## ➢ POWER DRIVES

- In machine tools, power is generally required for driving the main spindle, saddles and carriages and to some auxiliary units.

- The motors used for CNC system are of two kinds
  - ✓ Electrical - AC , DC or Stepper motors
  - ✓ Fluid - Hydraulic or Pneumatic

- In CNC, usually stepper and servo electrical drives are used

- They exhibit favourable torque-speed characteristics and are relatively inexpensive.

## ✓ STEPPER MOTOR

A stepper motor is a pulse-driven motor that changes the angular position of the rotor in steps.

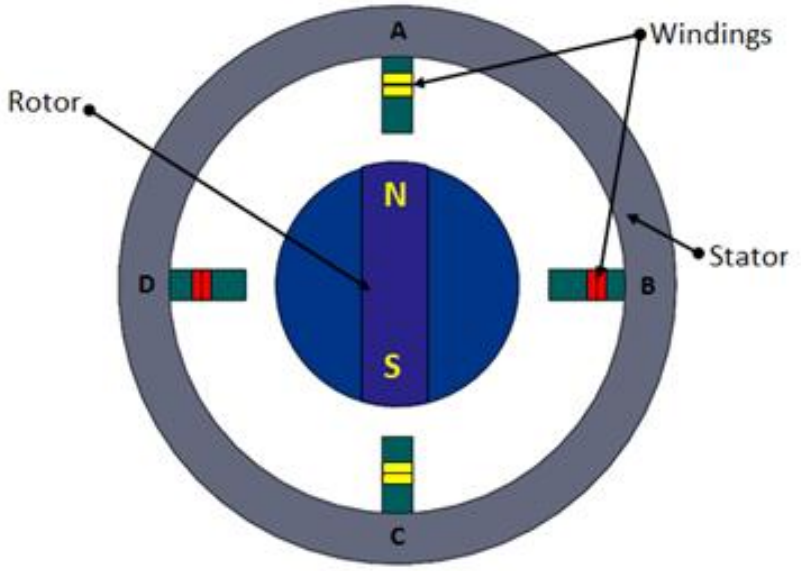
Due to this nature of a stepper motor, it is widely used in low cost, open loop position control systems.

Types of stepper motors:

- Permanent Magnet
  - Employ permanent magnet
  - Low speed, relatively high torque
- Variable Reluctance
  - Does not have permanent magnet
  - Low torque

# Permanent magnet (PM) stepper motor

- Rotor is a permanent magnet.
- PM motor rotor has no teeth and is designed to be magnetized at a right angle to its axis.
- Figure shows a simple, $90^0$ PM motor with four phases (A-D).
- Applying current to each phase in sequence will cause the rotor to rotate by adjusting to the changing magnetic fields.
- Although it operates at fairly low speed, the PM motor has a relatively high torque characteristic.



Permanent magnet stepper

- These are low cost motors with typical step angle ranging between $7.5^0$ to $15^0$

# Variable Reluctance Motor

- The cylindrical rotor is made of soft steel and has four poles
- It has four rotor teeth, $90^0$ apart and six stator poles, $60^0$ apart.
- Electromagnetic field is produced by activating the stator coils in sequence.
- It attracts the metal rotor. When the windings are energized in a reoccurring sequence of 2, 3, 1, and so on, the motor will rotate in a $30^0$ step angle.
- In the non-energized condition, there is no magnetic flux in the air gap, as the stator is an electromagnet and the rotor is a piece of soft iron; hence, there is no detent torque.

