

Antennianalysointori

Mikä on VNA ja miten se auttaa amatööriä
Juhani Jaakola OH1FSS

Sisälmys

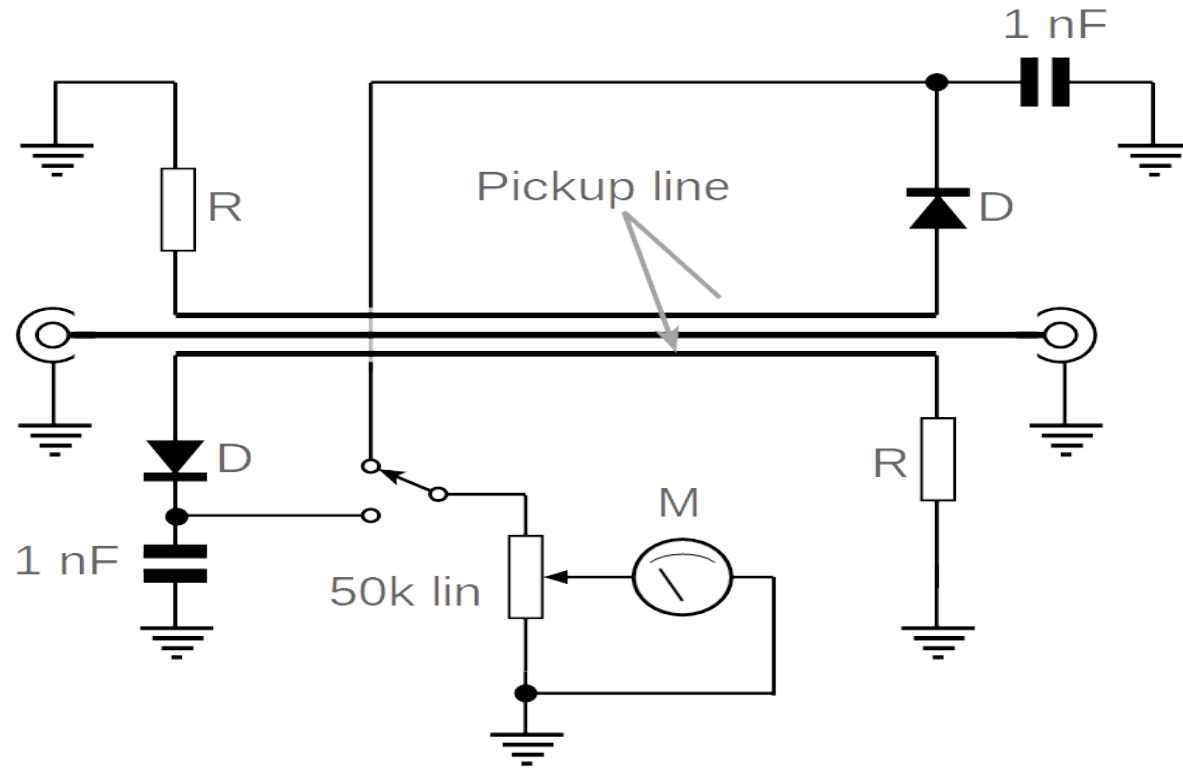
- Antennin mittalaitteita
- Mikä on VNA?
- Mittaus: dipoli
- Mittaus: keinokuorma
- Mittaus: stubi
- Mittaus: suodatin
- Smithin kartta
- TDR

Antennin mittalaitteita

- SWR-mittari
- Kohinasilta
- Dippimittari
- Antennianalysointilaite
- VNA

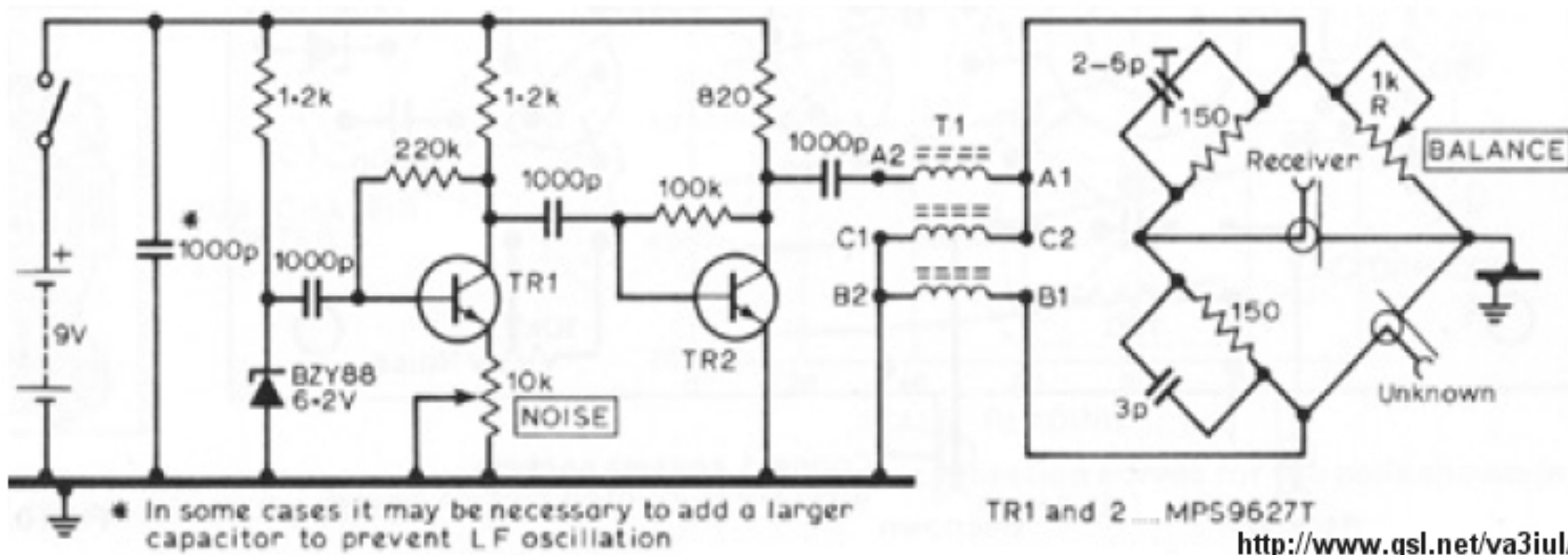
SWR-mittari

- Eteenpäinmenevän ja heijastuvan tehon suhde



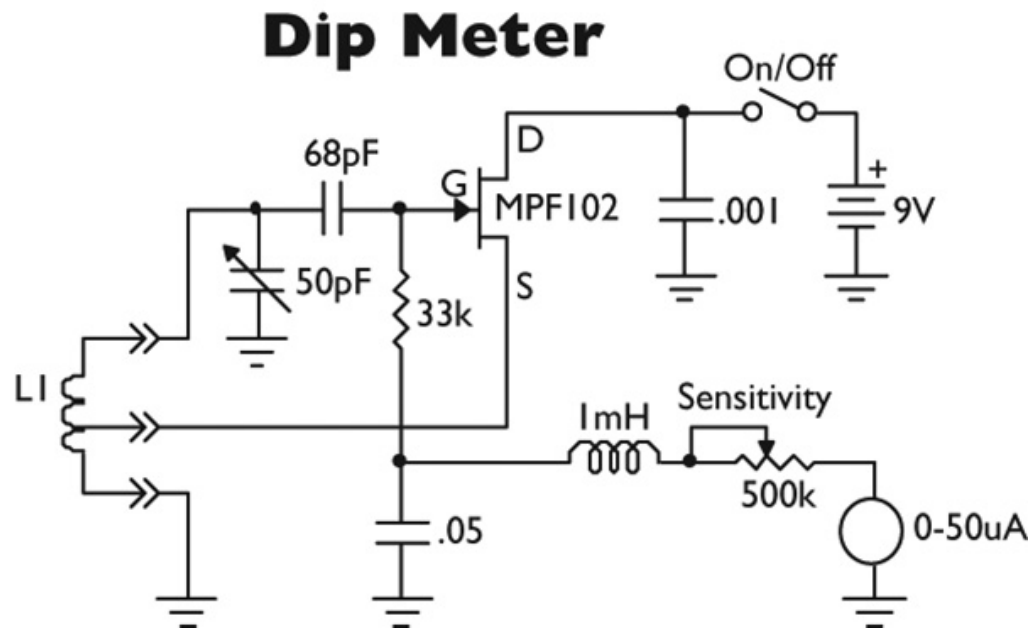
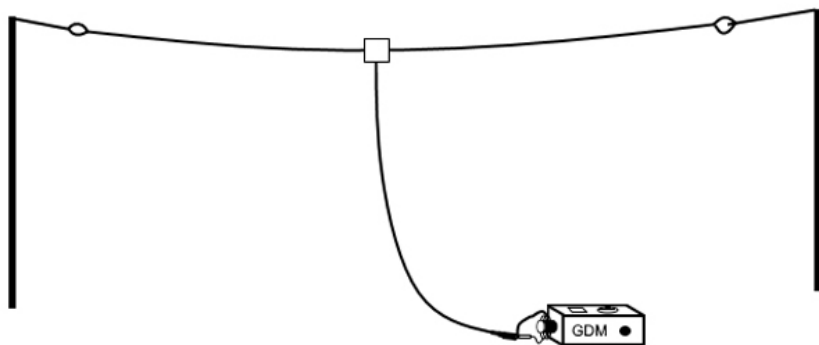
Kohinasilta

- Vastaanotin säädetään minimikohinaan
- Miltä näyttäisi SDR:n spektrissä?



Grid Dip Meter

- Resonanssitaajuus, ei näytä impedanssia

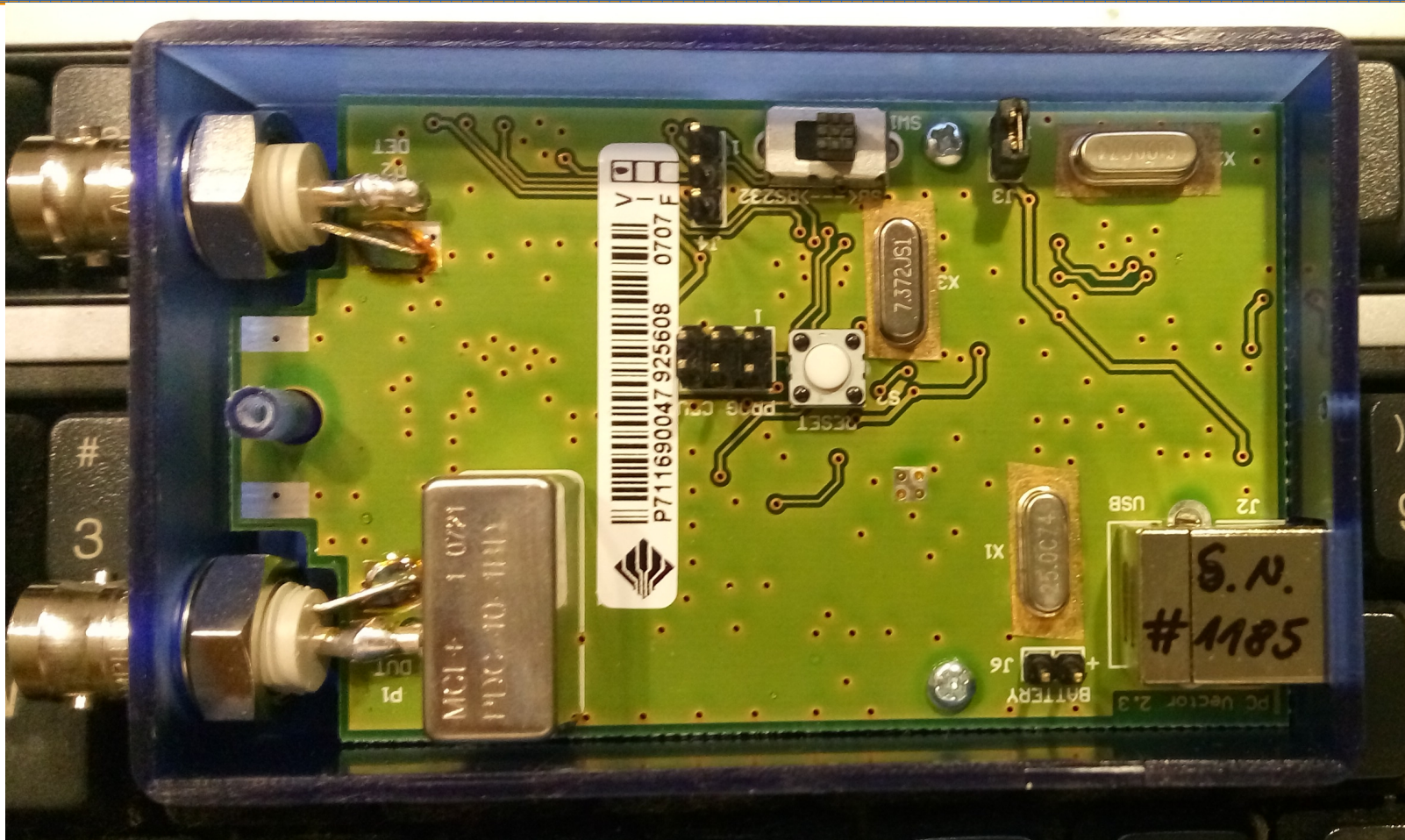


Antennianalysaattori

- Mittaa SWR:n, impedanssin, ...

