ECE 3251 – Electromagnetic Energy Conversion

Lab #3: Solenoid Characterization

Laboratory Goals

- Understand the DC magnetic properties of inductor coils and ferromagnetic materials.
- Characterize a solenoid to determine the inductance as a function of current and gap distance.

Lab Procedures:

1. Turn on scale; set scale to read force in Newtons.
2. Zero the scale to discount the weight of the cylinder holding the solenoid:
    - Adjust the gap distance (by turning the hand-crank counterclockwise so that the solenoid drops) until the scale reads a constant value. Zero the scale.
    - Turn the hand-crank clockwise (so that the solenoid rises) until the scale just reads a negative value. The negative value shows that the cylinder has bottomed out in the solenoid, and the weight of the cylinder is partially negated.
    - Turn the hand-crank counterclockwise until the scale reads zero. This will be your zero gap distance. Note the position.
    - Turn the hand-crank counterclockwise one revolution to set the gap to 0.05". This is your minimum gap.
3. Turn on the Agilent benchtop power supply.
    - Select the +25V output function on the front panel
    - Use the Display Limit function to set the current limit to 1A. Maximize the voltage.
    - Connect the solenoid to the power supply
4. Use the power supply in current-limited mode with the voltage set to about 18 Volts (because it is current-limited, it may not quite reach 18V). Vary the current from 0A to 1A in increments of 0.1A, stopping to record the force at each increment.
5. Increase the gap distance by 0.05" (1 revolution counterclockwise) and repeat step 4. Continue to increase the gap distance in increments of 0.05" until you have reached 0.5", repeating step 4 at each increment. Note that all of your gap measurements are in inches, but you will need to convert to meters before doing the calculations below.
6. Decrease the gap size back to 0.05". Swap the solenoid wires between the +25V and Com terminals so that current will flow the opposite direction through the solenoid. Make a single measurement of the force with the current at 1.0 A. How does this compare to the force measurement you made with the current flowing in the other direction? How would you explain this behavior?

Post-Lab Calculations:

1. Make a 2D plot of force as a function of the gap distance for each constant current.
2. Make a 3D plot of force as a function of current and the gap distance. Be sure to comment on the effects of saturation you observe in this plot in your conclusion.

3. Determine the inductance of the solenoid at each current and gap distance combination. Be sure to comment on any trends you observe in your conclusion.

Grading

- Formal report: Organization, neatness, clear writing, proper formatting of graphs, figures, tables, etc. (15 points)
- Lab Participation: Contributions from each lab partner are fairly distributed and documented (10 points)
- Introduction: What is the purpose of this lab? (5 points)
- Procedures: Brief account of the steps to obtain results (15 points)
- Results: Measurements and calculations for each lab step (35 points)
    - Plot of force vs. gap (10 points)
    - 3D plot of force, current, & gap (10 points)
    - Determination of inductance (15 points)
- Conclusions: Analysis and explanation of data (20 points)