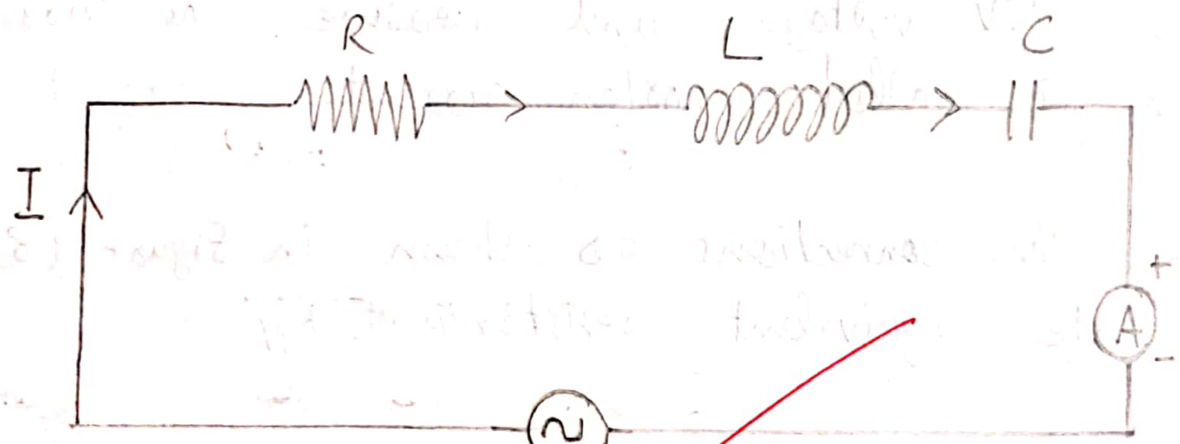
(Experiment → 5)

AIM :- To study frequency response of series RLC circuit and also calulate the quality factor.

Apparatus :- AC Supply, voltmeter, Ammeter, Resistor, connecting wires.

Circuit diagram :-



Observation Table :-

f	I
1000 Hz	7.5 mA
1500 Hz	8.5 mA
2000 Hz	17 mA
f_R ← 2300 Hz	19.5 mA
3000 Hz	13 mA
4000 Hz	7 mA
5000 Hz	5 mA

$f_R = 2300$ Hz

$I_r = 19.5$ mA

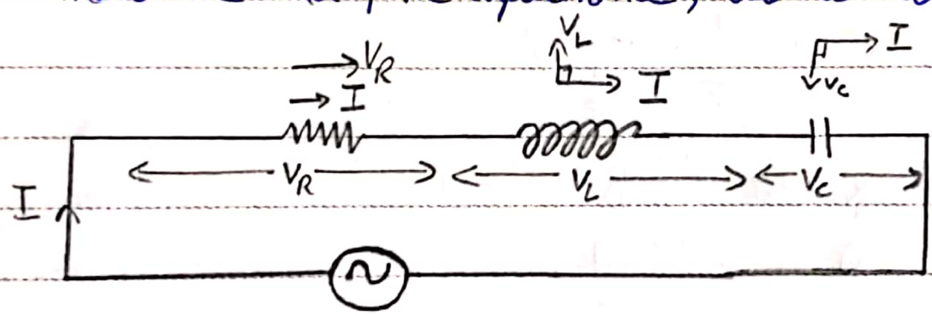
Experiment – 5

* **AIM** :– To study frequency response of Series RLC circuit and also calculate the quality factor.

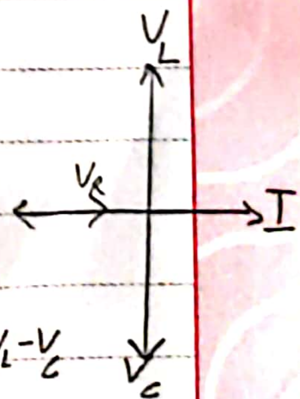
* **Apparatus** :– AC supply, Voltmeter, Ammeter, Resistor, Connecting wires.

* **Theory** :–

RLC series circuit → A Circuit that contains pure resistance, pure inductance and pure capacitance, all connected in series.



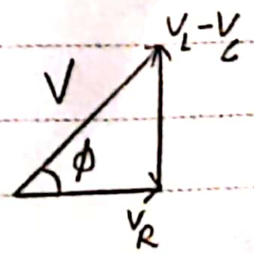
$V_R = IR$ i.e., voltage across R is in phase with I.
$V_L = I X_L$ (voltage across L leads I by $\pi/2$)
$V_C = I X_C$ (Voltage across C lags I by $\pi/2$)
⇒ V_L and V_C are 180° out of phase with each other.



$$V = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$$

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

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



$$\tan\phi = \frac{V_L - V_C}{V_R} = \frac{IX_L - IX_C}{IR} = \frac{X_L - X_C}{R}$$

Teacher's Signature.........................

Calculations :-

$R = 100\ \Omega$

$C = 0.2\ \mu F = 0.2 \times 10^{-6} F$

$L = 30\ mH = 30 \times 10^{-3} H$

$$Q\text{-Factor} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{1}{100}\sqrt{\frac{300 \times 10^{-3}}{2 \times 10^{6}}}$$

$$Q = \frac{1}{100}\sqrt{\frac{300 \times 10^{3}}{2}}$$

$$Q = \frac{1}{\cancel{100}} \times \cancel{100}\sqrt{\frac{30}{2}}$$

$$Q = \sqrt{15}$$

$$\Rightarrow \underline{Q = 3.8729}$$

Result :-

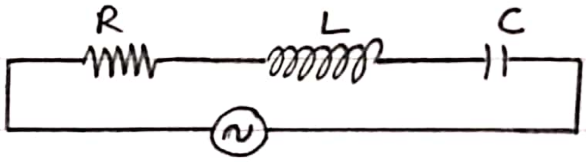
Resonance Frequency = 2.3k Hz
Quality Factor = Q = 3.8789

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{X_R}\right)$$

* Series Resonance in RLC circuit (voltage Resonance) :-

→ In RLC series ckt., when circuit current is in ~~place~~ phase with the applied voltage, circuit is said to be in series resonance.

