Emulating Electrical Properties of Magnetic Ferrite Tiles

Introduction

WIPL-D Pro is a full wave 3D EM solver based on the method of moments (MoM). It is well known for its ability to solve various EM problems **accurate and faster** than other commercially available tools due to unique features such as:

- Higher order basis functions (up to 2 lambda mesh elements with 8^{th} order of current polynomial)
- Quadrilateral mesh
- Efficient parallelization

The focus of the app note is not on the established qualities of the tool, but rather the usage of the code for the simulation of magnetic ferrite tiles. Such materials are very often used as absorbers in EMC problems. Their characteristics are often unknown so the question arising is how to simulate their characteristic in 3D EM solver.

Magnetic Ferrite Tiles

These materials are usually packed as thin (typically 5 mm) sheets (typically 100x100 mm). Their characteristic is usually their ability to reduce reflection from the material. One example can be TDK IB-017 whose datasheet can be found here:

https://product.tdk.com/info/en/catalog/datasheets/e9e_bdj_003.pdf

The main characteristic is the reflection improvement given as:

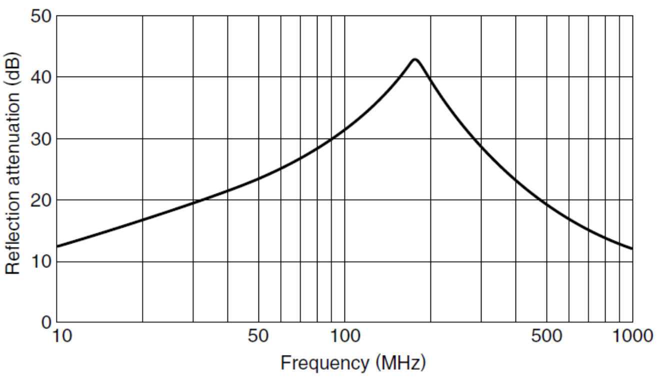


Figure 1. Typical characteristic of ferrite tile material

Although such a characteristic provides all the necessary detail to EM engineer, the question arises **how to simulate such a material in EM solvers**. One reference for the EM characteristic of such materials can be found in the book named Handbook of Modern Ferromagnetic Materials by Alex Goldman at page 578.

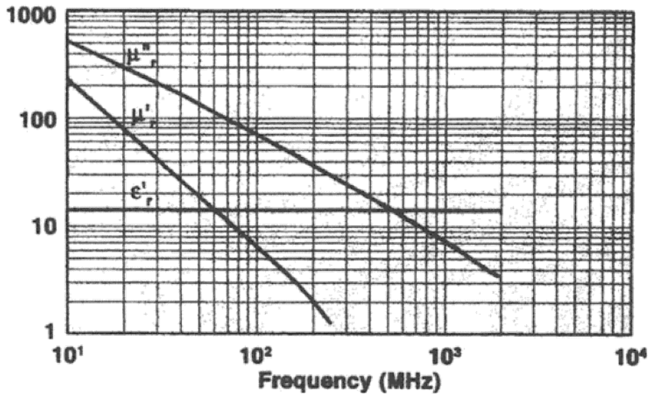


Figure 2. Typical ferrite characteristic

The characteristic can be in short described as constant for electric permittivity (ε_r) and linear for magnetic permeability (both real and imaginary part for μ_r) in log-log scale. Although it is obvious from Figure 2 that the characteristic is frequency dependent, this model might be sufficient.

Method for Extracting Properties

The method to **obtain the equivalent EM properties** for the material shown in Figure 1 is described below:

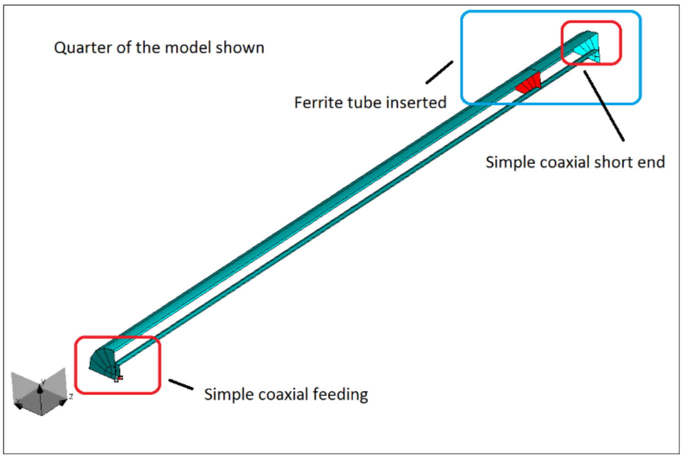
- Choose the 4 points from the graph in Figure 1 and estimate the return loss at the 4 distinct frequencies
- In EM solver model the coaxial tube measurement setup
- Optimize the characteristic of the ferrite material until the best possible match with the return loss from the Figure 1 is obtained.

