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QST Issue: Sep 1992
Title: Noise Bridge, The
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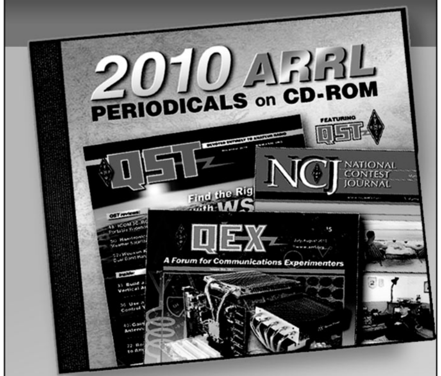

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The Noise Bridge

To do any job well, you need the right tools. For antenna work, an R-X noise bridge is just such a tool. Here's how to use one.

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A noise bridge is a simple, inexpensive and useful instrument for measuring antenna resistance and reactance, adjusting antenna tuners, characterizing tuned circuits and quarter- and half-wavelength transmission lines, and other jobs around your ham station.

An Overview of Bridge Circuits

The noise bridge, a ham invention,[1] differs from other bridge circuits. The first bridge circuit, the *Wheatstone bridge* (see Fig 1), gives insight into the workings of the noise bridge. The Wheatstone bridge is used to determine the value of an unknown resistance. A dc source drives the circuit. One leg of the bridge uses two equal-value resistors in series. Ohm's Law tells us that the voltage at point A is half the battery potential (if the resistors are equal, they drop equal voltages). The other side of the bridge uses a variable resistor with a dial calibrated for direct resistance readings. The variable resistor is in series with the unknown resistance.

Ohm's Law also tells us that, if we adjust the variable resistor to exactly equal the value of the unknown resistor, point B will be at exactly half the battery voltage. When this is the case, the bridge is *balanced* and the voltages at A and B are equal. There's no voltage drop across voltmeter V, so it doesn't deflect. The balanced condition is called the *null*. At any other setting of the calibrated variable resistor, the voltages at A and B will not be equal and the voltmeter will indicate a nonzero value. A zero-center meter is often used in bridge circuits because the meter may deflect in either direction, depending on the variable resistor's setting.

[1]Notes appear on page 78

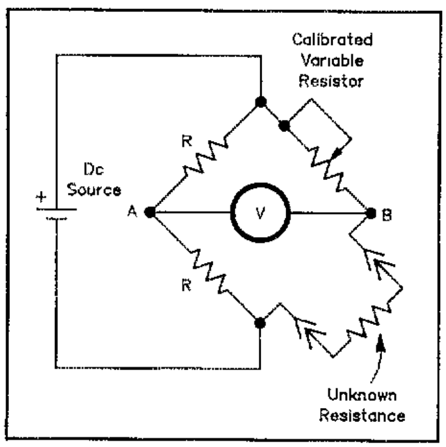

Fig 1—The basis for modern bridge circuits: the Wheatstone bridge. This circuit provides for the measurement of unknown resistance values using a direct current source, a dc voltmeter, an adjustable calibrated resistor and the voltage-divider principle. When the voltage across points A and B is equal, the bridge is *balanced* and the unknown resistance is equal to that of the calibrated variable resistor.

The RF Bridge

Instead of driving the bridge with a dc source, we can use an RF generator and an RF voltmeter (Fig 2). With the RF bridge, we can determine an antenna's resonant frequency and measure the antenna's resistance at that frequency.

A simple dipole antenna can be thought of as a series-resonant circuit made up of an inductor (L), a capacitor (C) and a resistor (R) (Fig 3). The inductor's reactance, X_L, increases with frequency. The capacitor's reactance, X_C, decreases with frequency. At some frequency, the reactances are equal (but opposite in sign) so they cancel. This is the resonant frequency of the antenna. Since only the resistance remains, we can measure it with a Wheatstone bridge.

But how do we find the resonant frequency? We vary the frequency of the RF generator until we can get a null. If the generator is not operating at the antenna's resonant frequency, the null we get by varying the calibrated resistor is shallow. As we move the generator closer to the resonant frequency, the null gets deeper. A perfect null (zero reading on the RF voltmeter) exists only at the resonant frequency. After we get that null, we can read the resonant frequency from a counter or the generator readout, and the antenna's resistance from the bridge's calibrated resistance dial.

