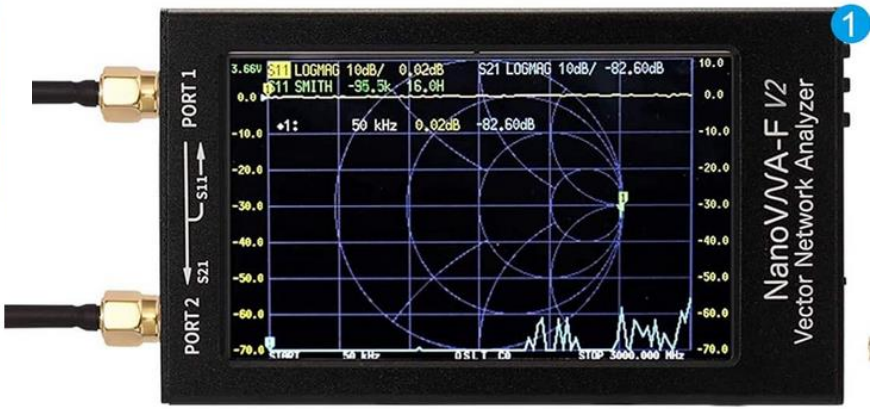
VNA Analyser

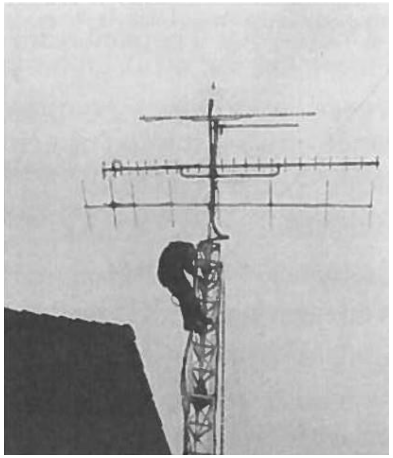
ON6FH, Michel – FORT Lier ON7LR / 17 November 2023

Good old time

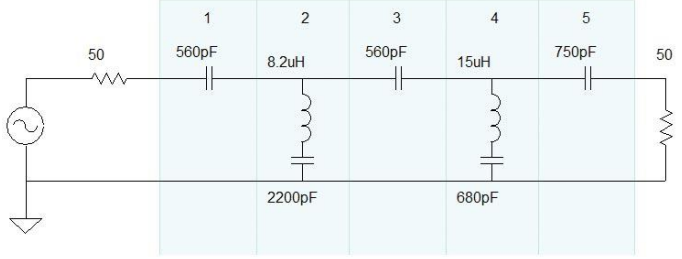
Moderne Network analyzer



Dagelijkse uitdaging voor radio amateurs



- SWR meten van een antenne
  - VSWR (SWR)
  - Return loss
- Kabels uitmeten
  - Qualiteit en Verlies
  - Lengte
- Filters uitmeten



Types van Network analyzer

- Scalar Network Analyzer (SNA)—meet alleen amplitude eigenschappen

- Vector Network Analyzer (VNA)—meet amplitude en phase eigenschappen

SNA / VNA

- SNA (scalaire netwerkanalysator)
  - Voert frequentie sweep
  - Meet alleen het magnitudegedeelte.
- VNA (vectornetwerkanalysator)
  - Voert de frequentie-sweep langzamer uit in vergelijking met SNA.
  - Meet de amplitude en fase van signaal en gereflecteerde golven.

Typische opstelling

HF in

HF uit

DUT

Waarvoor kan je VNA gebruiken

- 1 Poort
  - Reflectie
    - SWR Antennes
    - Complexe Impedanties
    - Componenten
      - Volt
      - RLC
    - Lengte kabels
- 2 Poorten
  - Transmitie
    - Filters (vorm en demping)
    - Verlies in kabels
    - Delay
    - Versterkers en

Meten van antennes, duplexers, filters, spoelen, versterkers, baluns, verzwakkers….

Maar wat is een VNA?

