Basic Electrical Technology

[ELE 1051]

L27- AC motors

Induction Motors

Introduction

Nearly 80% of the world's ac motors are poly-phase induction motors.

It has simple and rugged construction.

It is available from fractional horsepower ratings to megawatt levels.

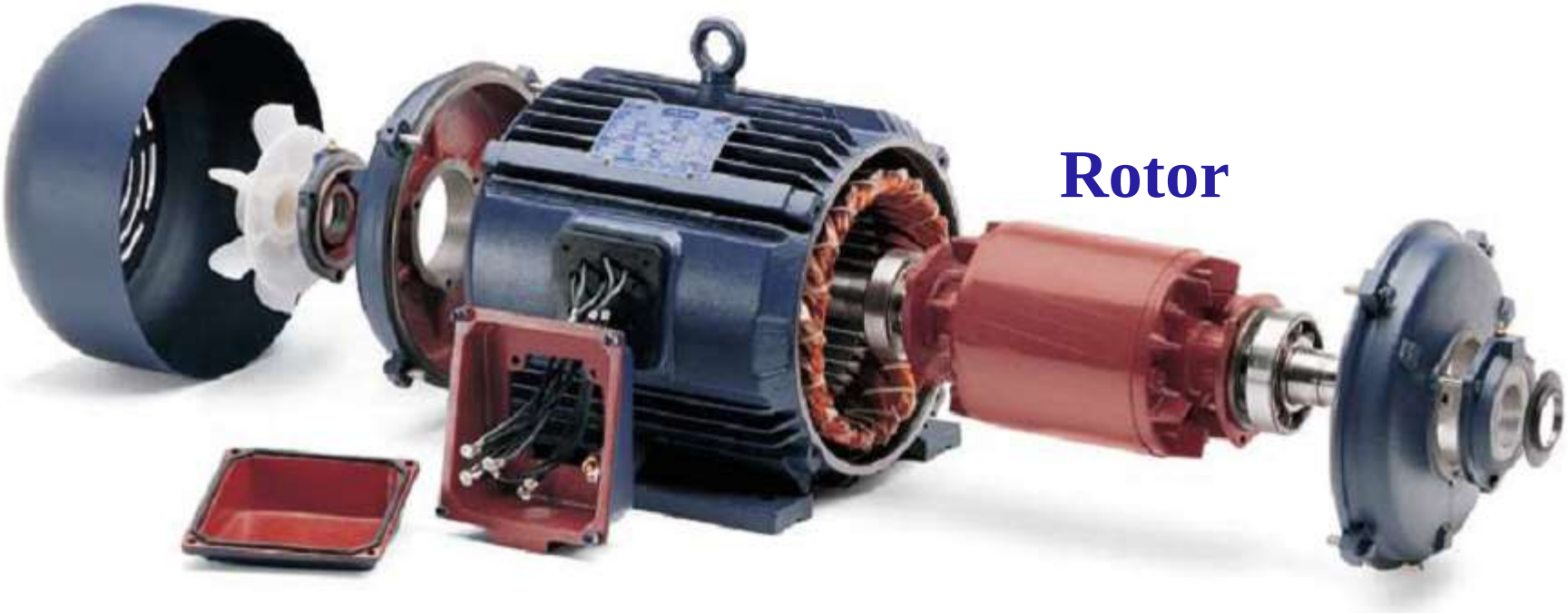
There are machines available to operate from 3 phase or single phase electrical input

Single phase induction motors are restricted to small power levels (say less than 2 hp)

3 phase induction motors are widely used as pump & fan drives

For all practical purpose, it may be considered as a constant speed drive with full load slip around 3 %.

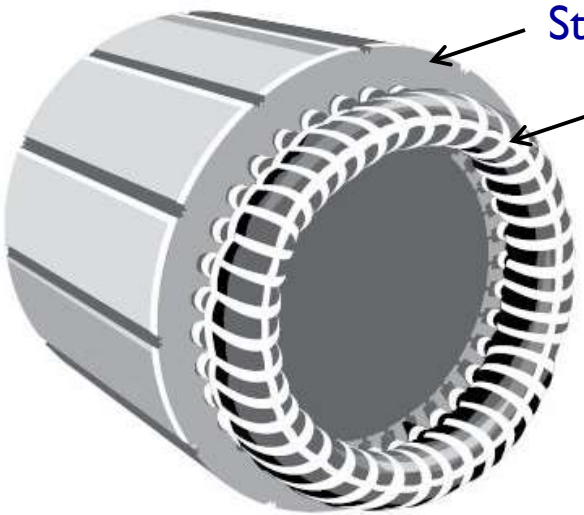
Construction



Construction

Stator

- **Stator frame** (cast iron) provides mechanical support to the stator core
- **Stator core** laminated and slotted to carry the 3 phase windings
- The balanced windings are displaced in space by 120 degrees electrical



