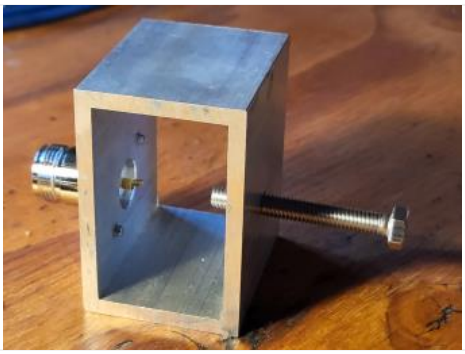
Intro

A given ferrite core of unknown impedance shall be classified by comparing to a ferrite of known material in a simple and effective way.

Test chamber, design and setup near to Kurt Poulsen's chamber [1] and hook up to the VNA as 1 port measurement:



Test chamber: Material = Aluminum, inner dimensions 42 x 32 x 50 mm, screw = stainless steel (none magnetizable), connector = N (UG 58 TG, w. gold plated pin)

About Ferrite Core or Beads Impedance Measurements in brief

Agilent Technologies Application Note [2], Impedance Measurements, pg. 4

> "*Two common methods used to perform impedance measurements with a vector network analyzer are the reflection method using one port and the shunt/series method using two ports.*"

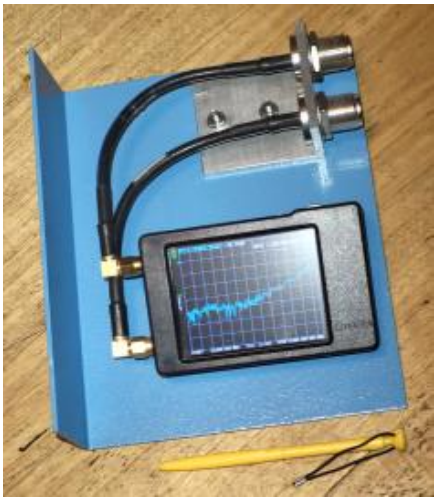
With an impedance Z of the Device under Test near the VNA inputs 50 ohms, S11 measurements (1 port) can be very accurate, while an S21 measurement (2 port) is said to be less affected by diverging VSWR of the test fixture. This is a reason why often S21 measurements are preferred. Tom Hagen and Whitham D. Reeve with Kurt Poulsen, OZ7OU have written a paper, named *Applying and Measuring Ferrite Beads, Part III* [1], documenting their combined efforts and findings measuring ferrite core impedances ending up with an elaborated test chamber design by Poulsen to fit higher frequencies, set to do single port S11 measurements.

Aims

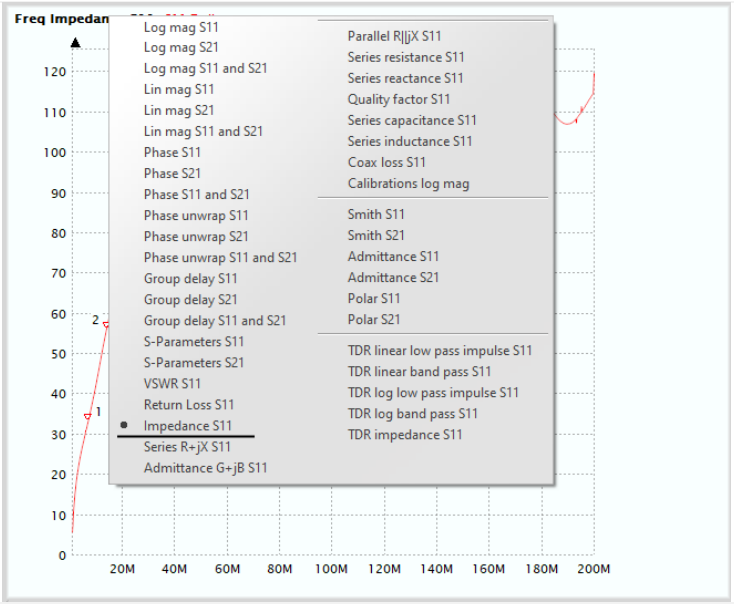
1. Will a setup with a simplified chamber deliver useful data? One test apart from comparing with published impedances could be a 'linearity test'. Thus 1 and 2 and 3 identical ferrite cores were lined up in the chamber and the measured impedances presented in a chart.
2. Classify the impedance of a ferrite core of material FeNiCu against a well-known material 43.

