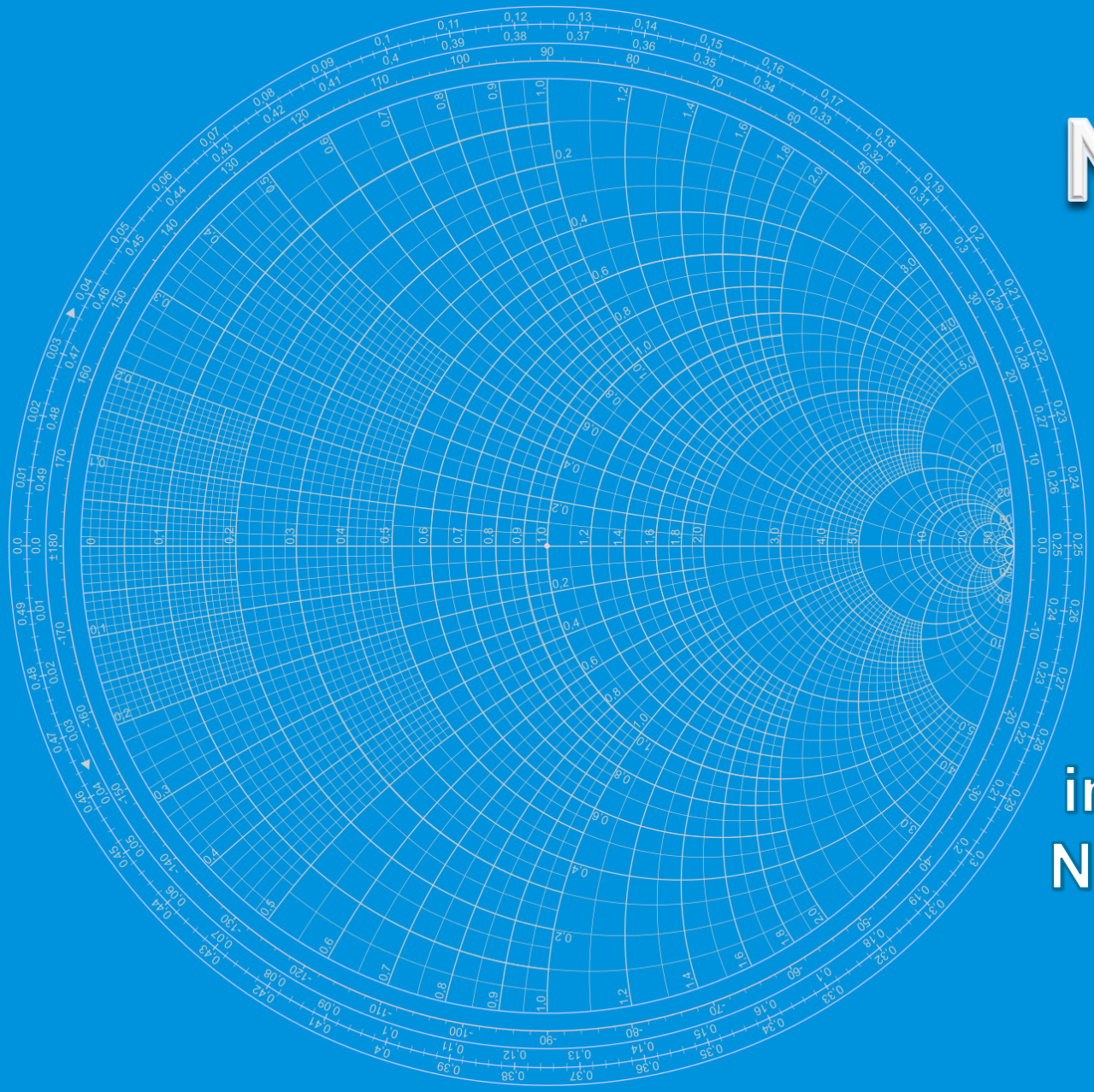


NanoVNA

Einführung in die vektorielle Netzwerkanalyse

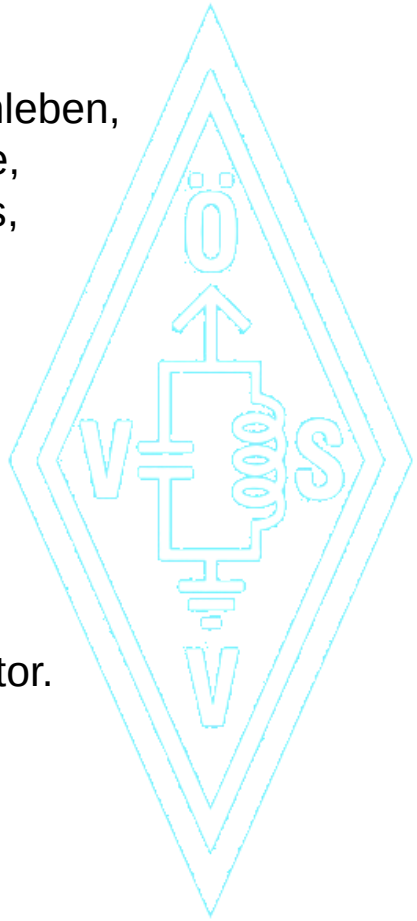
2019-12-04
OE3HBS

Agenda

1. NanoVNA
   Beschreibung, was man nicht erwarten darf, Menue, Clones, Innenleben, Blockschaltbild, Schaltung, Lieferumfang, technische Daten, Preise, Touchstone Export, Open Source SW, Forum, Console Commands,

2. THEORIE
   Scattering Parameter, Stehwelllenverhältnis, Reflexionsdämpfung, Smith Chart

3. MESSUNGEN
   Widerstand, Kondensator, Spule, Quarz, AL-Wert, Einfügungs-dämpfung, Filter (Tiefpass, Bandpass), Balun, Antennen (Dipol, Groundplane, Batwing), Dummyload, Koaxleitung, Verkürzungsfaktor.



Beschreibung

Der **NanoVNA** ist ein **Vector Network Analyzer**
für den Frequenzbereich von 50KHz bis 900MHz
mit einem 2.8" Touch LCD und LiPo Akku
in Scheckkartengröße.

Was man nicht erwarten darf

- schnelle Messreihen
- Genauigkeit auf ein Zehntel dB
- Dynamikbereich von 100dB
- GHz Frequenzbereich

Quelle: https: https://nuclearrambo.com/wordpress/comparing-nanovna-with-the-keysight-fieldfox-n9952a/

Was man nicht erwarten darf

Bad points:

1. Although calibrated, the S11 curve still fluctuates so much that the impedance plot on the Smith chart cannot be concentrated at one point.

2. As mentioned in 1, the noise floor of the S21 curve is very large, resulting in a reduction in the dynamic range of the S21 and inaccurate measurements.

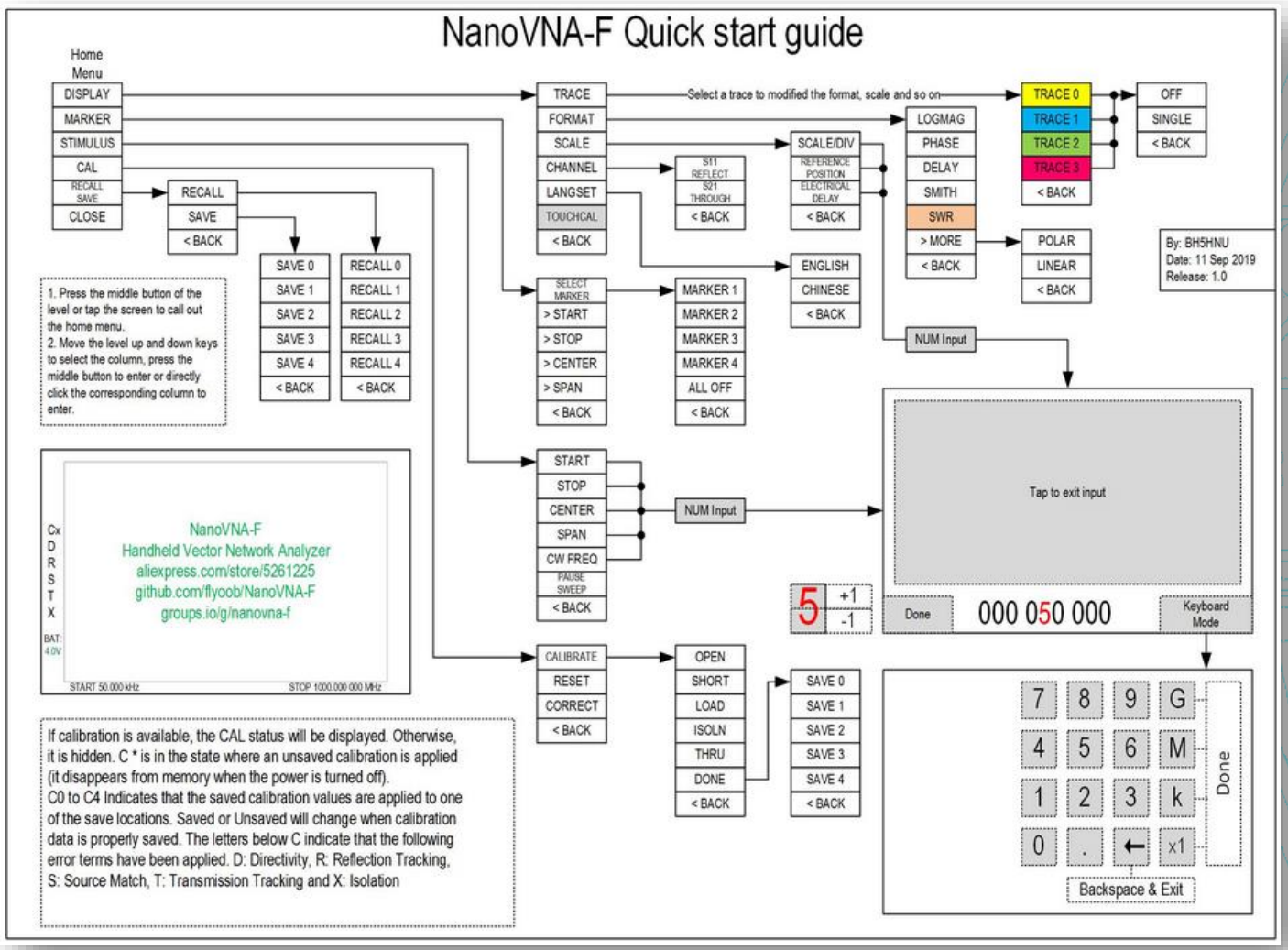
3. Without the shielding and protection of the metal case, it is a semi-finished product rather than a user-oriented product.

4. The large USB port is directly omitted, which causes the device to fail to supply power. Subsequent accessories, such as Bluetooth modules, cannot be supported.
and so on...

The producer does not seem to understand the basic principles of VNA calibration at all, it is just a simple hardware copy machine.

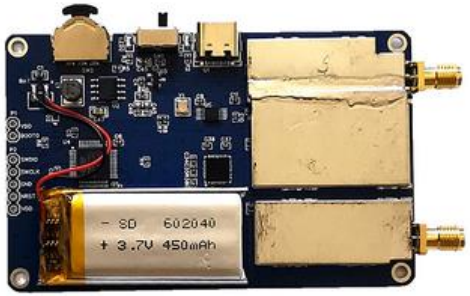
Quelle: https://groups.io/g/nanovna-users/photo/0/7?p=Created,,,20,2,0,0

Menü


NanoVNA-F Quick start guide
Home Menu
DISPLAY
MARKER
STIMULUS
CAL
RECALL SAVE
CLOSE
RECALL
SAVE
< BACK
SAVE 0
SAVE 1
SAVE 2
SAVE 3
SAVE 4
< BACK
RECALL 0
RECALL 1
RECALL 2
RECALL 3
RECALL 4
< BACK
1. Press the middle button of the level or tap the screen to call out the home menu.
2. Move the level up and down keys to select the column, press the middle button to enter or directly click the corresponding column to enter.
NanoVNA-F
Handheld Vector Network Analyzer
aliexpress.com/store/5261225
github.com/flyoob/NanoVNA-F
groups.io/g/nanovna-f
START 50.000 kHz
STOP 1000.000 000 MHz
If calibration is available, the CAL status will be displayed. Otherwise, it is hidden. C * is in the state where an unsaved calibration is applied (it disappears from memory when the power is turned off).
C0 to C4 Indicates that the saved calibration values are applied to one of the save locations. Saved or Unsaved will change when calibration data is properly saved. The letters below C indicate that the following error terms have been applied. D: Directivity, R: Reflection Tracking, S: Source Match, T: Transmission Tracking and X: Isolation
TRACE
FORMAT
SCALE
CHANNEL
LANGSET
TOUCHCAL
< BACK
Select a trace to modified the format, scale and so on
S11 REFLECT
S21 THROUGH
< BACK
SCALE/DIV
REFERENCE POSITION
ELECTRICAL DELAY
< BACK
LOGMAG
PHASE
DELAY
SMITH
SWR
> MORE
< BACK
TRACE 0
TRACE 1
TRACE 2
TRACE 3
< BACK
OFF
SINGLE
< BACK
POLAR
LINEAR
< BACK
ENGLISH
CHINESE
< BACK
By: BH5HNU
Date: 11 Sep 2019
Release: 1.0
SELECT MARKER
> START
> STOP
> CENTER
> SPAN
< BACK
MARKER 1
MARKER 2
MARKER 3
MARKER 4
ALL OFF
< BACK
NUM Input
START
STOP
CENTER
SPAN
CW FREQ
PAUSE SWEEP
< BACK
NUM Input
Tap to exit input
5
+1
-1
Done
000 050 000
Keyboard Mode
CALIBRATE
RESET
CORRECT
< BACK
OPEN
SHORT
LOAD
ISOLN
THRU
DONE
< BACK
SAVE 0
SAVE 1
SAVE 2
SAVE 3
SAVE 4
< BACK
7 8 9 G
4 5 6 M
1 2 3 k
0 . ← x1
Done
Backspace & Exit

