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

Master project, 2018-2019

– Optimization of PCB layout for improved performance of GaN-based power converters –

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Context

Electrical energy is managed by power electronics converters in a wide range of applications such as: solar charge controllers, battery chargers (e.g. mobile devices, electric vehicles), uninterruptible power supplies (e.g. data centers), actuators controls and motor drives (aircrafts, electric transportation, industrial applications). In many of these applications, efficiency is an important criteria to save power losses and increase power density.

New power switches using wide bandgap (WBG) materials such as Gallium Nitride (GaN) transistors are now available on the market and allow a significant increase of the converters efficiency (much lower conduction and commutation losses) as well as a strong reduction of the converter size (small devices footprint). However, their extremely fast commutations require careful implementation and proper design on the printed circuit board (PCB) on which they are mounted.

Objectives

As part of the CE2I project [1], GaN devices will be used to integrate a DC-to-AC converter (inverter) into a multiphase motor. A single-leg prototype has been designed recently and tested in the laboratory [2], as a preliminary step towards a complete 10-leg inverter (see *Figure*). However, voltage overshoots and ringing have been observed during the GaN commutations, constraining the transistor voltage rating and generating high electromagnetic noise.

Using the Advanced Design Systems (ADS) software, the commutation behavior will be reproduced by taking into account mutual inductive couplings between the PCB tracks. New arrangements of the power devices and current paths will be proposed to improve the commutation behavior of the GaN devices, reducing the voltage overshoots and increasing the converter efficiency.

Work Progress

- Understanding the transistor switching process in a power converter. Performing a bibliographic study focused on the PCB stray inductances that impact the GaN commutations (in both control and power stages)
- Getting familiar with ADS software to simulate inductive couplings between different tracks of the circuit
- Determining the influential parameters of the power and control stages that impact the transistor switching behavior
- Optimizing the devices placement and PCB layout to improve the GaN operation
- Validating experimentally by physically realizing the optimized inverter leg and performing the measurements in the laboratory

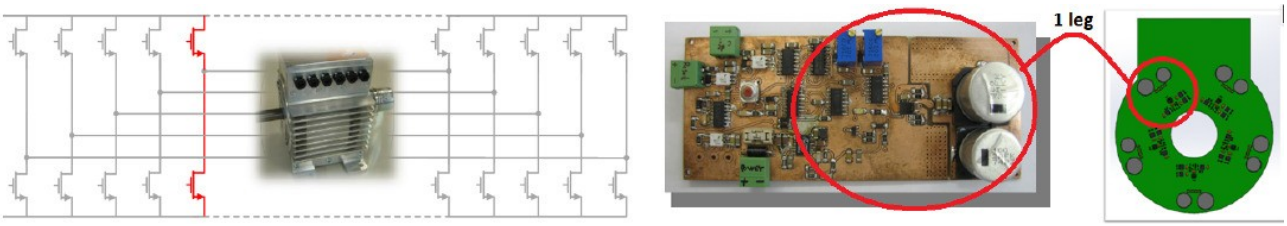

Figure: 10-leg inverter schematic and preliminary single-leg realization

[1] Integrated Smart Energy Converter. URL: http://ce2i.pole-medee.com/

[2] S. Vienot, H. Hoffmann, A. Videt, T. Duquesne, and N. Idir: "*Modeling and experimental analysis of a single leg towards the design of an integrated GaN converter*", in proc Twenty-fifth Symposium on Electromagnetic Phenomena in Nonlinear Circuits (EPNC), 06/2018