This will be illustrated on a specific example. From Figure 1, we can estimate return loss at 100, 200, 300, 400 MHz:

Table 1. Return loss from the datasheet

Frequency [MHz}	Estimated return loss [dB]
50	23.38
350	25.25
650	15.90
950	12.35

These are the 4 optimization goals. The simulation model is a simple coaxial cable ending with short circuit. Before the short circuit, the 5.5 mm thin disc of ferrite material is inserted. Before it is inserted, the return loss of short circuit is 0 dB. With the material the return loss is optimized to match the datasheet characteristic in 4 points.



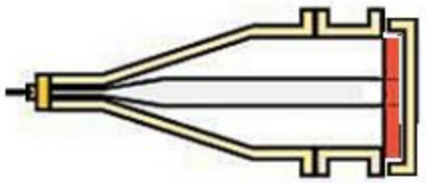


Figure 3. The simulation setup

The material properties are estimated as:

$$\varepsilon_r = 14$$

$$\log(\mu_r) = a \cdot log(f) + b$$

where *f* is the frequency in MHz, *a* and *b* are arbitrary constants. In this case, we split this equation into real and imaginary part. The real part is described with *a* and *b*, while imaginary part is described with *a1* and *b1*. The starting values are estimated from the graph (Figure 2).

Table 2. Material characteristics

Parameter	Initial value
a	-1.2284
b	3.2698
a1	-0.9205
b1	3.6365

The **simulation lasts merely a few seconds** on any given desktop or laptop PC. After it is completed, the comparison of optimized return loss and the datasheet result is given in Figure 4.

Conclusion

This application note demonstrates emulation of ferrite tile electrical properties in **WIPL-D Pro**, a full 3D EM method of moments based solver (with the **WIPL-D Optimizer**). Usually, the electrical property itself is unknown, while the performance of magnetic materials is provided in standard datasheets. Such materials are used as absorbers in EMC problems and thus the problem is of significant importance to electrical engineers.

In measurements, the characteristic of materials is usually determined via the coaxial tube method. A hollow tube is made of the material with the unknown characteristic and then inserted into a coaxial line.

By using a relatively simple expressions for EM properties of material, we can **optimize their performance until they reach the specification given in datasheets**. A coaxial tube method (employed in EM solver) is used as emulation tool, with simulation and optimization performed in WIPL-D software suite. The material in question was selected as TDK IB-017.

We demonstrate that the **efficient usage of EM software** allows simulation of magnetic ferrite tile materials. Although the electrcal properties are given as performance characteristic (from the datasheet), EM properties of the material are obtained by optimization. The simple linear characteristic model yields excellent results, while improved parabolic model yields almost the perfect agreement with the datasheet data. **All simulations are extremely short**, and do not require any particular hardware.

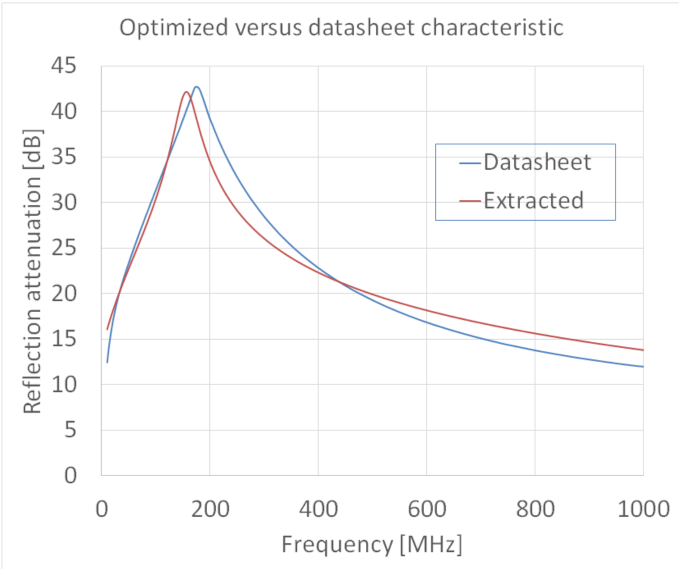


Figure 4. The extracted characteristic

References

[1] Branko Kolundzija; Milos Pavlovic: “Emulating magnetic ferrite tiles properties by WIPL-D software suite”, EUCAP 2017, DOI: 10.23919/EuCAP.2017.7928413, Paris, France

[2] Alex Goldman, Handbook of Modern Ferromagnetic Materials, Springer US, 1999, p. 578