AT-500 Antenna Tester

Operation Manual

Instruction Book Part Number 920-AT500 Rev. D

Safety Precautions

The following are general safety precautions that are not necessarily related to any specific part or procedure, and do not necessarily appear elsewhere in this publication. These precautions must be thoroughly understood and apply to all phases of operation and maintenance.

WARNING

Keep Away From Live Circuits

Operating Personnel must at all times observe general safety precautions. Do not replace components or make adjustments to the inside of the test equipment with the high voltage supply turned on. To avoid casualties, always remove power.

WARNING

Shock Hazard

Do not attempt to remove the RF transmission line while RF power is present.

WARNING

Do Not Service Or Adjust Alone

Under no circumstances should any person reach into an enclosure for the purpose of service or adjustment of equipment except in the presence of someone who is capable of rendering aid.

WARNING

Safety Earth Ground

An uninterruptible earth safety ground must be supplied from the main power source to test instruments. Grounding one conductor of a two conductor power cable is not sufficient protection. Serious injury or death can occur if this grounding is not properly supplied.

WARNING

Resuscitation

Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

Safety Symbols

WARNING
Warning notes call attention to a procedure, which if not correctly performed, could result in personal injury.

CAUTION
Caution notes call attention to a procedure, which if not correctly performed, could result in damage to the instrument.

The caution symbol appears on the equipment indicating there is important information in the instruction manual regarding that particular area

Note: *Calls attention to supplemental information.*

Warning Statements

The following safety warnings appear in the text where there is danger to operating and maintenance personnel, and are repeated here for emphasis.

> **WARNING**
>
> Live RF energy. Do not touch or ground the center conductor of a live RF connection. Failure to comply may result in equipment damage and serious burns or death to personnel.

On page 13.

> WARNING
>
> Care should be taken when handling batteries.
> Do not heat or dispose of batteries in fire. May burst or release toxic materials.
> Avoid forced discharge.
> Do not short circuit.
> Restrict charging current and time to the recommended value.
> Do not solder the battery directly.
> Do not disassemble, apply excessive pressure or deform.
> Avoid placing the battery in reverse polarity.
> Battery disposal method should be in accordance with local and state regulations.

On page 28.

> WARNING
>
> Replace with ONLY Nickel-Metal hydride (NiMH) rechargeable AA batteries with a nominal voltage of 1.2V and minimum capacity of 2000mAh. DO NOT install any type of battery such as alkaline or other type of secondary (rechargable) batteries.

On page 34.

> WARNING
>
> Charging batteries installed in reverse polarity can cause the battery to swell or rupture.

On page 34.

Caution Statements

The following equipment cautions appear in the text and are repeated here for emphasis.

> CAUTION
> Only use the AC adapter provided with the AT. Do not use the adapter with the batteries removed.

On page 11.

> CAUTION
> Follow guidelines for battery charging.
> Avoid constant charging of batteries for long periods of time. Overcharging can result in reduced battery efficiency, service life, and possible permanent damage.

On pages 11 and 29.

> CAUTION
> Required input is 11 to 16 VDC @ 250mA. Connector is wired outside positive, inside negative.

On page 12.

> CAUTION
> AVOID STATIC DISCHARGE
> Use proper Electrostatic Discharge (ESD) precautions to avoid static discharge when making connections to the test port. Equipment failure can occur if the test port is subjected to ESD.

On page 13.

> CAUTION
> 250mW max. input
> Exceeding the maximum input will cause damage to internal components. Do not connect transmitter output to the AT-500. Damage can also be caused by testing antennas near other transmitting antennas. If testing base station antennas, first measure the power at the coax end to be sure it does not exceed 250mW.

On page 13.

CAUTION
Harsh or abrasive detergents and some solvents can damage the display unit and information on labels.

On page 28.

CAUTION
Replace with only the same type and rating fuse. 315mA 250V

On page 35.

Safety Statements

USAGE

ANY USE OF THIS INSTRUMENT IN A MANNER NOT SPECIFIED BY THE MANUFACTURER MAY IMPAIR THE INSTRUMENT'S SAFETY PROTECTION.

USO

EL USO DE ESTE INSTRUMENTO DE MANERA NO ESPECIFICADA POR EL FABRICANTE, PUEDE ANULAR LA PROTECCIÓN DE SEGURIDAD DEL INSTRUMENTO.

BENUTZUNG

WIRD DAS GERÄT AUF ANDERE WEISE VERWENDET ALS VOM HERSTELLER BESCHRIEBEN, KANN DIE GERÄTESICHERHEIT BEEINTRÄCHTIGT WERDEN.

UTILISATION

TOUTE UTILISATION DE CET INSTRUMENT QUI N'EST PAS EXPLICITEMENT PRÉVUE PAR LE FABRICANT PEUT ENDOMMAGER LE DISPOSITIF DE PROTECTION DE L'INSTRUMENT.

IMPIEGO

QUALORA QUESTO STRUMENTO VENISSE UTILIZZATO IN MODO DIVERSO DA COME SPECIFICATO DAL PRODUTTORE LA PROZIONE DI SICUREZZA POTREBBE VENIRNE COMPROMESSA.

SERVICE

SERVICING INSTRUCTIONS ARE FOR USE BY SERVICE - TRAINED PERSONNEL ONLY. TO AVOID DANGEROUS ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS QUALIFIED TO DO SO.

SERVICIO

LAS INSTRUCCIONES DE SERVICIO SON PARA USO EXCLUSIVO DEL PERSONAL DE SERVICIO CAPACITADO. PARA EVITAR EL PELIGRO DE DESCARGAS ELÉCTRICAS, NO REALICE NINGÚN SERVICIO A MENOS QUE ESTÉ CAPACITADO PARA HACERIO.

WARTUNG

ANWEISUNGEN FÜR DIE WARTUNG DES GERÄTES GELTEN NUR FÜR GESCHULTES FACHPERSONAL.

ZUR VERMEIDUNG GEFÄHRLICHE, ELEKTRISCHE SCHOCKS, SIND WARTUNGSARBEITEN AUSSCHLIEßLICH VON QUALIFIZIERTEM SERVICEPERSONAL DURCHZUFÜHREN.

ENTRENTIEN

L'EMPLOI DES INSTRUCTIONS D'ENTRETIEN DOIT ÊTRE RÉSERVÉ AU PERSONNEL FORMÉ AUX OPÉRATIONS D'ENTRETIEN. POUR PRÉVENIR UN CHOC ÉLECTRIQUE DANGEREUX, NE PAS EFFECTUER D'ENTRETIEN SI L'ON N'A PAS ÉTÉ QUALIFIÉ POUR CE FAIRE.

ASSISTENZA TECNICA

LE ISTRUZIONI RELATIVE ALL'ASSISTENZA SONO PREVISTE ESCLUSIVAMENTE PER IL PERSONALE OPPORTUNAMENTE ADDESTRATO. PER EVITARE PERICOLOSE SCOSSE ELETTRICHE NON EFFETTUARRE ALCUNA RIPARAZIONE A MENO CHE QUALIFICATI A FARLA.

UNITS ARE EQUIPPED WITH RECHAREABLE BATTERIES.

THESE ARE TO BE REPLACED BY AUTHORIZED SERVICE PERSONNEL ONLY!!!

LAS UNIDADES VIENEN EQUIPADAS CON BATERIAS RECARGABLES.

¡¡¡Y SOLAMENTE EL PERSONAL DE SERVICIO AUTORIZADO PUEDE REEMPLAZARLAS!!!

GERÄTE SIND MIT WIEDER AUFLADBAREN BATTERIEN BESTÜCKT.

BATTERIEN SIND NUR VON QUALIFIZIERTEM SERICE PERSONAL AUSZUWECHSELN!!!

CES DISPOSITIFS SONT ÉQUIPÉS DE BATTERIES RECHARGEABLES.

