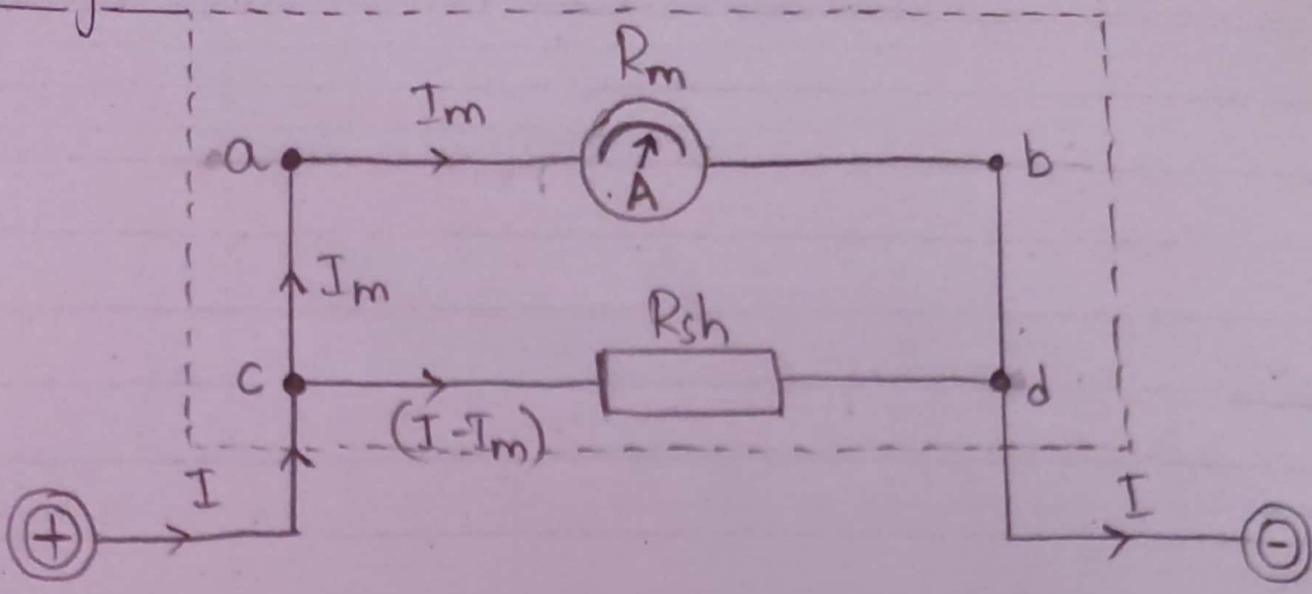
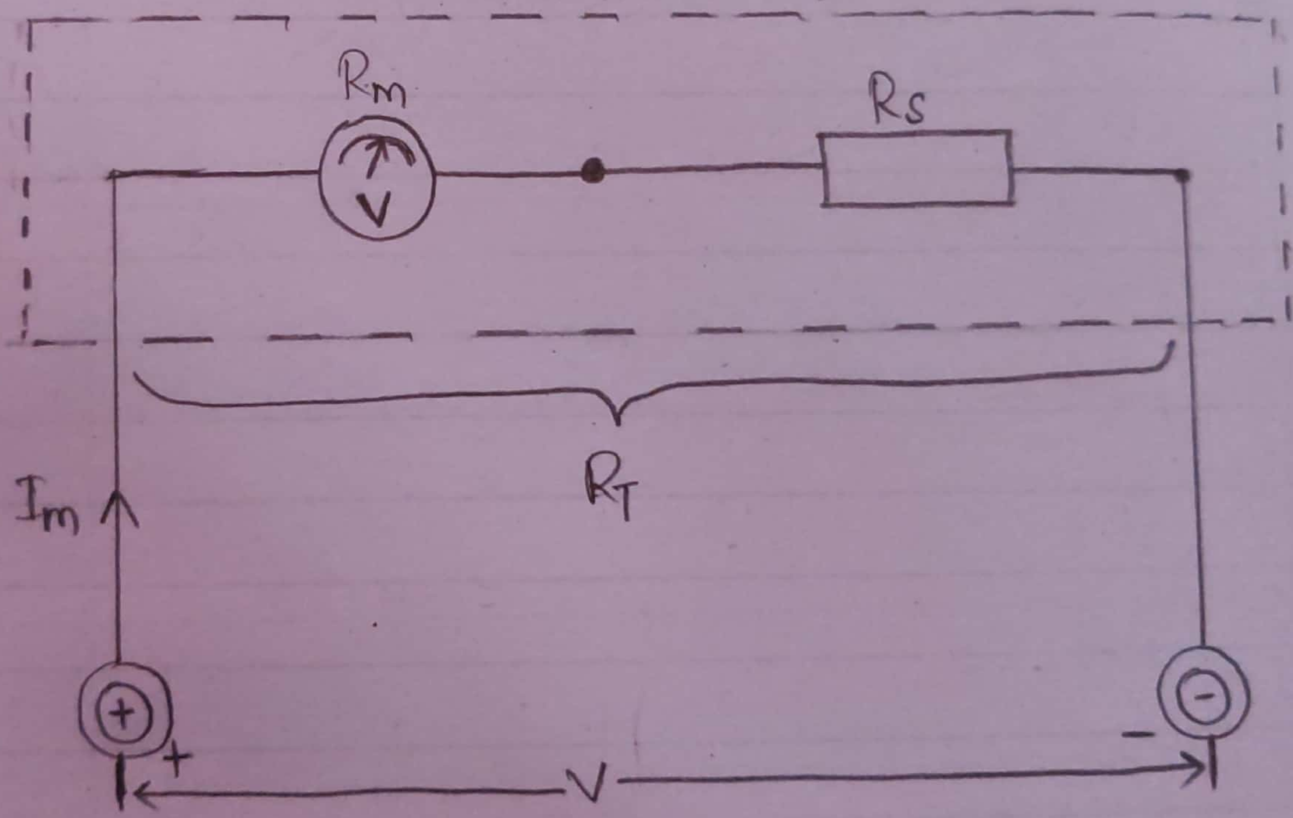
Circuit Diagram :



Fig(i) - AMMETER



Fig(ii) - VOLTMETER

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EXPERIMENT No: 01

PHYSICAL DEMONSTRATION OF DIFFERENT BASIC INSTRUMENTS.

Aim: To study physical demonstration of different basic instruments [Ammeter, Voltmeter & Wattmeter].

