Automated Magnetic Core Loss Tester

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Research Motivation

Improving the size, efficiency and overall performance of power electronic converters is foundational to improving virtually all of our electrical systems and devices. These converters rely on active semiconductor devices and passive energy storage components to operate. Magnetic energy storage components (transformers and inductors) currently present a critical bottleneck on performance.

A key challenge in improving these magnetic components is that their loss characteristics inherently vary piece-to-piece owing to manufacturing imperfections. Researchers/designers regularly use magnetic materials outside of their test specifications (e.g. with non-sinusoidal waveshapes, different frequencies, and different core shapes). This becomes a problematic burden on high performance power electronics design, as a designer can only be certain about magnetic performance after a full prototype has been commissioned, built, and tested.

Progress To Date

The Quality Factor Core Loss Tester has been built and tested. For automation, a motor has been connected to the variable capacitor through a 3d printed mount and connecting module. The setup is shown in Figure 3.

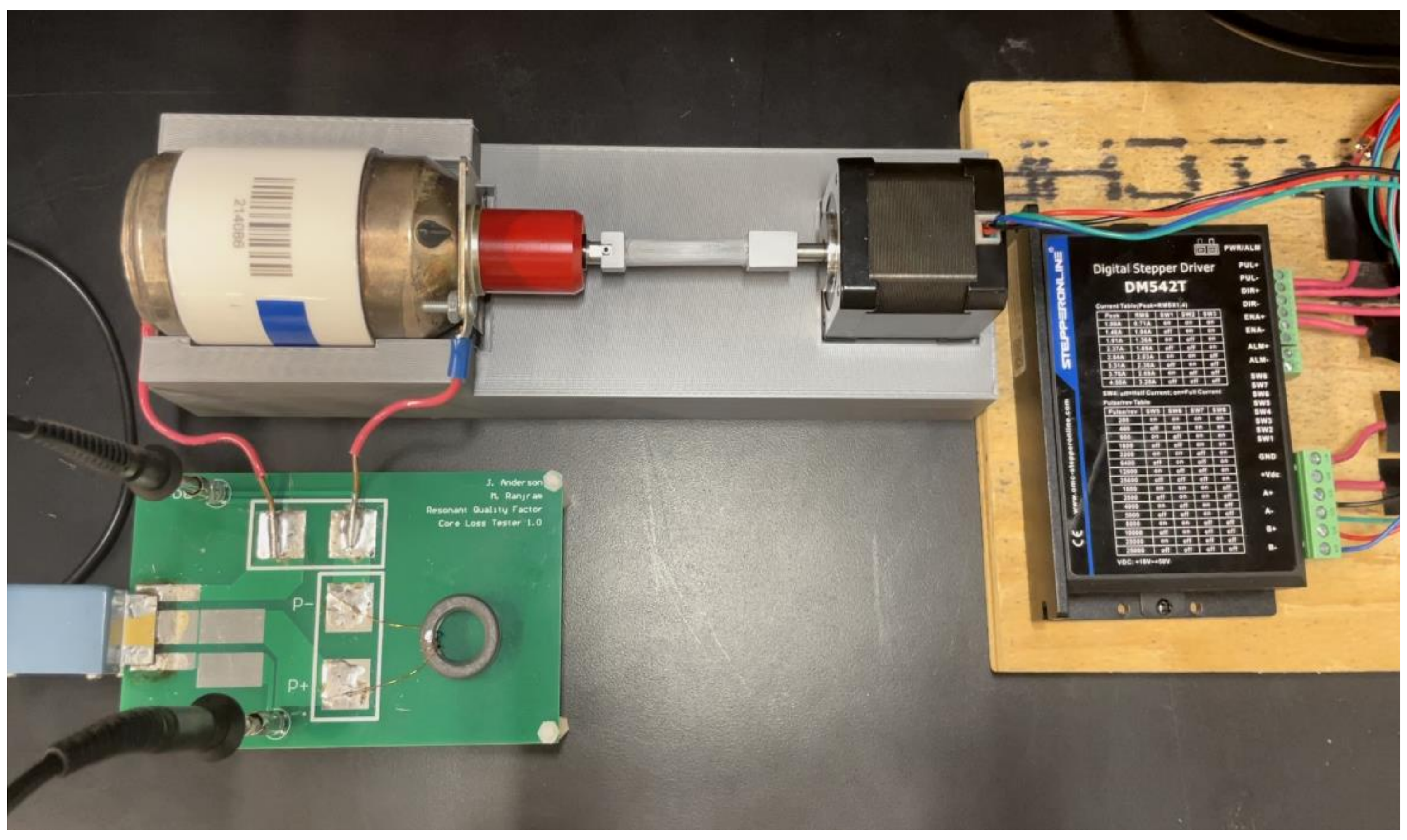

Figure 3: Quality Factor Test Setup

Results

At this stage of the project, automation of the data collection process is underway through remote control of test setup instrumentation (e.g. Oscilloscopes, Function Generators, RF Amplifiers, etc.). As can be seen in Figure 4, test data has been collected in order to validate the operation of the Quality Factor Core Loss Tester that has been constructed. Looking forward, the automation procedure will be completed, the Volt-Amperic method will be tested, and a new method for general wave shapes will be explored.

Research Methods

This research project explored two different schemes for a core loss tester, both of which have been constructed in-lab.

While resonance is fundamental to both of these schemes, the measurements they utilize for determination of core loss differ. The schematics and required measurements for both circuits are shown below:

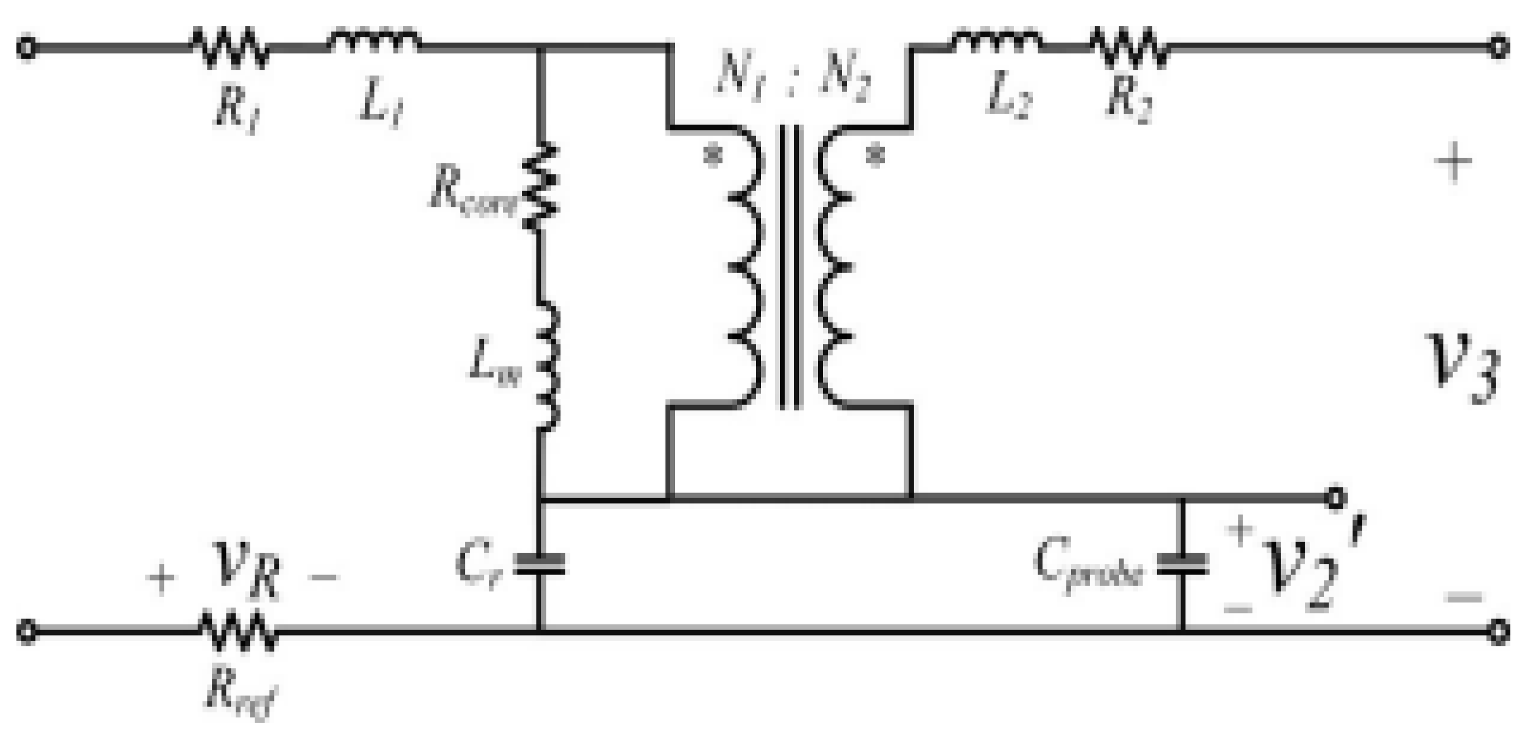

Figure 1: Resonant Volt-Amperic Core Loss Tester [2]

