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QST Issue: Sep 1996
Title: SWR Analyzer Tips, Tricks and Techniques: SWR Analyzer Hints
Author: George Badger, W6TC

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SWR Analyzer Tips, Tricks and Techniques

Hand-held SWR analyzers have become popular tools. Here's how several readers modified their analyzers and put them to work.

In the November 1993 issue of *QST*, ARRL Laboratory Engineer Mike Gruber, WA1SVF, product reviewed the MFJ-249 and MFJ-207 SWR Analyzers. These devices—more popularly known in many circles as *antenna* analyzers—have become about as commonplace a tool in many ham shacks as the digital multimeter. Realizing the analyzer's popularity, we published a call for papers and were quite pleased to receive a number of submissions. In this article and another to be published soon, we present those ideas that made it through our editorial and Lab filters. We hope you'll find them of interest.—*Paul Pagel, N1FB*

SWR ANALYZER HINTS

By George Badger, W6TC, 341 La Mesa Dr, Portola Valley, CA 94028

Line-Cord Isolation

◊ When using internal battery power, my MFJ-249 makes good unambiguous antenna measurements. When it's used with its ac-operated power supply, however, measurements become confused because of the RF path to ground through the power supply and 120-V line. My solution to this problem is to wrap 15 turns of the power-supply lead on a ferrite toroid core. Be sure the toroid ID is large enough so that the dc plug can make 15 turns through the core. Locate the toroid near the dc plug end of the cord.

Balun for Balanced-Load Measurements

When the MFJ-249 is used with a balanced load, hand-capacitance effects make consistent measurements difficult. I solved this problem by making a balun from a short length of RG-174 coaxial cable connected to a PL-259 at the measurement terminal. Ten turns of cable wrapped on a ferrite core make a good current balun that isolates the MFJ-249's cabinet from the balanced load. Now I can handle the instrument without affecting readings.

Measuring Antenna RF Resistance and Bandwidth

The included RF resistance meter brings the MFJ-259 a cut above the MFJ-249, but it has a small handicap. It's desirable to be able to measure antenna bandwidth at a wide range of load resistances. The RF resistance meter in the MFJ-259 (which basically measures the voltage across the load) gives a true indication of SWR bandwidth *but only if the load is 50 Ω*. To overcome this restriction, I modified my MFJ-249 by changing one of the 50-Ω resistors in the RF bridge circuit to a 500-Ω potentiometer. I calibrated the dial so that when the bridge is balanced (minimum SWR), the resistance can be read by the potentiometer's dial calibration. Then, by simply rocking the **FREQUENCY** control between the 2:1 SWR points (or whatever SWR criteria for bandwidth you choose), you can measure the bandwidth of the device under test. The bridge-balancing resistor must be a miniature potentiometer. I used an Allen Bradley Type W (Model WA2G056S501UA). I brought the potentiometer's shaft through the cabinet's bottom, added legs to the cabinet and installed a calibrated bezel. I calibrated the bezel using external resistors of various values. Because of the potentiometer's capacitance and inductance, I found that the bridge circuit does not work well in the VHF range. This modification is, therefore, primarily useful below 30 MHz.

Remote Indication of SWR Pattern

A particularly welcome characteristic of the MFJ-249 is that the self-excited oscillator frequency *is* affected by the load. Further, the oscillator signal is easily identified because of the modulation generated by the frequency counter gate. When working with open-wire transmission line, it's easy to determine the position of the voltage nodes. Excite the transmission line with the MFJ-249, listen to the signal in a receiver and walk alongside the transmission line while touching it with your hand or a metal rod. (This is the modern-day version of the tried-and-true neon-bulb indicator.) At voltage nodes, there'll be no frequency change when you touch the line. At current nodes, however, the tone you hear in the receiver will change substantially, and is roughly proportional to SWR. Be sure to use a receiver with a BFO. When out in the field far from the shack, I use my Sony ICF 7600D portable shortwave radio.

Of course, this method for detecting voltage nodes has the additional advantage of not putting a strong signal on the air.

Antenna Voltage/Current Node Detection

When working with wire antennas such as loops, watching the '249's SWR indication or listening to the tone shift in a receiver can also be used to determine the location of current maxima (maximum radiation) on the antenna.

