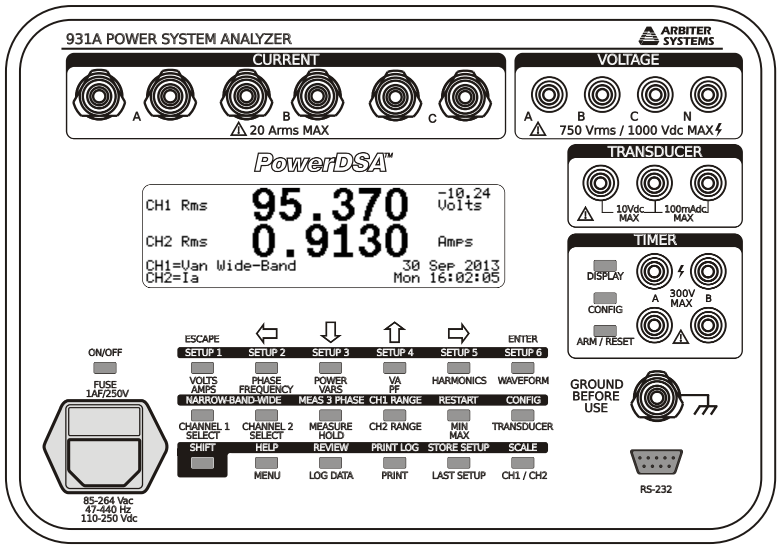
Model 931A
Power System Analyzer
Operation Manual



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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 931A Power System Analyzer™, and accessories.

Firmware and Firmware Updates

This manual was created based on the following firmware:

Copyright Program: 10 February 2010
Help Version: 25 JUNE 1996
DSP Version: 093098

The firmware versions indicated above are displayed on the Model 931A at startup. To freeze the display during this screen, press and hold the ESCAPE key until finished viewing. Also, the 931A will issue this information from the serial port using the VER command. See the VER command on page 124.

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

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2. If instrument return is authorized, forward prepaid to the manufacturer. If it is determined that the instrument is not covered by this warranty, an estimate will be made before the repair work begins, if requested.

See Contact Information on page ii.

Arbiter Systems, Inc.
Model 931A
Power System Analyzer
Operation Manual

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PD0017400R Reorder Number: AS0094000

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Chapter 1

General Information

1.1 Scope

The Arbiter Systems Model 931A Power System Analyzer is a 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 931A greatly enhances the precision measurement of these AC parameters. Powered by either an internal rechargeable battery or by AC line voltage, the Model 931A is truly portable. This manual is divided into four chapters and two appendices as follows:

Chapter 1.	General Information
Chapter 2.	Functional Description
Chapter 3.	Operation
Chapter 4.	Specifications
Appendix A.	RS-232C Commands
Appendix B.	Optional Accessories

1.2 Supplied Equipment

The Model 931A is supplied with a standard AC Power Cord (P09R), RS-232 Null-Modem Cable (P/N CA0019806), Safety Ground Lead (812HA-8) and one Operations Manual (AS0094000).

1.3 Available Accessories

The following accessories are available for use with the Model 931A:

Model Number	Description
931A/01	16-Megabyte internal memory
AS0060000	PowerCSV, Applications software (download only). Requires Option 01
AS0035901	Adjustable handle/bail Assembly
09311A	400 Amp 20:1 precision CT, 0.1% accuracy. Includes AS0036000 Mounting Bracket
AP0012800	1000:1 Clamp-on CT, 200 Amps
AP0012900	250:5, 500:5, 1000:5 Clamp-on CT, 1000 Amps
AP0001300	1000:1; 1000A, 600V, Cat. III, EN61010
811AT/CT*	3-Phase Universal Test Plug Current Lead Set
813AT/BT*	3-Phase Safety Voltage Lead Set
815AT/BT*	3-Phase Fused Voltage Lead Set
816AT/CT*	3-Phase Spade-lug Current Lead Set
817AT*	3-Phase CT Lead Set: red, yellow, blue

* This is a partial list. Other high-quality test leads and accessories are also available. Contact Arbiter Systems for further information.

Chapter 2

Functional Description

2.1 Introduction

The following paragraphs provide a brief functional description of some Model 931A components. Figure 2.1 illustrates the front panel.

2.2 Inputs

2.2.1 Voltage

Measure AC or DC voltages 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 or 1000 Vdc. 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 931A 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 Vpeak from chassis ground.

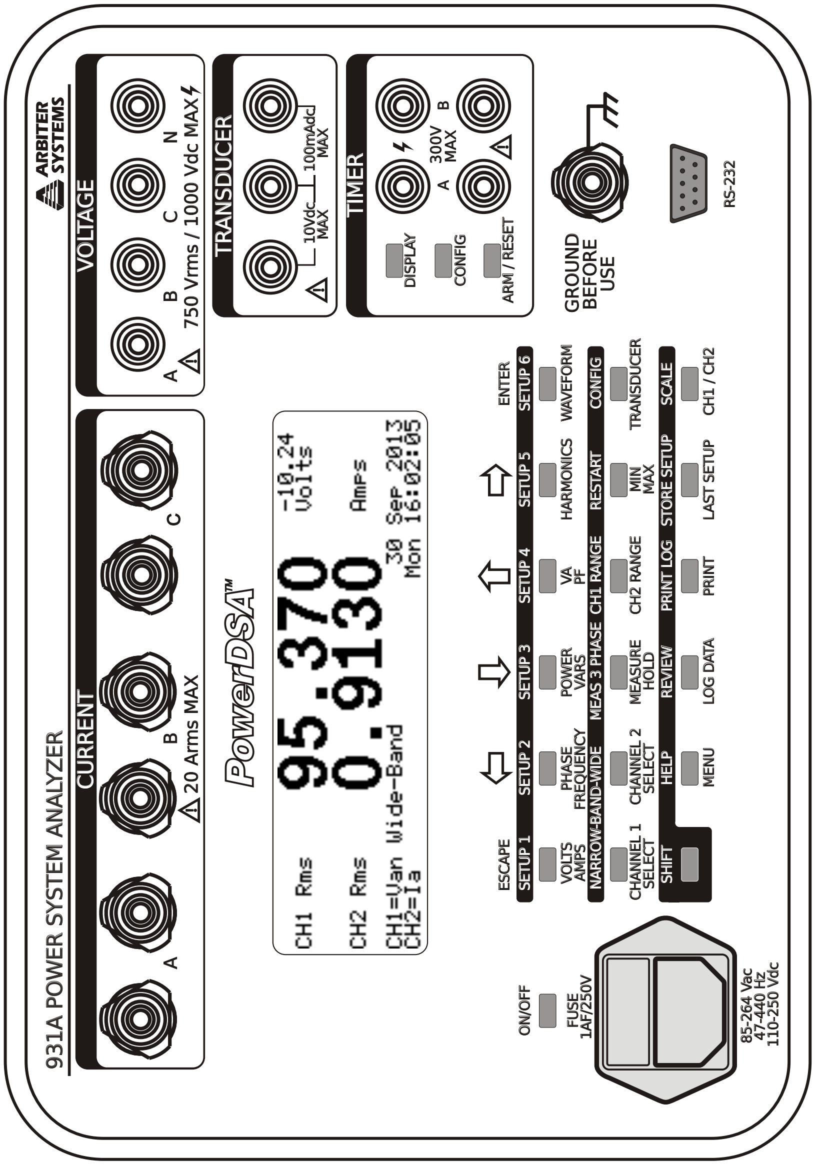


Figure 2.1: Model 931A Front Panel

2.2.3 Transducer

Two front panel inputs accept voltage or current transducer output signals. These inputs share a common return, and accept signals of up to 10 volts DC, or 100 mA DC. The Model 931A can be configured to measure the voltage or current directly, or convert the signals for display of either measured input units or a percentage of full-scale or percent error.

2.2.4 Timer

Timer inputs "A" and "B" accept signals of up to 300 volts peak or DC, without regard to polarity. The timer circuitry can be triggered by application or removal of AC/DC voltage, or by contact closure/opening. Display results of timer measurements in either seconds, or cycles.

2.3 Measurement Channels

The Model 931A 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.

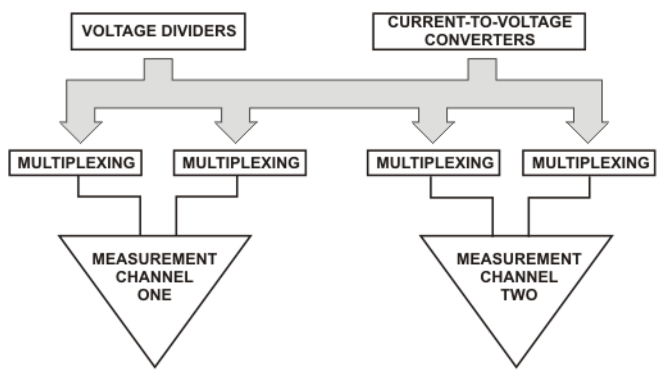


Figure 2.2: Input Multiplexing

Tables 2.1 and 2.2 list the possible input configurations for the two measurement channels. Table 2.1 lists AC Measurement Configurations and Table 2.2 lists DC Measurement Configurations. Using the two measurement channels individually allows concurrent measurements of separate signals (voltage and/or current).

Compare the amplitudes and phase angle of two voltage signals by connecting the first voltage (i.e. Va-b) to Channel 1 and the second voltage (i.e. Vc-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 931A digital signal processing (DSP) algorithms. Using only Channel 1, these measurements require a fairly clean signal. To make accurate measurement of the fundamental frequency, input signal must have less than 30% total harmonic distortion (THD). A stable frequency display indicates that the fundamental measurement was successful.

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

Table 2.2: DC Measurement Configurations

The Model 931A 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 931A 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 931A will lock on to the CH1 signal and the CH2 signal can be analyzed.

2.4.1 Sampling and Filtering

The Model 931A 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 931A 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 931A 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." Pressing the shift key twice, or issuing the SPD RS-232 command, starts this mode. 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 931A.

2.5 User Interface

The user interface for the Model 931A is designed to streamline overall operation by making the most commonly used functions easily accessible. The following paragraphs briefly describe the Model 931A 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.

2.6 RS-232C Interface

The Model 931A 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 931A 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 B. Refer to Section 3.11.6 for information on printing and exporting data. Table 2.3 lists the connector types, pin locations and signal descriptions for the RS-232C port of the Model 931A 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 931A 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 931A returns a "?" it signifies an unrecognizable command or an out-of-bounds number.

2.7 Power Supply and Battery

The Model 931A can operate either from an internal, rechargeable battery, or from an external AC/DC power source.

2.7.1 Battery Power

In normal operation, the battery will operate the Model 931A for eight hours on a full charge. Factors affecting the operating time include: backlight control (the backlight adds approximately 50% to power drain), use of the timer and transducer inputs, and the measurement function.

931A 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
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 2.3: RS-232C Port Pinout / Signal Description

2.7.2 Line Power/Battery Charging

Battery charging occurs whenever power is applied to the Model 931A main power inlet. The internal charger supplies a steady level of power to the instrument, whether powered on or off. If the 931A 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 931A 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 931A 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 931A 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.**

2.7.3 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 3.3.1.13).

2.8 Start-Up Sequence

Several tasks are performed during the power-on initialization sequence. First, the Model 931A 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 931A these dates are updated.

2.8.1 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.

2.8.2 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 931 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 2.4: 931A Reset Selection Screen

2.8.2.1 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.
3. Using the Cursor keys (up or down arrows) select "PARTIAL" from the three options shown in Table 2.4.
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 931A, Power System 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 eighteen connectors on the front panel (excluding the RS-232C and power inlet connectors), and all will accept a standard banana plug. Eleven 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

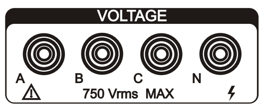
A ground lug, located in the lower right-hand corner of the front panel, is connected to the instrument chassis, and also to the safety ground lead of the AC power connector. When the Model 931A is operated with the power line cord connected, the chassis of the instrument will be connected to the safety 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

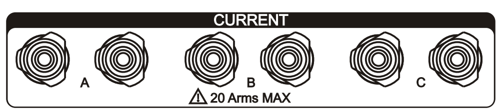
The Model 931A features four, front-panel inputs, which can be used for measurement of AC or DC voltages. These inputs are labeled "A", "B", "C", and "N" (for phase A, phase B, phase C, and Neutral, respectively).



All four of the inputs utilize identical circuitry, which allows for measurement of voltages up to 750 Vrms or 1000 Vdc 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. Measure voltage between any two of the inputs (e.g., "A" and "N"). Also, the 931A will measure voltage between the input and a synthesized neutral, which is the average of the voltages at inputs A, B, and C.

3.2.3 Current Inputs

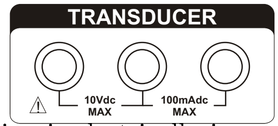
The Model 931A has three inputs for use in AC current measurement. Each of the inputs uses a pair of five-way binding posts, and has a maximum current capability of 20 amps rms. For each pair of terminals, the left-hand side is positive, and the right-hand side is negative.



For measurement of 3-phase neutral current, the neutral signal (In) is available on Channel 2.

$$In = -(Ia + Ib + Ic) \tag{3.1}$$

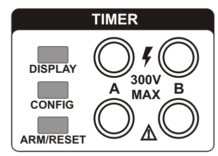
3.2.4 Transducer Inputs



Measure transducers via two front-panel inputs sharing a common return. One input permits measuring a voltage output from a transducer, and the other permits measuring a current output from a transducer. Make connections via insulated banana jacks. For safety, the measurement-input section is electrically isolated from the instrument chassis and all other inputs.

A transducer can be tested "live" in a circuit, or using an external source. The transducer inputs are connected to the Model 931A voltage or current measurement channels, and the transducer output is connected to the Model 931A transducer measurement input, except for Custom Pulse, which uses the Timer Input. For details on transducer testing, refer to Section 3.8.

3.2.5 Timer Inputs



Two timer inputs are provided via two pairs of insulated banana jacks, with the inputs being independently and optically coupled.

The timer is designed for testing of protective relays, and other similar or related tasks.

3.3 Front Panel Keys

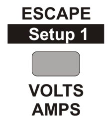
The following paragraphs describe the functions and features that can be accessed via Front Panel Keys. The functions of the keys in the main keyboard are divided into three groups: Main Functions, Secondary Functions, and Data Entry Functions. The Secondary and the Data Entry Functions differ from the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

There is also a separate group of three keys having functions associated with the control of the internal timer. The functions of these keys are referred to as Timer Control Functions.

3.3.1 Main Functions

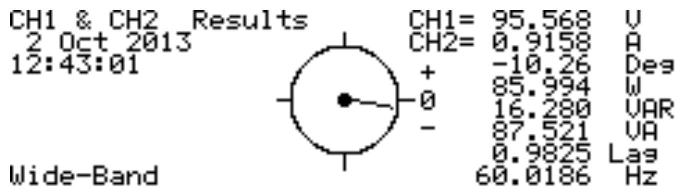
The primary functions of the front panel keys are described below. The text located directly below each key identifies its primary function. Press the key once to access these primary functions.

3.3.1.1 Volts/Amps



Press the VOLTS/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 3.5.1.2 and 3.5.2.2).

Press the VOLTS/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.

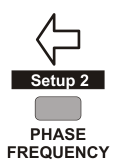


Make amplitude measurements with the instrument in either the narrow-band mode (fundamental only), or wide-band mode (true rms).

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.

3.3.1.2 Phase/Frequency

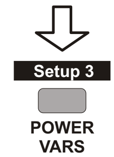


Press the PHASE/FREQUENCY key to display the frequency of the input signal routed to measurement Channel 1, and the phase angle of the signal routed to Channel 2 (relative to the signal on measurement Channel 1). The input multiplexing circuitry determines which input signals are connected to the measurement channels, according to selections made by the operator (see Sections 3.5.1.2 and 3.5.2.2).

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°C *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 3.3.1.13, under Menu. See Figure 3.1 for Phase Angle definitions.

3.3.1.3 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 3.5.1.2).

