INTERNET OF THINGS

UNIT – 2

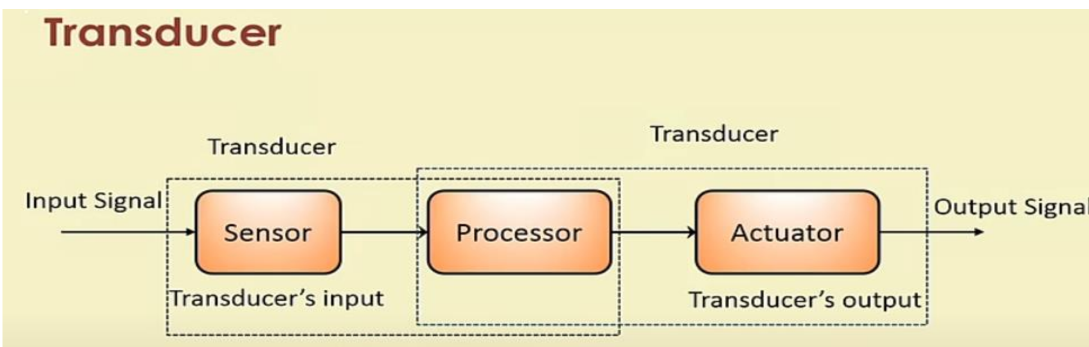
INTRODUCTION TO SENSORS

A significant portion of IoT applications revolves around sensing in various forms. Whether it's consumer IoT, industrial IoT, or hobby-based deployments, sensing marks the initial step, while actuation signifies the final stage in the operation of IoT application deployment.

The basic science of sensing and actuation is based on the process of transduction.

Transduction is the process of energy conversion from one form to another. A transducer is a physical means of enabling transduction.

Transducers take energy in any form electrical, mechanical,chemical, light, sound, and convert it into another, which may be electrical, mechanical, chemical, light, sound, and others.

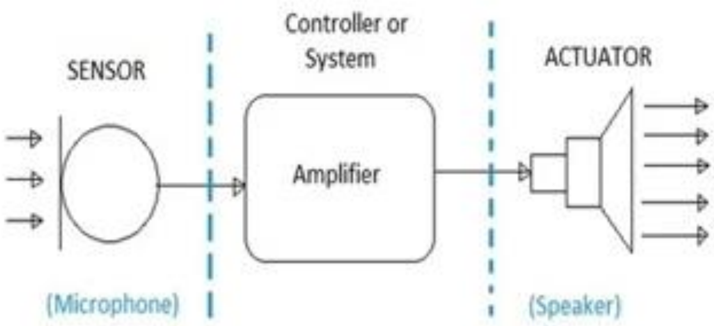


Sensors plus processor will basically process the input that is coming from these sensors is a transducer similarly actuator plus processor is also a transducer.

As you can see the transducer and sensor inside it takes some input signal and produces certain output which will be processed further and based on the processed data there will be something that will be actuated

so all through out we can see there is some kind of energy transforming happening and the actuator produces certain output so this is how sensors or actuator as a transducer work.

Sensors and actuators function as transducers. In a public announcement system, a microphone converts sound waves into electrical signals, which are then amplified by an amplifier system. Finally, a loudspeaker converts the amplified electrical signals back into sound waves.



DIFFERENT TYPES OF SENSORS

Differences between transducers, sensors, and actuators.

Parameters	Transducers	Sensors	Actuators
Definition	Converts energy from one form to another	Converts various forms of energy into electrical signals.	Converts electrical signals into various forms of energy, typically mechanical energy
Domain	Can be used to represent a sensor as well as an actuator.	It is an input transducer.	It is an output transducer.
Function	Can work as a sensor or an actuator but not simultaneously	Used for quantifying environmental stimuli into signals.	Used for converting signals into proportional mechanical orelectrical outputs
Examples	Any sensor or actuator	Humidity sensors, Temperature sensors, Anemometers Manometers , Accelerometers ,Gas sensors and others	Motors , Force heads

Sensors

A sensor is a device that measures physical input from its environment and convert it into data that can be interpreted by either a human or machine.

