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Title: Laboratory-Style RX Noise Bridge, A
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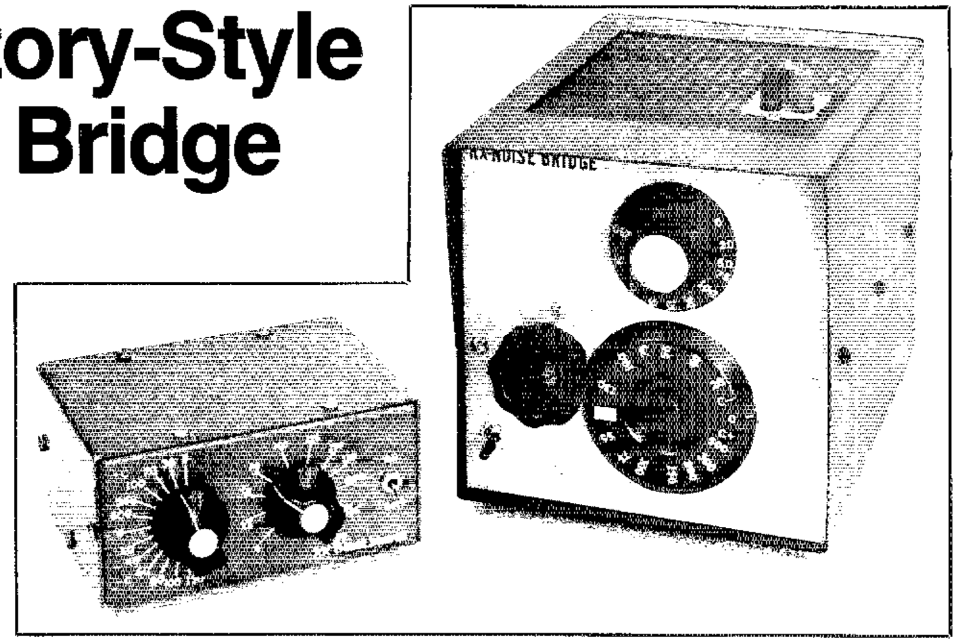
A Laboratory-Style RX Noise Bridge



Large, inflexible coaxial cable can make your small noise bridge hard to deal with on the lab bench. This project cures the problem.

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Is your antenna noise bridge too small for comfortable use in your workshop or at your antenna installation? If you have one of the miniature homemade or commercial units, chances are that the connecting cables won't let your bridge stay put on the bench. Another problem with small bridges and other small test equipment is the poor dial resolution that results from the limited panel space available for calibration marking.

There is no reason you can't use a large cabinet and big dials on the noise-bridge controls. I built a lab-style instrument of this type, and it is a pleasure to use. It stays put on the lab bench and on the antenna test-site table. Large R (resistance) and C (capacitance) dials are used on the controls, and the readout is greatly improved over that of the smaller bridges. This can be of great benefit to those of us who have weak or tired eyes! Today's apparent objective of developing miniaturized equipment need not apply when we build units for home station or workshop use. The practical project shown in this article reflects my efforts to build a solid and inexpensive lab style noise bridge.

The RX Antenna Bridge Circuit

I claim no credit for designing the heart of this noise bridge. The basic circuit is taken from the measurement chapter of *The ARRL Handbook*, as is the PC-board pattern.[1] My changes include adding a NiCd battery, binding posts (in addition to a BNC connector), a bigger cabinet and large readout dials. I also use a surplus WW-II Command receiver 3-section variable capacitor and gear train for the CAPACITANCE control. This provides nearly 330° of dial calibration space. A variable capacitor without this gear drive yields only 180° of dial calibration!

How Does it Operate?

The noise bridge circuit is shown in Fig 1. The basic bridge circuit consists of C1, C2, R1 and T1. The broadband transformer, T1, is trifilar wound (three identical windings). One winding is used to couple energy from the Zener-diode noise generator (D3) to the bridge circuit. Each of the two remaining transformer windings serves as an individual arm of the bridge. The third bridge arm consists of C1 and R1. The fourth and final bridge arm is formed by C2 and the unknown load at J2. With an unknown load connected to J2, C1 and R1 are adjusted to obtain a null in audible output noise (as monitored on a receiver that is connected to J1). The R1 and C1 control readings indicate the resistive and reactive (C or L) components of the load at J2.

