DC SERVO MOTOR:

A DC Servo Motor is a type of motor specifically designed for precise control of angular or linear position, velocity, and acceleration in a closed-loop system. It operates using a DC power source and receives feedback from a position sensor (such as an encoder or potentiometer) to correct any error between the desired and actual position. The motors which are utilized as DC servo motors, generally have separate DC source for field winding and armature winding. The control can be archived either by controlling the field current or armature current. Field control has some specific advantages over armature control and on the other hand armature control has also some specific advantages over field control. Which type of control should be applied to the DC servo motor, is being decided depending upon its specific applications.

Types of DC Servo Motors:

Based on Construction:

1. Separately Excited DC Servo Motor – Field winding is powered by a separate DC source.
2. Permanent Magnet DC Servo Motor – Uses permanent magnets for the field instead of windings.
3. Series DC Servo Motor – Armature and field windings connected in series.
4. Shunt DC Servo Motor – Armature and field windings connected in parallel.

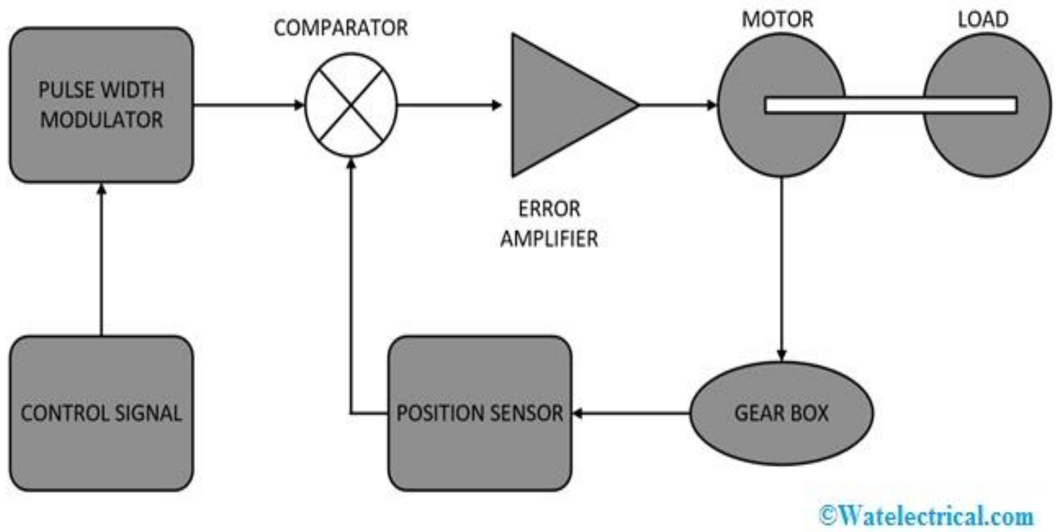
Based on Control Technique:

- Armature-controlled DC Servo Motor – Control signal regulates armature voltage/current.
- Field-controlled DC Servo Motor – Control signal regulates field winding current.

Working Principle:

1. Control Signal Input – The desired position/velocity command is given as an electrical signal.
2. Error Detection – The feedback device (encoder/potentiometer) measures the actual output and compares it with the input command.

3. Error Amplification – The difference (error signal) is amplified and used to adjust the motor's armature voltage or current.
4. Motor Movement – The motor rotates proportionally to the error signal.
5. Continuous Correction – As the motor approaches the desired position, the error decreases, and the motor slows/stops exactly at the target.



Applications:

- Robotics – Precise joint movement and positioning.
- CNC Machines – Accurate tool positioning.
- Radar and Antenna Systems – Directional control.
- Camera Pan/Tilt Systems – Smooth and accurate movements.
- Printing Presses – Controlled paper feed.
- Textile Machinery – Accurate control of fabric movement.
- Aircraft and Missiles – Control surface actuation.

Features:

- Closed-loop control with feedback.
- High torque at low speeds.

- Fast acceleration and deceleration.
- Excellent positioning accuracy.
- Smooth operation with minimal overshoot.
- Operates on low voltage DC supply.

Advantages:

- High precision and accuracy.
- Quick response to control signals.
- Stable operation with minimal error.
- Good torque-to-inertia ratio.
- Works well for both position and speed control.

