UNIVERSITY PHYSICS_ ELECTRICITY & MAGNETISM

Laboratory Manual

Department of Physics
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Experiment No: 1

Study of charging and discharging of a capacitor in RC circuit

Aim of the experiment: To study the charging and discharging of a capacitor in RC circuit and determine characteristic time scale of the circuit using CRO

Apparatus Required: Resistor, Capacitor, Key (one way), Source (DC) and Oscilloscope

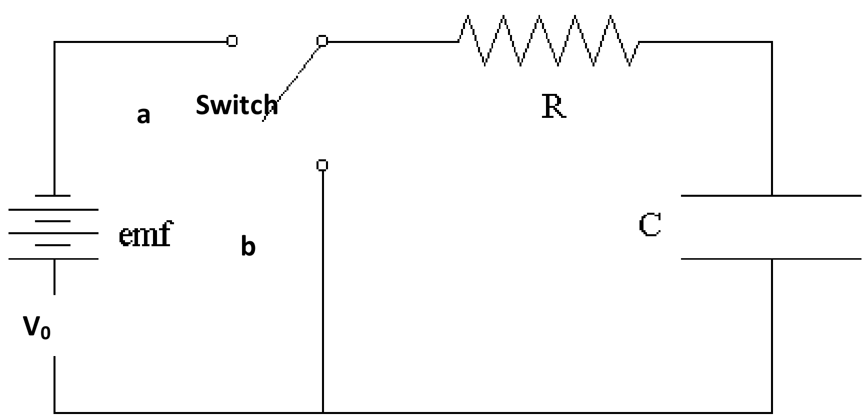


Figure 1: Circuit diagram

Theory:

If the switch is thrown into position, **a** capacitor will charge up.

The instantaneous charge, q on either plate of the capacitor during charging is

$$q = CV_0\left(1 - e^{-t/RC}\right) = q_0\left(1 - e^{-t/RC}\right)$$

Instantaneous voltage across the capacitor is

$$V_C = V_0\left(1 - e^{-t/RC}\right)$$

where, $V_0 = \frac{q_0}{C}$ is the maximum voltage developed across plates of the capacitor.

The characteristic time scale or time constant of the circuit, $\tau = RC$,

where C = capacitance and R = resistance of the circuit. At $t = \tau$, potential difference across the capacitor (V_C) is 63% of the maximum value, V_0.

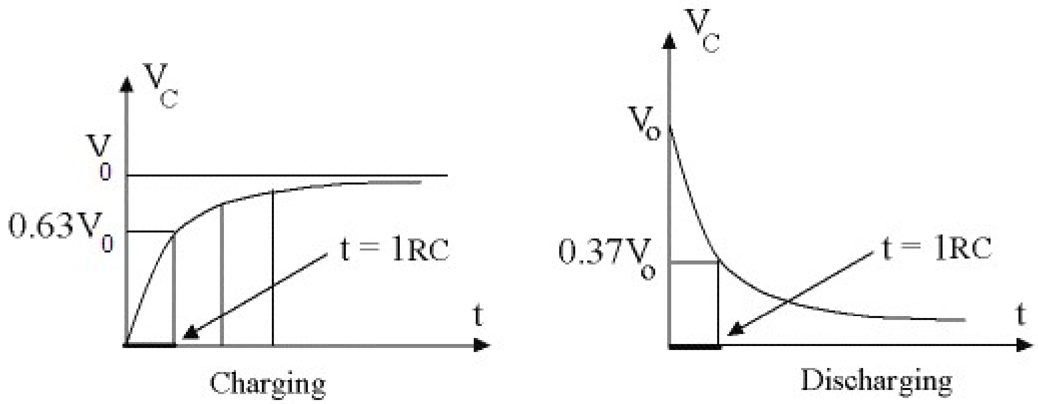


Figure 2: V_C versus time for charging discharging

When the switch is thrown into position **b**, capacitor will discharge through the resistor. In this case potential difference across the plates of the capacitor decays exponentially with time as given by the equation,

$$V_C = V_0 e^{-t/RC}$$

Time constant of both charging and discharging cases can be determined from graph as shown in figure 2.

Table:

No. of Obs.	**Time ‘t’ (ms)**	**Voltage V_c during charging (V)**	**Voltage V_c during discharging (V)**

Observation:

i. Observe the trace curve on the CRO carefully.

ii. Take the different sets of voltage and time values (at least 20 obs.) of the trace curve from CRO (refer data in the table)

iii. Plot the graph of voltage and time in graph sheet

iv. Draw a projection from the voltage value $\left(\frac{V_0}{e}\right)$ on the time axis

v. The intersection of the projection on time axis is the characteristic time scale

Experiment No: 2

RLC series circuit

Aim of the experiment: Measurement of voltage, current and power of a RLC series circuit excited by a single phase ac supply.

Apparatus Required:

Sl. No.	Instrument	Rating	Type	Quantity
1	Voltmeter	0-300V	AC	4
2	Ammeter	0-10A	AC	1
3	Inductor	230V,1A		1
4	Capacitor	10µF,400V		1
5	Rheostat	100Ω,5A		1
6	Wattmeter	300V,10A		1
7	Connecting Wires			As per required

Theory:

In any R L C series circuit connected across the supply, V.

