

MODEL 928A

POWER SYSTEM MULTIMETER

USER'S MANUAL



ARBITER SYSTEMS, INC.
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U.S.A.

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Model 928A

Power System Multimeter

Operation Manual

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Introduction

Welcome to Arbiter Systems' new Power System Multi-meter with *Floating Point DSP™*! The new Model 928A Power System Multimeter is filled with great features to help you measure electrical power. Whether you are a new or experienced user, you should find the Model 928A easy to use and accurate. Three power sources include alkaline or NiMH AA cells, and a +7 Vdc wall adapter for continuous use. The alkaline cells provide about 30 hours of use, and the NiMH should provide about 60 hours of use.

Some of the features include:

- 128X64 graphic LCD display
- 30-key multi-function keypad
- Isolated USB serial interface
- 4 AA cells or a +7 Vdc plug-in power supply
- Flash memory for approximately 6500 records
- Accurate internal real time clock
- Mlink application software

Simple Measurement

To make a measurement, simply set the inputs for voltage or current, connect the correct set of cables and press the desired function button.

Record Data

Store data by pressing the STO button or using one of the Auto-Log features. The 928A also stores Sags and Swells, and standard Triggers in flash memory. 400 KB of flash memory gives ample space for storing thousands of records.

Safety Information

Read the safety information inside this manual. Dangerous voltages may be present at the terminals of the equipment you are measuring, so take precautions!

Safety symbols are used throughout this manual to signify potential hazards to the equipment or to you, the user. Some of these are as follows.

“Warning” – identifies an action or a condition that poses a hazard to the user.

“Caution” – identifies a condition or action that may cause damage to the Model 928A.

Caution: Max CT Input Level

Never apply any signal directly to the CT inputs of Channel A or B greater than 1.2 Arms or 1.2 Vrms.

Connect voltage and current signals to two identical channels, labeled A and B. Prior to measuring, make sure that the channels have been correctly configured for the signal type (whether they are voltage or current).

Caution: No Direct Current Input

Do not connect a current signal directly to either Channel A or B. Always use a current-output or voltage-output CT when measuring current with the 928A.

Measuring Safety

Be sure to follow all precautions and safety information provided with any other equipment you are using.

Display

Using a 128x64 pixel display, the 928A can display all text and graphics necessary for operation. The LCD can be adjusted for contrast and backlighting operation.

The Instrument Case

Made from strong copolymer (similar to nylon), the 928A case is designed to protect it from certain mechanical and electrical hazards, however it is *not waterproof*. Water or other liquids can penetrate the case at a number of points, which can permanently damage the unit. Therefore, use care to protect it from rain, spills or condensing environments.

Caution: Water Damage

The case is not waterproof. Subjecting the 928A to rain or a wet environment will most likely damage it.

CT Characterization Service

While the 928A Starter kit includes a CT probe that has been characterized for accuracy, Arbiter provides a service for users to have their own CT's characterized for use with the 928A. After characterizing, receive a file for use with the 928A. Contact Arbiter Systems for more information.

928A Starter Kit

AP0011200 - +7 Vdc Power Supply

AP0009700 - Single-Phase Voltage Lead Set

AS0009800 - 100:1 Clamp--On CT, 100 Amp

BT0000201 - 1.5 Volt AA Battery, Alkaline, 4 ea.

CA0026106 - 928A USB Cable A-B, 6 ft.

CA0027100 - 928A CT Cable, Current Output

PD0030900 - Operation Manual

HD0065200 - 928A Soft Carrying Case

CTCAL01 - CT Calibration to the unit

AS0082900 - 928A Bail Assembly

Getting Started

Keyboard Operation

Most of the keys on your 928A perform one primary and one secondary function. The primary function of any key is indicated by the characters on the face of the key, for example **VI**. The secondary functions are indicated above the key, for example **RCL** (above the HOLD key).

Primary Function Keys

Primary keys need only to be pressed to function. For example, press **VI** to set the multimeter mode to read voltage or current for Channel A and B. See Appendix A for a complete listing and definitions of these keys.


Secondary Function Keys

To access the secondary functions, first press **2nd** followed by any key with symbol marked in blue above it.

Navigating Menus to Configure

1. To select a configure mode, press the desired function, then **2nd** **MENU**. For example, **PQ** **2nd** **MENU**, or **2nd** **LOG** **2nd** **MENU**.
3. Scroll through fields using **↑** or **↓** and press **ENT** to move the cursor to the value field.
4. Press **↑**, **↓** or numerical keys to change these values; press **ENT** to install and move to another value.
5. To save changes and exit, highlight <STOre And Exit> and press **ENT**. Alternatively, press **STO**.

Power On and Off

Press  to power the 928A ON and OFF. To conserve power, the multimeter can be configured to automatically turn itself off after an adjustable period of inactivity.

If you need help supplying inlet power, whether connecting the power source or installing batteries, see next page.

Auto Power Shutdown

The 928A auto shutdown feature allows you to select whether you want the 928A to automatically shutdown or not. If you do want it to automatically shut down, to conserve batteries, then the configuration panel allows you to select a number of different time intervals in which the 928A will automatically power down. See Auto Shutdown on page 14.

Battery Power Only

The Model 928A operates on four AA alkaline or Nickel-Metal Hydride batteries. Therefore, in the event of a battery failure, always carry a spare set of fully-charged batteries.

Caution: To optimize reliability, and reduce the possibility of corrosion between the contacts, keep all terminals as clean as possible. One method of cleaning the 928A and battery terminals is to rub them periodically with a cotton-tipped swab moistened with denatured alcohol.

AC Power Adapter

Included in the Model 928A Starter Kit is a power adapter (Arbiter part no. AP0011200) that provides power to the 928A and is suitable for continuous use. The power adapter is not designed to charge any batteries located in the battery compartment. For power adapter details and specifications, see “AC Power Adapter” on page 79.

Caution: The AC power adapter does not charge internal batteries. Batteries are disconnected when power adapter is connected to the Model 928A.

Operation

The power adapter supplies power to the 928A for normal operation. While using the power adapter, any batteries installed in the 928A are disconnected. To operate the 928A with the accessory power adapter:

1. Attach the power supply to a line outlet from 90 to 264 Vac and 47 to 63 Hz.
2. Connect the 3.5 mm miniplug into the 928A power receptacle.
3. Press **ON** to operate the 928A.

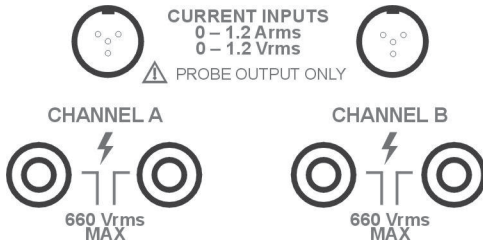
Battery Replacement

1. If the 928A is powered on, press **ON** to turn OFF the 928A prior to removing the batteries.
2. Remove the battery cover retaining screw and remove the cover by pulling it upwards at the screw side.
3. Replace the batteries. Note that battery orientation is indicated by symbols for polarity.
4. Replace the battery cover and retaining screw and put back into service.



Measurement Terminals

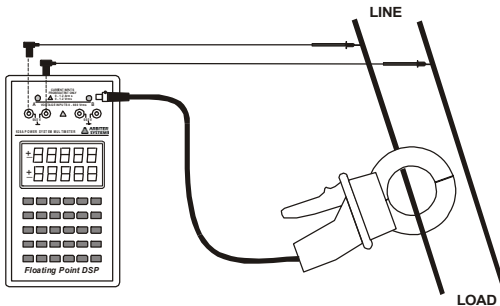
The Model 928A has two identical sets of measurement terminals, called Channel A and Channel B, that accept either a voltage or a current. To measure a current, select one of the current input connectors at the top of the instrument. To measure a voltage, select a set of voltage terminals found below the current input connectors.



Caution: Connect only current probes having an output of 0 to 1.2 Arms or 0 to 1.2 Vrms, maximum to Current Inputs.

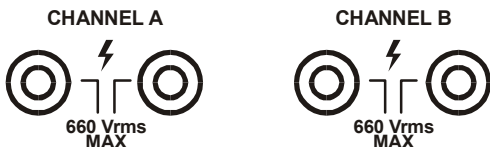
Versatile Inputs

For basic measurements (voltage, current, frequency and phase angle) any combination of inputs may be used. For power and energy measurements (active power, apparent power, reactive power or power factor), use a combination of voltage and current inputs.



Voltage Terminals - 660 Vrms, max

Two sets of voltage terminals allow you to directly connect voltages up to 660 Vrms, max. They may also be scaled for reading the primary voltage on a PT or transformer. These inputs are labeled “CHANNEL A” and “CHANNEL B.”

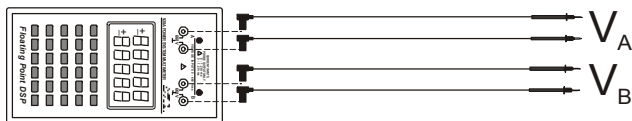


Normally, a direct connection (e.g. 1:1) is the default selection for measuring voltages, however, you can configure almost any voltage ratio for PT measurement at the secondary. To configure voltage ratios other than 1:1, see Configuring Channels A and B later in this section.

To set up Channel A to measure voltage press .

To set up Channel B to measure voltage press .

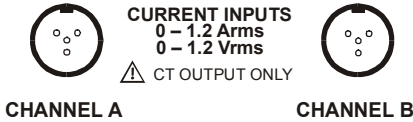
Note: Voltage inputs are isolated by 1.2 Megohms to each other and have a maximum input rating of 660 Vrms.



Caution – Max Voltage Input Level: Never apply any signal to Channel A or B voltage input terminals which is greater than 660 Vrms.

Current Terminals - 1.2 Arms, 1.2 Vrms, max

Two sets of current terminals allow you to connect two current transformers to the 928A so you can measure two currents simultaneously. The Current Input terminals for Channels A and B allow you to connect either a voltage-output CT or current-output CT to the 928A. A CT configuration screen allows you to setup CT values for both channels ahead of time, so they are ready to go at the job site.

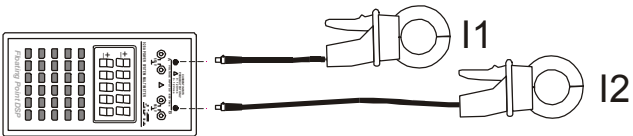


CT configuration includes entering the CT Output Type (either voltage or current), CT Ratio and Phase Offset.

To set up Channel A to measure current press .

To set up Channel B to measure current press .

NOTE Use care to select the correct probe type and scale factor to be able to measure accurately. Also, if using a characterized probe (by Arbiter Systems), be sure to select the correct characterization file. See CT SELECT, under Configuring Channels A and B on page 20.



Caution – No Direct Current Input: Do not connect a current signal directly to either Channel A or B. Always use a current-output or voltage-output CT probe when measuring current with the 928A.

Caution – Max CT Input Level: Never apply any signal to Channel A or B current input terminals which is greater than 1.2 Arms or 1.2 Vrms.

