EXPERIMENT -1a

One lamp Controlled by One Switch

Aim:- To wire up a circuit in conduit system one lamp controlled by one switch

Tools Required: -

Screwdriver 200mm-1no,

Combination pair 150mm-1no,

Line tester 500v-1no,

Wire stripper-1 no,

Pocker-1no,

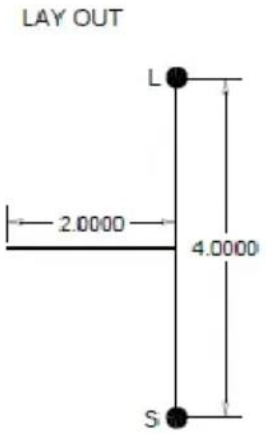
Hammer 1no,

PROCEDURE:-

1. Draw the lay out and connection diagram.
2. Collect the required wiring materials.
3. Connect the required materials on the work board as per connection diagram.
4. Check the circuit for continuity.
5. Given the supply to the circuit after checking.
6. Finished the work neatly and correctly.

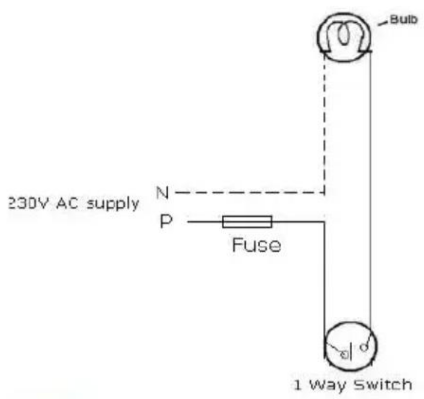
RESULT:-

Wired up a circuit in conduit system, one lamp controlled by one switch.



Switch	Lamp
OFF	OFF
ON	BRIGHT

Wiring Diagram:



Result:

EXPERIMENT 1 B

Wiring Of One Lamp Controlled by Two SPDT Switches - Stair Case Wiring

Aim: To wire for a staircase arrangement using a two-way switch.

Tool Required:

1. Screw driver
2. Hammer
3. Pliers
4. Line tester

Components Required:

1. Two-way switches
2. Bulb holders
3. Bulbs
4. Joint clips
5. Wires
6. Screws
7. Ceiling rose and
8. Switch board

Procedure:

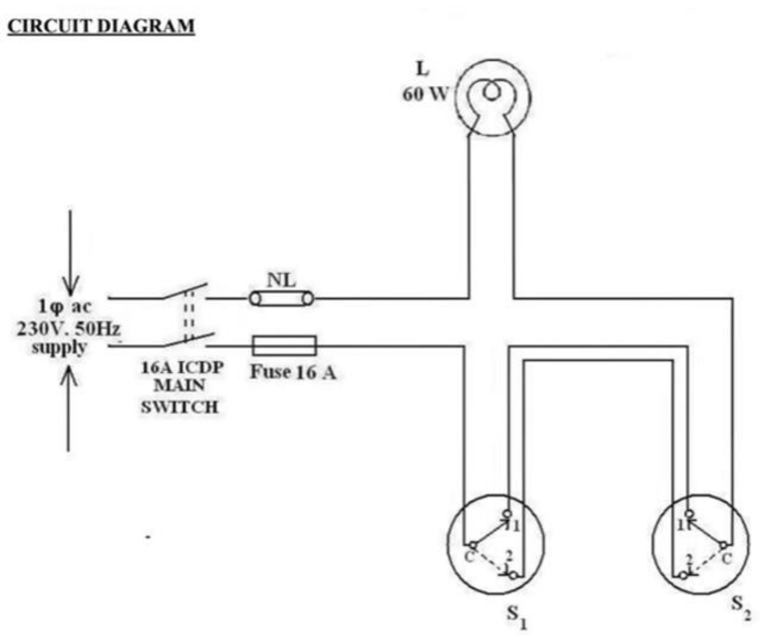
1. Mark switch and bulb location points and draw lines for wiring on the wooden Board.
2. Place wires along the lines and fix them with the help of clips.
3. Fix the two-way switches and bulb holder in the marked position on the wooden Board.
4. Complete the wiring as per the wiring diagram.
5. Test the working of the bulbs by giving electric supply to the circuit.

Theory:

A two switch is installed near the first step of the stairs. The other two way switch is installed at the upper part where the stair ends. The light point is provided between first and last stair at an adequate location and height if the lower switch switches on the light. The switch at the top or vice versa can switch it off. Two number of two way switches are used for the purpose. The supply is given to the switch at the short circuited terminals. The connection to the light point is taken from the similar short circuited terminal of the second switch; other two independent terminals of each circuit are connected through cables.

Wiring layout

Draw layout here



CONDITIONS

S1	S2	L
C1	C1	ON
C1	C2	OFF
C2	C1	OFF
C2	C2	ON

Result

EXPERIMENT 2

Three Phase Power Measurement-Two Wattmeter Method

Aim

Power measurement in three-phase star connected circuit with balanced and unbalanced load using two Wattmeter method

Apparatus Required:

Sl. No.	Name	Specification	Quantity
1	Wattmeter	(0-….)W, ….., UPF	2 Nos.
2	Voltmeter	(0-250)V, MI	1 Nos.
3	Ammeter	(0-5)A, MI	3 Nos.
4	Connecting Wires	PVC Insulated Copper	As per requirement
5	Three-phase Variac	(0-500)V, (5A/10A),	1 Nos.
6	Rheostat	(0-….)Ω, 5A	3 Nos.

Theory:

A watt meter is an instrument for measuring active power directly in a circuit. It has two coils i.e. current coil & pressure coil. Current coil measures the current through the circuit &pressure coil measures the voltage. Current coil is connected in series & pressure coil in parallel in the circuit. Two wattmeter can be used to measure power in a three phase 3-wire circuit, by making the connections as shown in circuit diagram. The load may be balanced or unbalanced. The current coils are connected in series with two phases and the pressure coils is connected between both phase and the third phase. The total power consumed by the two wattmeter = W_1+W_2 (algebraic sum).

Here current through the current coil of $W_1=I_R$ and $W_2=I_B$
While potential difference across pressure coil of $W_1=V_{RY}$ and $W_2=V_{BY}$

According to the phasor diagram

$W1=V_{RY}\, I_R \,Cos(30+\theta)$

$W2=V_{BY}\, I_B \,Cos(30-\theta)$

Total Power drawn by Three phase load is

$W1+W2= V_{RY}\, I_R \,Cos(30+\theta) + V_{BY}\, I_B \,Cos(30-\theta)$

Here $V_{RY} = V_{BY} =V_L$ then

$W1+W2=\sqrt{3}V_LI\ Cos\theta$

Precautions:

1. Don't switch on power supply without concerning respective teachers.
2. Three phase auto transformer must be kept at minimum potential point before starting.
3. Resistant value of all rheostats should be kept at maximum position at starting.