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, including 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.

$$Wide - band\ VARs = \sqrt{VA^2 + W^2} \tag{3.2}$$

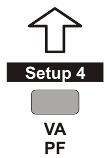
Mathematically, reactive power is defined as the square root of the quantity apparent power squared minus active power squared. The sign of the wide-band reactive power is determined from the sign of the narrow-band reactive power.

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.

$$Narrow - band\ Vars = V_{fund} \times I_{fund} \times Sin(-\Theta) \tag{3.3}$$

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.

3.3.1.4 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 3.5.1.2 and 3.5.2.2).

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 3.3.1.3).

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 3.3.1.13, 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.

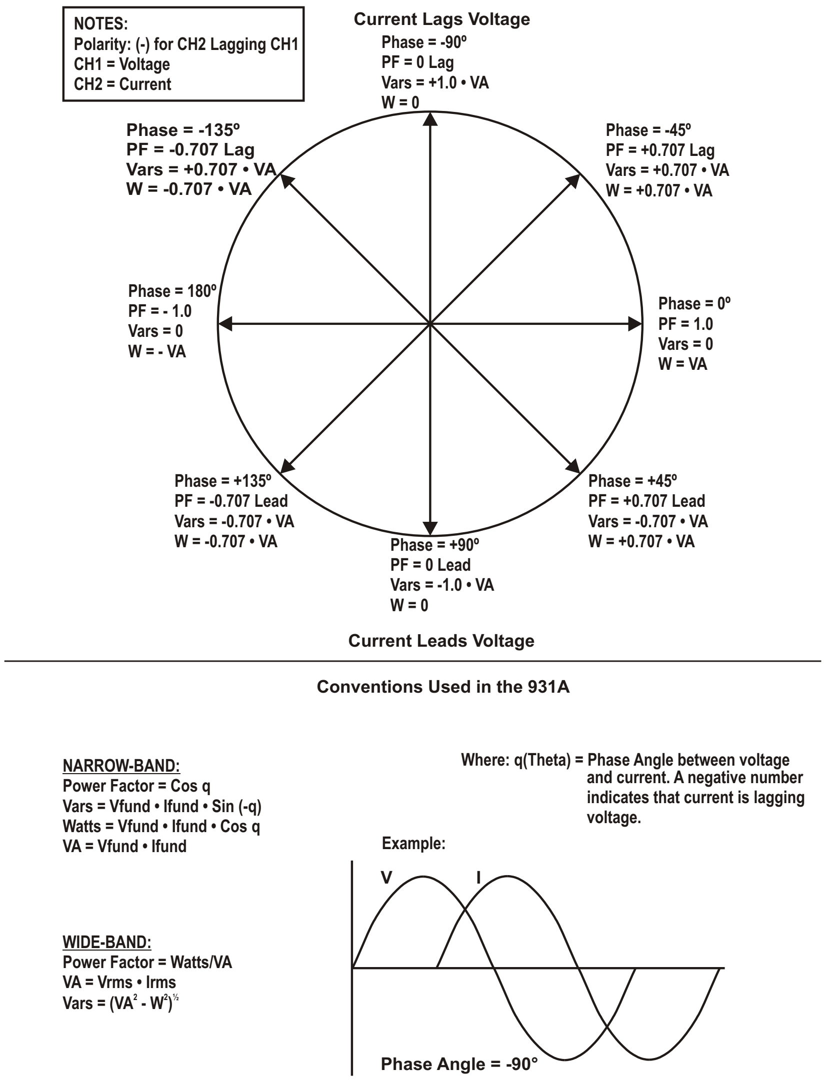


Figure 3.1: Phase, Power Factor, and VAR Definitions

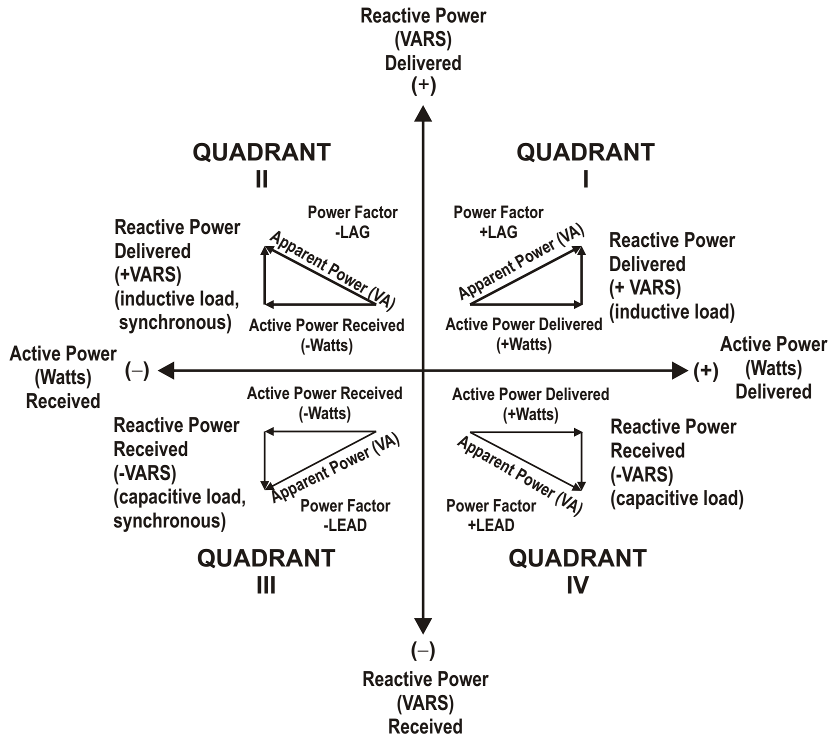


Figure 3.2: Phase, Power Factor, VAR Quadrants

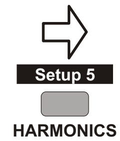
Phase Convention CH2 Lagging CH1	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
(-) for ±180°	0° to -90°	-90° to -180°	+180° to +90°	+90° to 0°
(+) for ±180°	0° to +90°	+90° to +180°	-180° to -90°	-90° to 0°
(-) for 0 - 360°	360° to 270°	270° to 180°	180° to 90°	90° to 0°
(+) for 0 - 360°	0° to 90°	90° to 180°	180° to 270°	270° to 360°

Table 3.1: Phase Angle Preferences

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

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

3.3.1.5 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 Sections 3.5.1.2 and 3.5.2.2).

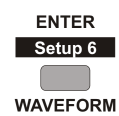
Harmonics up to the 50th are shown for fundamentals of 50 or 60 Hz. At 400 Hz, only harmonics up to the 7th are displayed, due to the instrument bandwidth limitation of 3.05 kHz.

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.

3.3.1.6 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.

3.3.1.7 Channel 1 Select

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

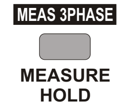
Always connect the lowest distortion input signal to Channel 1 since it is used as the internal reference. For most power systems the voltage has lower distortion than the current. If applying only one signal, it must be connected to Channel 1. If analyzing a single highly distorted waveform connect 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 twenty-seven choices; three AC currents (A, B, C); twelve AC voltages, and twelve DC 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”. Tables 2.1 and 2.2 list the possible input combinations.

3.3.1.8 Channel 2 Select

Press the CHANNEL 2 SELECT key to select the input configuration menu for Channel 2. Front panel input combinations allow twenty-eight choices; four AC currents (A, B, C, N); twelve AC voltages, and twelve DC 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”. Tables 2.1 and 2.2 list the possible input combinations.

3.3.1.9 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. Two other methods of activating the Measurement Hold mode is by reviewing Logged Data, or by the Timer Stop Gate (see 3.7.2.5).

3.3.1.10 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. 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):

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, Vrms

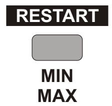
0 – 0.09	0.32 – 0.75	2.56 – 5.97
0.08 – 0.18	0.64 – 1.49	5.12 – 11.9
0.16 – 0.37	1.28 – 2.98	10.24 – 20.0

Table 3.3: Channel 2, AC Current Ranges, Arms

0 – 5	17 – 40	135.8 – 320
4.2 – 10	34 – 80	271.5 – 640
8.5 – 20	68 – 160	543 – 1000

Table 3.4: Channel 2, DC Voltage Ranges, Vdc

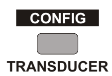
3.3.1.11 Min / Max / Ave



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/AVERAGE 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.

3.3.1.12 Transducer



Press the TRANSDUCER key to show measurements taken at the front-panel transducer voltage and current inputs. Configure the Model 931A to display the transducer-input magnitude as either the actual measured quantity or as a percentage of full scale. Likewise, display the transducer output level as either the measured quantity or percentage of full scale, or as a percent error (based on the input and output ranges). Prior to initiation of Transducer measurements, the Model 931A automatically performs a self-calibration.

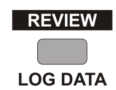
3.3.1.13 Menu

Press the MENU key to display a configuration menu used to define configurable parameters within the Model 931A. The submenus and functions available from the MENU key are defined as follows:

- **RS-232 Port Setup:** 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.

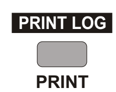
- **Phase Preference:** Select the conventions to be used for phase display. This includes whether phase angle is displayed as $\pm 180°$ or $0 - 360°$ and (–) for Channel 2 lagging Channel 1 or (+) for Channel 2 lagging Channel 1. The Phase Preference selection only affects the displayed phase angle and no other quantities. Section 3.6.1 describes the phase convention selection. There is also a selection for enabling or disabling the Power Factor "Lead/Lag" display.
- **Print Selections:** 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:** Allows automatic output of the selected print option at various time intervals.
- **Auto-Log Setup:** Shows up only when 16-Mbyte memory card is installed. See Section B.3.4 for details.

3.3.1.14 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 931A equipped with extended memory, see Section B.3.

3.3.1.15 Print

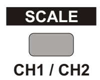


Press the PRINT key to transmit the current measurement data to a printer, modem, or computer connected to the RS-232 port. See Section 3.11 for a complete description of printing functions.

3.3.1.16 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.

3.3.1.17 Ch1/Ch2



Press the CH1/CH2 key to display the magnitude and phase of the signal at Channel 1 divided by the signal at Channel 2. Depending on the input signals selected, the displayed units for magnitude 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 3.6.1.3).

When using the CH1/CH2 function, any scaling factors for magnitude and/or phase will apply to the displayed result (see Section 3.3.2.17 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 931A 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 3.3.2.17) and press CH1/CH2. Using an external source, supply the appropriate level current.

3.3.2 Secondary Functions

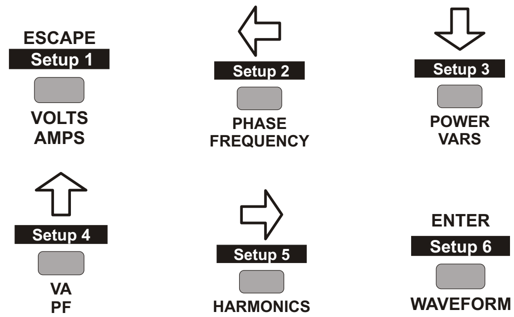
The secondary functions of the front panel keys are shown below. They are identified by the text located directly above each of the keys, and are highlighted in gray. Access these functions by pressing SHIFT prior to pressing the desired key.

3.3.2.1 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.

3.3.2.2 Setup 1 – 6

Up to six different instrument configurations can be stored for future measurements using STORE SETUP (see Section 3.3.2.16) 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, CT/PT Scale Factors, Transducer and Timer Configurations. Setup keys do not *enable* SCALE factors, and are shown below.

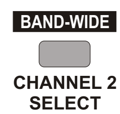


3.3.2.3 Narrow Band

Press the 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.

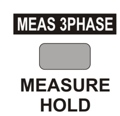
Channel 1 is used as the internal reference. Use Channel 1 if only one signal is measured. If measuring both a current and a voltage, use Channel 1 for measuring the voltage and Channel 2 for the current.

3.3.2.4 Wide Band



Press the 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.

3.3.2.5 Measure 3 Phase



Press SHIFT, then MEAS 3 PHASE to display the 3-phase measurement selection window. MEAS 3 PHASE permits the Model

931A to make sequences of measurements on sets of voltage and current inputs. The measured set of input combinations depends on the 3-phase measurement selection chosen (see Figure 3.3).

```
   3 PHASE MEASUREMENT SELECTION
→1Ph 3W 2E:    (Split: VanIa, VcnIc)
 3Ph 3W 2E:    (VabIa, VcbIc, 'Vac,Ib')
 3Ph 3W 3E:    (VasIa, VbsIb, VcsIc)
 3Ph 4W 3E:    (VanIa, VbnIb, VcnIc)
 3Ph 4W 2.5E:  (VanIa, 'Vb'Ib, VcnIc)
               (connect Vb to Vn)
```

Figure 3.3: Three-Phase Measurement Selection

To select the appropriate measurement mode, move the cursor to the desired mode and press ENTER. The input pairs shown in parenthesis are those used for the TABULAR display. The Model 931A displays the following display selection menu when you press ENTER:

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

Figure 3.4: Three Phase Display Selection

3.3.2.6 Tabular Display

The 931A 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 the right 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.

In 1-phase 3-wire, 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 current measurement.

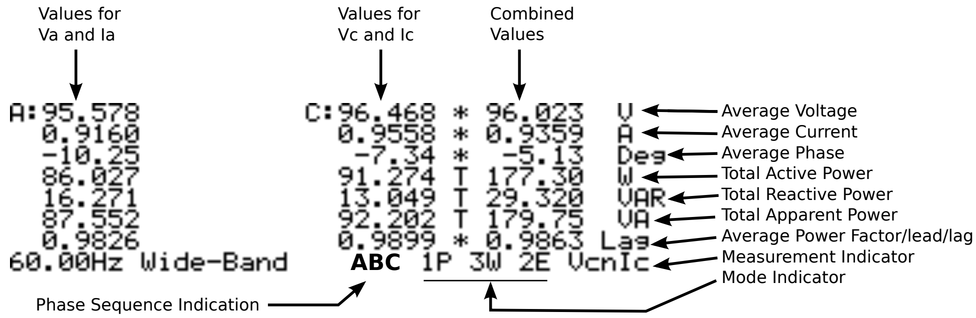


Figure 3.5: Three Phase Tabular Display

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”.

> **NOTE:** The “B” voltage input must be externally connected to the “N” voltage input.

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

In all three-phase modes, the Model 931A also measures and displays phase the sequence, "ABC" or "CBA". (see Figures 3-2 and 3-3). 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 the Model 931A could not measure a valid "Vab to Vac" phase. Phase rotation is determined by measuring "VcnVan".

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

3.3.2.7 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. A vector with a length of less than one pixel is not displayed. 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.

3.3.2.8 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 931A 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.

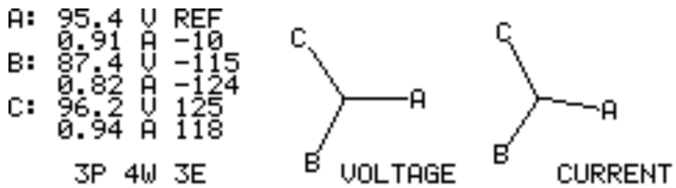
Negative-Sequence Currents (I2) and Voltages (V2) are the components in 3-phase systems that result from unbalanced phase-to-phase current and voltage. They cause undesired heating in motor and generator windings. Reversed phase sequence – ACB vs ABC – can be viewed as an extreme negative sequence case.

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.

