Review: The MFJ-225 Graphical Antenna Analyzer
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The MFJ-225 has a back-lit 3” LCD graphic display that simultaneously shows the frequency or swept frequency range, unsigned complex impedance, impedance magnitude, computed inductance or capacitance, battery voltage and SWR. And because it is a 2-port device, it provides additional features that can make it useful for the ham lab.

Table 1 shows the MFJ-225 basic performance measurements. The frequency accuracy was excellent, drift was undetectable, and the harmonic output was excellent. The output level variation must be considered if you want to use the MFJ-225 for receiver sensitivity testing. And the 1KHz minimum tuning step may preclude making receiver narrow filter measurements.

Table 1 - MFJ-225, serial number n/a

Manufacturer's Specifications	***Measured Performance***
Frequency range: 1.5–180 MHz, continuous	As specified.
SWR measurable range: 1:1–9.9:1	As specified.
Frequency steps: 1kHz, 10kKz, 100kHz, 1MHz, 10MHz	As specified.
Impedance range: Not specified	Output impedance ~2KΩ (28MHz), ~600Ω (50MHz), ~100Ω (144MHz). See text & Table 2
Impedance and SWR accuracy: Not specified.	See Table 3
Drift: Not specified.	See text.
Output power: –5 dBm.	–2.3 to –3.6 dBm (1.8-54 MHz), –6.5 dBm (144 MHz), –10 dBm (162 MHz), –13 dBm (180 MHz).
Harmonic & spurious suppression: Not Specified	>55 dB across entire frequency range.
Power requirements: 4.25 V dc (Four Internal NiMH or Alkaline batteries, or USB power.	
Size (HxWxD; including protrusions): 1.6×7.3×3.2 inches	
Weight (including batteries): 17 oz.	

Table 2 displays the open-circuit measured output impedance of the MFJ-225. This gives an indication of the impedance magnitude you can accurately measure. From these readings you would expect impedance-measuring inaccuracies at the higher frequencies and higher impedances. The data suggests an uncompensated shunt output capacitance of about 10pf. A better internal calibration routine would improve the measurement capability of the instrument.

Table 2 – MFJ-225 Open Circuit Output Z

Frequency	Measured Z
3.5 MHz	999Ω
14 MHz	999Ω
28 MHz	550Ω
50MHz	299Ω
146MHz	109Ω

Table 3 displays the MFJ-225 impedance, reactance and SWR measurements compared to measurements made on an Array Solutions VNA2180. As you can see the accuracy of the MFJ-225 suffers at very low impedances, as well as high impedances at the higher frequencies as suggested by Table 2.

Table 3 Impedance and SWR measurements

		MFJ-225		VNA2180	
Load (VSWR)	Frequency	SWR	Z/R/|X|	SWR	Z/R/X
50Ω (1:1)	3.5 MHz	1.08	49/49/3	1.00	50.2/50.2/-0.1
	14 MHz	1.08	49/49/3	1.01	50.2/50.2/-0.1
	28 MHz	1.10	49/49/4	1.00	50.2/50.1/0
	50 MHz	1.12	48/48/7	1.00	50.2/50.2/0
	146 MHz	1.35	44/42/15	1.01	50.6/50.6/0.2

		MFJ-225		VNA2180	
Load (VSWR)	Frequency	SWR	Z/R/|X|	SWR	Z/R/X
5Ω (10:1)	3.5 MHz	9.99	1/1/0	9.97	5.01/5.01/-0.03
	14 MHz	9.99	2/2/0	9.94	5.03/5.03/-0.06
	28 MHz	9.99	2/2/1	9.99	5.0/5.0/-0.09
	50 MHz	9.99	2/2/2	9.98	5.01/5.01/-0.1
	146 MHz	9.99	13/0/13	9.79	5.11/5.11/-0.25

		MFJ-225		VNA2180	
Load (VSWR)	Frequency	SWR	Z/R/|X|	SWR	Z/R/X
10Ω (5:1)	3.5 MHz	7.24	6/6/0	5.04	9.91/9.91/0.04
	14 MHz	7.07	7/7/0	5.04	9.92/9.92/0.20
	28 MHz	6.74	7/7/1	5.06	9.90/9.89/0.39
	50 MHz	6.88	7/7/3	5.05	9.93/9.90/0.72
	146 MHz	7.71	16/7/15	5.13	10.0/9.78/2.19

