Simulation of Core Losses Evaluation in EMI filters using the Jiles-Atherton hysteresis model

Saverio Guzzetta, Elisa Francomano, Fabio Viola, Guido Ala, Pietro Romano

Core loss evaluation is not a simple task, especially in magnetic components that are involved in EMI filters and in power electronics applications: considering the hysteretic behavior of magnetic materials, this purpose can not be rigorously approached all the times. In these applications, magnetic material is exposed to non-sinusoidal flux waveforms, and that is why conventional calculation methods do not lead to good results. EMI filter design can be realized using multi-objective optimization, as reported in [1]: core loss estimation improves this process and allows to achieve the best configuration of the filter.

The aim of this work is investigating the performances of Jiles-Ahterton hysteresis model, available on the AC/DC physic interface in COMSOL Multiphysics, when passive magnetic components are subjected to particular magnetic flux waveforms. The Jiles-Atherton parameters of analyzed materials have been derived from specific scientific literature.

Comsol simulation allows evaluating all of the electrical and magnetic features of the component, it could be a practical tool for the designing process of inductive passive filters. For this reason, investigating the possibility to evaluate core losses with the Jiles-Atherton model is an interesting task.

In this paper, Jiles-Atherton model is compared with models derived from modifications and extensions of the Standard Steinmenz Equation (SSE) in three different cases: triangular flux waveform; sinusoidal with third armonic flux waveform; trapezoidal flux waveforms.

In the first two cases, the applications are referred to a toroidal core of Ferrite and it is reported a comparison between Jiles-Atherton hysteresis model and MSE, GSE, iGSE [2]-[3].

Trapezoidal flux waveform is applied to a toroidal core of VITROPERM 500F, and the comparison is between Jiles-Atherton model and i^2GSE, which is one of the most advanced calculation method that takes in account excess losses [4].

References

[1] G. Ala, G. Giglia, A. Imburgia, R. Miceli, G. Rizzo, P. Romano, F. Viola and S. Quondam Antonio, H. P. Rimal: Design of Soft Ferrite filters for EMI reduction in Power Conversion Systems. IEEE International Conference on Environment and Electrical Engineering and IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), (2018).

[2] J. Li, T. Abdallah and C. R. Sullivan: Improved Calculation of Core Loss With Nonsinusoidal Waveforms. IEEE Industry Applications Society Annual Meeting, pp. 2203–2210 (Oct. 2001).

[3] K. Venkatachalam, C. R. Sullivan, T. Abdallah and H. Tacca: Accurate Prediction of Ferrite Core Loss with Nonsinusoidal Waveforms Using Only Steinmetz Parameters. IEEE Workshop on Computers in Power Electronics, pp. 1-6 (June 2002).

[4] J. Mühlethaler, J. Biela, J. W. Kolar and A. Ecklebe: Core Losses under DC Bias Condition based on Steinmetz Parameters. IEEE Transactions on Power Electronics, vol. 27, n. 2, pp. 953-963 (Feb. 2012)

This work is supported by PRIN2020 ISoREC project, funded by Italian Ministry of University and Research.