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QST Editor

MFJ-249 and MFJ-207 SWR Analyzers

Reviewed by Mike Gruber, WA1SVF

It was late last fall when we finally moved into our new home in the country. Its big yard and many tall trees meant lots of antenna potential—the kind I could only dream about as an apartment dweller. My enthusiasm was quickly chilled by what seemed to be an eternity of winter snowfalls and bad weather.

Not being one to admit to procrastination, I simply passed it off as rotten luck. As winter dragged on, though, strange visions of dipoles and rhombics continued to grow and dance in my head. "This springtime," I vowed, "the land will yield a particularly fine crop of new antennas."

As my upcoming antenna projects grew more and more ambitious, I began to consider the purchase of a new MFJ SWR Analyzer. Such a device can be a big timesaver when pruning a new antenna crop. For example, it can be used to determine an antenna's SWR, resonant frequency, or feed-point impedance at a particular frequency. For years I'd used my transmitter and SWR bridge to cut antennas to length, but an SWR analyzer is a lot more convenient to use. Besides, why transmit annoying test signals if you don't have to? (The SWR Analyzers transmit a signal, but it's only a few milliwatts.) And the analyzer solves the age-old problem of tuning a new antenna that initially appears to resonate outside the ham bands.

Fortunately, as they say, nothing lasts forever, and even my luck changed when the Product Review editor dropped by my office about a week later. Without hesitation I accepted his invitation to evaluate two MFJ SWR Analyzers!

The SWR Analyzers

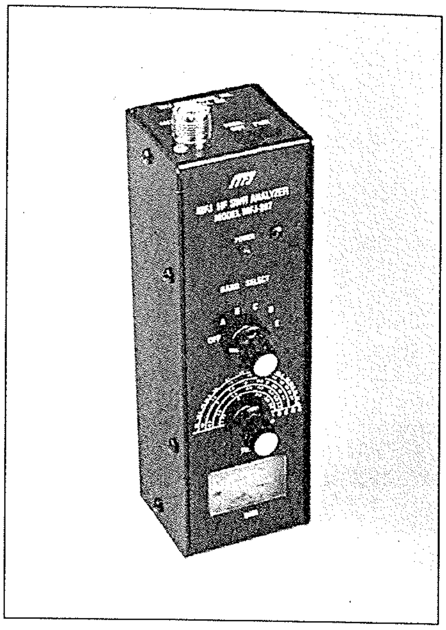
A number of such products are currently available on the market from several manufacturers. There are many different models to choose from, with a wide range of specifications and prices.

For this review, we chose two products from the MFJ line—the top-of-the-line MFJ-249 and the low-end MFJ-207. The '207 covers 1.8 to 30 MHz, and the '249 offers extended coverage to 170 MHz. Their small size, minimal weight and battery-powered circuitry make them ideal take-anywhere instruments for use on rooftops, towers, Field Day or backpacking. On the minus side, I didn't particularly like having to disassemble the cabinet (eight screws) to install or change the batteries.

When Put to Work

I installed two dipoles, one for 20 meters and one for 6 meters, as my first two test antennas. They had been intentionally made too long, resonating well below 14 and 50 MHz. Using the '249 and '207, I attempted to trim the 20-meter antenna for the CW portion of the band to a point just above 14.025 MHz. I used the MFJ-249 to trim the 6-meter dipole for final resonance at about 50.4 MHz. Table 1 shows the results.

MFJ-249 SWR Analyzer


MFJ-207 SWR Analyzer

The SWR Analyzers helped tremendously in trimming my test dipoles. Although there are differences in features and operation between the units tested, the basic drill goes like this: Connect your feed line to the SWR Analyzer's antenna input (an SO-239 connector). Set the Analyzer's band switch to the right range. Adjust the Analyzer's tuning control to the desired frequency, and read the SWR from the built-in meter. You can tune the SWR Analyzer's frequency up and down to determine your antenna's SWR-versus-frequency curve and then shorten (or lengthen) the antenna until the SWR is minimal at the desired frequency.

In adjusting the test dipoles, I was able to quickly determine the SWR at my target frequency. Next, I quickly determined the antenna's resonant frequency as well—even when that frequency occurred *outside* an amateur band. This feature was helpful in estimating the length of wire to trim from the antenna for the next pass.

The MFJ-249

The top-of-the-line MFJ-249 quickly became my favorite. It differs from the '207 in that it incorporates a frequency counter with an LCD display, and offers VHF coverage to 170 MHz. I found the counter to be a real time saver when reading or setting the '249's frequency. As an added bonus, the counter has an input jack for measuring external signals as well. (The MFJ-207 requires the use of your receiver or an external counter to accurately determine its frequency, but more about this later.)

