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# Design, Control and Experimental Validation of an 800 V Wide-Bandgap Power Converter for Fuel Cell Traction Applications

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# Declaration

I hereby declare that, the contents and organization of this dissertation constitute my own original work and does not compromise in any way the rights of third parties, including those relating to the security of personal data.

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Fuel cell electric vehicles represent a promising solution for high-efficiency and zero-emission transportation, but their adoption strongly depends on the availability of high-performance power electronic converters. In particular, the low and variable output voltage of fuel cell stacks requires efficient, compact, and reliable high-voltage conversion stages capable of interfacing with modern traction inverters.

This dissertation presents the analysis, design, control, and experimental validation of a high-voltage wide-bandgap power conversion system for fuel cell traction applications. The work focuses on a multilevel interleaved DC/DC converter based on GaN devices, complemented by a high-power SiC-based DC/AC traction inverter. A systematic analytical approach is developed to evaluate magnetic and electric stresses of active and reactive parts, demonstrating that the proposed four-leg multilevel interleaved architecture achieves a sixteen-fold reduction in the maximum peak flux ripple of the equivalent inductive path compared with the conventional bidirectional switching cell, together with a fourfold increase in effective ripple frequency. These characteristics enable reduced passive component size while preserving high efficiency and low current ripple.

A fully digital multi-loop control architecture is proposed for the DC/DC stage, including dedicated loops for differential current balancing and split DC-link voltage regulation. Small-signal modeling provides straightforward tuning guidelines and ensures stable operation and fast dynamic response. The control strategy is experimentally validated on a 75 kW prototype, achieving efficiencies above 98%.

The thesis further addresses the design and validation of a 150 kW SiC-based traction inverter and introduces an innovative back-to-back testing methodology for mapping full-power efficiency. Experimental results confirm the effectiveness of the proposed architectures and control strategies, demonstrating their suitability for high-power fuel cell electric powertrains.