



# 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: [HKNMA.COM](http://HKNMA.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](#)

**i** 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.

<b>Connector Type</b>	RF Connector
<b>Cable Type</b>	Coaxial
<b>Compatible Devices</b>	Amplifier
<b>Brand</b>	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

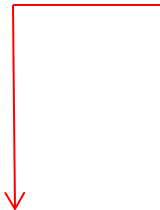
**v0.3.8 (Latest version)**



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.exe`

# NanoVNA Saver V 0.3.8 Display

**Sweep control**

Start  Center   
Stop  Span   
Segments  Hz/step  
Sweep settings ...  
0%  
Sweep Stop

**Markers**

Marker 1     
Marker 2     
Marker 3     
 Enable Delta Marker  
Show data Locked

**TDR**

Estimated cable length:  
Time Domain Reflectometry ...

**Reference sweep**

Set current as reference  
Reset reference

**Serial port control**

COM3 (NanoVNA) Rescan  
Connect to device Manage  
Files ... Calibration ...  
Display setup ... About ... Analysis ...

**Marker 1**

Frequency: VSWR:  
Impedance: Return loss:  
Series L: Quality factor:  
Series C: S11 Phase:  
Parallel R: S21 Gain:  
Parallel X: S21 Phase:

**Marker 2**

Frequency: VSWR:  
Impedance: Return loss:  
Series L: Quality factor:  
Series C: S11 Phase:  
Parallel R: S21 Gain:  
Parallel X: S21 Phase:

**Marker 3**

Frequency: VSWR:  
Impedance: Return loss:  
Series L: Quality factor:  
Series C: S11 Phase:  
Parallel R: S21 Gain:  
Parallel X: S21 Phase:

**S11 Smith Chart**

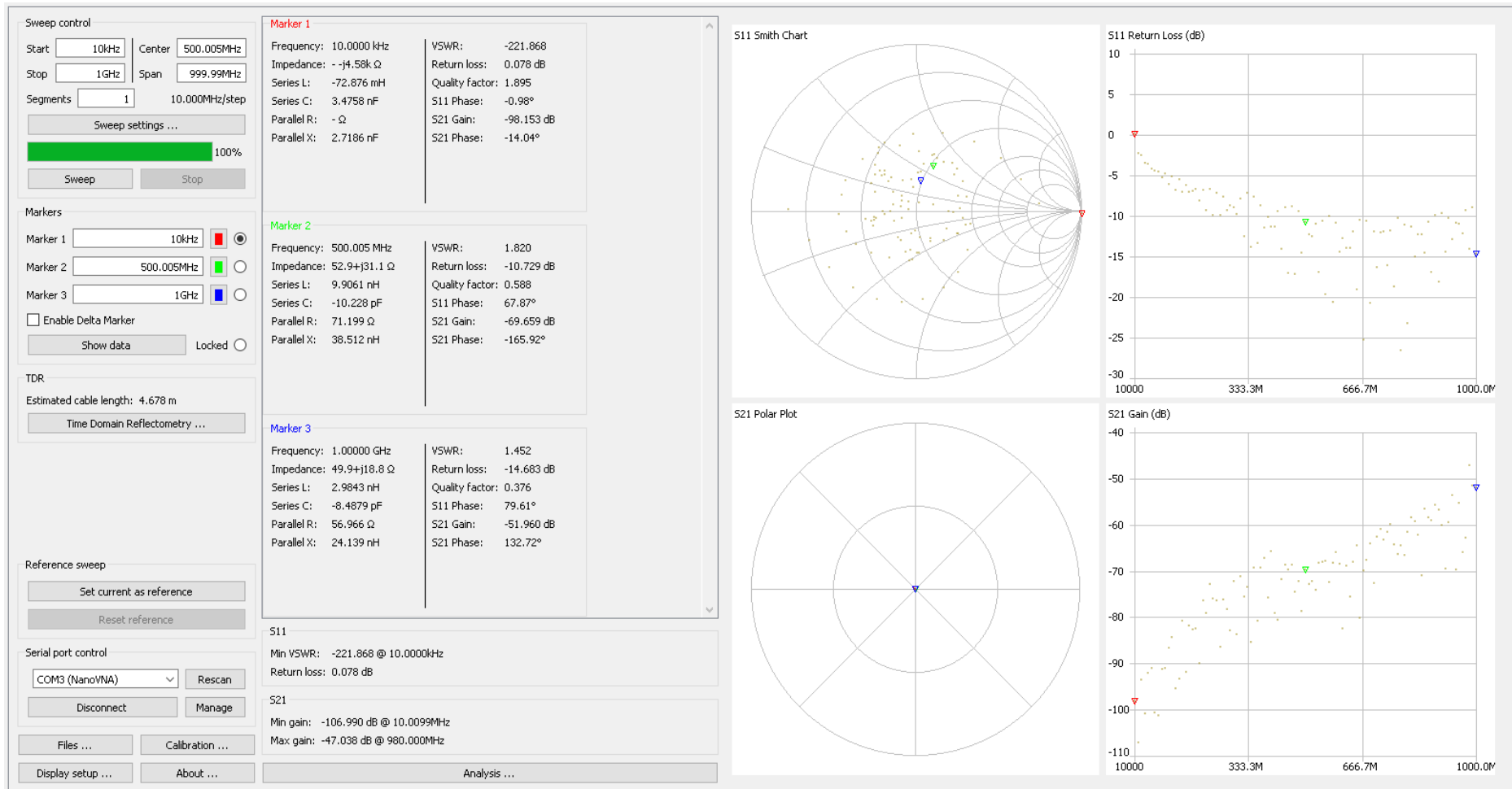
**S11 Return Loss (dB)**

**S21 Polar Plot**

**S21 Gain (dB)**

Connect computer to NanoVNA

# Connect to Device Result



# Frequency Span Setting

- The NanoVNA takes only 101 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

The screenshot displays the software interface for a network analyzer. The 'Sweep control' section is circled in blue, showing 'Start' at 10kHz, 'Center' at 5.005MHz, 'Stop' at 10 MHz, and 'Span' at 9.99MHz. The 'Markers' section shows three markers: Marker 1 at 10kHz, Marker 2 at 500.005MHz, and Marker 3 at 1GHz. The 'S11 Smith Chart' plot shows a cluster of points around the center. The 'S11 Return Loss (dB)' plot shows a curve starting at 0 dB at 10kHz and decreasing to approximately -10 dB at 10MHz. The 'S21 Polar Plot' shows a single point at the center. The 'S21 Gain (dB)' plot shows a curve starting at approximately -100 dB at 10kHz and increasing to approximately -50 dB at 10MHz. A red arrow points to the 'About...' button in the bottom right corner.

