



6^as Feiras Técnicas

VNA Vector Network Analyser

Uma Introdução

22 de Janeiro 2021 – Jorge Canelhas VPA 116



Vector Network Analyser – Muito simplificado

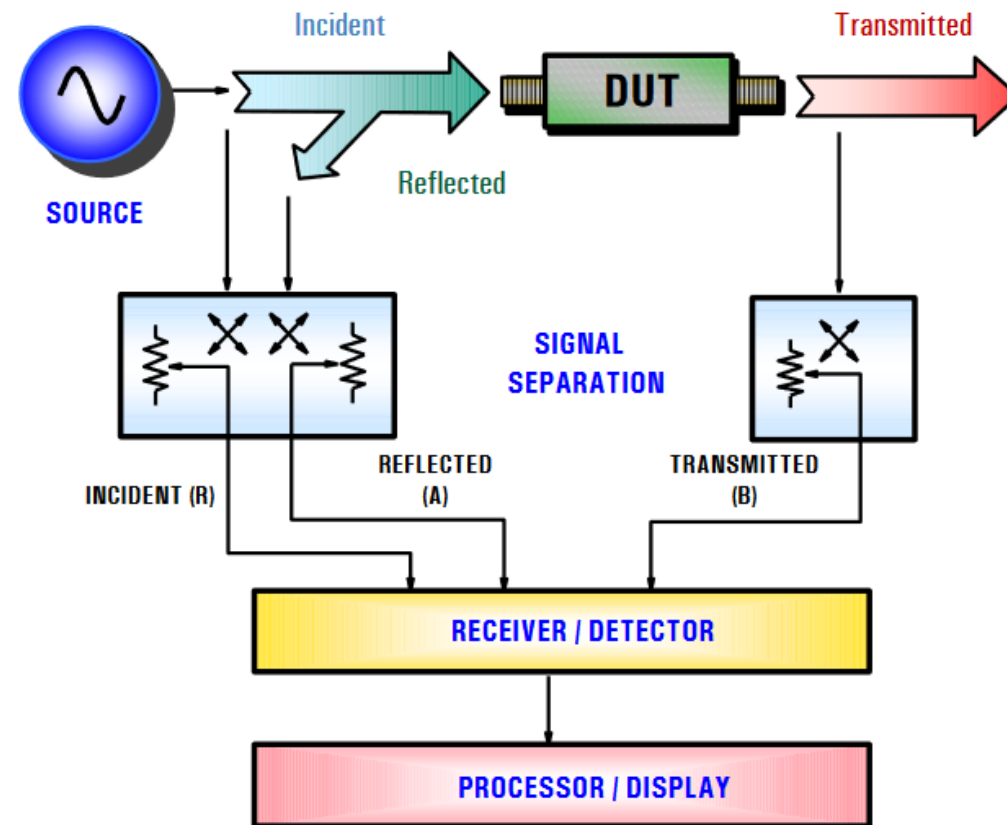
- **Mede a magnitude e fase (capacitância e indutância) do que sai e do que volta.**
- Tem um oscilador.
- Tem vários detetores.
- Mede o que sai para a antena/dispositivo.
- Mede o que retorna do DUT (Device Under Test). (S11)
- Mede o que atravessa o DUT. (S21)



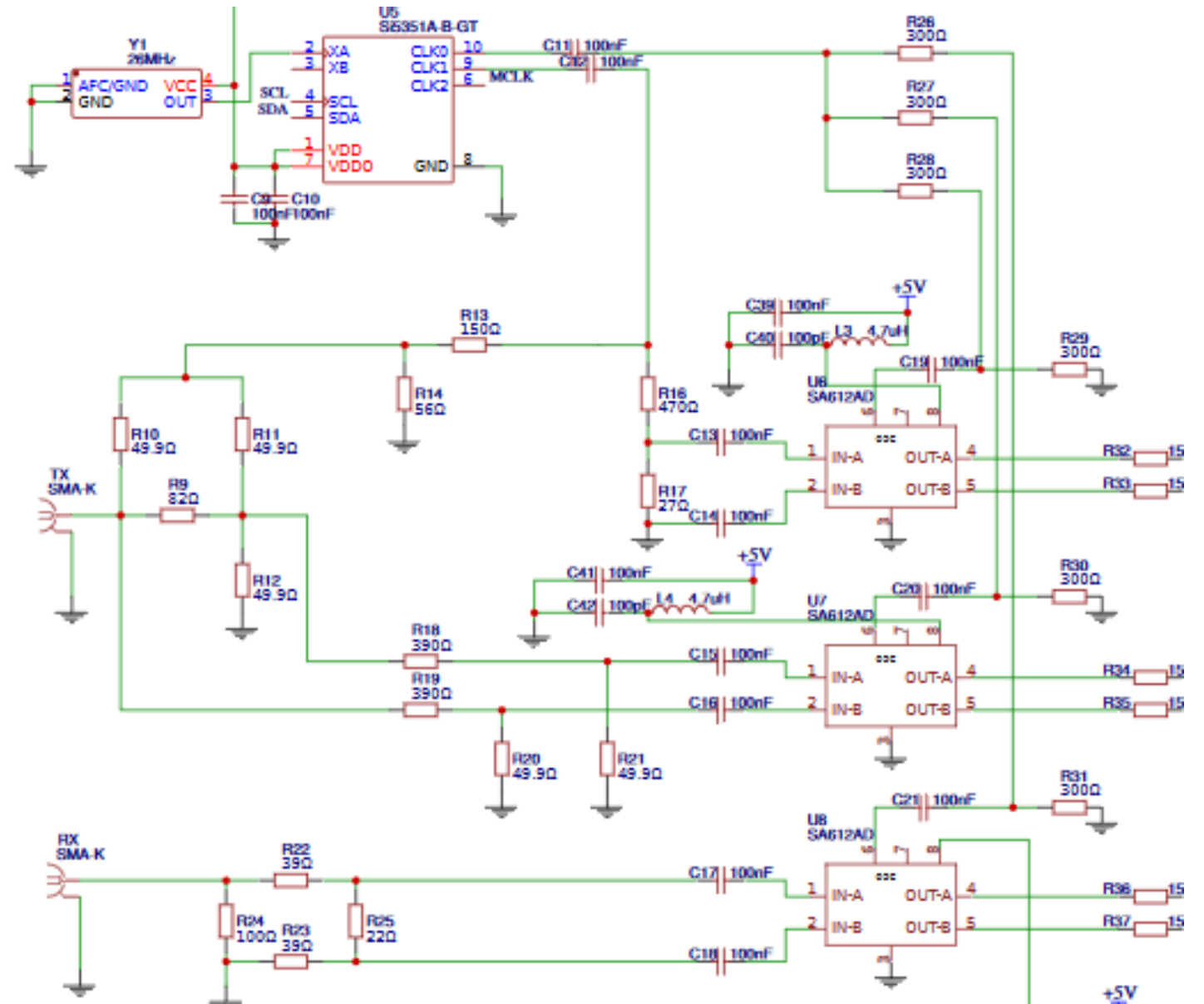
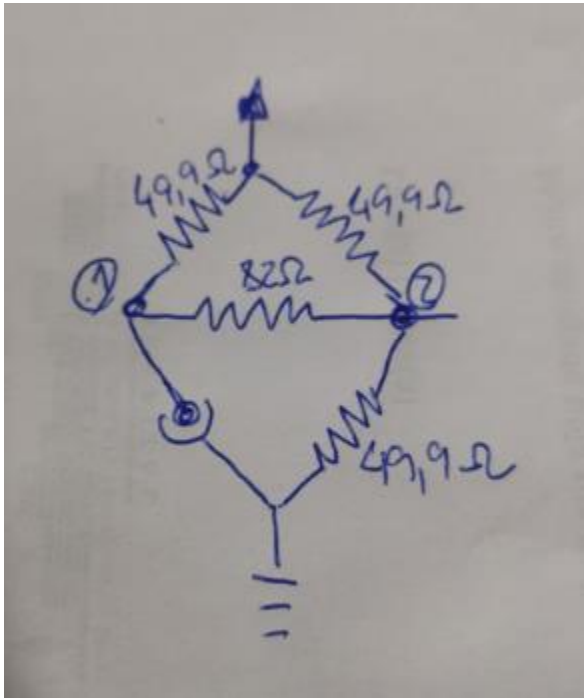
Serve para, entre outras coisas...

- Medir impedâncias
- 'Medir Antenas'
- 'Medir Filtros'
- Medir cabos com TDR.