The Resistive (R) Noise Bridge

We can use an RF bridge to find the resonant frequency of an antenna and measure its resistance at that frequency, but RF bridges are quite expensive. An accurately calibrated RF generator stable and powerful enough to give an adequate voltmeter reading may cost hundreds of dollars!

Ted Hart, W5QJR, solved this problem in an ingenious way. From the beginning of radio, RF bridges used variable-frequency generators and broadband detectors. Ted turned things around. He used a broadband noise generator and a narrow-bandwidth tunable detector (Fig 4). The inexpensive broadband noise generator, a Zener diode followed by a transistor amplifier, emits radio noise from 1 to 100 MHz. What kind of noise? Tune your receiver to a frequency where there is no signal and turn up the volume. That's it: "*noise* noise." But the noise bridge produces it at an S9+ level. The narrow-bandwidth tunable detector is expensive, but just about every Amateur Radio operator already has one: the station receiver!

To measure antenna resistance, we vary the calibrated resistor and tune the receiver until we get a deep null. You can see the null by watching the receiver's S meter or,

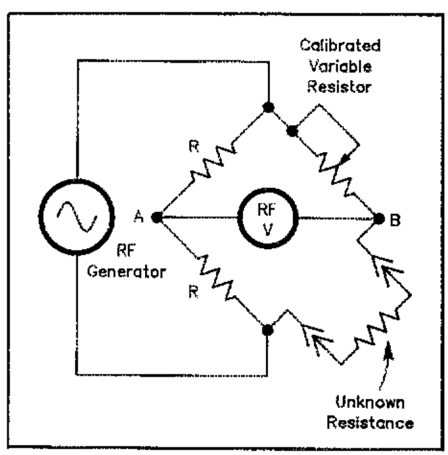

Fig 2—A natural follow-on to the Wheatstone bridge, the RF bridge uses an RF source and RF voltmeter to characterize an unknown resistance at radio frequencies.

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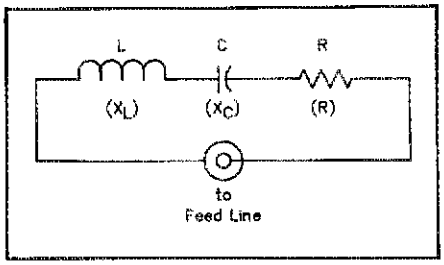

Fig 3—The equivalent circuit of a dipole antenna, showing how its resistance and capacitive and inductive reactances form a series-resonant circuit.

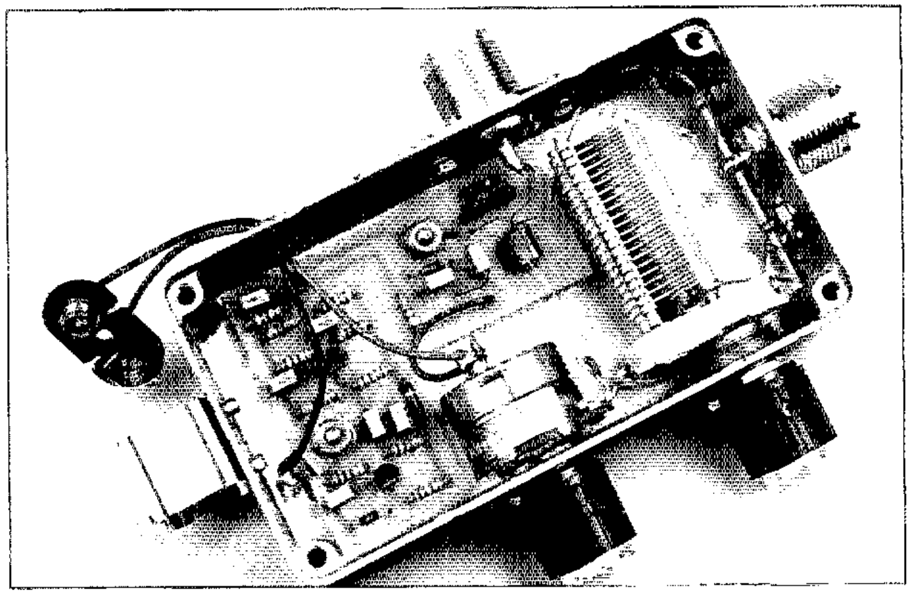

Fig 6—An inside photo of a typical commercially available noise bridge. *(photo by Kirk Kleinschmidt, NTØZ)*

with the AGC off, by listening to or measuring the receiver's audio output. The noise bridge's resistance scale tells us the antenna's resistance and the receiver readout shows the resonant frequency.

