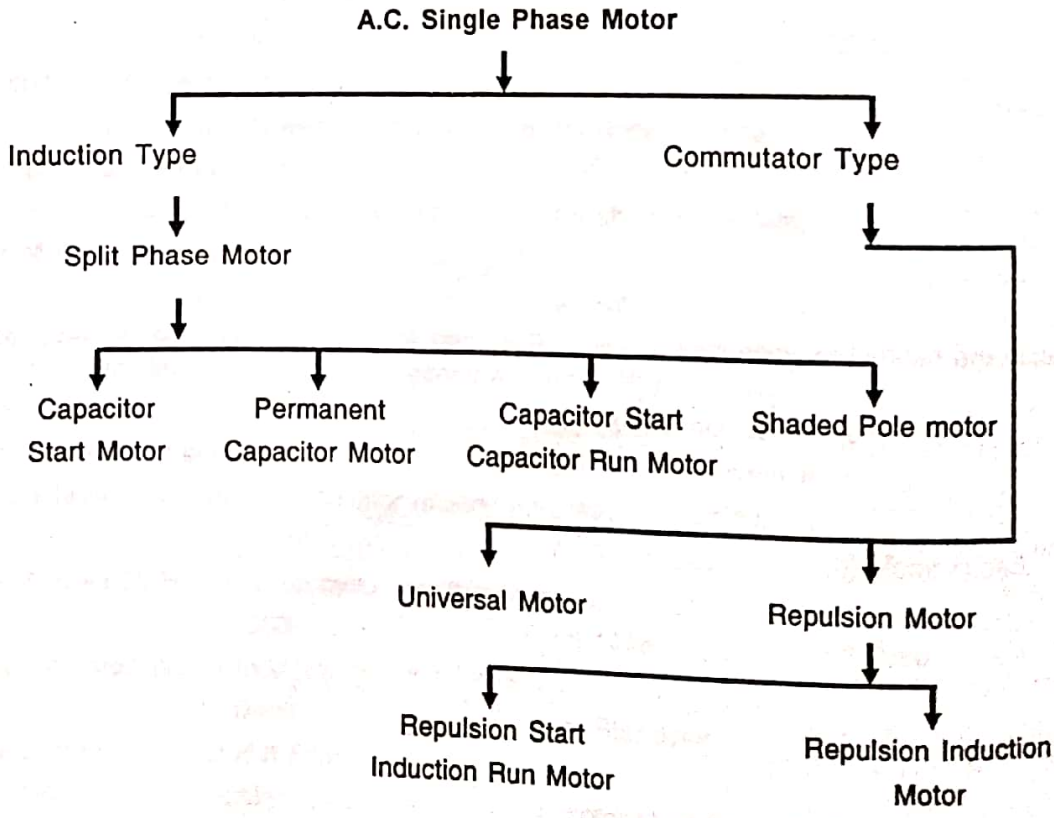
The motors which run on single phase supply are called single phase motors and convert electrical energy into mechanical energy.

Single phase motor not self starting motor:

This motor is similar in construction to the three phase motor, with the exception that the stator has a single phase winding. When the stator of the motor is connected to a single phase supply, it produces only alternating field which keeps on varying. It does not produce any torque. In this way, the rotor remains stationary. If the rotor is slightly rotated by hand in any direction, the rotor will rotate in the direction in which it is rotated by hand. It means the alternating flux cannot produce rotating torque. That is why a single phase motor does not self start. To make a motor self start, a rotating magnetic field is necessary to produce, just like in a three phase induction motor. To start a single phase motor, some form of starting device is necessary. Usually an auxiliary winding is done in the stator to form a second phase winding. It is also known as split phase winding. It produces a field with its poles between the main poles. The flux due to the current in the two windings combines and produces a rotating magnetic field and the rotor tends to rotate itself.

Principle of working of a single phase induction motor:

The motor works on the same principle as of three phase motor, *i.e.,* whenever a current carrying or short-circuited conductor is placed in a magnetic field, a torque is developed on the conductor, the conductor tends to rotate in the direction of rotating magnetic field.



