B.R.P GOVERNMENT POLYTECHNIC DHAMTARI (C.G)

DEPARTMENT OF ELECTRICAL ENGINEERING

AC MACHINES LAB MANUAL

IV SEMESTER

SUBJECT CODE: 2024462(024)

S.No	TITLE OF THE EXPERIMENT	Page No	Experiment Performed on	Signature/ Remark
1	To perform No - load test on 3 - phase Induction motor and to find the magnetizing resistance and reactance			
2	To conduct open circuit, short circuit and load test on the given single phase induction motor and to plot its performance characteristics			
3	Study of (manual and Semi automatic) Direct on line starter, Star- Delta Starter, connection and running a 3-phase induction motor and measurement of starting current			
4	Study of (manual and Semi automatic) Auto transformer starter, Rotor resistance Starter, connection and running a 3-phase induction motor and measurement of starting current.			
5	To study the types of single phase induction motor and their applications.			
6	To find regulation of a three-phase alternator by open circuit and short circuit tests			
7	To predetermine the regulation of three phase alternator by Potier methods and also to draw thevector diagrams.			
8	To draw the "V" and inverted "V"- curves of Synchronous motor			

EXPERIMENT - 1

NO - LOAD & BLOCKED ROTOR TESTS ON THREE PHASE INDUCTION MOTOR

AIM

To perform No - load test on 3 - phase Induction motor and to find the magnetizing resistance andReactance.

NAME PLATE DETAILS:

Motor

Voltage	
Current	
Rating	
Speed	
Phases	
Frequency	

APPARATUS:

S. No	Equipment	Type	Range	Quantity
1	3 phase auto transformer			
2	Ammeter			
3	Wattmeter			
4	Voltmeter			
5	Mechanical Load			

THEORY:

The no load test is similar to the open circuit test on a transformer. It is performed to obtain the magnetizing branch parameters (shunt parameters) in the induction machine equivalent circuit. In this test,the motor is allowed to run with no-load at the rated voltage of rated frequency across its terminals. Machine will rotate at almost synchronous speed, which makes slip nearly equal to zero. This causes the equivalent rotor impedance to be very large (theoretically infinite neglecting the frictional and rotational losses). Therefore, the rotor equivalent impedance can be considered to be an open circuit which reduces the equivalent circuit diagram of the induction machine **(Fig. 1)** Hence, the data obtained from this test will give information on the stator and the magnetizing branch.. The no load parameters can be found from the voltmeter, ammeter, and wattmeter readings obtained when the machine is run at no load.

In induction machine in its equivalent circuit form is akin to a transformer with 'slip' as an additional parameter. As a result, the equivalent circuit parameter estimation of induction machine proceeds on similar lines as that of a transformer's. The equivalent circuit for a single-cage induction machine is shown in **Fig.(1)**. Here, $(R_r' + R_r'(\frac{1-s}{s})) + jX_{r1}'$ represents the rotor circuit impedance as a function of slip s.

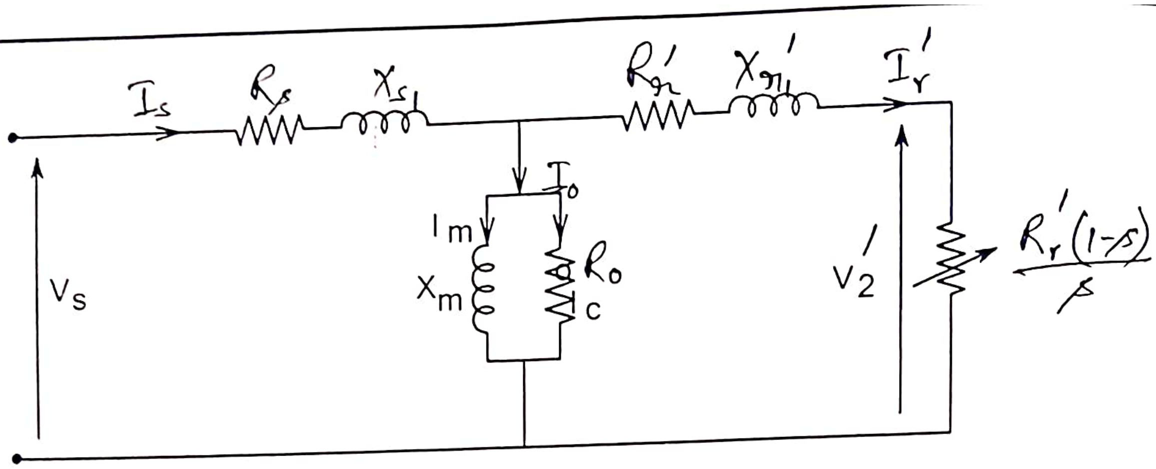


FIG (1) : Per phase equivalent circuit of Induction Motor

NO-LOAD TEST

The no-load test approximates the stator circuit (R_s and X_{s1}) and magnetization branch parameters(X_m) of an induction machine. The machine is brought to its rated speed by applying rated three phase volt-age at the stator (V_{nl}). Corresponding no-load current (I_{nl}) and no-load real power input(P_{nl}) are recorded.

When no mechanical load is driven by the machine, slip (s) is a very small value. As a result, referring to Fig.(1), the rotor circuit branch resistance quantity, $R_r'(\frac{1-s}{s})$ carries a large value. The impedance of rotor circuit branch is thus much higher compared to the magnetization branch impedance and their parallel combination would turn out to be close to jX_m (neglecting core conductance).

Thus,

$$X_{nl} = X_{s1} + X_m$$

$$Z_{nl} = \frac{V_{nl}}{I_{nl}}$$

$$R_{nl} = \frac{P_{nl}}{I_{nl}^2}$$

where, Z_{nl} and R_{nl} are the no-load equivalent impedance and resistance respectively. Next, using (1-3),we get,

$$X_{nl} = \sqrt{Z_{nl}^2 - R_{nl}^2}$$

Also, as no load current is drawn, the losses that occur under these conditions would represent the onlythe rotational losses arising from friction, core loss. Hence, $P_{loss} = P_{nl} - I_{nl}^2 R_s$

BLOCKED ROTOR TEST

The blocked rotor test is performed to estimate parameters that affect machine's performance under load such as its leakage impedance, similar to the short circuit test done for a transformer. In blocked rotor test, the machine shaft is locked or is prevented from rotating via external means. Block-ing the shaft essentially amounts to making the slip equal unity ($n_r = 0$). If E_2' is the voltage appearing across the rotor circuit, we have

$$s = \frac{n_s - n_r}{n_s} \quad \text{and} \quad I_r = \frac{E_2'}{\frac{R_r'}{s} + jx_{r1}}$$

It can be observed that, the rotor resistance offered in this case is 'effectively' lowered by a fraction of $1/s_0$ where s_0 is the slip under rated operation (0.01-0.04). Rated stator currents can thus be established for much lower than rated values of stator terminal voltage.

With the rated current (I_{br}) flowing in the stator, we note the stator applied voltage (V_{br}) and the power input(P_{br}). It should be noted that the rotor position in blocked state affects the stator voltage (V_{br}) required for setting up I_{br}. Hence, an average calculated over different rotor positions can be taken. Assuming we have the stator circuit parameters R_s ready, the other machine parameters can becalculated as indicated below.

$$Z_{br} = \frac{V_{br}}{I_{br}}$$

$$R_{br} = \frac{P_{br}}{I_{br}}$$

$$X_{br} = \sqrt{Z_{br}^2 - R_{br}^2} \quad \ldots\ldots \text{Eq (i)}$$

Here, $Z_{br} = R_{br} + jX_{br}$ is the equivalent impedance offered by the machine with rotor blocked. As the real power consumed during blocked rotor test is almost entirely the real power loss in the machine, we can use it to calculate the machine equivalent resistance as in (4). In other words, the applied statorvoltage being low, the core loss component is quite a small fraction of rated core-loss.

To approximate X_{sl}, X'_{rl} and R_r' it is needed to calculate the Thevenin equivalent impedance looking into the equivalent impedance of the machine from the stator terminals.

$$Z_{br} = R_{br} + jX_{br} \quad \ldots\ldots\ldots \text{Eq (ii)}$$

$$= R_s + jX_{s1} + \left[(jX_m) \parallel (R_r' + jX_{r1})\right]$$

$$\Rightarrow R_s + jX_{s1} + \frac{jX_m\left[R_r'^2 + jR_r'X_{r1} - jR_r'(X_{r1} + X_m) + X_{r1}(X_{r1} + X_m)\right]}{R_r'^2 + (X_{r1} + X_m)^2} \quad \ldots \text{Eq (iii)}$$

Letting $X_r = X_{r1} + X_m$

$$= R_s + jX_{s1} + \frac{jX_m\left[R_r'^2 - jR_r'X_m + X_{r1}X_r\right]}{R_r'^2 + X_r^2}$$

Equating the real and imaginary parts in Eq (i)

$$R_{br} = R_s + R_r' \frac{X_m^2}{R_r'^2 + X_r^2}$$

$$X_{br} = X_{s1} + \frac{X_m\left[R_r'^2 + X_{r1}X_r\right]}{R_r'^2 + X_r^2}$$

$$= X_{s1} + \frac{X_m \left[\frac{R_r'^2}{X_r} + X_r \right]}{\frac{R_r'^2}{X_r} + X_r}$$

Note: As $X_r >> R_r'$, the term $\frac{R_r'^2}{X_r}$ in Eq (ii) & $R_r'^2$ in eq (ii') can be neglected.