AMMETERS & VOLTMETERS:

Ammeters and Voltmeters operate on the same principle.

1. Ammeters:

An ammeter carries the current (or its definite fraction) to be measured and produces the deflecting torque.

An ammeter is connected in series with the circuit carrying the current to be measured. It must have very low resistance so that the voltage drop across the ammeter and the power absorbed from the circuit are as low as possible. Ideally, an ammeter should have zero resistance.

2. Voltmeters:

A voltmeter carries a current proportional to the voltage to be measured and produces the deflecting torque.

A voltmeter is connected in parallel with the circuit across which the voltage to be measured. It must have very high resistance, so that the currents taken by the voltmeter and the power absorbed from the circuit are as low as possible. Ideally, a voltmeter should have infinite resistance.

Circuit Diagrams:

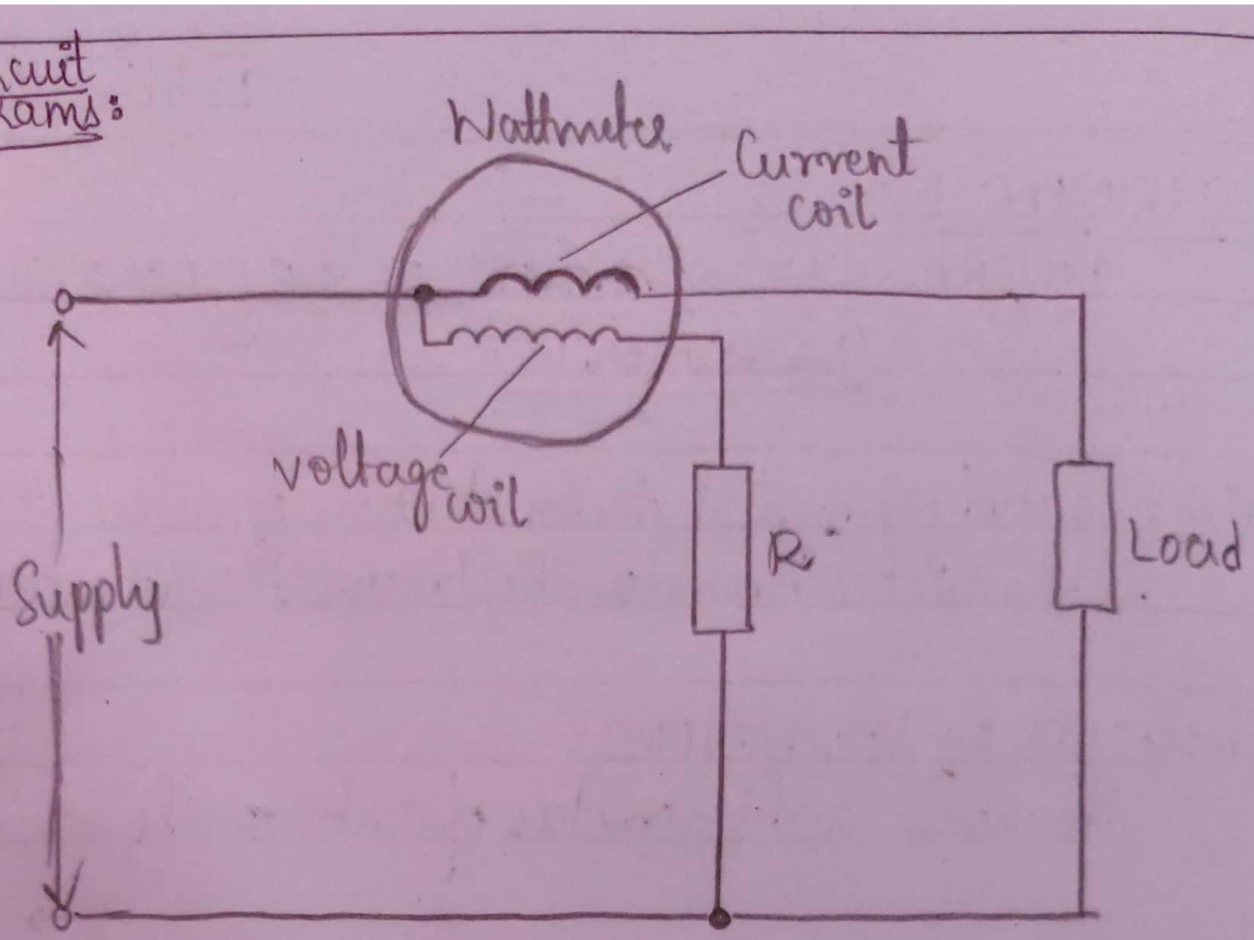

Fig (iii) - WATTMETER.

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WATTMETERS:

The wattmeter has 2 coils, namely fixed coil (current coil) and moving coil (voltage coil).

The fixed coil (which has usually 2 halves) is connected in series with the load and carries the load current. Hence, it is called current coil. It is wound with heavy thick wire so that it is capable of carrying large currents without much voltage drop.