Sensors can measure, quantify, or respond to the ambient changes in their environment or within the intended zone of their deployment.

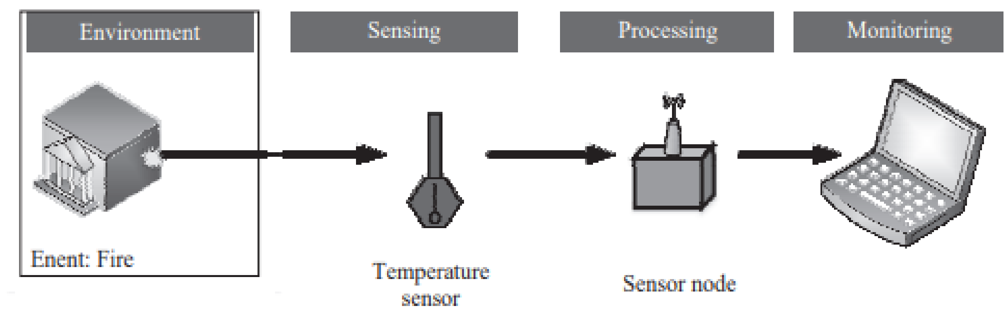
They generate responses to external stimuli and convert into typically electrical signals.

For example, heat is converted to electrical signals in a temperature sensor, or atmospheric pressure is converted to electrical signals in a barometer

A sensor detects only its designated property, like a temperature sensor sensing room temperature, and remains unaffected by other properties like light or pressure. measuring temperature doesn't change the temperature itself.

In the figure below a temperature sensor keeps on checking an environment for changes. In the event of a fire, the temperature of the environment goes up.

The temperature sensor notices this change in the temperature of the room and promptly communicates this information to a remote monitor via the processor.



The various sensors can be classified based on: 1) power requirements 2) sensor output and 3) property to be measured.

Power Requirements: The way sensors operate decides the power requirements that must be provided for an IoT implementation.

Some sensors need to be provided with separate power sources for them to function, whereas some sensors do not require any power sources.

Depending on the requirements of power, sensors can be of two types.

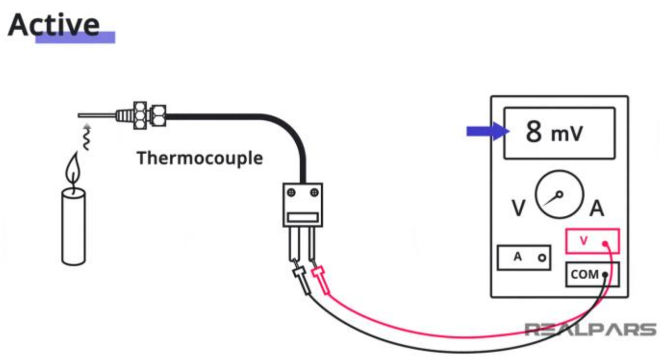
Active sensors: An active sensor is one which transmits a signal into the environment and then measures the response that comes back.

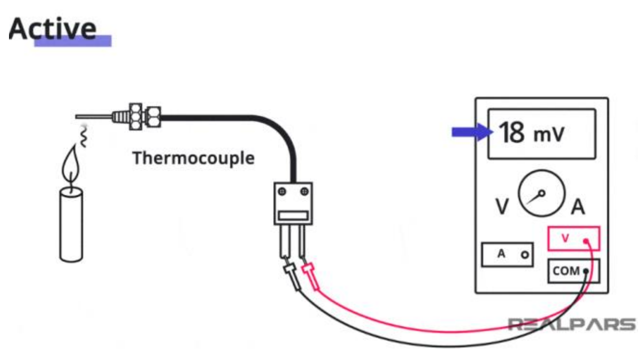
Active sensors do not require an external circuitry or mechanism to provide it with power. It directly responds to the external stimuli from its ambient environment and converts it into an output signal.

