

# TZ-900

## AntennaSmith™

# Hardware Manual

Revision 1.1



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# Table of Contents

1.	INTRODUCTION .....	5
1.1.	Power On/Off.....	5
1.2.	Automatic Power Off.....	6
1.3.	Function Modes .....	6
2.	SWEEP MODE.....	7
2.1.	SETTING SWEEP START AND STOP FREQUENCIES.....	7
2.1.1.	GRAPHICALLY SETTING SWEEP FREQUENCIES .....	8
2.1.2.	MANUALLY CREATING A NEW SWEEP RANGE.....	8
2.1.3.	SWEEPING A STANDARD SCAN RANGE .....	9
2.1.4.	SWEEPING THE SAME RANGE AS A REFERENCE MEMORY .....	9
2.2.2.	SWR.....	11
2.3.	POLAR GRAPH TYPES.....	12
2.3.1.	SMITH CHART.....	12
2.3.2.	REFLECTION COEFFICIENT (RHO).....	13
2.3.3.	PHASE SIGN CONSIDERATIONS:.....	13
2.4.	MEMORIES .....	15
2.4.1.	SCAN MEMORY USAGE: .....	15
2.4.2.	REFERENCE MEMORY USAGE .....	16
3.	MANUAL MODE .....	19
4.	HI-RESOLUTION FREQUENCY SYNTHESIZER MODE .....	20
5.	SYSTEM SETUP.....	21
5.1.	Settings.....	21
5.1.1.	Graphic Settings.....	21
5.1.2.	Smith SWR .....	22
5.1.3.	APO Settings.....	22
5.1.4.	Level Settings.....	22
6.	POWER SUPPLY.....	23
7.	HOST COMMUNICATIONS .....	24
8.	SPECIAL SERVICE AND SETUP MODES.....	25
8.1.	Restoring default settings.....	25
9.	APPLICATION NOTES .....	26
9.1.	Transmission Lines .....	26
9.2.	Antenna measurements on coax.....	27
9.3.	Obtaining the best accuracy .....	27
10.	QUICK TRICKS.....	28
10.1.	Rapidly Analyzing an Antenna.....	28
10.2.	Rapidly zooming to a section of a sweep.....	29
10.3.	To rapidly set sweep start and stop frequencies using the knob .....	29
10.4.	Rapidly setting a scan of 1.000.000 to 30.000.000.....	30
10.5.	Doing a detailed analysis of a frequency from a sweep.....	30
10.6.	Rapidly starting and stopping a sweep using the same settings.....	30
11.	AntennaSmith Connectors .....	31
12.	Additional Reading .....	32
13.	Troubleshooting.....	33

14.	Specifications .....	34
15.	Timewave.....	35
16.	Warranty .....	36
17.	Table of Figures .....	37

## 1. INTRODUCTION

The Timewave TZ900 AntennaSmith™ is a versatile rugged hand-held color graphical antenna analyzer.

The analyzer has a number of features required for use in a field application.

These features include:

A color graphic display visible in bright sunlight as well as at night.

Memory storage of measurements for reference and/or later download to a computer through either a USB 2.0 or RS232 type interface.

Color graphic comparison of previously stored measurements. This can be used for rapid determination of any changes made to the antenna system or for comparison of antenna system changes over time.

In addition other features include:

Highly stable and accurate direct digital synthesizer frequency generation.

Through the use of one knob and 4 buttons, a simple user interface is provided requiring a minimum of user inputs to rapidly acquire all of the data available.

An internal fast battery charger guarantees the instrument will always be available for use.

A 1 Hz resolution frequency generator mode for bench top signal generation.

Remotely controllable by a RS232 serial or USB 2.0 port.

### 1.1. Power On/Off

The instrument is powered on by pushing and holding the power button until the opening screen appears.

The instrument is powered off by pushing and releasing the power button or by having the “APO” (automatic power off) function turn off the unit (see section 1.2).

After powering the instrument on, the state of the internal battery charge can be monitored by the battery bar graph indicator. If the indicator shows less than about 10% green (90% red), it is advisable to connect the fast charger to the instrument to initiate a fast charge and also guarantee enough power so the normal measurement accuracy is maintained.

## 1.2. Automatic Power Off

The instrument has a battery conserving automatic power off mode. This mode can be selected from the systems settings screen and has four settings (Off, 5 minutes, 10 minutes (default), and 30 minutes). When the instrument does not receive a user input (either button, knob, USB, or RS232) for the “APO” time selected, the instrument will automatically turn off.

## 1.3. Function Modes

There are three major function modes:

The SWEEP mode is a frequency-sweeping mode that graphs chosen parameters as the frequency is swept from a start frequency to an end frequency. Graphs can be X-Y type where the X-axis is frequency or polar types such as the Smith chart or Reflection coefficient.

The MANUAL mode is used for analysis at a single frequency. This mode uses bar graphs to display measurable parameters and numeric output on the bar graphs when acquisition is stopped.

The Hi-resolution frequency SYNTHESIZER mode is used to produce a stable reference frequency that can be used for a number of bench type ham related activities.

The instrument is switched between the three major modes using the top “MODE” (#1) button.

The current MODE the instrument is in can be easily determined from viewing the top button (#1) text. The current mode is shown in green. Modes are labeled Swp, Man, and Synth on button #1.

## 2. SWEEP MODE

The sweep mode provides the user with the ability to rapidly view selected parameter(s) as the instrument is linearly swept between two chosen frequencies.

Two distinctly different graphic types of sweep are provided. When displaying single dependent variable resultants, an X-Y type graph is displayed. Polar graphs are used when two dependent variable resultants are simultaneously displayed.

Sweep type displays  
(Single Variable)  
SWR vs frequency  
Impedance ( $Z$ ) vs frequency  
Real Impedance ( $R$ ) vs frequency  
Imag. Impedance ( $jX$ ) vs. frequency  
(Polar (Two variable))  
Smith chart  
Rho chart (Reflection coefficient)

Sweep ranges can be manually set, recalled from scan memory, recalled from reference memory or manually set and saved to scan memory.

Graphics mode (SWR,  $Z$ ...), and can be changed instantly using the “GRAPH” (#2) button. The graphics mode is labeled in green on the button.

Upon stopping a running sweep either by pushing the knob or the “STOP SWP” (#4) button, the sweep frequency range can be manually entered or recalled from the SCAN or REFERENCE memories. If old values are OK, simply pushing the knob restarts the sweep, however if new sweep frequencies are desired, push “SWP SETUP” (#4) button and follow on screen directions to manually enter a new sweep frequency range or select from a pre-saved scan memory location.

