An Accurate Dip Meter Using the MFJ-249 SWR Analyzer

Here's how to add dip-meter performance to several popular antenna-system testers.

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The *dip meter* (often called *grid-dip meter* because vacuum tubes formerly implemented its function) has long been a de rigueur tool in amateur RF work. Not only is a dip meter useful for finding a "tank" circuit's resonant frequency, or an unwanted parasitic resonance, it can also be used to find the electrical length of a transmission line. Modern dip meters are battery operated, making them easy to take up a tower.

But dip meters have always had two major drawbacks. First, they generally aren't very accurate. You're lucky to guess a 14-MHz frequency within 200 kHz on an analog dipper dial, and when you dip a resonant circuit, the dipper's oscillator shifts frequency ("pulls"). You can minimize pulling by minimizing coupling, but this results in a barely discernible dip.

Hams have traditionally augmented dipper operation by using their receivers as calibrated frequency meters. But finding a warbly grid dipper's signal can be tedious, especially when it pulls during the dipping process. The slow tuning rates of modern receivers make this worse—and who wants to take a receiver up the tower, anyway? You could modify your dip meter, giving it a buffered oscillator output for a small frequency counter. That would be fine on the bench, but cumbersome up a tower.

MFJ has inadvertently provided part of the answer. The MFJ-249 HF/VHF SWR Analyzer contains nearly everything you need for accurate dipping: a bandswitched variable-frequency oscillator with built-in frequency counter covering 1.8 to 170 MHz, and an SWR meter. By adding the simple plug-in probe I'll describe, you can use an MFJ-249 as a dip meter![1]

The MFJ-249 as Dipper

Let's look at how the MFJ-249 operates. If you connect a 50-ohm resistor to the MFJ-249, it indicates a 1:1 SWR at all frequencies (ideally, anyway). If you put an inductor in series or parallel with that resistor, the indicated SWR can be anywhere between 1:1 and infinity, depending on the inductor's value, parasitic capacitance, and the measurement frequency.

Suppose you connect an inductor that reads between 2:1 and 5:1 in the frequency range you wish to use. If you couple that inductor to the inductor in a resonant tank circuit, energy extracted by the circuit under test reduces the SWR reading.[2] (Anything that removes energy from a badly matched RF circuit improves the match, lowering the SWR.) So as you tune through the tank's resonant frequency, the meter reading dips—like a dip meter.

With a coil in parallel with a 50-ohm resistor, the SWR decreases as you tune upward in frequency, eventually approaching 1:1. As you tune downward, the SWR approaches infinity. For dipping, the resting meter indication must not be at either extreme.

You can try this yourself with the coils from a conventional dip meter. The coils on my Heathkit Model HD-1250 dip meter have phono plugs. I tested the method with them and a Tektronix through-line 50-ohm terminator for the resistor, via UHF-to-BNC and BNC-to-phono adapters.

The green Heath coil (3 µH) covers 1.8 to 9 MHz. The blue coil (0.7 µH) covers 6.5 to 32 MHz, and the violet coil (0.16 µH) extends from 26 to 90 MHz. But the little 100- to 250-MHz Heath coil did not couple sufficiently. (It doesn't work well on Heath's dip meter, either.)

A Wide-Range Dipper Coil

I was unhappy with the limited frequency range of each coil (although I've had to put up with this dip meter "feature" for years). Unlike its role in a dip meter, the coil doesn't serve as part of the test oscillator in the MFJ-249 system, so one might expect its value to be uncritical. I set up an *Excel* spreadsheet to show the SWR over the whole frequency range, tried various circuits and parts values, and soon discovered a way to cover the entire range with *one* coil!

The circuit, Fig 1, uses a 0.7-µH coil (this value is not critical), a 1000-pF capacitor and two ¼-watt carbon-composition or metal-film resistors (15 and 180 ohms). As *Excel* predicted, the MFJ-249 SWR indication stays almost constant (about 3.6) over the entire frequency range when the probe isn't coupled to a resonant tank. (The probe's track on a 50-ohm Smith Chart is a circle centered on the middle of the chart.)

[1]Notes appear on page 46.

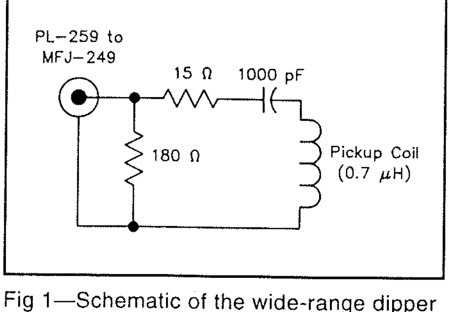

Fig 1—Schematic of the wide-range dipper probe for the MFJ-249 HF/VHF SWR Analyzer.

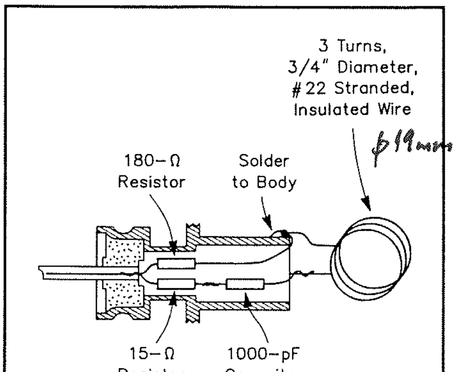

Fig 2—How the probe goes together.

I feared that coupling might be insufficient for a solid dip at the ends of this super-wide frequency range, but that fear proved unfounded. I built the circuit in and on a PL-259 connector, and its dips were weaker than those of my Heath dip meter only at the very low end of my range of interest—below 80 meters. An open-ended length of RG-58 coax with a small loop at the near end gave a strong dip at its 130-MHz quarter-wave resonance. You could increase the coil inductance to favor the low end of the range a bit more—presumably at the price of reduced performance at the high end.