I use a long, thin aluminum tube and touch the antenna at various points. Where the voltage is a minimum, there is no effect on SWR or audio tone, whereas at voltage maxima, the SWR increases and the frequency shifts. Thus, the positions of maximum radiation (and maximum voltage) on various shapes of wire antennas, including loops and elevated radials, is easily determined.

An RF Source for the Antennascope

Years ago, Bill Scherer, W2AEF, developed the famous Antennascope.[1] The RF power output of an MFJ-249 is sufficient to drive my Antennascope to a useful level provided the Antennascope null indicator is changed to a 50-μA meter (I use a Radio Shack 270-1754).[2] With this combination, antenna resistance at resonance from a few ohms to 1 kΩ is measured easily.

A Simple, Low-Cost Way to Measure Antenna Resistance

Another way to determine antenna resistance at resonance with the '249 is to use a resistor connected in parallel, or in series, with the load. First, find the minimum SWR, then place a 100-Ω resistor in parallel with the load. If the SWR *decreases,* you know that the load is *greater* than 50 Ω. Now, put the 100-Ω resistance *in series* with the load, and the SWR should *increase,* confirming that the resistance of the load is greater than 50 Ω. Calculate the antenna resistance by *multiplying* 50 Ω by the original SWR. Conversely, when the 100-Ω resistor is placed across the load (in shunt) and the SWR *increases,* you know that the load resistance is *less than* 50 Ω. In this case, the antenna resistance is determined by simply *dividing* 50 Ω by the original SWR.

An alternate—and perhaps more accurate—way to make this measurement is to use a small 50-Ω potentiometer in series or in parallel with the load. If the load is less than 50 Ω, put the variable resistor in series with the load and adjust the frequency and the resistor for a match. Measure the variable resistor with an ohmmeter. The load resistance is then equal to 50 Ω minus the ohmmeter reading.

The same procedure can be used if the load is more than 50 Ω by placing a variable 1-kΩ resistor across the load. Adjust the resistor for a match, measure the resistor's value, and calculate the load resistance, using the parallel resistance formula.

160-Meter Linear Amplifier "Design"

I have an excellent homebrew linear amplifier for 10 to 80 meters. I became interested in the "top band" and decided to modify my amplifier to work on 160 meters. Rather than play with a lot of algebra, I decided to "design" the modification the quick-and-easy way with my MFJ-249. The amplifier works well on 80 meters and it's the closest band to 160, so I decided to use that band as a model. I tuned-up the amplifier into a dummy load on 80 meters. I turned off all voltages (including the heater voltage), removed the dummy load, and placed a miniature variable resistor (with short leads) from the power amplifier tube plate to ground. Then, I connected my MFJ-249 (set for 80 meters) to the linear amplifier output connector and adjusted the variable resistance for a match. The value of the resistance is equal to the impedance the power tube likes to see for optimum performance.

To switch the amplifier to 160 meters, I use vacuum relays to introduce more capacitance and inductance into the tuned circuit. To maintain circuit Q, I added two capacitors to the output pi-network—one at the input, the other at output—to increase the capacitance values to approximately twice that used on 80 meters. I set the amplifier **TUNE** and **LOAD** controls to mid-scale. Then, I experimentally wound a stack of two-inch diameter 43-μ toroids with #10 Teflon wire. I added turns and experimentally adjusted for resonance on 160 meters. With the 160-meter components in place, I found that the SWR was not unity. So, I made small adjustments to the two capacitors and the number of turns on the toroid stack for a perfect match on the MFJ-249. After soldering everything in place, I removed the pot and switched to 160 meters. Presto! With no further adjustment, I had full power into the load on 160! It was the quickest RF circuit "design" I've ever accomplished! Now I have a legal-limit amplifier on 160 meters with the investment of just a few minutes "design" time.

Antenna Modeling

With my newly modified linear working perfectly, I wanted a good antenna for 160 meters. I have a suburban lot, so a full-size antenna is out of the question. I wanted vertical polarization with no radials. I'd had good luck with full-wavelength loops, so I decided to devise a way to fit a 550-foot loop on my property.