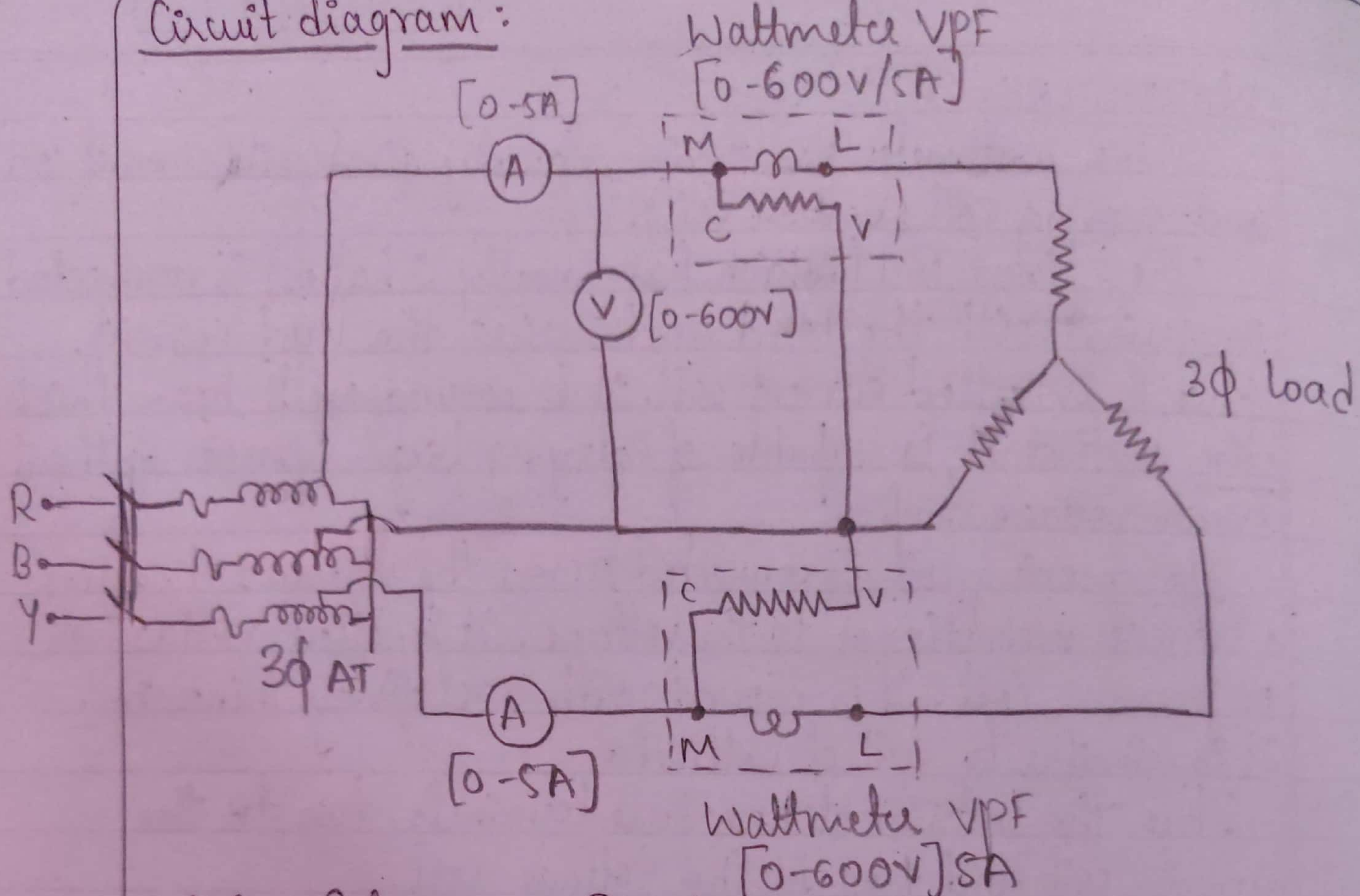
The moving coil is connected across the voltage. It carries a current proportional to the voltage. It is called voltage coil or pressure coil. It is wound with a relatively thin wire. It is similar to coil of voltmeter.

Thus the instrument has four terminals, two for the current coil and two for the voltage coil.

We use spring control in the wattmeter. These springs also carry current into and out of the current coil.

When used in an ac circuit, the deflection is proportional to the product of the voltage and the in-phase component of the current. Hence, the instrument measures the active power. In ac circuits, as the polarity of the applied voltage reverses, the direction of current in both the current coil & voltage coil also reverses. As a result, the fields due to the 2 coils also get reversed & hence the deflection of the instrument remains positive. Thus, this instrument is suitable for both ac & dc circuits.

Circuit diagram :



Tabular Column of Resistive Load :

No.	V in Volts	A_1 in Amperes	A_2 in Amperes	W_1 in Watts	W_2 in watts	$W = W_1 + W_2$	$\cos\phi$
1.	415	1.7	1.7	640	1360	2000	0.84
2.	415	2.8	2.8	968	2000	2968	0.85
3.	415	4.5	4.5	1440	3120	4560	0.84
4.	415	6.5	6.5	2240	4400	6640	0.87

Wattmeter Constant :

$$R = \frac{V \times I \times \cos\phi}{\text{full scale Read}} = \frac{600 \times 10 \times 1}{750} = 8$$

EXPERIMENT No: 02

MEASUREMENT OF POWER BY TWO-WATTMETERS METHOD WITH PHYSICAL DEMONSTRATION.

- Measurement of three phase power using two wattmeter method.

Aim: To measure three phase power using two wattmeters.

Apparatus Required:

1.	3ϕ Auto transformer	1 No.
2.	Ammeter [0-5A] MI	2 No.
3.	Wattmeter [0-600V] [0-5A] VPF	2 No.
4.	Voltmeter [0-600V] MI	1 No.
5.	Resistive load	1 No
6.	Inductive load	1 No.

Procedure:

1. Connections are made as shown in the circuit diagram.
2. Ensure that the 3ϕ auto transformer is in minimum position and load in zero position.
3. Now Switch on the power supply and vary the auto transformer to apply 415 volts.
4. Apply load in steps and note down the readings of ammeters and wattmeters at each step.

Tabular Column of Inductive Load:

No.	V in volts	A_1 in Amperes	A_2 in Amperes	W_1 in watts	W_2 in watts	$W=W_1+W_2$	$\cos\phi$
1.	415	1.7	1.7	60	-90	-30	0.11
2.	415	4	4	120	-195	-75	0.13
3.	415	5.1	5.1	150	-240	-90	0.132
4.	415	6	6	170	-285	-115	0.14

Calculations:

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

1. $\cos\phi = \left[\cos\left\{\tan^{-1}\sqrt{3}\,\frac{(640-1360)}{(640+1360)}\right\}\right] = \underline{0.84}$

2. $\cos\phi = \left[\cos\left\{\tan^{-1}\sqrt{3}\,\frac{(60-90)}{(60+90)}\right\}\right] = \underline{0.11}$