V_r =IR =Voltage drop across R in phase with I.

V_l =IX_L=Voltage drop across L leading by $\emptyset_{coil}$ with I.

V_c =IX_c=Voltage drop across C lagging by π/2 with I.

Applied Voltage, $V=\sqrt{IR^2+(IX_L-IX_C)^2}$

$$V=I\sqrt{R^2+(X_L-X_C)^2}$$

$$I=\frac{V}{\sqrt{R_{Total}{}^2+(X_L-X_C)^2}}$$

$$I=\frac{V}{\sqrt{R_{Total}{}^2+(X)^2}}=\frac{V}{Z}$$

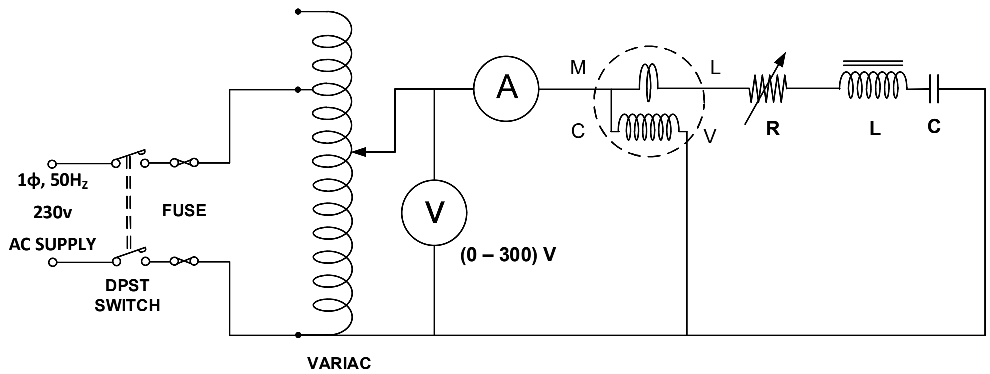
The term $\sqrt{R_{Total}{}^2+(X_L-X_C)^2}$ is known as impedance of circuit.

Power angle $\emptyset$ is given by $\tan\emptyset=\frac{X_L-X_C}{R_{Total}}=\frac{X}{R_{Total}}$

Power factor is $\cos\emptyset=\frac{R_{Total}}{Z}=\frac{R_{Total}}{\sqrt{R_{Total}{}^2+(X_L-X_C)^2}}=\frac{R_{Total}}{\sqrt{R_{Total}{}^2+(X)^2}}$

Power absorbed by circuit= $VI\cos\emptyset$

$\cos\emptyset$ = Overall power factor of the RLC circuit.



Circuit diagram

Procedure:

- Connect the circuit according to the circuit diagram.
- Switch on the supply.
- Take readings of voltmeter, ammeter & wattmeter.
- Also take ridings of voltage drop across Resister, Inductor & capacitor by the help of Multimeter.
- Draw the phase diagram and find power factor of circuit.

Observation table:-

Sl. No.	Supply Voltage (V_s)	V_r	V_{coil}	V_c	Current (I)	Power absorbed (W)	Power factor (CosØ =W/V_sI)	Ø

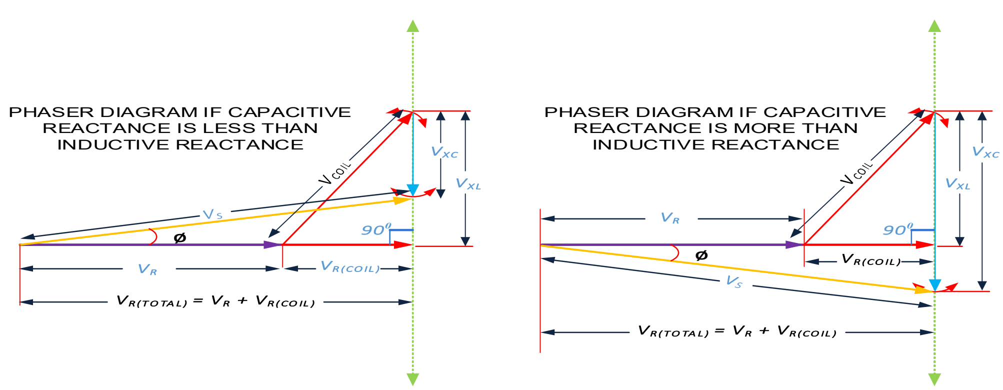
Discussion:-

- Draw the phase diagram of the circuit.
- Find the supply voltage from the phase diagram.
- Calculate the power absorbed by the circuit from phase diagram and analysis.

