Vector Network Analyzer

Measurements for Amateur Radio Communications

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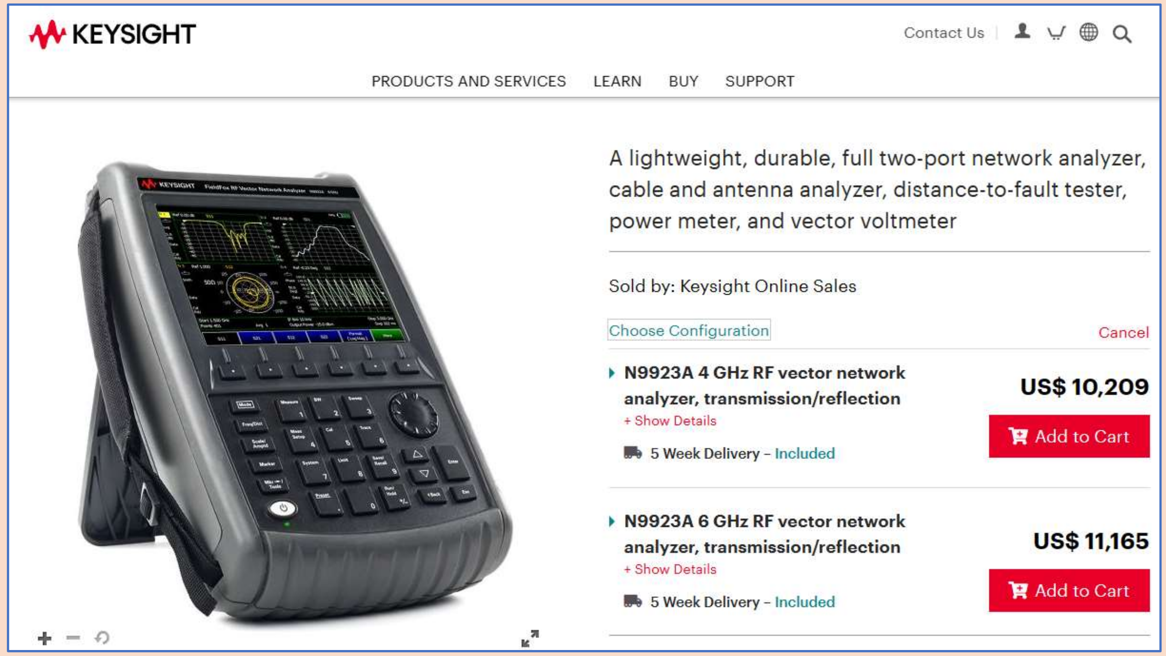
March 2024

- Configure as a full, two-port VNA, time-domain reflectometer, vector voltmeter, cable and antenna analyzer, and more.
- Measure all four S-parameters simultaneously with a single connection and up to 90 dB of dynamic range.
- Perform accurate testing with QuickCal, full two-port unknown thru Cal, and Thru, Reflect, Line (TRL) calibration in the field.
- Measure average and pulse power easily with a USB power sensor.



NANOVNA-F V2 3 GHz Mini Vector Network Analyzer is a new generation of portable, stand-alone VNA, featuring a 4.3 inch IPS LCD screen, metal enclosure, 5000 mAh battery and SMA connectors. The measurement frequency range of NanoVNA-F V2 is up to 3GHz. The S21 dynamic range is greater than 70dB at 50kHz-1.5GHz and greater than 60dB at 1.5GHz – 3GHz. **$ 190 USD**

AE5X Conclusion : 1 to 4 GHz: nanoVNA 2 Plus4 vs. Keysight FieldFox

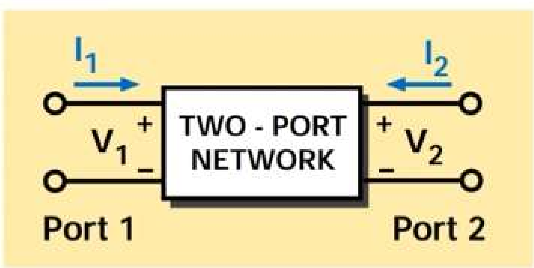
A **4 GHz FieldFox costs $12,000** - this does not include the calibration terminations - they're an additional $800. We have ours professionally calibrated every year in June - the one used for these comparisons was just calibrated.

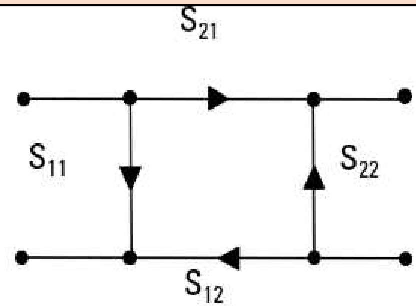
The **nanoVNA costs $160**, includes three SMA terminations (SOL) and has no means of being internally calibrated.

How can anyone not be impressed by the close correlation of these two VNA's, especially given the huge price delta? No, I'm not getting paid to say that and am in no way affiliated with anyone having anything to do with nanoVNA sales, development or anything else.

Vector Network Analyzer

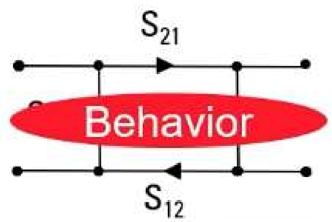
A vector network analyzer (**VNA**) is a device used to measure the electrical properties of RF and microwave devices and networks. It does this by sending a signal down a transmission line and measuring the reflected and transmitted signals. The VNA then uses these measurements to calculate the S-parameters of the device or network.





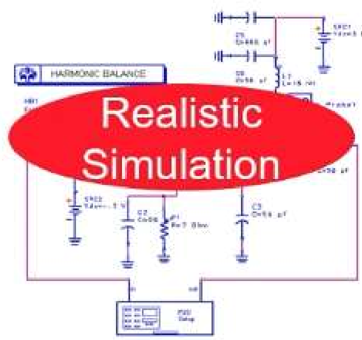
Vector Network Analyzer Measurements

1. Complete characterization of linear networks

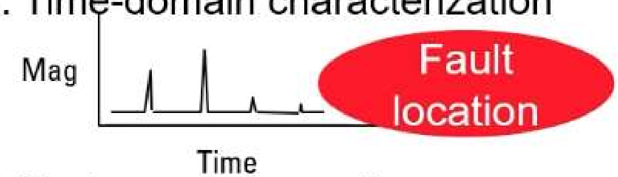


2. Complex impedance needed to design matching circuits

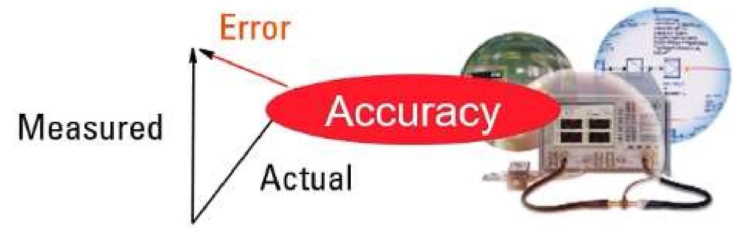
3. Complex values needed for device modeling



4. Time-domain characterization



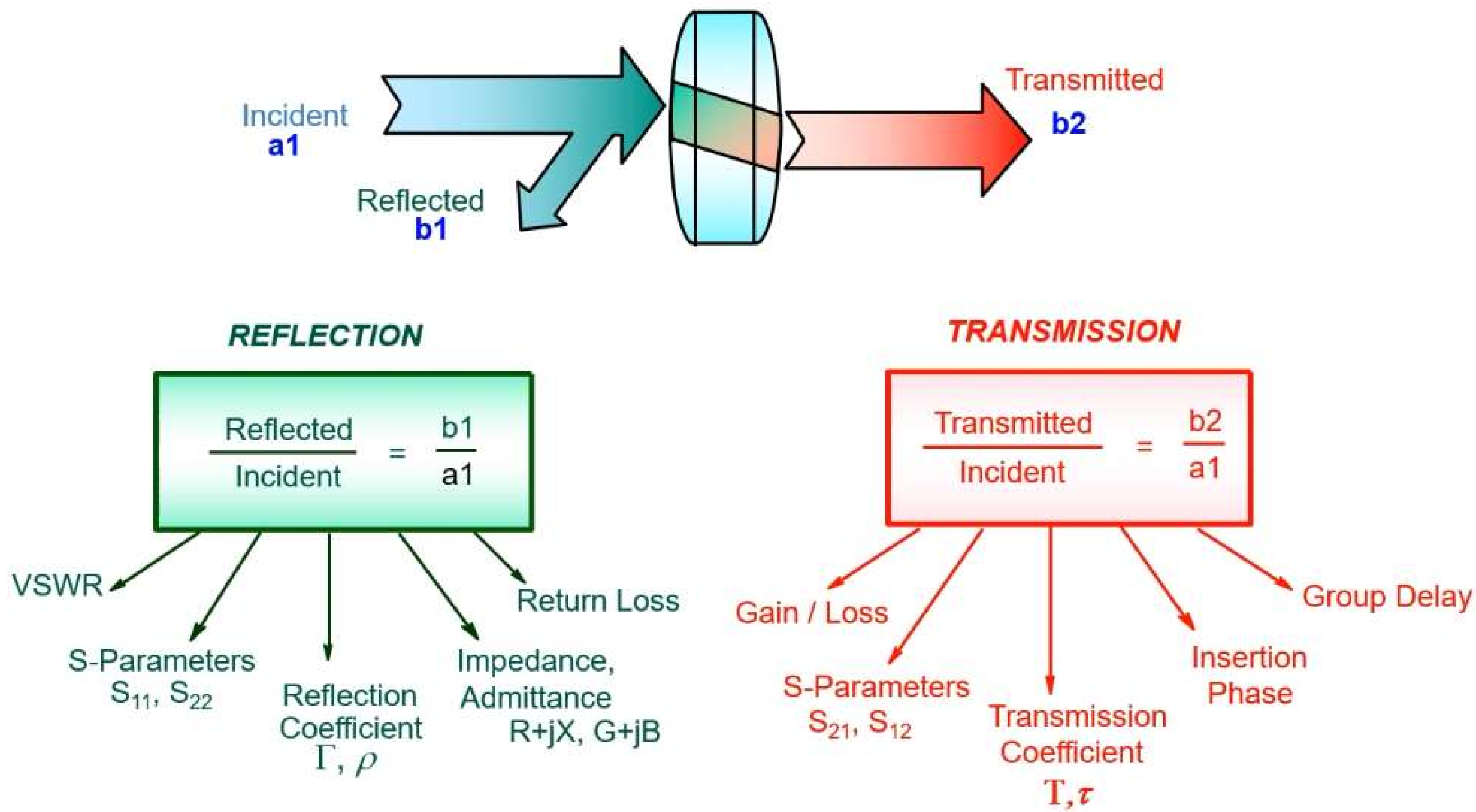
5. Vector-error correction



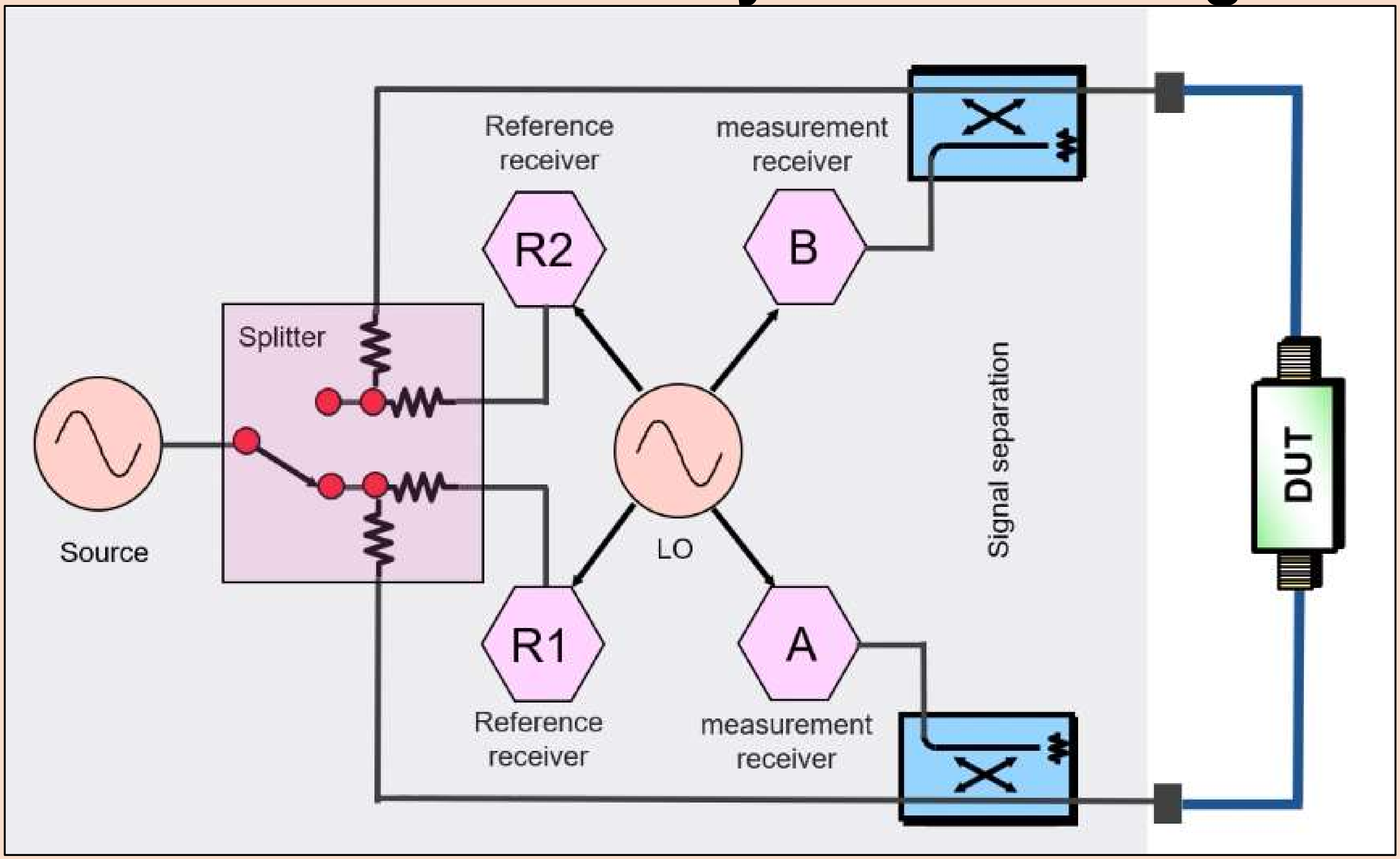
6. X-parameter (nonlinear) characterization

Pre-distortion

High-frequency Device Characterization



Vector Network Analyzer Block Diagram



NanoVNA H

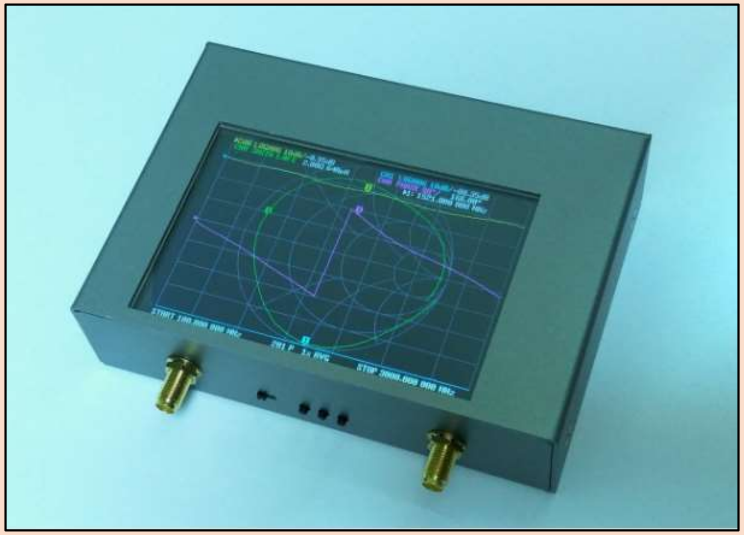
0.5 MHz - 1.5 GHz

2.8" TOUCHSCREEN

NanoVNA SAA2N

0.5 KHz - 3.0 GHz

4" TOUCHSCREEN



NanoVNA V2 Plus4

0.5 KHz - 4.0 GHz

4" TOUCHSCREEN

NanoVNA H4

0.5 MHz - 1.5 GHz

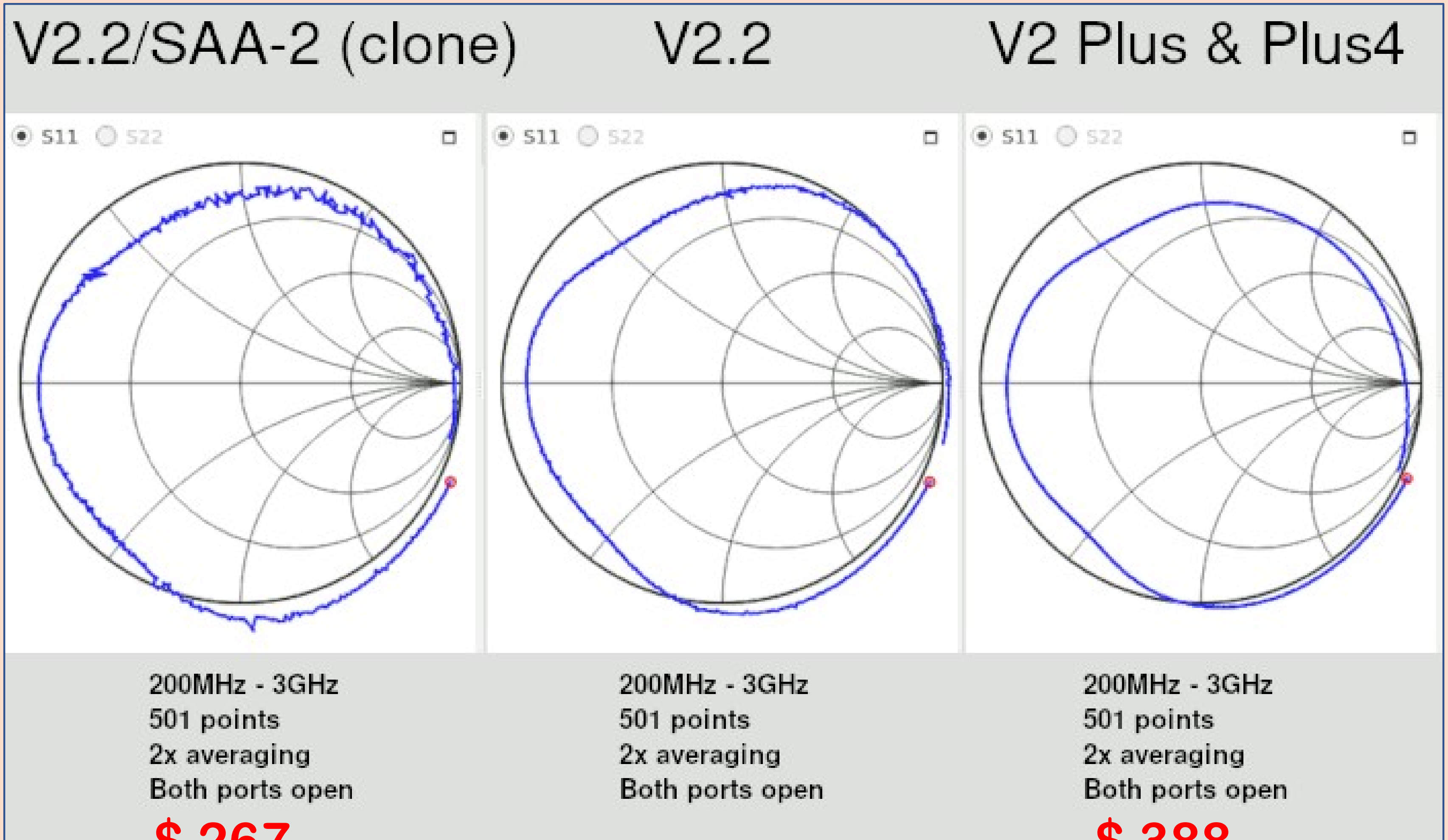
4" TOUCHSCREEN

NANO VNA-F V2

50 kHz – 3 GHz

4" TOUCHSCREEN

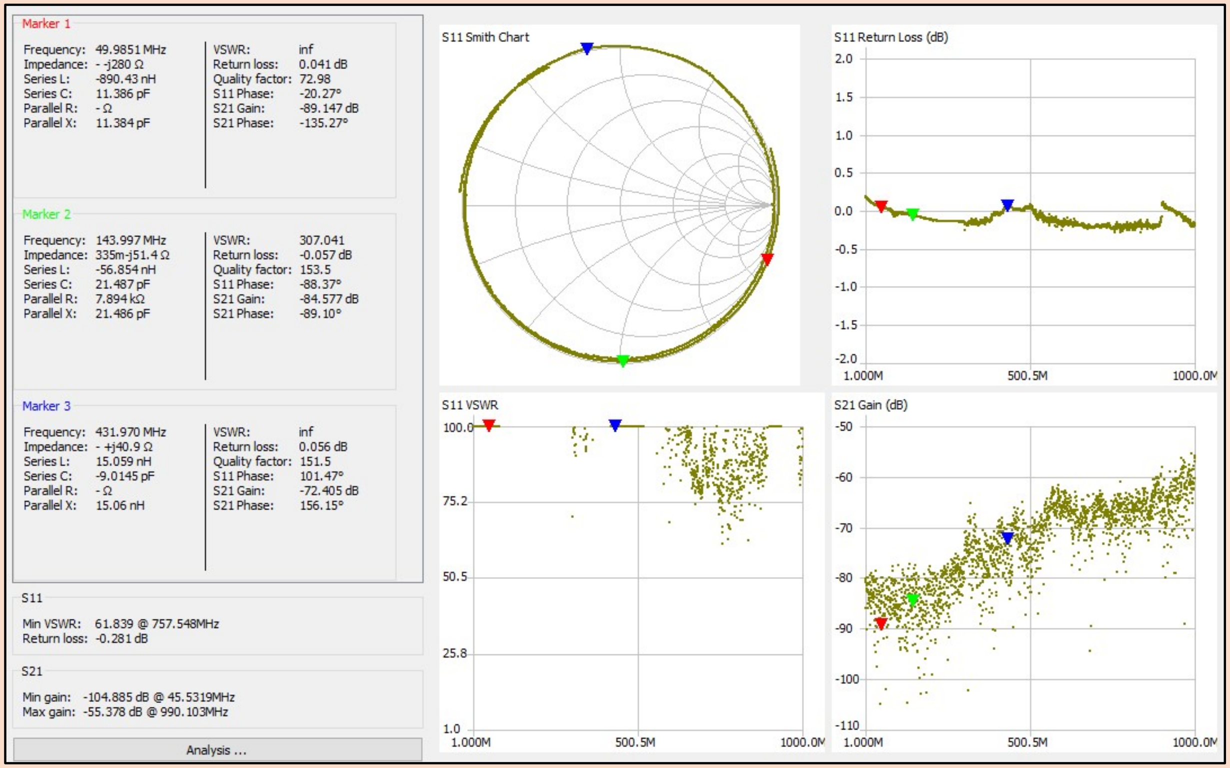
Vector Network Analyzer **Clones** versus Original

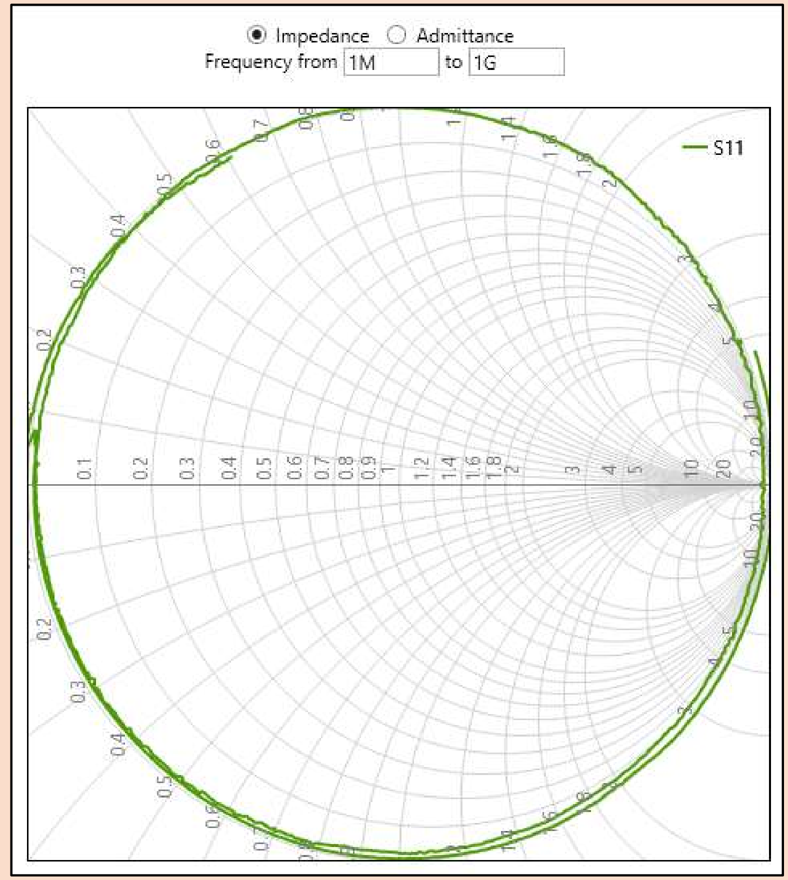


$ 267

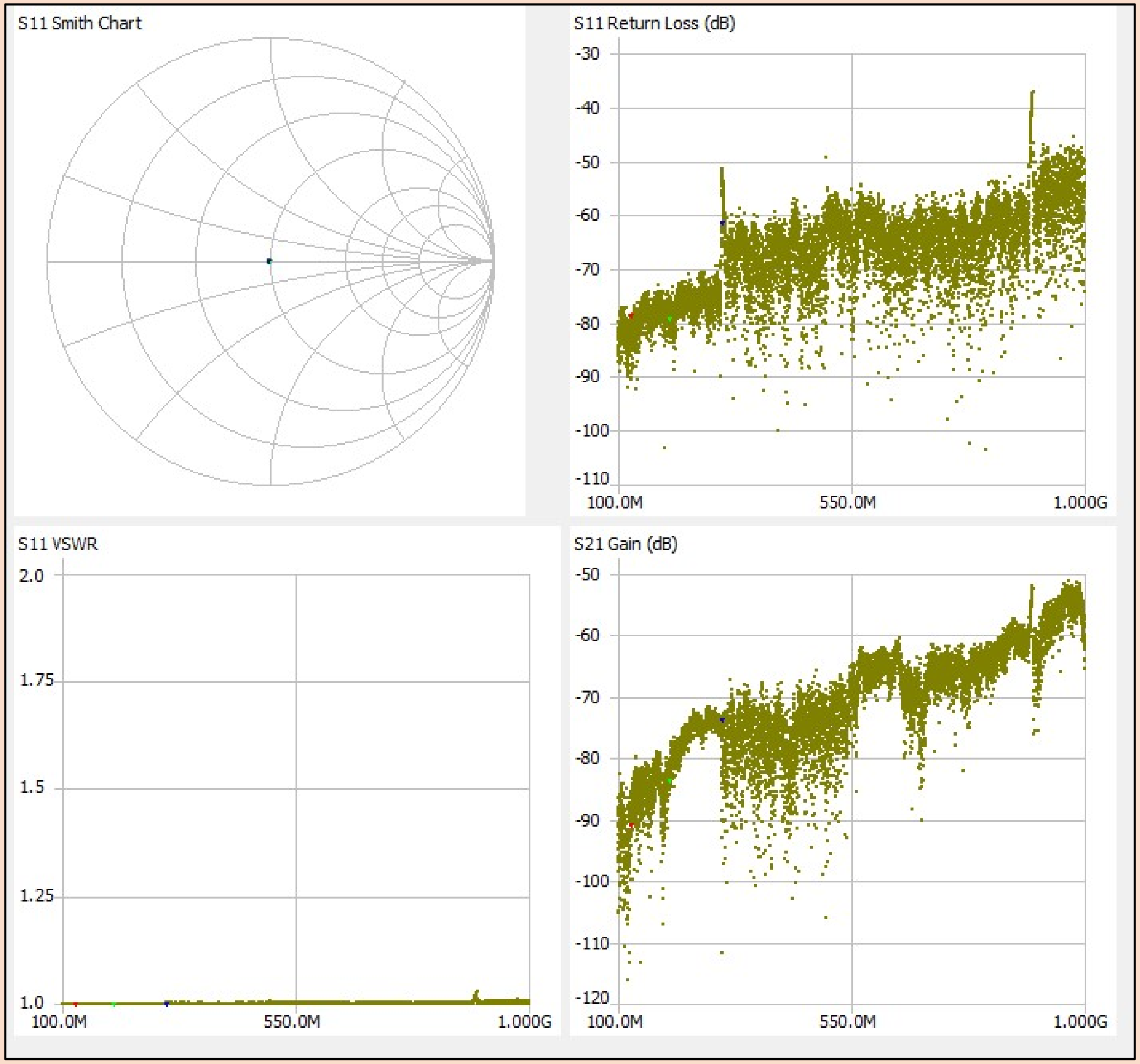
$ 388

Vector Network Analyzer   NanoVNA H





Calibrated Instrument provides Quantitative Measurements



Accuracy

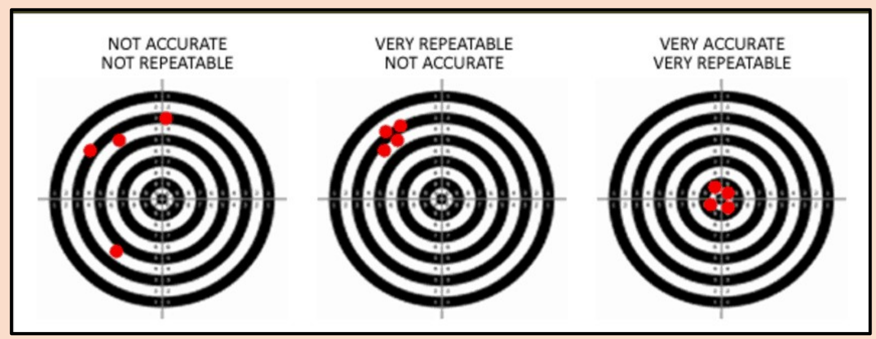
designates how close a measured value is to the true quantity of what is being measured.

Resolution

is the **smallest increment** the system can display or measure.

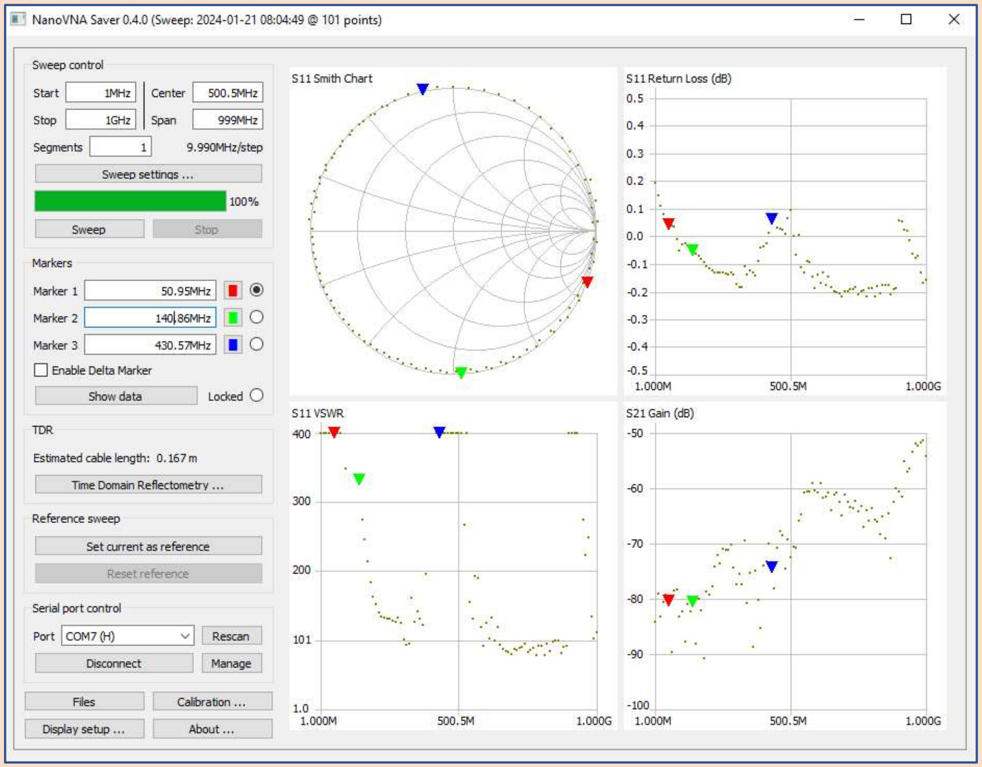
Repeatability

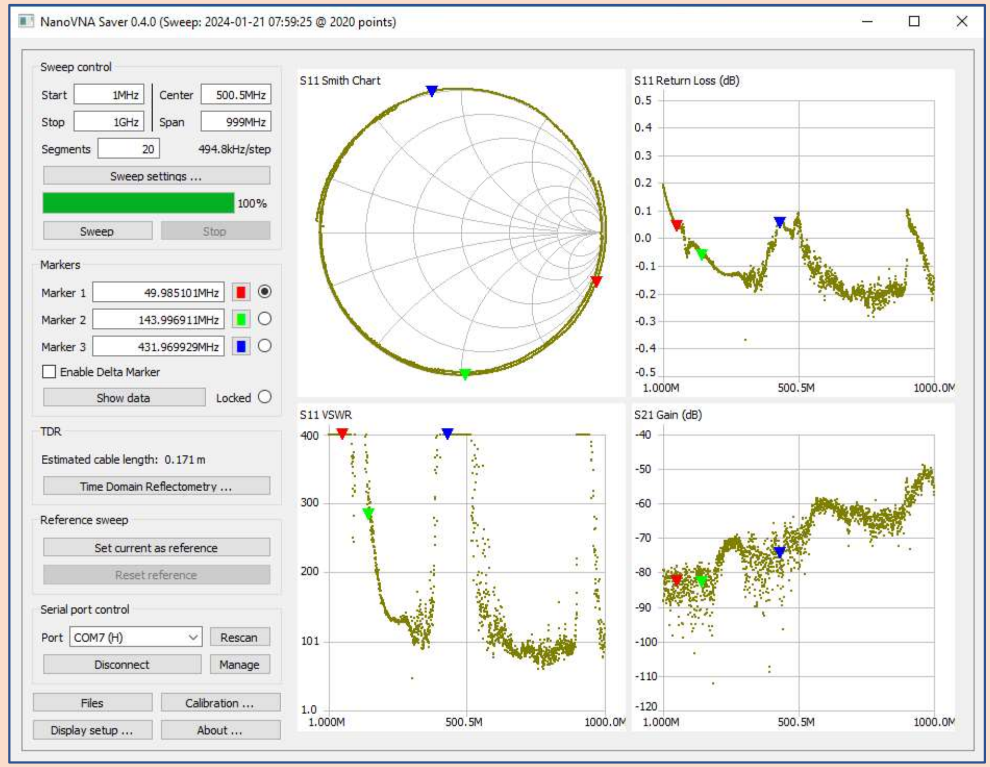
describes how well a system or device can **reproduce an outcome.**



Example NanoVNA H 50 ohm load

NanoVNA Saver Software

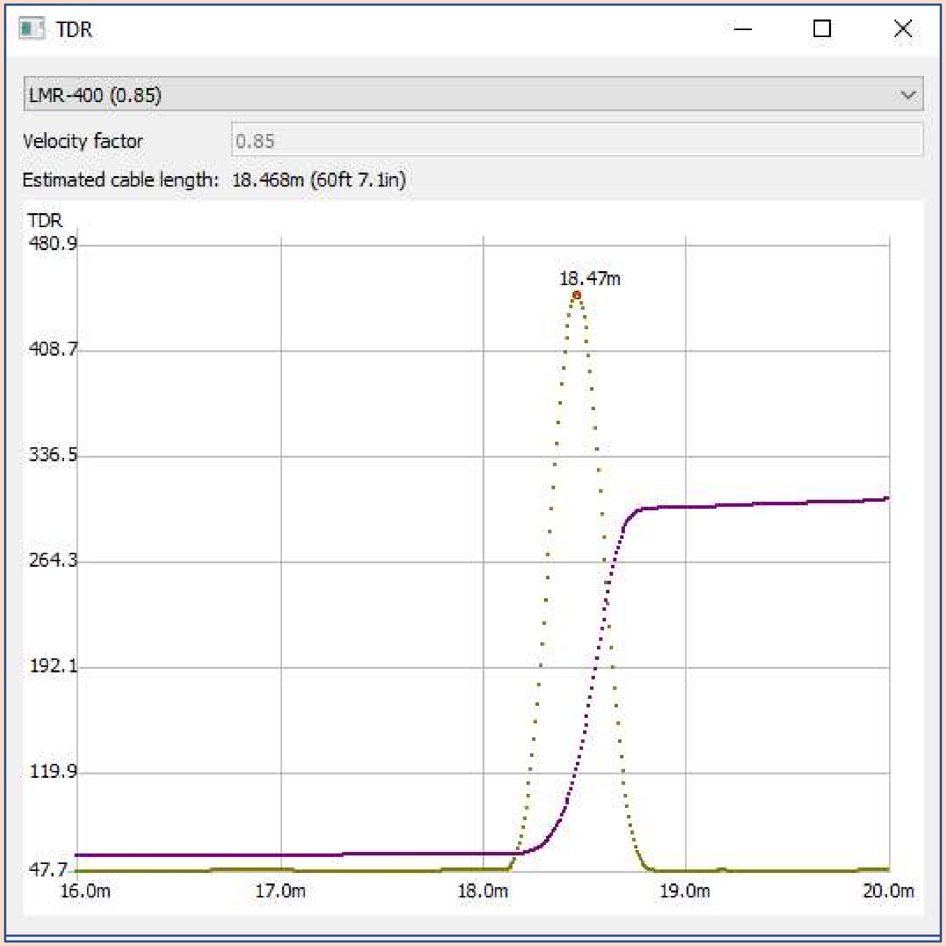




1 MHz – 1000 MHz, 1 Segment

1 MHz – 1000 MHz, 20 Segments

Vector Network Analyzer   Time Domain Reflectometry

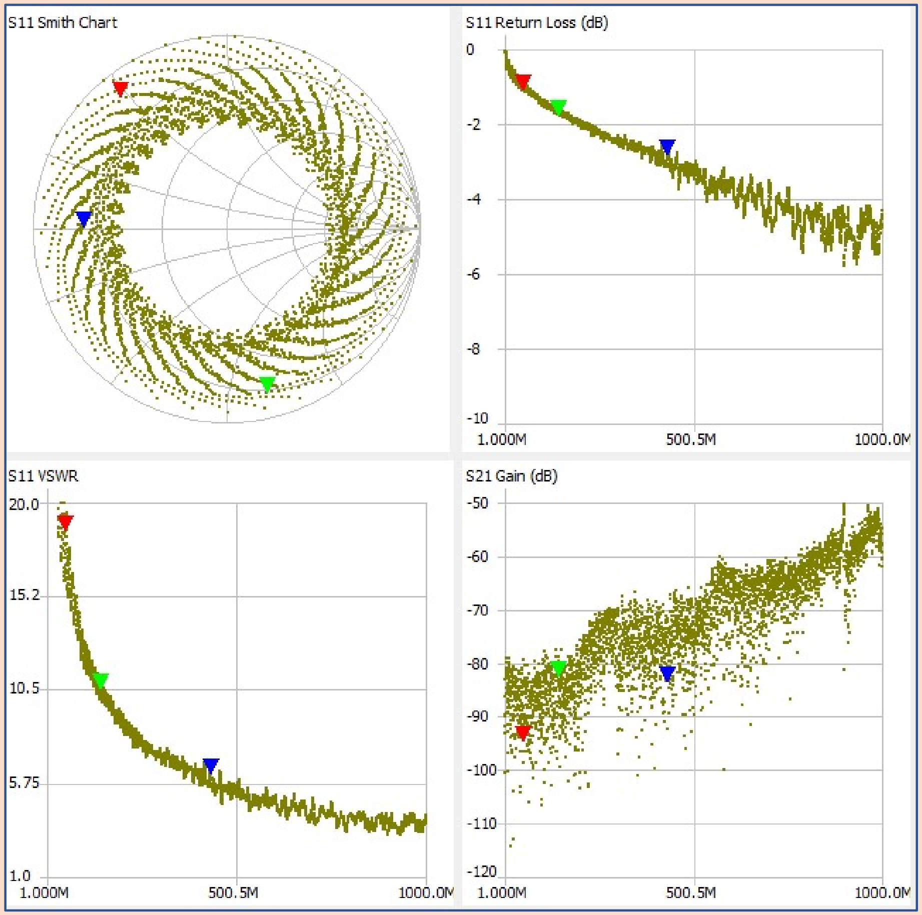


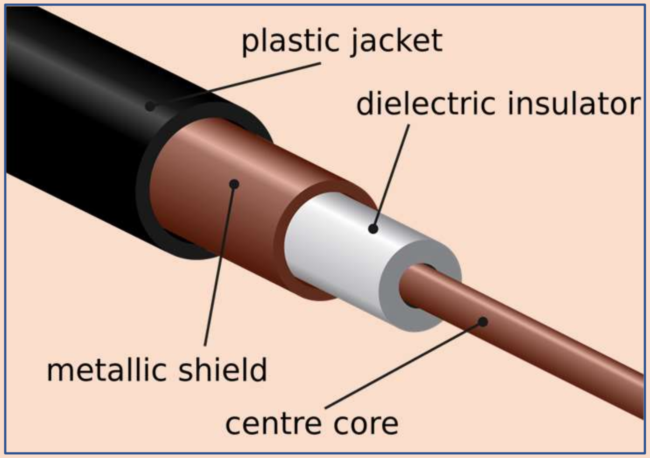
Identify both distance and magnitude of impedance discontinuities along a transmission line.

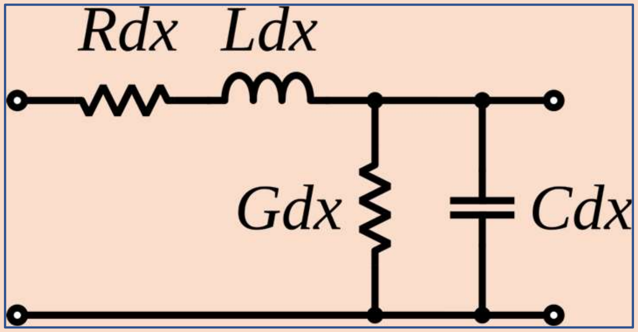
Commonly called distance to fault (DFT).