→ This condition is obtained in an R-L-C circuit when $X_L = X_C$

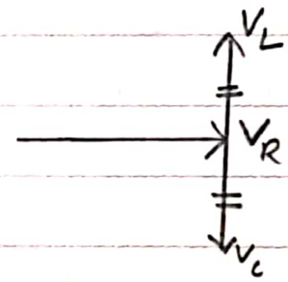


Impedance at resonance

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

$$Z = R$$

Current, $I_R = \frac{V}{R}$



→ When a series RLC circuit is in resonance, it possess minimum impedance $(Z=R)$. Hence, circuit current is max.

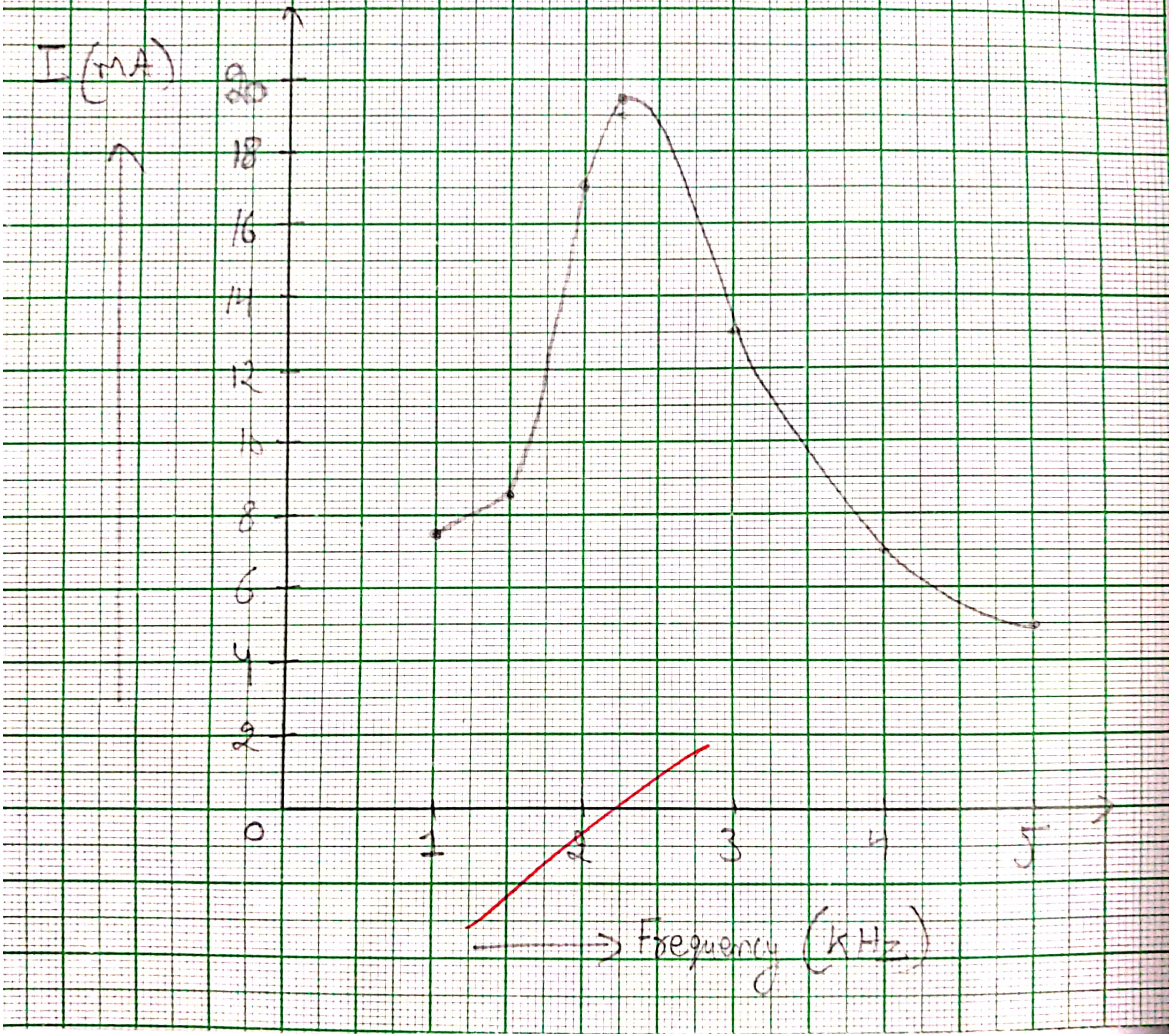
* Resonant Frequency :- The frequency at which net resistance of the series circuit is zero.

$$X_L - X_C = 0 \Rightarrow X_L = X_C$$

$$2\pi f_r L = \frac{1}{2\pi f_r C}$$

$$f_r^2 = \frac{1}{4\pi^2 LC}$$

$$\Rightarrow f_r = \frac{1}{2\pi\sqrt{LC}}$$


I (mA)
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
Frequency (KHz)

* Q – Factor of Series Resonant circuit (Quality Factor):–

It is given by voltage magnification produced in the circuit at resonance.

$$Q\text{-Factor} = \frac{\text{Voltage across } L \text{ or } C}{\text{Applied voltage}} = \frac{I_0 X_L}{I_0 R} = \frac{X_L}{R}$$

$$= \frac{W_0 L}{R} = \tan\phi$$

where; $W_0 = 2\pi f_0 = 2\pi \frac{1}{2\pi\sqrt{LC}} = \frac{1}{\sqrt{LC}}$

$$Q\text{-Factor} = \frac{L}{R} \times \frac{1}{\sqrt{LC}} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

* Procedure :–

1) Connect the circuit as ~~follows~~ shown in diagrams i.e, $R = 100\,\Omega$, $L = 30\,mH$, $C = 0.2\,\mu F$
2) Increase the frequency of signal upto 1 kHz
3) Find a point where current becomes maximum and then started decreasing by changing frequency. The frequency where current starts decreasing is known as resonance frequency.
4) Record the observations at different values of 'f' and find value of current.
5) Plot a graph between frequency vs current as shown.

