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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

II YEAR / IV SEMESTER

EE8401 – ELECTRICAL MACHINES II

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UNIT 05

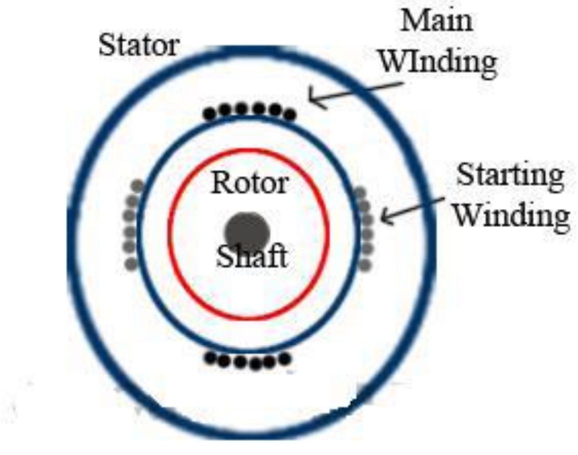
Single Phase Induction Motors and Special Machines

“Intellectuals solve problems, geniuses prevent them.”

—ALBERT EINSTEIN

CONSTRUCTIONAL DETAILS

Construction of a single phase induction motor is similar to the construction of three phase induction motorhaving squirrel cage rotor, except that the stator is wound for single phase supply. Stator is also provided with a 'starting winding' which is used only for starting purpose.



Working Principle

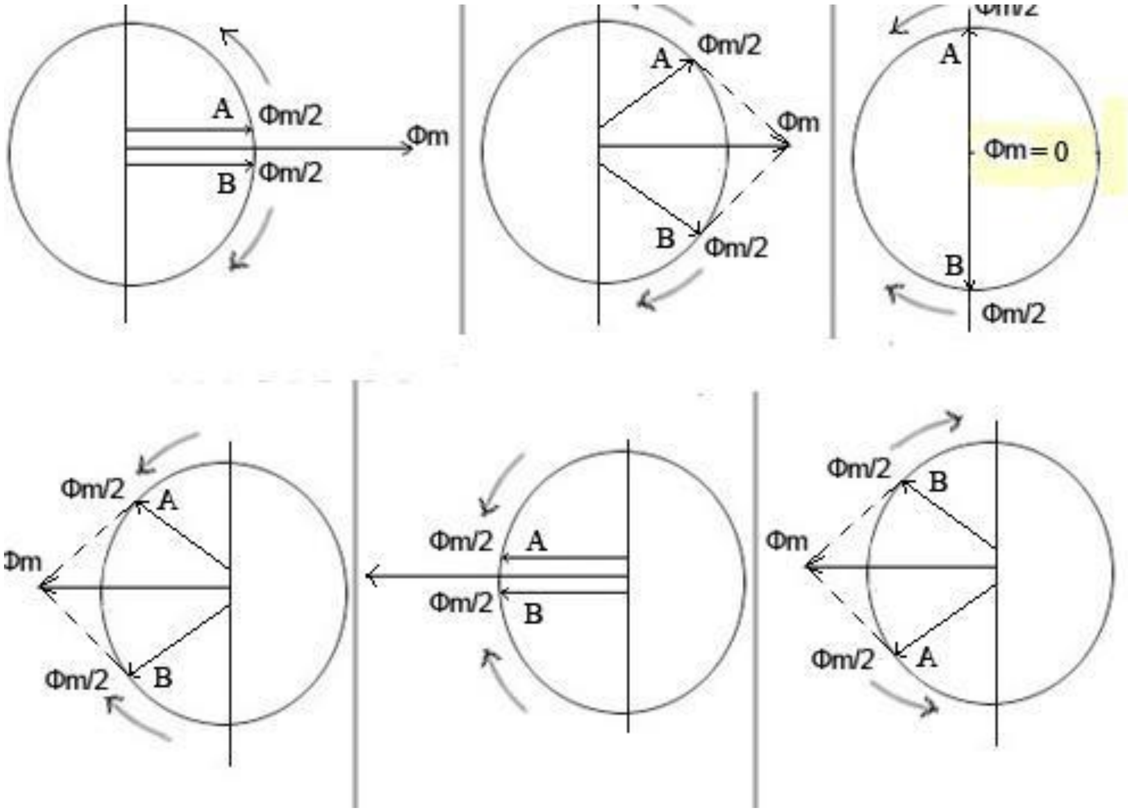
When the stator of a single phase motor is fed with single phase supply, it produces alternating flux in the stator winding. The alternating current flowing through stator winding causes induced current in the rotor bars accordingto Faraday's law of electromagnetic induction. This induced current in the rotor will also produce alternating flux. Even after both alternating fluxes are set up, the motor fails to start (the reason is explained below). However, if the rotor is given a initial start by external force in eitherdirection, then motor accelerates to its final speed and keeps running with its rated speed. This behavior of a single phase motor can be explained by double-field revolving theory.