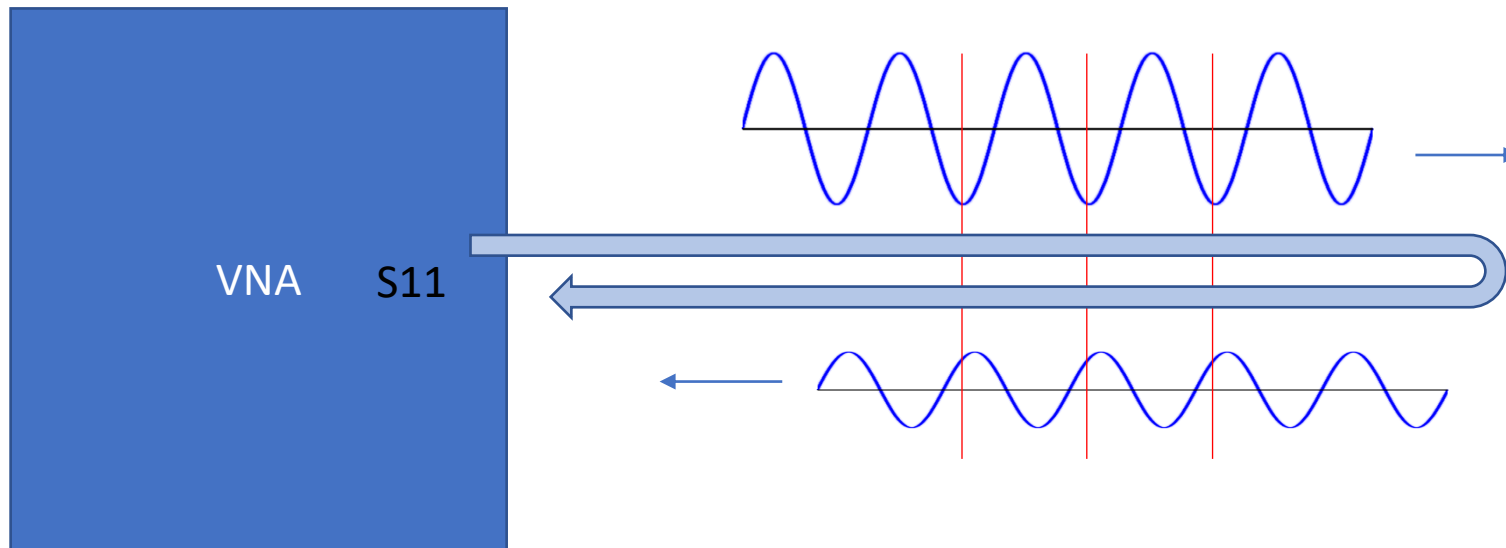
Diagrama de um VNA



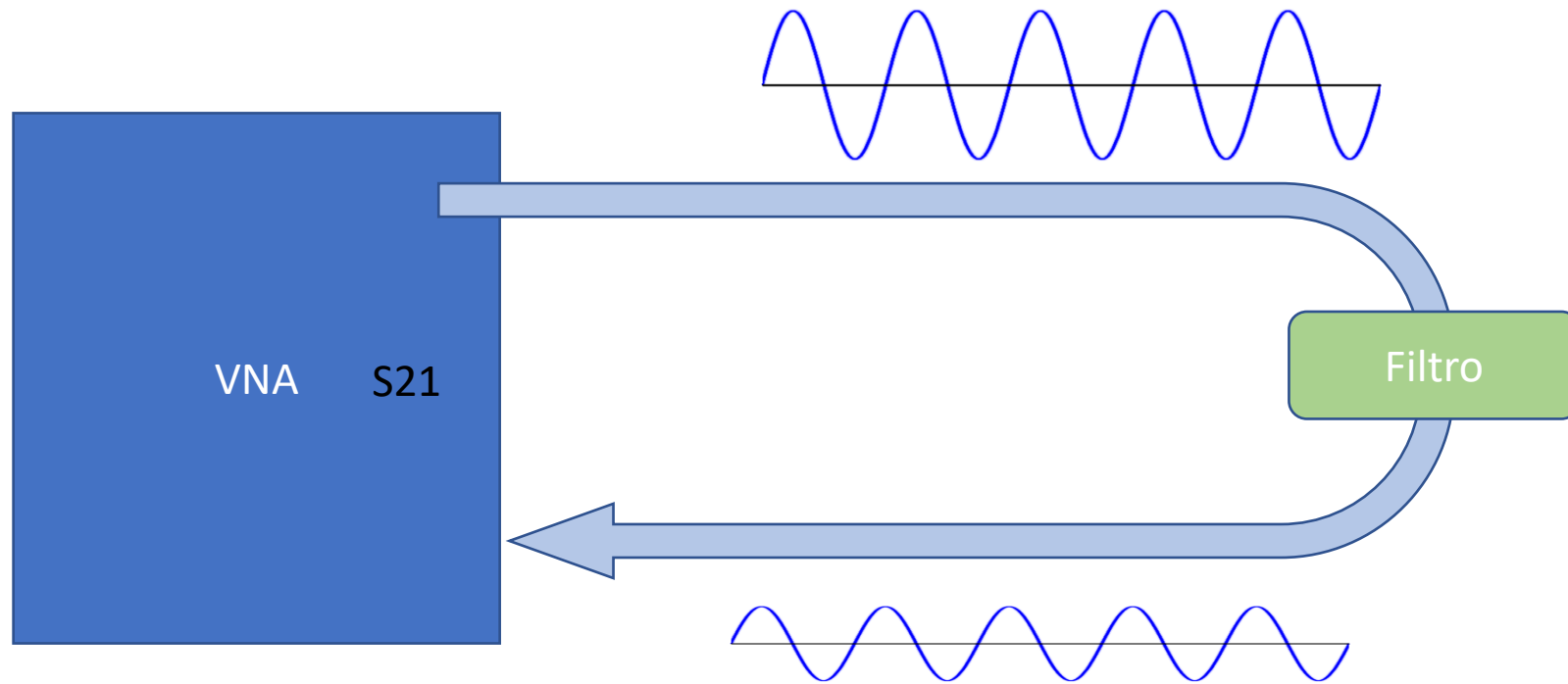
Base de um VNA



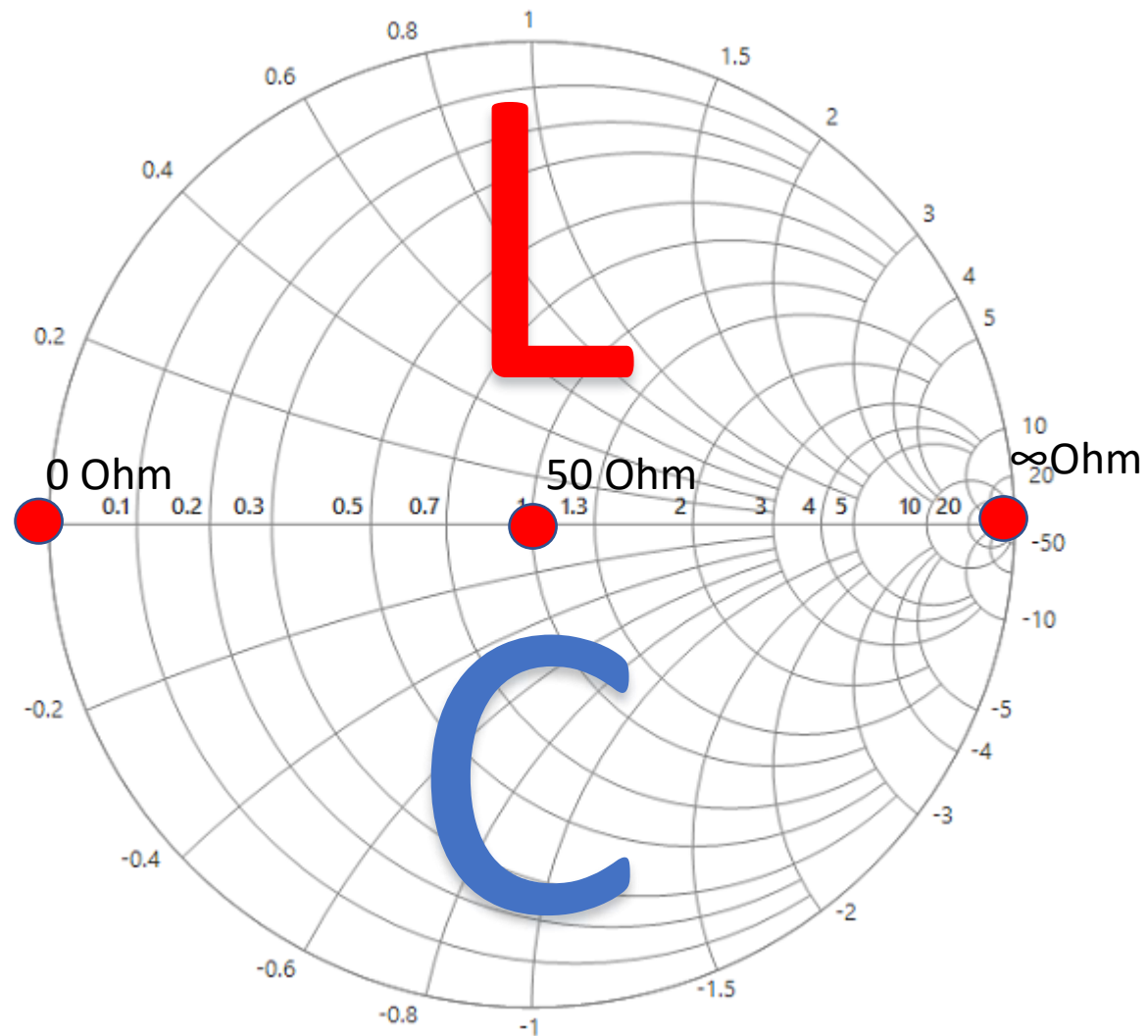
VNA a testar uma antena (S11)



