

Design of a 1 kV, 200 kW, 200 kHz High Power Transformer Based on Modular Electronic Winding

The design of high frequency (>100 kHz), high power (>30 kW) transformers is challenging due to the various trade-offs between power density, efficiency, and thermal performance. Due to the fact that these trade-offs are poorly understood, the current state-of-the-art standard for high power transformers dictates that designers must come up with entirely new designs when the power specification changes, or when many smaller transformers are paralleled. Redesigning for each new project is costly, while paralleling smaller transformers introduces various system level challenges, such as current sharing mismatch. This work seeks to resolve the aforementioned issues by showing the design of a high power transformer based on modular electronic winding building blocks.

Each building block is designed for 1 kV, 50 kW, 200 kHz and uses a switched floating capacitor in series with primary transformer winding. The switched capacitor operates with a 90° phase shift from the main bridge switches, which allows the voltage generated across the switch capacitor to cancel out the voltage drop of the transformer leakage inductance. With the leakage inductance canceled, the transformer current sharing is independent of the reactance of the transformer, resulting in even current sharing among different paralleled modules regardless of their position in the system. Each module contains integrated cold plates to reduce the transformer winding hot spot and allow the transformer to operate with currents beyond its designated power rating. To mitigate eddy current loss in the cooling system, this work also applies a novel shielding technique between transformer winding and cold plate.

This work presents a truly modular high power, high frequency transformer with automatic current sharing and integrated cooling. The total system rating of the example transformer is 1 kV, 200 kW, 99.7% efficiency and a power density of 800 W/in³ is achieved.

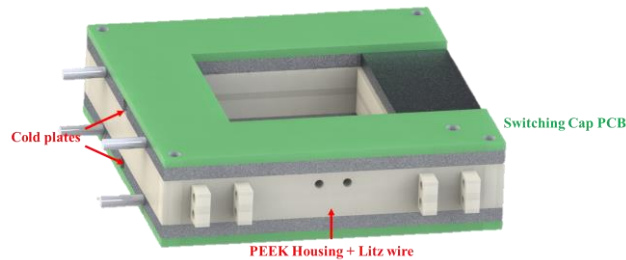


Fig. 1. Singular 50 kW module with integrated cold plate and switched capacitor PCB

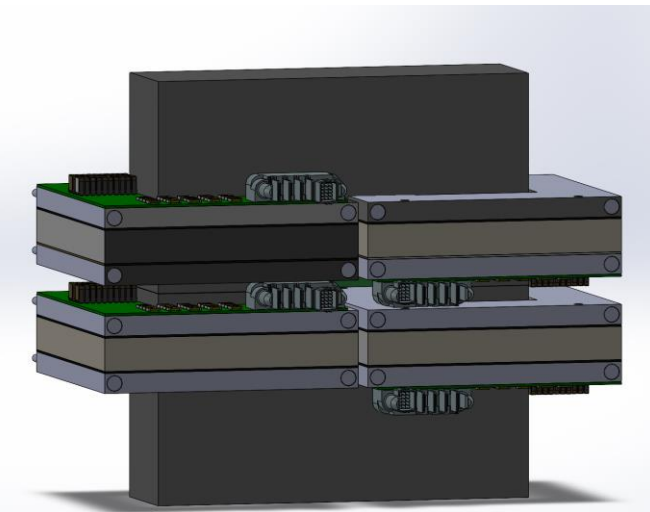


Fig. 2. Full 1 kV, 200 kW, 200 kHz without mechanical support system