SNS COLLEGE OF TECHNOLOGY

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COIMBATORE-35

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME: 23EEB210/Electrical Machines and Drives

II YEAR Mech / IV SEMESTER

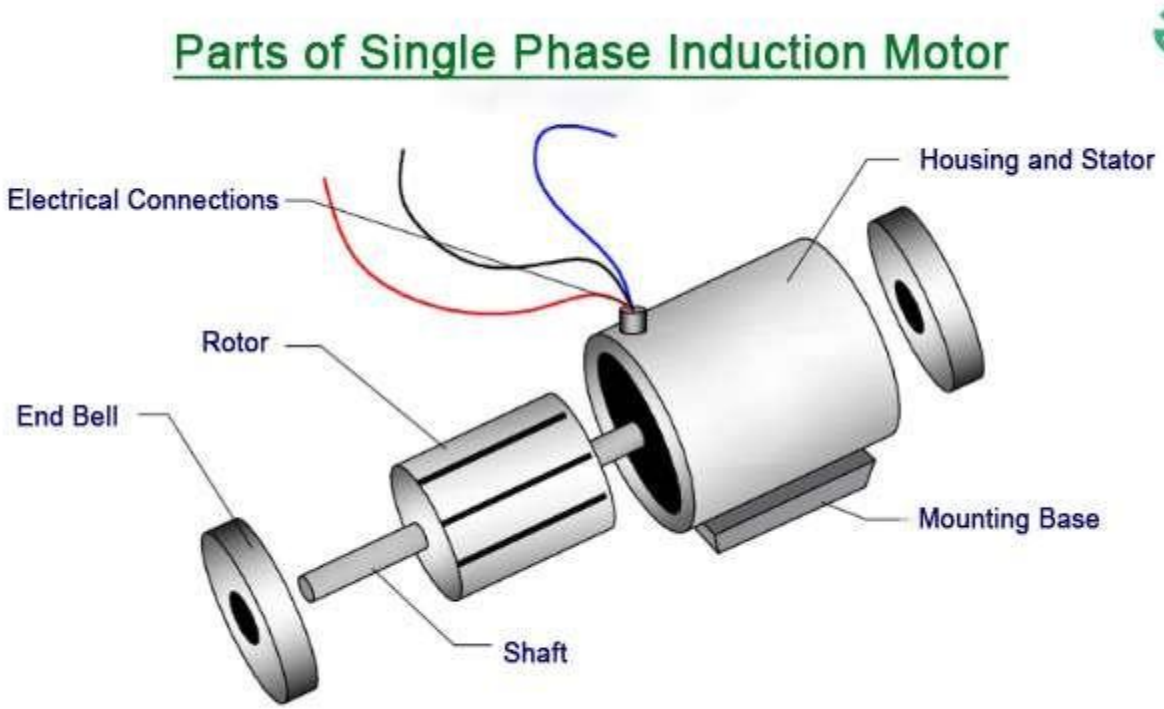
Unit II – ELECTRICAL MOTORS

Topic : Single Phase Induction Motor

Single Phase Induction Motor

A single-phase induction motor is a small-size motor with a fractional-kilowatt rating. They work on the principle of electromagnetic induction to create a rotating magnetic field. It is used in domestic appliances like fans, hair dryers, washing machines, vacuum cleaners, mixers, refrigerators, food processors and kitchen equipment employ these motors.

