Assignment No # 01

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Subject

Electrical Machine II

Program

EET 4th Sem.

Submitted to

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Q.No.1

Write introduction Advantages, disadvantages and Construction of three phase Induction Motor?

An electric motor is an electro mechanical device which Converts electrical energy into mechanical energy. In Case of three phase AC operation, the most wisdely used moter is a 3 phase induction motor.

Introduction:-

The Populasity of 3-ϕ induction moter on board Ships is because of their Simple, robust Construction and high reliability factor in the Sea enviroment. A 3-ϕ induction moter Can be used for different applications with various Speed and load requirements. The 3-ϕ induction moter are the most widely use electric moter in industry. They rem at essentialy Constant Speed from no-load to full-load. However, the Speed is frerquency dependent and Consequently these moter are not easily adapted to Spaed Control 3-ϕ Induction moter are Simple rugged, low priced, easy to maintain and Can be manufactured with Characteristics to Suit most industrial required. Like any electric moter a 3-ϕ induction moter has a Stator and a roter.

The Stator Carries a 3-ϕ winding while the rotor Carries a Short Circuited winding. Only the Stator winding is fed from 3-ϕ Supply. The rotor winding drives its voltages and power from the externally energized Stator winding through electromagnetic induction because the ones the name.

⇒ Advantages:-

* It has Simple and rugged Construction.
* It is relatively cheap.
* It requires little maintenance
* It has high efficiency and reasonably good Power factor.
* It has Self Starting torque.
* The operation of 3-ϕ Induction motor is quite reliable.

⇒ Disadvantages:-

* The Speed Control of an induction motor is not possible without Sacrifiany its efficiency level.
* Also the Speed of the motor decreases with increasing mechanical Load.
* Its Starting torque is a Little bit lower than that of a DC Shunt motor.

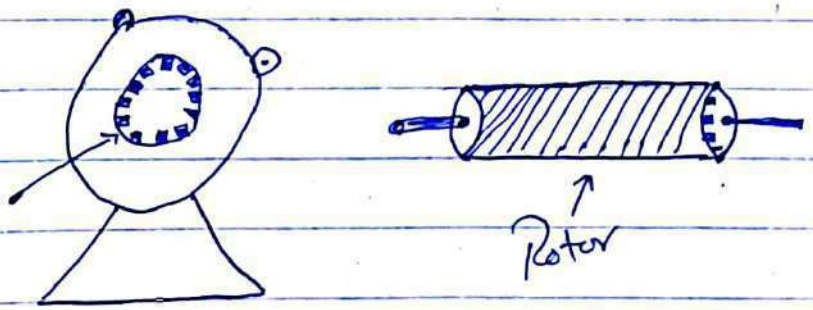
Construction:-

3-ϕ induction motor is the most widely used electrical motor Almost 80% of the mechanical power used by industries is provided by 3ϕ induction motor because of its simple and rugged Construction absence of Commuter and good Speed regulation. In 3-ϕ induction motor the power is transferred from Stator to rotor Winding through induction. The induction motor is also called asynchronous motor as it runs at a Speed other than the Synchronous Speed. Like any other electrical motor induction motor also have two main parts namely rotor and Stator.

A three phase induction motor has two main parts.

i) Stator ii Rotor

The rotor is separated from the Stator by a Small air-gap which rangers from 0.4mm to 4mm, depending on the power of the motor.



* Shaft for transmitting the torque to the load. This Shaft mad up of Steal.

* Bearing for Supporting the relating shaft.

* One of the problem with electrical motors is the production of heat during its rotation. In order to overCome this problem we need for fan Cooling.

* for reciving external electrical Connection terinal box in needed.

* There are a Small distance between roter and stater which usally varies from 0.4mm to 4mm. Such a distance is Called air Gap.

⇒ Rotor:-

The roter is a rotating part of induction motor. The roter is Connected to the mechanical load through the Shaft. Roter is Consists of Cylindrical luminator Core with parallel Slots that Carry Conductor bars. Conductors are heavy Copper or aluminium bars which fit in each Slots.

These Conductor are brazed to the Short Circuiting and rings. The Slots are not exactly made parallel to the axis of the Shaft but are slotted a little skewed for the following reason.