**Sweep control**

Start: 10kHz, Center: 5.005MHz, Stop: 10 MHz, Span: 9.99MHz

**Markers**

Marker 1: 10kHz, Marker 2: 500.005MHz, Marker 3: 1GHz

**Marker 1**

Frequency: 10.0000 kHz, Impedance: -j4.58k Ω, Series L: -72.876 mH, Series C: 3.4758 nF, Parallel R: -Ω, Parallel X: 2.7186 nF

VSWR: -221.868, Return loss: 0.078 dB, Quality factor: 1.895, S11 Phase: -0.98°, S21 Gain: -98.153 dB, S21 Phase: -14.04°

**Marker 2**

Frequency: 500.005 MHz, Impedance: 52.9+j31.1 Ω, Series L: 9.9061 nH, Series C: -10.228 pF, Parallel R: 71.199 Ω, Parallel X: 38.512 nH

VSWR: 1.820, Return loss: -10.729 dB, Quality factor: 0.588, S11 Phase: 67.87°, S21 Gain: -69.659 dB, S21 Phase: -165.92°

**Marker 3**

Frequency: 1.00000 GHz, Impedance: 49.9+j18.8 Ω, Series L: 2.9843 nH, Series C: -8.4879 pF, Parallel R: 56.966 Ω, Parallel X: 24.139 nH

VSWR: 1.452, Return loss: -14.683 dB, Quality factor: 0.376, S11 Phase: 79.61°, S21 Gain: -51.960 dB, S21 Phase: 132.72°

**S11**

Min VSWR: -221.868 @ 10.0000kHz, Return loss: 0.078 dB

**S21**

Min gain: -106.990 dB @ 10.0099MHz, Max gain: -47.038 dB @ 980.000MHz

**Reference sweep**

Set current as reference, Reset reference

**Serial port control**

COM3 (NanoVNA), Rescan, Disconnect, Manage

Files ..., Calibration ..., Display setup ..., About...

#2 calibrate

# Calibration Screen

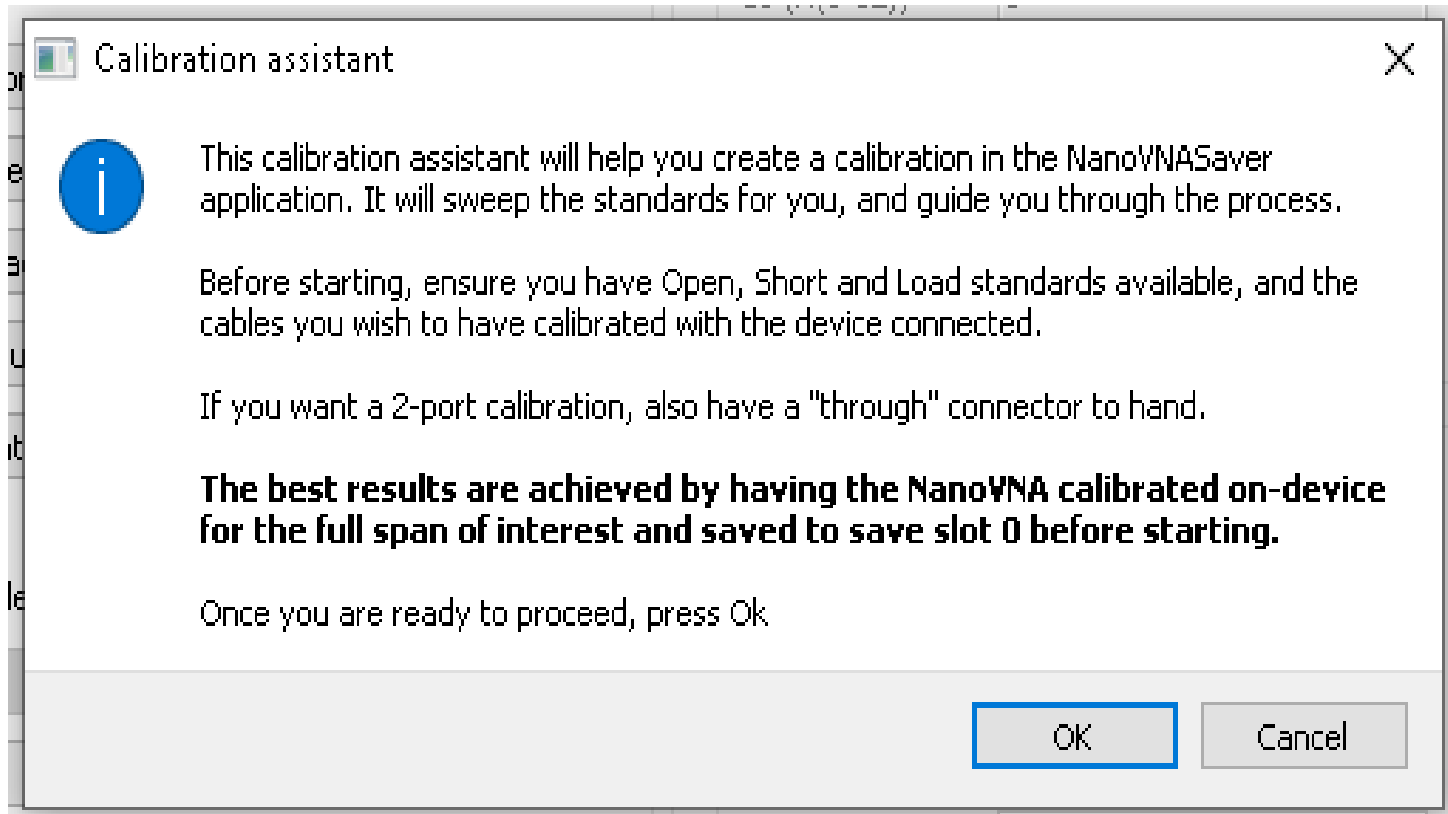
Click to bring up  
Calibration  
Assistant



The screenshot shows a software window titled 'Calibration'. It is divided into several sections:

- Active calibration:** Shows 'Calibration: Device calibration' and 'Source: NanoVNA'.
- Calibrate:** A list of calibration types with their status: Short (Uncalibrated), Open (Uncalibrated), Load (Uncalibrated), Through (Uncalibrated), and Isolation (Uncalibrated).
- Offset delay:** A text box containing '0.00 ps' with a dropdown arrow.
- Calibration assistant:** A button highlighted by a red arrow.
- Apply** and **Reset** buttons.
- Notes:** A large empty text area.
- Files:** 'Save calibration' and 'Load calibration' buttons.
- Calibration standards:** A section with a checked 'Use ideal values' checkbox and sub-sections for:
  - Short:** L0 (H(e-12)), L1 (H(e-24)), L2 (H(e-33)), L3 (H(e-42)), and Offset Delay (ps), all set to 0.
  - Open:** C0 (F(e-15)) set to 50, C1 (F(e-27)), C2 (F(e-36)), C3 (F(e-45)), and Offset Delay (ps) set to 0.
  - Load:** Resistance ( $\Omega$ ) set to 50, Inductance (H(e-12)), and Offset Delay (ps) set to 0.
  - Through:** Offset Delay (ps) set to 0.
- Saved settings:** A dropdown menu set to 'New' and 'Load', 'Save', and 'Delete' buttons.