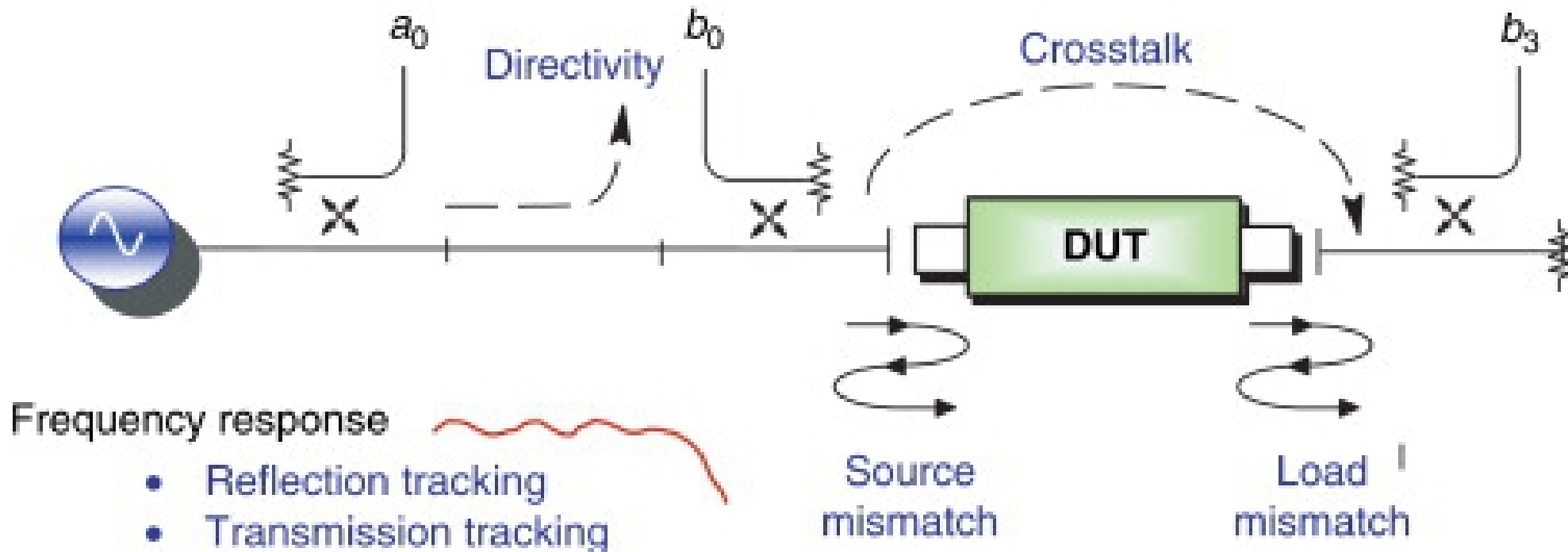


miniVNA



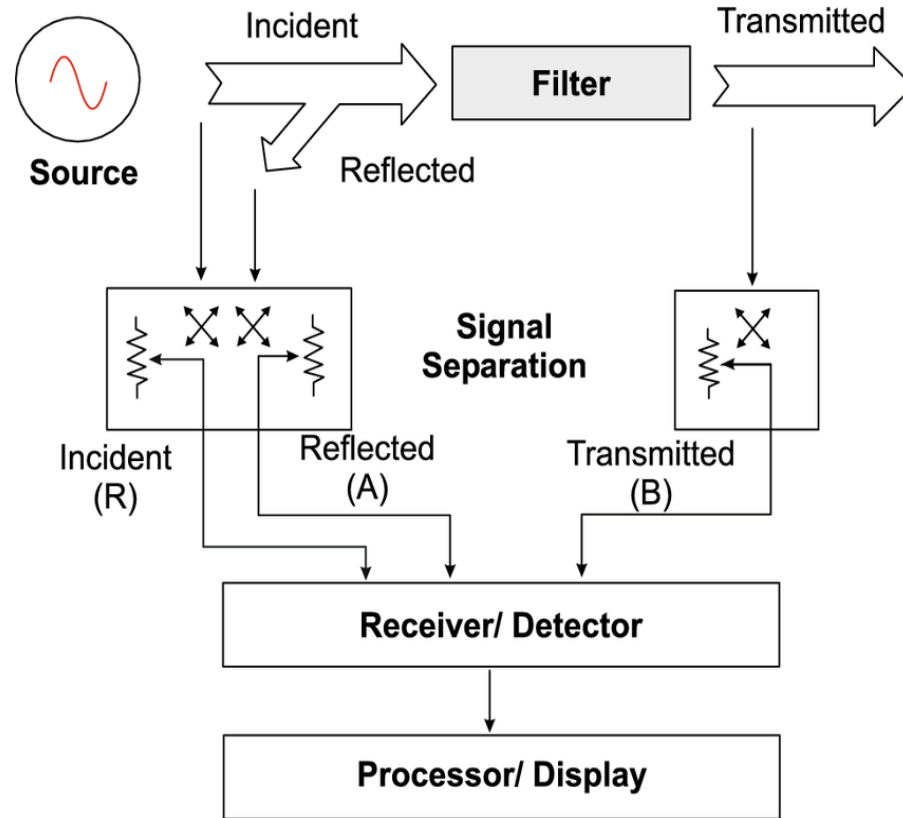
Vector Network Analyzer

- Kuten antennianalysointilaitte edellä ja lisäksi 2-porttiset laitteet (esimerkiksi suodattimet)



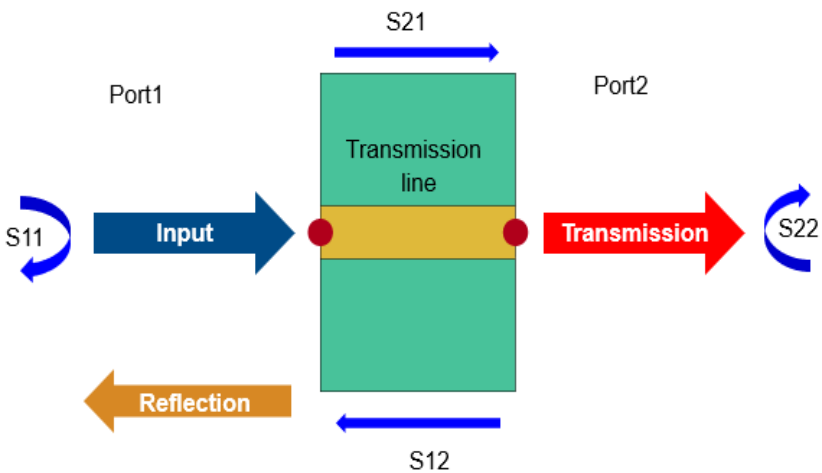
Vector Network Analyzer

- Suodattimen mittaus



Vector Network Analyzer

- S-parametrit eli sirontaparametrit (scattering)



Common S-Parameter Names

Forward reflection coefficient

- Input return loss
- Input match
- VSWR

S11

Forward transmission coefficient

- Gain
- Loss

S21

Reverse transmission coefficient

- Reverse isolation

S12

Reverse reflection coefficient

- Output return loss
- Output match
- VSWR

S22

Mitä VNA ei kerro?

- Säteilökuvio

Antennin tehokkuus

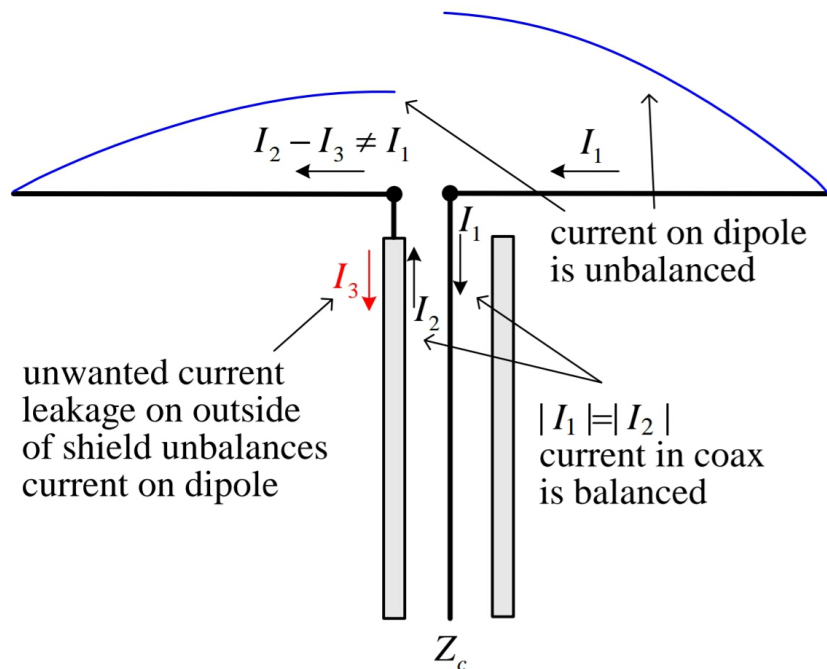
- Sovitus – paljonko tehoa menee antenniin? (SWR)
- Tehokkuus – paljonko muuttuu säteilyksi? (Resonanssi?)
- Suuntakuvio – paljonko säteilee oikeaan suuntaan?
- (lisäksi yhteyteen vaikuttaa polarisaatio)

Onko resonanssi tarpeen?

- Keinokuorma on täysin sovitettu mutta ei resonanssissa
- Resonanssissa värähtely säilyy pienellä energian syötöllä
- Mutta hetekallakin voi workkia!?!

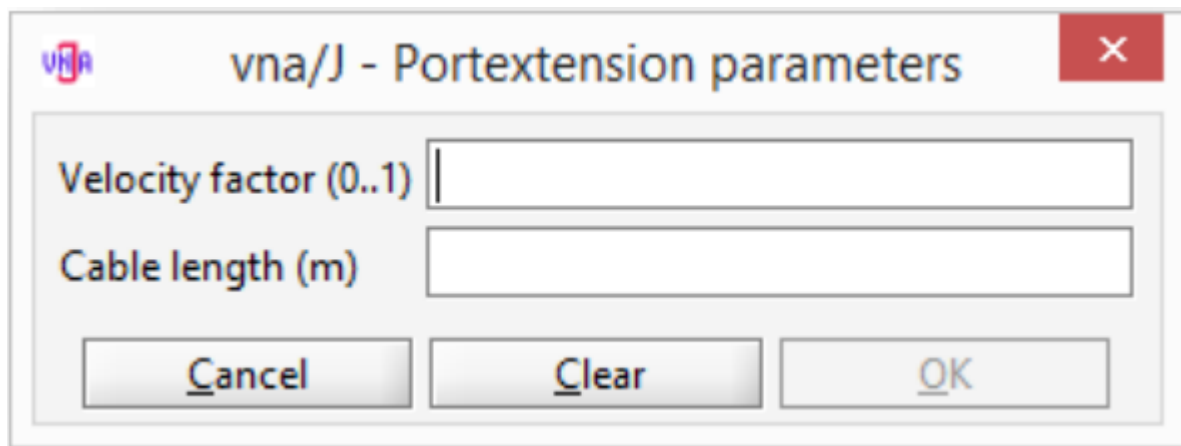
Mittaus tilanne - Dipoli

- Manttelivirta: balun vai ei balun?