So, $R_{br} = R_s + R_r' \left(\frac{X_m}{X_r}\right)^2$ or

$R_r' \approx (R_{br} - R_s)\left(\frac{X_m}{X_r}\right)^2$. Also, $X_{br} = X_{s1} + \frac{X_m X_{r1}}{X_r}$

$$= X_{s1} + \frac{X_{r1}}{1 + \frac{X_{r1}}{X_m}}$$

Again, in general, as $X_m >> X_{r1}$,

$\frac{X_{r1}}{X_m}$ can be neglected, Thus, $X_{br} \approx X_{s1} + X_{r1}$

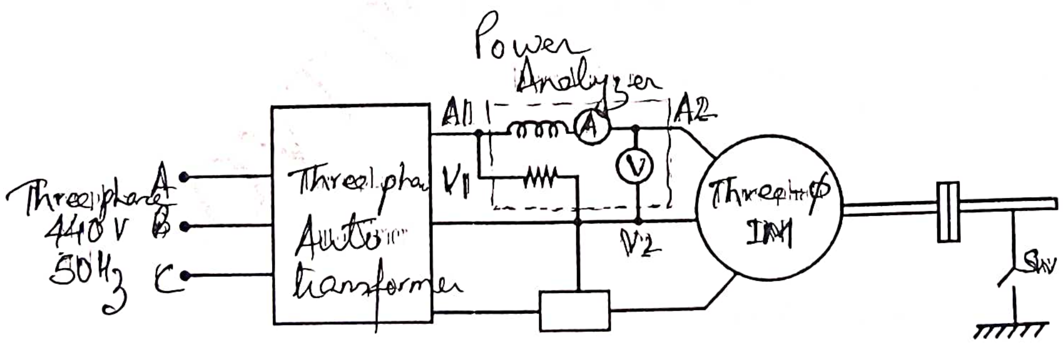
For wound-rotor construction, one can assume that $X_{s1} \approx X_{r1}$ resulting in $X_{s1} = X_{r1} = 0.5 * X_{br}$. However, for squirrel cage induction machines, the distribution of Xbr can be obtained from a look-up table indicating empirical distribution of leakage reactance for the machine type.

If X_{s1} is known, from the no-load test data, we have,

$$X_m = X_{nl} - X_{s1}$$

In this way, the machine parameters namely $X_{s1}, X_m, R_r', X_{r1}'$ can be calculated from the blocked rotor test using the above analysis.

CIRCUIT DIAGRAM:



Sw open: No load test

Sw closed: Blocked rotor test

PROCEDURE:

No - Load test:

V_{nl} (Vats)	I_{nl} (ANPS)	P_{nl} (Watts)	Speed (in r.p.m)

Blocked rotor test:

V_{br} (Vats)	I_{br} (AMPS)	P_{br} (Watts)

PRECAUTIONS:

1. Loose connections are avoided.
2. Properly note the rated stator voltage and full load current ratings.
3. Increase the supply voltage gradually and also while stopping decrease it gradually.

RESULT:

The parameters from no load and blocked rotor test are found as:

VIVA QUESTIONS

1. Explain what is meant by a 3 - phase induction motor.
2. Write the classification of 3 - phase induction motor.
3. State the steps to draw the equivalent circuit of 3 - phase induction motor.
4. State the condition for maximum torque of 3 - phase induction motor.
5. Give the different methods of speed control of I.M
6. How do you calculate slip speed?
7. State the condition when induction motor acts as induction generator.
8. Give the other name for induction generator.
9. Calculate the equivalent circuit parameters with the following machine dataMachine rating : 8 kW, 400 V, $R_{dc} = 0.6\ \Omega$ per phase
   No-load test: 400 V, 7 A, 250 W
   Blocked-rotor test: 90 V, 35 A, 1350 W
10. What machine parameters can be obtained from No-Load test?
11. What is the power factor of the machine? Comment on its value.

PROCEDURE:

No-load test :

1. Note down the machine ratings and calculate the rated current of the machine.
2. Disconnect any mechanical load connected to the induction motor.
3. Gradually apply three phase voltage across motor stator terminals via the autotransformer
4. As the stator voltage is increased, the machine speeds up. Make sure the voltage is applied suchthat the machine does not speed up too fast
5. Adjust the stator voltage to its rated value
6. Note down no-load quantities such as V_{nl}, I_{nl}, P_{nl}
7. Slowly decrease the stator voltage to zero and disconnect the supply.

BLOCKED ROTOR TEST :

1. Fasten the machine rotor shaft to the fixed disc with the help of screws provided. Make sure the rotor shaft is tightly held in position.
2. Slowly increase the three phase stator voltage from zero with the help of autotransformer.
3. Stop when rated current is established in the machine stator.
4. Record relevant quantities from the power analyzer
5. Slowly decrease the autotransformer voltage back to zero.

By voltmeter-ammeter method determine per phase equivalent stator resistance, R_1. If the machine is wound rotor type, find the equivalent rotor resistance R_2' also after measuring rotor resistance and required transformations are applied.

RECORD

NO-LOAD TEST :

- Input stator voltage at rated stator current (V_{nl}), stator current (I_{nl}), input real power(P_{nl})
- Use (2-4) to calculate Z_{nl}, R_{nl} and X_{nl}
- Use (5) to calculate rotational losses.

BLOCKED ROTOR TEST:

- Input stator voltage at rated stator current (V_{br}), stator current (I_{br}), input real power(P_{br})
- Use (4) and (5) to calculate R_{br} and X_{br}
- Further use (15),(19) and (20) to calculate machine parameters
  Use results of no-load test wherever necessary.

OBSERVATIONS:

2. What should be the no load current of an induction motor?

3. Even though there is no-load, why wattmeter reading is not zero?

4. Comment on the slip of the machine when operated at rated voltage.

5. How to obtain the no-load input power to an induction motor when two-wattmeter method of measuring power used?

6. Can a three phase induction motor be started from a single phase supply?

7. No load test is conducted at (a)rated current, (b)rated voltage, (c)high voltage, (d)high current

8. What is the nameplate reading on the machine? What inferences can be drawn from it?

9. What is the real and reactive power consumed in this test?

0. What are the different losses that are present in an induction machine?

1. Which loss in the machine is significant in no load test and why?

2. Why block rotor test of an induction motor is carried out?

3. When r2/s is split into a series connection of r2' and r2'{(1/s)-1} in the rotor equivalent circuit of an induction machine, what do the power absorbed by the individual resistors physically represent?

:4. How does the equivalent circuit of an induction motor simplify to under blocked rotor conditions? Justify.

:5. What is the power factor of the machine?

:6. Which loss in the machine is significant in blocked rotor test and why?

EXPERIMENT NO 2

PERFORMANCE EVALUATION OF SINGLE PHASE INDUCTION MOTOR

AIM

To conduct open circuit, short circuit and load test on the given single phase induction motor and to plot its performance characteristics.

APPARATUS REQUIRED:

S.NO	APPARATUS	SPECIFICATIONS	QUANTITY
1	VOLTMETER	(0-300V) MI (0-150V) MI	1 1
2	AMMETER	(0-10A) MI (0-5A) MI	1 1
3	WATTMETER	(300V,10A,UPF) (150V,10A, UPF) (300V,5A,LPF)	1 1 1
4	TACHOMETER	(0-10000 RPM)	1
5	Connecting wires	As required	

FORMULAE

Load test

1. Circumference of the brake drum = $2\pi R$ (m)

   R = Radius of the brake drum

2. Input power =W (watts)

   W = wattmeter readings

3. Torque (T) = 9.81x R x (S1 ~ S2) (N-m)

   where, S1, S2 = spring balance readings (Kg)

4. Output Power = $\frac{2\pi N T}{60}$ Watts, where N is the speed in r.p.m

5. % Efficiency (η) = $\frac{output\ power}{input\ power} \times 100$

6. Power Factor ($\cos \emptyset_0$) = W/ (V×I)

7. % slip , s = $\frac{N_s - N}{N_s}$, where N_s is the synchronous speed = (120 × f) / P where, P = No. of poles and f = supply frequency (Hz)

NO LOAD TEST

$R_1 = 1.5 \times R_{dc}$

$\cos \Phi = W_o / V_o I_o$

$$V_{AB} = \bar{V}_o - \bar{I}_o \times \left[\left(R_1 + \frac{r_2}{2}\right) + j(x_1 + x_2)\right]$$

$V_{AB} = I_o X_o X_o$

$= V_{AB} / I_o$

BLOCKED ROTOR TEST

$\cos \Phi sc = Wsc / (V_{sc} \times I_{sc})$

$Z_{eq} = V_{sc} / I_{sc}$

$R_{eq} = W_{sc} / (I_{sc})^2$

$R_{eq} = R_1 + R_2$

$R_2 = R_{eq} - R_1$ = rotor resistance referred to stator

$X_{eq} = \sqrt{(Z_{eq}^2 - R_{eq}^2)}$

Assuming $X_1 = X_2$

We have, $X_2 = X_{eq} / 2$

where W_0 = no-load input power in watts (watts)

W_{sc} = short circuit input power in watts (watts) V_0 = line voltage on no-load

I_0 = line current on no-load.

CALCULATIONS TO DRAW THE EQUIVALENT CIRCUIT

BLOCKED ROTOR TEST

$Z_{eq} = V_{sc} / Isc \; R_{eq}$

$= W_{sc} / (Isc)^2$

$X_{eq} = \sqrt{(Z_{eq}^2 - R_{eq}^2)}$

$R_1 = 1.5 * R_{dc}$

$R_{eq} = R_1 + R_2$

$R_2 = R_{eq} - R_1$

$X_{eq} = X_1 + X_2$

Assuming $X_1 = X_2$ and $R_1 = R_2$

We have, $X_2 = X_{eq} / 2$

$X_2 = X_{eq} / 2$

where V_{SC}= Short circuit voltage volts

I_{SC}= Short circuit current in amps and

W_{SC}= Short circuit power in watts

W_{SC}= Short circuit power in watts

NO LOAD TEST

$$V_{AB} = \bar{V}_o - \bar{I}_o \times \left[\left(R_1 + \frac{r_2}{2}\right) + j(x_1 + x_2)\right]$$

$V_{AB} = I_o x_o$

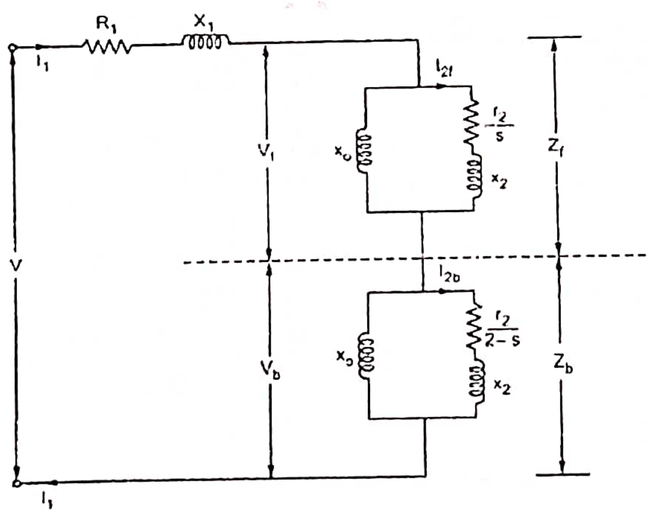
$$x_o = \frac{|VAB|}{Io}$$

where W_0 = no-load input power in watts (watts)

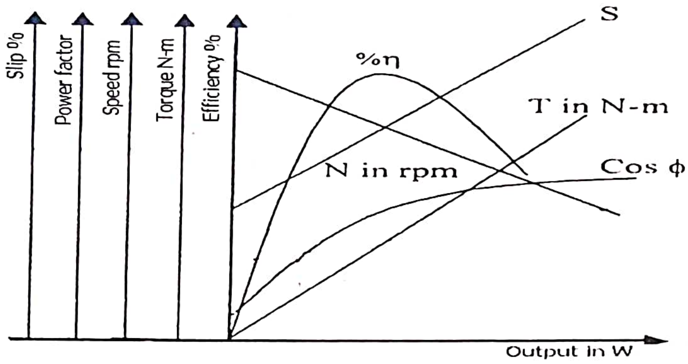
V_0 = line voltage on no-load and

I_0 = line current on no-load.

