ECE 18-316
INTRO TO DATA STORAGE
FALL 98
INSTRUCTION SHEET: LAB # 3: Hysteresis Looper

Due Friday, 9/25/98

In Class or To Jie Zou Before Start of Lab Section (1:30 PM)
Late submissions will not get credit

Purpose:

The purpose of this lab is to familiarize students with the behavior of soft magnetic material, the phenomenon of magnetic hysteresis, and to provide an opportunity to analyze an actual magnetic circuit.

In Class:

Setup
1.1) Organize yourselves into groups of three (at most) students and find a lab bench for your group to work at. As usual, please stick to the same bench and the same lab group all semester.

1.2) Follow the set-up instructions in the Operating Instructions Summary (OIS) sheet for this device, connect it and collect the loop for the default test conditions, using the computer interface provided.

Material Analysis:

1.3) Capture a series of loops with the drive voltages specified in Table I, and save them for later potting in Matlab. Verify that the voltage drop you are reading across the resistor is, in fact, approximately the same value that you have the function generator set to.

1.4) Set the drive field to 0.5 V. This should give a mostly closed loop that looks like a straight line. Capture a series of loops with this drive field and with offsets as given in Table II. Save for later plotting in Matlab.

Magnetic Circuit Analysis:

1.5) Look through the window of the coil device, and estimate the dimensions of the core (diameter and cross sectional area) and the number of turns you can see. There are two sets of windings. The visible ones are the primary windings containing the drive current, and the secondary windings, used for pickup are concentric with this first set of windings, but are hidden inside insulation. Both the primary windings (which are visible) and the secondary windings (which are hidden) have the same number of turns.

1.6) Measure the peak voltage on Ch 2 for a drive voltage of 5 V p-p, and note it.

Table I: Values for varying the drive level

#	Primary Voltage (Func. Gen) Volts
1	0.5
2	0.75
3	1
4	1.5
5	2
6	2.5
7	3
8	3.5
9	4
10	5

Table II: Values for varying the offset level

#	Offset Voltage (Func. Gen) Volts
1	0
2	0.025
3	0.05
4	0.075
5	0.1
6	0.15
7	0.2
8	0.25
9	0.5
10	1

Write-up: (Each student should submit his or her own write-up following the standard format)

2.1) Calculate the calibration constant for the horizontal axis of your measurements by applying Ampere's law to the loop, to find applied field as a function of applied current. Note that absolute value of the applied field calculated by the interface is given in units of A/m, but may not be calibrated correctly.

2.2) Calculate the calibration constant for the vertical axis of your measurements by noting that the saturation magnetization is of the core is .38 Tesla/μ_0. The actual measurements you get will be uncalibrated.

2.3) Plot the M-H loops you captured in 3, above, on a single page, each on its own axis, in a 2 column by 5 row arrangement. Order on the page according to the following table, where each number represents the number of the scan in Table I.

1	6
2	7
3	8
4	9
5	10

Make sure that all plots are plotted on the same vertical and horizontal scale, correctly calibrated (in A/m for x and y). Label axes and make sure that letters and numbers do not overlap.

2.4) Estimate the coercivity of each loop and make a plot of coercivity as a function of applied field. Plot on a separate page and label axes.

2.5) Make a plot of the loops you captured in 6), above, following the same single page plotting protocol and using the same calibration protocol.

2.6) Calculate the susceptibility of the core as a function of offset field, $\chi(H)$, for each value of offset field from Table 6. Make a plot of the susceptibility versus offset field. Susceptibility is defined by:

$$M = \chi(H)H$$

Since this material has (for small drive fields) a straight and closed M-H loop, it is simply necessary to find the slope of the hysteresis loop at each offset field.

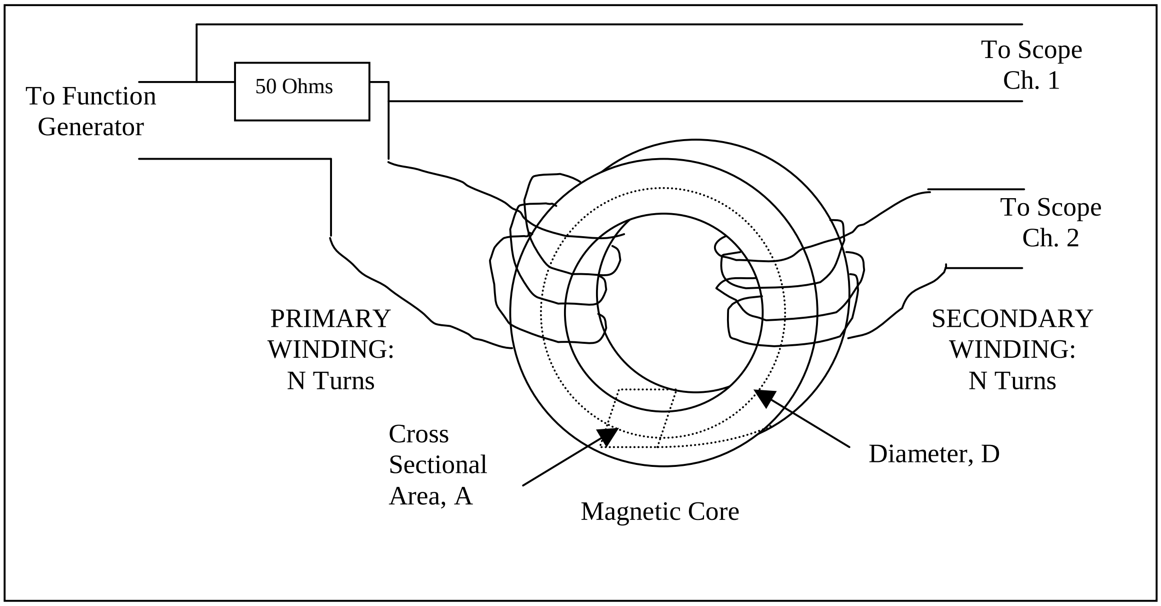
2.7) Include in your discussion a 3-5 sentence explanation of why the relative permeability behaves the way it does.

2.8) Check the induction (vertical scale) calibration by comparing the maximum voltage measured in 1.6, with the value you would predict from your knowledge of the core geometry, the drive field under which the voltage was measured, the core susceptibility at zero offset field, and the number of turns in the primary and secondary windings. This is accomplished as follows:

> i) Apply Faraday's law of induction to relate voltage in the pickup coil to flux in the core.
>
> ii) Identify what point in the drive cycle would produce the largest voltage.
>
> iii) Relate flux in the core to B in the core, through knowledge of the core geometry.
>
> iv) Relate B in the core to H in the core by knowing the permeability, which can be calculated from the susceptibility. Remember to use the appropriate point in the drive cycle.
>
> v) To complete the numerical computation, you will need to note that H varies sinusoidally with a maximum amplitude that you determined by setting the drive voltage to 5 V p-p in step 1.6. The frequency of the drive field is 50 Hz, and, as noted above, it is important to pay attention to where in the drive cycle you are evaluating the maximum voltage.

(See the device construction diagram attached as an appendix for reference in making this calculation). If you assume the computer interface is correct, include in your discussion an explanation of any significant differences between the value of voltage you estimated and the one you observed.

APPENDIX I: HYSTERESIS DEVICE CONSTRUCTION



Note: Only a few turns of each winding are shown, In reality, each coil goes all the way around the coil, such that they are completely concentric.