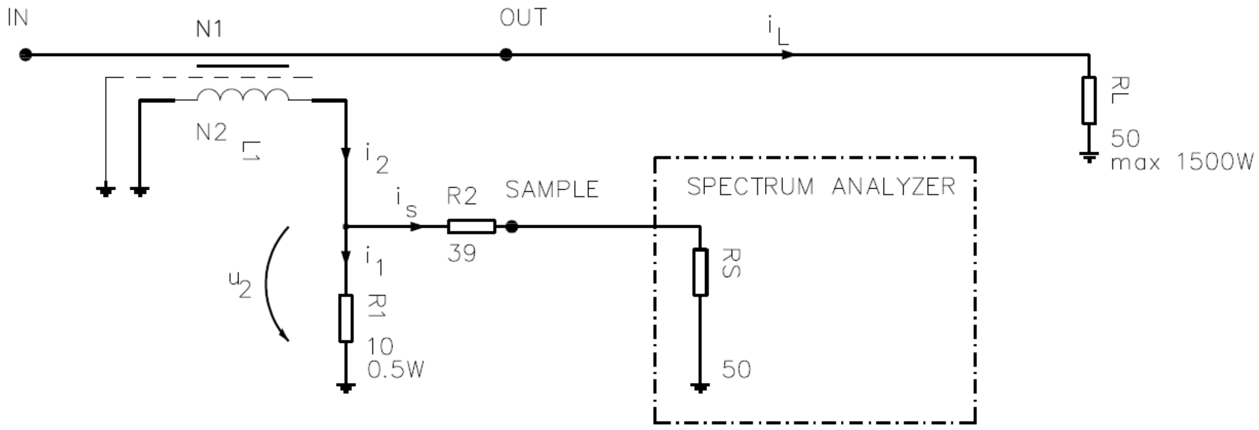
RF SAMPLER
1500W

-50 dB

P/N 18001009

1. RF sampler schematic



Designations:

IN	Input port
OUT	Output port
SAMPLE	RF sample port
N_1	Number of transformer primary turns
N_2	Number of transformer secondary turns
R_1	Resistor from secondary to ground
R_2	Resistor from secondary to SAMPLE port
R_S	Spectrum analyzer input impedance
P_2	Spectrum analyzer input power
R_L	Load impedance
P_1	Load power
f	frequency
A_e	Toroid core effective cross sectional area

2. Dimensioning

Requirements:
- Load power max 1500 W at 50 ohm (max +61,8 dBm)
- Sample port level -50 dB down from the output (max +11,8 dBm)
- Spectrum analyzer input impedance 50 ohm
- Bandwidth 50 MHz, preferably usable up to 150 MHz
- Minimum design frequency 100 kHz

3. Derivation of formulas

$$i_L = \sqrt{\frac{P_1}{R_L}}$$

$$i_2 = i_L * \frac{N_1}{N_2}$$

$$u_2 = i_2\left(\frac{1}{\frac{1}{R_1}+\frac{1}{R_2+R_S}}\right) = i_2\left(\frac{R_1(R_2+R_S)}{R_1+R_2+R_S}\right)$$

$$i_S = \frac{u_2}{R_2+R_S} = i_2\left(\frac{R_1}{R_1+R_2+R_S}\right)$$

$$P_2 = i_S{}^2 * R_S = \frac{R_1{}^2\, P_1}{(R_1+R_2+R_S)^2} * \left(\frac{N_1}{N_2}\right)^2 =>$$

$$\frac{P_2}{P_1} = \frac{R_1{}^2}{(R_1+R_2+R_S)^2}\left(\frac{N_1}{N_2}\right)^2 = \left(\frac{R_1 N_1}{(R_1+R_2+R_S)N_2}\right)^2$$

4. Selection of components

R_s=50 Ω (Spectrum analyzer input impedance)
Select R_1=10 Ω (arbitrary; must be relatively low in value as for a current transformer burden)
Therefore $R_1+R_2+R_s = R_2+60$ Ω
and by requirement attenuation is : $10 * log\left(\frac{P_2}{P_1}\right) = -50 => \frac{P_2}{P_1} = 10\text{x}10^{-6}$

By selecting R_2=40 Ω,

$$\frac{{}^{P_2}/{}_{P_1}}{\frac{10^2}{(40+60)^2}} = \left(\frac{N_1}{N_2}\right)^2 = 0{,}001$$

