Some of My Favorite Test Gear Comes from China
Michael Davis KB1JEY, Ambler PA

Introduction

The genesis of this paper and presentation was a workshop presentation that the author attended at the 2017 North East Weak Signal Group (N.E.W.S.) conference. The workshop, presented by Donald Twombly W1FKF, Michael Seguin N1JEZ, and Paul Wade W1GHZ, was titled *Microwaves Without a Wheelbarrow of Dollars*. Among the items the author saw was an inexpensive VHF-UHF RF Impedance Analyzer ("Antenna Analyzer") rated to an upper frequency limit of 2.7 GHZ. He was also intrigued by a RF signal source good to 4.4 GHz for only $65.

Some of the pieces of equipment covered during the workshop were already on KB1JEY shack workbench. The author was also struck by coincidence that all of the inexpensive items were sourced from China. He had hoped that the workshop authors make a similar presentation at the Mid-Atlantic VHF Conference. When it was apparent that this would not happen for the 2017 Mid-Atlantic VHF Conference, this author offered to prepare the following presentation, supplementing it with additional pieces of test gear in his possession that might be of interest to weak-signal VHF enthusiasts.

Pre-Chinese Gear

Figure 1
Heathkit "5280" Gear

Figure 2
KB1JEY Test Rack

The author's interest in inexpensive test gear goes back to the 1980s when he assembled some of the Heathkit "5280 Series" test gear shown in Figure 1. The author built the RCL (Resistance-Capacitance-Inductance) bridge and the audio and radio frequency signal generators. Being interested in "completeness", he subsequently added the matching VOM and signal tracer. While the author enjoys looking at these instruments, one would have to use imagination to figure out applications for them in the weak-signal VHF world.

Over recent years, the author has acquired some test gear that is more useful to a weak-signal VHF enthusiast. If you look at the equipment rack displayed in Figure 2, you will see a spectrum analyzer, a pair of frequency counters, a RF signal generator, and a network analyzer / sweep generator. These items were patiently acquired at hamfests, conferences, and through the kindness and foresight of fellow Packrat members. The author believes that all of this equipment from Tek and HP was assembled in the United States. While the "patient" acquisition approach worked for him and some other amateurs, it is not a good approach for someone just entering weak-signal VHF with a limited budget.

Affordable Test Equipment

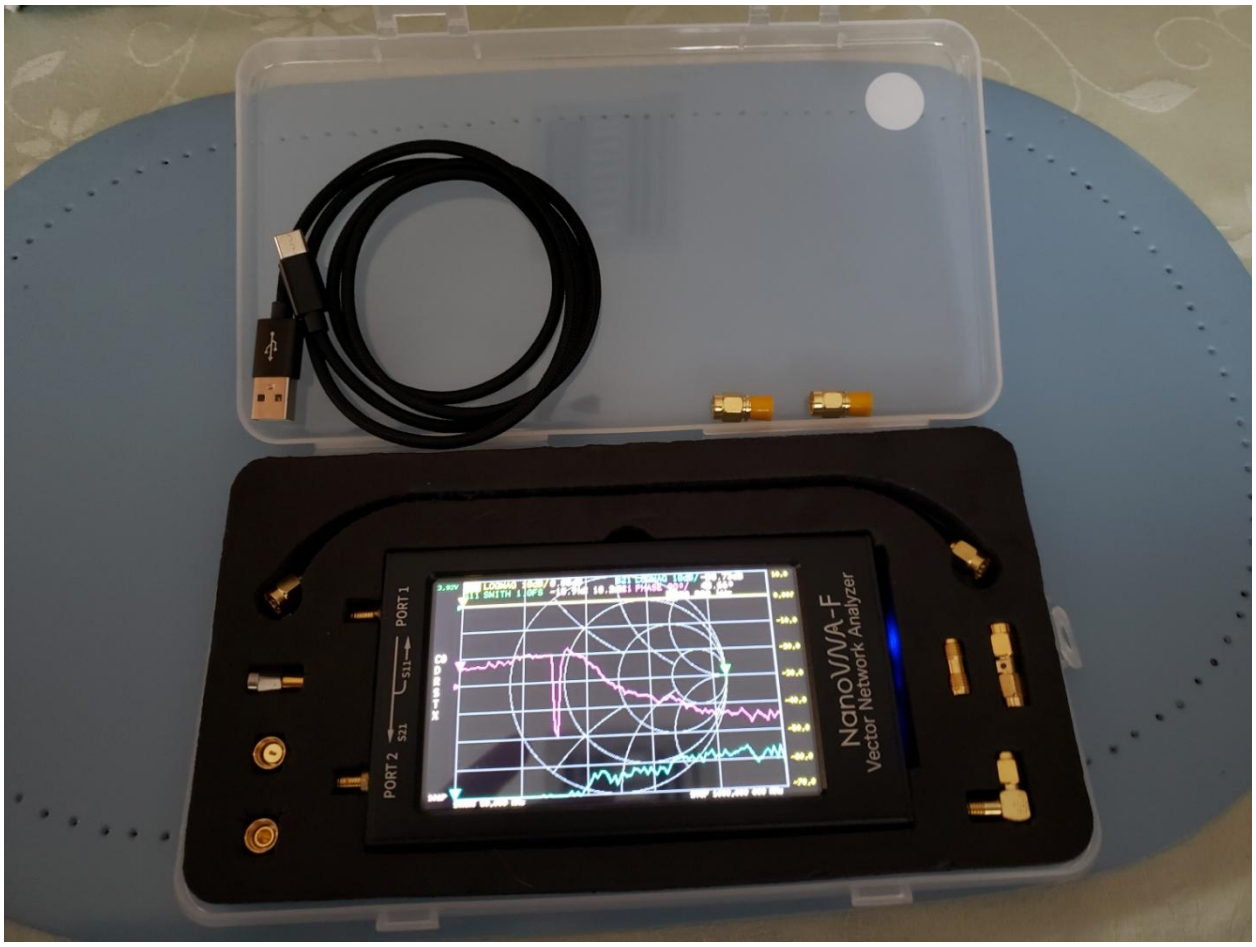
At the previously mentioned 2017 N.E.W.S. conference, the following list of test equipment was offered as useful to the pursuit of weak-signal VHF:

- Power meter or at least a detector
- Frequency counter
- Signal generator or some signal source
- Attenuator
- Spectrum analyzer
- Network Analyzer
- Noise Figure Meter

To this list, the author would add a digital oscilloscope. Digital oscilloscopes can display RF waveforms without using a demodulator probe. Thanks to the Fast Fourier Transformation (FFT) feature in many digital oscilloscopes, they can double as limited spectrum analyzers. You can add an "octopus" circuit to display voltage across a component to permit the oscilloscope to function as a curve tracer. The value of the feature of digital oscilloscopes to graph voltage across time cannot be overestimated.

At the N.E.W.S. conference, it was observed that the following items, when purchased as "state of the art" new equipment often would cost more than the cars that most amateurs might drive. While the author is still looking for a noise figure meter and more importantly, the knowledge to use the above gear to its fullest extent, the rest of this presentation intended is to give fellow weak-signal VHF enthusiasts some ideas on how to fill the empty spots on their test bench without incurring the wrath of the XYL or depleting their savings completely.

NanoVNA-F Vector Network Analyzer



Shortly after agreeing to reprise this presentation for the Susquehanna Valley Amateur Radio Club (SVARC) in January 2021, the author quickly realized that with the introduction of the NanoVNA vector network analyzer (VNA), any discussion of inexpensive test equipment that omitted coverage of the NanoVNA would be incomplete at best. Worst, that omission could potentially mislead hams about which test equipment that they should prioritize in their purchases.

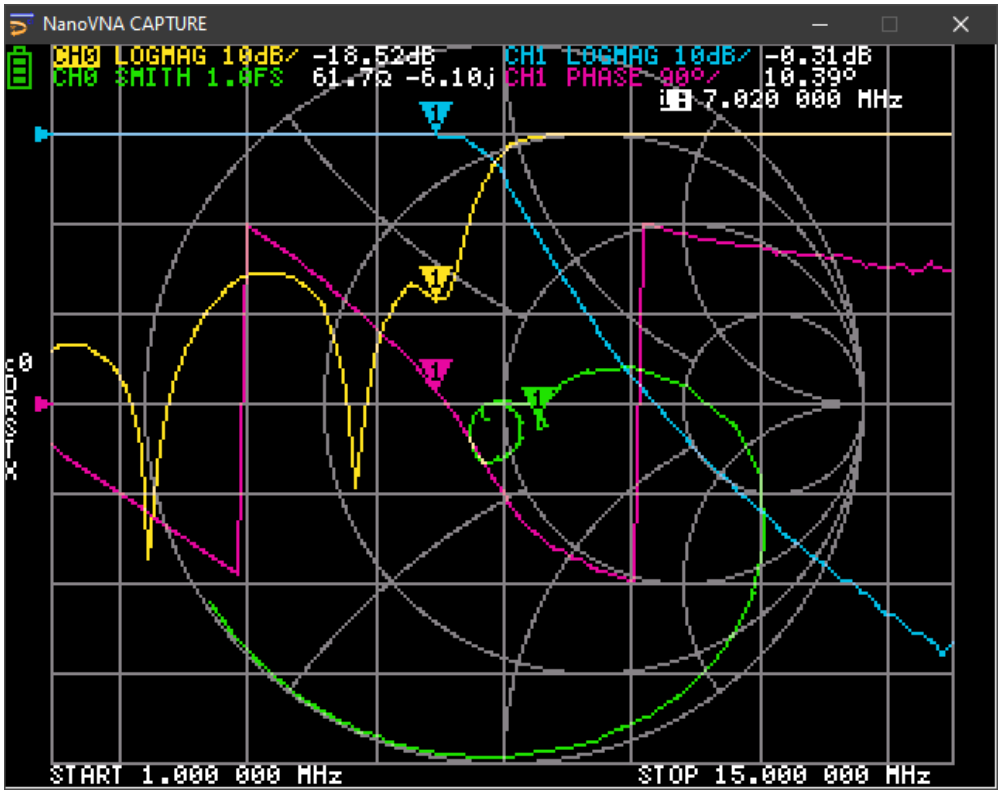
The NanoVNA has been distributed in three different versions:

- Original NanoVNA
- NanoVNA-H
- NanoVNA-F

The following link: https://radioaficion.com/news/nanovna-hardware-versions may be helpful in distinguishing among the different versions. The author chose to purchase the NanoVNA-F variant shown in the preceding illustration. Reasons for purchasing this version included the larger screen, a metal case, upgraded processor, and improved RTOS (Run-Time Operating System). The NanoVNA-F comes with a complete set of necessary cables, standards, and other accessories. The NanoVNA-F is shipped in a handy plastic storage box. More information about the NanoVNA-F version can found at the following link: https://deepelec.com/en/. DeepElec supplies the firmware for the NanoVNA-F.