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* Precautions :-

1) All the connections should be correct and tight.
2) Readings should be noted carefully.
3) Select appropriate value of inductor, resistor and capacitor for the experiment.

* Result:-

Resonance frequency = 2.3 kHz

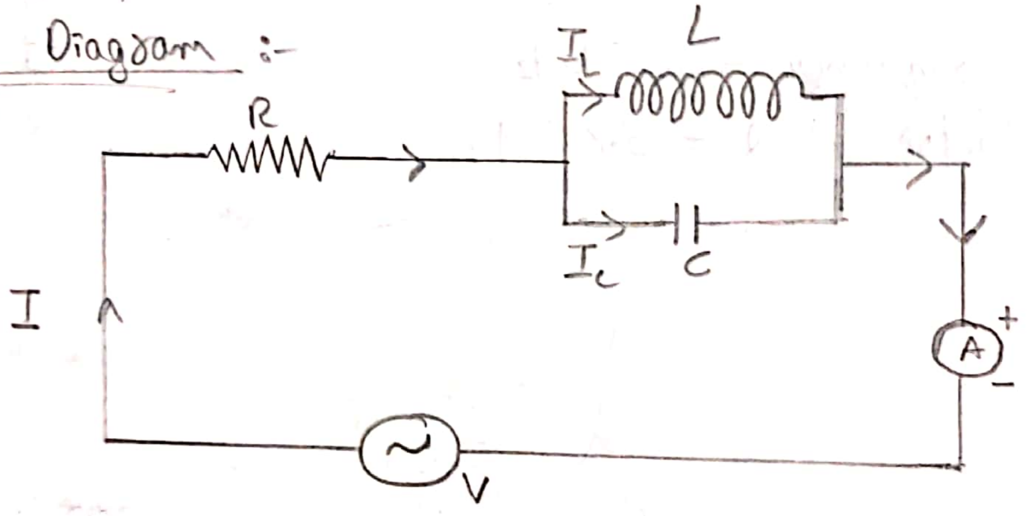
Quality Factor = Q = 3.8789.

Experiment - 6

AIM :- To Study the frequency response of parallel RLC circuit and also calculate Quality Factor.

Apparatus :- AC Power supply, voltmeter, Ammeter, Resistor 150 Ω, Inductor (30 mH), capacitor (0.1 μF), connecting wires.

Circuit Diagram :-



Observation Table :-

f(KHz)	I(mA)
1	11.5
1.5	10
2	6.5
2.5	1.5
$f_r \rightarrow$ 3.1	0.5 $\rightarrow I_0$
3.5	2
4	3
4.5	6.5
5	7.5

$f_r = 3.1$ kHz
$I_0 = 0.5$ mA

Experiment - 6

* **AIM** → To study the frequency response of parallel RLC circuit and also calculate Quality Factor.

* **Apparatus** → AC power supply, voltmeter, Ammeter, Resistor (50 Ω), Inductor (30 mH), Capacitor (0.1 μF), connecting wires.

* **Theory** →

Parallel Resonance (Current Resonance) :-

→ Consider an inductor of 'L' henry having some resistance 'R' connected in parallel with a capacitor of capacitance 'C' across a supply voltage of 'V' volts.

→ I_C will lead the voltage by 90°

→ For resonance, the relative component of circuit current must be zero.

$$I_C - I_L \sin\phi_L = 0 \Rightarrow I_C = I_L \sin\phi_L$$

where $I_L = \dfrac{V}{Z_L}$, $\sin\phi_L = \dfrac{X_L}{Z_c}$, $I_C = \dfrac{V}{X_C}$

$$\frac{V}{X_C} - \frac{V}{Z_L} \times \frac{X_L}{Z_L} = 0$$

$$\frac{V}{X_C} = \frac{V \times X_L}{Z_L^2}$$

$$Z_L^2 = X_L X_C$$

Teacher's Signature........................

Calculations :-

$$R = 50\ \Omega$$

$$C = 0.1\ \mu F = 0.1 \times 10^{-6}\ F$$

$$L = 30\ mH = 30 \times 10^{-3}\ H$$

$$Q\text{-Factor} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{1}{50}\sqrt{\frac{30 \times 10^{-3}}{0.1 \times 10^{-6}}}$$

$$Q = \frac{\cancel{100}^{\,2}}{\cancel{50}}\sqrt{30} = 2\sqrt{30}$$

$$\Rightarrow Q = 10.95$$

$$f_0 = \frac{1}{2\pi L}\sqrt{\frac{L}{C} - R^2}$$

$$f_0 = \frac{1}{2\pi \times 30 \times 10^{-3}}\sqrt{\frac{30 \times 10^{-3}}{0.1 \times 10^{-6}} - (50 \times 50)}$$

$$f_0 = \frac{10^3}{60\pi}\sqrt{30 \times 10^4 - 2500}$$

$$f_0 = \frac{10^4}{60\pi}\sqrt{2975}$$

$$f_0 = 2.893\ kHz$$

$$\Rightarrow Z_L^2 = \frac{\omega L}{\omega C} = \frac{L}{C}$$

$$R^2 + X_L^2 = \frac{\omega L}{\omega C}$$

$$R^2 + (2\pi f_0 L)^2 = \frac{L}{C}$$

$$2\pi f_0 L = \sqrt{\frac{L}{C} - R^2}$$

$$\Rightarrow f_0 = \frac{1}{2\pi L}\sqrt{\frac{L}{C} - R^2}$$

where, $f_0 \rightarrow$ Resonant frequency

Current at Resonance :-

The circuit current is $I = I_L \cos\phi_L = \frac{V}{Z_L} \times \frac{R}{Z_L} = \frac{VR}{Z_L^2}$

