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GOOD WRITE
A Mark of Quality

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OBJECTIVE

To study types of symbols and standard currently being used in electrical engineering.

Electrical Components

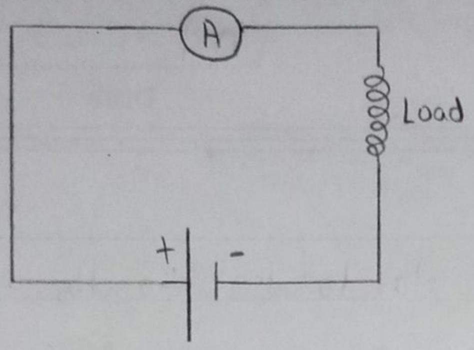
1. **Ammeter**: It is a device used to measure flow of charge in a circuit. It is connected in series and its unit is Ampere (A). In case of Ammeter current remains same and voltage is different in circuit.

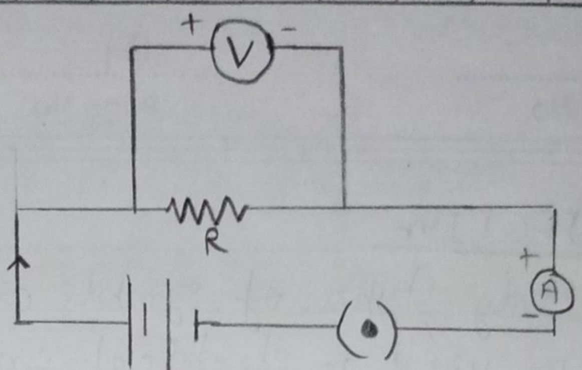
2. **Voltmeter**: It is a device used to measure voltage across the circuit. It is connected parallel in the circuit. Its unit is volt (v). Voltage remains same and current is different.

3. **Resistor**: It is a device which opposes the flow of charge and maintain a safe current value in the circuit. Its unit is Ohm (Ω).

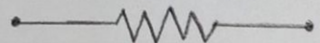
4. **Rheostat**: It is a device used in application that requires adjustable current or varying resistance in the circuit. Eg. Regulator, speed motor, etc.

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

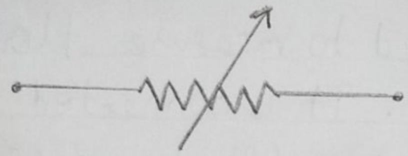




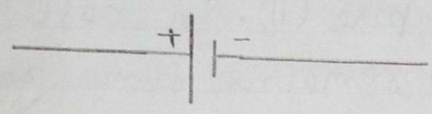
Electrical Circuits



Resistor

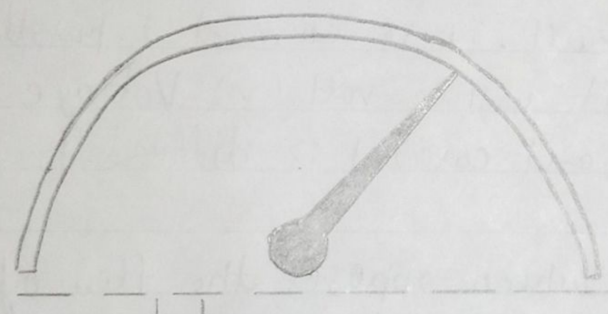


Variable Resistor

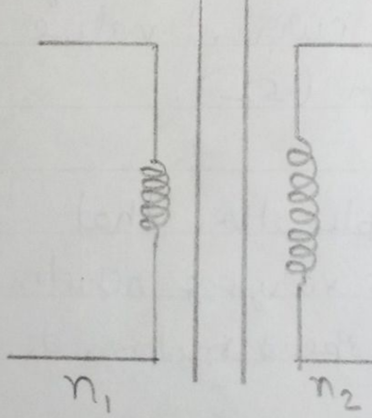


Battery

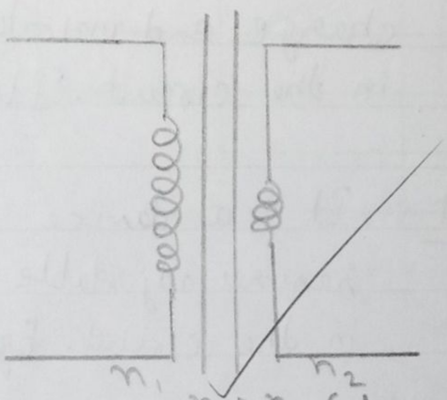
A.C. Source



Measuring Instrument



$n_2 > n_1$ (up)



$n_1 > n_2$ (down)

TRANSFORMER

5. Capacitor : It is a device that stores electrical energy in an electric field. It is designed as a component to add capacitance to a circuit. It unit is Farad (F).

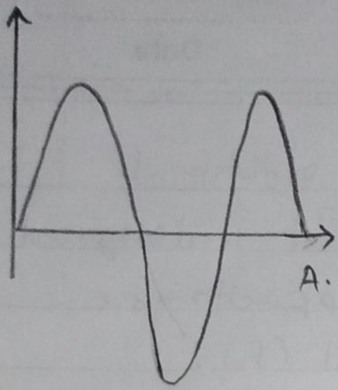
6. Wattmeter : It is a device used to measure power in an electric circuit. Its unit is watt (W).
$P = VI$, $P = \frac{V^2}{R}$, $P^2 = I^2 R$

7. Tachometer : It is a device used to measure rotation speed of a disk, as in motor. Its unit is RPM.

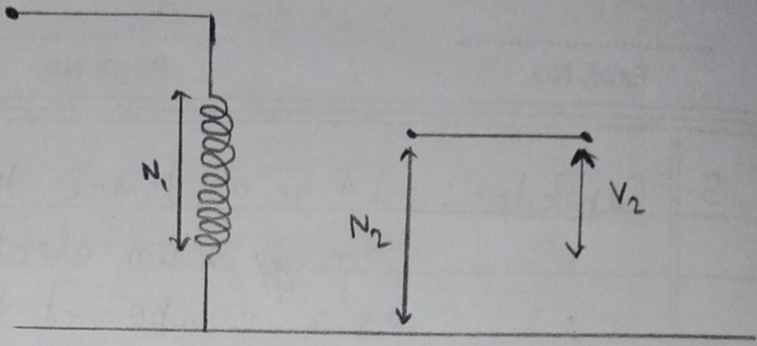
8. Transformer : It is a device that transfers electric energy from one alternating current circuit to other. It is also used as step up and step down. It works on the principle of ~~em~~ electromagnetic induction.

9. D.C. Supply : It stands for ~~alternating~~ direct current which is electrical current that flows in one direction.

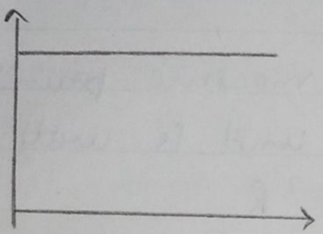
10. A.C. Supply : It stands for Alternating current which is electrical current that flows in two



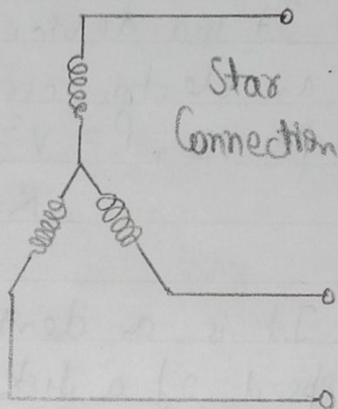
A.C.



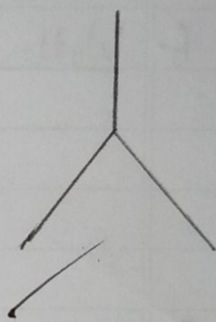
Auto-Transformer

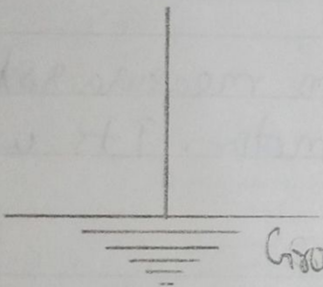


D.C.

