ELECTRICAL MACHINE II LAB

LIST OF EXPERIMENTS

1. To perform No- Load and Blocked rotor test on a three phase induction motor.
2. To perform Load test on a three phase induction motor to determine the performance characteristics.
3. To perform Load test on three phase induction motor and determine speed – torque characteristics for various stator voltages.
4. To perform slip test on three phase induction motor.
5. To study about the constructional detail of slip ring induction motor.
6. To plot V-curve of synchronous motor.
7. To study about the different techniques of synchronization of two synchronous machine.
8. To study about constructional detail of synchronous machine.
9. To perform speed control of slip ring induction motor by rotor resistance.
10. To study the starters for three phase induction motors.

EXPERIMENT NO 04

AIM: - To find Xd and Xq of a salient pole rotor type Synchronous machine by Slip Test.

APPRATUS:

1. Alternator (3 phase, 1 kw,4.2A, 1500 rpm)
2. DC motor (8A, 220 V, 1500 rpm, shunt)
3. Voltmeter (0-150V) AC.
4. Ammeter (0-5A) A.C
5. Tachometer

CIRCUIT DIAGRAM:-

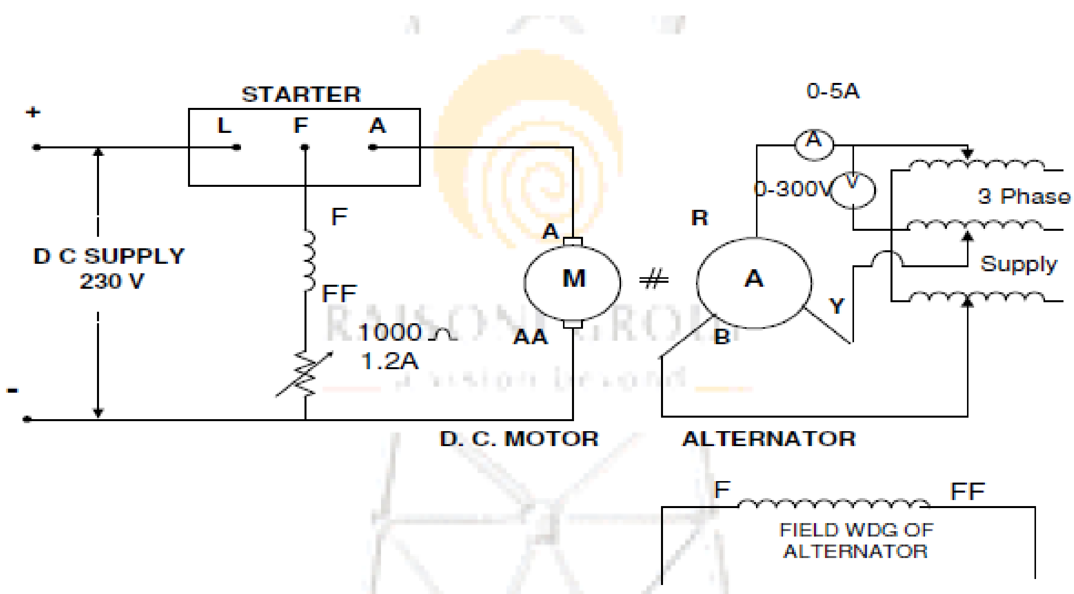


FIG: SLIP TEST ON A SYNCHRONOUS MACHINE

THEORY:-

The armature reactance varies from Xq to Xd periodically.

Xd - is the synchronous reactance of armature coil offered to the flow of direct axis current.

Xq – is the synchronous reactance of armature coil offered to the flow of quadrature axis current.

When voltage induced in the field winding is zero, armature current is minimum and the terminal voltage is maximum. At this instant direct axis coincides with armature mmf and corresponding reactance is Xd is given by

$$X_d = \frac{\text{Maximum value of armature voltage / phase}}{\text{Minimum value of armature current / phase}}$$

Similarly when the voltage induced in the field winding is maximum (positive or negative) armature current is maximum and terminal voltage is minimum. At this instant quadrature axis coincides with armature mmf and corresponding reactance is Xq is given by

$$X_q = \frac{\text{Minimum value of armature voltage / phase}}{\text{Maximum value of armature current / phase}}$$

If the readings of maximum and minimum armature current and voltage are taken Xd and Xq can be determined. The readings can not be taken at higher armature current to avoid synchronization. The ratio of Xq / Xd for the cylindrical rotor machine is around 0.95 this generally taken as one and for salient pole m/c this ratio is 0.66 to 0.7.

PROCEDURE:

(1) Connect the circuit as shown. Set the variac output zero.
(2) Put on the DC supply and run the DC motor of a speed close to the synchronous speed of alternator but less than synchronous speed.
(3) Put on the ac supply and increase the variac output to suitable value, observe the variations in the voltmeter and ammeter readings.
(4) Adjust the speed of complete dc motor further to get maximum swings in ammeter and voltmeter printers.
(5) Note maximum and minimum readings of voltage and current.
(6) Take additional sets of reading by adjusting different variation outputs.
(7) Now adjust the dc motor speed to a value little higher than synchronous speed and take similar readings as above.

OBSERVATION:

S.NO	SPEED	ARM. VOLTAGE		ARM CUURENT		Xd	Xq	Xq/ Xd	AVG.

$$X_d = \frac{\text{Max. Value of armature voltage / phase}}{\text{Min. value of armature current / phase}}$$

$$X_q = \frac{\text{Min. value of armature voltage / phase}}{\text{Max. Value of armature current / phase}}$$

RESULT: - The ratio of Xq/ Xd is determined for a salient pole rotor type synchronous machine by slip test which is found to be ------------

EXPERIMENT NO 09

AIM**:** To control speed of slip ring induction motor by rotor resistance.

APPARATUS:

S. No.	Apparatus	Specification	Qty
1	3 ph starting resistance	-	1
2	Tachometer	-	1

THEORY:
A three phase induction motor develops a starting torque and is self starting. However if the load torque is more than the starting torque, the motor will not be able to pick up speed. The motor can pick up speed fast if the starting torque is maximum. For this the rotor resistance should be high enough to satisfy the condition $R_2=X_2$.
Generally the rotor resistance is low. In slip ring induction motor, external variable resistance is connected across the slip ring. The motor is started with whole of the resistance included in the rotor circuit. This gives high starting torque. As the motor picks up speed, the resistance is slowly reduced. When the motor attains full speed, whole of the resistance is cut off. Similar procedure is followed in speed control. As rotor resistance is increased, the motor speed drops and cutting out of rotor resistance results in increase in the motor speed.

Procedure:

1. Make the connections as per circuit diagram.
2. Keep the rotor resistance to maximum position and switch on the supply.
3. Gradually cut out the rotor resistance and as the motor nears full load speed, cut out the entire resistance.
4. Now, gradually bring in the rotor resistance in the circuit and measure rotor speed with tachometer.
5. Repeat step4 with different values of rotor resistance and measure corresponding speed.
6. Bring rotor resistance to zero position and switch off supply.