1-kHz Modulation Feature

The NE555 timer IC, U1 in Fig 1, generates a 1-kHz square-wave tone with a duty cycle of roughly 50%. This energy, applied to the cathode of D3, modulates the wide-band noise generated by the Zener diode. This audio tone is not heard until the bridge is nearly at null, at which time it begins to override the noise. Nulling is continued to obtain the greatest audio-to-noise ratio. A complete bridge null will result in a clear audio tone with no discernible wide-band noise. This effect is evident only when the bridge is used with an AM detector. Noise nulling can be done using the SSB mode of your receiver, but the 1-kHz tone feature cannot be used.

Noise-Bridge Applications

The most popular use for an RX noise bridge is antenna matching. You can couple the bridge to the antenna feed point to permit precise adjustment of the antenna-matching network. You can also use the bridge at a distance from the feed point if you use a half-wavelength section of feed line between the bridge and the feed point. In calculating the cable length, you must consider the coaxial-cable velocity factor. A half-wavelength line (or multiple thereof) repeats the feed-point impedance at the opposite end of the line. Other coaxial cable lengths will provide misleading data. The antenna-matching network (gamma, T, hairpin or other) is adjusted until a purely resistive load (zero reading at C1) is noted at the desired operating frequency.

I find this bridge helpful in testing broadband transformers. Fig 2 illustrates the setup for doing this. The test transformer is terminated with a known resistance that is within the transformation range of the transformer. The other transformer terminals are connected to the binding posts of the bridge. C1 and R1 are adjusted to obtain a bridge null, and the dial readings are noted. This procedure is repeated for each band of interest. The amount of reactance (as read on the C1 dial) indicates the quality of the transformer. An ideal

[1]M. Wilson, ed, *The 1987 ARRL Handbook* (Newington: ARRL, 1986), pp 25-36 to 25-39.

