Design of A 50-kW Medium Frequency Medium Voltage Transformer for 10-kV SiC-Based Dual Active Bridge Converter

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INTRODUCTION

- 10-kV SiC MOSFETs have enabled reduced stages & volume of medium voltage (MV) dc/dc converters and brought more challenges on the insulation design & parasitics control.
- Leakage integration in MV transformer eliminates the phase shift inductor but may introduce high loss due to leakage flux across the core lamination.
- Dry type insulation for MV winding brings challenges for transformer design.

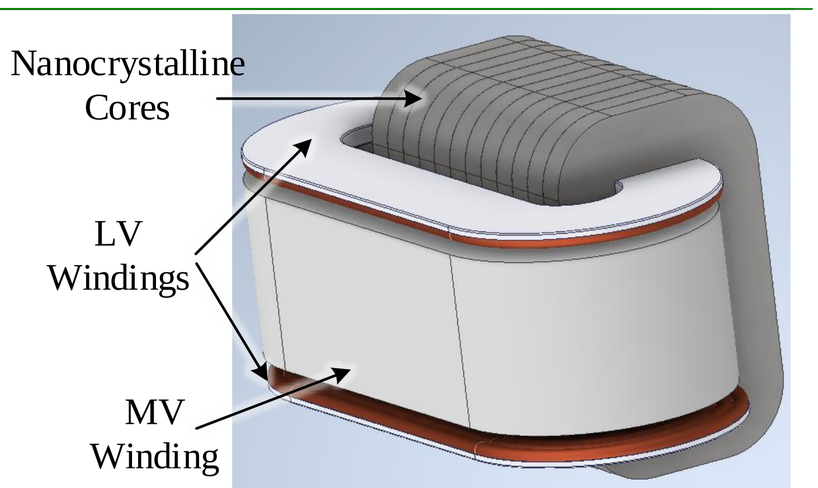


Fig. 1: Structure of MV DAB transformer

MV TRANSFORMER DESIGN

- Thin nanocrystalline cores are stacked to form the MV transformer.
- Dry-type insulation for MV winding is used with 3D printed case/bobbin and silicone encapsulation.
- Geometry-based optimization has been adopted for transformer parameter selection.

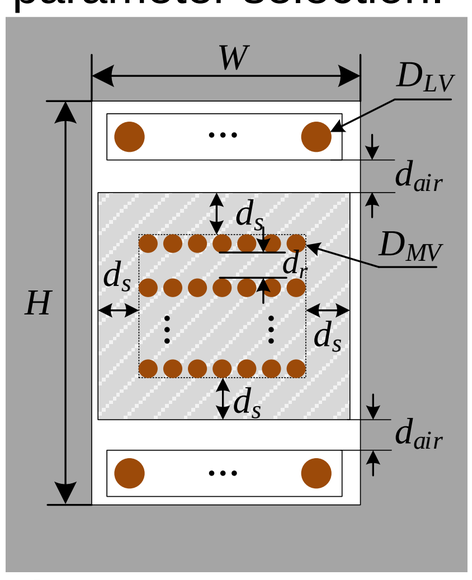


Fig. 2: Geometry constraint on windings

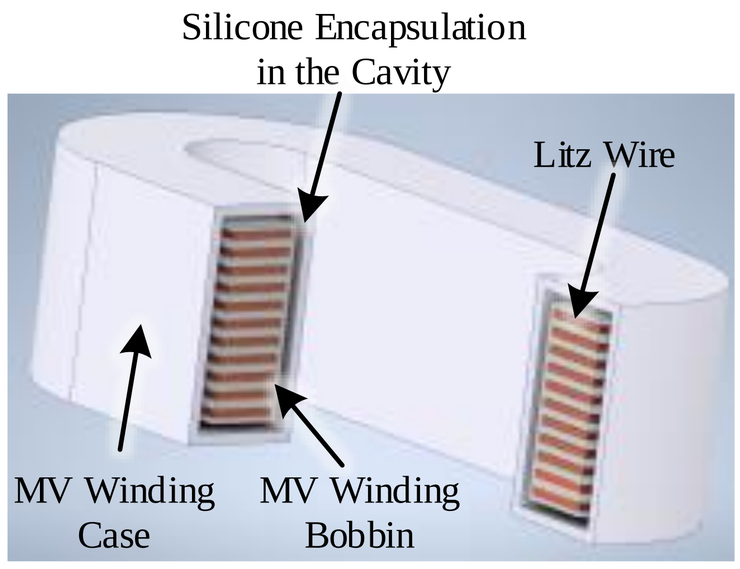
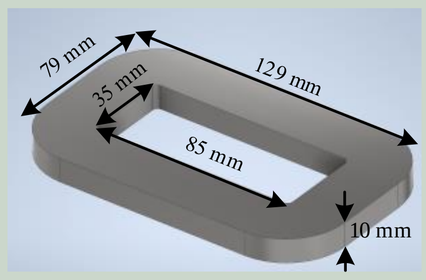


Fig. 3: Dry-type insulation for MV winding

Power Rating	50 kW
Voltage Rating	1 kV/6.25 kV (MV to ground > 12.5 kV)
Switching Frequency	10 kHz
Stacked Core	12 of 
Peak Flux Density	0.92 T
Efficiency	99.6%
Power Density	13.5 kW/L

SIMULATION AND TEST VERIFICATION

- Transformer leakage inductance is simulated as 62 μH, with eddy current loss ~23 W.
- The proposed transformer has been assembled and tested in a MV Dual-Active-Bridge (DAB) converter up to rated voltage power bidirectionally.
- DAB converter efficiency >99%, peak efficiency 99.3% at 40 kW.

