Exp9: Faraday’s law of induction

20210816 Phattharaphol

**Abstract**

This experiment was conducted to test the Faraday’s law of induction. The experiment set up using two coil with different radius and turn, the outer 200 turn coil connect to the signal generator and let the current flow, while inner 2000 turn coil was to be measure the induced emf. Each trial conduct with different waveforms, frequencies, and number of turn inner coil. The graphs show the relationship of emf as the derivative of input voltage. Also, the emf and signal frequency show the linear relationship.

**Introduction**

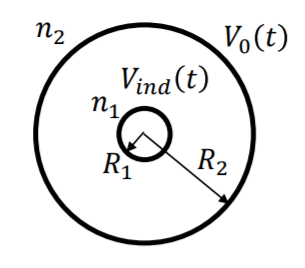
Faraday’s law is one of the maxwell’s equations that form the foundation of electromagnetism. The equation describes how time-varying magnetic field induce the electric field. In this experiment, the faraday’s law will be experimented using 2 coils with different radius and number of loops. The current run through outer coils will create the change in magnetic flux on inner coil, thus induce the emf in inner coil. The emf of both coils will be recorded at the same time. Effect of varying the signal frequency and waveform on the induced emf are to be observed.

**Theory**

Faraday’s law of induction states that the change in magnetic flux induce the electromotive force, written as

Where is the number of loops, magnetic flux at the center

In this experiment, the 2000 turn detector coil is placed inside 200 turn coil

From faraday’s law, emf is described as

And Biot-Savart Law

Where is permeability of free space and is displacement from wire to magnetic field point

**Method**

1. Set up the outer 200 turn coil and connect with the signal generator.
2. Place the 2000 turn detector coil inside. Add the resister at terminals to reduce noise.
3. Set signal generator to triangle wave at frequency 1000 Hz.
4. Measure the output voltage of outer coil and induced emf from inner coil.
5. Change the waveform to sine wave and square wave and measure voltage and emf.
6. Change back to triangle wave, adding up 500 Hz each trial.
7. Change the inner coil to 400 turn coil. Record output voltage and emf at 2000 Hz, and adding up 500 Hz each trial.

**Results**

Emf from 2000 turn detector coil and output voltage vs time of each waveform at frequency 1000 Hz

Sine wave

Triangle wave

Square wave

Data summary, induced emf of triangle wave

|  |  |  |
| --- | --- | --- |
| Frequency (Hz) | Emf amplitude (V) | |
| 2000 turn coil | 400 turn coil |
| 1000 | 0.029 | - |
| 1500 | 0.044 | - |
| 2000 | 0.059 | 0.015 |
| 2500 | 0.068 | 0.017 |
| 3000 | 0.088 | 0.02 |
| 3500 | - | 0.022 |
| 4000 | - | 0.024 |

**Discussion**

From the graph of both 2000 turn and 400 turn coil, the emf and frequency show the linear relationship where. Since and can be expressed as . So , which means is also proportional to frequency.

However, the R2 value of both 2000 turn and 400 turn coil graph is not exactly 1, and 2000 turn coil has larger R2 value. The error may occur because of the measurement error, or the process of obtaining data from analysis.

Since the magnetic flux of the outer coil is proportional to number of turn, and emf is proportional to the change of magnetic flux, so if generating coil change from 200 turn to 1000 turn, the emf induced should increase by 5 times.

**Conclusion**

In this experiment, the Faraday’s law of induction was examined. Letting the current flow in the outer coil makes the change of magnetic flux on the inner coil. The emf induced in the inner coil was measure in different ways, by vary the waveform, frequency, and change the number of turns of inner coil from 2000 to 400. The results graphs clearly show that the induced emf is the derivative of input voltage, which correspond with the Faraday’s law. Also, the relationship between emf and signal frequency is likely to be linear relation as stated in the theory.

**References**

https://genphylab.kaist.ac.kr/labs/general-physics-lab-1/faraday's-law-of-induction/manual