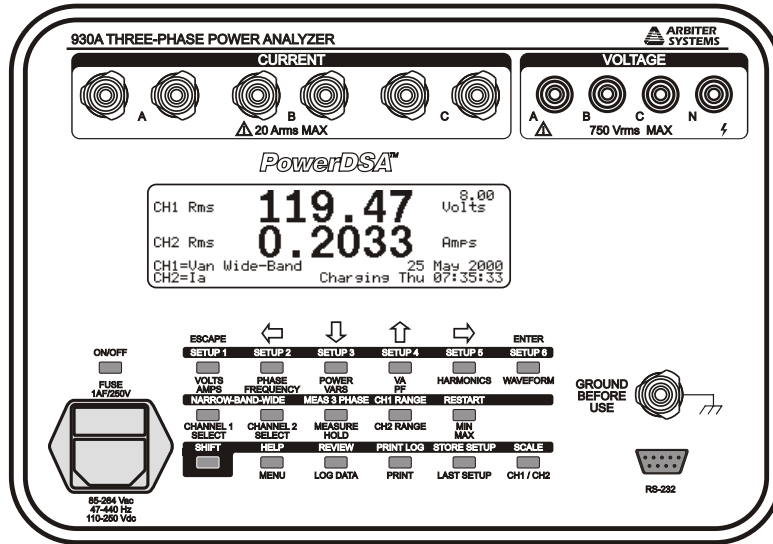


Model 929A Three-Phase Power Meter Model 930A Three-Phase Power Analyzer Operation Manual



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Description

This manual is issued for reference only, at the convenience of Arbiter Systems. Reasonable effort was made to verify that all contents were accurate as of the time of publication. Check with Arbiter Systems at the address below for any revisions made since the original date of publication.

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Definition

This manual describes the Model 929A Three-Phase Power Meter and the Model 930A Three-Phase Power Analyzer.

Firmware and Firmware Updates This manual was created based on the following firmware:

Copyright Program: 8 December 2010

Help Version: 25 JUNE 1996

DSP Version: 093098

The firmware versions indicated above are displayed on the Model 929A and 930A at startup. To freeze the display during this screen, press and hold the ESCAPE key until finished viewing. Also, the 930A will issue this information from the serial port using the VER command. See the VER command on page 87.

Firmware Updates are available as a ROM replacement from Arbiter Systems by contacting technical support at the information above.

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Model 929A Three-Phase Power Meter Model 930A Three-Phase Power Analyzer Operation Manual

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Chapter 1

General Information

1.1 Scope

The Arbiter Systems Model 929A Three-Phase Power Meter and the Model 930A Three-Phase Power Analyzer are state-of-the-art instrument offering unprecedented accuracy in the measurement of parameters related to AC Power Generation, Transmission, and Distribution. Using Arbiters proprietary PowerDSA™ Digital Signal Processing (DSP) circuitry, the Model 929A and 930A greatly enhance the precision measurement of these AC parameters. Powered by either an internal rechargeable battery or by AC line voltage, the Model 929A and Model 930A are truly portable.

This manual is divided into four chapters and two appendices as follows:

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1.2 Supplied Equipment

The Model 929A and 930A are supplied with the following items:

| <u>Part Number</u> | <u>Description</u> |
|--------------------|---------------------------|
| P09R | Standard AC Power Cord |
| 812HA-8 | Safety Ground Lead, 8 ft. |
| AS0094100 | Operation Manual |
| CA0019806 | RS-232C Null-Modem Cable |

1.3 Available Accessories

The following accessories are available for use with the Model 929A/930A:

| <u>Part Number</u> | <u>Description</u> |
|--------------------|---|
| 930A/01 | 16-Megabyte internal memory |
| AS0060000 | PowerCSV, Applications software; requires Option 01 |
| AS0035901 | Adjustable handle/bail Assembly |
| 09311A | 400 Amp 20:1 precision CT, 0.1% accuracy |
| AS0036000 | 400 Amp CT bracket |
| AP0010300 | 100:1, Clamp-on CT, 600 Amps |
| AP0012800 | 1000:1 Clamp-on CT, 200 Amps |
| AP0012900 | 250:5, 500:5, 1000:5 Clamp-on CT, 1000 Amps |
| 813AT* | 3-Phase Safety Voltage Lead Set |
| 816AT* | 3-Phase Spade-lug Current Lead Set |
| 811AT* | 3-Phase Universal Test Plug Current Lead Set |
| 817AA | A-Phase CT Lead, red |
| 817AB | B-Phase CT Lead, yellow |
| 817AC | C-Phase CT Lead, blue |
| 817AT | 3-Phase CT Lead Set: red, yellow, blue |

* A wide variety of high-quality test leads and accessories are also available. Contact Arbiter Systems for further information.

Chapter 2

Functional Description

2.1 Scope

The following paragraphs provide a brief functional description of some of the Model 929A/930A components. Figure 2.1 illustrates the Model 930A front panel. The Model 929A is not equipped for RS-232 communications, and the front panel does not have a serial connector.

2.2 Inputs

2.2.1 Voltage

Measurement of AC voltage is through four color-coded insulated banana jacks on the front panel. Labeled A, B, C, and N, each terminal can accept input voltages of up to 750 Vrms. Each input voltage terminal is isolated from signal common with an impedance of 1 megohm, and is physically isolated from the chassis.

2.2.2 Current

The 929A/930A features three independent, transformer-coupled AC current inputs, accessible via three pairs of front-panel binding posts, which are color-coded for polarity and labeled A, B, and C.

Each terminal can accept an AC signal with a rms current value of up to 20 amps. All current inputs are isolated to withstand a potential of 1000 V_{peak} from chassis ground.

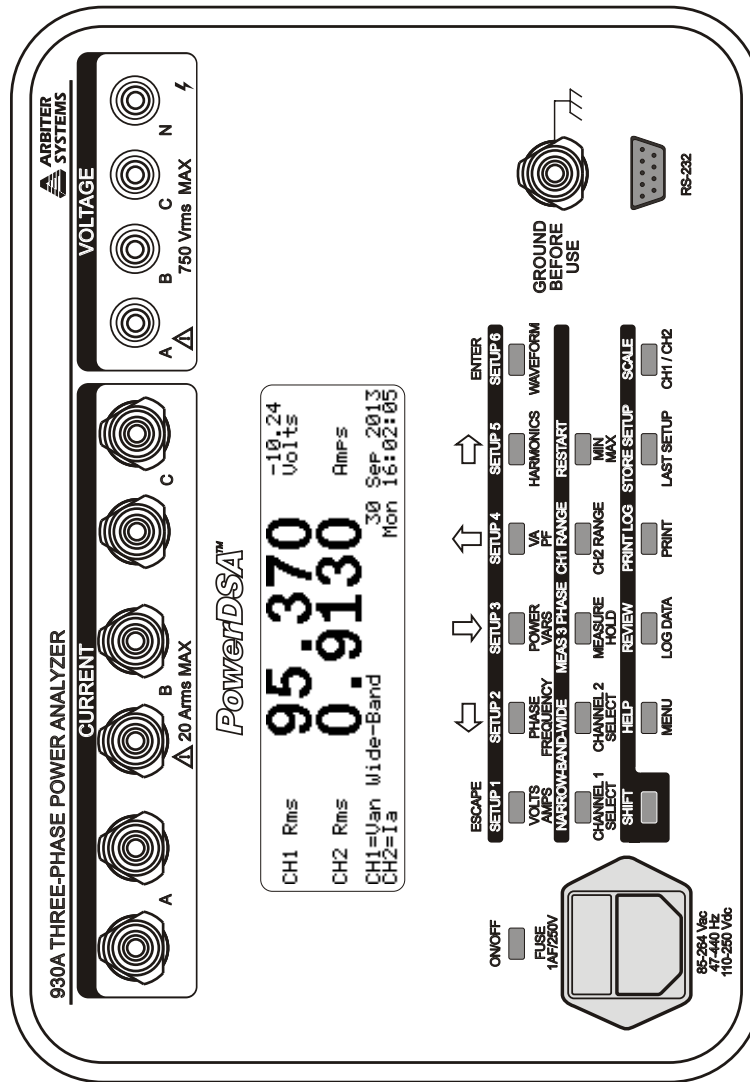


Figure 2.1: Model 930A Front Panel

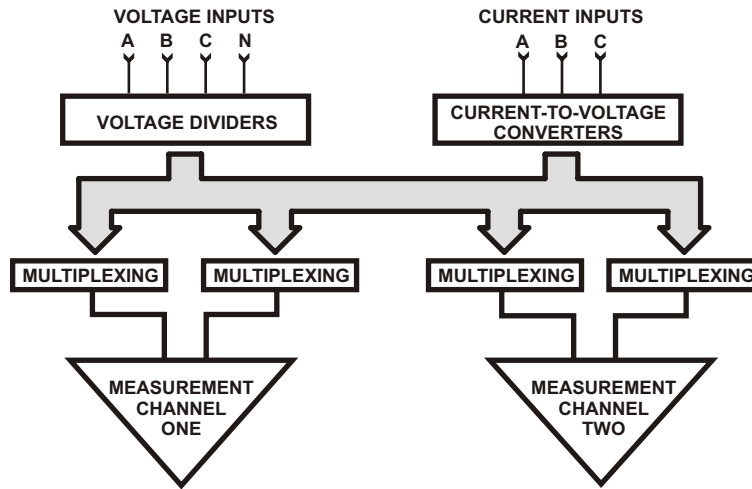


Figure 2.2: Input Multiplexing

2.3 Measurement Channels

The Model 929A/930A incorporates two measurement channels, referred to as Channel 1 and Channel 2. Multiplexing of the voltage and current inputs makes it possible to connect them to one or both of these measurement channels, in different configurations. Figure 2.2 illustrates multiplexing of voltage and current inputs between the two measurement channels.

Table 2.1 lists the possible input configurations for the two measurement channels. Table 2.1 lists AC Measurement Configurations. Using the two measurement channels individually allows concurrent measurement of separate signals (voltage and/or current).

Compare the amplitudes and phase angle of two voltage signals by connecting the first voltage (i.e. V_{a-b}) to Channel 1 and the second voltage (i.e. V_{c-n}) to Channel 2. Likewise, analyze two currents by referencing Channel 2 to Channel 1. For power quantities such as real power (POWER), vars (VARS), Volt-amperes (VA), and power factor (PF), connect the voltage signal to Channel 1 and current signal to Channel 2.

Since channel 1 is used as the internal reference, connect the lowest distortion input signal to Channel 1. For most power systems the voltage has lower distortion than the current. If analyzing only one signal, it must

be connected to Channel 1. If analyzing a single highly distorted waveform, connect a reference signal of the same fundamental frequency to Channel 1 and the highly distorted waveform to Channel 2.

| Configuration | Measured Input | Referenced To |
|----------------------|-----------------------|----------------------|
| Va-b | Voltage A | Voltage input B |
| Vb-c | Voltage B | Voltage input C |
| Vc-a | Voltage C | Voltage input A |
| Va-c | Voltage A | Voltage input C |
| Vc-b | Voltage C | Voltage input B |
| Vb-a | Voltage B | Voltage input A |
| Va-n | Voltage A | Voltage input N |
| Vb-n | Voltage B | Voltage input N |
| Vc-n | Voltage C | Voltage input N |
| Va-s | Voltage A | Synthesized neutral |
| Vb-s | Voltage B | Synthesized neutral |
| Vc-s | Voltage C | Synthesized neutral |
| Ia | Current A | Independent |
| Ib | Current B | Independent |
| Ic | Current C | Independent |
| In | - (Ia+Ib+Ic) | Channel 2 only |

Table 2.1: AC Measurement Configurations

2.4 Measurement Method

The fundamental frequency, of an input signal, is first analyzed by the Model 929A/930A digital signal processing (DSP) algorithms. Using only Channel 1, these measurements require a fairly “clean” signal. To make accurate measurement of the fundamental frequency, the input signal must have less than 30% total harmonic distortion (THD). A stable frequency display indicates a successful fundamental measurement.

The Model 929A/930A has two simultaneous measurement modes: wide-band and narrow-band. Except for harmonics and waveform, all measurements are made continuously, regardless of the measurement displayed. Changing the display selection, other than for harmonics or waveform, does not affect the measurement process. In contrast, the 929A/930A measures harmonics and waveform on-demand.

The Wide-Band Mode simulates the operation of an extremely accurate analog rms detector or analog multiplier. Therefore, measurements made in wide-band include the effect of harmonics within the instruments 3.05 kHz bandwidth.

The Narrow-Band mode is a completely different measurement process. Through proprietary DSP state-estimation algorithms, it accurately estimates the parameters (viz. frequency, magnitude, and phase angle) of the input waveform. This mode rejects the effects of noise, distortion, and DC offsets, measuring the fundamental parameters with great precision. Unlike an FFT, these algorithms are insensitive to the input frequency, and will make accurate measurements for any frequency within the rated range of 20-500 Hz.

For measuring a signal with more than 30% THD, or a signal that has any harmonic with greater amplitude than the fundamental component, apply the signal to be measured to CH2 and a clean synchronous signal with the desired fundamental frequency to CH1. The Model 929A/930A will lock on to the CH1 signal and the CH2 signal can be analyzed.

2.4.1 Sampling and Filtering

The Model 929A/930A normally samples input signals at approximately 62.5 thousand samples per second (kS/s) and employs a 15 kHz, two-pole analog anti-alias filter. The signals are filtered again using a digital low-pass filter to remove signals outside the measurement bandwidth (3.05 kHz). The digital filter provides greater accuracy and repeatability and a better rejection rate than could be accomplished with analog filtering. Measurements performed with this technique are essentially free of the harmful effects of aliasing.

8,192 samples are taken from Channels 1 and 2 during each measurement cycle. This process requires approximately 131 milliseconds. Depending on the exact measurements made, approximately three measurement cycles are executed per second. Since substantial dead time between measurements occur, the Model 929A/930A is not capable of performing cycle-by-cycle, real-time monitoring.

For fundamental signals below approximately 40 Hz, the sampling rate

is automatically reduced to 12.5 Ks/s, allowing accurate measurements at frequencies down to 5 Hz. The record length under these conditions is 655 ms.

The Model 929A/930A completes a measurement cycle 2 to 3 times per second. The cycle includes collecting data, processing and displaying results. A faster update rate of 4 to 5 times per second is achieved by initiating the “Fast mode.” Press the shift key twice, or issue the SPD RS-232 command, to change modes. The speed increase is accomplished by eliminating the computation of harmonic data. If the unit is in the Fast mode and the harmonics display is selected it will revert back to normal operation. Using the Fast mode does not degrade the accuracy of the Model 929A/930A.

2.5 User Interface

The user interface for the Model 929A/930A is designed to streamline overall operation by making the most commonly used functions easily accessible. The following paragraphs briefly describe the Model 929A and Model 930A user interface.

2.5.1 Graphics Display

A supertwist liquid crystal display (LCD) serves as the main display and is capable of displaying both characters and graphics, including the waveforms of the input signals. The display features a backlight that can be enabled for operation in subdued lighting conditions.

2.5.2 Keypad

The main keyboard consists of 18 multi-function keys whose primary functions generally relate to the most commonly used features. Access secondary functions by first pressing the SHIFT key and then the secondary function key. When a menu operation requires cursor movement or data entry, the top row of keys functions as such.

2.5.3 RS-232C Interface (Model 930A only)

The Model 930A includes an RS-232C communications port, which allows remote control and command of the instrument using a PC, modem, or terminal. When connecting the Model 930A to a PC, use the supplied null-modem cable. The RS-232C port may also be used to connect a

printer to the instrument. Serial port configuration information for the RS-232C port is described in Section 4.3.7 and RS-232C commands are listed in Appendix A. Refer to Section 3.11.6 for information on printing and exporting data. Table 2.2 lists the connector types, pin locations and signal descriptions for the RS-232C port of the Model 930A and other devices.

Once properly set up, a host computer may assume total control. All functions and data available from the front panel are also available to the host computer. All commands consist of three letter commands preceded in some cases by setup parameters separated by commas. The Model 930A does not echo commands. Once a valid three-letter command has been received, it will be acted upon immediately. The action taken depends on the command given. “Display change,” “setup modification,” “data output (or export),” and “data logging” are some examples. When the Model 930A returns a “?” it signifies an unrecognizable command or an out-of-bounds number.

| 930A DB9F | PC DB9F | PC DB25M | Seiko DPU-411 DB25M | ATENS XP-320 DB25M | EPSON FX-80 DB25M | Seiko DPU-414 DB9M |
|--------------|------------|-------------|---------------------------|--------------------------|-------------------------|--------------------------|
| 2 / RXD | 3 / TXD | 2 / TXD | N/C | 3 / TXD | 2 / TXD | 2 / TXD |
| 3 / TXD | 2 / RXD | 3 / RXD | 2 / RXD | 2 / RXD | 3 / RXD | 3 / RXD |
| 4 / DTR | N/C | N/C | N/C | N/C | N/C | N/C |
| 5 / GND | 5 / GND | 7 / GND | 7 / GND | 7 / GND | 7 / GND | 5 / GND |
| 7 / RTS | 6 / DSR | 5 / CTS | N/C | 4 / CTS | 4 / CTS | N/C |
| | 8 / CTS | 6 / DSR | N/C | 20 / DSR | 20 / DSR | N/C |
| 8 / CTS | 7 / RTS | 4 / RTS | 5 / Busy | 5 / RTS | 5 / RTS | 8 / RTS |

Table 2.2: RS-232C Port Pinout / Signal Description

2.6 Power Supply and Battery

The Model 929A/930A can operate from an internal, sealed rechargeable battery (see Section 4.3.6), or from an external AC / DC power source.

2.6.1 Battery Power

In normal operation, the battery will operate the Model 929A/930A for eight hours on a full charge. Factors affecting the operating time include: backlight control (the backlight adds approximately 50% to power drain) and the measurement function.

2.6.2 Line Power/Battery Charging

Battery charging occurs whenever power is applied to the Model 929A and Model 930A main power inlet. The internal charger supplies a steady level of power to the instrument, whether powered on or off. If the 929A/930A is powered on, power is split between instrument operation and battery charging. If using the back light, additional power is directed to the instrument, and increases the time to charge the NiMH battery. To charge the battery completely from a depleted state should take approximately 8 hours with the Model 929A/930A powered off. **Charge only if ambient temperature is in the range: 0 °C – 40 °C (32 °F – 104 °F).**

NiMH battery charging in the Model 929A/930A is monitored and controlled using three factors: (1) $\Delta T/\Delta t$, (2) $\Delta V/\Delta t$, and (3) time.

$\Delta T/\Delta t$: When the cell reaches full charge, most of the charging energy is converted to heat. This increases the rate of change of battery temperature, which can be detected by a sensor such as a thermistor.

$\Delta V/\Delta t$: When the battery is fully charged the voltage across its terminals drops slightly. The charger can detect this and stop charging.

Elapsed Time: Total charge time is monitored and battery charging stops when the preprogrammed time interval has elapsed.

The low battery state is indicated on the main display by “LOW BAT!!”, and flashes On and Off. The Model 929A/930A will automatically shut down if the low battery condition persists for longer than several minutes. **It is recommended that the unit be charged or shut off when it indicates a low battery condition.**

2.6.3 Auto-Shutdown Mode

Auto-Shutdown Mode extends the battery-life by deactivating the instrument power if no input signals are present and no keystrokes occur within

a period of approximately 10 minutes. To return to normal operation, simply press the ON/OFF key. Activate the Auto-Shutdown Mode by using the MENU key (see Section 3.3.12).

2.7 Start-Up Sequence

Several tasks are performed during the power-on initialization sequence. First, the Model 929A/930A reads calibration data from the EEPROM (installed only in units with serial numbers greater than A0194). The initial sign-on message reports any errors in the calibration data along with the calibration date. These errors are corrected using a built-in Hamming Code Algorithm. If the number of reported errors increases with subsequent start-ups it is an indication that the EEPROM should be replaced. The calibration date is displayed as a decimal number with the format: MMDDYY.

