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By Fred "Fritz" Hauff, W3NZ

The Gadget—an SWR Analyzer Add-On

In the September issue of *QST*, we presented several hints and tips on using the popular SWR analyzer. Here are a few more, and a simple project.

My fascination with antennas, their performance and secrets of matching is as strong today as it was 60 years ago when I put up my first Zepp for 40 meters. In those days, most hams didn't know anything about SWR, and we didn't have coaxial cable. Neon bulbs, pencils and RF burns on our fingers were our indicators of getting RF to the right place! Years went by. The Jones MicroMatch, SWR bridges, noise bridges and more appeared. All of these instruments are sitting on my radio shack's shelves ready for action. But then . . .

Then came the MFJ-249 SWR analyzer equipped with an internal digital frequency counter. I just *had* to have one! A cursory examination of the manual convinced me that—in addition to SWR checks—many other measurements could be made.

Soon after I bought my MFJ-249, I built a copy of Dave (AF6S) Barton's dip-meter attachment as described in *QST*.[1] After that, came the inspiration for a multipurpose Gadget that would be the foundation for performing all of the measurements mentioned in the MFJ-249's manual—and many more.

Constructing the Gadget

Refer to Figures 1 through 3. As you can see, the Gadget is a simple thing to build. Its base is a piece of double-sided PC board.[2] There's nothing critical about the Gadget's dimensions or construction; just ensure that all connections are solid. First, remove a rectangular section of foil from the mirror location on both sides of the board, leaving a "lazy-**L**" shaped section of foil common to both sides. Secure three red binding posts (A, B, C) to the bare section of board; attach three black binding posts (D, E, F) directly opposite each of the red posts on the board's foil section. A notch at one end of the board accepts the shell of a PL-259 connector that's soldered directly to the foil on both sides. (Binding posts A and F are closest to the PL-259 end of the Gadget.)

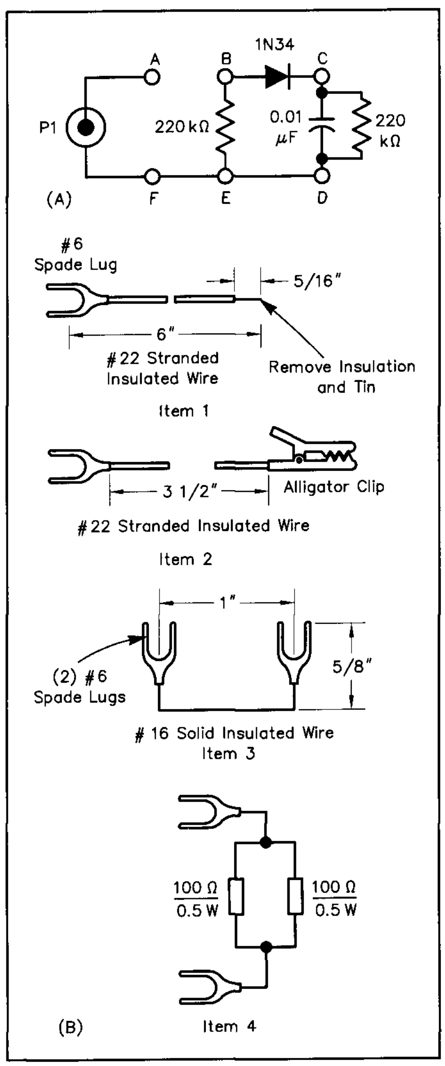


Figure 1—Schematic of the Gadget (A). Terminals A through F are binding posts. P1 is a PL-259 coaxial plug. Be sure to use a *germanium* diode (such as the 1N34 specified), not a silicon diode. Resistors can be 1/4 or 1/2-W units. Four accessory items are made as shown at B.

Before installing the PL-259, solder a piece of wire to its center pin. Connect the other end of the wire to the red binding post (A) nearest the PL-259. On the bottom of the board, connect the diode, capacitor and resistors to their proper binding posts by means of solder lugs secured to the posts. (See Figure 3.)