		MFJ-225		VNA2180	
Load (VSWR)	Frequency	SWR	Z/R/|X|	SWR	Z/R/X
12.5Ω (4:1)	3.5 MHz	5.07	9/9/0	3.96	12.63/12.63/0.15
	14 MHz	5.07	9/9/0	3.95	12.67/12.66/0.66
	28 MHz	4.98	10/20/2	3.97	12.68/12.61/1.34
	50 MHz	4.88	11/10/5	3.97	12.85/12.63/2.38
	146 MHz	4.67	24/12/21	4.14	14.16/12.34/6.95

		MFJ-225		VNA2180	
Load (VSWR)	Frequency	SWR	Z/R/|X|	SWR	Z/R/X
25Ω (2:1)	3.5 MHz	2.15	23/23/0	1.96	25.5/25.47/0.09
	14 MHz	2.15	23/23/0	1.97	25.44/25.44/0.34
	28 MHz	2.10	23/23/0	1.96	25.47/25.46/0.56
	50 MHz	2.06	23/23/1	1.97	25.46/25.44/1.04
	146 MHz	1.83	28/27/8	1.99	25.3/25.13/2.99

Load (VSWR)	Frequency	MFJ-225 SWR	MFJ-225 Z/R/|X|	VNA2180 SWR	VNA2180 Z/R/X
100Ω (2:1)	3.5 MHz	2.03	100/100/8	1.99	99.51/99.51/0.46
	14 MHz	2.09	103/103/9	1.99	99.48/99.46/2.05
	28 MHz	2.07	101/100/17	1.99	99.32/99.24/4.03
	50 MHz	2.10	98/94/29	1.99	99.12/98.86/7.13
	146 MHz	2.43	75/56/51	2.01	96.77/94.74/19.72

Load (VSWR)	Frequency	MFJ-225 SWR	MFJ-225 Z/R/|X|	VNA2180 SWR	VNA2180 Z/R/X
200Ω (4:1)	3.5 MHz	4.13	202/200/34	3.99	199.5/199.5/1.30
	14 MHz	4.30	209/205/43	3.99	199.2/199.2/4.82
	28 MHz	4.24	193/179/74	3.98	198.7/198.5/9.57
	50 MHz	4.27	165/134/99	3.98	197.9/197.1/17.46
	146 MHz	5.24	88/37/80	3.92	188.8/182.8/47.16

Load (VSWR)	Frequency	MFJ-225 SWR	MFJ-225 Z/R/|X|	VNA2180 SWR	VNA2180 Z/R/X
400Ω (8:1)	3.5 MHz	8.23	385/363/130	7.99	399.4/399.4/3.73
	14 MHz	8.96	409/372/166	8.02	400.6/400.4/13.97
	28 MHz	8.68	320/240/213	8.01	399.4/398.3/28.93
	50 MHz	8.67	225/121/190	7.99	396.1/393.0/49.09
	146 MHz	9.99	91/19/90	7.90	370.9/349.0/125.4

Load (VSWR)	Frequency	MFJ-225 SWR	MFJ-225 Z/R/|X|	VNA2180 SWR	VNA2180 Z/R/X
500Ω (10:1)	3.5 MHz	9.85	490/413/179	9.82	491.1/491.1/6.63
	14 MHz	9.99	494/433/239	9.84	491.3/490.8/23.8
	28 MHz	9.99	359/239/268	9.86	490.1/488.3/46.6
	50 MHz	9.99	237/112/211	9.81	483.1/476.1/82.1
	146 MHz	9.99	93/16/92	9.62	430.8/386.9/189.6

Notes:

[1]The MFJ-225 does not indicate inductive loads (+jX) or capacitive loads (–jX).

[2]The SWR Loads were measured on an Array Solutions VNA2180 by the reviewer. Except for the 50 ohm load, all loads were built by the reviewer.

