Certificate

Name : ANANT BHARTI Class /SEM :- III[rd]

Roll No. : BTECH/10675/21 Exam No. :

Institution BIRLA INSTITUTE OF TECHNOLOGY

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(N. B : The candidate is expected to retain his/her journal till he/she passes in the subject)

INDEX

B.M.Prasad 14.09.22

B.M.Prasad 12.10.22

INDEX

verification of superposition and Thevenin's Theorem:-

Aim:- (i) TO verify superposition theorem for a given circuit
(ii) To verify Thevenin's theorem for a given circuit

Apparatus required:-

1. superposition and Thevenin's theorem verification kit

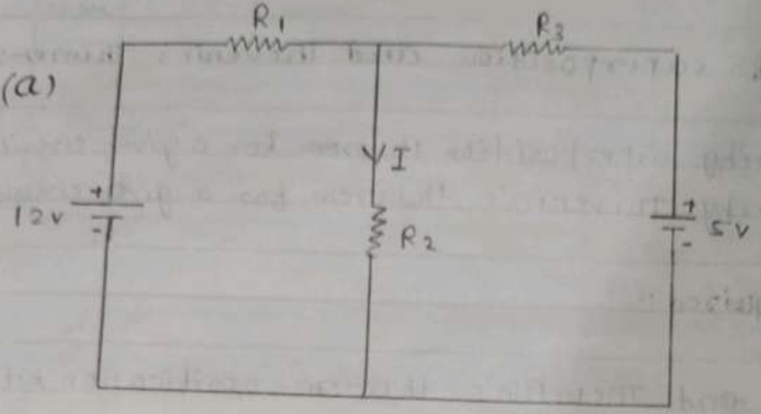
Theory:-

1. superposition theorem:-

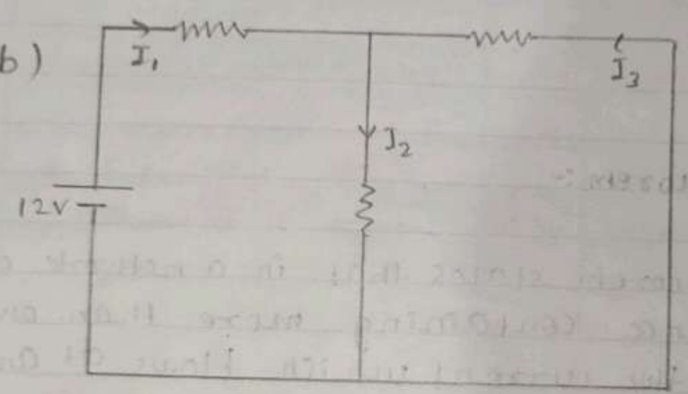
superposition theorem states that in a network of linear resistance containing more than one source of emf the current which flows at any point is the sum of all the currents which would flow at that point if each emf source (voltage source) were considered separately and all other emf source replaced for the time being by resistance equal to their internal resistances (if any).

Circuit diagram for superposition theorem:-

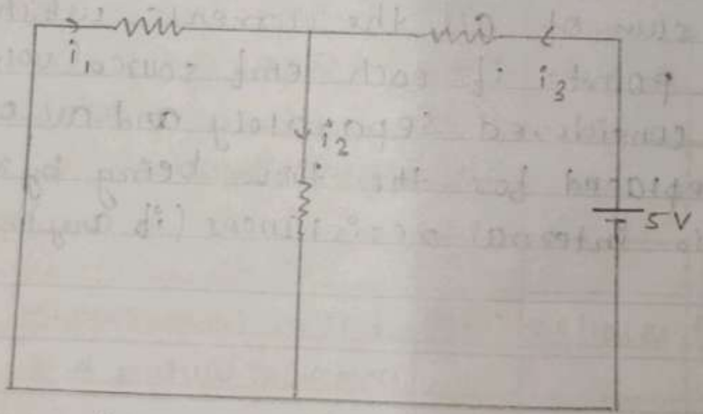
(a)



(b)



(c)



By superposition theorem,

$$I = I_2 + i_2$$

(2) Thevenin's theorem :-

Thevenin's theorem states that current flowing through a load resistance R_L connected across any two terminals of a linear, active bilateral network is given by $V_{OC} \,||\, (R_{Th} + R_L)$, where V_{OC} is the open circuit voltage (i.e. voltage across the two terminals when R_L is removed) and R_{Th} is the internal resistance of the network as viewed back into the open circuited network when all voltage sources replaced by their internal resistance (if any).

procedure :-

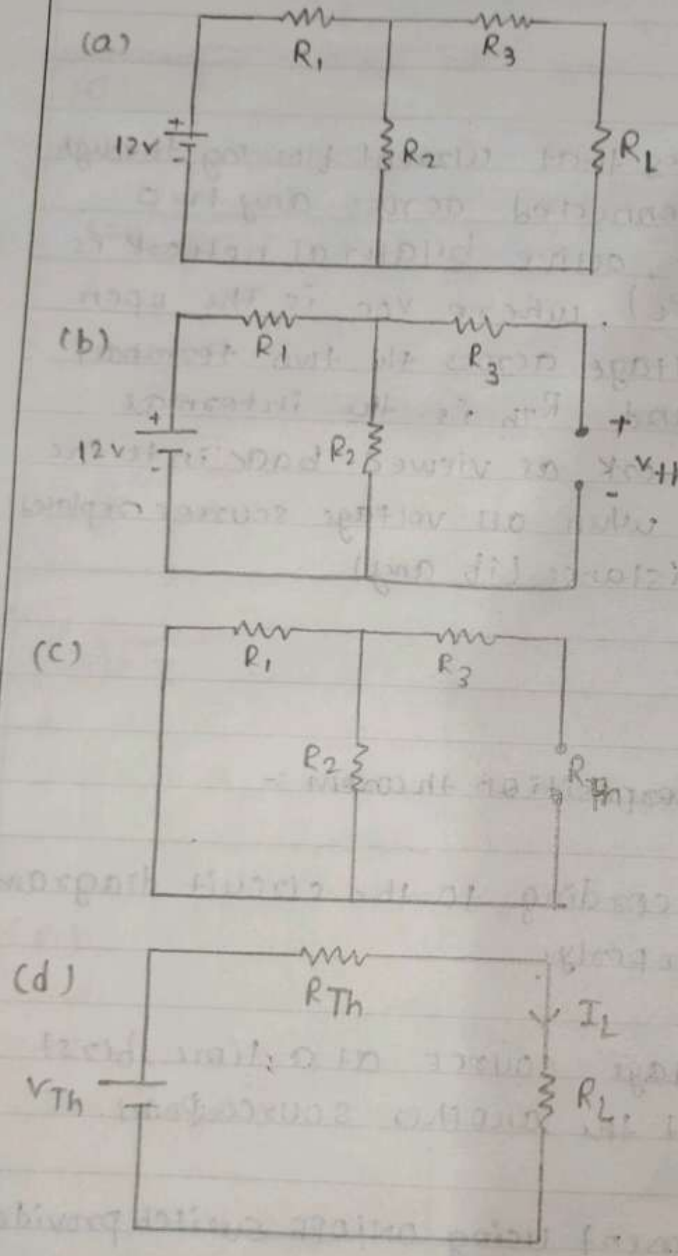
(1) For verification of superposition theorem :-

(a.) connect the circuit according to the circuit diagram in verification kit properly.

(b.) consider only one voltage source at a time, first 12V and short circuit the another source point.

(c) Switch ON the instrument using ON/OFF switch provided on the front panel.

circuit diagram for Thevenin's theorem:-



$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

(d) Note down currents I_1, I_2, I_3 one by one by connecting current meter in series of resistances R_1, R_2 and R_3

(e) compare the observe current readings to calculated current values

(f) Now short circuit 12 V source and consider only 5V DC source.

(g) switch ON the instrument by ON/OFF switch.

(h) Note down currents i_1, i_2, i_3 by connecting current meter in series of resistances R_1, R_2, R_3 respectively.

(i) compare the observed current value with calculated current value.

(J) so, by superposition theorem the current through the R_2 is equals to $(I_2 + i_2)$

(2) For verification of Theverin's theorem:-

(a) Connect the circuit as shown in the circuit diagram.

Observation table :-

① For superposition theorem :-

$R_1 = 100\,\Omega$, $R_3 = 50\,\Omega$ (fixed)

S. NO.	R_2 (Ω)	I (mA)	I' (mA)	I'' (mA)	$I_x = I' + I''$ (mA)	% error $= \frac{(I - I_x)}{I} \times 100\%$
1.	50	0.090	0.048	0.04	0.088	$= \frac{(0.09 - 0.088)}{0.09} \times 100\% = 2.2\%$
2.	100	0.056	0.03	0.025	0.055	$= \frac{(0.056 - 0.055)}{0.056} \times 100\% = 1.78\%$

② For Thevenin's theorem :-

S. NO.	R_L (Ω)	I_L (mA)	V_{Th} (V)	R_{Th} (Ω)	$I_L' = \frac{V_{Th}}{R_{Th} + R_L}$	% error
1.	10	10	1.96	183.3	10.1	1 %
2.	22	9.91	1.96	183.3	9.54	3.7 %
3.	50	8.6	1.96	183.3	8.4	2.3 %

(b) Now disconnect the load resistance R_L from output terminals and measure open circuit voltage (V_{th}) by connecting Analog voltmeter accross points z_1 and z_2.

Formula used to find V_{th} :-

$$V_{th} = (12V) \times \left(\frac{R_2}{R_1 + R_2}\right)$$

(c) Now to measure the R_{th} (Thevenin's resistance) disconnect R_L by open circuit and short circuit the voltage source (12 V) and calculate the R_{th} which will be in series with load resistance R_L.

Hence, formula used to calculate R_{th} :

$$R_{Th} = (R_1 \parallel R_2) \parallel R_3$$

d) Now calculate the current through the load resistance by connecting R_L in series with R_{th} and V_{th} and measure i_L by using current meter.

Formula used to calculate I_L :-

$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

Calculations:-

$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$ = current through load resistance

when, $R_L = 10\ \Omega$

$$I_L' = \frac{1.96}{183.3 + 10} = 10.1\ mA$$

when, $R_L = 22\ \Omega$

$$I_L = \frac{1.96}{183.3 + 22} = 9.54\ mA$$

when, $R_L = 50\ \Omega$

$$I_L = \frac{1.96}{183.3 + 50} = 8.4\ mA$$

Result :-

Hence the superposition theorem and thevenin's theorem is verified both practically and theoretically with some permissible error which is allowed in practical.

Precautions:-

1. Check all the resistance and connecting wires are properly connected or not.

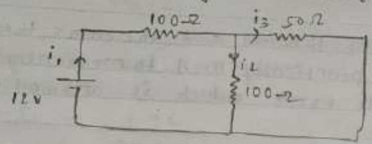
2. Terminal of voltage source of the kit should not be short circuited only circuit on the board should be short circuited.

3. The current and voltage given to ammeter and voltmeter repectively should not exceed beyond their maximum range.

5. Check the connecting lead if voltage or current is not displayed on respective meters.

Calculations:-

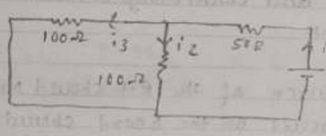
(1) Short circuiting 5V source



$$R_T = (50 \| 100) + 100 = \frac{400}{3}\ \Omega$$

$$i_1 = \frac{12 \times 3}{400} = 0.09A, \quad i_2 = 0.09 \times \frac{50}{150} = 0.03A, \quad i_3 = 0.09 \times \frac{100}{150} = 0.06A$$

(2) Short circuiting 12V source



$$R_T = (100 \| 100) + 50 = 100\ \Omega$$

$$i_1 = \frac{5}{100} = 0.05A, \quad i_2 = 0.05 \times \frac{100}{200} = 0.025A, \quad i_3 = 0.05 \times \frac{100}{200} = 0.025A$$

∴ According to superposition theorem current across P_2 i.e. 100Ω is: $(0.06 + 0.025)A$

$= 0.085A$

Expt. No. .... Date .... Page No. 6

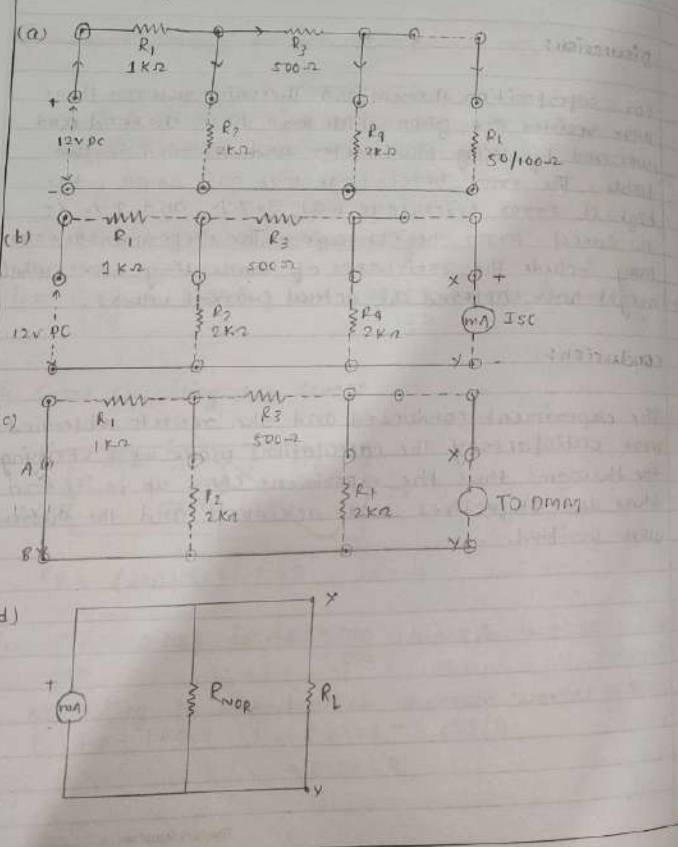
Discussion:

For superposition theorem and Thevenin's theorem there were resistors are given which were been checked and measured by using multimeter and recorded in the table. The error percentage was quit small, the highest error percentage was 3.7% and 1% is the lowest error percentage. The experimental error may include the resistance of connecting wires which might have altered the actual current values.

Conclusion:-

The experiment conducted and the results obtained were satisfactory. The calculations made were verifying the theorems thus the experiment come up to its end that the objectives was achieved and the theorems were verified.

Circuit diagram for Norton's theorem:



Verification of Norton's and Maximum power transfer theorem:-

Aim:- (i) To verify Norton's theorem for a given circuit.
(ii) To verify maximum power transfer theorem for a given circuit.

Apparatus required :-

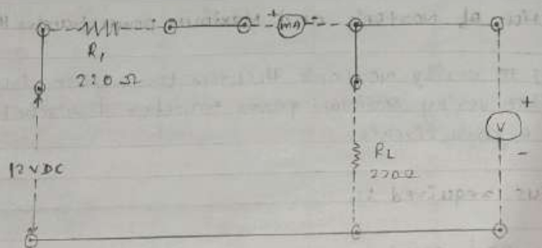
1. Norton's and Maximum power transfer theorem verification kit.