Tabular with Power

```
A:95.701 B:88.371 C:95.953 * 93.342  V
  0.9169   0.8298   0.9505 * 0.8991  A
  -10.26    -8.64    -7.28 *  -8.73  Deg
  86.219   71.915   90.310 T 248.44  W
  16.329   14.323   12.765 T 43.418  VAR
  87.752   73.328   91.208 T 252.28  VA
  0.9825   0.9807   0.9902 * 0.9845 Lag
60.02Hz Wide-Band    ABC 3P 4W 3E VbnIb
```

Vector Diagram



Voltage and Current Sequence

```
A:95.463 B:87.485 C:96.229 N:          V
     REF  -115.16   125.03             Deg
  0.9149   0.8205   0.9541   0.0001   A
  -10.26  -123.81   117.70  -174.38   Deg
V1: 92.981  V2: 5.3931  V0: 1.0182    V
       REF      -72.50       -7.30    Deg
I1: 0.8948  I2: 0.0783  I0: 0.0000    A
     -5.47      -83.08        5.62    Deg
```

Waveform

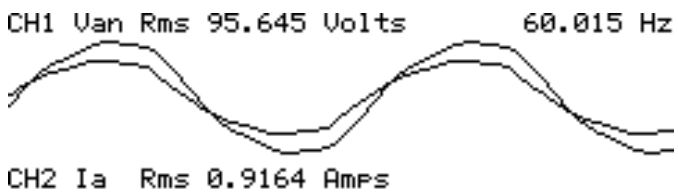


Figure 3.6: Three-Phase Displays for an ABC System

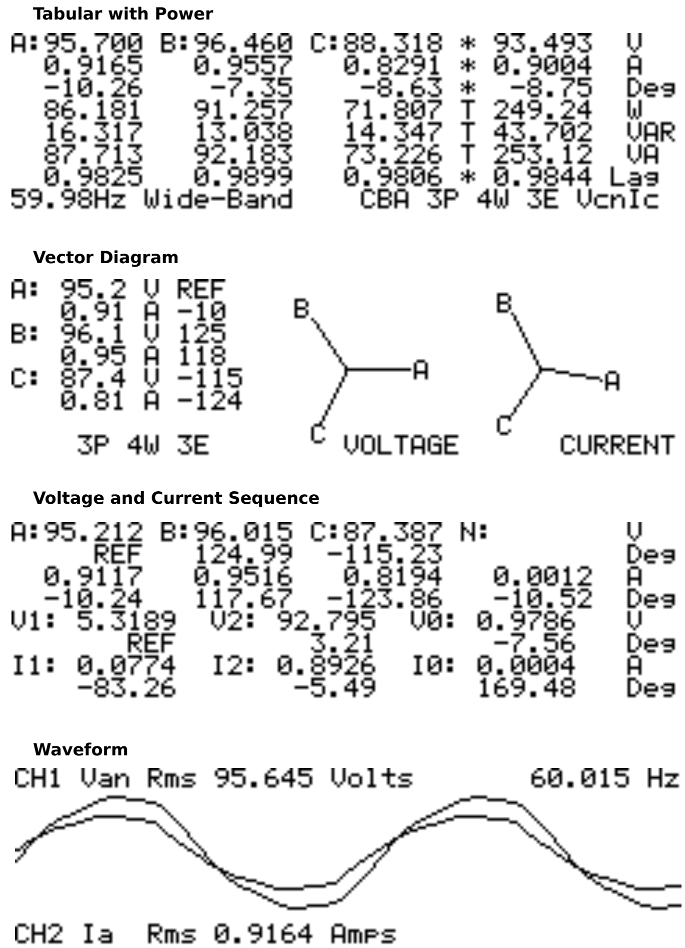


Figure 3.7: Three-Phase Displays for a CBA System

3.3.2.9 System Connections

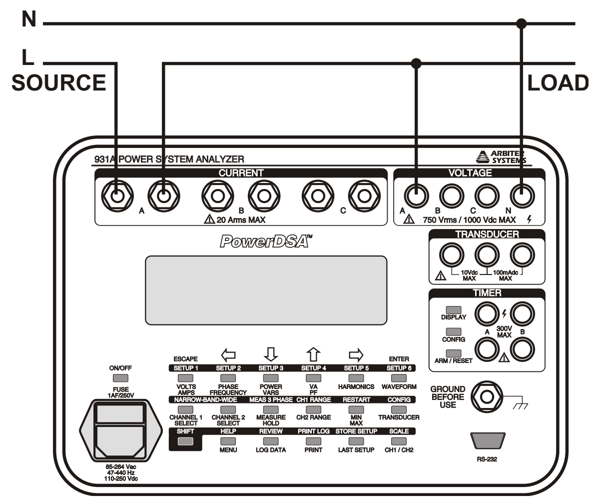


Figure 3.8: 1-Phase, 2-Wire, 1-Element Connections

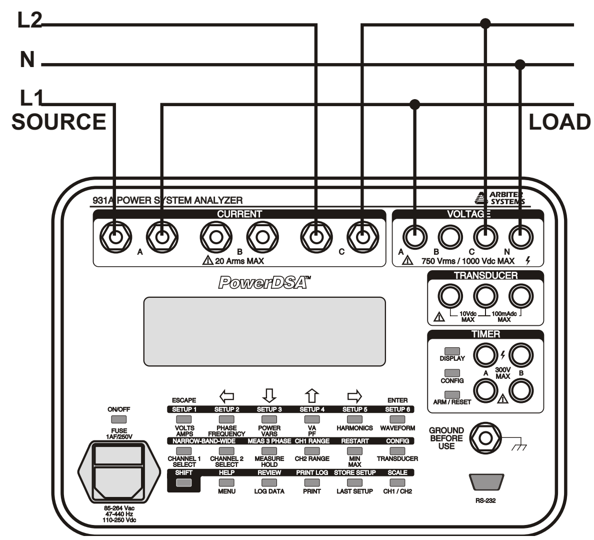


Figure 3.9: 1-Phase, 3-Wire, 2-Element Connections

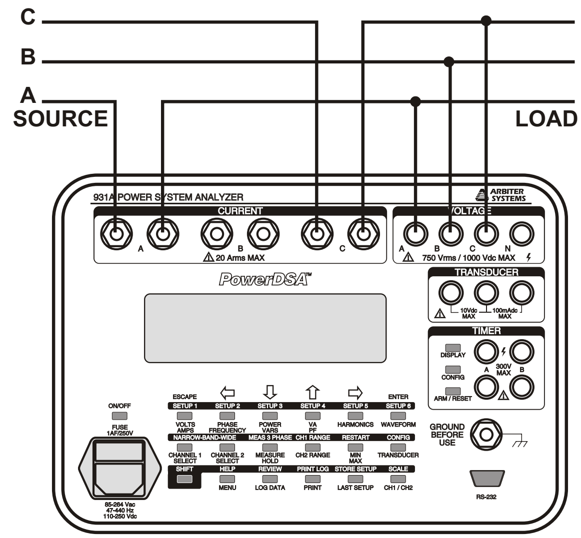


Figure 3.10: 3-Phase, 3-Wire, 2-Element Connections

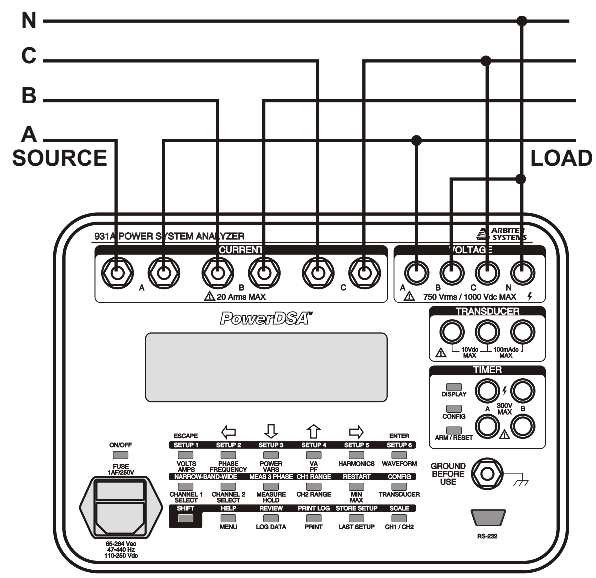


Figure 3.11: 3-Phase, 4-Wire, 2.5-Element Connections

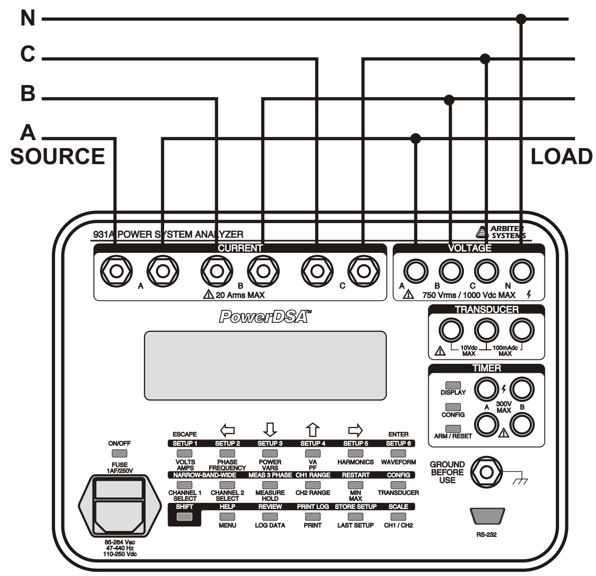


Figure 3.12: 3-Phase, 4-Wire, 3-Element Connections

3.3.2.10 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. 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 3.5: 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 3.6: Channel 1, AC Current Ranges, Arms

0 – 5	17 – 40	135.8 – 320
4.2 – 10	34 – 80	271.5 – 640
8.5 – 20	68 – 160	543 – 1000

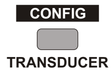
Table 3.7: Channel 1, DC Voltage Ranges, Vdc

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.

3.3.2.11 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.

3.3.2.12 Config (Transducer)



Press SHIFT then the CONFIG key to set the transducer input and output ranges; it affects the testing of transducers. The Model 931A can be set to automatically calculate and display transducer error as percent of full scale, when the same input signal is applied to the transducer under test and the Model 931A. Any calibrator or load box with source may be used, or transducers may be calibrated in-circuit.

Press the CONFIG key to view the following menu:

```
        TRANSDUCER CONFIGURATION
 Input Mode:            3Ph 4W 3E:
 Input Type:            Power
 Input Range:           0.0 - 750.0   W
 Output Range:          4.0 - 20.0   mA dc
→Display Input As:      Measured Quantity
 Display Output As:     Measured Quantity
```

Use the arrow keys to select a menu item, then press ENTER. Selections made from this menu will activate other sub-menus, which allow for various transducer-test configurations. Once all parameters have been set, press ESCAPE and Transducer Operation will begin. See Section 3.8 for further information on transducer testing.

3.3.2.13 Help

Press SHIFT then the HELP key to find reference information about the functions of the Model 931A. 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).

3.3.2.14 Review

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

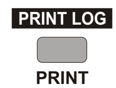
```
LOG SPACE 97%  AUX MEM 97%  FILES 6
0  Clear All!  ( Key Clears A File)
→1  30Sep13 14:19:51    1 Standard
2  30Sep13 14:20:05    1 Harmonic
3  30Sep13 14:20:16    1 Waveform
4  30Sep13 14:20:36    1 3 Ph Tab
5  30Sep13 14:21:04    1 3 Ph Vec
6   1Oct13 09:20:02    1 Standard
```

Review Method

1. Use the up and down arrow keys to select a record to be cleared or reviewed
2. 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.
3. When in the selection menu display, press the left arrow key to clear the highlighted record from memory.
4. To remove all data records from memory, press ENTER when Clear All Entries is highlighted.
5. Press escape to return the instrument to normal operation with out any modification of stored data.

3.3.2.15 Print Log

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).



3.3.2.16 Store Setup

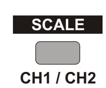
Use the STORE SETUP key to save the current instrument-state in one of six memory registers: SETUP 1 through SETUP 6. Press SHIFT then STORE SETUP to produce the following prompt on the display:

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 3.3.2.2.

3.3.2.17 Scale

Use the SCALE key to apply individual Scale Factors to each AC measurement input function. Scale Factor corrections can adapt the Model 931A 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.

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 3.3.2.16 to store global PT and CT scale factors (not individual) for later retrieval. The following assignments are made:

Set Scale:	Auto Sets:	Set Scale	Auto Sets:
Van	Vas, Vb	Vbc	Vcb
Vbn	Vbs	Vca	Vac
Vcn	Vcs	Ia	In
Vba	Vab		

SCALE does not allow scale factors to be entered for DC measurements.

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 931A input, displays 1000 volts. Therefore, if the Model 931A 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.

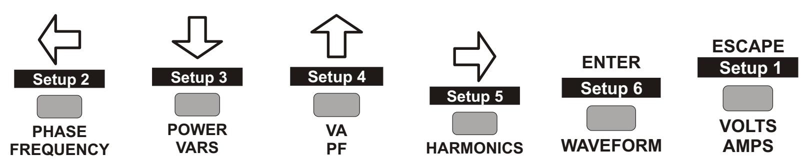
Measurements made in wide-band mode use digital true-rms detection. Phase corrections are applied for power quantities by using complex multiplication. The accuracy of this method depends on the absence of significant harmonic power and the size of the phase offset.

3.3.3 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 (+,,., 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.

3.3.3.1 Nomenclature



3.3.3.2 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.

3.3.3.3 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.

3.3.3.4 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.

3.3.3.5 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.

3.3.3.6 Enter

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

3.3.3.7 Escape

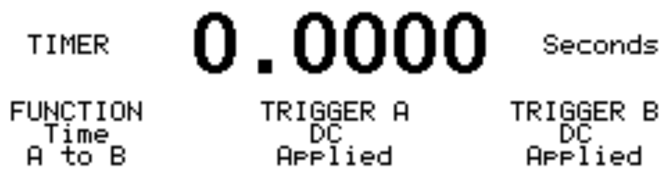
Press the ESCAPE key to back-out of menus or selections. While not necessary to precede ESCAPE with SHIFT, ESCAPE is automatically available when applicable. Also, use ESCAPE to terminate the display of waveforms, 3-phase, harmonics, or XMODEM file transfers. To view the sign-on message, press and hold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

3.3.4 Timer Control Functions

Three keys, located left of the timer connection terminals, control operation of the internal timer. The functions of these keys are described below.

3.3.4.1 Display

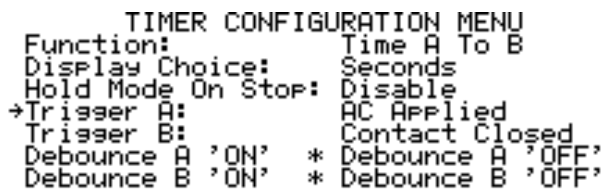
Use the DISPLAY key to view the main display for the timer; this includes the time measurement, the timer function and trigger modes. An example is shown below.



In the main timer display, FUNCTION shows the parameter that the timer is configured to measure. TRIGGER A and TRIGGER B describe the actions, which will constitute valid triggers for the "A" and "B" inputs.

3.3.4.2 Config

Press the CONFIG key to display the timer configuration menu, which appears as follows:



One or more sub-menus follow each of the menu selections, which allow configuration of the specific functions.

Section 3.7 provides more detailed information about the timer sub-menus and their functions.

3.3.4.3 Arm/Reset

Use the ARM/RESET key to arm and reset the active timer. Once stopped, pressing the ARM/RESET key will reset the timer. Pressing it a second time arms the timer for next cycle. The ARM/RESET function may also be used to manually stop the timer during a measurement cycle.

3.4 Front Panel Display

The Model 931A 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 3.3.1.13 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.

3.5 Direct Measurements

For measurement of certain parameters, the Model 931A 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
- DC Voltage
- Frequency
- Harmonics
- Waveform

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

3.5.1 AC Voltage Measurement

The Model 931A can measure and display AC voltages of up to 750 Vrms.

3.5.1.1 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 931A 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.

3.5.1.2 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
Vab    Vac    →Van    Vas    Ia
Vbc    Vcb     Vbn    Vbs    Ib
Vca    Vba     Vcn    Vcs    Ic
    CHANNEL 1 DC SELECTIONS
    Vab    Vac    Van    Vas
    Vbc    Vcb    Vbn    Vbs
    Vca    Vba    Vcn    Vcs
```

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 "Van" and use Channel 2 to measure "Vcn". The two voltage signals must have the same fundamental frequency.

3.5.1.3 Performing the Measurement

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

```
                              125.05
CH1 Rms      95.571           Volts

CH2 Rms      96.414           Volts
CH1=Van Wide-Band          2 Oct 2013
CH2=Vcn                  Wed 14:04:24
```

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

The display indicates the general measurement bandwidth near the lower left-hand corner. The Model 931A 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 931A 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.

3.5.2 AC Current Measurement

The Model 931A 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 3.3.2.17).

3.5.2.1 Input Connections

The Model 931A 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, $In = -(Ia + Ib + Ic)$, is available for measurement on Channel 2.

3.5.2.2 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 2 AC SELECTIONS
Vab    Vac    Van    Vas   →Ia   In
Vbc    Vcb    Vbn    Vbs    Ib
Vca    Vba    Vcn    Vcs    Ic
    CHANNEL 2 DC SELECTIONS
    Vab    Vac    Van    Vas
    Vbc    Vcb    Vbn    Vbs
    Vca    Vba    Vcn    Vcs
```

Arrows form 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.