The second part of the sign-on display shows the ROM program copyright date, the Help ROM version date and the DSP ROM version date. The DSP ROM date is displayed as a decimal number in the format: MMDDYY. As new features are added to the Model 929A/930A these dates are updated.

2.7.1 Holding the Start-Up Sequence

Holding the escape key during the startup sequence holds the startup displays, including the two parts mentioned above. Holding the enter key during the startup sequence allows resetting the setup parameters of calibration.

2.7.2 Reset – Instrument Default Setup

To reset the instrument to original default conditions when it shipped from the factory, follow the resetting procedure listed below. Three menu selections are available, shown in the simulated display below. Normally, only the first or second items should be selected. Selecting FULL will completely reset the instrument and calibration constants will be lost. To reset the 929A/930A to factory defaults, select PARTIAL. To escape from this menu, select EXIT and press the ENTER key.

| INSTRUMENT DEFAULT SETUP | |
|--------------------------|-----------------------------|
| EXIT | (Nothing Disturbed) |
| PARTIAL | (Calibration Not Disturbed) |
| FULL | (All Values Set To Default) |

Table 2.3: 929A/930A Reset Selection Screen

2.7.2.1 Resetting Procedure

NOTE: DO NOT SELECT “FULL” UNLESS YOU INTEND TO COMPLETELY ERASE THE INSTRUMENT CALIBRATION!

NOTE: Normally, select “PARTIAL” to restore the instrument to original default conditions.

1. Press the ON/OFF button to start the unit.
2. Press and release the ENTER key when the first display screen becomes visible, and the display should indicate as in Table 2.3 above.
3. Using the Cursor keys (up or down arrows) select “PARTIAL” from the three options shown in the diagram below.
4. Press ENTER and the instrument should ask, “ARE YOU SURE?? YES=UP NO=DOWN”. Press the UP arrow to complete the reset procedure. Otherwise, press the DOWN arrow to escape.
5. The display should indicate the message, “PLEASE WAIT 10s TO 4m”. After a short time the display should return to the final VOLTS AMPS display indication.
6. You may need to configure your settings under MENU and/or SHIFT > SCALE.

Chapter 3

Operation

3.1 Introduction

This section describes how to operate the Model 929A Three-Phase Power Meter and Model 930A Three-Phase Power Analyzer. Topics discussed in this section include: Front panel connectors, front panel controls and display, measurement configuration, taking measurements, use of external PT's and CT's, data logging, and printing/data exporting.

3.2 Front Panel Connections

There are a total of eleven connectors on the front panel (excluding the RS-232C on the Model 930A and power inlet connectors), and all will accept a standard banana plug. Four of the front panel banana jacks are recessed and insulated for safety at high voltages. The remaining seven jacks are of a type suitable for high-current applications. The following paragraphs describe the functions of each of these connectors.

3.2.1 Chassis Ground

A ground lug, located in the lower right-hand corner of the front panel, is connected to the instrument chassis, and also to the safety ground lead of the AC power connector. When the Model 929A/930A is operated with the power line cord connected, the chassis of the instrument will be connected to the safety ground for the AC outlet. However, when operated from the internal battery with the power cord disconnected, the chassis will be floating.

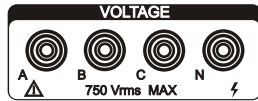


The purpose of the ground lug is to allow the chassis to be tied to a safety ground, especially during battery operation.

CAUTION: The front-panel ground terminal should always be connected to the safety ground for the circuit under test. This is especially critical for operation with the line cord unplugged, since the AC line input safety ground will not be connected.

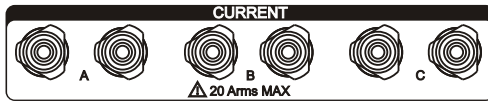
3.2.2 Voltage Inputs

The Model 929A/930A features four, front-panel inputs, which can be used for measurement of AC voltages. These inputs are labeled “A”, “B”, “C”, and “N” (for phase A, phase B, phase C, and Neutral, respectively).



All four of the inputs utilize identical circuitry, which allows for measurement of voltages up to 750 Vrms between inputs. The 1 megohm input voltage dividers are tied to a common point. Any unused voltage inputs will float at the average value of the used inputs. Safety-insulated banana jacks are used for the connections. Voltage measurements may be taken between any two of the inputs (e.g., “A” and “N”). Measurements may also be made between the input and a synthesized neutral. Synthesized neutral is the average of the voltages at inputs A, B, and C.

3.2.3 Current Inputs



The Model 929A/930A has three inputs for use in AC current measurement. Each of the inputs uses a pair of five-way binding posts, and has a maximum current capability of 20 amps rms. For each pair of terminals, the left-hand side is positive, and the right-hand side is negative.

For measurement of 3-phase neutral current, the signal $I_n = -(I_a + I_b + I_c)$ is available on Channel 2.

3.3 Front Panel Keys – Main Functions

The following paragraphs describe the functions and features that can be accessed via Front Panel Keys. The functions of the keys of the keypad are divided into three groups: Main Functions, Secondary Functions, and Data Entry Functions. The Secondary and the Data Entry Functions differ from the Main Functions in that they must be preceded by another keystroke (either the shift key, or one invoking a selection menu).

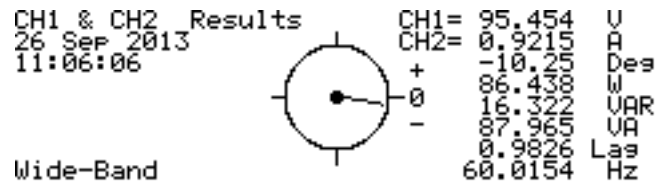
The primary functions of the front panel keys are described below. The text located directly below each key identifies its primary function. Press the key once to access these primary functions.

3.3.1 Volts/Amps

Press the VOLT/AMPS key to display the amplitude values for the signals routed to Channels 1 and 2. The input multiplexing circuitry determines which input signals are connected to the measurement channels, according to selections made by the operator (see Sections 2.3).



Press the VOLT/AMPS key again to produce a tabular display showing the signals routed to Channels 1 and 2. Also present is a graphical display of the phase angle. Tabular values, including phase, Watts, VARs, VA, Lead or Lag and frequency (Hz) are located on the right side of the display.



Make amplitude measurements with the instrument in either the narrow-band mode (fundamental only), or wide-band mode (true rms).

In wide-band mode, the square root of the average of the squared instantaneous sampled values determines the true rms amplitude. It includes harmonics up to 3.05 kHz and removes DC prior to calculation.

In narrow-band mode, an extremely accurate, proprietary digital signal processing (DSP) algorithm determines the fundamental amplitude. It also excludes the effects of DC, harmonics and noise.

3.3.2 Phase/Frequency

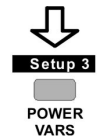


Press the PHASE/FREQUENCY key to display the frequency of the input signal routed to measurement Channel 1, and the phase angle of the signal routed to Channel 2 (relative to the signal on measurement Channel 1). The input multiplexing circuitry determines which input signals are connected to the measurement channels, according to selections made by the operator (see Sections 2.3).

Phase angle and frequency are always measured using narrow-band fundamental DSP techniques, guaranteeing accurate measurements in the presence of harmonics, noise, and DC offsets. The displayed phase angle is that of the fundamental component only.

Display phase angle as 0 to 360°C or as ±180°C, and a lagging phase angle may also be chosen to be positive or negative by convention. Select your preferred phase convention as described in Section 3.3.12, under Menu. See Figure 3.1 for Phase Angle definitions.

3.3.3 Power/Vars



Press the POWER/VARS key to display active and reactive power for the combination of signals routed to Channels 1 and 2. The input multiplexing circuitry determines which input signals are connected to the measurement channels, according to selections made by the operator. (see Section 2.3).

To use the POWER/VARS function, Channel 1 must be set to measure AC voltage, and Channel 2 must be set to measure AC current.

In wide-band mode, active power (watts) is measured by taking the average of the products of the instantaneous values of voltage and current, and includes the effects of harmonics.

Reactive power (Vars) is measured by taking the vector difference of the wide-band apparent power less the active power (active power is described above). The wide-band apparent power is the product of the wide-band rms voltage and the wide-band rms current.

$$(3.1) \quad \text{Wide - band VARs} = \sqrt{VA^2 - W^2}$$

Mathematically, reactive power is defined as the square root of the quantity apparent power squared minus active power squared. The sign of the wide-band reactive power is determined from the sign of the narrow-band reactive power.

In narrow-band mode, active power (Watts) is measured by multiplying the fundamental voltage and current magnitude and the cosine of their phase angle, all determined accurately by DSP. Harmonics are ignored. Narrow-band reactive power (Vars) is measured by multiplying the fundamental voltage and current by the sine of negative of the fundamental phase angle, all determined accurately by DSP. Again, harmonics are ignored.

$$(3.2) \quad \text{Narrow - band Vars} = V_{fund} \times I_{fund} \times \text{Sin}(-\Theta)$$

Press the POWER/VARS key a second time to toggle the display from Power to Energy. Both Watt-hours and VAR-hours are continuously accumulated. Use the RESTART key to zero the Energy readings. Power readings are summed once every second, using the real-time clock, to produce Energy readings.

3.3.4 VA/PF

Press the VA/PF key to display the apparent power and power factor for signals routed to Channels 1 and 2. The input multiplexing circuitry determines which input signals are connected to the measurement channels, according to selections made by the operator (refer to Section 2.3).



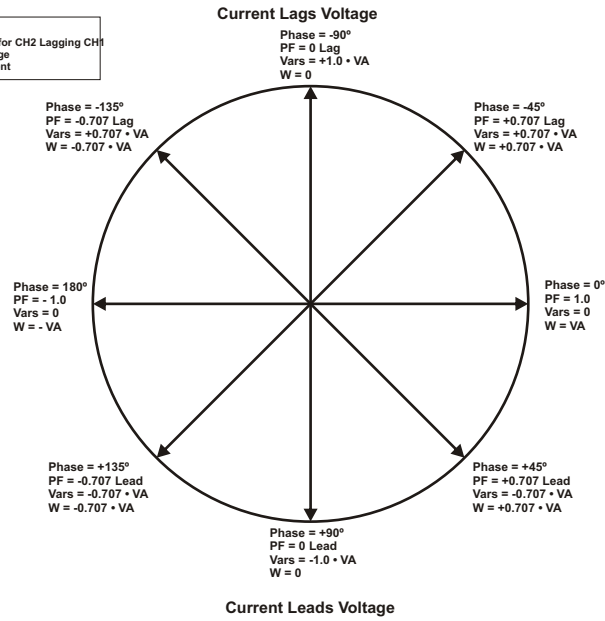
To use the VA/PF function, Channel 1 must be set to measure AC voltage, and Channel 2 set to measure AC current. Measurements may be made in either wide-band or narrow-band mode. The power factor range is between -1 and +1, leading or lagging (see Figure 3.1).

In wide-band mode, apparent power (volt-amps, or VA) is determined by multiplying the wide-band rms voltage by the wide-band rms current. Power factor is determined by dividing the wide-band active power by the wide-band apparent power (refer to Section 3.3.3).

In narrow-band mode, apparent power is determined by multiplying the fundamental amplitude of the voltage and the current (accurately by DSP). Power factor is the cosine of the phase angle between the fundamentals of the current and the voltage, ignoring harmonics. The Lead/Lag indication for Power Factor may be disabled. Refer to Section 3.3.12, Menu - Phase Preference.

Pressing the VA/PF key a second time toggles the display from Power to Energy. VA-hours are continuously accumulated. Use the RESTART key to zero the Energy readings. Power readings are summed once every second, using the real-time clock, to produce Energy readings.

NOTES:
Polarity: (-) for CH2 Lagging CH1
CH1 = Voltage
CH2 = Current

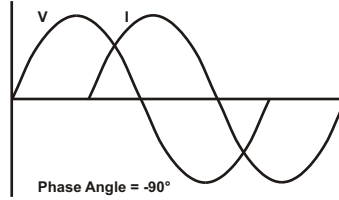


Conventions Used in the 931A

NARROW-BAND:
Power Factor = $\cos \theta$
Vars = $V_{fund} \cdot I_{fund} \cdot \sin(-\theta)$
Watts = $V_{fund} \cdot I_{fund} \cdot \cos \theta$
VA = $V_{fund} \cdot I_{fund}$

Where: θ (Theta) = Phase Angle between voltage and current. A negative number indicates that current is lagging voltage.

Example:



WIDE-BAND:
Power Factor = Watts/VA
VA = $V_{rms} \cdot I_{rms}$
Vars = $(VA^2 - W)^{1/2}$

Figure 3.1: Phase, Power Factor, and VAR Examples

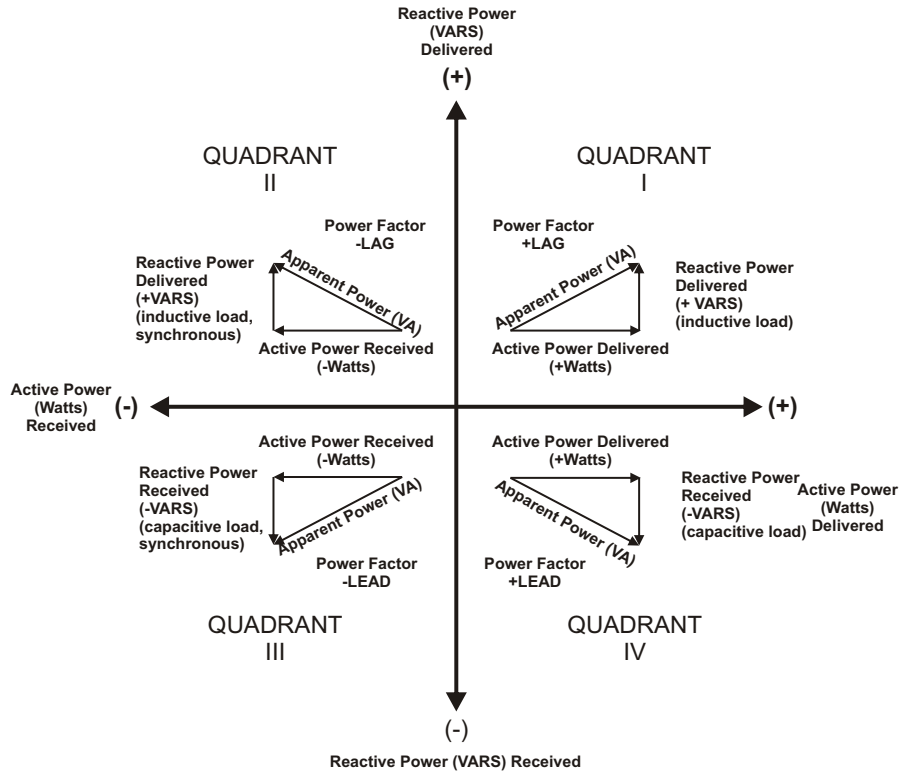


Figure 3.2: Phase, Power Factor, VAR Examples

| Phase Convention CH2 Lagging CH1 | Quadrant I | Quadrant II | Quadrant III | Quadrant IV |
|-------------------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|
| (-) for $\pm 180^\circ$ | 0° to -90° | -90° to -180° | $+180^\circ$ to $+90^\circ$ | $+90^\circ$ to 0° |
| (+) for $\pm 180^\circ$ | 0° to $+90^\circ$ | $+90^\circ$ to $+180^\circ$ | -180° to -90° | -90° to 0° |
| (-) for $0 - 360^\circ$ | 360° to 270° | 270° to 180° | 180° to 90° | 90° to 0° |
| (+) for $0 - 360^\circ$ | 0° to 90° | 90° to 180° | 180° to 270° | 270° to 360° |

Table 3.1: Phase Angle Examples*

* Phase angle of Channel 2 (current) relative to Channel 1 (voltage)

Lagging Current – An alternating current which, in each half-cycle, reaches its maximum value a fraction of a cycle later than the maximum value of the voltage that produces it.

3.3.5 Harmonics



Press the HARMONICS key to view a graphic display of the magnitude of individual harmonics for the signals routed to Channels 1 or 2. The input multiplexing circuitry determines which input signals are connected to the measurement channels, according to selections made by the operator (refer to Section 2.3).

Harmonics up to the 50th are shown for fundamentals of 50 or 60 Hz. At 400 Hz, only harmonics up to the 7th are displayed, due to the instrument bandwidth limitation of 3.05 kHz.

Harmonics are measured by first determining the AC fundamental and the DC components of the signal, and removing them algebraically from the digitized waveform. For the spectral display, K-factor, and individual harmonic measurements, Fast Fourier Transform analysis determines the residual. Dividing the rms of the residual by the wide-band rms amplitude determines the Total Harmonic Distortion (THD). With these techniques, harmonic measurement accuracy is not dependent upon fundamental frequency.

Select any harmonic with the movable cursor found in the graphic display using the arrow keys. The display also shows corresponding numerical values of the amplitude and the phase angle of the harmonic relative to fundamental. Press CHANNEL 1 SELECT or CHANNEL 2 SELECT to toggle the display between the signals applied to Channels 1 or 2.

Numerical display of THD and K-factor are always available. THD is the rms of the residual, including noise and spurious signals, as a percent of the wide-band rms. K-factor is the rms sum of the fundamental plus the individual harmonics (each weighted by the square of the harmonic number) expressed as a ratio to the fundamental. It is an estimate of the heating effect of harmonic energy in magnetic materials. K-factor is used to determine transformer de-rating. K-factor is 1.0 for a perfect sine wave and greater than 1.0 with distortion.

3.3.6 Waveform



Press the WAVEFORM key to view a graphic display of the waveforms for the signals, which are routed to Channels 1 and 2. The input multiplexing circuitry determines which input signals are connected to the measurement channels, according to selections made by the operator.

Displayed waveforms correspond to the input signals after they have been digitized and subjected to digital low-pass filtering. The

display includes all components of the signal up to 3.05 kHz.

The waveform display is normalized to positive going zero crossings of Channel 1 signal fundamentals. To inspect the current waveform, reference the current at Channel 2 to the voltage at Channel 1. The displayed waveform amplitude is relative to the displayed percentage of the selected range.

View waveforms individually by pressing CHANNEL 1 SELECT, or CHANNEL 2 SELECT, with the waveform display active.

3.3.7 Channel 1 Select

Press the CHANNEL 1 SELECT key to view the input configuration menu for Channel 1.

Always connect the lowest distortion input signal to Channel 1 since it is used as the internal reference. For most power systems the voltage has lower distortion than the current. If applying only one signal, it must be connected to Channel 1. If analyzing a single highly distorted waveform connect a reference signal of the same fundamental frequency to Channel 1 and the waveform to be analyzed to Channel 2.

Combinations from the front panel inputs allow fifteen choices; three AC currents (A, B, C) and twelve AC voltages. Each voltage terminal may be referenced to any other voltage terminal, to the front-panel neutral, or (for AC) to a synthesized neutral, which is the average of “Va”, “Vb” and “Vc”. Table 2.1 lists the possible input combinations.

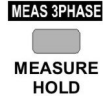


3.3.8 Channel 2 Select

Press the CHANNEL 2 SELECT key to select the input configuration menu for Channel 2. Front panel input combinations allow sixteen choices; four AC currents (A, B, C, N) and twelve AC voltages. The Neutral Current “N” is minus the vector sum of “Ia, Ib, and Ic”. Each voltage terminal may be referenced to any other voltage terminal, to the front-panel neutral, or (for AC) to a synthesized neutral, which is the average of “Va”, “Vb” and “Vc”. Table 2.1 lists the possible input combinations.



3.3.9 Measure Hold



Press the MEASURE/HOLD key to stop the measurement process and hold the instantaneous value of each measured parameter. With the exceptions of harmonics, waveform and 3-phase, any display function may be selected during the time that the measurement hold mode is active, and the corresponding values observed. Harmonics, waveform, or 3-phase information may only be displayed if the instrument was in that respective mode when the MEASURE/HOLD key was pressed. Press the MEASURE/HOLD key again to leave the Measurement Hold mode and resume measurements. The display indicates whenever the Measurement Hold mode is active.