PRECAUTIONS:

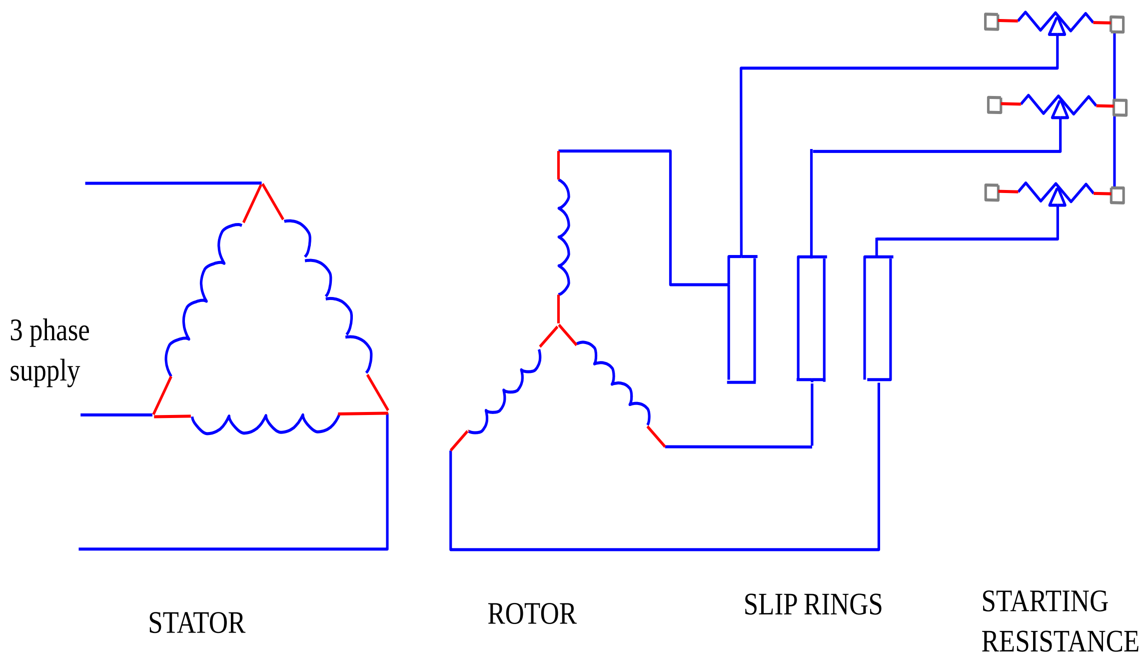
Before starting the motor, keep full resistance in rotor circuits.

1. Cut out the resistance gradually from the rotor circuit.
2. Before switching off, the rotor resistance should be zero.

Results:

Starting speed of slip ring induction motor was performed.

Circuit Diagram:



EXPERIMENT NO 03

AIM: To perform load test on 3 ph induction motor and determine speed- torque characteristics for various stator voltages.

APPRATUS:

S.No.	Apparatus	Specification	Quantity
1	Voltmeter	0-500V	1
2	Ammeter	0-5A	1
3	Tachometer	-	1
4	3 ph variac	400V, 10A	1

THEORY**:**

Load test on induction motor helps to compute performance characteristics i.e. torque, slip, efficiency, power factor etc. Rated voltage is applied to the motor and variable mechanical load is applied to the motor by brake and pulley arrangement. The parameters are calculated as

Slip:

The speed of rotor Nr drops slightly as the load on the motor is increased. The synchronous speed of rotating magnetic field is given by

$N_s = 120f/P$

Then slip $S = (N_s-N_r)/N_s$

Torque:

Net force exerted $W = (S_1-S_2)$ Kg

Load torque T= W*d Kg-m = 2 W * (d/2)*9.81 N-m

Where d is the effective diameter of the pulley.

Output Power:

$P_0 = 2\pi NT/60$ watts
Input power $P_i = (W_1+W_2)$ watts

Power factor $\cos\phi = \cos(\tan^{-1}((\sqrt{3})(W_{01} - W_{02})/(W_{01} + W_{02})))$

Efficiency: $\eta = (P_0/P_i)*100$

Full load efficiency of three phase induction motor lies in the range of 82%(for small motor) to 92% (for large motors).

PROCEDURE:

1. Make the connections as per circuit diagram.
2. Set 3 ph variac to minimum voltage and brake pulley arrangement is set for no load.
3. 3 ph supply is given to motor and variac is increased gradually till rated voltage is indicated by voltmeter.
4. Note the readings of various instruments.
5. Increase mechanical load on motor and note readings for various load settings.
6. Repeat step 5 with different stator voltages.
7.

OBSERVATION TABLE:

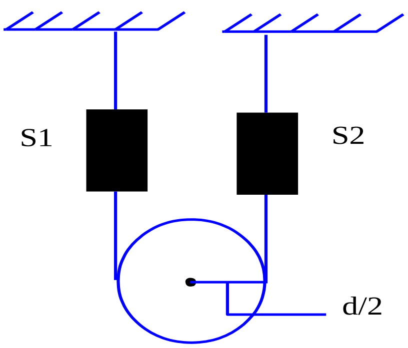
S. No.	Line Voltage	Input current	W_1	W_2	S_1	S_2	Speed
1							
2							

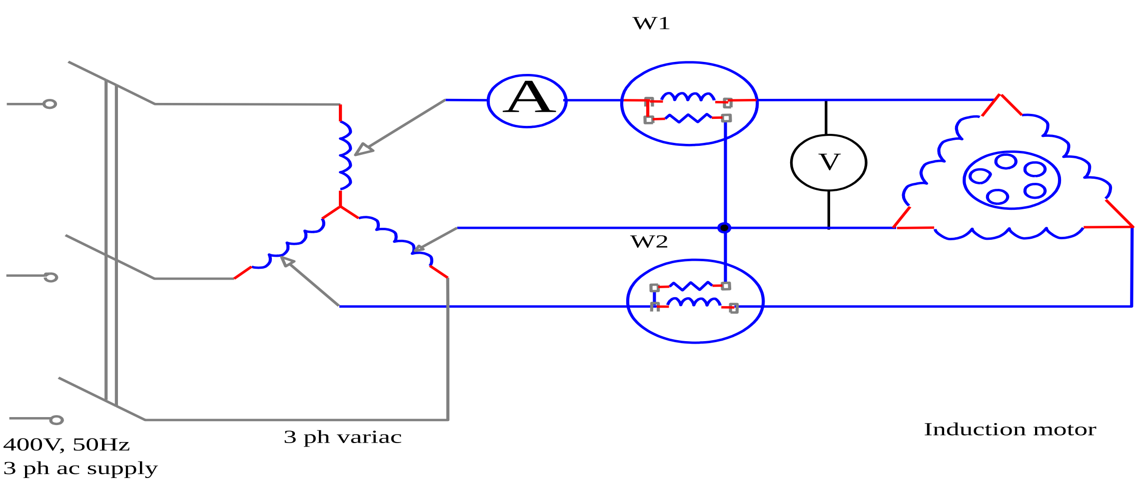
S.No.	Input voltage	Torque	Slip	Speed		
1						
2						

Precautions:

1. Never exceed rated current of the motor.
2. Before starting connections ensure that supply main switch is off.
3. All equipments and instruments should be connected tightly.
4. Special attention should be given for cooling of brake pulley.

