

Assignment

Electrical Machines

II

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Q No #1

Write Introduction, Advantages disadvantages and Construction of three Phase Induction Motor.

⇒ Introduction:-

In three Phase induction motor the Power is transferred from stator to rotor through Induction.

The Induction motor is also called an asynchronous motor as it runs at a speed other than the synchronous speed.

A 3-Phase Induction motor has two types. First is squirrel cage motor is generally used in household and industry because it is cheaper and easy to repair and the second type is slip ring Induction motor or wound rotor Induction motor.

The 3-Phase squirrel cage induction motor is widely used as industrial driver because they are self starting, reliable and economical.

⇒ Construction of 3-Phase Induction motor:-

An Induction motor has the same physical stator as a synchronous machine, with a different rotor construction.

3-Phase Induction motor is constructed from two main parts rotor and stator.

Stator:-

As its name indicates stator is a stationary part of induction motor. stator winding is placed in the stator of induction motor and three phase supply is given to it.

Rotor:-

The rotor is the rotating part of induction motor. The rotor is connected to mechanically load through the shaft.

These are two different types of induction motor Rotor which can be placed inside the stator, one is called squirrel cage induction motor rotor while the other is called wound rotor.

⇒ A cage induction motor rotor consists of a series of conducting bars laid into slot curved in the face of the rotor and shorted either end by large shorted rings. This design is referred to as a cage rotor.

⇒ The other type of rotor is a wound rotor. A wound rotor has a completed set of three phase winding that are similar to the winding on ^{the} stator. The three phase of rotor winding are tied to the slip ring on the rotor shaft. The rotor winding are shorted through brushes riding on the slip ring.

⇒ Advantages of Induction Motor:-

I. The advantages of an Induction motor is that its construction is quite simple in nature. The construction of stator is similar in both synchronous motor as well as Induction motor.

II. The working of the motor is independent of the environmental condition.

III. The squirrel cage induction motor does not contain brushes, slip rings and commutator. due to this reason the cost of the motor is quite low.

IV. Due to the absence of brushes there are no sparking.

V. The 3-Phase Induction motor has a high starting torque & good speed regulation and reasonable load capacity.

VI. And Induction motor is highly efficient machine.

VII. Full load efficiency varies

From 87 to 97 percent.

⇒ Disadvantages of three Phase Induction motor

I. The P.F of the motor is very low during the light load condition.

II. The three Phase induction motor is constant speed motor

III. The change in speed of the induction motor is very low during different load condition.

IV. During light load condition it operate at very low Power Factor.

V. The motor cannot use in like such application where high starting torque is necessary like traction and lifting weight.

VI. In low P.F High copper loss and efficiency loss occur.

Q #2

Write operation Principal (working) of three Phase induction motor.

