Single Phase Motors Review

The **main winding** of a single phase motor creates an *alternating* magnetic field on giving an AC supply to its windings. This field does not rotate, as in the case of a three-phase induction motor, but just oscillates back and forth. The main winding alone is not capable of generating a starting torque.

In order to self-start, single phase motors include an **auxiliary winding** offset 90 electrical degrees from the main windings which helps develop a *rotating* magnetic field to start the motor. Once started the auxiliary winding may be disabled and the motor will continue to run.

The main and auxiliary windings are alternately called the **run** and **start** windings. Interchanging the leads of *either* the start or the run winding will reverse the motor.

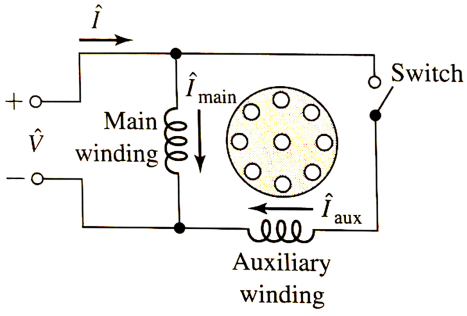
There are 5 types of single-phase induction motors categorized on the basis of their starting methods and design.

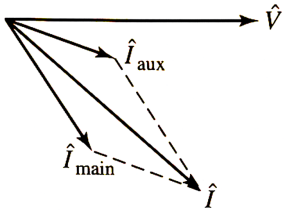
Split-Phase Motor (Resistance-Start Motor)

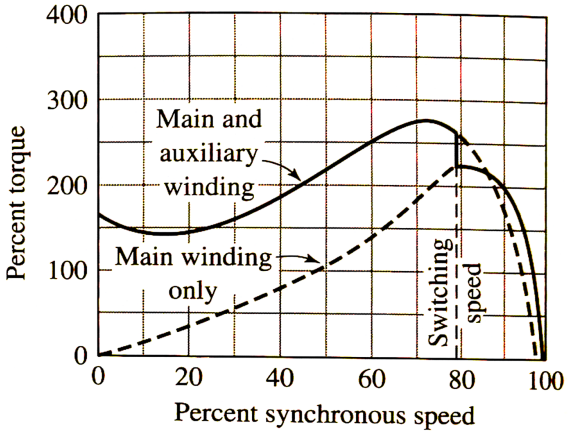
A split phase motor has a main winding, plus an auxiliary winding and centrifugal switch.

The main winding has a few turns of heavy wire, while the auxiliary winding is many turns of finer wire. As a result, the auxiliary winding has higher resistance and lower inductive reactance than the main winding. This causes its current to lead the main winding current by about 30°, creating the phase shift that makes the field rotate and produce some starting torque.

The centrifugal switch cuts out the start winding when the rotor reaches about 75% of nominal speed.





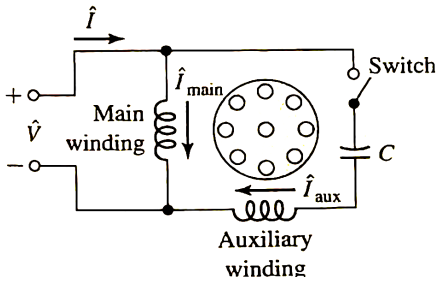


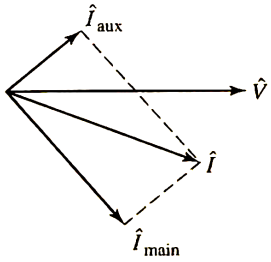
Capacitor-Start Motor (Capacitor-Start, Induction-Run Motor)

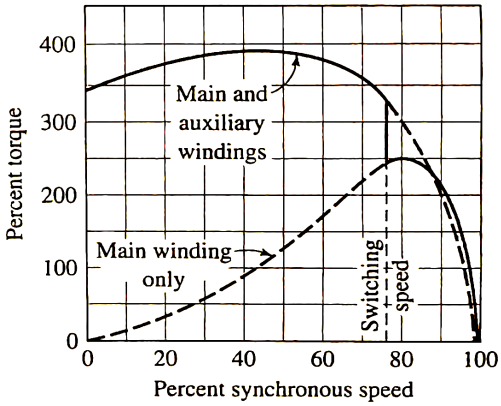
A capacitor-start motor adds a capacitor in series with the auxiliary winding.

