Design Of A Planar Transformer For Aeronautical 5 kW DC-DC Converter Using COMSOL Multiphysics

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Abstract

The increasing integration of power electronics into airborne systems drives the need for compact, efficient, and thermally robust solutions that comply with the demanding constraints of the aeronautical environment. In this context, planar transformers offer significant advantages, including low profile, enhanced thermal management, and compatibility with automated manufacturing processes.

This work presents the design and simulation of a planar transformer using COMSOL Multiphysics. A key challenge in power planar transformer design lies in balancing electrical, magnetic, and thermal constraints. High secondary currents are typically managed by multiplying the number of secondary windings. To minimize magnetic losses, alternating primary and secondary windings is preferred. However, increasing the number of interleaved layers also significantly raises parasitic capacitances, thus increasing losses. Finding the optimal trade-off in the number and arrangement of layers is essential for achieving a reliable and efficient design. Due to the coupling of multiple physical phenomena, this task can quickly become complex, making COMSOL Multiphysics a valuable tool in the development process.

By leveraging the RLC Group feature within the Magnetic and Electric Fields interface, we optimized the transformer layout. A 2D axisymmetric model enabled the comparison of various primary-secondary configurations (number of layers, series/parallel connections, interleaving, etc.). This feature also allowed accurate modeling of the magnetic core and computation of both magnetic and electric losses, which were then used to predict the thermal behavior of the transformer.

The planar transformer was successfully designed, fabricated, and tested. The experimental results validated the modeling approach and confirmed the effectiveness of the multiphysics simulation workflow.

Reference

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Figures used in the abstract

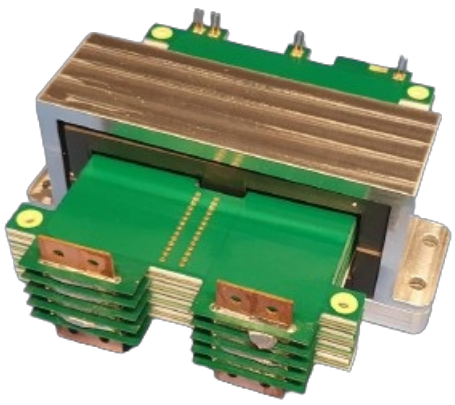

Figure 1 : Planar 5 kW transformer developed by SERMA Ingénierie. The surface of the transformer measures roughly 10x12 cm.