GOVT CO-ED POLYTECHNIC

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LAB MANUAL

Branch : Mechanical Engineering

Year & Semester : 2nd Year / 3rd Semester

2037371(025) = B E E *(Lab)*

EXPERIMENT - 1

(A) VERIFICATION OF KVL AND KCL

1.1 AIM:

To verify Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) in a Passive Resistive Network .

1.2 APPARATUS:

S. No	Apparatus Name	Range	Type	Quantity
1	RPS			
2	Ammeter			
3	Voltmeter			
4	Resistors			
5	Bread Board	-	-	01
6	Connecting Wires	-	-	As required

1.3 CIRCUIT DIAGRAMS:

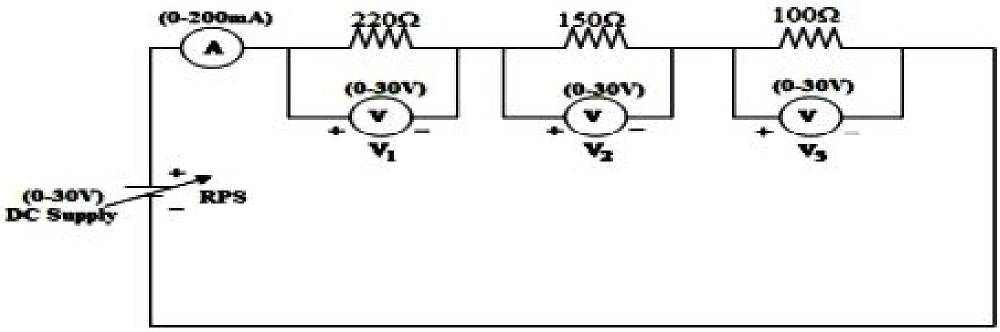


Figure – 1.1 Verification of KVL

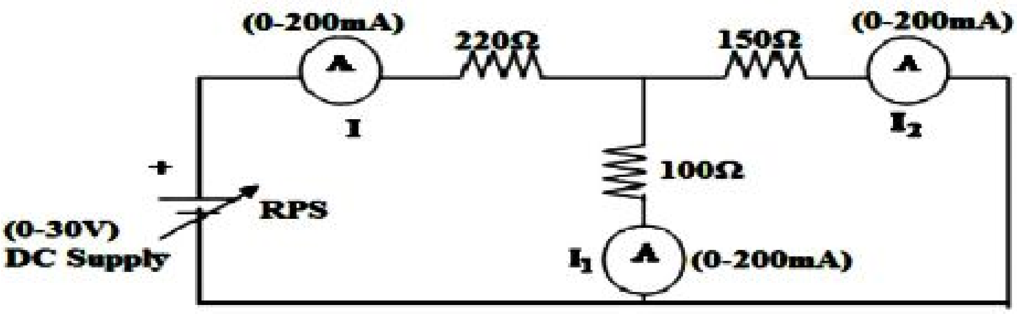


Figure – 1.2 Verification of KCL

1.4 PROCEDURE:

To Verify KVL

1. Connect the circuit diagram as shown in Figure 1.
2. Switch ON the supply to RPS.
3. Apply the voltage (say 5v) and note the voltmeter readings.
4. Gradually increase the supply voltage in steps.
5. Note the readings of voltmeters.
6. sum up the voltmeter readings (voltage drops) , that should be equal to applied voltage .
7. Thus KVL is Verified practically.

To Verify KCL

1. Connect the circuit diagram as shown in Figure 2.
2. Switch ON the supply to RPS.
3. Apply the voltage (say 5v) and note the Ammeter readings.
4. Gradually increase the supply voltage in steps.
5. Note the readings of Ammeters.
6. Sum up the Ammeter readings (I_1 and I_2) , that should be equal to total current (I).
7. Thus KCL is Verified practically

1.5 OBSERVATIONS:

For KVL

Applied Voltage V (volts)	V_1 (volts)		V_2 (volts)		V_3 (volts)		$V_1+V_2+V_3$ (volts)	
	Theoritical	Practical	Theoritical	Practical	Theoritical	Practical	Theoritical	Practical

For KCL

Applied Voltage V (volts)	I (A)		I_1 (A)		I_2 (A)		I_1+I_2 (A)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical

1.6 PRECAUTIONS:

1. Check for proper connections before switching ON the supply
2. Make sure of proper color coding of resistors
3. The terminal of the resistance should be properly connected.

1.7 RESULT:

(B)VERIFICATION OF KVL AND KCL USING DIGITAL SIMULATION.

1.8 AIM:

To verify Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) using digital simulation.

1.9 APPARATUS:

S. No	SOFTWARE USED	DESK TOP QUANTITY
1	MATLAB	01

1.10 CIRCUIT DIAGRAMS:

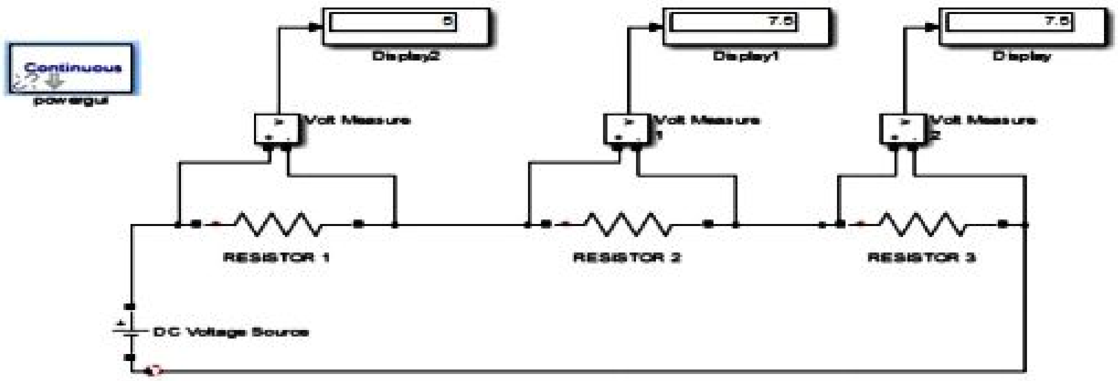


Figure – 1.3 Verification of KVL

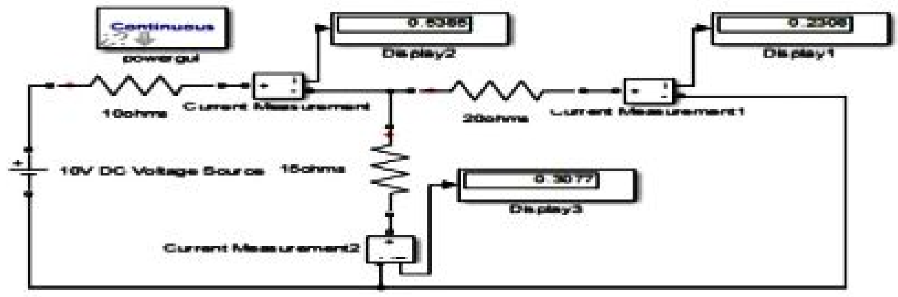


Figure – 1.4 Verification of KCL

1.11 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using MATLAB Simulink.
2. Measure the voltages and currents in each resistor.
3. Verify the KVL and KCL.