928A Keys

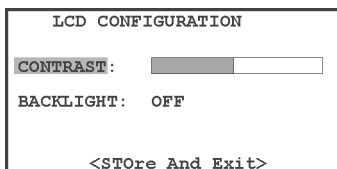
MIN/MAX Key










Press the MIN/MAX key to cycle through various measurements, including the minimum, maximum, average and normal (active). To reset, press and hold the backspace key



for 3 seconds while in MIN/MAX function.

LCD - Display Control Key



1. Press   to open the display configuration screen.
2. Press  or  to select LCD contrast or Backlight control.
3. Press  to select contrast slider bar or backlight condition.
4. Press  or  to adjust contrast, or select backlight ON or OFF and press .
6. Highlight <STOre And Exit> with the cursor and press  to install new values and exit.

Function Keys - f1 - f6

f1 – Custom User Screen

Press **2nd** **f1** to access either of two custom user screens. These screens are in tabular format and allow up to seven functional entries. Configure all user measurement functions through Mlink software – for more information see “Mlink Software Tutorial” starting on page 59.

	CUSTOM #1
CHAN-A:	120.0 V
CHAN-B:	5.123 I
THD-A:	7.125 %
FREQ:	59.995
PHASE:	19.09 °
VAR:	201.06
PF:	0.945

There are currently no functions assigned to the secondary keys labeled f2 through f6.

Splash Screen



When first powered on, the 928A will display an introductory message that describes the 928A. Press any of the main measurement keys (e.g. **VI**) to bypass the splash screen.

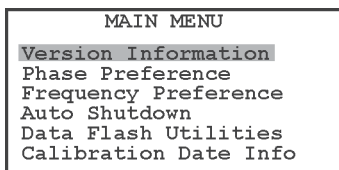
Up and Down Arrows

Use **↑** or **↓** to step through values in configuration menus or for choosing specific records held in memory.

MENU Key

Use the MENU key to set up the functions, preferences and operating parameters of the 928A. Access these menus through the Main Menu, or in context.

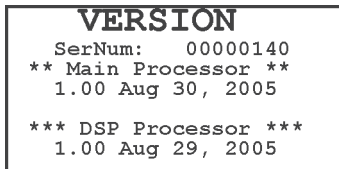
Main Menu



1. Press **2nd** **MENU** **2nd** **MENU** to open the main menu.
2. Press **ESC** to backup to previous menus.

Firmware Version

1. Open the main menu as shown above under Main Menu.
2. With the cursor highlight Version Information and press **ENT** and read information.



3. Press **ESC** to backup to previous menus.

Phase Preference

```

PHASE PREF SELECTION
REFERENCE:          A
POLARITY: (B LAGS A)  +
RANGE:              +/-180°
LEAD/LAG DISPLAY:   OFF

<STOre And Exit>
  
```

1. From the Main Menu, highlight Phase Preference with the cursor and press **ENT** to open the Phase Preference menu.
2. REFERENCE: Press **ENT** and **↑** or **↓** to set the Reference to Channel A or B. Press **ENT** to set it.
3. POLARITY: Press **ENT** to set POLARITY as + or – and **ENT** to set it.

Note: Notation changes from “B LAGS A” to “A LAGS B” when switching REFERENCE from A to B.

4. RANGE: Press **ENT** and **↑** or **↓** to select the range value (to either ± 180 or 0 to 360 degrees) and **ENT** to set it.
5. LEAD/LAG DISPLAY: Press **ENT** and **↑** or **↓** to switch the Lead/Lag display ON or OFF. When selecting ON, the words “LEAD” or “LAG” will be displayed in the **PF** (Apparent Power / Power Factor) function.
6. Highlight <STOre And Exit> and press **ENT** to install values.

Frequency Preference

FREQ PEF SELECTION	
REFERENCE:	A
SETTING:	60Hz
<STOre And Exit>	

1. From the Main Menu, highlight Frequency Preference and press **ENT** to open.
2. REFERENCE: Press **ENT** and **↑** or **↓** to access and change Reference value.
3. Press **ENT** and **↑** or **↓** to access and change Frequency SETTING to either 50Hz or 60Hz.
3. Highlight <STOre And Exit> with the cursor and press **ENT** to install the new value(s).

Auto Shutdown

AUTO SHUTDOWN	
Time Interval:	5min
<STOre And Exit>	

1. From the Main Menu, highlight Auto Shutdown and press **ENT** to open.
2. Press **ENT** and **↑** or **↓** to adjust the Auto Shutdown feature OFF or to one of the predetermined time intervals.
3. Highlight <STOre And Exit> with the cursor and press **ENT** install the new setting.

Flash Utilities Menu

```

FLASH UTILITIES MENU
Full Mode: Stop-Full
Erase Flash?: No

<STOrE And Exit>
  
```

Use the Flash Utilities Menu to manage flash memory in the 928A. In **Full Mode**, choose whether or not to overwrite stored values held in memory or to stop writing. **Erase Flash?** Allows you to delete all values held in flash.

Calibration Date Info

If your unit has a certification of calibration, highlight this selection and press **ENT** to view the calibration information.

```

CALIBRATION INFO

CAL: Oct 18, 2005
DUE: Oct 18, 2005
  
```

Menus in Context

To access these menus, you will need to be viewing the specific function and press **2nd** **MENU**. For complete information on configuring menus in context, see the next section entitled “Operation.”

ENT – Enter Data

Press **ENT** to open a menu selection, move between selections within a menu and to change to a new value.

Also, use **↑** or **↓** to select an item in a menu.

ESC – Escape

Press **ESC** to leave a specific menu or go back in key-strokes to the previous screen. For example, if you are viewing the Main Menu, press **ESC** to leave the Main Menu and view Channel Configuration.

STO - Store Held Value in Memory

Use **STO** to

1. Write to flash memory the current measured values at Channel A and B as shown on the display.
2. Save values during configuration of functions (e.g. a CT ratio or phase offset and moving to the next item). This can be used in the same way as you would highlight <STOre And Exit> and press **ENT**.

When Recording Data

Records are stored according to the date and time running in the internal, real-time clock. Before measuring, check the clock for the correct time in the case that it has drifted or was inadvertently changed. See DATE and TIME, on the next two pages, for information on setting the date and real-time clock.

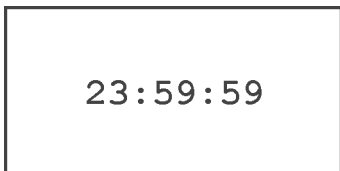
When Configuring Functions

When assigning values during configuration, generally you will press **2nd** **MENU** to open the configuration screen for a specific function. After changing the required values in each field, you can press **STO** to install the new value(s) in memory and leave that menu. Use **STO** in the same manner as you would with <STOre And Exit>.

TIME

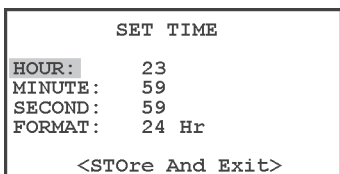
Viewing the Time

Press **2nd** **TIME** to view the time.



Adjusting the Time

1. While viewing the time, press **2nd** **MENU** to access the time adjust screen.



2. Press **↑** or **↓** to move between fields and to highlight desired value you want to change.
3. Press **ENT**, **↑** and **↓** (or number keys) to adjust the desired time value, and to move to the next value.
4. When finished, highlight **<STOre And Exit>** and press **ENT** to install new values and return to viewing the time.
5. Press **ESC** to leave viewing the time screen.

DATE

Viewing the Date

Press **2nd** **DATE** to view the date.

Jan 01, 2004

Adjusting the Date

1. While viewing the date, press **2nd** **MENU** to access the date adjust screen.

SET DATE

MONTH: Jan
 DAY: 01
 YEAR: 2004
 FORMAT: MMM DD YYYY

<STOre And Exit>

2. Press **↑** or **↓** to move between fields and **ENT** to highlight desired value you want to change.
3. Press **↑**, **↓** or number keys to adjust the desired date value, and **ENT** to move to the next value.
4. When finished, highlight <STOre And Exit> and press **ENT** to install new values and return to viewing the date.
5. Press **ESC** to leave viewing the date screen.

Using the Input Channels A and B

This page describes four steps in setting up and using the two input channels (A and B), for voltage and/or current.

1. **Configure the Channels** (see next page): In this step, you will set up *how* the channels measure. Configure Channels A and B scaling for reading any voltage or current signal. Once these are set up, you should be able to *select* the channel and begin measuring. Normally, you would not keep changing these values. However, if you change to a different CT, then you would need to configure this step again.
2. **Select the Channel:** In this step, you determine *what* each channel is measuring. Let's say you want to measure voltage on Channel A and current on Channel B. To set this up,

press to set Channel A to voltage

press to set Channel B to current

If you want to set up both channels to measure current, then,

press to set Channel A to current

press to set Channel B to current

Note: You must press the appropriate channel selection keys to correctly measure the desired function.

3. **Choose the Measurement Mode:** For example, press to display voltage and/or current values.
4. **Connect the Equipment:** To measure, connect the leads between the 928A and the circuit under test.

Configuring Channels A and B

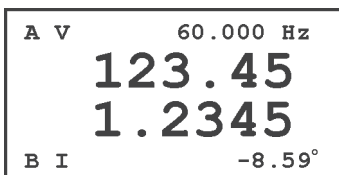
Configure Channels A and B, for both current and voltage through this menu. Four possibilities exist:

1. Ch-AV: Channel A measuring a voltage
2. Ch-AI: Channel A measuring a current
3. Ch-BV: Channel B measuring a voltage
4. Ch-BI: Channel B measuring a current.

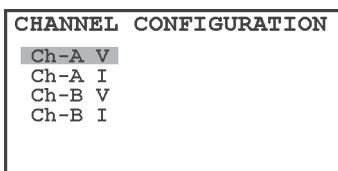
You can completely configure all these possibilities at one time from the Channel Configuration menu.

Voltage - Ch-A V

1. Press **VI** to open the measurement mode.



2. Press **2nd** **MENU** to open the configuration screen for Channels A and B.



3. Press **↑** or **↓** to highlight the channel and **ENT** to open the specific Channel configuration screen. In this example, Ch-A V sets the *voltage measurement parameters* for Channel A.

- You should see the display change to the Ch A VOLTAGE CONFIG screen (as shown below). The configured items for voltage are Input Ratio and Phase Offset.

```
Ch A VOLTAGE CONFIG
INPUT RATIO:      1.00
PHASE OFFSET:    0.0°
<STOre And Exit>
```

- Press or to select desired field and to select value to change.

Input Ratio

- Enter the ratio values from the numeric keypad and press to move to the next field. Note that all ratios are referenced to 1. For the example screen above, the Input Ratio is actually 1:1.

Phase Offset

- Enter the Phase Offset value from the numeric keypad and press to move to the next field. In this example, the phase offset is 0.0°.
- When finished configuring the channel, highlight <STOre And Exit> and press to install any new values and return to the Channel Configuration menu. Press to leave the Channel Configuration menu and return to the measurement mode.

Current Ch-A I

Current Configuration includes five items: CT Select, Input Type, Input Ratio, Phase Offset and Low Range Mode.

