NanoVNA

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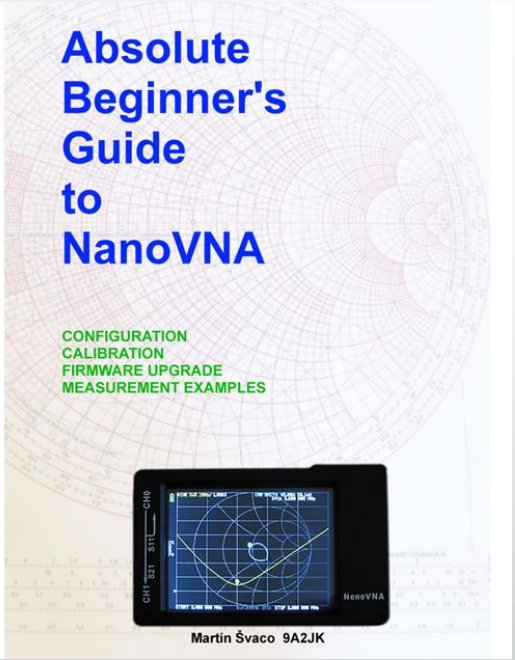
NanoVNA Overview



https://nanovna.com/

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

- A low-cost vector network analyzer
  - $60-$90 range

Includes:

- USB cable
- SMA extension cables
- SMA calibrations
  - short
  - open
  - load
  - thru

NanoVNA Overview

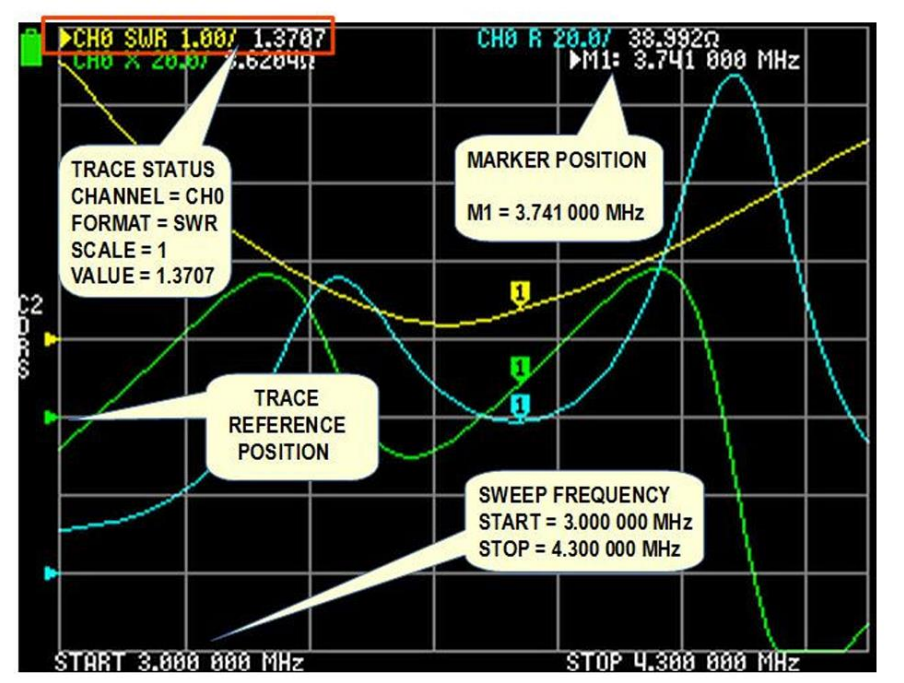
- Different models available
- Frequency range starts at 50kHz
- Some variants cover up to 3GHz
- Measurements are made over 101 'points'
  - Evenly distributed over the measurement's Start and Stop frequency range
- Dynamic range: 40-70dB (depending on frequency range)

NanoVNA Display Modes

- LOGMAG (log magnitude in dB)
- Phase
- Delay
- Smith (Smith Chart)
- SWR
- Polar
- Linear

- Four traces can be displayed at the same time
- Markers can be set for each trace