Procedures:

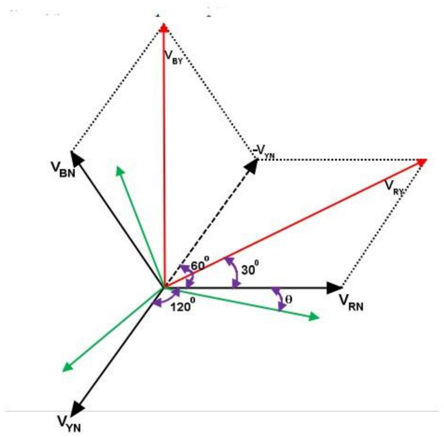
(i) Connect all the instruments as per circuit diagram.

(ii) Make sure i. e all instruments are showing zero error.

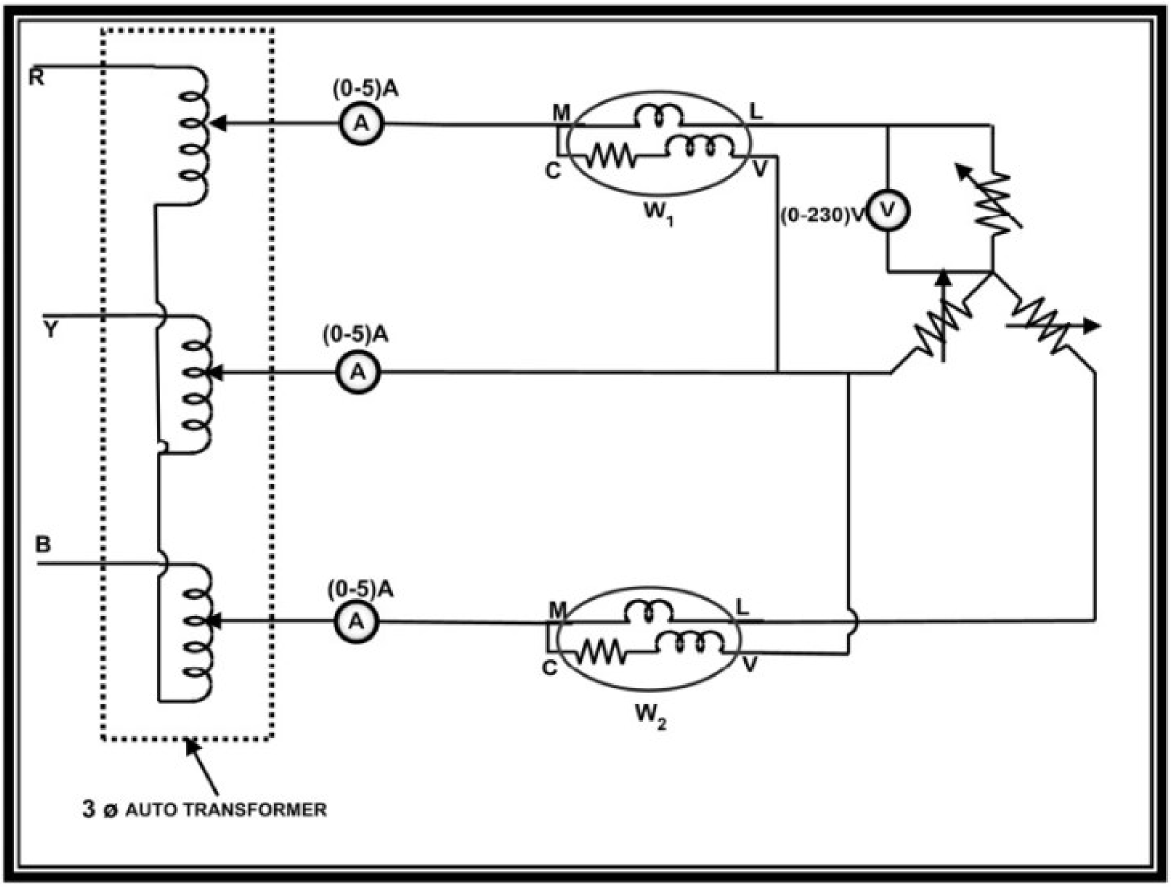
(iii) After connection, keep the rheostat in maximum position and slowly increase the output voltage of the Variac so that current in each phase is about 1A.

(iv) Then vary the resistance of the rheostats so the load is deliberately unbalanced, i.e. the current in each phase becomes different.

(v) Calculate the Three-phase power.



Circuit Diagram:



Observation Table: for Balance Load

Sl. No.	Power in Watts (W_1)	Power in Watts (W_2)	Line Voltage in Volts. (V_L=V_{RY})	Phase Current in Amp. (I_R)	Phase Current in Amp. (I_Y)	Phase Current in Amp. (I_B)	Total Power in watts. $P=W_1+W_2$
1							
2							
3							
4							
5							
6							
7							

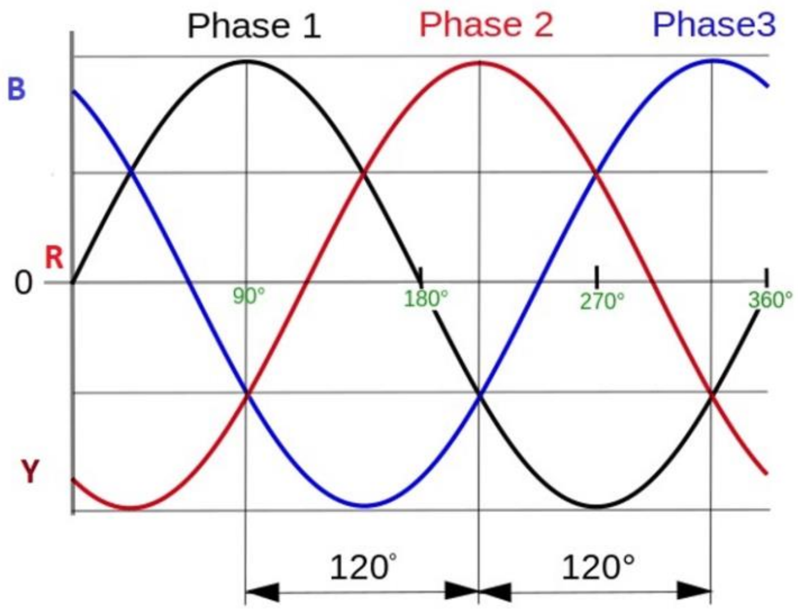
Result:

For your Reference:

In a three-phase AC circuit, electrical power is transmitted or distributed using three alternating currents that are 120 degrees out of phase with each other. This configuration offers several advantages over single-phase systems, including higher power transmission capacity, improved efficiency, and balanced power delivery.

Here's a breakdown of the theory behind three-phase AC circuits:

Phases and Waveforms:
In a three-phase system, there are three sinusoidal voltage waveforms, typically labeled as phases R, Y, and B. These waveforms are identical in frequency and amplitude but are offset from each other by 120 degrees. As one phase reaches its peak, the others are at different points in their cycle, ensuring a continuous and smooth supply of power.