1. Open the Channel A current configuration screen. See Configuring Channel A and B from previous page.

```

Ch A CURRENT CONFIG
CT SELECT:  USER
INPUT TYPE:           Amp
INPUT RATIO:         100.00
PHASE OFFSET:        0.0°
LOW RANGE MODE: OFF
<STOre And Exit>
  
```

2. Use or , and the numeric keys to enter the Input Type, Input Ratio, Phase Offset and Low Range Mode values as required.

CT Select

Selects either USER or M#####, where:

- M##### – the Arbiter-calibrated CT serial number
- USER – selects one user calibration constant

M##### selects a 12-point characterization set for the specified clamp-on CT, provided by Arbiter Systems. Calibration constants are installed in the 928A using Mlink software and obtained from Arbiter Systems. See Mlink Software Tutorial for uploading CT Characterization files.

3. If choosing a CT SELECT value of M#####, you cannot change Input Type, Input Ratio or Phase Offset.
4. If choosing a CT SELECT value of USER, you can change any value in configuration screen.
5. When finished configuring, highlight <STOre And Exit> and press to exit this menu.

Low Range Mode

For current measurements below 10 mArms it may be advisable to switch the Low Range Mode ON. The Low Range Mode, multiplies the input signal by a factor of 20, and can improve accuracy and stability of the signal. Input signals above 10 mArms run the risk of being clipped.

Voltage Ch-B V

Change the Channel B voltage configuration in the same manner as for Ch-A V above. Remember that these settings only apply for Channel B when selecting the voltage function.

Current Ch-B I

Change the Channel B current configuration in the same manner as for Ch-A I above. Remember that these settings only apply for Channel B when selecting the current function.

Current Probe Configuration Examples

For secondary side measurements, you will need to set up the instrument scale factors so that you can correctly read the primary value. The example below shows how to set up a specific probe values.

CAUTION: DO NOT connect any probe if the probe output exceeds the maximum input rating of the 928A.

EXAMPLE: Current Probe Specification

AC Current Probe

AC Input: 75 Arms, maximum

AC Output: 10 mA/A rms

660 Vrms Working volts, max.

This probe produces 10 mA at the output terminals (to the 928A) for an input current of 1 Amp.

MAXIMUM OUTPUT CURRENT

$$= \text{AC Input} \cdot \text{AC Output}$$

$$= 75 \text{ A} \cdot 10 \text{ mA/A}$$

$$= 750 \text{ mA (or 0.75 Arms)}$$

It is safe to apply a current or voltage to the Current Inputs if it is less than or equal to the specified maximum of 1.2 V/ A rms. In this case, 0.75 Arms, being less than 1.2 Arms, is safe to apply.

If using a voltage output CT, you would be able to apply up to 1.2 Vrms to the Current Inputs.

Selecting a Channel Function

To measure voltage at Channel A, press **2nd** **AV**.

To measure current at Channel A, press **2nd** **AI**.

To measure voltage at Channel B, press **2nd** **BV**.

To measure current at Channel B, press **2nd** **BI**.

NOTE: Remember that if you wish to measure voltage or current on a specific channel, you must connect the appropriate test leads between the specific terminals to the circuit you want to measure. If measuring voltage, use the voltage terminals. If measuring current, use the current terminals.

Measuring Voltage and Current

Most of the measured values available from the 928A are derived from the voltage, current and frequency measurements. Most of the advance functions using these basic measurements are found in the next section entitled “Operation.”

Using the M3 Current Probe

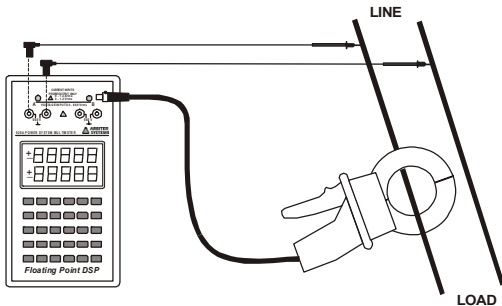
Connect the M3 current probe using the CA0027100 accessory current cable, to the Channel A or B current input connector on the Model 928A, and the safety sockets on M3. Observe the polarity markings for correct reading.

Warning: Always remove the clamp from the circuit under test prior to disconnecting the accessory cable at either end.



Operation

Information in this section provides more advanced details on configuring and operating specific functions of the 928A.



Certain fundamental procedures are covered in the previous chapter called, “Getting Started.” If you have not previously reviewed this section, it would be good to do so at this time, especially on Configuring Channels A and B.

Some of the more advanced features covered in this section are included in the list below.

Voltage and Current

Phase and Frequency

Power and Power Factor

Harmonics and Flicker

Power Quality

Triggering, AutoLogging and the Log Key

Recall of Data Stored in Flash Memory

Trending Data

Ratio Functions (A/B and B/A)

Making Measurements

VI - Voltage and Current Measurement

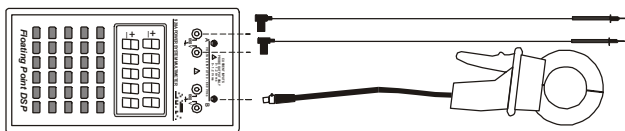
Choose either Channel A or Channel B to measure voltage and current. If necessary, refer to Configuring Input Channels in Getting Started. For example, if you wish to measure voltage using Channel A, then you would press

2nd **AV**.

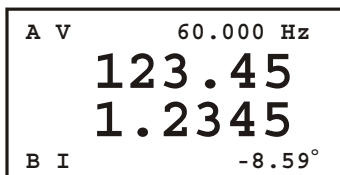
CAUTION Do Not Exceed the Maximum Ratings
Voltage Inputs: 660 Vrms
Current Inputs: 1.2 Arms or 1.2 Vrms

Setup

1. Verify that Channel A and Channel B are configured properly. If necessary, refer to Getting Started page 20, Configuring Channels A and B.



2. Press **VI** and connect the probe(s) between the 928A and the circuit elements.
3. Read values on the display.

**Display****Description****A V**

channel A with units in volts.

60.000 Hz

measured line frequency

123.45

measured channel A signal in volts

1.2345

measured channel B signal in Amps

B I

Channel B with units in amps.

Ph

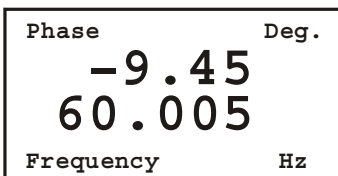
Phase angle of channel B signal relative to channel A.

ØF - Phase / Frequency Measurement

To measure phase, you will need to connect two signals to the Model 928A: current-current, voltage-current or voltage-voltage. Frequency requires only one input.

Setup

1. Verify that Channel A and B are configured properly for the type of signals that you are measuring. If necessary, see page 20, Configuring Channels A and B.
2. Press **ØF** and connect the probes to the circuit elements.



3. Read the values on the display.

Phase Preferences

In this example, Channel B signal (current) is lagging Channel A (voltage) and is configured to report the phase as negative (-9.45°). If you want Channel B lagging Channel A to be reported as positive, you would need to open the Phase Preferences screen (under the Main Menu), and select as follows:

Polarity: (B lags A) +

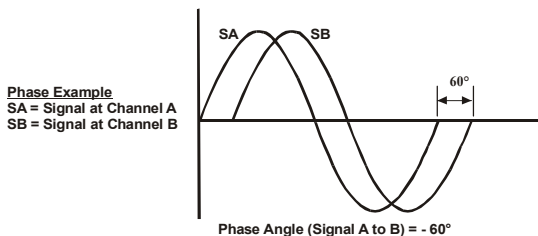
Make sure the cursor covers the sign and press one of the arrow keys to toggle it to the desired value and press **ENT**. For complete details on Main Menu Configuration, see page 13, under Phase Preference.

Note that the 928A is very flexible and always compares the

signals at channels A and B for their phase relationship, regardless of the type of signal, whether voltage or current.

Phase Conventions

The following chart illustrates the standard phase conventions as used in the Model 928A. In this example, the inputs measured by the 928A may be either voltage or current signals.



SB is delayed from SA by 60 degrees, or approximately 2.8 milliseconds in time at 60 Hz. The phase is therefore referred to as *lagging* and given a *negative sign*.

If you prefer to see a lagging signal given a positive sign, then you should configure this in Phase Preferences in the Main Menu. See page 13, under Phase Preferences.

Example from the figure above: Suppose you are monitoring two signals, with a voltage connected at Channel A voltage terminals and a current at Channel B Current Input terminal. Then, the current would be lagging the voltage by 60 degrees.

For additional details on phase conventions, please see page 87, Appendix C - Phase Conventions.

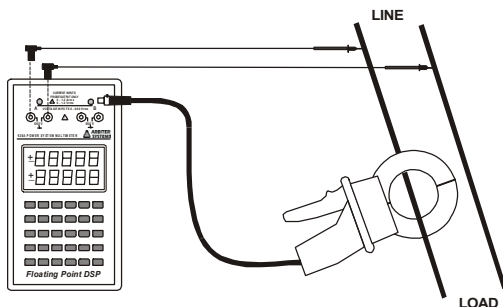
PWR - Active and Reactive Power

Use this mode to measure Active and Reactive Power.

To use the power measurement function on the 928A, you must select one measurement channel for voltage and the other for current. In this example, Channel A is configured as voltage and Channel B as current.

Setup

1. Press **2nd** **A V** to set Channel A to voltage and **2nd** **B I** to set Channel B to current.



Note: in this figure, voltage probes are connected to Channel A and CT connected to Channel B.

2. Press **PWR** and connect the probes to the circuit elements.
3. Read the display.

Active Power	Watt
129.06	
22.833	
React Power	Var

The display should indicate Active and Reactive power, showing the effective power to a load and wasted power returned to the line. The displayed units are Watts on the top and Vars on the bottom.

Determining Active Power

Active power is calculated from the real components of the current and the voltage.

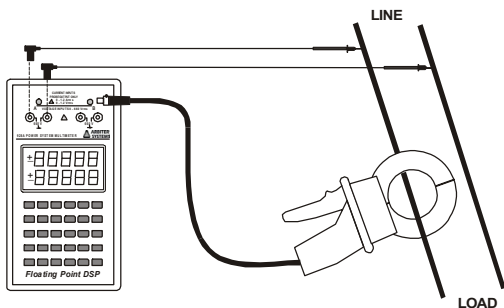
PF - Power Factor & Apparent Power

Use this mode to measure Power Factor and Apparent Power.

To use the Power Factor and Apparent Power function on the 928A, you will need to select one of the measurement channels for voltage and the other for current. In this example, Channel A is selected as voltage and Channel B as current.

Setup

1. Press **AV** to configure Channel A for voltage and press **2nd BI** to configure Channel B for current.



Note: in this figure, voltage probes are connected to Channel A and CT connected to Channel B.

2. Press **PF** and connect the probes between the 928A and the circuit elements.
3. Read the display.

Apparent Power	VA
129.06	
0.8765	
Power Factor	

The power factor displayed is determined from the reactive component of power.

Lead Lag Display

If you wish to know if the power factor is leading or lagging, configure this through the main menu, under Phase Preference. See page 13, under Phase Preference. The screen below shows a lagging power factor with the Lead/Lag indication turned ON.

Apparent Power	VA
129.06	
0.8765	
Power Factor	LAG

Wh - Watt-hour

Use this mode to view the energy received and delivered.