Conclusion:-

I. Ø is +ve or –ve (circuit is dominantly capacitive / inductive)

II. Comparing Ø for phase diagram with the observed value.



Phase Diagram:-

Experiment No: 3

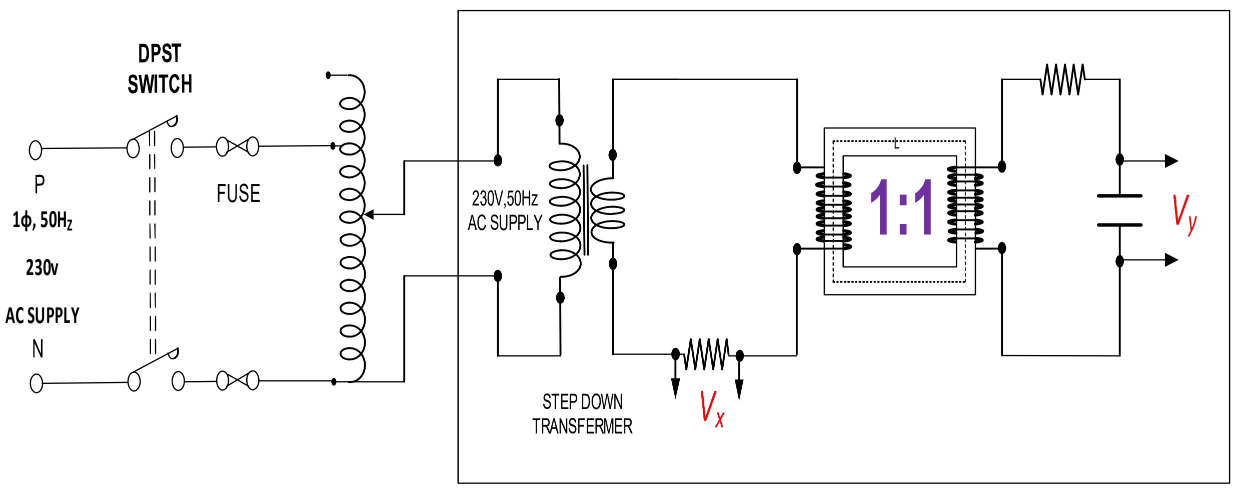
Measurement of Hysteresis Loss

Aim of the experiment: To trace Hysteresis loop of a specimen and find the Hysteresis loss.

Apparatus Required:

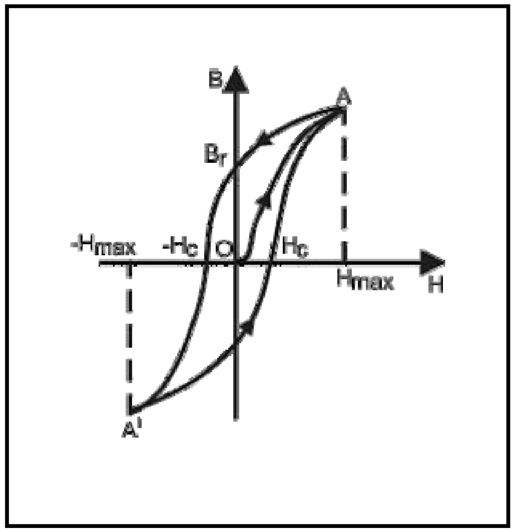
Sl.no.	Name of Item	Rating	Type	Quantity
1.	B-H Curve trainer			1 No.
2.	variac			1 No.
3.	CRO	30 MHz	Dual trace	1 No.
4.	CRO Probes	1:10, 1:1		one each
5.	Connecting Wires	1.5 mm^2		As reqd.

Circuit Diagram:



Theory:

Magnetic Induction B is measured in terms of voltage " V_Y" across the integrating capacitor



$$V_y = \frac{1}{C}\int i_2 dt$$
$$= \frac{1}{C}\int \frac{\varepsilon_2}{z_2} dt$$
$$= \frac{1}{CR_2}\int \varepsilon_2 dt$$
$$= \frac{N_2}{CR_2}\int \left| -\frac{d\emptyset}{dt} \right| dt$$

$(Since,\ \varepsilon_2: induced\ emf\ in\ the\ seconday\ ,\ Z_2 = \sqrt{{R_2}^2 + (X_l - X_c)^2}\ )$ and $X_L \approx X_C$

$$= \frac{N_2 \emptyset}{CR_2}$$
$$V_y = \frac{N_2 BA}{CR_2}$$

$\boxed{\boldsymbol{B \alpha V_y}}$

Magnetic field $H = \frac{N_1}{L}\ i_1 = \left(\frac{N_1}{L\, R_1}\right) V_x$

$\boxed{\boldsymbol{H\ \alpha\ V_x}}$ where,

L = length of the specimen in meter

N_1= No. of primary turns.