CLONES

My version



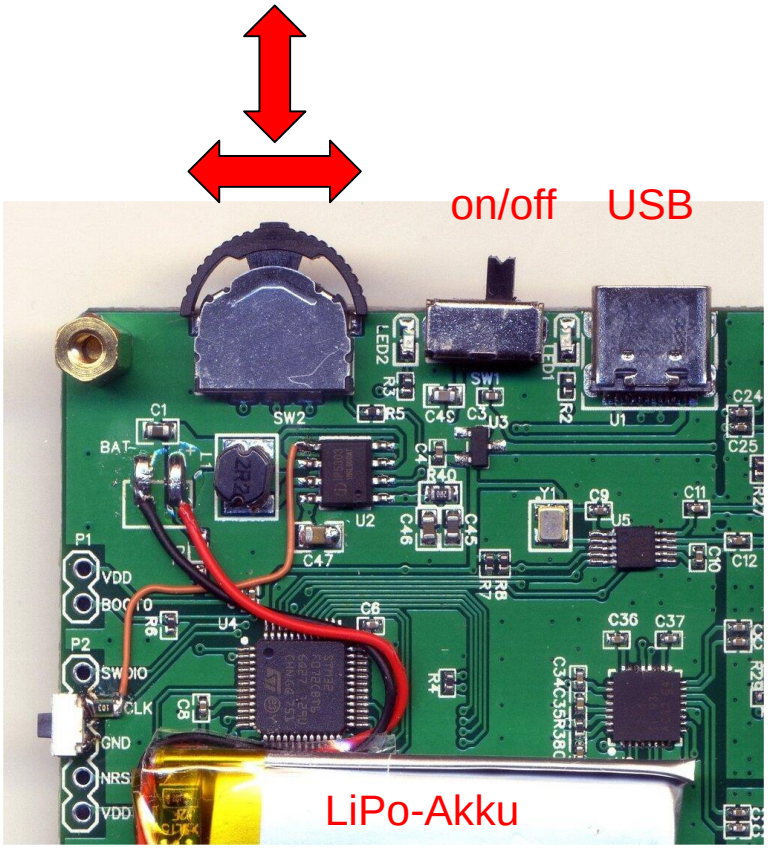
Bad clone

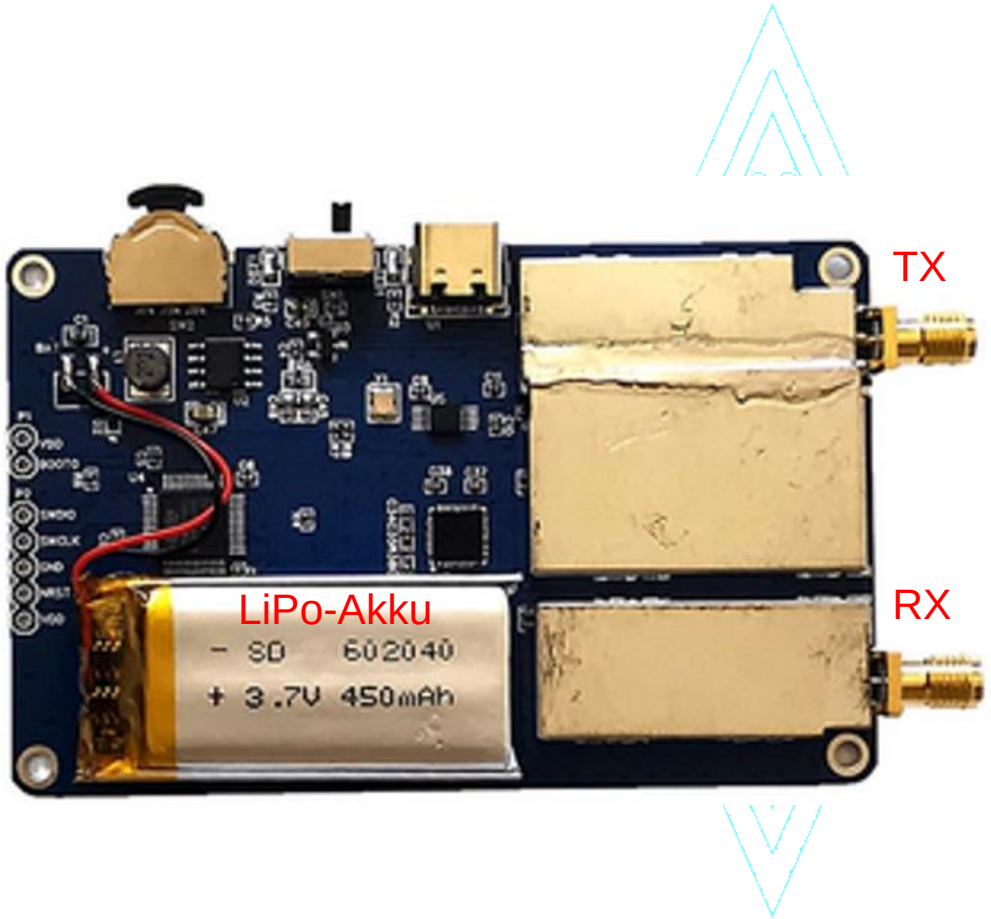
Worse clone

1.5GHz Version

Source: https://german.alibaba.com/
https://www.ebay.de/i

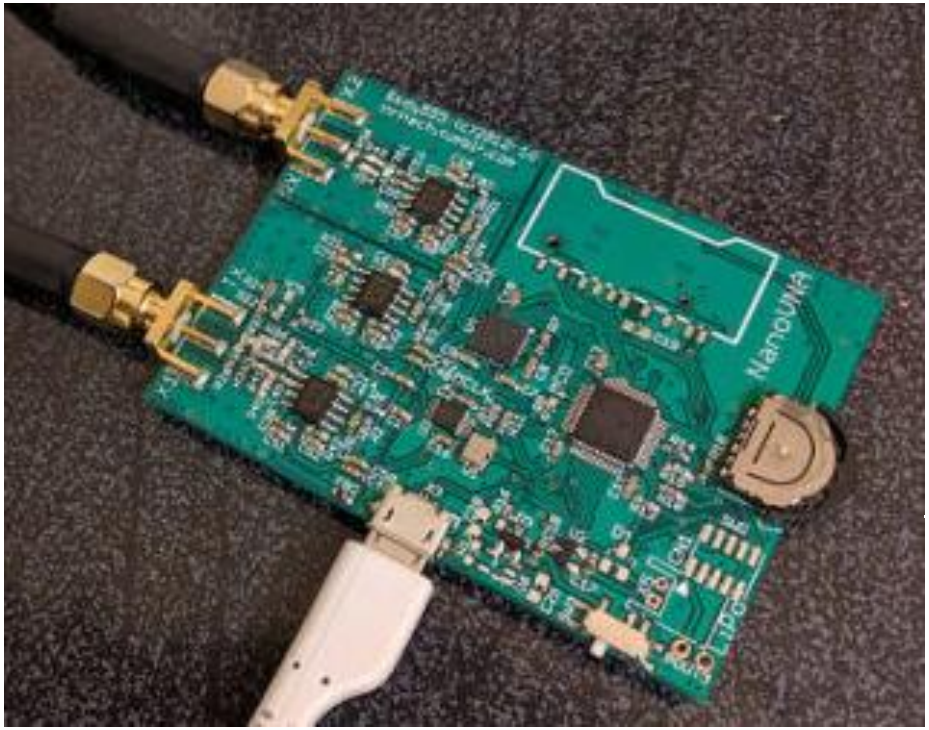
INNENLEBEN

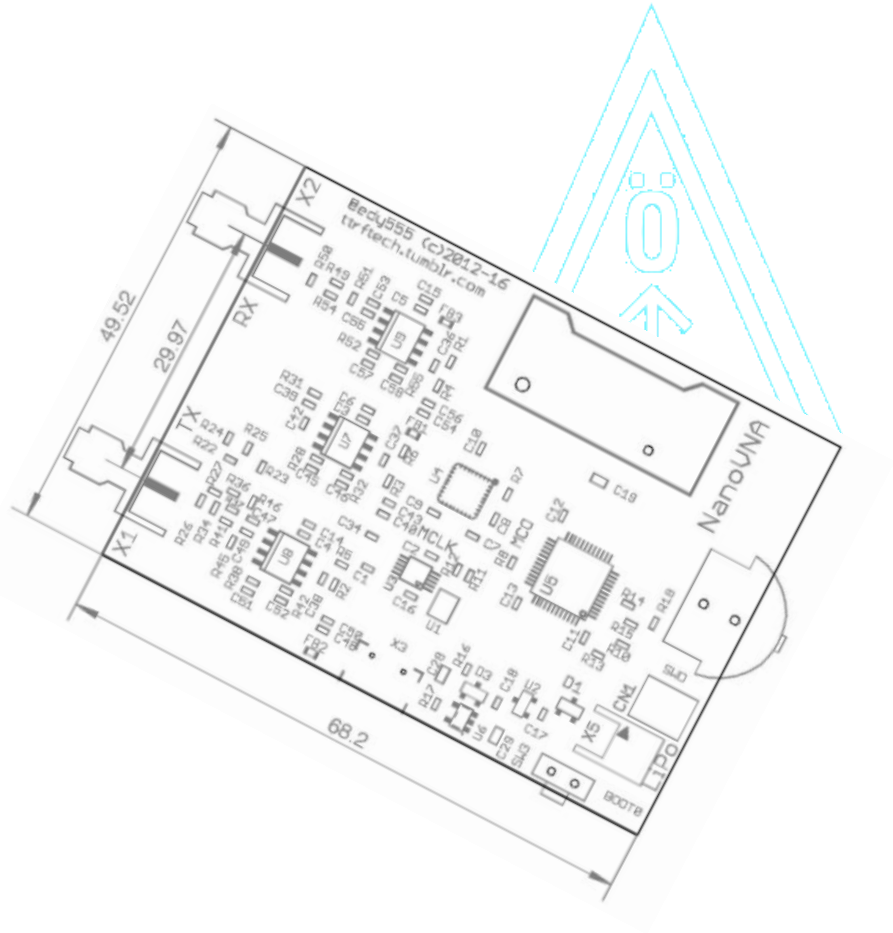




Quelle: https://groups.io/g/nanovna-users/attachment/957/0/NanoVNA_startup.jpg

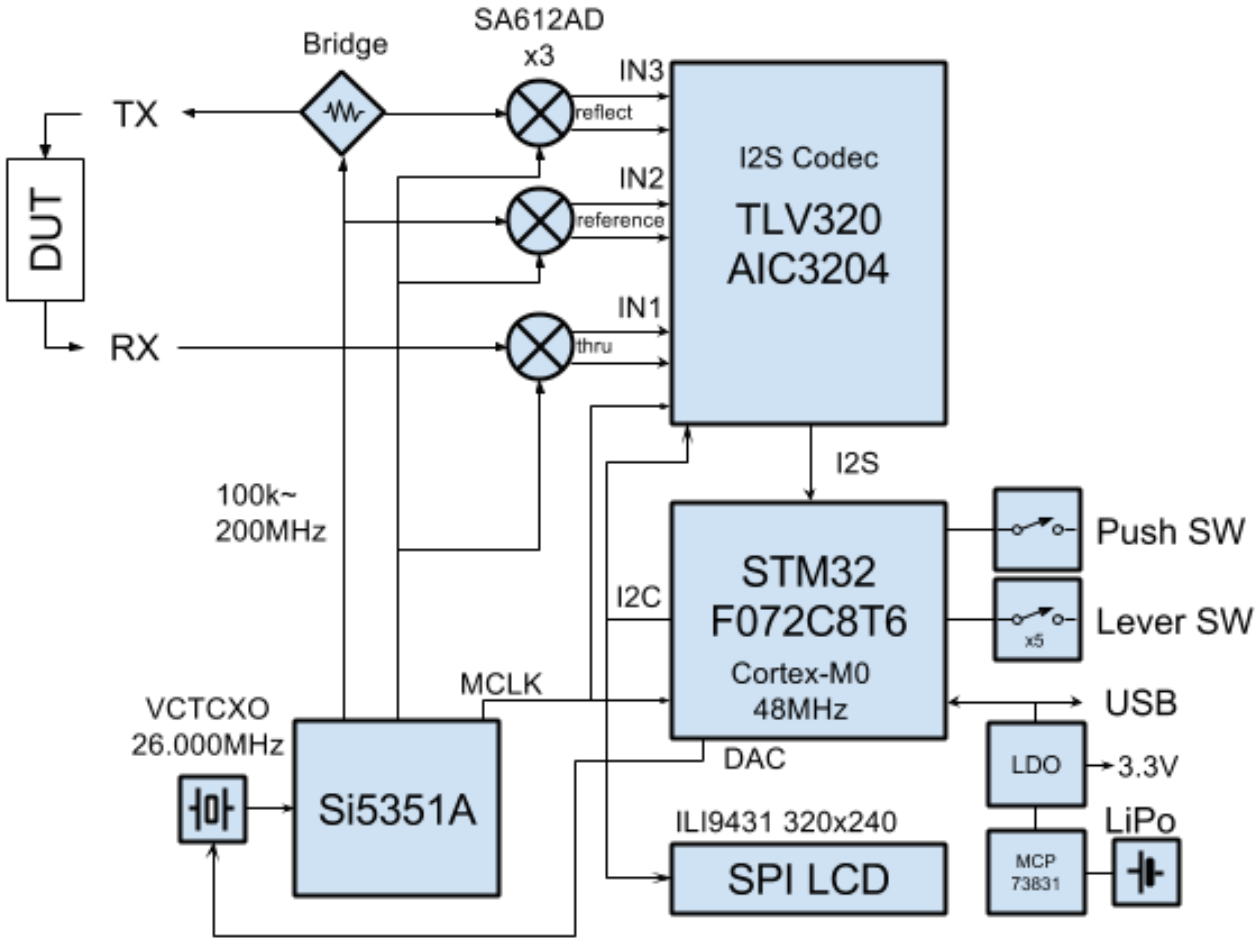
INNENLEBEN





https://ttrf.tk/posts/2016-11-08-calibration-process-in-python-for-nanovna/

BLOCKSCHALTBILD



SA612A is a low-power VHF monolithic double-balanced mixer with on-board oscillator and voltage regulator.

TLV320 is a high-performance stereo audio codec with highly integrated analog functionality.

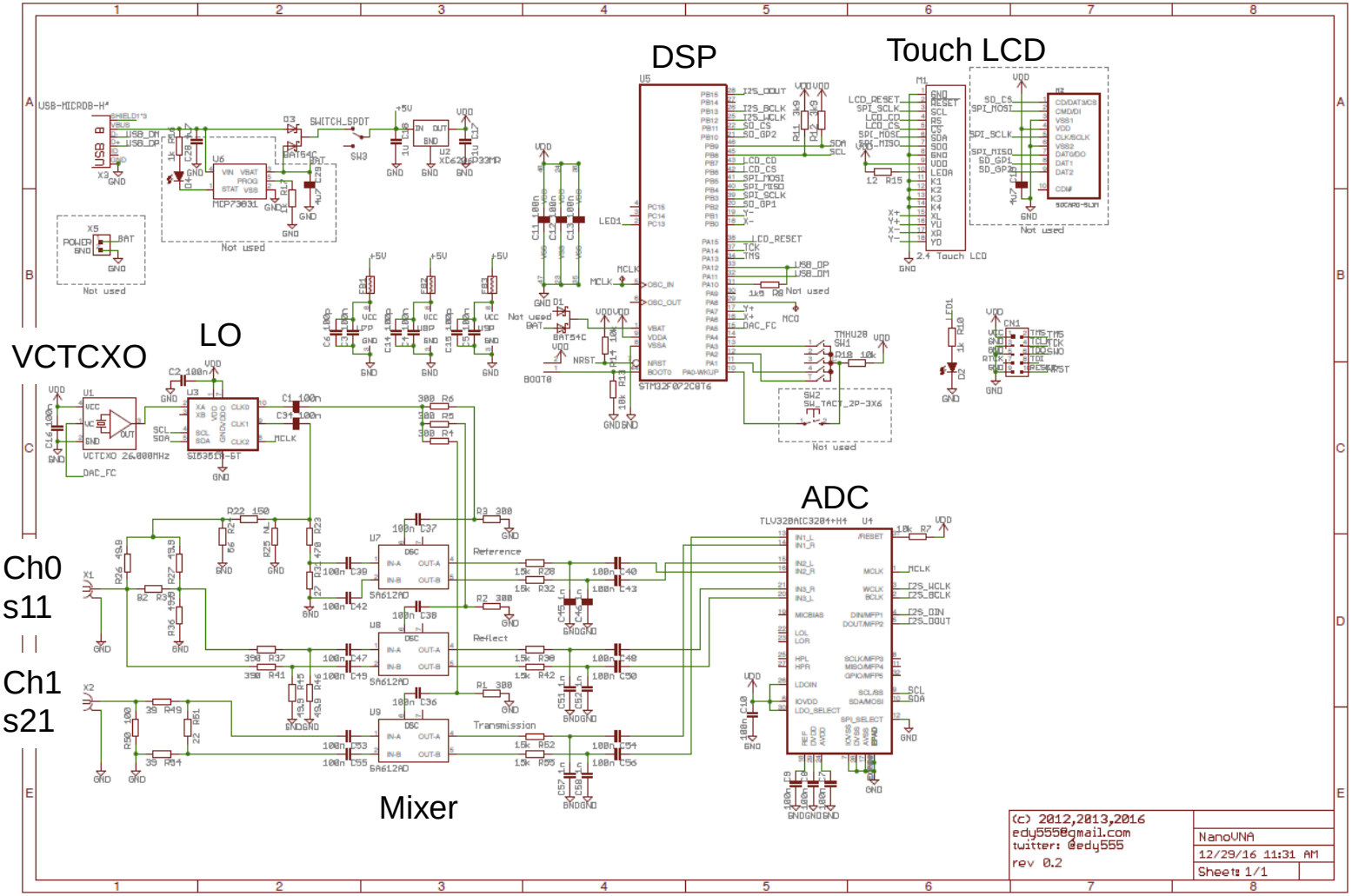
STM32F072C8T6 is a ARM®-based 32-bit MCU, up to 128 KB Flash, crystal-less USB FS 2.0, CAN, 12 timers, ADC, DAC & comm. interfaces, 2.0 - 3.6 V

ILI9341 is a 262,144-color single-chip SOC driver for a-TFT liquid crystal display with resolution of 240RGBx320 dots, comprising a 720-channel source driver, a 320-channel gate driver, 172,800 bytes GRAM for graphic display data of 240RGBx320 dots, and power supply circuit.

Si5351 is an I2C configurable clock generator that is ideally suited for replacing crystals, crystal oscillators, VCXOs, phase-locked loops (PLLs), and fanout buffers incost-sensitive applications.

Quelle: https://github.com/ttrftech/NanoVNA/blob/master/doc/nanovna-blockdiagram.png

SCHALTUNG



Quelle: https://github.com/ttrftech/NanoVNA/blob/master/doc/nanovna-sch.pdf

LIEFERUMFANG

NanoVNA

2x SMA Kabel

USB Kabel

Kalibrierungs-Set

Quelle: https://github.com/ttrftech/NanoVNA/blob/master/doc/nanovna-sch.pdf

Wichtige Spezifikationen für einen VNA

***Frequency range**:* This is the main specification. A network analyzer's frequency range defines the minimum and maximum frequencies it can measure.

Dynamic range: This defines the range of power that the network analyzer can measure.

Number of test ports: A network analyzer can have two, four, or more test ports.

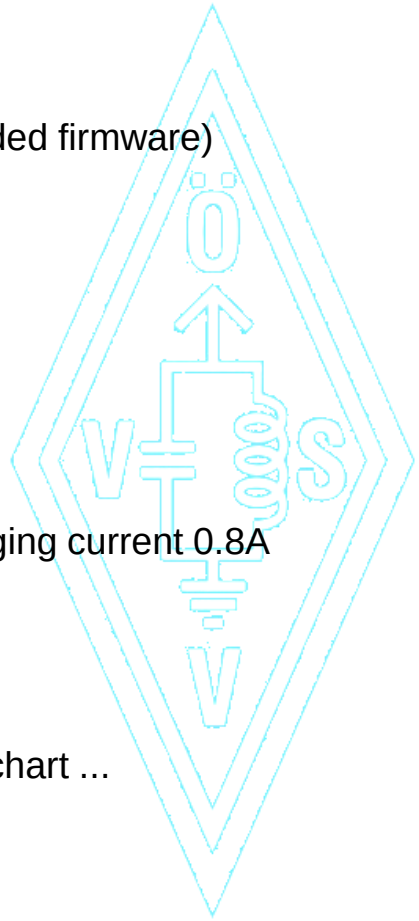
Measurement speed: This is the time required to perform measurements across a range of frequencies.

Quelle: https://www.mwrf.com/print/18192

TECHNISCHE DATEN

Basic performance:

- PCB: 54mm x 85.5mm x 11mm (without connectors, switches)
- Measurement frequency: 50KHz ~ 300MHz (50KHz -900MHz, enable extended firmware)
- RF output: -13dBm (maximum -9dBm)
- Measurement range:
  70dB (50kHz-300MHz),
  60dB (300M-600MHz),
  50dB (600M-900MHz) enable extended firmware)
- Port SWR: < 1.1
- Display: 2.8 inch TFT (320 x240)
- USB interface: USB type-C communication mode: CDC (serial)
- Power: USB 5V 120mA, built-in 300mAh or 500mAh battery, maximum charging current 0.8A
- Number of scanning points: 101 (fixed)
- Display Tracking: 4
- Marking: 4,
- Setting Save: 5
- Measuring: S parameters, voltage standing wave ratio, phase, delay, Smith chart ...



NanoVNA - PREISE

Preise

Touchscreen NanoVNA Vector Analyzer Network Antenna MF H...

EUR 33,92

~~EUR 35,70~~

Kostenloser Versand

Verkäufer 99.6% positiv

NanoVNA HF VHF UHF UV Vector Network Analyzer Antenna Analy...

EUR 38,53

~~EUR 40,56~~

+ EUR 34,96 Versand

NanoVNA Vector Network Analyzer 50KHz-900MHz HF VHF UHF Ant...

EUR 45,00

+ EUR 8,00 Versand

Verkäufer 99.7% positiv

2.8" 50KHz-900MHz NanoVNA Vector Network Analyzer HF VHF UH...

EUR 45,00

(EUR 45,00/Einheit)

+ EUR 10,00 Versand

Verkäufer 99.4% positiv

NanoVNA 50KHz-900MHz Vector Network Analyzer Kit MF HF VHF VHF...

EUR 38,53

~~EUR 40,56~~

+ EUR 34,96 Versand

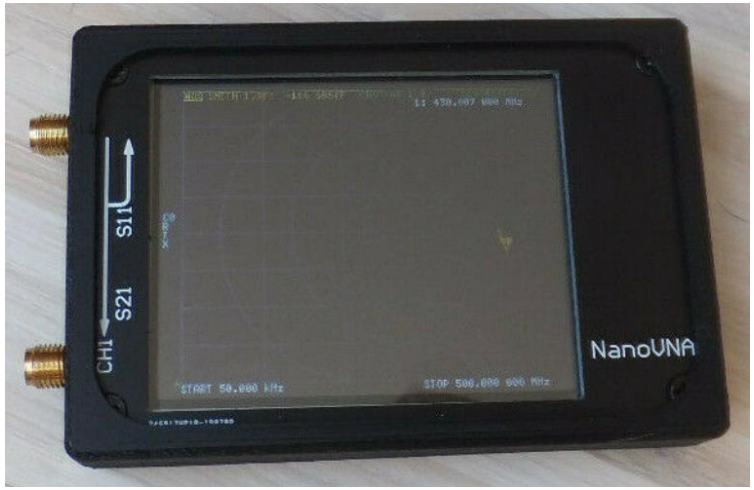
50KHz-900MHz Vector Network Analyzer MF HF VHF UHF Anten...