Example: ultrasonic system

A pulse of ultrasound is emitted
If an object is in the way, the pulse is reflected back
The sensor detects it
The time taken between emission and detection gives an indication of the distance of the object.

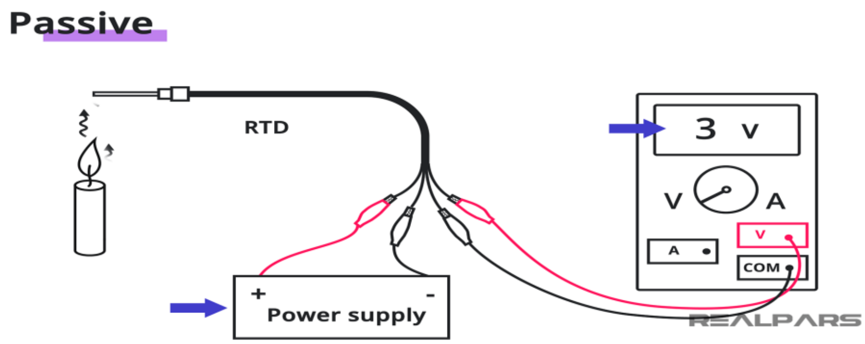
As a thermocouple is exposed to an increase in temperature, it will develop an increasing voltage across it.





Passive sensors: A passive sensor is one which just ‘listens’ to what is happening.

Passive sensors require an external mechanism to power them up. The sensed properties are modulated with the sensor’s inherent characteristics to generate patterns in the output of the sensor.
Examples:
A light sensor which detects if a light is shining on it
An infra-red sensor which detects the temperature of an object
A Resistance Temperature Detector It is a device that’s resistance will change with a change in temperature.



Sensor Output: The output of a sensor helps in deciding the additional components to be integrated with an IoT node or system.

Sensors are broadly divided into two types, depending on the type of output generated from these sensors, as follows.

Analog sensors: measure the external parameters and give an analog voltage as an output. They produce a continuous output sA thermometer is a scalar sensor unaffected by changes in orientation, capable of detecting temperature changes.

Vector: A vector quantity is described by a number, a unit, and a direction.

Vector sensors are affected by the magnitude as well as the direction and/or orientation of the property they are measuring.

Ex: an electronic gyroscope, which is commonly found in all modern aircraft, is used for detecting the changes in orientation of the gyroscope with respect to the Earth's orientation along all three axes.

signal or voltage which is proportional to the quantity being measured. The output voltage may be from the range of 0 to 5V

Physical quantities such as temperature, speed, pressure, displacement, strain, and others are all continuous and categorized as analog quantities.

For example, a thermometer can be used for measuring the temperature of a liquid . These sensors continuously respond toc changes in the temperature of the liquid (e.g., in household water heaters)

Digital sensors : act as electronic sensors where data is digitally converted and transmitted. Digital sensors produce discrete values (0s and 1s) or ‘binary’ signals.

Typically, binary output signals in the form of a logic 1 or a logic 0 for ON or OFF, respectively are associated with digital sensors.

Measured Property: The property of the environment being measured by the sensors can be crucial in deciding the number of sensors in an IoT implementation.

Sensor needs vary depending on whether the property being measured primarily changes over time, like temperature and pressure, or both spatially and temporally, like sound and image.

Depending on the properties to be measured, sensors can be of two types

Scalar: Are used to describe the motion of an object.
Scalar sensors produce an output proportional to the magnitude of the quantity being measured. The output is in the form of a signal or voltage.

Scalar physical quantities like color, pressure, temperature, and strain only require the magnitude of the signal for description.

A thermometer is a scalar sensor unaffected by changes in orientation, capable of detecting temperature changes.

Vector: A vector quantity is described by a number, a unit, and a direction.

