# Actuators

Chapter 3

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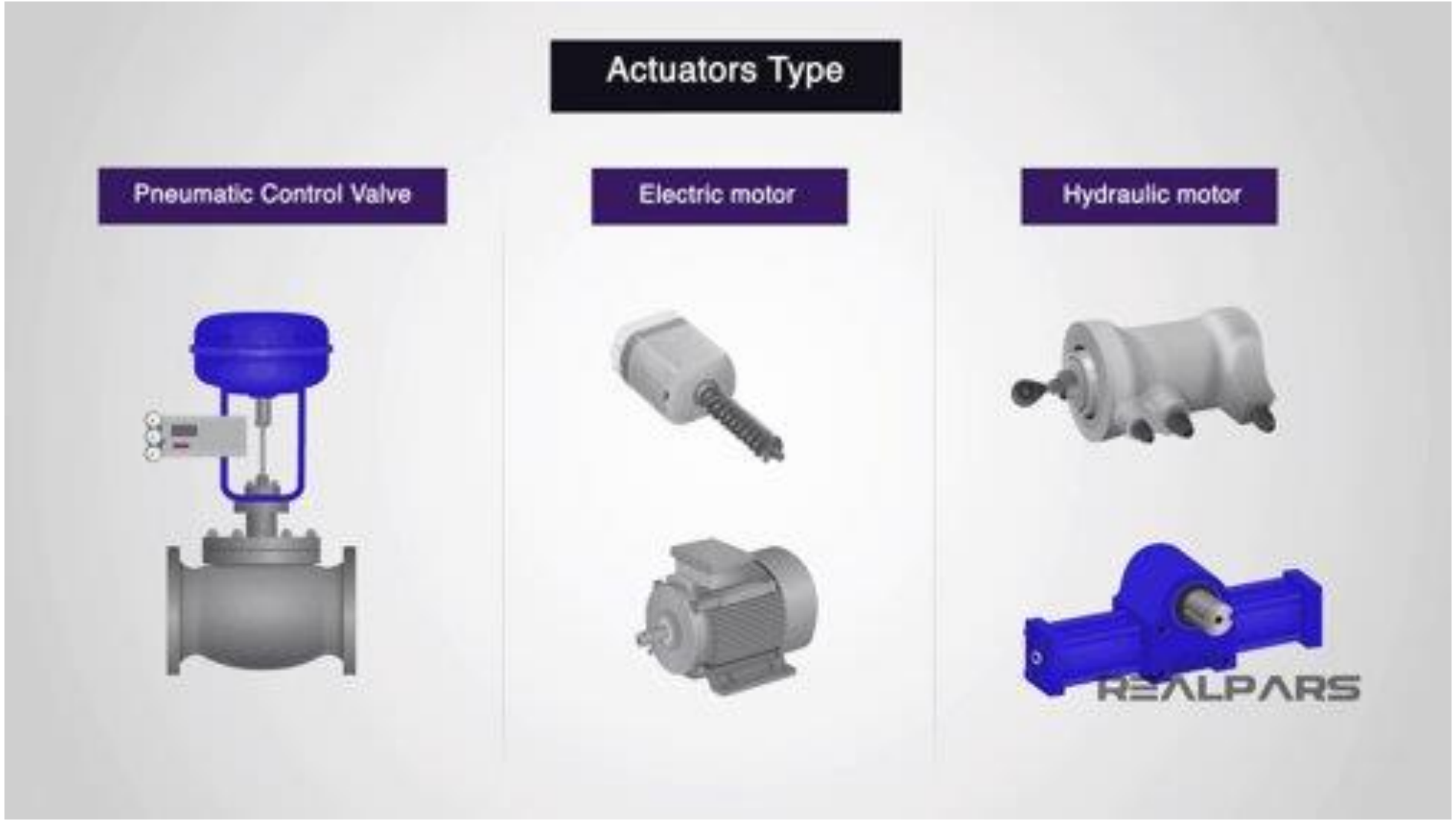
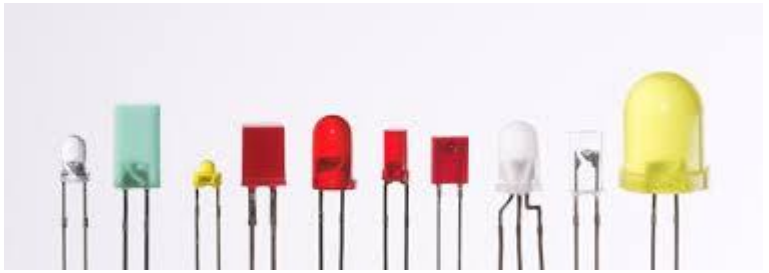
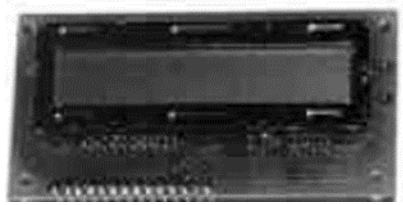
# Introduction

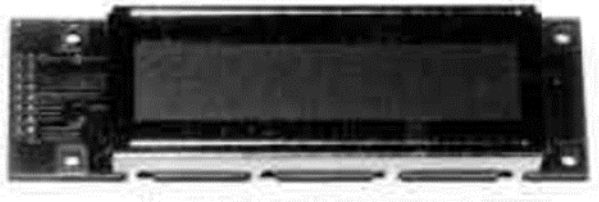


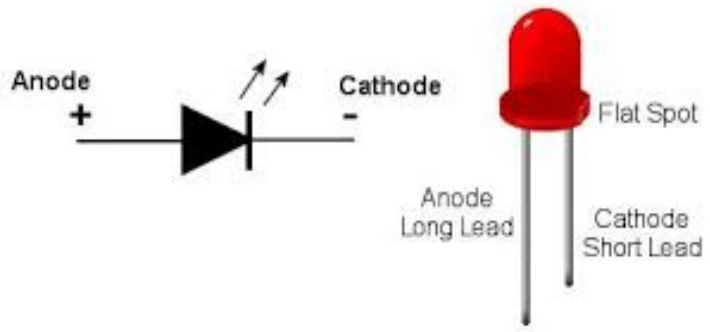
# Output

- Light-emitting diodes (LED)
- Seven Segments
- Liquid Cristal Display (LCD)

