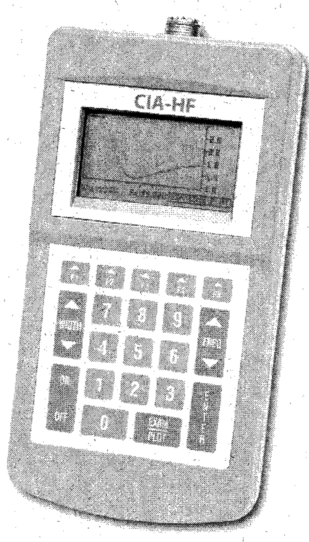
Operating Manual

CIA-HF ANALYZER



Complex Impedance Analyzer

AEA WIRELESS, INC.

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CIA-HF ANALYZER

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Printed in U.S.A.
PART No. 5012-3000-X (08/16)

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SECTION 1 INTRODUCTION

What It Does

The CIA-HF Complex Impedance Analyzer combines a microprocessor-controlled direct digital synthesizer with an accurate low-power Impedance bridge to present a graphical display of SWR, Impedance, Resistance, or Reactance. To create these graphical displays, the Analyzer continuously sweeps and plots a user-selectable frequency range. Alphanumeric data blocks common to each graphing screen are updated after every frequency sweep.

The Analyzer provides two modes of operation - a simple mode and an expert mode. When first activated, the Analyzer defaults to the simple mode, which operates with two graphing screens and enough data for basic antenna assement only. The expert mode provides the experienced user with four additional screens and more detailed data.

Features

- Graphical display of SWR, total Impedance, Resistance, and Reactance vs. frequency
- Graphical vector display of Real, Imaginary, and total Impedance with Phase Angle
- Data screen which displays:
  - Real and imaginary components of Impedance at a given frequency
  - Theta (phase) between Real and Imaginary componets of Impedance at a given frequency
  - Capacitance or Inductance value of Reactance at the plot's center frequency
  - Capacitance or Inductance value of required to provide a complex conjugated match
  - Q factor
  - 2:1 and two user-selectabl SWR bandwidths
- Auditory cues
- Self-tests

- Automatic off
- Low voltage DC voltmeter
- Simple frequency generator
- Display grid
- Optional AC-1 Wall Cube
- Optional soft case with shoulder strap and swivel hook
- Optional WINDOWS 95/98/ME/2000/XP VIA Director Software

Specifications

Frequency Range.....................	0.4 to 54 MHz
Frequency Resolution..............	Increments of 1 kHz
Frequency Accuracy................	± 200 Parts per Million
Display Width..........................	0 to 10 MHz in 1,2,5,10 sequence
Harmonics and Spurious...........	<-30 dB
SWR Impedance.....................	50 ohms
SWR Range...........................	1:1 to 20:1
Impedance Mag. Ranges...........	0 to 100, 0 to 250, 0 to 1000 ohms
Reactance Ranges....................	0 to 100, 0 to 250, 0 to 1000 ohms
Resistance Ranges..................	0 to 100, 0 to 250, 0 to 1000 ohms
Return Loss Range..................	-1 to -40 dB
Phase Angle...........................	-90° to +90° displayed, +45 to -45 real
Q Factor Range.......................	1 to 100 (defined as 2:1 Bandwidth/Fc)
Measurement Speed................	Approximately 1.2 seconds/sweep
Antenna Connector..................	SO-239
Output Power..........................	<5 mW into 50 ohms

DC Voltmeter...........................	2.5 digits, ±10% accuracy, **25 volts Maximum**
Power Requirements.................	8 AA Alkaline; 12 to 16 VDC @ <150 mA
Battery Saver Mode..................	Entered after 5 minute idle period
Size.......................................	4.3" W x 2.25" H x 8.5" L (including connector)
Weight....................................	1 lb. 10 oz. (including batteries)

SECTION 2 QUICK START

To help you get started, we've included this brief tutorial, which leads you through the general functions of the Analyzer.

First, press the ON key to activate the Analyzer. An introductory screen will flash briefly on the display, followed by a simple SWR plot. Since there is no antenna connected to the Analyzer, the plot is given an out-of-range value represented by a straight line across the top of the display.

Use the F5 softkey to toggle between the S (SWR) screen and the Z (total Impedance) screen. Notice that the boxed letter in the lower right corner changes as you toggle between the two screens. This letter identifies the screen that is currently displayed (refer to Screens section). Before continuing, return to the S screen.

Use the F3 softkey to scroll through the three data blocks displayed below the horizontal axis. Before continuing, return to the "W:100K:DIV Fc:14.200" data block. This data block provides the plot's default width (W:) and center frequency (Fc:) values. Change the center frequency to 1.900 Mhz by entering 1 9 0 0 ENTER on the keypad. Now, press the WIDTHq key three times to set the width to 10 kHz. The data block should now read "W:10K:DIV Fc:1.900".

To simulate actual operation, (with the Analyzer still on) attach the feedline of an 80-meter antenna to the antenna connector on top of the Analyzer. The S screen and "W:10K:DIV Fc:1.900" data block should still be displayed. Set the center frequency to 3.900 MHz by entering 3 9 0 0 ENTER on the keypad. The Analyzer will now sweep around this center frequency value. Now, use the WIDTH keys to experiment with different frequency sweep ranges. Also, use the F4 softkey to adjust the vertical scale (zoom factor). A well-matched antenna will produce a typical "V" or "U"-shaped SWR curve. Use the F3 softkey to obtain exact SWR, Return Loss, and total Impedance readings, or press the EXAM/PLOT key to freeze the display when an interesting plot appears. (Press EXAM/PLOT again to resume normal operation.)

Now, press the F1 softkey to enter the user menu screen. Press the WIDTHq key until the cursor aligns with the EXTRA FEATURES option. Press ENTER to turn this option ON. This will enable the additional screens and data blocks included in the expert mode. Press the F1 softkey again to return to the S screen. Now, use the F5 softkey to scroll through four new screens; use the F3 softkey to scroll through all 12 data blocks.

SECTION 3 OPERATION

SetUp

Attach the load under test to the antenna connector, which is located on the top of the Analyzer. Press the ON key to activate the unit.

