MFJ RF NOISE BRIDGE
Model MFJ-202B

Buttom UP

Bottom shows the Calibrating list, B½ = 50 Ohm.

MFJ-202B NOISE BRIDGE

Thank you for purchasing the MFJ-202B RF NOISE BRIDGE. The Noise Bridge is used to determine the value of an unknown impedance. A Range Expander feature is built into the MFJ-202B to extend its measuring capacity.

The range of the Resistance dial (R) is 0 to 250 ohms and the Reactance dial (X) is -150 to +150 pF. The Noise Bridge can be used with any receiver covering the desired frequency range. A patch cord is needed to connect the noise bridge "receiver" output to the receiver antenna input connection. Coax cable with PL-259 connectors is recommended.

A 9-V battery is used to power the Noise Bridge. Remove the screws on the sides of the box to install battery. The ON/OFF switch on the front panel cuts the power to conserve battery life when the Noise Bridge is not in use.

USING THE MFJ-202B

The unknown is connected to the "UNKNOWN" connector of the noise bridge and the receiver to the "RECEIVER" connector and the EXP/NOR button is set to NOR. A null can be achieved by tuning the "RESISTANCE" (R) and the "REACTANCE" (X) controls with the receiver set to a given frequency. Alternately, by setting the R and X controls at a desired setting and varying the receiver frequency, a null can also be found. A null is achieved when minimum noise is heard from the receiver. Set the receiver RF gain control at maximum and adjust RF gain control for desired audible noise. Since the R and X controls interact, they must be adjusted alternately until a deep null is obtained. The best way to achieve a null is to tune the R dial in small increments starting from zero. For each increment of R, slowly rotate the X dial over its range. Repeat this until a deep null is achieved.

NOTE: The "RESISTANCE" dial is marked with the letters A through G. These letters correspond to the resistance values on the Calibration Chart on the bottom of the Noise Bridge. Marking the resistances in this way allows a much higher degree of accuracy.

If a null cannot be achieved, then the impedance is outside the normal range of the noise bridge. In this case, set the EXP/NOR button to the EXP position. If the impedance is within the range of this combination, then a null will be found. Null tuning when the expander is used is the same as when the expander is not used.

NOTE: It is best not to use the Expander unless needed.

To Calculate Unknown Resistance and Reactance. The unknown resistance and reactance is determined from the dial readings and the following procedures:

A. Without the Expander. When measurements are made without the expander, the R dial indicates the actual resistance of the unknown in ohms. The X dial reading is converted to capacitive reactance (X_C) or to inductive reactance (X_L) by the following methods:

1. Use these equations to calculate reactance:

Eq.1 $X_L = \frac{888}{f} - \frac{160,000}{f(180+Cd)}$, if the reactance reading, Cd, is on the X_L side of the scale.

Eq.2 $X_C = \frac{888}{f} - \frac{160,000}{f(180-Cd)}$, if the reactance reading, Cd, is on the X_C side of the scale.

where, f= frequency in MHz
Cd= X dial reading in pF
X_C= Inductive reactance in ohms
X_L= Capacitive reactance in ohms

Example 1: if f= 7 MHz, X dial reading= 70 pF on the X_L side, use Eq.1.

$$X_L = \frac{888}{f} - \frac{160,000}{f(180+Cd)}$$
$$= \frac{888}{7} - \frac{160,000}{7(180+70)}$$
$$= +35.4 \text{ ohms}$$

Example 2: if f= 3.5 MHz, X dial reading= 100 pf on the X_C side, use Eq.2.

$$X_C = \frac{888}{f} - \frac{160,000}{f(180-Cd)}$$
$$= \frac{888}{3.5} - \frac{160,000}{3.5(180-100)}$$
$$= -317.7 \text{ ohms}$$

2. Use the impedance chart to find the reactance:
The impedance chart shown in FIGURE 1 is plotted at 1 MHz. For other frequencies, simply divide the reactance value found by the frequency desired in MHz.

Example 3: Use the conditions given in Example 2. We find X_L on the impedance chart to be approximately 248 ohms. Divide this value by 7 MHz to get 35.4 ohms, which agrees with Example 1.