I modeled the 160-meter antenna at 150 MHz on the dining room table. The impedance measurements weren't accurate, of course. I couldn't model impedance because of ground effects. The voltage nodes, however, were determined accurately by touching the antenna model and watching the SWR meter. When I touched voltage nodes (points of maximum radiation), the meter didn't flicker. At current nodes (voltage maxima), however, there was clear indication on the meter. I modeled the bottom half of the loop, simulating a closed loop radial in the crawl space under my house. The top-half of the loop I modeled as though it were folded over the top of my tower like a two-wire folded monopole. I adjusted the shape of the overall loop until the MFJ-249 indicated maximum current (maximum radiation), in both wires at the folded monopole halfway up the tower. This placed the current maximum at the optimum position, vertically polarized and in the clear. The input impedance of the model at the tower base measured about 45 Ω. (It turned out to be about 55 Ω when I erected the antenna.)

After erecting the real antenna, I matched the feed line to the feedpoint using a toroidal transformer, experimentally adjusting the turns ratio for a 1:1 match, again using my MFJ-249. The antenna efficiency appears to be high because the bandwidth is narrow (for a loop) and because my antenna seems to get out very well. A motor-driven roller coil opposite the feedpoint tunes the loop over the band.

With my new 160-meter antenna and amplifier, I worked 19 countries in my first four hours on the band!

Strong Nearby Signals Confuse the MFJ-249

During my work on the 160-meter antenna, I learned that sometimes the MFJ-249 reads erratically when working with large antennas. This erratic operation can be caused by interference from nearby broadcast stations or other strong local RF sources. My solution to this dilemma is to use the MFJ-249 to make initial adjustments, then make the final adjustments using my transceiver and a conventional SWR meter. The usual SWR meter is a relatively high-power device and therefore not easily affected by strong signals.

Adjusting a Tetrode Passive-Input Circuit

I modified my 8877 linear to use one of the inexpensive Svetlana tetrodes.[3] I like the 50-Ω passive-input circuit used with tetrodes because it eliminates nine tuned circuits and presents a flat load to my transceiver. On 10 meters, the input capacitance of the 4CX1600B tetrode across the 50-Ω input resistor causes the input SWR to be excessive. With a mock-up and my MFJ-249, I found that adjusting lead lengths in series with the 50-Ω resistor compensates for the tetrode input capacitance. I also found, almost by accident, that the lead from the linear RF input connector to the grid should be routed *through the center* of the 50-Ω Globar resistor. Passing the wire through the center of the resistor evidently forms a sort of lossy coax line, reducing lumped reactances. With this configuration, I adjusted the lead lengths in my mock-up until the SWR on 10 meters was 1. The reactance of the leads disappears on the other bands, so the input SWR on all bands (including 12, 17 and 30 meters) is a very satisfying 1:1. With my MFJ-249, this task was a pleasure!

Checking Open-Wire-Line RF Balance

I check for balance on open-wire lines by touching a screwdriver to each side of the transmission line. If the circuit is balanced, touching the screwdriver to each side of the

[1]Wilfred Scherer, W2AEF, "Building and Using the Antennascope," *CQ,* Sep 1950, pp 13-18 and 59-63.

[2]Although the meter is sold as a 0 to 15-V dc voltmeter, the meter movement is a 50-μA unit.—*Ed.*

[3]See *QST Congratulates...* George Badger, W6TC, as President of Svetlana Electron Devices, *QST,* Jul 1995, p 116.

transmission line causes the SWR to rise the same amount on either side. I use the same technique for determining the balance of voltage baluns.

Using the MFJ-249 for Antenna-Pattern Measurements

The MFJ-249 is handy as a signal source for rotary antenna pattern measurements. The oscillator is reasonably stable and there is enough signal so that, with a short dipole, good pattern measurements can be made. Put the MFJ-249 into a tree, as high as possible, several wavelengths from the antenna you're measuring. I found that wind affected the measurement, so I wrapped the MFJ-249 in an old sweater—that solved the problem.

Battery operation makes the MFJ-249 particularly useful because pattern measurements can be affected by wires feeding power to the oscillator. A word to the wise: The MFJ-249 eats batteries! [See "An Alternate Power Pack" following.—*Ed.*] I measured the total battery current at 175 mA. With the counter disconnected, only 75 mA is consumed. I modified the MFJ-249 by cutting the +5-V trace to the counter and added a jumper to disconnect the counter and digital readout from the battery supply. Now my batteries last longer.