TDR nanoVNA, 10 feet cable, 50 feet LMR400, open load

Vector Network Analyzer   Frequency Domain Analysis

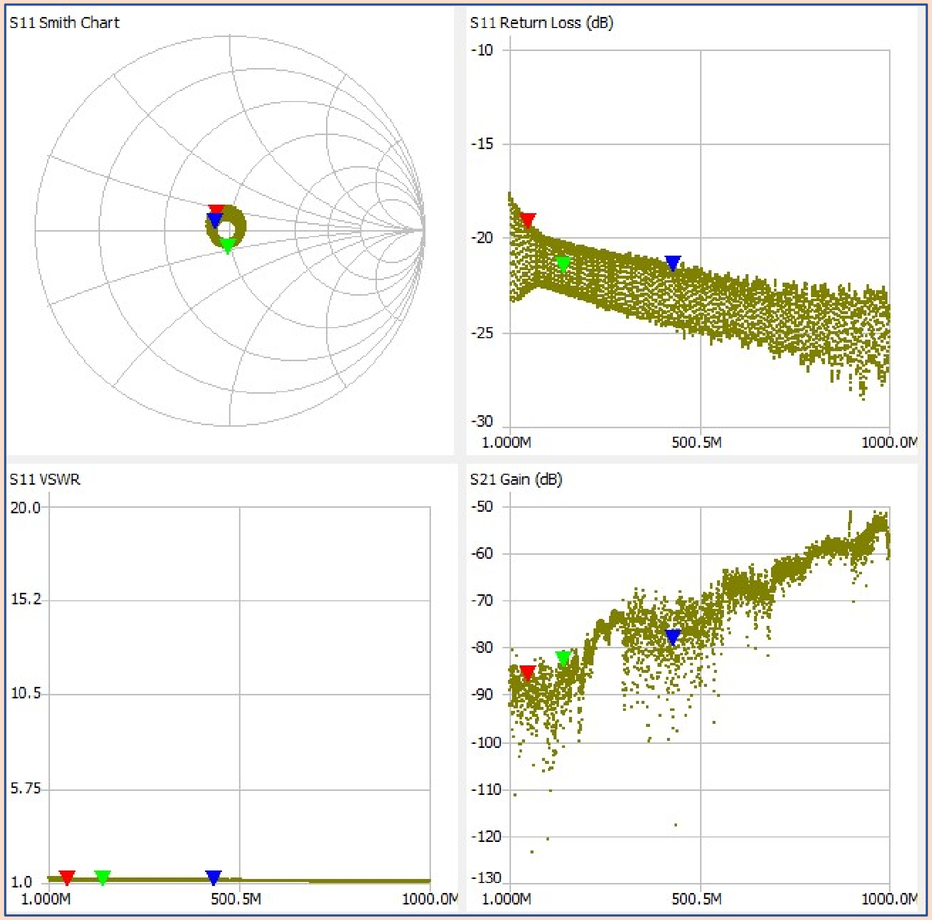


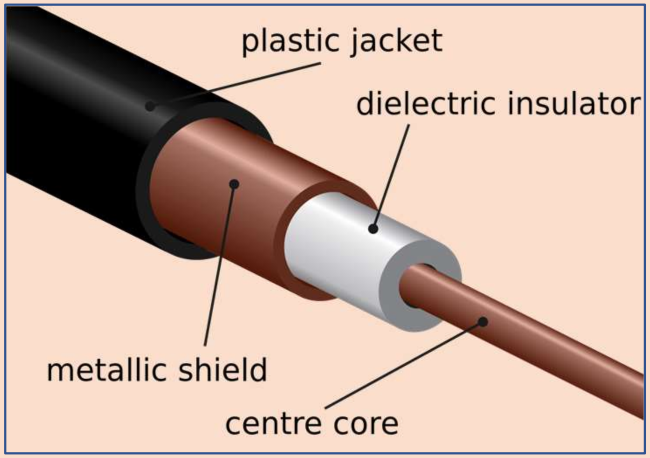


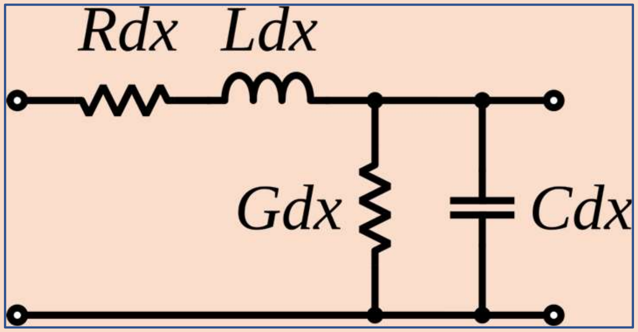


TDR nanoVNA, 50 feet LMR400, open load

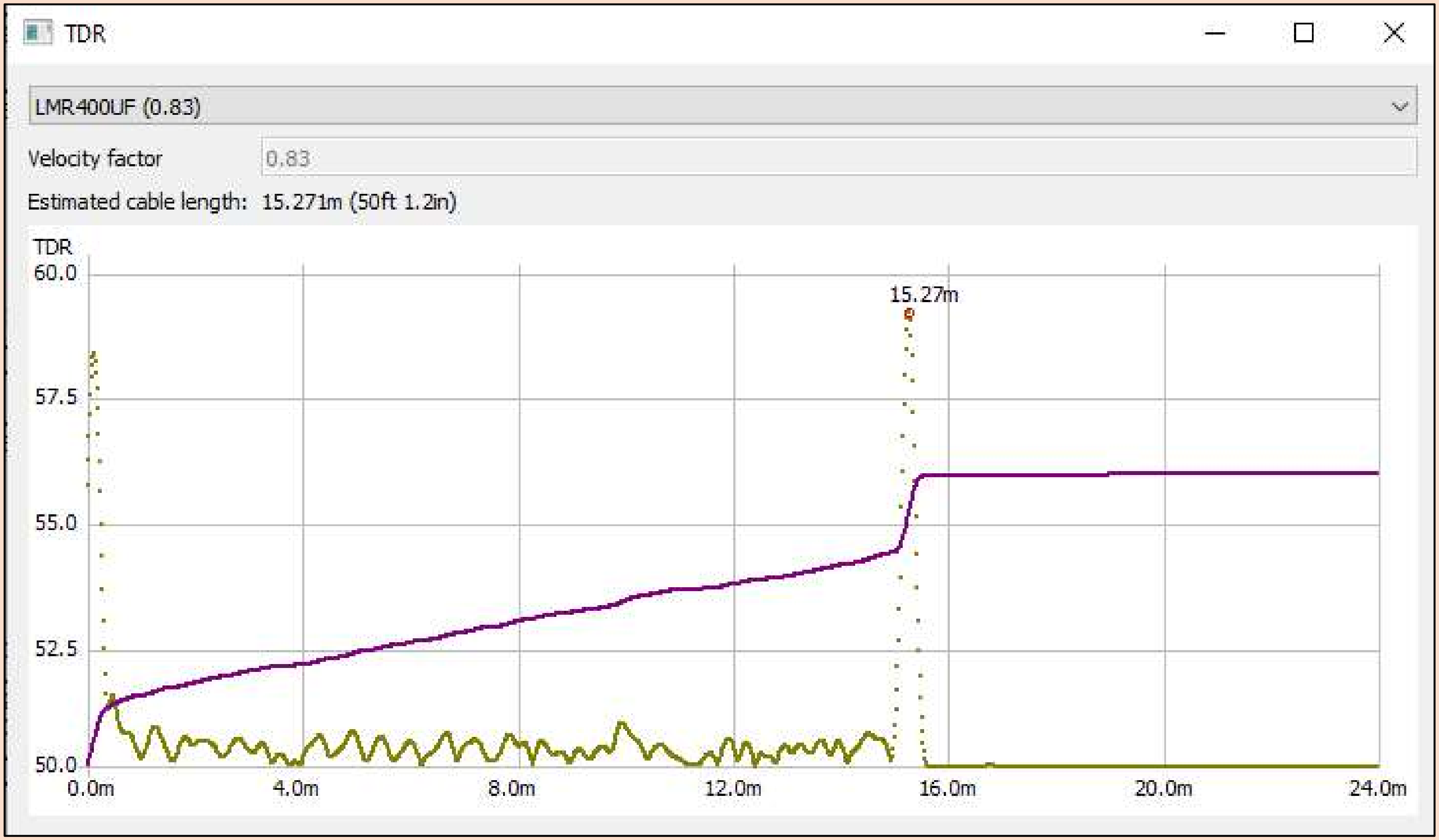
Vector Network Analyzer   Frequency Domain Analysis



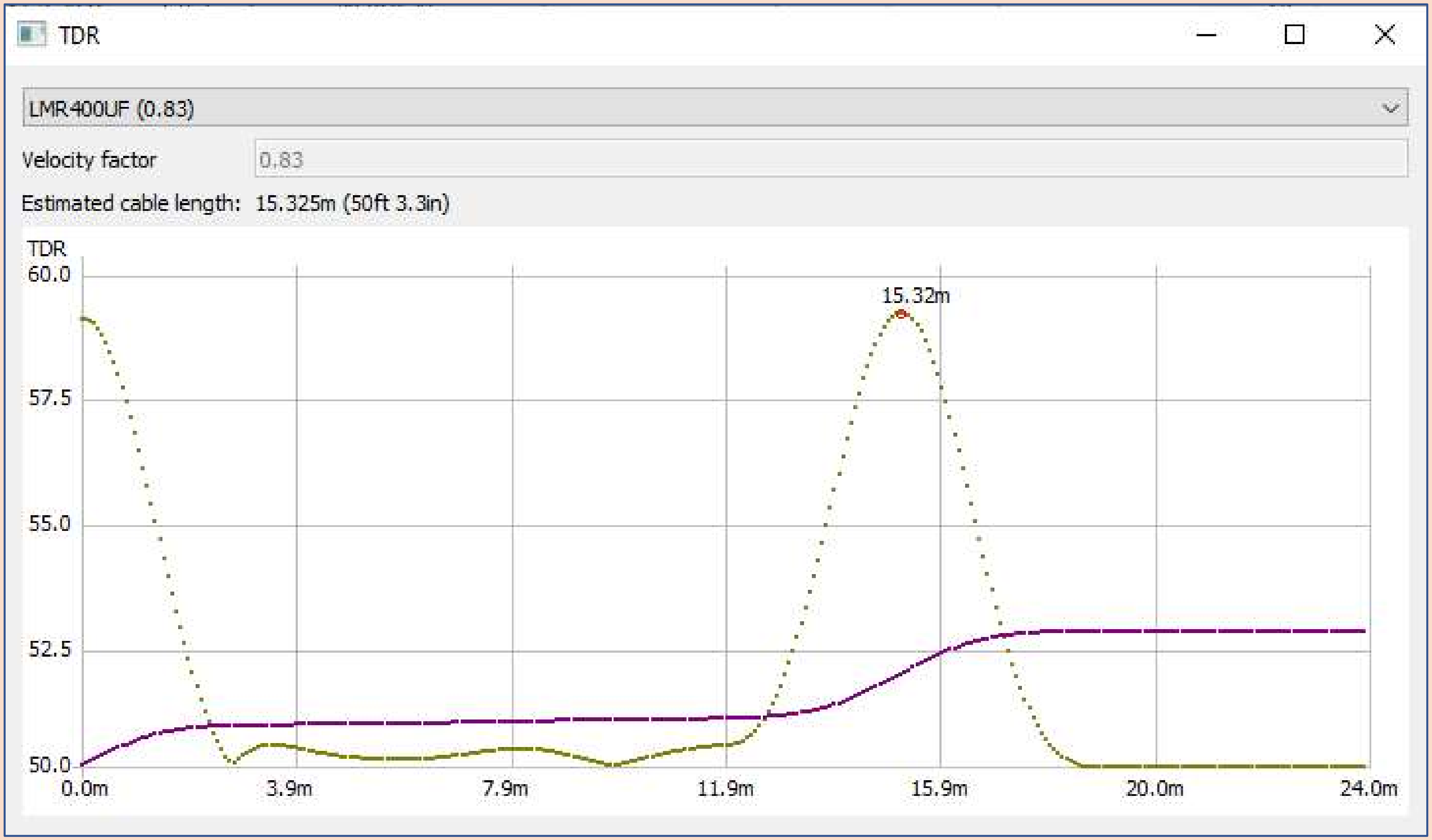




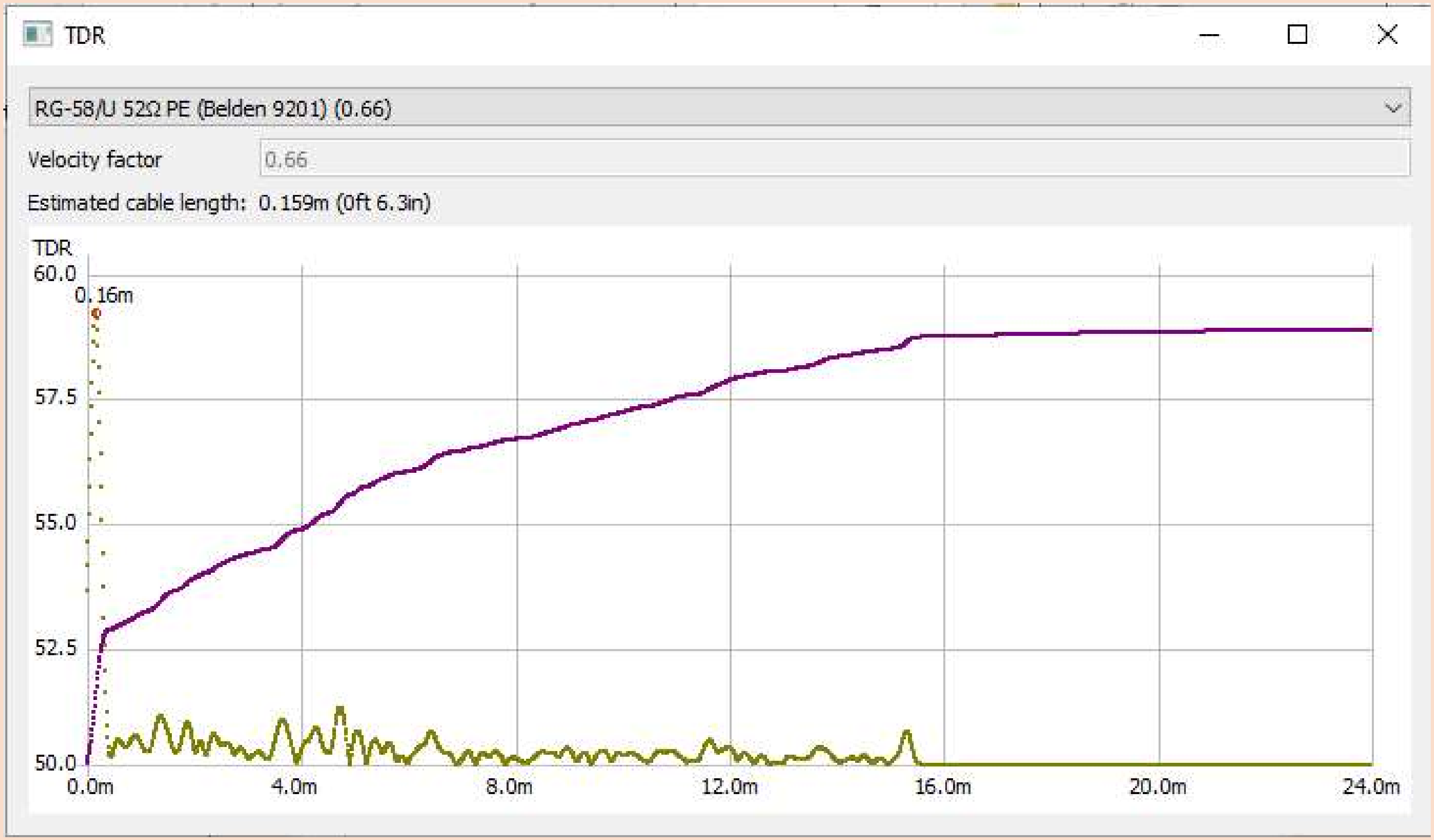
TDR nanoVNA, 10 dB Pad, 50 feet LMR400, open load



LMR 400 50 feet 50 ohm Load 1 MHz – 1000 MHz Sweep

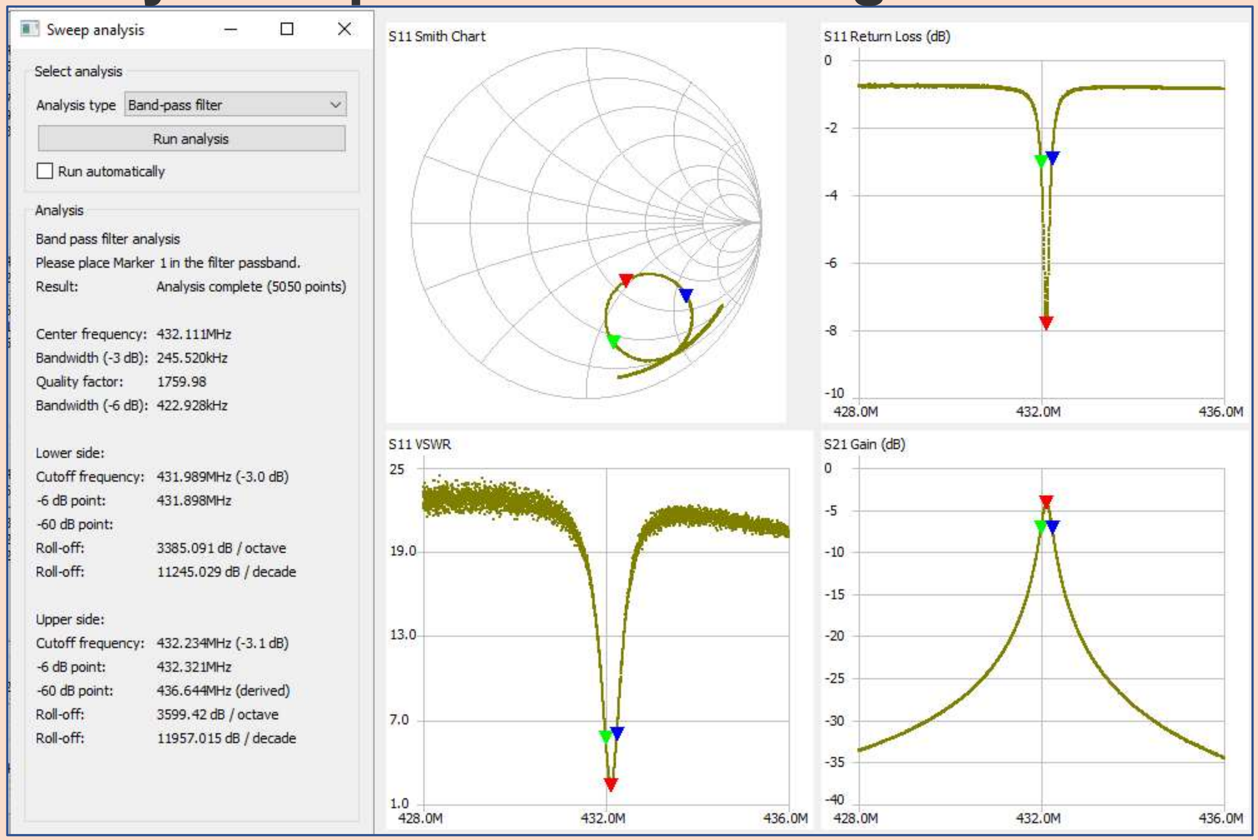


LMR 400 50 feet 50 ohm Load 1 MHz – 100 MHz Sweep



RG58 50 feet 50 ohm Load 1 MHz – 1000 MHz Sweep

UHF Resonant Cavity Bandpass Filter Testing

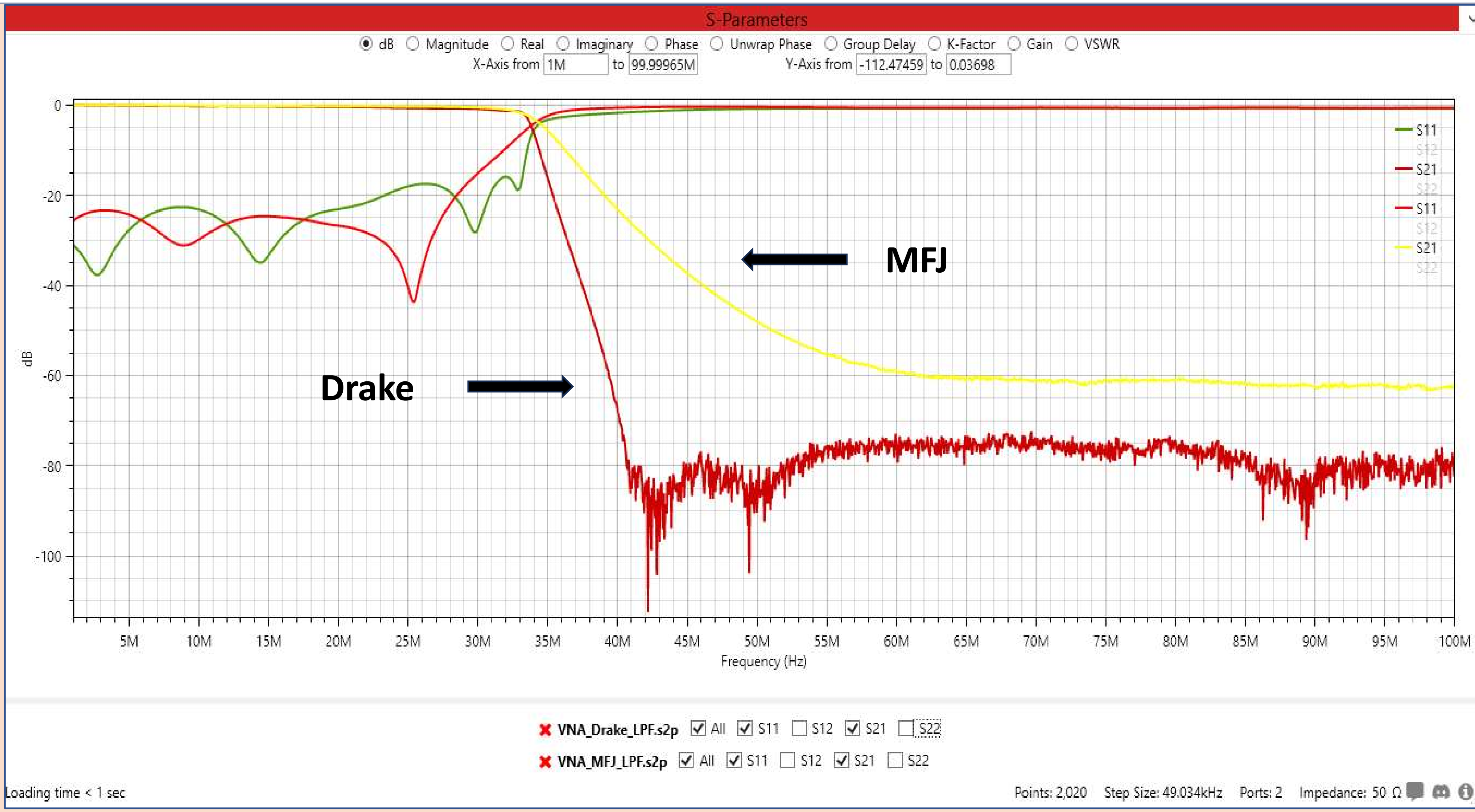


Center Frequency 421.111 MHz

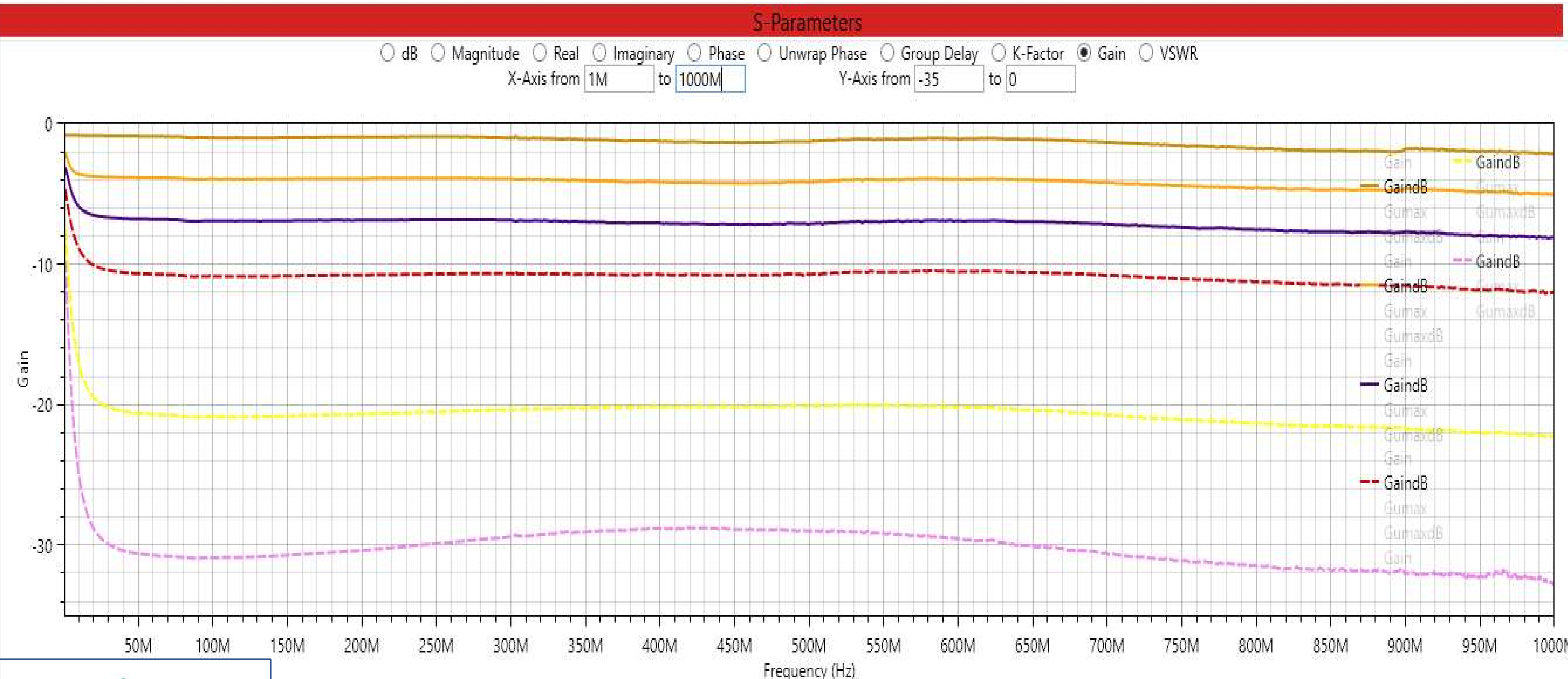
Bandwidth 245.520 KHz

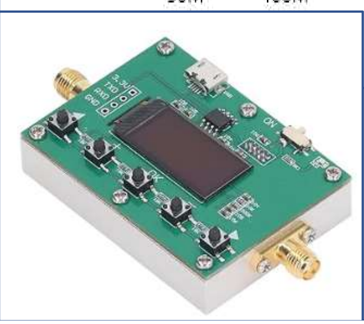
Test and Compare HF Low Pass Filters

Vintage versus Modern , how do they compare?

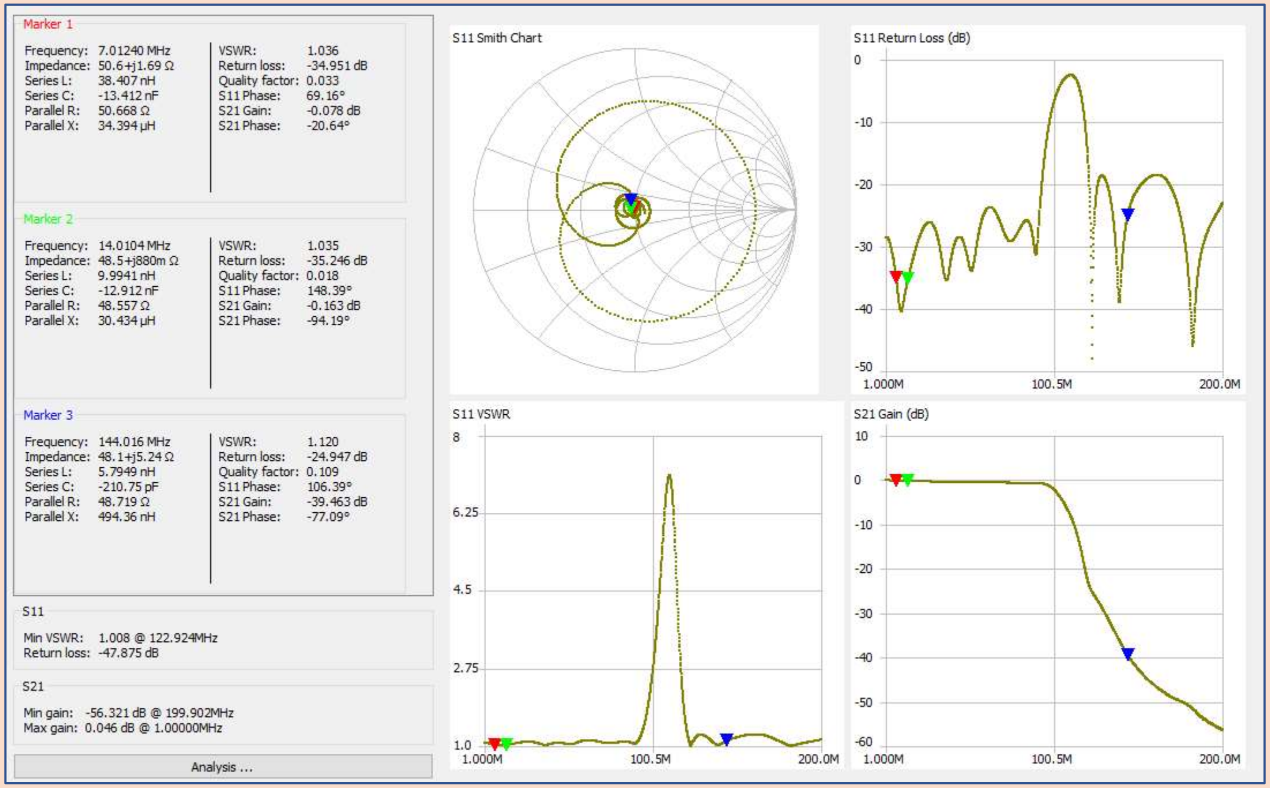


S11 , S21 Comparison Drake versus MFJ HF Low Pass Filters





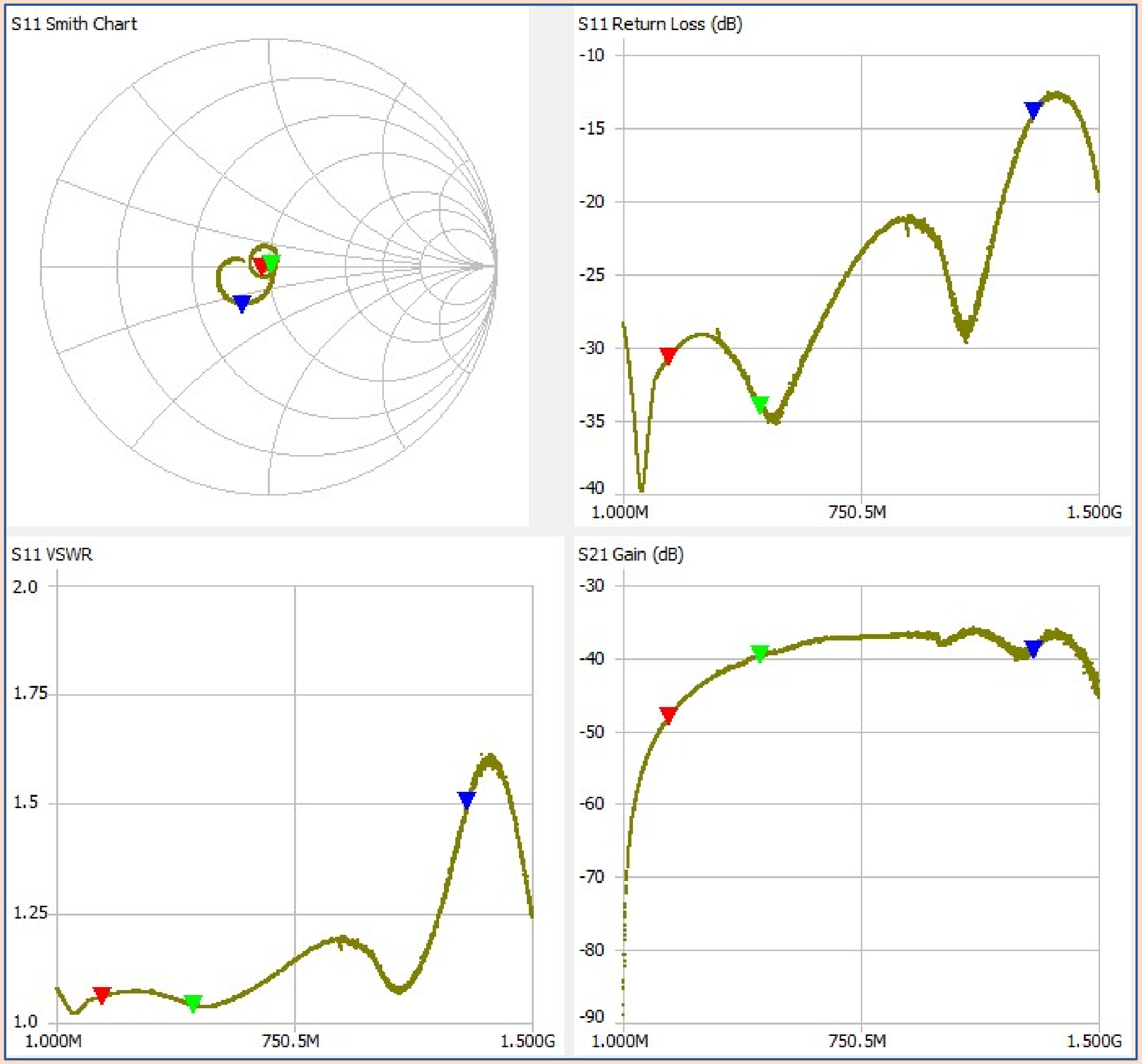
Digital RF Attenuator



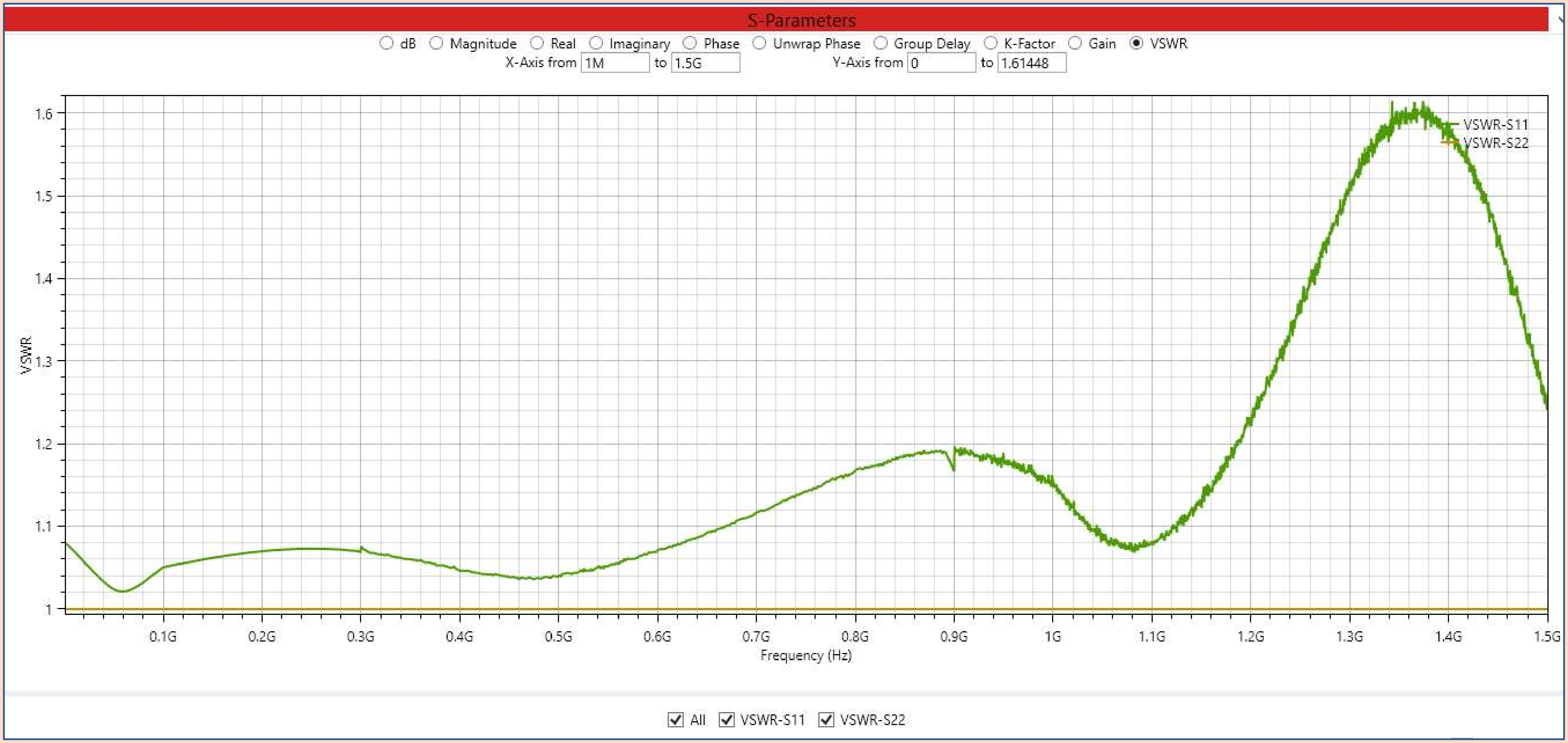
Comet CF-530 Duplexer

Band Pass		Ins Loss	Max Power
Low Pass:	1.3 - 90MHz	.2dB	600W PEP
High Pass:	125 - 470MHz	.2dB	600W PEP