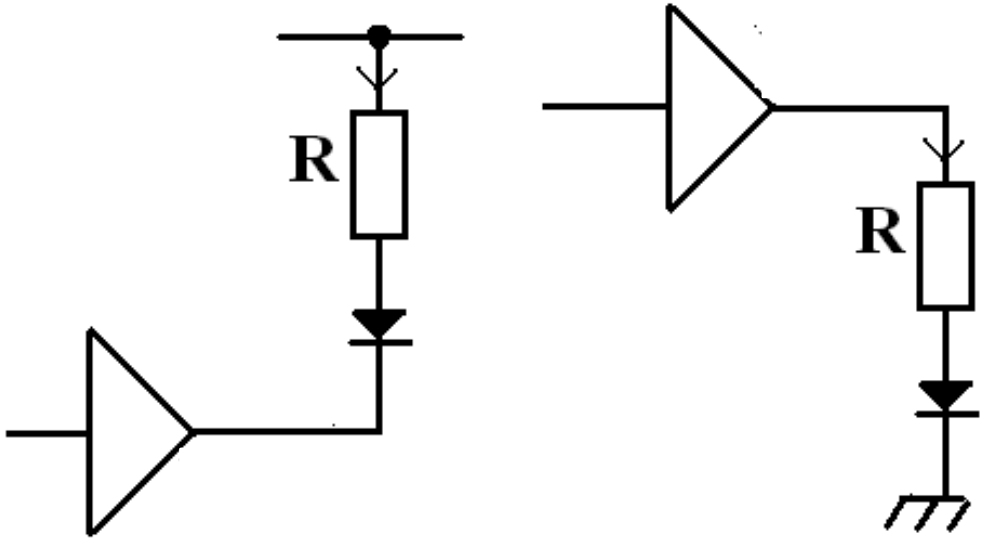




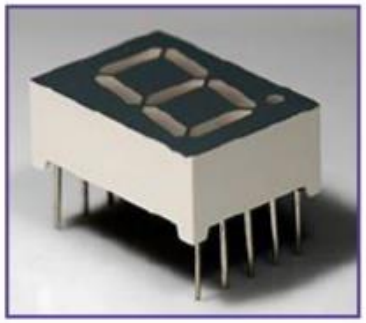


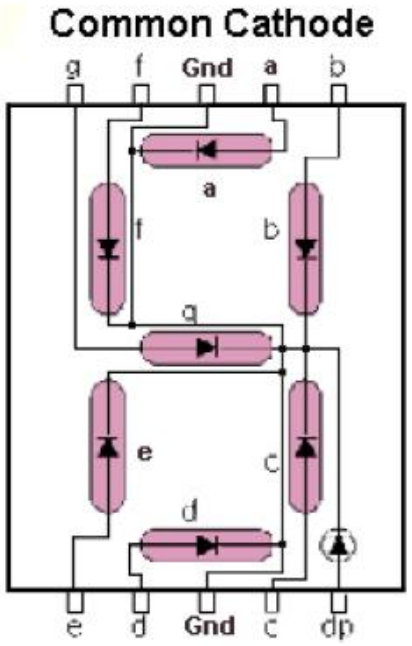


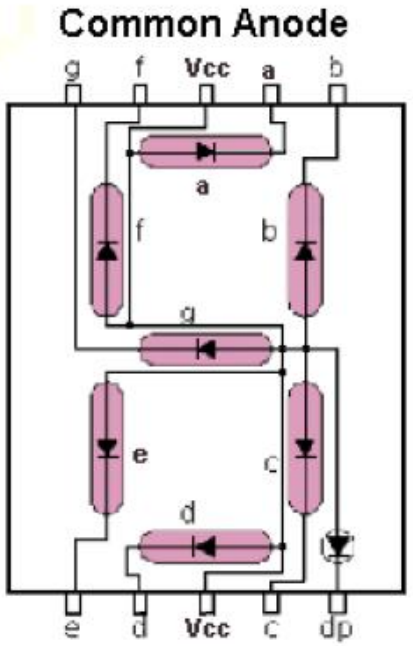

# Interface LED



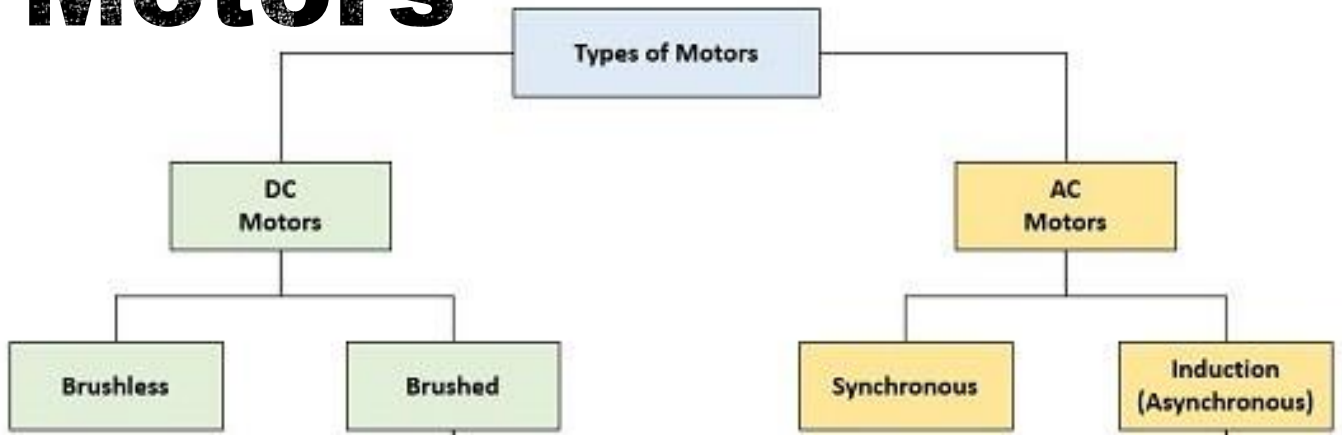
# Seven Segment decoder

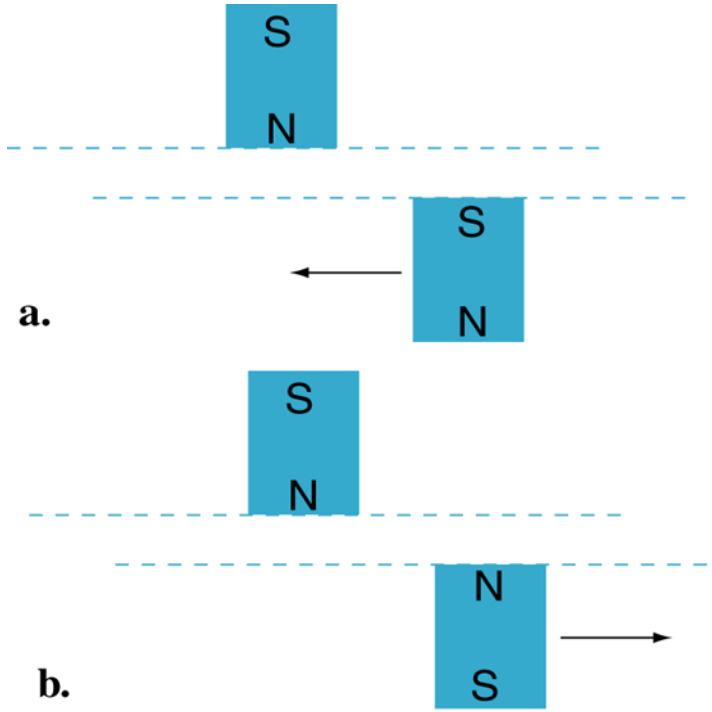


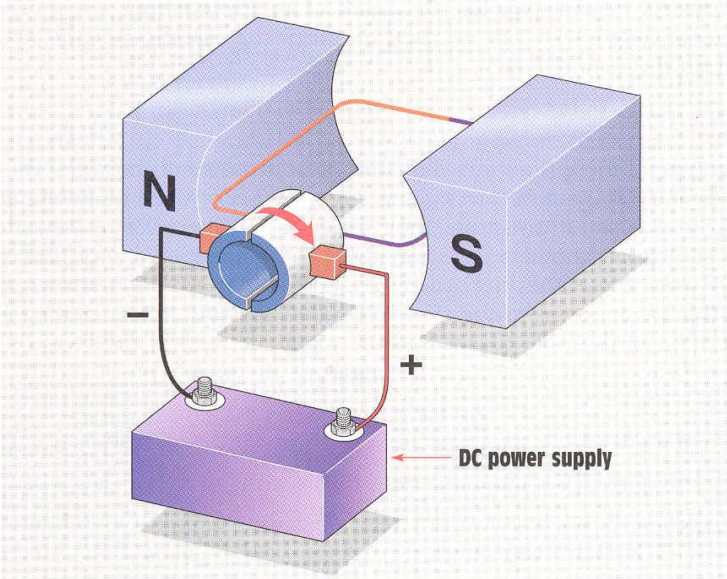
# Electrical Motors

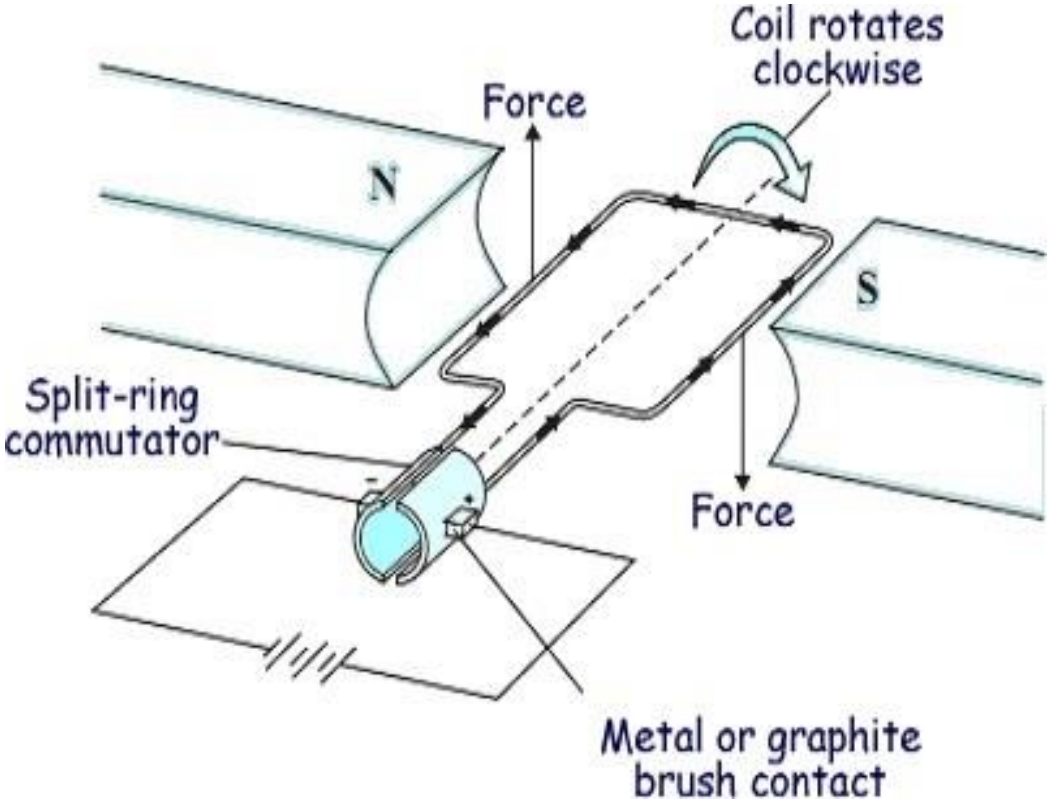


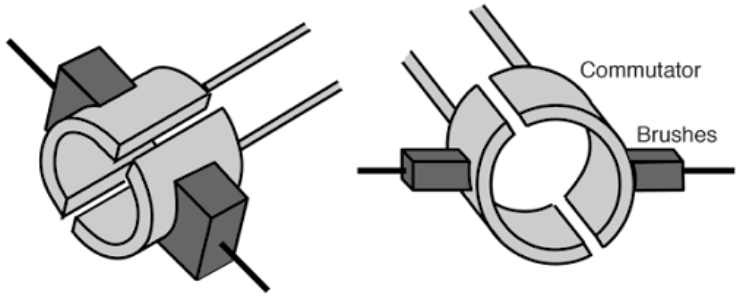

- Most common of all actuators
- Many types and variations.
- All motors operate on the principle of repulsion or attraction between magnetic poles
- Most motors are magnetic devices:
  - operate by attraction or repulsion between current carrying conductors or
  - between current carrying conductors and permanent magnets.
- Motors include magnetic materials (mostly iron), in addition to permanents or electromagnets



# Brushed DC Motor with commutator

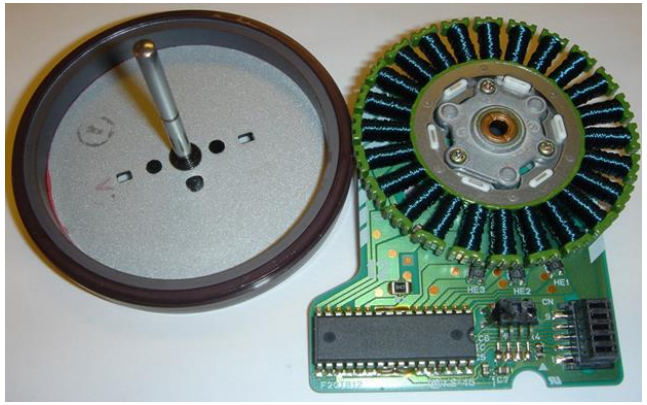


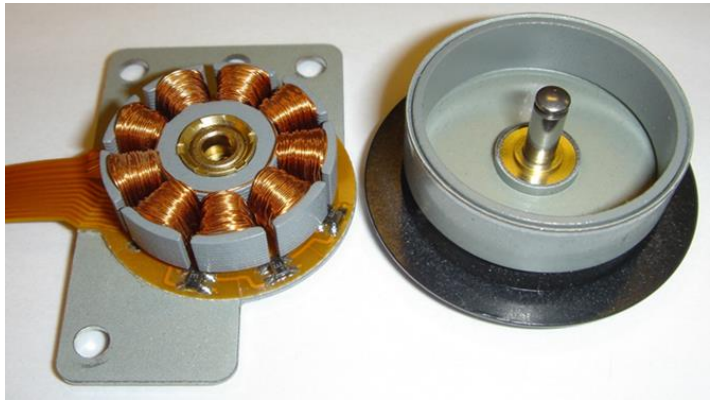



# Brushless DC Motors

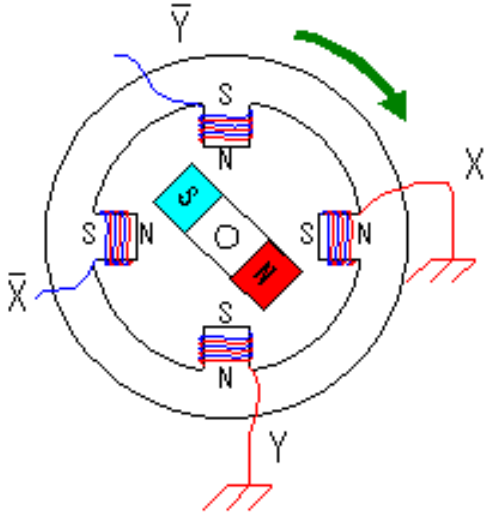
