Analysis and Design of Fully Integrated Planar Magnetics for Primary-Parallel Isolated Boost Converter

A high efficient planar integrated magnetics (PIM) design approach for primary-parallel isolated boost converters is presented. All magnetic components in the converter including two input inductors and two transformers with primary-parallel and secondary-series windings are integrated into an E-I-E core geometry, reducing the total ferrite volume and core loss. The transformer windings are symmetrically distributed into the outer legs of E-cores and the inductor windings are wound on the center legs of E-cores with air gaps. Therefore, the inductor and the transformer can be operated independently. Due to the low reluctance path provided by the shared I-core, the two input inductors can be integrated independently, and also the two transformers can be partially coupled each other. Detailed characteristics of the integrated structure have been studied in this paper. AC losses in the windings and the leakage inductance of the transformer are kept low by interleaving the primary and secondary turns of the transformers substantially. Because of the combination of inductors and transformers, maximum output power capability of the fully integrated module needs to be investigated. Winding loss, core loss and switching loss of MOSFETs are analyzed in-depth in this work as well. To verify the validity of the design approach, a 2-kW prototype converter with two primary power stages is implemented for a fuel cell fed traction applications with 20-50 V input and 400-V output. An efficiency of 95.9% can be achieved during 1.5-kW nominal operating conditions. Experimental comparisons between the PIM module and three separated cases have illustrated the PIM module has advantages of lower footprint and higher efficiencies.

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