In addition to the Gadget, prepare four accessory items: three short lengths of wire configured as shown in Figure 1B, and a 50-Ω load resistor. These accessories come in handy when using the Gadget to make various measurements.

In Use

Before you start playing with the Gadget/SWR Analyzer combination, measure the Analyzer's RF-output voltage. I recommend you perform this step before conducting any tests in which the SWR Analyzer's output voltage is part of an equation. (I've discovered that it takes about 18 minutes after turn-on for the RF-output voltage to become steady.) Like others, I've also learned it's best to use an ac-operated supply for the Analyzer because by the time the RF-output voltage settles down, the battery shows signs of tiring.

To measure the Analyzer's RF-output voltage, connect the Gadget's PL-259 to the SWR Analyzer's output connector and attach a digital voltmeter (DVM) to binding posts C and D. (See Figure 4.) A short piece of wire (Item 3) connects post A to post B. The DVM reads the dc voltage produced by the rectified RF output voltage of the analyzer presented across the 200-kΩ resistor. In my case, I recorded 0.43 V at

[1]Notes appear on page 35.

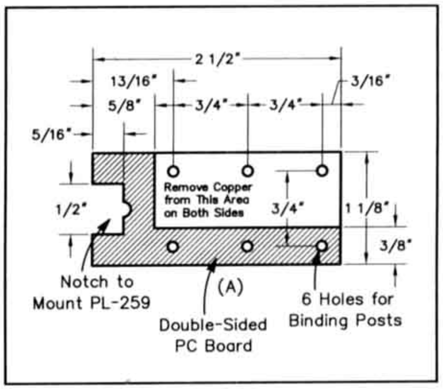


Figure 2—Physical layout of the Gadget; dimensions are not critical. Remove a "lazy-L" area of foil from *both* sides of a piece of double-sided PC board. A ½-inch-wide notch at one end of the board accepts the PL-259 shell, which is soldered to the foil on both sides of the board. Six holes accept the binding posts (Radio Shack #274-661).

1.8 MHz. Because the Analyzer's output voltage varies with frequency, I measured and recorded its output voltage at the bottom end of each of the HF amateur bands. I did this at 35, 40, 45, 50 and 55 MHz, too, for use when checking filters.

While in Florida at my winter hideaway, I became aware of the Sun's effect on the Gadget's 1N34 diode. In bright sunlight and with a temperature of 82°, the output of the diode changed considerably as it became warmer. I recommend providing some means of shading the Gadget from sunlight and drafts.

Checking RF Chokes

I needed two RF chokes to separate a dc relay voltage from RF, both being supplied to a remote point by a coaxial feed line. In my junk box, I'd found some chokes with unknown properties. I removed the jumper wire between Gadget posts A and B and inserted a likely candidate (a two-pie choke) in its place. What an eye opener! At 4 MHz, the meter read 0.09 V, at 5 MHz it was down to 0.004 V and at 5.795 MHz the reading was zero. That choke was okay for use above 7 MHz, but certainly wouldn't perform well on the 80 or 160-meter bands. The lower the voltage at and above the frequency of interest, the better the RF choke is suited for use at those frequencies.

A Super Dipper

I needed to dip a circuit that used a very small toroid inductor. The toroid was nestled among other components and I couldn't get the dip-meter attachment close enough to the toroid to obtain a dip. The Gadget came to the rescue. I was able to thread a length of wire (Accessory Item 1) through the small toroid. I attached the wire's spade lug to post A and the tinned end to post E (ground). The dip at 7.048 MHz was phenomenal! From full scale down to zero! Now I've no need for a dip meter and its plug-in coils, and no need to hunt for the dip meter's oscillator signal in the receiver for an accurate confirmation of the resonant frequency. The SWR Analyzer does the trick.