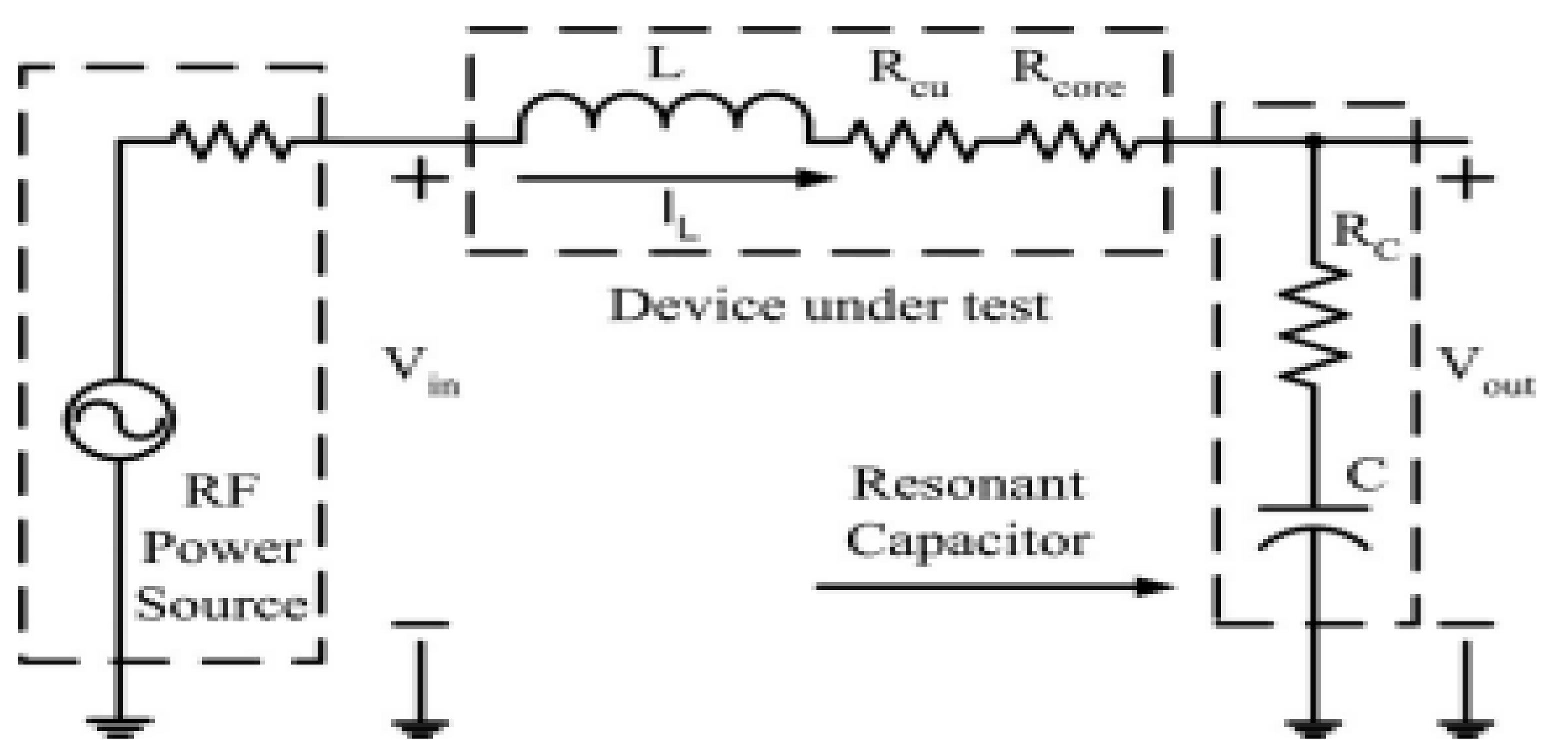

Figure 2: Resonant Quality Factor Core Loss Tester [1]

Two main issues arise from these methods. The first is that very large errors can be introduced into the measurement due to even small deviations from system resonance. The second is that to remove and solder different capacitors for each desired test frequency is extremely time consuming. A variable capacitor and motor are being introduced in order to automatically vary capacitance. This will allow for a fast sweep of measurements across a broad range of frequencies without requiring slow human intervention.