Single Phase Induction Motor



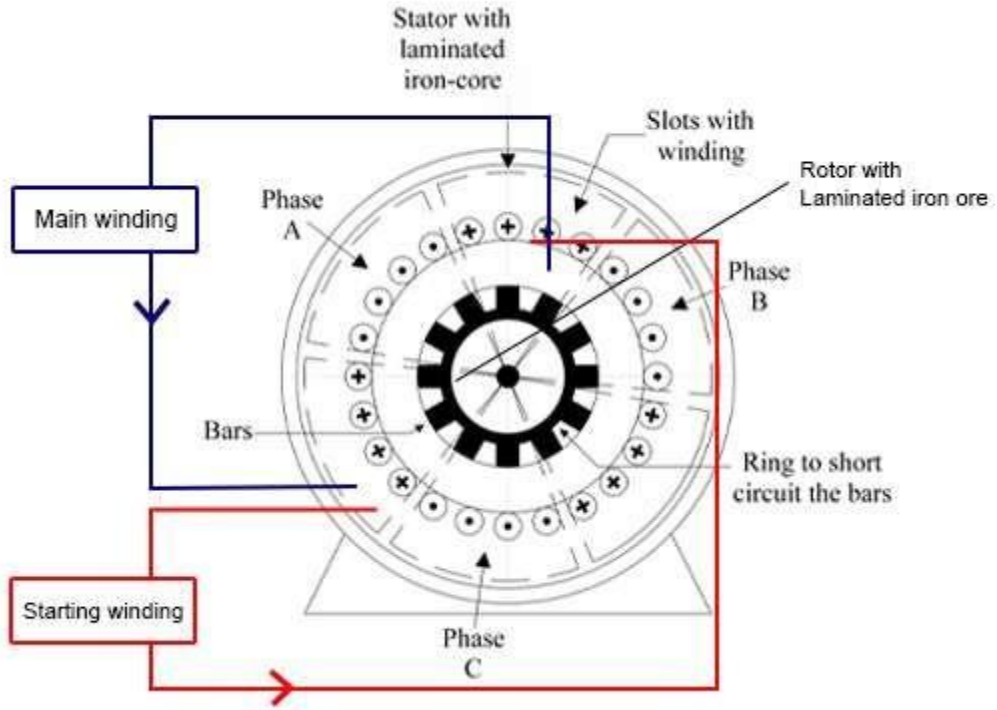
Construction of Single-Phase Induction Motor

To construct Single Phase Induction Motor, it comprises of two major components which is the rotor and the stator.

Stator: As the name implies, a stator is a stationary component of an induction motor. The stator of a single phase induction motor receives a single phase alternating current source.

Rotor: The rotor is a rotating component of an induction motor. The rotor transmits mechanical load via the shaft. The squirrel cage rotor is used in the single-phase induction motor.

Construction of Single-Phase Induction Motor



Components of Single-Phase Induction Motor

A single-phase induction motor consists of several key components:

1. Stator of Single Phase Induction Motor

The stator is the stationary part of the motor and contains the primary winding and an auxiliary winding. The main winding is designed to produce a magnetic field when an AC voltage is applied. The auxiliary winding, found in motors, provides a phase shift to create a rotating magnetic field. When a single phase AC supply is applied to the stator winding, the magnetic field is generated, and the motor starts rotating at a speed slightly less than the synchronous speed N_s. Synchronous speed N_s is given by:

$$N_s = 120f/P$$

Where,

f = supply voltage frequency

P = No. of poles of the motor.

Construction of Single-Phase Induction Motor

Rotor of Single Phase Induction Motor

The rotor is the rotating part of the motor. In single-phase induction motors, the rotor is made up of a squirrel-cage consists of conductive bars embedded in slots around in rotor's periphery.

These bars are short-circuited at both ends by end rings. When the rotating magnetic field from the stator cuts across the squirrel cage bars, it induces currents, generating a magnetic field in the rotor that interacts with the stator's field and produces rotation.
These rotor conductors are braced to the end ring to provide mechanical strength, forming a complete closed circuit resembling a cage, hence the name squirrel cage induction motor. Because the end rings permanently short the bars, the rotor electrical resistance is very low, and adding external resistance is not conceivable because the bars are constantly shorted. The lack of a slip ring and brushes simplifies and strengthens the construction of a single phase induction motor.

Working of Single-Phase Induction Motor

Operation and Working of Single-Phase Induction Motor

A single-phase induction motor is similar in construction to that of a polyphase induction motor with the difference that its stator has only one winding. When a single phase AC supply is applied to the stator winding of single phase induction motor, the alternating current starts flowing through the stator or main winding. The flux is then generated by the AC current. The flux also links with the rotor conductors and hence cut the conductors of the rotors.

Working of Single-Phase Induction Motor

According to the Faraday's law of electromagnetic induction, emf gets induced in the rotor. The current begins to flow in the rotor after the rotor circuit is closed. The flux created by this rotor current is known as the rotor flux. Since this flux is produced due to the induction principle so, the motor working on this principle got its name as an induction motor. There are currently two fluxes: the main flux and the rotor flux. The desired torque, which the motor needs to rotate, is produced by these two fluxes.

Its motors consist of a single-phase winding mounted on the stator and a cage winding on the rotor. When a single-phase supply connected to stator winding pulsating magnetic field is produced. Under these conditions, the rotor does not rotate. It requires some special starting methods.

Working of Single-Phase Induction Motor

Why Single Phase Induction Motor is not Self Starting?

