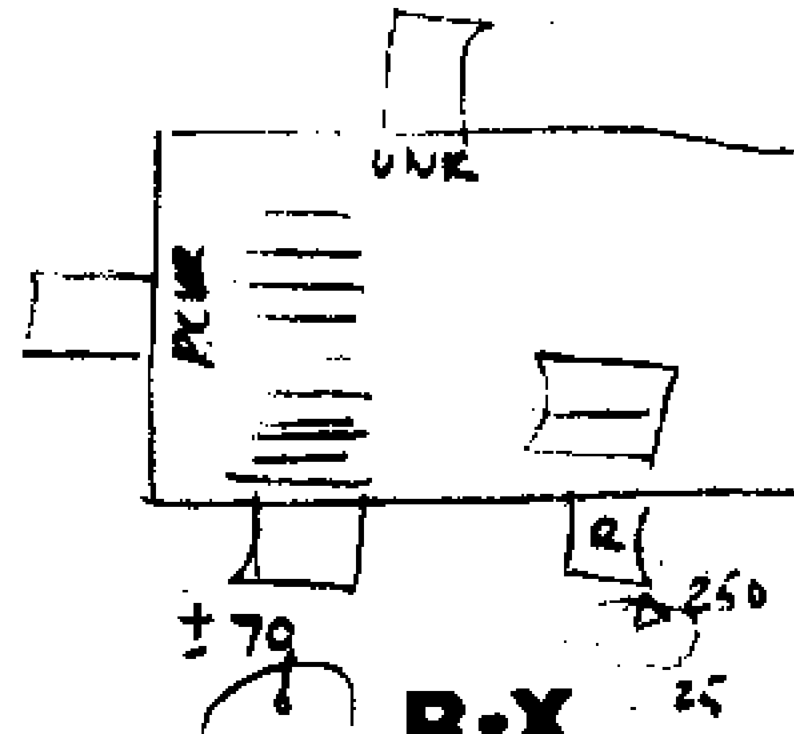
HENDLER
2606 N. W. 38th ST.
GAINESVILLE, FL 32606

CAUTION!

Do not turn on transmitter or let VOX turn it on when R X Noise Bridge is connected to antenna.



Price: $2

R-X NOISE BRIDGE

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OPERATOR'S MANUAL

PALOMAR ENGINEERS

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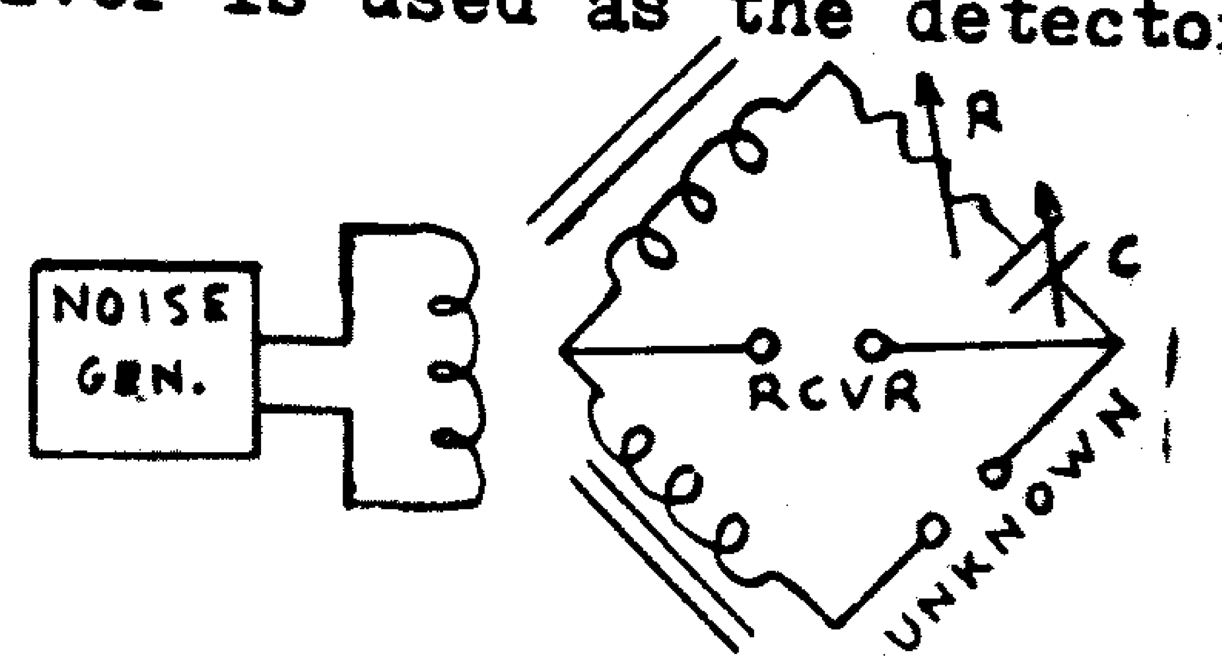
Escondido, California 92025 • Tel. (619) 747-3343