Circuit Diagram:





EXPERIMENT NO 02

AIM: To perform load test on a three phase induction motor to determine the performance characteristics.

APPRATUS:

S.No.	Instruments	Specification	Qty
1	Wattmeter	0-600W	2
2	Ammeter	0-3A	1
3	Three phase variac	0-500V, 15A	1

THEORY:

Load test is performed at rated voltage and frequency of the motor to compute its complete performance i.e. torque, slip, efficiency, power factor etc. The motor is loaded with brake and pulley arrangement. Let the reading of ammeter, voltmeter and two wattmeter be I_0 , V_0, W_{01}, W_{02} respectively during the test then

$$\tan_{\phi} = (\sqrt{3})(W_{01} - W_{02}) / (W_{01} + W_{02})$$

Slip:
The speed of rptor Nr drops slightly as the load on the motor is increased. The synchronous speed of rotating magnetic field is given by

$N_s = 120f/P$

Then slip $S = (N_s - N_r)/N_s$

Normal range of full load slip is 2 to 5 %.

Torque:

Net force exerted $W = (S_1 - S_2)$ Kg

Load torque $T = W*d$ Kg-m $= 2\ W * (d/2)*9.81$ N-m

Where d is the effective diameter of the pulley.

Output Power:

$P_0 = 2\pi NT/60$ watts

Input power:

$P_i = (W1+W2)$ watts

Efficiency:

$\eta = (P_0/P_i)*100$

Full load efficiency of three phase induction motor lies in the range of 82%(for small motor) to 92% (for large motors).

Procedure:

1. Make the connections as per circuit diagram.
2. Ensure that motor is unloaded & variac is set to zero position.
3. Switch on the supply and increase the voltage gradually till the rated voltage of the motor. Thus motor runs at rated speed on no load.
4. Record the reading of all the meters in the circuit and the speed under no load connection.
5. Increase the load on the motor gradually by turning of hand wheels thus tightening the belt. Record readings of all the meters connected in the circuit and the speed at every setting of the load.
6. Reduce the load on the motor and finally unload it completely.
7. switch off the supply to the motor and set the variac to zero position.

8. Note the effective diameter of the pulley.

Observation Table:

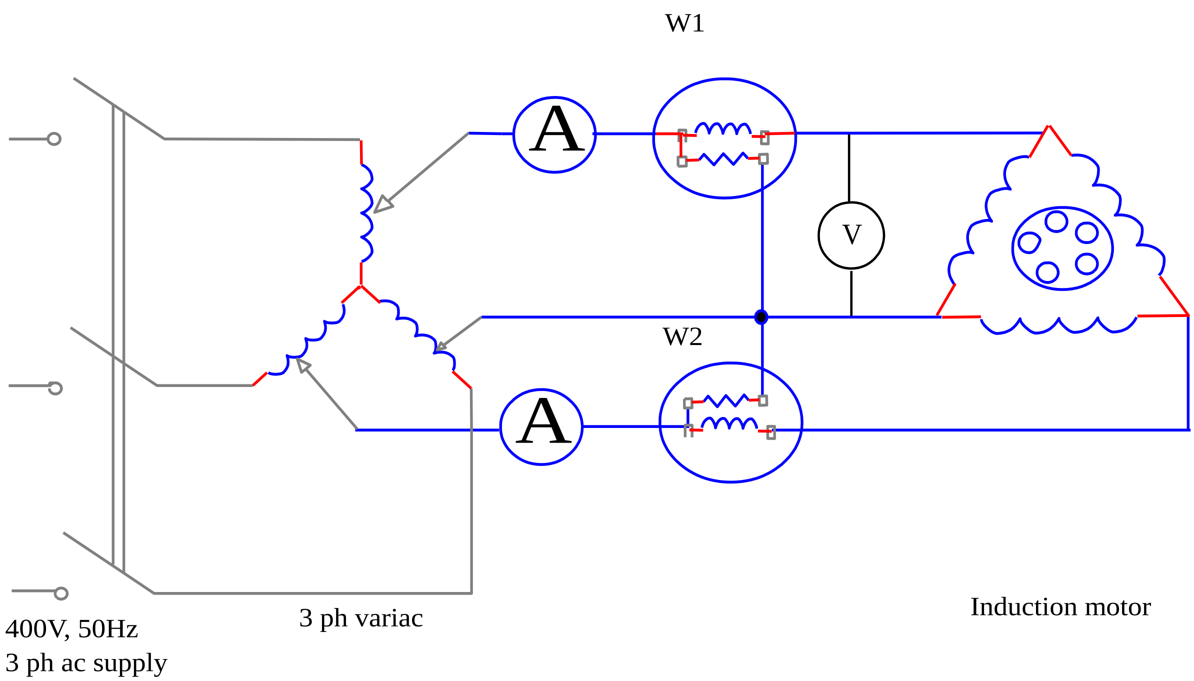
S. No.	Line Voltage	Input current	W_1	W_2	S_1	S_2	Speed
1							
2							

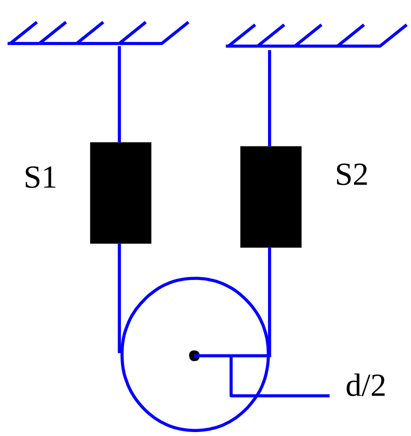
S. No.	Slip	Torque	Power factor	Input power	Output power	Efficiency
1						
2						

Precautions:

1. Never start the motor on load.
2. Before starting connections ensure that supply main switch is off.
3. All equipments and instruments should be connected tightly.
4. Before starting the motor variac should be on zero position.

Circuit Diagram:





EXPERIMENT NO 01

AIM: To perform No-Load and Blocked rotor test on a three phase induction motor.

APPRATUS:

S. No.	Instruments	Specification	Quantity
1	Watt meter	0-600 W	2
2	Volt meter	0-500 V	1
3	Ammeter	0-5 A	1
4	Three phase variac	0-500 V, 15 A	1

THEORY:

No-Load Test:
Under no load test rated voltage and frequency is applied to the motor. The motor draws small current to meet iron , friction, & windage losses. If I_0 , V_0, W_{01}, W_{02} be the readings of no load current, no load voltage, two wattmeters respectively then

$$\tan\phi = (\sqrt{3})(W_{01} - W_{02}) / (W_{01} + W_{02})$$

Iron losses = $W_{01} + W_{02}$

$\cos\phi$ = no load power factor

Blocked rotor test:

Under blocked rotor test, stator voltage is gradually increased keeping the rotor stationary till rated current flows through stator. If Isc , Vsc, Wsc_1, Wsc_2 be the readings of short circuit current, short circuit voltage , readings of wattmeters respectively then

$\tan\phi = (\sqrt{3})(Wsc_1 - Wsc_2)/(Wsc_1 + Wsc_2)$

Iron losses = $Wsc_1 + Wsc_2$

$\cos\phi$ = short circuit power factor

Procedure:

No-Load Test:

1. Make the connections as per circuit diagrams.
2. Ensure that motor is unloaded & variac is set to zero position.
3. Switch on the supply and increase the voltage gradually till the rated voltage of the motor.
4. Record the reading of all the meters in the circuit.
5. Switch of ac supply.

