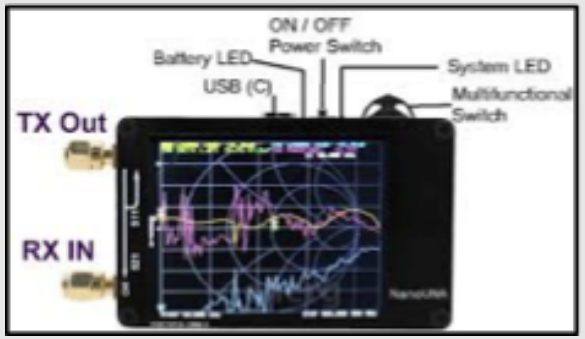
An Introduction to NanoVNA Vector Network Analyzers



Hamfesters Radio Club
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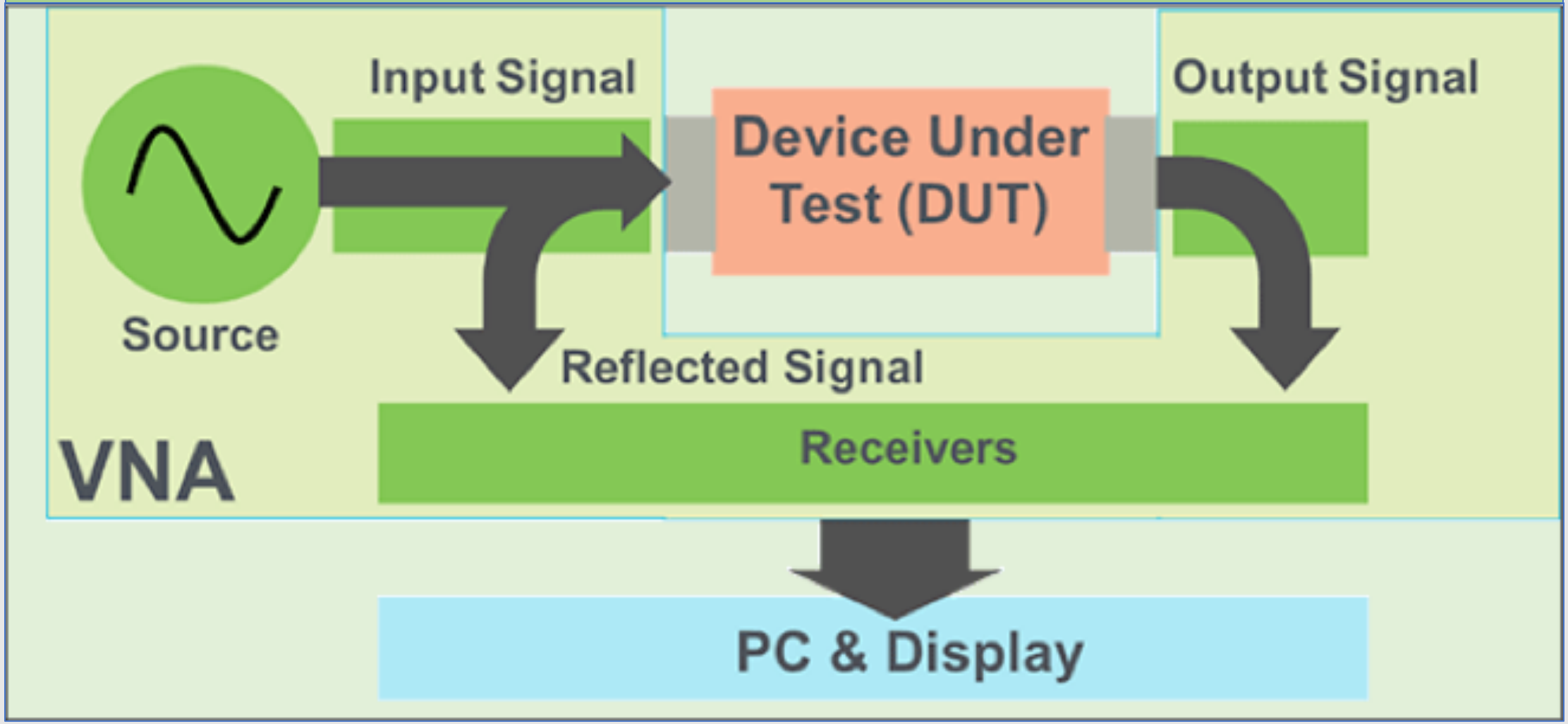
Gregory D. Rosenberg

What is a Vector Network Analyzer (VNA)

- A VNA contains both a **source**, used to generate a known stimulus **signal**, and a **set of receivers**, used to determine **changes to this stimulus** caused by the **device-under-test** or (**DUT**).
- The **stimulus signal is injected** into the **DUT** and the VNA measures both the **signal that's reflected** from the **input side**, as well as the signal that passes through to the output side of the DUT.
- The Vector Network Analyzer **receivers measure the resulting signals** and **compare them to the known stimulus signal**. The measured results are then processed by either the VNA's internal processor (or an external PC) and sent to a display.

Visual Representation of How a VNA Works



What is a NanoVNA used for (1 of 3)

- Vector Network Analyzers (VNAs) are used to perform two types of measurements:
  - Transmission Measurements
  - Reflection Measurements
    - Testing Antenna SWR
    - Testing Coax Performance
  - Testing Circuits
  - Testing Coils

What is a NanoVNA used for (2 of 3)
Transmission Measurements

- Transmission measurements pass the Vector Network Analyzer stimulus signal through the **device under test**, which is then measured by the VNA's receivers on the other side.
- The most common transmission S-parameter measurements are **S21** and **S12** (Sxy for greater than 2-ports).
- **Swept power measurements** are a form of transmission measurement. Some other examples of transmission measurements include **gain**, **insertion loss/phase**, **electrical length/delay** and **group delay**.

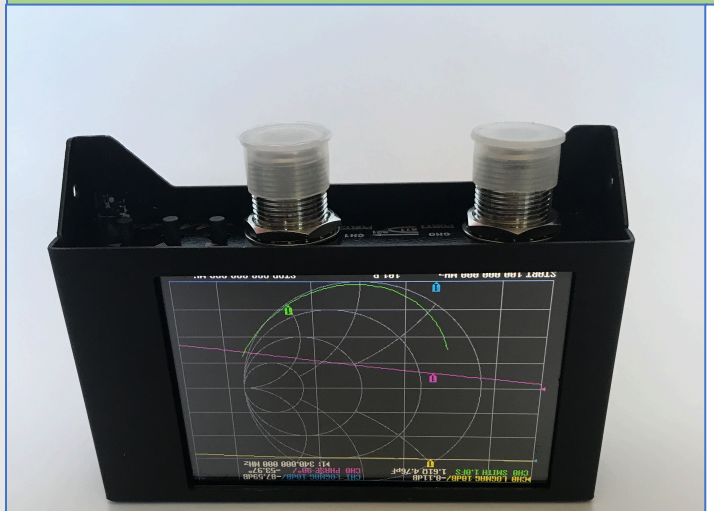
What is a NanoVNA used for (2 of 3)
Reflection Measurements

- Reflection measurements measure the part of the VNA stimulus signal that is incident upon the **DUT** but does not pass through it. Instead, the reflection measurement measures the **signal that travels back towards the source due to reflections**.
- The most common reflection S-parameter measurements are **S11** and **S22** (Sxx for greater than 2-ports).

What can Amateur Radio Operators use a Vector Network Analyzer for?

- They can measure antenna or coax parameters, such as:
  - **SWR**
  - **Impedance**
  - **Loss**
- They can also be used to **characterize and tune filters.**
- They are invaluable for measuring the **resonant frequency of**
  - **commercial antennas**
- They are very useful if you are **building and tuning homemade:**
  - **Antennas**
  - **Filters**
  - **RF circuits**

R&L's NanoVNA SAA2N



https://tinyurl.com/krmflunv

Using an N-Connector or BNC connector is far better than using an SMA connector.