Theory:-

1. Norton's theorem:-

Norton Theorem's states that any two terminal active network containing voltage sources and resistances when viewed from its output terminals, is equivalent to a constant current source (I_{sc}) and a parallel resistance (R_{Nor}). The constant current is equal to the current which would flow in a short circuit placed across the terminals and parallel resistance is the resistance of the network when viewed from these open circuited terminals after all voltage sources have been removed and replaced by their internal resistance (if any).

circuit diagram for maximum power transfer theorem :-



$R_1 = 220\ \Omega$ (fixed)

$R_L = 50/100/220/300/470\ \Omega$

Date ....

Expt. No. ....

2. Maximum power transfer theorem:-

when load is connected across a voltage source, power is transferred from the source to the load. The amount of power transferred will depend upon the load resistance. If the load resistance R_L is made equal to the internal resistance R_i of the source, then maximum power is transferred to the load R_L. This is known as maximum power transfer theorem and can be stated as follows.

"Maximum power is transferred from a source to a load when the load resistance is made equal to the internal resistance of the source". This applies to DC as well as AC power.

procedure:-

1. For verification of Norton's theorem:-

1. connect the circuit as given in the circuit diagram

2. Disconnect the load resistance (R_L) from output terminals and connect current meter across x and y points. Note down the short circuit current I_{sc}.

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Observation table for Norton's theorem.

S. No.	R_L (Ω)	I_L (Theoretical) (mA)	I_L (experimental) (mA)	% error
1.	50	6.39	6.4	0.916 %
2.	100	5.99	6.0	1.010 %

	Theor. value	Exp. value	% error
I_{SC}	6.85 mA	6.7 mA	2.189 %
R_{NOR}	737 Ω	793 Ω	0.814 %

Observation table for Maximum power transfer theorem:

S. No	R_1 (Ω)	R_L (Ω)	voltage(V) (volts)	current(I) (mA)	Power = V×I (m watts)
1	220	50	2.24	44.3	99.232
2.	220	100	4.00	35.0	140
3.	220	220	5.92	25.8	158.65 max^m power
4.	220	300	6.85	22.5	154.12
5.	220	470	8.05	16.8	135.24

3 To measure the resistance across x and y Points, Disconnect voltage source and short the A and B points & Now connect DMM (Digital multimeter) across x and y Points set the mode of DMM and note down the value of resistance x and y.

Formula used to calculate the value of resistance (R_{NOR})

$$R_{NOR} = [(R_1 \parallel R_2) + R_3] \parallel R_4$$

4 vary R_L resistance and measure I_L and V_L in each step

Formula used to calculate short circuit current (I_{SC})

$$I_{SC} = \frac{V_{NOR}}{R_{NOR}}$$, V_{NOR} is the open circuit voltage

5. To measure the current from load resistance R_L. connect the current meter in series of load resistance

Calculations:

$$R_{NOR} = [(R_1 \parallel R_2) + R_3] \parallel R_4 \ \Omega$$

$$= [(1k\Omega \parallel 2k\Omega) + 500\Omega] \parallel 2K \ \Omega$$

$$= \left(\frac{2}{3} \times 1000 + 500\right) \parallel 2K\Omega$$

$$= \left(\frac{3500}{3}\Omega\right) \parallel (2000 \text{ Ohm})$$

$$= 737\Omega$$

$$I_{SC} = V_{NOR} / R_{NOR}$$

, V_{NOR} = open circuit voltage $= 5V$

$$= \frac{5V}{737\Omega}$$

$$= 6.78mA$$

Expt. No.................. Date..........

Page No. 10

2. For verification of Maximum power transfer theorem:

1 connect the circuit as shown in the circuit diagram.

2. connect resistance $R1 = 220\Omega$ and also connect the load resistance value $RL = 220\Omega$. connect current meter of 250mA and voltmeter of 15 v range in the circuit.

3. Note down the voltage and current and calculate the output power by using formula.

$$P_{out} = \text{voltage} \times \text{current}$$

4. Now increase and decrease the value of load resistance (RL) and every time note down the corresponding value of voltage and current. calculate output power for each reading and note down the observation in a table.

Result :-

In the verification of Norton's theorem, we have first calculate R_{NOR} and then I_{SC} which is coming 6.85 mA which is approximately equal to observed value with an error of 2.180%. which is allowed in practical.

Teacher's Signature :

Calculations:-

P_{out} = voltage × current

case 1: $R_1 = 50\ \Omega$

$P_{out} = 2.24 \times 44.3 = 99.2$

case 2: $R_1 = 100\ \Omega$

$P_{out} = 4.0 \times 35.0 = 140.0$

case 3: $R_L = 220\ \Omega$

$P_{out} = 5.92 \times 26.8 = 158.65$ (Max^m power)

case 4: $R_L = 300$

$P_{out} = 6.85 \times 22.5 = 154.12$

case 5: $R_1 = 470$

$P_{out} = 8.05 \times 16.8 = 135.24$

Date ....

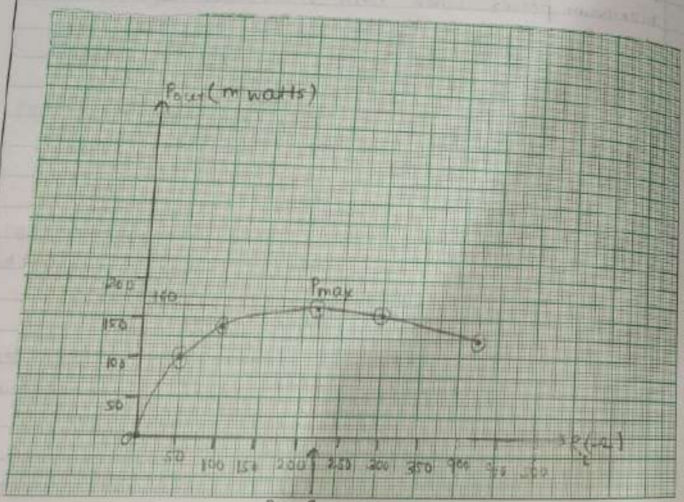
Expt. No. ....

During the verification of maximum power transfer theorem, it is clearly visible that source provide maximum power when load resistance equals to the internal resistance.

precautions:-

1. Check all the resistance and connecting wires are properly connected or not.
2. Terminals of voltage source of the kit should not be short circuited only circuit on the board should be short circuited.
3. The current and voltage given to ammeter and voltmeter respectively should not exceed beyond their maximum range.
4. check the connecting lead if voltage or current is not displayed on respective meters
5. Switch off the power supply and circuit after the experiment.

Teacher's Signature :



$R_L = R_1 = 220\Omega$

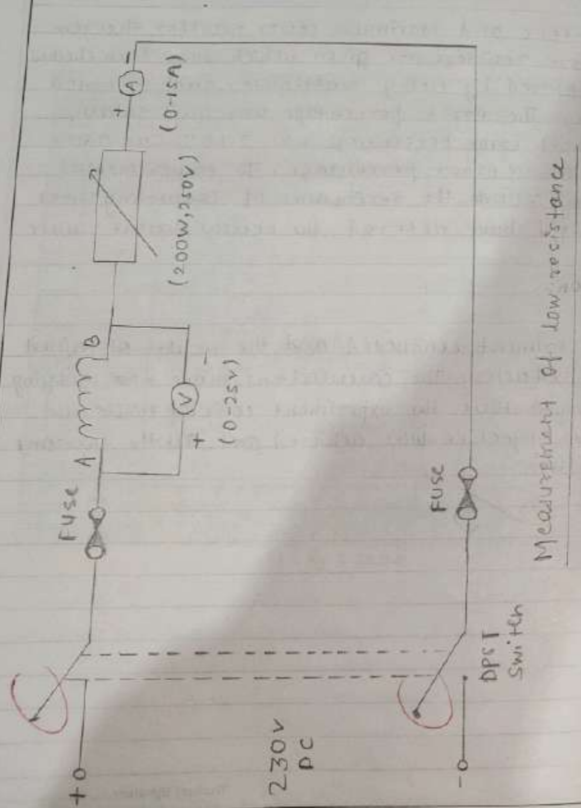
Discussion:

For Norton's and Maximum power transfer theorem there were resistors are given which were been checked and measured by using multimeter and recorded in table. The error percentage was quit small, the highest error percentage was 2.18% and 0.81% is the lowest error percentage. The experimental error may include the resistance of connecting wires which might have altered the actual current values

Conclusion:

The experiment conducted and the results obtained were satisfactory. The calculations made were verifying the theorems thus the experiment come up to its end that the Objective was achieved and all the theorems were verified.

Circuit diagram:-



Expt. No. 1.(i)

Date ....

Page No. 13

Name of the experiment:-

Measurement of low and high resistance of DC shunt motor

Aim of the experiment:-

(a) To measure low resistance of armature winding by voltmeter ammeter method.

Apparatus required:-

S.NO	Component	Specifications
1.	DC voltmeter	(0-25)V
2.	DC Ammeter	(0-10)A
3.	1-Phase lamp load	200W, 250V
4.	DC motor	230V, 13.3A, 6HP, 1450 rpm

Theory:-

Ohm's law: The ratio of potential difference (V) between the ends of a conductor to the current (I) flowing between them is constant, provided the physical conditions (e.g. temperature) doesn't change

i.e. $\frac{V}{I}$ = constant = R

Teacher's Signature: ______

Observation table :-

S. No.	V (volts)	I (A)	$R = V/I$ (Ω)	Average
1.	1.15	0.9	1.27	
2.	2.27	1.8	1.26	
3.	3.25	2.7	1.25	
4.	3.98	3.4	1.17	
5.	4.65	4.2	1.08	$R_{avg} = 1.13\,\Omega$
6.	5.45	5.0	1.09	
7.	6.15	5.7	1.07	
8.	6.87	6.5	1.05	
9.	7.67	7.4	1.02	
10.	8.37	8.1	1.03	

Resistance, $R = \frac{V}{I}$

we use a 1-phase lamp load to find the low resistance. If we plot the V-I characteristics, we obtain a straight line. The reciprocal of the slope of the graph also gives us the resistance.

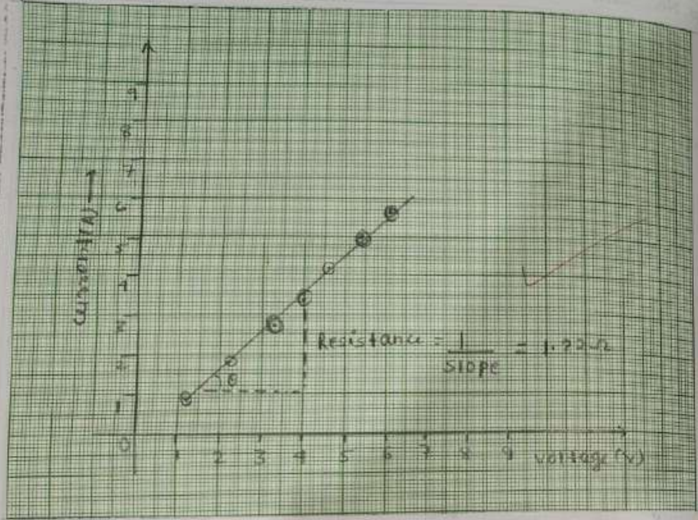
procedure:-

1. Make all the electrical connections as shown in the circuit diagram
2. switch on the power supply and note the readings on the voltmeter and ammeter
3. vary the number of lamps switched on in the lamp load
4. Note the readings for every load.
5. plot the V-I graph

precautions:-

1. The connections should be tight.
2. Avoid touching naked wire

Graph:-



Calculations

$$\text{Resistance} = \frac{1}{\text{slope}} = \frac{\Delta V}{\Delta I} = \frac{2.3 - 1.2}{1.8 - 0.9} = \frac{1.1}{0.9} = 1.22\,\Omega$$

$$\%\ \text{error} = \frac{1.22 - 1.13}{1.22} \times 100\% = 7.55\%$$

Expt. No. .... Date ....

3. Wear shoes while performing the experiment

4. Readings should be taken only when the instruments give stable readings

5. Main supply should not be on, while assembling the circuit

Result:-

The low resistance of the armature winding of DC shunt motor is 1.13 ohm.

Conclusion:-

The experiment conducted and the results obtained were satisfactory. there is a error of 7.55 %. which is permissible thus the experiment came up to its end that the objective of the experiment was achieved

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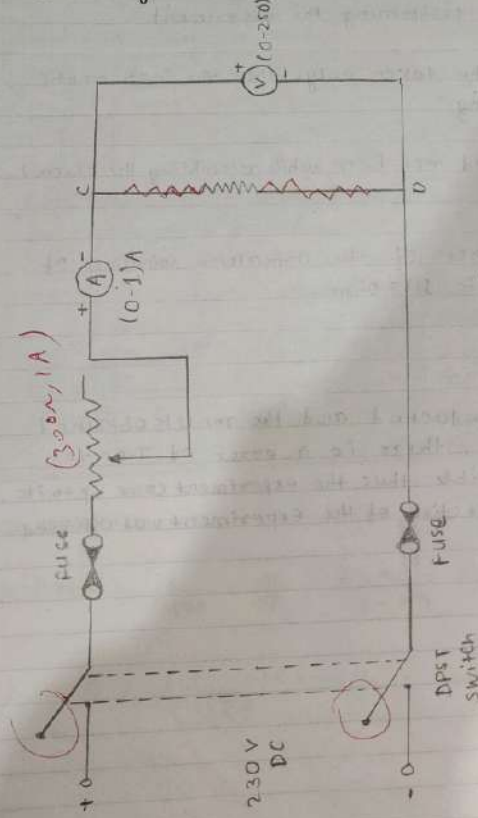
Circuit diagram :-



Measurement of high resistance

Expt. No. ....

Date ....

Aim of the experiment:-

(b) To measure high resistance shunt field winding of a DC shunt motor by ammeter voltmeter method.