The Bottom Line

MFJ's 249 and 207 SWR Analyzers are handy devices for hams who like to play with antennas. With its built-in frequency counter, the versatile MFJ-249 is a particularly good investment.

The MFJ-249 covers 1.8 to 170 MHz continuously in six bands. The **RANGE** control selects the band; the **TUNE** control adjusts the oscillator to the desired frequency. I found the **TUNE** control somewhat touchy: Small changes in the knob's position result in relatively large frequency changes. When setting specific frequencies, several tries are usually required, and setting a frequency to within 10 kHz or so is not possible. The MFJ-207 shares this characteristic. A reduction drive might help.

The '249's counter made the task of taking measurements much easier than with the MFJ-207. I was able to immediately determine where I was relative to the target frequency. The effects of frequency drift could be negated by observing the counter's display.

The '249's manual is an 18-page booklet. It includes instructions for using of the analyzer and frequency counter and step-by-step procedures to:

- Measure an antenna's SWR at a specified frequency and find the frequency at which the antenna has the lowest SWR.
- Adjust an antenna for minimum SWR.
- Measure the feedpoint resistance of an antenna.

Table 1
Dipole Test Results

20-Meter Dipole

Length per leg	MFJ-249 Resonant freq	MFJ-249 SWR at 14.025	MFJ-207 Resonant freq	MFJ-207 SWR at 14.025	Bird 43 SWR at 14.025
16' 4.25"	13.315	2.9	13.360	2.7	1.99
16' 2.00"	13.505	2.0	13.523	2.2	1.79
15' 11.25"	13.703	1.6	13.719	1.6	1.46
15' 8.00"	13.911	1.5	13.937	1.1	1.15
15' 6.00"	14.108	1.1	14.106	1.1	1.15

6-Meter Dipole

Length per leg	MFJ-249 Resonant freq	MFJ-249 SWR at 50.400	Bird 43 SWR at 50.400
57' 6"	47.220	3.0	2.49
55' 6"	49.080	1.8	2.04
54' 6"	49.838	1.6	1.63
53' 8"	50.552	1.4	1.51

All frequencies are in MHz.

Table 2
MFJ-249 SWR Analyzer

Manufacturer's claimed specifications	*Measured in the ARRL Lab*
Band ranges (MHz): 1.8-4, 4-10, 10-26.2, 26.2-62.5, 62.5-113, 113-170.	Ranges measured with external frequency counter: 1.733-4.021 MHz 3.903-9.982 MHz 9.633-26.108 MHz 25.711-62.740 MHz 61.422-113.838 MHz 112.761-172.932 MHz
Warm-up drift: Not specified.	–14.6 kHz after 15 minutes from a cold start at room temperature (72 °F) at 14 MHz.
Frequency drift with temperature: Not specified.	After adjustment to 14.0 MHz at 72 °F room temperature, the MFJ-249 moved to: 14.057 MHz at 40 °F 13.993 MHz at 90 °F
Output power: Not specified	3.4 mW (max)
Power requirements: 8 to 18 V at 200 mA. MFJ-1312B power supply (optional) or 8 AA alkaline batteries.	190 mA with battery supply

Size: (height, width, depth) 2⅜ × 4 × 6¾ inches; weight, 1.75 lb.

- Test and tune stubs and transmission lines.
- Determine the velocity factor of a transmission line.
- Determine the characteristic impedance of a transmission line.
- Adjust an antenna tuner.
- Adjust amplifier matching networks.
- Test RF transformers.
- Measure inductance and capacitance.
- Measure the resonant frequency of tuned circuits.
- Test RF chokes.

At first glance, the MFJ-249 seemed to have more functions and features than a Swiss Army knife. All of these procedures, however, are actually creative applications of the '249's SWR measurement capability. I found they can be performed easily with a minimum of additional components. Here are some of my impressions of these procedures:

Testing and tuning transmission-line stubs requires only the use of a 50-ohm non-inductive resistor in series with the coax center conductor. The stub's resonant frequencies are determined by tuning the '249 for dips in SWR. If the stub is open at the far end, dips will occur at odd multiples of ¼ wavelength (¼, ¾ etc); if the stub is terminated (shorted), dips will occur at even multiples (½, 1, 1½ etc). I used an unterminated length of RG-8 approximately 22 feet long as my stub. I found a pronounced dip at 7.319 MHz and approximately at odd multiples of that frequency (22.170, 37.039, 51.933 MHz).