- Eliminates the mechanical commutator
- For very demanding applications, such as in disk drives a variation of the dc motor is used in which the commutation is done electronically.
- The physical structure is often different to allow fitting in tight spaces or incorporation on integrated circuits.
- These motors are often flat (hence the name flat motors).
- An additional important aspect is that the coils are stationary, and the magnets rotate.



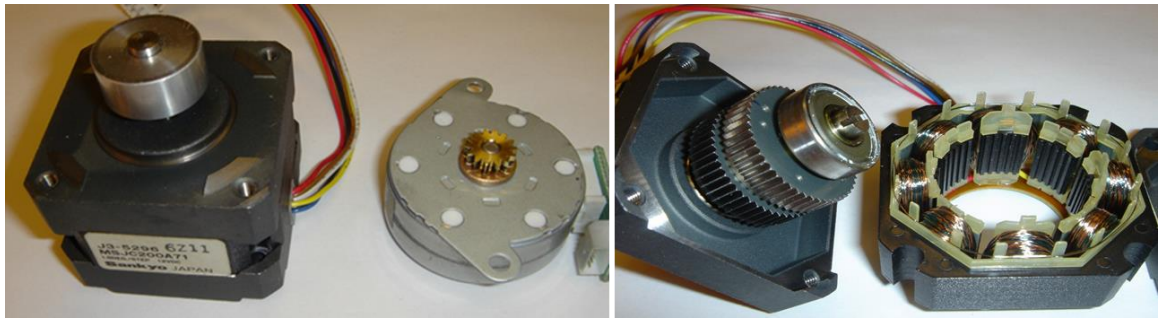


# Stepper motors

- A stepper motor is an incremental rotation or motion motor.
- They are often viewed as “digital” motors, in the sense that each increment is fixed in size and increments are generated by a train of pulses.
- Very simple to control
- Usually relatively small, low power motors
- Actuation requires control of a motor:
  - exact and repeatable positioning
  - requires some means of feedback,
  - counting rotations,
- Motors which incorporate these means are called servomotors