Apparatus required:-

S. No.	component	specification	quantity
1.	DC voltmeter	(0 - 250 V)	1
2.	DC Ammeter	(0 - 1) A	1
3.	Rheostat	300 Ω , 1.5 A	1
4.	DC shunt motor (panel no 15)	230 V, 23 A, 6HP, 1450 rpm high resistance (390 Ω), shunt field winding, low resistance (1.7 Ω) armature winding	1
5.	DC shunt motor (panel no. 16)	220 V, 20A, 5HP, 1500 rpm High resistance (335 Ω) shunt field winding), low resistance (1.9 Ω) armature winding	1
6.	connecting wires		—
7.	DC power supply	230 V	—

Teacher's Signature ....

observation table :-

S. No.	V (volts)	I (A)	R = V/I (Ω)	Average
1.	120	0.38	315.79	
2.	130	0.41	317.07	
3.	140	0.44	318.18	
4.	150	0.46	326.08	
5.	160	0.49	333.32	$R_{avg} = 326\ \Omega$
6.	170	0.52	326.92	
7.	180	0.55	321.42	
8.	190	0.58	327.58	
9.	200	0.60	333.33	
10.	210	0.62	338.70	

Theory :-

ohm's law :- The ratio of potential difference (V) between the ends of a conductor to the current (I) flowing between them is constant, provided the physical conditions (e.g temperature) doesn't change i.e. $V/I = \text{constant} = R$

To find the high resistance of DC shunt field winding. ohm's law is used with Ammeter voltmeter method. Resistance $R = V/I$. The V-I characteristics is a straight line. The reciprocal of the slope of V-I characteristics is the value of resistance

procedure:

1. Do the connections as per circuit diagram
2. Check the position of Rheostat, it should be at maximum position initially
3. The rheostat positions are changed from maximum to the lowest limit, corresponding to which ammeter and voltmeter readings are noted down.
4. The ratio ($V/I = R$) is calculated for each set of observation and noted, average value of R is calculated

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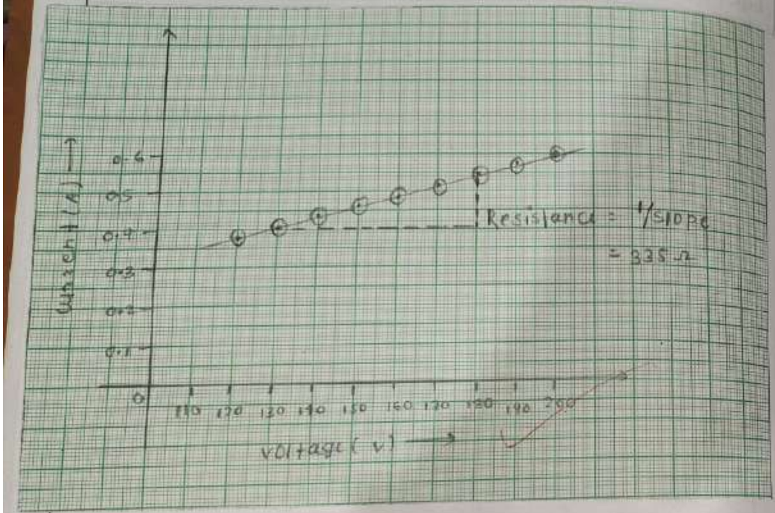
Graph:-



Calculations:-

Calculated resistance = 326 Ω

Standard resistance = 335 Ω

$\% \text{ error} = \left(\frac{335 - 326}{335}\right) \times 100\% = \frac{9}{335} \times 100\%$

$= 2.68\%$

Expt. No. .... Date ....

Page No. 18

5. A graph is plotted between current (I) and voltage (V). The reciprocal of its slope gives the value of the resistance.

Result and discussion:-

The average value of the high resistance of the shunt field winding of the dc shunt motor is 326 Ω.

The measured value of resistance is deviated by 2.68%.

Precautions:-

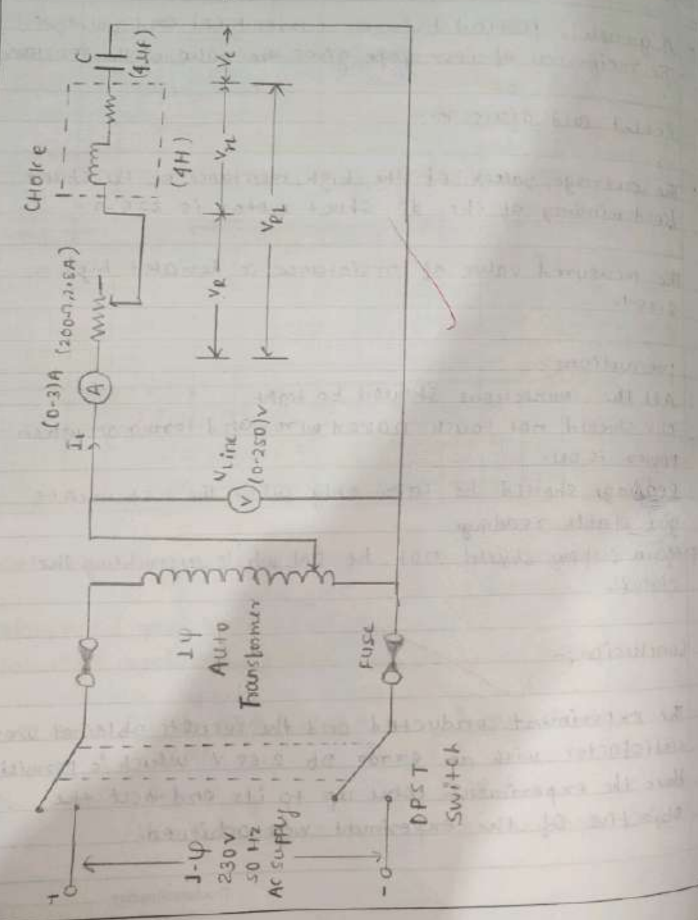
1. All the connections should be tight
2. One should not touch naked wires and terminals when power is ON.
3. Readings should be taken only when the instruments give stable readings
4. Main supply should not be ON, while assembling the circuit.

Conclusion:-

The experiment conducted and the results obtained were satisfactory with an error of 2.68% which is permissible thus the experiment came up to its end that the objective of the experiment was achieved.

Teacher's Signature :

Experimental setup :-



Expt. No. 2.(i) AC RLC series circuit :- Date. 14/03/22 Page No. 19

Aim of the experiment :-

(a) To obtain the current and voltage distribution in AC RLC series circuit.

(b) To draw the phasor diagram.

Instruments and component required :-

S. No.	Name	Specification	Quantity
1.	1-phase auto Transformer	Input (0-230)V Output (0-270)V frequency (50-60)Hz	1
2.	AC voltmeter	(0-250)V	1
3.	AC Ammeter	(0-3)A	1
4.	Rheostat	200Ω, 2.8A	1
5	choke coil	4H	1
6.	Capacitor	4μF	1
7.	connecting wires	—	—

Theory :-

The basic VI relationship of resistance, inductance and capacitance are given by

1. $V_R = R \times I_R$
2. $V_L = L \, di/dt$
3. $V_C = 1/C \int i\,dt$

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Observation table:-

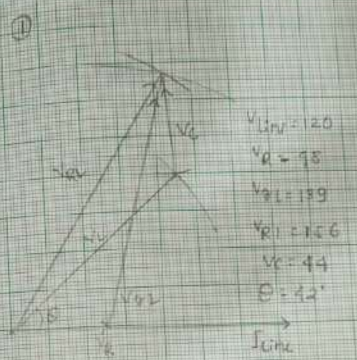
S.No	I	V_{Line}	V_R	V_{rL}	V_{RL}	V_C
1.	0.25	120	98	139	156	44
2.	0.25	140	50	148	165	47
3.	0.30	160	62	180	202	58
4.	0.35	180	67	194	217	62
5.	0.40	200	76	214	241	71

Scale:-

1 x division = 20 units

1 y division = 20 units

(1)



$V_{Line} = 120$

$V_R = 98$

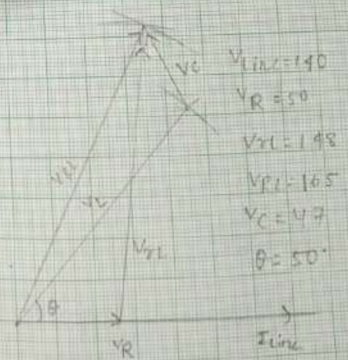
$V_{rL} = 139$

$V_{RL} = 156$

$V_C = 44$

$\theta = 42^\circ$

(2)



$V_{Line} = 140$

$V_R = 50$

$V_{rL} = 148$

$V_{RL} = 165$

$V_C = 47$

$\theta = 50^\circ$

Observation table:-

S.No	I	V_{Line}	V_R	V_{rL}	V_{RL}	V_C
1						
2.						
3.						
4						
5.						

Date..........

Expt. No. ....

As R, L, C are connected in series, the current through each component is same best.

voltage drop across resistor.

$$V_R = R\, I_m \sin(\omega t)$$

voltage drop across inductor,

$$V_L = \omega L\, I_m \cos\omega t = \omega L\, I_m \sin(\omega t + 90^\circ)$$

voltage drop across capacitor

$$V_C = \frac{1}{\omega C} I_m \cos\omega t = \frac{1}{\omega C} I_m \sin(\omega t - 90^\circ)$$

It can be concluded that, the voltage across a resistance is in phase with the current through it, the voltage across inductance leads the current by 90° and the voltage across capacitance lags by 90°

V_R is the phase with I, V_L is leading by $\pi/2$, V_L and V_C are out of phase by π. Therefore the applied voltage V is vectorial sum of V_R and $(V_L - V_C)$ represented by

$$V^2 = V_R^2 + (V_L - V_C)^2 = (IR)^2 + (IX_L - IX_C)^2$$

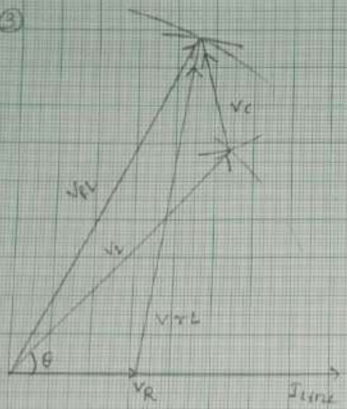
$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

And $I = \frac{V}{Z}$, Z = impedance of the circuit

Phase angle $\theta = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$

Teacher's Signature :

(3)



Scale :-

1 x-division = 20 units

1 y-division = 20 units

$V_{line} = 160$

$V_R = 62$

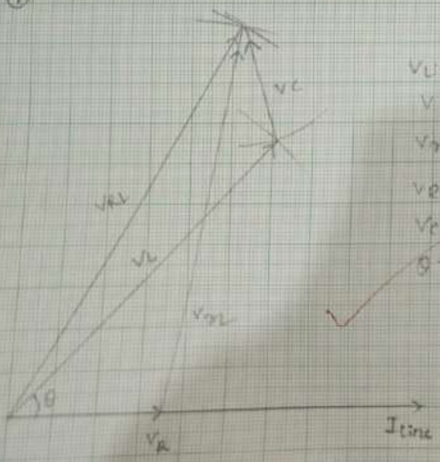
$V_{rL} = 180$

$V_{RL} = 202$

$V_C = 58$

$\theta = 47^\circ$

(4)



$V_{line} = 180$

$V_R = 67$

$V_{rL} = 194$

$V_{RL} = 217$

$V_C = 62$

$\theta = 47^\circ$

Date ....

Expt. No. ....

Procedure :-

1. connect circuit as shown in the experimental setup. Adjust the rheostat for maximum and auto transformer to position of zero output and switch on power supply.

2. Adjust voltage across the circuit for total as 100v. Note the I, V_L, I_L, V_r, V_{rL}, V_{RL} and V_C.

3. Adjust the value of voltage input while keeping the value of Rheostat constant. Repeat above steps.

4. compare the value of phase angle as obtained from the meter readings and form phasor diagram

Observation :-

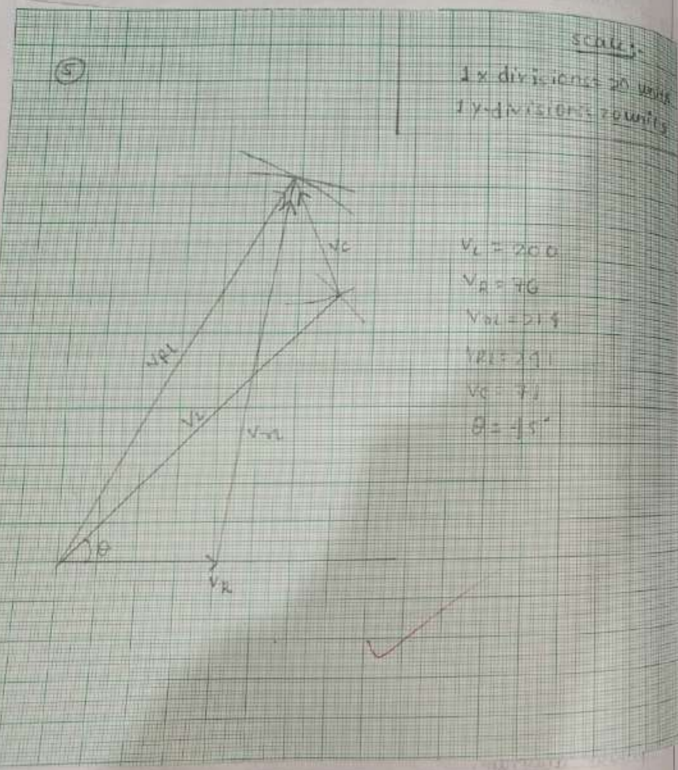
1. when $x_L > x_C$, circuit is inductive in nature and the current lags the applied voltage.

2. when $x_C > x_L$, circuit is capacitive in nature and the current leads the applied voltage.

Result :-

The current and voltage distribution for the AC RLC series circuit was obtained and conventially represented in the phasor diagram.

Teacher's Signature :-



Date ....

Expt. No. ....

Precautions:-

1. The transformer voltage should be increased in small steps.
2. Don't switch the main supply ON while assembling the circuit.
3. The zero error of the voltmeter and ammeter should be checked before starting the experiment.
4. Don't wear any metallic articles while performing the experiment.

Discussion:-

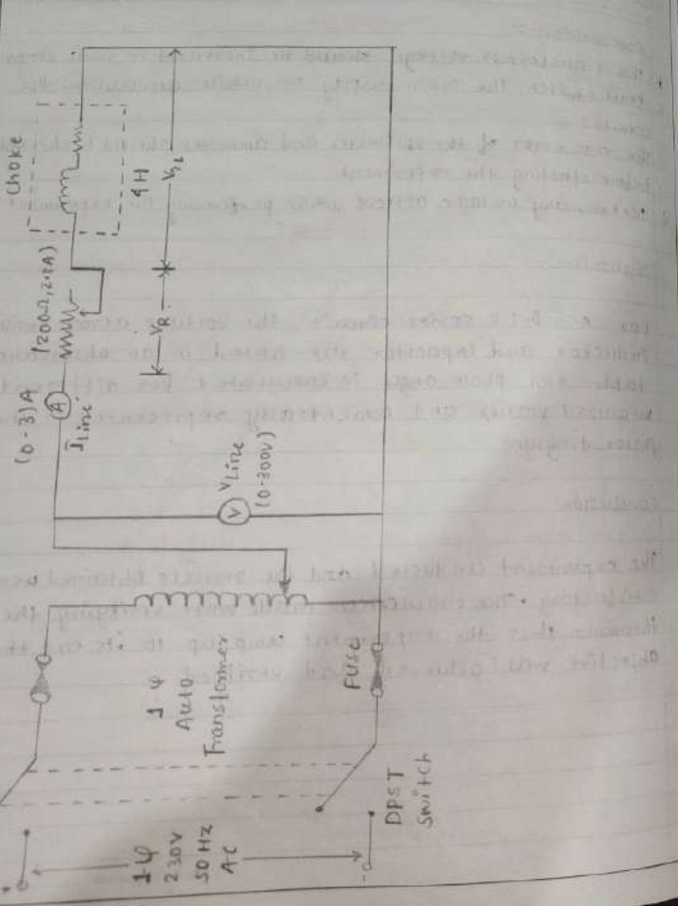
For AC R-L-C series circuit, the voltage across resistor, inductor and capacitor are noted in an observation table and phase angle is calculated for different measured values and conventially represented in the phasor diagram.