1.12 OBSERVATIONS:

For KVL

Applied Voltage V (volts)	V_1 (volts)		V_2 (volts)		V_3 (volts)		$V_1+V_2+V_3$ (volts)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical

For KCL

Applied Voltage V (volts)	I (A)		I_1 (A)		I_2 (A)		I_1+I_2 (A)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical

1.13 RESULT:

1.14 PRE LAB VIVA QUESTIONS:

1. Define current.
2. Define voltage.
3. What is resistance?
4. Define ohm's law.
5. State KCL and KVL.

1.15 POST LAB VIVA QUESTIONS:

1. What do you mean by junction?
2. Derive current division rule.
3. Explain the sign conventions.
4. Explain the color coding of resistors.

4.11 PROCEDURE:

1. Make the connections as shown in the circuit diagram by using MATLAB Simulink.
2. Measure the Peak value of the voltage obtained
3. Verify with the practical results obtained with theoretical results

4.12 OBSERVATIONS & CALCULATIONS:

Peak value (V)	RMS value (V)	Averagevalue (V)

4.13 RESULT:

4.14 PRE LAB VIVA QUESTIONS:

1. What is complex wave?
2. Define Instantaneous value.
3. Why RMS value is not calculated for DC quantity?
4. Define RMS Value.
5. What is the expression for form factor and peak factor?

4.15 POST LAB VIVA QUESTIONS:

1. What is RMS value of Sin wave?
2. Why RMS value is specified for alternating Quantity?
3. Why average value is calculated for half cycle for an sine wave?
4. Define form factor and peak factor for an alternating wave.

EXPERIMENT - 2

AVERAGE VALUE, RMS VALUE, FORM FACTOR, PEAK FACTOR OF SINUSOIDAL WAVE, SQUARE WAVE

4.1 AIM:

To determine the average value, RMS value, form factor, peak factor of sinusoidal wave, square wave.

4.2 APPARATUS

S. No	Name	Range	Quantity
1	Resistors	100Ω	2 Nos
2	Inductor	1 mH	1 No
3	Function Generator		1 No
4	Multimeter		1 No
5	CRO		1 No

4.3 THEORY:

In alternating current (AC, also ac) the movement (or flow) of electric charge periodically reverses direction. An electric charge would for instance move forward, then backward, then forward, then backward, over and over again. In direct current (DC), the movement (or flow) of electric charge is only in one direction.

Average value: Average value of an alternating quantity is expressed as the ratio of area covered by wave form to distance of the wave form.

Root Mean Square (RMS) Value: The RMS value of an alternating current is expressed by that steady DC current which when flowing through a given circuit for given time produces same heat as produced by that AC through the sane circuit for the same time period. In the common case of alternating current when I(t) is a sinusoidal current, as is approximately true for mains power, the RMS value is easy to calculate from the continuous case equation above. If we define Ip to be the peak current, then in general form

$$I_{\mathrm{RMS}} = \sqrt{\frac{1}{T_2 - T_1}\int_{T_1}^{T_2} (I_{\mathrm{p}}\sin(\omega t))^2 dt}.$$

Where t is time and ω is the angular frequency ($\omega = 2\pi/T$, where T is the period of the wave).
For a sinusoidal voltage,

$$V_{\mathrm{rms}} = \frac{V_{\mathrm{peak}}}{\sqrt{2}}.$$

The factor is called the crest factor, which varies for different waveforms. For a triangle wave form centered about zero.

$$V_{\text{rms}} = \frac{V_{\text{peak}}}{\sqrt{3}}.$$

For a square wave form centered about zero

RMS (Root Mean Square) value of an ac wave is the mean of the root of the square of the voltages at different instants. For an ac wave it will be $1/\sqrt{2}$ times the peak value.

4.4 CIRCUIT DIAGRAM:

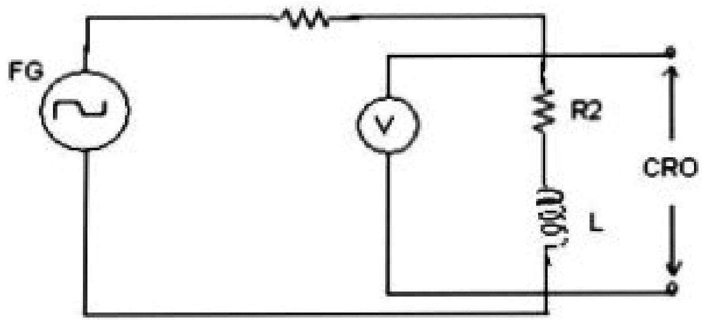


Fig – 4.1 Basic Circuit

4.5 PROCEDURE:

1. Connect the circuit as shown in the circuit diagram of fig. 4.1.
2. Set the value of frequency say 100 Hz in the function generator.
3. Adjust the ground of channel 1 and 2 of Cathode Ray Oscilloscope and then set it into DC mode.
4. Connect CRO across the load in DC mode and observe the waveform. Adjust the DC offset of function generator.
5. Note down the amplitude and frequency.
6. Set the multimeter into AC mode and measure input voltage and voltage across point AB. This value gives RMS value of sinusoidal AC.
7. Calculate the average value.
8. Repeat experiment for different frequency and different peak to peak voltage.
9. Measure the RMS and Average value of DC signal also where instead of function generator you can use DC supply.

4.5 OBSERVATIONS & CALCULATIONS:

Peak value (V)	RMS value (V)	Average value (V)

4.6 PRECAUTIONS:

1. Check for proper connections before switching ON the supply
2. Make sure of proper color coding of resistors
3. The terminal of the resistance should be properly connected

4.7 RESULT:

(B) AVERAGE VALUE, RMS VALUE, FORM FACTOR, PEAK FACTOR OF SINUSOIDAL WAVE, SQUARE WAVE USING DIGITAL SIMULATION

4.8 AIM:

To Determine the average value, RMS value, form factor, peak factor of sinusoidal wave, square wave.

