

Master project, 2023-2024

Design and realization of a calorimetric test bench to measure losses in power converters

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Context

The energy sector is currently experiencing a revolution thanks to the increasing share of renewable energies on the grid. This includes both, photovoltaic panels and wind turbines. However, these 2 energy sources produce a voltage which is not adapted to the existing grid, making the use of power electronics mandatory. On its side, power electronics is also experiencing a revolution, made this time possible by the launch of new "wideband gap" SiC and GaN components with much better characteristics than Si components already available on the market (Figure 1a). Among all characteristics, low on-state and switching losses of SiC and GaN MOSFET can be especially mentioned, enabling power converters to achieve efficiencies up to 99%. There's no doubt that those components will allow a better use of the energy produced from renewable sources. However, as efficiency in converters increase, characterization and measurement of losses are becoming more and more complex, necessitating the development of new techniques to measure them [1].

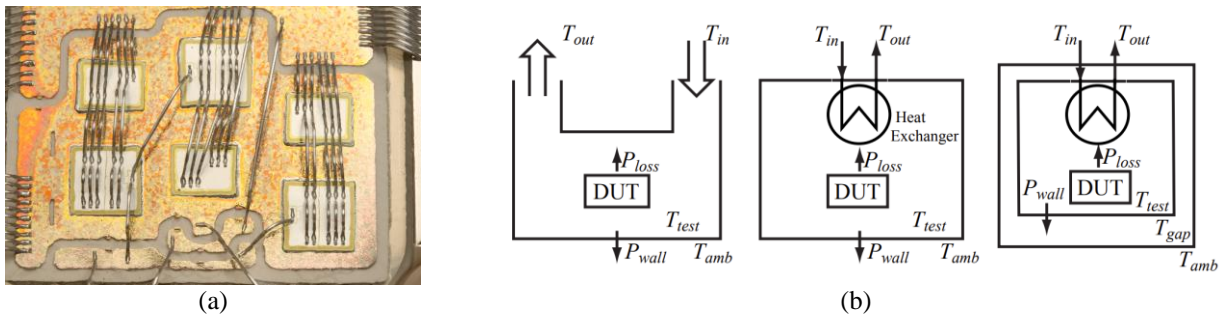


Figure 1: (a) Power electronics layout with Si chips; (b) Schematic open, single-cased closed and double cased closed of calorimetric techniques [2]

In particular, measurement techniques based on power measurements at the converter's input and output are highly dependent on the quality of the measurements, and are not sufficiently accurate to measure losses of highly efficient power converter. For this reason, measurements based on calorimetric methods are becoming increasingly popular [2][3]. However, there is a large number of calorimetric techniques, all of which have limitations at some level (Figure 2b). One of the objectives of the power electronics team of L2EP laboratory is to develop and generate design rules to build innovative power electronics converter using SiC and GaN components. The development of an accurate calorimetric testbench is one of the key elements to achieve such a goal.

Objectives

The aim of the research project is to develop a calorimetric testbench for measuring losses in highly efficient power converters.

The project will be divided in 4 steps. First, the best calorimetric techniques for measuring losses in converters, regarding accuracy, will have to be selected according to the given specifications (loss, volume, accuracy, etc.). Selection of the technique will be followed by simulation phase in order to size and design correctly the future testbench. Then, different parts needed will have to be bought, and assembled to build the bench. Finally, test in real condition will have to be implemented and compared with expectation in order to confirm the measurement accuracy.

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 loss measurement, and an intermediate scientific project related to simulations and calorimetric techniques. 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

- [1] "*Étude et réalisation d'un calorimètre isotherme – Mesure des pertes d'un transformateur planar de 5.5kW*", S. Vagheti, C. Rizet, B. Cogitore, SGE2014, ENS Cachan FRANCE, 2014 url: <https://www.sirepe.fr/pdf/etude-realisation-calorimetre-isotherme.pdf>
- [2] "*Calorimetric Power Loss Measurement for Highly Efficient Converters*", D. Christen, U. Badstuebner, J. Biela and J. W. Kolar, The 2010 International Power Electronics Conference - ECCE ASIA -, Sapporo, Japan, 2010, pp. 1438-1445, doi: 10.1109/IPEC.2010.5544503.
- [3] "*Simple and Precise Calorimetry Method for Evaluation of Losses in Power Electronic Converters*" N. Mary, R. Perrin, S. Mollov and C. Buttay, CIPS 2020; 11th International Conference on Integrated Power Electronics Systems, Berlin, Germany, 2020, pp. 1-6.