CORRELATION OF MAGNETIC FLUX AND ELECTRICAL CAPACITANCE

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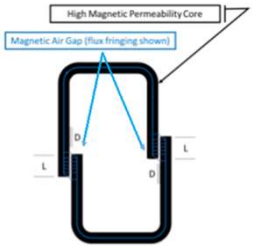
FLUKE

Motivation

- Understand how magnetic flux behavior shifts between core concentration and air leakage.
- Arriving at a relationship between capacitance and flux enhances magnetic component design by minimizing energy loss and maximizing field utilization via geometric adjustments.

Background

- Magnetic flux concentrates in magnetic cores but may leak through air in high-reluctance areas like gaps.
- Capacitance, tied to gaps, is measurable with applied electric signals.
- Geometric parameters variations enable measurement gathering for these variables.



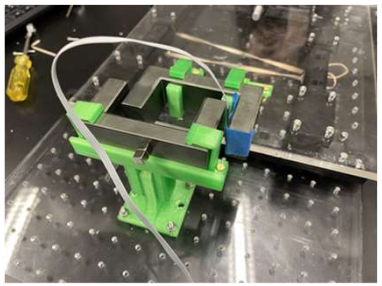
Simulation

- Traditional simulation applications like LTSpice, MultiSim were unhelpful due to their lack of magnetic simulation support.
- After investigating different applications, Finite Element Method Magnetics (FEMM) has been chosen for its feasibility of simulating both magnetic and electric properties of circuits.

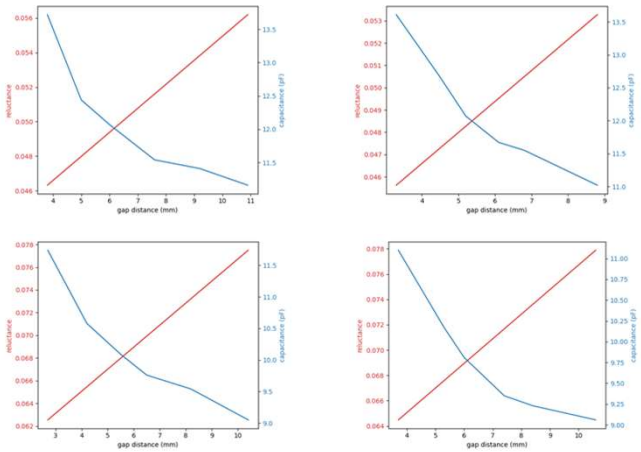
SIMULATION SETUP DIAGRAM

Physical Setup

- A physical setup was built to test the hypothesis using transformer cores and N35 grade cube magnets.
- Guassmeter was used to measure the magnetic field between the magnetically induced parallel plates.
- LCR meter with a high resolution testing with 10kHz was used to measure the capacitance.



Results



- The graphs depict the relationship between Reluctance and Capacitance with respective to gap distance.
- Each graph is for different setup with increasing number of magnets as we move horizontally, and increasing overlap distance as we move vertically.

- After meticulous testing, a relationship between capacitance and reluctance was arrived at.
- An inverse exponential relationship between induced capacitance and gap distance was observed with an increase in the value of capacitance as the number of magnets were increased.
- This relationship was as anticipated because of the increasing gap distance that leads to a decrease in the capacitance but the higher magnitude is the result of increase in the induced charges due to more magnets.
- A directly proportional relationship between the reluctance associated with the air leak and gap distance was observed with an increase in magnitude for more overlap distance and magnets.
- This relationship was also as anticipated because of the increasing gap distance that leads to a increase in the reluctance and the higher magnitude is the result of increase in the induced charges due to more magnets and larger overlap area.
- The simulated data also supports these claims of the relationships between the magnetic and electric properties of the setup.

Assumptions

- The transformer cores are made out of MnZn PC40 material. After extensive research we were not able to find any packages for this material in FEMM. Our simulated setup assumes a pure iron core.
- The edges for cores and magnets are not perfectly straight and this has not been taken into account, which leads to a very slight (thousandth digit) change in the value of field and capacitance.

Future Work, References, and Acknowledgments

Future work:

We expect to be able to build a fully working meter by leveraging this relationship making it easier to find magnetic properties of circuits

Faculty: Tai-Chang Chen
TA: Tim Amish

References:
[1] Applied Electromagnetics, Ulaby
[2] FEMM working manual

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