There are two main types of a rotors.

i) Sequiral rotor:.

ii) Wound rotor:-

i Squirrel Cage rotor:-

The rotor of the Squirrel Cage 3-ϕ induction motor is Cylindrical in Shape and have 3 lots on its periphery. The Slots are not made parallel to each other but are bit Skewed as the Showing prevents. magnetic locking of Stator and rotor teeth and make the working of motor more Smooth and quieter. The Squirrel Cage rotors Consists of a luminum, brass or Copper bars

Advantages:-

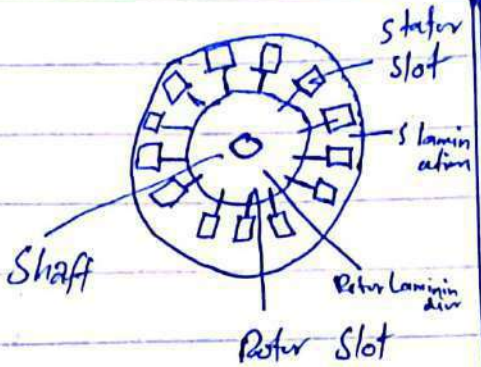
* Its Construction is very Simple and rugged.
* As there are no brushes and Slip rings these motor reqiuires less maintenance,

Application:-

Squirrel Cage induction motor is used in lathes, drilling machines, fan, blower printing machines etc.

ii Wound Rotor:-

Slip ring or wound three phase induction motor in this types of three phase induction motor the rotor is wound for same no. of poles as that of stator but it has less number of slots and has less turn per phase of a heavier Conductor. The rotor also carries star or delta winding similar to that of stator winding The rotor Consists of no. of slots and rotor winding are placed init inside these slots. The three end terminals are Connected together to form Star Connection. As its name induction 3-ϕ Slip ring induction motor Consists of Slip ring Connected on same Shaft as that of rotor. The three end of 3-ϕ winding are permanently Connected to these Slip rings and hence used for Speed Control and improving the Starting torque of 3-ϕ induction motor. The external Resistance are used during Starting Period only when the motor normal Speed 3 brushes are Short Circuited so that the wound rotor runs like a Squirrel Cage rotor.



Advantages of slip ring:-

* It has high Starting torque and low Starting Current.
* Possibility of adding additional resistance to Control Speed.

Application:-

Slip ring induction motor are used where high Starting torque is required in hoists Cranes elevator etc

ii Stator:-

As its name indicates stator is a stationary part of induction motor. A Stator Winding is placed in the Stator of induction motor and the 3-ϕ Supply is given to it.

Stator is made up of no stamping in which different Slots are cut to receive 3ϕ Winding Circuit which is Connected to 3-ϕ AC Supply.

The 3-ϕ Winding are arranged in Such a manner in the Slots that they produced a rotating magnetic field after AC is given to them.

It Consists of a steel frame which enclose a hollow, Cylindrical Core made of thin lamination of 'Silicon Steel to reduce hysteress and eddy Current losses. when 3-ϕ Supply is given to the Stator winding a rotating magnetic field of an Constant magnitude is produced. This rotating field. induces Current in the rotor by electromagnetic inductor.

The Stator of these phase introduction motor Consists of three main parts.

i) Stator frame:-

It is the outer most part of the 3-ϕ induction motor. It mains function is to Support. The Stator Core and the field winding. It acts as a Covering and it provide protection and mechanical Strength to all the inner parts of the induction motor. The frame is either made up to die Cast or Fabricated Steel.

ii Stator Core:-

The main function of the Stator Core is to Carry the alternating flux.

In order to reduce the eddy Current loss the Stator Core is laminated.

These laminated types of structure are made up to stampings which is about 0.4 to 0.5mm thick. All the stamping are stamped together to form stator core, which helps to reduced the hysteresis loss occuring in motor.

iii Stator Winding:-

The slots on the periphery of stator core of the motor carries 3ϕ windings. This 3ϕ windings is supplied by 3ϕ AC Supply. The 3ϕ of the winding are connected either in star or delta depending upon which type of starting method is used. The squirred cage motor is mostly started by star-delta starter and hence starter of squrrial cage motor is delta connected.