Single Phase Induction Motor Is Not Self Starting:

The stator of a single phase induction motor is wound with single phase winding. When the stator is fed with a single phase supply, it produces alternating flux (which alternates along one space axis only). Alternating flux acting on a squirrel cage rotor can not produce rotation, only revolving flux can. That is why a single phase induction motor is not self starting.

Double-Field Revolving Theory

The double-field revolving theory states that, any alternating quantity (here, alternating flux) can be resolved into two components having magnitude half of the maximum magnitude of the alternating quantity, and both these components rotating in opposite direction.

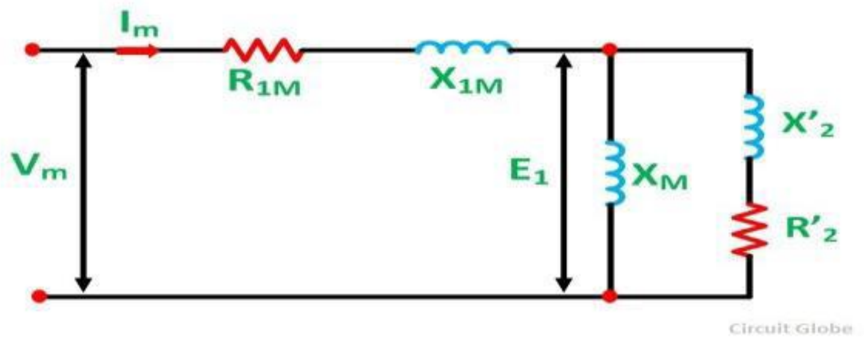


A
Φm/2
Φm
Φm/2
B
Φm/2
A
Φm
B
Φm/2
A
Φm = 0
B
Φm/2
Φm/2
A
Φm
Φm/2
B
Φm/2
A
Φm/2
B
Φm/2
B
Φm
Φm/2
A

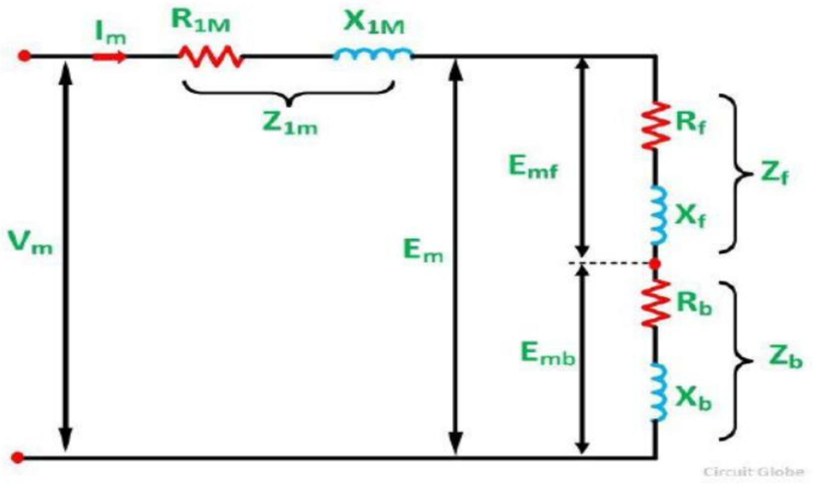
Equivalent circuit

The **Equivalent circuit** of a **Single Phase Induction Motor** can be obtained by two methods named as the Double Revolving Field Theory and Cross Field Theory. Firstly the equivalent circuit is developed on the basis of double revolving field theory when only its main winding is energized.

