Workshop on using NanoVNA to test aerials/antennae using a mini-far field setup in the workshop. EUCARA Harwell Campus UK September 2025

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With grateful thanks to Bryan Harber G8DKK for use of his slides and Jason Burntfield for his help in preparation of workshop

Topics

- Nano Vector Network Analyser
- NanoVNA Features
- Calibration
- NanoVNA Measurements
- NanoVNA PC Software
- Using NanoVNA to check your amateur radio telescope – this will be covered in the demonstration

NanoVNA-H 2.8” Package

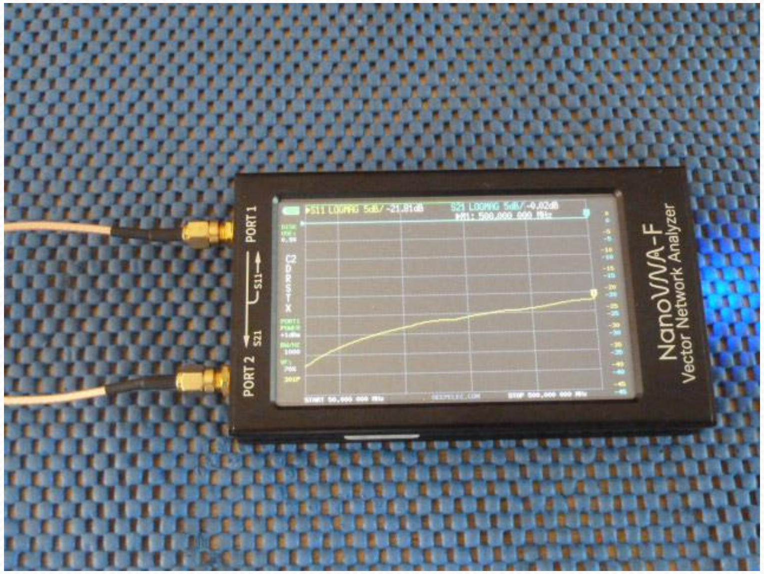
NanoVNA Features

- Built-in touch screen, LCD Display
  - 2.8”, 4” and 4.3” versions
- Handheld, stand-alone 2-Port VNA
  - Frequency ranges 50kHz to 600MHz, 900MHz, 1.5GHz, 3GHz, 4GHz, (6GHz)
  - Not just an antenna analyser
  - Measure VSWR/Return Loss, Gain/Loss & cable length
  - Must be calibrated with a Cal Kit
  - Linear or Polar (Smith Chart) displays
- Measurement Points originally fixed at 101 points, upgrade now 51, 201, 301 and more in some models
- Internal rechargeable Lithium battery

VSWR

- VSWR, or Voltage Standing Wave Ratio, is a measure of how efficiently radio frequency (RF) power is transmitted from a source to a load, like an antenna.

NanoVNA Frequency Ranges



Frequency Range	50kHz–300MHz	300MHz–600MHz	600MHz-900MHz
S_{11} Dynamic Range	>60dB	>50dB	>40dB
S_{21} Dynamic Range	>70dB	>70dB	>60dB
Harmonic	Fundamental	3rd Harmonic	3rd Harmonic

S11 dynamic range

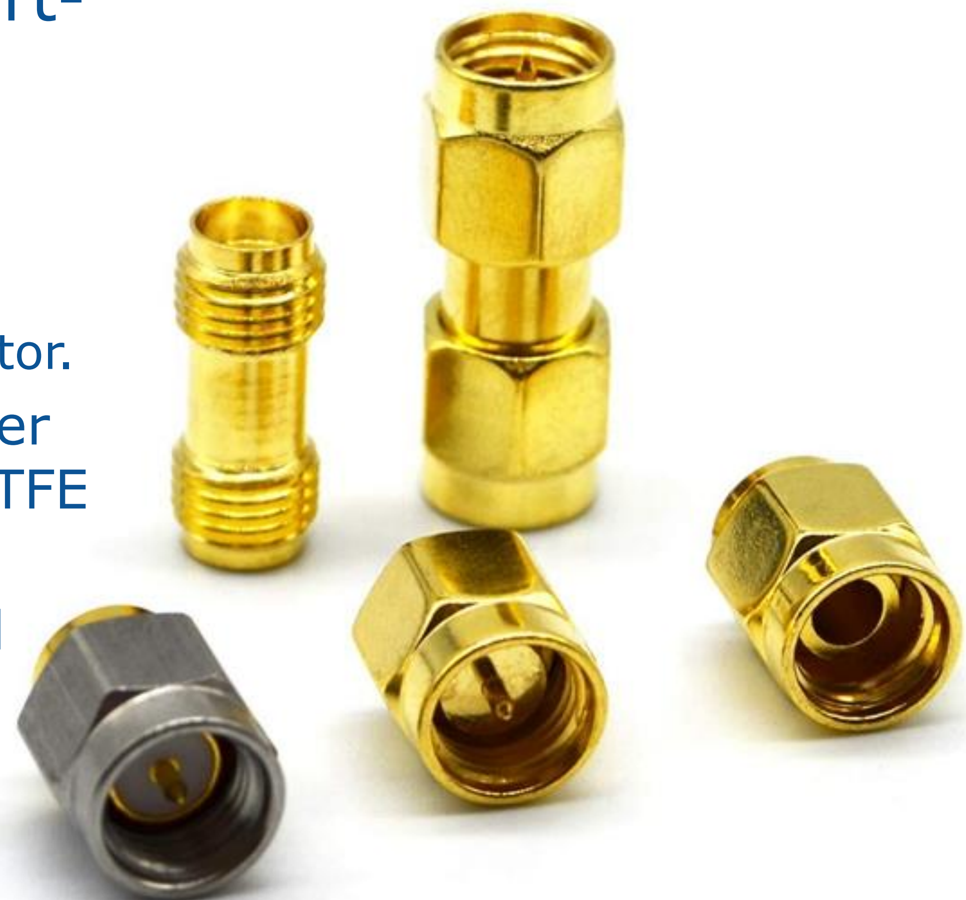
- S11 Parameter indicates amount of power reflected back from input port of network when output port terminated with matched load.
- S11 dynamic range refers to decibel (dB) difference between maximum signal level that Vector Network Analyzer (VNA) can accurately measure & minimum detectable signal level, for S11 parameter (reflection coefficient). In simpler terms, it indicates how well the VNA can measure both strong and weak reflected signals from a device under test (DUT).

S21 dynamic range

- S21 Parameter, also known as forward transmission coefficient, represents ratio power leaving port 2 to power entering port 1 (power transfer). In simpler terms, it indicates how well a signal passes through a device or system from input to output.
- S21 dynamic range is the range of signal levels that can be accurately measured for signal transmission (S21) through a Device Under Test (DUT) = Difference between maximum measurable signal level & VNA noise floor when measuring S21. Higher dynamic range allows for more accurate measurements of devices with a wide range of transmission characteristics.

