LABORATOIRE D'ÉLECTROTECHNIQUE ET D'ÉLECTRONIQUE DE PUISSANCE DE LILLE

Master project, 2017-2018

— *Power electronic DC/DC converter for planar transformer with high parasitic capacitance* —

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Context

Magnetic components (transformer and inductance) play an essential role in power electronic (PE) converters. Regarding integration of magnetic components, Planar magnetics are a prevalent solution. These components made of PCB, or copper foil, combined with low profile magnetic material, are dedicated to embedded and transportation systems like Electrical Vehicles (EV) or aircraft.

One of the main drawback of planar transformer (PT) deals with their parasitic capacitances that can limit power electronic converter functioning. At the opposite, parasitic capacitances, as well as leakage inductances, can be useful for other type of specific PE converters.

Objective

The aim of this study is to work and develop some PE converter suitable with high parasitic capacitances. LLC converter seems an interesting solution when the capacitance value is controlled but other solutions can be explored.

Based on the available transformer presented in Fig.1, the work will focus on the development of a specific DC/DC converter according to the prototype specificities.

The approach will be reversed to some classical design, where components are developed for a converter design. In this work, the converter will be developed based on a central component.

In order to develop the converter some questions need to be answered:

- What kind of converter is more suitable for such planar transformer?
- What is the capacitance values of the planar transformer?
- How to model all these effects?
- How to use its parameters in the best way?

Fig.1: 2.5 kW 2-winding planar transformer

Work steps

The work will be divided in some steps more or less independent:

1. Bibliographical review on power electronic converter suitable with high capacitance value
2. Characterization of the 2.5 kW planar transformer in order to obtain high frequency equivalent circuit.
3. 2-D numerical modeling of the planar transformer: Capacitance calculation
4. Simulation of a complete converter including HF equivalent circuit of a PT
5. Sizing of the converter
6. Conception of the power electronic DC/DC converter

This work will be realized at the Ecole Centrale de Lille and the Bat P2 at the University.
Software: Matlab, PSIM, Pspice, Ansys

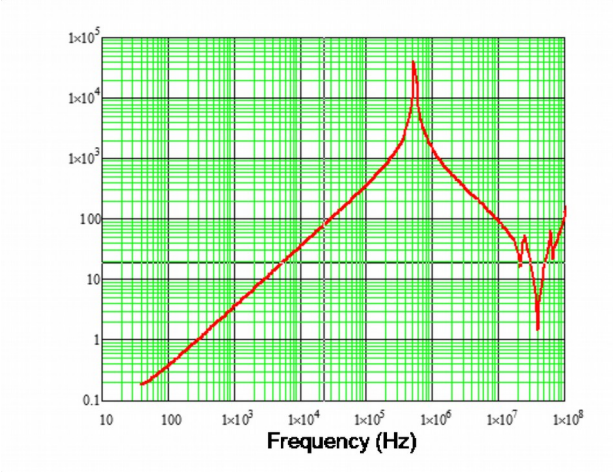

Fig.2: Impedance modulus versus frequency

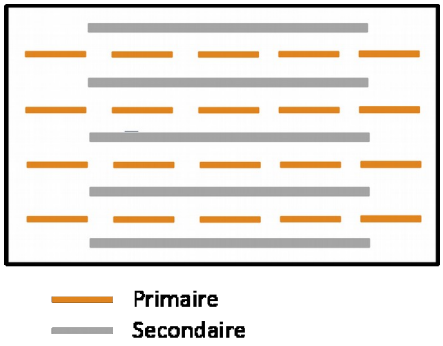

Fig.3: Transformer's winding window

Bibliography

[1] M. A. Saket, N. Shafiei and M. Ordonez, "LLC Converters With Planar Transformers: Issues and Mitigation," in *IEEE Transactions on Power Electronics*, vol. 32, no. 6, pp. 4524-4542, June 2017.
[2] Z. Ouyang, M. A. E. Andersen, "Overview of Planar Magnetic Technology Fundamental Properties," in *IEEE Trans. Power Electron.*, vol.29, no.9, pp.4888-4900, Sep 2014.
[3] Colonel Wm T. McLyman, Transformer and Inductor Design Handbook, 2011
[4] Y. Guan, N. Qi, Y. Wang, X. Zhang, D. Xu and W. Wang, "Analysis and design of planar inductor and transformer for resonant converter," *2016 IEEE Energy Conversion Congress and Exposition (ECCE)*, Milwaukee, WI, 2016, pp. 1-7.
[5] M. A. Saket, N. Shafiei and M. Ordonez, "Planar transformer winding technique for reduced capacitance in LLC power converters," *2016 IEEE Energy Conversion Congress and Exposition (ECCE)*, Milwaukee, WI, 2016, pp. 1-6.
[6] W. Tan, *Modeling and Design of Passive Planar Components for EMI Filters*, Thèse de doctorat de l'Ecole Centrale de Lille, 30 novembre 2012.