Another worry was that the MFJ-249's oscillator might pull. It does, slightly, but you can always read the frequency at the bottom of a dip. As a plus, the MFJ-249 never exhibits the "stretch, then break" phenomenon of a dip meter.

How to Dip a Dipole

You can dip a coax-fed dipole by plugging it right into the MFJ-249. Sometimes, though—when setting up parasitic elements in a beam antenna, for instance—you may want to dip a dipole that isn't coax-fed. According to dip-meter lore, you can dip a dipole by inserting a small pickup loop at its center. The problem is that the loop's inductance detunes the dipole.

To avoid detuning the dipole, the loop itself must be resonant at roughly the dipole's resonance frequency. You can accomplish this with either a series or parallel trimmer capacitor (Fig A). The loaded Q of the loop must be low, so small errors in its tuning won't affect the dipole being measured. For low Q in the parallel connection, the inductor's reactance must be higher than the dipole's radiation resistance—say, over 100 ohms. If you choose the series circuit, make the inductor's reactance less than 50 ohms.

Either way, you must tune the loop when it is *not* connected to the dipole. The series circuit requires a removable shorting strap for tuning. For optimum coupling, the pickup-loop diameter should be similar to your dip meter's coil diameter. At 2 meters, a hairpin loop ½ inch long and ¾ inch wide works fine in the parallel circuit. At lower frequencies, you can use multiturn loops to bring the inductance into range.

Form the loop and its trimmer capacitor to fit the dipole's terminals.

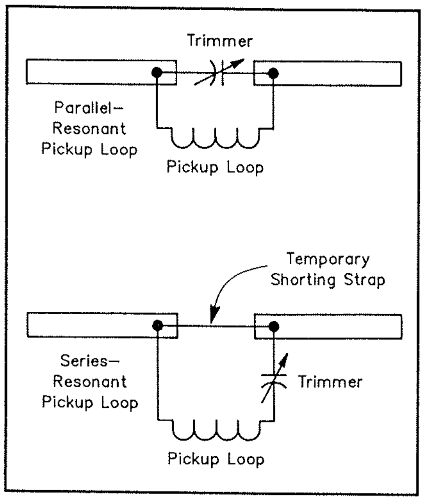

Fig A—If you can't plug your antenna into the MFJ-249 to check its resonance by measuring its SWR, the MFJ-249/dipper can help—if you equip the antenna under test with a resonant coupling loop as shown here.

Remove it and adjust the trimmer for resonance at the test frequency. Then reinstall it and dip the antenna.

The low Q and initial tuning guarantee low error, but you can do even better. Follow the above procedure and record the dipole's resonance frequency. Then remove the pickup loop and readjust it to exactly the same frequency. Now reinstall the loop on the dipole and dip once more.—*AF6S*

Constructing the Probe

Fig 2 shows the physical construction of my add-on gimmick. I twisted and soldered the two resistors' wires to each other, poked them into a PL-259's pin from the inside, and soldered them to the pin. I folded the 180-ohm resistor's other lead back against the outside of the connector's body and soldered it. Then I cut the 15-ohm resistor's remaining lead and both leads of an axial-lead 1000-pF ceramic capacitor to ¼ inch, soldered the capacitor to the resistor, and soldered an 8-inch length of #22 insulated, stranded hook-up wire to the capacitor.

I slipped heat-shrink tubing over the resistor and capacitor and wound the wire three times around my finger before soldering its other end to the PL-259's body. Three small strips of tape and a tie-wrap completed the assembly.

If you have the parts in stock, you can build the gimmick in less time than you've spent reading this. That effort will get you a better dip meter than any you can buy. It's portable, battery-operated, accurate and completely self-contained, and you never have to change coils. With it, you even avoid the necessity of carrying another instrument up the tower, because you can pull off the probe and use the MFJ-249 in its intended role as an SWR meter.

So if you've been coveting the MFJ-249 but couldn't quite justify its expense, now you can. And sell that old dip meter while it's still worth something!

Notes

[1]The technique and coupling probe described also work with the '249's superseded MFJ-247 sibling, and with the AEA SWR-121 HF Antenna Analyst. The MFJ-247 and -249 simulate the *feel* of a classical dip-meter somewhat more closely than the AEA device because they include tuning knobs and analog SWR meters, but all provide a useful dip meter *function* when used with Dave Barton's probe.—*Ed.*

[2]This requires magnetic coupling between the dipper and the circuit under test. This is easy to achieve merely by bringing the dipper coil close to the coil in the circuit under test if that coil is a solenoidal or hairpin inductor. Dipping a *toroidal* tuned circuit is problematic, however, because a toroidal coil has little external field and therefore affords insufficient coupling for a good dip. As shown in Fig 69 on page 2-35 of the 1993 *ARRL Handbook*, link coupling can allow you to dip a toroidal tuned circuit—but see Charles J. (W7XC) Michaels's "Beware the One-Turn Loop!" (Technical Correspondence, *QST*, Oct 1986, p 50) for a caution on how this technique can introduce error.—*Ed.* QST

Strays

◊ As part of its Field Day preparation, San Angelo (Texas) ARC Activities Chairman Dave Dobbins, KB5UBW (l) requested Mayor Dick Funk (center) to proclaim Amateur Radio Week, and at the urging of the city's emergency management division, presented club president Glenn Miller, AA5PK, with a plaque in appreciation of the club's "many hours of volunteer service to the citizens of San Angelo."—*thanks, ARRL West Gulf Division Assistant Director Noel Johnson, KE5NO*