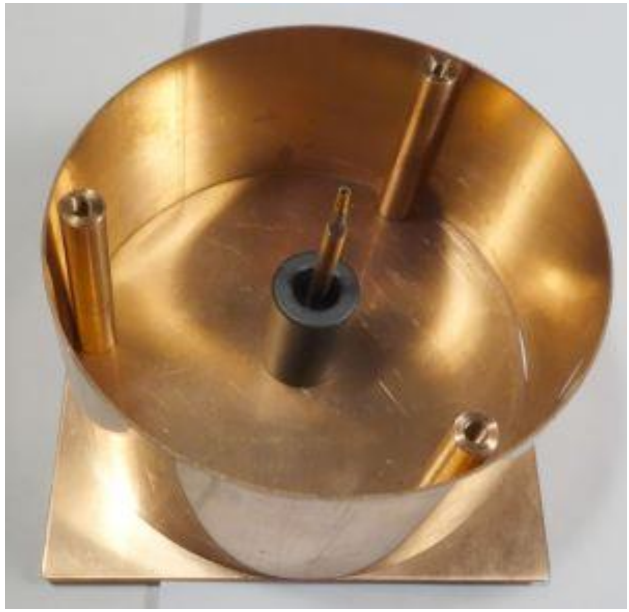
Het meten van spoelen met Ferriet

Timo Lampe, PE1FOD





Introductie

- **Basis kenmerken**
- **Soorten & Merken**
- **Meten & Tools**
- **VNA Info**
- **VNA Kalibratie**
- **Balun meten**
- **µ meten met VNWA**

Basis kenmerken

- <u>Algemeen</u>
- Wat is ferriet
- Hoe wordt het gemaakt
- Wat heb je er aan

- <u>Er aan meten</u>
- Inductie
- Werk frequentiebereik
- **μ'r - μ"r**

- Tools:
- MiniRingkern , van inductie → winding aantal
- Coil64, voor simpele μ bepaling
- VNA voor het echte meten

- **Poeder/IJzer**
- IJzerdeeltjes met een isolerende bindmiddel geperst en gebakken.
- μ max 75

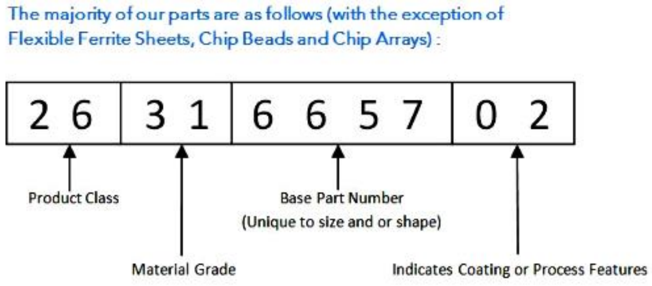
- **Ferrites** (een soort ceramic)
- Ijzer oxide +ander metaal+bindmiddel:
- (Resonant, WB)
- -Nickel/Zink (NiZn, > 1MHz, 10-1000MHz)
- -Mangaan/Zink (MnZn, < 3MHz, 10-100MHz)
- -Magnesium (MgZn)
- Gemixt, voorgebakken ->granulaat, in vorm geperst en gesinterd
- μ max 15000

- Nanocrystalline μ > 15000

Soorten & Merken

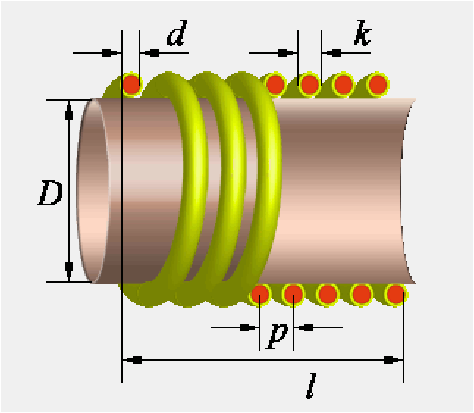
Ferrite is uitgevonden door Dr. Kato en Dr. Takei in 1930 en is een magnetisch oxidemateriaal met als belangrijkste ingrediënt ijzer. Ferriet is geclassificeerd in **zacht ferriet** (magnetische kernmateriaal) en **hard ferriet** (magneetmateriaal).
TDK was opgericht voor de productie van zacht ferriet in 1935.

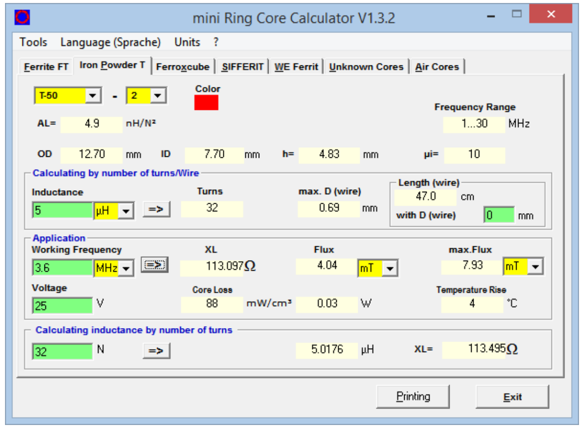
- EMC / Suppression
- Inductive / Resonant
- Power RF & LF
- Wideband / Broadband Transformer



• Ferrite Cores (AMIDON,Fair-Rite)	FT50-43
• Iron Powder Cores (AMIDON,Fair-Rite)	T50-2
• Ferroxcube (ex Philips)	TN36/23/15 3C90/4C65
• WE (WÜRTH ELEKTRONIK)	742 725 95
• TDK-Epcos (SIFFERIT, ex Siemens)	B64290
• NEOSID	F100b

Meten - Tools





<u>Inductie berekenen/voorspellen</u>

- Mini Ringkern-Rechner V1.32
- Coil32/64 (RFsim99, Qucs)

<u>Inductie meten</u>

- LC Meter
- Antenne analyzer
- DG8SAQ VNWA
- Nano VNA

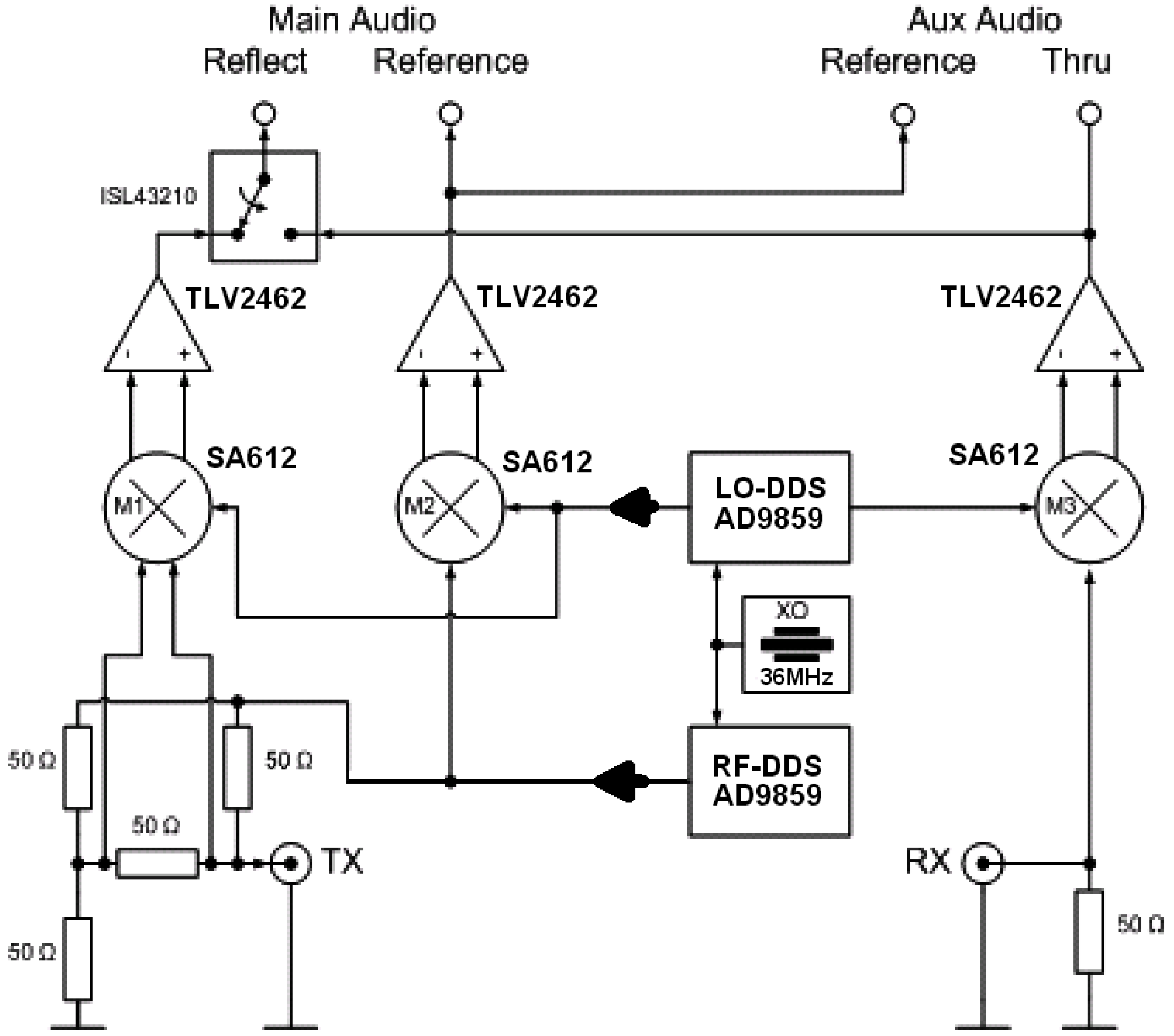
VSWR Tabel

VSWR=Lineair

Return loss=Log(dB)

Z1/Z2 VSWR	Returnloss dB	Voltage Reflectie Coëfficiënt x	TxPow %	Refl.pow %	Refl.pow dB	Z1= 50 Z2=	Z1= 50 Z2=
1.020	40	0.010	99.99	0.01	0.000	51.01	49.01
1.065	30	0.032	99.90	0.10	0.004	53.27	46.93
1.119	25	0.056	99.68	0.32	0.014	55.96	44.68
1.152	23	0.071	99.50	0.50	0.022	57.62	43.39
1.222	20	0.100	99.00	1.00	0.044	61.11	40.91
1.253	19	0.112	98.74	1.26	0.055	62.64	39.91
1.499	14	0.200	96.02	3.98	0.176	74.93	33.37
1.577	13	0.224	94.99	5.01	0.223	78.84	31.71
1.671	12	0.251	93.69	6.31	0.283	83.54	29.92
1.785	11	0.282	92.06	7.94	0.359	89.24	28.01
1.925	10	0.316	90.00	10.00	0.458	96.25	25.97
2.000	9.54	0.333	88.88	11.12	0.512	100.02	24.99
2.100	9	0.355	87.41	12.59	0.584	104.99	23.81
2.323	8	0.398	84.15	15.85	0.749	116.14	21.53
2.615	7	0.447	80.05	19.95	0.967	130.73	19.12
3.000	6.02	0.500	75.00	25.00	1.250	150.01	16.67
3.570	5	0.562	68.38	31.62	1.651	178.49	14.01
4.419	4	0.631	60.19	39.81	2.205	220.97	11.31
5.848	3	0.708	49.88	50.12	3.021	292.40	8.55