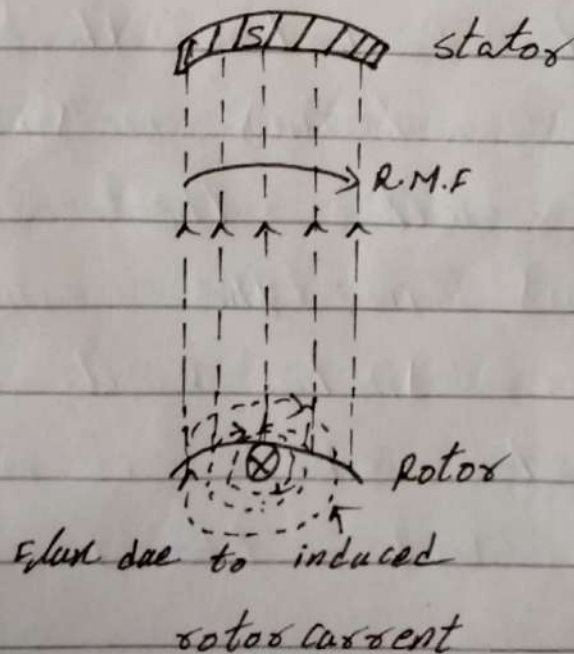
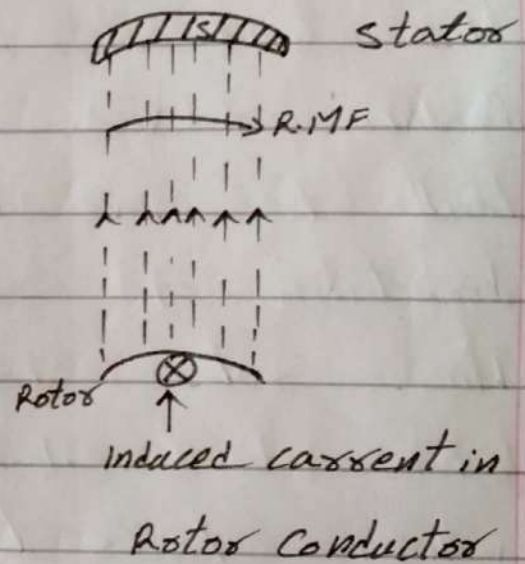
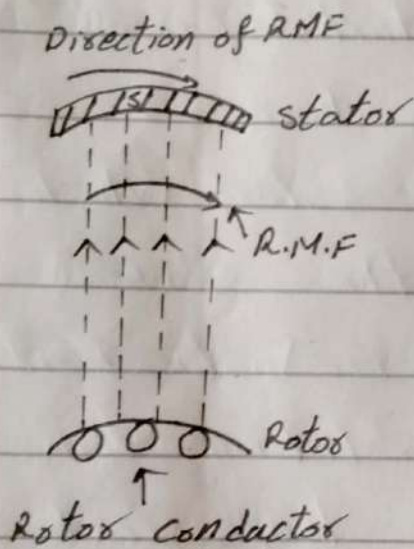
The motor which works on electro magnetic induction called Induction motor. The electro magnetic induction is the phenomenon in which the electro motive Force induces across the electrical conductor when it is placed in a rotating magnetic field. This law is also called Faraday's law.

- When the motor is excited with three phase supply. Three phase stator winding produce a magnetic field with 120 displacements at constant magnitude which rotates at synchronous speed. This changing magnetic field cuts the rotor conductor and induces a current in them according to the principle of Faraday's law of electro magnetic induction.

As these rotor conductors are shorted the current starts to flow through these conductors.

- In the presence of magnetic field of stator, rotor conductors are placed and therefore according to the Lorentz force principle, a mechanical force acts on the rotor conductor. Thus all the rotor conductor forces. The sum of mechanical forces produce torque in the rotor which tend to move it in the same direction of rotating magnetic field.
 - This rotor conductor rotation can also be explained by Lenz's law which tells that "the induced currents in the rotor oppose the cause for its production." Here this opposition is rotating magnetic field. This results the rotor starts rotating in the same direction of magnetic field.
- IF the rotor speed is more than stator speed therefore no

Current will induce in the rotor because the reason for rotor rotation is the relative speed of rotor and stator magnetic fields. This how 3-Phase motor is called as asynchronous machine due to this relative speed difference between the stator and rotor.



The difference of speed or slip of the AC Induction motor is given as

$$S = \frac{n_s - n_r}{n_s}$$

The slip also be expressed in Percent slip as follow

$$\text{Percent slip} = \frac{n_s - n_r}{n_s} \times 100$$

At other speeds the rotor frequency is proportional to the

$$F_r = SF$$

F_r = Frequency of rotor current.

- When the stator is stationary, $N_r = 0$ so the slip becomes 1 or 100%
- When N_r is at synchronous speed the slip becomes zero: so the motor never runs at synchronous speed
- The slip in the 3 phase induction motor from no load to full load is

about 0.1 to 3; that's why the induction motors are called as constant speed motors.