In-Circuit Frequency Measurement of Toroidal Tuned Circuits

The resonant frequency of a toroidal tuned circuit is difficult to measure with a dip meter because there is little field outside of the core. Using the MFJ-249, you can measure the resonant frequency by threading one turn through the toroid. Connect one end of the loop to the coax outer conductor (ground) and connect the other end of the loop through a 100-Ω resistor to the center conductor. The SWR meter should read 2, and should deflect upward at the resonant frequency. If it doesn't, put another loop through the toroid and connect it to a sensitive RF indicator. I use my field-strength meter (any sensitive RF meter will do). The RF indicator meter peaks as you tune the MFJ-249 through the toroid-tuned circuit resonant frequency.

MORE SENSITIVITY FOR THE MFJ-249

By Wayne W. Cooper, AG4R, 1113 Beverly Dr, Alexandria, VA 22302-2423

◊ I recently purchased an MFJ-249 SWR Analyzer and found that its otherwise excellent frequency counter was not sensitive enough to pick up the various oscillator check points that I wanted to measure in my transceiver.

Some time ago, I'd built an RF amplifier test module using a Motorola hybrid wideband amplifier (MHW591)[4]. This device produces an average gain of 35 dB over the frequency range of 1 to 250 MHz and requires a 13-V supply (see Figure 1A). Inserting the amplifier in line with the FC input of the '249 did the trick! If a little less gain will suffice, the low-noise RF amplifier I described in Hints and Kinks[5] can also perk up the frequency counter.

I've also used my MFJ-249 to check the quality of other ham-shack components such as coaxial switches and relays. All you need is a noninductive 50-Ω load and some interconnecting coax (see Figure 1B). You should know the characteristics of your 50-Ω load before you start checking other equipment. For instance, my 1-kW load requires a series capacitor to present an SWR of 1 from 10 to 50 MHz. By testing the equipment at frequencies of 10 MHz and up, you'll be able to evaluate overall performance and spot trouble should it arise.

CHECKING A FILTER'S CUT-OFF FREQUENCY

By Wayne W. Cooper, AG4R, 1113 Beverly Dr, Alexandria, VA 22302-2423

◊ You can use your MFJ SWR Analyzer to check a 50-Ω filter's cut-off frequency. Connect a 50-Ω dummy load to one end of the filter and the Analyzer to the other end. Within the filter's passband, you'll get an SWR of 1 and an SWR increase beyond the filter's upper and lower cut-off frequencies. How closely the SWR approaches 1 depends on the filter losses. The sharpness of the rise in SWR beyond the filter cut-off points gives you an indication of the filter quality.

Although this filter-checking method isn't as good as having a spectrum analyzer(!), it does provide a reasonable bench check of filters used in amateur equipment.

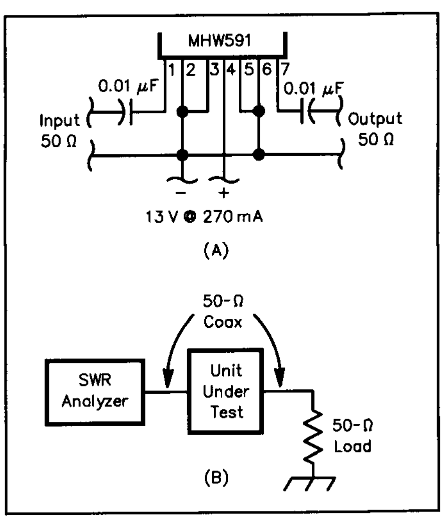


Figure 1—There's not much to do to get the broadband amplifier (A) going! Just add three capacitors, a power source and you're up and running. At B, coupling your SWR analyzer through the device under test to a known load can help you identify troublespots and evaluate overall performance equipment.

MFJ-247 HINTS

By Dave Miller, NZ9E, 7462 Lawler Ave, Niles, IL 60714-3108

◊ I have an early MFJ-247 that exhibited two problems right from the start. First, the LCD intermittently locked up when bandswitching. I found that the display would unlock and return to normal if I quickly turned the power on and off. I installed an SPST toggle switch on the front panel directly below the **GATE** pushbutton and wired it in series with the positive battery lead to allow easy on/off switching when that lockup occurs. I believe MFJ has a factory fix for this problem (a replacement band-selector switch), but adding the toggle switch was easier and less expensive for me than returning the unit to MFJ.

