Experiment (7)

MAGNETIC INDUCTION

OBJECTIVE
To verify Faraday's law of induction. The induced voltage in the secondary circuit is measured as a function of the amplitude and frequency of the current in the primary circuit. The variation of the induced voltage with the number of turns and the cross-sectional area of the secondary circuit is also studied.

EQUIPMENT REQUIRED
1. Frequency counter.
2. Function generator.
3. Digital multimeter.
4. Analog multimeter.
5. Voltage transformers 125/220 (two).
6. Field coil 485 turns/meter, 750 *mm* long.
7. Induction coil, 300 turns, 41 *mm* diameter.
8. Induction coil, 300 turns, 33 *mm* diameter.
9. Induction coil, 300 turns, 26 *mm* diameter.
10. Induction coil, 200 turns, 41 *mm* diameter.
11. Induction coil, 100 turns, 41 *mm* diameter.

INTRODUCTION
According to Faraday's law of induction, voltage can be induced in a circuit due to current passing through a nearby circuit. In this experiment, a large solenoidal field coil (item 6 in the equipment list) is used to generate a time-varying magnetic field by passing an *AC* current (I_1) through it. Smaller coils (items 7-11 in the equipment list) are used for induction (see Figure 1).
The *AC* current I_1 passing through the field coil produces a time-varying magnetic field given by:

$$\overline{B} = \mu_o n I_1 \quad \text{..........} \quad (1)$$

where n is the turns density (turns/meter) of the coil. If the current I_1 is sinusoidal and given by:

$$I_1 = I_o \cos(\omega t) \quad \text{..........} \quad (2)$$

then, the induced voltage, v, in the induction coil is given by:

$$v = \mu_o n \pi a^2 N \omega I_o \sin(\omega t) \quad \text{..........} \quad (3)$$

where a and N are the radius and the number of turns of the induction coil, respectively.

PROCEDURE
<u>*RART A: Induced voltage vs. current*</u>
1. Connect the function generator to the field coil and to the frequency counter.
2. Adjust the frequency to 10.7 *kHz*.
3. Measure the amplitude of I_1, using the analog multimeter.
4. Insert the 300-turn, 41 *mm* diameter coil into the field coil. Insure that the coil is well into the field coil. Measure the induced voltage in the coil using the digital multimeter.

5. Repeat for a range of I_1 from 0 to 30*mA*.

PART B: Induced voltage vs. number of turns

1. Fix the current I_1 to 30*mA* and the frequency to 10.7 *kHz*. Measure the induced voltage across the 300-tum, 41 *mm* diameter coil.
2. Repeat step (1) for the 200-turn, 41 *mm* diameter and the 100-turn, 41 *mm* diameter coils.
3. Repeat step (1) for a 400-turn, 41 *mm* diameter coil (not provided but a combination can be used).
4. Repeat step (1) for a 500-turn, 41 *mm* diameter coil.

PART C: Induced voltage vs. coil diameter

1. Fix the current I_1 to 30*mA* and the frequency to 10.7*kHz*. Measure the induced voltage across the 300-tum, 41 *mm* diameter coil.
2. Repeat step (1) for the 300-tum coils of diameters 33 *mm* and 26 *mm*.

PART D: Induced voltage vs. frequency

1. Fix the current I_1 to 30*mA* and the frequency to 1 *kHz*. Measure the induced voltage across the 300-turn, 41 *mm* diameter coil.
2. Repeat step (1) for a frequency range from 1 to 12 *kHz* (make sure that the current is maintained at 30*mA* each time you change the frequency).

QUESTIONS FOR DISCUSSION

1. Plot the experimental and the theoretical relations between the induced voltage and current, number of turns, coil diameter and frequency.
2. From your experimental curves, find the induced voltage for the case: N=350, a= 15 *mm*, I_1= 10*mA* and f=10 *kHz*.
3. Use equation (3) to find a theoretical value of the induced voltage for the case in question (2). Compare with your answer of question (2). This is a good measure of the accuracy of your experimental results.

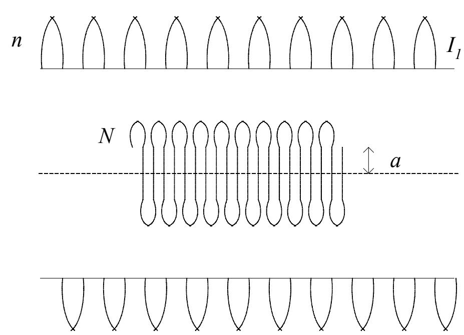

Figure 1: Field and induction coils