# Calibration Assistant



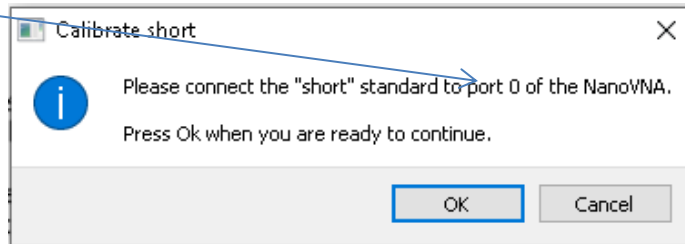
# Calibration Connectors



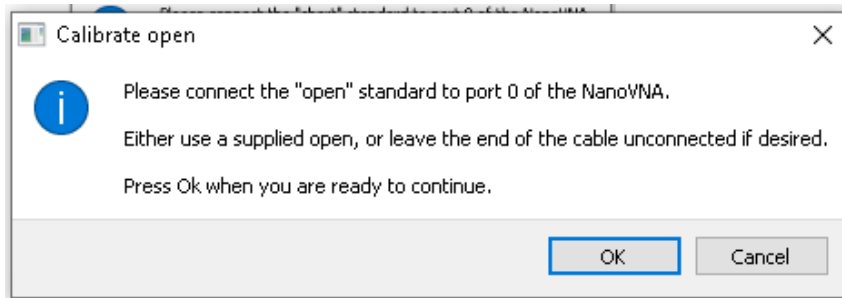
# Calibration Steps

Note: Port 1 on this NanoVNA is their Port 0

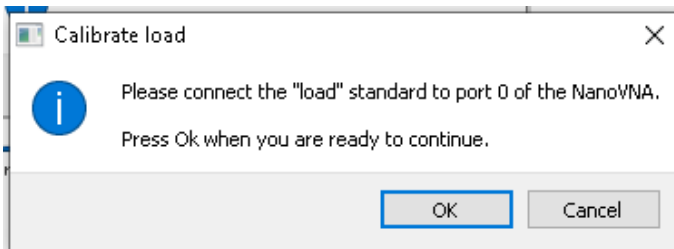
Step 1



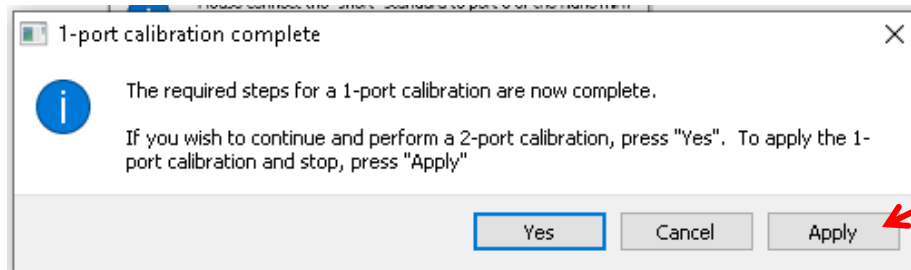
Step 2



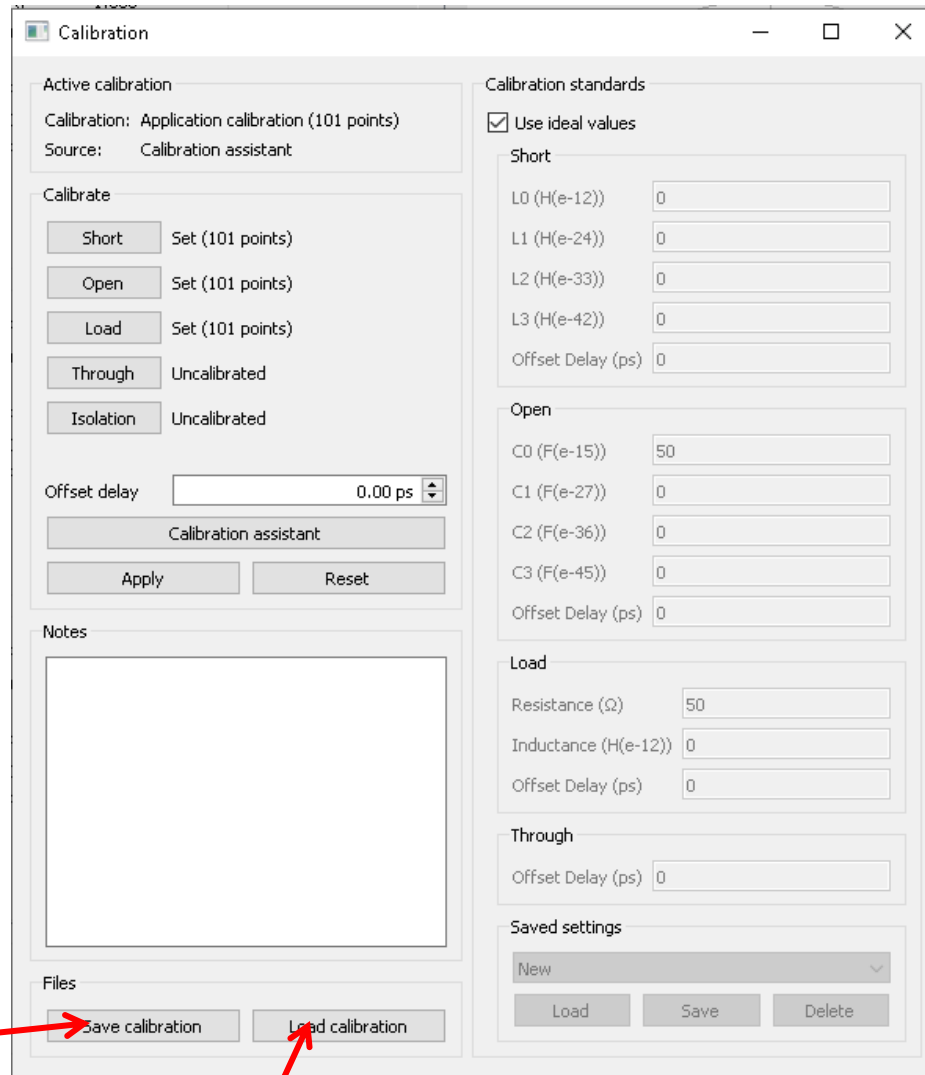
Step 3



Step 4



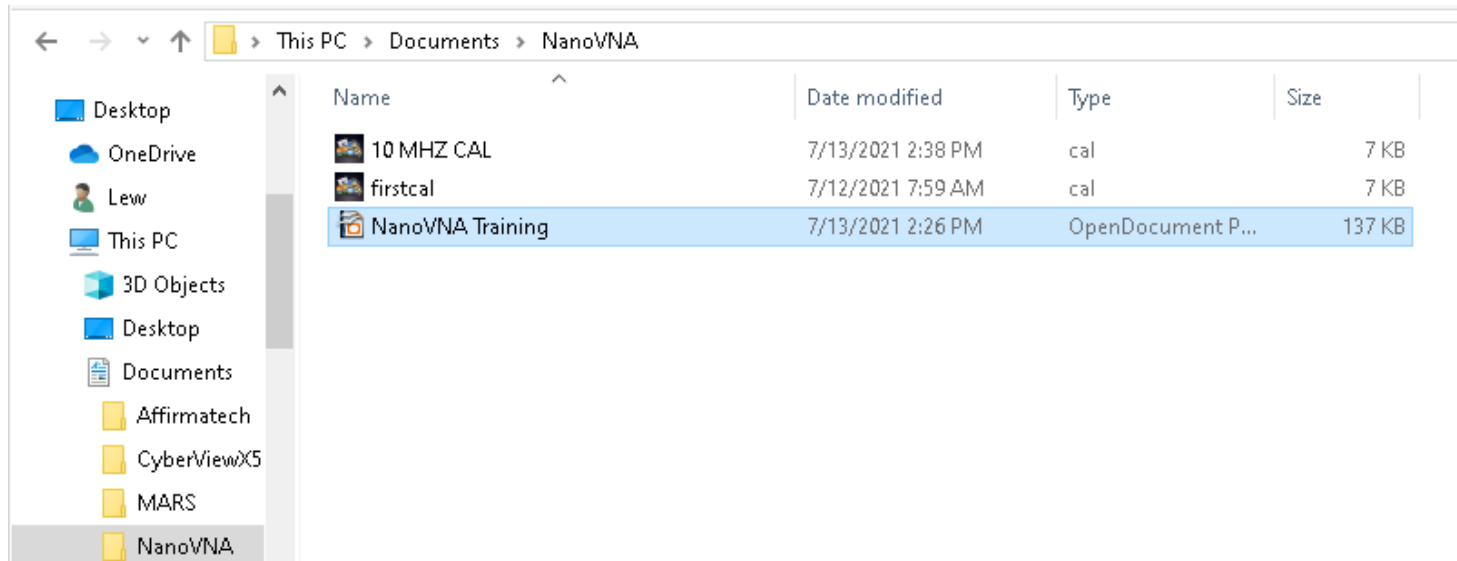
# Save Calibration



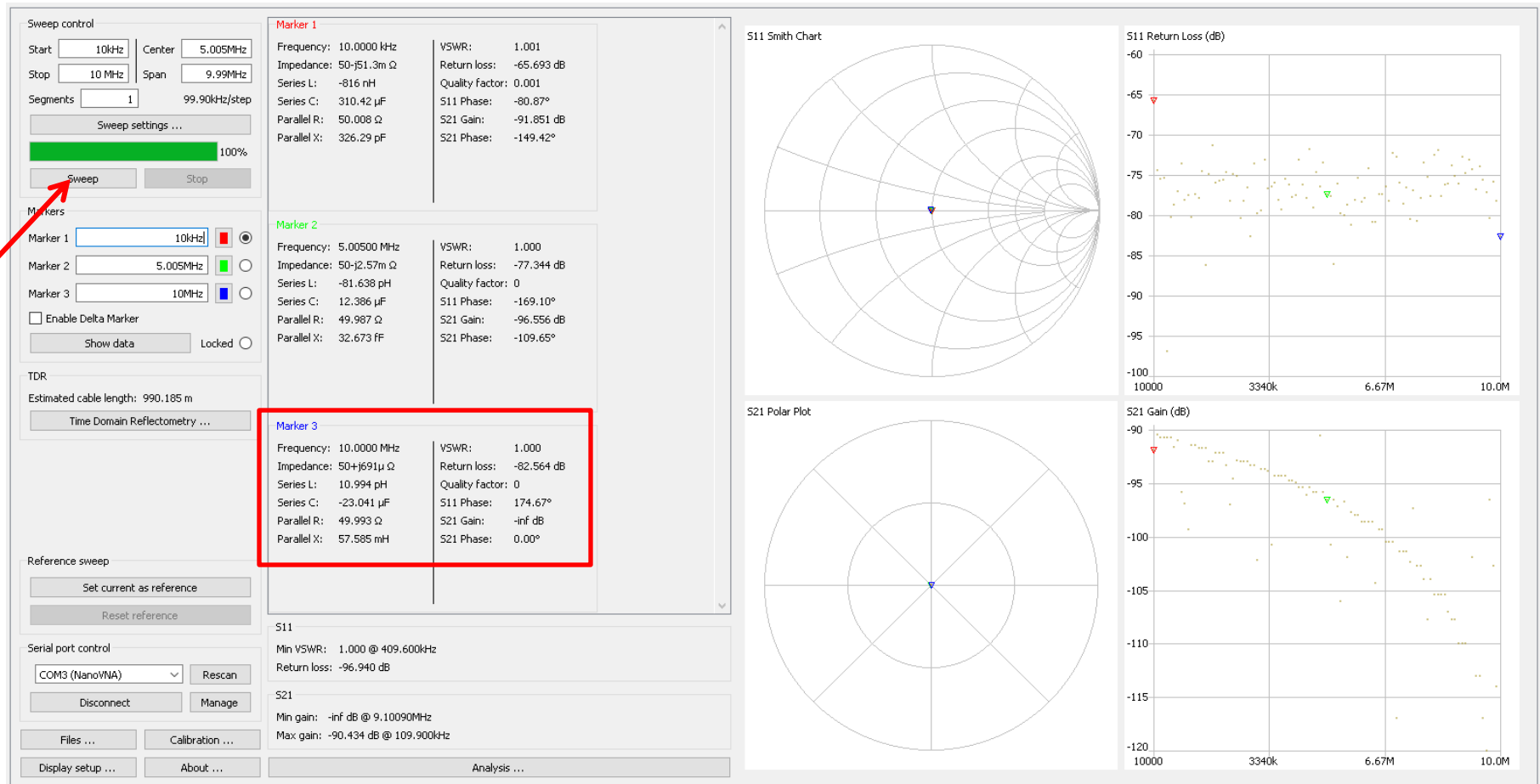
Save your  
Calibration

After shutting down Nano VNA, must load Cal file

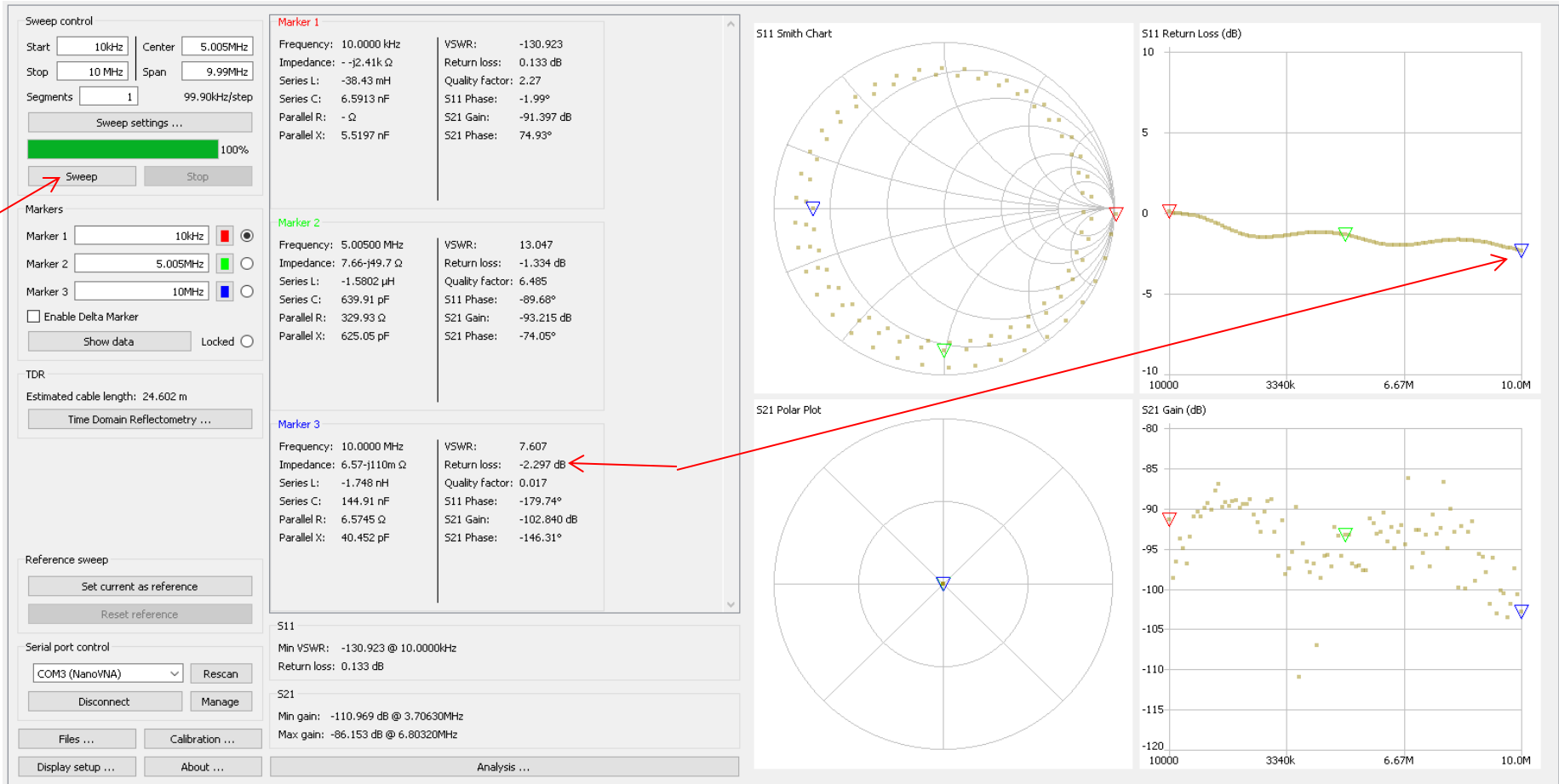
# Calibration Files Example



# Test Sweep with 50 ohm load



# Cable Sweep – RG8X



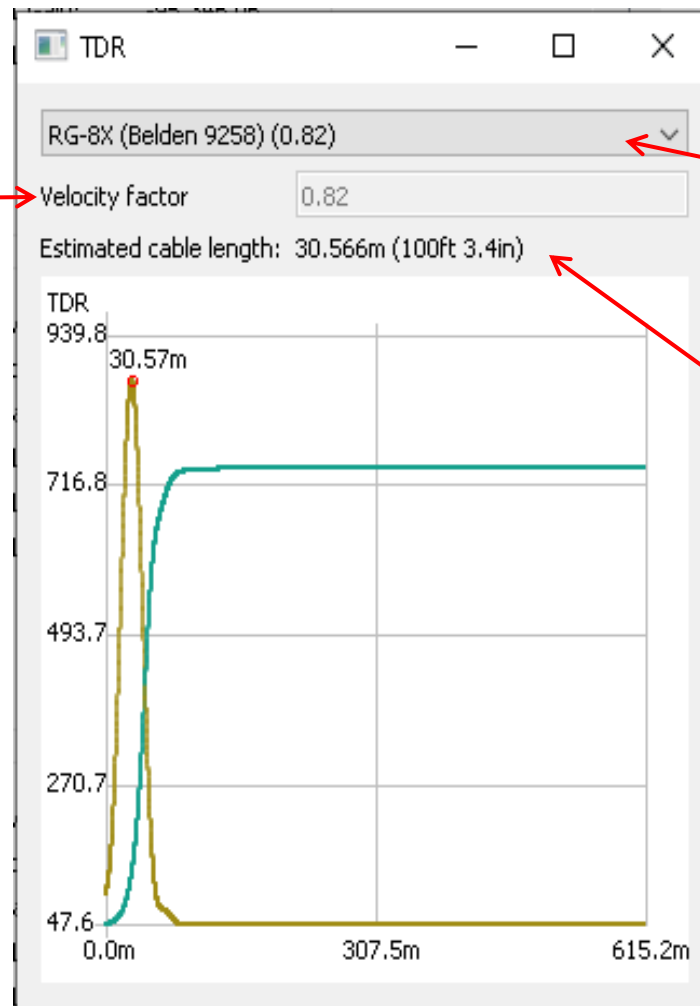
# Cable Length?

The screenshot displays a network analyzer interface with the following sections:

- Sweep control:** Start 10kHz, Center 5.005MHz, Stop 10 MHz, Span 9.99MHz, Segments 1, 99.90kHz/step. A green progress bar shows 100% completion. Buttons for Sweep and Stop are present.
- Markers:** Three markers are defined:
  - Marker 1 (Red):** Frequency: 10.0000 kHz. Parameters: Impedance: 184-j3.26k Ω, Return loss: -0.015 dB, Series L: -51.812 mH, Series C: 4.8889 nF, Parallel R: 57.657 kΩ, Parallel X: 4.8733 nF.
  - Marker 2 (Green):** Frequency: 5.00500 MHz. Parameters: Impedance: 7.39-j50.2 Ω, Return loss: -1.272 dB, Series L: -1.5979 μH, Series C: 632.83 pF, Parallel R: 349.24 Ω, Parallel X: 619.44 pF.
  - Marker 3 (Blue):** Frequency: 10.0000 MHz. Parameters: Impedance: 6.26-j57.6m Ω, Return loss: -2.187 dB, Series L: -915.96 pH, Series C: 276.54 nF, Parallel R: 6.2624 Ω, Parallel X: 23.358 pF.
- TDR:** Estimated cable length: 24.602 m. A red arrow points to the "Time Domain Reflectometry ..." button.
- Reference sweep:** Buttons for "Set current as reference" and "Reset reference".
- Serial port control:** COM3 (NanoVNA) selected. Buttons for Rescan, Disconnect, and Manage.
- Files, Calibration, Display setup, About:** Additional utility buttons.
- Analysis ...:** A button at the bottom center.
- S11 Smith Chart:** A Smith chart showing the impedance response across the frequency range. Three markers are placed on the chart corresponding to the marker frequencies.
- S11 Return Loss (dB):** A line graph showing the return loss in dB versus frequency. The curve starts at 0 dB at 10 kHz and shows a dip at 5.005 MHz and 10 MHz.
- S21 Polar Plot:** A polar plot showing the transmission coefficient S21 across the frequency range.
- S21 Gain (dB):** A scatter plot showing the gain in dB versus frequency. The gain is relatively flat around -95 dB until approximately 6.67 MHz, where it drops significantly.