Considering the case when the rotor is stationary and only the main winding is excited. The motor behaves as a single phase transformer with its secondary short circuited. The equivalent circuit diagram of the single phase motor with only its main winding energized the is shown below



The simplified equivalent circuit of a single phase induction motor with only its main winding energized is shown in the figure below.



Starting Methods of Single Phase Induction Motor:

To make it self-starting, it can be temporarily converted into a two-phase motor while starting. This can be achieved by introducing an additional 'starting winding' also called as auxillary winding.

- Hence, stator of a single phase motor has two windings: (i) Main winding and (ii) Starting winding (auxillary winding). These two windings are connected in parallel across a single phase supply and are spaced 90 electrical degrees apart. Phase difference of 90 degree can be achieved by connecting a capacitor in series with the starting winding.

- Hence the motor behaves like a two-phase motor and the stator produces revolving magnetic field which causes rotor to run. Once motor gathers speed, say upto 80 or 90% of its normal speed, the starting winding gets disconnected form the circuit by means of a centrifugal switch, and the motor runs only on main winding.

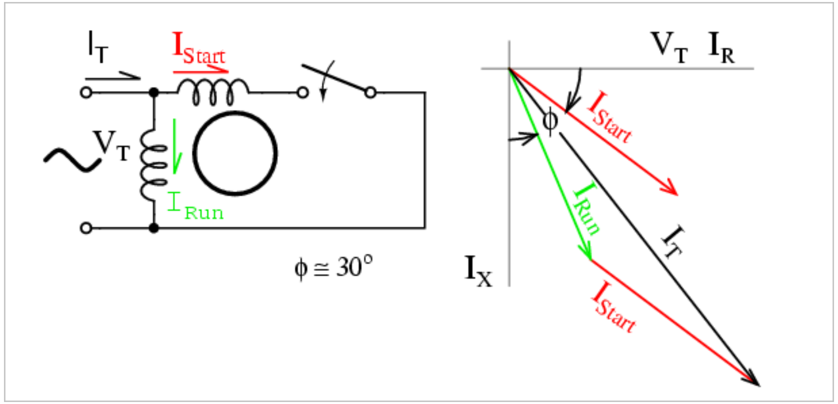
Types Of Single Phase Induction Motor:

The single phase induction motors are made self starting by providing an additional flux by some additional means. Now depending upon these additional means the single phase induction motors are classified as:

1. Split phase induction motor.
2. Capacitor startinductor motor.
3. Capacitor start capacitor runinduction motor (two value capacitor method).
4. Shaded pole induction motor.

Split Phase Induction Motor

In addition to the main winding or running winding, the stator of single phase induction motor carries another winding called auxiliary winding or starting winding. A centrifugal switch is connected in series with auxiliary winding. The purpose of this switch is to disconnect the auxiliary winding from the main circuit when the motor attains a speed up to 75 to 80% of the synchronous speed. We know that the running winding is inductive in nature. Our aim is to create the phase difference between the two winding and this is possible if the starting winding carries high resistance.



Capacitor Start IM and Capacitor Start Capacitor Run :

The working principle and construction of Capacitor start inductor motors and capacitor start capacitor run induction motors are almost the same.