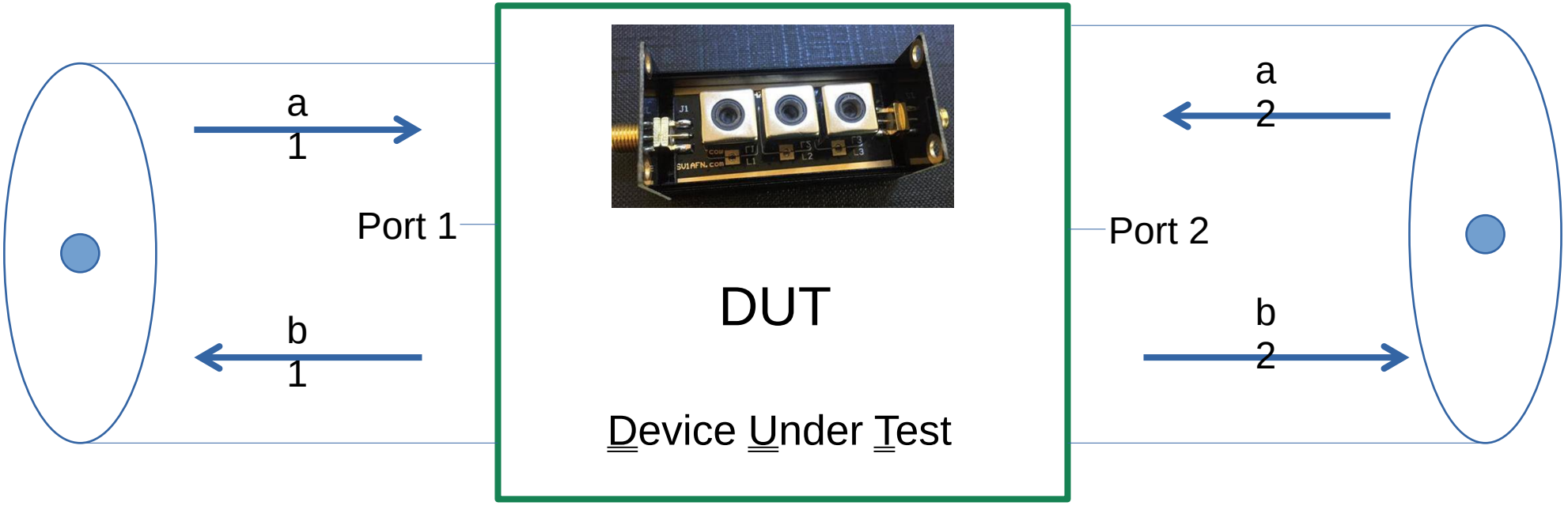
- Is geen Spectrum Analyzer

- Meet enkel S-parameters van een DUT

  Scattering parameters

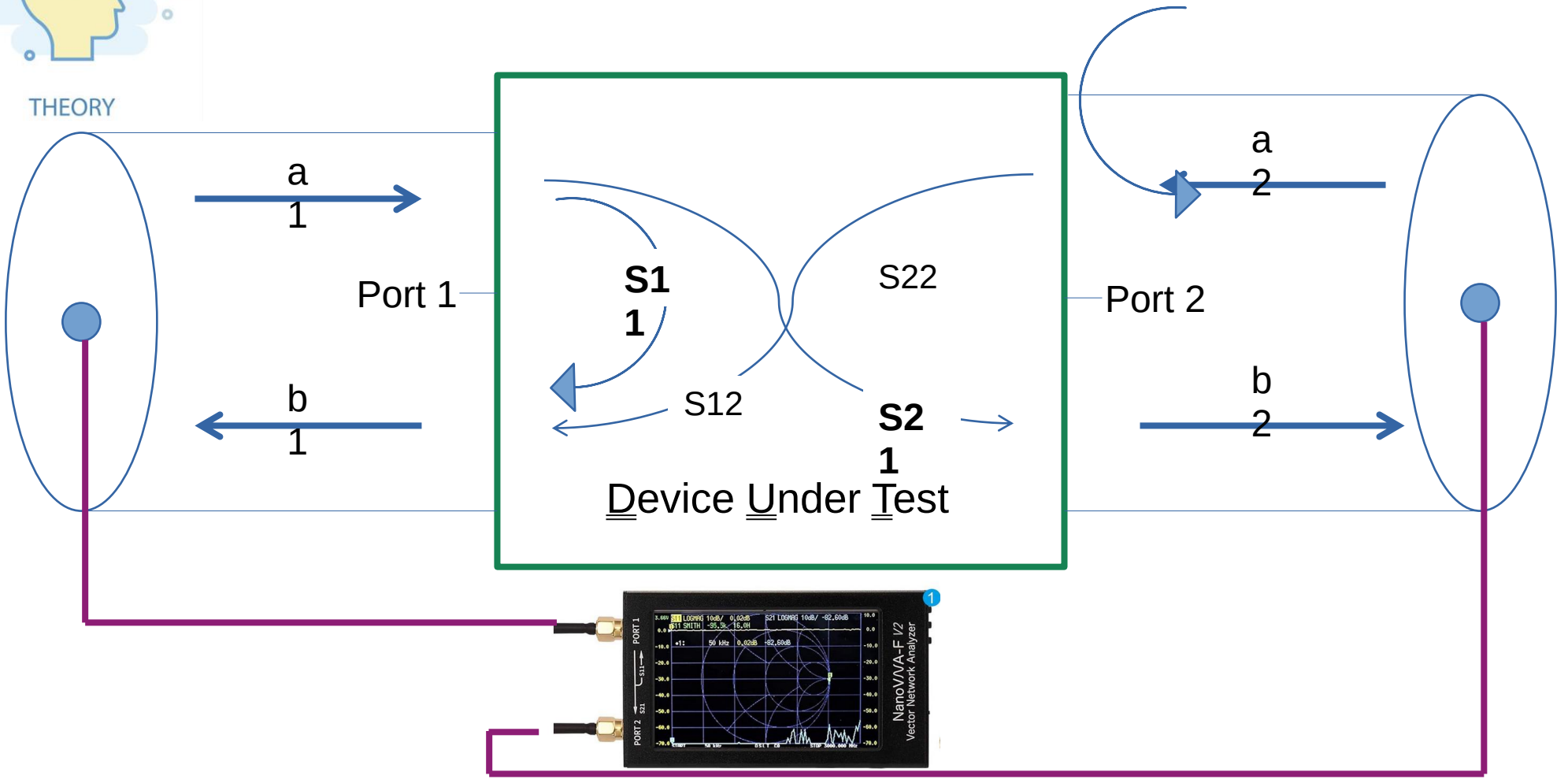
  - DUT = 

S Parameters en DUT



S Parameters en DUT

THEORY



S 11 , S21 en DUT

a
1

b
1

Port 1

S1
1

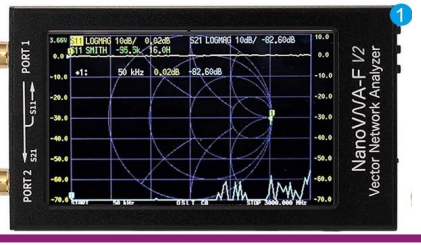
S2
1

Device Under Test

Port 2

a
2

b
2



S parameters

S11 Forward reflection coefficient

Input return loss

Input match en VSWR

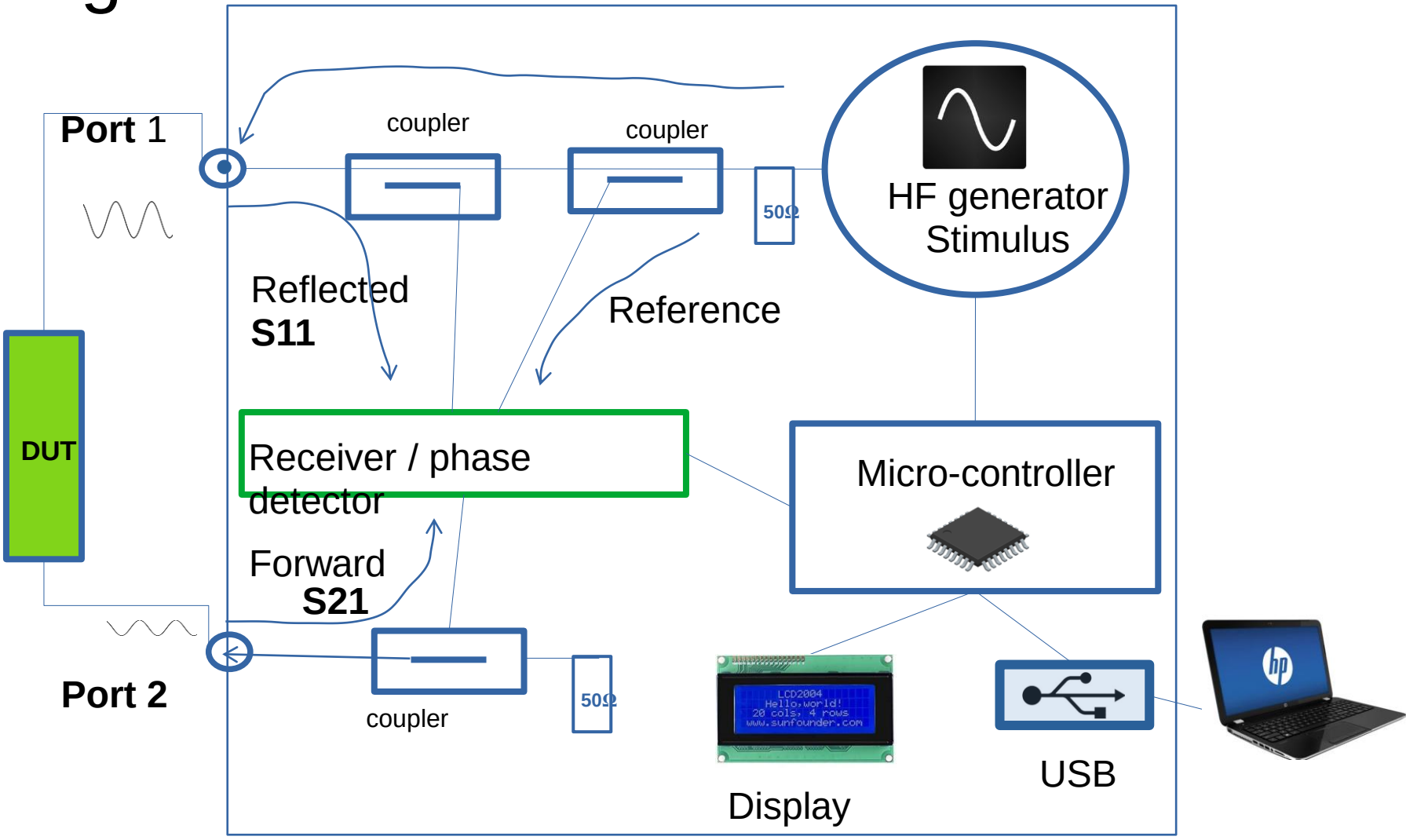
Poort 1

S21 Forward transmission coefficient

Gain

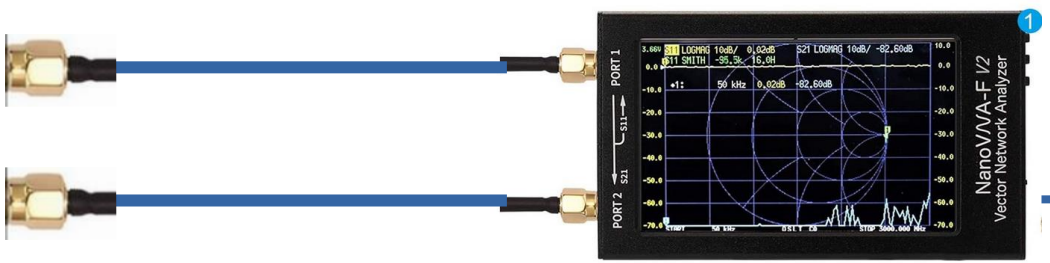
Loss

Block Diagram

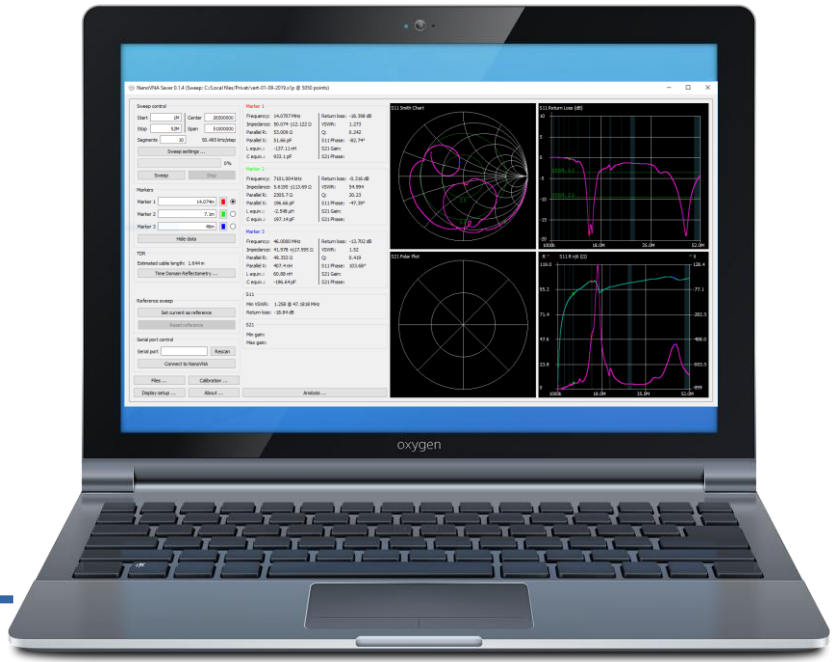


Beste opstelling

App: NanoVNA-Saver



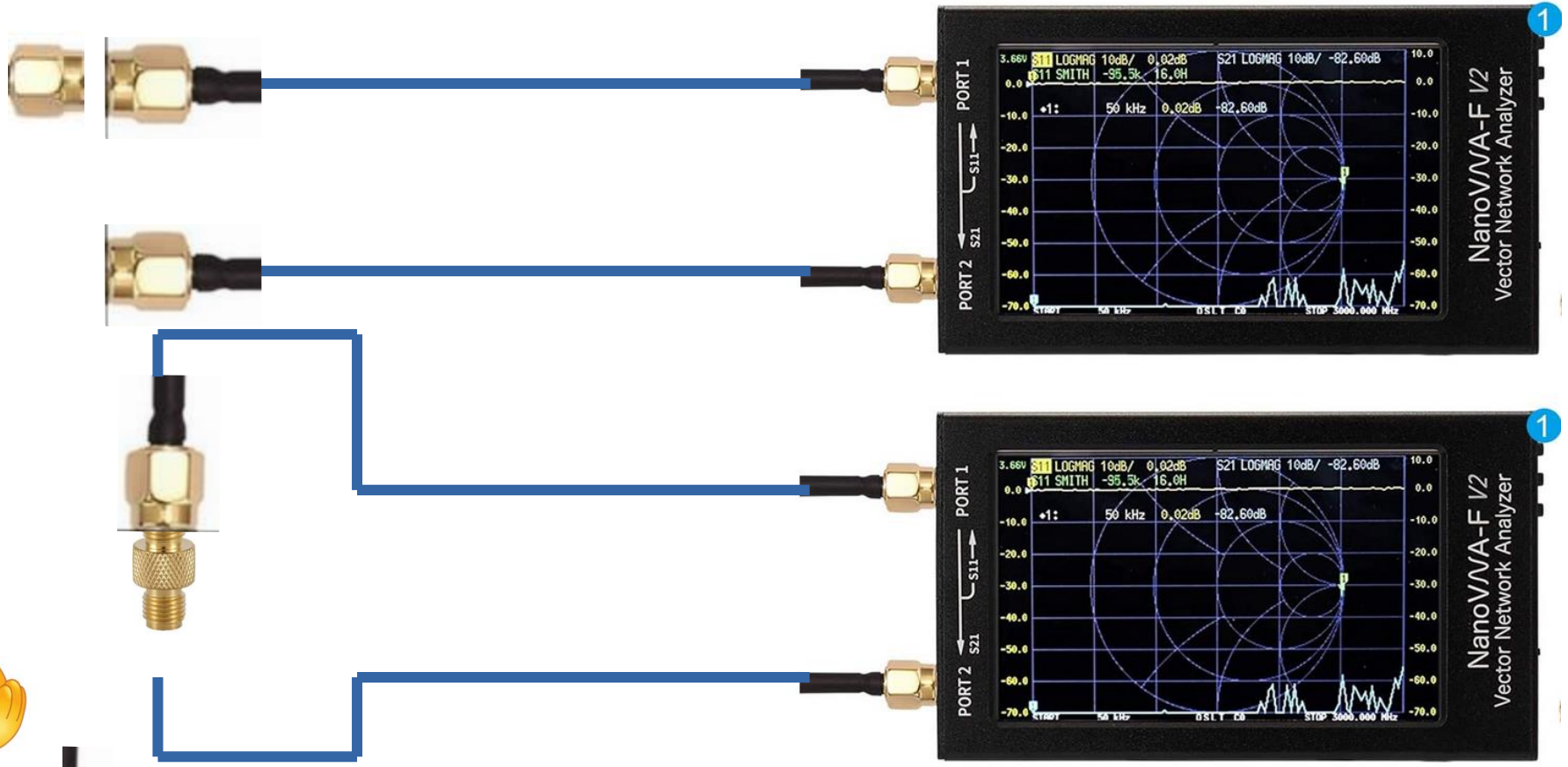
USB



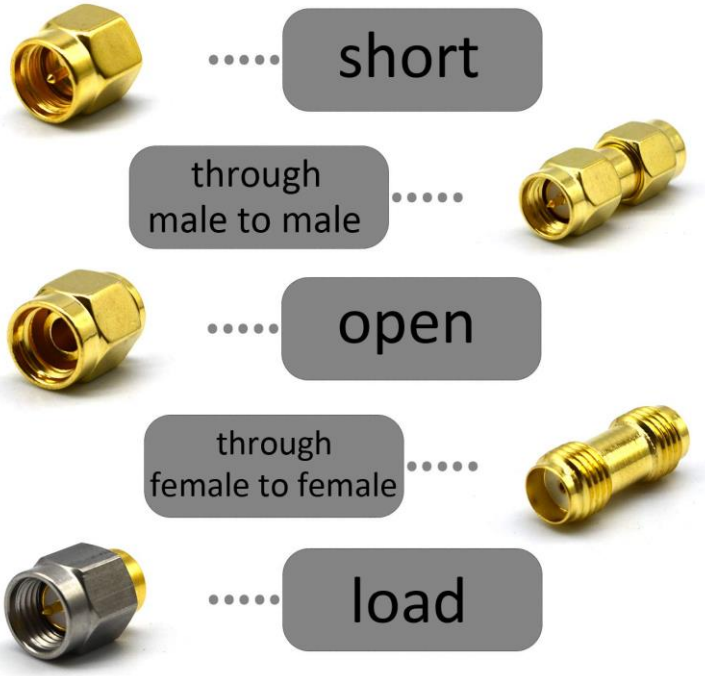
Calibratie van de VNA

1-OPEN
2-SHORT
3-LOAD