SEUL LE PERSONNEL D'ENTRETIEN AUTORISÉ EST HABILITÉ À LES REMPLACER !

LE UNITÀ SONO DOTATE DI BATTERIE RICARICABILI,

CHE DEVONO DA COME SPECIFICATO DAL PRODUTTORE LA PROTEZIONE DI SICUREZZA POTREBBE VENIRNE COMPROMESSA.

RF VOLTAGE MAY BE PRESENT IN RF ELEMENT SOCKET - KEEP ELEMENT IN SOCKET DURING OPERATION.

DE LA TENSION H.F. PEAT ÊTRE PRÉSENTE DANS LA PRISE DE L'ÉLÉMENT H.F. - CONSERVER L'ÉLÉMENT DANS LA PRISE LORS DE L'EMPLOI.

HF-SPANNUNG KANN IN DER HF-ELEMENT-BUCHSE ANSTEHEN - ELEMENT WÄHREND DES BETRIEBS EINGESTÖPSELT LASSEN.

PUEDE HABER VOLTAJE RF EN EL ENCHUFE DEL ELEMENTO RF - MANTENGA EL ELEMENTO EN EL ENCHUFE DURANTE LA OPERACION.

IL PORTAELEMENTO RF PUÒ PRESENTARE VOLTAGGIO RF - TENERE L'ELEMENTO NELLA PRESA DURANTE IL FUNZIONAMENTO.

About This Manual

This manual covers the operating and maintenance instructions for the following models:

AT-500

Changes to this Manual

We have made every effort to ensure this manual is accurate. If you discover any errors, or if you have suggestions for improving this manual, please send your comments to our Solon, Ohio factory. This manual may be periodically updated. When inquiring about updates to this manual refer to the part number and revision on the title page.

Chapter Layout

Introduction — Describes the features of the antenna tester, lists equipment supplied and optional equipment.

Basic Operations — Describes the base level operation instructions.

Installation — Describes the power supply and antenna connection instructions.

Measure Match — -Describes how to use the antenna tester in it's various modes of operation.

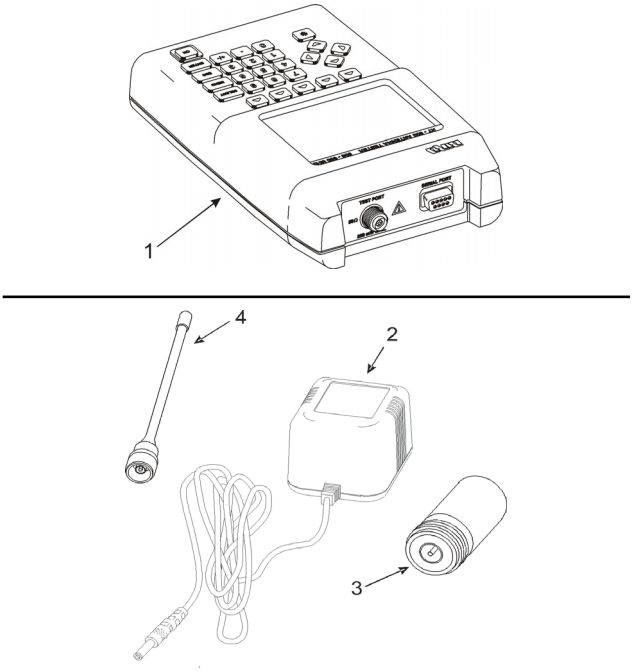
Field Strength — Describes how to use the field strength detection mode.

Maintenance — Describes cleaning, calibration, and other maintenance procedures vital to the operation of the antenna tester.

Table of Contents

Items Supplied

Figure 1 Supplied Items



1. Bird AT-500
2. AC Mains Adapter
3. Female “N”-Type Connector
4. Field Strength Antenna
5. Operation Manual (Not Shown)

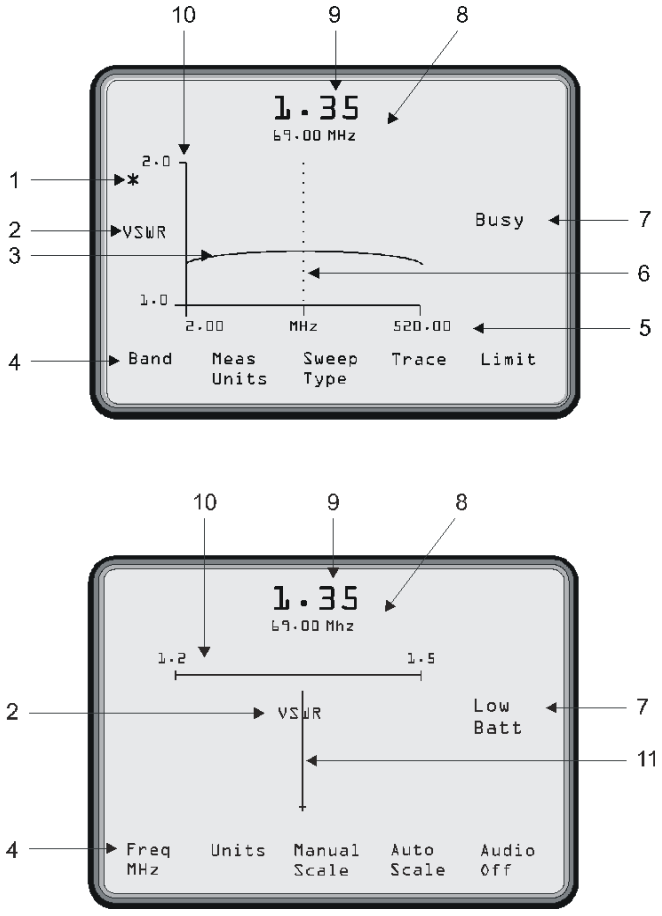
Component Description

Figure 2 Component Description

1. LCD Display	Backlit liquid crystal display.
2. External DC Connector	Connect either the ac adapter or the cigarette lighter adapter. External supplies operate the unit and charge the internal battery.
3. Cursor Keys	
Left Arrow	Press in swept frequency mode to move the cursor to the left. Press during data entry to erase data.
Right Arrow	Press in swept frequency mode to move the cursor to the right.
Up Arrow	Moves the cursor to the maximum point on the displayed trace. Press during data entry to increase numeric data.
Down Arrow	Moves the cursor to the minimum point on the displayed trace. Press during data entry to decrease numeric data.
4. Backlight Key	Turns the backlight on or off. Backlight is on a timer to increase battery life.
5. On Key	Press to turn tester on, press and hold to turn tester off.
6. +/- Key	Toggles between positive and negative numbers.
7. Enter Key	Completes data entry.
8. ESC Key	Back up through menu structure. At the top menu level, blanks menu. Exits data entry without saving changes.
9. Menu Key	Displays software menu and enables menu select keys.
10. Select Key	Allows current parameter, indicated by flashing cursor, to be changed. Press again to enable the next parameter to be changed.
11. Numeric Keys	Input numeric values.
12. Menu Select Keys	Used to access the menu sections described directly above them. Can also be used to scroll through available settings in a particular parameter.
13. Test Port	Connect antenna or antenna lead.
14. Serial Port	Connect communication cable to allow data transfer to a PC.

Display Description

Figure 3 Display Description



1. Sweep Rate Indicator	Blinks when sweeping.
2. Measurement Units	Indicates selected measurement units.
3. Trace	Graphic display of measured results across selected frequency band.
4. Menu Select Key Labels	Defines function of menu select keys located below the display.
5. Frequency Band Scale	Displays frequency band selected.
6. Cursor	Used to select measurement position on the trace.
7. Utility Label	Area for displaying general data (Lo Batt, Busy, Hold, Noise, and test results).
8. Frequency	Selected Frequency (for swept mode this is frequency at the cursor position).
9. Measured Value	Numeric display of measured value (for swept mode this is the value at the cursor position).
10. Scale	Displays user defined measurement scale.
11. Pointer	Moves across scale to show analog type indication of measured value.