Blocked rotor test:

1. Re-adjust the variac to zero position.
2. Change the range of all instruments.
3. Block the rotor by tightening the belt or by hand.
4. Switch on ac supply and gradually increase the applied voltage till full load current flows in the stator.

5. Record the readings of all meters.
6. Switch of ac supply to the motor and set the variac to zero position.

Observation Table

No-Load Test:

S.No.	No Load Voltage (V_0)	No Load Current(I_0)	W_{01}	W_{02}

Blocked rotor test:

S.No.	Short Circuit Voltage (V_{sc})	Short Circuit Current(I_{sc})	Wsc_1	Wsc_2

Calculation:

No-Load Test:

Blocked rotor test:

Result:

From No load and blocked rotor test

Iron losses =

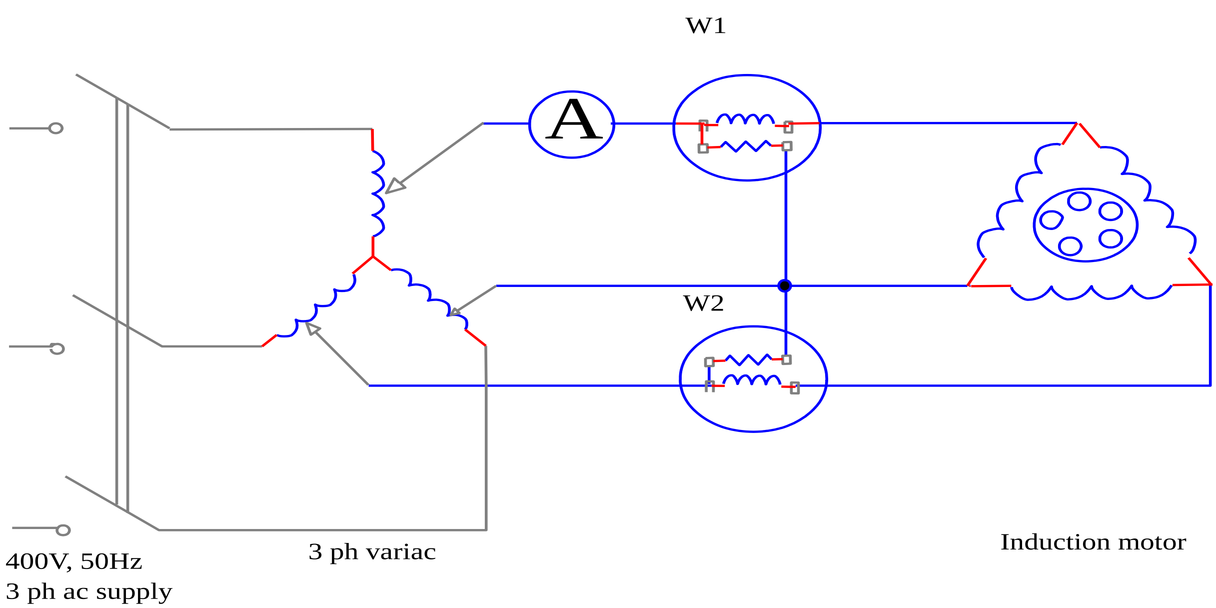
Copper losses =

No Load power factor =

Precautions:

1. Before starting connections ensure that supply main switch is off.
2. All equipments and instruments should be connected tightly.
3. Never start the motor on load.
4. Never exceed rated current of stator.
5. In block rotor test, do not release the rotor pulley till the supply if off.

Circuit Diagram:



EXPERIMENT NO 06

AIM: To plot V- curve of Synchronous Motor.

APPRATUS:

S.No.	Instrument	Type	Range	Qty.
1.	Ammeter	MI	0-5a	1
2.	Ammeter	MC	0-5a	1
3.	Voltmeter	MI	0-300/600v	1
4.	Ammeter	MC	0-10A	1
5.	Voltmeter	MC	0-300V	1
6.	Synchronous Motor	3 phase	400V,4.5A,1440rpm, 1	

THEORY:

With constant mechanical loading on the synchronous motor . the variation of field current change the armature current drawn by the motor and also its power factor . The behaviour of the synchronous motor is described below under different mode of field excitation.

1. Normal Excitation:
   The armature current is minimum at a particular value of field current, which is called the normal field excitation. The operating power factor of the motor is unity at this excitation and the motor is equivalent to a resistive type of load.
2. Under Excitation:

When the field current is decreased gradually below the normal excitation . the armature current increases and the operating power factor of the motor decreases. The power factor under this condition is lagging. Thus, the motor draw a lagging current, when it is under excited and is equivalent to an inductive load.

3. Over Excitation:
   When the field current is increased gradually beyond the normal excitation . the armature current again increases and the operating power factor decreases .the power factor is leading under this condition. Hence, the motor draws a leading current, when it is over excited and is equivalent to a capacitive load.

PROCEDURE:

1. connect the circuit as per figure
2. Switch on the ac supply feeding to 3-phase synchronous motor and start the motor using the starter.
3. In this case field winding is exited automatically with the help of exciter provided on the shaft of the motor.
4. Set the rheostat in the field circuit of the motor to the poison of normal excitation. Under this condition armature will draw minimum current from the mains. Note down the reading of all the meters connected in the circuit.
5. Reduce the excitation in step and note down the corresponding armature current and field current. Excitation may be reduced, till the current in the armature winding is of rated value. Under this

condition armature current increases on reducing the excitation.

6. Now increase the excitation in steps and note down the reading of armature current and field current at each setting of increased excitation. Excitation may be increased, till the behavior of the motor is normal

OBSERVATION:

S.No.	V(volts)	I_f (amp)	I_a (amp)
1			
2			

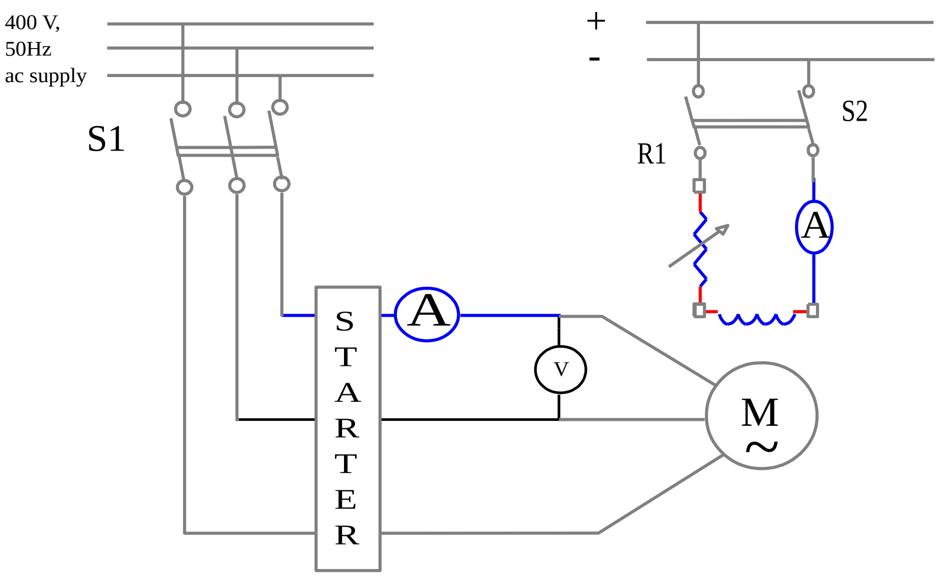
PRECAUTION:

1. connection should be made properly as per the circuit diagram.
2. while starting the synchronous motor. Field excitation should be zero.
3. meter should be proper range and type (mi and mc)

Result:

v-curve for synchronous motor is plotted against field current and armature current .this is of v shape.