Stock MFJ-247s don't provide continuous coverage of the HF bands. So, directly to the left of the main tuning knob, I installed another SPST switch. It switches in a 75-pF ceramic capacitor to fill in the band-coverage voids. This capacitor can be selected any time you need to extend the frequency coverage below the analyzer's normal range; this provides additional coverage and better centering within any band. Connect one lead of the capacitor to the main tuning capacitor's *high side* and the other end to one of the switch terminals. The other switch terminal goes to circuit ground via the shortest path. Because my '247 has the built-in LCD frequency counter, no recalibration was needed; the counter simply reads the RF oscillator output.

My '247 doesn't cover the 2-meter band, so I've coupled an MFJ-208 analyzer (140 to 160-MHz) to the '247 by using an aluminum plate spanning the rear of each unit; I call it a "docking adapter." (See Figure 2.) It's a 6 1/4-inch-wide, 4 3/4-inch-high, 1/8-inch-thick black aluminum plate that holds the two units together via a single #8 sheet metal screw in the back of each analyzer.

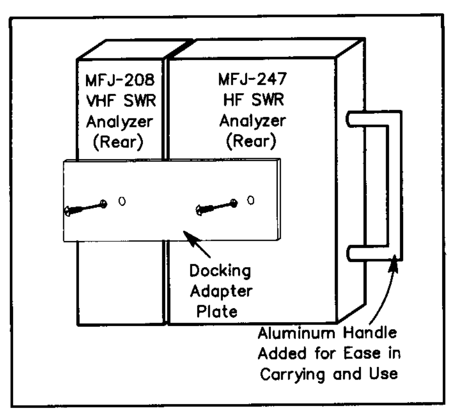


Figure 2—NZ9E's docking adapter and carry handle allow easy transport of his MFJ-247 and MFJ-208.

[4]The MHW591 is available from Newark Electronics; it costs about $50. A less-expensive replacement to consider is one of the Motorola MWA-series amplifiers; those units have a gain of about 15 dB and cost about $10 each (Newark's minimum order is $25). Contact your local Newark representative (tel 800-463-9275) or Newark Electronics, 4801 N Ravenswood Ave, Chicago, IL 60640-4496, tel 312-784-5100; fax 312-907-5217.

[5]Wayne Cooper, AG4R, "A One-Transistor RF Amplifier," Hints and Kinks, *QST*, Aug 1984, pp 46-47.

This makes the docking adapter plate easy to remove when the batteries in either analyzer need replacing. The **FREQ OUT** connector of the '208 loops to the **FREQ IN** connector of the '247 via a short length of coaxial cable for reading the frequency of the '208 on the B input of the '247's counter. (The counter in the '247 operates well beyond 2 meters even though the analyzer itself doesn't.) For carrying ease, I attached a husky handle to the left side of the '247.

A QRP ACCESSORY PACK

By John Roessler, KB6WB, 392 N Westwind Dr, El Cajon, CA 92020

◊ I'm a QRP enthusiast and do some homebrewing. I needed something to check the crystals I use and to align a QRP rig that I'd built. I own an MFJ-259 SWR Analyzer and decided I'd combine the ancillary equipment I needed in one box that I dubbed the Accessory Pack (see Figures 3 and 4). The Pack contains an eight-position, switchable 81-dB attenuator[6] for receiver alignment; four crystal sockets to accommodate different-size crystal holders for crystal checks, and a 50-Ω **L** pad for testing and tuning stubs and transmission lines and checking transmitter alignment using an MFJ SWR Analyzer's frequency counter.

CW Offset

For QRP transmitter CW-offset calibration, connect a UHF **T** to the transmitter's RF output jack. Using short pieces of coaxial cable, connect one side of the **T** to a 50-Ω dummy load and the other side to J4. Connect J6 to the analyzer's **Frequency Counter** input. Note: The transmitter's output must be reduced to an acceptable level at the input to the SWR analyzer—see the analyzer's operating manual. (The resistive network between J4 and J6 can handle transmitter power-output levels of up to 5 W.) Then you can key the transmitter and check and adjust the CW offset using the frequency counter, comparing the received and transmitted frequencies.

Crystal Checking

Connect the analyzer to J3 of the Accessory Pack using a double-male coaxial adapter. Carefully adjust the **TUNE** knob around the frequency of the crystal under

[6] A suitable attenuator is described in The 1995 *ARRL Handbook* on pages 26.40 to 26.41. Materials for a PC-board enclosure are available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269, tel 847-836-9148 (voice and fax).