Conclusion:-

The experiment conducted and the results obtained were satisfactory. The calculations made were verifying the theorems thus the experiment come up to its end that objective was achieved and verified.

Teacher's Signature ....

Experimental setup:-



Date.........

Expt. No. 2.(ii) 3-voltmeter method :- Page No. 23

Aim of the experiment :-

(a) To measure the power and power factor of a single phase load by 3-voltmeter method.

(b) To draw phasor diagram

Apparatus required :-

S. No.	Name	Specification	Quantity
1.	1-phase auto transformer	230 V, 50HZ, AC supply	1
2.	AC Ammeter	(0-3) A	1
3.	AC voltmeter	(0-300)V	1
4.	Rheostat	(200 Ω, 2.8 A)	1
5.	choke coil	4H	1
6.	connecting wires	—	—

Theory :-

The single phase load under consideration is a choke coil. In this method, a known resistance is connected in series with the choke and a.c voltage is applied to the combination. The voltage across the resistance gives the value of current and phasor diagram can be obtained.

Teacher's Signature :

Observation table:-

S.NO	V_L	I_{Line}	V_R	V_{rL}
1.	160	0.3	41.5	131.8
2.	180	0.3	47.11	149.4
3.	200	0.4	55.2	174.5
4	220	0.4	58.2	182
5.	240	0.5	64	200

Calculations:-

case ①:- $V_L = 160$, $I_{Line} = 0.3$, $V_R = 41.5$, $V_{rL} = 131.8$

$$(V_L)^2 = (V_R)^2 + (V_{rL})^2 + 2 V_R V_{rL} \cos\phi$$

$$(160)^2 = (41.5)^2 + (131.8)^2 + 2 \times 41.5 \times 131.8 \cos\phi$$

$$\cos\phi = 0.5947$$

$$\phi = \cos^{-1}(0.5947) = 53.50^\circ$$

power: $V_{rL} I_L \cos\phi = 131.8 \times 0.3 \times 0.5947$

$= 23.51\ W$

case ②:- $V_L = 180$, $I_{Line} = 0.3$, $V_R = 47.11$, $V_{rL} = 149.4$

$$(V_L)^2 = (V_R)^2 + (V_{rL})^2 + 2 V_R V_{rL} \cos\phi$$

$$(180)^2 = (47.11)^2 + (149.4)^2 + 2 \times 47.11 \times 149.4 \cos\phi$$

$$\cos\phi = 0.5583$$

$$\phi = \cos^{-1}(0.5583) = 56.06^\circ$$

power = $V_{rL} I_L \cos\phi = 149.4 \times 0.3 \times 0.5583$

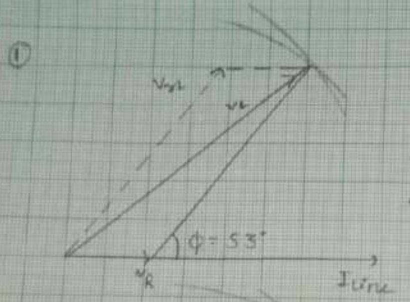
$= 25.02W$

Scale:

1 X-division = 20 units

1 Y-division = 20 units

(1)

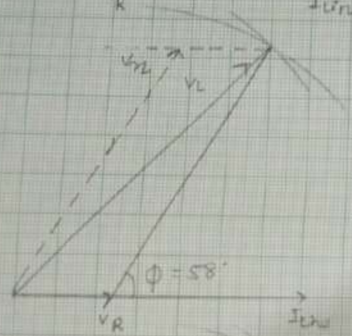


$V_L = 160$, $I_L = 0.3$

$V_R = 41.5$, $V_{rL} = 131.8$

$\phi = 53°$

(2)

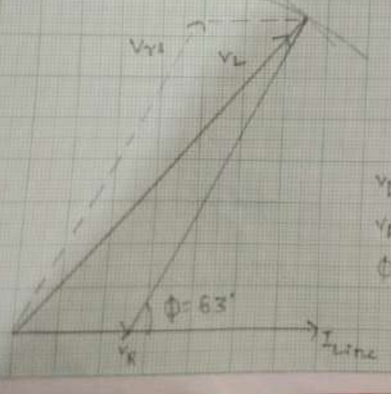


$V_L = 180$, $I_L = 0.3$

$V_R = 47.11$, $V_{rL} = 149.4$

$\phi = 58°$

(3)



$V_L = 200$, $I_L = 0.4$

$V_R = 55.2$, $V_{rL} = 179.5$

$\phi = 63°$

- $V_L^2 = V_R^2 + V_{rL}^2 + 2V_R \cdot V_{rL} \cos\phi_2$
- power factor $= \cos\phi_2$
- power $= V_L I_L \cos\phi_L$

procedure:-

1. connect circuit as shown in the experimental setup. Adjust the rheostat for maximum and auto transformer to the position of zero output and switch on power supply
2. Adjust voltage across the circuit for total as 100 V. Note the I_L, V_L, V_R, V_{rL}
3. Adjust the value of input voltage while keeping the value of Rheostat constant and repeat above steps.
4. compare the value of phase angle as obtained from the meter readings and form phasor diagram.

Result:-

The current and voltage distribution for the given experimental circuit was obtained and conventially represented in the phasor diagram and also power and power factor was calculated for different measured value

1 case ③ :- $V_L = 200$, $I_L = 0.4$, $V_R = 55.2$, $V_{rl} = 174.5$

$$(V_L)^2 = (V_R)^2 + (V_{rL})^2 + 2 V_R V_{rl} \cos\phi$$

$$(200)^2 = (55.2)^2 + (174.5)^2 + 2 \times 55.2 \times 174.5 \cos\phi$$

$$\cos\phi = 0.3375$$

$$\phi = \cos^{-1}(0.3375) = 70.27^\circ$$

$$\text{power} = V_{rl} I_L \cos\phi$$

$$= 174.5 \times 0.4 \times 0.3375 = 23.5575 W$$

2 case ④ :- $V_L = 220$, $I_L = 0.4$, $V_R = 58.2$, $V_{rl} = 182$

$$(V_L)^2 = (V_R)^2 + (V_{rL})^2 + 2 V_R V_{rL} \cos\phi$$

$$(220)^2 = (58.2)^2 + (182)^2 + 2 \times 58.2 \times 182 \cos\phi$$

$$\cos\phi = 0.5611$$

$$\phi = \cos^{-1}(0.5611) = 55.86^\circ$$

$$\text{power} = V_{rL} I_L \cos\phi$$

$$= 182 \times 0.4 \times 0.5611 = 40.84 W$$

3 case ⑤ :- $V_L = 240$, $I_L = 0.5$, $V_R = 64$, $V_{rl} = 200$

$$(240)^2 = (64)^2 + (200)^2 + 2 \times 64 \times 200 \times \cos\phi$$

$$\cos\phi = 0.5275$$

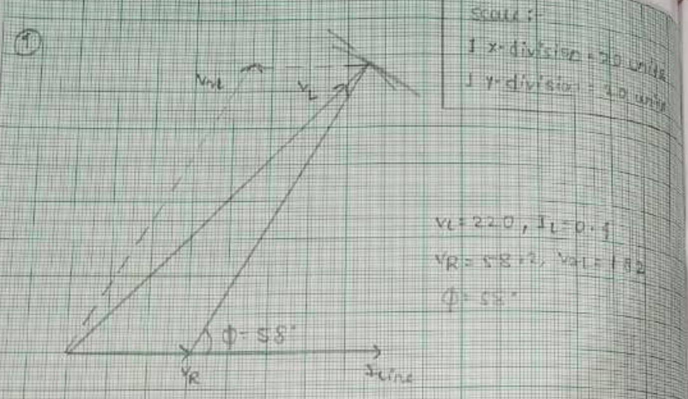
$$\phi = \cos^{-1}(0.5275)$$

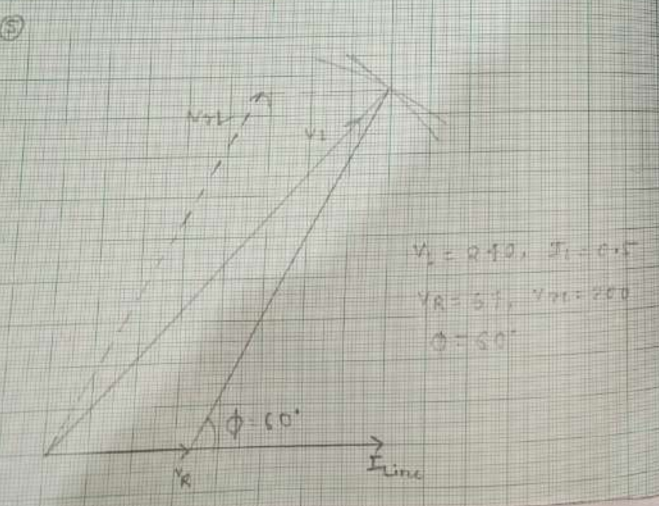
$$= 58.16^\circ$$

$$\text{power} = V_{rL} I_L \cos\phi$$

$$= 200 \times 0.5 \times 0.5275$$

$$= 52.75 W$$





precautions:-

1. The transformer voltage shoued be increased in small steps
2. Don't switch the main suppy on while assembling the circuit
3. The zero error of the voltmeter and ammeter shoud be checked before starting the experiment.
4. Don't wear any metallic articles while performing the experiment.

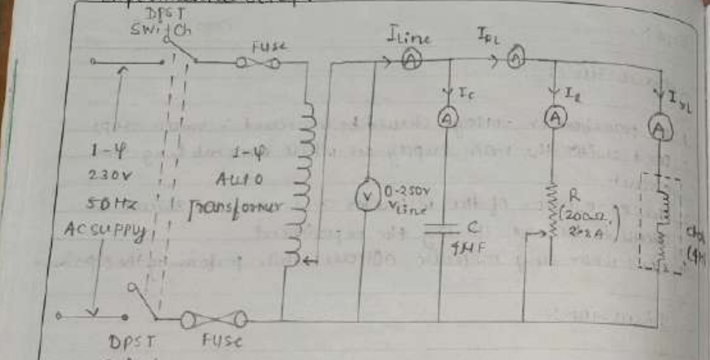
Discussion:-

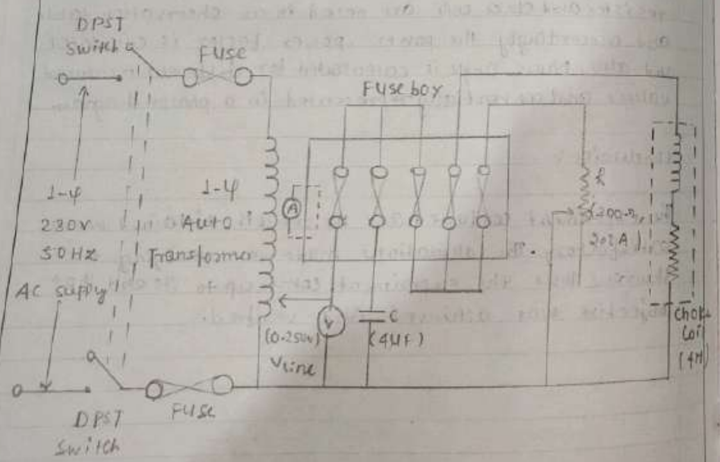
For the given experimental circuit, the voltage across resistor and choke coil are noted in an observation table and accordingly the power, power factor is calculated and also phase angle is calculated for different measured values and conventially represented in a phasor diagram.

conclusion:-

The experiment conducted and the results obtained were satisfactory. The calculations made were verifying the theorems thus the experiment come up to its end that objective was achieved and verified.

Experimental setup:-





Date 21/03/22

Expt. No. 3. (i) AC R-L-C parallel circuit :- Page No. 26

Aim of the experiment :-

(a) To obtain the current and voltage distribution in AC R-L-C parallel circuit.

(b) To draw the phasor diagram

Apparatus required :-

Sl. no.	Apparatus	Specification
1	Auto Transformer	1-phase, output - (0-270V), Input - 230 V
2.	Rheostat	200 Ω, 2.8 A
3.	Choke coil	4 H
4.	capacitor	4 μF
5.	AC Ammeter	0-3A, 0-1 A, 0-10 A
6	AC voltmeter	0-250 V

Theory:-

The basic V-I relationship of resistance, inductance and capacitance are given by

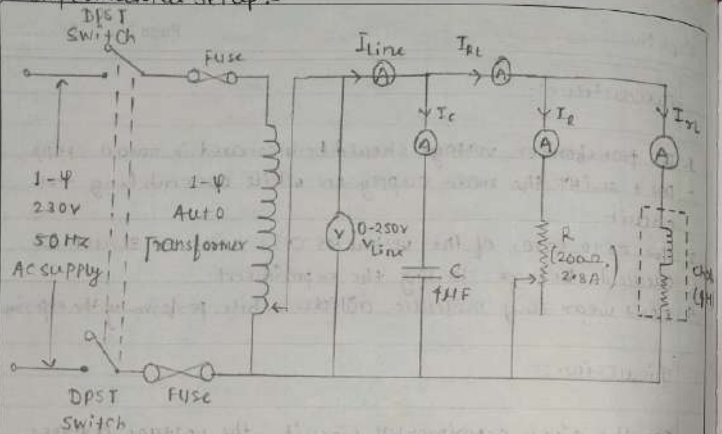
i) $I_R = V_R/R$

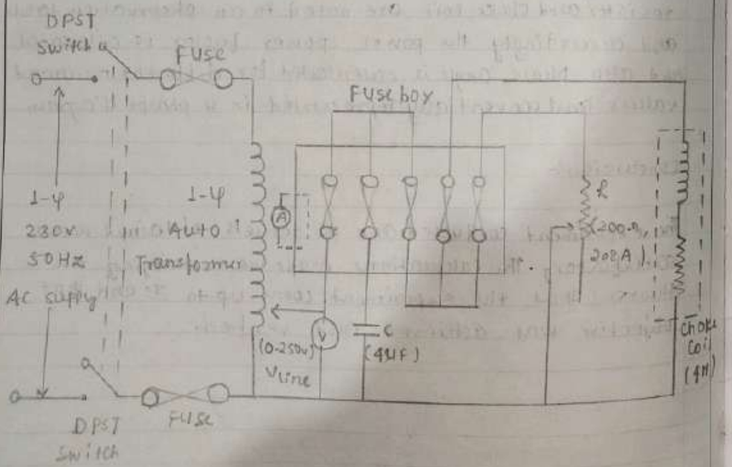
ii) $I_L = (1/L)\int V_L\,dt$

iii) $I_C = C\,dV_C/dt$

Teacher's Signature :

Experimental setup:-





Date 21/09/22

Expt. No. 3. (i) AC R-L-C parallel circuit :- Page No. 26

Aim of the experiment :-

(a) To obtain the current and voltage distribution in AC R-L-C parallel circuit.

