Master project, 2022-2023

Comparison of Power Transistor Technologies for Battery Chargers onboard Electric Vehicles

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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.

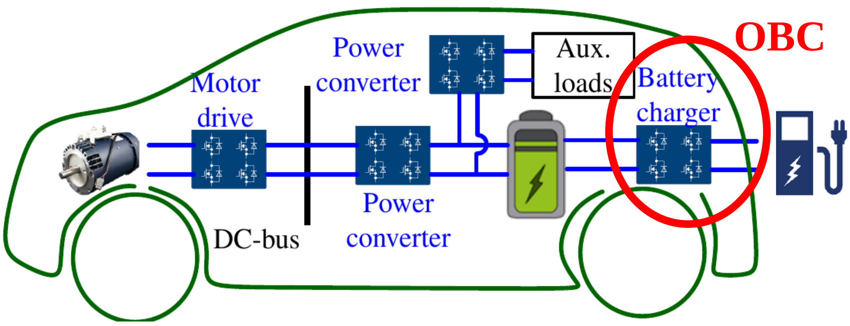

Figure 1: Power converters in an electric vehicle [3]

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 silicon carbide (SiC) and gallium nitride (GaN) components that generally offer superior performance over conventional silicon (Si) devices. Various works focused on the characterization [2-4], modeling [5-7], and implementation constraints [8] of GaN 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 the benefits of wide bandgap (WBG) power devices regarding especially the power losses in a three-phase AC to DC isolated power conversion structure suitable for OBC application.

SPICE software simulations scripted through a higher-level programming language will be used to compare the power losses of conventional and WBG devices. To handle large current with reduced losses, the paralleling technique will be considered, possibly taking into account the influence of self-heating. Parameter variations will be investigated regarding the power flow control at the AC network interface and the switching mode of the power transistors.

Based on the obtained results, an expected efficiency improvement of the converter will be quantified, demonstrating the performance of WBG devices and allowing to determing the optimal components to be implemented for a charger structure and control developed at L2EP.

Schedule

Motivated candidates apply by e-mail at arnaud.videt@univ-lille.fr 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 OBC structures and devices, and an intermediate scientific project related to simulations and estimation of losses. 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.

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