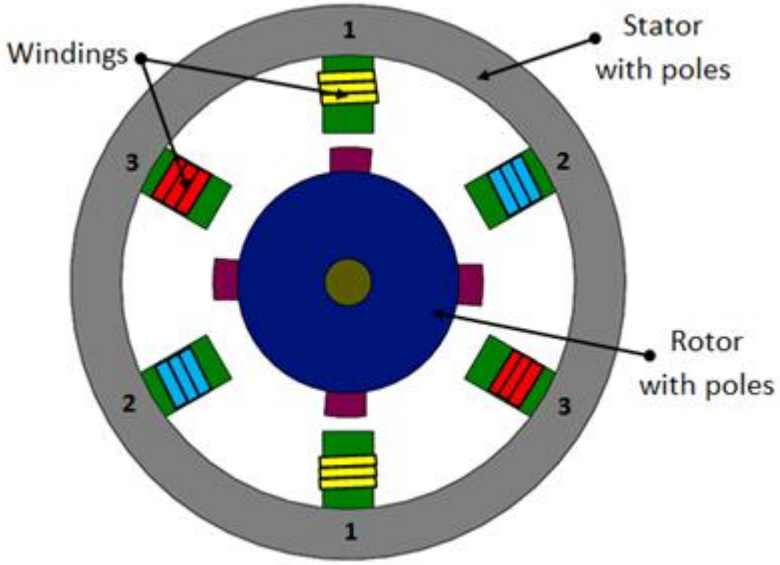
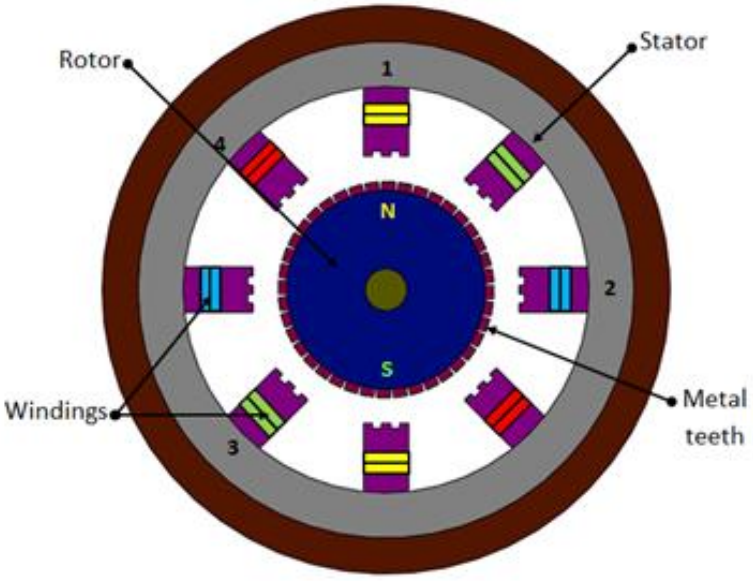



Fig. Variable reluctance stepper motor

# Hybrid stepper motor

- Hybrid stepping motors combine a permanent magnet and a rotor with metal teeth to provide features of the variable reluctance and permanent magnet motors together.

- The number of rotor pole pairs is equal to the number of teeth on one of the rotor's parts. The hybrid motor stator has teeth creating more poles than the main poles windings




**Hybrid stepper**

- Rotation of a hybrid stepping motor is produced in the similar fashion as a permanent magnet stepping motor, by energizing individual windings in a positive or negative direction.

- When a winding is energized, north and south poles are created, depending on the polarity of the current flowing.

- These generated poles attract the permanent poles of the rotor and also the finer metal teeth present on rotor.

- The rotor moves one step to align the offset magnetized rotor teeth to the corresponding energized windings.

- Hybrid motors are more expensive than motors with permanent magnets, but they use smaller steps, have greater torque and maximum speed.

- Step angle of a stepper motor is given by,

$$\text{Step angle} = \frac{360^0}{number\ of\ poles}$$

## Advantages of stepper motors

- Low cost
- Ruggedness
- Simplicity of construction
- Low maintenance
- Less likely to stall or slip
- Will work in any environment
- Excellent start-stop and reversing responses

## Disadvantages of stepper motors

- Low torque capacity compared to DC motors
- Limited speed
- During overloading, the synchronization will be broken. Vibration and noise occur when running at high speed.