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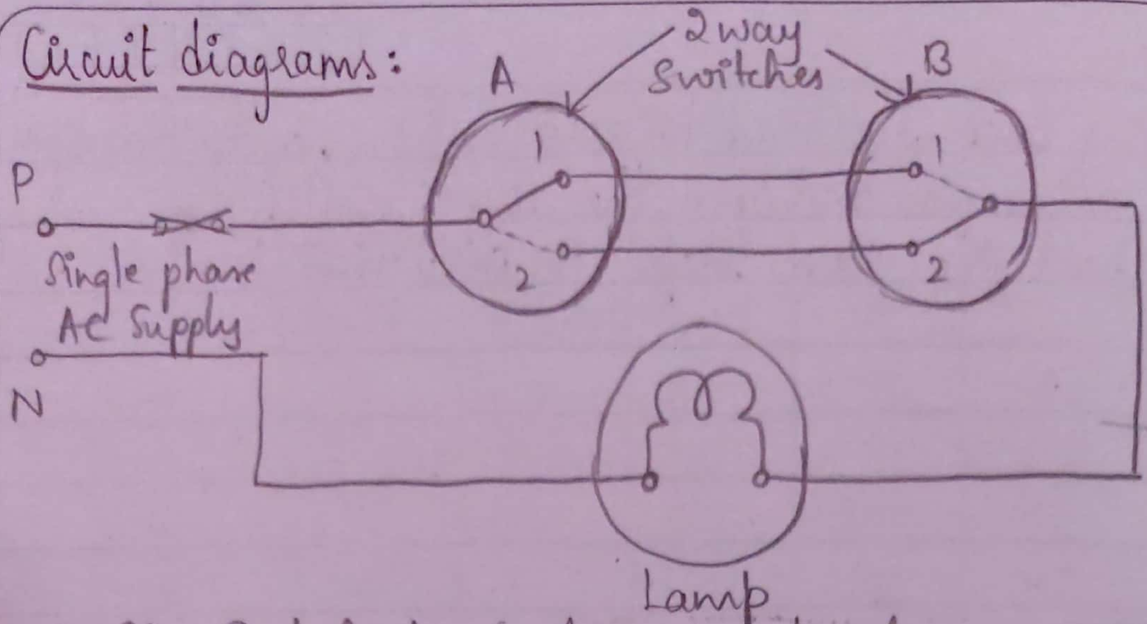
5. Bring back the load to zero position, auto transformer to minimum and open the supply switch.
6. Repeat the above steps for inductive load.

Result:

Measuring of 3 phase power using two wattmeters is conducted.

Circuit diagrams:



Fig(i) - Control of one from two points.

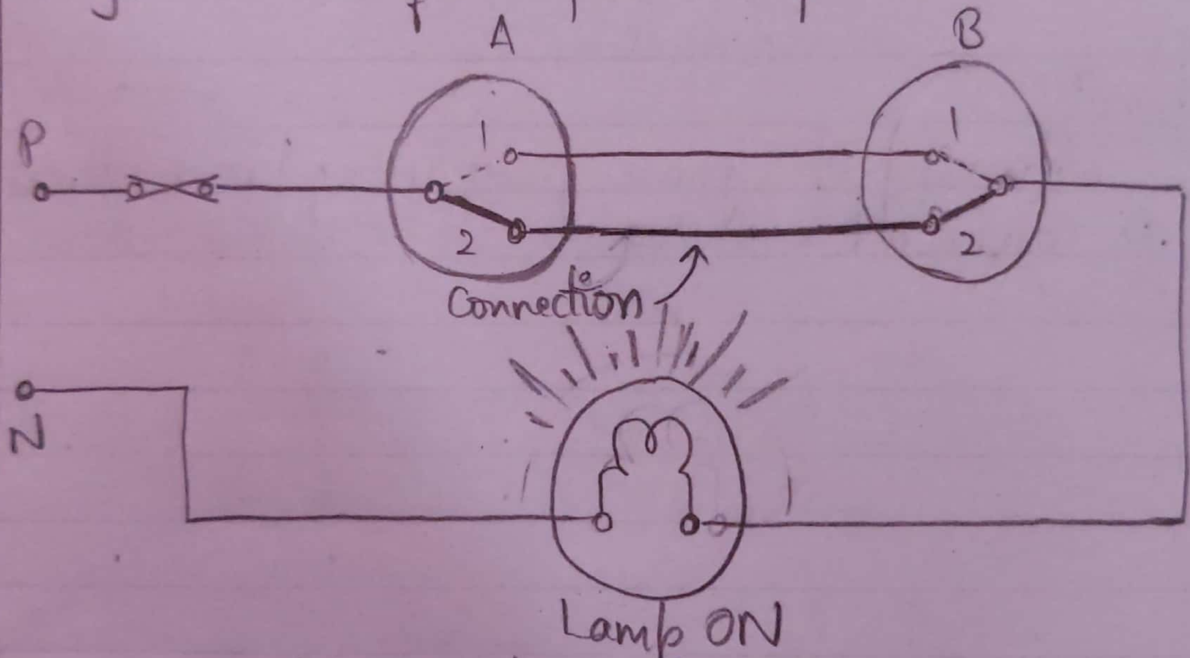


Fig (ii) - "ON" Position of lamp.

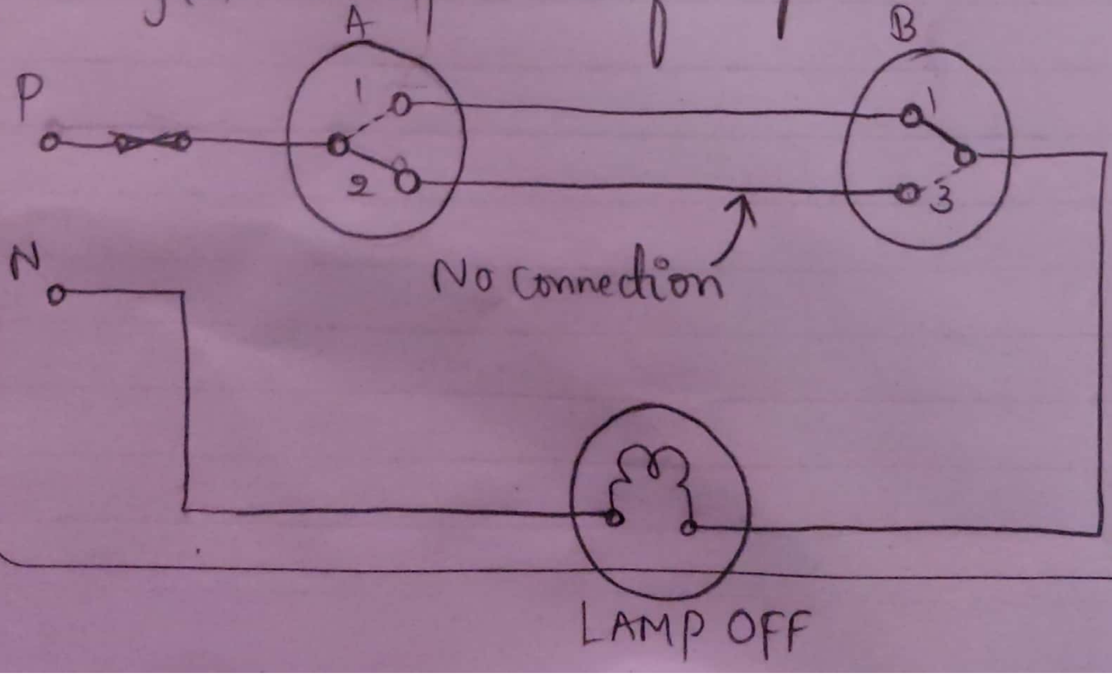


Fig (iii) "OFF" Position of lamp

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EXPERIMENT NO: 03
TWO-WAY AND THREE-WAY CONTROL OF LAMP WITH PHYSICAL EXPERIMENT.