Example 4: Use the conditions given in Example 2. From the impedance chart we find X_C=1050 ohms. Divide by the frequency, 3.5 to give X_C=300 ohms.

Knowing the resistance and reactance of the unknown, we can calculate the magnitude of the impedance by using the following equation:

$$Z = \sqrt{R^2 + X^2}$$

where, Z= Magnitude of the impedance in ohms
R= Resistance in ohms
X= Inductive reactance or capacitive reactance in ohms.

B. <u>Finding Impedance When Using the Expander</u>.

When measurement is made with the Expander, <u>both</u> the R reading and the X reading from the dials must be converted to resistance and reactance by using the following procedure:

<u>NOTE</u>: Do not use the impedance chart in FIGURE 1 to obtain the reactance. The answer is not correct for measurement with the Expander.

1. Use Equation 3 and 5 to calculate the resistance of the unknown when using the Expander:

Eq.3 $$Ru = \frac{200[200Rd - Rd^2 - (Xeq)^2]}{(200 - Rd)^2 + (Xeq)^2}$$

Eq.4 $$Xu = \frac{(40000)(Xeq)}{(200-Rd)^2 + (Xeq)^2}$$

Eq.5 $$Xeq = \frac{(888)(Xd)}{f(Xd + 180)}$$

where, Xu= The unknown reactance in ohms. Inductive reactance is "+" Xu; capacitive reactance is "-" Xu.

Ru= The unknown resistance in ohms.

f= Frequency in MHz

Xeq= Equilvalent reactance in ohms, Xeq is <u>first</u> calculated from Xd and f in order to calculate Xu and Ru.

Rd= The R dial reading from the Noise Bridge in ohms.

Xd= The X dial reading from the Noise Bridge in pF. If the reading is on the X_L side, then Xd is positive and if the reading is on the X_C side, then Xd is negative.

<u>NOTE</u>: Be sure to use the proper sign for Xd when substituting into Equations 4 and 5.

Example 5: The Expander is used to measure the impedance of an antenna at 7 MHz. The Noise Bridge is at a null when the R dial reads 150 ohms and the X dial reads 10 pf on the X_C side. Under these conditions, we have Rd=150 ohms, Xd= -10 pF (on the X_C side, therefore Xd is negative), f= 7MHz.
To find the resistance, first use Equation 5 to find the equivalent reactance, Xeq.

Eq.5 $$Xeq = \frac{(888)(Xd)}{f(Xd + 180)}$$

$$= \frac{(888)(-10)}{7(-10 + 180)}$$

$$= -7.46 \text{ ohms}$$

Use Equation 3 to find the unknown resistance, Ru.

$$\text{Eq.3} \quad Ru = \frac{200[200Rd - Rd^2 - (Xeq)^2]}{(200 - Rd)^2 + (Xeq)^2}$$

$$= \frac{200[200(150)-(150)^2-(-7.46)^2]}{(200 - 150)^2 + (-7.46)^2}$$

= 583 ohms, the unknown resistance

To find the reactance, Xu, of the unknown, Equation 4 is used .

$$\text{Eq.4} \quad Xu = \frac{(40000)(Xeq)}{(200 - Rd)^2+(Xeq)^2}$$

Xeq= -7.46 ohms, found above

Rd= 150 ohms, read from R dial

$$Xu = \frac{(40000)(-7.46)}{(200-150)^2 + (-7.46)^2}$$

Xu= -116.8 ohms, the unknown reactance (negative sign indicates capacitive reactance).

Example 6: If f= 3.5 MHz, Rd= 150 ohms, and Xd= 50 pF on the X_L side. The unknown resistance and reactance can be calculated by using equations 3, 4, and 5. First find Xeq (Note that Xd is positive since Xd is read on the X_L side).

$$\text{Eq.5} \quad Xeq = \frac{(888)(Xd)}{f(Xd + 180)} = \frac{(888)(50)}{(3.5)(50 + 180)}$$

Xeq= 55.2 ohms

$$Ru = \frac{200[200Rd - Rd^2 - (Xeq)^2]}{(200 - Rd)^2 + (Xeq)^2}$$

$$Ru = \frac{200[200(150) - (150)^2 - (55.2)^2]}{(200 - 150)^2 + (55.2)^2}$$

Ru= 160.6 ohms, the unknown resistance

Xu is found using Equation 4.

$$\text{Eq.4} \quad Xu = \frac{(40000)(Xeq)}{(200-Rd)^2 +(Xeq)^2}$$

$$Xu = \frac{(40000)(55.2)}{(200-150)^2 + (55.2)^2}$$

Xu= 398 ohms, the unknown reactance (positive sign indicates inductive reactance.)

