3

13.5
15

4

NORTH SOUTH UNIVERSITY

Department of Mathematics & Physics

Experimental Physics

PHY-108L·8

Name of the Experiment: **INDUCED EMF AND MUTUAL INDUCTANCE**

Name: **Shakil Ahmed** ID: **2221453042**

Serial No: **21**

Group Member's Name: (i) **Mortaza Morshed** ID: **2212697643**

(ii) **Safayat Ibrahim** ID: **2131174642**

Date: (i) Experiment Performed: 28/08/2023

(ii) Report Submitted: 04 /09/2023

Mahadul

Plot #15, Block # B, Bashundhara, Dhaka-1229, Bangladesh

Phone: +88 2 55668200, Fax: +88 2 55668202, Web: www.northsouth.edu

EXPERIMENT 4: INDUCED EMF AND MUTUAL INDUCTANCE

1. Objectives:

(a) To verify the concept of induced emf
(b) To calculate the turns-ratio of a transformer
(c) To verify the effect of frequency on a transformer

2. Background:

If two inductors are placed in the vicinity of each other, an induced emf appears in one coil if the current is changed in the other coil. It obeys Faraday's law of induction and is given by the formula

$$E_L = -L\frac{di}{dt} \qquad E \propto \frac{dB}{dt}$$

It means that an induced emf (E_L) appears in the coil when there is a change in current. It is also called mutual induction.

A transformer is a widely used device that works on the principle of mutual induction. It consists of two coils with different number of turns wound around an iron core. The primary winding (called primary) of N_p turns is connected to an alternating current generator whose emf at any time t is given by

$$\mathcal{E} = \mathcal{E}_m \sin\omega t$$

This sinusoidally changing primary current produces a sinusoidally changing magnetic flux in the iron core. The core acts to strengthen the flux and to bring it through the secondary winding (called secondary). As the flux varies, it induces an emf in each turn of the secondary. In fact, this emf per turn $\mathcal{E}_{turn}$ is the same in the primary and the secondary. Across the primary, the voltage $V_p$is the product of $\mathcal{E}_{turn}$ and the number of turns in the primary, N_p, i.e., $V_p = \mathcal{E}_{turn} * N_p$

Similarly, for the secondary side, $V_s = \mathcal{E}_{turn} * N_s$

Thus, we can write, $\mathcal{E}_{turn} = \frac{V_P}{N_P} = \frac{V_S}{N_S}$

If $N_s > N_p$, the device is called a step-up transformer because the secondary voltage is greater than the primary voltage.

If $> N_s$, the device is called a step-down transformer because the secondary voltage is smaller than the primary voltage. However, for a transformer, the ratio of the voltages of across two terminals- called the turns ratio - is equal to the ratio of the number of turns of the corresponding terminals.

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

In this experiment, a step-down center-tapped transformer (12V – 0 – 12V) will be use

3. Procedures and Observations:

Part 1: Induced EMF:

1. Complete the circuit diagram, as shown in Figure 1.
2. Connect the primary of the transformer to a DC power supply. Set the voltage to 5V. Adjust the current knob, if necessary.
3. Connect the secondary of the transformer to one of the channels of an oscilloscope.
4. Make sure the channel is set to DC coupled with volt/div set at **0.2V**.
5. Measure the voltage. It will be zero volt.
6. Observe the voltage on the oscilloscope closely as you turn on and off the power supply. (**Be patient; wait for at least 30 seconds between turning on and off)**

