MARELLI MOTORSPORT

Master Thesis: Advanced 1MHz Power Planar transformer modelling for motorsport

Our company

Marelli Motorsport has been developing electronic and electromechanical systems for both two and four-wheeled racing vehicles since 1919, supplying leading teams in the most prestigious world championships, as well as manufacturers, sanctioning bodies, and promoters. We design and produce a wide range of highly technological and customizable solutions. We work in close synergy with other divisions to develop technologies for racing vehicles that can be transferred to road cars and vice versa. Our customers include teams from Formula 1, Formula E, WEC, WRC, MotoGP, SBK, and other championships, offering a portfolio of solutions ranging from small data acquisition modules to large power inverters. Our products include Electronic Control Units (ECUs), Vehicle Control Units (VCUs), displays, drivers, regulators, power converters, logic platforms and others.

Background

Isolated power converters, specifically DC/DC converters, play an essential role in the electrical and hybrid vehicle architectures, ensuring the vehicles operate efficiently, safely, and reliably. These converters are pivotal in managing the power flow between the high voltage battery and the low voltage subsystems.

The isolation factor in these converters is crucial, as it provides a physical barrier between the input and output, enhancing safety by preventing electrical shocks, and protecting sensitive electronic components from potential damage caused by high voltage or current transients.

Planar transformers, a critical component within isolated DC/DC converters, bring about a marked improvement in the performance and safety of these systems. Unlike traditional wire-wound transformers, planar transformers consist of flat windings made from conductive sheets, stacked or layered alongside magnetic materials, to form a compact and efficient magnetic core. This design offers several advantages in automotive applications.

Planar transformers can operate at higher frequencies with lower losses, thus reducing the size and weight of the power converters, a crucial factor in vehicle design where space and weight are at a premium. Furthermore, their slim profile and superior thermal management capabilities ensure better reliability and longevity of the system.

Thesis task

The target of the thesis is to build a complete 3D design flow for a power planar transformer for motorsport applications (F1, FE, WEC and others).

The design of a planar transformer will start with the analytical magnetic sizing.

This initial step provides a preliminary design framework, utilizing MATLAB/Excel tools for precise calculations of the transformer's operational points.

Following the magnetic sizing, Finite Element Method (FEM) simulations are conducted using Ansys (Maxwell and 3QD software). These simulations offer deeper insights into the electromagnetic and thermal behaviours of the transformer, enabling the identification and optimization of critical design parameters like core and copper losses, and the evaluation of the transformer's efficiency under various load conditions.

Additionally, FEM simulations are used in estimating parasitic elements, which are crucial for accurately predicting the transformer’s performance in the high-frequency range.

Also topology studies, with several transformers in replacement of a bigger one, can be considered.

The thesis activity will be carried out in collaboration with the R&D department of the Marelli Motorsport with and expected duration of 6-9 months.

Requirements

- Basic knowledge of power electronics converters principles and topologies
- Background on power electronics components
- Good knowledge of MATLAB and FEM concept
- Basic knowledge of analog circuit design
- Analytical skills

Contact Marelli:

Campailla Salvatore

Salvatore.Campailla@marelli.com