EXPERIMENT #8 - PHYSICS 31

Inductance

OBJECT: To study inductors

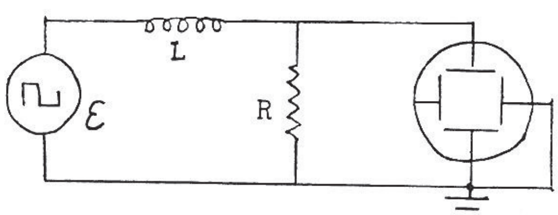
EQUIPMENT: inductor (25 mH) resistor (1 K) signal generator oscilloscope

THEORY: Refer to chapter 38 of Halliday and Resnick. For the oscilloscope's operation refer to pages 8 to 11 of "Electric Circuits" and pages 19 to 25 of "Electronic Instrumentation", Berkeley Physics Laboratory, by Portis and Young, 2nd Ed.

GENERAL DIRECTIONS:

1. For this experiment you will be using an oscilloscope to measure voltages which change rapidly. In order to become familiar with the oscilloscope read the available literature about the oscilloscope, and then connect the output of the signal generator to the vertical input of the oscilloscope and attempt to obtain a picture of the generator's square wave and sine wave. The ground terminals of the signal generator and oscilloscope should be directly connected to each other. Be sure you understand the basic functions of the oscilloscope and generator before you continue this experiment.

2. Connect the following circuit:



$L = 25$ mH

$R = 1\ K\Omega$

3. Set the signal generator to some value between 4,000 and 10,000 hertz and obtain the waveform for the voltage across the resistor. Decrease and increase the generator's frequency by reasonable amounts. Observe the new waveforms and explain what is happening.

4. After obtaining the best waveform for the increasing voltage across the resistor, measure the half-life which is the time required for the inductor's current to reach one-half of its maximum value. Also record at least five values of the resistor's increasing voltage as a function of time and plot this function. The voltage may be expressed in terms of the maximum voltage V_m across the resistor R, and time axis of the oscilloscope is to be calibrated by using the frequency of the generator.

5. Write down the differential equation for the increasing current in the inductor and find the solution. Using this time dependent function for the current find the mathematical function which describes the voltage V_R across the resistor R in terms of R, L, time t, the signal generator's resistance R_S, the inductor's resistance R_L, and the maximum voltage V_m across the resistor R. Use this mathematical function for V_R and the known or measured values for R, L, R_L, and R_S to calculate the theoretically predicted value for V_R for each time point that was used in part 4. Plot these theoretical values for V_R on the same graph that you made for the experimental data.

6. Derive a theoretical equation for the half-life in terms of L and the circuit's total resistance. Use this equation to calculate the half-life, and compare this calculated value to the experimental value measured in part 4.

7. Make a table for all your experimental and calculated (theoretical) values of voltage versus time. Compare the calculated values to the experimental values and explain why there may be any errors or differences. Also, generally discuss the entire circuit and include the reason why V_m is a fraction of the maximum voltage generated by the signal generator.