Generation:
Three-phase power can be generated using a three-phase generator or by using three single-phase generators connected together. In rotating electrical machinery such as alternators or synchronous motors, three-phase power is naturally produced due to the arrangement of the windings.

Balanced Loads:
In an ideal three-phase system, loads are evenly distributed across all three phases. This balanced configuration ensures that the total power demand is evenly spread, minimizing voltage drops and current imbalances. Balanced loads result in efficient power transmission and utilization.

Connection Methods:
Three-phase systems can be connected in either a star (Y) or delta (Δ) configuration. In a star connection, one end of each phase winding is connected together to form a common neutral

point, while in a delta connection, the phases are connected end-to-end in a loop. Each configuration has its advantages depending on the application.

Power Calculation:
Power in a three-phase system can be calculated using various formulas. For balanced loads, the total power (P) is the sum of the power in each phase. The formula for calculating power (P) in a balanced three-phase system is:

$P=\sqrt{3}\times Vline\times Iline\times \cos(\phi)$Where,(Vline)isthelinevoltage(phasevoltage),(Iline)isthelinecurrent,(ϕ)isthephaseanglebetweenvoltageandcurrent.

Applications:
Three-phase AC power is commonly used in industrial and commercial applications for powering machinery, motors, pumps, and other equipment. It is also used in residential settings for large appliances such as air conditioners and electric stoves.

Advantages:
Three-phase power offers several advantages over single-phase systems, including higher power transmission capacity, improved efficiency, smoother power delivery, and reduced conductor size requirements for the same power rating.

Difference Between Three Phase and Single Phase AC Circuit.

Three-phase and single-phase AC circuits differ in several key aspects, including their configuration, power transmission characteristics, applications, and efficiency. Here's a breakdown of the main differences between the two:

1. **Number of Phases**:

- **Single-phase**: Single-phase AC circuits consist of one sinusoidal voltage waveform and one current waveform. This configuration is commonly used in residential applications and smaller commercial setups.
- **Three-phase**: Three-phase AC circuits consist of three sinusoidal voltage waveforms, each offset by 120 degrees from the others. These circuits are typically used in industrial applications and large commercial setups.

2. **Power Transmission**:

1.

- **Single-phase**: Single-phase circuits are suitable for low to moderate power transmission and are commonly used for lighting, small appliances, and single-phase motors.
- **Three-phase**: Three-phase circuits are capable of transmitting higher power levels more efficiently than single-phase circuits. They are used for heavy-duty industrial machinery, motors, pumps, and large-scale commercial applications.

3. **Efficiency**:

1.

- **Single-phase**: Single-phase circuits may suffer from higher losses and voltage drops, especially over long distances or when transmitting high power loads.
- **Three-phase**: Three-phase circuits offer improved efficiency due to balanced loads and reduced voltage drops. They are more suitable for high-power transmission over long distances.

4. **Applications**:

    1.

- **Single-phase**: Single-phase circuits are commonly found in residential buildings for powering lighting, small appliances, air conditioning units, and single-phase motors.
- **Three-phase**: Three-phase circuits are used in industrial settings for powering heavy machinery, motors, compressors, pumps, and other large-scale equipment. They are also used in commercial buildings for large HVAC systems, elevators, and data centers.

5. **Voltage and Current Characteristics**:

    1.

- **Single-phase**: In single-phase circuits, voltage and current waveforms peak and reverse polarity at regular intervals. Power delivery fluctuates with each cycle.
- **Three-phase**: In three-phase circuits, voltage and current waveforms maintain a steady and balanced flow, resulting in smoother power delivery and reduced fluctuations.

6. **Connection Methods**:

    1.

- **Single-phase**: Single-phase circuits typically have two conductors: one for the phase and one for the neutral. Loads can be connected between the phase and neutral.
- **Three-phase**: Three-phase circuits can be connected in either a star (Y) or delta (Δ) configuration. Each configuration has its advantages depending on the application's requirements.

Understanding the differences between three-phase and single-phase AC circuits is essential for designing, installing, and maintaining electrical systems in various settings, from residential buildings to industrial complexes.

Viva-Voce Question: –

1. What are the advantages of using a three-phase AC circuit over a single-phase AC circuit ?

Answer: There are several advantages of using a three-phase AC circuit over a single-phase AC circuit:

a. **Higher Power Transmission Capacity**: Three-phase circuits can transmit higher power levels more efficiently compared to single-phase circuits. This is because three-phase systems utilize three alternating currents that are 120 degrees out of phase with each other, providing a continuous and balanced power flow.

b. **Efficiency**: Due to the balanced nature of three-phase circuits, they experience fewer voltage drops and losses compared to single-phase circuits. This results in improved efficiency, especially over long transmission distances.

c. **Balanced Loads**: In a three-phase system, loads are evenly distributed across all three phases, leading to balanced current flow. This minimizes voltage fluctuations and ensures stable power delivery to connected loads.

d. **Reduced Conductor Size**: For the same power rating, three-phase circuits require smaller conductor sizes compared to single-phase circuits. This is because the three-phase system utilizes the space between phases more effectively, reducing the overall size and cost of the conductors.

e. **Suitability for Industrial Applications**: Three-phase circuits are well-suited for powering heavy machinery, motors, pumps, and other industrial equipment due to their higher power transmission capacity and efficiency. They are commonly used in industrial settings where high-power requirements are prevalent.

f. **Flexibility in Connection Methods**: Three-phase circuits can be connected in either a star (Y) or delta (Δ) configuration, providing flexibility in system design based on specific application requirements.

1.

2. How is power measured in a three-phase star-connected circuit with balanced and unbalanced loads using the two-wattmeter method ?

Answer: The two-wattmeter method is a commonly used technique for measuring power in a three-phase circuit, particularly in star (Y) connected configurations.

Here's how power measurement is carried out using this method for both balanced and unbalanced loads:

1. Balanced Load:

Setup:

- Connect two wattmeters, labeled as W1 and W2, to the three-phase circuit.
- Connect the phase voltages to the potential coils of the wattmeters.
- Connect the current coils of each wattmeter in series with one of the phases and the load.
- Ensure that the load across all phases is balanced, meaning each phase has the same impedance.

Measurement:

Record the readings (W_1) and (W_2) displayed on each wattmeter.

Total power (P_{total}) in the circuit is given by the sum of the readings of the two watt meters:

$P_{total}=W_1+W_2$

This method provides accurate measurement of total power in a balanced three-phase circuit.

2. Unbalanced Load:

Setup:

- Follow the same setup as for the balanced load.
- Introduce different impedances or loads across the phases to create an unbalanced condition.

Measurement:

Record the readings (W_1) and (W_2) displayed on each wattmeter.

Total power (P_{total}) in the circuit is still given by the sum of the readings of the two wattmeters:
$P_{total}=W_1+W_2$

Despite the unbalanced load, the two-wattmeter method accurately measures the total power in the circuit by accounting for the individual power contributions from each phase.

Significance:

The two-wattmeter method is advantageous as it can accurately measure power in both balanced and unbalanced three-phase circuits.