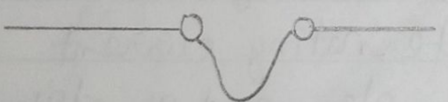


Star Connection

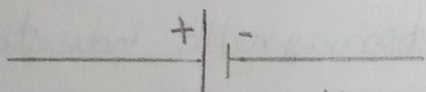




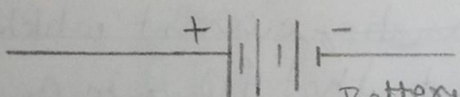
Ground



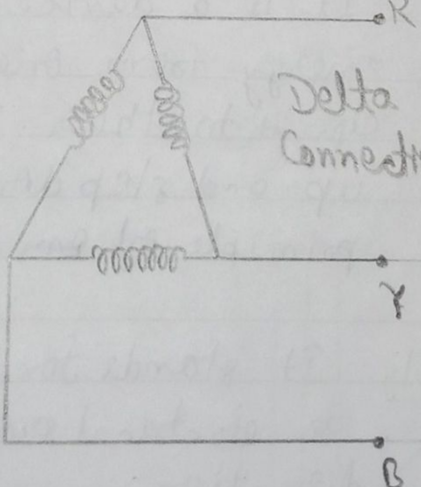
Short circuit Connection



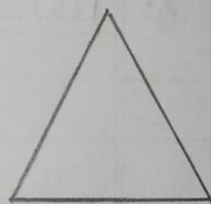
Battery

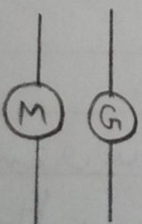


Battery in series



Delta Connection





Motor Generator

directions.

11. Earthing: It is a system that connects specific parts of an electric power system with the ground typically the Earth.

12. Fuse: It is an electrical safety device that operates to provide over current protection of an electrical unit.

13. Cell: It is a device used to power electrical circuits. It has two terminals: positive & negative.

14. Battery: It is a collection or arrangement of two or more cells.

15. Motor: It is a device that converts electrical energy into mechanical energy. It depends on the interaction of magnetic and electric field.

16. Generator: It is a device that converts motive power into electrical power for use in an external circuit.

17. Auto Transformer: It is an electrical transformer with only one winding. It only uses single coil.

18. Star Connection : ~~It is general~~ It is generally used for small, high voltage transformers.

19. Delta Connection : It is a connection used in a three phase electrical system in which three elements in series ~~for~~ form a triangle.

17/4

- DIAGRAM

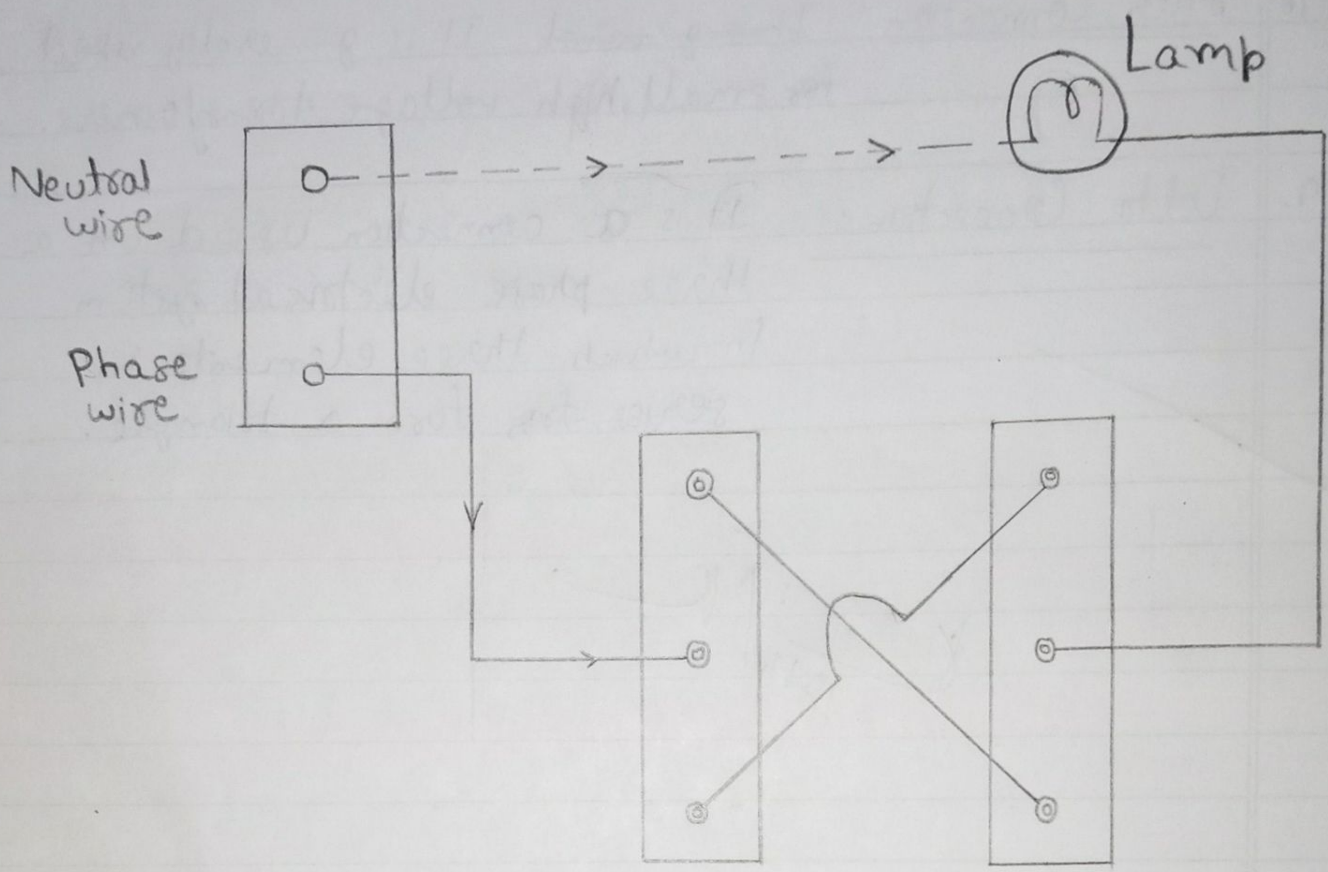


Fig. Connection Diagram for Stair Case Wiring System

OBJECTIVE

To wiring for a lamp to be controlled from two different positions. (Two way switch method)

APPARATUS REQUIRED

S. No	Name of ~~Experiment~~ Equipment	Range / Type	Quantity
1	1-Ph. AC Power Supply	230 Volts	01
2	Two way Switches	SPST, 6A	02
3	Lamp	60W / 100W	01
4	Lamp Holder	6A, 230V	01
5	Connecting Leads / Wire	14SWG / 16SWG	As req.

THEORY

Staircase Wiring is a special type of wiring, which is different from the ordinary wiring due to field of application the lightning the stairs. In staircase wiring, lamp used for the lightning the stairs can be switched ON or OFF from either side, UPSTAIRS or DOWNSTAIRS.

When both switches are in SAME position, Lamp will be in OFF stage as it only connects with neutral only. Now if position of any switch is changed, then phase is applied to the one end of the lamp and it becomes ON (comes in glowing stage). Now if the position of any switch changed the lamp will again come in off position, same as again and again.

A two way switch probably refers to three way connections, where a single common terminal can make or break contacts with two possible contact points (one incoming & two outgoing potential connections) SPDT switch is used when a device needs to be controlled from more than one location. (i.e. the top and bottom of stairs, at both ends of hallway, etc) A three way switch allows for a device to be controlled independently from two locations, regarding the position of the other switch.

By this system, we can operate any electrical device from two locations.

This system works as XOR GATE.

- PROCEDURE

STEP 1: Make the connection as shown in the connection diagram. Keep all the switches in off position.

STEP 2: Connect phase terminal (wire) at middle terminal of switch 1.

STEP 3: The upper & lower terminals of switch 1 should be

- **OBSERVATION TABLE**

S.NO.	Position of Switches (switch 1 & switch 2)	Position of Lamp (Glowing Or Not)
01	UP-UP	OFF
02	UP-DOWN	ON
03	DOWN-DOWN	OFF
04	DOWN-UP	ON

connected with opposite terminals of switch.

STEP4: Connect the middle terminal of switch 2 to the one end (terminal) of lamp.

STEP5: Now connect neutral terminal (wire) to the other terminal of lamp.

STEP 6: Turn ON the supply (MCB), check the connections by using the SPDT switches.

STEP 7: After note down the observations, switch OFF the power supply.

- RESULT

We studied about the house wiring & made the connections for Staircase wiring.

- PRECAUTIONS

→ Before switching on the AC supply, connections should be checked by the lab staff.

→ Do not touch any live wire. Do not keep any joint open.

→ Use only proper current & voltage rating Equipments.

- **AIM**

To study and demonstration of Household wiring system.

