Revised - Use of The NanoVNA For Antenna Measurements

W5IFQ

7 AUG 2021

Uses For the NanoVNA

- VNA – Vector Network Analyzer
- Make a wide range of transmission Line and Antenna measurements.
- Will discuss only two tonight:
  - Transmission Line loss
  - SWR

Transmission Line Loss

- To evaluate the quality of your transmission line you need to make two sets of measurements as follows:
  - DC Continuity between the ends of the transmission Line with an Ohmmeter.
  - RF loss versus frequency and compare this loss in dB/100 ft. with the manufacturer's specification. This is best done with an Vector Network Analyzer. A NanoVNA and the free NanoVNA Saver software can provide excellent cable loss analysis.

NanoVNA-F Used

NanoVNA-F Vector Network Analyzer SWR Meter Smith 【Upgraded】 Hardware V3.1,10KHz-1.5GHz 4.3 Inch IPS TFT Shortwave MF HF VHF Portable Handheld Antenna Analyzer

Brand: HKCNMA.COM

47 ratings | 13 answered questions

Price: $149.73 & FREE Returns

Combined Purchase (Amazon)

Frequently bought together

Total price: $165.32

Add all three to Cart

These items are shipped from and sold by different sellers. Show details

- ☑ **This item:** NanoVNA-F Vector Network Analyzer SWR Meter Smith【Upgraded】 Hardware V3.1,10KHz-1.5GHz 4.3 … $149.73
- ☑ DHT Electronics Handheld Antenna Cable SMA Male to UHF SO-239 Female Connectors 6" Pack of 2 $6.80
- ☑ SMA-UHF RF Connectors Kit SMA to UHF PL259 SO239 4 Type Set SMA Jack/Plug to UHF Nickel Gold Plated Test C… $8.79

Connector Adapters-page 1

DHT Electronics Handheld Antenna Cable SMA Male to UHF SO-239 Female Connectors 6'' Pack of 2

Brand: DHT Electronics

1,721 ratings | 22 answered questions

Amazon's Choice in Cable Gender Changers by DHT Electronics

Price: $6.80 Get **Fast, Free Shipping** with Amazon Prime & FREE Returns

Get $50 off instantly: Pay $0.00 ~~$6.80~~ upon approval for the Amazon Rewards Visa Card. No annual fee.

Connector Type	RF Connector
Cable Type	Coaxial
Compatible Devices	Amplifier
Brand	DHT Electronics

Connector Adapters-page 2

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 ...

Visit the onelinkmore Store

1,322 ratings | 9 answered questions

Amazon's Choice for "sma to pl259 adapter"

Price: $8.79 Get **Fast, Free Shipping** with Amazon Prime & FREE Returns

Color: **Black**

 **$8.79**  $11.98

- SO239 FEMALE jack to SMA MALE plug RF coax adapter included
- SO239 FEMALE jack to SMA FEMALE jack RF coax adapter included
- PL259 MALE plug to SMA MALE plug RF coax adapter included
- PL259 MALE plug to SMA FEMALE jack RF coax adapter

Connector Comment

- Several articles on the use of the NanoVNA to make antenna and cable measurement recommend using a flexible cable jumper cable, as shown on page 6, to connect a stiff, heavy cable to the NanoVNA. Apparently the connectors on the NanoVNA are solder directly to the PC board and can easily be broke off by applying bending moments to the small SMA connectors.
- This said, I have found that when doing a remote cable calibration as discussed on page 40, that I must connect the remote test cable directly to the NanoVNA via the SMA to UHF adapter without even the short extension cable.

NanoVNA Saver Software Download

(QST – May 2020, pages 39 – 43)

https://nanorfe.com/nanovna-v2-software.html

NanoVNA Saver

v0.3.8 (Latest version)

Linux executable

MacOS executable

Windows 64 bit

Windows 32 bit

NanoVNASaver.x64(2).zip	7/13/2021 1:31 PM	WinZip File	75,649 KB

Unzip

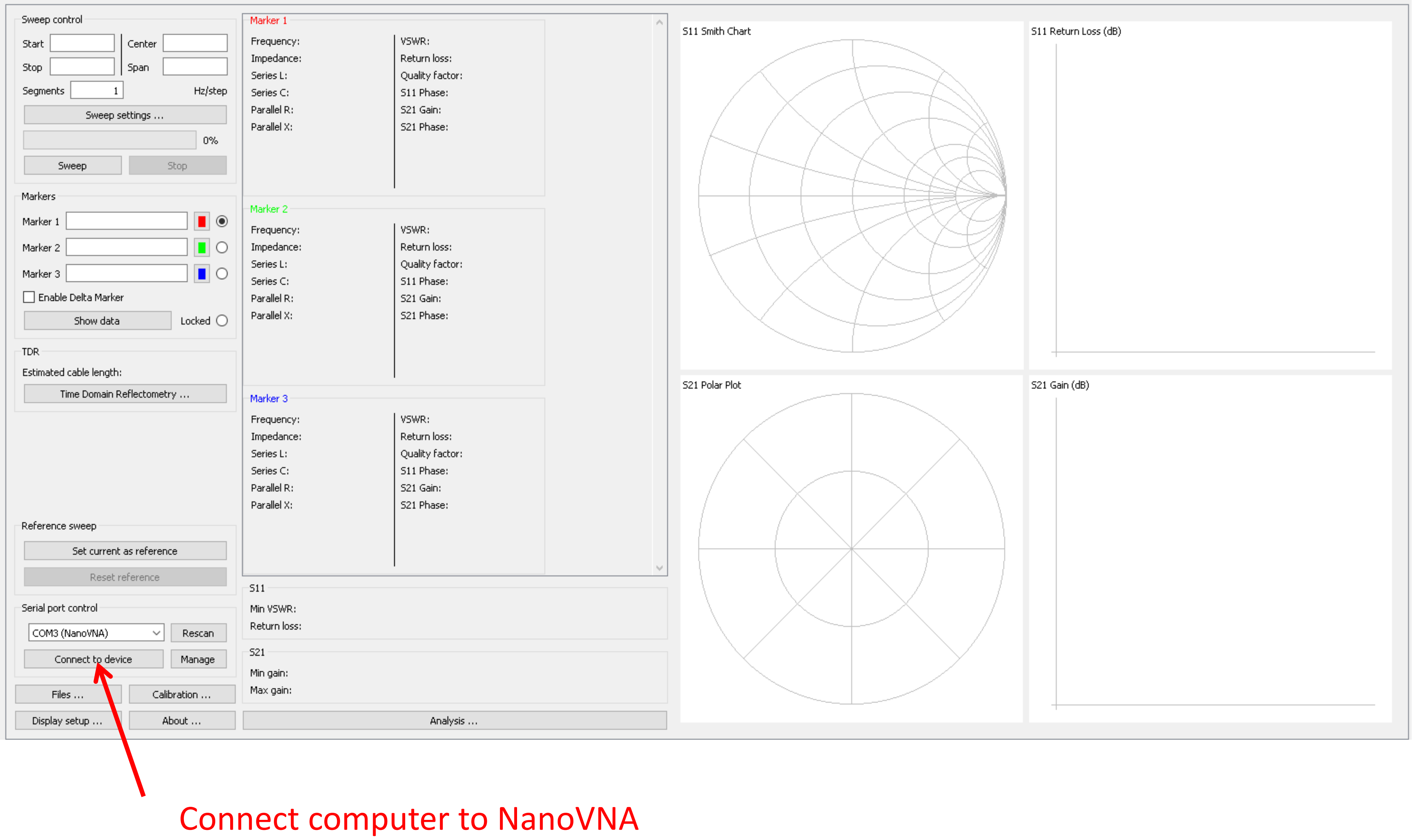
nanovna-saver.exe	11/1/2020 12:33 PM	Application	76,167 KB