This improves motor performance over split phase motor because the capacitor causes the auxiliary current to lead the main winding current about 90°. This produces high starting torque and a more effective rotating magnetic field.

The auxiliary winding is cut out once the motor comes up to about 75% of full speed, and the motor runs on one phase, like the split phase motor.





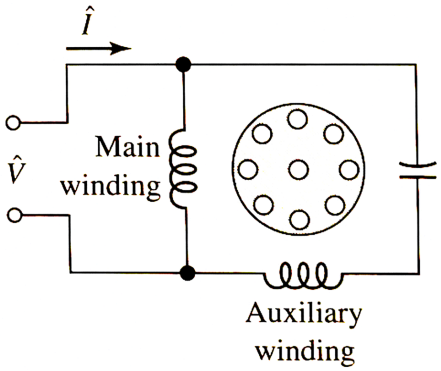


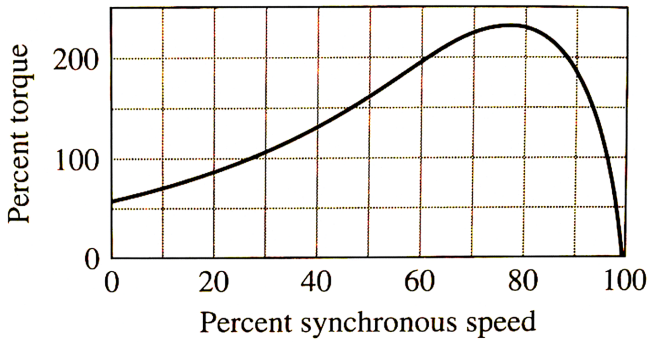
Capacitor-Run Motor (Permanent-Split Capacitor or PSC Motor)

The permanent-split capacitor motor is similar to the capacitor-start motor, but omits the centrifugal switch, so the auxiliary winding never cuts out. Elimination of the centrifugal switch reduces the cost.

This motor runs more smoothly, without the torque pulsations of the previous two designs, because both windings together produce a smoothly rotating magnetic field. Losses due to the counter-rotating field are eliminated making the motor more efficient and with a better power factor than the capacitor-start motor.

This motor has relatively low starting torque and is suitable for small loads, less than about 1/2 hp.