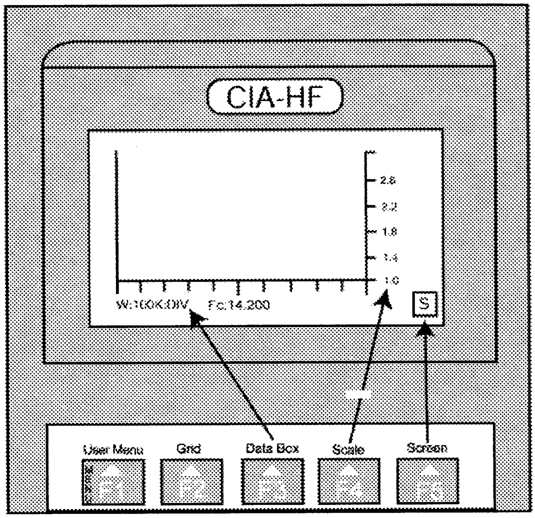
CAUTION: Do not connect any transmitting equipment directly to the antenna connector. Excessive RF at the antenna connector will damage the Analyzer. Damage may also occur when the load under test is near a transmitting antenna. In addition, never leave the Analyzer attached to an antenna after testing is complete; a lightning storm in the vicinity may damage the Analyzer's sensitive bridge network. Damage resulting from these situations is not covered under warranty.

NOTE: The Analyzer's sensitive instrumentation may cause erroneous readings (elevated minimum SWR values) to occur in the presence of RF fields (i.e. near commercial broadcast stations). To reduce the potential for interference, the Analyzer's output power is less than 5 mW. With a good antenna match, however, the reflected power can be up to 20dB lower, alevel that can be masked by other transmitters.

Screens

The Analyzer provides seven real time screens, which include two data screens and five graphing screens.

The two real time data screens include the Data screen and the Numerical Entry screen. The Data screen consolidates much of the information displayed in the Data Box (described below). The Data screen specifically displays: center frequency, SWR, Return Loss, Bandwidth2.0, Q factor, Resistance, Reactance, Impedance, Phase Angle, Capacitance, and Inductance values.



The Numerical Entry screen cannot be accessed by any of the function keys, but will automatically appear whenever you enter numbers on the keypad. The numbers will appear onscreen as they are entered. To terminate an entry and resume normal operation, press the ENTER key or one of the FREQ keys (refer to Dedicated Keys section).
The five real time graphing screens include: SWR screen, Magnitude of Impedance screen, Reactance screen, Resistance screen, and Vector screen. These screens contain a graphing area, Data Box, and Logo Box (Figure1).

The graphing area is 100 pixels wide. It is bordered on the right by a vertical axis containing a user-selectable scale, and on the bottom by a horizontal axis containing tick marks every ten pixels. The center (longest) tick mark represents the center frequency (center of the plot).

The Data Box, which contains three (simple mode) to 12 (expert mode) data blocks, is located below the horizontal frequency axis. The data blocks are updated after each frequency sweep, center frequency adjustment, or width adjustment.

NOTE: A data block will display the acronym "NA" when numerical data is Not Available for a particular value. This usually occurs when the SWR is too high or the Magnitude of Impedance is too far from 50 ohms.

The Logo Box, located in the lower right hand corner of the display, contains a letter that identifies the screen you are currently viewing. This box becomes vital in the expert mode when keeping track of your location becomes a little more challenging. The following key lists the real time screens and their identifying letters.

S...........	SWR screen
Z...........	Magnitude of Impedance screen (absolute value)
X...........	Reactance screen (absolute value)
R...........	Resistance screen (Real value of Impedance)
V...........	Vector screen (rectangular display of Impedance, X vs. R)
D...........	Data screen
N...........	Numerical Entry screen (displays numbers entered on the keypad)

Dedicated Keys

The dedicated keys, which include all but the F1-F5 softkeys, are used to adjust operational parameters.

The ON and OFF keys activate and deactivate, respectively, the Analyzer.

In the real time graphing screens, the WIDTH keys determine the frequency sweep range represented in a plot (refer to Frequency Sweep Range section). To adjust this range, use the WIDTHp and WIDTHq keys to step through eight preset width values (0kHz, 10 kHz, 20 kHz, 50 kHz, 100 kHz, 200 kHz, 500 kHz, 1 MHz).

When the width is set to 0 kHz, the unit will analyze SWR, Impedance, etc. at a single frequency (center frequency value). In addition, a beep sound at a rate that is proportional to the SWR at the center frequency (i.e. a low beep rate indicates a low SWR). This auditory cue allows you to make antenna adjustments without having to visually consult the display.

The center frequency of a plot, which defines the midpoint of the frequency sweep range, can be adjusted in three ways. One way is to use the FREQp and FREQq keys to step the center frequency value up and down in increments one-tenth the width value. For example, when the width is set to 500 kHz, the step size value will equal 50 kHz. Each time you adjust the width, the step size value will also change. This automatic feature enables fine-tuning within a plot.

You can also use the number keys to enter new center frequency values. Simply input a value between 0.001 and 54.000 MHz, followed by the ENTER key. Since the decimal point is in a fixed position, zeros will precede any values that are less than five digits long (i.e. 00.545).

As soon as you begin inputting numbers, the Numerical Entry screen will appear (refer to screens section). Once you press ENTER to terminate an entry, the Analyzer will resume normal operation according to the new center frequency value.

It is also possible to use the number keys in conjunction with the FREQ keys to add or subtract values from the current center frequency value. For example, entering 5 0 0 FREQp will add 500 kHz to the current center frequency value. (The FREQq key subtracts the input value from the center frequency.)

In the user Menu (described below), the WIDTH and FREQ keys perform different functions. The WIDTHp and WIDTHq keys allow you to scroll through the user Menu selections. The FREQp and FREQq keys allow you to adjust the CONTRAST level and SWR Bandwidth values once you have scrolled to these selections.

The ENTER key has multiple functions. In the Numerical Entry screen, it is used to terminate new center frequency values entered on the keypad. In the real time graphing screens, pressing the ENTER key reverses the direction in which the F3-F5 softkeys scroll through data, scale values, and screens, respectively. A small minus (-) sign will appear in the Logo Box when the Analyzer is in the reverse scrolling mode. Press the ENTER key again to revert to forward scrolling. Once you become familiar with the sequence of data, scale values, and screens, you may find that backward scrolling is more efficient than forward scrolling.

Pressing the EXAM/PLOT key in any of the real time graphing screens allows you to freeze the display when you want to more closely examine a plot. In this EXAM mode, only the width and center frequency values are accessible in the Data

Box. In addition, the words "EXAMINE PLOT" are displayed in place of the Logo Box. You cannot access any more data or make any plot changes in this mode. Once you have finished examining a plot, press EXAM/PLOT again to resume normal operation.

NOTE: In the EXAM mode, power is removed from much of the Analyzer's circuitry. Enter this mode whenever possible to extend battery life.

Function Keys

The F1-F5 softkeys allow you to access different screens, data, and plot parameters.