Aim: To study two-way and three-way control of lamp with physical experiment.

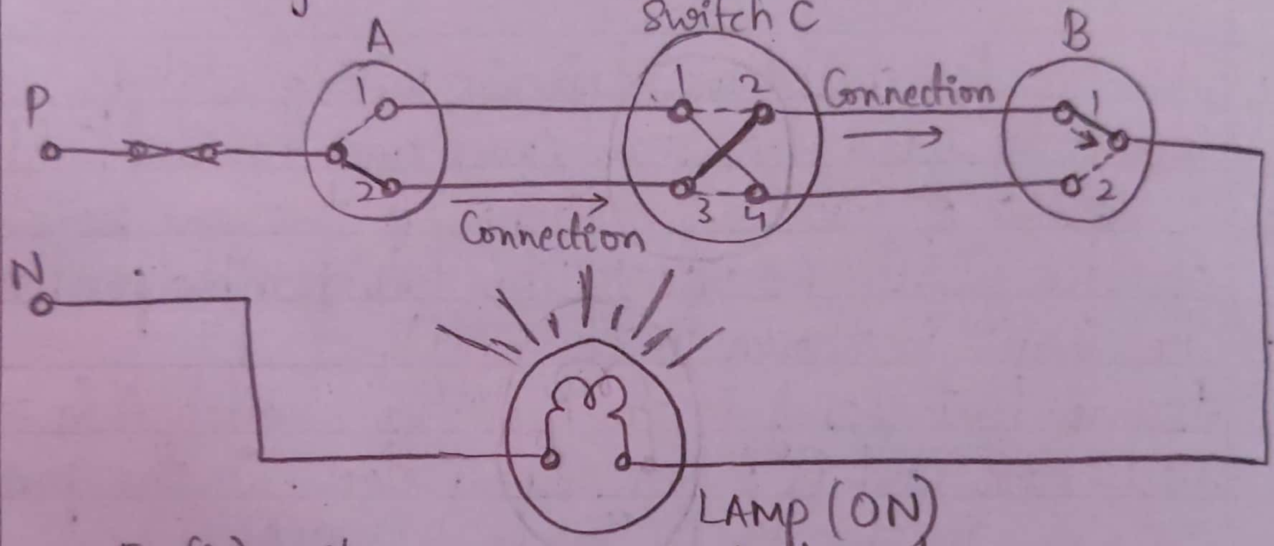
TWO-WAY CONTROL OF LAMPS-

1. This is also called as staircase wiring as it is commonly used for stair cases and corridor lighting.
2. It consist of two way switches. A two way switch operates always in one of the two possible positions.
3. The circuit is shown in the fig(i).
4. Assume that lamp is on first floor. Switch A is on first floor and B is on second floor. In the position shown in the fig(i), the lamp is OFF.
5. When person changes position of switch A from (1) to (2) then lamp gets phase through switches A and B & it gets switched ON.
6. This is shown in fig(ii).
7. When person reaches on second floor, the lamp is required to be switched OFF.
8. So person will change switch B from (2) to (1), due to which phase connection reaching to the lamp gets opened and lamp will be switched OFF
9. This is shown in the fig(iii)
10. Thus ON & OFF of one lamp can be controlled from 2 positions with the help of two way switches.

Switching table: Two-way control of lamps.

Switch →	A	B	Lamp
Positions →	1	1	ON
	1	2	OFF
	2	1	OFF
	2	2	ON

Circuit diagrams:



Fig(iv) - Three way control of lamps

Switching table: Three-way control of lamps.

Switch →	A	C	B	Lamp
Positions →	1	1-2, 3-4	1	ON
	1	1-4, 2-3	1	OFF
	1	1-2, 3-4	2	OFF
	1	1-4, 2-3	2	ON
	2	1-2, 3-4	1	OFF
	2	1-4, 2-3	1	ON
	2	1-2, 3-4	2	ON
	2	1-4, 3-4	2	OFF

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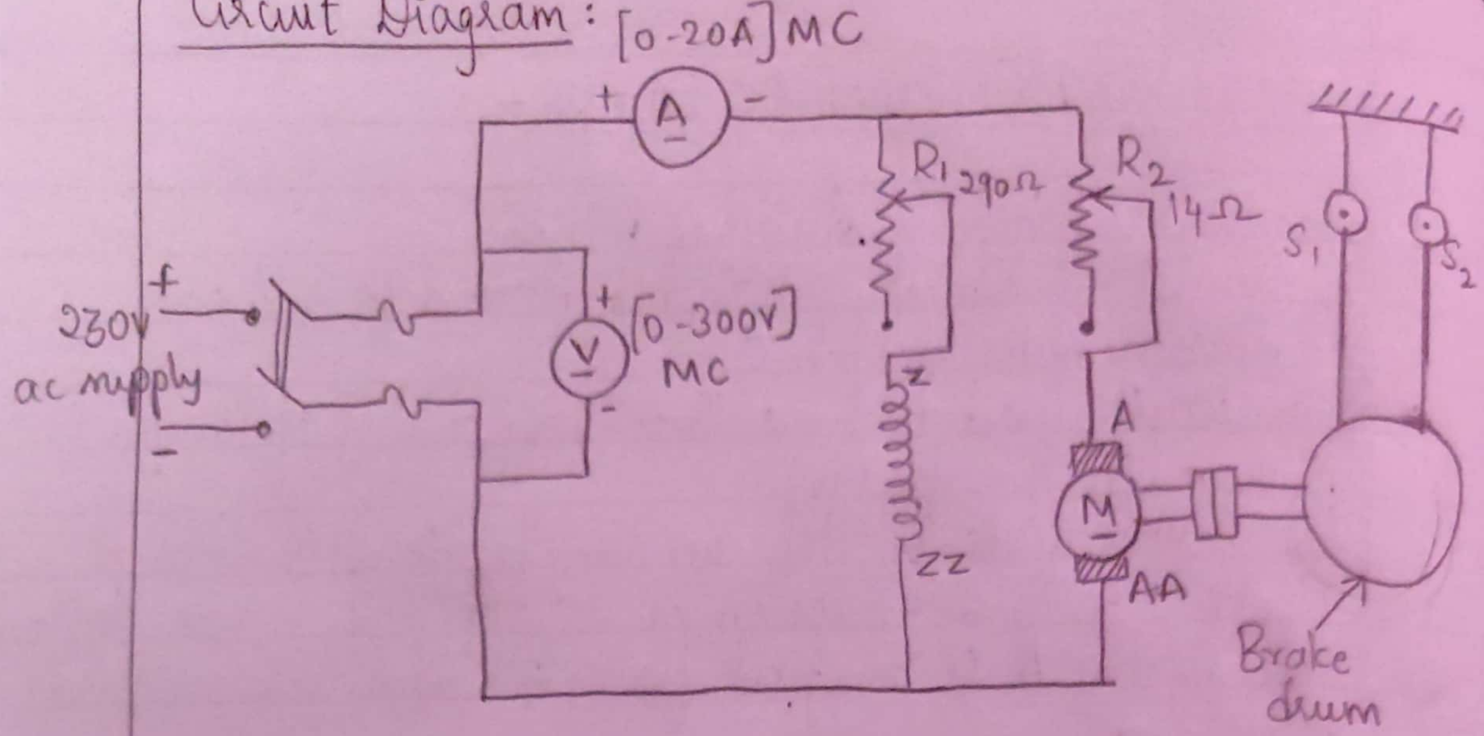
THREE-WAY CONTROL OF LAMPS -