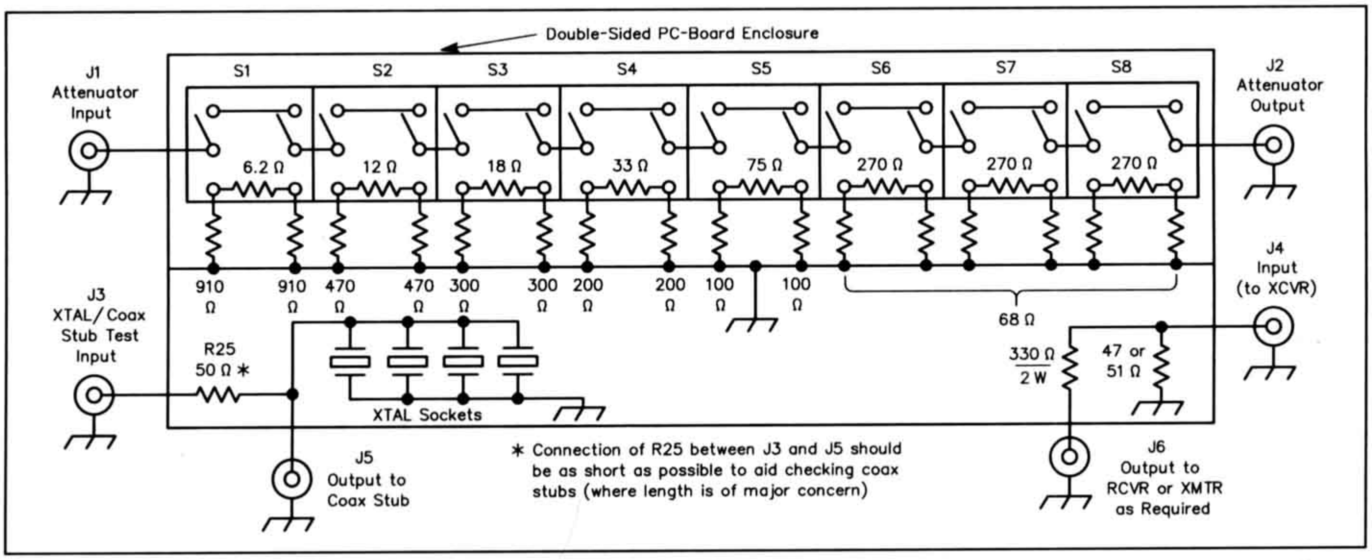
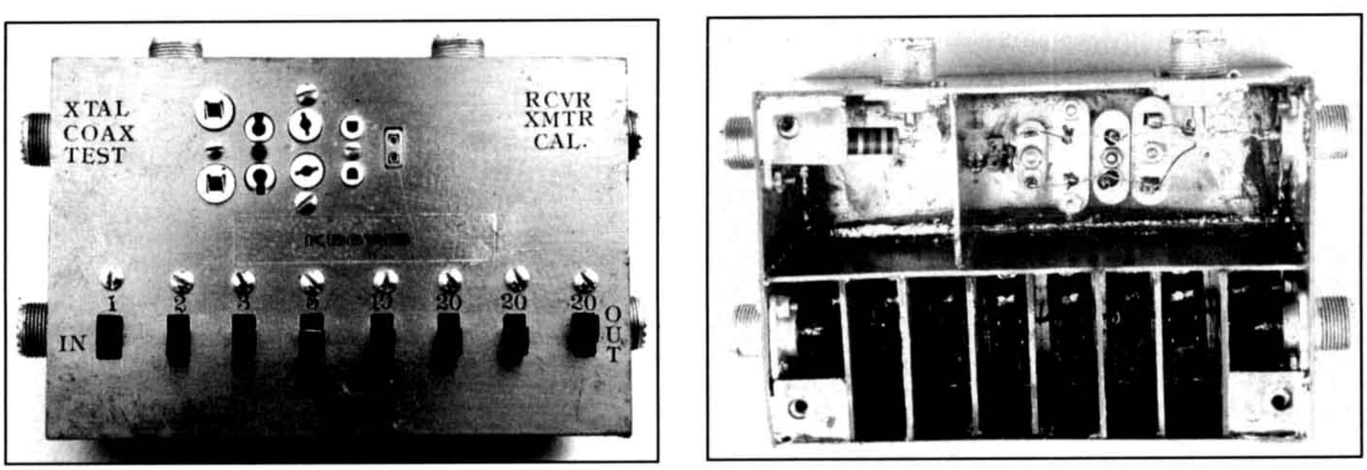


