# DC-DC converter multiobjective-optimization for OBC and Fast-DC chargers

## Manuel Gomez
## Supervisors: Prof. Pirri Candido
## Prof. Luciano Scaltrito

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## Research context and motivation

- LLC converter is a mainstream topology for the DC-DC stage of On Board Battery chargers (OBCs) and Fast DC chargers.

- Main performance parameters of these applications are efficiency, power density ,cost and robustness.

- Currently electric vehicle battery voltage are migrating from 400V to 800V, input-series output-parallel, input-parallel output series and input-parallel output-parallel configuration could be exploit in order to further improve performance indices.

- The goal of this research is the development a tool able to map different DC-DC converter (i.e LLC topology+configuration+control strategy+ selected semiconductor and passive component) in a performance space for OBCs and Fast DC charger application. The tool should be able to correlate measurable figure of merits of semiconductors and passive components to the performance indices of the overall system.

- The tool could be use as an optimization tool and to predict the performance of improvement of the introduction of new semiconductor devices or a new technology in a particular application.

## Addressed research questions/problems
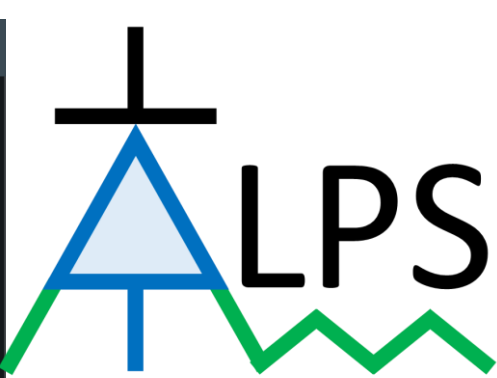
1st and 2nd research years :
- Understanding of the state of the art offered by the market and different optimization trends for OBCs and Fast DC Chargers.
- Definition of measurable figure of merits that take account for the stresses and the operation conditions of semiconductors and passive components in the applications under study