By which the transformer can be dimensioned:

- Turns:
  - Primary :N1=1 (main line once through)
  - Secondary: $N_2 = \sqrt{1000}$= 31,6 ≈32

- Peak magnetic flux density

$$\hat{B} = \frac{\hat{U}}{4{,}44\, A_e f\, N_2}$$

For the selecter core

$A_e \approx 50\ mm^2$

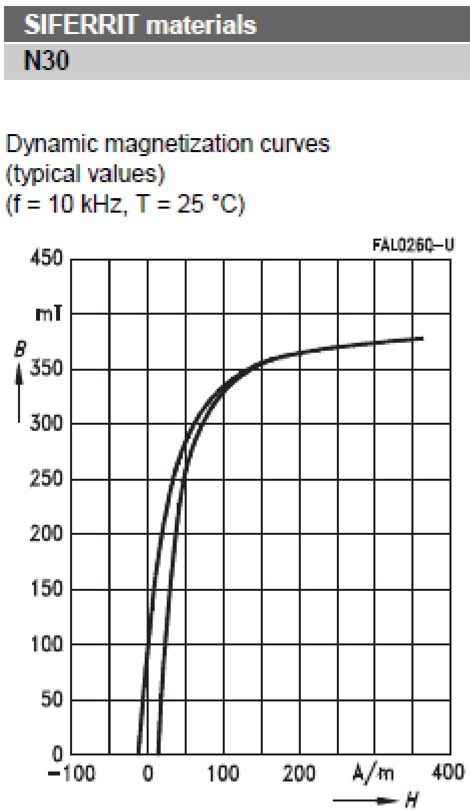
Peak secondary voltage

$$\hat{U} = \sqrt{2}\sqrt{\frac{P_1}{R_L}}\ \frac{N_1}{N_2}\left(\frac{R_1(R_2+R_S)}{R_1+R_2+R_S}\right) = 2{,}18V$$

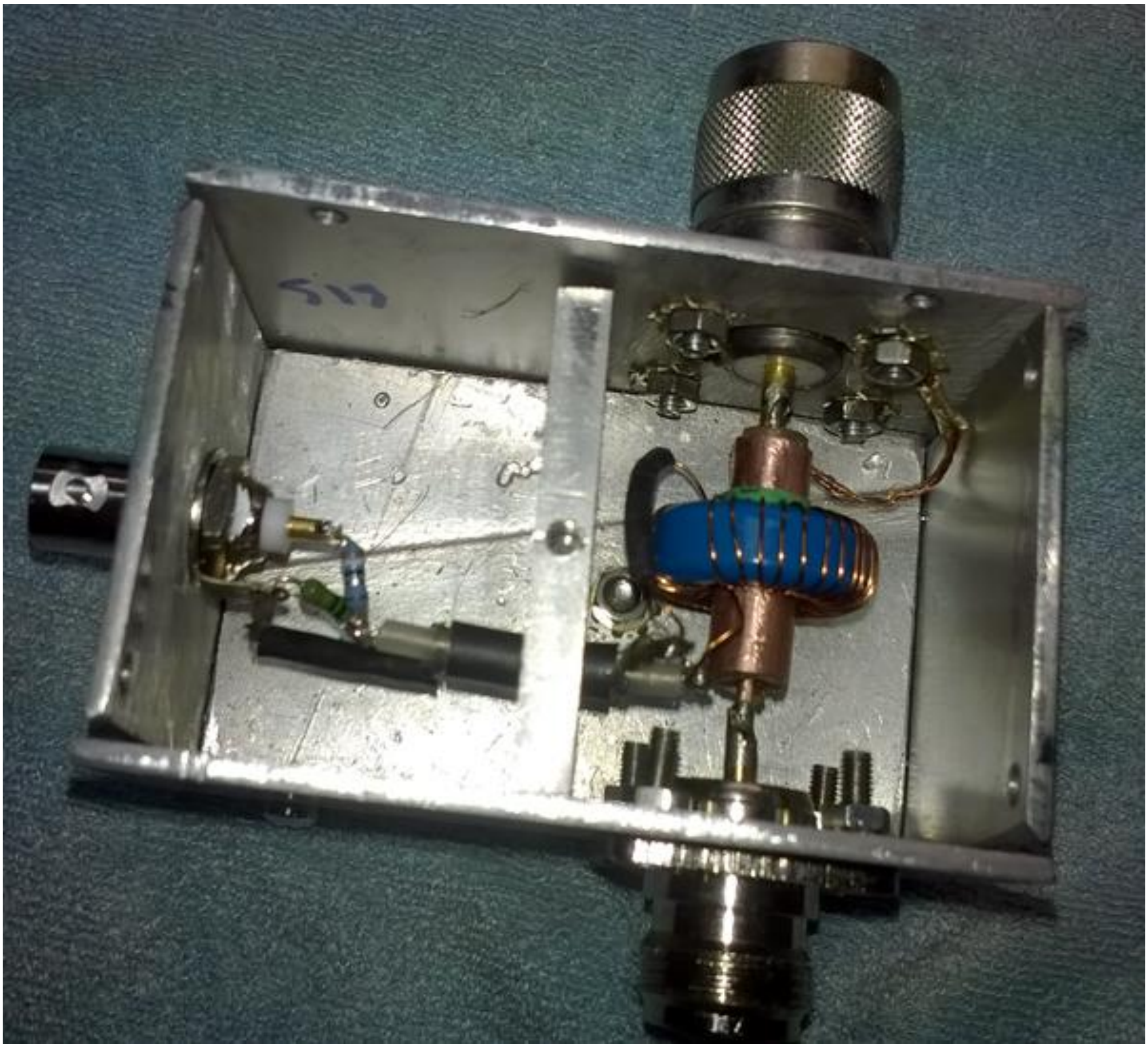
Peak magnetic flux density (at minimum design frequency 100 kHz)

