Master project, 2020-2021

Performance Assessment of GaN-based Power Devices for E-Mobility

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Context

Electrical energy is managed by power electronics converters in a wide range of applications including solar charge controllers, battery chargers (e.g. portable devices, e-mobility), uninterruptible power supplies (e.g. data centers), actuators controls and motor drives (aircrafts, electric transportation, industrial applications). Especially, installed power electronics onboard vehicles is rapidly increasing, as the whole European automotive market is expected to include some sort of electrification from mild hybrid to fully electrical vehicles by 2030 [1], calling for numerous power converters such as on-board battery charger, motor drive inverter, and DC/DC converters (Figure 1). This huge demand for power electronics will be driven by the technological breakthrough of new power devices such as SiC and GaN components that will supersede the conventional silicon ones. Indeed, improvement of power electronics technology is a strategic focus towards smaller power losses and reduced converter volume and mass, which saves vehicle consumption and useful space to increase onboard stored energy, resulting in improved overall energy efficiency and mileage of electric vehicles.

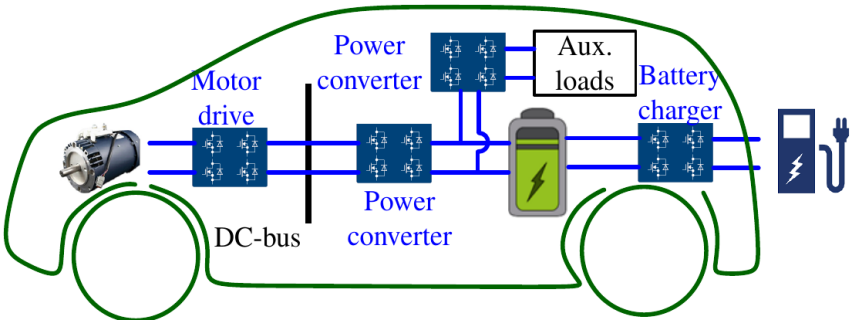

Figure 1: Power converters in an electric vehicle [3]

The Power Electronics team of the L2EP laboratory develops a research activity based on the new switching power devices, especially GaN components that are now commercially available and offer the best performance in a voltage range that is suitable for e-mobility applications. Various works focused on the characterisation [2-4], modeling [5,6], and implementation constraints [7] of GaN devices so as to fully benefit from their outstanding electrical performance and improve the converters energy efficiency and power density. Further, GaN devices are currently being used to build laboratory prototypes of integrated motor drives into an electrical machine [8-10], which can benefit to automotive applications.

Objectives

Proper implementation of the new GaN power devices requires good understanding of the device operation and system parameters under various constraints such as voltage stress and temperature, which must not be overlooked so that optimal design of the power converter can be achieved. For instance, dynamic effects have been reported that directly impact the device performance in terms of power losses [3,4] or implementation reliability [7,9]. For efficient and reliable converter design, it is crucial to evaluate the performance of GaN devices under various operating conditions and its sensibility to surrounding circuit parameters so as to propose guidelines that will allow optimal converter design and ease the adoption of this technology in automotive applications.

This internship proposal aims at supporting the ongoing research of the Power Electronics team by performing GaN devices characterisation and modeling to study the device performance and robustness to various operation parameters. It will be based on the existing models, equipment and know-how of the team and may involve some experimental works on the instrumentation of a dedicated test bench and the associated measurements (Figure 2). System-level computer simulations with dedicated software will be considered to compare the models with experimental data and provide performance indicators such as power losses estimations and comparisons with conventional devices.

Using GaN devices in power conversion is currently a hot research topic as can be appreciated from the reference list including very recent publications from L2EP members. Accordingly, this master project will likely come in support of a newly starting PhD thesis in L2EP laboratory in collaboration with Coventry University, UK, that will focus on the design of GaN-based power converters for e-mobility [11].

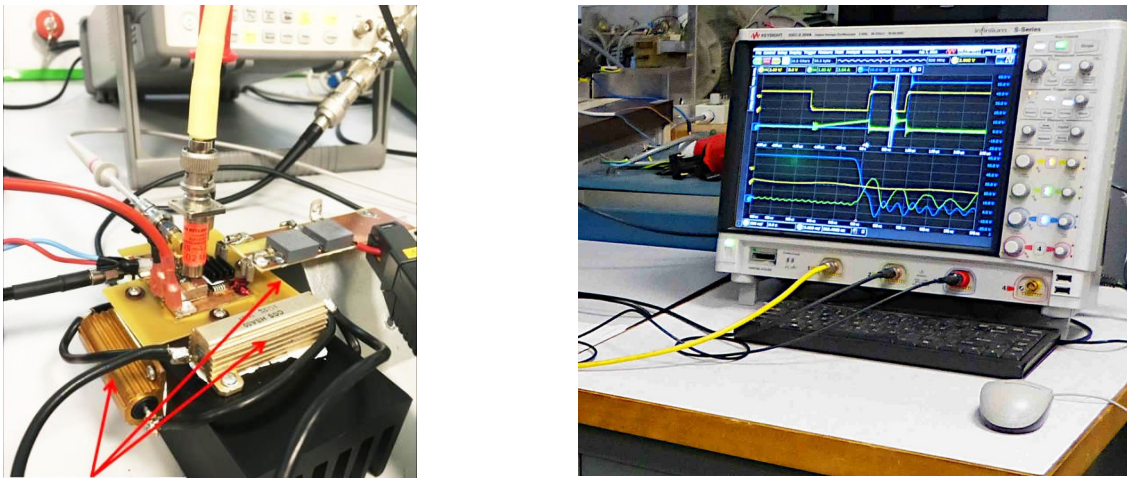

Figure 2: laboratory measurements on a GaN-based power converer

Schedule

Interested candidates can promptly apply by e-mail at arnaud.videt@univ-lille.fr to request an appointment. Latest transcripts may be provided. Useful skills to succeed in this project are solid scientific background and willingness to learn an area of electrical engineering by focusing on devices that assemble into a functioning system, with possible experimental and simulation parts. In-depth knowledge of devices physics is not expected. Preliminary experience in electric circuit simulation or CAD design is appreciated but not mandatory. Expect a few technical questions to evaluate the match with this project and adapt the working progress in an efficient way.

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 state-of-the-art GaN devices, converters and test setups, and an intermediate scientific project related to experimental instrumentation or power losses estimations by simulation. 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.

References

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