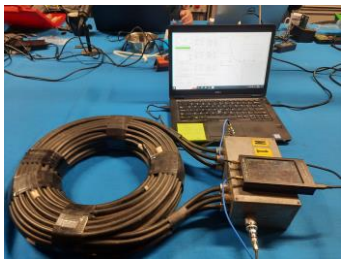
4-
Through

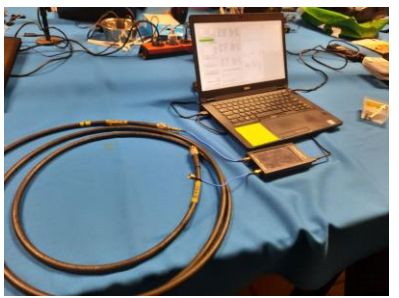


Calibratie Kit



VNA Demos





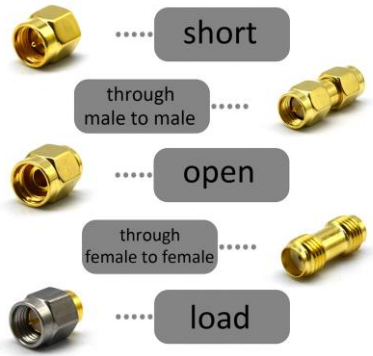
160M filter

Voorbereiding

- Frequentie Range
  1MHz - 3MHz

- Double check connection

- Calibratie



NanoVNA Saver 0.6.2.post1.dev2+g2f8c534 (Sweep: nanovna_2023-11-11 14:27:51 @ 101 points)

Sweep control

Start 1MHz | Center 2MHz
Stop 3MHz | Span 2MHz
Segments 1 | 20.00kHz/step

Sweep settings ...

100%

Sweep | Stop

Markers

Marker 1 1.86MHz
Marker 2 2.76MHz
Marker 3 1MHz

Enable Delta Marker | Reference

Hide data | Locked

TDR

Estimated cable length: 66.727m

Time Domain Reflectometry ...

Reference sweep

Set current as reference

Reset reference

Serial port control

Port COM6 (F_V2) | Rescan

Disconnect | Manage

Files ... | Calibration ...

Display setup ... | About ...