Putting the value of $Z_L^2 = \frac{L}{C}$

$$\Rightarrow I = \frac{VR}{L/C} = \frac{V}{L/CR}$$

$\frac{L}{CR}$ is Known as ~~equivalent~~ / dynamic impedance of the parallel circuit at resonance.

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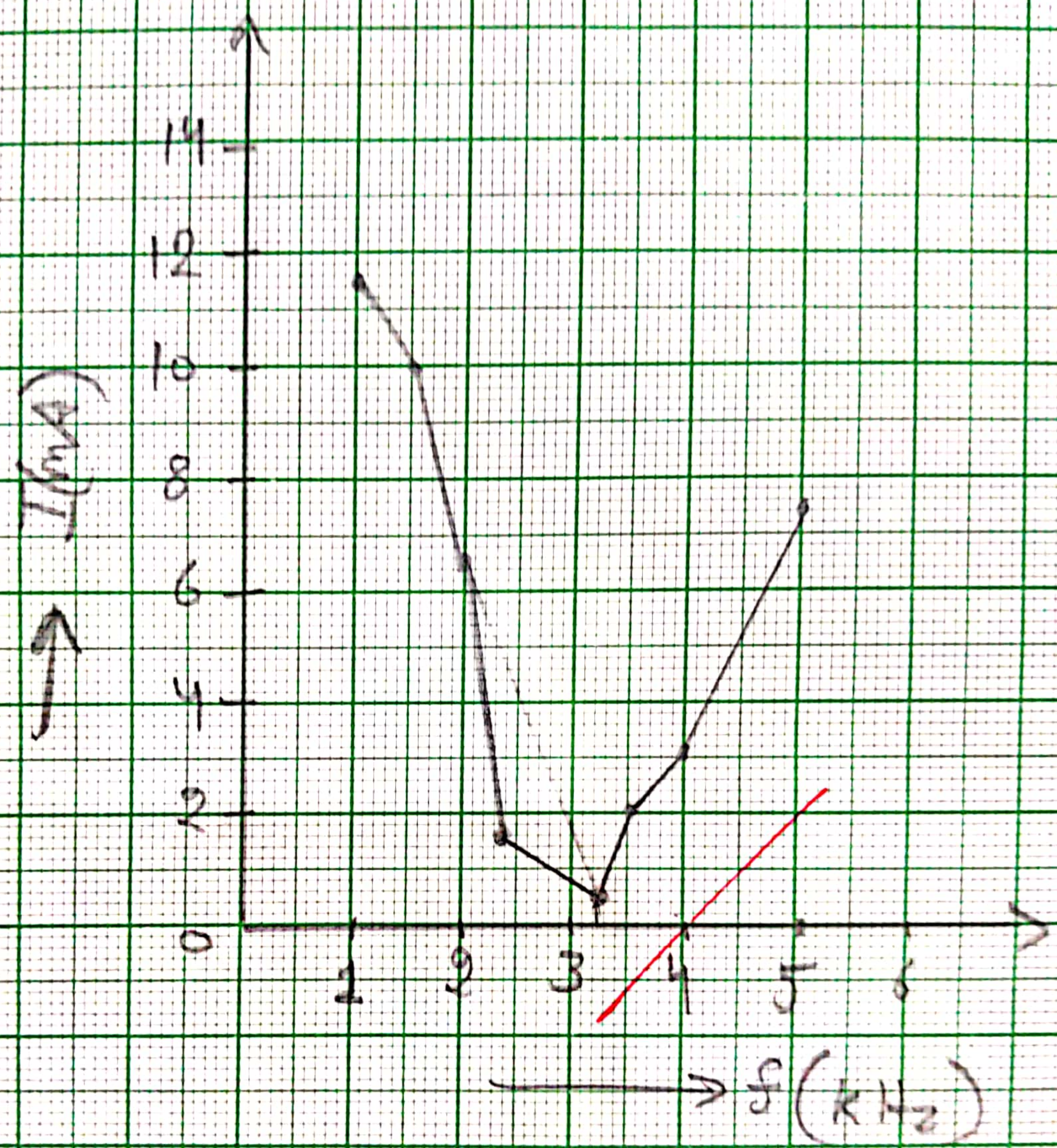


I(mA)
14
12
10
8
6
4
2
0
1
2
3
4
5
6
f (kHz)

Q - Factor of Parallel Resonance Circuit :-

The ratio of current circulating between it's two branches is to the line current down from the supply.

$$\text{Q-Factor} = \frac{\text{Current circulating b/w L and C}}{\text{Line current}} = \frac{I_C}{I}$$

$$I_C = \frac{V}{X_L} = \frac{V}{1/\omega C} = \omega C V$$

and $$I = \frac{V}{L/CR}$$

$$\text{Q-Factor} = \frac{\omega C V}{V/L/CR} = \frac{\omega C V L}{VCR} = \frac{\omega L}{R} = \frac{2\pi f L}{R}$$

$$\therefore f = \frac{1}{2\pi\sqrt{LC}}$$

$$\text{Q-Factor} = \frac{2\pi \times \frac{1}{2\pi\sqrt{LC}} \cdot L}{R}$$

$$\Rightarrow \text{Q-Factor} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

* **Procedure** →

1) Connect the circuit as shown in circuit diagram taking $R = 50\,\Omega$, $C = 0.1\,\mu F$, $L = 30\,mH$

2) Increase the frequency of signal upto 1 kHz.