Mittaustilanne - Dipoli

- Syöttökaapeli toimii impedanssimuuntimena
- vna/J Port extension parameters: kaapelin nopeuskerroin & pituus



The image shows a software dialog box titled "vna/J - Portextension parameters". The dialog has a standard Windows-style title bar with a red close button on the right. Inside the dialog, there are two input fields: "Velocity factor (0..1)" and "Cable length (m)". Below the input fields are three buttons: "Cancel", "Clear", and "OK".

vna/J - Portextension parameters

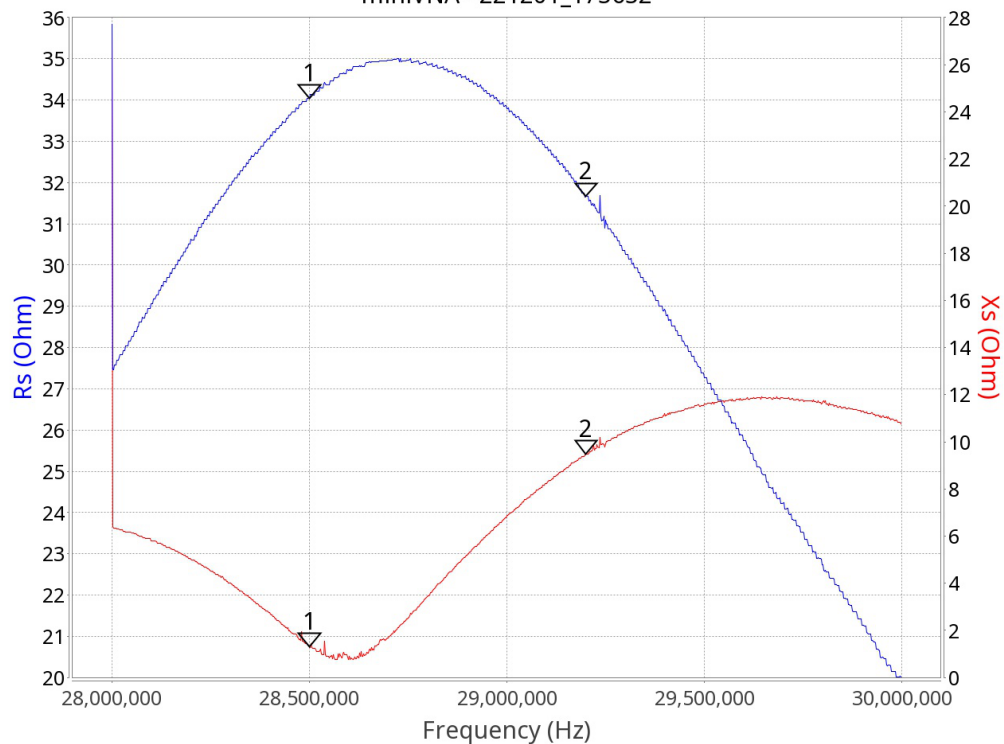
Velocity factor (0..1)

Cable length (m)

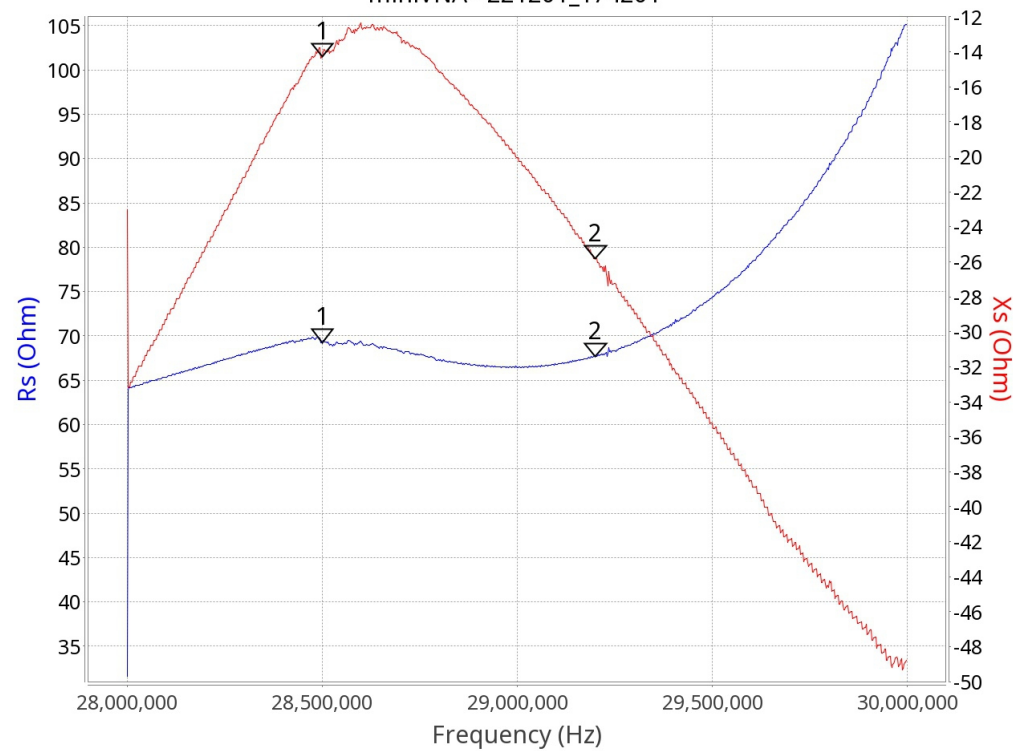
Mittaustilanne - Dipoli

- 5m syöttökaapeli, port extension -koriaus. ilman ia kanssa

miniVNA - 221201_173632



miniVNA - 221201_174201

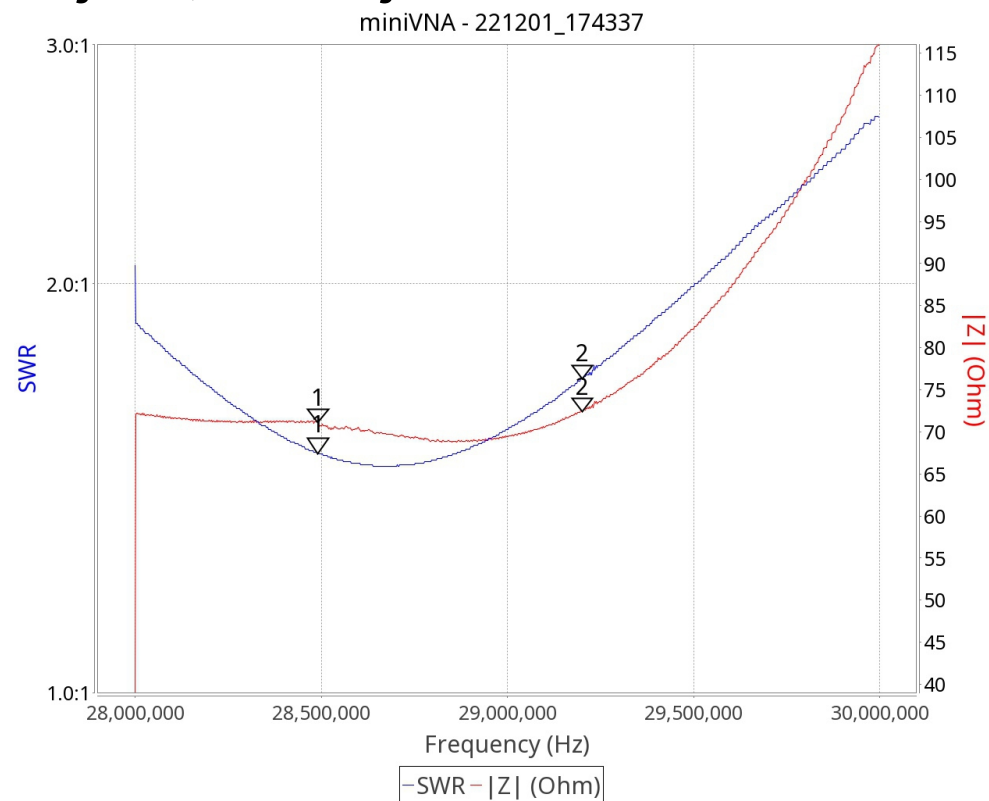
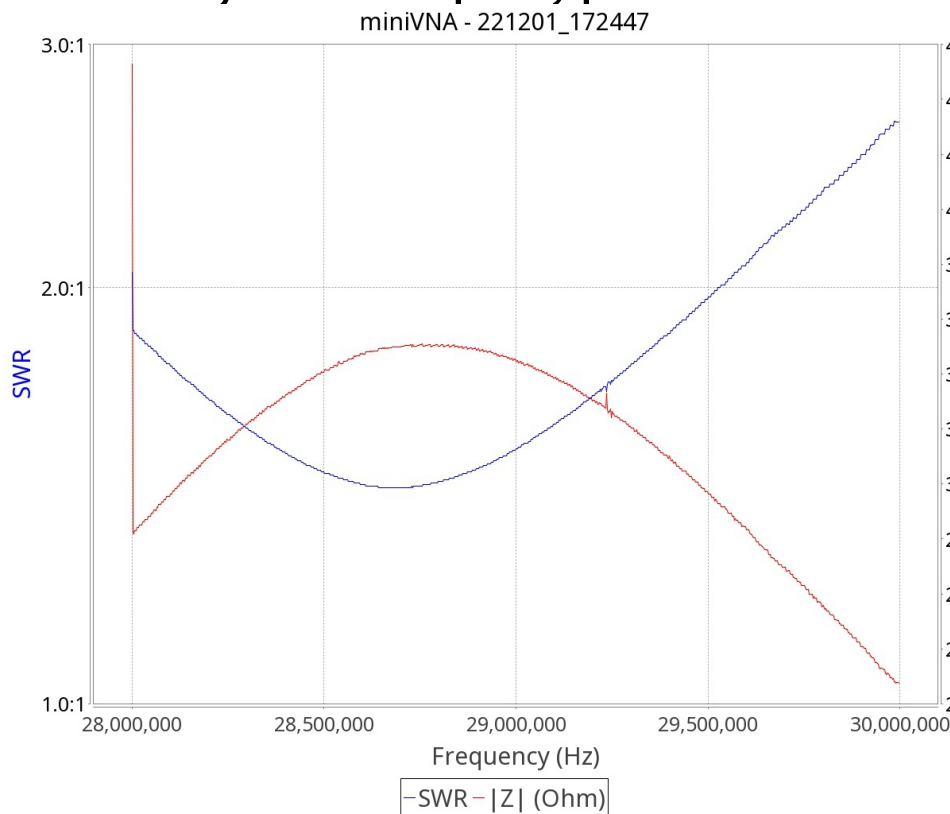


-Rs (Ohm) -Xs (Ohm)

-Rs (Ohm) -Xs (Ohm)

