

~ Operating Guide ~

Micro908 Antenna Analyst

Revision 4.0

(Corresponds to AA908 software, version 4.0 and beyond)



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1.0 Overview

The Micro908 Antenna Analyst is a quality measurement instrument that determines antenna system performance across the amateur bands through use of automatically collected SWR and complex impedance readings. It was designed to be easily operated on the bench as well as in-hand while portable. The analyzer is comprised of a base printed circuit board containing all components, connectors, controls and a 2 row by 16 character liquid crystal display (LCD). The base pcb also accommodates two essential daughtercards that provide the computing power and the RF signal generation. The enclosure holds an 8-cell AA battery back enabling convenient field use.

The Antenna Analyst utilizes a powerful 8-bit microcontroller to instruct a Direct Digital Synthesis (DDS) integrated circuit to generate RF signals from 1 MHz to 30 MHz. The DDS generates extremely precise and accurate signals that give the Analyst the ability to also serve as a stable RF signal source for testing and basic network analysis. The low-current 68HC908AB32 microcontroller also handles the user interface of an LCD, pushbuttons and rotary encoder to allow full control of the instrument. The “field-programmable” feature allows the user to download new or updated software from the Micro908 website and load it into the Antenna Analyst.

The figure below shows the block diagram of the Antenna Analyzer.

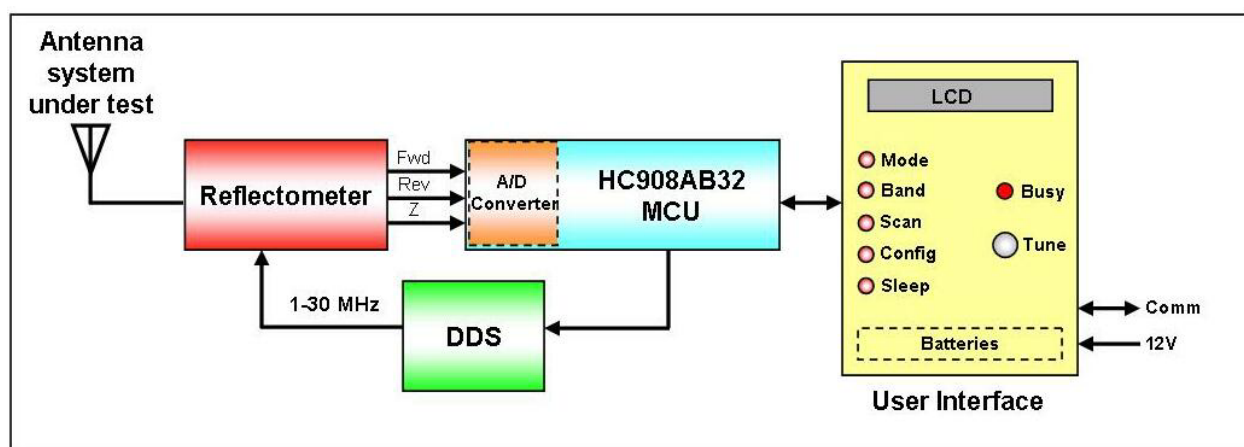


Figure 1 – Block Diagram of the Micro908 Antenna Analyst

A very low power transmitter is automatically swept across selected frequencies by a microcontroller. The transmitter's signal is delivered to the antenna system through a reflectometer consisting of an absorptive SWR bridge using diode detectors and compensated buffer amplifiers. The data provided by the reflectometer are digitized and used by the microcontroller to compute SWR and impedance values for each frequency sampled. The microcontroller retains the frequency and corresponding results throughout the measurement period, and at the end of the scan the microcontroller statically displays the SWR and impedance at the resonant frequencies.

Thus, with a press of a button the Antenna Analyst is able to quickly and automatically determine the frequencies for which the antenna system is best matched, and display the associated complex impedance values at those frequencies. The stored data for frequency, SWR and impedance can then be sent to a PC over the built-in serial port for post-processing and plotting of the antenna's characteristics.