Measuring Inductance

I needed three switchable matching networks for my "invisible" 27-foot sloper. The low end of that antenna is only seven feet off the ground and terminated in a small feed-through insulator attached to a metal awning. Access to the feed end is easy. Sorry to say, I haven't the expertise to calculate the component values I needed for the matching networks. So I breadboarded an **L** network using a rotary inductor and a variable capacitor. With the help of my SWR Analyzer, in less than three minutes I obtained an SWR of 1 at 14.025 MHz. Carefully, I removed the inductor—making sure I didn't disturb its setting—and transferred it to the workbench. There I connected a mica capacitor of known value (100 pF) in parallel with the inductor. Then, with the Gadget, I dipped this circuit and calculated the value of L using the following formula:

$$L = \frac{1}{0.00003948 \times f^2 \times C} \qquad \text{(Eq 1)}$$

where:

L = Inductance in microhenries
f = Analyzer frequency readout in megahertz
C = Capacitance in picofarads

I consulted the *The ARRL Handbook* and calculated the number of turns of #18 wire I'd need on the 1⁵⁄₁₆-inch-diameter form I had. I repeated this procedure for 18 and 21 MHz. I'm happy to report that after assembling the components, I have a three-band antenna with an SWR of better than 1.4:1. Sure, the Gadget doesn't read the inductance value directly, but with the help of an inexpensive calculator, determining the inductance is a snap!

Checking Tuned-Circuit Q

To check the Q of a tuned circuit, disconnect the 220-kΩ resistor connected between binding posts B and E. Connect the tuned circuit under test between posts B and E, with a single loop of wire (use Item 1) passing through the toroid core (to create a one-turn loop). Attach a DVM to Gadget posts C and D. Measure the resonant-frequency output voltage ($V_{OUT(RES)}$) and the voltage at the high and low-frequency 3-dB points ($V_{OUT(RES)} \times 0.707$). Then, calculate the tuned circuit's Q by using the equation

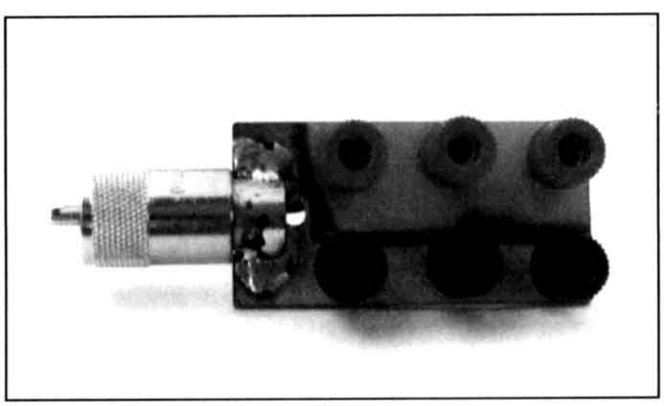
$$Q = \frac{f_{RES}}{f_{HIGH} - f_{LOW}} \qquad \text{(Eq 2)}$$

where

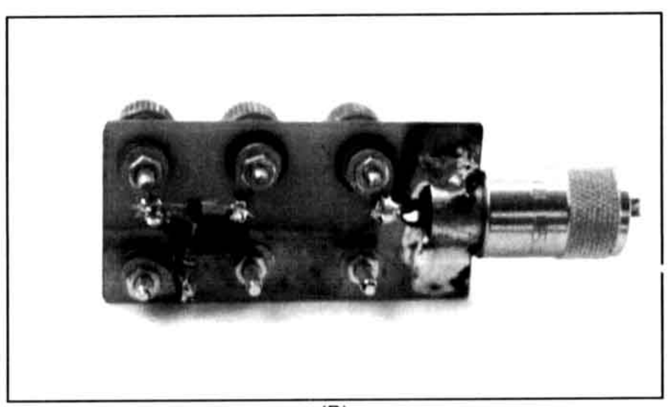
f_{RES} = Resonant frequency
f_{HIGH} = –3 dB high frequency
f_{LOW} = –3 dB low frequency

Other Uses

I've used the Gadget/SWR Analyzer combination to find lossy coaxial cable and a bad low-pass filter. To check a piece of coax, connect a 50-Ω, ¼-W resistor between the Gadget's posts A and F. This resistor is the load resistance for the cable under test. Connect a shorting jumper between Gadget posts A and B and attach your DVM to posts C and D. With the Gadget



(A)



(B)

Figure 3—At (A), the top side of the Gadget. Three red binding posts are mounted on the *nonfoil* section of the board. Three black binding posts are secured to the *foil* area. Beneath the board, (B), the diode, resistor and capacitor are secured to the binding posts by means of solder lugs. The red binding post nearest the PL-259 connector connects to the center conductor of the coaxial plug.