The R-X Noise Bridge

The R noise bridge has a serious limitation: If the antenna resonance is outside the amateur band and the station receiver tunes only the amateur bands, you can't find resonance with the bridge. Sometimes, you can't even determine a trend that indicates whether a resonance is above or below the target amateur band. This problem was solved by Pappot,[2] who put a capacitor—a reactance, X—in series with the **UNKNOWN** terminal of the bridge and a variable capacitor in the calibrated-resistor leg of the bridge. The resistance noise bridge thus became the resistance-reactance (R-X) noise bridge. Pappot's scheme, which I later simplified, became widely used in commercial R-X noise bridges.[3] See Fig 5. Fig 6 is an inside view of a typical commercial noise bridge.

The capacitor in series with the **UNKNOWN** terminal is 70 pF. The variable capacitor in series with the calibrated resistor is 140 pF, but is set at midrange. The two capacitors balance each other out and the bridge can be operated as though the capacitors were not there.

So, what have we gained? The ability to measure reactance! To see how this works, let's look at a practical example: using a noise bridge to trim a dipole antenna to resonance.

Using an R-X Noise Bridge to Adjust a Dipole Antenna

The first step is to connect the bridge in series with the antenna and receiver as indicated in the bridge manufacturer's instructions. Fig 7 shows a typical hookup. Tune the receiver to the desired resonant frequency. Let's suppose that the antenna is too short. (A dipole antenna that's too short—resonant at a higher frequency than desired—shows capacitive reactance.) If we adjust only the **R** control, we won't see a deep null because of the antenna reactance. But by adjusting the variable capacitor, we can introduce a compensating reactance and we'll get a deep null.

After we get the null, we read the two dials. The **R** dial tells us the antenna resistance, in ohms, at the frequency to which the receiver is tuned. The **X** dial tells us the antenna's reactance in ohms, and whether the reactance is capacitive or inductive.

In finding the null, we moved the **X** dial away from its centered position to its capacitive-reactance (X_C) side. In doing so, we adjusted the bridge's variable capacitor for *less* capacitance than it provides with the **X** dial centered. (Reducing the bridge capacitance increases the **X** dial's X_C indication because a capacitor's reactance increases as its capacitance decreases.)

Because our dipole shows capacitive reactance, we know that it's too short. If the antenna had been too long, it would

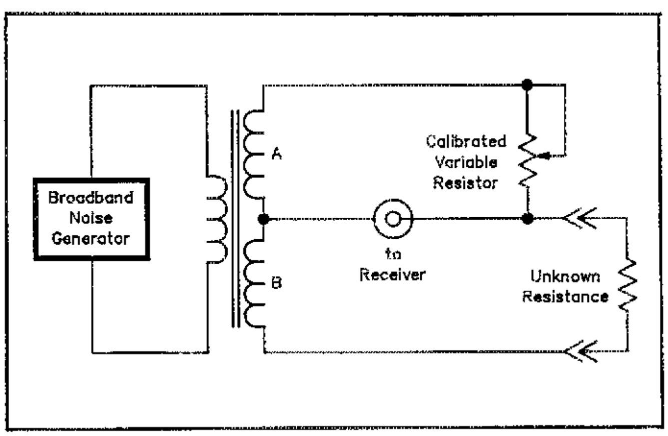

Fig 4—The noise-bridge circuit, originally described by Ted Hart, W5QJR, modifies the roles of the signal source and RF voltmeter in the earlier RF bridge to create a circuit more suitable for Amateur Radio applications. Transformer windings A and B must be identical for this circuit to yield accurate results.