If Xd is at "0", Xeq is zero, therefore Xu is zero. The unknown is purely resistive. Under this condition, Ru can be calculated by using Equation 6.

$$\text{Eq.6} \quad Ruo = \frac{200[200(Rd)-Rd\ ]}{(Rd)^2}$$

where, Ruo= the unknown resistance when Xd=0

Rd= the R dial reading in ohms

Example 7. If, f=21 MHz, Xd=0, and Rd=180 ohms.

Eq.6 $$Ruo= \frac{200[200(Rd) - Rd^2]}{(200-Rd)^2}$$

$$Ruo= \frac{200[200(180) - (180)^2]}{(200-180)^2}$$

Ruo=1800 ohms

IMPORTANT: Equation 6 can only be used when Xd is zero.

APPLICATION OF THE NOISE BRIDGE

1. To find the antenna resonant frequency.

Measured at the Antenna with no feedline. Antenna resonant frequency can be found at the antenna by connecting the antenna to the "UNKNOWN" of the Noise Bridge and the receiver to the "RECEIVER" connection. Do not use the Expander at this time. Tune the receiver to the expected resonant frequency of the antenna. Adjust the X and R dials on the Noise Bridge for a null.

NOTE: When a null is obtained and if the X dial is on the X_C side, the receiver is tuned above the resonant frequency. If the X dial reading is on the X_L side, the receiver is tuned below the resonant frequency. Tune the X dial toward the "zero" setting in small increments and each time retune the receiver frequency for a null. Repeat untill a null is achieved with the X dial at "zero". At resonance the X dial is at zero and the antenna resistance is read directly from the R dial, if the Expander is not used for this measurement.

For antenna resistances above 250 ohms the expander should be used. Tuning is the same as above. At resonance, the X dial should read zero. The antenna resistance is not the reading indicated on the R dial. Antenna resistance in this case must be calculated from the R dial reading by using EQ.6 and the method described in "Calculation."

2. To Measure Antenna Impedance at any Frequency.

A. To Measure at Antenna with no Feedline. Antenna impedance can be found at any frequency by using the Noise Bridge. Connect the antenna to the "UNKNOWN" of the Noise Bridge and the receiver to the "RECEIVER". Set the receiver to the frequency at which you wish to find the antenna impedance. Adjust the R and X dials on the Noise Bridge for a null. At null the resistance of the antenna is read directly from the R dial and the reactance is found by using the methods described in the previous section on calculation. If the Expander is used, be sure to use the appropiate method to find both the resistance and the reactance of the antenna.

B. <u>To Measure the Impedance of Antenna System at Feedline.</u> The impedance of an antenna system may be measured an any frequency with the Noise Bridge. The method is the same as described in 2A. Remember that measurement at the feedline end of the antenna is not the same as at the antenna. The impedance found here is the impedance at this measuring point.

C. <u>To Find the Antenna Impedance at the Feedline.</u> The antenna impedance can be found at the feedline if the feedline is a electrical half-wave or a multiple. Of course this only occurs at one frequency. If the feedline is not a half-wave length, the Smith Chart can be used to find the actual antenna impedance. The procedure is described in detail in the ARRL Antenna Book (13th Edition, 1974). The electrical length of the feedline must be known to find the antenna impedance with the Smith Chart. The number of an electrical length (N) can be calculated by using Eq.7.

