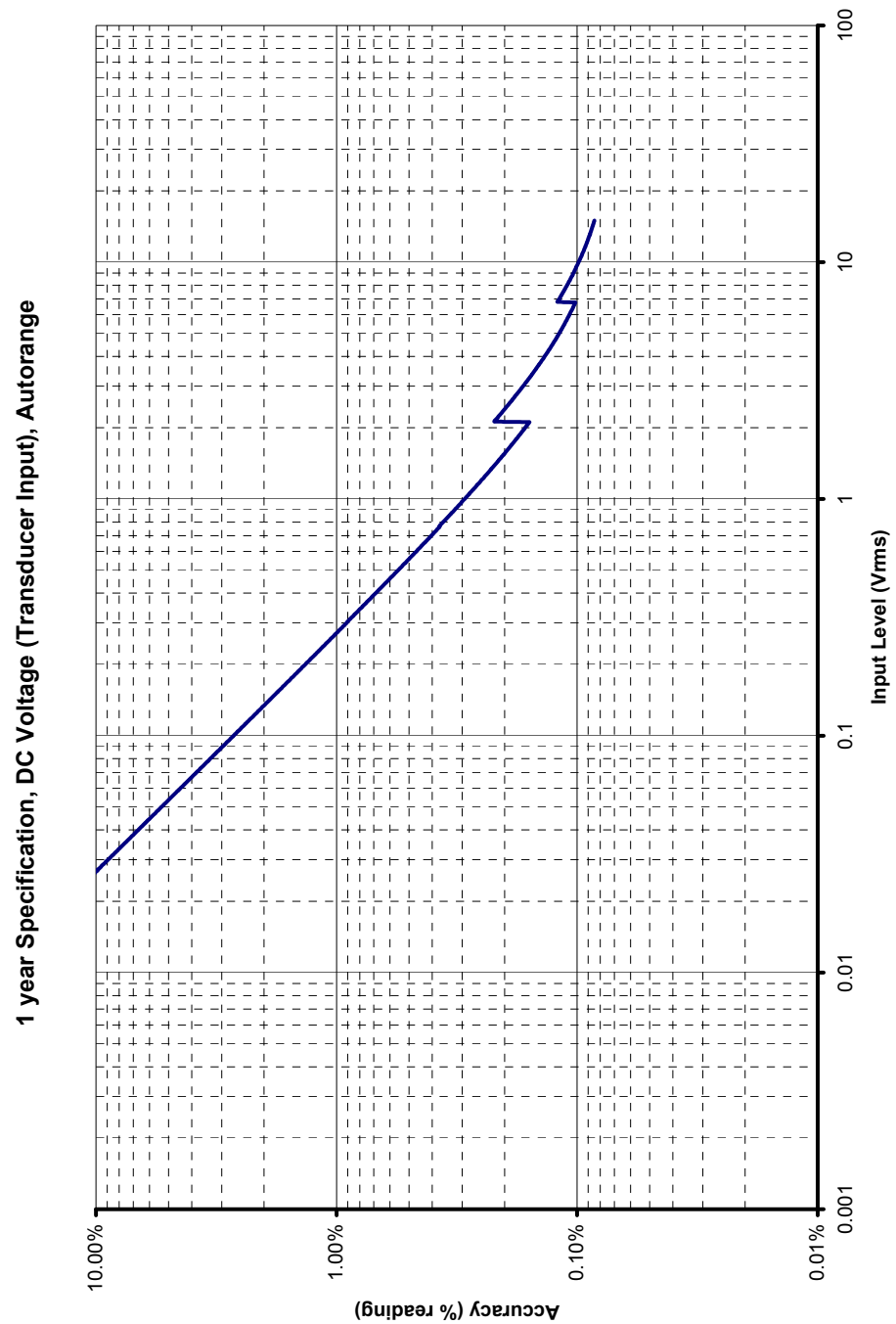


Figure 89. DC Voltage, (Transducer), Autorange

