Autek Research RF5 VHF Analyst

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What can only be described as a long late spring afternoon of gripping tension finally concluded as my wife, Debbie, drove up the driveway. Years of coaxing and persuasion had finally paid off. My wife had taken her first Amateur Radio exam, and she was beaming with that special infectious pride that comes only with accomplishment! Later that week, the FCC granted her N1YYB. So began the saga!

Debbie's initial contacts were on simplex. Later that spring, however, she surprised me by showing up on the local repeater one morning as I was on my way to work. "W1DG, this is N1YYB calling," she declared with utmost confidence. Her first repeater contact! That was the good news. The bad news was that our basement was completely flooded (every silver lining has a cloud).

As Debbie gained experience, antennas began sprouting from each of the family vehicles, and 2-meter radios began to proliferate. Complaints about "repeater hogs" and the like soon followed. Yes, I had created a monster! I soon began to realize I needed a way to properly tune all those antennas. True, the radios all *seemed* to be working at maximum rated output, but the desire to optimize performance kept gnawing at me.

Why Tune?

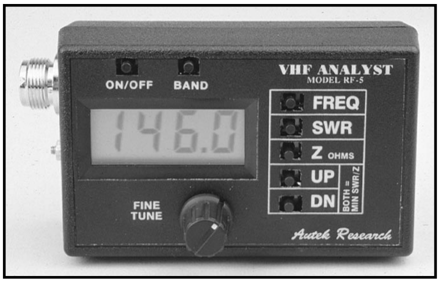
The effect of SWR is to *increase* the existing loss in a transmission line. Since line loss tends to increase with frequency, things can be quite different on 2 meters than on HF. True, most mobile installations require only relatively short transmission lines, but these lines are typically smaller diameter and more flexible than the premium cable I might otherwise select for non-mobile VHF use. The convenience of the smaller-diameter line often has its price in terms of loss, aggravated by SWR. If it's severe enough, a mismatch can even cause a transmitter to fold back its output power.

My goal was to optimize my $^5/_8$-wavelength 2-meter mobile antenna so I could hit a distant repeater. Besides, I just love experimenting with such things.

If only there was a VHF/UHF RF Analyst similar to the Autek RF1 (see "Product Review," *QST* May 1995). My prayers were soon answered by the RF5!

Features and Functions:

The Autek RF5 looks nearly identical to its HF cousin, the RF1. Both have a black plastic enclosure ($4\times2^3/_8$ inches) that easily and conveniently fits in one hand (the RF5 weighs just under 8 ounces); both feature a $1^{11}/_{16}\times^5/_8$-inch LCD display window with $^1/_2$-inch high numerals. Directly below the RF5 display is a **FINE TUNE** knob. Above the case are two buttons, **ON/OFF** and **BAND**. The latter selects one of the three available bands. To the right of the display is a vertical row of five buttons to select display information: **FREQ**, **SWR**, and **Z OHMS**. The bottom two buttons, **UP** and **DN**, provide coarse frequency selection. An SO-239 connector and a ground terminal protrude from the left side of the RF5.



> **BOTTOM LINE**
>
> The Autek RF5 is a handy and reasonably accurate device that can serve a variety of testing and measurement functions at VHF and UHF frequencies. Accuracy suffers as you move higher in frequency, however.

With its large numerals, the display was easy to see under a variety of light conditions and angles, but it did fade a bit when the bottom of the RF5 was tilted away from me. Maximum contrast occurred when I tilted the top of the RF5 away from me.

A common 9 V battery powers the RF5, and battery replacement is real snap. The unit can be powered externally from a 9 V source, but the manual warns that it will not work properly at 12 V. At a nominal 50 mA current draw, the manual indicates the RF5 is good for 6 to 12 hours of typical intermittent use with a standard alkaline battery. An automatic shut-off feature turns off the unit after it's been idle for 15 or 20 minutes. This function can be disabled.

The nine-page instruction manual (actually a set of five sheets stapled in the upper left corner) not only covers operation and use of the RF5 but numerous measurement techniques and graphs for such things as line loss and characteristic impedance (more about these later). The manual is adequate, but it could benefit from some professional editing. Larger charts and graphs also would help.