### 2.1. **SETTING SWEEP START AND STOP FREQUENCIES**

There are four methods that can be used to set the beginning and ending frequencies required for a sweep type graph.

If the graph is currently sweeping --- pushing the “STOP SWP” (#4) button or pushing the knob will stop the sweep and allow a new sweep range to be set. At this point the device under test can be disconnected while still preserving the display.

(If it is desired to keep using the current range, simply pushing the knob will restart the sweep.)

Once the sweep is stopped two options are available.

One option is to graphically set the sweep center frequency and the width of the sweep. This method is rapid and convenient but limited to sweep frequencies that are within the range currently being displayed on the graph. To use this method see section 2.1.1.

The second option allows three different non-graphic manual methods. This option is preferable if it is desired to manually create a new sweeping range (Section 2.1.2), sweep standard ranges previously saved (Section 2.1.3), or compare current measurements with a previously saved reference.

### **2.1.1. GRAPHICALLY SETTING SWEEP FREQUENCIES**

If the sweep has been stopped (by pushing button #4 or the knob), a new center frequency can be selected using the cursor and the “SET Center” (#3) button. After selecting the desired center frequency with the cursor, pushing the “SET Center” (#3) button will select the cursor as the center frequency and display an additional “start sweep” and “end sweep” light blue pair of cursors. These cursors can be positioned using knob to accurately set the range of the sweep frequencies to be analyzed. When the desired sweep width has been made, then the “SET WIDTH” (#3) button can be used to initiate a sweep with the newly defined sweep frequencies.

### **2.1.2. MANUALLY CREATING A NEW SWEEP RANGE**

To set a new range it is first necessary to stop the sweep. This can be accomplished by pushing the “STOP SWP” (#4) button or pushing the knob. This mode can be identified, as button #4 will be labeled “SWP SETUP”. Push this button to start manual sweep setup.

The first frequency that needs to be set is the sweep start frequency. Rotate the knob to set the starting frequency. Pushing the knob will sequentially step through the digits to be set and the current digit to be changed will be temporarily shown in RED. To set a frequency less than 1000 kHz push the button to enter the 100 kHz digit after previously setting the start frequency to 1000 kHz. When first entering the start sweep frequency mode rapidly rotating the knob to a lower frequency will rapidly set the lower limit to 1000 kHz for convenience.

After the desired starting frequency is showing in the window pushing the “SET START” (#4) button will advance to the end sweep frequency setting mode.



Use the same technique as setting the start sweep frequency to set the end sweep frequency. In this case rapidly rotating the knob to a lower frequency will set the ending sweep frequency to the previously set starting sweep frequency for convenience. Then rotate the knob to higher frequencies to set the ending frequency pushing the knob to change the selected digit. When the desired end sweep frequency has been set, pushing the “SET END” (#4) button will start a new sweep over the desired range.

It is possible to save this sweep range before starting the sweep by using the “SAVE SCAN” (#3) button to enter the scan memory page. Use the knob to select the memory location desired. At this point pushing the “STRT SWP” (#4) button will start the sweep with the new endpoint frequencies that have been saved for easy recall later (See Section 2.1.3—Sweeping a standard scan range).

### **2.1.3. SWEEPING A STANDARD SCAN RANGE**

To sweep over a previously saved scan range it is first necessary to stop the sweep. This can be accomplished by pushing the “STOP SWP” (#4) button or pushing the knob. This mode can be identified as button #4 will be labeled “SWP SETUP”.

Push button “SWP SETUP” (#4) and then “RCL SCAN” (#2) to enter the scan memory page.

Use the knob to select the desired scan range previously stored.

Push the “STRT SWP” (#4) button to start sweeping over the scan memory range.

### **2.1.4. SWEEPING THE SAME RANGE AS A REFERENCE MEMORY**

It is possible to scan and graphically compare results with a previously saved set of data.

To choose a reference memory scan range it is first necessary to stop the sweep. This can be accomplished by pushing the “STOP SWP” (#4) button or pushing the knob. This mode can be identified as button #4 will be labeled “SWP SETUP”

Push “SWP SETUP” (#4) and then “RCL REF” (#3).

Choose the desired reference memory using the knob followed by the “LOAD REF” (#4) button.

At this point the reference measurement will be displayed.

Pushing the “COMP SWP” (#3) button or the knob will start the sweep with a colored graphic comparison of the current measurement and the reference memory data.

## 2.2. VARIABLE VS. FREQUENCY TYPE OF GRAPH



Figure 1: Sweep

The sweep starting frequency is shown at the bottom left of the graph while the ending frequency is shown at the bottom right of the graph.

Two yellow lines are also shown on the graph. The vertical line is the cursor, which can be moved using the knob. The measured value and the frequency of the cursor location are displayed above the graph. The horizontal line is a reference line provided to assist the user in quickly analyzing the results. The frequencies with measured

parameters above the line are shown in red and those below are shown in green. The location of this line and the span of the y-axis for each graphic type can be set by the user (See System Setup Chapter 5).

If desired, pushing the “MODE” (#1) button while sweeping will switch modes to the “Manual mode” while automatically transferring the frequency of the current cursor location to the manual mode for more detailed analysis (See Manual Mode Chapter 3).

When in the sweep mode, the three lower buttons (#2, #3, #4) are active and let the user change the sweeping frequencies and other parameters as required.

Button #2 (GRAPH) allows the user to switch sequentially between the six different graph types. (SWR, Z, Real(R), Imag(jX), Smith Chart, and Reflection Coefficient). This button is active when in Sweep mode if the sweep is currently active or stopped.

Button #3 has two functions when in sweep mode. If the analyzer is currently sweeping, button #3 allows the user to quickly access the reference memory screen (see REFERENCE MEMORY USAGE Section 2.3.2) so that the current measurement may be stored as a reference or a previously stored reference can be loaded. If the sweep is stopped button #3 allows the user to set the new desired center frequency.

### 2.2.1. SINGLE VARIABLE GRAPH TYPES

### **2.2.2. SWR**

The SWR graph displays SWR from the starting to ending sweep frequency. The y-axis can be varied from 6,11,20,50, and 100 to 1. The default setting is 6:1 with the horizontal bar set at 2:1. This gives the user a quick means to determine the 2:1 SWR bandwidth with frequencies meeting the criteria shown in green and those not meeting the criteria shown as red.

### **2.2.3. IMPEDANCE (Z)**

The Impedance (Z) graph displays impedance of the device under test from the starting to ending sweep frequency. The y-axis can be varied from 100,200,400,1000, and 2000 ohms and the horizontal bar can be conveniently placed at any of 9 levels on the graph, as the user prefers. Frequencies with values above the bar shown in red and those below the bar are shown in green for user convenience.