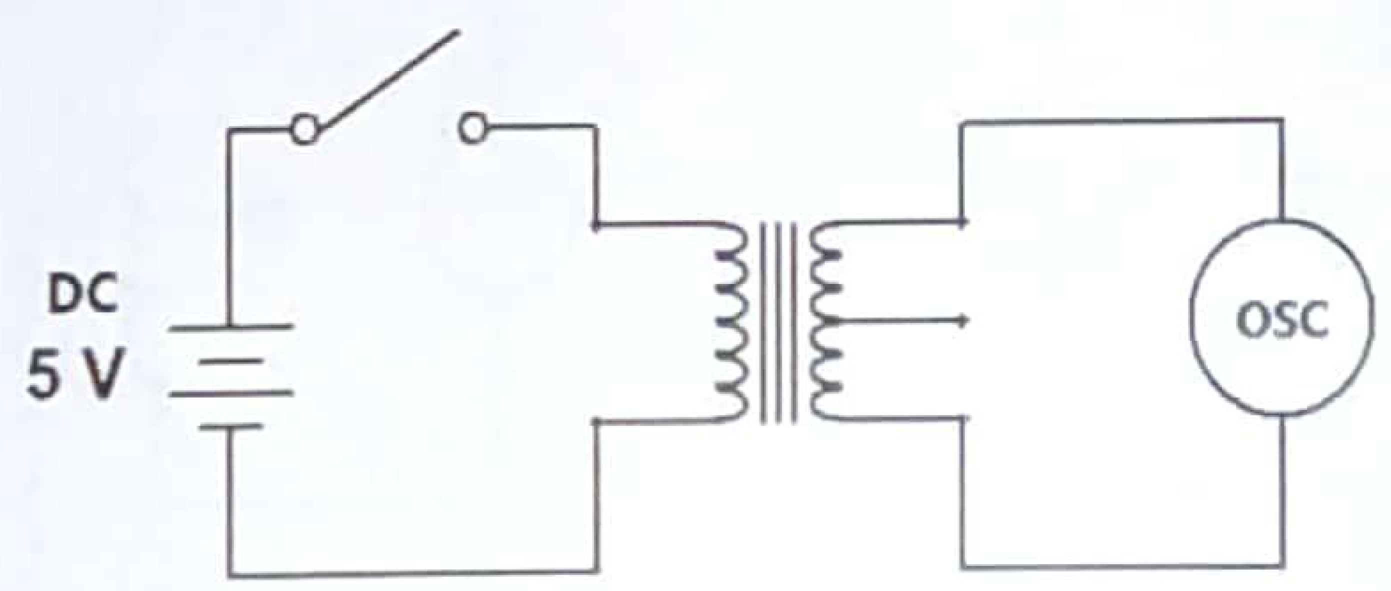


Figure 1

7. What did you notice? Note your observation below.

8. Using the oscilloscope, measure the amplitude of the induced voltage as you turn on and turn off the power supply. Use the STOP button to measure the amplitude of the voltage.

Turn on: Amplitude of the induced voltage $\Delta V = 644\ mV$

Turn off: Amplitude of the induced voltage $\Delta V = 180\ mV$

Part 2: Calculating the Turns Ratio

1. Complete the circuit diagram, as shown in Figure 2.
2. Connect the function generator to the primary and oscilloscope to both primary and secondary terminals of the transformer.
3. Set the function generator to produce **sinusoidal signal** with a frequency of 50Hz.
4. Use the function generator to set the input voltage and measure the peak-to-peak output voltage from the oscilloscope.
5. Calculate the turns-ratio of the transformer to complete Table 1.
6. Connect the equipment according to the circuit diagram in Figure 3 and repeat the steps above to fill out Table 2.