[3]An Array Solutions precision 50 ohm termination was used for the 50-ohm tests. This termination has a wide frequency range.

Power Requirements

The MFJ-225 is powered by four AAA internal batteries or your computer’s USB port. Because the MFJ-225 will primarily be used away from a computer, the installation of four NiMH AAA batteries is recommended. You can use alkaline batteries, but changing the batteries is not trivial. You must not only open up the case, but also unplug the internal display assembly to access the battery holder. Further, the MFJ-225 can be damaged if an external voltage source is connected when alkaline batteries are installed. The 2.1x5.5mm coaxial DC jack on the right-hand side is ONLY for charging internal NiMH AAA batteries – i.e. an external power source will not power the unit. Connecting an external power source automatically initiates charging via an internal smart charger. A red LED charge indicator turns off when charging is complete. After a full charge, new 800mah NiMH AAA batteries will power the MFJ-225 for about one hour and 20 minutes before recharging is required.

Using the MFJ-225

The MFJ-225 should arrive already calibrated, but this wasn't the case with the reviewed unit. I determined that there was a calibration problem while tuning the MFJ-225 up in frequency with its output open-circuited. At approximately 130MHz the open-circuit SWR suddenly dropped from 9.99:1 to 3.2:1. After calibration, the open-circuit SWR stayed at 9.99:1 through 180MHz. To calibrate the MFJ-225, leave the OUTPUT port open and rapidly turn the TUNE knob until the display says "Calibrating…". Within a few seconds the display will say "Done". The calibration information is stored in on-board non-volatile memory, and cycling power returns the MFJ-225 to normal operation. Because the unit was not calibrated when received, and because I also had one occurrence of calibration data loss, occasional recalibration is probably prudent.

When the MFJ-225 is powered up, the display prompts you to select ANT-G (single frequency mode), CABLE (cable length, loss and velocity factor measurements), ANT-S (swept frequency response), and PC>USB (more on this later).