- **APPARATUS REQUIRED**

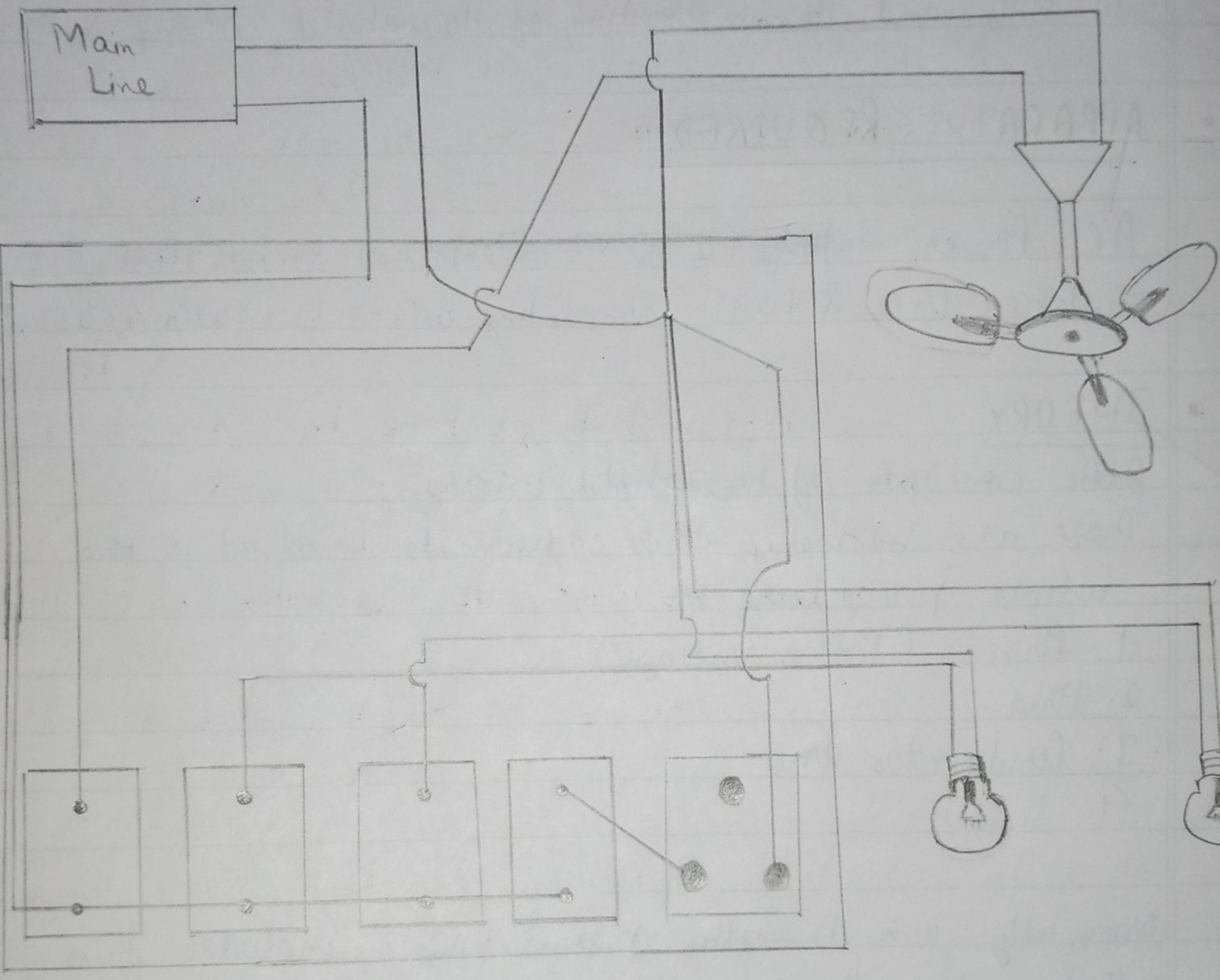
AC Power Supply (230 V), Electrical Board, Bulb (100W), switches (6A & 16A), connecting wires. (14 SWG / 16 SWG)

- **THEORY**

Basic concepts of household wiring:
There are basically four components involved in the whole procedure viz:
1. Power (Mains voltage)
2. Load
3. Conductor and
4. Switch

Normally our domestic mains power includes two ~~parts~~ paths, the incoming phase and outgoing or the return path through neutral. Other than these two the third conduction path in an electrical wiring is the "earth" or the ground. The top pin in a wall socket is where the earth connection is given. The 'earthing' is like a huge electrical dumping ground where stray or residual current leakages are nullified. The bodies of potentially dangerous appliances like electric irons,

• DIAGRAM



Connection Diagram of Electrical Board

geysers, refrigerators, & soldering irons tend to produce electric shock over time on their bodies due to some portion of the phase leakage. Therefore; these appliances have their bodies connected to their plug's "earthing" pin which ultimately gets configured with the socket's earthing terminal once plugged in. The path or passage of power from phase to neutral is implemented using conductors or wires & the system constitutes an electrical circuit. However, connecting the phase to neutral directly will cause havoc in the form of a big short circuit & the melting of wires. Therefore, the right procedure is to ~~convert~~ connect a load in between these two polarities so that the power flows through the load & operates it. But the above procedure will keep the load switched ON permanently, which can become quite undesirable & therefore the introduction of a manually operated circuit breaking or switching device becomes imperative. For this we just need to connect a mechanical switch in line or in series with the load & the phase - that simply solves the issue.

• PROCEDURE

Step 1: Make the connection as shown in the connection diagram. Keep all the switches in off position.
Step 2: Connect phase terminal (wire) at upper end of switch 1.
Step 3: Connect the lower end of switch 1 to the one end (terminal) of lamp.

Step 4: Now connect neutral terminal (wire) to the other terminal of lamp.

Step 5: Turn ON the supply (MCB), check the connections by using the SPOT switches.

Step 6: After note down the observations, switch OFF the power supply.

Step 7: Repeat above ~~proc~~ procedure for other home appliances.

- RESULT

We study about the house wiring & made the connections for lamp wiring.

- PRECAUTIONS

1. For all configurations, the switch must always come in line with the phase & before the load.

2. The socket's right side outlet should provide (or be connected) with the phase which again comes only after passing through the switch.

3. Before switching on the AC supply, connection should be checked properly.

4. Do not touch any line, do not keep any joint open.

8/5

• CONNECTION DIAGRAM

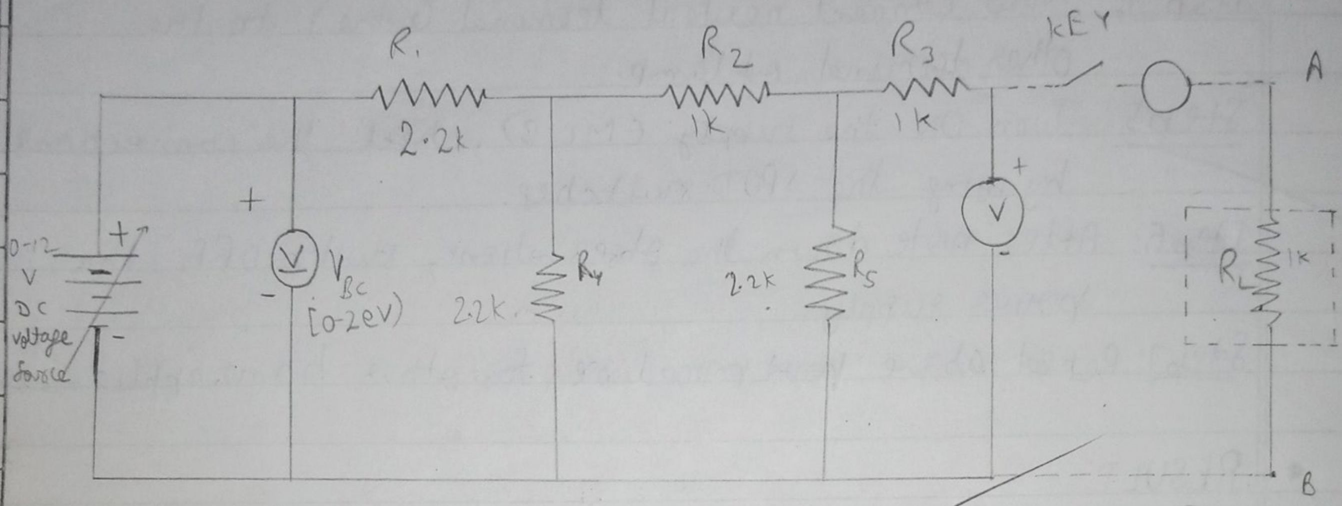


Fig 1 Connection Diagram for verification of Thevenin's Theorem

Two Port Net Work

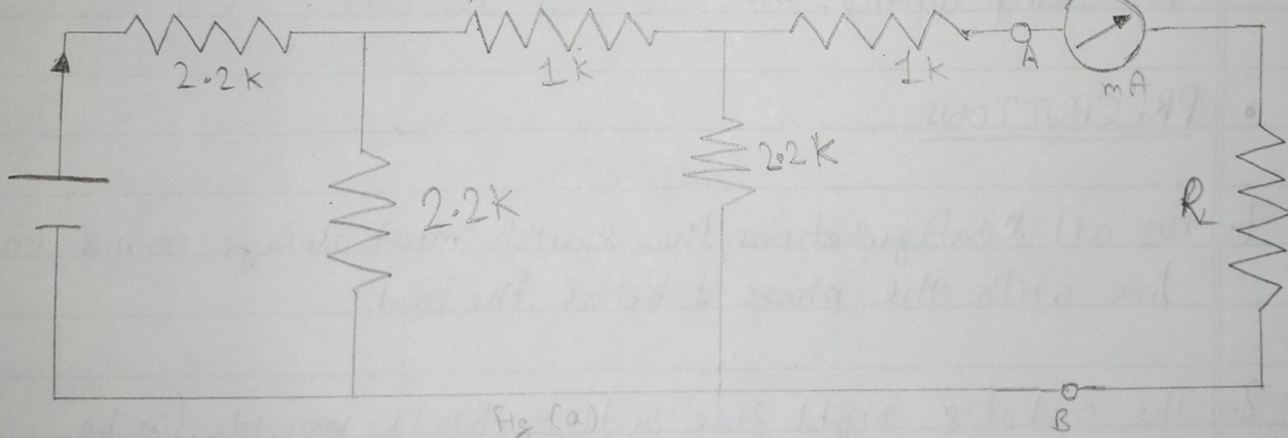


Fig (a)