Marker 1

Frequency:	1.86000 MHz	VSWR:	1.023
Impedance:	51.1-j368m Ω	Return loss:	38.778 dB
Series L:	-31.48 nH	Quality factor:	0.007
Series C:	232.58 nF	S11 Phase:	-18.22°
Parallel R:	51.107 Ω	S21 Gain:	-0.171 dB
Parallel X:	12.053 pF	S21 Phase:	-99.95°

Marker 2

Frequency:	2.76000 MHz	VSWR:	17.719
Impedance:	3.9-j30.8 Ω	Return loss:	0.981 dB
Series L:	-1.775 µH	Quality factor:	7.901
Series C:	1.8733 nF	S11 Phase:	-116.54°
Parallel R:	247.09 Ω	S21 Gain:	-9.425 dB
Parallel X:	1.8438 nF	S21 Phase:	155.85°

Marker 3

Frequency:	1.00000 MHz	VSWR:	1.513
Impedance:	35.5-j9.91 Ω	Return loss:	13.805 dB
Series L:	-1.5774 µH	Quality factor:	0.279
Series C:	16.059 nF	S11 Phase:	-139.04°
Parallel R:	38.266 Ω	S21 Gain:	-0.372 dB
Parallel X:	1.1612 nF	S21 Phase:	-48.43°

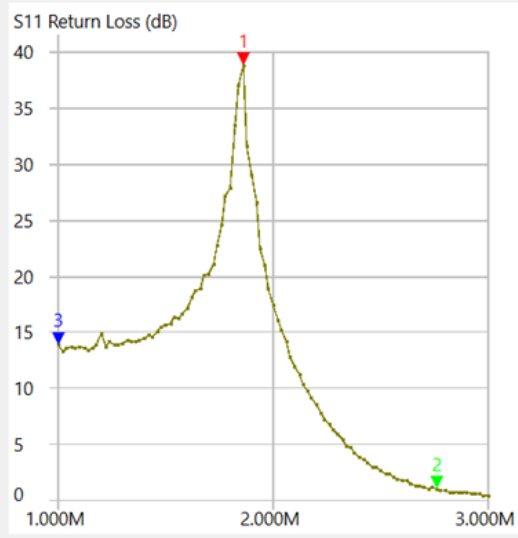
S11

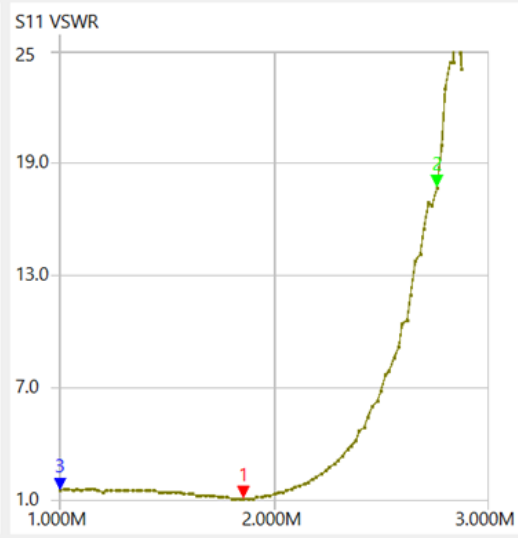
Min VSWR: 1.023 @ 1.86000MHz
Return loss: -38.778 dB

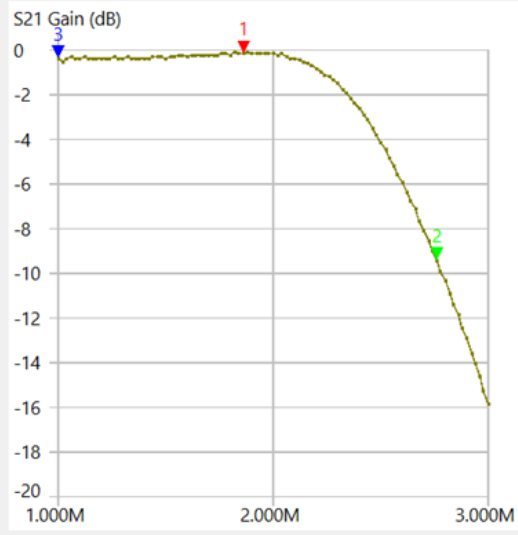
S21

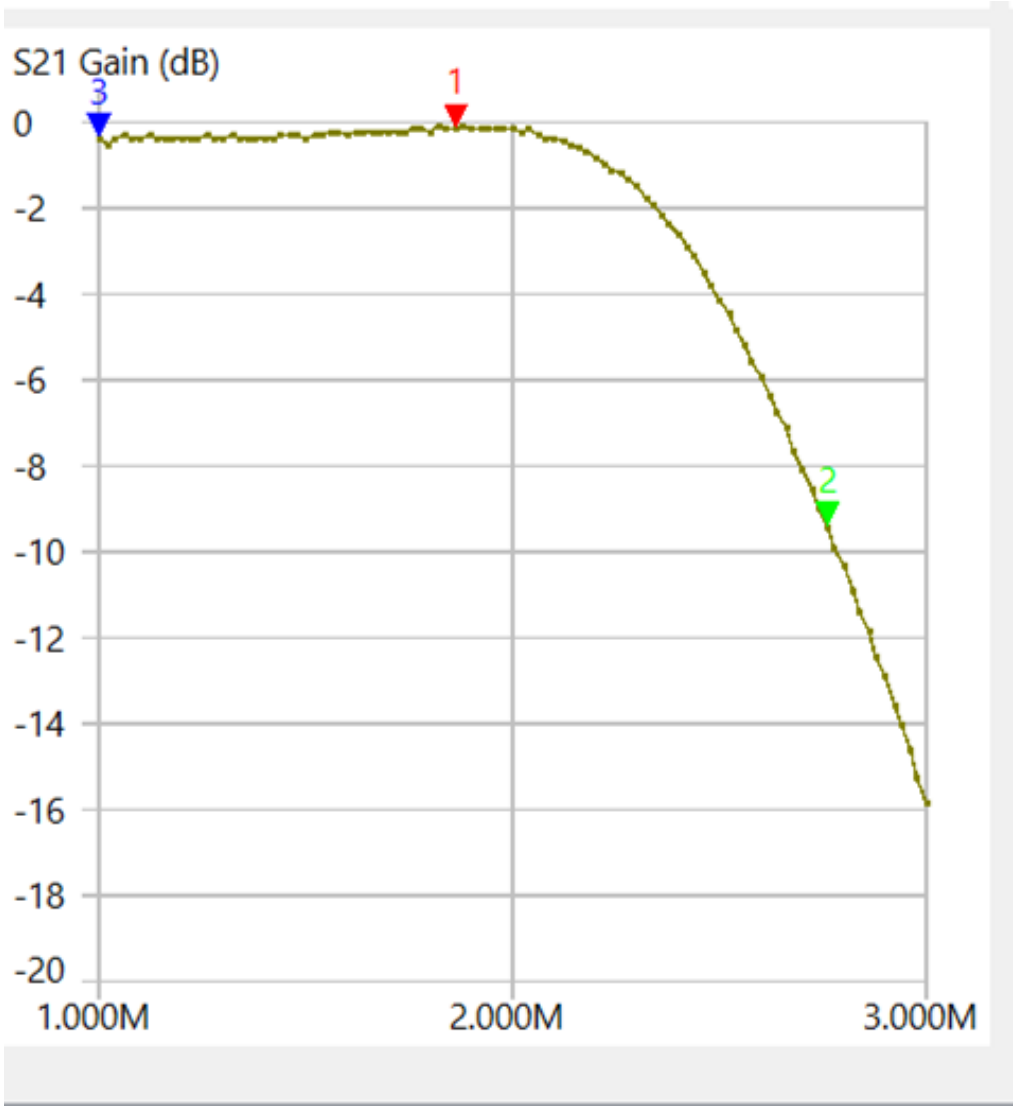
Min gain: -15.871 dB @ 3.00000MHz
Max gain: -0.096 dB @ 1.82000MHz

