

NanoVNA and Ham Radio

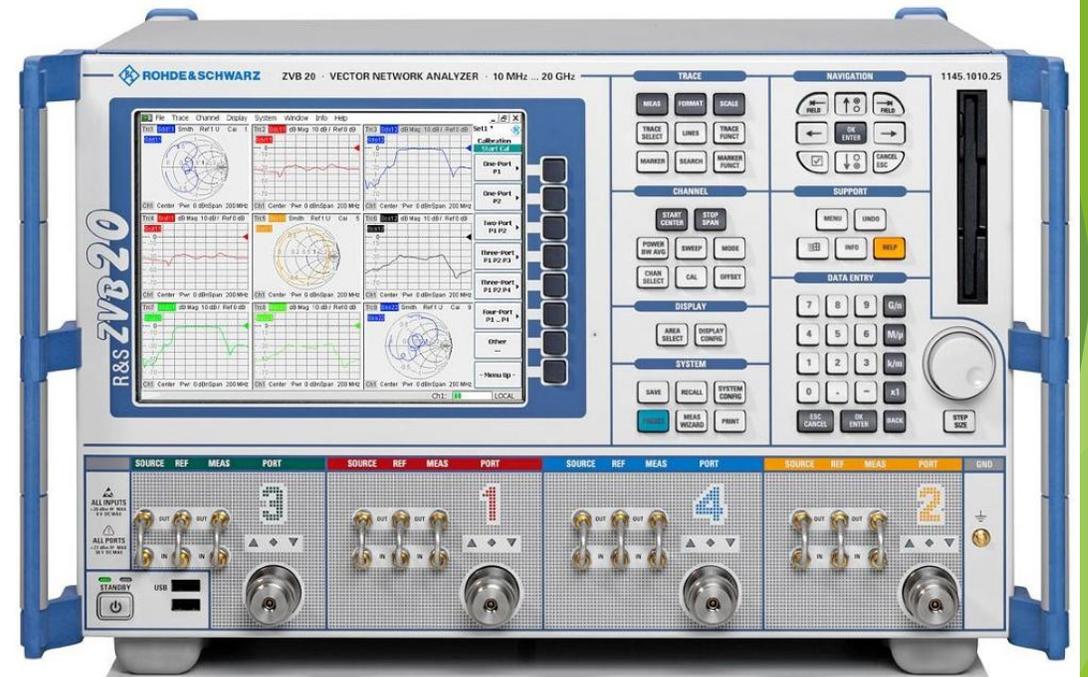
Why you want a NanoVNA but may not know it yet!

What is a NanoVNA?



A dual (1-1/2?) port analyzer that can measure SWR, resistance, reactance, cable length, and frequency response. Information is displayed in graphical and numeric formats. Can use software to display and store data on PC.

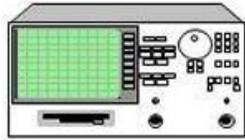
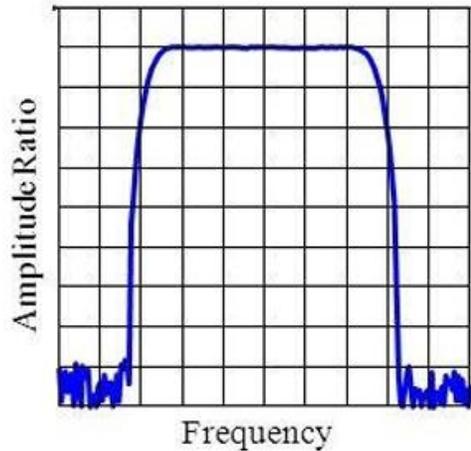
Professional Vector Network Analyzers