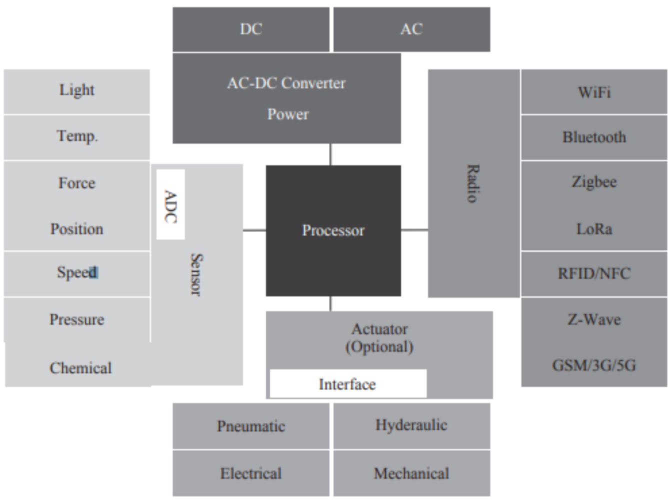
Vector sensors are affected by the magnitude as well as the direction and/or orientation of the property they are measuring.

Ex: an electronic gyroscope, which is commonly found in all modern aircraft, is used for detecting the changes in orientation of the gyroscope with respect to the Earth’s orientation along all three axes.

INTERNET OF THINGS

UNIT – 2

FUNCTIONAL BLOCKS OF A TYPICAL SENSOR NODE



A sensor node is made up of four components are

- Sensing unit
- Processor unit
- Communication unit(Radio unit).
- Power unit

A wireless sensor networks consists of sensor nodes that are deployed in high density and often in large quantities and support sensing, data processing, embedded, computing and connectivity

A sensor node is made up of four components power unit, sensor/sensors, a processor unit and communication unit(Radio unit).

Sensing Unit: the sensor collects data from physical world and an ADC converts this digital data. Then this digital data /signal are feed into processing unit.

Processing Unit: the main processing unit which is usually a microprocessor or a microcontroller, performs an intelligent data processing and manipulation. It is general associated with a small storage unit

Communication (radio unit): it connects the node to the network. This unit consists of radio system usually a short range radio for data transmission and reception

Power Unit: As all components are low level devices a small battery like CR-2302 is used to power the entire system. A sensor node can be equipped with limited power sources (< 0.5 Ah, 1.2 V)

The nodes are capable of sensing the environment they are set to measure and communicate the information to other sensor nodes or a remote server.

A sensor node should have low-power requirements and be wireless. This enables them to be deployed in a vast range of scenarios and environments without the constant need for changing their power sources or managing wires.

The wireless nature of sensor nodes would also allow them to be freely relocatable and deployed in large numbers without bothering about managing wires.

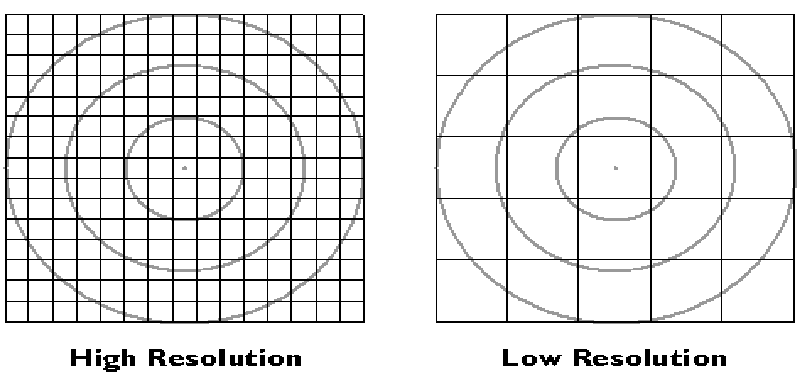
SENSOR CHARACTERISTICS

All sensors can be defined by their ability to measure or capture a certain phenomenon and report them as output signals to various other systems.

sensors can be characterized by their ability to sense the phenomenon based on the following three fundamental properties

Sensor Resolution: Smallest change in measurable quantity that a sensor can detect. especially in digital sensors . Higher resolution means more precise measurements, but accuracy isn't directly linked to resolution.