# 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.

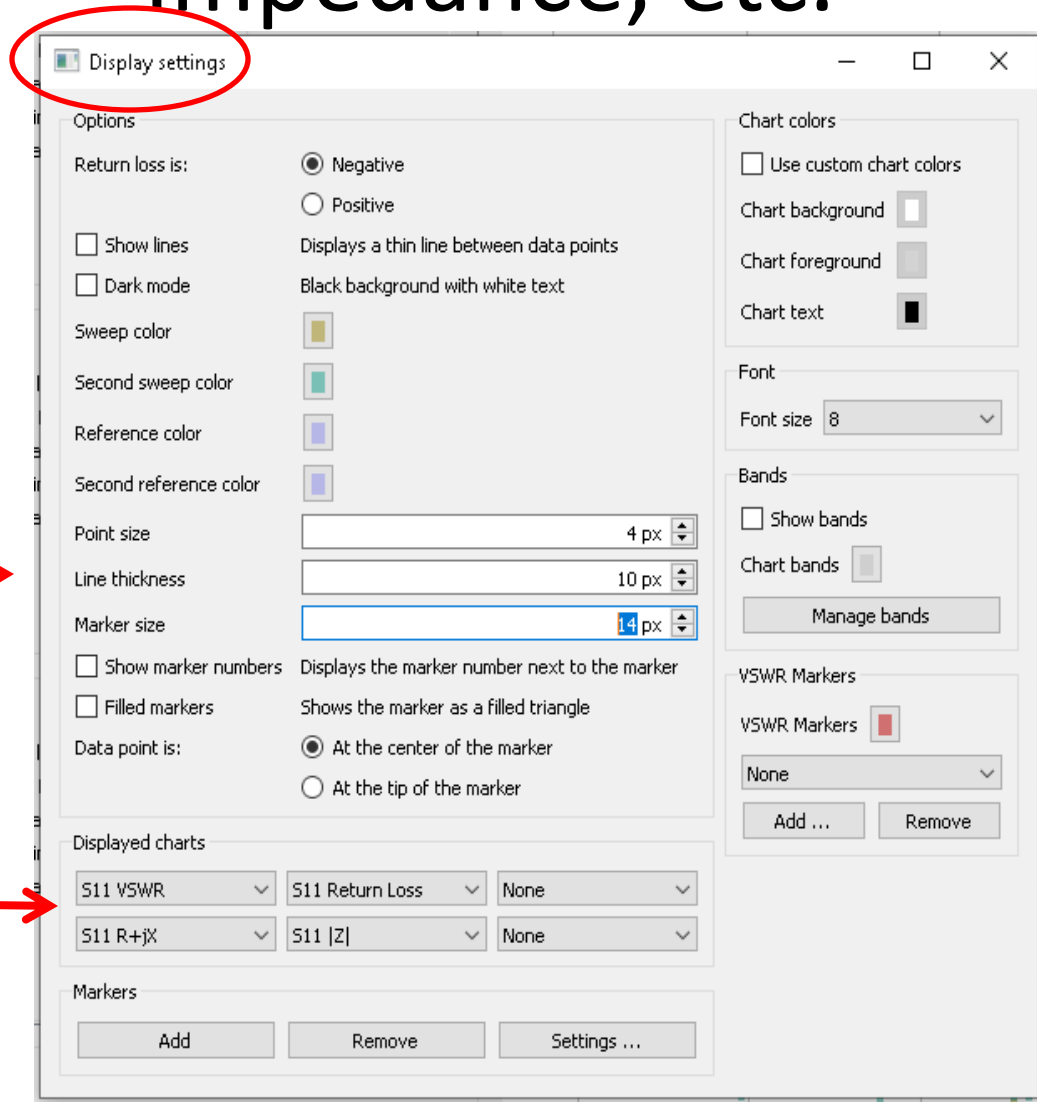
3.6dB @ 150MHz/0.55kW/43.5% E.

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.