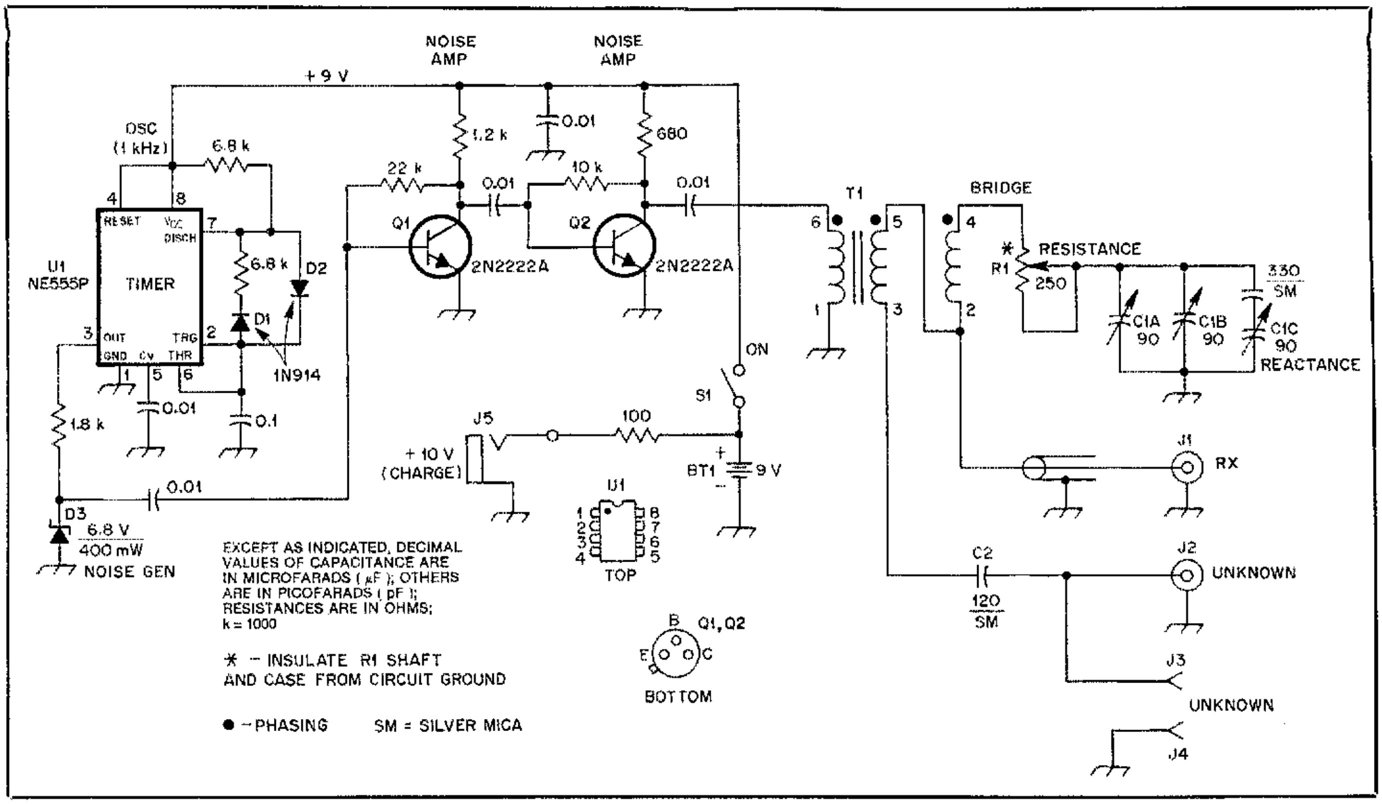

Fig 1—Schematic diagram of the RX noise bridge. Capacitors are disc ceramic unless otherwise indicated. Resistors are ¼-W carbon-composition units.

BT1—9-V NiCd or standard transistor-radio battery.
C1—Variable capacitor, 250 pF maximum capacitance. Surplus 3-section air variable, 90 pF per section, or equivalent (see text).
C2—Fixed-value capacitor, approximately half the value of C1 (120 pF).
J1, J2—BNC coaxial connector.
J3, J4—Plastic binding-post connector.
J5—Phono jack.
D1, D2—Small-signal silicon switching diode, 1N914 or equivalent.
D3—Zener diode, 6.2 or 6.8 V, 400 mW.
R1—High quality, 250-Ω, linear taper potentiometer (Allen-Bradley or equivalent).
S1—SPST toggle.
T1—Broadband, trifilar-wound transformer. Use 8 trifilar turns of no. 26 enam wire on an Amidon FT-37-43 toroid core (850 µi).
U1—NE555 timer IC.

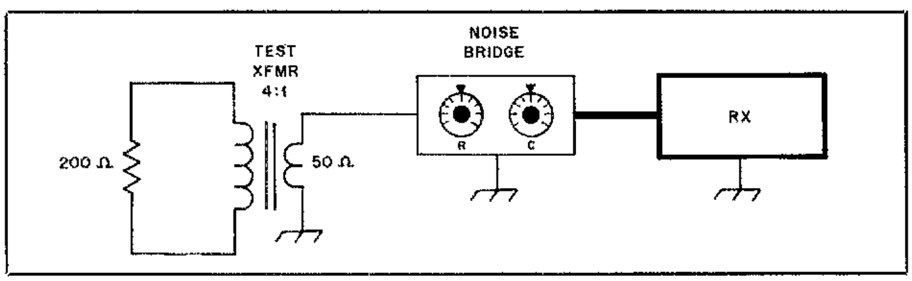

Fig 2—Setup for using a noise bridge to test broadband transformers for reactance and turns ratio.

transformer will exhibit zero reactance across the transformer frequency range. This is seldom possible to achieve, but low reactance is possible and acceptable for most amateur designs.

A noise bridge permits adjustment of a Transmatch without putting a signal on the air. This allows us to log the Transmatch settings for various frequencies with each of our antennas without causing QRM.

Construction Details

The leads of critical components are kept short by the geometry of the circuit board. Use short signal leads to minimize unwanted stray capacitance and wide leads to minimize stray inductance. This applies to the leads that join C1, J1, J2, J3 and J4 to the PC board. I recommend strips of flashing copper, 3/16 to 1/4 inch wide.

