The nanoVNA, an inexpensive Vector Network Analyzer

by Stephen Flowers - W2WF

Overview

- What is a Vector Network Analyzer (VNA)?
- A brief history of the "nanoVNA"
- nanoVNA calibration
- How can <u>you</u> setup the nanoVNA HW & SW
- nanoVNA measurements (demos)
- Questions, comments, & feedback

What is a Vector Network Analyzer (VNA)?

• A device used to characterize antennas, filters, crystals, transmission lines, and other networks.



A brief history of the nanoVNA

- The original NanoVNA was designed by edy555 in Japan and he placed his source code & circuit design in Github.com*.
- Github is an online repository used by a global community of software developers that share code. Here they work on each others' code to implement bug fixes & enhancements.
- After edy555 lost interest and discontinued the project, a developer in China, hugen or hugen79, then picked up the mantle and improved the circuit. What improvements did hugen79 do?*
 - Improved the battery charging circuit
 - Boosted voltage on the RF mixers
 - Changed the microUSB to a type-C USB interface
 - Replaced the Voltage controlled oscillator (VCXO) with a Temperature Controlled oscillator (TCXO)

* source = QEX magazine, Jan-Feb 2020 issue, "An Ultra Low Cost Vector Network Analyzer" by George Steber

nanoVNA calibration (1/3)









Calibration prelim - set scale









nanoVNA calibration (2/3)









nanoVNA calibration (3/3)









Voilá! A calibrated nanoVNA!



How can <u>you</u> setup the nanoVNA? (Hardware)



How can <u>you</u> setup the nanoVNA? (Software)

- I used "NanoVNAsaver" version 0.2.1
- NanoVNAsaver is free to use and is written in Python on Windows, using Pycharm, and the modules PyQT5, numpy, scipy and pyserial.
- You can download the .exe file at this Github URL: https://github.com/mihtjel/nanovna-saver/releases
- Note that the QEX article mentions another software called "NanoSharp" which needs MS Framework 4.0 (heads up!)

NanoVNA Saver – easy to use

ManoVNA Saver 0.2.1 (Sweep: 2019-12-30 19:55:21 @ 101 points)

- 🗆 🗙



Final impressions & thoughts

- I've *learned* about Vector Network Analyzers.
- You can't go wrong with the price of the nanoVNA, \$54 at Amazon (and their return policy is good).
- It's a nice addition to the PC oscilloscope in my HAM shack (Mantra = measure, measure, measure).
- The device is portable, so I could take it to the field (with care). The E&M environment <u>will</u> be different there.
- I've delved into S11, S21, S12, and S22 "scattering" parameters (S-matrix). This applies to Physics <u>and</u> EE.
- Do 2 radials work better than 1? If so, how *much* better??
- I've had <u>fun</u> characterizing all antennas at home!

Your Questions & Comments



Appendix 1 – Amazon order info

Delivered Dec 30, 2019

Your package was picked up from Amazon Locker



NanoVNA 50KHz-900MHz Vector Network Analyzer Kit MF HF VHF UHF Antenna Analyzer Sold by: Qianfengyueying Return eligible through Jan 31, 2020 \$54.99 Buy it again View your item

Delivered Dec 28, 2019

Your package was picked up from Amazon Locker



SMA-UHF RF Connectors Kit SMA to UHF PL259 SO239 4 Type Set SMA Jack/Plug to UHF Nickel Gold Plated Test Converter Pack of 4 ... Sold by: OneLinkMore Tech Return eligible through Jan 31, 2020 \$7.68 Buy it again View your item

Appendix 2

Antenna characterizations

- Wolf River Coils TIA 1000 "bug catcher"
- Nagoya UT 72 mag mount stays on
 Prius roof at 80mph in West Texas!





Nagoya UT-72 @ 2m (notice customized scale in lower right)

× WanoVNA Saver 0.2.1 (Sweep: 2019-12-31 10:03:44 @ 101 points) Sweep control Marker 1 S11 Smith Chart 11 Return Loss (dB) Frequency: 148.000MHz VCWR. 1.621 Start 144MHz Cente 146MHz Impedance: 39.52 +j18.97 Q Return loss: -12.511 dB 148MHz 4MHz Stop Span Series R: 39.52 Q Quality factor: 0.48 39.60kHz/step S11 Phase: 106,94* 1 20,400 nH Segments Series L: Series Ct -56,688 pF S21 Gaint -86.052 dB -12 Sweep settings Parallel 8 -48.63 Ω S21 Phase: -178.11* 100% Parallel L/C: 108.94 nH Sweep Marker 2 VSWR: Frequency: Markers Impedance: Return loss: 148000000 Marker-Quality factor: Series R: S11 Phase: Series L: Marker 2 Series C: S21 Gain: Marker 3 S21 Phase: Parallel R: Parallel L/C: Hide data Locked C Marker 3. TDR -18 VSWR: Frequency: Estimated cable length: 6.341 m Return loss: Impedance: Quality factor: Time Domain Reflectometry Series R: S11 Phase Series L: -20 Series C: S21 Gain: 144.08 145.3M 146.7M 148.01 Parallel R: S21 Phase: S11 VSWR S11R+jX (0) Parallel L/C 40.0 -21.0 511 Min V5WR: 1.621 @ 148.000MHz 38.2 -17.5 Return loss: -12 511 dB 7.67 \$21 36.5 14.0 Min gain: -110.592 dB @ 146.080MHz Max gain: -77.153 dB @ 145.960MHz 34 8 10.5 Reference sweep 33.0 Set current as reference Serial port control 29.5 n n Serial port COM4 Q. Rescan Disconnect 27.8 Calibration Files ... Display setup About Analysis ... 145.00 146.00 147.08 145.3 146.7% 148.0M 144.0 148.00

Nagoya UT-72 @ 70 cm

SanoVNA Saver 0.2.1 (Sweep: 2019-12-31 10:04:50 @ 101 points)

– 🗆 X



Wolf River Coils TIA 1000 @ 40 m

ManoVNA Saver 0.2.1 (Sweep: 2019-12-30 18:43:22 @ 101 points)

- 🗆 X



Wolf River Coils TIA 1000 @ 80 m

ManoVNA Saver 0.2.1 (Sweep: 2019-12-30 18:20:57 @ 101 points)

- 🗆 X



WRC TIA 1000 w/2 radials deployed

😁 NanoVNA Saver 0.2.1 (Sweep: 2019-12-30 19:06:05 @ 101 points)

- 0



WRC TIA 1000 w/1 radial deployed

WanoVNA Saver 0.2.1 (Sweep: 2019-12-30 19:03:25 @ 101 points)

- 🗆 X



Appendix 3 - Useful Links

Ham Radio Crash Course episode on nanoVNA https://youtu.be/tLMAStiaAxU What's the accuracy of the nanoVNA? https://youtu.be/ggcQ7GsGc8s Using an Oscilloscope to find the location of an open or short in a coax, i.e. a "poor man's TDR" https://youtu.be/II eju4D TM