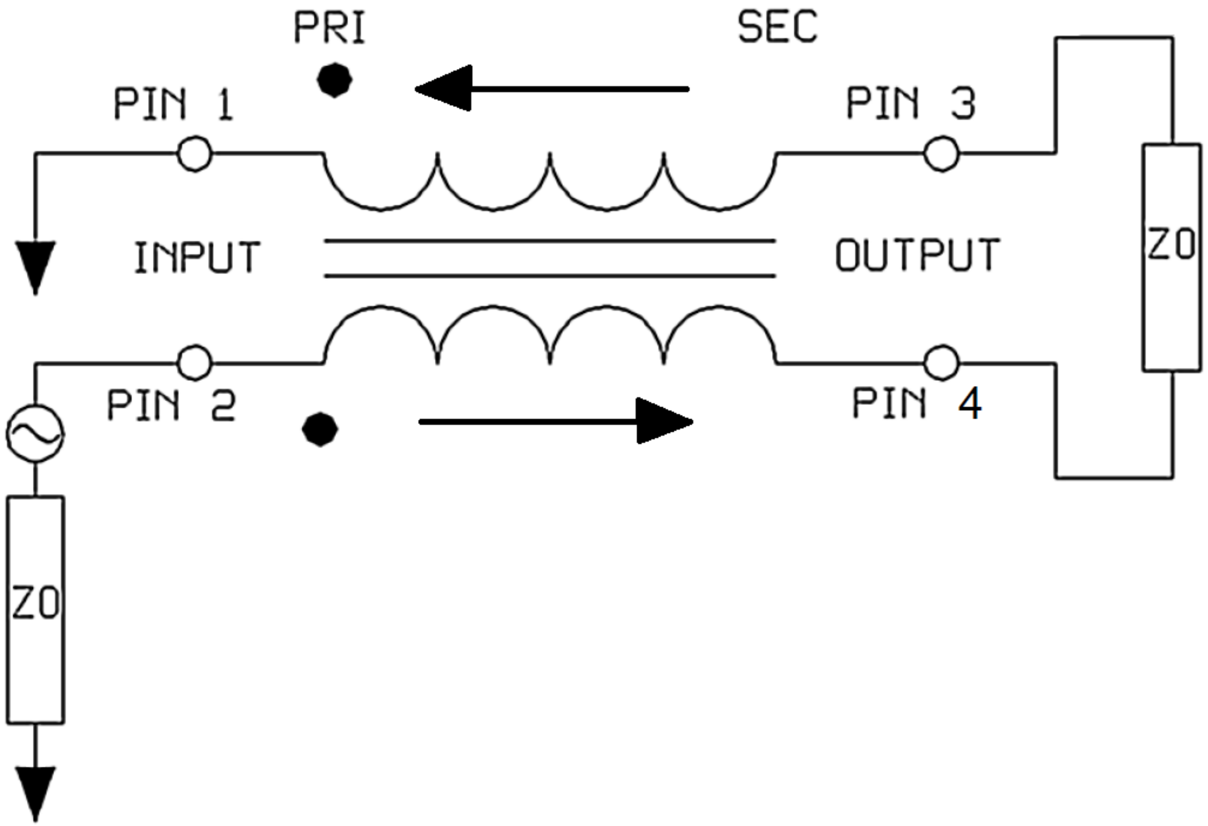
VNWA Blokschema



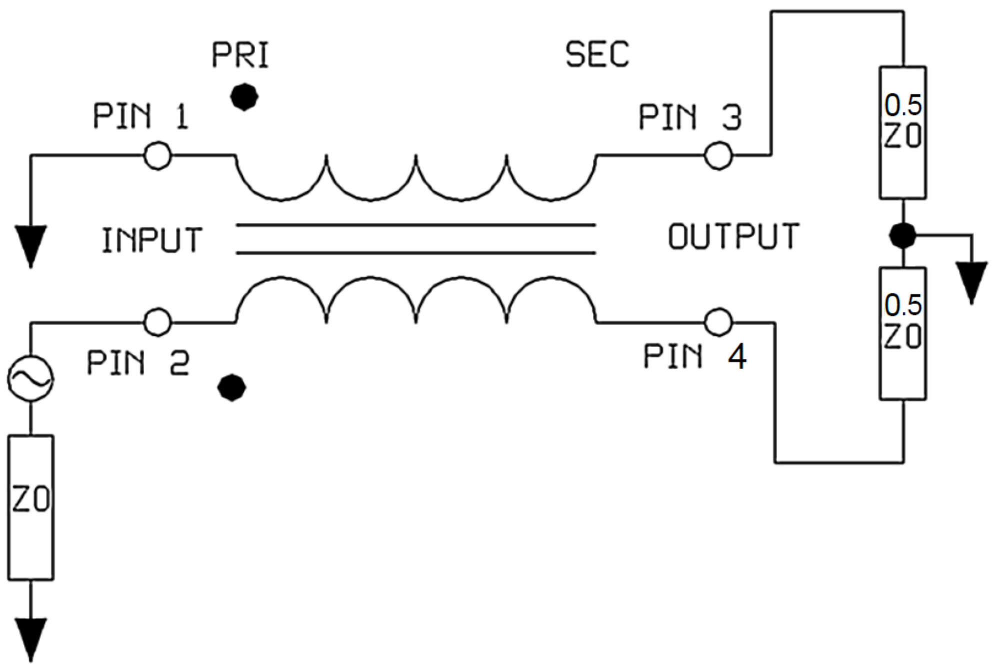
Kalibratie

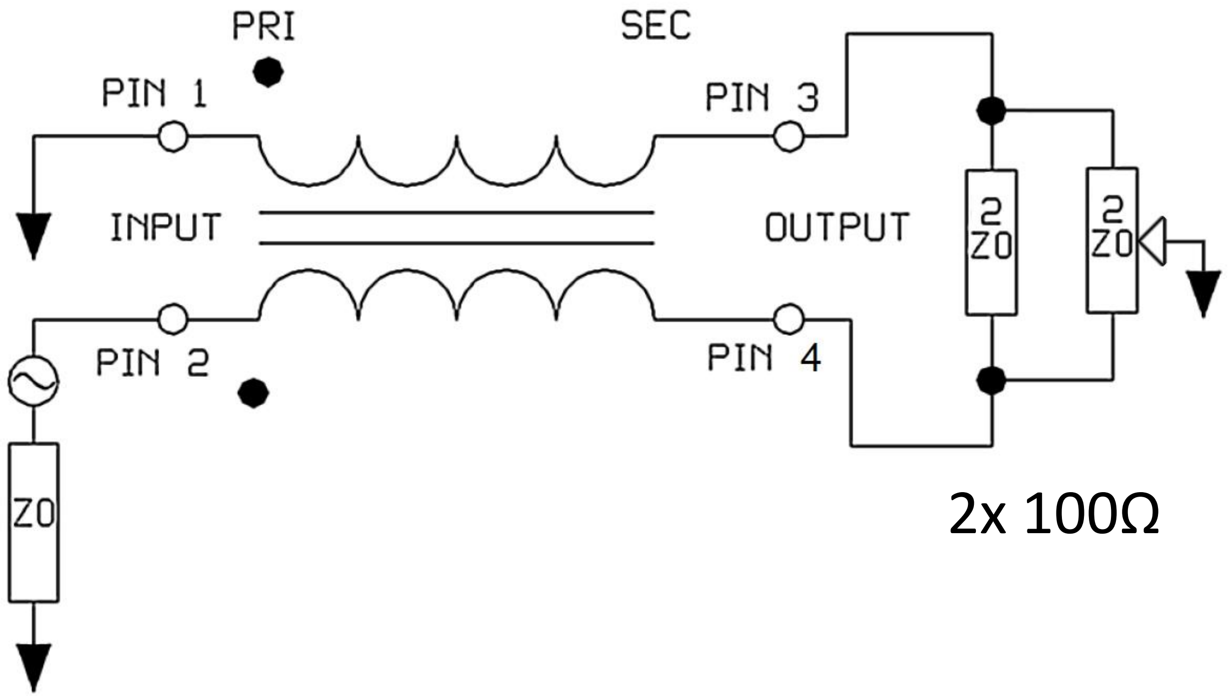
- Zonder Cal lijkt het op Spectrum Analyzer + TG
- Open
- Short
- Load
- Coax Kabels wegrekenen
- Laten zien dat het klopt in Smith kaart
- Referentievlak (Reference plane)
- Poort extensie, om extra aansluit kabel te compenseren

Balun, ook wel symmetreer trafo



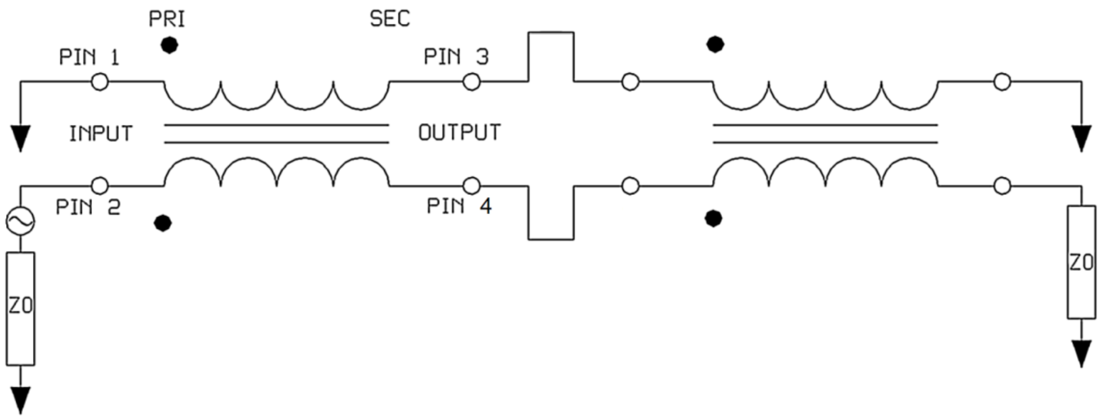
Met center aan aarde om de balans te meten