Isolation: 45dB minimum

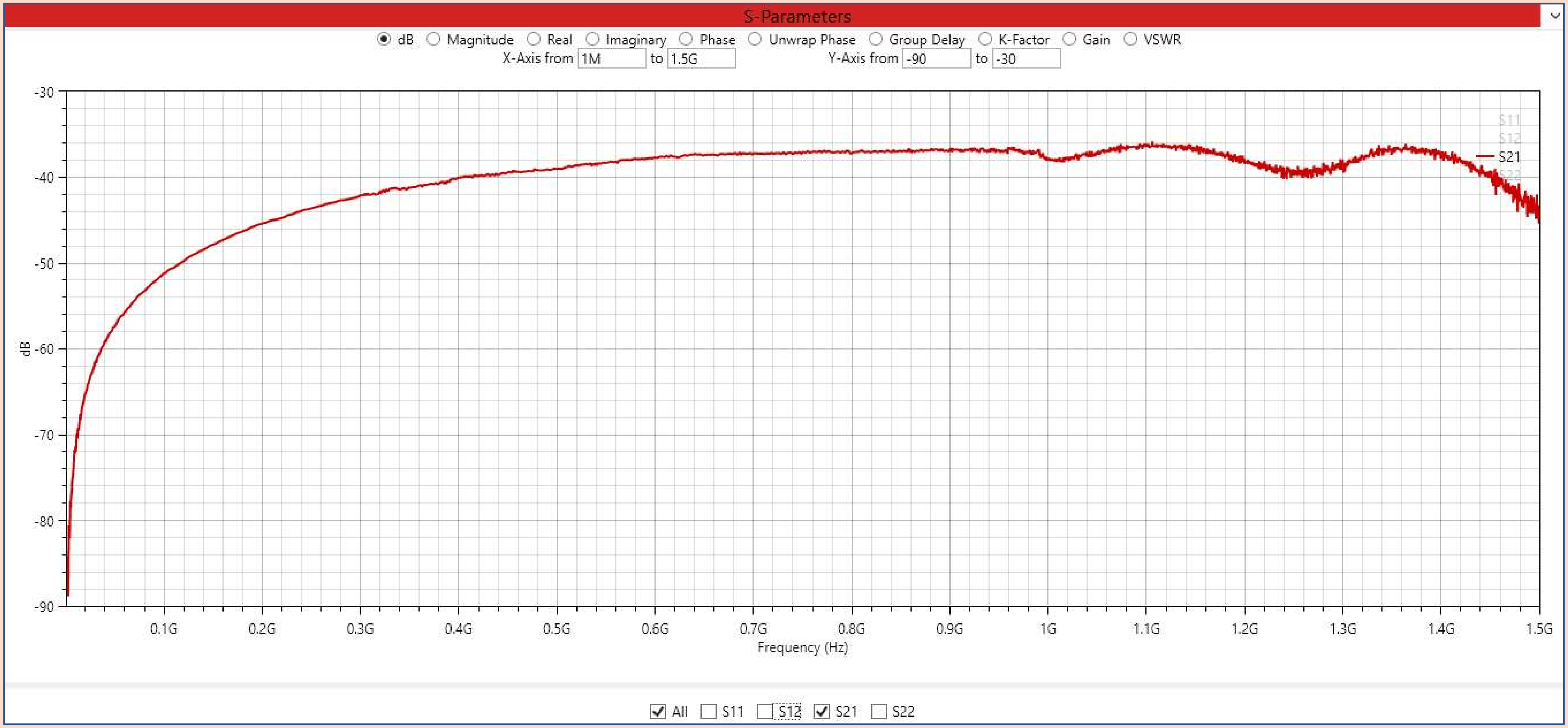


RF Coaxial Directional Coupler
400 - 470MHz
40dB   500 Watt

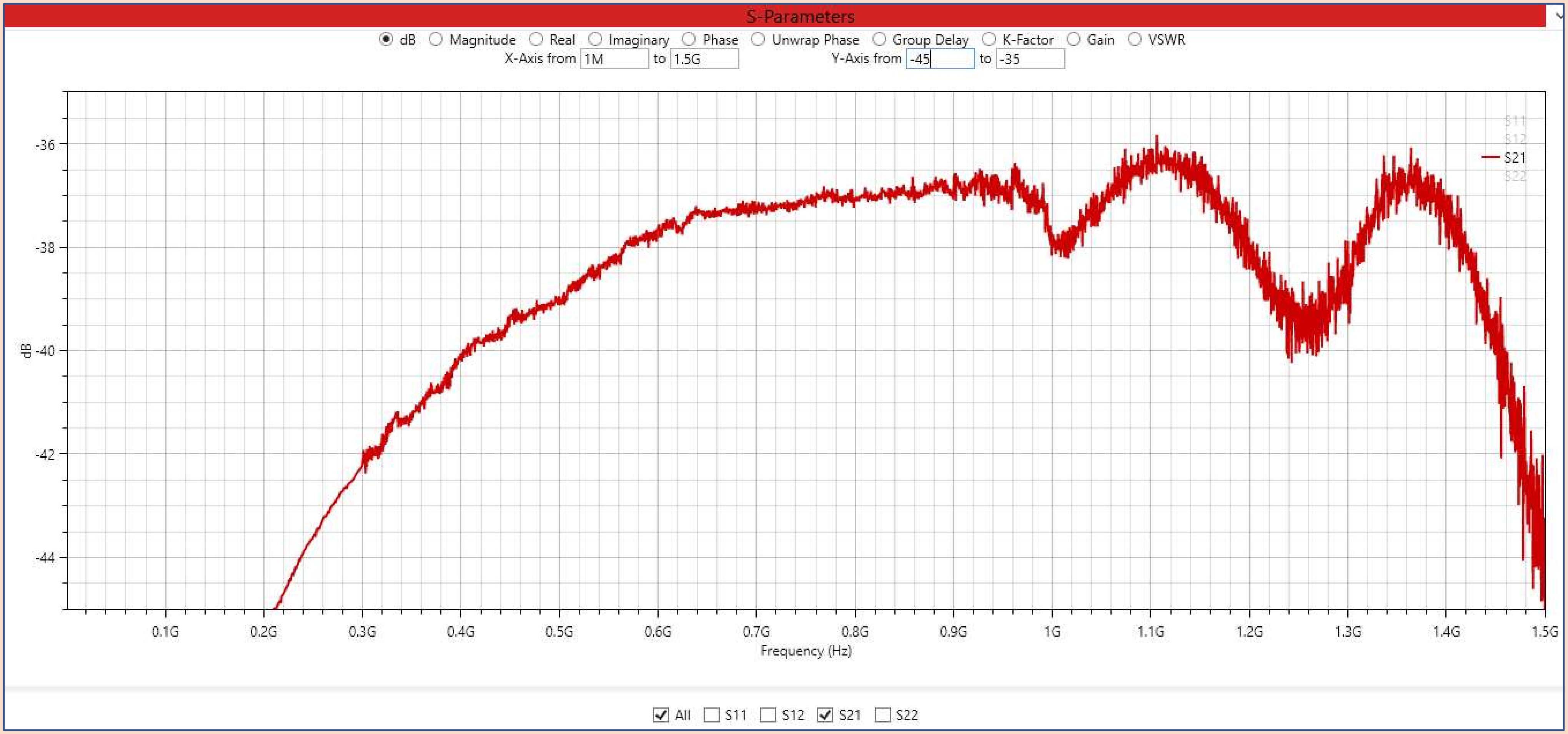


RF Coaxial Directional Coupler 400 - 470MHz

40dB 500 Watt

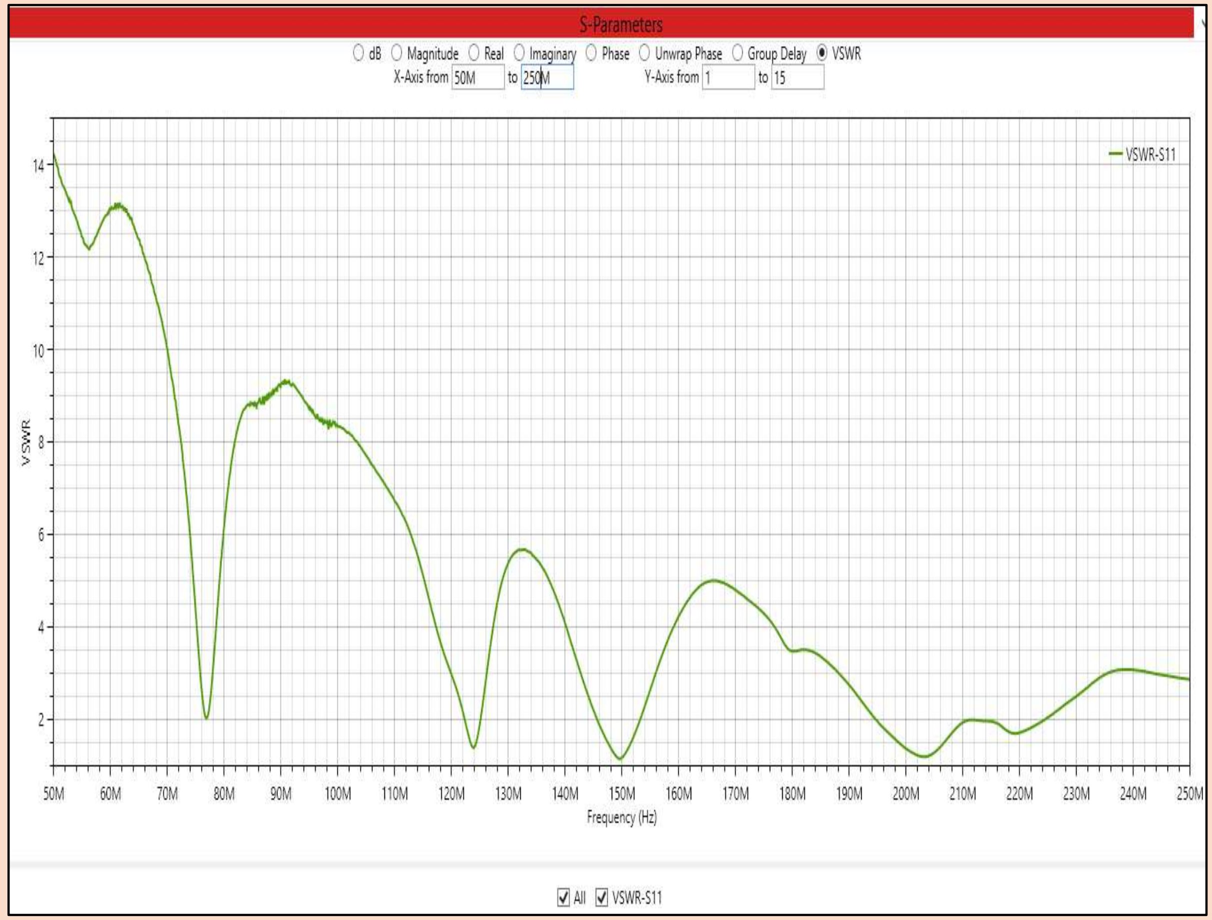


RF Coaxial Directional Coupler 400 - 470MHz
40dB 500 Watt

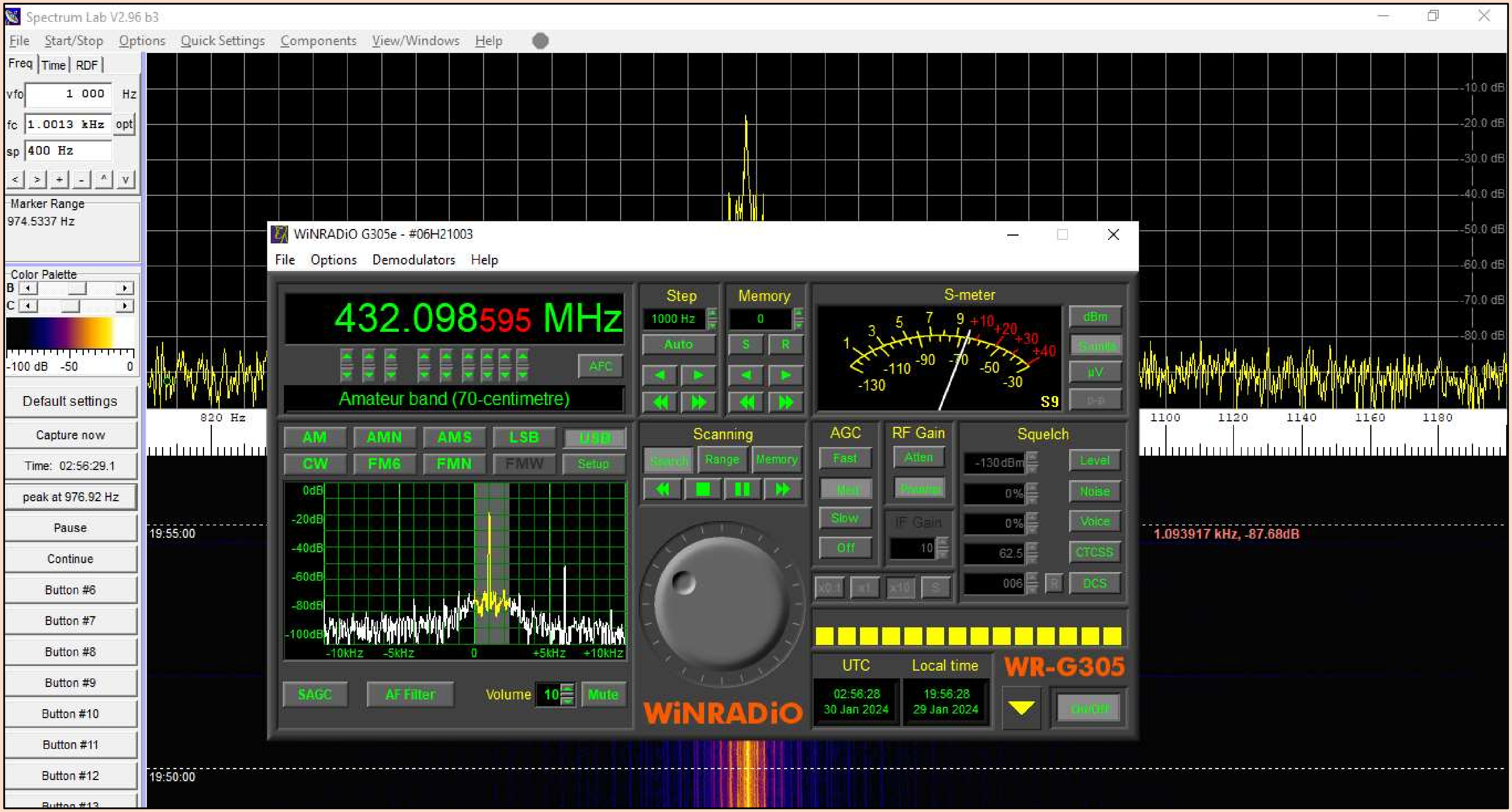


RF Coaxial Directional Coupler 400 - 470MHz

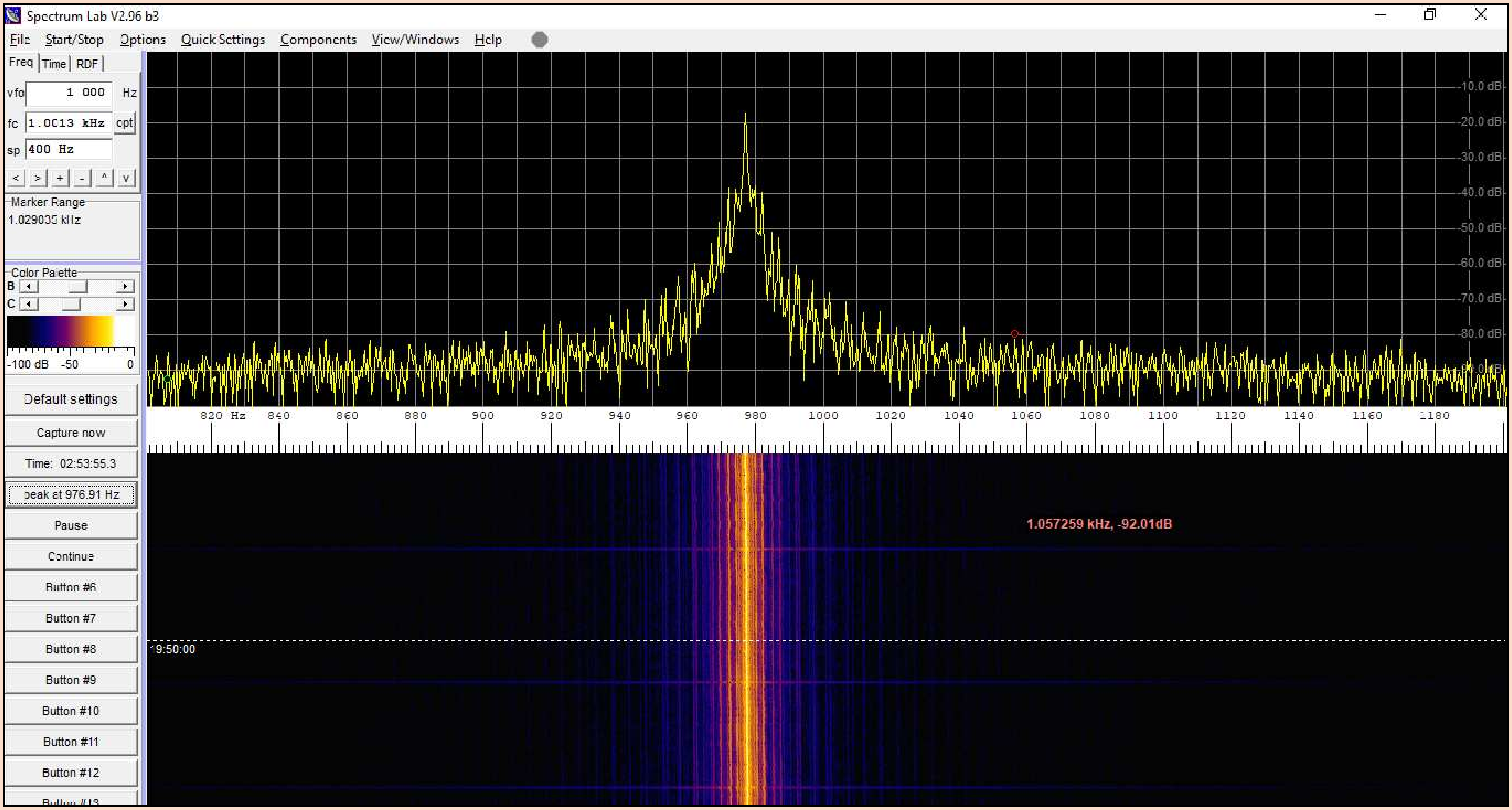
40dB 500 Watt



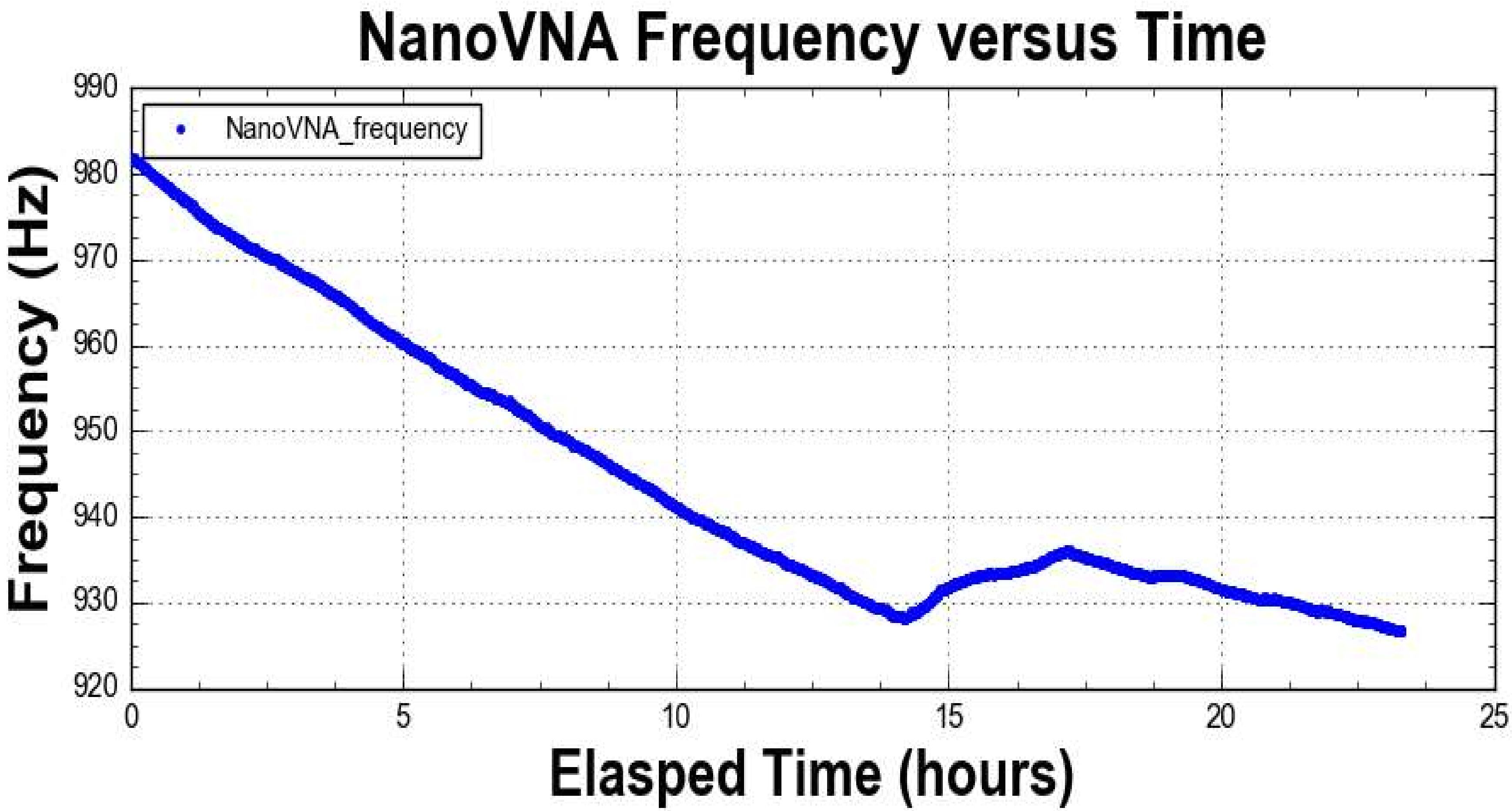
50 cm Vertical Antenna



NanoVNA RF Signal Generator



NanoVNA RF Signal Generator



NanoVNA RF Signal Generator @ 432 MHZ

Don has pursued a lifelong interest in science and engineering beginning as a youth in western Canada. He received his first amateur radio license at the age of 15 while attending high school in Edmonton, Alberta, Canada.

Don continued this interest and graduated from the University of Alberta receiving a Bachelor Science in Electrical Engineering. During the last 41 years he has worked in energy industry in Canada, the United States, Europe, South America, the Middle East and the Far East.

His technical area of interest lead to publications of nuclear magnetic resonance applied to reservoir characterization. He was granted numerous US patents for developments of pressure core technology. Don was honored to be the Distinguish Speaker at the Harvard University Energy Conference. During 2020, Don received the prestigious Hart Energy Innovators Award.

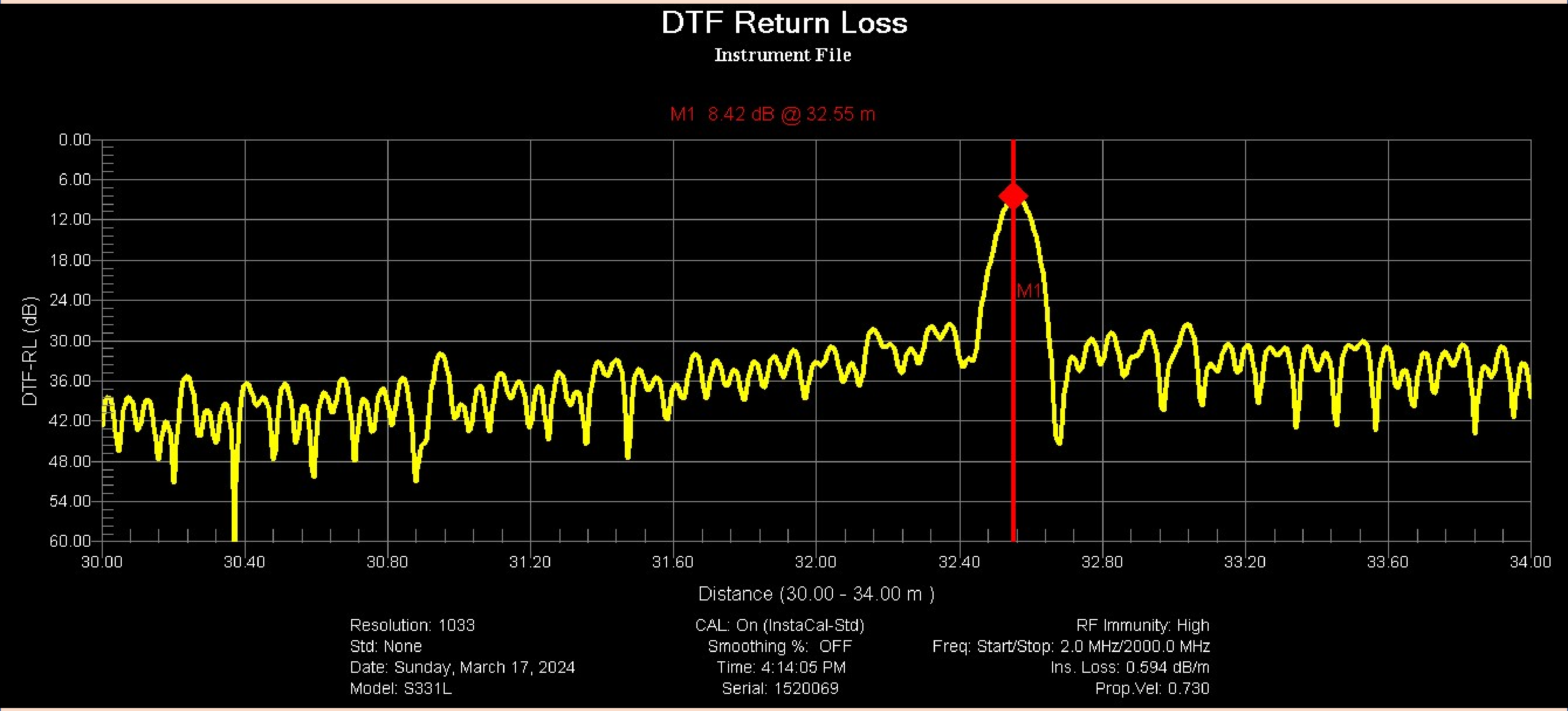
I obtained an amateur radio license in 1967 as VE6ANW, a year later achieved the advanced certification as VE6RI. I initially pursued 20-meter DX working. Soon after, I became interested in weak signal UHF propagation. After more than 50 years have passed, I have rejoined the amateur radio ranks and currently active on 20 meters and VHF / UHF bands.

