A 10-kHz Medium-Voltage Transformer with Integrated Leakage Inductance for 10-kV SiC-Based Dual-Active-Bridge Converter

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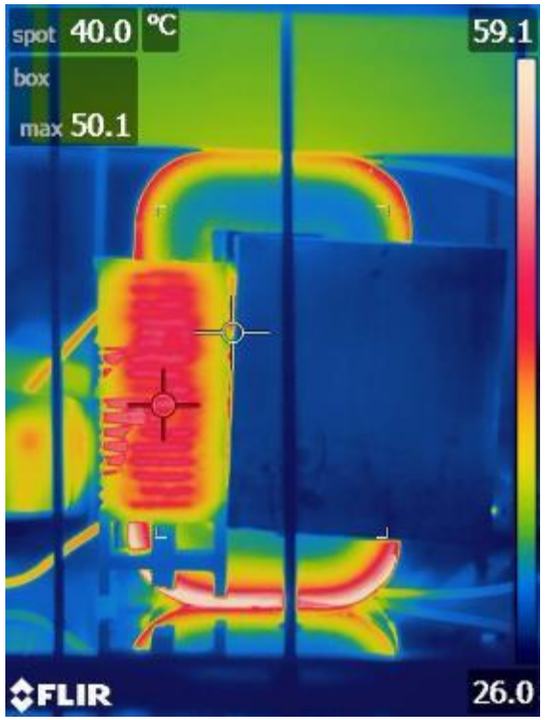
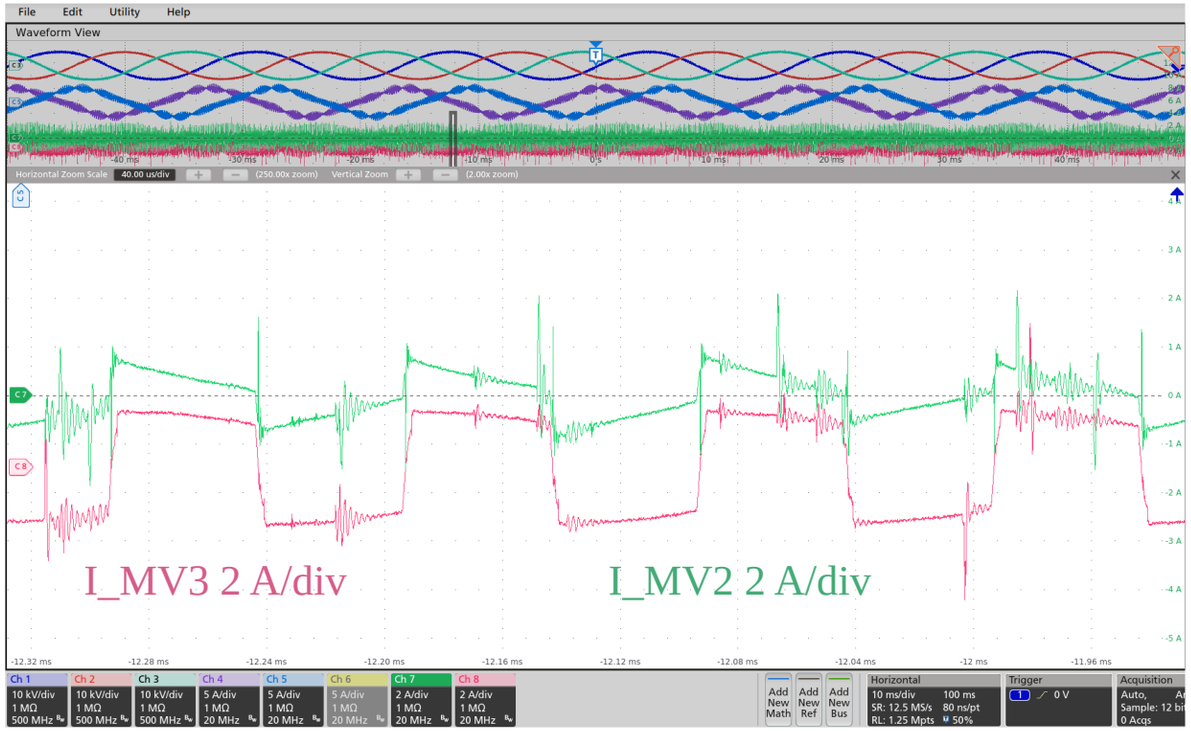
Introduction