F1: User Menu

Use the F1 softkey to toggle between the real time screens and the user Menu screen. This screen contains a list of operational selections as well as a brief definition of each softkey. These definitions are located in boxes directly above their corresponding softkeys

The list of operational selections includes: TEST, KEYS, CONTRAST, SWR BW1, SWR BW2, METER, and EXTRA FEATURES. A flashing arrow cursor is automatically positioned next to the TEST selection whenever you enter this screen. Use the WIDTHp and WIDTHq keys to cursor through the list.

When the cursor is aligned with the TEST option, press ENTER to initiate a series of self-diagnostic tests. The word "TESTING" will flash on the TEST line until the self diagnostics are complete, whereupon one of the three types of messages will appear. If the self-diagnostics do not detect any problems, the "PASSED" message will appear. If the Analyzer detects low battery levels, the "LO BAT" massage will appear - refer to the Internal Access section for battery replacement information. Finally, if any problems are detected during the self-diagnostics, a "FAILURE" message will appear. In this case, call AEA's technical support department for troubleshooting assistance (refer to In Case of Trouble section).

When the cursor is aligned with the KEYS option, press ENTER to display a new screen listing the function definitions of the number keys and softkeys. Press ENTER a third time to return to the main user Menu screen.
When the cursor is aligned with the CONTRAST option, use the FREQp and FREQq to adjust the display contrast level.

The two SWR lines allow you to input specific SWR values (between 1.2 and 3.5) at which the Analyzer will display the corresponding bandwidths. When the cursor is aligned with either SWR selection, use the FREQ keys to adjust the displayed value.

Default values: 1.5 and 3.0

When the cursor is aligned with the METER option, press ENTER to display the Analyzer's remaining battery voltage. The Analyzer will also measure and display the Dc voltage of an external voltage source connected to the antenna connector.

When the cursor is aligned with the EXTRA FEATURES option, use the ENTER key to toggle this option ON and OFF. Turn this feature ON to activate the expert mode, which provides nine additional data blocks and four additional real time screens.

Default: Off

F2: Grid

While viewing the S, Z, R, or X real time screens, press the F2 softkey to superimpose a grid (graticule) over the plot. The grid allows you to more precisely determine values within a plot. Press F2 again to remove the grid.

Default: Off

F3: Data Box

Use the F3 softkey to scroll through the data blocks located in the Data Box. This key is useful because it allows you to access data without having to exit the real time screen. The three data blocks that are available in both the simple and expert modes include:

W:xxx Fc:xxx	Width, Center Frequency
SWR:xxx RL:xxx	Standing Wave Ratio, Return Loss
Z:xxx R:xxx X:xxx <:xxx	Absolute value, Real component, Reactive component, and Phase Angle of Impedance

To expand the number of data blocks displayed in the Data Box, enable the expert mode (refer to the F1: User Menu section). In the expert mode, the following nine data blocks will become available within the Data Box:

L:xxx C:xxx	Inductance or Capacitance value relating to the Reactance at the center

	frequency; describes the complex conjugate value of the Inductance or Capacitance needed to resonate a load to the center frequency
BW2.0:xxx Q:xxx	2:1 SWR Bandwidth in MHz, Q factor (Fc/2:1BW)
FL:xxx BW2.0: FH:xxx	Lower Frequency @ SWR 2:1, Higher Frequency @ SWR 2:1
FL:xxx BW3.0: FH:xxx	Lower Frequency @ SWR 3:1, Higher Frequency @ SWR 3:1
FL:xxx BW1.5: FH:xxx	Lower Frequency @ SWR 1.5:1, Higher Frequency @ SWR 1.5:1
MIN SWR:xxx at F:xxx	Lowest SWR, Frequency at which MIN SWR appears
NORMALIZED Z:xxx	50-ohm Normalized value of Z expressed as real ±j Imaginary components
<xxx Fc:xxx xxx>	Minimum, Center Frequency, maximum values in the frequency sweep range

-xxx Fc:xxx +xxx	Lowest frequency in the sweep range (Fc - half width), Center frequency, Highest frequency in sweep range (Fc + half width)

F4: Scale

To change the vertical axis' scale factor in the S, Z, X, and R screens, use the F4 softkey to scroll through three sets of scale values. Use this feature to zoom in and out of a plot quickly.

Default values: 1.0-6.0

F5: Screen

Use the F5 softkey to scroll through the real time screens. Notice that the Logo Box will update as you scroll through the screens.

Default: S screen

Frequency Sweep Range

During normal operation, the Analyzer continuously sweeps and plots a user-selected frequency range. This range, termed the frequency sweep range, is defined by the width and center frequency values.

Each tick mark on the horizontal axis represents an interval equal to the width value. When the width is set to 100 kHz, for example, each tick mark represents an interval of 100 kHz. Thus, the total frequency sweep range represented within the plot is 1000 kHz, or the sum of all ten intervals. This can be simplified as Frequency Sweep Range = 10 x Width. The center frequency value determines the midpoint of this 1000 kHz frequency sweep range.

With the EXTRA FEATURES function enabled, the Data Box displays the frequency sweep range in three ways. For example, assuming the center frequency is set to 7.100 MHz and the width is set to 100 kHz, the sweep range will alternately appear as "W:100K:DIV Fc:7.100", which indicates the basic plot values and lets you calculate the actual range, "<6.600 Fc:7.100 7.600>", which calculates the minimum, canter, and maximum frequency values represented in the plot, and "-0.500 Fc:7.100 +0.500", which simply informs you that the Analyzer is sweeping 500 kHz above and below the center frequency value.

Resetting the instrument

In the expert mode, the current screen and plot settings (i.e. center frequency, frequency step size, scale value, and width) are saved when you turn off the Analyzer. This feature allows you to power backup to the same screen and settings. To reset the Analyzer to its factory default settings, press any of the number keys to enter the Numerical Entry screen. Then simply power the Analyzer off. The next time you activate the Analyzer, it will operate according to the factory default settings: center frequency: 14.200 MHz, width: 100 kHz, frequency step size: 10 kHz, and scale: 1.0-6.0.

Automatic off

The Analyzer is programmed to automatically power off after a five minute idle period in order to conserve battery power. The Analyzer begins to calculate the idle period each time you press a key.

SECTION 4 APPLICATIONS

The following examples by no means describe the extent of the Analyzer's capabilities, but are intended as jumping off points. To follow along with the examples, first activate the Analyzer's expert mode (refer to Function Keys section).

Tuning Simple Antennas

Example: Tuning an 80-meter inverted "V" antenna to 3800 kHz.