1. This is also type of staircase wiring.
2. It Consist of two way switches A and B and one intermediate switch C.
3. The circuit used to have three way control of lamps is shown in the fig (iv).
4. The intermediate switch can have positions to connect points 1-4, 3-2 as shown or 1-2 & 3-4 shown dotted The switch A is on first floor & switch B is on third floor say.
5. In the position shown in fig(iv), the lamp is ON.
6. When person from floor 2 changes switch C position to have connections 1-2, & 3-4, then there is open circuit in the connection and lamp gets switched OFF.
7. Now if the person from third floor changes the position of switch B from 1-2, then again lamp gets supply through position 2 of A, 3-4 of C & 2 of B. The lamp gets switched ON.
8. Again if switch A position is changed, lamp gets switched OFF.
9. Thus we have the control of lamp from three different positions which is called three way control of lamps.
10. This is suitable for stair cases and corridors.

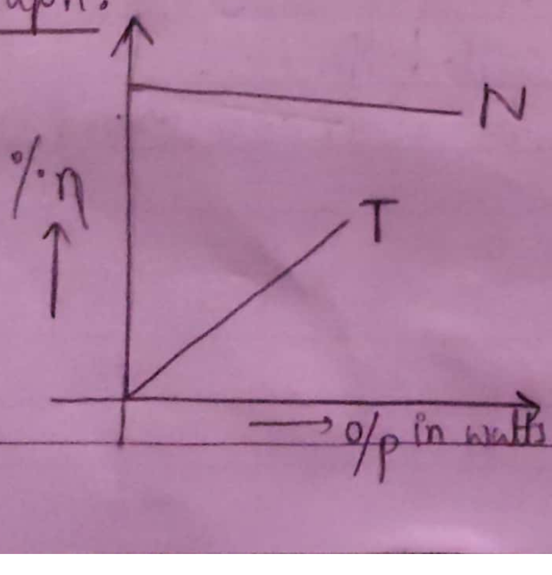
Circuit Diagram :



Tabular Column:

Sl. no	V in volts	I in Amperes	N in RPM	S_1 Kgs	S_2 kgs	Torque Nm	Input W	Output W	%η
1.	224	1.8	1500	0	0	0	403.2	0	0
2.	224	4.2	1460	6.5	1.8	3.507	940.8	535.11	56.8
3.	224	6.0	1420	9.6	3.0	4.49	1344	731.61	54.4
4.	224	6.6	1385	12	5.4	5.31	1478.4	7700	52.08

Ideal Graph:



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EXPERIMENT NO : 04

EXPERIMENTAL DEMONSTRATION OF TORQUE SPEED CHARACTERISTICS OF DC MOTORS.

- Load test on a DC motor Determination of speed and torque v/s efficiency characteristics.

Aim: To determine the load characteristics of DC shunt motor by conducting a load test on the given machine and plot the curves.

Apparatus Required:

1.	Ammeter MC	0-20A	2No.
2.	Voltmeter MC	0-300V	1No.
3.	Rheostat	0-290Ω/2.8A	2No
		0-14Ω/12A	1No
4.	Tachometer		1No.
5.	Connecting wires		as required.

Name plate details:

1.	kW/BHP	5kW/3.7BHP
2.	Voltage	230V
3.	Current	19A
4.	Speed	1500 rpm.

Calculations :

1. Torque $= [S_1 - S_2] \times r \times 9.81$ Nm

(i) $= [6.5 - 1.8] \times 0.082 \times 9.81$

$= 3.507$ Nm

(ii) $= [9.6 - 3.0] \times 0.082 \times 9.81$

$= 4.92$ Nm

2. Input $= V \times I$

(i) $= 224 \times 1.8 = 403.2$ W

(ii) $= 224 \times 4.2 = 940.8$ W

3. Output $= 2\pi N \times \frac{T}{60}$

(i) $= 2\pi \times 1460 \times \frac{3.50}{60} = 535.11$ W

(ii) $= 2\pi \times 1420 \times \frac{4.92}{60} = 731.61$ W

4. % Efficiency $= \frac{\text{Output}}{\text{Input}}$

(i) $= \frac{535.11}{940.8} = 56.87\%$

(ii) $= \frac{731.61}{1344} = 54.4\%$

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Procedure :

1. Make all the connections as per the circuit diagram.
2. Keeping the field Rheostat of motor [R_1] in cutout position and Rheostat connected in series with Armature [R_s] in cut in position. Close the supply switch.
3. The motor is brought to its rated speed first by cutting out the Armature Rheostat [R_2] and the motor and then by cutting in field Rheostat if necessary.
4. Note down the no load readings N, I and V.
5. Load the machines in steps by taking care to cool the drum. At each step note down the readings of S1 and S2 also.
6. To stop the machine, remove the load, bring the Rheostat to their original positions and open the supply switch.
7. Plot the curves (i) output v/s torque.
   (ii) output v/s speed.

