Master Thesis project, 2022-2023

— AI for the design of HF planar magnetics —

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Context

Magnetic components (transformers, inductors) play an essential role in power electronic (PE) converters (Fig.1). With improvements made on High Frequency (HF) active components with new materials (SiC, GaN), HF passive components have to be upgraded also to be more efficient and more compact.
Planar components are prevalent solution for the integration of power magnetic devices. Indeed, these components exhibit low profile, high power density and high reproducibility compared to other types of HF magnetic components [1, 2]. They can obviously be found on embedded systems (automotive, avionics) for example.
The design of magnetics is a key point of power electronic converter development. In isolated DC/DC converters, leakage inductance and copper losses of HF transformer are parameters of main interest. Thanks to AI, the tuning of these both parameters could bring new high-performance solution in the case of planar magnetics.

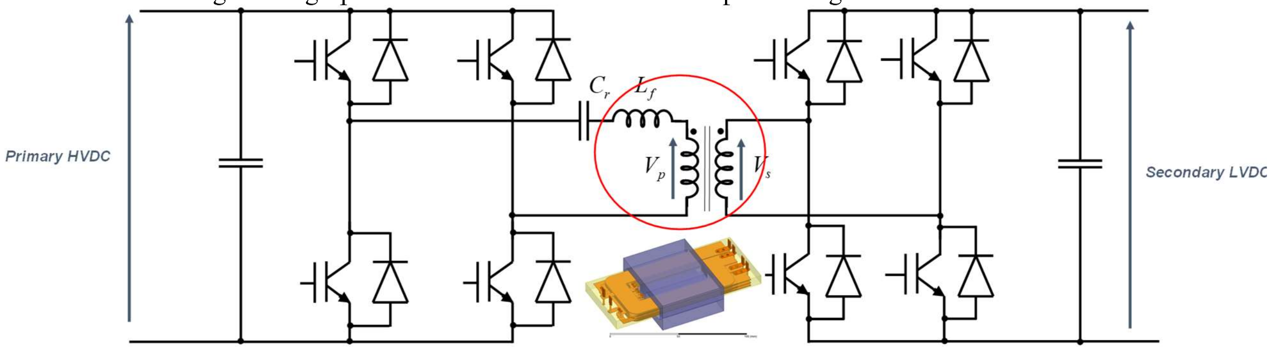

Figure 1: Isolated DC/DC converter with planar transformer

Objective

The goal of this master thesis is to work on the development of AI methods for the design of HF planar transformers. The focus will be on leakage inductance (L_{lk}) and copper losses (R_{AC}) parameters.
Data are available for a 2-winding 6-layer planar transformer (transformer ratio: 2/3) [3]. Examples of winding configurations that minimize and maximize L_{lk} are shown in Fig.2. These data come from multi-objective optimization performed with Finite Element Analysis (FEA) coupled with Matlab optimization algorithm. (Fig.3). 12 prototypes have been developed to validate the previous tuning/optimization. Based on these data, the work of this master thesis will deal with the development of AI method [4-8] to design optimized HF planar transformer in terms of leakage inductance and copper losses
Such AI problem is of major interest for PE designers and manufacturers. Indeed, if the leakage is well controlled and the loss value is minimal, expensive prototypes could be avoided or, at least, further reduced.

(a) ***(b)***

Figure 2: Example of configurations for a 2-winding 6-layer planar transformer: (a) configuration for a minimal L_{lk}, (b) configuration for a maximal L_{lk}

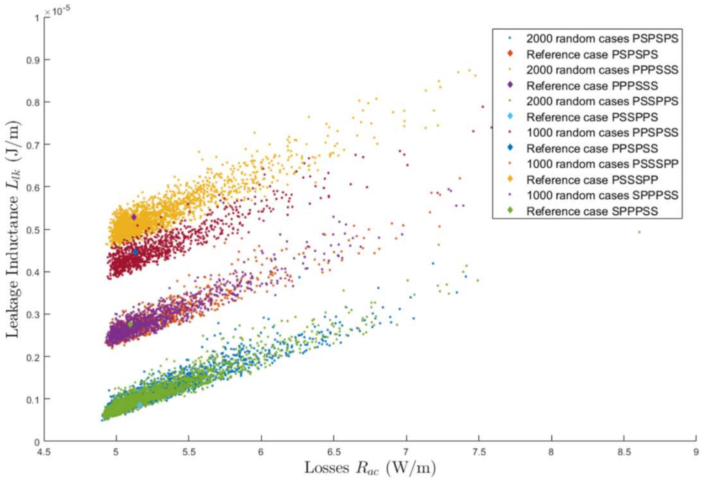

Figure 3: Configuration random cases: L_{lk}=f(R_{AC})

Work steps

This work is suitable with master thesis: bibliographical project, scientific project and master thesis. The work will be divided in some steps:

1. Bibliographical review on planar magnetics
2. Bibliographical review on AI and their application on HF magnetics
3. Study of data from [3]. FEA simulation on test cases (L_{lk} and R_{AC}).
4. Study of code from [5]
5. Application to planar transformers
6. Prototype validation of some designs (conception & characterization)

Keywords

Planar magnetics, Power electronics, AI, Design, Modeling, Leakage inductance, HF copper losses

Localization

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

Skills

General knowledge on power electronics, MATLAB programming, FEA simulations (FEMM)

References

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