Features

Swept Frequency Mode — Fast scan shows VSWR, ρ, match efficiency or return loss across an entire band. A movable cursor can be used to pinpoint a scan frequency and the corresponding measurement value is displayed.

Single Frequency Mode — Provides measurement information in units of Reflection Coefficient (ρ); Voltage Standing Wave Ratio (VSWR);% Match, or Return Loss (dB) at one frequency on a simulated meter movement. An audio generator can be enabled to produce a tone that is proportional to the match condition.

Auto Scaling — Used in either swept or single frequency modes, sets the Y axis for best measurement display.

Relative Field Strength — Provides means for optimizing the radiated signal of any transmitter within the specified frequency band.

Limit Testing — Quick pass-fail indication; compares measurements to user selected limits.

Data Storage — Saves and recalls up to 12 traces to be used to set limit or long term monitoring of antenna performance.

Serial Communication Link — Built in serial port and optional software uploads data to a personal computer for analysis or storage.

Optional Equipment

Automobile Cigarette Lighter Adapter (P/N 5A2238-1) — Connects tester to standard 12V automotive cigarette lighter jack.

Carrying Case (P/N 5000-030) — Convenient and protective, large enough to carry the tester, AC adapter, connectors, field strength antenna and instruction book.

Verification Kit (P/N 7000A545) — Used to verify tester performance. Includes standard mismatch and connector adapter.

Interface Software (P/N 7000B840) — PC software used to upload trace data for analysis, printing or storage.

> **Note:** *System requirements: IBM PC or equivalent; Windows 95 or later, 6 MB free hard disk space; VGA monitor, open com port. Includes interface cable.*

Chapter 2 Basic Operations

Getting Started

This section describes initial quick steps to get started. For detailed information regarding connecting the Antenna Tester refer to that section at the end of this chapter.

> **Note:** *This unit is shipped with the batteries not charged. Charge batteries overnight or for at least 8 hours before use.*

Power On/Off

- To turn the Antenna Tester on, momentarily press the **ON** key.

  > **Note:** *The results of a self test will be displayed if a failure is present. For more information about the self test or a failure, refer to* "Maintenance" on page 28.

- To turn the Antenna Tester off, press and hold the **ON** key for 1 second.

Backlight

- To turn the backlight on, press the **BACKLIGHT** key.
- To increase or decrease display contrast, press and hold the **BACKLIGHT** key while pressing either the **UP** or **DOWN** arrow key.
- To turn the backlight off, press the **BACKLIGHT** key.

Software Menu

- Press the **MENU** key to display the software menu.

Blinking Cursor (black square)

The cursor will be blinking in the selected area, indicating that the parameter for that area can be changed.

Enter Key

All data entry, and mode changes accessed using select key, require the enter key to be pressed before they are initiated.

Up/Down Arrow Keys

When a function is enabled for change, the **UP** or **DOWN** arrow keys can be used to either scroll through your choices or increase/decrease the numerical value. The actual increments depend on the function.

Left Arrow Key

The **LEFT** arrow key can be used to backspace erasing one character at a time during data entry.

Escape (ESC)

Returns to previous menu without initiating a change.

Select Key

The operator instructions written for this manual were based on stepping through the software menu using the keys below the display. Once you are comfortable operating the AT-500, you might find it faster to use the **SELECT** key to access some functions. These include: Units, Scale, Start and Stop Frequencies in swept frequency mode and Units, Scale and Frequency in single frequency mode.

Press the **SELECT** key until the cursor is blinking at the desired function. The first function enabled depends on the last function selected through the menu.

Messages

There are five utility messages that can be displayed to inform you of equipment, or procedural, conditions.

“Lo Batt”

Displayed when battery voltage is less than 6.6V, See "Charging Batteries" on page 28.

“Busy”

Displayed during mode changes indicating the measurement information is being updated.

“Hold”

Displayed when in the Swept Frequency mode, and Single Hold is the selected sweep type.

“Pass” or “Fail”

Displayed indicating the appropriate results of a limit test.

“Noise”

Displayed if there is excessive background noise measured. The measurement may not be accurate. See "Troubleshooting" on page 36 if this condition is persistent.

Out of Range Values

When entering numeric data, it is possible to enter a value out of range. Depending on the function, the Antenna Tester will either enter the minimum or maximum value, or the cursor will continue to blink on the function out of range waiting for the correct entry.

Setting the Auto Shut-Off Timer

In order to preserve battery life, the Antenna Tester will automatically shut off after 5,15,30 or 60 minutes without any keystrokes.

Follow the steps below to select the length of time, before auto shut-off occurs.

1. Press the **MENU** key.
2. Press the **UTIL** key.
3. Press the **TIMER** key until the desired interval is displayed.

Return to Factory Presets

When the Antenna Tester is turned on, the various software parameters will be set to the condition they were at when the tester was turned off.

To return the parameters to the factory setting follow the steps below.

- The parameters will be set to the conditions listed below.

Software Parameter	Factory Setting
Mode	Swept Frequency
Start	2.0MHz
Stop	520.0MHz
Measurement Units	VSWR
Scale	min. 1.0; max. 5.0
Sweep Type	Continuous
Limit Value	1.5
Limit Audio	ON
Baud Rate	9600
Auto Shut-off Timer	5
Audio	ON
Cursor	67MHz

1. Press the **MENU** key.
2. Press the **UTIL** key.
3. Press the **PRESET** key.

Set Serial Baud Rate

Measurement data can be transferred between the AT-500 and a personal computer using the serial port and optional interface software. The data can then be used for analysis, printed, or stored.

The data transfer rate (baud rate) between the Antenna Tester and computer must be identical and set to 9600. To change the baud rate for the serial port on the Antenna Tester, follow the steps below.

Complete interface software instructions are included with the software.

1. Press the **MENU** key.
2. Press the **UTIL** key.
3. Press the **SERIAL** key.
4. Repeatedly press the **SERIAL** key until the 9600 is displayed.

Chapter 3 Installation

The following paragraphs will explain how to connect the Bird Antenna Tester for various operations. Refer to "Component Description" on page 2, if needed.

Power Supply

The AT-500 can use an external power source. Using the ac adapter or the 12V cigarette lighter adapter will also charge the battery. Using the ac adapter, charge time is about 8 hours. Using the cigarette lighter adapter, charge time will depend on the car battery charge. Battery life is 2 hours continuous operation, minimum, with the backlight on. “Lo Batt” is displayed when the batteries require charging.

Note: *This unit is shipped with the batteries not charged. Charge batteries for at least 8 hours before use.*

CAUTION
Follow guidelines for battery charging.
Avoid constant charging of batteries for long periods of time. Overcharging can result in reduced battery efficiency, service life, and possible permanent damage.

Note: *For optimum battery life, only charge the batteries after the low battery indicator is displayed.*

CAUTION
Only use the AC adapter provided with the AT. Do not use the adapter with the batteries removed.

AC Mains Adapter

To use the AC adapter, insert the adapter's barrel connector into the Antenna Tester's DC jack. Insert the adapter plug into a wall receptacle.

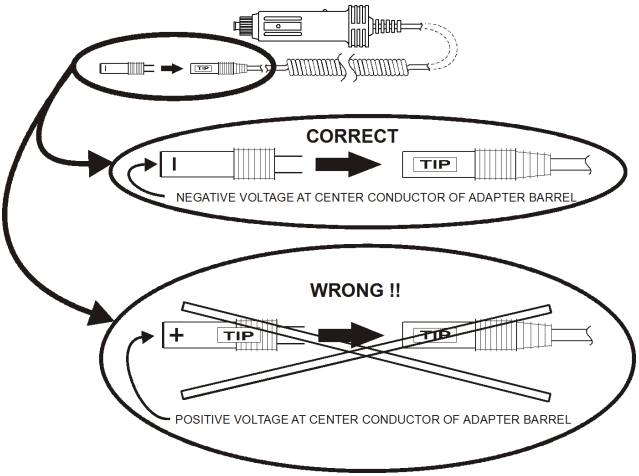
> CAUTION
> Required input is 11 to 16 VDC @ 250mA. Connector is wired outside positive, inside negative.