At the time this paper was written, the NanoVNA-F was available from the Aliexpress.com in the DeepElec store for $93.60. Or you could purchase it via Amazon (Prime) for about $150. Be sure to order with the buttons (not wheel) and with the battery. NanoVNA and NanoVNA-H versions can be purchased for as little as $50-60. If you buy a NanoVNA, the author's recommendation is you purchase one that comes with buttons instead of a thumbwheel, a metal case, and a battery.

So what is a NanoVNA? It is an affordable vector network analyzer (VNA). A VNA is a two port instrument that injects a signal in port 1 and reads the response (e.g. return loss, insertion loss) at port 2. It is ideal for checking coaxial lines, connectors, and filters among other components. The received signal can be displayed as either a 2-D plot or as a Smith Chart. A Smith Chart for a 40 meter low pass filter, displayed on a NanoVNA is shown.



If you want more understanding of how to read Smith Charts, consider visiting Alan Wolke W2AEW's presentations on interpreting Smith Charts on his YouTube channel.

Depending upon the firmware installed in one's NanoVNA, the working frequency response range is at least 500 kHz through 900 MHz and can potentially be wider. So what does a NanoVNA measure?

- SWR (Standing Wave Ratio)
- S Parameters (S11 and S21)
- TDR (Time Domain Reflectometry) with post-processing
- Frequency sweep of connectors and filters

From GitHub, one can download the NanoVNASaver software for a variety of software platforms (e.g. Linux and Windows 10) NanoVNASaver saves measurements that the NanoVNA generates as Touchstone files. Touchstone files are a common data interchange format for vector network analyzers and have the extension of .s*N*p, where *N* is the number of ports. Using NanoVNASaver allows one to customize the display of information extracted from the NanoVNA. As an example, one can gain the ability to do TDR analysis (measure cable length, loss, and distance to fault).

If there is a complaint to be made about the NanoVNA, the learning curve required to make simple measurements such as SWR is much steeper than with some of the other instruments discussed later in this paper. To get the greatest benefit from the NanoVNA, you may need to learn some more electrical theory and math. The best advice the author can offer is to go to Alan Wolke W2AEW's YouTube channel and review his presentations on using the NanoVNA. There are other useful tutorials by others, such as one presented by the IMSAI Guy that simplifies using the NanoVNA to measure SWR. There is also a great presentation on the NanoVNA by Daniel Marks KW4T found at:

http://www.kb5tx.org/Presentations/RARS-Club-NanoVNA-presentation.pdf

AAI N1201SA UHF-VHF RF Vector Impedance Analyzer

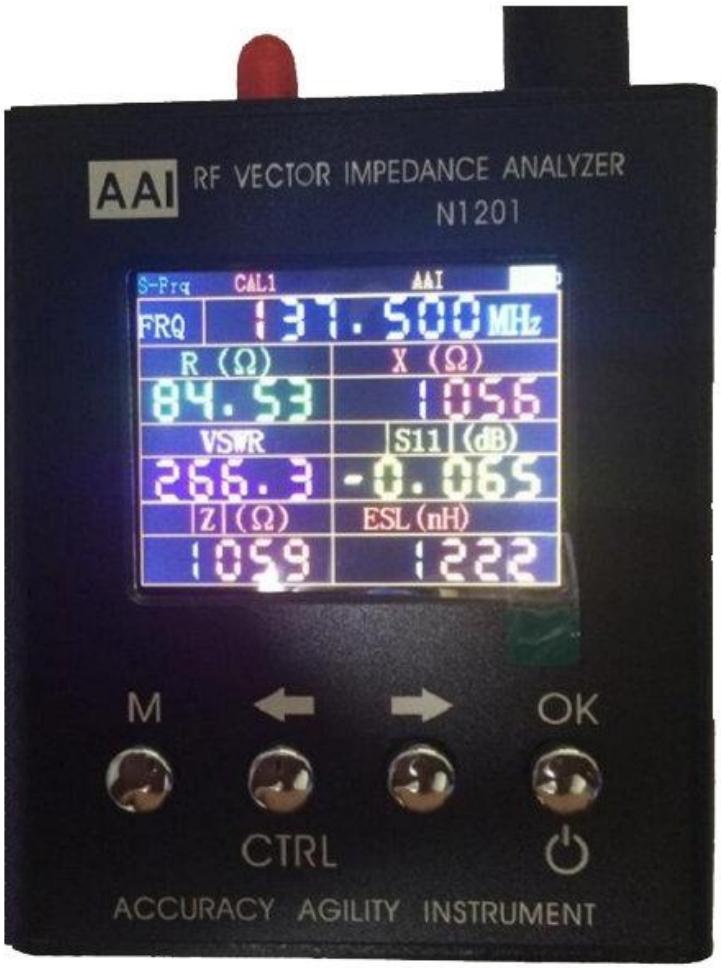


Figure 3
N1201SA Analyzer

The author first held one of these analyzers through the courtesy of Paul Wade at the N.E.W.S. Conference in 2017. His quip: "It is cheap enough to drop from a tower." At $165, one arrived shortly at the KB1JEY QTH. When fellow amateurs hold one and learn that the frequency range goes up to 2.7 GHz and that it has the ability to graph the impedance response, they have to have one, too.