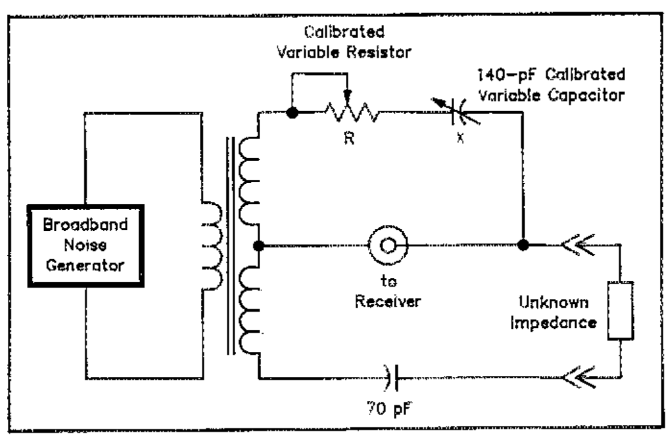

Fig 5—With the addition of a calibrated variable capacitor and a fixed capacitor in the unknown leg, the noise-bridge concept shown in Fig 4 gains the ability to be used in measuring not only unknown resistance, but also reactance.

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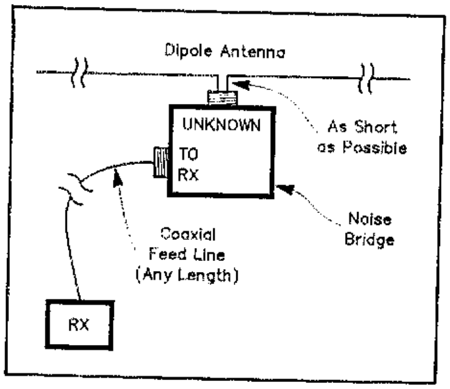

Fig 7—Test setup for measuring a dipole antenna's resonant frequency.

have shown inductive reactance and we'd have moved the **X** dial to the X_L side to get a deep null.

With just one reading, we can tell whether the antenna is too long or too short. We don't yet know *how much* it's too long or too short, but by adjusting the antenna length and taking another reading, we can rapidly find the correct length. Once that's done, we've tuned the antenna to resonance at the desired frequency and we know its feed-point resistance.

Connecting the Bridge to the Antenna

We haven't yet explained how to connect the bridge to the antenna. This is an important point. For best accuracy, the bridge must be located *at the antenna's feed point*. The connection can be made with an adapter between the antenna and the socket on the noise bridge.

"But," you say, "my antenna is way up there and my receiver is down here! Why can't I connect the noise bridge at the receiver end of the coax?" You can, but you'll get misleading results unless you make calculations that account for feed-line effects.[4] We're trying to measure the resistance and reactance of the *antenna*. The resistance and reactance measured at the other end of the cable is that of the feed line and the antenna *as a system*. These results nearly always differ, often *greatly*.

An SWR meter can be put at either end of a feed line because SWR does not change with cable length. (Actually, it does change a bit because of cable loss, but below 30 MHz, this change is usually insignificant in ham applications.) But an SWR meter doesn't tell us much, either. For example, if the antenna is resonant and has a resistance of 25 Ω, we'll read an SWR of 2:1 with the meter in the shack or at the antenna. If the antenna is 100 Ω, we'll also read an SWR of 2:1. The SWR meter can't tell the difference between 25- and 100-Ω antennas—but a noise bridge can. If the antenna impedance is 25 Ω, the bridge will read 25 Ω; if the antenna impedance is 100 Ω, it will read 100 Ω. This difference can be very important, especially when you get into complicated antenna systems (such as those using matching transformers, phased elements and the like).

So, for accurate results, connect the noise bridge right at the antenna. The receiver doesn't have to be located there; a remote speaker line or radio link can convey the speaker noise so you can look for a null.

Adjusting Other Antennas

Noise bridges can be used to check and resonate all kinds of antennas, and for other useful applications. Here are a few common examples:

Trap Dipoles

The noise bridge will give a null on each band on which the trap dipole resonates. Start with the highest-frequency band the antenna covers, and measure the resistance and reactance as described for a dipole. Adjust the dipole's center section as needed to resonate the antenna at the desired frequency. (This adjustment changes resonance on *all* the bands the antenna covers. This is why you should start with the highest-frequency band.)

Move to the next lower band. Measure antenna resonance and adjust as needed. This adjustment will not change the higher-frequency resonance, but will affect all lower bands. Proceed downward in frequency for each additional band the antenna covers. Some commercial multiband dipoles use different resonating schemes. So, before starting, read the antenna's instructions.