For example, a temperature sensor A can detect up to 0.5◦ C changes in temperature; where as another sensor B can detect up to 0.25◦ C changes in temperature. Therefore, the resolution of sensor B is higher than the resolution of sensor A.

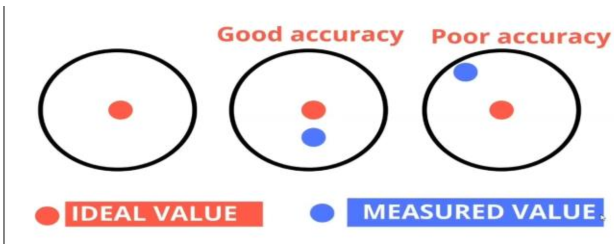


Higher pixel value will give high clarity as the image has more divisions for different values.

Lower pixel value will give Low clarity as the image has lesser divisions for different values.

Sensor Accuracy: The accuracy of a sensor is the ability of that sensor to measure the environment of a system as close to its true measure as possible.

For example, a weight sensor detects the weight of a 100 kg mass as 99.98 kg. We can say that this sensor is 99.98% accurate, with an error rate of ±0.02%.



Sensor Precision: The principle of repeatability governs the precision of a sensor. Only if, upon multiple repetitions, the sensor is found to have the same error rate, can it be deemed as highly precise.

Ex: consider upon three repeat measurements for a mass of actual weight of 100 kg.

sensor gives these values 98.28 kg, 100.34 kg, and 101.11 kg The weight sensor's precision is considered low because it shows significant variations in repeated measurements of the same object under identical conditions.

SENSORIAL DEVATIONS

The various sensorial deviations that are considered as errors in sensors.

In IoT, many sensor functions are non-critical, meaning slight sensor output variations rarely affect tasks significantly.

Yet, critical IoT applications like healthcare and industrial monitoring demand sensors with precise measurement abilities. The quality of sensor measurements depends on numerous factors, necessitating key considerations for critical

Drift: If the output signal of a sensor changes slowly and independently of the measured property. Ex: Noise is the temporary varying random deviation of signals.

Offset Error or Bias: If the output of the senor differs from the actual value to be measured by a constant.

Ex: when measuring an actual temperature of 0 degree Celsius, A temperature sensor outputs 1.1 degree Celsius every time you measure you get same 1.1 degree Celsius so this deviation is called offset error.

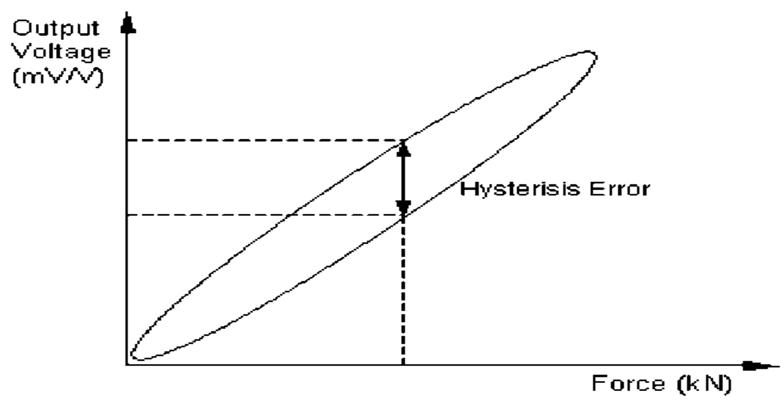
Sensitivity error: Ever sensor have fixed value maximum and maximum that will be fixed Ex: Temperature sensor values are 0 degree Celsius minimum value and 35 degrees as a maximum value.

