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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VII Semester

AU3008 Sensors and Actuators

UNIT – 4 - AUTOMOTIVE ACTUATORS

4.1 Electromechanical actuators- Fluid-mechanical actuators

- An **electromechanical actuator** is a type of device that converts electrical energy into mechanical motion. It typically uses electrical motors or solenoids to produce movement in a mechanical system, making it a key component in a variety of applications, from robotics to industrial machinery.
- Electromechanical actuators rely on electrical input to drive mechanical parts, usually through a motor or solenoid mechanism. This electrical energy may be transformed into linear or rotary motion, depending on the design:

  i. **Motors**: Often, small electric motors turn a screw or a gear system to generate linear or rotational movement.
  ii. **Solenoids**: Electromagnetic coils can create rapid, short linear motions by pulling or pushing a magnetic plunger.
  iii. **Step Motors and Servos**: These can provide precise control over the actuator’s position, which is important in automated and robotic systems.

- **Fluid-Mechanical Actuators**

  Fluid-mechanical actuators use pressurized fluid (hydraulic or pneumatic) to produce mechanical motion. These systems are valued for their high force output and durability in challenging environments.

- **Types:**

  Hydraulic Actuators:

- Use incompressible liquids.
- Generate high forces at low speeds.

Pneumatic Actuators:

- Use compressed air or gas.
- Operate at higher speeds with lower force.

❒ **Components:**

- ❖ **Cylinder:** Houses the piston or diaphragm.
- ❖ **Piston/Rod:** Converts fluid pressure into mechanical force.
- ❖ **Valves:** Control fluid flow.
- ❖ **Pump or Compressor:** Provides the required pressure.

❒ **Advantages**:

- ❖ High power-to-weight ratio.
- ❖ Operate in harsh and explosive environments.
- ❖ Capable of generating large forces.

❒ **Applications:**

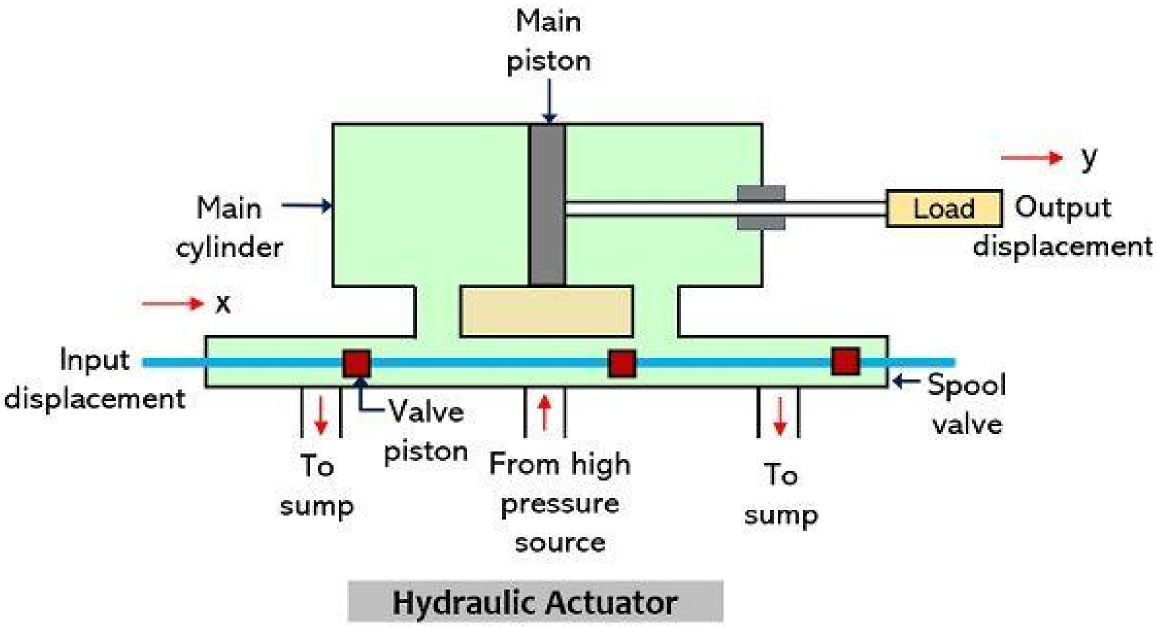
- ❖ Construction machinery (e.g., excavators, loaders).
- ❖ Aircraft (e.g., landing gear systems).
- ❖ Automation (e.g., pneumatic arms).
- ❖ Industrial presses and jacks.

❒ **Comparison**

Feature	Electromechanical Actuators	Fluid-Mechanical Actuators
Power Source	Electricity	Hydraulic fluid or compressed air
Force Output	Moderate	High
Precision	High	Moderate
Speed	Moderate to High	High (pneumatics), Low (hydraulics)
Maintenance	Low	High
Environment	Clean	Harsh
Efficiency	High	Lower (losses in fluid systems)

Hydraulic Actuators:

Hydraulic actuators use pressurized fluid (typically oil) to produce mechanical motion. These devices are widely used in applications requiring high force and precision.