(b) To draw the phasor diagram

Apparatus required :-

Sl. No.	Apparatus	Specification
1.	Auto Transformer	1-phase, output - (0-270V), Input - 230 V
2.	Rheostat	200 Ω, 2.8 A
3.	Choke coil	4 H
4.	Capacitor	4 μF
5.	AC Ammeter	0-3A, 0-1A, 0-10A
6.	AC voltmeter	0-250V

Theory:-

The basic V-I relationship of resistance, inductance and capacitance are given by

i) $I_R = V_R / R$

ii) $I_L = (1/L) \int V_L \, dt$

iii) $I_C = C \, dV_C / dt$

Teacher's Signature :

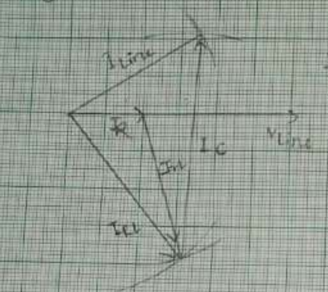
Observation table:-

S. No.	V_{Line}	I_{Line}	I_R	I_{r1}	I_{RL}	I_c
1.	100	0.4	0.2	0.4	0.5	0.6
2.	110	0.5	0.2	0.4	0.5	0.6
3.	140	0.57	0.36	0.58	0.72	0.8
4.	160	0.67	0.40	0.64	0.86	0.96
5.	180	0.74	0.47	0.78	0.98	1.0

(1)

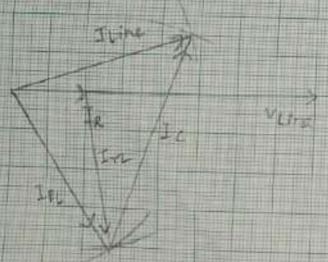
Scale :-

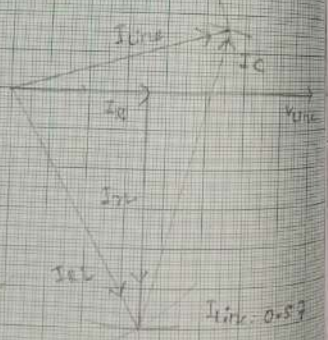
1 x-division = 0.1 units
1 y-division = 0.1 units



$I_{Line} = 0.4$
$I_R = 0.2$
$I_{RL} = 0.4$
$I_{RL} = 0.5$
$I_C = 0.6$

(2)





$I_{Line} = 0.5$
$I_R = 0.2$
$I_{RL} = 0.4$
$I_{RL} = 0.6$
$I_C = 0.6$

$I_{Line} = 0.57$
$I_R = 0.36$
$I_{RL} = 0.48$
$I_{RL} = 0.72$
$I_C = 0.8$

And when the voltage across each element is $v = V_m \sin\omega t$, the currents are given by

$I_R = (1/R)\, V_m \sin\omega t$
$I_L = (1/\omega L)\, V_m \cos\omega t$
$I_C = \omega C\, V_m \sin(\omega t + 90^\circ)$

It can be concluded that, the current in a resistance is in phase with the voltage across it, the current in inductance lags the voltage by 90° and the current in a capacitance leads by 90°. The phase relationship can be conventionally expressed in a phasor diagram

procedure :-

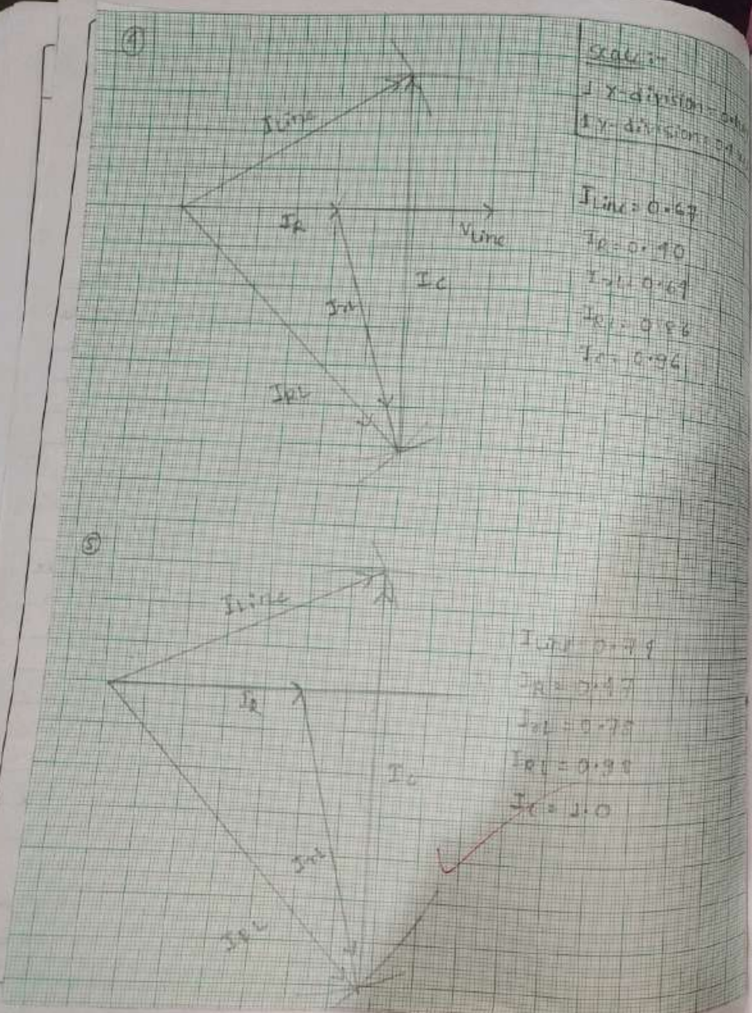
1. connect circuit as shown in the experimental setup. Adjust the rheostat for maximum and auto transformer to position of zero output and switch on power supply.

2. Adjust voltage across the circuit and note down I_{Line}, I_R, I_{RL}, I_{R1} and I_C

3. Adjust the value of input voltage while keeping the value of Rheostat constant. Repeat above steps.

4. compare the value of phase angle as obtained from the meter readings and from phasor diagram.

Teacher's Signature : ....



Result :-

The current and voltage distribution for the AC R-L-C parallel circuit was obtained and conventially represented in the phasor diagram.

precautions :-

1. The transformer voltage should be increased in small steps.
2. Don't switch the main supply on while assembling the circuit.
3. The zero error of the voltmeter and Ammeter should be checked before starting the experiment.
4. Don't wear any metallic articles while performing the experiment.

Discussion:-

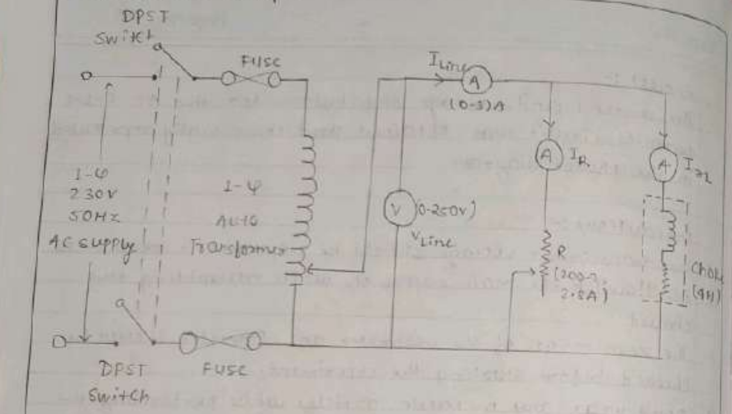
For AC RLC parallel circuit, the current voltage across resistor, inductor and capacitor are noted in an observation table and phase angle is calculated for different measured values and conventinally represented in the phasor diagram.

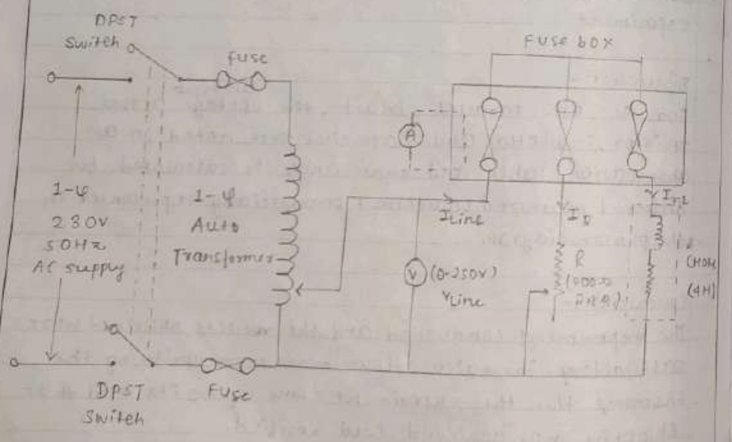
Conclusion :-

The experiment conducted and the results obtained were satisfactory. The calculations made were verifying the theorems thus the experiment come up to its end that objective was achieved and verified.

Teacher's Signature

Experimental setup:-





Expt. No. 3(ii) **3- Ammeter method:-** Date: 21/02/22 Page No. 23

Aim of the experiment:-

(a) To measure the power and power factor of a single phase load by 3 ammeter method.

(b) To draw phasor diagram

Apparatus required:-

S. No.	Apparatus	Specification
1.	Auto Transformer	1-phase, output (0-270V), Input (230V)
2.	Rheostat	200-Ω, 2.8A
3.	Choke coil	4H
4.	AC Ammeter	~~4 of~~ 0-3 A, ~~0-1 A~~, 0-10 A
5.	AC voltmeter	0-250 V

Theory:-

A unknown resistance is connected in parallel to the choke and the line current in the resistance give the supply voltage. The vector diagram can be calculated and power and power factor can be calculated.

Teacher's Signature:

Observation table :-

S. NO.	V_L	I_L	I_R	I_{rL}
1.	100	0.52	0.26	0.42
2.	120	0.63	0.31	0.51
3.	140	0.74	0.37	0.59
4.	160	0.85	0.42	0.69
5.	180	0.97	0.46	0.78

calculations :-

case ① :- $I_L = 0.52$, $I_R = 0.26$, $I_{rL} = 0.42$

As we know,

$$I_L^2 = I_R^2 + I_{rL}^2 + 2 I_R I_{rL} \cos\phi$$

$$(0.52)^2 = (0.26)^2 + (0.42)^2 + 2\times0.26\times0.42 \cos\phi$$

$$\cos\phi = 0.1208$$

$$\phi = \cos^{-1}(0.1208) = 83.06^\circ$$

$$\text{power} = V_L I_{rl} \cos\phi = 100\times0.42\times0.1208$$

$$= 5.0736 \text{ W}$$

case② :- $I_L = 0.63$, $I_R = 0.31$, $I_{rL} = 0.51$

$$I^2_L = I^2_R + I^2_{rL} + 2 I_R I_{rL} \cos\phi$$

$$(0.63)^2 = (0.31)^2 + (0.51)^2 + 2\times0.31\times0.51 \cos\phi$$

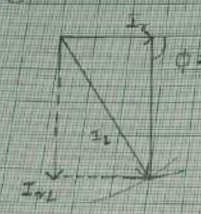
$$\cos\phi = 0.4070 = 65.98^\circ$$

$$\text{power} = V_L I_{rl} \cos\phi = 120\times0.51\times0.4070$$

$$= 24.90 \text{ W}$$

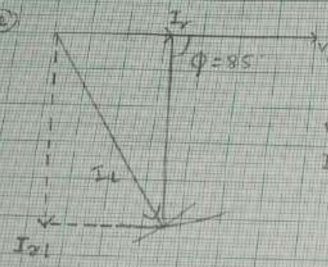
Scale :-
1 x-division = 0.1 unit
1 y-division = 0.1 unit

(1)



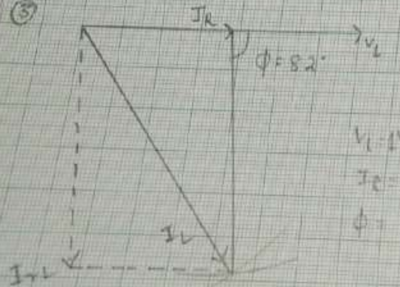
$V_L = 100$, $I_L = 0.42$
$I_R = 0.26$, $I_{rL} = 0.42$
$\phi = 83°$

(2)



$V_L = 120$, $I_L = 0.63$
$I_R = 0.31$, $I_{rL} = 0.51$
$\phi = 85°$

(3)



$V_L = 140$, $I_L = 0.74$
$I_R = 0.37$, $I_{rL} = 0.53$
$\phi = 82°$

Expt. No. .... Date ....

procedure :

1. connect circuit as shown in the experimental setup. Adjust the rheostat for maximum and auto transformer to the position of zero output and switch on power supply.

2. Adjust the voltage across the circuit and note down the value of I_L, I_R, I_{rL}.

3. Adjust the value of input voltage while keeping the value of Rheostat constant and repeat above steps.

4. compare the value of phase angle as obtained from the meter readings and form phasor diagram

Result :-

The current and voltage distribution for the given experimental circuit was obtained and conventionally represented in the phasor diagram and also power and power factor was calculated for different measured value.