Automobile Cigarette Lighter Adapter Cable

> **Note:** *Before inserting the adapter's barrel connector into the Antenna Tester's DC jack (Figure 4), verify that the polarity of the adapter barrel is correct (Figure 4). The negative (–) symbol must be adjacent to the word TIP as the center is negative and the outside is positive.*

Insert the adapter plug into a cigarette lighter.

Figure 4 Cigarette Lighter Adapter Cable Tip Connection



Connecting the Antenna

WARNING
Live RF energy. Do not touch or ground the center conductor of a live RF connection. Failure to comply may result in equipment damage and serious burns or death to personnel.

CAUTION
AVOID STATIC DISCHARGE
Use proper Electrostatic Discharge (ESD) precautions to avoid static discharge when making connections to the test port. Equipment failure can occur if the test port is subjected to ESD.

CAUTION
250mW max. input
Exceeding the maximum input will damage the unit. Do not connect transmitter output to the AT-500. Damage can also be caused by testing antennas near other transmitting antennas. If testing base station antennas, first measure the power at the coax end to be sure it does not exceed 250mW.

Antenna leads and the Field Strength Antenna are connected to the test port. A known good RF cable can be used to connect the antenna tester directly to a coupler box, bypassing the antenna system lead. A female TNC connector is provided. Other connectors are available, see Parts List in the maintenance section for more information.

Special consideration must be given to the RF energy present at the feed line of site antennas. At active sites, RF energy from transmitters can be coupled to the antenna under test. If large enough, these signals will cause inaccurate measurements. For best results, the AT-500 should be used with all transmit antennas powered down.

Understanding the Operating Modes

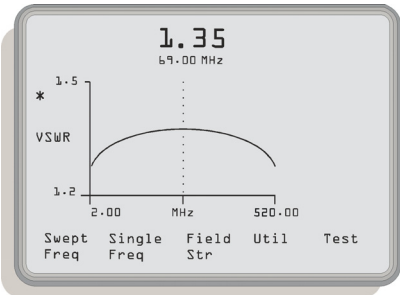
The Antenna Tester is connected and the operating frequency band is selected. User selections are customized, the power is on, and the top level menu is displayed (see "Basic Operations" on page 7).

Since the AT-500 will change the way antennas are tested, Bird recommends taking some time to explore the different operating modes and find what is best for specific applications.

Swept Frequency vs. Single Frequency

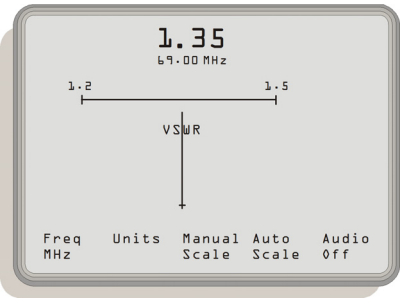
Swept frequency graphically displays the unit of measure over a band of frequencies. The cursor, a vertical dotted line, can be moved with the arrow keys to pinpoint a particular frequency. The measured match value and the frequency at the cursor position are shown at the top of the display.

Figure 5 Swept Frequency



Single Frequency mode displays the unit of measure in a simulated analog meter graphic. This mode, particularly when audio is on, is useful when tuning an antenna.

Figure 6 Single Frequency



Measurement Units

Rho (Reflection Coefficient), VSWR (Voltage Standing Wave Ratio), Match Efficiency (%), and Return Loss (dB), are different units of measurement that can be used to present the same information. (Similarly, Celsius and Fahrenheit are different units of measurement used to express the same temperature). These units can be used to express the degree of match between an antenna system and a transceiver.

Rho

Rho is the ratio of reflected wave voltage to forward wave voltage. A perfect antenna would not have any reflected waves, hence would have a 0.00 reflection coefficient.

VSWR

VSWR refers to the ratio of maximum and minimum voltages that are set up on a transmission line resulting from the combination of a forward wave and reflected wave. If the antenna system is perfectly matched, the VSWR would be 1:1 and shown as 1.00.

Match Efficiency (%)

Match Efficiency (%) indicates how much of the transmitted power is being used and how much is wasted. If the antenna system is perfectly matched, the Match Efficiency would be 100%.

Return Loss (dB)

Return Loss (dB) is a comparison of the reflected signal to the forward signal in decibels. If the antenna system is perfectly matched, the Return Loss would be negative infinity dB.

Antenna manufacturers often use VSWR for specifications. Match Efficiency is popular for testing because it is easy to determine a good match versus a bad match. For example a system with a VSWR of 1.50 would show -13.98 dB Return Loss and 96% Match Efficiency.

Auto Scale vs. Manual Scale

In swept mode Auto Scaling sets the measurement unit scale to make the trace easier to read. However, if you plan to look at the size or shape of traces for quick comparisons, it might be more meaningful to set a standard scale. Remember that it is possible to set the scale manually so the information is not on the display at all.

Figure 7 Auto Scaling Swept Frequency Mode

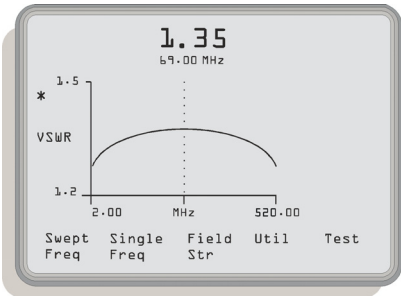
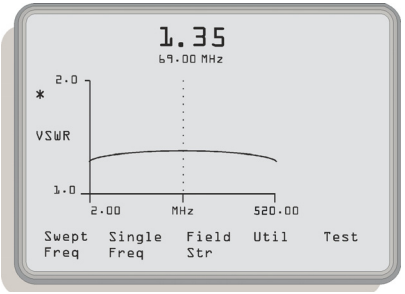
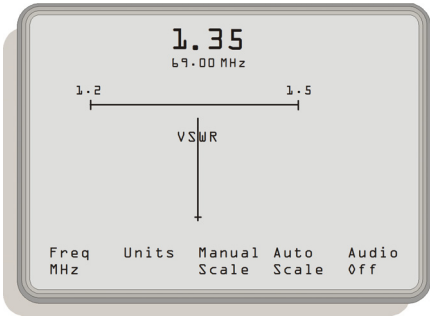


Figure 8 Manual Scaling Swept Frequency Mode



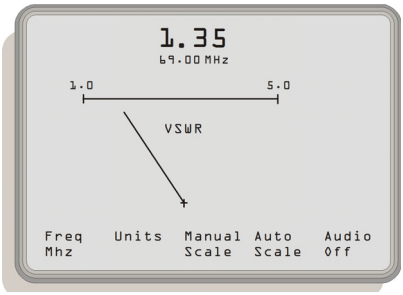
In the single frequency mode Auto Scaling sets the measurement unit scale so the pointer is mid range of the previous reading. The maximum and minimum scale values are approximately 10% higher or lower than the measured value.

Figure 9 Manual Scaling Swept Frequency Mode



This setting is an operator preference based on the mode that best presents the desired information.

Figure 10 Manual Scaling Single Frequency Model



Sweep Type-Single Hold vs. Continuous

Continuous sweep continually sweeps the selected frequency band updating the measured value with each sweep. An asterisk (*) is blinking on the left side of the display to indicate sweep rate. The single hold mode will freeze a trace on the display and hold is displayed on the right. Holding a trace is also helpful before saving the trace, (more about saving traces under that heading later in this section).