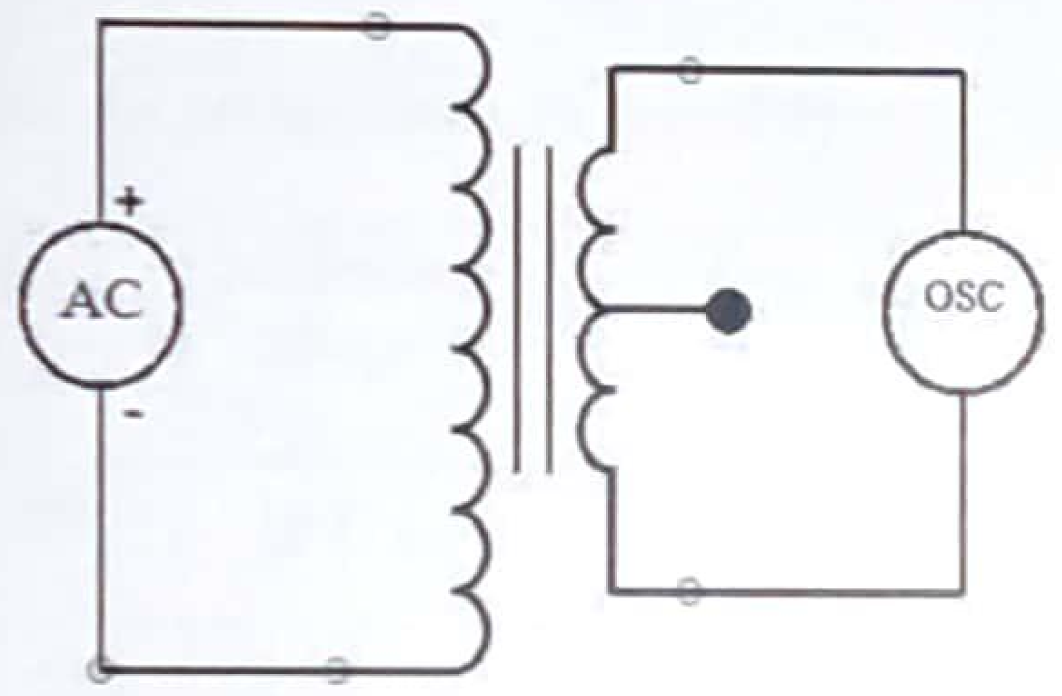


Figure 2

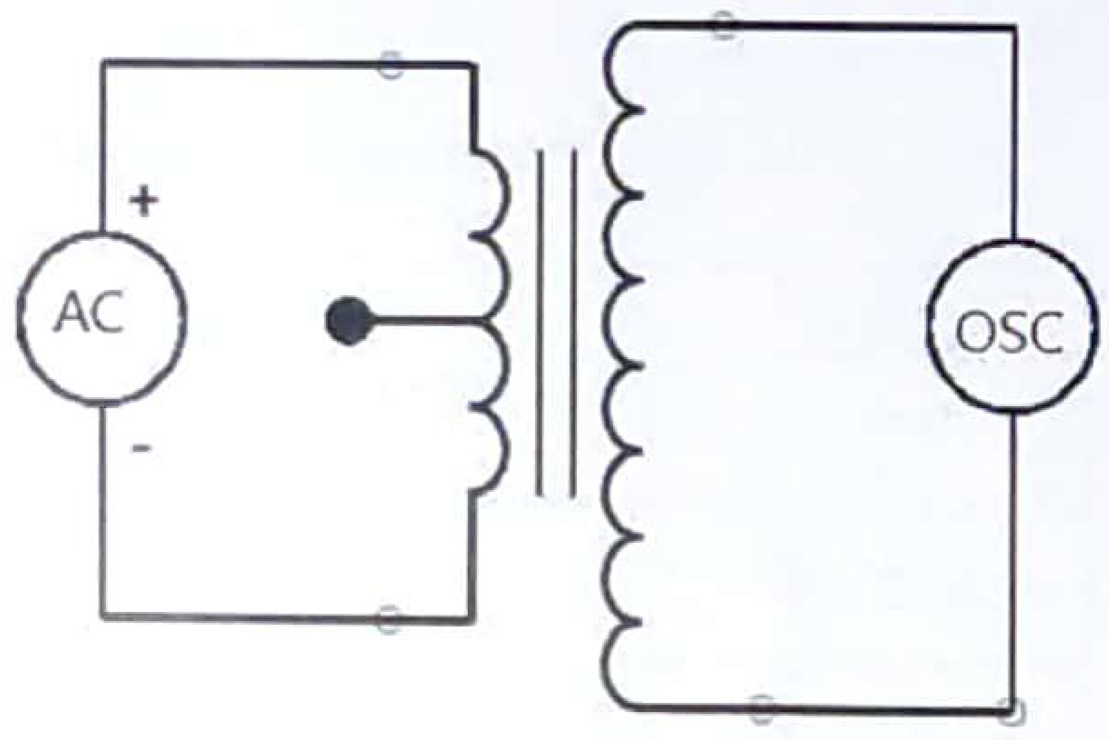


Figure 3

Lab Report:

Date:	28.08.2023
Name of the Students and IDs	(1) Shakil Ahmed 2221453042
	(2) Mortaza Morshed 2212697643
	(3) Safayat Ibrahim 2131174642

Data Tables:

Table 1 (Use the set up shown in Figure 2)

Primary Voltage ($V_{P(p-p)}$)	Secondary Voltage ($V_{S(s-s)}$)	$\frac{V_{P(p-p)}}{V_{S(s-s)}}$
1.04	108 mV	9.62 ✓
2.02	244 mV	8.278 ✓
3	350 mV	8.571 ✓
4.02	478 mV	8.41 ✓
5	616 mV	8.11 ✓
6	708 mV	8.474 ✓
7.04	860 mV	8.16 ✓
8	976 mV	8.196 ✓

Table 2 (Use the set up shown in Figure 3)

Secondary Voltage ($V_{S(s-s)}$)	Primary Voltage ($V_{P(p-p)}$)	$\frac{V_{P(p-p)}}{V_{S(s-s)}}$
1	7.20 ✓	7.20 ✓
2	15.30 ✓	7.65 ✓
3	22.50 ✓	7.50 ✓
4	29.60 ✓	7.40 ✓
5	36.60 ✓	7.32 ✓
6.04	44.20 ✓	7.35 ✓
7	52.00 ✓	7.428 ✓
8	59.40 ✓	7.425 ✓

Tasks and Questions:

#1: Explain briefly your observation in *Part #1* of the experiment with reference to induced EMF.

Ans: We know that EMF induction takes place when there is a change in the relative position of the conductor and magnetic field lines, When the switch was tuned on, the output voltage achieved 444 mV and when turned off reached 180 mV both for a brief moment, when we turn on switch and EMF induced in the secondary coil and for a very brief period of time. This is because as the primary coils circuit was turning on it is magnatic field was charging for zero to a certain and itis field line were moving and getting for a brief period. But as soon as the magnetic field reached the peak velue it remained constant throughout the coind became constant. In the same way, whenever turn off the switch the magnetic field change value for a brief peroid another EMF induction but in the opposite direction.

#2: What happens to the amplitude of the induced voltage if the number of turns in the primary coil (output terminal) of the transformer is reduced?

Ans: When we reduce the number of turns in the primary coil, the amplitude of the induced voltag increases.

Our observation is supported by the formula for tranformer,.

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

which implies,

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$\Rightarrow V_S = \frac{N_S \cdot V_P}{N_P}$$

that is keeping V_P and N_S constant

$$V_S \propto \frac{1}{N_P}$$

#3: Does a transformer work when a DC current flows through the primary? If not, why?

Ans: A transfor doesn't work when a constant DC current flows through the primary as there is no induced emf. But in case of power off and on the change of current is resulting induced emf. Change of current is resulting induced emf. We know,

$$E_L = -L \frac{di}{dt}$$

when we turn off power, $i = 0t$, $E_L = -L \frac{d(0)}{dt} = 0$

when —— on ——, $i = i$, $E_L = -L \frac{di}{dt}$ (so charged current leading induced emf)

this will be constant till power is turn off of DC current

#4: Use the data in Table 1 to calculate the average turns-ratio of the transformer.

The average transf~~orma~~-ratio of,

$$= \frac{9.62 + 8.278 + 8.571 + 8.41 + 8.91 + 8.479 + 8.16 + 8.196}{8}$$

$$= \frac{}{108 + 244 + 350 + 470 + 616 + 708 + 860 + 976}$$

$$= \frac{1.04 + 2 + 3 + 4.02 + 5 + 6 + 7 + 8}{(108 + 244 + 350 + 476 + 616 + 708 + 860 + 976) \times 10^{-3}}$$

$$= 8.30 \, V$$

?

-0.3

#5: If the transformer in this experiment has 400 turns in the primary, how many turns does it have in its secondary?