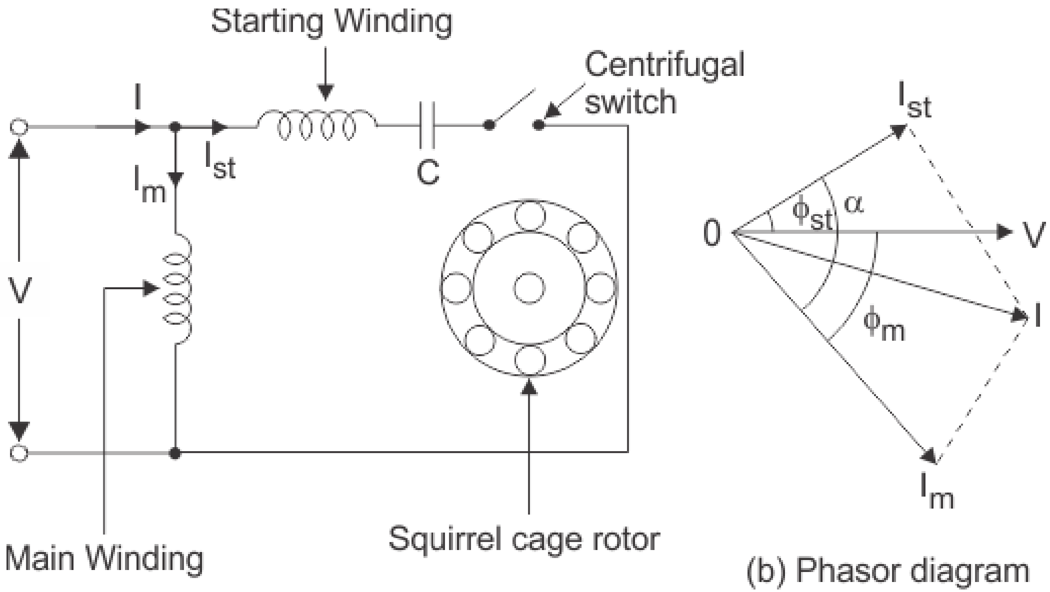
The single phase induction motor is not self starting because the magnetic field produced is not rotating type.

In order to produce rotating magnetic field there must be some phase difference. In case of split phase induction motor we use resistance for creating phase difference but here we use capacitor for this purpose.

We are familiar with this fact that the current flowing through the capacitor leads the voltage.

So, in **capacitor start inductor motor** and **capacitor start capacitor run induction motor** we are using two winding, the main winding and the starting winding.

With starting winding we connect a capacitor so the current flowing in the capacitor i.eIst leads the applied voltage by some angle, φst.



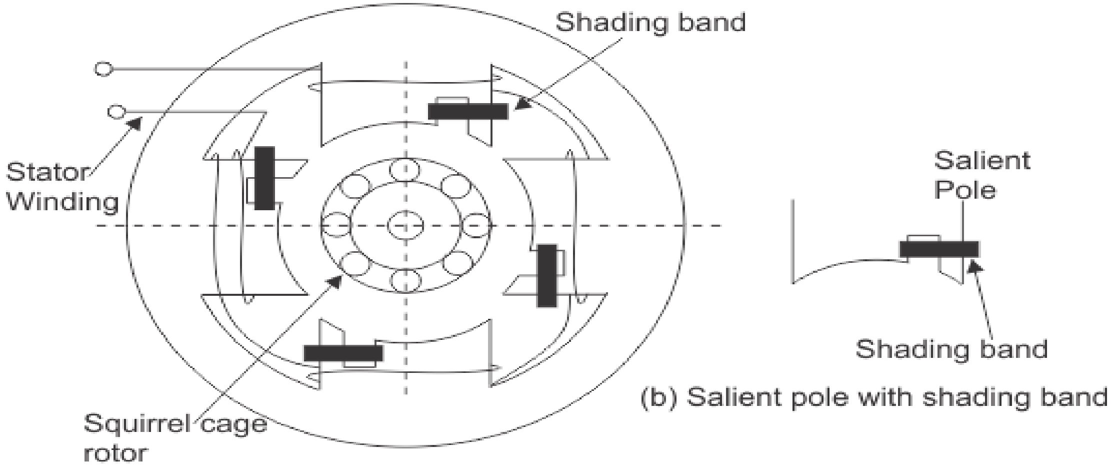
(a) Schematic representaion

(b) Phasor diagram

Application of Capacitor Start IM and Capacitor Run IM:

These motors have high starting torque hence they are used in conveyors, grinder, air conditioners, compressor, etc. They are available up to 6 KW.