Connect NanoVNA To Computer

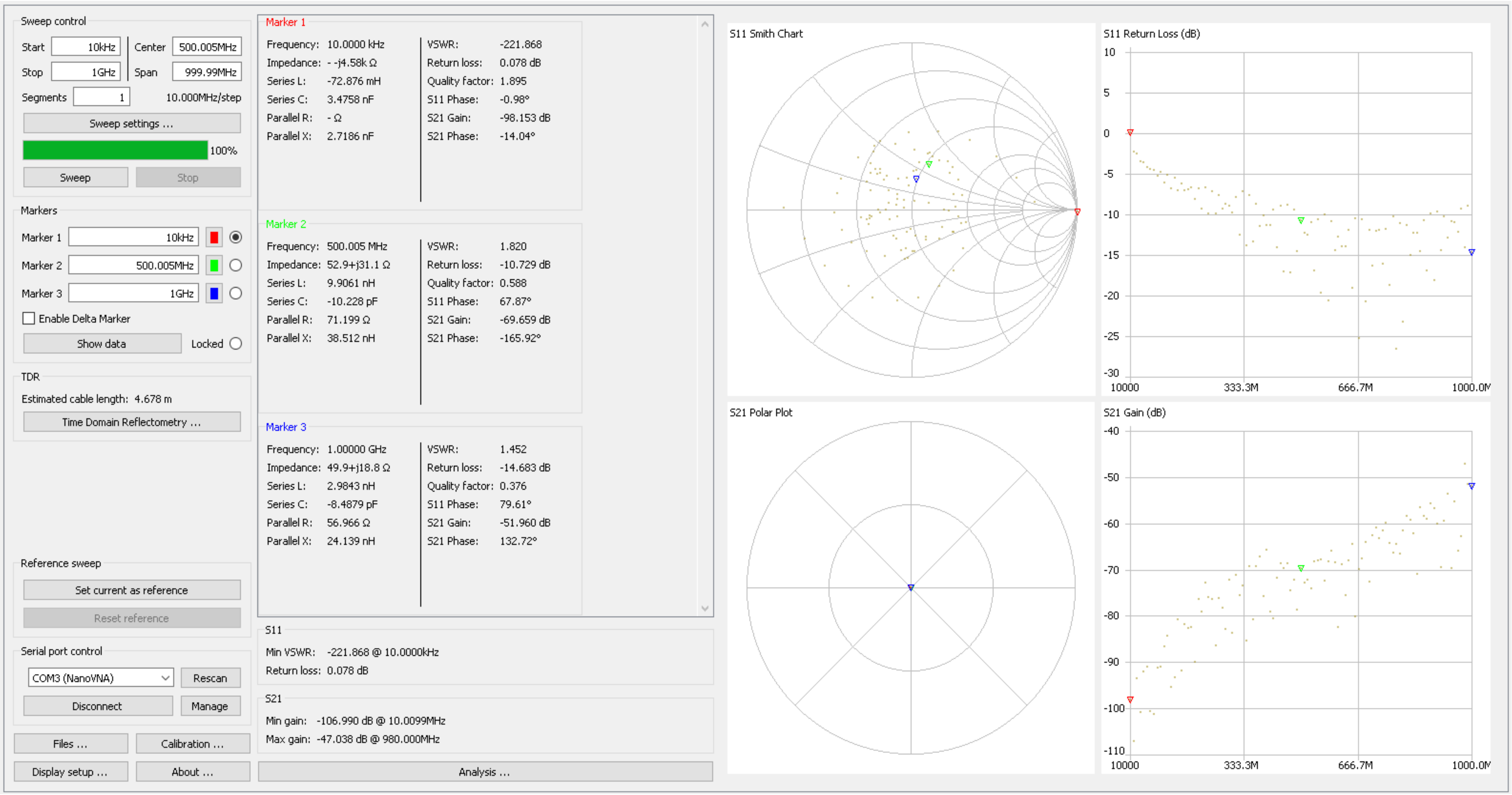
Running NanoVNA Saver

- Connect NanoVNA to computer USB port as shown on page 10.
- Turn on NanoVNA.
- Computer should acknowledge driver loaded (beep)
- Double Click on 

NanoVNA Saver V 0.3.8 Display



Connect to Device Result

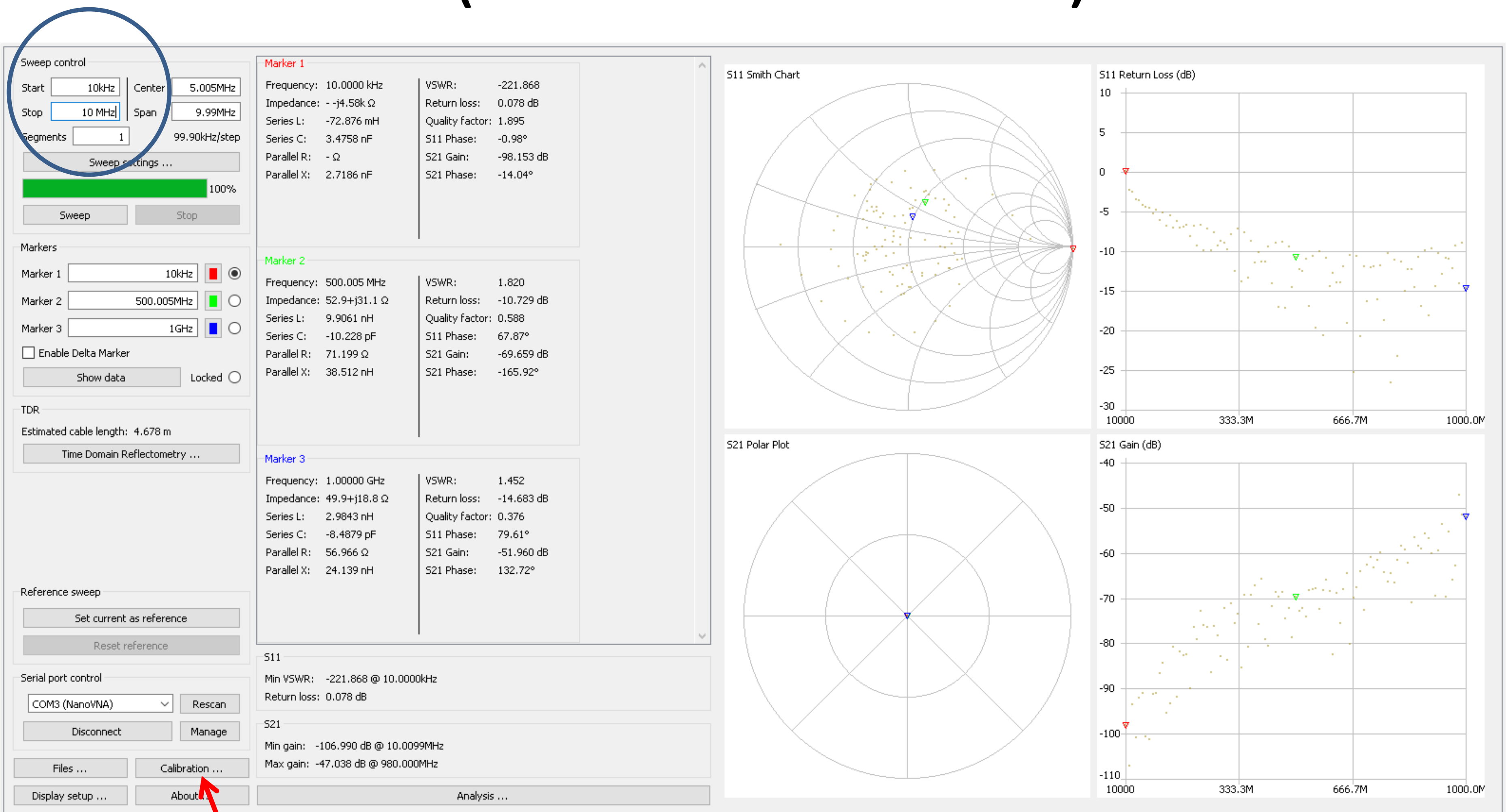


Frequency Span Setting

- The NanoVNA takes only <u>101</u> data points across the complete frequency span setting.
- For maximum accuracy distribute these data points across your frequency band of interest.
- For example, for NVIS antenna and cable measurements, use 10 KHz to 10 MHz. You can narrow this range to 2 – 10 MHz or even more narrow range to detect sharp resonances.

Set Frequency Span Then Calibrate (10 KHz – 10 MHz)