JOKALYM **5934**	*YOU COAX AND SMITH*	**$ 9.95**	**Buy 5934**
JOKALYM **5965**	*GUIDE TO NANOVNA*	**$ 14.95**	**Buy 5965**
JETSTREAM **JT2110**	*N MALE - SO239*	**$ 3.95**	**Buy JT2110**
NANOVNA **NANOVNATESTK**	*TEST JIG FOR TESTING YOUR OWN CIRCUIT (SMA CONN)*	**$ 7.95**	**Buy NANOVNATESTK**

50KHZ-3GHz VNA 4" Touchscreen SWR ANALYZER RADIO ACCESSORIES

R&L's SAA-2N NanoVNA V2.2 w/ N-Connector

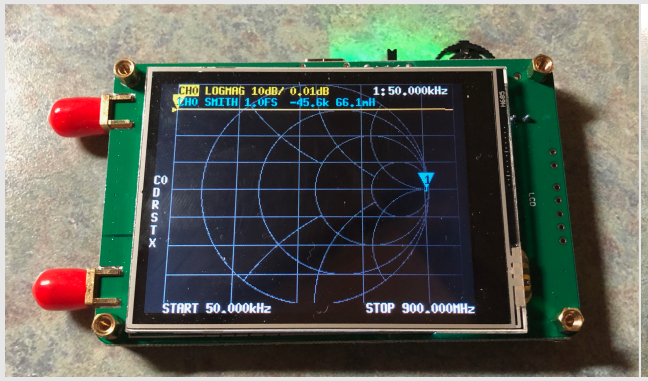
3GHz vector network analyzer, designed by OwOComm, under the LGPL license agreement, it is completely manufactured according to the v2_2 files issued by OwOComm at: **https://github.com/nanovna/S-A-A**

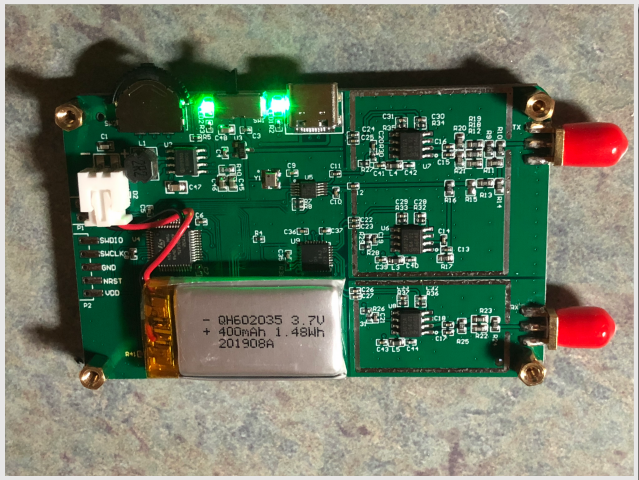
It uses a similar user interface to the NanoVNA, but with a different technical architectureVNA-QT software download:
https://github.com/nanovna/NanoVNA-QT/releases

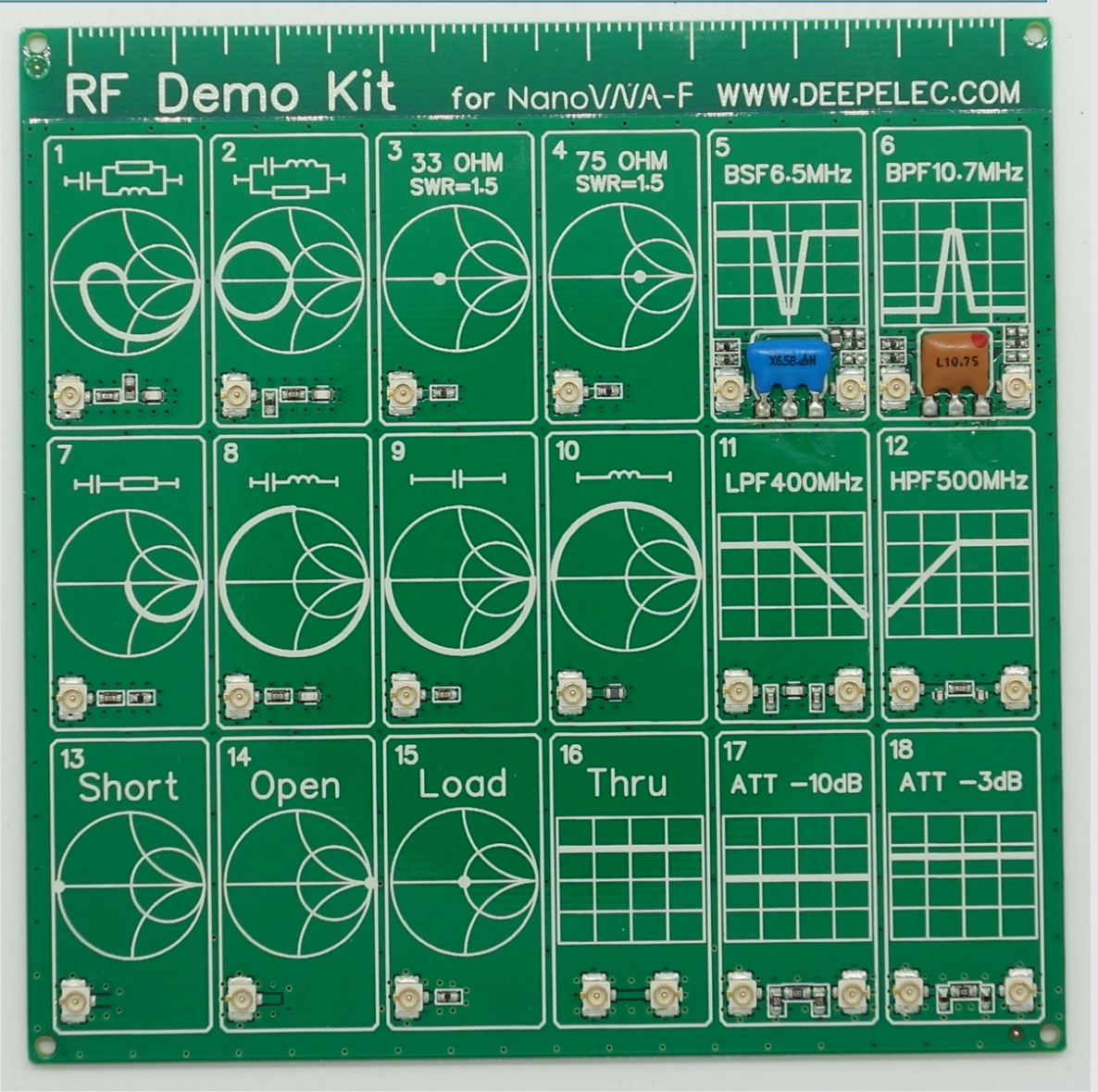
nanovna-saver:
https://github.com/NanoVNA-Saver/nanovna-saver/releases