VNA and Setup

Measurement mode in principle: S11 Input Reflection > plotted as *Impedance Z over frequency*



liteVNA62 with the nanoVNA-App



Plot graph > *Impedance S11*

This test is named ***Comparative*** *Ferrite Measurement* as the author thinks absolute values will not be determined with such a simple setup, yet alone the simple chamber, though taken into the calibration of the VNA, will lead to offsets.

This works also with the numerous nanoVNA versions and the nanoVNA-App as the protocol of these and the liteVNA are similar.

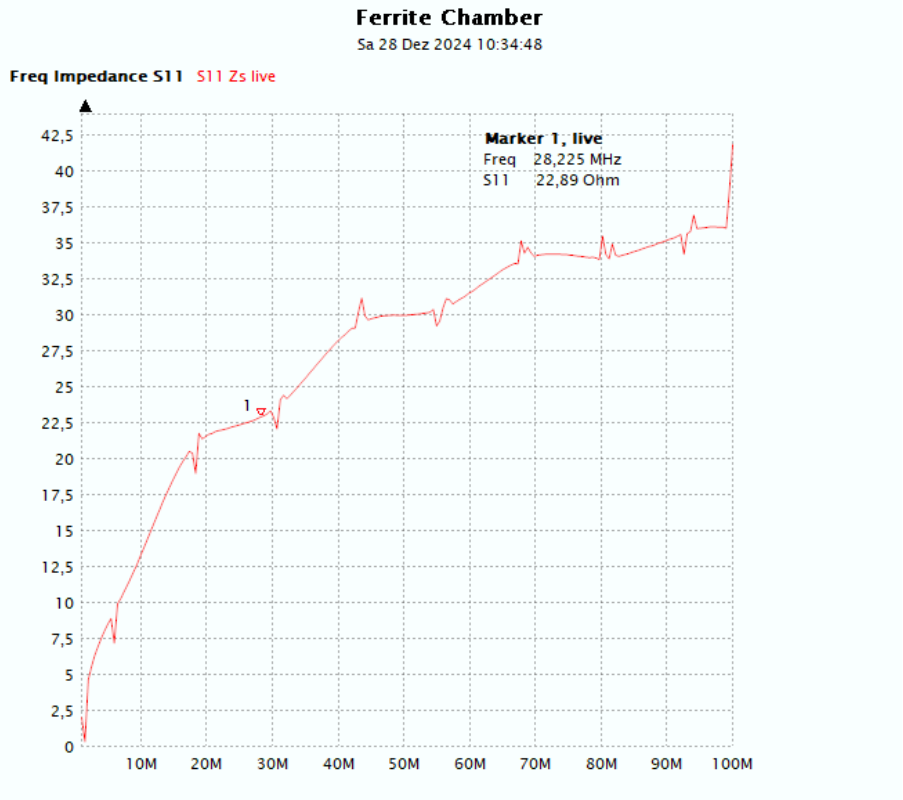
Simplified explanation of S11 Measurement of Impedance

Ferrite cores or beads shall act as a ‘resistance’ against the flow of RF. The test chambers inner, from bushing to screw to walls, short cycles between braid and core of the end of the measurement coax. That is as far as DC is concerned. Hence at 0 MHz the impedance is 0. When placing a ferrite core onto the screw it will hinder AC or RF passing this extended core, the screw, to the braid side to a certain extend. Impedance is a measure for how much the ferrite hinders the flow of RF at a given frequency. We find for example an impedance of 47 ohms at 28 MHz and 64 ohms at 90 MHz.