It is particularly useful in practical scenarios where loads may not always be perfectly balanced.

EXPERIMENT 3

Load Characteristics Of Dc Shunt Generator

Aim: – To draw the load characteristics (External and Internal characteristics) of the DC shunt generator with Self-excitation.

Name plate details:

	Motor	Generator
Voltage		
Current		
Power		
Speed		
Excitation Current		

Fuse Rating: For Load condition, Fuse rating = 125% of rated current = --------Amps.

Apparatus Required:

Apparatus	Range	Type	Quantity
Ammeter			
Voltmeter			
Rheostat			
Tachometer			

Safety Precautions:

1. The DPST switch should be at open condition.
2. The field rheostat of the motor should be kept at minimum resistance position.
3. The field rheostat of the generator should be kept at maximum resistance position.
4. The starter of the motor should be at OFF position.
5. The load bank also should be at OFF position.

THEORY:

In a shunt generator, the field winding is connected in parallel with the armature winding so that terminal voltage of the generator is applied across it.The shunt field winding has many turns of fine wire having high resistance. Therefore, only a part of armature current flows through shunt field winding and the rest flows through the load.

For a DC Shunt Generator$E_0 = V + I_a R_a$

$I_a = I_L + I_{sh}$

$I_{sh} = V/R_{sh}$

Where, E_0 is the induced emf

V is the terminal voltage

I_a is the armature current

I_L is the load current

Internal characteristics: it is the plot of the induced voltage E with armature current. Drop in voltage is due to armature reaction which increases with increase in load current.

External characteristics: It is the plot of terminal voltage with load current at constant field resistance and speed. As the load on the machine is varied the terminal voltage drops it is due to

1. The drop in voltage across the armature resistance, $I_a R_a$ drop.
2. Armature reaction the air gap flux decreases which will reduced the induced emf.
3. The drop in terminal voltage due to 1 & 2 results in decrease field current which further reduces the induced emf.

PRECAUTIONS:

- The field rheostat of motor should be at minimum position.
- The field rheostat of generator should be at maximum position.
- No load should be connected to generator at the time of starting and stopping.

PROCEDURE:

- Connections are made as per the circuit diagram.
- After checking minimum position of DC shunt motor field rheostat and maximum position of DC shunt generator field rheostat, DPST switch is closed and starting resistance is gradually removed.
- Adjust the motor field rheostat to adjust the speed to rated speed of generator.
- Under no load condition, Ammeter and Voltmeter readings are noted, after bringing the voltage to rated voltage by adjusting the field rheostat of generator.
- Load is varied gradually until rated current and for each load, voltmeter and ammeter readings are noted.
- Then the generator is unloaded and the field rheostat of DC shunt generator is brought to maximum position and the field rheostat of DC shunt motor to minimum position, DPST switch is opened.

PROCEDURE (B) : To Find Armature Resistance:

1. Give the connections as per circuit (B).

2. The supply is given.

3. The DPST switch is closed.

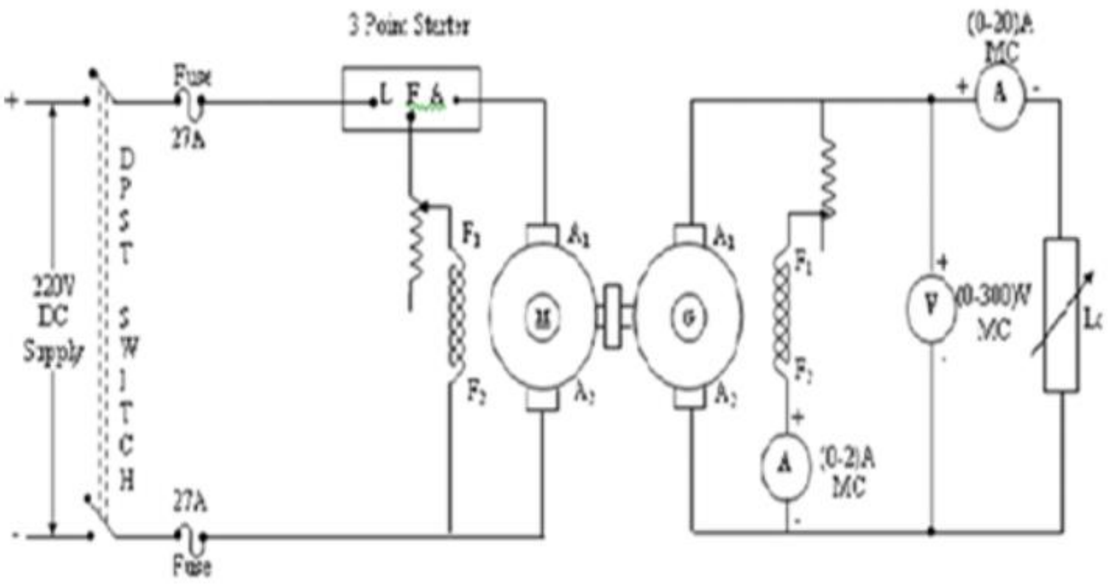
4. The current is passed through armature of generator by applying load.

5. The load is applied gradually. For three or four different values of load currents, the readings of ammeter and voltmeter are noted and tabulated (B).

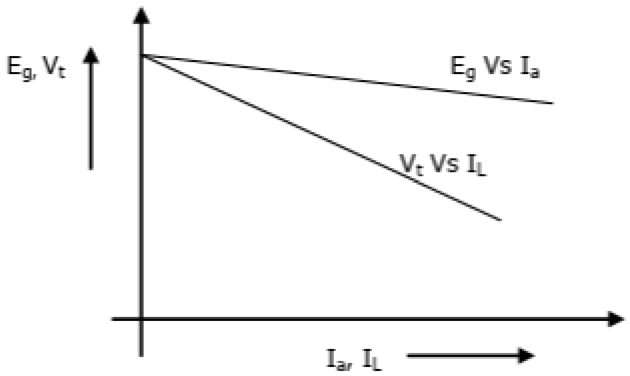
6. Armature resistance is calculated with the formulae; Ra = Va / Ia □

7. Mean value of Ra is calculated.

CIRCUIT DIAGRAM:



Model graph:



Tabular column (a):

V_t	I_L	I_f	$I_a = I_L+I_f$	$E_g = V_t+I_aR_a$

Tabular Column (B) : [To Find R_a]

V_a	I_a	$R_a = (V_a / I_a)\ \Omega$

Result

EXPERIMENT 4

Load Test On DC Series Motors

Aim To determine the characteristics of dc **series motor** by performing a load test.

Apparatus Required: –

Sl. No.	Name	Specification	Quantity
1	DC series motor with spring balance load		1 no.
2	Tachometer	Digital type	1 no.
3	Ammeter	(0-20) A, PMMC	1 no.
4	Voltmeter	(0-150) V, PMMC	1 no.
5	Connecting wires	PVC insulated copper	As per required.