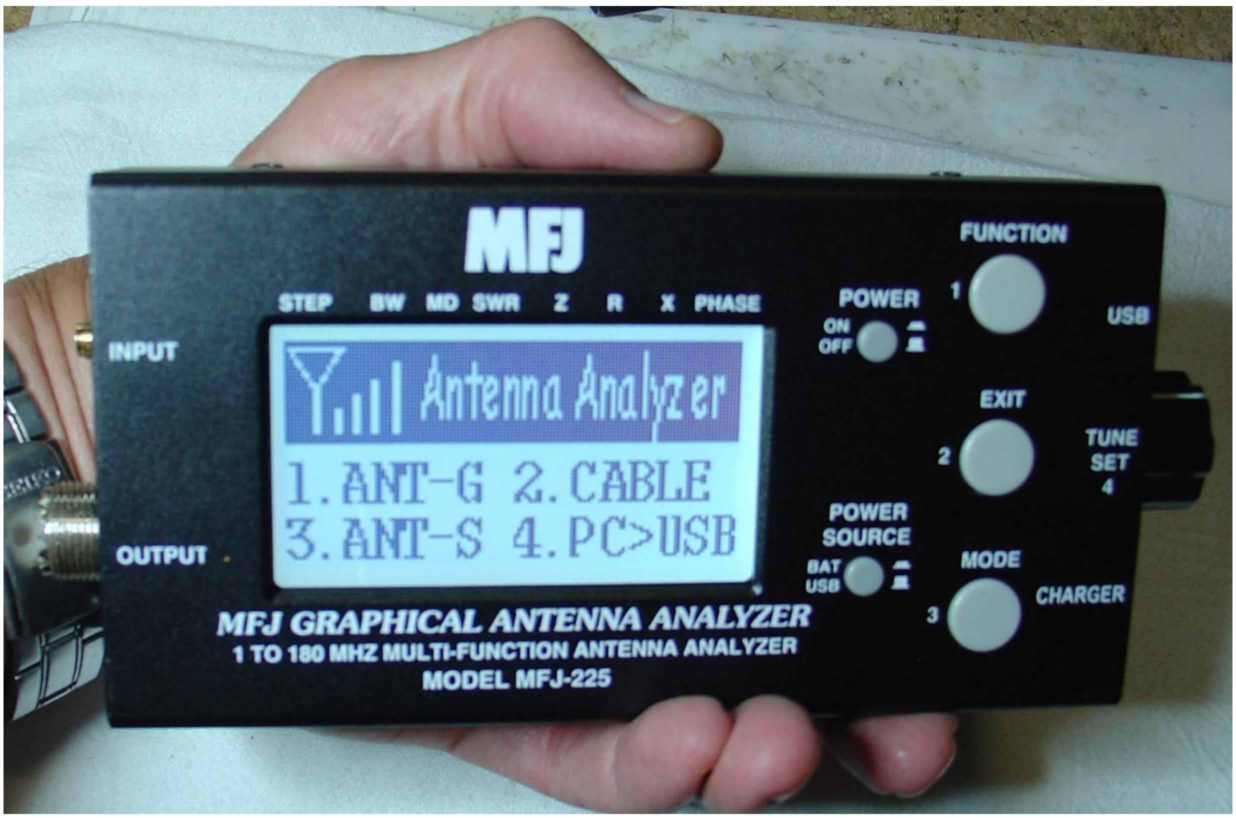


Figure 1: The MFJ-225 high level menu

The ANT-G mode will normally be used for antenna measurements. Besides providing digital read-outs of pertinent antenna information, it also provides a bar-graph display that makes tuning the frequency for minimum SWR very easy. Changing ham bands requires selecting a large tuning step, tuning to the ham band of interest, and then re-selecting a lower tuning step for tuning across the band of interest. Pressing the EXIT button prior to turning the unit off saves your last settings.

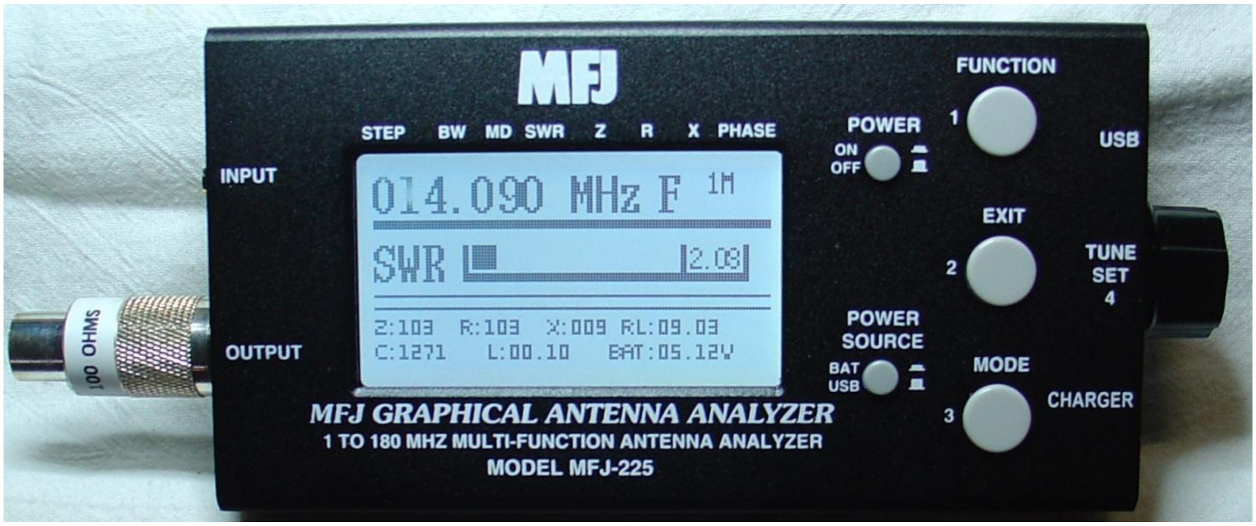


Figure 2: Single-frequency (ANT-G) mode measuring a 100Ω load

The CABLE mode is used to determine unknown coax cable length, velocity factor, and loss. Just connect an open-circuit section of coax to the output port and press the MODE button. This starts a scan, after which the cable parameters are displayed. Incidentally, you must hold the EXIT button for about 4-5 seconds to exit the CABLE mode. For the ANT-G and ANT-S modes only a 1-2 second push of EXIT is required.