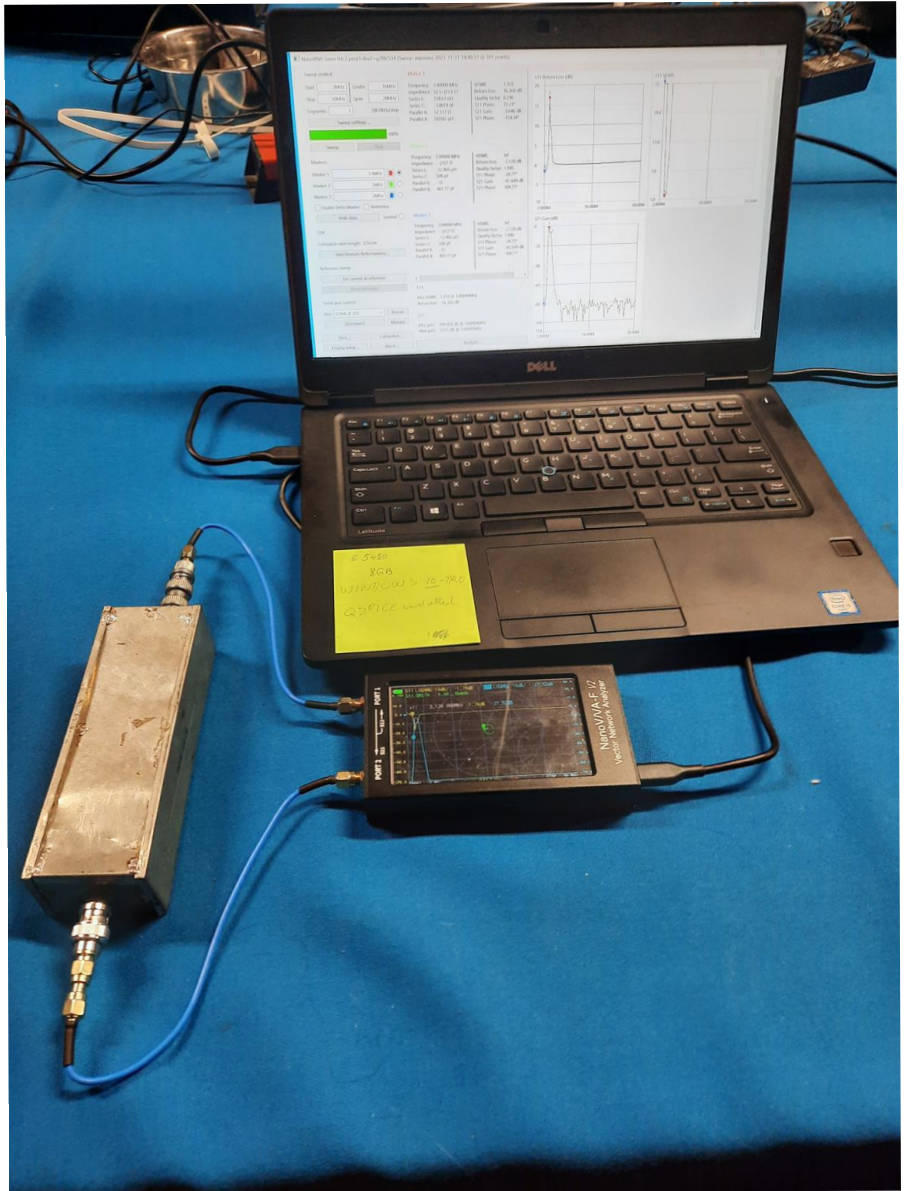
Analysis ...








S21 Gain (dB)
3
1
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
1.000M
2.000M
3.000M



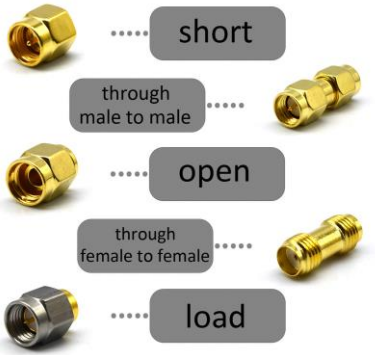
Onbekende filter

Voorbereiding

- Frequentie Range
  2MHz - 16MHz

- Double check connection

- Calibratie



NanoVNA Saver 0.6.2.post1.dev2+g2f8c534 (Sweep: nanovna_2023-11-11 14:48:51 @ 101 points)

Sweep control

Start 2MHz | Center 16MHz
Stop 30MHz | Span 28MHz
Segments 1 | 280.0kHz/step
Sweep settings ...
100%
Sweep | Stop

Markers

Marker 1 3.4MHz
Marker 2 2MHz
Marker 3 2MHz
Enable Delta Marker | Reference
Hide data | Locked

TDR

Estimated cable length: 0.561m
Time Domain Reflectometry ...

Reference sweep

Set current as reference
Reset reference

Serial port control

Port COM6 (F_V2) | Rescan
Disconnect | Manage

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

Marker 1

Frequency:	3.40000 MHz	VSWR:	1.359
Impedance:	52.5+j15.6 Ω	Return loss:	16.360 dB
Series L:	728.61 nH	Quality factor:	0.296
Series C:	-3.0074 nF	S11 Phase:	72.23°
Parallel R:	57.117 Ω	S21 Gain:	-3.646 dB
Parallel X:	9.0185 µH	S21 Phase:	-154.34°

Marker 2

Frequency:	2.00000 MHz	VSWR:	inf
Impedance:	- -j157 Ω	Return loss:	-2.128 dB
Series L:	-12.466 µH	Quality factor:	1.945
Series C:	508 pF	S11 Phase:	-28.77°
Parallel R:	- Ω	S21 Gain:	-81.649 dB
Parallel X:	401.77 pF	S21 Phase:	104.71°

Marker 3

Frequency:	2.00000 MHz	VSWR:	inf
Impedance:	- -j157 Ω	Return loss:	-2.128 dB
Series L:	-12.466 µH	Quality factor:	1.945
Series C:	508 pF	S11 Phase:	-28.77°
Parallel R:	- Ω	S21 Gain:	-81.649 dB
Parallel X:	401.77 pF	S21 Phase:	104.71°

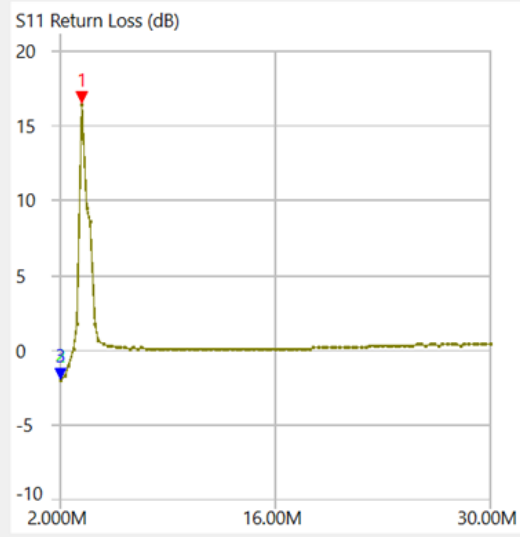
S11

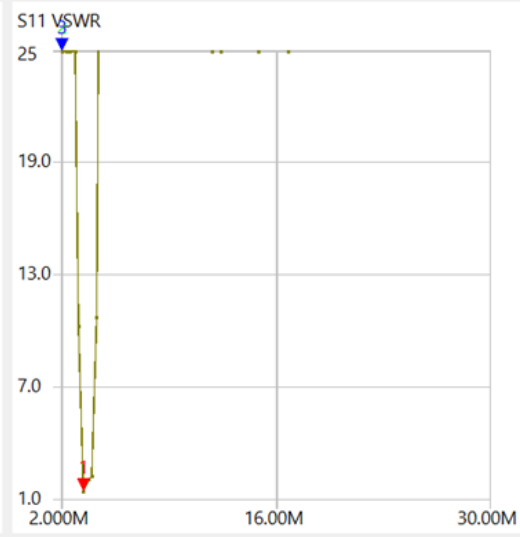
Min VSWR: 1.359 @ 3.40000MHz
Return loss: -16.360 dB

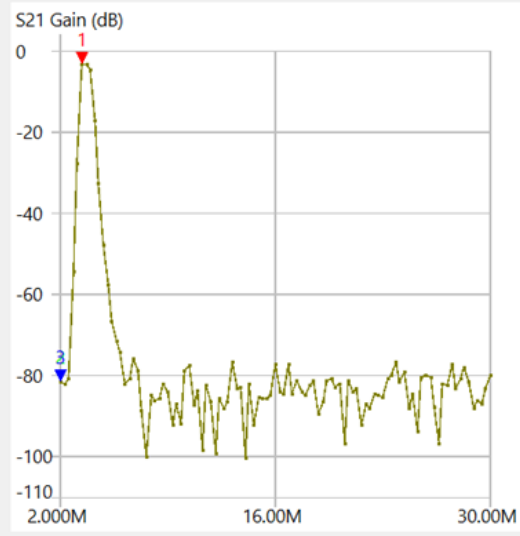
S21

Min gain: -100.458 dB @ 14.0400MHz
Max gain: -3.615 dB @ 3.68000MHz

Analysis ...







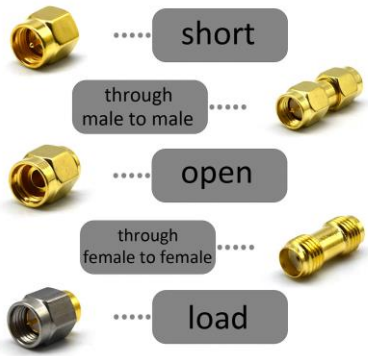
Kabel lengte

Voorbereiding

Frequentie Range
1MHz - 3MHz

Double check connection

Calibratie



NanoVNA Saver 0.6.2.post1.dev2+g2f8c534 (Sweep: nanovna_2023-11-11 15:04:15 @ 101 points)

Sweep control

Start 2MHz | Center 16MHz
Stop 30MHz | Span 28MHz
Segments 1 — 280.0kHz/step
Sweep settings ...
100%
Sweep | Stop

Markers

Marker 1	3.4MHz	●
Marker 2	2MHz	○
Marker 3	2MHz	○

☐ Enable Delta Marker ☐ Reference
Hide data — Locked ○

TDR

Estimated cable length: 3.688m
Time Domain Reflectometry ...