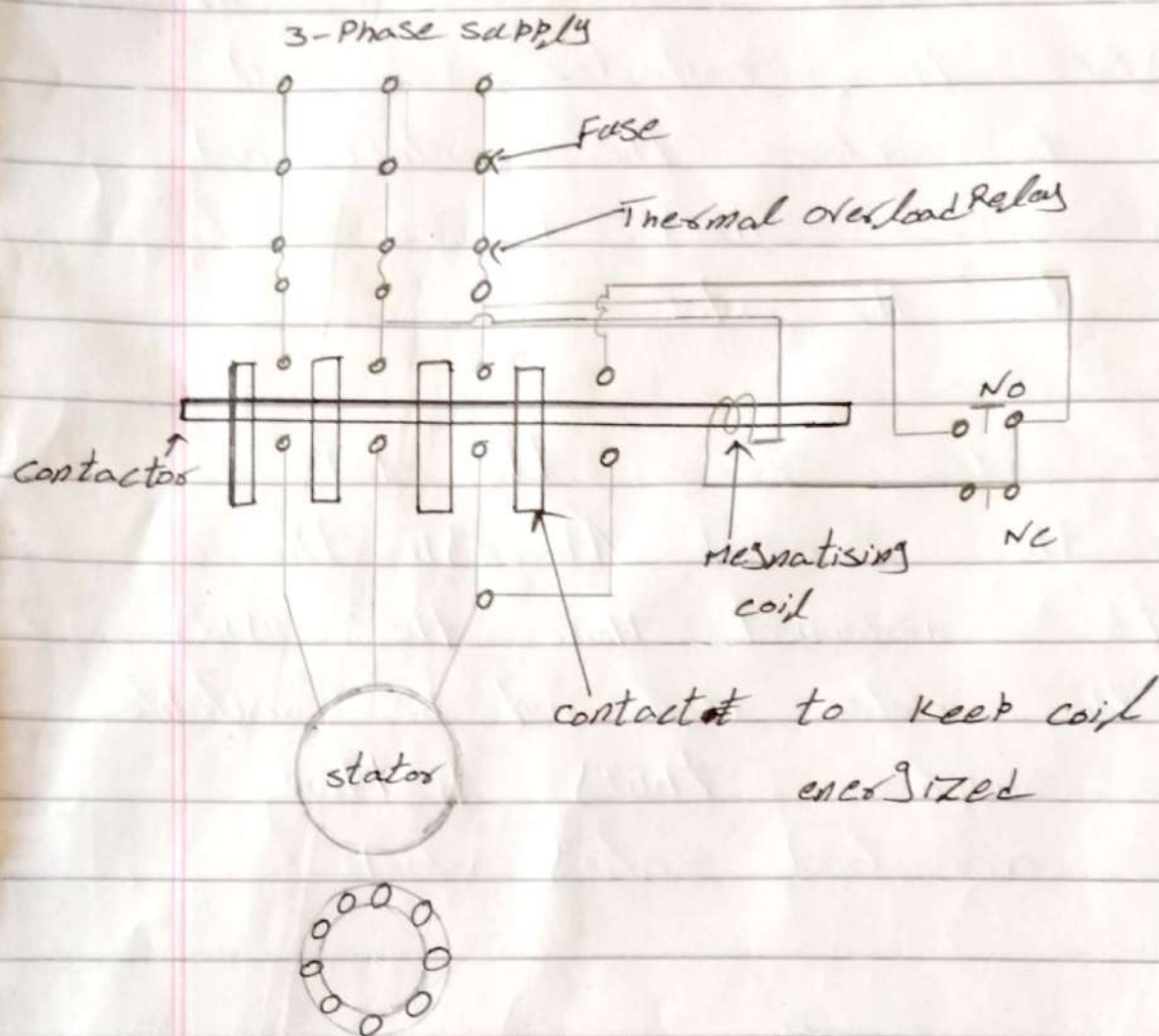
Q.No3:-

Discuss different types of starter for three phase induction motor.

i) Direct on-line starter (DOL)

A DOL starter is the method of starting a 3-phase induction motor. In DOL starter an induction motor is connected directly across its 3-phase supply. And the DOL starter applies the full line voltage to the motor terminals. Despite this direct connection no harm is done to the motor. A DOL starter contains protection devices and in some cases condition monitoring.