3.3.10 CH2 Range



Press the CH2 RANGE key to select the operating voltage or current range for Channel 2. The ranges are only approximate and vary from unit to unit. Press the CH2 RANGE key to view a range selection. Range values allow selection of either auto range, or a fixed range made available from one of the following groups (depending on the input mode selected):

AC Voltage Ranges are approximately (Vrms):

| | | |
|---------|----------|-----------|
| 0 – 3.5 | 12 – 28 | 96 – 224 |
| 3 – 7 | 24 – 56 | 192 – 448 |
| 6 – 14 | 48 – 112 | 384 – 750 |

Table 3.2: Channel 2, AC Voltage Ranges

AC Current Ranges are approximately (Arms):

| | | |
|-------------|-------------|--------------|
| 0 – 0.09 | 0.32 – 0.75 | 2.56 – 5.97 |
| 0.08 – 0.18 | 0.64 – 1.49 | 5.12 – 11.9 |
| 0.16 – 0.37 | 1.28 – 2.98 | 10.24 – 20.0 |

Table 3.3: Channel 2, AC Current Ranges

3.3.11 Min/Max

Press the MIN/MAX key to display the minimum, maximum and average values for any and all measured parameters. Accumulation of 3-phase minimum and maximum parameters occur only while the 3-phase display is active. The MIN/MAX feature continuously updates the minimum, maximum and average values stored since initial power-on. During display of a parameter, any new value exceeding the currently stored minimum or maximum will overwrite it. Averaging is continually updated during the measurement period. Accumulation of data can also be re-initiated, by pressing the SHIFT key, then the RESTART key.



Pressing the MIN/MAX key repeatedly scrolls between minimum, maximum, average and present data.

3.3.12 Menu



Press the MENU key to display a configuration menu used to define configurable parameters within the Model 929A/930A. The sub-menus and functions available from the MENU key are defined as follows:





- RS-232 Port Setup (930A only): Used to set the baud rate, data bits, stop bits, parity, and flow control for the RS-232C communications port.
- Set Real-Time Clock: Set the Year, Month, Day, Hour, Minute, Second, and also the Daylight Saving mode.
- Backlight and Auto-Shutdown: Select the operating mode for the display backlight and for the Auto-Shutdown function. The Auto-Shutdown function will turn the instrument off if there are no input signals or keystrokes for approximately 10 minutes.
- Phase Preference: Select the conventions to be used for phase display. This includes whether phase angle is displayed as $\pm 180^\circ$ or $0 - 360^\circ$ and (-) for Channel 2 lagging Channel 1 or (+) for Channel 2 lagging Channel 1. The Phase Preference selection only affects the displayed phase angle and no other quantities. Section 3.8.2 describes the phase convention selection. There is also a selection for enabling or disabling the Power Factor “Lead/Lag” display.

- Print Selections (930A only): Allows selection of the type of data to be printed or exported when pressing the PRINT key. A complete description of the printing function is contained in Section 3.11.
- Print Broadcast Mode (930A only): Allows automatic output of the selected print option at various time intervals.
- Auto-Log Setup (930A with flash memory only): Shows up only when 16-Mbyte memory card is installed. See Section B.3.4 for details.



3.3.13 Log Data



 Press the LOG DATA key to store measurement data to non-volatile memory. Stored data includes current time and date, according to the built-in real-time clock. The memory location in which data is stored will be indicated momentarily in the lower right corner of the display. Displays a diagnostic message if the memory is full. See Section 3.10 for details of data logging features and controls. For a Model 930A equipped with extended memory, see Section B.3 and following.

3.3.13.1 Print (Model 930A only)



 Press the PRINT key to transmit the current measurement data to a printer, modem, or computer connected to the RS-232 port. A complete description of printing functions is contained in Section 3.11.

3.3.14 Last Setup



 Press the LAST SETUP key to restore the instrument-state to what it was immediately prior to the last change. It may be used to undo an unwanted change, or to toggle between two different setups. When LAST SETUP is pressed, the current state is also stored as the new LAST SETUP.

3.3.15 Ch1/Ch2

Press the CH1/CH2 key to display the measured results as the magnitude and phase angle of the ratio of the signal at Channel 1 divided by the signal at Channel 2. Depending on the input signals selected, the display units will be either ohms (Channel 1 voltage and Channel 2 current), mhos (Channel 1 current and Channel 2 voltage), or P/U (both channels the same). The value shown for phase represents the phase angle between the signal at Channel 1 and the signal at Channel 2. It is displayed in accordance with the phase convention defined for the instrument (see Section 3.8.2.3).



When using the CH1/CH2 function, any scaling factors for magnitude and/or phase will apply to the displayed result (see Section 3.4.12 for a discussion of scaling factors).

CH1/CH2 is useful for checking the amplitude and phase angle accuracy of current transformers. Connect the primary in series with a Model 929A/930A current input and set that input to Channel 1. Connect the transformer secondary to another current input and set that input to Channel 2. Set the scale factor for the CT input (see Section 3.4.12) and press CH1/CH2. Using an external source, supply the appropriate level current.

3.4 Front Panel Keys – Secondary Functions

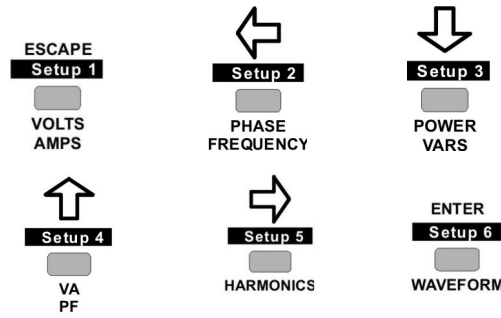
The secondary functions of the front panel keys are shown below. They are identified by the text located directly above each of the keys, and are highlighted in gray. Access these functions by pressing SHIFT prior to pressing the desired key.

3.4.1 Shift

Press the SHIFT key to access the functions in the shaded gray areas above the keys. An indicator in the display shows when the SHIFT key has been pressed. Press SHIFT a second time to prevent access to the secondary functions.

3.4.2 Setup 1 – 6

Up to six different instrument configurations can be stored for future measurements using STORE SETUP (see Section 3.4.11) and recalled by first pressing SHIFT and then the applicable SETUP 1 through SETUP 6 front panel key. The stored setup information includes Channel Selection and Scale Factors. The SETUP keys are shown below.



3.4.3 Narrow Band

Press SHIFT, then NARROW-BAND key to change the measurement mode for amplitude and power quantities to measure the fundamental frequency only. The system uses proprietary DSP algorithms in which harmonics are ignored. Refer to the help screens for each individual measurement for more detailed descriptions.



Channel 1 is used as the internal reference. Use Channel 1 if only one signal is measured. If measuring both a current and a voltage, use Channel 1 for measuring the voltage and Channel 2 for the current.

3.4.4 Wide Band

Press SHIFT, then BAND-WIDE key to change the measurement mode to wide-band for amplitude and power quantities; this includes all frequencies up to 3.05 kHz. For more information, refer to the help screens for each individual measurement.



3.4.5 Measure 3 Phase

Press SHIFT, then MEAS 3 PHASE to display the 3-phase measurement selection window. MEAS 3 PHASE permits the Model 929A/930A to make sequences of measurements on sets of voltage and current inputs. Actual measured values depend on the selection (as shown below).



```

3 PHASE MEASUREMENT SELECTION
→1Ph 3W 2E: (Split; VanIa, VcnIc)
3Ph 3W 2E: (UabIa, UcbIc, 'Uac, Ib')
3Ph 3W 3E: (UasIa, UbsIb, UcsIc)
3Ph 4W 3E: (VanIa, VbnIb, VcnIc)
3Ph 4W 2.5E: (VanIa, 'Ub' Ib, VcnIc)
                (connect Ub to Un)

```

Move the cursor to the desired input configuration and press ENTER; the display then supplies you with some display choices (e.g. tabular or vector data). The input pairs shown in parenthesis are those used for the TABULAR display. Figure 3.3 illustrates some of the display choices.

```

3 PHASE DISPLAY SELECTION
→TABULAR DISPLAY (with Power)
TABULAR DISPLAY (with energy)
VECTOR DIAGRAM
VOLTAGE & CURRENT SEQUENCE
VOLTAGE SEQUENCE
CURRENT SEQUENCE

```

Figure 3.3: Three Phase Display Selection

3.4.5.1 Tabular Display

The 929A/930A makes a sequence of measurements as shown in the 3-phase Measurement Selection menu. Amplitude, power and phase quantities for the individual phases are shown along with the totals for the system. In one column the screen identifies totals by a “T”, energy readings by “H” and as averages by a “*”. The sample Tabular display below identifies the individual quantities.

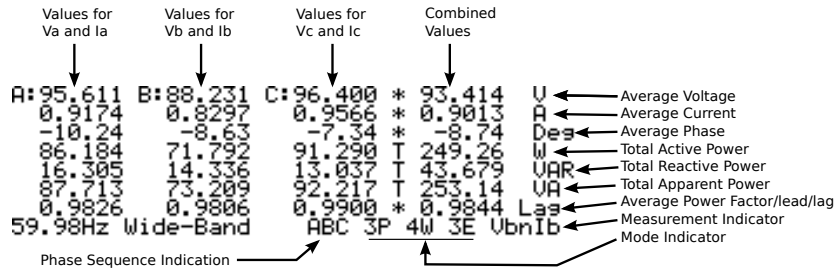


Figure 3.4: Three Phase Tabular Display

In **1-phase, 3-wire, 2-element mode**, the instrument alternates between measurements of “Van,Ia” and “Vcn,Ic”. This is useful for making measurements on split-phase systems. The column on the far right shows

the averages for voltage, current, phase and the totals for power quantities. The columns for “A” and “C” show the voltage; characters in the lower right-hand corner of the display alternate between “VanIa” and “VcnIc”, indicating the measured voltage and current.

In **3-phase 3-wire 2-element mode**, the instrument alternates between measurements of “Vab,Ia”, “Vcb,Ic”, “Vac,Ib”, and “Vcb,Vab”. It computes “Vac” and includes it in the 3-phase average voltage. While Ib is measured, it is not included in the 3-phase results. This procedure yields accurate results for active power, but to estimate apparent power, a correction of 0.866 must be arbitrarily applied since accuracy depends on the symmetry of the phase voltages. “VcbVab” phase is measured to determine phase rotation.

In **3-phase 3-wire 3-element mode**, the instrument sequences between measurements of “Vas,Ia”, “Vbs,Ib”; and “Vcs,Ic” (“s” denotes synthesized neutral, which is the average of the signals present at voltage inputs “a”, “b”, and “c”). Results are accurate for active power, but to estimate apparent power synthesized neutral is used, and accuracy depends on symmetry of the phase voltages. Reactive power, power factor, and phase angle also are estimated. “VasVbs” phase is measured to determine phase rotation.

In **3-phase 4-wire, 3-element mode**, the instrument sequences between measurements of “Van,Ia”, “Vbn,Ib”, and “Vcn,Ic”. All results are accurate. This is the preferred mode for 3-phase measurements when neutral is available. Phase rotation is determined by measuring “VanVcn”.

In **3-phase 4-wire 2.5 element mode**, the instrument sequences between measurements of “Van,Ia”, “Vb,Ib”, “Vcn,Ic”, and “VcnVan”.

| |
|--|
| <p>NOTE: The “B” voltage input must be externally connected to the “N” voltage input.</p> |
|--|

“Vb” is internally generated using the synthesized neutral circuit, and the accuracy of all results depend on the symmetry of the phase voltages.

In all three-phase modes, the Model 929A/930A also measures and displays phase the sequence, “ABC” or “CBA”. (see Figures 3.5 and 3.6). A phase measurement of “Vab to Vac” is made at the end of each sequence. If the “Vab to Vac” phase is negative, the sequence is “ABC” otherwise it is “CBA”. Phase Sequence may be checked using the waveform display. With Channel 1 set to “Van” and Channel 2 set to “Vbn”, the waveform display will show the peak of “Vbn” 120 degrees after the peak of “Van” for an “ABC” Phase Sequence. The waveform display always begins at

the zero crossing of the Channel 1 signal. Dashes displayed for the phase sequence indicate that a valid “Vab to Vac” phase was not measured. Phase rotation is determined by measuring “VcnVan”.

The second tabular display (Watt/VAR/VA Hour) replaces the total power quantities with accumulated energy readings. Set the energy readings to zero by pressing the RESTART key.

3.4.5.2 Vector Diagram

The Vector Diagram consists of a table of the measured voltages, currents and phase angles along with their vector representation. The “A” phase voltage vector is fixed in the horizontal direction. Positions of all other vectors rotate according to their phase angle with respect to the “A” phase voltage. Positive phase angle is denoted by counter-clockwise rotation. The length of the vectors shows the relative amplitude of each phase. The largest voltage and the largest current each have the longest vectors. The 929A/930A does not display a vector with a length of less than one pixel. All voltage and current phases are made with respect to the “A” phase voltage. The “A” phase voltage must be present for a proper Vector Diagram display.

3.4.5.3 Voltage and Current Sequence

The Voltage and Current Sequence display shows the measured voltages, currents and phase angles in the top portion of the display. The bottom half of the display shows the positive (V1, I1), negative (V2, I2) and zero (V0,I0) sequence values. The Model 929A/930A defines the positive sequence as the values in the “ABC” direction and negative sequence as values in the “CBA” direction. Also included is a computed value for the neutral current amplitude and phase angle. All voltage and current phases are made with respect to the “A” phase. The “A” phase must be present for a proper Voltage and Current Sequence display.

Positive-Sequence Current (I1) and Voltage (V1) are the normal components represented in balanced three-phase (3-wire and 4-wire) systems. They are present in operating motor and generator windings.

Negative-Sequence Currents (I2) and Voltages (V2) are the components in 3-phase systems that result from unbalanced phase-to-phase current and voltage. They cause undesired heating in motor and generator windings. Reversed phase sequence – ACB vs ABC – can be viewed as an extreme negative sequence case.

Zero-Sequence Currents (I0) and Voltages (V0) are characteristic of

unbalanced 3-phase four-wire systems, and correlate to “neutral shift”, where there is a current and potential difference in motor or generator windings with respect to system ground. Zero-Sequence conditions result from unequal phase-to-neutral parameters.

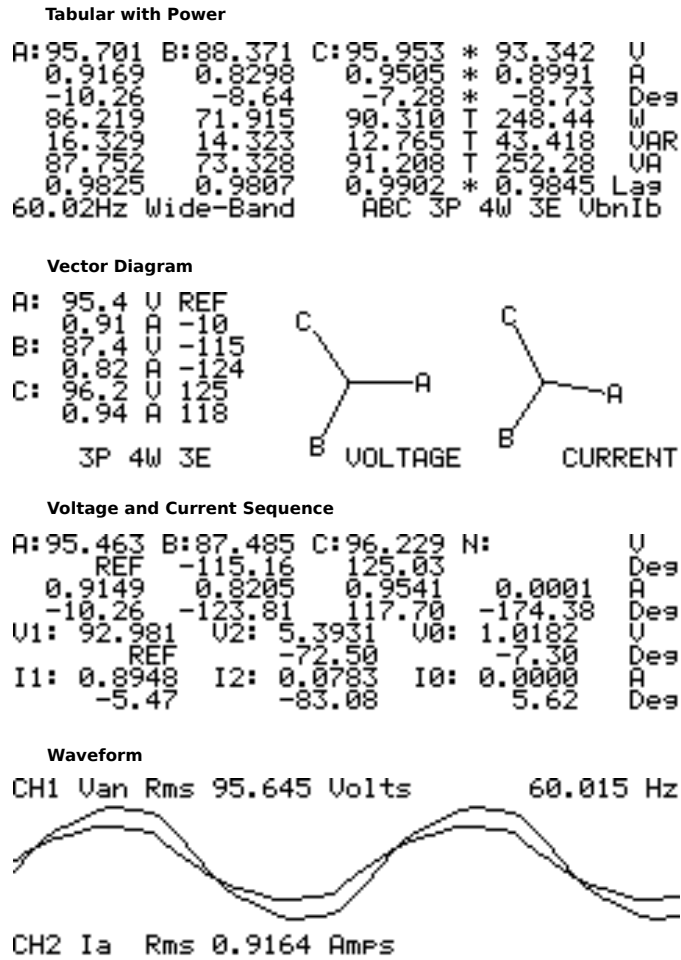


Figure 3.5: Three-Phase Displays for an ABC System

```

Tabular with Power
A: 95.700 B: 96.460 C: 88.318 * 93.493 U
  0.9165  0.9557  0.8291 * 0.9004 A
 -10.26   -7.35   -8.63 * -8.75 Des
 86.181   91.257   71.807 T 249.24 W
 16.317   13.038   14.347 T 43.702 VAR
 87.713   92.183   73.226 T 253.12 VA
  0.9825  0.9899  0.9806 * 0.9844 Lpf
59.98Hz Wide-Band CBA 3P 4W 3E VcnIc

```

```

Vector Diagram
A: 95.2 U REF
  0.91 A -10
B: 96.1 U 125
  0.95 A 118
C: 87.4 U -115
  0.81 A -124
      3P 4W 3E

```

```

Voltage and Current Sequence
A: 95.212 B: 96.015 C: 87.387 N:
  REF      124.99 -115.23
  0.9117  0.9516  0.8194  0.0012
 -10.24   117.67   -123.86 -10.52
U1: 5.3189 U2: 92.795 U0: 0.9786
  REF      3.21   -7.56
I1: 0.0774 I2: 0.8926 I0: 0.0004
 -83.26   -5.49   169.48

```

```

Waveform
CH1 Van Rms 95.645 Volts 60.015 Hz

```

```

CH2 Ia Rms 0.9164 AmPs

```

Figure 3.6: Three-Phase Displays for a CBA System

3.4.5.4 System Connections

The following pages illustrate some standard methods of connecting an electrical system directly to the Model 930A and 929A. Connecting the 930A/929A to a test switch would be one example of a direct connection. If using a current probe, it will be necessary to set up scaling for the probe's ratio, and the lines would not be routed directly through the 930A/929A current input terminals.

