Comparison of Nano Vector Network Analyzers

Nathan Heier

July 20, 2026

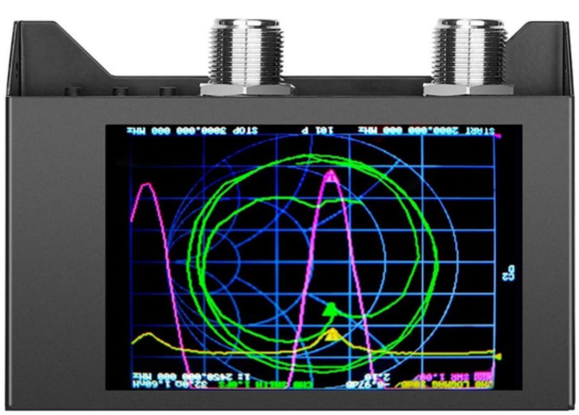
1 Introduction

Vector Network Analyzers (VNAs) are used to characterize RF components such as antennas, filters, cables and so on. This can enable users to adjust their RF component or antenna designs to better match their needs. While laboratory and pro-grade VNAs are highly accurate for this job, their costs places them out of reach for hobbyists and CHART users.

The NanoVNA was introduced in 2019 as an open source handheld VNA designed by a HAM radio hobbyist in Japan. The popularity of the device led to widespread adoption and for many manufacturers to produce their own versions. Official hardware is now produced by NanoRFE with their internal testing showing their VNAs to be quite similar to Laboratory grade VNAs. This Memo will compare a laboratory grade VNA to cheaper NanoVNAs not produced by NanoRFE that are available on Amazon, often described as 'clones' by the hobbyist community.

2 Equipment

Below are the two NanoVNAs purchased from Amazon. Although the physical construction is different between the two, both use the same firmware and can be controlled using "nanovna-saver" software.



(a) 2n NanoVNA

(b) v2 NanoVNA

Table 1: Equipment Used

Item	Model	Link
Laboratory VNA	Copper Mountain CMT304U	Data Sheet
SMA2.1 Calibration Kit	Calibration Kit included with CMT304U	————
Band-pass Filter	Band-pass filter included with CMT304U	————
NanoVNA v2	Nooelec NanoVNA v2 (S-A-A-2)	Amazon
v2 Calibration Kit	Calibration Kit included with NanoVNA v2	————
NanoVNA 2n	SAA-2n VNA Antenna Analyzer, SEESII	Amazon
2n Calibration Kit	Calibration Kit included with NanoVNA 2n	Standards Used
SMA and N Type Cables	Coaxial cables included with 2n NanoVNA	————
SMA Adapters	onelinkmore SMA to N Type Adapter	Amazon
Attenuators	Nooelec 6pc 2W 50 Ohm SMA in-Line Attenuators	Amazon

Unless otherwise noted, measurements were performed using the same test cables, same adapters and the same measurement configuration for each instrument.

3 Procedure and Results

All instruments were configured with the following settings:

- Frequency range: 1 MHz to 3.2 GHz
- 201 Data Points
- Output power: -7dBm

I chose to use the same N type cables that came with the 2n VNA for every test. The N type to SMA adapters were used to connect the cables to the attenuators, band-pass filter, and the the calibration kits. The v2 VNA had to use an extra set of N type adapters on both of the VNA ports.

For the laboratory VNA, its own proprietary software was used to collect the data on my laptop. For the two NanoVNAs I used a software called "nanovna-saver" which can be found on the NanoRFE website. I chose to measure the forward transmission coefficient (S21) of each VNA to show performance of both ports. Each VNA was measured for each test configuration, new calibrations were performed on each instrument for every test configuration.

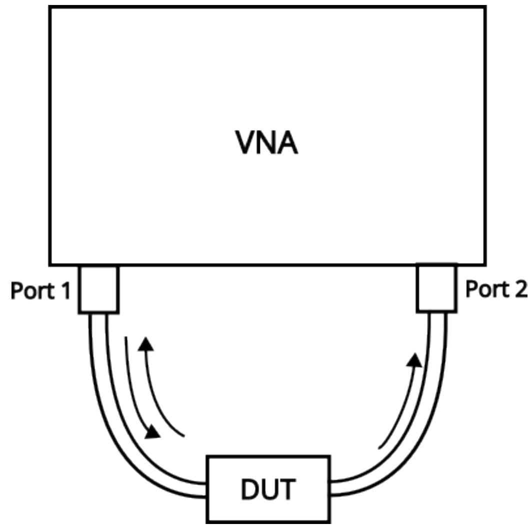


Figure 2: Test setup diagram. The device under test (DUT) is either an attenuator or a band-pass filter. The arrows show the signal path for the NanoVNA, where port 1 transmits and receives while port 2 only receives. This setup measures S11, the signal reflected back to port 1, and S21, the signal transmitted from port 1 to port 2.

