6 Electromagnetic Induction

1. Section Purpose:

Understand Faraday's Law of electromagnetic induction from the temporal interaction between magnet and coil.

2. Introduction:

When the bar magnetic passes the coil, there is a change of magnetic flux, Φ, through the coil. That induces an Electromotive Force (emf, ε) in the coil, which follows Faraday's law of electromagnetic induction,

$$\varepsilon = -N\frac{d\varphi}{dt} \tag{1}$$

N is the number of turns of wire in the coil. $\frac{d\varphi}{dt}$ is the rate of change of the magnetic flux through the coil.

The experimental result would be presented by a curve plot of the electromotive force, ε, versus time. The area under the curve, found by integration, represents the magnetic flux through the coil,

$$\int \varepsilon dt = -N\int d\varphi = -N\Phi \tag{2}$$

3. Instruments Required：

SW750 interface, voltage sensor, coil, adhesive tape.

4. Steps to the Experiment:

In this experiment, the voltage sensor can measure the induced voltage in the coil. When a falling bar magnetic passes through the coil, it will activate the computer program to record and display the coil's induced voltage as a function of time.

(1) Basic installation and set up:

1. Connect SW750 interface to the computer. First, turn on the power of SW750 interface, and then turn on the power of the computer, to enable the computer connected with SW750 interface.
2. Using the cable provided, connect the voltage sensor to the Analog Channel A on SW750 interface, by inserting the 8-PIN jack into the socket on the interface, such as Figure 1. Put the two alligator clips on the other end of the voltage sensor across the coil, as Figure 2.
3. As the installation of Figure 2, allow the bar magnet dropped through the coil on circuit board smoothly. However, do not touch the inner wall of coil. (Make sure that coil does not strike the floor, or it may break! And do not let the bar magnet near computers or monitors, otherwise it will cause damage)

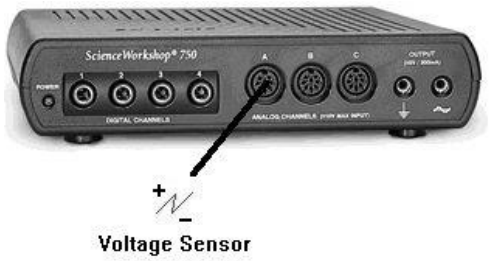

Fig. 1

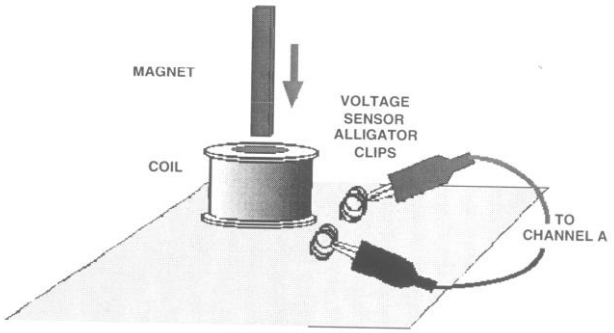

Fig. 2

4. On computer screen, use your computer mouse and choose the icon of "Faraday's Law of Electromagnetic Induction", click on the left key twice to open the function window. Once you activate the window you will see the brief introduction of this experiment on Induction Workbook-Page 1, click on 1▷, you can move to Page 2, and look up the setup values of this experiment: such as, Periodic Sample rate = 200 Hz: Read out 200 data

points per second.

5. Then, for the need of this experiment, one can choose the necessary function among the list under “Display” functions. For example, when you need windows of “Graph”, “Table”, and “Meter”, you can double-click “Graph”, “Table”, or “Meter” under the function list to open it, as Figure 3.