To view or record any of the 10 energy values measured in the Model 928A, you must select one of the measurement channels for voltage and the other for current. It does not matter which channel you select for voltage or current. In this example however, Channel A is selected as voltage and Channel B as current.

Setup

1. Check to see if the internal clock is displaying the correct date and time. If necessary Date and Time, under Getting Started on pages 17 and 18.
2. Press **2nd** **AV** to configure Channel A for voltage.
Press **2nd** **BI** to configure Channel B for current.
3. Connect the test probes between the 928A and the circuit or meter under test.
4. Press **Wh** to display the calculated Watt-hours.

ENERGY VALUES		
Value	Rec	Del
Watt-h	0.000	122.313
Q-h	0.000	000.000
VA-h	0.000	305.821
Accum Time: 0:04:51		

Note: Del refers to the power delivered to the load, and Rec refers to the power delivered to the source.

5. Press **Wh** again to access the second set of energy values.

Energy Values	
VAR-h	Value
Q1	000.00
Q2	000.00
Q3	000.00
Q4	325.256
Accum Time:	0:09:06

Important Note: Possible Data Loss - You will lose energy data if the 928A shuts down while measuring energy. Since energy values require time to accumulate, consider configuring the Auto Shutdown feature so that the 928A does not shut down during a measurement. Prior to collecting energy values, set the Auto Shutdown feature to OFF. See Auto Shutdown on page 14.

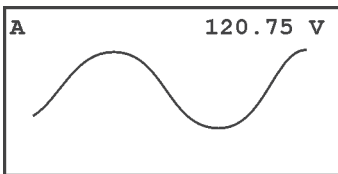
WAV - Waveform

To view or record signal waveforms on the 928A, select one or both of the measurement channels, for voltage and/or current. You can view up to two voltages, two currents or one voltage and one current. It does not matter which channel you select (A or B) to measure voltage or current.

Setup

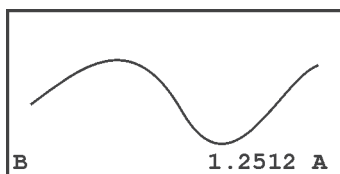
1. Make sure that Channel A and B are set up properly with at least one channel configured for voltage and/or current. If necessary, refer to Configuring Channels A and B on page 20.
2. Press the appropriate Signal Selection key in order to measure the signal properly - for example, press **2nd** **AV** to select Channel A to measure voltage.
3. Connect the probe(s) between the 928A and the circuit under test.
4. Press **WAV** and read the channel A graph on the display.

Channel A

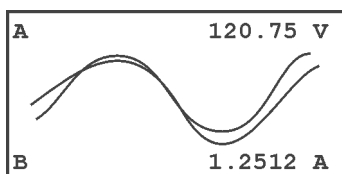


5. Press **WAV** again to view the channel B graph on the display.
6. Press **WAV** a third time for a combined view of channels A and B on the display.

Channel B



Combined



HRM - Numerical Harmonics

To view or record signal harmonics on the 928A, you must select one or both of the measurement channels, for voltage and/or current. You can view up to two voltages, two currents or a voltage and current. It does not matter which channel you select (A or B) to measure voltage or current.

Setup

1. Make sure to select the correct signals for Channels A and B - for example **2nd** **AV** to measure voltage on channel A.
2. Press **HRM** and connect the meter probes between the 928A and the circuit under test.
3. Read the display. In this example the display indicates channel A voltage in volts and phase angle in degrees.




A	V	Phase
1	5.1000	-152.564
2	0.0100	21.010
3	0.0050	137.459
4	0.0004	-108.247
5	0.0039	49.934
6	0.0002	-5.094
7	0.0025	178.137

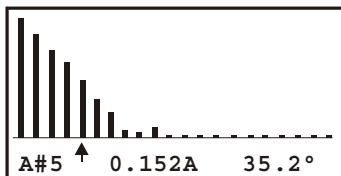
4. Press **↑** or **↓** to view the full range of tabulated harmonic values from the 2nd to the 50th. Pressing the arrow keys moves through the individual harmonic numbers and levels in groups of seven.
5. To read Channel B numerical harmonics, press **HRM**. Repeated pressing **HRM** toggles between Channel A and B numerical harmonic data.







- Graphical Harmonics

To view a graphical representation of harmonics on the 928A, you must select one or both of the measurement channels, for voltage and/or current. The Model 928A allows you to view both voltages and currents, however it will allow you to view only one channel at a time. Each channel must be viewed separately due to the allowable space on the display.

Setup

1. Press the appropriate Signal Selection key in order to measure the signal properly - for example  .
2. Press  and connect the meter probes between the 928A and the circuit under test.



3. Read the display.
4. Press  or  to move the cursor to select the desired harmonic (e.g. in display above, cursor identifies 5th harmonic for channel A). Pressing the arrow keys, after reaching the last harmonic entry on the screen, will open the next (higher or lower) set of harmonics.
5. To read Channel B graphical harmonics, press  . Repeatedly pressing   toggles between Channel A and B graphical harmonic data.

Flicker Information

Flicker measurements deal with a fluctuation of the line voltage. It is a very specific problem related to human perception and incandescent light bulbs, but not a general term for voltage variations.

The basic concept behind placing limits on voltage fluctuations is that they cause lights to flicker, which can be irritating and may cause discomfort. Voltage fluctuations are caused by loads on the power distribution system, which are located near lighting equipment (within the same building or powered by the same distribution transformer), and have changing power or current levels.

Based on groups of people tested for irritation from light fluctuations, most tend to be irritated when the light fluctuates at around 1000 changes/minute. Apparently above 1800 changes/minute light flicker is no longer perceived. Fluctuations in the rms voltage of only 0.25% are sufficient to cause noticeable flicker in light bulbs.

Some Definitions

Voltage Fluctuation: a series of voltage changes or a continuous variation of the rms voltage.

Flicker: Impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.

Short-Term Flicker Indicator, Pst: The flicker severity evaluated over a short period (10 minutes); $Pst = 1.0$ is the conventional threshold of irritability. A reasonable goal might be to limit Pst values to less than 1.0 for 95% of the time.

Long-Term Flicker Indicator, Plt: The flicker severity evaluated over a long period (over 2 hours) using succes-

sive Pst values. The Plt threshold is 0.8. *Plt is not measured by the 928A.*

FLK - Instantaneous Flicker

FLK - Flicker is defined as the instantaneous flicker that is updated each second. By simply pressing **FLK** the 928A will display instantaneous flicker based on the signals applied to channel A and B. The displayed value will be updated each second.

To view flicker on the 928A, you must select voltage for measurement channels A and/or B

Press **2nd** **AV** and/or **2nd** **BV** and read the instantaneous flicker.

Flicker values are measured at approximately 100 millisecond intervals and updated on the 928A display each second.

Pst - Short-Term Flicker

Pst - Flicker is defined as Short-Term Flicker and averages the flicker values over a configured time period in seconds. The display shows a countdown value as Pst is being processed. At the end of the countdown period, Pst is displayed based on the signals applied to channels A and B.

To measure short-term flicker (Pst) by the 928A, you must select either Channel A or B, and set the channel(s) to voltage. Do this as follows:

Press **2nd** **AV** and/or **2nd** **BV** and read the short-term flicker.

PQ – Power Quality / Sags and Swells

Method

The Model 928A measures sags, swells and power interruptions by using the **PQ** power quality triggering function.

PQ follows the CBEMA method of measuring the signals at Channels A and B and compares them to Point Limits over assigned time intervals. The rules used to measure the two input signals, including Point Limits, are called a *Profile*. An example of the CBEMA method used in the 928A is illustrated on the next page.

Power Quality data stored in the 928A is actually a record of sags and swells of any voltage or current applied to Channels A and B that exceed the set Point Limits. Any one profile may consist of up to 10 Point Limits, with each point defined over integer-multiples of 1/2-cycle of the nominal frequency.

Note: the PQ function measures RMS values only.

PQ Profiles

The Model 928A can store up to 5 different PQ profiles that are configured and uploaded into the 928A using Mlink software. Each profile is a different configuration for measuring sags and swells. Profiles are listed in the Model 928A as PROF-1, ... , PROF-5.

USER Profile

Select USER to set one Limit Point directly in the 928A. This selection is only available from 928A keyboard.

Profiles – OFF

Select OFF when not using PQ Triggering. Otherwise, PQ triggering could fill up the available memory. See “Selecting PQ Profiles” on following pages.

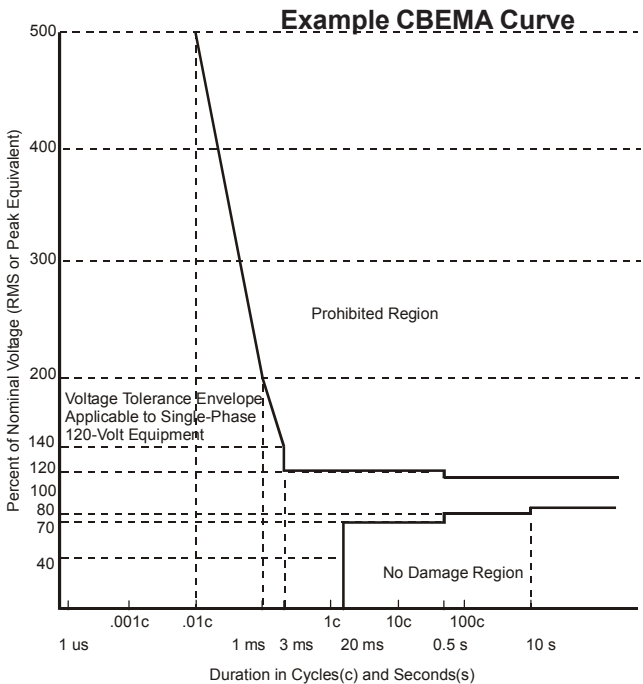
PQ Records

When the signals measured at either Channel A or B exceed any Point Limit, the Model 928A will record the following values:

- Start & Stop Times
- MAX & MIN values within Start and Stop Times

Press **PQ** to view recorded events by time and date. To view PQ data from Excel or other spreadsheet, use Mlink software to download records from 928A.

To select a specific PQ profile see the next page under “Selecting PQ Profiles.”



Working with PQ Profiles and Records

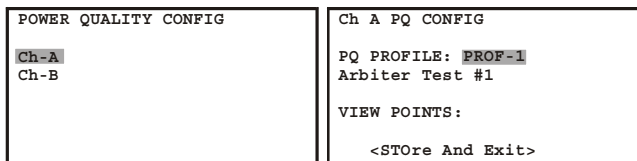
Internal flash memory will store all PQ event records until flash memory is full, overwritten or erased. View event records directly from flash on the 928A by pressing **PQ**. Changing the PQ profile will not disturb records already stored in flash memory.

NOTE: Make sure to download event records using Mlink software prior to deleting from flash in the 928A.

Selecting PQ Profiles

Except for one PQ profile named USER, all PQ Profiles are configured by using Mlink software. Configure the profile named USER only from the 928A keyboard. Additionally, Channels A and Channel B may be configured independently.