MODEL EQUIVALENT CIRCUIT



MODEL GRAPH



<u>TABULAR COLUMN</u>

NO LOAD TEST

V_0 (volts)	I_0 (amps)	W_0 (watts)

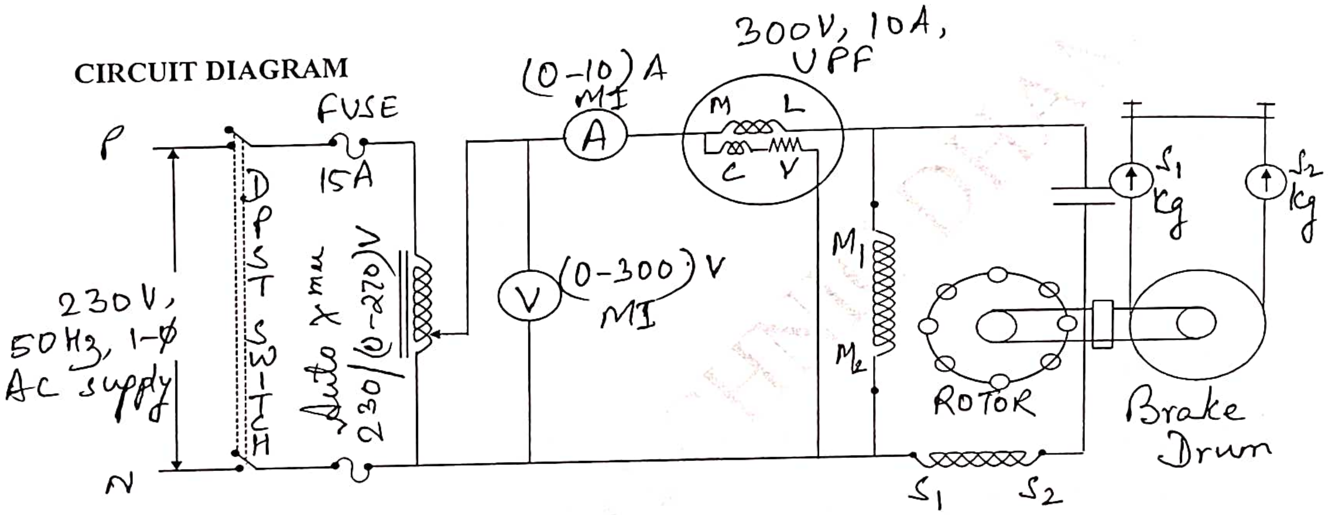
LOAD TEST

VoltageV (volts)	Current Amps	Speed N (rpm)	Spring balance readings (Kg)				Torque (T) N-m	Output Power (watts)	Power factor (cos Φ)	% efficiency (η)	%Slip (s)
			S1	S2	S1~S2						

BLOCKED ROTOR TEST

V_{SC} (volts)	I_{SC} (amps)	W_{SC} (watts)

CIRCUIT DIAGRAM



FUSE RATING

125 % of rated current

(125 × 9.5)/100 = 15 Amps

S_1, S_2 are the auxiliary winding

M_1, M_2 are the main winding

NAME PLATE DETAILS

Rated Voltage	220 V
Rated Current	9.5 A
Rated Power	3 H.P
Rated Speed	1470 r.p.m

PROCEDURE

LOAD TEST

1. Connections are given as per the circuit diagram
2. The DPST switch is closed and the single phase supply is given to the motor.
3. By adjusting the autotransformer, the rated voltage is applied and the correspondingno load values of speed, spring balance and meter readings are noted down. If the wattmeter readings show negative deflection on no load, switch of the supply & interchange the terminals of current coils (M & L) of the

wattmeter. Now, again start the motor (follow above procedure for starting), take readings.

4. The procedure is repeated till rated current of the motor is reached.
5. The motor is unloaded, the auto transformer is brought to the minimum voltage position, and the DPST switch is opened.
6. The radius of the brake drum is measured.

NO LOAD TEST

1. Connections are given as per the circuit diagram.
2. The motor is kept at no load condition.
3. The DPST switch is closed
4. By adjusting the 1Φ auto transformer the machine is brought to rated voltage.
5. The ammeter, voltmeter and wattmeter readings are noted down.

BLOCKED ROTOR TEST

1. Connections are given as per the circuit diagram.
2. The rotor is made standstill (held tight) by applying Load to the motor.
3. Close the DPST switch.
4. By adjusting the 1Φ auto transformer rated current is allowed to circulate.
5. The ammeter, voltmeter and wattmeter readings are noted down.

RESULT

PRECAUTIONS

LOAD TEST

1. The auto transformer must kept at minimum voltage position.
2. The motor is started at no load condition.
3. The motor should not be stopped under loaded condition

NO LOAD TEST

1. Initially DPST Switch is kept open.
2. Auto transformer is kept at minimum potential position.
3. The machines must be started on no load.

BLOCKED ROTOR TEST

1. Initially the DPST Switch is kept open.
2. Auto transformer is kept at minimum potential position.
3. The machine must be started at full load (blocked rotor).

VIVA QUESTIONS

1. What are the inherent characteristics of plain 1-Ø Induction motor?
2. Why single phase induction motor has low power factor?
3. State double field revolving theory.
4. How the direction of a capacitor start Induction motor is reversed?
5. Why is the starting torque of a capacitor start induction motor high, when comparedto that of a split phase induction motor?
6. What are the types of single phase induction motor?
7. Why single phase induction motors are not self-starting?
8. How the direction of a capacitor start Induction motor is be reversed?
9. In what respect does a 1-phase Induction motor differ from a 3-phase Inductionmotor?
10. What is the rating of single phase machines? State its applications

EXPERIMENT NO 3

Aim- Study of (manual and Semi automatic) Direct on line starter, Star-Delta Starter, connection and running a 3-phase induction motor and measurement of starting current.

APPARATUS REQUIRED:-

Sl. No	Name of the Equipment	Specification	Quantity
1	3-ϕInduction Motor	440 V, 1500 RPM, 3 H.P	1no
2	Insulated Combination Pliers	150 mm	1no
3	Screw driver	200 mm	1no
4	Line Tester	1100v, 6"	1no
5	3-ϕ DOL Starter	440V, 16A	1no
6	Star-Delta Starter(Manual)	440 V,16A	1no
7	Star-Delta Starter(Semi automatic)	440 V,16A	1no
8	Multimeter	-	1 no
9	Wires	2.5 sq mm	As per required

Theory:-

3-ϕ Induction Motor:-

The three-phase AC induction motor is a rotating electric machine that is designed to operate on a three-phase supply. This 3 phase motor is also called as an asynchronous motor. These ACmotors are of two types: squirrel and slip-ring type induction motors.

It works on the same principle as a DC motor, that is, the current-carrying conductors kept in a magnetic field will tend to create a force.

Direct on line (DOL) starter:-

DOL Starter (Direct Online Starter) is also known as "across the line starter". DOL starter is a device consists of main contactor, protective devices and overload relay which is used for motor starting operations. It is used for low rating usually below 5HP motors.

In direct online starter method of motor starting, the motor stator windings is directly connected to the main supply where the DOL protect the motor circuit from high inrush current which may damage the overall circuit as the initial current is much more higher than the full rated current.

Construction of DOL Starter:-

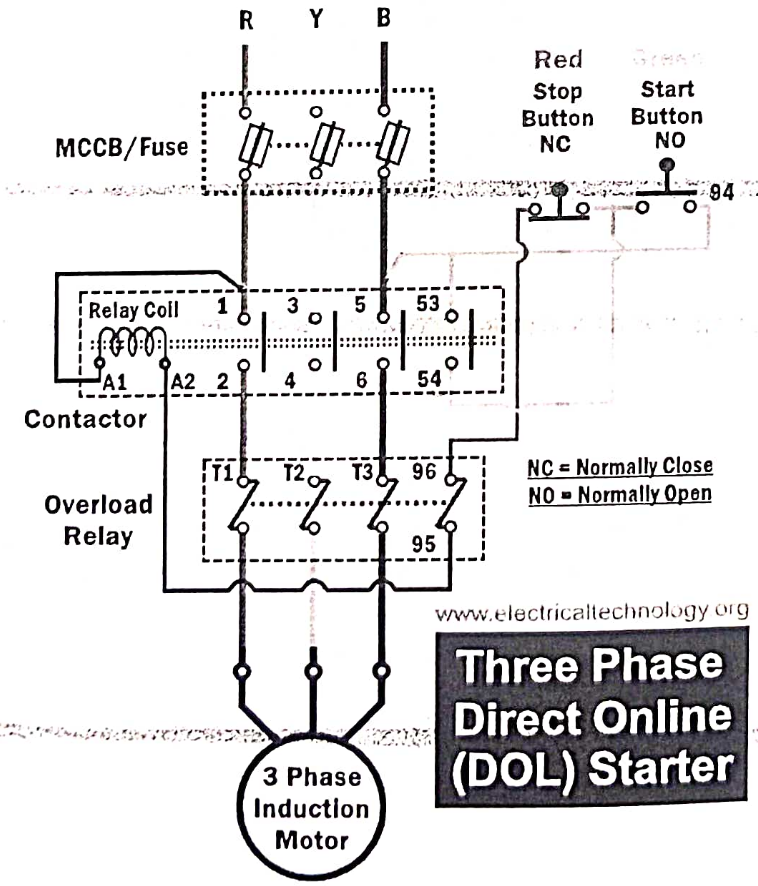
A DOL or Direct Online starter has simply two buttons; Green and Red, where the green button is used for starting and the red is used for stopping the motor. The green button connects the terminals and closes the circuit while the red button disconnects the terminals and breaks the circuit.