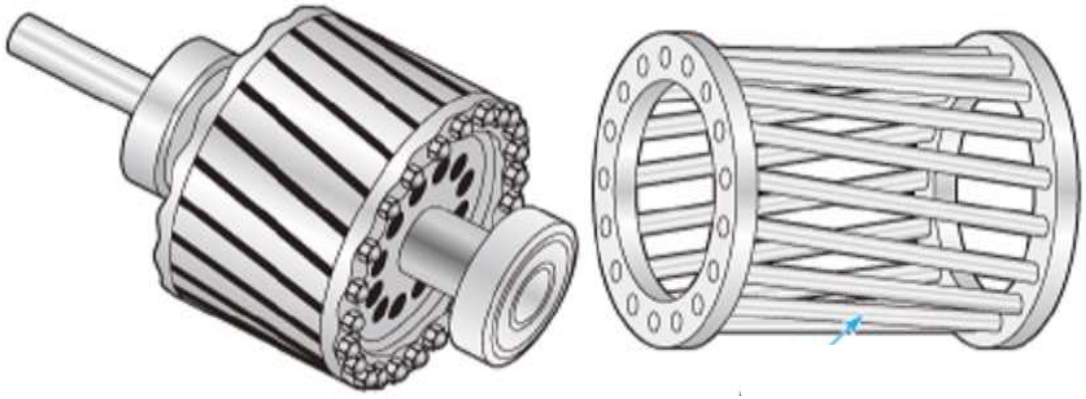
Construction

- Types on the basis of rotor construction
  - **Squirrel Cage Rotor**
  - **Slip Ring Rotor**
- Cylindrical Laminated core
- Slots cutout on outer periphery
- Conductors placed in slots

Construction

Squirrel Cage Rotor

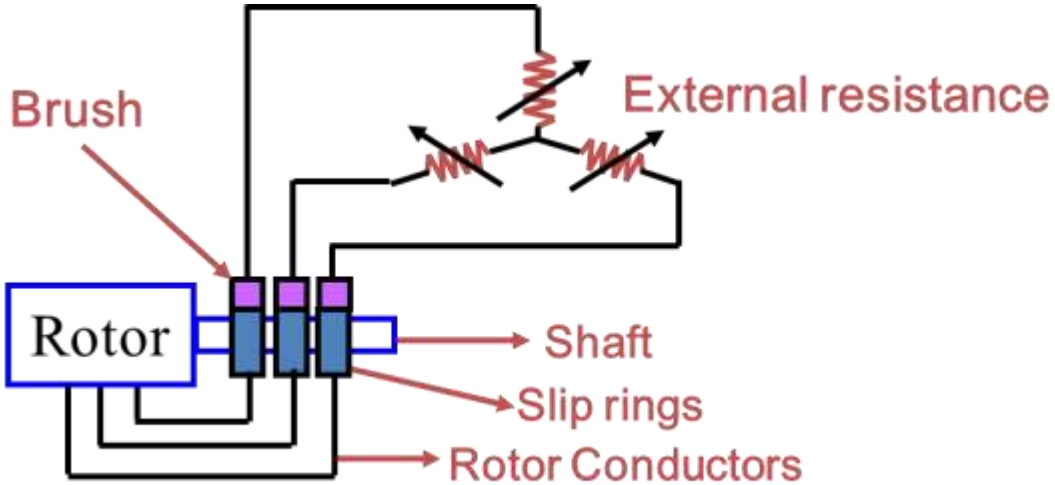
- Skewed arrangement
- Copper or Aluminum Bars
- Conductors shorted by end rings
- Closed rotor circuit
- Cheap, rugged and needs little or no maintenance