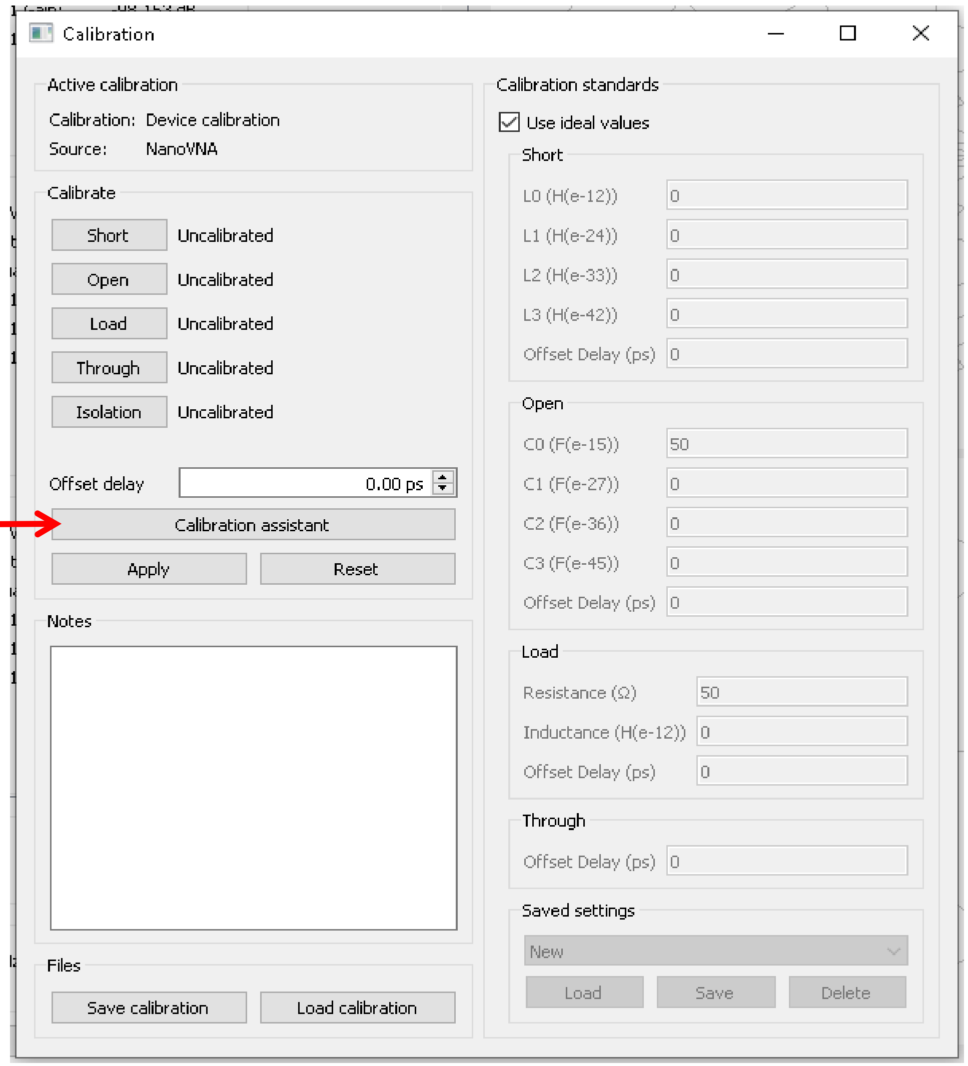
#1 set span



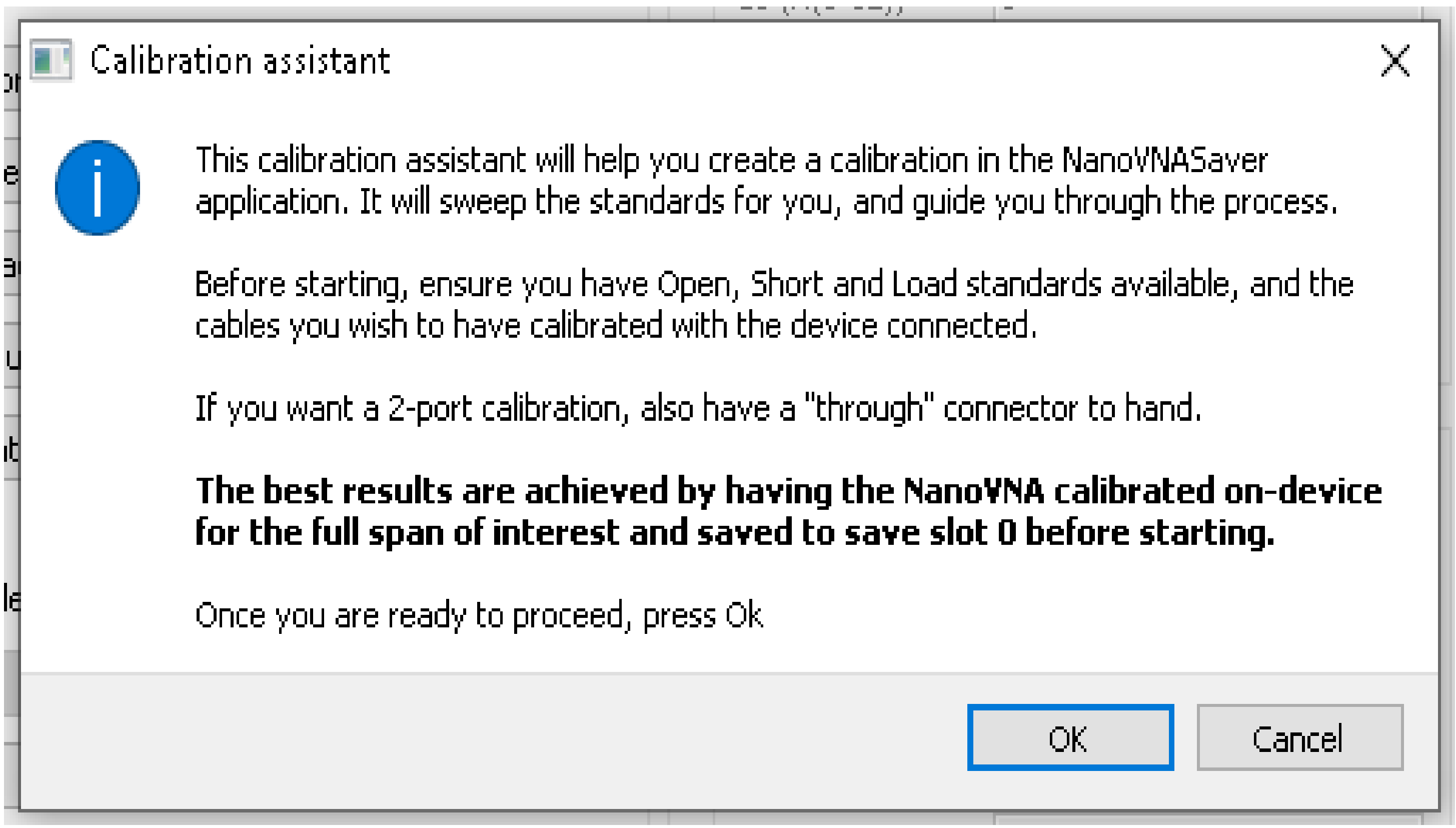
#2 calibrate

Calibration Screen

Click to bring up Calibration Assistant



Calibration Assistant

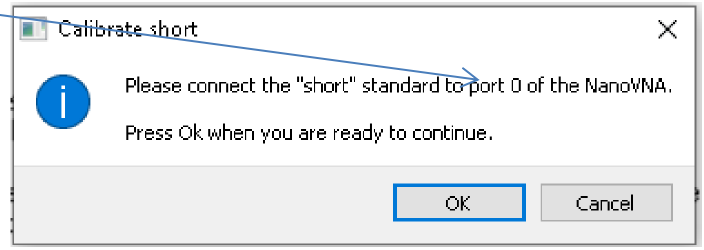


Calibration Connectors

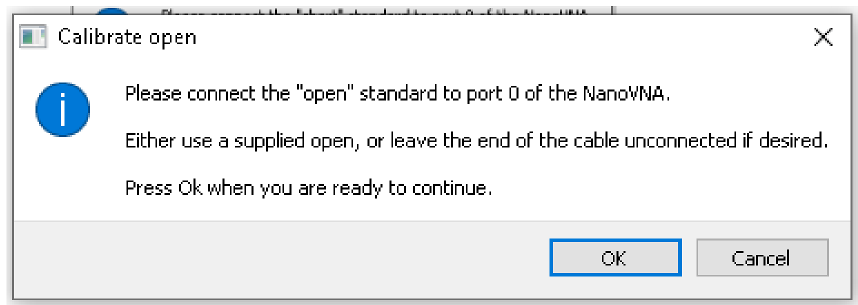
Calibration Steps

Note: Port 1 on this NanoVNA is their Port 0

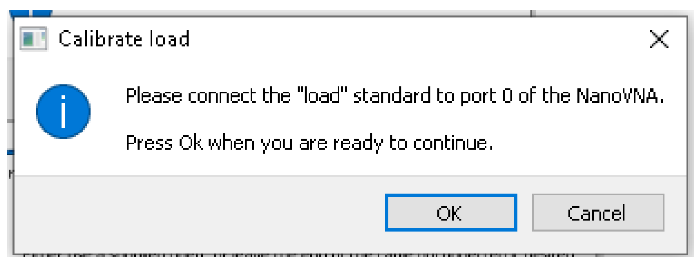
Step 1



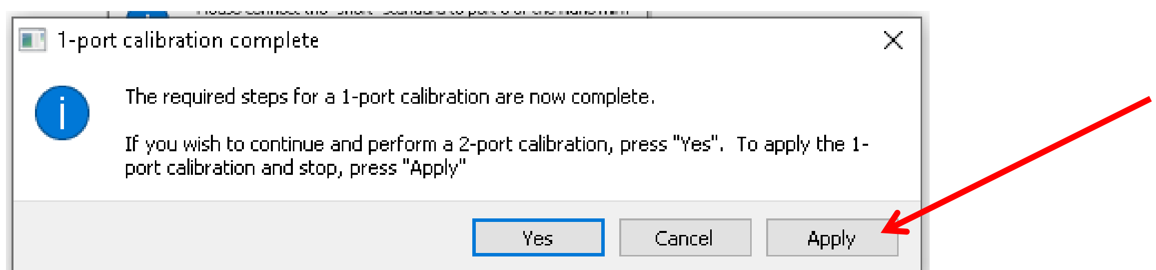
Step 2



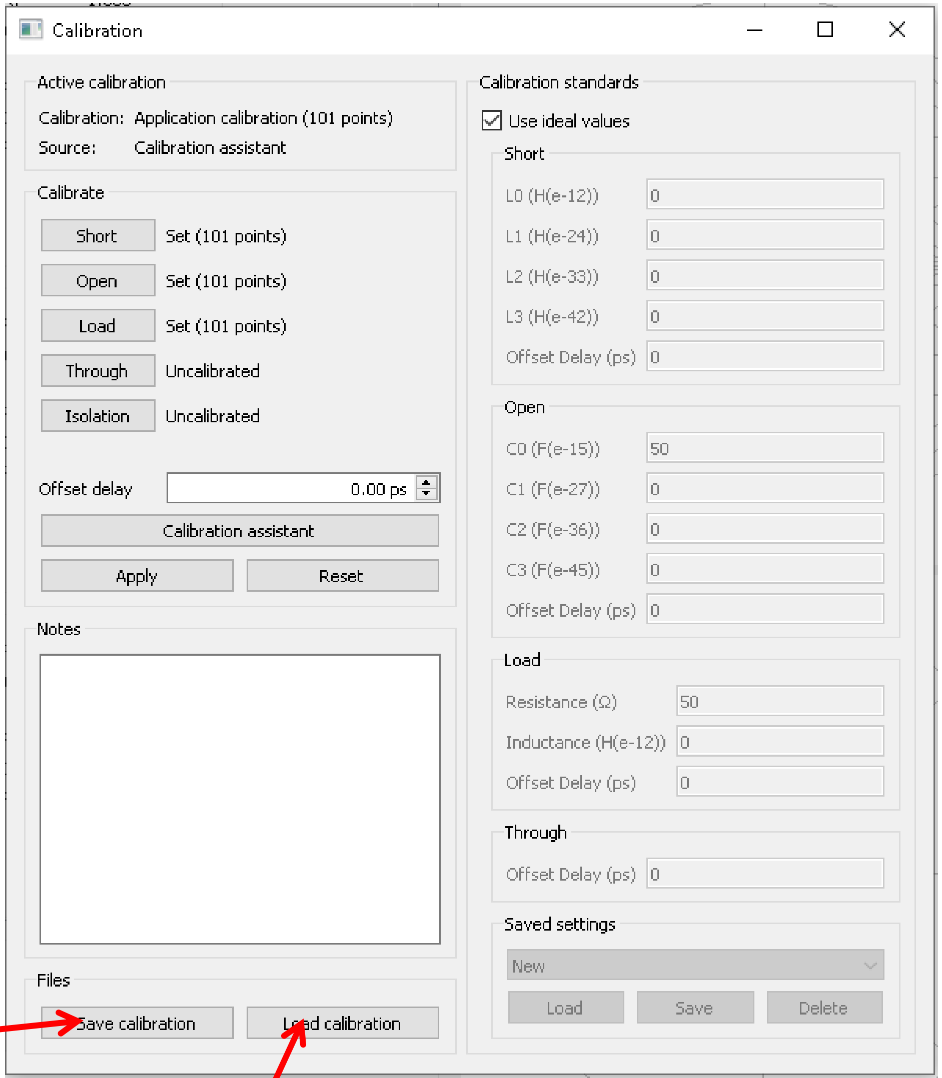
Step 3



Step 4



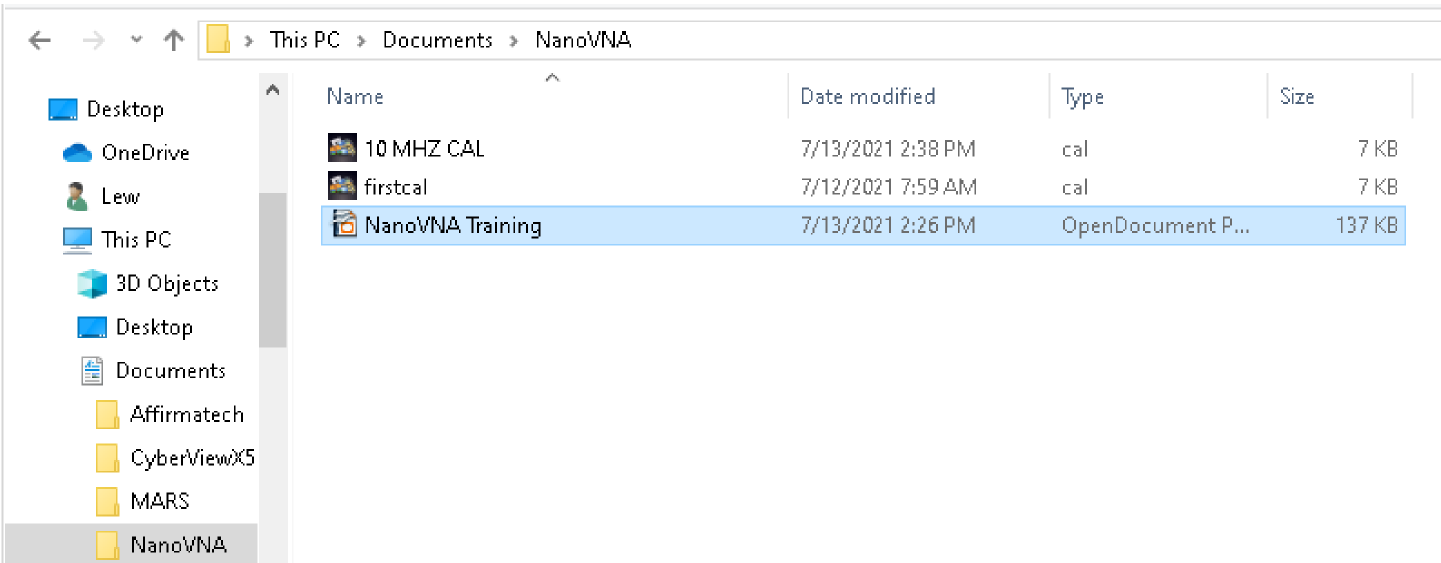
Save Calibration



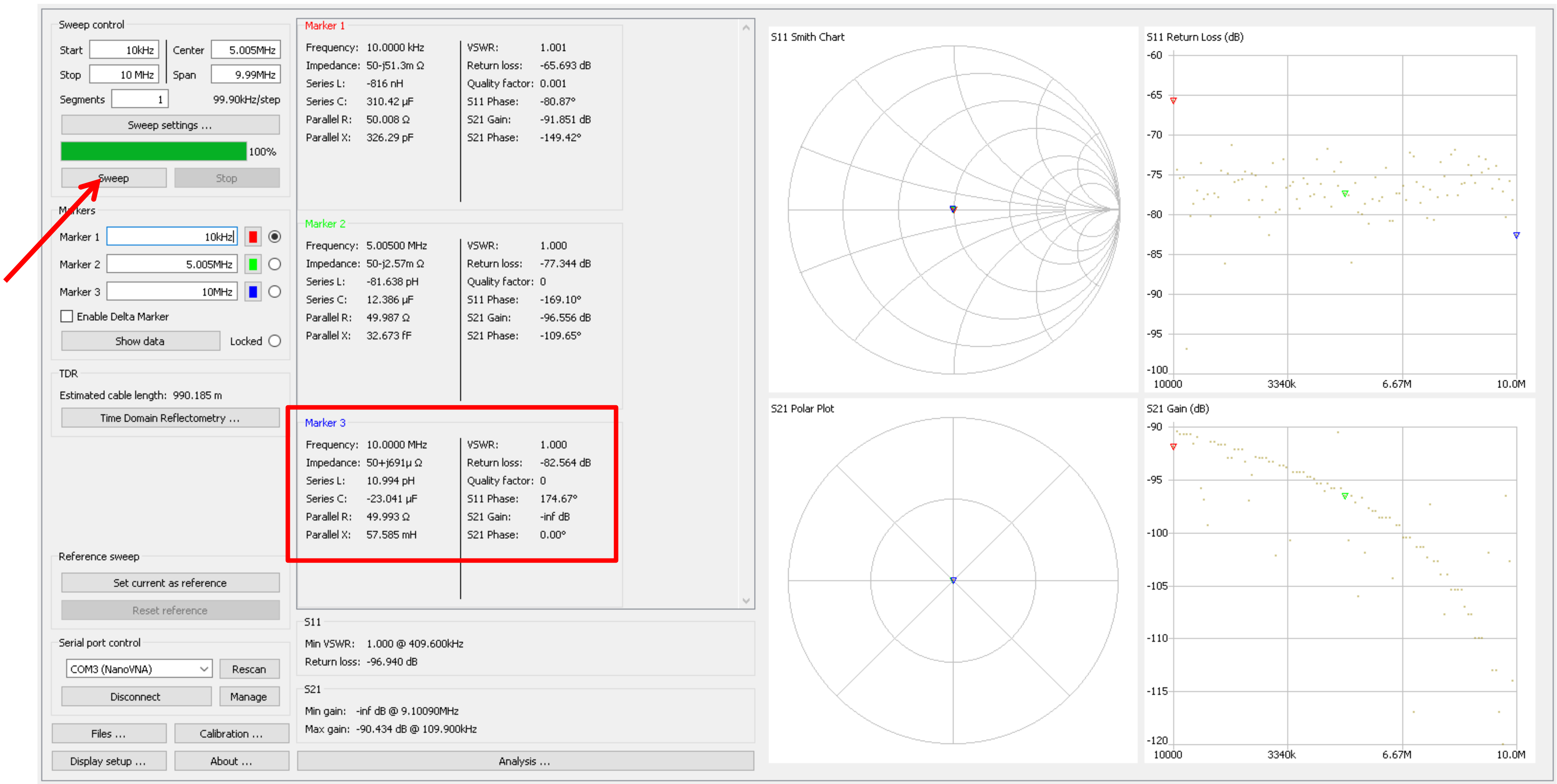