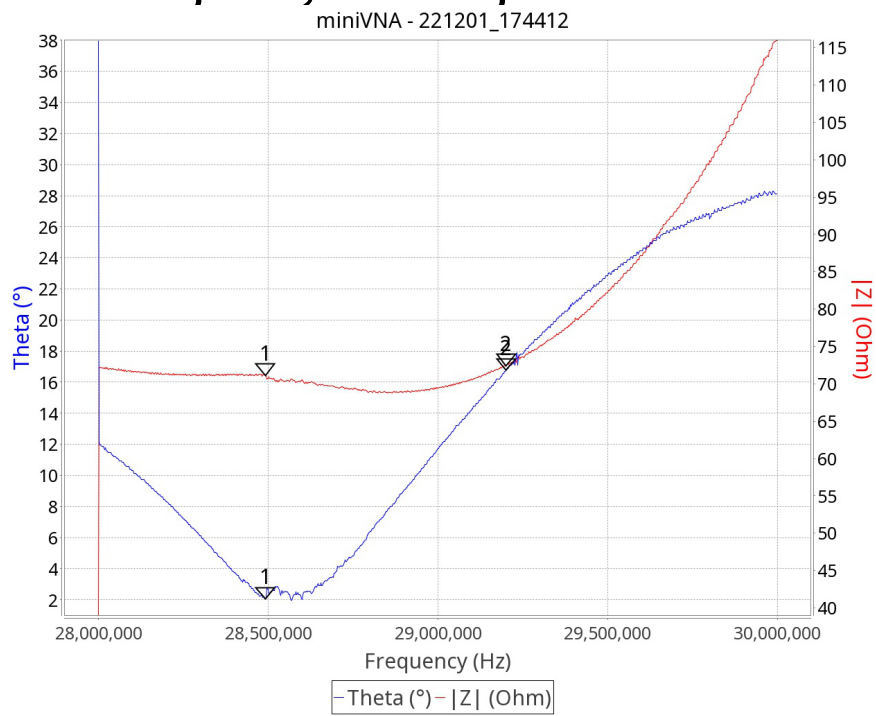
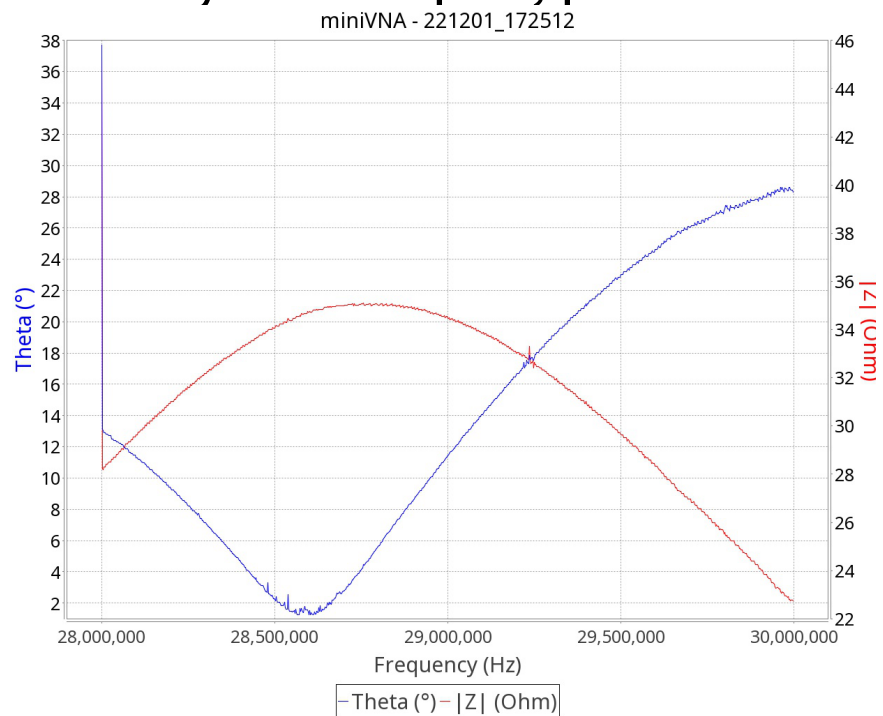
Mittaustilanne - Dipoli

- 5m syöttökaapeli, port extension -korjaus, ilman ja kanssa



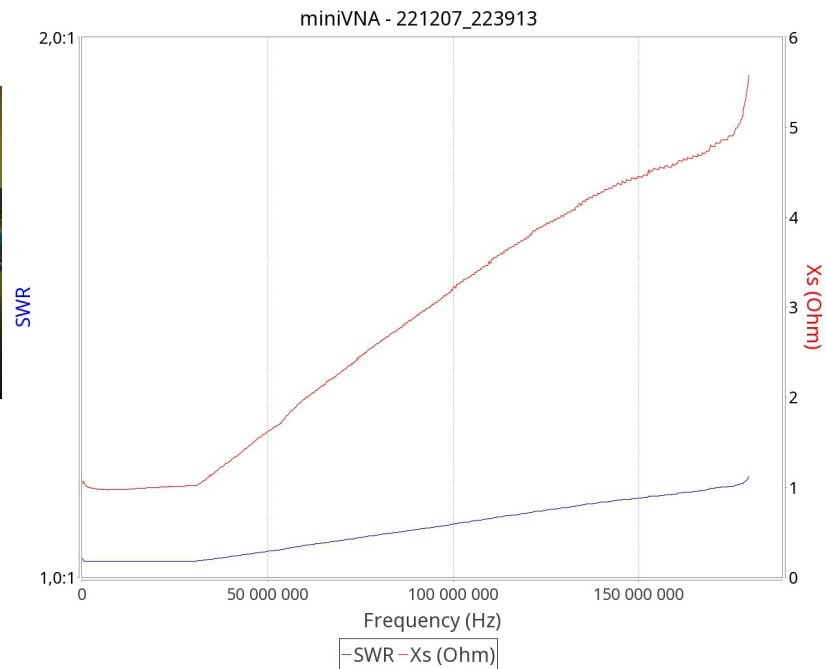
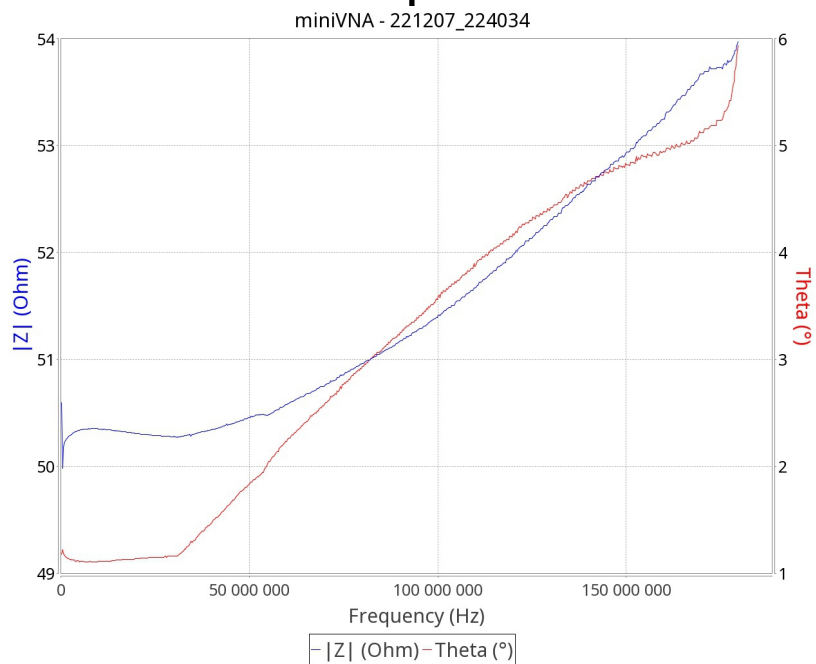
Mittaustilanne - Dipoli

- 5m syöttökaapeli, port extension -korjaus, ilman ja kanssa



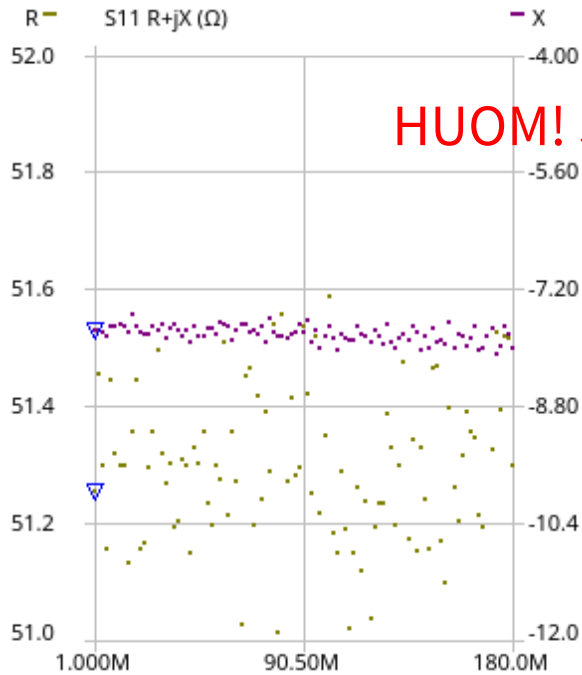
Mittauustilanne – 50Ω terminaattori

- 50Ω Amphenol terminaattori

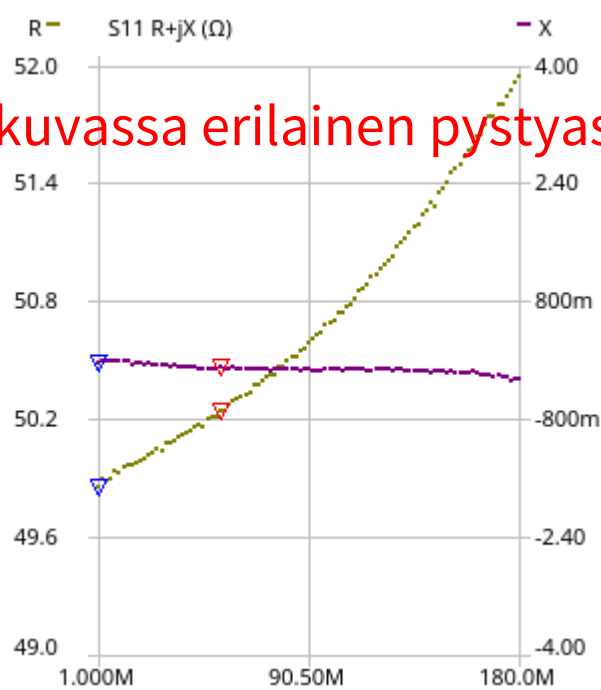


Mittaustilanne – kolme 50Ω

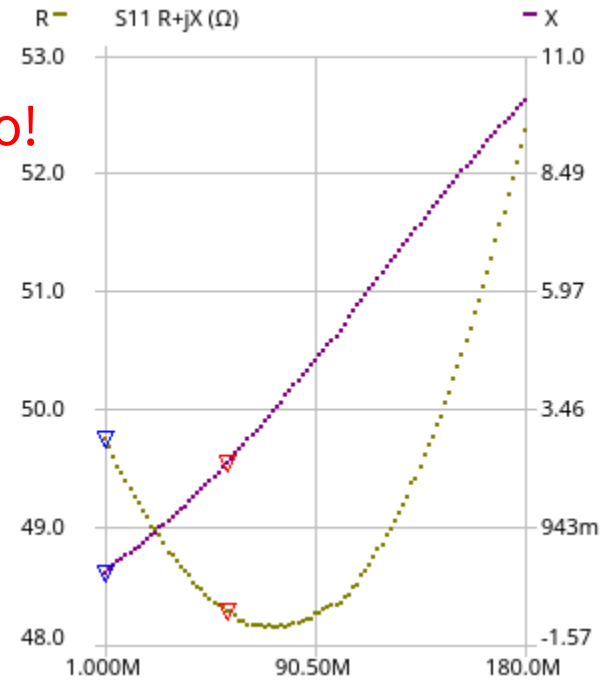
HUOM! Joka kuvassa erilainen pystyasteikko!