If a sensor's output exceeds its designed limits, it's set to the maximum or minimum value. The range between a sensor's minimum and maximum values is called its full-scale range. In real conditions, sensor sensitivity may vary from the specified value, causing sensitivity errors.

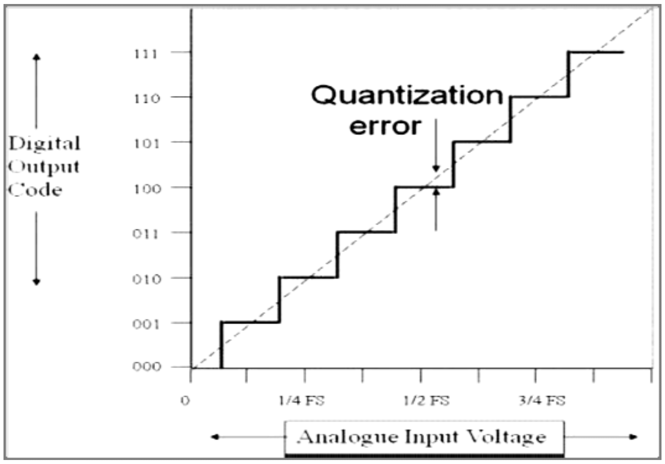
Some sensors don't follow a straight line in their performance; this is called non-linearity. Most sensors behave linearly.

Hysteresis error : occurs when a sensor's output shifts due to previous input alterations. It's often seen in analog and magnetic sensors, and even in heated metal strips.

To assess hysteresis, we observe how the sensor's output fluctuates as we raise and lower input values across its entire range. This variation is usually quantified as positive and negative percentages of the sensor's full range.

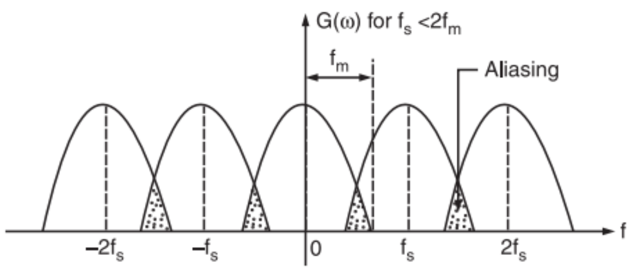


Quantization error: In digital sensors, when the digital output approximates the measured property, it creates quantization error. If I get 98 as temperature I say as 100 that is we sample the error.



<u>Analog-to-Digital conversion:</u> This error is the difference between the actual analog signal and its nearest digital approximation during analog-to-digital conversion sampling

<u>Aliasing:</u> Mishandling sampling frequencies can cause dynamic errors leading to aliasing. Aliasing occurs when signals of different frequencies are mistaken for a single signal due to incorrect sampling frequency, making the input signal a multiple of the sampling rate.



The environment is important for sensor accuracy, as external factors can affect sensor readings. Sensors may be sensitive to influences not directly related to the property they measure, causing output deviations. For instance, semiconductor-based sensors are influenced by environmental temperature.

Sensing Types

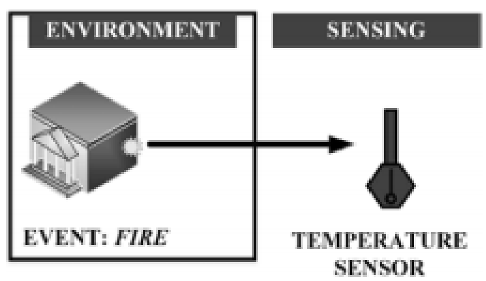
Sensing can be broadly divided into four different categories based on the natureof the environment being sensed and the physical sensors being used to do so

1) scalar sensing,
2) multimedia sensing,
3) hybrid sensing, and
4) virtual sensing