Save your Calibration

After shutting down Nano VNA, must load Cal file

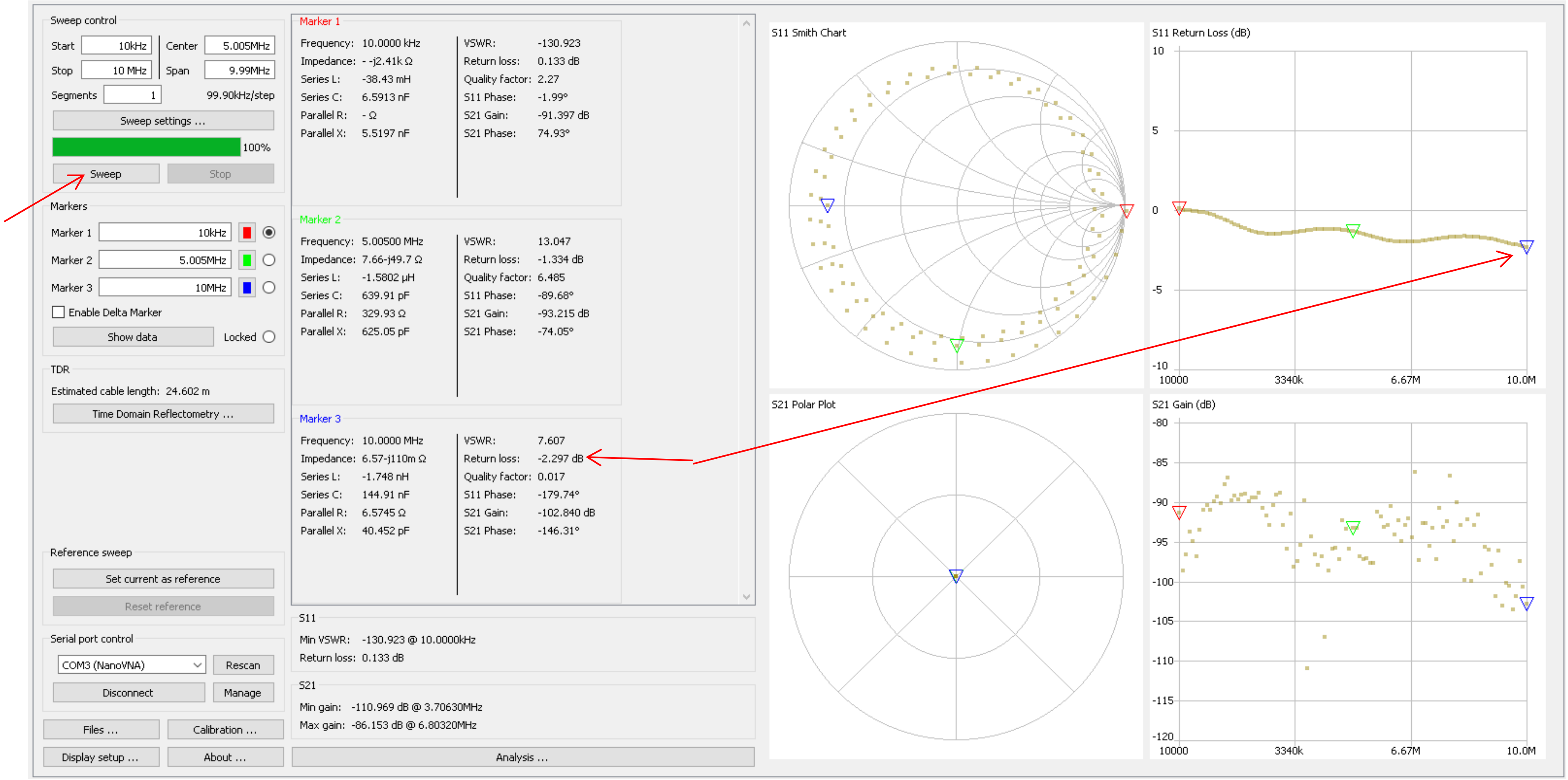
Calibration Files Example



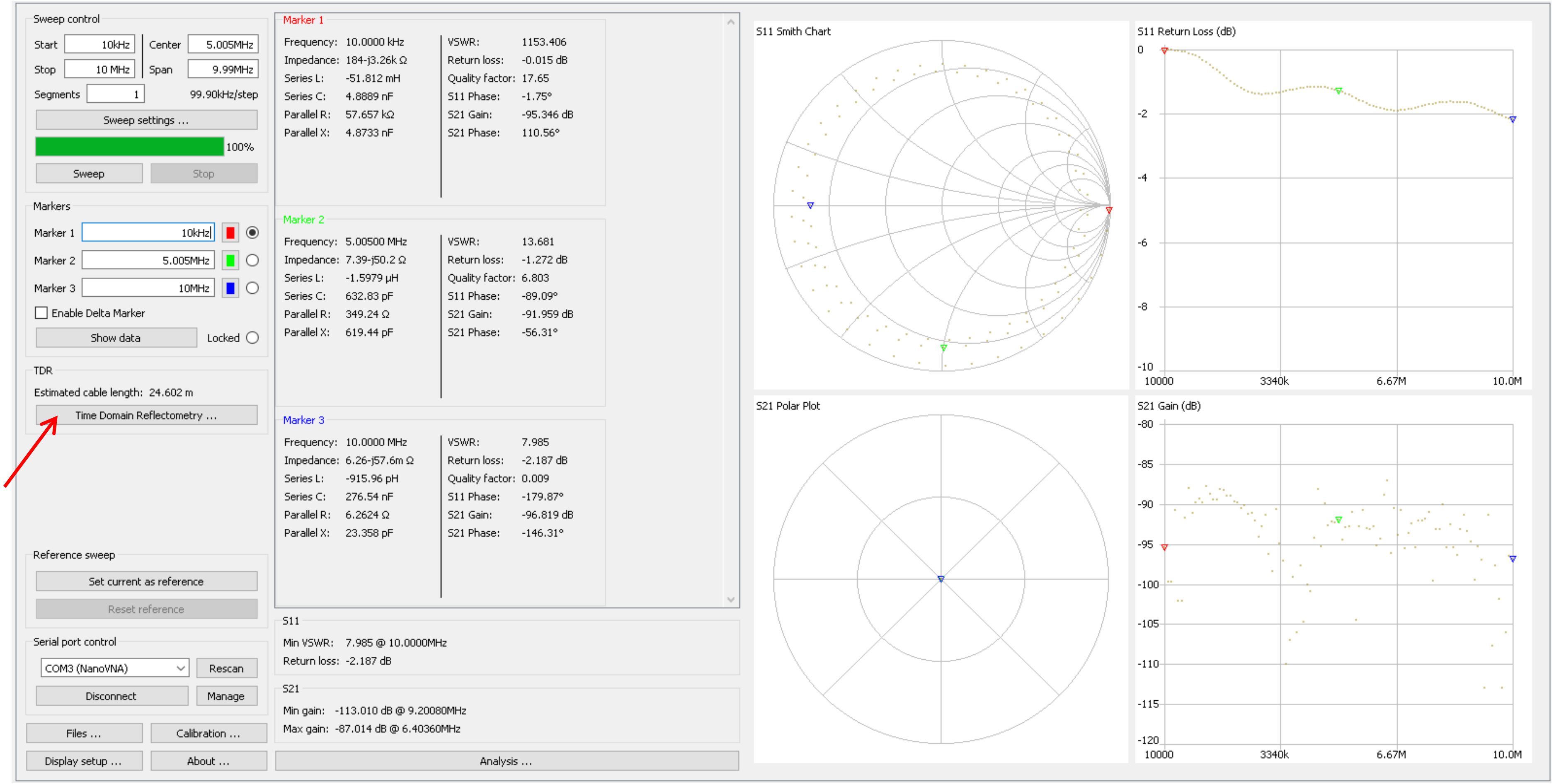
Test Sweep with 50 ohm load



Cable Sweep – RG8X

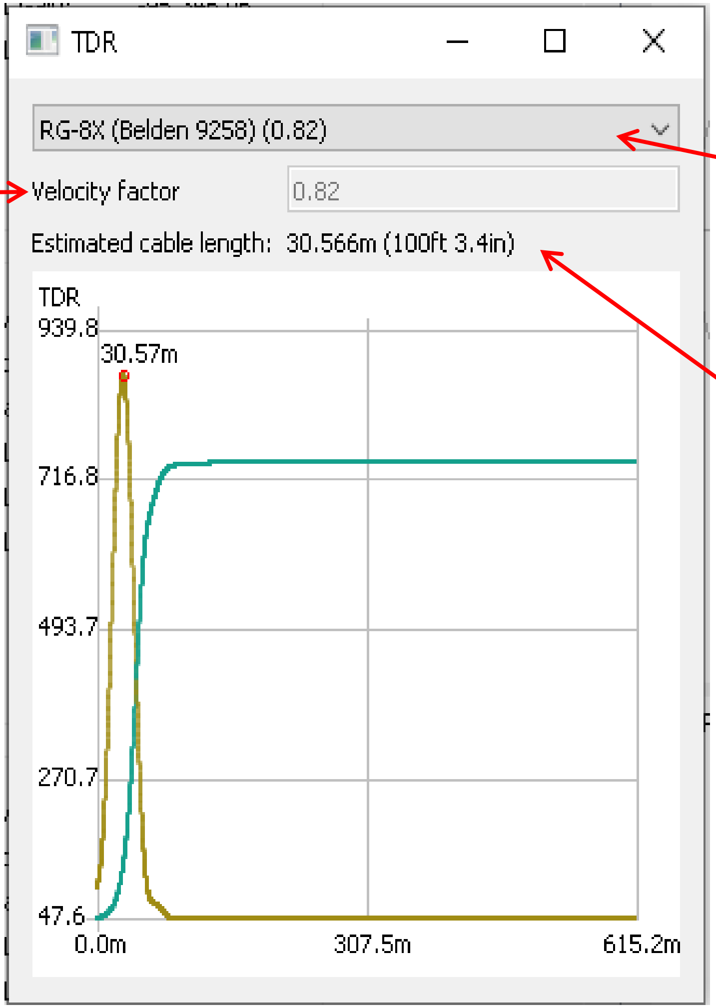


Cable Length?



Using TDR function to get Electrical Length and Check for damage

The correct Velocity Factor must be entered to get actual length



Select cable type Or dielectric

Cable Length

Cable Loss – RG8X

- The Return Loss, S11, on page 23, for 10 MHz is -2.297 dB. This is the two way loss, out and back, so the cable loss is one-half this amount or 1.1485 dB.
- Loss is specified in dB per 100 ft. This cable happens to be 100 ft. length as both physically measured by me and also measured by the TDR routine as shown on page 25. So the measured loss is 1.1485 dB/100 ft.
- To adjust for other cable lengths, multiple the length by 100 and divide by the physical length to calculate the loss/100 ft.
- The specified cable loss for this ABR Industries RG8X, as shown on page 27, is 0.9 dB/100 ft. at 10 MHz. So this several-year-old cable is still good and this difference is well within the manufacturer's variability.