Cable Test Experiment

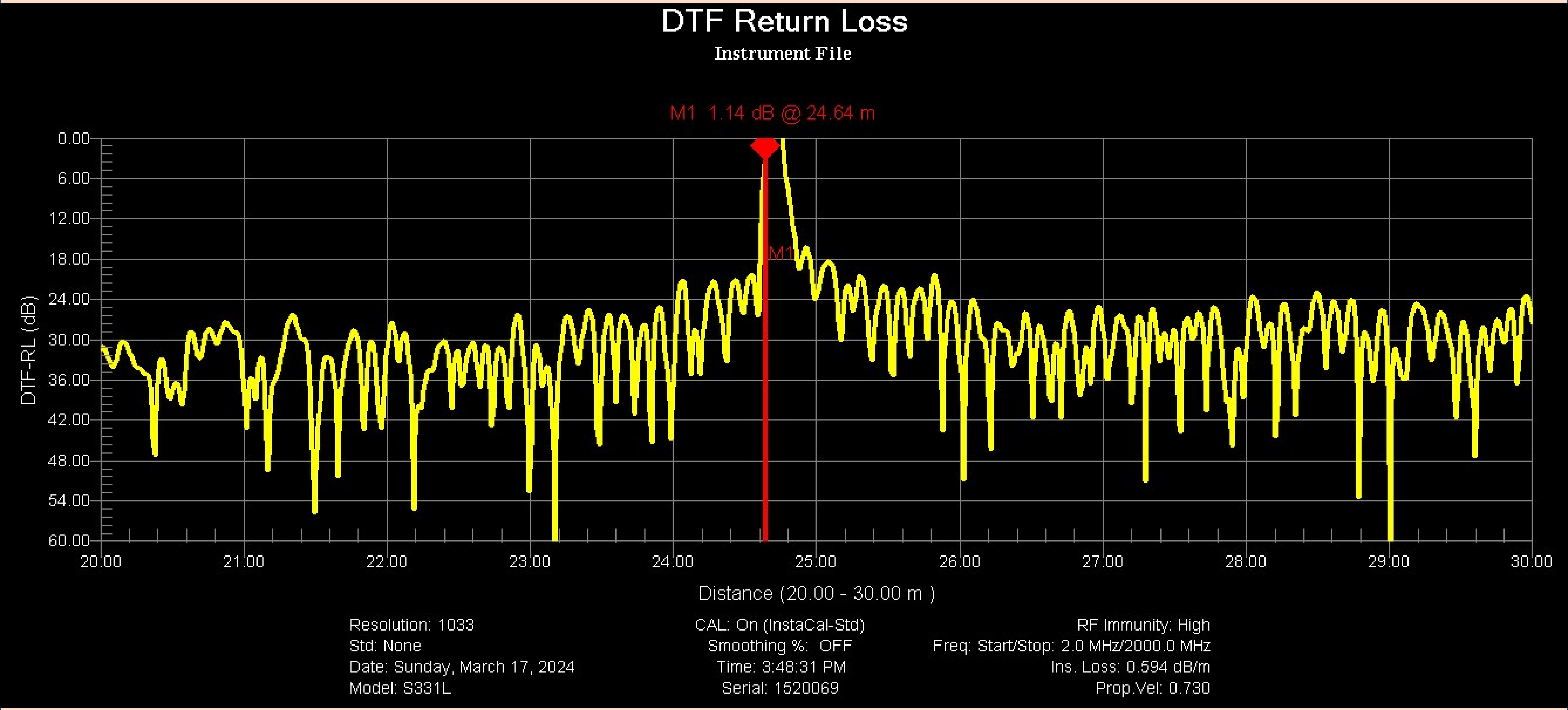
RG 58a/u

Determine Cable Quality

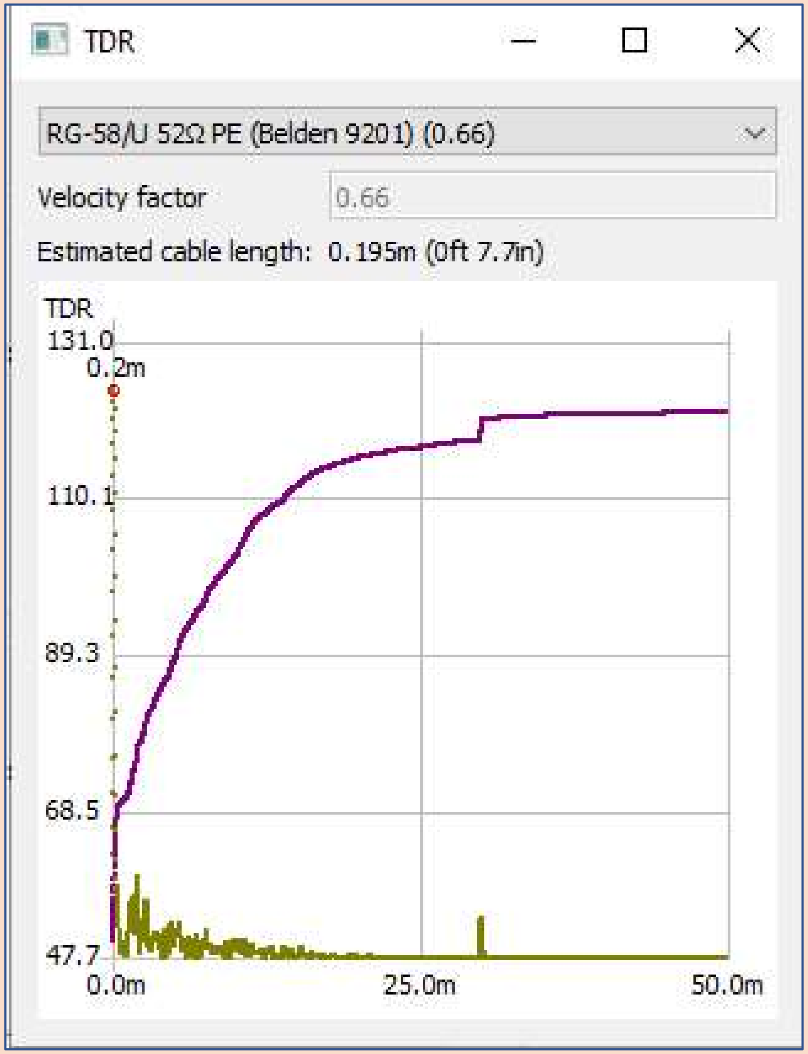
Cable A and Cable B



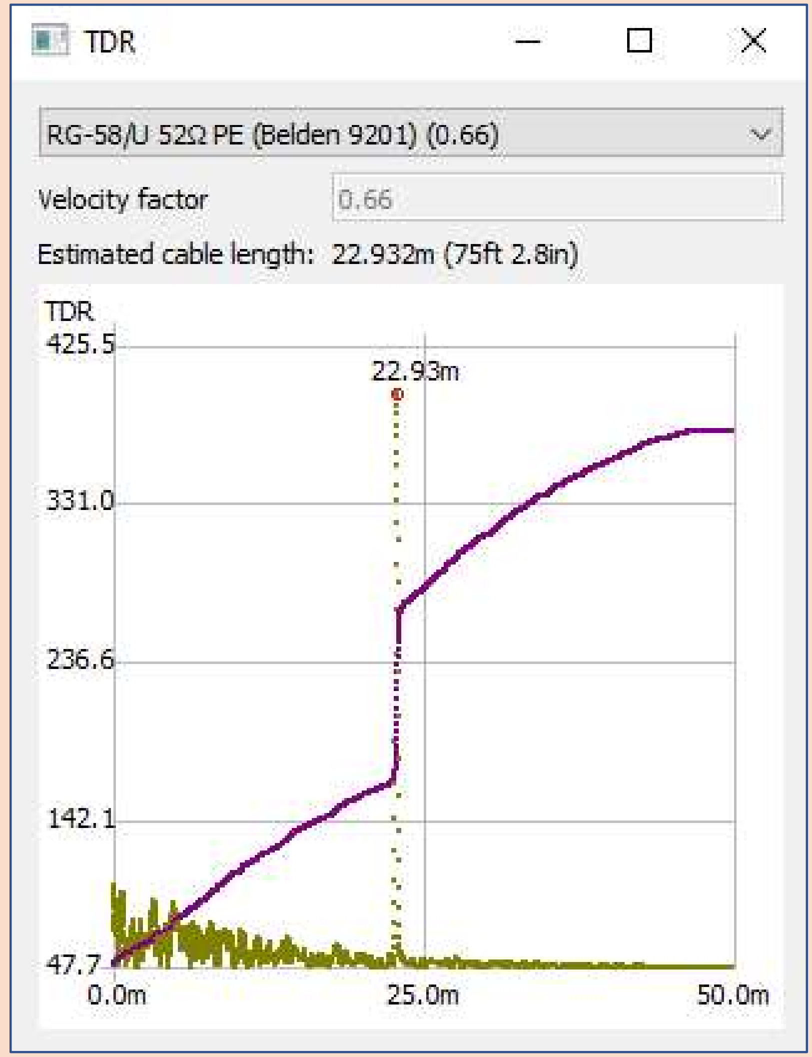
SiteMaster S331L DTF Cable A



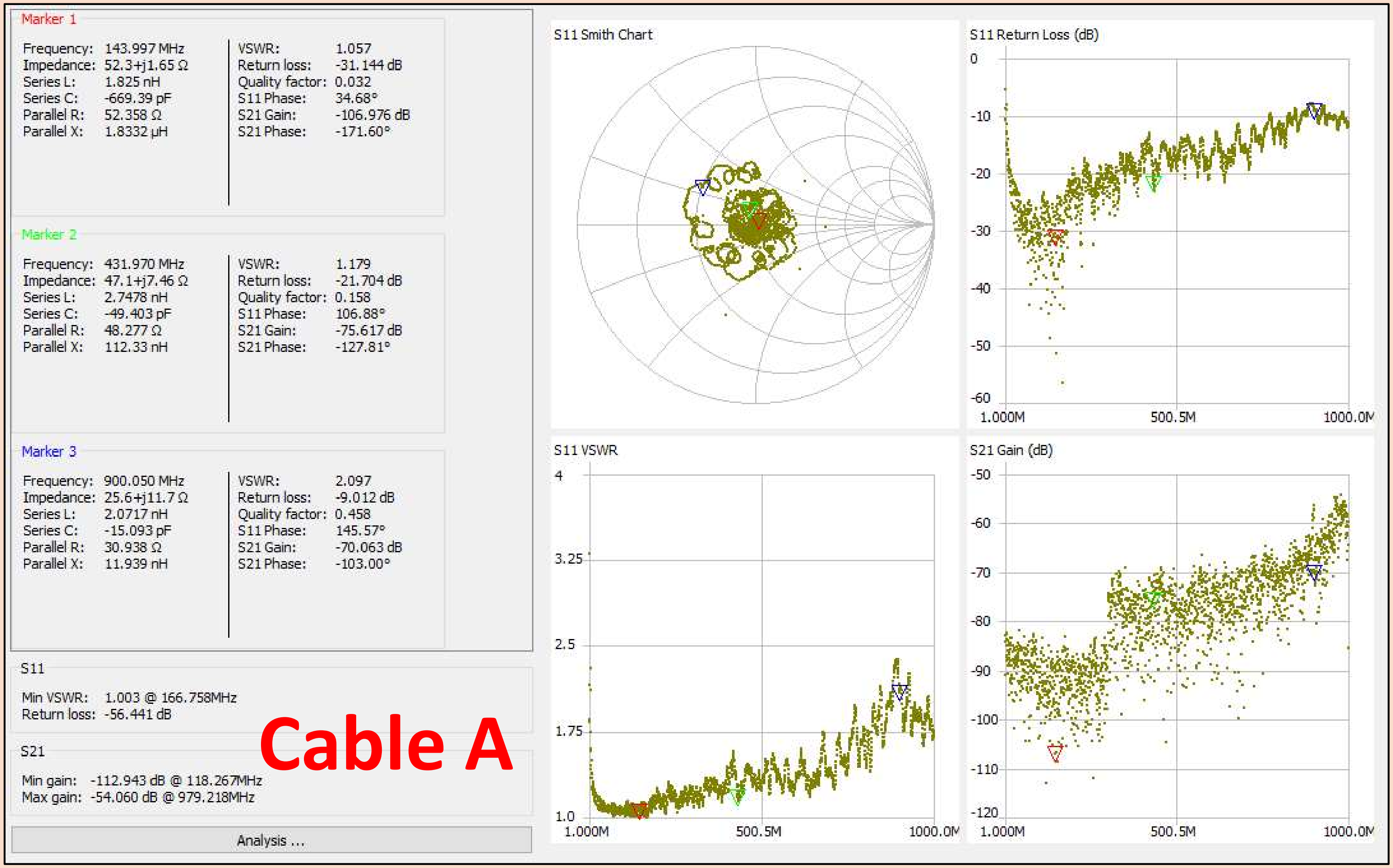
SiteMaster S331L DTF Cable B



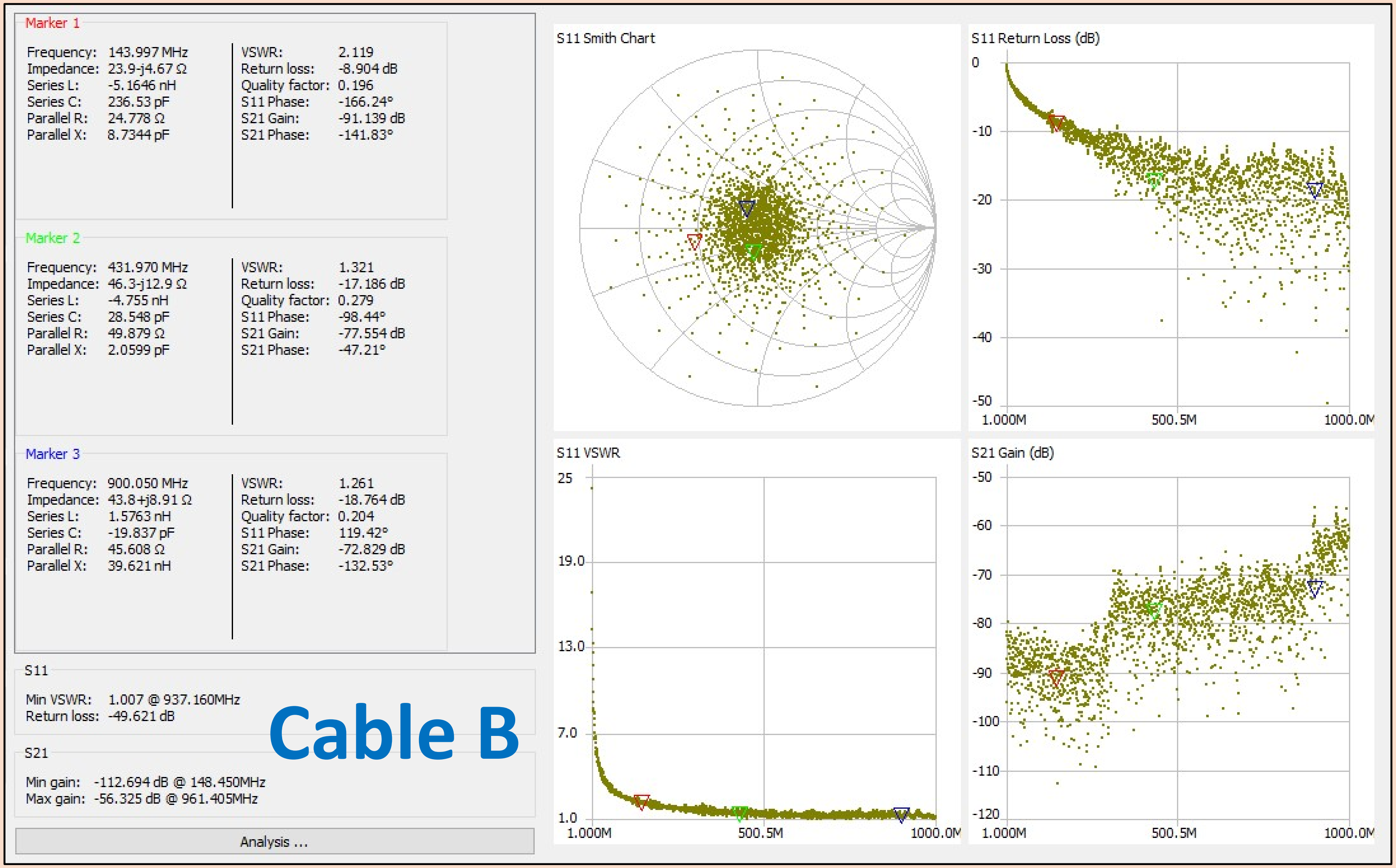
nanoVNA Cable A



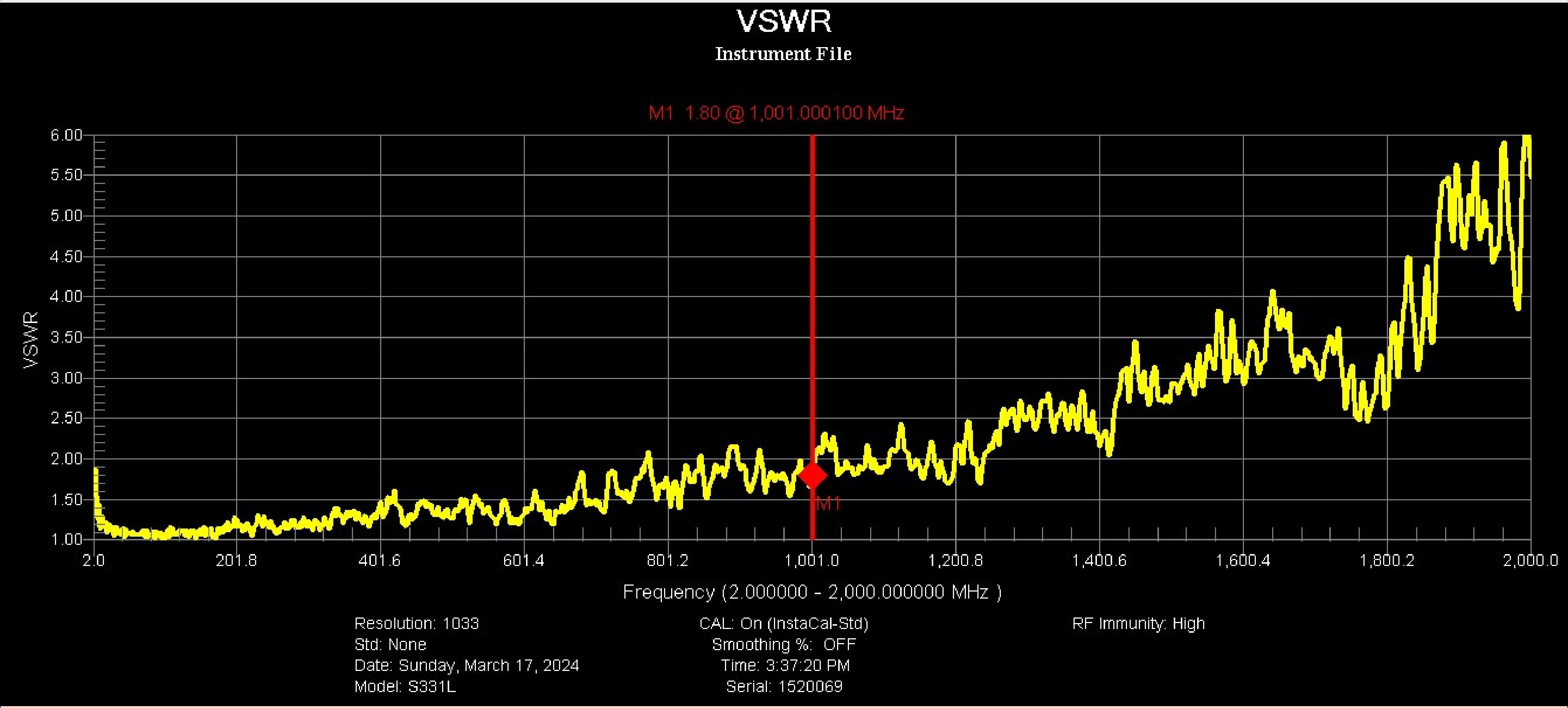
nanoVNA Cable B



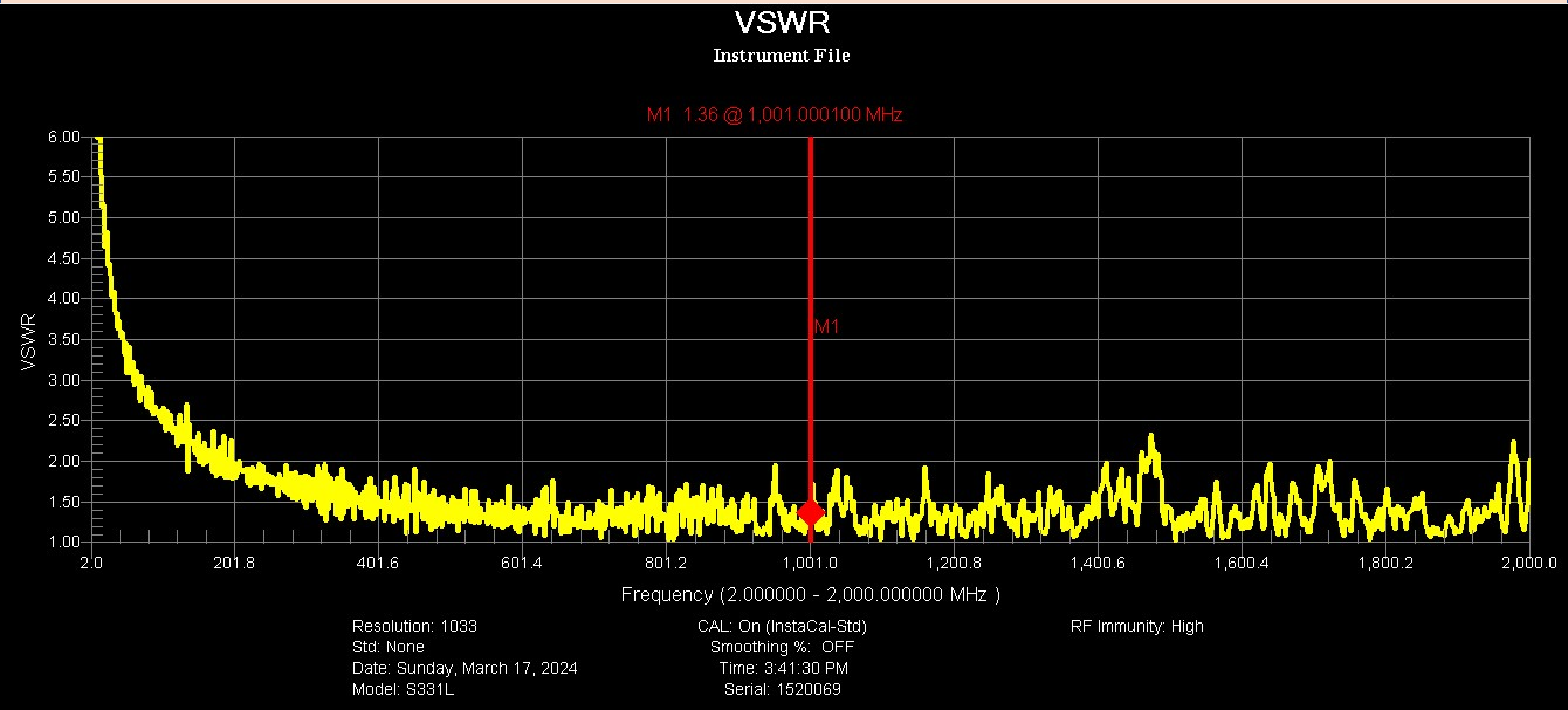
nanoVNA Cable A



nanoVNA Cable B



SiteMaster S331L **Cable A**



SiteMaster S331L **Cable B**

Benchmark Tests

nanoVNA_H

and

Anristu SiteMaster S331L

Anristu SiteMaster S331L

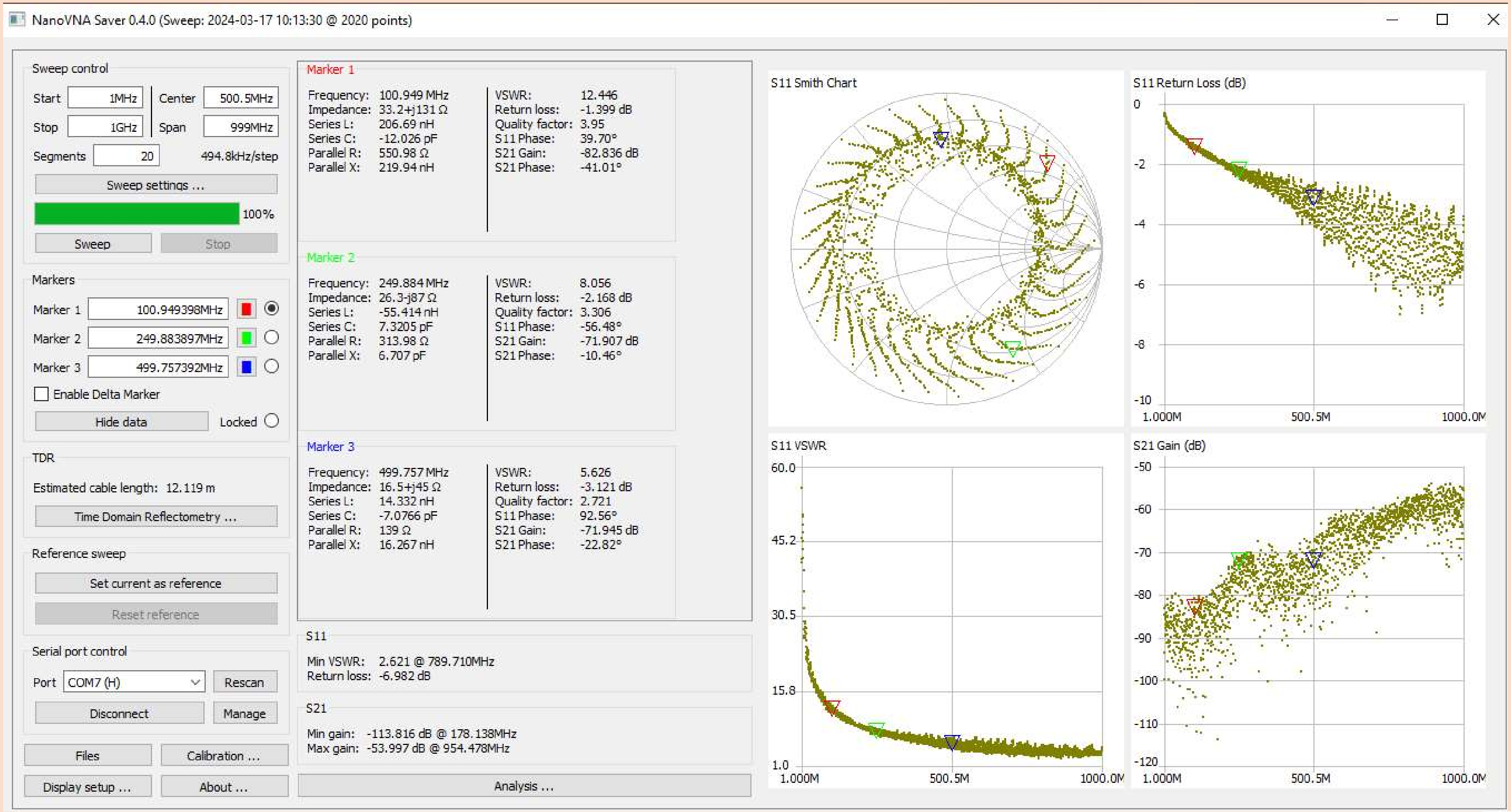
2 MHz – 4 GHz

$ 8500

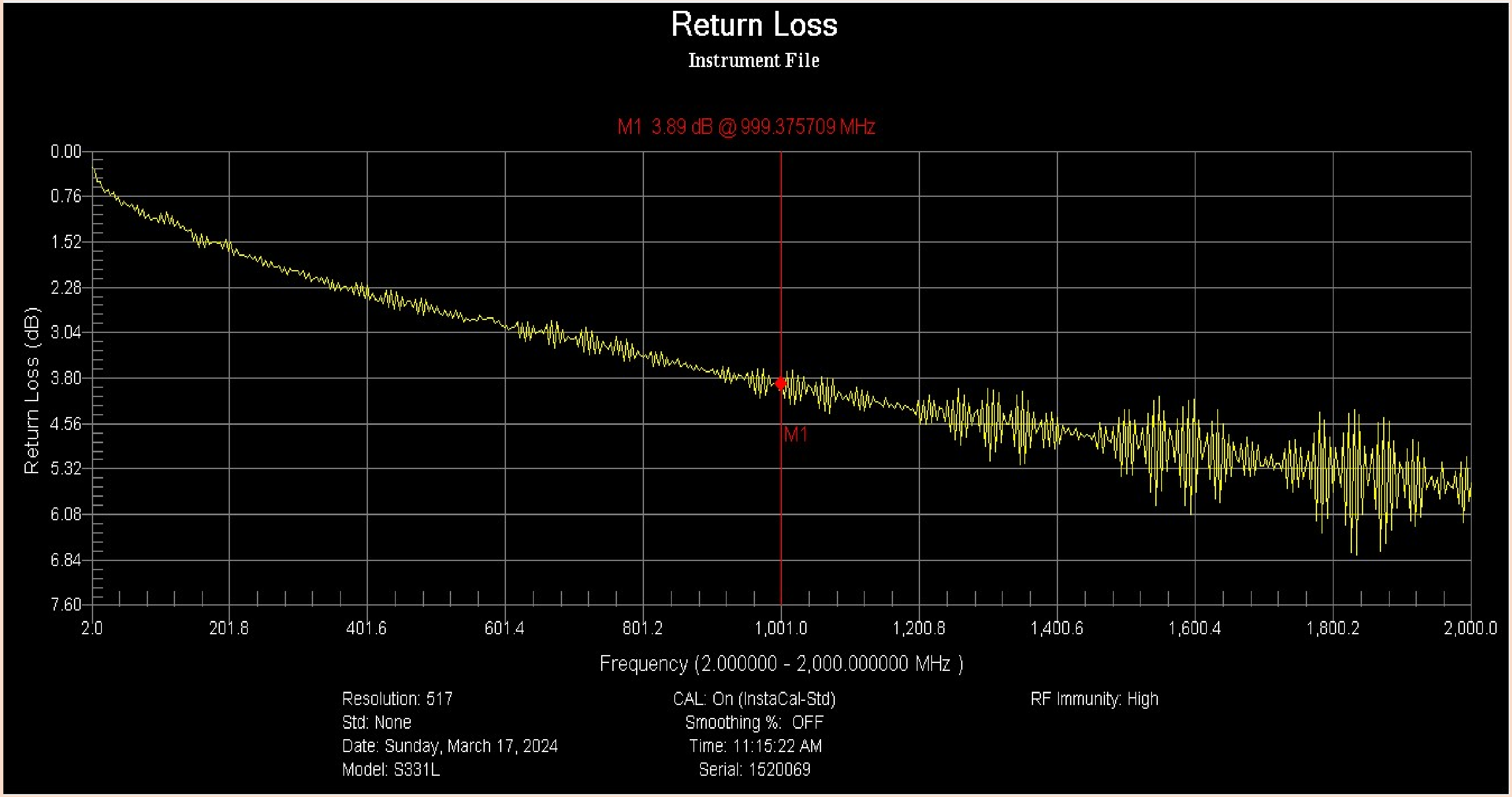
NanoVNA H

0.5 MHz - 1.5 GHz

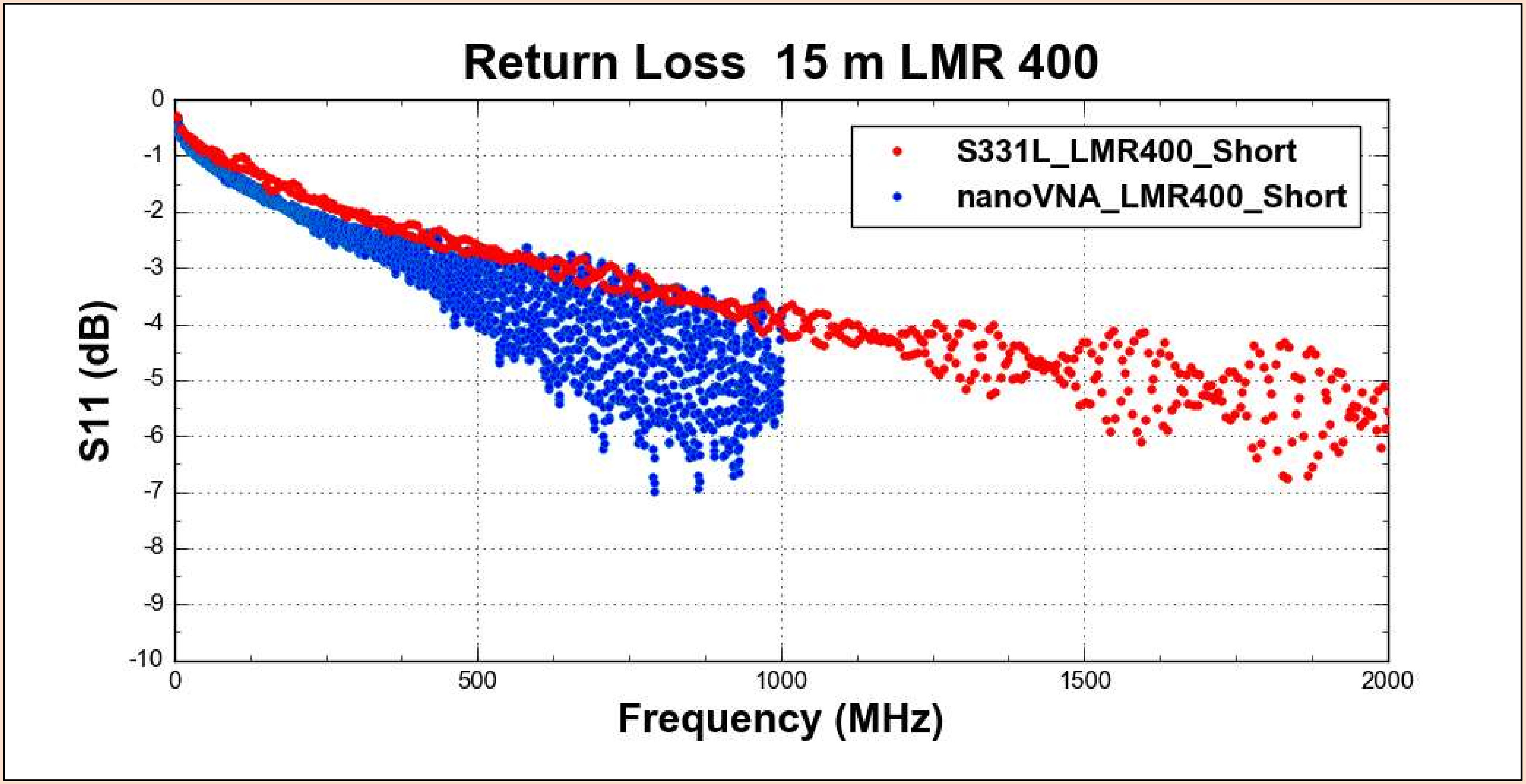
$ 75



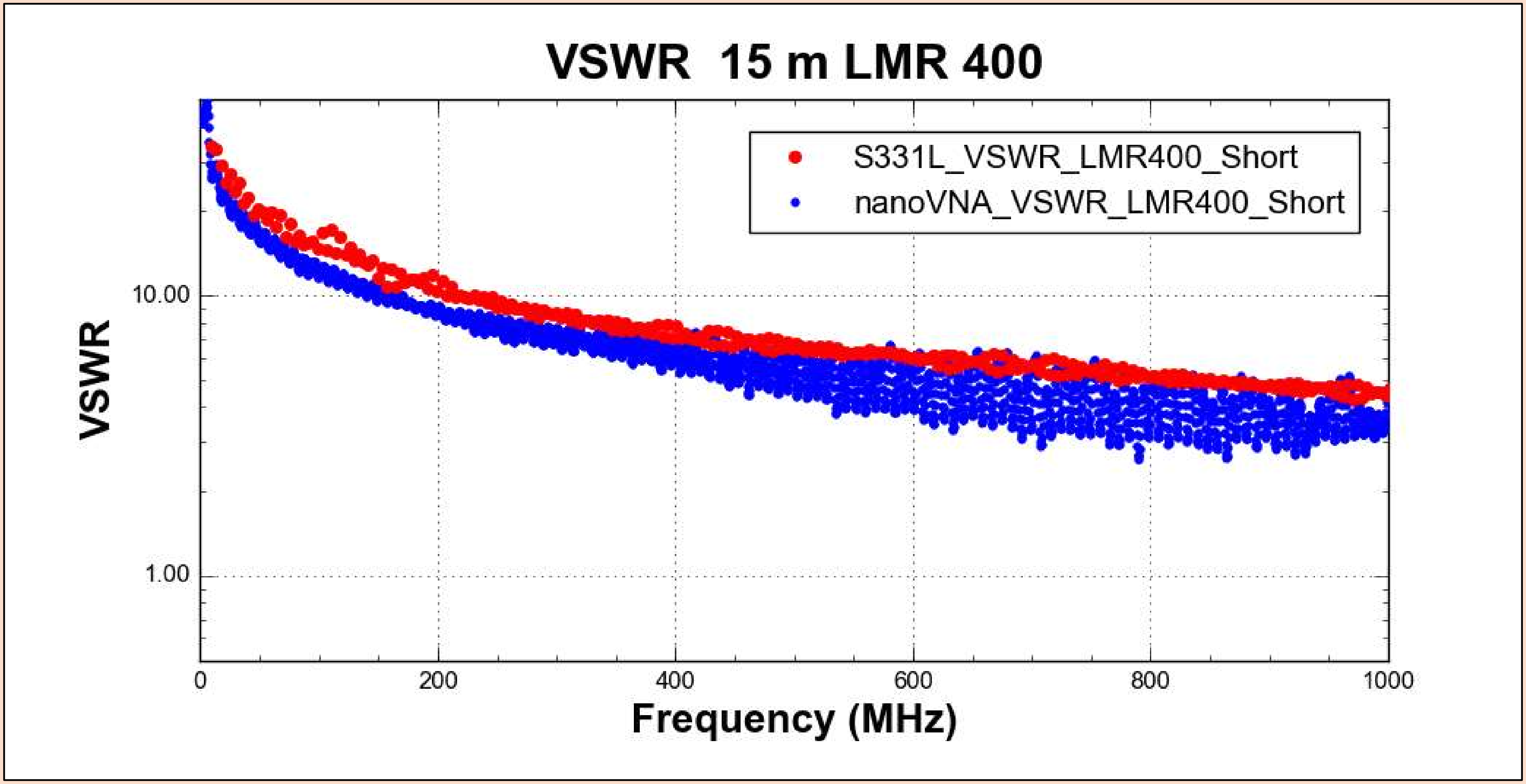
nanoVNA_H LMR 400 15 m (50 ft) Shorted



SiteMaster S331L LMR 400 15 m (50 ft) Shorted



S11 nanoVNA_H and SiteMaster S331L



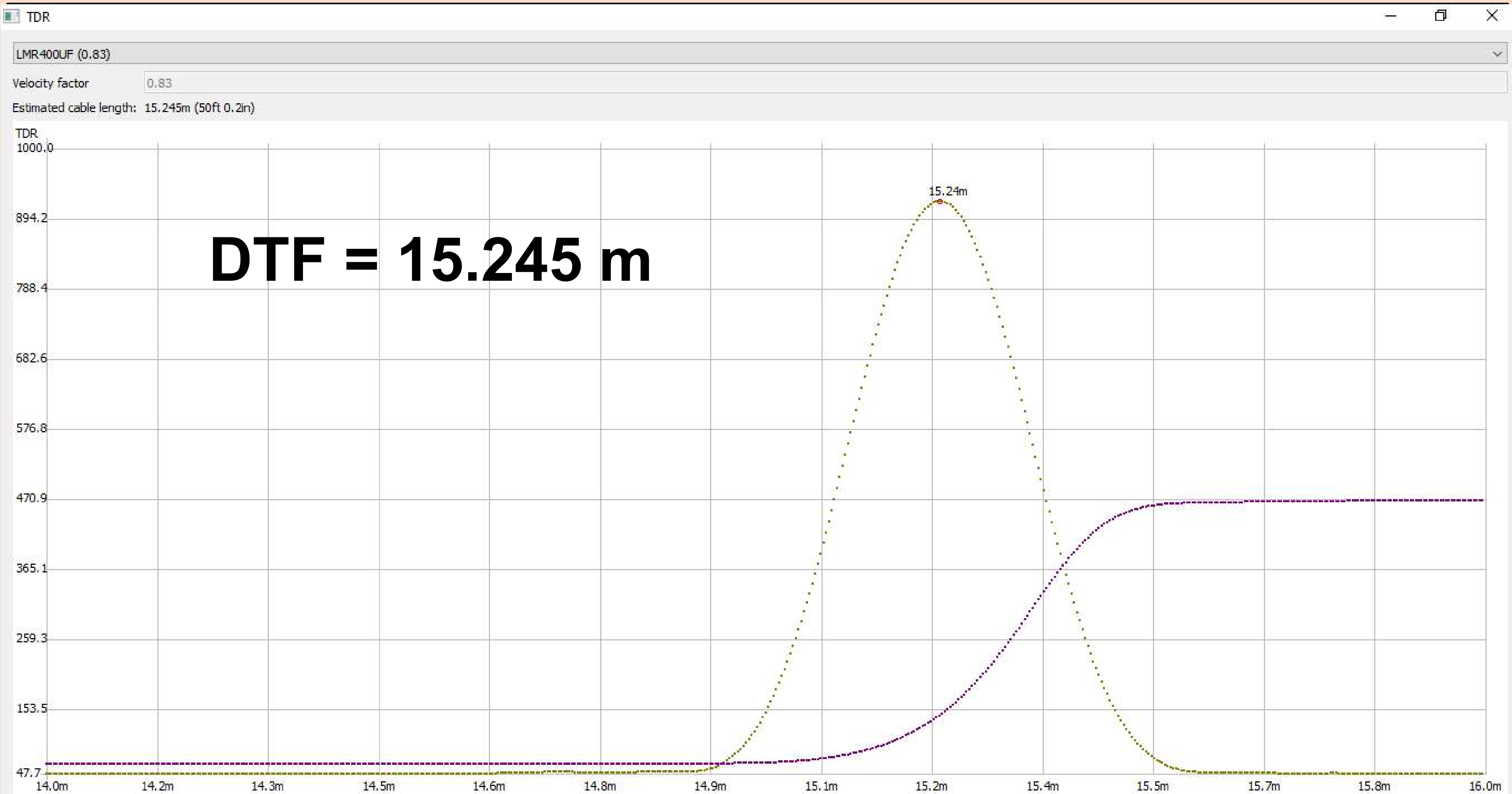
S11 / VSWR nanoVNA_H and SiteMaster S331L

Benchmark Tests

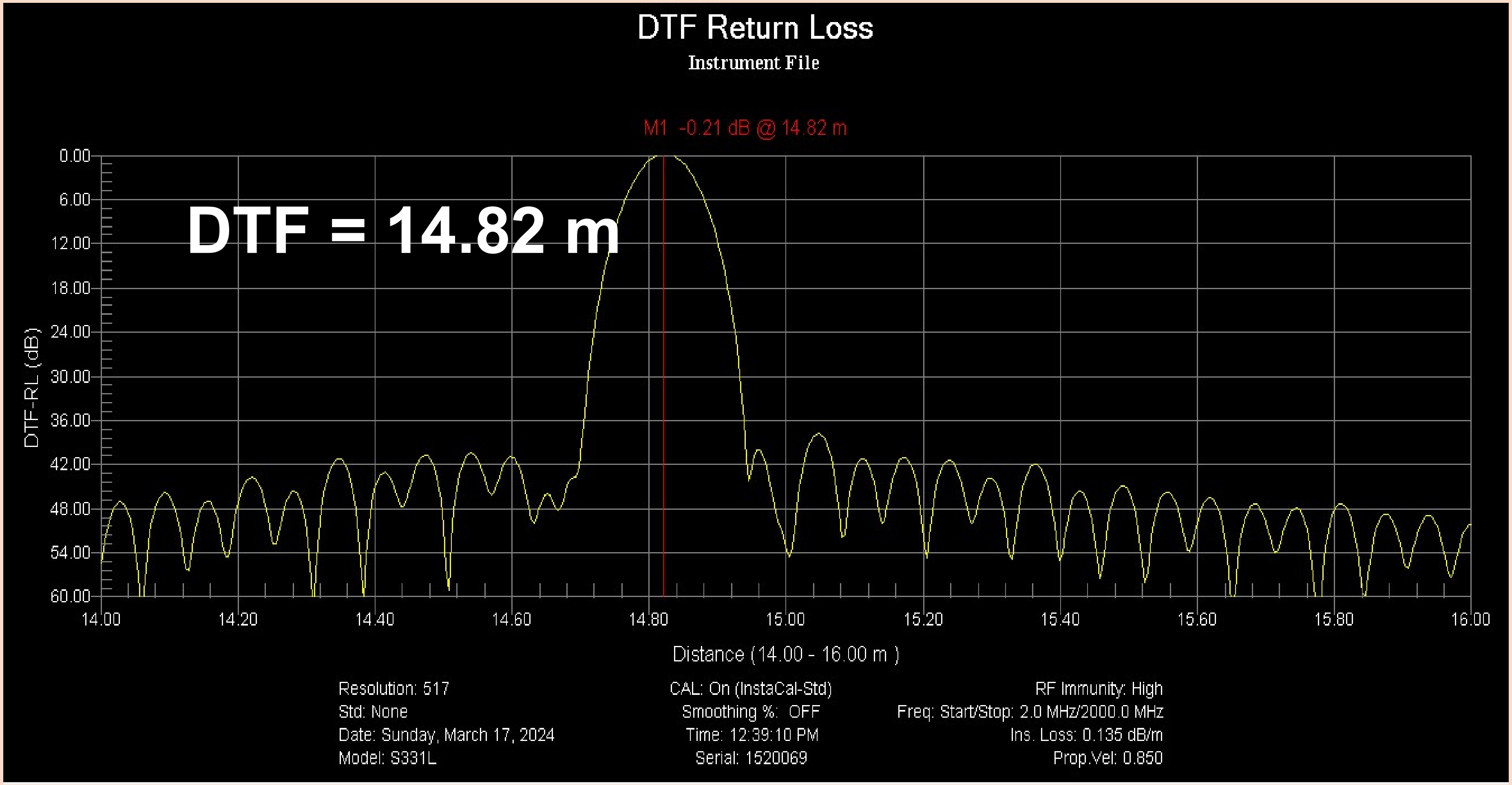
Distance to Fault

nanoVNA H

Anristu SiteMaster S331L



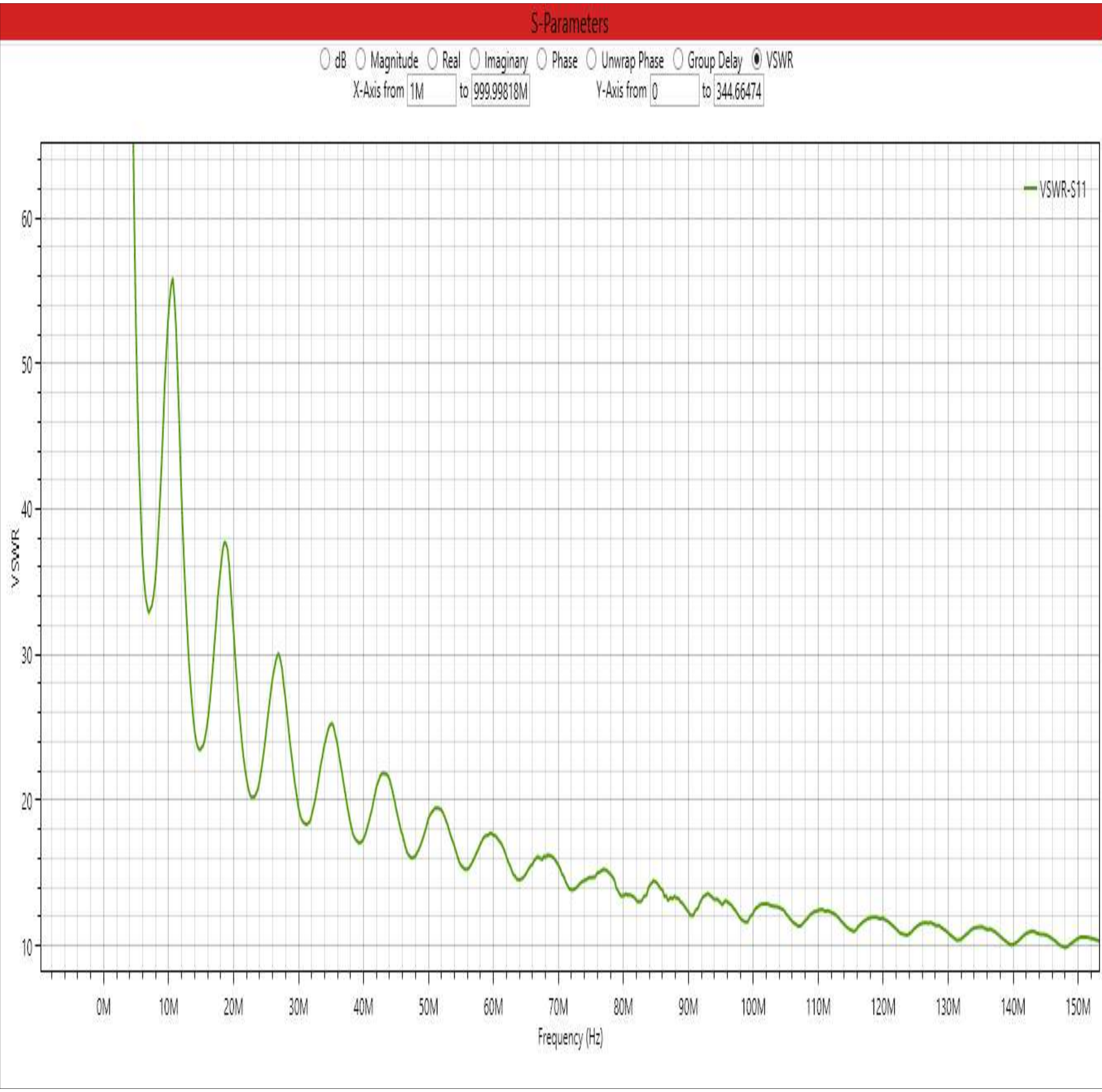
nanoVNA_H LMR 400 15 m (50 ft) Shorted

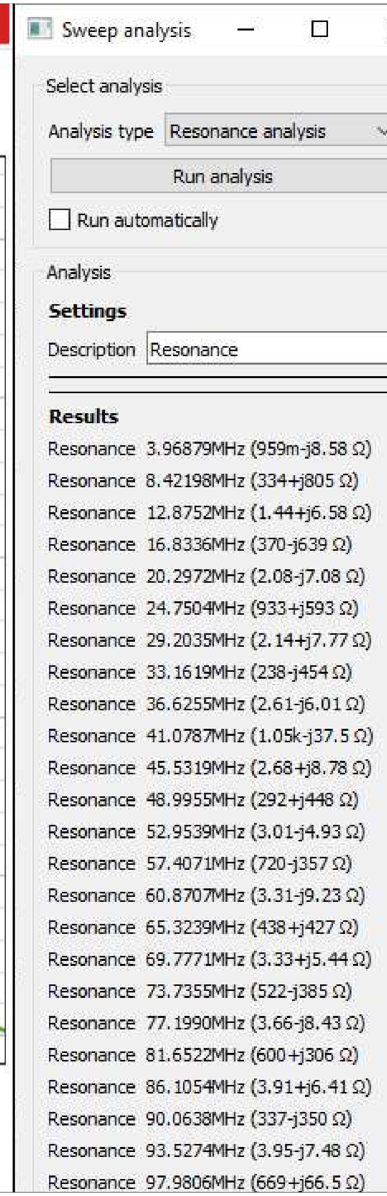


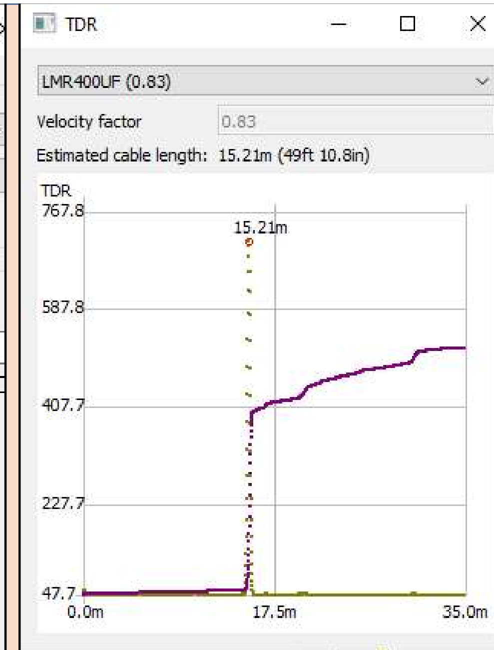
SiteMaster S331L LMR 400 15 m (50 ft) Shorted

Some VNAs are capable of **using inverse Fourier transforms** to convert swept frequency measurements into the time domain. In this way, data displayed in the time domain allows the VNA to be used to find problems in cables and connections by detecting the locations of impedance mismatches or discontinuities as the signal passes through the DUT.

For time domain measurements, the ability to resolve two signals is inversely proportional to the measured frequency span. Therefore, the wider the frequency span, the greater the ability the VNA has to distinguish between closely spaced discontinuities. The maximum frequency span is set by the user and may be defined by either the frequency range of the VNA or the viable bandwidth of the DUT.



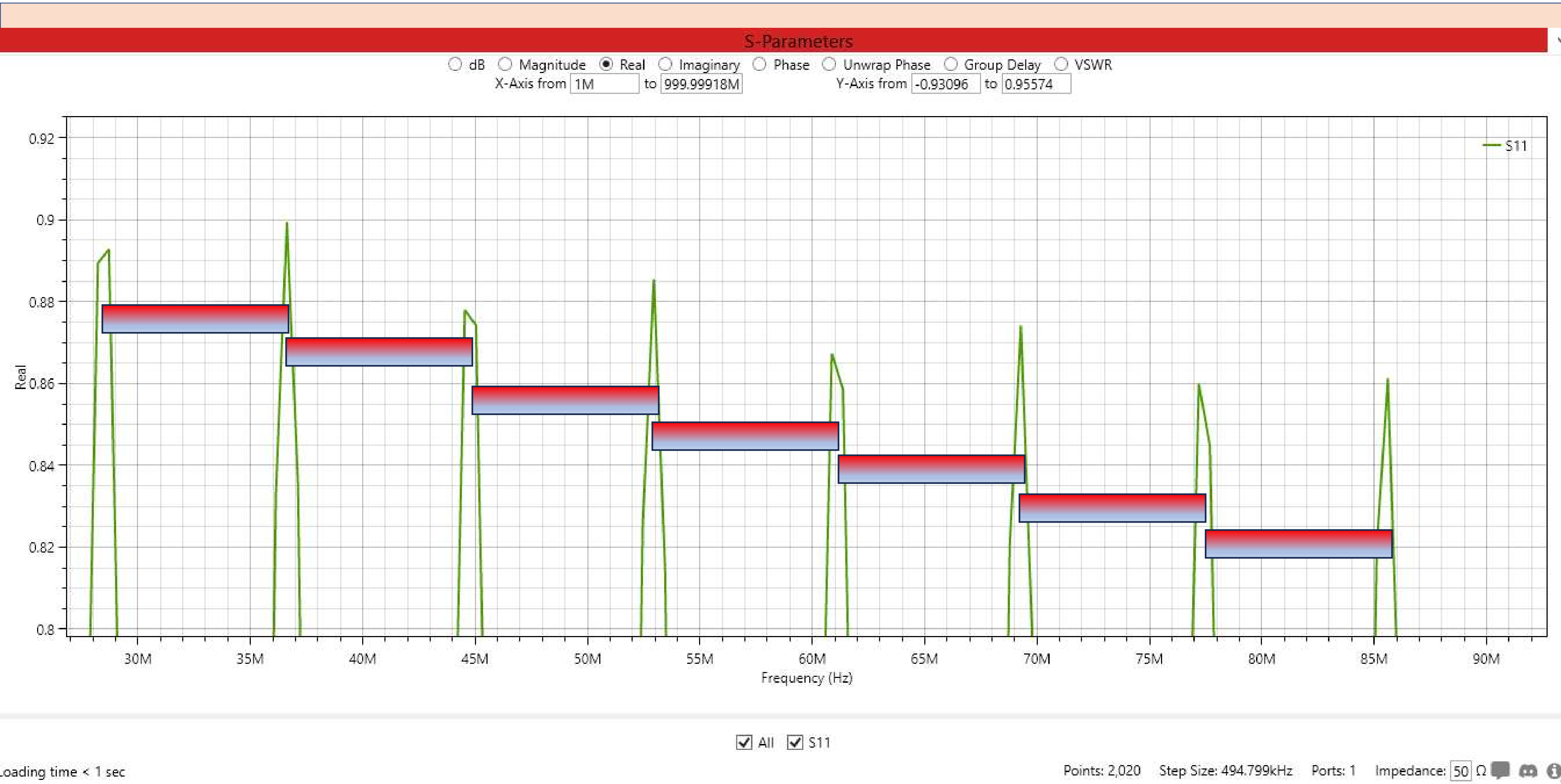




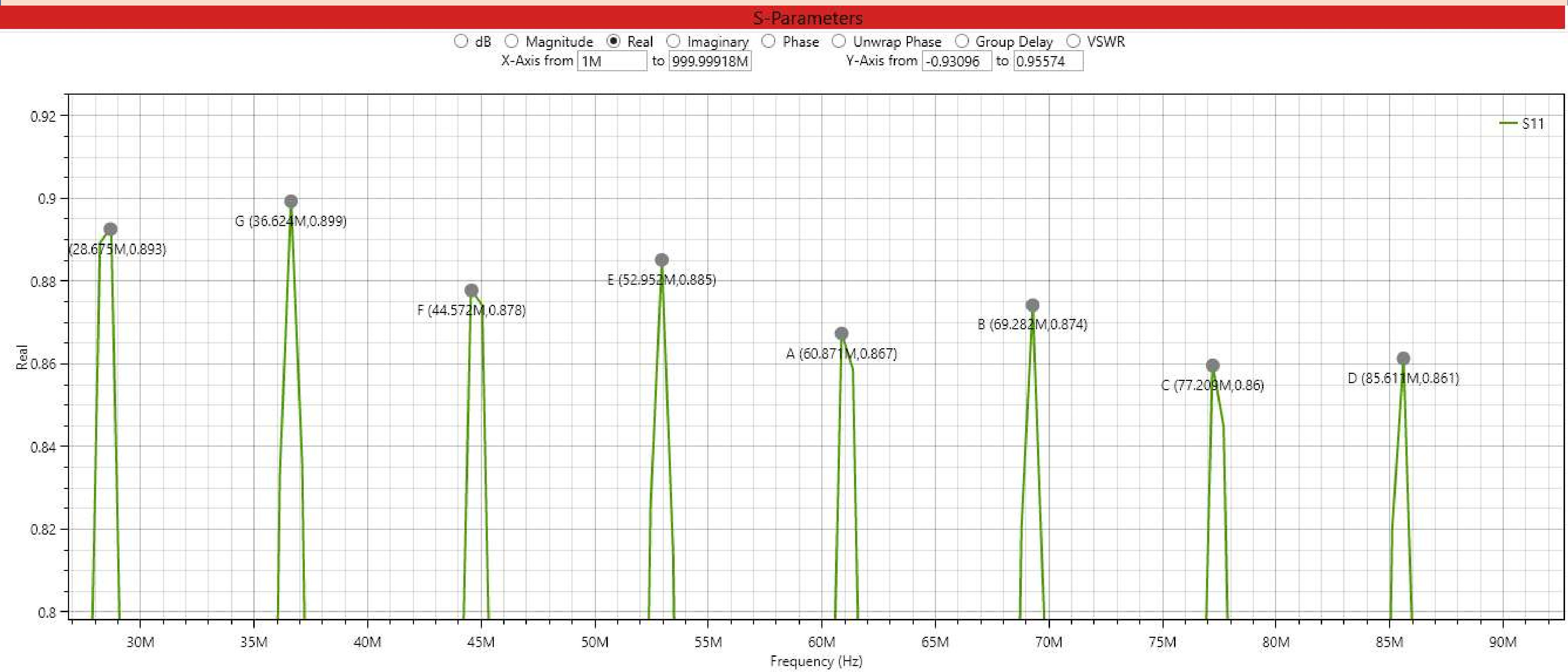
LMR 400 50 feet

Open Load

1 – 1000 MHz



LMR 400 50 feet Short Load 1 – 1000 MHz (detail presentation)



LMR 400 50 feet Short Load 1 – 1000 MHz (detail presentation)

LMR 400 50 feet Short Load nanoVNA Data

- Peaks are 8.2 MHz Spacing
- LMR 400 Velocity Factor = 0.83

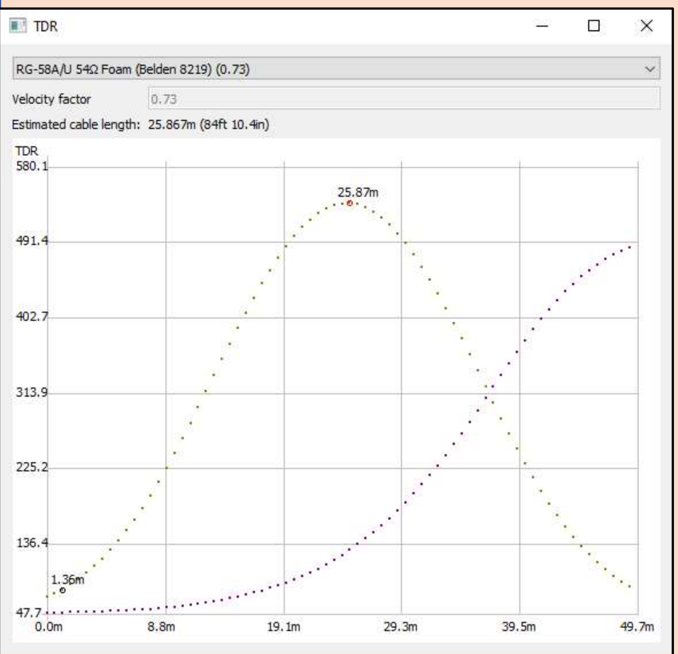
Since : **λ = c/f**

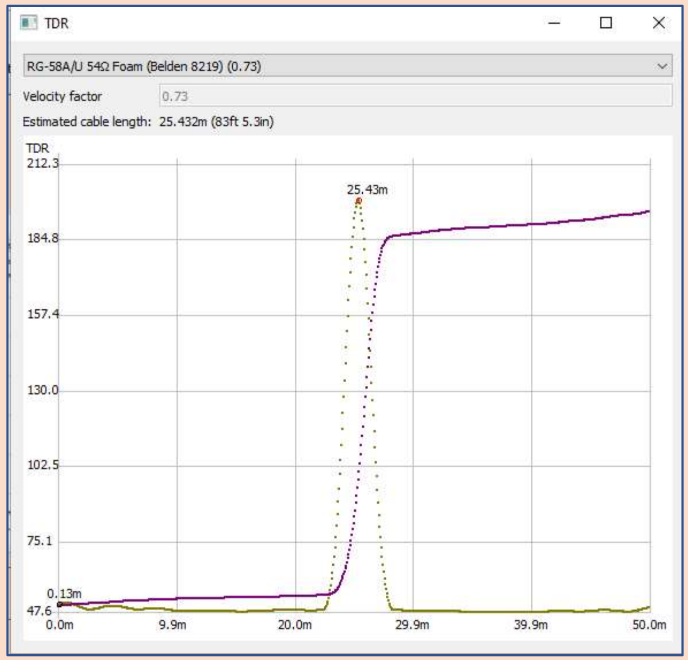
Then λ = 0.83 * 3e8 / 8.2e6

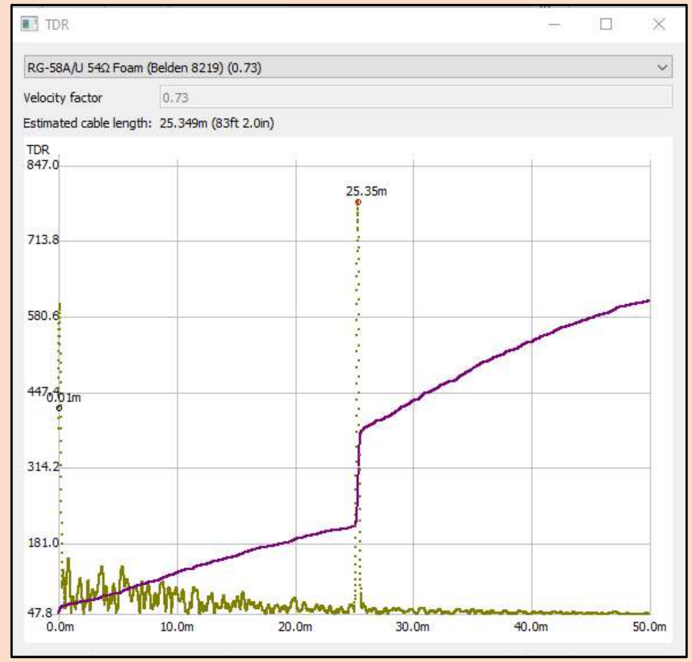
λ = 30.365 m (2 way length /time)

Thus Cable Length = 15.18 m (49.8 feet)

Fourier Transform and Spatial Resolution







0.1 – 10 MHz **0.1 – 100 MHz** **0.1 – 1000 MHz**

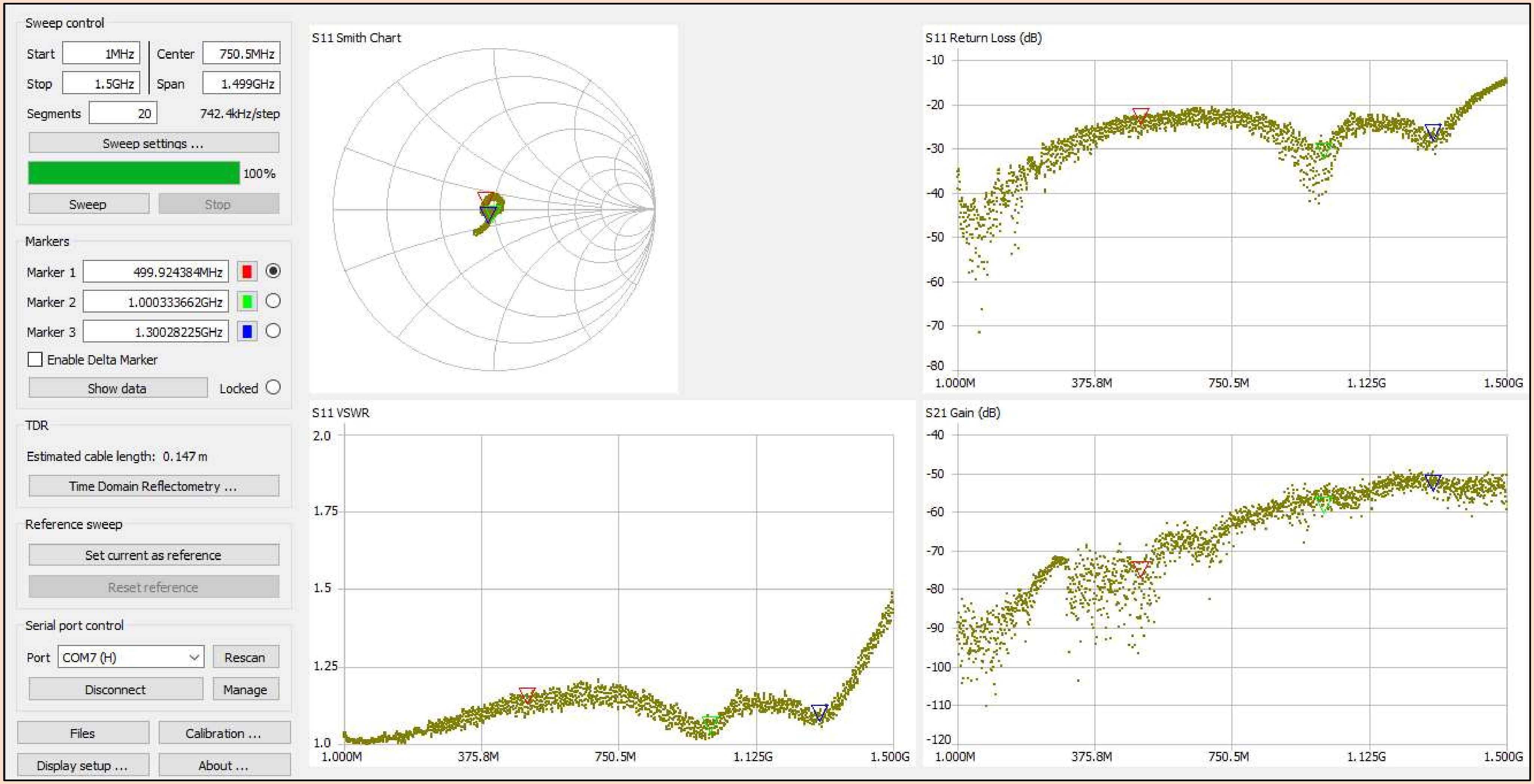
nanoVNA data

Benchmark Tests

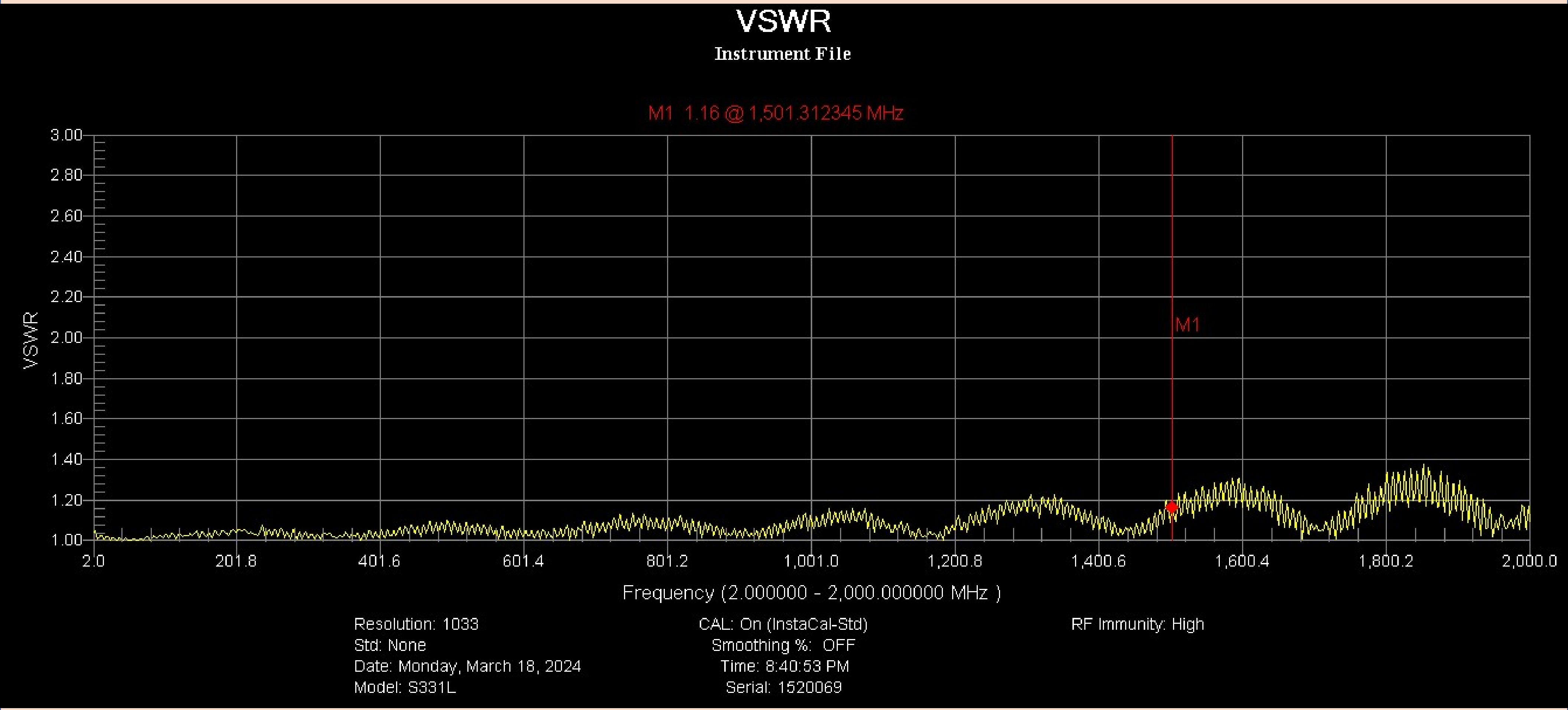
Response > 1 GHz

nanoVNA H

Anristu SiteMaster S331L



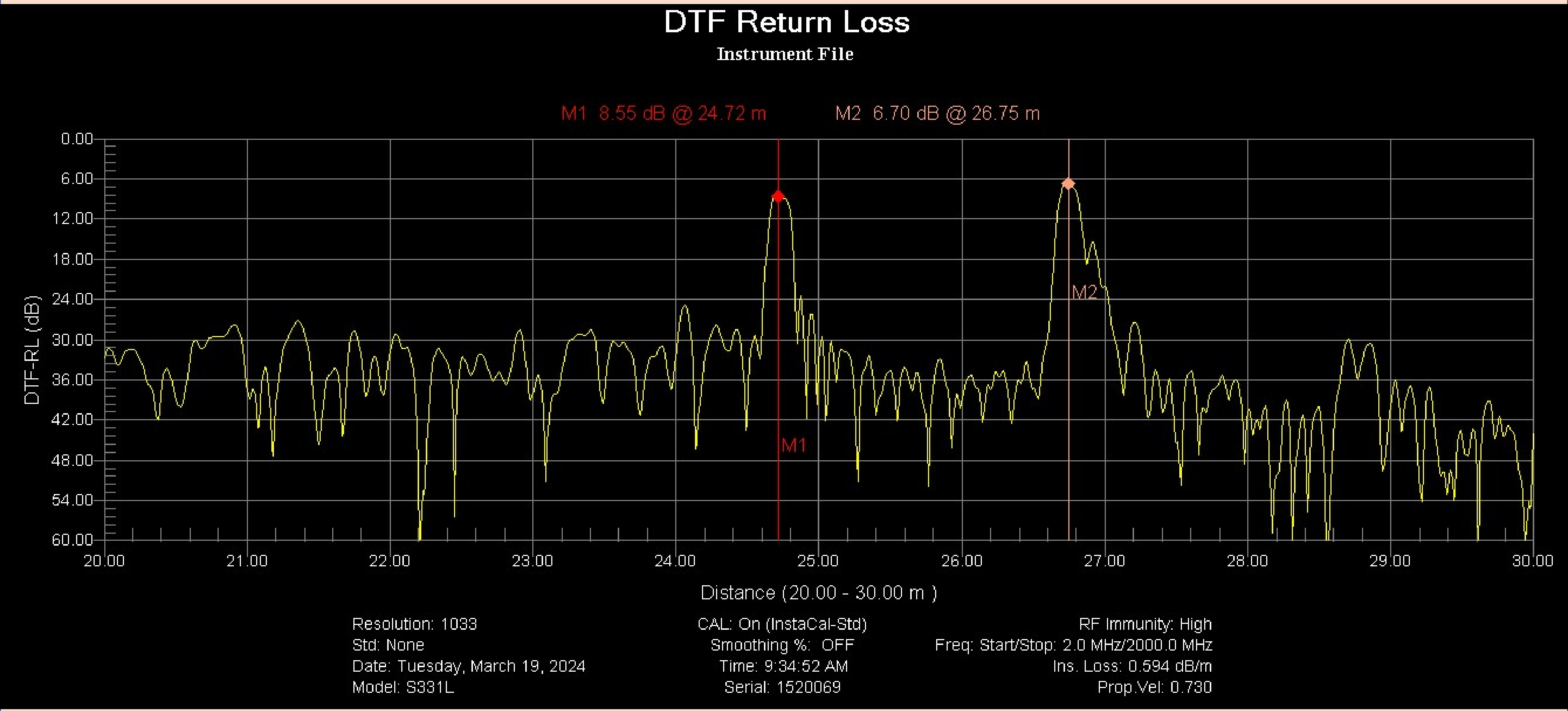
nanoVNA 1 – 1500 MHz 50 feet LMR 400 plus 50 ohm termination load