The ANT-S mode is the final internal display mode. This permits the display of your antenna or circuit performance over fixed swept bandwidths of 118KHz, 590KHz, 1.18MHz, 2.36MHz, 5.9MHz, 11.8MHz, and 23.6MHz. The digitally displayed data corresponds to the center frequency of the display as selected by the TUNE control. Figure 3 is an example of the swept return loss display of a 2-meter bandpass filter I had available.

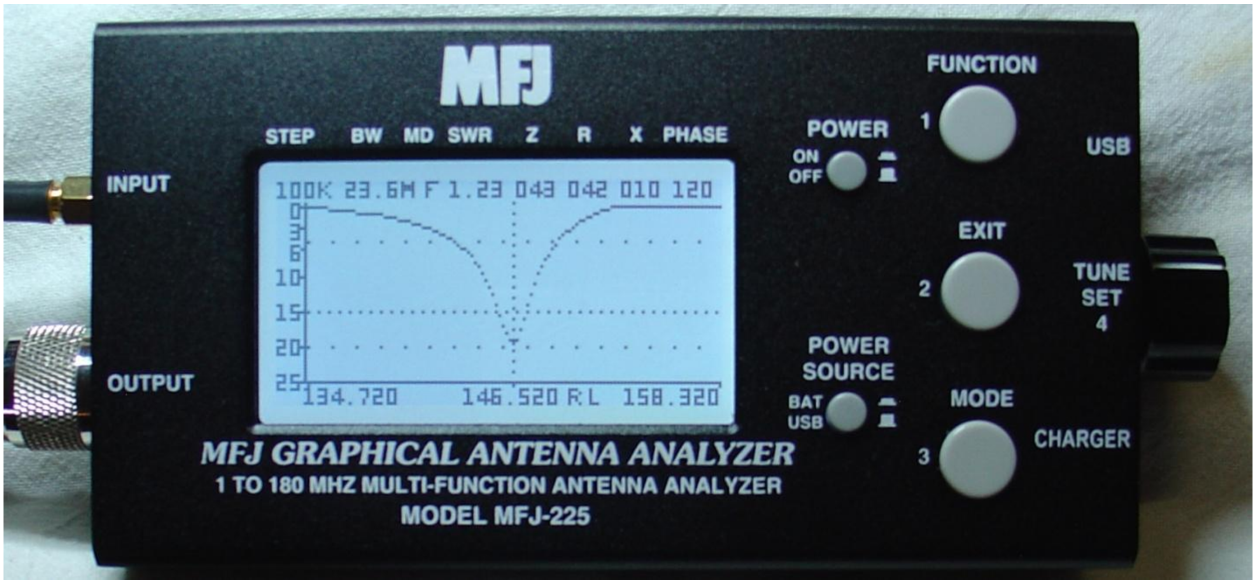
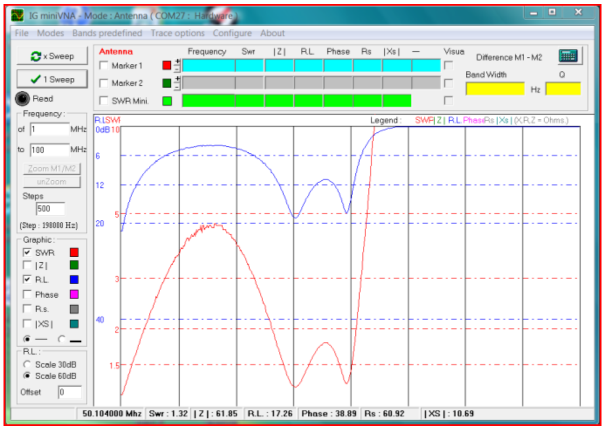


Figure 3: Return loss sweep of a 2-meter bandpass filter

PC>USB Mode

In addition to traditional single-port reflected-power measurements, the MFJ-225 includes the capability to make two-port forward-power measurements. This is very useful for designing and optimizing 2-port devices such as filters and diplexers. However, in order to use this capability you must use an external PC and the IG-miniVNA free-ware program available from http://clbsite.free.fr/articles.php?pg=art4. As this is a French site, everything is written in French. However, scroll down to New Ig MiniVna V 2010 06 11 and download this ZIP file to a folder on your PC. Navigate to this folder and “Extract all files”. For convenience, create a desktop shortcut by right-clicking on the program and select “Create Shortcut”. Then drag the shortcut icon to your desktop.