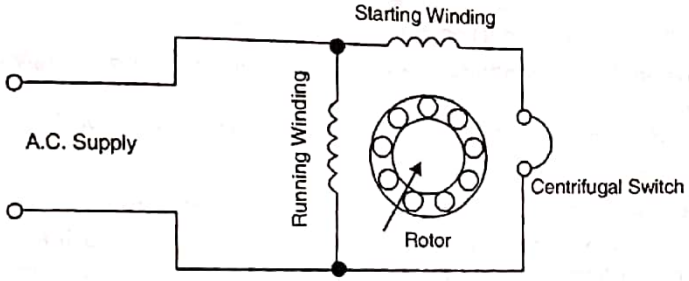
Split phase induction motor:

Construction: The rotor of this motor is of squirrel cage type. It is made of laminated iron cores, having closed slots all around the periphery of the rotor in which copper or aluminium bars are driven and their ends are welded to rings on either side.

Methods for making self start:

As the single phase motor is not self started, it can be started by any one way of the following methods:

1. Phase splitting method: Splitting one phase into two phases.
2. By commutator method.



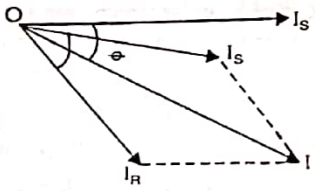


Fig. No. 1 Split phase induction motor

It has two stator windings *i.e.,* Starting Winding (S.W.) and Running Winding (R.W.). The starting winding consists of a thin enamelled copper wire so as to have a high resistance and low inductance, while the running winding consists of thick enamelled copper wire so as to have a low resistance with high inductance. These two are spaced at 90° (electrical degrees) from each other and the impedance of the two circuits are so made that the phase difference between their currents is nearly 90° (elect). This is called splitting the phase. The starting winding is connected in series with the centrifugal switch, it is fitted on the rotor shaft, and it automatically cuts out the starting winding when the motor is nearly upto its full speed. Connections are shown in the Fig. 1.

Working Principle: When the motor is connected across the supply, the current flows in both the windings, but this current is out of phase due to the unequal resistance and inductance. A rotating magnetic field is produced, a torque is exerted on the rotor and rotor tends to rotate. When the motor attains its 75% or 80% of the speed, the centrifugal switch disconnects the starting winding and now, motor is running on running winding only.

The starting torque is low, but the starting current is high.

Use: It is used to drive blowers, fans, centrifugal pumps etc.

Types of split phase motors:

The split phase motors are of many types:

1. Permanent capacitor motor.
2. Split phase induction motor capacitor start.
3. Split phase induction motor capacitor start capacitor run.
4. Shaded pole motor.

1. Permanent Capacitor Motor: The rotor of this motor is similar to that of a squirrel cage type. But the stator has starting and running winding. The starting winding consists of a thin-wire more turns and has a high resistance and low inductance while the running winding consists of a thick-wire less turns and has a low resistance with high inductance. Some times both the windings are designed to have same parameters. A capacitor (2 to 2.5μf) is connected in series with the starting winding. This capacitor remains permanently in series even on running condition. There is no centrifugal switch used in such type of motor. Connections are shown in Fig. 2.

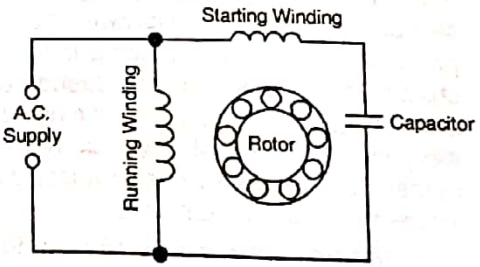


Fig. No. 2 Permanent capacitor motor

Use: This type of motor is used only in ceiling and table fans, where low torque is required. The average power consumption of a fan is 60 watts to 85 watts.

2. Split Phase Induction Motor Capacitor Start: The rotor and stator of this motor is of split phase type. The two types of windings are done on the stator *i.e.*, a starting winding and running winding. A capacitor is connected in series with the starting winding.