R-X NOISE BRIDGE

General Description. The R-X Noise Bridge contains a wideband noise generator and an r-f impedance bridge. Two arms of the bridge are driven equally by the noise generator through a broadband ferrite transformer. A third leg of the bridge has a calibrated variable resistor R and a calibrated variable capacitor C in series. The antenna or other "Unknown" circuit to be measured is connected as the fourth leg of the bridge. A short-wave receiver is used as the detector.



When R and C are adjusted for a null (minimum noise out of the receiver) their dial settings can be read to find the resistance and reactance of the unknown. A capacitor is in series with the unknown so that, if the unknown is a pure resistance, capacitor C is at half scale for balance. Thus both capacitive and inductive impedances can be measured. By tuning the receiver, the R and X of the unknown can be found at different frequencies.

The useful range of the Noise Bridge is 1-100 MHz. It measures R = 0-250 ohms and C = ±70 pf.

Antenna Resonance. Connect the antenna to the "Unknown" terminal, a receiver to the "Receiver" terminal (through any convenient length of line), and a 9-v transistor battery to the clips provided.

Tune the receiver to the expected resonant frequency of the antenna and turn the Noise Bridge on. A loud noise will be heard. Adjust the R and X controls for null; the controls interact and must be adjusted alternately until a deep null is obtained.

If the reading is on the X_L side of zero, the receiver is tuned to a frequency above resonance. If the X reading is on the X_C side of zero, the receiver is tuned below resonance. Using the X reading as a guide, retune the receiver and readjust the the R and X dials for null. With this procedure it is easy to find the resonant frequency of an antenna.

At the resonant frequency (X=0) the R reading is the antenna resistance at the measurement point. If the measurement is made at a current loop (the center of a dipole antenna, for example) the indicated resistance is effectively the antenna radiation resistance.

Sometimes it is not possible to make the measurements at the antenna. Instead the R-X Noise Bridge can be connected to the antenna's coax feedline. There are two ways to do this:

1. If the feedline is an electrical half wave long, or some multiple of a half wave, then the readings taken at the end of the feedline are exactly the same as though they were taken at the antenna. Of course there is just one frequency where the feedline is a half wave long so all measurements must be taken at this frequency.

2. If the feedline length is known, readings taken at the end of the feedline at any frequency can be converted using the Smith chart to find the antenna resistance and reactance. The procedure is described in detail in the ARRL Antenna Book (13th , edition, 1974).

Antennas Off-Resonance. With the antenna connected as the "Unknown" its resistance and reactance off resonance can be found. At frequencies lower than resonance an antenna appears as a capacitor and resistor in series. Above resonsnce it appears as an inductor and resistor in series. The resistance is read directly from the R dial. The reactance is found from the X dial reading and the impedance chart. The chart gives reactance in ohms for a measurement frequency of 1-MHz. To find the reactance at higher frequencies, divide the tabulated values by the frequency in MHz.

