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

Master project, 2020-2021

— High Frequency Electro-Thermal Modeling of Inductors —
— Application to the volume optimization of the component —

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Context

Electrical mobility, like hybrid and full electric cars, the more electric aircrafts, drives the design of static converters for embedded and integrated applications. Volume and mass spared with compact converters help reduce the vehicle consumption. The power density is therefore a critical factor for a static converter, and is mainly impacted by passive components like inductors, capacitors and the cooling system. High switching frequency is usually used to reduce the size of these components, and achieved with wide bandgap transistors.

Nevertheless high frequency comes with drawbacks like higher losses in the components that convert to heat, and interferences that circulate in the converter through the parasitic impedances like the inter-winding capacitance of the magnetics. Bulky EMI (Electromagnetic Interferences) filters are added to the converters, to mitigate these interferences but they impact the overall power density [13] (Figure 1).

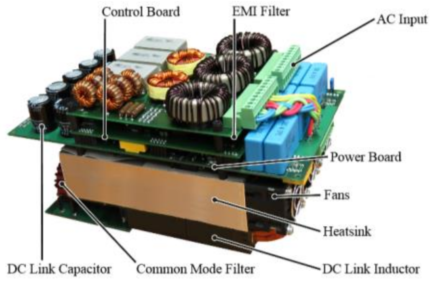

Figure 1: Details of a power converter [1]

Magnetics components provides several degrees of freedom to the designer like shape of core, shape and spacing of windings [12], and choice of magnetics material. The performances of the latter's are dependent of the temperature, therefore to avoid over or under sizing of an inductor a good knowledge of its thermal behaviour is necessary.

This work is part of a continuous work of the team regarding inductors for filtering applications [2-7], and will be in support of an undergoing PhD thesis (PhD Student: F. Salomez).

Objective

The objectives of the work is to develop thermal models dedicated to the optimization of the volume of the magnetic components. Sensitivity analysis will be performed on the models to study new degrees of freedom like the shape of conductors, or the spacing of the winding for example. Indeed, in the literature some Joule losses [8] and iron losses models [9] are available, but thermal exchange models are less studied [10 sec. IV. C, 11] and with no possibility for new degrees of freedom at the moment.

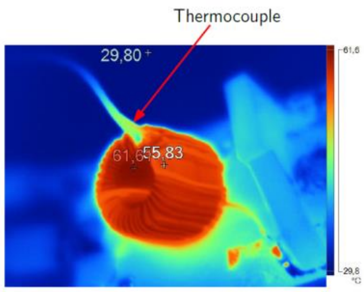

Figure 2: Thermal image of an inductor [2]

The developed models will be used with other models currently developed at the lab regarding parasitic capacitance, and magnetic performance to solve an optimization problem regarding volume vs electrical performance vs thermal performance.

Computer tools based on these models will be optionally developed and added to the toolbox of the team.

Work steps

This work is eligible to master thesis: bibliographic project, scientific project and internship. The bibliographic project will focus on literature review on thermal and losses modeling for inductors. Then during the scientific project a first simple model will be developed and some measurements performed (Figure 2) and finally during the internship the work will be continued according to the student findings.

Skills

In addition to be eager to learn and to be proactive, curiosity, creativity and rigor are wished qualities.
The following technical skills will be appreciated but not mandatory: general knowledge on power electronic converters, use of circuit simulation software, Matlab or Python general programming skills.

Localization

The work will take place at the L2EP laboratory in ESPRIT building (Campus for Science – Villeneuve d'Ascq).

Key word

Power Electronics, Inductor, Loss and Thermal modelling, Electromagnetic Compatibility

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