Eq.7 $$N = \frac{Lf}{984V}$$

where, N= Number of wave length
L= Feedline physical length in feet
f= Frequency in MHz
v= Velocity factor of the feedline

Example 8: To find the electrical length of RG-8/U coax line at 7 MHz, v for RG-8/U is .66

Eq.7 $$N = \frac{Lf}{984v} = \frac{(65)\ (7)}{(984)(.66)} = .70 \text{ wavelengths}$$

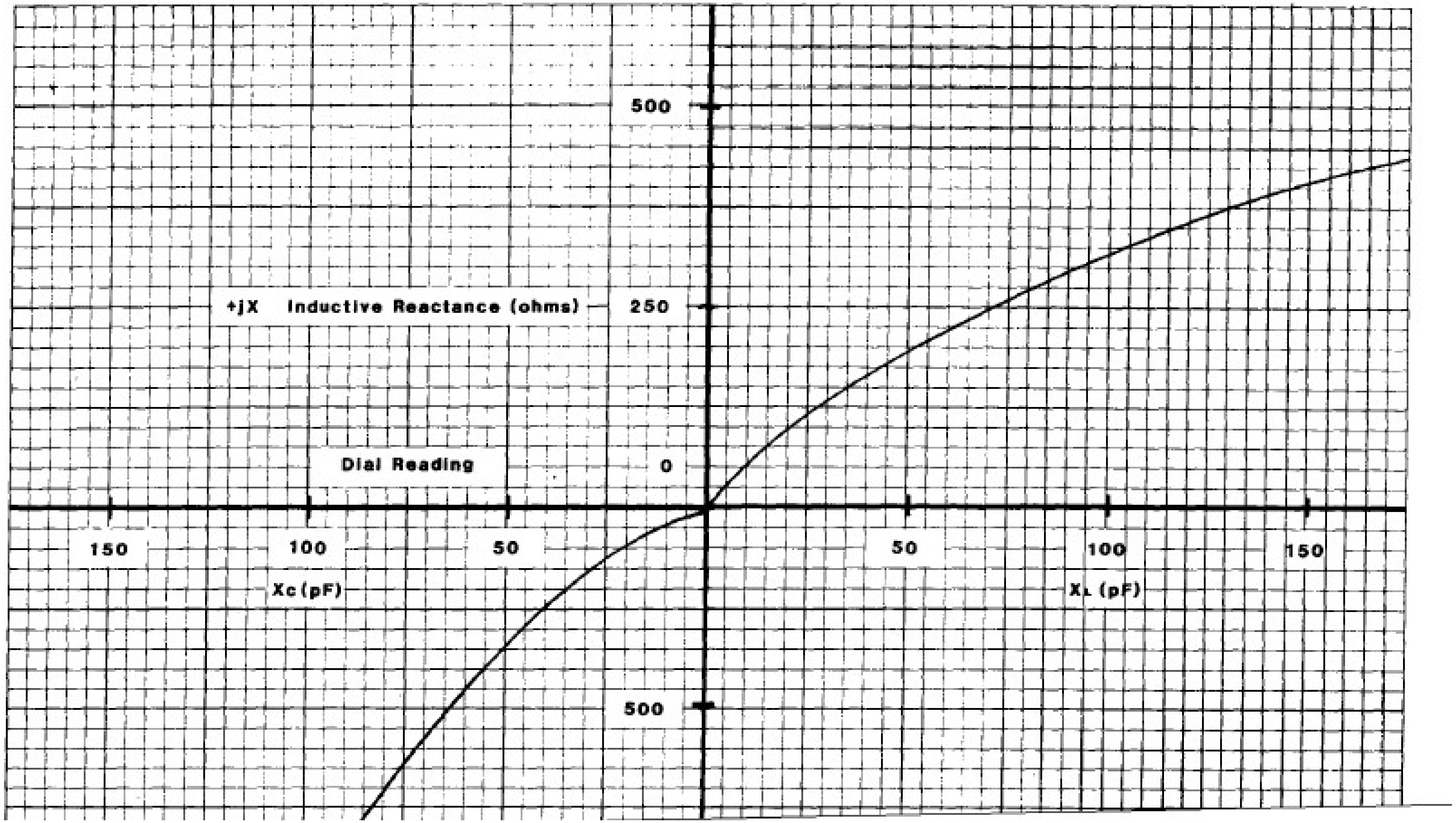
The velocity factor of a transmission line can be found in any transmission line table.
Velocity factor may also be found if the electrical length is known by using Eq.8.