Reference sweep

Set current as reference
Reset reference

Serial port control

Port COM6 (F_V2) — Rescan
Disconnect — Manage

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

Marker 1

Frequency:	3.40000 MHz	VSWR:	297.413
Impedance:	1.09-j117 Ω	Return loss:	0.058 dB
Series L:	-5.4835 µH	Quality factor:	107.4
Series C:	399.6 pF	S11 Phase:	-46.23°
Parallel R:	12.579 kΩ	S21 Gain:	-82.646 dB
Parallel X:	399.57 pF	S21 Phase:	-159.35°

Marker 2

Frequency:	2.00000 MHz	VSWR:	inf
Impedance:	- -j149 Ω	Return loss:	-2.236 dB
Series L:	-11.824 µH	Quality factor:	0.464
Series C:	535.59 pF	S11 Phase:	-6.94°
Parallel R:	- Ω	S21 Gain:	-80.024 dB
Parallel X:	94.898 pF	S21 Phase:	-158.84°

Marker 3

Frequency:	2.00000 MHz	VSWR:	inf
Impedance:	- -j149 Ω	Return loss:	-2.236 dB
Series L:	-11.824 µH	Quality factor:	0.464
Series C:	535.59 pF	S11 Phase:	-6.94°
Parallel R:	- Ω	S21 Gain:	-80.024 dB
Parallel X:	94.898 pF	S21 Phase:	-158.84°

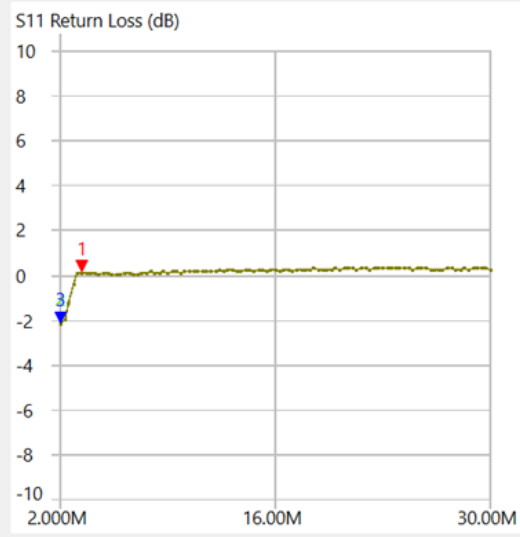
S11

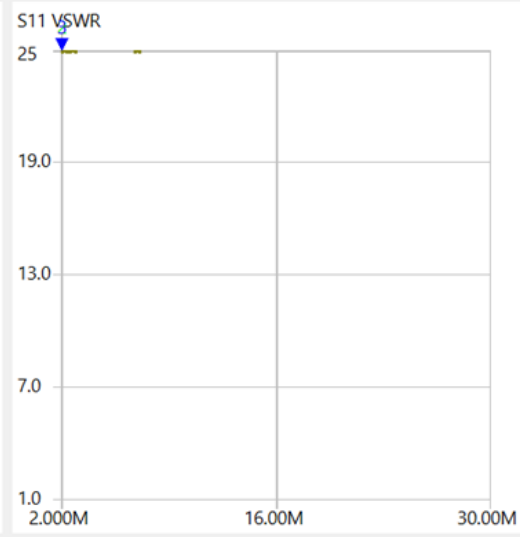
Min VSWR: 53.730 @ 22.7200MHz
Return loss: -0.323 dB

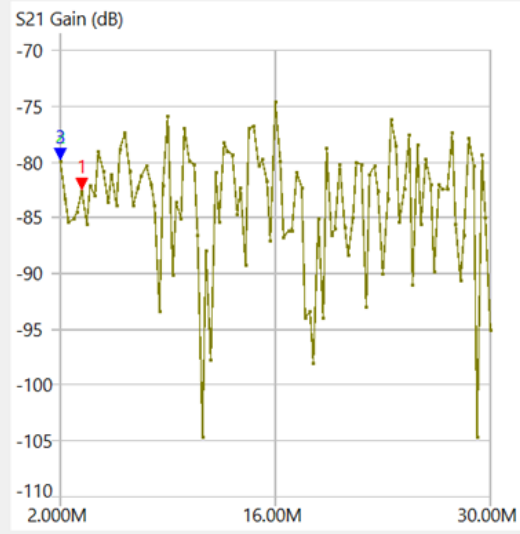
S21

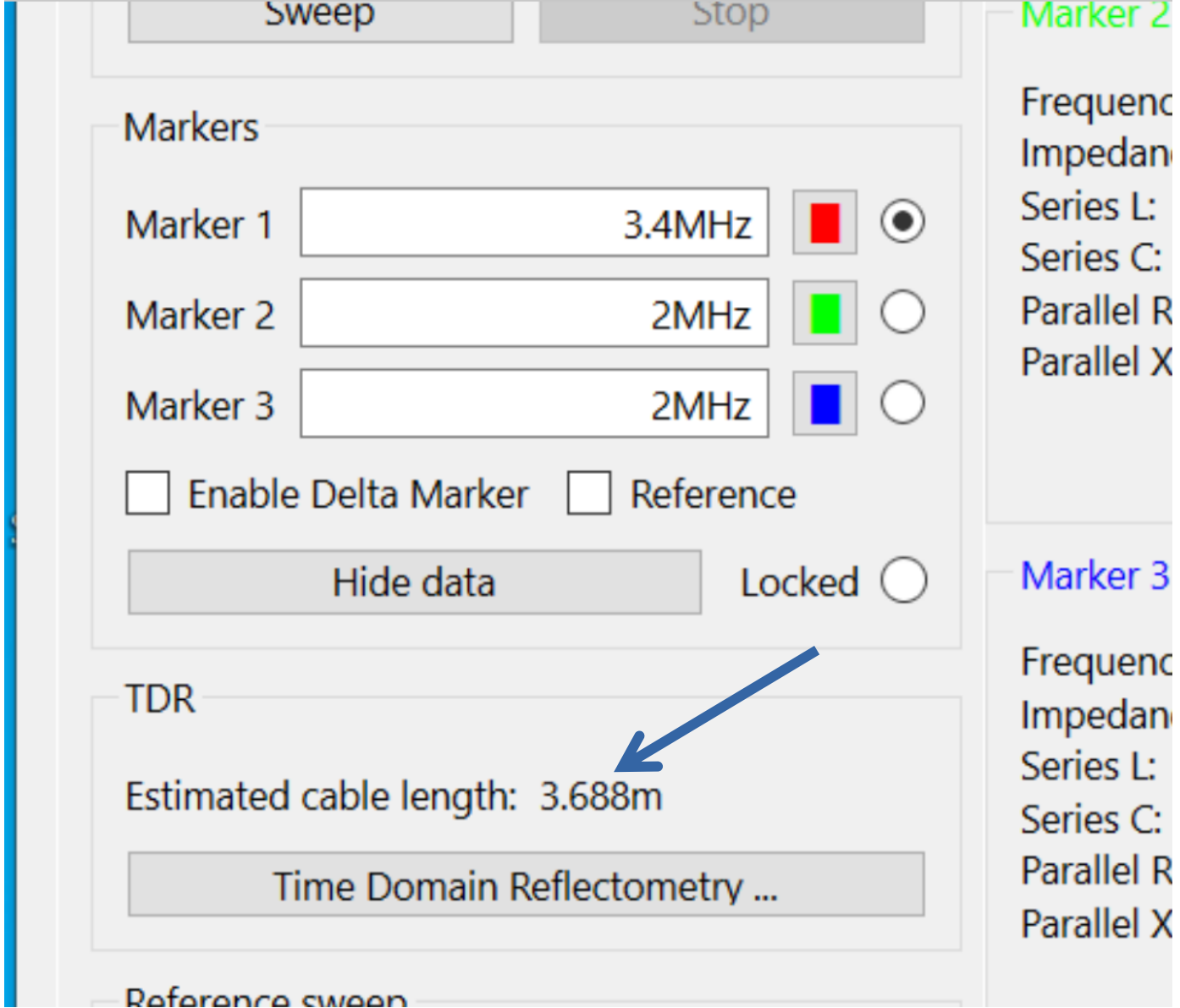
Min gain: -104.685 dB @ 11.2400MHz
Max gain: -74.626 dB @ 16.0000MHz

Analysis ...





