Geometry-Based Planar Transformer Impedance and CM EMI Noise Estimation

Jacob Silber, Electrical Systems Engineering
Mentor: Ayan Mallik (Associate Professor), Connor Reece (PhD Student)
Arizona State University Polytechnic School

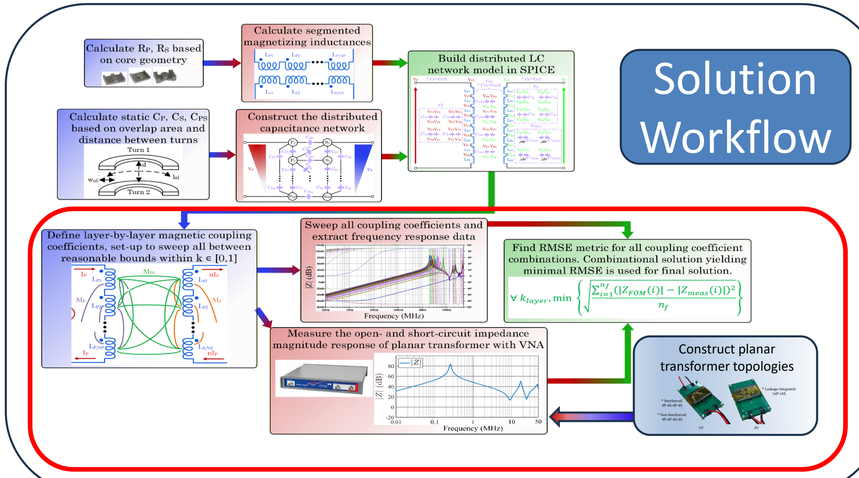
Motivation

- For planar transformer designs applications such as electric vehicle on-board chargers, the winding parasitic capacitance is a crucial parameter to consider for safety, extending component lifetime, efficiency, and EMI compliance
- Mitigation of high parasitic capacitance requires shielding and/or addition external capacitors
- Main traditional model of transformer parasitic capacitances considers a lumped-element layout
- While intuitive and quick to use, it is often only effective in transformer impedance modeling up to the first resonant frequency from the order of 100s of kHz to a few MHz.
- Distributed element transformer models have been developed for better high-frequency accuracy
    - These models are overly complex and require FEA to analyze
- This proposed solution investigates an analytical/parameterized model to find the distributed element network.

Goal

Derive and validate a full-order distributed LC element wideband impedance model of 2- winding planar transformers without (FEA) simulation.

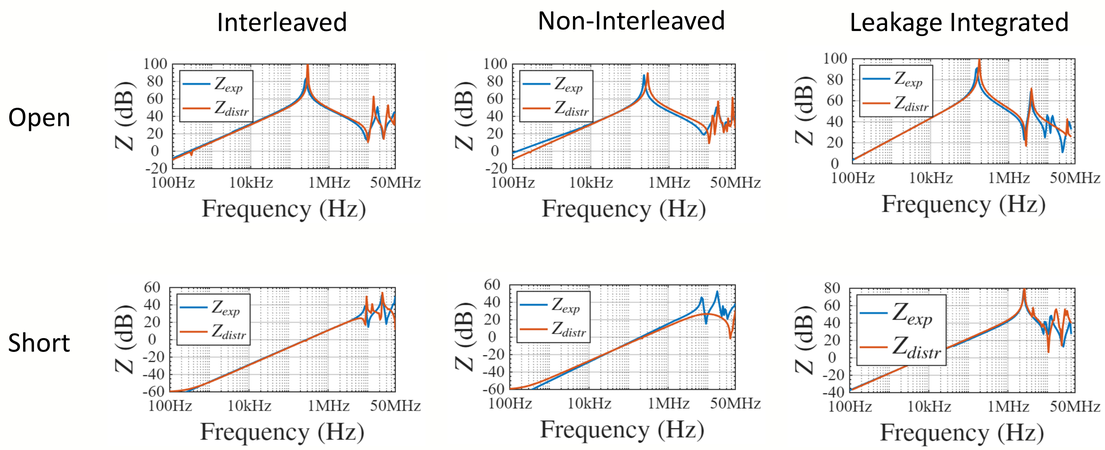
Solution Workflow



Process

- Parameterized LTSpice sweep simulations
- Exported data from simulations to Excel spreadsheet
- Configured Excel to process raw data
- Utilized MATLAB to generate graphs, min RMSE calculations, and interpret data

Results



Winding	Common Coefficient (B)	Mutual Coefficient (A)	RMSE Value
Interleaved Open	0.937	0.946	4.786
Interleaved Short	0.932	0.941	5.277
Non-Interleaved Open	0.963	0.969	5.783
Non-Interleaved Short	0.997	0.998	7.081
Leakage Integrated Open	0.999	0.995	4.0998
Leakage Integrated Short	0.946	0.945	6.044

Conclusion

The model demonstrated low open- and short-circuit impedance magnitude response error when compared to VNA measurement on non-interleaved, interleaved, and leakage-integrated planar transformer designs

Future Work

Possible future work is extension to apply model to more complex winding topologies, and to multi-winding transformers.

FURI

Ira A. Fulton Schools of Engineering
Arizona State University