NanoVNA Calibration Kits

- NanoVNA provided with SMA male S.O.L.T. (Short-Open-Load-Through) calibration kit:
  - Short – male SMA with pin protruding from flat 4mm diameter disc. No PTFE insulator.
  - Open – male SMA with outer ring but no inner pin. No PTFE insulator.
  - Load – male SMA 50Ω load
  - Through - 2 lengths coax provided for through-cal when SOLT calibration required.



NanoVNA Calibration

- A single port calibration is suitable for one port devices like antennas (aerials) or dummy loads
  - Only the short, open and load (SOL) are necessary
  - Options are to calibrate directly at test port 1 (Ch 0 in H version) or at the end of a cable connected to test port 1
- Two port devices require calibration at the end of a single cable, even when 2 cables are used
- From the architecture we can infer that port 2 for the through measurement only compensates for the source match
  - There is no "through match" calibration possible

Port 2 Test

- Set a wide span for example 50MHz to 500MHz
- Connect one of the cables to port 1 + SMA female adapter
- Press “Reset” and perform a Short, Open, Load Calibration
  - Press done immediately after the Load calibration
  - Store the calibration in one of the stores
- Connect the cable to Port 2 and run the marker to max frequency. Note the marker value
- Now press “Reset” & perform a new SOLT calibration at the end of cable. Store in same store (or different)
- Connect cable to Port 2 and note the marker value and trace shape. It will be the same as first measurement

Calibration at End of Cable

- An important aspect of a VNA is the ability to calibrate at the end of a coaxial cable
  - A "cable" could also be connector adapters (e.g. test just the aerial on your H-Line setup by calibrating at end of cable you use to connect to the aerial for the test.)
  - The calibration pieces from the cal kit are applied to the end of the cable attached to the Tx port, port 1
  - This type of calibration reduces cable ripple
  - Using 2 cables, the cable on the Rx port, port 2 is more difficult to reduce cable ripple as it relies on the source port calibration plus the match of the Rx port

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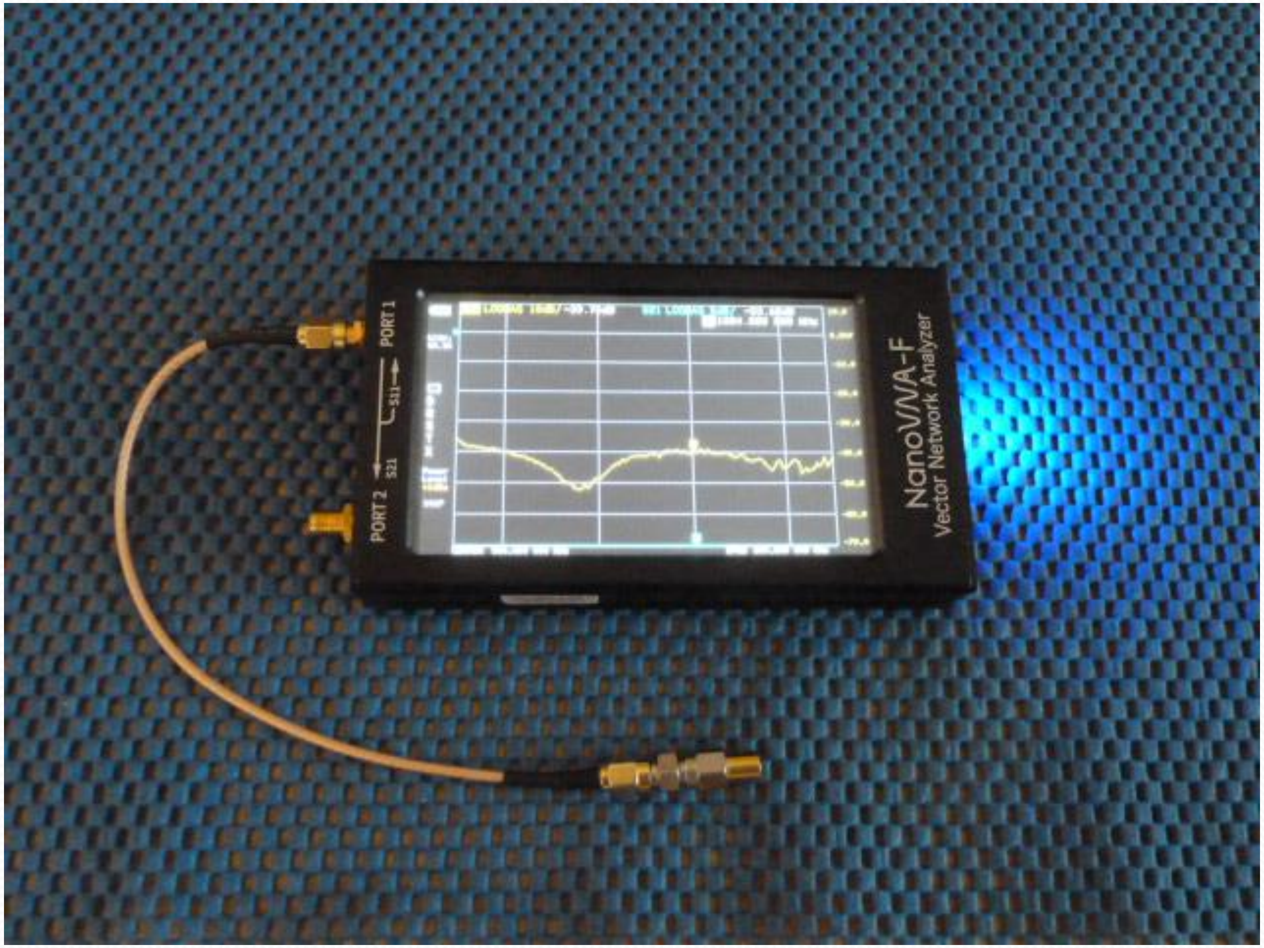
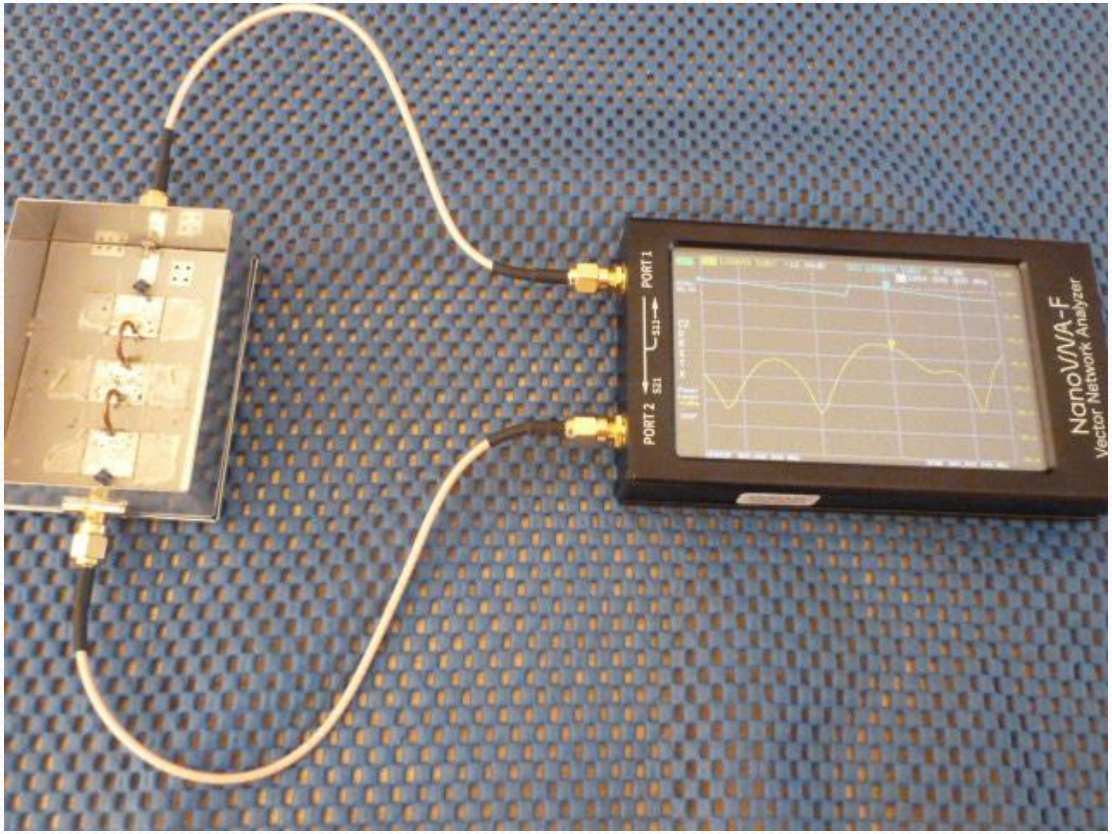
This means antennas can be tested using cables that will be used in live observations but separate results from cables measured