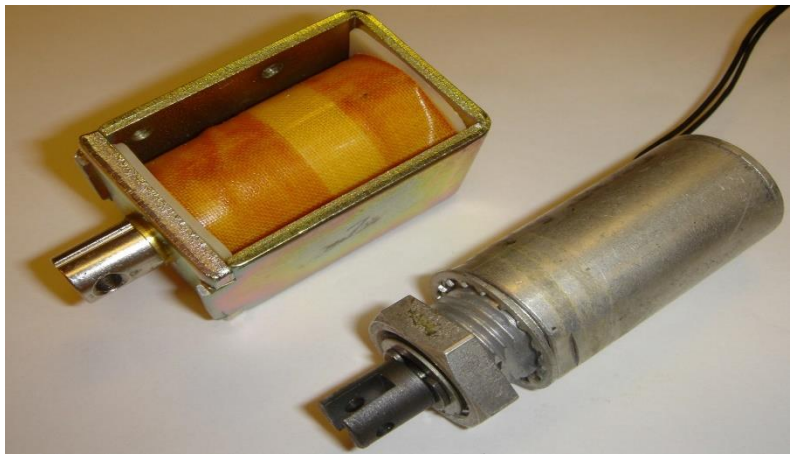


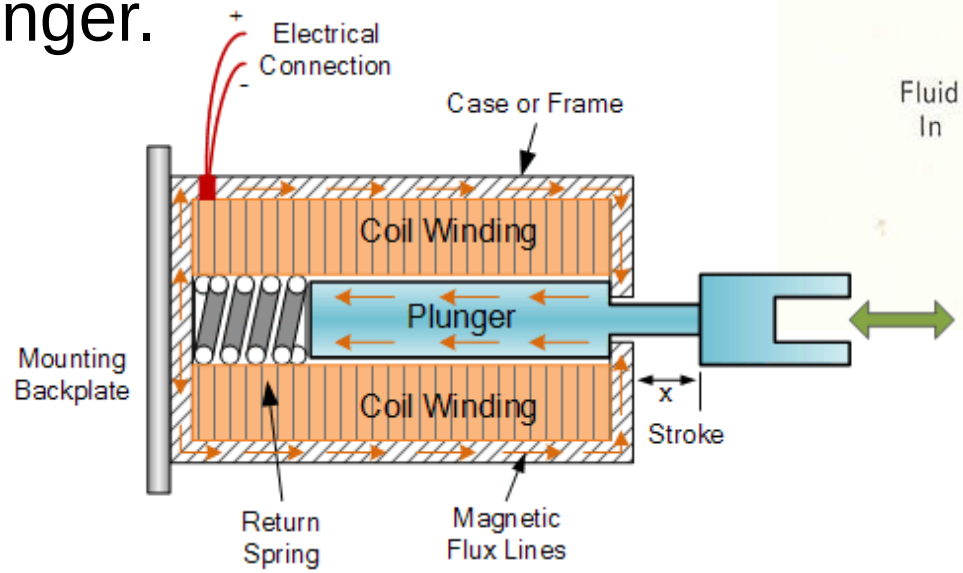

| X | X̄ | Y | Ȳ |
|---|---|---|---|
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 |

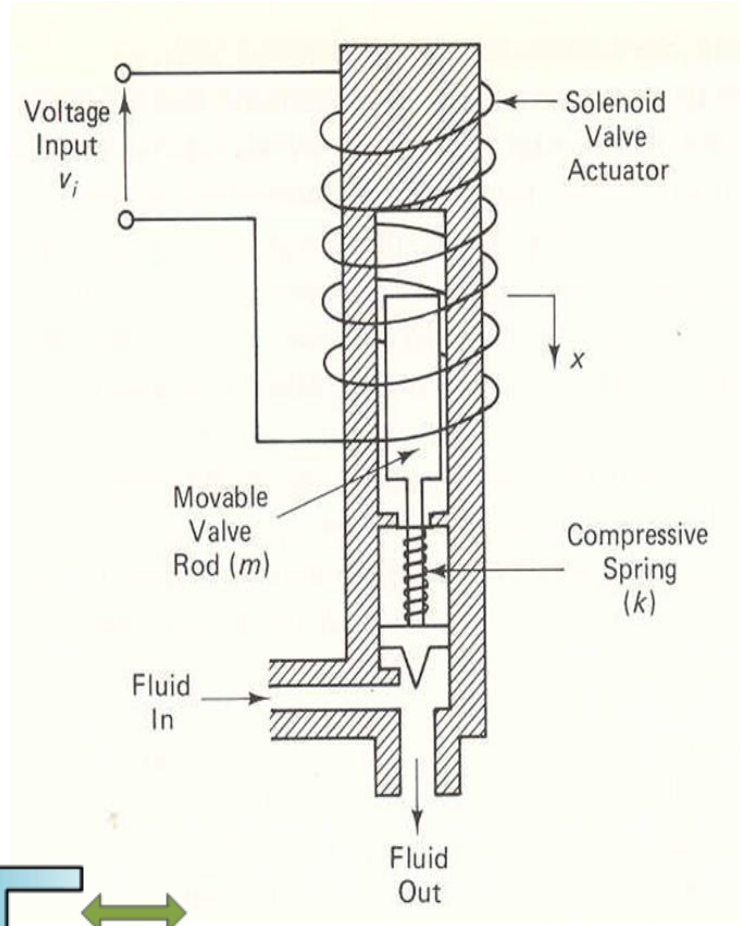


# Magnetic Solenoid

- Magnetic solenoid actuators are electromagnets designed to affect linear motion
- Principle: a coil generates a magnetic field everywhere, including in the gap between the fixed and movable iron pieced.
- The movable piece called plunger.





# Human Machine Interface (HMI)

- HMI is the user interface, in the industrial design field of human–machine interaction, where interactions between humans and machines occur.
- The goal of this interaction is to allow effective operation and control of the machine from the human end, whilst the machine simultaneously feeds back information that aids the operators' decision making process. Other term for HMI is man–machine interface (MMI)

# Importance

- Why to use Human Machine Interface (HMI) systems?

  *Problems of fitting machines and their uses for humans.*

- Human characteristics: *To understand how humans communicate, and people's physical and psychological requirements.*
- Human-machine fit and adaptation
  - Improve the fit between the designed object and its use
    - how systems are selected and adopted; how users create routine systems; how systems adapt to the user (customization); how users adapt to the system (training, ease of learning); user guidance (help, documentation, error-handling)
- HMI system and interface architecture must have:
  - Input and output devices
  - Dialogue techniques
  - Machine Graphics

# History

This panel shows many discrete devices as well as mimic panels showing process lines.

