IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

Introduction: Sensing & Actuation

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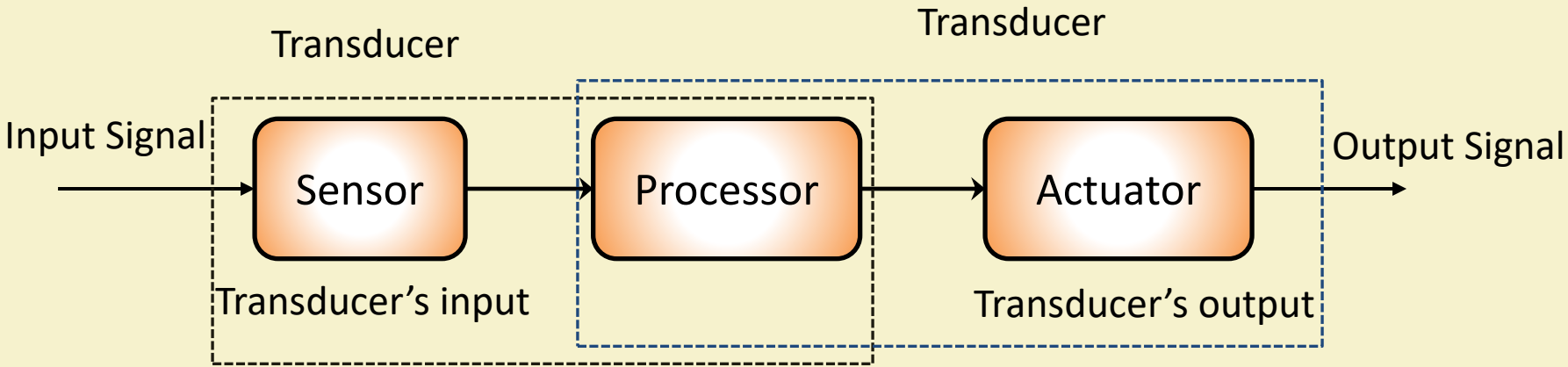
Transducer



Source: "Sensor" Online: https://ielm.ust.hk/dfaculty/ajay/courses/alp/ieem110/lecs/sensors/sensors.html

Transducer (Contd.)

- Transducer:
  - Converts a signal from one physical form to another physical form
  - Physical form: thermal, electric, mechanical, magnetic, chemical, and optical
  - Energy converter
  - Example:
    - Microphone : Converts sound to electrical signal
    - Speaker : Converts electrical signal to sound
    - Antenna : Converts electromagnetic energy into electricity and vice versa
    - Strain gauge : Converts strain to electrical

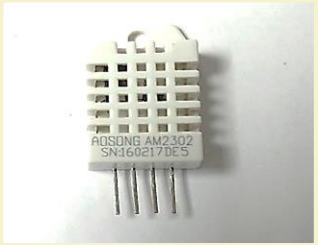
Definition of Sensor

- The characteristic of any device or material to detect the presence of a particular physical quantity
- The output of sensor is signal, which is converted to human readable form

Sensor

- Performs some function of input by sensing or feeling the physical changes in the characteristic of a system in response to stimuli
- Input: Physical parameter or stimuli
  - Example: Temperature, light, gas, pressure, and sound
- Output: Response to stimuli

Sensor (Contd.)

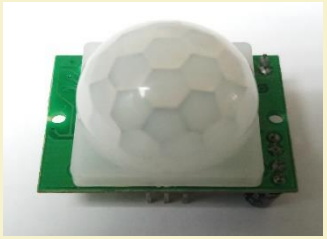


Temperature and Humidity sensor – DH22

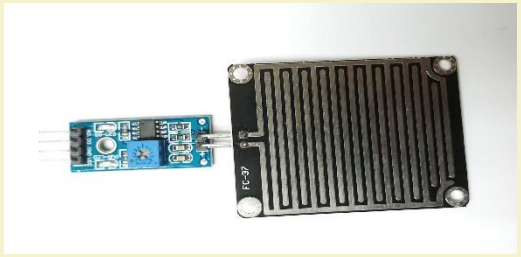
Gas (LPG, CH4, and CO) detector sensor - MQ-5