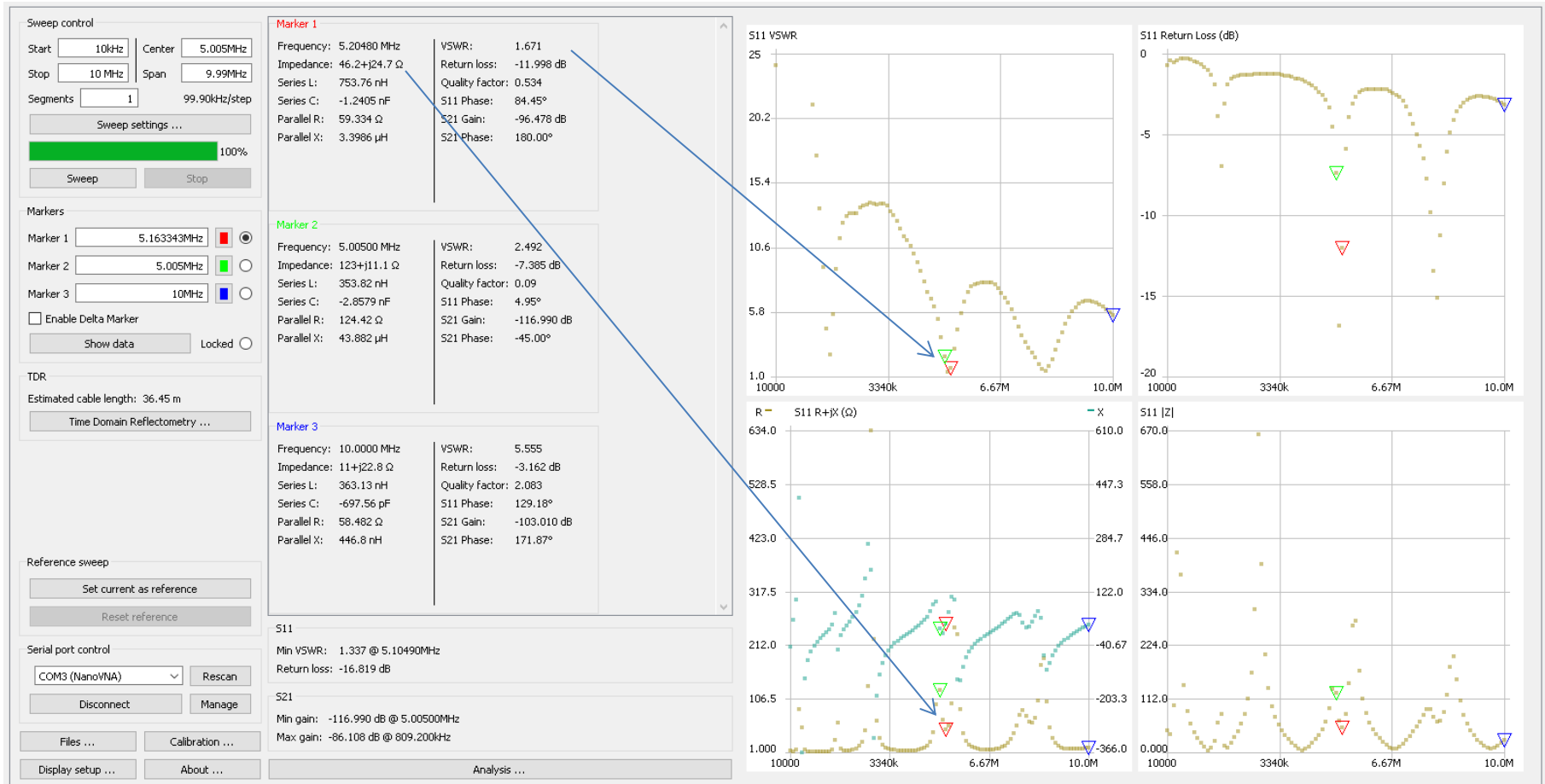
Improvement to graph readability



Other Charts



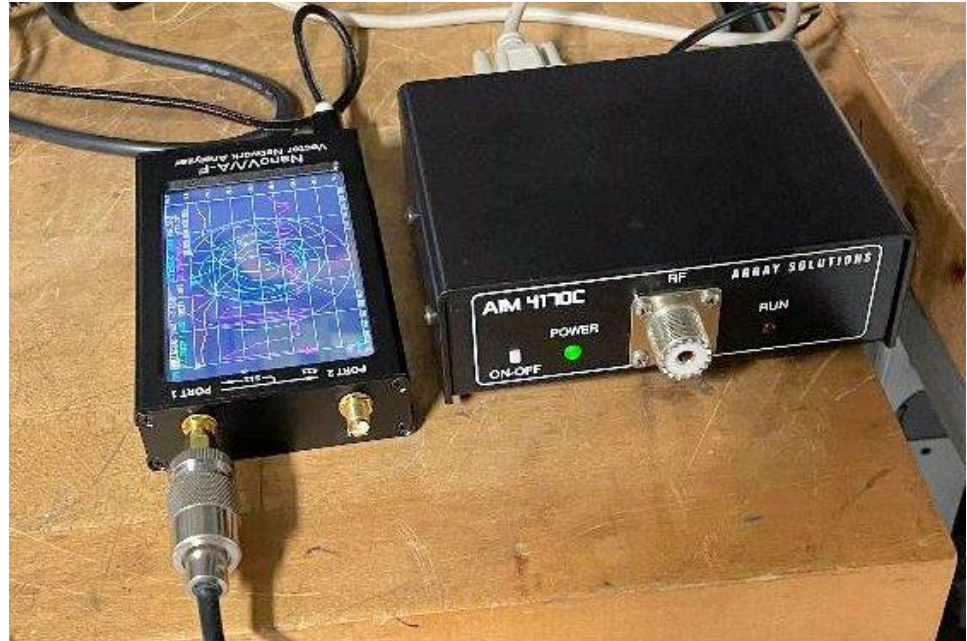
# SWR and Impedance – Auto-Tuned Antenna at 5.202 MHz