EUR 39,19

Kostenloser Versand

Verkäufer 99.2% positiv

Gehäuse für NanoVNA



https://picclick.de/Geh%C3%A4use-f%C3%BCr-den-NanoVNA-233348301384.html#&gid=1&pid=1

NanoVNA-H mit erweitertem Frequenzbereich bis 1.5GHz

EUR 45,38

Lieferumfang

Quelle: https://www.ebay.de/itm/50K-1-5GHz-NanoVNA-H-HF-VHF-UHF-Netzwerkantennenanalysator-Gehause/333398845312?_trkparms=aid%3D333200%26algo%3DCOMP.MBE%26ao%3D1%26asc%3D40735%26meid%3Dc1e254dc056e4dcd9202c7915f22fb20%26pid%3D100008%26rk%3D7%26rkt%3D12%26sd%3D362800305573%26itm%3D333398845312%26pmt%3D1%26noa%3D0%26pg%3D2047675&_trksid=p2047675.c100008.m2219

Touchstone Export

```
!Created with skrf (http://scikit-rf.org)
# MHz S RI R 50.0
!freq ReS11 ImS11
1.0 0.012460355 -0.015879744
3.99 -0.008661273 -0.069707974
6.98 -0.042227279 -0.115677334
9.97 -0.092017509 -0.143823102
12.96 -0.147657468 -0.149449899
15.95 -0.201385751 -0.135523363
18.94 -0.243053123 -0.102494128
21.93 -0.270805299 -0.057194426
24.92 -0.279718816 -0.006995845
27.91 -0.26907292 0.044069305
30.9 -0.240883052 0.086606264
33.89 -0.198594421 0.115753814
36.88 -0.148413732 0.127066627
39.87 -0.095692999 0.120097838
42.86 -0.051569625 0.092090547
45.85 -0.021049311 0.050145152
48.84 -0.008668005 0.000488108
51.83 -0.01736783 -0.046825736
54.82 -0.043845944 -0.085811898
57.81 -0.07889305 -0.108475185
60.8 -0.115591615 -0.111082322
```

OPEN SOURCE

Prepare ARM Cross Tools

Install cross tools and firmware updating tool.

```
$ brew tap PX4/px4
$ brew install gcc-arm-none-eabi
$ brew instal dfu-util
```

Otherwise, use toolchains included inside LPCxpresso. Like this.

```
$ PATH=$PATH:/Applications/lpcxpresso_7.8.0_426/lpcxpresso/tools/bin
```

Build firmware

Fetch ChibiOS submodule into tree.

```
$ cd nanovna
$ git submodule update --init --recursive
```

Just make in the top directory.

```
$ make
```

Flash firmware

Boot MCU in DFU mode. To do this, jumper BOOT0 pin at powering device. Then, burn firmware using dfu-util via USB.

```
$ dfu-util -d 0483:df11 -a 0 -s 0x08000000:leave -D build/ch.bin
```


Quelle: https://github.com/ttrftech/NanoVNA

NanoVNA - Forum

Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe

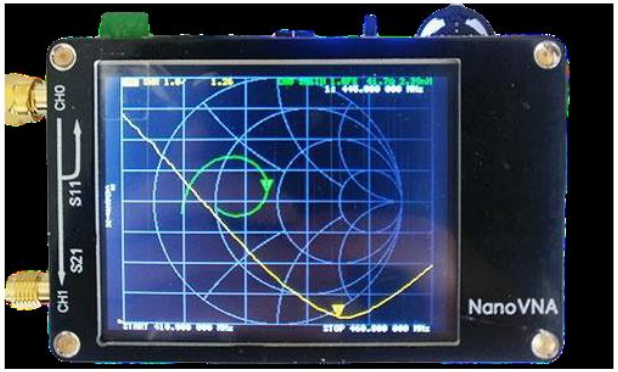
Suchergebnis auf Amazon.de f… | AD8362 50HZ-3.8GHZ,RF Radio… | NanoVNA-H Vector Network A… | nanovna-users@groups.io | Ho…

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

Meistbesucht ft991-wsjt-x.pdf Arduino Reference

Groups.io Find or Create a Group

Home
Messages
Hashtags



nanovna users nanovna-users@groups.io

Group Description

Users of nanovna small VNA
Files: https://groups.io/g/nanovna-users/files
Wiki: https://groups.io/g/nanovna-users/wiki

Group Information

2,620 Members
729 Topics, Last Post: 9:14pm
Started on Jun 3
Feed

Group Settings

All subscribers can post to the group.
Posts to this group do not require approval from the moderators.
Messages are set to reply to group.
Subscriptions to this group require approval from the moderators.
Archives are visible to anyone.
Wiki is visible to subscribers only.
Members can set their subscriptions to no email.

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

NanoVNA – Console Commands

NanoVNA connects to USB as a virtual COM port and supports plain text commands based on ChibiOS/RT shell. Commands can be found in firmware main.c source code.

NanoVNA Console Commands: **Updated Nov 4, 2019**

(Change list moved to end of document) © L. Rothman

NOTE: The following is an ***evolving*** description of the NanoVNA's USB *console* command list and is updated as new commands are added/removed or functionality of existing commands changes. For additional info on a command, ask about it in the forum. Please send any corrections or updates to my attention.

This list can be found online at: https://groups.io/g/nanovna-users/wiki/shellcommands

New Commands or F/W News:

QRP's firmware release v0.4.3 now supports a battery voltage calibration command: vbat_offset

Console Commands (in no particular order):

help – **Note**: Commands in ( ) may or may not be present for an individual developer's F/W release.

- Prints the following text string to the console:

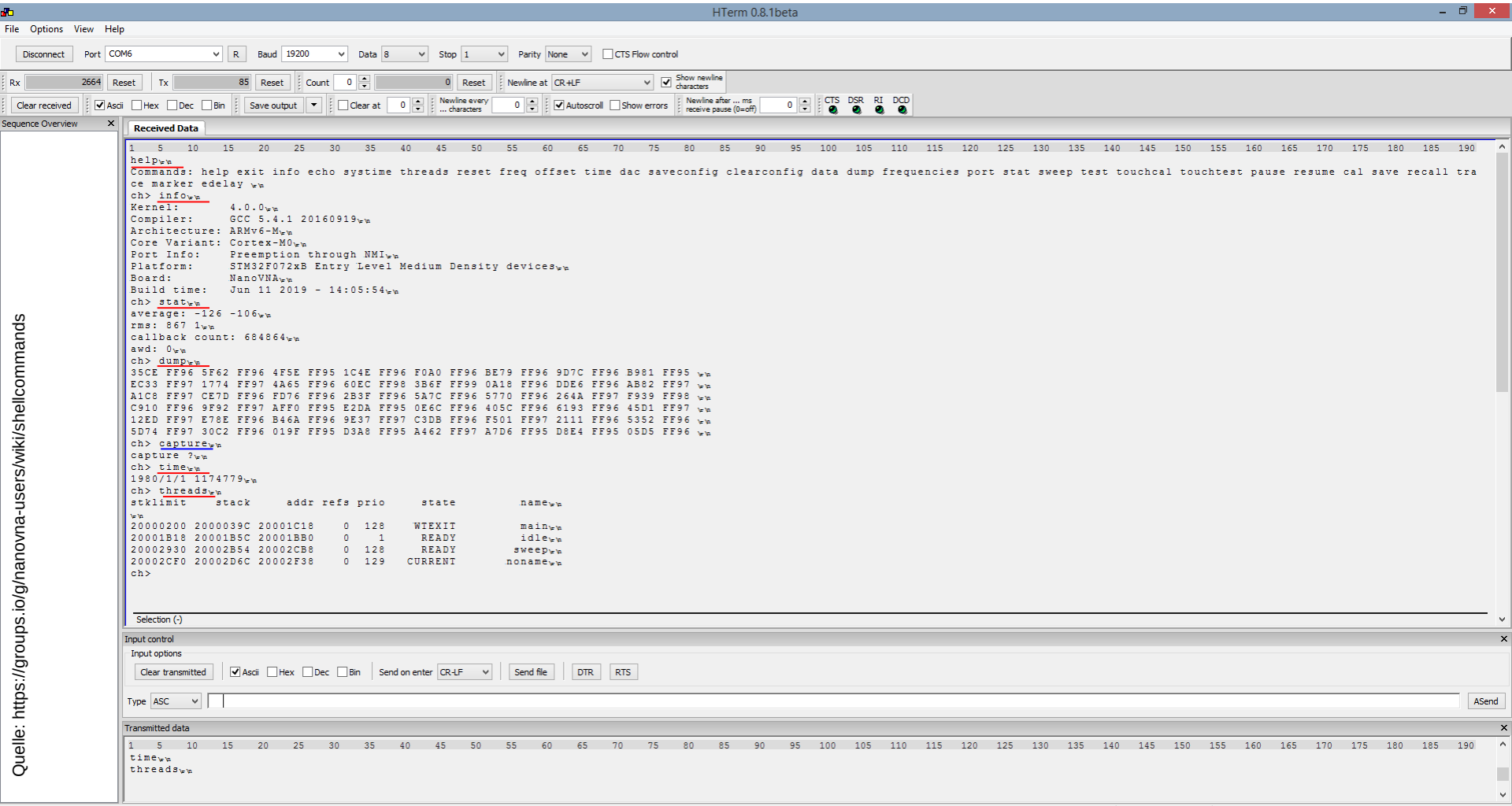
```
help, exit, info, threads, version, reset, freq, offset, time, dac,
saveconfig, clearconfig, data, dump, frequencies, port, stat, gain, power,
sample, (scan), (scanraw), sweep, test, touchcal, touchtest, pause, resume,
cal, save, recall, trace, marker, edelay, (capture), (vbat), transform,
threshold, (color), (vbat_offset)
```

exit – exits and then restarts console mode

```
outputs:   "ChibiOS/RT Shell"
```

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

NanoVNA – Console Commands



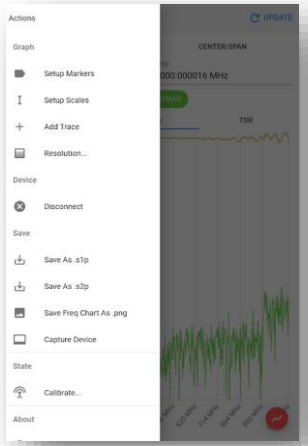
Quelle: https://groups.io/g/nanovna-users/wiki/shellcommands

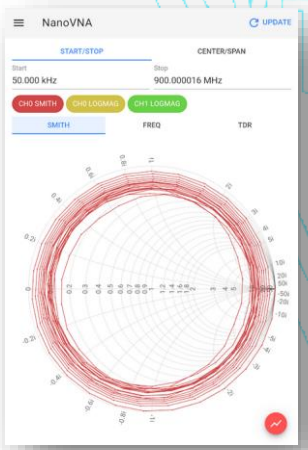
NanoVNA - App

NanoVNA WebApp is an open source Android application for NanoVNA / NanoVNA-H.
It works by connecting with NanoVNA via USB.

You can do the following:
* Increase in measurement points (multi-segment scan)
* Get NanoVNA screen capture
* s1p s2p file generation
* Time domain measurement

A USB OTG cable connector is required to connect NanoVNA to an Android smartphone.

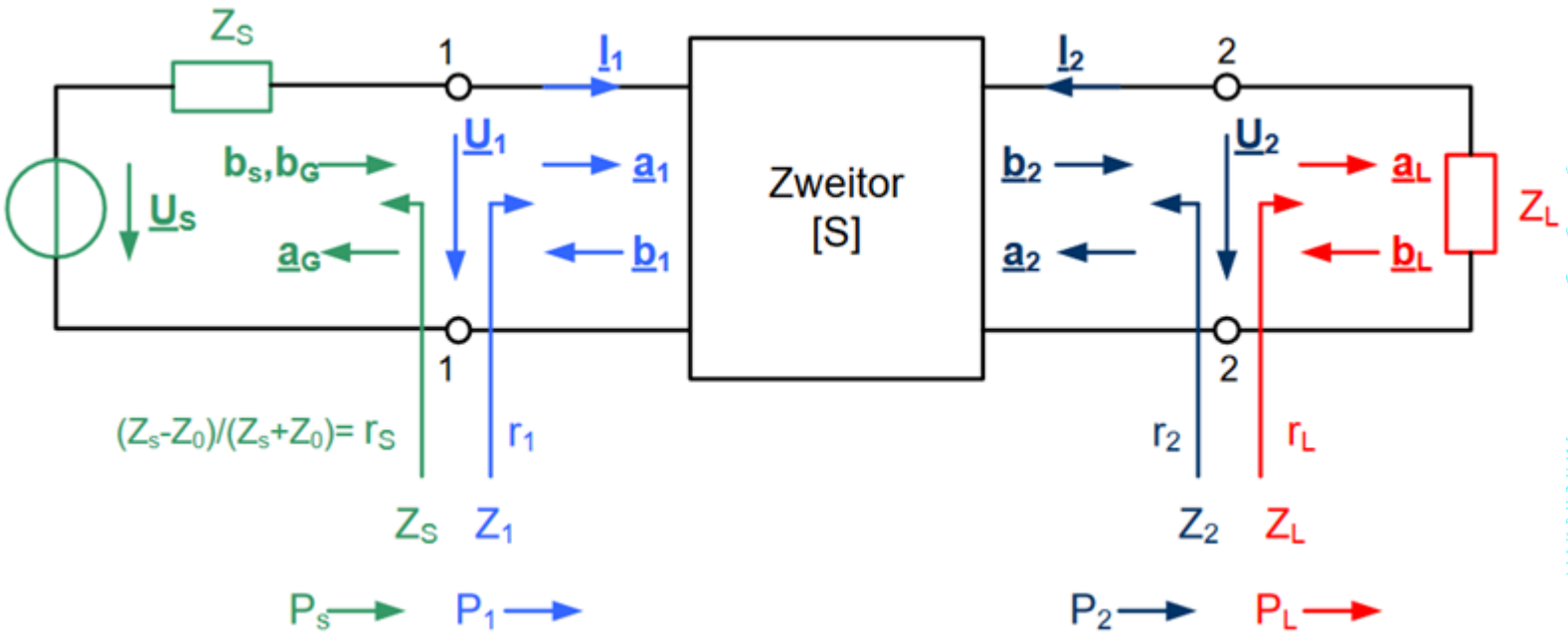




https://play.google.com/store/apps/details?id=net.lowreal.nanovnawebapp&hl=de_AT

Theorie

STREUPARAMETER (Scattering Parameter)



$$S_{11} = \frac{b_1}{a_1}$$

Eingangs-Reflexionsfaktor

$$S_{12} = \frac{b_1}{a_2}$$

Rückwärts-Transmissionsfaktor

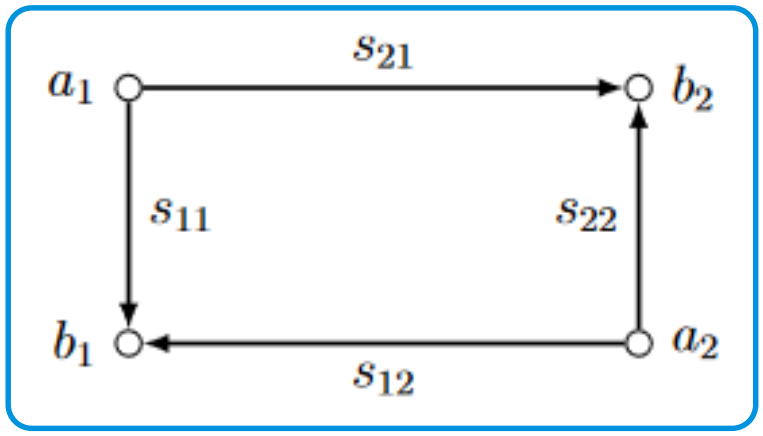
$$S_{21} = \frac{b_2}{a_1}$$

Vorwärts-Transmissionsfaktor

$$S_{22} = \frac{b_2}{a_2}$$

Ausgangs-Reflexionsfaktor

STREUPARAMETER (Scattering Parameter)



S11 is the input port voltage reflection coefficient
S12 is the reverse voltage gain
S21 is the forward voltage gain
S22 is the output port voltage reflection coefficient

$$s_{11} = \frac{b_1}{a_1} \text{ für } a_2 = 0\text{: } Eingangsreflexionsfaktor\ bei\ angepasstem\ Ausgang$$

$$s_{12} = \frac{b_1}{a_2} \text{ für } a_1 = 0\text{: } Rückwärtstransmissionsfaktor\ bei\ angepasstem\ Eingang$$

$$s_{21} = \frac{b_2}{a_1} \text{ für } a_2 = 0\text{: } Vorwärtstransmissionsfaktor\ bei\ angepasstem\ Ausgang$$

$$s_{22} = \frac{b_2}{a_2} \text{ für } a_1 = 0\text{: } Ausgangsreflexionsfaktor\ bei\ angepasstem\ Eingang$$

STEHWELLENVERHÄLTNIS (Voltage Standing Wave Ratio, VSWR)

Das Stehwellenverhältnis (VSWR) ist wie folgt definiert:

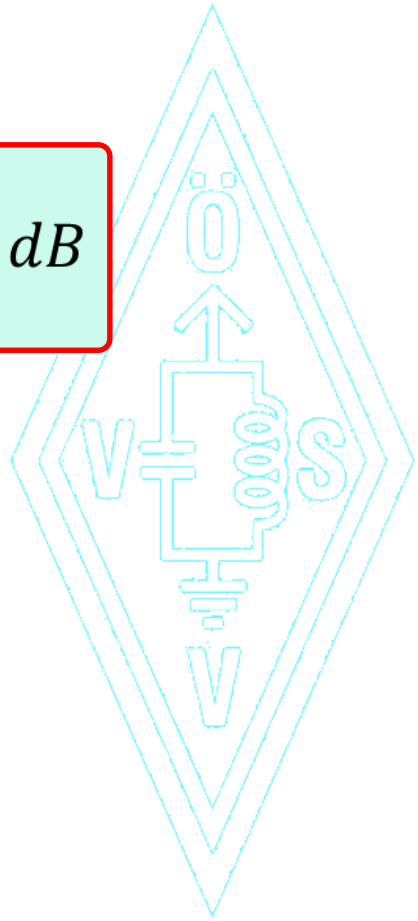
$$VSWR = \frac{1 + |S_{11}|}{1 - |S_{11}|}$$

REFLEXIONSDÄMPFUNG (Return Loss, RL)