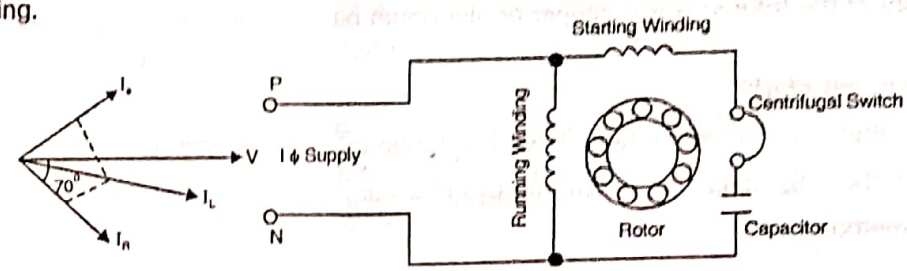


Fig. No. 3 Split phase induction motor capacitor start

The capacitor is of the electrolytic type. When the motor attains the 75% of the speed, the centrifugal switch disconnects the starting winding circuit and the motor remains running on running-winding. Connection is shown in the Fig. 3. The current in each winding is out of phase. This has high torque. The value of the capacitor depends upon the H.P. of the motor.

Use: It is used in lathe machines, drill machines, grinders, etc.

3. Split Phase Induction Motor Capacitor Start Capacitor Run: In this type of motor, two capacitors are used. Both the capacitors are connected in parallel at the time of starting. One capacitor is known as starting capacitor and other capacitor as running capacitor. The value of starting capacitor is three times more than that of running capacitor. The starting capacitor is connected in series with the starting winding as shown in Fig. 4. When the motor attains the 75% of the speed, starting capacitor is switched out by the centrifugal switch and thereby leaving the other capacitor and the running winding in the circuit during running. The starting and running torque is better than the one capacitor motor. At the time of starting, both the capacitors remain in the circuit, as the motor attains its full speed only one capacitor remains in the circuit.

Use: This type of motor is used where a high starting torque is required as in refrigerators and air conditioner, air compressors, blowers, etc.

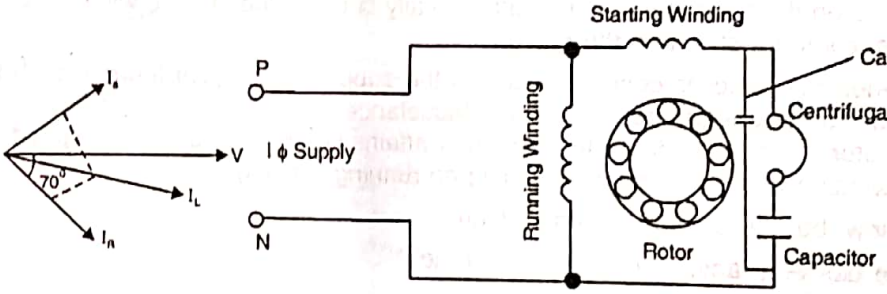


Fig. No. 4 Split phase induction motor capacitor start capacitor run

4. Shaded Pole Motor: The rotor of this motor is of ordinary squirrel cage type, but the stator has salient poles each provided with its own exciting coil, very much like a D.C. field system. At about one third of each pole shoe, there is a shallow slot which houses a short circuited copper ring which is known as shading ring. This shaded ring works as a second winding. When an A.C. current is passed through the exciting winding it produces a alternating flux. Some of the flux through each pole links with the shading ring thereby inducing current in ring. This induced current sets up a magnetic flux of its own. The alternating current produced by the main winding induces current in the shading coils, when the flux through a shading coil is increasing, the current is in such a direction as to oppose the growth. As a result, the flux in the shaded portion reaches a maximum value at a later time than it does that in the unshaded portion.

