Co-supervised Master thesis, 2021-2022

SPeED – Scalability of Power electronic converter for ElectrifieD vehicles

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Context

Due to the new regulation of greenhouse gas emissions in the transport sector, the automotive industry is changing to move toward low and zero-emission mobility. With such an electrification trend, the automakers are facing not only new challenges to address the needs of a dramatically shifting industry but also a tight timeline to respond to the new carbon dioxide CO_2 targets. Thus, there is a need for fast development of electrified vehicles (xEV) and reduce their time-to-market.

This can be achieved by accelerating the design process of the electrified powertrain components, e.g. Voltage Source Inverters (VSI) and Electrical Machines (EM). To do so, scalable component models are of high interest and valuable tools in powertrain simulations and optimization routines. These scalable models allow studying the behavior and performances of different component design choices in a fast way. Hence, scalability can provide results that can serve as a starting point for a final design. In literature, there are considerable works on the scalability of EM. Scaling laws are developed and validated based on finite element analysis to generate different EM designs, based on a reference design. During the scaling process of EM, there is a need to scale the associated VSI as well.

Unlike EM, few studies have been published on the scalability of VSI. Broadly speaking, manufacturers provide power electronics components according to voltage and current ratings of the EM in some discrete sets of values. These devices should be accordingly chosen from a catalog and they can be then modeled and analyzed using the manufacturer's datasheets. This method does allow neither to consider the interaction between the electric drive subcomponents during the sizing process nor to investigate the impact of different VSI designs on efficiency, which results in a sub-optimal design of the electric drive. This master thesis will be done within the STeVE[1] project (Scalability of powerTrain of electrified Vehicles of an Eco-campus), a new collaborative project between the University of Lille (France) and Ghent University (Belgium), and will support an ongoing PhD that investigating the scalability of the different xEV powertrain components.

Objective

The objective of this Master thesis is to develop a scaling methodology of reference traction VSI, to supply different ratings of traction EM for different xEV classes. The scaling methodology should be able to predict the losses for a different range of power. The Master student will first start by doing a literature review on the subject. Then, the next step consists in studying the sizing of different rating VSI and developing a parametrized losses model, that takes into account the different input parameters. Based on the simulation results, the student should be able to model the evolvement of losses during the scaling process and deduce some rules allowing a fast calculation of the scaled losses.

References

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[1] STeVE is one of the projects of the CUMIN program (Campus of University with Mobility based on Innovation and carbon Neutral), which aims to develop a demonstrator campus, based on electro-mobility, in order to reduce greenhouse gas emissions at the campus Cité Scientifique of the University of Lille – https://cumin.univ-lille.fr/