### **2.2.4. REAL IMPEDANCE (R)**

This display is similar to the impedance display except only the real part of the impedance is displayed. Y-axis scale factors for the horizontal bar settings are the same as described for the IMPEDANCE (Z) graph.

### **2.2.5. Imaginary (jX)**

The imaginary (reactive) component of the impedance is displayed. The imaginary component can be negative (capacitive) or positive (inductive) and so this graph is centered about 0. The sign of the imaginary part is algorithmically determined during the sweep so it is necessary to properly set up the sweep frequencies so that the sign of the imaginary impedance will be correctly displayed (see section 2.2.3). In any event, the magnitude will always be correct. Y scale factors have the same range of settings as provided for the Impedance graph.

## 2.3. POLAR GRAPH TYPES

Two types of polar graphs are provided.

### 2.3.1. SMITH CHART

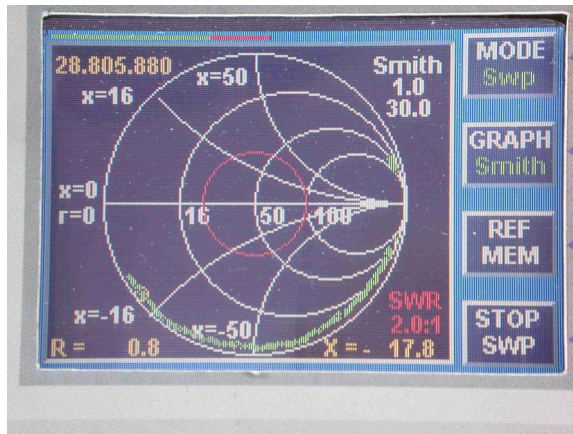


Figure 2: Smith Graph

The Smith chart conveniently provides the relationship between frequency, SWR, real and imaginary components for the range of swept frequencies. It is important to set the sweep parameters so that the instrument's algorithms can correctly display the proper polar graphic (Section 2.3.3).

The cursor provided consists of a small yellow circle encircling the point defined by the frequency chosen by the knob. This frequency is provided in yellow letters at the top of the screen while the measured impedance parameters (real and imaginary) at this frequency are seen in yellow at the bottom of the graph.

If enabled, a constant SWR circle is provided on the graph and the SWR this represents is described in red letters at the lower right hand corner of the graph. Anything falling inside the red circle has a SWR less than that of the circle's value with the center of the chart representing a perfect 50-ohm match and a SWR of 1:1. Corresponding to the horizontal bars on the X-Y types of graphic displays, the SWR circle value can be set by the user. Values available are: (None, 1.5:1, 2:1, 3:1, and 5:1). This feature, if enabled, (SEE SYSTEM SETUP Section 5.0) allows the user to rapidly determine if the SWR is low enough to be usable at a chosen frequency.

### 2.3.2. REFLECTION COEFFICIENT (RHO)

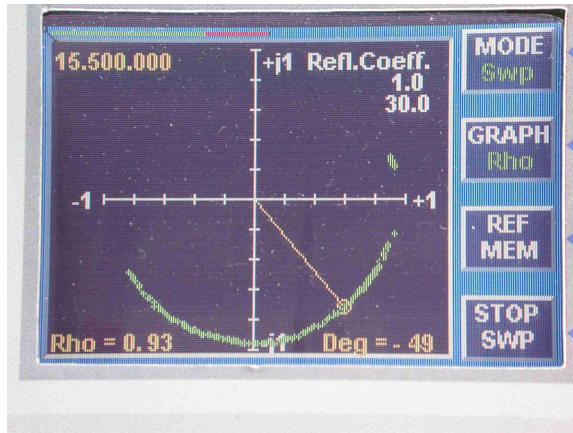


Figure 3: Rho Graph

The reflection coefficient graph is used to determine the angle and magnitude of the reflection coefficient over the sweep range. The cursor consists of a yellow circle encircling the measured point of the desired frequency and a vector to the origin. Values displayed at the cursor point consist of frequency, magnitude of reflection coefficient (0-1) and the angle of reflection coefficient (-180 deg to +180 deg). It is important to set the sweep parameters so that the instrument's algorithms can correctly display the proper polar graphic (Section 2.2.3).

### 2.3.3. PHASE SIGN CONSIDERATIONS:

The Smith Chart, Reflection coefficient chart and the imaginary impedance graph all depend on the algorithmic determination of the sign of the phase angle. This determination is accurately made in the case of open or shorted transmission lines, antenna resonance measured right at the antenna, and most other cases.

However there are instances where multiple resonances occur at closely spaced frequencies or antennas are measured at the end of a random length piece of coax, where the algorithm incorrectly determines the sign of the complex impedance. Where this occurs, that portion of the graph will

be on the opposite side of the complex impedance half plane but with the correct magnitude.

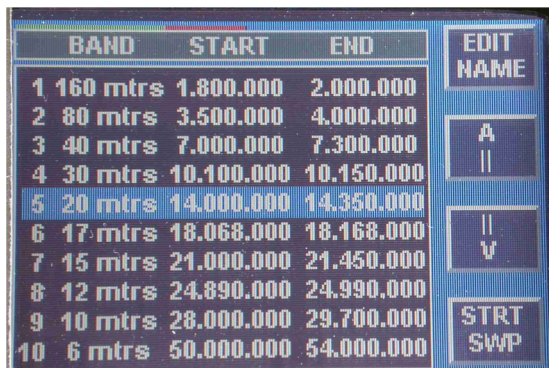
To optimize the instrument for proper complex impedance phase sign determination, adjust the sweep frequencies such that one major resonance can be seen on the SWR or Impedance ( $Z$ ) graph before switching to the Smith or Reflection coefficient graph. Multiple resonance as seen on the graph within the sweep range chosen will result in multiple cycles of the sweep being drawn on the Smith or Complex Impedance chart which can be sometimes confusing to interpret or not have the desired resolution.