A single-phase induction motor lacks a naturally rotating magnetic field, which makes it non-self-starting. Unlike three-phase motors that generate a rotating magnetic field with three alternating currents, single-phase motors rely on a single alternating current that produces a pulsating magnetic field. This field is unable to initiate continuous rotation in the motor's rotor due to its non-uniform nature and inability to provide sufficient starting torque.

Working of Single-Phase Induction Motor

At the starting condition of the motor, **both φ_f (forwarding component of alternating flux(φ_m)) and φ_b(backward component of alternating flux(φ_m))** are equal in magnitude but opposite in direction. They cancel each other out, which results zero net torque on the rotor. This zero torque at the starting condition is why single-phase induction motors are not self-starting.

To overcome this limitation, various techniques are used, such as adding an auxiliary winding and a capacitor to simulate a rotating magnetic field during startup or using centrifugal switches to disconnect the starting winding once the motor reaches a certain speed. These methods help single-phase induction motors achieve the necessary torque for self-starting and sustained operation.

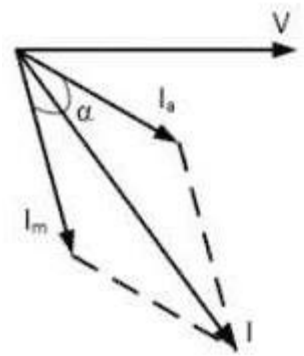
Working of Single-Phase Induction Motor

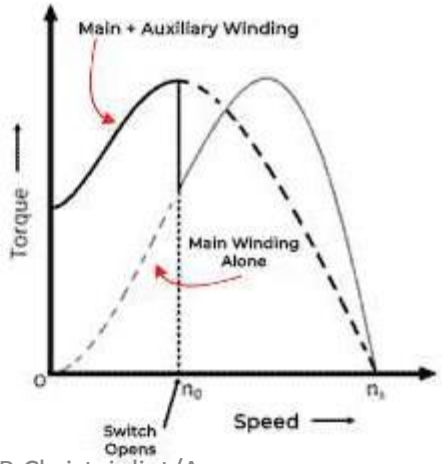
Starting Methods and Types of Single-Phase Induction Motor

1.Split-phase motor
2.Capacitor-start motor
3.Capacitor-start capacitor-run motor (or two-value capacitor motor)
4.Permanent-split capacitor (PSC) motor (or single-value capacitor motor)
5.Shaded-pole motor

1. Split-Phase Induction Motor

It is also called a resistance start motor. It has a single-cage rotor and its stator has two windings- a main winding and a starting (auxiliary) winding which is displaced 90° in space. The main winding has very low resistance and high inductive reactance.





Working of Single-Phase Induction Motor

The starting winding has a resistance connected in series with it. It has high resistance and low inductive reactance. Auxiliary winding current I(a) is nearly in phase with the line voltage. There is a time phase difference between the currents in the two winding usually of the order of 30°. which is enough to produce a rotating magnetic field. Since the current in two winding is not the same the rotating magnetic field is non-uniform and the starting torque is small as of the order of 1.5 to 2 times the rated running torque.

During starting the main and auxiliary windings are connected in parallel. When the motor reaches the speed of about 70 to 80 percent of synchronous speed the starting winding is disconnected from the supply automatically.

Working of Single-Phase Induction Motor

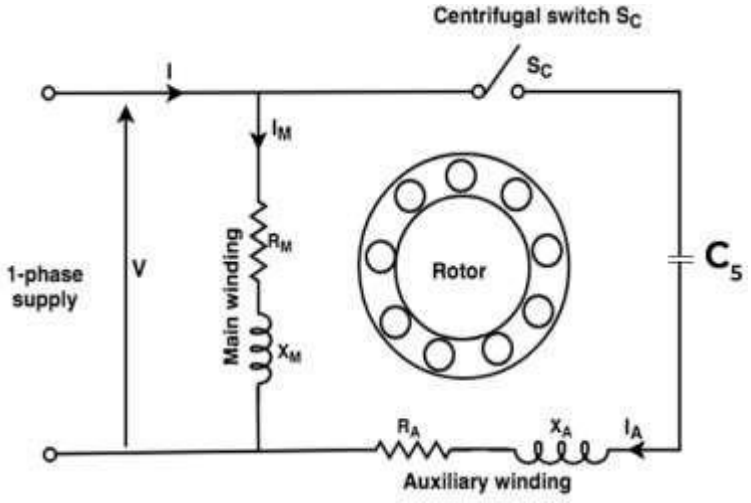
For motors rated about 100W or more, a centrifugally operated switch is used to disconnect the starting winding.