NanoVNA Display Modes



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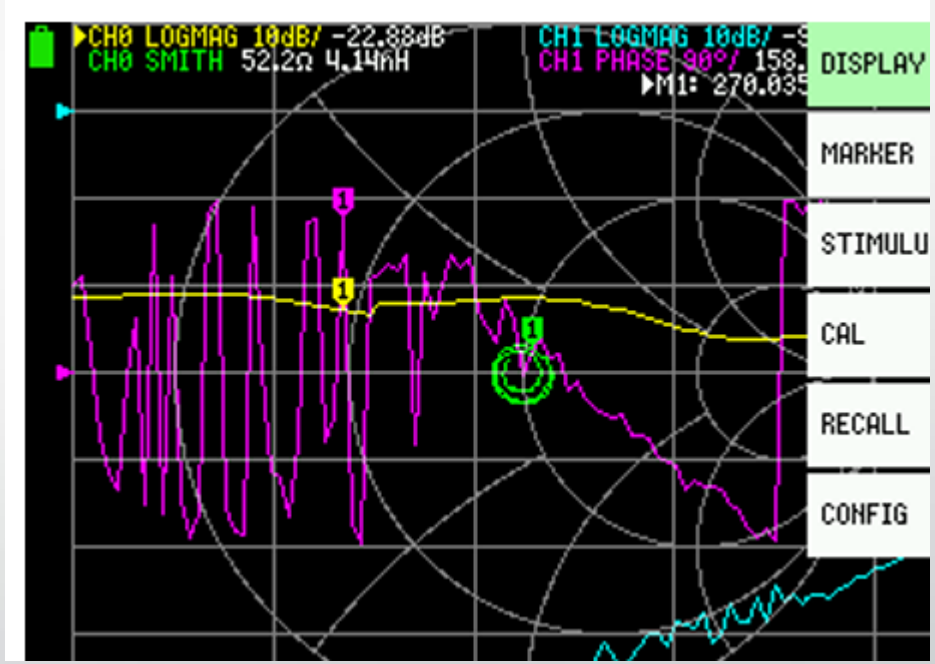
One-port SWR Example



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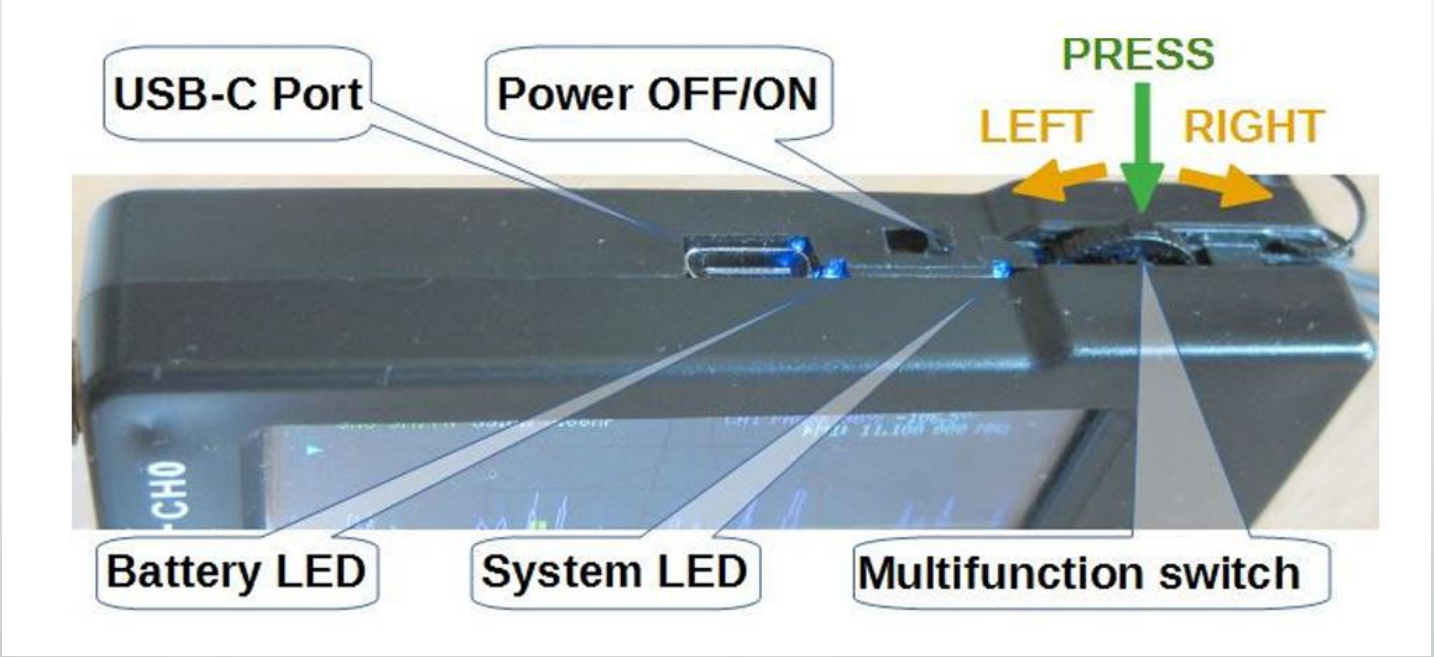
Two-port Device Example

NanoVNA User Interface



Touchscreen operation for all other functions

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NanoVNA Typical Use Cases

NanoVNA's PORTS

NanoVNA has two ports labeled: **CH0** (Port 1) and **CH1** (Port 2) (Fig. 23).

