Development of a High Power, High Voltage DC-DC Converter for Fuel Cell Electric Vehicles with 800V DC Bus

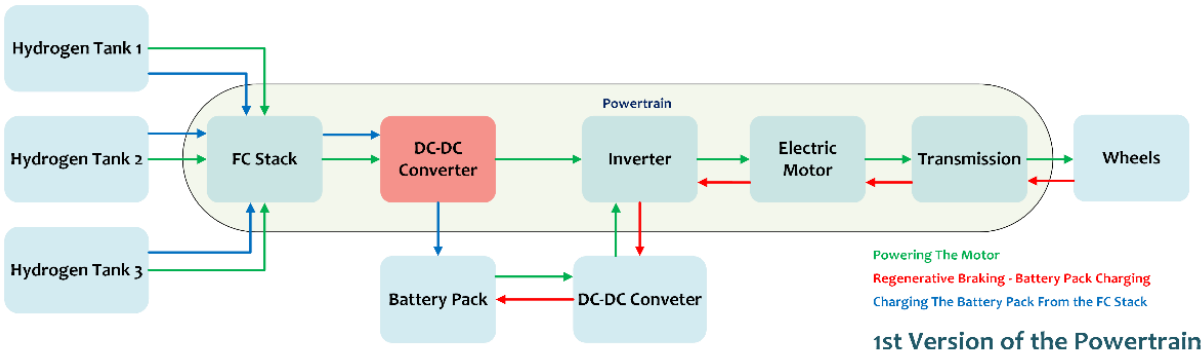
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The automotive landscape is rapidly evolving with the growing adoption of 800V electrical architectures, which offer greater efficiency and increased range. However, integrating fuel cell systems, into these new platforms presents a technical challenge for which there is not yet a standard solution.

This PhD thesis, conducted in an industrial partnership with VALEO, aims to address this challenge by developing a high-power (100kW), high-power-density DC-DC converter. To define the system specifications, a comprehensive analysis of existing powertrain architectures and components was conducted. A modular approach, based on four 25kW converters, was adopted to ensure scalability, fault tolerance, and efficiency at partial load.

To date, the work has focused on the creation of a dedicated design toolchain. This includes developing Python-based tools for magnetic component design and optimization (ferrite and powder cores), and for estimating SiC transistor switching losses via automated LTspice simulations.
Building upon this foundational toolchain, new tools are now being developed specifically for the critical task of multi-objective topology optimization. These tools are tasked with the comparison of candidate DC-DC converter topologies for our 25kW module, by evaluating them against a unified set of performance objectives and physical constraints, with a primary focus on minimizing total semiconductor losses, reducing magnetic component volume, and enhancing overall efficiency. The final stage of this research will leverage the selected optimal topology, applying a market-component-driven optimization process that utilizes comprehensive databases of commercially available SiC devices, capacitors, and core materials to finalize the sizing and selection of all parts, ultimately guiding the construction and experimental validation of a highly efficient and compact prototype.



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