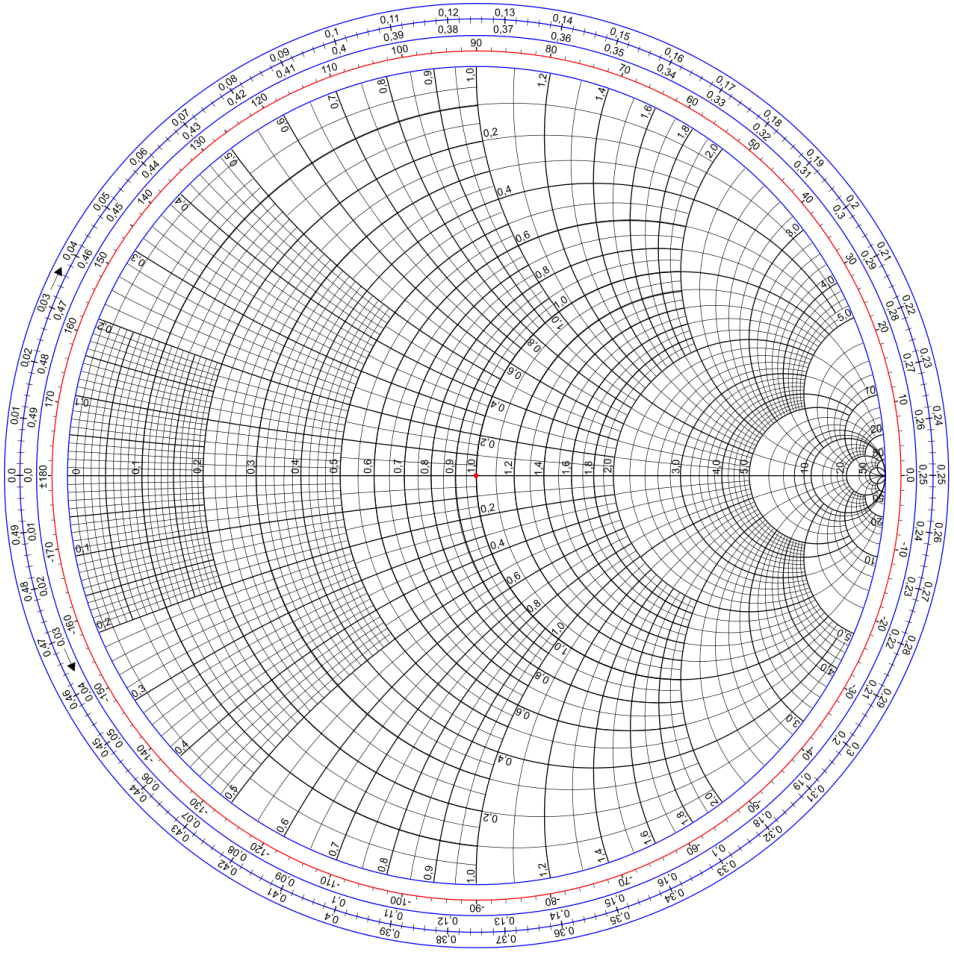
Die Reflexionsdämpfung sagt aus wie nahe man an der Systemimpedanz ist.

$$RL_{in} = 10\,log_{10}\left|\frac{1}{S_{11}^2}\right| = -20\,log_{10}|S_{11}|\;dB$$

$$RL_{out} = -20\,log_{10}|S_{22}|\;dB$$



SMITH CHART



Wir messen …

Kalibrierung

In practice, there are several VNA calibration methods, each of which has unique benefits in various applications.
The following two VNA calibration methods exist:

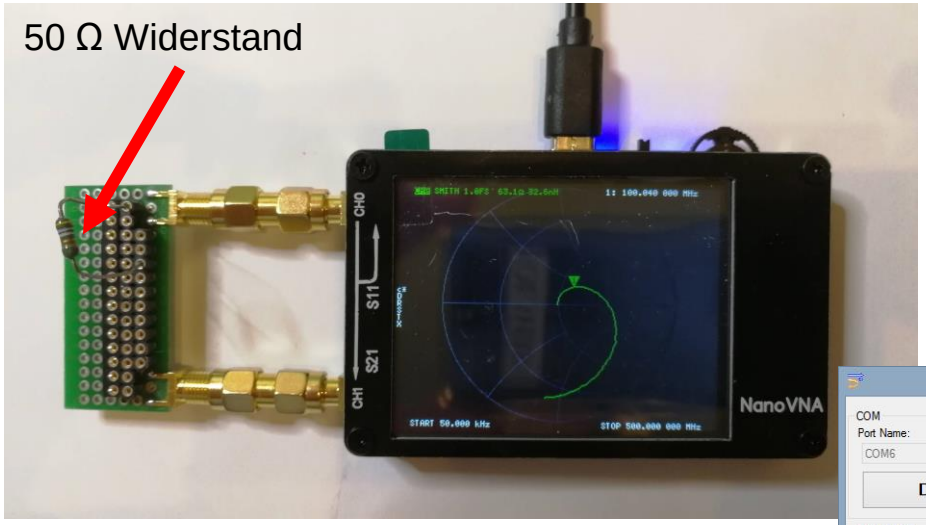
- Short-Open-Load-Through (SOLT)
- Through-Reflect-Line (TRL)

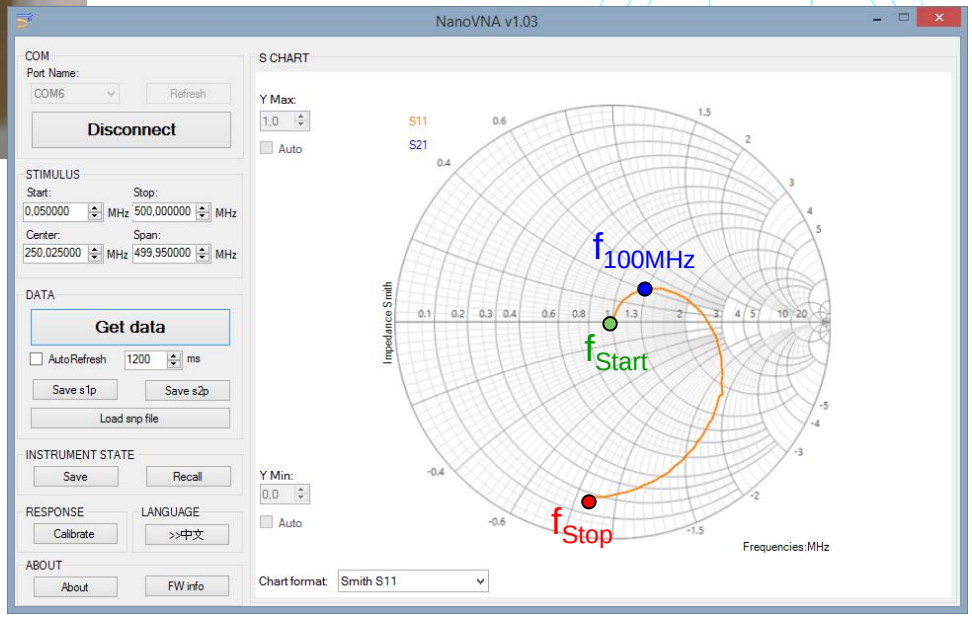
Automatic VNA Calibration Kit

nanoVNA
Kalibrierungs-Set

http://download.ni.com/evaluation/rf/Introduction_to_Network_Analyzer_Measurements.pdf

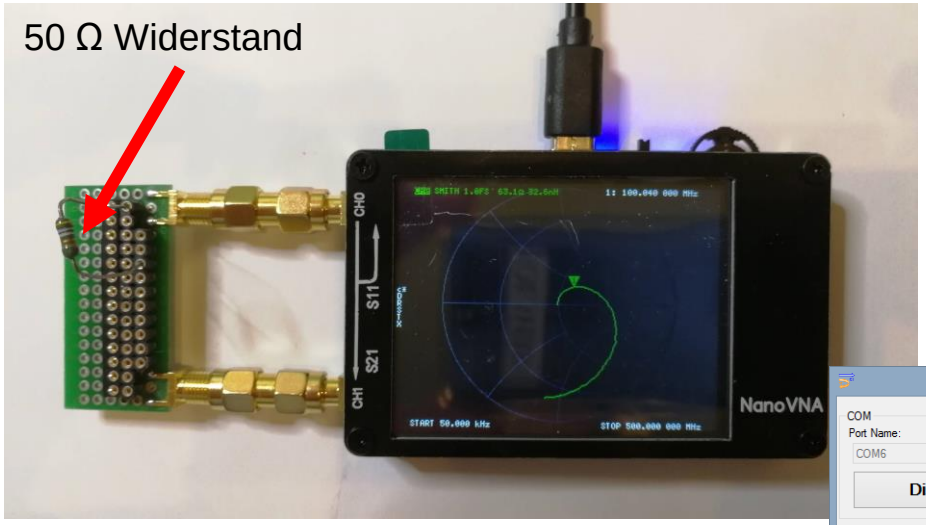
Messung an einem Widerstand (s11)

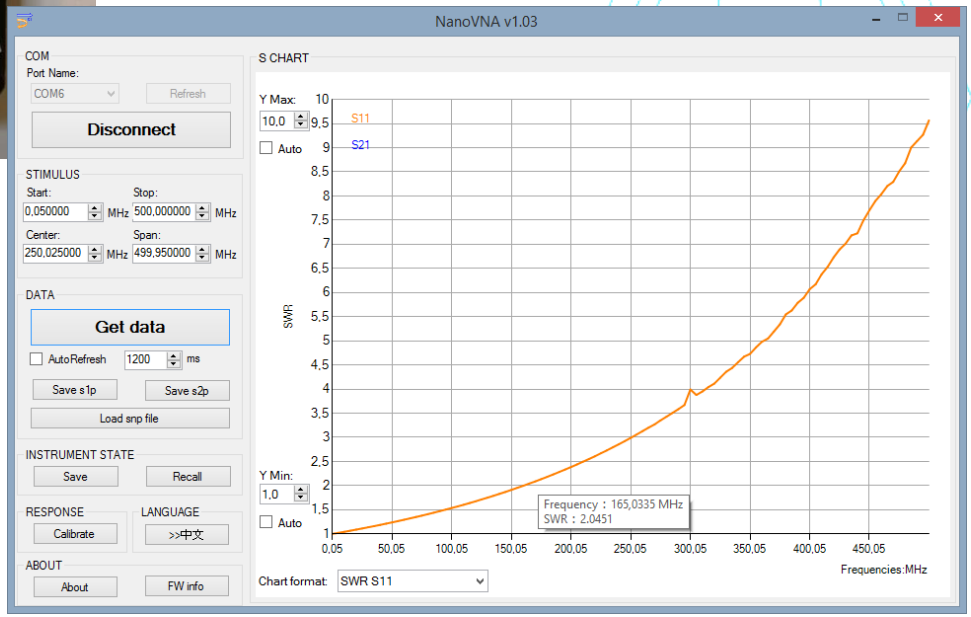




Start: 50KHz
Stop: 500MHz

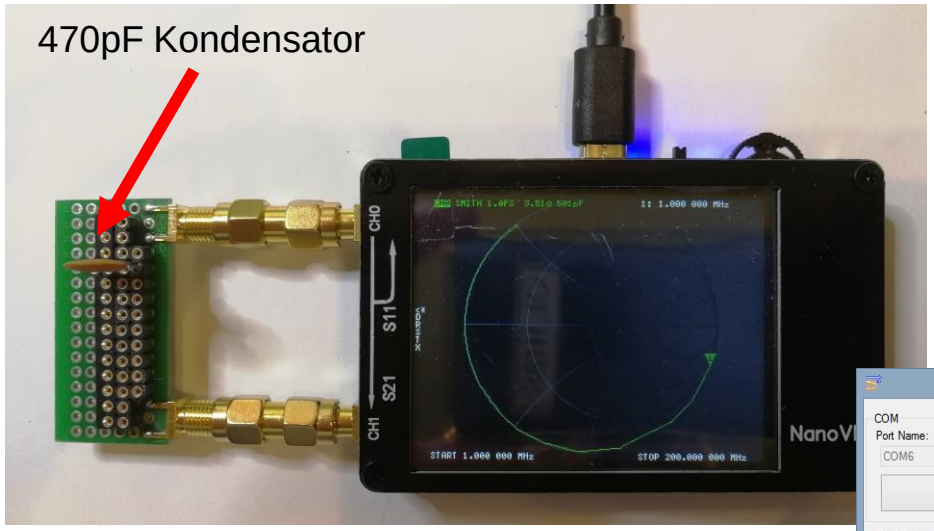
Messung an einem Widerstand (SWR)

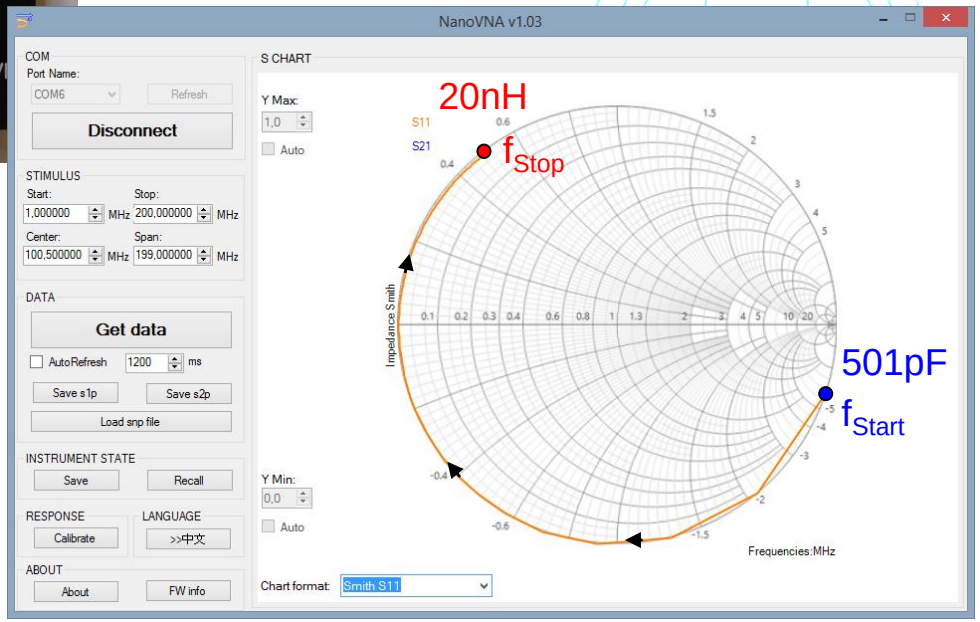




Start: 50KHz
Stop: 500MHz

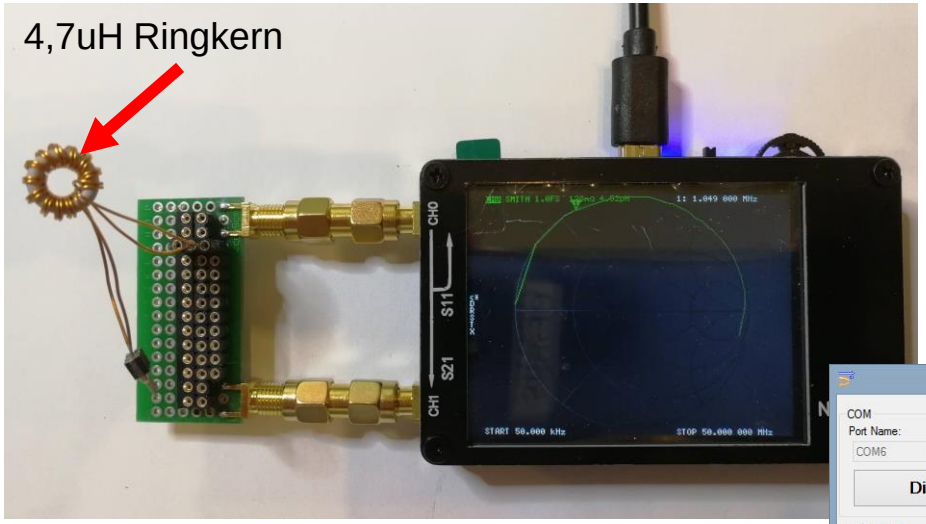
Messung an einem Kondensator (s11)

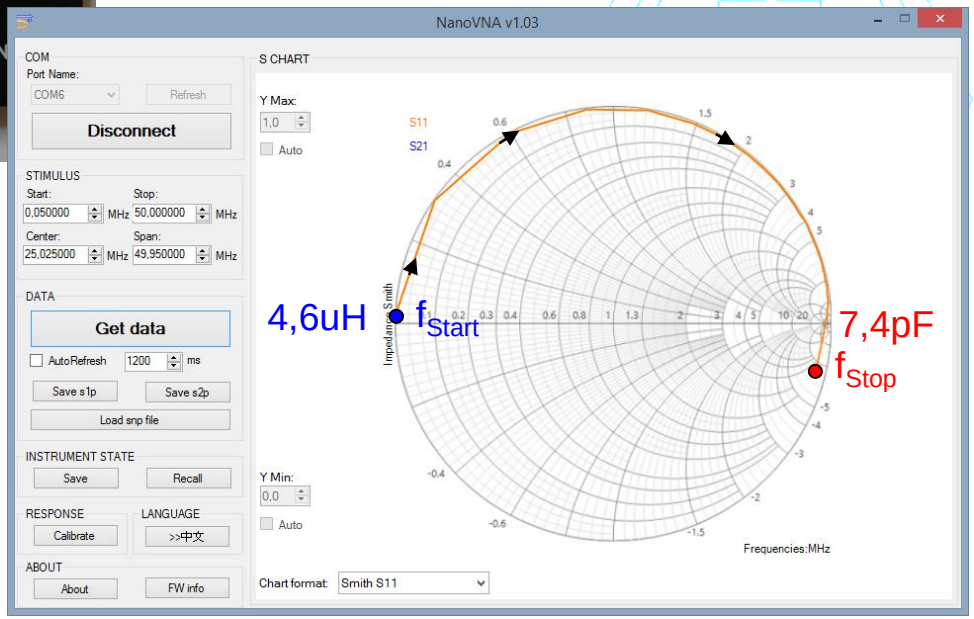




Start: 1MHz
Stop: 200MHz

Messung an einer Spule (s11)