On CH0 NanoVNA measures the reflected signals from the DUT (e.g. antenna).
On CH1 NanoVNA measures the signals that have passed through the DUT (e.g. filter).

CH0
(Port 1)

CH1
(Port 2)

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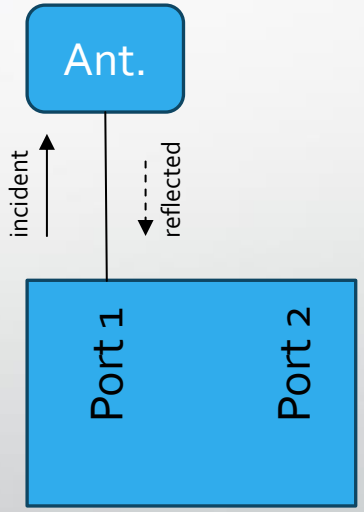
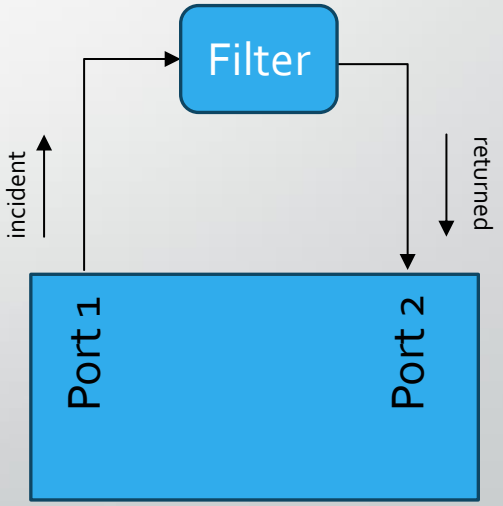


S_{11}
"one-port"
measurement



S_{21}
"two-port"
measurement

NanoVNA Use Case Warning

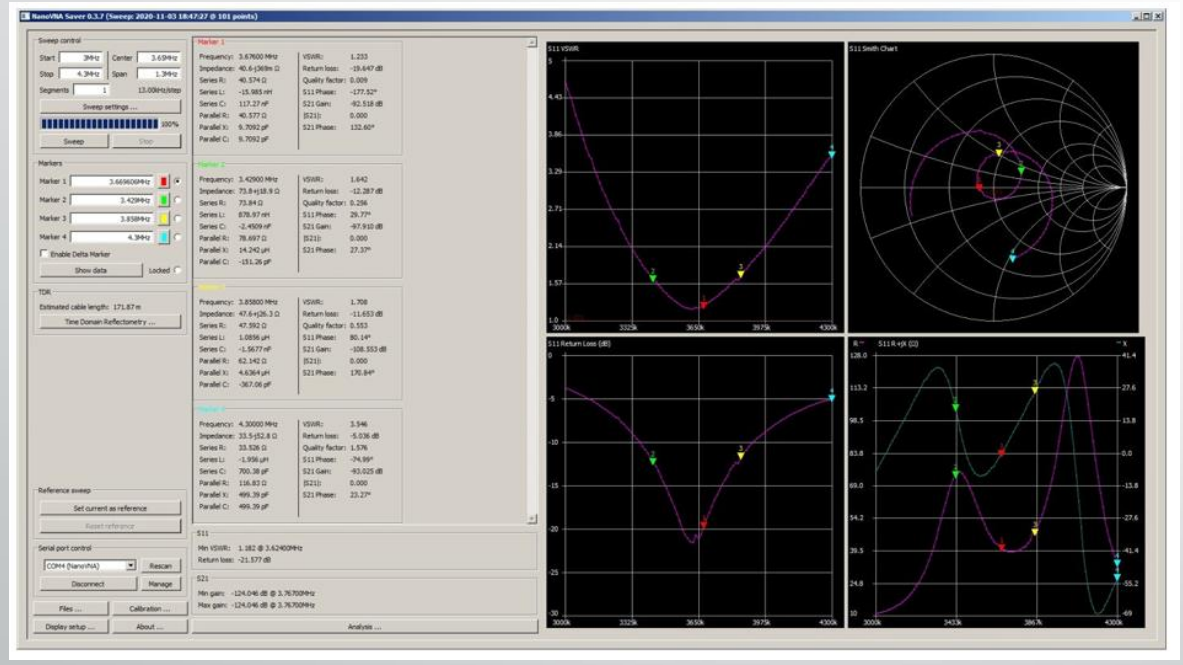
- Several web sites, user forums, etc. indicate that the NanoVNA (and similar variants) **do not have ESD (static) protection on the inputs**
- Directly connecting a large outdoor antenna can induce voltages large enough to damage the input circuitry
- Antenna protectors (Polyphaser, Alpha Delta, etc.) use gas discharge tubes (GDT) that **do not** offer the necessary low-voltage protection
- ESD protection diode circuit
  - https://www.qrpforum.de/index.php?attachment/23764-nanovna-input-protector-pdf/
- NanoVNA protection video
  - https://youtu.be/totwu4IbavE?si=gSgomIKITool3UEb