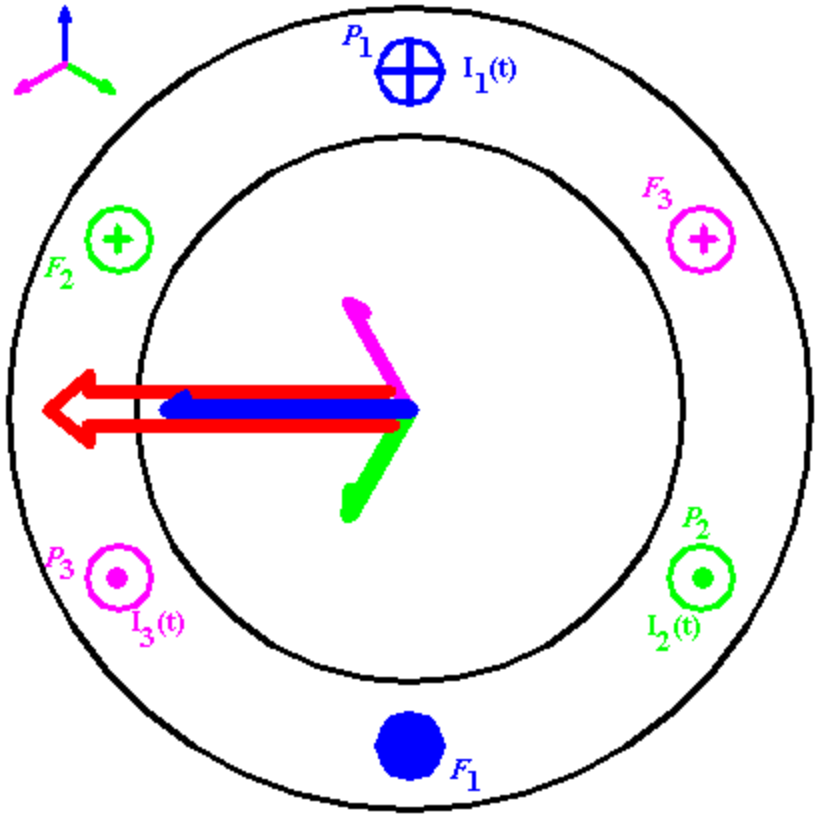
Construction

Wound Rotor

- rotor winding is uniformly distributed and is usually connected in star.
- The terminals of the winding are brought out to three slip rings
- Slip rings in contact with brushes
- Brushes connected to external resistance for higher starting torque