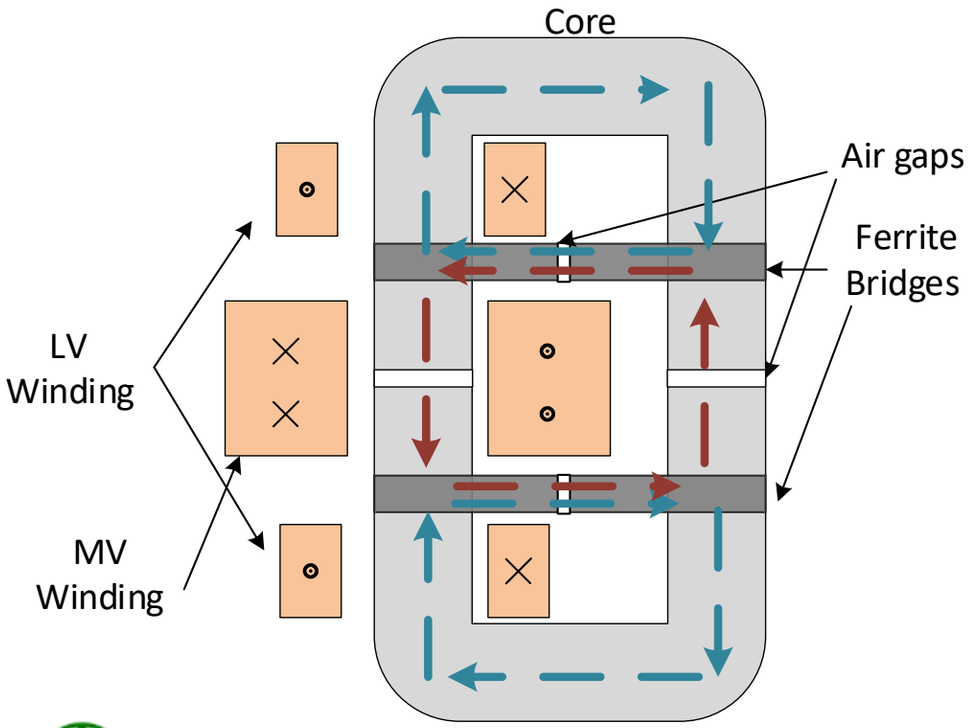
- MV SiC MOSFETs enable on reducing stages & volume of MV DC/DC converters.
- Leakage integration in MV transformer eliminates the bulky insulated series inductor, but may introduce high loss due to leakage flux.
- Parasitic capacitances interact w/ front-end converter, grounding loop, generating EMI.