Note to those who refuse to consult user manuals. You have to hold CTRL button while simultaneously pressing the power button to turn the N1201SA on. While the specifications indicate that frequency range goes up to 2.7 GHz, the lower frequency limit of N1201SA is only 140 MHz (2 meters). Thus the author's MFJ-269 analyzer, which covers HF bands and also measures cable loss, will not be offered for sale at a hamfest anytime in the near future.

The N1201SA+ model frequency range goes down to 37.5 MHz, which would allow one to analyze 6 meter antennas. It is offered for about $250. It has been reported that there is an N1201SAC model which allows one to read data from the USB port and to measure transmission line impedance. The

author has never seen a N1201SAC offered for sale. At the time this presentation was originally written, one could only purchase the N1201SA from vendors who will ship orders from China, such as Banggood.com but this has changed. You can review the manual from their website:

https://img.banggood.com/file/products/20160922213704N1201SA%20-%20USER%20MANUAL.pdf

LYQQFY MR300 Antenna Analyzer

Some VHF amateurs might be interested in checking out their 6 meter antennas or even perhaps their HF dipoles. To supplement their N1201SA analyzer, which only measures down to 2 meters, they might consider buying an LYQQFY MR300 antenna analyzer, which was only $62 when the author last checked the Banggood site:

https://www.banggood.com/MR300-Digital-Shortwave-Antenna-Analyzer-Meter-Tester-1-60M-For-Ham-Radio-p-1133552.html

The author's unit, which has "Analyzer" properly spelled, is shown below:

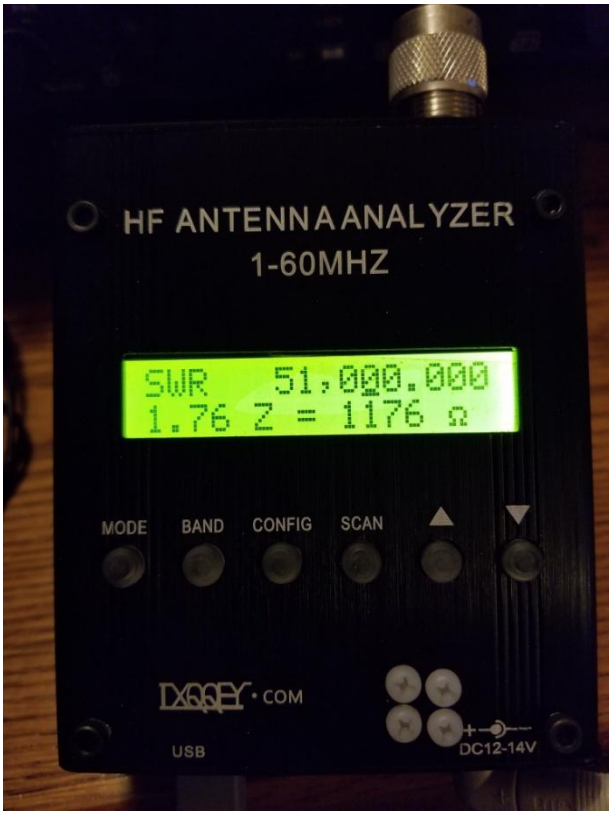


Figure 4
LXQQFY MR300 Antenna Analyzer

The LXQQFY.com website has a 32 page PDF manual for the unit, which is very readable and complete. Unlike the N1201SA, the MR300 does not come with a built-in Lithium Ion battery or charger/power supply. The instruction manual shows a NiMH battery pack that is designed for the unit. However, not all units have the pins on the board to connect up the shown NiMH battery pack. It might be easier to hook up an external "wall-wart" or connect a gel cell.

The other teaser is the USB port, which allows one to hook the MR300 up to a free Windows client. LXQQYY.com offers a model with Bluetooth connectivity for about $90. The problem for many is that the Android app is only available from the manufacturer's website, not Google Play. The author is still working getting the Windows client to work with his MR300 but the build-in display is more than adequate.

RF Explorer Signal Generator

Figure 5
RF Explorer Signal Generator

At Dayton Hamvention 2016, Tom Frederiksen KA3FQS and the author spotted the handheld RF Explorer Signal Generator (Model RFE6GEN) available from SEEED Studio at a modest "Dayton discount". We

were both intrigued by the specifications: generated frequencies up to 6 GHz and the ability to sweep. We each ordered one to be shipped to our homes.