User guide:
https://github.com/nanovna/NanoVNA-QT/raw/master/ug1101.pdf

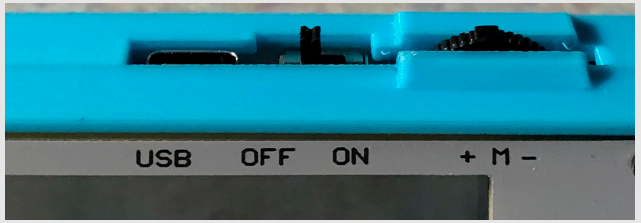
Unboxing your NanoVNA and Demo Board

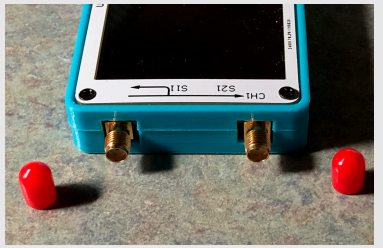






NanoVNA Vector Network Analyzer
W/ 2.8" LCD, 50KHz-900MHz, in a 3D Printed Case

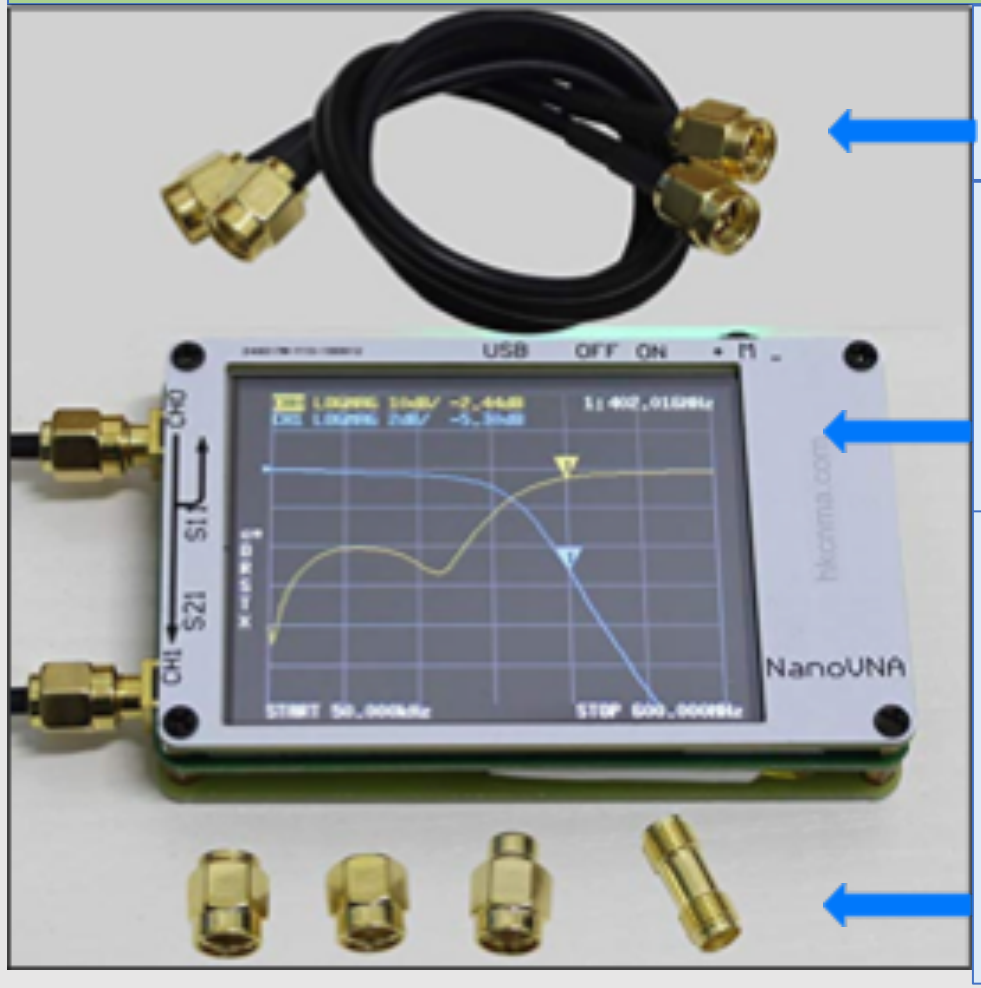




You can by it on Amazon, eBay, or from HKCNMA.COM. Allow 4 - 6 weeks for delivery from China. That said there Are newer and better units. Many have 4.3” or larger diagonal screens.

Many companies make and/or resell NanoVNAs very similar to this one. Prices range from $60 to $200 depending on how they are packaged and what accessories are included.

NanoVNA Calibration Cables and Terminators

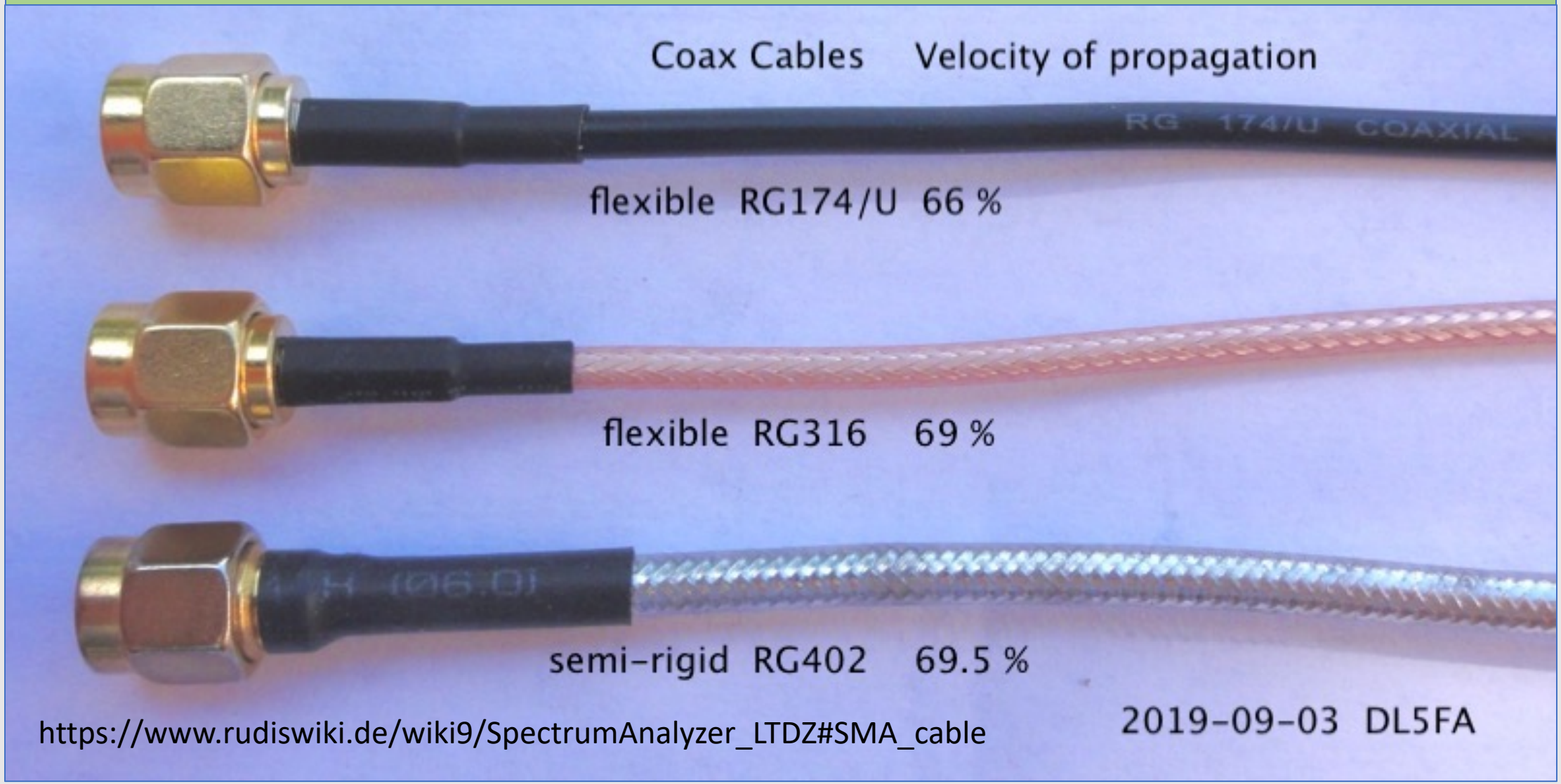


The NanoVNA kit comes with **two cables**. You can buy or make better quality cables.

You can purchase them with or without a 3D printed case. There are plans in **http://ThingVerse.com** for making cases if you own or have access to a 3D printer.

The kit includes a **female-to-female coupler**, as well as **Open**, **Short**, and **50 Ohm Load terminators** for calibrating the NanoVNA. ***These are adequate to get you started, But you might want to invest in higher quality terminators.***