The DOL starter is made of a circuit breaker or MCCB or fuse, an overload relay and contactor or coil. The circuit breaker is used for protection against short circuits while the overload relay protects the motor from overloading. The contactor is used for starting and stopping the motor where the green and red buttons are connected.

DOL Starter Working Principle:-

The working principle of a DOL starter begins with the connection to the 3-phase main with the motor. The control circuit is connected to any two phases and energized from them only. When the start button is pressed, the current flows through contactor coil (magnetizing coil) and control circuit also. The current energizes the contactor coil and leads to close the contacts, and hence 3-phase supply becomes available to the motor.

When the stop button is pressed, the current through the contact becomes discontinued, hence supply to the motor will not be available, and the similar thing will happen when the overload relay operates. Since the supply of motor breaks, the machine will come to rest. The contactor coil (Magnetizing Coil) gets supply even though we release start button because when we release start button, it will get supply from the primary contacts as illustrated in the diagram ofthe Direct Online Starter.



Star- Delta Starter:-

A star delta starter is the most commonly used method for the starting of a 3 phase inductionmotor. In star delta starting an induction motor is connected in through a star connection throughout the starting period. Then once the motor reaches the required speed,the motor is connected in through a delta connection.

A star delta starter will start a motor with a star connected stator winding. When motor reaches about 80% of its full load speed, it will begin to run in a delta connected stator winding.

A star delta starter is a type of reduced voltage starter. We use it to reduce the starting current of the motor without using any external device or apparatus. This is a big advantage of a star delta starter, as it typically has around 1/3 of the inrush current compared to a DOL starter.

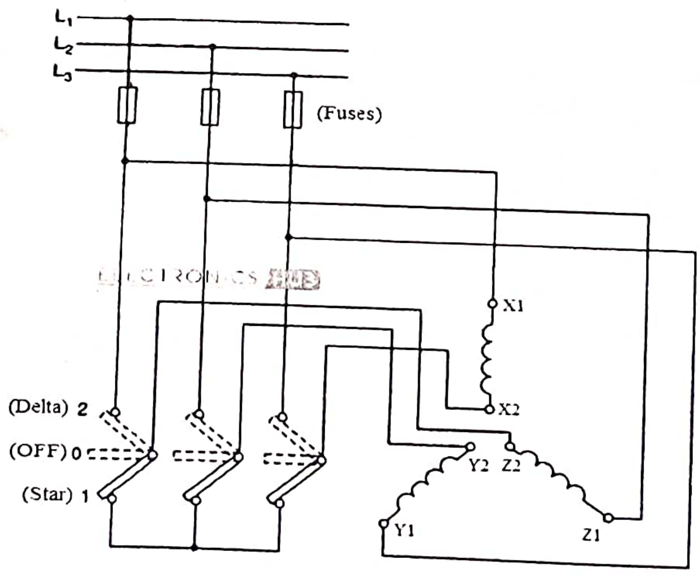
Manual Star-Delta Starter:-

The switch in this starter has three positions: 0 (for OFF), 1 (for Star) and 2 (for Delta). If the switch is placed in 0 – position, the windings of the motor are open and the motor is OFF. To activate the Star Connection, the switch is moved to 1 – position.

During this position of the switch, the finishing ends of the windings i.e. X2, Y2 and Z2 are shorted. This completes the star connection and the motor starts rotating.

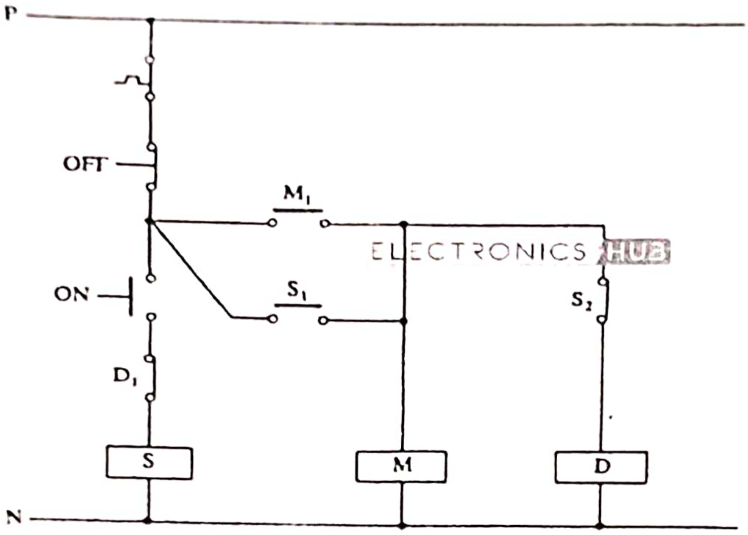
As the motor accelerates, it gains speed and as the speed of the motor approaches its rated speed, the switch is moved from 1 – position to 2 – position.

The 2 – position of the switch activates the Delta Connection as it establishes X2-Y1, Y2-Z1 and Z2-X1 contacts. The motor now runs in Delta Connection and reaches its rated speed without any problem.



Connection.

To turn off the motor, the OFF button is pushed, which will de – energize the contactors M and D (main and delta).



PROCEDURE:-

* Make the connections as shown in the circuit diagram.
* Set the timer at the marked position (10 secs).
* Check the three phase supply at the voltmeter.
* check the sequence of the operations of the contactors after switching the start button.
* Connect the power supply terminals R Y B to the M C and delta power terminals RYB on the board.
* Record the no-load current at starting with the help of ammeter.

Tabulation:-

Sl. No	Name of Starters	Starting Current in Amp
1		
2		
3		

CONCLUSION

From the above experiment, we learnt about the, manual and Semi automatic Direct on line starter, Star-Delta Starter, connection and running a 3-phase induction motor andits starting current.

VIVA QUESTIONS

1. What type of starter is mostly used in slip type Induction Motor?
2. Star- delta starter is used for starting which type of motor?
3. What type of starter is used in high rating slip ring induction motor?
4. What is the rotor frequency at the starting of induction otor?
5. Which type of starting is referred as full voltage starting for a three phase induction otor?
6. A three phase squirrel cage induction motor is started with a star delta starter, what will be the starting current of the motor?
7. What will be the backup fuse rating recommended for 7.5 h.p, three phase, 415 V, 11.2 A, motor with D.O.L starter?
8. Till what rating of a motor, a D.O.L starter can be used?

EXPERIMENT NO 4

Aim: Study of (manual and Semi automatic) Auto transformer starter, Rotor resistance Starter, connection and running a 3-phase induction motorand measurement of starting current.

APPARATUS REQUIRED:-

Sl. No	Name of the Equipment	Specification	Quantity
1	3-ϕInduction Motor	440v, 1500 RPM, 3HP	1no
2	3-ϕSlip-ring Induction Motor	440v, 1500 RPM, 3HP	1no
3	Insulated Combination Pliers	150mm	1no
4	Screw driver	200mm	1no
5	Line Tester	1100v, 6""	1no
6	Wire Stripper	150mm	1 no
7	3-ϕ Auto Transformer Starter	440V, 16A	1no
8	Rotor Resistance Starter	440v,16A	1no
9	Multimeter	-	1no
10	Wires	2.5 sq mm	As per required

THEORY:

A three-phase Induction Motor is **Self Starting**. When the supply is connected to the stator of a three-phase induction motor, a rotating magnetic field is produced, and the rotor begins rotating and the induction motor starts. At the time of starting, the motor slip is **unity**, and the starting current is very large.

The purpose of a starter is not to just start the motor, but it performs the two main functions. They are as follows:

- To reduce the heavy starting current,
- To provide overload and under-voltage protection.

The three-phase induction motor may be started by connecting the motor directly to the full voltage of the supply. The motor can also be started by applying a reduced voltage to the motor. The torque of the induction motor is proportional to the square of the applied voltage. Thus, greater torque is exerted by a motor when it is started on full voltage than when it is started on the reduced voltage.

AUTO TRANSFORMER STARTER:-

Squirrel cage induction motor started on full line voltage using D O L starter as a starting method draw very large starting current which can damage motor winding and also create a current surge on the power system. Hence another starting method is used to start three phase induction motor called an autotransformer starter. Auto transformer Starter can be used for

both star/delta connected induction motors.

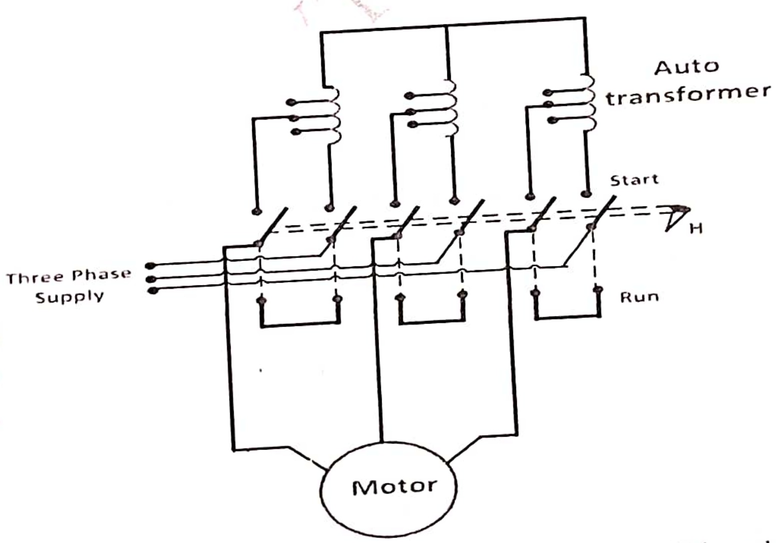
The starting current 6 to 8 times the rated current and this can cause voltage dip in supply and also motor and motor-driven equipment experience large torque surge which can damage the motor as well as connected equipment. Three phase autotransformer is used to reduce high inrush starting current.