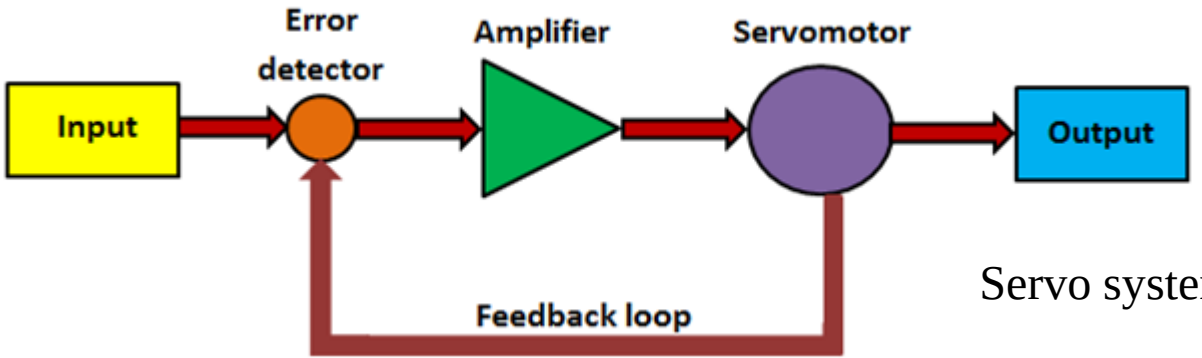
# ✓ SERVO MOTORS

- Servomotors are special electromechanical devices that produce precise degrees of rotation.

- A servo motor is a DC or AC or brushless DC motor combined with a position sensing device.

- Servomotors are also called control motors as they are involved in controlling a mechanical system.

- The servomotors are used in a closed-loop servo system as shown in Figure A reference input is sent to the servo amplifier, which controls the speed of the servomotor.




Servo system block diagram

- A feedback device is mounted on the machine, which is either an encoder or resolver.
- This device changes mechanical motion into electrical signals and is used as a feedback.
- This feedback is sent to the error detector , which compares the actual operation with that of the reference input.
- If there is an error, that error is fed directly to the amplifier, which will be used to make necessary corrections in control action.

- In many servo systems, both velocity and position are monitored.

- Servomotors provide accurate speed, torque, and have ability of direction control.

**DC servomotors**

DC operated servomotors are usually respond to error signal abruptly and accelerate the load quickly. A DC servo motor is actually an assembly of four separate components, namely:

  - DC motor
  - gear assembly
  - position-sensing device
  - control circuit

## AC servo motor

- Magnetic force is generated by a permanent magnet and current which further produce the torque.

- It has no brushes so there is little noise/vibration. This motor provides high precision control with the help of high resolution encoder.

- The stator is composed of a core and a winding. The rotor part comprises of shaft, rotor core and a permanent magnet.

- Digital encoder can be of optical or magnetic type. It gives digital signals, which are in proportion of rotation of the shaft.

## Advantages of servo motors

- Provides high intermittent torque, high torque to inertia ratio, and high speeds
- Work well for velocity control
- Available in all sizes
- Quiet in operation
- Smoother rotation at lower speeds

## Disadvantages of servo motors

- More expensive than stepper motors
- Require tuning of control loop parameters
- Not suitable for hazardous environments or in vacuum
- Excessive current can result in partial demagnetization of DC type servo motor

# ➢ LINEAR MOTION DRIVES

- Linear motion drives are mechanical transmission systems which are used to convert rotary motion into linear motion.
- The conventional thread forms like vee or square are not suitable in CNC because of their high wear and less efficiency.
- Therefore CNC machines generally employ ball screw for driving their workpiece carriages.
- These drives provide backlash free operation with low friction-wear characteristics.
- These are efficient and accurate in comparison with that of nut-and-screw drives. Most widely used linear motion drives are ball screws.