It is not uncommon to measure an antenna at the end of a transmission line. When doing this it is common to see a periodic range of impedances as a function of frequency. These are caused by the antenna looking like a high impedance at frequencies other than it was designed to operate on. Therefore the impedance graph will resemble that of an open transmission line. To produce a good Smith chart of this situation, simply center the sweep frequency on the antenna resonance point (or frequency of minimum SWR) and make the width of the sweep great enough that a portion of the transmission line impedance can be seen on either side of the antenna resonant frequency. If the width of the sweep chosen is too small, it is possible that the phase sign algorithm will not be able to ascertain which half of the Smith chart some of the impedance points should be on. Widening the sweep width will allow the software algorithms to correct for the phase sign in this case. If the sweep width is set too wide, multiple circular paths will be seen on the Smith and Rho chart. This often results in a “busy” graph with the points spaced widely thus sacrificing resolution. With a little practice, it is possible to obtain the desired polar plot by setting the proper sweep widths for almost all situations.

## 2.4. MEMORIES

Two banks of ten memories are available. The first bank is the “SCAN MEMORIES”. These are used for storing sweep settings for rapid setup. The second bank is the “REFERENCE MEMORIES”. These memories store the complete data set of the results of a scanned antenna or other device being tested. This “REFERENCE” can be used to compare with a future measurement and any differences will rapidly be observable. All memories (SCAN and REFERENCE) can be uploaded and downloaded to a RS232 or USB 2.0 connected device.

### 2.4.1. SCAN MEMORY USAGE:



	BAND	START	END	EDIT NAME
1	160 mtrs	1.800.000	2.000.000	EDIT NAME A    V STRT SWP
2	80 mtrs	3.500.000	4.000.000	
3	40 mtrs	7.000.000	7.300.000	
4	30 mtrs	10.100.000	10.150.000	
5	20 mtrs	14.000.000	14.350.000	
6	17 mtrs	18.068.000	18.168.000	
7	15 mtrs	21.000.000	21.450.000	
8	12 mtrs	24.890.000	24.990.000	
9	10 mtrs	28.000.000	29.700.000	
10	6 mtrs	50.000.000	54.000.000	

Figure 4: Scan Memory

10 User selectable scan memory locations are available to store commonly used sweep settings.

Each scan memory stores an 8 character name, a starting frequency, and an ending frequency. These memories are set to default for the standard amateur radio bands but can be edited to be anything desired by the user. All data is permanently saved in flash.

To enter the Scan Memory, it is necessary to stop any active sweep (button #4) and enter the sweep setup screen (button #4)

Pushing button #2 (RCL SCAN) will then display the 10 scan memory selections possible and one can be chosen using the knob or the “^” (#2) or “V” (#3) buttons. After selection, pushing the “STRT SWP” (#4) button will start the sweep. The graph will have the label of the scan memory name chosen.

To save new sweep settings to scan memory-----  
Stop sweep if running (button #4 = “STOP SWP”).  
Use the “Swp SETUP” (#4) button to start the process.  
Select the starting frequency or accept the one shown.

Push the “Set Start” (#4) button.  
Select the ending frequency or accept the one shown.  
Push the “Save Scan” (#3) button.  
Using the knob or the “^” (#2) or “V” (#3) buttons select the desired scan memory location.  
Push the “Sel Mem” (#4) button and the data will be saved.

The name of the scan memory will be changed to ‘USER n’ where n is the scan memory location.

If desired, names can be edited using the “EDIT NAME” (#1) button.  
Select the character using the knob, switch which character is being edited with the “BACK” or “FWD” button.  
When done, push the “SAVE MEM” (#4) button to save the name and exit the edit name mode.

When finished saving a scan memory use the “STRT SWP” (#4) button to escape back to the sweep screen and restart sweeping using the current scan memory sweep values.

## **2.4.2. REFERENCE MEMORY USAGE**

10 User selectable reference memory locations are available to store reference analysis.

Any of the reference analysis can be compared graphically to the current analysis being performed.

In addition, the reference memory data can be uploaded to a host computer at a later time so that a history of an analysis performed may be kept.

When using the reference memory compare function, additional colors are used on the graphical swept display so that the visual comparison of what has changed is rapidly understood by the user. A ‘semi-transparent’ with ‘highlighted’ values presentation of the reference data aids in a quick comparison to the new data.

Each reference memory stores an 8-character name, a starting frequency, and an ending frequency, and the measured data. All data is permanently saved in flash.

When entering the Sweep mode, it is possible to select one of the reference memories by using the “RCL REF” (#3) button after using the “Swp SETUP” (#4) button. This will then display the 10 reference memory selections possible and one can be chosen using the knob or the “^” (#2) or



“V” (#3) buttons. After selection, pushing the “LOAD REF” (#4) button will display the reference memory graphically.

At this point, everything is set up to do a comparison of the reference memory to what is currently connected to the analyzer. To start the comparison, simply push the knob. The reference measurements and the current measurements will be overlaid and simultaneously displayed.

The graph will have the label of the reference memory name chosen.

To save a current analysis to a reference memory:

First, do at least one full sweep of the graph so there is data available



Figure 5: Scan to be saved as a Reference

Next use the “REF MEM” (#3) button to access the reference memory screen.

Using the knob or the “^” (#2) or “V” (#3) buttons select the desired reference memory location.

Push the “SAVE REF” (#2) button and the data will be saved.

The name of the reference memory will be changed to ‘Ref. n’ where n is the reference memory location.

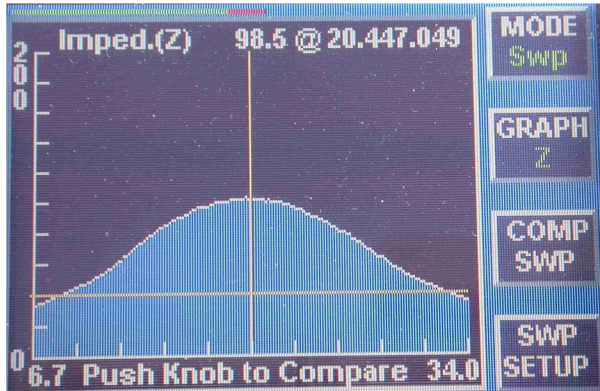
REF MEM.	START	END	EDIT NAME
1 Ref. 1	10.723.526	21.982.354	SAVE REF  LOAD REF
2 Empty	1.000.000	30.000.000	
3 Empty	1.000.000	30.000.000	
4 Ref. 4	6.799.999	34.094.101	
5 Ref. 5	10.723.526	21.982.354	
6 Empty	1.000.000	30.000.000	
7 Empty	1.000.000	30.000.000	
8 Empty	1.000.000	30.000.000	
9 Empty	1.000.000	30.000.000	
10 Empty	1.000.000	30.000.000	

If desired, names can be edited using the “EDIT NAME” (#1) button.

Select the character using the knob, switch which character is being edited with the “BACK” (#2) or “FWD” (#3) button.

When done, push the “SAVE REF” (#2) button to save the name and exit the edit name mode.