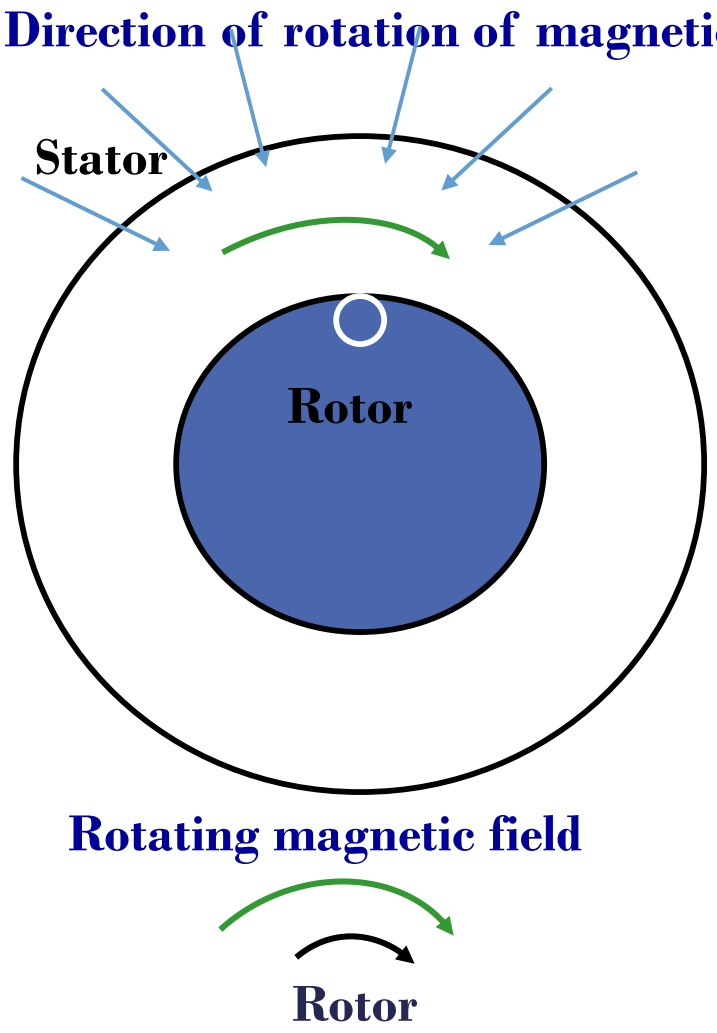


Working Principle



3-phase currents flowing in the stator winding produce a rotating magnetic field rotating at synchronous speed.

Working Principle



- Rotating magnetic field is cut by the rotor conductor
- EMF is induced in rotor conductor
- Current in the rotor conductor sets up a magnetic field which opposes the rotation of main field
- Main field is independent and hence rotor field tries to catch up the speed of main field to reduce the relative speed
- Rotor rotates in the same direction as that of rotating magnetic field

Working Principle

The axis of the magnetic field rotates at a synchronous speed

$$N_S = \frac{120\,f}{P}$$

N_S = Speed of RMF, rpm
f = Frequency of ac supply, Hz
P = No. of poles

N_S = Synchronous Speed,rpm
N = rotor speed, rpm

- If $N = N_S$,

  - ✓ **No flux cut by rotor conductors**
  - ✓ **No emf induced across rotor conductors**
  - ✓ **No current flow, no torque**

Hence N < Ns must for rotor rotation

Working Principle

Slip speed = $(N_S - N)$, rpm

$$\%\, s = \frac{N_S - N}{N_S} \times 100\ \%$$

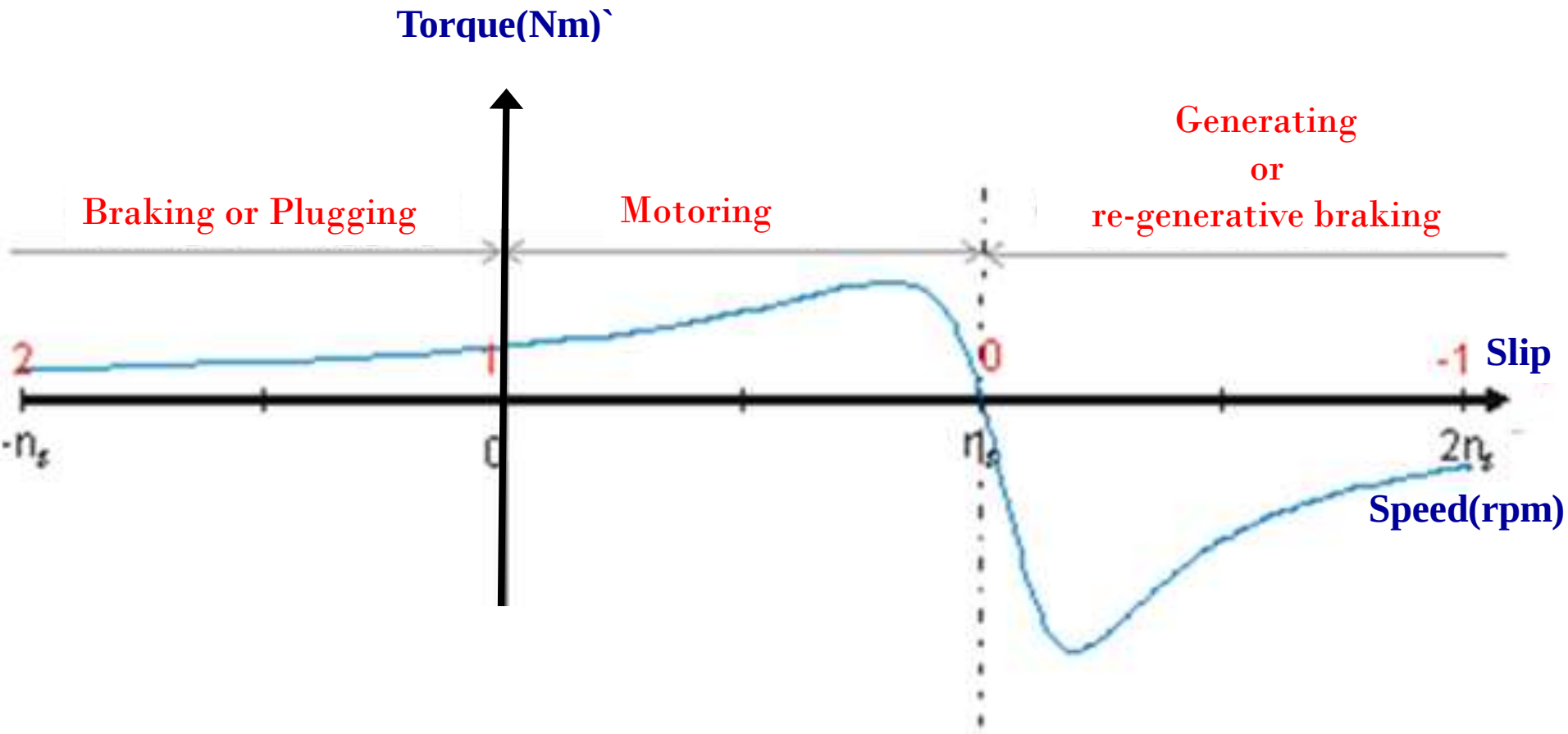
- For rotor speed N, relative speed = $N_S - N$