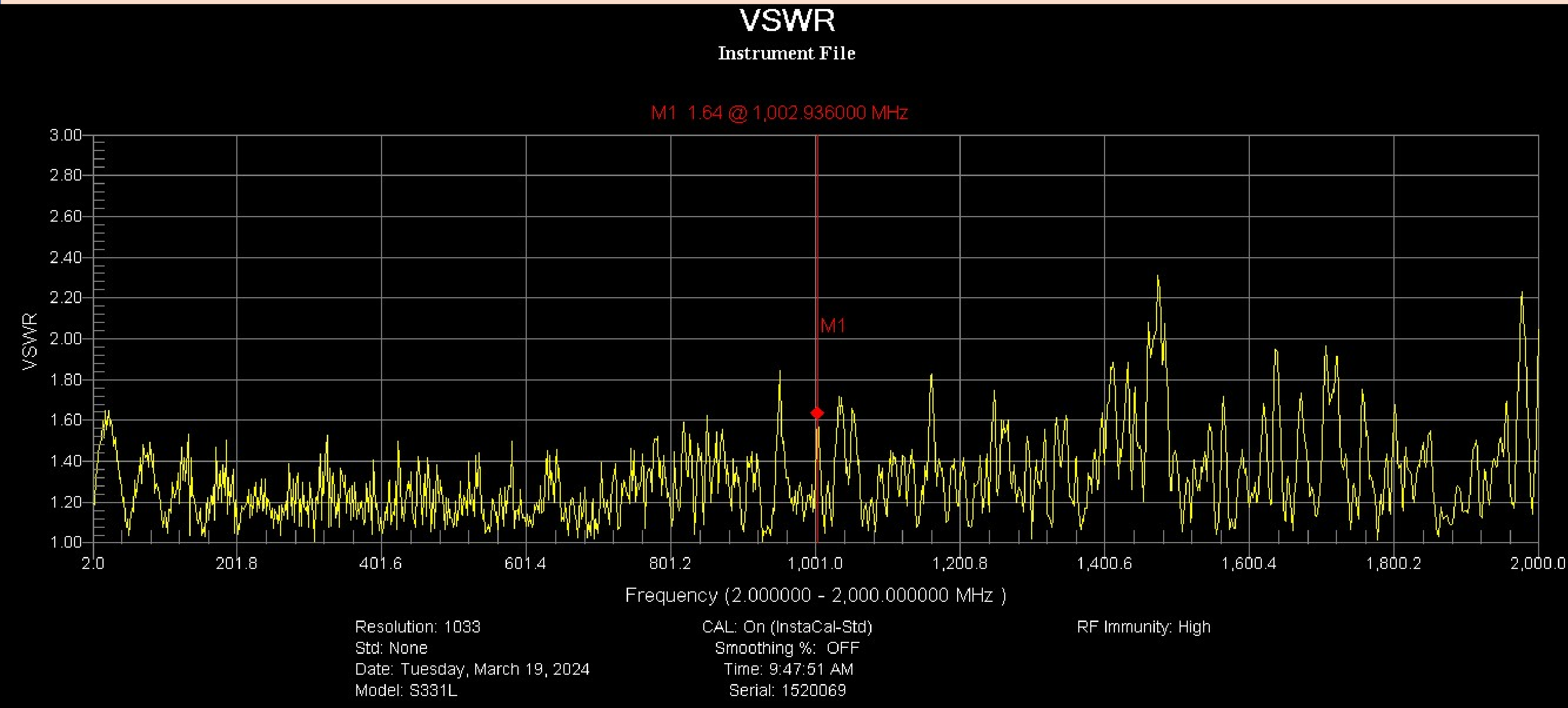
SiteMaster S331L 1 – 1500 MHz 50 feet LMR 400 plus 50 ohm termination

Transmission Line Network

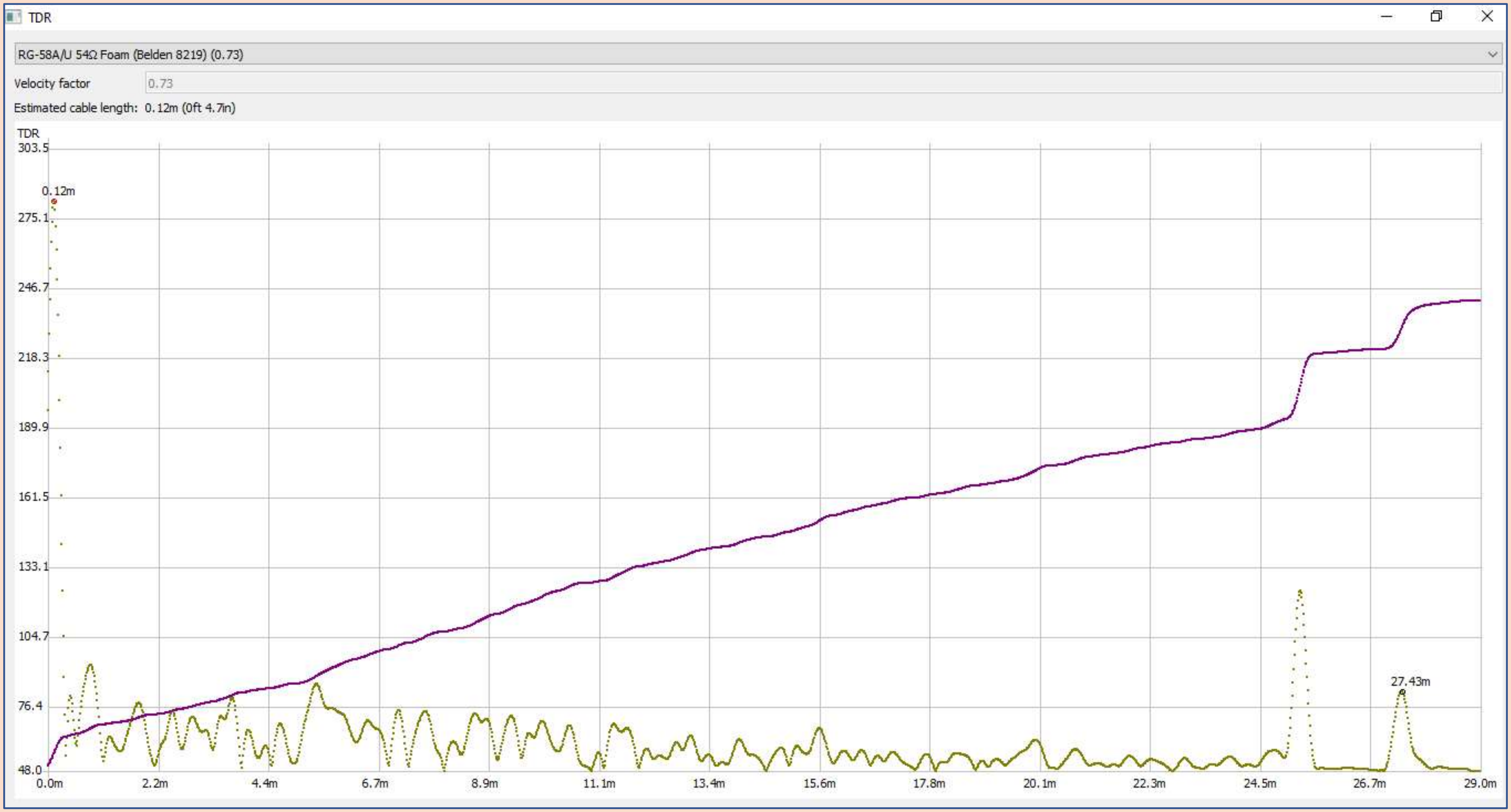
• RG 58a/u	Z= 50 ohm	75 feet
• RG 59u	Z = 75 ohm	6 feet
• Load	Z = 50 ohm	



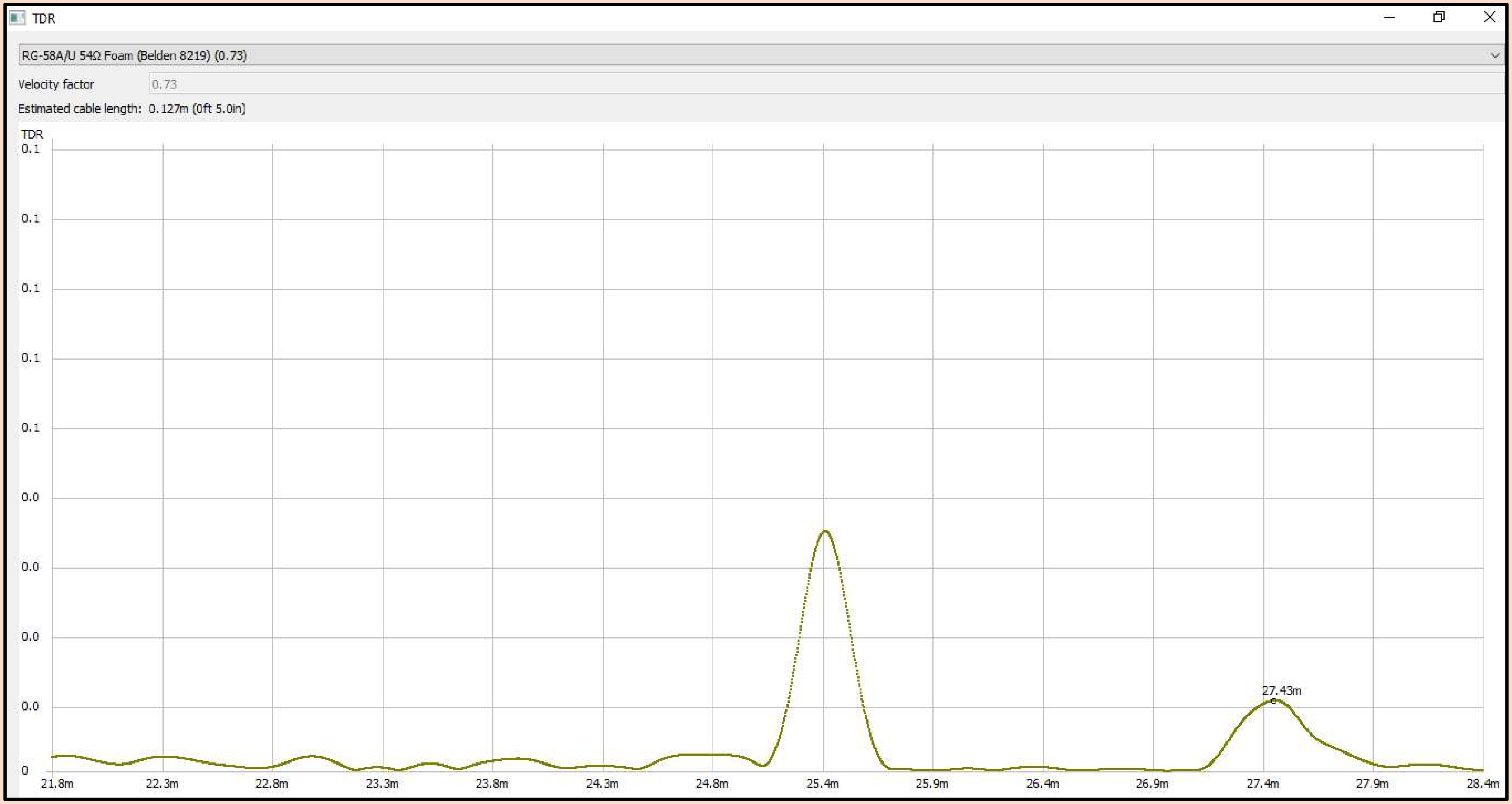
SiteMaster S331L DTF Transmission Line Network



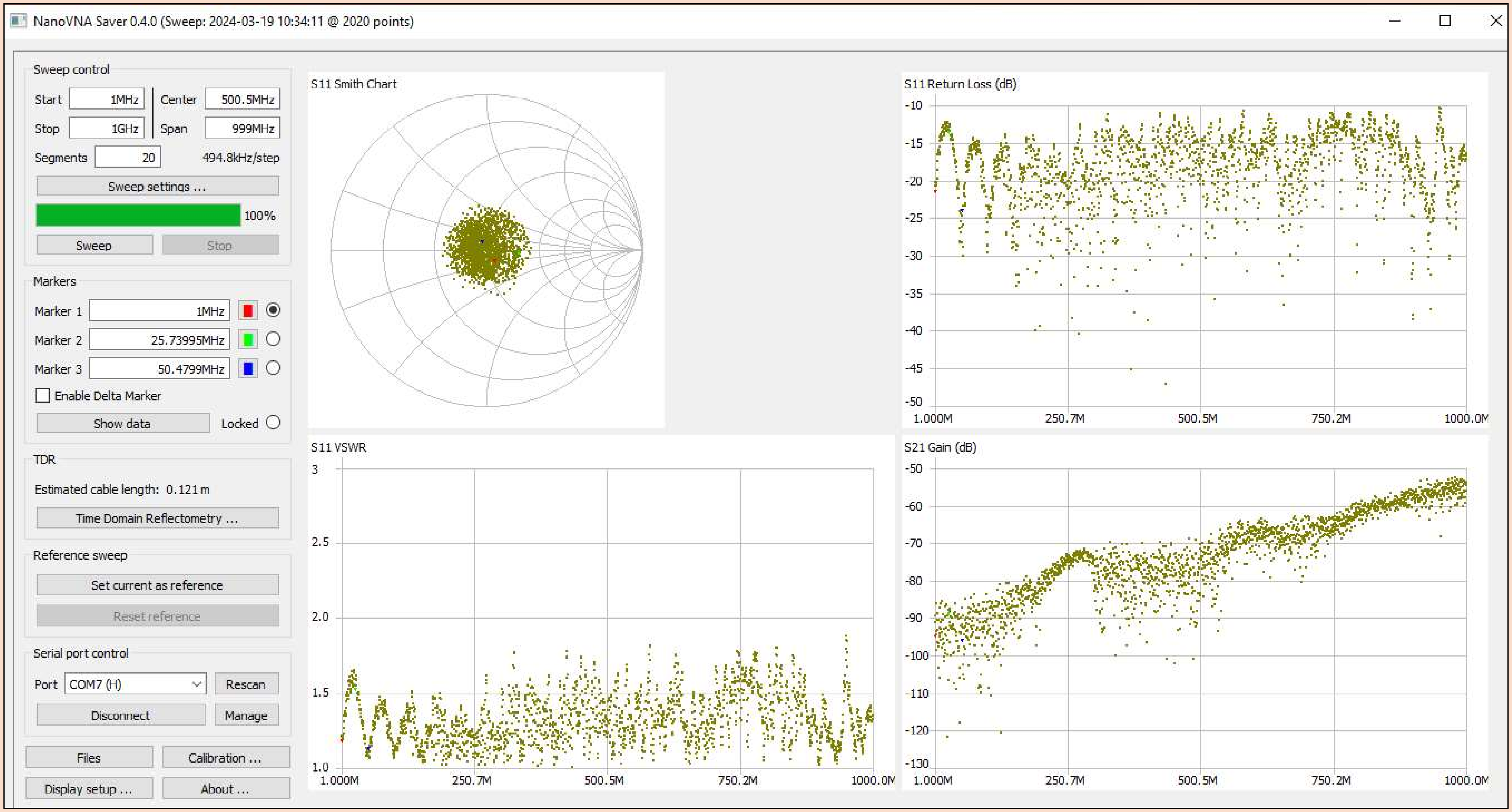
SiteMaster S331L VSWR Transmission Line Network



nanoVNA DTF Transmission Line Network



nanoVNA DTF Transmission Line Network

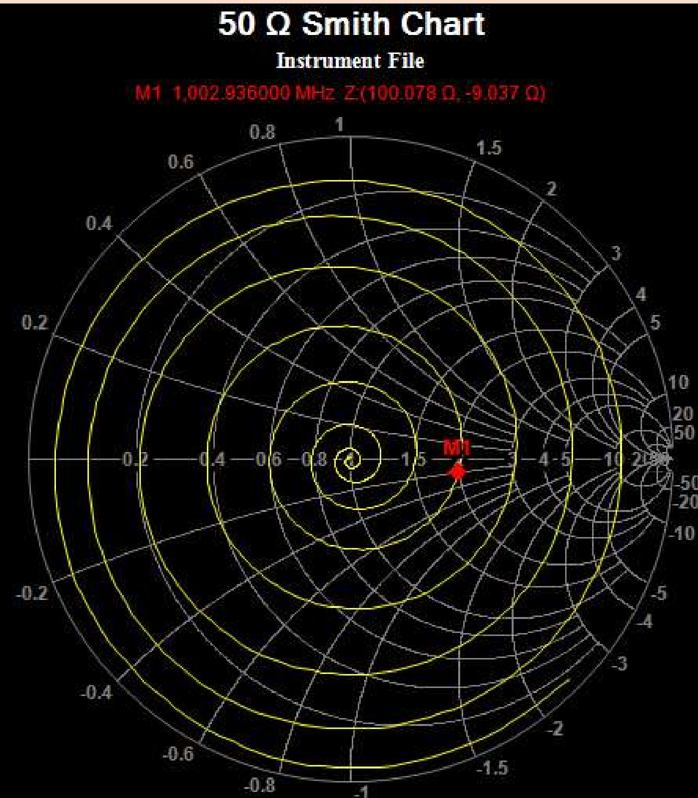


nanoVNA VSWR Transmission Line Network

Benchmark Tests

Dummy Loads

Anristu SiteMaster S331L

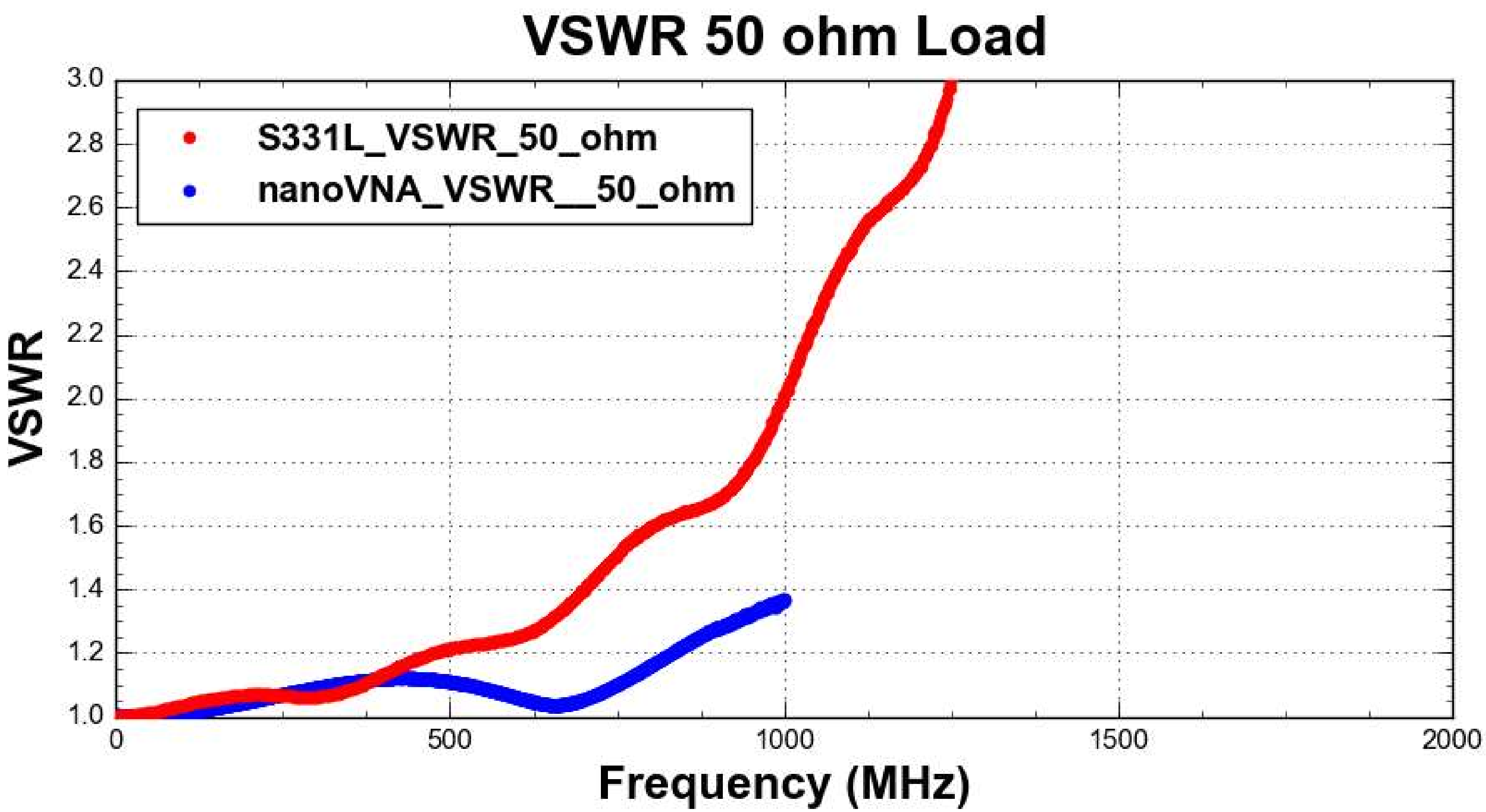


Resolution: 1033
Std: None
Date: Tuesday, March 19, 2024
Model: S331L

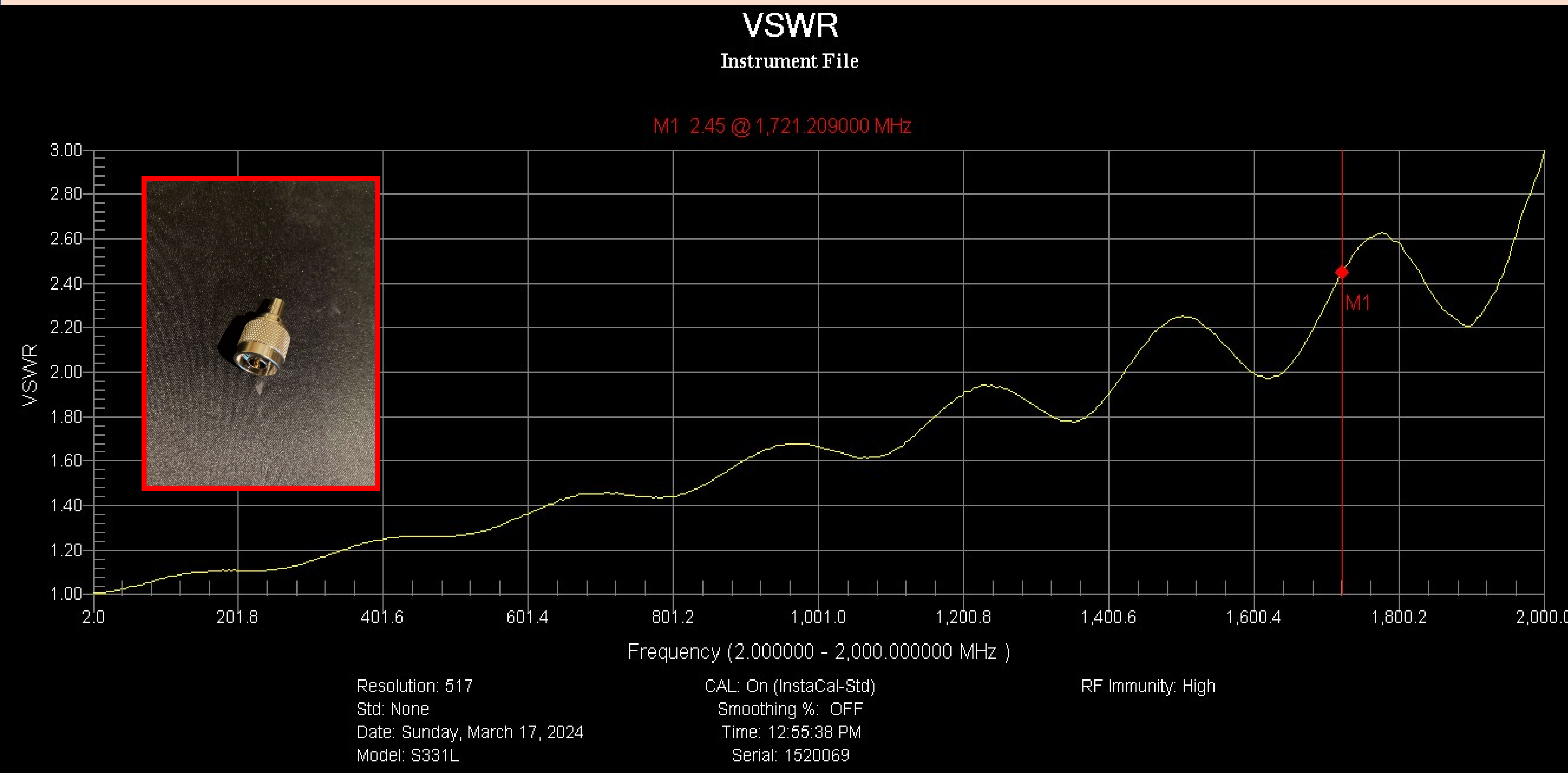
CAL: On (InstaCal-Std)
Time: 11:42:44 AM
Serial: 1520069

RF Immunity: High
Reference Impedance: 50Ω

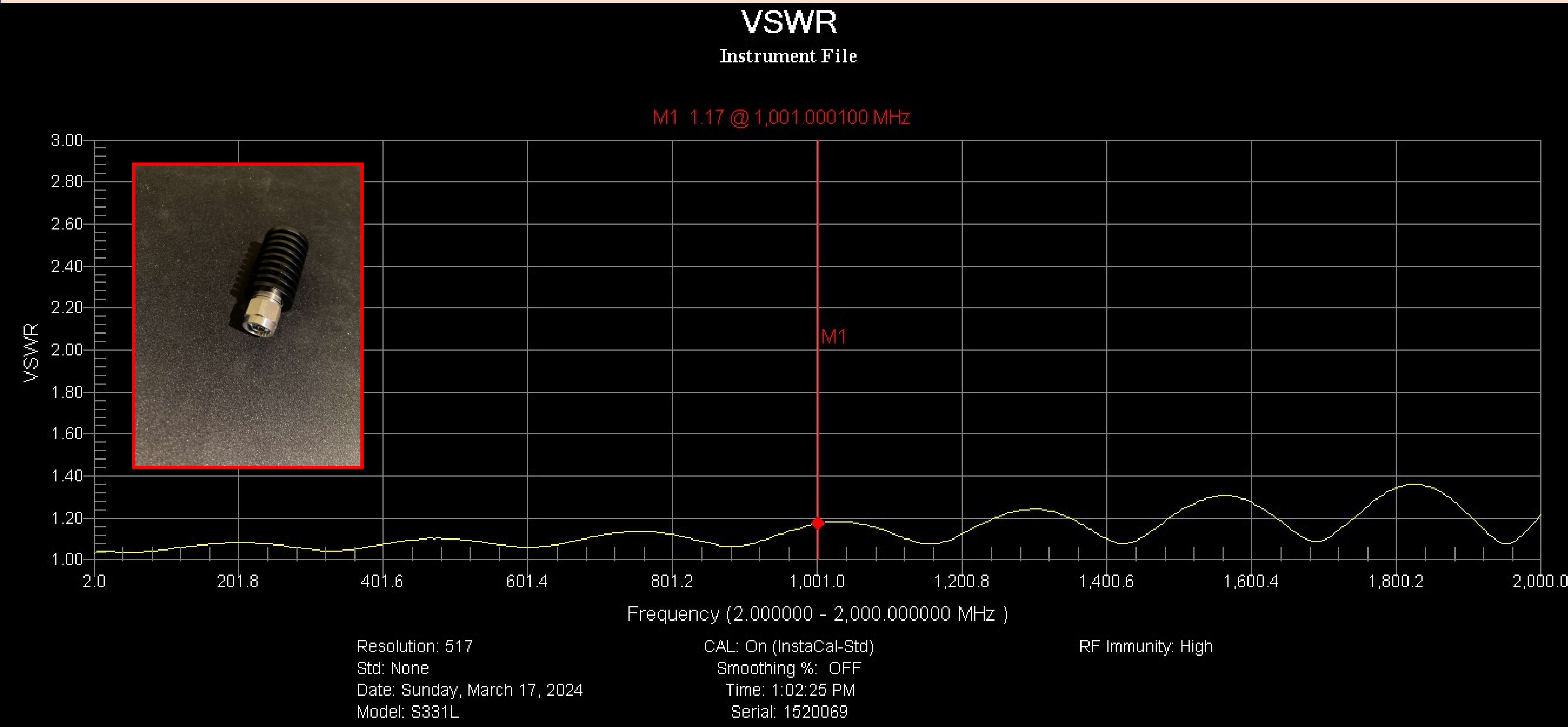
SiteMaster S331L Smith Chart 50 ohm Load



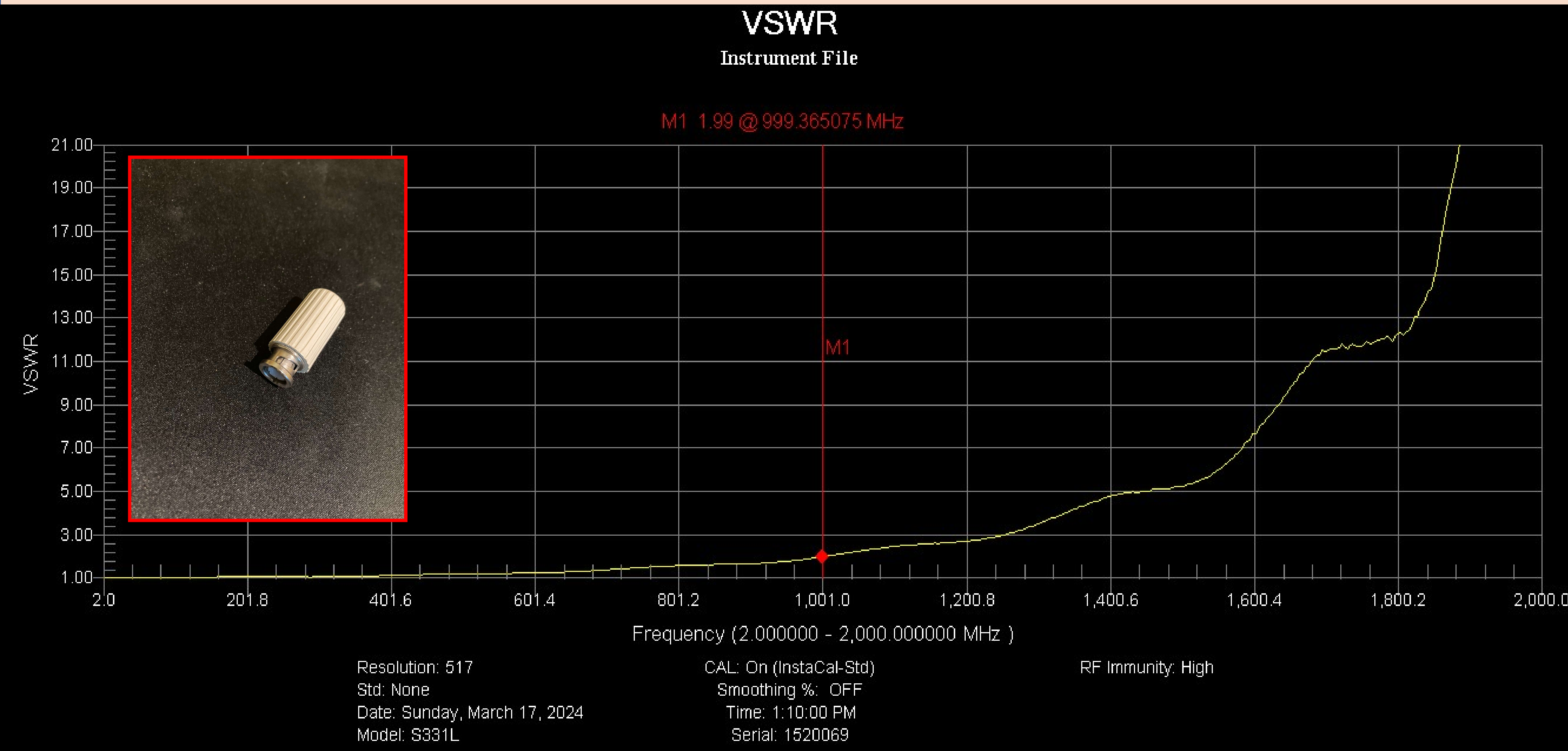
SiteMaster S331L and nanoVNA SWR 50 ohm Load