NanoVNA Test Port Cables

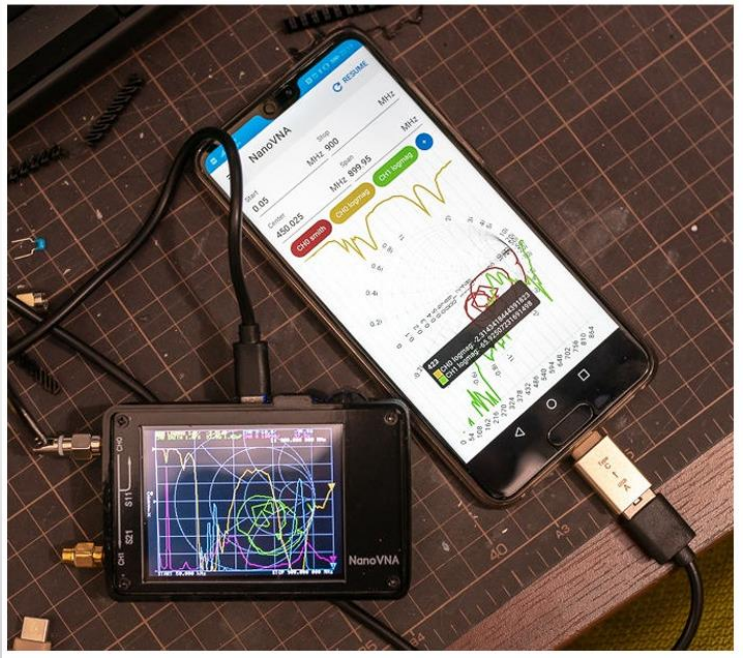
https://groups.io/g/nanovna-users

- The use of short test port cables is **HIGHLY** recommended
- Prevents accidental damage to the NanoVNA connectors
- Reduces stress and wear on NanoVNA SMA connectors

NanoVNA Display Software



Windows PC



Android App

https://groups.io/g/nanovnausers/wiki#Software

NanoVNA Calibration

CALIBRATION

The proper NanoVNA calibration is absolutely crucial for correct measurement.

For one port measurement, e.g. SWR, we only need **OSL** (OPEN, SHORT, LOAD) calibration. The first three steps as described below.

For two port measurement, e.g. filter, we need full calibration. All five steps as described below.

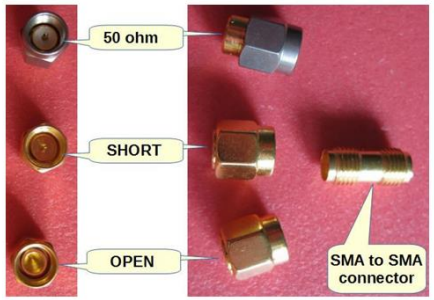


Figure 36

Calibrate the NanoVNA with the calibration standards that came with the device: OPEN, SHORT and 50 ohm (Fig 36).

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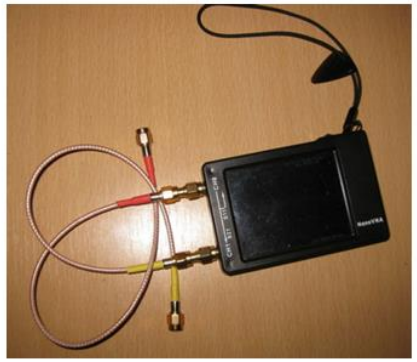

Figure 37

I use a short flexible cable such as the RG174 to relieve the mechanical stress on the SMA connector on my NanoVNA (Fig 37). This means that the calibration must be done at the end of that cable, not on the NanoVNA.