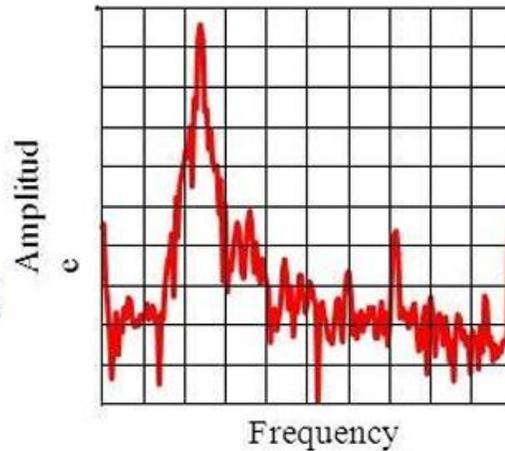
A professional Vector Network Analyzer can have much wider operating bandwidth and more bi-directional channels. They are much more expensive than a NanoVNA. These are a two-channel portable that operates from 9 KHz to 6 GHz and a four-channel model that operates from 10 MHz to 20 GHz. Some models operate up to 40 GHz and have up to 8 active channels.

A Nano VNA should not be confused with a TinySA!

Network Analyzers Vs Spectrum Analyzers



Measures known signal



Measures unknown signals

Network analyzers:

- measure components, devices, circuits, sub-assemblies
- contain source and receiver
- display ratioed amplitude and phase (frequency or power sweeps)
- offer advanced error correction

Spectrum analyzers:

- measure signal amplitude characteristics (carrier level, sidebands, harmonics...)
- can demodulate (& measure) complex signals
- are receivers only (single channel)
- can be used for scalar component test (*no phase*) with tracking gen. or ext. source(s)