V_X = Voltage applied to horizontal plane.

i_1= Current in the primary coil

Procedure:

- The circuit was arranged as shown in the circuit diagram the input to primary of the core was supplied by the variac. The voltage across C_2 feeds the vertical input of the CRO.
- The horizontal and vertical gain controls of the CRO were adjusted to get a loop of the convenient size.
- The B-H loop was traced on the tracing paper.
- The vertical selectivity (S_1) and the horizontal selectivity (S_2) were determined. The sensitivity was expressed in volts per centimeter.
- Flux density:- $B=(R_2C /N_2A)V_Y$ Wb/m^2
- Hysteresis loss:- $\vec{B}.\vec{H}= (R_2C /N_2A)(N_1/R_1L)\ V_X.V_Y$ $Joule/m^3/cycle$

Calculation:

The physical quantities: B_{max} , Retentivity (B_r) , $Coercivity\ (H_c)$ and Hysteresis loss ($\vec{B}.\vec{H}$) per volume per cycle are calculated from the data corresponding to different positions on the hysteresis loop observed in the oscilloscope screen and traced in the graph sheet.
The hysteresis loss is calculated as follows:

The horizontal scale of the oscilloscope is adjusted to read one volt per division which is equivalent to 1 cm in the graph sheet. One small division in the graph sheet therefore is equivalent to 0.1 V

The vertical scale oscilloscope is adjusted to read 50 mV per division which equivalent to 1 cm in the graph sheet. One small division in the graph sheet, therefore is equivalent to $5.0X10^{-3}$ V.

The area of each small division in the graph sheet $\boldsymbol{v_x v_y = 5.0 \times 10^{-4}\ V^2}$
If number of small divisions enclosed in the B-H loop on the graph sheet is **n**, the equivalent quantity: $\boldsymbol{V_x V_y = \sum v_x v_y = n \times 5.0 \times 10^{-4}\ V^2}$ from which the hysteresis loss is calculated as $\boldsymbol{\vec{B}.\vec{H} = \frac{R_2 C}{N_2 A} \times \frac{N_1}{R_1 L} \times n \times 5.0 \times 10^{-4} \frac{J}{m^3}/cycle}$

Conclusion:

The physical quantities B_{max}, Retentivity, Coercivity and hysteresis loss are found to be ------------, ---------,

---------- and ---------, respectively

Experiment No: 4

Resistance measurement

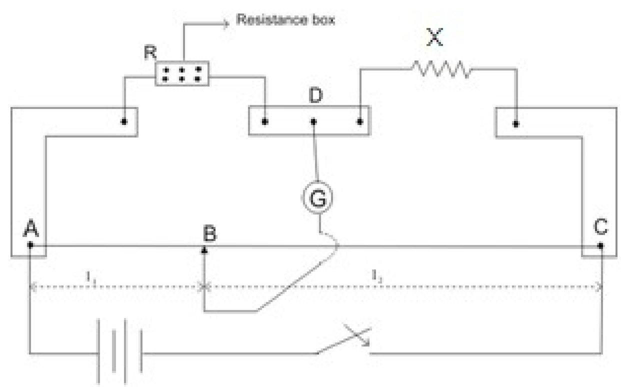
Aim of the Experiment: To determine the resistance of a given wire using a meter bridge

Apparatus:
A meter bridge, leclanche cell, key, resistance box, galvanometer, jockey, connecting wires, sand paper and wire of unknown resistance

Theory: When the meter bridge is balanced (zero deflection in galvanometer), the resistance, **X** of the experimental wire is given by

$$\boldsymbol{X = R\,\frac{100 - l_1}{l_1}}$$

where R = resistance introduced from the resistance box and l_1= length of wire between A and B (see figure)



Procedure:

1. *Electrical connections* (i) Remove the insulation from the ends of the connecting wire with the help of sand paper. (ii) Mark the connections according to the scheme of fig. and remove the plug from key. Make all the keys of the resistance box tight.
2. *Checking correctness of connections*. Take out small resistance plug (0.1 to 0.5 ohm) from $\boldsymbol{R}$. Press jockey on left end of the wire and note the direction of deflection. Now press the jockey on right end of the wire and again note the direction of deflection. If the deflection, in galvanometer, in these two cases is opposite the connections are correct.
3. *Obtaining balance point*. (i) Adjust the jockey along the length of wire till deflection in galvanometer is zero. Note the value of $\boldsymbol{l_1}$ and calculate the unknown resistance roughly. (ii) Introduce resistance, from resistance box R. having value nearest to that calculated in step (i). Adjust the jockey to have the balance point. Balance point should be taken twice, once approaching from left and second time approaching from right. Mean of these two readings gives the correct value of position of balance point. This balance point will, now, be near the centre. (iii)Repeat step (ii) by introducing resistance $\boldsymbol{R}$ having values one and two ohm above and below that taken in step (ii)

Observations:

Sl. No	R (ohm)	l_1 (cm)		Mean l_1 (cm)	$X = R\,\dfrac{100 - l_1}{l_1}$ (ohm)
		(i)	(ii)		
1					
2					
3					
4					
5					
				Mean $X =$	ohm

Precautions:

1. Remove the insulation from the ends of connecting wires, completely, before making the connections
2. The connections should be tight
3. All the plugs of the resistance box should be tight
4. Remove the plug from the key while making the connections.
5. Do not pass the current through the wire for a longer time, lest the wire will be heated. So, while you are writing the reading on the note book, see that the plug of the key should be taken out.
6. All the reading must be taken with such value of R that the balance point remains nearly in the centre

Exercise 1: Verify the laws of resistances in series and parallel

Hints: (i) Connect resistance r_1 in gap (ii) and repeat the above experiment to determine r_1

(ii) Remove $r_1$and connect r_2 in gap (ii). Repeat the above experiment to determine r_2

(iii) Connect r_1 and r_2, in series with each other, as shown fig. Connect this combination in gap (ii) and repeat the above experiment to determine the combined resistanceR_s.