Theory: –

The load test on a DC series motor is performed to analyze its performance characteristics under varying load conditions. It provides valuable information about the motor's torque-speed characteristics, speed regulation, efficiency, and ability to handle different loads. Here is the theory behind the load test on a DC series motor:

Torque-Speed Characteristics: The torque-speed characteristic of a DC series motor shows the relationship between the motor's torque output and its speed of rotation. As the load on the motor increases, the torque required to overcome the load also increases. The motor responds by decreasing its speed to maintain the balance between the torque produced and the torque required by the load. The torque-speed characteristic curve is typically a downward-sloping curve, indicating that the motor's speed decreases as the load torque increases.

Torque Calculation: Torque is the rotational force generated by the motor. It is proportional to the current flowing through the armature windings. The torque can be calculated using the formula:

Torque(T)=KtIa

T=(W2−W1)×r×9.81

Where: T=Torque in (Nm) K_t=Torque constant of the motor

I_a=Armature current(A) W1and W2 are loads in kg r is the effective radius of the pulley.

Power Calculation: Power is the rate at which work is done. In the case of a motor, it represents the output power generated by the motor. The power output of the motor can be calculated using the formula:

Power(P)=2πNT/60 Where:P Power output in watts

N Speed of the motor in RPM

T Torque in Nm

Efficiency Calculation: Efficiency is an important parameter that indicates how effectively the motor converts electrical energy into mechanical energy. It is calculated using the formula:

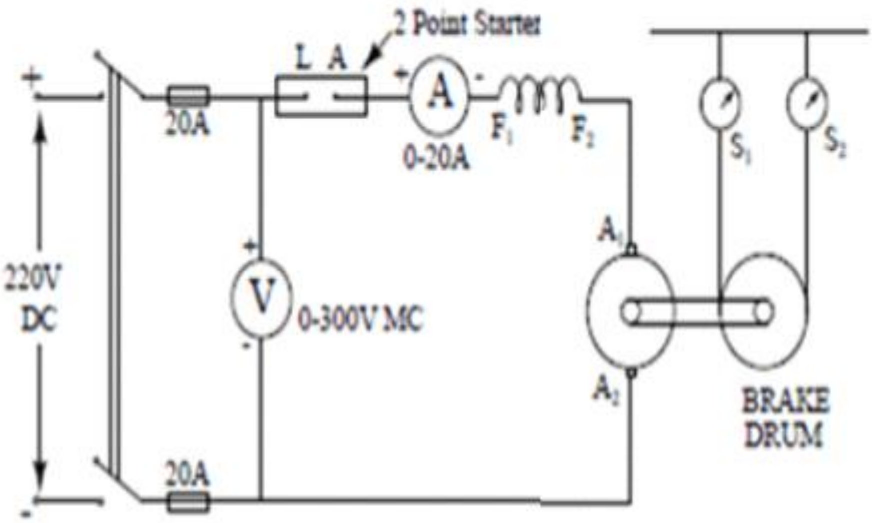
%Efficiency=PoweroutputPowerinput×100Where:Poweroutput=PowerdeliveredtotheloadPowerinput=Electricalpowerinputtothemotor

By varying the load and calculating the power and efficiency at different load settings, we can observe how the motor performs under different operating conditions.

Procedure: –

1. Connect all the apparatus as per circuit diagram.
2. Start motor with the help of starter and take the readings from measuring instruments in no load condition at rated speed.
3. Gradually increase the load on the pully and take the corresponding readings as per observation table.
4. During the experiment pour water in the groove of the pulley to keep it cool.

Circuit Diagram: –



Observation Table: –

Radius of the pully(r) in meter =…………

Sl. No.	**Input Voltage (V) in Volts.**	**Armature Current (I) in Amps.**	**Speed (N) in RPM**	**W_1 in Kg**	**W_2 in Kg**	**W=(W_2-W_1) in Kg**	**Torque (T) in N-m**	**Output Power (P_o) in watts**	**Input Power (P_i) in watts**	**% Efficiency**
1										
2										
3										
4										
5										
6										

Table No. 6.2

Calculation:

W=(W2−W1)inKgT=(W2−W1)×r×9.81inNmPi=2πNT60watt.P0=V×Iwatt.%Efficiency=P0Pi×100BHP=Pi746

Draw curve between

1. BHP vs Torque
2. Speed vs Torque
3. BHP vs Speed
4. BHP vs Efficiency

EXPERIMENT 5

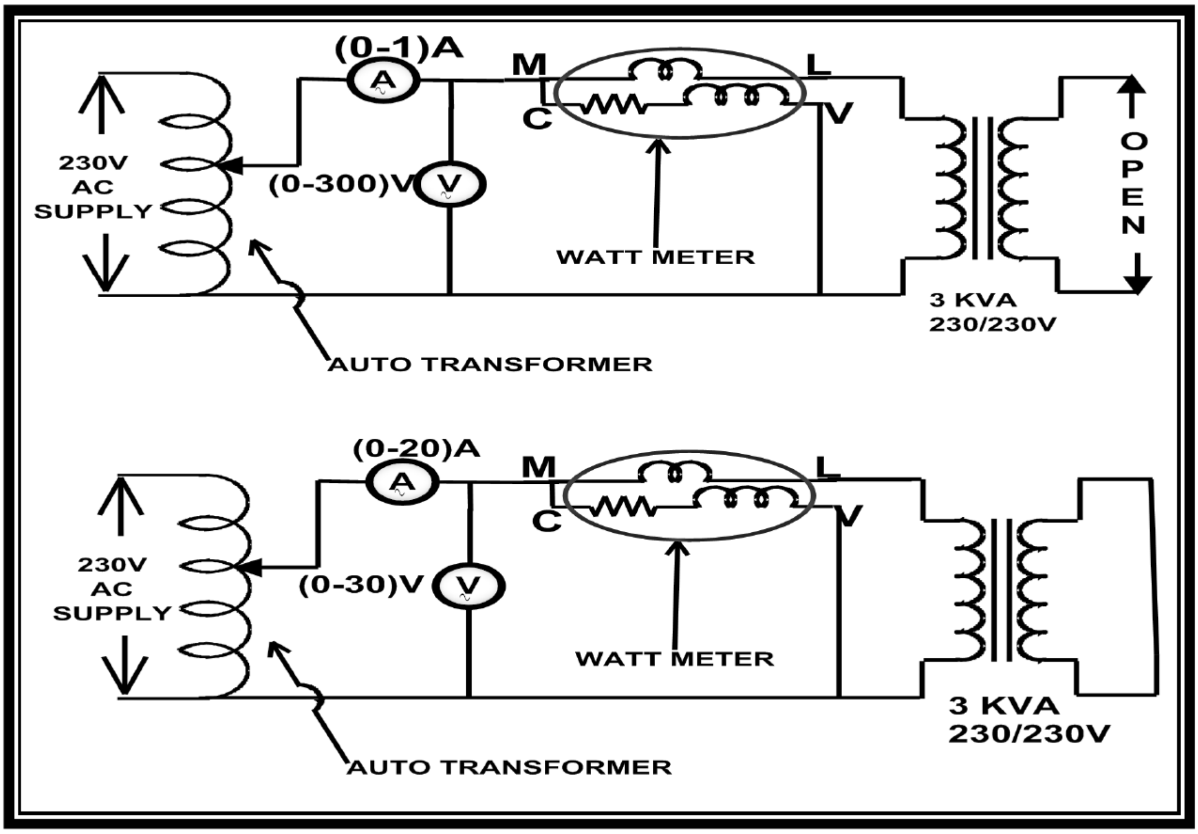
Open Circuit And Short Circuit Test Of A Single-Phase Transformer

Aim : To perform the open circuit and short circuit test of a single-phase transformer and to draw the equivalent circuit after determining its constants.