Many reduce voltage starting methods are used to start induction motor. one of them is autotransformer starter. autotransformer starter is also reduced

voltage starter particularly used for higher rating motors greater than 10HP.

Auto-transformer starter (Variable Autotransformer) can be used with any squirrel cage induction motor, motor supplied through taps of three-phase auto transformer starter. In Auto- transformer Starter, Motor is directly connected on secondary of autotransformer.

The taps provided on auto-transformer limit the starting voltage and supply motor in steps of50% 65% or 80% of nominal voltage. Using auto transformer for starting purpose the line current is always less than motor nominal current during start, because of motor connected to the secondary side of auto-transformer starter during acceleration.



If motor connected to 50% tap of auto transformer, the motor current would be reduced up to 50% of nominal starting current. But the line current will be only 25% of nominal starting current. The difference between line current and motor current due to auto transformer is in thecircuit.

Due to the lower line, current auto transformer starter is a very popular type of reduce voltagestarter. Since motor starting current is greater than the line current with autotransformer starter, the starter produced more torqu per ampere of line current than any other type of reduce voltage starter

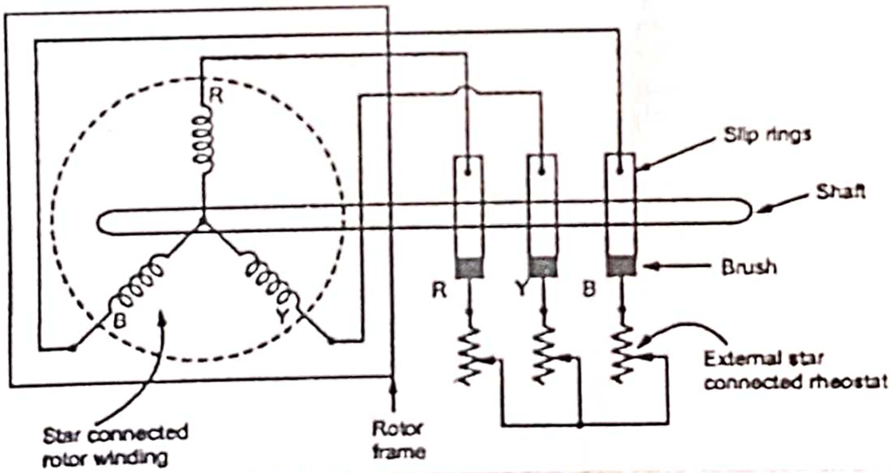
lip-ring Induction Motor:-

A slip ring induction motor is referred to as an asynchronous motor as the speed at which it operates is not equal to the synchronous speed of a rotor. The rotor of this type of motor is wound type. It comprises of a cylindrical laminated steel core and a semi-closed groove at the outer boundary to accommodate a 3-phase insulated winding circuit.

Rotor Resistance Starter:-

These motors are practically started with full line voltage applied across the stator terminals. Starting current is adjusted by introducing a variable resistance or rheostat in the rotor circuit. The rheostat connected in star & the resistance being gradually cut out of the rotor circuit equally in each phase as motor picks up the speed. By increasing the rotor resistance, is the rotor current is reduced at starting and the starting torque is also increased due to improvementin power factor.

The controlling rheostat is either contact type as in this experiment on that of the stud type. Starter usually having a line switching contactor for the stator along with no voltage and order current protective device. There is some kind of interlocking to ensure sequential operation of the line contactor and the starter. This interlocking prevents the closing of stator contactor unless the starter is all in. The additional external resistance in the rotor circuit enables a slip ringmotor to develop a high starting torque with moderate starting current. Additional resistance cuts as the motor gains speed.



PROCEDURE:-

- Make the connections as shown in the circuit diagram.
- Set the timer at the marked position (10 secs).
- Check the three phase supply at the voltmeter.
- check the sequence of the operations of the contactors after switching the startbutton.

* Connect the power supply terminals R Y B to the M C and delta power terminals RYBon the board.
* Record the no-load current at starting with the help of ammeter.

TABULATION:-

Sl.No	Name of Starters	Starting Current in Amp
1		
2		
3		

CONCLUSION:-

From the above experiment, we learnt about the, Auto Transformer Starter, Rotor resistance Starter, connection and running a 3-phase induction motor and its starting current.

EXPERIMENT NO 5

AIM: - To study the types of single phase induction motor and their applications.

THEORY:-

SINGLE PHASE INDUCTION MOTORS:-

The single-phase induction motor in construction is somewhat similar to a polyphase induction motor, except that the stator winding is supplied with a single phase AC power. The single phase AC voltage of stator winding produces a alternating magnetic field, but this alternating magnetic field cannot generate induced voltage, in a standstill rotor, hence single phase Induction motor is basically not a self starting motor. To start the motor additional starting winding is required to be used which is disconnected by a centrifugal switch when the rotor gathers 70 to 80% of its rated speed.

STARTING OF SINGLE PHASE INDUCTION MOTORS:-

The various methods of starting basically employ a starting winding and a centrifugal switch, in some cases when starting winding is required to be disconnected while normal running of the motor. The starting and running or main winding are spaced 90 electrically apart and are connected in parallel across the single phase supply. It is so arranged that the phase difference between the currents in the two-stator windings in very large (Ideal value being 90). Hence the motor behaves like a two-phase motor. These two currents produce a revolving flux and hence make the motor self-starting.

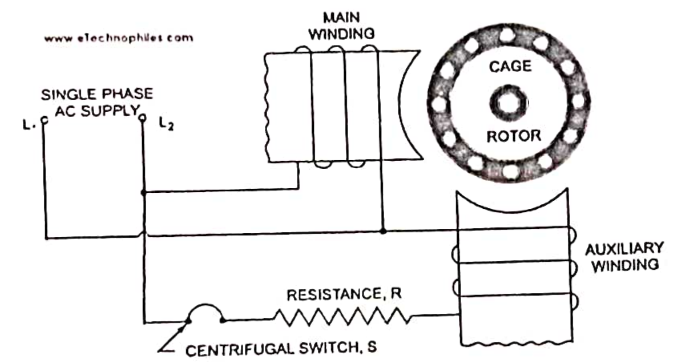
There are different methods by which necessary phase difference between the two currents can becreated.

Based on the type of impedance connected to the auxiliary winding of the motor, there are five types of single-phase induction motors.

1. Resistance start motor
2. Capacitor start motor
3. Capacitor start capacitor run motor
4. Permanent capacitor motor
5. Shaded pole motor

RESISTANCE-START SINGLE-PHASE INDUCTION MOTOR

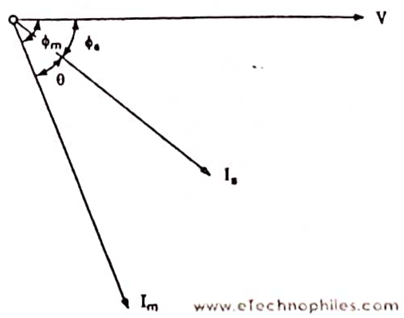
In this method, we connect a high resistance in series with the auxiliary winding of the motor, as shown in the figure.



The overall inductance in both the windings is as follows:

- The auxiliary winding has a high resistance but a low inductive reactance.
- The primary winding has a low resistance but a high inductive reactance.

Due to this, the primary winding current (Im) lags the applied voltage by 65-75 degrees, while the auxiliary winding current (Is) lags by 35-45 degrees. Thus, there is a difference of about 20-30 degrees between both currents, as shown in the phasor diagram below.



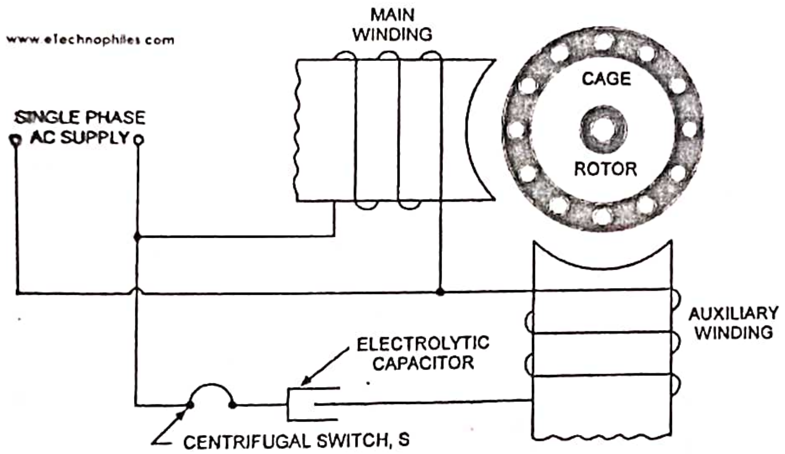
Although there lies a small phase difference between the currents, it is still sufficient to start the motor.

As the motor speed reaches 75 to 80% of synchronous speed, a centrifugal switch disconnects the auxiliary winding from the motor circuit. It protects the auxiliary winding from overheating and burning.

APPLICATIONS:-

- These motors are ideal only for small inertia loads that require moderate starting torque.
- It includes woodworking tools, grinders, fans, blowers, etc.

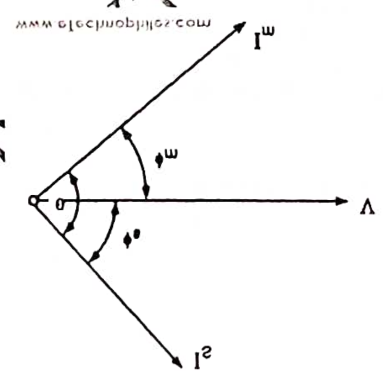
CAPACITOR-START SINGLE-PHASE INDUCTION MOTOR



It is an improved form of the resistance-start method. It contains an electrolytic capacitor in series with the auxiliary winding. In this case:

- The auxiliary winding has a higher capacitive reactance.
- The primary winding has a high inductive reactance.