Shaded Pole Single Phase Induction Motors



(a) 4-pole shaded pole construction

(b) Salient pole with shading band

The stator of the **shaded pole single phase induction motor** has salient or projected poles. These poles are shaded by copper band or ring which is inductive in nature. The poles are divided into two unequal halves. The smaller portion carries the copper band and is called as shaded portion of the pole.

ACTION:

When a single phase supply is given to the stator of shaded pole induction motor an alternating flux is produced. This change of flux induces emf in the shaded coil. Since this shaded portion is short circuited, the current is produced in it in such a direction to oppose the main flux. The flux in shaded pole lags behind the flux in the unshaded pole. The phase difference between these two fluxes produces resultant rotating flux. We know that the stator winding current is alternating in nature and so is the flux produced by the stator current. In order to clearly understand the working of shaded pole induction motor consider three regions-

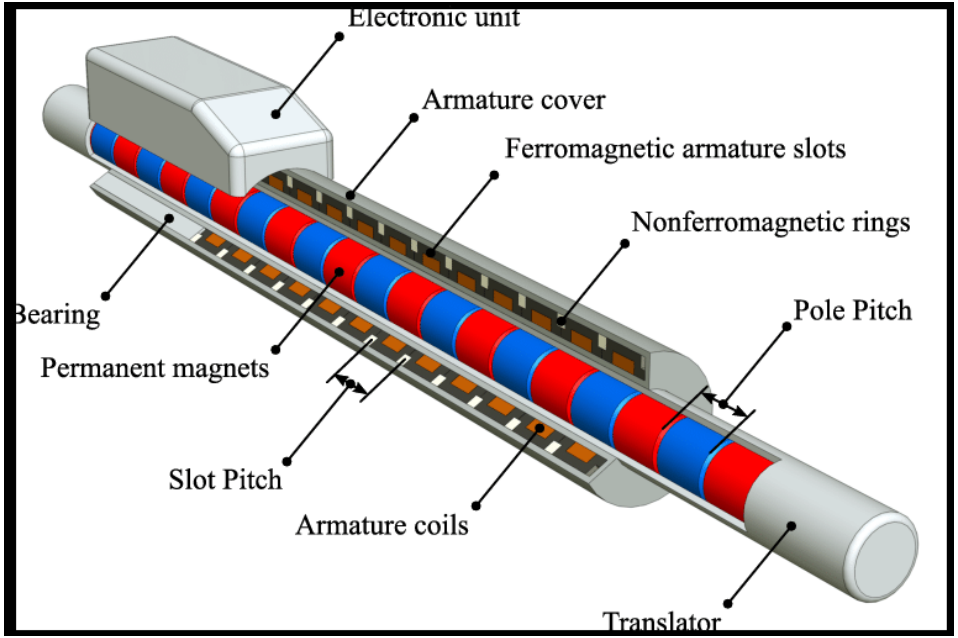
1. When the flux changes its value from zero to nearly maximum positive value.
2. When the flux remains almost constant at its maximum value.
3. When the flux decreases from maximum positive value to zero.

LINEAR INDUCTION MOTOR:

A **linear induction motor** (**LIM**) is an alternating current (AC), asynchronous linear motor that works by the same general principles as other induction motors but is typically designed to directly produce motion in a straight line. Characteristically, linear induction motors have a finite primary or secondary length, which generates end-effects, whereas a conventional induction motor is arranged in an endless loop.

