Using the Micro908 Antenna Analyzer

The Micro908 antenna analyzer is an extremely useful instrument to have around the ham shack or homebrewer's workbench. This section describes the basic uses, as well as some advanced techniques for which you can use the analyzer to get intermediate measurements in order to compute the desired result.

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. *See Figure 7.*

Measure Feed Point Impedance

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 ¼ 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. *See Figure 5.*

Capacitor Measurement

There are several ways to measure capacitance with the Micro908. The simplest is to connect the capacitor across the RF output connector and select Capacitance from the Mode pushbutton menu. You can accurately measure capacitance values as long as the reactance at the measurement frequency is within the impedance measurement specifications of the analyzer (about 10-to-1000 ohms).

Another way to measure capacitance with the Micro908 is to measure it in a series resonant circuit. *(See as Figs 1 and 6).* You will need an inductor of known value and a 51-ohm carbon composition or film resistor. It is recommended that a small 5% tolerance choke with an inductance of between 1 and 10 uH be used. Common RF chokes are fine and can be obtained from most full-service mail order component suppliers.

To measure capacitance by the second method, connect the components as shown in Figure 1. Then adjust the operating frequency for lowest SWR and record the frequency. Now you can calculate the capacitance using the formula:

$$C = 25330/(F*F*L)$$

where C is the capacitance in picofarads, F is the frequency in MHz and L is the inductance in microhenries.

Inductor Measurement

There are several ways to measure inductance with the Micro908. The simplest way is to connect the inductor across the RF output connector J3 and select Inductance from the

Mode pushbutton menu. You can accurately measure inductor values as long as the reactance at the measurement frequency is within the impedance measurement specifications of the analyzer (about 10-to-1000 ohms).

Yet another method is to do the measurement in a series resonant circuit as shown below in Figure 1.

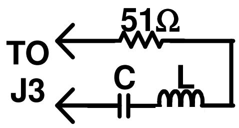


Figure 1

This requires a capacitor of known value in addition to a 51-ohm carbon composition or film resistor. The capacitor should have a tolerance no wider than 10% and have a low loss dielectric composition such as NP0 ceramic or mica. A capacitance value of about 100 pf is appropriate for many RF measurements.

You can make your own precision capacitor from a piece of coaxial cable. Common RG-58 type 50 ohm coax has a capacitance of about 29 to 30 pf (detailed data is available at http://thewireman.com/coaxdata.pdf). For example RG58/U is specified at 28.8 pf per foot so a length of about 3.5 ft – including a 1" pigtail for attachment will serve as a fairly accurate 100 pf capacitor.

To measure inductance by the second method, connect the components as shown in as Figure 1. *See also Figure 6.* Adjust the operating frequency for lowest SWR and record the frequency. Now you can calculate the capacitance using the formula:

$$L = 25330/(F*F*C)$$

where L is the inductance in microhenries, F is the frequency in MHz and C is the capacitance in picofarads.

Measure Inductor Q

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

First measure the inductive reactance XL of the inductor and record this value. Now connect it to the Analyzer as shown below in Figure 3.

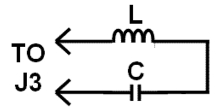


Figure 3

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.

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:

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

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). Record this resistance value. Now connect the 51-ohm resistor directly across the analyzer's RF output connector and measure its exact value at the resonance frequency and record it. Next subtract the exact 51-ohm resistor value from the measured R value and use this new resistance in the above formula to calculate the Q value.

Transmission Line Characteristic Impedance

The characteristic impedance of coaxial, twisted pair, open wire or ribbon type feedlines can be estimated using the

Micro908. Practical measurements are best done in the mid-tuning range of the instrument where accuracy is optimum and feedline lengths are reasonable; so this procedure will be performed between 7 and 21 MHz.

The measurements need to be done with a transmission line over frequencies where the feedline is at about 1/8 wavelength at the low frequency end and something over ¼ wavelength at the high frequency end, so it is recommended that a length of about 16 feet is used.

Connect the near end of the feedline to the Micro908. Connect a 1000-ohm carbon or Cermet potentiometer to the far end with leads no longer than an inch or so. Initially set the pot to its highest value. *See Figure 8.*

Ensure that the transmission line is supported for its entire length in a fairly straight line and kept several inches from any conductive surface or material. This is important to minimize any detuning effects. Ideally the line should be dressed along to top of a wooden fence or supported by fiber rope or string.