4.9 APPARATUS:

S. No	SOFTWARE USED	DESKTOP QUANTITY
1	MATLAB	01

4.10 CIRCUIT DIAGRAM:

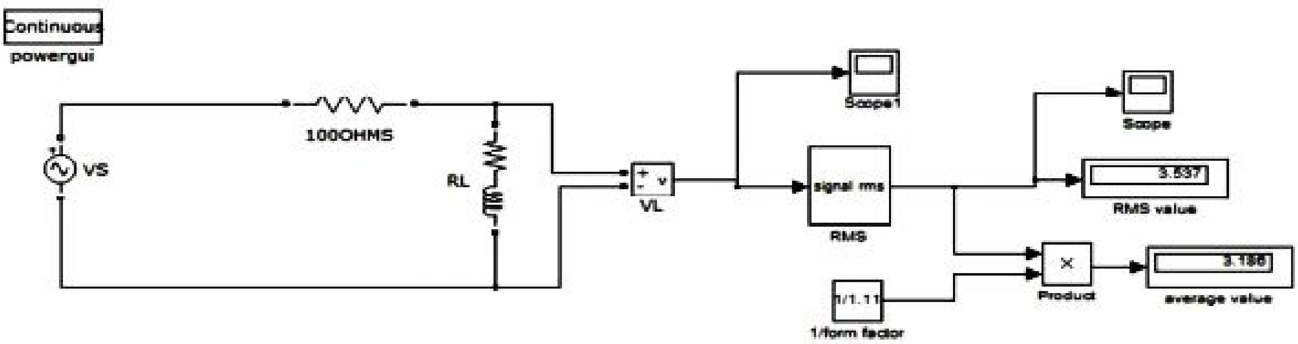


Fig – 4.2 MATLAB Simulink circuit

EXPERIMENT NO. 03

Measurement of Power in Single Phase a.c. Circuit

Object :

To measure the Active and Reactive.

Power in single phase a.c. circuit.

Apparatus Used :

(1) 1-Phase Auto transformer-1 No. (10 A, – 270 V)

(2) Wattmeter-Dynamometer type-1 No. (10 A, 250 V)

(3) Ammeter-Moving Iron type-1 No. (0—10 A)

(4) Voltmeter-Moving Iron type ; 1 No. (0—250 V)

(5) Resistive and Inductive load.

(6) Connecting leads.

Theory :

The power which is actually consumed or utilised in an a.c. circuit is called true power or active power or real power.

As power is consumed only in resistance and a pure inductor and a pure capacitor do not consume any power in a cycle. Since in a half cycle whatsoever power is received from the source by Inductor and capacitor and the same amount of power is returned to the source. This power which flows back and forth or reacts upon itself is called reactive power. It does not do any useful work in circuit.

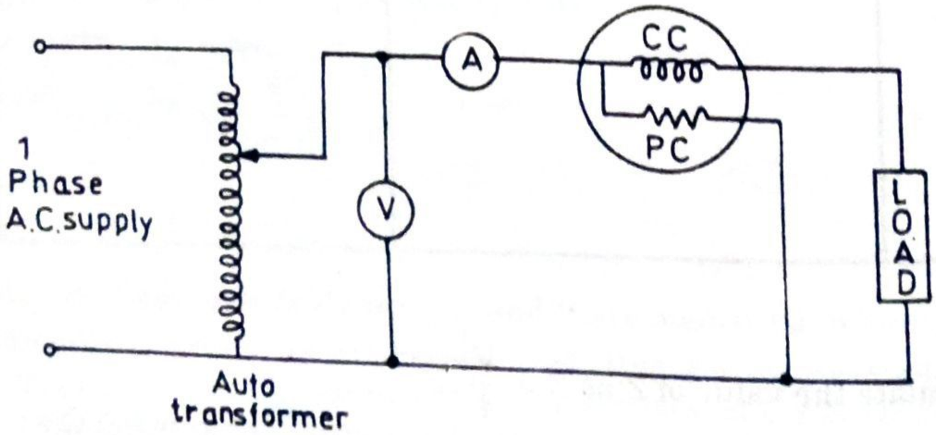
Therefore true power or active power = Voltage × Current in phase with voltage

$= V \times I \cos \phi = VI \cos \phi$ watt.

and Reactive power = Voltage × Current 90° out of phase with voltage.

$= V \times I \sin \phi = VI \sin \phi.$

Circuit Diagram :



(*a*)

Procedure :

(1) Connect the Instruments, Autotransformer and Load as shown in Fig. (*a*) and setup to Auto transformer to zero position.

(2) Switch on the supply and adjust the Autotransformer till a suitable voltage.

(3) Vary the voltage by Autotransformer and take down the various readings of Voltmeter, Ammeter and Wattmeter.

Observations :

S. No.	*Voltmeter Readings V in volts*	*Ammeter Reading I in Amp.*	*Wattmeter Readings P in watts.*	*Reactive Power $Q = VI \sin \phi$*
1.				
2.				
3.				
4.				
5.				

Calculation :

(*i*) Calculate the value of P.F. $\cos \phi$ from different readings as

$$\cos \phi = \frac{\text{Wattmeter Reading}}{(\text{Voltmeter} \times \text{Ammeter}) \text{ Reading}}$$

(*ii*) Calculate the value of Reactive power as

$$Q = VI \sin \phi = VI\,(1 - \cos^2 \phi)^{1/2}.$$

Result : Power at different voltages is ..... watts and conclusion is that power varies as square of the applied voltage.

EXPERIMENT NO. 04

Measurement of Power in 3 Phase A.C. circuit by Two Wattmeter Method

Object :

(1) To Measure the Active Reactive power in 3ϕ circuit.

(2) To measure the power factor.

Apparatus Used :

1. 3-phase Auto transformer 10 Amp.
2. Wattmeter Dynamometer type 2 No. (10 A; 500 V)
3. Ammeter Moving Iron type : 1 No. (10 A)
4. Voltmeter Moving Iron type 1 No. (500 V)
5. 3ϕ Inductive load or 3ϕ Induction motor (415 V, 5 H.P.)
6. Connective leads.