Swept Frequency

Select Frequency Band

There are two options for selecting the frequency band. The first is simply to enter the start and stop frequencies. The second is to enter a span frequency, which is the desired width of the band, and a center frequency, that will be used as the center of the band.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **BAND** key.
4. Depending on desired method press either **Start Stop MHz** or **Center MHz**:

Start Stop MHz

> **Note:** *The cursor will blink on the start frequency and Start Stop MHz will be highlighted.*

1. Enter the frequency using the numeric keypad or change the frequency using the **UP/DOWN** arrow keys.
2. Press the **ENTER** key. The cursor will blink on the stop frequency.
3. Enter the frequency using the numeric keypad or change the frequency using the **UP/DOWN** arrow keys.
4. Press the **ENTER** key. The tester will begin sweeping.

Center MHz

> **Note:** *The cursor will blink on the Center frequency and Center MHz will be highlighted.*

1. Enter the frequency using the numeric keypad or change the frequency using the **UP/DOWN** arrow keys.
2. Press the **ENTER** key.

   > **Note:** *The tester will begin sweeping.*

3. Press the **SPAN** key.
4. Enter the frequency using the numeric keypad or change the frequency using the **UP/DOWN** arrow keys.
5. Press the **ENTER** key.

   > **Note:** *The tester will begin sweeping.*

Select Measurement Units

Antenna match information can be presented using four different measurement units. Depending on the application, follow the steps below to select Rho, VSWR,%Match or Return Loss.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **MEAS UNITS** key.
4. Press the **UNITS** key.
5. Press either the **RHO**, **VSWR**,**%MATCH** or **RETURN LOSS** key.

   Note: *The selected unit will be shown on the left side of the display.*

6. Press **RETURN** to go back one menu level or **MENU** to return to the top menu level.

Select Auto or Manual Scale

Selecting the scale simply sets up how the information will look on the display.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **MEAS UNITS** key.
4. Depending on desired mode press either **AUTO** or **MANUAL SCALE**:

Auto Scale

The units scale changes and the Antenna Tester begins sweeping.

Manual Scale

Note: *The cursor will blink on the minimum scale value and Manual Scale will be highlighted.*

1. Enter the desired value using the **numeric keypad** or change the value using the **UP/DOWN** arrow keys.
2. Press the **ENTER** key.

   Note: *The cursor will blink on the maximum scale value.*

3. Enter the desired value using the **numeric keypad** or change the value using the **UP/DOWN** arrow keys.
4. Press the **ENTER** key. The tester will begin sweeping.

   Note: *If an out of range value is entered, the minimum (if under-range) or maximum (if over-range) value will be substituted. If a maximum value that is lower than the minimum value is entered, the cursor will blink again on the minimum value waiting for a correct entry. The actual range depends on the units selected.*

Note: *HINT: Using the arrow keys will keep you in the acceptable range. If you are not sure if the larger value should be at the top or bottom of the scale, press the auto scale key to see where the software puts it.*

Selecting the Sweep Type

Sweep types are continuous or single hold. Continuous will sweep and update the trace automatically. Single hold will sweep once and the trace will remain in the display. Each time single hold is pressed, the trace is updated.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **SWEEP TYPE** key.
4. Do one of the following, depending on desired mode:
   - Press **SINGLE HOLD** key.

     Note: *HOLD will be displayed.*
   - Press **CONT** key.

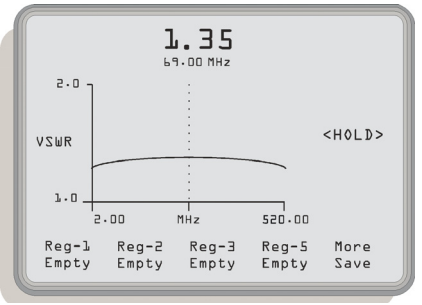
     Note: *The tester begins sweeping.*

Saving a Trace

The AT-500 can store up to 12 traces. A saved trace can be used to evaluate long term antenna performance, compare performance under different conditions or for comparison to another antenna. A saved trace is also a powerful tool in limit testing (more about limit testing later in this section). The information can later be uploaded to a PC using optional interface software and the serial port. Traces are stored in nonvolatile memory so they are not lost when the Antenna Tester is turned off.

Since the reflection coefficient is the information actually saved when saving a trace, and everything else is calculated from that, you have some flexibility when using the trace for comparison. For example, if you save a trace displayed in VSWR, you can compare it to a trace displayed in %Match. You can also change the frequency band of the new trace to effectively zoom in on a particular section of the saved trace. This may be helpful in pinpointing a problem area in a failed limit test.

Figure 11 Save a Trace



The desired units, band, and scale should be selected. You should be in the single hold mode and the trace you want stored should be displayed. If continuous sweep type is selected, the trace displayed when you save will be stored.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **TRACE** key.
4. Press the **SAVE TRACE** key.
5. Press a **REG-n** key that has EMPTY displayed.
6. Do one of the following:
   - If a full register is selected, the new trace will overwrite the old trace.
   - If registers 1-4 are full, press the **MORE SAVE** key to access 5-8 and again to access 9-12.

Note: *If needed, use the* **ESC** *key to back up.*

Note: *HINT: It is a good idea to keep a record of which traces are in which register as they are identified by register number only.*

Recalling a Trace

Follow the steps below to recall a saved trace.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **TRACE** key.
4. Press the **RECALL TRACE** key.
5. Press the **REG-n** key for the desired trace, press the **MORE RECALL** key to access 5-8 and again to access 9-12. If needed, use the **ESC** key to back up. The saved trace will be displayed and the corresponding register number will be shown at the bottom of the display.

Note: *The arrow keys can be used to move the cursor, and the corresponding measurement and frequency at the cursor will be displayed. Remember the up arrow key will move the cursor to the highest value on the trace and the down arrow key will move it to the lowest.*

- Press the **RETURN** key to return to register selection.
- Press the **ESC** key to return to trace menu.

Clearing a Trace

When a trace is no longer needed or you need to clear registers for space, follow the steps below.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **TRACE** key.
4. Press the **CLEAR TRACE** key.
5. Press the **REG-n** key for the desired trace, press the **MORE CLEAR** key to access 5-8 and again to access 9-12. If needed, use the **ESC** key to back up. The word full will be replaced by empty at the selected register.
6. Press the **ESC** key to return to the trace menu.

Limit Testing

Limit testing is a quick pass-fail test using operator defined limits or a stored trace as a minimum for acceptability. Pass or fail will be displayed at the top of the display and an audible tone can be enabled to indicate a fail situation.

Limit testing is probably the most labor-efficient mode for operating the AT-500. Since all the software settings are retained when the tester is turned off, once the limit test is set up its simply a matter of connecting the next antenna system, turning on the power and reading pass or fail.

Turn Audio On/Off

Audio tone for fail indication.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **LIMIT** key.
4. Pressing the **AUDIO** key will toggle between on and off.

Selecting Limit Values

Valid limit values depend on measurement units selected. Valid entries are:

VSWR

Between 1.0 and 100.0

% Match

Between 0 and 100%

Return Loss

Between -32 and 0 dB

RHO

Between 0.000 and 1.000

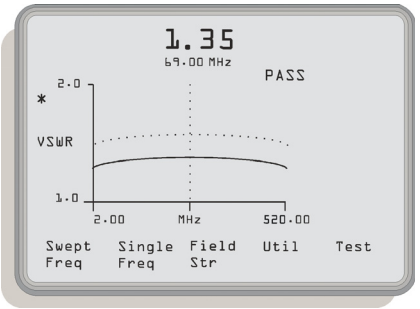
1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **LIMIT** key.
4. Press the **VALUE** key. The cursor will blink next to off.
5. Enter the desired value using the **numeric keypad** or change the value using the **UP/DOWN** arrow keys.
6. Press the **ENTER** key.

> **Note:** *Pass or Fail will be displayed, a tone will be heard for fail if audio is enabled.*

Using a Trace as the Limit

The trace you want to use for the limit must be saved. You can have the current antenna test running or start it after you set up the limit test.