$$\hat{B} = \frac{2{,}18\ V}{4{,}44 * 50 * 10^{-6} m^2 * 100\ x 10^3 \frac{1}{s}\ x\ 32} = 3{,}1\ mT$$

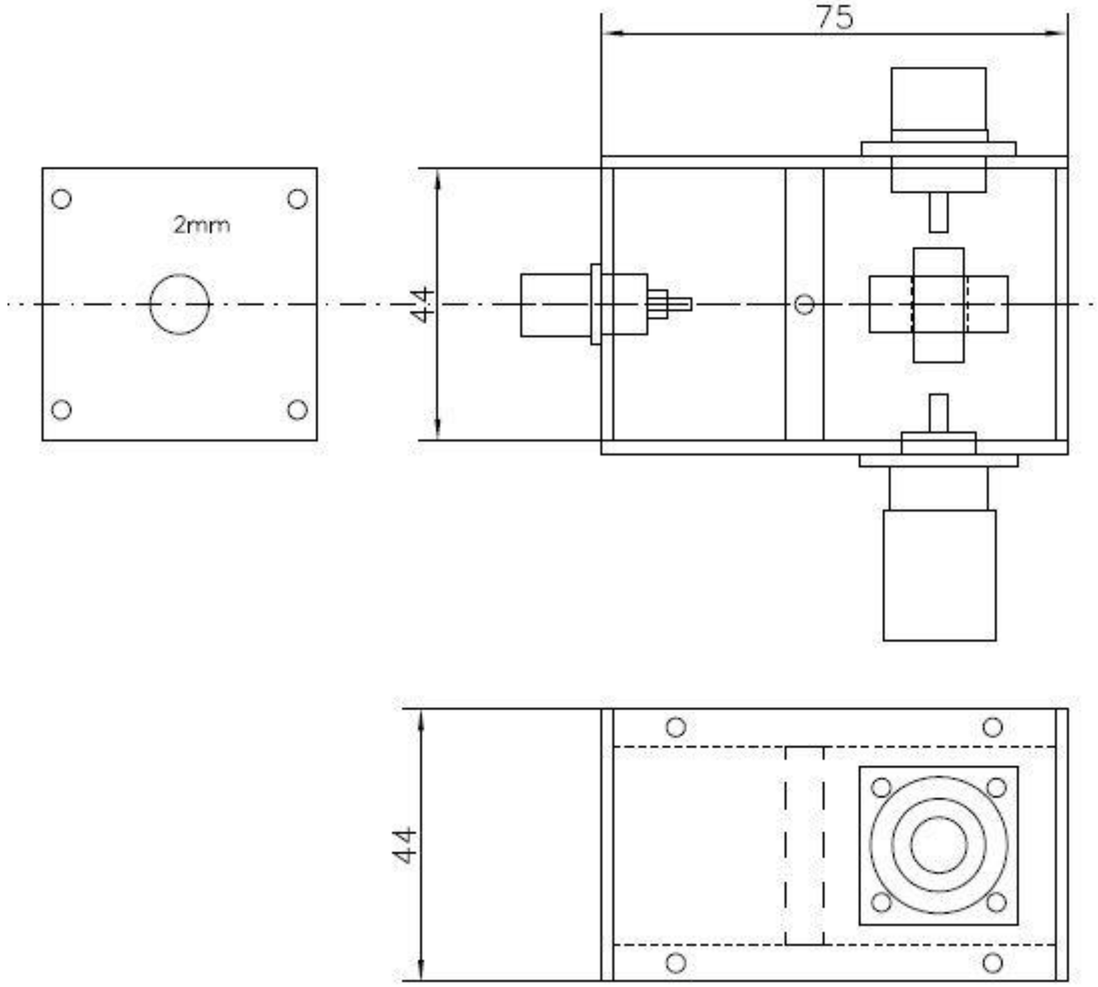
Core is not close to saturation.