SEEED is probably better known for their handheld RF Explorer spectrum analyzer, which was described in the previously cited N.E.W.S. Friday workshop. The specifications for the RF Explorer spectrum analyzer indicate that it is capable of displaying frequencies up to 2.7 GHz. At a price of about $280, it could be a good choice for some amateurs. Since the author "scooped up"a gently used Tek 492A spectrum analyzer earlier during Dayton 2016 Hamvention, it did not make a lot of sense to double-up on spectrum analyzers. As a personal note, the RF Explorer weighs much less than the 42 pound Tek 492A.

The author's RF Explorer Signal Generator has stayed mostly in its shipping carton. However, Tom put his on a lab-grade spectrum analyzer. Some of the graphs are reproduced below.

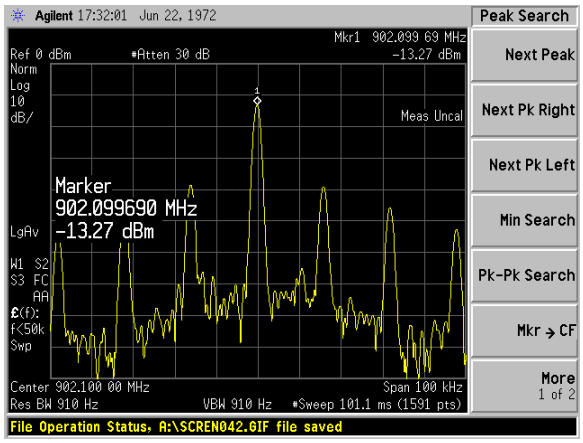


Figure 6
Marker at 902 MHz

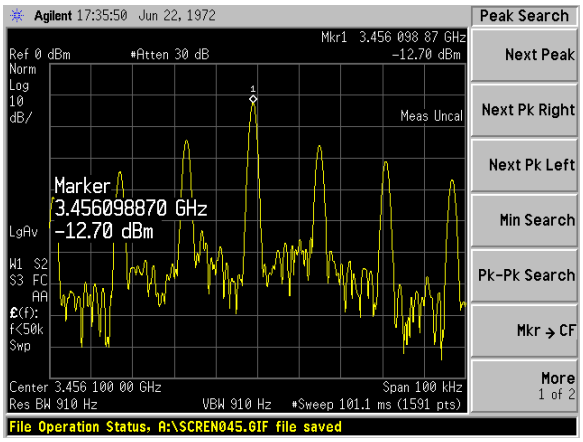


Figure 7
Marker at 3.4 GHz

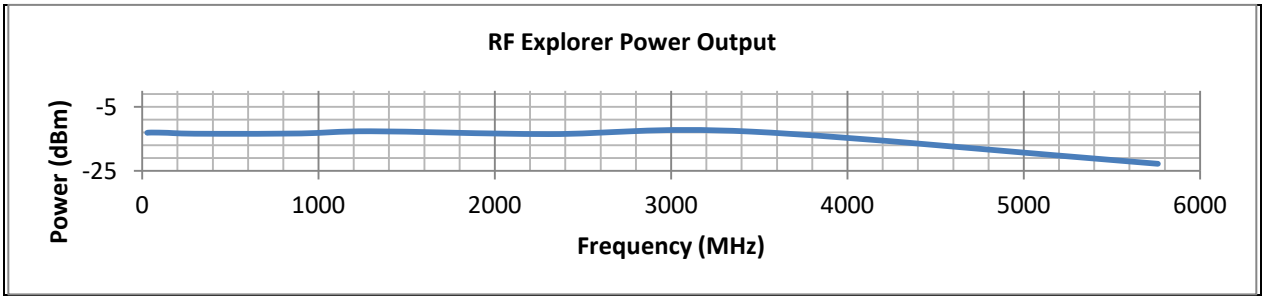


Figure 8

Tom's first impression: "Not great but for under $200 not horrible". The basis for his comment is that there are a good many spurs and the measured power drops off significantly at the 4-5 GHz region. Neither Tom nor the author has tested the RF Explorer's sweep feature as of this paper.

The manual for the RF Explorer signal generator can be found at the following link:

http://j3.rf-explorer.com/download/docs/RF%20Explorer%20Signal%20Generator%20User%20Manual.pdf

RF Explorer Spectrum Analyzer

When the author shared an early draft of this presentation with some of his amateur radio colleagues, one of them, Roger Rehr W3SZ shared the following screen shot from the Windows client for his RF Explorer Signal Generator and Spectrum Analyzer pair.