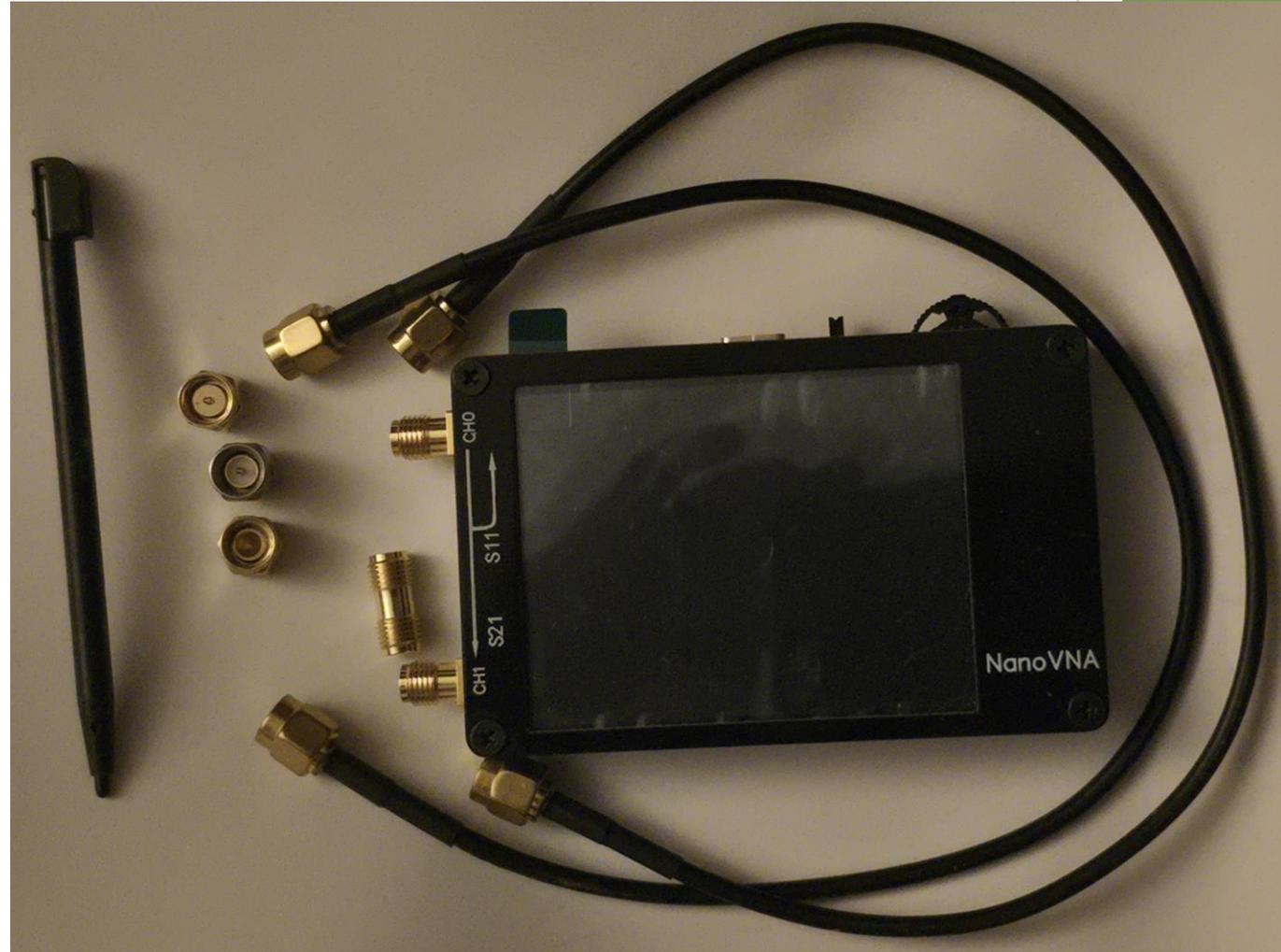
Common uses for a NanoVNA

- Antenna testing and tuning
 - Standing Wave Ratio measurements
 - Resonance Measurements
 - Complex Impedance Measurements
 - Resistance
 - Reactance
- Cable testing and fault isolation
 - Length Measurements
 - Distance to impedance changes
 - Distance to faults.
- Testing tuned circuits
 - Filter bandpass
 - Trap resonance
 - Analyze duplexers
- Measure Insertion Loss

What do we need to use a NanoVNA?

- ▶ NanoVNA body
- ▶ SMA 50Ω LOAD
- ▶ SMA SHORT
- ▶ SMA OPEN
- ▶ SMA F to F Barrel Connector
- ▶ SMA Male to Male cable x 2
- ▶ Stylus (Optional)

- ▶ Not included are adapters need to connect to Device Under Test (DUT)



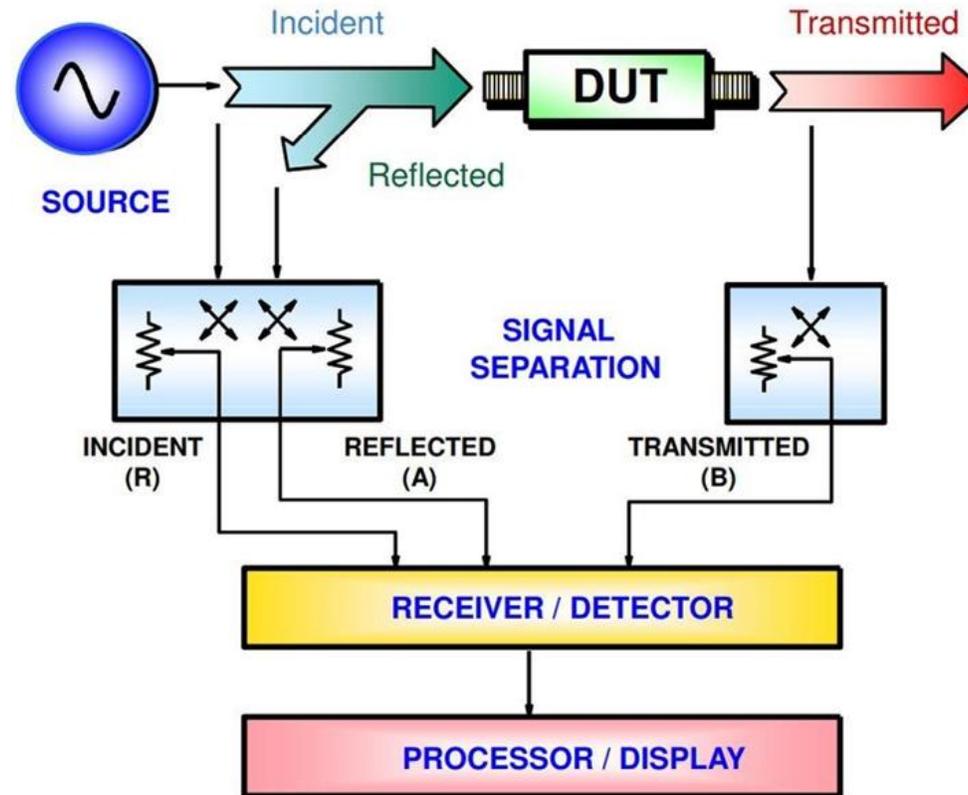
How does a NanoVNA work?