5. Mechanical implementation



Input connector : N-male
Output connector: N-female
Sample port connector: BNC
Transformer: Ferrite toroid 22x9x9 N30 AWG 22 magnet wire (enameled copper)
Faraday shield: Copper tubing 8 mm dia
Main line inner conductor: 2,5 mm2 solid copper wire
Main line insulation: Teflon (out of coax cable)
Box: 6mm and 2mm aluminum


75
2mm
44
44

6. Measurements

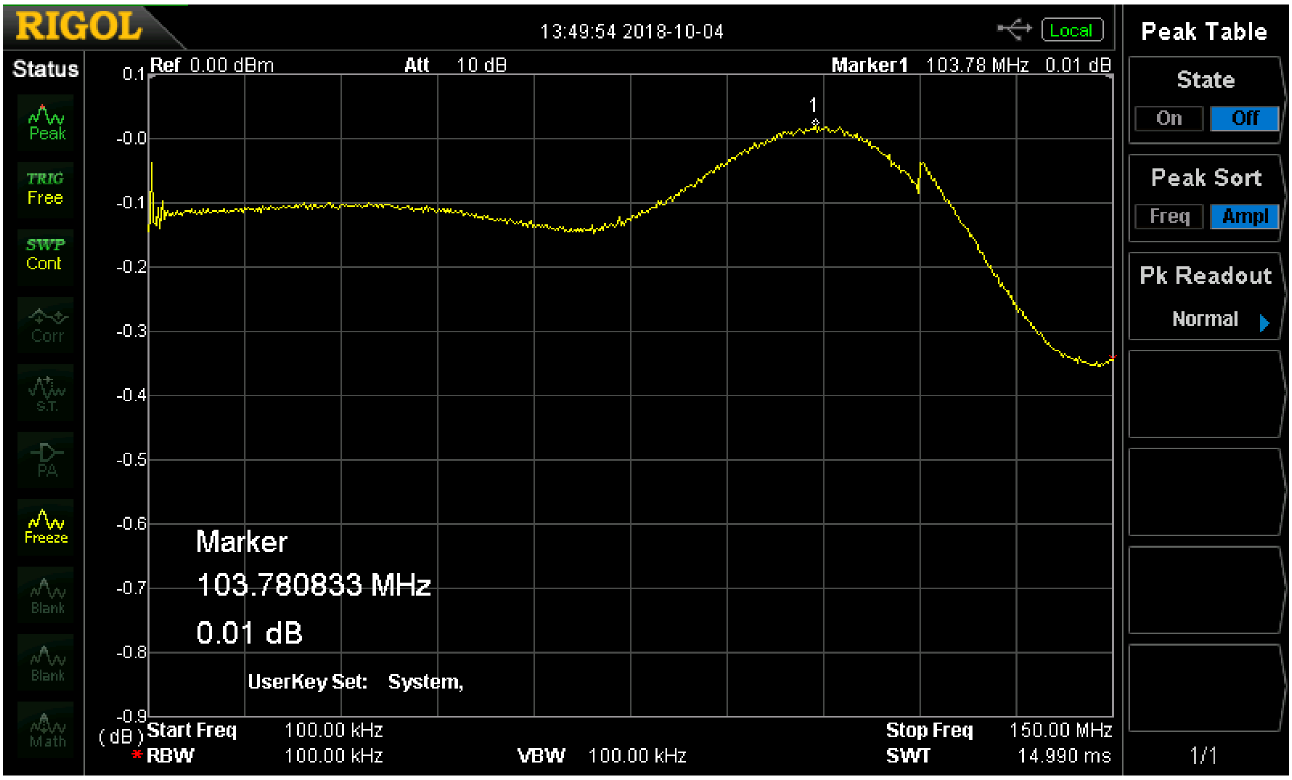


Figure 1. Main line attenuation (insertion loss) 100 kHz-150 MHz.

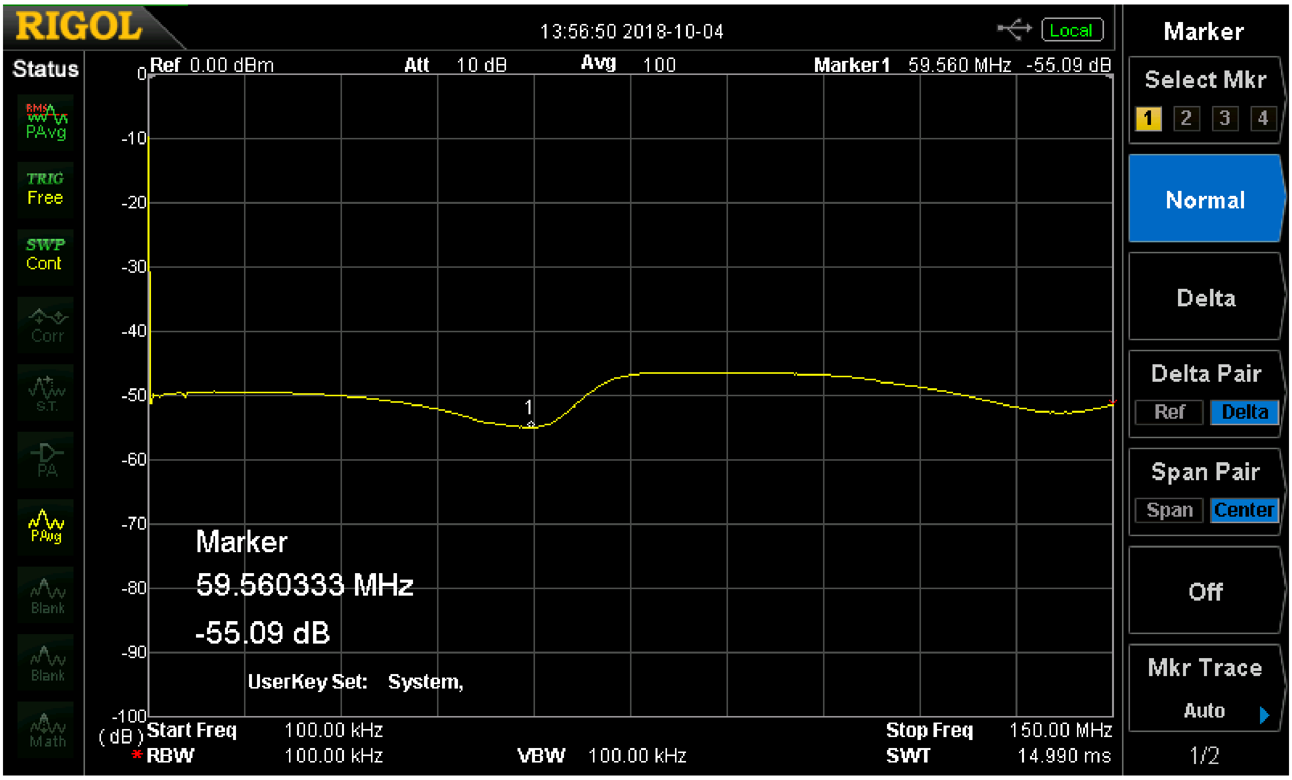


Figure 2. Attenuation at sample port 100 kHz-150 MHz