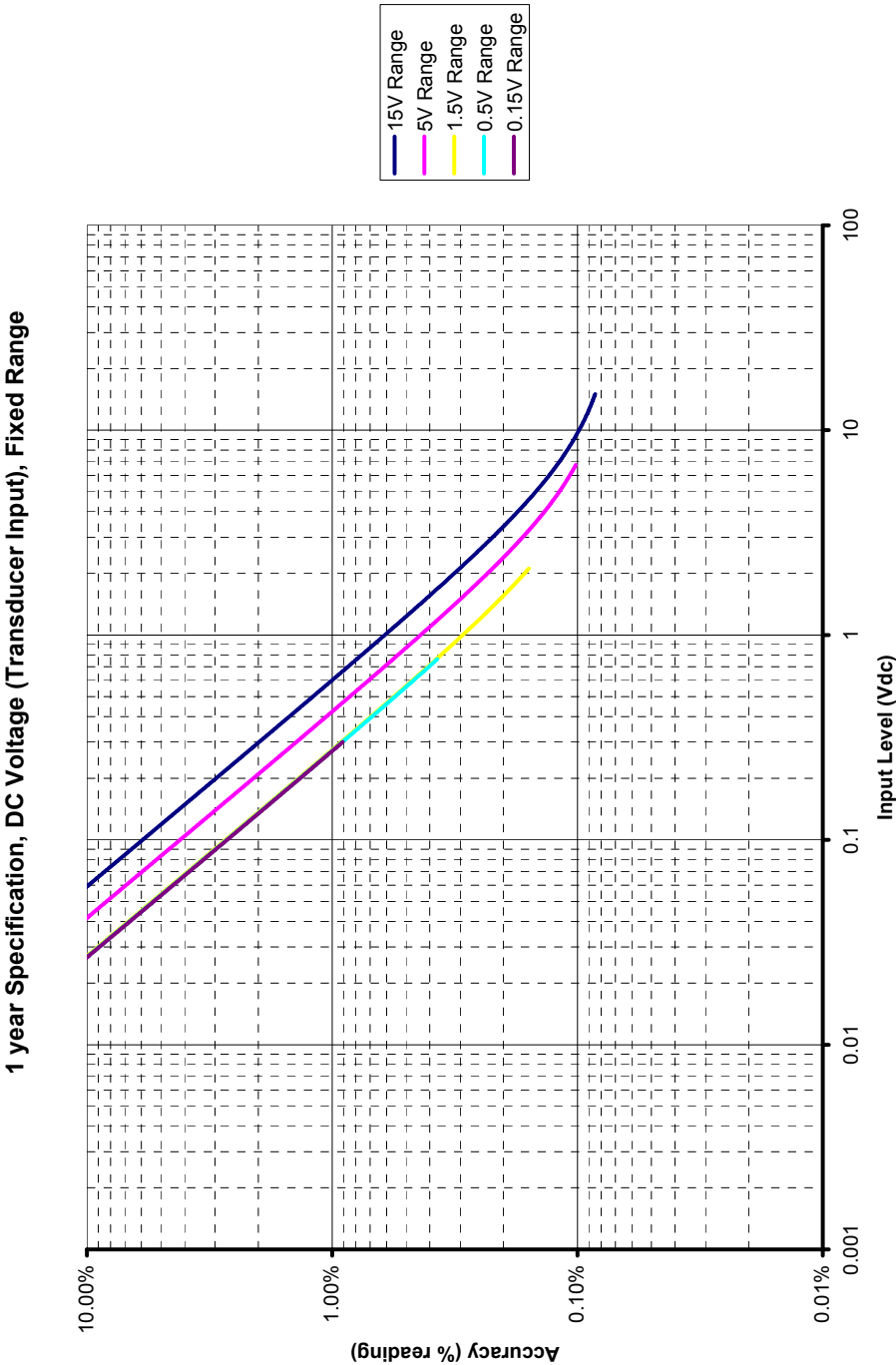


Figure 90. DC Voltage, (Transducer), Fixed Range