Series Tuned Circuits. To find the resonant frequency of a series tuned circuit, connect it across the

"Unknown" terminals. Set the R control to minimum resistance (most tuned circuits used in communications work have very low series resistance). Set the X control to zero. Tune the receiver for a null. The X control can be used as described above to determine whether resonance is above or below the frequency to which the receiver is tuned.

<u>Parallel Tuned Circuits</u>. A coupling link of two turns or so should be connected to the "Unknown" terminal. The link is then brought close to the tuned curcuit and the procedure described above is used to find the resonant frequency.

If the tuned circuit uses a toroid inductor, the link must thread through the toroid core.

<u>Measurement of Inductance and Capacitance</u>. The R-X Noise Bridge can be used to find the values of unknown capacitors and inductors. To do this, a standard capacitor (100-pf mica) and a standard inductor (5 microhenry) are used.

To measure the inductance of a coil connect it in series with the standard capacitor and find the resonant frequency. To measure a capacitor, connect it in series with the standard inductor and find the resonant frequency.

$$L = \frac{25{,}330}{f^2 C} \qquad C = \frac{25{,}330}{f^2 L}$$

where: f= resonant frequency in MHz
L= inductance in microhenrys
C= capacitance in picofarads

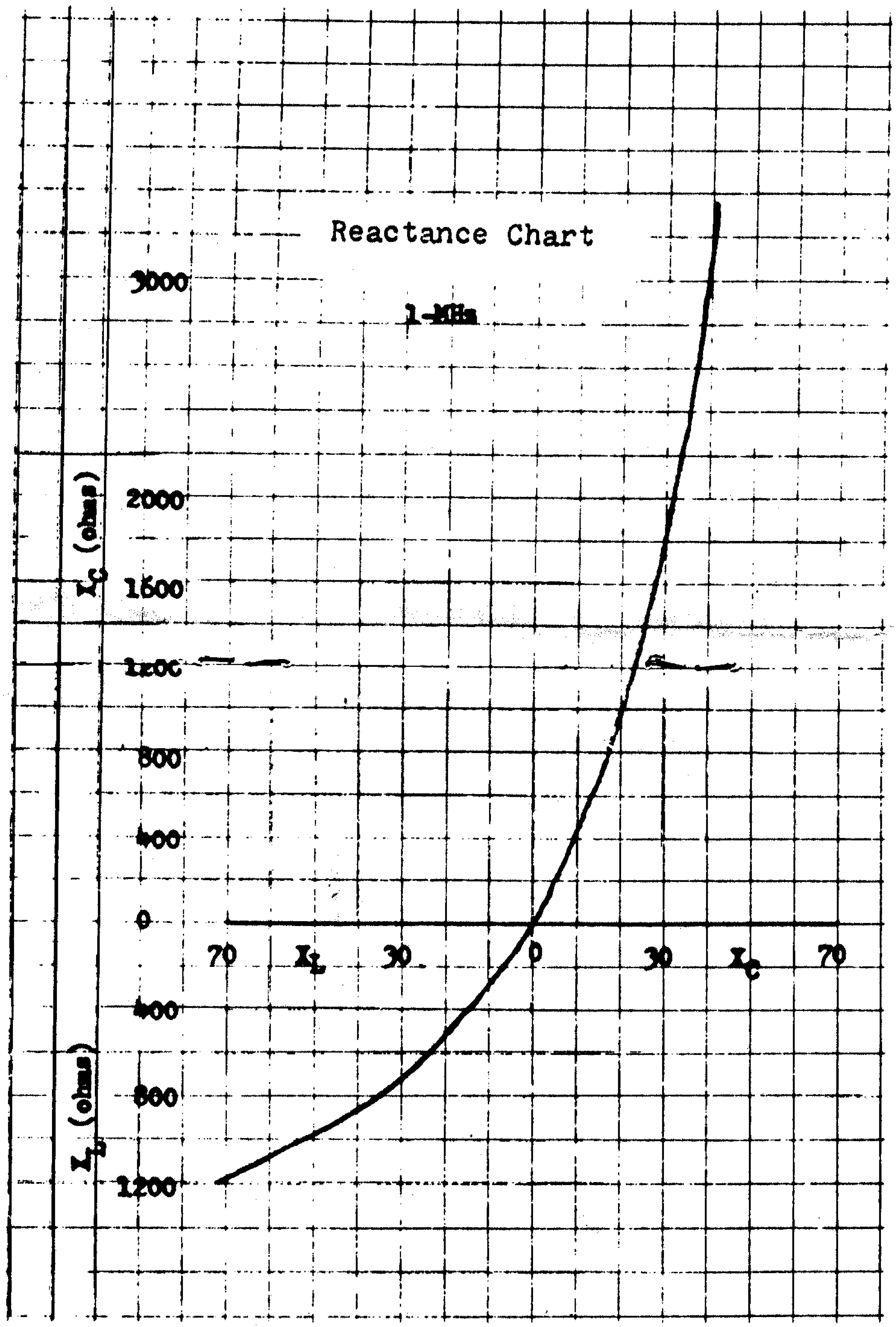
With the resonant frequency known and either the standard capacitor or standard inductor in use an unknown inductor or unknown capacitor va[illegible] can be calculated.