You can use other techniques to determine a coaxial cable's velocity factor and characteristic impedance. Following the instructions in the manual, I obtained a velocity factor of 0.65 for a sample of RG-8, which compares very favorably with the published figure of 0.66. (I did find an error in the manual, though. Velocity factor testing with the '249 involves a quarter-wavelength section of transmission line. The equation at the bottom of page 9 is shown as: Velocity Factor = Free space ¼ wavelength ÷ Actual feed line length. It should be Velocity Factor = Actual feedline length ÷ Free space ¼ wavelength.) Using the procedure described for finding characteristic impedance of coaxial cable, my test length of RG-8 measured 54.3 ohms—very close to the published value.

Measuring inductance and capacitance with the MFJ-249 requires the use of known component values. The unknown component is resonated with one of the known values, and the resonant frequency of the resulting L-C circuit is then determined by a 50-ohm resistor and the '249. Although a calculation is required for this procedure, I nonetheless found it fairly simple, easy and quick to perform. Values measured with the MFJ-249 and the ARRL Lab's Q meter agreed closely.

Adjusting an antenna tuner with the MFJ-249 is a real snap. Using a 25-ohm dummy load, I was able to quickly tune a typical commercially available antenna tuner for minimum SWR. Because the MFJ-249 transmits only a low-level signal, this is a great way to reduce unnecessary interference and QRM. You can use the '249 to make a chart of tuner control settings for a variety of frequencies for quicker on-the-air tune-ups.

According to the manual, the '249 can also be used to estimate the loss of 50-ohm feed lines if the losses are between 3 and 10 dB. I tried some line-loss measurements with RG-8 and RG-213. The measurement is simple to perform and results were reasonably close to what I expected from the published figures.

Although it's not described in the manual, you can add a few external parts and use the MFJ-249 as a dip meter. Dave Barton, AF6S, describes how to do it elsewhere in this issue.

The frequency counter in the MFJ-249 is surprisingly good, and MFJ provides an external input so you can use the counter independent of the SWR Analyzer. ARRL Lab testing revealed that its frequency range is 1 Hz to approximately 230 MHz, with a 1-Hz resolution possible. Sensitivity is 200 mV at HF. Its accuracy ranges from 10 Hz at 2 MHz to 700 Hz at 146 MHz, which is more than adequate for most amateur applications.

The MFJ-207

The MFJ-207 is the lowest-priced MFJ SWR Analyzer. It does not include a frequency counter, and it covers 1.75 to 30 MHz in five bands. Coverage is not quite continuous (see Table 3). The **BAND SELECT** switch sets the frequency range, and its **TUNE** control sets the oscillator to the desired frequency.

The **TUNE** control, although calibrated, only serves to provide a rough approximation of the actual frequency. The '207 lacks an integral frequency counter, so the manual describes two options to achieve useful accuracy: 1) Connect an external frequency counter to the phono jack provided for this

Table 3
MFJ-207 SWR Analyzer

Manufacturer's claimed specifications	*Measured in the ARRL Lab*
Band ranges (MHz): A, 1.75-3; B, 3-5; C, 6.5-11.7; D, 11.65-20; E, 18-30.	Ranges measured with external frequency counter: A, 1.735-3.044 MHz; B, 2.984-5.342 MHz; C, 6.402-11.501 MHz; D, 12.019-21.903 MHz; E, 17.393-32.118 MHz
Dial calibration (front-panel markings): 1.75-2.9 MHz (lowest range); 6.5-11 MHz (middle range); 18-33.5 MHz (highest range).	Approximately as specified: 1.771-2.835 MHz (lowest range); 6.445-10.731 MHz (mid range); 17.495-31.766 MHz (highest range)
Warm-up drift: Not specified.	+2.6 kHz after 15 minutes from a cold start at room temperature (72 °F) at 14 MHz.
Frequency drift with temperature: Not specified.	After adjustment to 14.0 MHz at 72 °F room temperature, the MFJ-207 moved to: 14.111 MHz at 40 °F; 14.018 MHz at 90 °F
Output power: Not specified	2.5 mW (max)
Power requirements: MFJ-1312B power supply adapter (optional) or 9-V alkaline battery	36 mA with 9-V battery supply

Size: (height, width, depth) 2⅜ × 2$^{3}/_{16}$ × 7½ inches; weight, 14 oz.