ABR Industries RG8X Specification

Gas Injected Foam Polyethylene Dielectric VP: 80%

our Closed-Cell-GIFP dielectric is a major advantage over standard RG8x; those products use a chemical foam dielectric; which causes higher losses, will-not stand-up to heat, and that will cause the center conductor to migrate into the braid, and short-out.

Voltage DC: 1500Volts RMS: 5000

Maximum permissible D.C. voltage level is conservatively 3 times the A.C. level.

PP kW: 5.6

RoHS Compliant.

Overall Diameter: .242"

Weight 4#/100ft

All cable are fully tested. Hi-Pot® and continuity.

Nominal Attenuation-per 100ft/Power Rating(kW)/Efficiently%

0.9dB @ 10MHz/2.16kW/80% E.

1.6dB @ 30MHz/1.24kW/69% E.

2.1dB @ 50MHz/.96kW/62% E.

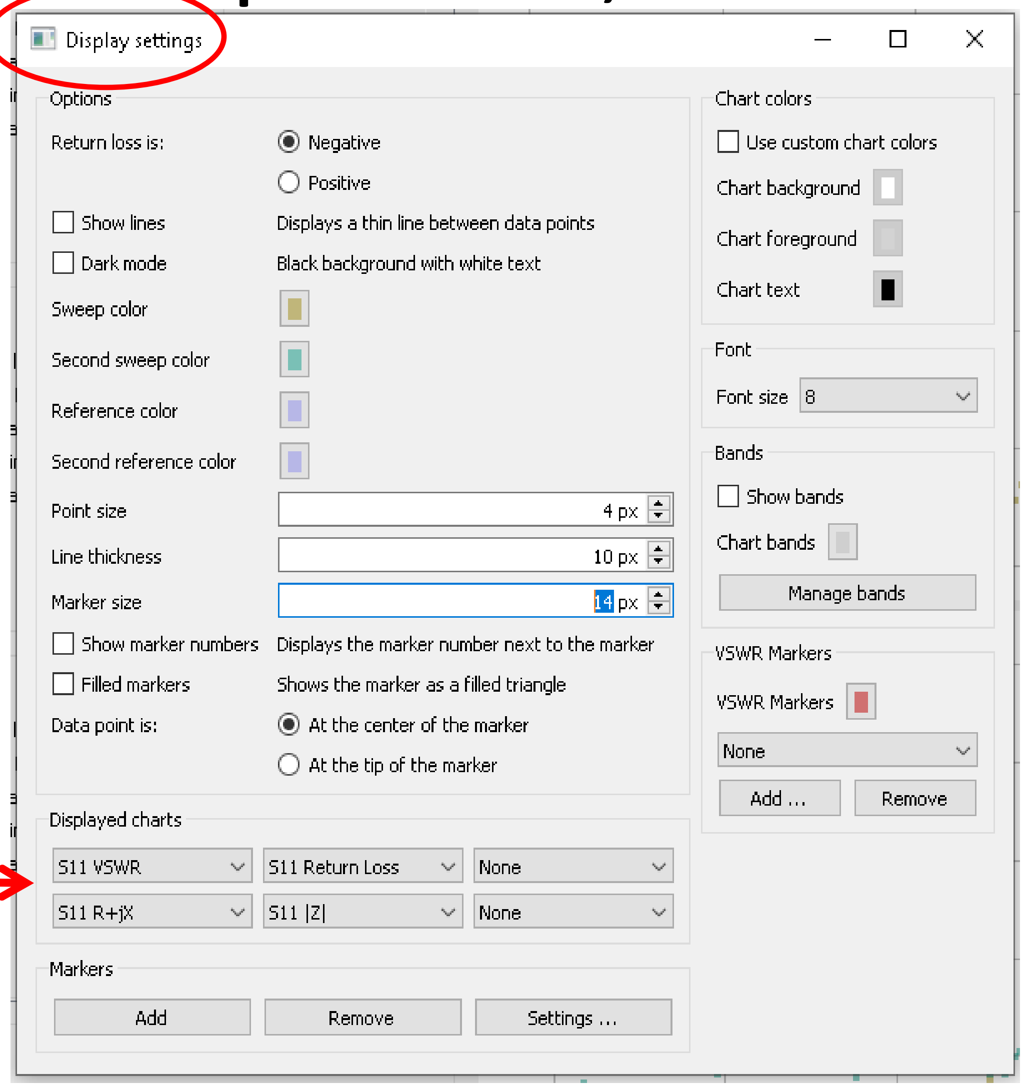
3.6dB @ 150MHz/0.55kW/43.5% E.

6.3dB @ 450MHz/0.31kW/23.2% E.

Cable Loss – RG8/U

- Losses in coaxial cable increase with frequency, so a better loss test might be to sweep from 10 KHz to 30 MHz or even up to 100 MHz. Check the manufacturer's specifications so you can duplicate their measurement.
- For example, a test of an old 73.5 ft. length of JSC 3030 RG 8/U resulted in a measured loss of 2.56 dB/100 ft. at 100 MHz. The manufacturer's spec is 2.2 dB/100 ft. at 100 MHz. I recalibrated the NanoVNA for a new frequency range of 10 KHz to 100 MHz and saved this calibration also. I did measure the actual length rather than using the TDR. I have found that assuming a specific type of cable and center insulator type, i.e. PE, many not result in the correct physical length. Better to simply measure the physical length. The return loss is not affected by the TDR length. This measurement is only used to adjust the loss to dB/100 ft.
- I would recommend that you run a sweep on a new cable and save the results so that any cable deterioration over time can be detected.
- Remember, a 3dB loss is a loss of half your transmit power!

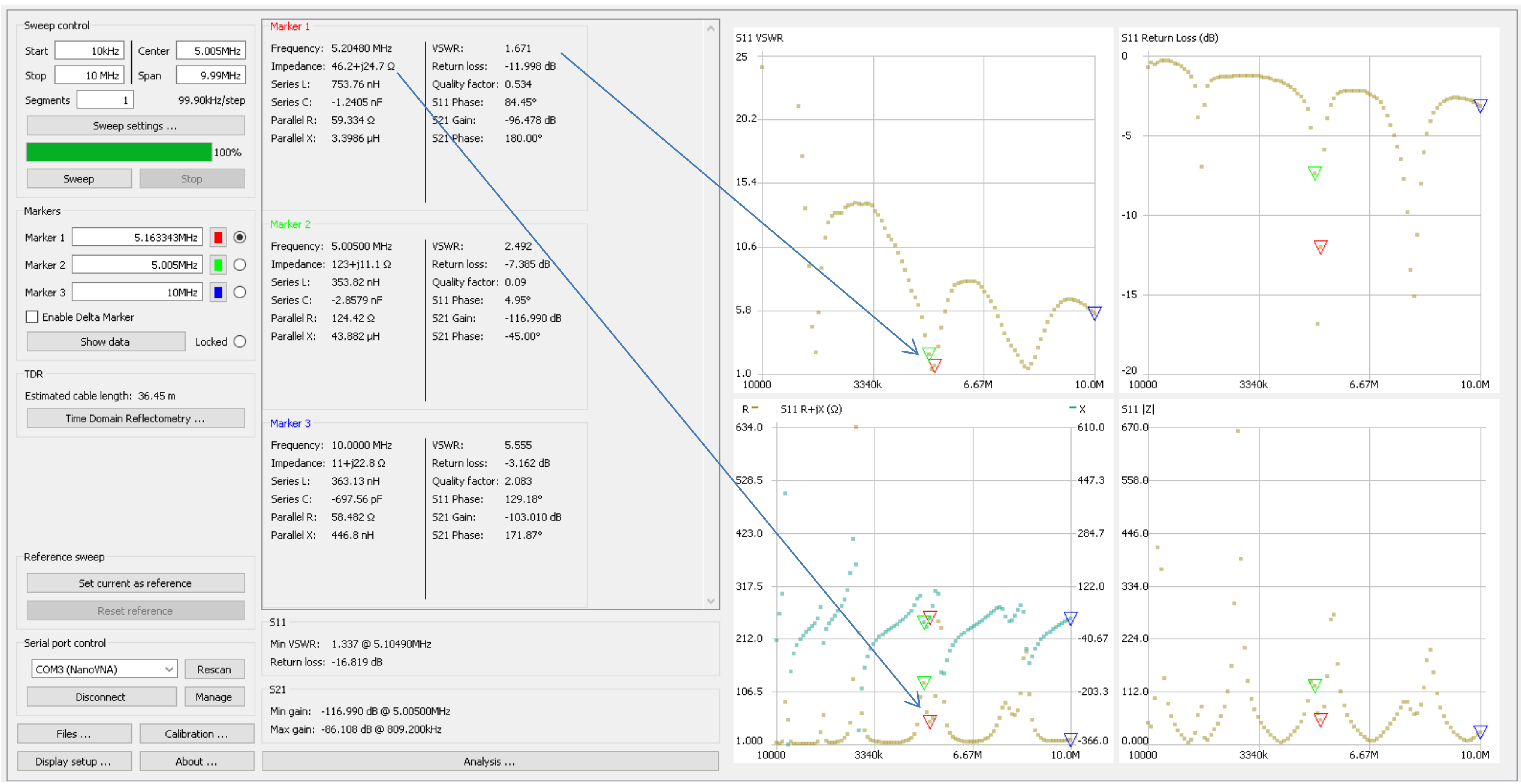
Other Measurements, SWR, Impedance, etc.