The diagram illustrates a **hydraulic actuator** system, specifically showing the operation of the **main piston**, **spool valve**, and the flow of hydraulic fluid to generate mechanical displacement. Let's break it down:

Key Components:

1. **Main Cylinder:**
   - The central chamber where the **main piston** operates.
   - Hydraulic fluid applies pressure to the piston, creating motion.
2. **Main Piston:**
   - Moves inside the cylinder to exert force on the **load**.
   - Its motion (up or down, depending on fluid pressure) produces **output displacement (y)**.
3. **Spool Valve:**

  - Directs hydraulic fluid from the **high-pressure source** to the appropriate side of the main piston.
  - Can also divert fluid to the **sump** (fluid reservoir) for recirculation.

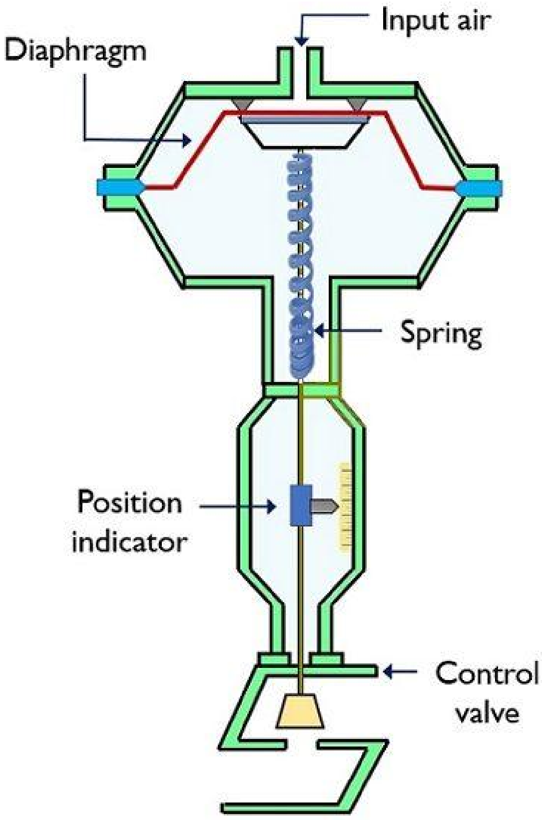
4. **Valve Piston:**
   - Controls the flow path of the fluid by moving the spool valve based on input displacement (x).
   - Input displacement can be generated manually, electrically, or automatically.
5. **Hydraulic Fluid Flow:**
   - **From High-Pressure Source:** Pressurized fluid is supplied to the main cylinder.
   - **To Sump:** Fluid is returned to the reservoir after completing its cycle.

Working Principle:

1. **Input Displacement (x):**
   - A control signal (mechanical or electrical) moves the spool valve, directing fluid flow.
2. **Fluid Routing:**
   - Depending on the spool valve position, high-pressure fluid enters one side of the main piston, while fluid from the other side is diverted to the sump.
3. **Output Displacement (y):**
   - The piston moves in response to the pressure differential, creating mechanical motion and displacing the load.

Pneumatic actuators:

Pneumatic actuators use compressed air or gas to create mechanical motion, typically linear or rotary. These actuators are widely used in applications requiring fast and reliable movements, particularly in automation systems.



This diagram illustrates a **diaphragm-based pneumatic actuator** typically used in control valve systems. Let's analyze its components and working principle:

Components

1. **Diaphragm:**
   - A flexible membrane that moves up or down based on the input air pressure.
   - Converts pneumatic energy into mechanical motion.
2. **Input Air:**
   - Pressurized air enters the actuator, causing the diaphragm to flex.
3. **Spring:**
   - Opposes the diaphragm's motion and provides a restoring force when the air pressure decreases.
   - Ensures precise control of the actuator position.

4. **Position Indicator:**
    - Displays the current position of the actuator (or valve) for monitoring purposes.
5. **Control Valve:**
    - The main output device controlled by the actuator.
    - Regulates the flow of fluids (liquids or gases) based on the actuator's motion.

Working Principle

1. **Input Air Pressure:**
    - Compressed air is supplied to the actuator through the input air port.
2. **Diaphragm Movement:**
    - The air pressure causes the diaphragm to move downward, compressing the spring and displacing the control valve.
3. **Spring Action:**
    - When air pressure decreases, the spring pushes the diaphragm back to its original position, resetting the control valve.
4. **Valve Operation:**
    - The movement of the diaphragm is transferred to the control valve, adjusting the flow rate or pressure in the connected piping system.

Advantages

- Simple and reliable design.
- Cost-effective for controlling valve operations.
- Safe to use in hazardous environments.
- Requires minimal maintenance.

Applications

- **Process Control Systems:**
    - In industries such as oil and gas, petrochemicals, and water treatment.
- **HVAC Systems:**
    - For regulating airflows.
- **Pneumatic Circuit Controls:**

- In manufacturing and automation systems.

This actuator is ideal for applications requiring **linear motion** and precise control, particularly in automated valve systems.

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