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PRESENTATION TYPE: Poster

TITLE: Including Frequency Dependent Complex Permeability Into SPICE Models To Improve EMI Filters Design

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ABSTRACT BODY:

Abstract Body: EMI filters design is a rather difficult task. This is particularly true for common mode and differential mode inductors. Indeed, engineers have to choose adequate materials, design the magnetic circuit, and choose the number of turns. The final design must achieve the attenuation requirements (constraints) and has to be as compact as possible (goal).

AC analysis is a powerful tool to predict global impedance or attenuation of any filter. However, AC analysis are generally performed without taking into account the frequency-dependent complex permeability behaviour of soft magnetic materials.

That's why, in this paper, we developed two complex permeability frequency dependent models. Both models are build thanks to the references [1], [2] and [3]. Simulated (from one model only) and measured (on a Fe-based nanocrystalline material) real and imaginary parts of the complex permeability are shown in Fig 1.

Once the model fully implemented, 4 different simulations of a complete EMI filter were carried out (see Fig.2):

case "a" : Inductors and capacitors are ideal

case "b" : Inductors are ideal and capacitors are not (replaced by serial RLC model)

case "c" : Inductors are replaced by one of our model, capacitors are as in case 2

case "d" : Windings parasitic capacitances are added to the EMI filter model

It can be seen in Fig.2, that including the frequency-dependent complex permeability model in the EMI filter simulation improved significantly the accuracy (case "c" versus "a" and "b") between 20 kHz and 1 MHz. It is specifically in this range that the permeabilty is changing a lot (see Fig.1). After 1 MHz, it is necessary to add a parasitic capacitor to the model to be more realistic (case "c" versus "d" and measurement).

The extended paper will explain in detail the both models of frequency-dependent complex permeability and how to implement them in LTSpice software. Results of both models will be compared and discussed (some new cases of simulation may be added).

References: [1] Alger P. L. , Induction Machines , Gordon and Breach, New York, 1970.

[2] Katsuya Nomura, Naoto Kikuchi and Yoshitoshi Watanabe, Applied Power Electronics Conference and Exposition (APEC), 2016 IEEE, 10.1109/APEC.2016.7468314

[3] F. Mesmin, B. Ahmadi, H. Chazal, A. Kedous-Lebouc and F. Sixdenier, 2011 IEEE International Instrumentation and Measurement Technology Conference, 2011, Pages: 1 - 6, DOI: 10.1109/IMTC.2011.5944231

KEYWORDS: frequency-dependent, complex-permeability, EMI filters.