Calibration at End of Cable

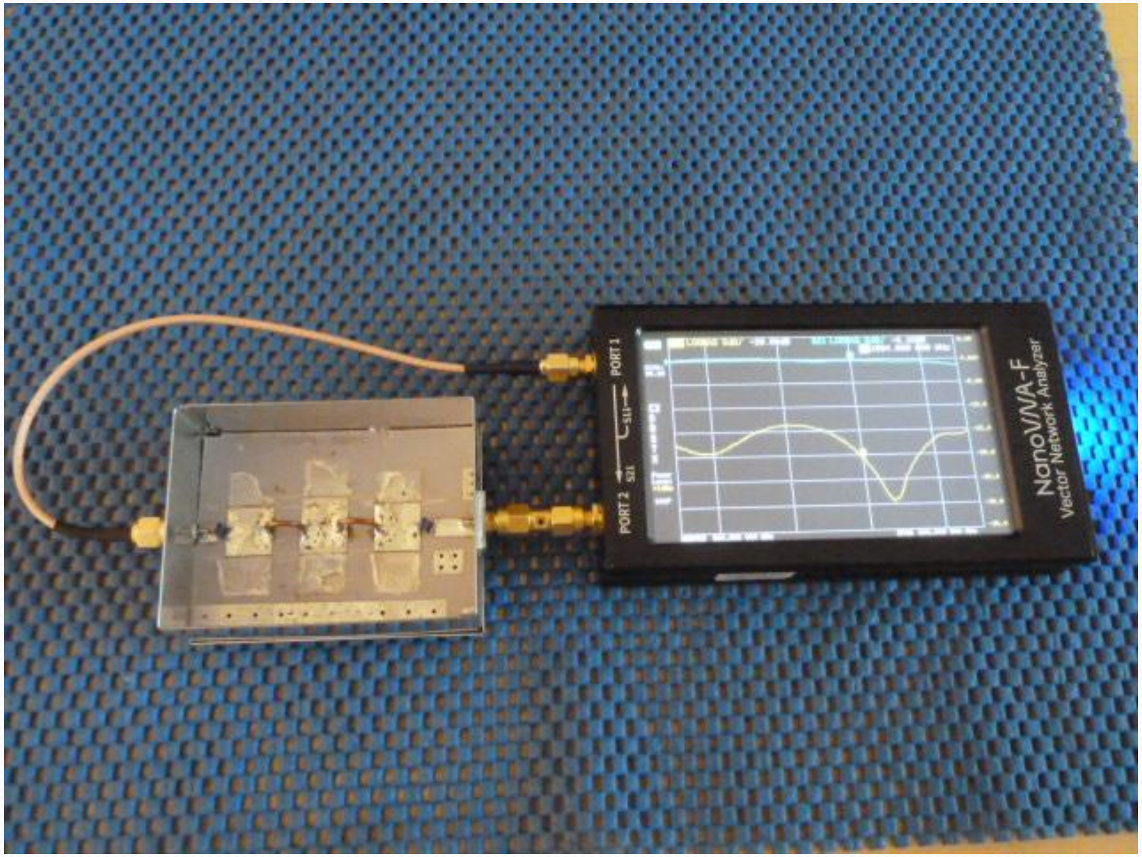


NanoVNA Measurements



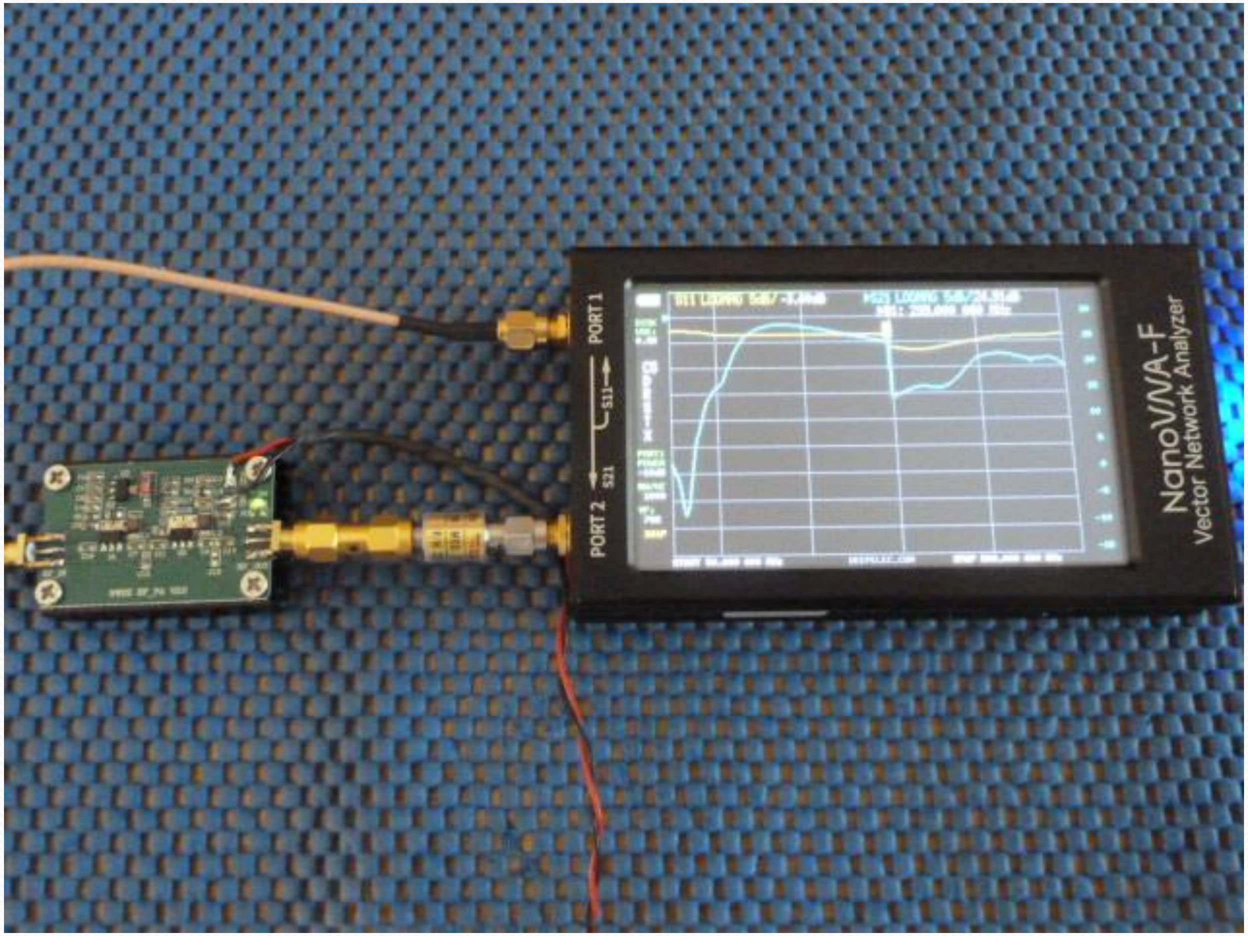
1500MHz LP Filter swept from 500MHz to 1300MHz
Two cables

Single Cable with D.U.T

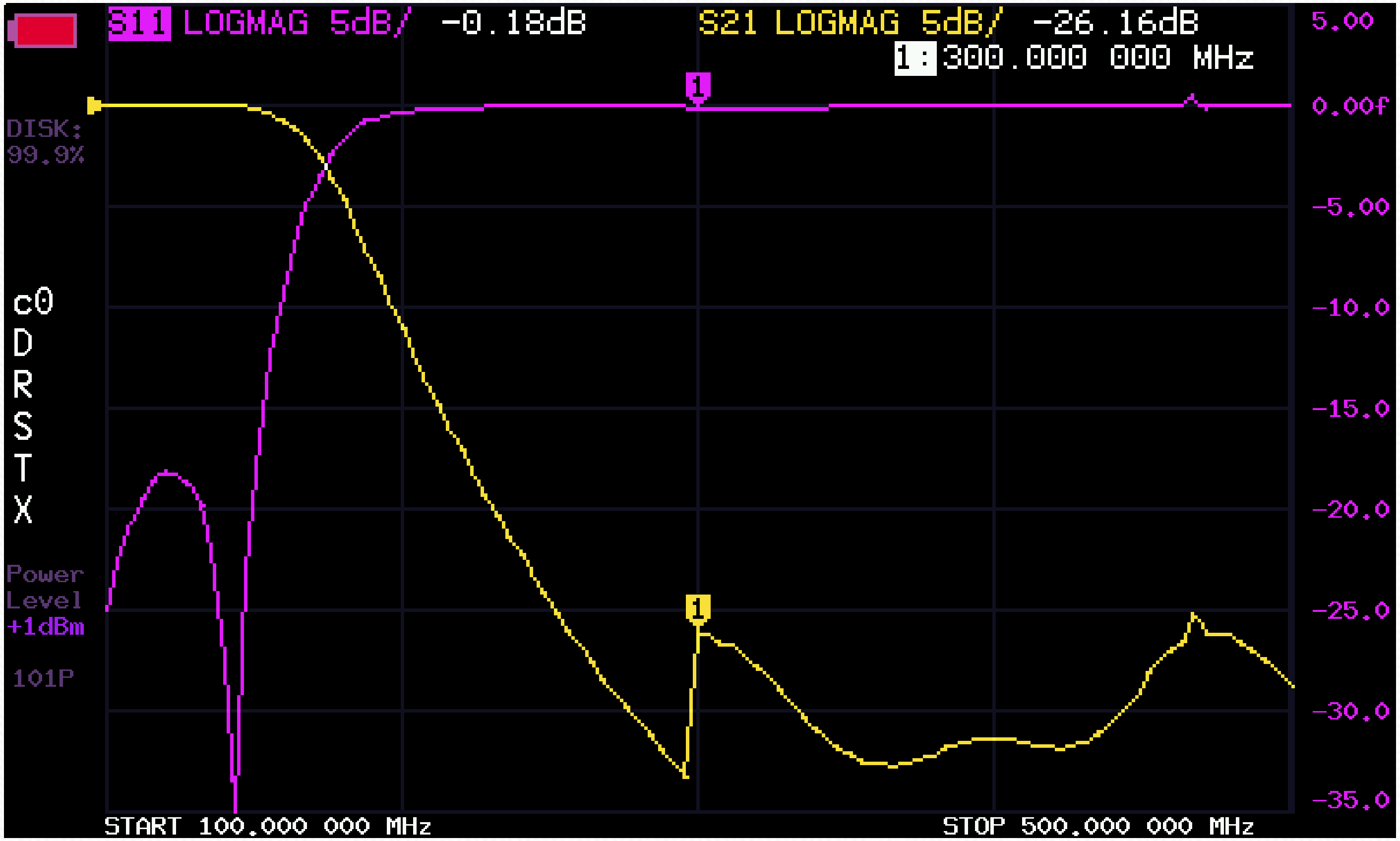


1500MHz LP Filter swept from 500MHz to 1300MHz

Amplifier Measurement



NanoVNA-F Screen Capture



Smith Chart

- Named after Phillip Hagar Smith, introduced in Electronics magazine Jan 1939.
- Designed to simplify mathematical calculations & allow problems to be solved graphically using compass, ruler + pencil.
- Still useful for visualizing complex impedances, especially as function of frequency.
- Mainly used when for one-port measurements, particularly to visualize reflection coefficients. It represents the load impedance, ZL, relative to source impedance, Z0. Complex impedance values can be plotted as individual points or as lines that depict impedance over range of frequencies.