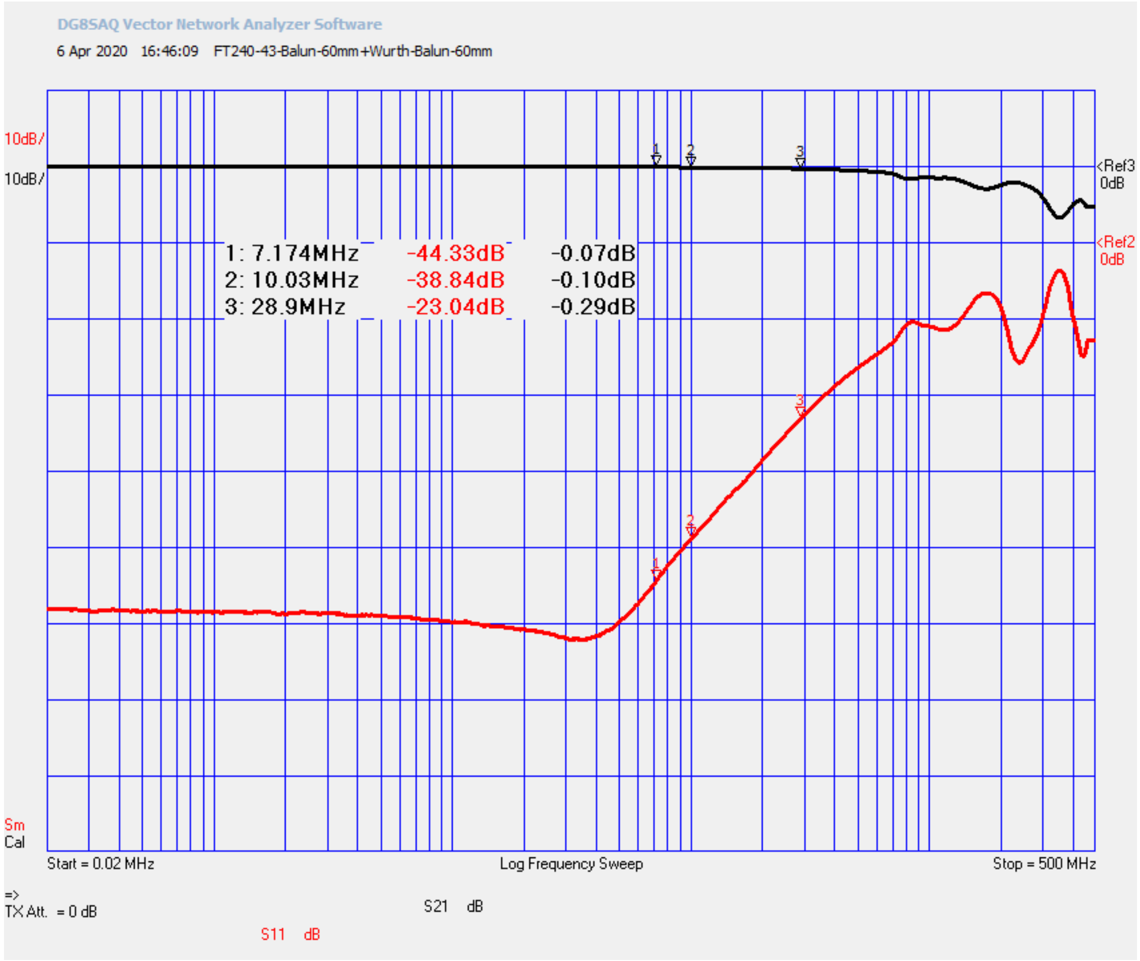




2x 100Ω

2x Balun in serie om het verlies te meten



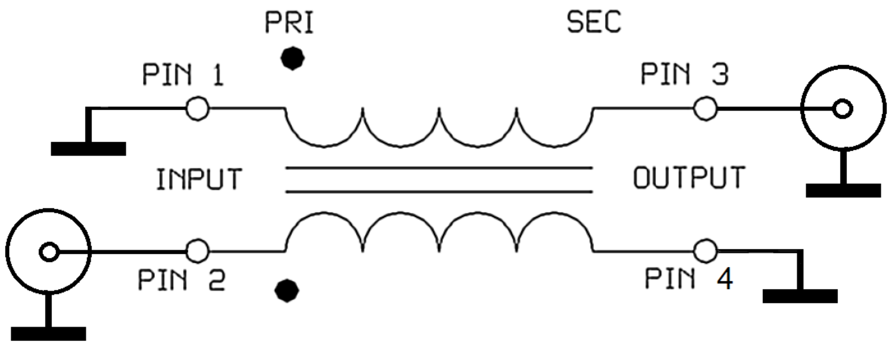


0.3 / 2 = 0.15dB = 1.035x

100 / 1.035 = 96.6W

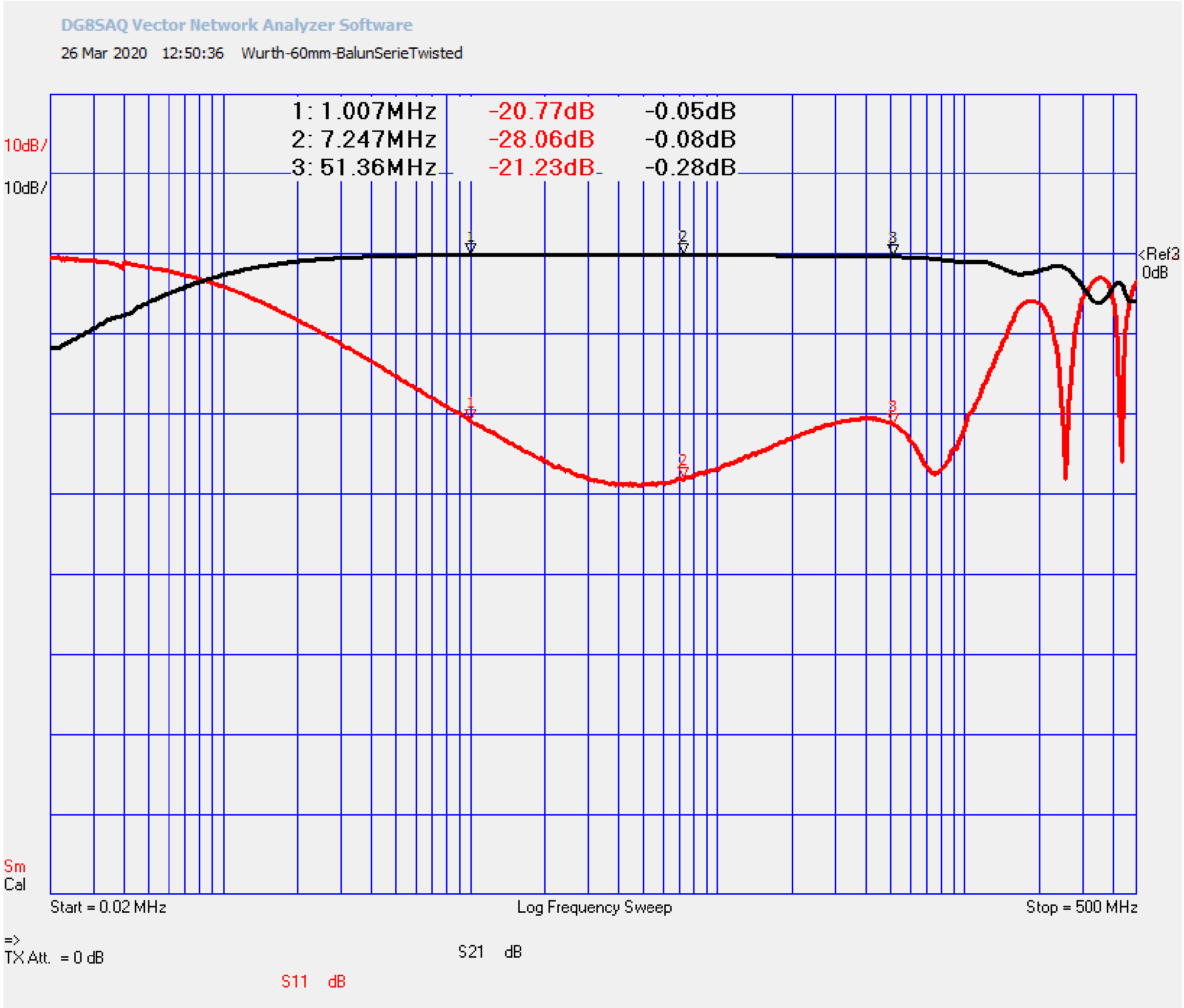
Is dus een verlies van 3.4W in de balun

Balun meten 1

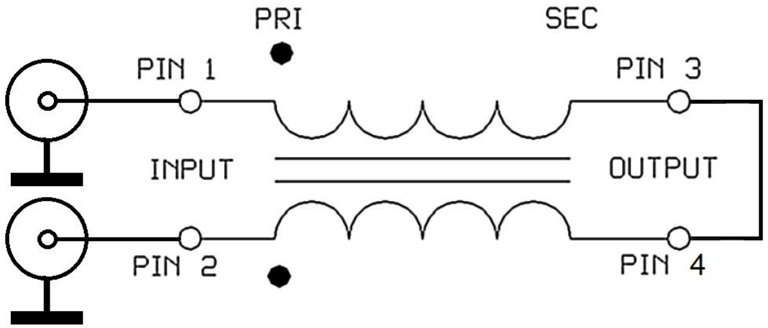


DC niet verbonden
Return loss van af 1MHz

74270097-61x35x13-4W620