3.1 NanoVNA Differences

When I was collecting data I noticed the two NanoVNA models produced very similar measurements. Both devices used the same data collection software and required approximately the same amount of time to complete each sweep. Figure 3 compares both NanoVNA models measuring a 1dB attenuator. The measured S21 traces are close enough that their noise makes them indistinguishable from each other.

During testing, I did notice slight shifts of ± 0.08 dB in the gain on the v2 VNA after recalibration. This shift was not repeatable, so I concluded this was likely an issue related to calibration or the use of an extra set of adapters required on the v2 VNA. Because the two NanoVNAs produced similar results, I decided to focus on the 2n NanoVNA for further instrument tests. The 2n had stronger physical construction and N type connectors which made collecting data easier and more similar to the laboratory VNA.

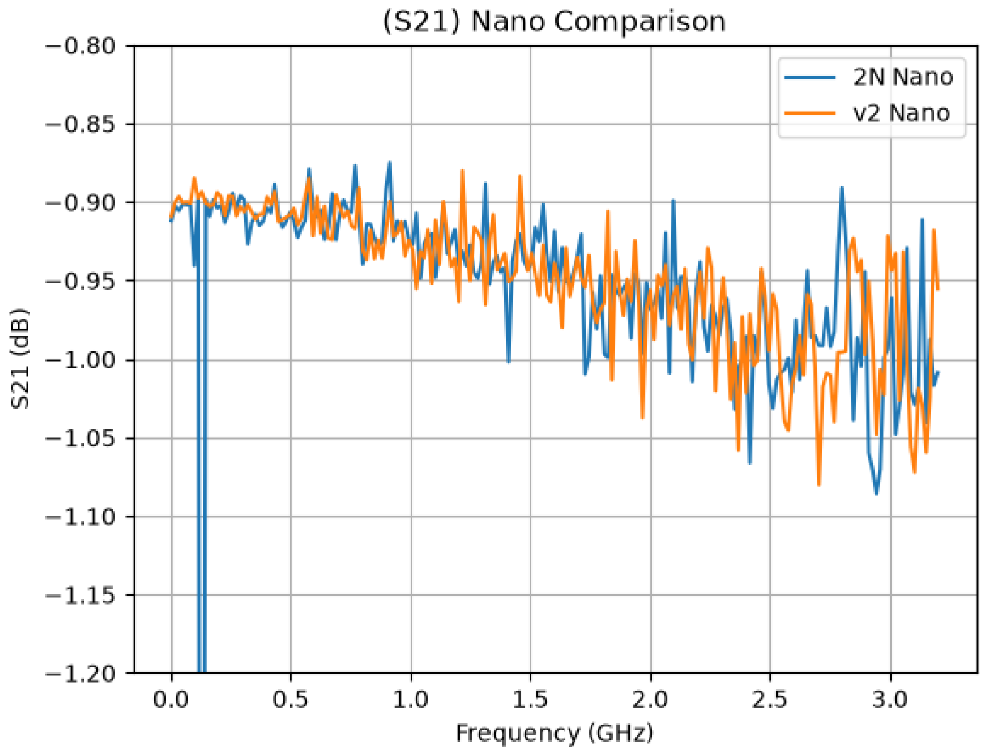


Figure 3: S21 graph of both NanoVNAs measuring a 1dB attenuator. Both VNAs were calibrated using the 2n calibration kit. The negative spike at approximately 0.15 GHz in the 2n trace was present in all my results, but the cause is unknown.