Circuit Diagram:



EXPERIMENT NO 08

AIM: To study about constructional detail of synchronous machine.

APPRATUS: A cut model of synchronous machine.

THEORY:

The synchronous electrical generator (also known as alternator) belongs to the family of electric rotating machines.

Synchronous machines are one of two types

1. The stationary field
2. The rotating dc magnetic field.

The stationary field synchronous machine has salient poles mounted on the stator—the stationary member. The poles are magnetized either by permanent magnets or by a dc current. The armature, normally containing a three-phase Winding, is mounted on the shaft. The armature winding is fed through three slip rings (collectors) and a set of brushes sliding on them. This arrangement can be found in machines up to about 5 kVA in rating.

The rotating magnetic field (also known as revolving-field) synchronous machine has the field-winding wound on the rotating member (the rotor), and the armature wound on the stationary member (the stator). A dc current, creating a magnetic field that must be rotated at synchronous speed, energizes the rotating field-winding.

- The stator core is made of insulated steel laminations. The thickness of the laminations and the type of steel are chosen to minimize eddy current and hysteresis losses, while maintaining required effective core length and minimizing costs.
- The rotor field is either of salient-pole or non-salient-pole construction, also known as round rotor or cylindrical rotor. Non-salient-pole (cylindrical) rotors are utilized in two- or four-pole machines, and, very seldom, in six-pole machines.

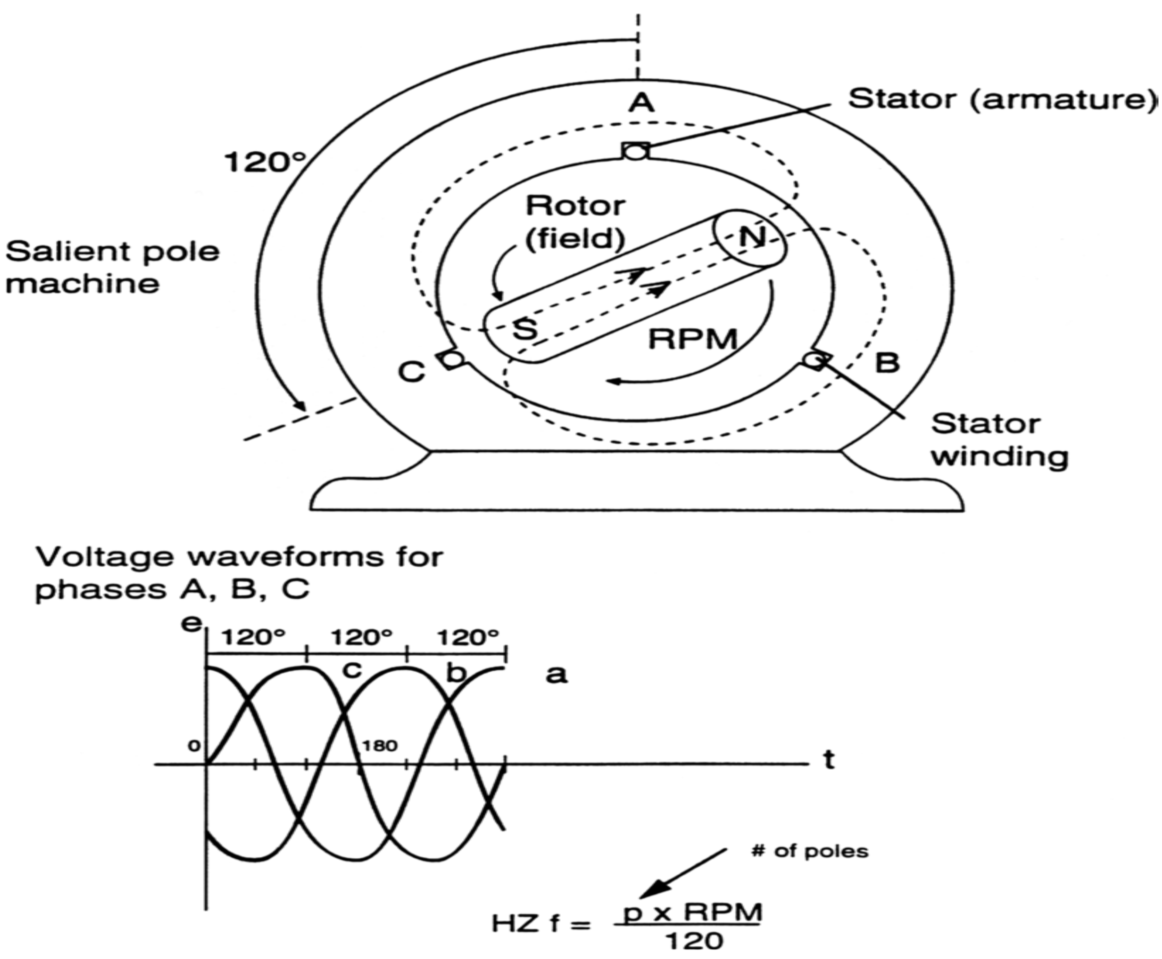
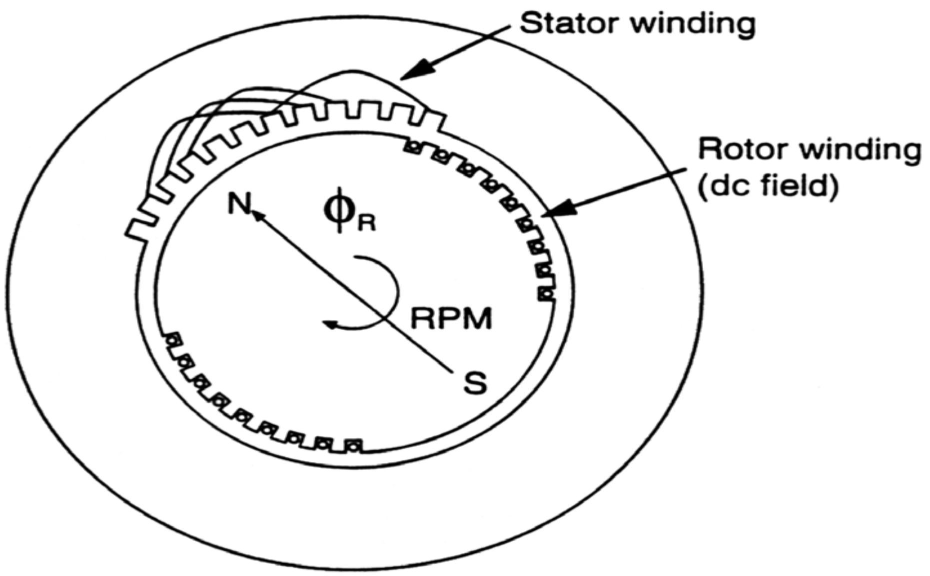
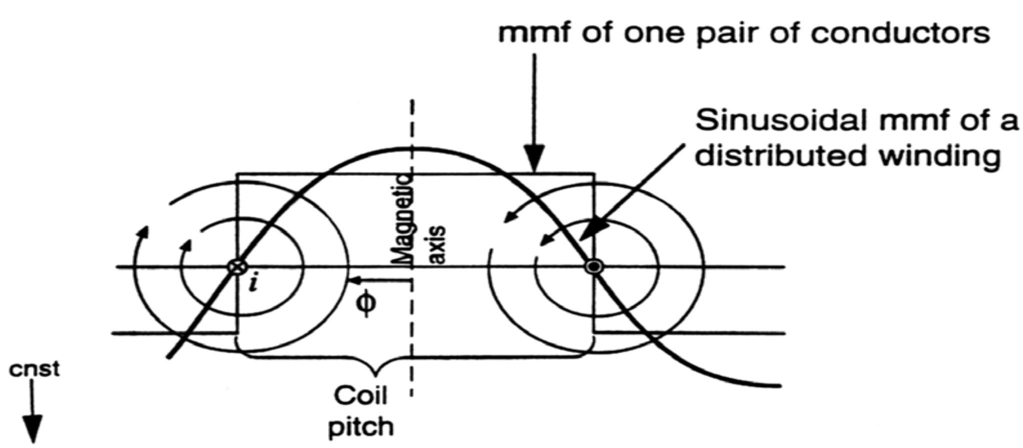