$$f_r = \frac{P\,(N_S - N)}{120} \qquad \boxed{f_r = s\,f}$$

Note

At instant of starting, N = 0, s =1 , $f_r = f$

Speed-Torque Characteristics



Applications

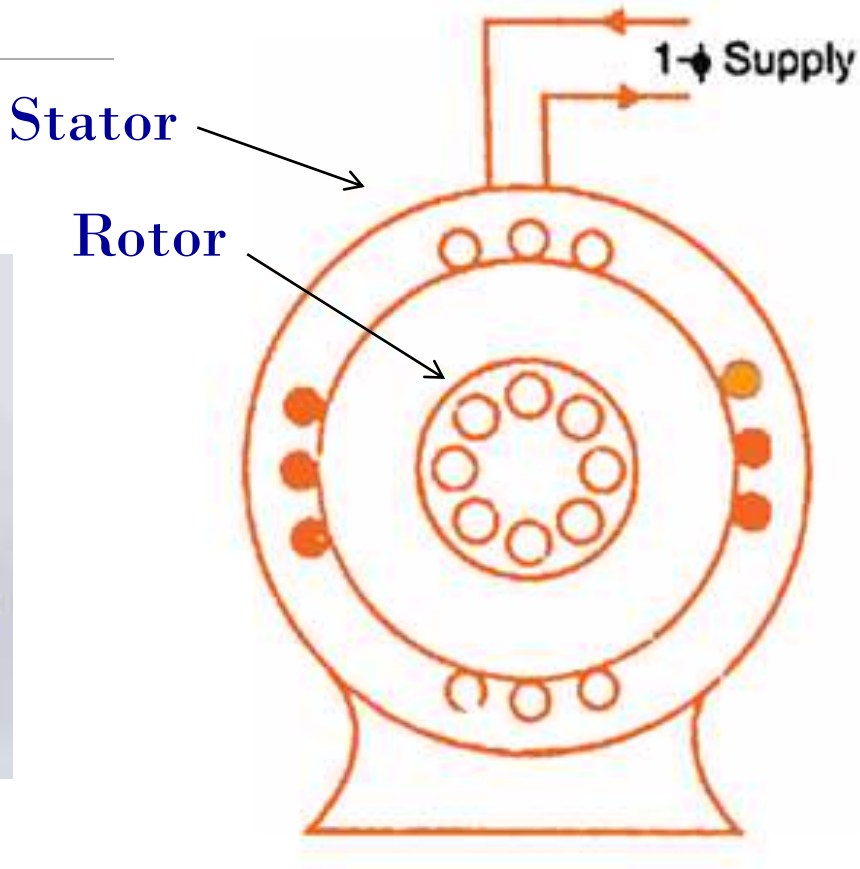
- Industrial & Commercial Applications
  - Pumping Systems
  - Refrigeration Systems
  - Compressors
  - Fans & Blowers
  - Industrial Drives