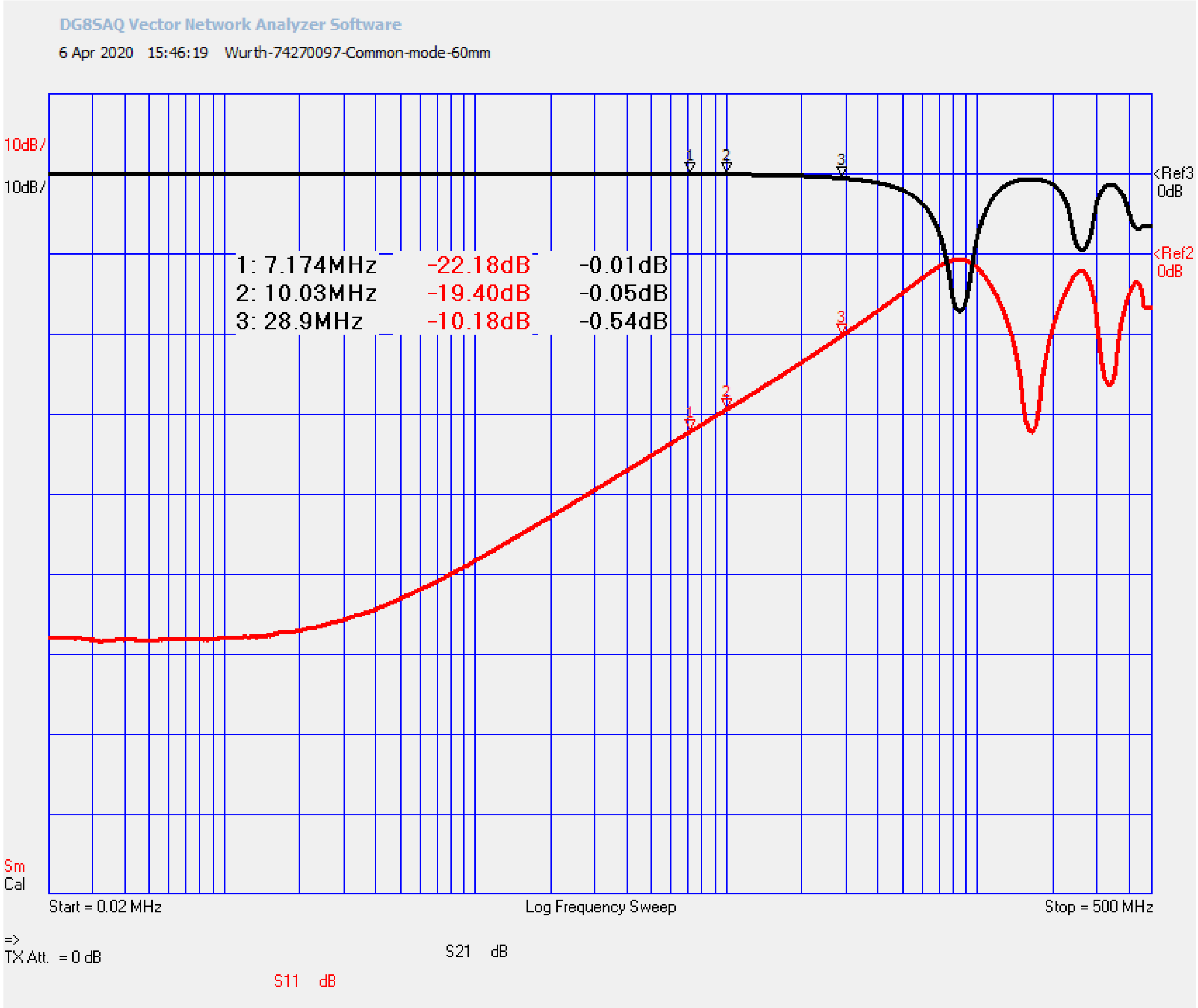


Balun meten 2

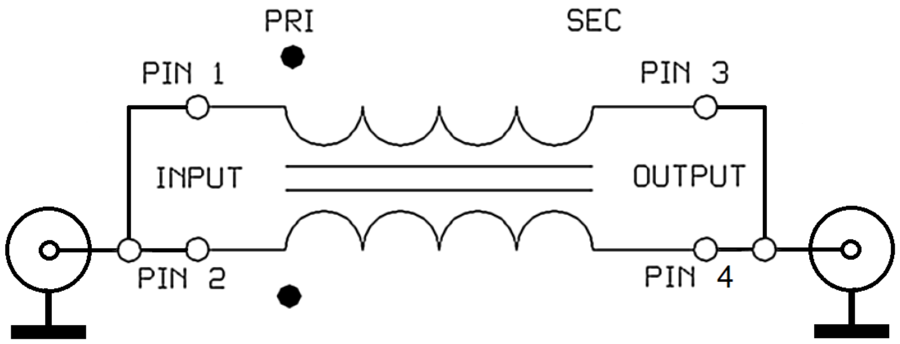


DC verbonden
Return loss tot 0Hz

74270097-61x35x13-4W620

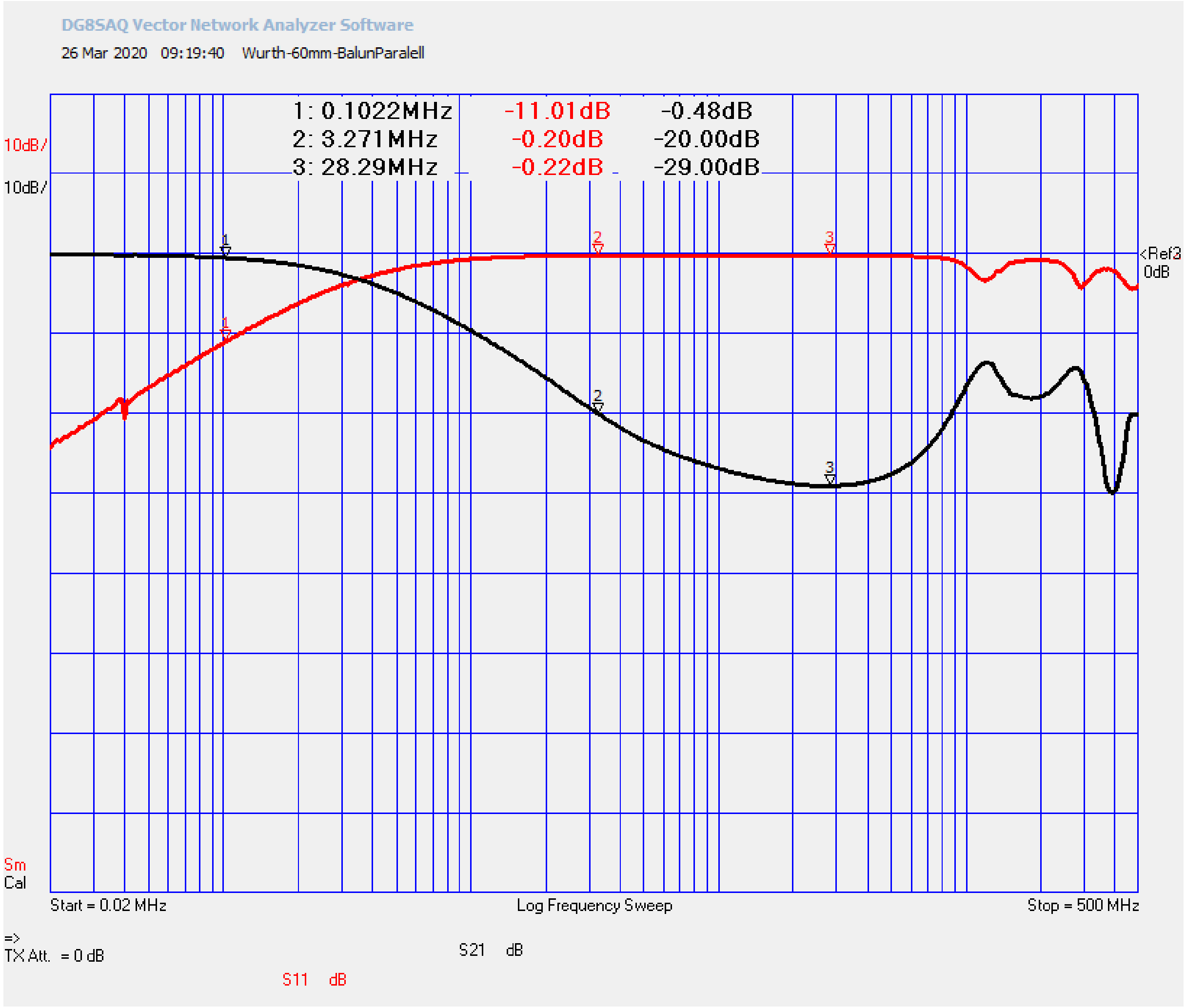


Balun meten 3



Isolatie, commonmode signal wordt onderdrukt

FT240-43

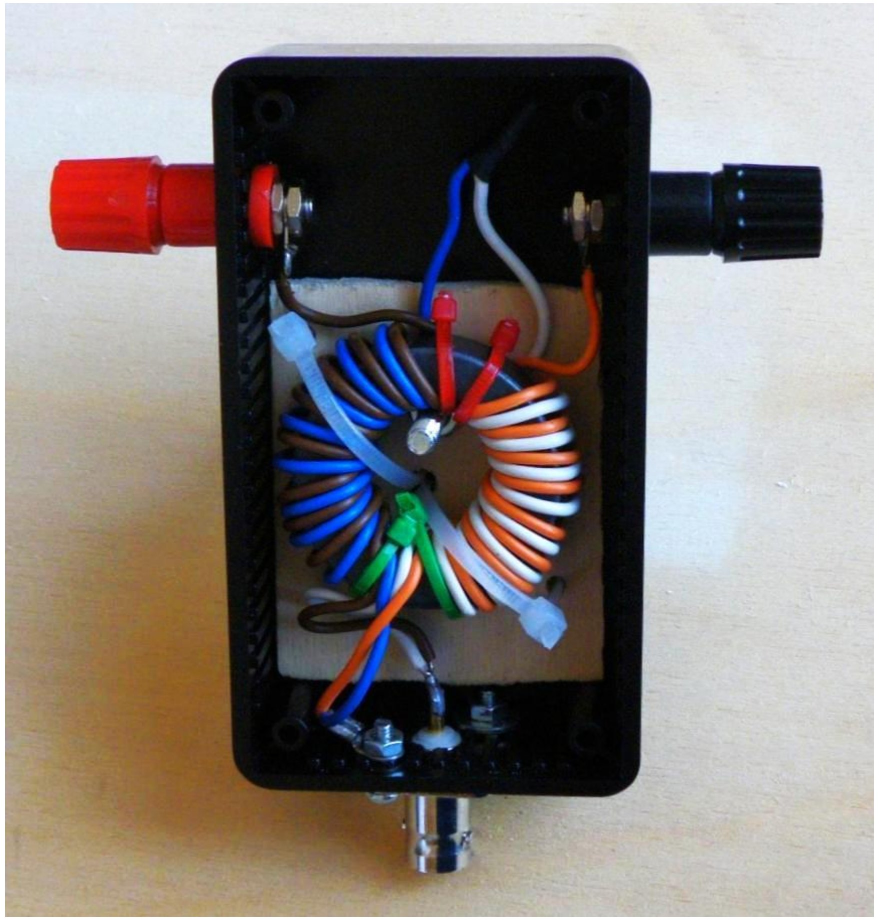


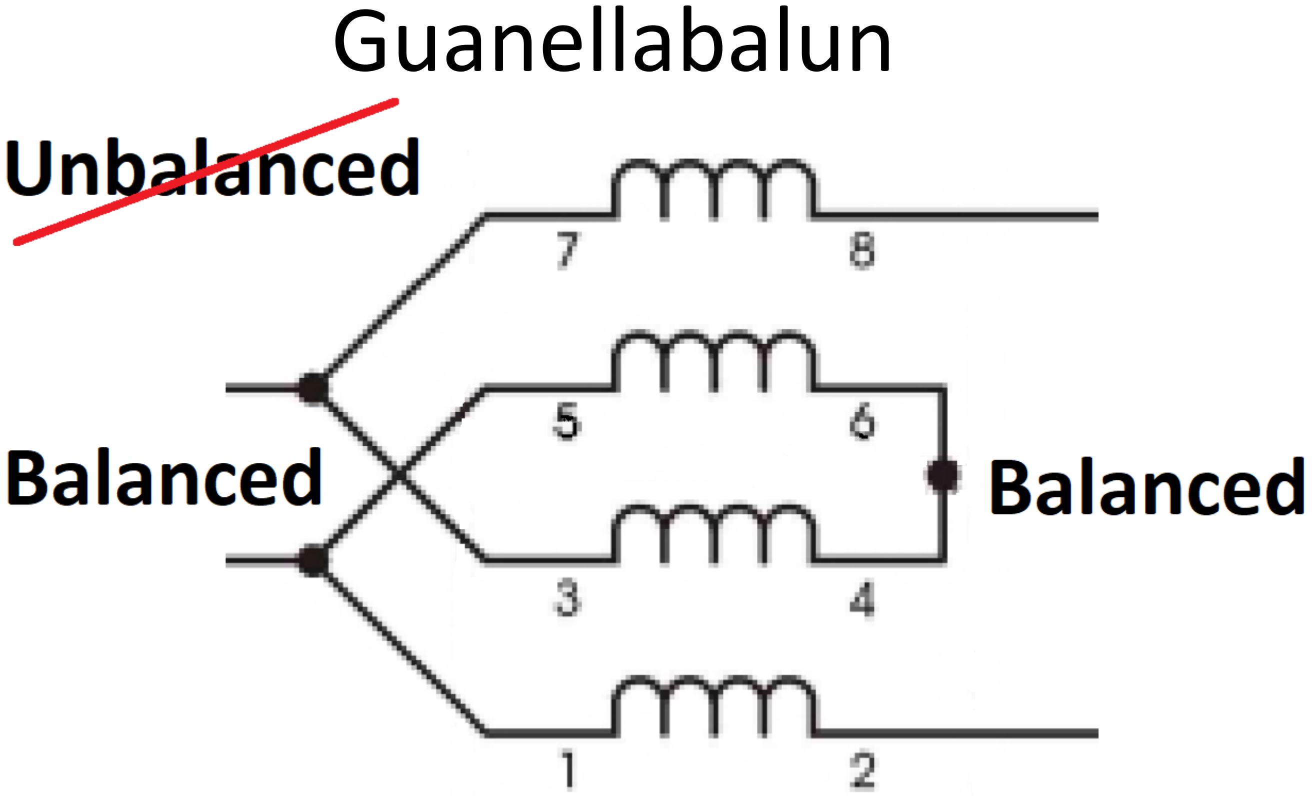
Is **20dB** demping genoeg?