Figure showing schematic cross section of a salient-pole synchronous machine. In a large generator, the rotor is magnetized by a coil wrapped around it. The figure shows a two-pole rotor. Salient-pole rotors normally have many more than two poles. The bottom part of the figure shows the three-phase voltages obtained at the terminals of the generator, and the equation relates the speed of the machine, its number of poles, and the frequency of the resulting voltage.

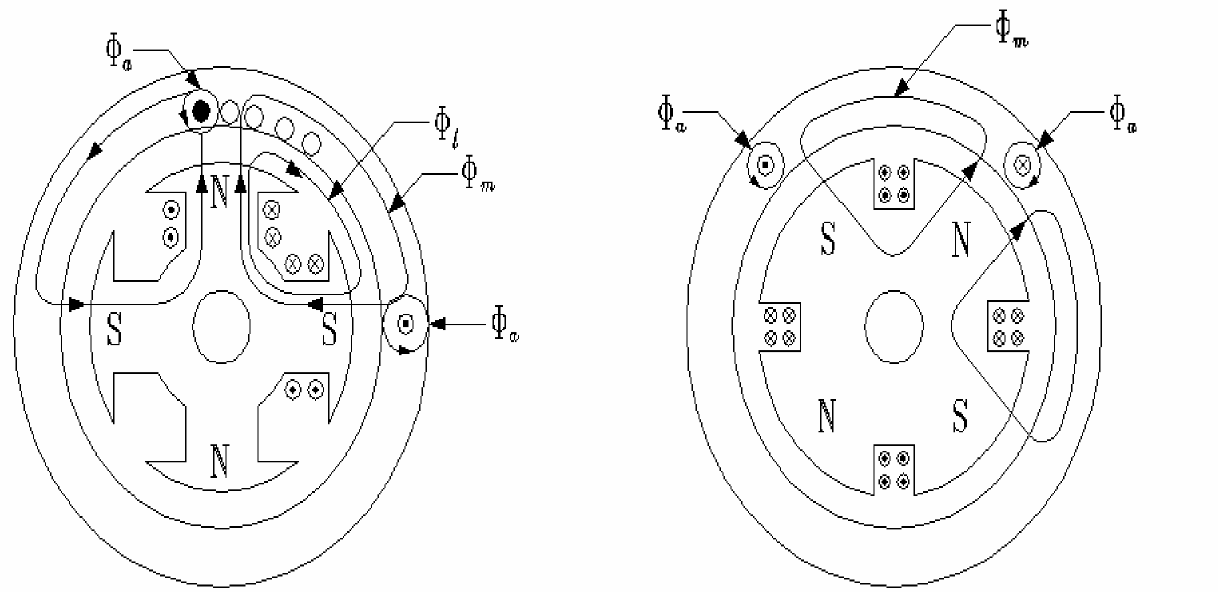


Production of mmf and flux



$F(mmf) = k \times i \times \cos\phi$

Figure showing Schematic cross section of a synchronous machine with a cylindrical round-rotor. This is the typical design for all large turbo generators. Here both the stator and rotor windings are installed in slots, distributed around the periphery of the machine. The lower part shows the resulting waveforms of a pair of conductors, and that of a distributed winding.



(a) Salient-pole flux distribution

(b) Non-salient-pole flux distribution

RESULT:

The constructional analysis of synchronous machine is done successfully.

EXPERIMENT NO 05

AIM: To study about the constructional detail of slip ring induction motor.

APPRATUS: A cut model of slip ring induction machine.

THEORY:

An induction or asynchronous motor is a type of AC motor where power is supplied to the rotor by means of electromagnetic induction, rather than by slip rings and commutators as in slip-ring AC motors. These are widely used in industrial drives, particularly polyphase induction motors, because they are robust, have no friction caused by brushes, and can have the speed of the motor controlled easily.

On the basis of the rotor construction Induction motor can be sub divided into two parts:

1. Squirrel cage induction motor.
2. Slip ring induction motor.

CONSTRUCTION OF SLIP RING INDUCTION MOTOR:

STATOR:

The stator construction is same for both squirrel cage & slip ring induction motor. The main difference in slip ring induction motor is on the rotor construction and usage. Some changes in the stator may be encountered when a slip ring motor is used in a cascaded system, as the supply for the slave motor is controlled by the supply from rotor of other slip ring motor with external resistance mounted on its rotor.

ROTOR

The slip ring induction motors usually have “Phase-Wound” rotor. This type of rotor is provided with a 3-phase, double-layer, distributed winding consisting of coils used in alternators. The rotor core is made up of steel laminations which has slots to accommodate formed 3-

single phase windings. These windings are placed 120 degrees electrically apart.

The rotor is wound for as many poles as the number of poles in the stator and is always 3-phase, even though the stator is wound for 2-phase. These three windings are “starred” internally and other end of these three windings are brought out and connected to three insulated slip-rings mounted on the rotor shaft itself. The three terminal ends touch these three slip rings with the help of carbon brushes which are held against the rings with the help of spring assembly.