Wiring diagram of a DOL starter



DOL starter working principle

The working principle of DOL starter begins with the connection to the 3-phase main with the motor. The control circuit connected to any two phases and energized from them only when we press the start

button, The current flow through contactor coil and control circuit also. The current energises the contactor coil and leads to close the contact and hence 3-phase supply becomes available to the motor.

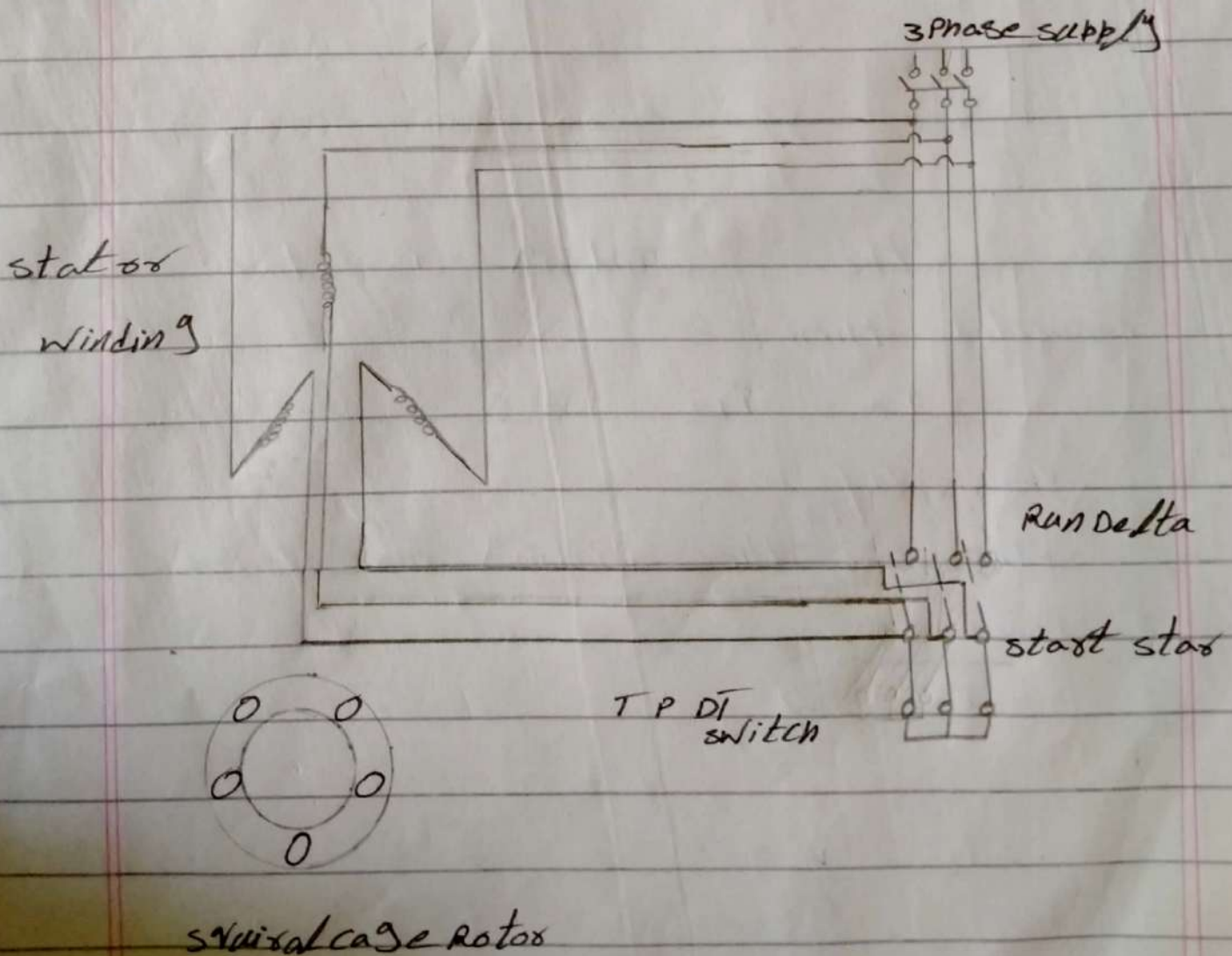
Hence we press the stop button the current through the contacts disconnect. Hence the supply to the motor will not be available and similar thing happens when over load relay works.