Although I used a Command receiver variable capacitor for C1, you may use any variable capacitor with a maximum capacitance of 250 pF. The lower the minimum capacitance, the better. This yields a greater range for the reactance readings. A 365-pF broadcast-band capacitor can be used if you remove sufficient plates to reduce its maximum capacitance to 250 pF.

Check the surplus outlets and flea markets for old Command receivers. Fig 3 shows the dial, gear train and variable capacitor I used. The 330-pF silver-mica capacitor above the tuning capacitor, at the left in Fig 3, is added in series with one of the tuning-capacitor sections to reduce the total capacitance to 250 pF maximum (see Fig 1). As arranged in Fig 1, the minimum capacitance is 36 pF. Although this is a trifle high, the reactance range of the bridge is entirely adequate for my needs.

It is necessary to file or grind the frame of the variable capacitor to allow its three rotors to unmesh completely. I cut a rectangular groove in the frame where each rotor stops (visible in Fig 7). This decreases the minimum capacitance of the assembly. The capacitor must be mounted on spacers if you plan to attach it to the chassis or cabinet bottom. Without spacers, the rotors contact the chassis before they are fully unmeshed.

I drilled the end of the tuning shaft (spline) and tapped it for a no. 4-40 thread. I use a headless no. 4-40 bolt to join the

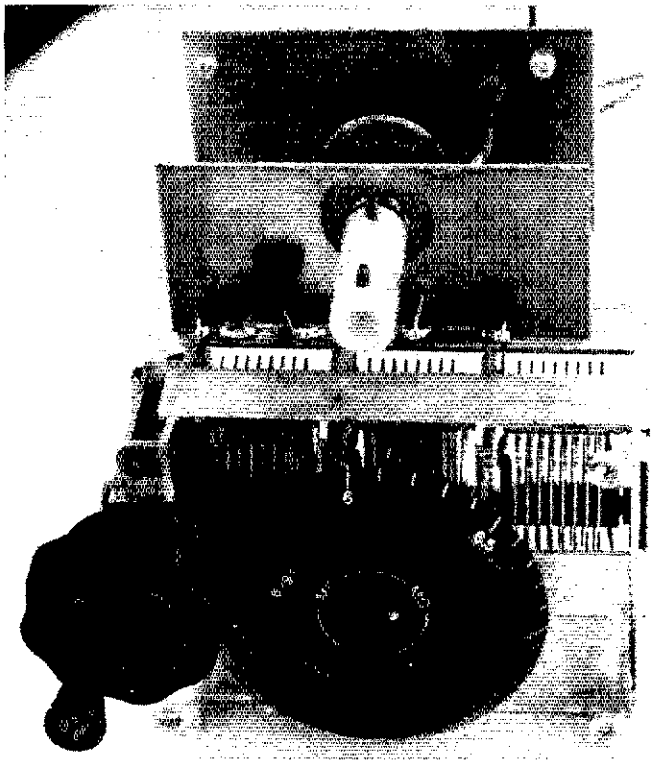

Fig 3—The surplus 3-section Command receiver tuning capacitor. Remove all padder capacitors from the assembly to reduce minimum capacitance. See text for details of adding a tuning shaft and modifying the capacitor frame. Details of the homemade U-channel assembly are covered in text.