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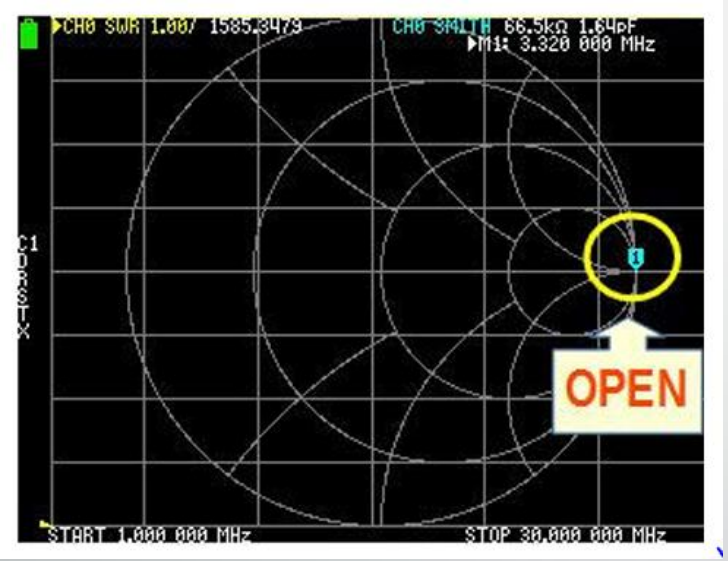
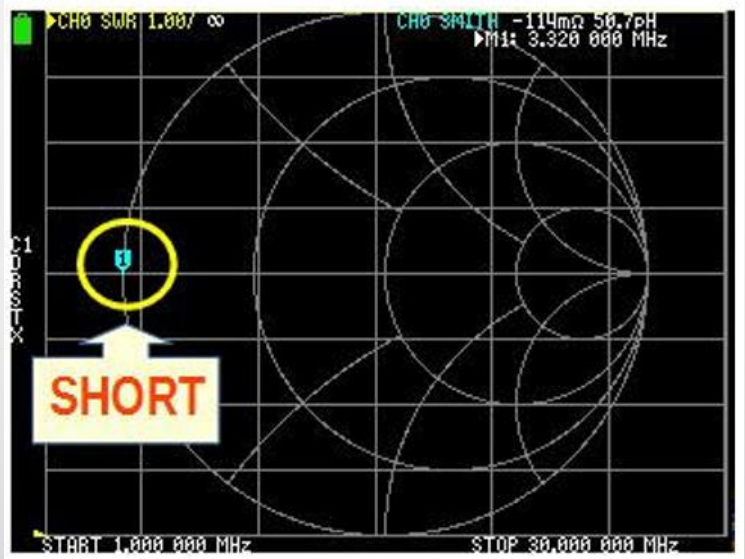
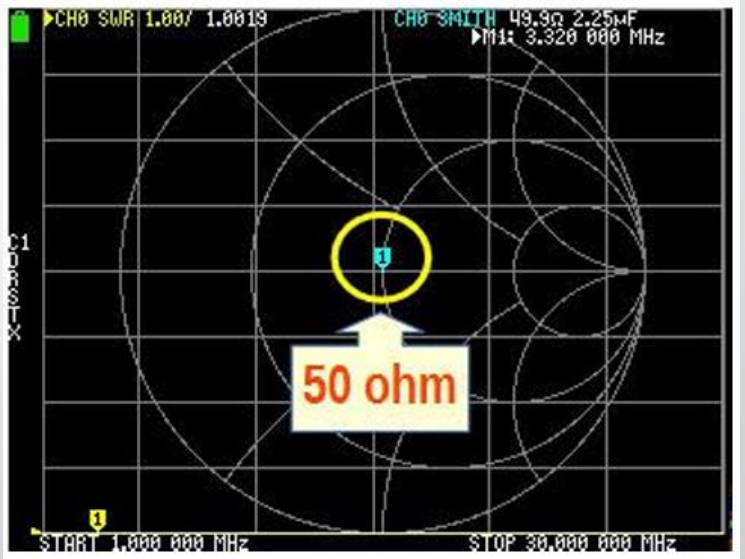
Calibration Steps	Measurements
Open	One & Two Port
Short	One & Two Port
Load	One & Two Port
Isolation	Two Port
Thru	Two Port

NanoVNA Calibration







The calibration process compensates for frequency-dependent imperfections in the internal circuitry

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“I know you are but what am I…?”

- There are multiple variants of the NanoVNA on the market
- Some are “genuine” while others are poor quality clones
- “Turf wars” for some of the variants regarding licensing

Typical “Scary” Language…

Please note that some websites and individuals may claim that they offer upgraded versions of NanoVNA and that they are the original developers of these products. These products are not related to NanoVNA, and they may violate the GPL agreement. The NanoVNA community is unable to provide support for these products.

NanoVNA V2 (S-A-A-2) is a 4GHz vector network analyzer (VNA) capable of measuring antennas, filters, duplexers, and amplifiers. It is a new from-scratch design by HCXQS/NanoRFE not based on the earlier edy555 V1 design.

As of October 2024 there are many clones of our earlier S-A-A-2 design sold under various names. Beware that most exaggerate their specs, and some variants are highly noisy due to using incorrect or lower quality parts. Update (2023): we have now seen clones that display a false lower noise floor when measured value is below a threshold, which allows a higher dynamic range to be advertised but can introduce measurement errors. See official stores above and look for NanoVNA V2 Plus4 and VNA6000 versions only to avoid getting a bad clone.