Result:

The load characteristics of DC shunt motor by conducting a load test and plot the curves
(i) o/p v/s torque.
(ii) o/p v/s speed has been drawn.

EXPERIMENT No: 05

DEMONSTRATION OF CUT SECTION OF DC MACHINE.

Aim: To study the demonstration of cut section of DC machine.

A DC Machine mainly consists of two parts (i) stationary part and (ii) rotating part. The stationary part produces a constant magnetic flux and the rotating part converts the mechanical energy into electrical energy.

STATIONARY PARTS:

The Stationary parts consists of (i) Yoke or magnetic frame, (ii) Main poles along with pole shoes and pole coils (iii) Base plate, (iv) Lifting eye, (v) Brush box with brushes and (vi) Terminal box.

(i) Yoke or magnetic frame:

Yoke forms the outer cover for the D.C. machine & is cylindrical in shape as shown in fig(i). For small generators, yoke is made of cast iron whereas for large generators, it is made of cast steel. The yoke supports the field system and also forms the part of the magnetic circuit.

(ii) Main poles, pole shoes and pole coils:

The main poles are made of an alloy steel of high relative permeability. The pole core is laminated to reduce eddy current losses. Thin sheets of alloy steel are

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from one another and pressed together to form the core. The laminations are held tightly with the help of end plates, which are rivetted together. The poles are fixed to the yoke with the help of bolts. The tail end of the bolt is screwed into the threaded holes of the steel bar, so that the poles are held tightly to the yoke. The pole core supports the field coils. The pole shoe is fixed to the pole core by means of counter sunk screws. The shape of the pole shoe is cylindrical at the bottom.

The base plate, the lifting eye, the terminal box and the brush box are cast integral with the yoke.

(iii) Base plate:

The base plate enables the machine to be placed conveniently on the ground or any platform

(iv) Lifting eye:

The lifting eye is used to lift the generator (machine) and to transfer it from one place to the other.

(v) Brush box along with brushes:

The brush box carries the brushes inside them, which are made of carbon or graphite. The brushes collect current from the armature conductors via commutator segments and deliver it to the external load.

(vi) The terminal box:
The terminal box contains the output terminals of the DC machine, to which, any load can be connected.

ROTATING PARTS:
The rotating parts consists of the (i) Armature, (ii) Armature windings, (iii) Commutator & (iv) Shaft.

(i) Armature:
The armature consists of armature core and armature windings.
The armature core is made of high permeability & low loss silicon steel laminations, which are usually 0.4 to 0.5mm thick and are insulated from one another by varnish. The laminations are clamped together tightly b/w two flanges. There are slots cut uniformly on the outer periphery of the armature core and armature conductors are placed in these slots as shown in fig (iii).

(ii) Armature windings:
The armature conductors are connected together either as a lap winding or a wave winding.

(iii) Commutator:
The commutator converts the alternating emf generated in the armature windings into direct current voltage in the external circuit. The commutator is cylindrical in shape and is built of wedge shaped

segments made of hard drawn copper, which are insulated from one another and from the shaft by mica strips.

(iv) Shaft:

The shaft of the DC machine is rotated by a prime mover, due to which, the armature fixed to it also rotates.

EXPERIMENT NO: 06
DEMONSTRATION OF TRANSFORMER CUT SECTIONS.

Aim: To study the demonstration of transformer cut section.

The main parts of an actual transformer used in power circuits are as follows:

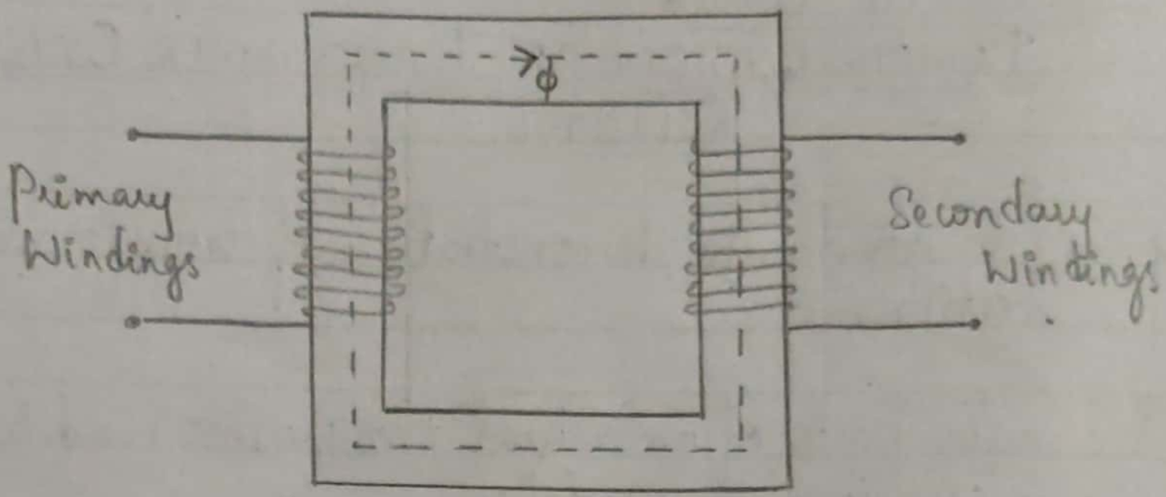
(i) An iron core that provides a magnetic circuit
(ii) Two inductive coils wound on the core. These are suitably insulated from each other and also from the core.
(iii) A suitable container for the assembled core and windings
(iv) A suitable medium (transformer oil) for insulating the core and windings from the container. This medium also cools the windings and core of the transformer.
(v) Suitable porcelain bushings for insulating and bringing out winding terminals from the tank.

CORE OF TRANSFORMER:

The core is made of steel laminations so as to minimise eddy-current losses. The laminations are about 0.35 mm thick and are insulated from each other by a light coat of varnish on the surface.

Depending upon the construction of the core, there are two types of transformers:

Diagrams:



Fig(i) - Core type transformer

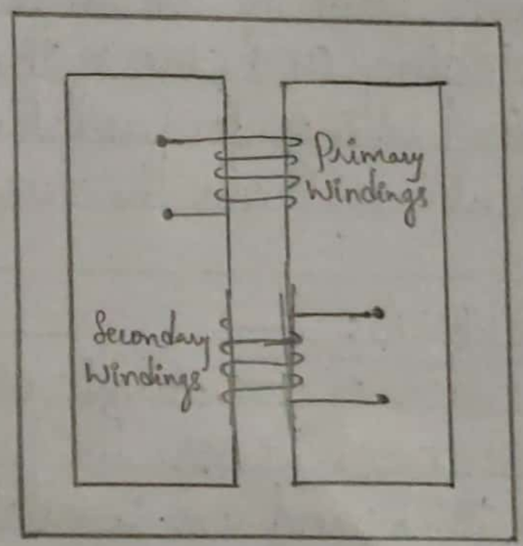


Fig (ii) - Shell type transformer.