To measure Thevinin's Voltage

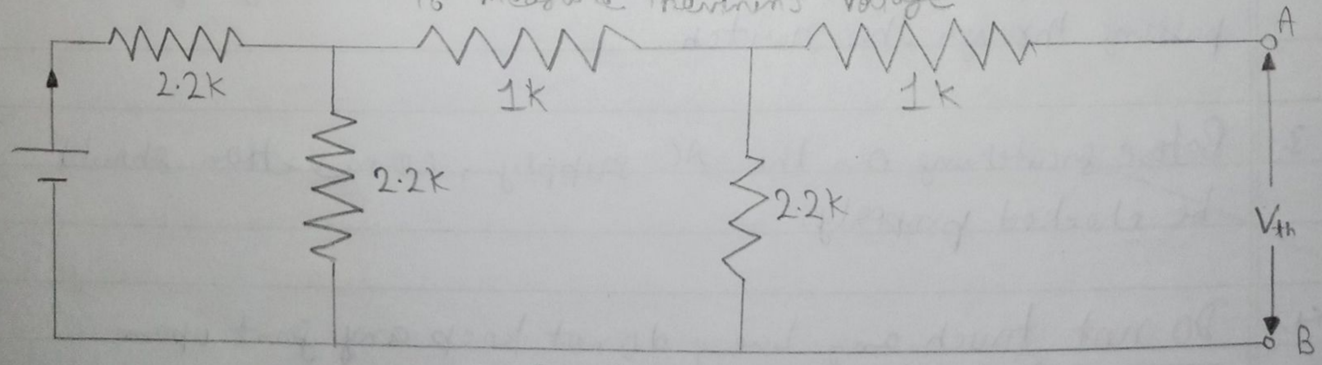


Fig (b)

- OBJECTIVE

To verify Thevenin's theorem & calculate Thevenin voltage (V_{th}) and Thevenin resistance (R_{th}).

- THEORY

The Thevenin's theorem provides a mathematical technique for solving the linear circuits:

➤ Any linear electrical network with voltage and current sources and resistances can be replaced by Thevenin's equivalent circuit elements, at terminals A-B by an equivalent voltage source, V_{TH} in series connection with an equivalent resistance R_{TH}.

➤ This equivalent voltage, $V_{TH} = V_{oc}$ is the voltage obtained at terminals A-B of the network with terminals A-B open circuited.

➤ This equivalent resistance R_{TH} is the resistance obtained at terminals A-B of the network with all its independent current sources open circuited & all its independent voltage sources short circuited.

For AC systems, the theorem can be applied to reactive impedances as well as resistances.

To measure Thevinin's Resistance

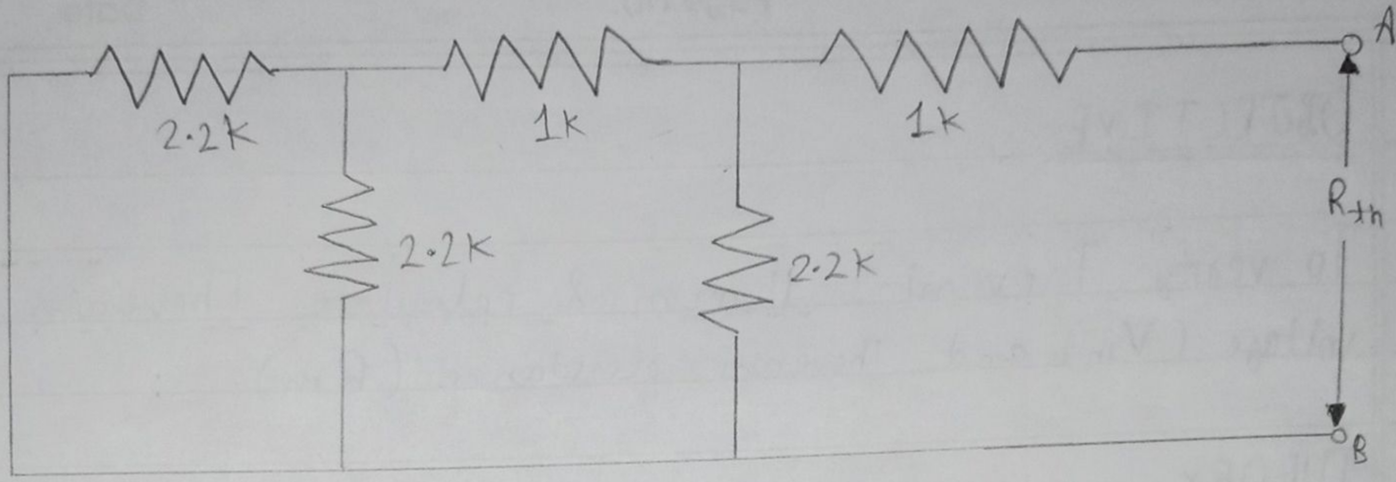


fig (c)

Thevinin's Equivalent Circuit

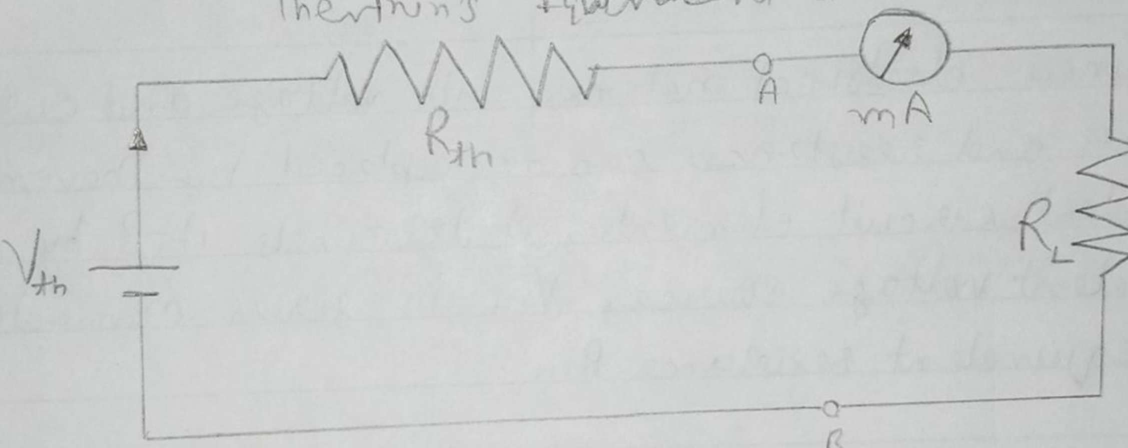


fig (d)

- APPARATUS REQUIRED

Sr. No.	Name of Equipment	Range/ Type	Quantity
01	DC Power Supply	0–12 Volts	01
02	Bread Board		01
03	Voltmeter (DC) / DMM	0-20 Volts	02
04	Ammeter (DC) / DMM	0-20mA, MC type	01
05	Resistor	2.2kΩ & 1kΩ	03 Each
06	Potentiometer	0–5kΩ	01
07	Key (Switch)	1 Amp	01
08	Connecting Leads / Wire	14SWG / 16SWG	As Required

- PROCEDURE

STEP 1: Make connection as shown in the connection diagram.

Step 2: Measure the values of thevenin's resistance, R_{TH} at A-B after replace the voltage source by short circuit and Load resistance, R_L with the help of Ohmmeter/ DMM.

Step 3: Keep the pot at maximum value to keep the source voltage at its lowest value. Connect the Ammeter & Voltmeter correctly as of their polarities.

Step 4: Switch on the supply, set the certain value of source voltage, V_{SC} with the help of pot.

Step 5: Record the readings of source voltage, V_{SC} and load current, I_L'.