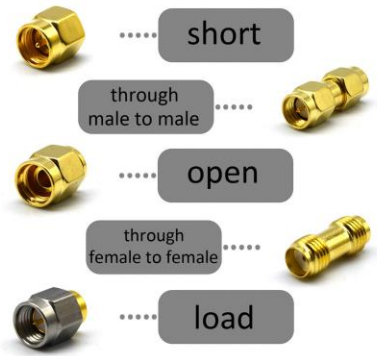



Sweep
Stop
Markers
Marker 1
3.4MHz
Marker 2
2MHz
Marker 3
2MHz
Enable Delta Marker
Reference
Hide data
Locked
TDR
Estimated cable length: 3.688m
Time Domain Reflectometry ...
Marker 2
Frequenc
Impedan
Series L:
Series C:
Parallel R
Parallel X
Marker 3
Frequenc
Impedan
Series L:
Series C:
Parallel R
Parallel X

Kabel verzwakking

<u>Voorbereiding</u>

- Frequentie Range 20MHz - 400MHz
- Double check connection
- Calibratie



NanoVNA Saver 0.6.2.post1.dev2+g2f8c534 (Sweep: nanovna_2023-11-11 15:11:53 @ 101 points)

Sweep control

Start 20MHz | Center 210MHz
Stop 400MHz | Span 380MHz
Segments 1 | 3.800MHz/step

Sweep settings ...

100%

Sweep | Stop

Markers

Marker 1 400MHz
Marker 2 20MHz
Marker 3 20MHz

Enable Delta Marker | Reference

Hide data | Locked

TDR

Estimated cable length: 0.003m

Time Domain Reflectometry ...

Reference sweep

Set current as reference

Reset reference

Serial port control

Port COM6 (F_V2) | Rescan

Disconnect | Manage

Files ... | Calibration ...

Display setup ... | About ...

Marker 1

Frequency:	400.000 MHz	VSWR:	1.354
Impedance:	54.6-j15.2 Ω	Return loss:	16.453 dB
Series L:	-6.0555 nH	Quality factor:	0.279
Series C:	26.144 pF	S11 Phase:	-64.85°
Parallel R:	58.857 Ω	S21 Gain:	-0.947 dB
Parallel X:	1.8838 pF	S21 Phase:	-160.09°

Marker 2

Frequency:	20.0000 MHz	VSWR:	1.017
Impedance:	49.9-j821m Ω	Return loss:	41.648 dB
Series L:	-6.5333 nH	Quality factor:	0.016
Series C:	9.6927 nF	S11 Phase:	-96.09°
Parallel R:	49.919 Ω	S21 Gain:	-0.141 dB
Parallel X:	2.6225 pF	S21 Phase:	-134.77°

Marker 3

Frequency:	20.0000 MHz	VSWR:	1.017
Impedance:	49.9-j821m Ω	Return loss:	41.648 dB
Series L:	-6.5333 nH	Quality factor:	0.016
Series C:	9.6927 nF	S11 Phase:	-96.09°
Parallel R:	49.919 Ω	S21 Gain:	-0.141 dB
Parallel X:	2.6225 pF	S21 Phase:	-134.77°

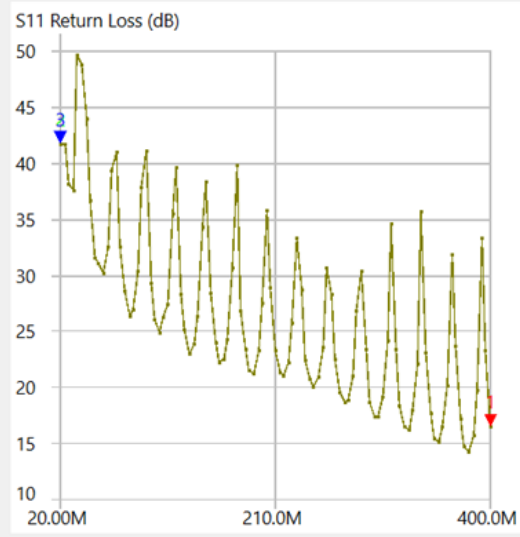
S11

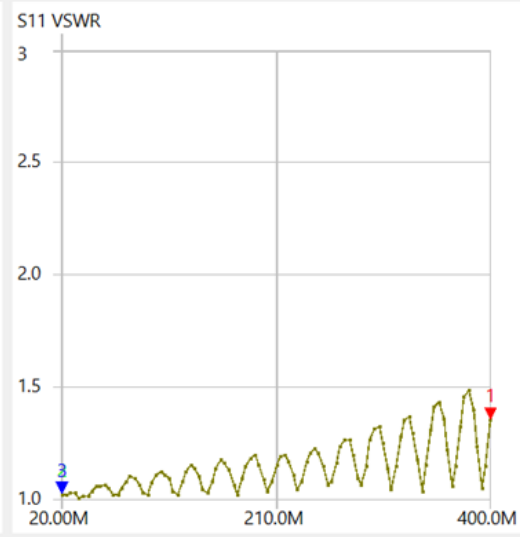
Min VSWR: 1.007 @ 35.2000MHz
Return loss: -49.638 dB

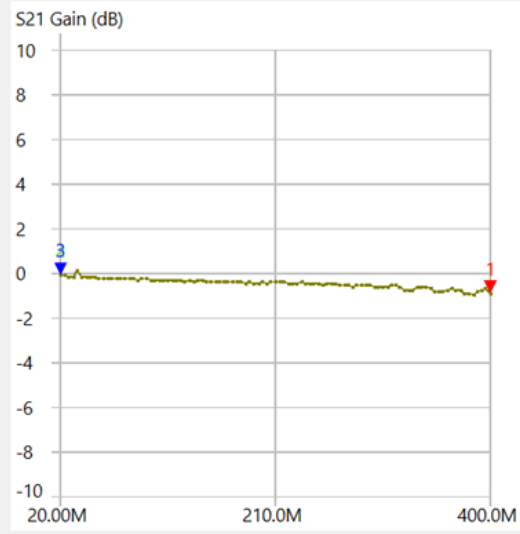
S21

Min gain: -0.966 dB @ 384.800MHz
Max gain: 0.096 dB @ 35.2000MHz

Analysis ...





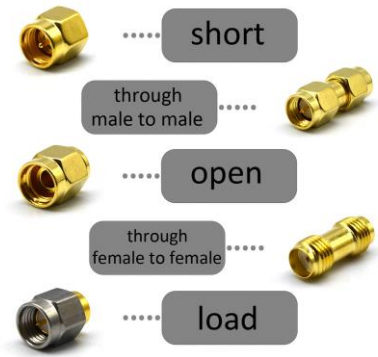


Kristal Filter

Voorbereiding

Frequentie Range
1MHz - 3MHz

Calibratie



NanoVNA Saver 0.6.2.post1.dev2+g2f8c534 (Sweep: nanovna_2023-11-11 15:28:42 @ 101 points)

Sweep control

Start 7.5MHz | Center 8MHz
Stop 8.5MHz | Span 1MHz
Segments 1 | 10.00kHz/step

Sweep settings ...

100%

Sweep | Stop

Markers

Marker 1	8MHz	●
Marker 2	7.5MHz	○
Marker 3	7.5MHz	○

☐ Enable Delta Marker ☐ Reference

Hide data | Locked ○

TDR

Estimated cable length: 1.208m

Time Domain Reflectometry ...

Reference sweep

Set current as reference

Reset reference

Serial port control

Port COM6 (F_V2) | Rescan

Disconnect | Manage

Files ... | Calibration ...

Display setup ... | About ...

Marker 1

Frequency:	8.00000 MHz	VSWR:	5.994
Impedance:	93.8-j133 Ω	Return loss:	2.925 dB
Series L:	-2.639 µH	Quality factor:	1.414
Series C:	149.97 pF	S11 Phase:	-29.04°
Parallel R:	281.39 Ω	S21 Gain:	-4.711 dB
Parallel X:	99.981 pF	S21 Phase:	-60.68°

Marker 2

Frequency:	7.50000 MHz	VSWR:	156.676
Impedance:	3.15-j149 Ω	Return loss:	0.111 dB
Series L:	-3.1579 µH	Quality factor:	47.29
Series C:	142.6 pF	S11 Phase:	-37.13°
Parallel R:	7.0398 kΩ	S21 Gain:	-24.467 dB
Parallel X:	142.54 pF	S21 Phase:	54.34°

Marker 3

Frequency:	7.50000 MHz	VSWR:	156.676
Impedance:	3.15-j149 Ω	Return loss:	0.111 dB
Series L:	-3.1579 µH	Quality factor:	47.29
Series C:	142.6 pF	S11 Phase:	-37.13°
Parallel R:	7.0398 kΩ	S21 Gain:	-24.467 dB
Parallel X:	142.54 pF	S21 Phase:	54.34°