The adjustments that give the desired resonant frequency may leave us with an antenna resistance other than 50 Ω. This is to be expected, because the resistance of a dipole depends on its height above ground.[5] The height of a trap dipole, measured in wavelengths, is different for each band. For example, a dipole that's one wavelength high at 40 meters is ½ wavelength high at 80 meters.

Beams

The driven element and matching networks of triband Yagi and quad antennas can be adjusted as described earlier. Adjustment of the parasitic elements is best done with field-strength measurements.

Checking Coaxial Cable

Coaxial cable types vary in velocity factor. A given cable's velocity factor may also differ considerably from its published specifications—often by as much as 10%. For this reason, if you need a quarter- or half-wave section of line and cut it according to a formula, you may not get the electrical length you want. A noise bridge can help.

To check a half-wavelength cable (or one that's any multiple of a half wavelength), we can take advantage of the fact that the resistance at the input end of the cable is equal to the resistance at the load end. If we short one end of the cable, we will see a short at the other end (plus a small resistance due to cable loss). If the cable is not exactly a half wavelength long (or a multiple thereof), some reactance will be present, and the noise bridge will not give a perfect null.

The first step is to short the noise bridge's **UNKNOWN** terminal and adjust the bridge for a null. This is more accurate than setting the controls by eye. Next, connect the cable under test to the **UNKNOWN** terminal and short its far end. Listen at the frequency you expect to find the null. Don't touch the **X** dial. Tune the receiver to see if you can find a better null. Adjust the **R** knob slightly. Make these adjustments alternately until you get the deepest possible null.

The receiver readout gives the frequency at which the cable is ½ λ long (or an exact multiple thereof). You can then calculate the velocity factor of the cable and cut it to the desired length. If the indicated frequency is too low, your cable is too long, and vice versa.

A cable that's ¼ λ long (or any *odd* multiple thereof) appears as a short circuit if the far end is open-circuited. To check such a cable, leave the far end open-circuited and proceed as described for half-wavelength cables.

Measuring Coaxial-Cable Impedance

A noise bridge can be used to accurately measure the characteristic impedance of coaxial cable, twisted pairs and open-wire transmission lines. Procedures for doing this were recently described in *QST*.[6]

Tuned Circuits

To find the resonant frequency of any series-resonant circuit, connect the circuit across the **UNKNOWN** terminal of the noise bridge (Fig 8A). Set the **R** control to minimum resistance (most tuned circuits used in communications work have very low series resistance). Tune the receiver to the frequency where you expect to find resonance. Adjust the **X** and **R** controls for a deep null. When the **X** control is zeroed, the circuit under test resonates at the receiver frequency.

To adjust a tuned circuit to a particular frequency, set the receiver to that frequency, then set the **X** knob to zero reactance. Adjust the circuit until the null occurs at that frequency.

Antenna Tuners and Baluns

You can use a noise bridge to adjust an antenna tuner without using your transmitter. Connect the noise bridge to the transmitter side of the tuner. Set the noise-bridge controls to **X** = 0 and **R** = 50 Ω. Adjust the tuner for a null. Now the tuner is adjusted to match the antenna system to 50 Ω resistive—just what your transmitter wants to see. A bonus for us all is that using

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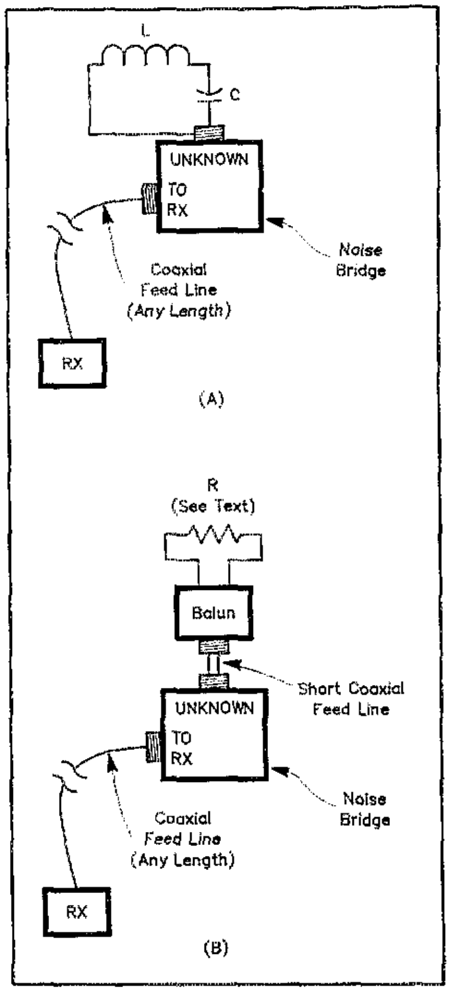
Fig 8—At A, the test setup for measuring the resonant frequency of a series-resonant circuit. At B, the hookup for testing a balun.



this method reduces interference on the ham bands!