Disadvantages

- More expensive than simple DC motors.
- Requires a feedback device and control circuitry.
- More complex to maintain due to electronics.
- Limited speed range compared to AC servo motors in some cases.
- Brush wear in brushed types reduces lifespan (maintenance required).

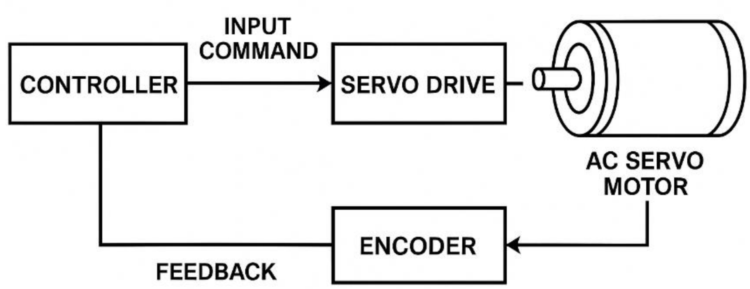
AC SERVO MOTOR:

An AC Servo Motor is a type of electric motor that operates on AC supply and is designed for precise control of angular position, velocity, and acceleration. It works as part of a servo mechanism with feedback (usually from an encoder or resolver) to ensure accurate control. The AC servo motor works on the same basic electromagnetic principle as other AC motors — a rotating magnetic field is produced in the stator, inducing torque in the rotor. However, it is specially designed for closed-loop control with high accuracy.

Detailed Working Steps:

1. Input Command – A control signal (from a controller, PLC, CNC, etc.) specifies the desired position, speed, or torque.
2. Controller Output – The servo driver converts the control signal into an AC supply with the correct frequency, voltage, and phase.
3. Motor Rotation – The stator's magnetic field interacts with the rotor, producing torque.
4. Feedback Loop – A sensor (e.g., encoder or resolver) sends actual position/speed back to the controller.
5. Error Correction – The controller compares the actual feedback with the commanded value and adjusts the supply to minimize error.

Controller → Amplifier/Driver → Motor → Feedback → Error Correction → Precision Motion



Applications:

AC servo motors are used where precise and smooth motion control is required:

- Robotics – precise joint movement
- CNC Machines – accurate cutting/engraving
- Conveyor Systems – speed & position control
- Automatic Door Systems – controlled opening/closing
- Printing Machines – paper feed alignment
- Textile Machines – thread and fabric movement control

- Packaging Machines – accurate product positioning

Features:

- High precision due to feedback control
- High torque-to-weight ratio
- Wide speed range (including low speeds without cogging)
- Smooth acceleration and deceleration
- Works well in both constant speed and variable speed applications
- Quick response to command signals

Advantages:

- High Accuracy – Positioning errors are automatically corrected.
- Smooth Operation – Minimal vibration and noise.
- Fast Response – Can quickly change speed/direction.
- High Efficiency – Converts electrical energy effectively into motion.
- Reliable for Continuous Operation – Suitable for industrial automation.

Disadvantages:

- Higher Cost – More expensive than standard AC motors.
- Complex Control System – Requires driver and feedback devices.
- Maintenance Needs – Feedback sensors and electronics can fail.
- Size & Weight – Can be bulkier than equivalent stepper motors for some uses.
- Limited Overload Capacity – Cannot handle heavy overloading for long durations.

STEPPER MOTOR:

A stepper motor is a type of electromechanical actuator that converts electrical digital pulses into discrete angular movements (steps).

- The rotation of the motor shaft is divided into a number of equal steps, hence the name stepper.

- Every time a control pulse is applied, the motor advances by a fixed angle called the step angle.
- Stepper motors are widely used in open-loop control systems, where the position can be controlled without the need for feedback sensors.

Stepper Motors are also electromechanical actuators that convert a pulsed digital input signal into a discrete (incremental) mechanical movement are used widely in industrial control applications. A stepper motor is a type of synchronous brushless motor in that it does not have an armature with a commutator and carbon brushes but has a rotor made up of many, some types have hundreds of permanent magnetic teeth and a stator with individual windings.

Detailed Working of Stepper Motor:

Stepper motors work on the principle of electromagnetism.