The L/C/F calculator (available from the American Radio Relay League) finds the answers without the need for arithmetic calculations.

<u>Transmission Lines</u>. The length of a quarter wave line is:

$$L_{(feet)} = \frac{246}{f} V$$

where: f = frequency in MHz
V = velocity factor of the line


Reactance Chart
1-MHz
3000
2000
1600
800
400
0
400
800
1200
X_C (ohms)
X_L (ohms)
70
X_L
30
0
30
X_C
70

V is approximately 0.66 for coaxial cables, 0.8 for foam dielectric coaxial cables, 0.82 for twin-lead cables.

To find the frequency at which a given line is an electrical quarter wave first set the noise bridge by shorting the "Unknown" terminal and adjusting the R and X knobs for null. The null will be at R=0 and X=0 but, by using this procedure you will be able to set the knobs more accurately than by reading the printed scales.

Now connect your quarter-wave line to the "Unknown" terminal Leave the other end of the line open. Tune the receiver to the expected frequency. If the line is an exact electrical quarter wave, the null will be at X=0. If the receiver is tuned too low in frequency the null will be on the X_C side. If the receiver is tuned too high, the null will be on the X_L side of zero. If the null is not sharp, adjust the R knob slightly (Losses in the line show up as increased R readings).

If it is desired to prune the line to resonance at a given frequency the line should be disconnected from the R-X Bridge. Short the "Unknown" terminal and adjust the X and R controls for a null with the receiver at the desired frequency. Reconnect the line and do not readjust the X control. Find the quarter wave frequency by tuning the receiver to null and adjusting the R knob for a sharp null. Prune the line slightly, retune the receiver, and repeat the procedure until the desired frequency is reached.

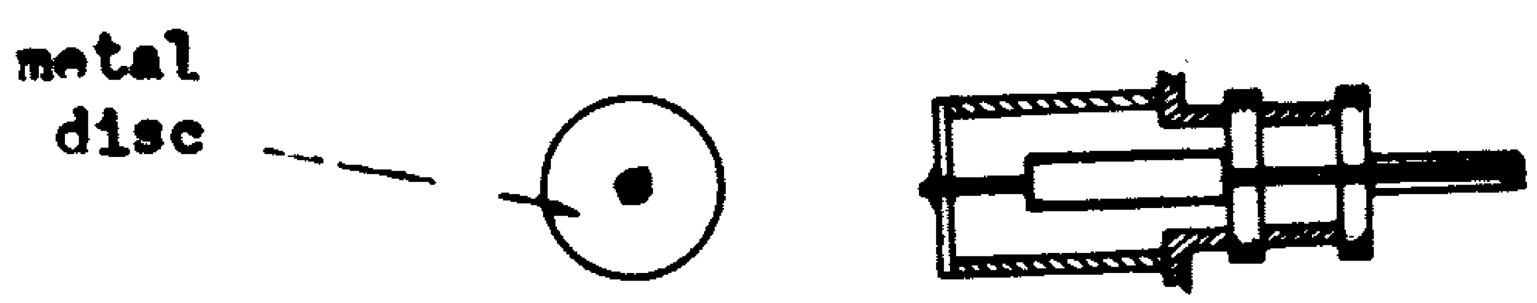
The length of a halfwave line is:

$$L_{(feet)} = \frac{492}{f} V$$

To find the frequency for a halfwave line, the far end of the line should be short-circuited (instead of open-circuited as for a quarter wave line). Then follow the same procedure as described for quarter wave lines.

Calibration. The R-X Noise Bridge has wide range controls (0-250 ohms and ±70-pf) to take care of the many uses to which it may be put. Because of this, and because of variations in bridge components, the dials cannot be read as precisely as desired for some measurements. To find the precise setting for a given antenna resistance and to check the calibration of the bridge, resistors of known values can be connected to the "Unknown" terminal. ¼ watt or ½ watt carbon resistors are suitable for this purpose. They should be mounted in a PL-259 coaxial plug as shown below. The plug is then mated with the "Unknown" receptacle of the Noise Bridge.

Resistors connected to the "Unknown" terminal by banana plugs or other open wiring methods invariably will give incorrect X readings because of lead inductance.

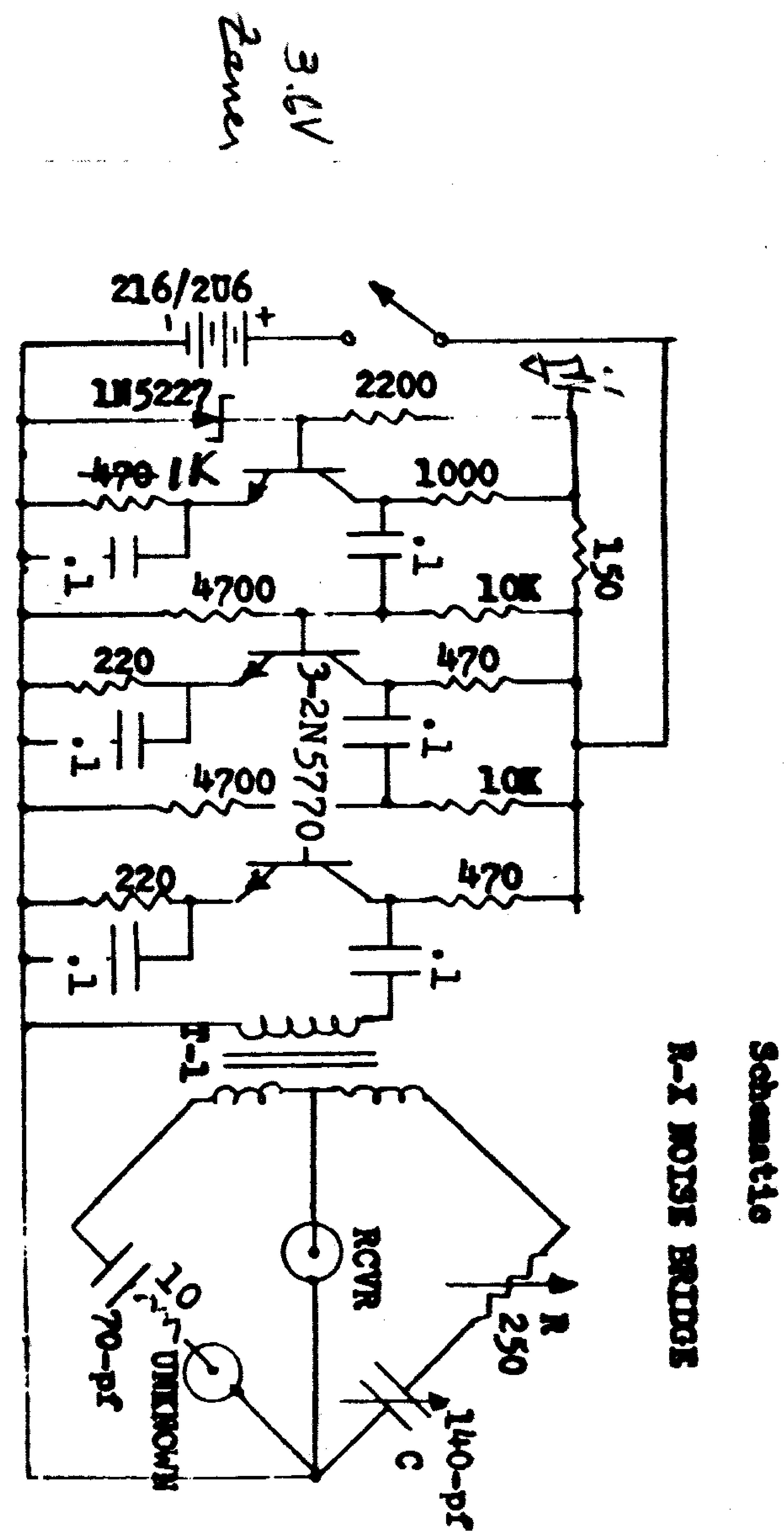


<u>Reactance Chart</u>. Refer to the <u>schematic diagram on page</u> 7. R and C are the panel controls labeled R and X. C = 70 pf at a dial reading of X = 0. There is a 70-pf capacitor in series with the unknown. If the unknown series resistance and reactance are R_U and X_U then at null.

$$R = R_U \text{ and } X_C = X_U + X_{(70\text{-pf})}$$

Schematic

R-X NOISE BRIDGE



The reactance chart shows this last relationship with reactance values given for f=1-MHz. To find the reactance at higher frequencies divide the tabulated values by the frequency in MHz.

<u>Trap Diploles</u>. The noise bridge will give a null on each band that the trap dipole resonates. Start with the highest requency band and measure the resistance and reactance as described for a dipole. Adjust the center (or lower) section if necessary to resonate. Then repeat the procedure on the next lower band. The method works with either horizontal or vertical trap antennas.