Scalar sensing

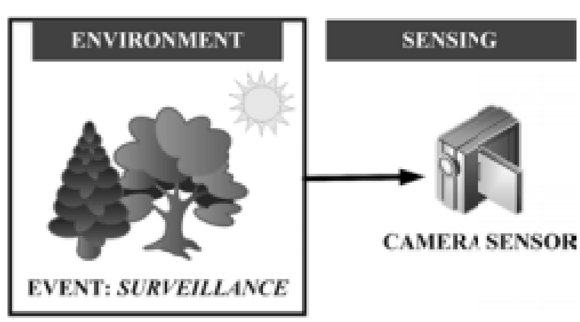
Scalar sensing means measuring changes in values over time to understand features better. It applies to quantities like temperature, current, pressure, rainfall, light, humidity, and flux, which typically lack directional or spatial properties

Scalar sensors measure these changes over time, providing information about these quantities without spatial considerations.



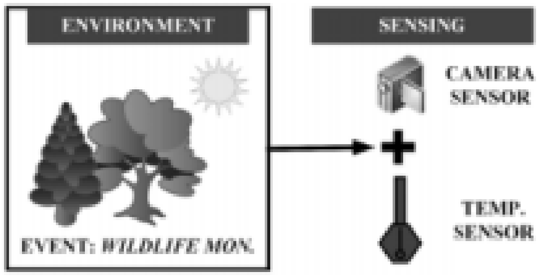
Multimedia sensing

Multimedia sensing detects features with spatial and temporal changes, unlike scalar sensors. Quantities such as images, direction, flow, speed, acceleration, sound, force, mass, energy, and momentum have magnitude and direction, following vector addition laws, and can vary in different directions simultaneously.
Sensors for these measurements are known as vector sensors.



Hybrid sensing

The act of using scalar as well as multimedia sensing at the same time is referred to as hybrid sensing.



Many a time, there is a need to measure certain vector as well as scalar properties of an environment at the same time. Under these conditions, a range of various sensors are to measure the various properties of that environment at any instant of time, and temporally map the collected information to generate new information.

In a farm field, we use sensors underground to check if plants have enough water and the right soil temperature. But there are many other things that can affect plant health besides just water.

The additional inclusion of a camera sensor with the plant may be able to determine the actual condition of a plant by additionally determining the color of leaves.

Example: where a camera and a temperature sensor are collectively used to detect and confirm forest fires during wildlife monitoring
other examples are smart traffic management system etc

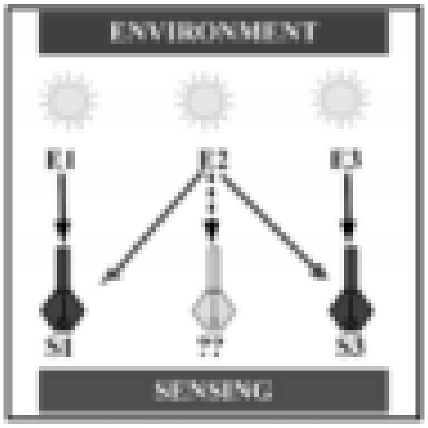
Virtual Sensing

In agriculture, sensors are often spread widely to monitor soil conditions like moisture and temperature. If farmer A installs sensors, they can likely give accurate readings for farmer B's nearby fields because the conditions don't vary much between them.

Exploiting this property, if the data from A’s field is digitized using an IoT infrastructure and this system advises him regarding the appropriate watering, fertilizer, and pesticide regimen for his crops, this advisory can also be used by B for maintaining his crops.

In short, A ’s sensors are being used for actual measurement of parameters; whereas virtual data (which does not have actual physical sensors but uses extrapolation-based measurements) is being used for advising B. This is the virtual sensing paradigm.

Two temperature sensors S1 and S3 monitor three nearby events E1, E2, and E3 (fires). The event E2 does not have a dedicated sensor for monitoring it; however, through the superposition of readings from sensors S1 and S3, the presence of fire in E2 is inferred.



IV. Sensor Considerations

The choice of sensors in an IoT sensor node is critical and can either make or break the feasibility of an IoT deployment.
The following major factors influence the choice of sensors in IoT-based sensing solutions:

1) sensing range
2) accuracy and precision,
3) energy and
4) device size.