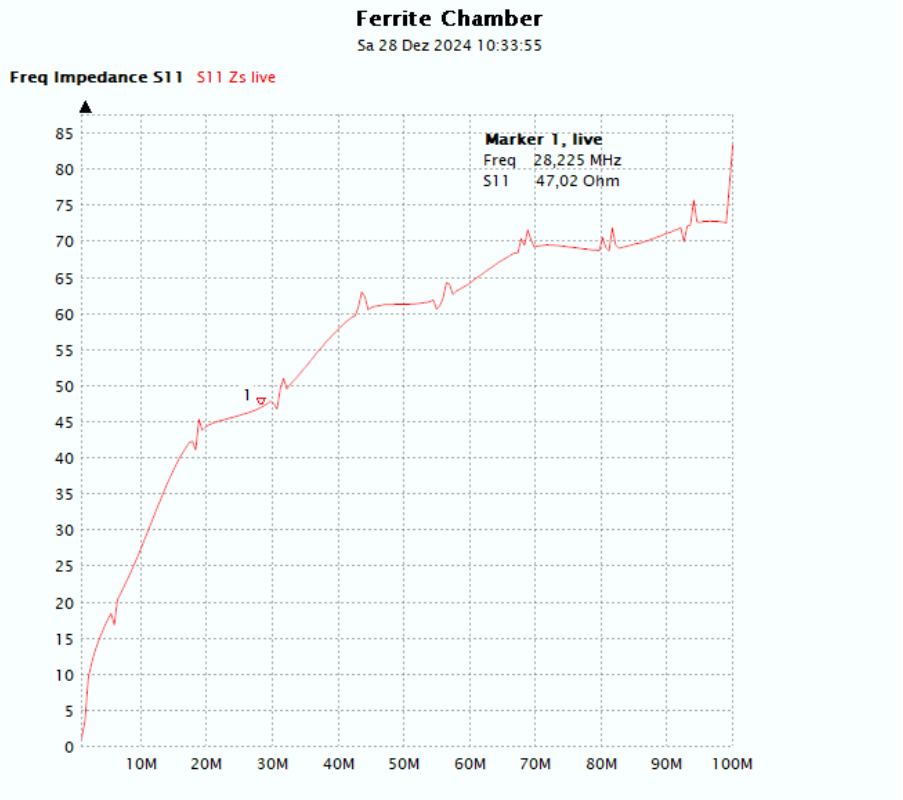
Same mechanism applies when the ferrite is placed on the outside of a feed line coax (common mode choke) near the feed point of an antenna to hinder RF running down the feed line from the ‘cold’ side of a dipole (common mode current). The higher the impedance of the choke i. e. the ferrite core used, the better.

Tests

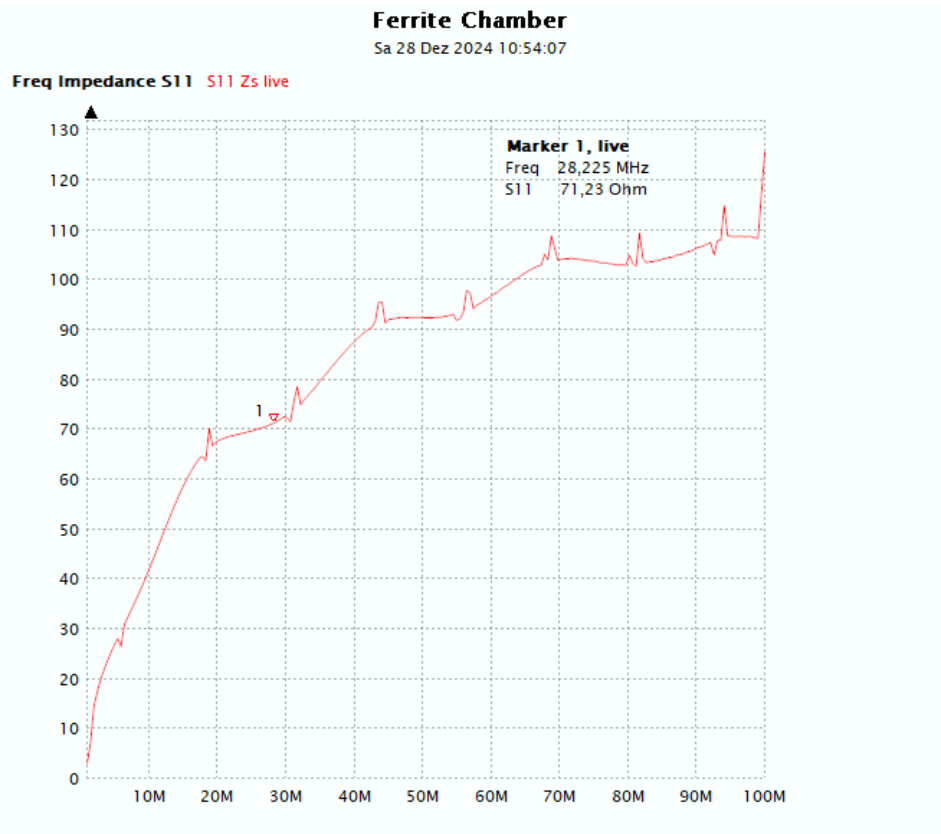
Ferrite: 1 x FT-114-43; Di = 18.8 mm, Da = 29 mm, length = 7,5 mm



