實驗八　Electromagnetic Induction

Object:

To determine the *induction voltage* as a function of ; the *strength* of the magnetic field, the *frequency* of the magnetic field, the *number of turns* of the induction coil and the *cross-section* of the induction coil.

Principle:

A magnetic field of variable frequency and varying strength is produced in a long coil. The voltages induced across thin coils which are pushed into the long coil are determined as a function of *frequency* (*f*), *number of turns per unit length* (*n*), *diameter* and *field strength*.

The magnetic field flux is expressed by,

$$\Phi_B = \int_S \vec{B} \cdot d\vec{A} \tag{1}$$

According to Maxwell's 3rd equation, if $\frac{d\Phi_B}{dt} \neq 0$, there will be an induced electric voltage in an arbitrary closed path *C*, *i.e.*

$$V = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\int_S \vec{B} \cdot d\vec{A} = \oint_c \vec{E} \cdot d\vec{l} \tag{2}$$

In the present case, the magnetic field is produced by a long *field* coil ("*field* coil", denoted as "*f*"). For a long solenoid coil (*field* coil) with N_f turns, a current $I_f = I_{fo} \sin \omega t$ flows through the *field* coil. Then, the magnitude of $\vec{B}$ field inside the *field* coil is,

$$B_z = u_o I_f \frac{N_f}{L_f} = u_o I_f n_f \tag{3}$$

Here, $u_o = 1.26 \times 10^{-6} N/A^2$ (or $4\pi \cdot 10^{-7} Vs/Am$) is the permeability of free space. Then, from Eq. (2), the voltage induced in an *induction* coil (N_i turns, cross-section area A_i) is obtained:

$$V = -\frac{d\Phi_B}{dt} = -N_i \frac{d}{dt}(u_o I_f \frac{N_f}{L_f} A_i) = \frac{-u_o \omega N_i N_f A_i I_{fo} \cos \omega t}{L_f} \tag{4}$$

Equipments List:

Field Coil, d=120 mm	1
Induction Coil 1, 300 turns, A (cross-section)= 50×50 mm^2	1
(Coil 1 is also provided with 100 and 200 turns)	
Induction Coil 2, 300 turns, A (cross-section)= 30×50 mm^2	1
Induction Coil 3, 300 turns, A (cross-section)= 20×50 mm^2	1
Function Generator (AC power supply)	1
SW750 Interface Box	1
PC with interfacing software	1

Experimental Procedure:

a) Measure the induction voltage V as a function of the area (cross-section) A of the induction coils and obtain V ***vs.*** A curve.

b) Measure the induction voltage V as a function of the number of turns N_i (choosing coil *1*) and obtain V ***vs.*** N_i curve.

c) Measure the induction voltage V as a function of frequency I_f (choosing coil *1*) and obtain V ***vs.*** I_f curve.

d) Measure the induction voltage V as a function of frequency f (choosing coil *1*) and obtain V ***vs.*** f curve.

Tips for using Interfacing software:

a) Click "**Data Studio**" on the screen.

b) Click "**Create Experiment**".

c) Choose "**Voltage Sensor**" from "**Experiment Setup**".

d) Choose various displaying functions from "**Displays**".

e) In the "**Sampling Options**", set up the *time interval* of obtaining data.

f) Then you may begin your experiment anytime by click "**Start**" key.

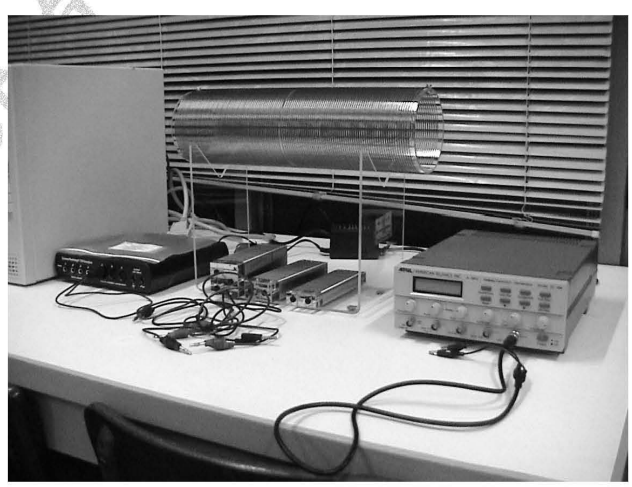

Figure 1 Experimental set-up for magnetic induction.