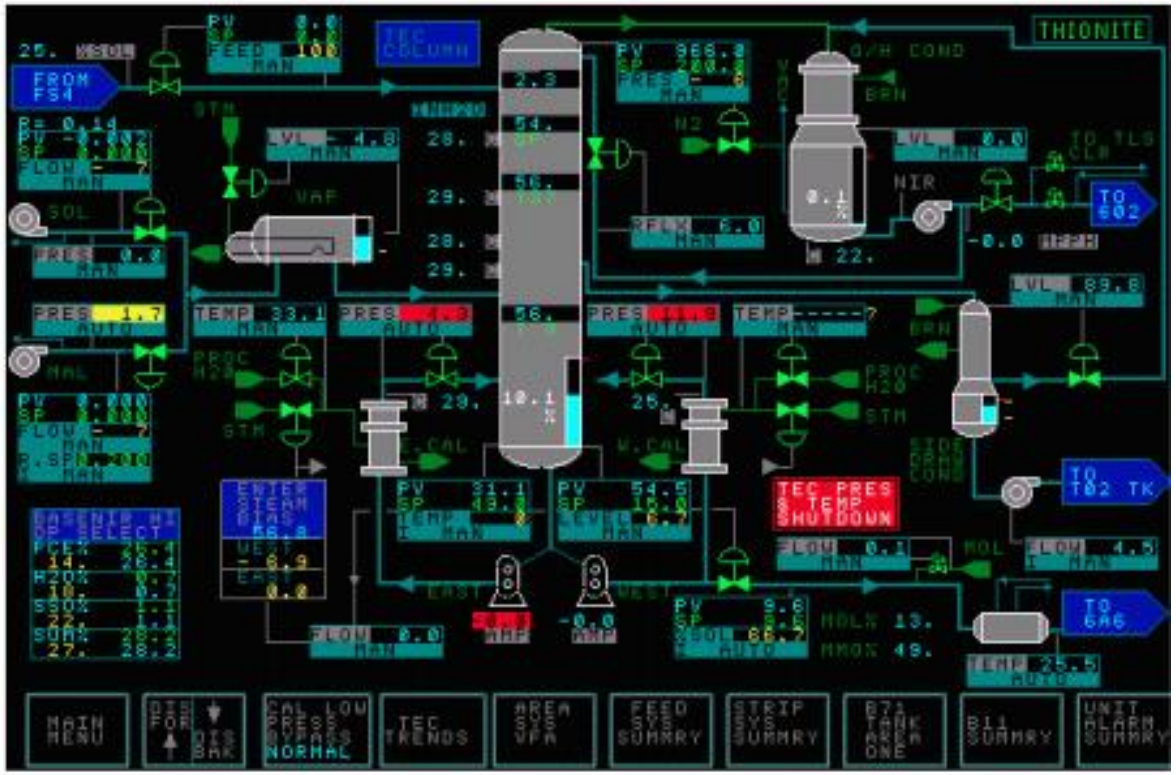
Meters show levels or flows of various devices.

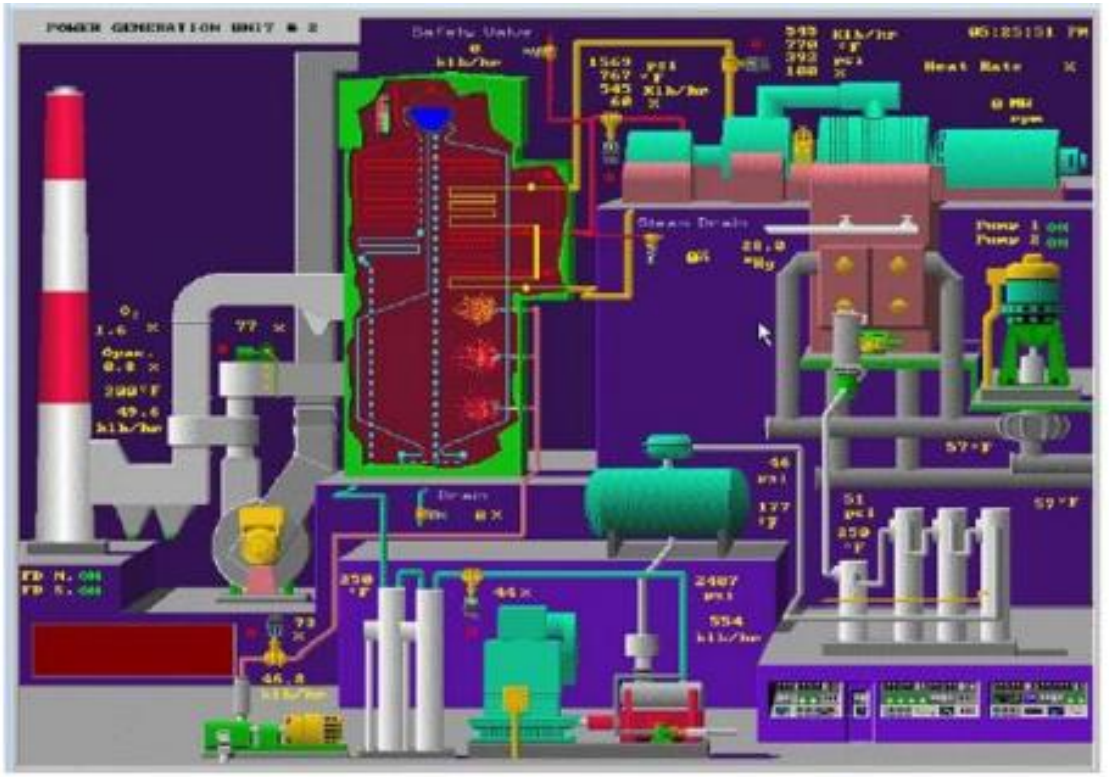
Alarms are shown in grids of illuminated push buttons.

Alarm panels were designed with discrete panels that lit or blinked with each alarm. Buttons were used to acknowledge each alarm point

Data was collected with recording devices. Multiple points were individually recorded and studied

# Modern HMI

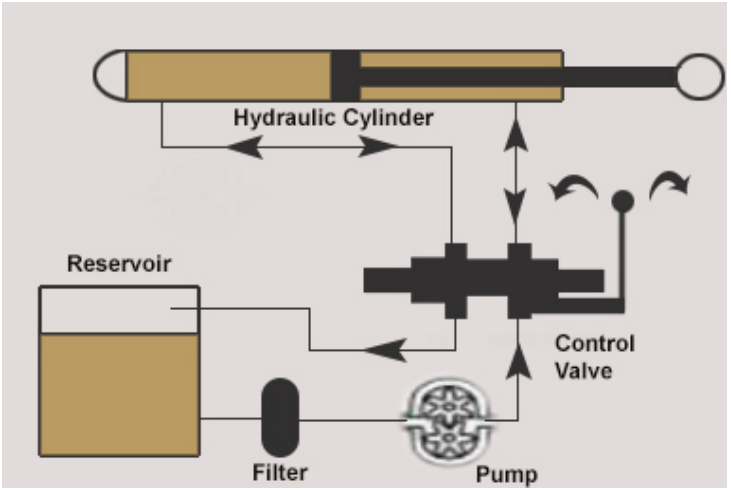


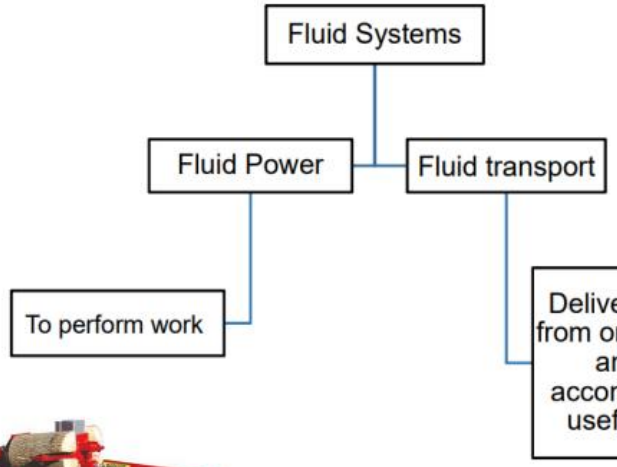

Graphics were developed over 20 years ago and remain common throughout the industry. Indeed, inertia, not cost, is the primary obstacle to the improvement of HMIs. Engineers and operators become familiar to this style of graphic and are resistant to change

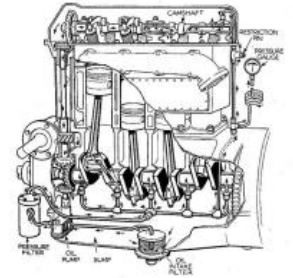
Modern HMI design:
Show Information Instead of Raw Data
Proper Use of 3d graphics
Proper Use of Colors