- OBSERVATION TABLE

Sr. No.	Load Resistance R_L (Ω)	Thevenin's Resistance R_{th} (Ω)	Source Voltage V_{SC} (V)	Load Current I_L' (mA)	Thevenin's Voltage $V_{th} = V_{OC}$ (V)	Load Current (by Thevenin's) I_L (mA)
01	971	3220	8	0.91	4.02	0.95
02	971	3220	10	1.81	4.99	1.19
03	971	3220	12	1.43	5.95	1.43

- CALCULATION

Error $\frac{I_L - I_L'}{I_L} \times 100$	Mean Error
a) 4.21%	
b) 0.84%	1.68%
c) 0%	

Step6: Open the switch and take reading of open circuit voltage, V_{oc}. This is the open circuit voltage between terminals A-B and gives the Thevenin's equivalent Voltage V_{TH}.

Step7: For another set of readings, put another value of source voltage, V_{sc} with the help of pot, repeat the steps 5-6.

Step8: Switch off the supply.

Step9: Make the connections for Thevenin's equivalent circuit, using R_{TH}, R_L and V_{TH}.

Step10: Adjust the value of V_{TH} with the help of pot. And record the value of load current I_L.

Step11: Repeat the above for all values of V_{TH} recorded earlier.

Step12: Switch off the supply, disconnect the circuit safely.

- RESULT :

From the observation table; It is observed that the actual value of load current, I_L is tallies with the calculated value of the load current, I_L'. Hence, Thevenin's theorem is verified with some permissible error which is allowed in practical.

PRECAUTIONS

→ Before connecting the DC supply, the zero readings of ammeter and voltmeter should be checked.

→ Check all the resistances and connecting wires are properly connected on the bread board.

→ Terminals of voltage source of the kit should not be ~~th~~ short circuited, only circuit on the bread board, should be short circuited.

→ Current in the ammeter is in milli amperes not in amperes.

→ Connections should be tight and correct.

→ Terminals of rheostat should be connected properly.

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Expt. No. 5. Page No. 15 Date 8/5/23

- AIM

To verify the Norton's Theorem & calculate Norton current I_N & Norton Resistance R_N.

- APPARATUS

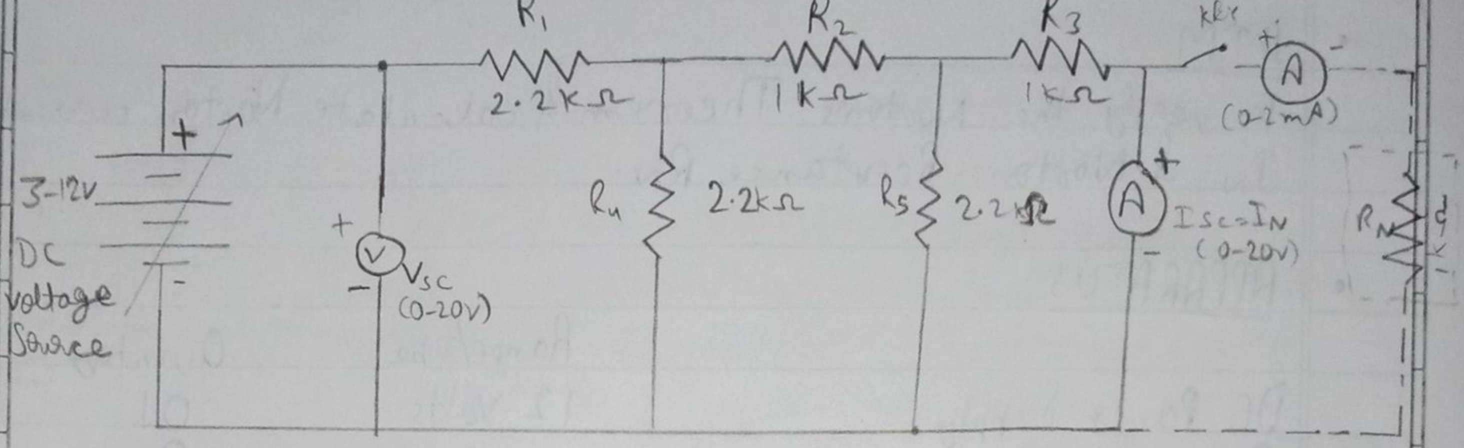
	Range/Type	Quantity
DC Power Supply	12 Volts	01
Bread Board / Norton's Kit	.	01
Voltmeter / DMM	0-20 Volts	02
Ammeter / DMM	0-20 mA	01
Resistor	2.2 kΩ & 1kΩ	03 each
Rheostat	1kΩ	01
Key	1 Amp	01
Connecting lead / wire	SWG	As Required.

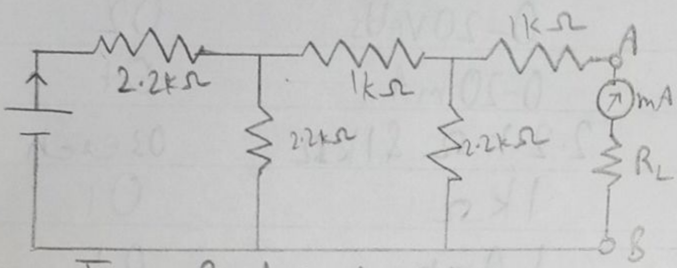
- THEORY

Any linear passive, electrical circuit can be replaced by Norton's equivalent circuit, by replacing an equivalent current source, I_N in parallel with an equivalent resistance R_N. where $I_N = I_{SC}$ is the Norton current obtained at terminals A-B of the network, with terminals A-B short circuited.

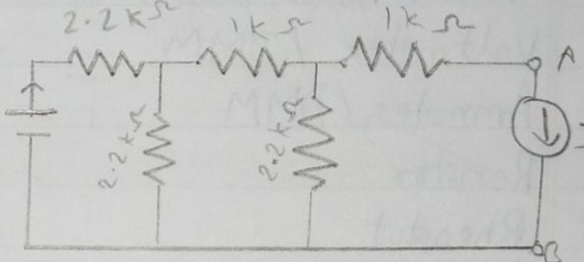
(R_N = Norton equivalent resistance)

- Diagram

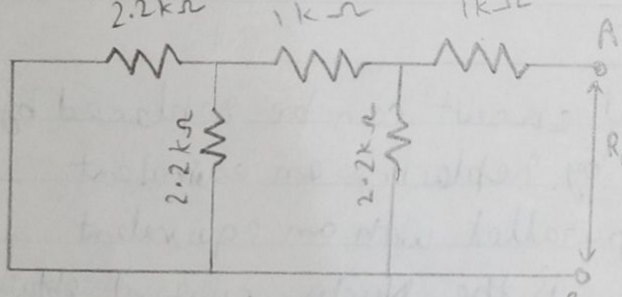




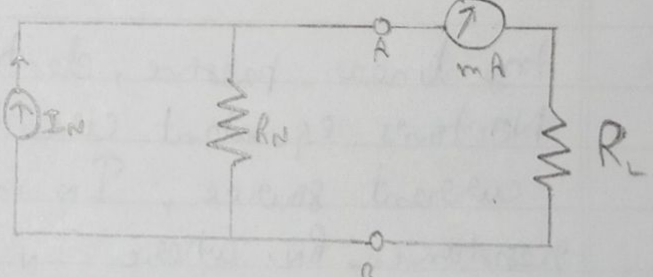
Two Port Network



To measure Norton's Current



To measure Norton's Resistance



Norton's Equivalent Circuit

- PROCEDURE

1. Make the connection as shown in diagram.
2. Measure the values of Norton's resistance, R_N at A-B after replace the voltage ~~ba~~ source by short circuit & load resistance, R_L with the help of ohmmeter / DMM.
3. Keep the pot at maximum value to keep the source voltage at its lowest value. Connect the ammeter & voltmeter correctly as of their polarities.
4. Switch on the supply, set the certain value of source voltage V_{sc} with the help of pot.
5. Record readings of source voltage, V_{sc} & load current, I_L.
6. Open the switch & take the reading of short circuit current I_{sc}. This is the short circuit current b/w terminals ~~A & B~~ AB & gives Norton's equivalent current I_N.
7. For another set of readings, put another value of ~~sou~~ source voltage, V_{sc} with the help of pot, repeat the step 5-6.
8. Switch off the supply.
9. Make connections for Norton's equivalent circuit, using R_N, R_L & I_N.
10. Adjust the value of I_N with help of pot. And record the value of load current I_L.
11. Repeat the above for all values of I_N, recorded earlier.
12. Switch off the supply, disconnect circuit safely.