Process:

1. Insert the feedline of the 80-meter inverted "V" antenna into the Analyzer's antenna connector.
2. Turn the Analyzer on. When the S screen appears, press 3 8 0 0 ENTER to change the default center frequency value to 3800 kHz. Maintain the default width value.
3. A "V" or "U"-shaped SWR curve will appear.
4. Using the F4 (zoom factor) softkey, select the lowest scale values that maintain the bottom of the SWR curve below the scale's midpoint. (You may have to experiment a little to determine which scale values work.)
5. Determine on which side of the center frequency the bottom of the SWR curve rests. The bottom of the curve should indicate the antenna's resonant frequency.
6. To confirm the value of the resonant frequency, press F3 to scroll through the data blocks until "MIN SWR:xxx at F:xxx" is displayed. This data block indicates the location of the minimum SWR.
7. Press F5 to enter the Z screen. A "V" or "U"-shaped curve will appear, indicating the absolute value of Impedance versus frequency.
8. Press F5 again to enter the X screen. The Reactance plot will dip down toward 0 ohms (on the vertical scale) at the resonant frequency.

If the resonant frequency is higher than the center frequency in the SWR plot, you can assume the Reactance is Capacitive. To tune the antenna to resonance, you either need to add equal lengths of wire to each side of the "V" antenna, or add an inductor, in series with the center conductor of the antenna's feedline, at the feedpoint. Press F3 until the Data Box displays the "L:xxx C:xxx" data block. The C:" value indicates the antenna's equivalent series Capacitance at the center frequency. The L:" value indicates the series Inductance (conjugate value) needed to resonate the antenna at the center frequency. You will likely have to experiment with the Inductance value to find an exact match. Depending on both the Impedance mismatch at the antenna feedpoint and the length of the feedline, you can use either an inductor or capacitor, in series with the center conductor of the feedline, to tune for resonance.

If the resonant frequency is below the center frequency, you can assume that the Reactance is Inductive (i.e. the antenna is TOO LONG). In this case, perform the reverse of the operation described in the above paragraph.

Tuning 1/2 and 1/4 Transmission Lines and Stubs

Example: Using a standard Wilkenson power divider to stack two 15-meter yagi antennas with two ¾ wave sections of RG 11, 75-ohm coax lines. The ¾ wavelength cable is used in this example because two ¼ wavelength cables would not be long enough to allow optimum stacking distance between the two antennas.

Process:

1. Use the following equation to determine the length of coax cable needed for ¼ wave phasing lines. (For solid polyethylene coax, assume a velocity factor of 0.6.)

$$\frac{234}{F} \times Vf = \frac{234}{21.250} \times 0.6 = 6.61 \text{ feet}$$

For ¾ wave phasing lines, plug 6.61 feet into this equation:

6.61 x3 = 19.8 = 19 feet 9 5/8 inches

2. Cut two, 22 foot-long lengths of coax cable (the lengths of coax cable are cut approximately 10% longer than the computed length to allow for fine tuning).
3. Solder a coax "PL-259" connector to one end of each cable.
4. Attach the "PL-259" connector to a "T" connector already attached to the antenna connector. Attach a 50-ohm load to the other end of the "T" connector (Figure 2).
5. Turn the Analyzer on. At this point, follow the steps for either the ½ Wave Cutting Method or the ¼ Wave Shorting Method

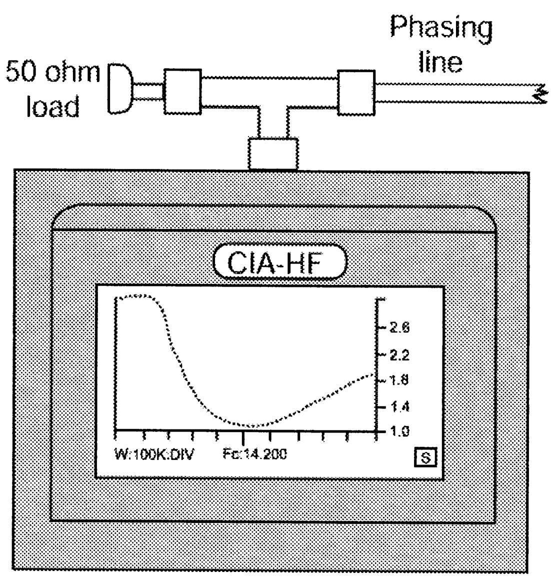


FIGURE 2. T Connector

1/2 Wave Cutting Method

1. When the S screen appears, press the WIDTH▲ key twice to select an initial width of 500 kHz. Enter 4 2 5 0 0 ENTER to set the center frequency to 42.500 MHz (the frequency at which the tuned phasing lines will be 1.5 wavelengths). This center frequency value is twice the 21.250 frequency value used in the above equation.
2. A "V" or "U"- shaped SWR curve will appear.
3. If the calculations for determining the length of coax cable were correct, the SWR curve should dip at a frequency of approximately 38.250 MHz. You are now ready to start tuning the phasing line.
4. Begin cutting inch-long pieces off of the unterminated end of the phasing line. The resonant frequency of the SWR curve will increase as the line is shortened.
5. As the SWR dip descends lower in the plot, shorten the cuts to 1/4 inch long. This allows you to finely tune the line. In addition, use the WIDTH▼ key to increase the display resolution. Use the F4 softkey to zoom in on the dip. Once the SWR dip reaches a minimum, your antenna is tuned.
6. Repeat this process for the second phasing line. It is imperative that the bottom of the two SWR curves are aligned on the same frequency. If the bottom of one of the curves is at 0 over a narrow group of frequencies, average the two extreme frequencies where the SWR is at a minimum.

1/4 Wave Shorting Method

1. Enter 2 1 2 5 0 ENTER to set the center frequency to 21.250 MHz.
2. Use a very sharp ice pick to short through the coax cable.
3. Determine the position that produces the lowest SWR point at the center frequency. Cut the cable at this point and install a coax connector. Your cable is now tuned.
4. Repeat this process for the second phasing line.

You can also use the 1/2 Wave Cutting or 1/4 Wave Shorting methods described above to tune phasing lines any number of degrees for a particular frequency. For example, if you want to cut a transmission line for 21° at 3.795 kHz, simply use the following equation to determine the frequency for 180°:

$$\frac{180}{21} \times 3.795 = 32.529 \text{ MHz}$$

Since 21° at 3.795 kHz is equivalent to 180° at 32.529 MHz, simply use the 1/2 Wave Cutting Method to tune the line for 32.529 MHz.

Measuring Inductors and Capacitors

When measuring inductors and capacitors, it is highly recommended that you assemble an accessory connector to maximize Analyzer accuracy. To do this, solder one end of a 50-ohm resistor onto the center pin of a coax PL-259 connector. Then, splice an alligator test lead to the resistor; solder a second test lead to the connector shell (Figure 3).

