## Experiment

**9**

Electromagnetic Induction

**Introduction and Theory**

In your own words, discuss the purpose of this experiment. *Don’t forget to discuss the meaning of the relevant concepts (Magnetic flux, Faradays Law, and Lenz’s Law).*

 **Materials**

3400-turn big coil

Galvanometer

A 1.5V battery

A small compass

BNC cables

PASCO 400-turn and 2000-turn small loop coil

Function Generator

Oscilloscope

#### Procedure

##### **Part 1**

1. Connect a 3400-turn big coil (62.5Ω) to a 1.5 V battery through a touch switch. Place a small compass inside the coil with its needle pointing perpendicular to the coil axis.



Now temporarily push the switch. What happens to the compass? Why? See if you can deduce the direction of the polarity of the compass needle **(enter your response below)**.

1. Connect one big coil to a Galvanometer and the other big coil to 1.5v battery through a touch switch. Make sure the faces of the coils are parallel to each other (within 1 cm ).

Now temporarily complete the circuit by touching the switch. What happens to the galvanometer? Does it deflect? Which way and why? Give an everyday example where this effect occurs **(enter your response below)**.

##### **Part 2**

A small coil of 400-turns will be connected to a signal generator (called the field coil). An oscilloscope will monitor the voltage applied to the coil. Since the current through the coil varies with time, the field produced by the coil will vary with time. A 2000-turn coil called the detector coil will be also connected to an oscilloscope. The detector coil signal will be monitored simultaneously with the voltage applied to the field coil. Follow the procedure below.

1. **Square wave input signal.**
* Connect the 400-turn small loop to the signal generator. Turn on the generator and the oscilloscope. Set the signal generator to produce a 1V square wave (peak-to-peak) at 100Hz with the aid of the oscilloscope. Make sure that the signal is observed on channel 1 of the oscilloscope. If the vertical setting is set to 0.5V/division, the overall height (peak-to-peak) of the observed signal will be 2.0 cm.
* The 2000-turn small loop will be connected to channel 2 of the oscilloscope. Bring the coils into contact with each other so that their axes coincide. Adjust the Volts/div setting so that the detector signal can be observed. Sketch your observations below. (make sure that the drawing matches the indicated scales)

100Hz Square Wave Input

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Channel 1 Volts/div = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; Vpp1 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Channel 2 Volts/div = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; Vpp2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Horizontal Sweep (time/div) = \_\_\_\_\_\_\_\_\_\_\_\_

When is an EMF observed on the 2000-turn coil? Is it observed over the flat part of the square wave? Why or why not **(enter your response below)?**

Is the induced EMF on the detector coil larger or smaller than the voltage across the field coil? Is this what you expected? Why **(enter your response below)?**

Rotate the detector coil by 90°. What happens? Explain **(enter your response below)?**

Rotate the detector coil by 180°. What happens? Is the maximum induced voltage the same or different? Explain **(enter your response below)?**

1. **Triangle wave input signal.**
* Change the square wave into a triangle wave (don’t change the frequency). Repeat the measurements from step 1.

100Hz Triangle Wave Input

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Channel 1 Volts/div = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; Vpp1 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Channel 2 Volts/div = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; Vpp2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Horizontal Sweep (time/div) = \_\_\_\_\_\_\_\_\_\_\_\_

*Does the shape of the observed signal agree with Faraday’s Law?* Explain. Please comment on any additional observations. Please be as detailed as possible. **(enter your response below)**.

Rotate the detector coil by 90°. What happens? Explain **(enter your response below)?**

Rotate the detector coil by 180°. What happens? Explain **(enter your response below)?**

Vary the frequency from 100Hz to 2000Hz. Sketch the signal at 2000Hz. Explain your observation **(enter your response below)?**

2000Hz Triangle Wave Input

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Channel 1 Volts/div = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; Vpp1 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Channel 2 Volts/div = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; Vpp2 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Horizontal Sweep (time/div) = \_\_\_\_\_\_\_\_\_\_\_\_