Performance

Operating the RF5 is pretty intuitive. First, connect your feed line to the SO-239. Then, press the buttons as required to turn on the unit, select a frequency, and pick the meter display (either SWR or Z) that you want. It's really quite simple.

Typical operation starts by tapping the **ON/OFF** button. The display first flashes the firmware version (ours was 5.1) before automatically entering the frequency mode. The RF5 always initializes with the second lowest frequency band—conveniently, it's the one that covers 2 meters. If you need another band, press the **BAND** button. The unit features three "bands" that cover the following approximate frequency ranges: 35 to 86 MHz; 132 to 300 MHz; and 255 to 532 MHz. Note there is some overlap.

Say, for example, that you want to tune your antenna to 147.600 MHz (which just happens to be our local repeater input). To do this, you first select the correct band. The display indicates approximately 135 MHz with the **FINE TUNE** control centered. Use the **UP** and **DN** buttons to get within striking distance (in my case, it was 147.8 MHz after about 15 taps on the **UP** button, but holding the **UP** or **DN** button lets you change frequency more rapidly) From there, a slight adjustment of the **FINE TUNE** control puts you right on the money.

You now have a choice between measuring SWR or Z (in ohms) by tapping the appropriate button. Tapping **FREQ** will return you to the frequency mode. Pressing two or three of these buttons simultaneously causes the RF5 to cycle between the modes selected. This can be a handy feature for some types of measurements and awkward situations, such as when you're up on a tower. If all you desire is a typical SWR measurement at 147.600 MHz, simply tap the SWR button, and the display switches from frequency to SWR.

Other typical measurement possibilities include varying the frequency while in the SWR or Z mode. You can, for example, sweep through a range of frequencies to

Table 2—Autek Research RF5 VHF Analyst

Manufacturer's claimed specifications	*Measured in ARRL Lab*
Frequency range: Not specified.	Band 1, 34-85 MHz; Band 2, 133-300 MHz; Band 3, 255-531 MHz.
Impedance accuracy: At 50 MHz, better than 10% from 10 to 600 Ω; better than 5% from 30 to 400 Ω.	See Table 3.
SWR accuracy: Generally accurate to 10% below 3:1 and 15% up to 6:1.	See Table 4.
Power requirements: 6-12 V dc.	50 mA max with 9 V battery.

find the point of minimum SWR. Like most microprocessor-based instruments, the RF5 includes some neat features not normally found in non-microprocessor counterparts. In the case of the RF5, one such feature is the *Instant SWR Mode*—something that wasn't available on the RF1. This mode provides fast, easy scanning of an entire band for minimum SWR or impedance. All you have to do is select the appropriate band, then press both the **UP** and **DN** buttons. Within a few seconds, the frequency of minimum SWR (or minimum Z) appears. Only manual fine tuning is required. I found this to be a valuable feature, and it's one that's sure to please.

The Instant SWR Mode does have some limitations. To save scan time, the RF5 only searches 120 frequencies across each band instead of the 240 available via the **UP** and **DN** buttons. This increases the possibility that a minimum frequency might be missed. Less smoothing of SWR and Z is also used. Nonetheless, I consistently obtained successful results using this feature.

A Word on Accuracy

Autek says the RF1 and the RF5 are the only analysts that measure *true* impedance, because they look at the current through the load as well as the voltage across the load. The company also points out that the RF5 uses 1% components in "critical areas" and high-quality microwave diodes in the RF head, plus digital correction. But, let's face it. One can only expect so much from an instrument in this price class. Autek says the unit should work pretty accurately at 50 MHz, and our ARRL Lab tests bore out that assertion. On higher frequencies, however, users will encounter greater errors in measuring impedance at, say, 440 MHz, where stray capacitance, lead length, and other factors can affect measurement accuracy. In fact, this was one of the factors that prevented us from making accurate impedance measurements with reactive loads on 2 meters and on 70 cm in the ARRL Lab (see Table 3). The RF5 can be used to determine the frequency of minimum impedance on the higher frequencies, however.