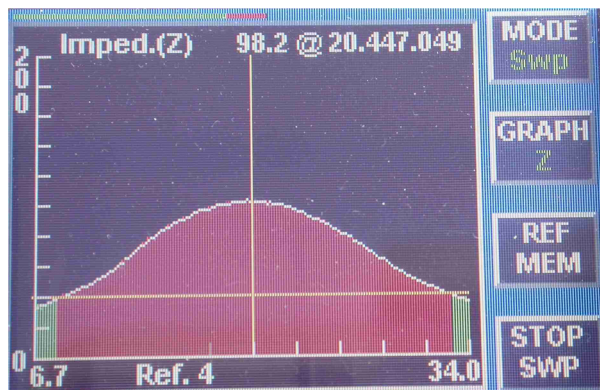
When done saving a reference memory use the “LOAD REF” (#4) button to escape back to the sweep screen which will display the reference memory graphically.



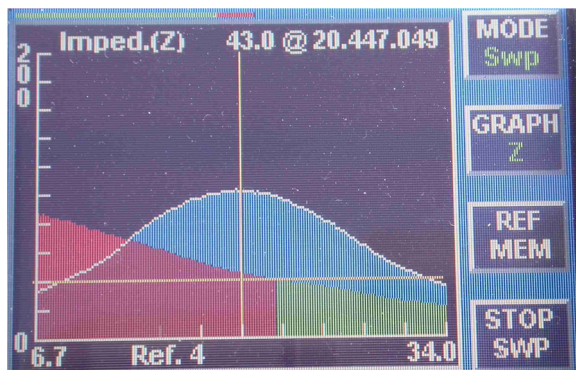
The reference memory is shown in blue with a white outline.

By pushing the knob, the analyzer will start sweeping through the range set by the saved reference and compare in real time the two overlaid graphs.

If the current data of the device being analyzed is identical to the saved reference memory, a picture similar to above will be displayed. In this case all of the blue reference memory is overlaid with the current data. Note that the name of the reference memory displayed is shown on the bottom of the graph and the outline of the reference memory is shown by the white line following the top of the graph.



This figure shows the results of a comparison of a reference memory and a current scan where the results are not the same. Notice that you can easily see the reference and the current scan as the colors are transparently overlaid. This case is for demonstration only. Typically if analyzing the same antenna over time, or a small adjustment made to an antenna compared to the reference, only small areas of color differences will be evident but readily discernable.



### 3. MANUAL MODE

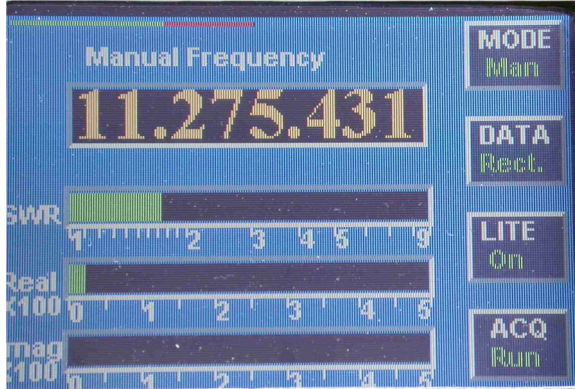


Figure 6: Manual Screen

Data acquisition can be started and stopped using the “ACQ” (#4) button.

The backlight can be turned on and off using the “LITE” (#3) button.

The knob is used to set the desired frequency. Pushing the knob allows the user to change the tuning step size.

There are two options for the bar graph display. The Data (#2) button lets the user change between Polar or Rectangular coordinates. The current selection is displayed in green letters on the Data (#2) button.

When in Polar mode the bar graphs display:

SWR	1:1-1:9
Z x 100	0-5
Deg x 10	0-9

When in Rectangular mode the bar graphs display:

SWR	1:1-1:9
Real x 100	0-5
Imaginary x 100	0-5

When acquisition is stopped using the “ACQ” (#4) button bar graph values are displayed on the bar graph. As acquisition is stopped in this condition real time data is not being collected and the data shown represents the state when the acquisition was stopped

Current state of the battery voltage, input charging voltage, processor temperature, software version and serial number can be determined by simultaneously pushing buttons (#1) and (#4) when on the Manual screen with acquisition stopped.

## 4. HI-RESOLUTION FREQUENCY SYNTHESIZER MODE



Figure 7: Set Manual Frequency Screen

*Use Knob to Set Frequency*

Push knob to change Tuning Step (current selected tuning step digit shown in Red)

The instrument will output any frequency from 200 kHz to 60 MHz. at 1 Hz. resolution. Output level is approximately 2.84 V p-p into an open circuit and 1.32 V p-p into a 50 ohm load.

To Calibrate Frequency synthesizer of the instrument:

Change frequency while measuring with an accurate frequency counter or zero-beating with WWV. When exactly 10 MHz. output is obtained, use "STORE CAL" (#3) button to permanently store calibration values in flash memory. This is now the reference standard for all subsequent frequency settings in all modes.

As it is possible to significantly mis-calibrate the instrument using the calibration feature, or if there is some other reason to suspect the frequency calibration, it is possible to get back to the original factory calibration for 10 MHz by using the "DELETE CAL" (#4) button. This is convenient if no calibration source is available and the user does not need the benefit of a calibration accurate to 1 Hz but does want to guarantee relatively accurate measurements.

## 5. SYSTEM SETUP

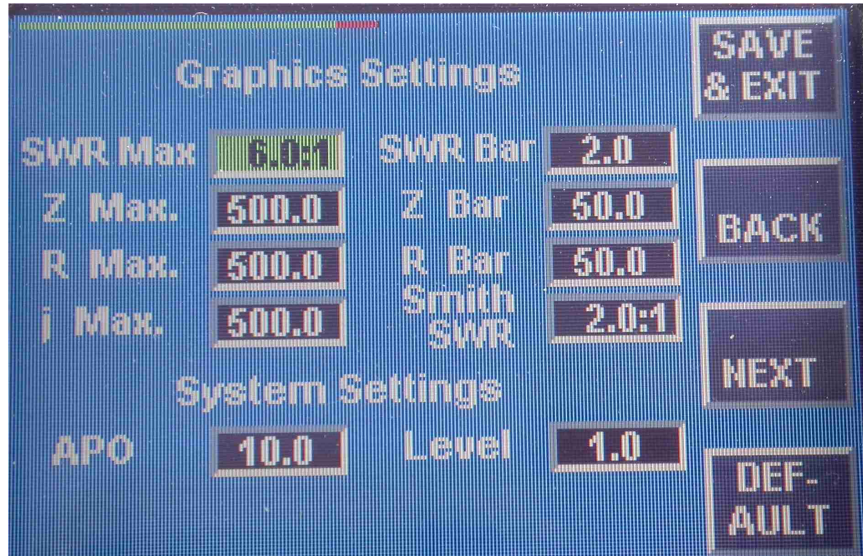


Figure 8: Setup Screen

### 5.1. Settings

Graphics parameters and system settings can be set on the “Settings” Screen. This screen is accessed by simultaneously pushing buttons (#1 and #3).