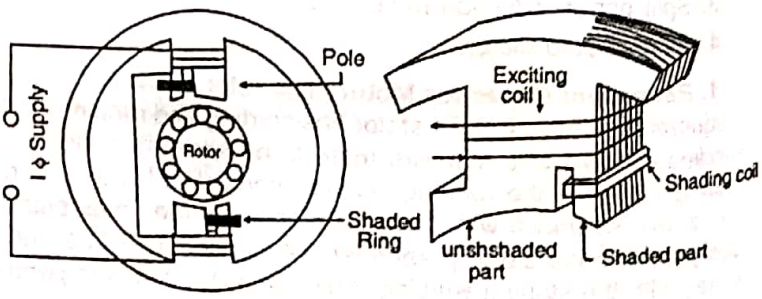


Fig. No. 5 Shaded pole motor

As the flux in the shaded portion decreases, the current in a coil helps to keep the flux in the original direction. As a result the flux in the shaded portion reaches a zero value at a later time than it does that in the unshaded portion. Thus, the action of the shading coil is to cause a shift in the magnetic field in the direction from the unshaded portion of pole to the shaded portion. This shift across the rotor bars induces a current in them and that causes the rotor to rotate in the

direction of this shift *i.e.*, from unshaded portion to the shaded one. The starting torque of the motor is very low.

Use: This type of motor is used where power needed for the drive is small as in cooler pumps, small fans, hair dryer, electric wall clocks, etc.

Commutator Motor: There are two types of commutator motor.

(1) Universal motor or A.C. series motor.

(2) Repulsion motor.

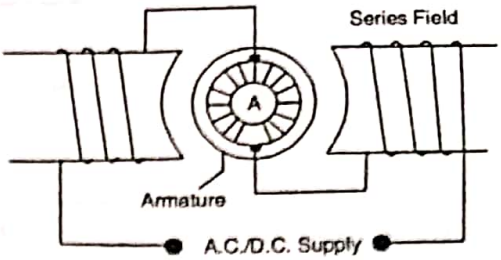


Fig. No. 6 Universal motor

(1) Universal Motor: This motor works on A.C. and D.C. both supply, that is why it is known as universal motor. The stator is made of laminations of silicon steel to reduce the hysteresis and eddy current losses. The armature of the motor is the same as that of the D.C. series motor. In some large motors compensating winding is fitted to improve the commutation. It is connected in series with the field and the armature. The field winding is connected in series with the armature as shown in Fig. 6. Whenever motor is connected to the supply, the current carrying conductors are placed in the magnetic field and a torque is produced to rotate it in a particular direction. The performance of the motor will be generally similar to that with D.C. series motor.

Use: This motor is widely used in portable drill machines, sewing machine, vacuum cleaner, mixi and kitchen appliances, etc.

Note: The direction of rotation of this motor can be changed by changing the direction of current in series field or in armature.

(2) Repulsion Motor: This is also one form of commutator motor. It works on the principle of magnetic repulsion *i.e.*, the like poles of the two magnets repel and unlike poles attract each other. Same type of pole is induced in the motor and hence, rotor gets torque due to repulsion and rotor tends to rotate.

There are following types of repulsion motors:

(i) Plain repulsion motor

(ii) Repulsion start induction motor

(iii) Repulsion induction motor

(i) Plain Repulsion Motor: The stator of the motor is the same as single phase induction motor. The stator winding has distributed concentric winding for two or more number of poles. There is only one winding in the stator. The construction of the rotor is quite similar to that of a D.C. armature. The rotor is provided with commutator and carbon brushes. Short circuited brushes are fixed directly opposite to each other on the commutator as shown in Fig. 7(a, b).

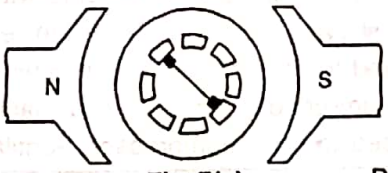


Fig. 7(a)

Plain Repulsion motor

Fig. No. 7(b)

When A.C. is given to the stator, an e.m.f. is induced in the rotor winding. The current will flow in the rotor producing a torque, as a result of which the rotor rotates in a particular direction. The speed and load torque of this motor depends upon the angle between the field and brushes. If the brushes are set in line with the stator field, there will be no torque on the rotor and if set at 90° to the flux, no voltage will be induced in the rotor. So the brushes are set between 12° to 20° for maximum torque.

The motor has series motor type characteristic *i.e.*, high starting torques with normal starting current.

Use : It is used in cranes, hoists etc.

Note : The D.O.R. can be changed by shifting the brushes in reversed position as shown in Fig. 7. (b).