Q. No. 2

Write operation principle (working) of three phase induction motor.

The stator of the motor consists of overlapping winding effect by an electrical angle of 120°. When we connected to primary winding as the stator to a 3-ϕ AC source it establishes rotating magnetic field which rotates at the synchronous speed.

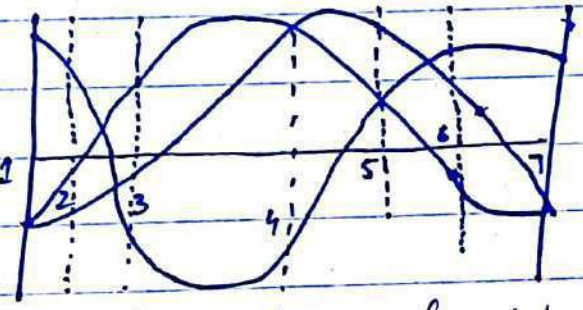
Secrets behind the rotation: According to faraday's law an emf induced in any circuit is due to the rate of change of magnetic flux linkage through the circuit As the rotor winding in an induction motor are either closed through an external resistance or directly shorted by end ring. Cut the Stator rotating magnetic field an emf is include in the rotor Copper bar and due to this emf a current flows through the rotor Conclude

Thus from the working principle of 3-ϕ induction motor it may be observed that the rotor speed should not reach. The Synchronous speed produced by the Stator if the speed become equal, there would be no such relative speed, so no emf induced in the rotor, and no current would be following and therefore no torque would be generated. Consequently, the rotor Cannot reached the Synchronous speed the difference b/w the Stator and rotor speed is called the Slip. The rotation of the magnetic field in an induction motor has the advantages that no electrical Connection need to be made to the rotor.

Three phase Rotating field:-

Three phase induction motor also oprates on the principle of a rotating magnetic field. The following discussion Connected to a 3ϕ AC Input and howe a resultant magnetic field that rotates.

The 3ϕ Input voltage to the Stator in the graph of figure.



use the left hand rule for determing the electromagnetic.

Polarity of the poles of any given instant. In applying the rule to the Coil in figure Consider that Current flows towards the terminal number of positive voltage and away from the terminal no for negative voltage.

Generation of rotating magnetic field:-

When a 3ϕ winding is energized from a 3-ϕ Supply a rotating magnetic field is produced.

This field is such that its poles do no remain in a fixed position on the Stator but go no shifting their position. Around the Stator for this reason it is called a rotating field.

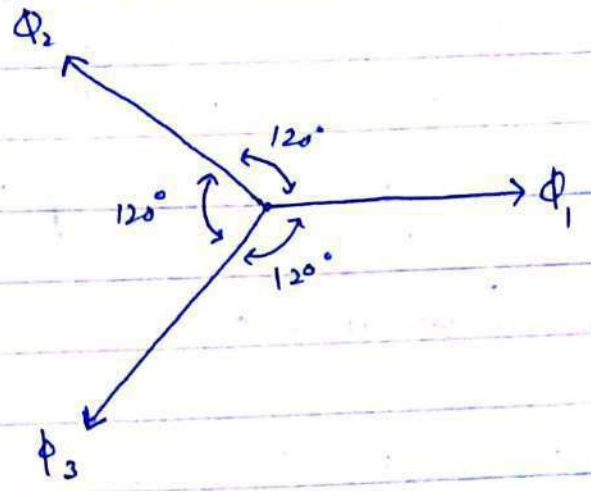
Considered a 3ϕ winding displaced in a Space by 120°. Supply by 3ϕ AC Supply. The 3ϕ current are also displaced from each other by 120°. The flux each phase current is also Sinusidal in nature and all three flux are Seprated from each other by 120°. Then the mathematical eq for the instruments value of the fulux ϕ_1, ϕ_2, ϕ_3 can be given.