1 year Specification, Power, Autorange, 20-400Vrms, CF < 2.5, Any Measurements

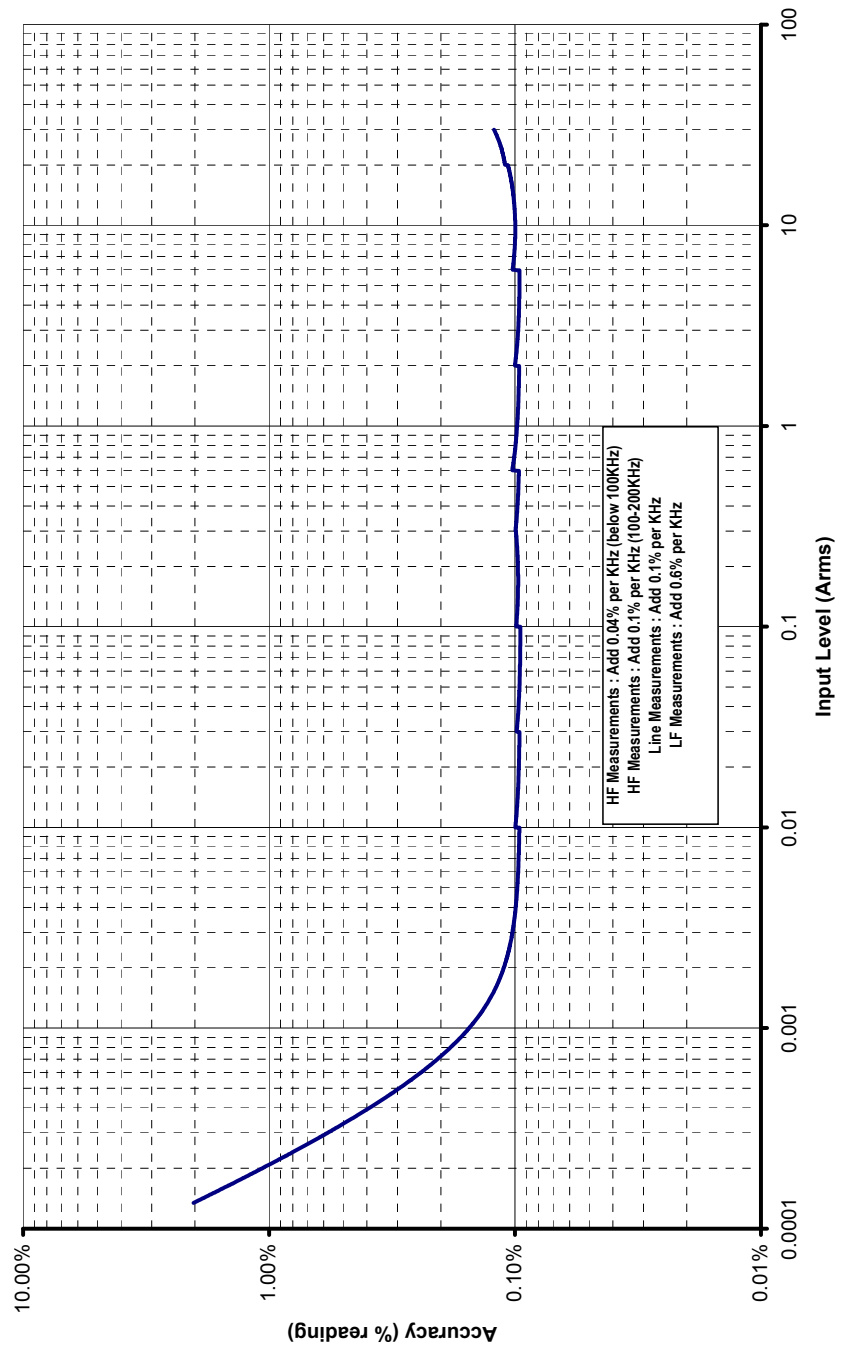


Figure 91. Power, Autorange

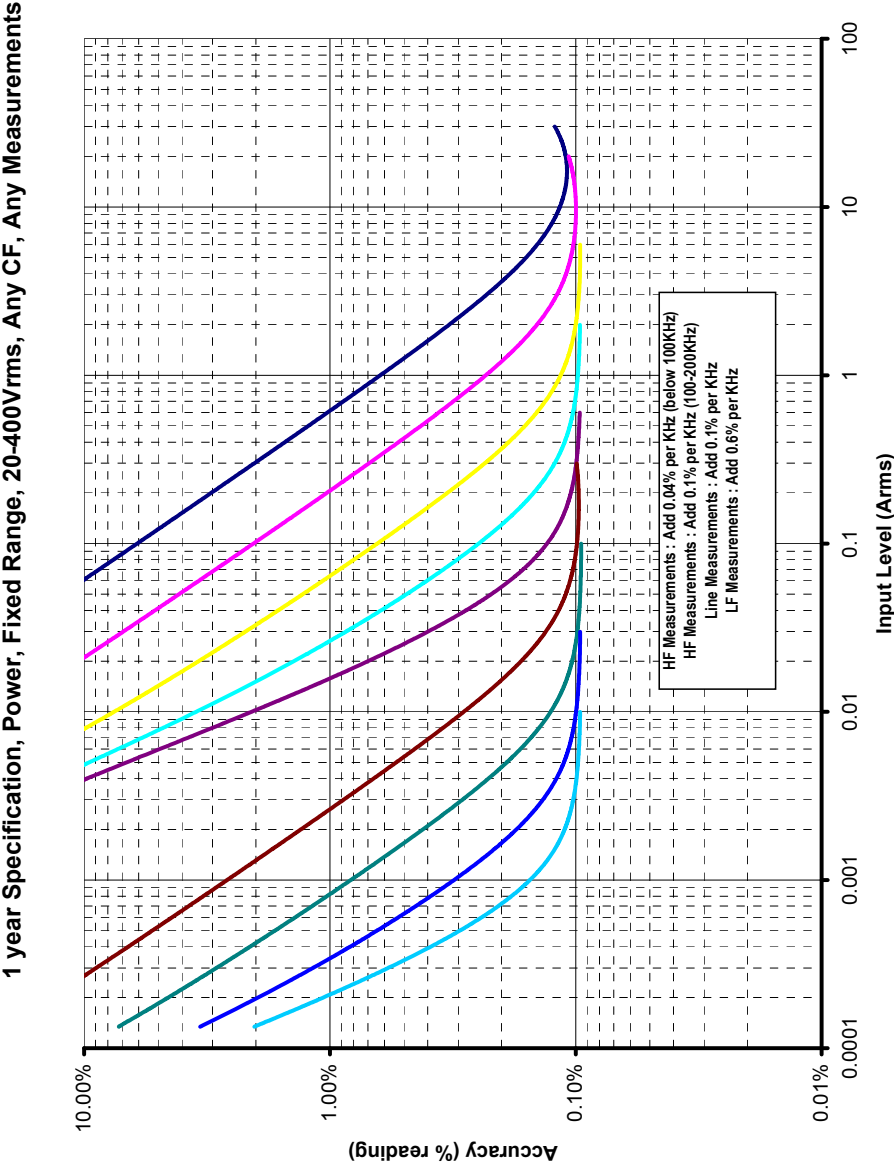