Theory :

Two Wattmeter Method can be employed to measure power in a 3-phase, 3 wire star or delta connected balance or unbalanced load. In this method, the current coils of the wattmeters are connected in any two lines say *R* and *Y* and the potential coil of each wattmeter is joined across the same line and the third line *i.e.*, *B*.

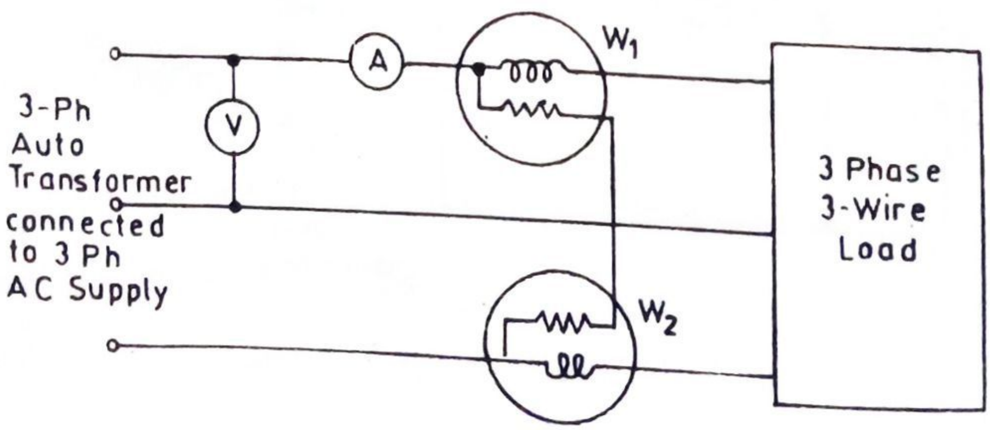
Then the sum of the power measured by two wattmeters W_1 and W_2 is equal to the total power absorbed by the 3ϕ load.

Total power $$P = \sqrt{3}\, V_L I_L \cos\phi = W_1 + W_2 \text{ watts.}$$

∴ Power factor $$= \cos\phi = \frac{W_1 + W_2}{\sqrt{3}\, V_L\, I_L}$$

and reactive power of load $= Q = \sqrt{3}\,(W_1 - W_2)$.

Circuit Diagram :



(*a*)

Procedure :

1. Connect the Voltmeter, Ammeter and Wattmeters to the load through 3ϕ Autotransformer as shown in Fig. (*a*) and set up the Autotransformer to zero position.

2. Switch on the 3ϕ A.C. supply and Adjust the Autotransformer till a suitable voltage. Note down the readings of wattmeters, voltmeter and ammeter.

3. Vary the voltage by Autotransformer and note down the various Readings.

Observations :

S.No.	*Voltmeter Readings V in volts.*	*Ammeter Readings I in Amp.*	*Wattmeter Readings in Watt*		*Total Power* $P = W_1 + W_2$	*Total Reactive Power* $Q = \sqrt{3}(W_1 - W_2)$	*Power factor* $\cos\phi = \frac{W_1 + W_2}{\sqrt{3}V_L I_L}$
			W_1	W_2			
1.							
2.							
3.							
4.							
5.							

Calculation :

$$\text{Total Power} = (W_1 + W_2) \times \text{Multiplying factor}$$

$$\tan\phi = \sqrt{3}\,\frac{W_2 - W_1}{W_1 + W_2}$$

$$\phi = \tan^{-1}.\ \sqrt{3}\,\frac{W_2 - W_1}{W_1 + W_2}$$

$$P \text{ Factor} = \cos\phi$$

$$\text{Reactive power} = \sqrt{3}\ W_1 - W_2.$$

Result : The power measured in the circuit is shown in test and the corresponding power factors in last column.

Precautions and Sources of Errors :

1. Proper currents and voltage ranges must be selected before putting the instruments in the circuit.

2. If any wattmeter reads backwards, reverse its pressure coil connections and record the reading as negative.

3. As the supply voltage fluctuates it is not possible to observe the readings correctly.

Report. Whether the power can be measured by one Wattmeter in above case if possible, draw the connection diagram.

EXPERIMENT NO. 05

Study of Transformer Name Plate Rating and Determination of Ratio and Polarity

Object :

(1) Study of transformer.

(2) To measure transformation Ratio.

(3) To find polarity of primary and secondary windings.

Apparatus Used :

1. Single phase transformer.
2. Single phase Autotransformer.
3. Voltmeter MI type 3 Nos. (Different Range).
4. Connecting leads.

Theory :

(A) Theoretically it may seem that transformers may be built to handle any voltage or current. But in reality there are limits to both the voltage and the current. The name plate rating of a power transformer usually contains.

1. Volt-amperes ☐ kVA
2. Voltage Ratio.

Rated Primary voltage/secondary voltage ☐ V_1/V_2 volt or kV.

3. Frequency ☐ Hz.
4. Type 1ϕ or 3ϕ.
5. Equivalent Impedance ☐ %.

(B) Transformation Ratio : The induced e.m.f. per phase in primary and secondary windings of a transformer is given by Induced e.m.f. in primary $E_1 = 4.44 f \phi N_1$.

Induced e.m.f. in secondary $E_2 = 4.44 f \phi N_2$.

For Ideal transformer $E_1 = V_1$ and $E_2 = V_2$.

Hence the transformation Ratio $(K) = \frac{V_2}{V_1} = \frac{T_2}{T_1}$.

(C) Polarity Test : Each of the terminals of primary as well as secondary winding of a transformer is alternatively positive and negative with respect to each other.

It is essential to know the relative polarities at any instant of the primary and secondary terminals for making correct connections if the transformers are to be opened in parallel or are to be used in a 3ϕ circuit.

When viewed from the primary side the terminals are marked A_1 and A_2. Now terminal A_1 is connected to one end of the secondary winding and a voltmeter is connected between A_2 and other end of the secondary winding. When the voltmeter reads the difference $(V_1 - V_2)$, the transformer is said to possess a subtractive polarity and when voltmeter reads $(V_1 + V_2)$ the transformer has additive polarity. Subtractive polarity means that same polarity terminals are connected. While additive polarity means that same polarity terminals are connected.