$$\phi_1 = \phi_m \sin(\omega t) = \phi_m \sin(\phi - 0^\circ)$$

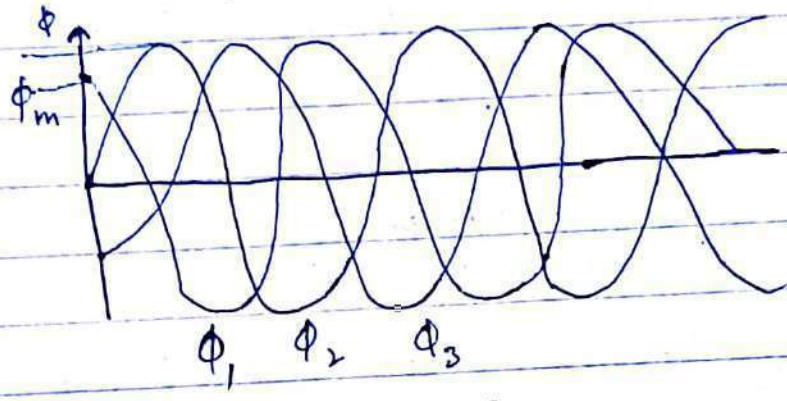
$$\phi_2 = \phi_m \sin(\omega t - 120^\circ) = \phi_m \sin(\phi - 120^\circ)$$

$$\phi_3 = \phi_m \sin(\omega t - 240^\circ) = \phi_m \sin(\theta - 240^\circ)$$

⇒ Assume positive direction



Wave from 3-phase flux



In Case #01 When $\theta = 0^\circ$

$$\phi_1 = \phi_m = \sin(\omega t) = \phi_m \sin 0^\circ = 0$$

$$\phi_2 = \phi_m \sin(\omega t - 120^\circ) = \phi_m \sin(0^\circ - 120^\circ) = -0.866\phi_m$$

$$\phi_3 = \phi_m \sin(\omega t - 240^\circ) = \phi_m \sin(0^\circ - 240^\circ) = 0.866\phi_m$$

$$\phi_T = \phi_1 + \phi_2 + \phi_3$$

⇒ According to diagram:-

Since $OD = DA = \Phi T/2$

Since ΔOBD the angle of $BOD = 30°$

So $\cos 30° = OD/OB = (\Phi T/2) / 0.866 \Phi_m$

$\Phi_T = 2 \times 0.866 \Phi_m \times \cos 30° = \boxed{1.5 \Phi_m}$

In Case #2 When angle $\theta = 60°$

$\phi_1 = \phi_m \sin(\omega t) = \phi_m \sin 60° = 0.866 \phi_m$

$\phi_2 = \phi_m \sin(\omega t - 120°) = \phi_m \sin(60° - 120°)$

$= 0.866 \phi_m$

$\phi_3 = \phi_m \sin(\omega t - 240) = \phi_m \sin(60 - 180°) = 0$

$\Phi_T = \phi_1 + \phi_2 + \phi_3$

⇒ According to diagram:-

Since $OD = DA = \Phi_T/2$

Since ΔOBD, the angle of $BOD = 30°$

So $\cos 30° = OD/OB = (\Phi_T/2) / 0.866 \Phi_m$

$\Phi_T = 2 \times 0.866 \Phi_m \times \cos 30° = \boxed{1.5 \Phi_m}$

So the magnitude of resultant flux is $1.5 \Phi_m$ time the maximum value if flux

Case #04 when $\theta = 180^\circ$

$$\phi_1 = \phi_m \sin(\omega t) = \phi_m \sin 180^\circ = 0$$

$$\phi_2 = \phi_m \sin(\omega t - 120^\circ) \cdot \phi_m \sin(180^\circ - 120^\circ)$$

$$\phi_2 = 0.866\, \phi_m$$

$$\phi_3 = \phi_m \sin(\omega t - 240^\circ) = \phi_m \sin(180^\circ - 240)$$

$$\phi_3 = -0.866\, \phi_m$$

$$\phi_T = \phi_1 + \phi_2 + \phi_3$$

⇒ According to daigram

Since $OD = DA = \phi_T/2$

Since ΔOBD the angle of $BOD = 30^\circ$

So $\cos 30^\circ = OD/OB = (\phi_T/2)/0.866\, \phi_m$

$$\phi_T = 2 \times 0.866\, \phi_m \times \cos 30^\circ$$

$$\phi_T = 1.5 \phi_m$$

So, the magnitude of resutent flux is $1.5\phi_m$ time the maximum value flux.