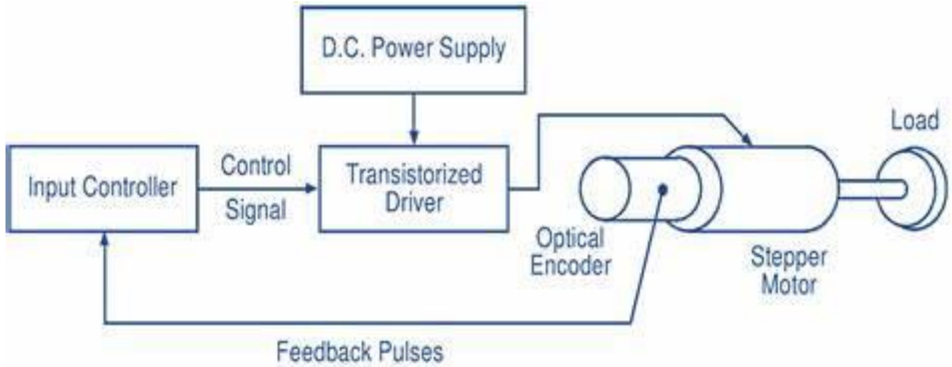
Construction:

- Stator → Made of laminated steel with multiple poles carrying winding coils.
- Rotor → May be a toothed soft iron (Variable Reluctance type) or a Permanent Magnet.
- Driver Circuit → Provides the sequence of current pulses to stator windings.

Principle of Operation:

1. Energizing Windings: When current flows through a stator winding, it produces a magnetic field.
2. Rotor Alignment: The rotor (magnet or soft iron teeth) aligns itself with the energized stator pole.
3. Stepwise Rotation: Sequential energization of windings causes the rotor to rotate in discrete steps.
4. Direction Control: The order of excitation (clockwise or anticlockwise) determines the direction of rotation.
5. Speed Control: The frequency of input pulses determines the speed of the motor.

Working of Stepper Motor (Step by Step):



1. Input Command:
   - The controller (microcontroller, PLC, CNC, etc.) generates digital pulses.
   - Each pulse = one step (fixed angle of rotation).
2. Pulse Generator / Sequence Logic:
   - Converts the input pulses into a sequence of signals to energize the stator windings in proper order.
   - The sequence determines the direction of rotation (CW or CCW).
3. Driver Circuit (Amplifier):
   - The logic signals are amplified to provide enough current/voltage to the stepper motor windings.
4. Stepper Motor:
   - The stator windings are energized step by step.
   - The rotor (permanent magnet or toothed iron) aligns with the energized stator pole.
   - Sequential energization causes the rotor to rotate in discrete steps.
5. Mechanical Output:
   - The shaft produces controlled angular displacement.
   - Speed is proportional to pulse frequency.
   - Position is proportional to number of pulses applied.

Modes of Excitation:

- Single-phase excitation → Only one winding energized at a time (lower torque).
- Two-phase excitation → Two windings energized (higher torque).
- Half-step excitation → Alternating one-phase and two-phase excitations → doubles step resolution.
- Micro stepping → Current divided proportionally between windings → very smooth motion.

Features of Stepper Motor:

- Converts digital pulses into mechanical rotation.
- Step angle typically ranges from 0.9° to 90°.
- Provides high torque at low speeds.
- Can operate in open-loop control (no feedback required).
- Excellent starting, stopping, and reversing response.
- Simple construction and high reliability (no brushes).
- Provides holding torque when windings are energized.

Applications of Stepper Motor:

Stepper motors are used in systems requiring precise position and repeatability.

- Printers, Scanners, and Typewriters (head positioning).
- CNC machines and 3D printers.
- Robotics – robotic arms, pick-and-place machines.
- Camera control – zoom and focus adjustment.
- Medical instruments – syringe pumps, imaging equipment.
- Automobile dashboard instruments.
- Textile machines and packaging machines.
- Antenna and satellite dish positioning.

Advantages of Stepper Motor:

- Precise positioning without feedback.
- Simple and robust construction (no brushes, less wear)
- Excellent low-speed torque.
- Easy control using digital circuits (microcontrollers, PLC)
- Quick start, stop, and reverse response.
- Stable operation and good repeatability
- Holding torque when energized (maintains position).

Disadvantages of Stepper Motor:

- Low efficiency – draws current even when not moving.
- Limited high-speed performance – torque decreases with speed.
- Resonance and vibration problems at certain speeds.
- Requires driver circuit for operation.
- Open-loop errors – can lose steps if load is excessive.
- Lower power output compared to DC/AC motors of same size.