① case ③ :- $I_L = 0.74$, $I_R = 0.37$, $I_{rL} = 0.59$

$$I_L^2 = I_R^2 + I_{rL}^2 + 2 I_r I_{rL} \cos\phi$$

$$\cos\phi = \frac{I_L^2 - I_R^2 - I_{rL}^2}{2 I_r I_{rL}} = 0.14338$$

$$\phi = \cos^{-1}(0.14338) = 81.75^\circ$$

$$\text{power} = V_L I_{rL} \cos\phi$$

$$= 140 \times 0.59 \times 0.1433 = 11.83 \text{ W}$$

② case ④ :- $I_L = 0.85$, $I_R = 0.42$, $I_{rL} = 0.69$

$$I_L^2 = I_R^2 + I_{rL}^2 + 2 I_r I_{rL} \cos\phi$$

$$(0.85)^2 = (0.42)^2 + (0.69)^2 + 2 \times 0.42 \times 0.69 \cos\phi$$

$$\cos\phi = 0.1207$$

$$\phi = \cos^{-1}(0.1207) = 83.06^\circ$$

$$\text{power} = V_L I_{rL} \cos\phi = 160 \times 0.69 \times 0.1207$$

$$= 13.32 \text{ W}$$

③ case ⑤ :- $I_L = 0.97$, $I_R = 0.46$, $I_{rL} = 0.78$

$$I_L^2 = I_R^2 + I_{rL}^2 + 2 I_r I_{rL} \cos\phi$$

$$(0.97)^2 = (0.46)^2 + (0.78)^2 + 2 \times 0.46 \times 0.78 \cos\phi$$

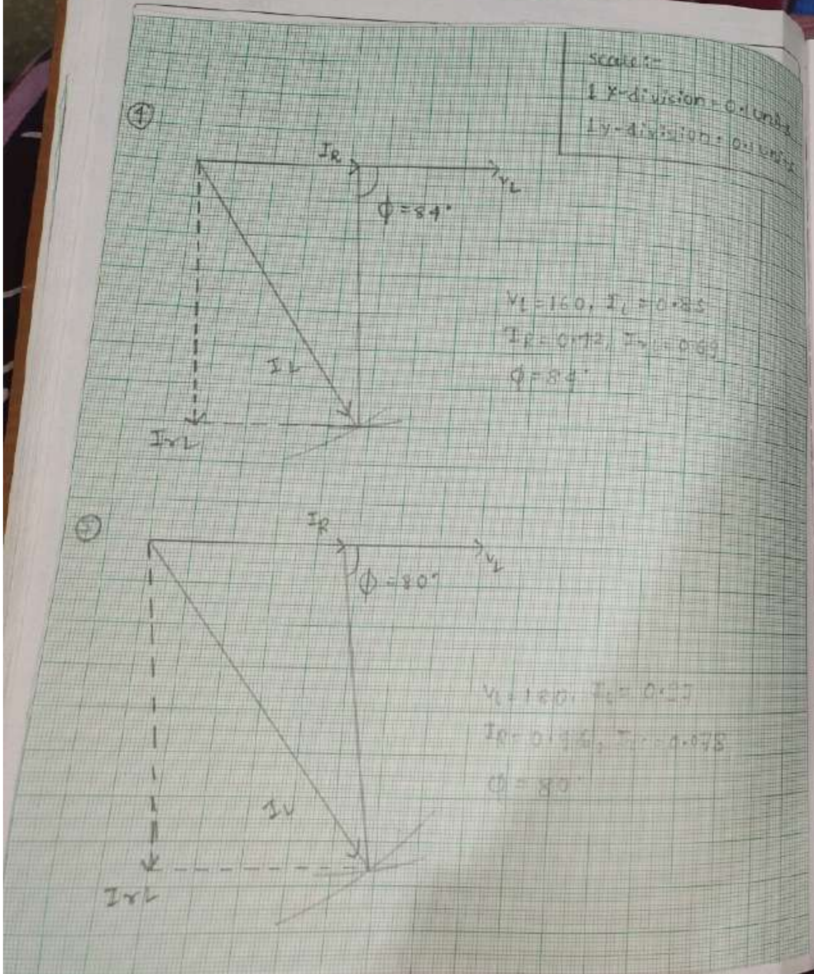
$$\cos\phi = 0.1684$$

$$\phi = \cos^{-1}(0.1684) = 80.30^\circ$$

$$\text{power} = V_L I_{rL} \cos\phi$$

$$= 180 \times 0.78 \times 0.1684$$

$$= 23.64 \text{ W}$$



precautions:-

1. The transformer voltage should be increased in small steps.
2. Don't switch the main supply on while assembling the circuit.
3. The zero error of the voltmeter and ammeter should be checked before starting the experiment.
4. Don't wear any metallic articles while performing the experiment.

Discussion:-

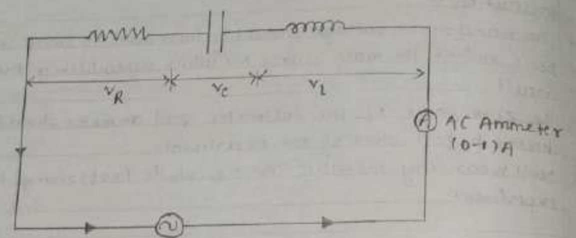
For the given experimental circuit, the current, voltage across resistor and choke coil are noted in an observation table and accordingly the power, power factor is calculated and also phase angle is calculated for different measured values and conventially represented in a phasor diagram.

Conclusion:-

The experiment conducted and the results obtained were satisfactory. The calculations made were verifying the theorems thus the experiment come up to its end that objective was achieved and verified.

Teacher's Signature : ____________

Circuit setup:-



Sine wave generator
(0·14)V, (0-26)MHz

Observation table :-

S. No.	f(KHz)	I(mA)	V_L(V)	V_C(V)	V_R(V)	V_S(V)
1.	0·507	02	0·141	6·491	0·230	6·321
2.	1·02	07	0·609	6·56	0·483	6·288
3.	1·50	11	1·541	7·63	0·779	6·244
4.	2·04	17	3·581	9·24	1·275	6·054
5.	2·50	22	6·91	11·50	1·950	5·626
6.	3·02	30	12·13	13·18	2·682	4·768
7.	3·55	27	12·10	9·53	2·357	4·905
8.	4·01	24	10·89	6·99	1·883	5·168
9.	4·50	19	9·28	4·99	1·481	5·254
10.	5·02	17	8·03	3·62	1·132	5·196
11.	5·55	15	7·14	2·66	0·90	5·06

STUDY OF RESONANCE IN RLC SERIES CIRCUIT :-

Aim of the experiment :-

(a) To find the condition of resonance in a RLC series circuit.

(b) Draw the different phasor diagram.

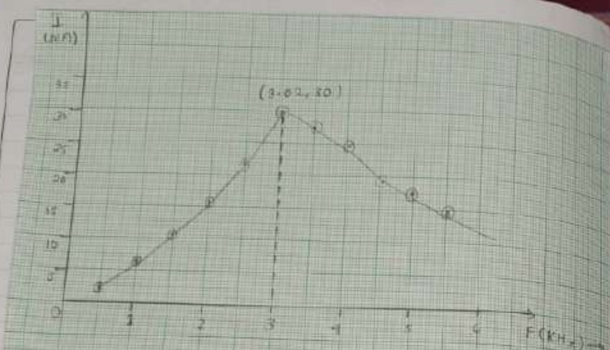
Apparatus required:-

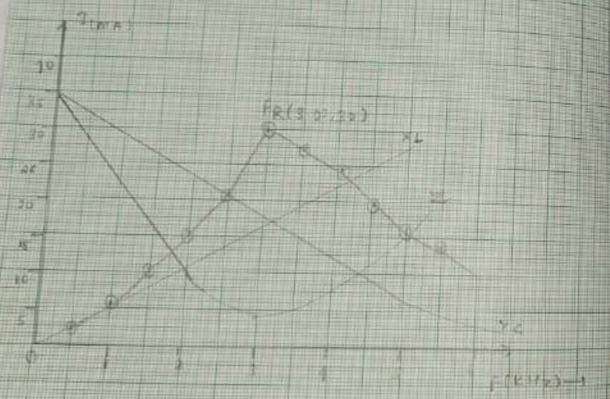
S. No.	Apparatus	Specification	Quantity
1.	AC Ammeter	(0-1) A	1
2.	AC voltmeter	(0-25) V	1
3.	Sine wave generator	(0-26) MHz	1
4.	Connecting wires		

Theory:-

When a sinusoidal potential of varying frequency is applied to RLC series circuit, the response (current) is maximum at a particular frequency. This frequency is known as resonant frequency.

First we review the mathematical description of the behavior of the R-L-C circuit when connected to a sinusoidal signal. Since current is the same at all





points in the series R-L-C circuit, we write.

$I = I_0 \sin\omega t$ where $\omega = 2\pi$

The voltage across each component are then

$V_R = IR$

$V_L = IX_L$

and $V_C = IX_C$

The phase angle between the supply voltage and the current is zero at resonance. This phase angle is given by Φ.

$$\tan\Phi = (\omega L - 1/\omega C)/R$$

and the resonant frequency is given by,

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

At resonance, the conditions are:

1. $X_L = X_C$
2. current is maximum
3. Impedance is minimum

procedure:-

① Observe the circuit connections and make connections as shown in the diagram.

② The multimeter is used as a voltmeter to measure the potential difference across different elements.

③ Now for different frequencies from the sine wave generator, potential difference and current are measured.

④ Ammeter is used to measure the current.

⑤ The frequency is kept on varying and the potential difference and current across the elements are measured.

calculations:-

Before resonance:-

$$v = \left((V_R)^2 + (V_C - V_L)^2\right)^{1/2}$$
$$= \left((1.950)^2 + (11.50 - 6.91)^2\right)^{1/2}$$
$$= (3.8025 + 21.0681)^{1/2} = \sqrt{24.8706} = 4.98V$$

After resonance:-

$$V = \left((V_R)^2 + (V_L - V_C)^2\right)^{1/2}$$
$$= \left((2.357)^2 + (12.40 - 9.53^2)\right)^{1/2}$$
$$= (5.593 + 34.45) = \sqrt{40.0069} = 6.32\ V$$

At Resonance:-

$$V = \left((V_R)^2 + (V_L - V_C)^2\right)^{1/2}$$
$$= \left((2.682)^2 + (13.18 - 12.13)^2\right)^{1/2}$$
$$= (7.193 + 1.1025)^{1/2} = 2.88V$$

Teacher's Signature :

Before resonance.

$$x_L = wL = 2\pi f L = \frac{V_L}{I} = \frac{6.91}{22}$$

$$x_C = \frac{1}{wC} = \frac{V_C}{I} = \frac{11.50}{22}$$

At resonance :-

$$x_L = x_C$$

Result :-

At resonance $x_L = x_C$

Frequency at resonance = 3.02 kHz

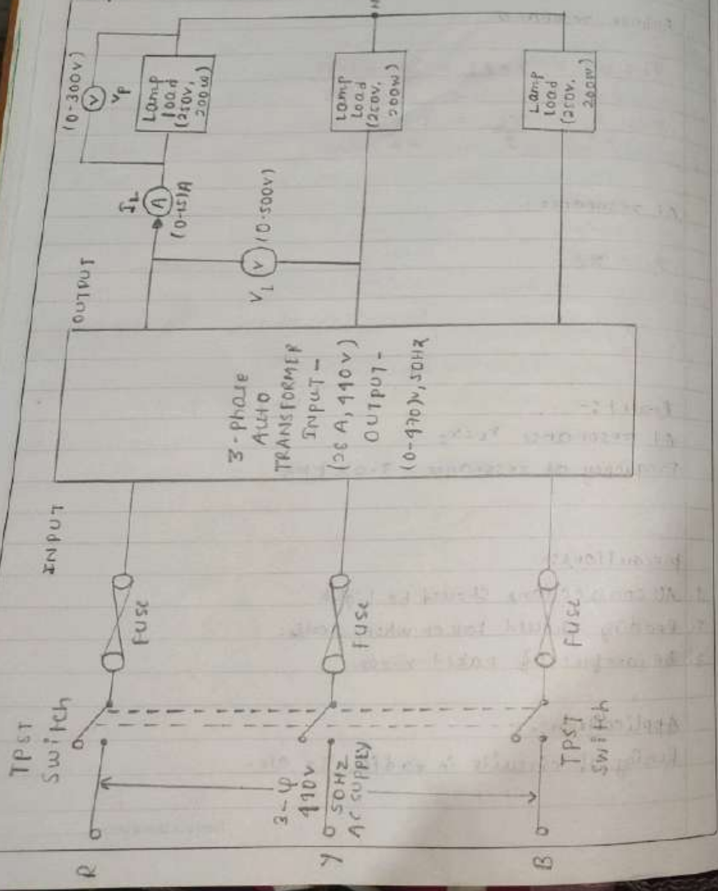
precautions:-

1. All connections should be tight
2. Reading should taken when stable.
3. Be careful Of naked wires.

Application:-

Tuning of circuits in radio, TV etc.

Experimental circuit diagram :-



THREE PHASE STAR CONNECTED LOAD :-

Objective of the experiment:-

1. To obtain the relationship between line and phase quantity in 3-phase star connection
2. To obtain the phasor diagram.

Apparatus required :-

S. No.	Apparatus	Specification	Quantity
1.	3-phase auto transformer	Input : 28A, 440V. Output (0-470)V, 50HZ	1
2.	AC voltmeter	(0-300)V, (0-500)V	1
3.	AC voltmeter	(0-300)V, (0-500)V	1
4.	AC Ammeter	(0-10)A	1
5.	Lamp load	3-phase (250V, 200W)	1
6.	connecting wires	—	—

Theory:-

A set of three sinusoidal voltages that is equal in magnitude but has a progressive phase difference of $2\pi/3$ (120°) constitutes a balanced three voltage system. In instantaneous form, these voltages (known as phase voltages and are w.r.t the neutral)

Observation table :-

S.NO.	I_L	V_P	V_L	V_L/V_P
1.	2.1	200	355	1.77
2.	2.0	180	320	1.77
3.	1.9	160	285	1.78
4.	1.8	140	245	1.75
5.	1.6	120	215	1.78

calculations :-

$$\text{Average} = \frac{1.77+1.77+1.78+1.75+1.78}{5}$$

$$= 1.77$$

$$\% \text{ error} = \frac{1.77-1.732}{1.77} \times 100\%$$

$$= 2.2\%$$

are considered as reference and expressed as-

$V_R = V_m \sin\omega t$ ......(i)

$V_Y = V_m \sin(\omega t-120°)$ ......(ii)

$V_B = V_m \sin(\omega t+120°)$ ......(iii)

From the phasor diagram, when identical loads are connected in star to the 3-phase supply, the line currents and the phase currents are same but line voltages are given by :

$V_{RY} = V_R - V_Y = \sqrt{3}\, V_m \sin(\omega t+30°)$ ......(iv)

$V_{YB} = V_Y - V_B = \sqrt{3}\, V_m \sin(\omega t+30°-120°)$ ......(v)

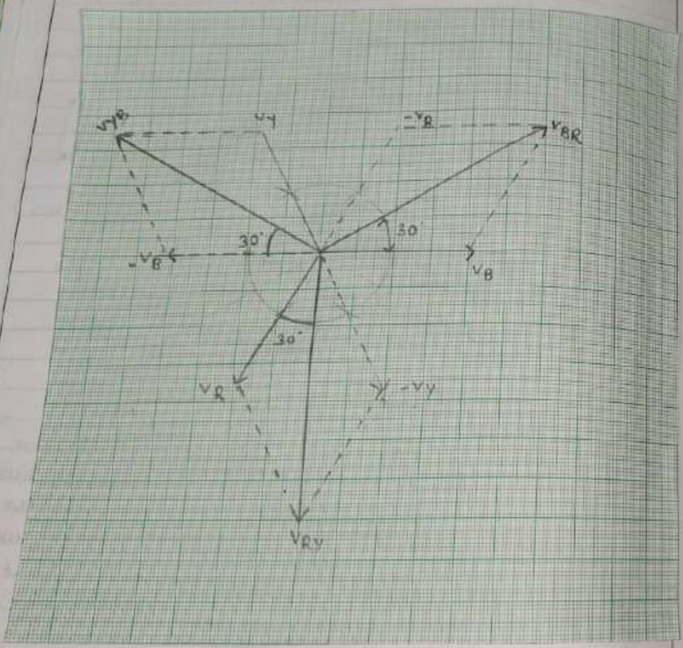
$V_{BR} = V_B - V_R = \sqrt{3}\, V_m \sin(\omega t+30°+120°)$ ......(vi)

and $V_L^2 = V_P^2 + V_P^2 + V_P^2 \cos 60°$

$V_L^2 = 3V_P^2$

$V_L = \sqrt{3}\, V_P$ ......(vii)

Where V_m is the maximum voltage. Thus, the line current and the phase current are same in star but line voltage is $\sqrt{3}$ times the phase voltages leads the reference phase voltage by 30°. The vector sum of the balanced three phase voltages is zero at all times



Expt. No. .... Date ....