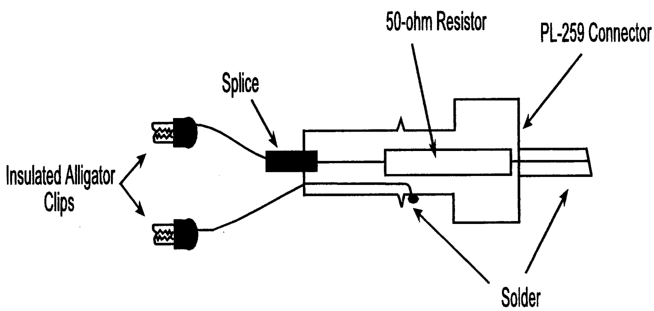


Figure 3
50 ohm accessory connector

For best results, when determining the value of an inductor or capacitor, take measurements at the frequency where the Reactance of the load is equal to the 50-ohm resistor in the accessory connector.

• Inductors

Example: Determining the Inductance of a relatively small coil.

Process:

1. Plug the 50-ohm accessory connector into the Analyzer and clip the coil between the two test leads.
2. Turn the Analyzer on and use the F5 softkey to scroll to

the X screen. Enter 2 5 0 0 0 ENTER to select an initial center frequency of 25 MHz. Press the WIDTH▲ key until the width is set to 1 MHz. Also, use the F4 softkey to set the scale to the 0-250 ohms range.

3. Unless you select a higher frequency, low Reactance will probably cause the plot to flat line near the bottom of the screen. If Inductance is relatively high in higher frequencies, the Reactance plot will flat line near the top of the scale.
4. Experiment with different center frequency values until you find the point at which the Reactance plot reaches approximately 50 ohms.
5. Use F5 to scroll to the Data screen. The Phase Angle (<:) should read approximately 45°. If it does not, press the FREQ▲ or FREQ▼ key until it does. Now, identify the Inductance (L:) value within the Data screen.

• **Capacitors**

Example: Determining the Capacitance of a small capacitor (approximately 1000 pF).

Process:

1. Plug 50-ohm accessory connector into Analyzer, and clip the capacitor between the two test leads.
2. Turn the Analyzer on, and use the F5 softkey to scroll to the X screen. Enter 5 0 0 0 ENTER to select an initial center frequency of 5 MHz. Press the WIDTH▲ until the width is set to 1 MHz.
3. The Reactance plot will sweep down from the left side of the display, leveling out as it approaches the right side.
4. Adjust the center frequency value until you determine the point at which the Reactance is approximately 50 ohms.
5. Press F3 until the "Z:xxx X:xxx R:xxx <:xxx" data block is displayed. The Phase Angle (<:) should read approximately 45° since the R and X values are roughly

equal. If it does not, adjust the center frequency until it reads as close to 45° as possible.

6. Press F3 to scroll to the "L:xxx C:xxx" data block. Refer to the "C:" value to determine Capacitance.

Tuning Antenna Traps

Example: Using the 50-ohm accessory connector constructed for the above example to tune an antenna trap (composed of a coil in parallel with a capacitor).

Process:

1. Leave the coil and capacitor of the trap connected at one end, separated at the other.
2. Clip one test lead of the accessory connector to the coil, the other test lead to the capacitor.
3. Turn the Analyzer on. Maintain the default S screen and plot values.
4. Determine on which side of the center frequency the bottom of the SWR curve rests. The bottom of the curve should indicate the antenna's resonant frequency.
5. To confirm the value of the resonant frequency, use F3 to scroll through the data blocks until "MIN SWR:xxx at F:xxx" is displayed. This data block indicates the location of the minimum SWR.
6. Press F5 to enter the Z screen. A "V" or "U"-shaped curve will appear, indicating the absolute value of Impedance versus frequency.
7. Press F5 again to enter the X screen. The Reactance plot will dip down toward 0 ohms (on the vertical scale) at the resonant frequency.
8. Refer to the analysis paragraphs following the "Tuning A Simple Antenna" procedure.

Determining Resonant Frequency

Example: Using the 50-ohm accessory connector constructed for the above example to determine the resonant frequency of an LC-tuned circuit.

Process:

1. Use the test leads of the 50-ohm accessory connector to connect the inductor and capacitor in series.
2. Turn the Analyzer on. Maintain the default S screen.
3. Find the resonance point of the circuit by locating the lowest SWR point.
4. Use the FREQ keys to center the lowest SWR point.
5. Access the Data screen to read the 2:1 SWR bandwidth and Q factor directly.

Determining Characteristic Impedance

For this type of measurement, you will need to assemble another accessory connector using a 500-ohm potentiometer (Figure 4).

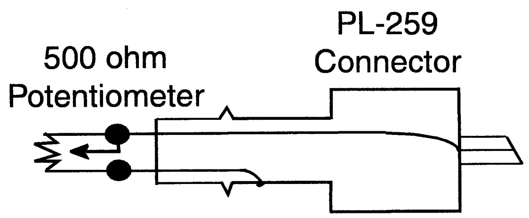


Figure 4
5000 ohm potentiometer connector

Example: Determining the characteristic Impedance of an unknown coax cable.

Process:

1. Attach the unknown cable to the Analyzer's antenna

connector. Attach the potentiometer accessory connector to the unterminated end of the cable using a PL-258 barrel connector.

2. Use the F5 softkey to scroll to the R screen. Press 2 5 0 0 0 ENTER to select a new center frequency value of 25 MHz, and press the WIDTH▲ key until the width is set to 1 MHz. Use the F4 softkey to set the vertical scale to 100 ohms full scale.
3. Depending on the length of the cable (hopefully at least 25 feet), two or more sine waves will appear on the display.
4. Use the potentiometer to adjust the plot for minimum amplitude variance on the sine waves.
5. Now, disconnect the potentiometer from the cable. Use a volt-ohmmeter to determine the Resistance of the potentiometer. Usually a 50-ohm cable will read between 49 and 52 ohms of Resistance. It is also possible to read the Resistance value of the potentiometer by disconnecting it from the cable and plugging it directly into the Analyzer. Use the F5 softkey to scroll to the Data screen; once there, identify the Resistance (R:) value.

Testing Baluns

Example: Using the 500-ohm potentiometer accessory connector constructed for the above example to determine the output (or input) Impedance of an unknown balun.

Process:

1. Insert the 50-ohm port of the balun into the Analyzer, and the potentiometer connector into the balun's vacant port.
2. Turn the Analyzer on. Maintain the default S screen.
3. Adjust the potentiometer for minimum SWR. (The balun may not flat line over a wide range of frequencies.)
4. To identify the balun's useful range, experiment with

different center frequency and width values. You may see larger SWR values at the extreme lower and upper frequencies.