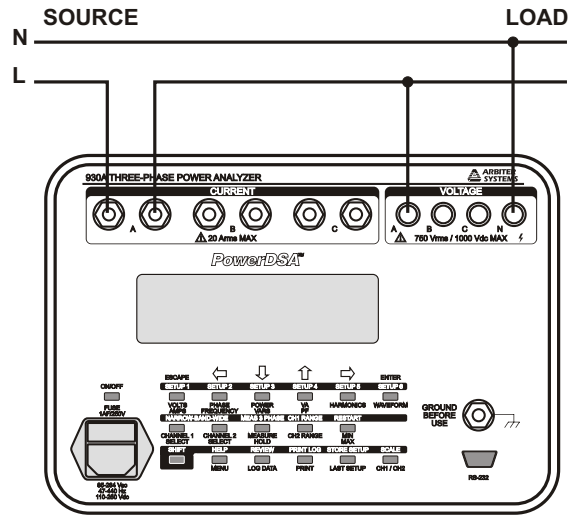


Figure 3.7: Single-Phase, 2-Wire, 1-Element Connections

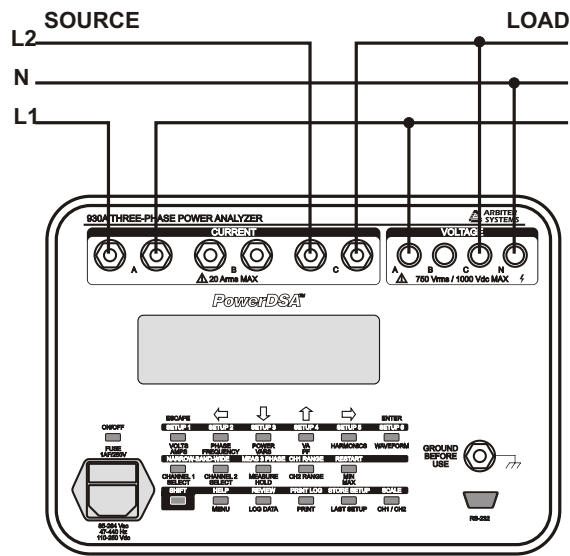


Figure 3.8: Single-Phase, 3-Wire, 2-Element Connections

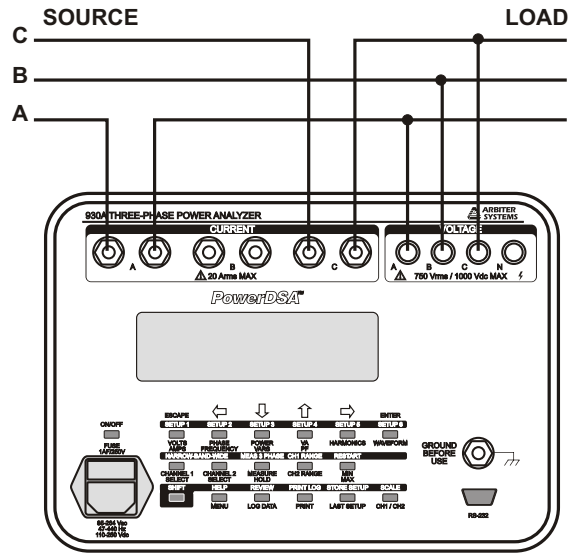


Figure 3.9: 3-Phase, 3-Wire, 2-Element Connections

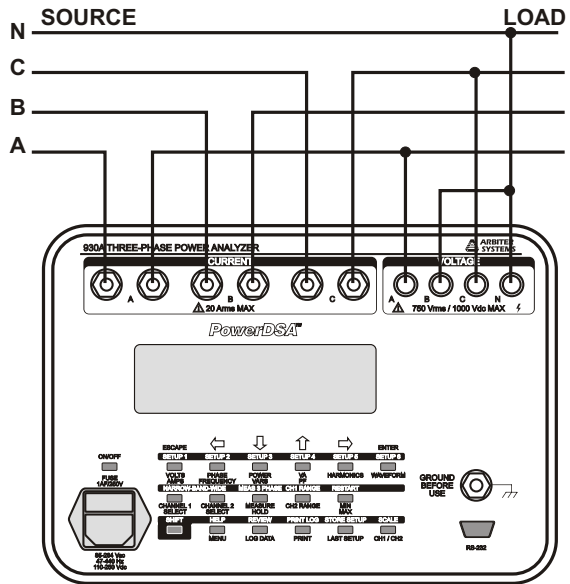


Figure 3.10: 3-Phase, 4-Wire, 2.5-Element Connections

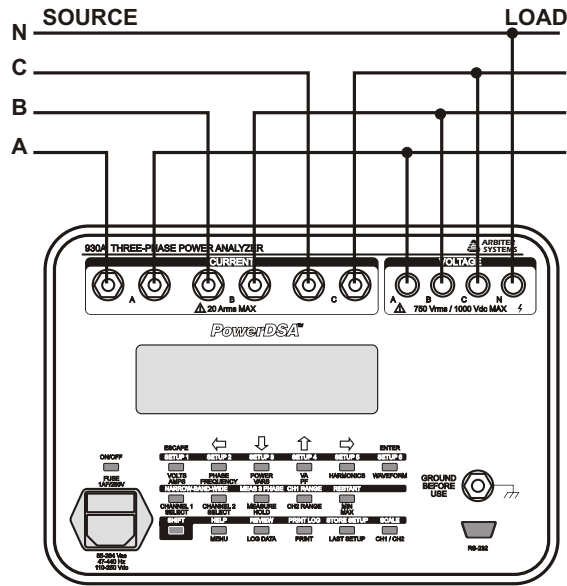


Figure 3.11: 3-Phase, 4-Wire, 3-Element Connections

3.4.6 CH1 Range

Press the CH1 RANGE key to select the operating voltage or current range for Channel 1. The ranges are only approximate and vary from unit to unit. Press SHIFT then the CH1 RANGE key to view a menu showing a selection of auto range or a fixed range. Depending on the input mode selected, the following fixed range groups are available:

| | | |
|---------|----------|-----------|
| 0 – 3.5 | 12 – 28 | 96 – 224 |
| 3 – 7 | 24 – 56 | 192 – 448 |
| 6 – 14 | 48 – 112 | 384 – 750 |

Table 3.4: Channel 1, AC Voltage Ranges, Vrms

| | | |
|-------------|-------------|--------------|
| 0 – 0.09 | 0.32 – 0.75 | 2.56 – 5.97 |
| 0.08 – 0.18 | 0.64 – 1.49 | 5.12 – 11.9 |
| 0.16 – 0.37 | 1.28 – 2.98 | 10.24 – 20.0 |

Table 3.5: Channel 1, AC Current Ranges, Arms

When an input signal exceeds the upper limit of a range which is held, the numbers in the display will change to dashes, and the message “Channel 1 Overload” will appear.

3.4.7 Restart

Press the RESTART key to erase minimum, maximum and average values previously stored and begin recording new ones. Pressing RESTART will also reset Energy values to zero.



3.4.8 Help

Press SHIFT then the HELP key to find reference information about the functions of the Model 929A/930A. To get help for a specific function, press SHIFT, then HELP, followed by the key for the desired function. Use the up and down arrow keys to page through the help message; press the ESCAPE key to return to normal operation. Display a menu featuring help topics for general operation by pressing SHIFT then HELP twice (i.e. SHIFT/HELP/SHIFT/HELP).



3.4.9 Review

Press SHIFT then REVIEW to view a menu of stored records. An example display is shown below:



```
LOG SPACE 98%  AUX MEM 98%  FILES 5
0  Clear All!  ( Key Clears A File)
→1  30Sep13 14:19:51      1 Standard
2  30Sep13 14:20:05      1 Harmonic
3  30Sep13 14:20:16      1 Waveform
4  30Sep13 14:20:36      1 3 Ph Tab
5  30Sep13 14:21:04      1 3 Ph Vec
```

Review Method

- Use the up and down arrow keys to select a record to be cleared or reviewed
- Press ENTER to view the highlighted record. After pressing ENTER, the unit goes into measurement hold mode and the stored record overwrites the current data. See Section 3.10 for further information on data logging and reviewing. Press measure/hold to release the instrument from the measurement hold mode.
- When in the selection menu display, press the left arrow key to clear the highlighted record from memory.
- To remove all data records from memory, press ENTER when Clear All Entries is highlighted.
- Press escape to return the instrument to normal operation without any modification of stored data.

3.4.10 Print Log (Model 930A only)


Press SHIFT then PRINT LOG to print to a list of the stored records to printer or computer connected to the serial interface (RS-232 port).

PRINT LOG

PRINT

3.4.11 Store Setup

Use the STORE SETUP key to save the current instrument-state in one of six memory registers: SETUP 1 through SETUP 6. Press SHIFT then STORE SETUP to produce the following prompt on the display:


STORE SETUP

LAST SETUP

Press SHIFT and desired SETUP key to store current instrument-state.

Press SHIFT, followed by one of the six SETUP keys (highlighted in gray across the top row) to store the current instrument setup into the corresponding register (SETUP 1 through SETUP 6). All setups are stored in non-volatile memory. For instructions on recalling instrument setups, see Section 3.4.2.

3.4.12 Scale

Use the SCALE key to apply individual Scale Factors to each AC measurement input function. Scale Factor corrections can adapt the Model 929A/930A for use with current or potential transformers. These adjustments can compensate for phase or amplitude error, and account for the ratio of a CT or PT.

SCALE

CH1 / CH2

Amplitude and phase scale factors may be entered for:

- Each of the three current inputs;
- Each of the three voltage inputs relative to neutral;
- The three, voltage inputs relative to each other.

Use the store SETUP FUNCTION described in Section 3.4.11 to store specific Scale Factors for later retrieval. The following assignments are made:

| <u>Set Scale:</u> | <u>Auto Sets:</u> | <u>Set Scale</u> | <u>Auto Sets:</u> |
|-------------------|-------------------|------------------|-------------------|
| Van | Vas, Vb | Vbc | Vcb |
| Vbn | Vbs | Vca | Vac |
| Vcn | Vcs | Ia | In |
| Vba | Vab | | |

Press SHIFT > SCALE to view Scale Factor Gain and Phase Selections. The display then shows the magnitude and phase scale factors for each of the input functions as seen below.

```

SCALE FACTOR GAIN & PHASE SELECTIONS
Vab +1.0000 +0.00 Ia 1.0000 +0.00
Vbc 1.0000 +0.00 Ib 1.0000 +0.00
Vca 1.0000 +0.00 Ic 1.0000 +0.00
Van 1.0000 +0.00 PT 1.0000 +0.00
Vbn 1.0000 +0.00 CT 1.0000 +0.00
Vcn 1.0000 +0.00 PT/CT * ON OFF
Scale Factor * Enable Disable

```

For magnitude, the factor represents the number by which a measured value is multiplied during the measurement process. For example, a magnitude scale factor of 100, with 10 volts applied to the Model 929A/930A input, displays 1000 volts. Therefore, if the Model 929A/930A was used to measure the voltage at the output of a 100:1 PT, and the magnitude scale factor was set to 100, the display would show the actual voltage value present at the PT input (compensating for the 100:1 reduction of the PT). Valid range for Scale Factors is 999999 to 0.0001.

Apply global PT and CT scale factors and simplify operation when desiring to use a PT or CT on any input. For example, press SHIFT > SCALE, then select PT with the cursor, then press ENTER. Using the cursor, select the appropriate digit, or decimal point, using the right and left arrow keys. Finally, use the up and down arrow keys to change the numerical digit, or decimal point, and press ENTER. After the changing the PT and CT values, move the cursor to PT/CT ON, and press ENTER.

When done, this applies the new scale factors for PT and CT to every input, and blocks out the individual scale factors shown for Vxy and Ix.

Phase angle scale factors indicate the offset, in degrees, that will be added to the input signal before it is displayed. Additionally, these offsets apply only at the fundamental frequency of the signal. In the harmonic display mode, phase offsets equal the offset at the fundamental frequency multiplied by the chosen harmonic number.

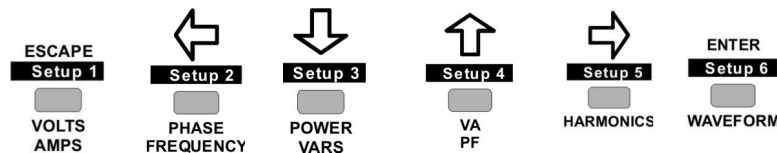
Enable or disable individual scale corrections globally using the SCALE menu (see Scale Factor Screen above), bottom line.

Measurements made in wide-band mode use digital true-rms detection. Phase corrections are applied for power quantities by using complex multiplication. The accuracy of this method depends on the absence of significant harmonic power and the size of the phase offset.

3.5 Front Panel Keys, Data Entry Functions

When performing operations, which require modification of parameters or making selections from menus, the arrow keys in the top row of the keyboard are used for cursor movement as described in the following paragraphs.

The general procedure for selecting items from a menu is to use the arrow keys to move the cursor (arrow symbol) to the desired selection and press the ENTER key. If the menu selection was a number to be modified, the cursor (flashing underline) will appear under the digit to be modified. Use the right/left arrow keys to select the digit to be modified. Use the up/down arrow keys to cycle the digit (\pm , ., 0, 1, 2, 3, 4, 5, 6, 7, 8, 9). Press ENTER when the number is correct. The plus, minus and decimal point will only be included in the cycle where appropriate.



3.5.1 Left Arrow

Use the left arrow key to move the display cursor to the left. The cursor movement function associated with this key is automatically enabled when required. After making a menu selection, this key will return to its primary function.

3.5.2 Down Arrow

Use the down arrow key to move the display cursor down. The cursor function associated with this key is automatically enabled as required. After making a menu selection, this key will return to its primary function.

3.5.3 Up Arrow

Use the up arrow key to move the display cursor up. The cursor movement function associated with this key is automatically enabled when required. After making a menu selection, this key will return to its primary function.

3.5.4 Right Arrow

Use the right arrow key to move the display cursor right. The cursor movement function associated with this key is automatically enabled as required. After making a menu selection, this key will return to its primary function.

3.5.5 Enter

Press the ENTER key to make menu selections and accept modified numbers.

3.5.6 Escape

Press the ESCAPE key to back-out of menus or selections. While not necessary to precede ESCAPE with SHIFT, ESCAPE is automatically available when applicable. Also, use ESCAPE to terminate the display of waveforms, 3-phase, harmonics, or XMODEM file transfers. To view the sign-on message, press and hold the ESCAPE key while the Sign-On message is being displayed; release to continue.

3.6 Front Panel Display

The Model 929A/930A uses a supertwist liquid-crystal display with a resolution of 240 horizontal pixels by 64 vertical pixels. In most cases, both measurement channels simultaneously display information from measurements and some instrument configuration.

The display has a bright CCFL backlight available for low ambient light situations. See Section 3.3.12 Menu, Backlight and Auto-shutdown control,

for directions on using the backlight. Use of the backlight significantly increases the battery drain.

Display changes in response to keystrokes allow selections from multiple menu levels, resulting in a self-prompting interface.

3.7 Direct Measurements

For measurement of certain parameters, the Model 929A/930A computes results from one or both channels individually. Always use Channel 1 if only one input signal is present. These measurement parameters include the following:

- AC Voltage
- AC Current
- Frequency
- Harmonics
- Waveform

The following sections provide instructions for performing measurements of parameters within this group.

3.7.1 AC Voltage Measurement

The Model 929A/930A can measure and display AC voltages of up to 750 Vrms.

3.7.1.1 Input Connections

Four inputs, labeled “A”, “B”, “C”, and “N” are available for measuring AC voltage, and each uses identical circuitry. Input multiplexing circuitry allows measurement of the value at inputs “A”, “B”, or “C”, relative to any other input. For example, to measure a voltage between terminals “A” and “N” simply connect the leads to those two terminals.

NOTE: The Model 929A/930A does not provide for measurement of voltage between voltage inputs and chassis ground lug. Make all measurements between two (or more) of the voltage inputs. The ground lug is included for safety purposes only, especially during battery operation. See Section 3.2.1.

3.7.1.2 Configuring the Channels

Configure the chosen measurement channel after connecting the voltage to the appropriate input terminals. If measuring only one AC voltage (e.g. single-phase), use Channel 1, since this channel is used for frequency measurements.

Press the CHANNEL 1 SELECT key to configure the measurement channel and to display the following menu:

```
CHANNEL 1 AC SELECTIONS
Uab  Uac  →Van  Uas  Ia
Ubc  Ucb  Ubn  Ubs  Ib
Uca  Uba  Ucn  Ucs  Ic
```

Arrows form the cursor, highlighting one of the selections. Press the arrow keys to locate the measurement value. For example, using the arrow keys move the cursor to Van to measure an AC voltage between inputs “A” and “N”. Press the ENTER key to confirm the selection.

Measure two separate voltages concurrently by configuring both Channels 1 and 2. For example, use the selection method above to use Channel 1 to measure “Vab” and use Channel 2 to measure “Vcn”. The two voltage signals must have the same fundamental frequency.

3.7.1.3 Performing the Measurement

Press the VOLT/AMPS key to display the measured AC voltage and produce a display similar to the one shown below:

```
CH1 Rms    95.370    -10.24
              Volts
CH2 Rms    0.9130    AmP
CH1=Van Wide-Band    30 Sep 2013
CH2=Ia              Mon 16:02:05
```

The large number at the top of the display indicates the voltage value measured by measurement Channel 1. The large number below it indicates the current value measured by measurement Channel 2.

The display indicates the general measurement bandwidth near the lower left-hand corner (i.e. Wide-Band). The Model 929A/930A uses either wide-band or narrow-band mode to measure and display AC voltage.

Press the SHIFT key then BAND-WIDE to change the measurement mode to wide-band RMS and include all frequencies up to 3.05 kHz. Press the SHIFT key then NARROW-BAND to measure the fundamental magnitude only, using DSP algorithms; harmonics are ignored.

The Model 929A/930A displays dashes for Channel 1 and Channel 2, when in narrow-band mode, if the signal present on Channel 1 is below a value, which can be accurately measured.

NOTE: Channel 1 is used as the internal reference; if only one signal is measured, Channel 1 must be used. If both a current and a voltage are measured, Channel 1 should be used for the voltage and Channel 2 for the current.

3.7.2 AC Current Measurement

The Model 929A/930A can directly measure and display AC currents of up to 20 Arms. It can measure higher currents using a current transformer (CT) and with direct readout using the scaling feature (see “Scale” in Section 3.4.12).

3.7.2.1 Input Connections

The Model 929A/930A provides three sets of input connectors for measuring AC current: labeled “A”, “B”, and “C”. All three inputs use identical circuitry and are electrically isolated from all others: the voltage inputs, and chassis ground. The input multiplexing circuitry allows measurement of the value at any one the inputs. The Neutral Current In ($-(I_a+I_b+I_c)$) is available for measurement on Channel 2.

3.7.2.2 Configuring the Channel

Configure the chosen measurement channel after connecting the current to the appropriate input terminals. If measuring only one AC current (e.g. single-phase), use Channel 1, since this channel is used for frequency measurements.

To configure measurement Channel 1 and view the menu selection options, press the CHANNEL 1 SELECT key.

| | | | | |
|-------------------------|-----|-----|-----|-----|
| CHANNEL 1 AC SELECTIONS | | | | |
| Vab | Vac | Van | Vas | →Ia |
| Vbc | Vcb | Vbn | Vbs | Ib |
| Vca | Vba | Vcn | Vcs | Ic |

Arrows from the cursor and highlight one of the selections. Press the arrow keys to locate the measurement value. For example, using the arrow keys move the cursor to Ia to measure an AC current at the two “A” terminals. Confirm selection by pressing ENTER.

3.7.2.3 Performing the Measurement

Press the VOLT/AMPS key to display the measured AC current, and produce a display similar to the one shown below:

```

CH1 Rms      0.9182      -113.14
                AmPS
CH2 Rms      0.8296      AmPS
CH1=Ia  Wide-Band      30 Sep 2013
CH2=Ib                               Mon 16:24:30

```

The large number at the top of the display indicates the current value measured by Channel 1. The number below it corresponds to the value for Channel 2, which is not being used for this example.

The display indicates the general measurement bandwidth (i.e. Wide-Band) near the lower left-hand corner. The Model 929A/930A uses either wide-band or narrow-band mode to measure and display AC voltage.

Select measurement bandwidth by pressing SHIFT, followed by either NARROW-BAND or BAND-WIDE.

Press SHIFT then BAND-WIDE to change the measurement mode to wide-band RMS and include all frequencies up to 3.05 kHz.

Press SHIFT then NARROW-BAND to measure the fundamental magnitude only, using proprietary DSP algorithms. Harmonics are ignored.

If the signal at Channel 1 is too low to be accurately measured, when in narrow-band mode, the Model 929A/930A displays dashes for both Channel 1 and Channel 2.

3.7.3 Frequency Measurement

The Model 929A/930A measures Fundamental Frequencies within the range of 20 Hz to 500 Hz. The following paragraphs describe the steps required to perform Frequency measurements.

3.7.3.1 Input Connections

The Model 929A/930A can measure the frequency of AC voltages or currents connected only on Channel 1. Make connections in the same manner as for magnitude measurements (see Section 3.2.2 for AC voltages, and Section 3.2.3 for AC currents).

3.7.3.2 Configuring the Channels

Frequency measurement is permitted only on signals routed to measurement Channel 1. Configure Channel 1 by first pressing CHANNEL 1 SELECT; the following menu will appear on the display:

```
CHANNEL 1 AC SELECTIONS
Vab   Vac   +Van   Vas   Ia
Vbc   Vcb   Vbn   Vbs   Ib
Vca   Vba   Vcn   Vcs   Ic
```

Use the arrow keys to locate the measurement value and press ENTER. For example, using the arrow keys move the cursor to highlight Van to measure an AC voltage between inputs “A” and “N” (“Van” is in the third row up from the bottom). For frequency measurement of an AC current at input “A”, select “Ia” in the top row.