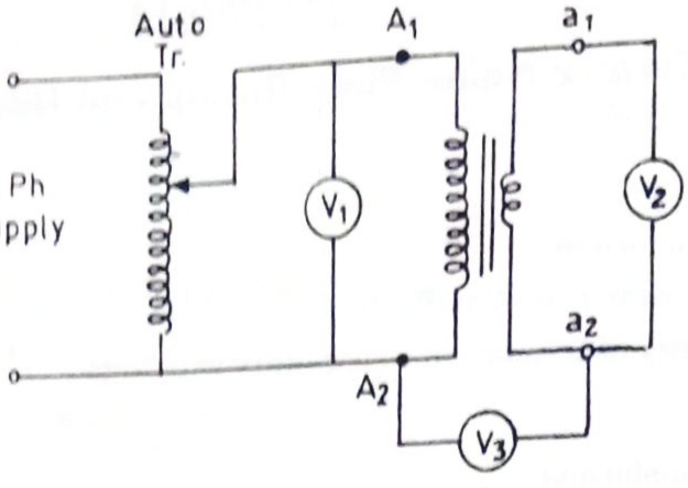


Fig. (a) Polarity Test.

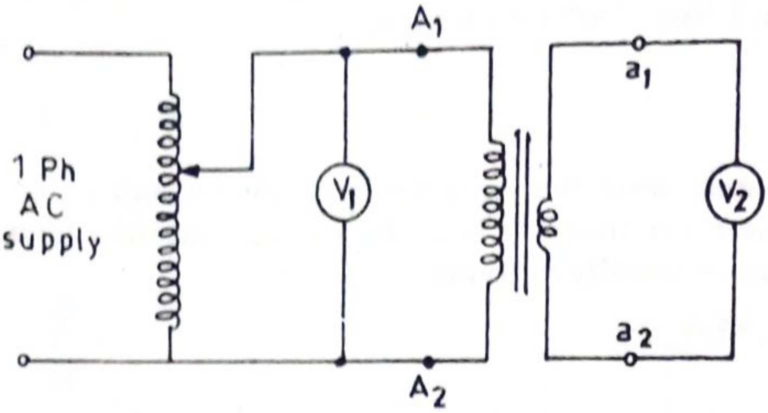


Fig. (b) Transformation Ratio Test.

Procedure :

(a) Transformation Ratio Test :

1. Connect the circuit as per Fig. (b) and set up Auto transformer to zero position.
2. Switch on a.c. supply and adjust the Autotransformer till a suitable (below rated) voltage.
3. Record the voltages V_1 across the primary and V_2 across secondary.
4. Vary the Autotransformer and repeat step 3, take at least 5 readings.
5. Switch off the supply.

(b) Polarity Test :

1. Connect the circuit as per Fig. (a) and set up Autotransformer to zero position.
2. Switch on single phase a.c. supply.
3. Record the voltages V_1, V_2 an V_3.

If V_3 is less than V_1 the polarity is subtractive otherwise additive.

4. Vary the autotransformer and repeat step 3. Take at least 5 readings.
5. Switch off the supply.

Observations :

(a) Name plate ratings : Write down all specifications marked on name plate rating.

(b) **Transformation Ratio Test**

S. No.	V_1	V_2	$K = V_2/V_1$
1.			
2.			
3.			
4.			
5.			

(c)

S. No.	V_1	V_2	V_3	Additive or Subtractive
1.				
2.				
3.				
4.				
5.				

Result : The transformation ratio of given transformer is ..... .

Report :

(i) Which type of transformer is tested by you ?

(ii) If a transformer is connected to D.C. supply what will happen to the transformer ?

(iii) What type of core is being used in transformer ?

EXPERIMENT NO. 06

Study of Constructional Features of D.C. Machines

Object :

1. To study the constructional features of D.C. machine.
2. To measure winding resistance.

Apparatus Used :

1. D.C. machine compound.
2. Voltmeter moving coil type
3. Ammeter moving coil type
4. Rheostat.

Theory :

A d.c. machine is an electro-mechanical energy conversion device. It can convert mechanical power into d.c. electrical power and is known as a d.c. generator. On the other hand, when it converts d.c. electrical power into mechanical power it is known as a d.c. motor.

The complete assembly of various parts in a scattered form of d.c. machine is shown in Fig. (*a*). The essential parts of a d.c. machine are described below :

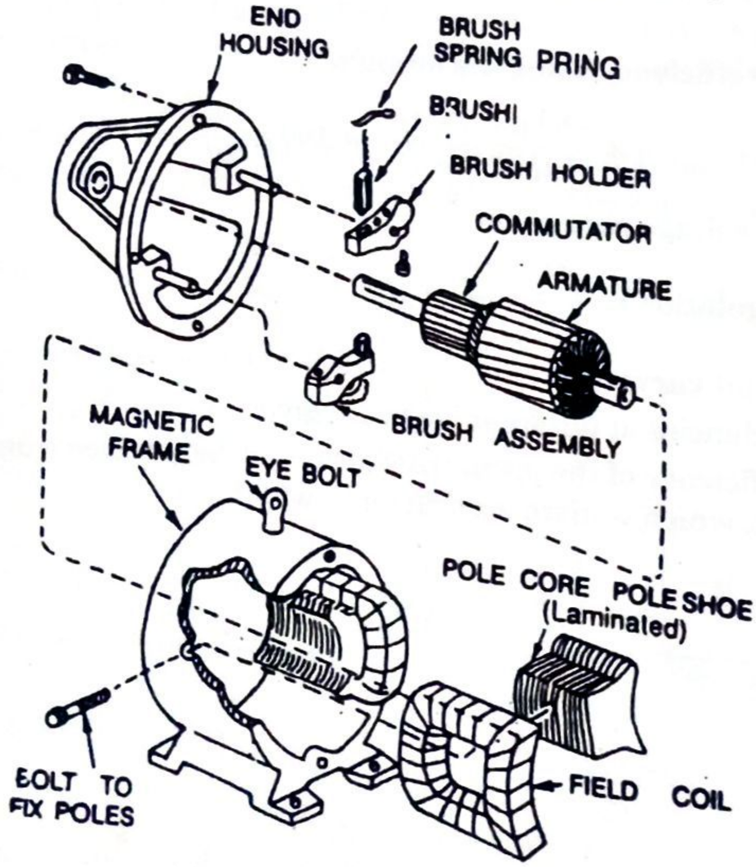


Fig. (*a*).

1. Magnetic frame or Yoke : The outer cylindrical frame to which main poles and inter poles are fixed and by means of which the machine is fixed to the foundation is called the *yoke*. It serves two purposes :

(*i*) It provides mechanical protection to the inner parts of the machine.

(*ii*) It provides a low reluctance path for the magnetic flux.

The yoke is made of cast iron for smaller machines and for larger machines, it is made of cast steel or fabricated rolled steel since these materials have better magnetic properties as compared to cast iron.