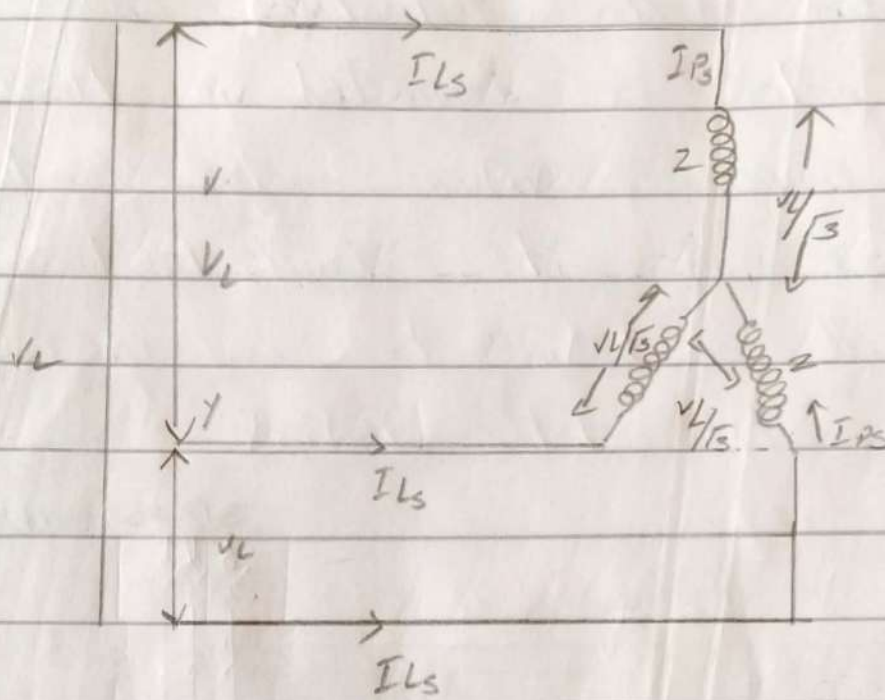
ii) star Delta starter

star delta starter is most commonly used method of the starting a 3-phase induction motor

In star delta starting an induction motor is connected in through a star connection. When motor reaches about 80% of its Full load speed, it will begin to run in a delta connected stator winding.



The stator mainly consist of a TPDP (Triple pole double throw) switch. This switch changes stator winding from star to delta



as the winding is star connected then

$$I_{Ph} = I_{Ls}$$

$$V_{Ph} = \frac{V_L}{\sqrt{3}}$$

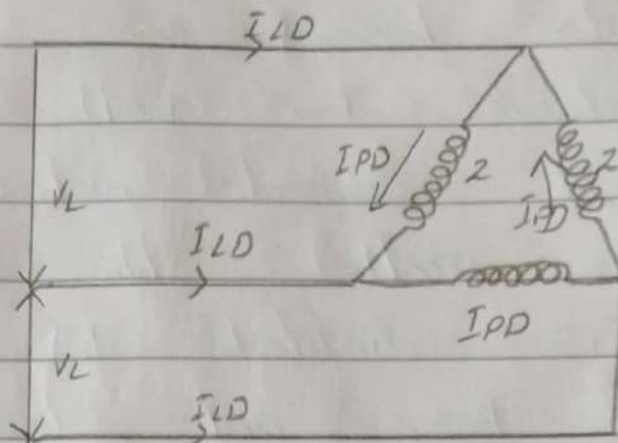
Hence the winding current per

Phase is

$$I_{Ph} = \frac{V_L}{\sqrt{3}Z}$$

$$I_{Ls} = \frac{V_L}{\sqrt{3}Z}$$

when the motor gets in delta connected



$$I_{LD} = \sqrt{3} I_{PD}$$

$$I_{PD} = \frac{V_L}{2}$$

$$I_{LD} = \sqrt{3} I_{PD} = \frac{\sqrt{3} V_L}{2}$$

Now by comparing supply line current

$$\frac{I_{LP}}{I_{LS}} = \frac{\frac{\sqrt{3} V_L}{2}}{\frac{V_L}{\sqrt{3}}} = 3 \Rightarrow I_{LS} = \frac{1}{3} I_{LD}$$