Higher Quality NanoVNA Calibration Cables

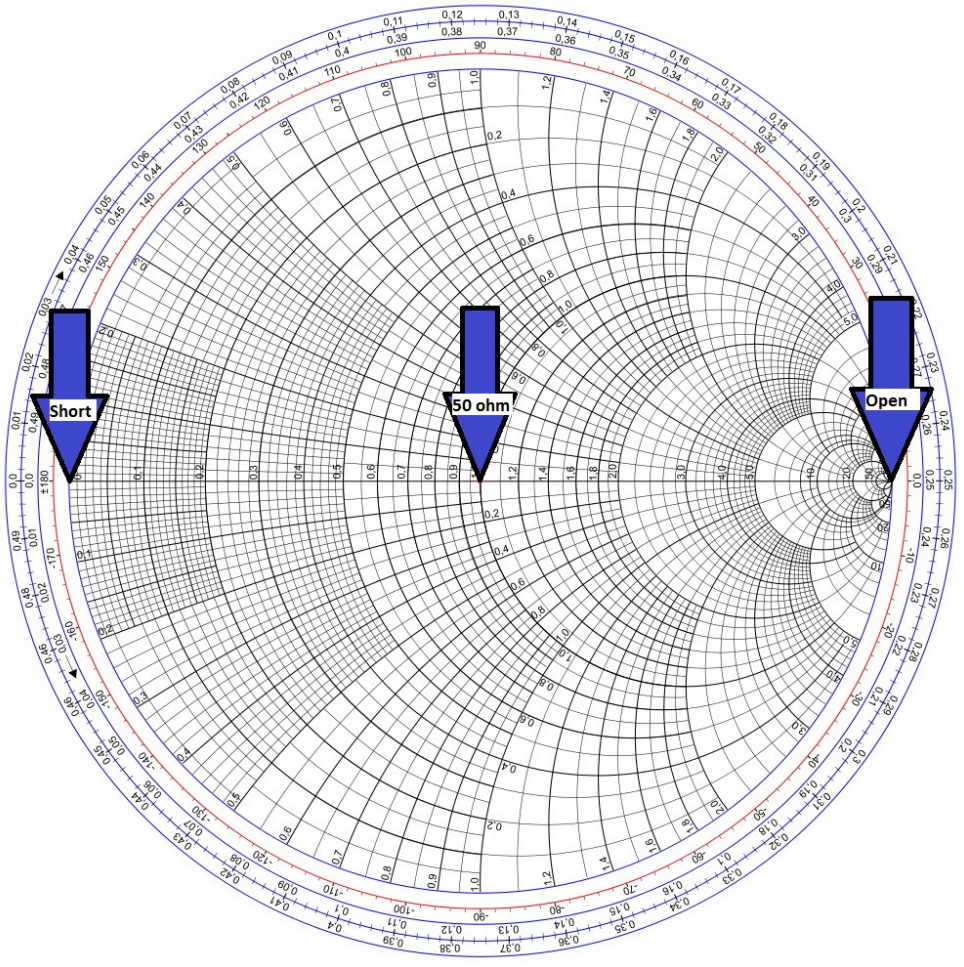


It is important to calibrate your Vector Network Analyzer per its instructions.

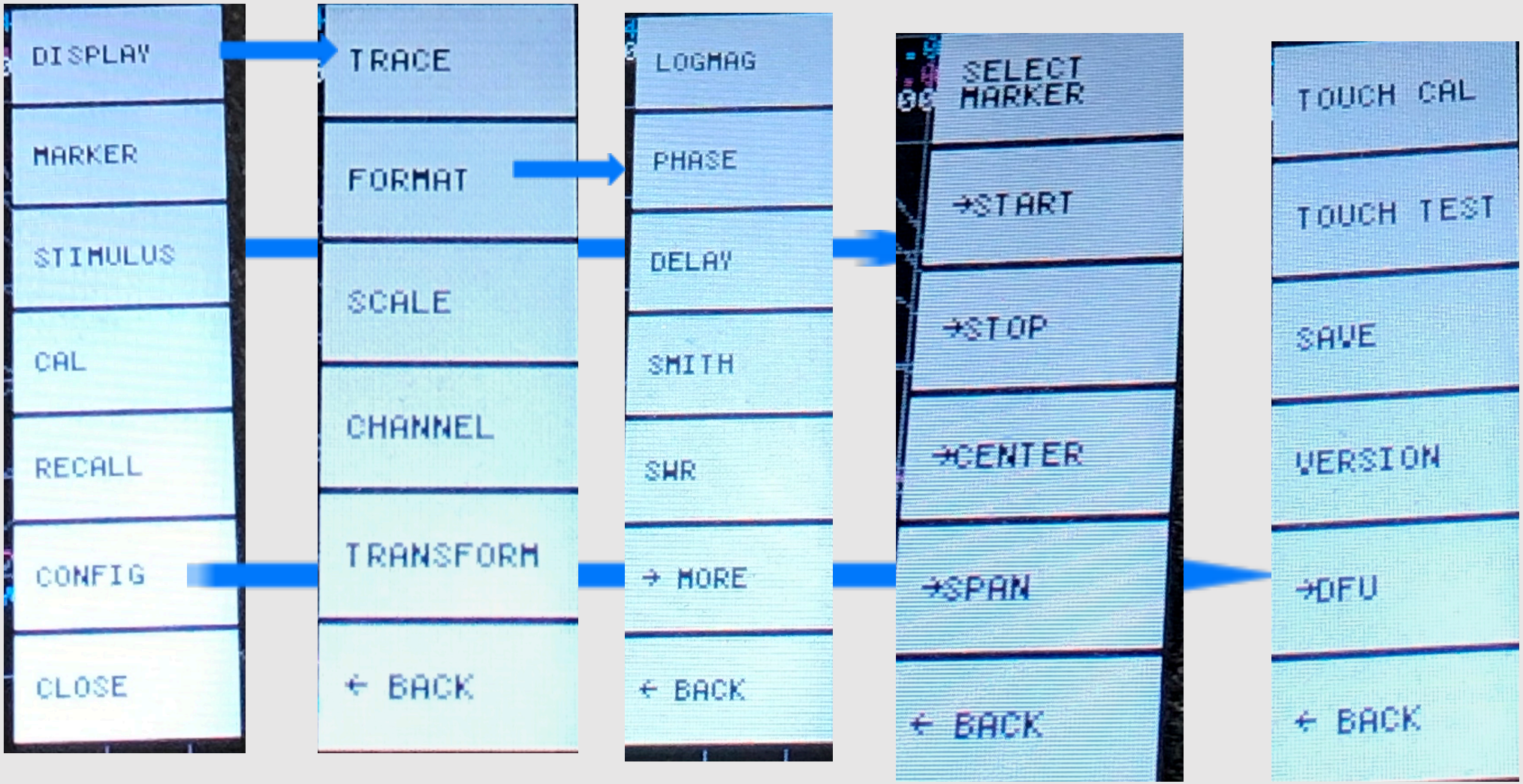
As with any instrument, you first need to ensure that it is calibrated properly. Three test loads used to calibrate a standard RF vector network analyzer are short circuit, open circuit, and a 50-ohm terminator.

The following link provides a basic tutorial for calibration and use of your NanoVNA

https://www.youtube.com/watch?v=mKi6s3WvBAM



NanoVNA Menus



VNA S-Parameters

- You can use vector network analyzer to measure S-parameters, or scattering parameters.
- S-parameters describe the behavior of RF devices **under linear conditions**.
- Each parameter is typically characterized by **magnitude**, **decibel** and **phase**.
- The subscripts of S parameters represent the port or ports at which measurements are made.
  - The S parameter that is equivalent to **forward gain** is **S21**.
  - The S parameter that represents **return loss or SWR** is **S11**.

Question: Which of the following can be measured with a vector network analyzer? (E4B11)

A) Input impedance

B) Output impedance

C) Reflection coefficient

ANSWER: All these choices are correct

QUESTION: What three test loads are used to calibrate an RF vector network analyzer? (E4B05)

- **ANSWER:**
  - **Short circuit**
  - **open circuit**
  - **50-ohm load**

QUESTION: What do the subscripts of S parameters represent? (E4B07)

ANSWER:

The port or ports at which measurements are made.

QUESTION: Which S parameter is equivalent to forward gain? (E4B03)

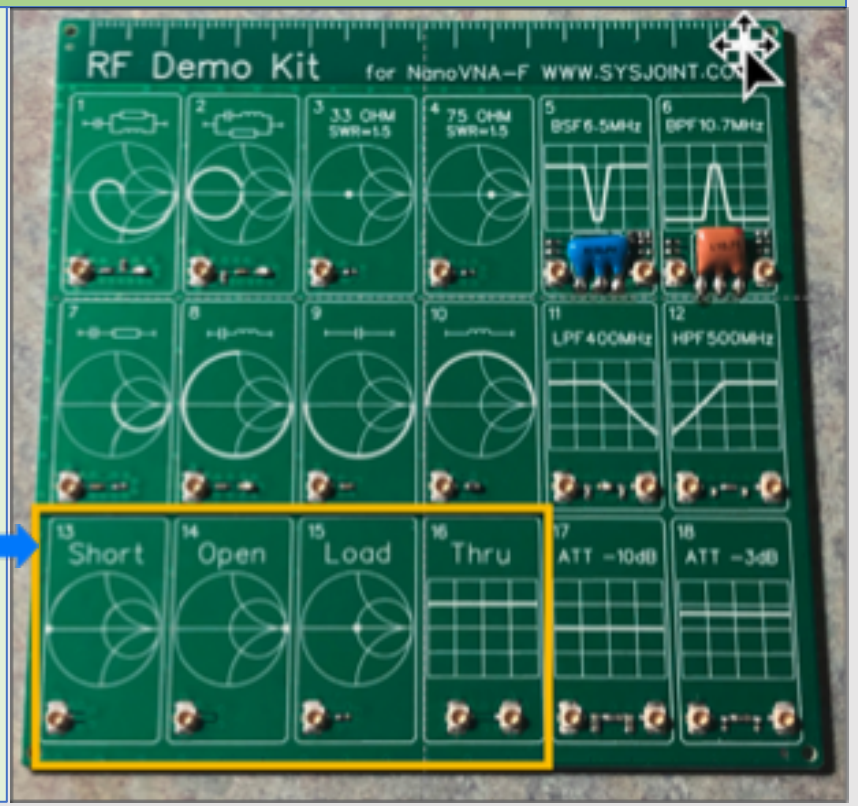
ANSWER: S21

QUESTION: Which S parameter represents input port return loss or reflection coefficient (equivalent to VSWR)? (E4B04)