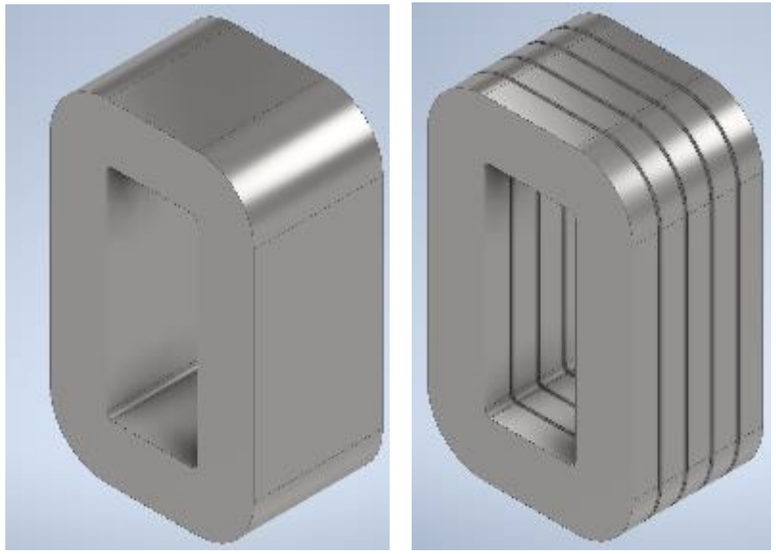


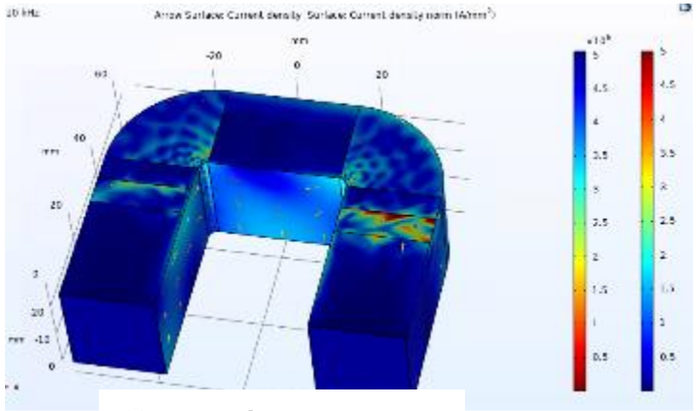


Low-Loss Leakage Integration

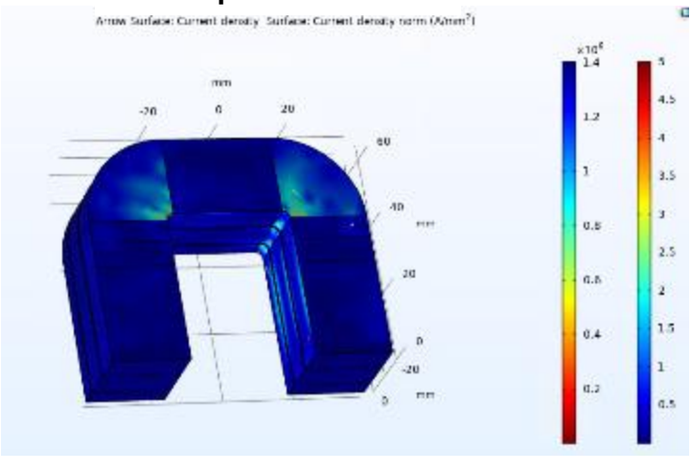
- Total Leakage = Intrinsic Leakage + External Leakage.
- Try to minimize the intrinsic leakage inductance to avoid eddy current.
- Ferrite bridges added to generate extra leakage flux.
- Cores can be further sliced to reduce eddy current…