3.7.3.3 Performing the Measurement

Press the PHASE/FREQUENCY key to display the measured frequency and produce a display similar to the one shown below:

```
PHASE      - - - - - Des.
FREQUENCY  60.001 Hz
CH1=Van Wide-Band
CH2=Vcb
                               30 Sep 2013
                               Mon 16:41:41
```

The large number in the middle of the display indicates the frequency of the signal on Channel 1. The indication for phase angle is blank because only one signal is being input, making phase comparison impossible.

The display shows dashes when the signal at Channel 1 is below a value that can be accurately measured, indicating that the signal is insufficient.

3.7.4 Harmonic Measurement

The Model 929A/930A can measure harmonic content up to the 50th harmonic for fundamental signals of 50 or 60 Hz. Use either Channel 1 or 2 to measure harmonics, but on only one channel at a time.

3.7.4.1 Input Connections

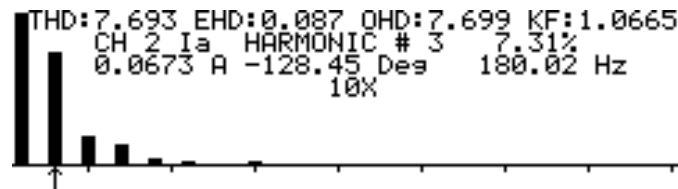
Make connections for harmonic measurement in the same manner as for AC voltage or current magnitude measurements. Since the Model 929A/930A derives the harmonic value from the same inputs, simply press the HARMONICS key to view them. See Section 3.2.2 (AC voltages) and Section 3.2.3 (AC currents) for descriptions of AC Input connections.

3.7.4.2 Configuring the Channel(s)

To configure the Model 929A/930A for harmonic measurement, press either the CHANNEL 1 SELECT or CHANNEL 2 SELECT key and use the cursor keys to select the measurement signal from the channel menu. The Model 929A/930A measures harmonics on signals processed by either channel.

3.7.4.3 Performing the Measurement

Press the harmonics key to display harmonics. By default, Channel 1 initially displays harmonics. To switch between harmonics on either channel, press the CHANNEL 1 SELECT or CHANNEL 2 SELECT keys. The harmonics display appears as follows:



In the example above, the display shows the harmonic content of the AC current at the input of a switching power supply. While all harmonics are shown, only the odd harmonics have enough amplitude to be displayed.

The first, vertical bar (on the left) represents the fundamental. A cursor (arrow) lies beneath the second bar, which represents the third harmonic. All even harmonics are so low that they are not visible and appear blank. Move the cursor in increments of 1 harmonic with the right and left arrow keys. Change the vertical scale to better view harmonics with the up and down arrow keys. The harmonic magnitude factor applied from using the up/down arrow keys appears in the upper right corner.

The second and third lines of display text describe individual harmonic information, highlighted by the cursor. These values include the following:

- The channel being measured
- The input configuration for the channel
- The harmonic number
- The harmonic amplitude as a percentage of fundamental amplitude
- The rms amplitude of the harmonic
- The phase angle of the harmonic, relative to the fundamental
- The frequency of the harmonic

The top line of text shows THD and K-factor, which relate to the overall input signal, and do not change when the cursor is moved.

The Model 929A/930A analyzes harmonics by first determining the AC fundamental and the DC components of the signal. It then removes them algebraically from the digitized waveform. Fast Fourier Transform (FFT) analysis determines the residual for the spectral display, K-factor, and individual harmonic measurements. Total Harmonic Distortion (THD) is determined by dividing the rms of the residual by the wide-band rms amplitude. With these techniques, harmonic measurement accuracy does not depend upon fundamental frequency.

3.8 Combined Measurements

With two separate measurement channels, the Model 929A/930A can compare and combine the signals from each channel. Combination measurements of power quantities include:

- Phase
- Active Power
- Reactive Power
- Apparent Power
- Power Factor
- Waveform Display

The following sections provide instructions for performing measurements of parameters within this group.

3.8.1 Connecting the Inputs

When comparing two signals, configure the inputs of the Model 929A/930A individually, as specified in earlier sections. See Section 3.2.2 to set up voltage connections and Section 3.2.3 for current connections. Make any comparison of voltage-to-voltage, voltage-to-current, or current-to-current in this manner.

For phase angle and/or power quantity measurements, route the voltage signal to Channel 1, and the current signal to Channel 2. Since the voltage in a power system is usually more stable and less distorted than the current, the Model 929A/930A uses Channel 1 as a reference for phase measurements. Both a voltage and current input signal are required to measure all power quantities.

3.8.2 Phase Angle Measurement

The Model 929A/930A can measure and display the phase angle between two AC signals routed to channels 1 and 2. A narrow-band quantity, phase is the difference between the two fundamental signal components. A signal at Channel 1 provides the reference to which the signal at Channel 2 is compared. For correct comparison, both signals must have the same fundamental frequency.

3.8.2.1 Configuring the Channels

NOTE: See Section 3.2.2 and 3.2.3 for input connection description.

Connect the signals to the appropriate input terminals and configure the measurement channel by pressing CHANNEL 1 SELECT and CHANNEL 2 SELECT. See channel selection screens below.

```

CHANNEL 1 AC SELECTIONS
Uab  Uac  →Uan  Uas  Ia
Ubc  Ucb  Ubn  Ubs  Ib
Uca  Uba  Ucn  Ucs  Ic

```

```

CHANNEL 2 AC SELECTIONS
Uab  Uac  Uan  Uas  →Ia  In
Ubc  Ucb  Ubn  Ubs  Ib
Uca  Uba  Ucn  Ucs  Ic

```

3.8.2.2 Performing the Measurement

Press the PHASE/FREQUENCY key to produce a display similar to the one shown below:

```

PHASE      -10.30  Des.
FREQUENCY  59.988  Hz
CH1=Uan Wide-Band
CH2=Ia
                        30 Sep 2013
                        Mon 17:29:02

```

The large number at the top of the display shows the phase angle of the signal routed to Channel 2, relative to that of Channel 1. It also shows the frequency of the signal at Channel 1. Dashes will appear for phase angle with signals of insufficient amplitude routed to Channel 1 and Channel 2.

For a more detailed description of Frequency Measurement, see Section 3.7.3.

3.8.2.3 Phase Preference

If the value displayed for Phase Angle does not appear correct, the phase preference may need changing. Choose either $\pm 180^\circ$ or $0 - 360^\circ$. Also, set the phase to read negative or positive for Channel 2 lagging Channel 1. The selected phase preference effects only the displayed phase angle, but none of the power quantities.

Press the MENU key and select Phase Preference (Section 3.3.12) to set the phase preference. Table 3.6 describes the four possible phase settings and the resultant displays for each, when the signals, shown in Figure 3.12, are applied. See Section 3.8.1 for input connection description.

| Range Setting | Polarity Setting for Ch 2 lagging Ch 1 | Resultant Reading |
|-----------------|--|-------------------|
| $\pm 180^\circ$ | negative | -60° |
| $\pm 180^\circ$ | positive | $+60^\circ$ |
| $0 - 360^\circ$ | negative | 300° |
| $0 - 360^\circ$ | positive | 60° |

Table 3.6: Phase Convention

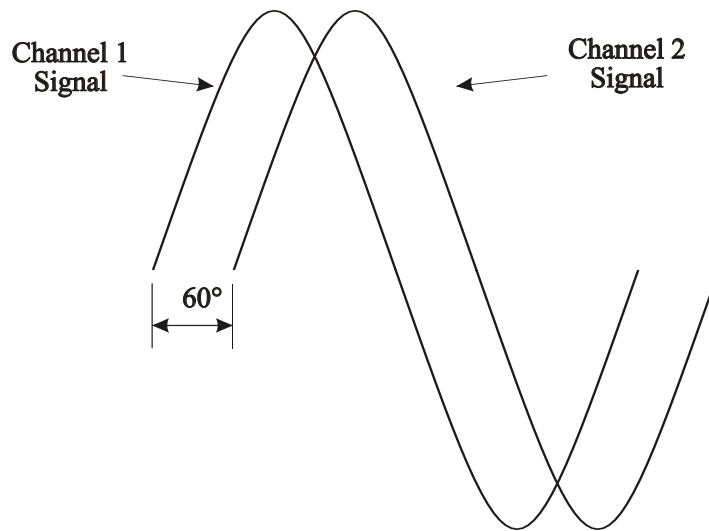


Figure 3.12: Phase Angle Example

3.8.3 Active Power – Reactive Power

The Model 929A/930A can measure the active power (rms watts) and reactive power (vars) from the combination of an AC voltage routed to measurement Channel 1 and an AC current routed to Channel 2.

NOTE: Refer to Section 3.8 for input connection description.

3.8.3.1 Configuring the Channels

Configure the chosen measurement channels after connecting the voltage and current to the appropriate input terminals (see Figure 2.1 for instrument locations).

Press CHANNEL 1 SELECT to begin configuring channel 1. The following menu will appear on the display:

```
CHANNEL 1 AC SELECTIONS
Uab  Vac  →Van  Uas  Ia
Ubc  Vcb  Ubn  Ubs  Ib
Uca  Vba  Ucn  Ucs  Ic
```

Arrows form the cursor, which highlights one of the selections. Press the arrow keys to locate the measurement value. For example, using the arrow keys move the cursor to “Van” to measure an AC voltage between inputs “A” and “N”. Press ENTER to confirm the selection. Press CHANNEL 2 SELECT to begin configuring channel 2. Configure channel 2 in the same manner as configuring channel 1 above.

```
CHANNEL 2 AC SELECTIONS
Uab  Vac  Uan  Uas  →Ia  In
Ubc  Vcb  Ubn  Ubs  Ib
Uca  Vba  Ucn  Ucs  Ic
```

Move the cursor to the desired measurement value and press ENTER to confirm the selection. For example, using the arrow keys move the cursor to “Ia” to measure an AC current at the “A” input terminals.

3.8.3.2 Performing the Measurement

Press the POWER/VARS key to produce a display similar to the one shown below:

```
ACTIVE POWER      85.771      Watt
REACTIVE POWER    16.193      Var
CH1=Uan Wide-Band      1 Oct 2013
CH2=Ia                Tue 08:44:24
```

The large number at the top of the display shows the active power measured. The lower number shows the reactive power. Also, the display

indicates if the Model 929A/930A is making wide-band or narrow-band measurements.

The DSP computes wide-band (i.e. to 3.05 kHz) active power in Watts by taking the average of instantaneous values of voltage and current multiplied by each other. Wide-band reactive power (VARs) is determined by taking the vector difference of the product of the wide-band rms voltage and current (wide-band apparent power) less the active power. The formula is shown below:

$$(3.3) \quad \text{ReactivePower} = \sqrt{(VA)^2 - (\text{ActivePower})^2}$$

The polarity of the wide-band reactive power is determined by the narrow-band result. Press SHIFT then NARROW-BAND to switch the measurement mode from wide-band to narrow-band. Narrow-band mode measures the fundamental magnitude of the voltage and current only, using proprietary DSP algorithms. Harmonics are ignored. Dashes will appear in the display if insufficient signals are present during measurements performed in narrow-band mode.

$$(3.4) \quad \text{ActivePower} = V_{fund} \times I_{fund} \times \cos(\theta)$$

$$(3.5) \quad \text{ReactivePower} = V_{fund} \times I_{fund} \times \sin(-\theta)$$

3.8.4 Apparent Power – Power Factor

The Model 929A/930A can measure the apparent power (volt-amps, or VA) and power factor from the combination of an AC voltage routed to Channel 1 and an AC current routed to Channel 2.

NOTE: See Section 3.8.1 for input connection description

3.8.4.1 Configuring the Channels

Configure the chosen measurement channels after connecting the voltage and current to the appropriate input terminals (see Figure 2.1 for instrument locations).

Press CHANNEL 1 SELECT to configure measurement channel 1 and to view the following menu:

```

CHANNEL 1 AC SELECTIONS
Vab  Vac  →Van  Vas  Ia
Vbc  Vcb  Vbn  Vbs  Ib
Vca  Vba  Vcn  Vcs  Ic

```

Arrows form the cursor, which highlight one of the selections. Press the arrow keys to locate the measurement value. For example, using the arrow keys move the cursor to “Van” to measure an AC voltage between inputs “A” and “N”. Press ENTER to confirm selection.

Press CHANNEL 2 SELECT to configure Channel 2 in the same way as for channel 1. Except for In, the selection menu is identical as for Channel 1.

```

CHANNEL 2 AC SELECTIONS
Vab  Vac  Van  Vas  →Ia  In
Vbc  Vcb  Vbn  Vbs  Ib
Vca  Vba  Vcn  Vcs  Ic

```

Move the cursor to the desired measurement value and press ENTER to confirm the selection. For example, using the arrow keys move the cursor to “Ia” to measure an AC current at the “A” input terminals.

3.8.4.2 Performing the Measurement

Press VA/PF to produce a display similar to the one shown below:

```

APPARENT      87.768      VA
POWER         0.9826      La9
FACTOR
CH1=Van Wide-Band      1 Oct 2013
CH2=Ia                Tue 09:07:25

```

The large number at the top of the display shows the apparent power measured. The lower number shows the power factor. Also, the display indicates whether the values are wide-band or narrow-band measurements.

Press SHIFT then BAND-WIDE to change the measurement mode to wide-band RMS, including all frequencies up to 3.05 kHz. Wide-band apparent power is determined by multiplying the wide-band voltage and current as shown below. Power factor is the quotient of the Active Power divided by the Apparent Power.

Wide-Band:

$$(3.6) \quad VA = V_{rms} \times I_{rms}$$

$$(3.7) \quad PF = ActivePower \div VA$$

Press SHIFT then NARROW-BAND to change the measurement mode to measure the fundamental magnitude of the voltage and current only, using proprietary DSP algorithms. This measurement mode ignores harmonics, and also displays dashes with insufficient signal levels. *Narrow-band apparent power is determined by multiplying the fundamental voltage by the fundamental current.* Power Factor is the cosine of the angle.

Narrow-Band:

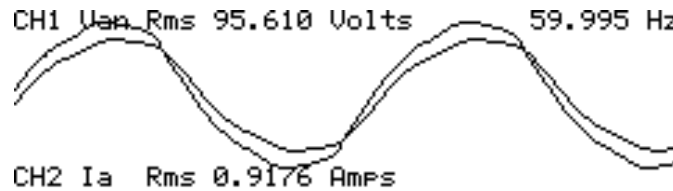
$$(3.8) \quad VA = V_{fund} \times I_{fund}$$

$$(3.9) \quad PF = Cos(\theta)$$

3.8.5 Waveform Display

Press the WAVEFORM key at any time to display waveforms for the signals at measurement channels 1 and 2. Initially, waveforms for both channels will be displayed. Display individual channels by pressing CHANNEL 1 SELECT or CHANNEL 2 SELECT. Press the WAVEFORM key again to display both waveshapes simultaneously.

The Model 929A/930A Waveform Display includes a text display showing the rms magnitudes for the two signals and the frequency of the signal at Channel 1. The following example shows a typical Waveform Display:



Signals are aligned so that the zero crossings of each channel appear at the left-hand edge of the display.

3.9 Using External PT's and CT's

Use an external current transformer (CT) and potential transformer (PT) to extend the measurement range of the Model 929A/930A. If used, however, do not exceed the input range of the instrument (refer to Chapter 4,

Specifications). Using an external PT and/or CT by directly displaying measured primary CT and PT values greatly simplifies measurement. Programming the scaling feature of the Model 929A/930A, whether for magnitude or phase, effectively cancels offset errors. To activate and configure the scaling function, press the SCALE key. See Section 3.4.12 for details on using the Scale feature.

Measure the ratio and phase error of a CT or a PT by using the CH1/CH2 function included in the Model 929A/930A. Press the CH1/CH2 key to display the phase difference and magnitude ratio of the signals measured by Channel 1 to the signal measured by Channel 2. Further discussion of the CH1/CH2 function can be found in Section 3.3.15.

1. As an example, measure the ratio of a PT by performing the following steps:
2. Use Channel 1 to configure the Model 929A/930A to measure the voltage at the input of the PT.
3. Use Channel 2 to configure the Model 929A/930A to measure the output of the PT.

Apply the operating voltage to the input of the PT, and press the CH1/CH2 key.

The resultant display shows the voltage at Channel 1 divided by the voltage at Channel 2, along with the phase angle between the two.

3.10 Data Logging

The Model 929A/930A data-logging feature greatly simplifies recording measurements, either from the front panel or through the serial interface for later review. The following paragraphs describe how to record and review data.

3.10.1 Capturing Data

Use the LOG DATA function to record four different data type measurement results in internal memory. These data types are:

- **Standard data** includes all of the Narrow-Band and Wide-Band parameters for Channels 1 and 2. All logged data is tagged with the time and date. This type of record occupies the least memory space. Internal memory stores approximately 40 sets of standard data.

- **Harmonic data** incorporates all of the features of standard data but includes harmonic information from Channel 1 and 2 signals. Press the LOG DATA key anytime while displaying harmonics to log data. Because harmonic data uses more memory space than standard data, internal memory stores approximately 10 sets of harmonic data, if not currently storing any other type of data.
- **Waveform data** includes standard data, harmonic data, plus a record of waveforms present on Channel 1 and 2. Press the LOG DATA key, while displaying waveforms, to record waveform data. Because waveform data recording uses the most memory of any of the three data types, internal memory stores about 7 waveform displays if not currently storing any other type of data.
- **3-phase data** includes all the data presently on the 3-phase display.

When the Model 929A/930A captures a data record, it displays a momentary message in the lower right-hand corner. The message confirms that the data was saved and shows the assigned record number. Because any of the four different types of data may be recorded at any time, the total number of records saved will vary.

3.10.2 Reviewing Data

Review stored data records by using the second function of the LOG DATA key. Press SHIFT then REVIEW to view a screen similar to the following:

```

LOG SPACE 97%  AUX MEM 97%  FILES 6
0  Clear All!  ( Key Clears A File)
→1  30Sep13 14:19:51    1 Standard
2  30Sep13 14:20:05    1 Harmonic
3  30Sep13 14:20:16    1 Waveform
4  30Sep13 14:20:36    1 3 Ph Tab
5  30Sep13 14:21:04    1 3 Ph Vec
6  10Oct13 09:20:02    1 Standard

```

In the upper right of the display it indicates that there are 6 data records, with 97% of the allotted memory space remaining. With additional records, only the first 6 data records are shown. To view the remaining records scroll down with the down arrow key.

To view a particular record scroll the cursor to that entry and press the ENTER key. All of the same values present at the time of recording will appear. Use the top row of keys in the main keyboard to look at the different parameters of the stored data record (e.g. POWER/VARS). These parameters are as follows: Volts, Amps, Phase, Frequency, Watts, Vars, Volt-Amps, Power Factor and CH1/CH2 Data.

The Model 929A/930A also displays harmonics, waveform, or 3-phase data if the instrument was in one of those modes when data logging took

place. When entering the view log mode, the instrument is automatically placed in hold mode. After reviewing a data record, press SHIFT then REVIEW to select another data record for review. Press MEASURE/HOLD to return the instrument to normal operation.

3.10.3 Erasing Logged Data

To erase all stored records, scroll the cursor to “0 Clear All Entries” and press ENTER. Firmware displays a message to confirm this decision to erase all records. To erase a single entry, select the entry to be erased, using the UP/DOWN arrow keys, and then press the left arrow key. Press the ESCAPE key to return the instrument to normal operation.