Single Phase Induction Motor

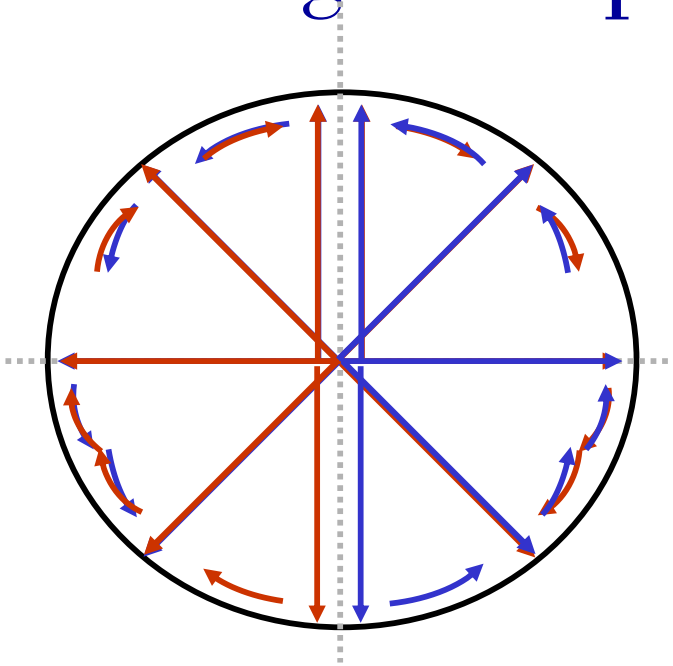
Introduction

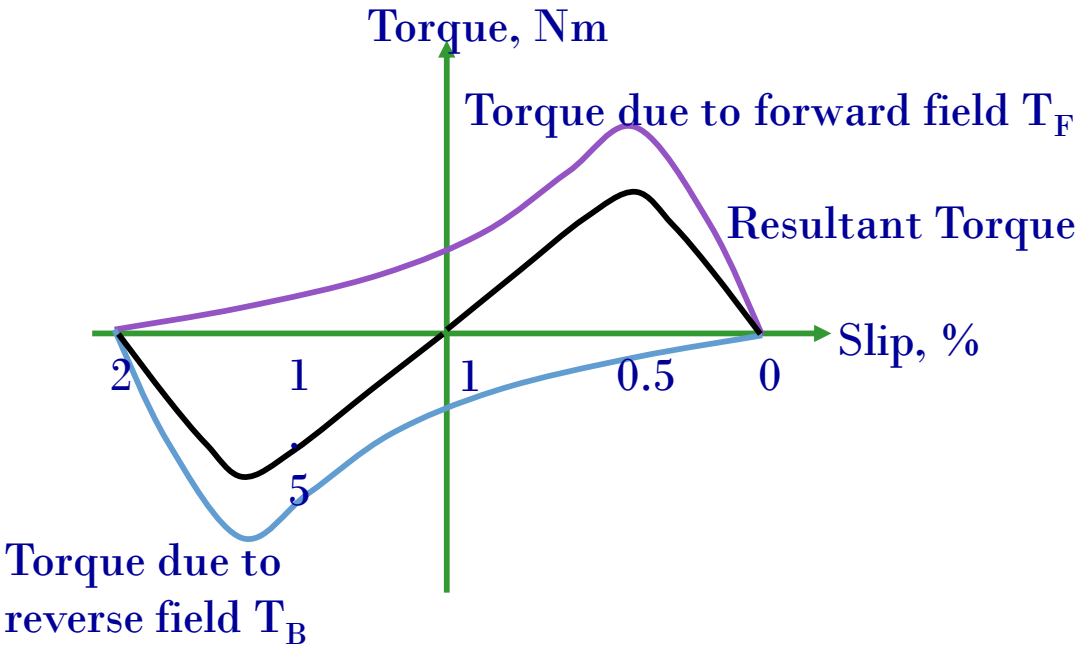
- Construction is similar to 3 phase induction motor except the stator has TWO winding - starting & running.
- The rotor is of squirrel cage type
- A capacitor is connected in series with the starting winding to achieve phase split.
- The motor is started as two phase machine.