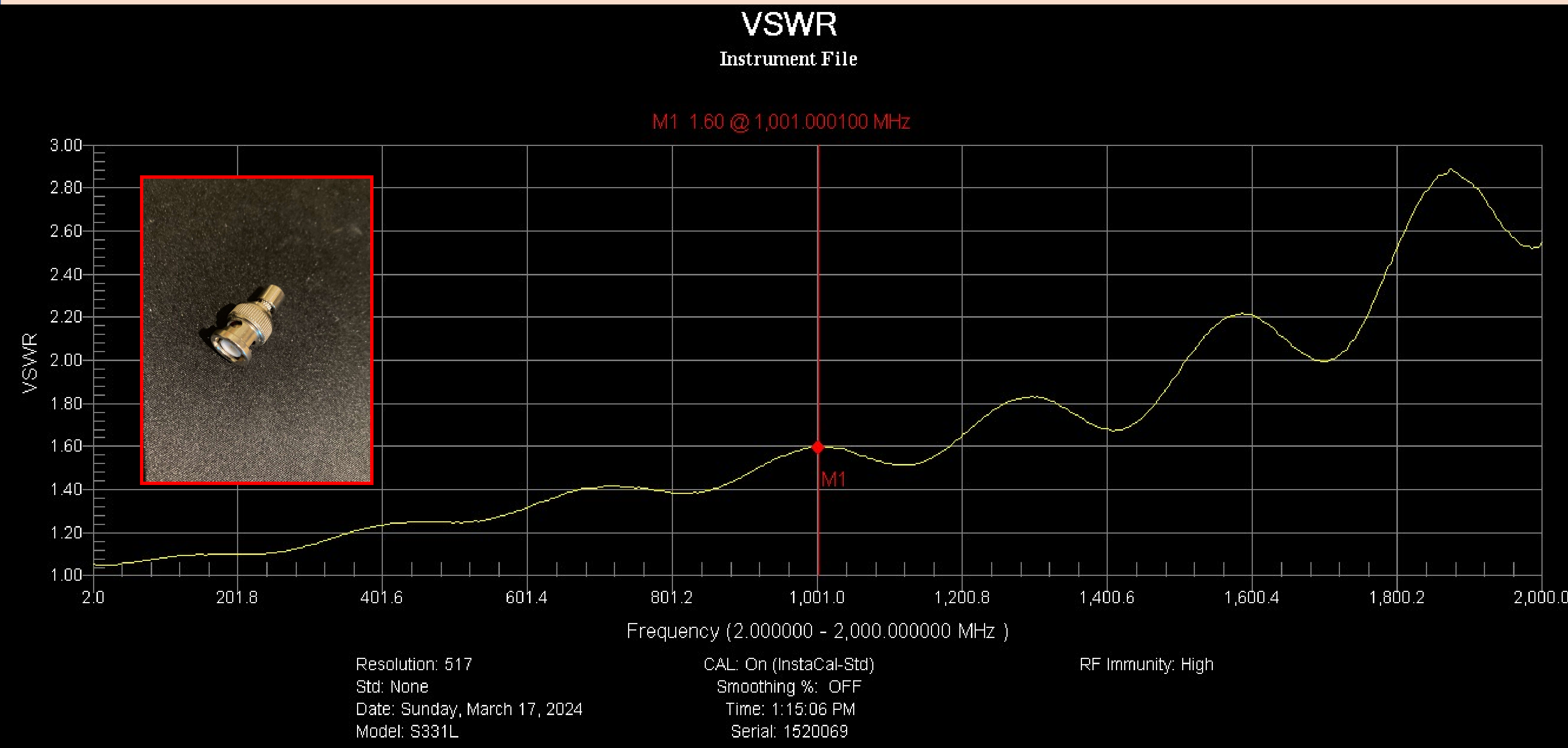
SiteMaster S331L Dummy Load 1



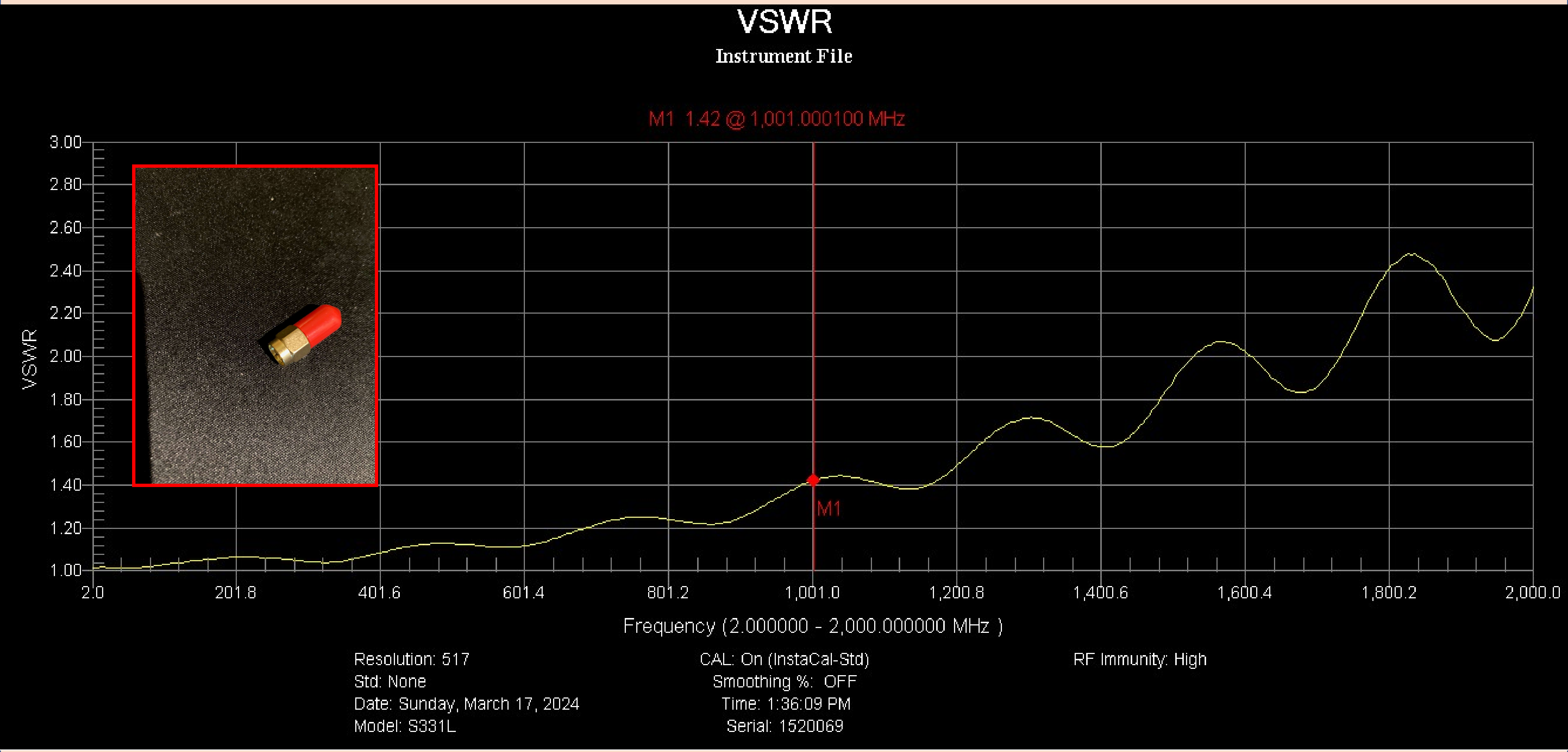
SiteMaster S331L Dummy Load 2



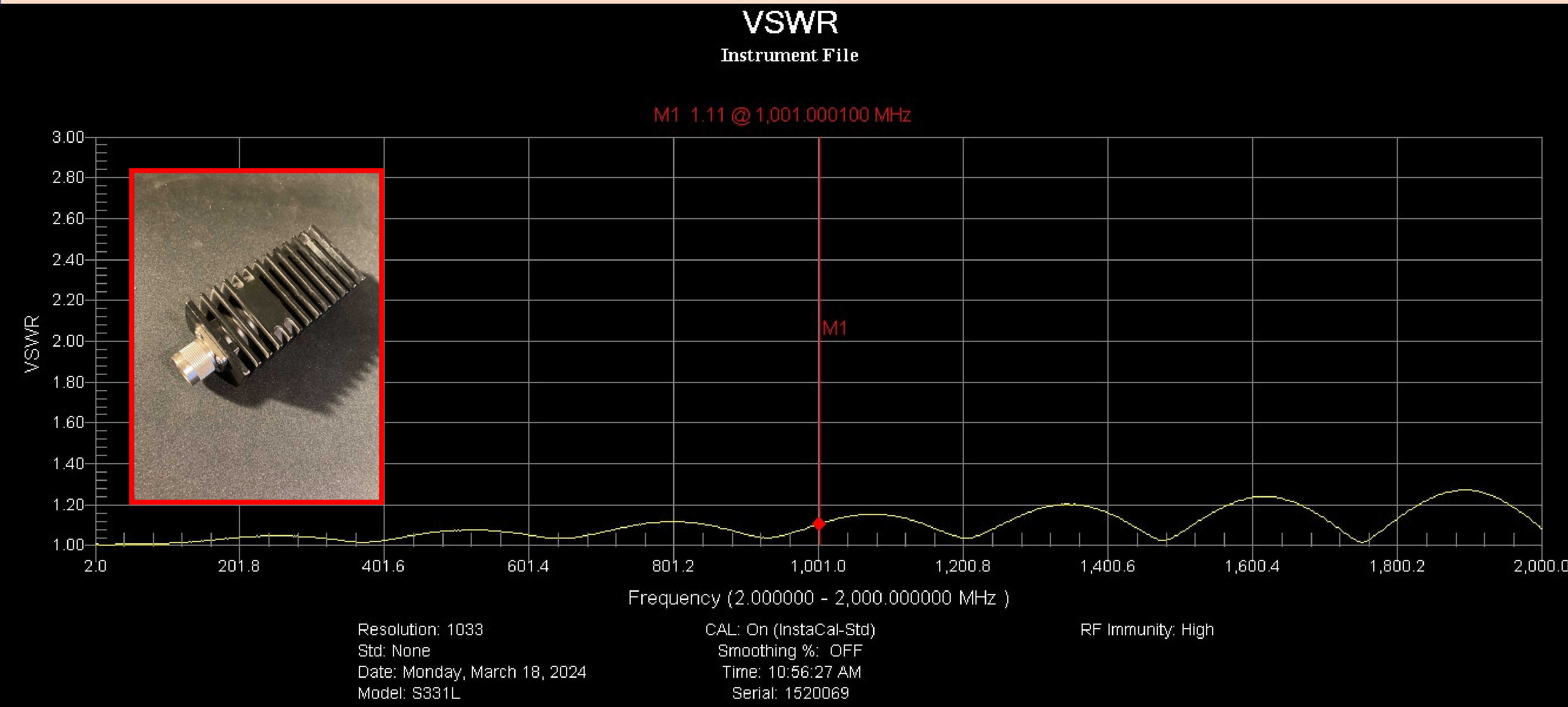
SiteMaster S331L Dummy Load 3



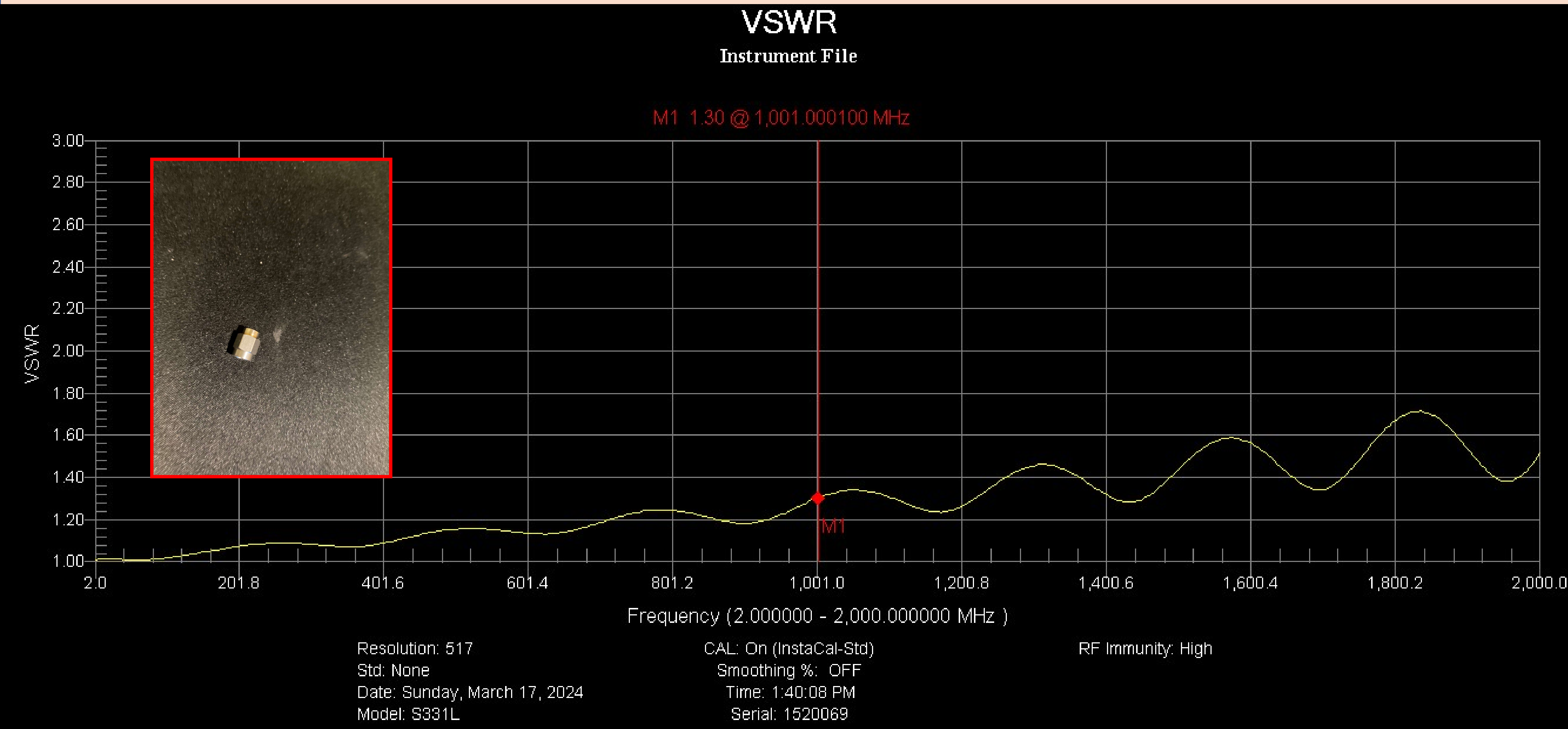
SiteMaster S331L Dummy Load 4



SiteMaster S331L Dummy Load 5



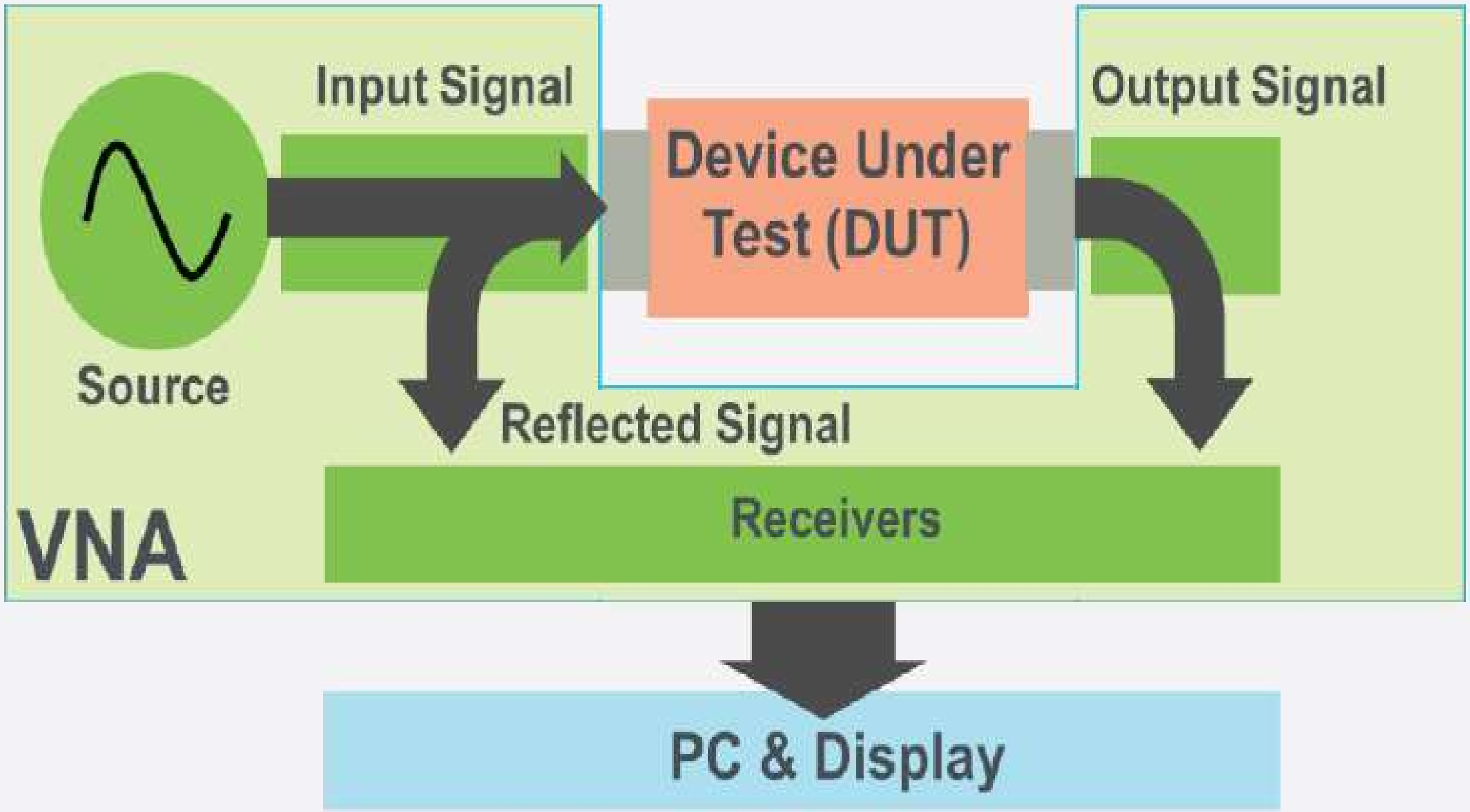
SiteMaster S331L Dummy Load 6

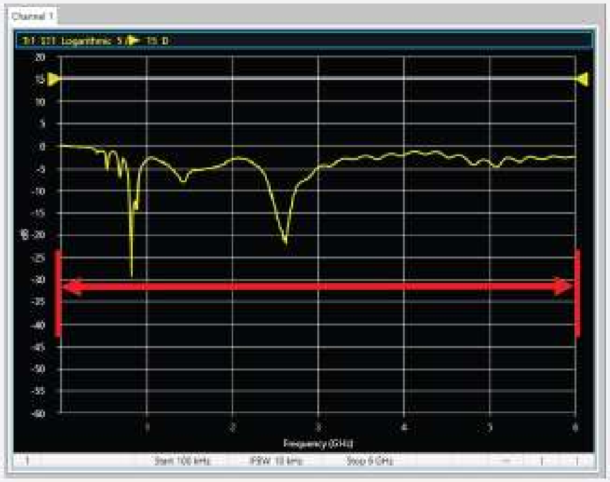


SiteMaster S331L Dummy Load 7 nanoVNA 50 ohm

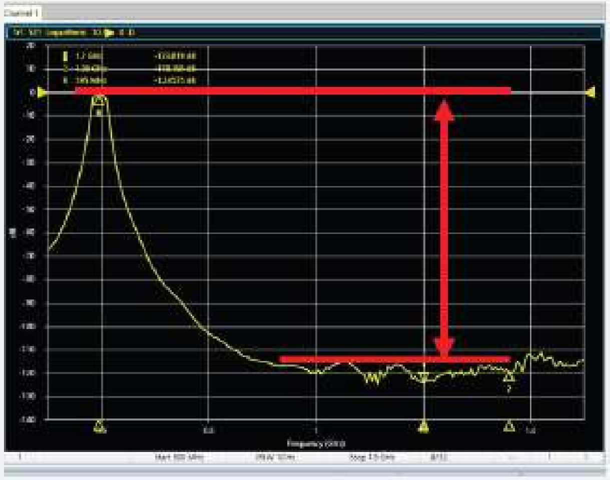
Additional

Documentation

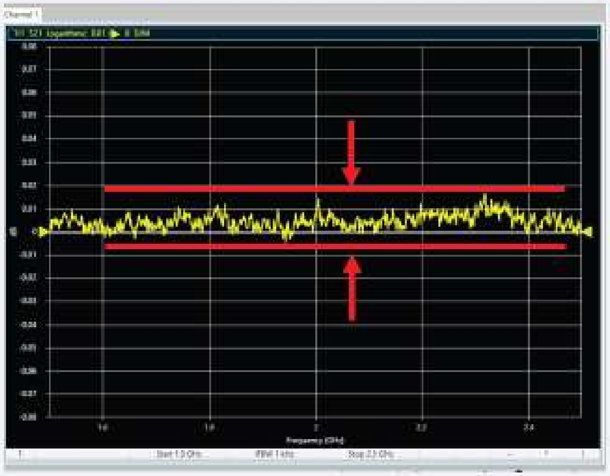

Input Signal
Device Under Test (DUT)
Output Signal
Source
Reflected Signal
VNA
Receivers
PC & Display



(a) Frequency Range



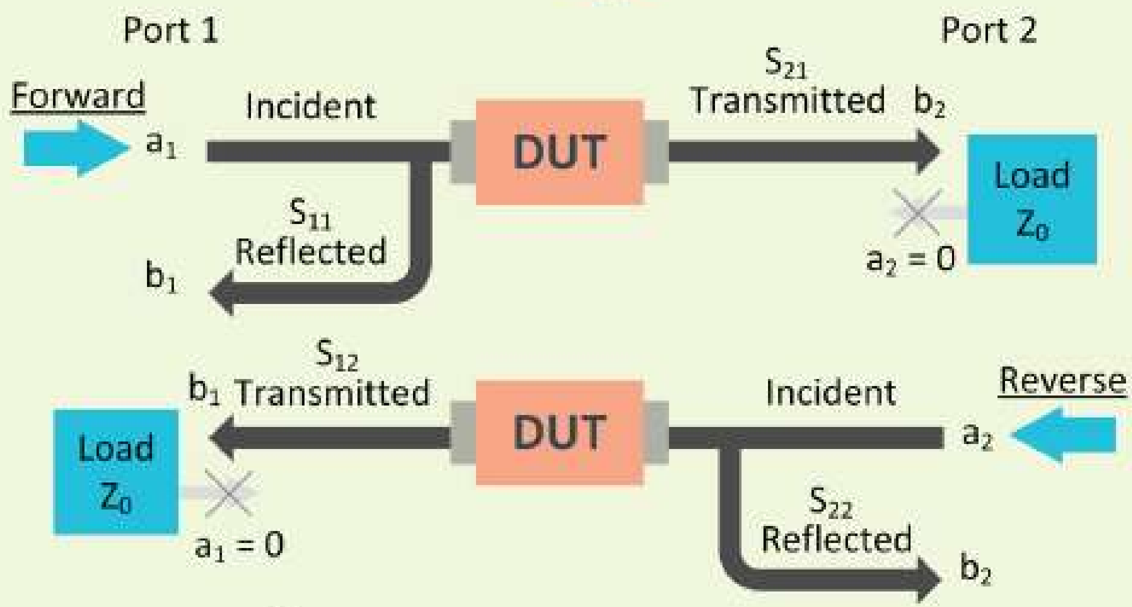
(b) Dynamic Range



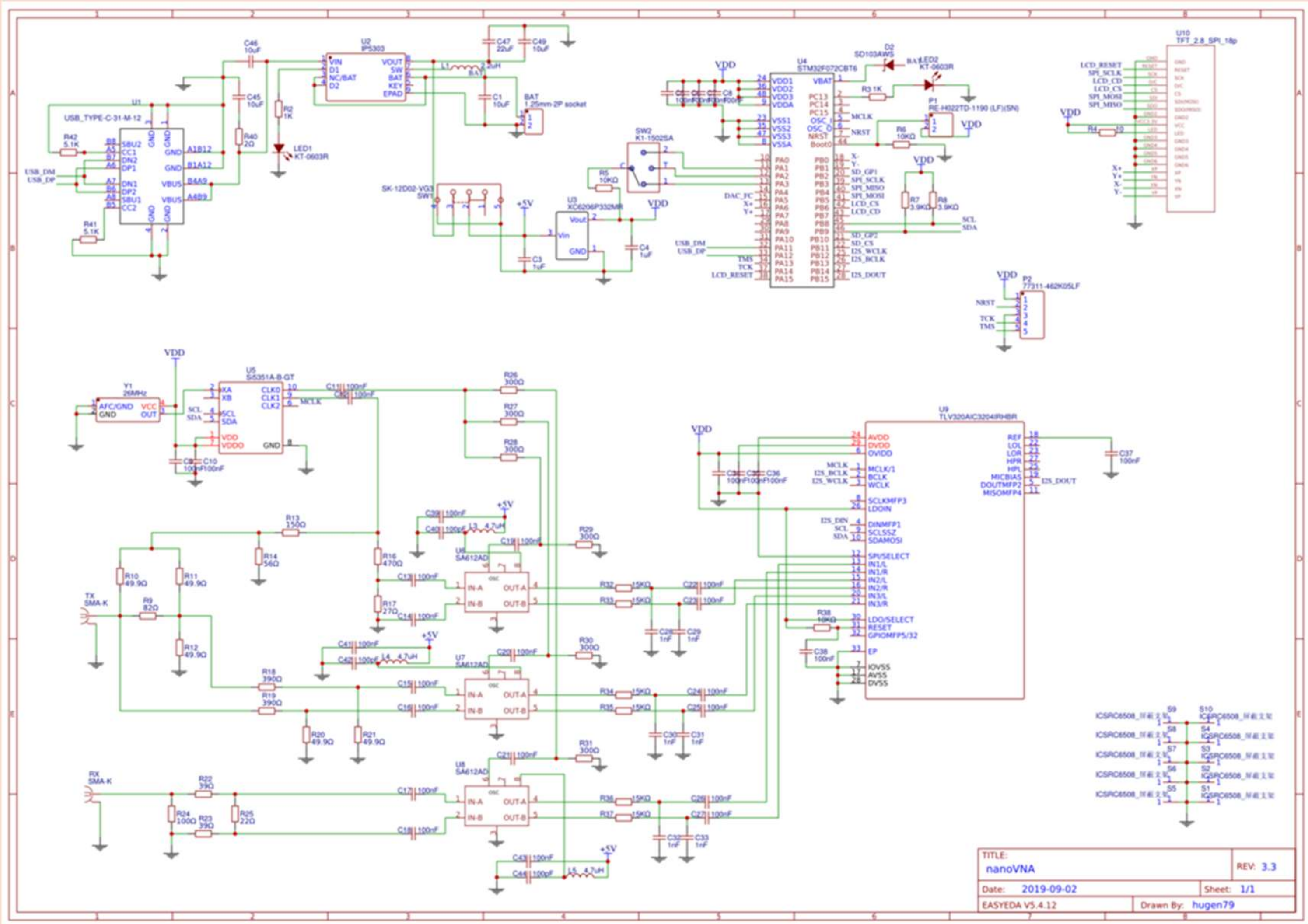
(c) Trace Noise

(d) Measurement speed

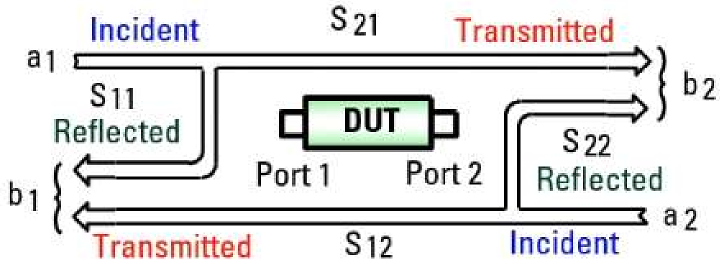
S-Parameter Theory View



	Forward:	Reverse:
Reflection:	$S_{11} = \dfrac{\text{Reflected}}{\text{Incident}} = \dfrac{b_1}{a_1}\Big\vert_{a_2=0}$	$S_{22} = \dfrac{\text{Reflected}}{\text{Incident}} = \dfrac{b_2}{a_2}\Big\vert_{a_1=0}$
Transmission:	$S_{21} = \dfrac{\text{Transmitted}}{\text{Incident}} = \dfrac{b_2}{a_1}\Big\vert_{a_2=0}$	$S_{12} = \dfrac{\text{Transmitted}}{\text{Incident}} = \dfrac{b_1}{a_2}\Big\vert_{a_1=0}$

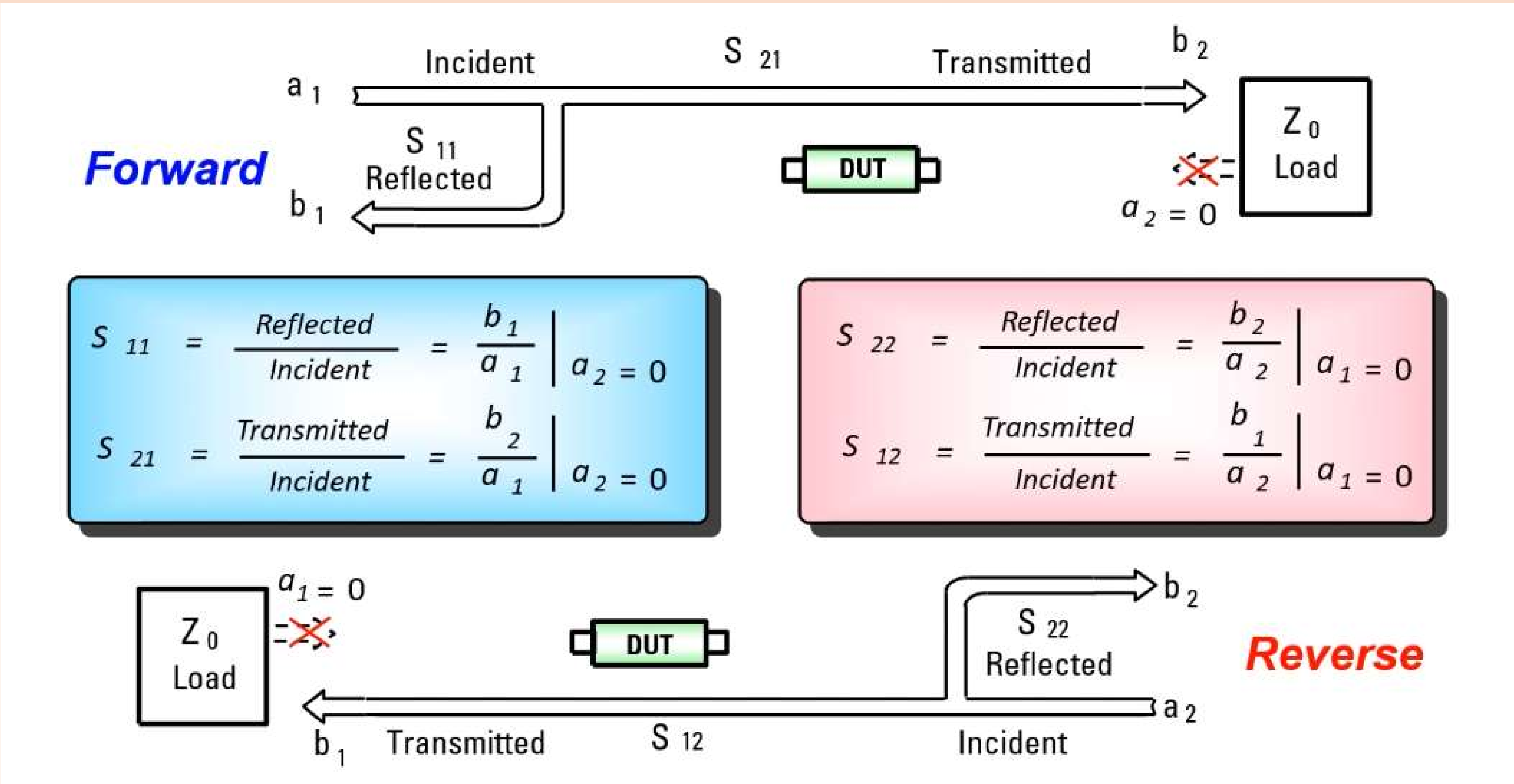

TITLE:
nanoVNA
REV: 3.3
Date: 2019-09-02
Sheet: 1/1
EASYEDA V5.4.12
Drawn By: hugen79

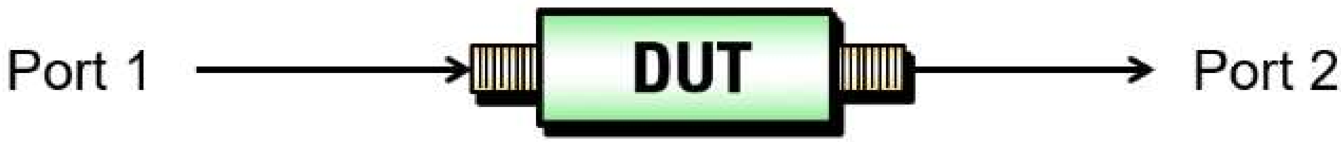
- Relatively easy to **obtain** at high frequencies
  - Measure voltage traveling waves with a vector network analyzer
  - Don't need shorts/opens (can cause active devices to oscillate or self-destruct)
- Relate to **familiar** measurements (gain, loss, reflection coefficient ...)
- Can **cascade** S-parameters of multiple devices to predict system performance
- Can **compute** H-, Y-, or Z-parameters from S-parameters if desired
- Can easily import and use S-parameter files in **electronic-simulation** tools



$$b_1 = S_{11} a_1 + S_{12} a_2$$

$$b_2 = S_{21} a_1 + S_{22} a_2$$


Forward
a 1
Incident
S 21
Transmitted
b 2
S 11
Reflected
b 1
DUT
Z 0
Load
a 2 = 0
S 11 = Reflected / Incident = b 1 / a 1 | a 2 = 0
S 21 = Transmitted / Incident = b 2 / a 1 | a 2 = 0
S 22 = Reflected / Incident = b 2 / a 2 | a 1 = 0
S 12 = Transmitted / Incident = b 1 / a 2 | a 1 = 0
Z 0
Load
a 1 = 0
DUT
b 2
S 22
Reflected
Reverse
a 2
b 1
Transmitted
S 12
Incident



S_{11} = forward reflection coefficient ***(input match)***

S_{22} = reverse reflection coefficient ***(output match)***

S_{21} = forward transmission coefficient ***(gain or loss)***

S_{12} = reverse transmission coefficient ***(isolation)***

Remember S-parameters are inherently complex, linear quantities – however, we often express them in a log-magnitude format

V2 Plus4 fixes the drift and linearity issues with older NanoVNA/S-A-A-2 based analyzers. It is a complete redesign using our new VNA-R architecture, which features the following improvements:

Temperature drift cancellation, only available in the V2 Plus4 and VNA6000 series, gives you repeatable and reliable measurements, allowing you to keep calibrations for longer (>3 months compared to <30 minutes for earlier versions).

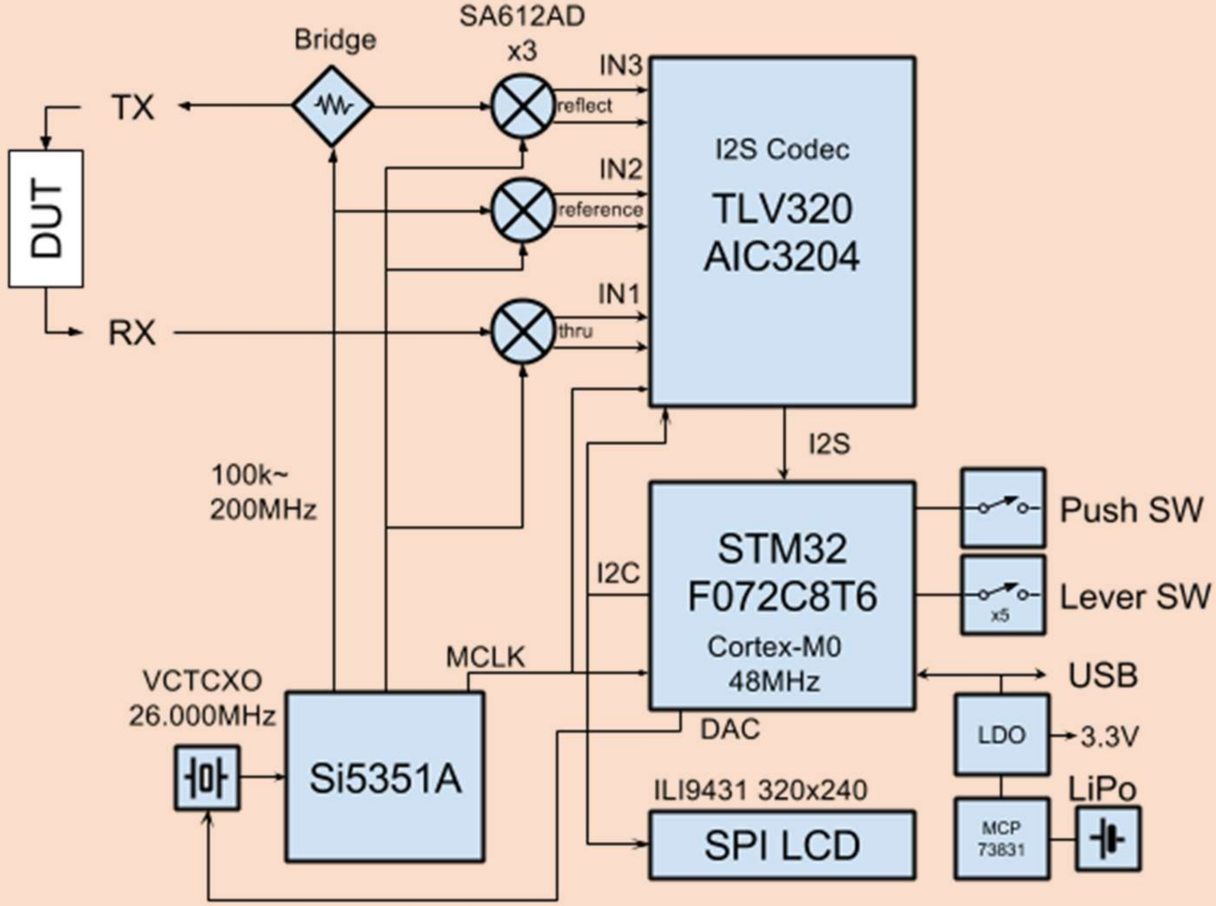
Synthesizer rated for the full frequency range - V2 Plus4 does not overclock the synthesizer or use harmonics, making accurate measurements without interference from spurious signals.

Factory tuning of each individual instrument allows the V2 Plus4 to have trace noise 90% lower than previous versions, and improved linearity eliminating harmonic response.

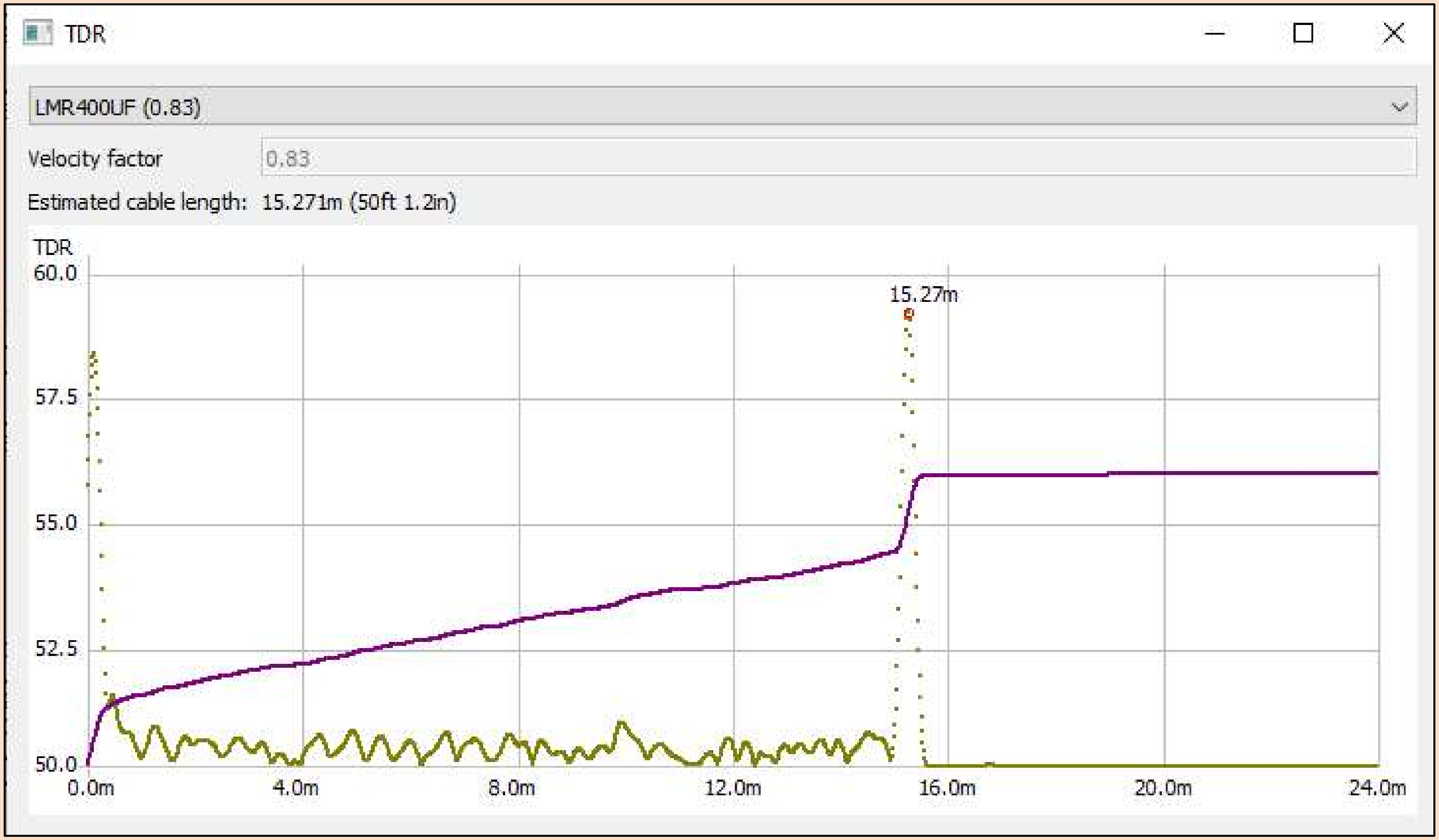
Improved USB protocol allows full speed streaming of measured data to the PC, achieving 4x faster measurement than our earlier S-A-A-2 (6x faster for V2 Plus4 Pro).

The **all aluminum enclosure and improved shielding** allows the V2 Plus4 to reach >90dB real dynamic range, achieving similar results as professional VNAs, and allows measuring duplexers.

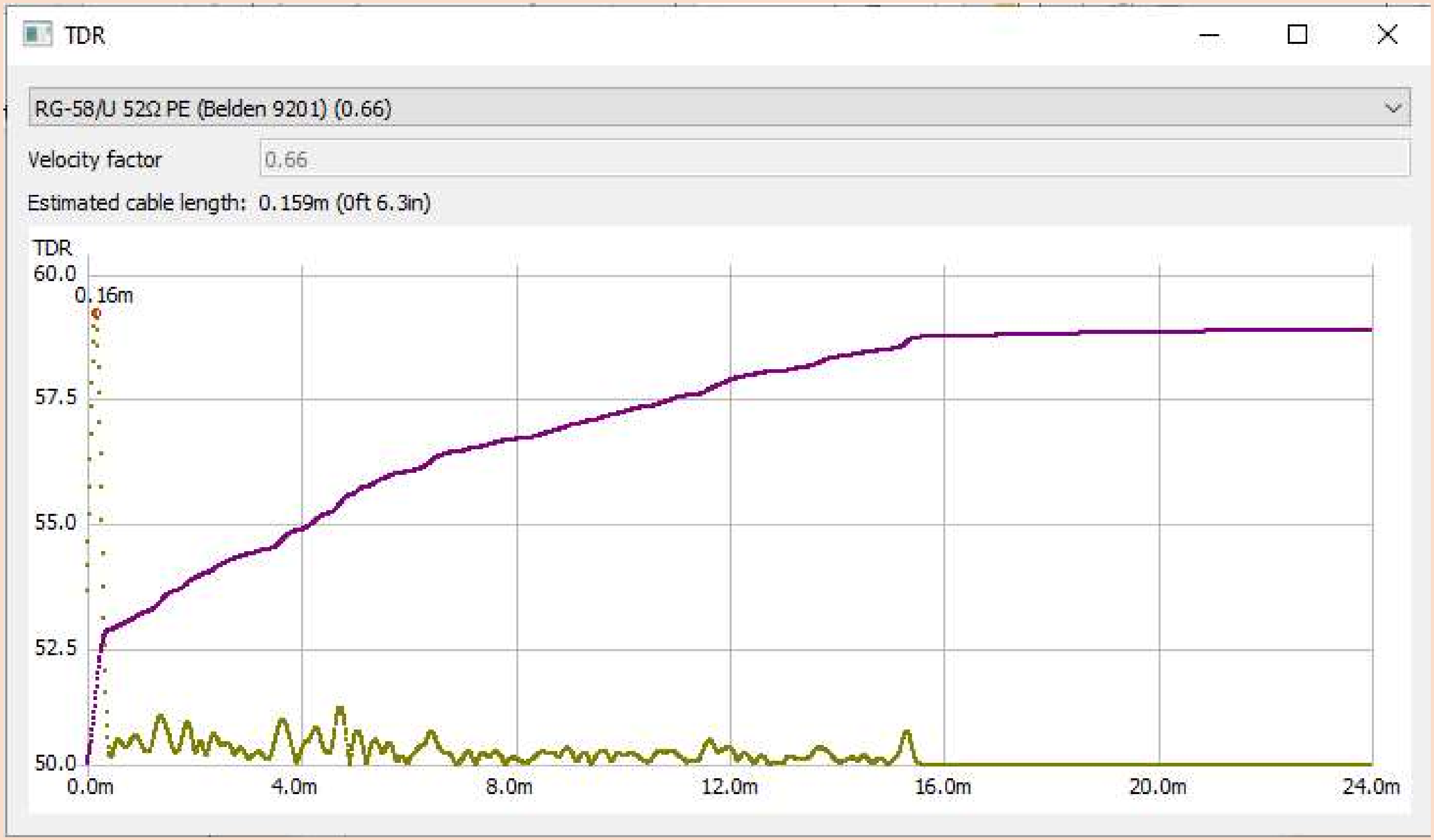
	NanoRFE portable VNA series				Other portable VNAs		
	V2 Plus4	V2 Plus4 Pro	VNA6000-A	VNA6000-B	KeyS FieldF N9912A	Anr MS2025B	R-S ZNH4
Max dynamic range	**90dB**	**90dB**	**95dB**	**110dB**	**72dB**	**100dB**	**100dB**
Freq. range (Hz)	50k - 4G	50k - 4G	50k - 6G	50k - 6G	2M - 6G	500k - 6G	30k - 4G
Trace noise	Low	Lower	Lower	Lower	Lower	Lower	Lower
Sweep time	0.25s	< 0.2s	< 0.2s	< 0.2s	< 0.1s	< 0.1s	< 0.1s
Adjustable IFBW		√	√	√	√	√	√
Temperature drift compensation	√	√	√	√	?	?	?
TDR	√	√	√	√	√	√	√
TDR resolution	9mm	9mm	6mm	6mm	6mm	6mm	9mm
Weight	300g	300g	300g	300g	2.8kg	3.5kg	3.1kg
Touchscreen	√	√	√	√		√	√



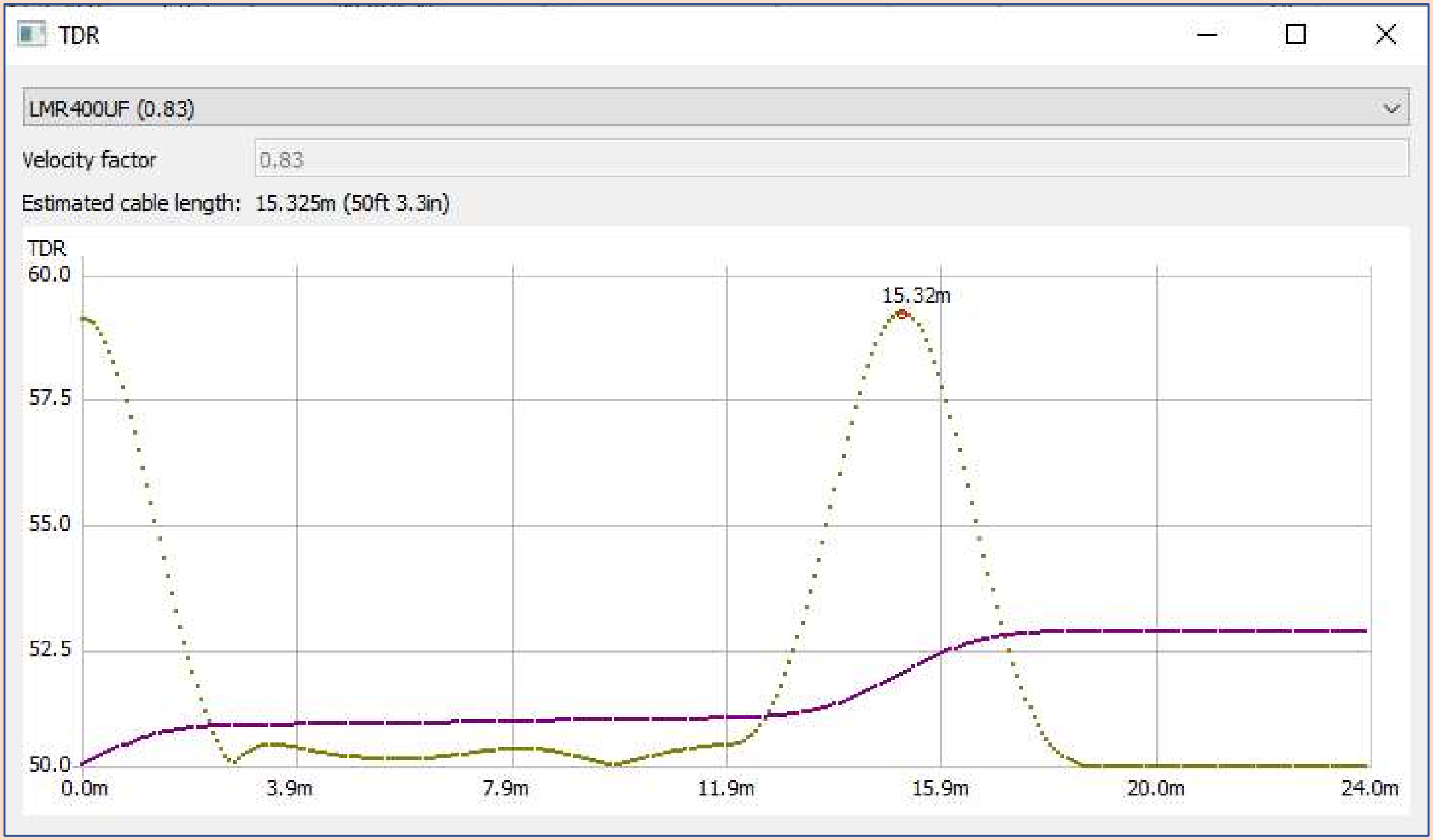
SA612AD
x3
Bridge
TX
RX
DUT
IN3
reflect
IN2
reference
IN1
thru
I2S Codec
TLV320
AIC3204
I2S
100k~
200MHz
STM32
F072C8T6
Cortex-M0
48MHz
I2C
Push SW
Lever SW
x5
USB
MCLK
VCTCXO
26.000MHz
Si5351A
DAC
LDO
3.3V
LiPo
MCP
73831
ILI9431 320x240
SPI LCD



