LABORATORY OF ELECTRICAL ENGINEERING AND POWER ELECTRONICS

Virtual prototyping of HF transformers for SiC reversible automotive battery charger

Postdoctoral Research position, 9 months, Lille, France

Scientific context: The development of high-performance SiC power converters require mastery in the design and the development of High Frequency (HF) magnetics (transformers, inductors). Indeed, these passive components are essential in power electronic converters but as drawbacks, they:

1. Limit compactness of power converter;
2. Increase losses in HF if design is not optimal;
3. Can affect the functioning if their parameters' values are not guaranteed and mastered;
4. Are costly because they need specific studies and designs.

Passive components and especially magnetics appear as the bottleneck of integration and efficiency of power converters. Extensive work on magnetics must be performed to obtain upgraded components to be suitable for the use inside HF SiC-based power converters.

In order to reduce developing cost, virtual prototyping of magnetics is mandatory. Models must be developed to predict the functioning and the performances of HF magnetics in their design step, avoiding costly prototypes. However, because of the increase of switching frequencies due to better SiC active devices, the impact of the surroundings of the component cannot be neglected anymore. A component can no longer be designed alone but all its surroundings must be taken into account in its design step.

Job mission: This job is proposed in the context of a collaboration between Valeo-Siemens and the L2EP, carried out within the framework of a European project about SiC technology development. The mission consists in developing virtual prototyping tools for HF transformers inside SiC reversible battery chargers. The main studies will focus on HF leakage inductance and losses.

In a DC/DC power converter, the leakage inductance parameter needs to be specified and tuned as precisely as possible to enable the soft switching process. The leakage value is usually estimated based on analytical modeling or FEM simulations. The goal of this work is to include, in the design step, the impact of the casing in the transformer leakage value estimation. Indeed, when the HF transformer is packed into its casing the value of leakage inductance varies and sometimes becomes too low to insure the soft-switching. Moreover, the casing induces supplementary losses that need to be estimated.

Throughout the project, 2D and 3D FEM simulations will be performed to model the phenomena. Measurements will be performed on prototypes to characterize components and quantify the impact of housing on leakage inductance and supplementary losses. Analytical or semi-analytical models will be developed to quickly estimate the impact of the surrounding before prototyping. Finally, all the results will be combined in a virtual prototyping tool to be useful for designers.

In collaboration with

Valeo SIEMENS eAutomotive

Period

From 12/2022 to 08/2023.

The position is located in a restricted area (ZRR) within the meaning of article R413-5-1 of the penal code. Your assignment can only take place, depending on your situation, after receiving the opinion of the High Official of Defense and Security (HFDS).

Required skills and tools

Power Electronics / HF magnetics

FEM Software (ANSYS Maxwell 2D/3D), Matlab, Measurement skills

Application procedure

To apply for this job, please send:

- Curriculum Vitae
- One-page cover letter
- Reference letter (if any)

@: xavier.margueron@centralelille.fr

Acknowledgement

This job opportunity is co-financed by BPI-France PSPC program and the European-Union H2020-ECSEL Joint Undertaking

The project started 18 months ago and a postdoc has already worked on the topic for 14 months. A paper was presented at the 2022 EPE ECCE conference in Hanover [1].
The job is in the continuation. It will take place at Centrale Lille Institut – Laboratory L2EP. As part of a European project, the work will be conducted in collaboration with Valeo-Siemens and other academic or industrial partners.

[1] R. Bakri, X. Margueron, W. da Cunha Alves, X. Cimetiere, F. Gillon, A. Bruyere, L. Vatamanu, "Impact of aluminum casing on high-frequency transformer leakage inductance and AC resistance" *2022 24th European Conference on Power Electronics and Applications (EPE'22 ECCE Europe)*, Hannover, Germany, 2022

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