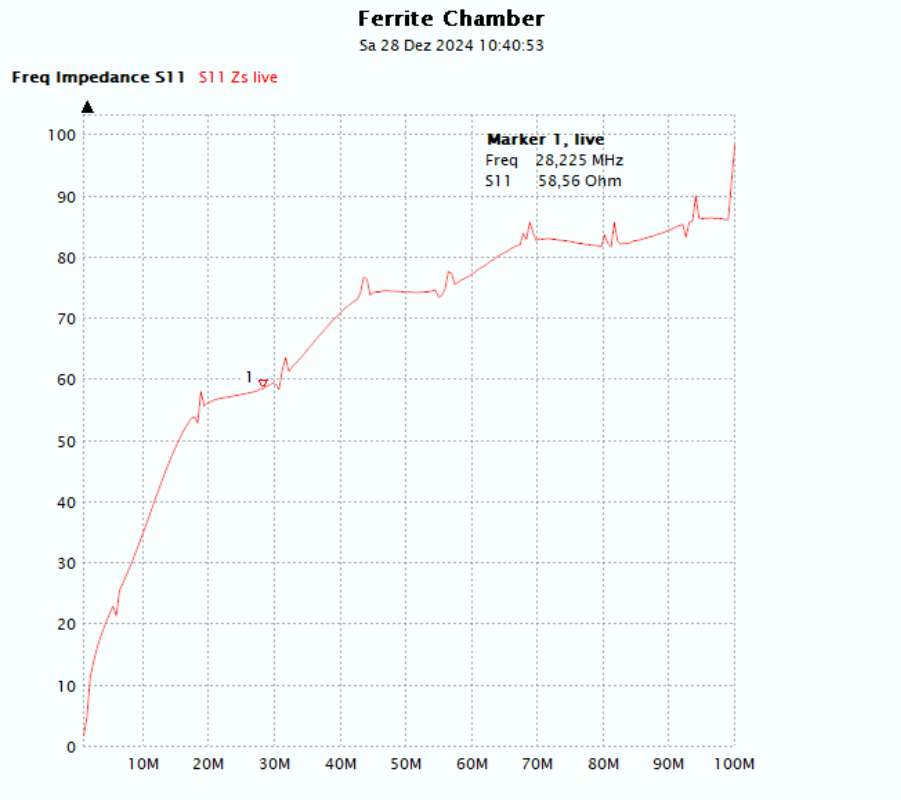
Ferrite: 2 x FT-114-43; Di = 18.8 mm, Da = 29 mm, length = 7.5 + 7.5 = 15 mm



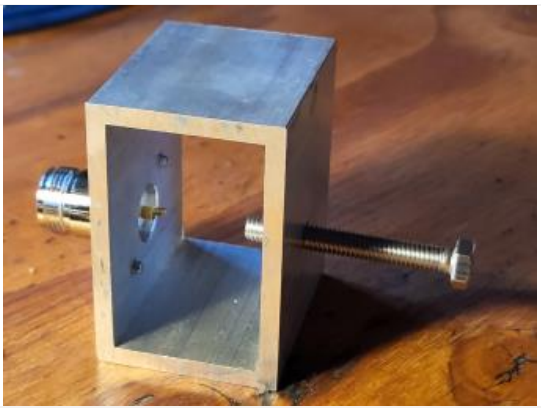
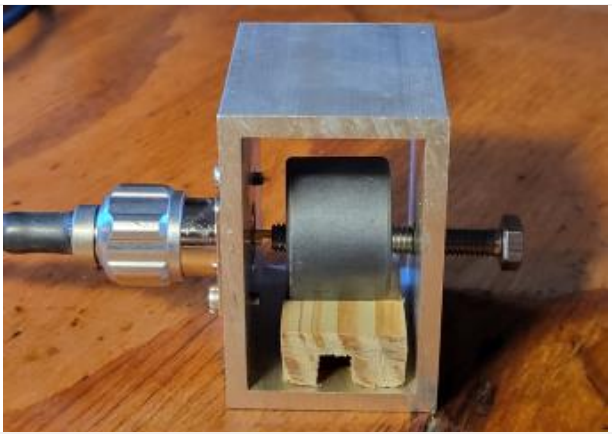
Ferrite: 3 x FT-114-43; Di = 18.8 mm, Da = 29 mm, length = 7.5 + 7.5 + 7.5 = 22.5 mm