- To select a PQ Profile, press **PQ** > **2nd** > **MENU**. With the cursor, highlight either Channel A or B and press **ENT** to open the profile selection screen (seen in right screenshot).



There will be 7 available choices: 5 PQ Profiles, 1 USER Profile and OFF (to disable).

- Press **ENT** to highlight the profile name (e.g. PROF-1), and **↑** or **↓** to select the desired PQ profile name. Press **ENT** to assign the profile name and to move to VIEW POINTS.

3. Press **ENT** (with cursor on VIEW POINTS) to open the Point Limit viewing screen. Press **↑** or **↓** to view each Point Limit. Press **ESC** to exit.

```

PQ PROFILE 1 CHAN A-V
Arbiter Test #1
REF: 0.000 (ABS)
HYS: 5.000 (ABS)

POINT: 1 of 10
LIM: 130.000 (ABS)
X>LIMIT DUR: 4
  
```

Accessing PQ Events

1. Press **PQ** to view power quality event records. Power Quality events are listed according to Record Number (RECS), Date and Time.

PQ TRIGGER	INACTIVE	PQ TRIGGER	ACTIVE
CH-A PROF:1	PNT: **	CH-A PROF:1	PNT: 1
DATE: Sep 20, 2005		DATE: Sep 20, 2005	
TIME: 10:00:17.084277		TIME: 10:00:12.893066	
MIN: 125.122		MIN: *****	
MAX: 134.124		MAX: *****	
REC: 2 of 4		REC: 1 OF 4	
AVAIL RECS: 24526		AVAIL RECS: 24526	

2. Scroll through the listed events by pressing **↑** or **↓** – shows MIN/MAX values when PQ Trigger is Inactive (left screen), no MIN/MAX values when Active (right screen).
3. Press any other function key to leave the PQ Event List.
4. Use Mlink software to download PQ records in CSV format to view in Excel spreadsheet.

NOTE: PQ profiles (PROF-1, ..., PROF-5) must be configured through Mlink software prior to uploading to the Model 928A.

TRIG - Working with Triggers

Use TRIG to test various input signal conditions such as voltage interruptions or frequency changes. When these conditions match the defined triggering limits, the 928A will record the start and stop times, and the maximum, or minimum signal value during the event (i.e. the date and time in which the trigger is active).

Viewing Triggers

1. Press **2nd** **TRIG** to view the Trigger Events screen.

Press **↑** or **↓** to move through the record list.

```

TRIG#: 1                ACTIVE
DATE:  May 19, 2005
TIME:  16:57:29.400
TYPE:  CH-A MAG
Limit: X<LIMIT
MAX:   *****
REC:   1 of             8
AVAIL RECS: 29646
  
```

```

TRIG#: 1                INACTIVE
DATE:  May 19, 2005
TIME:  16:57:31.750
TYPE:  CH-A MAG
Limit: X<LIMIT
MAX:   109.689
REC:   2 of             8
AVAIL RECS: 29646
  
```

In the screenshots above, REC 1 of 8 indicates the date and time that TRIG #1 first became active (i.e. triggered); note that no input signal levels are recorded.

REC 2 of 8 shows the date and time TRIG #1 returned to normal limits, and became inactive (i.e. “non-triggered”). Notice that REC 2 of 8 also indicates a MAX (or MIN) value of the input signal during the time while the trigger was active.

In this example, the Limit was set to 110.00, and the lowest value recorded during this event was 109.689 volts.

Configuring Triggers

To configure individual triggering conditions of any trigger, press **2nd** **TRIG** **2nd** **MENU**. Once in this menu, step through each condition and view or edit any value. There are 8 individual triggers available to configure or edit.

```

TRIGGER SETUP
Trigger: 1
Signal: INACTIVE
Logic: X<LIMIT
Limit: 110.00
Ref: 0.0
Dwell: 20
<SToRE And Exit>

```

1. Press **ENT** and **↑** or **↓** to select trigger.
2. Use **ENT** **↑** and **↓**, or the number keys to the configure triggering conditions.
3. Highlight <Store And Exit> and press **ENT** to store new values.
4. Press **ESC** to exit the TRIG configuration screens.

Trigger Setup Value Definitions

Trigger 8 possible profiles to compare with input signals

Signal Allowable input signal values: INACTIVE (means trigger is not armed), CH-A MAG, CH-B MAG, WATTS, VA, VAR, PF

Logic Four conditions available: $x < \text{Limit}$; $x > \text{Limit}$; $|x| > \text{Limit}$; $|x - \text{ref}| > \text{Limit}$; $x = \text{input signal value}$

Limit Numerical value compared to signal: floating point

Ref A nominal signal value (e.g. 60 Hz) used to compare to Limit: floating point

Dwell The persistence in alarm condition before trigger becomes active: in 50 millisecond increments (e.g. 20 = 1 second): an integer

A/B Function

Use the A/B function to find the ratio of the two measured input signals to Channels A and B. If, for example, you wish to know the ratio of a voltage at channel A to a current at channel B, pressing the A/B button will display the results of dividing the voltage by the current giving resistance and phase offset of Channel B from Channel A.

Setup

1. Make sure that Channel A and B are set up properly with both channels configured for voltage and/or current; *you must use two channels to use A/B*. If necessary, see Configuring Channels A and B on page 20.
2. Press **A/B** and connect the measurement probes to the circuit under test.
3. Read the display.

Ch A / Ch B		
A/B	10.000	Ohms
Ph	9.0000	°
A: 120.0V	B: 12.00I	

NOTES If you configure channel A as current and channel B as voltage, then the units will be in mhos and degrees. If you choose two voltages or two currents, then the units will be a strict ratio (with no displayed units for A/B) and degrees.

B/A Function

Use the B/A function in the same manner as you would with the A/B, only with the reverse response as with the A/B function and input signals.

Use the B/A function to find the ratio of the two measured input signals to Channels A and B. If, for example, you wish to know the ratio of a voltage at channel B to a current a channel A, pressing the B/A button will display the results of dividing the voltage by the current giving resistance and phase offset of Channel A from Channel B.

Setup

1. Press **B/A** and connect the measurement probes to the circuit under test.
2. Read the display.

Ch B / Ch A		
B/A	0.1000	Mhos
Ph	9.0000	°
A: 120.0V	B: 12.00I	

NOTES If you configure channel A as voltage and channel B as current, then the units will be in mhos and degrees. If you choose two voltages or two currents, then the units will be a strict ratio (with no displayed units for B/A) and degrees.

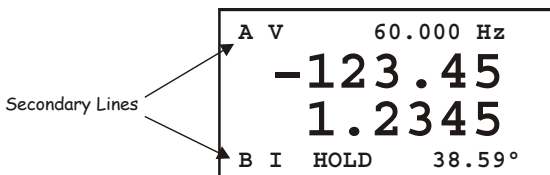
HOLD - Hold Metered Value

Press **HOLD** to freeze the measured value on the display.

Press **HOLD** again to return to the measurement mode.

The Hold function operates only with measurement functions, and not with setup screens or with Date and Time. To view and/or change the Date and Time, see DATE or TIME on pages 17 and 18.

When in the hold mode, you will see the word “HOLD” in the lower secondary line of the display, as illustrated below. When not in hold mode, the word “HOLD” will disappear.



Procedure

1. Set up the 928A to measure the values you wish to observe. If necessary, see Configuring Channels A and B on page 20ff.
2. Connect the measurement probes between the 928A and the circuit under test and press **HOLD**. This puts the display in the hold mode.
3. Read the values.
4. To return to the measurement mode, press **HOLD** again.

RCL - Recall Stored Values (STO)

Use the RCL function to open the list of eight records stored from using the STO key. Records are replaced when storing a new record over the old record location. The Model 928A can store up to eight records with the **STO** key. Records are identified by number from 1 to 8.

Records are stored according to number, type, date and time as shown in the example below.

Viewing Procedure

Selected →	<pre> 1 PF 01/14/04-11:23:16 2 VI 01/25/04-08:14:01 3 PW 02/12/04-12:01:05 4 FQ 02/24/04-14:22:19 5 WV 03/01/04-23:15:01 6 HM 03/04/04-01:34:55 7 HG 03/05/04-04:05:37 8 PW 03/08/04-09:55:28 </pre>	←
------------	--	---

1. Press **RCL** to view the Recall Stored Data screen.
2. Use **↑** or **↓** to select the record for viewing.
3. Press **ENT** to view the selected record in the same data viewing mode as saved. Note “REC1,” for Record #1, in the lower right of the display.

Apparent Power	VA
129.06	
0.8765	
Power Factor	REC1

4. Press **ESC** to return to the Recall Data screen and select a new record. Press **ESC** again to leave the Recall Stored Values list.

Integration Key

Purpose

Use the Integration key to view a plot of the selected signal over time. Signals include voltage, current, frequency, phase and power factor. The signal sampling interval can be configured in seconds from 1 to 65535. For better viewing, configure upper and lower limits of plotted input signal. The vertical range scales according to the upper and lower limits that you configure.

Press **2nd** **AXIS** to scale the plotted values to the desired viewing range. This includes the upper and lower limits, the last measured value, a vertical graticule and the units of the measured signal. See next page for setup details.

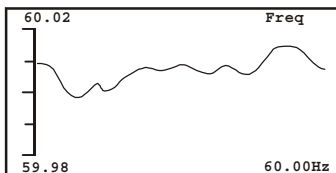
Procedure

Press **2nd**  to plot and view the configured signal.

Press  and hold for three seconds to restart the plot.

Example

In the example below, the plotted signal (i.e. Source) is frequency, the upper and lower limits (Axis Max and Axis Min) are 60.020 and 59.980 Hz, and the last measured value is 60.00 Hz. Since the Graph Type chosen is Scroll, the previously plotted frequency moves to the left.



AXIS Key

Use the AXIS key to configure how the Integration function plots the signal source. There are five categories to set up in this menu.

```

INTEGRATION GRAPH
SOURCE:  Freq
INTERVAL:      1 (sec)
GRAPH TYPE:    Scroll
AXIS MAX:      60.020
AXIS MIN:      59.980
<STOre And Exit>
```

Graph Definitions

Signal	Channel A or B, freq, phase, PF, Actpwr
Interval	From 1 to 65535, in seconds
Graph Type	Scroll or Fixed
Axis Max	Maximum plotted value on display
Axis Min	Minimum plotted value on display

Procedure

1. Press **2nd** **AXIS** to open the Integration Key configuration screen.
2. Press **↑** or **↓** to locate the desired field and **ENT** to enter the variable field.
3. Press **↑**, **↓** or number keypad to change the required values(s) and press **ENT** to move to other fields.
4. Finally, highlight <STOre And Exit> with the cursor and press **ENT** to save any changes and exit this menu.
5. Press **ESC** at any time to quit the menu function.

LOG Key

Purpose

Use the LOG key to automatically record basic electrical data to the 928A flash memory over a specified time interval. This function, also called AUTOLOG, makes it convenient to record measured electrical quantities while the equipment is unattended.

Logging Features

- Records Basic Data only (see list at end of section).
- Logging interval is measured in seconds
- Stores up to 6592 records, maximum

Viewing Autolog Information

To view Autolog information, press **2nd** **LOG**, and the screen will display some basic information about the data logging features.

