Numerical Validation of the Absorption of Ferrite Material in NEMP applications

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***Abstract*— The goal of the present work is to perform a numerical validation of the absorption characteristics of frequency dependent ferrite tiles surrounded by metallic walls. In particular, we are interested in the absorption performance of the ferrite when illuminated by Nuclear ElectroMagnetic Pulse (NEMP) fields generated using a bounded wave antenna inside an anechoic chamber.**

Ferrite; NEMP; Debye Model; FDTD; Complex Permeability

I. INTRODUCTION

There is a clear tendency in both commercial and military EMC laboratories to install pulsed electromagnetic test systems inside anechoic chambers. The reasons are obvious: (1) protect the environment against the generated high amplitude test fields and (2) take advantage of the available free volume, continuous ground plane and test monitoring equipment. In the particular case of a bounded wave antenna installed inside an anechoic chamber, special care needs to be taken in order to choose the maximum antenna size (determining the test object size) that fits in a given chamber, without the signal in the working volume being affected by the neighboring walls. In this context, FDTD electromagnetic wave simulations using Debye models for magnetic materials can be used to predict the effect of existing ferrite tiles. It is also well adapted for the optimization of the parameters of the ferrite tiles (permeability, depth of the ferrite tile, depth of the dielectric layer between the ferrite and the metallic wall).

II. THEORY

The parameter dominating the absorption of electromagnetic waves in ferrites is the magnetic loss. In analogy with the electric losses in conductors, the magnetic losses are linked to the magnetic conductivity which is a function of the imaginary part of the complex permeability and of the frequency.

Due to its strong dispersive character, the complex permeability of ferrites $\tilde{\mu}_r(f)$ can be described in the frequency domain using a one-pole Debye model as follows:

$$\tilde{\mu}_r(f) = \left(1 + \frac{a_1(\mu_{r1} - 1)}{1 + \mathrm{j}2\pi f \tau_1}\right)\mu_0 \qquad (1)$$

where: μ_{r1} is the static relative permeability of the pole, a_1 is amplitude of the pole, τ_1 is the relaxation time of the pole and f is the frequency.

III. RESULTS

The reflection of electromagnetic waves from ferrites whose permeability corresponds to Equation (1) was evaluated using an FDTD based electromagnetic simulation tool [1]. The results of the simulations were contrasted with theoretical calculations and with experimental results reported in the literature.

A first series of validations were performed in the frequency domain. The experimental setups reported in reference [2] where reproduced by simulation and the results were compared. The frequency range was defined between 30 MHz and 1 GHz. The influence of the depth of the ferrite material, the depth of the dielectric spacing between the ferrite and the surrounding wall and the angle of incidence of the wave were studied.

Following this, a second set of simulations studying the reflection of time-domain signals was performed. The simulation of a real case, consisting on a 1.8 m high bounded wave antenna inside a small anechoic chamber, is worth noting. Preliminary results can be seen in Figure 1 where the effect of the ferrite tiles on the reflection of the electric field can be observed.

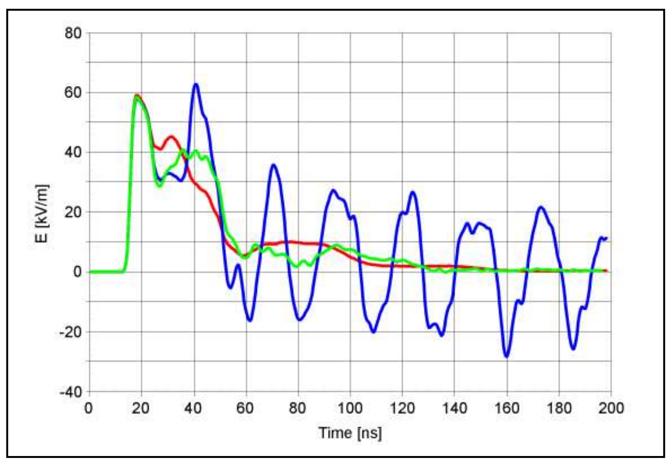

Figure 1. Comparison of the vertical component of the electric field in the test zone of a bounded wave antenna located: (red) in free-field, (blue) in a small sized fully metallic shielded room, (green) in the same shielded room with ferrite tiles covered walls.

REFERENCES

[1] SPEAG, SemcadX Reference Guide, 2013.
[2] C. L. Holloway, R.R. Delyser, R. F. German, P. McKenna, and M. Kanda, "Comparison of Electromagnetic Absorber Used in Anechoic and Semi-Anechoic Chambers for Emissions and Immunity Testing of Digital Devices" IEEE Transactions on Electromagnetic Compatibility, Vol. 39, No. 1, February 1997.