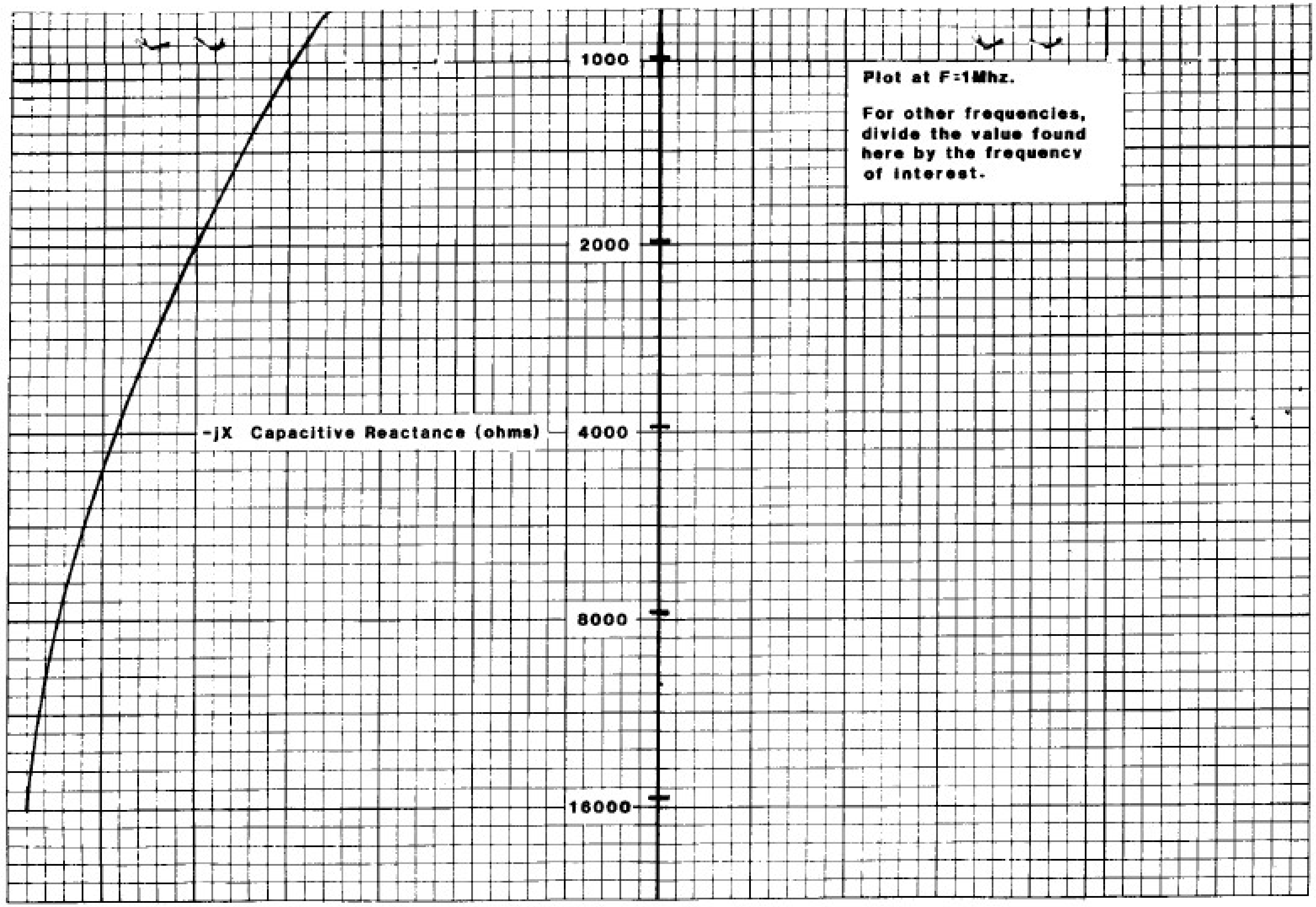
Eq.8 $$v = \frac{Lf}{984N}$$

where, v= Velocity factor
L= Feedline physical length in feet
f= Frequency in MHz
N= Electrical length of the feedline

D. <u>To Cut a Half-Wave Dipole to Resonance</u>. The resonant frequency of an antenna can be found at the transmitter feedline end or at the antenna feed point. When the antenna feedpoint is not easily accessible, resonant frequency may be measured at the transmitter feedline end. In order to have the same measurements at both locations, the feedline must be half-wave or multiples. A half-wave multiple coax feedline can be cut as described in Section 7 by using Equation 11. For best results, locate the feedline at the permanent antenna location during measurement. After properly cutting the feedline to a half-wave or multiple, cut the half-wave dipole antenna to the proper length by using Equation 8A.