2. Pole core and Pole shoes : The pole core and pole shoes are fixed to the magnetic frame or yoke by bolts. They serve the following purposes :

(*i*) They support the field or exciting coils.

(*ii*) They spread out the magnetic flux over the armature periphery more uniformly.

(*iii*) Since pole shoes have larger *X*-section, the reluctance of magnetic path is reduced.

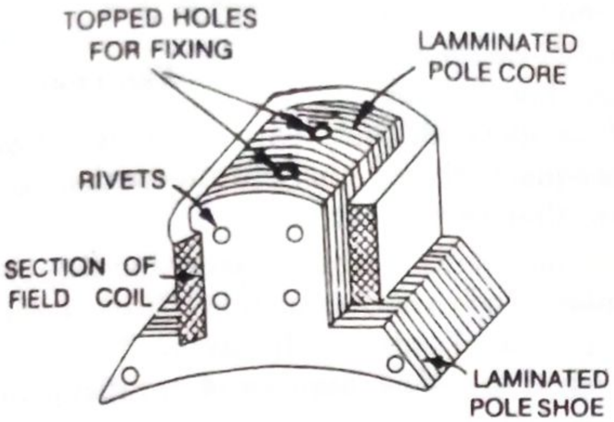


Fig. (*b*).

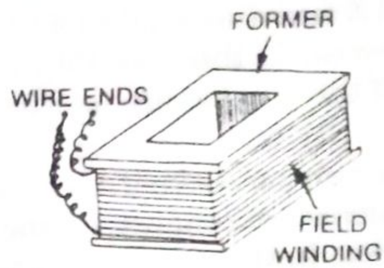


Fig. (*c*).

Usually, the pole core and pole shoes are made of thin cast steel or wrought iron laminations which are riveted together under hydraulic pressure as shown in Fig. (*b*).

3. Field or Exciting coils : Anamelled copper wire is used for the construction of field or exciting coils. The coils are wound on the former [See Fig. (*c*)] and then placed around the pole core as shown in Fig. (*b*). When direct current is passed through the field winding, it magnetises the poles which produce the required flux. The field coils of all the poles are connected in series in such a way that when current flows through them, the adjacent poles attain opposite polarity as shown in Fig. (*d*).

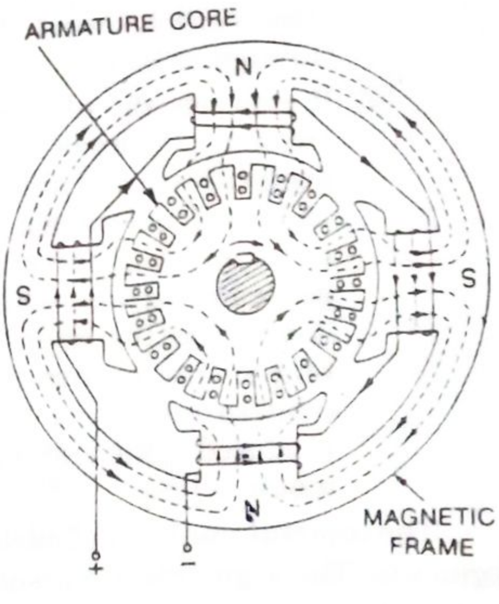


Fig. (*d*).

4. Armature core : It is cylindrical in shape and keyed to the rotating shaft. At the outer periphery slots are cut as shown in Fig. (*e*), which accommodate the armature winding. The armature core serves the following purposes :

(*i*) It houses the conductors in the slots.

(*ii*) It provides an easy path for magnetic flux.

Since armature is a rotating part of the machine, reversal of flux takes place in the core, hence hysteresis losses are produced. To minimise these losses *silicon steel* material is used for its construction. The rotating armature cuts across the magnetic field which induces an e.m.f. in it. The e.m.f. circulates eddy currents which results in *eddy current loss* in it. To reduce these losses, armature core is laminated, in other words we can say that about 0.3 to 0.5 mm thick stampings are used for its construction. Each lamination or stamping is insulated from the other by varnish layer [See Fig. 14(*e*)].

5. Armature winding : The insulated conductors housed in the armature slots are suitably connected. This is known as armature winding. The armature winding is the heart of d.c. machine. It is a place where conversion of power takes place *i.e.*, in case of generator, mechanical power is converted into electrical power and in case of motor, electrical power is converted into mechanical power. On the basis of connections, there are two types of armature windings named as (*i*) Lap winding and (*ii*) Wave winding.

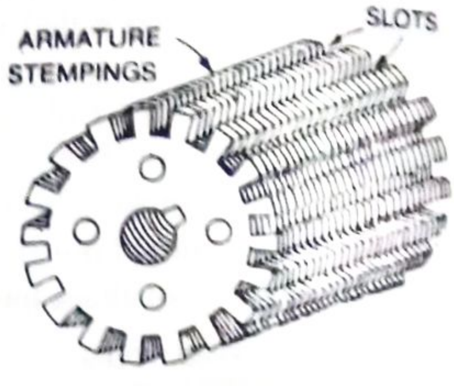


Fig. 14(*e*).

(*i*) *Lap winding* : In lap winding, the conductors are connected in such a way that number of parallel paths are equal to the number of poles. Thus, if machine has P poles and Z armature conductors, then there will be P parallel paths, each path will have Z/P conductors in series. In this case, the number of brushes is equal to the number parallel paths. Out of which half the brushes are positive and the remaining (half) are negative.

(*ii*) *Wave winding* : In wave winding, the conductors are so connected that they are divided into two parallel paths irrespective of the number of poles of the machine. Thus, if machine has Z armature conductors, there will be only two parallel paths each having $Z/2$ conductors in series. In this case, the number of brushes is equal to two *i.e.* number of parallel paths.

6. Commutator : It is the most important part of a d.c. machine and serves the following purposes :

(*i*) It connects the rotating armature conductors to the stationary external circuit through brushes.

(*ii*) It converts the alternating current induced in the armature conductors into unidirectional current in the external load circuit in generator action, whereas, it converts the alternating torque into unidirectional (continuous) torque produced in the armature in motor action.