APPARATUS REQUIRED: –

Sl. No.	Name	Specification	Remarks/Quantity
1	Single phase transformer		1 Nos.
2	Wattmeter		1 Nos.
3	Wattmeter	(	1 Nos.
4	Ammeter	(0-5) A	1 Nos.
5	Ammeter	(0-30) A	1 Nos.
6	Voltmeter	(0-300) V	1 Nos.
7	Voltmeter	(0-30/75) V	1 Nos.
8	Single Phase Variac	5 KVA,(0-300) V, 30 A	1 Nos.
9	Connecting Wire	PVC insulated copper	As per required

CIRCUIT DIAGRAM: –



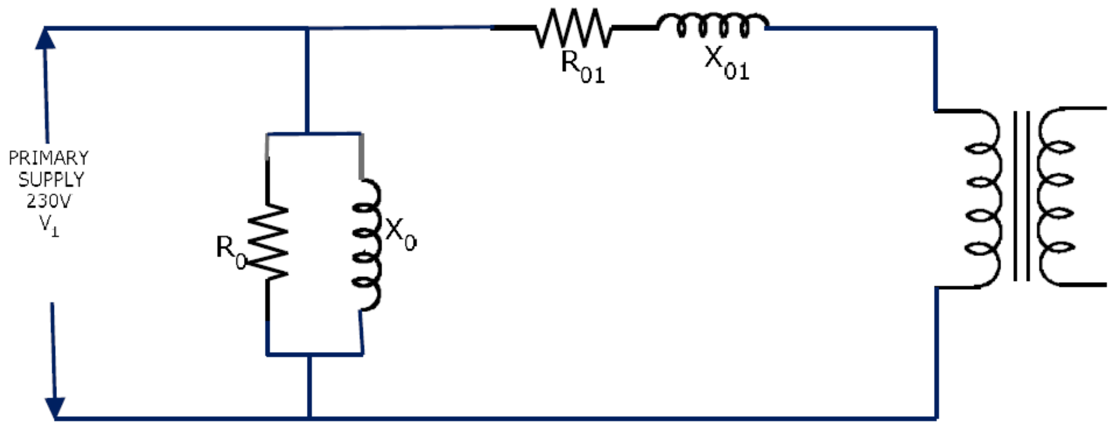
THEORY: –

The performance of a transformer can be calculated on the basis of its equivalent circuit which contains four main parameters, the equivalent resistance R_{01} as referred to primary(or secondary R_{02}), the equivalent leakage reactance X_{01} as referred to primary, the core-loss conductance G_0 and the magnetizing susceptance B_0. These constants or parameters can be easily determined by two test i.e. Open circuit test and short circuit test. These are very economical and convenient, because they furnish the required information without actually loading the transformer.

The purpose of O.C. test is to determine no load loss or core loss and no load I_0 which is helpful in finding X_0 and R_0. One winding of the transformer, whichever is convenient but usually high voltage winding, is left open and the other is connected to its supply of normal voltage and frequency. A wattmeter (W), Voltmeter (V) and ammeter (A) are connected in the low voltage winding i.e. primary winding in the present case. With normal voltage applied to the primary, normal flux will be set up in the core, hence normal iron loss will occur which is recorded by the wattmeter. As the primary no load current I_0 is small, Copper loss is negligibly small in primary and nil in secondary. Hence, the wattmeter reading represents practically the core loss under no load condition.

For short circuit test, one winding, usually the low voltage winding, is solidly short circuited by a thick conductor (or through an ammeter which may serve the additional purpose of indicating rated load current). A low voltage (usually 5 to 10% of normal primary voltage) at correct frequency (though for Cu losses it is not essential) is applied to the primary and is cautiously increased till full- load current is flowing both in primary and secondary (as indicated by the respective ammeters). Since, in this test, the applied voltage is a small percentage of the normal voltage, the mutual flux ø produced is also a small percentage of its normal value. Hence, core loss is very small with the result that the wattmeter reading represents the full load Cu loss or I^2R loss for the whole transformer i.e. both primary Cu loss and secondary Cu loss. If Vsc is the voltage required to circulate rated load current, then $Z_{01} = Vsc/I_1$.

A two winding transformer can be represented by means of an equivalent circuit as shown below



PROCEDURES: –

Open Circuit Test:

1. Connect all the instruments as per the circuit Diagram.
2. Open circuit the secondary and apply full load voltage to the primary through a Variac. The copper loss is negligible since there is only no load current flowing. Hence power consumed is the core losses of the core.
3. Note voltmeter, ammeter and wattmeter readings.

Short Circuit Test:

1. Connect as shown in the circuit diagram.
2. Short circuit the secondary and apply a low voltage to the primary through an auto transformer. The iron losses are negligible since the flux will be very low on account of the primary and secondary.
3. Increase the voltage gradually till full load current flows in the primary.
4. Note voltmeter and ammeter and wattmeter reading

PRECAUTIONS: –

1. Don’t switch on the power supply without concerning teachers.
2. Single-Phase Auto transformers must be kept at minimum potential point. Before switching on the experiment.

