Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Title:	ELE302 Electric Networks
Course Number:	ELE302
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Instructor:	S. Jassar

Assignment/Lab Number:	5
Assignment/Lab Title:	Mutual Inductance PostLab

Submission Date:	
Due Date:	

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*By signing above you attest that you have contributed to this written lab report and confirm that all work you have contributed to this lab report is your own work. Any suspicion of copying or plagiarism in this work will result in an investigation of Academic Misconduct and may result in a "0" on the work, an "F" in the course, or possibly more severe penalties, as well as a Disciplinary Notice on your academic record under the Student Code of Academic Conduct, which can be found online at: http://www.ryerson.ca/senate/current/pol60.pdf

5.0 IN-LAB IMPEMENTATION & MEASUREMENTS (5 marks in total):

Part I: Measurements of the Parameters of the Magnetically-Coupled Coils

(a) Step 1: Connect the circuit shown in **Figure 1.0**. Connect Channel (1) of the oscilloscope to display the voltage across the 20Ω-current-sampling resistor (please use the 20Ω-resistor from the green-resistance box), and Channel (2) to display the voltage $v_i(t)$. By setting the trigger source at Channel (1) on the *falling edge,* the input current is now selected as the reference sinusoid.

Set the function generator to provide a sinusoidal input voltage $v_i(t)$ of maximum value at a frequency of 50kHz. [$v_i(t)$ maximum should be approximately 0.6V]

(b) Step 2: Use the oscilloscope to measure the phase angle φ of $v_i(t)$ relative to $i_p(t)$, and the peak values of $v_i(t)$ and $v_{20\Omega}(t)$. ***Note that, after pushing the "Auto Scale" button, you might have to adjust the horizontal time scale knob and the trigger knob to get a stable read out on the oscilloscope.***

Determine the no-load input impedance $Z_{i(NL)}$ seen by the source, as:

$$Z_{i(NL)}=\frac{V_i}{I_p}=20+R_p+jX_p$$

Find the numerical values of X_p ($\omega L_p=2\pi f L_p$) and R_p. Record your results in **Table 1.0**.

63.235 ∠ 68.7

Table 1.0 (0.5 marks)

φ (degree)	|Vi| (mV)	|Ip| (mA)	$Z_{i(NL)}$ (Ω)	X_p (Ω)	R_p (Ω)
68.7°	430 mV	$\frac{136}{20}$ = 6.8	$\frac{430}{6.8}$ = 63.235	-25.49j	57.86

(c) Step 3: Use Channel (2) to display the open-circuit voltage $v_s(t)$, and measure the phase-angle of $v_s(t)$ relative to $i_p(t)$.

Suppose that the top terminal of the primary coil in **Figure 1.0** is selected as the dotted terminal, then based on your phase measurement, which terminal of the secondary coil should be dotted? …………………………….

Measure the peak value of $v_s(t)$. Find the numerical value of the mutual inductance M, and record your results in **Table 2.0**.

Table 2.0 (0.5 marks)

|Vs| (mV)	∠$V_{s\ to\ i}$ (degrees)	X_M (Ω)
287	90	37.03

(d) Step 4: Interchange the primary and secondary coils; the primary terminals are now open circuited, and the reference phasor is I_s, instead of I_p. Repeat your measurements as in Step 2 and Step 3. Evaluate the numerical values of X_s, R_s, and X_M ($\omega M=2\pi fM$) , and record your results in **Table 1.0** and **Table 2.0.**

Table 3.0 (0.5 marks)

φ (degree)	|Vi| (mV)	|Is| (mA)	$Z_{i(NL)}$ (Ω)	X_s (Ω)	R_s (Ω)
45	318	10.75	29.58	20.9	6.92

Table 4.0 (0.5 marks)

$\lvert V_p \rvert$ (mV)	$\angle V_{p\ to\ i}$ (degrees)	X_M (Ω)
606	90	37.03

(e) Step 5: Draw the equivalent circuit of the magnetically-couple coils in the time domain indicating the values of its parameters. Use a numerical value for M that is equal to the average value for M found from **Table 2.0** and **Table 4.0.**

Find the value of the coefficient of coupling:

$$k = \frac{M}{\sqrt{L_p L_s}} = \frac{X_M}{\sqrt{X_p X_s}}$$

From table 2.0:

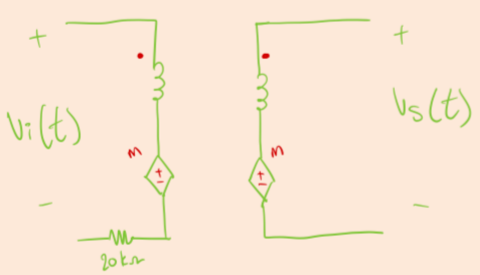
$$k = \frac{X_M}{\sqrt{X_p X_s}} = \frac{37.03}{\sqrt{(74.4)(20.9)}} = 0.939$$

From table 4.0:

$$k = \frac{X_M}{\sqrt{X_p X_s}} = \frac{37.03}{\sqrt{(74.4)(20.9)}} = 0.939$$

$$M = \frac{37.03 + 37.03}{2}$$

$$= 37.03$$



(f) Step 6: Demonstrate Step 1 to Step 5 to your TA. (1 mark)

Part II: Measurement of the Mutual Inductance as a Self-Inductance

(g) Step 7: Modify your circuit connections as shown in **Figure 2.0**, where the coils are connected in series-aiding arrangement. Repeat your measurements as in Step 2, and determine the value of X_A. Record your results in **Table 5.0**. Note that angle φ in this case is the phase angle of $v_i(t)$ relative to i(t).

Table 5.0 (0.5 marks)

φ (degree)	|Vi| (mV)	|I| (mA)	$Z_i = V_i / I$ (Ω)	X_A (Ω)
82	600	3.3	181.82	180.1

(h) Step 8: Interchange the connections of the secondary terminals; the coils are now in series-opposing form. Repeat your measurements as in Step 2, and determine the value of X_B. Record your results in **Table 6.0:**

Table 6.0 (0.5 marks)

φ (degree)	|Vi| (mV)	|I| (mA)	$Z_i = V_i / I$ (Ω)	X_B (Ω)
41.8	600	20	30	20

Determine the value of X_M as:

$$X_M = \frac{X_A - X_B}{4}$$

(i) Step 9: Demonstrate Step 7 and Step 8 to your TA. (1 mark)

6.0 POST-LAB QUESTIONS (2 marks in total, 1 mark for each question):

(1) In comparing the different methods of measuring the value of the mutual inductance between the two coils, which one would you consider to be more reliable? Explain your answer.

Analyzing both methods of measuring the value of mutual inductance the most reliable one is the open circuit. This is due to the fact that the results are more accurate.

(2) Suppose the coefficient of coupling between the two coils is close to unity, what would be the value of the turn ratio of the coils set?

If the coefficient between the two coils is close to unity the value of the turn ratio would be:

$$k = \frac{X_M}{\sqrt{X_P X_S}}$$

$$\boxed{X_m = X_p = X_s}$$

$$= \frac{X}{\sqrt{X^2}}$$

$$= \frac{X}{X}$$

$$k = 1$$