Smith Chart Display - Load

Smith Chart - Short

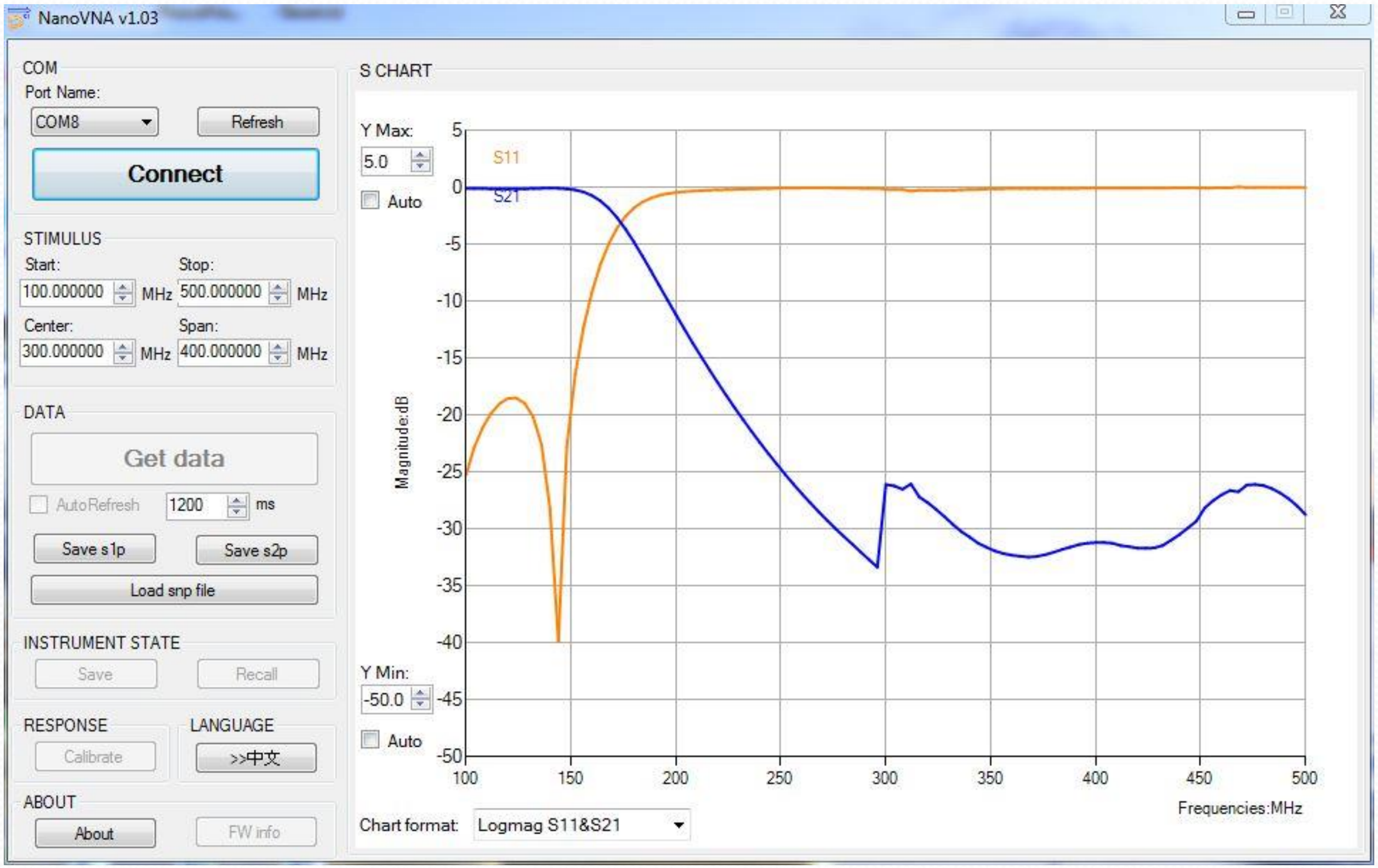
Nano VNA Software

NanoVNA#, NanoVNA server

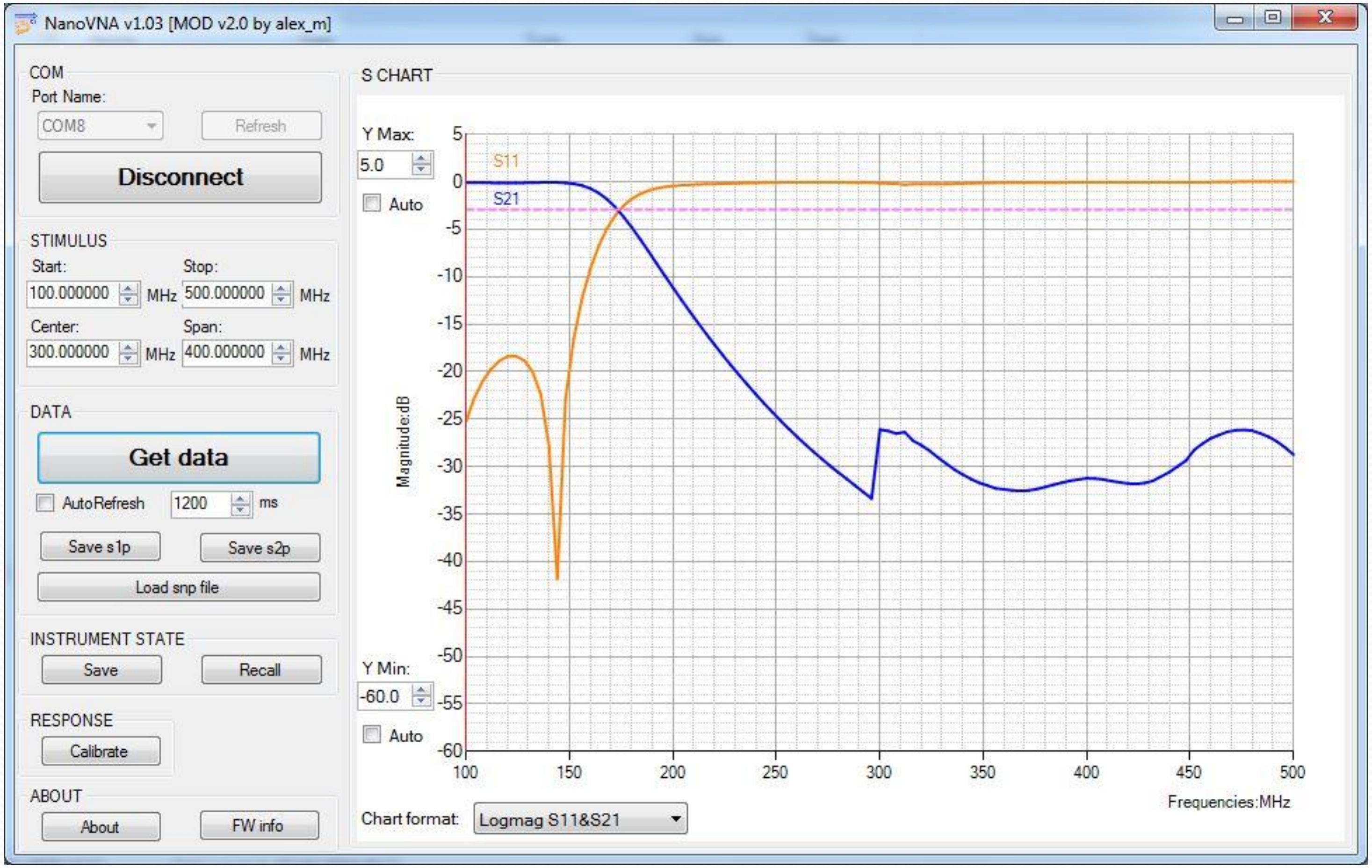
NanoVNA PC Software

- The NanoVNA-F manual points to two PC software packages for use with these units:
  - **Nanovna.exe**
  - **Nanovna-saver by Rune B. Broberg**
  - **A modified version of nanovna is nanovna#**
- NanoVNA & NanoVNA# are capture & display programs. They can run calibration routines but 101 points only plus save & load files in Touchstone format
- NanoVNA-saver is a large program with many features including chaining sweeps to gain more than 101 display points