OBSERVATION TABLE : –

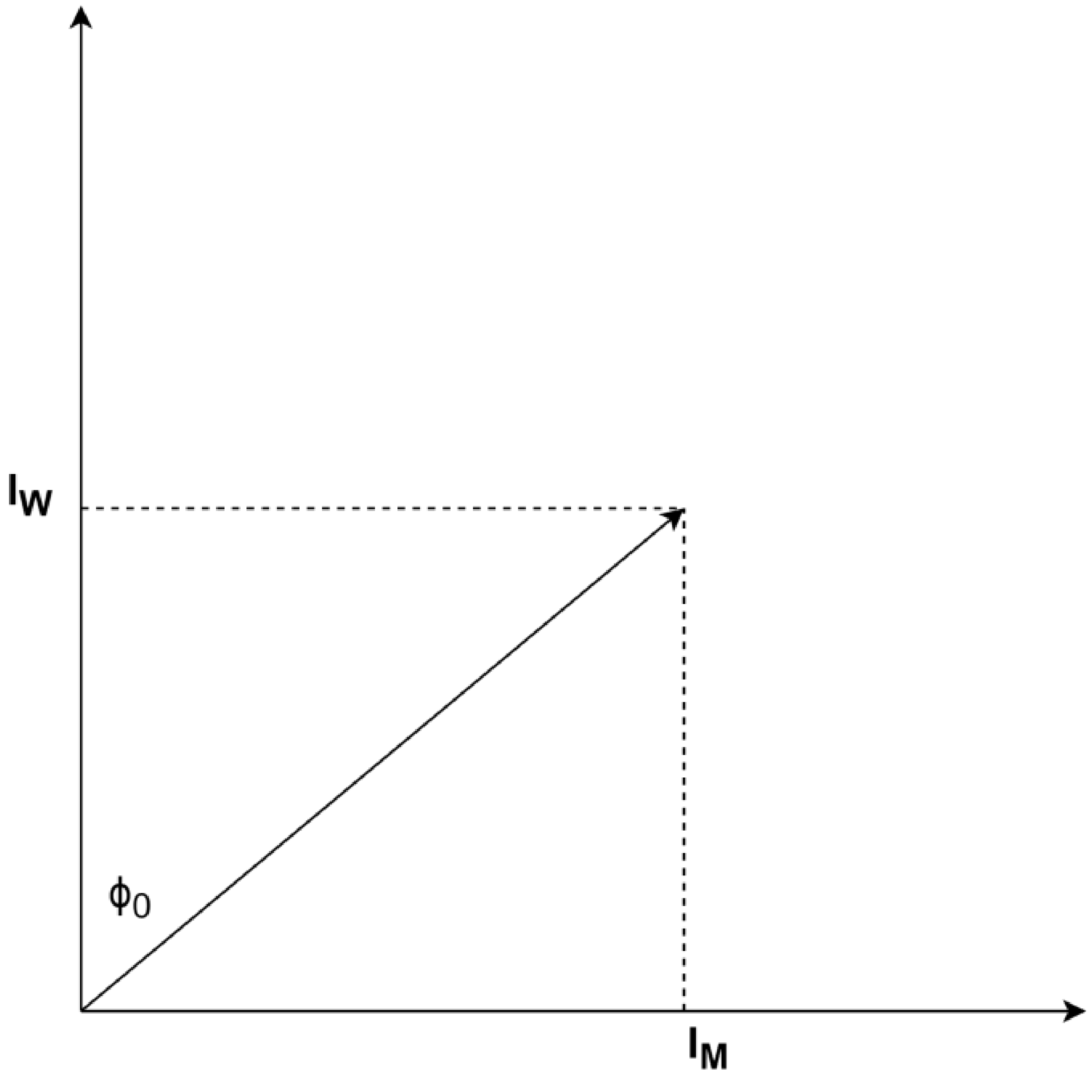
For Open Circuit Test:

Sl. No.	V (in Volts.)	I_0 (in Amps.)	W_0 (in Watts.)	I_w (in Amps.)	I_m (in Amps.)	$Cos\phi_0$
01						

Table No. 2.2

Calculation:

See the no load phasor diagram below



$W = VI_0 Cos\phi_0$

$I_W = \frac{W}{V}$,

$I_M = \sqrt{I_0^2 - I_W^2}$,

$R_0 = \frac{V}{I_W}$,

$X_0 = \frac{V}{I_M}$

For Short- Circuit Test:

Sl. No.	**V (in Volts.)**	**I_{sc} (in Amps.)**	**W_c (in Watts.)**
01			

Calculation:

Let the total equivalent resistance of primary and secondary referred to primary side be R_1
ohms and the total equivalent leakage reactance referred to primary side be X_1 ohms.

$$W_c = I^2 R_1$$

$$Hence\ R_1 = \frac{W_c}{I^2}$$

$$Also\ \frac{V}{I} = Z_1$$

$$and\ X_1 = \sqrt{Z_1^2 - R_1^2}\ ohms.$$

Now draw the equivalent circuit.

EXPERIMENT NO. : 6

Load test on Single phase Induction Motor.

Aim

To conduct Load test on Single phase Induction Motor and plot performance characteristics

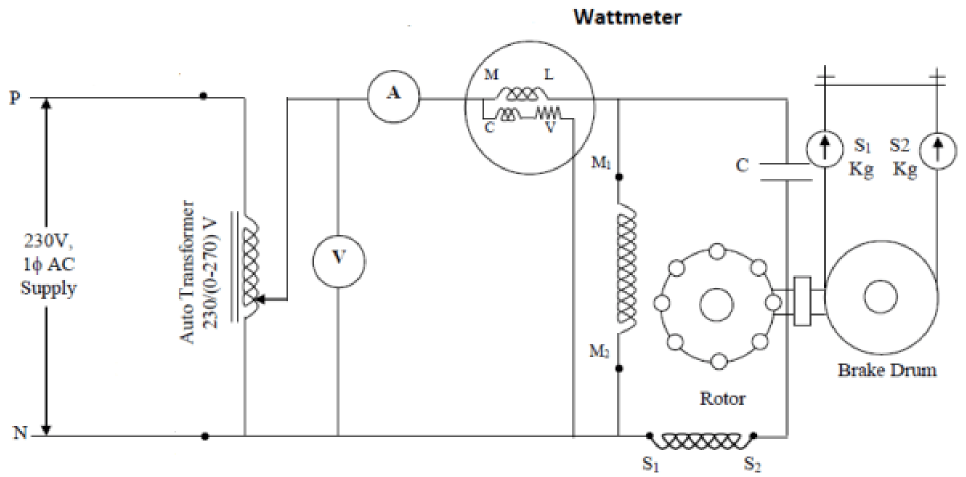
Objectives: –

To be written by student.

Apparatus Required: –

Sl. No.	Name	Specifications	Quantity
1	Single Phase Induction Motor with spring balance Load.		1 No.
2	Single Phase Auto-Transformer (VARIAC)		1 No.
3	Voltmeter		1 No.
4	Ammeter		1 No.
5	Wattmeter		1 No.
6	Tachometer		1 No.
7	Connecting Wires		As per required

Circuit Diagram: –



: Circuit Diagram for Load Test on single phase IM.

Theory: –

A **single-phase induction motor** is an **AC motor** that operates on a **single-phase power supply** and is commonly used in household and industrial applications for low-power requirements.

A single-phase induction motor consists of two main parts: **Stator** (Stationary Part) and **Rotor** (Rotating Part).

When a **single-phase AC supply** is applied to the stator winding, it produces an **alternating magnetic field**. Unlike a three-phase induction motor, a single-phase induction motor **does not** generate a rotating magnetic field on its own. Instead, it produces an **oscillating field**, which cannot start the rotor. To start the motor, an **auxiliary winding or starting mechanism** is used to create a phase difference.

Types of Single-Phase Induction Motors are

- Split-Phase Induction Motor.
- Capacitor-Start Induction Motor.
- Capacitor-Start, Capacitor-Run Induction Motor.
- Shaded-Pole Induction Motor.

The **load test** on a **single-phase induction motor** is conducted to determine its **performance characteristics** such as **efficiency, power factor, torque, slip, and output power** under different loading conditions.