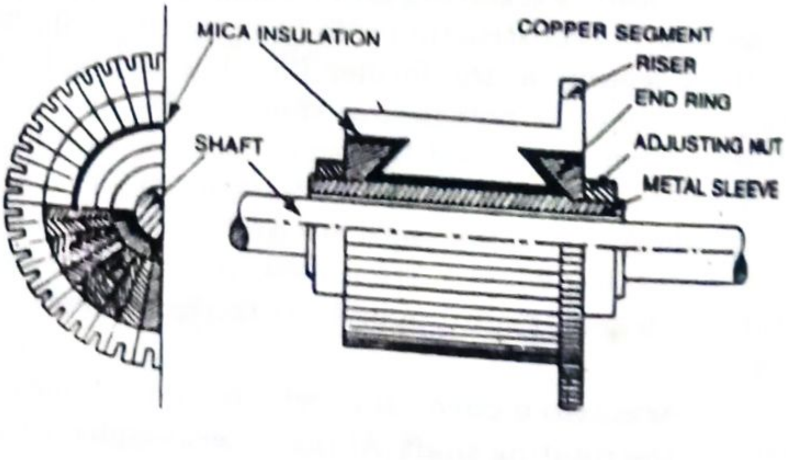


Fig. (*f*).

The commutator is of cylindrical shape and is made up of wedge-shaped hard drawn copper segments. The segments are insulated from each other by a thin sheet of mica. The segments are held together by means of two V-shaped rings that fit into the V-grooves cut into the segments. Each armature coil is connected to the commutator segment through riser. The sectional view of the commutator assembly is shown in Fig. (*f*).

7. Brushes : The brushes are pressed upon the commutator and form the connecting link between the armature winding and the external circuit. They are usually made of high grade carbon because carbon is conducting material and at the same time in powdered form provides lubricating effect on the commutator surface. The brushes are held in particular position around the commutator by brush holders.

8. End housings : End housings are attached to the ends of the main frame and support bearings. The front housing supports the bearing and the brush assemblies whereas the rear housing usually supports the bearing only.

9. Bearings : The ball or roller bearings are fitted in the end housings. The function of the bearings is to reduce friction between the rotating and stationary parts of the machine. Mostly high carbon steel is used for the construction of bearings as it is very hard material.

10. Shaft : The shaft is made of mild steel with a maximum breaking strength. The shaft is used to transfer mechanical power from or to the machine. The rotating parts like armature core, commutator, cooling fan etc. are keyed to the shaft.

Circuit Diagram :

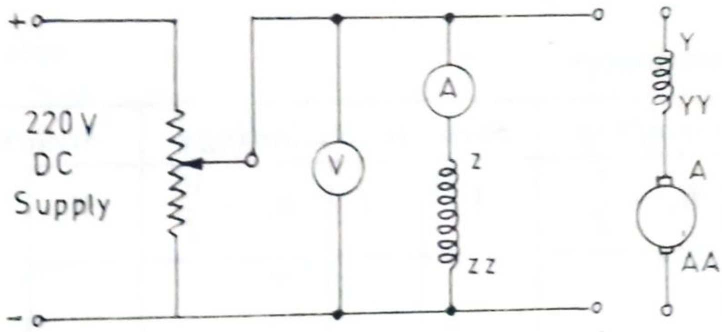


Fig. (g). To measure shunt field winding Resistance.

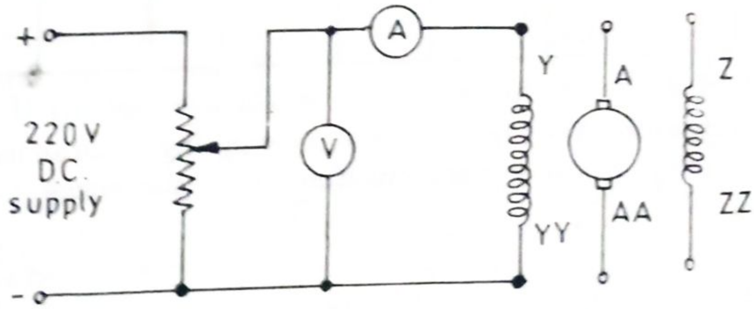


Fig. (h). To measure series field winding Resistance.

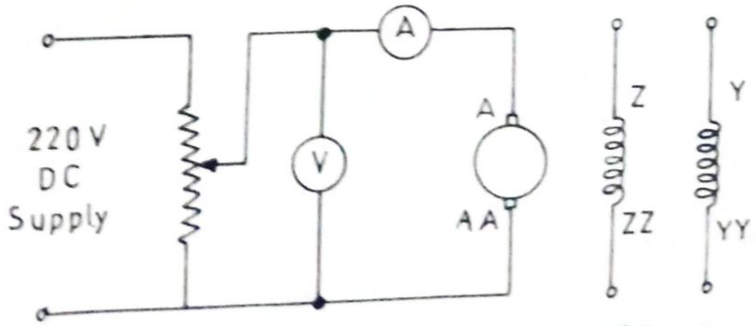


Fig. (i). To measure armature winding Resistance.

Procedure :

1. Study and record the name plate specifications, various components, their material and approximate dimensions.

2. Set up the circuit as in Fig. (g) to measure the shunt field winding resistance. Switch on the 220 V d.c. supply across the shunt field winding.

3. Record voltmeter and ammeter Readings. Several readings may be obtained by applying different voltages to the winding through potentiometer arrangement.

4. For measuring series winding and Armature winding Resistance, set up the circuit as in Fig. (*h*) and Fig. (*i*) and repeat the processes 2 and 3. It should be noted here that the voltage given to the Armature winding and series field winding should be low as possible.

5. Switch of the d.c. supply.

Observations :

(*a*) **Study**

1. Machine specification.
2. Components.

(*b*) **Winding Resistances**

S. No.	*Shunt field winding*			*Series field windings*			*Armature*		*Windings*
	V	I	$R_{sh} = \frac{V}{I}$	V	I	$R_{se} = \frac{V}{I}$	V	I	$R_a = \frac{V}{I}$
1.									
2.									
3.									
4.									
5.									

Calculation : Obtain the winding resistance as the average of V/I in each case.

Result and conclusion. Write the values of the winding resistances, as determined from the experiment. Conclude your study of the machine in few sentences.

EXPERIMENT NO. 107

Study of Constructional Features of 3 Phase Induction Motor

Object :

(*i*) To study the constructional details.

(*ii*) To start a three phase squirrel cage and slip ring induction motor.

Apparatus Used :

1. Three phase induction motor.
2. 3ϕ Autotransformer.
3. Tachometer.

Theory :

A 3-phase induction motor consists of two main parts namely *stator* and *rotor*.

1. Stator : It is the stationary part of the motor. It has three main parts, namely; (*i*) Outer frame, (*ii*) Stator core and (*iii*) Stator winding.