Construction



Working Principle –Double field revolving theory





Resultant field is alternating. Hence,

Single Phase induction motors are Not Self Starting in nature

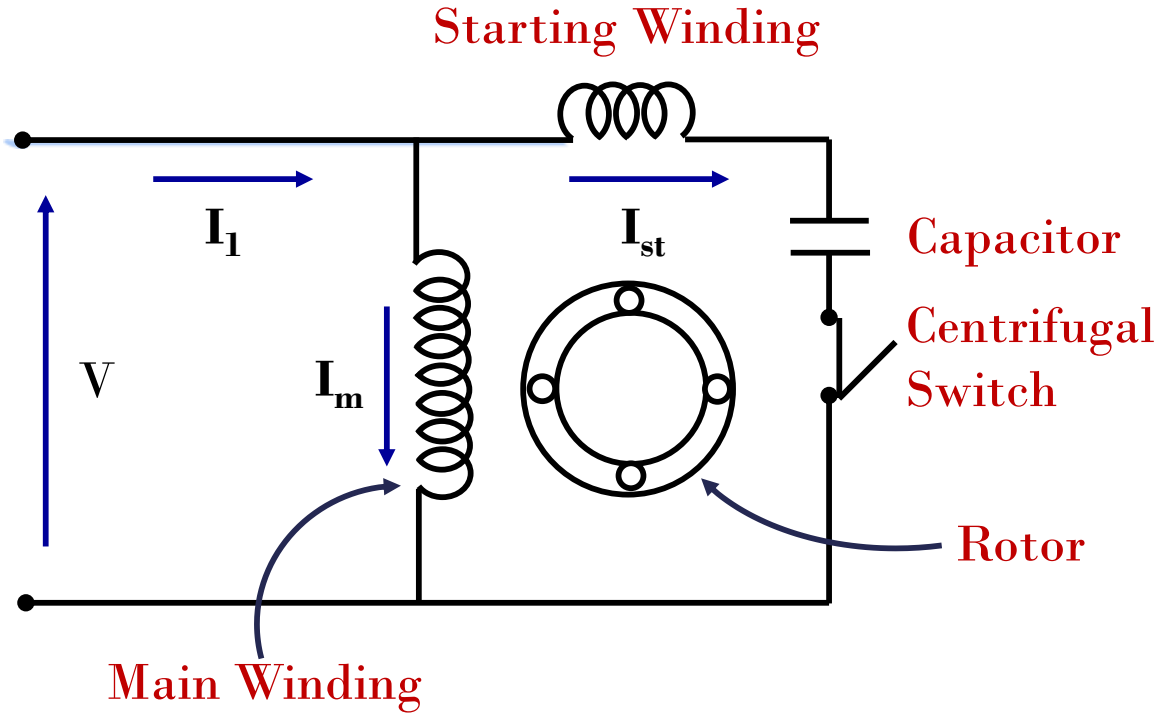
Starting

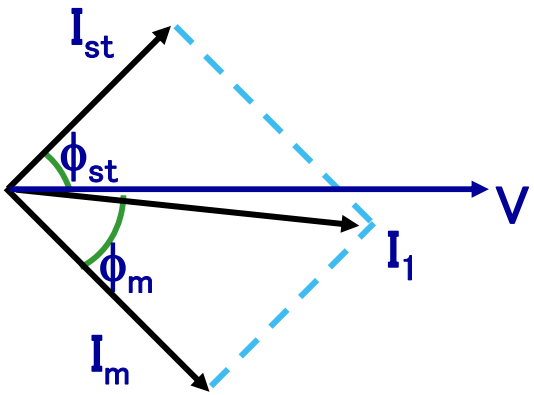
- The motor is started as two phase induction motor
- Phase split is achieved by connecting a series capacitor with starting winding

Types

- Capacitor Start Motor – pump / compressor motors
- Capacitor Run Motor – ceiling fan motor

Capacitor Start Motor





- Centrifugal Switch opens the circuit when speed is near about rated speed
- Capacitor present in circuit only at starting

Applications

- Low power applications such as Air conditioners, Pumps, Fans.

- Refrigerators, Washing Machines etc…

Summary

- Three phase Induction motors have inherent self- starting torque . It can never run at synchronous speed.

$$N_S = \frac{120f}{P} \qquad \%s = \frac{N_S - N}{N_S} \times 100$$

- Single phase Induction motors are used for small power applications The common forms are capacitor start and capacitor run motor.