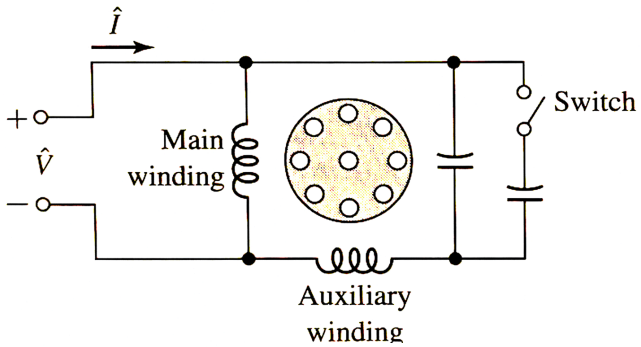


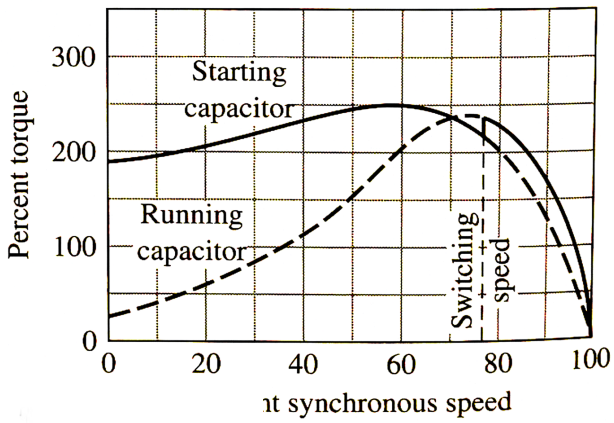
Capacitor-Start/Capacitor-Run Motor

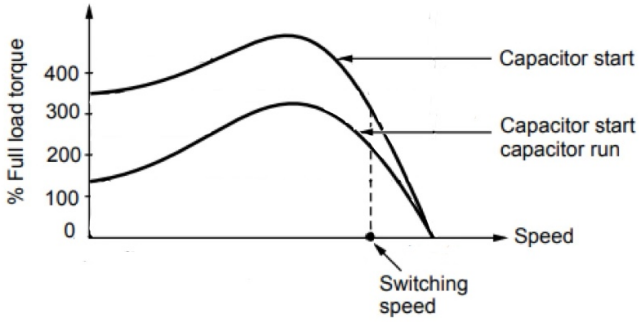
This motor uses two capacitors: a large starting capacitor (electrolytic) and a smaller running capacitor (non-electrolytic).

The starting capacitor is cut out with a centrifugal switch, but the auxiliary winding and run capacitor remain in the circuit.

Like the PSC motor, retaining the auxiliary winding improves efficiency, power factor, and provides smoother operation.



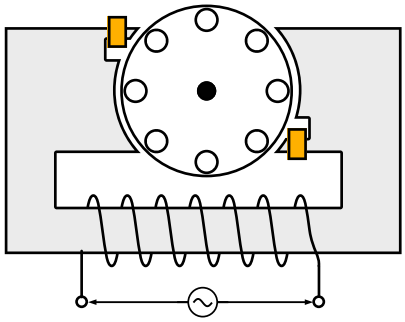


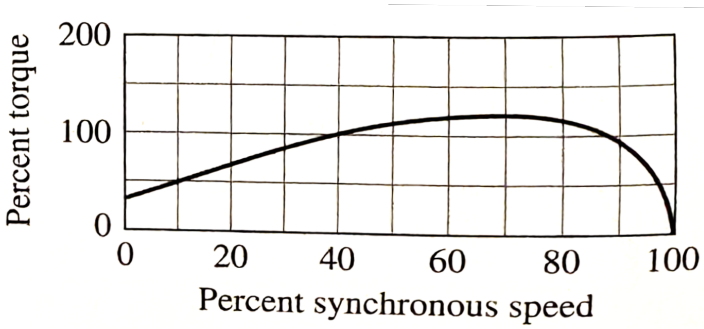


Shaded Pole Motor

A shaded pole motor creates a rotating field by adding a short-circuited copper coil, called the "shading coil", around a portion of the pole faces. The induced current in the shading coil causes the magnetic flux in the shaded section to lag behind the unshaded portion, generating a weak rotating field.

This type of motor has low efficiency (15 to 30%) and low starting torque, but is inexpensive. They are not reversible. Shaded pole motors are only used for small loads, less than about 1/3 hp.





"C" Frame Shaded Pole Motor

Square Core Shaded Pole Motor

Summary

Split-phase motors use different resistance and reactance values in the windings to create a phase shift for starting.

Capacitor-start motors use a capacitor during startup only; the auxiliary winding is disconnected afterward.

PSC motors use a capacitor in series with the auxiliary winding, which remains energized during both start and run.

Capacitor-start/capacitor-run motors use separate capacitors for starting and running, combining high starting torque with efficient operation.

Shaded pole motors use a shading coil to create a rotating field and are suited only for small, low-performance applications.

Motor Type	Starting Torque	Efficiency	Power Range	Cost	Typical Use
Split Phase	**Low to Moderate** 150 to 250% of rated torque	**Low** 0.3-0.4	Up to about 2 hp	Low	Washers, air compressors
Permanent Split Capacitor	**Low** 30 to 150% of rated torque	**Moderate** 0.6-0.65	Up to about 1/3 hp	Medium	HVAC blowers, fans
Capacitor Start	**High** 200 to 400% of rated torque	**Moderate** 0.5-0.6	Up to about 10 hp	Medium	Refrigerators, pumps
Capacitor Start/ Capacitor Run	**Medium** 200 to 350% of rated torque	**Highest**	From about 3 to 10 hp	Highest	Compressors, pumps, conveyers
Shaded Pole	**Low** 25 to 75% of rated torque	**Very Low** 0.15-0.3	Up to about 1/2 hp	Low	Desk fans, small appliances

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