Due to this, the current in the primary winding lags the applied voltage, while the auxiliary winding current leads the applied voltage, as shown in the phasor diagram.



It is visible that the phase difference between the currents has increased significantly. Hence the starting torque of the motor also increases.

APPLICATIONS:-

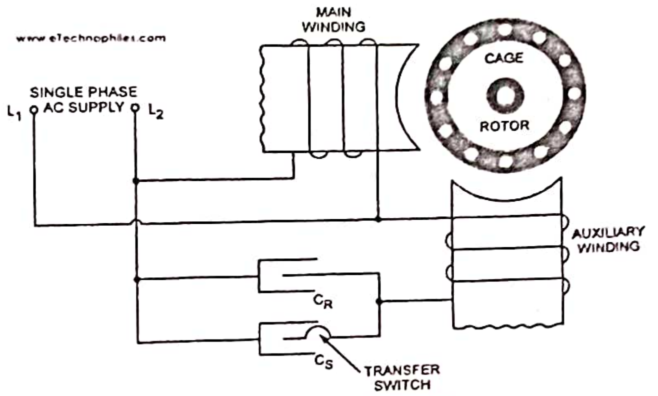
- Capacitor start motors are efficient to use in fans, blowers, jet pumps, sump pumps, etc.
- They are also ideal for farm and home workshop tools, oil burners, etc.

CAPACITOR-START, CAPACITOR-RUN SINGLE-PHASE INDUCTION MOTOR

Although the use of an electrolytic capacitor increases the starting torque, it has two problems:

- These capacitors are rated only for short-duty service. It gets damaged if used for a longer time.
- The dielectric of the capacitor gets damaged if the motor is started too frequently in a short time interval.

So, to get smooth starting and running conditions, we use capacitor-start, capacitor-run motors. It uses two different capacitors placed parallel to each other, as shown in the figure.



- The first one is an oil-impregnated capacitor (Cr). It is a continuous rating capacitor with a smaller value.
- The second one is an electrolytic capacitor (Cs). It is a short-duty capacitor with a higher value.

During starting, both the capacitors remain in the circuit. The overall capacitance gets added, which gives a higher starting torque.

When the motor picks 75% of the synchronous speed, the centrifugal switch disconnects the starting capacitor (C_s) from the circuit. Thus after that, only the running capacitor (Cr) remains with the auxiliary winding.

This method is different from the above two types of single-phase induction motors. Here, the auxiliary winding remains connected in the circuit at all times, i.e., both starting and running.

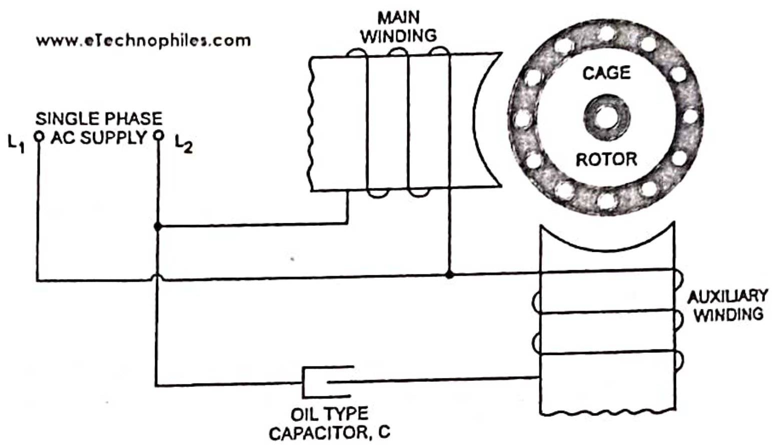
ADVANTAGES

- It produces a constant torque and generates less noise.
- These motors have a 25% better overload capacity.
- Its efficiency is better than the above two types.

APPLICATIONS

- Due to a better starting and running torque, these motors are ideal for compressors, refrigerators, and pumps.
- Their low noise feature makes them beneficial to use in hospitals and studios.

PERMANENT CAPACITOR SINGLE-PHASE INDUCTION MOTOR



This motor uses only one capacitor in series with the auxiliary winding. Here, the capacitor remains connected in the circuit during the starting as well as running. So, there is no need for a centrifugal switch, as discussed in the above types of single-phase induction motors.

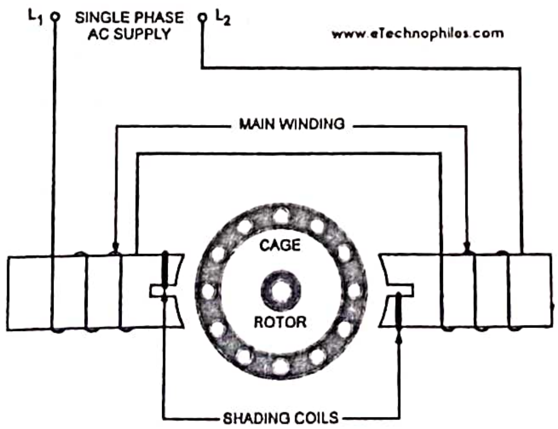
The advantages of this motor are similar to that of a capacitor start, capacitor run induction motor. But due to the use of only one capacitor, this motor can't give optimum starting and running conditions. It uses a Pyranol insulated foil paper capacitor.

APPLICATIONS

- They are ideal for ceiling fans, blowers, room coolers, and other domestic applications.
- Due to the simple reversal of the motor, they are best for induction regulators and furnace controls.

SHADED POLE MOTOR

This motor is entirely different from the above types of single-phase induction motor. It does not have any capacitors or moving switch parts. Its stator has salient poles, provided with its exciting coil. A copper strap (shading coil) wraps around 25% of the stator pole, as shown in the figure.



WORKING:

A single-phase supply to the stator coil sets an alternating magnetic field in the core. This alternating magnetic field interacts with the shading coil and induces a current in the shading coil. The shading coil current creates a flux (shading coil flux), which lags the main coil flux by some angle.

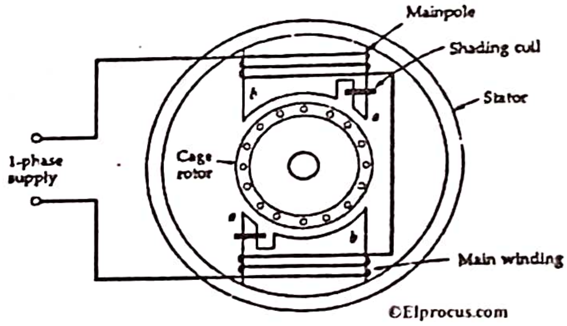
It appears that field flux shifts from the unshaded portion to the shaded part of the pole. This shifting of flux is like a weak rotating field. This rotating field interacts with the rotor and creates a starting torque.

APPLICATIONS

- Due to low starting torque, they are only suitable for toys, small fans, electric clocks, etc.
- They are also ideal for small business machines like photocopying and vending machine.

SHADED POLE MOTOR

A shaded pole induction motor is a simple single-phase induction motor, which is self-starting with one of the poles shaded by the copper ring. The other name of the copper ring is a shaded ring, where it acts as a secondary winding motor. It rotates only in one direction particularly and reverses moment is impossible. This motor has very high power induction losses and also has a very low power factor. Starting torque induced in the motor is very low. Due to these reasons, it has poor efficiency. This, it has low power ratings. It is also a salient pole split phase motor.



In the core, when a single phase is applied an alternating flux is generated. This flux links with the shaded coil in fraction amounts. Then voltage gets induced in the coil due to the variation in the flux linking. Hence, the shaded portion is short-circuited due to which it produces the circulating current in it. In such a way, the direction is opposing the main flux.

The main core flux is opposed by the flux in the ring that is developed by the circulating current. Hence, flux is induced in the shaded portion of the motor along with the unshaded portion with a phase difference, which is lagging behind the unshaded pole flux. There is also a space displacement that is less than 90 degrees between a shaded ring flux and the main motor flux. Due to this space displacement, a rotating magnetic field is produced which leads to a torque on the cage motor. In order to obtain reversal in the direction of rotation, we have to provide two shading coils.

CHARACTERISTICS

The shaded pole motor characteristics include the following.

- It produces starting torque that equals to half of the torque on full load
- Efficiency is low due to power loss in the shading coil.
- Used in small devices like fans
- Depending on the shaded coil position, the direction of rotation depends.

ADVANTAGES OF SHADED POLE MOTOR

- Low cost,
- Capable of self-starting
- Simple in construction
- Robust in nature
- Reliability
-

DISADVANTAGES OF SHADED POLE MOTOR

- Very low starting torque
- Low power factor
- High losses
- Less efficiency
- Difficult in speed reversal as it requires expensive copper rings

APPLICATIONS

The applications of the shaded pole motor include the following:-

- Relays, Fans and other small devices due to its low cost
- Exhaust fans
- Hairdryers
- Table fans
- Cooling fans
- Refrigerators
- Air conditioners
- Projectors
- Record players
- Tape recorders
- Photocopying machines and many more.

VIVA QUESTIONS:

1. Where do we require single phase induction motors?
2. Why is the power factor of single phjase induction motor low?
3. Why is the starting torque of a capacitor start induction motor high?
4. What is a fractional H.P motor?
5. What type of rotor is used in single phase motors?
6. Why shaded-pole single phase induction motor does not need any special starting technique like capacitors and auxiliary winding etc.
7. If a single phase motor is driven in any direction by any means, it starts running in that direction. Explain why?