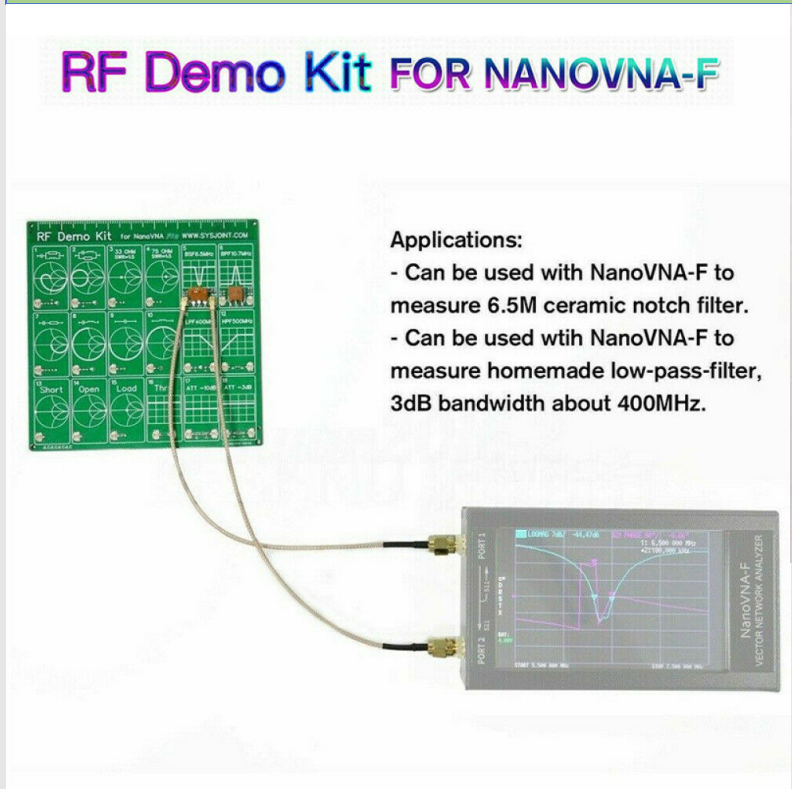
ANSWER: S11

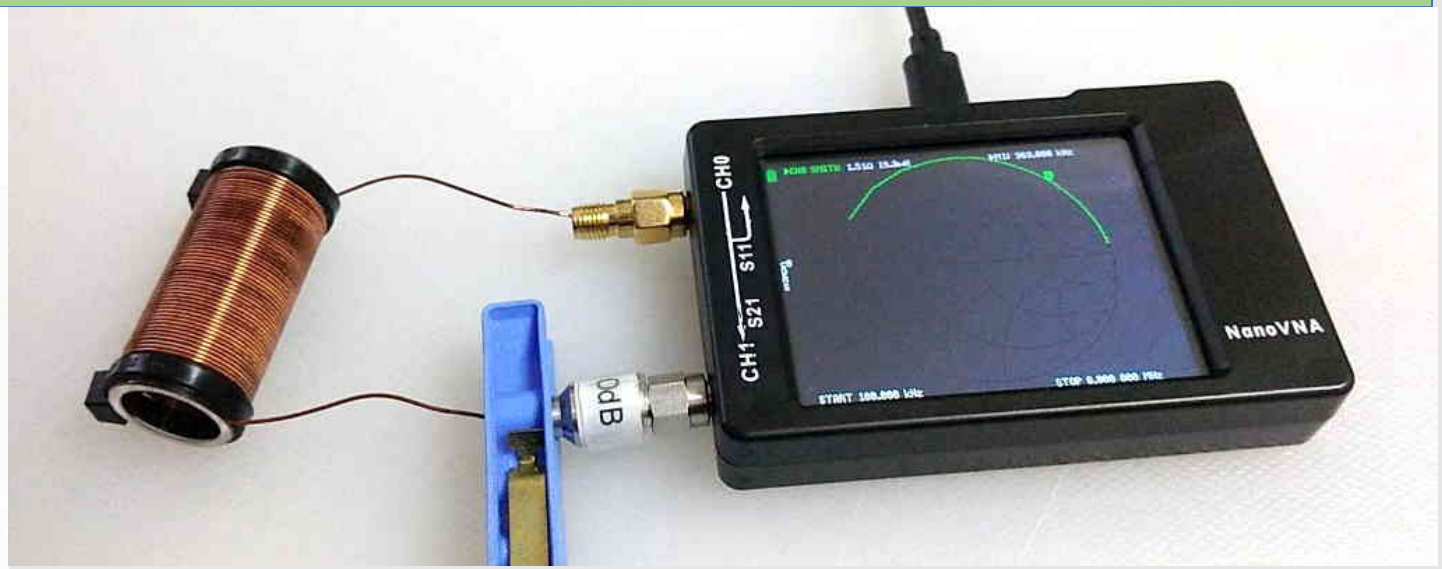
VNA RF Demonstration Kit

- You can buy this “RF Demo Kit” for from Amazon, eBay, or Sysjoint for <=$36. It comes with
- two adapter cables. **http://www.sysjoint.com.**
- ***You can use “Short”, “Open”, ”50 Load”, and “Thru” for Performing basic calibration Tests on the NanoVNA.***