Manual operation allows the user to control the frequency of operation while selecting among four operational modes: Impedance, Inductance, Capacitance and VFO. The VFO mode allows the Micro908 to serve as a precise and stable frequency source, useful for troubleshooting RF equipment or serving as an outboard local oscillator.

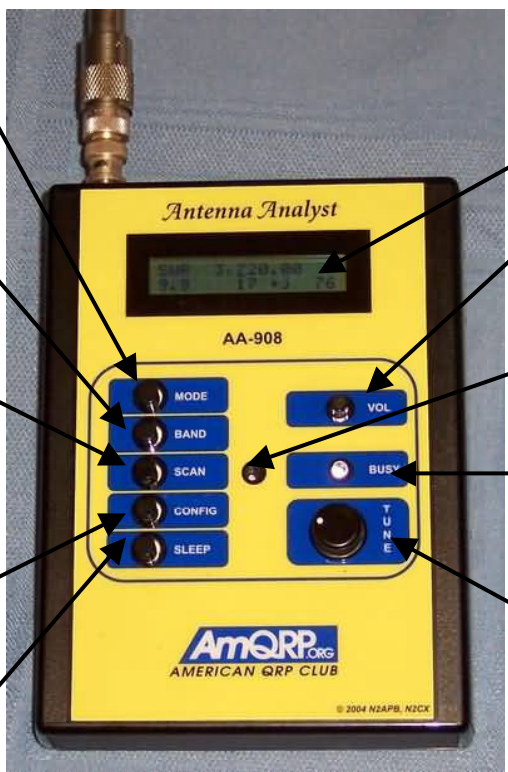
The Antenna Analyst is designed to be field-usable and operator friendly. The handheld form factor lends itself to convenient operation while away from the bench by means of pushbutton controls along the left top side of the unit. The operator is able to easily select the various modes and options with the left hand while making frequency with the right hand. The RF connector is located at the top of the instrument to provide convenient connection to the antenna system being measured. The external power jack and the power switch are located on the side of the instrument. The unit can be battery operated and the enclosure was selected to hold eight AA cells.

2.0 Features

- Manual and automated antenna analysis based on SWR and complex impedance measurements
- Operating modes provided for measurement of network impedance, and inductors and capacitors
- Operating mode provide RF signal source at output serves as external VFO and test signal
- Powerful 8-bit microcontroller controls all aspects of the operation
- High-precision, low power DDS signal generator is used as rock-solid signal source
- Internal reflectometer measures forward, reflected and impedance signals
- Automatic scanning results displayed as frequencies with lowest SWR
- Configurable frequency scanning limits and step sizes
- Manual control option displays SWR and complex impedance at selected frequencies
- Audible tone indicates resonance – lower tone indicates lower SWR (May be enabled/disabled.)
- Serial port connects to PC for field-upgradable software
- Serial port connects to PC for uploading and graphical display of measurement data
- Battery-operated for convenient field use, or can use external 9-16V for bench operation
- Other uses of the Instrument:
 - Measure antenna bandwidth
 - Measure feedpoint impedance
 - Measure ground loss
 - Measure coaxial cable Loss
 - Adjust antenna tuners and determine loss
 - Measure coax transmission line (SWR, length, velocity factor, approximate Q and loss, resonant frequency, and impedance)
 - Measure and determine optimum settings for tuning stubs: SWR, approximate Q, resonant frequency, bandwidth, impedance
 - Determine characteristic impedance of transmission line.
 - Determine length of $\frac{1}{4}$ and $\frac{1}{2}$ wave phasing lines.
 - Measure balun loss.
 - Measure inductor Q
 - Estimate quartz crystal parameters
 - Measure magnetic loop resonance and SWR.

3.0 Connections and Controls

- MODE**
User can change the AA-908 to any of the 4 available moperating modes: Impedance (default), Capacitance, Inductance, and VFO.
- BAND**
User can select one of three bands, or a custom-set band, for the scan operation: 1-10 MHz, 10-20 MHz, 20-30 MHz, or Custom Band.
- SCAN**
Pressing this control initiates a scan of the frequencies selected in the BAND function. Scan exits to Impedance mode showing the resonant point in the antenna system.
- CONFIG**
Provides menu of user-configurable settings and functions: Custom Scan settings, Audio tone enable/disable, Software Load, Calibrate, Debug Mode, and View Settings.
- SLEEP**
This button has no function at this time.