Figure 92. Power, Fixed Range

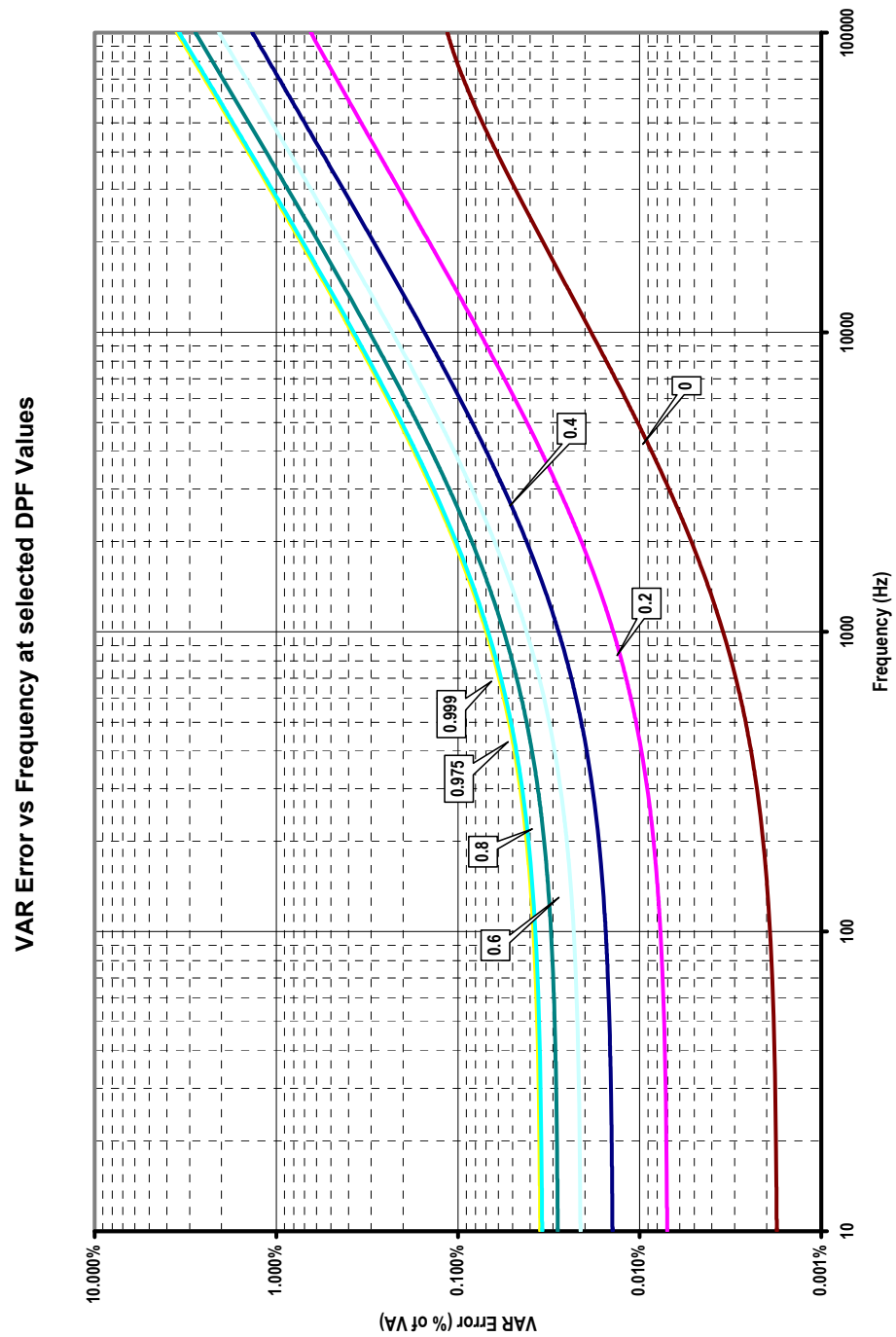