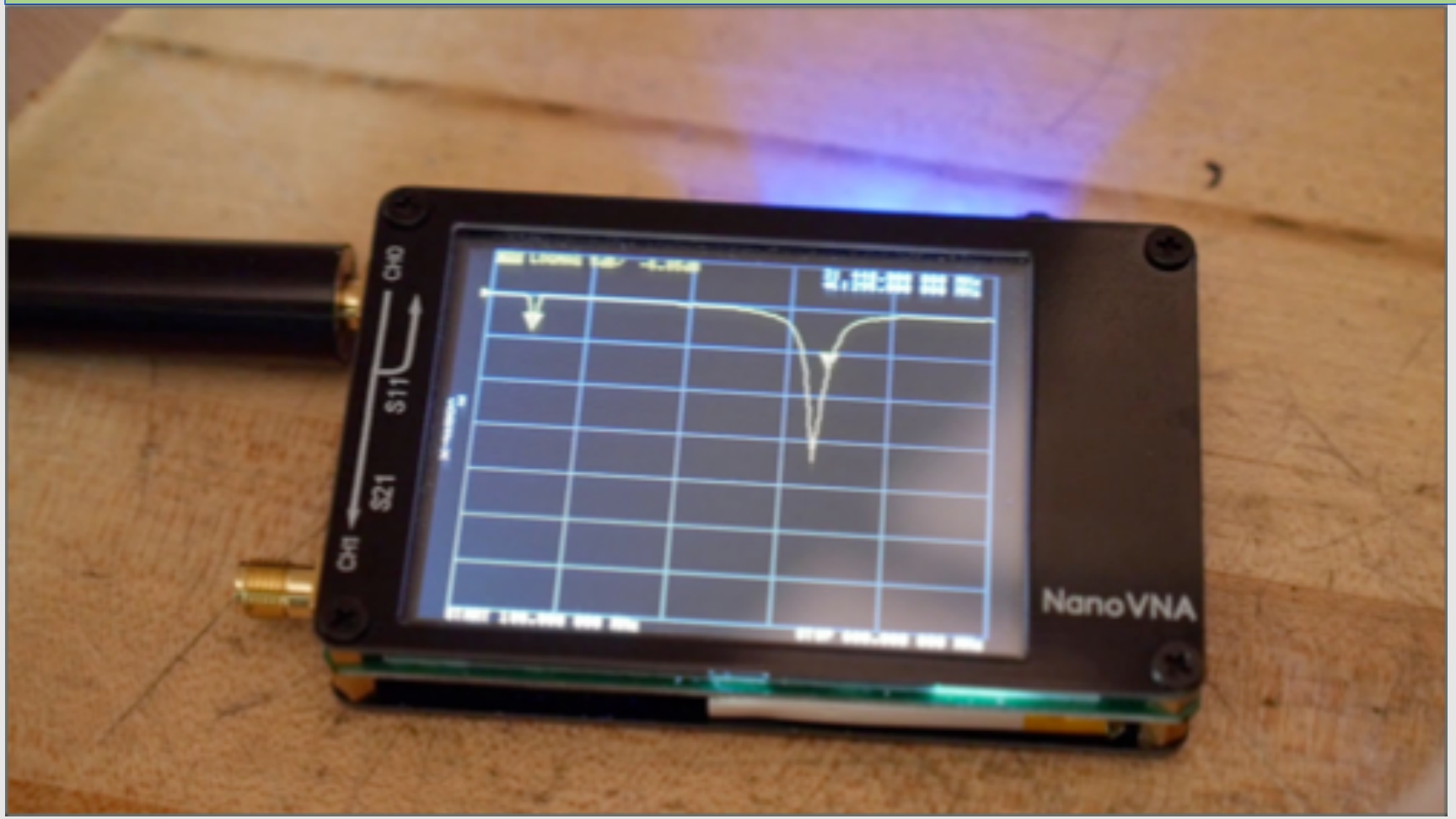
VNA RF Demonstration Kit and a coil



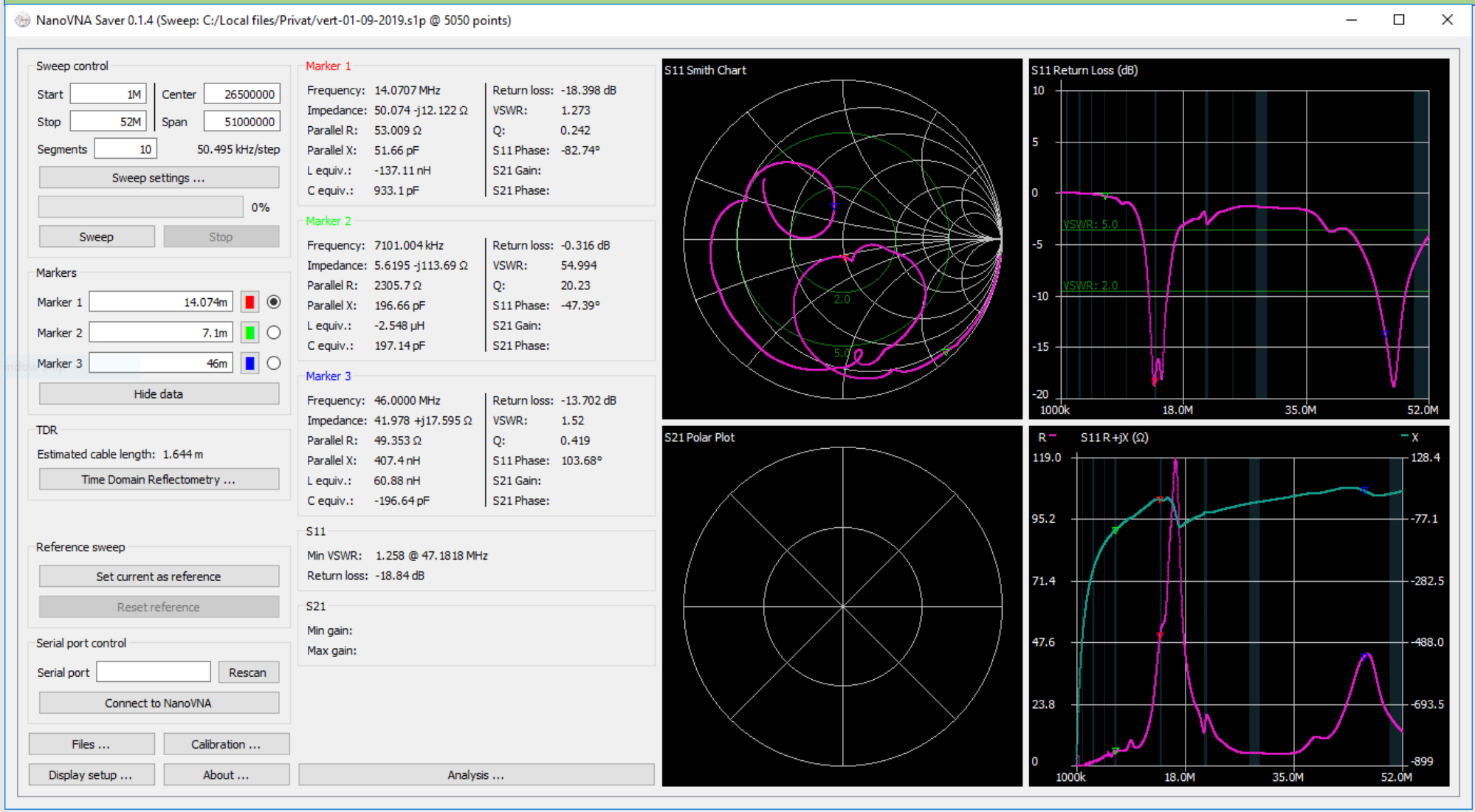


Testing a coil's impedance, resistance, or reactance.