For platforms such as Amazon or AliExpress, please buy directly through the store provided by the link. Other advertising links on the platform may sell bad clones.

Amazon
AURSINC

AliExpress
Zeenko

Beware that nanovna .com is not owned by the original developers of either V1 or V2 NanoVNAs, and is being used to mislead users into buying clones from one clone manufacturer. These clones are not supported by any updates from the developers, and violate the license conditions of our V2.2 design.

The following stores have sold at least one bad clone.

- Banggood
- Eleshop
- R&L electronics - still selling clones despite being asked not to by the original developers

This is the only official NanoVNA V2 users group. Be careful and note the URL is **NanoVNAV2**.

Beware of cheap underperforming clones

As of 2023 there are many badly performing clones on the market. V2/3GHz NanoVNA uses parts like ADF4350 and AD8342 which are costly and clones have been cutting costs by using salvaged or reject parts.

See official store and **look for V2 Plus4/V2 Plus4 Pro versions only** to avoid getting a bad clone. We have stopped selling V2.2 versions since October 2020, so all V2 hardware that are not Plus or Plus4 are not made by us and we can not guarantee performance.

Conclusion

- Overall, the NanoVNA is a good unit for general amateur radio use
  - Best performance (based on dynamic range) is below 300MHz
- Buy the NanoVNA from "approved" vendors
- Be mindful of ESD precautions
- Handle SMA connectors with care

Backup – Technical Material

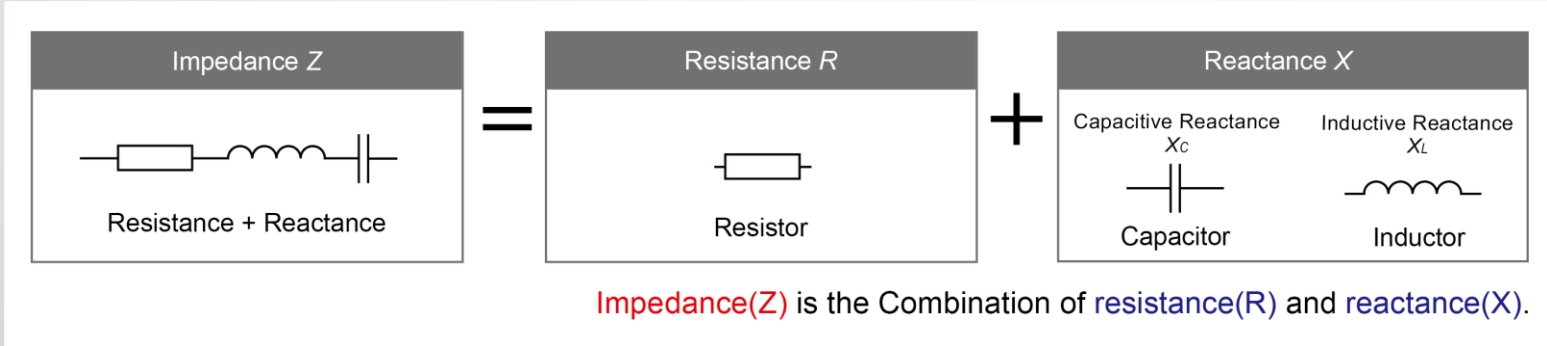
What is a ‘VNA’?

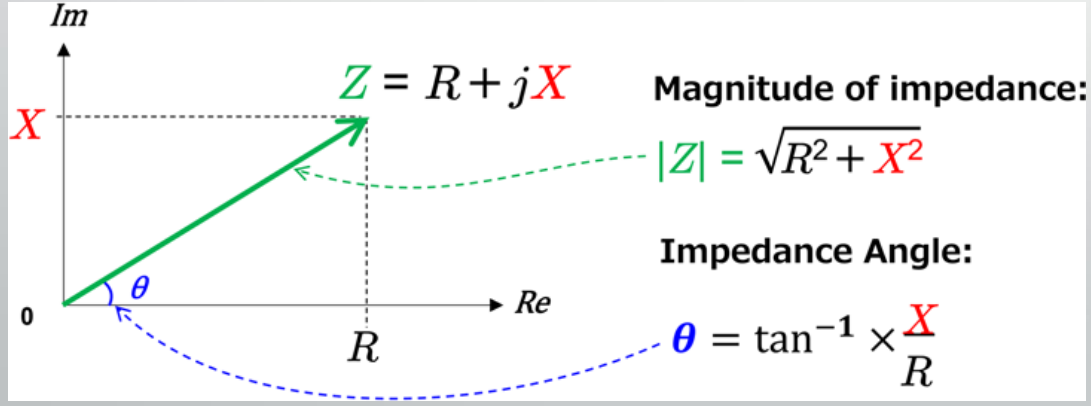
- VNA = **V**ector **N**etwork **A**nalyzer
- What’s a ‘vector’?
- What’s a ‘network’?