Teacher's Signature........................

Result :-

Resonance Frequency = 3.1 KHz

Quality Factor = 10.95

(3) Find the point where current becomes minimum and then starts increasing by changing frequency. The frequency where current starts increasing is known as resonant frequency.

(4) Record the observations at different values of 'f' and find value of current. Note down all the reading.

(5) Plot a graph between frequency and current as shown.

* Precautions →

(1) All the connections shown should be correct and tight.

(2) Readings should be noted carefully.

(3) Select appropriate values of inductor, resistor and capacitor for the experiment.

* Result →

Resonance frequency = 3.1 kHz

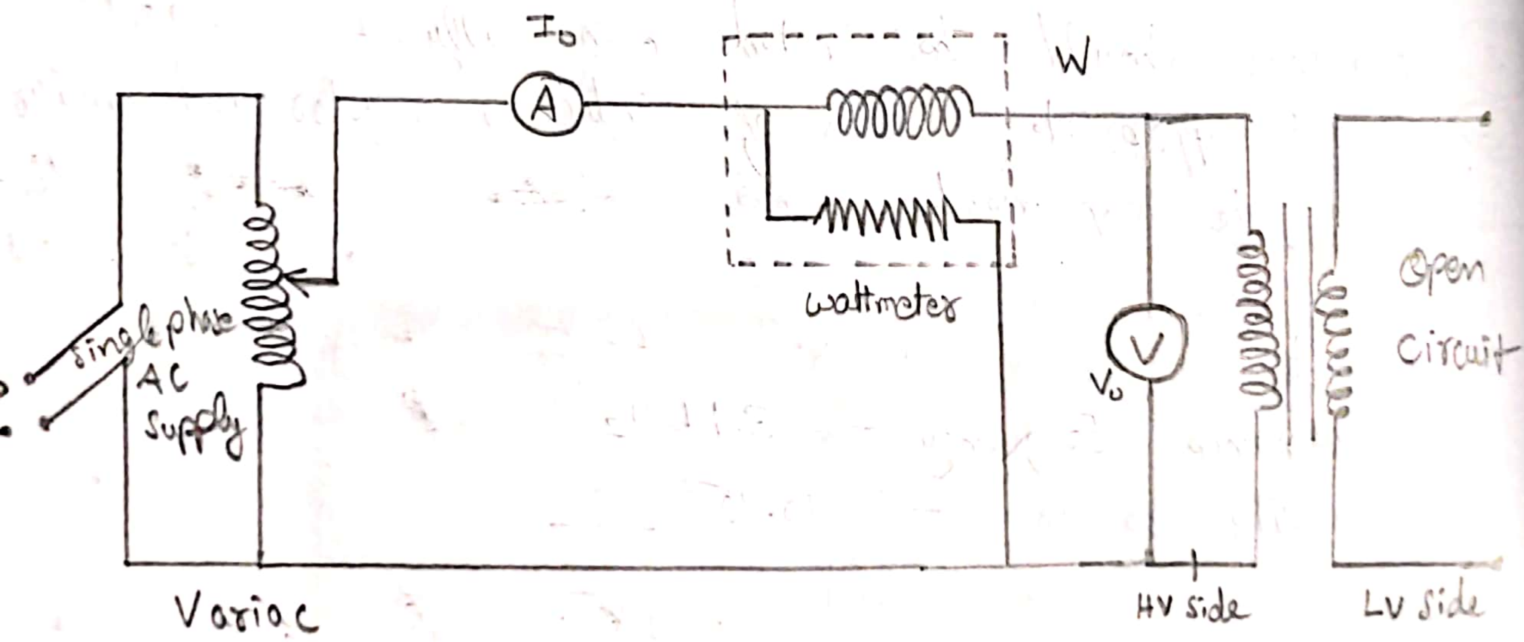
Quality factor = 10.95

Experiment - 7

AIM:- To perform open test on single phase transformer.

Apparatus:- Single phase transformer (1kVA 230/115V) - 01, Single phase voltage Variac (0-270V) - 01, wattmeter (150V, 5A) - 01, voltmeter (0-30V) - 01, Ammeter (0-5A) - 01, and connecting wires.

Circuit Diagram:-



Experiment - 7

AIM:- To perform open circuit test on single phase Transformer.

Apparatus:- Single phase transformer (1kVA 230/115V) - 01, Single phase voltage variac (0-270V) - 01, wattmeter (150V, 5A) - 01, Voltmeter (0-30V) - 01, Ammeter (0-5A) - 01, and connecting wires.

Theory:- Open circuit test (No load Test):-

The purpose of this test is to determine the core loss and no load current I_0, which is helpful in finding no load parameter R_0 and X_0 of transformer.

→ This test is carried out on low voltage side of the transformer, Primary winding is connected to normal voltage V_L.

→ Secondary is kept open circuited.

→ Since the secondary is open, the current drawn by the primary is no load current I_0 (2 to 10% of full rated current)

→ Copper loss is primary are negligibly small and there is no copper loss is secondary as it is open.

→ Therefore, wattmeter reading represents core / iron loss.

Teacher's Signature.........................