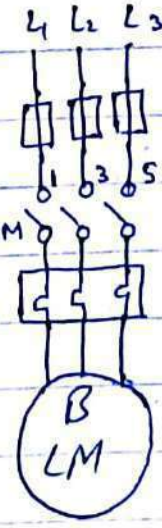
Q. No. 3 (16)

Discuss different types of Starter for 3ϕ induction motor.

i) Direct On-Line Starter (DOL)

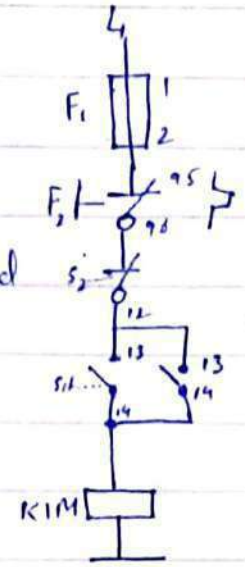
The direct on Line (DOL) Starter is the simplest and the most inexpensive of all starting methods and is usually used for Squirrel Cage inductor motors. It directly Connects the Contacts of the motor to the full Supply voltage. The Starting Current is very large, normally 6 to 8 Times the rated Currents. The Starting torque is likly to be 0.7o to 2 times the full load torque. In order to avoid excerise voltage drops in the Supply due to high Starting Currents. The DOL Starter is used for motors with a rating of less than 5kw.

These are Safety mechanisms inside the DOL Starter which provides protection to the motor as well as the operate of the motor. The power and Control Circuits of induction motor with DOL Starter and the real picture of Contacts are shown in figure →



The DOL Starter Consists of a Power and Coil operated Contactor KIM Controlled by Start and Stop push button on Pressing the Start Push button S, the Contactor Coil KIM is

is energized from line L_1. The 3 main Contacts (1-2) (3-4) and (5-6) are closed. The motor is then to the Supply when the Stop push button S_2 is pressed, the Supply through the Contactor K1M is disconnected. Since the K1M is de-energized the main Contacts (1-2), (3-4) and (5-6) are opened. The Supply to motor is disconnected and the motor Stops.

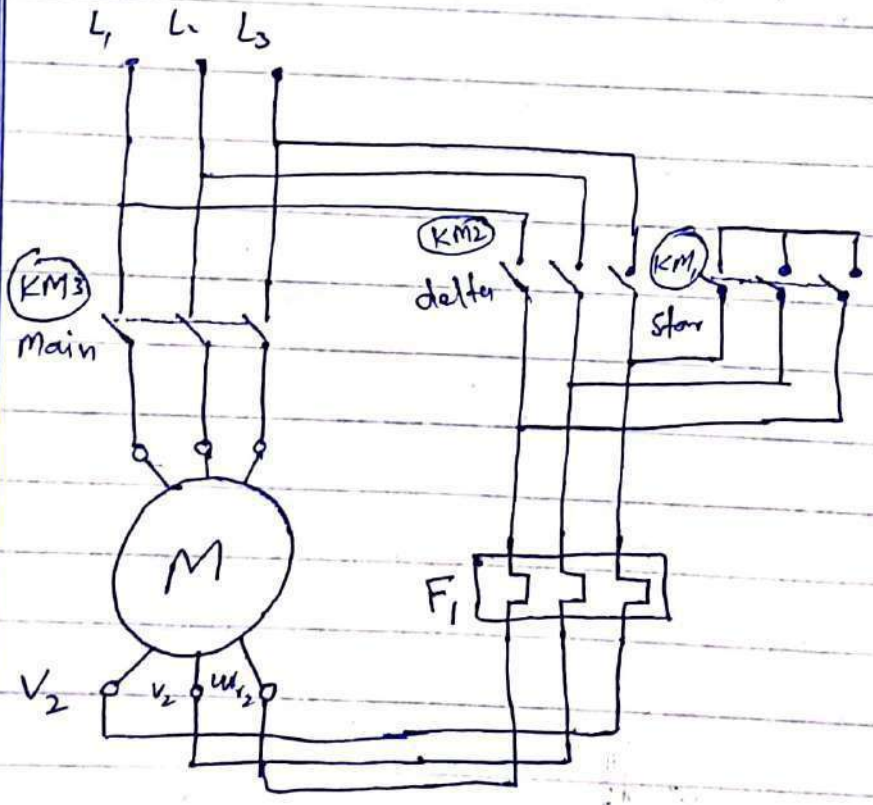


(Control Circuits)

