Bob's TechTalk #23
by Bob Eckweiler, AF6C

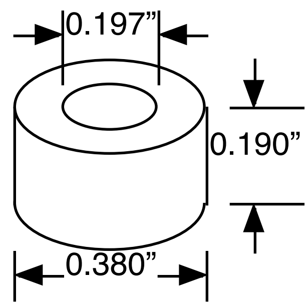
Impedance (Part VIII of X)

More on Baluns & The RX Noise Bridge

W2DU Balun:

One of the baluns that we discussed last month was the very effective W2DU current balun. Here are some practical tips on their construction. The ferrite beads most commonly used in the HF range (80 through 10 meters) are the Amidon FB-73-2401 or equivalent. The 73 refers to the ferrite material (mix #73, µ of 3000). The 2401 is an arbitrary reference to the size of the bead. These beads measure: 0.038" OD, 0.197" ID, by 0.190" L, see figure 1. The HF balun is made by slipping 50 of these beads (9 1/2 inches total length) over about a foot long piece of coax. One end of the coax can have a connector of your choice and the other end wire leads to attach to the antenna. Appropriate weather protection is required. A VHF balun (6 through 1.25 meters) is made similarly except using 25 Amidon FD-43-2401 (or equivalent) beads (µ of 850). For low power RG-58 (0.195 dia.) can be used as the coaxial cable; it fits snugly through the bead hole. For higher power, RG-303 is recommended. Though actually thinner than RG-58 (0.170 dia.), the Mil. Spec. RG–303 is easily capable of handling more than double the legal amateur power. Since you're only using a foot of it, the losses are negligible. If you insist on using RG-8 sized coax you can use 11 or 12 FB-77-1024 beads. These beads measure 1.020 OD, 0.500 ID, 0.825 L; and are considerably more expensive.

Palomar advertises W2DU type balun kits for RG-8 and RG-58/59/62 cables. The kit includes beads and a piece of shrink tubing to hold the beads in place and provide weather protection. I don't have specifications on these baluns, but they appear to be #43 material and only 5 1/2" in effective length. (I believe it uses five each Palomar FB-102 – equivalent to Amidon FD-43-1020 – beads) I'm doubt that they will provide results as good as the baluns above; however, they may still do an adequate job.



FB-xx-2401 Size
Figure 1

See the Resource List for more information.

The Noise Bridge:

In numerous past TechTalk articles we've talked about antenna and feed line impedance, and perhaps you've wondered how to measure these impedances. Impedance measuring, for the most part, used to be done in labs with multi "kilobuck" test equipment. With today's microprocessors, handheld impedance measuring devices are suddenly available at prices hams can afford. However, there is one piece of equipment that has been around for a long time that can measure impedance with reasonable accuracy and is inexpensive; that device is the Noise Bridge.

To understand the noise bridge you must first understand the basic bridge circuit. Figure 2 is a schematic of a typical bridge circuit. A signal of known frequency is applied to the primary of a transformer with two identical secondaries. The secondaries are wired as a bridge with four legs, the two transformer secondaries, Z Unknown (The impedance to be measured) and Z Adjustable

(An adjustable and known impedance.) The adjustable impedance normally has two controls, one for resistance "R" and one for reactance "X". The reactance control is usually center zero and is marked with inductance in one direction and capacitance in the other. A sensitive RF detector is connected as shown. As long as the two impedances are different RF from the signal source appears at the detector. However, when the adjustable impedance is equal to the unknown impedance, the bridge is balanced and no RF reaches the detector. The known resistance and inductance or capacitance can then be read from the dials, the inductance or capacitance converted to reactance using the frequency of the signal source and the impedance R±jX determined. Let's say we want to measure an impedance at 1 MHz. We set the signal source to 1 MHz and adjust the bridge for minimum signal on the detector. The bridge balances with R reading 88 ohms and X reading 159 pF. First we must determine the reactance of 15.9 pF at 1 MHz; From your General or Technician Class written test you remember:

$$X_C = \frac{1}{2\pi f C}$$

$$X_C = \frac{1}{2 \times 3.14 \times 10^6 \times 159 \times 10^{-12}}$$

$$X_C = \frac{10^6}{999} = 1001\Omega$$

Thus the measured impedance at the at the bridge is 88–j1001Ω (remember capacitive reactance is negative!) If the other end of the coax is attached to the antenna you can now transform the impedance you've just measured to the other end of the coax using either the Smith Chart or a calclator. The ARRL Antenna book has the formulas and a good section on using Smith Charts.