▶ VNA (Vector Network Analyzer) measures the frequency characteristics of reflected power and passing power of an RF Network. NanoVNA measures the following elements:

- ▶ Input voltage I/Q signal
- ▶ Reflected voltage I/Q signal
- ▶ Pass voltage I/Q signal

▶ From here we calculate:

- ▶ Reflection coefficients S_{11}
- ▶ Transmission coefficient S_{21}



NanoVNA Output

- ▶ NanoVNA measures the reflection coefficient and transmission coefficient for 101 points in the frequency band to be measured. It measures the Start Frequency and then steps up 100 times, measuring at each step.
- ▶ The local frequency of NanoVNA is 50kHz to 300MHz. For higher frequencies, use harmonic mode. The fundamental wave is not attenuated even in harmonic mode.
- ▶ The usage modes for each frequency are as follows.
 - ▶ Up to 300 MHz: fundamental wave
 - ▶ 300MHz to 900MHz: 3rd harmonic
 - ▶ 900MHz to 1500MHz: 5th harmonic
- ▶ Note that there is always a fundamental wave input, especially when checking a dual band antenna. The 2 Meter band is in the fundamental range and the 70 Centimeter band is in the third order harmonic range.
- ▶ Digital data is signal processed by the MCU.

To Prepare for Use

- ▶ Determine the frequency range to be measured
 - ▶ The NanoVNA measures at 101 points within the range selected
 - ▶ The range should be limited to the relevant band
- ▶ Determine the type of measurement
 - ▶ SWR, Return Loss, other S11 measurements only require a partial calibration
 - ▶ Insertion loss, filter bandwidth, other S21 measurements require full calibration
- ▶ Calibrate for the frequency range and type
 - ▶ Set start and stop frequencies, or center frequency and span
 - ▶ Calibrate as needed: Open, Short, Load, Isolation, Through

Calibration

- ▶ Open Menu
- ▶ Cal
- ▶ Reset current calibration state. Select CAL MENU →RESET
- ▶ Then →CALIBRATE
- ▶ Connect OPEN standard to CH0 port and execute →OPEN
- ▶ Connect SHORT standard to CH0 port and execute →SHORT
- ▶ Connect the LOAD standard to the CH0 port and execute →LOAD
- ▶ Connect the LOAD standard to CH0 and CH1 ports and execute →ISOLN
 - (If there is only one load, the CH0 port can be left unconnected)*
- ▶ Connect a cable between the CH0 and CH1 ports, and execute →THRU
- ▶ Finish calibration and calculate error correction information →DONE
- ▶ Specify the dataset number (0 to 4) and save.