Ferrite: 7arrays FeNiCu; Di = 15.7 mm, Da = 27.9 m, length = 20.2 mm



Details

Test chamber, basic setup near to setup by Kurt Poulsen, Tom Hagen and Whitham D. Reeve, *Applying and Measuring Ferrite Beads, Part III*	Reference ferrite core: *Amidon FT-114-43*
	
3 x FT-114-43	1 x 7arrays, FeNiCu (size 2)
	

Equipment:

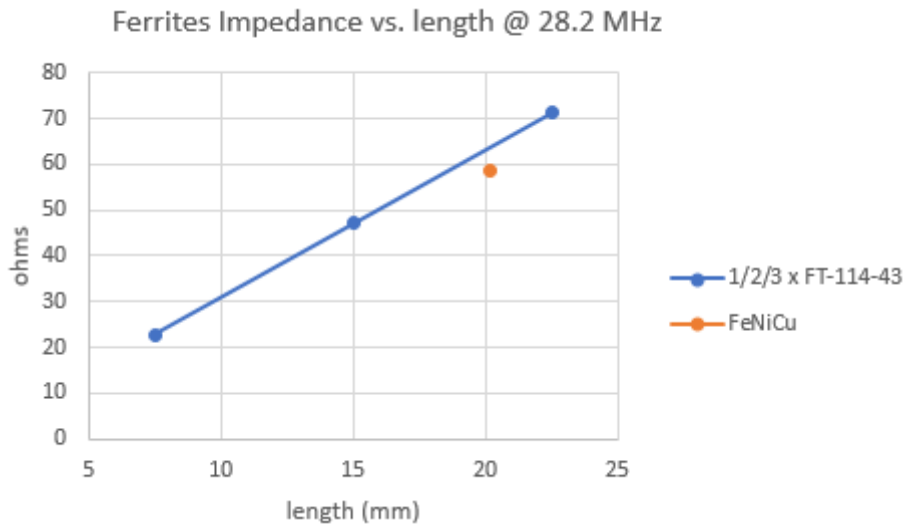
VNA:	LiteVNA62
Coax:	Suhner Enviroflex LF400/4.0 m
Software:	NanoVNA-App v1.1209

Calibration:

50 Ohms:	to be done forehand w. termination load connected instead of chamber. Reference load used: Suhner 65 N 50-0-27.
Open:	test chamber with screw not touching the N.
Short:	test chamber with screw touching the N.

Mind this not a full SOLT calibration. ‘Load’ (Termination 50 ohms) and ‘Through’ are done forehand with the to be used set of measurement coaxes. ‘Through’ is not much relevant for an S11 plot.

Comparation at 28.2 MHz in a chart



Conclusions

Re. Aim 1 - linearity: In the chart line for the 1/2/3 x FT-114-43 we find linearity between the length of the ferrite core(s) and impedance at 28 MHz. The impedance doubles respectively triples with the number of enclosed specimen of FT-114-43 cores.

Re. Aim 2 - Classification of the impedance of a not known ferrite against a reference ferrite:

With respect to the, though nearly same size but still a little differing in total volume and length ferrite cores, a classification of ferrite vs the reference ferrite works out. At 28.2 MHz the FeNiCu ferrite core performs not significantly less to the 3 x FT-114-43'.

Normalising the FT-114-43 measurement yields 3.164 ohms/mm @ 28.2 MHz.
With that the FeNiCu ferrite core shows 8% less impedance @ 28.2 MHz compared to the FT-114-43.

Additional

In their paper *Applying and Measuring Ferrite Beads, Part III*, Kurt Poulsen et all show a chamber consisting of front and rear plate and a number of tubes as intersection to house the ferrite core. So, I also had two plates of aluminum to close the open sides of the aluminum profile i.e. chamber … but the effect on the plot was marginal up to 100 MHz. It is understood that for measuring up to 500 MHz or higher a concentric chamber design per Kurt Poulsen is to be much preferred though.

References

[1] Hagen, T., Reeve, W. D., Poulsen, K.: *Applying and Measuring Ferrite Beads, Part III, https://reeve.com/Documents/Articles%20Papers/Ferrite%20Beads/Reeve-Hagen-Poulsen_FerriteBeads_P3.pdf*

[2] Agilent Technologies Application Note 5989-9887EN, *Impedance Measurements of EMC Components with DC Bias Current*, pg. 4, https://www.keysight.com/us/en/assets/7018-01969/application-notes/5989-9887.pdf