SMA calibrator

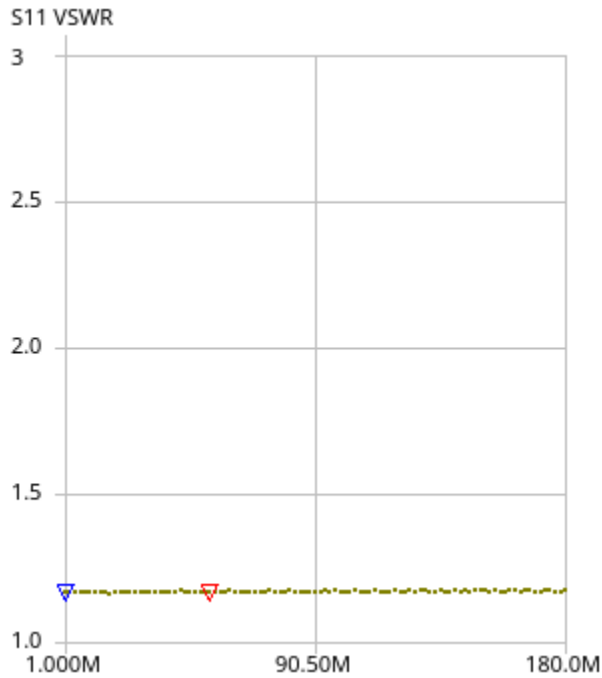


Amphenol terminator

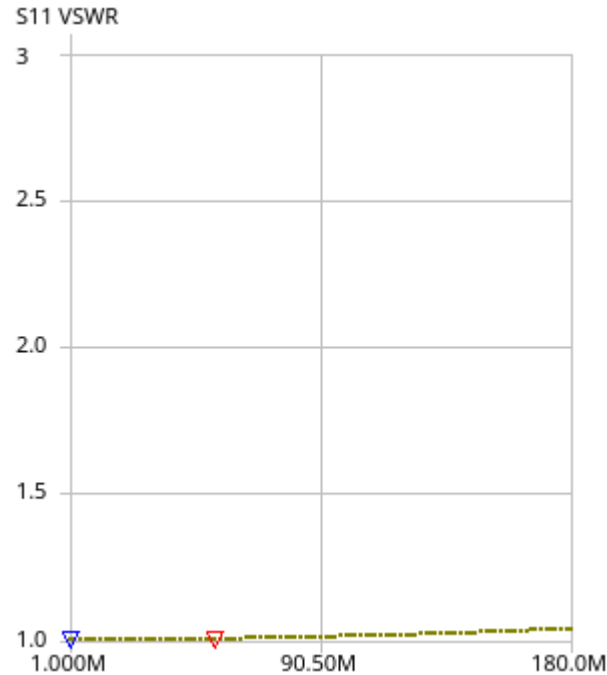


Omatekemä

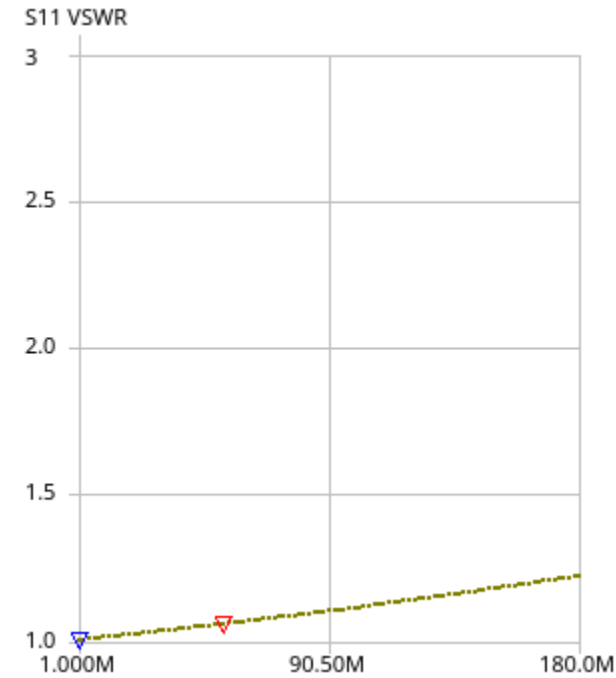
Mittaustilanne – kolme 50Ω



SMA calibrator



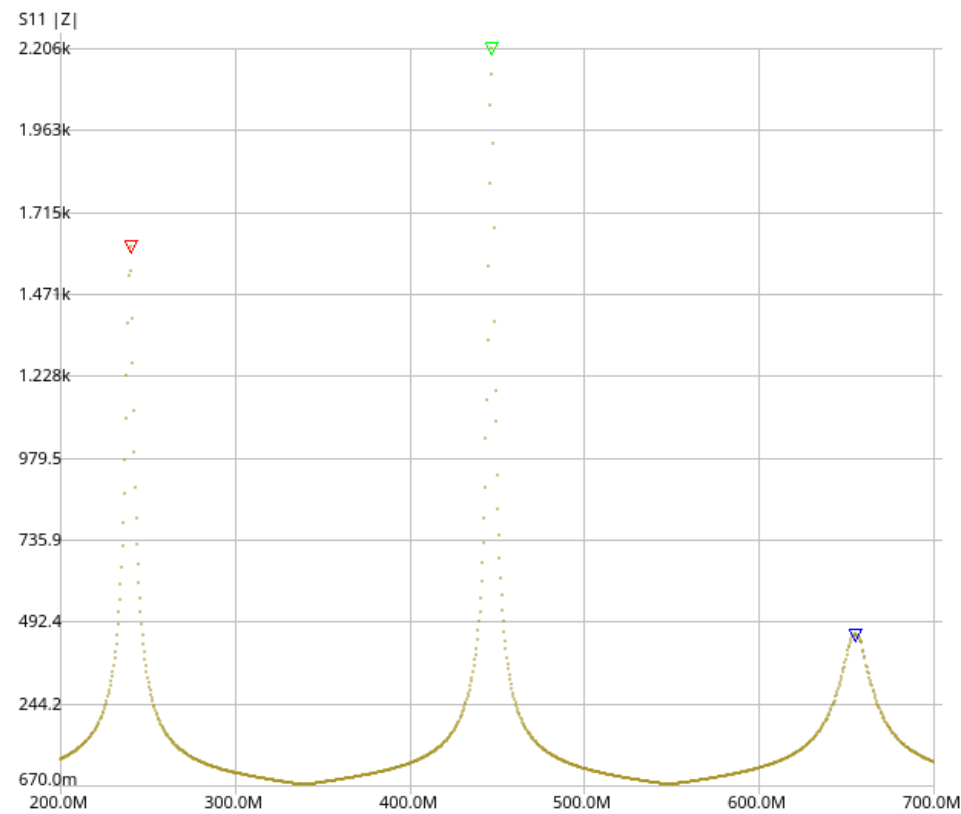
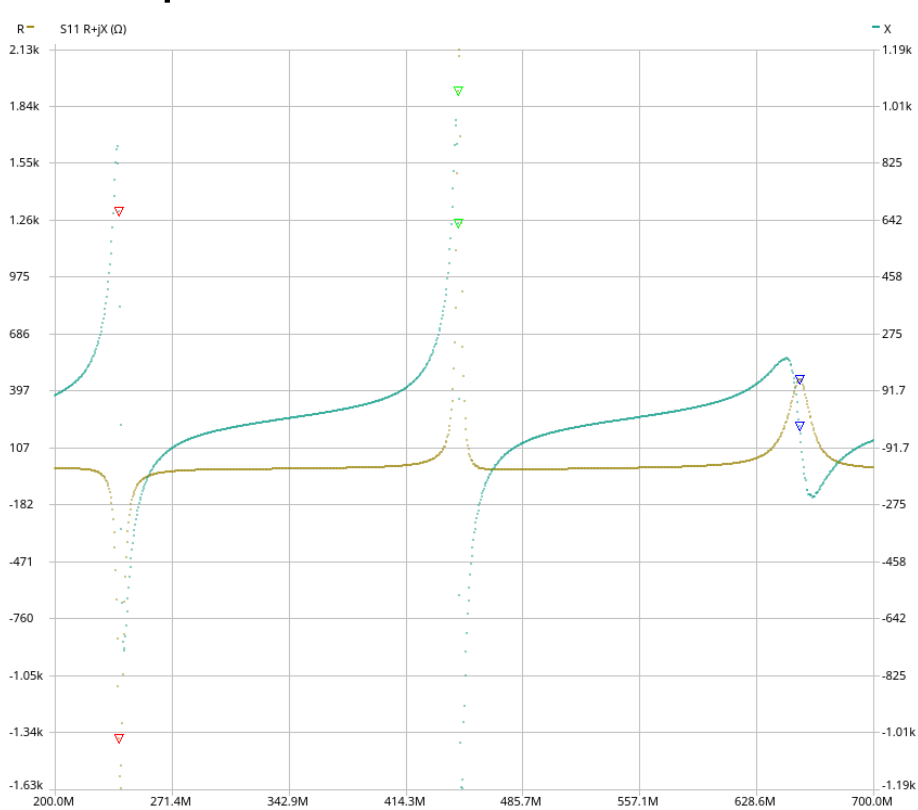
Amphenol terminator



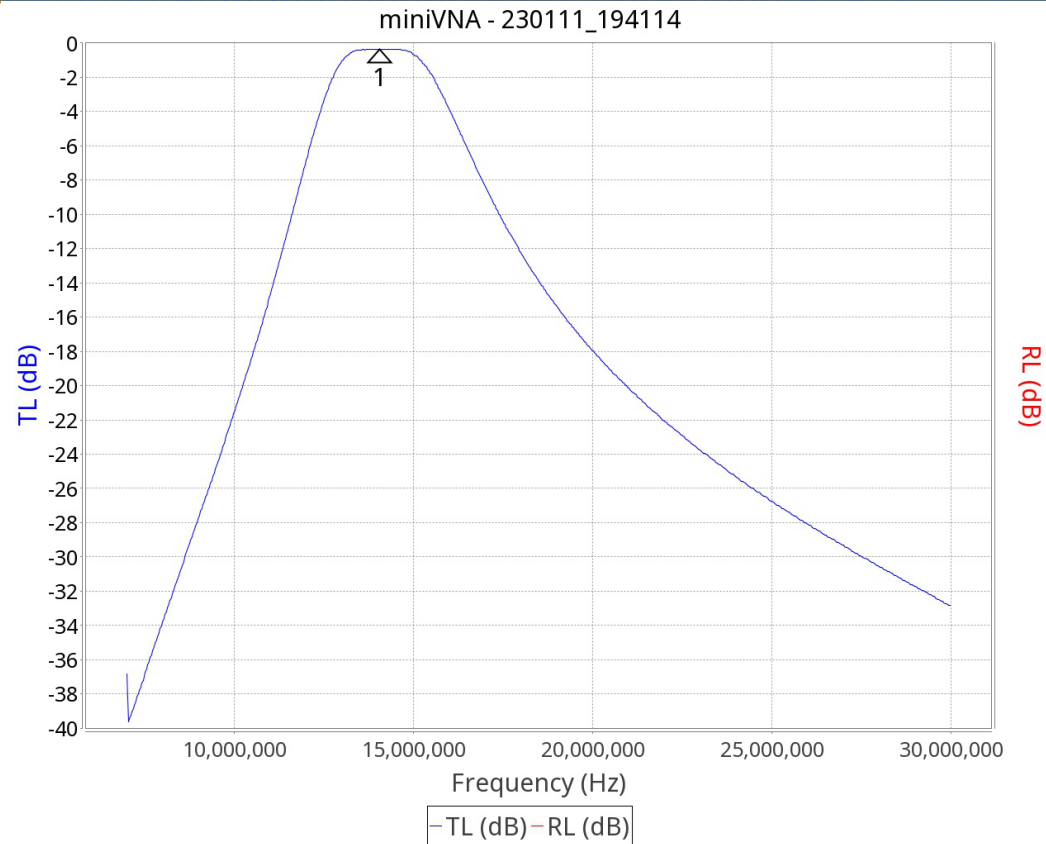
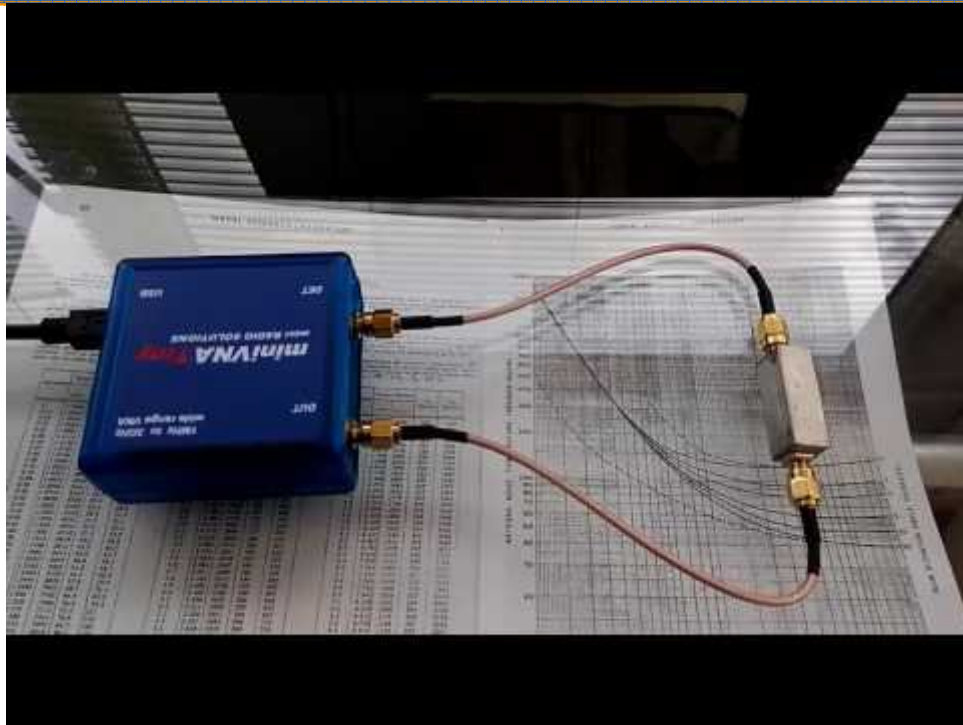
Omatekemä

