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

Master project, 2023-2024

SiC power devices characterization and modeling for embedded power converters

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Context

Electrical energy is managed by power electronics converters in a huge amount of applications from daily-life home appliances to high-power industrial systems. Among them, e-mobility is a sector in heavy need for power electronics [1] due to their many conversions internally involved, such as electric powertrain (DC/AC), auxiliary loads (DC/DC notably), or battery charger (AC/DC). Figure 1 shows an example of various power conversion stages in an electrical vehicle. Among them, the on-board battery charger (OBC) typically ensures single-phase or three-phase AC conversion to the high-voltage battery, including a galvanic isolation stage that makes it a bulky and expensive device. In addition, power losses inside the converter require complex cooling system and impair efficiency. As a result, innovative OBC power electronics structures making use of the newest component technologies and special control techniques are needed. By achieving higher efficiency and power density, they will contribute to meet the high demand of electrical vehicles to improve the cost, available space, and energy consumption.

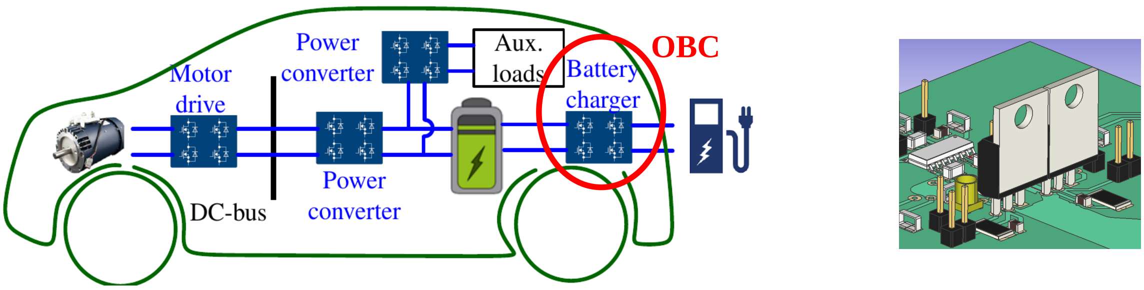

Figure 1: Power converters in an electric vehicle [3] & computer-aided design (CAD) of power electronics circuit

The **Power Electronics** team of the L2EP laboratory carries out a research project focusing on the design and control of high-efficiency and high-power-density OBC. The power devices technologies that operate at the core of the converter have been studied in-depth in previous research, notably regarding new-generation wide-bandgap (WBG) devices such as silicon carbide (SiC) and gallium nitride (GaN) components, that generally offer superior performance over conventional silicon (Si) ones. Various works focused on the characterization [2-4], modeling [5-7], and implementation constraints [8] of WBG devices so as to fully benefit from their outstanding electrical performance and improve the converters energy efficiency and power density. Further, these devices are currently being used to build laboratory prototypes of integrated motor drives [9-11].

Objectives

This research project aims at evaluating and improving the performance of SiC power devices for use in embedded power converter suitable for OBC application.

SPICE software simulations scripted through a higher-level programming language will be used to assess the power losses of SiC devices. Manufacturer model will be used at first, and will further be improved with respect to measurement results of switching transients that will be performed on a dedicated double-pulse test (DPT) board for different operating conditions to assess the model robustness. Notably, characterization and modeling of the circuit stray inductance and of reverse recovery effects [12] will be carried out, as they greatly impair device performance, and notably power losses. Using dedicated software for electromagnetic analysis of the circuit, improved circuit designs will be proposed to make better use of SiC devices in high-efficiency power converters.

Schedule

Motivated candidates apply at the aforementioned email addresses to request an appointment. Latest transcripts should be provided. If the application is selected as part of the master thesis program, then preliminary works will be proposed in the first few months to gradually acquire specific knowledge on the subject. It includes a bibliographic study focusing on SiC devices, and an intermediate scientific project related to circuit simulations and DPT measurement technique. Consequently, the full-time internship in the second semester will take benefit from the former projects and continue toward the aforementioned objectives. The work will take place in the ESPRIT building of the University of Lille.

References

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