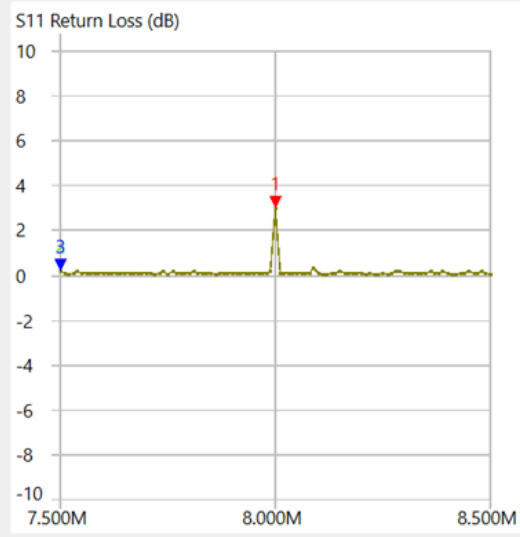
S11

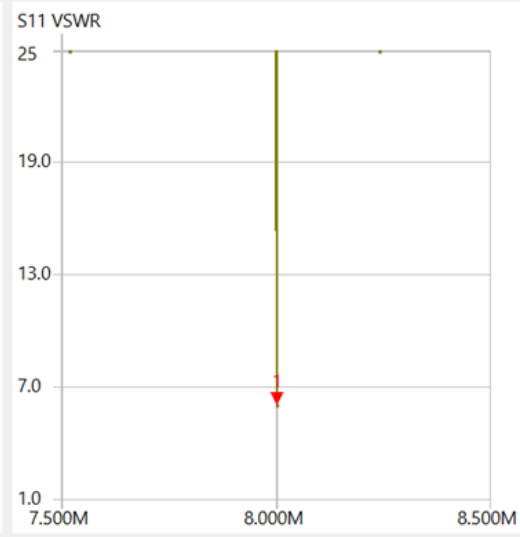
Min VSWR: 5.994 @ 8.00000MHz
Return loss: -2.925 dB

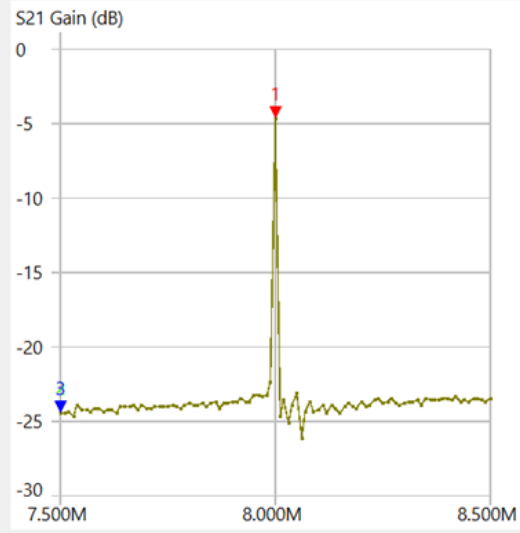
S21

Min gain: -26.216 dB @ 8.06000MHz
Max gain: -4.711 dB @ 8.00000MHz

Analysis ...





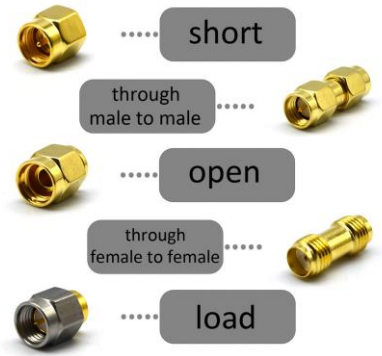


Wifi Antenne

Voorbereiding

Frequentie Range
1MHz - 3MHz

Calibratie



NanoVNA Saver 0.6.2.post1.dev2+g2f8c534 (Sweep: nanovna_2023-11-16 12:10:22 @ 101 points)

Sweep control

Start 1.7GHz | Center 2.35GHz
Stop 3GHz | Span 1.3GHz
Segments 1 | 13.00MHz/step
Sweep settings ...
100%
Sweep | Stop

Markers

Marker 1 2.324GHz
Marker 2 1.7GHz
Marker 3 1.7GHz
Enable Delta Marker | Reference
Hide data | Locked

TDR

Estimated cable length: 2.885m
Time Domain Reflectometry ...

Reference sweep

Set current as reference
Reset reference

Serial port control

Port COM6 (F_V2) | Rescan
Disconnect | Manage

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

Marker 1

Frequency:	2.32400 GHz	VSWR:	1.391
Impedance:	69-j4.13 Ω	Return loss:	15.727 dB
Series L:	-282.95 pH	Quality factor:	0.06
Series C:	16.575 pF	S11 Phase:	-10.26°
Parallel R:	69.284 Ω	S21 Gain:	-68.081 dB
Parallel X:	59.157 fF	S21 Phase:	-52.52°

Marker 2

Frequency:	1.70000 GHz	VSWR:	1.362
Impedance:	42.5-j12.2 Ω	Return loss:	16.287 dB
Series L:	-1.1437 nH	Quality factor:	0.287
Series C:	7.6638 pF	S11 Phase:	-113.89°
Parallel R:	46.048 Ω	S21 Gain:	-71.273 dB
Parallel X:	583.84 fF	S21 Phase:	40.40°

Marker 3

Frequency:	1.70000 GHz	VSWR:	1.362
Impedance:	42.5-j12.2 Ω	Return loss:	16.287 dB
Series L:	-1.1437 nH	Quality factor:	0.287
Series C:	7.6638 pF	S11 Phase:	-113.89°
Parallel R:	46.048 Ω	S21 Gain:	-71.273 dB
Parallel X:	583.84 fF	S21 Phase:	40.40°

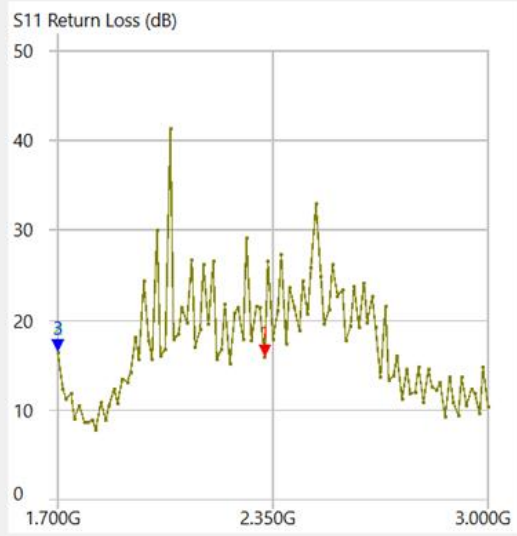
S11

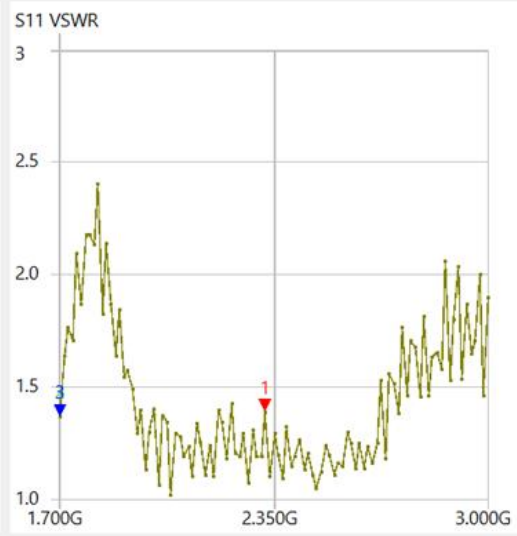
Min VSWR: 1.017 @ 2.03800GHz
Return loss: -41.328 dB

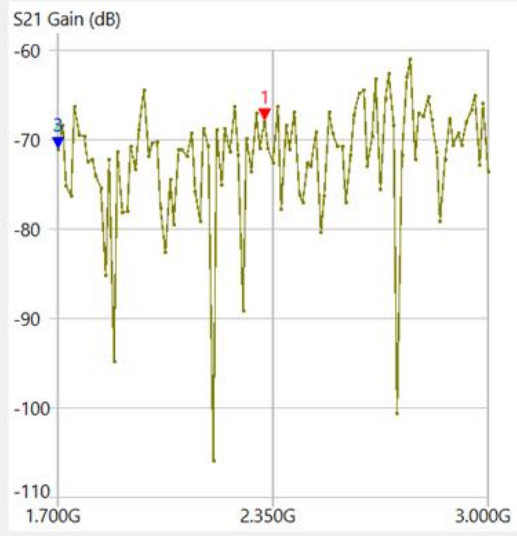
S21

Min gain: -106.021 dB @ 2.16800GHz
Max gain: -61.106 dB @ 2.76600GHz

Analysis ...








Q
&
A

S11: SWR en Return Loss

VSWR	Return loss in db	Linear
4	4.43 db	2.77
3	6.02 db	3.99
2	9.54 db	4.43
1.5	13.98 db	25.00
1.2	20.82 db	120.7
1.1	26.44 db	440.55
1	∞	∞