3.5.2.3 Performing the Measurement

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

```
CH1 Mag   0.9105   127.88
                   Amps
CH2 Mag   0.9481   Amps
CH1=Ia  Narrow-Band       2 Oct 2013
CH2=Ic               Wed 14:29:46
```

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

The display indicates the general measurement bandwidth (i.e. Wide-Band) near the lower left-hand corner. The Model 931A 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 931A displays dashes for both Channel 1 and Channel 2.

3.5.3 DC Voltage Measurement

The Model 931A can directly measure and display DC voltages of up to 1000 Vdc.

3.5.3.1 Input Connections

The Model 931A provides four connectors for measuring dc voltage. Labeled "A", "B", "C", and "N", all four inputs use identical circuitry. Additionally, input multiplexing circuitry allows referencing the voltage across any two, voltage terminals. For example, to measure a voltage from "A to N", connect the leads between those two terminals.

NOTE: The Model 931A does not have a provision for measurement of voltage between any of the voltage inputs and the chassis ground lug. Make all voltage measurements between two (or more) of the voltage terminals. *The ground lug is included for safety purposes only.*

3.5.3.2 Configuring the Channels

Configure the chosen measurement channel after connecting the voltage to the appropriate input terminals. Configure Channel 1 by first pressing the CHANNEL 1 SELECT key, and 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
   CHANNEL 1 DC SELECTIONS
  →Vab    Vac    Van    Vas
   Vbc    Vcb    Vbn    Vbs
   Vca    Vba    Vcn    Vcs
```

Arrows form 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 highlight Van to measure a DC voltage between inputs "A" and "N" ("Van" is in the third row up from the bottom). Confirm the selection by pressing ENTER.

3.5.3.3 Performing the Measurement

Press the VOLTS/AMPS key to display the measured DC voltage and view a display similar to the one shown below:

```
CH1 DC     9.0430   ------
                    Volts
CH2 Rms    0.0001   Amps
CH1=Van Wide-Band        21 Jan 1999
CH2=Ib                  Thu 11:20:31
```

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

The display indicates the general measurement bandwidth near the lower left-hand corner. However, the bandwidth setting has no effect on DC measurements.

3.5.4 Frequency Measurement

The Model 931A measures fundamental frequencies within the range of 20 Hz to 500 Hz. The following paragraphs describe the steps required to perform Frequency measurements.

3.5.4.1 Input Connections

The Model 931A 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).

3.5.4.2 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
    CHANNEL 1 DC SELECTIONS
    Vab    Vac    Van    Vas
    Vbc    Vcb    Vbn    Vbs
    Vca    Vba    Vcn    Vcs
```

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”. For frequency measurement of an AC current at input “A”, select “Ia” in the top row.

3.5.4.3 Performing the Measurement

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

The large number in the middle of the display indicates the frequency of the signal on Channel 1. The indication for phase angle may consist of dashes because only one signal is being input or the signal level is too low, 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.

3.5.5 Harmonic Measurement

The Model 931A 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.

3.5.5.1 Input Connections

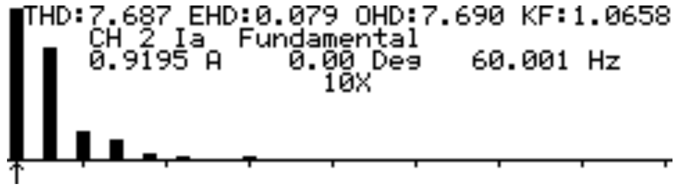
Make connections for harmonic measurement in the same manner as for AC voltage or current magnitude measurements. Since the Model 931A derives the harmonic value from the same inputs, simply press the HARMONICS key to view them. See Section 3.2.2 (AC voltages) and Section 3.2.3 (AC currents) for descriptions of AC Input connections.

3.5.5.2 Configuring the Channel(s)

To configure the Model 931A 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 931A measures harmonics on signals processed by either channel.

3.5.5.3 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. An arrow, below the second bar, represents the cursor, and lies under the third harmonic. 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 931A 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.

3.6 Combined Measurements

With two separate measurement channels, the Model 931A 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.

Connecting the Inputs
When comparing two signals, configure the inputs of the Model 931A 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 931A uses Channel 1 as a reference for phase measurements. Both a voltage and current input signal are required to measure all power quantities.

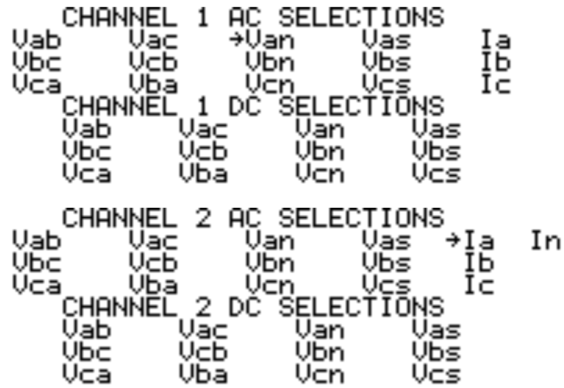
3.6.1 Phase Angle Measurement

The Model 931A 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.

3.6.1.1 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.



3.6.1.2 Performing the Measurement

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

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 if signals of sufficient amplitude are not routed to both Channel 1 and Channel 2.

For a more detailed description of Frequency Measurement, see Section 3.5.4.

3.6.1.3 Phase Preference

If the value displayed for Phase Angle does not appear correct, the phase preference may need changing. Choose either $\pm 180°$ or $0 - 360°$. 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 3.3.1.13) to set the phase preference. Table 3.8 describes the four possible phase settings and the resultant displays for each, when the signals, shown in Figure 3.13, are applied. See Section 3.6 for input connection description.

Range Setting	**Polarity Setting for Ch 2 lagging Ch 1**	**Resultant Reading**
±180°	negative	-60 °
±180°	positive	+60 °
0 – 360°	negative	300°
0 – 360°	positive	60°

Table 3.8: Phase Convention

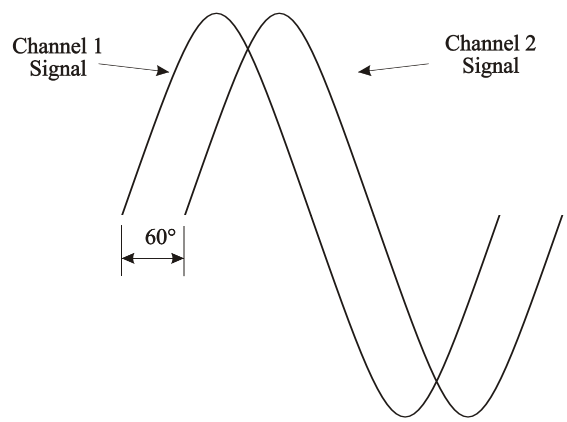


Figure 3.13: Phase Angle Example

3.6.2 Active Power – Reactive Power

The Model 931A 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 3.6 for input connection description.*

3.6.2.1 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
Vab     Vac     →Van     Vas     Ia
Vbc     Vcb      Vbn     Vbs     Ib
Vca     Vba      Vcn     Vcs     Ic
        CHANNEL 1 DC SELECTIONS
        Vab     Vac     Van     Vas
        Vbc     Vcb     Vbn     Vbs
        Vca     Vba     Vcn     Vcs
```

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 configure channel 2 current (e.g. Ia).

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

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.

3.6.2.2 Performing the Measurement

Pressing POWER/VARS will produce a display similar to the one shown below:

```
ACTIVE
POWER        85.771      Watt

REACTIVE
POWER        16.193      Var

CH1=Van 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 931A 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 in 3.4 below:

$$ReactivePower = \sqrt{(VA)^2 - (ActivePower)^2} \tag{3.4}$$

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. Narrow band results are computed in 3.5 and 3.6.

$$ActivePower = V_{fund} \times I_{fund} \times cos(\theta) \tag{3.5}$$

$$ReactivePower = V_{fund} \times I_{fund} \times sin(-\theta) \tag{3.6}$$

3.6.3 Apparent Power – Power Factor

The Model 931A 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 3.6 for input connection description

3.6.3.1 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 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
   CHANNEL 1 DC SELECTIONS
   Vab    Vac    Van    Vas
   Vbc    Vcb    Vbn    Vbs
   Vca    Vba    Vcn    Vcs
```

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. An almost identical menu (except for *In*) will appear:

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

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.

3.6.3.2 Performing the Measurement

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

```
APPARENT
POWER          87.768        VA

POWER
FACTOR         0.9826        Lag

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 as seen in 3.7 and 3.8.
Wide-Band:

$$VA = V_{rms} \times I_{rms} \tag{3.7}$$

$$PF = ActivePower \div VA \tag{3.8}$$

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 as seen in 3.9. Power Factor is the cosine of the angle between V_{fund} and I_{fund} as seen in 3.10.
Narrow-Band:

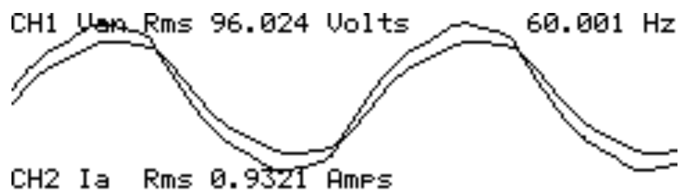
$$VA = V_{fund} \times I_{fund} \quad (3.9)$$

$$PF = Cos(\theta) \quad (3.10)$$

3.6.4 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 wave shapes simultaneously.

The Model 931A 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.

3.7 Timer Measurements

The Model 931A includes a timer for measuring events such as relay contact timing. The timer has two channels, which are optically isolated from the instrument common and from each other. Both inputs can accept various triggering inputs, including:

- Contact opening or closure,
- AC applied or removed (20 - 300 Vrms),
- DC applied or removed (4 - 300 Vdc).

See Section 3.7.2.4, "Select Timer Trigger A" for more information.

3.7.1 Connecting the Inputs

The two timer inputs are labeled "A" and "B", with one black terminal and one red terminal for each input. Apply AC or DC input signals to either channel without regard to polarity.

NOTE: In contact closure or opening mode, external voltage should not be applied to the inputs; only DRY contacts should be used.

3.7.2 Configuring the Timer

Press the CONFIG key to invoke the timer configuration menu, which will be similar in appearance to the following:

```
      TIMER CONFIGURATION MENU
→Function:           Time A To B
 Display Choice:     Seconds
 Hold Mode On Stop:  Disable
 Trigger A:          DC Applied
 Trigger B:          DC Applied
```

Select timer functions using the arrow keys; highlight the desired item and press ENTER to confirm the selection. The following sections describe the individual selections from this menu.

3.7.2.1 Select Timer Function

Select *Function* from the Timer Configuration menu and press ENTER to view the following display:

```
SELECT TIMER FUNCTION
  Time A To B
 →Time A For X Counts
  Time Width Of A
  Rate Of A
  Count A Events
  Count A Gated By B
```

- "**Time A to B**" configures the timer circuitry to display the time elapsed between a valid trigger for the "A" input and a valid trigger for the "B" input.

- "**Time A For X Counts**" configures the timer to display the time elapsed between a valid trigger for the "A" input and the Xth valid trigger for the "A" input.

- "**Time Width of A**" sets the timer circuitry to measure the duration of the triggering event on the "A" input.
- "**Rate of A**" causes the timer to display the rate of a valid triggering event at the "A" input.

  NOTE: The timer triggers without regard to polarity. If selecting DC Applied as the trigger and a symmetric signal of greater than 6 Vpp is applied, the rate displayed will be double the actual frequency.

- "**Count A Events**" configures the timer circuitry to display the number of valid trigger events, which occur on the "input". These may be periodic or random.
- "**Count A Gated By B**" sets the timer circuitry to count events on input "A" only during the time in which a valid trigger condition exists on input "B". The events counted during successive valid "B" input trigger periods are cumulative.

3.7.2.2 Timer Display Choices

To select whether time data is displayed in seconds or in cycles, select Display Choice from the Timer CONFIG main menu and press ENTER. For cycles, the data may be based on 50 Hz, 60 Hz, or the fundamental frequency of the signal present at measurement Channel 1 (Ch 1 Hz).

Select *Display Choice* from the Timer Configuration Menu to view the following display:

```
SELECT DISPLAY CHOICE
      →Seconds
       Cycles (50 Hz)
       Cycles (60 Hz)
       Cycles (Ch 1 Hz)
```

- Seconds sets the timer to display measurement results in seconds.
- Cycles (50 Hz) causes the timer to display the measurement result in cycles, assuming a frequency of 50 Hertz.
- Cycles (60 Hz) causes the timer to display the measurement result in cycles, assuming a frequency of 60 Hertz.
- Cycles (Ch 1 Hz) causes display of measurement results in cycles, using the signal present at Channel 1 as the reference frequency.

3.7.2.3 Hold Mode on Stop

Select Hold Mode On Stop from the Timer Configuration Menu and press ENTER to view the following sub-menu:

```
SELECT HOLD MODE ON STOP
      →Disable
       Enable
```

Use this sub-menu to leave the instrument in the measure hold mode at the end of a timer cycle.

Select Disable to continue normal operation, with all measured parameters being updated continuously.

Select Enable to continue in the measure hold mode at the end of the timer cycle. It then retains values for all measured parameters as of the end of the timer cycle.

3.7.2.4 Select Timer Trigger A

Select Trigger A from the Timer Configuration Menu and press ENTER to view the following display:

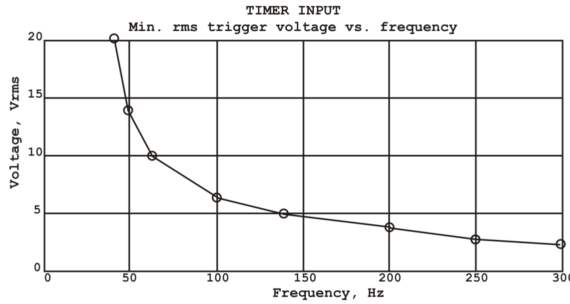
```
SELECT TIMER TRIGGER A
      DC Applied
      DC Removed
      AC Applied
      AC Removed
      Contact Open
     →Contact Closed
```

This sub-menu allows selection of the type of input to be used for the trigger for timer "Channel A". The following are descriptions of each of the choices:

- "**DC Applied**" configures the timer input to trigger with a ± 3 volts DC or greater signal.

- "**DC Removed**" configures the timer input to trigger with removal of a ± 3 volts DC or greater signal.

- "**AC Applied**" configures the timer input to trigger with an AC voltage. The minimum triggering voltage is frequency dependent, but must be greater than 3 volts rms at any frequency. Slight errors may occur, when using this mode of triggering, that depend on the instantaneous voltage. The minimum trigger voltage, as a function of frequency, is shown in the following graph:



NOTE: The minimum rms voltage at 60 Hz is (approx.) 11 volts.

- "**AC Removed**" configures the timer to trigger on the removal of an ac voltage, as described above. The point in time at which the signal last falls below the threshold is interpreted as the trigger. Slight errors may occur, when using this mode of triggering, that depend on the instantaneous trigger voltage. However, this error should not exceed 1 millisecond.

- "**Contact Open**" configures the timer input to recognize the opening of an electrical contact as a trigger event. The threshold is (approx.) 2.9 volts, with a pull-up impedance of (approx.) 47 kilohm to a source voltage of (approx.) 8 volts.

- "**Contact Closed** configures the timer input to recognize the closing of an electrical contact as a trigger event. The threshold is (approx.) 2.6 volts, with a pull-up impedance of (approx.) 47 kilohm to a source voltage of (approx.) 8 volts.