EXPERIMENT - 6

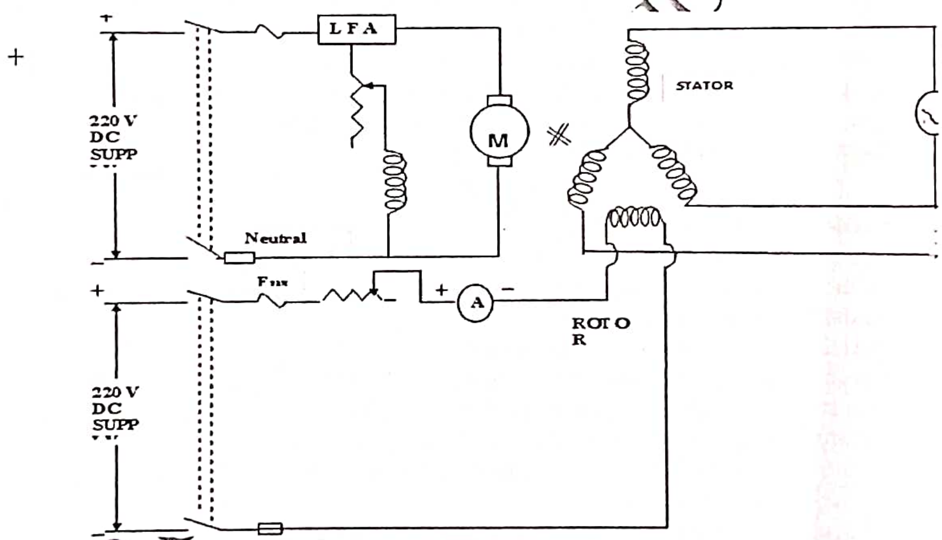
AIM:- TO FIND REGULATION OF A THREE-PHASE ALTERNATOR BY OPEN CIRCUIT AND SHORT CIRCUIT TESTS

APPARATUS REQUIRED:-

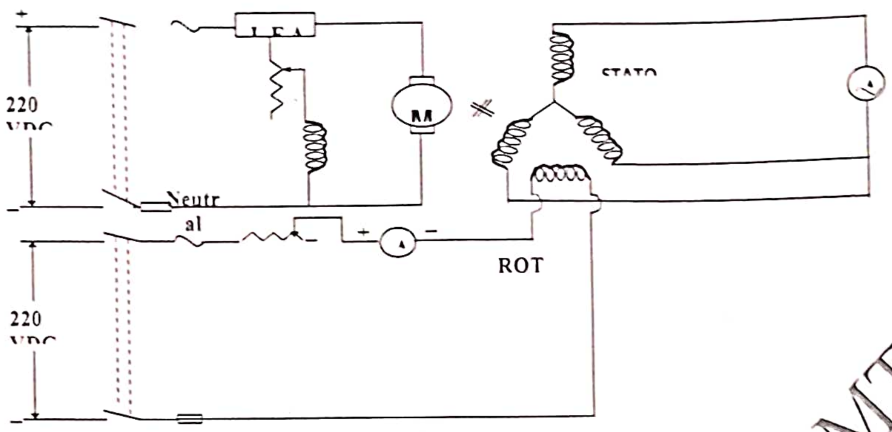
1. Ammeter (0-5A) AC-1No; (0-1A) DC-1 No.
2. Voltmeter (0-300V) AC-1 No.
3. Tachometer - 1 No.
4. Rheostats (400 .1.7A) 1No; 1000 .1.2A 1No.
5. Alternator 3 kVA, 4.2A, 1500 RPM, 3
6. D.C. Motor 3 HP, 220V, 1500RPM
7. Connecting wires etc.

CIRCUIT DIAGRAM:-

[A] OPEN CIRCUIT TEST



[B] SHORT CIRCUIT TEST



PROCEDURE:

[A] OPEN CIRCUIT TEST

1) Connect the circuit as shown.
2) Set potential divider to zero output position and motor field rheostat to minimum value.
3) Switch on dc supply and start the motor.
4) Adjust motor speed to synchronous value by motor field rheostat and note the meter readings.
5) Increase the field excitation of alternator and note the corresponding readings.
6) Repeat step 5 till 10% above rated terminal voltage of alternator.
7) Maintain constant rotor speed for all readings.

[B] SHORT CIRCUIT TEST

1) Connect the circuit as shown.
2) Star the motor with its field rheostat at minimum resistance position and the potentialdivider set to zero output.
3) Adjust the motor speed to synchronous value.
4) Increase the alternator field excitation and note ammeter readings.
5) Repeat step 4for different values of excitations (field current). Take readings up to rated armaturecurrent. Maintain constant speed for all readings
6) Measure the value of armature resistance per phase Ra by multimeter or by ammeter-voltmeter method.
7) Plot the characteristics and find the synchronous impedance.

PRECAUTIONS:

1)All connections should be perfectly tight and no loose wire should lie on the work table.
2)Before switching ON the dc supply , ensure that the starter's moving arm is at it's maximumresistance position.
3)Do not switch on the supply, until and unless the connections are checked by the teacher4)Avoid error due to parallax while reading the meters.
5)Hold the tachometer with both hands steady and in line with the motor shaft so that it reads correctly.
6) Ensure that the winding currents do not exceed their rated values.

OBSERVATIONS:

Alternator armature resistance per phase Ra = ------- Ω
Rotor speed = …………………… RPM

O.C TEST			S.C TEST		
Sr. No	Field current I_f (Amp)	Terminal voltage Per phase V_o	Sr. No.	Field current I_f	Short circuit current I_{sc}

GRAPH: Plot the readings to draw following graphs. Use same graph paper for both curves.

1. I_f versus V_o (from OC test)
2. If versus I_{sc} (from SC test)

CALCULATIONS:

PHASOR DIAGRAMS:

Draw phasor diagrams for above three loads and verify the calculated results.

RESULT:

Regulation of alternator at full load is found to be:

At unity pf = ...
At 0.8 lagging = ...
At 0.8 leading = ...

Synchronous Impedance varies for different values of excitation.

VIVA QUESTIONS

- Why OCC looks like B-H curve?
- Why SCC is a straight line?
- When is the regulation negative and why?
- One ton is equal to how many watts
- Define voltage regulation of an alternator
- Why is EMF method of determining regulation called a pessimistic method?
- Why is MMF method of determining regulation called a optimistic method?
- How is the armature winding in alternators different from those used in dc machines?
- Write down the equation for frequency of emf induced in an Altenator.
- What are the advantages of salient pole type construction used forSynchronous machines?
- Name the types of Alternator based on their rotor construction
- Why are Alternators rated in kVA and not in kW?
- What is the necessity for predetermination of voltage regulation?
- Name the various methods for predetermining the voltage regulation of 3-phase Alternator.
- What are the advantages and disadvantages of estimating the voltage regulation of an Alternator by EMF method?
- What are the test data required for predetermining the voltage regulation of an Alternator by MMF method?

EXPERIMENT - 07

REGULATION OF 3 - PHASE ALTERNATOR BY ZPF METHOD

AIM:

To predetermine the regulation of three phase alternator by Potier methods and also to draw thevector diagrams.

NAME PLATE DETAILS:

Alternator		DC Shunt Motor	
Voltage		Voltage	
Current		Current	
Frequency		Capacity	
Capacity		Speed	

APPARATURS:

S. No.	Equipment	Type	Range	Quantity
1	Ammeter			
2	Ammeter			
3	Voltmeter			
4	Voltmeter			
5	Rheostat			
6	Rheostat			
7	Tachometer			
8	TPST knife switch			

DIAGRAM:

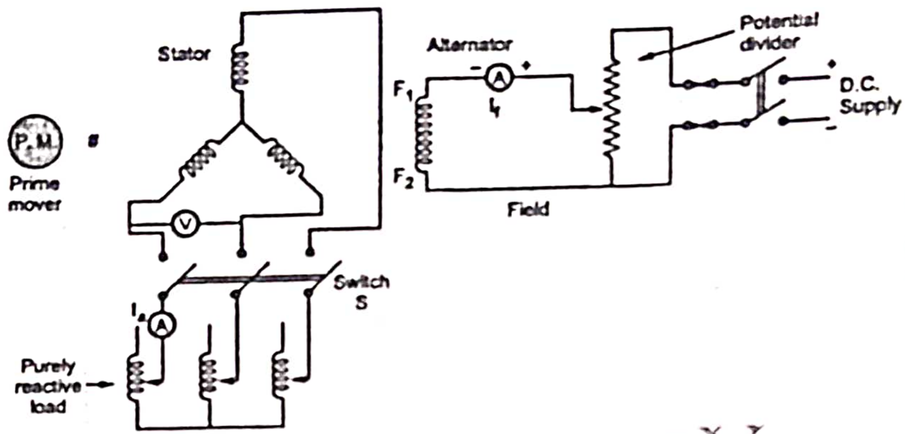


Fig: 7.1 Regulation of 3-Phase Alternator by Zpf and ASA Methods

THEORY:

ZPF method (Potier method)

Conduct tests to find OCC (up to 125% of rated voltage) SCC (for rated current)

ZPF (for rated current and rated voltage), Armature Resistance (if required)

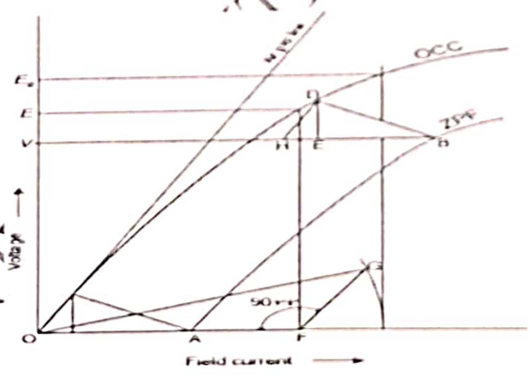


Fig – 7.2 Regulation of 3-Phase Alternator by ZPF and ASA Methods

STEPS:

1. By suitable tests plot OCC and SCC
2. Draw tangent to OCC (air gap line)
3. Conduct ZPF test at full load for rated voltage and fix the point B.
4. Draw the line BH with length equal to field current required to produce full load current at short circuit.
5. Draw HD parallel to the air gap line so as to touch the OCC.
6. Draw DE parallel to voltage axis. Now, DE represents voltage drop *IXL* and BE
7. Represents the field current required to overcome the effect of armature reaction.

Triangle BDE is called Potier triangle and XL is the Potier reactance

Find E from V, IX_L and Φ. Consider *Ra* also if required. The expression to use is

$$E = \sqrt{(V\cos\Phi + IR_a)^2 + (V\sin\Phi + IX_L)^2}$$

Find field current corresponding to *E*.

Draw FG with magnitude equal to BE at an angle (90+Ψ) from field current axis, where Ψ is the phase angle

of current from voltage vector *E* (internal phase angle).