= starting torque in star connected

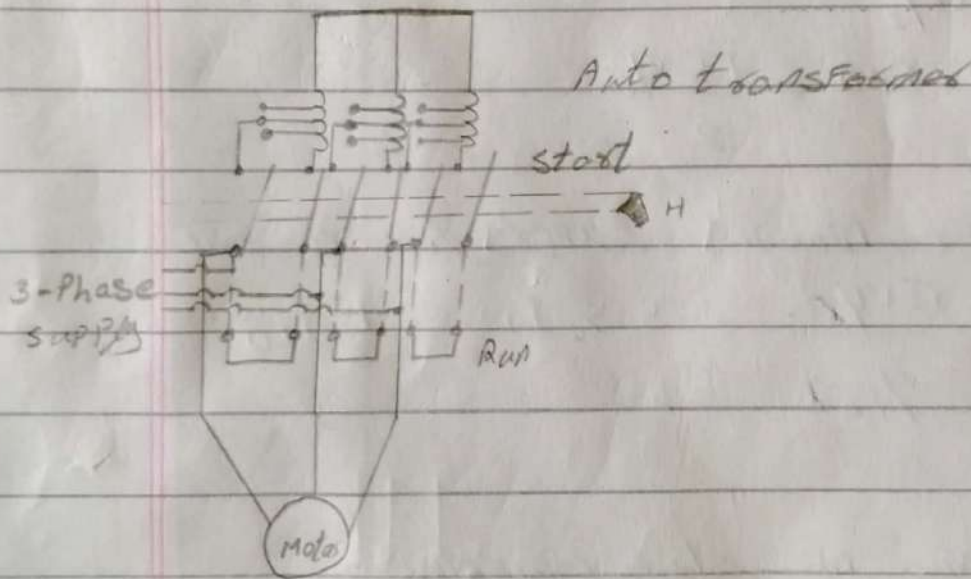
starting torque in Delta connected

$$\frac{\left(\frac{V_L}{\sqrt{3}}\right)^2}{(V_L)^2} = \frac{1}{3}$$

This eq show that Star delta starter reduces the starting torque to $\frac{1}{3}$ of that produced by DOL starter.

iii) Auto transformer starter

An auto transformer starter is suitable for both star and delta connected motors. In this method the starting current is limited by using a three phase auto transformer to reduce the initial stator applied voltage.