(iv) Connect r_1 and r_2 in parallel with each other, as shown in fig. connect this combination in gap (ii) and repeat the above experiment to determine the combined resistance R_p.

	Sl. No.	R (ohm)	l_1(cm)		Mean l_1(cm)	$R\,\dfrac{100 - l_1}{l_1}$
			(i)	(ii)		
r_1	1					
	2					
	3					
					Mean $r_1 =$	ohm
r_1	1					
	2					
	3					
					Mean $r_1 =$	ohm
R_s	1					
	2					
	3					
					Mean $R_s =$	ohm
R_p	1					
	2					
	3					
					Mean $R_p =$	ohm

Verification: From the above observation it can be observed that

(i) $R_s = r_1 + r_2$

This verifies the law of resistance in series.

(ii) $R_p = \frac{r_1 r_2}{r_1 + r_2}$

This verifies the law of resistance in parallel.

Exercise 2: Determine the specific resistance of the material of given wire

Hint: Resistance ***X*** of a wire is given by

$$X = \rho \frac{l}{a}$$

where, ρ = resistivity or specific resistance of the material of wire

l = length of wire

a = area of cross-section of wire

r = radius of wire

$$\therefore \rho = \frac{Xa}{l} \quad or, \quad \rho = X.\frac{\pi r^2}{l}$$

i. Connect the given wire in gap (ii) and determine its resistance ***X*** as explained above.
ii. Cut the wire from the points where it emerges out of the terminals and find its length with the help of a metre rod.
iii. Find the diameter of the wire, with the help of a screw gauge at three or four places. At each place the diameter should be determined in two mutually perpendicular directions.

(ii) Length of wire $l =$ cm

= m

(iii) Diameter of the wire (with screw gauge)

Pitch of screw gauge (**P**) = ………….. **L.C.** of screw gauge = …….

No. of Obs.	I.C. S. R. (I)	F.C. S. R. (F)	No. of Rotation (N)	C.S.R (I~F) x L.C (cm)	P.S.R N x P (cm)	Total= PSR+CSR (cm)	Mean (cm)
1							
….	……	….	….	….	….	….	….
5							

Radius of the wire $r = \frac{D}{2}$

Calculations:

$$\rho = X \frac{\pi r^2}{l}$$

$$\rho = \cdots \text{ohm meter}$$

<u>Experiment No: 5</u>

Magnetic Effect of Current

Aim of the Experiment: To study the variation of magnetic field with distance along the axis of a current carrying circular coil

Apparatus: Stewart and Gee's type tangent galvanometer, a battery, a rheostat, an ammeter, a one-way key, a reversing key, connecting wires, and sand paper etc.

Theory:

The intensity of magnetic field at a point on the axis of a circular coil of radius *a* having *n* turns, at a distance *x* from the centre of the coil is given by

$$B = \frac{\mu_0}{4\pi} \text{ x } \frac{2\pi n I a^2}{(a^2 + x^2)^{3/2}} \frac{wb}{m^2} = \frac{\mu_0 n I \ ^2}{2(a^2 + x^2)^{3/2}} \text{ x } 10^4 \ gauss$$

where, *I* is the current in ampere flowing through the coil.

If the field *B* is perpendicular to the horizontal component of earth's field *H* and *θ* is the deflection produced in a deflection magnetometer, at a distance *x* due to earth's magnetic field, then

$$B = H \tan\theta = \frac{\mu_0 n I a^2}{2(a^2 + x^2)^{3/2}} \text{ x } 10^4$$

or

$$\cot\theta = \frac{2H}{\mu_0 n I a^2} (a^2 + x^2)^{3/2} \text{ x } 10^{-4}$$

Procedure:

1. Place the instrument on the table so that the arms of the magnetometer lie roughly east and west the magnetic needle lies at the centre of the vertical coil, the needle and its image in the mirror provided at the base of the compass box all lie in the same vertical plane. The coil is thus set roughly in the magnetic meridian. Rotate the compass box so that the pointer lies on the 0-0 line.
2. Connect the galvanometer to a battery, a rheostat, a one way key and an ammeter through a reversing key as shown in figure

3. Adjust the value of the current so that the magnetometer gives a deflection of the order of 60^0 - 70^0. Reverse the current and again note the deflection. If the mean deflection in the two cases agrees closely, the coil lies exactly in the magnetic meridian. If the mean deflection in the two cases does not agree closely, slightly turn the instrument till the deflection with the direct and the reversed currents agree closely.
4. Now slide the magnetometer along the axis and find the position where the maximum deflection is obtained. In this position the centre of the needle coincid3es with the centre of the vertical coil.
5. Note the position of the arm against the reference mark A and also the value of the current as indicated by the ammeter. Read both ends of the pointer in the magnetometer, reverse the current and again read both ends. Shift the magnetometer by 2 cm and note the reading of the magnetometer keeping the current constant at the same value both for direct and revered current. In this position the centre of the magnetic needle is at a distance of 2 cm from the centre of the vertical coil. Take a number of observations by shifting the magnetometer by 2 cm at a time.
6. Similarly repeat the observation by shifting the magnetometer in the opposite direction and keeping the current constant at the same value.