- LCD Display**
2 lines x 16 characters
- VOL**
Control volume of tones generated during Impedance and Scan operations.
- Audible Tones**
When enabled, tones indicate value of SWR.
- BUSY Light**
Turns on when scanning and when saving user settings.
- Dial**
Main part of user interface, used to select menu items and frequency settings.



External Power Jack
2.1mm jack, center positive, 9-16V DC

Power Control

Audio In, Out, Keyboard, Paddle, Aux
Not used with the AA-908 software.



Serial Port
Connect to PC when loading new software.

RF Output
BNC jack provides connection to antenna system.

4.0 Operation

1) Power On Sequence

Upon applying power, the unit will sequence through two LCD displays before automatically entering the Impedance mode display.

a) The first information shown on the LCD after turning on the instrument indicates the approximate battery (or supply) voltage, and it is displayed for about ½ second. This is a useful feature that indicates the relative state of the instrument's power source.

Battery: 9.04V

b) The next information shown on the LCD is the version number of the software loaded in the instrument, and it is also displayed for about ½ second.

AA908 v4.0

c) The instrument then enters the Impedance mode, which is the most common use of the analyzer, indicating a screen such as that shown below. The initial frequency that is generated and displayed is 10.00000 MHz, and with no antenna or load connected to the RF output jack, the open circuit SWR and impedance will likely indicate as shown below. (See "Impedance Mode" for detailed description of this display and mode operation.)

SWR 10,000.00
>10 Z>600

2) User Interface

The user interface consists of five pushbuttons, one for each instrument function as described in the next section, and a rotary dial that is used to select various options presented in a menu-like manner. You use the function pushbuttons and the dial to operate the Antenna Analyst – just press a function button and rotate the dial and the various menu options for that function are sequentially displayed on the LCD. Once you have dialed up the desired option or operation on the LCD, you may select it by pressing the dial pushbutton.

3) Function Selection

At any time during the instrument's operation, you have the option of pressing any of the function pushbuttons to perform the corresponding operation, as described below.

- a) **Band** -- Pressing BAND pushbutton will present four band options: 1-10 MHz, 10-20 MHz, 20-30 MHz, and "Custom Band". (The Custom Band is a user-specified start/stop frequency pair, set under the Configuration function, that allows the user to specify a custom frequency range for scanning.) Once you have dialed in the range that you wish to automatically scan, press the dial pushbutton to select it. You will then exit back to the Impedance display.
- b) **Scan** -- Pressing the SCAN pushbutton will automatically sweep the Antenna Analyst test signal across the band range previously selected, incrementing from the lower frequency limit to the upper frequency limit, in steps of 100 Hz, 1 kHz, 10 kHz, or 100 kHz, as preset in the Config menu. The red BUSY LED is turned on during the scan and the following message is displayed:

~~Scanning~~
(please wait)

The reflectometer signals are sampled after each step change and are used to compute the SWR and complex impedance at each frequency step. Each SWR value is compared to previous value in order to determine if a minima, or a "dip", has occurred at this point in the scan. If so, that data point is stored for later display. The Scan takes approximately 6 seconds at the 1 kHz step rate. At the end of the scan, the Impedance mode is automatically entered and the SWR and impedance data at the frequency of resonance is displayed.

c) **Mode** -- Pressing the MODE pushbutton presents sub-displays representing the four modes available in the instrument: Impedance, Capacitance, Inductance and VFO. To enter a specific mode, press the dial pushbutton when that mode name is displayed.

- **Impedance** -- This is the main operational mode for the Antenna Analyst. Impedance mode is entered automatically during the power-on sequence, and can be re-entered from any other mode pressing the dial pushbutton when Impedance is displayed. Upon entry to the Impedance mode, you will see the following typical display:

```
SWR 10,345.00
2.1  49 +j 23
```

- The top line indicates the frequency
- The first number on the second line is the SWR. In this case it indicates 2.1:1
- The middle value is Resistance, the real part of Impedance. In this case it is 49 ohms
- The rightmost value is the Reactance, or the reactive part of Impedance. In this case it is 23-ohms inductance. (Capacitive reactance would indicated as a negative number.)