3.11 Printing/Exporting Data

The Model 930A can print or export data, in several formats, directly over the RS-232C communications port. Refer to Section 2.5.3, 4.3.7 and Appendix A for information on using the RS-232 port. Print or export data at the time the measurement is performed, or store it for later printing or exporting (using the LOG DATA key). Most printed or exported data records are stamped with the date and time, according to the real-time clock in the Model 930A. Each data record also includes a record number, referred to as the log data number. Data that is printed or exported directly during measurement has a log data number of zero. Data printed or exported from memory has the same log data number as recorded when the data was initially stored. For information on storing and reviewing data, refer to Section 3.10.

3.11.1 Print/Data Export Setup

Configure the Model 930A for the desired format prior to printing or exporting data. Use the Print Selections menu to configure the format.

Access the Print Selections menu through the Instrument Setup Functions menu. Press the MENU key to access the Instrument Setup Functions:

```
INSTRUMENT SETUP FUNCTIONS
RS-232 Port Setup
Set Real-Time Clock
Backlight & Auto-Shutdown
Phase Preference
→Print Selections
Print Broadcast Mode
Auto-Log Setup
```


Move the cursor to Print Selections and press ENTER to view the Print Selections menu, which appears as follows:

```
PRINT SELECTIONS
Print Screen:  Ascii Format
               Graphics (FX-80)
               →Bitmap (Xmodem Transfer)

Spreadsheet:  Send Spreadsheet
              (Comma Delineated)
```

The following paragraphs describe the different print/export modes.

3.11.2 ASCII Format

The ASCII Format export mode is suitable for driving a serial printer, or for viewing on a computer or terminal. The serial port returns ASCII data with a layout closely resembling the current display.

3.11.3 Graphics Format (FX-80)

The current display is output in Epson FX-80 graphics format.

3.11.4 Bitmap

Select Bitmap to export a direct image of the display contents to a bitmap file (.BMP).¹ Bitmap files can be imported into graphics and word-processing programs, and is useful for graphics displays of harmonics or waveforms. Bitmap data uses (2110+) bytes per captured screen. The bitmap export feature utilizes the XMODEM file transfer protocol (with CRC), which allows the file to be captured using most common communications programs, e.g., Procomm and Windows HyperTerminal. The procedure for capturing bitmap files is as follows:

1. Press the MENU key > Print Selections and choose Bitmap (Xmodem Transfer).
2. Connect the Model 930A to the host computer, using a 9-pin RS-232C cable. Make sure that the serial communication parameters (baud rate, parity, data bits, stop bits, and flow control), for the Model 930A, match those of the host computer (refer to Section 3.3.12).

¹Most of the screenshots of the display in this manual are bitmap exports from a Model 930A.

3. Configure the communications software in the host computer to receive binary files using the XMODEM protocol. Enable the communications software for reception of the file by assigning a file name with the extension “.BMP”.
4. Set the Model 930A to make the desired measurement, or select a stored data record and configure the Model 930A to display the desired data.
5. Press the PRINT key and wait for the prompt message to disappear. At this point, the Model 930A suspends normal operation waits for the host computer to initiate the transfer. Use the ESCAPE key to abort the transfer and resume normal operation.

It takes several seconds for the Model 930A and the host computer to establish communication and begin the transfer.

3.11.5 Spreadsheet

Using this mode import data directly into spreadsheet programs. Data is comma and quote-delimited; commas separate all data fields (number and text), with text enclosed in quotes.

The type of exported data depends on which operating mode the Model 930A is set for at the time the PRINT key was pressed. Firmware outputs all spreadsheet data as ASCII text. The following paragraphs provide a breakdown of the different data types, and their corresponding formats.

3.11.5.1 Standard Data

The Model 930A exports standard data with each press of the PRINT key. Export data either while performing measurements or reviewing stored data in one of the following modes of operation:

| | | |
|------------|-----------------|------------|
| Volts/Amps | Phase/Frequency | Power/Vars |
| VA/PF | CH1/CH2 | |

Standard data is exported with the following format: log data #, date, time, min/max/average/normal, CH1 select, CH1 dc/rms/mag, CH2 select, CH2 dc/rms/mag, phase, frequency, power, vars, VA, PF

| | |
|----------------------------|---|
| Log Data #: | A number assigned to the data record. If the data was stored prior to print/export, this number will correspond to the record number assigned when stored. If the data is printed or exported directly, this number will always be zero. |
| Date: | An integer, corresponding to the date, in standard format for dates in spreadsheet applications. The integer for the date is determined from the following: $1/1/1600 = -109,571$ $12/30/1899 = 0$ $1/1/95 = 34700$ $12/31/3199 = 474, 816$ |
| Time: | As a decimal fraction of 1, corresponds to the time of day, and is the standard format for time in spreadsheet applications. This number is determined by the formula: $n=S/86400$, where: S = number of seconds elapsed since midnight. |
| Min, Max, Average, Normal: | Denotes whether the data corresponds to the minimum-recorded values, maximum-recorded values, average-recorded values or normal measurement. |
| Ch1 Select: | Describes the input configuration for measurement Channel 1. For example, "Van" corresponds to voltage measurement between inputs "A" and "N". |
| Ch1 DC, RMS, MAG: | The value measured on Channel 1. |
| Ch2 Select: | Describes the input configuration for Channel 2. For example, "Ia" corresponds to current measurement on current input A. |
| Ch2 DC, RMS, MAG: | The value measured on Channel 2. |

| | |
|------------|---|
| Phase: | The phase angle between the signals on Channels 1 and 2. Channel 1 acts as the reference. |
| Frequency: | The frequency of the signal present at Channel 1. |
| Power: | The active power of the combination of signals at Channels 1 and 2. |
| VARs: | The reactive power of the combination of signals at Channels 1 and 2. |
| VA: | The apparent power of the combination of signals at Channels 1 and 2. |
| PF: | The power factor of the combination of signals at Channels 1 and 2. |
| VARs: | The reactive power of the combination of signals at Channels 1 and 2. |
| VA: | The apparent power of the combination of signals at Channels 1 and 2. |
| PF: | The power factor of the combination of signals at Channels 1 and 2. |

3.11.5.2 3-Phase Data

The Model 930A exports 3-phase data when executing the print operation. This occurs in one of the 3-phase tabular display operating modes. The 3-phase data is exported with the following format:

log data #, date, time, min/max/normal, 3 phase mode, ABC/CBA, V, A, phase, frequency, power, vars, VA, PF

| | |
|-------------|--|
| Log Data #: | A number assigned to the data record. If the data was stored prior to print/export, this number will correspond to the record number assigned when stored. If the data is printed or exported directly, this number will always be zero. |
|-------------|--|

| | |
|----------------------------|--|
| Date: | An integer, corresponding to the date, which is the standard format for dates in spreadsheet applications. The integer for the date is determined from the following: $1/1/1600 = -109,571$ $12/30/1899 = 0$ $1/1/95 = 34700$ $12/31/3199 = 474,816$ |
| Time: | A decimal fraction of 1, corresponding to the time of day, which is the standard format for time in spreadsheet applications. This number is determined by the formula: $n=S/86400$, where: S = number of seconds elapsed since midnight. |
| Min, Max, Average, Normal: | Denotes whether the data corresponds to the minimum-recorded values, maximum-recorded values, average-recorded values or normal measurement. |
| 3 Phase Mode: | Identifies which 3-phase measurement mode was in use at the time of export. The choices are: 1 phase 3 wire 2 element 3 phase 3 wire 2 element 3 phase 3 wire 3 element 3 phase 4 wire 3 element 3-phase 4 wire 2.5 element |
| ABC/CBA: | Indicates phase swquence. |
| V: | Average voltage for all phases. |
| A: | Average current for all phases. |
| Phase: | Average Phase angle between current and voltage for all phases. |
| Frequency: | The frequency of the measured signals. |
| Power: | The total active power of all of the phases. |
| VARs: | The total reactive power of all of the phases. |
| VA: | The total apparent power of all of the phases. |
| PF: | The average power factor for all three phases. |

| | |
|--------|-------------------------|
| V: | A-Phase voltage. |
| A: | A-Phase current. |
| Phase: | A-Phase angle. |
| Power: | A-Phase power. |
| VARs: | A-Phase reactive power. |
| VA: | A-Phase apparent power. |
| PF: | A-Phase power factor. |
| V: | B-Phase voltage. |
| A: | B-Phase current. |
| Phase: | B-Phase angle. |
| Power: | B-Phase power. |
| VARs: | B-Phase reactive power. |
| VA: | B-Phase apparent power. |
| PF: | B-Phase power factor. |
| V: | C-Phase voltage. |
| A: | C-Phase current. |
| Phase: | C-Phase phase angle. |
| Power: | C-Phase power. |
| VARs: | C-Phase reactive power. |
| VA: | C-Phase apparent power. |
| PF: | C-Phase power factor. |
| PF: | Lead/Lag |

3.11.5.3 Harmonic Data

The Model 930A exports harmonic data when the print operation is executed. This occurs while performing measurements in the harmonic display mode, or reviewing stored data while in that mode.

Harmonic data differs from most of the other data types, in that it is a tabular format consisting of 49 records. Each record contains data for a single harmonic, up to the 50th. The format for the data is as follows:

log data #, date, time, CHx select, THD, K factor >
 “” ””, harmonic 2 amplitude ,harmonic 2 phase >
 “” ””, harmonic 3 amplitude, harmonic 3 phase >
 ... >
 ... >
 “” ””, harmonic 50 amplitude, harmonic 50 phase >

Log Data #: A number assigned to the data record. If the data was stored prior to print/export, this number will correspond to the record number assigned when stored. If the data is printed or exported directly, this number will always be zero.

Date: An integer, corresponding to the date, which is the standard format for dates in spreadsheet applications. The integer for the date is determined from the following:
 1/1/1600 = -109,571
 12/30/1899 = 0
 1/1/95 = 34700
 12/31/3199 = 474,816

Time: A decimal fraction of 1, corresponding to the time of day, which is the standard format for time in spreadsheet applications. This number is determined by the formula:
 $N = S/86400$, where:
 S = number of seconds elapsed since midnight.

CH X Select: Indicates the input configuration for the measured harmonic data.

THD: Total harmonic distortion for the measured signal.

K Factor: K-factor, which is a measure of the heating effect of harmonic energy in magnetic materials.

Harmonic Amplitude: Amplitude in Volts or Amps of harmonic 2 through 50.

Harmonic Phase: Phase angle of harmonic 2 through 50 with respect to the fundamental.

3.11.5.4 Waveform Data

The Model 930A will export waveform data while the print operation is executed. This occurs when performing measurements in the waveform display mode, or reviewing stored data while in that mode.

Waveform data is tabular format and similar to harmonic data. It consists of 240 records, which correspond to points on the waveforms for measurement channels 1 and 2.

Following is the format for waveform data:

```
log data #, date, time, channel 1, channel 2 ⤵  
" , " , " , channel 1, channel 2 ⤵  
" , " , " , channel 1, channel 2 ⤵  
... ⤵  
... ⤵  
" , " , " , channel 1, channel 2 ⤵
```

- Log Data #: A number assigned to the data record. If the data was stored prior to print/export, this number will correspond to the record number assigned when stored. If the data is printed or exported directly, this number will always be zero.
- Date: An integer, corresponding to the date, which is the standard format for dates in spreadsheet applications. The integer for the date is determined from the following:
1/1/1600 = -109,571
12/30/1899 = 0
1/1/95 = 34700
12/31/3199 = 474,816
- Time: A decimal fraction of 1, corresponding to the time of day, which is the standard format for time in spreadsheet applications. This number is determined by the formula:
 $N = S/86400$, where:
S = number of seconds elapsed since midnight.
- Channel 1: Data point for Channel 1 Waveform.
- Channel 2: Data point for Channel 2 Waveform.

3.11.6 Initiating Printing / Exporting

To print or export data directly, press the PRINT key during the measurement (see Section 3.11.4 for Bitmap transfers). Ensure that all RS-232C connections and parameters are properly configured. To print or export data which had been previously stored, recall the data using the REVIEW key, select the desired display mode, then press the PRINT key.

Chapter 4

Specifications

4.1 Inputs

4.1.1 Voltage

| | |
|--------------|---|
| Inputs: | Four: A, B, C and N Phase to Phase Phase to Neutral Phase to Synthesized Neutral |
| Input Range: | 1.5 – 750 V _{rms} (under range to 200 mV) |
| Impedance: | 1 megohm |
| Leakage: | < 3.5 mA, per IEC 348 and UL 1244 |

4.1.2 Current

| | |
|--------------|--|
| Inputs: | Three: A, B, and C |
| Input Range: | 0.04 – 20 A _{rms} (under range to < 1 mA) |
| Burden: | 0.01 Ω , maximum |
| Isolation: | 1000 V _{peak} (transformer coupled) |

4.2 Measurements

4.2.1 Voltage and Current

Method: Wideband: True RMS, 3 kHz BW
Narrowband: Fundamental Magnitude

Accuracy: 0.05% of reading
Under range: < 1% of reading, typical at 0.3 mArms

4.2.2 Phase Angle

Input: Channel 1 to Channel 2

Range: 0 – 360° or ±180°

Accuracy: 0.05°
Under range: < 1 degree, typical at 0.3 mArms

4.2.3 Frequency

Input: Channel 1

Fundamental Range: 20 – 500 Hz (voltage under range to 5 Hz)

Accuracy: 0.005% of reading

4.2.4 Harmonics

Input: Channel 1 or Channel 2

Range: 2nd to 50th harmonic, 50 Hz or 60 Hz fundamental

Accuracy: 0.01% THD + 5% of reading

4.2.5 Power Quantities

Range: 0 – 99999 MVA;
±99999 MW;
±99999 MVAR;
±1.0000 PF, lead or lag.

Accuracy: 0.11% of VA, 0.001 PF

4.3 General Specifications

4.3.1 Measurement Bandwidth

Wideband Mode: 3.05 kHz.

Narrowband Mode: 20 – 500 Hz, fundamental only (determined by DSP)

4.3.2 Memory

Type: Non-volatile (battery-backed RAM)

Data stored: User setups, measurement results; Time and date tagged.

4.3.3 Display

Type: Supertwist Liquid Crystal.

Resolution: 240(h) by 64(v) pixels

Dimensions: 130 mm(width) by 37 mm(height).

Backlight: Cold-cathode fluorescet lamp.

Auto Mode: Shutdown 10 seconds after last keystroke.

4.3.4 Keypad

Main Keyboard: 18 multi-function keys.

4.3.5 Environment

Operating: -10° to +50° C.

Storage: -40° to +75° C.

Humidity: Non-condensing.

Size: 205 x 305 x 225 mm (8 x 12 x 8.75”).

Weight: 5.5 kg (12 lbs.).

4.3.6 Input Power

| | |
|----------------|---|
| Line Voltage: | 85 – 264 Vac (47 – 440 Hz), 110 – 250 Vdc. |
| Power: | 15 W / 15 VA, max. |
| Battery: | Internal NiMH, 7.2 Vdc, 6.5 Ah, 8 hours. |
| Charger: | Automatic, measures $\Delta T/\Delta t$, $\Delta V/\Delta t$, charging time. |
| Charge Time: | 8 hours, powered off. |
| Auto-Shutdown: | 10 minutes with no activity or input. |

4.3.7 Serial Port (Model 930A only)

| | |
|----------------|---|
| Port Type: | RS-232C. |
| Baud Rate: | 1200 – 115200. |
| Data Bits: | 7 or 8. |
| Stop Bits: | 1 or 2. |
| Parity: | None, even, or odd. |
| Flow Control: | XON/XOFF or hardware. |
| Pin Locations: | 1 N/C 2 RXD 3 TXD 4 DTR (10k pull-up output) 5 Signal Common 6 N/C 7 RTS (driver output – high) 8 CTS (hardware flow control input) 9 N/C |
| Cable type: | Null-modem (for PC compatible). |
| Isolation: | 300 Vrms. |

Appendix A

RS-232C Commands

A.1 Introduction

The following appendix contains a listing of commands, definitions and examples that may be used to control and communicate with the Model 930A via the RS-232C serial interface.

Commands that request information from the instrument return either current or previously logged data. Numeric data is returned as an ASCII string of numeric characters, with leading sign and embedded decimal point as needed. The string is terminated with carriage return and line feed characters.

Take care to completely set up the desired measurement prior to issuing a data request command. Verify that the following items are setup properly:

Channel 1 and 2 Input Signal: Use Channel 1 if only one signal is to be measured. Set Channel 1 to measure AC voltage and Channel 2 to measure AC current, if measuring power quantities (power, VARS, VA, or power factor).

Measurement Bandwidth: To measure fundamental frequencies only, select the narrow-band mode. Select the wide-band mode for measurements to include all harmonics up to 3.05 kHz.

Minimum and Maximum: Set the display for each parameter for the desired minimum, maximum, average or present values. Before requesting data, set the display using the MMN command.

Note 1: Use the EEP command to permanently store Calibration Data in the EEPROM.

A.2 Serial Port Examples

This section contains examples of controlling the Model 930A with serial commands from a computer, or terminal, to access its various features. In each example the left-hand column gives the example command. The right-hand column gives a brief description of the result after entering the command.

Compare command sequence in each example with details contained in the Command Summary (see Section A.3) for definitions of each character and range of values. In each case the command characters are contiguous, without spaces and on the same line. All command sequences are exactly as shown without pressing the ENTER key on the keyboard, or sending a carriage-return/line-feed sequence from a program.

| Example | Result |
|----------------------------|---|
| 6,1CHS | Select channel 1 to measure “Van” |
| LOG | Stores a record of the current measurement channel in standard or extended memory. |
| 3RLD | Overwrites the display with record number 3 stored in standard memory. |
| 3,2HMA | Returns (via the serial port) the third harmonic magnitude measured on channel 2. |
| 1999:01:15:12:30: 00TDS | Sets the date and time to January 15, 1999, 12:30 p.m. Model 930A displays correct date and time at next power up. |
| PWR | Returns (via the serial port) the active power measured by channels 1 and 2. |
| 41PHM | Starts the 3 phase, 4wire, 3 element, tabular display with energy measurement mode. |
| 6,1SRG | Sets the Channel 1 analog input range to 96 – 224 Vac. Unit is placed in Range-Hold mode (seen on display) Use 1RRH to release Range-hold on Channel 1. |

A.3 Command Summary

A.3.1 Battery Charging Status

Command: **BAT**

Returns Battery and charging status.

| <u>Return Value</u> | <u>Meaning</u> |
|---------------------|----------------|
| 0 | Nothing |
| 1 | Low Battery |
| 2 | Charging |

A.3.2 Backlight, Set

Command: **#BLT**

Controls the front panel LCD backlight.

| <u>ch#</u> | <u>Response</u> |
|------------|---|
| 0 | Backlight OFF |
| 1 | Backlight ON |
| 2 | Backlight AUTO. The backlight remains on for approximately 20 seconds after the last keystroke. |

A.3.3 Channel Calibrate

Command: **ch#,ac/dc#,range#,gain#,ph/off#,s/r#CCH**

Sets or returns the calibration constants for Channel 1 and Channel 2. Each channel has a set of calibration constants for each range.

| <u>ch#</u> | <u>Action</u> |
|----------------|--|
| 1 | Select Channel 1 |
| 2 | Select Channel 2 |
| <u>ac/dc#</u> | |
| 1 | AC |
| <u>range#</u> | |
| 0 ... 8 | (see SRG command (below)) |
| <u>gain#</u> | Corrected gain = uncorrected gain \times (1 + Gain# \div 1000) |
| <u>ph/off#</u> | Corrected Phase = uncorrected phase + (ph/off# \times frequency) |

s/r#

- 0 Set Calibration Constant
- 1 Return Calibration Constant

Return format: *gain* < *cr* >< *lf* > phase/offset< *cr* >< *lf* > Numbers are returned in fixed-point format with 5 digits to the right of the decimal point.

A.3.4 Ratio CH1/CH2

Command: **CCR**

Displays (on the Model 930A) the measured results as the magnitude and phase angle of the ratio of Channel 1 divided by Channel 2. Depending on the input signals selected, the display units for magnitude will be ohms, mhos, or p/u.