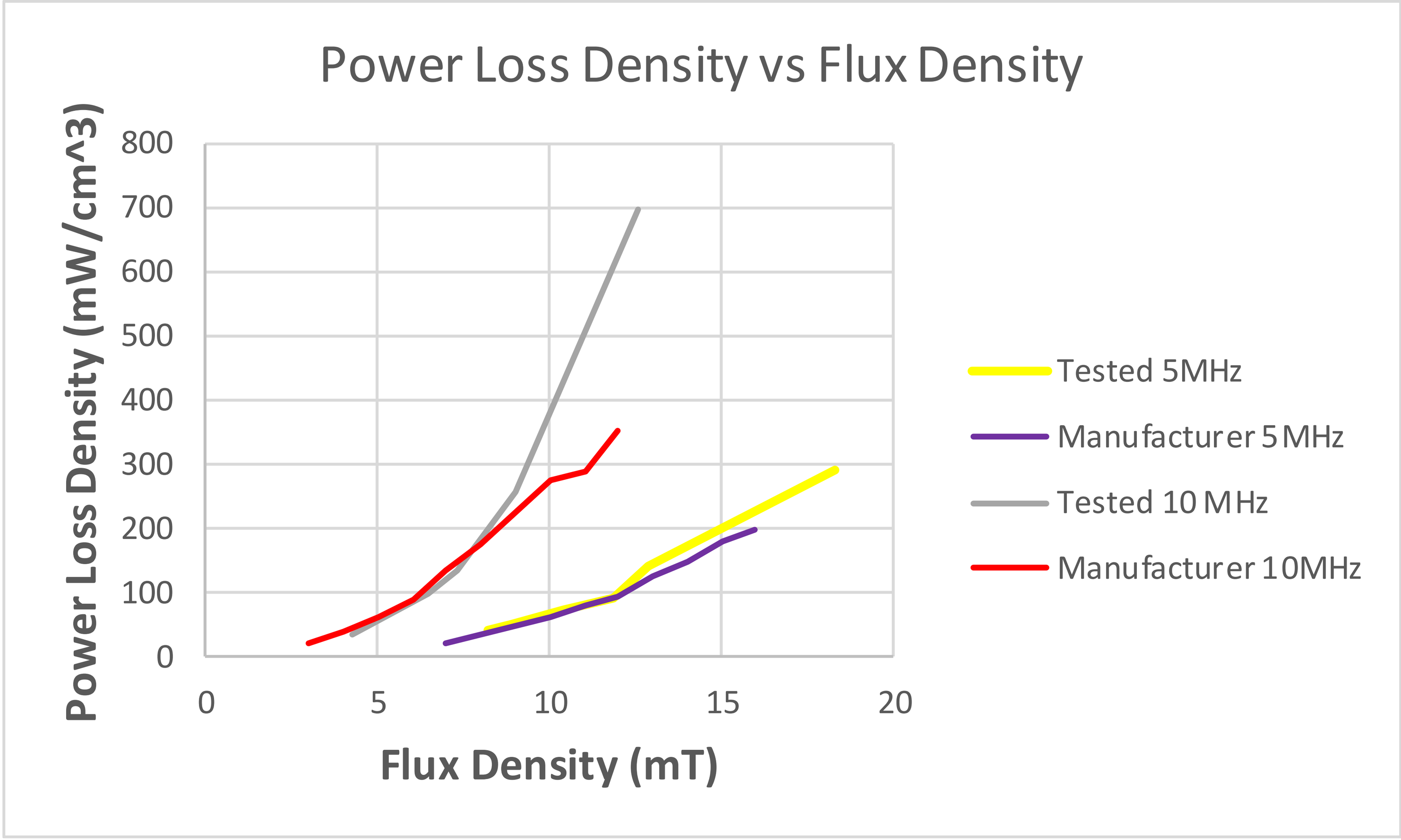

Figure 4: Tested Core Loss Results vs Manufacturer Provided Data

[1] A. J. Hanson, J. A. Belk, S. Lim, C. R. Sullivan, and D. J. Perreault, “Measurements and Performance Factor Comparisons of Magnetic Materials at High Frequency,” IEEE Transactions on Power Electronics, vol. 31, no. 11, pp. 7909–7925, Nov. 2016, doi: 10.1109/TPEL.2015.2514084.
[2] M. Mu, Q. Li, D. J. Gilham, F. C. Lee, and K. D. T. Ngo, “New Core Loss Measurement Method for High-Frequency Magnetic Materials,” IEEE Trans. Power Electron., vol. 29, no. 8, pp. 4374–4381, Aug. 2014, doi: 10.1109/TPEL.2013.2286830..

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