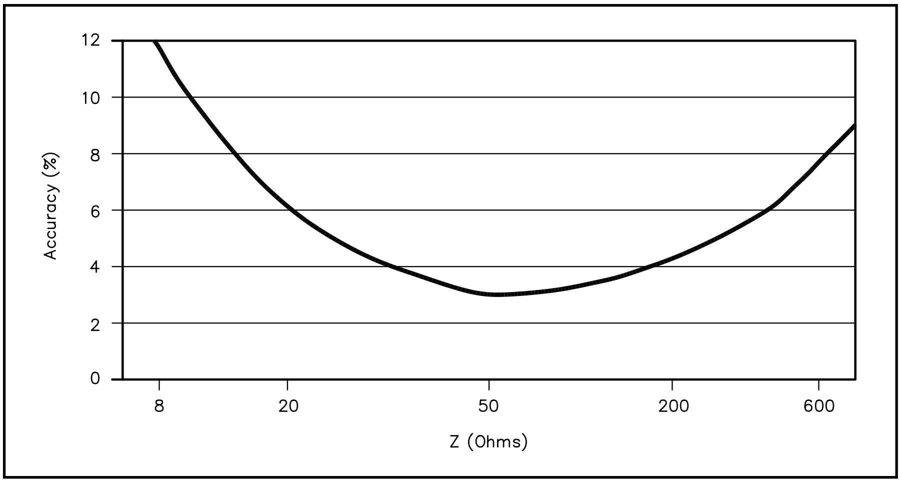


Figure 4—Here's a plot of impedance accuracy for the Autek RF5, as provided by the manufacturer. The plot shows the accuracy you can expect at 50 MHz with negligible lead length and an impedance below 100 Ω. At higher impedances, the meter's output capacitance makes the impedance appear smaller.

As Figure 4 shows, at 50 MHz, you can expect pretty reasonable impedance-measurement accuracy at 50 Ω. At higher impedances, the meter's output capacitance makes the impedance appear smaller. We found the RF5 to be pretty consistent on a 50-Ω termination up through 450 MHz, however (see Table 3).

Autek says the same holds true for SWR measurements on 2 meters and—especially—on 70 cm (see Table 4). As the manual points out, at frequencies of 440 MHz or higher, "any SWR less than 1.5 is usually considered good, and 2.0 is usually 'acceptable.'"

The bottom line is that in terms of impedance, the RF5 provides acceptable accuracy on the lower portions of its coverage range, but stray reactances must be taken into account in determining impedance at higher frequencies.

More than Meets the Eye

The RF5 manual also describes a plethora of other uses for this device—essentially, creative applications of standard SWR or impedance measurements. In addition to antenna length adjustments based on SWR, you'll find techniques for

• *Feed line loss measurements*: The RF5 manual offers two methods to determine cable loss. The first method, using SWR, seemed to offer consistent results. The second method, using a measured impedance, was found to be inaccurate in some cases. This method uses an equation that assumes low cable loss, so cables that have more than a few dB of loss might yield inaccurate results—despite the manufacturer's note in the manual that this method is the more accurate of the two. This method also involves the measurement of low impedances, but the RF5's accuracy degrades significantly below 20 Ω (see Figure 4), so this method appears to be a poor match for this instrument.

• *Total feed line loss at any SWR*: This procedure is similar to the feed line loss measurement, above. First, measure the SWR of the unterminated feed line, then measure the SWR at the transmitter end with the antenna connected. The manual provides a convenient graph to determine the percentage of power reaching the antenna using these two measurements.

• *Finding a short or open in cable*: This technique requires you to look up or mea-

Table 3—
Impedance (Z) Measurement Accuracy: RF5 vs HP-8753/HP-4815A

Frequency (MHz)	*Load Z (Ω)*	*RF5 Z (Ω)*	*HP-8753 Z (Ω)*
52	5	6	7
	25	24	25
	50	50	49
	200	176	172
Frequency (MHz)	*Load Z (Ω)*	*RF5 Z (Ω)*	*HP-4815A Z (Ω)*
52	52+*j*25	60	58
	46–*j*42	62	64
80	50	52	n/a
146	50	53	n/a
222	50	56	n/a
275	50	62	n/a
420	50	54	n/a
440	50	57	n/a
530	50	86	n/a