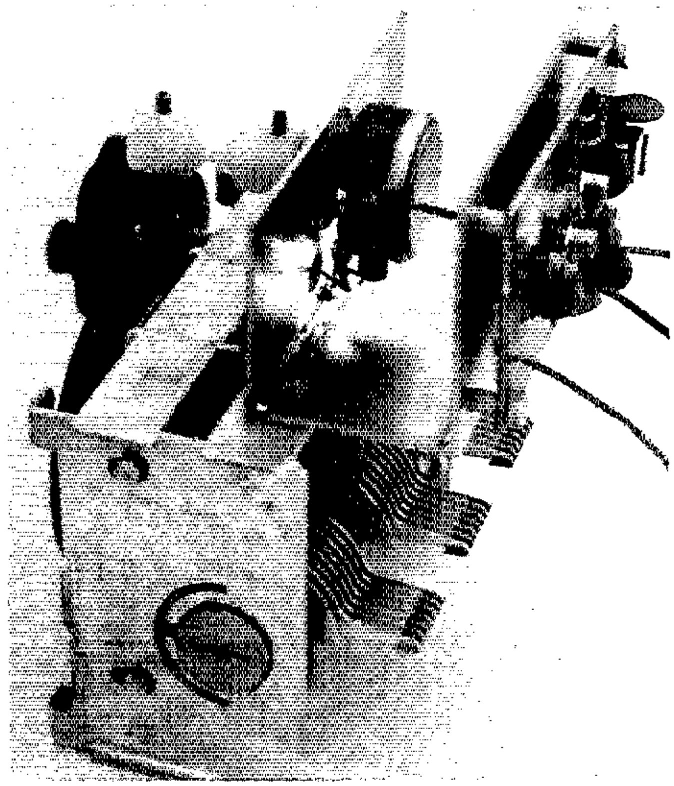

Fig 4—The piggy-back U-channel assembly. The noise bridge PC board is mounted to the rear wall of the channel. Braces are added between the front and rear walls to strengthen the channel assembly.

tuning shaft to a 1-inch-long, ¼-inch-OD spacer that is internally tapped for a no. 4-40 screw. A drop of epoxy glue at the junction of the spacer and the capacitor shaft secures them. The shaft extension permits use of a standard knob with a ¼-inch-diameter hole. I selected a spinner knob for my unit.

A U-channel-shaped compartment is visible on top of the variable capacitor, Fig 3. It is made from double-sided PC board sections that are soldered together. This channel holds R1. The copper is ground away from the R1 mounting hole to insulate the control from ground. Use an insulated shaft coupler, as shown. The main PC board is bolted to the rear side of the channel compartment to ensure short leads for the critical components (see Fig 4).

My cabinet measures 6 × 6 × 9 inches (hwd). I built it several years ago when I had access to a metal and welding shop. Any cabinet of similar dimensions is suitable. I painted the front panel gray, and used a matte black paint on the rest of the cabinet. A PC-board bracket is bolted to the rear of the cabinet to contain J1, the dc input jack (J5), and a ground post. J2, J3 and J4 are mounted on a piece of unclad glass-epoxy board (2 × 2¼ inches). This board is installed inside the cabinet top, directly above the main PC board and R1. This keeps the connecting leads short. Sheet-metal screws hold the jack board in place below the cut-out area.

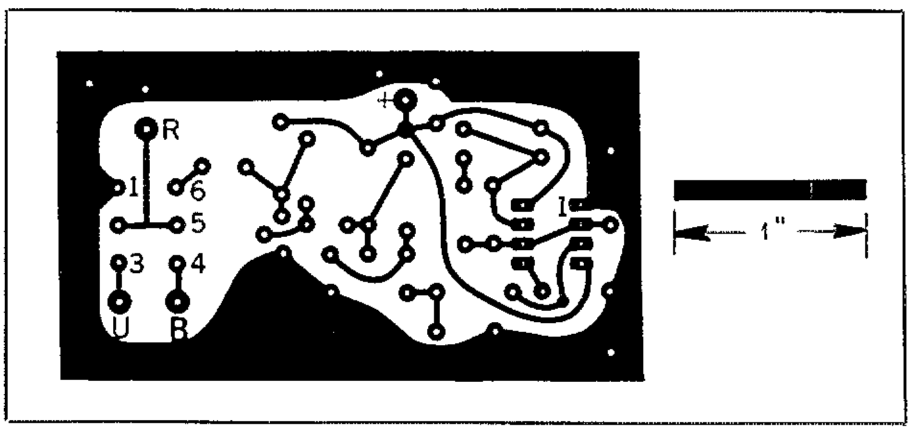

Fig 5—Circuit-board etching pattern for the RX noise bridge. The pattern is shown full-size from the foil side of the board. Black areas represent unetched copper foil.

I found a large, skirted knob for R1. White press-on decals provide calibration marks for C1 and R1. I painted the CAPACITANCE dial plate black before I applied the decals. Fig 5 is a parts-placement guide for the PC board, and Fig 6 is a full-scale etching pattern. Fig 7 shows an interior rear view of the bridge.