ii) Star-Delta Starter:-

The star delta starter is a very simple common type of starter and extensively used compared to the other type of the starters. The method achived low starting current by first connecting the stator winding is star configuration and then after the motor reaches a certain speed, throw switch changes the winding arrangment from star to delta configuration connecting the starter windings first on star and then in delta the line current drawn by the

motor at Starting is reduced to one third as Compared to Starting Current with the Winding Connected in delta. At the time of Starting when the Starter windings and Star Connected each Stator Phase gets voltage $V_L/\sqrt{3}$, where V_L is the Line voltage Since the torque developed by an inductive motor is proportional to the Square of the applied voltage Star-delta Starting reduces the Starting torque to one third that obtained by direct delta Starting.



iii Auto Transformer Starter:-

The operation principle of auto transformer method is similar to the star delta starter method. The starting current is limited by (using a 3φ auto T/F) reduced the initial starter applied voltage. The auto Transformer starter is more expensive more complicated in operation and bulkier in construction when compared with the star delta methods. But an auto transformer starter is suitable for both star and delta connected motors and the starting current and torque that be adjusted only by factor of $1/\sqrt{3}$.

⇒ It can brief operation of auto T/F as

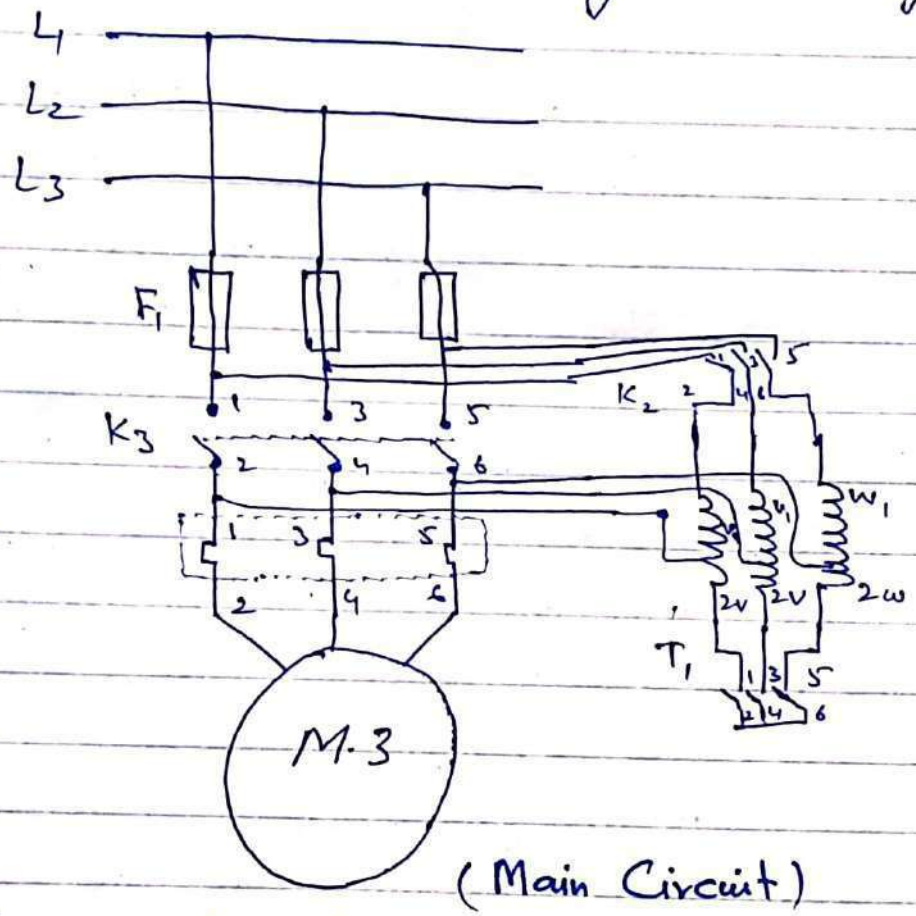
i) operated by a two position switch manually using a timer to change over from start run position.