Use the “Back” (#2) or “Next” (#3) buttons to select the parameter to change. Change the parameter using the knob. When all desired parameters are set, exit the Graphics Setup mode by pushing the “Save and Exit” (#1) button. The factory default instrument settings can be selected using the “Default” (#4) button before exiting the Graphics Setup screen.

#### 5.1.1. Graphic Settings

The settings labeled Max(SWR Max, Z Max, etc.) control the span(y-axis) of the corresponding graph. The settings labeled Bar(SWR Bar, Z Bar, etc.) determine the level of the yellow horizontal bar displayed on the graph. Setting a ‘Max’ value automatically sets the ‘Bar’ value to a convenient level. If desired, it is then possible to reset the bar level.

### 5.1.2. Smith SWR

The Smith SWR setting determines the size of the SWR circle on the Smith Chart.

### 5.1.3. APO Settings

The automatic power off function can be set to “Off, 5 minutes, 10 minutes (default), and 30 minutes”.

### 5.1.4. Level Settings

Two separate user level settings are provided to accommodate different operating scenarios when using the AntennaSmith.

#### Level 1.0 (Start with new sweep)

In this level, when powered on, the analyzer initiates a 1-30 MHz continuous sweep and the graphics “SWR” screen is displayed. This is a convenient way to start a measurement on an unknown antenna. The frequencies of minimum SWR are easily recognized and using the “center” and “width” functions (see section...) the user can rapidly zoom in on an area of interest to analyze.

This is the default level.

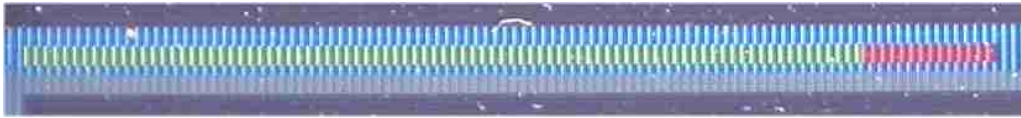
#### Level 2.0 (Retained settings)

When the user level is set to 2.0, the analyzer retains the current mode, frequencies, and graphic parameters whenever powered down, either from the APO function (see section...) or if manually turned off. This data is used at power on to reset the analyzer to the point at which it was when powered off. This setting is the preferred setting for the user who tends to make measurements from time to time on the same system and doesn't want the analyzer to default to the 1-30 MHz SWR sweep at power on. Another use for this mode is by the user who is using the analyzer as a bench top signal generator and always wants to return to the same place after a power on/off cycle. The disadvantage to the use of level 2.0 is that the user can easily get left in a mode that is not desired at the next power on, thus possibly requiring the user to execute a number of mode change / frequency setting s/ etc. to make the next desired measurement.

## 6. POWER SUPPLY

The analyzer is powered by 4 internal Ni-MH 2500 mAh AA penlight cells. These cells are fast charged from an external wall wart or other 12 Volt source.

Along the top of the display is a thin bar graph that always displays the current state of the batteries. The relative amount of charge is denoted by the ratio of green (charge remaining) to red (charge used).



With good batteries and a full charge, the instrument can run approximately 5-6 hours.

Connecting an external 12 VDC 500 mA supply initiates a fast charge. Fast charging is terminated when the batteries reach full charge at which time a slower maintenance charge is initiated. Fast charging is also terminated based on time. The fast charger detects end of charge by monitoring the slight voltage drop that occurs at the end of charge.

### SPECIAL INSTRUCTIONS FOR BENCHTOP USE:

When powered on, the instrument always runs from battery power. If the instrument is not connected to an external power source or the charging system is in 'maintenance charge' mode, and the instrument is left on (APO turned off) the battery will slowly be depleted. Also if the instrument is in fast charge mode when it is powered on, the battery charging circuit will detect the slight voltage drop and will enter 'maintenance charge' mode. In either case, simply disconnecting and reconnecting the external power source will always initiate a fast charge cycle. Reconnecting the external power thus initiating a fast charge should be evident by observation of the battery charge indicator unless the batteries are already completely charged.

## **7. HOST COMMUNICATIONS**

The AntennaSmith uses a USB 2.0 and/or a RS232 connection to communicate with a computer. It is possible to upload and download reference and scan memories as well as control the instrument and upload realtime measurement data.

After the supplied USB 2.0 drivers are installed, the device appears as a serial port running at 115 kbps, no parity and one stop bit to the host computer. The host computer should use the same settings as if the actual RS232 serial port is used.



## 8. SPECIAL SERVICE AND SETUP MODES

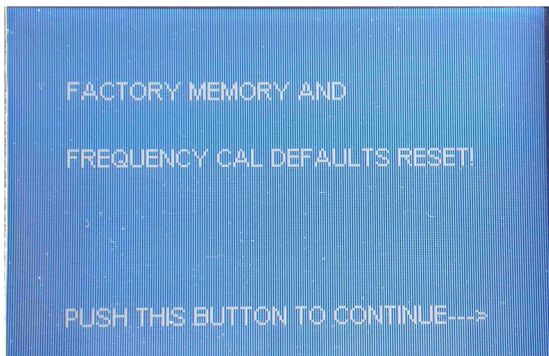
### 8.1. Restoring default settings

Hold the third button (#3) in when turning on instrument and wait until a pure blue screen appears with the message:

'FACTORY MEMORY AND FREQUENCY CAL DEFAULTS RESET!'



**WARNING!** This will reset the all the user settings, including timeouts.



Note: All user set scan memories will be overwritten with the standard factory ham band memories. In addition all reference memories will be cleared and all instrument default parameters will be set.

## 9. APPLICATION NOTES

### 9.1. Transmission Lines

Transmission lines can easily be characterized by displaying the swept impedance of the un-terminated (open) line. (Use the Impedance (Z) sweeping graph mode). It may be necessary to change the impedance (Z) graphic scale to 1000 if the peak of the impedance cannot be seen on the current range chosen. (See SYSTEM SETUP). If the line is very long electrically or lossy, the impedance peak will be less so the original default setting of 500 or less may be used in this case.