Figure 3—Schematic of KB6WB's QRP Accessory Pack. J1-J6, SO-239; J1—attenuator input; J2—attenuator output; J3—input for crystal and coaxial stub testing. Attach J3 to the MFJ-249 through a double-male coaxial connector adapter. J4 is the input to the resistive network used for transceiver checking. Interconnect J2 and J4 for receiver testing. For transmitter testing, connect J4 to the MFJ-249's **Frequency Counter** connector. J5 is the coaxial stub-test output; connect the stub under test to this jack. J6, the resistive network output, is connected to a receiver or transmitter for their specific checks. Resistors are 1/4-W, 5%-tolerance units except for the 330-Ω resistor, which is a 2-W unit. Remember: The attenuator is a low-power unit! S1-S8 are DPDT slide switches.



(A) (B)

Figure 4—KB6WB's QRP Accessory Pack is constructed in a 2½×4×6-inch enclosure made of double-sided PC board. In the top (A) view, you can see the four crystal sockets that accept crystals in different-size holders. The attenuator section switches are below. The bottom/inside view of the Pack (B) reveals the shielding between the attenuator sections and the compartments.

test until you note a dip in the SWR reading. At that point, the crystal is oscillating. Slow and careful tuning is required to avoid bypassing the crystal's resonant frequency. I installed a larger knob on my MFJ-259 to allow for better tuning control.

Checking Coaxial Stubs and Transmission Lines

Connect the SWR analyzer to J3 using a double-male coaxial adapter. Attach the coax under test to J5. Follow the instructions in the analyzer's operating manual under "Testing and Tuning Stubs and Transmission Lines."

AN ETHERNET ANALYZER

By Austin McCaskill, Jr, AA0QX, 115 Manlyn Dr, Kirkwood, MO 63122

◊ Several months ago, our computer network went down. It's a Novell network connected with thin Ethernet cable. We often had intermittent cabling and connection problems that were hard to locate.

Once, while I was trying to locate a bad connector, it occurred to me that thin Ethernet uses 50-Ω termination—in essence, a "dummy load." I borrowed a friend's MFJ analyzer and it enabled us to locate the bad connection immediately, without bringing down the network and disconnecting all users. All we did was connect the analyzer to the **T** connector. Because the cable is terminated at both ends, the resistance reads as 25 Ω at 10 MHz (an SWR of 2). If the analyzer's needle jumps when we wiggle the connector, we know it's bad. Occasionally we'll have to disconnect the **T** connector to determine which connector is the problem one. In that event, the SWR drops to 1, as the impedance is now 50 Ω.

Commercial-grade network analyzers cost $1500 to $4500. Continuity testers require that the network be brought down to test a connection since a break in either end could still show continuity. The MFJ analyzer proved so successful a test instrument, our office purchased one. (Now I can tune my antennas with much less trouble, too!)

LOCATING SHORTED COAX CONNECTORS

By Joe Wonoski, N1KHB, 1121 West Lake Ave, Guilford, CT 06437

◊ Shortly after purchasing my MFJ-259, I decided to build the $^1/_3$-λ antenna described in the October 1993 issue of *QST*.[7] With everything ready, I thought that I should do my best to keep our "friend" Murphy out of the picture by doing at least a cursory dc check of the system *before* applying RF. Sure enough! A prepared length of coax purchased for the project had a dead dc short from center conductor to shield. I reasoned that the most likely culprit was one of the commercially installed crimp connectors and not the coax itself. I had a digital multimeter, but its resolution was insufficient to detect which end of the coax was shorted. Yet I did not want to arbitrarily remove one connector because (Murphy "assisting" again) a 50% chance existed of needlessly cutting off the unshorted connector.

So, I thought for a moment and decided that this 100-foot length of coax was a $^1/_2$-λ stub at *some* frequency and that the cable should act like an ac low impedance at or near that frequency and a higher impedance at other frequencies. Enter the antenna analyzer. I connected the coax to the MFJ-259 and swept frequencies, finding zero impedance readings *everywhere* in the frequency range of the analyzer. I marked that end of the cable as highly suspect. Then, as a doublecheck, I connected the other end of the coax to the analyzer. Sure enough, at *periodic* frequency intervals, the antenna R meter showed a relatively sharp dip, then rose again as frequency continued to change—proof that the first connector contained the short. I learned three lessons: (1) transmission-line theory does work; (2) Murphy is a constant companion in all aspects of life and (3) the SWR analyzer (and other instruments) can have unexpected uses.