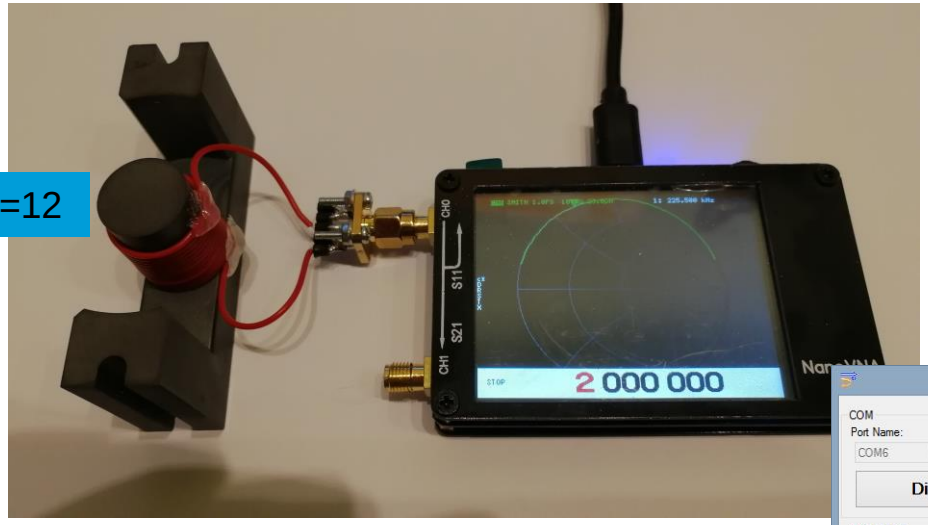


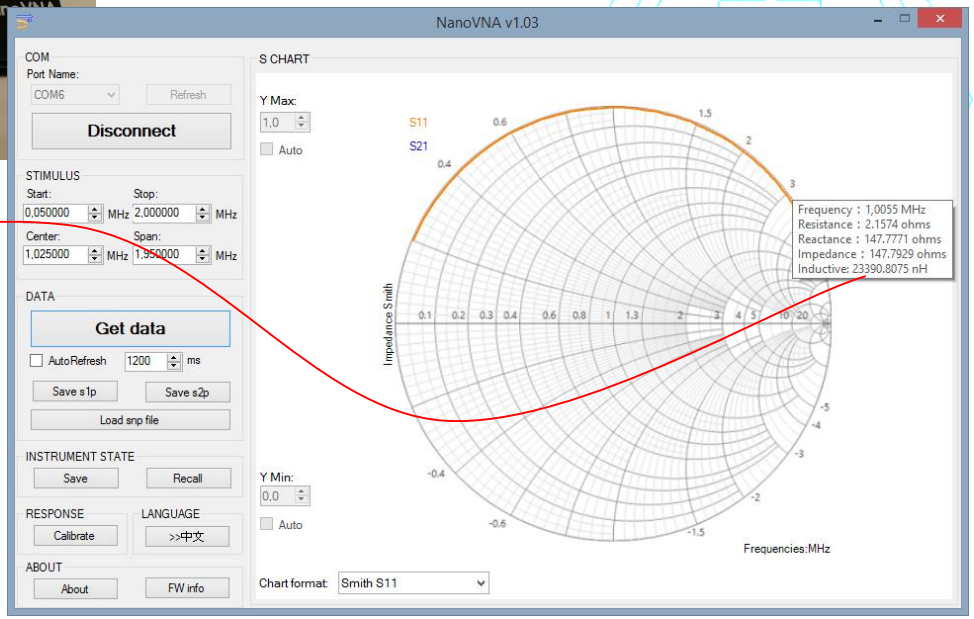


Start: 50KHz
Stop: 50MHz

Bestimmung des A_L-Wertes einer Spule

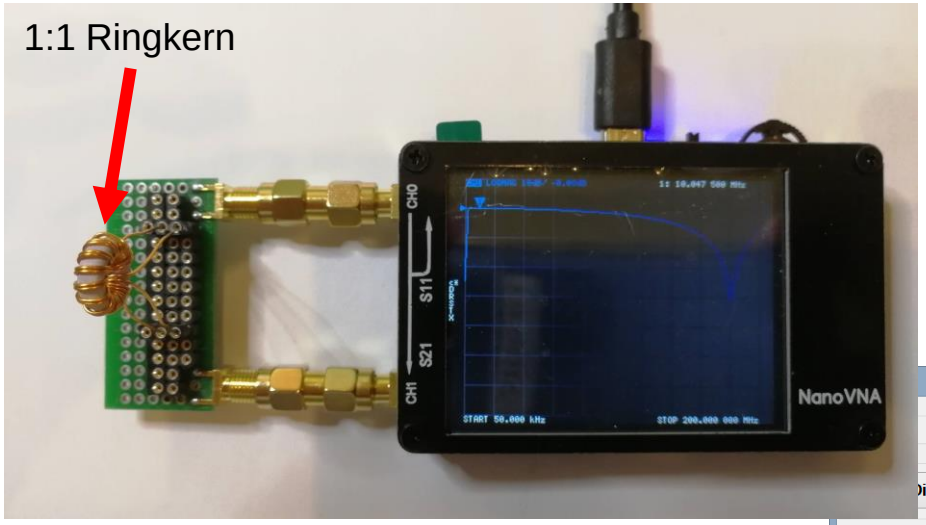
N=12

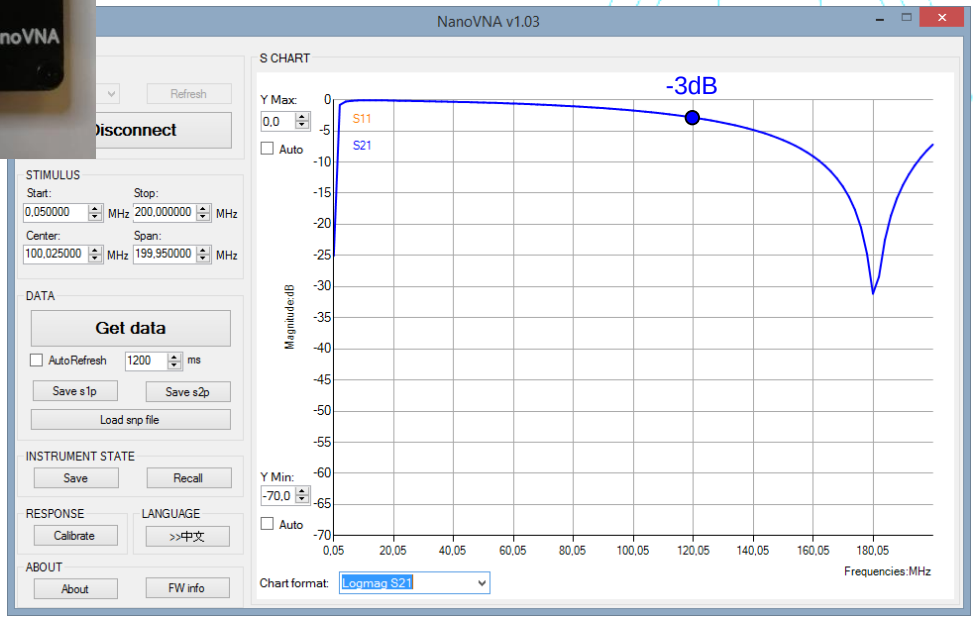




$$A_L = \frac{L}{N^2} = \frac{23390nH}{12^2} = 162nH$$

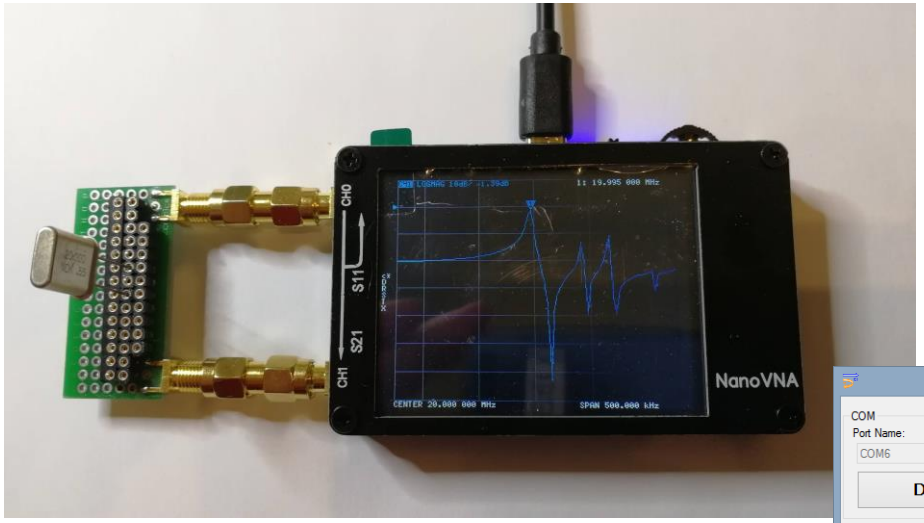
Messung an einem Ringkerntrafo (s21)



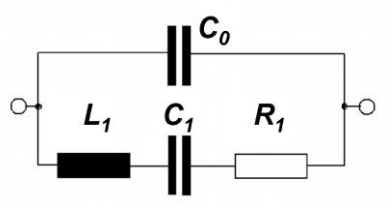


Start: 50KHz
Stop: 200MHz

Messung an einem Quarz (s21)

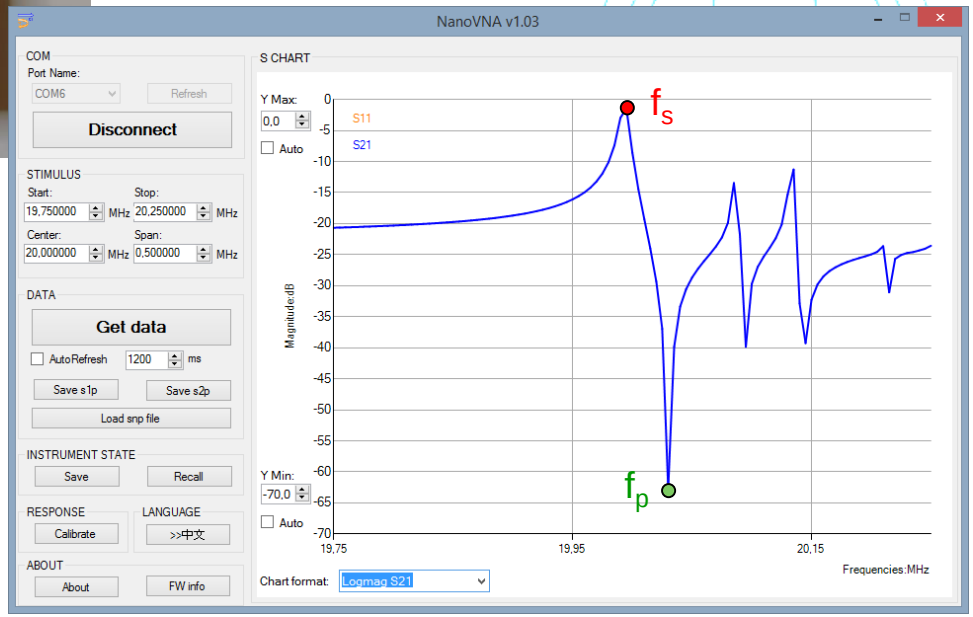


Quarz 20MHz

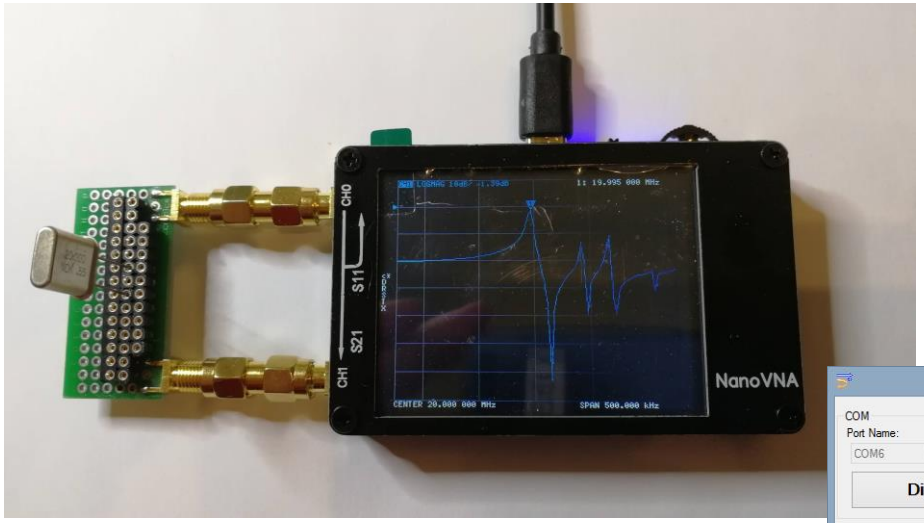


Ersatzschaltbild Quarz

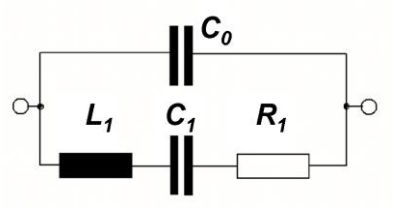
Center: 20MHz
Span: 50KHz



Messung an einem Quarz (s21)

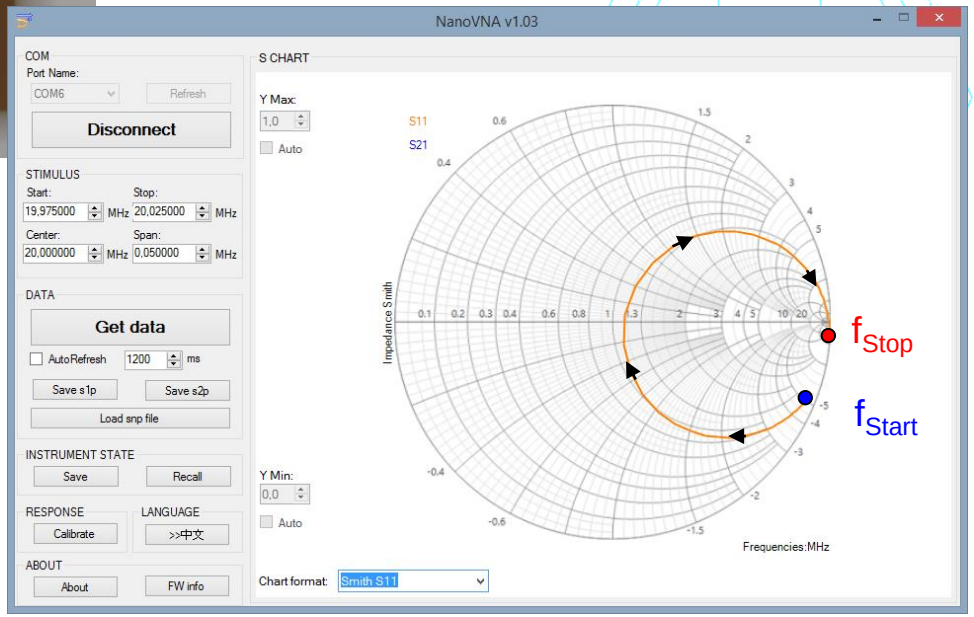


Quarz 20MHz

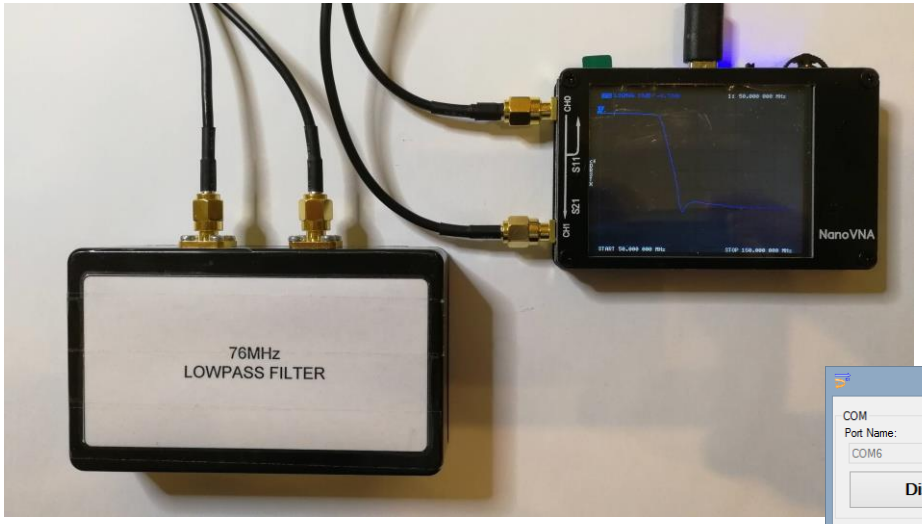


Ersatzschaltbild Quarz

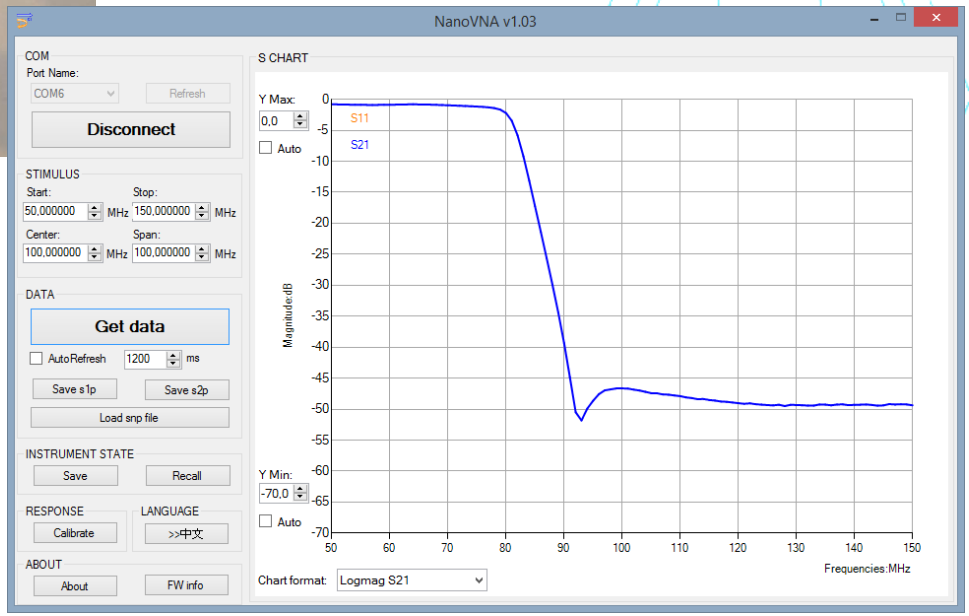
Center: 20MHz
Span: 50KHz



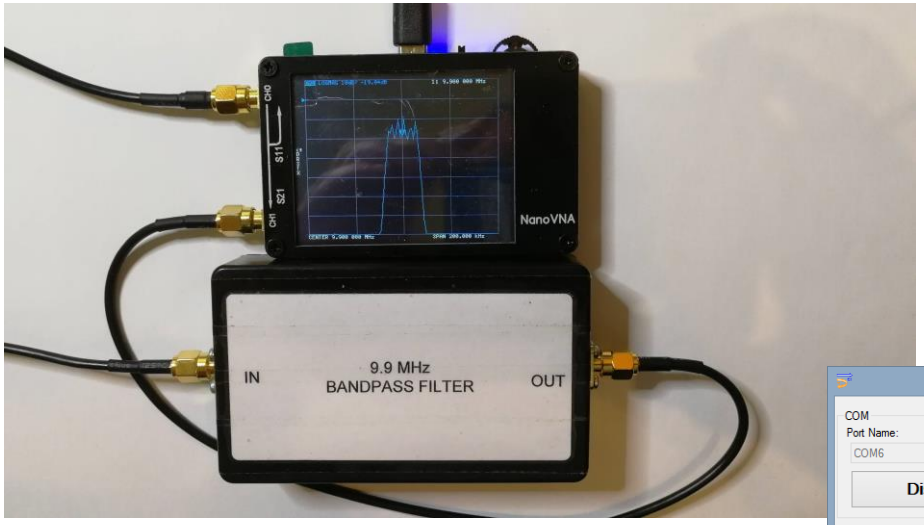
Messung an einem Tiefpass-Filter (s21)