5. To determine the balun's Resistance, disconnect the potentiometer from the balun and plug it directly into the Analyzer. Then, access the Data screen (F5 softkey) to identify the Resistance (R:) reading.

Adjusting Antenna Tuners

Example: Adjusting an antenna tuner without transmitting a signal on the air.

Process:

1. Connect a cable from the input of your antenna tuner to the center connector of a two-position coax switch (be sure to use a switch that shorts the unused position).
2. Connect the open position of the switch to the output of your transceiver.
3. Connect a cable from the closed position of the switch to the antenna connector on the Analyzer.
4. Turn the Analyzer on. Set the center frequency and width to values of your choice. Use the F5 softkey to scroll to the Z screen.
5. Adjust the tuning on the antenna tuner (with the proper antenna connected to the antenna tuner output) until the center frequency displays an Impedance value of 50 ohms.
6. Use the F5 softkey to scroll to the X screen to make sure Reactance is zero.
7. Use F5 to scroll to the S screen. Note the low SWR value at the center frequency. Flip the coax switch to the transceiver. The low SWR presented to the Analyzer will now be presented to the transceiver.

Adjusting antenna Tuners

Example: Adjusting an antenna tuner without transmitting a signal on the air.

Process:

1. Connect a cable from the input of your antenna tuner to the center connector of a two-position coax switch (be sure to use a switch that shorts the unused portion).
2. Connect the open position of the switch to the output of your transceiver.
3. Connect a cable from the closed position of the switch to the antenna connector on the Analyzer.
4. Turn the Analyzer on. Set the center frequency and width values of your choice. Use the F5 softkey to scroll to the Z screen.
5. Adjust the tuning on the antenna tuner (with the proper antenna connected to the antenna tuner output) until the center frequency displays an Impedance value of 50 ohms.
6. Use the F5 softkey to scroll to the X screen to make sure Reactance is zero.
7. Use F5 to scroll to the S screen. Note the low SWR value at the center frequency. Flip the coax switch to the transceiver. The low SWR presented to the Analyzer will now be presented to the transceiver.

Measuring Cable Length/Distance to Fault

NOTE: The following data block will be referenced in this addendum:

"Fc:xxx VF:xxx FT:xxx (x)"	Center Frequency, Velocity Factor, Feet, (O) Open or (S) Short

The Analyzer measures the physical length of a coax cable, or the distance to the first short or open present on a coax cable, by determining the frequency at which cable impedance goes to zero. This frequency is inversely proportional to the length of the cable, and is used, along with the user-programmable velocity factor, to compute the distance to the end of the cable. Generally, an open cable will exhibit a nearly zero impedance at the ¼ wavelength frequency.

Example: Determining cable length/the distance to an open or short present on a coax cable.

Process:

1. Attach the coax cable under test to the antenna connector. Turn the Analyzer on.
2. Press F1 to access the user Menu screen. Use the WIDTHq key to scroll down to the "VF:50 (open)" (velocity factor) selection
3. Use the FREQp and FREQq keys to change the velocity factor to a value between 0.50 and 0.99. (The velocity factor for your cable is listed in the Radio Amateur's Handbook or in the ARRL Antenna Handbook, or is available directly from the manufacturer.) If you toggle past 0.99, the velocity factor value will revert to 0.50, and the fault type indicated in parentheses will change from open to short and vice versa. NOTE: A correct velocity factor is critical in obtaining accurate distance measurements.
4. Press F1 to return to the real time graphing screen. Use F3 to scroll to the "W:xxx Fc:xxx" data block. Input 5 0 0 0 ENTER to set the center frequency to 5.000 MHz. Use the WIDTHp key to set the width to 1 MHz.
5. Use F5 to scroll to the Z (impedance) screen.
6. Depending on the length of the cable, you should observe one or several dips in the impedance curve. Select the LOWEST center frequency value (above zero) that displays a full dip. Experiment with the center

frequency value until it is as close to the center of the dip as possible. As a general rule, enter lower center frequencies for longer cables and higher center frequencies for shorter cables. For example, enter a center frequency of 5.000 MHz to display the dip of a 32-foot long cable possessing a velocity factor of 0.66.

7. Press ENTER to reverse data block scrolling. Press F3 once to display the "Fc:xxx VF:xxx FT:xxx (x)" data block. Consult the "FT:" reading to determine the length of the cable. If the footage reading is shorter than expected, an open or short may be present on the cable at the distance indicated.

If there is a known fault on the cable, and the distance to fault ("FT:") reading seems inaccurate, verify that the open termination is truly an infinite DC open, or that the short is a direct short with no inductance. An incorrect velocity factor will also contribute to an inaccurate footage reading. Occasionally, a cable's true velocity factor will vary from the published or manufacturer specification because of a production variance or because of cable deterioration due to ultraviolet or water contamination. Please note that since the velocity factor is allotted only two decimal places, it is not possible to measure distance with better than 1% accuracy.

Measuring Cable Loss

Example: Determining cable loss.

Process:

1. Turn the Analyzer on.
2. Before you attach the cable under test, enter the center frequency at which you want to determine Return Loss.
3. Use F3 to scroll to the "SWR:xxx RL:xxx" data block. The "RL:" reading should be less than 2 dB, depending

on the center frequency selected. Note this reading.

4. Now attach the cable under test to the antenna connector. Note the new Return Loss reading. Confirm that the cable under test has either a direct short or a complete open at the termination end.
5. Subtract the initial Return Loss reading (without the cable connected) from the new reading. The result is the total (round-trip) Return Loss present in the cable.
6. Divide the result by two (2) to determine actual cable loss (one-way) at the selected center frequency.

Other Applications

Uses for the CIA-HF Analyzer are limited only by your imagination and experience. We encourage you to explore all of the Analyzer's capabilities - those listed here and those wanting to be discovered. For more information on Antenna Impedance Matching, consult the ARRL Antenna Handbook.

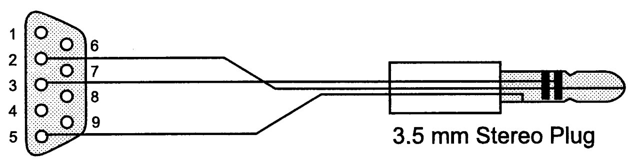
Remote Operation

Serial Port Protocol
9600 baud
8 data bits
no parity
1 stop bit

Power Up

To perform remote operation, you will need to connect the Analyzer to your PC via a serial interface cable. You have the option to assemble a cable yourself or purchase one of the serial interface cables displayed below, directly from AE

Female 9-Pin Sub-D



The Analyzer can be powered up manually, using the On key, or remotely, using your PC. To remotely power up the Analyzer, simply send the letter "K" until you receive a "?" in response. At this point, you can begin sending commands. When the Analyzer is already powered on, it will automatically time out after a five-minute idle period in order to conserve batteries. It will power back up when it detects an incoming serial stream.

