LABORATOIRE D'ELECTROTECHNIQUE ET D'ELECTRONIQUE DE PUISSANCE DE LILLE

Virtual prototyping of high-frequency planar transformer

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Context

Magnetic components (transformers and inductors) are essential in power electronic (PE) converters. Regarding integration of magnetic components, Planar magnetics are a prevalent solution. These components are made of Printed Circuit Boad (PCB), or copper foil (Fig.1) for the windings, combined with low profile magnetic material. Planar components are dedicated to embedded and transportation systems like Electrical Vehicles (EV) or aircraft [1, 2].

In such applications, thermal constraints are of main concern for designers. In order to evaluate the thermal distribution inside windings and magnetic core of high frequency (HF) planar transformers a Thermal Automated Tool for Planar Magnetics (TATPM) has been developed in the L2EP. This tool enables to obtain enables to obtain 3D temperature distribution inside windings and core of planar transformers or inductors, in steady state or in transient case [3, 4]. TATPM is a valuable support for the design of planar magnetics

Fig.1: 2-winding planar transformer (100kHz 2.5kW)

Objectives

The aim of this study is to use the TATPM modeling to achieve a more complete virtual prototyping process [5]. The goal is to obtain temperature distribution inside planar transformers based on electrical constraint of power converter. Fig.2 presents a schematic drawing illustrating the principle of this virtual prototyping process. The DC/DC power converter (Full bridge ou Dual Active Bride) generates electrical constraints that vary with the system operations (VE or aircraft). Based on these constraints, copper losses and core ones are computed and serve as input of TATPM. Then the temperature distribution evolution inside the component is computed.

Progress

This work is suitable with master thesis: bibliographical project (*BP*), scientific project (*SP*) and master thesis (*MT*). The work will be divided in some steps:

BP
1. Bibliographical review on HF transformer thermal modeling and HF loss modeling.

SP
2. Exploring TATPM functionalities and simulation of some prototypes
3. Exploring circuit simulation software (PSIM or another one) and MATLAB co-simulations

MT
4. Analytical development of power electronic converter functioning
5. Development of copper and core losses models based on bibliographical review. The models need to be compatible with TATPM and input electrical parameters
6. Computation of TATMP with analytical electrical model
7. Co-simulation tests
8. *(Validation of simulation results with an experimental bench)*

This work is a first step in the development of HF Hardware In the Loop (HIL) emulation [6] of planar magnetic.

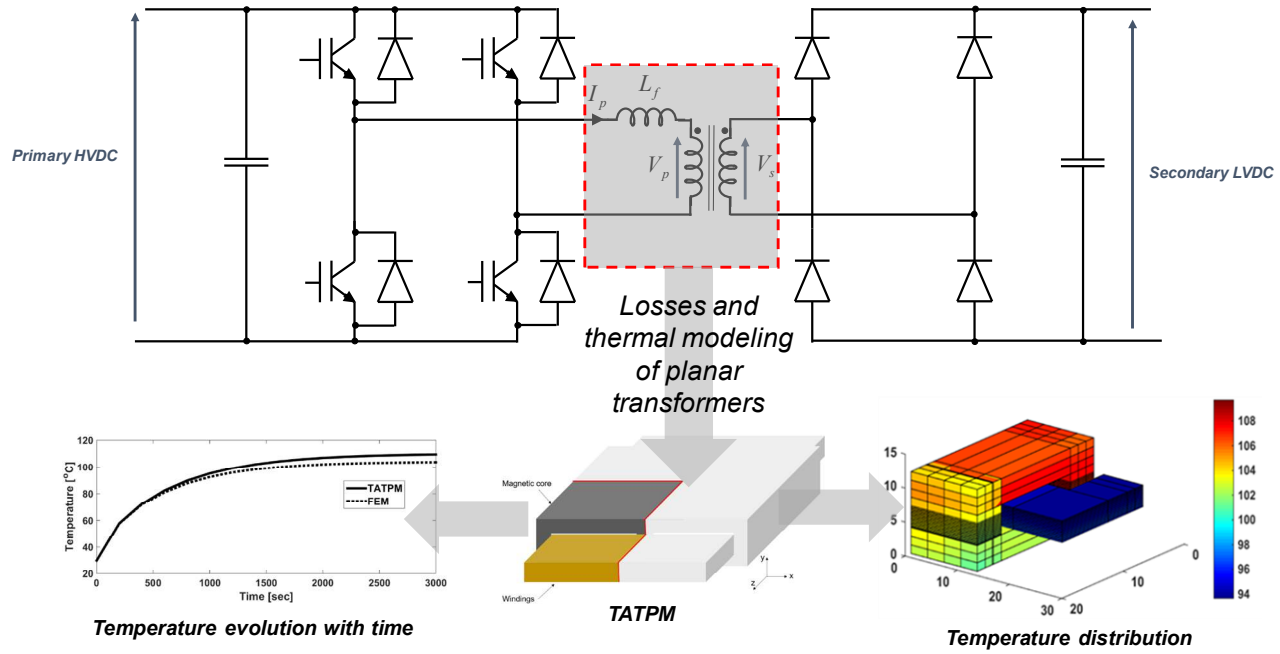

Fig.2: Virtual prototyping for thermal analysis of planar transformers

Keywords: planar transformer, loss and thermal modelling, virtual prototyping

Localization: The work will take place in ESPRIT building with some moves to the Art et Metiers location.

Skills: General knowledge on power converters, use of circuit simulation software, MATLAB programming, *(experimental skills)*

References

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