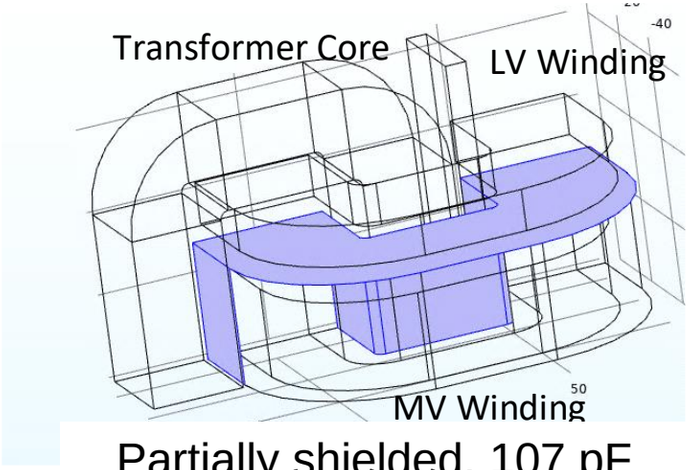
One-piece core



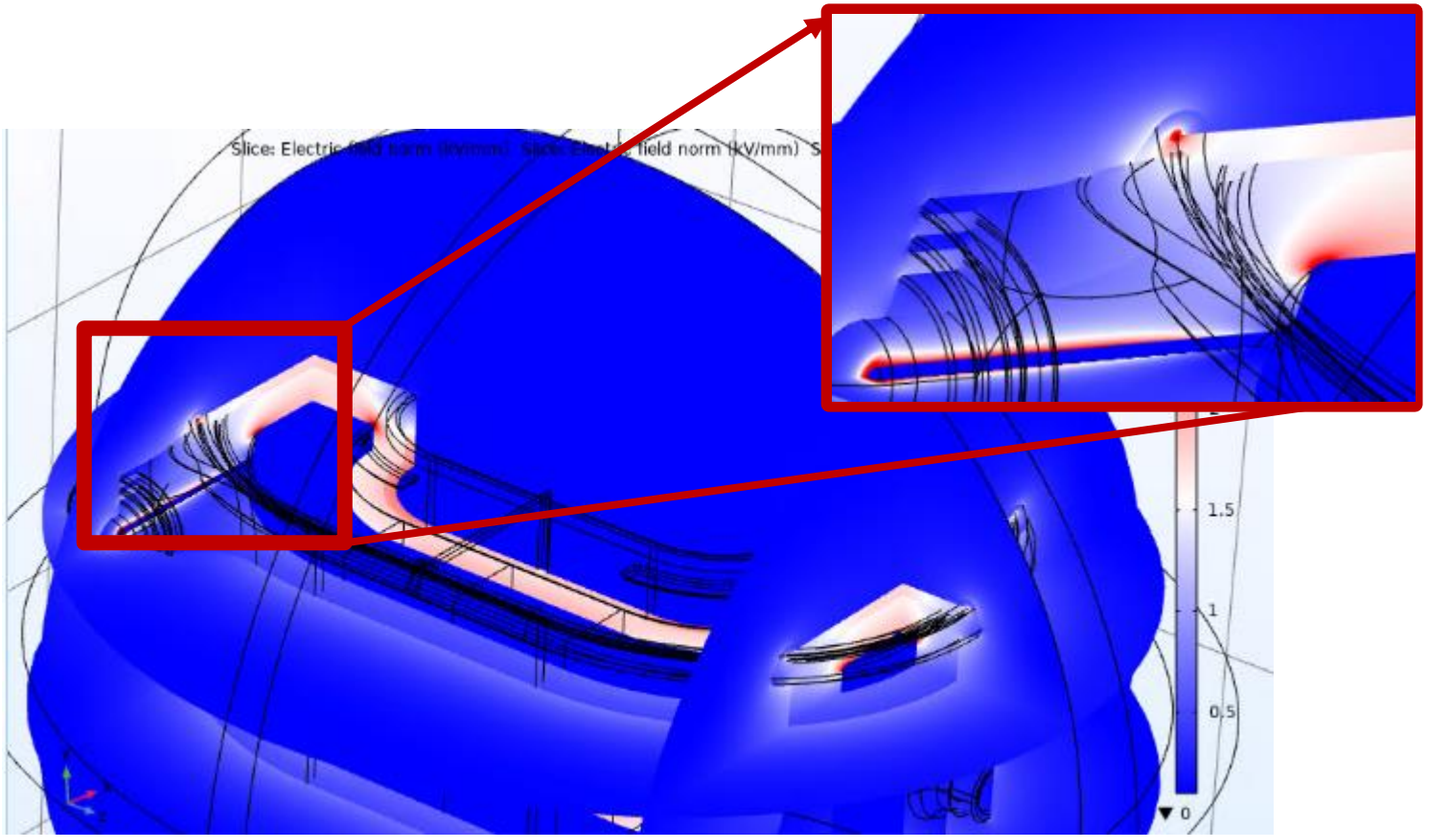
Sliced core

Common-Mode Capacitance Reduction

- Partially shielding used to confine only part of electric filed.
- “Edge termination” needed for shielding boundary.
- Silicone putty used to confine high electric field for shielding boundary.



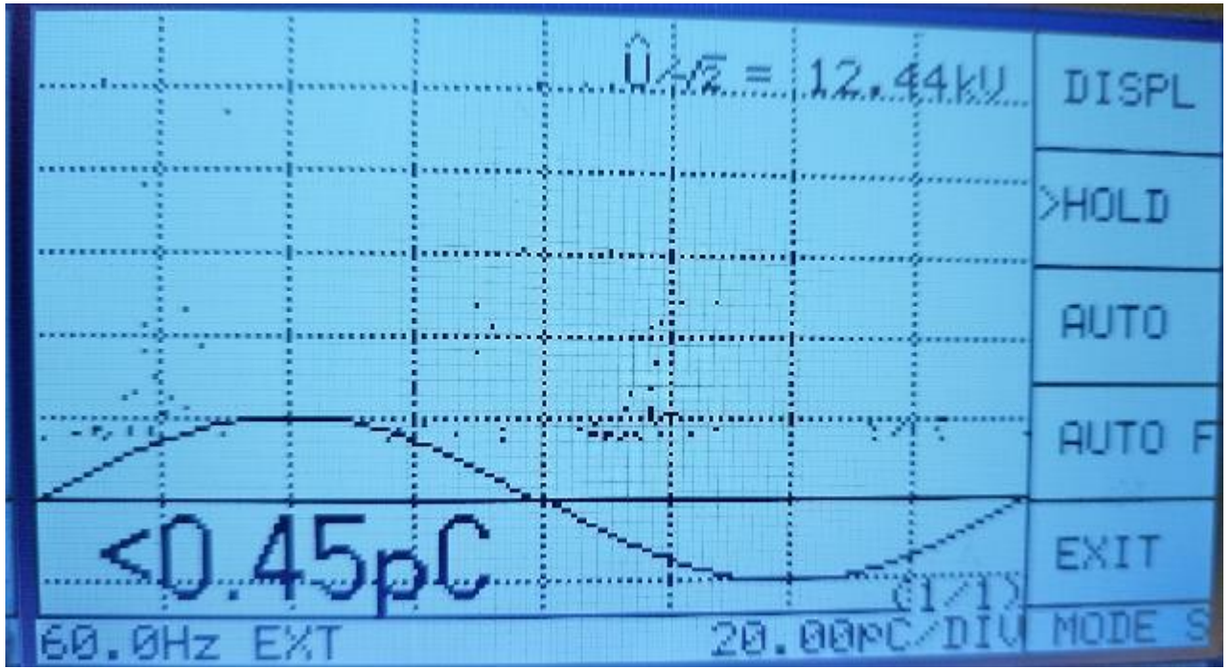
Partially shielded, 107 pF (50% reduction on CM capacitance)