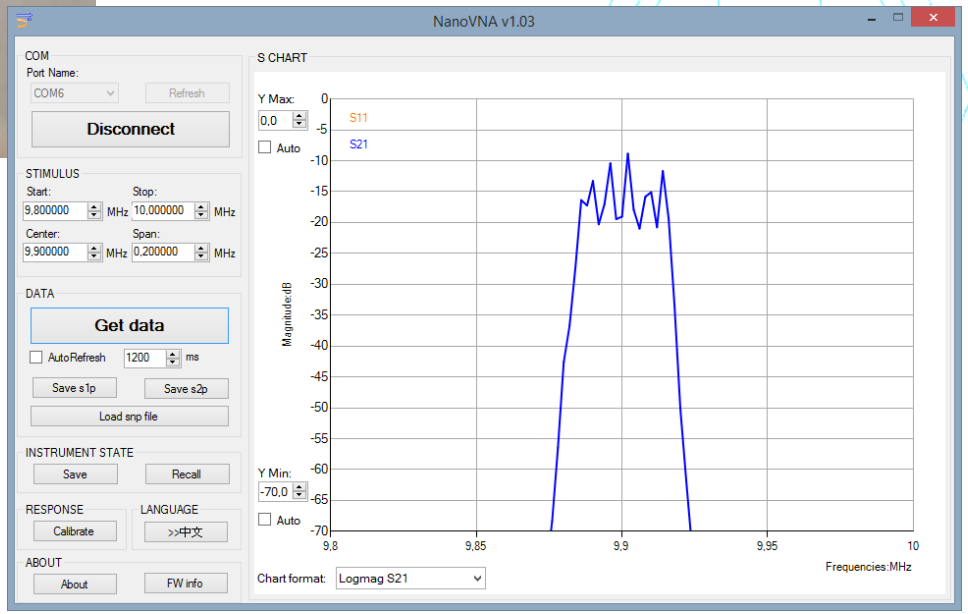
Tiefpassfilter 76MHz



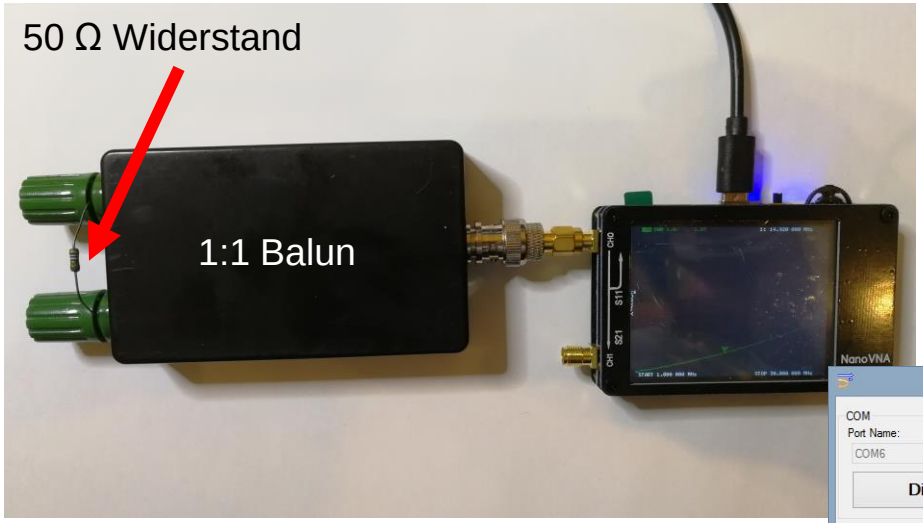
Messung an einem Bandpass-Filter (s21)

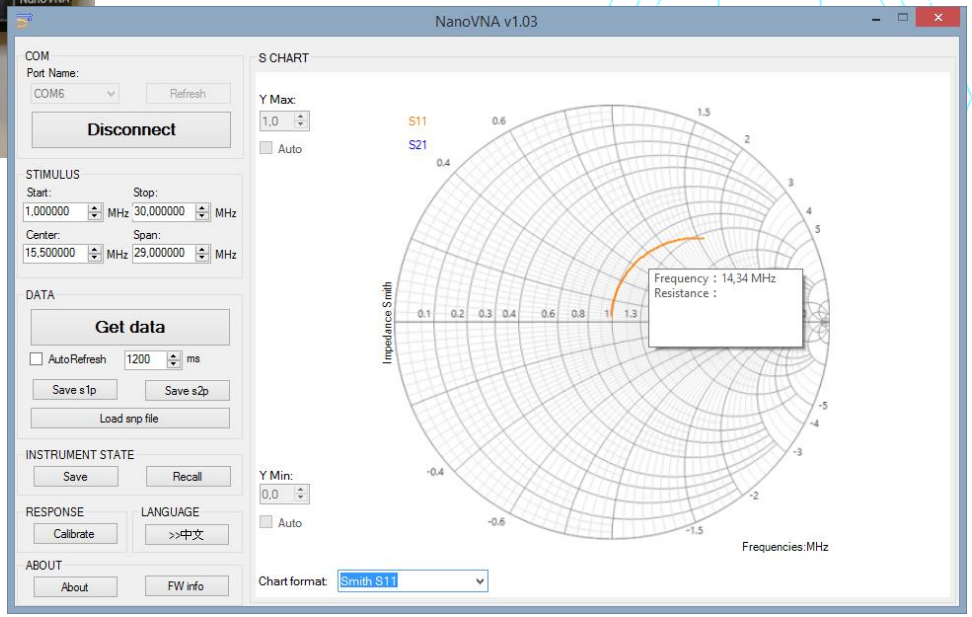


Bandpassfilter 9,9MHz

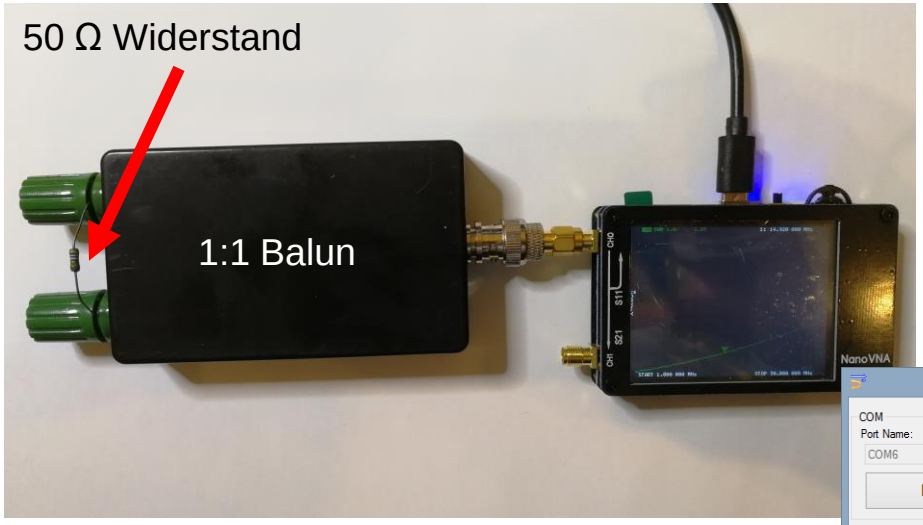


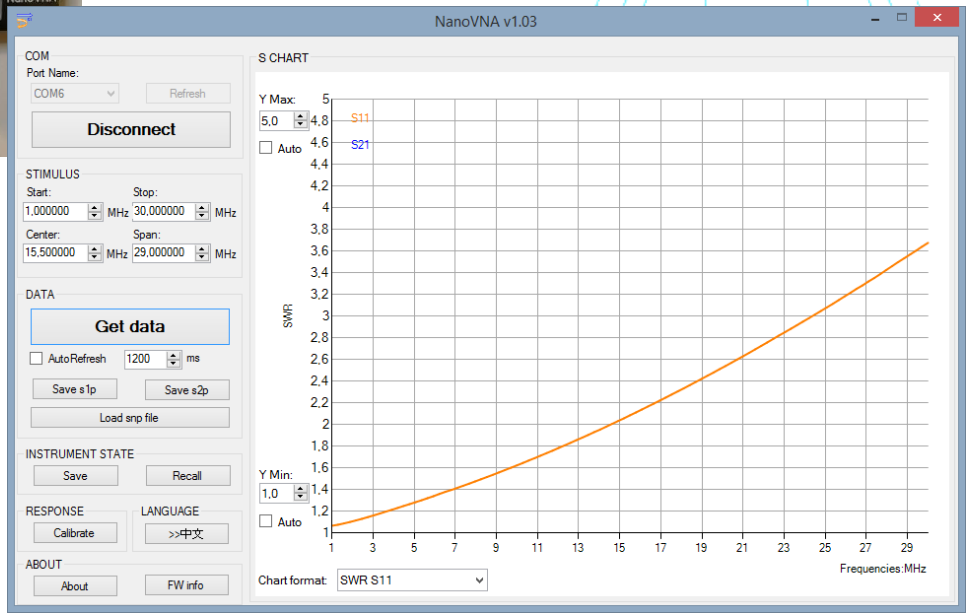
Messung an einem 1:1 Balun (s11)



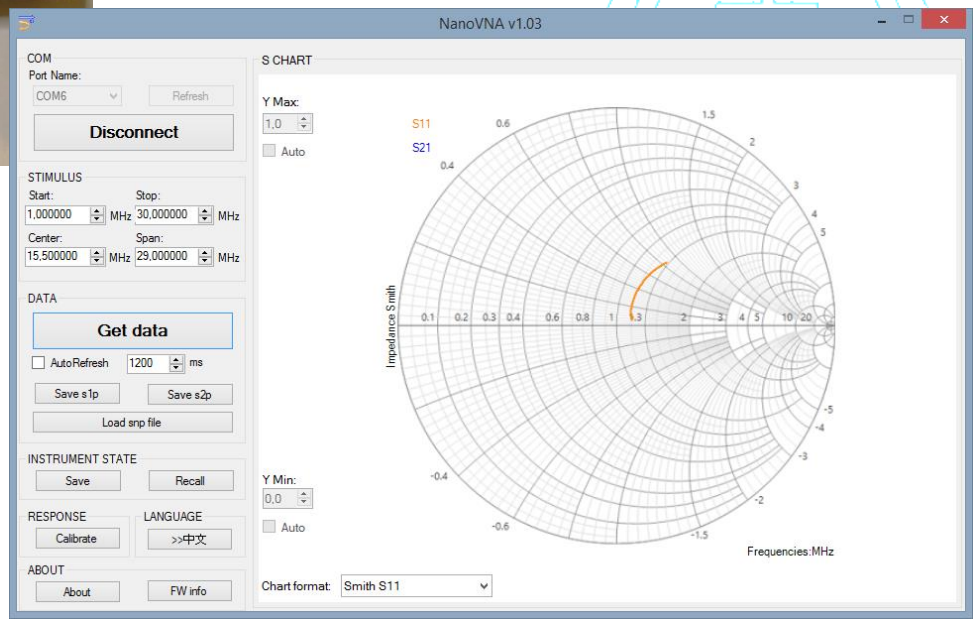


Messung an einem 1:1 Balun (SWR)

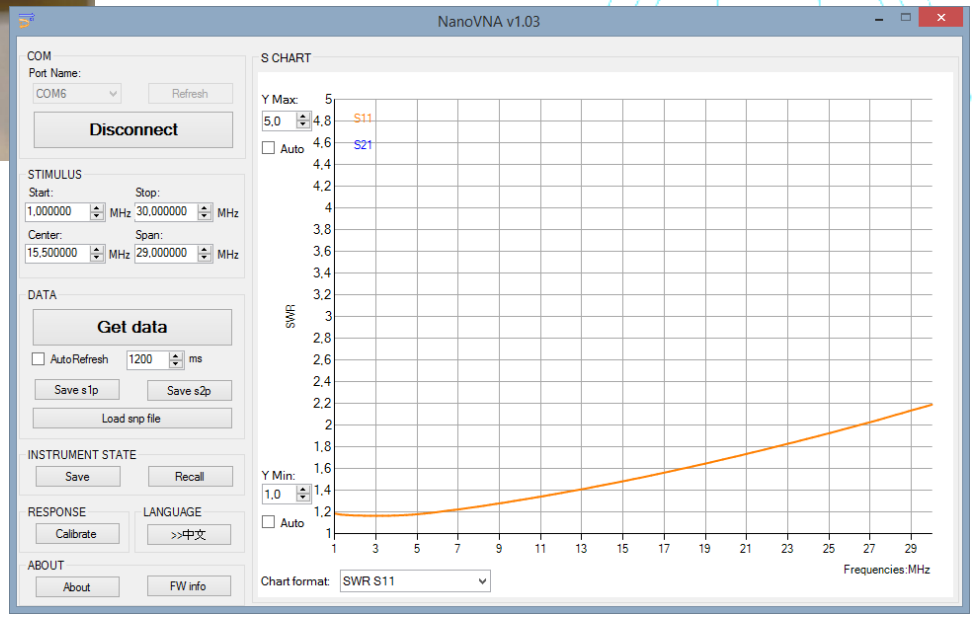




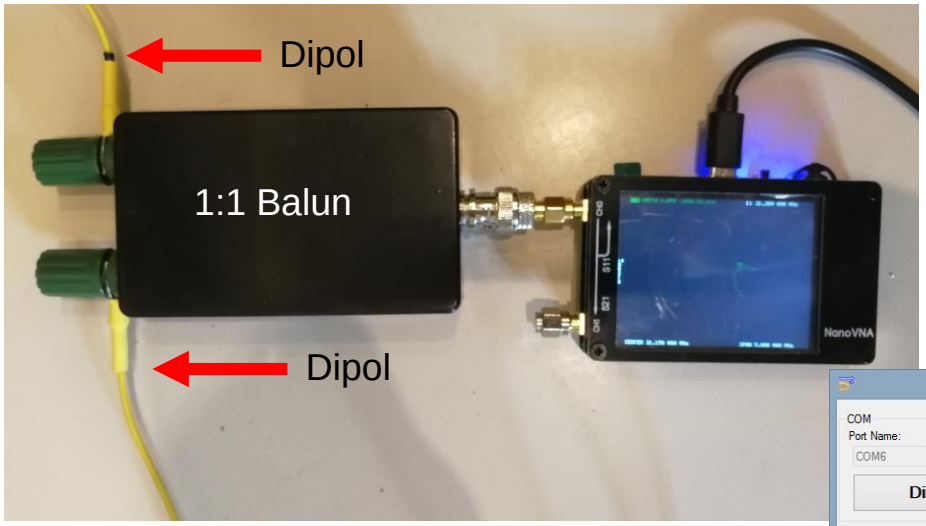
Messung an einem 1:2 Balun (s11)

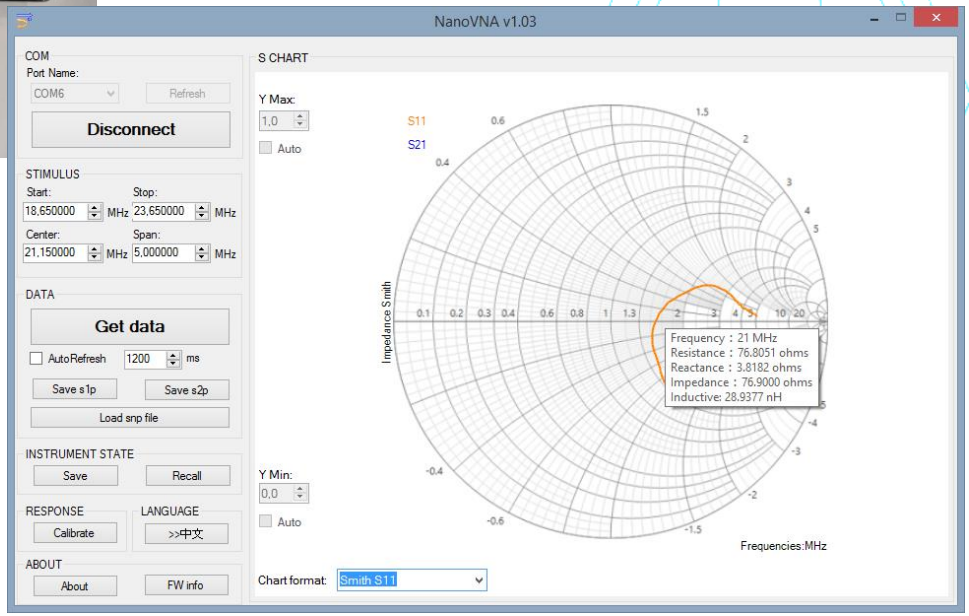


Messung an einem 1:2 Balun (SWR)

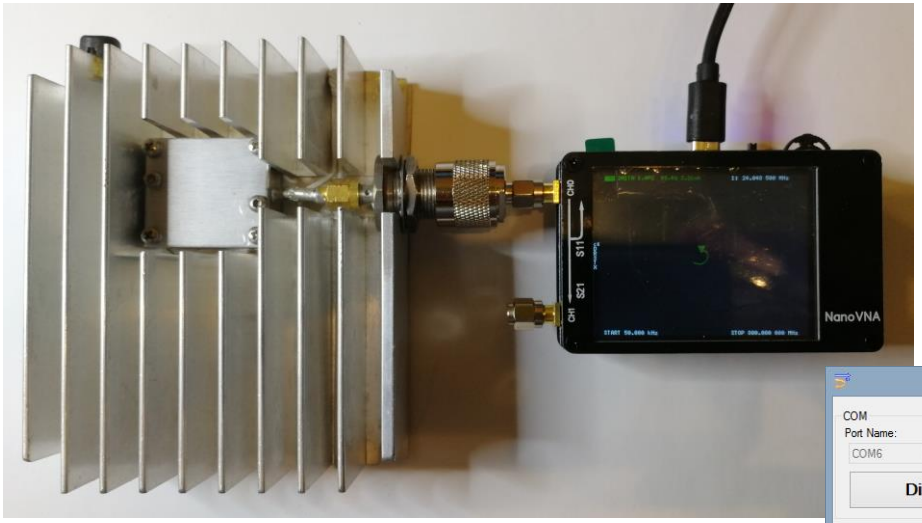


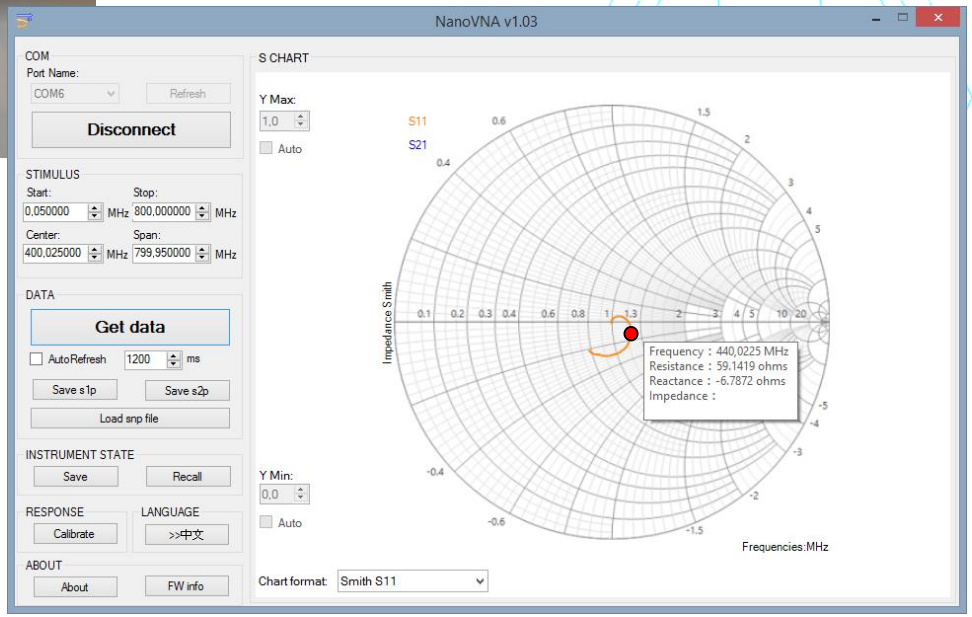
Messung an einem Dipol (s11)