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(i) CORE TYPE TRANSFORMER:

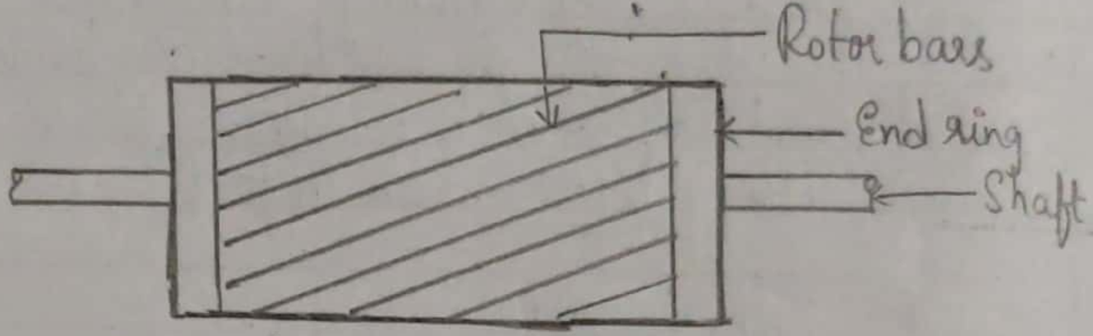
In this type, the windings surround a considerable part of the core. Both the windings are divided into 2 parts and half of each winding is placed on each limb, side by side as shown in fig (i).

(ii) SHELL TYPE TRANSFORMER:

It has three limbs. Both the windings are placed on the central limb as shown in fig (ii). Here, the core surrounds a considerable part of the windings.

In core-type transformer, the flux has single path. But in shell-type transformer, the flux in the central limb divides equally and returns through the outer two legs. Since there is more space for insulation in the core-type transformer, it is preferred for high voltages. On the other hand, the shell-type construction is more economical for low voltages.

Diagram:



Fig(i) - Squirrel Cage Rotor

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EXPERIMENT No: 07
DEMONSTRATION OF INDUCTION MOTOR CUT SECTION.

Aim: To study the demonstration of induction motor cut section.

An induction motor has a stator and a rotor.

STATOR: The stator has three-phase windings which receive energy from three-phase ac supply.
The stator core is hollow cylindrical structure. It is made of sheet-steel laminations, each about 0.4 mm thick, slotted on its inner surface. The slots in large size motors are open type to facilitate the insertion of form-wound coils. In small size motors, the slots are partially closed type. The coils are extremely wound and are inserted through the narrow openings one wire at a time.

ROTOR: The rotor is an inner cylindrical core. It may be either squirrel-cage type or wire-wound type.

1. Squirrel Cage Rotor: This rotor has two main advantages. First, it is adaptable to any no. of poles. Secondly, it is simple in construction, has no slip rings and brushes, is very rugged and is very economical in manufacturing. The only disadvantage it has is that its resistance is low (and fixed) and hence it has low starting torque.

Diagram:

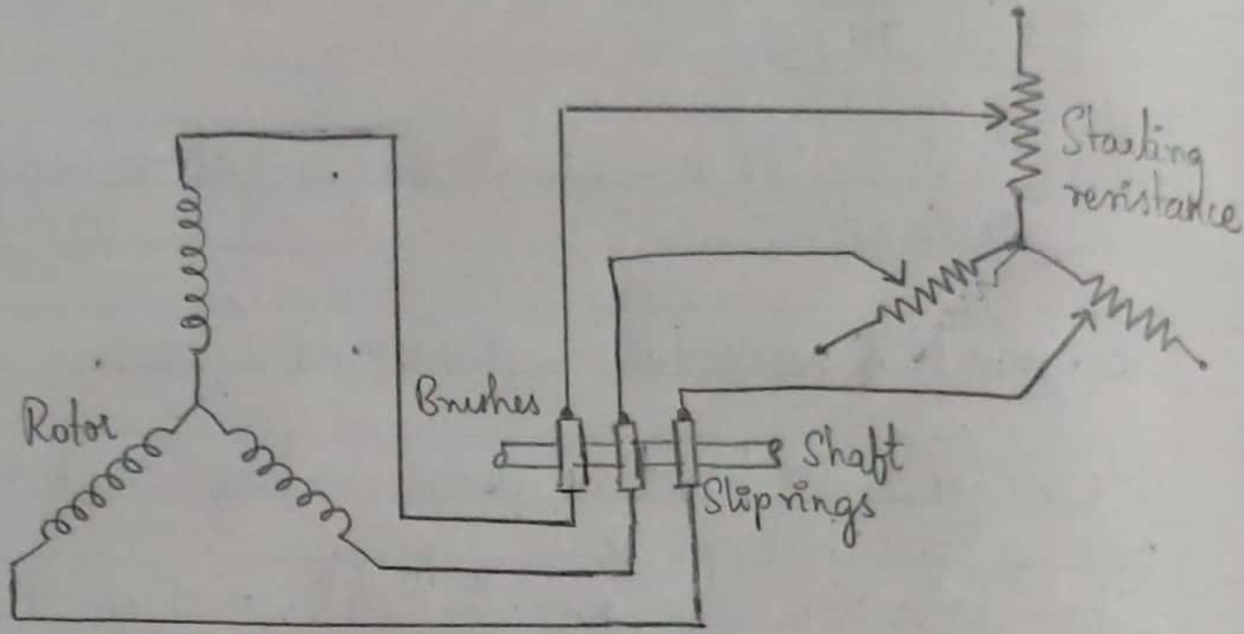

Fig (ii) - Wire (or) Phase Wound Rotor

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2. Wire - (or) Phase - Wound Rotor: It has three-phase double layer distributed windings placed in the slots of the rotor core. It is wound for the same no. of poles as the stator. The windings are usually connected in star, though they may be connected in delta. The 3 ends of the windings are brought out and are soldered to the slip rings mounted on the shaft. Carbon brushes, fixed with the stator, make contact with these moving slip rings. This arrangement makes it possible to connect additional resistances in the rotor windings to give high starting torque.