[7]Andrew S. Griffith, W4ULD, "The $^1/_3$-Wavelength Multiband Dipole," *QST*, Sep 1993, pp 33-35.

AN ALTERNATE POWER PACK

By Walter D. Davis, WA6ODQ, 3130 Elliott St, San Diego, CA 92106-1322

◊ I couldn't survive without my MFJ-249 SWR Analyzer! Early on, I realized that the original battery pack didn't last long enough for me. Although the battery wasn't fully discharged, the voltage dropped sufficiently to make the instrument unusable. Most of the time I used an external 12-V dc ac-operated supply to power the analyzer, but this doesn't allow use away from ac power. So, I removed the original 6-AA-cell battery pack and replaced it with a 10-cell NiCd battery pack. This pack consists of a series-connected group of two 4-cell packs and one 2-cell pack, the cells in each pack connected in series. I attached a pair of wires to the battery pack, fed the wires out of the '249 case and terminated them in a Molex connector. This allows me to charge the battery pack without having to open the '249's case. Now I can use the '249 for several weeks before recharging is necessary, and I don't have to open the case, saving wear and tear on the case's screw holes.

DETERMINING COMPLEX IMPEDANCE

By John Stanley, K4ERO, 8495 Highway 157, Rising Fawn, GA 30738

◊ I've owned three Autek Research RF-1s, having left the other two with overseas hams that I visited. In my opinion, any SWR analyzer that does not give R ± *j*X information is limited in that you don't have a good idea of how to improve the match without that information and you must fall back to cut and try.

On page 10 of a later Autek instruction sheet, there's a formula for determining

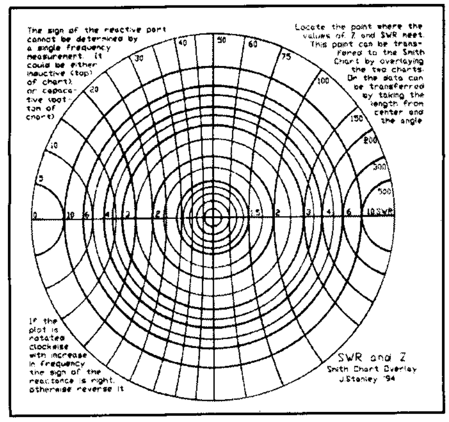


Figure 5—K4ERO devised a Smith Chart overlay to graphically convert SWR and Z measurements to the R ± *j*X format. It can be used with instruments such as the Autek RF-1 to provide complex impedance information for matching purposes. A full-size, transparent overlay is available from the ARRL (see text and Note 7).

R ± *j*X, which was not with the first unit I bought. Therefore, I'd devised my own system of finding R ± *j*X by using SWR and Z. The SWR/Z chart of Figure 5[8] is the same size as a standard Smith Chart. When the SWR and Z have been located (and the sign ambiguity resolved), the SWR/Z chart can be laid over the Smith Chart and the R and *j*X read or matched.

I prefer my graphical method to that of using the formula because it gives you a picture of what's happening and an idea of the accuracy to be expected from the measurements. The formula is simple enough, but it's accompanied by a number of warnings about when it will deliver inaccurate results. With the graphical method, the approximate accuracy to be expected is quite obvious. If an "error circle" is mentally placed around the points SWR and Z, you can quickly see what possible values of R and X can be expected. Of course, for those not familiar with the use of the Smith Chart, the formula is probably the way to go. The graphical method also has finite accuracy, but it is probably as accurate as the measurements themselves, and would not, therefore, give a false idea of having greater accuracy than is justified.

Editor's Note

We hope you'll find these tips useful. We've got a few more scheduled for an upcoming issue.

Bibliography

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

[8]Full-size SWR/Z transparent overlays are available postpaid from the ARRL for $2 for members and $4 for nonmembers. Address your request for the STANLEY SWR/Z OVERLAY to the Technical Department Secretary, ARRL, 225 Main St, Newington, CT 06111.