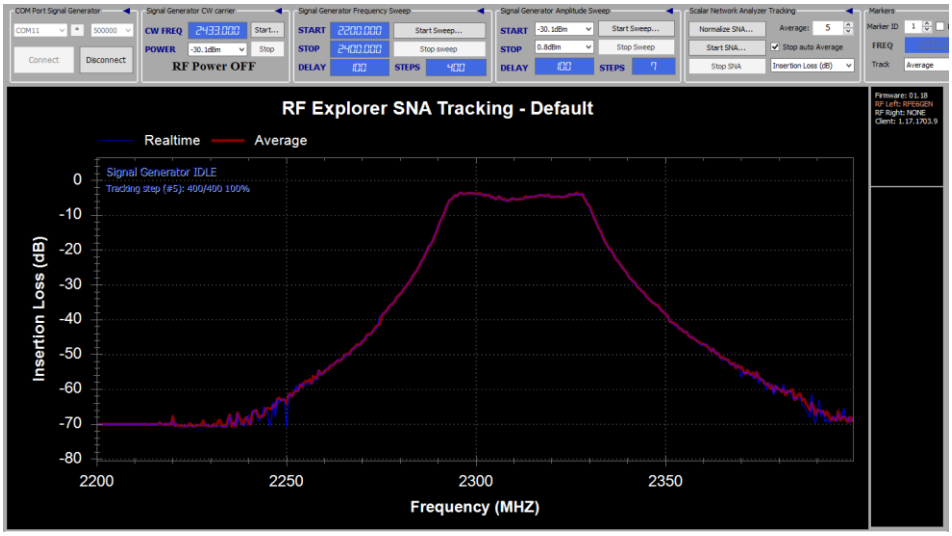


Figure 9

So how does one go from the non-linear displays shown in Figures 6-7 to a very useful graph of a filter's response? A tracking signal source coupled to the frequency controls of the spectrum analyzer. Normally, a spectrum analyzer is a passive device, only displaying what it receives. The Windows client for the RF Explorer Signal Generator – Spectrum Analyzer allows one to pair up the two devices, linking (tracking) the sweep of the signal generator to the spectrum analyzer. The displayed response is normalized to compensate for the non-linearity of the signal generator.

In effect, the RF Explorer pair can function as a battery-powered and very portable network analyzer. There are many choices for options when purchasing the RF Explorer Spectrum Analyzer. The author settled in on the "combo" that goes up to 2.7 GHz. Hams can use the pair to inspect and tune filters and other components. The author keeps his RF Explorer pair in an inexpensive foam case with cables, ready to go to demos and other ham shacks as shown in Figure 10. With accessories, the pair set back the author by only $600.

Figure 10
The RF Explorer pair in a foam-lined case

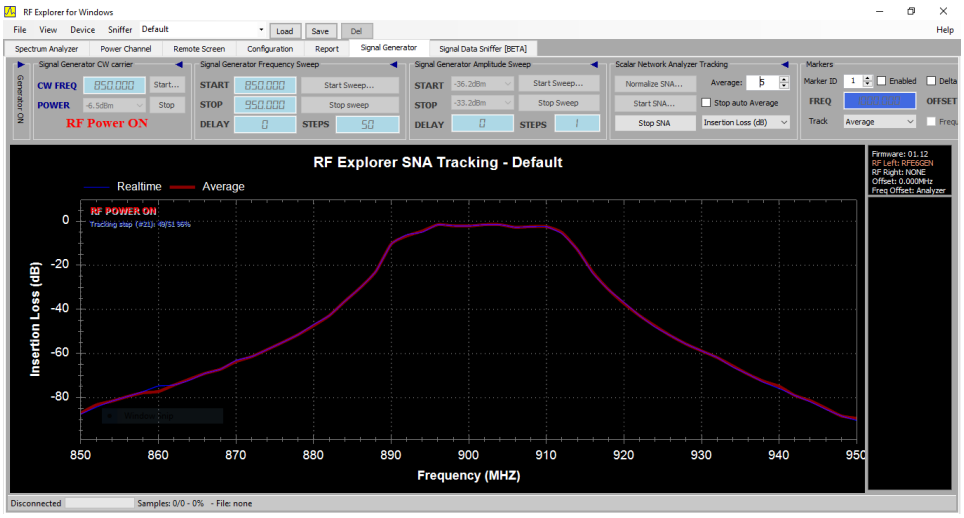


Figure 11

Figure 11 shows another display from the Windows Client, showing the response from the author's RF Explorer pair. The device being measured is a 890-905 MHz filter that can be tuned to accommodate special needs.