Working Principle

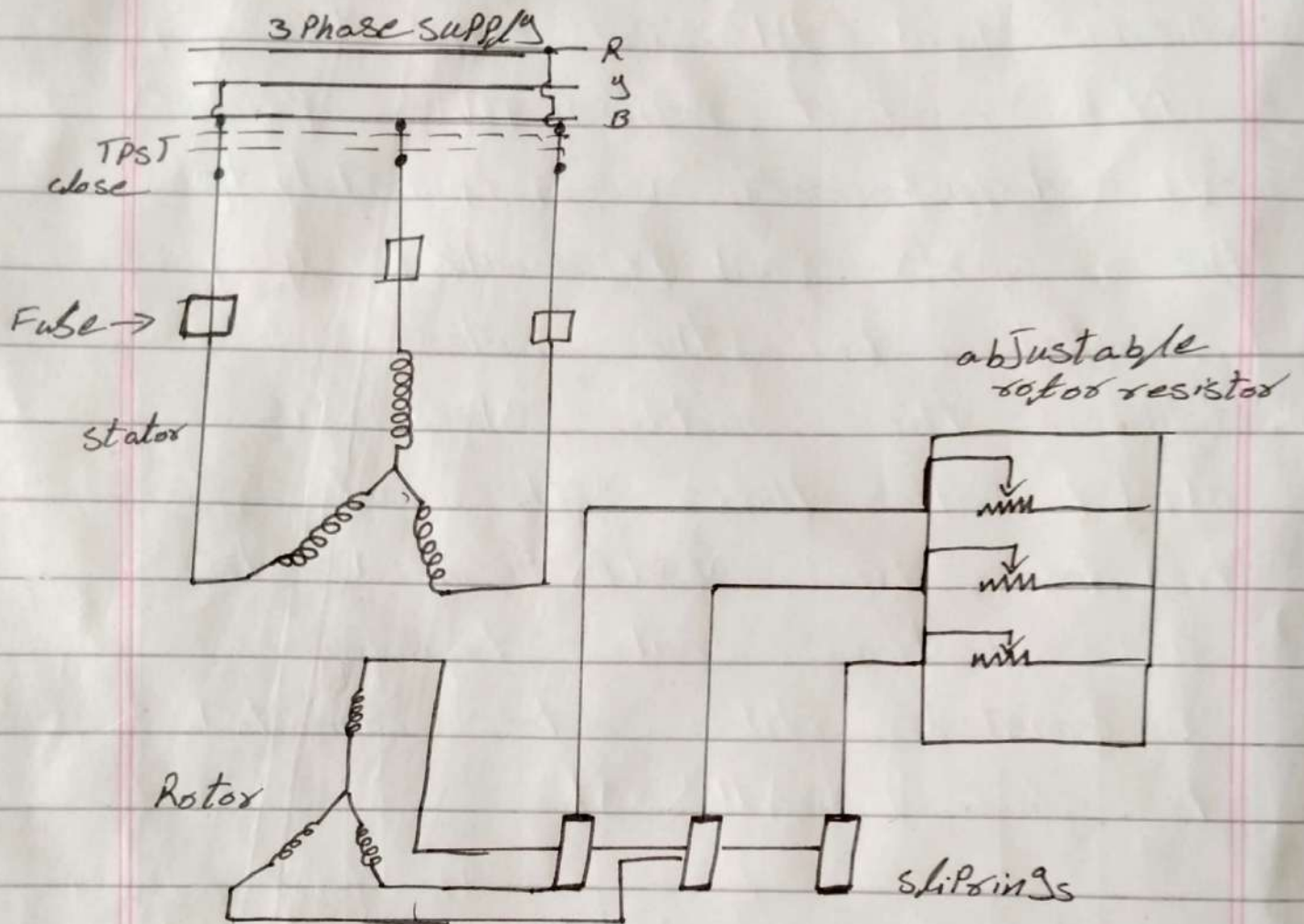
Auto transformer is provided with a number of tapings the starter is connected to one practical tapping to obtain the most suitable starting voltage.

A double throw switch is used to connect the auto transformer in the circuit for starting when hand H is in the 'switch start position'. The primary of transformer is connected to the supply and secondary is connected to the motor. When the motor speed is about 80% thus the auto transformer is quickly moved to Run position and transformer is disconnected and motor connected to line directly.

iv) Rotor Impedance stator

stator means which limiting starting current. Rotor Impedance/Resistance stator is used with wound rotor induction motor. It uses an external resistance in the rotor circuit. So that rotor will develop a high value of torque. High torque is produced.

at low speed when the external resistance is at high level



Working Principle

We know maximum torque is independent of the rotor resistance yet the accurate location of the T_{max} is dependent on it. The larger the value of the resistance larger will be the value of the slip at which the maximum torque occurs.

if the resistance of the motor is increased then the Pull out speed of the motor decreases. But T_{max} remain constant thus by this method the speed control is provided by the rated speed to the lower speed.

The torque evaluation for Poly Phase induction motor is

$$T = \frac{m V_1^2 s / s}{\omega_s [(r_1 + \frac{r_2}{s})^2 + (x_1 + x_2)^2]}$$

$\therefore s/s \gg r_1, x_1$ therefore ev is

$$s = \frac{T}{k_t} \cdot r_2$$

This ev show that Torque and the slip is directly proportional to the rotor resistance if the resistance increase the slip increased and the speed of the rotor decreased.