- 100 W Tx
- SWR = 1 : 1.95
- 10 W   Terug
- 20dB Loss
- = 0.1W Tx @ coax

- S4 = -103dBm Rx
- S9 Ruis signaal uit Huis
- S9 = -73dBm
- Dan is 30dB demping nodig

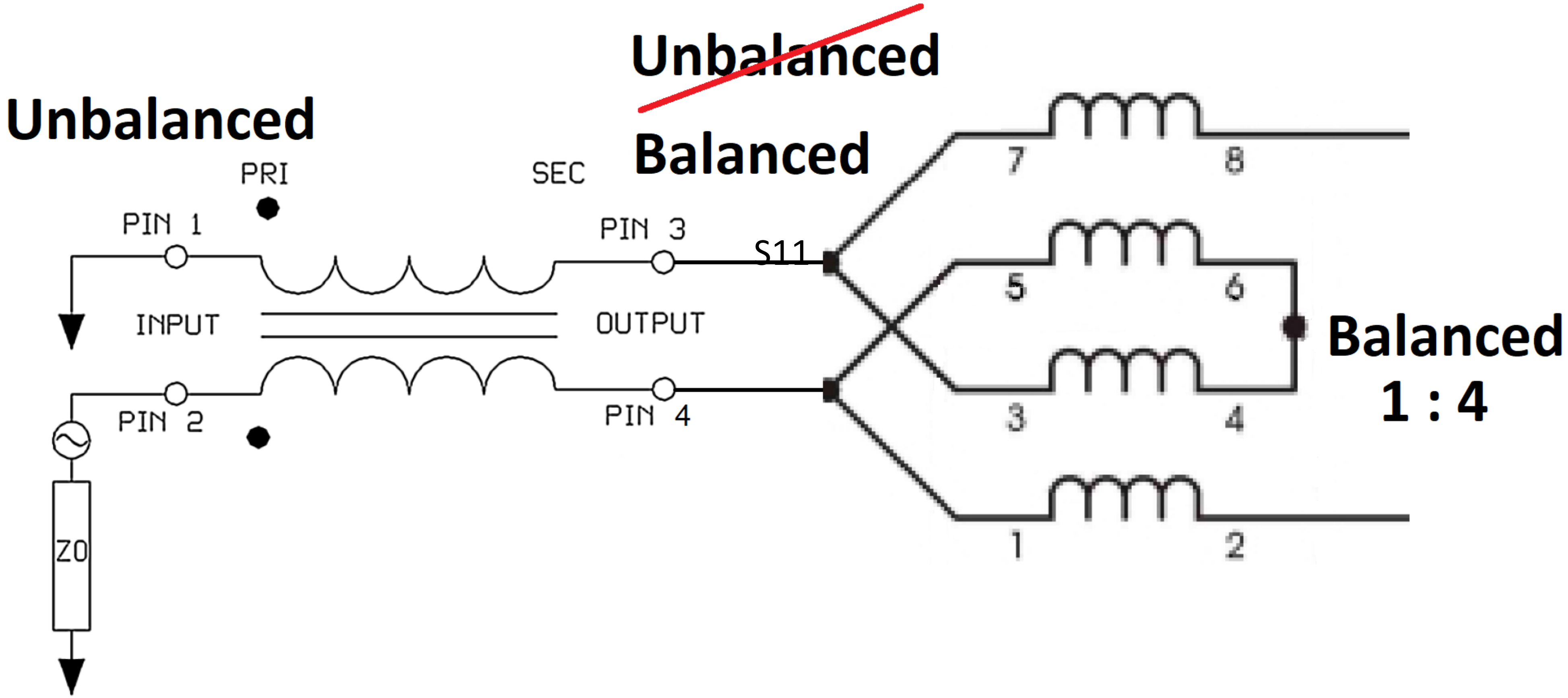
1 : 4 Trafo of mantelstroom filter ?





Is dus geen mantelstroom filter maar een 1:4 trafo

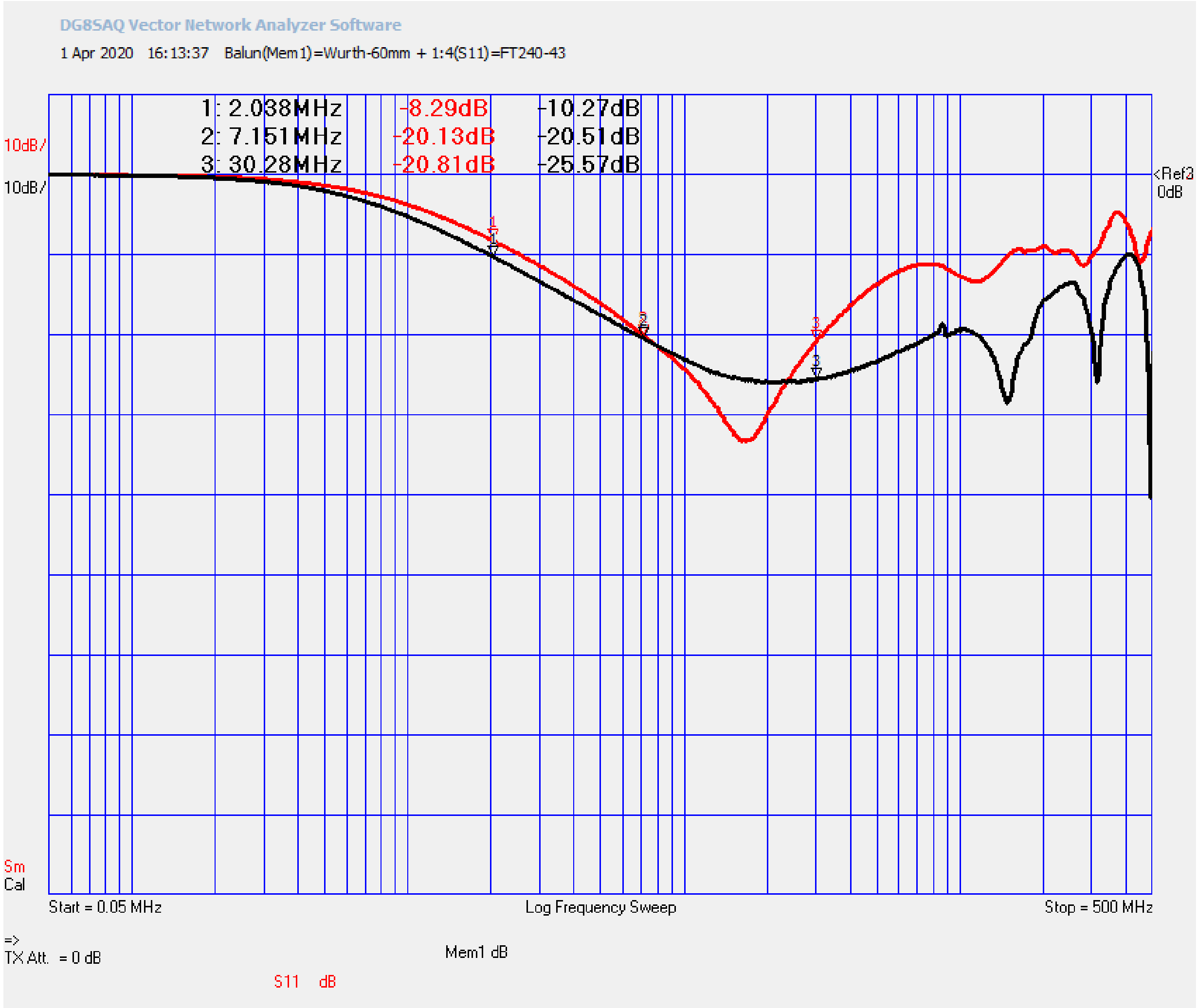
Balun + 1 : 4 Trafo



Balun + 1 : 4 Trafo met 200Ω afgesloten

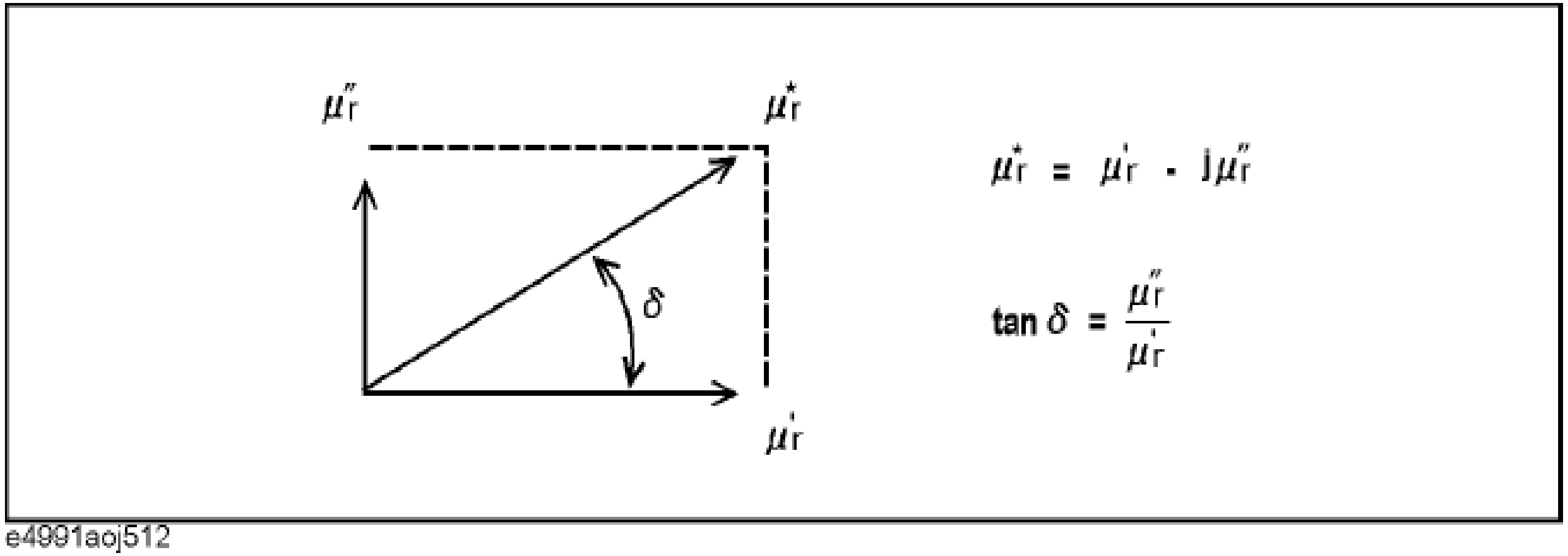
Mem1 = Balun = Wurth 60mm zwart

S11 = 1:4 Trafo FT240-43 rood



Definition of Complex Relative Permeability

$$\mu^*r = \mu'r - j\mu''r$$



Keysight : 16454-90020.pdf

De oplossing van Thomas Baier

The inductance of a coil with **b** turns on a toroid is calculated to be **L=μ _0*μ _r*b^2*A/Length**
Where:

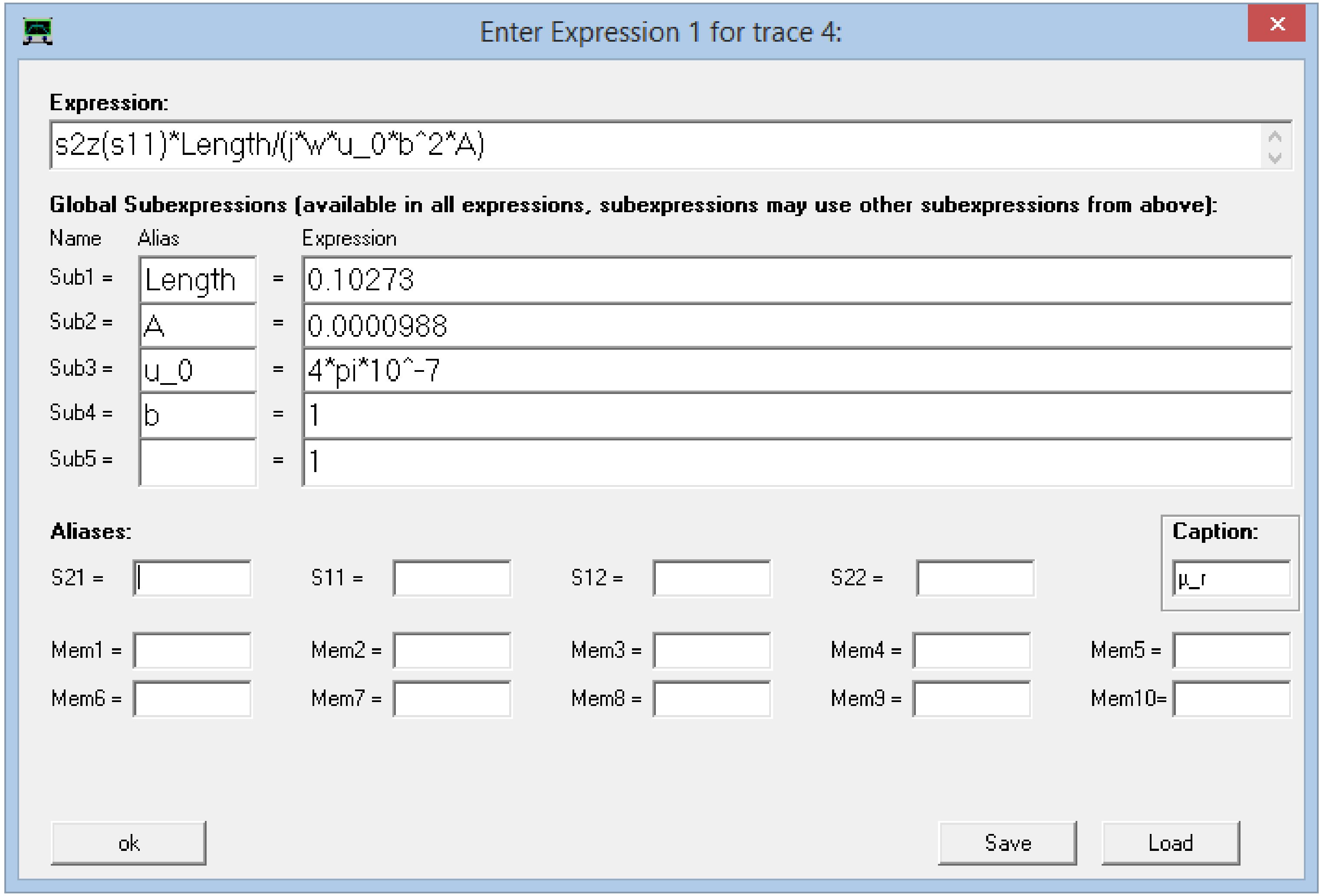
L = in Henry
μ_0 = magnetic field constant = **4*pi*10^-7 Newton/Ampere^2**
μ_r = permeability=**μ'+j*μ''** which you are after
A = cross sectional area of the core
Length = magnetic path length, i.e. **average** circumference of the core
b = turns

- So, if you measure the impedance of a coil wound onto the core you will obtain
- Z=**j*w*L**
- Actually, with a VNA you measure S11.
- But you can calculate Z from S11 with the VNWA function: **s2z(s11).**
- So, you can solve the whole thing for u_r:
- **μ_r=s2z(s11)*Length/(j*w* μ_0*b^2*A)**
- Copy above formula into a VNWA custom trace and display the **real part** and the **imaginary part** of the result.

- Hope this is helpful.
- Best regards,
- Tom

μ_r=s2z(s11)*Length/(j*w* μ_0*b^2*A)

Directe omrekening naar μ’r en μ’’r met de VNWA

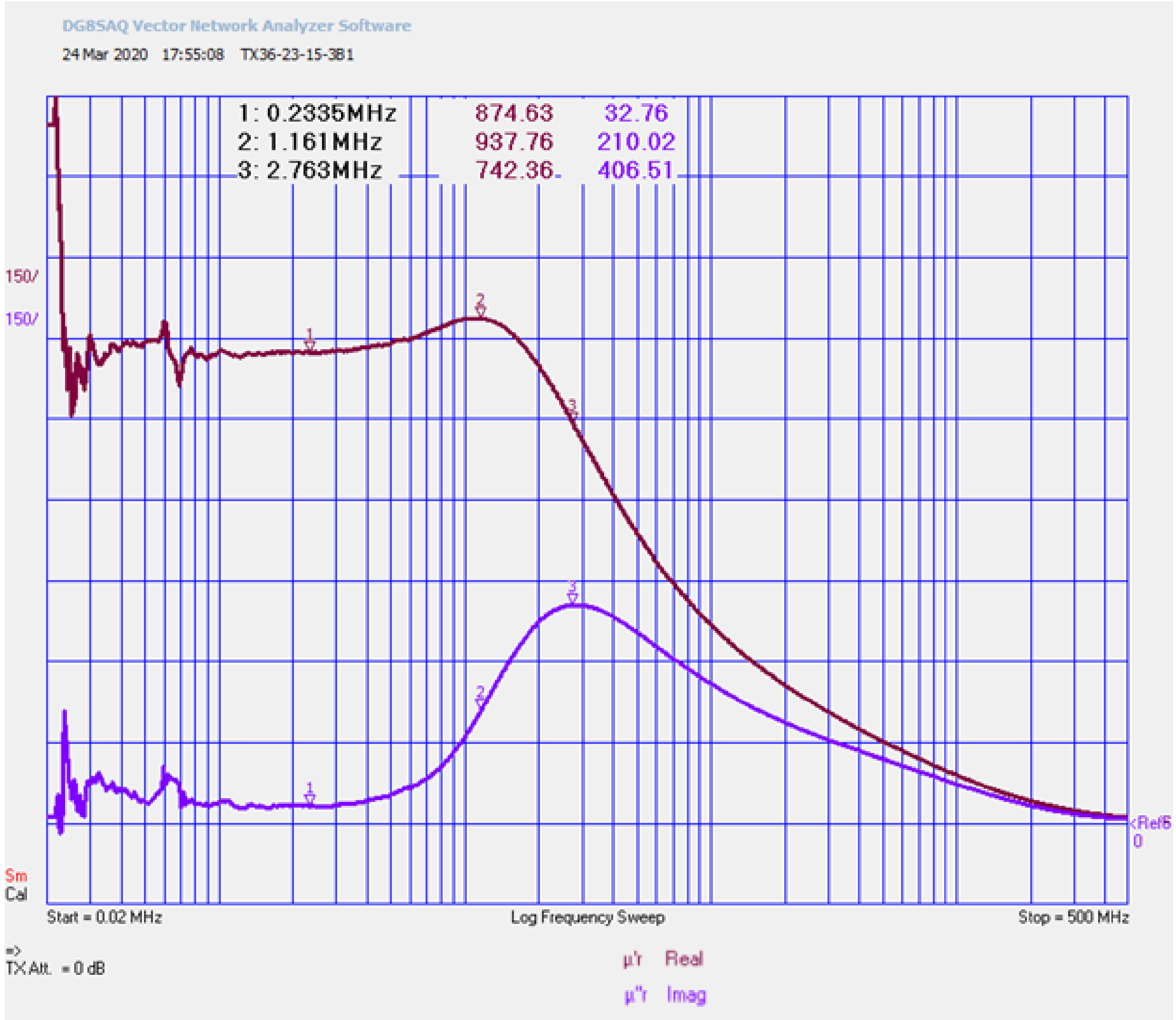


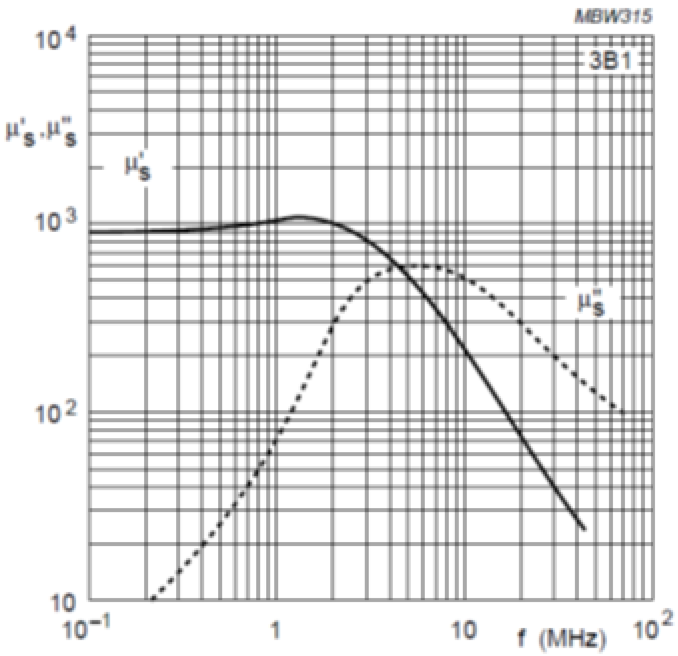
Ferrieten meten:

Met VNWA

Frequentiebereik : 20kHz to 500MHz

- **in grafiek zijn de μ'r en μ''r met de marker af te lezen**

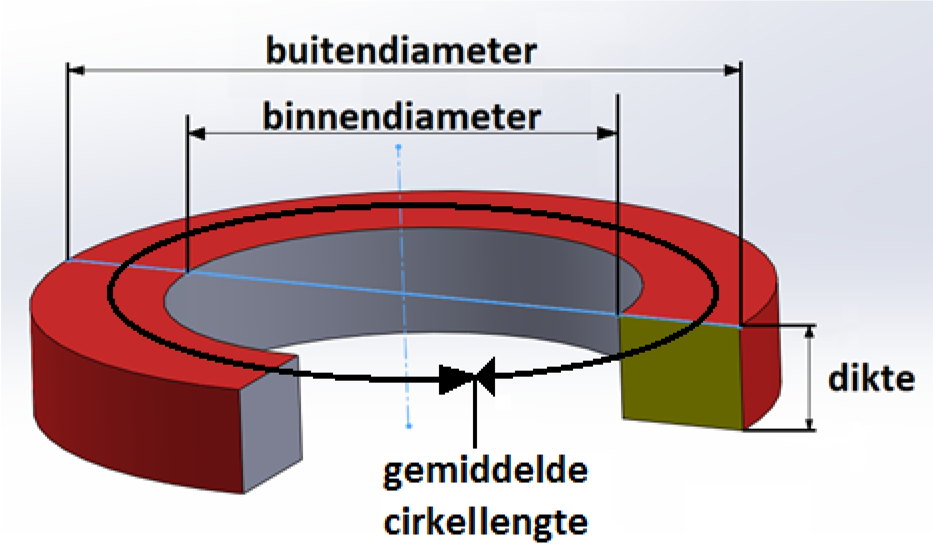


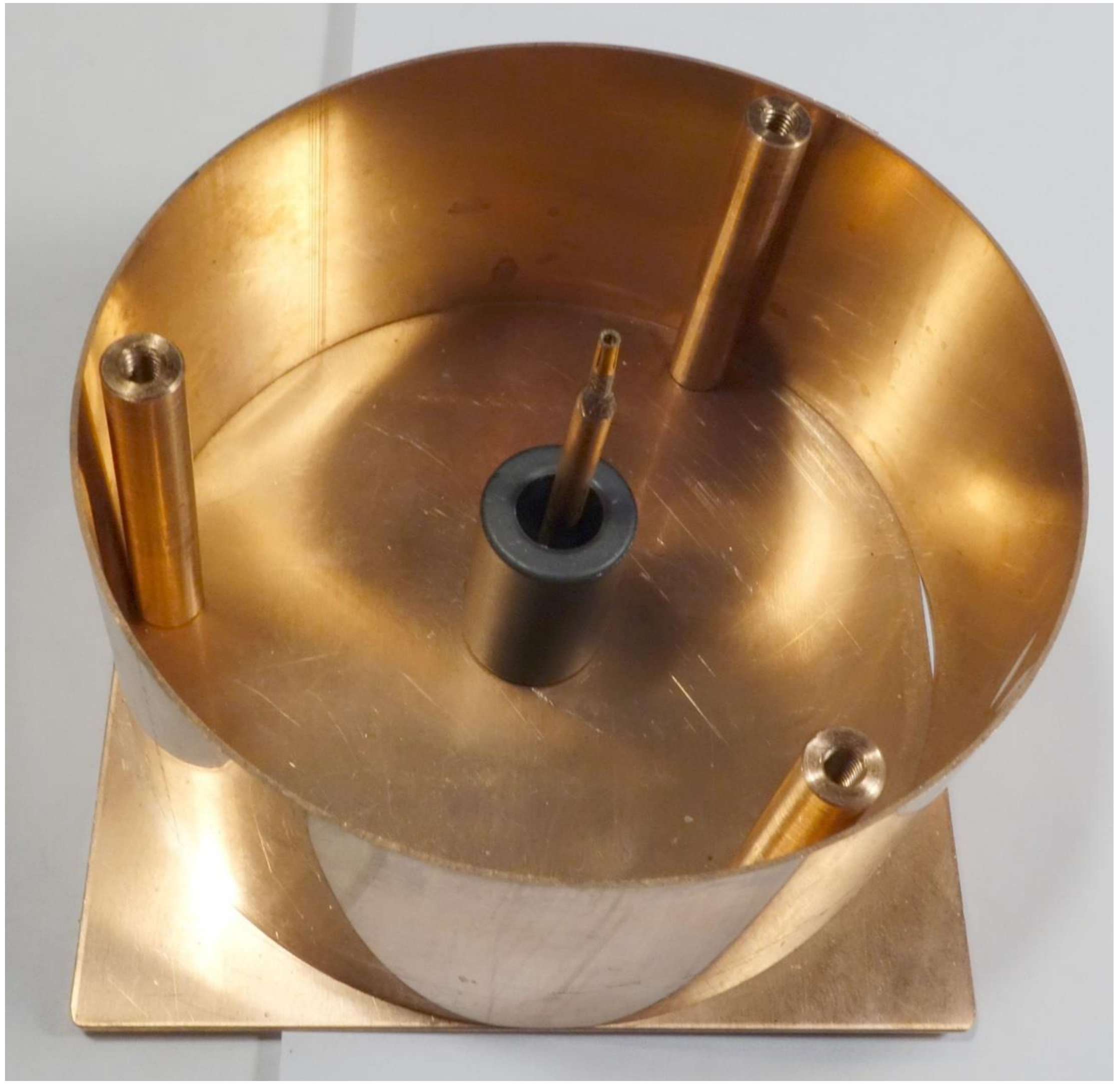


De Meetkamer

VNA Calibratie

Lege meetkamer als short

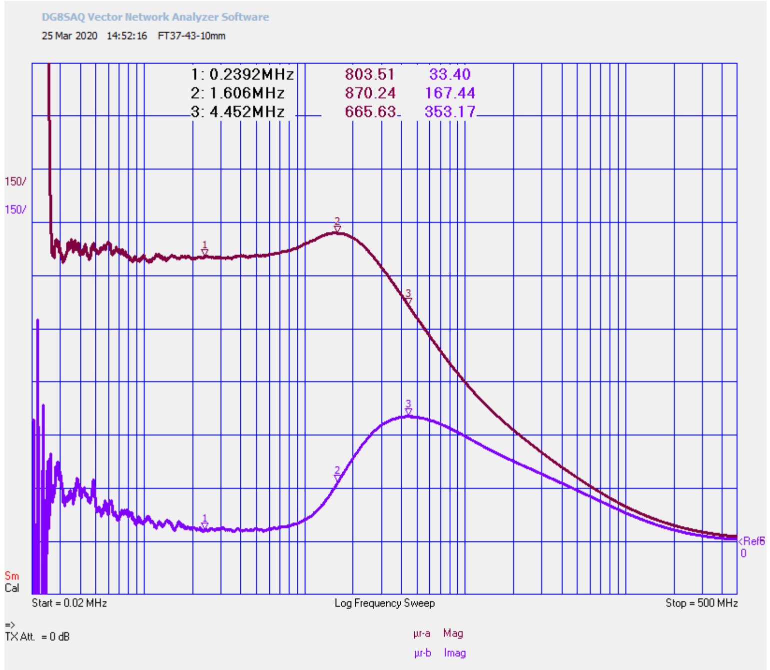


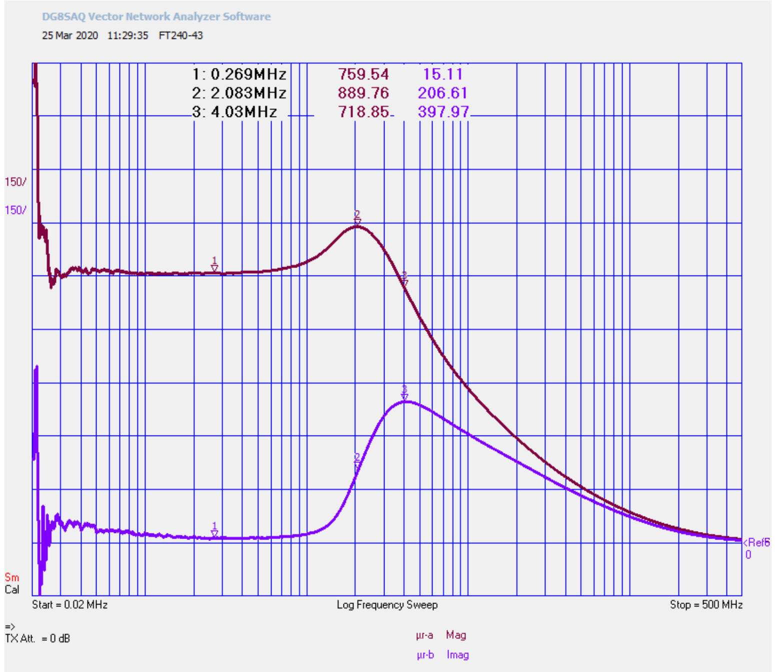


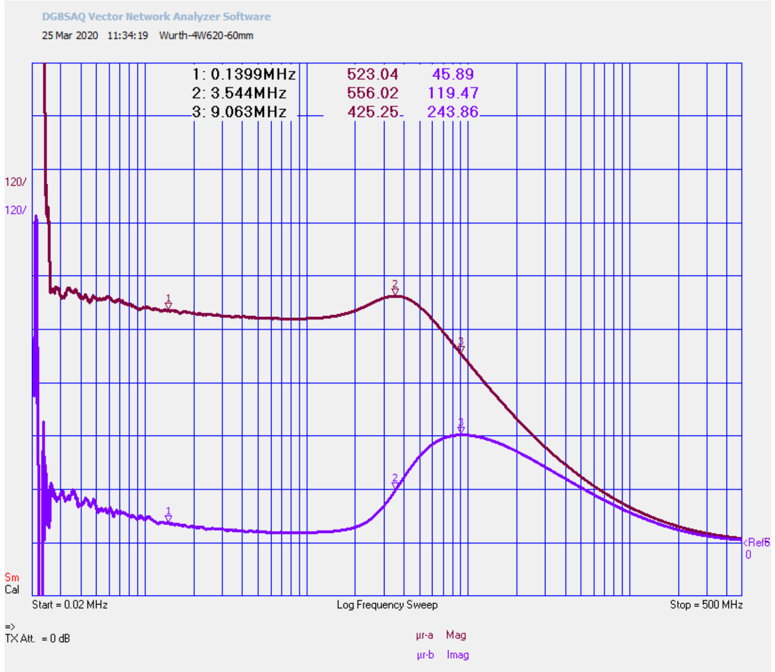
Fair-Rite

FT37-43 FT240-43

Wurth 4W620

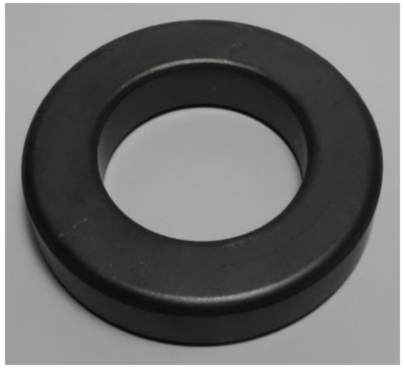




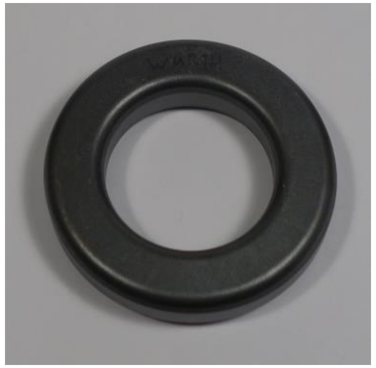


10mm

µ=800

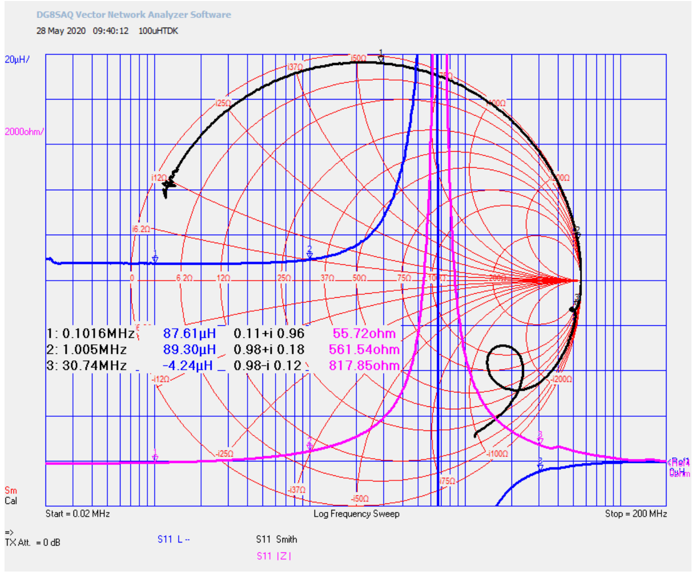


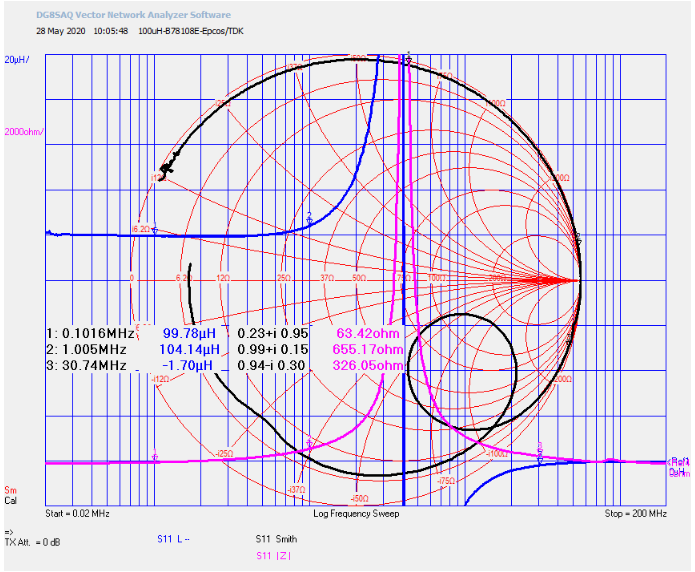
60mm

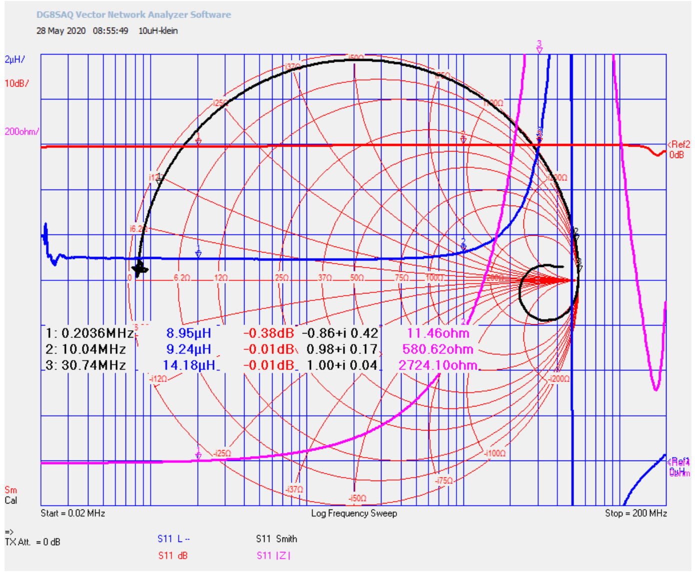


µ=620