Ultrasonic sensor - HC-SR04

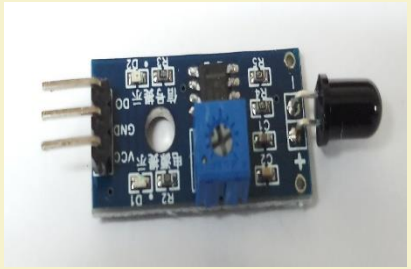
CMOS Camera



PIR sensor



Rain detector sensor



Fire detector sensor

Sensor Characteristics

- Static characteristics
  - After steady state condition, how the output of a sensor change in response to an input change
- Dynamic characteristics
  - The properties of the system's transient response to an input

Static characteristics

- Accuracy
  - Represents the correctness of the output compared to a superior system
  - The different between the standard and the measured value
- Range
  - Gives the highest and the lowest value of the physical quantity within which the sensor can actually sense
  - Beyond this value there is no sensing or no kind of response

Static Characteristics (Contd.)

- Resolution
  - Provides the smallest change in the input that a sensor is capable of sensing
  - Resolution is an important specification towards selection of sensors.
  - Higher the resolution better the precision
- Errors
  - The difference between the standard value and the value produced by sensor

Static Characteristics (Contd.)

- Sensitivity
  - Sensitivity indicates ratio of incremental change in the response of the system with respect to incremental change in input parameter.
  - It can be found from slope of output characteristic curve of a sensor
- Linearity
  - The deviation of sensor value curve from a particular straight line

Sensor Characteristics (Contd.)

- Drift
  - The difference in the measurements of sensor from a specific reading when kept at that value for a long period of time
- Repeatability
  - The deviation between measurements in a sequence under same conditions

Source : “Sensor”, Hong Kong University of Science and Technology, online: https://ielm.ust.hk/dfaculty/ajay/courses/alp/ieem110/lecs/sensors/sensors.html
Source: “Repeatability”, MIT, Online: https://ocw.mit.edu/courses/mechanical-engineering/2-693-principles-of-oceanographic-instrument-systems-sensors-and-measurements-13-998-spring-2004/

Dynamic Characteristics

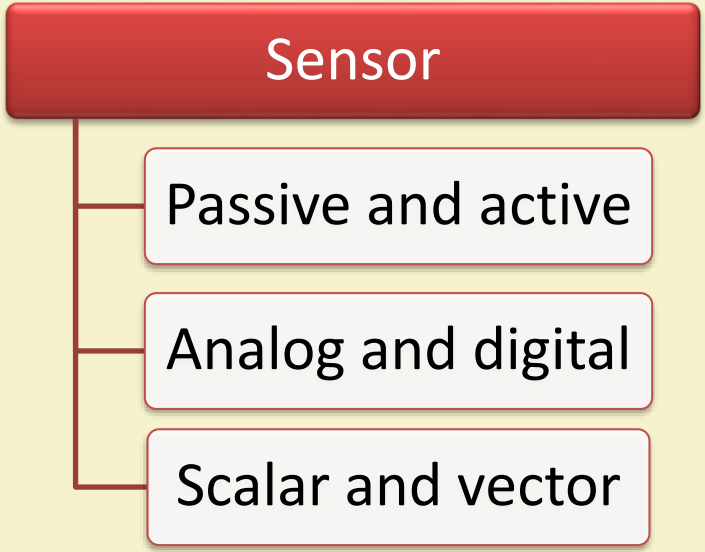
How well a sensor responds to changes in its input

- Zero order system
  - Output shows a response to the input signal with no delay
  - Does not include energy-storing elements
  - Example: Potentiometer measures linear and rotary displacements

Dynamic Characteristics (Contd.)