Velleman HPG1 1 MHz Pocket Function Generator

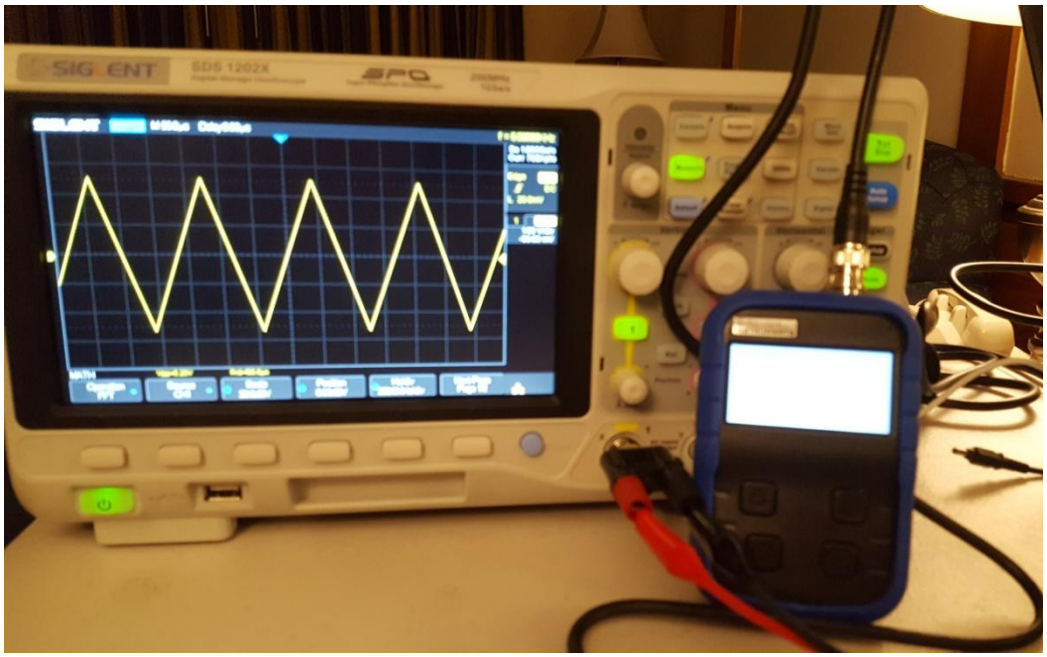


Figure 12
HPG1 Generated Triangle Wave

Sometime after the author bought a digital oscilloscope, he saw a promotional offer for the Velleman HPG1 pocket function generator. The price was well below $100. Retail and mail order prices for this function generator were often as high as $250. The author has happily owned a Velleman VOM for years. So he ordered it. The HPG1 is apparently no longer manufactured. Its replacement is the Velleman HPG1MK2, available for about $130-$140.

Most weak-signal amateurs can live without a function generator. They are probably most useful for testing audio amplifiers and filters. But if one decides to acquire one, accepts that it is a pocket instrument, acknowledges that it is good only to 1 MHz and that it has flexibility limitations, then the HPG1 might be a good purchase.

Yaege FC-1 Handheld Frequency Counter

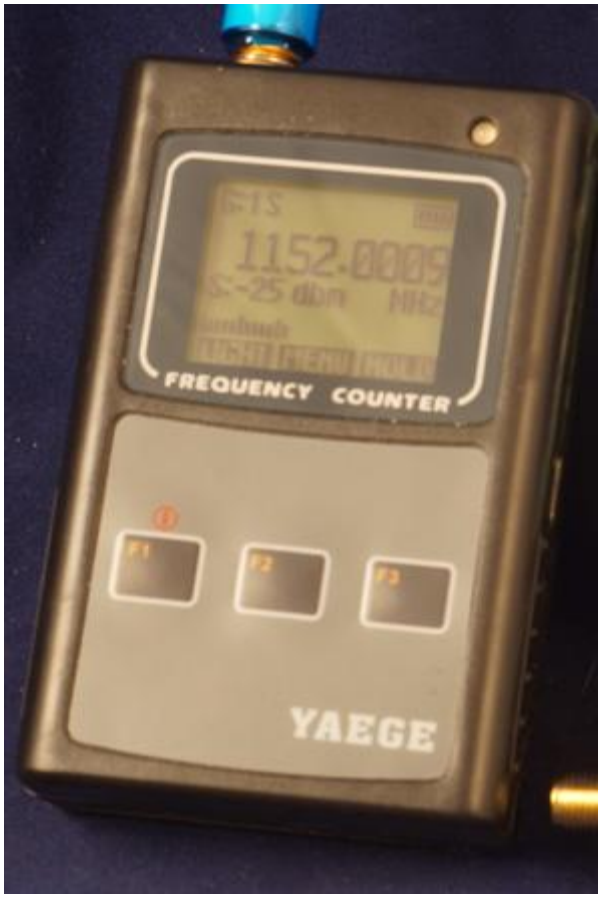


Figure 13
Yaege FC-1

Several years, the Packrat radio club organized a group purchase of Yaege FC-1 frequency counters. The FC-1 was originally offered for sale in 2010. It FC-1 offers the selection of two ranges: 10 Hz to 50 MHz and 50 MHz to 2.6 GHz. It is powered by a rechargeable Li-Ion battery. You can trim it to match your handy calibrated time base.

When researching this presentation, the author noted a blog post from Julian Moss G4ILO from 2010 that offered the observation that unlike many frequency counters, the Yaege FC-1 offers a signal strength reading calibrated in power ratio in decibels (dBm) units. Thus the FC-1 could be used as a rudimentary digital field strength meter, useful for making antenna comparisons.

At about $45 on eBay the Yaege FC-1 remains a good value. Yaege also offers an FC-2 model, available for about $35-$40. Unlike the FC-1, the FC-2 has a single frequency range, 10 MHz to 2.6 GHz. The Yaege FC-2 is powered by a pair of Ni-MH AA cells instead of the Li-Ion battery of the FC-1.

Excelvan Capacitor Meter (Model M6013)

Figure 14
M6013 Capacitor Meter

Somewhere in author's shack is a vintage Heathkit IT-2250 handheld digital capacitance meter. He is certain to find it sometime soon. So when the author opened the January 2017 issue of QST magazine, read the review of the Excelvan M6013 meter, and learned that it could be had for less than $30 from Amazon, he ordered one. Its upper measurement range is good to 470 mF. The M6013 read the values of a sample of spare capacitors correctly.