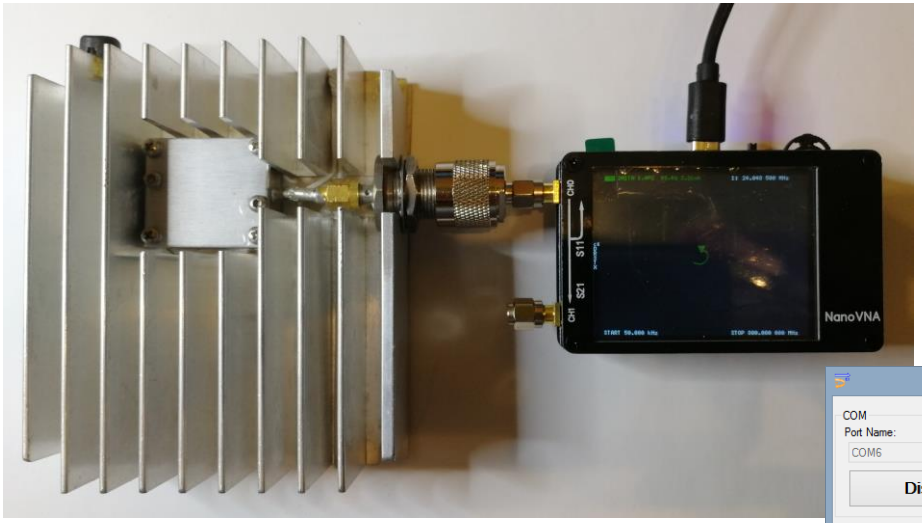
Messung an einer Dummy Load (s11)

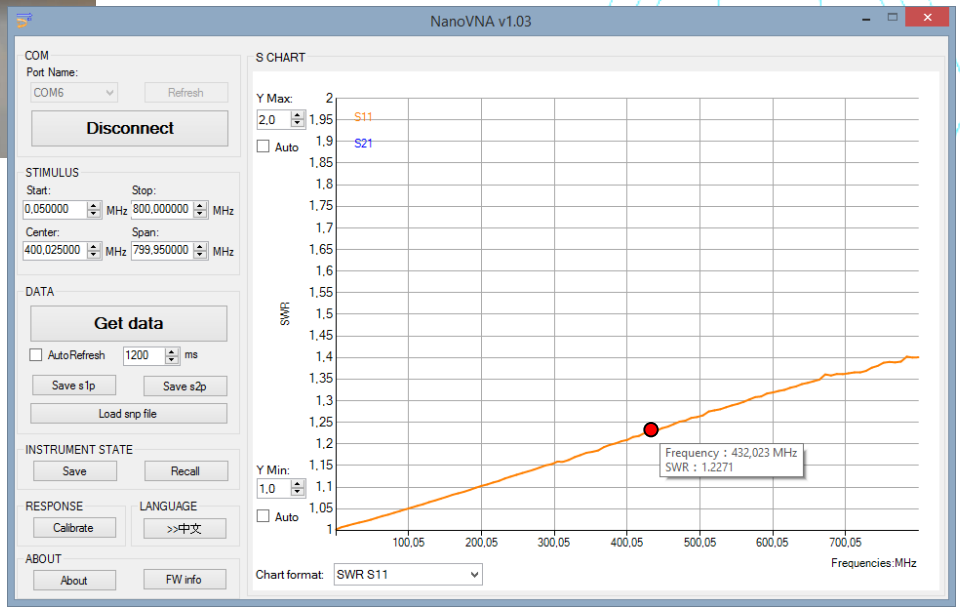




Start: 50KHz
Stop: 800MHz

Messung an einer Dummy Load (SWR)



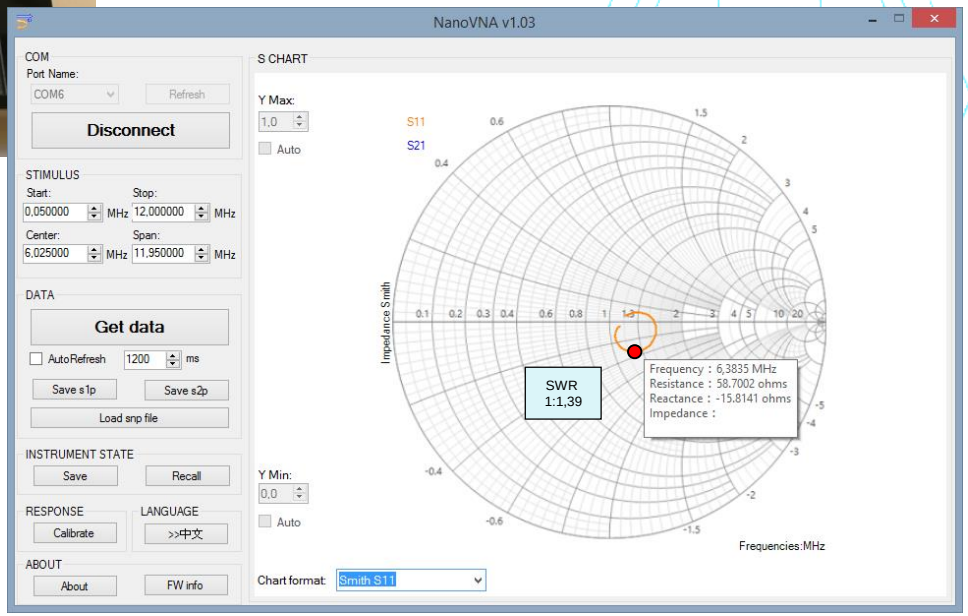


Start: 50KHz
Stop: 800MHz

Messung an einer Koaxleitung (s11)

50 Ω Widerstand

Fernes Ende mit 50 Ω Widerstand abgeschlossen.

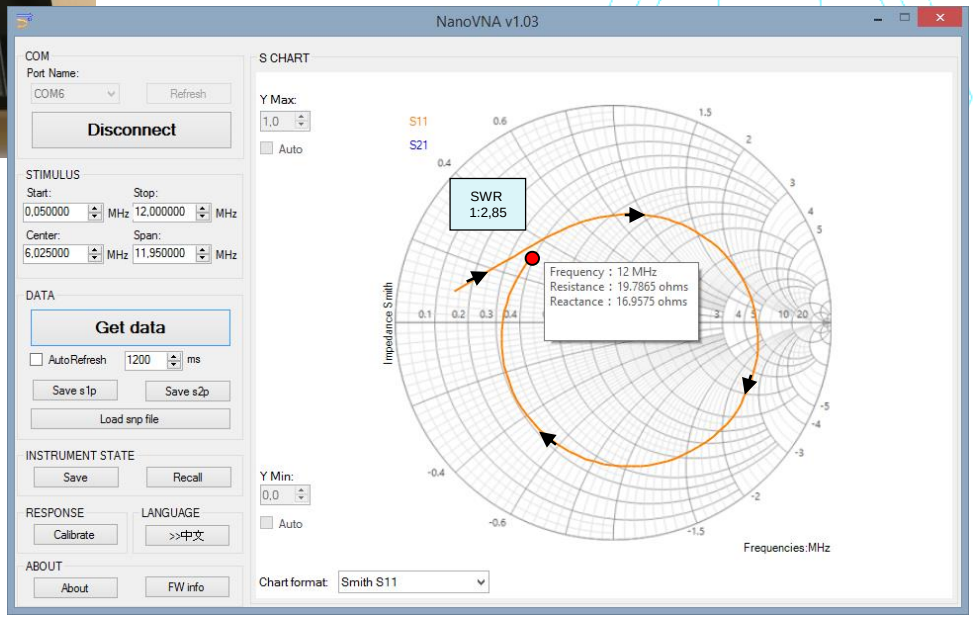


Start: 50KHz
Stop: 12MHz

Messung an einer Koaxleitung (s11)

0 Ω Widerstand

Fernes Ende mit 0 Ω Widerstand abgeschlossen.

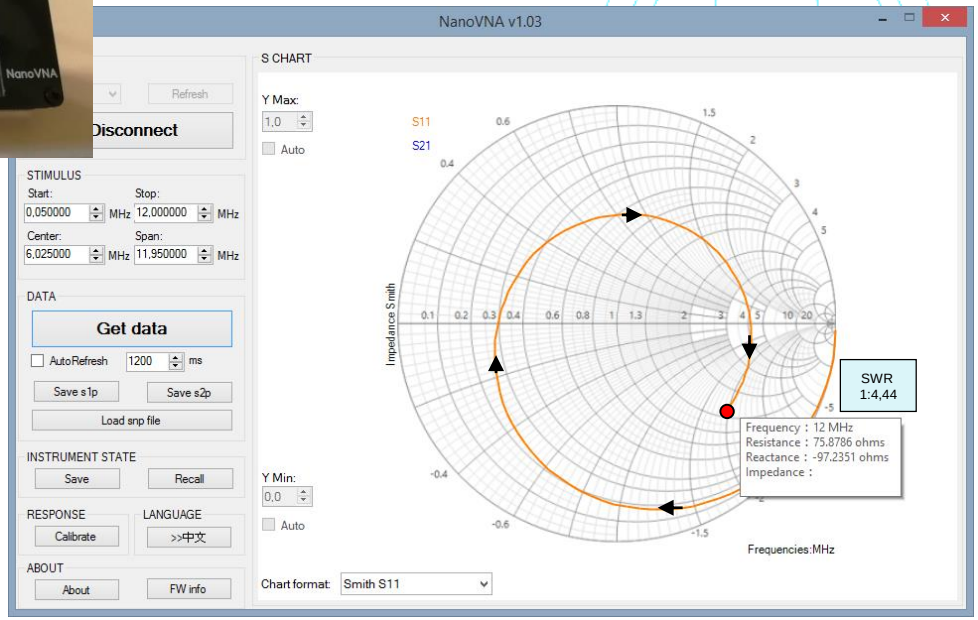


Start: 50KHz
Stop: 12MHz

Messung an einer Koaxleitung (s11)

Leerlauf

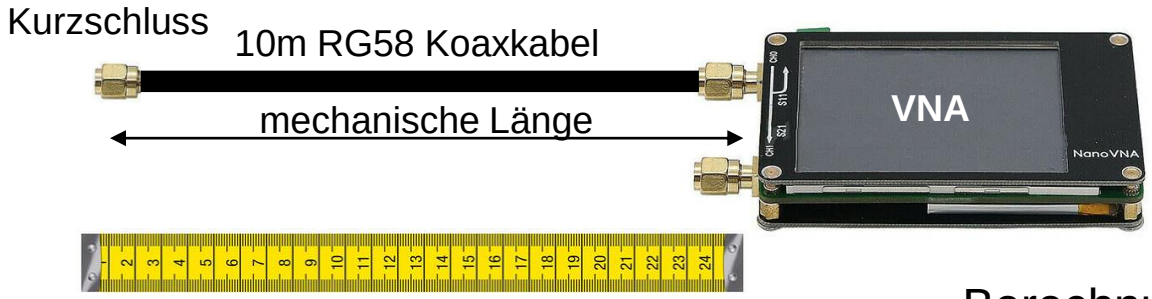
Fernes Ende mit ∞ Ω Widerstand abgeschlossen. Leerlauf.



Start: 50KHz
Stop: 12MHz

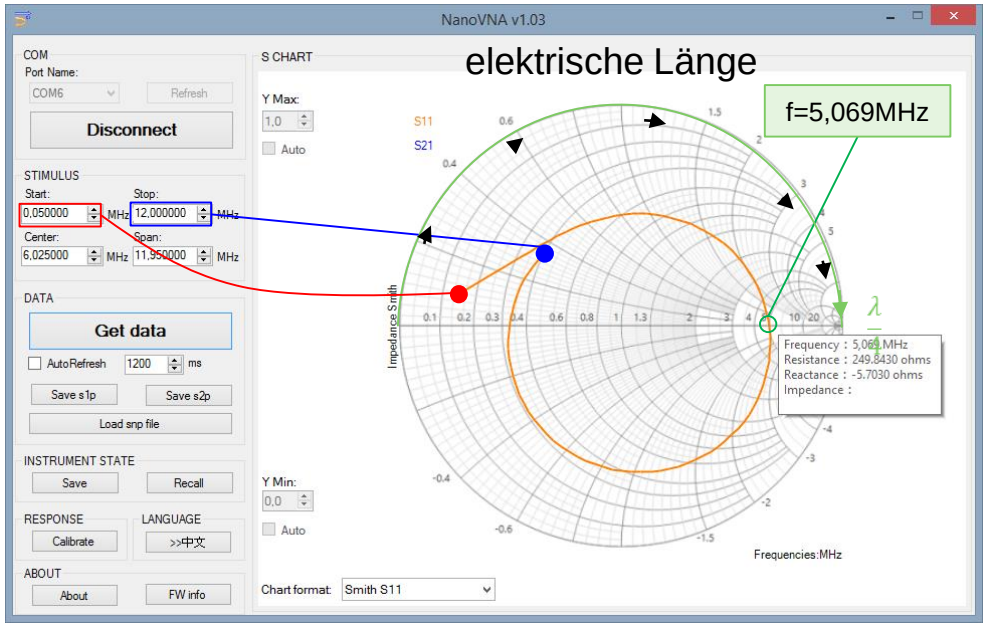
Messung an einer Koaxleitung (s11)

Verkürzungsfaktor an einem Koaxkabel messen



Auszug aus dem Datenblatt

ELECTRICAL PROPERTIES at 20°C	
IMPEDANCE	50 ± 2 Ohm
CAPACITANCE	100 pF/m
VELOCITY RATIO	66%



Berechnung der elektrischen Länge:

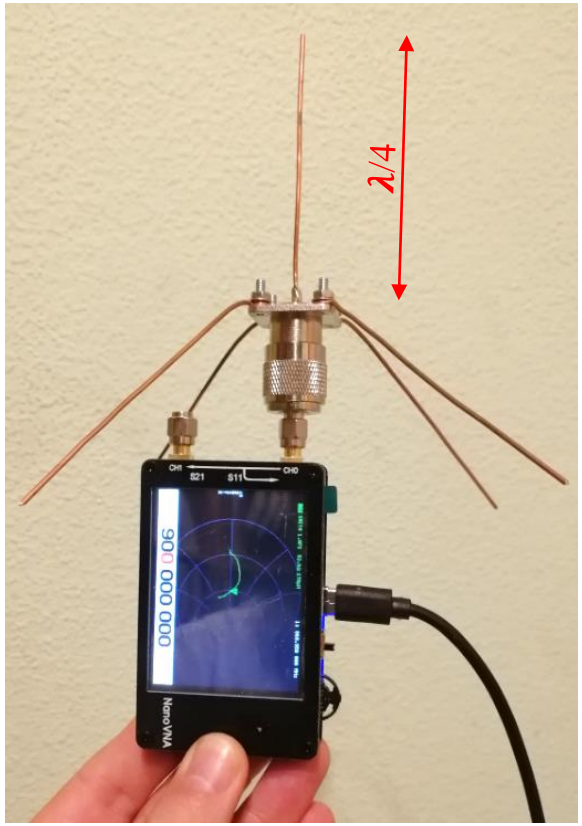
$$\lambda = \frac{c}{f} = \frac{2{,}998 * 10^8}{5{,}069 * 10^6} = 59{,}144m$$

$$\frac{\lambda}{4} = 17{,}786m$$

Berechnung des Verkürzungsfaktors:

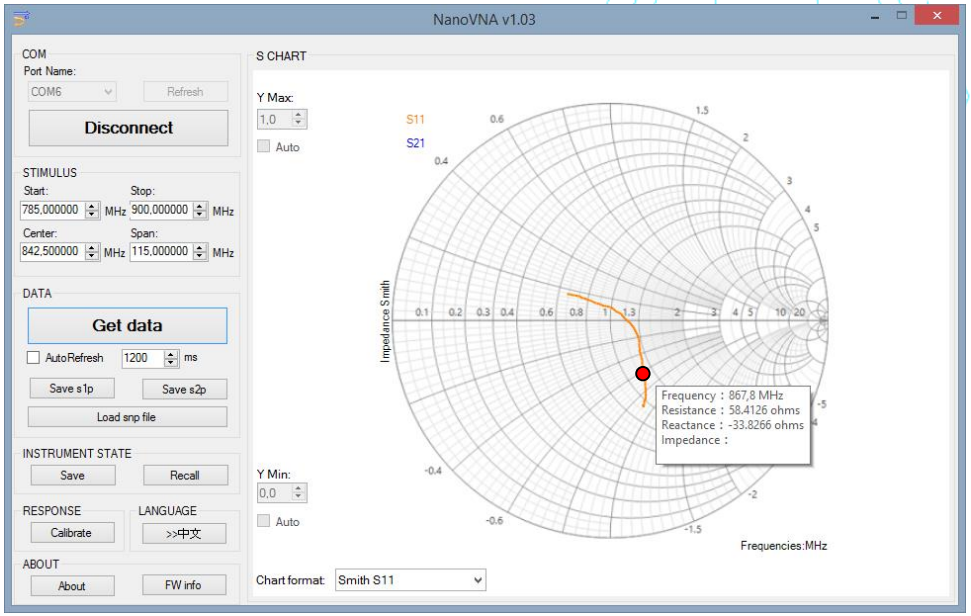
$$v = \frac{l_m}{l_e} = \frac{10}{17{,}786} = 0{,}676$$

Messung an einer Groundplane Antenne für 868MHz (s11)



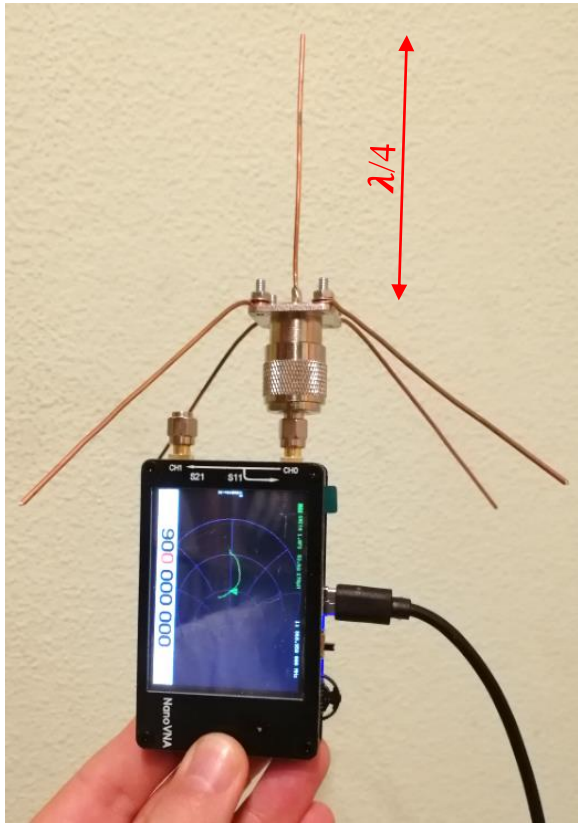
Step 1:

Antenne ist zu lang,
Resonanz bei 802MHz.