VNA a testar um filtro (S21)

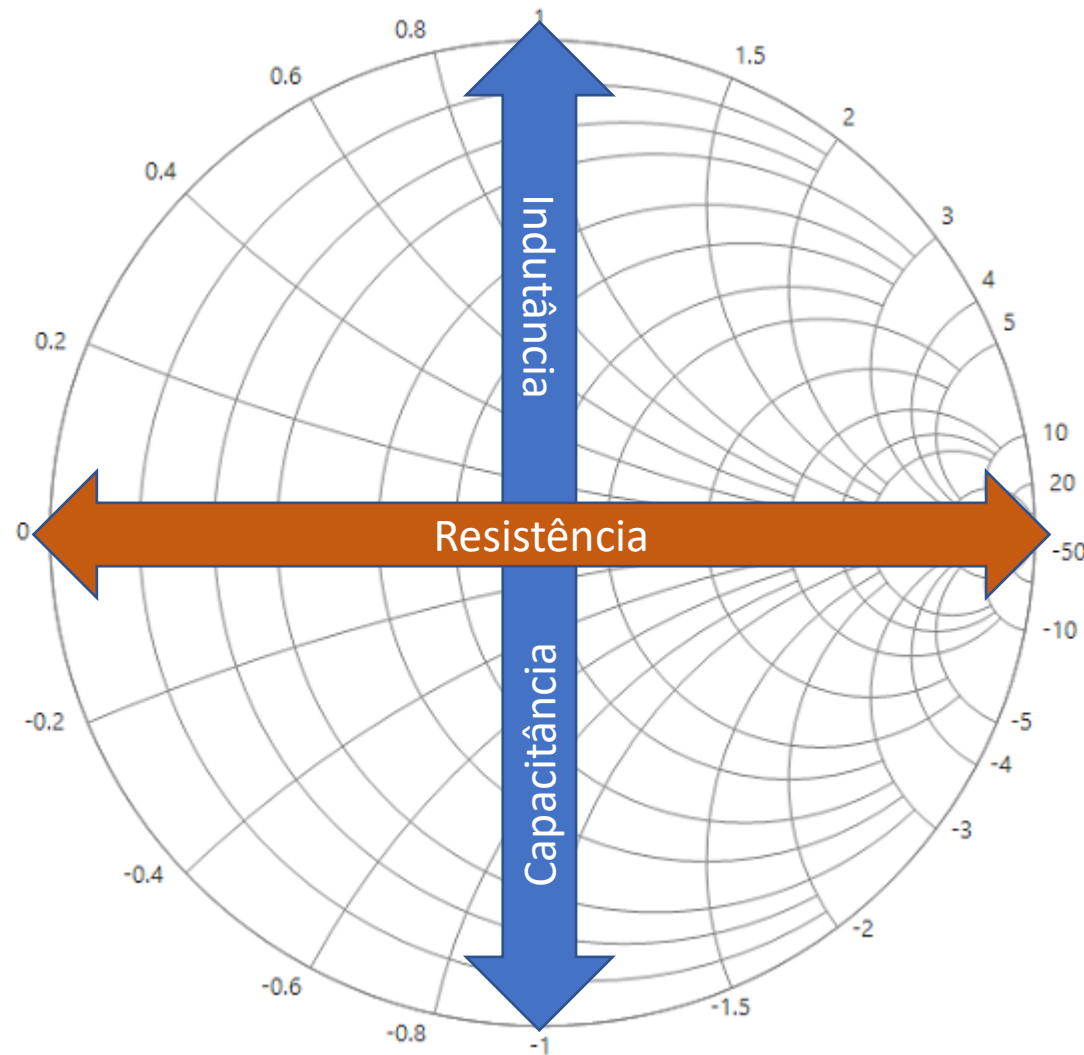


Smith Chart



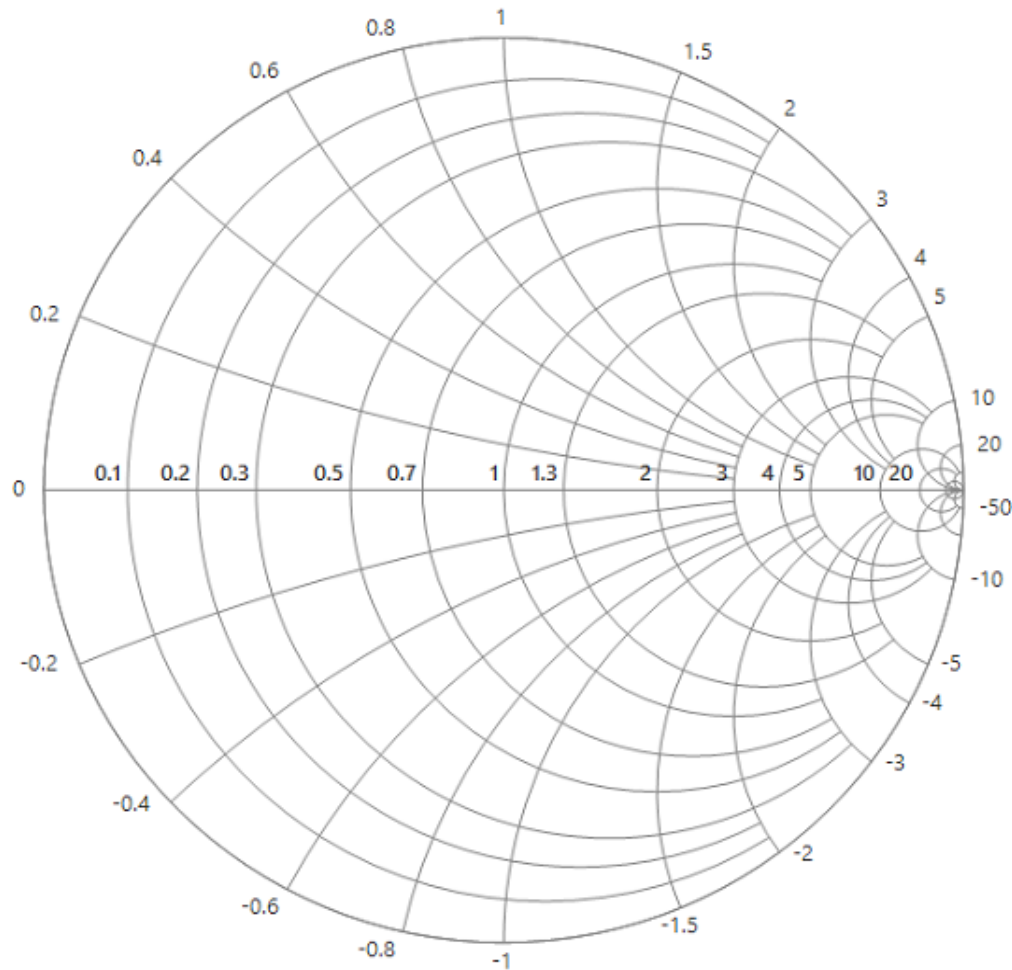
- Mostra:
 - Resistência.
 - Capacitância.
 - Indutância.
 - Cima Indutancia.
 - Baixo Capacitancia.
- Objectivo é o centro

Smith Chart



- Objetivo é o centro
 - Para andar para baixo adicionar capacitância
 - Para andar para cima adicionar indutância.
 - Na linha central resistância.