FIGURE 1. Impedance Chart for Reactance Measurements without Range Expander





Plot at F=1Mhz.
For other frequencies, divide the value found here by the frequency of interest.
-jX Capacitive Reactance (ohms)
1000
2000
4000
8000
16000

$$\text{Eq. 8A} \quad \text{Length (feet)} = \frac{468}{f(\text{Mhz})}$$

NOTE: Antenna and feedline should be cut a few inches longer than the calculated value before measurement, for trimming purposes. If balun is to be used with the antenn system, be sure to connect it before making any measurements. Set the receiver frequency to the same frequency for which the feedline was cut. Adjust the Resistance and Reactance controls on the Noise Bridge for a null (do this without the Expander). If a null is found at the X_L side (inductive reactance), the antenn is too long and should be shortened an inch at a time. If a null is found on the X_C side (capacitive reactance), the antenna is too short and should be lengthened an inch at a time. Adjust until the Reactance control is at zero when a null occurs. The Resistance control should read approximately 50 to 75 ohms for a coax feedline with a 1:1 balun or without a balun. Reading of the Resistance control will be different for different types of feedline and for different balun ratios. NOTE: If the antenna or the feedline is not cut at the operating location, the reasonant frequency may not be the same once it is moved. Feedline and antenna may need to be readjusted after they are permanently installed.

3. Tuned Circuit Adjustment.

A. Series Tuned Circuit. The Noise Bridge can be used find the resonant frequency of a series tuned circuit This allows proper adjustment for desired resonant frequency. Connect the series tuned circuit directly across the "UNKNOWN" of the Noise Bridge. The R dial should be set at minimum since a series tuned circuit has a low series resistance at resonance. Set X dial to zero. Tune the receiver frequency for a null. When resonant frequency is found, the series tuned circuit can be adjusted for a lower or higher frequency.

B. Parallel Tuned Circuit. A coupling link such as a few turns of wire should be used to couple the parallel tuned circuit to the Noise Bridge "UNKNOWN". The link should be brought close to the tuned circuit. If a toroid core is used, the link must be threaded through the toroid core to assure proper coupling. Resonant frequency can be found as described in Series Tuned Circuit.

To Tune Transmatch and to Synthetize RF Impedance with Transmatch and Dummy Load.

The Noise Bridge can be used to tune the transmatch to your antenna system for an accurate match to your transmitter without radiating any RF power. Connect the antenna to the output of the transmatch and the input of the transmatch to the "UNKNOWN" of the Noise Bridge. Do not use the Expander here. Tune the receiver to frequency of interest. Set the R dial to 50 ohms and the X dial to zero. Tune the transmatch controls for a null. If a null cannot be found, this indicates that your transmatch cannot match the antenna system for a 50 ohm impedance. Try a different frequency. If a null is achieved, the impedance at the measuring point is 50 ohms as indicated on the R dial. Disconnect the Noise Bridge from the transmatch. Connect the transmatch to your transmitter. A low SWR should be expected. A final touch up may be needed in the transmatch if a SWR meter is used when transmitting.

A transmatch with a dummy load on its output can be used to synthesize and RF impedance. By connecting the input of the transmatch to the Noise Bridge "UNKNOWN" connector, the impedance can be found when the null is found. At null, resistance is read directly from R dial and reactance can be calculated using the methods described in "CALCULATION". An RF impedance can be synthesized by setting the resistance and reactance controls for a desired impedance and adjusting the transmatch for a null.

The Expander can be used to cover more range. Be sure to follow the procedures described in "CALCULATION" to find the unknown resistance and reactance when the Expander is used.