(ii) Repulsion Start Induction Motor: The stator of this type motor is similar to that of a plain repulsion motor. The rotor is provided with a centrifugal switch in addition to a commutator. This switch consists of circular disc which is thrown down by centrifugal force on the commutator. It operates as the motor attains nearly synchronous speed, the switch short circuits the commutator segments and motor continues to run as an induction motor. The motor starts as a repulsion motor and runs as an induction motor, so the name implies, repulsion start induction motor. The direction of rotation can be reversed by changing the brush position as shown in Fig. 8.

Use: It is used where high starting torque and constant speed is required as in wood cutting machine, water pumps etc.

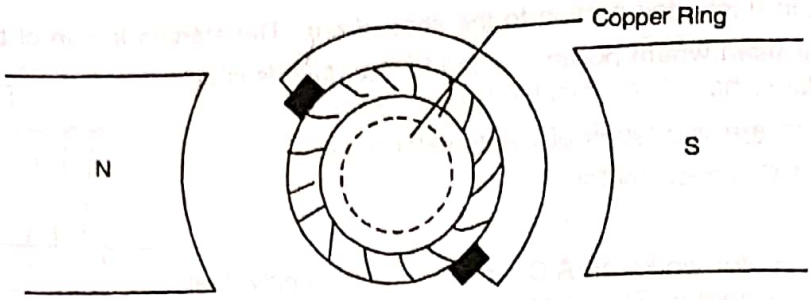


Fig. No. 8 Repulsion start induction motor

(III) Repulsion Induction Motor: The stator winding is similar to that of an induction motor, but the rotor has two types of windings in common slots. The inner winding is of squirrel cage type, while the outer winding is of armature type which is connected to a commutator as shown in Fig. 9. When A.C. is supplied to the motor, the squirrel cage winding has no effect owing to its high inductance. So less current flows through the inner winding, while more current flows through the outer winding. The motor starts as a repulsion motor giving high starting torque. When the motor speeds up, the effect of squirrel cage winding increases, and both the windings become operative. The torque produced by both the windings helps each other, so the motor runs at a constant speed on varying load. The motor is started by directly switching oN to the supply.

Use: It is used in air-conditioners, machine tools, refrigerators, blowers etc., where high starting torque is required.

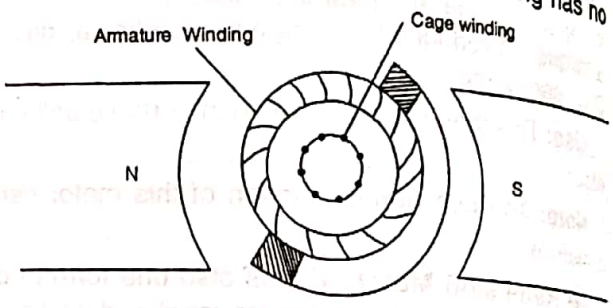


Fig. No. 9 Repulsion induction motor

Application of A.C. Single Phase Motors

S.No.	Important Motors	Important Applications
1.	Capacitor Start Motor	1. It is used to drive refrigerator, drill machine, grinder, etc.
2.	Capacitor Start-Capacitor Run Motor	2. It is used to drive air-conditioner, refrigerator, centrifugal pump, etc.
3.	Permanent Capacitor Motor	3. It is used to drive ceiling fan, table fan, etc.
4.	Shaded Pole Motor	4. It is used in gramophone, electric wall clock, cooler pump, shaving machine, small fan, etc.
5.	Universal Motor	5. It is used to drive lift, sewing machine, vacuum cleaner, mixer cum grinder, portable drill machine, etc.
6.	Repulsion start-induction run Motor	6. It is used to drive compressor, ventilating fan, pump, etc.

Table for A.C. Single Phase Motor Current

Horse Power (H.P.)	Phase, 220 Volts
1/6	1.60 amps.
1/4	2.50 amps.
1/2	3.80 amps.
3/4	5.10 amps.
1	5.50 amps.
1½	9.50 amps.
2	12.20 amps.
3	18.00 amps.
5	30.00 amps.
7½	40.30 amps.
10	58.00 amps.
15	80.00 amps.