Before making measurements, open the CONFIGURE menu in the IG-miniVNA software and select the minVNA dialog box. Then perform the reflection and transmission calibration steps. You will need an SMA-to-UHF adapter cable for the transmission calibration, and for making 2-port measurements on a connected 2-port circuit. I found SMA/UHF and SMA/N cables at very reasonable prices on a popular auction site. Figures 4 and 5 show the SWR/Return Loss and Transmission measurements made on a 6-meter low pass filter.



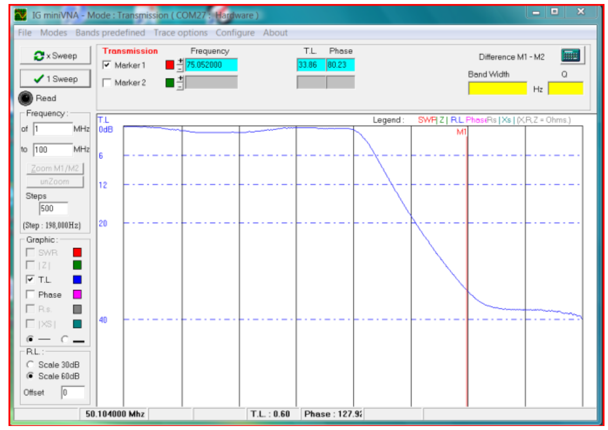


Figure 4: SWR/Return Loss plot of a 6M filter   Figure 5: Insertion loss plot of the 6M filter

Because my measurements indicated that the SWR accuracy was degrading towards the upper end of the frequency range, I ran a SWR scan of the Array Solutions precision 50 ohm load over the full frequency range. The results are shown in Figure 6. As you can see, the SWR measurement is pretty good through 2-meters, but then degrades rapidly above 160MHz, going to about a 5:1 SWR at 180 MHz.