Figure 93 VAR vs. Frequency



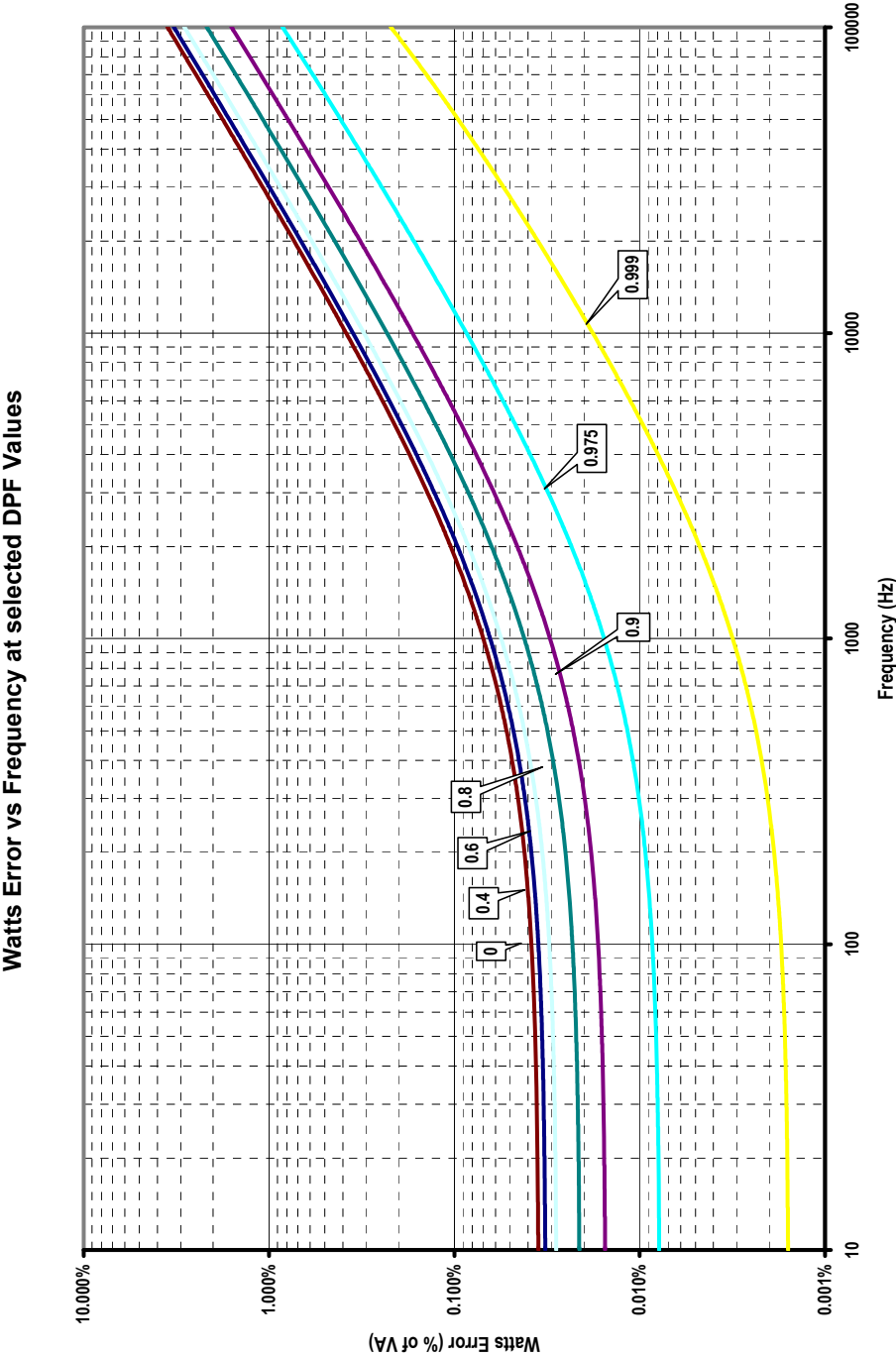


Figure 94. Watts vs. Frequency