Smith Chart



$R = 50$ $R = 25$ $SWR = 2$
 $X = 0$ $X = 0$ $\Gamma = 0,333 \angle 180$
 $\rightarrow W = 0,444$ $\rightarrow W = 0,889$
 $\downarrow V_j = 4,714,94,28m$ $\downarrow V_j = 4,714,94,28m$

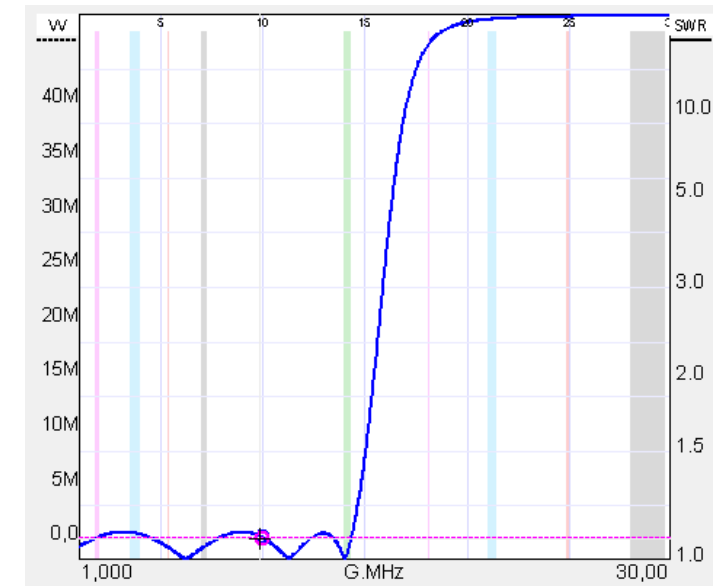
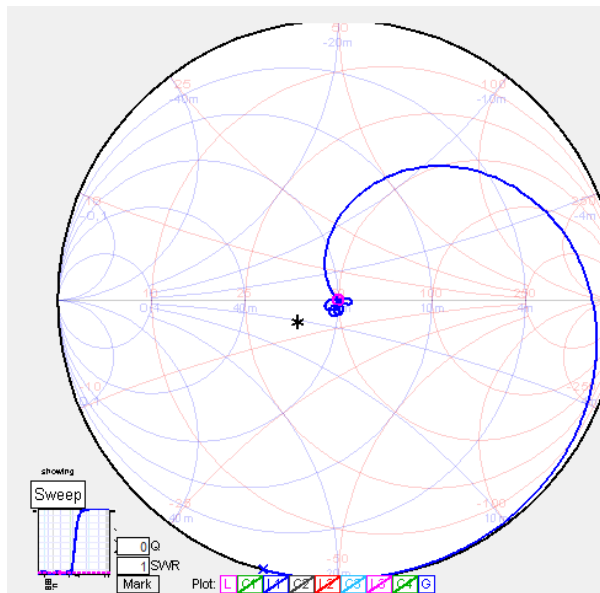
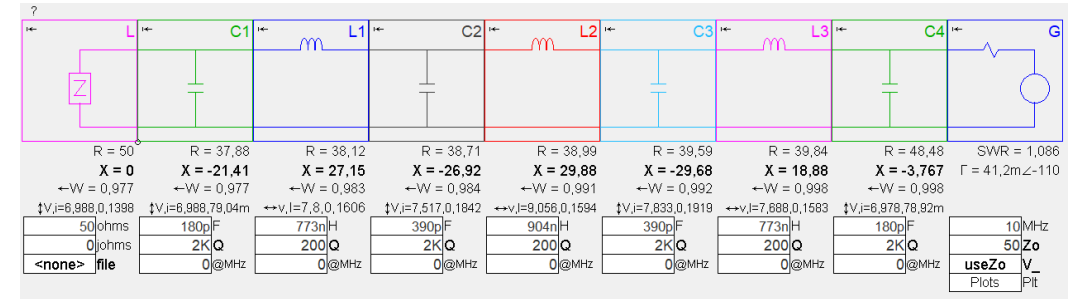
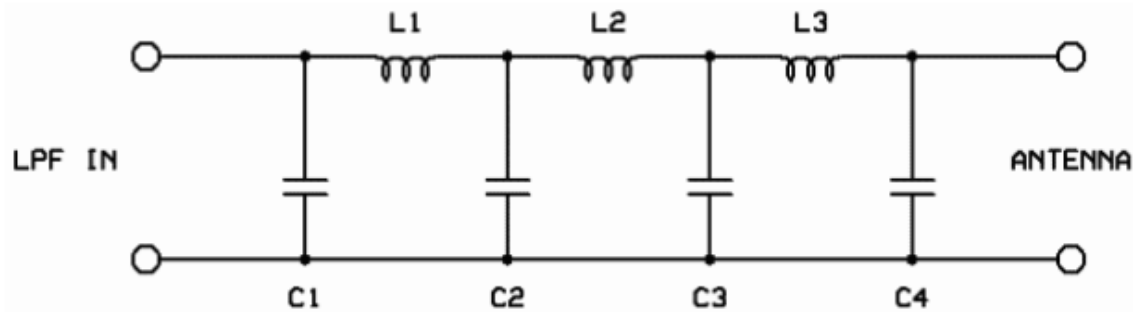
50ohms	50ohms	10MHz
0johms	0johms	50Zo
<none>	file	useZo
		V_
		Plots
		Fit

$R = 50$ $R = 25$ $R = 25,25$ $R = 6,001$ $R = 6,026$ $R = 2,77$ $SWR = 19,96$
 $X = 0$ $X = 0$ $X = 50$ $X = 26,47$ $X = -23,53$ $X = -16,23$ $\Gamma = 0,905 \angle -144$
 $\rightarrow W = 88,4m$ $\rightarrow W = 0,177$ $\rightarrow W = 0,179$ $\rightarrow W = 0,181$ $\rightarrow W = 0,182$ $\rightarrow W = 0,182$
 $\downarrow V_j = 2,103,42,05m$ $\downarrow V_j = 2,103,42,05m$ $\leftrightarrow V_j = 4,205,84,11m$ $\downarrow V_j = 4,711,94,22m$ $\leftrightarrow V_j = 8,68,0,1736$ $\downarrow V_j = 4,217,84,34m$

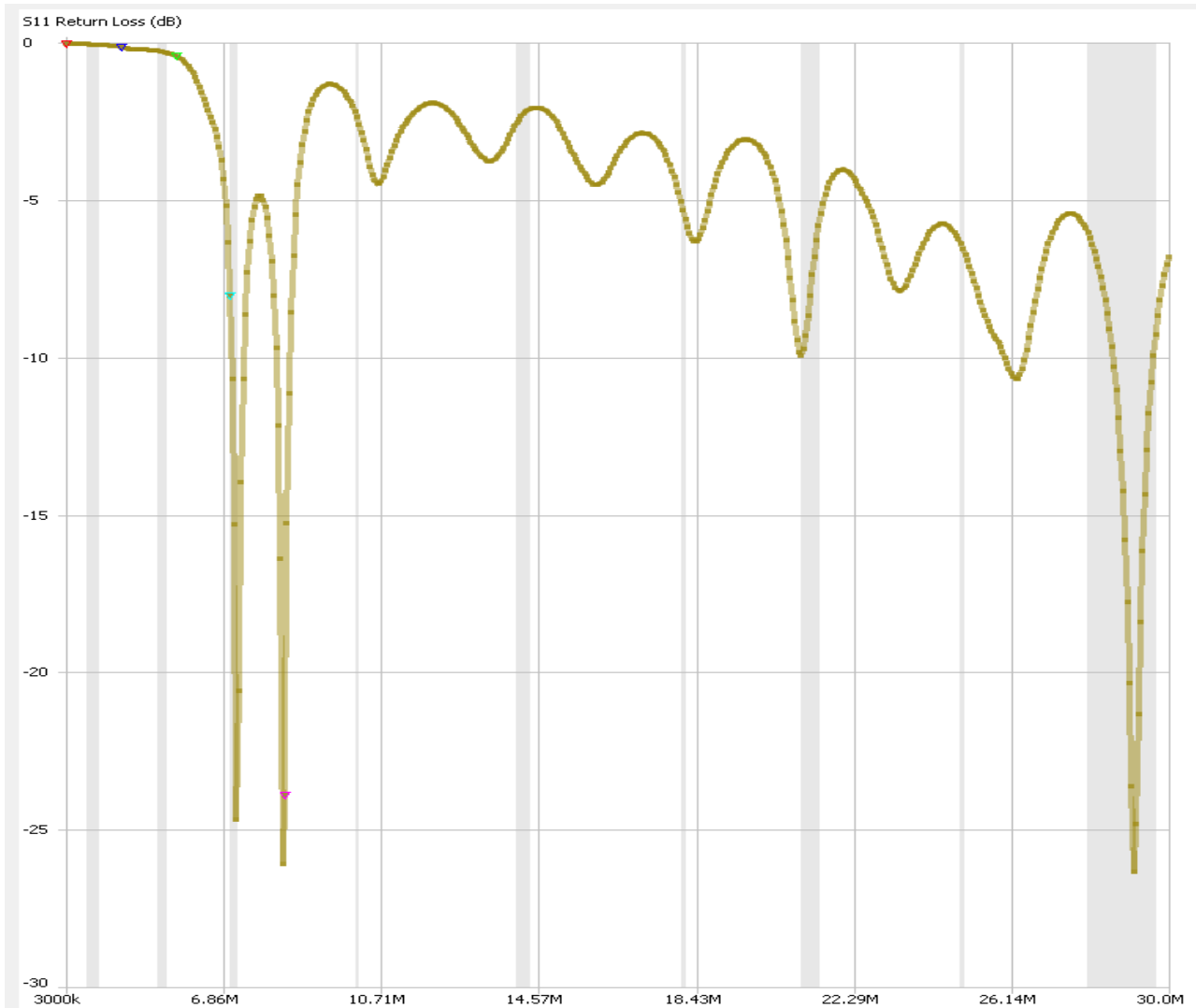
50ohms	50ohms	795,8nH	795,8nH	318,3pF	318,3pF	10MHz
0johms	0johms	200Q	200Q	2KQ	2KQ	50Zo
<none>	file	<none>	file	<none>	file	useZo
						V_
						Plots
						Fit