In the Impedance mode, you have the ability to manual adjust the frequency and see the SWR, Resistance and Reactance values at whatever frequency is dialed up.

Frequency is changed by adjusting a single digit indicated at the point in the display where the cursor (_) is. Upon power-up of the instrument, the 10 kHz digit is the adjustment point, as shown by the digit with the cursor in the display above.

To move the cursor to a different digit to be adjusted, press the dial pushbutton while simultaneously turning the dial. The cursor will move to any of the seven available digits, allowing subsequent up/down adjustment of that digit with the dial pushbutton is released.

Rotating the dial clockwise will increase the digit value and, correspondingly, the signal generated by the unit. Counter-clockwise rotation will decrease the digit and the generated signal.

When the digit is incremented past 9, or when it is decremented past 0, the digits above the selected adjustment point are rolled up or down, respectively.

Using this frequency adjustment scheme, the user can conveniently pick an “increment” digit and manually scan frequencies with the desired granularity. Rough scans can manually be done by positioning the cursor under the 100 kHz digit or the 1 MHz digit, giving a wide and course scan of the frequencies with a quick twist of the dial. The signal frequency can then be set to the area of interest and the cursor set to a lower granular digit (e.g., 10 kHz or 1 kHz) in order to manually perform a detailed scan while watching displayed results for SWR, impedance and reactance.

An audio tone may be configured to sound when turning the dial in Impedance mode. When you approach a resonance (i.e., an SWR "dip"), the tone lowers according to the SWR. Thus the operator will have an audible indication of when minimum SWR is found. The tones may be enabled or disabled in the Config menu, and the setting is saved in nonvolatile EEPROM so the selection stays in the unit when power is turned off.

To exit the Impedance mode and return to the Home Display, press the Mode pushbutton.

NOTE: Although the Antenna Analyst may be adjusted to produce signals as low as 10 Hertz, the practical lower limit of the unit is about 1 MHz due to the coupling capacitors used in the internal circuitry. Signal levels will drop to an unusable level with frequency settings below 1 MHz. The upper limit of the instrument is restricted to 30 MHz, as this is the highest quality signal safely obtainable from a DDS clocked at 100 MHz.

- **Capacitance** -- Capacitance mode may be entered at any time by pressing the dial pushbutton when Capacitance is displayed. Upon entry to the Capacitance mode, you will see the following typical display for about ½ second:

Capacitance (pF)

Then, the capacitance display screen is shown, as illustrated below when a 120 pF capacitor is connected to the RF output jack.

```
10,000.00
C = 126.4 pF
```

- The top line indicates the frequency
- The second line is the computed value for the load connected to the output jack.

Capacitance values that may be displayed must fall within the measurement range of the instrument. Recalling the 600-ohm maximum resistance or reactance specification for the Antenna Analyst, the display will only indicate a numeric value for the capacitance when its reactance is less than that 600-ohm spec. The equation used to compute the capacitance is: $XC = 1 / (2 * \pi * F * C)$.

When the frequency and/or capacitance is beyond the instrument's capabilities, producing a value for XC greater than 600 ohms, the display will indicate as shown below.

```
10,000.00
C = (Z>600)
```

- **Inductance** -- Inductance mode may be entered at any time by pressing the dial pushbutton when Inductance is displayed. Upon entry to the Inductance mode, you will see the following typical display for about ½ second:

Inductance (uH)

Then, the inductance display screen is shown, as illustrated below when a 2.2 uH capacitor is connected to the RF output jack.

```
10,000.00
L = 2.2 uH
```

- The top line indicates the frequency
- The second line is the computed value for the load connected to the output jack.