LMR 400 50 feet 50 ohm Load 1 MHz – 1000 MHz Sweep



RG58 50 feet 50 ohm Load 1 MHz – 1000 MHz Sweep

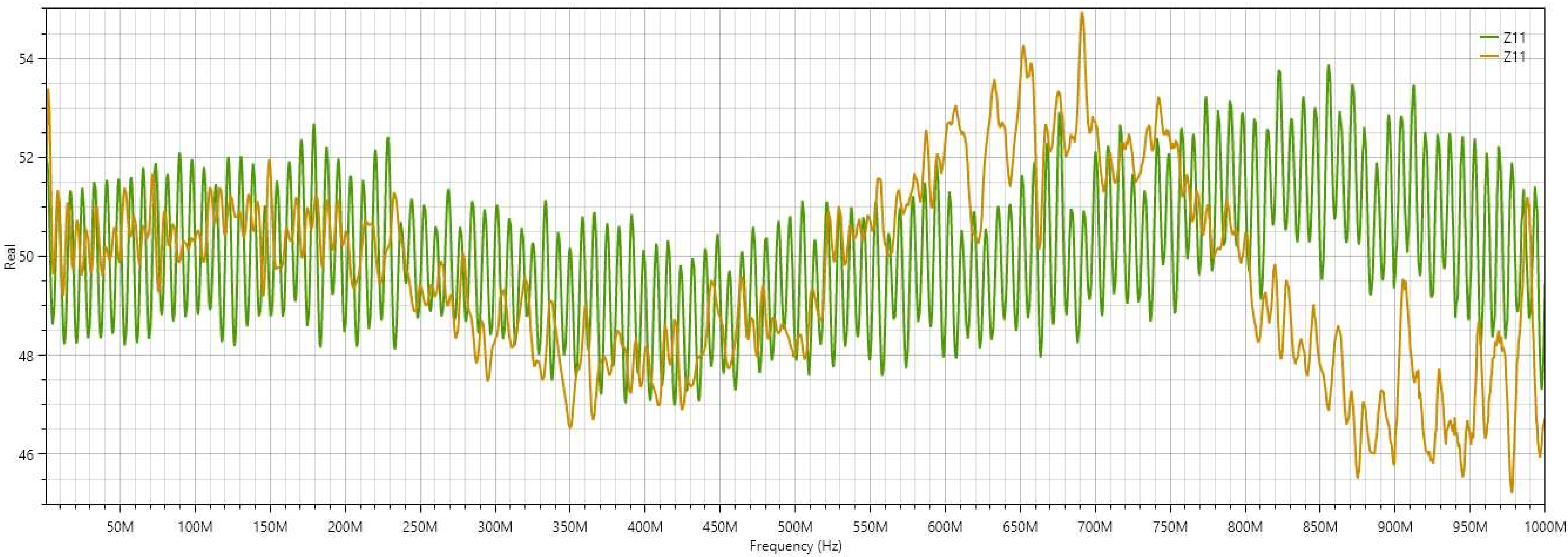


LMR 400 50 feet 50 ohm Load 1 MHz – 100 MHz Sweep

Z-Parameters

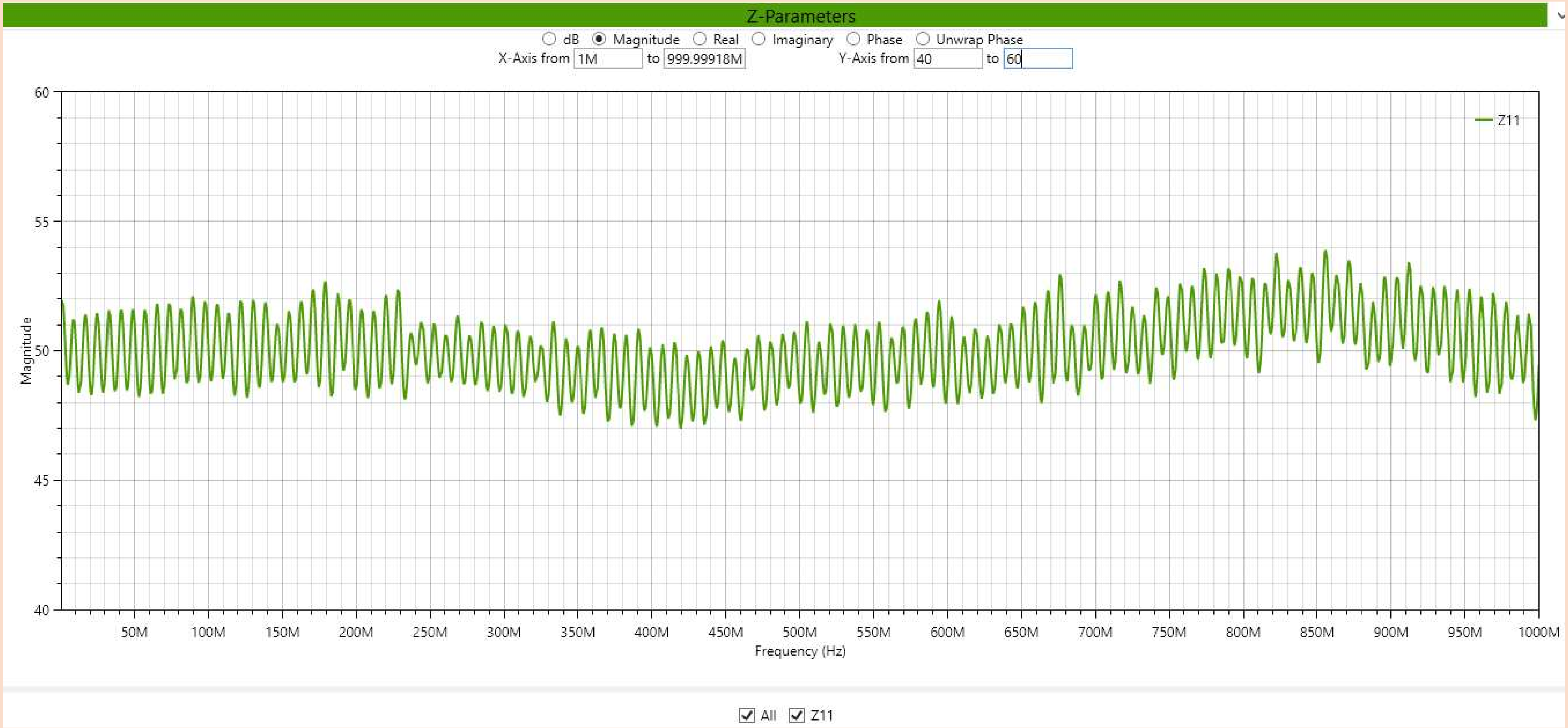
○ dB ○ Magnitude ◉ Real ○ Imaginary ○ Phase ○ Unwrap Phase

X-Axis from 1M to 999.99918M   Y-Axis from 45 to 55

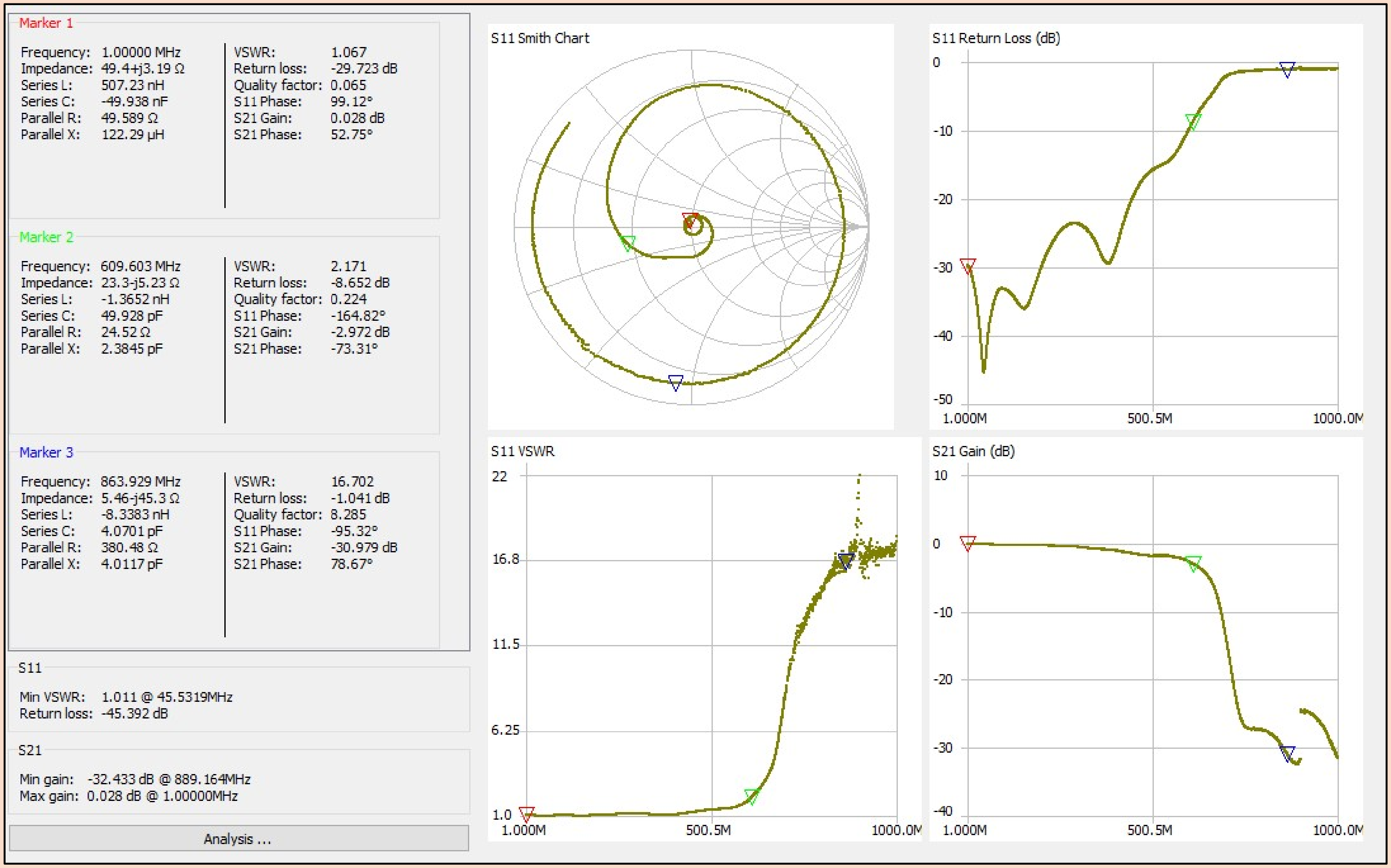


✖ vna_LMR400_50_feet_.s1p ☑ All ☑ Z11

✖ vna_RG58_50_feet_.s1p ☑ All ☑ Z11

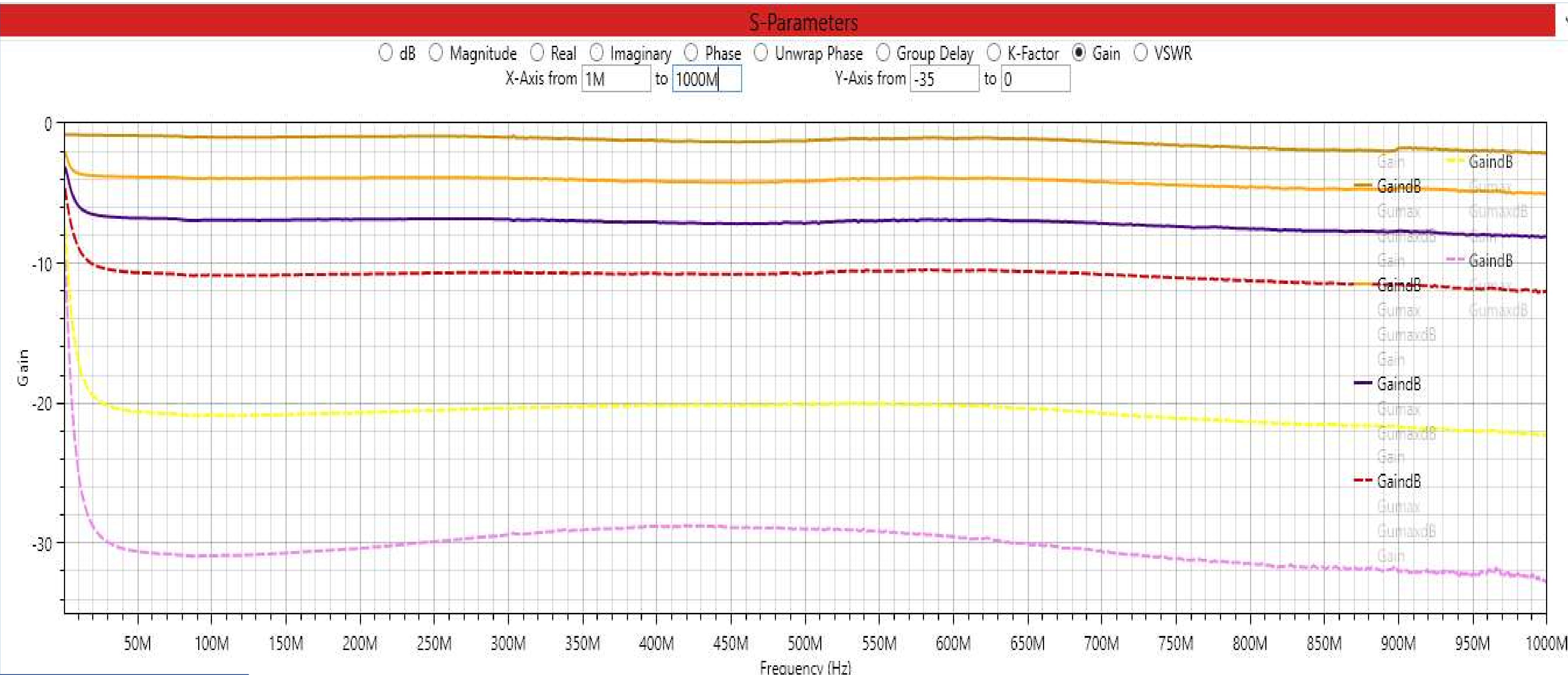


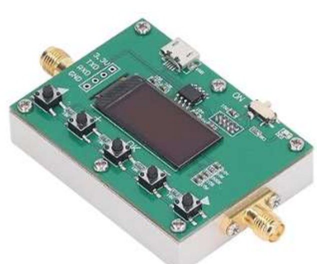
LMR 400 50 feet 50 ohm Load



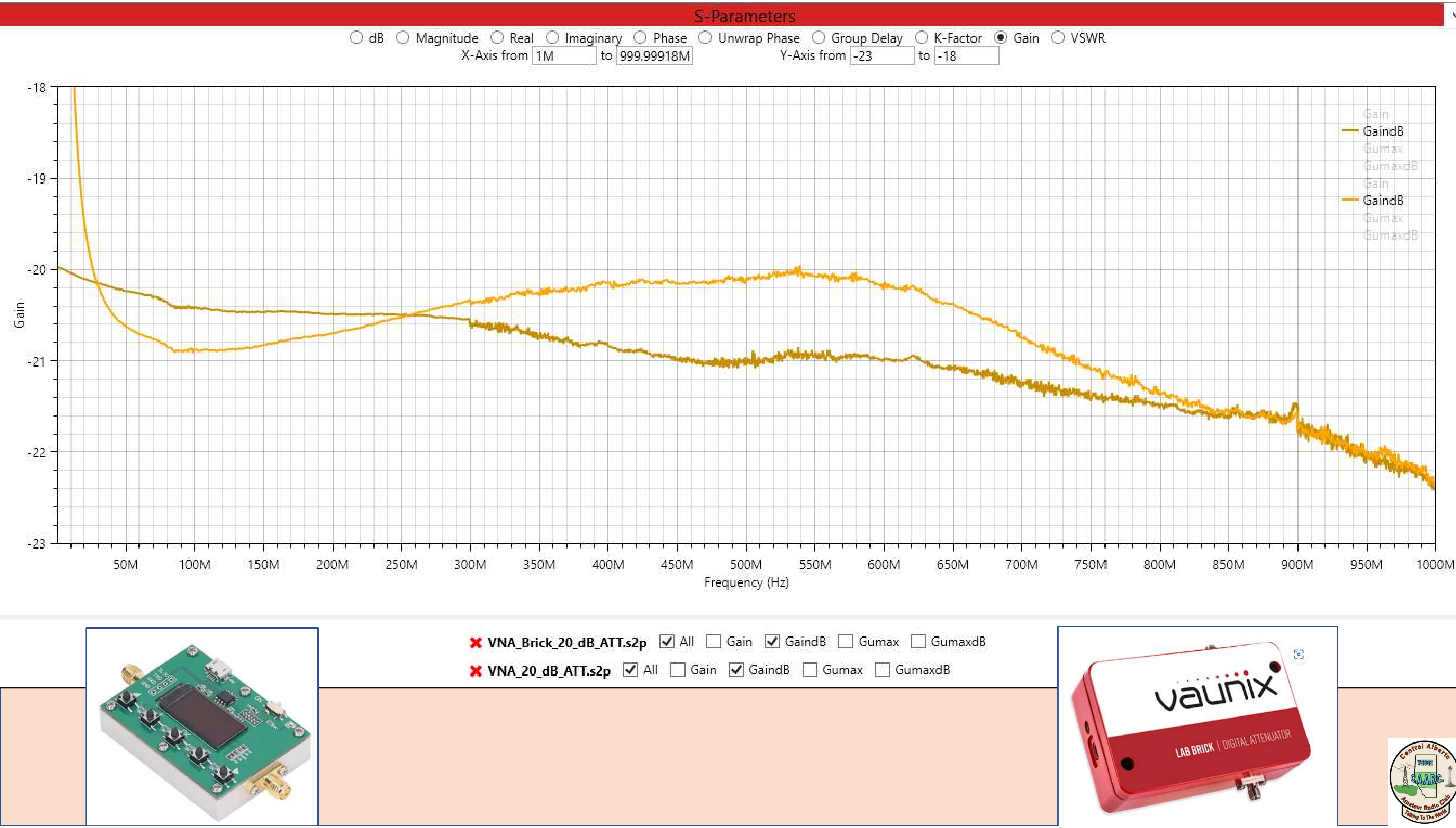
UHF Low Pass Filter

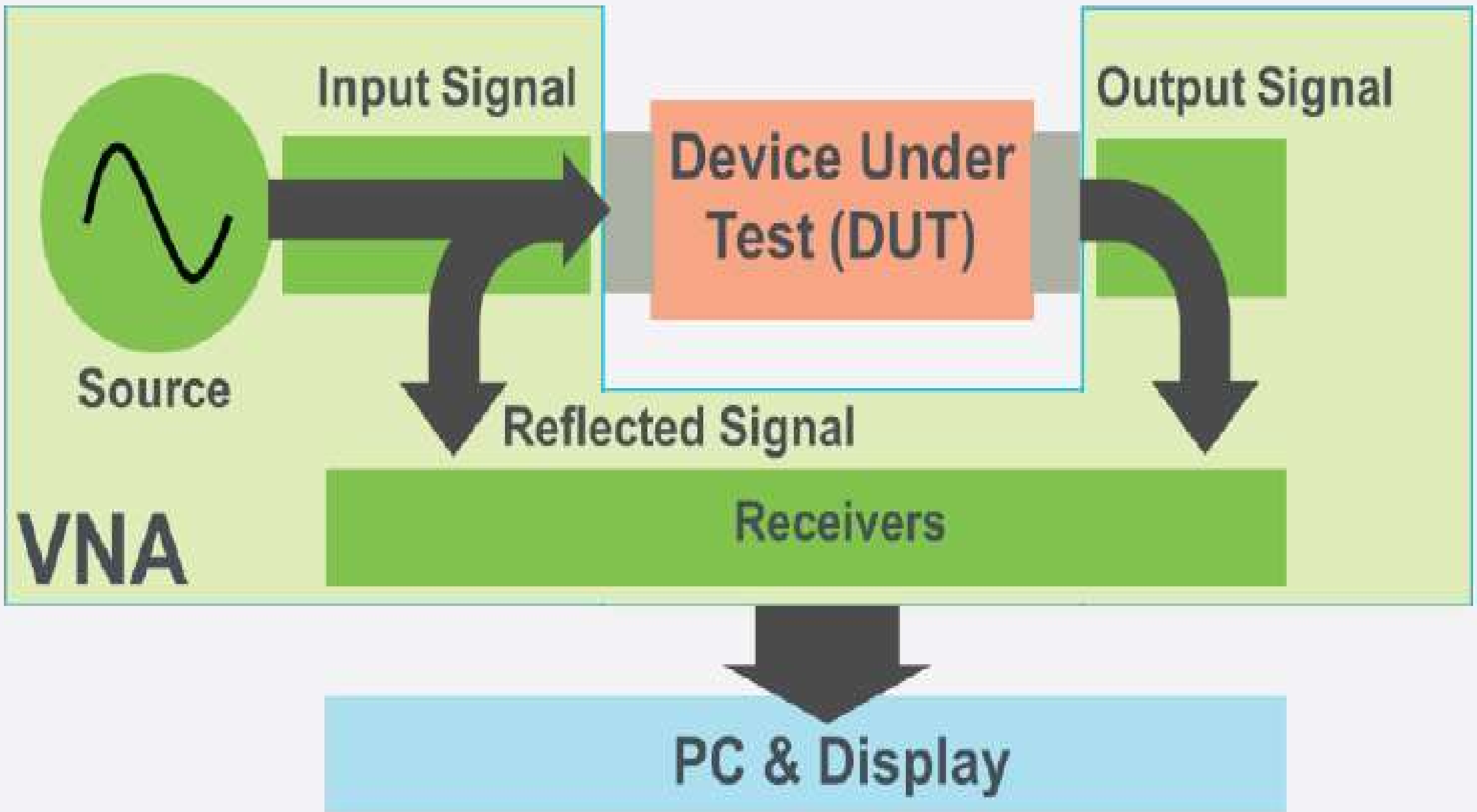
UHF Low Pass Filter



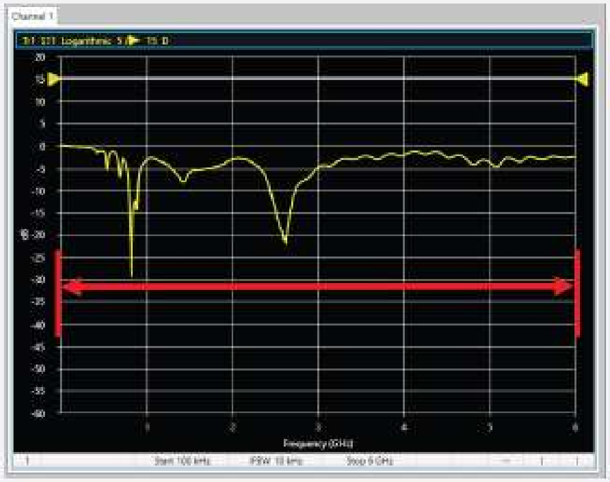


Digital RF Attenuator

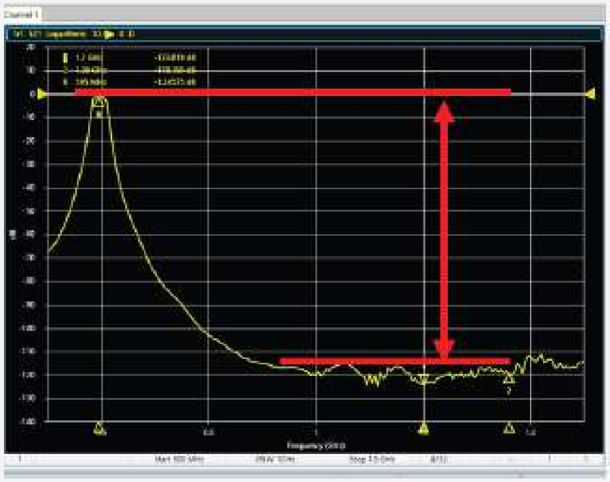

S-Parameters
dB Magnitude Real Imaginary Phase Unwrap Phase Group Delay K-Factor Gain VSWR
X-Axis from 1M to 999.99918M
Y-Axis from -23 to -18
Gain
-18
-19
-20
-21
-22
-23
50M 100M 150M 200M 250M 300M 350M 400M 450M 500M 550M 600M 650M 700M 750M 800M 850M 900M 950M 1000M
Frequency (Hz)
GaindB
GaindB
VNA_Brick_20_dB_ATT.s2p All Gain GaindB Gumax GumaxdB
VNA_20_dB_ATT.s2p All Gain GaindB Gumax GumaxdB
vaunix
LAB BRICK | DIGITAL ATTENUATOR



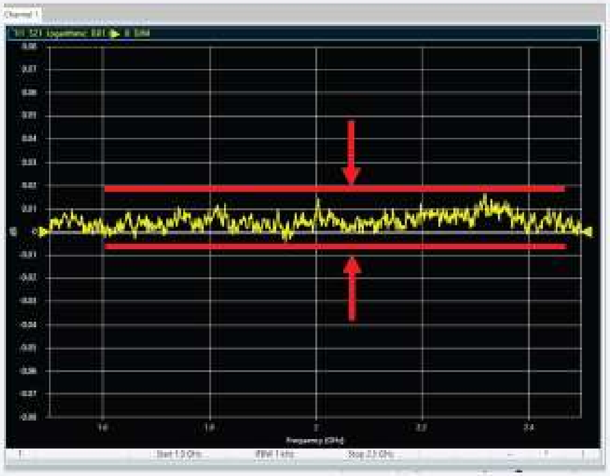
Input Signal
Device Under Test (DUT)
Output Signal
Source
Reflected Signal
VNA
Receivers
PC & Display



(a) Frequency Range



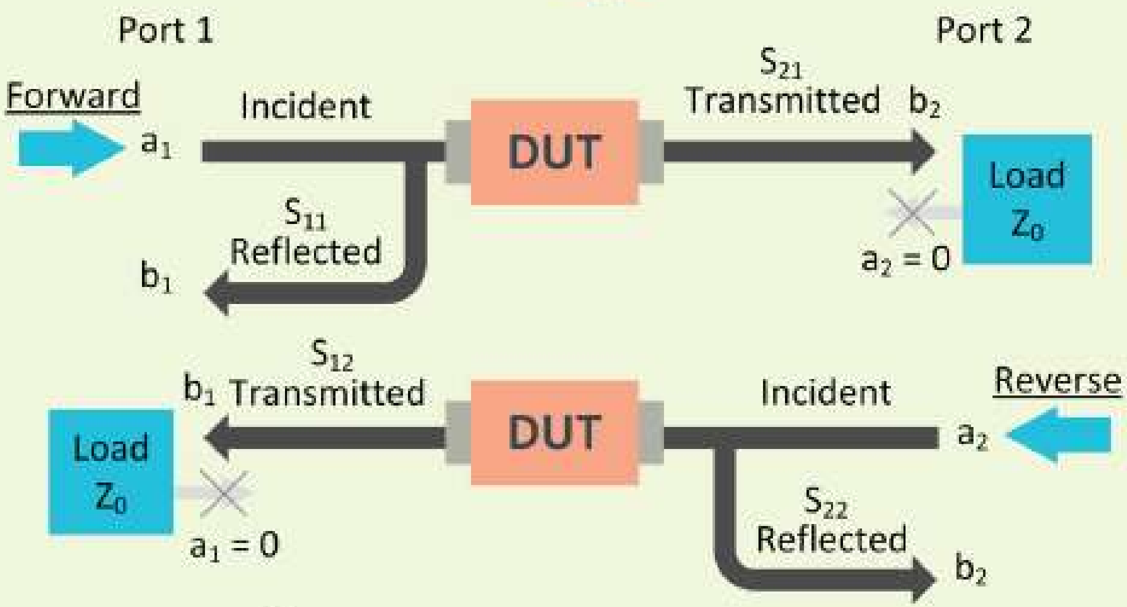
(b) Dynamic Range



(c) Trace Noise

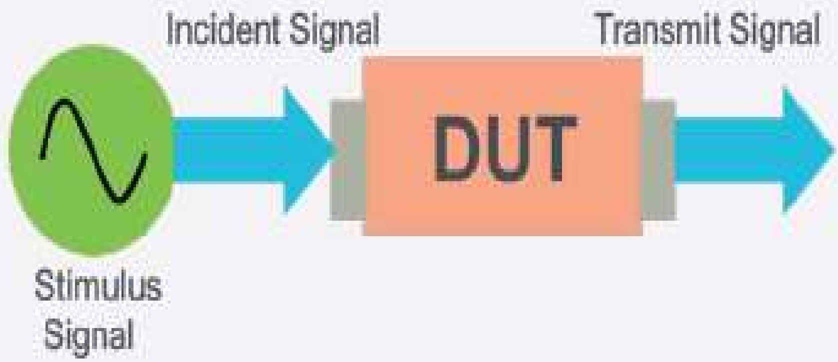
(d) Measurement speed

S-Parameter Theory View



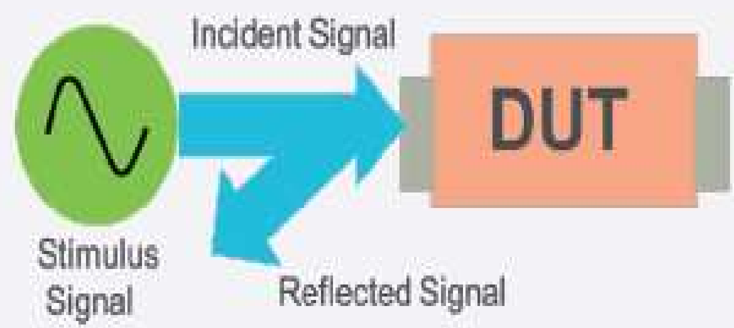
	Forward:	Reverse:
Reflection:	$S_{11} = \frac{\text{Reflected}}{\text{Incident}} = \frac{b_1}{a_1}\Big\vert_{a_2=0}$	$S_{22} = \frac{\text{Reflected}}{\text{Incident}} = \frac{b_2}{a_2}\Big\vert_{a_1=0}$
Transmission:	$S_{21} = \frac{\text{Transmitted}}{\text{Incident}} = \frac{b_2}{a_1}\Big\vert_{a_2=0}$	$S_{12} = \frac{\text{Transmitted}}{\text{Incident}} = \frac{b_1}{a_2}\Big\vert_{a_1=0}$

Transmission Measurements



- Transmission Coefficients (S_{21}, S_{12})
- Gain
- Insertion Loss/Phase
- Electrical Length/Delay
- Group Delay

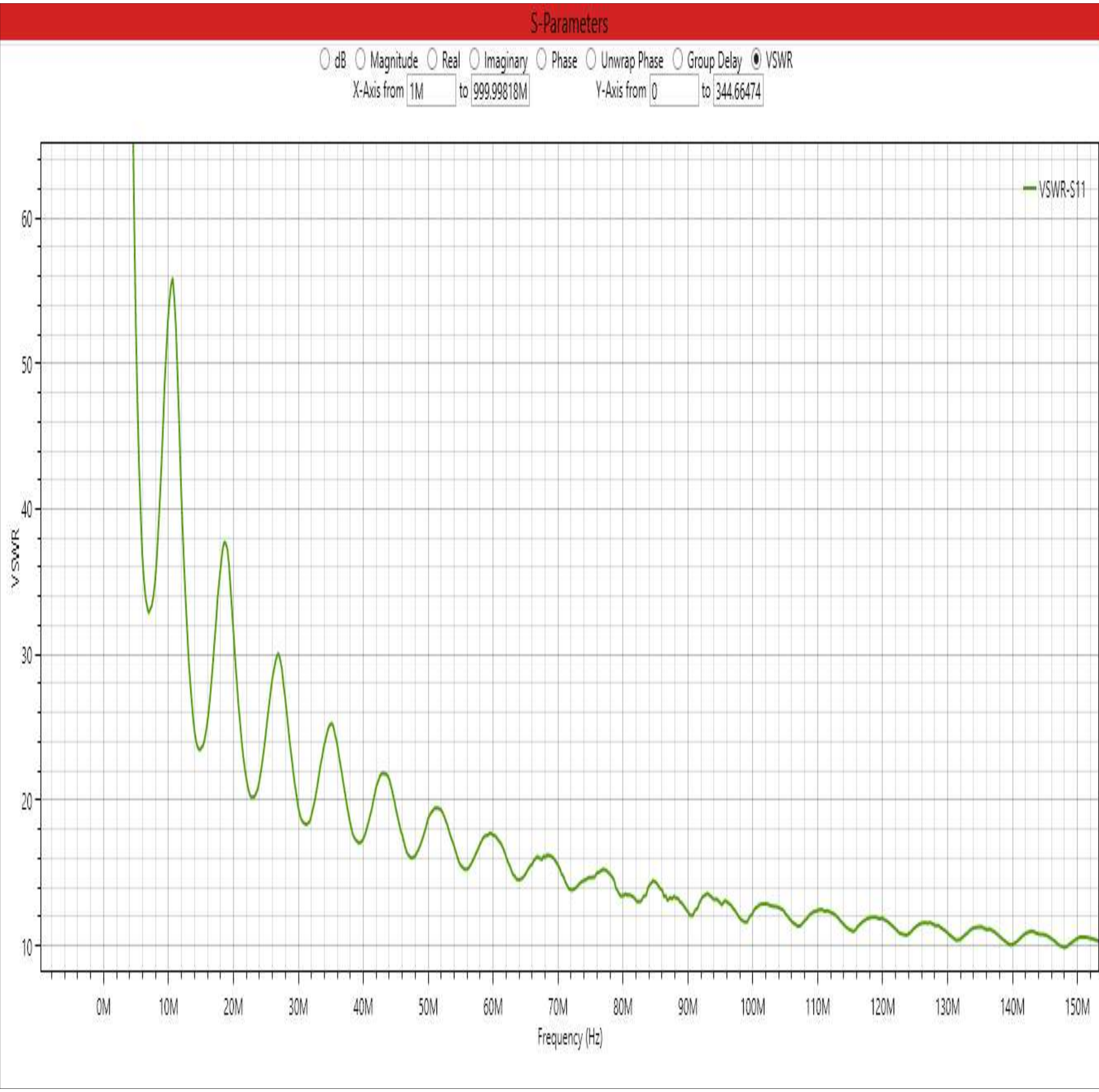
Reflection Measurements



- Reflection Coefficients (S_{11}, S_{22})
- Return Loss
- VSWR (Voltage Standing Wave Ratio)
- Impedance (R+jX)

Some VNAs are capable of using inverse Fourier transforms to convert swept frequency measurements into the time domain. In this way, data displayed in the time domain allows the VNA to be used to find problems in cables and connections by detecting the locations of impedance mismatches or discontinuities as the signal passes through the DUT.

For time domain measurements, the ability to resolve two signals is inversely proportional to the measured frequency span. Therefore, the wider the frequency span, the greater the ability the VNA has to distinguish between closely spaced discontinuities. The maximum frequency span is set by the user and may be defined by either the frequency range of the VNA or the viable bandwidth of the DUT.



Sweep analysis

Select analysis

Analysis type: Resonance analysis

Run analysis

Run automatically

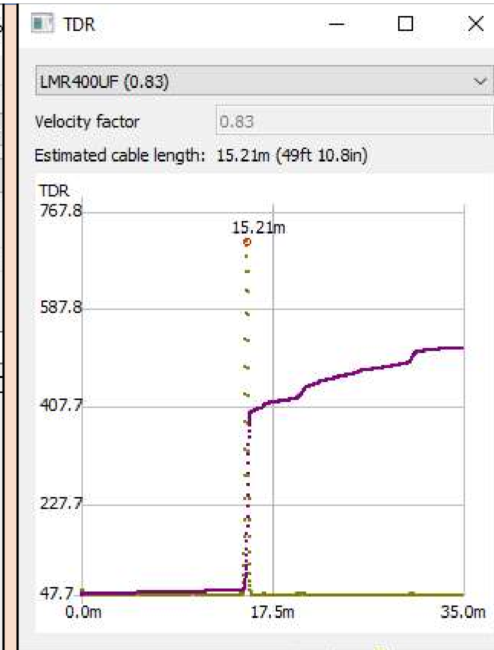
Analysis

Settings

Description: Resonance

Results

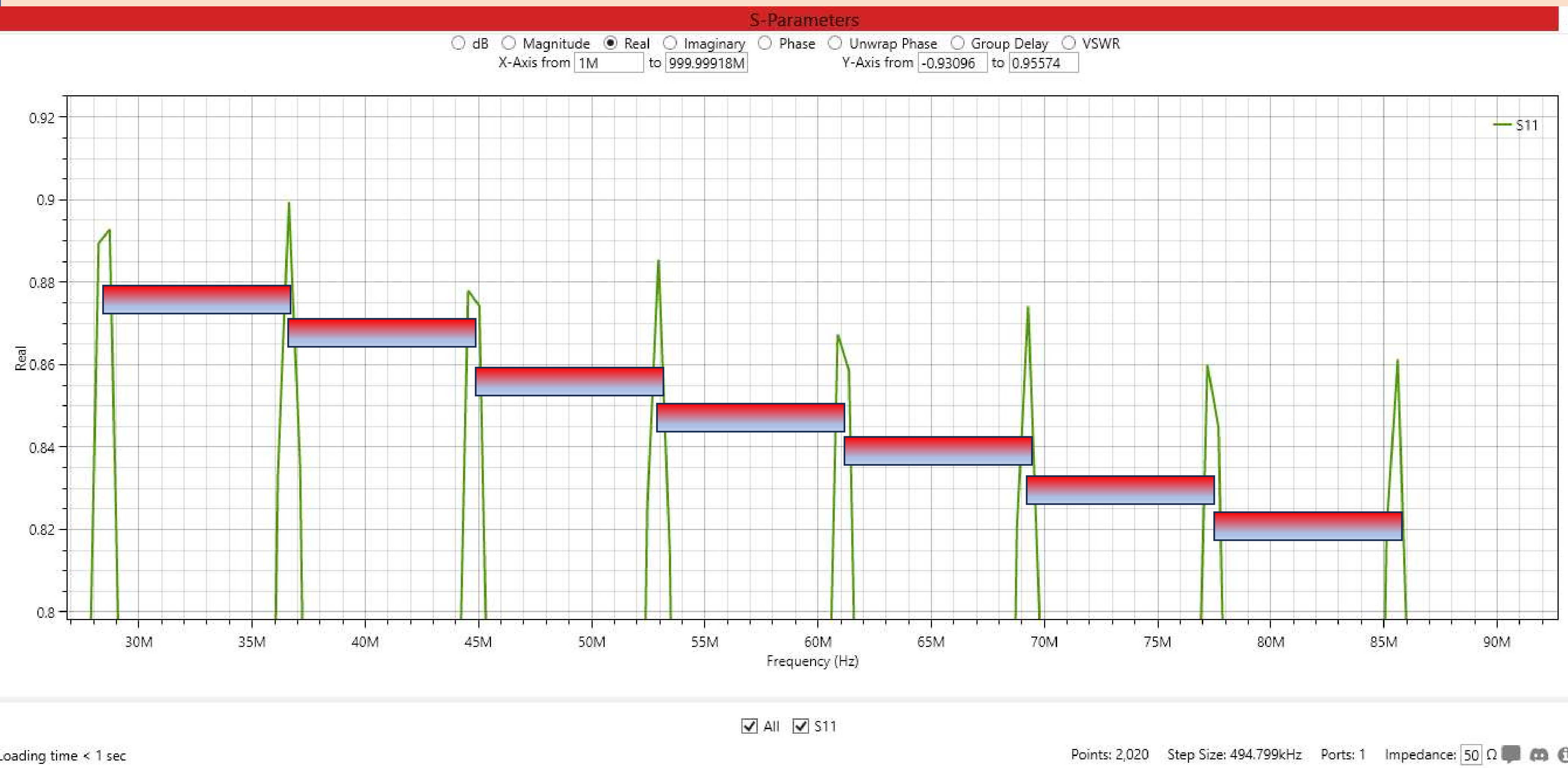
Resonance 3.96879MHz (959m-j8.58 Ω)
Resonance 8.42198MHz (334+j805 Ω)
Resonance 12.8752MHz (1.44+j6.58 Ω)
Resonance 16.8336MHz (370-j639 Ω)
Resonance 20.2972MHz (2.08-j7.08 Ω)
Resonance 24.7504MHz (933+j593 Ω)
Resonance 29.2035MHz (2.14+j7.77 Ω)
Resonance 33.1619MHz (238-j454 Ω)
Resonance 36.6255MHz (2.61-j6.01 Ω)
Resonance 41.0787MHz (1.05k-j37.5 Ω)
Resonance 45.5319MHz (2.68+j8.78 Ω)
Resonance 48.9955MHz (292+j448 Ω)
Resonance 52.9539MHz (3.01-j4.93 Ω)
Resonance 57.4071MHz (720-j357 Ω)
Resonance 60.8707MHz (3.31-j9.23 Ω)
Resonance 65.3239MHz (438+j427 Ω)
Resonance 69.7771MHz (3.33+j5.44 Ω)
Resonance 73.7355MHz (522-j385 Ω)
Resonance 77.1990MHz (3.66-j8.43 Ω)
Resonance 81.6522MHz (600+j306 Ω)
Resonance 86.1054MHz (3.91+j6.41 Ω)
Resonance 90.0638MHz (337-j350 Ω)
Resonance 93.5274MHz (3.95-j7.48 Ω)
Resonance 97.9806MHz (669+j66.5 Ω)



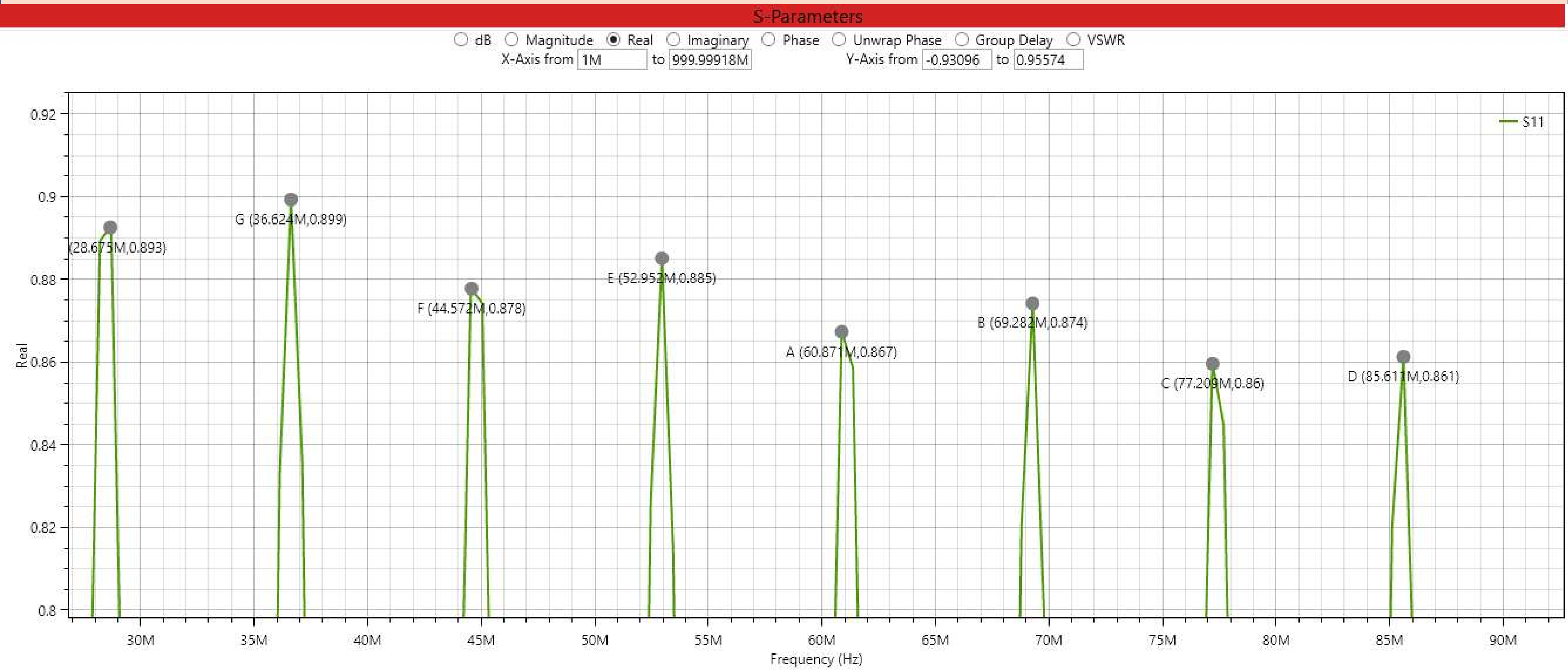
LMR 400 50 feet

Open Load

1 – 1000 MHz



LMR 400 50 feet Short Load 1 – 1000 MHz (detail presentation)



LMR 400 50 feet Short Load 1 – 1000 MHz (detail presentation)