Calibration

Before calibration, check that the noise bridge is operating properly. Connect J1 to the receiver antenna jack. Tune your receiver to any part of the 15-meter band. Set S1 (POWER) to ON. You should hear considerable noise from the receiver at a fairly high level.

Resistance Dial

Calibration of the RESISTANCE (R) dial is accomplished by connecting resistors of known value across J3 and J4 and nulling the bridge with the R control. You will have to adjust the C control during this procedure to get a complete null for each resistor. I used 5% resistors I had on hand, and I chose values from 20 to 250 Ω. You may use 10% resistors, with calibration

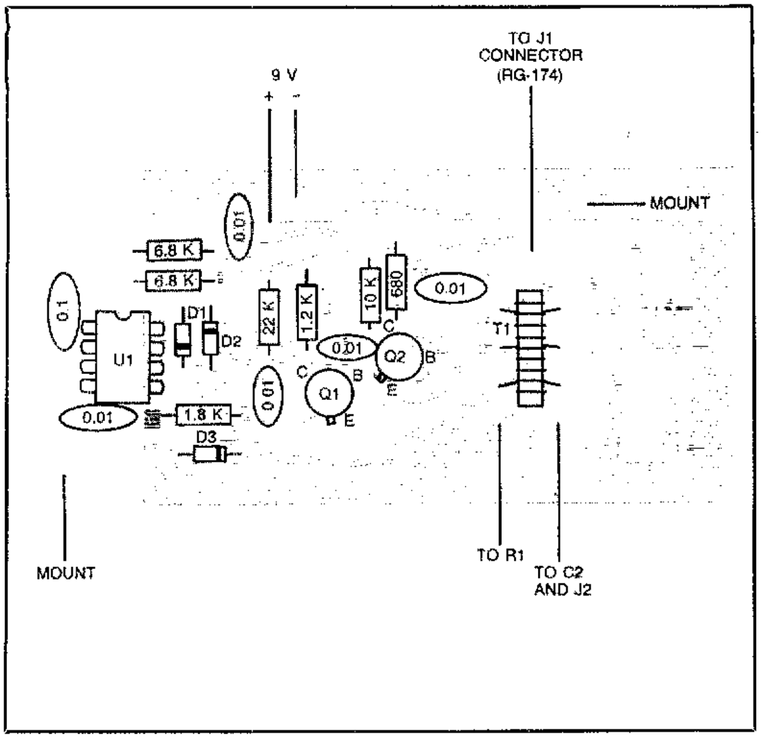

Fig 6—Parts-placement guide for the RX noise bridge. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern.

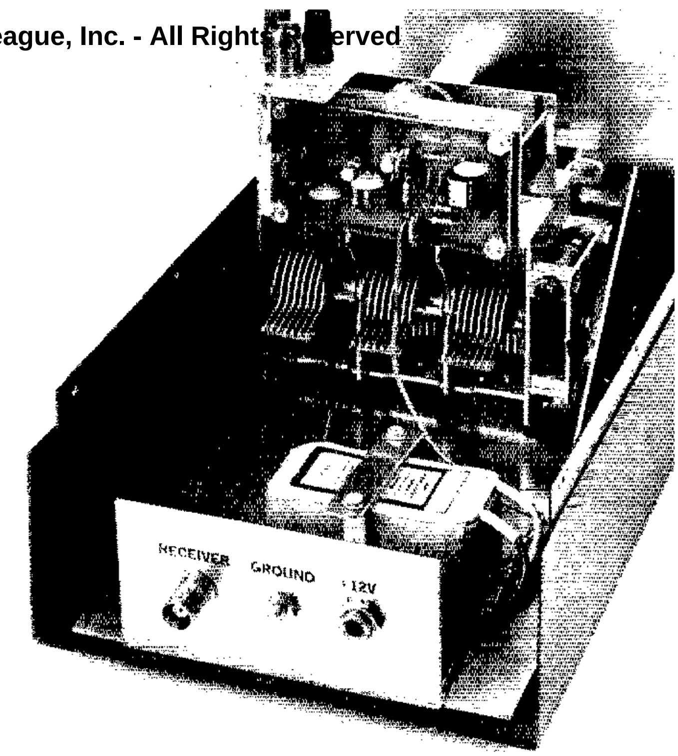

Fig 7—Interior view of the RX noise bridge. The chassis and front and rear panels are made from double-sided PC-board stock. The homemade battery clamp is fashioned from two metal standoff posts and a piece of PC board stock.

marks every 25 or 30 Ω. The more marks you include, the better the dial resolution. As each resistor is checked for a null, make a small mark on the dial skirt and keep a record of the resistance represented by each mark. The decals can be added after you complete this step.