CONSTRUCTION:

A linear electric motor's primary typically consists of a flat magnetic core (generally laminated) with transverse slots that are often straight cut[6]with coils laid into the slots, with each phase giving an alternating polarity so that the different phases physically overlap.



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Hysteresis Motor

A **Hysteresis Motor** is a synchronous motor with a uniform air gap and without DC excitation. It operates both in single and three phase supply. The Torque in a Hysteresis Motor is produced due to hysteresis and eddy current induced in the rotor by the action of the rotating flux of thes s stator. The working of the motor depends on the working of the continuously revolving magnetic flux. For the split phase operation, the stator winding of the motor has two single phase supply. This stator winding remains continuously connected to the single phase supply both at the starting as well as the running of the motor.

Construction of Stator of Hysteresis Motor

The stator of the hysteresis motor produces a rotating magnetic field and is almost similar to the stator of the induction motor. Thus, the stator of the motor is connected either to single supply or to the three phase supply.

The three phase motor produces more uniform rotating field as compared to that of the single phase supply. The stator winding of the single-phase hysteresis motor is made of permanent split capacitor type or shaded pole type.The capacitor is used with an auxiliary winding in order to produce a uniform field.

Construction of Rotor of Hysteresis Motor

The rotor of the hysteresis motor consists of the core of aluminium or some other non-magnetic material which carries a layer of special magnetic material. The figure below shows the rotor of the hysteresis motor.

REPULSION MOTOR:

Repulsion Motor is a special kind of single phase AC motor which works due to the repulsion of similar poles. The stator of this motor is supplied with 1 phase AC supply and rotor circuit is shorted through carbon brush.

Construction of Repulsion Motor:

The main components of repulsion motor are stator, rotor and commutator brush assembly. The stator carries a single phase exciting winding similar to the main winding of single phase induction motor. The rotor has distributed DC winding connected to the commutator at one end just like in DC motor. The carbon brushes are short circuited on themselves.

Stepper Motor:

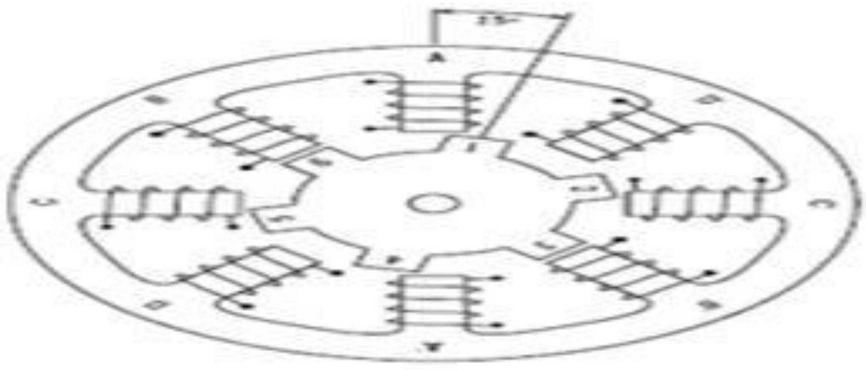
A stepper motor (or step motor) is a brushless DC electric motor that can divide a full rotation into a large number of steps. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence, and the motor's position can be controlled precisely without any feedback mechanism (an open-loop controller), as long as the motor is carefully sized to the application. Stepper motors may be used for locomotion, movement, positioning, and many other functions where we need precise control of the position of a shaft, lever or other moving part of a mechatronic device.