Now tune the Micro908 over the range of 7-to-21 MHz while noting the resistive (R) and reactive (X) values. More than likely they will vary widely over the tuning range. Now readjust the potentiometer to a slightly lower value and do another sweep while observing the variation of R and X values. At some potentiometer setting the R value will vary very little over the tuning range while the X value will remain near zero. This is the estimated characteristic resistance.

Transmission Line Loss

Transmission line loss for 50-ohm feedlines can be easily measured using the analyzer. The basic operating principle is that loss in transmission lines attenuates RF sent through them. When the line is connected to the analyzer and the far end is short or open-circuited there is a theoretically infinite SWR. If the feedline had zero loss this would be the case. However since any real line has some loss both the forward and reflected power are attenuated and a finite SWR is measured.

For most good quality new coaxial feedlines the loss at HF frequencies will not exceed several dB per hundred feet; however as they age the dielectric becomes lossy to it is a good idea to periodically check the loss.

Measurement is simple. All you have to do it is to remove the load, short-circuit the far end of the feedline, and then connect the near end to the analyzer's RF output connector. Measure the SWR and refer to Table 1 for the approximate corresponding loss. If the measured SWR is above 9:1 that's good news since the SWR then is less than 1 dB. If you vary the analyzer frequency you will see that SWR decreases with frequency indicating that loss increases at higher frequencies.

Table 1 – SWR vs line loss (infinite load SWR)

Approx Loss	**Measured SWR**
1 dB	9:1
2 dB	4.5:1
3 dB	3:1
4 dB	2.3:1
5 dB	2:1
6 dB	1.7:1
7 dB	1.6:1
8 dB	1.5:1
9 dB	1.4:1
10 dB	1.3:1

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 it 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 "Velocity Factor Measurement" section in this manual 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:

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

To determine the length of a **half wave stub**, connect the near end of the transmission line through a 51-ohm resistor as shown in Figure 4 to the analyzer's RF output connector. Short circuit the two leads at the far end of the half wave stub.

Ensure that the transmission line is supported for its entire length in a fairly straight line and kept several inches from any conductive surface or material. This is important to minimize any detuning effects. Ideally the line should be dressed along to top of a wooden fence or supported by fiber rope or string.

Now tune the Micro908 for minimum SWR and note the frequency. This is the frequency where the transmission line is exactly a half wavelength long. If the initial length was chosen properly it should be below the desired frequency. If so, cut off a short length making sure the far end is still short-circuited, and repeat until resonance is achieved at the desired frequency.

For a **quarter wave stub**, the above procedure can be used except, of course that the length is different and that the far end needs to be open-circuited.

Transmission Line Velocity Factor

Velocity factor of a transmission line can be measured using techniques similar to the ones used for measuring quarter and half wave stubs.

The procedure can be performed at any frequency that the Micro908 tunes but it is most practical in the vicinity of 10 MHz where line lengths are reasonable and instrument accuracy is optimum.

Either a quarter wave or half wave length can be used; but using the shorter length consumes less feedline if it will be discarded after the measurement.

Begin by cutting a quarter wavelength of feedline using the formula:

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

for a frequency of 10 MHz and assuming a VF (Velocity Factor) of 1.

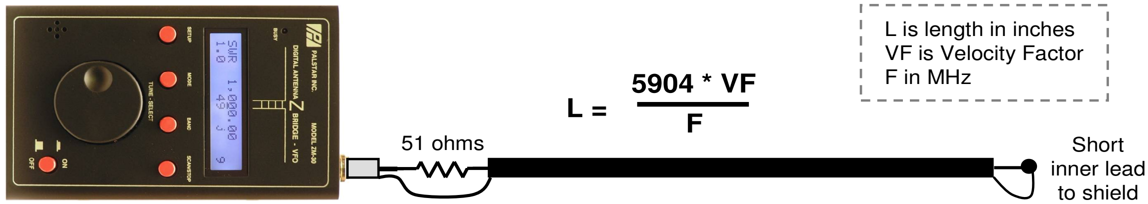
Now connect the near end of the feedline to a 51-ohm resistor as shown in Figure 9 then to the analyzer's RF output connector. The far end must be open circuited.