Mittaustilanne – 50cm avoin stub

- Impedanssi menee äärettömäksi $\lambda/2$ välein

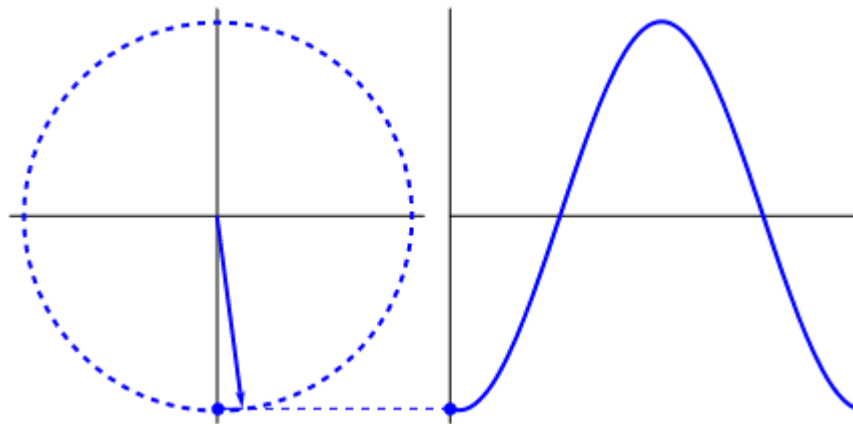


Mittauustilanne – filteri



Miksi Smithin kartta?

- Mihin tarvitaan vektoreita, eikö Ohmin laki riitä?
- Vektorin suuruus ja suunta ~ amplitudi ja vaihe

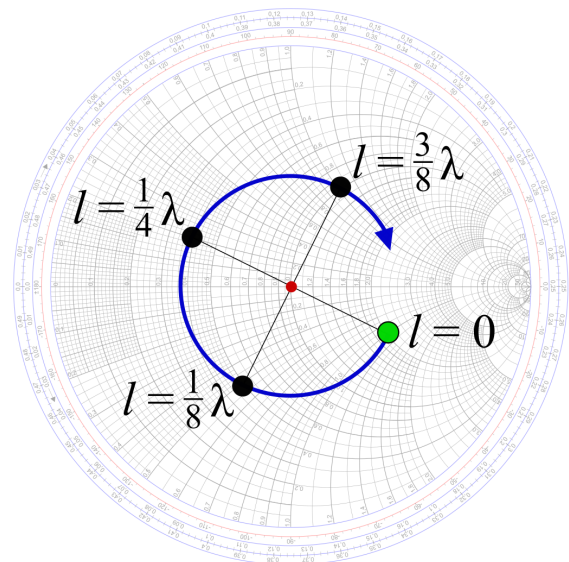
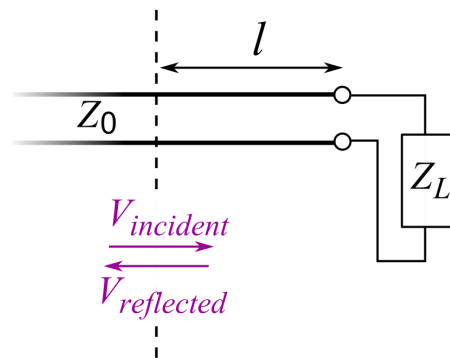


Miksi Smithin kartta?

- Jos kaapelin (nopeuskerroin V_P) toisessa päässä on impedanssi Z_L , mikä impedanssi näkyy syöttöpäässä?

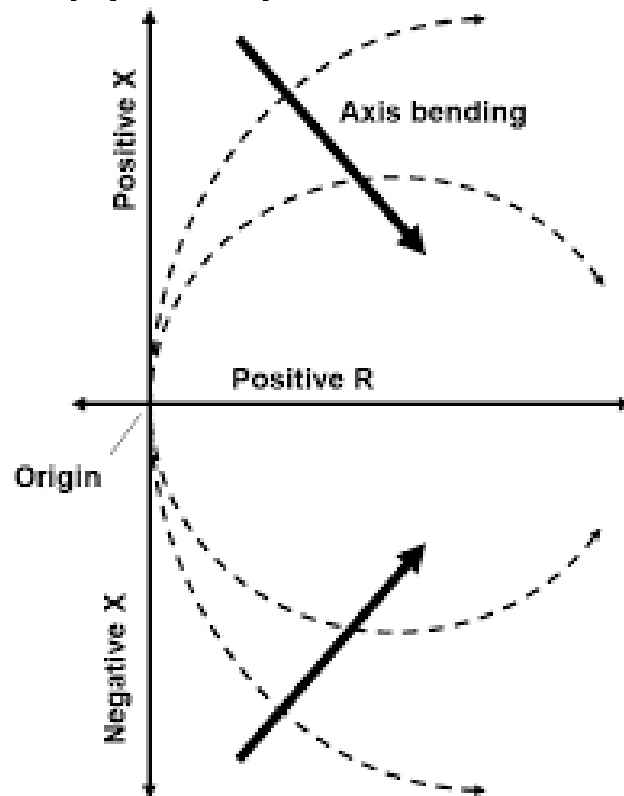
$$Z_{IN} = Z_0 \left[\frac{Z_L + j Z_0 \tan(\beta \ell)}{Z_0 + j Z_L \tan(\beta \ell)} \right]$$

- Z_L is the termination impedance
 - ℓ is line length.
 - $\beta = 2\pi f / (V_P)$
- kompleksiluku

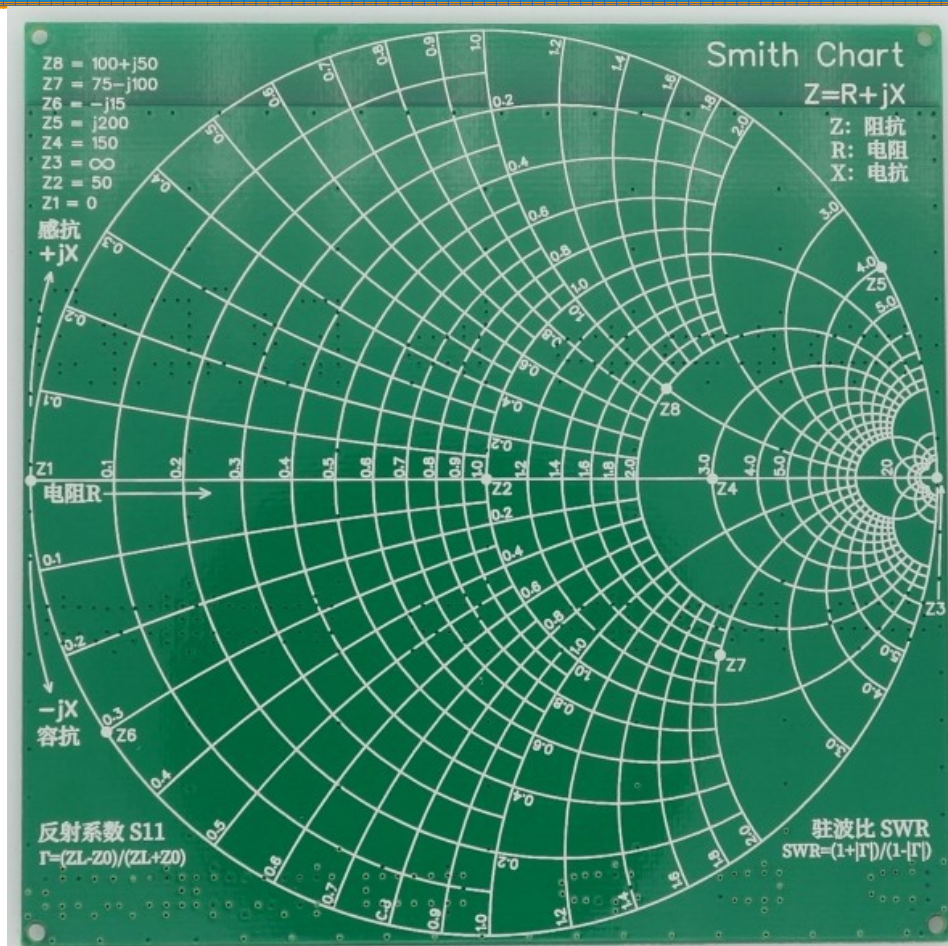


Smith kartta

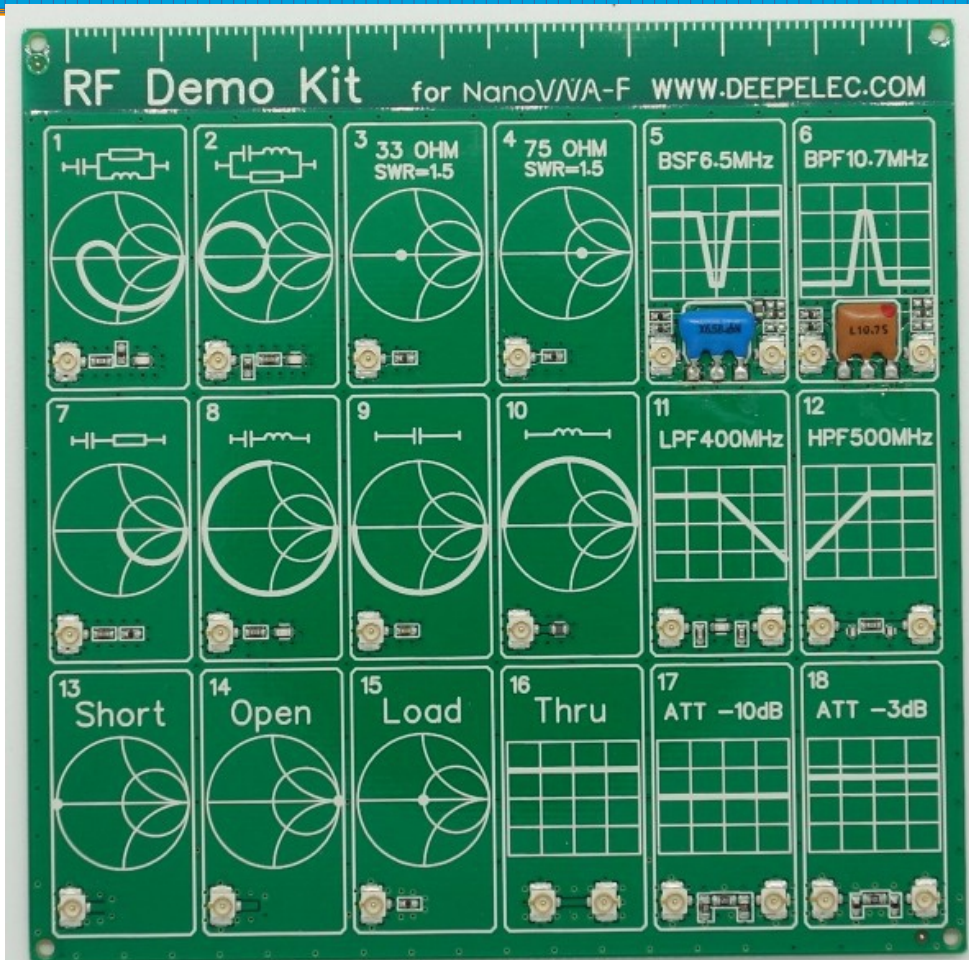
- Taso taivutetaan ympyräksi, äärettömät kohtaavat oikealla