AUTOLOG INFO	
# AVAIL RECORDS:	6592
# SAVED RECORDS:	0
STATUS:	INACTIVE

In order to operate, the Autolog function needs start and stop times and dates, a logging interval (in seconds), and stop mode. Set up these features in the Autolog Setup menu.

Note: Viewing Autolog Data

Use Mlink software to download Autolog records to computer and view in spreadsheet format. They cannot be viewed on the 928A itself.

Autolog Setup

- From the Autolog Info screen, press **2nd** **MENU**. The Autolog Setup screen should appear.

```

      AUTOLOG SETUP
Start-D: Feb 09 2005
Start-T: 08:10:00
Stop-D:  Feb 09 2005
Stop-T: 16:00:00
INTERVAL:      5 sec

  <STOre And Exit>

```

- Use the arrow keys to locate the field you wish to alter, and press **ENT** to open the field value. Both screens below show the start date and time. *Stop date and time screens are very similar. Be sure to configure them.*

```

      SET LOG START DATE
MONTH:  Feb
DAY:    9
YEAR:   2005

  <STOre And Exit>

```

```

      SET LOG START TIME
HOUR:   8
MINUTE: 10
SECOND: 0
MODE:   24 HR

  <STOre And Exit>

```

- Adjustment procedure:* Use the arrow keys to locate the desired field value and press **ENT** to enter the value. Use the numeric keypad to enter the desired parameters and press **ENT** to store.
- When you have finished adjusting any parameters, always move the cursor to **<STOre And Exit>** and press **ENT**.

5. When finished adjusting the 928A clock features, or to quit for any reason, press **ESC** to leave the Autolog setup.

Autolog Time Mode

The Autolog Time Mode is set when you set up the Time features. See Time Adjustment.

***Note:** check the 928A Time and Date for accuracy prior to starting the Autologging. To adjust time and date, see pages 17 and 18.*

Basic Data List

1. Channel A and B magnitude
2. Power Factor
3. Q
4. VARs
5. Watts
6. Relative Phase (B to A)
7. Frequency
8. Frequency Deviation
9. Frequency Rate
10. Channel A and B Flicker

Mlink Software Tutorial

Introduction

This tutorial was written to assist you in using Mlink, the new software interface written specifically for the Model 928A.

Mlink not only gives you a simple method of moving your important data from the 928A to your computer, it simplifies configuring complicated measurement functions like Power Quality. Additionally, Mlink uploads the newest firmware release to the 928A, giving you the latest features at no extra cost.

Mlink Advantages

Since the 928A was developed as a portable instrument, most of the features are accessible from the front panel. However, more complex features are only accessible by using Mlink software, and these include:

- Uploading CT Profiles (probe characterization)
- Configuring Power Quality & Downloading Records
- Downloading Auto-Logged & Triggered Records
- Configuring Custom User Screens
- Uploading New 928A Firmware

Download Mlink

The latest version of Mlink is available by contacting Arbiter Systems at the information listed on page ii of this manual or by downloading from the web site at <http://www.arbiter.com/software/downloads.php>

Installing USB Driver

Before using Mlink, you will need to load USB/Virtual COM Port drivers on your pc. USB drivers for Windows are available to you by contacting Arbiter Systems, or by downloading from the web site at <http://www.arbiter.com/software/downloads.php>.

After you have acquired the drivers, you should load them on your system.

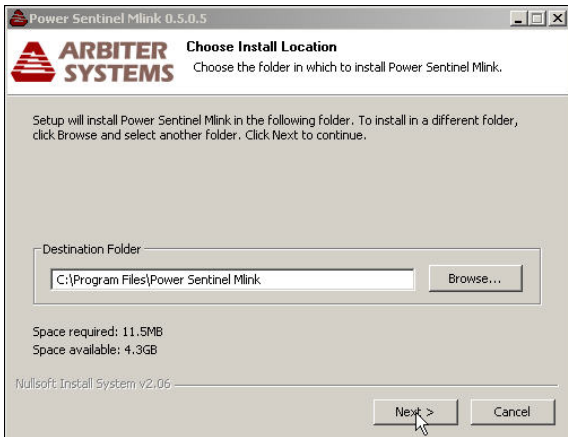
FTDI Driver on Windows XP™

1. Unzip the downloaded file to a directory.
2. Connect the 928A to your computer via the included USB cable. Make sure that the 928A is powered on.
3. Windows XP™ should give you a “Found New Hardware” message (small bubble message at task bar). It may also open a window that indicates that it is searching for a driver.
4. At the conclusion, the Windows new driver installation window should allow you to choose a driver. Pick from specific location and point to the unzipped directory.
5. Click “Finish.”
6. A message should appear, “Found USB Serial Port” (small bubble message at task bar).
7. From specific location point to the same directory as above.
8. Click “Finish,” and it should be ready to use.

NOTE – Linux Version: The Mlink Linux version is also available from Arbiter, however it will only connect with the 928A if the drivers have been compiled in with the kernel. Some Linux distributions may have these drivers available.

Installing Mlink

Load the Mlink installation file on your computer, and either double-click on the file or select Start > Run and browse to locate the Mlink self installation file. Select the Mlink self-installing program and begin the installation.



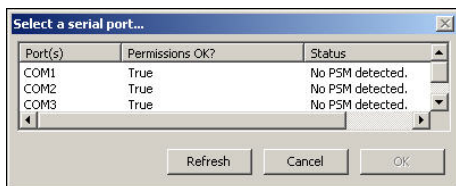
Connecting the 928A to a Computer

Prior to starting Mlink, make sure that:

1. The 928A is powered ON
2. The USB cable is connected between the pc and the 928A.

Startup - USB Connection

When starting Mlink for the first time, you may be greeted with the connection window shown below, and an opportunity to select a COM port. This selection is necessary, even though it is a USB port, since the 928A uses an RS-232-to-USB Bridge technology to create a virtual COM port. Otherwise, you should only see the Mlink main window (next page) with a green connection light.



Connecting

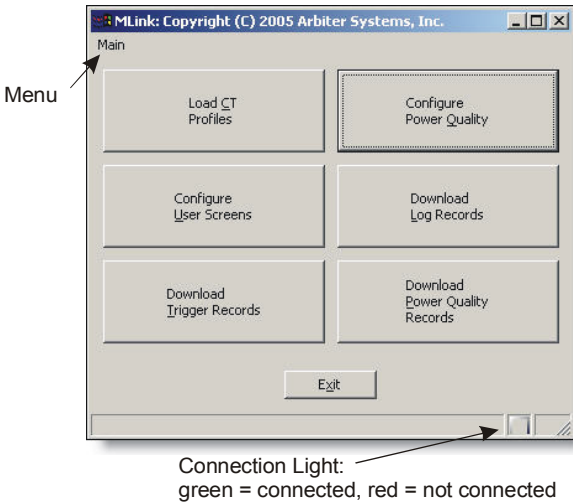
1. To connect, select the desired COM port number and click the OK button. A short delay may occur for the OK button to become available.
2. If the port number does not appear, click the Refresh button; another port should appear (e.g. COM3). It may take a few seconds to appear. Then, repeat step 1.
3. Under the Status column, it should indicate if the 928A (PSM) is detected or not. The unit serial number should appear - e.g. "PSM 00001109 detected."

NOTE: If you do not see the correct COM port in the connection window, you may need to do the following:

4. Close Mlink and power cycle the 928A.
5. Restart Mlink and check for your COM port as per steps 1 – 3 above.

Mlink Main Window

Located on the main screen are six basic function buttons useful for configuring and downloading records from the 928A to your pc. There are also several important functions found under one menu item called “Main.” On the lower-right of the status bar there is a *connection light* that strobes, notifying you of the connection status. When finished, close Mlink by clicking the Exit button.



Available Functions

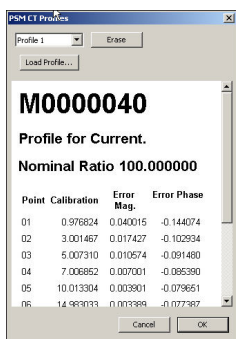
- Load CT Profiles
- Configure User Screens
- Download Trigger Records
- Configure Power Quality
- Download Log Records
- Download Power Quality Records

Upload CT Profiles

Improve the accuracy of the 928A by installing characterization files for the specific CT probes you use. In Mlink software, this characterization file is called a *Profile*. This allows the 928A to store 5 separate profiles for different probes or different characterizations for the same probe.

To Install Profiles

1. Power on the 928A and connect the USB cable between the 928A and the computer.
2. Start Mlink and check for a green connection light! If red, go back to “Startup – USB Connection.”
3. From the main screen, click the “Load CT Profiles” button.
4. Select the Profile number that you wish to install – e.g. Profile 1 (this includes any of the five filenames).
5. Click the Load Profiles button to view the various profiles. Select the file and click OPEN. Profile data should immediately appear in the Load CT Profiles window.



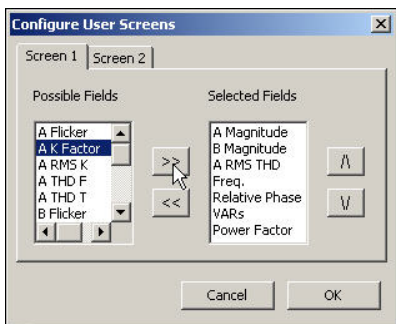
To Erase Profiles

1. Select one profile number you wish to erase – e.g. Profile 1, ... , Profile 5 and click the Erase button. The profile data will be erased and replaced with zeros.
2. Click OK to close the CT Profile window.

NOTE: To apply profiles in the 928A, see “Current Ch-AI” on page 22.

Configure User Screens

Two user screens are available for you to customize the 928A display. Once configured you can toggle between the two screens by pressing **[2nd]** **[f1]** successively. If your requirements change, you can run Mlink again to change the order or type of functions listed in the 928A User Screens.



To Configure User Screens

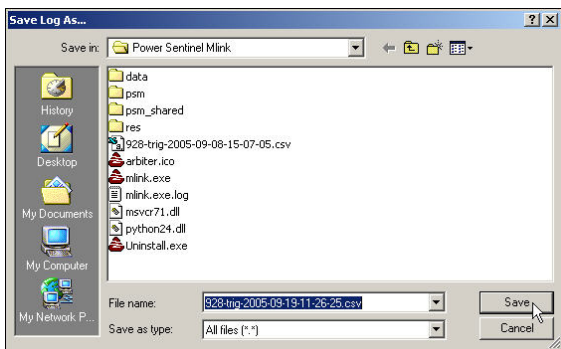
1. Power on the 928A and connect the USB cable between the 928A and the computer.
2. Start Mlink and check for a green connection light! If red, go back to “Startup – USB Connection.”
3. To add new fields, select the desired fields in the Possible Fields box and click the right arrows.

NOTE: Each user screen allows a maximum of seven items – the maximum number of lines on the 928A display.

4. To remove fields, select the desired fields in the Selected Fields box and click the left arrow.
5. To change the order in the Selected Fields window, select the desired field in the Selected Fields box and click either the Up or Down arrow.
6. Click OK to close the Configure window.