Start the analyzer sweeping from 1 to 30 MHz.

Once the first, leftmost, lowest frequency peak is seen, the following steps can be used to rapidly get the actual frequency of the peak. This frequency represents the electrical half wavelength of the transmission line.

1. Stop sweep (push button #4).
2. Center cursor on top of peak and set the center (push button #3).
3. Change sweep width using knob for desired display and set width (push button #3)

Repeat these three steps if required thus improving accuracy until an accurate frequency of the peak top is known. This frequency is the frequency where the transmission line is one half wavelength in electrical length.

The velocity factor of the transmission line can be determined by making an accurate physical length measurement of the line.

Velocity factor is equal to measured length (in. ) X frequency (MHz.) / 5904.

Typical velocity factors vary from 0.66 (RG-174(Belden 8216),RG-8A(Belden 8237)) , 0.85 (RG-8 TMS LMR400) up to 0.89 for hardline.

If it is desired to cut a transmission line to a known half wavelength, estimate the approximate length by calculating given the previously measured velocity factor.  
(Length(in) = (Velocity factor \* 5904) / Frequency(MHz))

While the velocity factor can be determined from manufacturer's data, it is preferable to measure the actual line being used to determine the actual velocity factor for more accurate results as this can vary from lot to lot or manufacturer.

Cut the line to a length ten per-cent longer than the calculated length. By watching the graphic impedance sweep, trim the line until the first half-wave peak is exactly on the frequency of interest. Be careful and not overshoot this point as you cannot go back.

Transmission line parameters can also easily be viewed on the Smith Chart and the electrical length can easily be determined using the cursor. One trip around the Smith chart represents one-half wavelength.

## **9.2. Antenna measurements on coax**

It should be noted that complex antenna impedances are only accurate when measured right at the antenna or the feedline is exactly one-half wavelength multiple of the frequency being measured. All other cases cause the impedance as seen by the analyzer is modified by the feedline characteristics and electrical length. As the feedline cannot be one-half wavelength at all of the frequencies displayed during a sweep, the one-half wavelength requirement can only be met when in the Manual mode.

On the other hand, the SWR measurement is independent of feedline length except for small effects caused by line loss. Line loss will actually lower SWR at the expense of reducing the signal delivered to the antenna.

## **9.3. Obtaining the best accuracy**

The AntennaSmith uses a number of advanced software algorithms as required to generate the wide range of graphic displays. It therefore uses the data available from measurements in different ways depending on the display type desired. The SWR display, the Z display and the manual mode are the three cases where accuracy has been enhanced at the expense of phase information.

Therefore it is recommended when measurements are being made that require the greatest accuracy; the use of these types of displays would be the preferred choice.

## 10. QUICK TRICKS

### 10.1. Rapidly Analyzing an Antenna

As the TZ900 is shipped, it is factory set to User Level 1.0. This allows rapid measurement of any unknown antenna.

To quickly get all of the parameters of any desired HF antenna:

Briefly short the feedline or other connection of the antenna to remove any possible static charge buildup and then connect it to the TZ900.

Power on the TZ900 by pushing the power switch until the opening screen appears.

While viewing the sweeping SWR screen, rotate the knob until the cursor is over the frequency of interest.

Push “STOP SWP” (#4) button.

Push the “SET Center” (#3) button.

Rotate the knob to set the desired sweep width.

Push “SET Width” (#3) button to resume sweeping with new settings.

The actual value can be determined from the graph; however putting the cursor over the frequency of interest will display accurately the value where the cursor is located.

If desired --Push “Graph” (#2) button to switch measurement displayed.

IF IT IS DESIRED TO SAVE THESE MEASUREMENTS FOR FUTURE USE:

Push “REF MEM” (#3) button and select a storage location with the knob.

Push “SAVE REF” (#2) button to save all measurement data.

Push “LOAD REF” (#4) button to return to sweep screen with reference displayed.

Push knob to compare the real-time current analysis to saved reference.

## **10.2. Rapidly zooming to a section of a sweep**

1. Stop sweep by pushing “STOP SWP” (#4) button.
2. Using knob put cursor over desired center frequency.
3. Push “SET Center” (#3) button.
4. Using knob set desired sweep width as determined by blue cursors.
5. Push “SET Width” (#3) button.
6. New sweep will automatically start.

## **10.3. To rapidly set sweep start and stop frequencies using the knob**

If the analyzer is currently sweeping, push the “STOP SWP” (#4) button to stop the sweep.

Push the “SWP SETUP” (#4) button again to enter the Start frequency setup screen.

Rotate the knob rapidly towards lower frequencies until frequency is 1.000.000 then rotate knob in opposite direction to the desired starting frequency. (push on the knob to change tuning step for additional resolution).

Push the “SET START” (#4) button to lock in the start frequency.

Rotate the knob rapidly towards a lower frequency until the frequency runs into the start frequency just set.

Rotate knob in opposite direction to get to the desired ending frequency. (you can push on knob to change the tuning step for additional resolution).

Push the “Set End” (#4) button again to start sweep.

## **10.4. Rapidly setting a scan of 1.000.000 to 30.000.000**

It is very convenient to start a sweep of 1.000.000 to 30.000.000 to quickly determine interesting impedance or SWR points that can then be quickly analyzed using the Set Center, Set Width method discussed in Section 2.1.1.

When the instrument is powered on and is set to User Level 1.0, sweeping automatically starts over this range.

**Method 1:** Turn the instrument off and back on again. (User Level 1.0 only)

**Method 2:** Have the 1.000.000 to 30.000.000 set as reference or scan memory number 1. Then simply reload it after stopping sweep.

**Method 3:** Use the “To rapidly set sweep start and stop frequencies using the knob” method described above.

## **10.5. Doing a detailed analysis of a frequency from a sweep**

While sweeping, simply push the “MODE” (#1) button and the cursor frequency will be transferred to the fixed frequency mode. This only works while sweeping so do not stop the sweep first.

Pushing the “MODE” (#1) button 2 more times will return back to the sweep mode with the previous settings.

## **10.6. Rapidly starting and stopping a sweep using the same settings**

**Method 1:**

Pushing the knob when sweeping will stop sweep, pushing it again will restart the sweep with the same settings.

**Method 2:**

Pushing the “Stop Swp” (#4) button will stop the sweep, pushing it three more times without changing any settings will restart the sweep using the same settings.