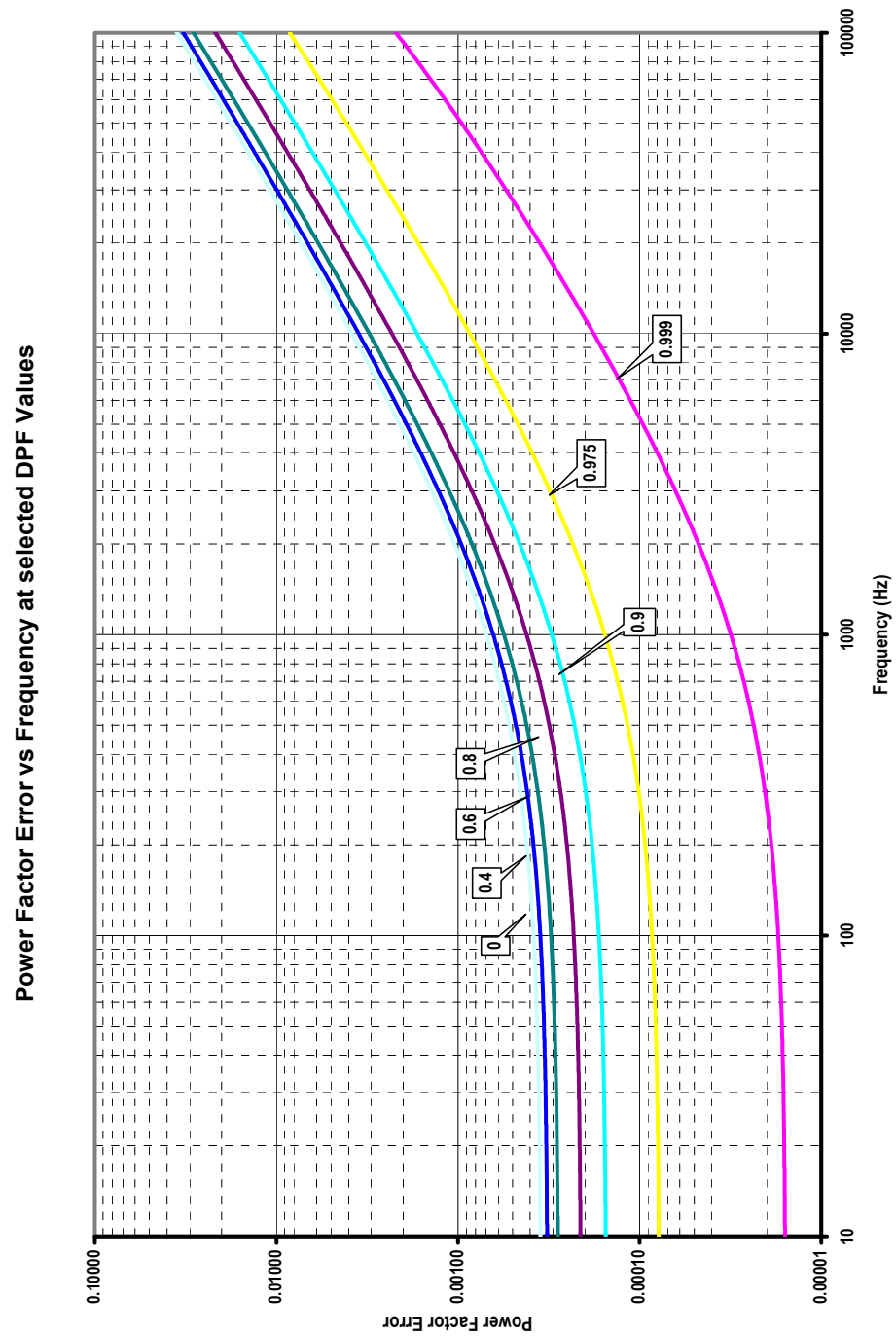


Figure 95. Power Factor vs. Frequency