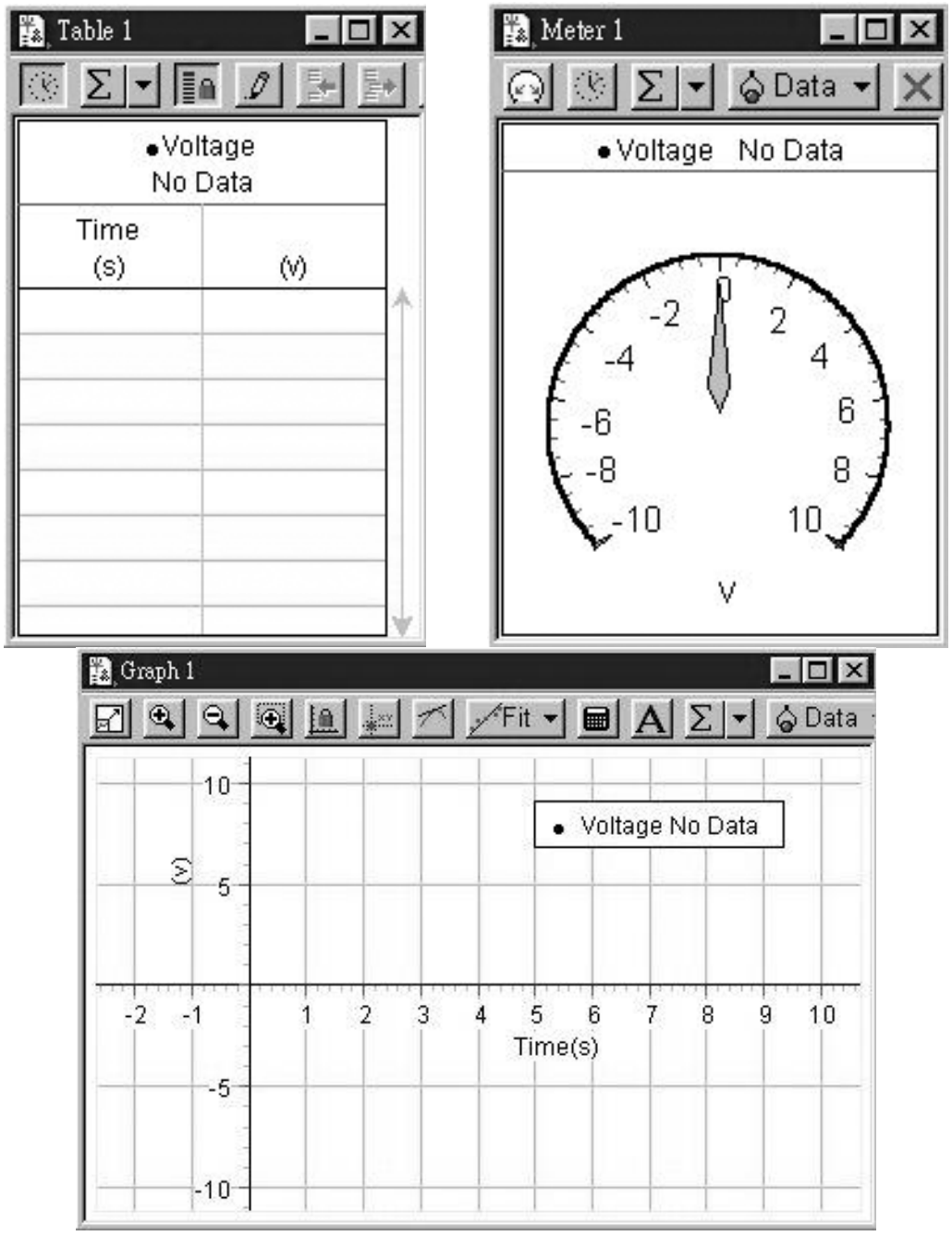

Figure 3

6. From the screen interface window, you click on the function key of Setup ， the window of “Experiment Setup” will show. And then, you click on the function key, Options... ， and activate a window of “Sampling Options”, as Figure 4：