Current I = …………….

Observation:

Sl. No.	**Distance from the centre x**	**Left side**				**Mean θ**	***tan θ***	**Right side**				**Mean θ**	***tan θ***
		Direct		**Reverse**				**Direct**		**Reverse**			
		1	**2**	**3**	**4**			**1**	**2**	**3**	**4**		
1													
2													
3													
4													
5													

Graphical Analysis:

- Plot *tan θ* versus *x*. It will be similar to the graph between *B* and *x*, as shown in Figure-1

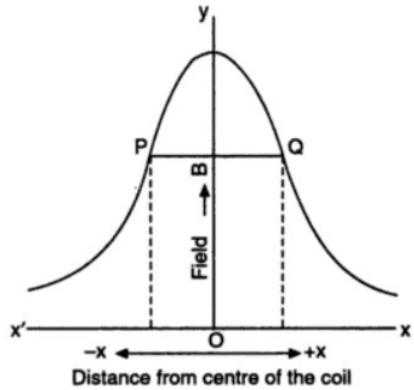


Figure-1

The variation of magnetic field B with x is known from $\frac{dB}{dx}$ and $\frac{d^2B}{dx^2}$.

It is straight forward to see

$$\frac{d^2B}{dx^2} = \frac{-3}{2}(\mu_0 IR)(a^2 + x^2)^{-7/2}(a^2 - 4x^2)$$

$\frac{d^2B}{dx^2} = 0,\ when\ \ x = \pm {a}/{2}$ (points of inflection which are shown in the Figure-1)

- Plot $(Cot\ \theta)^{2/3}$ versus x^2. The x- intercept of the graph gives square of the radius of coil

Exercise 1: *Find the radius of the coil from Figure-1*

Exercise 2: *Find the distance where the field due to the coil is equal to the horizontal component due to earth's field*

Exercise 3: *Find the value of the magnetic field at*

i. *the centre of the coil*
ii. *a distance a/2*

Precautions:

1. There should be no magnet, magnetic substances and current carrying conduction near the apparatus.
2. The plane of the coil should be set in the magnetic meridian
3. The current should remain constant and should be reversed for each observation
4. To avoid error due to parallax, the eye should be placed in such a way that the pointer covers its image in the mirror below