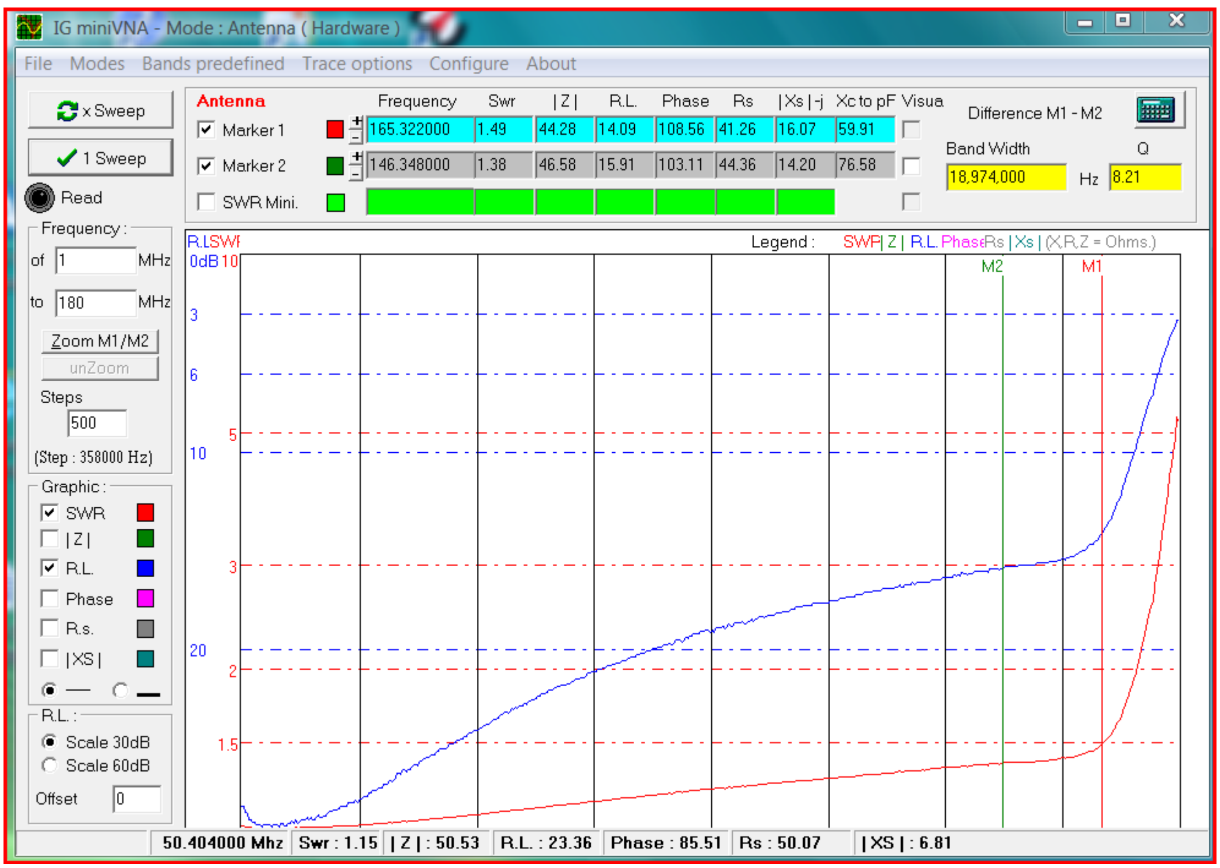


Figure 6: Precision 50 ohm load as measured by the MFJ-225 and IG-miniVNA software.

Next I examined the accuracy of insertion loss measurements. For this I used precision SMA attenuators of 3dB, 14dB and 30dB. These attenuators were within 0.1dB of their spec'd values as measured by an Array Solutions VNA2180. Table 4 lists the MFJ-225 nominal measurements from 1.5-148MHz.

Table 4: MFJ-225 Attenuation Accuracy

Actual Attenuation	MFJ-225 Measured Attenuation
3dB	2.7dB
14dB	13.3dB
30dB	28.8dB

As with the SWR measurements, the accuracy of the loss measurements suffer significantly above 150 MHz. Figure 7 shows the 30dB attenuator measurement from 1-180MHz..