Types:

1. Variable Reluctance Stepper Motor
2. Permanent Magnet Stepper Motor
3. Hybrid Stepper Motor:

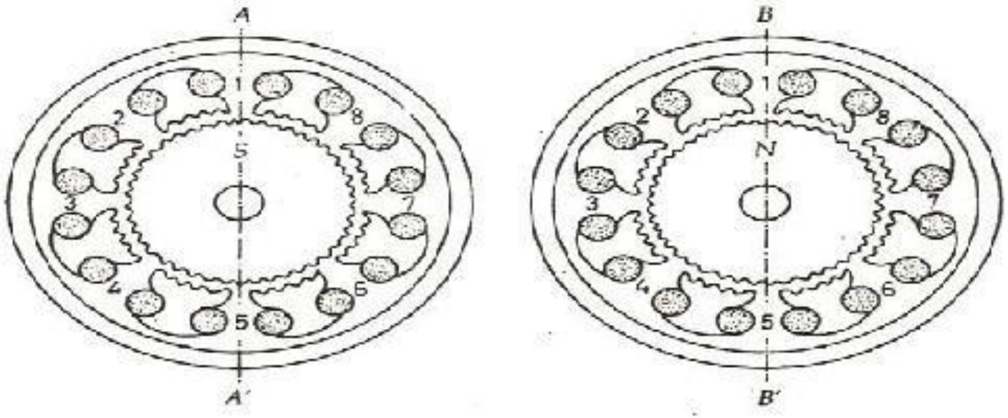
Variable Reluctance Stepper Motor:

Variable-reluctance type stepper motors, that are the simplest type of steppers, consist of a soft iron multi-toothed rotor and a wound stator. When DC is applied to the stator windings, the poles become magnetized. Rotation occurs when the rotor teeth are attracted to the energized stator poles. Since the magnets of the variable reluctance step motors are smaller and lighter than those of permanent magnet step motors, they are faster. The smaller the area between the rotor and thestator gears of VR type stepper motors, the less the loss of the magnetic force.



Hybrid Stepper Motor

The word Hybrid means combination or mixture. The Hybrid Stepper Motoris a combination of the features of the Variable Reluctance Stepper Motor and Permanent Magnet Stepper Motor. In the center of the rotor, an axial permanent magnet is provided. It is magnetized to produce a pair of poles as North (N) and South (S) as shown in the figure below.



Servo Motor – Types and Working Principle

The servo motor is most commonly used for high technology devices in the industrial application like automation technology.

It is a self contained electrical device, that rotate parts of a machine with high efficiency and great precision.

The output shaft of this motor can be moved to a particular angle. Servo motors are mainly used in home electronics, toys, cars, airplanes, etc.

This article discusses about what is a servo motor, servo motor working, servo motor types and its applications.

Types of Servo Motor

Servo motors are classified into different types based on their application, such as AC servo motor, DC servo motor, brushless DC servo motor, positional rotation, continuous rotation and linear servo motor etc.

DC Servo Motor

The motor which is used as a DC servo motor generally have a separate DC source in the field of winding & armature winding. The control can be archived either by controlling the armature current or field current. Field control includes some particular advantages over armature control. In the same way armature control includes some advantages over field control. Based on the applications the control should be applied to the DC servo motor. DC servo motor provides very accurate and also fast respond to start or stop command signals due to the low armature inductive reactance. DC servo motors are used in similar equipments and computerized numerically controlled machines.

AC Servo Motor

AC servo motor is an AC motor that includes encoder is used with controllers for giving closed loop control and feedback. This motor can be placed to high accuracy and also controlled precisely as compulsory for the applications. Frequently these motors have higher designs of tolerance or better bearings and some simple designs also use higher voltages in order to accomplish greater torque. Applications of an AC motormainly involve in automation, robotics, CNC machinery, and other applications a high level of precision and needful versatility.

Magnetic Levitation

Magnetic fields are actively excluded from superconductors (Meissner effect).
If a small magnet is brought near a superconductor, it will be repelled because induced supercurrents will produce mirror images of each pole. If a small permanent magnet is placed above a superconductor, it can be levitated by this repulsive force.
Levitation currents in the superconductor produce effective magnetic poles that repel and support the magnet.
The black ceramic material in the illustrations is a sample of the yttrium based superconductor.
By tapping with a sharp instrument, the suspended magnet can be caused to oscillate or rotate.
This motion is found to be damped, and will come to rest in a few seconds.