3.2 Sweep Averaging

When testing, I found that the NanoVNAs had significantly higher noise compared to the laboratory VNA. In order to reduce the noise, I decided to use the average sweep feature in “nanovna-saver” to average the sweeps of the NanoVNA. this feature does take extra time to use, since each sweep takes a few seconds to complete. To test the effects of averaging, I performed tests on the 2n NanoVNA with a 6dB attenuator all the way up to 100 sweeps. The calibrations were taken with the same amount of averaged sweeps for each trial using the 2n calibration kit. Figure 4 shows that averaging removed a decent amount of noise. Increasing the sweep count beyond 6 sweeps seems to have a very minor effect on the results. I chose a middle ground of 3 sweeps for further tests as this provided a good balance between noise reduction and test time.

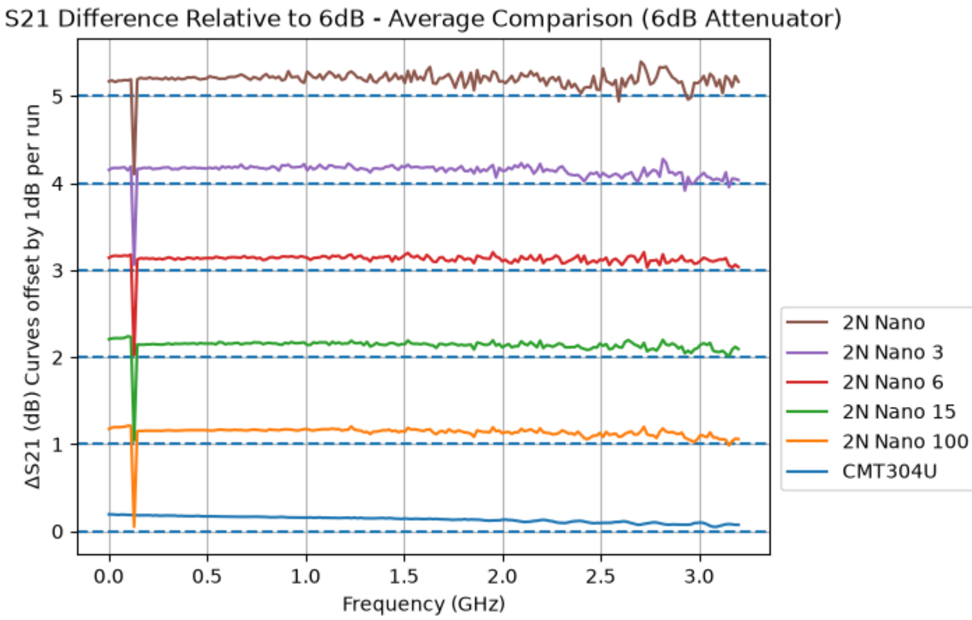


Figure 4: S21 graph of the 2n NanoVNA measuring a 6db attenuator calibrated using the 2n calibration kit. Each run was subtracted by 6dB and offset by 1dB from the previous run. The number of sweeps is indicated in the legend with the laboratory VNA included as a baseline

3.3 Calibration Comparisons

The 2n NanoVNA was calibrated using both calibration kits, including the laboratory SMA 2.1 calibration kit and the calibration kit supplied with the 2n NanoVNA. I also chose to use a third calibration kit included with the v2 NanoVNA that used ideal parameters. I then measured a 6dB attenuator for each kit as a baseline. The resulting measurements were compared to determine whether the calibration kits included with the NanoVNA introduced measurement errors.

For both the 2n kit and the SMA2.1 kit their calibration parameters included with the documentation were used. Calibration was performed using the same cables and adapters used to measure the attenuators. After comparing the results, I found that if you use the parameters included with the kit the calibration difference is very close and mostly dominated by noise.