ii) In starting position supply in connected to ~~sep~~ starter winding through an auto T/F which reduce applied voltage to 50, 60 and 70% of normal value depending on tapping used.

iii) for an induction motor torque T is developed by V_2, thus as 50% tapping torque at starting is only (0.5V) of the obtained by DOL starting Hence 25% torque is produced.

ii) Starter used in larger industries, it is larger in size and expensive.

v) Switching from start to run position causing transient current which can be greater in value than those obtained by DOL starting.

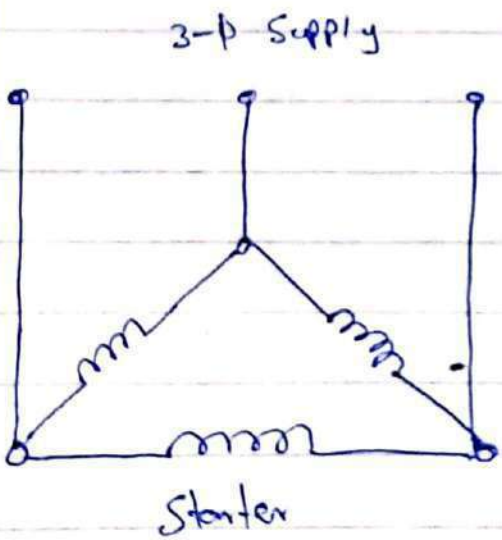


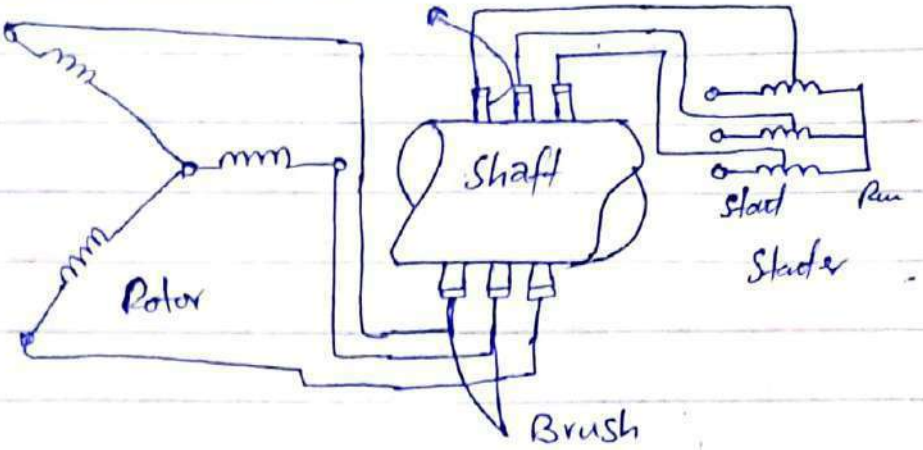
(Main Circuit)

Power and Control Circuit of 3ϕ IM with auto T/F Starter.

iv) Rotor impedance Starter:-

This method allows ~~through~~ ~~Slip rings an~~ external resistence connected to rotor through slip rings and brushes. Initially, the rotor resistance is set to maximum and is then gradually decrease as the motor speed increase until it becaux zero. The rotor impedance starting mechanism is usually very bulky and expensive when compared with other methods. It has very high maintinence costs. Also a considerable amount of heat is greate through the resistance when current runs through them. The starting frequency is also limited in this method, However, the rotor impedance method allows, the motor to be started while on load.





This will decrease the Starting Current increase the Starting torque and also improves the Power factor. The Circuit diagram is Show below In the Circuit daigram three Slip rings Show are Connected to the rotor terminals of the wound rotor motor. All the time of Starting of the motor the entire external resistance is added in the rotor Circuits. Then the external rotor resistance is decreased in steps as the rotor Speeds up however, the motor torque remains maximum during the acceleration period of the motor. Under normal Condition when the motor developed load the external resistance is removed.