• Observation Table

S. No.	Load Resistance R_L (Ω)	Norton's Resistance R_{Th} (Ω)	Source voltage V_{SC} (V)	Load current I_L' (mA)	Load current I_L (mA) (By Norton)	Norton current I_N (A)
1	1	3.21	6	0.701	0.700	0.92
2	1	3.21	9	1.052	1.050	1.38
3	1	3.21	12	1.395	1.370	1.83

Error $\frac{I_L - I_L'}{I_L} \times 100$	Mean Error
0.14%	0.71%
0.19%	
1.32%	

- Result

From table; It is observed that the actual value of load current, I_L is equal with the calculated value of load current I_L. Hence, Norton's Theorem is verified with some permissible error.

- Precautions

→ Before connecting the DC supply, the zero readings of ammeter & voltmeter should be checked.

→ Check all the resistances & connecting wires are properly connected on bread board.

→ Terminals of voltage source of kit should not be short circuited, only circuit ~~of~~ on the bread board, should be short circuited.

→ Current in the ammeter is in milli amperes not in amperes.

→ Connections should be tight & current.

→ Terminals of rheostat should be connected properly.

- Aim

To determine parameter of series RLC Circuit.

- Apparatus

S.No.	Name of Equipment	Range/Type	Quantity
1.	Power Supply	220 volts, AC	01
2.	RLC series Circuit kit		01
3.	Voltmeter/DMM	0-20 volts, MC type	04
4.	Ammeter / DMM	0-2 Amp, MC type	01
5.	Resistors, Inductors & Conductors		01 each
6.	Potentiometer	5 kΩ	01
7.	Key/Switch	1Amp, DC	01
8.	Connecting Loads/ wires	SWG	As required

- Theory

Circuit Diagram containing resistance R ohms, inductance L henry and capacitance C farad connected in series. Let the current flowing through the circuit be of I amperes and supply frequency F (Hz).

Voltage drop across resistance, $V_R = IR$ in phase with I.

Voltage drop across inductance, $V_L = I\omega L$ leading I by $\pi/2$ radians or 90°.

Voltage drop across capacitance, $V_C = \frac{I}{\omega C}$ lagging behind

I by $\pi/2$ radians or $90°$.
V_L or V_C are $180°$ out of phase with each other (or reverse in phase), therefore, when combined by parallelogram they cancel each other. The circuit can be effectively inductive or ~~capacitance~~ capacitive depending upon which voltage drop (V_L or V_C) is predominant. Let us consider the case when V_L is greater than V_C. The applied voltage V, being equal to the phasor sum of V_R, V_L & V_C is magnitude by:

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

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

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

The term $\sqrt{(R^2) + (X_L - X_C)^2}$ is known as impedance of the circuit & is represented by z. Its units is ohms.

Phase angle ϕ b/w voltage & current is given by:

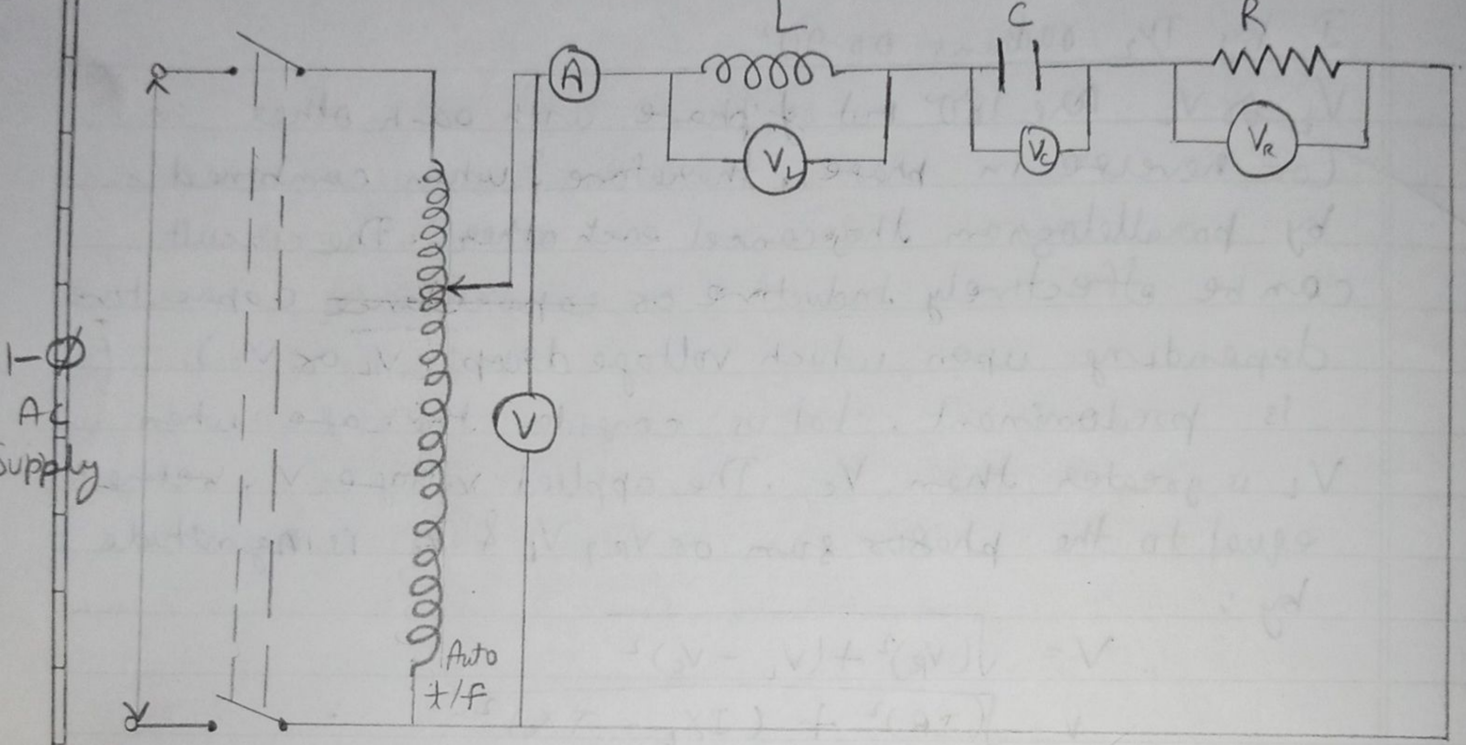
$$\phi = \tan^{-1}\left(\frac{V_L - V_C}{V_R}\right)$$

$$\phi = \tan^{-1}\left(\frac{IX_L - IX_C}{IR}\right)$$

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

$$\phi = \tan^{-1}(X/R)$$

. Diagram



ϕ will be +ve i.e. applied voltage will lead current if $X_L > X_C$
Power factor of circuit is given by

$$\cos\phi = \frac{R}{Z} = \frac{R}{R^2+(X_L-X_C)^2}$$

Power consumed in the circuit ; $P = I^2R$ or $VI\cos\phi$

- REACTANCE

In a series RLC circuit one cannot definitely say whether the current lags or leads the applied voltage. It depends upon the relative values of the terms ωL and $\frac{1}{\omega C}$ (X_L and X_C). Inductive reactance,

X_L is directly proportional to frequency wing equal to $2\pi f L$ or ωL and capacitance reactance, X_C is inversely proportional to frequency being equal to $\frac{1}{2\pi f C}$ or $1/\omega C$.

Inductive reactance causes the current to lag behind the applied voltage, while the ~~capacitance~~ capacitive reactance causes the current to lead the voltage. So when inductance & capacitance are connected in series, their effects tries to neutraliy each other & their combined effect is then their difference. The combined effect of inductive & capacitive reactance is called the

- ## Observation Table

S.No.	Applied voltage (V_{IN}) (V)	Current Drawn I (A)	Voltage across Inductor V_L (V)	Voltage across capacitor V_C (V)	Voltage across resistor V_R (V)
1	10.6	5.7	0.7	9.6	6.55
2	16.24	8.66	0.912	13.79	8.71
3	20.42	10.87	1.601	14.87	10.88

- ## Calculations

S. No.	Inductive Reactance $X_L = \frac{V_L}{I}$ (Ω)	Capacitive Reactance $X_C = \frac{V_C}{I}$ (Ω)	Phase Angle $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$	Power factor ($\cos\phi$) $\frac{R}{\sqrt{R^2+(X_L-X_C)^2}}$
1.	0.122	1.684	53.67°	0.587
2.	0.105	1.592	55.95°	0.312
3.	0.092	1.643	57°	0.294

S. No.	$Z = \frac{V_S}{I}$	$R = \frac{V_R}{I}$ (Ω)	$L = X_L/2\pi f$ (mH)	$C = \frac{1}{2\pi f C}$ (μF)	$F_R = \frac{1}{2\pi\sqrt{LC}}$
1	1.93	1.149	0.388	1890	0.005880
2	1.73	1.005	0.39	2000	0.005701
3	1.61	1.01	0.29	1900	0.007187

reactance & is ~~formed~~ found by subtracting the capacitive reactance from the inductive ~~reacta~~ reactance or according to equation : $X = X_L - X_C$.

