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DOCTOR OF ENGINEERING SCIENCES

of **Dai-Duong Tran**

The public defense will take place on **Thursday, 28th January 2021 at 5pm.**

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MULTIDISCIPLINARY CODESIGN OPTIMIZATION FRAMEWORKS FOR MULTIPORT CONVERTERS AND HYBRID ELECTRIC POWERTRAINS

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Abstract of the PhD research

Plug-in hybrid electric vehicles have been demonstrated as auspicious solutions for ensuring improvements in fuel-saving and emission reductions as well as a good transition towards full electric vehicles. From the system design perspective, there are numerous indicators affecting the performance of such vehicles. The optimization of energy conversion systems such as power electronics converter and the optimization of powertrain components plays crucial role enabling high-efficiency, high power-density at a concurrently lower total cost of ownership, weight, volume and less development time.

This PhD dissertation has proposed a novel simultaneous codesign optimization framework (COF) to optimize the power conversion stage and dual-loop controller of a non-isolated interleaved boost converter in a wide bandgap-based multiport converters (MPCs) such as SiC-based MPCs and their multifunctionalities. The COF adopts a non-dominated sorted genetic algorithm to solve a multi-objective optimization problem including four objective functions (i.e. input current ripple, the total weight of inductors, power losses, and integral of time-weighted absolute error). Moreover, a post-processing algorithm, namely average ranking, is applied as a decision-maker to select the best solution among the optimal solutions of the Pareto frontier. As a consequence, the optimal solution including the number of phases, switching frequency, and inductor size can be determined optimally. To validate the merits of the proposed design framework, a full-scale 60kW prototype of SiC-based MPC has been built and experimentally tested in our ETEC laboratory. In this dissertation, advanced real-time digital controllers based on dSPACE platform have been developed towards fast dynamic performance and fast prototyping approaches.

In this dissertation, an advanced nested-codesign optimization framework is developed for the powertrain systems of plug-in hybrid heavy-duty vehicles such as buses and trucks. The proposed co-design framework composes of an optimal control strategy using an equivalent consumption minimization strategy, which is nested into a component sizing optimization loop employing genetic algorithms. Considering a particular transport assignment, the optimization objective is to find the optimal sizing of key components such as internal combustion engine (ICE), electric motor (EM) and battery system to minimize a total cost of ownership of the powertrain (denoted as $pTCO$) without impairing the performance requirements. The $pTCO$ includes the investment cost of main powertrain components and operational cost over the vehicle lifetime. In the proposed nested codesign framework, the ICE power, EM power and battery capacity are optimally selected as design variables of the optimization problem. The optimal solution of the developed GA-based codesign framework is verified via a comparison with the brute force search method.