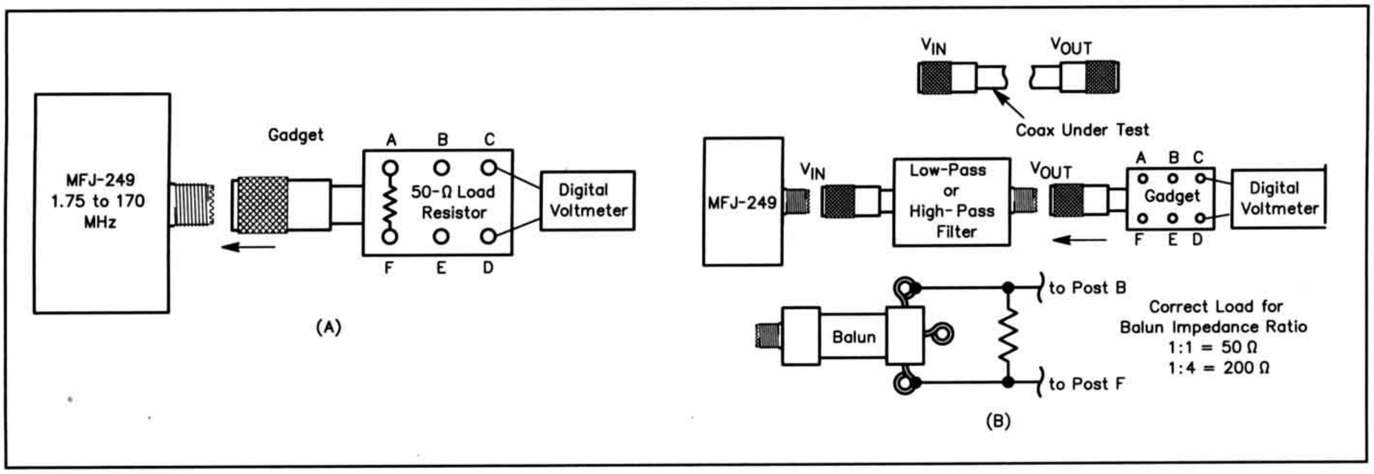


Figure 4—At (A), measuring the output of the antenna analyzer across a 50-Ω resistor at the test frequency. A jumper wire is needed between posts A and B, with a digital voltmeter connected between posts C and D. At B, a few ideas on how to measure coaxial-cable loss and the characteristics of low-pass and high-pass filters and baluns. Be sure to terminate the load end of the balun with a resistor of the proper value. At some time, you're sure to need one or more adapters (such as a double-female coaxial connector) to make required equipment interconnections.

attached directly to the SWR Analyzer, record the Analyzer's output voltage; this is V_{IN}. Because the RF-output voltage is frequency dependent, also record the measurement frequency. (I was mostly interested in the frequencies between 3.6 and 21 MHz.) Next, connect the Gadget to one end of the line under test and attach the SWR Analyzer to the other end of the line. Set the Analyzer to the frequency of interest. (Before proceeding, be sure the SWR is 1:1) Record the voltage at the frequency of interest and label it V_{OUT}. To calculate the line loss in decibels, use the following formulas:

$$\text{Loss (dB)} = 20 \log \frac{V_{IN}}{V_{OUT}}$$

$$\text{and } 10 \log \frac{P_{IN}}{P_{OUT}} \qquad \text{(Eq 3)}$$

where

$$P = \frac{E^2}{R} \qquad P_{IN} = \frac{{V_{IN}}^2}{50} \qquad P_{OUT} = \frac{{V_{OUT}}^2}{50} \qquad \text{(Eq 4-6)}$$