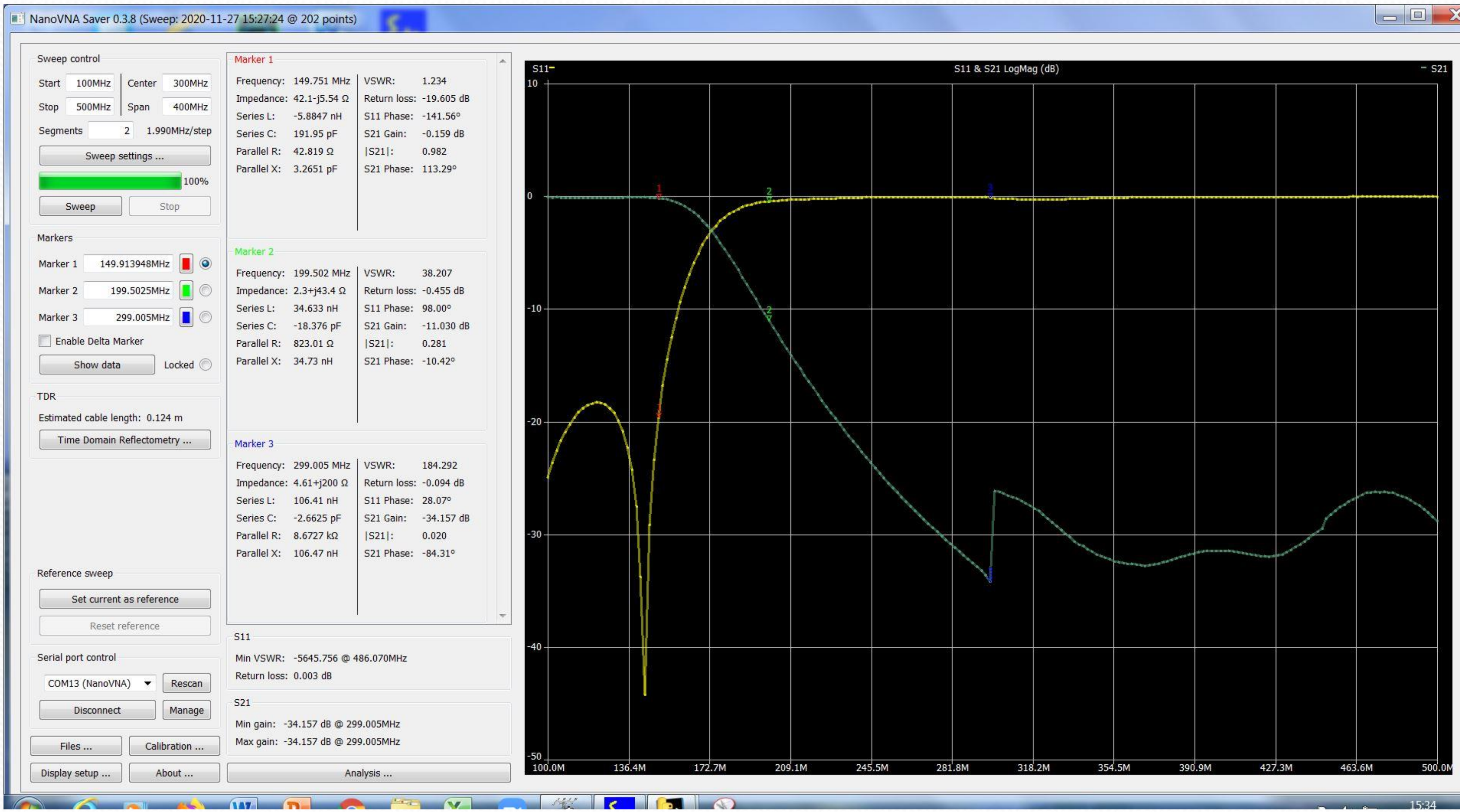
NanoVNA V1.03 170MHz LPF



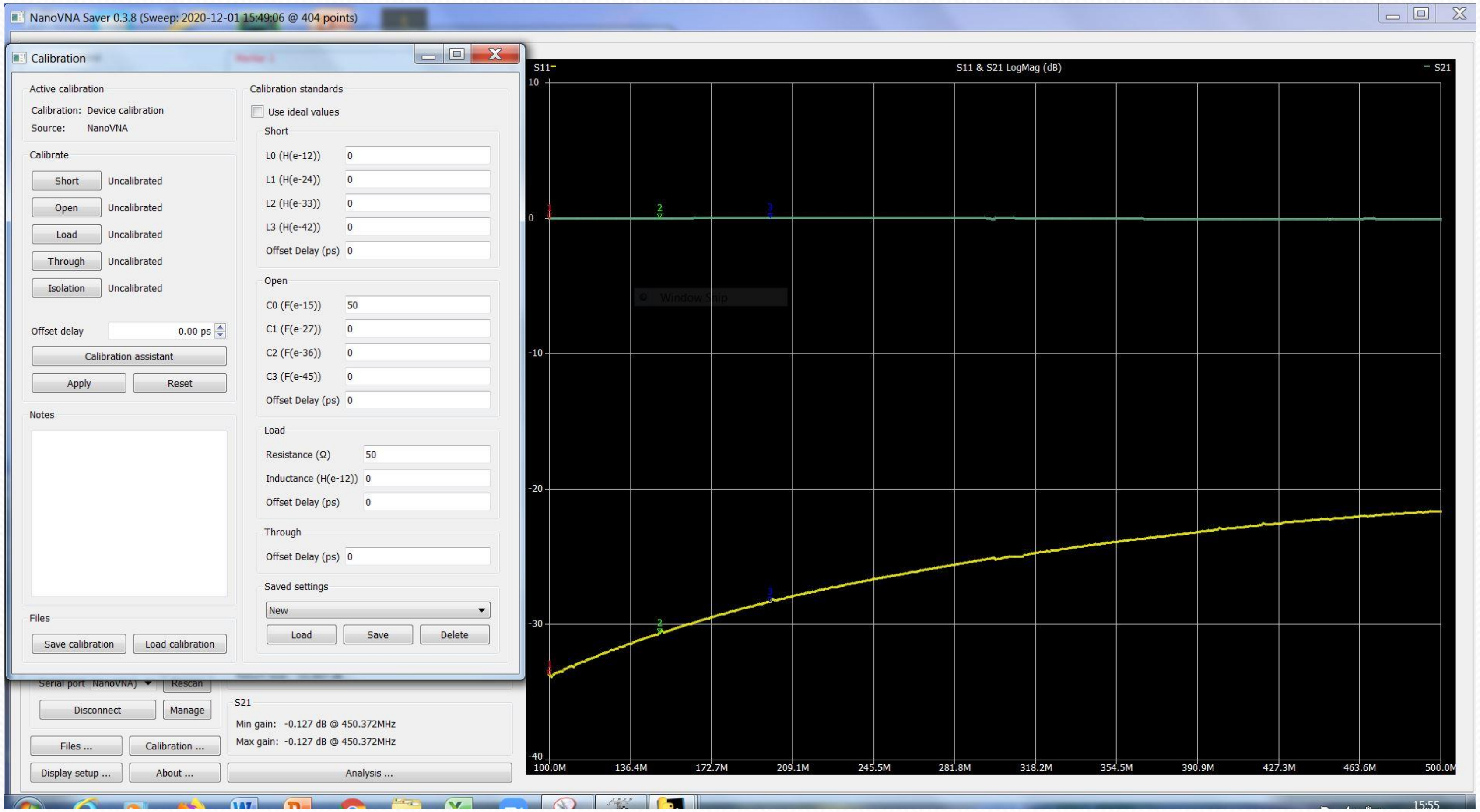
NanoVNA Sharp Capture



NanoVNA Saver

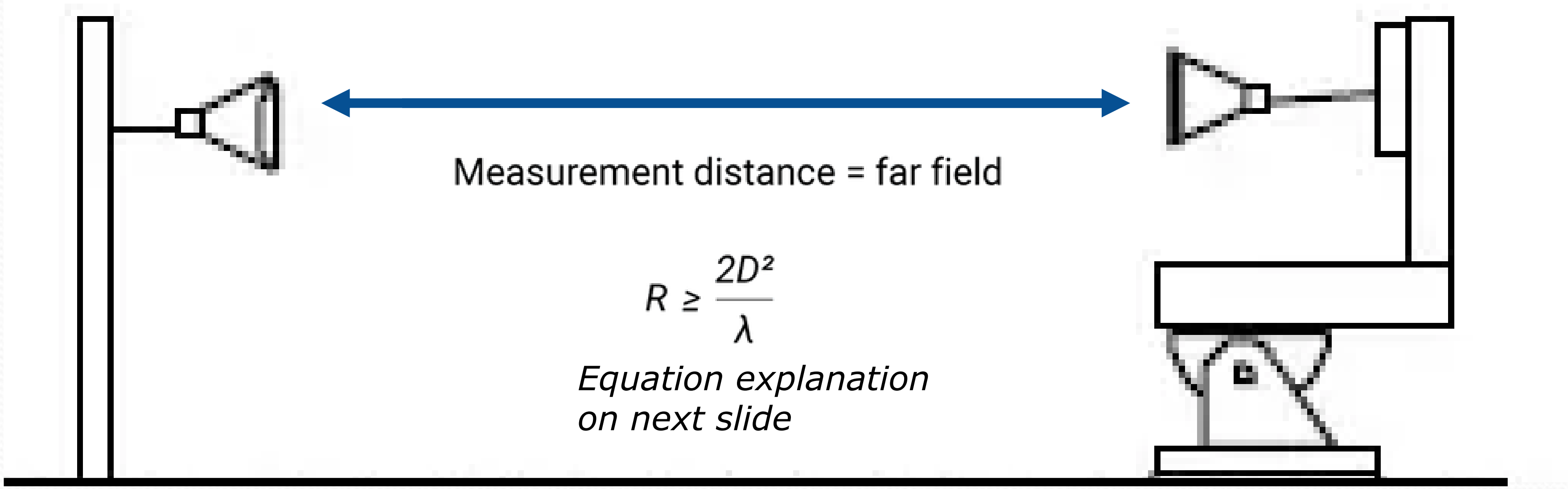


NanoVNA Saver – Cal Kits



Indoor antenna testing range

Ideally in anechoic chamber, but we don't have one today, so hopefully all of you will absorb any reflections!