Rules for Commands

- All commands must be in upper case letters. Lower case letters are invalid.

- All incoming commands to the Analyzer must be terminated with the letter "K". If the Analyzer detects an incoming stream containing ten or more characters, that is not terminated with the letter "K", it will output a "?" and discard the characters. All commands contain fewer than ten characters.

- All outgoing responses from the Analyzer are terminated with either a "K" or a "?". the letter "K" indicates that the incoming command was properly executed and that no further information is outgoing. The "?" indicates that the Analyzer did not understand the incoming command. Re-enter the proper command.

- The Analyzer will accept commands manually entered on its keypad **or** remotely transmitted from a terminal (serial commands). Do not attempt to use both methods at the same time. The Analyzer will not accurately respond to mixed manual and serial commands.

Commands

The following serial commands direct the Analyzer to perform certain functions. Remember, each of these commands must be terminated with a "K", as shown.

SK Send 100 SWR data points
ZK Send 100 Z (Impedance Magnitude) data points
XX Send 100 X (Reactance) data points
RX Send 100 R (Reactance) data points

WxK	Set the WIDTH to the following values: x = 0 width set to 0 kHz per data point x = 1 width set to 1 kHz per data point x = 2 width set to 2 kHz per data point x = 3 width set to 5 kHz per data point x = 4 width set to 10 kHz per data point x = 5 width set to 20 kHz per data point x = 6 width set to 50 kHz per data point x = 7 width set to 100 kHz per data point
UxxK	Set the User #1 SWR threshold to xx xx must be in the range of 12 to 35
VxxK	Set the User #2 SWR threshold to xx xx must be in the range of 12 to 35
BxxK	(Directs the DATA BOX Field to retrieve the data contained in the Analyzer's Data Box. Refer to the F3: DATA BOX section for more detailed information on the responses you will receive.) Set the Data Box to xx, where xx must be the following: xx = 00 Report width, and center frequency xx = 01 Report SWR, and Return Loss xx = 02 Report the Z, R, X, and Angle at the center frequency xx = 03 Report equivalent L, C at center frequency xx = 04 Report 2:1 Bandwidth Q xx = 05 Report lower (2:1) frequency, 20, upper (2:1) frequency xx = 06 Report lower (X:1) frequency, X, upper (X:1) frequency

	xx = 07 Report lower (Y:1) frequency, Y, upper (Y:1) frequency
	xx = 08 Report minimum SWR, frequency @ minimum SWR
	xx = 09 Report Normalize R, ±j Normalized X
	xx = 10 Report frequency low, center frequency, frequency high
	xx = 11 Report -offset, center frequency, +offset
	xx = 99 Power off Analyzer
FxxxxxK	Set the center frequency to xxxxx. xxxxx must be in the range of 00400 to 54000. Leading zeros are required.

Responses

Below is a list of "live" serial commands and responses (left column) and the information communicated by each command/response (right column).

IK	; Illegal command sent
?	; Response from Analyzer
F12345K	; Illegal command sent (lower case "f")
?	; Response from Analyzer
F12345K	; Command sent to Analyzer: set center frequency to 12.345 MHz
F12345K	; Response from Analyzer: center frequency set to 12.345 MHz
Book	; Command to Analyzer: report width and center frequency
...	;

464,	; Response: data point #96 (@ 12.6 MHz) SWR = 4.64
477,	; Response: data point #97 (@ 12.7 MHz) SWR = 4.77
488,	; Response: data point #98 (@ 12.8 MHz) SWR = 4.88
502,	; Response: data point #99 (@ 12.9 MHz) SWR = 5.02
515,K	; Response: data point #100 (@ 13.0 MHz) SWR = 5.15, END
ZK	; Command to Analyzer: send the SWR data
Z=	; Response from Analyzer
2006,	; Response: data point #1 (@ 3.0 MHz) Z = 200.6 Ohms
1952,	; Response: data point #2 (@ 3.1 MHz) Z = 195.2 Ohms
1852,	; Response: data point #3 (@ 3.2 MHz) Z = 185.2 Ohms
1787,	; Response: data point #4 (@ 3.3 MHz) Z = 178.7 Ohms
...,	;
...,	; Response: data points #5 - #95
...,	;(not shown here, for clarity)
...,	;
1116,	;Response: data points #96 (@ 12.6 MHz) Z = 111.6 Ohms
1138,	;Response: data points #97 (@ 12.7 MHz) Z = 113.8 Ohms

1160,	;Response: data points #98 (@ 12.8 MHz) Z = 116.0 Ohms
1180,	;Response: data points #99 (@ 12.9 MHz) Z = 118.0 Ohms
1205, K	;Response: data points #100 (@ 13.0 MHz) Z = 120.5 Ohms
B99K	;Command to Analyzer: power off
	;No response, Analyzer is powered off
B=	;Response from Analyzer
10,12345K	;Response: Width = 10 kHz per data point, center frequency = 12.345
W7K	; Command to Analyzer:set width to 100 kHz per data point
W7K	; Response from Analyzer: width set to 100 kHz per data point
BOOK	; Command to Analyzer: report width and center frequency
B=	; Response from Analyzer
100,12345K	; Response: width = 100 kHZ per data point, center frequency = 12.345
F08000K	; Command sent to Analyzer: set center frequency to 08.000 MHz
F08000K	; Response from Analyzer: center frequency set to 8.0 MHz
B01K	; Command to Analyzer: report SWR and Return Loss at center frequency
B=	; Response from Analyzer:
107,294K	; Response: SWR = 1.07, Return Loss = 29.4 dB

B02K	; Command to Analyzer: report Z, R, X, and Angle
B=	; Response from Analyzer:
501,501,0,-0K	; Response: Z = %0.1, R = 50.1, X = 0, angle = -0°
B05K	; Command to Analyzer: report frequency low, high for 2:1 bandwidth
B=	; Response from Analyzer:
6550,20,9650K	; Response: frequency (low) = 6.55 MHz, BW = 2:1, frequency (high) = 9.65 MHz
B06K	; Command to Analyzer: report frequency low, high for USER #1 bandwidth
B=	; Response from Analyzer:
7300,15,8900K	; Response: frequency (low) = 7.3 MHz, BW = 1.5:1, frequency (high) = 8.9 MHz
U18K	; Command to Analyzer: set the USER #1 Bandwidth to 1.8
U18K	; Response from Analyzer: USER #1 Bandwidth set to 1.8
B06K	; Command to Analyzer: report frequency low, high for USER #1 bandwidth
B=	; Response from Analyzer:
6850,18,9350K	; Response: frequency (low) = 6.85 MHz, BW = 1.8:1, frequency (high) = 9.35 MHz
B08K	; Command to Analyzer: report minimum SWR and frequency at the minimum SWR
B=	; Response from Analyzer:
105,8100K	; Response: minimum SWR detected = 1.05, at 8.1 MHz