The percentage of loss is calculated by

$$\text{Loss}(\%) = \frac{P_{IN} - P_{OUT}}{\frac{P_{IN}}{100}} \qquad \text{(Eq 7)}$$

Use the same approach to check your low-pass filter, substituting the filter for the coaxial cable section. By sweeping the Analyzer frequency higher (past 30 MHz), the upper cut-off frequency of the filter is indicated by the DVM voltage reading dipping toward zero.

If rare DX never comes back to you and everyone else beats you out in the pileups, it may be time to check your feed line! The instruments to perform this task are within easy reach.

Summary

It's apparent that the SWR Analyzer has found a home in the shacks of many hams. Over time, hams are sure to find many other ways of putting this useful piece of gear to work.

Fred "Fritz" Hauff, W3NZ, was born and raised in Germany. At 19, with a 400-word English vocabulary, his journeyman toolmaker's diploma, a few greenbacks and a strong desire to expand and explore, Fritz emigrated to the US. Five and a half years later, he became a US citizen—the next day, he was at the FCC Field Office taking his General class test! First licensed as W3GHS, Fritz upgraded to Extra class in 1968 and received his present call sign, W3NZ. That same year, Fritz was invited to join the FOC (First-Class Operator's Club). In 1971, he received 5-Band DXCC award #71.

In October 1995, Fritz and his wife, Jean, celebrated their 60th wedding anniversary. (Jean used to be W3INL. Their son, Richard, formerly held W3SCY.) At age 75, Fritz learned to type and now generates his CW primarily via a keyboard. To keep fit, he swims, hikes and climbs his 50-foot tower! You can contact Fritz at 437 S Lewis Rd, Royersford, PA 19468.

Notes

[1] Dave M. Barton, AF6S, "An Accurate Dip Meter Using the MFJ-249 SWR Analyzer," *QST*, Nov 1993, pp 45-46.

[2] A PC board for this project is available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269, tel 847-836-9148 (voice and fax). Price: $3 plus $1.50 shipping for up to four boards. Visa and MasterCard accepted with a $3 service charge.

Strays

SOFTWARE FOR NEW FCC RF HAZARD STANDARDS

◊ As a result of the new FCC ruling that will require some amateurs to look at their stations' RF-exposure levels, Brian Beezley, K6STI, is making available, at no cost, a special version of *AO Antenna Optimizer* software that calculates electric and magnetic near fields. NF.EXE requires a 386 or better, math coprocessor, VGA, and DOS 3.0 or later.

You can download the 245K NF/ZIP file from **ftp://n6nd.nosc.mil**. You may copy this free software for others, as long as no charge is involved and the software is used for Amateur Radio purposes only. After you unzip the file, see READ.ME for more information. Please carefully read the section of accuracy limitations of near-field modeling. The software includes extensive documentation and 92 example antenna files.

Brian is providing this free software without support. Please don't contact him with questions.

NEW HAM SOFTWARE AVAILABLE

◊ Some interesting new software is available on the ARRL HIRAM BBS (860-594-0306) and via ftp from **oak.oakland.edu/pub/hamradio/bbs/programs**. Written by Roger Hedin, SM3GSJ, the software draws Great Circle maps for any location (specified by either grid square or latitude and longitude), and allows the user to set the level of detail to be shown and the range to be drawn. It can also plot beam headings.

FORT MYERS (FLORIDA) ARC WWW PAGE

◊ The Fort Myers ARC now has a WWW page at **http://www.naples.net/~nfn04694/fmarc.html**. It will contain an on-line edition of the club's monthly newsletter and links to other Amateur Radio Web sites. The FMARC Web site was created to help keep the club's many seasonal members in touch with the club, while avoiding the high cost of printing and mailing a traditional hard-copy newsletter.