Sim Smith - Simulador

Sim Smith - Simulando o LPF do QCX de 20m

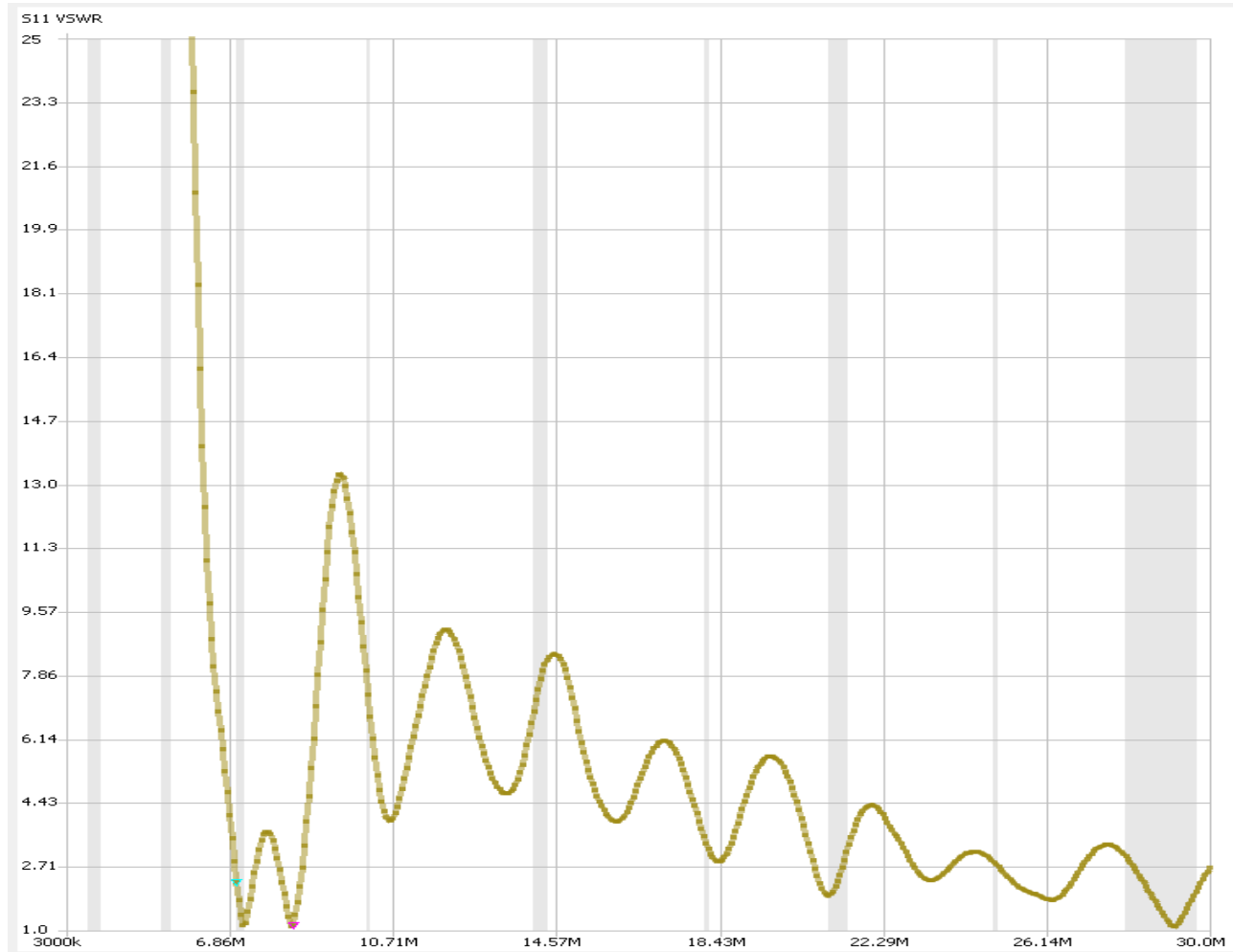


Return Loss



- Representa quanto a antena devolve.
- Objetivo é a menor return loss possível.

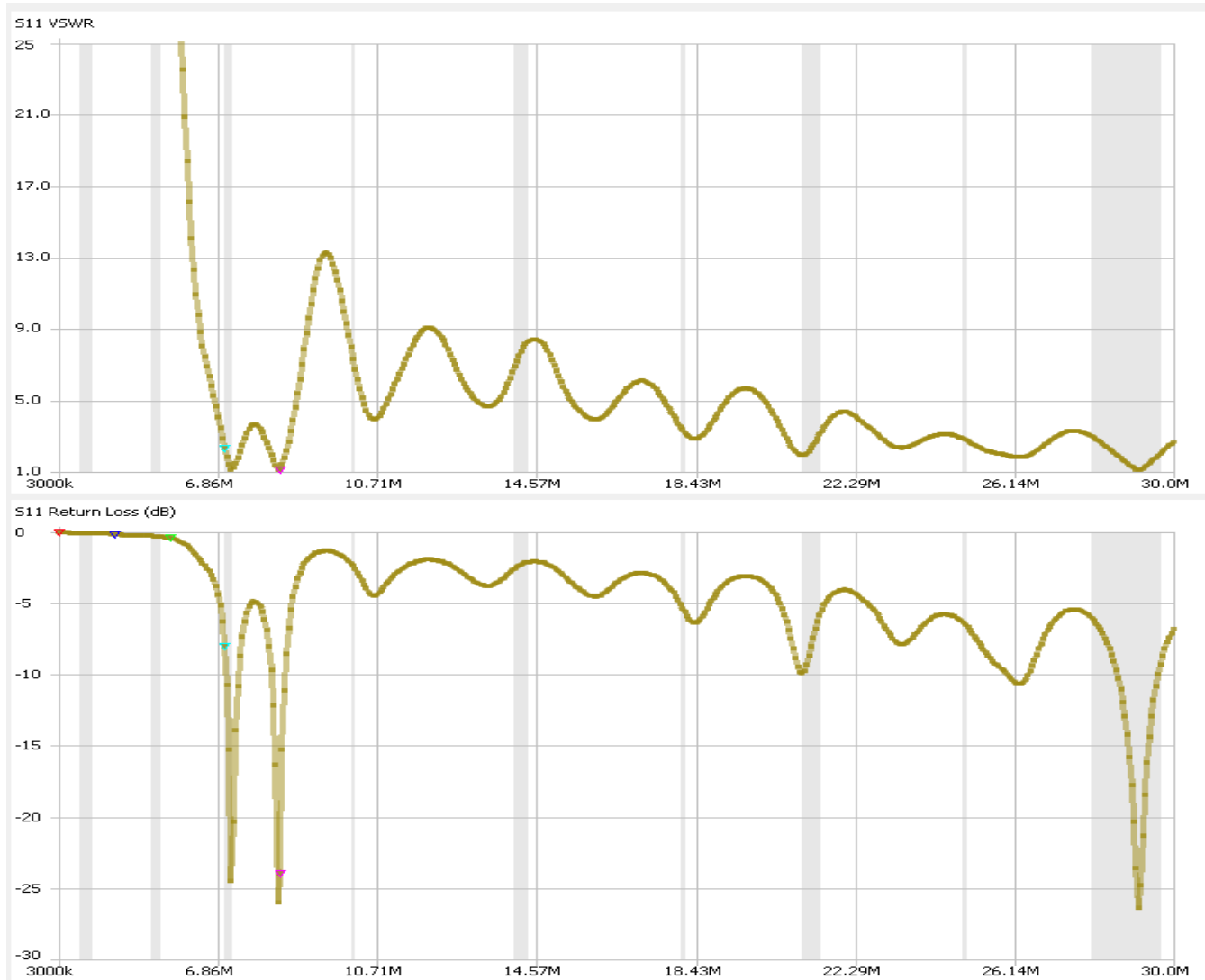
VSWR



- Representa quanto a antena devolve.
- Objetivo é um SWR o mais próximo de 1 possível

Relação Return Loss VSWR

- Medem o mesmo.



$$\Gamma = \frac{VSWR - 1}{VSWR + 1}$$

$$L_R = -20 \log_{10} \Gamma$$

VNAs

- R&S® FPC1500
 - 5kHz to 1/2/3 GHz
 - Single port opcional

- 2890 + 890 €



Nano VNA

The NanoVNA-H and H4 is a low-cost and high-performance antenna and vector network (VNA) analyzer that covers the HF, VHF frequency bands from 50 KHz to 300 MHz with a sensitivity of 70dB, the UHF band from 300 MHz to 900 MHz with a sensitivity of 60dB and 900 to 1500Mhz with a sensitivity of 40dB.