Ensure that the transmission line is supported for its entire length in a fairly straight line and kept several inches from any conductive surface or material. This is important to minimize any detuning effects. Ideally the line should be dressed along to top of a wooden fence or supported by fiber rope or string.

Now tune the Micro908 for lowest SWR and note the frequency. VF can now be calculated using the formula:

$$VF = 10/F$$

where F is the measured frequency in MHz.

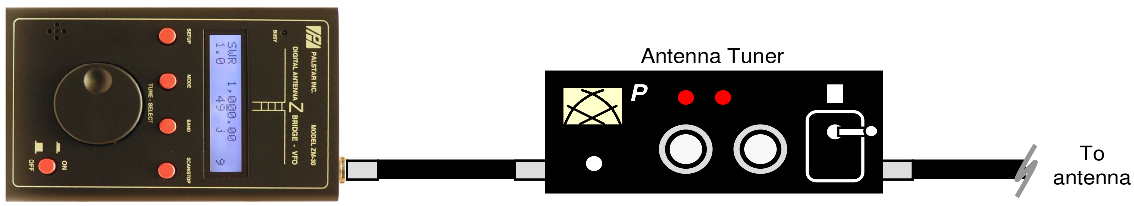


$$L = \frac{5904 * VF}{F}$$

L is length in inches
VF is Velocity Factor
F in MHz

Tune for minimum SWR.
Freq where SWR is min is ½-wavelength

Figure 4: Determining Length of Halfwave Stub



Use VFO mode to dial in the desired operating frequency.
Then disconnect ZM-30, connect Xcvr and operate!

Figure 5: Adjust Antenna Tuners

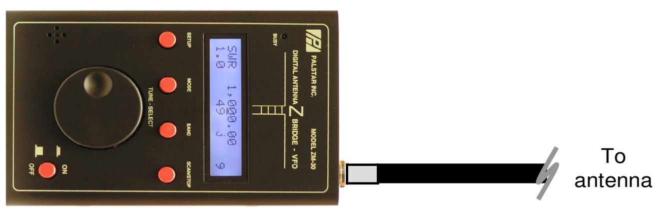
$$C = \frac{25330}{F^2 * L}$$

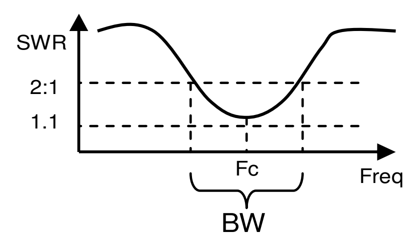
$$L = \frac{25330}{F^2 * C}$$

C in pF
L in uH
F in MHz

Adjust freq “F” for lowest SWR

Figure 6: Capacitor or Inductor Measurement





Sweep frequency to find minimum SWR point at “Fc”.
Then find freqs where SWR=2:1 below and above

Figure 7: Antenna Bandwidth

Set pot to max (1K-ohm).
Adjust pot slightly lower.
Tune ZM-30 from 7-21 MHz.
Note variations in R and X.
Relatively constant? no
yes
Pot setting is cable’s
characteristic impedance

Figure 8: Determining Feedline Characteristic Impedance

Sweep ZM-30 to find minimum SWR at some frequency “F”.

$$VF = \frac{10}{F}$$

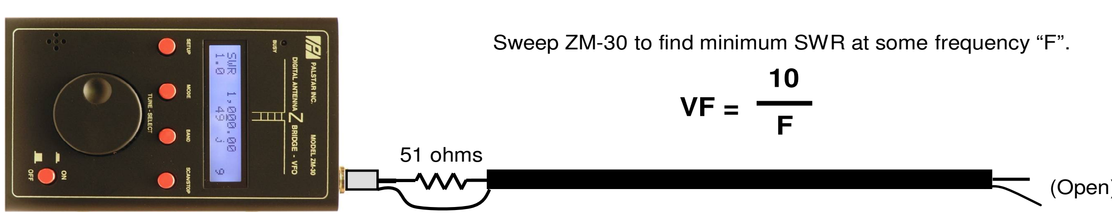


Figure 9: Determining Feedline Velocity Factor