Caution: Don't forget to take the noise bridge out of the circuit before transmitting!

To check a balun (Fig 8B), connect the noise bridge at the balun input and terminate the balun with the appropriate noninductive resistor (50 Ω for a 1:1 balun, 200 Ω for a 4:1 unit, and so forth, assuming a 50-Ω source impedance). Keep the resistor leads short to introduce minimal inductance. At frequencies above 14 MHz, you may need to use wide copper braid or straps to do this. Check the balun over its rated frequency range. If you need to adjust the X control to a nonzero value to get a null, or if the R dial doesn't indicate 50 Ω for a null at the test frequency, the balun may not be suitable for use at that frequency.

Summary

Noise bridges are quite useful around the ham shack. I've covered some of the more common applications here. I'm sure you can find many other uses for this simple and inexpensive instrument. Once you try one, you may wonder how you got along without it!

Notes

[1]R. T. Hart, "The Antenna Noise Bridge," *QST*, Dec 1967, pp 39-41.

[2]G. Pappot, "Noise Bridge for Impedance Measurements," *ham radio*, Jan 1973, pp 62-64. As improved, this product is currently marketed by Palomar Engineers.

[3]"Measurement with Capacitor in Series with Unknown," *Reference Data for Radio Engineers*, fifth ed (Howard Sams & Co, 1968), p 11-4.

[4]John Grebenkemper, KI6WX, explained how to do this in a recent *QST* article, "Improving and Using R-X Noise Bridges." (See the References.)

[5]J. Hall, ed, *The ARRL Antenna Book*, 15th ed (Newington: ARRL, 1988), p 3-11.

[6]J. Althouse, "Using a Noise Bridge to Measure Coaxial-Cable Impedance," Technical Correspondence, *QST*, May 1991, p 45.

References

J. Althouse, "Antenna Tuning with a Noise Bridge," *Worldradio*, May 1978, pp 5-6. Reprinted in *Ham Radio Horizons*, Nov 1978, pp 38-40; and *Break-In*, Dec 1979, pp 527-528.

L. Anderson, "Antenna Bridge Calculations," *ham radio*, May 1978, pp 34-44.

T. Anderson, "Noise Bridge Calculations," *ham radio*, May 1978, pp 45-47.

J. Belrose, "RX Noise Bridges," *QST*, May 1988, pp 34-35, 39.

J. Carr, "Using the Antenna Noise Bridge," *ham radio*, May 1986, pp 69-71.

D. DeMaw, "A Laboratory-Style RX Noise Bridge," *QST*, Dec 1987, pp 32-35.

D. Elkins, "Noise Bridge Aids Transmitter Output-Network Adjustment," Hints and Kinks, *QST*, Nov 1988, pp 39-40.

F. Gehrke, "A Precision Noise Bridge," *ham radio*, Mar 1983, pp 50-56.

J. Grebenkemper, "Improving and Using R-X Noise Bridges," *QST*, Aug 1989, pp 27-32, 52.

R. Hubbs and F. Doting, "Improvements to the R-X Noise Bridge," *ham radio*, Feb 1977, pp 10-20.

D. Nelson, "The RF Bridge," *ham radio*, Dec 1970, pp 18-21.

A. Popodi, "A VHF Noise Bridge," *ham radio*, Jul 1986, pp 10-19.

"The RF Noise Bridge," *Radio Handbook*, 20th ed (Indianapolis: Howard W. Sams and Co, 1975), pp 31.25-31.29.

D. Rodman, "Noise Bridge Audio Links," Hints and Kinks, *QST*, Dec 1988, p 44.

A. Weiss, "Noise Bridge," *ham radio*, May 1974, pp 71-72.

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