What's a Vector?

- A measure of the magnitude and angle of a signal in an AC circuit
- In RF, the angle is a representation of the phase difference between two signals
- In RF, the magnitude is a representation of the amplitude difference between two signals
- The phase and magnitude are measured at a single frequency

What's a Vector?





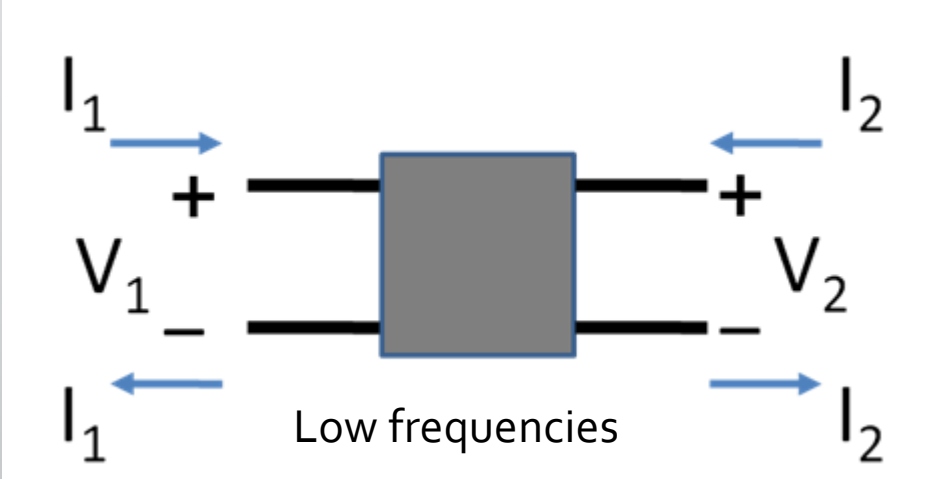
- Resistance: current and voltage are always in phase
- Reactance: current and voltage are 90 degrees out of phase

https://techweb.rohm.com/product/power-device/si/15939/

What's a Network?

- A network is a "stimulus/response" representation of an electronic circuit
- A network could consist of multiple components – we are analyzing the cumulative behavior
- Think of a network as a "black box" where you don't know exactly what's inside – you're trying to figure out how it behaves by stimulating it with a signal and measuring the corresponding response

What's a Network?



A generalized two-port network
The voltage and current at each port can be independently measured

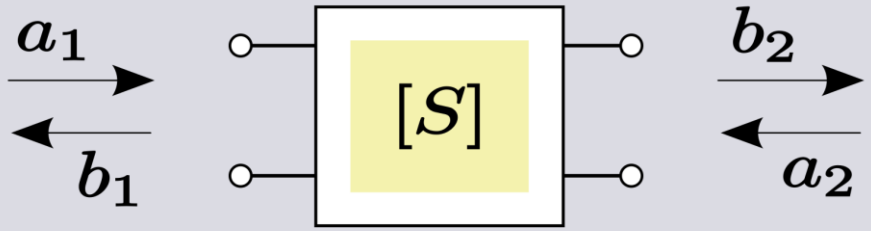
Types of low-frequency Network Parameters

- H parameters (hybrid)
- G parameters (inverse hybrid)
- Z parameters (impedance)
- Y parameters (admittance)
- ABCD parameters (cascade)

Typical network numbering convention:
Port 1 = input and Port 2 = output

https://en.wikipedia.org/wiki/Two-port_network

What's a Network?



RF & Microwave frequencies

An S-parameter two-port network
The incident and reflected power at each port can be independently measured

