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

Course Title:	ELE302 Electric Networks
Course Number:	ELE302
Semester/Year (e.g.F2016)	F2024

Instructor:	S. Jassar

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

Submission Date:	
Due Date:	Nov 22, 2024

Student LAST Name	Student FIRST Name	Student Number	Section	Signature*
Malik	Hamza	501112545	26	HamzaMalik

ELE 302
Laboratory #5

Mutual Inductance

1.0 INTRODUCTION:

When a time-varying current flows in a coil, it generates a time-varying magnetic flux in the space surrounding it. The time-varying magnetic flux induces a voltage in any conductor linked by this flux. Thus, if a second coil exists in a close physical proximity, an induced voltage will be generated across its terminals; its value is related to the time-varying current in the first coil by a parameter known as mutual inductance. Although the coils are physically separate, their interaction is due to the magnetic coupling that exists between them. The practical application of magnetic-coupling is important, especially in electrical power systems and communication systems.

2.0 OBJECTIVES:

- To determine the dot-convention of a given magnetically-coupled set.
- To measure the resistive and inductive parameters of the set.
- To verify the measured-value of the mutual inductance of the set by using an alternative method: measurement of mutual inductance as a function of self-inductance.
- To examine the concept of impedance reflection between magnetically-coupled networks.

3.0 REQUIRED LAB EQUIPMENT & PARTS:

- Function Generator (FG) and Oscilloscope.
- ELE202 Lab Kit and ELE302 Lab Kit: various components, breadboard, wires and jumpers.
- Magnetically-Coupled Coils (from your TA).

4.0 PRE-LAB ASSIGNMENT (3 marks with 1.5 marks for each step):

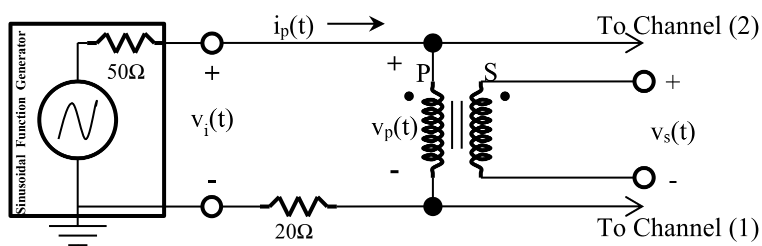


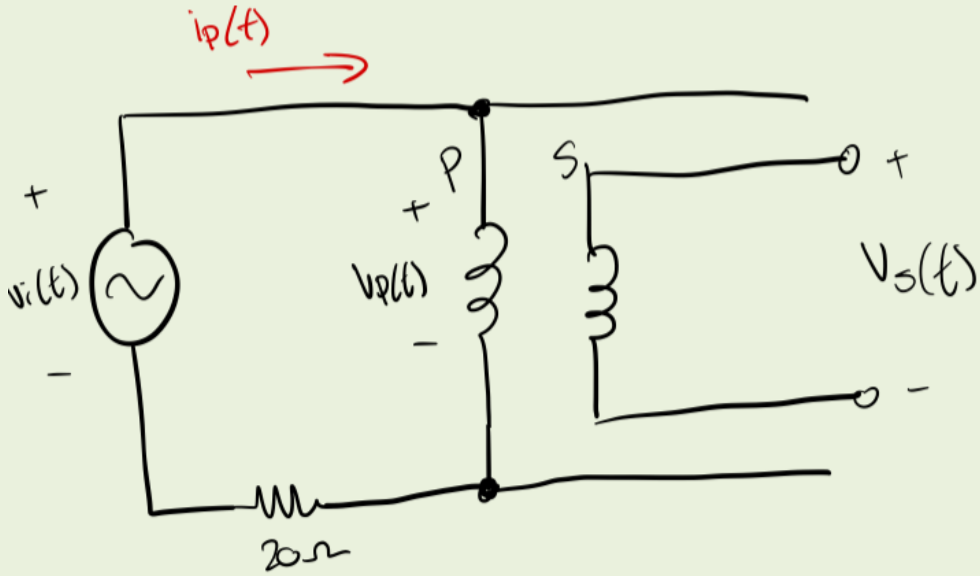
Figure 1.0: Measuring Parameters of Magnetically-Coupled Coils

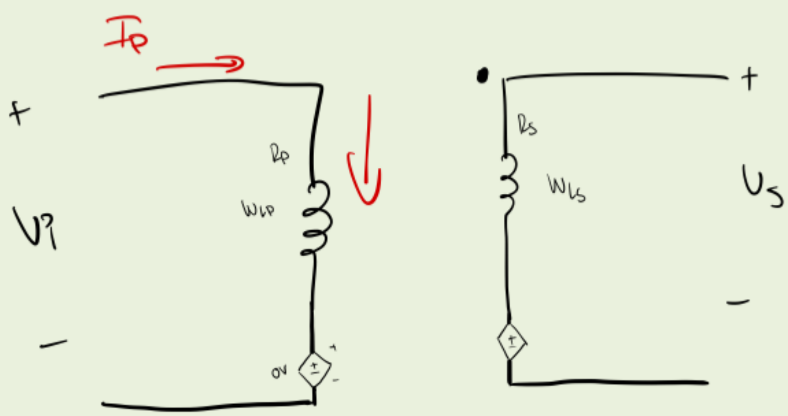
(a) Step 1: The circuit shown in **Figure 1.0** consists of magnetically-coupled coils, where the primary coil is connected in series with a sinusoidal source and a current-sampling 20Ω-resistor, while the secondary coil is open-circuit; i.e., has no load (NL).