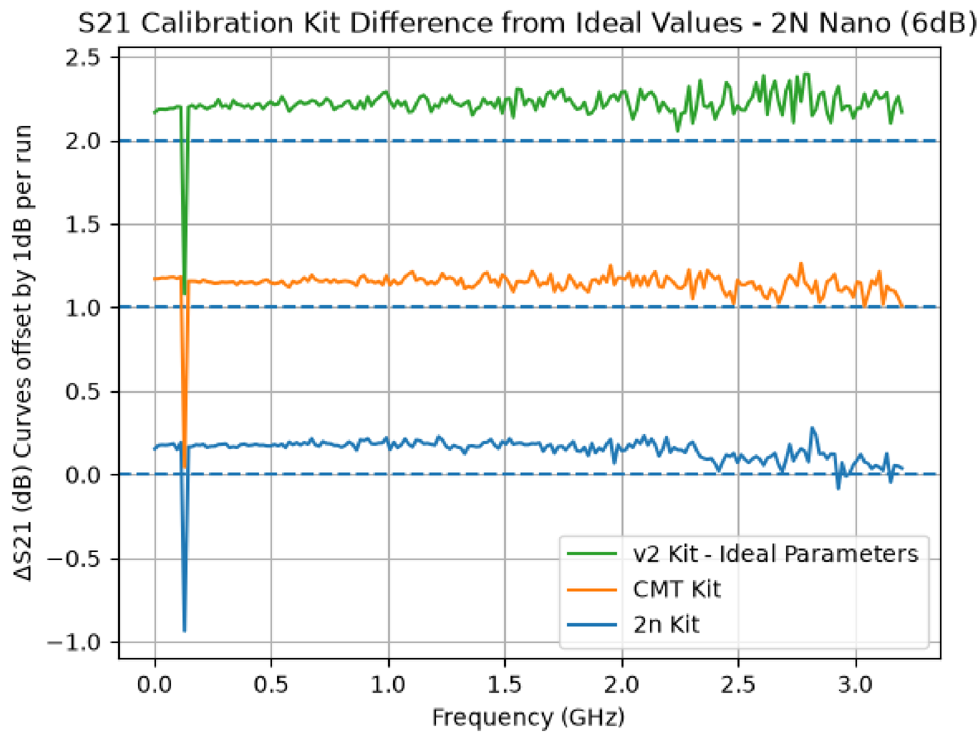


Figure 5: Comparison of the included calibration kits using the 2n Nano. "v2 Kit" was measured using a calibration kit that came with the v2 VNA and ideal values for the parameters.

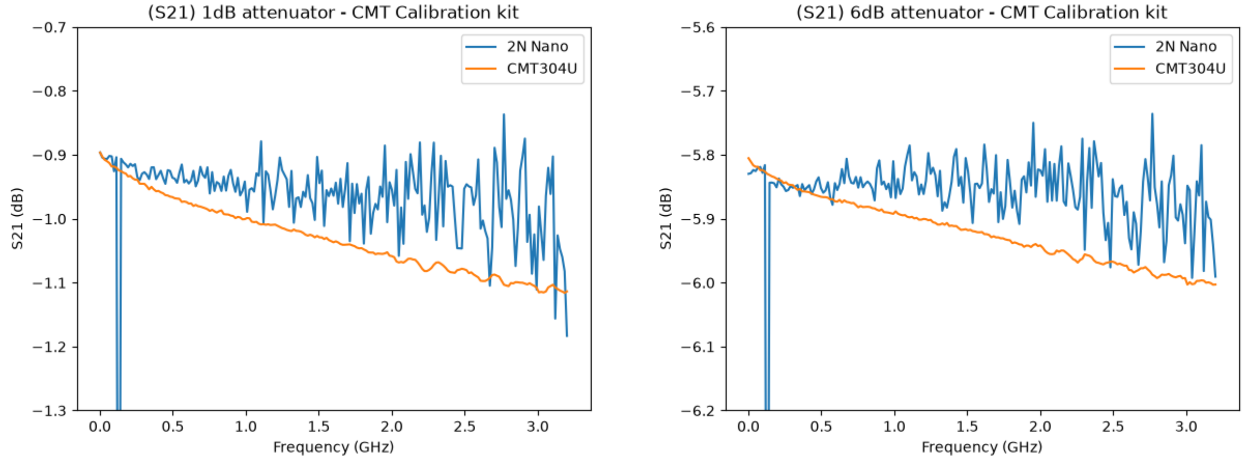
3.4 VNA Comparison

To compare the overall performance of the VNAs I collected S21 measurements on the same test devices with the same calibration standards. The following devices were:

- 1dB attenuator
- 6dB attenuator
- Band-pass filter

The results for both attenuators on the 2n NanoVNA are shown in figure 6. In comparison to the laboratory VNA, the 2n NanoVNA showed significantly more variation due to noise. The variation increased with higher frequencies on all measurements.