- First order system
  - When the output approaches its final value gradually
  - Consists of an energy storage and dissipation element
- Second order system
  - Complex output response
  - The output response of sensor oscillates before steady state

Sensor Classification



Passive Sensor

- Cannot independently sense the input
- Example: Accelerometer, soil moisture, water-level, and temperature sensors

Active Sensor

- Independently sense the input
- Example: Radar, sounder, and laser altimeter sensors

Analog Sensor

- The response or output of the sensor is some continuous function of its input parameter
  - Example: Temperature sensor, LDR, analog pressure sensor, and Analog Hall effect/Magnetic Sensor
    - A LDR shows continuous variation in its resistance as a function of intensity of light falling on it

Digital Sensor

- Responses in binary nature
- Designs to overcome the disadvantages of analog sensors
- Along with the analog sensor it also comprises of extra electronics for bit conversion
- Example: Passive infrared (PIR) sensor and digital temperature sensor (DS1620)

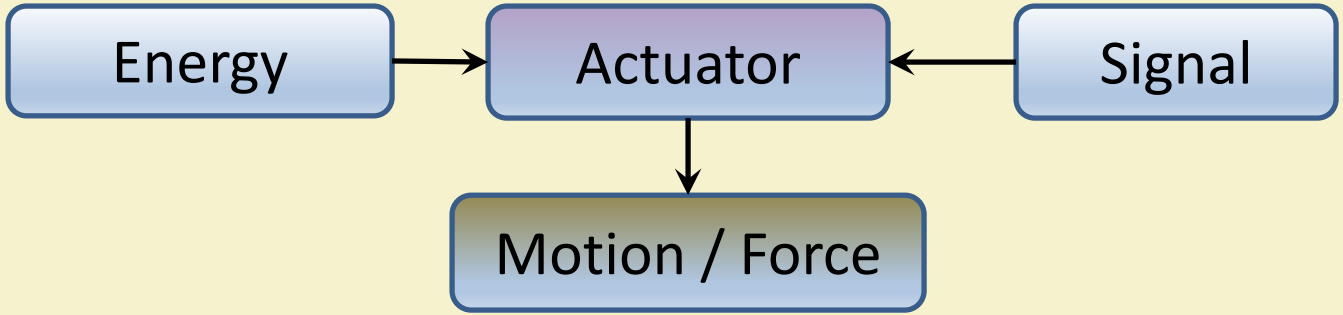
Scalar Sensor

- Detects the input parameter only based on its magnitude
- The response of the sensor is a function of magnitude of the input parameter
- Not affected by the direction of the input parameter
- Example: Temperature, gas, strain, color, and smoke sensors

Vector Sensor

- The response of the sensor depends on the magnitude of the direction and orientation of input parameter
- Example : Accelerometer, gyroscope, magnetic field, and motion detector sensors

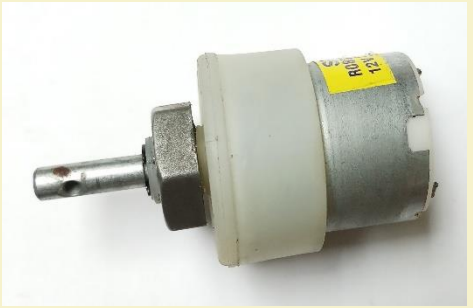
Actuator



- An actuator is part of the system that deals with the control action required (mechanical action)
- Mechanical or electro-mechanical devices

Actuator (Contd.)

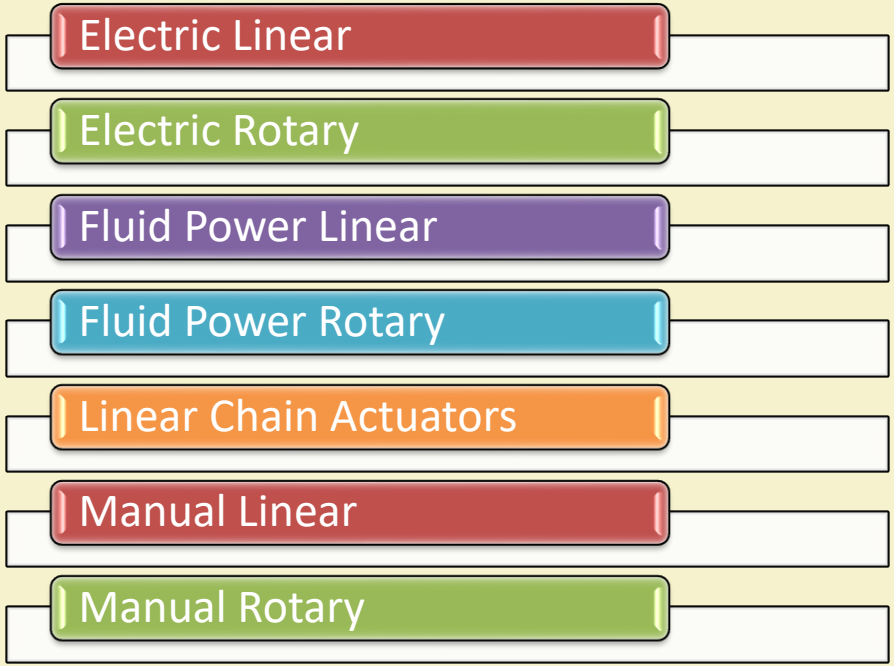
- A control signal is input to an actuator and an energy source is necessary for its operation
- Available in both micro and macro scales
- Example: Electric motor, solenoid, hard drive stepper motor, comb drive, hydraulic cylinder, piezoelectric actuator, and pneumatic actuator