The primary coil has self-inductance L_p and inherent resistance R_p, and the secondary coil has self-inductance L_s and inherent resistance R_s; the mutual inductance between the two coils is M.

i) Determine the expressions for V_i and V_s in terms of I_p and the coils parameters, where V_i, V_s and I_p are the phasors for $v_i(t)$, $v_s(t)$ and $i_p(t)$, respectively.

Pre-Lab workspace (show your analysis here)





$$-V_i + j\omega L_p I_p + R_p I_p = 0$$

$$\boxed{V_s = j\omega M I_p}$$

$$\boxed{V_i = (j\omega L_p + R_p) I_p}$$

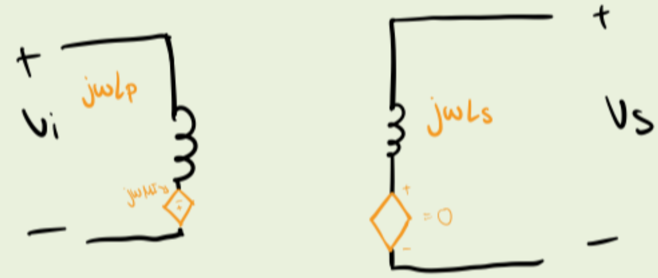
$$\boxed{V_p = j\omega L_p I_p}$$

$$-V_s + j\omega M I_p = 0$$

The I_p current flows on primary side. The dot represents the secondary side

ii) Suppose that the primary and secondary coils are interchanged; i.e., the primary terminals are now open circuited, and the current flow through L_s is $i_s(t)$. Find the expressions for V_i and V_p in terms of I_s and the coils parameters, where V_i, V_s and I_s are the phasors for $v_i(t)$, $v_s(t)$ and $i_s(t)$, respectively.

Pre-Lab workspace (show your analysis here)



$V_p = 0$

$$-V_i - j\omega M I_s = 0$$

$$\boxed{V_i = -j\omega M I_s}$$

$$j\omega L_s I_s + V_s + R_s I_s = 0$$

$$\boxed{V_s = -I_s(j\omega L_s + R_s)}$$

When current is opposite:

$$-V_i + j\omega M I_s = 0$$

$$\boxed{V_i = j\omega M I_s}$$

$$-V_s + (j\omega L_s + R_s) I_s = 0$$

$$\boxed{V_s = (j\omega L_s + R_s) I_s}$$

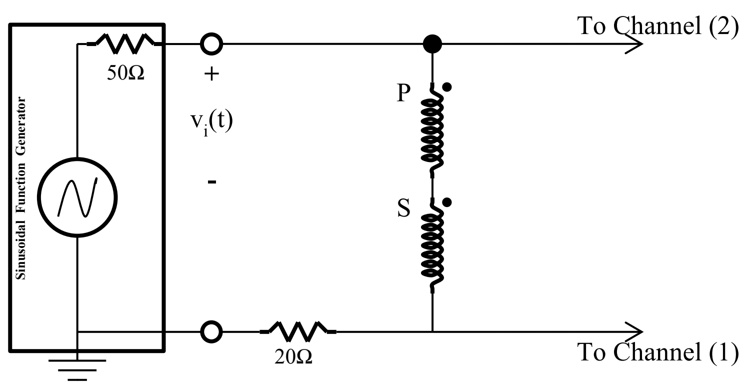


Figure 2.0: Measuring Mutual Inductance as Self-Inductance

(b) Step 2: The primary and secondary coils shown in **Figure 2.0** are connected in series-aiding with the current i(t) entering each of the coils from its dotted terminal. Let the total inductance of this arrangement be L_A. Upon interchanging the secondary terminals connections, however, total inductance of the series-opposing arrangement becomes L_B.

Show that the mutual inductance M is:

$$M=\frac{[L_A-L_B]}{4}$$

Pre-Lab workspace (show your analysis here)

$$-v_i(t) + Ri(t) + L_1\frac{di}{dt} + L_2\frac{di}{dt} + \frac{Mdi}{dt} + \frac{Mdi}{dt} = 0$$

$$(L_1 + L_2 + 2M)\frac{di}{dt} = v_i(t) - Ri(t)$$

$$(L_1 + L_2 + 2M) = \frac{v_i(t)}{di/dt} - \frac{Ri(t)}{di/dt}$$

$$L_1 + L_2 + 2M = L_n - \frac{Ri(t)}{di/dt}$$

$$(L_1 + L_2 - 2M)\frac{di}{dt} = v_i(t) - Ri(t)$$

$$(L_1 + L_2 - 2M) = L_B - \frac{Ri(t)}{di/dt}$$

$$L_A - L_B = 4M$$

$$\boxed{M = \frac{L_A - L_B}{4}}$$