65€ - original

>26 € Aliexpress (15 de Janeiro 2021)

Compromissos , por exemplo Resolução, Velocidade, ...





Utilização Prática do NanoVNA

- Medir antenas
- Medir Filtros
- Medir Cabos
- Etc 😊

- DEVE SER CALIBRADO



Calibração NanoVNA

- Usam se 3 'medidas' conhecidas
 - Short
 - 50 Ohm
 - Open
- Se se pretender medir com o S21 deve-se calibrar também o through.



Setups possíveis (Que eu testei)

- Nano VNA só.
- Nano VNA ligado a um computador.
- Nano VNA ligado a um dispositivo Android.

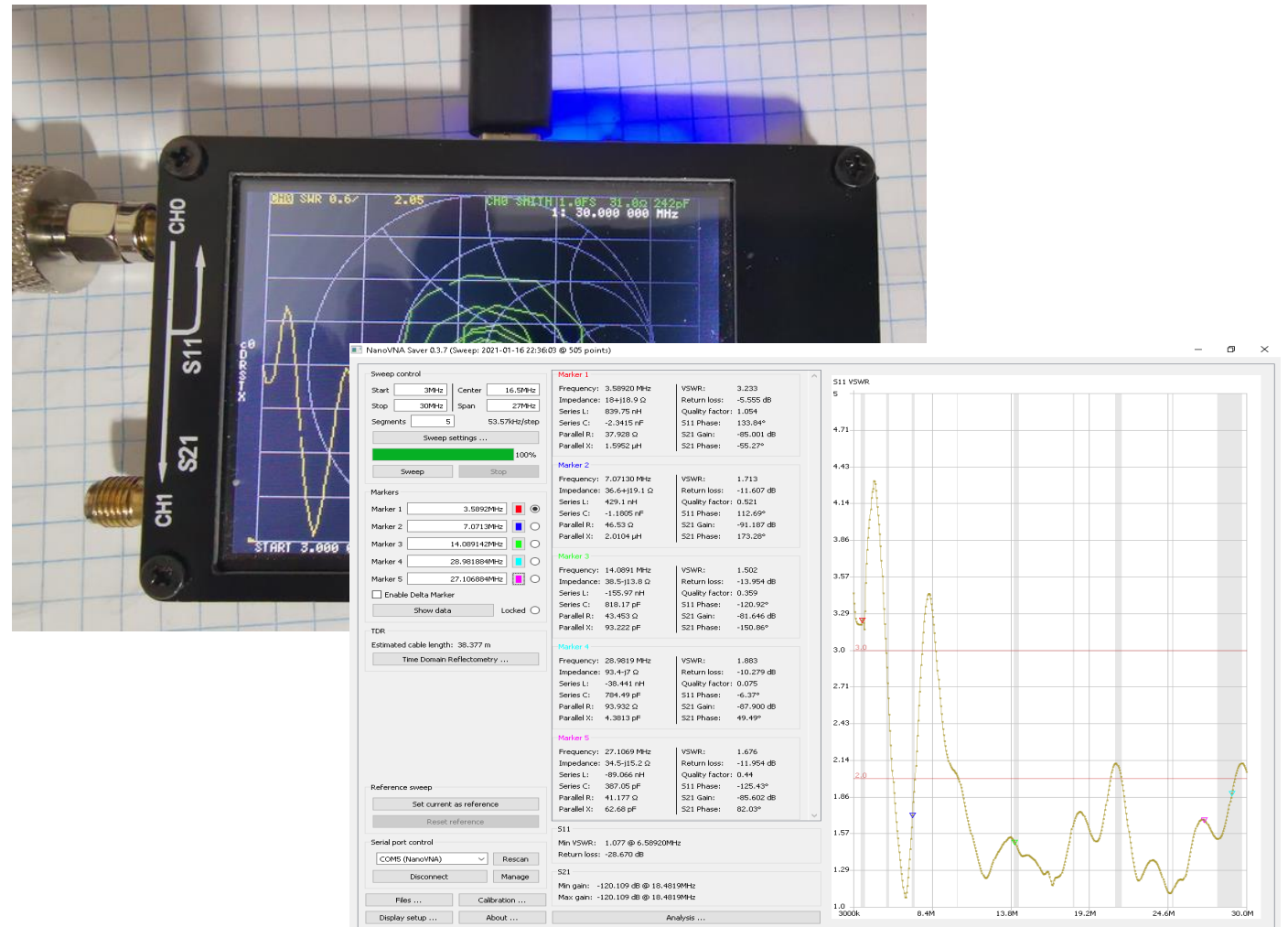
NanoVNA Só

- Prático
- Ecrã pouco brilhante.
- Não grava resultados.



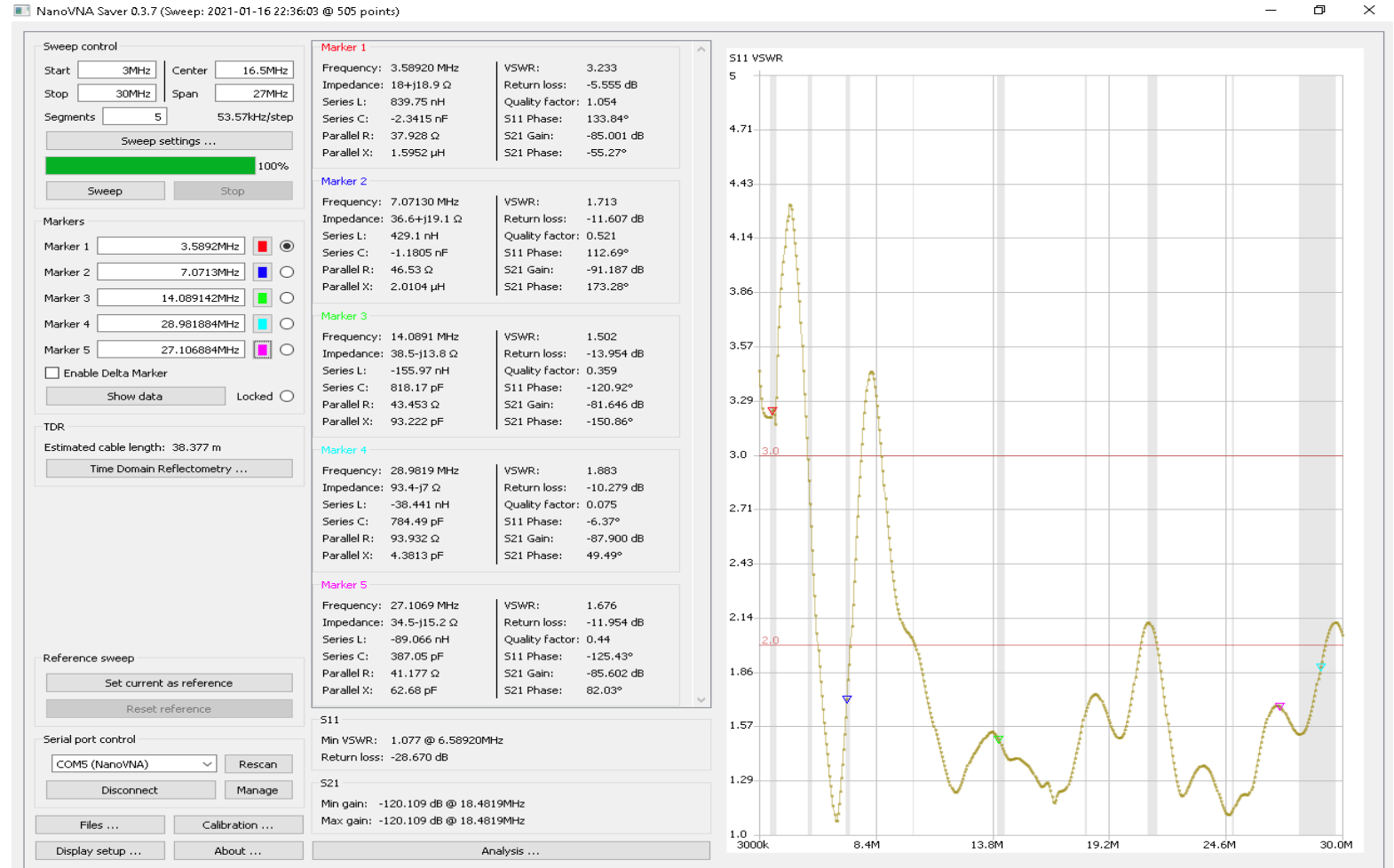
NanoVNA Ligado a PC

- Requer PC
- Pouco portátil.
- Mais opções de análise



Utilizar o NanoVNA com um computador (Windows)