Observation Table :-

S.No.	Open circuit voltage V_0	Open circuit Current I_0	Open circuit wattage W_0	$\cos\phi = \frac{W_0}{V_0 I_0}$	$I_M = I_0 \cos\phi$
1.	230 V	0.2 A	15 W	0.326	0.652 A

$I_M = \sqrt{I_0^2 - I_\omega^2}$
0.189 A

Result

Open circuit test has been performed.

let the wattmeter reading $= W_0$
Voltmeter reading $= V_1$
Ammeter reading $= I_0$

Iron loss, $P_i = W_0$

$$V_1 I_0 \cos \phi_0 = W_0$$

No load power factor, $\cos \phi = \frac{W_0}{I_0 V_1}$

$$\Rightarrow \cos \phi = \frac{W_0}{I_0 V_1}$$

Procedure :-

1) Make the connections as shown in ciruited diagram.
2) Check the primary winding should be at least low voltage.
3) Switch on the supply after setting zero input voltage with variac.
4) Adjust the primary voltage equal to rated voltage with the help of variac and record V_0, I_0 and W_0
5) keep the variac at zero position and switch off the supply.

Precautions :-

1) Ranges of different voltmeter, ammeter, wattmeter should be kept in mind.

2) Circuit should have tight connections.

Result :-

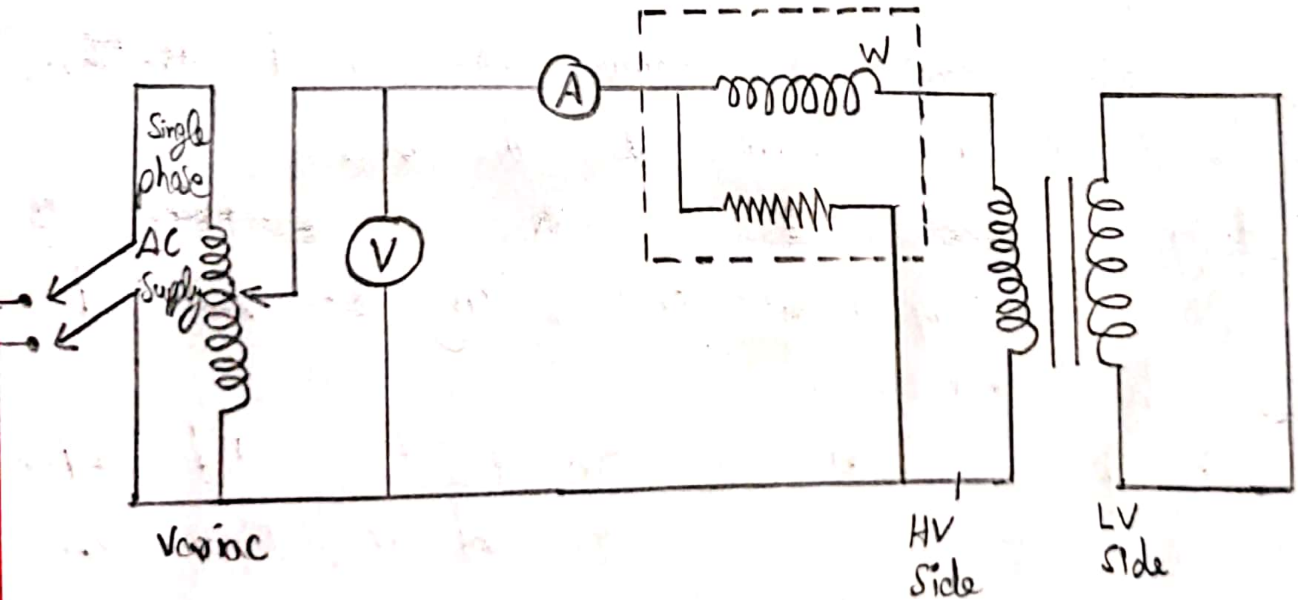
Open circuit test has been performed.

Experiment -8

AIM :- To perform short circuit test on single phase transformer

Apparatus :- Single phase Transformer (1KVA/230/115 V)-01, Single phase voltage variac (0-270 V) -01, wattmeter (150V, 5A)-01, voltmeter (0-30V)-01, Ammeter (0-5A)-01, connecting wires.

Circuit Diagram :-



Experiment - 8

AIM:- To perform Short circuit test on single phase transformer.

Required Apparatus:- Single phase transformer (1KVA/230)-01, Single phase voltage variac (0-270 V)-01, wattmeter (150V, 5A)-01, voltmeter (0-30 V)-01, Ammeter (0-50A)-01, connecting wires.

Theory:-

→ The purpose of this is to determine full load copper loss and equivalent resistance and reactance referred to metering side.

→ Test is usually carried out on high voltage side of the transformer.

→ Terminals of secondary winding (low voltage winding) are short circuited by thick wire.

→ Since a low voltage (5 to 10% of normal rated voltage is applied to the transformer winding.

∴ flux ~~set~~ up in the core is also small and therefore iron losses are also small that there can be neglected.

→ Hence wattmeter reading represent copper loss.

Teacher's Signature.........................

Observation Table :-

S. No.	Short circuit current I_{sc}	Short circuit Voltage V_{sc}	Short circuit wattage W_{sc}	$R_{es} = \frac{W_{sc}}{I_{sc}^2}$ (Ω)	$Z_{es} = \frac{V_{sc}}{I_{sc}}$ (Ω)	$X_{es} = \sqrt{Z_{es}^2 - R_{es}^2}$ (Ω)
1	1.9	10	15	4.1551	5.2631	3.2303
2	2.7	15	30	4.1152	5.5555	3.73211
3	3.7	20	45	3.2870	5.8823	4.87221

Calculations

Equivalent resistance required $\Rightarrow R_{es} = \frac{W_{sc}}{I_{sc}^2}$

$$= \frac{15}{1.9} \Rightarrow 4.1551\,\Omega$$

Equivalent impedance required $\Rightarrow Z_{es} = \frac{V_{sc}}{I_{sc}}$

$$= \frac{10}{1.9} \Rightarrow 5.2631\,\Omega$$

Equivalent leakage reactance $\Rightarrow X_{es} = \sqrt{Z_{es}^2 - R_{es}^2}$

$$= 3.2303\,\Omega$$

Result

Equivalent parameters i.e, $R_{eq} = 4.1551\,\Omega$ and $X_{eq} = 3.2303$ were calculated along with copper loss.