These three carbon brushes are further connected externally to a 3-phase start connected rheostat. Thus these slip ring and external rheostat makes the slip ring induction motors possible to add external resistance to the rotor circuit, thus enabling them to have a higher resistance during starting and thus higher starting torque.

When running during normal condition, the slip rings are automatically short-circuited by means of a metal collar, which is pushed along the shaft, thus making the three rings touching each other. Also, the brushes are automatically lifted from the slip-rings to avoid frictional losses, wear and tear. Hence, under normal running conditions, the wound rotor is acting as same as the squirrel cage rotor.

Advantages of slip ring induction motors

- The main advantage of slip ring induction motor is that its speed can be controlled easily.
- "Pull-out torque" can be achieved even from zero r.p.m
- High starting torque when compared to squirrel cage induction motor. Approximately 200 - 250% of its full-load torque.
- A squirrel cage induction motor takes 600% to 700% of the full load current. But a slip ring induction motor takes a very low starting current approximately 250% to 350% of the full load current

EXPERIMENT NO 07

AIM: To study the parallel operation of synchronous generators.

APPRATUS:

S.no.	Instrument	Type	Range	Qty.
1.	Ammeter	MI	0-15A	1
2.	Voltmeter	MI	0-60V	1
3.	Synchronous generator		1440rpm, 4.5A, 415V, 50Hz	1

THEORY:

Conditions for Synchronization:

The process of connecting an alternator in parallel with an existing operating alternator or with the common supply bus bars is called Synchronization. The following conditions are to be satisfied before synchronizing the additional with the existing one or more common bus bars:

1. The terminal voltage magnitude of the alternator must be made equal to the existing alternator or the bus bar voltage magnitude.
2. The phase sequence of the incoming alternator voltage must be equal to the bus bar voltage.
3. The frequency of the incoming alternator must be same as the bus bar voltage.

Synchronizing Procedure:

Among the three conditions listed above, condition (1) can be checked with the help of voltmeters. Condition (2) can be checked either by using a phase sequence meter or synchronizing lamps and condition (3) can be checked by either synchronizing lamps or synchroscope.

Three Dark Lamp Method:

In Figure the alternator marked as G1 is the already existing one, which is connected to the common bus bar RYB. G1 supplies power to the load. The alternator marked as G2 is the new alternator which s connected to the common bus bars through the synchronizing switch. Across each pole tpf the switch L1, L2 and load of the lamps are connected.

To synchronize G2 w2ith the common bus bars it is driven yb its prime mover at a speed very close to the synchronizing speed decided by its prime mover at a speed very close to the synchronizing speed decided by the bus bars frequency and the number of poles in G2. The field current G2 is increased so that the voltage across the machine terminus Vm becomes equal to the bus bar voltage Vb. Thus the first condition is satisfied.
Now the three sets of lamps of glow bright and dark. Condition (ii) about the correctness of the phase sequence can be checked by looking at these sets of lamps. If the lamp glows bright and dark in unison it is an indication of the correctness of the phase sequence. If on the other hand

they become bright and dark one after the other connections to any machine terminals has to be interchanged after shutting down the machine this will correct phase sequence. The machine is once again started and condition (i) and (ii) are satisfied checking for condition (iii) the frequency can be carried out by looking into the rate of the flickering of the lamp. The rate of flickering account for the frequency difference between the bus bar voltage and the incoming alternator voltage. The rate of flickering then has to be reduced to as low as possible by adjusting the speed of the alternator G_2 by its prim mover control. When all the three sets of lamps become dark the synchronizing switch can be closed and thus the alternator G_2 gets synchronized with alternator $G_{1.}$

Advantage:

1. The synchronizing switch is inexpensive.
2. Checking for correctness of the phase sequence can be obtained in a simple manner. Which is essential especially when the alternator is connected for the first time or for fresh operation after disconnection.

Disadvantages:

1. The rate of flickering of the lamps only indicates the frequency difference between the bus bar and the incoming alternator. The frequency of the incoming alternator in relation to the bus bar frequency is not available.

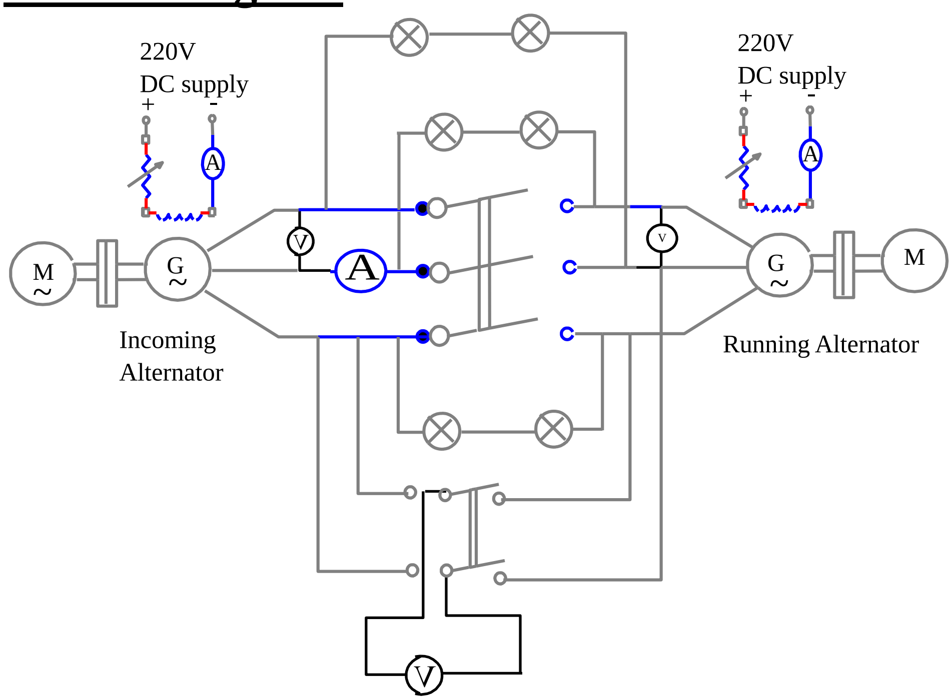
PRECAUTIONS**:**

1. Connections should be made properly as per circuit diagram.
2. While starting the synchronous machine field excitation should be zero.
3. Three lamps should be continuously observed while synchronization.
4. The phase sequence should be checked by phase sequence indicator before connecting alternator in parallel with alternator.

RESULT:

Two alternators were connected after synchronization test.

<u>Circuit Diagram</u>:



EXPERIMENT NO 10

Aim: To study the starters for three phase induction motors.

Apparatus: Various types of starters.