NanoVNA Showing Resonance Dips from a Portable Antenna

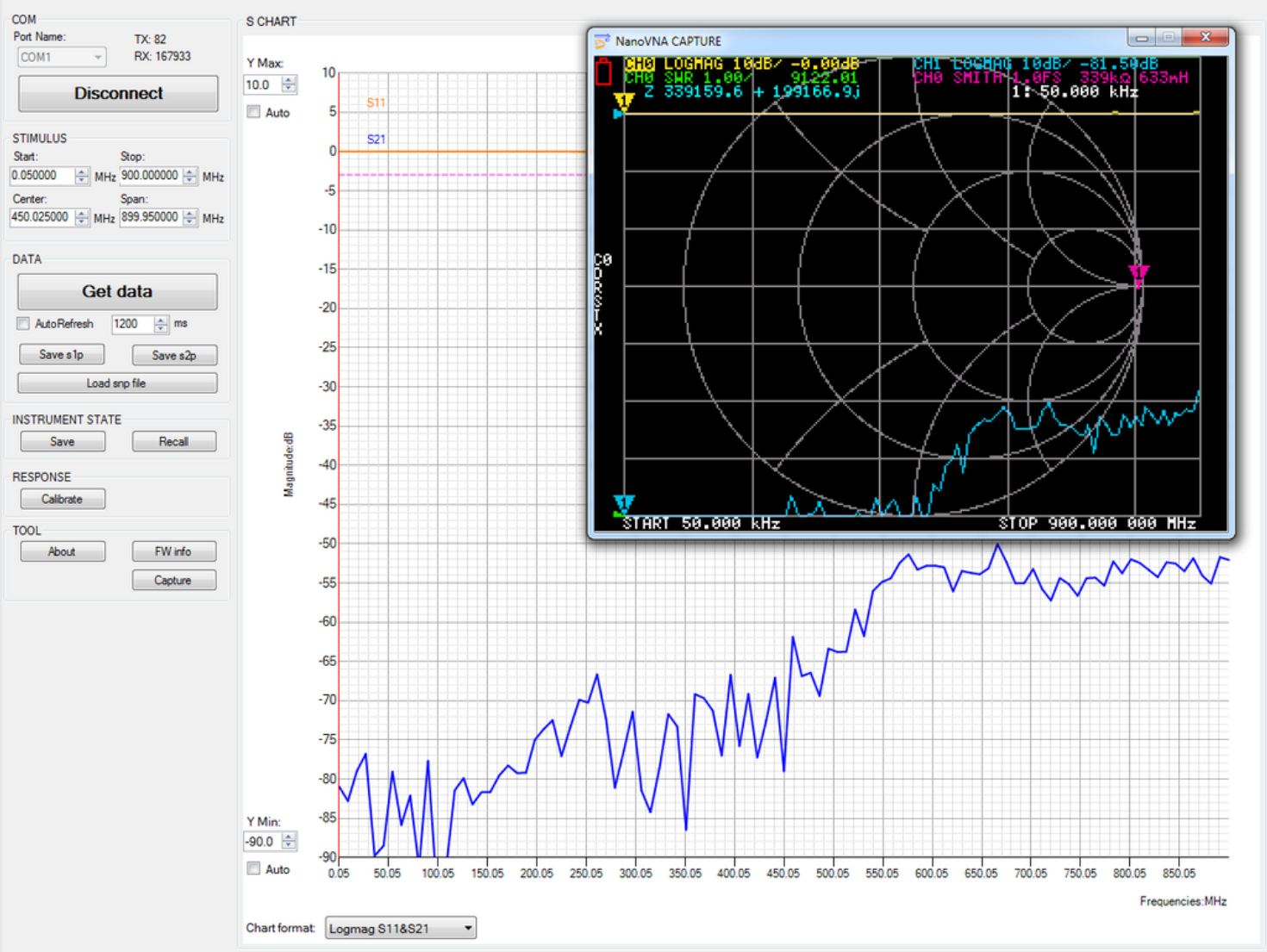


NanoVNA connected to your computer



https://groups.io/g/nanovna-users/wiki

NanoVNA connected to your computer



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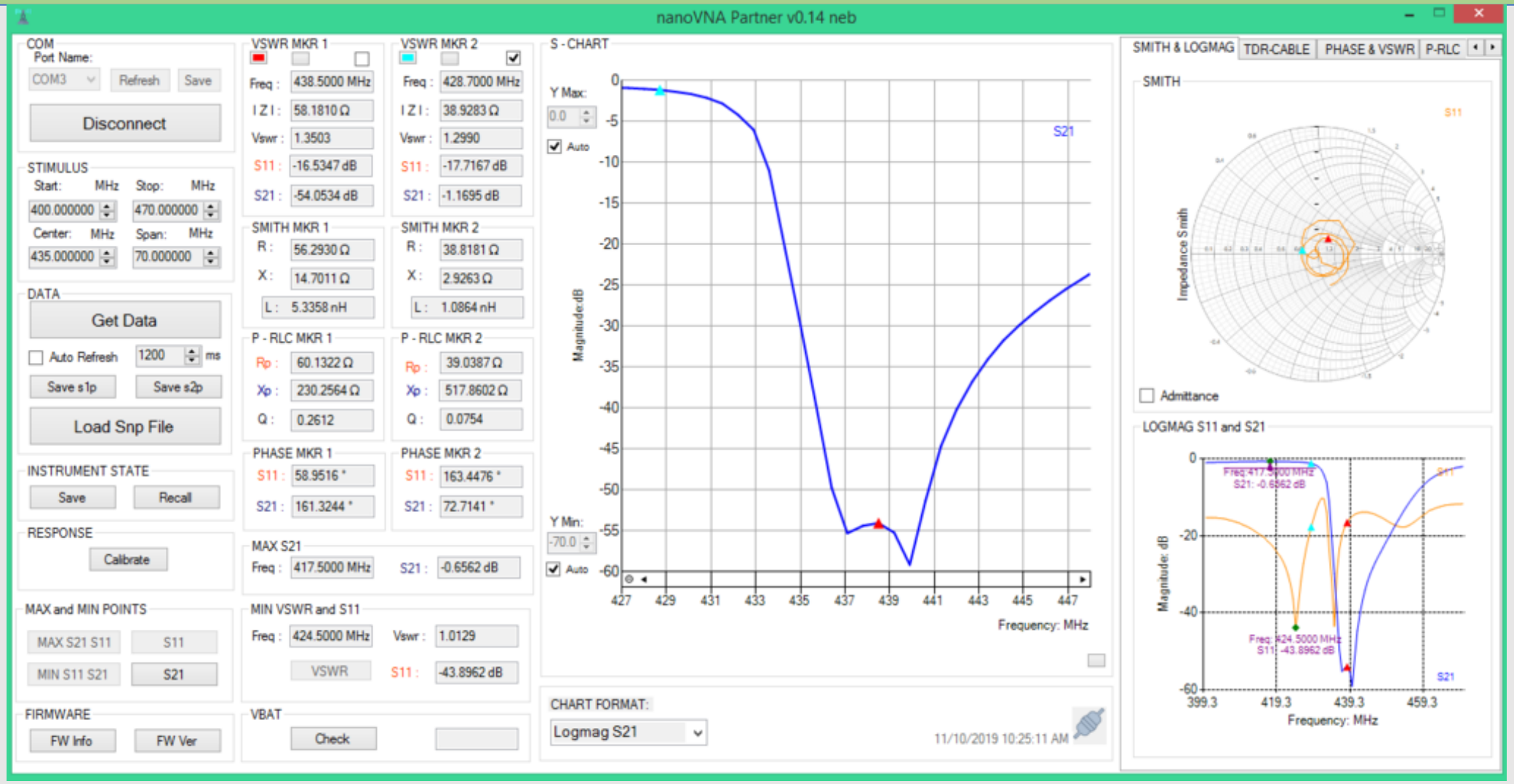

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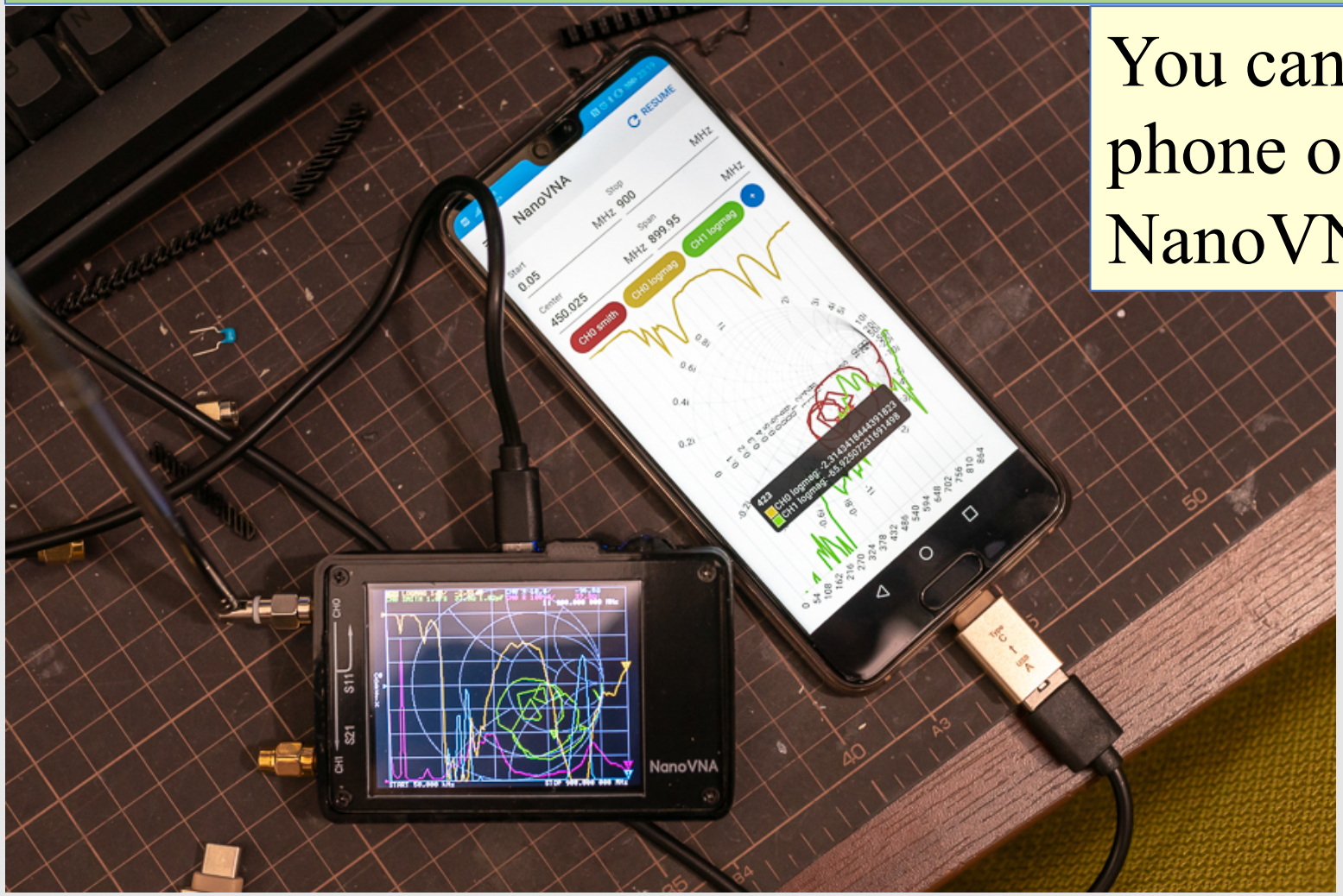
NanoVNA connected to your Android Device



You can use any Android phone or tablet with your NanoVNA.

https://groups.io/g/nanovna-users/wiki

NanoVNA Groups.io Group

The Groups.IO group is a good place to start:
https://groups.io/g/nanovna-users

You need to join the Groups.io NanoVNA group to access to documentation, files, firmware, and discussion forums.