Download Trigger Records

The 928A allows you to quickly move event-triggered records to your pc using Mlink. Triggers must first be defined and activated in the 928A – see “TRIG - Working with Triggers” on page 48.



To Download Trigger Records

1. Power on the 928A and connect the USB cable between the 928A and the computer.
2. Start Mlink and check for a green connection light! If red, go back to “Startup – USB Connection.”
4. If the 928A has Trigger Records to download, a Save Log As window should appear with supplied filename for the data. Click the Save button, or type in another filename and click Save.
5. A Download records window should display the progress or will say, “Nothing to Download.”
6. Wait for the download to finish and click OK to close the Download Triggers window.

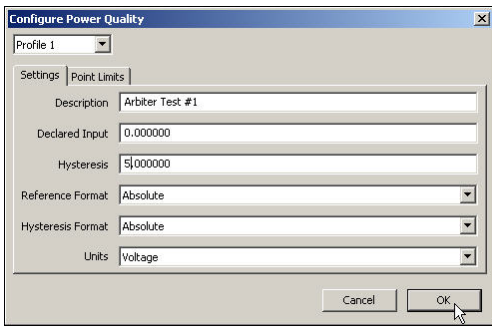


Configure Power Quality

Use this section to assist you in configuring the 928A to measure sags and swells by using CBEMA curve-type Point Limits. Point Limits are voltages or currents and stored in a profile. The 928A can store up to five separate profiles.

For more information on measuring sags and swells, see “PQ - Power Quality” on pages 44 to 47.

Configure Power Quality Settings



1. Power on the 928A and connect the USB cable between the 928A and the computer.
2. Start Mlink and check for a green connection light! If red, go back to “Startup – USB Connection.”
3. Click the Configure Power Quality button and check to see if the Settings tab is on top.
4. **Profile:** Select the Profile number (1 - 5) in the drop-down window at the top, and type in a profile name for “Description.”
5. **Declared Input:** Leave this value blank unless you are choosing Percent as a Reference. It is also used as the initial condition for a sliding reference.

6. **Hysteresis:** Select a value (for Units, Voltage or Current) that represents the allowable Hysteresis (e.g. 5.000000 in screen shot).

7. **Reference Format:** Select either Absolute or Sliding.

NOTE: Choose Sliding as the Reference Format only if choosing the Limit Format as Percent. Sliding Reference is defined with a 1-minute time constant.

8. **Hysteresis Format:** Select Absolute or Percent.

9. **Units:** Select the appropriate input signal Units: either Voltage or Current.

User Profile

One selection named USER is available with one Point Limit that is *only accessible from the 928A keypad*. See “PQ – Power Quality,” on page 46, for information on setting up the USER profile.

OFF – Deactivate PQ Trigger

When not recording, select OFF for Channels A and B PQ Config to deactivate the PQ Event Recording. Otherwise, trigger records will continue to fill up the available flash memory module. See “PQ Event Storage and Viewing” on page 44.

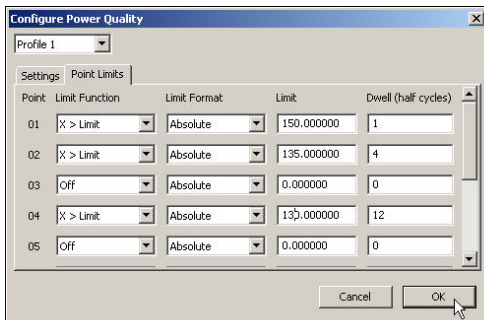
NOTE: The PQ function triggers on the RMS values of voltages and currents that exceed the specified Point Limits. The RMS value must exceed the Limit for the duration specified as Dwell.

See the next page for configuring Point Limits.

Configure Power Quality Point Limits

There are ten identically-appearing Point Limit values, all of which are set up in the same manner, and can be placed in any order.

In the example below there are three separate Point Limits defined. All of the Limit Functions are $X > \text{Limit}$, and Limit Formats are Absolute. The Limits are defined in decreasing voltages as 150, 135 and 130 with increasing Dwell times of 1, 4 and 12 half-cycles.



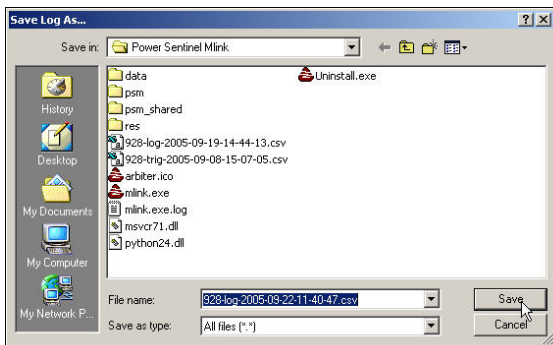
Point Limit Definitions

1. **Point** - denotes the number of the Point Limit (1 – 10)
2. **Limit Function** – set to OFF, $X < \text{Limit}$, $X > \text{Limit}$
3. **Limit Format** – set to Absolute or Percent
4. **Limit** – sets the numerical value against which the measured signal is compared: a floating point value.
5. **Dwell** – during trigger condition, sets the number of input signal half-cycles that must occur before recording begins: an integer number.
6. Click OK to install PQ Profiles in the 928A, or Cancel to quit without making any changes.

Download Log Records

The 928A is designed to transfer AutoLogged records to your pc using the LOG key. To configure Autologging see “LOG Key” on pages 56 to 58. Records stored using the **STO** function are *not* available for download using Mlink software, but only for viewing from the 928A.

To transfer records from the 928A to the pc, you will need to have some records already stored in the 928A flash memory module. Logging is based on a start and stop time and date. In order to use this feature effectively make sure to set the correct time and date. See TIME and DATE on page 17 and 18.

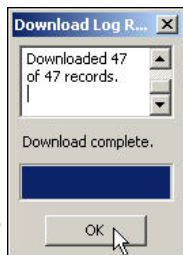


Downloading

1. Power on the 928A and connect the USB cable between the 928A and the computer.
2. Start Mlink and check for a green connection light! If red, go back to “Startup – USB Connection.”
3. Click the Download Log Records button.
4. If you have records to download, a Save Log As window should appear with supplied filename. Click

the Save button, or type in another filename and click Save.

5. A Download records window should indicate the number of records downloaded and say, “Download Complete,” or will say, “Nothing to Download” if there are no records to download.



6. Click OK to finish and close the Download progress window.

Download Power Quality Records

Use this feature to transfer power quality records from your 928A to your pc. Downloading is very much the same as for Standard Log Records or for Trigger Records, and requires that records be stored in the 928A flash memory module.

Downloading

1. Power on the 928A and connect the USB cable between the 928A and the computer.
2. Start Mlink and check for a green connection light! If red, go back to “Startup – USB Connection.”
3. Click the Download Power Quality Records button.
4. If you have records to download, a SaveAs window should appear with supplied filename. Click the Save button, or type in another filename and click Save.
5. A Download records window should indicate the number of records downloaded and say, “Download Complete,” or will say, “Nothing to Download” if there are no records to download.



6. Click OK to finish and close the Download progress window.

NOTE: PQ records take more time to download, so do not close the progress window if you do not see immediate progress.

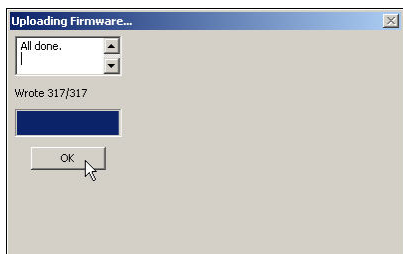
Uploading New Firmware

Mlink provides an easy method for uploading firmware to the 928A, and optimizing performance. When new firmware versions become available, they may be obtained by downloading from the web site at

<http://www.arbiter.com/software/downloads.php>,

or by contacting Arbiter Systems technical support.

1. Once you have obtained a new version of 928A firmware, you can upload it to the 928A by using Mlink and selecting Main > Upload Firmware, or by holding the Alt key and pressing U. The firmware file is normally in a .zip format (e.g. 928A_Upload.zip).
2. Select the file and click OPEN and you should see the progress as shown in the window below. Click OK when finished.



Functional Description

The Model 928A is a two-channel, AC power measurement instrument, providing 0.1% accuracy in a handheld package. Besides voltage, current and power quantities, it measures power quality, including harmonics, flicker, sags, surges and interruptions. Also, it includes a graphical display, real-time clock, approximately 400 KB of flash for data storage, and full-time battery operation using common AA-size NiMH or Alkaline cells.

User Interface

The user interface consists of a 128 x 64 graphic LCD with backlight, and 30-key silicone keypad. Also included is a USB serial interface for configuring and data retrieval.

Details

Input Sections: Two identical input channels (A and B) allow users to connect to voltage sources (0 to 660 Vrms) and to current sources (0 to 1.2 Arms or 0 to 1.2 Vrms), designed to work with CTs up to approximately 1000 A. To allow accurate measurements at low current levels (< 10A) there will be a x100 'booster' amplifier available to extend the input current range downwards to about 10 - 100 mA (with a 1000:1 external CT) for full accuracy and lower with somewhat reduced performance. Current Inputs are connected to the upper connectors and allow for voltage output and current output CTs. The current input section has a 1000:1 CT giving an output current of 0 to 1 mA, which is then converted to a voltage. The voltage input section uses medium-power, low TC resistors that accept up to 660 Vrms with a 1 Vrms signal to the ADC.

The current input sections are able to accept either 1.2 Arms or 1.2 Vrms max input. This will accommodate either current or voltage output probes.

MUX and ADC: The ADC is a 24-bit Texas Instruments ADS1251 sigma delta converter running at 10240 samples-per-second. There are two multiplexers being used: a 74HC4053 and a 74HC4052. The '4053 is being used to switch between the voltage and current channel inputs, and the '4052 switches the source for current channels: either a current CT (maximum input 1.2 Arms), voltage CT (maximum input of 1.2 Vrms) or gain of 20.

DSP: The DSP is a Texas Instruments TMS320VC33-120 and runs from 1.8 to 3.3 V power supplies. The TMS320 will perform all of the DSP and 'control' processing, reducing the parts count and power requirement.

Power Supplies: The 928A will operate from four-AA cells, which can be either NiMH or Alkaline. Rechargeable batteries may be recharged from a third-party NiMH recharger, available at many consumer outlets. Also available is accessory Kit power adapter AP0011200.

Accessories

Arbiter Systems recommends the use of the following accessories for use with the Model 928A.

Current Measurement

CT Leadset

AS0027100/AS0027200 (current/voltage output): This accessory current leadset connects directly between a Model AP0009800 CT (using safety banana connectors) and the Model 928A current terminals. It is constructed of high-quality silicone-insulated, fine-stranded wire for durability and safety.

Standard CT

AP0009800, 100:1 clampon CT: (LEM M3 100A) @ 100

Arms, 10 mA/A; standard banana connectors.

Optional CT

Model 09113A clampon CT (AEMC SR601) 1000:1, 1000 Arms, 660 Vrms, 1 mA/A; shrouded banana connectors. Requires CT cable assembly, CA0027100.

Voltage Measurement

For voltage measurement, use the AP0009700 voltage leadset. This leadset includes Arbiter's professional leadset material and voltage probe kit accessories for connecting to a variety of circuit connections.