The resultant field current is given by OG. Mark this length on field current axis.

From OCC find the corresponding *E0*.

PROCEDURE:

1. Note down the complete nameplate details of motor and alternator.
2. Connections are made as per the circuit diagram.
3. Switch on the supply by closing the DPST main switch.
4. Using the three point starter, start the motor to run at the synchronous speed by varying the motor field rheostat.
5. Conduct an open circuit test by varying the potential divider for various values of field current and tabulate the corresponding open circuit voltage readings.
6. Conduct a short circuit test by closing the TPST knife switch and adjust the potential divider the set the rated armature current, tabulate the corresponding field current.
7. Conduct a ZPF test by adjusting the potential divider for full load current passing through either an inductive or capacitive load with zero power and tabulate the readings.
8. Conduct a stator resistance test by giving connection as per the circuit diagram and tabulate the voltage and current readings for various resistive loads.

PROCEDURE TO DRAW THE POTIER TRIANGLE:

(All the quantities are in per phase value)

1. Draw the Open Circuit Characteristics (Generated Voltage per phase VS Field Current)
2. Mark the point A at X - axis, which is obtained from short circuit test with full load armature current.
3. From the ZPF test, mark the point B for the field current to the corresponding rated armature current and the rated voltage.
4. Draw the ZPF curve which passing through the point A and B in such a way parallel to the open circuit characteristics curve.
5. Draw the tangent for the OCC curve from the origin (i.e.) air gap line.
6. Draw the line BC from B towards Y-axis, which is parallel and equal to OA.
7. Draw the parallel line for the tangent from C to the OCC curve.
8. Join the points B and D also drop the perpendicular line DB to BC, where the line DE represents armature leakage reactance drop (IXL) BE represents armature reaction excitation (**I_{fa}**)

PROCEDURE TO DRAW THE VECTOR DIAGRAM (ZPF METHOD)

1. Select the suitable voltage and current scale.
2. For the corresponding power angle (Lag, Lead, Unity) draw the voltage vector and current vector OB.
3. Draw the vector AC with the magnitude of IRa drop, which should be parallel to the vector OB.
4. Draw the perpendicular CD to AC from the point C with the magnitude of IXL drop.
5. Join the points O and D, which will be equal to the air gap voltage (Eair).
6. Find out the field current (Ifc) for the corresponding air gap voltage (Eair) from the OCC curve.
7. Draw the vector OF with the magnitude of Ifc which should be perpendicular to the vector OD.
8. Draw the vector FG from F with the magnitude Ifa in such a way it is parallel to the current vector OB.
9. Join the points O and G, which will be equal to the field excitation current (If).
10. Draw the perpendicular line to the vector OG from the point O and extend CD in such a manner to intersect the perpendicular line at the point H.
11. Find out the open circuit voltage (Eo) for the corresponding field excitation current (If)
12. Find out the regulation from the suitable formula.

OPEN CIRCUIT TEST:

S.NO	Field Current (I_F)	Open Circuit Line Voltage(V_{OC})	Open Circuit Phase Voltage(V_{PH})
1			
2			
3			
4			
5			

ZPF TEST:

S. No	Field Current(I_F)	Rated armature Current(I_A)	Rated armature Voltage(V_A)	W_1	W_2	Total Power ($W_1 + W_2$)
1						
2						
3						
4						
5						
6						

PRECAUTIONS:

1. The motor field rheostat should be kept in the minimum resistance position.
2. The Alternator field potential divider should be in the position of minimum potential.
3. Initially all switches are in open position.

RESULT:

VIVA QUESTIONS:

1. Find out voltage regulation of alternator by Potier triangle method?
2. Find out voltage regulation of alternator based on separation of reactance due to leakage flux?
3. Calculate the voltage regulation of alternator by conducting the direct load test using 3- phaseinductors as load?
4. Calculate the voltage regulation of alternator by running the alternator as an over excited syn. Motoron no load?
5. What is meant by ZPF Test?
6. What is Potier reactance? How is it determined by Potier triangle?
7. What is meant by armature reaction reactance?
8. What is the significance of the ASA modification of MMF method?
9. What is air gap line in Potier method?
10. What is regulation of alternator?
11 Under what condition, regulation is positive or negative?
12 What is regulation at UPF?
13 Why Regulation is so important in alternator?
14 How the regulation is effected by armature reaction?

EXPERIMENT - 8

V AND INVERTED V- CURVES OF 3 - ϕ SYNCHRONOUS MOTOR

AIM:

To draw the V and inverted V- curves of Synchronous motor.

NAME PLATE DETAILS:

DC MOTOR		SYNCHORONOUS MOTOR	
HP		HP	
Voltage		Voltage	
Current		Current	
Field voltage		Poles	
Field current		Frequency	

APPARATUS:

S. No	NAME	RANGE	TYPE	QUANTITY
1	Ammeter			
2	Ammeter			
3	Voltmeter			
4	Wattmeter			
5	Rheostat			
6	Load			

CIRCUIT DIAGRAM:

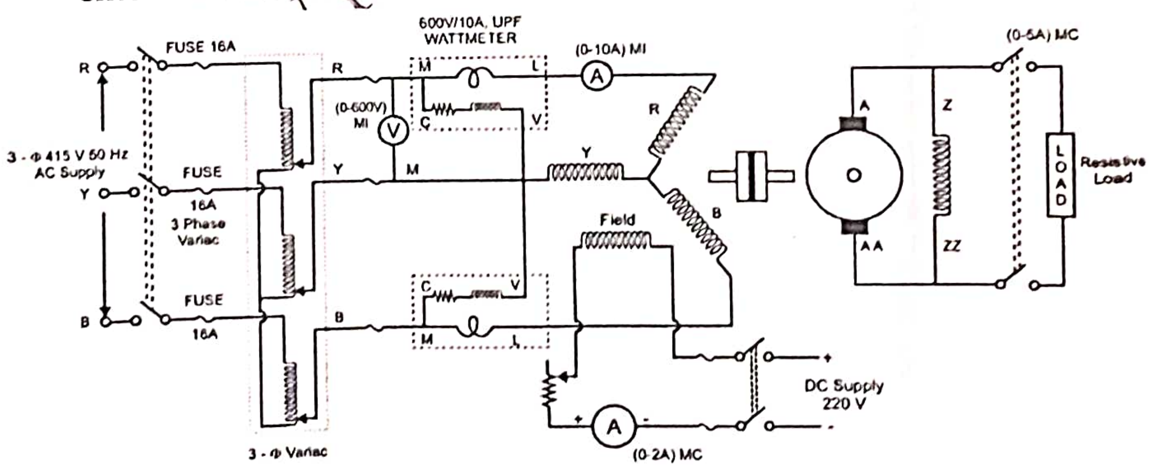


Fig – 8.1 V and Inverted V-Curves of 3-ϕ Synchronous motor

PROCEDURE:

1. Make the connections as per the circuit diagram.
2. Switch on the AC supply feeding to 3-phase synchronous motor and start the motor using 3- phase variac
3. Ensure that the motor is running at no-load and synchronous Speed.
4. Now the field winding of the synchronous motor is exited with excitation unit.
5. Set the Rheostat of the field winding of the motor to the position of the normal excitation. (Here the armature current will draw the minimum current from the mains.)
6. Note down all meter readings at this position.
7. Decrease the excitation current in steps an note down ammeter and wattmeter readings. (Excitation current may be reduced till the rated armature current flows in the armature circuit of the synchronous motor) (I_f as I_a).
8. Again set back rheostat position to normal excitation position, now increase the excitation in steps and note down all meter readings.
9. Repeat the step - 5, 6, 8, and 8 for half load and full load.
10. Decrease the load on the motor and switch of the supply.

Note:

1. Keeping fixed load on the dc machine (DC Generator), the data for a V-curve is obtained by varying the field current and note down the armature current as suggested earlier. The V-curves are drawn for no load, Full load and one intermediate load.
2. For same data inverted V- curves are drawn between Cosϕ (p.f) and I_f.

MODEL GRAPHS:

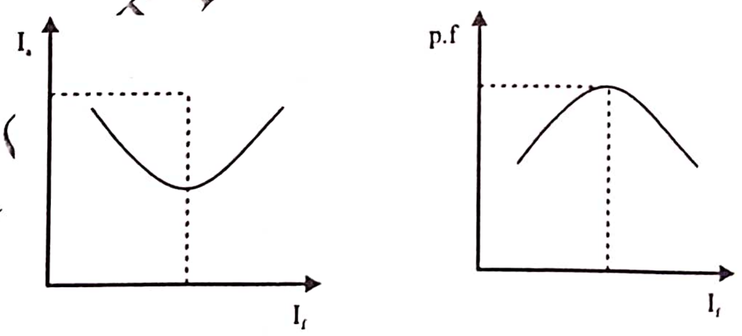


Fig – 8.2 V and Inverted V-Curves of 3-ϕ Synchronous Motor

TABULAR COLUMN:

At Full load

S.No	I_f (A)	I_a (A)	W (Watts)	Cos Φ
1				
2				

Half full load

S.No	I_f (A)	I_a (A)	W (Watts)	Cos Φ
1				
2				

At No Load

S.No	I_f (A)	I_a (A)	W (Watts)	Cos Φ
1				
2				

PRECAUTIONS:

1. Loose connections are avoided.
2. Note down all meter readings without any parallax error.
3. If the watt meter reading shows negative reading (Kick backs), then interchange the connection of **M** and **L** of the wattmeter.

RESULT:

VIVA QUESTIONS:

1. At what condition the power output of a synchronous generator connected to an infinite bus is maximum.
2. How can we run a synchronous motor as synchronous condenser?
3. Why Synchronous motor is not self-starting motor.
4. What happens if excitation is changed?
5. When load is increased on a synchronous motor, does the speed fall like an induction motor? If not, explain how the load torque is produced.
6. When do we say an alternator is under floating condition during parallel operation?
7. What are the conditions required to synchronous an alternator with APSEB supply?
8. How can you increase the share of an alternator when it is connected to an infinite bus?
9. What are the different types of field constructions in Synchronous machines?
10. Draw "V" and inverted "V" curves of a synchronous motor.