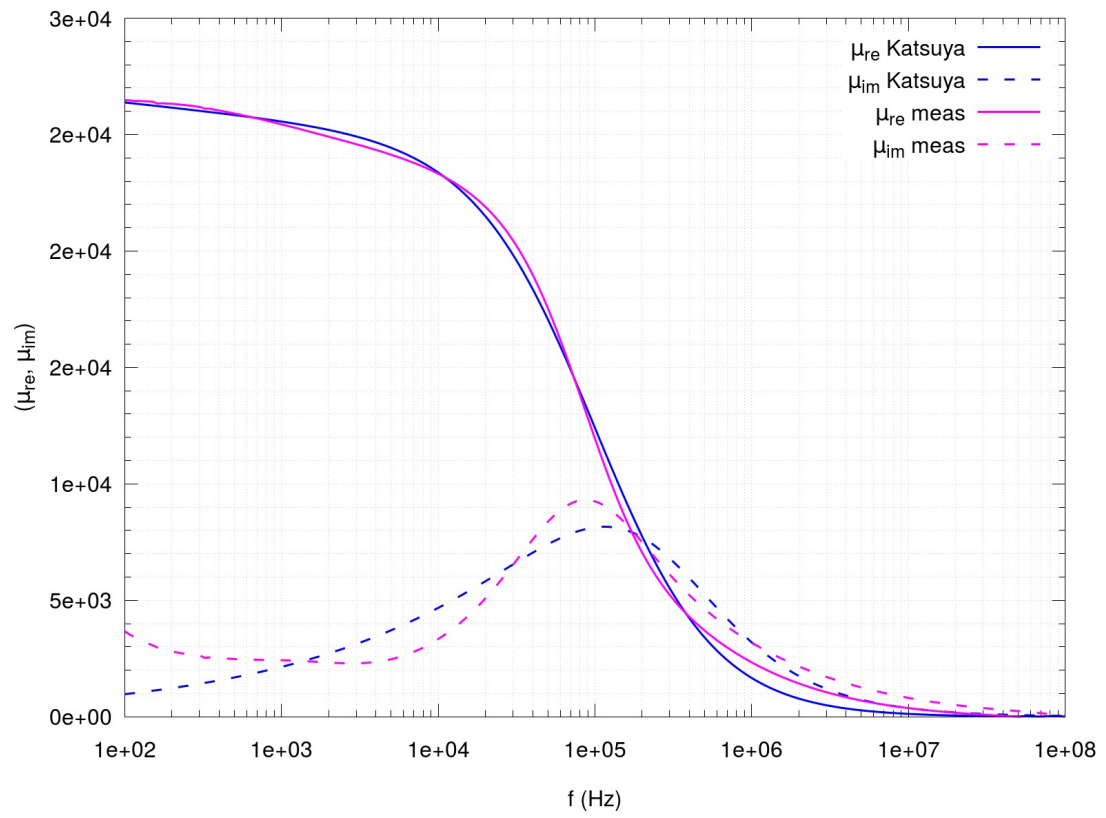


Fig 1 Simulated (blue) and measured (magenta) real (full line) and imaginary (dotted line) part of the complex permeability

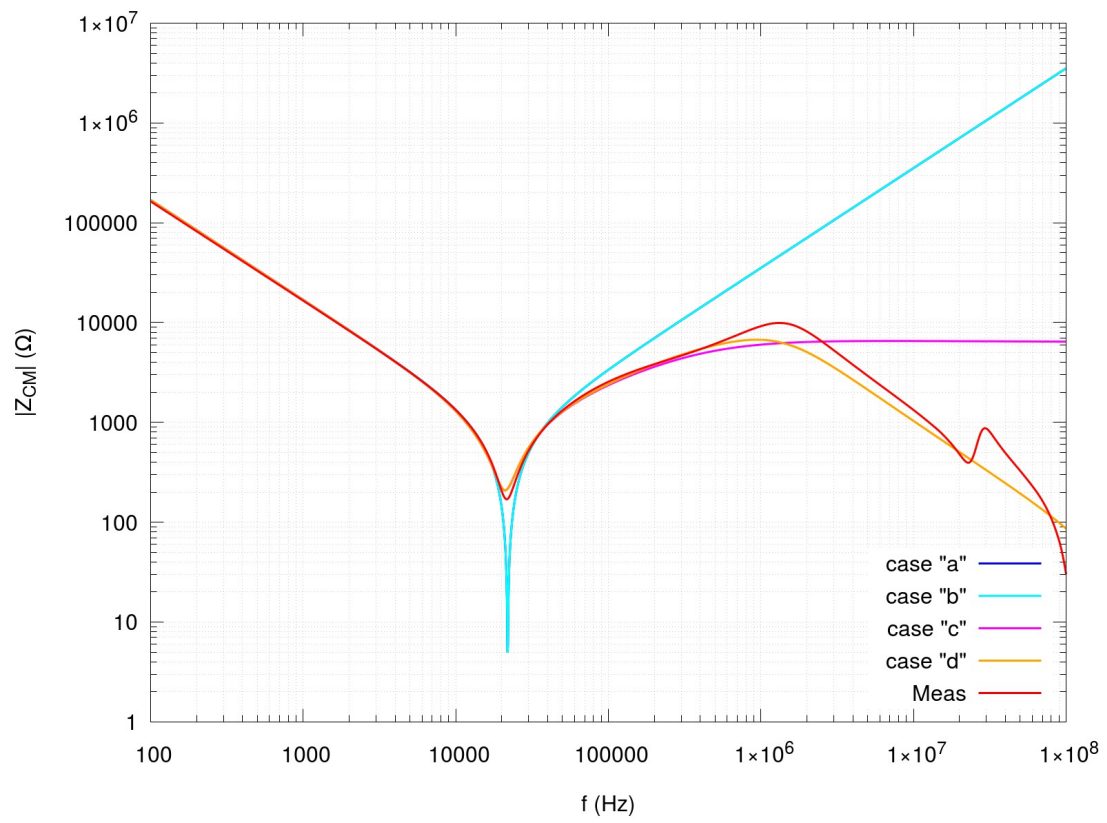


Fig 2 Impedance modulus of the EMI filter versus frequency for simulation cases (a, b, c, d) and comparison with measurement (Meas)

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