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Subject: Mutual Inductance and Capacitance

In this lab, mutual inductance and capacitance was studied. For studying inductance, two inductors were placed near to each other and two configurations were used to determine the equivalent inductance. One configuration caused the equivalent to be less, and the other configuration caused a greater inductance. For studying mutual capacitance, two copper pipes and a plate of aluminum were used. All three were put together closely, and the capacitance of each was measured. The purpose of doing this experiment is to show that a mutual inductance and a mutual capacitance exists between two inductive or capacitive elements when placed close to each other.

The dots on the inductors simply correspond to the positive end of a voltage drop. In *figure 1(a) (Appendix 1)* the dots correspond to the voltages v_1 and v_2, but in *figure 2(b)*, v_2 is actually labeled opposite of what it actually is (because the + end is not by the dot). Note that there is always a voltage drop across a passive component (such as an inductor). The inductor with the greater loop area has the greatest inductance because by definition, the inductance is directly proportional to the loop area. In other words, the greater the loop area, the greater the inductance.

In this experiment it was observed that the greater separation between the capacitors, the less the capacitance was. This is because again, by definition, the capacitance is inversely proportional to the distance between the capacitor's plates (which in this experiment was the pipes and aluminum plate). Also, by the definition of capacitance, it is important that the capacitor's materials have the potential for being capacitive. The self-capacitance as well as the mutual capacitance created both depend on the capacitive potential of the material

Appendix I - Inductors
Mutual Inductance and Capacitance

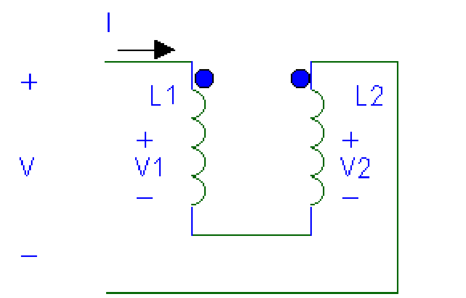

Figure 1 (a)

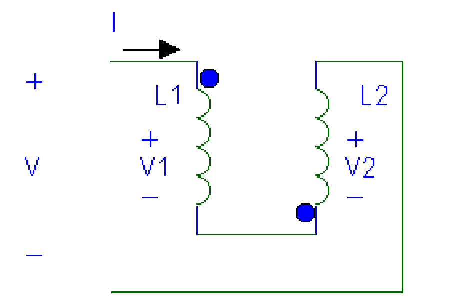

Figure 1 (b)

$\mathbf{L_{eqa}}$**:** 47.3 µH
$\mathbf{L_{eqb}}$**:** 104.9 µH

LCR Frequency setting: 1 kHz

L1	L2
Designation: #1 Loop length: 9 in. Loop width: 8 in. Enclosed Area: 72 sq. in. Inductance: 46.5 µH	Designation: #2 Loop length: 9 in. Loop width: 6 in. Enclosed Area: 54 sq. in. Inductance: 30.2 µH

From Preliminary:
(1) $L_{eqa}=L_1+L_2-2M$
(2) $L_{eqb}=L_1+L_2+2M$

$\mathrm{Max}\{L_{eqa}, L_{eqb}\} = L_{eqb} = L_1+L_2+2M$ *Which implies that* $2M = \mathrm{Max}\{L_{eqa}, L_{eqb}\}-L_1-L_2$
Therefore, $\mathbf{M = (Max\{L_{eqa}, L_{eqb}\}-L_1-L_2) / 2 = 14.1\ \mu H}$

$\mathrm{Min}\{L_{eqa}, L_{eqb}\} = L_{eqa} = L_1+L_2-2M$ *Which implies that* $2M = -\mathrm{Max}\{L_{eqa}, L_{eqb}\}+L_1+L_2$
Therefore, $\mathbf{M = -(Min\{L_{eqa}, L_{eqb}\}-L_1-L_2) / 2 = 14.7\ \mu H}$

% Difference: 4.08 %

Appendix I - Capacitors
Mutual Inductance and Capacitance

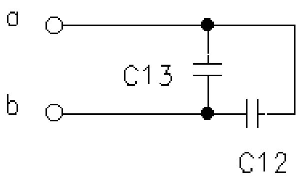

figure 2 (a)

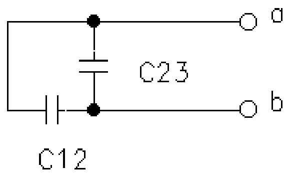

figure 2 (b)

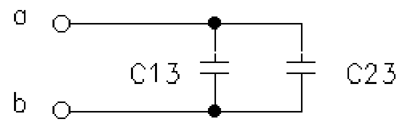

figure 2 (c)

Results from preliminary:
(1) $C_1 = C_{13} + C_{12}$
(2) $C_2 = C_{23} + C_{12}$
(3) $C_3 = C_{13} + C_{23}$

$\mathbf{(C_1+C_2 - C_3)/2} = [(C_{13} + C_{12}) + (C_{23} + C_{12}) - (C_{13} + C_{23})] / 2 = 2^* C_{12} / 2 = \mathbf{C_{12}}$

$\mathbf{(C_2+C_3 - C_1)/2} = [(C_{23} + C_{12}) + (C_{13} + C_{23}) - (C_{13} + C_{12})] / 2 = 2^* C_{23} / 2 = \mathbf{C_{23}}$

$\mathbf{(C_1+C_3 - C_2)/2} = [(C_{13} + C_{12}) + (C_{13} + C_{23}) - (C_{23} + C_{12})] / 2 = 2^* C_{13} / 2 = \mathbf{C_{13}}$

Using one sheet of paper:

C_a (C_1 with #2 and #3 shorted): 140.0 pf
C_b (C_2 with #1 and #3 shorted): 144.0 pf
C_c (C_3 with #1 and #2 shorted): 219 pf

∴ **C_{12} = 32.5 pf**
C_{23} = 111.5 pf
C_{13} = 107.5 pf

Using two sheets of paper:

C_a (C_1 with #2 and #3 shorted): 121.5 pf
C_b (C_2 with #1 and #3 shorted): 126.4 pf
C_c (C_3 with #1 and #2 shorted): 187 pf

∴ **C_{12} = 30.45 pf**
C_{23} = 95.95 pf
C_{13} = 91.05 pf