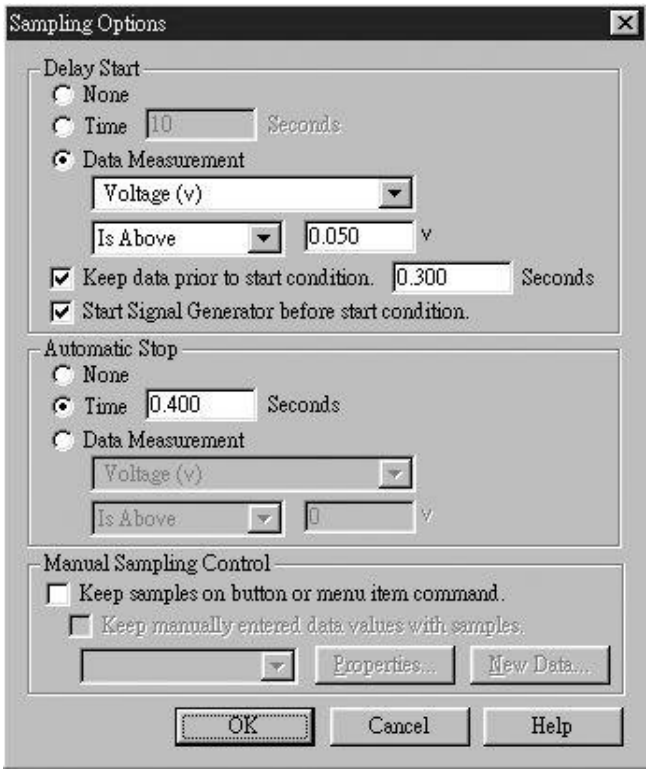

Figure 4

The setting of the sampling options shown on Figure 4 is like:

Start Condition =0.3 sec

Stop Condition =Time at 0.4 seconds

Because of the recording rate is one data point during every $\frac{1}{200}$ second, there will be 140 data points within 0.7 seconds.

(. i.e. $\frac{0.7}{1/200} = 140$)

**The above two groups of data recording configuration may be adjusted as one sees fit, during the practice of experiment.

(2) Data Recording:

1. Click on the “Start” button on the program window.
2. Set the bar magnet about 5 centimeters above the coil, and then allow the bar magnet dropped freely.

3. Data recording of the induced voltage will begin when the magnet falls through the coil. After 0.7 seconds it will automatically stop recording and display on the (voltage / time) screen the induced voltage data curve as a function of time. Also, the curve indicated as “RUN # 1” on the configuration window presents the first 140 data points during the data recording.

(3) Data Analysis:

1. Click on the button from the curve-display window. You can choose the proper function to analyze the size and area, and or so, of the recorded data graphs.
2. Press the left key on the computer mouse and drag on the graph on display window, to select the area you want to enclose for area integration under the data curve. As Figure 5, if the gray area is the chosen area, the statistics box area above the curve picture would present its corresponding statistical information of the chosen area.

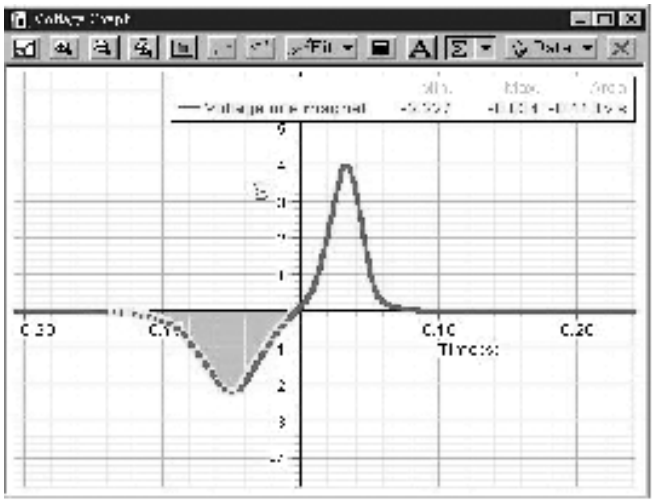

Figure 5

3. Write down the area values of the first and the second peaks on your laboratory report.

5. Discussions:

(1) Is the magnetic flux value of the in-coming bar magnet entering the coil equal to the flux value of the out-going bar magnet leaving the coil? Please elaborate.

(2) From the recorded data curve picture, one can clearly observe that the peak value of the out-going status (i.e., the second peak) must be greater than the one of the in-coming status, namely first peak. Why?

(3) From the recorded data curve picture, why are the first and second peaks opposite in direction?

(4) Following the two situations below, repeat the experiment of Faraday's law of Electromagnetic Induction and discuss the results:

1. Put two similar bar magnets consecutively together: North to North, or South to South; and then closely tie them together, with adhesive tape.
2. Put two similar bar magnets consecutively together: North to South, or South to North; and then closely tie them together, with adhesive tape.