- Ligar com cabo usb.
- Software :
 - NanoVNA Saver





NanoVNA Saver

NanoVNA Saver 0.3.7 (Sweep: 2021-01-16 22:36:03 @ 505 points)

Sweep control

Start: 3MHz | Center: 16.5MHz
 Stop: 30MHz | Span: 27MHz
 Segments: 5 | 53.57kHz/step

Sweep settings ...

100%

Sweep | Stop

Markers

Marker 1: 3.5892MHz

Marker 2: 7.0713MHz

Marker 3: 14.089142MHz

Marker 4: 28.981884MHz

Marker 5: 27.106884MHz

Enable Delta Marker

Show data | Locked

TDR

Estimated cable length: 38.377 m

Time Domain Reflectometry ...

Reference sweep

Set current as reference

Reset reference

Serial port control

COM5 (NanoVNA) | Rescan

Disconnect | Manage

Files ... | Calibration ...

Display setup ... | About ...

Marker 1

Frequency: 3.58920 MHz | VSWR: 3.233
 Impedance: 18+j18.9 Ω | Return loss: -5.555 dB
 Series L: 839.75 nH | Quality factor: 1.054
 Series C: -2.3415 nF | S11 Phase: 133.84°
 Parallel R: 37.928 Ω | S21 Gain: -85.001 dB
 Parallel X: 1.5952 μH | S21 Phase: -55.27°

Marker 2

Frequency: 7.07130 MHz | VSWR: 1.713
 Impedance: 36.6+j19.1 Ω | Return loss: -11.607 dB
 Series L: 429.1 nH | Quality factor: 0.521
 Series C: -1.1805 nF | S11 Phase: 112.69°
 Parallel R: 46.53 Ω | S21 Gain: -91.187 dB
 Parallel X: 2.0104 μH | S21 Phase: 173.28°

Marker 3

Frequency: 14.0891 MHz | VSWR: 1.502
 Impedance: 38.5-j13.8 Ω | Return loss: -13.954 dB
 Series L: -155.97 nH | Quality factor: 0.359
 Series C: 818.17 pF | S11 Phase: -120.92°
 Parallel R: 43.453 Ω | S21 Gain: -81.646 dB
 Parallel X: 93.222 pF | S21 Phase: -150.86°

Marker 4

Frequency: 28.9819 MHz | VSWR: 1.883
 Impedance: 93.4-j7 Ω | Return loss: -10.279 dB
 Series L: -38.441 nH | Quality factor: 0.075
 Series C: 784.49 pF | S11 Phase: -6.37°
 Parallel R: 93.932 Ω | S21 Gain: -87.900 dB
 Parallel X: 4.3813 pF | S21 Phase: 49.49°

Marker 5

Frequency: 27.1069 MHz | VSWR: 1.676
 Impedance: 34.5-j15.2 Ω | Return loss: -11.954 dB
 Series L: -89.066 nH | Quality factor: 0.44
 Series C: 387.05 pF | S11 Phase: -125.43°
 Parallel R: 41.177 Ω | S21 Gain: -85.602 dB
 Parallel X: 62.68 pF | S21 Phase: 82.03°