Procedure :-

1. Connect circuit as shown in the experimental setup.

2. By using 3-φ phase auto Transformer fixed V_L at a particular value and take reading of V_P and I_L with respect to that particular value of V_L.

3. Gradually increase input voltage using 3-phase auto transformer and note down the value of V_L, I_L, V_P and calculate V_L / V_P.

4. Tabulate all the measured values.

5. Graphically plot all the measured quantities in a phasor relationship.

Result :-

From the observation table and the experiment, the value of $\frac{V_L}{V_P}$ was found to be nearly 1.732.

Precautions:-

1. The transformer voltage should be increased in small steps
2. Don't switch ON the main supply while assembling the circuit
3. Don't wear any metallic articles while performing the experiment.

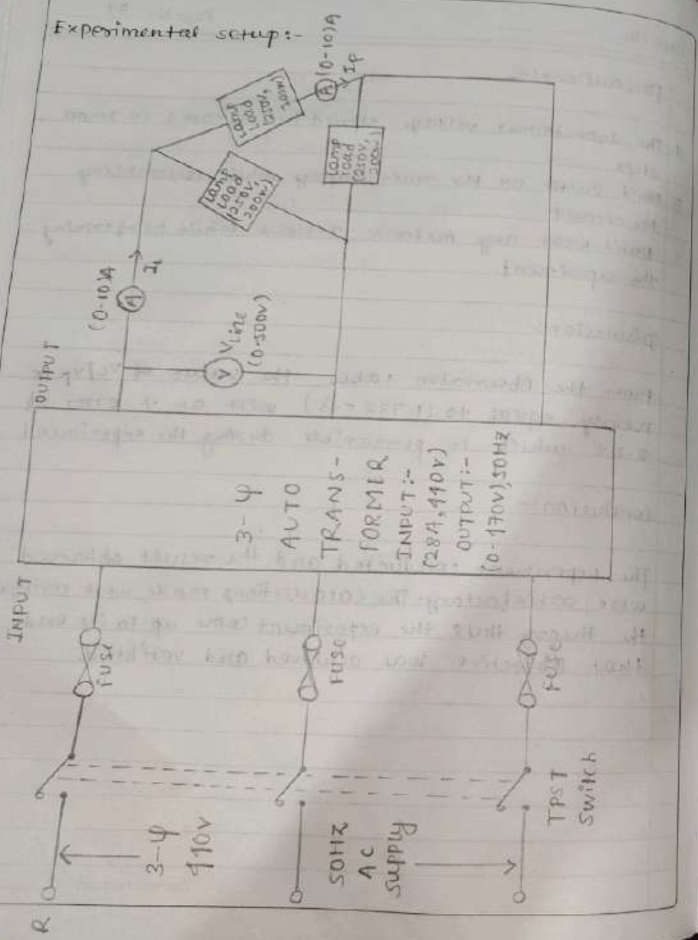
Discussion:-

From the observation table the value of V_L/V_P is nearly equal to $(1.732 = \sqrt{3})$ with an % error of 2.2% which is permissible during the experiment.

Conclusion:-

The experiment conducted and the result obtained were satisfactory. The calculations made were verifying the theory thus the experiment come up to its end that objective was achieved and verified.

Experimental setup:-



Expt. No. 6 Date ....

THREE PHASE DELTA CONNECTED LOAD :

Objective:-

(A) To obtain the relation between line and phase quantity in 3 phase delta connection

(B) To obtain the phasor diagram.

Apparatus required:-

S. NO	Apparatus	Specification	Quantity
1.	Auto Transformer	3 Phase Input : 28 A, 440 V Output : (0-470V, 50HZ)	1
2.	Voltmeter	(0-500)V, A.C.	1
3.	Ammeter	(0-7.5)A, A.C.	1
		(0-15)A, A.C.	1
4	Lampload	3 phase, 250V, 200W	1

Theory:-

A balanced system of 3-phase voltages had the property that their voltages are same but differing in phase from one another by 120°.

Teacher's Signature : ________

Observation table:-

S.No	I_L	I_p	V_L	I_L/I_p
1.	3.1	1.8	150	1.72
2.	3.4	1.9	170	1.78
3.	3.5	2.0	200	1.75
4.	3.6	2.1	210	1.71
5.	3.7	2.2	220	1.76

Calculations:-

$$\text{Average} = \frac{1.72 + 1.78 + 1.75 + 1.71 + 1.76}{5}$$

$$= 1.744$$

$$\%\ \text{error} = \frac{1.744 - 1.732}{1.744} \times 100\ \%$$

$$= 0.68\ \%$$

Date ....

Expt. No. .... Page No. 41

$$I_{RY} = I_m \sin(\omega t)$$
$$I_{YB} = I_m \sin(\omega t - 120^\circ)$$
$$I_{BR} = I_m \sin(\omega t + 120^\circ)$$

when identical loads are connected in delta to the 3-phase supply, the line voltage and phase voltage are same but the line currents are given by:

$$I_R = \sqrt{3}\ I_m (\sin(\omega t - 30^\circ))$$
$$I_Y = \sqrt{3}\ I_m \sin(\omega t - 30^\circ - 120^\circ)$$
$$I_B = \sqrt{3}\ I_m \sin(\omega t - 30^\circ + 120^\circ)$$

Thus the line voltages and the phase voltages are same in delta but line current is $\sqrt{3}$ times of phase current.

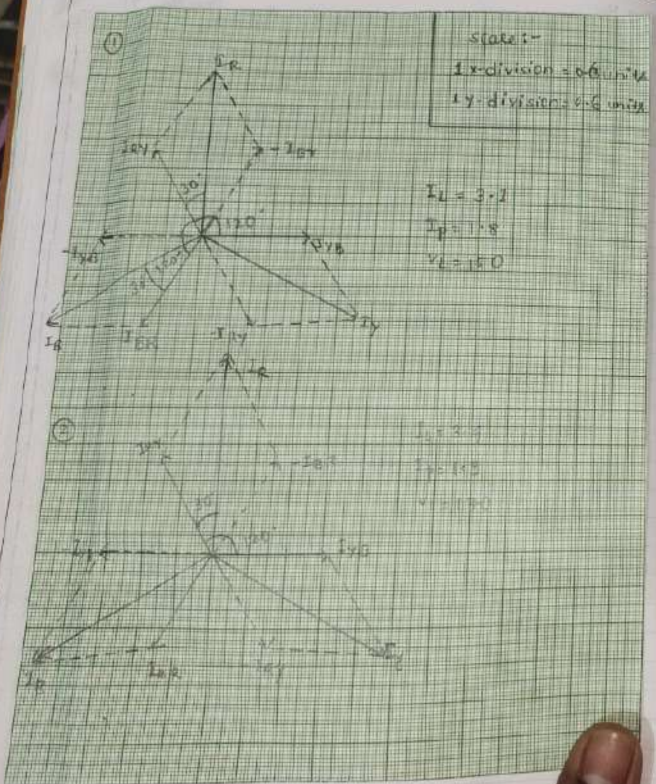
procedure:-

1. connect circuit as shown in the experimental setup.

2. By using 3-ϕ auto transformer fixed V_L at a particular value and take reading of I_p and I_L with respect to that particular value of V_L.

3. Gradually increase input voltage using 3-phase auto transformer and note down the value of I_L, I_p and V_L and accordingly calculate I_L/I_p

Teacher's Signature : ....



Expt. No. .... Date ....
Page No. 12

4. Tabulate all the measured values.

5. Graphically plot all the measured quantities in a phasor relationship

Result :-

From the observation table and the experiment the value of I_L / I_p is found to be nearly equal to 1.732.

precautions :-

1. The transformer voltage should be increased in small steps

2. Don't switch ON the main supply while assembling the circuit

3. Don't wear any metallic articles while performing the experiment.

4. connect the circuit as per the experimental setup.

Teacher's Signature : ....

Expt. No.

Date

Conclusion:-

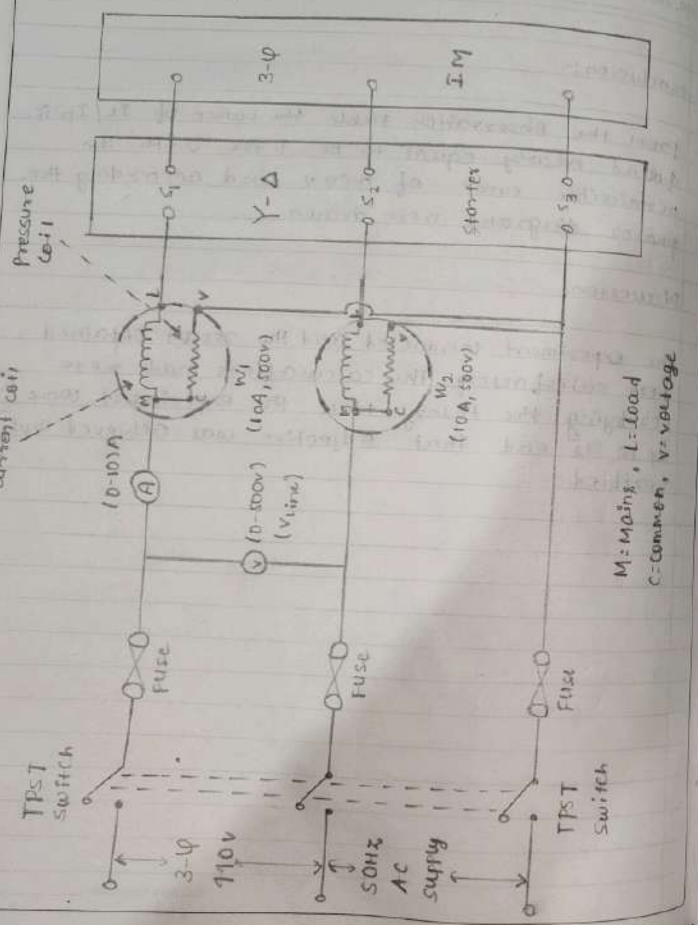
From the observation table the value of I_L/I_p is found nearly equal to be 1.732 with an permissible error of 0.68% and according the phasor diagrams were drawn.

Discussion:-

The experiment conducted and the result obtained were satisfactory. The calculations made were verifying the theory thus the experiment come up to its end that objective was achieved and verified.

Teacher's Signature :

Experimental setup:-



Measurement of Three phase power :-

Objective:-

1. To measure power input of 3-phase induction motor using 2-wattmeter method.
2. Draw phasor diagrams for the observations.

Apparatus required:-

S. No.	COMPONENTS	SPECIFICATIONS	QUANTITY
1.	A.C. wattmeter	10 A, 500V	2
2.	A.C. Ammeter	0-10A	1
3.	A.C. voltmeter	0-500 V	1
4.	3 phase induction motor	4.75A, 50HZ, 110V	1

Theory:-

A wattmeter is essentially an inherent combination of an ammeter and a voltmeter and therefore, consists of two coils known as current coil and pressure coil. It gives true power (active power) in the three phase circuit.

Teacher's Signature :

Observation table :-

$V_L = 395$ V

	I	W_1 (×4)	W_2 (×4)	ϕ	Power (W_1+W_2)	Power $\sqrt{3}V_LI_L\cos\phi$
1.	2.4	140	0	59.53	560	820
2.	3.2	280	10	57.67	1160	1153.99
3.	3.4	320	20	56.50	1360	1283.88
4.	3.8	360	50	52.06	1640	1598.45
5.	4.2	420	100	46.12	2080	1891.71
6.	4.4	460	120	44.71	2320	2139.35
–						
7.	2.4	160	-100	-81.67	240	289.01

Calculations:-

(1) $\phi = \tan^{-1}\left(\frac{\sqrt{3}(W_1 - W_2)}{(W_1 + W_2)}\right)$

$= \tan^{-1}\left(\frac{\sqrt{3}\times 140}{140}\right)$

$= 60°$

power $= W_1 + W_2$

$= 140 \times 4 + 0$

$= 560$

power $= \sqrt{3} V_L I_L \cos\phi$

$= \sqrt{3} \times 395 \times 2.4 \times \cos(59.53)$

$= 820$

% error $= \frac{820 - 560}{820}$

$= 4.6\%$

Expt. No.............. Date ....

FOR STAR CONNECTION, suppose the reading of the first wattmeter be W_1 and that of the second wattmeter is W_2. From vector diagram, we have,

$W_1 = I_R \times V_{RB} \cos(30 - \phi)$

$W_2 = I_Y \times V_{YB} \cos(30 + \phi)$

where $I_R = I_Y = I_B = I_L$ (Line current)

$V_{RB} = V_{YB} = V_{BY} = V_L$ (Line voltage)

$V_{YB} = V_Y - V_B$ and $V_{RB} = V_R - V_B$

So,

$W_1 = V_L I_L \cos(30 - \phi)$

$W_2 = V_L I_L \cos(30 + \phi)$

$W = W_1 + W_2$ (total power in the 3-phase load)

$= \sqrt{3} V_L I_L \cos\phi$

$W_1 - W_2 = V_L I_L \sin\phi$

$\tan\phi = \frac{(\sqrt{5}(W_1 - W_2))}{(W_1 + W_2)}$

If W_2 reading is taken after reversing the pressure coil, then W_2 is negative hence the relation between $\tan\phi = -(\sqrt{3}(W_1 - W_2))/(W_1 + W_2)$

Multiplying factor for wattmeter = $(VI\cos\phi)$/(Full scale reading)

It is used for accurate reading because induction motor uses high ampere.