Smithin kartta

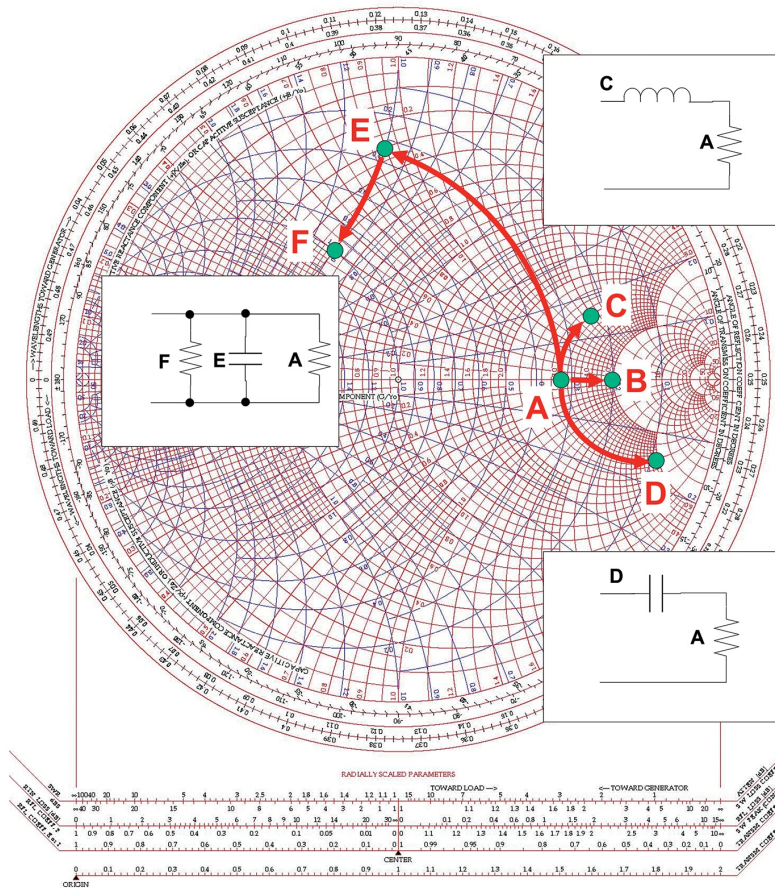


Smithin kartta



Smithin kartta

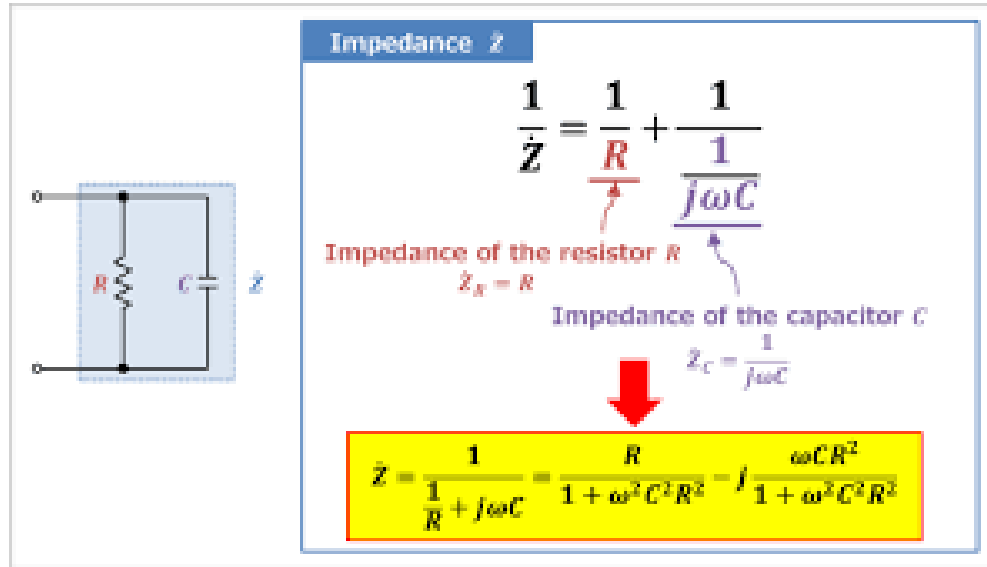
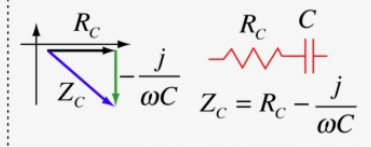
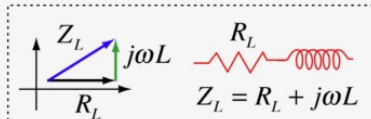
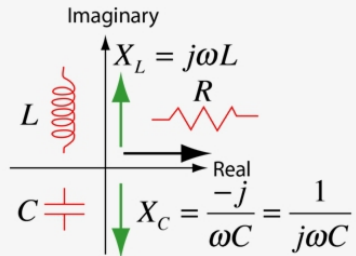
NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



- A $3\Omega + j0$
- B Sarjaan $2\Omega + j0$
- C Sarjaan $0 + j2\Omega$
- D Sarjaan $0 - j6\Omega$
- E Rinnan $0 + j1S$
- F Vielä rinnan $0.67S + j0$

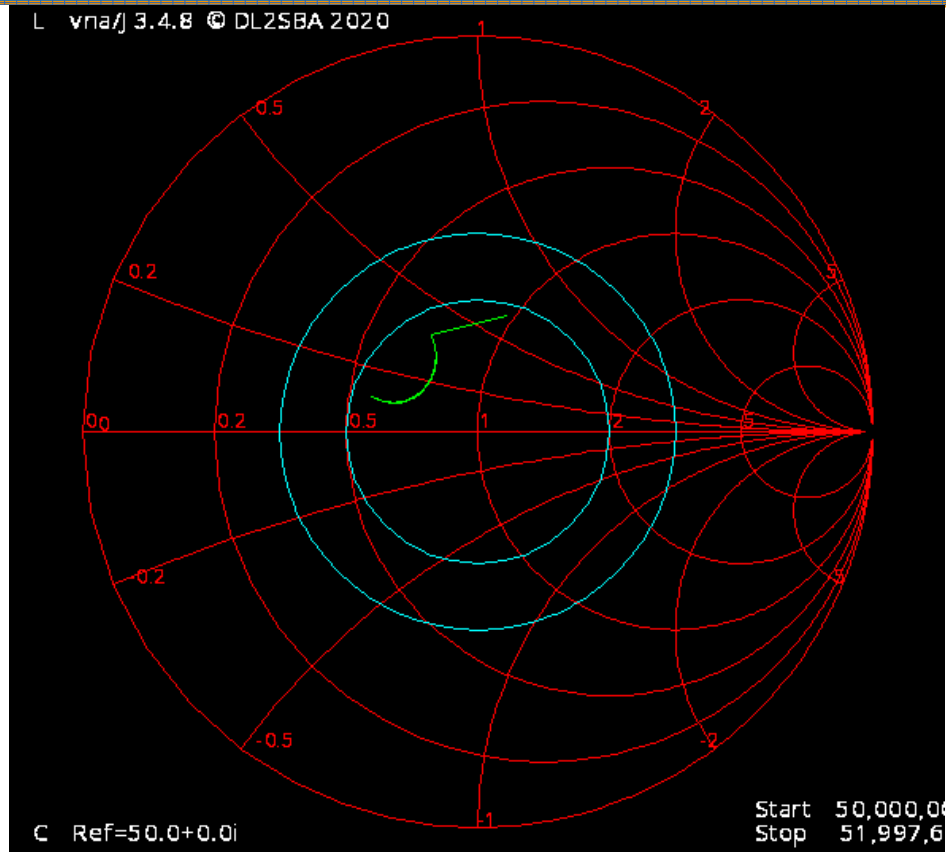
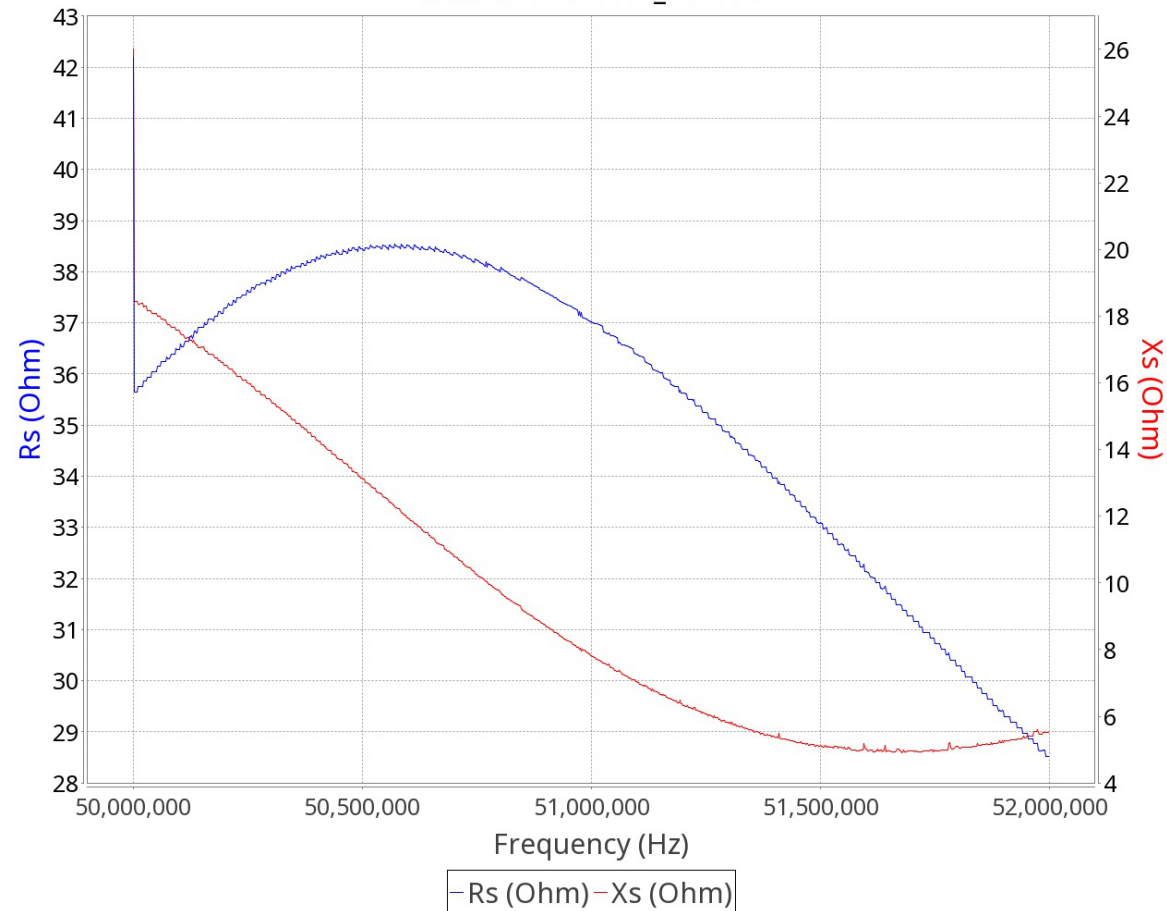
Smithin kartta