## 11. AntennaSmith Connectors

### RS-232 Data Control Connector

Type: DB-9F

1. NC
2. TX
3. RX
4. NC
5. Return (ground)
6. NC
7. NC
8. NC
9. NC

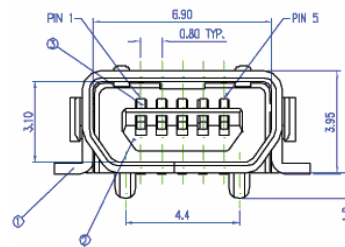


### USB Connector

Type: USB “Mini-B”

Signal: USB Full Speed (12 MHz)

1. +VBUS
2. D<sub>IN</sub>
3. D<sub>OUT</sub>
4. Return (Ground)
5. N/A



### Power Connector

Type: DC Power coaxial – 5.5 x 2.1 mm, center positive

Signal: 12 VDC @ 500 mA.

The analyzer is powered by 4 internal Ni-MH 2300 mAh type AA penlight cells. These cells can be charged by an external wall wart. Charging voltage and cell voltage can be monitored by the instrument.

There is an internal battery charger. Connecting the 12 volt, 500 ma external power initiates a fast charge. Fast charging is terminated when the batteries reach full charge and a slower maintenance charge is initiated. Fast charging is also terminated based on time.

The unit always discharges the batteries when turned on so if a fast charge is desired in addition to running the unit on external power, it is necessary to unplug and reconnect the charger to reinitiate a fast charge after powering on the unit.

With good batteries and a full charge, the instrument can run approximately 5-6 hours.

## 12. Additional Reading

ARRL Antenna Book 20<sup>th</sup> Edition (R.Dean Straw Ed)  
ISBN: 0-87259-904-3

Antenna Impedance Matching (Wilfred N. Cohen) First Edition  
ISBN: 0-87259-220-0

Mysteries of the Smith Chart -- Transmission Lines, Impedance Matching and Little  
Known Facts (Stephen D Stearns-Pacificon 2001)

REFLECTIONS II Transmission Lines and Antennas  
(M. Walter Maxwell) ISBN: 0-9705206-0-3



## 13. Troubleshooting

- When connecting the AntennaSmith, there is no data.
  - Reset the TZ-900.
  - Make sure the Serial is plugged in.
  - Exit and restart the program.

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If there is still a problem, contact Timewave Technical Support.

Timewave Technical Support  
1025 Selby Ave, Suite 101  
St. Paul, MN 55104  
(651) 489-5080  
[support@timewave.com](mailto:support@timewave.com)

## 14. Specifications

### Processors

- 50 MHz CPU

### Memory

- Scan range memories: 10 (user settable 8 character names, start sweep frequency, and end sweep frequency -- stored in flash.)
- Reference memories: 10 (user settable 8 character names, start sweep frequency, and end sweep frequency -- stored in flash.)

### Input/Output

- Accuracy: Frequency 1 ppm (1 Hz) after calibration  
Impedance 8% @ 50 Ohms
- Resolution: 100 Hz Manual mode  
100 Hz Sweep mode  
1 Hz Hi-res synthesizer mode
- Range: 0.2-55.0 MHz. Manual and Sweep mode  
0.2-55.0 MHz. Hi-res synthesizer mode
- Measurements: Manual mode: SWR, Z, R, jX,  $\theta$  (Phase Angle)  
Sweep mode: SWR, Z, R, jX, Smith, complex  $\rho$
- Sweep scale factors: SWR 1:6, 11, 20, 50, 100  
Z, Real(Z), Imag.(Z) 100, 200, 500, 1000, 2000
- Measurement resolution: SWR 0.01  
Z, Real(Z), Imag.(Z) 0.1 ohm  
 $\theta$  0.01 degrees

### Physical

- Enclosure: Extruded Aluminum, rack mount option, NEMA option
- Size: 1 $\frac{5}{8}$  wide x 7 $\frac{1}{2}$  deep x 4 $\frac{1}{4}$  inches high
- Weight: 1 lb. 6.5 oz. (0.635 Kg.)
- Operating Temp.: 0° C to 50° C
- Power: +9 to +16 VDC @ 500 mA.  
Recommended 12 VDC @ 500 mA  
(5.5 mm x 2.1 mm coaxial power jack, center +)
- Output: Typically 2.8 V p-p
- Display: Bright sunlight readable (transreflective) 6.92 cm Diagonal Reflective Graphic Color LCD. Internal light for indoor operation.

## 15. Timewave

Timewave Technology Inc. designs, manufactures, and sells leading-edge digital and voice communications products and instrumentation products to the world-wide military, government, industrial, and amateur radio marketplaces. Timewave's cost effective communication products enhance and upgrade the efficiency of new and existing radio and digital systems to the latest technology levels. Timewave's instrumentation products combine Timewave's extensive signal processing technology with its communication technology to create innovative networked and remote access solutions.

This product is the AntennaSmith.

Timewave was established in 1984 in St. Paul, Minnesota. All Timewave products are manufactured in the U.S.A.

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Fax : (651) 489-5066  
E-mail: [sales@timewave.com](mailto:sales@timewave.com)

## 16. Warranty

# Product Warranty

Timewave Technology Inc. products carry the following warranty:

Timewave hardware products are warranted against defects in materials and workmanship. If Timewave receives notice of such defects during the warranty period, Timewave shall, at its option, either repair or replace hardware products which prove to be defective.

Timewave software and firmware products which are designated by Timewave for use with a hardware product are warranted not to fail to execute their programming instructions due to defects in materials and workmanship. If Timewave receives notice of such defects during the warranty period, Timewave shall, at its option, either repair or replace software or firmware media which do not execute their programming instructions due to such defects. Timewave does not warrant that operation of software, firmware, or hardware shall be uninterrupted or error free.

The warranty period for each product is one year from date of shipment.

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## Limitation of Warranty

The forgoing warranty shall not apply to defects resulting from:

1. Improper or inadequate maintenance by the Buyer;
2. Buyer-supplied software or interfacing;
3. Unauthorized modification or misuse;
4. Operation outside the environmental specifications of the products;
5. Improper site preparation and maintenance.

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## Exclusive Remedies

The remedies provided herein are the Buyer's sole and exclusive remedies. In no event shall Timewave be liable for direct, indirect, special, incidental or consequential damages (including loss of profits) whether based on contract, tort, or any other legal theory.

## 17. Table of Figures

Figure 2: Smith Graph .....	12
Figure 3: Rho Graph .....	13
Figure 4: Scan Memory .....	15
Figure 5: Scan to be saved as a Reference.....	17
Figure 6: Manual Screen.....	19
Figure 7: Set Manual Frequency Screen.....	20
Figure 8: Setup Screen.....	21