Figure 12 Dotted Outline of Limit Trace



1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.

3. Press the **LIMIT** key.
4. Press the **TRACE -> LIMIT** key.
5. Press the **REG-n** key where the trace is stored.

> **Note:** *A dotted outline of the limit trace will be displayed with the new trace displayed over it. Pass or Fail will be displayed.*
>
> **Note:** *You can still move the cursor, change measurement units, frequency band and scale. The dotted outline of the limit trace will be automatically adjusted to provide a direct comparison with the antenna system under test.*

Clearing a Limit

Follow the steps below to clear either an operator defined limit value or a trace limit. The trace will still be stored in memory, the limit value will be erased.

1. Press the **MENU** key.
2. Press the **SWEPT FREQ** key.
3. Press the **LIMIT** key.
4. Press the **CLEAR LIMIT** key.

The value field will change to off if an operator value was being used, the dotted outline of the limit trace will be removed if a trace was being used.

Single Frequency

This mode is useful for tuning antennas, particularly with the audio on. The frequency can be selected following the instructions below.

Selecting the Frequency

1. Press the **MENU** key.
2. Press the **SINGLE FREQ** key.
3. Press the **FREQ MHZ** key. The cursor will be blinking at the frequency and Freq MHz will be highlighted.
4. Enter the desired frequency using the **numeric keypad** or change the value using the **UP/DOWN** arrow keys.
5. Press the **ENTER** key. The measured value and the frequency will be shown at the top of the display.

Select Measurement Units

Antenna match information can be presented using three different measurement units. Depending on your application, follow the steps below to select Rho, VSWR, %Match or Return Loss.

1. Press the **MENU** key.
2. Press the **SINGLE FREQ** key.
3. Press the **UNITS** key.
4. Press either the **RHO**, **VSWR**, **%MATCH** or **RETURN LOSS** key. The selected unit will be shown in the center of the display.
5. Press the **RETURN** key to go back one menu level.

Select Auto or Manual Scale

Selecting the scale simply sets up how the information will look on the display.

1. Press the **MENU** key.
2. Press the **SINGLE FREQ** key.
3. Depending on desired method press either **AUTO** or **MANUAL SCALE**:

Auto Scale

The units scale changes.

Manual Scale

The cursor will blink on the maximum scale value and Manual Scale will be highlighted.

1. Enter the desired value using the **numeric keypad** or change the value using the **UP/DOWN** arrow keys.
2. Press the **ENTER** key. The cursor will blink on the minimum scale value.
3. Enter the desired value using the **numeric keypad** or change the value using the **UP/DOWN** arrow keys.
4. Press the **ENTER** key.

> **Note:** *If an out of range value is entered, the minimum (if under-range) or maximum (if over-range) value will be substituted. If a maximum value that is lower than the minimum value is entered the cursor will blink again on the minimum value, waiting for a correct entry. The actual range depends on the units selected.*
>
> **Note:** *Using the arrow keys will keep you in the acceptable range. If you are not sure if the larger value should be at the right or left side of the scale, press the auto scale key to see where the software puts it.*

Turn Audio On/Off

The pitch varies with the match condition allowing you to tune an antenna without having to look at the display.

1. Press the **MENU** key.
2. Press the **SINGLE FREQ** key.
3. Pressing the **AUDIO** key toggles between on and off.

Field Strength Measurement

With the field strength antenna installed, the Antenna Tester can be used to optimize the radiated signal of any transmitter from 2 to 520 MHz. This is a relative measurement. The measurement sensitivity is such that a full scale deflection will occur for a field of 8 Volts/Meter at 100 MHz. The gain factor can be adjusted to increase the measurement sensitivity to 0.08 Volts/Meter.

Turn Audio On/Off

The pitch varies with the field strength.

1. Press the **MENU** key.
2. Press the **FIELD STR** key.
3. Pressing the **AUDIO** key toggles between on and off.

Enter Gain Factor / Select Auto Gain

Increasing the gain factor increases the measurement sensitivity. Setting the gain to auto will set a gain factor so that the pointer is in the middle of the scale.

1. Press the **MENU** key.
2. Press the **FIELD STR** key.
3. Press either:

Auto Gain

The pointer moves to the approximate middle of the scale.

Gain

The cursor will blink on the gain value. Enter the desired value using the **numeric keypad** or change the value using the **UP/DOWN** arrow keys. Press the **ENTER** key.

Cleaning

CAUTION
Harsh or abrasive detergents and some solvents can damage the display unit and information on labels.

Clean the antenna tester and the display with a soft cloth dampened with mild detergent and water only.

Calibration

For best performance and accuracy, the Antenna Tester should be calibrated once every 12 months. Return the unit to an authorized Bird Service Center.

Charging Batteries

WARNING
Care should be taken when handling batteries.
Do not heat or dispose of batteries in fire. May burst or release toxic materials.
Avoid forced discharge.
Do not short circuit.
Restrict charging current and time to the recommended value.
Do not solder the battery directly.
Do not disassemble, apply excessive pressure or deform.
Avoid placing the battery in reverse polarity.
Battery disposal method should be in accordance with local and state regulations.

Fully charged batteries will provide a minimum of 2 hours continuous operation with the backlight on. Charging time is typically 8 hours. The batteries are being charged when the Antenna Tester is connected to AC, with the AC mains adapter, or DC, with the automobile cigarette lighter adapter. The unit does not have to be on to charge the batteries.

Note: *For optimum battery life, charge the batteries only after the low battery indication is displayed.*

CAUTION
Follow guidelines for battery charging.
Avoid constant charging of batteries for long periods of time. Overcharging can result in reduced battery efficiency, service life, and possible permanent damage.

Batteries and Long Term Storage

Do not store the instrument for long periods of time without recharging the batteries. When the instrument is stored for long periods of time without use, the batteries will loose their charge and also loose the ability to reach full charge when put into service. To restore the battery charge, perform a full charge for 8 hours. If the batteries are not fully charged after eight hours, completely discharge the batteries then perform a full charge again. If necessary, repeat this discharge and charge cycle up to three times. If the batteries do not remain charged after three discharge-charge cycles, replace the batteries.

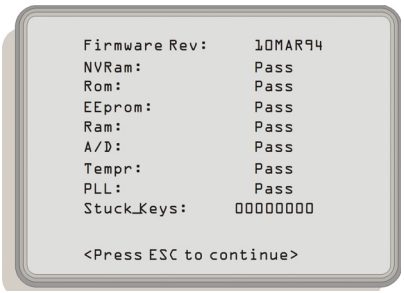
CAUTION
If subjected to an ESD spike directly to the metal portion of the case the unit may go into an interrogative state. A power cycle of the unit may be required to return to normal operation. See "Power On/Off" on page 7.

Operational Tests

Power-up

There are several operational tests run at power up. The test is displayed only if any of the tests fail. The results are displayed to the right of the test as shown in Figure 13. If you would like the test screen displayed regardless of results, press any key while pressing the ON key at initial power up. If any test fails, check the troubleshooting section for possible correction. When displaying the tests as described above, a stuck key will be indicated.

Figure 13 Power-up Test



Firmware Rev

Revision date for the firmware installed.

NVram—	Checks for valid contents
Rom—	
EEprom—	
Ram—	

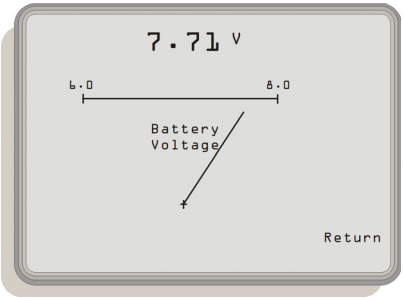
A/D—	Checks for proper circuit operation
Tempr—	
PLL—	

Stuck_Keys	Check keys for depressed at power up.

Battery Test

The battery test checks the output voltage of the batteries. The result is displayed in a simulated analog meter type graphic with the value shown at the top of the display. The scale is set from 6-8V.