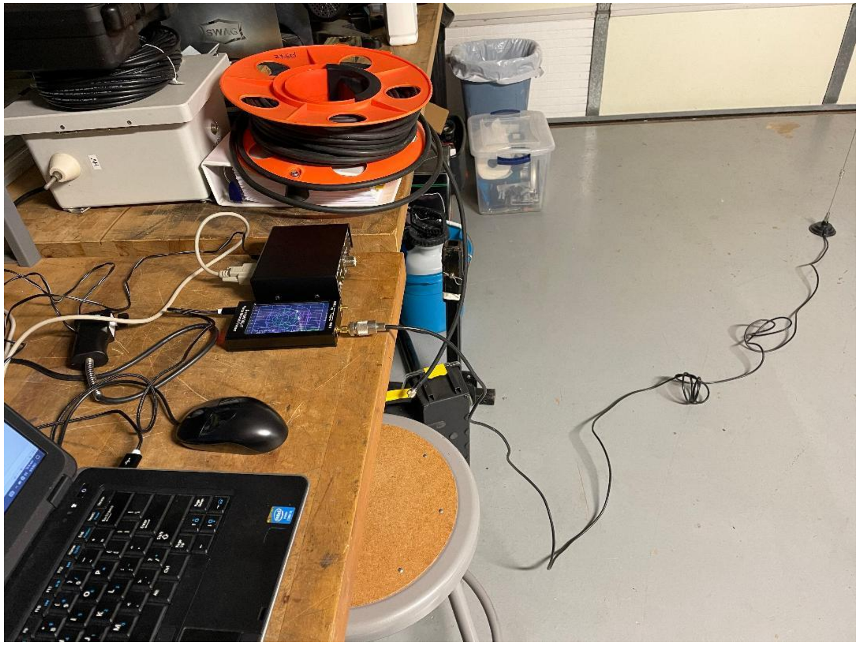
Improvement to graph readability

Other Charts

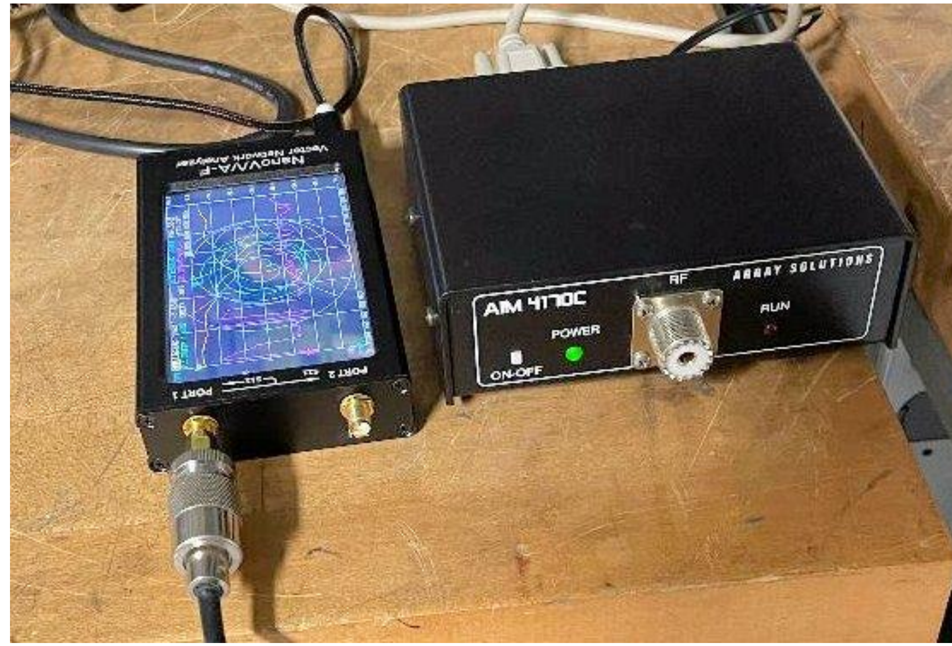
SWR and Impedance – Auto- Tuned Antenna at 5.202 MHz