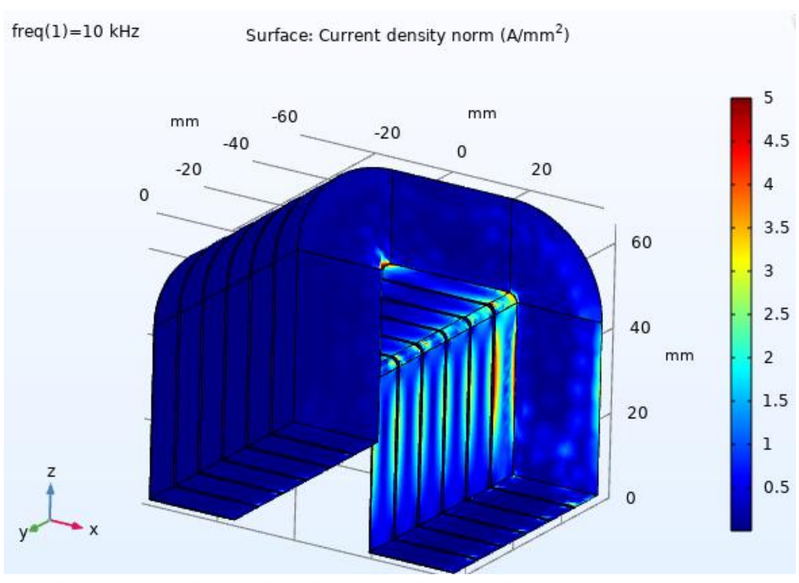


Fig. 4: Simulation of eddy current

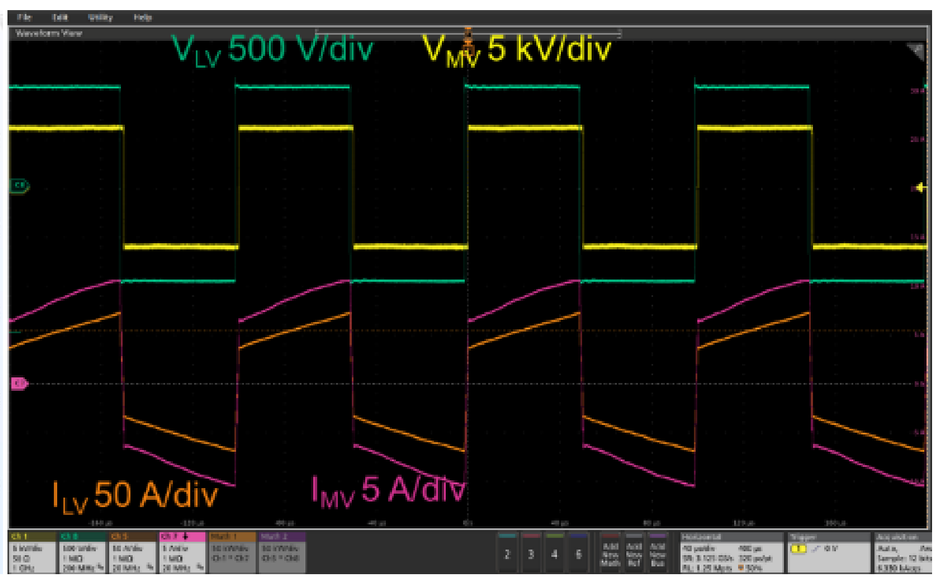


Fig. 5: Test waveform at full load

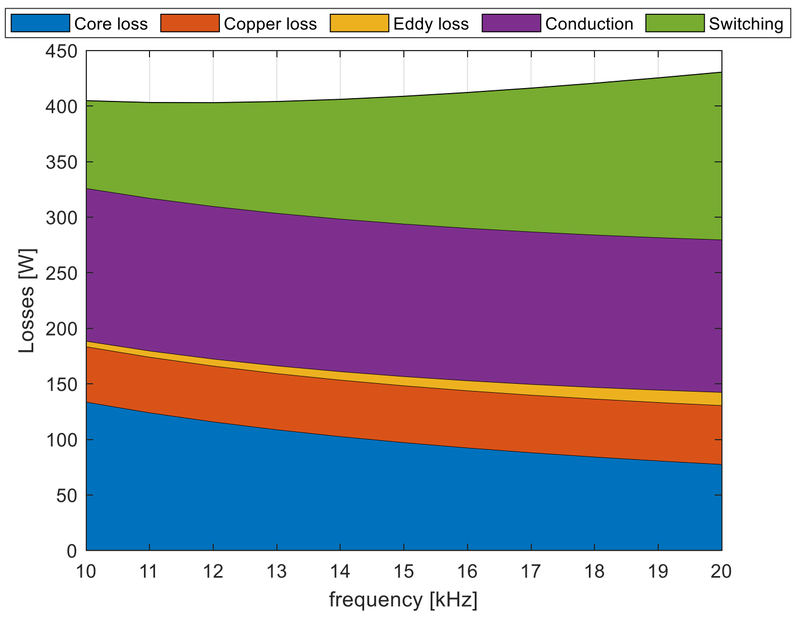


Fig. 6: Loss breakdown at full power

CONCLUSION

- MV dc/dc transformer with stacked cores and geometry-based optimization can realize high efficiency and power density design.
- The analysis and test validate the transformer design with stacked transformer cores and dry type insulation.

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