Experiment No: 6

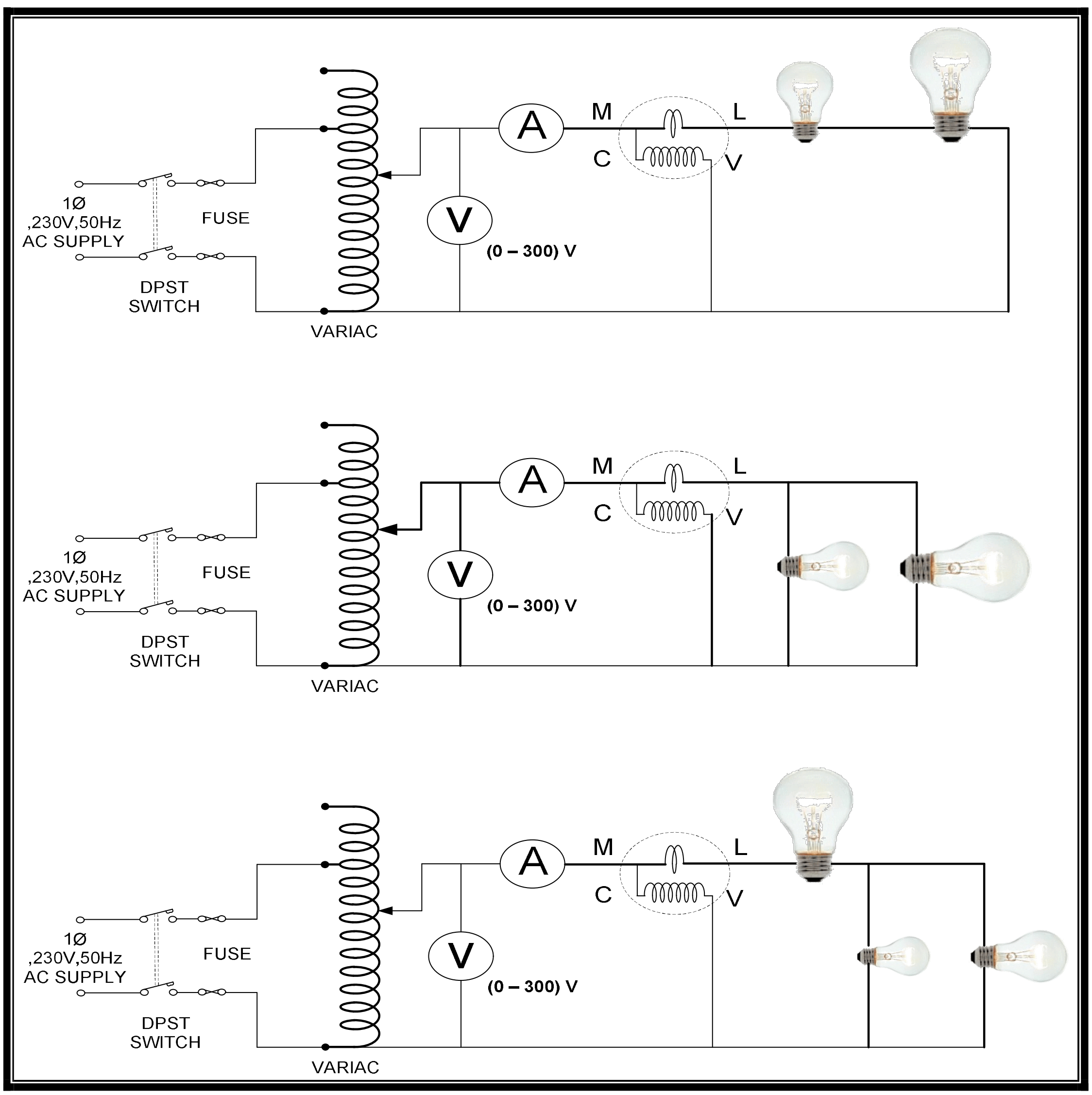
(A) AIM OF THE EXPERIMENT

To compare the intensity of light emitted by the bulbs connected in (i) Series (ii) Parallel and (iii) mixed circuit and find actual power consumed in each circuit.

APPARATUS REQUIRED:

SL.NO.	INSTRUMENT	RATING	QUANTITY
1	Autotransformer	230V/(0–270V), 2.5	1
2	Voltmeter(AC)	0–300V	1
3	Ammeter(AC)	0-2.5A	1
4	Wattmeter	230V, 2.5A	1
5	Bulb		3
6	Connecting wires		As required

CIRCUIT DIAGRAM:



THEORY:

Series Connection:

- The current (I) through the filament of each bulb is same for a given supply voltage (V). the power consumed (P_1, P_2) in the bulb (1, 2) with resistance (R_1, R_2) is given by

  $P_1 = I^2 R_1$, $P_2 = I^2 R_2$

  $\therefore P_1/P_2 = R_1/R_2$ --- (1)

- If rated voltage of the bulbs used is (V_R), the actual power consumed in the circuit is

  $$P_{actual} = \frac{V^2}{\frac{V_R^2}{P_1}+\frac{V_R^2}{P_2}} = \left(\frac{V}{V_R}\right)^2 \frac{P_1 P_2}{P_1+P_2} \text{ ---------------------------------- (2)}$$

  when, $V = V_R$; $P_{actual} = \frac{P_1 P_2}{P_{1+P_2}}$ ---------------------------------- (3)

***Parallel Connection**:*

- The voltage across each of resistance (R_1, R_2) connected in parallel is same. The power consumed in the bulbs with wattage (P_1, P_2) is given by

  $P_1 = V^2/R_1$, $P_2 = V^2/R_2$

  $\therefore P_1/P_2 = R_2/R_1$ --- (4)

- In such circuit, the actual power consumed is

  $$P_{actual} = \frac{V^2}{\frac{V_R^2}{P_1}} + \frac{V^2}{\frac{V_R^2}{P_2}} = \left(\frac{V}{V_R}\right)^2 (P_1 + P_2) \text{ -------------- (5)}$$

  when $V = V_R$; $P_{actual} = P_1 + P_2$------------------------------ (6)

Mixed Connection:

- If a bulb with wattage P_3 is connected in series with two bulbs with wattage P_1 & P_2 (connected in parallel), it is said to be a mixed circuit. The actual power consumed in such circuit is found to be

  $$P_{actual} = \left(\frac{V}{V_R}\right)^2 \left(\frac{P_3(P_1+P_2)}{P_1+P_2+P_3}\right) \text{ ------------------------------- (7)}$$

  when $V = V_R$; $P_{actual} = \frac{P_3(P_1+P_2)}{P_1+P_2+P_3}$--------------------------------- (8)

PROCEDURE:

1. Make connection as per the circuit diagram.
2. Switch on the supply. Adjust the variac to provide the supply voltage of 210 V to the series circuit.
3. Note the values of supply voltage, current and power from the voltmeter, ammeter and wattmeter, respectively
4. Repeat step (2) and (3) for supply voltage of 220 V and 230 V (rated voltage of bulbs is 230 V)
5. Repeat step (1), (2), (3) & (4) for the parallel and mixed circuits.
6. Calculate and note the actual power consumed in each case using Eq. (2,3) , (5,6) and (7,8) for the series, parallel & mixed circuits, respectively
7. Compare the observed value of power consumed read from wattmeter to the actual power consumed.

OBSERVATION:

Type of Connection	Supply Voltage (V) (volt)	Current (I) (ampere)	P_{actual}(P) (watt)	Power consumed (wattmeter reading) (watt)
Series	210			
	220			
	230			
Parallel	210			
	220			
	230			
Mixed	210			
	220			
	230			

EXERCISE:

- Why household wiring requires parallel not series connections?
- What safety measures should be taken in household wiring?
- Cite a case where series connection of electrical equipment is used & why?