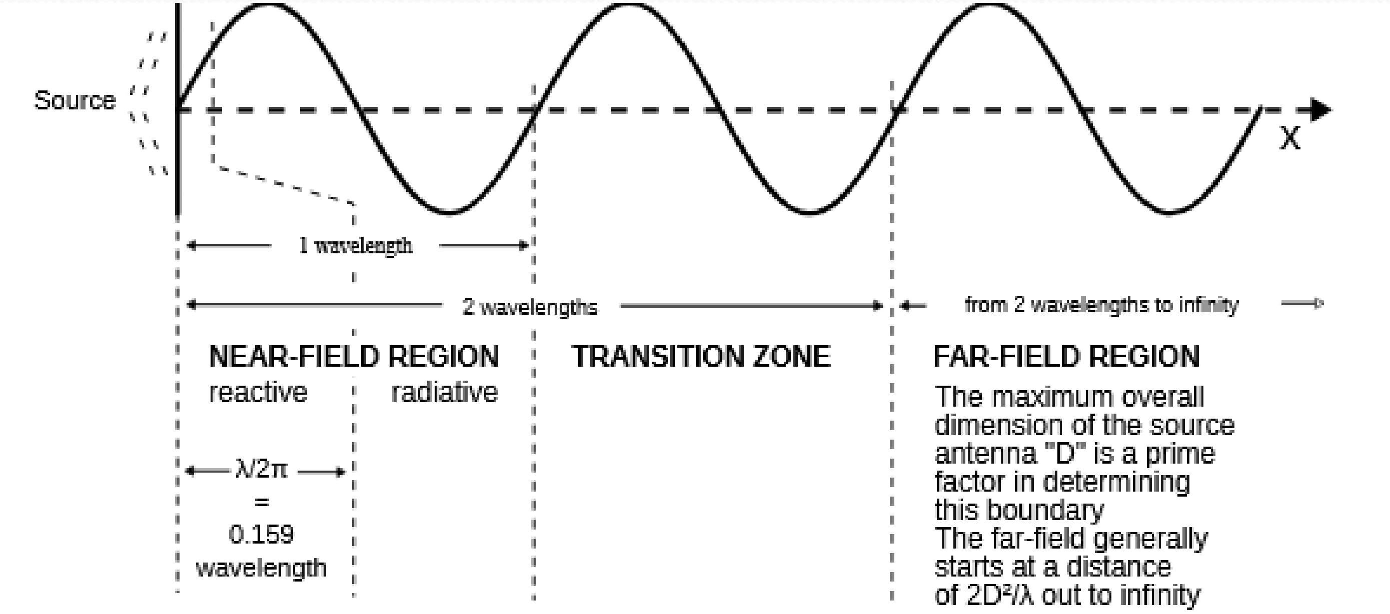


Equation explanation on next slide

Signal Source

Aerial under test, able to move
Also known as Device Under Test (DUT)

General Far Field Condition



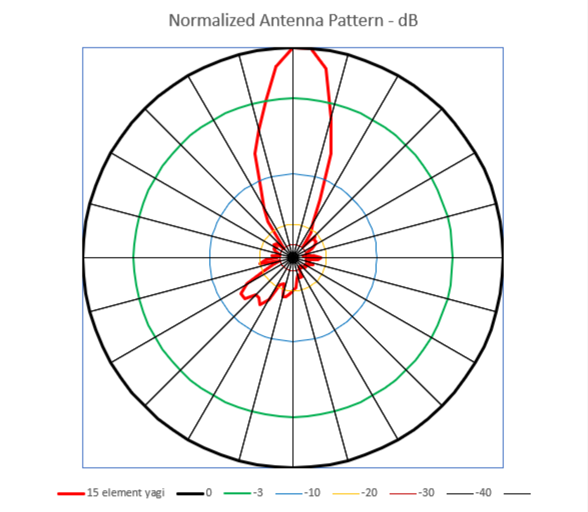
- “Rule of thumb" for determining if a point is in the far field is to check if the distance (r) from the source is much greater than $\lambda/2\pi$ (where λ is the wavelength).
- Far field starts at distance from source of 2 x square of diameter of source antenna (“D”) / wavelength being used for test.

Jason Burnfield's Excel Template to plot mini-antenna range measurements

Jason Burnfields antenna test template 5 degree resolution 230525.xlsx - Excel

E3 =10^($E$2/$G$1)

	A	B	C	D	E	F	G	H	I	J	K
1		15 element yagi				scale	25				
2	theta	dB	-10.00		0	-3	-10	-20	-30	-40	
3	360	10.00	0.00	1	1	0.76	0.398	0.158	0.063	0.025	1
4	355	10.00	0.00	1	1	0.76	0.398	0.158	0.063	0.025	0
5	350	9.00	-1.00	0.91	1	0.76	0.398	0.158	0.063	0.025	0
6	345	6.00	-4.00	0.69	1	0.76	0.398	0.158	0.063	0.025	1
7	340	3.00	-7.00	0.52	1	0.76	0.398	0.158	0.063	0.025	0
8	335	-3.00	-13.00	0.3	1	0.76	0.398	0.158	0.063	0.025	0
9	330	-8.00	-18.00	0.19	1	0.76	0.398	0.158	0.063	0.025	1
10	325	-11.00	-21.00	0.14	1	0.76	0.398	0.158	0.063	0.025	0
11	320	-19.00	-29.00	0.07	1	0.76	0.398	0.158	0.063	0.025	0
12	315	-11.00	-21.00	0.14	1	0.76	0.398	0.158	0.063	0.025	1
13	310	-12.00	-22.00	0.13	1	0.76	0.398	0.158	0.063	0.025	0
14	305	-12.00	-22.00	0.13	1	0.76	0.398	0.158	0.063	0.025	0
15	300	-13.00	-23.00	0.12	1	0.76	0.398	0.158	0.063	0.025	1
16	295	-15.00	-25.00	0.1	1	0.76	0.398	0.158	0.063	0.025	0
17	290	-19.00	-29.00	0.07	1	0.76	0.398	0.158	0.063	0.025	0
18	285	-20.00	-30.00	0.06	1	0.76	0.398	0.158	0.063	0.025	1
19	280	-23.00	-33.00	0.05	1	0.76	0.398	0.158	0.063	0.025	0
20	275	-15.00	-25.00	0.1	1	0.76	0.398	0.158	0.063	0.025	0
21	270	-12.00	-22.00	0.13	1	0.76	0.398	0.158	0.063	0.025	1
22	265	-13.00	-23.00	0.12	1	0.76	0.398	0.158	0.063	0.025	0
23	260	-20.00	-30.00	0.06	1	0.76	0.398	0.158	0.063	0.025	0
24	255	-20.00	-30.00	0.06	1	0.76	0.398	0.158	0.063	0.025	1
25	250	-15.00	-25.00	0.1	1	0.76	0.398	0.158	0.063	0.025	0
26	245	-17.00	-27.00	0.08	1	0.76	0.398	0.158	0.063	0.025	0
27	240	-20.00	-30.00	0.06	1	0.76	0.398	0.158	0.063	0.025	1
28	235	-18.00	-28.00	0.08	1	0.76	0.398	0.158	0.063	0.025	0
29	230	-18.00	-28.00	0.08	1	0.76	0.398	0.158	0.063	0.025	0
30	225	-22.00	-32.00	0.05	1	0.76	0.398	0.158	0.063	0.025	1
31	220	-20.00	-30.00	0.06	1	0.76	0.398	0.158	0.063	0.025	0
32	215	-22.00	-32.00	0.05	1	0.76	0.398	0.158	0.063	0.025	0
33	210	-22.00	-32.00	0.05	1	0.76	0.398	0.158	0.063	0.025	1
34	205	-15.00	-25.00	0.1	1	0.76	0.398	0.158	0.063	0.025	0
35	200	-15.00	-25.00	0.1	1	0.76	0.398	0.158	0.063	0.025	0
36	195	-17.00	-27.00	0.08	1	0.76	0.398	0.158	0.063	0.025	1



Test1

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