Well, I promised you a cheap way to measure impedances, but so far I haven't delivered. Stable signal generators and RF detectors are high priced lab equipment not found in most ham shacks. Fortunately there is a solution. Let's replace the accurate generator that you must set to the desired frequency of measurement with a noise generator. All that's needed is a circuit that generates strong white noise from 1 MHz up to 100 MHz or so. This circuit (once the secret of every electrical power company) is simple and very inexpensive to build. Now all you need is a detector that must be frequency selective, have a signal strength meter, be very stable and have an accurate frequency readout. This piece of is also expensive; luckily you probably own one. It's your receiver or receiver part of your transceiver. The receiver must cover the frequencies you want to measure impedances at; this is not a problem with as most ham transceiver/receivers no-a-days have general coverage receive. (If you're going to use a transceiver, be sure not to transmit into the noise bridge!)

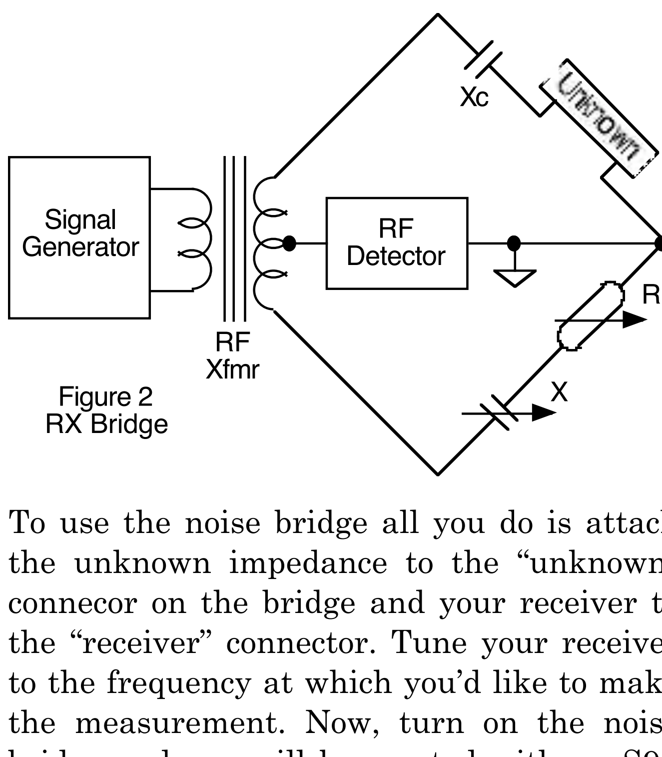


Figure 2
RX Bridge

To use the noise bridge all you do is attach the unknown impedance to the "unknown" connecor on the bridge and your receiver to the "receiver" connector. Tune your receiver to the frequency at which you'd like to make the measurement. Now, turn on the noise bridge and you will be greeted with an S9+ noise level on your receiver. Using the S-meter, alternately adjust the "R" and "X" knobs on the noise bridge for minimum noise. You should reacha sharp null where the S meter reacges zero. At this point use the "R" and "X" readings as described above to determine the impedance at the point of measurement.

Commercial noise bridges have been produced by Palomar and Heathkit to name two. They are also easy to make. The February 1977 issue of ***Ham Radio*** describes construction of an inexpensive noise bridge. It was written by W6BXI and W6KNU. (W6BXI was a resident of Orange and a guest speaker at one of our club meetings many years ago. He discussed construction of the noise bridge, and I still have his notes and the original article if anyone would like a copy.

What Else?

You might wonder what else you can do with a noise bridge. Here are a few things. We'll discuss them further in a future TechTalk:

- Measure SWR.
- Determine the length of a feedline.
- Measure the loss of a length of feedline.
- Determine nominal impedance of a feedline.
- Determine the velocity factor of coax.
- Adjust your antenna tuner off the air.
- Evaluate Amplifier pi-networks.

Next month we'll introduce the Smith Chart. This handy tool does more than I could ever discuss in this column. However, I'll try to give you a start so you can follow the execllent Smith Chart chapter found in many editions of the ARRL Antenna Book.

73, from AF6C

This article is based on the TechTalk article that originally appeared in the November 2003 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.

W2DU Balun Resource List:

Fully manufactured W2DU baluns by:

Unadilla
The Wireman, Inc.

W2DU Balun Kits by:

The Wireman, Inc.
Palomar Engineering

Ferrite Beads from:

Amidon:
FB-73-2401 or FB-43-2401 $4.50/dozen
FB-43-1020 $2.00 each
FB-77-1024 $2.50 each

The Wireman:
FB-73-2401 or FB-43-2401 $0.25 each*

Palomar Engineering:
FB-24-77 or FB-24-43 $4.85 dozen
(replaces: FB-73-2401 or FB-43-2401)
FB-56-43 $1.65 each
FB-102-43 $3.30 each

Coaxial Cable from:
The Wireman:
RG-303 $1.24 per ft.

* Quantity discounts available.