The results for the band-pass filter is shown in figure 7. The 2n Nano VNA had a shift in frequency of approximately 15.26 MHz at 201 sweep points. This value is very similar to the step size of 15.995 MHz. When I increased the amount of sweep points, the shift also decreased matching the step size. I also noticed a similar shift in the v2 NanoVNA as well. The exact cause of this is still unknown and will require some further investigation.



(a) 1dB attenuator

(b) 6dB attenuator

Figure 6: S21 graphs of the 2n NanoVNA and the laboratory VNA measuring a 1dB and 6dB attenuator. The NanoVNA was using 3 averaged sweeps to reduce noise.

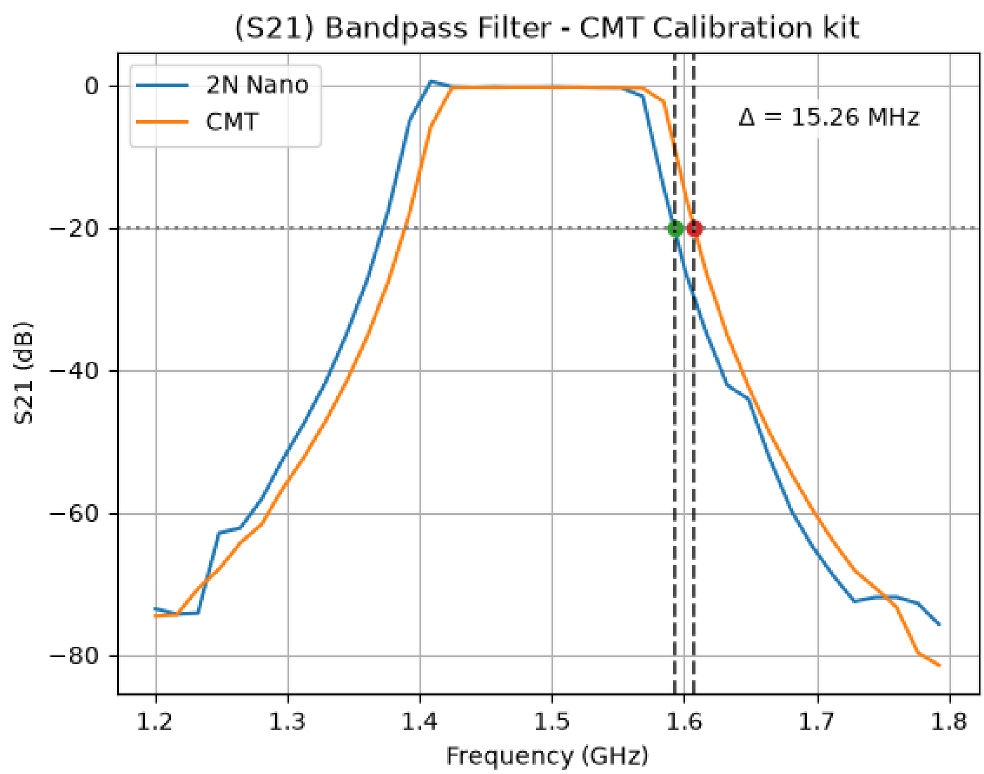


Figure 7: A zoomed in S21 graph of the 2n NanoVNA and the laboratory VNA measuring a band-pass filter. The offset between both VNAs was measured at -20dB.

4 Conclusion

The results show that the lower cost NanoVNAs can provide useful S21 measurements, especially for simple RF components. Both the 2n NanoVNA and v2 NanoVNA behaved similarly, and the differences between them were small and dominated by measurement noise. Therefore, the choice between the two devices is more strongly affected by construction quality, connector type, and ease of use than by measurement performance.

The main limitation of the NanoVNAs was noise. Compared with the laboratory VNA, the NanoVNA traces were less smooth and showed more variation across frequency. Sweep averaging improved this problem, but it did not completely remove it. A small number of averages, such as 3 sweeps, provided a practical improvement without making the measurement process too slow. If you are looking to perform S21 RF measurements with errors less than ± 0.3 dB, I'd recommend staying away from these NanoVNAs. The official NanoVNAs from NanoRFE do claim to have a high accuracy compared to the units tested in this memo, which we plan to investigate soon.

Overall, these NanoVNAs are a useful low cost instrument for basic RF testing. It should not be considered a full replacement for a laboratory VNA, but it is accurate enough for many hobbyist and CHART measurements such as locating and tuning the resonance frequency.