3.7.2.5 Select Timer Trigger B

Press the Timer CONFIG key and select Trigger B from the Timer Configuration Menu and press ENTER. Select the appropriate trigger signal type for timer "Channel B" from this menu. The choices for input "B" are exactly the same as those for input "A". See Section 3.7.2.4.

3.7.3 Timer Measurement Categories

All measurements performed by the timer section of the Model 931A can be classified as either *time* or *count* measurements. The following paragraphs describe both categories.

3.7.3.1 Timer States

The Timer has four states of operation: Standby, Armed, Active, and Stopped. Initially, the timer will be in Standby. After configuring the timer, press the ARM/RESET key to Arm the timer.

A timing cycle begins with a start trigger, and the Timer switches from Armed to Active. When the predetermined stop trigger occurs, the timing cycle ceases, and the timer Stops (except in Count Modes, where it switches to Standby).

The ARM/RESET key functions as a reset key, when the timer stops in time measurement modes, or at any time in count measurement modes. Press ARM/RESET to clear the timer data and reset the display to zero. Pressing ARM/RESET also switches the timer from the Stopped to Standby.

The Model 931A displays the timer-state below the word "Timer." A blank status indicator signifies the instrument is in Standby.

3.7.3.2 Time Measurements

Time Measurement Timer functions return a time value with finite start and stop points. Measurements falling in this category are:

- Time A to B
- Time A for X Counts
- Time Width of A

During these modes of operation, the timer cycles through all four timer states.

3.7.3.3 Count Measurements

Count Measurement Timer functions result in measurements having a finite starting point, then are continuously updated. Measurements falling into this category are:

- Rate of A
- Count A Events
- Count A Gated by B

In these modes of operation, the timer can only be in the Standby, Armed or Active states as described in Section 3.7.3.1. The Stopped State is invalid with these modes.

3.7.3.4 Displaying the Timed Value

The Timer reports a time measurement after the timer stops (the Stopped State). The Model 931A then displays this value until pressing the ARM/RESET key (which returns the timer to the Standby state).

During count measurements, the display continuously updates the count during the measurement cycle. Pressing the ARM/RESET key resets the count display back to zero, and also re-arms the timer.

3.8 Transducer Testing

Testing transducers with the Model 931A is straightforward using an external source, such as a calibrator or source and load box. Also perform live, in-circuit tests. Prior to starting a transducer test the Model 931A automatically makes a self-calibration.

Use the main measurement inputs to precisely monitor the transducer input values. Transducer output may be set to either Measured Quantity, Percent Full Scale, or Percent Error, while simultaneously displaying the transducer inputs. This provides a look at the input and output quantities for better control during the measurement, and fewer chances for measurement or setup errors.

The Model 931A Transducer input uses accurate, optically isolated input sections to accept transducer outputs in the range of 0 − 10 Vdc or 0 − 100 mA. Alternatively, transducer custom pulse outputs may also be tested using the Model 931A Timer A input.

3.8.1 Configuring the Transducer

Press SHIFT > CONFIG to configure transducer measurement section via a series of menus (a second function of TRANSDUCER). The main menu, in the series, is the Transducer Configuration menu, which is similar in appearance to the display shown below:

```
        TRANSDUCER CONFIGURATION
 Input Mode:           3Ph 4W 3E:
 Input Type:           Power
 Input Range:          0.0 - 750.0   W
 Output Range:         4.0 - 20.0    mA dc
→Display Input As:     Measured Quantity
 Display Output As:    Measured Quantity
```

The following paragraphs describe the functions and capabilities of each of the Transducer Configuration menu selections.

3.8.1.1 Input Mode

Select Input Mode from the Transducer Configuration menu and press ENTER to view the following sub-menu:

```
        TRANSDUCER MODE SELECTION
  1Ph 2W 1E:    (Single Phase)
  1Ph 3W 2E:    (Split; VanIa, VcnIc)
  3Ph 3W 2E:    (VabIa, VcbIc)
→3Ph 4W 3E:    (VanIa, VbnIb, VcnIc)
  3Ph 4W 2.5E: (VanIa, 'Vb'Ib, VcnIc)
                (connect Vb to Vn)
```

Select any of the available input modes for testing transducers from this menu. For 3-phase measurements, see description in Section 3.3.2.5. Menu selections are described below and help explain how these selections apply when performing Transducer Testing.

- "**1Ph 2Wire 1E**" sets the Model 931A to measure values in a single-phase circuit, having a hot wire and a neutral wire. Since sequential measurements are not necessary, the internal operating software for the Model 931A utilizes whichever inputs are currently routed to measurement channels 1 and 2.

  For a voltage or frequency transducer, use Channel 1 for the transducer input. For a current transducer, use Channel 2 for the transducer input, and route a voltage or current of the same frequency to Channel 1. Do not select the same input for both Channel 1 and Channel 2. See Figure 3.14.

- "**1Ph 3Wire 2E**" sets the Model 931A to measure values in a circuit having two hot wires and a neutral wire. Commonly referred to as Split-Phase, this type of circuit is generally used to supply residential service. This particular configuration is intended for testing 2-element transducers. See Figure 3.15.

  Use internal operating software definitions for inputs as follows: VanIa, "VcnIc" (i.e., a sequential measurement of the following two combinations: voltage "A" to "N" with current "A", and voltage "C" to "N" with current "C").

- "**3Ph 3Wire 2E**" sets the Model 931A to measure values on a 3-phase delta circuit, for comparison with a 2-element transducer. Use internal operating software definitions for inputs as follows: "VabIa", "VcbIc" (i.e., a sequential measurement of the following two combinations: voltage "A" to "B" with current "A", and voltage "C" to "B" with current "C").

- "**3Ph 4Wire 2.5E**" sets the Model 931A to measure values on a 3-phase delta circuit, for comparison with a 2.5-element transducer. See Figure 3.16.

  Use the internal operating software definitions for inputs as follows: "VanIa"; "VbIb"; and "VcnIc" (i.e., a sequential measurement of the following three combinations: voltage "A" to "N" with current "A", voltage "b" with current "B", and voltage "C" to "N" with current "C"). To create voltage "b", connect the "B" voltage input to the "N" voltage input.

- "**3Ph 4 Wire 3E**" sets the Model 931A to measure values on a 3-phase Y circuit, for comparison to a 3-element transducer. See Figure 3.17. Use internal operating software definitions for inputs as follows: "VanIa"; "VbnIb"; and "VcnIc" (i.e., a sequential measurement of the following three combinations: voltage "A" to "N" with current "A"; voltage "B" to "N" with current "B"; and voltage "C" to "N" with current "C").

  Three-phase display and percent error calculations use the average for V, A, θ (phase), and PF, and the total for W, VAR, and VA.

3.8.1.2 Input Type

Select Input Type from the Transducer Configuration menu and press ENTER to view the following sub-menu:

```
    TRANSDUCER INPUT TYPE
  Volts              Amps
  Phase              Frequency
 →Power              Vars
  Volt-Amps          Power Factor
```

- "**Volts**" sets the Model 931A to make Voltage measurements at the predefined input routed to Channel 1, for comparison to a voltage transducer. For 3-phase configurations, the display shows average voltage. See Section 3.2.2 for a description of AC voltage measurements.

- "**Phase**" sets the Model 931A to measure the Phase Angle between the voltage and current at the predefined inputs, for comparison to a phase angle transducer. For 3-phase configurations, the display shows average phase angle. See Section 3.6.1 for a description of phase measurements.

- "**Power**" sets the Model 931A to calculate active power (watts). Based on voltage and current measurements from the predefined inputs, the results are compared to an active power transducer. For three-phase configurations, the display shows total active power. See Section 3.6.2 for a description of power measurements.

- "**Volt-Amps**" sets the Model 931A to calculate apparent power (VA). Based on voltage and current measurements from the predefined inputs, the results are compared to an apparent power transducer. For three-phase configurations, the display shows the total apparent power. See Section 3.6.3 for a description of apparent power measurements.

- "**Amps**" sets the Model 931A to make current measurements on the predefined input routed to Channel 2 and compares it to a current transducer. Route input to measurement Channels 1 and 2 if only a current signal is available.

  If available, route synchronous voltage signal to channel 1. For three-phase configurations, the display shows average current. See Section 3.2.3 for a description of AC current measurements.

- "**Frequency**" sets the Model 931A to measure frequency at (predefined) channel 1, for comparison to a frequency transducer. The displayed frequency actually represents the instantaneous value, which is updated with each measurement cycle. See Section 3.5.4 for a description of frequency measurements.

- "**Vars**" sets the Model 931A to calculate reactive power (vars) based on voltage, current, and phase measurements from the predefined inputs. The results are compared to a reactive power transducer. For three-phase configurations, the display shows the total reactive power. See Section 3.6.2 for a description of reactive power.

- "**Power Factor**" sets the Model 931A to calculate power factor based on voltage and current from the predefined inputs. The results are compared to a power factor transducer. For three-phase configurations, the display shows average power factor. See Section 3.6.3 for a description of power factor measurements.

3.8.1.3 Input Range

Select Input Range from the Transducer Configuration menu and press the ENTER key to view the available input ranges. The displayed range selection menu varies and depends on the selected input type (see Section 3.8.1.2 for a description of available Input Types). When the Model 931A is configured to test a voltage transducer, the display shows following selection menu:

```
    TRANSDUCER INPUT POWER
 0 - 100           0 - 1000
 0 - 250           0 - 1500
 0 - 500           0 - 2500
→0 - 750           Custom
```

Custom allows the user to determine the upper and lower limits of the measurement range. Determine a custom range, as a part of this sub-menu, for all input types. See Section 3.3.3 for Data Entry Function description.

3.8.1.4 Output Range

Select Output Range from the Transducer Configuration menu to view the following sub-menu:

```
     TRANSDUCER OUTPUT
 0 - 0.5 mA     0 - 50 mV
 0 - 1 mA       0 - 1 V
 0 - 20 mA      0 - 5 V
→4 - 20 mA      0 - 10 V
 0 - 50 mA      Custom V
 0 - 100 mA     Custom mA
 20 - 100 mA    Custom Pulse
```

The Model 931A allows these output ranges when the transducer outputs are connected to the transducer terminals on the front panel.

Within the ranges shown, the Model 931A accepts either voltage or current signals. Refer to Section 3.8 for details on connecting transducer inputs, and Section 3.3.3 for a description on data entry.

- Custom V allows the user to enter a voltage range within the limits of 0 to 10 volts DC.
- Custom mA allows the user to enter a current range within the limits of 0 to 100 milliamperes DC.
- Custom Pulse allows the user to setup the Model 931A to accept a calibrated pulse from the transducer that is proportional to the measured transducer value.

3.8.1.5 Display Input As

Select Display Input As from the Transducer Configuration menu and press the ENTER key to view the following sub-menu:

```
TRANSDUCER INPUT DISPLAY MODE
     →Measured Quantity
      Percent Full Scale
```

- "Measured Quantity" displays the value present at the Model 931A measurement inputs in actual measurement units (e.g. volts, amps).
- "Percent Full Scale" displays the value present at the Model 931A measurement inputs as a percentage of full-scale. Full-scale is defined by the lower and the upper limit of the currently selected input range (see Section 3.8.1.3 for a description of Input Ranges).

3.8.1.6 Display Output As

Select Display Output As from the Transducer Configuration menu to display the following sub-menu:

```
TRANSDUCER OUTPUT DISPLAY MODE
     →Measured Quantity
      Percent Full Scale
      Percent Error
```

- "**Measured Quantity**" sets the Model 931A to display the actual value measured at the output of the transducer under test (i.e., volts or milliamperes).
- "**Percent Full Scale**" displays the measured value (at the output of the transducer under test) as a percentage of full-scale. Full-scale is defined by the lower and the upper limit of the selected output range. Does not apply for Custom Pulse.
- "**Percent Error**" displays the measured error of the transducer based on the measured input and output quantities.

  To properly utilize the Percent Error feature, enter the following: (1) the upper and lower transducer input quantities and (2) the upper and lower transducer output range limits. Setting the output range limits are critical for transducers having a lower output range limit of other than zero. For example a typical transducer may have a $4-20$ mA output. With such a transducer, zero at the input corresponds to 4 mA at the output.

3.8.2 Connecting the Inputs

If needed, use the main measurement inputs on the Model 931A as the input for transducer tests at any value up to their rated maximum (see Specifications in Section 4).

Connect the voltage and current measurement inputs according to the type of transducer being tested. The operating software defines which combination of inputs to use for testing of each type of transducer (except 1-Phase 2-Wire). These definitions are described in the Transducer Mode Selection menu, shown in Section 3.8.1.1.

Figures 3.14 through 3.17 illustrate various examples of connections for transducer testing.

Use any of the voltage and current inputs to measure single-phase, two-wire transducers since they do not require sequential measurements. Use channel 1 for voltage and channel 2 for current, as channel 1 is used as a reference channel, as the voltage signal is typically the most stable signal.