Notation

S_{21}

Output at port 2 ← Due to input at port 1

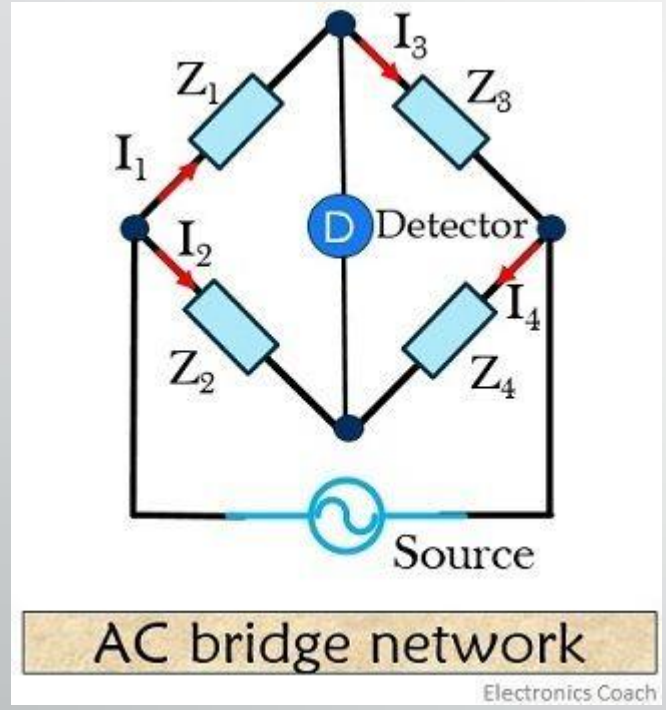
S_{11}

Output at port 1 ← Due to input at port 1

Typical network numbering convention: Port 1 = input and Port 2 = output

https://en.wikipedia.org/wiki/Two-port_network

The ‘Bridge’ is the Key Component



https://electronicscoach.com/ac-bridges.html

- The bridge is predominantly used in low frequency measurements
- When the bridge is ‘balanced’ there is no difference signal at the Detector

General Case

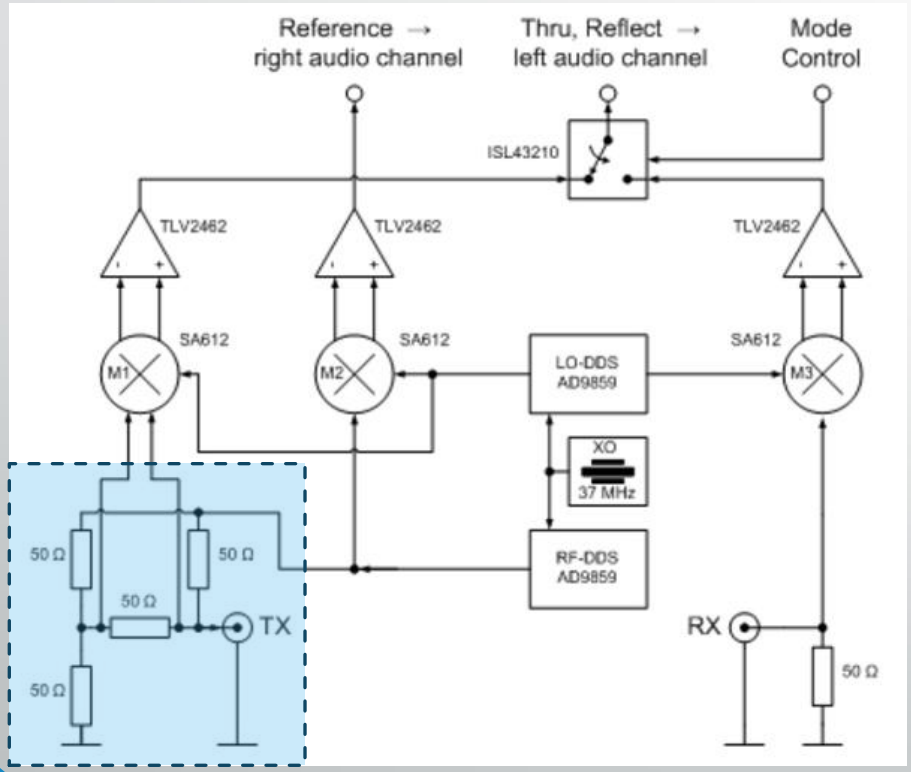
$$\frac{\mathbf{Z}_1}{\mathbf{Z}_3} = \frac{\mathbf{Z}_2}{\mathbf{Z}_4}$$

occurs when:

$$\frac{|\mathbf{Z}_1|}{|\mathbf{Z}_3|} = \frac{|\mathbf{Z}_2|}{|\mathbf{Z}_4|} \quad \text{and} \quad \theta_1 - \theta_3 = \theta_2 - \theta_4$$

At microwave frequencies, directional couplers replace the ‘arms’ of the bridge circuit to measure RF power ratios

Bridge Concept Used in the NanoVNA



- The 'fourth arm' of the bridge connects to the TX port
- The resistor in the middle supports the Detector connection (mixer M1)
- The local oscillator (LO) and stimulus (RF) oscillator are offset in frequency by a few kHz and measured at audio frequencies with soundcard-type components
- Two-port thru measurements use the TX and RX ports to measure the one-way transmission parameters.
- A one-port measurement at the TX port can still be performed, even if the device under test is connected between the TX and RX ports for a two-port measurement (i.e., you can measure both S_{11} and S_{21} with the same two-port configuration).

https://axotron.se/blog/vector-network-analyzer-a-christmas-present-to-myself/