VHF/UHF SWR Measurements



Experimental Setup



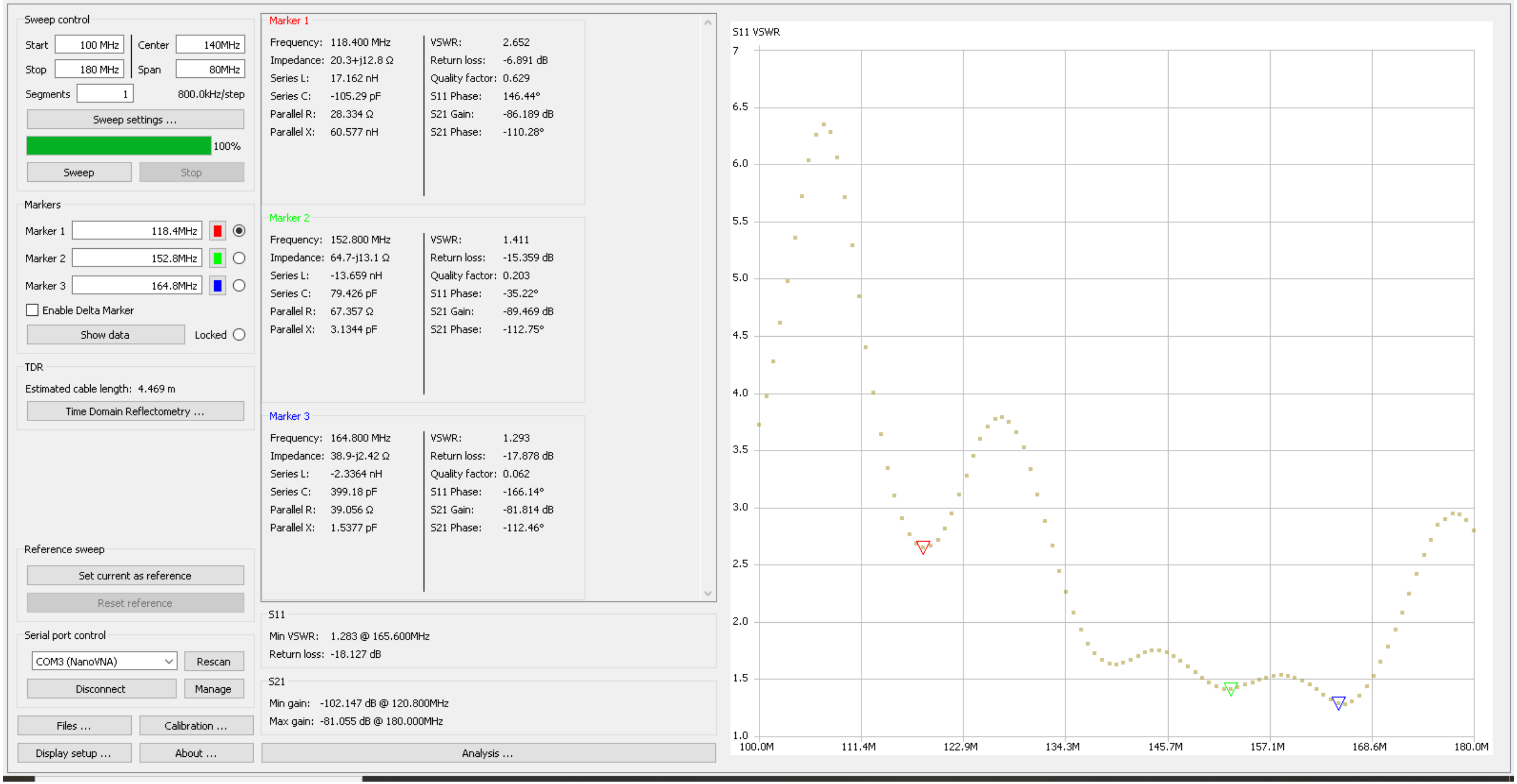
NanoVNA and AIM 4170C VNA

2 m/70 cm Mag Mount Antenna

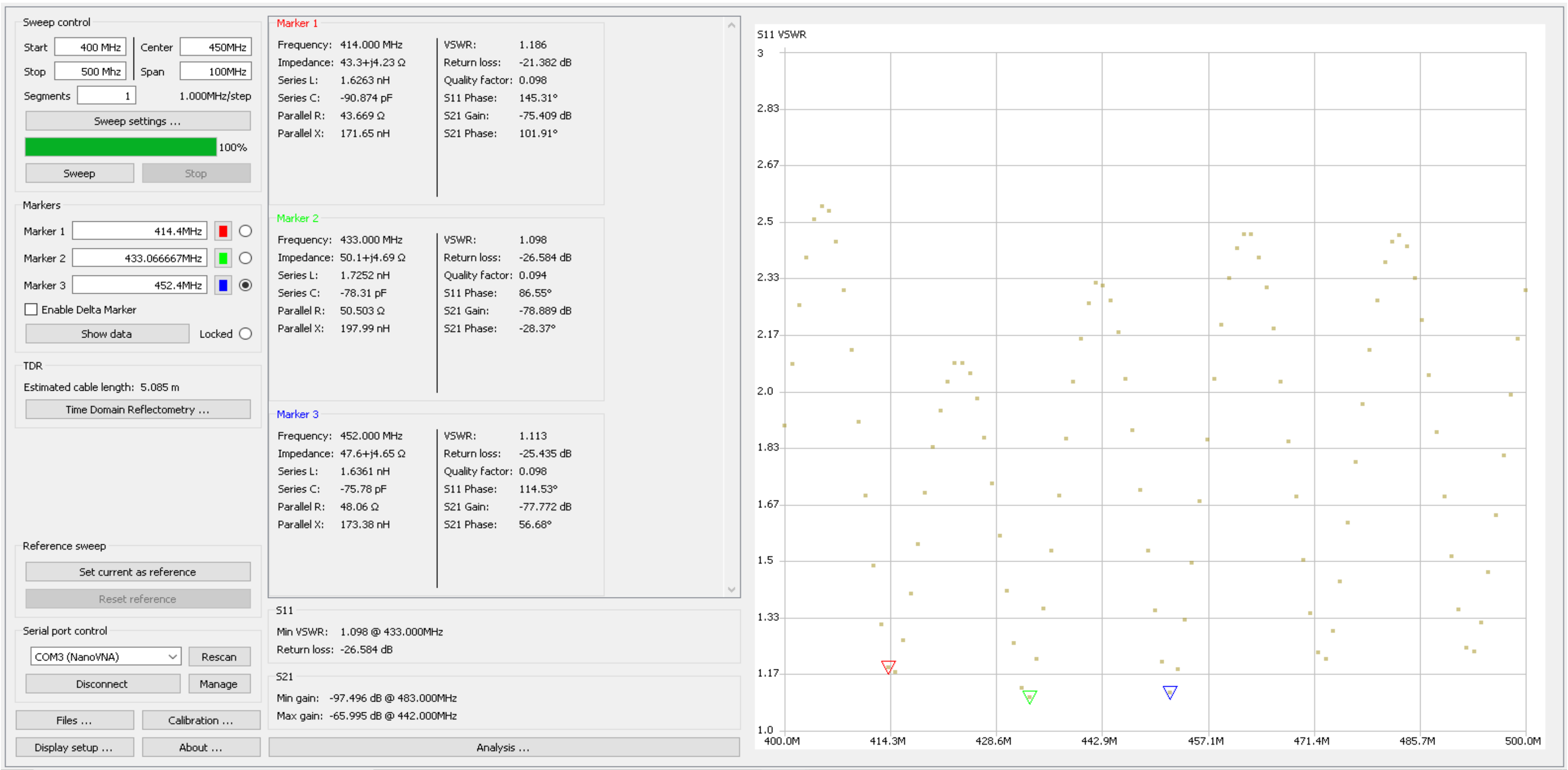
New Calibration Files

Name	Date modified	Type	Size
10 MHZ CAL	7/13/2021 2:38 PM	cal	7 KB
100 MHz cal	7/15/2021 8:08 AM	cal	7 KB
100-180 MHz Cal	8/6/2021 10:28 AM	cal	7 KB
100-200 MHz	7/22/2021 4:20 PM	cal	7 KB
400-500 MHz	7/22/2021 4:36 PM	cal	7 KB
cable cal 1	7/15/2021 8:44 AM	cal	7 KB
firstcal	7/12/2021 7:59 AM	cal	7 KB
NanoVNA Training	8/6/2021 10:25 AM	OpenDocument P...	446 KB

2m/70 cm Mag Mount Antenna



2m/70 cm Mag Mount



NanoVNA Accuracy Verification Tests

- The NanoVNA accuracy was evaluated using a Array Solutions AIM 4170C at HF and VHF frequencies for cable loss and VHF SWR. See page 31 for experimental setup.
- The Array Solutions VNA 4170 was evaluated by ARRL Test Labs as reported in a QST article of Aug 2007 when the 4170 was favorable compared with an Agilent 4291B, a laboratory grade network analyzer.
- Therefore comparing the NanoVNA against the AIM 4170 will provide a valid accuracy comparison with the Agilent 4291B.

HF Cable Loss Comparisons

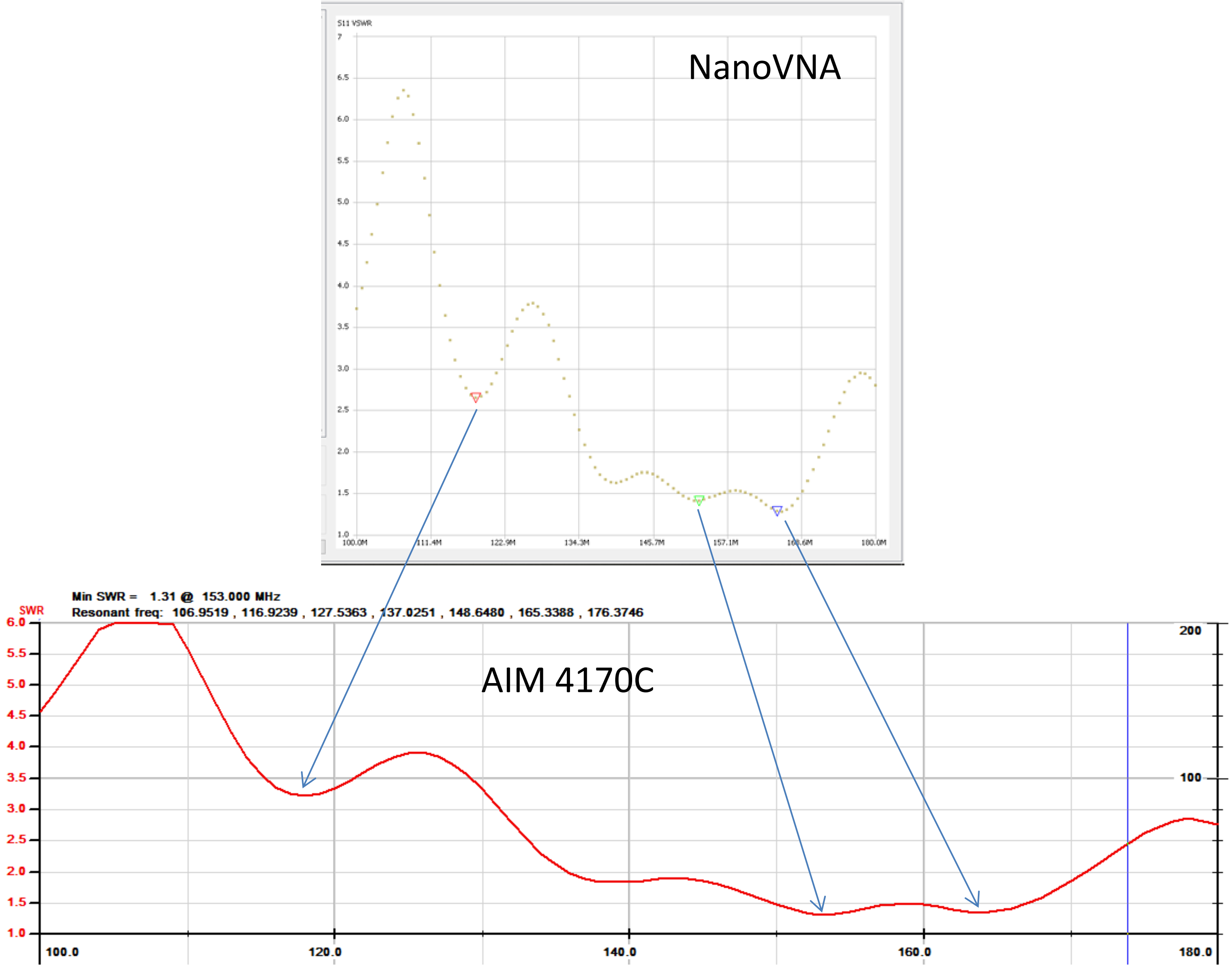
CABLE	NanoVNA	AIM 4170C	Difference	Measurement Units
RG8X	1.15 dB	1.03 dB	.12 dB	dB/100 ft. at 10 MHz
RG8U	2.56 dB	2.4 dB	.16 dB	dB/100 ft. at 100 MHz

VHF SWR Comparison

(See Plot Comparison on page 38)

Freq. MHz	NanoVNA	AIM 4170C	Difference
118	3.39	3.22	0.17
153	1.29	1.31	0.02
165	1.44	1.37	0.07

VHF SWR Plot Comparisons



Making Remote Measurements

- The NanoVNA running the NanoVNA Saver can be calibrated to make measurements at the end of a test coaxial cable as if the NanoVNA were located at this remote location.
- To successfully calibrate the remote test cable, it must be directly connected to the NanoVNA via a SMA to UHF adapter as shown on page 40. Using the short jumper cable, shown on page 6, did not result in a valid calibration that produced accurate measurements.
- To remote calibrate, follow the procedure found on pages 15-22. Connect the calibration connectors (short, open, and load) to the end of the test cable as shown on page 40. Remember to set your frequency range before doing this process, then save the results i.e. "Remote cable cal 10 MHz". Remember to do a sweep with the load connector installed to verify that you see 50 ohms at the highest sweep frequency.

NanoVNA Remote Cable Calibration

Remote Calibration Result

- After this remote calibration process, I repeated the cable loss measurement, discussed on page 26, for the 100 ft. of RG 8X cable and got the exact same return loss.
- This remote measurement technique should allow the SWR and impedance to be measured at the end of a ladder line, or balun, of a wide-bandwidth dipole. This information would allow the selection of the best balun for this antenna and provide an estimate of the expected coaxial cable loss from the balun to the rig-located tuner using SWR versus frequency.
- I have not yet fully explored the higher frequency (100+ MHz) performance of this remote measurement method.

Summary & Conclusions

- The NanoVNA with the NanoVNA Saver software can make a wide variety of useful antenna and transmission line measurements. This can include coaxial cable loss and antenna SWR.
- The cost of the NanoVNA and its free software is magnitudes cheaper than any other Vector Network Analyzer with similar capability.
- The NanoVNA Saver software is user friendly and provides very accurate results without having to rely on the rather difficult NanoVNA display buttons.