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

Evaluation of dynamic effects impacting power losses in high-frequency GaN converters

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Context

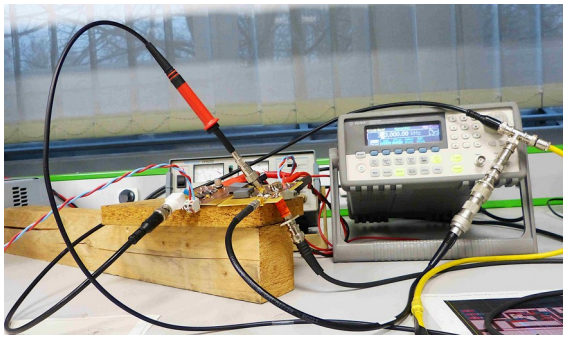
Electrical energy is managed by power electronics converters in a wide range of applications: solar charge controllers, battery chargers (e.g. mobile devices, electric vehicles), uninterruptible power supplies (e.g. data centers), actuators controls and motor drives (aircrafts, electric transportation,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

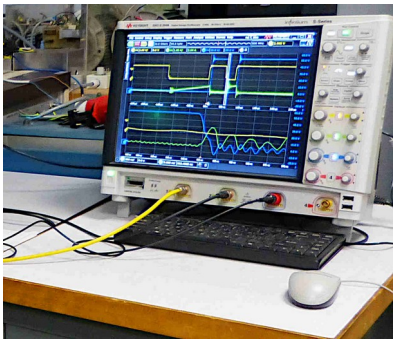
New GaN power switches are now available on the market and allow a significant increase of the converters efficiency (much lower power losses) as well as a strong reduction of the converter size. Yet, they also have a specific behaviour related to charges trapping when the device is in OFF state. This effect impairs the device operation and notably impacts converter efficiency.

Objectives

As part of the CE2I project [1], GaN devices are used to integrate a DC/AC converter with high power density [2]. The overall power losses must be estimated by taking into account the trapping effects such as the dynamic on-state resistance [3]. This issue is currently studied in collaboration with a UK university [4] and needs to be further investigated.

This master thesis subject aims at designing an experimental bench to characterize GaN devices with about 400 volts and 10 amps rating. This test bench will be used to evaluate the trapping-related dynamic effects depending on various operation parameters (voltage, ON/OFF durations). The obtained results will make it possible to evaluate the impacts on the power losses, and thereby on the converter efficiency.





Figures: laboratory measurements on a GaN power switch

Progress

1. Bibliographic study on GaN power switches
2. Specifications and design of the test board
3. Validation of the expected operation
4. Measurements on a commercial GaN device
5. Extraction of behaviour laws
6. Modeling and assessment of converter efficiency

References

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

[2] *"Modeling and experimental analysis of a single leg towards the design of an integrated GaN converter"*, S. Vienot, H. Hoffmann, A. Videt, T. Duquesne, N. Idir, *EPNC conference*, 06/2018

[3] *"Characterisation and modeling of Gallium Nitride power semiconductor devices dynamic on-state resistance"*, K. Li, P. Evans, M. Johnson, *IEEE Transactions on Power Electronics*, vol. 33, no. 6, pp. 5262–5273, 06/2018

[4] *"Experimental investigation of GaN transistor current collapse on power converter efficiency for electrical vehicles"*, K. Li, A. Videt, N. Idir, P. Evans, M. Johnson, *IEEE VPPC conference*, 10/2019