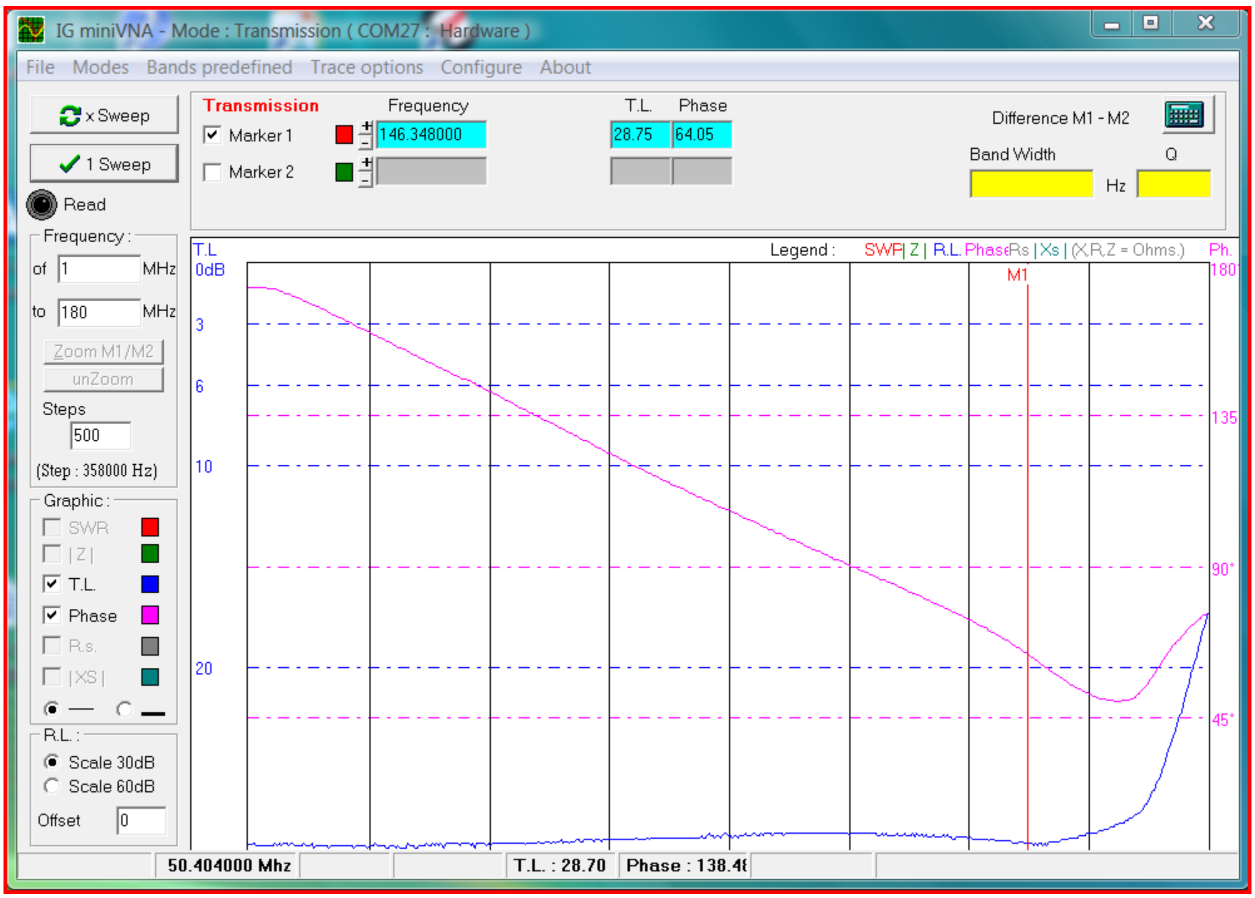


Figure 7: Attenuation of precision 30dB attenuator

Finally I measured the SMA port input impedance with the VNA2180. The return loss was reasonably good, measuring about 32dB at 30MHz, 27dB at 50MHz, and 18dB on 2-meters.

Some Issues

While the MFJ-225 works well, there are some things that could be improved. First, battery operation time would be extended if you could turn off the display back-light and/or if a sleep mode was available. Along these lines, an auto-off setting would be nice in case you forget to turn off the unit, or if the battery voltage gets too low. This would prevent damaging the batteries due to over-discharge.

It would be nice if you could save stand-alone swept-frequency graphs and transfer them to a PC later. This is not a big deal, but it would help those of us who like to document antenna configurations. Of course, you can do this with the IG-miniVNA software. But this requires a connected computer during the measurement.

Then there was the loss of calibration data. I have not been able to figure out when or why this happened, though I suspect it may have been due to how I may have exited a menu. Again, re-calibration is easy and only takes a few seconds.

Finally, there are the inaccurate measurement issues at very low impedances and high impedances at the higher frequencies, and the rapid accuracy degradation above 150MHz. While probably not an issue for most ham applications, this is something to keep in mind.

Documentation

The MFJ-225 comes with a 16-page manual that includes instructions on how to perform the many stand-alone tasks that this analyzer can accomplish. However, the instructions do not cover the IG-miniVNA software package. Including some basic information and instructions on this software package would minimize set-up and use issues for those who want to use the MFJ-225 2-port analysis capability.

Conclusion

The MFJ-225 has more capability than is normally found in an antenna analyzer under $500. Besides providing normal antenna analyzer readouts, it also provides swept graphical displays. And when connected to a computer, it provides 2-port transmission parameters useful for the design and analysis of RF circuits. While not a precision instrument, the MFJ-225 will satisfy the needs of many hams for both field and bench use.