DC Motor

Relay

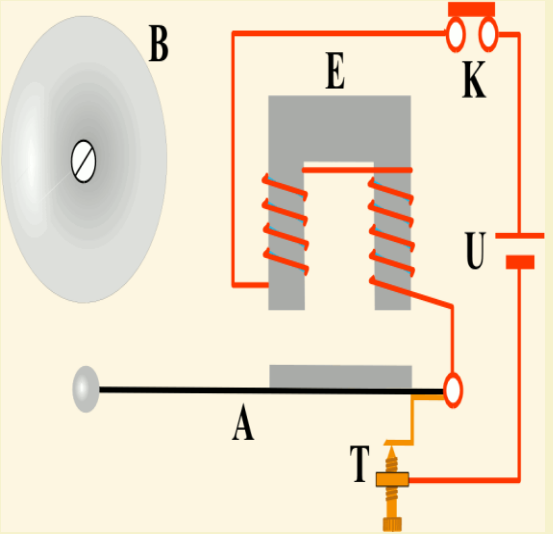
Classification of Actuators



Source : “Classification of actuators” Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

Electric Linear Actuator

- Powered by electrical signal
- Mechanical device containing linear guides, motors, and drive mechanisms
- Converts electrical energy into linear displacement
- Used in automation applications including electrical bell, opening and closing dampers, locking doors, and braking machine motions

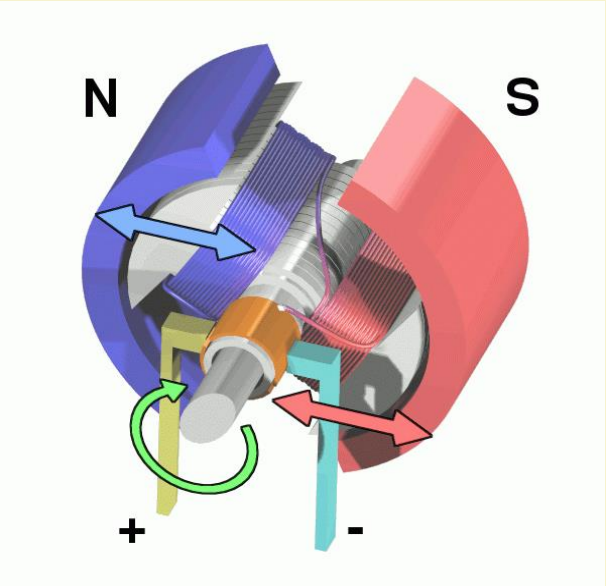


Source: "Electric bell", ЮК/ Wikimedia Commons/, Published date: 18 February 2008, Online: https://commons.wikimedia.org/wiki/File:Electric_Bell_animation.gif

Source: "Classification of actuators" Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

Electric Rotary Actuator

- Powered by electrical signal
- Converts electrical energy into rotational motion
- Applications including quarter-turn valves, windows, and robotics



Source: "Electric motor", Abnormaal / Wikimedia Commons / CC-BY-SA-3.0 Unported/ GFDL. Published date: 21 May 2008, Online: https://commons.wikimedia.org/wiki/File:Electric_motor.gif

Source: "Classification of actuators" Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