LMR 400 50 feet Short Load nanoVNA Data

- Peaks are 8.2 MHz Spacing
- LMR 400 Velocity Factor = 0.83

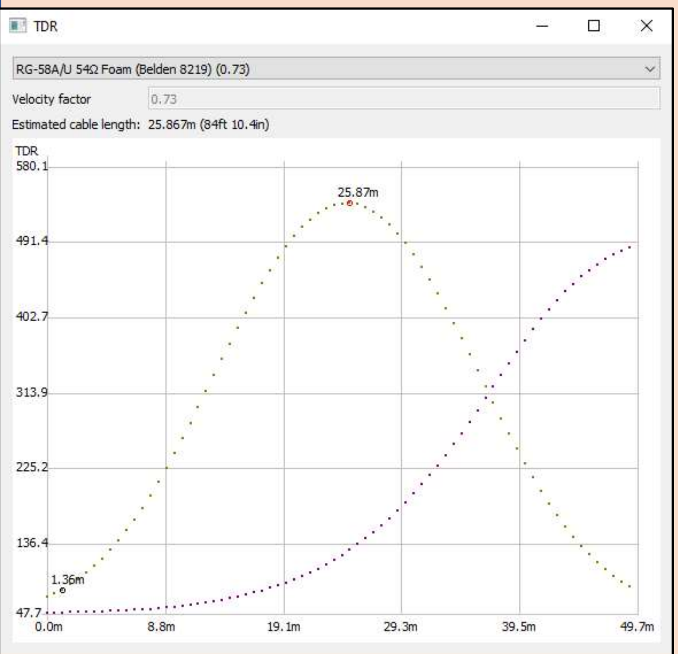
Since : **$\lambda = c/f$**

Then $\lambda = 0.83 * 3e8 / 8.2e6$

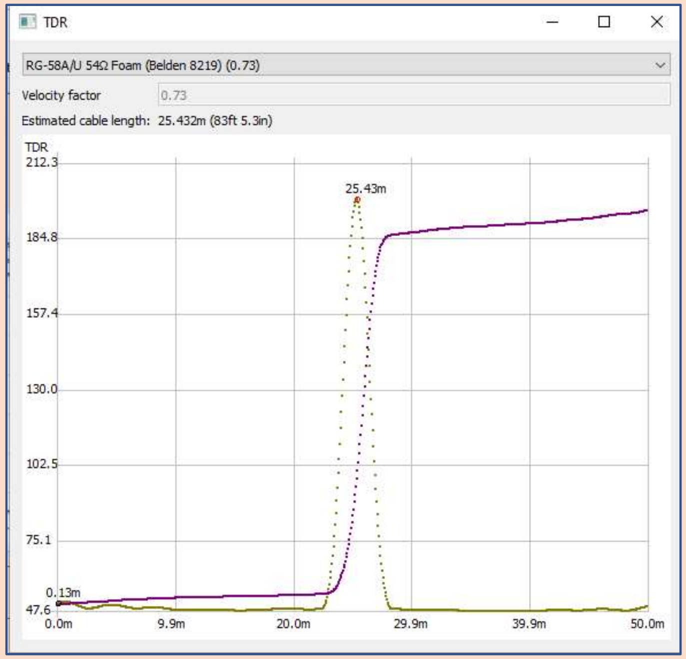
$\lambda = 30.365$ m (2 way length /time)

Thus Cable Length = 15.18 m (49.8 feet)

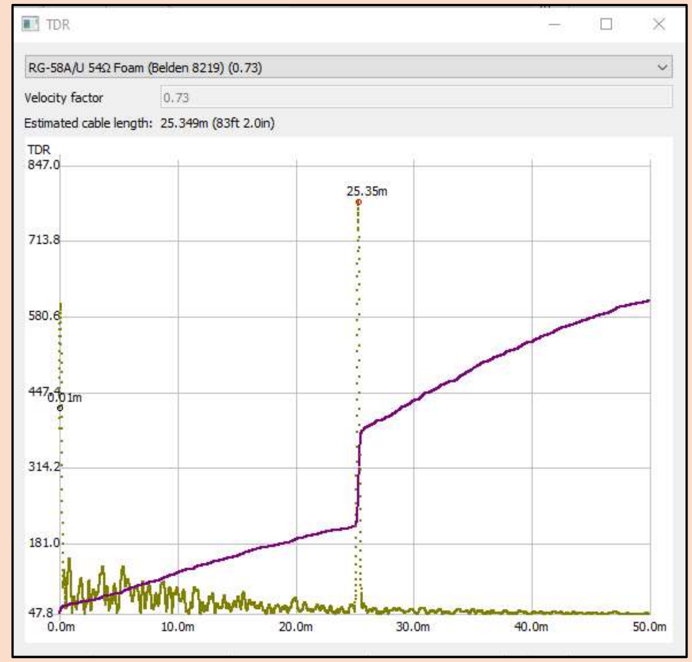
Fourier Transform and Spatial Resolution



0.1 – 10 MHz

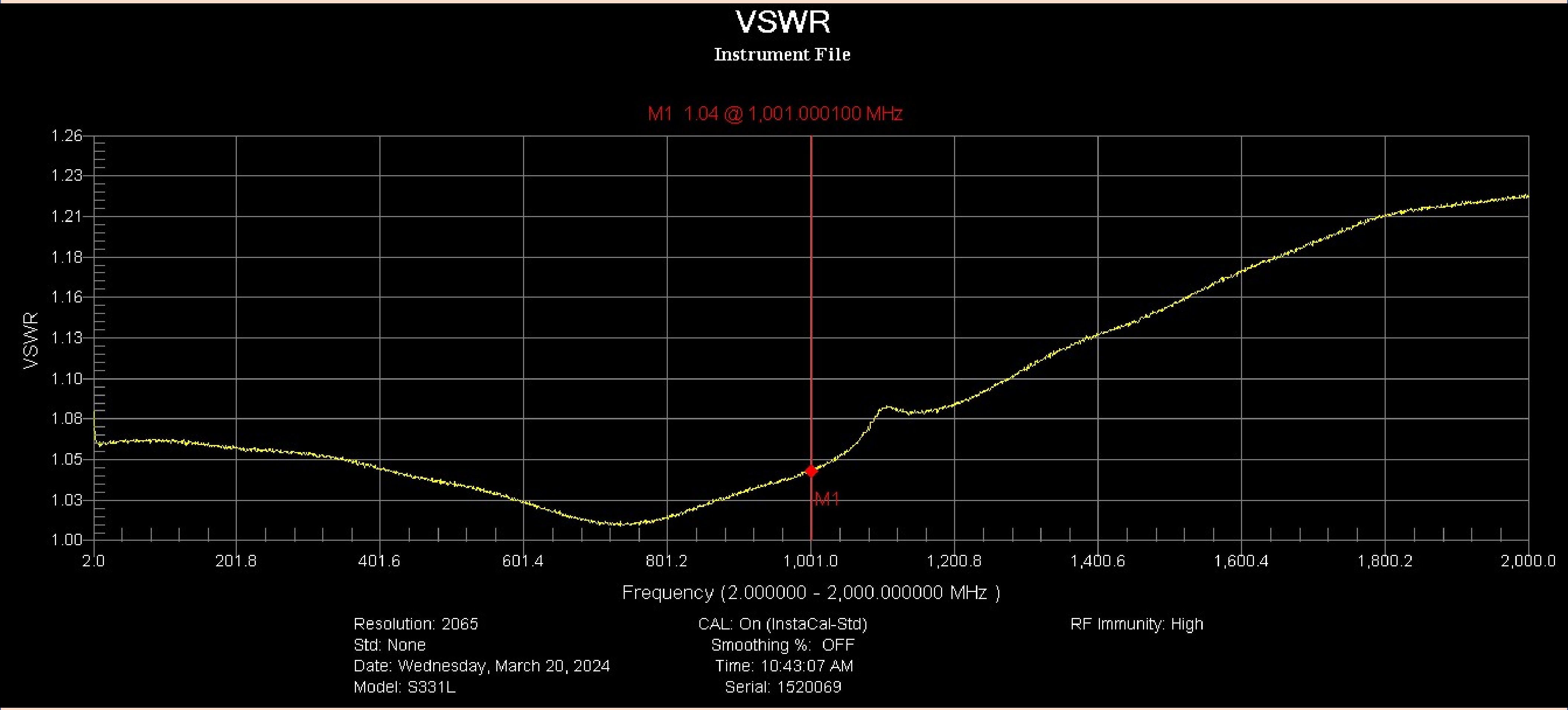


0.1 – 100 MHz

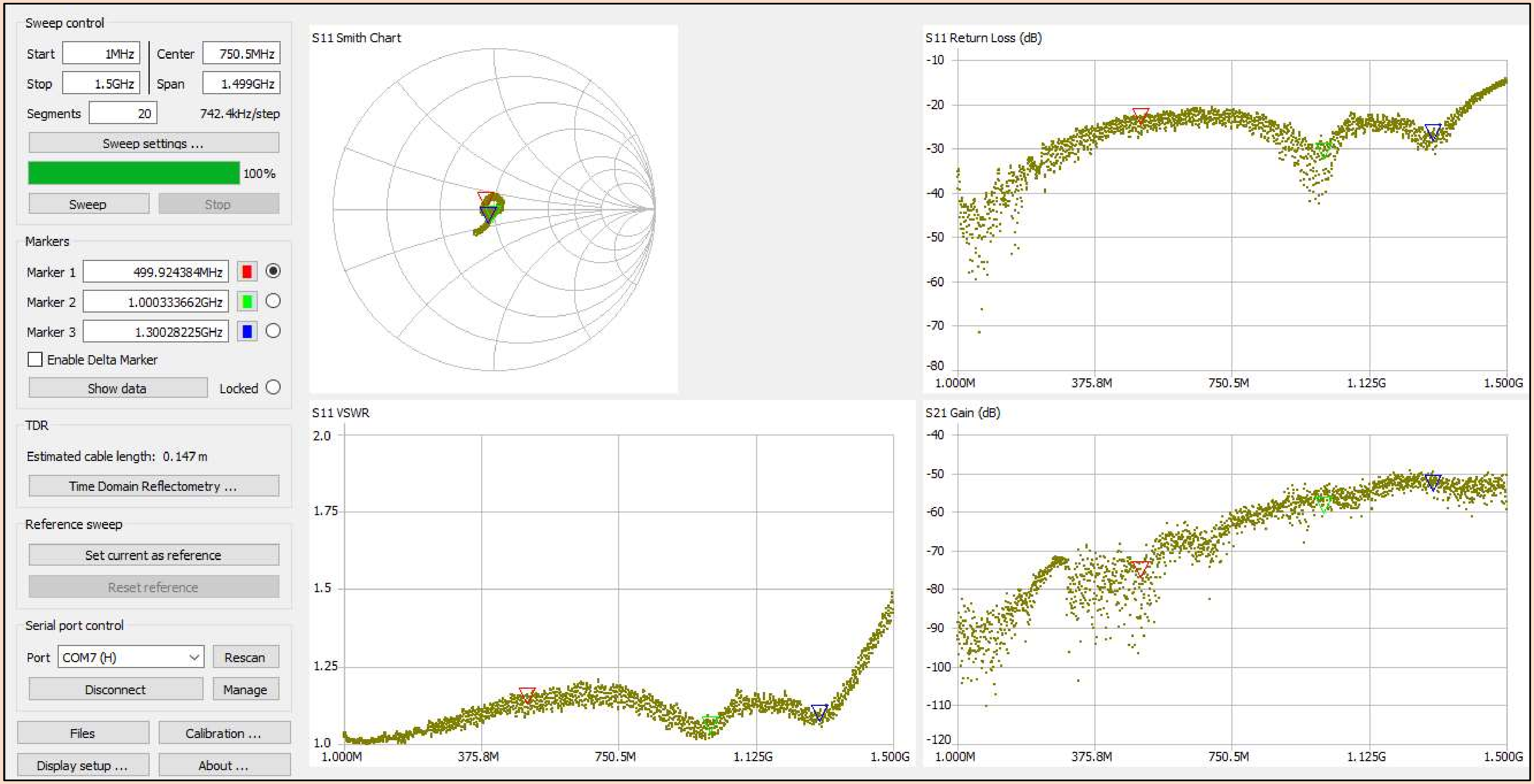


0.1 – 1000 MHz

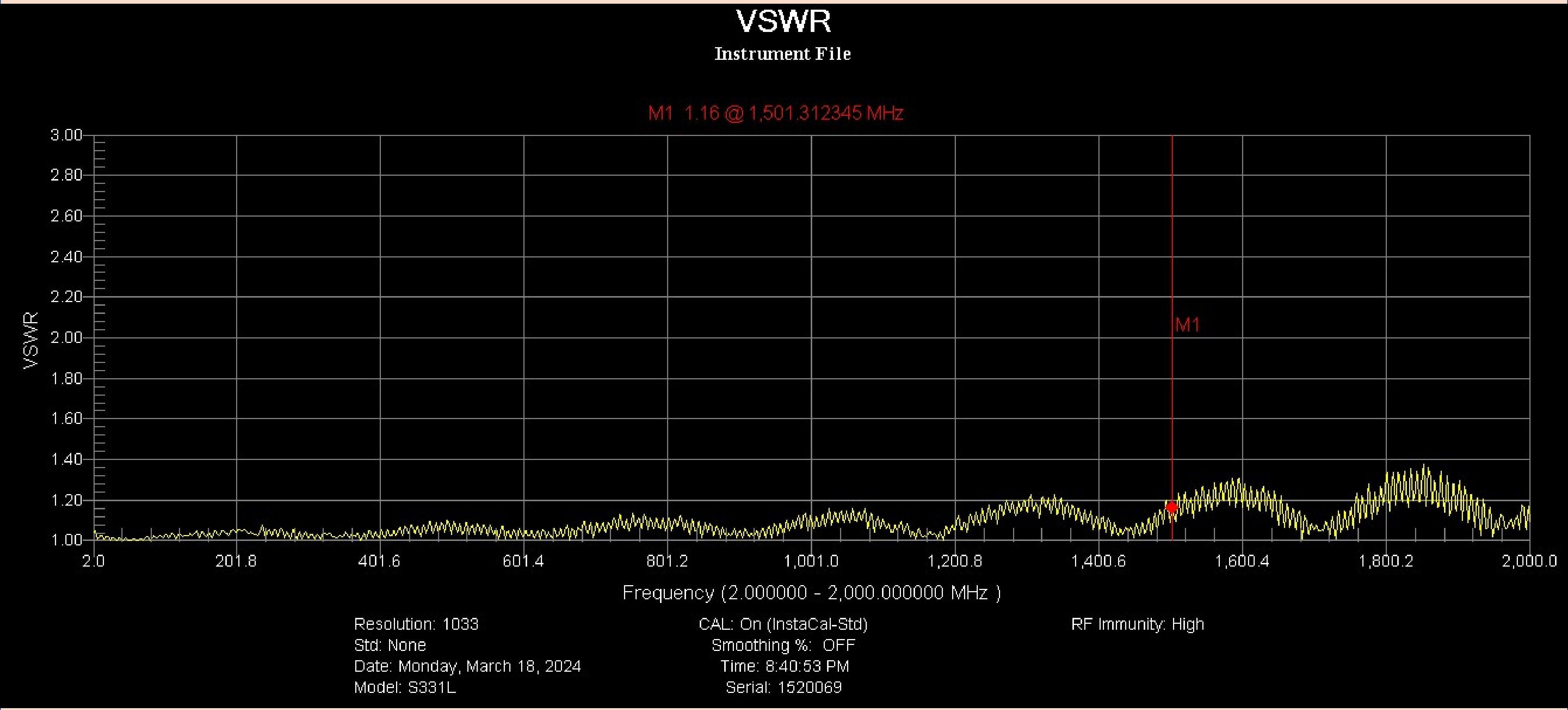
nanoVNA data



SiteMaster S331L Calibration 2 – 2000 MHz 2065 data points



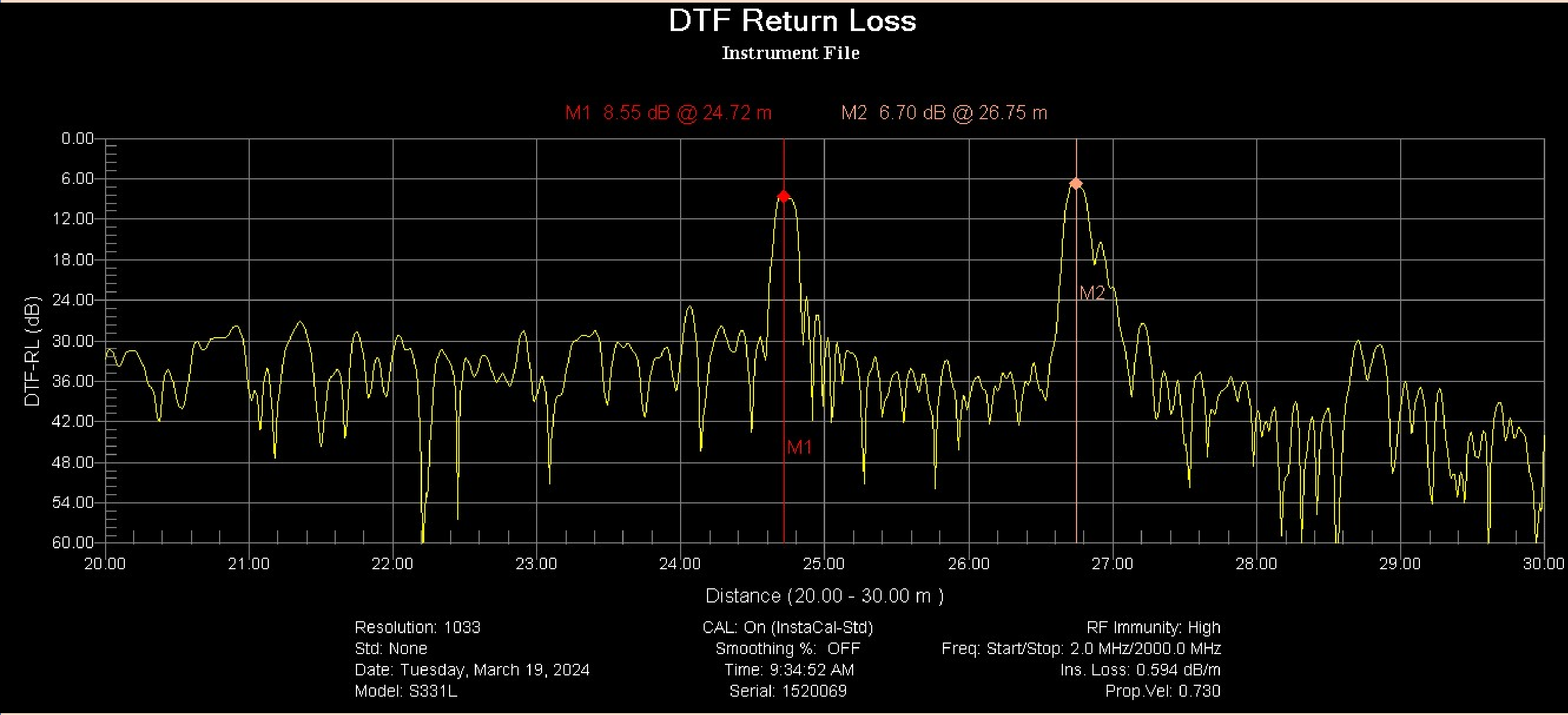
nanoVNA 1 – 1500 MHz 50 feet LMR 400 plus 50 ohm termination load



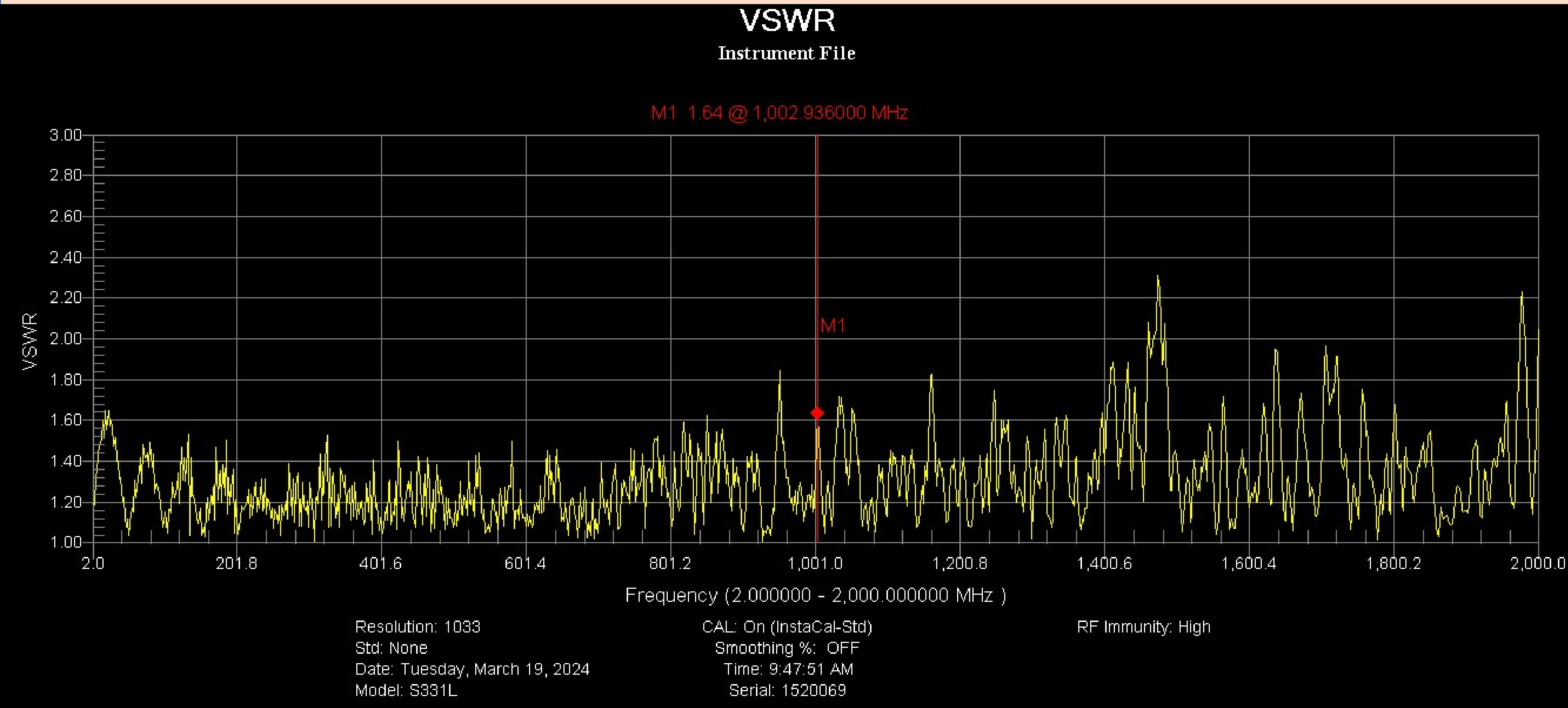
SiteMaster S331L 1 – 1500 MHz 50 feet LMR 400 plus 50 ohm termination

Transmission Line Network

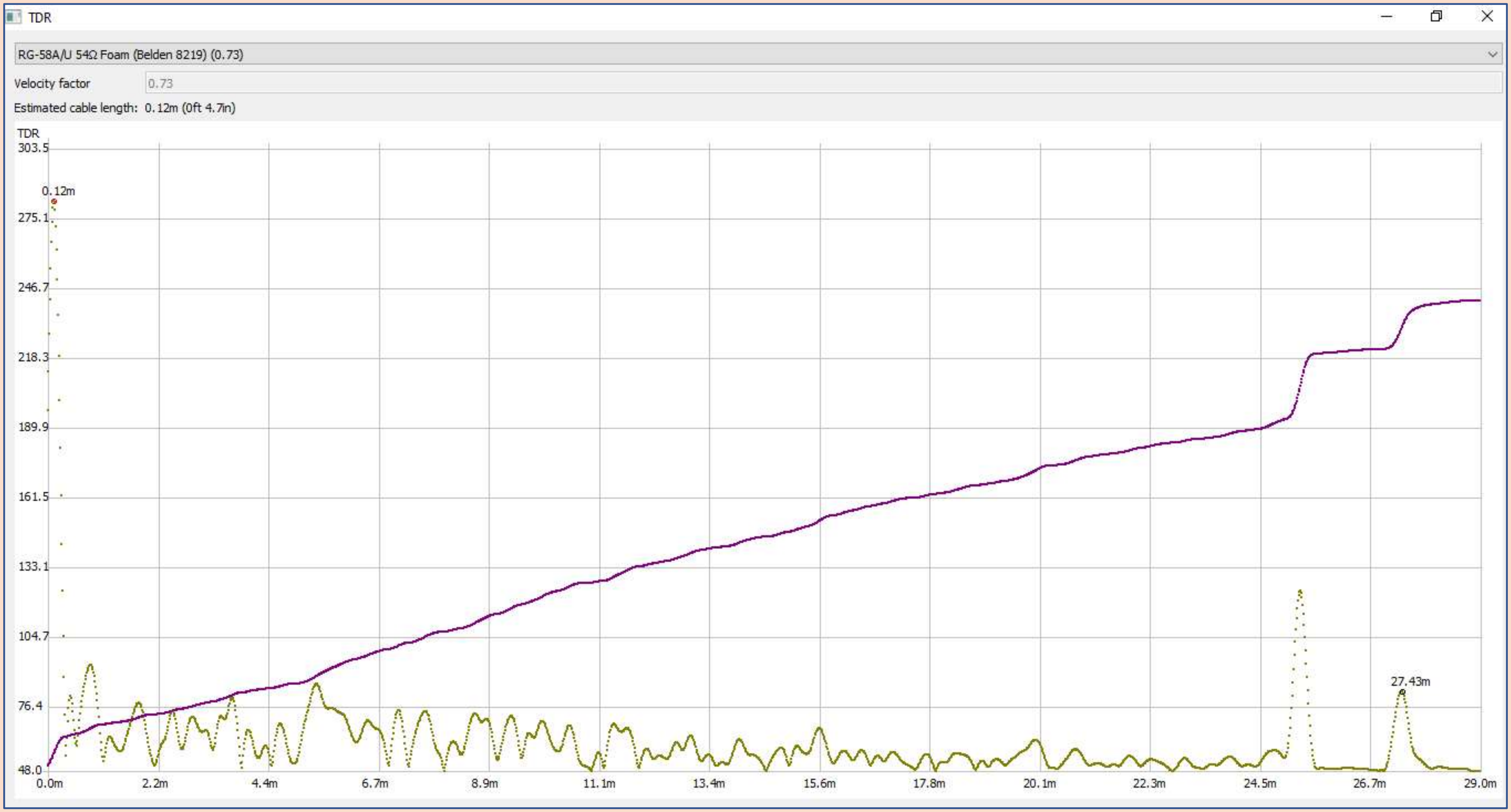
- RG 58a/u Z= 50 ohm 75 feet
- RG 59u Z = 75 ohm 10 feet
- Load Z = 50 ohm



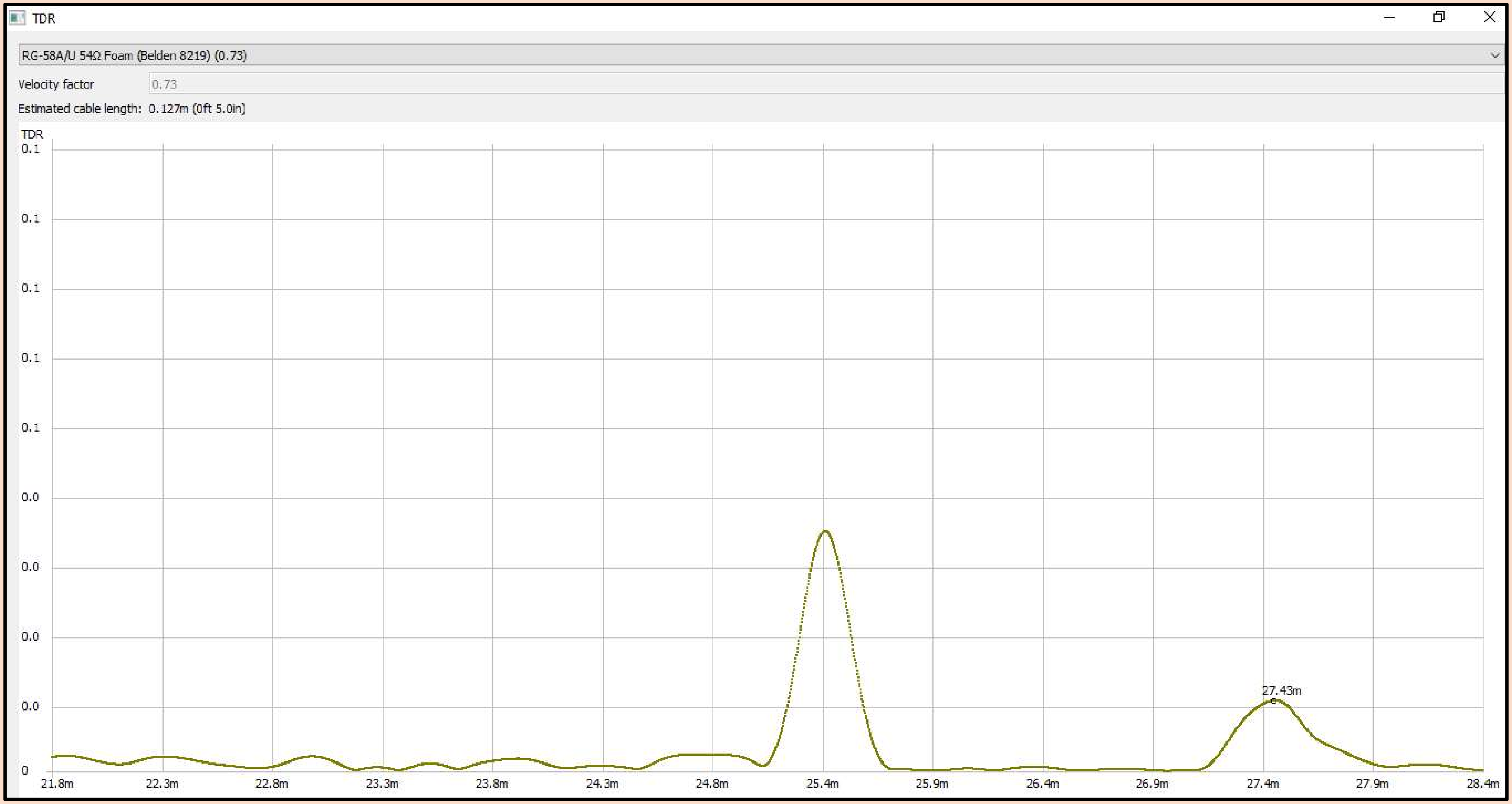
SiteMaster S331L DTF Transmission Line Network



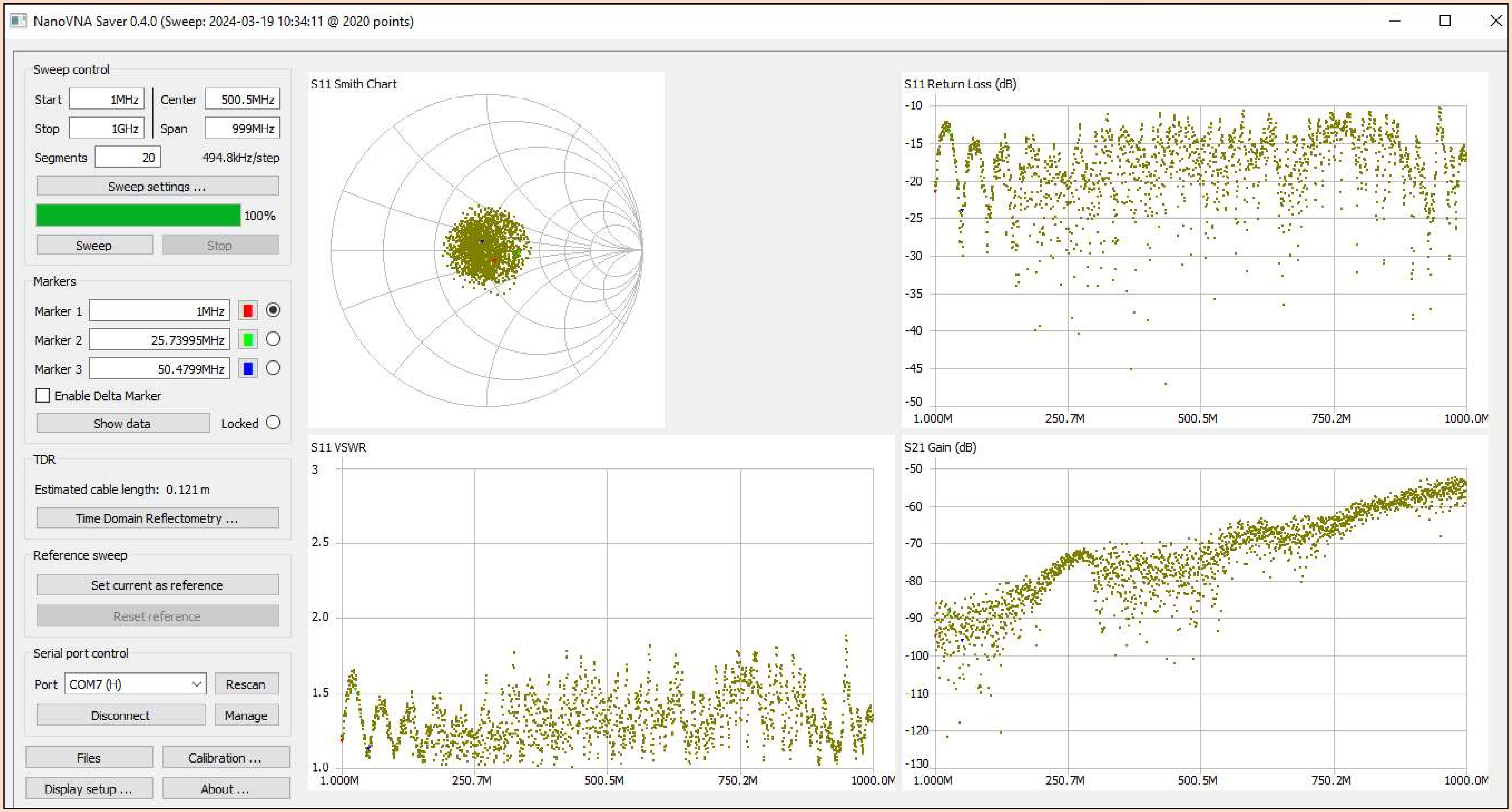
SiteMaster S331L VSWR Transmission Line Network



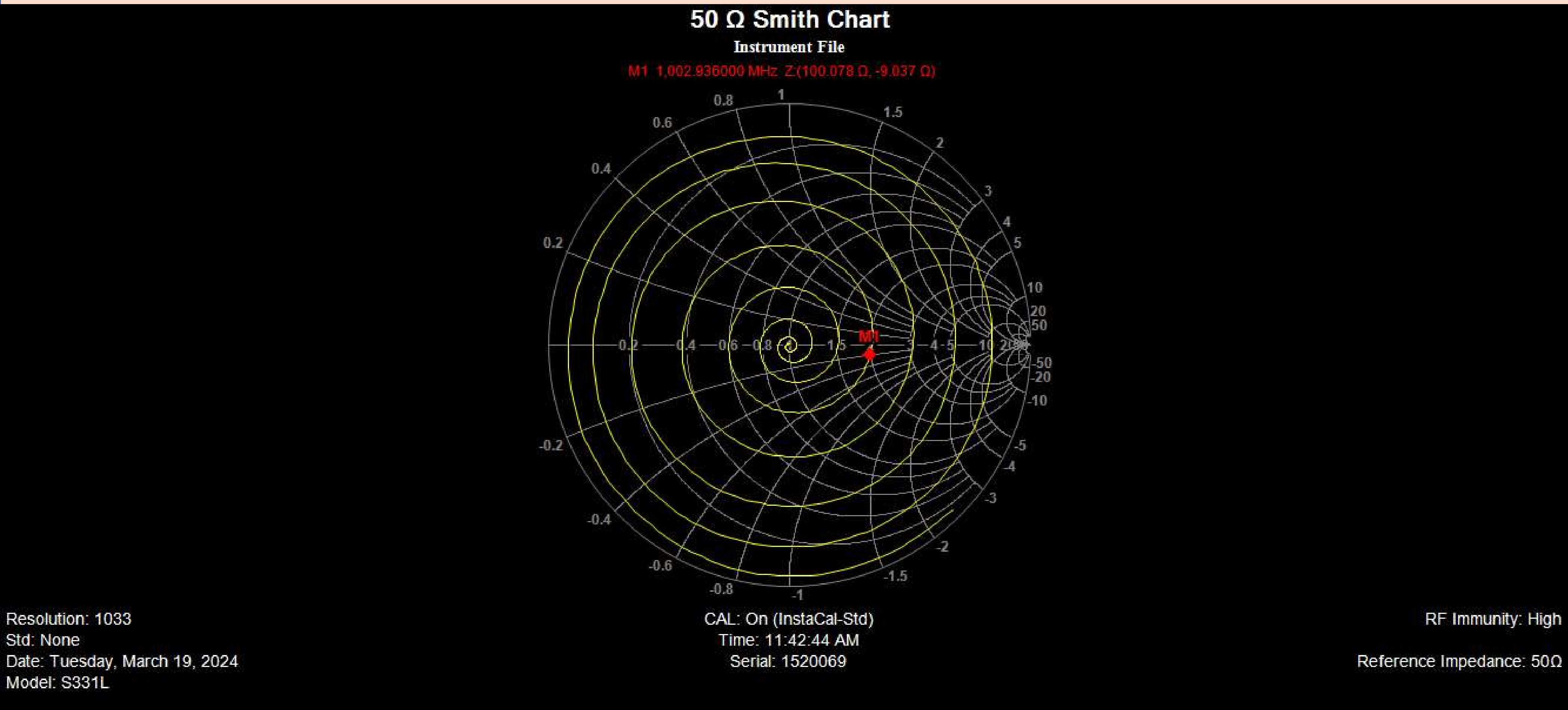
nanoVNA DTF Transmission Line Network



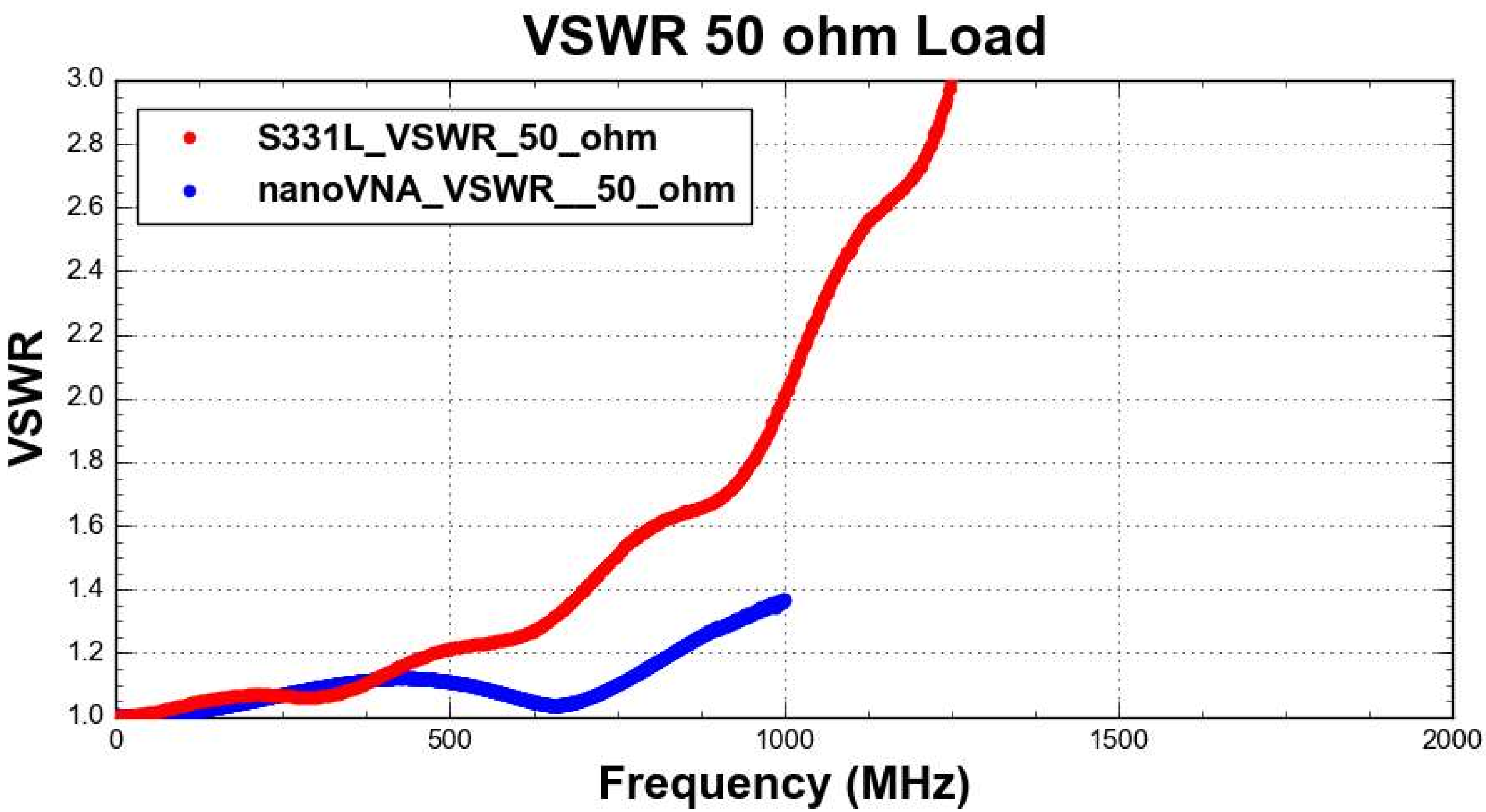
nanoVNA DTF   Transmission Line Network



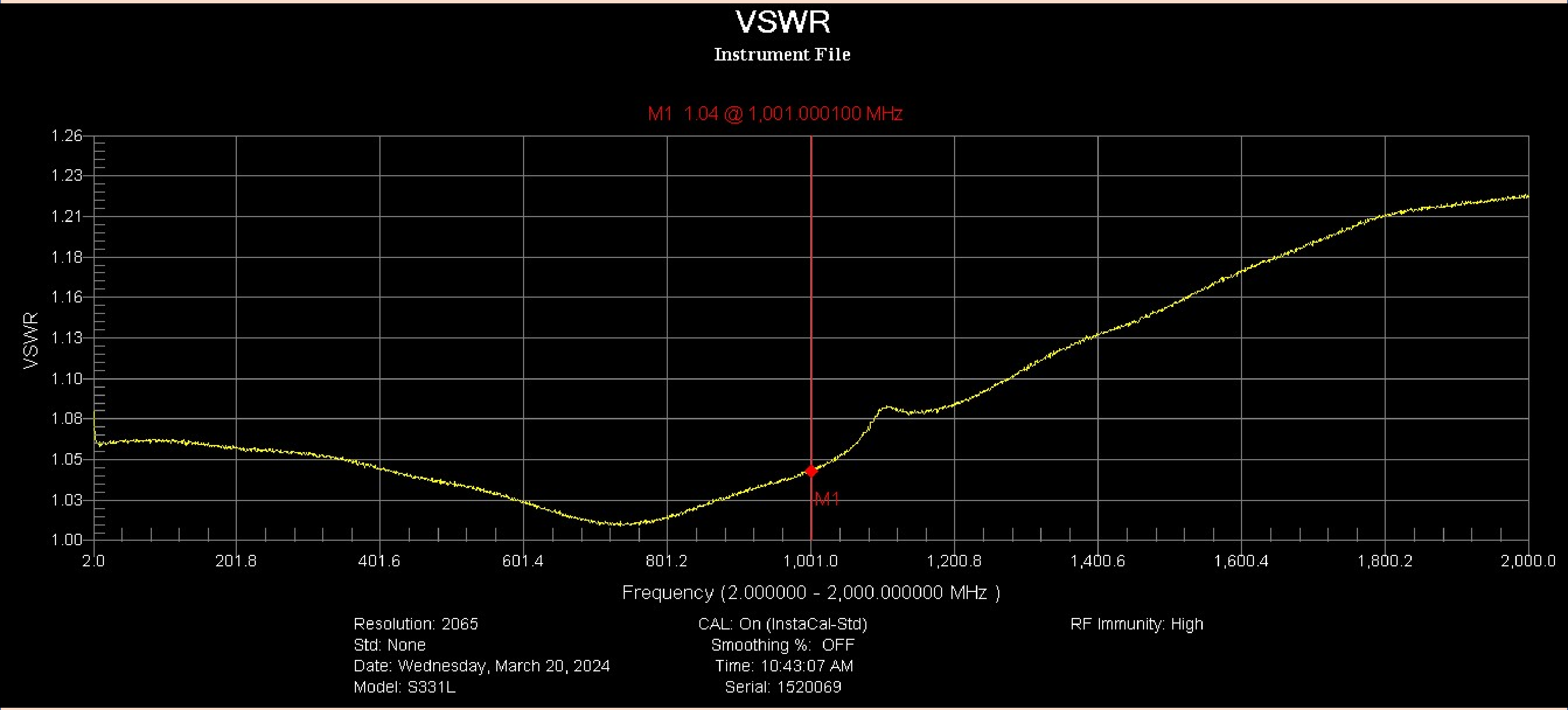
nanoVNA VSWR Transmission Line Network



SiteMaster S331L Smith Chart 50 ohm Load



SiteMaster S331L and nanoVNA SWR 50 ohm Load



SiteMaster S331L Calibration 2 – 2000 MHz 2065 data points