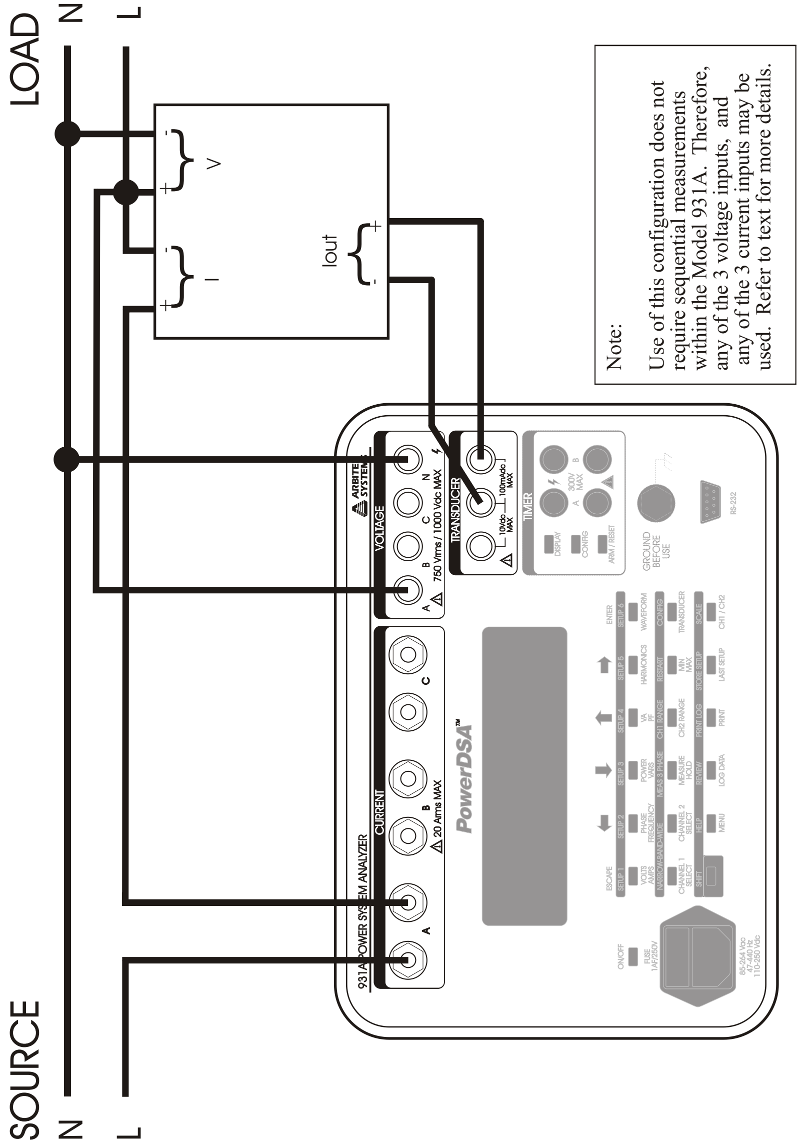


Figure 3.14: 1-Phase, 2-Wire, 1-Element Transducer Test

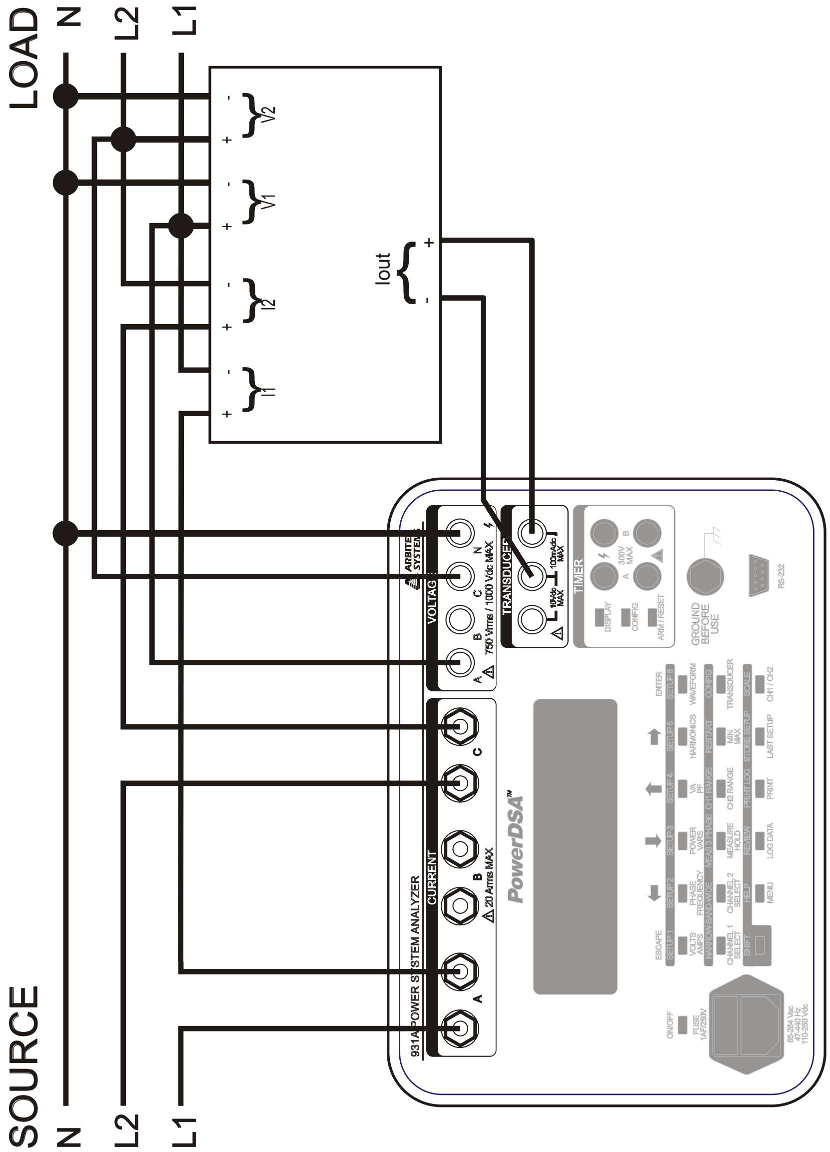


Figure 3.15: 1-Phase, 3-Wire, 2-Element Transducer Test

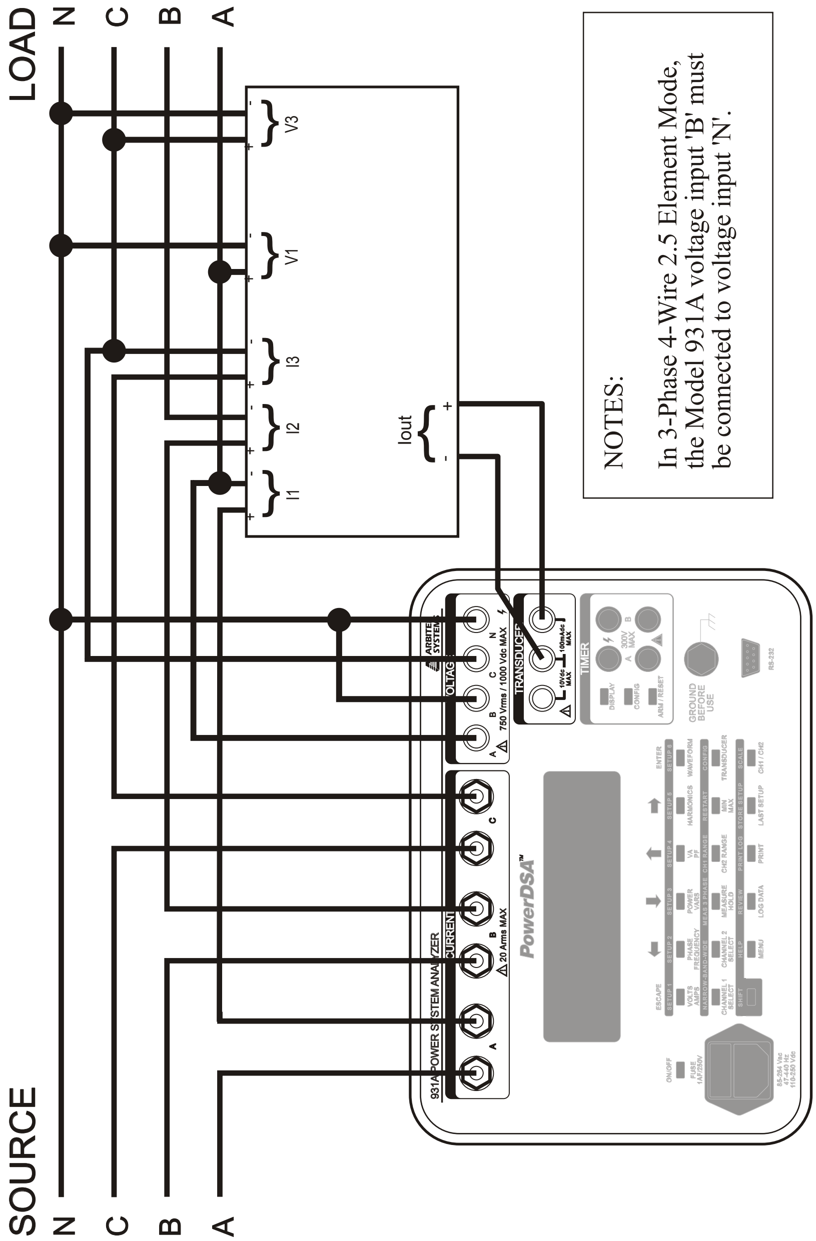


Figure 3.16: 3-Phase, 4-Wire, 2.5-Element Transducer Test

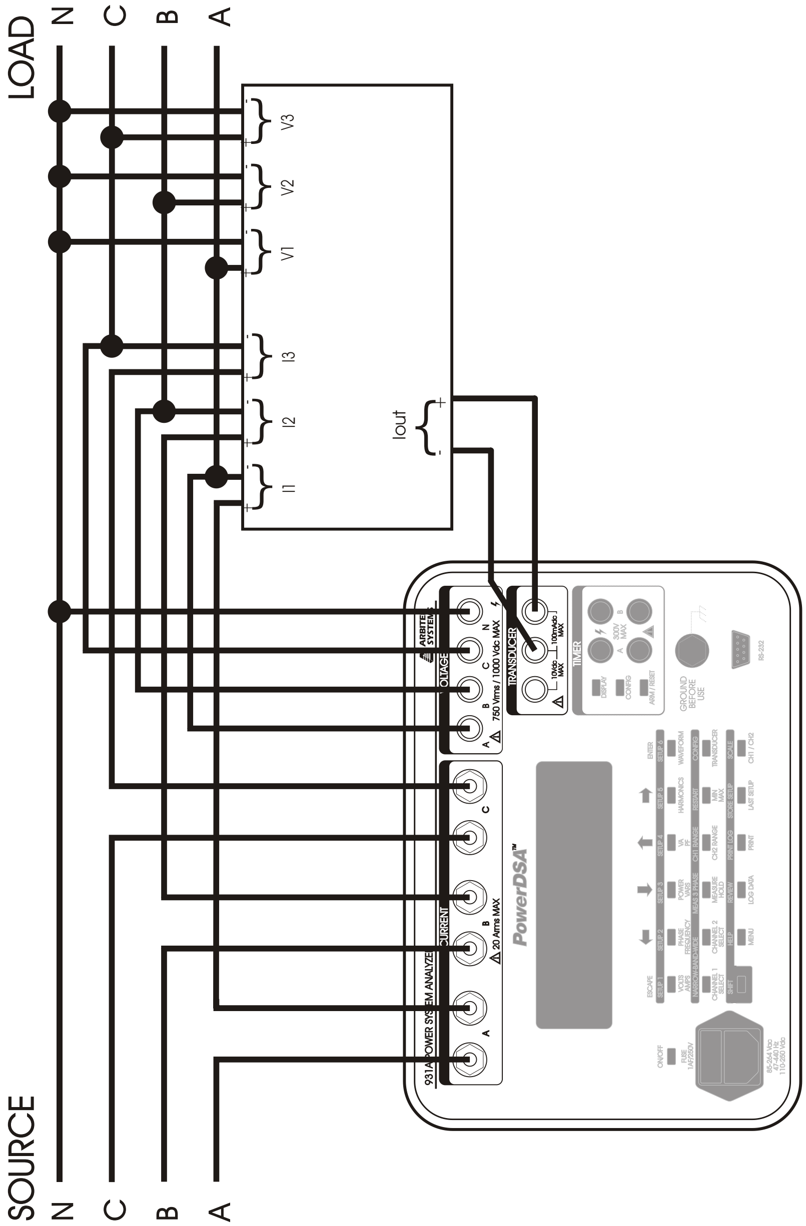


Figure 3.17: 3-Phase, 4-Wire, 3-Element Transducer Test

3.8.3 Connecting the Outputs

Figures 3.14 through 3.17 illustrate the Transducer Signal Outputs connected between the transducer current input (far right) and common (middle). If testing transducers with voltage outputs, connect them between the transducer voltage input (left) and common (middle).

NOTE: Be certain to configure the Model 931A to accept the type of transducer signal and range, whether voltage or current output. Section 3.8.1.4 describes available Output Ranges.

3.8.4 Performing the Measurement

Once in the Transducer Configuration Menu, press the ESCAPE key to automatically place the unit in the transducer measurement mode. To access the Transducer Configuration Menu, press SHIFT then CONFIG.

Instrument configuration determines the appearance of the display during transducer measurements. The upper number represents the transducer input, and the lower number represents the transducer output. Display configuration determines whether measurement results are presented as a measured value, or as a percent of full-scale. Sections 3.8.1.5 and 3.8.1.6 describe the Display Modes.

Additionally, the Model 931A can present the lower number as a percentage of error in the transducer. Percentage error is determined by comparing the ratio of the input and output values to the ratio of the input and output ranges. Section 3.8.1.6 describes how to set the Model 931A to display percentage error in transducer measurements.

3.8.5 Custom Pulse, or Contact Output Tests

3.8.5.1 Choosing a Test Method

Testing transducers with contact outputs can be accomplished by using the Custom Pulse feature of the Model 931A. By following the steps outlined below, most transducers with contact outputs may be tested simply and accurately.

1. Determine the type of transducer output.
2. Configure the Transducer menu, on the Model 931A.
3. Configure the Timer menu, on the Model 931A.
4. Setup the required test equipment and transducer.
5. Test the transducer.

3.8.5.2 Determine the Transducer Type

Most transducers with contact (or pulse) outputs use either an electromechanical or a solid-state relay. If the transducer has an electromechanical relay at the output, it is important to use the Debounce feature on the Model 931A. Otherwise, do not use it.

3.8.5.3 Configuring in the Transducer Menu

Press SHIFT then CONFIG to access the Transducer Configuration menu. Set each of the six categories in the Transducer Configuration menu that best fits the transducer being tested. Use the arrow keys and ENTER to make and confirm selections. As each of the six categories is setup, the arrow cursor moves down to the next category.

The sample menu shown below pertains to a 3-phase power transducer illustrated in Figure 3.18.

```
          TRANSDUCER CONFIGURATION
→Input Mode:          3Ph 4W 3E:
 Input Type:          Power
 Input Range:       0.0 - 1500.0    W
 Output Range:        1.00000  Whr/Pulse
 Display Input As:    Measured Quantity
 Display Output As:   Percent Error
```

Make these selections as follows (as shown in the screen above).

1. **Input Mode** - select the Phase, number of Wires and Elements (e.g. 3P 4W 3E).

2. **Input Type** - select Volts, Phase, Power, Volt-Amps, Amps, Frequency, Vars, or Power Factor (e.g. Power).

3. **Input Range** - select the transducer range being tested (e.g. 0 1500).

4. **Output Range** - this selects the Custom Pulse feature. Choose Custom Pulse (only) for this menu item. Note that after Custom Pulse is selected (under the Transducer Output menu) the bottom line will clear and read Watt-hours per pulse = 0.00000. Use the right and left arrows to move the cursor and the up and down arrows to change the digit value. 100 (watt hours per pulse) is the largest acceptable value

5. **Display Input As** - select either Measured Quantity or Percent Full Scale (e.g. the above settings will display Measured Quantity in kWatts).

6. **Display Output As** – select either Measured Quantity or Percent Error. Although the menu choices include Percent Full Scale, only Measured Quantity and Percent Error pertain to Custom Pulse.

The sample Transducer Configuration Menu shown below illustrates settings for a different transducer using the "Rate of A" Function instead of "Time A to X Counts." Notice the large difference in Output Range compared to the "Time A to X Counts" configuration above.

```
        TRANSDUCER CONFIGURATION
 Input Mode:          3Ph 4W 3E:
 Input Type:          Power
 Input Range:       0.0 - 1000.0    W
 Output Range:        0.00001  Whr/Pulse
→Display Input As:    Measured Quantity
 Display Output As:   Percent Error
```

When all of the six categories are set up correctly, press ESCAPE to return to the main menu. If initially setting up a transducer custom pulse test, proceed to the section on Timer Configuration below.

3.8.5.4 Configuring in the Timer Menu

Press the Timer CONFIG key to access the Timer Menu. A sample menu is shown below.

```
         TIMER CONFIGURATION MENU
 →Function:           Time A For X Counts
  Display Choice:     Seconds
  Hold Mode On Stop:  Disable
  Trigger A:          AC Applied
  Trigger B:          Contact Closed
* Debounce A 'ON'     Debounce A 'OFF'
  Debounce B 'ON'   * Debounce B 'OFF'
```

Only two selections under Timer Function apply to the Custom Pulse feature: "Time A For X Counts" and "Rate of A."
Make the Timer Configuration selections as follows:

1. **Function** – select either Time A For X Counts, or Rate Of A. Use Time A for X counts if the contact closure rate is < 1/sec. Use Rate of A if the contact closure rate is > 1/sec. For more details on which function to choose, see below under "Contact Closures < 1/second", or "Contact Closures > 1/second."

```
SELECT TIMER FUNCTION
  Time A To B
 →Time A For X Counts
  Time Width Of A
  Rate Of A
  Count A Events
  Count A Gated By B
```

2. If choosing "Time A For X Counts", a numerical value will replace X awaiting confirmation. Use the Up or Down arrow keys to change this value.

3. **Display choice** – select Seconds

4. **Hold Mode On Stop** – select Disable

5. **Trigger A** – select Contact Closed or Contact Open

6. **Trigger B** – do not use this item for the Custom Pulse function.

7. **Debounce A** - select "ON" for electromechanical contacts, "OFF" for solid-state contacts.

8. **Debounce B** - do not use this item for the Custom Pulse function.

3.8.5.5 Contact Closures < 1/second

The best selection for contact closures < 1/second is Time A For X Counts. This function allows the Model 931A to measure transducers with contact outputs that are relatively slow - in the range of seconds between pulses. Typical devices that fit into this category could be transducers.

1. Select Function, in the Timer Configuration Menu, and press ENTER.

2. Select Time A For X Counts in the Select Timer Function menu, using the arrow keys and press ENTER.

3. When ENTER is pressed, a numerical value replaces X and awaits adjustment or confirmation.

4. Use the UP or Down arrow keys to increase or decrease the number of contacts.

5. Press ENTER to confirm the selection and return to the Timer Configuration menu.

Any time X is set to a value greater than 1, in the Time A to X Counts function, the Model 931A computes average output values, or the % error. It does this by measuring the overall time for multiple contacts (defined by X) and divides that time by the number of contact closures. At the end of a test, the Model 931A displays and holds the Input and Output values until pressing ARM/RESET, which begins a new test.