A.3.5 Channel Input Select

Command: **in#,ch#CHS**

Specifies the input signal for the selected channel as follows:

| <u>in#</u> | AC <u>Config.</u> | <u>in#</u> | AC <u>Config.</u> |
|------------|----------------------|------------|----------------------|
| 0 | Vab | 11 | Vcs |
| 1 | Vbc | 12 | Ia |
| 2 | Vca | 13 | Ib |
| 3 | Vac | 14 | Ic |
| 4 | Vcb | 27 | Vb(Ch1 only) |
| 5 | Vba | 28 | In (Ch2 only) |
| 6 | Van | | |
| 7 | Vbn | | |
| 8 | Vcn | | |
| 9 | Vas | | |
| 10 | Vbs | | |

| <u>ch#</u> | To select |
|------------|-----------|
| 1 | Channel 1 |
| 2 | Channel 2 |

A.3.6 Calibrate Input

Command: **in#,gain#,ph/off#,s/r#CIN**

Sets or returns the magnitude and phase calibration constants for the individual inputs.

| | AC | | AC |
|------------|---------------|------------|---------------|
| <u>in#</u> | <u>Config</u> | <u>in#</u> | <u>Config</u> |
| 0 | Vab | 8 | Vcn |
| 1 | Vbc | 9 | Vas |
| 2 | Vca | 10 | Vbs |
| 3 | Vac | 11 | Vcs |
| 4 | Vcb | 12 | Ia |
| 5 | Vba | 13 | Ib |
| 6 | Van | 14 | Ic |
| 7 | Vbn | 27 | Vb |
| | | 28 | In |

| | |
|----------------|--|
| <u>gain#</u> | Corrected gain = uncorrected gain \times (1 + gain# \div 1000) |
| <u>ph/off#</u> | Corrected phase = uncorrected phase + (ph/off# \times freq) |
| <u>s/r#</u> | <u>Action</u> |
| 0 | Writes calibration to memory |
| 1 | Returns stored calibration value |

Return format: gain< *cr* >< *lf* > phase/offset< *cr* >< *lf* >

Numbers are returned in fixed-point format with 5 digits plus a decimal point.

A.3.7 Daylight Saving Time, Set

Command: **#DAY**

Sets the daylight saving time mode for the real-time clock.

| <u>#</u> | <u>Designation</u> |
|----------|--|
| 0 | Daylight saving time OFF |
| 1 | Daylight saving time ON; adds one hour to the standard time. |
| 2 | AUTO daylight saving time; automatically adjusts the time for USA standard daylight saving time (2:00 AM on the first Sunday in April to 2:00 AM on the last Sunday in October). |

A.3.8 Display Dump, ASCII

Command: **DDA**

Screen dump in ASCII format

Response: Returns up to 8 lines of 40 ASCII characters, each corresponding to the front panel display presentation; Omits blank lines and converts graphics characters to standard ASCII representation.

A.3.9 Data Dump, Bitmapped

Command: **DDB**

Screen dump in bitmap format

Response: Enables XMODEM binary file-transfer protocol-CRC only. May be sent by host computer prior to initiating transfer request. Suspends normal instrument operation pending file transfer.

The file consists of ≈ 2110 8-bit bytes including 62 bytes of header information and 2048 bytes of graphics data. The header describes the picture as monochrome, 32 bytes per row, 240 pixels per row and 64 rows. This data, when stored as a file, may be imported into most PC word processing, drawing or painting programs.

A.3.10 Store Calibration Data in EEPROM

Command: **mmddyEEP**

Stores Calibration Data currently residing in RAM to EEPROM using a Hamming-Code. Sets Calibration Date to the current date. MM DD YY is the current date.

A.3.11 DSP Frequency, Set or Return

Command: **c#,s/r#FRD**

Sets or returns the Calibration Constant to correct the DSP frequency. 1 plus $(c\# \div 1,000,000)$ multiply the frequency measurements made by the DSP.

c# Frequency Calibration Constant

| <u>s/r#</u> | <u>Action</u> |
|-------------|-----------------------------|
| 0 | Set Calibration Constant |
| 1 | Return Calibration Constant |

Return format: Numeric ASCII string.

A.3.12 Frequency, Return

Command: **#FRQ**

Returns the frequency of the input signal selected for Channel 1. Use CHANNEL 1 SELECT (**#CHS**) to select the desired input.

Response: Numeric ASCII string.

| <u>#</u> | <u>Action</u> |
|----------|---|
| 0 | (or # missing) - return frequency immediately |
| 1 | Return only if there is a new reading |

A.3.13 Harmonics Display

Command: **harm#,ch#HAR**

Displays the selected harmonic (with others) for the selected channel. Shows magnitude, phase and frequency data for the harmonic number specified as harm#.

| <u>Ch#</u> | <u>To select</u> |
|------------|------------------|
| 1 | Channel 1 |
| 2 | Channel 2 |

A.3.14 Harmonic Magnitude, Return

Command: **harm#,ch#HMA**

Returns individual harmonic magnitudes for the selected channel. Set the unit to measure harmonics, on the selected channel using the HAR command, prior to issuing the HMA command.

| <u>harm#</u> | <u>To select</u> |
|--------------|---------------------------------|
| 2-50 | Harmonic number (2 through 50) |
| 1 | THD (Total harmonic distortion) |

| <u>ch#</u> | |
|------------|-----------|
| 1 | Channel 1 |
| 2 | Channel 2 |

Response: Numeric ASCII string.

A.3.15 Harmonic Phase Angle, Return

Command: **harm#,ch#HPH**

Returns individual harmonic phase angle for the selected channel. Set the unit to measure harmonics, on the selected channel using the HAR command, prior to issuing this command.

| <u>harm#</u> | <u>To select</u> |
|--------------|---------------------------------|
| 2-50 | Harmonic number (2 through 50) |
| 1 | THD (Total harmonic distortion) |

| <u>ch#</u> | |
|------------|-----------|
| 1 | Channel 1 |
| 2 | Channel 2 |

Response: Numeric ASCII string.

A.3.16 Power Down

Command: **KIL**

Turns unit OFF.

A.3.17 Log Data

Command: **LOG**

Stores the current measurement data (using current date, time and instrument settings) in the next available location of the non-volatile data memory. Stores all data with current data type (standard data, standard with harmonic data, or standard with harmonic and waveform data). Recall data using the review logged data (**#RLD**) command.

A.3.18 Last Setup

Command: **LSU**

Restores the instrument to the state it was in immediately prior to the last change. Use this command to undo an unwanted change, or to toggle between two different setups. When this command is sent, the current state is also stored as the new last setup.

A.3.19 Magnitude (Channel), Return

Command: **ch#,Q#MAG**

Returns the selected channel magnitude. Use the Channel Select (#, ch#CHS) input select command prior to using this command. In 3-phase mode, MAG returns the average of the measured magnitudes.

| <u>ch#</u> | <u>Selection</u> | <u>Q#</u> | <u>Selection</u> |
|------------|------------------|-----------|------------------|
| 1 | Channel 1 | 0 | RMS |
| 2 | Channel 2 | 1 | Peak |
| | | 2 | Reserved |
| | | 3 | Narrow Band |
| | | 4 | Residual |

A.3.20 Measure Hold

Command: **#MHD**

| <u>#</u> | <u>Result</u> |
|----------|---|
| 0 | Measure-Hold OFF. Releases measurement hold and resumes measurements. |
| 1 | Measure-Hold ON. Stops the measurement process, holding all parameters at their current values. Select the desired display function prior to issuing this command and observe the corresponding values. |

A.3.21 MIN/MAX, Display

Command: **#MMN**

Displays the minimum, maximum, average or present values for each parameter. Updates minimum, maximum and average continuously. Use the RST command to restart the accumulation process.

| <u>#</u> | <u>Response</u> |
|----------|-------------------------|
| 0 | Displays present values |
| 1 | Displays minimum values |
| 2 | Displays maximum values |
| 3 | Displays average value |

A.3.22 Bandwidth-Narrow, Set

Command: **NAB**

Changes the measurement mode for amplitude and power quantities to fundamental frequency only.

A.3.23 Overload Status

Command: **OVD**

Returns:

| <u>Value</u> | <u>Status</u> |
|--------------|--------------------------------|
| 0 | No overload |
| 1 | Channel 1 overload |
| 2 | Channel 2 overload |
| 3 | Both Channels 1 and 2 overload |

A.3.24 Phase/Frequency Display

Command: **P.F**

Displays Channel 1 frequency and the phase angle of Channel 2 relative to Channel 1. Uses Channel 1 as an internal reference. When measuring a voltage and a current, use Channel 1 for the voltage and Channel 2 for the current.

A.3.25 Power/Vars Display

Command: **#P.V**

Displays the active and reactive power of the signals on Channels 1 and 2. Set Channel 1 to measure AC voltage and Channel 2 AC current.

| <u>#</u> | <u>To select</u> |
|----------|-------------------------|
| 0 | (or absent) Power, Vars |
| 1 | Watt hours, Var hours |

A.3.26 Power Factor, Return

Command: **PFA**

Returns the power factor of Channel 1 and 2 together. Channel 1 must be set to measure AC voltage and Channel 2 AC current. In 3 phase mode, returns the average of the individual power factors.

Response: Numeric ASCII string.

A.3.27 Phase Mode, Set

Command: **mdPHM**

Starts single or 3 phase measurement mode.

| <u>m</u> | <u>Mode</u> | <u>d</u> | <u>Mode</u> |
|----------|--|----------|----------------------------------|
| 0 | 1ph, 2 wire, single phase | 0 | Tabular Display (with Power) |
| 1 | 1ph, 3 wire, 2 element, split phase | 1 | Tabular Display (with Energy) |
| 2 | 3ph, 3 wire, 2 element | 2 | Vector Diagram |
| 3 | 3ph, 3 wire, 3 element | 3 | Voltage & Current Sequence |
| 4 | 3ph, 4 wire, 3 element | 4 | Voltage Sequence |
| 5 | 3ph, 4 wire, 2.5 element | 5 | Current Sequence |

A.3.28 Phase, Return

Command: **PHS**

Returns the phase angle of Channel 2 relative to Channel 1. Use the #SPH command to set the phase preference – 0 to 360 or ± 180 degrees, leading or lagging. In 3-phase mode, returns the average of the individual phase measurements.

Response: Numeric ASCII string.

A.3.29 Power, Return

Command: **#PWR**

Returns the active power of Channel 1 and 2 together. Channel 1 must be set to measure AC voltage and Channel 2 AC current. In 3-phase mode, it returns the total active power. When “1” precedes the PWR command, it replaces Power Quantities with Energy Readings.

Response: Numeric ASCII string.

A.3.30 Range Hold, Set

Command: **ch#RHD**

Freezes the current analog input range setting for the selected channel.

| | |
|------------|-----------|
| <u>Ch#</u> | To select |
| 1 | Channel 1 |
| 2 | Channel 2 |

A.3.31 Logged Data, Review

Command: **#RLD**

Selects a specific stored data record for display if # is included in the command, otherwise returns a list of the stored data records by #, date, time and type. Store data records manually using the log data key, or via RS-232C using the LOG command. Use 0RLD to clear all logged data.

When issuing this command, the specified record is written to the Model 930A display, overwriting current measurement data and placing the Model 930A in Measurement Hold Mode. Use 0MHD to release Measurement Hold Mode, and resume measurement.

See appendix B for use of this command with the Extended Memory Option.

A.3.32 Release Range Hold

Command: **ch#RRH**

Releases range hold for the selected channel. Places the selected channel in auto range as necessary.

| | |
|------------|---------------|
| <u>ch#</u> | <u>select</u> |
| 1 | Channel 1 |
| 2 | Channel 2 |

A.3.33 MIN/MAX, Restart

Command: **RST**

Restarts the minimum and maximum accumulation. Will also zero the Energy Readings.

A.3.34 Serial Number

Command: **serial#,s/r#SER**

Sets or returns instrument Serial Number.

| | |
|-----------------------|--------------------------------|
| <u>Serial# (s/r#)</u> | <u>ASCII number (5 digits)</u> |
| 0 | To enter serial number |
| 1 | To return serial number |

A.3.35 Flash Log

Command: **#1,#2,#3,#4,#5,#6SLO**

Sets the Flash Log operation. See Appendix B for use of this command with the Extended Memory Option.

1. If no numbers present, it starts a new file
2. If 1 number present: 0 = disable flash, 1 = enable flash
3. If 3 numbers present:
 - #1 = 0 manual trigger from log key or RS-232 Log command
 - #1 = 1 trigger from timer
 - #1 = 2 auto trigger with period set by #2
 - #2 = 1 to 86400 auto log store trigger period in sec
 - #3 = 32 bit data descriptor entered as decimal number
4. If 7 numbers present
 - #1 = 0 #2 ... #7 = autolog start time
 - #1 = 1 #2 ... #7 = autolog stop time
 - #2 = yyyy year
 - #3 = 1 through 12, month
 - #4 = 1 through 31, day of month
 - #5 = 0 through 23, hour of day
 - #6 = 0 through 59, minute of hour
 - #7 = 0 through 59, seconds of minute

A.3.36 Scale On/Off

Command: **#SOO**

Globally activates or deactivates input scale corrections. The scale factors are set for individual inputs using the SSC command.

| # | To select |
|---|-----------------------|
| 0 | All scale factors OFF |
| 1 | All scale factors ON |

A.3.37 DSP Speed

Command: **#1,s/r#SPD**

| | |
|-------------|------------------|
| <u>#1</u> | <u>To select</u> |
| 0 | Slow mode |
| 1 | Fast mode |
| <u>s/r#</u> | |
| 0 | To set speed |
| 1 | To return speed |

A.3.38 Phase Preference, Set

Command: **#SPH**

Specify the format for phase display.

| | |
|----------|---|
| <u>#</u> | <u>Phase Format</u> |
| 0 | ±180 degrees leading (negative display means Channel 2 lagging Channel 1) |
| 1 | ±180 degrees lagging (positive display means Channel 2 lagging Channel 1) |
| 2 | 0 to 360 degrees leading (negative display means Channel 2 lagging Channel 1) |
| 3 | 0 to 360 degrees lagging (positive display means Channel 2 lagging Channel 1) |

Add 4 to each of the numbers above to disable the Lead/Lag indication on the Power Factor Display.

A.3.39 Range, Set

Command: **rng#,ch#SRG**

Used to set the analog input range. After the range is set, puts the selected channel into Range-Hold Mode. Use the ch#RRH command to release Range-Hold. The approximate input ranges are as follows:

| <u>Rng#</u> | <u>AC Voltage</u> | <u>AC Current</u> | <u>Rng#</u> | <u>AC Voltage</u> | <u>AC Current</u> | <u>Ch#</u> | <u>To Select</u> |
|-------------|-------------------|-------------------|-------------|-------------------|-------------------|------------|------------------|
| 0 | 0 – 3.5 | 0 – 0.09 | 5 | 48 – 112 | 1.28 – 2.98 | 1 | Channel 1 |
| 1 | 3 – 7 | 0.8 – 0.18 | 6 | 96 – 224 | 2.56 – 5.97 | 2 | Channel 2 |
| 2 | 6 – 14 | 0.16 – 0.37 | 7 | 192 – 448 | 5.12 – 11.9 | | |
| 3 | 12 – 28 | 0.32 – 0.75 | 8 | 384 – 750 | 10.24 – 20.0 | | |
| 4 | 24 – 56 | 0.64 – 1.49 | | | | | |

A.3.40 Scale Factors, Set or Return

Command: **in#,m#,p#,s/r#SSC**

Set or return calibration factors to be applied to each input function, such as for CT or PT corrections. Scale factors consist of a magnitude correction, which is a ratio (or p/u) number; and a phase angle, in degrees. Multiplies the measured result by the magnitude correction and adds the phase angle.

in# – specifies the input signal configuration, as follows:

| <u>in#</u> | <u>Config.</u> | <u>in#</u> | <u>Config.</u> | <u>in#</u> | <u>Config.</u> |
|------------|----------------|------------|----------------|------------|----------------|
| 0 | Vab, Vba | 8 | Vcn, Vcs | 27 | Vb |
| 1 | Vbc, Vcb | 9 | N/A | 26 | In |
| 2 | Vca, Vac | 10 | N/A | | |
| 3 | N/A | 11 | N/A | | |
| 4 | N/A | 12 | Ia, In | | |
| 5 | N/A | 13 | Ib | | |
| 6 | Van, Vb, Vas | 14 | Ic | | |
| 7 | Vbn, Vbs | | | | |

m#: Magnitude correction 0 to ± 999999
p#: Phase angle correction 0 to ± 359.9
s/r#: 0 to enter scale value; 1 to return scale value.

A.3.41 Store Setup

Command: **#SST**

Stores the present instrument setup in Setup Location #.

= 1 through 6

A.3.42 Setup, Recall

Command: **#SUP**

Recalls the instrument setup# as stored with Store Setup (SST).

= 1 through 6

A.3.43 Time, Return

Command: **TDR**

Returns the present time in the format: hh:mm:ss dd mmm yyyy

A.3.44 Time, Set

Command: **yyyy:mm:dd:hh:mm:ssTDS**

Sets Date and Time for the real-time clock. Time is always set to standard time. Use the #DAY command to adjust for daylight saving time.

yyyy = Year; mm = Month; dd = Day; hh = Hour; mm = Minute; ss = Second

A.3.45 Volts/Amps Display

Command: **#V.A**

| <u>#</u> | <u>Result</u> |
|----------|--|
| 0 | (or absent) Displays Channel 1 and 2 measured amplitude values |
| 1 | Tabular Display |
| 2 | Volt hours, Amp hours |

A.3.46 VA/PF Display

Command: **#V.P**

| <u>#</u> | <u>Result</u> |
|----------|--|
| 0 | (or # absent) Displays the apparent power and power factor of the signals on Channels 1 and 2. Channel 1 must be set to measure AC voltage and Channel 2 AC current. |
| 1 | VA hours |

A.3.47 Volt Amps, Return

Command: **#VAM**

Returns the apparent power of Channel 1 and 2 together. Set Channel 1 to measure AC voltage and Channel 2 AC current. Returns total volt amps in the 3-Phase Mode. Replaces Power Quantities with Energy Readings when a "1" precedes the VAM command.

Response: Numeric ASCII string.

A.3.48 VARS, Return

Command: **#VAR**

Returns the reactive power of Channel 1 and 2 together. Set Channel 1 to measure AC voltage and Channel 2 AC current. Returns total reactive

power in 3-Phase Mode. Replaces Power Quantities with Energy Readings when a “1” precedes the VAR command.

Response: Numeric ASCII string.

A.3.49 Version, Return

Command: **VER**

Returns the firmware revision date, with the following format:

dd mmm yyyy DSPnnnnnn HLP dd mmm yyyy

Where:

| | |
|-------|------------------|
| dd: | day |
| mmm: | month (e.g. Oct) |
| yyyy: | year |

There is one space between Day and Month and another between Month and Year. “DSPnnnnnn” refers to Digital Signal Processor firmware number. “HLP” refers to help ROM date.

A.3.50 Waveform Display

Command: **ch#WAV**

Enables the waveform display of channel 1 and channel 2.

| <u>Ch#</u> | <u>To select</u> |
|------------|----------------------|
| 1 | Channel 1 |
| 2 | Channel 2 |
| 3 | Both Channel 1 and 2 |

A.3.51 Bandwidth Wide, Set

Command: **WIB**

Changes the measurement mode for amplitude and power quantities to wide-band including all harmonics up to 3.05 kHz.

Appendix B

Optional Accessories

This appendix contains both technical specifications and operational information for optional accessories available for use with the Model 930A Power System Analyzer.

B.1 Precision Current Transformer

The Model 09311A, Precision Current Transformer, is an optional accessory that extends the Model 929A/930A input current measurement range to 400 Amps RMS while retaining an overall accuracy of 0.1% and 0.1°.