S11

Min VSWR: 1.077 @ 6.58920MHz
 Return loss: -28.670 dB

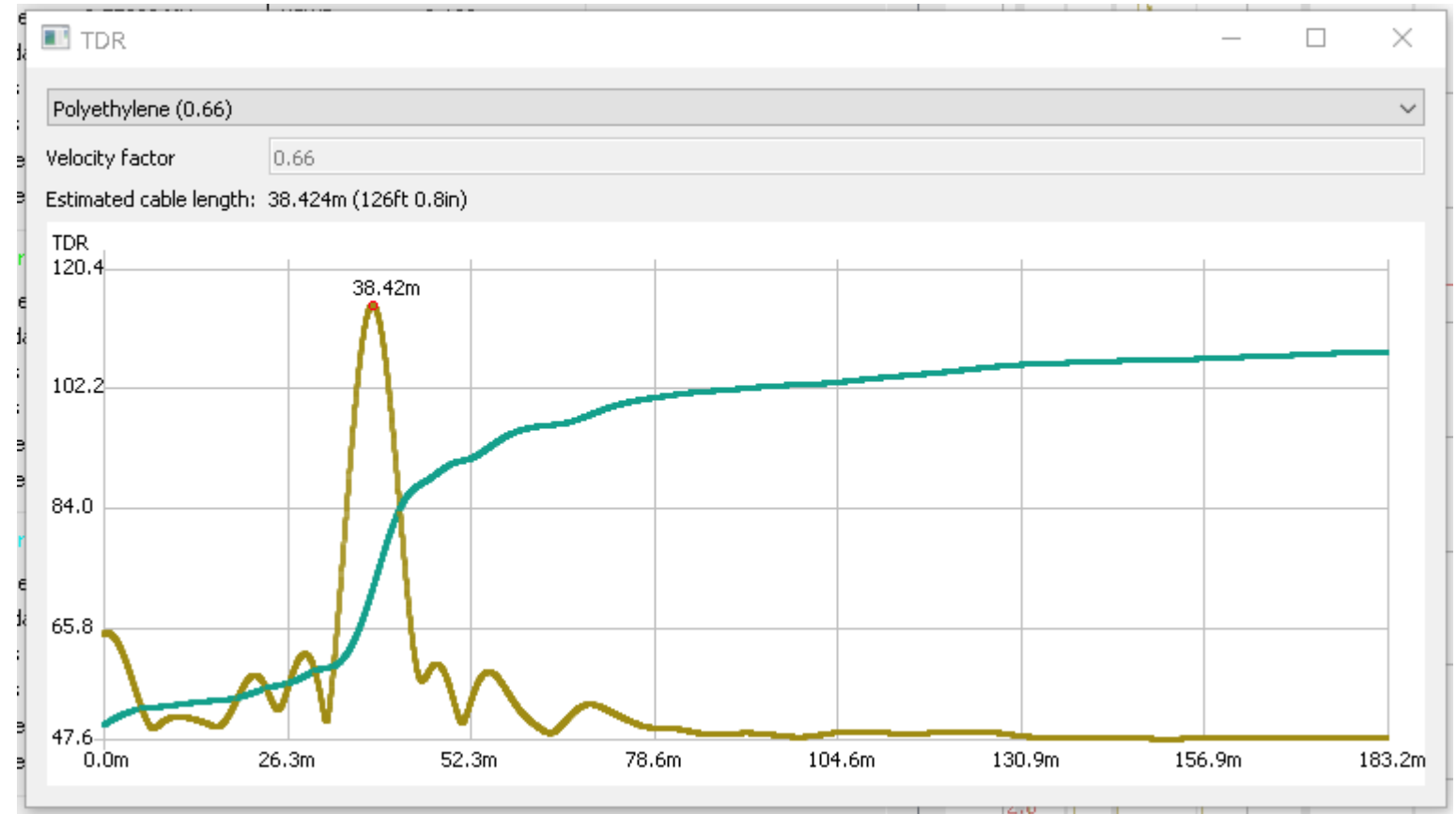
S21

Min gain: -120.109 dB @ 18.4819MHz
 Max gain: -120.109 dB @ 18.4819MHz

S11 VSWR

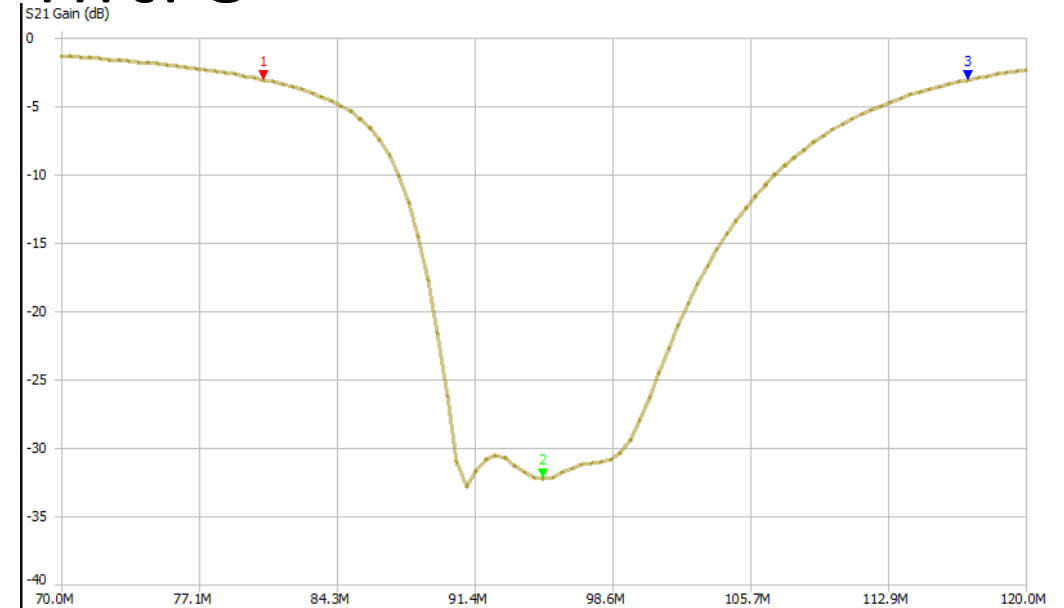
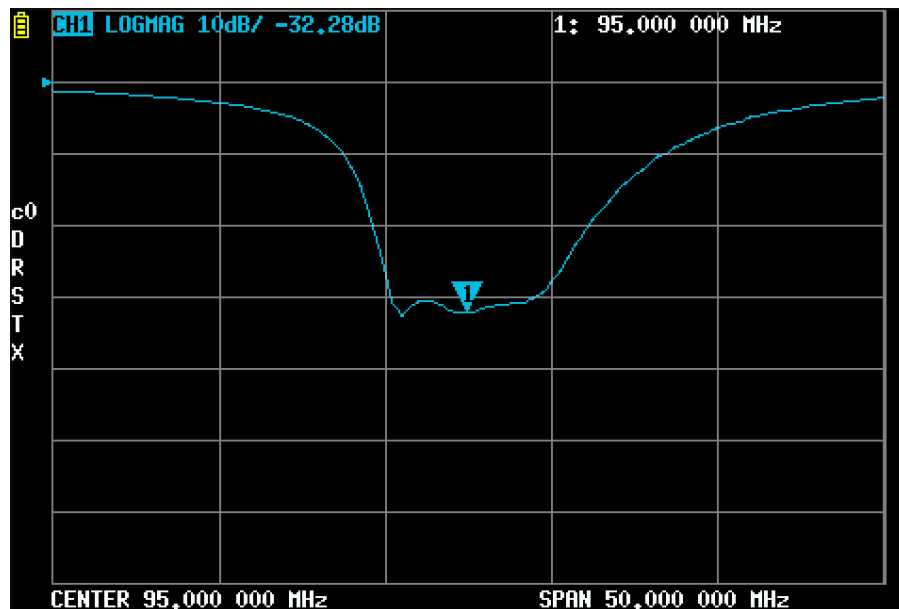
Time Domain Reflectometry (mede cabos)

- Usa-se a porta s11



Exemplo de Medição de um filtro

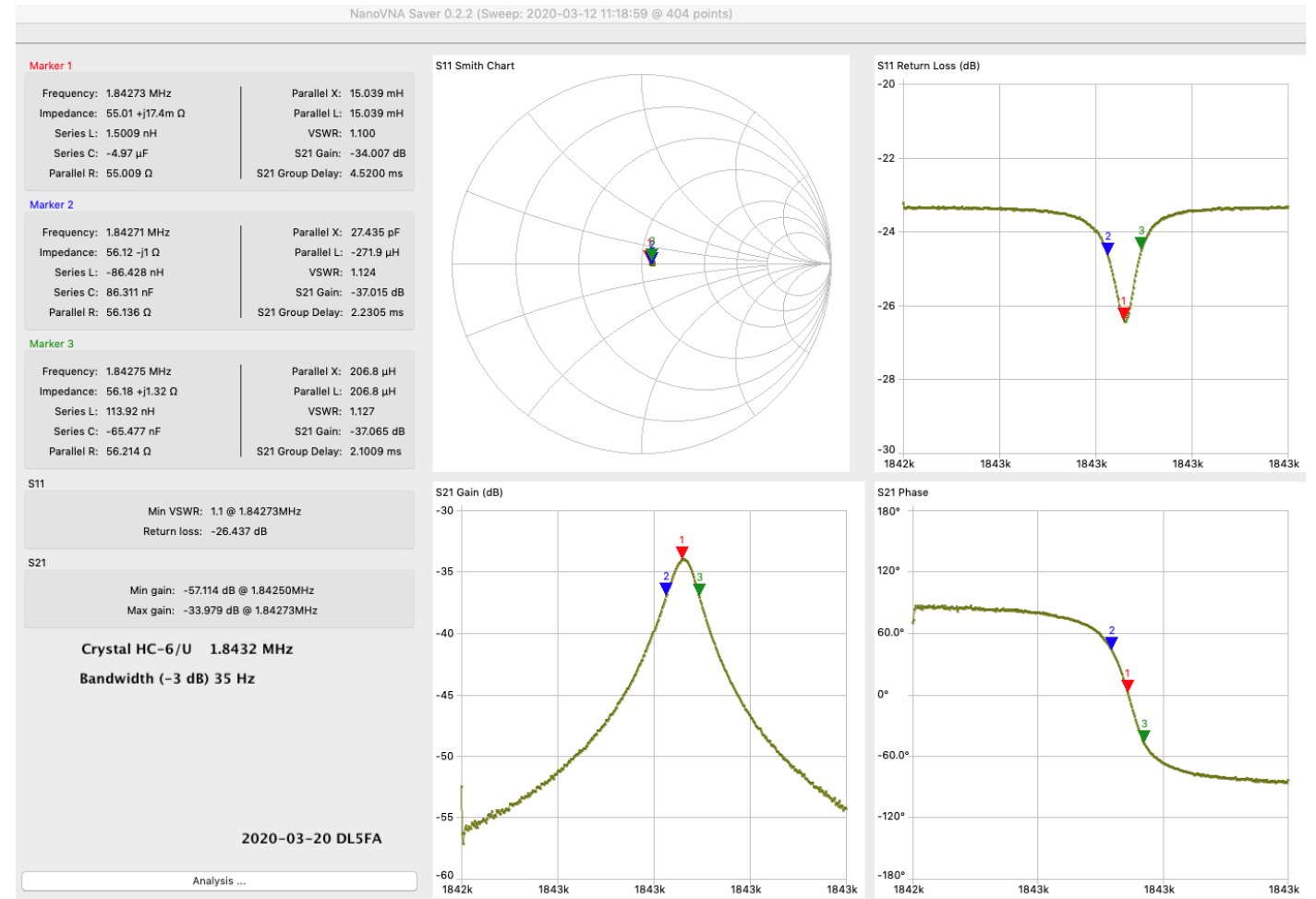
- Usa-se a porta s21
- Nas fotos NooElec FM Band Reject filter.



Exemplo de Medição de um cristal

Exemplo tirado de rudiswiki.de

Utilizou uma *pi network* para atenuação.





Mostrar utilização ao vivo



Questões ?



MUITO OBRIGADO

Site da ARRLx : <https://www.arrlx.pt>

O meu blog : <http://www.belkadog.com>

o meu contacto : jcanelhas@gmail.com



Referências

- <https://abracon.com/uploads/resources/Abracon-White-Paper-Antenna-Impedance-Matching.pdf>
- <https://nanovna.com/>
- <https://github.com/NanoVNA-Saver/nanovna-saver>
- http://www.ae6ty.com/Smith_Charts.html
- https://www.youtube.com/channel/UCu7_D0o48KbfhpEohoP7YSQ
- <https://www.rudiswiki.de/wiki9/nanoVNA>
- <https://s3-us-west-1.amazonaws.com/groupsioattachments/34671/34397283/4059/0?AWSAccessKeyId=AKIAJECNKOVVMCCU3ATNQ&Expires=1610913153&Signature=xeU5bFD3IUiRTRr%2FkDEsblcd4wY%3D&response-content-disposition=inline%3B+filename%3D%22NanoVNA+Schematic.pdf%22>
- https://www.ietlabs.com/pdf/application_notes/030122%20IET%20LCR%20PRIMER%201st%20Edition.pdf