<u>Beams</u>. Connect the noise bridge to the driven element. Tune your receiver to the operating frequency and read the resistance and reactance. Adjust the element to resonance if needed.

<u>Test a Balun</u>. How do you tell if a balun is good? Not with an ohmmeter, because most baluns have all input and output terminals connected together at DC; you read a direct short whether the balun is good or not.

Instead, connect your noise bridge to the coax fitting of the balun. Then, if it is a 1:1 balun, put a 50-ohm resistor across the output terminals. A ¼ or ½ watt carbon resistor will do.

Now turn on the noise bridge and adjust it for null. You should read X = 0 and R=50 ohms.

<u>Save that Final</u>. If you use an antenna tuner, you can use the noise bridge to set its controls without turning on your transmitter. Just connect the noise bridge to the transmitter side of the tuner.

Set the noise bridge controls to X=0 and R=50 ohms. Adjust tuner for null. Now the tuner input is 50 ohms resistive, just what your transmitter wants to see.

CAUTION: Remove the noise bridge from the line before transmitting.

Antenna tuning with a noise bridge

(Ed. note — We've had many requests for information on noise bridges, so we turned to Mr. Noise Bridge himself, Jack Althouse, K6NY, of Palomar Engineers.)

Jack Althouse, K6NY
Palomar Engineers

The noise bridge

The noise bridge is a measuring instrument used to find the resonant frequency of an antenna, to tell whether to make an antenna longer or shorter to make it resonant, and to measure the antenna's resistance. Also it will measure the resistance and reactance on an antenna off-resonance and make other useful measurements around the amateur operating room.