- Procedure

1. Make the connection as show in the connection diagram. Keep potentiometer at their max value to keep source voltage at its lowest value. Connect ammeter & voltmeter correctly as of their polarities.
2. Switch on the supply, set the certain value of voltage with the help of potentiometer.
3. Note the readings from ammeter & voltmeters.
4. For another set of readings, change voltage at source with the help of potentiometer & repeat step 3.
5. Switch off the supply, disconnect the circuit safely.

- Result

From the table, it is observed that, the different parameters of series R-L-C circuit are found. The different values of the power factor are almost same for each set of observations.

- Precautions

→ Before connecting the AC supply, the zero readings of ammeter & voltmeter should be checked.

→ Check all the resistances, inductors and capacitors properly.

→ Connections should be tight & correct.

→ Use correct range instruments only, for better results.

—x—

- Aim

To measure power & power factor in single phase AC circuit using three - ammeter method.

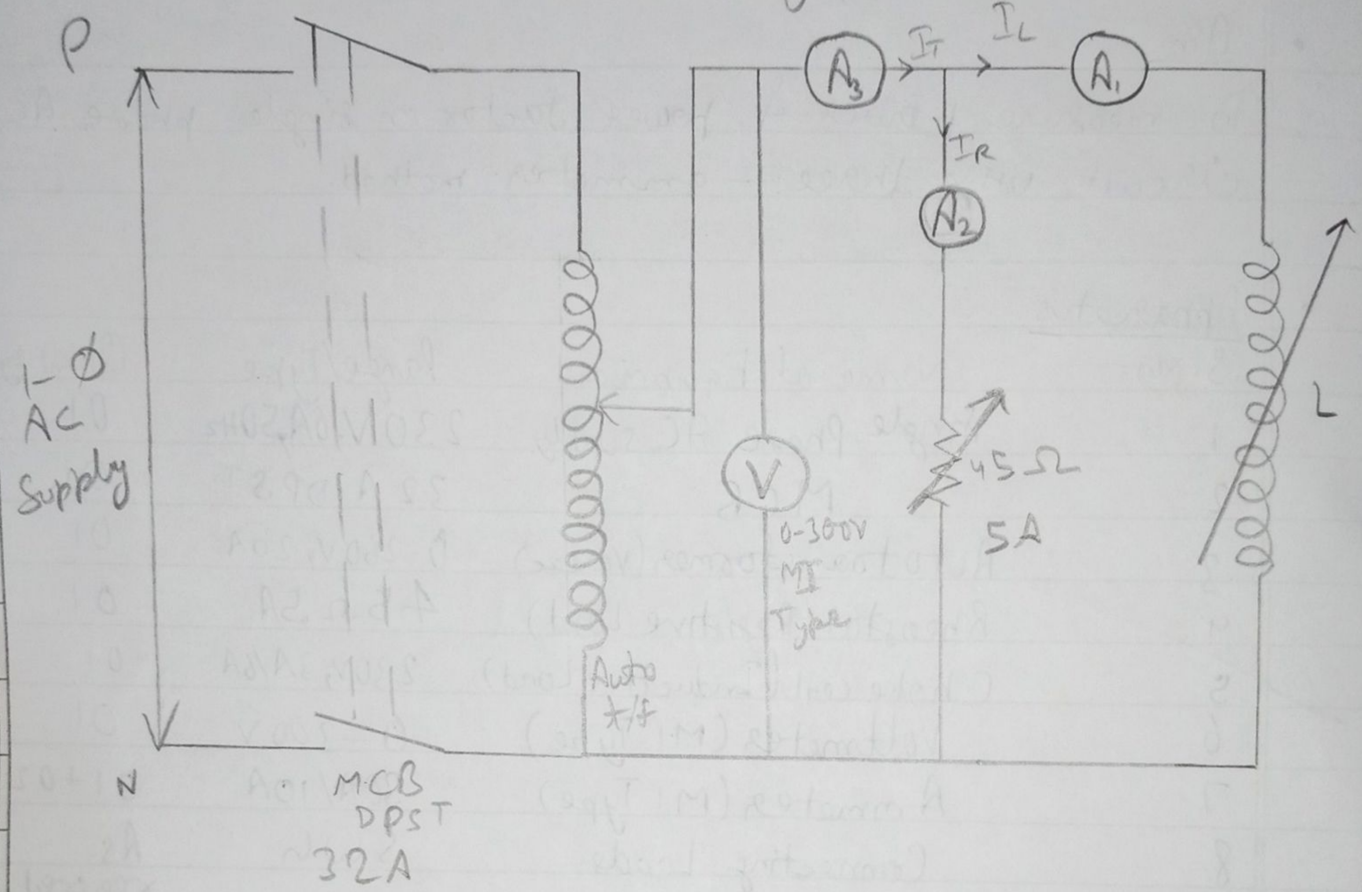
- Apparatus

S.No.	Name of Equipment	Range/Type	Quantity
1	Single Phase AC supply	230 V, 6A, 50Hz	01
2	MCB	32 A/DPST	01
3	Autotransformer (Variac)	0-260V, 20A	01
4	Rheostat (Resistive Load)	45Ω, 5A	01
5	Choke coil (Inductive Load)	230V, 3A/6A	01
6	Voltmeter (MI Type)	0-300V	01
7.	Ammeter (MI Type)	30A/10A	01+02
8	Connecting Leads	SWG	As required

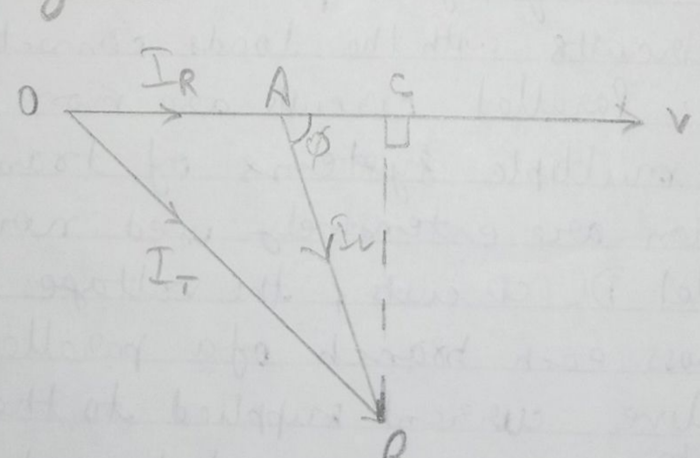
- Theory

Practically all lighting & power circuits are constant voltage circuits with the loads connected in parallel. Parallel circuits are more often used because multiple systems of transmission & distribution are extensively used nowadays. As in parallel DC circuits, the voltage is the same across each branch of a parallel AC circuit. The total line current supplied to the circuit is equal to the phasor sum of branch currents. The total line current supplied to a parallel.

- <u>Circuit Diagram</u>



<u>Phasor Diagram</u>



circuit ~~no~~ may be determined by determining the currents in each branch and adding them. taking into account their phase relations or by determining equivalent impedance & dividing the applied voltage by equivalent impedance.

The power consumed by the inductive load is given as:

$$P = VI\cos\phi$$

Therefore, unlike for a DC circuit it is not possible to find power in an AC circuit, simply from the readings ~~of~~ a voltmeter and ammeter. The power is normally measured by wattmeter. However, it is possible to measure power in an AC circuit by using Three - Ammeters.

Phaser Diagrams for AC circuit shows that the current I_R through the rheostat is in phase with the applied voltage, V. The current I_L through the ~~individual~~ inductive load lags the voltage by an angle ϕ. The total current I_T is the phaser sum of currents I_R & I_L. Therefore, we can write:

$$I_T^2 = I_R^2 + I_L^2 + 2I_R I_L \cos\phi$$

$$pf = \cos\phi = \left(\frac{I_T^2 - (I_R^2 + I_L^2)}{2I_R I_L}\right)$$

$$I_L \cos\phi = P/V$$

$$\cancel{I_T^2 + I_R} \quad I_T^2 = I_R^2 + I_L^2 + \left(\frac{2I_R P}{V}\right)$$

- Procedure

1. Make connections as per the circuit diagram. Connect the ammeter & voltmeter correctly as of their polarities.
2. Connections should be checked by the lab faculty technician before ~~start~~ switch on the supply.
3. Set the variac at zero voltage output & switch on the AC supply.
4. Change the supply voltage with the help of variac, so that some observable readings are obtained in the meters..
5. Note down the readings of the voltmeter & three ammeters.
6. Enter the observations & results in tabular form.
7. Change the position of variac & ~~kept~~ repeat the steps

Observation Table

S.	Resistance Value	Applied voltage	Current drawn by Circuit	Current drawn by Resistive Load	Current drawn by Inductive Load
NO.	R	V	I_T	I_R	I_L
	Ω	V	A	A	A
1	45	50	1.7	1	1.2
2	45	90	3.1	1.9	2.2
3	45	130	5	2.8	3.2
4	45	185	10	4.3	5

- CALCULATIONS

S. NO.	Power factor ($\cos\phi$) $\left(\frac{I_T^2-(I_R^2+I_L^2)}{2 I_R I_L}\right)$	Power Consumed ($P=\omega$) $I_T^2-(I_R^2+I_L^2) = \left[\frac{V}{2 I_R}\right]$
1	0.187	10.125
2	0.138	26.1
3	0.386	155.7
4	1.314	1244.47

5 & 6 for different set of readings.