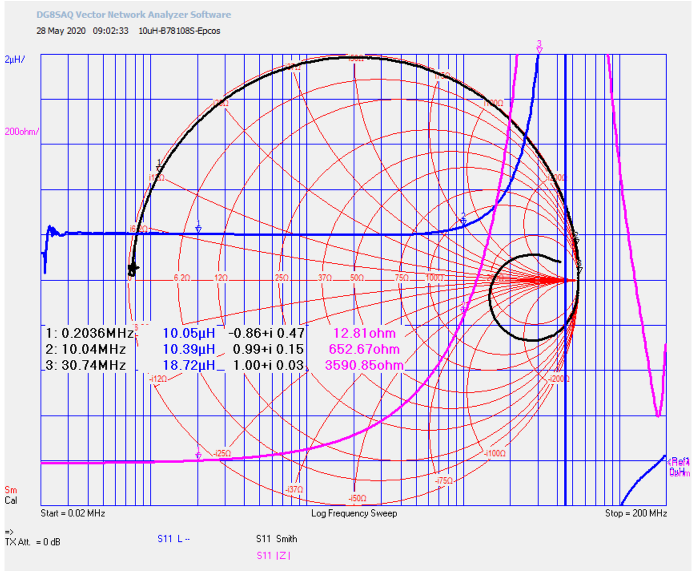
Spoel 100uH→



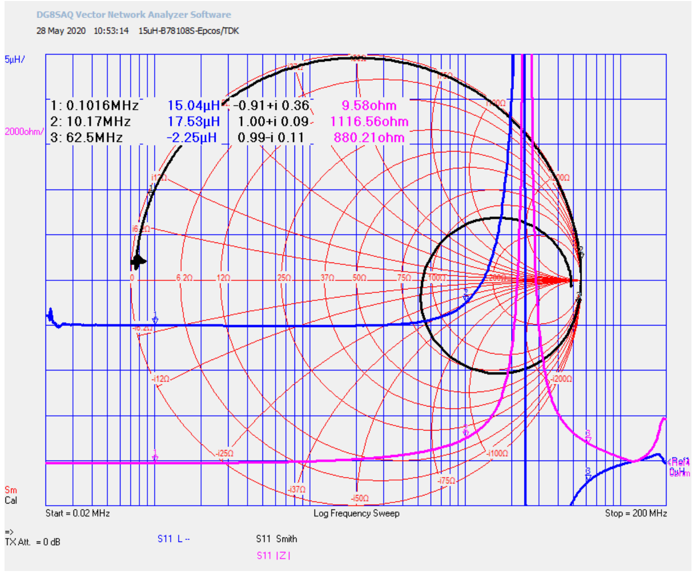




10uH klein

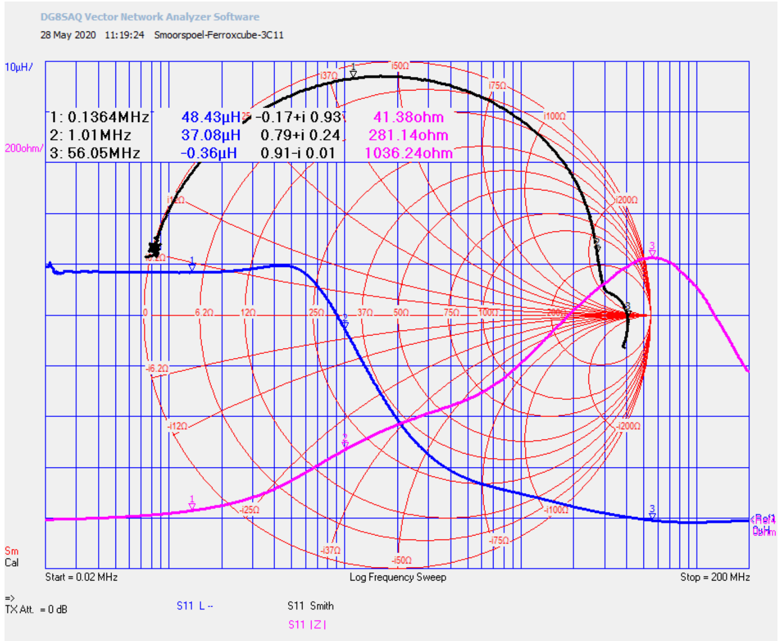


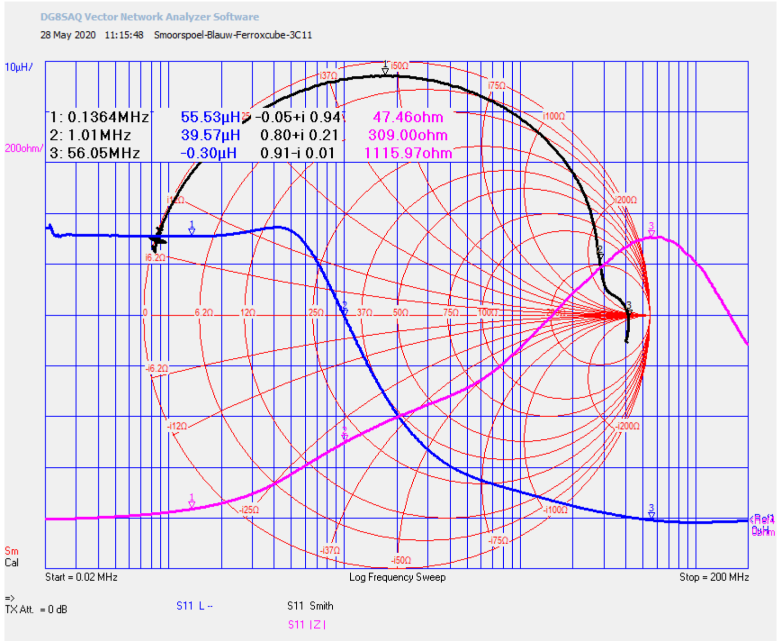
10uH B78108S

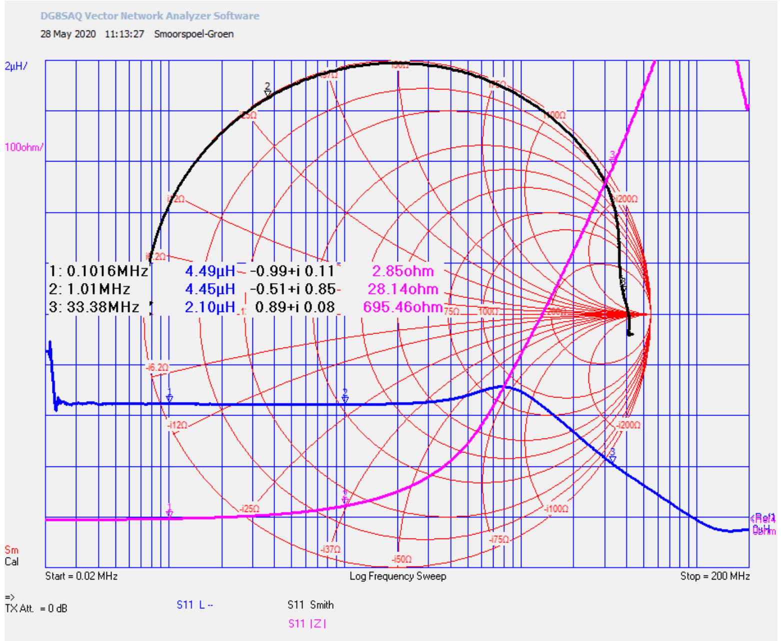


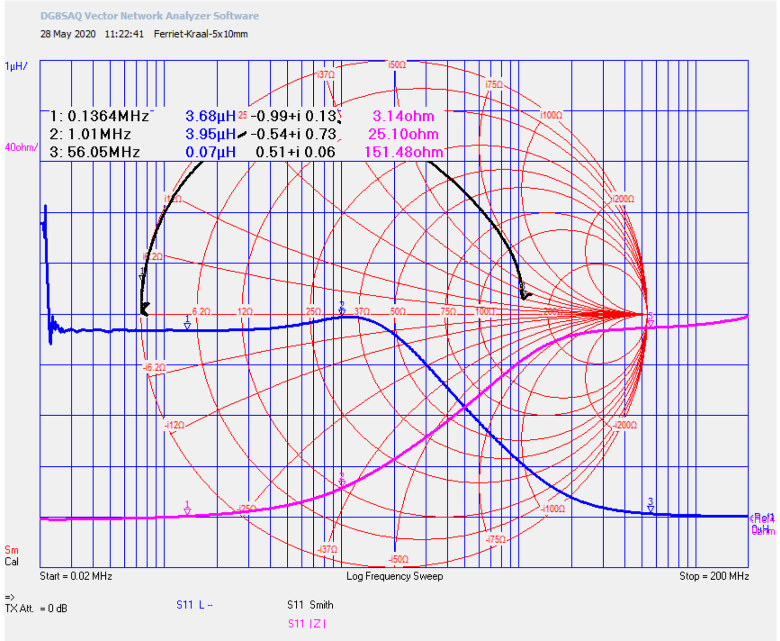
15uH B78108S

Ferriet-Kraal (Smoorspoel)









- Info :
- Fair-Rite-Catalog-17th Edition.pdf
- Ferroxcube_HB2013.pdf
- Keysight: 16454-90020.pdf
- Reeve-P1-Hagen_FerriteBeads.pdf
- Reeve-P2-Hagen-Poulsen_FerriteBeads.pdf
- Reeve-P3-Hagen-Poulsen_FerriteBeads.pdf
- RinKernMetenMetMeetkamer.xls
- neoFerrit_Werkstoffdat.pdf
- TDK : eemc_basic_06.pdf

Dank U voor uw aandacht