# Fluid Introduction



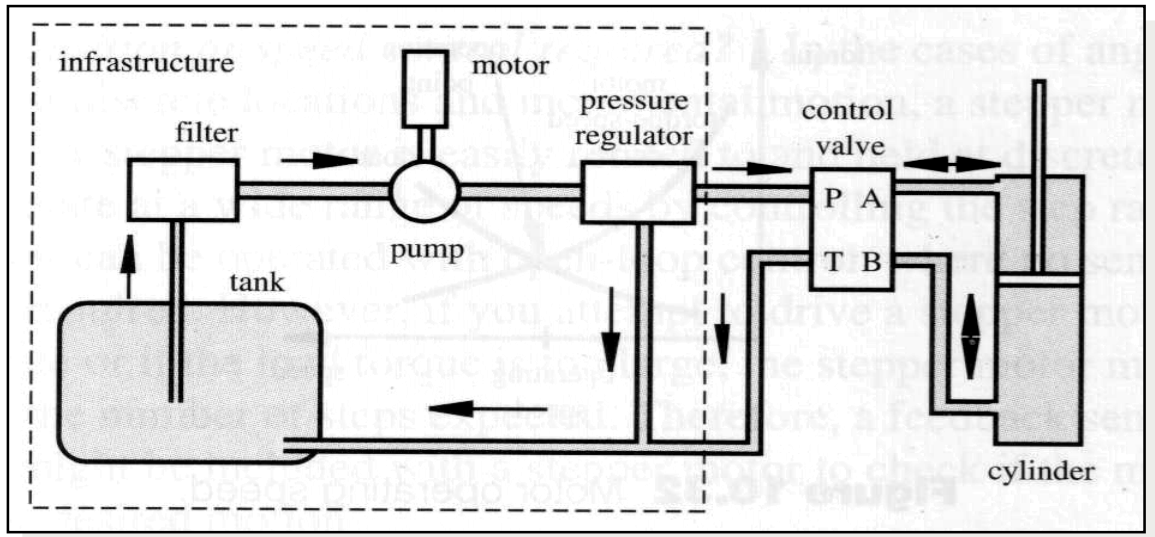

- Fluid is a material that continually flows under an applied external force. Fluids are a phase of matter and include liquids, gases.
- Fluid power is the use of fluids under pressure to generate, control, and transmit power. Fluid power is subdivided into hydraulics using a liquid such as oil or water, and pneumatics using a gas such as air or other gases.
- Key components of Fluid power system
  - Pump/Compressor
  - Valve
  - Actuator



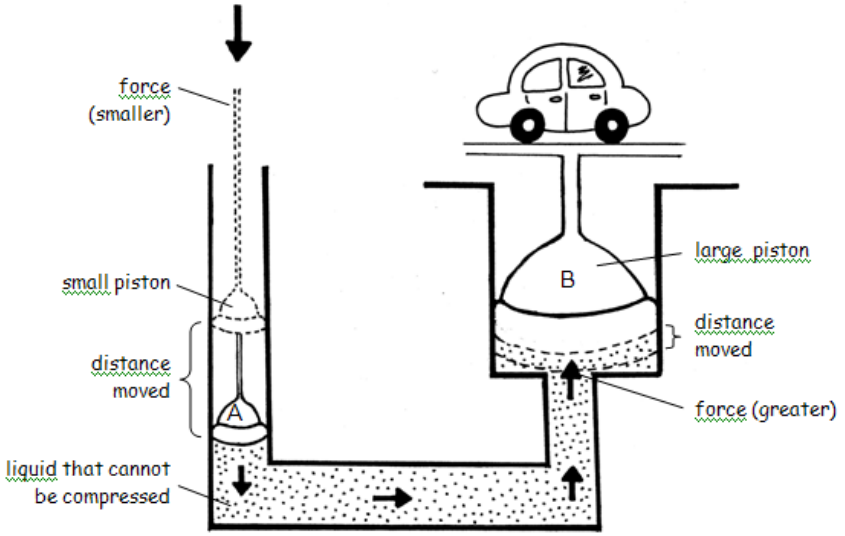
# Hydraulic Systems

- Move large loads by controlling high-pressure fluid in distribution lines and pistons with mechanical or electromechanical valves
- 7000 k pascal – 21000 k pascal
- Closed systems, always recirculating same fluid



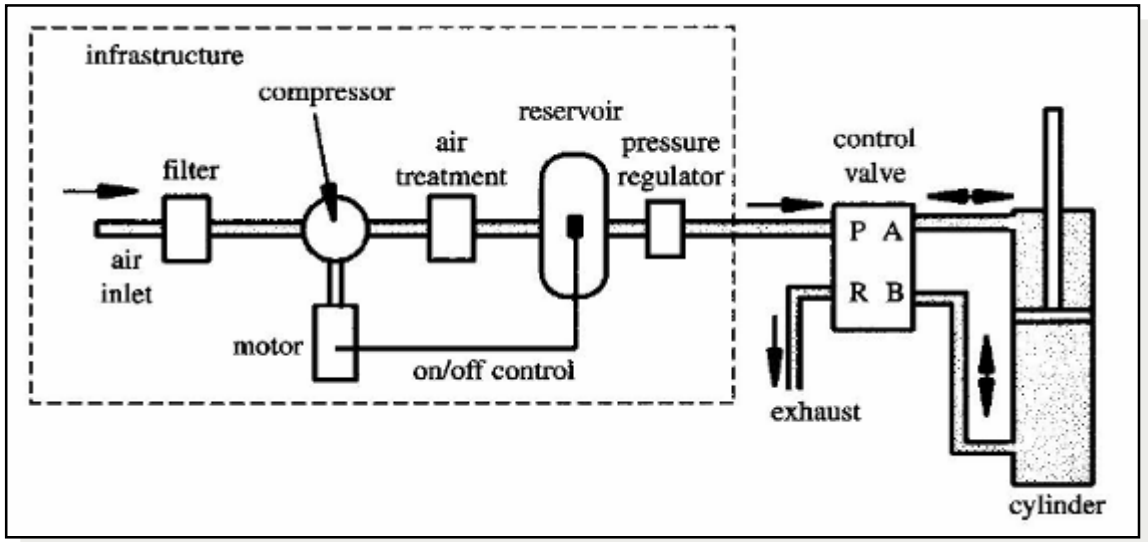
# Hydraulic Systems

- Advantage:
  - Able to generate extremely large forces from compact actuators
  - Easy to control speed
  - Easy to implement linear motion
- Disadvantage:
  - Large infrastructure (high-pressure pump, tank, distribution lines)
  - Potential fluid leaks
  - Noisy operation
  - Vibration
  - Maintenance requirements, expensive
  - Characteristics of working fluids change with temperature and moisture

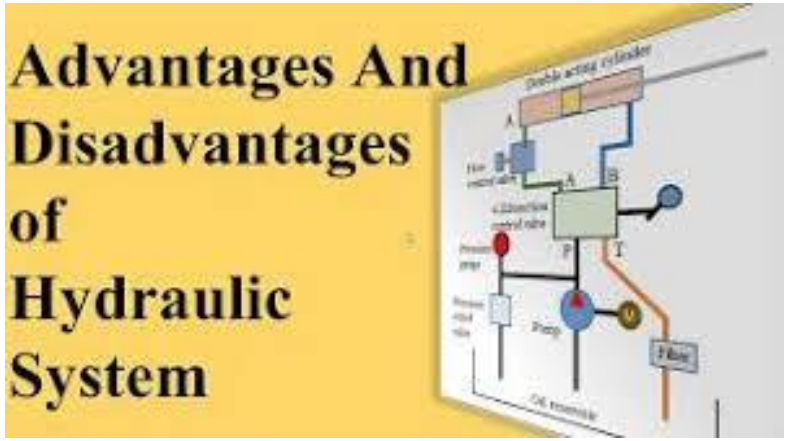
# Pneumatic Systems

- Pneumatic systems similar to hydraulic systems
- Use compressed air as working fluid rather than hydraulic liquid
- 500 k pascal – 1000 k pascal, much lower than hydraulic system pressures, much lower forces than hydraulic actuators
- Energy can be stored in high pressure tanks
- Open systems, always processing new air