8. Switch off the supply & disconnect the circuit safely.

• Result

On changing the power supply voltage, the power consumed by the inductive load also changes. But for all sets of readings, the values of the power factor have minor changes.

• Precautions

→ Before switching on the AC supply, the zero readings of the voltmeter & ammeters should be checked.

→ Meters of proper range & type should be selected.

→ The terminals of the rheostat should be connected properly.

→ While taking different readings, care should be taken that current recorded by ammeter does not exceed 5A, the current rating of the rheostat.

→ Connections should be tight & correct.

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- **AIM**

To measure power & power factor in a balanced three-phase circuit using two single-phase wattmeters.

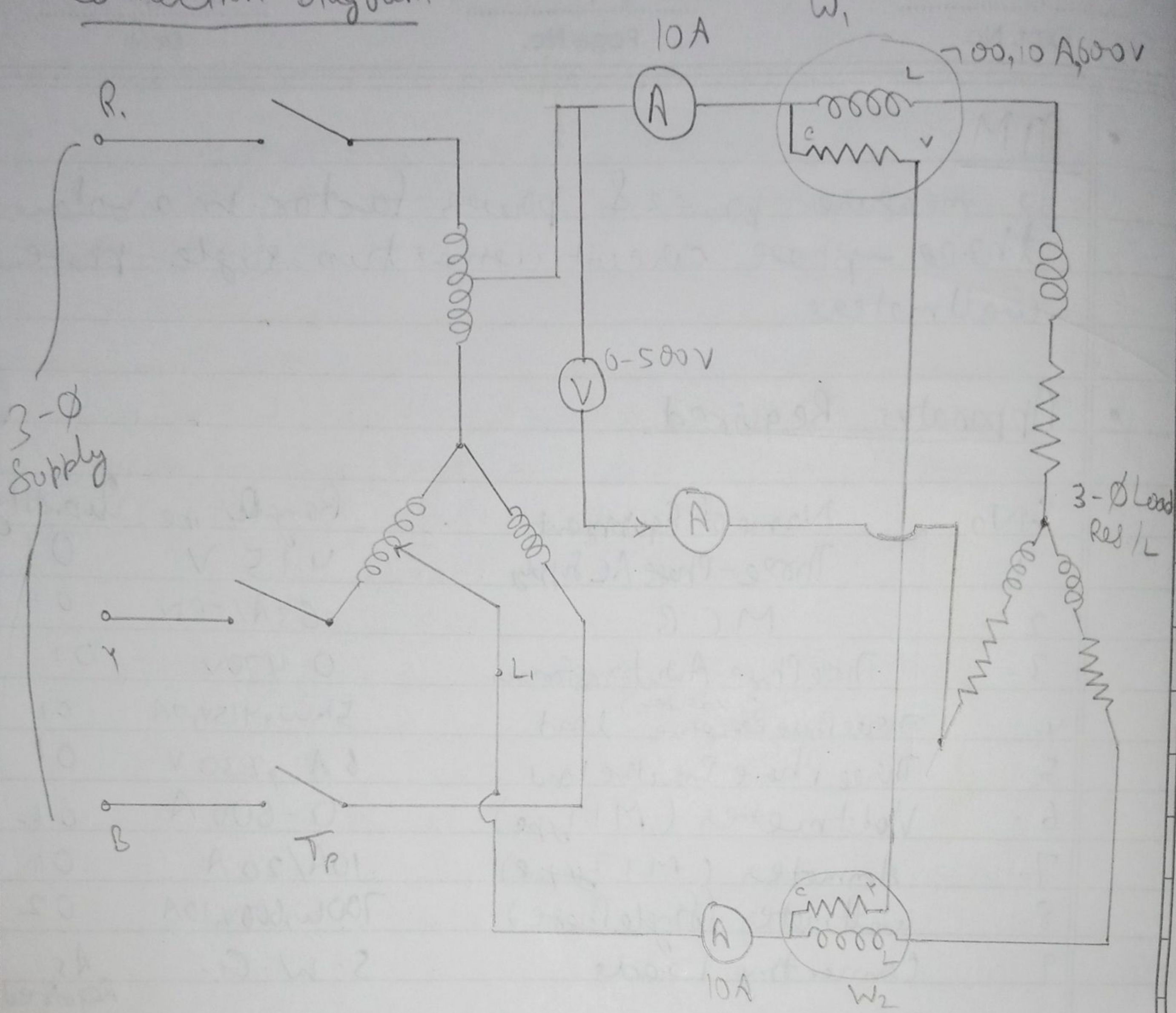
- **Apparatus Required**

S.No.	Name of Equipment	Range/Type	Quantity
1	Three-Phase AC Supply	415 V	01
2.	MCB	63A/TPN	01
3.	Three Phase Autotransformer (variac)	0-470V	01
4.	Three Phase Resistive Load	5KW, 415V, 7A	01
5.	Three Phase Inductive Load	6 A, 230 V	01
6.	Voltmeter (MI Type)	0-600 A	01
7.	Ammeter (MI Type)	10A/20 A	01
8.	Wattmeter (Single Phase)	700W, 600V, 10A	02
9.	Connecting Leads	S.W.G.	As Required,

- **Theory**

Surprisingly, only single phase wattmeters are sufficient to measure the power factor and total power in a balanced three-phase load. The current coils of wattmeters are connected in series with any two phases (lives) say R & Y. The voltage (pressure) coils of two wattmeters are connected b/w

• Connection Diagram



that phases (lines) and the third line.
If W1 & W2 are the readings of wattmeters, the total power consumed by three-phase load is:

$$P = W_1 + W_2$$

The phase angle of load can be calculated from the expression.

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

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

Then power factor is given as:

$$PF = \cos\phi$$

If V_L & I_L are the line voltage & line current for the balanced load, the total power is given as,

$$P = V_L I_L \cos\phi$$

- PROCEDURE

1. Make connection. Connect wattmeter, ammeter & voltmeter correctly as of their polarities and properly choose the current & voltage ranges of wattmeter.
2. Keep the 3-ϕ variac at zero voltage output & switch on the 3 ϕ AC supply.

- Observation Table

S. No.	Power through RY $W1 * MF$ (W)	Power through YB $W2 * MF$ (W)	Power drawn by 3ϕ Load $P = W_1 + W_2$ (W)	Line Voltage V_L (V)	Line current I_L (A)
1	$45 \times 8 = 360$	$55 \times 8 = 440$	100	420	0.7
2	$55 \times 8 = 440$	$95 \times 8 = 760$	150	420	1.6
3	$140 \times 8 = 1120$	$140 \times 8 = 1120$	280	420	2.8
4	$185 \times 8 = 1400$	$175 \times 8 = 1400$	360	420	3.7
5.	$240 \times 8 = 1920$	$220 \times 8 = 1760$	460	420	4.6

- CALCULATIONS :

S. No.	Phase angle $\phi = \tan^{-1}\sqrt{3}\left(\frac{(W_1 - W_2)}{(W_1 + W_2)}\right)$	Power factor $\cos\phi$	Power $P = \sqrt{3}\, V_L I_L \cos\phi$
1	−9.82	0.98	499.03
2	−24.79	0.90	1047.54
3	0	1	2036.89
4	2.75	0.998	2686.22
5.	4.30	0.997	3336.28

3. Gradually increase the AC voltage with the help of 3Ø variac till the meters give enough deflection (415V), so that some observable readings are obtained in meters.
4. Put some value of load with the help of inductive coil.
5. Note down the readings of the ~~ua~~ voltmeter, ammeter & both the wattmeters
6. Increase the value of inductive load by change the position of switch on inductive load.
7. Switch off the supply, disconnect the circuit safely.

- Result

The power & power factor of three phase circuit has been calculated by 2-wattmeter method. And total power calculated by two wattmeter method & V-I method is approx same.

- Precautions

1. Before switching on the AC supply, the zero readings of the voltmeter and ammeters should be checked.
2. Meters of proper range and type should be selected.
3. The readings in the ammeter ~~and~~ should not exceed the current ratings of the wattmeters & load used.

4. Connections should be tight & correct.
5. During experiments, one ~~of~~ the wattmeter may give a negative reading. Since the ~~motor~~ meter does not have any marking for negative readings, the connections of either the current coil or the pressure coil should be reversed. The reading of ~~these~~ this meter should then ~~be~~ be recorded with negative sign.

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