- Impedanssin laskenta ilman Smithin karttaa



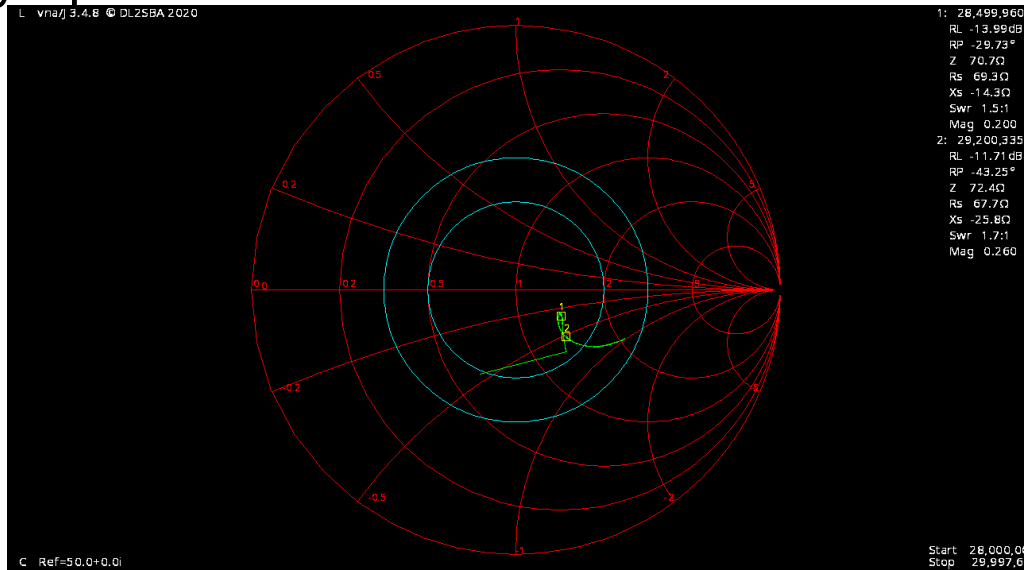
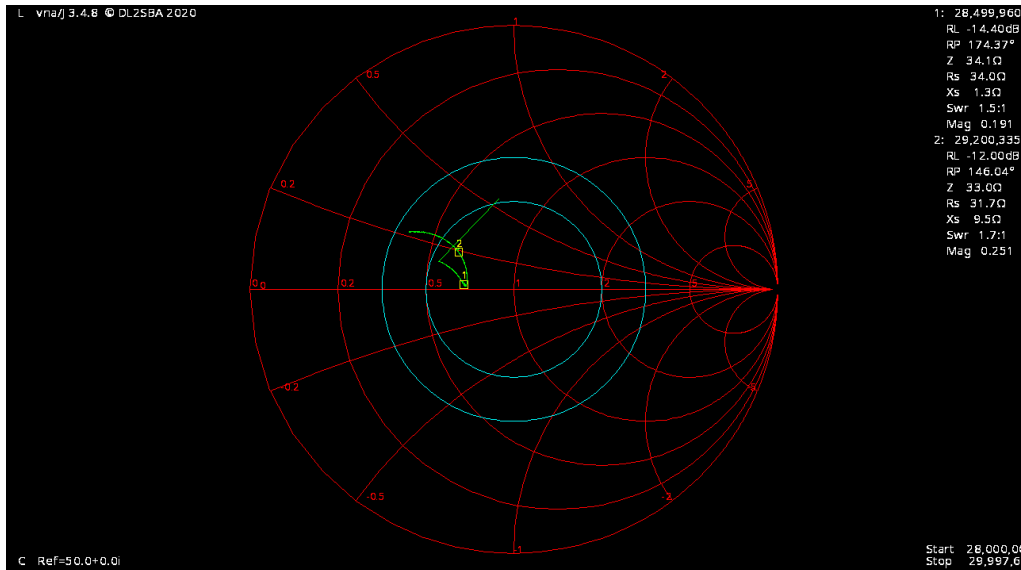
Smithin kartta – 6m dipoli

miniVNA - 221110_213710

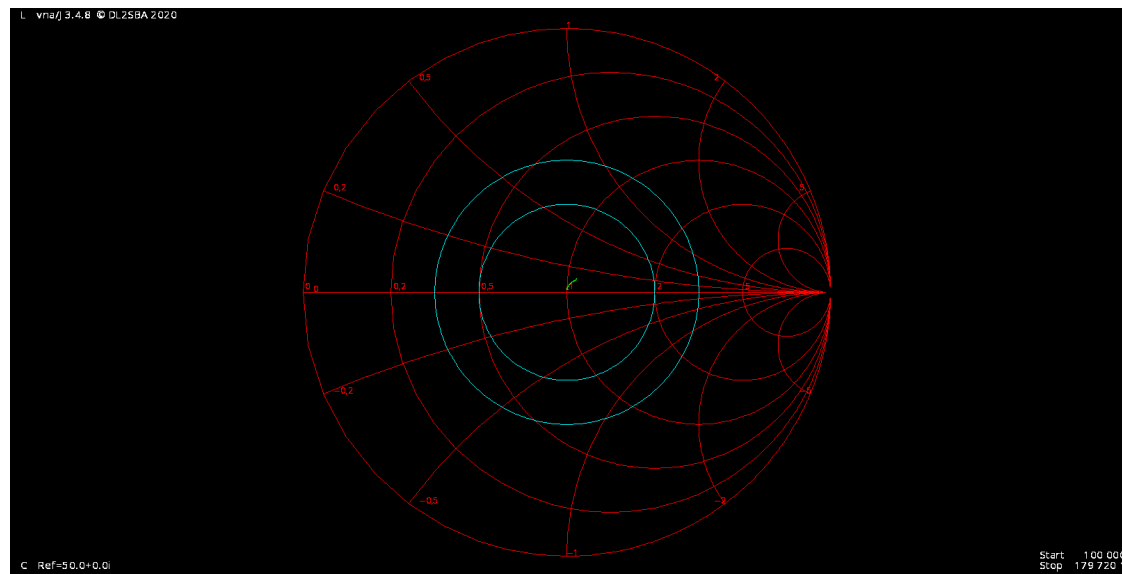
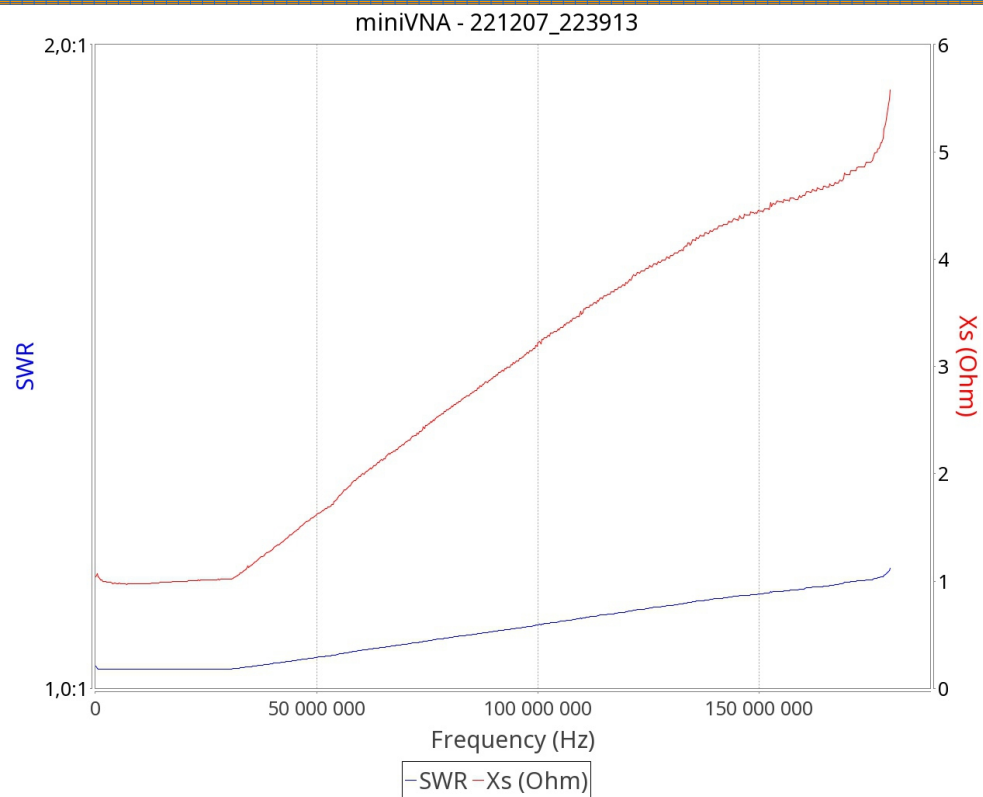


Smithin kartta

Port extension kiertää kuviota keskustan ympäri



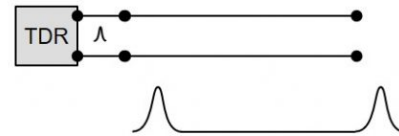
Smithin kartta – 50Ω terminaattori



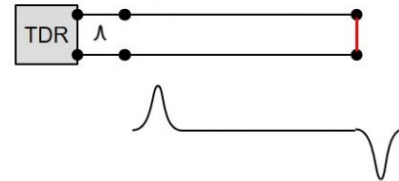
Time Domain Reflectometry

- Lähetetään lyhyt pulssi ja katsotaan mitä tulee vastauksena

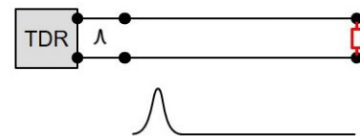
Open End



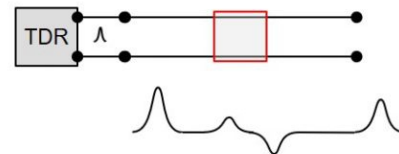
Short at Cable End



Matched Impedance (Telecom)



Joint



Time Domain Reflectometry

- Sovellus: kaapelin pituuden määrittäminen

vna/J - Cable length measurement

Fixed velocity factor

Velocity factor	Type	Vf	Z0	f1 (MHz)	loss@f1 (dB/100...)	f2 (MHz)	loss@f2 (dB/100...)
	RG-55 A/U	0,66	50,00Ω	10.0	1.30	100.0	4.80
	RG-58 /U	0,66	53,50Ω	10.0	1.25	100.0	4.65
	RG-58 A/U	0,66	53,50Ω	10.0	1.25	100.0	4.65
	RG-58 C/U	0,66	50,00Ω	10.0	1.40	100.0	4.90
	RG-58 foam	0,79	53,50Ω	100.0	3.80	300.0	6.0
	RG-59 A/U	0,66	75,00Ω	10.0	1.10	100.0	3.40
	RG-59 B/U	0,66	75,00Ω	10.0	1.10	100.0	3.40
	RG-59 foam	0,79	75,00Ω	100.0	3.80	300.0	6.0
	RG-62 A/U	0,84	93,00Ω	10.0	0.85	100.0	2.70
	RG-74 A/U	0,66	50,00Ω	10.0	0.38	100.0	1.50
	RG-83/U	0,66	35,00Ω	10.0	0.80	100.0	2.80
	RG-142 B/U	0,70	50,00Ω				
	RG-174 A/U	0,66	50,00Ω	10.0	3.40	100.0	10.60
	RG-178 B/U	0,70	50,00Ω				
	RG-179 B/U	0,70	75,00Ω				
	RG-188 B/U	0,70	50,00Ω				

Calculated length

Known cable length

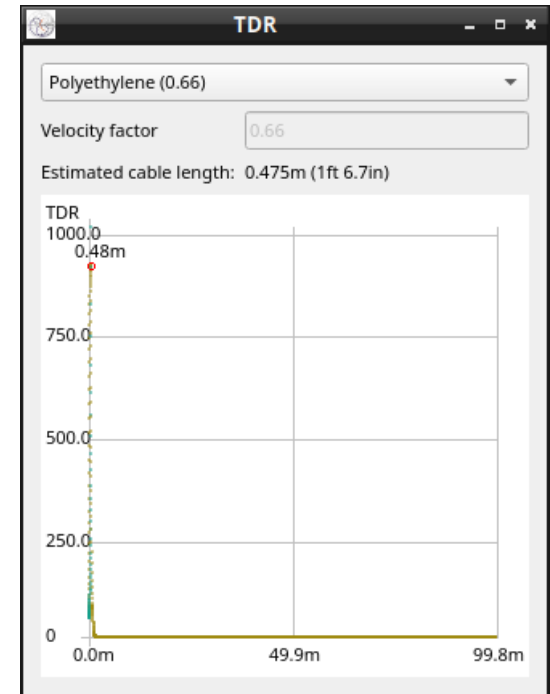
Measured length Velocity factor

Variable velocity factor

Velocity factor Calculated length

Measure Unit m ft Close

Status



Laitteet ja ohjelmistot

- MiniVNA (180 MHz versio)
- vna/J 3.4.8
- NanoVNA gen111.taobao.com
- nanovna-saver-0.5.3-1.fc37
(patch #572 asennettu)