NanoVNA Tutorials

Hex and Flex offers the following NanoVNA tutorials.

- *part 1 Posted on September 15, 2019 by hexandflex*
  Getting Started with the NanoVNA Part 1
- *part 2 Posted on September 8, 2019 by hexandflex*
  Getting Started with the NanoVNA Part 2
- *Part 3 – PC Software Posted on August 31, 2019 by hexandflex*
  Getting Started with the NanoVNA Part 3

Techtronic’s VNA White Papers

Techtronic’s offers some very nice reference papers:

VNA Basics

This paper discusses why VNAs are used and how they are unique compared to other RF test equipment. We'll define S-Parameters, the fundamental VNA measurement, and how best to use them when evaluating your Device-Under-Test or DUT. We'll review various VNA calibration techniques and show how VNA user calibrations help achieve the best accuracy possible. Finally, we'll review typical VNA measurements such as swept frequency measurements, time domain measurements, and swept power measurements and how they're used and why they are important.

https://tinyurl.com/3q9lahsl

Vector Network Analyzer Fundamentals Poster

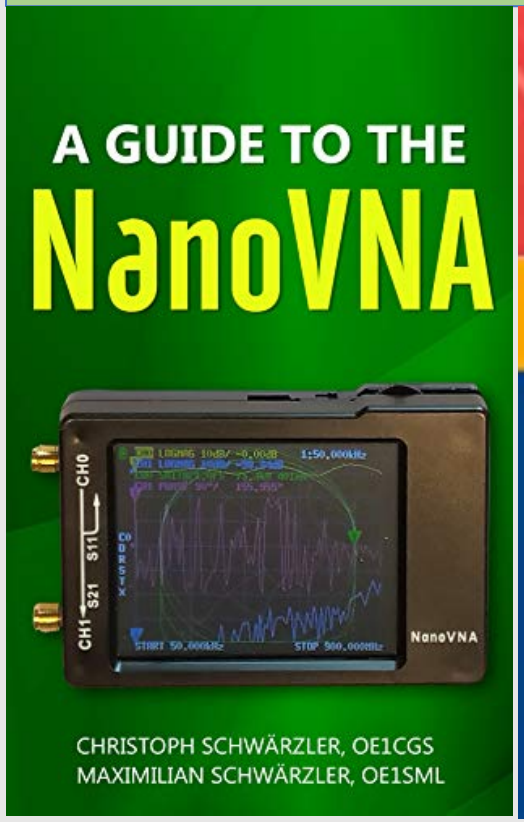
This poster that shows types of measurement errors, Basic VNA operation, Smith chart basics, Common S-parameter names, VNA calibration methods and more.

https://tinyurl.com/14cr3qq0

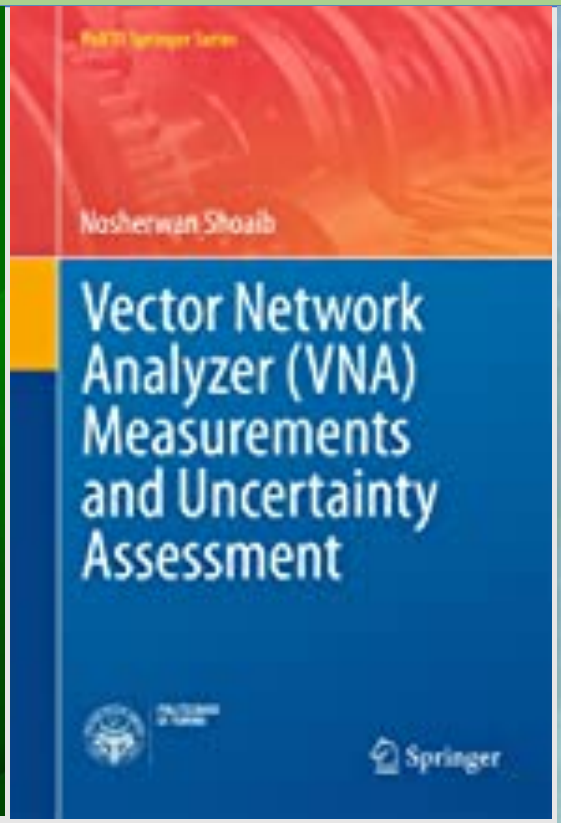
General VNA References

- More than just an antenna analyzer
- Low Cost RF Vector Network Analyzer
- From the trade magazines: litz wire, vector network analyzers, SDR
- 2020 Extra Class study guide: E4B – Measurement technique and limitations: instrument accuracy and performance limitations; probes; techniques to minimize errors; measurement of Q; instrument calibration; S parameters; vector network analyzers

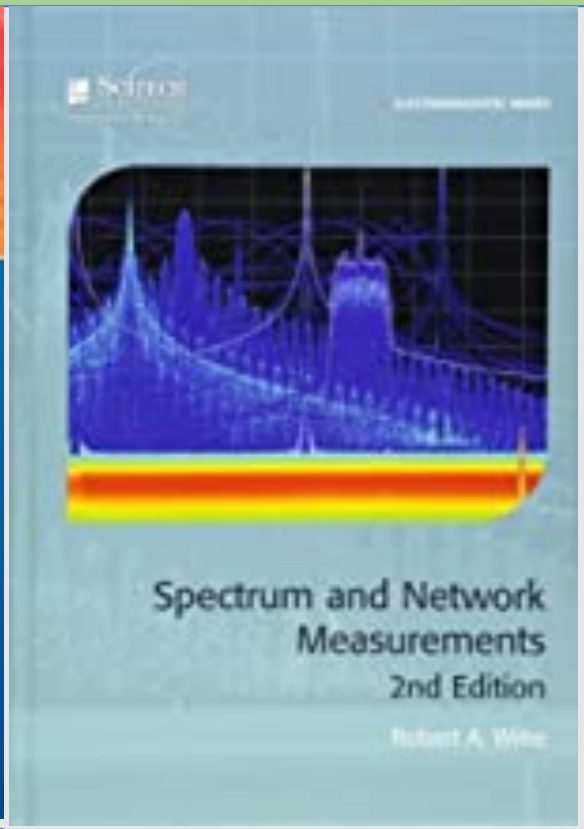
Books About NanoVNA or VNAs in General



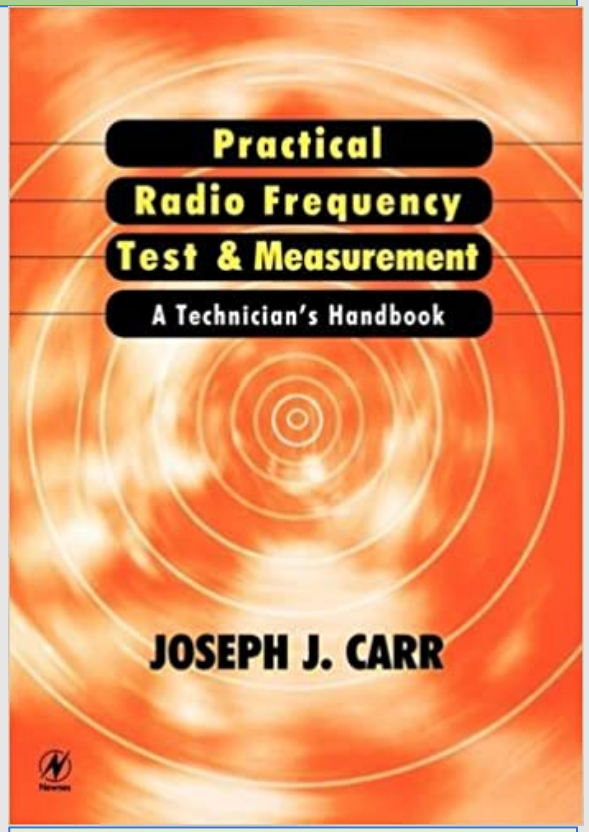
Amazon.com link to book: https://tinyurl.com/8dnggbid



Amazon.com link to book: https://tinyurl.com/epm1xww



Amazon.com link to book: https://tinyurl.com/4m9dg2vs



Amazon.com link to book: https://tinyurl.com/85luhw2b

Questions and Answers