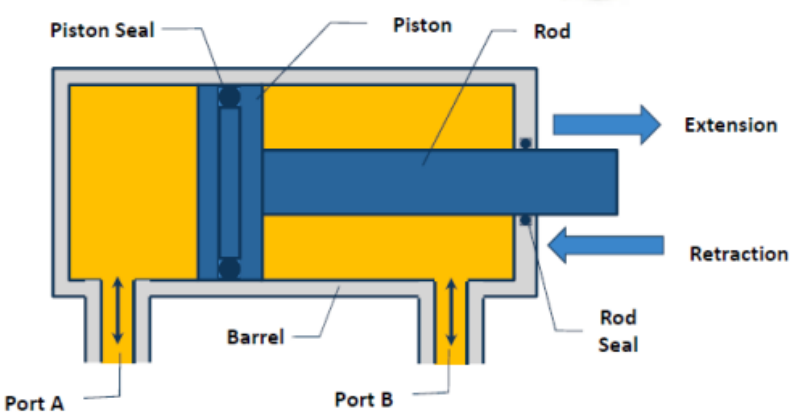
# Pneumatic Systems

- Advantage:
  - Constant force
  - Clean (food industry)
  - No return lines needed
  - Adaptable infrastructure
  - Possible light, mobile pneumatic systems
  - Fast system response
- Disadvantage:
  - Difficult to achieve position control (compressible air)
  - Noisy



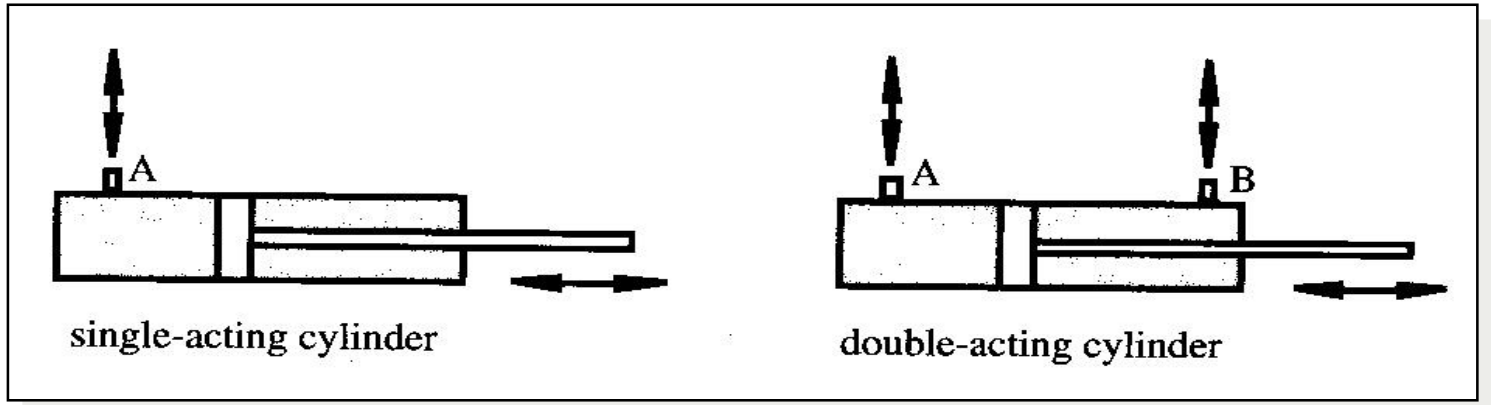

# Cylinder Introduction

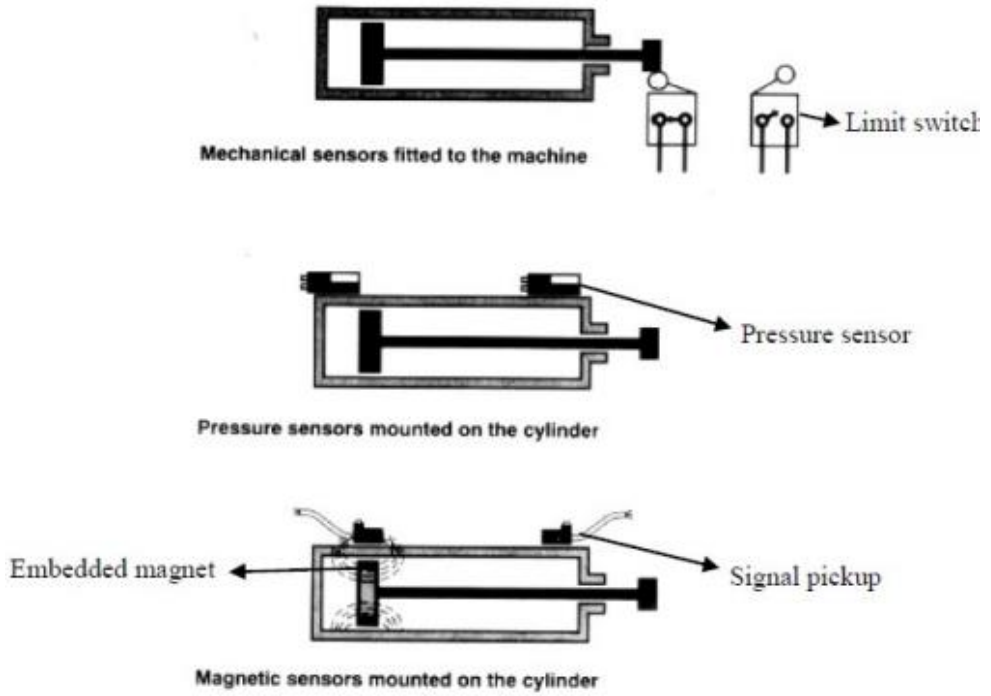
- Pneumatic actuators are the devices used for converting pressure energy of compressed air into the mechanical energy to perform useful work
- The air cylinder is a simple and efficient device for providing linear motions with a rapid speed of response.
- Their chief limitation is that the elastic nature of the compressed air makes them unsuitable for powering movement where steady forces or motions are required, or where extreme accuracy of feed is necessary.
- The air cylinder is also limited in push/pull output by the relatively low supply pressure.
- On the other hand, hydraulic cylinders, also called linear actuators provide a high linear stable force that drives an external load along a straight line . They extract energy from a fluid, and convert it to mechanical energy to perform useful work

# Key parameters in choosing air cylinders

- Stroke length
- Pressure rating
- Mounting style
- Return type
  - Single acting cylinder (SAC)
  - Double acting cylinder (DAC)
- Loads
- Temperature range
- Lubrication
- Material Compatibility

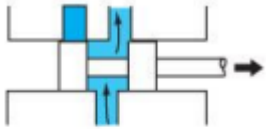


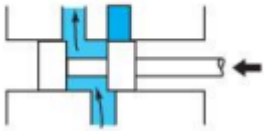



# Valve Introduction

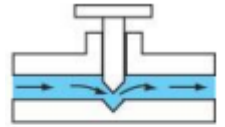
- Devices which are used to regulate and control the flow and pressure in any assigned manner are called control valves or simply valves .
- A valve is a device that receives an external signal (mechanical, fluid pilot signal, electrical or electronics) to release, stop or redirect the fluid that flows through it.
- There are three basic types of valves used in circuits .
  - Directional control : They determine the path through which a fluid traverses a given circuit.
  - Pressure control : They protect the system against overpressure, which may occur due to excessive actuator loads or due to the closing of a valve.
  - Flow (Volume) control: They are used to control the flow rate of the fluid
- The function of a DCV is to control the direction of fluid flow in any fluid power system. A DCV does this by changing the position of internal movable parts. Any valve contains ports that are external openings through which a fluid can enter and exit via connecting pipelines. The number of ports on a DCV is identified using the term “way . ” Thus, a valve with four ports is a four -way valve .