(*i*) *Outer frame* : It is the outer body of the motor. Its function is to support the stator core and to protect the inner parts of the machine. For small machines the frame is casted but for large machines it is fabricated. To place the motor on the foundation, feet are provided in the outer frame as shown in Fig. (*a*).

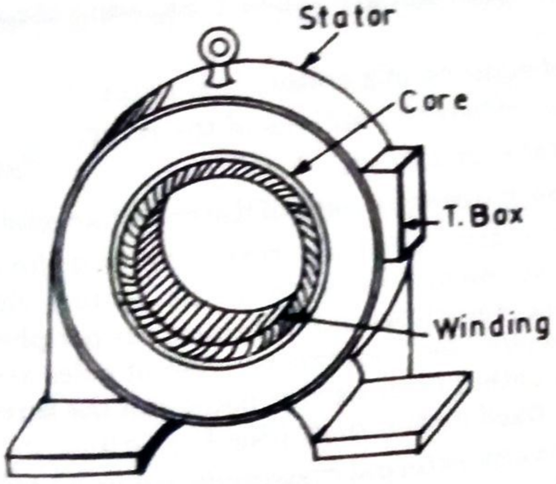


Fig. (*a*).

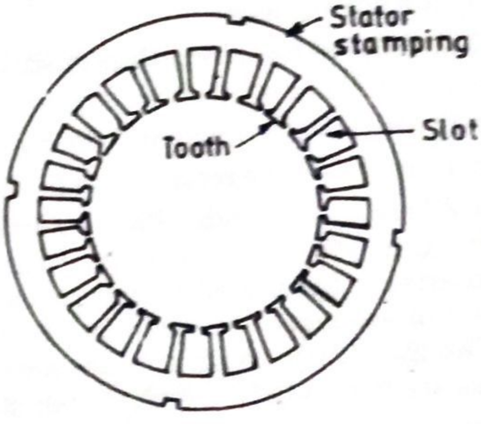


Fig. (*b*).

(*ii*) *Stator core* : The stator core is to carry the alternating magnetic field which produces hysteresis and eddy current losses, therefore core is built up of high grade silicon steel stampings. The stampings are assembled under hydraulic pressure and are keyed to the frame. Each stamping is insulated from the other with a thin varnish layer. The thickness of the stamping varies usually from 0.3 to 0.5 mm. Slots are punched on the inner periphery of the stampings, as shown in Fig. (*b*), to accommodate stator winding.

(*iii*) *Stator winding* : The stator core carries a three-phase winding which is usually supplied from a three-phase supply system. The six terminals of the winding (two of each phase) are connected in the terminal box of the machine. The stator of the motor is wound for definite number of poles, the exact number being determined by the requirement of speed. It will be seen that greater the number of poles, the lower the speed and vice-versa, since $N_s \propto \frac{1}{P}\left(\because N_s = \frac{120f}{P}\right)$. The three-phase winding may be connected in star or delta externally through a starter.

2. Rotor : It is the rotating part of the motor. There are two types of rotors, which are employed in 3-phase induction motors :

(*i*) Squirrel cage rotor (*ii*) Phase wound rotor.

(*i*) *Squirrel cage rotor* : The motors employing this type of rotor are known as squirrel cage induction motors. Most of the induction motors are of this type because of simple and rugged construction of rotor. A squirrel cage rotor consists of a laminated cylindrical core having semi-closed circular slots at the outer periphery. Copper or aluminium bar conductors are placed in these slots and short circuited at each end by copper or aluminium rings, called short circuiting rings, as shown in Fig. (*c*). Thus, the rotor winding is permanently short circuited and it is not possible to add any external resistance in the rotor circuit.

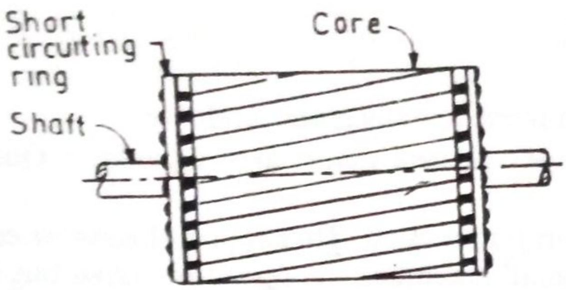


Fig. (*c*)

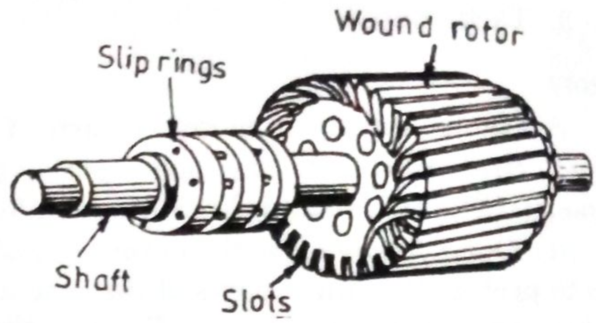


Fig. (*d*).

The rotor slots are usually not parallel to the shaft but are skewed. Skewing of rotor has the following advantages :

(*a*) It reduces humming thus ensuring *quiet* running of a motor,

(*b*) It results in a smoother torque curves for different positions of the rotor,

(*c*) It reduces the magnetic locking of the stator and rotor,

(*d*) It increases the rotor resistance due to the increased length of the rotor bar conductors.

(*ii*) *Phase wound rotor*. Phase wound rotor is also called *slip ring rotor* and the motors employing this type of rotor are known as phase wound or slipring induction motors. Slip ring rotor consists of a laminated cylindrical core having semi-closed slots at the outer periphery and carries a 3-phase insulated winding. The rotor is wound for the same number of poles as that of stator. The three finish terminals are connected together forming star point and the three start terminals are connected to three copper sliprings fixed on the shaft [See Fig. (*d*)].

In this case, depending upon the requirement any external resistance can be added in the rotor circuit. In this case also the rotor is skewed.

A mild steel shaft is passed through the centre of the rotor and is fixed to it with key. The purpose of shaft is to transfer mechanical power.

Procedure :

(*i*) Study the constructional details of the stator and its winding, rotor and its winding, slip rings etc.

(*ii*) Note down the name plate specifications.

(*iii*) Start the squirrel cage motor with the help of starter.

(*iv*) To reverse the direction of rotations interchange any two supply terminals.

Observation :

- Motor specification.
- components :
- Material :
- Approx. Dimension.