Table 4
SWR Accuracy of MFJ-249 and MFJ-207

Load	*Frequency*	*MFJ-207*	*MFJ-249*
50 ohms resistive (Calculated SWR 1:1)	3.5 MHz	1.0:1	1.0:1
	14.0 MHz	1.0:1	1.0:1
	28.0 MHz	1.0:1	1.0:1
	50.0 MHz	n/a	1.1:1
	144.0 MHz	n/a	1.4:1
25 ohms resistive (Calculated SWR 2:1)	3.5 MHz	1.7:1	2.0:1
	14.0 MHz	1.7:1	2.0:1
	28.0 MHz	1.7:1	2.1:1
	50.0 MHz	n/a	2.2:1
	144.0 MHz	n/a	2.4:1
100 ohms resistive (Calculated SWR 2:1)	3.5 MHz	2.0:1	2.0:1
	14.0 MHz	2.0:1	2.0:1
	28.0 MHz	1.9:1	2.0:1
	50.0 MHz	n/a	2.0:1
	144.0 MHz	n/a	2.0:1
Reactive load, 50 ohms – *j*50 (Calculated SWR, 2.6:1)	3.5 MHz	2.5:1	2.6:1
	14.0 MHz	2.4:1	2.5:1
	28.0 MHz	2.1:1	2.3:1
	50.0 MHz	n/a	2.3:1
	144.0 MHz	n/a	1.7:1
Reactive load, 50 ohms + *j*50 (Calculated SWR, 2.6:1)	3.5 MHz	2.4:1	2.5:1
	14.0 MHz	2.2:1	2.3:1
	28.0 MHz	2.1:1	2.3:1
	50.0 MHz	n/a	2.5:1
	144.0 MHz	n/a	2.4:1

purpose, or 2) zero beat the analyzer's signal with an MF/HF receiver. A general-coverage receiver is advantageous if you need to locate resonance outside the ham bands.

I found tuning the '207 to a specific frequency to be somewhat tricky. Like the '249, relatively small changes in the **TUNE** control produce large changes in the analyzer's frequency. Setting this critical adjustment almost always took several tries. Retuning was frequently required when the '207 drifted outside the receiver's passband or the beat note became a high-pitched squeal.

There are some definite advantages to the MFJ-249, with its built-in counter. I found that locating the '207's signal on my receiver (a Sony ICF-2010) was more time consuming than the using '249 with its built-in frequency counter. With the '207, SWR measurements on the roof or on a tower are more difficult because you need to bring a receiver or frequency counter along. If your receiver or counter aren't portable, you must set the frequency before leaving for the antenna site—and once there, you don't have an accurate way of changing the frequency. You may also suffer errors caused by vibration and drift.

The MFJ-207's eight-page manual is adequate. It describes how to measure an antenna's SWR at a particular frequency, find the frequency at which an antenna has the lowest SWR, adjust an antenna for lowest SWR, and adjust an antenna tuner.

Conclusion

An SWR Analyzer is very handy when working with antennas. I especially like the ability to measure the resonant frequency of an antenna without having to transmit a high-power signal into it. This feature minimizes interference within the amateur bands and provides a noninterfering means to measure SWR outside the amateur bands. The latter can be extremely helpful when estimating the length that must be trimmed from an antenna.

On the minus side, I would prefer less touchy tuning controls and better oscillator stability in each of the units I reviewed. Controlled testing in the ARRL Lab's temperature chamber confirmed that both SWR Analyzers tend to drift in frequency with temperature, particularly as the temperature falls. For example, if you set our MFJ-207 to 14.0 MHz at room temperature in your station and then brought it outside for antenna measurements on a crisp 40° fall day, the frequency would be off by about 100 kHz. The MFJ-249 suffers from temperature drift as well, but it's not as important because you can compensate for drift with the '249's internal frequency counter. See Tables 2 and 3.

Table 4 shows the results of SWR measurements with both units using controlled resistive and reactive loads. The MFJ-249 SWR readings tended to be slightly closer to the calculated SWR values, but both units were easily close enough for useful work.

My favorite is the MFJ-249. I found its built-in frequency counter and extended frequency coverage to be a real plus. In addition, its external counter input and other functions make the '249 a versatile piece of test equipment with many uses around the shack. Although the MFJ-207 does not have a counter, it's a handy, low-cost device for testing and adjusting MF/HF antennas.

As my antenna farm continues to grow, I wonder how I've gotten by without an analyzer for so long. The bottom line is that I have found them to be a big help when working with antennas.

Manufacturer: MFJ Enterprises, Inc, PO Box 494, Mississippi State, MS 39762, tel 1-800-647-1800, fax 601-323-6551. Manufacturer's suggested retail price: MFJ-249, $200; MFJ-207, $80; MFJ-1312B power supply, $13.