You should get the best null when the capacitor plates are set for midrange capacitance (zero reactance). Locate this setting by placing a 51-Ω resistor across J3 and J4, then adjust R1 and C1 for the deepest noise null. Mark the CAPACITANCE dial for this setting. It will be your zero mark for the capacitance calibration. Should you be unable to get a good null with C1 at the midrange position, experiment with the value of C2 until a deep null does occur at midrange for C1. If you have difficulties, you may use a 150-pF trimmer at C2.

Capacitance Dial

Calibration of the CAPACITANCE dial is a bit trickier than for the RESISTANCE dial. Good quality fixed-value capacitors (silver mica recommended) are used as standards. The capacitors are used in parallel with a 51-Ω resistor (for negative range), and in series with a 51-Ω resistor (for positive range). To calibrate the negative range, set the CAPACITANCE dial to the zero mark (midrange as determined previously), and connect a 20- or 22-pF capacitor in parallel with the 51-Ω resistor, keeping the leads very short. Connect these parts across J3 and J4, and adjust R1 and C1 for a null. Mark the CAPACITANCE dial plate and record the capacitance value for later application of decals. Repeat this procedure with capacitors that allow approximately 20 pF per step. I used 20 pF to 130 pF for the negative range on my dial.

Calibration of the positive range is done similarly, but with the capacitor in series with the 51-Ω resistor. I used capacitors that provide markers from 55 to 500 pF. You may use values of your choice. This part of the range on my unit is limited by the high minimum capacitance of the Command receiver capacitor. You should be able to get a null with 20 or 25 pF of capacitance at J3 and J4 if your variable capacitor has a low minimum capacitance (such as 10 or 15 pF).

Interpreting the Readings

Remember that when the bridge is nulled, minus readings on the CAPACITANCE dial indicate that the load has inductive reactance (X_L). If, for example, your antenna is too long, there will be an X_L indication. Conversely, the positive portion of the CAPACITANCE dial indicates capacitive reactance (X_C), which indicates that your antenna is too short.

The ARRL Handbook description of the noise bridge includes a graph that shows the inductance versus frequency when X_L is present. It also includes the equation for determining the X_C, in ohms, when a positive reading is obtained on the CAPACITANCE dial.

Final Comments

My purpose in writing this article is to show you how to make a laboratory style noise bridge. I want also to mention the advantages of using a Command receiver capacitor and gear train. Other surplus equipment contains similar mechanisms that you may want to consider, such as the capacitor, dial and gear mechanism from an old BC-221 or LM frequency meter. I bought two complete units at a flea market for $5 each.

Try to use a high quality carbon potentiometer for R1. I prefer Allen-Bradley commercial grade potentiometers for test equipment. These controls are sealed and last a long time. If you are unable to use the capacitor I used at C1, be sure the capacitor you use is a high quality type. It should have a bearing at each end of the rotor.

BT1 is a 9-V (actually 8.75-V) NiCd battery that I obtained at a flea market. I charge it from a 10 V dc supply through a 100-Ω series resistor. This results in a slow charging rate over 15-18 hours. A lower series resistance, or a temporary higher charging voltage, may be used to increase the charge rate to 50 mA, maximum. A 50-mA rate occurs with 15 V applied to a discharged battery through the 100-Ω resistor. I do not recommend charging a NiCd battery at 50 mA unless you have a charger with a circuit to control the voltage and current. Careless charging can destroy a battery quickly.

If you have never built or used an RX noise bridge, now may be the time for you to do it. You will find this instrument particularly handy if you are an antenna experimenter. It tells you much more than your ordinary SWR indicator can. QST