The relay is connected in series with the main winding. At the time of starting, a heavy current flows in the relay coil causing its contact to close. As the motor reaches its predetermined speed of the order of 70 to 80 percent of the synchronous speed the current through the relay coil decreases. Consequently, the relay opens and disconnects the auxiliary winding from the main supply and the motor then runs only on the main winding.

Working of Single-Phase Induction Motor

Capacitor-Start Motor

It has a cage rotor and its stator has two winding (main winding and auxiliary winding) which are displaced 90° in space. The capacitor C_s is connected in series with starting windings. The centrifugal switch S_c is also connected.

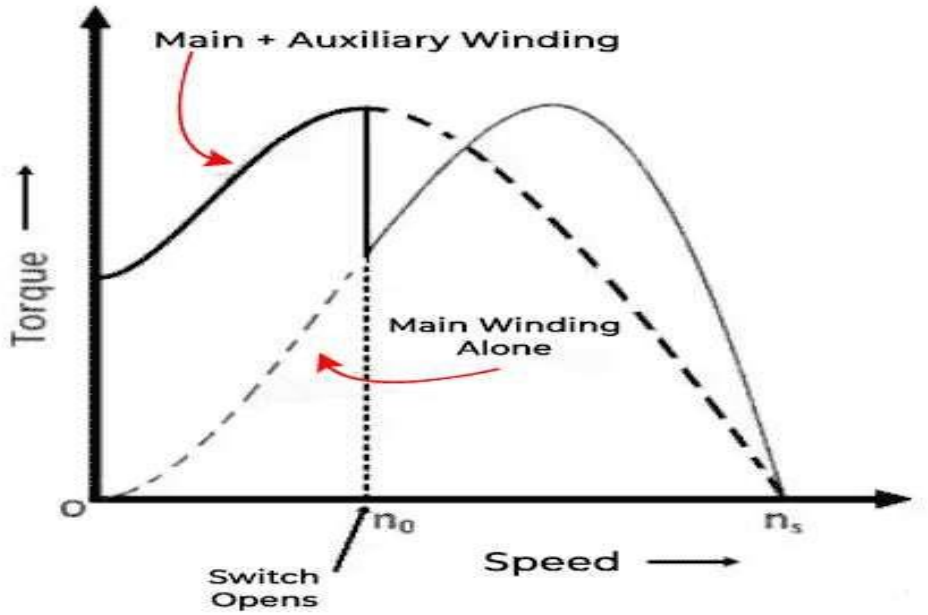


Working of Single-Phase Induction Motor

By choosing the capacitor of proper rating the current I(M) in the main winding may be made to lag the current in IA in the auxiliary winding by 90°. Thus, a single-phase supply current is split into two phases to be applied to the stator windings.

The windings MMFs are equal in magnitude but 90° apart in time phase. Therefore, the motor acts like a balanced two-phase motor. As the motor approaches its rated speed, the auxiliary winding and the starting capacitor Cs are disconnected automatically by the centrifugal switch Sc mounted on the shaft.