It is not an antenna tuner; it is used with a receiver to make resistance and reactance measurements.

How it works

The R-X noise bridge contains a wideband noise generator and an RF impedance bridge. The "known" leg of the bridge has a calibrated variable resistor and a calibrated variable capacitor controlled by front panel knobs. The "unknown" leg of the bridge connects to the antenna to be measured. A receiver tuned to the measurement frequency is used as the detector.

When the noise bridge is first turned on, a loud noise from the noise generator will be heard in the receiver. The R and C knobs, controlling the variable resistor and capacitor, are then adjusted for a noise null. The R knob reads the antenna resistance.

The X knob, if it points at zero, says that the antenna is resonant. If it reads on the X_L side of zero, the antenna is inductive; that is, it is too long to be resonant at the measurement frequency. If it reads on the X_C side, the antenna is capacitive; that is, it is too short to resonate on the measurement frequency.

Tuning a dipole

Let us now use the R-X noise bridge to tune a dipole or inverted Vee to resonance. First, connect the "unknown" terminal of the noise bridge to the center of the dipole. Later in this article we'll explain how to make this measurement at the bottom end of the coaxial transmission line, but, for now, connect the noise bridge right up at the center of the antenna. Next, connect your receiver to the "receiver" terminal of the bridge through any convenient length of coaxial line.

Tune your receiver to the frequency on which you want the antenna to resonate. Turn off the receiver's AGC and place the speaker so you can hear the noise signal, or arrange to be able to see the "S" meter. Turn on the noise bridge and adjust the R and X knobs for null. The controls interact and must be adjusted alternately until a deep null is obtained.

If the X reading is on the X_L side, the antenna is too long. If the reading is on the X_C side, the antenna is too short.

Adjust the antenna length and take another measurement. Repeat this until the null is at X = O. The antenna is now resonant on the desired frequency. The R knob indicates the feed point resistance.

Trap dipoles

The noise bridge will give a null on each band that the trap dipole resonates. Connect the bridge at the center of your horizontal trap dipole or at the base of your vertical trap antenna.

Start with the highest frequency band and measure the resistance and reactance as described above. Adjust the center (or lower) section if necessary to resonate. Then repeat the procedure on the next lower frequency band. Work your way down in frequency until you have adjusted the lowest frequency section.

Beams

Connect the noise bridge to the driven element. Tune your receiver to the operating frequency and read the resistance and reactance. Adjust the element to resonance if needed.

Ladder is too short

Sometimes it is not possible to make the measurements at the antenna. Instead, the noise bridge can be connected at the bottom of the antenna's feedline. But beware! The readings you get at the bottom of the feedline may be completely different than those you got up at the antenna.

Why? Because the resistance and reactance seen at the bottom of the feedline change with the length of the line. The noise bridge measures what it sees.

But there is a magic feedline length, the half-wave line. If the feedline is an electrical half-wave, or a multiple of a half-wave, readings taken at the end of the line are exactly the same as those taken at the antenna. Of course, there is just one frequency where the line is a half-wave and all measurements must be made at this frequency. To cut your line to a half-wave use the formula in the Handbook, then check it with the noise bridge using the procedure described in this article.

More than likely, the distance between your antenna and your transmitter is not half-wave or anything close to it. What then?

If you know the electrical length of your line you can convert the readings taken at the end of the line to those you would read if you were at the antenna. This is done with the Smith chart. This is not something you can master in an evening but it's not all that difficult either. The procedure is described in the ARRL Antenna Book. Also see the March 1978 issue of *Ham Radio* magazine.

Transmission lines

The length of a half wave line is:

$$L\ (\text{feet}) = 492/f\ V$$

where f = frequency in MHz, V = velocity factor of the line.

V is about 0.66 for coaxial cables, 0.8 for foam dielectric coaxial cables, 0.82 for twin-lead cables.