3rd research year:
- Clustering of the component offer by the market for each of the applications under study based on the standard electrical characteristics and the previously defined figure of merit
- Creation of cost models for semiconductors and passive component that allow to estimate the cost of the converter.
- Development of a multi-objective optimization algorithm for the design of OBCs and Fast DC chargers considering efficiency, power density and cost.
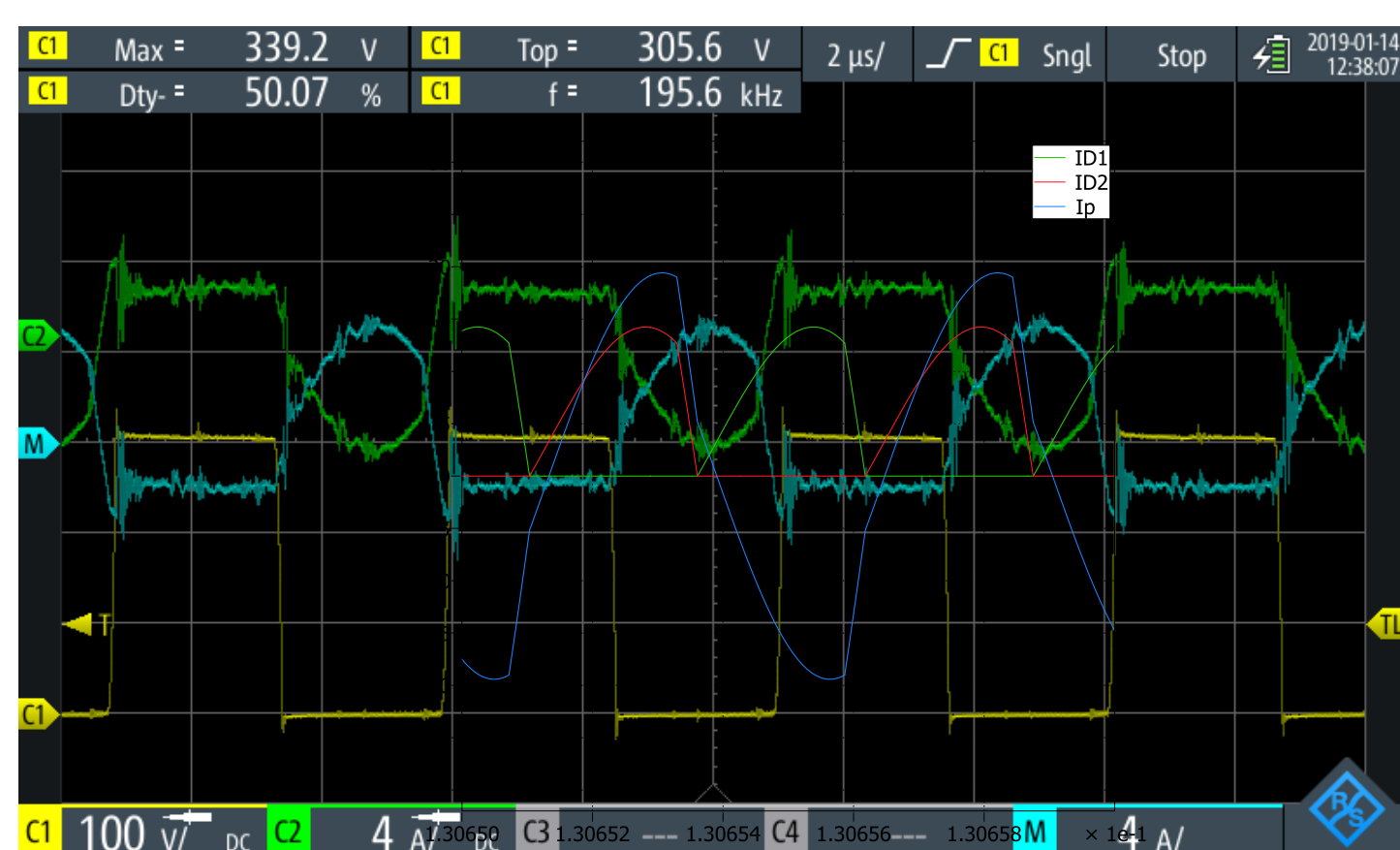
## Novel contributions

- Understanding of the state of the art offered by the market and different optimization trends for OBCs and Fast DC Chargers.

- Definition of measurable figure of merits that take account for the stresses and the operation conditions of semiconductors and passive components in the applications under study

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## Submitted and published works

## Adopted methodologies



INPUT SERIES
OUTPUT PARALLEL

Full Harmonic Approximation

Equivalent circuit of half converter

$$C_{r,eq} = C$$
$$L_{r,eq} = 2 \cdot L_r = 2 \cdot (L_{induttore} + 2 \cdot L_{leakage})$$
$$L_{m,eq} = 4 \cdot L_m$$

Resonant tank gain



@ Vout=500V Iout=1A    @ Vout=500V Iout=5A

DC-DC temperature sensors 15KW @500V; 30-3A; 50°C



## Future work

- Application of machine learning techniques for clustering data and identifying the correlation between the parameters of the diodes and the overall performance of the system.
- Figure of merit definition for diodes in critical applications
- Experimental validation of performance space trajectories dependence on component choice involving different designs for applications.
- Evaluation of the cost benefit relationship between the overall performance optimization of the system and the electrical characteristic of the single component.
- Definition of Visualization techniques
- Application of the development tool to CLLC converter.

## List of attended classes

- 02LPNOQ – Power Electronics (26/02/2018, 6)
- 01PEGOQ – Advance Electronic Drives (25/06/2018, 6)
- 01NNNOQ – Elettronica Analogica e di Potenza (Date, 10)
- 01SCUIU – Visualization and visual analytics (17/11/2017, 4)
- 01SHCRV – Unsupervised neural networks (09/04/2018, 6)
- 01QORRV- Writing scientific papers in English (06/06/2019,15 hours)