Inductance values that may be displayed must fall within the measurement range of the instrument. Recalling the 600-ohm maximum resistance or reactance specification for the Antenna Analyst, the display will only indicate a numeric value for the inductance when its reactance is less than that 600-ohm spec. The equation used to compute the inductance is: $XL = 2 * \pi * F * L$

When the frequency and/or inductance is beyond the instrument's capabilities, producing a value for XL greater than 600 ohms, the display will indicate as shown below.

```
10,000.00
L = (Z>600)
```

- **VFO** – The VFO mode may be entered at any time by pressing the dial pushbutton when VFO is displayed. Upon entry to the VFO mode, you will see the following typical display:

```
10,000.00
VFO
```

- The top line indicates the frequency of the continuous signal available on the output connector.

The feature that makes the VFO mode valuable is the constant signal being generated the selected frequency. The impedance mode uses a technique of frequency shifting at ½-second intervals in order to determine the sign of the reactance component. This frequency shifting makes the signal unusable for purposes other than impedance measurement. When the signal is to be used as an external VFO,

local oscillator or test signal, it is desirable to have a steady and constant-frequency signal, and the VFO mode provides just this.

d) Configuration-- Pressing the CONFIG pushbutton presents sub-displays to allow setting of configurable settings for the instrument. Press the dial pushbutton when the given operation is displayed in order to select that function.

- **Start Frequency** – This function allows the user to set a custom Start Frequency for the scan operation. This custom-set parameter is used when the Custom Band item is selected in the BAND menu.
- **End Frequency** – This function allows the user to set a custom End Frequency for the scan operation. This custom-set parameter is used when the Custom Band item is selected in the BAND menu.
- **Set Scan Step Size** – This function allows the user to select the step size to be used for the Scan operation. Available step sizes are 100 kHz, 10 kHz, 1 kHz (default), and 100 Hz. This custom-set parameter is used when the Custom Band item is selected in the BAND menu.
- **Enable Tones** – This function provides an audible tone whose pitch corresponds to the SWR being measured. This is useful in low-light conditions or by visually-impaired users. Additional tones and clicks are provided to signify control changes made on the Analyst.
- **Disable Tones**– This function disables the audible tone.
- **Battery Voltage** – Select this function to display the approximate voltage of the battery.
- **Default Settings** – This function restore the default settings of all data stored in nonvolatile EEPROM memory.
- **View Settings** – This function sequences through a display of all settings stored in nonvolatile EEPROM memory when the dial is turned.
- **Debug Mode** – Enabling the Debug mode sends raw measurement data out the serial port which, when the instrument is connected to the the serial port of a PC, can provide diagnostic information about the Micro908 operation in the field.
- **Calibrate**– Entering this function instructs the operator to follows a sequence of steps that result in new calibration data being stored on the unit. This is a useful function to be performed in the field when a new software program is loaded, necessitating a recalibration. (For additional detail on Instrument Calibration, please refer to Appendix E.)
- **Update Software** – This function is used when upgrading the Analyst software in the field. Whenever newer improved-capability software is available, the customer may download the binary file from the AmQRP website to his local PC. Then, with the Analyst connected to the serial port of the PC, control is transferred to the serial terminal program on the PC, thus allowing the user to erase the current (old) program on the Analyst and send the newly-downloaded program to the instrument. (For additional detail on upgrading Micro908 software programs in the field, see Appendix D.)

e) Sleep – This pushbutton has no function in the instrument at this time.

5.0 Basic Uses

The Micro908 Antenna Analyst is an extremely useful instrument to have around the ham shack or homebrewer's workbench. The analyzer is suitable to serve in the following ways:

Antenna measurements:

The antenna is simply connected to the analyzer antenna terminal and the analyzer is set to the desired frequency. The readout gives the resultant SWR, impedance, reactance and resistance. If the frequency is tuned across a ham band, the minimum SWR point (resonance) can be found as well as the SWR end points (usually 2:1) yielding the bandwidth of the antenna system.

Measure feed point impedance of antenna:

Connecting the analyzer directly at the antenna terminals or remotely through a half-wavelength of transmission line allows direct measurement of the antenna terminal impedance. This is often useful with vertical antennas.

