Experiment No. 6: Self Induction and Mutual Induction

1. Objective

The objective of this experiment is to verify the phenomenon of self-induction and mutual induction.

2. Apparatus

- IT-100, IT-100B and IT-100B Trainer
- 2mm Patch Cords
- 12V AC Lamp

3. Theory

3.1 Self-Induction

Any change in current causes an expansion or collapsing of the magnetic field around a conductor, which in turn induces an e.m.f. in the conductor. This phenomenon is self-induction induction. The magnitude of the self-induced e.m.f. is proportional to the amplitude and frequency of the current. By Lenz's Law, we can also find the relationship between the induced e.m.f. and the applied voltage that causes the current flow is such that the two voltages are always 180 degrees out of phase.

Since the magnitude of the magnetic flux is proportional to the magnitude of current in the coil. The self-induced e.m.f. of coil can be expressed by the Equation 6.1. Of course, the magnetic field of a coil can be made stronger, more flux lines too, by keeping a soft iron core inside the coil.

$$e = L\frac{di}{dt} \qquad (6.1)$$

Where L is the inductance of the coil due to which it opposes the change of current flowing through it. Inductance is attained by a coil due to the self-induced e.m.f produced in the coil itself by changing the current flowing through it. If the current in the coil is increasing, the self-induced e.m.f produced in the coil will oppose the rise of current, which means the direction of the induced e.m.f is opposite to the applied voltage. If the current in the coil is decreasing, the e.m.f induced in the coil is in such a direction as to oppose the fall of current; this means that the direction of the self-induced e.m.f is same as that of the applied voltage. This property of the coil only opposes the changing current (alternating current) and does not affect the steady current that is (direct current) when flows through it. The unit of inductance is **Henry** (H).

The circuit of Fig. 6.1 can be used to demonstrate the phenomenon of self-induction. When the switch is closed, the coil then current changes in the coil and build a magnetic field (flux). If the switch is opened, the magnetic flux will collapse rapidly.

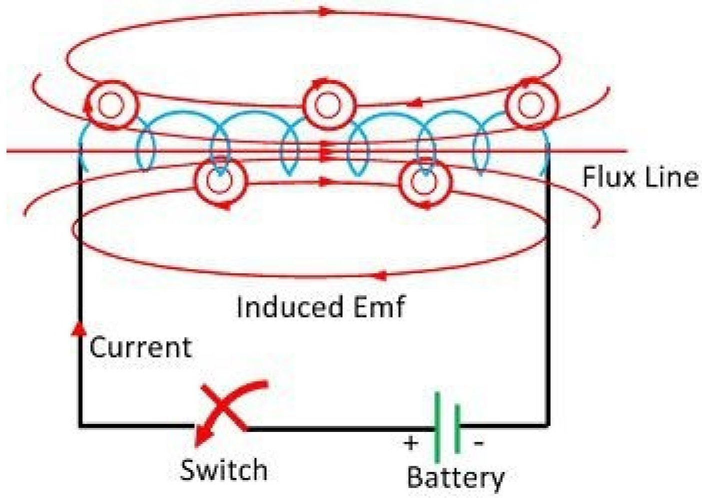

Figure 6.1: Self-Induction

3.2 Mutual Induction

When the current in a coil is changing that a voltage will be induced in another coil placed near to it. This effect is called mutual-induction. Consider the Figure 6.2, current flowing through the coil of inductance L_1 builds up a magnetic field (flux) around itself. A part of this flux which links only coils 1. The other part links both the 1 and 2 coils and therefore is a component of mutual flux. This mutual flux sets up an induced e.m.f. in coil L_2 given by Equation 6.2.

$$e_m = M\left(\frac{dI_1}{dt}\right) \qquad (6.2)$$

Or

$$M = e_m \Big/ \left(\frac{dI_1}{dt}\right) \qquad (6.3)$$

Where, e_m is the voltage induced in the secondary coil and I_1 is the current flowing in the primary coil. *M* is the mutual inductance, defined as the property of the coils that enables it to oppose the changes in the <u>current</u> in another coil and measured in **Henry** (H).We can use this formula when we know the value of the mutually induced e.m.f as well as the change of current in coil two, or the neighboring coil.

Now, if $e_m = 1$ and $dI_1 / dt = 1$, then on substituting the value in the given equations, we see that the value of M, that is mutual inductance is 1 Henry. Thus two coils have a mutual inductance of 1 henry when e.m.f of 1 volt is induced in coil 1 and when the current flowing through coil 2 is changing at the rate of one ampere per second.

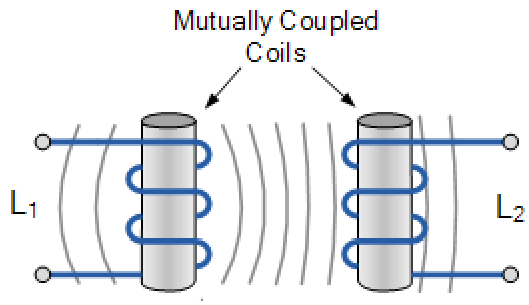

Figure 6.2: Mutual Induction

4. Procedure

1. Set the module IT-100B and locate the Self Induction block.
2. According to Figure 6.3, complete the experiment circuit with short-circuit clips.
3. Observe the states of the lamp while pressing or releasing the switch and conclude your observation.
4. Set the module IT-100D and locate the Mutual Induction block.
5. Connecting the battery through a switch at one coil
6. Connect the other coil with the Galvanometer(G)
7. Observe the deflection on the galvanometer while pressing or releasing the switch and conclude your observation.

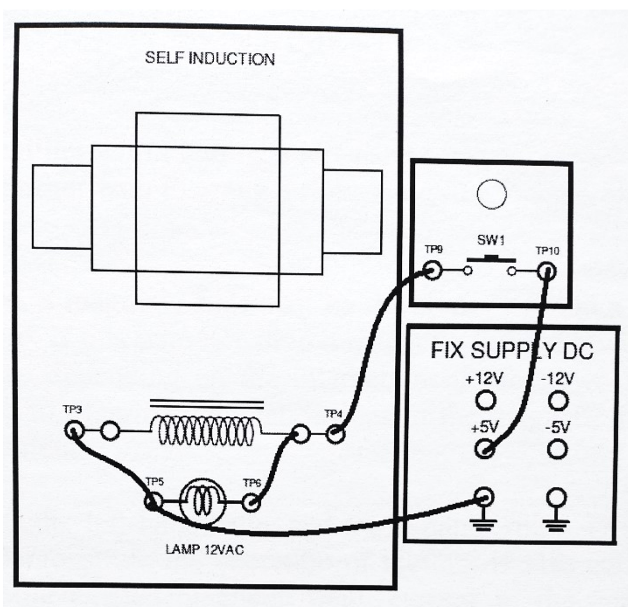

Figure 6.3: Connection Diagram of Self Induction Experiment

5. Lab Task:

1. Connect the secondary coil in mutual induction experiment with the lamp. Will the lamp brighten? Why?

6. Conclusions