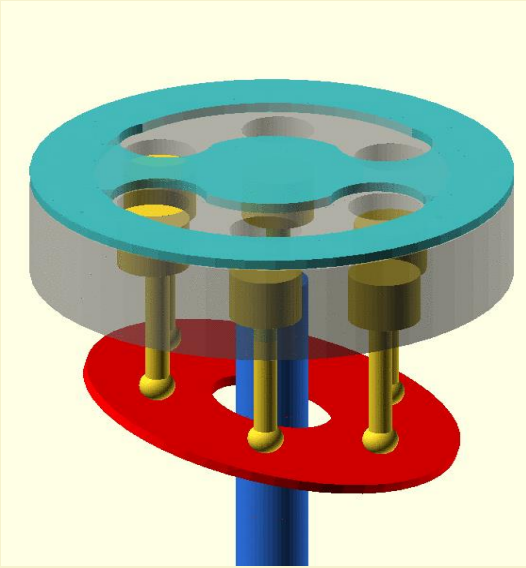
Fluid Power Linear Actuator

- Powered by hydraulic fluid, gas, or differential air pressure
- Mechanical devices have cylinder and piston mechanisms
- Produces linear displacement
- Primarily used in automation applications including clamping and welding

Source : “Classification of actuators” Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

Fluid Power Rotary Actuator

- Powered by fluid, gas, or differential air pressure
- Consisting of gearing, and cylinder and piston mechanisms
- Converts hydraulic fluid, gas, or differential air pressure into rotational motion
- Primarily applications of this actuator are opening and closing dampers, doors, and clamping

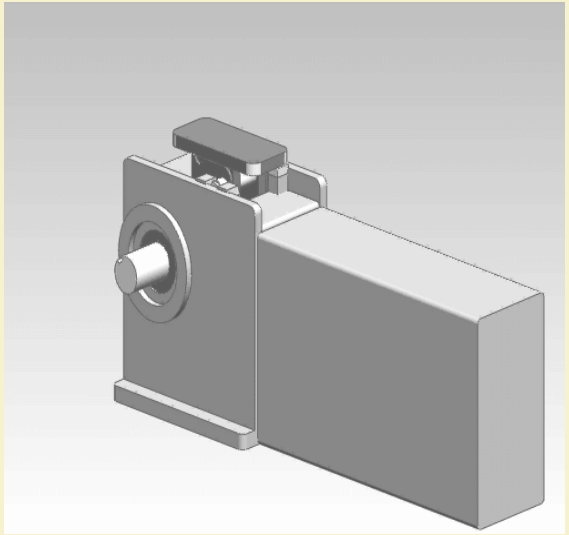


Source: "Axial piston pump", MichaelFrey / Wikimedia Commons / CC-BY-SA-4.0 International/. Published date: 11 August 2017, Online: https://commons.wikimedia.org/wiki/File:Axialkolbenpumpe_-_einfache_Animation.gif

Source: "Classification of actuators" Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

Linear Chain Actuator

- Mechanical devices containing sprockets and sections of chain
- Provides linear motion by the free ends of the specially designed chains
- Primarily used in motion control applications



Source: "Rigid chain actuator", Catsquisher/ Wikimedia Commons/, Published date: 11 January 2011, Online: https://commons.wikimedia.org/wiki/File:Rigid_Chain_Actuator.gif

Source: "Classification of actuators" Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

Manual Linear Actuator

- Provides linear displacement through the translation of manually rotated screws or gears
- Consists of gearboxes, and hand operated knobs or wheels
- Primarily used for manipulating tools and workpieces

Source: “Classification of actuators” Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

Manual Rotary Actuator

- Provides rotary output through the translation of manually rotated screws, levers, or gears
- Consists of hand operated knobs, levers, handwheels, and gearboxes
- Primarily used for the operation of valves

Source: “Classification of actuators” Online: https://www.thomasnet.com/articles/pumps-valves-accessories/types-of-actuators

References

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6. “Axial piston pump”, MichaelFrey / Wikimedia Commons / CC-BY-SA-4.0 International/, Published date: 11 August 2017, Online: https://commons.wikimedia.org/wiki/File:Axialkolbenpumpe_-_einfache_Animation.gif
7. “Rigid chain actuator”, Catsquisher/ Wikimedia Commons/, Published date: 11 January 2011, Online: https://commons.wikimedia.org/wiki/File:Rigid_Chain_Actuator.gif

Thank You!!