* **Procedure :-**

1) Connect the circuit as shown in fig.
2) Set the variac at zero position.
3) Switch on the supply.
4) Gradually increase the voltage by variac to make primary current equal to rated current.
5) Note down the readings of ammeter, voltmeter and wattmeter.
6) Keep the variac at zero position and switch off supply.

* **Precautions :-**

1) All the connections should be tight and clean.
2) Special care should be taken while selecting the ranges of the meters for conducting short-circuit test.
3) While conducting the short-circuit test, the voltage applied should be initially set at zero, and then increase slowly. If a little higher voltage than the required voltage be applied, there is a danger of transformer being damaged.

* **Result :-**

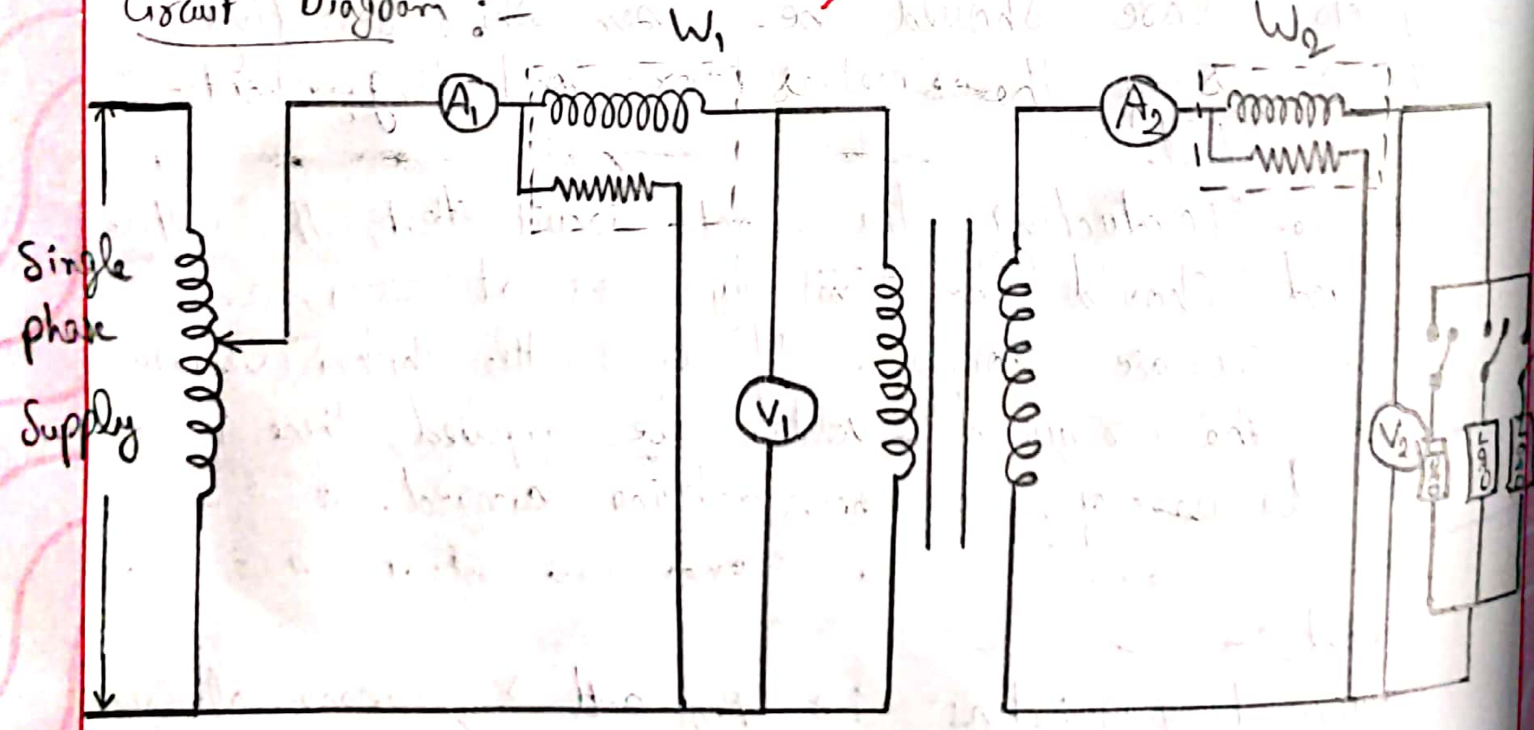
Equivalent parameters i.e, R_{eq} and X_{eq} were calculated along with copper ~~loss~~ loss.

(Experiment – 9)

AIM :- To perform direct load test on a single phase transformer and plot graph between efficiency and load current.

Apparatus :-
1) Single phase Transformer (2kVa, 230/115 V) – 1no.
2) Auto Transformer (0 – 270V) – 1no.
3) Wattmeter (0 – 750W) – 2no.
4) Voltmeter (0 – 300V) – 2no.
5) Ammeter (0 – 10A) – 2no.
6) Resistive load and connecting wires

Circuit Diagram :-



Experiment -9

AIM:- To perform direct load test on a single phase transformer and plot graph b/w efficiency and load resistance.