Table 4—SWR accuracy of the Autek RF5

Load	*Freq (MHz)*	*Measured SWR*
25 Ω resistive (calculated SWR 2:1)	52	1.7:1
	146	1.6:1
	435	1.8:1
50 Ω resistive (calculated SWR 1:1)	52	1:1
	146	1:1
	435	1:1
100 Ω resistive (calculated SWR 2:1)	52	1.8:1
	146	1.9:1
	435	1.9:1

sure the velocity factor in an equivalent piece of cable. You then measure the frequency difference between impedance nulls and enter these data into an equation.

The RF5 also will permit you to determine the characteristic impedance and velocity factor of an unknown piece of coaxial cable, check the input and output impedance of baluns and other RF transformers, make $^1/_2$ and $^1/_4$-wavelength lines (eg, for phased arrays or for matching stubs), and measure trap impedance. You can even use the RF5 to tune an antenna tuner without transmitting, and it can fill in as a sine wave generator. In this last application, however, note that the RF5 VCOs, while shielded and buffered, are not synthesized and are noisy and subject to drift. These limitations—plus a lack of modulation capability, output level control, and 100 kHz resolution on VHF and UHF—tend to make me want to consider alternative signal generators. In a pinch, however, the RF5 may work.

The manual finishes up with discussions on accuracy, measurements above 300 MHz, determining R+*j*X, and a small table of cable data. There is quite a bit of info here.

In the Shack and Field

I made the first RF5 test run with my 3-element 6-meter beam and 50 feet of RG-8 mini coax. First, I connected the RF5 to the transmitter end of the feed line inside the shack and tried the Instant SWR Mode. I made several passes and found good consistency among them. The frequency ranged between 50.1 and 50.44 MHz, even with the relatively broad bandwidth of this antenna system.

Next, I checked the SWR at the target frequency of 50.4 MHz. It measured a nice 1.0—no surprise, since I had already tuned it using a conventional SWR meter. I had often thought about replacing that mini coax with something a bit heavier and less lossy; Now I had the opportunity to actually measure how bad it was. I grabbed a ladder from the garage and climbed onto the roof. With the antenna disconnected, I measured an SWR of 3.7 in the shack. A careful look at the graph in the manual revealed the loss to be about 2.3 dB—a bit higher than I had expected, and more incentive to change the cable. The bottom line here is that this technique would have been impossible using a conventional SWR instrument.

Next I tackled Debbie's mag mounted $^5/_8$-wavelength 2-meter vertical. The Instant SWR Mode showed the resonant frequency to be around 144.0 MHz, a bit low for FM repeater work. The whip was already as far down as possible, so pruning was required. I removed about $^3/_4$ inch and tried again. (I had about an inch of adjustment without cutting the antenna.) The resonant frequency came up about halfway to the target. Again I trimmed off about $^3/_4$ inch. This time, the RF5 showed the SWR to be 1.0 at 147 MHz, with minimal or no variation between 146 and 148 MHz. This is where most of the local repeaters can be found, so decided to call it quits.

Wish List and Overall Impressions

Perhaps first and foremost on my wish list would be HF capability, with an ability to measure capacitance and inductance—sort of an RF1 and RF5 rolled into one. A protective case and a convenient strap or tether point for tower work would probably tie for second place. Rounding out my list would be a wall power cube and a better manual. Autek says most 9 V dc adapters work fine with the RF5 (the manual recommends two Radio Shack units). A carrying case will be available soon. During my time with the RF5, I came to regard it as indispensable for VHF and UHF antenna tuning. I like its quality, fit and finish, convenient size and affordable price.

The RF5 was just what the doctor ordered for the new Tech in our family. And I've already received two calls from friends wanting to stop by and "show" me their new 2-meter mobile antennas. Maybe one of them has a pump I can borrow for the basement.

Manufacturer: Autek Research, Box 8772, Madeira Beach, FL 33738; tel 813-886-9515. Manufacturer's suggested retail price, VHF Analyst Model RF5, $230.

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