CONCLUSION:

- With same operating voltage an electric bulb with low wattage (high resistance) is found to glow more in series connection
- With same operating voltage, an electric bulb with high wattage (low resistance) is found to glow more in parallel connection
- When supply voltage equals the rated voltage the power consumed in the circuits is found to be maximum.

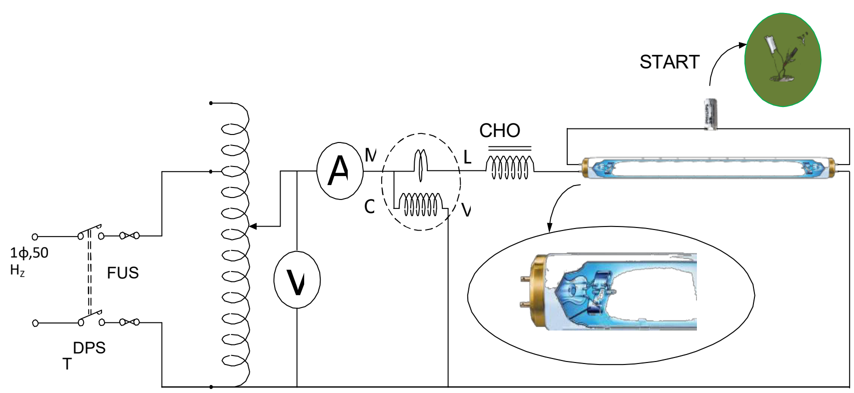
(B) AIM OF THE EXPERIMENT:

To determine inception voltage & extinction voltage of a fluorescent lamp and measure the power consumed in the circuit using the fluorescent lamp at different operating voltages.

APPARATUS REQUIRED:

SL. NO.	INSTRUMENT	RATING	QUANTITY
1	Autotransformer	230V/(0–270V), 2.5	1
2	Voltmeter(AC)	0–300V	1
3	Ammeter(AC)	0-2.5A	1
4	Wattmeter	230V, 2.5A	1
5	Fluorescent lamp, starter, choke		1
6	Connecting wires		As required

CIRCUIT DIAGRAM:



VARIAC

THEORY:

Tube light is a long glass tube, in side wall of which is coated with phosphor. The tube contains a small amount of mercury and a small quantity of argon gas at low pressure. Two filaments coated with barium oxide are provided inside the tube light to help the heating and ionization of gas. When 230 VAC is supplied to the circuit, it appears across the two filaments. But due to high resistance conduction is not possible. So the applied voltage appears across the starter.

When such a high voltage appears across the small gap existing between the starter electrodes, this produces an arc which warms up the electrodes. Due to heating the bimetallic strip expands and the two electrodes touch each other. It completes the circuit and causes the current to flow through the filaments, thus heating them and starting the emission of electrons. In the mean time the potential across the electrodes of starter falls to zero. Thus the electrodes cool down and it causes the strips to be separated out thus breaking the circuit. Due to presence of inductor (Choke) in the circuit this break causes a high induced voltage (**Ldi/dt**) of the order of 1000 V across the tube.

Consequent upon ionization, the energetic radiation of the discharge through the tube falls on the fluorescent powder (phosphor) coated inside the tube. That ultimately radiates lesser frequency rays in the visible spectra and we see the tube light up with characteristic wavelength.

PROCEDURE:

1. Make connection as per the circuit diagram
2. Switch on the supply. Adjust the variac to provide the minimum voltage (Inception voltage) at which the fluorescent tube starts giving steady light.
3. Note the values of Inception Voltage ($\mathbf{V_I}$), Current (I) and power (P) consumed in the circuit from the voltmeter, ammeter and wattmeter reading, respectively.
4. Repeat step (2) and (3) for higher supply voltage of 210 V and then for 230 V which happens to be the rated voltage ($\mathbf{V_R}$) of the fluorescent tube.
5. Decrease the supply voltage from 230 V to a small value which below the inception voltage with fluorescent tube still giving light ($\mathbf{V_E} < \mathbf{V} < \mathbf{V_I}$) and note the voltage, current & power at this supply voltage (V).
6. Decrease slowly the supply voltage to that value at which the tube stops giving light (I=0). This voltage is known as Extinction voltage ($\mathbf{V_E}$).

OBSERVATION: Inception Voltage ($\mathbf{V_I}$), Rated Voltage ($\mathbf{V_R}$), Extinction Voltage ($\mathbf{V_E}$)

No. of observation	Supply Voltage (V) (volt)	Current (I) (ampere)	Power (P) (watt)	Power Factor $\cos\theta = P/VI$
1	$V = V_I$			
2	V = 220			
3	$V = V_R = 230$			
4	$V_E < V = \ldots\ldots < V_I$			
5	$V = V_E$			

EXERCISE:

- Why inception voltage is greater than extinction voltage?
- Why do you use a choke in the circuit while lighting up a tube?
- What would happen if the inner surface of tube is not coated with phosphor?

CONCLUSION:

- The inception voltage is found to be greater than the extinction voltage.
- When supply voltage equals the rated voltage of the tube the power consumed in the circuit is found to be maximum.