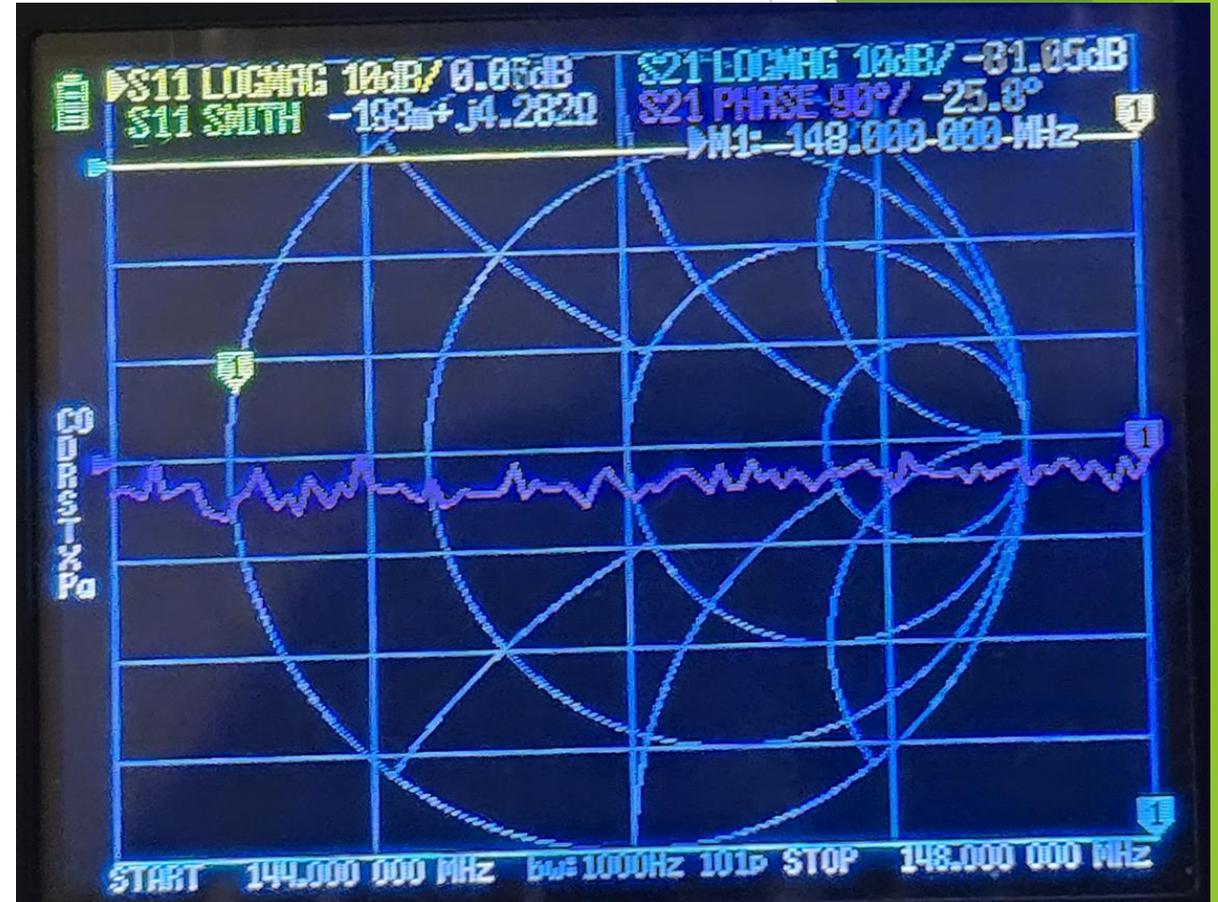
Menu
Cal
→RESET
→CALIBRATE
→OPEN
→SHORT
→LOAD
→ISOLN
→THRU
→DONE
→SAVE 0

Select Measurement(s)

- ▶ LOGMAG : Logarithm Magnitude of absolute value of measured value of the Return Loss
- ▶ PHASE : Phase in the range of -180° to $+180^{\circ}$
- ▶ DELAY : Delay
- ▶ SMITH : Smith Chart
- ▶ SWR : Standing Wave Ratio
- ▶ POLAR : Polar coordinate format
- ▶ LINEAR : Absolute value of the measured value
- ▶ REAL : Real number of measured value
- ▶ IMAG : Imaginary number of measured value
- ▶ RESISTANCE : Resistance component of the measured impedance
- ▶ REACTANCE : The reactance component of the measured impedance