Precautions: –

1. The auto transformer is kept at minimum voltage position.
2. The motor is started at no load condition.

Procedure: –

1. Connect all apparatus as per the circuit diagram.
2. By adjusting the Single phase auto transformer (VARIAC) the rated voltage is applied and the corresponding no load values of speed, spring balance and meter readings are noted down.
3. The procedure is repeated till rated current of the machine.
4. The motor is unloaded, the auto transformer is brought to the minimum voltage position.
5. The radius of the brake drum is measured.

Observation Table: –

Sl. No.	**V (in Volts.)**	**I (in Amps.)**	**P_i (in Watts)**	**S_1 (in Kg)**	**S_1 (in Kg)**	**W=(S_1-S_2)(in Kg)**	**Speed N (in rpm)**	**Cos Φ=(P_i/V*I)**	**Torque (T) in N-m**	**P_0 (in Watts)**	**% efficiency η= (P_0/P_i)*100**
1											
2											

Sl. No.	V (in Volts.)	I (in Amps.)	P_i (in Watts)	S_1 (in Kg)	S_1 (in Kg)	W=(S_1-S_2)(in Kg)	Speed N (in rpm)	Cos Φ=(P_i/V*I)	Torque (T) in N-m	P_0 (in Watts)	% efficiency η=(P_0/P_i)*100
3											
4											
5											
6											
7											

Calculation: –

Calculation: –

$$1.\ Input\ power\ (P_i)\ =\ Wattmeter\ reading\ \ in\ Watt.$$

$$2.\ Torque\ (T)\ =\ 9.81 * r * W\ \ in\ N - m$$

$$Where,\ \ r\ is\ radius\ of\ pully\ (brake\ drum)\ \ in\ meter$$

$$3.\ Output\ power\ (P_0)\ =\ \frac{2 * \pi * N * T}{60}\ in\ Watt.$$

$$Where,\ \ N\ is\ Speed\ of\ the\ motor\ \ in\ rpm$$

$$4.\ Power\ factor,\ Cos\ \Phi\ =\ \frac{P_i}{V * I}$$

$$5.\ \%\ Efficiency\ (\eta)\ =\ \frac{P_0}{P_i} * 100$$

$$6.\ \%\ Slip\ (S)\ =\ \frac{N_s - N}{N_s} * 100$$

$$6.\ \%\ Slip\ (S)\ =\ \frac{N_s - N}{N_s} * 100$$

$$Where, N_S\ =\ synchronous\ speed\ =\ \frac{120 * f}{P}$$

$$Where,\ P\ =\ no.\ of\ poles$$

$$f\ =\ frequency\ of\ supply\ (Hz)$$

Plot graph:

Efficiency vs Load

Power factor vs Load

Speed vs Load

Slip vs Load

Torque vs Load

For Viva Question:

1. What is the purpose of this experiment ?

Answer: A **Load Test** on a **Single-Phase Induction Motor (IM)** is conducted to evaluate its **performance, efficiency, and torque characteristics** under actual working conditions. The primary objectives of this test are:

- Determine Efficiency,
- Measure Power Consumption,
- Torque vs Speed Characteristics
- Determine Slip of the Motor
- Analyze Power Factor Performance
- Determine Temperature Rise
- Identify Mechanical Losses

- Check Motor Performance under Different Loads

2. Whether single phase induction motor self starting motor ?

Answer: No, a **single-phase induction motor is not a self-starting motor**.

1. **Single-Phase Supply Produces an Alternating Magnetic Field**
    - When a single-phase AC supply is given to the stator winding, it creates a **pulsating (alternating) magnetic field**, not a **rotating magnetic field** (like in a three-phase motor).
    - This pulsating field **induces equal forward and backward torques** in the rotor, making the net torque **zero** at standstill.
    - As a result, the rotor does not start rotating on its own.
2. **Lack of Rotating Magnetic Field**
    - Unlike a **three-phase induction motor**, which inherently produces a **rotating magnetic field**, a single-phase induction motor lacks this mechanism.
    - The motor requires an **auxiliary starting method** to initiate rotation.

To overcome this problem, **auxiliary starting methods** are used to create a phase shift, generating an initial rotating magnetic field. The commonly used methods are:

1. **Split-Phase Induction Motor**
    - Uses an **auxiliary winding** (starting winding) placed at **90°** to the main winding.
    - A **centrifugal switch** disconnects the auxiliary winding once the motor reaches about **75-80%** of its rated speed.
2. **Capacitor-Start Induction Motor**
    - Uses a **capacitor in series** with the starting winding to provide **better phase shift** and **higher starting torque**.
3. **Capacitor-Start Capacitor-Run Induction Motor**
    - Uses two capacitors:
        - **Start capacitor** for high starting torque.
        - **Run capacitor** for smooth operation after starting.
4. **Shaded-Pole Induction Motor**
    - Uses **shaded poles (copper rings)** on a portion of the stator poles to create a **weak rotating magnetic field**.
    - Suitable for **low-power applications** like fans and clocks.

3. What are the starting methods of single phase induction motor ?

Answer: Since a single-phase induction motor is not self-starting, various methods are used to initiate its rotation. These methods create a phase shift between stator windings to produce a rotating magnetic field, allowing the motor to start.

6. What are the inherent characteristics of plain 1-phase Induction motor ?

Answer: A plain single-phase induction motor (without any starting mechanism) exhibits the following inherent characteristics:

Not Self-Starting, Double Revolving Field Theory, Low Starting Torque, Slip (S) and Speed Characteristics, Poor Power Factor, Efficiency is Lower Compared to Three-Phase Motors, Noisy Operation and Vibrations, Torque-Speed Characteristics, Overheating Issues, Application Suitability.

7. Why single phase induction motor has low power factor ?

Answer: A single-phase induction motor typically operates at a low power factor (0.6 to 0.8 lagging) due to the following reasons:

High Inductive Reactance in the Stator Winding, No Rotating Magnetic Field in Standalone Operation, High Magnetizing Current Requirement, Presence of Auxiliary Windings in Some Designs, Higher Copper Losses and Core Losses.

8. State double field revolving theory.

Answer: The Double Field Revolving Theory explains the principle of operation of a single-phase induction motor. It states that an alternating (single-phase) magnetic field can be resolved into two rotating magnetic fields of equal magnitude but opposite directions.

Since an induction motor requires a rotating field to generate torque, this theory helps understand why a single-phase induction motor is not self-starting and how it can be made to rotate.

9. How the direction of a capacitor start Induction motor is reversed ?

Answer: A capacitor-start induction motor has a main winding and an auxiliary (starting) winding with a capacitor to create a phase shift and generate starting torque. The direction of rotation depends on the relative phase difference between these two windings.

10. Why is the starting torque of a capacitor start induction motor high, when compared to that of a split phase induction motor ?

Answer: A capacitor-start induction motor produces a higher starting torque than a split-phase induction motor due to the following reasons:

Greater Phase Angle Between Main and Auxiliary Winding Currents, Higher Starting Current in Auxiliary Winding, Improved Power Factor at Start, Larger Auxiliary Winding Size in Capacitor-Start Motors, Higher Torque Multiplication.

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