A matching network can be connected to the antenna and then adjusted for best SWR on the analyzer.

Measure ground loss:

With short vertical antennas measuring the impedance directly at the feedpoint allows estimation of ground loss or loading coil loss. For example a $\frac{1}{4}$ wave vertical will have a resistance of about 36 ohms at resonance. Any higher reading indicates ground loss. Similarly shorter antennas (when resonated) will have lower resistance values. Reading a good SWR may mean excess loss and measuring the actual impedance allows gauging just how much loss.

Adjust antenna tuners:

The analyzer can be used to adjust an antenna tuner for a perfect match without the need to transmit a strong signal from the station rig. The analyzer uses only milliwatts of power lessening the possibility of causing interference.

Measure inductors, capacitors and tuned circuits :

The analyzer can measure the values of inductors and capacitors connected across its antenna terminal. Series resonance of a tuned circuit can be accurately measured. The series combination is connected across the analyzer antenna terminal and the analyzer is tuned for the lowest resistance. The frequency where this occurs is the resonant frequency.

Measure coax transmission line factors:

SWR, length, velocity factor, loss, resonant frequency, and impedance

Measure and determine optimum settings for tuning stubs:

SWR; resonant frequency, bandwidth, impedance

Measure and determine optimum settings for tuning stubs:

Resonant frequency

9.0 Advanced Uses

The analyzer is an instrument that can be used for a number of uses well beyond simple SWR and impedance measurements. The following list presents some of these advanced uses.

Tuned Circuit Resonance

Resonance of a tuned circuit can be measured in several ways.

The most accurate method is to connect it as series resonant circuit by putting it in series with a non-inductive (carbon composition or film) ¼ or ½ watt 51 ohm resistor as shown in Figure 1.

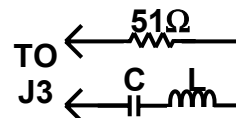


Figure 1

Now connect this to J3 on the Analyzer and tune for lowest SWR.

The frequency at which this is seen is the tuned circuit resonant frequency.

2. If the individual L and C are connected as a parallel resonant circuit and cannot be connected in series as above (for example an antenna trap) the parallel resonance can be estimated. Connect the parallel resonant circuit as shown in Figure 2.

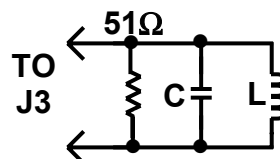


Figure 2

Connect the circuit to J3 on the Analyzer and again tune for lowest SWR.

The measured frequency is slightly lower than the tuned circuit resonant frequency due to stray capacitance of the test setup.

Inductor Q

The Q of an RF inductor can be measured with a very simple setup.

First measure the inductive reactance X_L of the inductor and record this value. Now connect it to the Analyzer as shown in Figure 3. Capacitor C must be chosen to resonate with L at the frequency where you want to measure the inductor's Q. The Inductor and Capacitor Measurement section of this manual shows how this capacitor value can be determined.

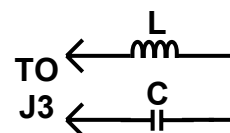


Figure 3

Now tune the Analyzer for the lowest R (resistance) value with a reading of zero X (reactance). If R is above 10 ohms you can now calculate inductor Q using the formula:

$$Q = \frac{X_L}{R}$$

If R is less than 10 ohms a slightly different method needs to be used. In this case use the test setup shown in Figure 1. Adding the non-inductive (carbon composition or film) ¼ or ½ watt 51ohm resistor allows more accurate measurement of the series resistance of the inductor.

Again tune the analyzer for lowest R (resistance) value with a reading of zero X (reactance). Next subtract 51 ohms from the measured R value and use this new resistance in the above formula to calculate the Q value.

Transmission line Stub Lengths

Measurement of quarter and half wave transmission line stubs can be performed regardless of the transmission line characteristic impedance. The method relies on the fact that an open-circuited quarter wavelength line or a short-circuited line acts like a precise short circuit at the chosen frequency of operation.