B10K	; Command to analyzer: report lower, center, and upper frequency
B=	; Response from Analyzer:
3000,8000,	; Response: frequency (low) = 3.0 MHz,
13000K	center frequency = 8.0 MHz, frequency (high) = 13.0 MHz
SK	; Command to Analyzer: send the SWR data points
S=	; Response from Analyzer:
1278,	; Response: data point #1 (@ 3.0 MHz) SWR = 12.78
1204,	; Response: data point #2 (@ 3.1 MHz) SWR = 12.04
1130,	; Response: data point 3# (@ 3.2 MHz) SWR = 11.30
1072,	; Response: data point #4 (@ 3.3MHz) SWR = 10.72
...	;
...	; Response: data points #5 - #95...
...	; (not shown here, for clarity)
...	;

SECTION 5 GLOSSARY

Capacitive Reactance - The Reactance of a circuit resulting from Capacitance, or the property of a device or component that enables it to store energy in an electrostatic field and release it later.

Center Frequency - The frequency corresponding to the center of a plot; defines the midpoint of the frequency sweep range.

Data Box - Displays the data blocks described in the Function Keys section; located below the horizontal axis in the real time graphing screens.

Graticule - A dotted grid superimposed on a plot to aid the user in discerning numerical values.

Idle Period - The amount of time that elapses between user inputs; the Analyzer will power off after a five minute idle period in which no keys have been pressed.

Impedance - The total passive opposition offered to the flow of an alternating current; total (absolute) Impedance consists of Resistance plus either Capacitive or Inductive Reactance.

Inductive Reactance - The Reactance of a circuit resulting from the presence of Inductance, or the property of an inductor that opposes any change in a current that flows through it.

Logo Box - Displays a letter identifying the currently displayed screen; located in the lower right corner of each real time graphing screen.

Plot - The analog display of various antenna values relative to frequency.

Q factor - As it relates to the Analyzer, this value, which is calculated by dividing the center frequency by the 2:1 SWR bandwidth, provides a relative indication of how sharp an antenna or tuned circuit is.

Reactance - The part of total Impedance resulting from Inductance or Capacitance.

Real Time - A term applied to the seven primary graphing and data screens; indicates that there is no significant delay between data capture and display.

Resistance - The opposition of a material to the flow of electric current; Resistance is equal to a voltage drop through a given material, divided by the current flow through it. The standard unit of Resistance is the ohm.

Return Loss - The approximate loss that a signal experiences when traveling "round-trip" through a cable, expressed in decibels (dB).

Scale - The values displayed on the Y (vertical) axis of the graphing area.

Screen - A display containing either real time plots or data:

S: Real time sweep display of a test load's SWR curve.

Z: Real time sweep display of a test load's Impedance (absolute value) vs. frequency curve.

R: Real time sweep display of a test load's Resistance vs. frequency curve.

X: Real time sweep display of a test load's Reactance vs. frequency curve.

V: Real time sweep display of a test load's Impedance (Resistance vs. Reactance) vector for a selected center frequency.

D: Consolidates a number of the data blocks displayed in the Data Box; these data blocks are displayed and updated in real time.

N: Displays numbers as they are entered on the keypad.

<u>Standing Wave Ratio (SWR)</u> - The ratio of the maximum to minimum voltage on a transmission line connected to an antenna.

<u>User Menu</u> - A display screen (separate from the seven primary screens) used to define keys, initiate self-diagnostic tests, set the display contrast level, select special functions, enter the voltmeter mode, etc.

SECTION 6 INTERNAL ACCESS

Battery Replacement

Confirm that the Analyzer is off before replacing the batteries. Then, remove the two screws behind the rubber foot to access the battery compartment. To avoid damaging the Analyzer, be sure to insert the batteries according to the markings located on the inside wall of the case. Replace all eight batteries at the same time. Make sure the foot's pegs are securely positioned in the slots in the top of the battery cover before reinstalling the screws.

SECTION 7 LIMITED WARRANTY

AEA, WIRELESS, INC. warrants to the original purchaser that the CIA-HF Complex Impedance Analyzer shall be free from defects in material or workmanship for a period of one year from the date of shipment. All units returned to the factory, delivery charges prepaid, and deemed defective under this warranty, will be replaced or repaired at this company's option. No other warranties are implied, nor will responsibility for operation of this instrument be assumed by AEA, WIRELESS, INC.

SECTION 8 IN CASE OF TROUBLE

If your Analyzer doesn't seem to be working properly, please try the following suggestions before sending the unit in for repair:

- When the Analyzer is being used as a portable instrument, low batteries are the most likely cause of difficulty. Run the TEST function in the user Menu screen to check battery levels.

- If the Analyzer is plugged into an external power source, determine whether or not your power supply is capable of providing 12 to 16 VDC while the unit is on. If you're not sure, use a known 12 VDC power supply. Also, make sure the center pin of your power cable is positive or you may risk damage to the Analyzer.

- Make sure all cables are securely connected. Check cable continuity with an ohmmeter.

If you can't solve the problem yourself, please let us try to help you over the phone before sending in the unit. Many of the products we receive for service are in perfect working order. Calling us for technical assistance can save you both time and money.

For application and troubleshooting assistance, please call AEA Wireless, Inc. between 7:00AM and 4:00PM Pacific Standard Time. The phone number for the technical support department is (760) 798-9687.

When you call for assistance, please have the Analyzer's serial number available. Also, have the Analyzer connected to a load and powered on. The technician you speak with may ask you to perform certain functions to aid in diagnosis. You will also need to identify the nature of any other equipment connected to the Analyzer.

If the Analyzer needs to be returned to the factory, please call (760) 798-9687 for a Return Material Authorization (RMA) number. Also, please include a statement giving a complete description of the problem, including the conditions under which it occurred. Complete return information (name, company, address, and daytime phone number) should be included with each unit.

Units should be sent to:

AEA, Wireless Inc.
Repair Department, RMA No.
1487 Poinsettia Ave Suite 127
Vista, CA 92083

AEA WIRELESS, INC.

1487 Poinsettia Ave Suite 127 • Vista, CA 92083
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