# VHF/UHF SWR Measurements



Experimental Setup











NanoVNA and AIM 4170C VNA

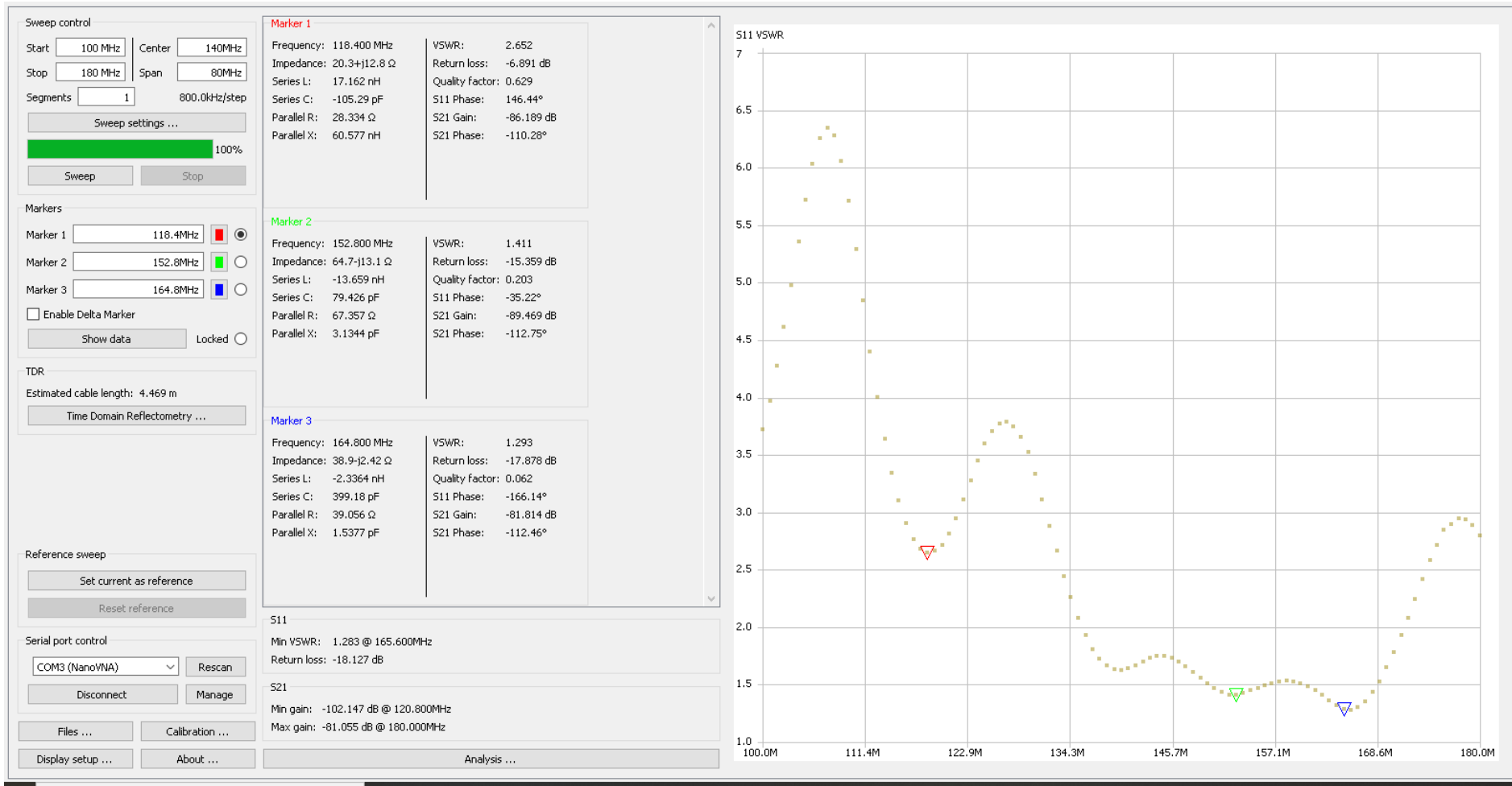


2 m/70 cm Mag Mount Antenna

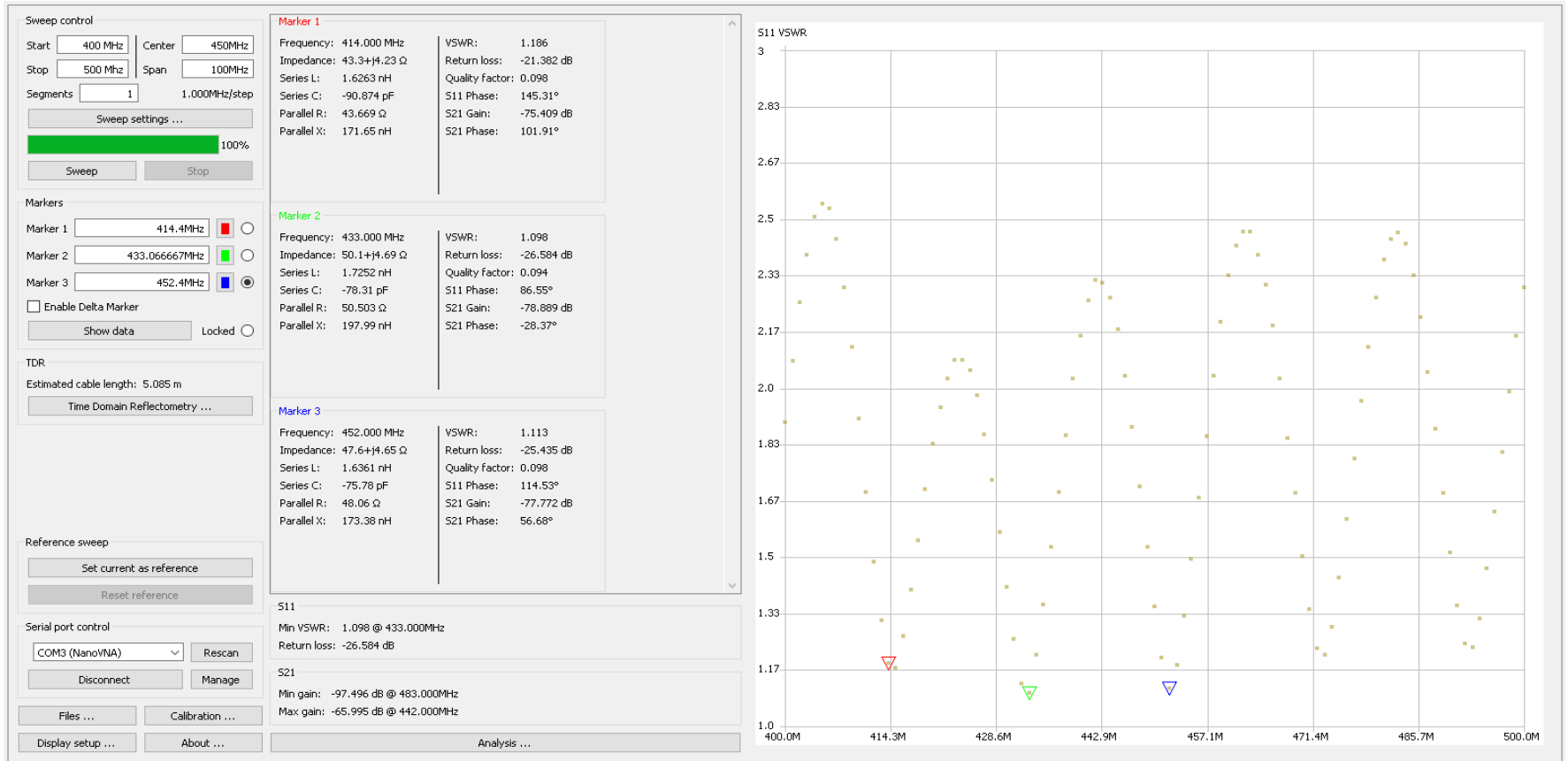
# New Calibration Files

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

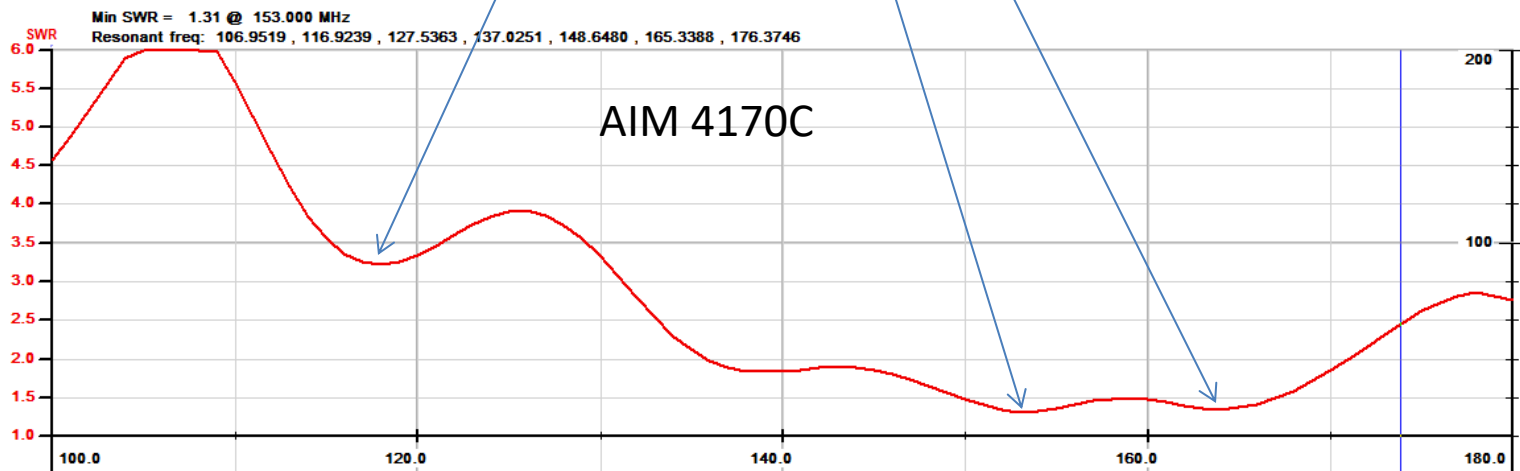
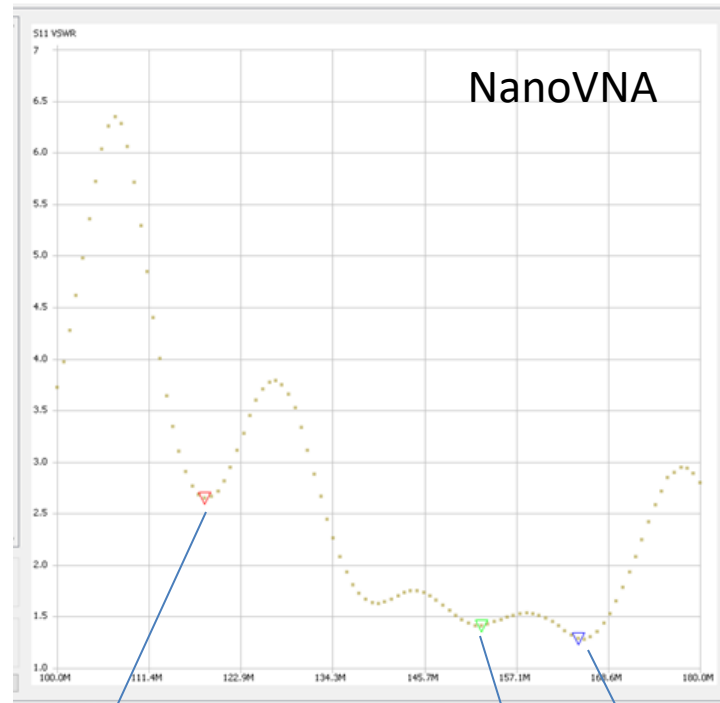
CABLE	NanoVNA	AIM 4170C	Difference	Measurement Units
RG8X	1.15 dB	1.03 dB	.12 dB	dB/100 ft. at 10 MHz
RG8U	2.56 dB	2.4 dB	.16 dB	dB/100 ft. at 100 MHz

# 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.