

Magnetic Materials Characterization Project

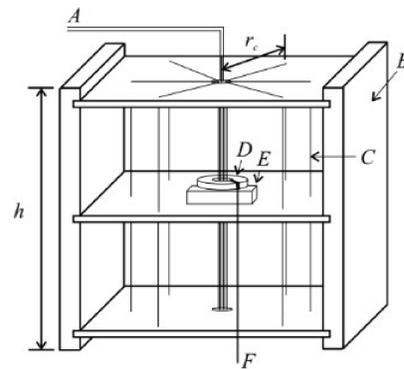


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Advisors: Chris Lute and Prof. Jim Cale

Summary

We are extracting the magnetic characteristics from toroidal samples using a newly proposed test configuration that improves upon the standard from IEEE 393-1991. This year, with the global Coronavirus pandemic in effect, the project was broken into three pieces; data collection, Graphical User Interface (GUI), and power supply.

Test Fixture

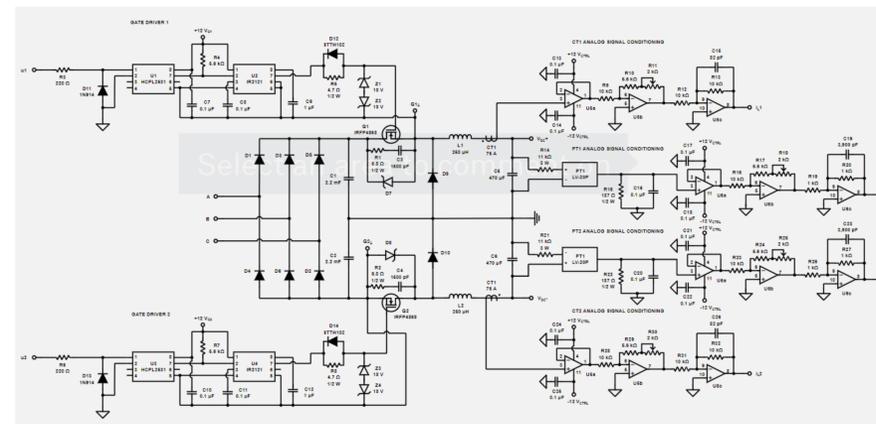


Above, there is a diagram of the test fixture and a simplified toroid setup. Section A of the test fixture is the input wiring which is a 14AWG magnetic wire. B is the non-magnetic structure of the test stand. It holds the top bottom plates at distance of $h = 469.9\text{mm}$ apart. Each of the top and bottom plates pieces have 24 holes placed radially, with radius $r_c = 230.6\text{mm}$, in them so you can wind the 14AWG wire around the center toroid. C labels these return wires. The D piece is the magnetic toroid sample. The dimensions of the toroid samples are identical and outlined in the parts tab at the top of the website. E is a non-magnetic stand to hold the toroid directly in between the top and bottom pieces of the test fixture. F is a non-magnetic spacer that fits into the center of the toroid and holds the bundle of wires out from the inner edge.

The toroid seen above is a simplified image that represents the configuration in the IEEE 393-1991 standard. The loops shown on each side of the toroid are actually expanded by going through the holes in section B of the test fixture. The reason they are expanded like this is to essentially remove the influence on the magnetic field in the toroid sample caused by the return conductors. The primary resistance, r_p , is constant so we can adjust the primary voltage, v_p , such that the primary current, i_p , is 10A. The turn ratio for this setup is 24:18. The output impedance is extremely high because it's going directly in the NI analog input module, so the secondary current, i_s , should be zero and not affect the magnetic field intensity in the sample. It is important to have the winding evenly spaced around the toroid.

Grid Sim

Anyone who has ever bought a laptop, or a gaming console knows what a power supply is. It is the black box that takes outlet power and delivers it to the device. Most consumers never ask how or why the power supply must act as intermediary for the device and the outlet. In general, the power supply takes current from the source and corrects the voltage, current and frequency for the load (device). Broadly speaking there are two types of power converters; linear and switching.



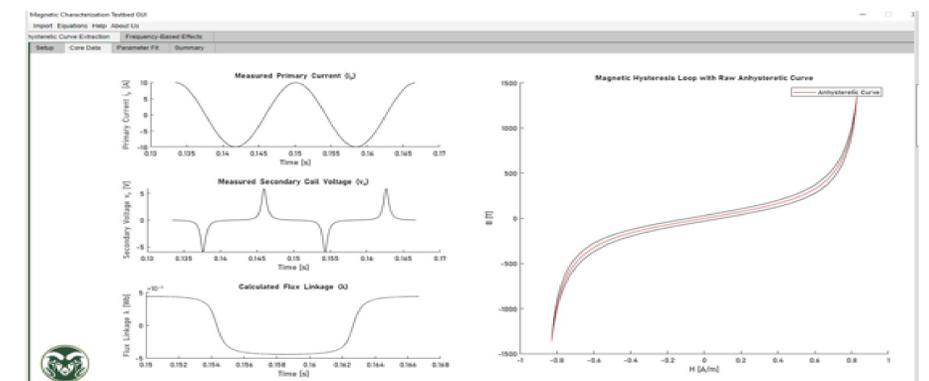
The focus of this aspect of the project was to work with Chris Lute to actualize his designs for the power supply of the microgrid simulator. The power supply is a switched-mode-power supply (SMPS); the AC input is rectified and filtered to obtain a DC voltage. This is then switched on and off via a Buck converter, which (via pulse width modulation) attenuates the power by discretizing the input voltage signal (the signal coming through when the Buck converter is on, and the signal being stopped when it's off). The signal is then sensed for voltage and current, and each of these is attenuated by conditioning operational amplifiers to be delivered finally to a push/pull amplifier.

In going from a design to a physical prototype of the power supply, we used KiCAD, which is a free electronic design automation (EDA) software package. The process involves copying the design into a schematic, labeling and noting all of the physical dimensions of the components and then designing the layout of the printed circuit board (PCB).

Graphical User Interface (GUI)

The purpose of creating this GUI is to provide immediate feedback through streamlined data analysis of the data collected by the magnetic characterization testbed. By processing raw current and voltage measurements into useful parameters and graphs, students and faculty who use the testbed can immediately obtain feedback regarding the behavior of the tested toroid

The GUI has two major functions: one is to derive a hysteresis (B-H) curve for the tested toroid, extract an anhysteretic curve, and fit the expected magnetization curve with a numerically optimized curve generated by a genetic algorithm. The other is to analyze the frequency-based effects on the toroid by deriving multiple hysteresis loops and extracting frequency-based properties such as remnance and coercion. All data generated is extracted from raw data input that reflects the primary current and secondary voltage from the pickup coil in the testbed setup. All data is imported via Excel spreadsheets by the user and the rest is automatic within the GUI. The user has the option to control core geometries and input frequencies.



The first tab of the anhysteretic curve extraction portion of the GUI allows the user to import the measured data from the testbed. This data is displayed in a table for verification. This tab also gives the user the option to manually change the core geometry The core data tab displays the primary current, secondary coil voltage, and calculated flux linkage from the imported data. The parameter fit tab allows the user to run a genetic algorithm using the GOSET toolbox to develop a numerically optimized parameter fit of the measured magnetization curve.

The other portion of the GUI deals with the frequency-based effects. This portion is similar to the anhysteretic portion except that the user must import data for each specific electrical source frequency at which the data was collected