Start: 785MHz
Stop: 900MHz

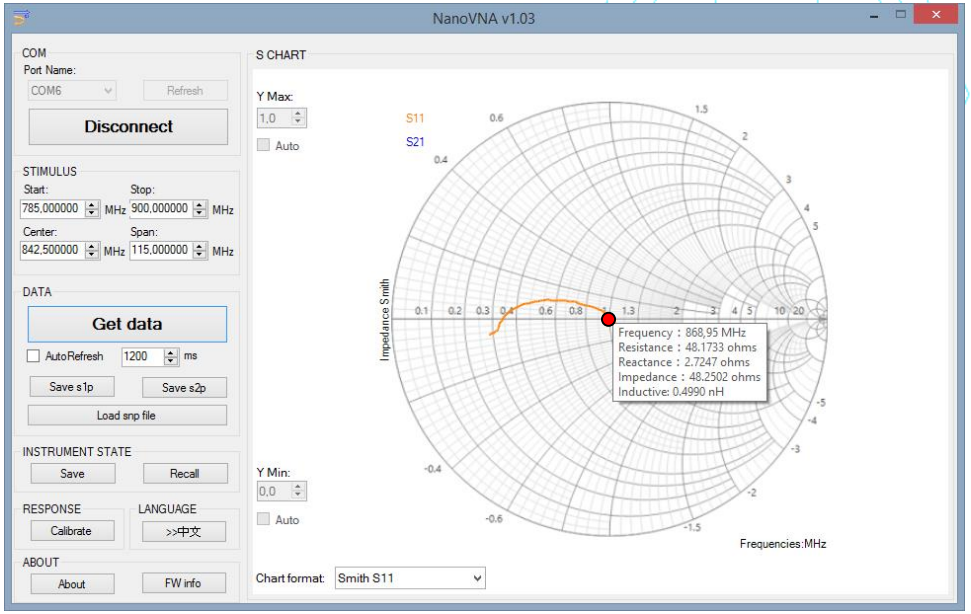
Messung an einer Groundplane Antenne (s11)



Start: 785MHz
Stop: 900MHz

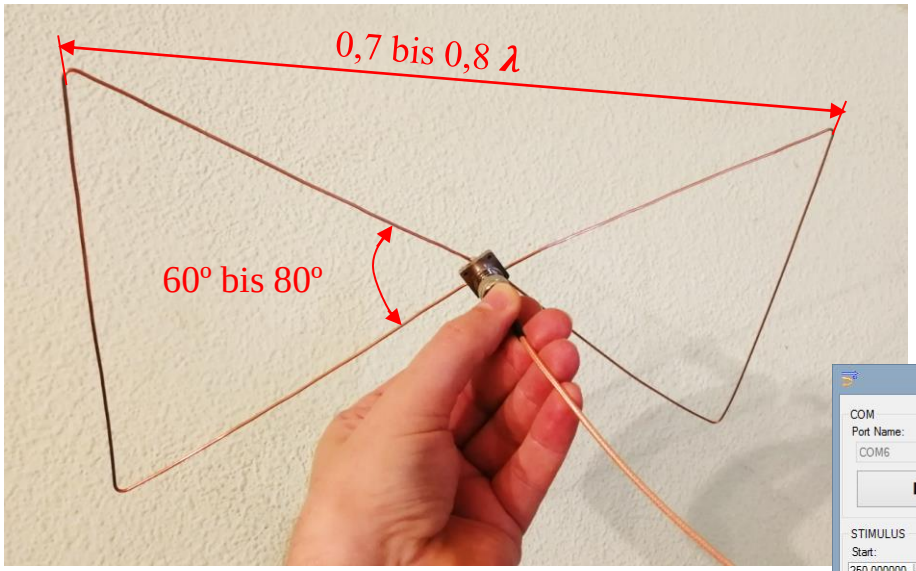
Step 2:

Durch vorsichtiges Abschneiden von 1mm Stücken auf 868MHz getrimmt, SWR 1:1,1

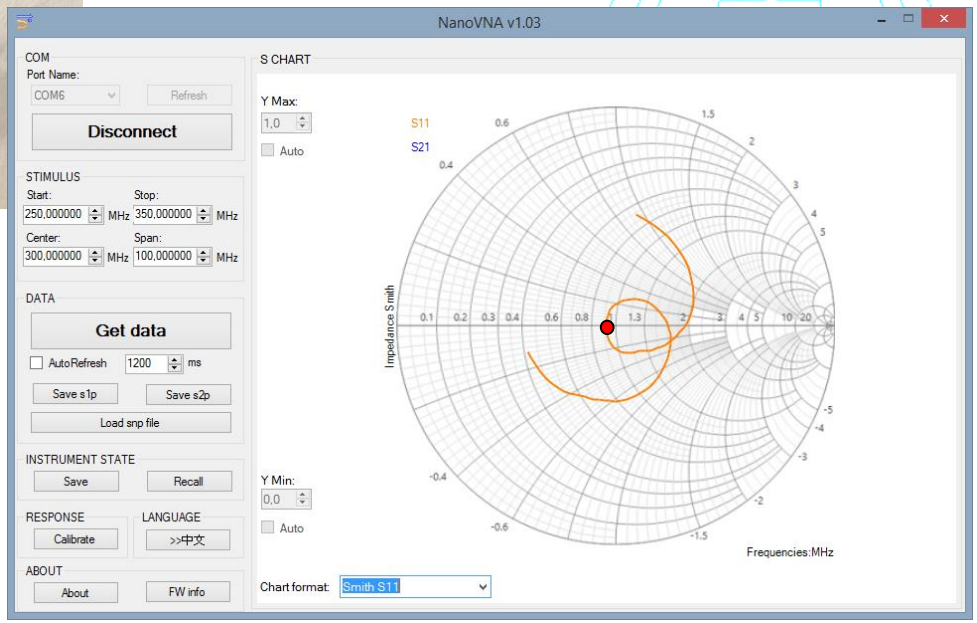


Messung an einer Batwing Antenne (s11)

Breitbanddipol



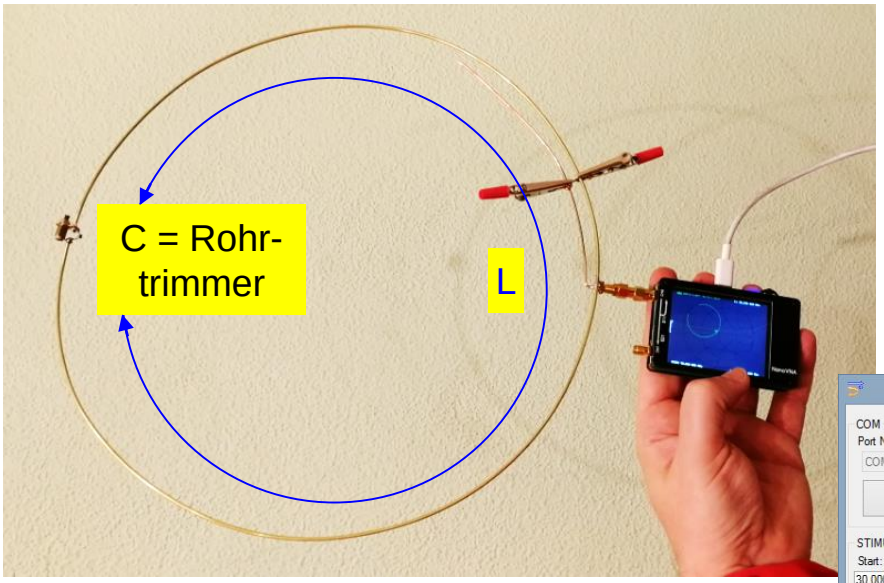
Quelle: Antennenbuch, 7. Auflage, Seite 445, Rothammel,

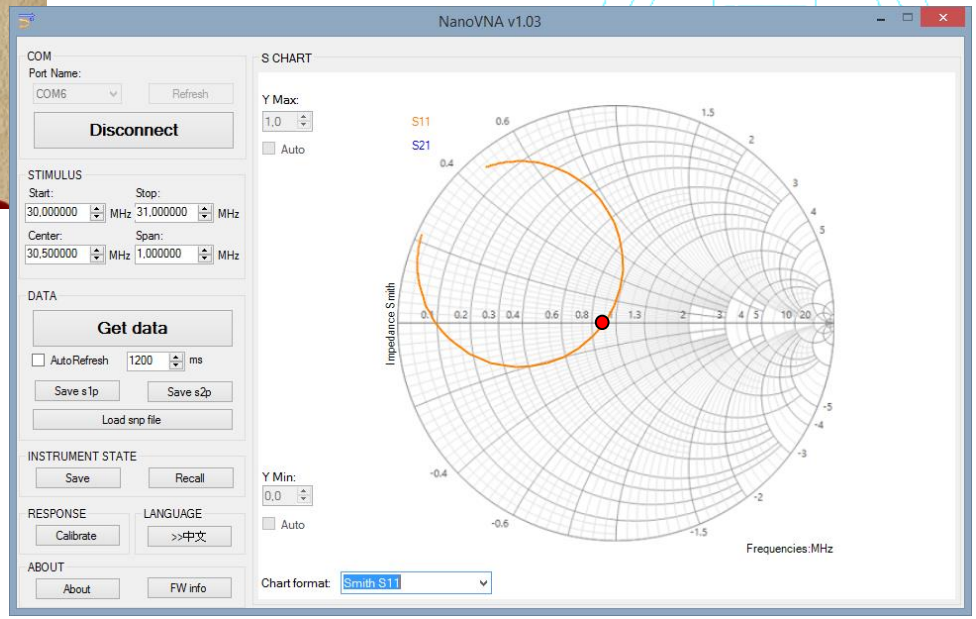


Center: 300MHz
Span: 100MHz

Messung an einer Magnetic Loop Antenne (s11)

Anpassung mittels Gamma-Match

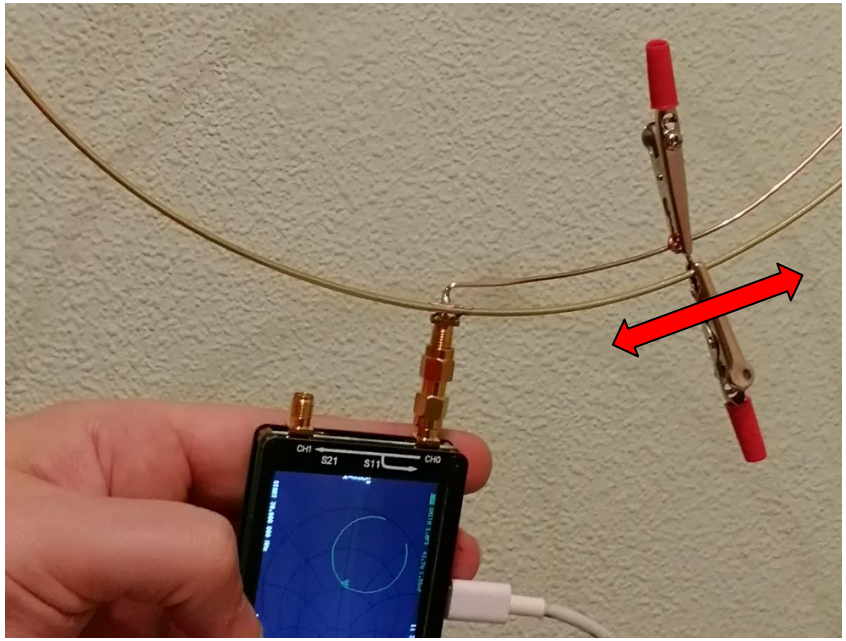




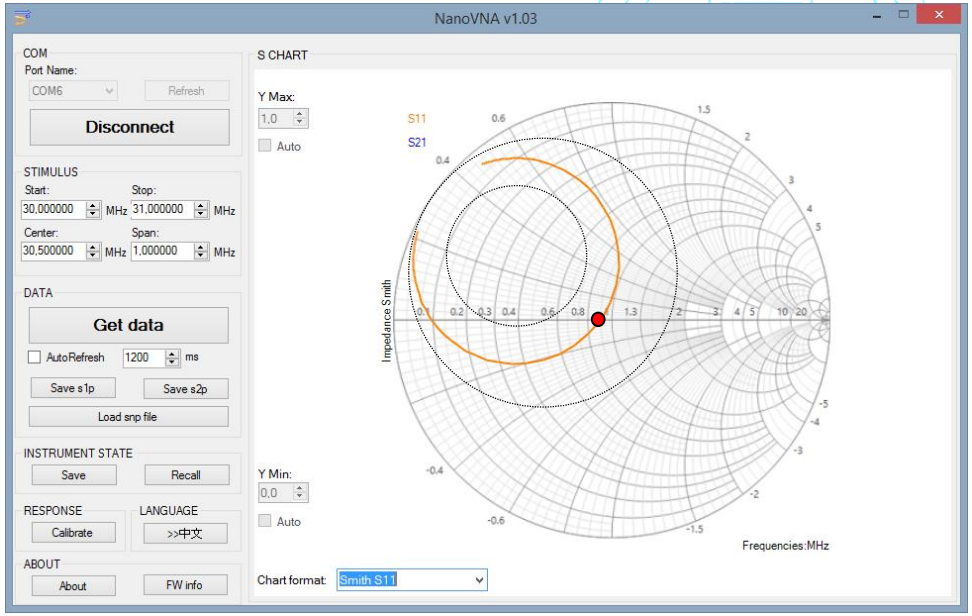
Start: 30MHz
Span: 31MHz

Messung an einer Magnetic Loop Antenne (s11)

Anpassung mittels Gamma-Match



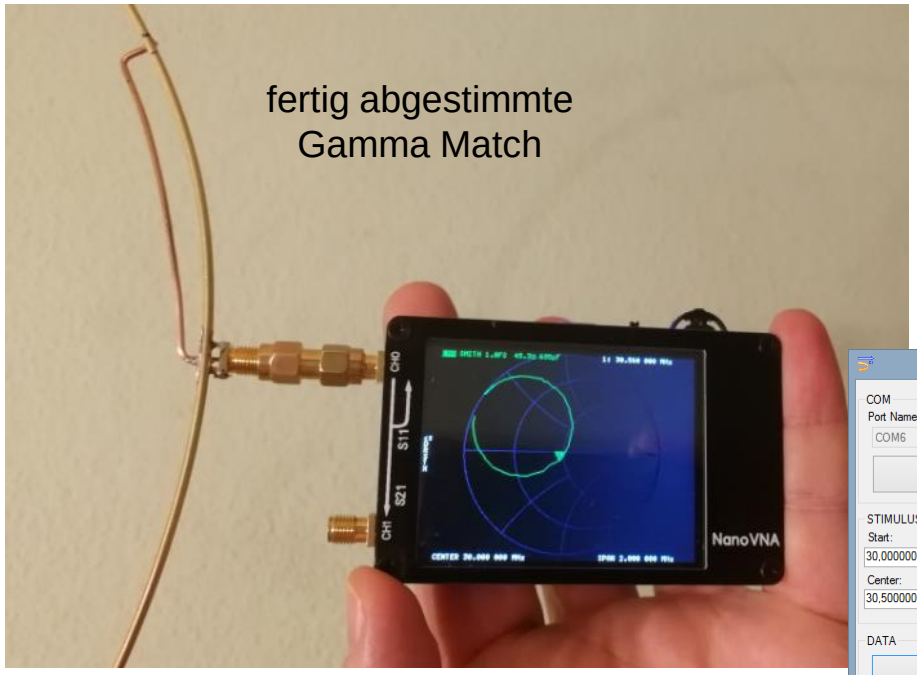
Durch Verschieben der Gamma-Match kann eine optimale Anpassung erreicht werden

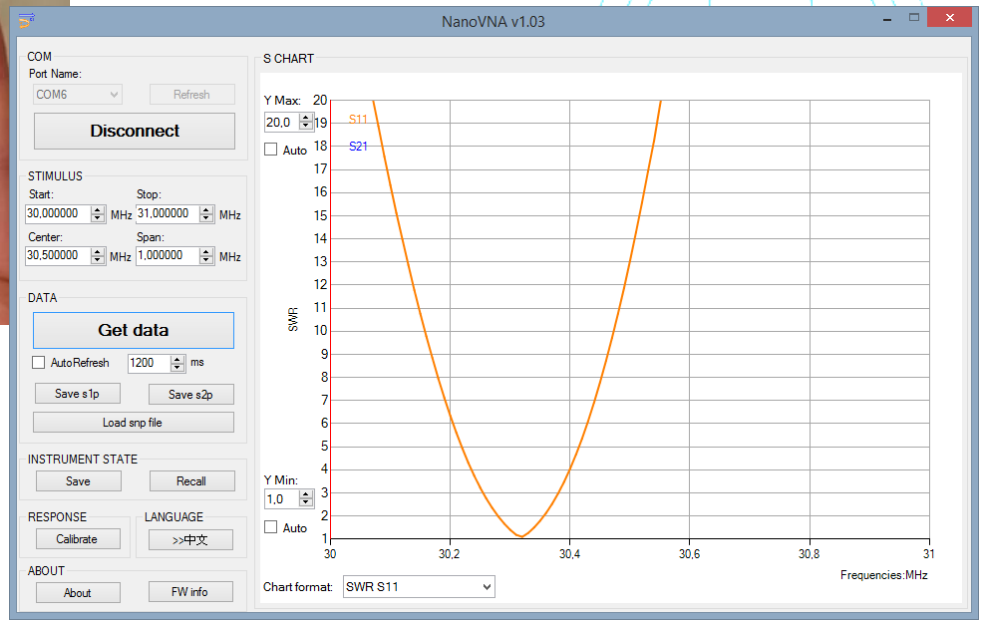


Start: 30MHz
Span: 31MHz

Messung an einer Magnetic Loop Antenne (SWR)

Magnetic Loop





Start: 30MHz
Span: 31MHz

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ADL319
Metafunk
https://metalab.at/wiki/MetaFunk