Average turns

Now $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

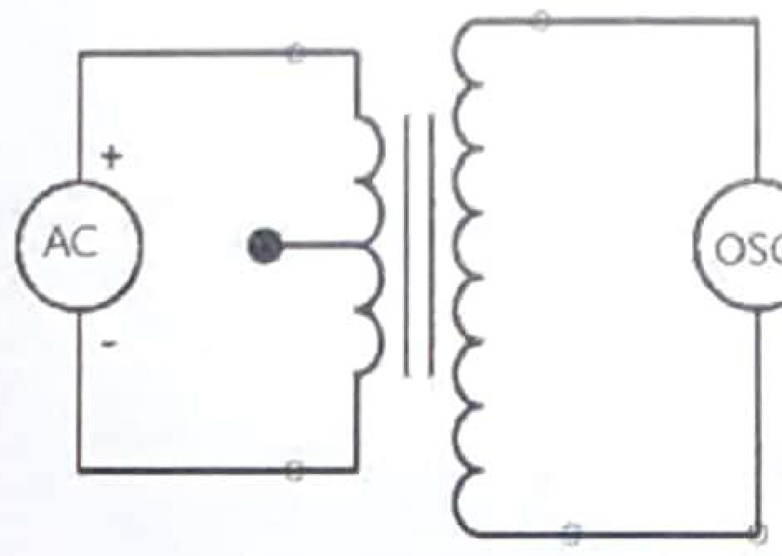
$\Rightarrow \frac{N_p}{N_s} = 9$ 9 -1

$\Rightarrow N_s = \frac{400}{9}$

$= 44.44$

≈ 44

#6: If the frequency of the input signal is increased to 250 kHz, what happens to the output? You can build the following circuit to answer to this question. [Give input voltage 5V (peak-peak) and observe the output] 42.6 mV



In this experiment we use 250 kHz, when we increase $V_s = 42.6$ mV

As here the frequency is increased the transformer loss also increases. Like core loss our conductor skin effect. Besides due to highly supply frequency the magnetizing current became low. Thus 250 khz resulted in voltage has decreased.

Result: In this lab, we observed the charged its induced EMF due to the change in electricity. supply the change is number of turns. In part 1, DC supply when the switch is turned on, ~~turns~~ there are spikes in the screan, of the oscilloscope. In part 2, we noted the primary voltage and secondary voltage. Then we calculated the ratio this is equivalent to $\frac{N_p}{N_s}$. When the primary coils secondery coils we reversed the $\frac{V_p(p\text{-}p)}{V_s(p\text{-}p)}$ ratio remains the same. Both the primary and secondery

Results: coils. We have ~~to~~ turns & connected to the oscilloscope.

Discussion:

In part-1, we noticed that the oscilloscope shows 0V for DC supply of 5V. because in DC supply the direction of current doesn't change so there is no EMF induced in the secondery coil. However, when we turn on switch and off in every sec, spike s are seen on the screen. of oscilloscope. This is because EMF is include in secondary coil.

For part-2, we connect the AC power supply to the primary coil. Then measured the primary voltage and secondary voltage of calculated ratio. We reversed the coils of connected the secondary coil to the AC supply & again measured the primary and secondary voltage.

Lab Report:

Date: 28.08.2023	
Name of the Students and IDs	(1) Shakil Ahmed ·2221453042
	(2) Mortaza Morshed 2212697643.
	(3) Safayat Ibrahim 2131174642

Data Tables:

Table 1 (Use the set up shown in Figure 2)

Primary Voltage ($V_{P(p-p)}$)	Secondary Voltage ($V_{S(s-s)}$)	$\frac{V_{P(p-p)}}{V_{S(s-s)}}$
1.04	108mV	9.62 V
2.02	244mV	8.278 V
3	350 mV	8.571 V
4.02	478mV	8.41 V
5	616mV	8.11 V
6	708 mV	8.474 V
7.04	860 mV	8.16 V
8	976mV	8.196 V

Table 2 (Use the set up shown in Figure 3)

Secondary Voltage ($V_{S(s-s)}$)	Primary Voltage ($V_{P(p-p)}$)	$\frac{V_{P(p-p)}}{V_{S(s-s)}}$
1	7.20V	7.20 V
2	15.30V	7.65 V
3	22.50V	7.5 V
4	29.60V	7.4 V
5	36.60 V	7.32 V
6.04	44.20V	7.35 V
7	52.00	7.428 V
8	59.4.	7.425 V

Mahadul.
28.8.23