With either type of feedline first cut the feedline to about 10% longer than the desired length, taking the appropriate velocity factor into account. The velocity factor of common feedlines is available from manufacturer's literature or

references such as the ARRL Antenna Book. If you cannot find the value or if you are using a custom type of feedline, the section in this manual titled “Velocity Factor Measurement” provides a way to determine this value.

The following formulas can be used to estimate the length of transmission line required.

For a half-wavelength stub the length is:

$$L = \frac{5904 * VF}{F}$$

Where L is the length in inches, VF is the velocity factor and F is the operating frequency in MHz for the stub.

Similarly for a quarter-wave stub use the formula:

$$L = \frac{2952 * VF}{F}$$

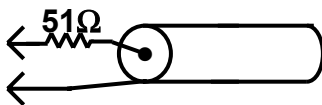


Figure 3

10.0 TECHNICAL SUPPORT

If you experience problems with this instrument, or if you have questions relative to its operation or specifications, please contact the designers: George Heron, N2APB (n2apb@amqrp.org) or Joe Everhart, N2CX (n2cx@amqrp.org). Be sure to visit the Antenna Analyst website at www.amqrp.org/kits/micro908 to check for Analyst product updates and other technical information

APPENDIX A:

Specifications

- **Frequency Generation & Control:**
 - 1 - 30 MHz
 - Source Impedance: 50-Ohms
 - Stability: +/- 50 ppm
 - Spectral Purity: Harmonics down >-35 dB beyond 30 MHz
 - Step Size: User configurable increments of 10 Hz, 100 Hz, 1 kHz, 10 kHz, and 100 kHz
- **Usable Measurement Range:**
 - SWR: 1.0 to 9.9
 - Impedance: approx. 5 to 600 ohms
- **RF Output:**
 - 2 Volts p-p (typical)
- **Power Supply:**
 - External: 9-to-16.0 Volts DC
 - Internal: Eight AA-cells, alkaline or NiMH
 - Current Requirements: 200 ma (typical)
- **User Interface:**
 - Pushbuttons (5): “Mode”, “Band”, “Scan”, “Config”, “Sleep”
 - Rotary Encoder: “Tuning”, 24-position/rotation, smooth/detentless operation
 - LED: “Busy”
 - Switch: “Power On”
 - 2 line x 16 character LCD display
- **Connectors:**
 - External Power: 2.1mm coaxial power plug (center pin positive)
 - RF Out: BNC
 - Serial Port: RS232 (DB9F)
- **Environmental**
 - Temperature: 0-70C
 - Humidity: 0-100% RH

APPENDIX B:

Loading New Software into the Micro908

This appendix overviews a way the user can load an updated software program into the Micro908, as provided on the project's Internet web site.

BACKGROUND

Increasingly today, microcontrolled projects have an ability to be “field updated” with new capabilities and software updates made available by the designer. So instead of needing to send your instrument back for re-programming to get these new features, you can now simply download the program update from the Internet and send it to the Micro908 and the instrument automatically updates its internal memory with the new program. What a great way to keep your project completely up to date with the latest features!

PC REQUIREMENTS

- Windows 95, Windows 98, Windows 2000, and Windows XP.
- Works with computers ranging from 33 MHz Intel 486 processors up to 2.4 GHz P4 processors.
- An available RS-232 serial port. (USB-to-RS232 adaptors may work for those computers having only USB-based serial ports.)
- A dumb terminal emulator program, such as TeraTerm (provided on the Micro908 Resource CDROM.)