So how did the Excelvan M6013 make it into this review of inexpensive test equipment for the weak-signal VHF enthusiast? Besides originating from China and living on the author's test bench, even weak-signal VHF enthusiasts need to check the condition of capacitors before they get soldered into gear and to verify the markings. Also while some DMMs (Digital Multimeters) also measure capacitance, their upper range is usually not as high as that of the M6013.

Excelvan MESR-100 ESR Capacitance Ohm Meter

Figure 15
Execlvan MESR-100

While examining the box in which the Excelvan M6013 arrived, the author noticed that it was the same box used for the MESR-100 ESR Capacitance Ohm Meter, depending upon which checkbox was blackened. The next questions was “What is an ESR Capacitance meter?” It is an instrument used to measure the equivalent series resistance (ESR) of capacitors, even when in-circuit. The author decided to add the MESR-100 to his test bench. He ordered the MESR-100 from a vendor on the Newegg portal for $51, including shipping.

Using the MESR-100 is a two-step process. First, connect it across the capacitor of interest (after discharging it first !!) and note the reading. Then consult the table at the bottom of the MESR-100. If the reading is higher than the value given in the table, the capacitor is not filtering “ripple” properly, is probably damaged, and should be replaced. Because the MESR-100 is so easy to use on capacitors in-circuit, a good practice is to inspect other nearby capacitors in circuit to catch them before they fail badly enough to cause issues.

Rike RK-88 Frequency Counter

Figure 16
Rike RK-88

This handheld frequency counter is not particularly helpful for weak-signal work but is in this paper for a few reasons. What was the author's motive for acquiring it? Another Packrat, John Taylor K3DMA, had bought a similar one and showed how it would decode CTCSS (Continuous Tone-Coded Squelch System) and DCS (Digital Code Squelch) tones used with most repeater systems. It never occurred to the author that one could buy a piece of equipment with this feature so he bought the RK-88.

The price of a new Rike RK-88 should be about $35. This model is billed as having an upper frequency limit of 2.4 GHz. However, when Tom Frederiksen KA3FQS tested it with a lab-grade signal generator, he reported that the specified upper frequency limit is probably optimistic. Besides, if you are interested in acquiring a frequency counter with the CTCSS / DCS tone decoder, there is a better choice.

Surecom SF401 Plus

Figure 17
Surecom SF401 Plus

The Surecom SF401 Plus can replace the functions provided by the Rike RK-88. It is available on Amazon and from other sources for just a little bit more ($40-$45). Unlike the Rike RK-88, it features an attractive color display. The SF-401 frequency counter is often available from new equipment vendors at hamfests. Here is the link to this unit on the Surecom website:

http://www.surecom.com.hk/surecom01_product.php?id=114911

You will want to get the Plus model. It can be used to read the frequency of analog radios, plus digital handheld radios such as DMR (Digital Mobile Radio) transceivers that are becoming more popular. The Plus model also features a switchable (and unmarked) 10 db attenuator. While the given frequency range is 27 MHz to 3 GHz, the Surecom website cautions that the function of the SF401 is not guaranteed between 27 MHz to 100 MHz. The SF401 Plus comes with two BNC-mount antennas. It appears that the longer antenna is the one that is tuned for UHF work. Surecom suggests that if one is not getting good measurements, to hold it so that the SF401's antenna is at an angle relative to the transceiver's (handheld's) antenna.

Cautions When Using Chinese Test Equipment

Amateurs accustomed to using robust test equipment from manufacturers such as HP/Agilent, Tektronics, and Bird Technologies may need to change their expectations when using test gear from China. Some of the Chinese gear is nicely packaged and is accompanied by modest instructions. By contrast, Items such as the just mentioned signal source and power meter are just small boards supplied with no instructions. For such items, only experimentation or hints from a mentor will yield how they are operated.

Even the nicely packaged test gear from China may have menus that are even more cryptic than menus for domestically sourced test gear. Also, the least expensive items are sold and shipped directly from China. You often have to wait for them to arrive from the overseas factory. As an example, if you purchase the AAI NS1201SA from Banggood, it will take about two weeks for it to wander into your QTH. Plan accordingly.

Last, some Chinese gear may not have the overload and other protections to which amateurs may have become accustomed. Coupled with non-existent documentation and cryptic menus, sometimes not written in English, amateurs should be very careful to not release the "magic smoke" prematurely.

Conclusion

One of the most common questions we field about the amateur radio hobby is "how much does the needed equipment cost?" The cost of equipment is often more problematic when one leaves the world of HF and VHF/UHF FM gear and ventures into weak-signal VHF/UHF/microwave. Judicious acquisition and use of test gear from China may be part of the answer to keeping the cost of one's amateur radio hobby within budget.

Acknowledgements

The author is indebted to Paul Wade W1GHZ for sharing two slide decks originally presented during the 2017 N.E.W.S. Conference Friday Workshop. One was titled ***Cheap Test Equipment 2017*** and the other was titled ***Microwaves Without a Wheelbarrow of Dollars***. The workshop was a collaboration of Paul with Donald Twombly W1FKF and Michael Seguin N1JEZ

The test results for the RF Explorer Signal Generator and the Rike RK-88 were courtesy of Tom Frederiksen KA3FQS. Roger Rehr W3SZ alerted the author to the value of the RF Explorer pair when used as a network analyzer.