Figure 14 Battery Test



If the voltage measured is less than 7V you should charge the batteries.

> **Note:** *The AT-500 will shut off if the battery is too low however, full accuracy is maintained at any battery voltage.*

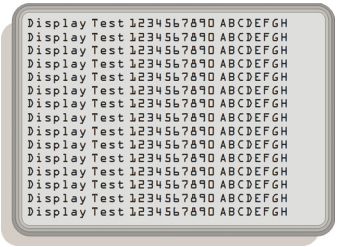
Be sure the AC mains adapter is not connected.

1. Press the **MENU** key.
2. Press the **TEST** key.
3. Press the **BATT TEST** key.
4. Press the **RETURN** key to end the test.

Display Test

The display test is used to be sure that each area of the display is functional. When the test is started the display is filled with various characters. Each pixel then changes state, either from black to white or white to black. If there is any area that is not functional return the tester to Bird Electronic for repair.

Figure 15 Display Test

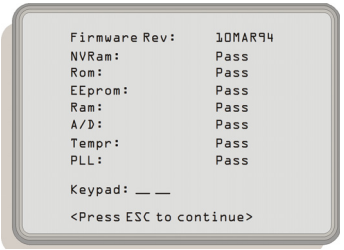


1. Press the **MENU** key.
2. Press the **TEST** key.
3. Press the **DISP TEST** key.
4. The test is started.
5. Press the **ESC** key to end the test.

Self Test

The self test is similar to the operational tests run at power up described on page 30 of this section. The one difference is the keypad test.

Figure 16 Self Test



1. Press the **MENU** key.
2. Press the **TEST** key.
3. Press the **SELF TEST** key.
4. Press each key (except **ESC** and **ON**) to test keypad.

   Note: *The value next to Keypad is hexadecimal and corresponds to the key pressed. If the value does not change for each key, refer to Troubleshooting in this section.*

5. Press the **ESC** key to stop the test.

If the Self Test fails, then perform the following:

1. Press the **ESC** key.
2. Press the **MENU** key.
3. Press the **Util** key.
4. Press **Preset**.
5. Rerun the Self Test. See "Self Test" on page 33.

   Note: *If the unit still fails, return the unit for service.*

Battery Replacement

The batteries need to be replaced when fully charged batteries provide less than 2 hours operation. Carefully follow the instructions below to replace the batteries.

For models equipped with 700 mAh Nickel-Cadium batteries (p/n 5A2230):

Note: *Unit may contain six 700 mAh Nickel-Cadium (NiCAD) batteries. Replace these batteries with six Nickel-Metal Hydride NiMH) (p/n 5B2230).*

For models equipped with minimum 2000 mAh Nickel-Metal Hydride (NiMH) batteries
(p/n 5B2230):

WARNING
Replace with ONLY Nickel-Metal hydride (NiMH) rechargeable AA batteries with a nominal voltage of 1.2V and minimum capacity of 2000mAh. DO NOT install any type of battery such as alkaline or other type of secondary (rechargable) batteries.

Note: *To retain trace data stored in nonvolatile RAM, leave the AC mains adapter connected during battery replacement.*

1. Lay the Antenna Tester, display side down, on a clean surface.
2. Using a small phillips screwdriver, remove six screws from the back cover.
3. Lift the back cover approximately two inches above the front cover.
4. Flip the back cover in the direction of the arrow shown below. To avoid disconnecting P2, (battery connector), lay the back cover next to the front.
5. Remove the old batteries.
6. Install the new batteries checking the orientation of the positive and negative terminals. Polarity is indicated on the case, and in Figure 17.

WARNING
Charging batteries installed in reverse polarity can cause the battery to swell or rupture.

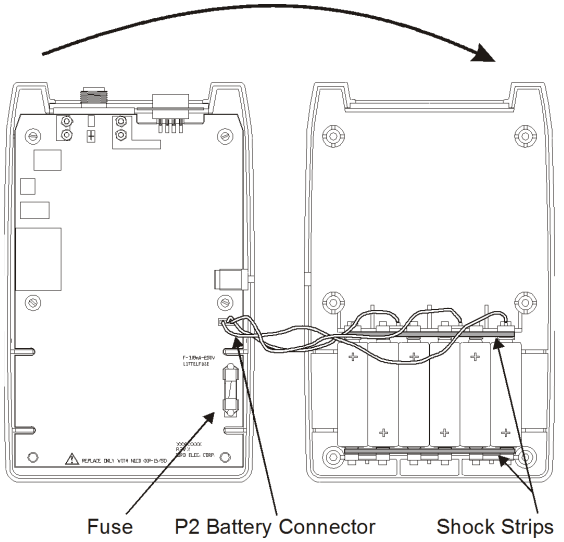
7. Be sure P2 is connected and the shock strips are still in place.
8. Place the back cover over the front cover making sure it is properly seated.
9. Replace the six screws.
10. Run the battery test on page 31 of this section.

Fuse Replacement

CAUTION
Replace with only the same type and rating fuse. 315mA 250V

Note: *Follow the steps outlined in Battery Replacement replacing the fuse where replacing the batteries is indicated.*

Figure 17 Battery / Fuse Replacement



Troubleshooting

Operator maintenance or service is limited to battery and fuse replacement. Any other required service must be performed at an authorized Bird Service Center.

Refer to the following paragraphs for help in isolating error conditions.

The Antenna Tester will not power up.

Power for the Antenna Tester can be provided in three ways—the internal batteries, an AC mains adapter or an optional automobile cigarette lighter adapter. Try to power the tester using each available means. The internal batteries may need charged, or if recently replaced, are installed incorrectly. The AC mains adapter may not be securely connected, may be damaged, or there is no power supplied at the wall receptacle. The internal fuse may have opened and requires replacement.

If the unit was recently opened, recheck P2, the battery connector, be sure it is securely connected. Follow the instructions for battery and fuse replacement when opening the unit.

NVRAM Test Fails

An NVRAM error indicates the information in nonvolatile RAM, a type of memory, is not valid. The probable cause is power was lost. When the unit is off, the batteries, if charged and present, or power from the AC mains adapter, if connected, supply power to retain stored trace data and software settings. This information is lost if all power is removed. Clear the error by pressing the ESC key. Be sure to read battery charging and replacement sections if the problem persists.

ROM, EEPROM, RAM, A/D, TEMPR, PLL Test Fails

Ensure the results are valid by repeating the self test or turning the unit off then back on. If the problem persists return the unit for service.

Stuck Keys Test Fails

If any characters other than 0 are displayed next to stuck keys during power up test, perform the keypad test on page 33 of this section. Remember, if a key is depressed during power up to display the power up test results it is normal for other characters to be displayed. If the key remains stuck return the unit for service.

"Noise" is Displayed During Testing

The Antenna Tester measures background noise to determine if nearby signals could cause an erroneous match measurement. Power down all nearby transmitting antennas. All interfering signals must be removed before resuming measurement.

Antenna Tester indicates a Perfect Match

When measuring the match of an antenna in a high RF environment, the Antenna Tester indicates a perfect match (i.e. VSWR = 1.00, Return Loss = -32 dB, or Match Efficiency = 100%). This is caused by the coupling of interfering signals into the Antenna-Under-Test. If sufficiently strong, the interfering signals can over-power the measurement signal inside the Antenna Tester. Normally, this results in degraded measurement accuracy. Bird Antenna Testers minimize this effect by measuring the interfering signal during the time between match measurements. The inter-ferer magnitude is subtracted from the magnitude of the measurement signal. For relatively small interferers (i.e. interfering signal smaller than the measurement signal), this technique yields approximately 10 dB better rejection. If the interfering signal becomes larger than the measurement signal, the correction output approaches zero, corresponding to a perfect match. Measurement results are not accurate under these circumstances. The remedy is to disable the interfering source, if possible, or postpone the measurement to a time when the interfering source is not operating.