Theory:

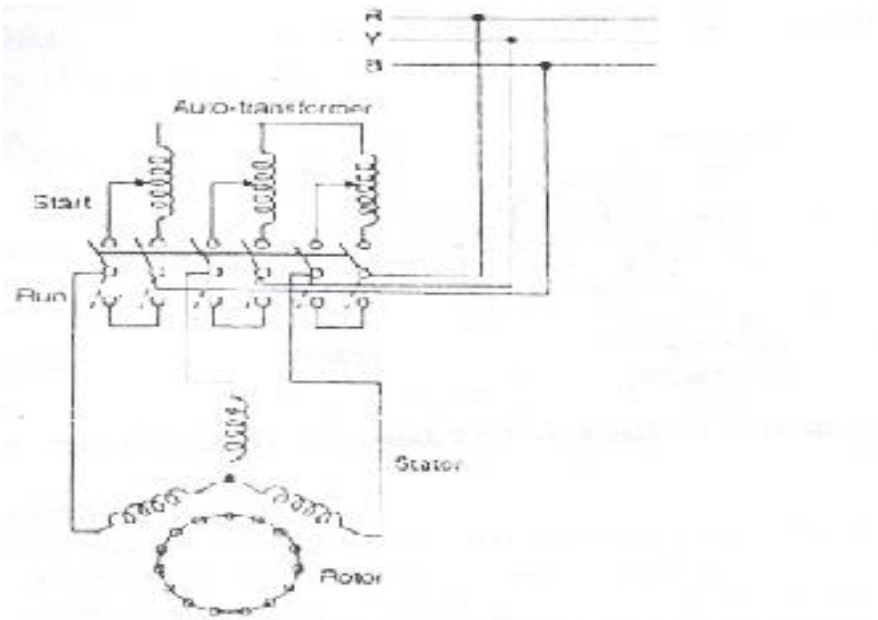
Need of a starter:

When we connect the supply voltage to an induction motor, there is an induced emf in the rotor circuit. This emf is proportional to the slip. At standstill, the slip is unity, and the induced emf in the rotor is high. In fact, the motor behaves like a transformer with its secondary short circuited. Heavy current flows in the rotor circuit consequently the current drawn by the rotor is high. Therefore there is a need of a starter.

Various types of starter:

Auto transformer starter:

A three phase auto transformer is used to supply a reduced voltage to the motor at the starting. See figure from standard book. Two or three voltage steps are used during the starting process. The auto transformer is set to supply full voltage once the motor picks up speed to its rated value and then the connections are switched over to the normal supply voltage with help of the switch.



1. A manual auto-transformer starter.

Star-Delta starter:

In star delta starter the stator phase windings are connected in star and full voltage is connected across its three terminals. The voltage of each phase is 1/root(3) times the normal value. As the motor picks up speed, the change-over switch disconnects the windings of the motor and then reconnects them in delta across the supply terminals. This method reduces the current drawn if it was directly connected in delta, However the starting torque too is reduced to one third. This method is cheap but it can be used only where high starting torque is not necessary, e.g. machine tools, pumps, motor-generator sets, etc.

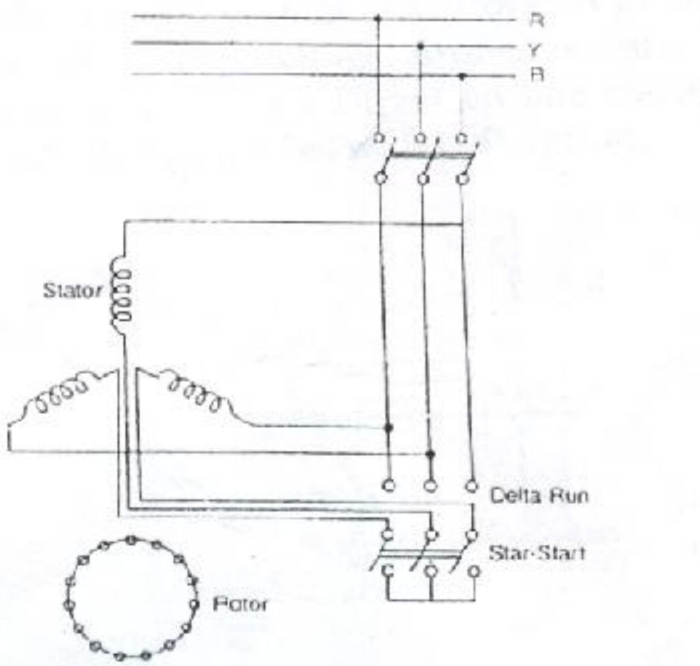
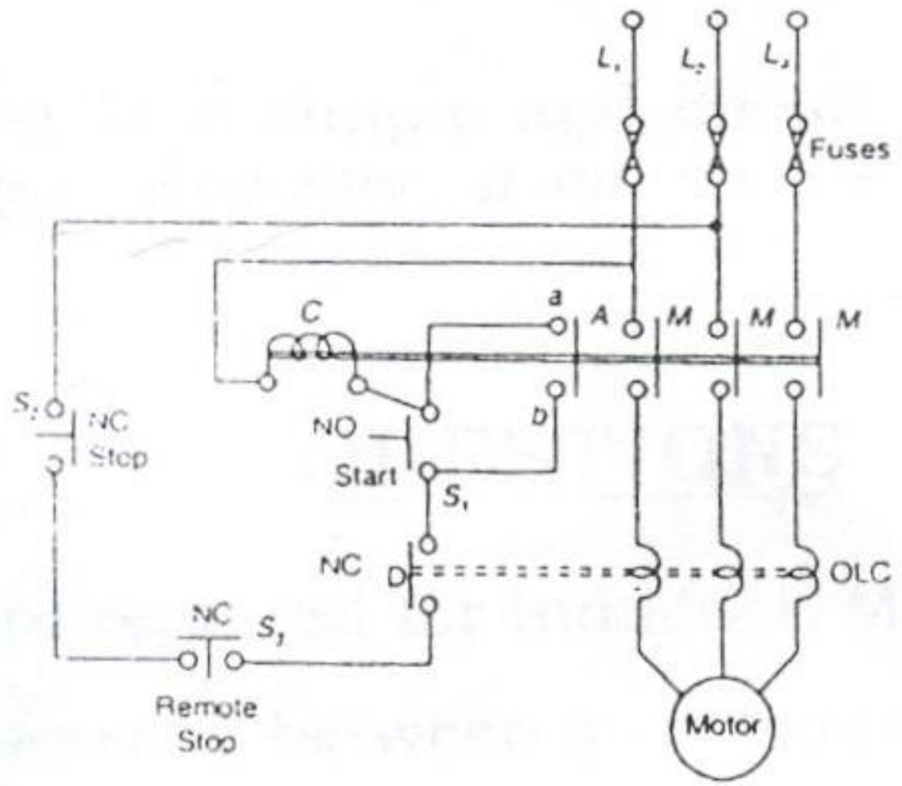


Fig. 2. A manual start-delta starter.

Direct On-Line Starter:

The principle of operation of this type of starter is reflected by its name. Unlike, in case of other type of starter, full supply voltage is connected to the motor. This starter does not provide a reduction in starting current or a higher starting torque. But, the utility of using its type of starter lies in the in-built protections provided in direct On-Line starters. These protections are under voltage protection and over voltage protection. Fig 4 shows the connections for a Direct on-line starter used for starting of 3 ph induction motors of below 5 H.P. rating.



L1
L2
L3
Fuses
C
a
A
M
M
M
b
S2
NC
Stop
NO
Start
S1
NC
D
OLC
NC
S3
Remote
Stop
Motor