5. To Measure Amplifier RF Impedance.

Input impedance and output impedance of an RF amplifier can be determined by using the Noise Bridge. Connect the input of the amplifier to the "UNKNOWN" of the Noise Bridge. Adjust the R and X dials for a null. Refer to "CALCULATION" to calculate the impedance. Output impedance can be determined the same way as above. The Expander can be used for this measurement if needed.

6. RF Transformers and Baluns.

To measure the impedance at any two terminal ports with one terminal grounded, of RF transformers. Connect that port of the transformers to the "UNKNOWN" of the Noise Bridge. Set the receiver to the desired frequency and adjust the R and X dials for a null. The Expander may be used to cover additional range. Use the procedures described in "CALCULATION" to find the unknown impedance.

7. Transmission Lines.

To accurately cut a feedline for a quarter wave length, first cut the line using Equation 10.

Eq.10 $$L = \frac{246v}{f}$$

where, L= Feedline in feet
f= Frequency in MHz
v= Velocity factor of the line

Connect one end of the line to the "UNKNOWN" of the Noise Bridge. The other end of the line should be left OPEN. Tune the receiver to the expected frequency. Set the R dial to zero and adjust the X dial for a null. If the X dial is on the X_C side, the receiver frequency is too high. If the X dial is on the X_L side, the frequency is too low. Trim the line and readjust the X dial for a null. Repeat the above procedure until a null is obtained at zero on the X dial. When a null occurs at R=0 and X=0, the feedline is a quarter wave length at the measuring frequency. Line should be trimmed 1/2 inch at a time.

For a half-wave feedline, cut the line by using Eq. 11.

Eq.11 $$L = \frac{492v}{f}$$

where, L= Feedline in feet
f= Frequency in MHz
v= Velocity factor of feedline

For half-wave feedline, the load end of the line should be shorted when making measurements. Follow the same procedure as for quarter-wave line in trimming the line.

Transmission line impedance can be found at any frequency by using the Noise Bridge. Lines should connect to the "UNKNOWN". Tune the receiver to the frequency of interest and adjust the R and X dials for a null. The Expander can be used if needed. At null, the R and X readings can be converted to impedance by the procedures described in "CALCULATION".

8. Measure Capacitance and Inductance.

To measure capacitance and inductance with the Noise Bridge a standard capacitor and inductor are needed.
Suggested values: 100 pF and 5 uH.

A. Inductance Measurement.

Connect the unknown inductor in series with the standard capacitor. This series capacitor inductor is connected to the "UNKNOWN" of the Noise Bridge. Set R and X dials to zero. Adjust receiver frequency for a null. Knowing the resonant frequency of the unknown, Eq. 12 is used to calculate the unknown inductor.

Eq.12 $$L = \frac{25,330}{f^2 C}$$

where, L= Inductance in uH
f= Frequency in MHz
C= Standard series capacitor

B. Capacitance Measurement.

Connect the unknown capacitor in series with the standard inductance. Use the same method as above to adjust for a null. When R=0 and X=0, at null the unknown capacitance can be calculated using Equation 13.

Eq.13 $$C = \frac{25,330}{f^2 L}$$

where, C= Unknown capacitor in pF
f= Frequency in MHz
L= Standard series inductor used

A FEW IMPORTANT NOTES

1. The toroid transformer used in the Noise Bridge is factory balanced. Do not try to rewind or alter the winding. The Bridge will not work accurately if the transformer is off balance.

2. The equations used in this instruction manual are intended to be used only with the MFJ-202B Noise Bridge. If components are changed in the circuit, some equation may not be valid.

3. When using the Noise Bridge with a transceiver be sure not to transmit when the Noise Bridge is connected at the antenna connector of the transceiver. Transmitting through the Noise Bridge will completely destroy the unit.

4. The MFJ-202B is not designed to obtain precision measurements. It may not be used for measurements that require precision accuracy, although hand calibration of the dials will result in improved accuracy.