You can cut the line to correct length using the formula but, because of different manufacturing methods and tolerances, the line you have may not have exactly the velocity factor listed above. If so, the formula will give you the wrong length, so you should check using the noise bridge.

The magic property of a half-wave line is that what you connect to one end of the line is what you read at the other end. If you put a short circuit at one end then you will read a short circuit at the other end. that is R = O and X = O.

Before making the measurement you should set the noise bridge by shorting the "unknown" terminal and adjusting the R and X knobs for null. The null will be at R = O and X = O but, using this procedure, you will be able to set the knobs more accurately than by reading the printed scales.

Now connect your half-wave line to the "unknown" terminal. Short the far end. Do not adjust the R or X controls. Find the half-wave frequency by tuning your receiver to noise null. Prune the line slightly, retune the receiver to null, and repeat the procedure until the desired frequency is reached.

Helpful hint: It is easier to cut the length of a line than it is to add to it. Start with your line a bit longer than the formula says.

Save that final

If you use an antenna tuner, you can use the noise bridge to set its controls without turning on your transmitter. Just connect the noise bridge to the transmitter side of the tuner.

Set the noise bridge controls to X = O and R = 50 ohms. Adjust tuner for null. Now the tuner input is 50 ohms resistive, just what your transmitter wants to see.

Caution: Remove the noise bridge from the line before transmitting.

If you have a dummy load you can tune your transmitter into it. Then connect the transmitter to the tuner and you are all tuned up and ready to transmit without ever having been on the air.

How nice it would be if everyone tuned up this way! We'd have no more of those interminable carriers that go on while someone is trying to find that magic combination of knob settings that loads his transmitter properly. Tubes last a lot longer, too; more damage is done to finals in tune-up than in many many hours of operating.

Test a balun

How do you tell if a balun is good? Not with an ohmmeter, because most baluns have all input and output terminals connected together at DC; you read a direct short whether the balun is good or not.

Instead, connect your noise bridge to the coax fitting of the balun. Then, if it is a 1:1 balun, put a 50-ohm resistor across the output terminals. If it is a 4:1 balun, put a 200-ohm resistor across the output terminals. A quarter or half-watt carbon resistor will do.

(please turn page)

Now turn on the noise bridge and adjust it for null. You should read X = O and R = 50 ohms.

Tuned circuits

A dipole antenna looks like a series resonant circuit and the noise bridge is designed to find the resonant frequency. It's easy to see that you could connent any other series resonant circuit to the noise bridge and find its resonant frequency.

But there is one difference: the antenna has a radiation resistance of 50 ohmns or so; tuned circuits used in transmitters and receivers have very little resistance. So, to check a series tuned circuit, set the R knob and the X knob at zero. Tune your receiver to the frequency you want and adjust your tuned circuit for a noise null.

You can check parallel circuits the same way but they have to be connected to the noise bridge by a one or two-turn link threaded through the coil.

The noise bridge works better than a dip meter for this purpose because the frequency of measurement is determined by your receiver which is calibrated a lot better than a dip meter, and is more stable.

Noise bridge vs SWR meter

If you've been using your SWR meter to adjust antennas, you've been working with one hand tied behind your back. The R-X noise bridge is a lot more useful because it tells you which way to go; the SWR meter does not.

Suppose, for example, that you have a 25-ohm antenna and 50-ohm coax. SWR = 2. Suppose further that you have a 100-ohm antenna. The SWR = 2. In other words, the SWR meter can't tell the difference between a 25-ohm and a 100-ohm antenna, but the noise bridge can. If the antenna is 25 ohms it reads 25 ohms; if 100 ohms, it reads 100 ohms.

Also, the SWR meter can't tell if you are above or below resonance. The noise bridge can. It reads XL above and XC below.

For routine operating the SWR meter is great. Every amateur operating room should have one. But for antenna construction and test, and for many other jobs around the station, the noise bridge can't be beat. Try one, you'll be pleasantly surprised. □

Worldradio, May 1978