Teacher's Signature : ____________

② $\phi = \tan^{-1}\left(\frac{\sqrt{3} \times (270)}{(290)}\right)$

$= 58.19^\circ$

power $= 280 \times 4 + 10 \times 4$

$= 1120 + 40$

$= 1160$

power $= \sqrt{3}\ V_L I_L \cos\phi$

$= \sqrt{3} \times 395 \times 3.2 \times \cos(58.19$

$= 1153.99$

% error $= \frac{1160 - 1153.99}{1160}$

$= 0.5\%$

③ $\phi = \tan^{-1}\left(\frac{\sqrt{3} \times (300)}{340}\right)$

$= 56.50^\circ$

power $= w_1 + w_2$

$= 320 \times 4 + 20 \times 4$

$= 1280 + 80$

$= 1360$

power $= \sqrt{3}\ V_L I_L \cos\phi$

$= \sqrt{3} \times 395 \times 3.4 \times \cos(56.50$

$= 1283.88$

% error $= \frac{1360 - 1283.88}{1360}$

$= 0.5\%$

④ $\phi = \tan^{-1}\left(\frac{\sqrt{3} \times 310}{410}\right)$

$= 52.06^\circ$

power $= w_1 + w_2$

$= 360 \times 4 + 50 \times 4$

$= 1440 + 200$

$= 1640$

power $= \sqrt{3} \times V_L I_L \cos\phi$

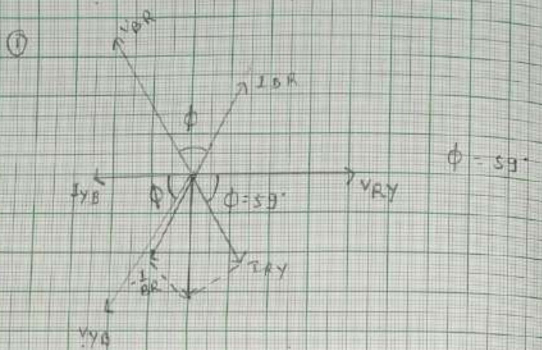
$= \sqrt{3} \times 395 \times 3.8 \cos(52.0$

$= 1598.45$

% error $= \frac{1640 - 1598.45}{1640}$

$= 2.5\%$

1



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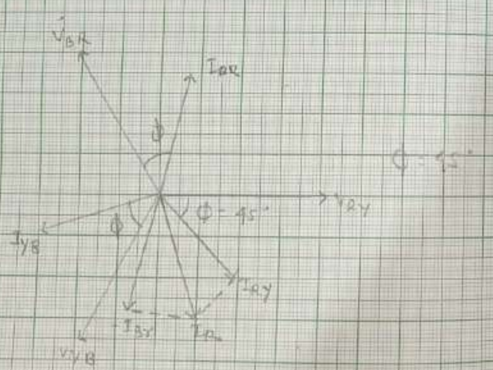


procedure:-

1. Make the connection as per the circuit diagram shown in figure

2 with the auto-Transformer in minimum position. switch ON the suppy

3. For balanced load conditions measured the values of wattmeters, ammeters and voltmeters.

4. switch off all the loads and supply after performing the experiment.

Resuet:-

wattmeter readings were found to be 560, 1160, 1360, 1640, 2080, 2320 and 240 for different values of current and voltages and according phasor is drawn.

(5) $\phi = \tan^{-1}\left(\frac{\sqrt{3} \times 320}{520}\right)$

$= 46.12'$

power = $W_1 + W_2$

$= 420 \times 4 + 100 \times 4$

$= 2080$

(6) $\phi = \tan^{-1}\left(\frac{\sqrt{3} \times 340}{580}\right)$

$= 44.71'$

power = $W_1 + W_2$

$= 460 \times 4 + 120 \times 4$

$= 2320$

(7) $\phi = -\tan^{-1}\left(\frac{\sqrt{3} \times 260}{60}\right)$

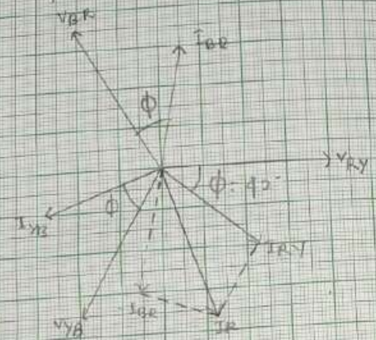
$= -81.63$

power = $W_1 + W_2$

$= 160 \times 4 - 100 \times 4$

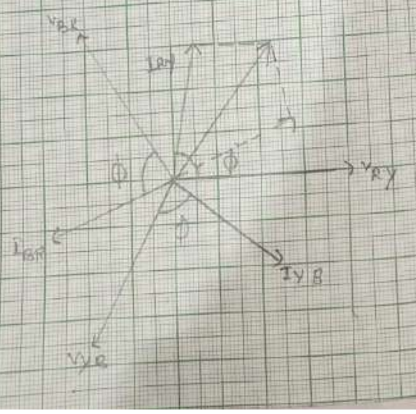
$= 240$

③



$\phi = 42°$

④



$\phi = -81°$

Expt. No. ....

Date ....

precaution:-

1. connect the circuit as shown in the experimental setup.

2. Don't switch on the main supply while assembling the circuit.

3. Don't wear any metallic articles while performing the experiment.

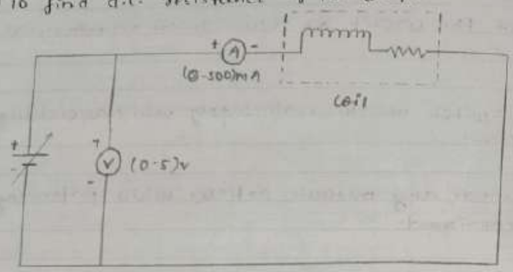
conclusion:-

The experiment conducted and the result obtained were satisfactory. The calculations made were verifying the theorems thus the experiment comes up to its end that objective was achieved and verified.

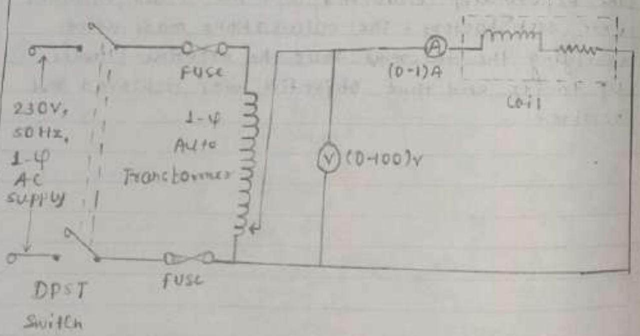
Teacher's Signature : ....

Experimental setup:-

(i) To find d.c. resistance of the coils:-



(ii) To find self inductance of the coils:-



Measurement of self and mutual Induction :-

Aim of the experiment :-

To determine self and mutual inductance of two inductive coils.

Apparatus required :-

Sl NO	Apparatus	Type	Range	Quantity
1.	Auto Transformer	1-φ		1
2.	Regulated power supply	DC	—	1
3.	Inductive coils	—	—	2
4	Ammeter	DC	(0-500)mA	1
5.	Voltmeter	DC	(0-5)V	1
6	Ammeter	AC	(0-1)A	1
7.	Voltmeter	AC	(0-100)V	1

Theory:-

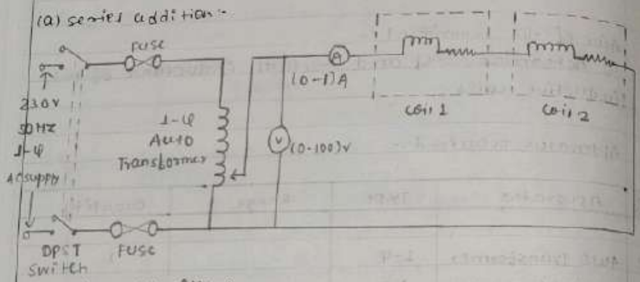
$E = L \frac{di}{dt}$, (L is called self inductance)

$L = \frac{N\phi}{I} = \frac{N^2}{S}$ ⇒ N is the number of turns and S is the reluctance

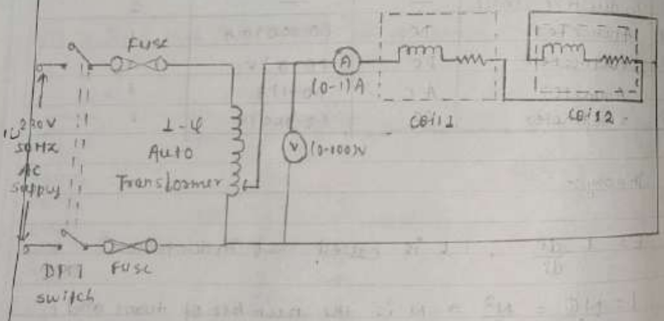
$S = \frac{l}{a\mu}$

(iii) To find mutual inductance between the coils :-

(a) series addition :-



(b) series opposition :-



Expt. No.................... Date............

$C_M = \frac{M\,di}{dt}$, where M is a constant called Mutual inductance or inductance of coil.

$M = \frac{N\phi}{I}$, $M = K\sqrt{L_1 L_2}$, where K is the coefficient of coupling.

For inductance in series.

Total inductance $= L_T = L_1 + L_2 \pm 2M$

where, $L_1 \rightarrow$ Inductance of first coil

$L_2 \rightarrow$ Inductance of second coil

$M \rightarrow$ Mutual inductance between 2 coil.

For inductance in parallel with no mutual inductance

$$L_T = \frac{L_1 L_2}{L_1 + L_2}$$

with mutual inductance.

$$V_1 = R_1 L_1 + L\frac{di_1}{dt} + M\frac{di_2}{dt}$$

$$L_T = \frac{L_1 L_2 - M^2}{L_1 + L_2 \pm 2M}$$

$$V_2 = R_2 L_2 + L_2\frac{di_2}{dt} + M\frac{di_1}{dt}$$

$$Z_1' = \sqrt{(R_1+R_2)^2 + (X_{L_1} + X_{L_2} + 2\omega M)^2}$$

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Observation table :-

① DC resistance of two coils :-

Coil-1 $R_1 = 63.2$

Coil-2 $R_2 = 47.4$

② To find inductance of two coils :-

	$V_1(V)$	$I_1(mA)$	$Z_1 = V_1/I_1$	$X_{L1} = \sqrt{Z_1^2 - R_1^2}$	$L_1 = \frac{X_{L1}}{2\pi f}$
coil-1	100	0.2	500	497.67	1.58
	120	0.24	480	477.67	1.52
	130	0.28	464	461.49	1.47

	$V_2(V)$	$I_2(mA)$	$Z_2 = V_2/I_2$	$X_{L2} = \sqrt{Z_2^2 - R_2^2}$	$L_2 = \frac{X_{L2}}{2\pi f}$
coil-2	100	0.18	555.56	551.82	1.75
	120	0.22	545.45	541.64	1.72
	130	0.23	565.21	561.54	1.76

③ To find mutual inductance between coils :-

(a) series addition :-

$V_1(V)$	$I_1(mA)$	$Z_1 = V_1/I_1$
100	0.1	1000
150	0.14	1071.42
170	0.17	1000

(b) series opposition :-

$V_2(V)$	$I_2(mA)$	$Z_2 = V_2/I_2$
130	0.12	1083.33
150	0.14	1071.42
170	0.16	1062.5

$$X_{L1} + X_{L2} + 2\omega M = \sqrt{Z_1^2 - (R_1+R_2)^2} = M_1 \quad \text{— ①}$$

$$Z_2' = \sqrt{(R_1+R_2)^2 + (X_{L1}+X_{L2}-2\omega M)^2}$$

$$X_{L1} + X_{L2} - 2\omega M = \sqrt{Z_2'^2 - (R_1+R_2)^2} = M_2 \quad \text{— ②}$$

From ① and ②

$$4\omega M = M_1 - M_2$$

$$M = \frac{M_1 - M_2}{4\omega} = \frac{M_1 - M_2}{8\pi f} \quad \text{— ③}$$

Procedure:-

1. Connect the circuit as shown in the experimental setup.

2. Apply a low voltage dc and note down the dc meter reading to determine dc resistance R_1 of the first coil.

3. Repeat steps (1) and (2) with the second coil to determine its dc resistance R_2.

4. Re arrange the circuit as shown in fig (ii) using coil(1)

5. Switch on the ac supply, keeping auto transformer in zero output position.

Calculations:-

$$Z_1 = \frac{V_1}{I_1} = \frac{100}{0.2} = 500$$

$$X_{L_1} = \sqrt{(Z_1)^2 - (R_1)^2} = \sqrt{(500)^2 - (63.2)^2} = 497.67$$

$$L_1 = \frac{X_{L_1}}{2\pi f_1} = \frac{497.67}{2 \times 3.14 \times 50} = 1.58\,H$$

$$L_1 = \frac{1.58 + 1.52 + 1.47}{3} = \frac{4.57}{3} = 1.52\,H$$

$$Z_2 = \frac{V_2}{I_2} = \frac{100}{0.18} = 555.56$$

$$X_{L_2} = \sqrt{(Z_2)^2 - (R_2)^2} = \sqrt{(555.56)^2 - (47.4)^2} = 551.82$$

$$L_2 = \frac{X_{L_2}}{2\pi f_1} = \frac{551.82}{2 \times 3.14 \times 50} = 1.75\,H$$

$$L_2 = \frac{1.75 + 1.72 + 1.76}{3} = \frac{5.23}{3} = 1.74\,H$$

Expt. No. .... Date ....

6. Apply a reduced voltage by adjusting the auto-transformer and note down the ammeter readings to calculate the self-inductance L_1 of the first coil

7. Repeat steps (5) and (6) with coil 2, to determine its self-inductance L_2.

8. Connect both the coils in series addition, as shown in fig (iii) (a) and repeat the steps (5) and (6) to determine the reactance M_1, care must be taken to see that the two coils are co-axial by keeping them exactly one above the other.

9. Connect both the coils in series opposition, as shown in fig (iii) (b) and repeat the steps (5) and (6) to determine the reactance M_2.

Result:-

$L_1 = 1.52\,H$ (Self inductance of coil-1)
$L_2 = 1.75\,H$ (Self inductance of coil-2)
$M = 0.033\,H$ (Mutual inductance between the coils

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Series addition:-

$$M_1' = \sqrt{(Z_1)^2 - (R_1+R_2)^2}$$

$$= \sqrt{(1000)^2 - (110.6)^2} = 993.86$$

$$M_2'' = \sqrt{(Z_1)^2 - (R_1+R_2)^2}$$

$$= \sqrt{(1071.42)^2 - (110.6)^2} = 1065.27$$

$$M_1 = \frac{993.86 + 1065.27}{2} = 1029.56$$

Series opposition:-

$$M_2' = \sqrt{(Z_2)^2 - (R_1+R_2)^2}$$

$$= \sqrt{(1083.33)^2 - (110.6)^2} = 1077.66$$

$$M_2'' = \sqrt{(Z_2)^2 - (R_1+R_2)^2}$$

$$= \sqrt{(1071.42)^2 - (110.6)^2} = 1065.69$$

$$M_2 = \frac{1077.66 + 1065.69}{2} = 1071.67$$

$$M = \frac{1071.67 - 1029.56}{8\pi f} = 0.033\,H$$

Expt. No. .... Date ....

Precautions:-

1. Connect the circuit as shown in the experimental setup.

2. Don't switch ON the main supply while assembling the circuit

3. The transformer voltage should be increased in small steps.

4. Don't wear any metallic articles while performing

Conclusion:-

The experiment conducted and the result obtained were satisfactory. The calculations made were verifying the theory thus the experiment comes up to its end that objective was achieved and verified

Teacher's Signature : ....

Date ....

Expt. No. ....

Page No. ....

Teacher's Signature : ....