Soft Carrying Case

For carrying the Model 928A and some accessories, choose the HD0065200. Made from rugged polyester, it provides two compartments for clampon CTs, leadsets and manual.

USB Data Cable

Use CA0026106 USB cable when configuring the Model 928A or downloading data from the flash memory module with Mlink software.

Specifications

Input

Input Configuration

The Arbiter Systems Model 928A Power System Multimeter has two identical measurement channels, Channel A and Channel B. Each input channel has a voltage input and a current input. Current inputs are intended for use with external CTs having a nominal output of 0-1 Arms or 0-1 Vrms. For basic measurements (voltage, current, frequency, phase angle) any combination of inputs may be used. For power and energy measurements (active power, apparent power, reactive power and power factor), one voltage and one current must be selected.

Voltage

Input Range	0 to 660 Vrms
Impedance	1.2 megohm, differential

Current

Input Range	0.01 to 1 Arms (underrange to < 1mA)
Burden	0.01 ohm max. (> 10 Mohms)

Interface

Operator Interface

Display	128X64 graphic LCD
Keyboard	30 key keyboard
Serial	USB 1.1
Memory	512 KB Flash
Data	User Setups
	Real Time Clock
	Approx. 400 KB measurement data

Power Requirements

Batteries

Type	4-AA Cells, alkaline or NiMH
Operation	30 hours typical with alkaline cells 60 hours typical with NiMH

External Power Supply (part no. AP0011200)

Type	+7 Vdc, regulated
------	-------------------

Measurements

Voltage and Current

Method	True rms, 3 kHz Bandwidth
Accuracy	0.1% of reading (voltage) 0.1% of reading (current) + CT errors

Phase Angle, A-B

Range	0 to 360 or $\pm 180^\circ$
Accuracy	0.1°
underrange	< 1°, typical at TBD mArms

Frequency

Range	50 or 60 Hz ± 5 Hz
Accuracy	0.005% of reading

Harmonics

Input	Channel A and Channel B, simultaneous
Range	2 nd to 50 th Harmonic (50 or 60 Hz fund.)
Accuracy	0.1% THD + 5% reading
Display	THD; K-factor; Amplitude bar graph; and individual harmonic magnitude and phase (simultaneous).

Waveform

Display Channel A and/or Channel B

Power and Energy Quantities

Range 0 to 99999 MVA or MVAh
 ± 99999 MVAR or MVARh
 ± 99999 MW or MWh
 ± 1.0000 PF, lead or lag

Accuracy 0.1% of VA, for VA, VAR, and W
0.001 PF

General

Physical

Size 190 x 101.6 x 32.64 mm
(7.5 x 4 x 1.285 in.)

Weight 18 oz (928A only, with batteries)

Environmental

Temperature Operating: -10° to $+50^{\circ}$ C
Nonoperating: -40° to $+75^{\circ}$ C

Humidity Noncondensing.

AC Power Adapter

Part no. AP0011200

For benchtop or continual use with available line power, use the AP0011200, AC Power Adapter. It provides a regulated +7 Vdc at up to 800 mA to the 928A.

INPUT VOLTAGE: 90 Vac to 264 Vac

INPUT CURRENT: < 0.5 Arms at 90 Vac Input

INPUT FREQUENCY: 47 to 63 Hz

OUTPUT VOLTAGE/CURRENT: +7 Vdc at 800 mA

EMI: FCC Part 15 Class B when tested with a resistive load, both conducted and radiated.

MTBF: 50,000 hours or greater at 25° C

OPERATING TEMPERATURE: 0° to 70° C

STORAGE TEMPERATURE: -40° to +80° C

HUMIDITY: 0 to 90% Relative Humidity

WEIGHT: 90 g MAX



M3 Current Probe

Part no. AP0009800

For up to 120 amps, use the M3 100:1 socket output current probe with the Model 928A, Power System Multimeter.

Using the latest transformer technology, the M3 100 A/1 A socket output can measure currents from 0.1A to 120A over a frequency range of 40 Hz to 10 kHz.

Specifications

Electrical Characteristics

Current Range	100 Arms
Measuring Range	0.1 to 120 Arms
Output Sensitivity	10 mA/A
Load Impedance	< 10 Ohms
Conductor Position Sensitivity	< 0.5% @ 50/60 Hz
Error due to adjacent conductor	< 15 mA/A @ 50 Hz
Phase Shift at 2 kHz @ 10 A	± 1 degree
Frequency Range	40 Hz to 10 kHz
Temperature Coefficient	0.015% / °C
Working Voltage	600 V ACrms or DC

General Characteristics

Maximum Conductor Size	15 mm diameter
Output Connection	4 mm safety sockets
Operating Temperature Range	-10 to +55 °C
Storage Temperature Range	-20 to +70 °C
Operating Humidity	15% to 85%
Weight	175 g (6.2 oz)

Appendix A. Keypad Definitions

This appendix lists all of the keys on the Model 928A keypad, for both the primary and secondary purposes. For Primary keys, press only the key itself. For secondary keys, press **2nd** and then the key with blue label above the key button.

Primary Keys

- | | |
|-----------------------|---|
| 0 ... 9 | Numeric keys - including decimal point; press to enter any necessary value during configuration menus. |
| 2nd | Secondary key - access any of the secondary keys (located above the nomenclature printed on the key itself). |
| ∅F | Phase/Frequency key - view the phase and frequency at channels A and B. Phase requires two signals and frequency only one signal (frequency channel is selectable). |
| A/B | Channel B/A ratio key - divides channel A by channel B. Results are in Ohms, Mhos, unitless and degrees. |
| ENT | Enter key - open a hidden menu and to install a configuration value. |
| ESC | Escape key - press to return to a previous screen or to leave a specific menu. |
| FLK | Instantaneous Flicker - view the instantaneous flicker, updated once per second. |

- HOLD** Hold key - press to hold the reading of the signals at channels A and B; press again to return to the measurement mode. Works with any of the specific measurement functions.
- HRM** Numerical Harmonics key - view the harmonics of the signals at channels A and B, from the 2nd to the 50th.
- ON** On key - press to switch the 928A on and off.
- PF** Power Factor & Apparent Power key - read the Power Factor and Apparent Power in Volt-Amps.
- PQ** Power Quality key - currently unused; will report valuable data concerning sags and swells, interruptions and data records.
- PWR** Active & Reactive Power key - read the power in Watts and Vars.
- STO** Store key - this key has two major functions: (1) to write current measurements to the flash memory card, and (2) to assign values during configuration; this is the same as highlighting <STOre And Exit> and pressing **ENT**.
- VI** Voltage/Current key - view the voltage and/or current signals input to channels A and B.

WAV

Waveform key - view the signal waveforms at channels A and B (as A and B, A or B).

Wh

Watt-hours key - press once to read the current energy values. Press again to view Q-hours.

←

Backspace key - move left in any configuration screen, to erase any numerical value to the left, or to restart a process, like Integration graph. Also, press to enter a negative number during configuration.

↑, **↓**

Up and Down arrow keys - browse through values in menus, browse through function values (like harmonics) or for choosing specific records held in memory.

Secondary Keys

AI

Channel A current selection - selects channel A for current measurement.

AV

Channel A voltage selection - selects channel A for voltage measurement.

AXIS

Axis key - press the axis key to set up the axes for the Integration function.

B/A

Channel B/A ratio key - divides channel B by channel A. Results are in Ohms, Mhos, unitless and degrees.

BI

Channel B current selection - selects

channel B for current measurement.

BV

Channel B voltage selection - selects channel B for voltage measurement.

DATE

Date key - view or adjust the date on the Real Time Clock.

f1 ... **f6**

Multi-function keys (soft keys) - f2 to f6 are currently unused.

LCD

LCD Display adjust key - access the display configuration menu. Allows control of both contrast and backlighting.

LOG

Log key - displays auto log data based on start and stop time and date.

MENU

Menu key - access the various 928A systems' configuration screens.

**MIN
MAX**

MIN/MAX key - press to cycle through the four different measurement modes: minimum, maximum, average and normal (measurement mode).

Pst

Short-term flicker - displays flicker for a 10-minute average.

RCL

Recall Data key - lists data saved in flash memory when using the **STO** key.

TIME

Time key - view or adjust the time on the Real Time Clock.



Integration key - press to view a progressive plot of the signal SOURCE, defined by pressing **2nd** **AXIS** and changing the input signal defined under SOURCE. Scaled by sample time, upper and lower limits.

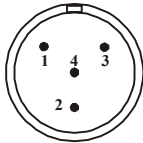


Graphical Harmonics - displays harmonics in graphical form.

Appendix B. CT Input Connector

928A Current Input Connector

The 928A Channel A and B Current Inputs allow two types of output signals from the CT: voltage or current. These CT output signals are limited to 1.2 Vrms and 1.2 Arms. Pin locations and their descriptions for these two connectors are given in the drawing below.



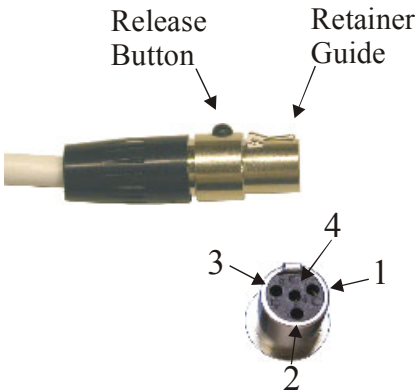
928A Current Input Connector

Pin Designations (names reflect the signal source)

- 1 CT Output Current (Dot Side)
- 2 CT Output Voltage - referenced to Pin 4
- 3 CT Output Current (No Dot)
- 4 CT Output Voltage; Connected to cable shield on current cable – Ca0027100

CT Cable Connector

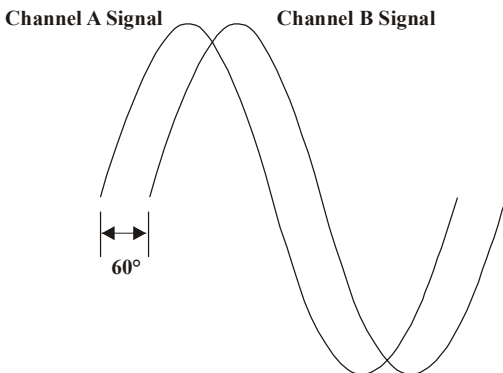
Connector Type: Switchcraft TA4FL



Appendix C. Phase Conventions

This appendix contains supplemental material for determining how the Model 928A responds to the various settings contained in the Phase/Freq Preferences menu.

The 928A allows you to select the reference channel, lag polarity, range ($\pm 180^\circ$ or 0 to 360°), lead-lag display ON or OFF, frequency source (A or B) and frequency (50 or 60 Hz). The items below provide interpretation for these settings. Switching Phase Preference to B effectively reverses the polarity of these settings.



Range Setting	Polarity Setting	Resultant Reading
$\pm 180^\circ$	(-) for Channel B lagging Channel A	-60°
$\pm 180^\circ$	(+) for Channel B lagging Channel A	$+60^\circ$
0 - 360°	(-) for Channel B lagging Channel A	300°
0 - 360°	(+) for Channel B lagging Channel A	60°

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