B.1.1 Specifications

| | |
|------------|-----------------|
| Range: | 0.8 – 400 Arms |
| Burden: | 14 μ ohms |
| Accuracy: | |
| Amplitude: | 0.1% of reading |
| Phase: | 0.1° |

B.1.2 Input Connections

Connect a high-current source as follows:

1. Slip the transformer output spade lugs into one set of the Model 929A/930A current input binding posts (A, B, or C), and tighten securely.
2. Connect the high-current source to the 5/16-18 bolts at the top of the transformer, using a 1/2" wrench to fasten securely. Make sure

that the polarity matches the polarity indicated on the front panel of the Model 929A/930A.

B.1.3 Display

To display the input current reading directly on the Model 929A/930A, press SCALE and set the CT value to 20. Refer to Section 3.4.12 for details on setting Scale Factors.

B.2 Handle/Bail

This section contains information and procedures for installing the optional handle/bail onto the Model 929A/930A case.

B.2.1 Parts and Accessories

Included with the installation kit are the following components:

| <u>Description</u> | <u>Qty</u> | <u>Arbiter P/N</u> |
|--------------------|------------|--------------------|
| Mounting Bracket | 2 | HD0049800A |
| Handle/Bail | 1 | HD0049900A |
| Fastener Knob | 2 | HP0014200A |

B.2.2 Required Tools

The only tool required for installation of the bail is a 2.5mm Allen wrench.

B.2.3 Procedure

NOTE: Perform the following steps to attach a mounting bracket to one side of the case. Repeat for the opposite side (see Figure B.1).

1. Remove the four existing M5 screws that hold the instrument to the outer case.
2. Assemble Handle/Bail onto mounting brackets with the studs facing out. Use the knobs provided.
3. Install assembled mounting bracket onto the case using the four M5 screws previously removed.

B.2.4 Operation

To move the handle/bail to different positions/locations (see Figure B.1) simply loosen both fastening knobs, reposition handle and re-tighten knobs.

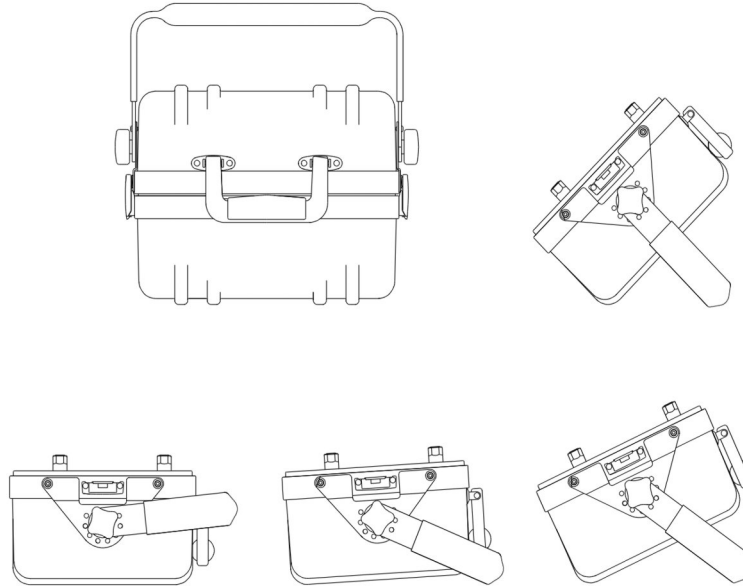


Figure B.1: Model 930A Case, Side views Showing Handle/Bail

B.3 Extended Memory (Model 930A only)

A 16-megabyte PCMCIA flash-memory card provides additional storage space for recording the various data types, which may be recalled later for analysis. To record measurements to extended memory, press the LOG DATA key in the same manner as with standard memory. Data recorded with extended memory is identical to that stored when the Model 930A is equipped with standard memory, however the record structure is more elaborate. Additionally, users can customize recorded data with the Custom function.

Note: *Do not attempt to remove or modify the memory card as it is permanently mounted within the Model 930A.*

Regardless of the power “On/Off” state of the analyzer, the extended memory module retains the stored data and instrument configurations. Only by deliberate action may the operator erase the data stored in memory.

When the extended memory module is installed, an additional selection is added to the MENU key selections, called Auto-Log Setup. Auto-Log Setup is used to specify the triggering device and method for logging data.

B.3.1 Data Organization

The extended memory option organizes data recordings as a set of one or more files - up to 20. Each file consists of one header record and a set of data records. The first record, with the header information, resides in standard memory, and subsequent records reside in extended memory. As new records are logged, they will be sent into this file unless a new Data Type is specified, or a new Log is begun (in the Auto-Log Setup).

When the Model 930A creates a header record, it contains two types of information: measurement data and instrument configuration data. Measurement data consists of everything described in the following paragraph under Normal or Custom Data types. Whereas configuration data contains everything necessary to reconfigure the instrument exactly as it was at the time of recording.

Two categories of data may be recorded to extended memory: Normal and Custom. Normal data consists of a complete set of data parameters, whereas the custom data function allows the user to select the individual parameters to be recorded, changing the record structure. The custom data feature can be used to maximize the number of data records stored in extended memory.

B.3.1.1 Normal

Each record stored as normal data contains enough information to completely restore the Model 930A to its state when the record was logged. The type of data stored depends on the active instrument display at the time the record was logged. There are four types of normal data:

- **Standard data** includes all of the Narrow-Band and Wide-Band parameters for Channels 1 and 2. Press the LOG DATA key when viewing any of the standard data formats (i.e. VOLTS/AMPS, PHASE/FREQUENCY, POWER/VARS, VA/PF). All logged data is tagged with the time and date. This type of record occupies the

least memory space. One record of Standard data occupies 153 bytes of memory.

- **Harmonic data** incorporates all of the features of standard data but includes harmonic information from Channel 1 and 2 signals. Press the LOG DATA key anytime while displaying harmonics to record this data. Harmonic data uses more memory space than Standard data. One record of Harmonic data occupies 945 bytes of memory.
- **Waveform data** includes Standard data, Harmonic data, plus a record of waveforms present on Channel 1 and 2. Press the LOG DATA key, while displaying waveforms, to record waveform data. Waveform data recording uses the most memory of any of the four data types. One record of Waveform data occupies 1,425 bytes of memory.
- **3-phase data** includes all the data presently on the 3-phase display. One record of 3 phase data occupies approximately 366 bytes of memory.

Each record in the same data file contains the same set of parameters. Changing the data type after logging data causes the Model 930A to create a new file, with its own header and associated set of records. Even with custom record definitions, new files with record structures are started when pressing the log data key after changing the display.

B.3.1.2 Custom

Users may program custom record structures from the front panel or through the RS232 port. Custom data records allow the operator to store only the parameters of interest, maximizing the number of data records stored in extended memory. Defined by a 32-bit word, each bit of the word defining the record corresponds to a particular data parameter. When recalling custom data records, only the parameters that are part of the custom record will be updated. All other parameters will be recalled from the header of the logged file.

There is a direct relationship between the active display and the collected data. When harmonics, waveform or three phase data are selected for storage the respective display must be active.

B.3.1.3 Custom Data Setup

See Section B.3.4 for details on setting up the custom data feature. Unless the Model 930A has an extended memory option installed, there will not

be an opportunity to setup custom data, as the Auto-Log Setup is added as a selection item on the main menu.

| ID Bit# | Decimal Weight | Name | #Bytes |
|----------------|-----------------------|-----------------------|---------------|
| 0 | 1 | Time | 6 |
| 1 | 2 | Frequency | 4 |
| 2 | 4 | Phase | 4 |
| 3 | 8 | Power | 8 |
| 4 | 16 | PF | 8 |
| 5 | 32 | VA | 8 |
| 6 | 64 | VAR | 8 |
| 7 | 128 | Ch1 DC | 4 |
| 8 | 256 | Ch1 RMS (wide-band) | 4 |
| 9 | 512 | Ch1 MAG(narrow-band) | 4 |
| 10 | 1024 | Ch1 Residual | 4 |
| 11 | 2048 | Ch1 Phase reference | 4 |
| 12 | 4096 | Ch1 Min | 20 |
| 13 | 8192 | Ch1 Max | 20 |
| 14 | 16,384 | Ch2 DC | 4 |
| 15 | 32,768 | Ch2 RMS (wide-band) | 4 |
| 16 | 65,536 | Ch2 MAG (narrow-band) | 4 |
| 17 | 131,072 | Ch2 Residual | 4 |
| 18 | 262,144 | Ch2 Phase reference | 4 |
| 19 | 524,288 | Ch2 Min | 20 |
| 20 | 1,048,576 | Ch2 Max | 20 |
| 21 | 2,097,152 | Ch1&2 Min | 80 |
| 22 | 4,194,304 | Ch1&2 Max | 80 |
| 23 | 8,388,608 | 3Ph Tabular | 293 |
| 24 | 16,777,216 | 1Ph Sequence | 12 |
| 25 | 33,544,432 | 3Ph Sequence | 48 |
| 26 | 67,108,864 | Timer | 10 |
| 27 | 134,217,728 | Transducer | 35 |
| 28 | 268,435,456 | Harmonic | 784 |
| 29 | 536,870,912 | Ch1 Waveform | 240 |
| 30 | 1,073,741,824 | Ch2 Waveform | 240 |
| 31 | 2,147,483,648 | Not Used | — |

Table B.1: Custom Data Table

B.3.2 Computing the Number of Files and Records

With the 16-megabyte, extended-memory option installed, the Model 930A is limited to a maximum of 20 files. Beyond that, it is only the size and the number of records that limit filling up the entire 16 megabytes.

Each type of record requires a fixed number of bytes of memory. When the extended memory is cleared there are 16,777,216 bytes (16 megabytes) available for data record storage. Divide 16,777,216 by the number of bytes per record to determine the number of records that may be stored. To determine the size of a particular custom record, add the number of bytes for each selected parameter as found in Table B.1.

B.3.3 Log Data Triggering

Data logging may be triggered from the front panel LOG DATA key, the RS232 LOG command or on a programmed time interval. Press the LOG DATA key and the Model 930A will record the data type selected on the display. Send the RS232 LOG command to the Model 930A serial port to accomplish the same thing.

To trigger data on a programmed time interval, three parameters must be set: the time interval, the start time, and the stop time. The time interval may be set from one second to 23 hours, 59 minutes and 59 seconds. This setting represents the interval between each data recording. The Model 930A will continue to log data at the chosen time interval for as long as the clock time is between the start and stop times, and the stop time is later than the start time. Data logging will stop when the stop time is reached or when the extended memory is full.

B.3.4 Front Panel Operation

If the Model 930A is equipped with the extended memory option, the first sign-on display will show "16 Mbyte Log Memory Card Installed." In the main menu, a new selection appears at the bottom of the list named "Auto-Log Setup." When you press the MENU key and select "Auto-Log Setup," the following display will appear.

```
  AUTO-LOG SETUP (Active Selection = *)
  Trisser:  *->Log Data Key or RS232
            Timer
            Time Interval
  Start Log: Date/Time
  Stop Log:  Date/Time
  Log Data: * Normal    Custom
  Auto-Log: * Enable    Disable    New Log
```

First, select a trigger condition. If Time Interval is selected set the Start Log and Stop Log date and time. Next choose the Log Data category, either Normal or Custom. The type of Normal data recorded will depend on the active display at the time data is logged. Selecting Custom data allows the user to define the parameters to be logged. After selecting Custom the operator is led through a list of 32 data parameters. Use the up and down arrow keys to select or deselect the parameter as each parameter is displayed. Press the ENTER key to move to the next parameter and the ESCAPE key to quit the selection process. Along with the name of each data parameter is the number of bytes it requires each time it is logged. Table B.1 contains a list of the available custom data parameters. Time is shown as an optional parameter, however it is automatically stored with each data record.

Select Enable or New File to begin logging the selected data. Each time New Log is selected a new file will be created for the next set of data records. Select Disable to stop data logging.

The first time data is stored in a new log data file the header is created. An indication will appear on the display (e.g. Saved in #1) showing the number of the new file created. As each subsequent record is logged a message will appear showing the file number with the record number in brackets (i.e. Saved in 1[3]).

Press SHIFT then REVIEW to recall logged data illustrated in the figure below.

```

LOG SPACE 97%  AUX MEM 97%  FILES 6
0  Clear All!  ( Key Clears A File)
→1  30Sep13  14:19:51      1 Standard
2  30Sep13  14:20:05      1 Harmonic
3  30Sep13  14:20:16      1 Waveform
4  30Sep13  14:20:36      1 3 Ph Tab
5  30Sep13  14:21:04      1 3 Ph Vec
6  10Oct13  09:20:02      1 Standard

```

Select 0 to clear all the data in the extended memory. Percentage numbers following LOG SPACE and AUX MEM show the amount of memory available. The LOG SPACE is where the headers for each file are stored. As the number of files increases the amount of LOG SPACE will decrease. AUX MEM describes where the individual records are stored. To compute the number of records that may be stored, refer to Section B.3.2. As the number of records increases, the available AUX MEM will decrease.

Use the up and down arrow keys to select individual logged data files. Press the ENTER key to recall the selected file. Press the left arrow key to erase the selected file. After selecting and recalling a file the display will include a message indicating the file number (i.e. Hold Log 2). Press the

LOG DATA key to proceed through the logged records of the selected file. The record number will be displayed in square brackets. The arrow keys are used to control the record retrieval direction and increment number. Press SHIFT and the appropriate arrow key to change viewing conditions.

- Up arrow Review records in ascending order.
- Down arrow Review records in descending order.
- Left arrow Set review increment to 1.
- Right arrow Set review increment to 10.

B.3.5 Remote Operation

There are three RS232 commands that provide for remote operation of the extended memory. These commands allow the user to configure, store and recall data in the extended memory.

B.3.6 Setup of Logged Data Operation

#1,#2,#3,#4,#5,#6,#7SLO – sets flash log operation

If no numbers present:

starts new file.

If 1 number is present:

0=disable data logging.

1=enable data logging.

If 3 numbers are present:

#1=0 manual trigger from front panel LOG key or RS232 LOG command.

#1=1 trigger from timer A.

#1=2 auto trigger with interval set by #2.

#2=1 to 86400 auto log store trigger interval in seconds.

#3=32 bit data descriptor entered as decimal number.

If 7 numbers are present:

#1=0 #2...#7 = autolog start time.

#1=1 #2...#7 = autolog stop time

#2=yyyy year.

#3=1 thru 12 month.

#4=1 thru 31 day of month.

#5=0 thru 23 hour of day.

#6=0 thru 59 minute of hour.

#7=0 thru 59 seconds of minute.

B.3.6.1 Examples using SLO Command

Command: Action

SLO: A new extended log file is started. If time interval data storage is selected the start time must be later than the present time.

0SLO: Data logging is disabled.

1SLO: Data logging is enabled. A new file will be started. See “SLO” above.

0,0,0SLO: Configures data logging for normal data with the store trigger set for the front panel LOG key or the RS232 LOG command.

0,0,33281SLO: Configures data logging for custom data with the store trigger set for the front panel LOG key or the RS232 LOG command. The custom data includes time, Channel 1 rms and Channel 2 rms.

0,5,2SLO: Configures data logging for normal data with the store trigger set for automatic with a time interval of 5 seconds. The start time must be set to a time later than the present time.

0,1996,12,25,12,0,0SLO: Sets the autolog start time to December 25, 1996 at 12:00 noon. The start time must be set to a time later than the present time.

1,1997,1,1,0,0,0SLO: Sets the autolog stop time to January 1, 1997 at midnight. Stop time must be later than start time.

The configuration of custom data is contained in a 32-bit word. Each bit in this word refers to a data parameter. The custom data Table B.1 lists each of the available parameters along with their assigned ID bit and decimal weight. To remotely program the custom word add the decimal weight of each desired parameter. The following example shows how to compute the custom data word for logging time and channels 1 and 2 magnitude data.

| <u>Parameter</u> | <u>Decimal weight</u> |
|----------------------------|-----------------------|
| Time | 1 |
| Channel 1 rms | 512 |
| Channel 2 rms | 32768 |
| Custom configuration value | 33281 |

B.3.7 Review of Logged Data

#1,#2RLD selects a log record for review or removal.

If #1 and #2 are absent: A list of stored records is returned.

If only 1 number is present:

- #=0 All records are cleared including flash memory if present
- #>1 The specified record data overwrites current instrument data and measure hold is enabled to allow data review or return.

If both numbers are present:

- #1=0 Clears file selected by #2
- #1>0 Reviews the record indicated by #2 of the file indicated by #1.

B.3.7.1 Examples Using RLD Command

| <u>Command</u> | <u>Action</u> |
|----------------|---|
| RLD | Returns a list of the logged data files, as shown in the following example of a returned message. |

```
LOG SPACE 87% AUX MEM 98% FILES 6
1  9 Dec 1996 13:37:54  9 Waveform
2  9 Dec 1996 13:38:05  4 Harmonic
3  9 Dec 1996 13:38:37 15 Custom
4  9 Dec 1996 14:17:25  0 Standard
5  9 Dec 1996 14:17:40  0 Standard
6  9 Dec 1996 14:17:47  1 Custom
```

The message includes the file numbers, the file date, the number of flash records in the file, and the type of data. Auto-Log must be enabled to get the information on the number of records in each file.

| | |
|---------------|---|
| 0RLD | All data records are erased. |
| 3RLD | Recalls the header data for the third file. The unit will be configured to the state it was in when the file was created. The unit is placed in measure hold mode. To return to normal operation, issue the "0MHD" command or press the MEASURE HOLD key. |
| 0,4RLD | Erases logged data file number four and decrements the file number of all files 5 and greater by one. |

| <u>Command</u> | <u>Action</u> |
|----------------|---|
| 3,12RLD | Recalls the data stored in the twelfth record of the third file. Sets all the unrecorded parameters to their values in the file header if custom data was recorded. |

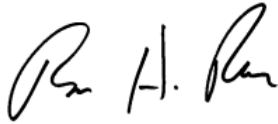
B.3.8 Trigger Remote Data Logging

To log data remotely via the RS232 port, send the LOG command. If the log data trigger is set to “Log Data Key or RS232,” issuing this command causes one data record to be stored. Press the MENU key and select Auto-Log Setup to assign the log data trigger to “Log Data Key or RS232.”

Appendix C

CE Mark Certification

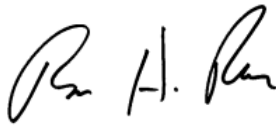
Date of Issue: October 1, 2008
Directives: 89/336/EEC Electromagnetic Compatibility
73/23/EEC Low Voltage Safety
Model Number: 929A Three-Phase Power Meter
Manufacturer: Arbitr Systems, Inc.
1324 Vendels Circle, Suite 121
Paso Robles, CA 93446 – USA
Harmonized EN55011 Class A, Radiated and Conducted
Emissions
Standard EN50082-1 Generic Immunity, Part 1
Referenced: Residential, Commercial and Light Industrial
Environments
EN61010-1 Safety requirements of Electrical
Equipment for Measurement, Control
and Laboratory Use.



Signed:
Signatory: Bruce H. Roeder

This certificate declares that the described equipment conforms to the applicable requirements of the directives on Electromagnetic Compatibility 89/339/EEC, Safety 73/23/EEC, and amendments by 93/68/EEC adopted by the European Union.

Date of Issue: October 1, 2008
Directives: 89/336/EEC Electromagnetic Compatibility
73/23/EEC Low Voltage Safety
Model Number: 930A Three-Phase Power Analyzer
Manufacturer: Arbiter Systems, Inc.
1324 Vendels Circle, Suite 121
Paso Robles, CA 93446 – USA
Harmonized EN55011 Class A, Radiated and Conducted
Emissions
Standard EN50082-1 Generic Immunity, Part 1
Referenced: Residential, Commercial and Light Industrial
Environments
EN61010-1 Safety requirements of Electrical
Equipment for Measurement, Control
and Laboratory Use.



Signed: _____
Signatory: Bruce H. Roeder

This certificate declares that the described equipment conforms to the applicable requirements of the directives on Electromagnetic Compatibility 89/339/EEC, Safety 73/23/EEC, and amendments by 93/68/EEC adopted by the European Union.