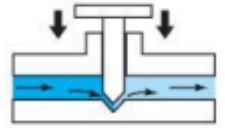
Pressure control





Directional control

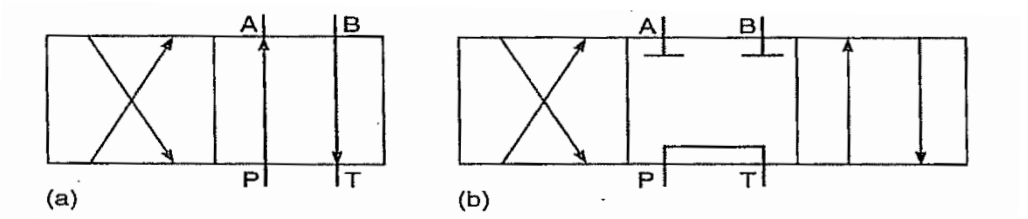


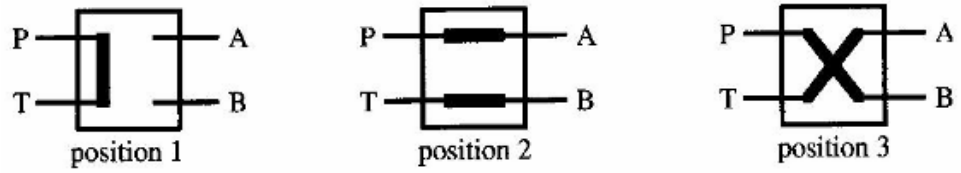


Volume control

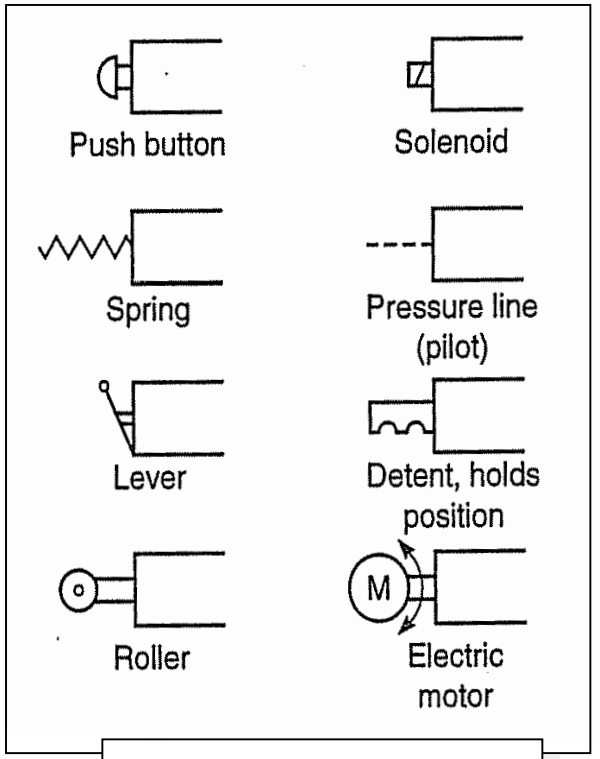
# Direction Control Valves (DCV)

- DCV can be classified according to the following :
  - Number of ports
  - Number of positions
  - Method(s) of actuation
- Infinite position valve as shown in figure on right:
  - allows any position between open and closed to modulate flow or pressure
- Finite position valve:
  - has discrete positions, usually just open and closed, providing different pressure and flow condition
- Ports: inlet and outlet connections to valve
- Finite position valve usually specified as “x/y valve”
  - x: number of ports (sum of inlets and outlets)
  - y: number of positions
  - 4/3 valve: 4 ports and 3 positions



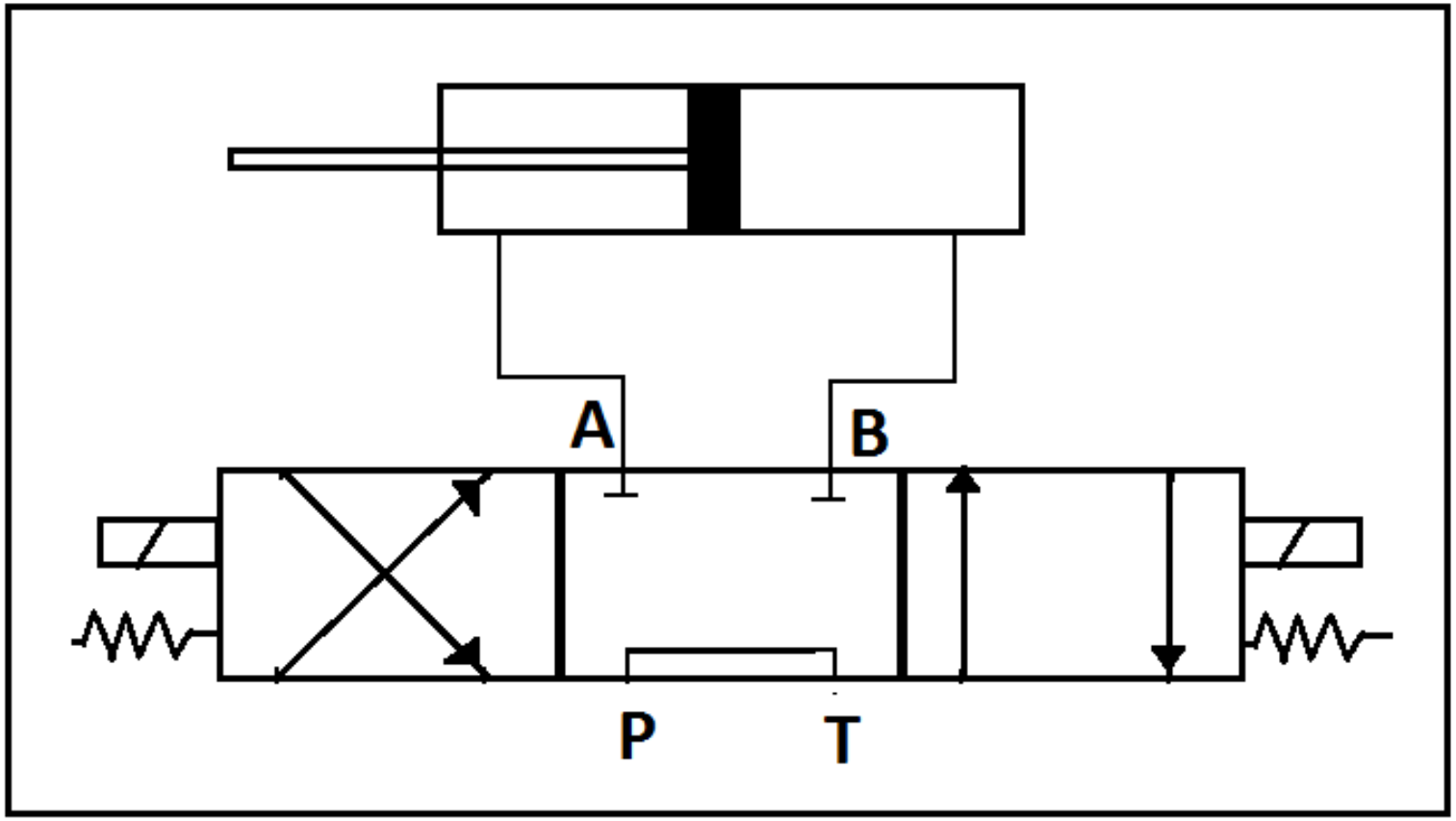




Valve Ports and Positions




Actuation methods

# Example



# Basic Combinational Logic

- Decoders
- Combinational Logic Functions Design