Apparatus:- Single phase transformer (2K.V.a /115 V) - 1 no. Single phase voltage variac (Make B.R. Trading Co.) (0-270V) - 1 no., wattmeter (0-750W, 5A/300V) (Make: Denko) - 2 no's, voltmeter (0-300) - 2 no., ammeter (0-10 amp.) - 02 no., resistive load and connecting wires.

Theory:- Input to the transformer is observed with the help of the wattmeter, let it be W1. The output of the transformer is calculated from the product of the voltage, V_2 and current I_2 in the secondary of the transformer or from wattmeter reading W2, the load is taken as resistive load only and therefore has the power factor of unity. So we can write,

% efficiency of transformer = (output / input) x 100

$= (W_2 / W_1) \times 100$

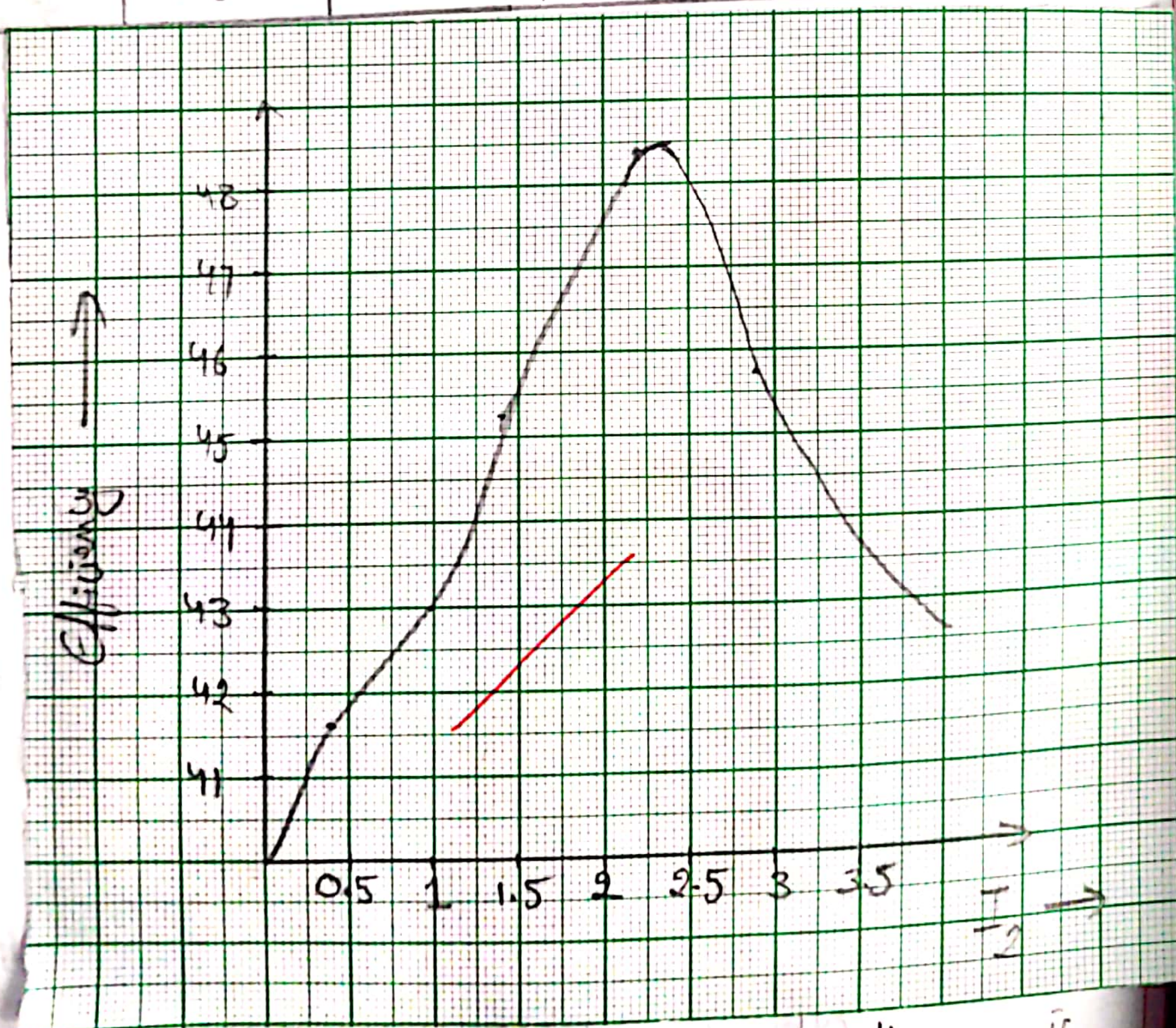
Procedure:-

1) Connect the circuit as per circuit diagram.
2) Ensure that there is no load on secondary winding of transformer.

Observation Table :-

Input voltage V_1	Input current I_1	Input power P_1	output voltage V_2	output current I_2	output power P_2	% efficiency $= \frac{P_2}{P_1} \times 100$
220 V	0.6 A	180 W	215 V	0.4 A	75 W	41.6
220 V	1.5 A	345 W	210 V	1.4 A	165 W	45.3
220 V	2.3 A	510 W	205 V	2.2 A	225 W	47.8
220 V	2.8 A	645 W	200 V	2.9 A	300 W	45.8

Graph



Result :- When the load current is increasing efficiency is increasing.

3) Switch on the AC supply & record no load voltage across the secondary windings.
4) Adjust approx. 10% of full load current in load & record the readings of all meters.
5) Repeat the above for various load currents till the full load.
6) Reduce the load
7) Switch off the supply.

Precautions :-

1) The connections should be tight.
2) Readings should be taken carefully.
3) Voltmeter and ammeter should be of proper range.
4) Handle the instrument carefully.

Result :-

When the load current is increasing efficiency is increasing.