Customer Service

Any maintenance or service procedure beyond the scope of those in this chapter should be referred to a qualified service center.

If the unit needs to be returned for any reason, request an Return Material Authorization (RMA) through the Bird Technologies website. All instruments returned must be shipped prepaid and to the attention of the RMA number.

Bird Service Center
30303 Aurora Road
Cleveland (Solon), Ohio 44139-2794
Fax: (440) 248-5426
E-mail: *bsc@birdrf.com*

For the location of the Sales Office nearest you, visit our Web site at:

http://www.birdrf.com

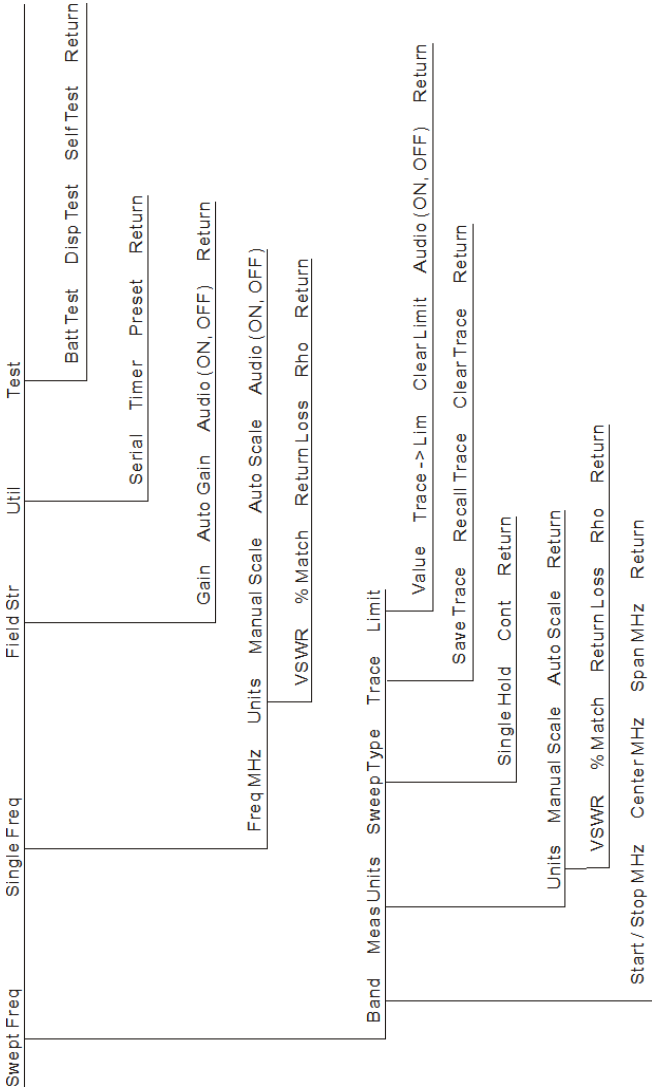
Parts List

Part Name	Part Number
AT-500 Complete	7000A501
Parts Supplied with AT-500 Complete, or installed when shipped.	
Battery (6 required)	5A2230 (in older models)
or	
Battery	5B2230 (in newer models)
Fuse	RP5-1976-11
AC Mains Adapter, 115v	5A2229
or	
AC Mains Adapter, 230v	5A2226
Female N Connector	4240-403
Field Strength Antenna	5A2228-3
Instruction Book	920-AT500
Foam Shock Strips (2)	5A2243-2
Optional Adapters:	
N/m	4240-402
BNC/m	4240-404
BNC/f	4240-405
TNC/m	4240-406
TNC/f	4240-407
UHF/m	4240-408
UHF/f	4240-409
SMA/m	4240-410
SMA/f	4240-411
Optional Parts or Accessories:	
Automobile Cigarette Lighter Adapter	5A2238-1
Interface Software	7000B840
Includes Cable	5A2264-09-MF-10
Verification Kit	7000A545
Carrying Case	5000-030

Specifications

Frequency Range	2 to 520 MHz
Frequency Resolution	20 kHz
Measurement Range	
VSWR	1.00 to 100.00
Match Efficiency	0 to 100%
Return Loss	-32 to 0 dB
Rho	0.000 to 1.000
Measurement Speed	(Typical)
Single Frequency	5 Readings/second
Swept Frequency	1 Sweep/second
Test Port	
Impedance	50Ω nominal
Connector	(Field Interchangeable) Female N
Field Strength	
Range	0 to 100% Relative
Sensitivity	Full scale deflection at 8 Volts/Meter at 100 MHz, depending on gain setting. 0.22 V/m @ 400 MHz using supplied antenna
Power Requirements	
Batteries (5A2230) (in older models)	Six 1.22V AA, 700 mAH Rechargeable NiCAD
Batteries (5B2230) (in newer models)	Six 1.2V AA (HR 15/51) Rechargable NiMH
External DC	12 VDC <400mA
External AC Adapter	120 ± 10% VAC 50/60 Hz
Interface	Serial (female DB-9 connector)
Operating Temperature	0°to 50°C (32° to 122°F)
Storage Temperature	-40° to 71°C (-40° to 160°F)
Humidity	95% ± 5% max (non condensing)
Size (including connector)	8" x 4-5/8" x 1-3/4” (204mm x 118mm x 42mm)
Weight	<2.0 lb (0.9 kg)
CE Compliance	EN 61326-1-2:2006 Electrical equipment for measurement and control use. EMC 61010-1:2001 - Safety 89/336/EEC, EMC 73/23/EEC and Amendment 93/68/EEC - Low Voltage
Electrostatic discharge (ESD)	This equipment is not specified to operate in an environment where it may be subjected to an ESD voltage spike directly on the metal portion of the enclosure.

Menu Structure



Limited Warranty

All products manufactured by Seller are warranted to be free from defects in material and workmanship for a period of one (1) year, unless otherwise specified, from date of shipment and to conform to applicable specifications, drawings, blueprints and/or samples. Seller's sole obligation under these warranties shall be to issue credit, repair or replace any item or part thereof which is proved to be other than as warranted; no allowance shall be made for any labor charges of Buyer for replacement of parts, adjustment or repairs, or any other work, unless such charges are authorized in advance by Seller.

If Seller's products are claimed to be defective in material or workmanship or not to conform to specifications, drawings, blueprints and/or samples, Seller shall, upon prompt notice thereof, either examine the products where they are located or issue shipping instructions for return to Seller (transportation-charges prepaid by Buyer). In the event any of our products are proved to be other than as warranted, transportation costs (cheapest way) to and from Seller's plant, will be borne by Seller and reimbursement or credit will be made for amounts so expended by Buyer. Every such claim for breach of these warranties shall be deemed to be waived by Buyer unless made in writing within ten (10) days from the date of discovery of the defect.

The above warranties shall not extend to any products or parts thereof which have been subjected to any misuse or neglect, damaged by accident, rendered defective by reason of improper installation or by the performance of repairs or alterations outside of our plant, and shall not apply to any goods or parts thereof furnished by Buyer or acquired from others at Buyer's request and/or to Buyer's specifications. Routine (regularly required) calibration is not covered under this limited warranty. In addition, Seller's warranties do not extend to the failure of tubes, transistors, fuses and batteries, or to other equipment and parts manufactured by others except to the extent of the original manufacturer's warranty to Seller.

The obligations under the foregoing warranties are limited to the precise terms thereof. These warranties provide exclusive remedies, expressly in lieu of all other remedies including claims for special or consequential damages. SELLER NEITHER MAKES NOR ASSUMES ANY OTHER WARRANTY WHATSOEVER, WHETHER EXPRESS, STATUTORY, OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS, AND NO PERSON IS AUTHORIZED TO ASSUME FOR SELLER ANY OBLIGATION OR LIABILITY NOT STRICTLY IN ACCORDANCE WITH THE FOREGOING.