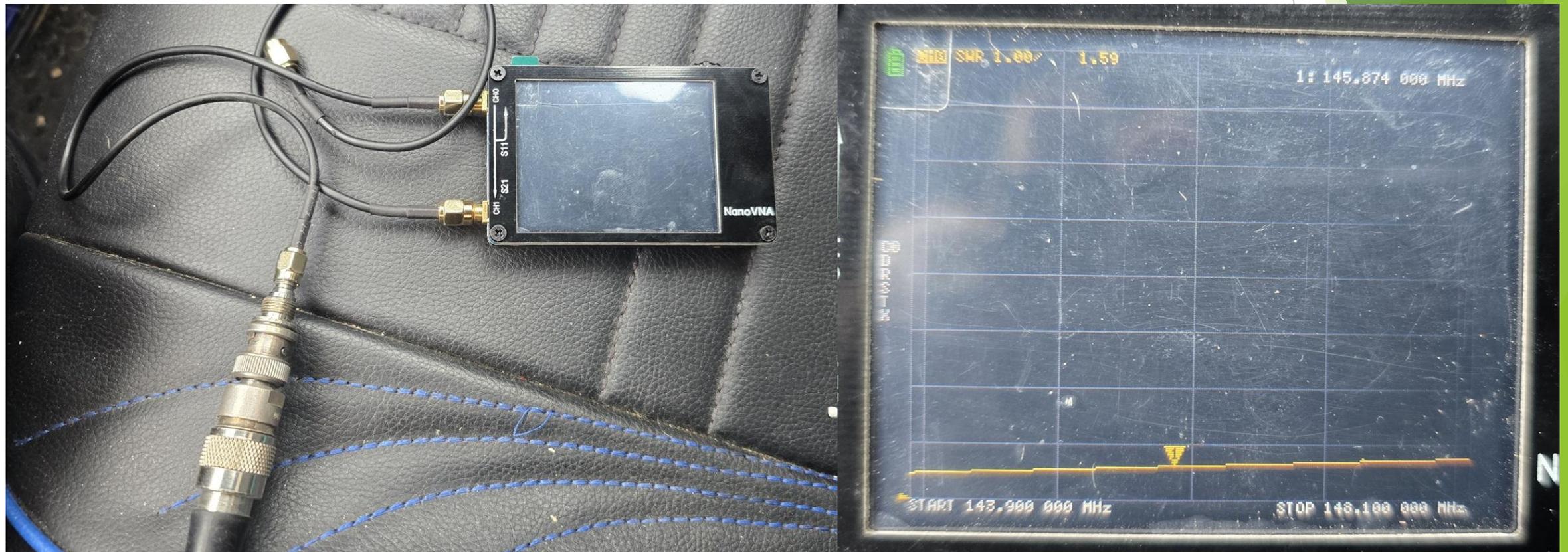
Select Display Trace

- ▶ Four Traces available, with different colors
- ▶ Multiple Markers can be displayed and selected
- ▶ Display shows start and stop frequencies
- ▶ Display shows calibration information



Connect and Measure

- ▶ Adapt as needed, paying attention to characteristic impedance
- ▶ Measure!



NanoVNA Saver

- ▶ Windows Software
- ▶ Interfaces with USB port on NanoVNA
- ▶ Controls NanoVNA and displays data
- ▶ Saves data
- ▶ Can compare current data to saved reference

NanoVNA Saver 0.7.3.0

Sweep control

Start Center
Stop Span
Segments 1 Hz/step
Sweep settings ...
0%
Sweep Stop

Markers

Marker 1
Marker 2
Marker 3
 Enable Delta Marker Reference
Hide data Locked

TDR

Estimated cable length:
Time Domain Reflectometry ...

Reference sweep

Set current as reference
Reset reference

Serial port control

Port Rescan
Connect to device Manage

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

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

Min VSWR: _____
Return loss: _____

S21

Min gain: _____
Max gain: _____

S11 Smith Chart

S11 Return Loss (dB)

S21 Polar Plot

S21 Gain (dB)

Analysis ...

Summary

- ▶ NanoVNA is an inexpensive and versatile piece of test equipment
- ▶ A NanoVNA can make a variety of measurements
 - ▶ Antennas
 - ▶ Filters
 - ▶ Duplexers
 - ▶ Cables
 - ▶ Components
- ▶ You need to Calibrate your NanoVNA before use
 - ▶ Calibrate for the band/mode to be tested
 - ▶ Calibration can be saved for later use
- ▶ NanoVNA Saver software allows saving of reference and data files