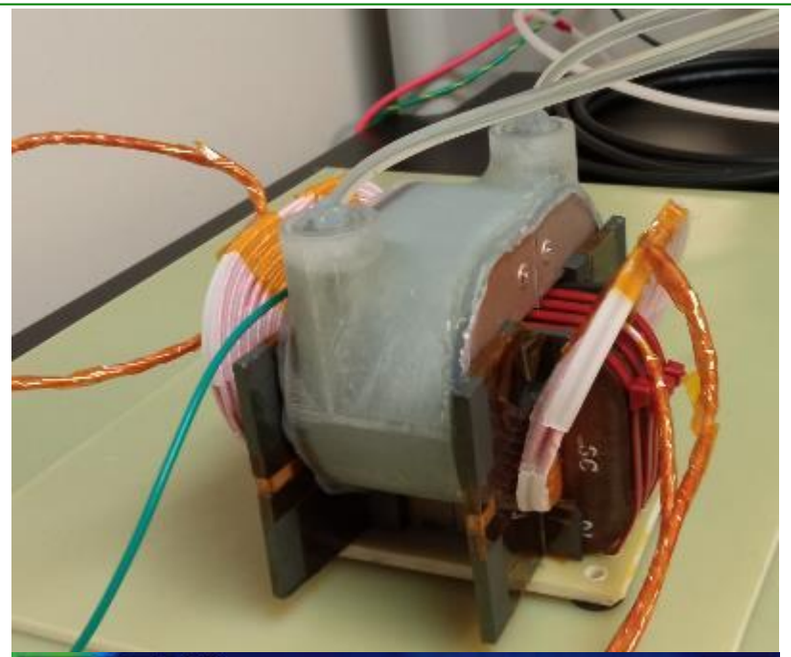


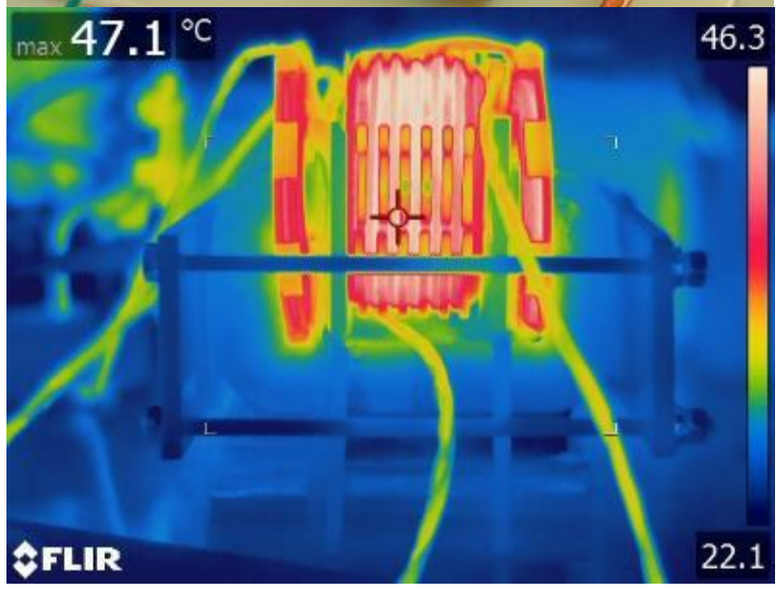
Field simulation

Test Results

- PD (partial discharge) tested per IEEE Std. C57.12.91-2020.
- Eddy current loss reduced by 93% (317 W).
- Est. transformer efficiency ~99.3% (↑0.4 percent point).







Acknowledgements

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