USAGE

1. Download the latest Micro908 software from the project website located at <http://www.amgrp.org/kits/micro908>. Save the S19 file in a known location on your PC (e.g., your desktop folder.) The S19 file is the file with the “.s19” extension to its filename. This is a text representation of the binary image to be loaded onto the Micro908.
2. Connect your Micro908 to the PC using a standard, straight-through male-female DB9-type serial cable. (Do not use a null modem cable that swaps pins 2 and 3 from end-to-end.)
3. Start up the TeraTerm program on your PC. If not already set up, configure the communications as 9600 8N1, no flow control (in the **Setup** → **Serial Port** menu), and be certain to have the line delay set to at least “20ms/line”. Make sure that you have TeraTerm configured to be using the active serial port in your PC. Be certain that no other program has control of the serial port – e.g., if your Palm HotSync program is running, as evidenced by its icon in the system tray in the lower right of the screen, you must quit that program by right-clicking the icon and select “exit”).
4. Issue the **Update Software** command on the Micro908, located as an option under the CONFIG menu. See the debug monitor program called “HCmon” display its sign-on message.
5. Type **C** to clear out memory. See the C character echoed to the screen and the HCmon> prompt displayed again.
6. Type **L** to load new program. See message “...waiting ...”
7. Pull down **the File** → **Send File** menu.
8. Navigate to where you saved the *.s19 file
9. Once in the folder that contains AA_908v4-0.s19 file, select that file and click the Open button. (Be careful to only load S19 files! If you mistakenly select any other file extension, it is highly likely that you'll mess up the bootstrap loader program.)
10. See line after line of ASCII data displayed in short one-second bursts. This will continue for about 2 minutes until the entire program has been sent to the Micro908 and flashed into its memory. **DO NOT INTERRUPT THIS PROCESS!!** When it is complete, the **HCmon** > command prompt will be displayed again.
11. Disconnect the serial cable and restart the Micro908 (i.e., turn the power off and on again) to start the newly-loaded program. You will observe the new version number presented in the sign-on display.

APPENDIX C:

Calibrating the Antenna Analyst

The user will need to calibrate the Micro908 Antenna Analyst when first constructed. The instrument may also need to be recalibrated later, such as when new software updates are available that change the way in which calibration data are used, or when the characteristics of the DDS signal source change in any regard. In these cases, the instrument may be quickly and easily calibrated by following a short sequence of operations located in the “Calibrate” function, located beneath the CONFIG pushbutton.

1. Select the Calibrate function, located within CONFIG.
2. See “Calibrate now?” displayed in the LCD. Confirm by selecting “yes” with the dial. (Press the dial when “yes” is displayed.)
3. See “Open load” displayed on the LCD. Ensure that nothing is connected to the RF output jack, then confirm by selecting “yes” with the dial.
4. See a display of numbers representing the reflectometer channel voltages for V_f , V_r , V_z and V_a . Ensure that the first three hex numbers are generally “high” numbers above 90 (9x, Ax, Bx, Cx, Dx, or Ex), and that the last number (V_a) is very close to zero (e.g., 04).
5. If the displayed numbers are in the acceptable range, as explained above, press the Dial to continue. However, if the “3 high and one low” condition of numbers is not present, or if any channel is very high in the hex number range of F0 to FF, then you cannot proceed with calibration and you should contact Support.
6. See “Shorted load?” displayed on the LCD. Place a short circuit on the RF output jack and select “yes” with the dial.
7. See “270-ohm load on?” displayed on the LCD. Place the supplied 274-ohm resistive load on the RF output connector and confirm by selecting “yes”.
8. See “Make SWR=5.4” displayed on the first line of the LCD, and a number on the second line. Adjust the dial to make the number on the second line be as close as possible to 5.4. Press the dial when this number is 5.4.
9. See “50-ohm load on?” displayed on the LCD. Place a 50-ohm load on the RF output connector and confirm by selecting “yes” with the dial.
10. See “Saving data” displayed on the LCD and the red BUSY LED will turn on for several seconds.
11. When the BUSY LED turns off, “Exit” will be displayed on the LCD. Confirm by pressing the dial and control will again be placed in the Impedance mode, with measurements being made using the newly-created calibration data.

Aside: “What is being calibrated?”

In order to normalize the gains of the four reflectometer channels with respect to each other, the software creates “gain correction factors” for the V_r , V_z and V_a channels. When each channel is multiplied by its respective correction factor, it will equal the value of the V_f channel, as determined under the specific conditions of open/short/50-ohm loads presented during the calibration sequence. These correction factors are then used during the normal operation of reading raw V_r , V_z and V_a signals to compute the SWR, R and X values displayed on the LCD in Impedance mode. The correction factors are saved away to nonvolatile memory such that they can be used each time the instrument is turned on.