3.8.5.6 Contact Closures > 1/second

"Rate of A" is generally used for calibration standards (transducers) with output rates normally much greater than 1 Hz. Notice the values listed in the Timer Configuration Menu. Remember that Trigger B and Debounce B are not used in Custom Pulse transducer measurement functions.

```
          TIMER CONFIGURATION MENU
  Function:            Rate Of A
 →Display Choice:      Seconds
  Hold Mode On Stop:   Disable
  Trigger A:           AC Applied
  Trigger B:           Contact Closed
* Debounce A 'ON'      Debounce A 'OFF'
  Debounce B 'ON'    * Debounce B 'OFF'
```

1. Press the Timer CONFIG key to access the Timer Configuration Menu. With the cursor, select "Function" and press ENTER to access the Timer Function menu.

2. In the Timer Function menu select "Rate of A" and press ENTER.

```
SELECT TIMER FUNCTION
  Time A To B
  Time A For X Counts
  Time Width Of A
 →Rate Of A
  Count A Events
  Count A Gated By B
```

3. The Rate of A Function also continuously updates the transducer measurements during a test.

In this example, "Rate of A" was chosen based on the nameplate rating of 0.00001 Whr/pulse. Dividing the number of Transducer Input Watts by 0.00001 Whr/pulse and dividing by 3600 sec/hour gives a pulse rate of approximately 20,000 pulses per second. The calculation is shown in 3.11 below.

(3.11) $(718.8W \div 0.00001Whr/pulse) \div 3600sec/hr = 19,966pulses/sec$

3.8.5.7 Equipment Setup

Connect the transducer pulse output to the Model 931A Timer A input terminals with suitable cables. The Custom Pulse function works only with Timer Input A. Connect the transducer and the Model 931A to a source providing the required output levels for testing the transducer. Refer to Figure 3.18 for an illustration of using a power transducer.

Note: Check the Model 931A maximum ratings prior to applying power, to avoid damaging the equipment.

Always consult the manufacturers original documentation for the power source and the transducer for proper test setup. This may be a manual, or simply be the nameplate on the transducer.

3.8.6 Performing a Test

3.8.6.1 For Contact Closures < 1/second

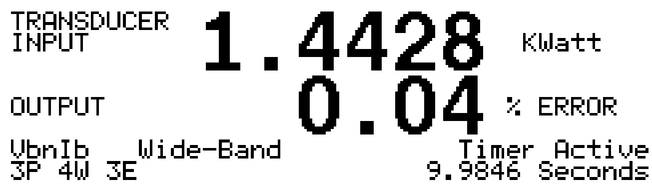
Use Time A For X Counts. After setting up the test and configuring the Model 931A, apply the input power source to the transducer and Model 931A. Refer to Figure 3.18. Press the TRANSDUCER key to view the standard measurement screen. Initially, the Model 931A display will appear similar to the screen below.

1. Allow a few seconds for the Transducer Input value to stabilize.

2. Press the ARM/RESET key twice to reset and arm the timer function. For $X = 1$, the first pulse starts the timer and the next pulse concludes the timing interval. If using multiple counts per measurement ($X > 1$), the timer will begin counting on the first pulse and stop with the last pulse.

3. During the custom pulse test the OUTPUT value will change to dashes, as shown below and the date (in the lower right) will be replaced with a timer value, incrementing in seconds.

4. When the test is complete the OUTPUT measurement value will replace the dashes, and the timer value will freeze, indicating the transducer input, transducer output and the number of seconds. The Model 931A will be placed in Hold Mode.



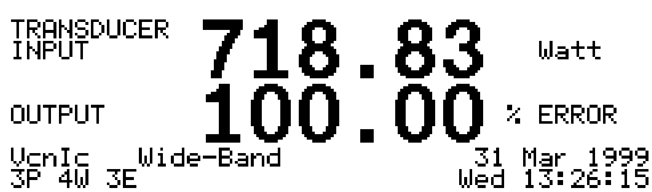
5. To repeat the test with the same or different transducer input, press the ARM/RESET key, adjust the source as necessary, allow the transducer input display to stabilize and press the ARM/RESET key again.

6. To configure new test parameters, press either SHIFT then CONFIG (transducer) or CONFIG (timer) to change the measurement settings. After re-configuring the test parameters, press the TRANSDUCER key and the Model 931A is ready for another test. To start the next test, press the ARM/RESET key twice.

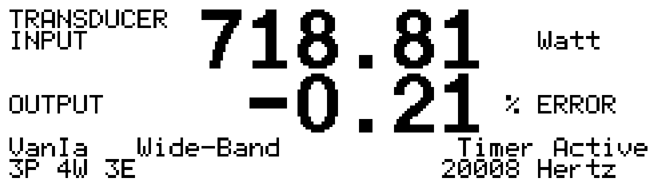
3.8.6.2 For Contact Closures > 1/second

After setting up the test and configuring the Model 931A, apply the input power source to the transducer and Model 931A. Refer to Figure 3.18.

1. Press the TRANSDUCER key to view the standard measurement screen. Press the ARM/RESET key again if the display is not indicating a reasonable output value, as illustrated below.



2. If date and time information is showing (found in the lower right corner of the display) press the ARM/RESET key. It should immediately begin measuring the transducer. Also, the Timer information (including the contact or pulse output rate in Hertz) should appear and replace the date and time information. The screen below illustrates the Model 931A measuring a transducer using "Rate of A."



3. Using the "Rate of A" Function, the Model 931A should continually update the measurement values. The Model 931A also cycles between each measured phase indicated in the lower left corner of the display.

4. The Transducer Input value indicates the total input, in this case three-phase power.

5. Adjust the source for subsequent tests to be performed.

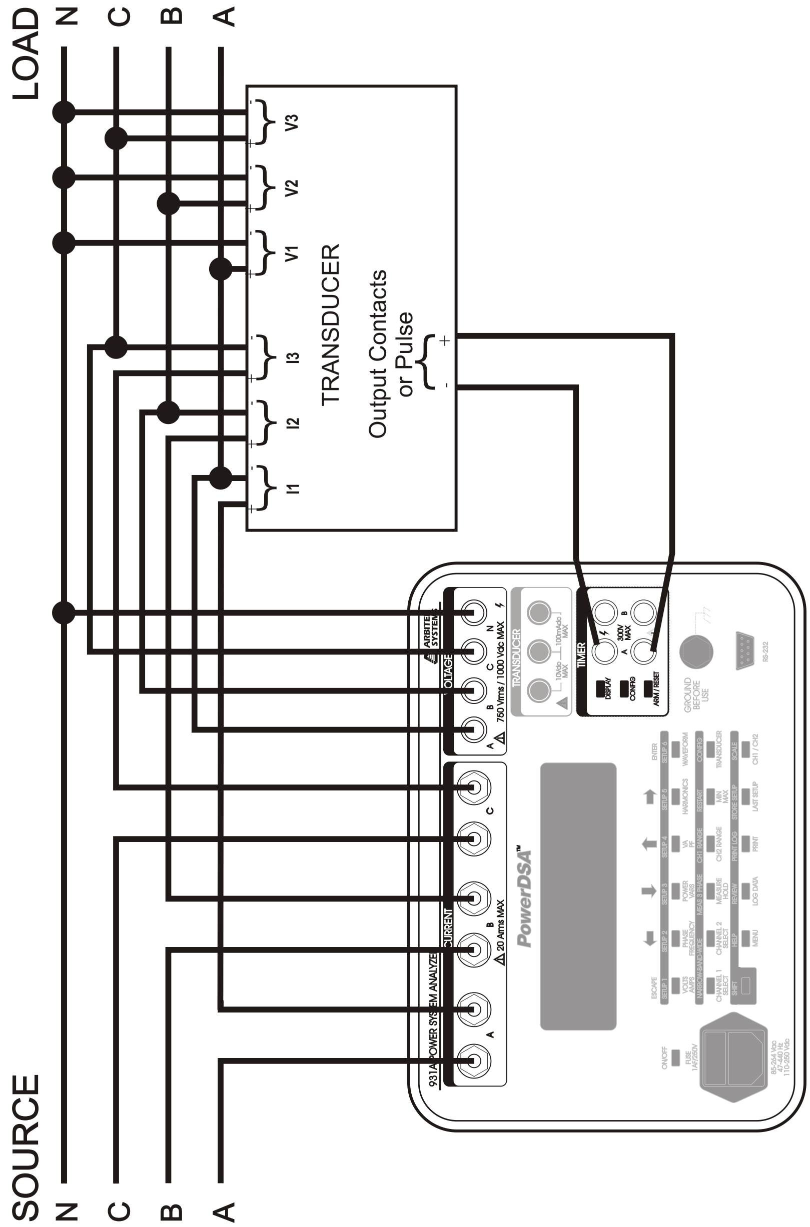


Figure 3.18: 3-Phase, 4-Wire, 3-Element Custom Pulse Transducer Test

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 931A. 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 931A, whether for magnitude or phase, effectively cancels offset errors. To activate and configure the scaling function, press SHIFT then SCALE. See Section 3.3.2.17 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 931A. 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 3.3.1.17.

Example: measure the ratio of a PT by performing the following steps:

1. Use Channel 1 to configure the Model 931A to measure the voltage at the input of the PT.
2. Use Channel 2 to configure the Model 931A to measure the output of the PT.
3. Apply the operating voltage to the input of the PT, and press the CH1/CH2 key.
4. 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 931A 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, along with Timer and Transducer results. 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.hen the Model 931A 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 7
0  Clear All!  ( Key Clears A File)
→1   8Nov11 17:06:02    1 Standard
 2   8Nov11 17:07:31    1 3 Ph Tab
 3   8Nov11 17:08:11    1 3 Ph Vec
 4   8Nov11 17:08:24    1 Harmonic
 5   8Nov11 17:08:36    1 Waveform
 6   8Nov11 17:08:45    2 Standard
```

This display shows that there are 7 data records, with 97% of the allotted memory space remaining. The first 6 data records are shown. To view the remaining record(s) 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. These parameters are as follows: Volts, Amps, Phase, Frequency, Watts, Vars, Volt-Amps, Power Factor, Timer, Transducer and CH1/CH2 Data.

The Model 931A 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 *every stored record* scroll the cursor to "0 Clear All" 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 931A can print or export data, in several formats, directly over the RS-232C communications port. Refer to Sections 2.6, 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 931A. 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 931A 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). 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, Windows HyperTerminal and Tera Term Pro. 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 931A 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 931A, match those of the host computer (refer to Section 3.3.1.13).

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 931A to make the desired measurement, or select a stored data record and configure the Model 931A to display the desired data.
5. Press the PRINT key and wait for the prompt message to disappear. At this point, the Model 931A 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 931A and the host computer to establish communication and begin the transfer.

3.11.5 Spreadsheet

Use this mode to 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 931A 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 931A 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	Timer	Transducer
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.

Standard Data, continued

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.

3.11.5.2 3-Phase Data

The Model 931A 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 sequence.
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 Timer Data

The Model 931A exports timer data when executing the print operation. This occurs while performing measurements or reviewing stored data in the timer mode of operation.

Timer data is exported with the following format:

log data #, date, time, min/max/normal, function, trigger A, trigger B, cycles/sec, timer result

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
Timer Result:	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.
Function:	Describes the type of Timer measurement. For details on the different types of timer measurements, refer to Section 3.7.
Trigger A:	Describes the type of trigger input signal used for the A trigger.
Trigger B:	Describes the type of trigger input signal used for the B trigger.
Cycles/Sec:	Describes whether the time value displayed for the timer measurement is in seconds or cycles. For further details on timer operation, refer to Section 3.7.
Timer Result:	The time value for the current measurement or record.

3.11.5.4 Transducer Data

The Model 931A exports transducer data when executing the print operation. This occurs while performing measurements or reviewing stored data in the transducer mode of operation. Transducer data is exported with the following format:

log data #, date, time, input value, input units, output value, output units

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.
Input Value:	The input value measured or displayed when the record was stored or exported.
Input Units:	The unit or measurement used for the input value.
Output Value:	The output value measured or displayed when the record was stored or exported.
Output Units:	The unit or measurement used for the output value.

3.11.5.5 Harmonic Data

The Model 931A 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.

3.11.5.6 Waveform Data

The Model 931A 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 Vrms (under range to 200 mV) 2 – 1000 Vdc (under range to 300 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 Arms (under range to $<$ 1 mA)
Burden:	0.01 Ω, maximum
Isolation:	1000 Vpeak (transformer coupled)

4.1.3 Transducer

Inputs:	Two (one for voltage and one for current, common return terminal)

Transducer, continued

Range:	±10 Vdc ±100 mAdc
Input Impedance:	100 kΩ (voltage)
Burden:	20 Ω nominal, including PTC resettable fuse 1 kΩ for ≦ 1 mA

4.1.4 Timer

Inputs:	Two
Maximum:	300 Vrms or DC
Isolation:	300 Vrms
Threshold: Contact open	2.9 Volts
Threshold: Contact closed	2.6 Volts
Source Impedance (for dry contact):	≈ 25 kΩ

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 DC Voltage: 0.1% of reading + 25 mV (typical)

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 Timer

Inputs:	Two, voltage or dry contact
Input Ranges:	4 to 300 Vdc 20 to 300 Vrms
Isolation:	300 Vrms (each channel) optical
Range:	0.0001 to 9999.9 seconds 0.01 to 999999 cycles
Accuracy:	0.005% of reading + 1 digit
Trigger Error: (for AC Trig.)	1 millisecond maximum, 0.15 milliseconds @ 120 Vrms

4.2.5 Transducer

Accuracy:	0.05% of reading + 0.01% of range

4.2.6 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

4.2.7 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:	134mm(h) by 31mm(v).
Backlight:	Cold-cathode fluorescet lamp.
Auto Mode:	Shutdown 10 seconds after last keystroke.

4.3.4 Keypad

Main Keyboard:	18 multi-function keys.
Timer Control:	3 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 V, 6.5 Ah, 8 hours of operation.
Charger:	Automatic, monitors $\Delta T/\Delta t$, $\Delta V/\Delta t$, and time.
Charge Time:	8 hours.
Auto-Shutdown:	10 minutes with no activity or input.

4.3.7 Serial Port

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 931A 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 931A 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.
0,1,1,0,0,0TCF	Sets the Timer configuration as follows: Display in seconds; Function to Time A to next A; Enable Hold Mode on Stop; A & B triggered by DC applied.
1999:01:15:12:30:00TDS	Sets the date and time to January 15, 1999, 12:30 p.m. Model 931A 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 (BAT)

Command: **BAT**

Returns Battery and charging status.

Return Value	Meaning
0	Nothing
1	Low Battery
2	Charging

A.3.2 Backlight Set (BLT)

Command: **#BLT**

Controls the front panel LCD backlight.

#	Response
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 (CCH)

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.

#	Action
1	Select Channel 1
2	Select Channel 2
ac/dc#	
0	DC
1	AC
range#	
0 . . . 8	(see SRG command (below)
gain#	Corrected gain = uncorrected gain $\times$ (1 + Gain# $\div$ 1000)
ph/off#	Corrected Phase = uncorrected phase + (ph/off# $\times$ frequency) Offset = ph/off# $\div$ 1000 (DC)

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 (CCR)

Command: **CCR**

Displays the measured results (on the Model 931A) 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 (CHS)

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

Specifies the input signal for the selected channel as follows:

in#	AC Config.	in#	AC Config.	in#	DC Config.
0	Vab	11	Vcs	15	Vab
1	Vbc	12	Ia	16	Vbc
2	Vca	13	Ib	17	Vca
3	Vac	14	Ic	18	Vac
4	Vcb	27	Vb(Ch1 only)	19	Vcb
5	Vba	28	In (Ch2 only)	20	Vba
6	Van			21	Van
7	Vbn			22	Vbn
8	Vcn			23	Vcn
9	Vas			24	Vas
10	Vbs			25	Vbs
				26	Vcs

Ch#	To select
1	Channel 1
2	Channel 2

A.3.6 Calibrate Input (CIN)

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

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

#	AC Config	in#	AC Config	in#	DC Config	in#	DC Config
0	Vab	8	Vcn	15	Vab	24	Vas
1	Vbc	9	Vas	16	Vbc	25	Vbs
2	Vca	10	Vbs	17	Vca	26	Vcs
3	Vac	11	Vcs	18	Vac		
4	Vcb	12	Ia	19	Vcb		
5	Vba	13	Ib	20	Vba		
6	Van	14	Ic	21	Van		
7	Vbn	27	Vb	22	Vbn		
		28	In	23	Vcn		

gain#	Corrected gain = uncorrected gain × (1 + gain# ÷ 1000)
Ph/off#	Corrected phase = uncorrected phase + (ph/off# × freq) Offset = ph/off# ÷ 1000 (DC)
s/r#	Action
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 Transducer Configuration (COT)

Command: **m#,int#,infs#,inll#,dco#,ofs#,oll#,oll#,di#,do#COT**

Configures the parameters necessary for transducer calibration.

m#	Mode	Input
0	1 phase 2 wire single phase	(select inputs, use CHS cmd)
1	1 phase 3 wire split phase	(Van,Ia; Vcn,Ic)
2	3 phase 4 wire	(Vab,Ia; Vcb,Ic)
3	3 phase 4 wire	(Van,Ia; Vbn,Ib; Vcn,Ic)
4	3 phase 4 wire 2.5 element	(Van,Ia;‘Vb’,Ib; Vcn,Ic) (connect Vb to Vn)

(Transducer Configuration, continued)

int#	Input Type	infs#	Input Full Scale
0	Volts		0 to 9999.9
1	Amps		
2	Phase	inll#	Input Lower Limit
3	Frequency		0 to 9999.9
4	Power		
5	Vars	dco#	DC Output
6	Volt Amps	0	Volts
7	Power Factor	1	Millamperes
ofs#	Output Full Scale (DC)	di#	Display input as:
	0 to ±10 VDC or	0	Measured quantity
	0 to ±100 mAdc	1	% full scale
oll#	Output Lower Limit(DC)	do#	Display Output as:
	0 to ±10 Vdc or	0	Measured Quantity
	0 to ±100 mAdc	1	% full scale
		2	% error

A.3.8 Daylight Saving Time, Set (DAY)

Command: **#DAY**

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

#	Designation
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.3.9 Display Dump, ASCII (DDA)

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.3.10 Data Dump, Bitmapped (DDB)

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 $\approx$ 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.3.11 Store Calibration Data in EEPROM (EEP)

Command: **mmddyyEEP**

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.3.12 DSP Frequency Calibrate (FRD)

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

Sets or returns the Calibration Constant to correct the DSP frequency.
1 + (c# ÷ 1,000,000) multiplies the frequency measurements made by the DSP.

c#	Frequency Calibration Constant

s/r#	Action
0	Set Calibration Constant
1	Return Calibration Constant

Return format: Numeric ASCII string.

A.3.13 Frequency, Return (FRQ)

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.

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

A.3.14 Timer Calibrate (FTM)

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

Sets or returns the calibration constant to correct the timer time and frequency reference. 1 + (c# ÷ 1,000,000) multiply the time measurements made by the timer.

c#	Timer Calibration Constant

s/r#	Action
0	Set Timer Calibration
1	Return Timer Calibration

A.3.15 Harmonics Display (HAR)

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#.

Ch#	To select
1	Channel 1
2	Channel 2

A.3.16 Harmonic Magnitude, Return (HMA)

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.

harm#	To select
2–50	Harmonic number (2 through 50)
1	THD (Total harmonic distortion)

ch#	
1	Channel 1
2	Channel 2

Response: Numeric ASCII string.

A.3.17 Harmonic Phase Angle, Return (HPH)

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.

harm#	To select
2–50	Harmonic number (2 through 50)
1	THD (Total harmonic distortion)

ch#	
1	Channel 1
2	Channel 2

Response: Numeric ASCII string.

A.3.18 Power Down (KIL)

Command: **KIL**

Turns unit OFF.

A.3.19 Log Data (LOG)

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.3.20 Last Setup (LSU)

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.3.21 Magnitude (Channel), Return (MAG)

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 (RMS, mag, or DC).

ch#	Selection
1	Channel 1
2	Channel 2

Q#	Selection
0	RMS
1	Peak
2	DC mode only
3	Narrow Band
4	Residual

A.3.22 Measure Hold (MHD)

Command: **#MHD**

#	Result
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.3.23 MIN/MAX, Display (MMN)

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.

#	Response
0	Displays present values
1	Displays minimum values
2	Displays maximum values
3	Displays average value

A.3.24 Bandwidth-Narrow, Set (NAB)

Command: **NAB**

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

A.3.25 Overload Status (OVD)

Command: **OVD**

Returns:

Value	Status
0	No overload
1	Channel 1 overload
2	Channel 2 overload
3	Both Channels 1 and 2 overload

A.3.26 Phase/Frequency Display (P_F)

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.3.27 Power/Vars Display (P_V)

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.

#	To select
0	(or absent) Power, Vars
1	Watt hours, Var hours

A.3.28 Power Factor, Return (PFA)

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.3.29 Phase Mode, Set (PHM)

Command: **mdPHM**

Starts single or 3 phase measurement mode.

m	Mode	d	Mode
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.3.30 Phase, Return (PHS)

Command: **PHS**

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

Response: Numeric ASCII string.

A.3.31 Power, Return (PWR)

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.3.32 Range Hold, Set (RHD)

Command: **ch#RHD**

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

Ch#	To select
1	Channel 1
2	Channel 2

A.3.33 Logged Data, Review (RLD)

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 931A display, overwriting current measurement data and placing the Model 931A 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.3.34 Range Hold, Release (RRH)

Command: **ch#RRH**

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

ch#	select
1	Channel 1
2	Channel 2

A.3.35 MIN/MAX, Restart (RST)

Command: **RST**

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

A.3.36 Transducer Channel (SCC)

Command: **ref#,r1#,r2#,s/r#SCC**

Includes DC Reference, and Shunt Resistance Values – Set or Return (see Note 1 on page 105). Sets or returns the transducer channel DC reference and shunt resistance values as follows:

ref#	Reference voltage in volts
r1#	9 ohm shunt resistance in ohms. This calibrates the 1 to 100 mA DC current ranges.
r2#	1000 ohm plus 9 ohm shunt resistance in ohms. This calibrates the 0 to 1 mA DC current ranges.

s/r#	
0	To store reference and resistance values.
1	To send reference and resistance values.

A.3.37 Serial Number (SER)

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

Sets or returns instrument Serial Number. See Note 1 on page 105.

Serial# (s/r#)	ASCII number (5 digits)
0	To enter serial number
1	To return serial number

A.3.38 Flash Log (SLO)

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 DATA 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.3.39 Scale On/Off (SOO)

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, including PT/CT, OFF
1	All individual scale factors ON
2	Enable PT/CT ratios

A.3.40 DSP Speed (SPD)

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

#1	To select
0	Slow mode
1	Fast mode
s/r#	
0	To set speed
1	To return speed

A.3.41 Phase Preference, Set (SPH)

Command: **#SPH**

Specify the format for phase display.

#	Phase Format
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.3.42 Range, Set (SRG)

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:

Rng#	AC Voltage	AC Current	DC Voltage
0	0 - 3.5	0 – .09	0 - 5
1	3 - 7	0.8 - 0.18	4.2 - 10
2	6 - 14	0.16 - 0.37	8.5 - 20
3	12 - 28	0.32 - 0.75	17 - 40
4	24 - 56	0.64 - 1.49	34 - 80
5	48 - 112	1.28 - 2.98	68 - 160
6	96 - 224	2.56 - 5.97	135.8 - 320
7	192 - 448	5.12 - 11.9	271.5 - 640
8	384 - 750	10.24 - 20.0	543 - 1000

ch#	To Select
1	Channel 1
2	Channel 2

A.3.43 Scale Factors, Set or Return (SSC)

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:

in#	Config.	in#	Config.	in#	Config.
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.3.44 Store Setup (SST)

Command: **#SST**

Stores the present instrument setup in Setup Location #.

= 1 through 6

A.3.45 Setup, Recall (SUP)

Command: **#SUP**

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

= 1 through 6

A.3.46 Timer, Arm (TAM)

Command: **TAM**

Arms the Timer. For proper operation, the Timer must be armed prior to a valid trigger condition. If there is a non-zero number on the Timer display, the TAM command will set it to zero.

A.3.47 Time, Return (TDR)

Command: **TDR**

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

A.3.48 Time, Set (TDS)

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.3.49 Timer Configuration, Set or Return (TCF)

Command: **d#,f#,h#,at#,bt#,s/r#TCF**

Returns or sets the parameters necessary for timer operation.

d#	Display	f#	Function
0	Seconds	0	Time A to B
1	Cycles (50Hz)	1	Time A for X Counts
2	Cycles (60Hz)	2	Time width of A
3	Cycles (Ch1 Hz)	3	Frequency of A
		4	Count A Events
		5	Count A events gated by B

h#	Hold mode on stop
0	Disable
1	Enable

at#	A Trigger	bt#	B Trigger
0	DC Applied	0	DC Applied
1	DC Removed	1	DC Removed
2	AC Applied	2	AC Applied
3	AC Removed	3	AC Removed
4	Contact Open	4	Contact Open
5	Contact Closed	5	Contact Closed

s/r#	Set or Return Value		
0	Set Value	1	Return Value

A.3.50 Transducer Display (TDU)

Command: **TDU**

Displays Transducer Quantities as set up using transducer configuration (COT). Starts transducer operation.

A.3.51 Timer Display (TIM)

Command: **TIM**

Displays the Timer results in seconds, cycles, counts, or Hertz on the Model 931A, according to the timer function. The Timer must be configured using the TCF command. Once the Timer has been configured, it may be armed using the TAM command. Displays the accumulated time after a valid trigger condition.

A.3.52 Timer Reading, Return (TMR)

Command: **TMR**

Returns the Timer reading.

Response: Numeric ASCII string.

A.3.53 Timer, Reset (TRS)

Command: **TRS**

Resets the Timer to prepare for a new timing cycle. NOTE: Arm the Timer before starting the timing cycle (either via front panel ARM/RESET key, or the RS-232C TAM command).

A.3.54 Timer, Stop (TSP)

Command: **TSP**

Stops the Timer.

A.3.55 Timer, Start (TST)

Command: **TST**

Activates the Timer. Arm the Timer prior to starting a timing cycle (either via front panel ARM/RESET key, or the RS-232C TAM command).

A.3.56 Volts/Amps Display (V_A)

Command: **#V_A**

#	Result
0	(or absent) Displays Channel 1 and 2 measured amplitude values
1	Tabular Display
2	Volt hours, Amp hours

A.3.57 VA/PF Display (V_P)

Command: **#V_P**

#	Result
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.3.58 Volt-Amps, Return (VAM)

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.3.59 VARS, Return (VAR)

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.3.60 Version, Return (VER)

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.3.61 Waveform Display (WAV)

Command: **ch#WAV**

Enables the waveform display of channel 1 and channel 2.

Ch#	To select
1	Channel 1
2	Channel 2
3	Both Channel 1 and 2

A.3.62 Bandwidth Wide, Set (WIB)

Command: **WIB**

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

A.3.63 Transducer Input, Display (XDI)

Command: **XDI**

Returns the value for the Transducer input, as it appears on the main display.

A.3.64 Transducer Output, Display (XDO)

Command: **XDO**

Returns the value for the Transducer output, as it appears on the main display.

Appendix B

Optional Accessories

This appendix contains both technical specifications and operational information for optional accessories available for use with the Model 931A Power System Analyzer.

B.1 Precision Current Transformer

The Model 09311A, Precision Current Transformer, is an optional accessory that extends the Model 931A input current measurement range to 400 Amps RMS while retaining an overall accuracy of 0.1% and 0.1°. Mounts in 931A transit case; includes mounting bracket and hardware (P/N AS0036000).

B.1.1 Specifications

Range:	0.8 – 400 Arms
Burden:	14 mohms
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 931A 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 931A.

B.1.3 Current Display

To display the input current reading directly on the Model 931A, press SHIFT, then SCALE and set the CT value to "20," and set PT/CT to "ON." Refer to Section 3.3.2.17 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 931A case.

B.2.1 Parts and Accessories

Included with the installation kit are the following components:

Description	Qty	Arbiter P/N
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.

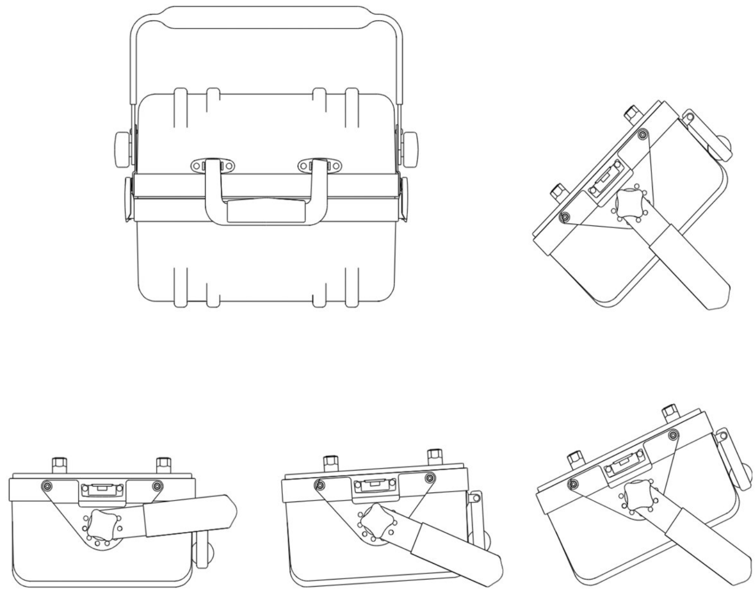


Figure B.1: Model 931A Case with Handle/Bail

B.3 Extended Memory

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 931A 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 931A.*

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 931A 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 931A 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, along with Timer and Transducer results. 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 931A 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 931A 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 931A 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 in four ways: the front panel LOG DATA key, the RS232 LOG command, a valid Timer-A event, or on a programmed time interval. Press the LOG DATA key and the Model 931A will record the data type selected on the display. Send the RS232 LOG command to the Model 931A serial port to accomplish the same thing.

Using the timer for triggering requires a bit more setup. First select the timer as the trigger using the auto-log setup. Next use the timer configuration to select the desired Timer A trigger condition. If the normal data-type has been selected, set the display for the desired data type. When ready to begin data collection, arm the timer by pressing the front panel ARM/RESET key or issue the RS232 TAM command. Data will be logged each time a valid Timer-A trigger is received. Data logging will not occur faster than once per second. Triggers received faster than once per second will be ignored. Press the ARM/RESET key or issue the TRS command to suspend data logging.

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 931A 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 931A is equipped with the extended memory option, the first sign-on display will show "16 Mbyte Log Memory Card Installed." "Auto-Log Setup" has been added as a selection item on the main menu. Press the MENU key and select "Auto-Log Setup" and the following display will appear.

```
 AUTO-LOG SETUP (Active Selection = *)
Trigger:  *→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 7
 0  Clear All!  ( Key Clears A File)
→1   8Nov11 17:06:02    1 Standard
 2   8Nov11 17:07:31    1 3 Ph Tab
 3   8Nov11 17:08:11    1 3 Ph Vec
 4   8Nov11 17:08:24    1 Harmonic
 5   8Nov11 17:08:36    1 Waveform
 6   8Nov11 17:08:45    2 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.

1,0,0SLO: Configures data logging for normal data with the store trigger set for timer A. Use the timer RS232 commands (TCF, TAM, TSP, TST) to configure the timer. Each time a valid event occurs on Timer A data will be logged.

2,5,0SLO: 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.

1,1997,1,1,0,0,0SL0: 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.

Parameter	Decimal weight
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

Command	Action
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.
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:	931A Power System Analyzer
Manufacturer:	Arbiter Systems, Inc. 1324 Vendels Circle, Suite 121 Paso Robles, CA 93446 − USA
Harmonized	EN55011 Class A, Radiated and Conducted Emissions
Standard Referenced:	EN50082-1 Generic Immunity, Part 1 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.