Working of Single-Phase Induction Motor

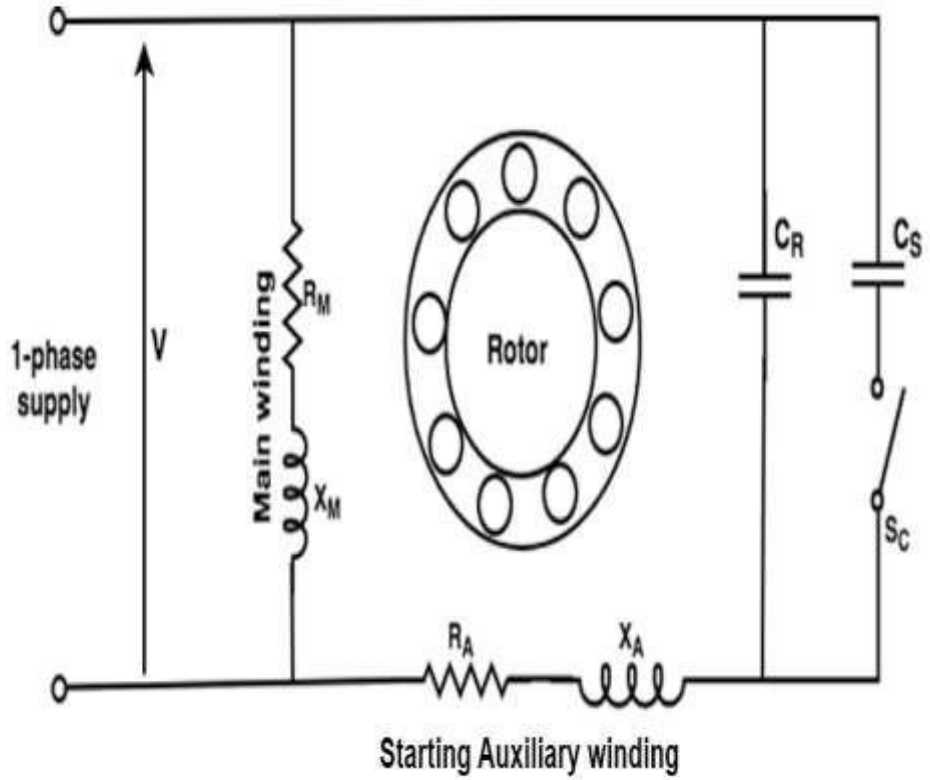


Working of Single-Phase Induction Motor

Capacitor-Start Capacitor-Run Motor (Two Value Capacitor Motor):-

It has a cage rotor and its stator has two windings (main winding and auxiliary winding) displaced by 90° in space. The motor uses two capacitors Cs (starting capacitor) and C_R (run capacitor). The two capacitors are connected in parallel at the start. To obtain a high starting torque, a large current is required therefore the capacitive reactance X in the starting torque should be low. For this Cs should be large (XA=12ΠfCA$X_A = 2\Pi f C_A 1$).

Working of Single-Phase Induction Motor



Working of Single-Phase Induction Motor

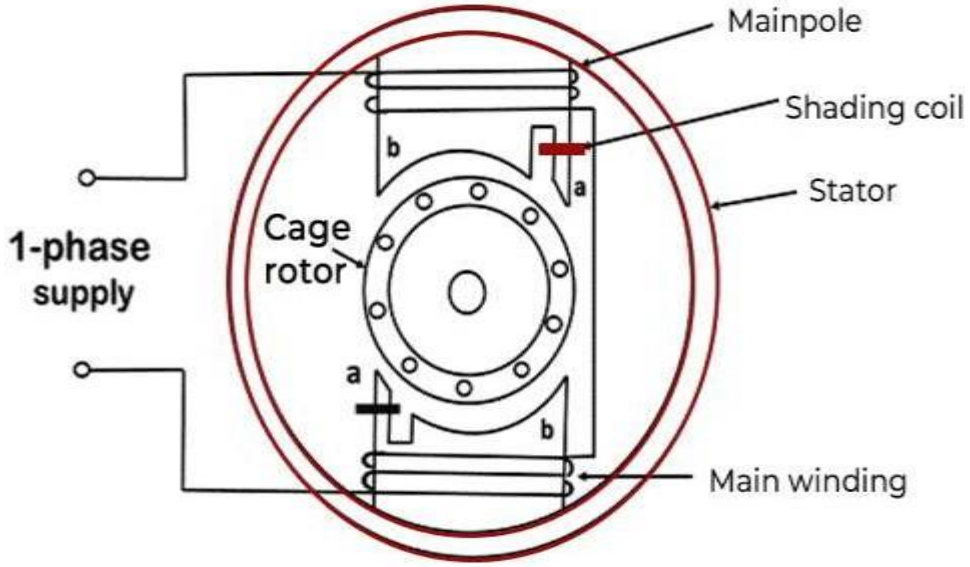
During normal operation, the rated line current is smaller than the starting current. Hence the capacitive reactance should be large. For this C_R should be small (XR=12ΠfCR$XR = 2\Pi fCR1$). As the motor approaches synchronous speed, the capacitor Cs is disconnected by a centrifugal switch SC.

The capacitor CR is permanently connected to the circuit. Since the capacitor Cs is used only at starting and the other C_R for continuous running, this motor is also called a capacitor-start capacitor-run motor.

Working of Single-Phase Induction Motor

Shaded Pole Motor

A shaded pole motor is a single-phase induction motor that is typically seen in tiny appliances and low-power applications. The shading coils, which are copper or aluminium rings or bands wrapped around a portion of the motor's pole pieces (thus "shaded" poles), give it its name. These shading coils are critical to the motor's functionality.



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Thank u

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