5. The R and X dials are factory calibrated. Calibration can be made by installing the Expander at the "UNKNOWN" and a receiver to the "RECEIVER" connector. Tune receiver to 7.0 MHz. Adjust the R and X dial for a deep null. At null, the R knob should be pointing to 200 ohms and the X knob shoul be pointing to 0, if not, loosen the knobs and set accordingly. When the Noise Bridge is used at 100 MHz, calibration may be needed to obtain better accuracy.

NOTE: When the capacitor on the X dial is fully closed (maximum capacitance), the pointer should point to 150 on X_L side.

SPECIFICATIONS

Frequency Range: 1 MHz to 100 MHz

Impedance Range:

Without using Range Expander.

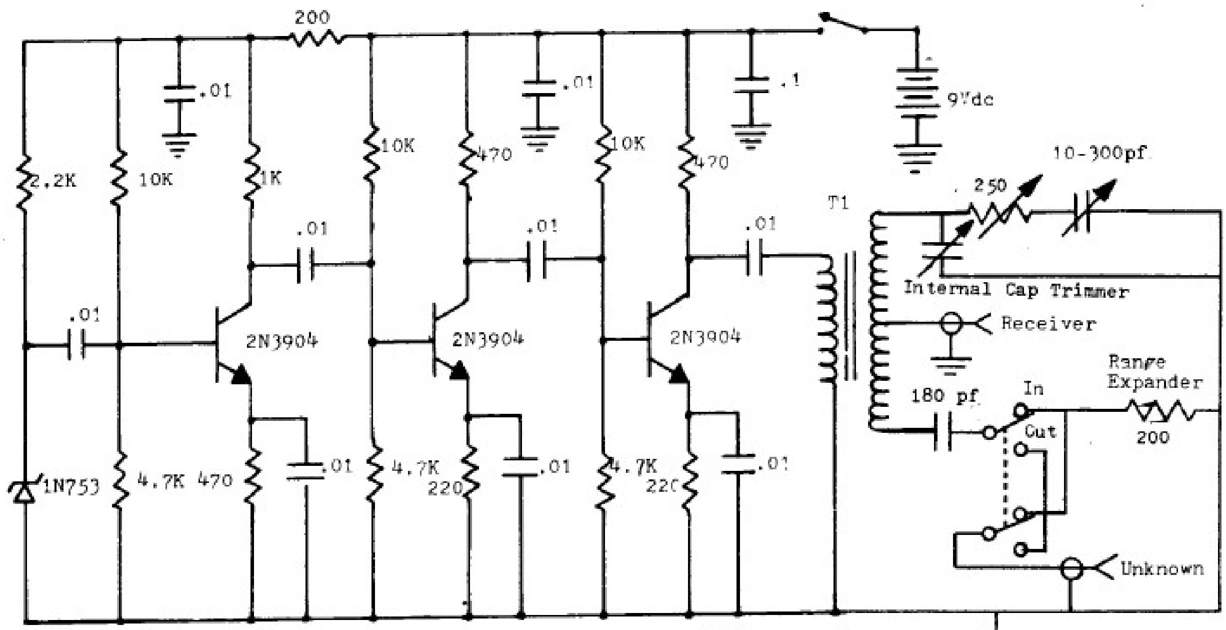
- Unknown resistance range: 0 to 250 ohms at 1 MHz to 100 MHz
- Unknown inductive reactance range: 0 to 500 ohms at 1 MHz, 0 to 5 ohms at 10 MHz
- Unknown capacitive reactance range: 0 to 15 K ohms a 1 MHz, 0 to 150 ohms at 100 MHz.

Using Range Expander.

- Unknown resistance range: 0 to 2000 ohms at 1 MHz
  0 to 2200 ohms at 4 MHz
  0 to 3800 ohms from 6 MHz to 100 MHz
- Unknown inductive and capacitive reactance range:
  0 to 360 ohms at 1 MHz
  0 to 1800 ohms at 4 MHz
  0 to 1900 ohms from 6 Mhz to 100 MHz

Resistance Dial Range: 0 to 250 ohms

Reactance Dial Range: -150 to +150 pF



*Capacitors are in uf, Resistor in ohm, T1 is 7 turns trifilar-wound on FT-23-61 ferrite core.

MFJ-202B RF Noise Bridge Circuit Diagram

Made readable public by OZ6YM, Palle A. Andersen