Service range: The sensing range of a sensor node defines the detection fidelity of that node. (or) The detection accuracy of a sensor node depends on its sensing range.

Typical approaches to optimize the sensing range in deployments include fixed k-coverage and dynamic k-coverage.

A lifelong fixed k-coverage tends to user in redundancy as it requires a large number of sensor nodes, the sensing range of some of which may also overlap.

dynamic k coverage incorporates mobile sensor nodes post detection of an event, which, however, is a costly solution and may not be deployable in all operational areas

Ex: A proximity sensor has a typical sensing range of a couple of meters. In contrast, a camera has a sensing range varying between tens of meters to hundreds of meters.

As the complexity of the sensor and its sensing range goes up, its cost significantly increases.

Accuracy and Precision: The accuracy and precision of measurements providedby a sensor are critical in deciding the operations of specific functional processes.

Off-the-shelf consumer sensors are cheap but lack precision, suitable only for basic applications.
Industrial sensors, though expensive, offer high accuracy and precision, making them ideal for demanding

conditions.

Energy: The energy consumption of a sensing solution determines its lifespan and deployment cost. If sensor nodes are energy inefficient, maintenance becomes costly and deployment infeasible, especially in remote locations like glaciers where access is limited and recharging or changing energy sources isn't possible.

Device Size: In modern IoT applications, small sensing solutions are preferred to avoid disruption to regular activities. Larger sensor nodes increase costs and energy needs, reducing demand. Wearable sensors gained popularity due to their small size, energy efficiency, and integration into everyday attire.

DHT22:

- Temperature: A measure of the warmth or coldness of an object or substance with reference to some standard value.

- Humidity: A quantity representing the amount of water vapour in the atmosphere.

DHT22: Digital Humidity Temperature Sensor

The DHT-22 (also named as AM2302) is a digital-output relative humidity and temperature sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin.

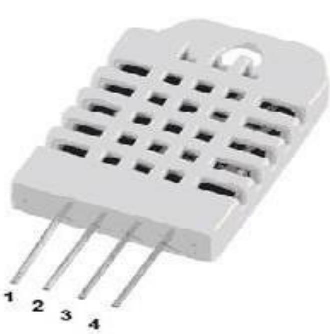
Features

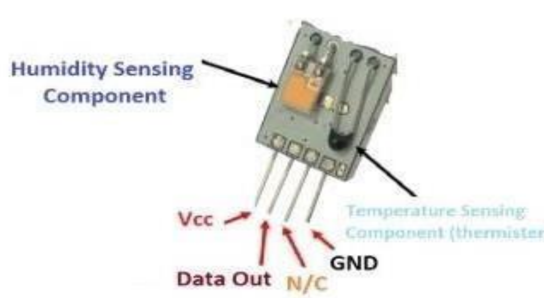
- The range of operating voltage is 3 V to 5 V power.
- It measures temperature in a range of $-4^{0}0$ C to $+125^{0}$Cwith an accuracy of +/- 0.5 degrees.
- The measuring range for humidity is from 0 to 100% with an accuracy of 2-5%.
- The maximum operating current for DHT22 sensor is 2.5mA.
- The sampling rate for DHT22 sensor is 0.5 Hz. It takes measurement once every 2 seconds.

Pin Description

- The DHT22 sensor is very simple and easy to use. It has only 4 pins.
- **Vcc:** is the power pin. Apply voltage in a range of 3.5 V to 5.0 V at thus pin.
- **Data Out:** is the digital output pin. It sends out the value of measured temperature and humidity in the form of serial data.
- **N/C:** is a not connected pin.
- **GND:** connect the GND pin to main ground.

DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND





DHT22 Working

Consists of two electrodes in between two electrodes you have substrate which is used to hold moisture or humidity.

If humidity or moisture changes the conductivity of substrate also changes or the resistance between two electrode changes. the change in the ressitance is measured and processed by the IC (8-bit micro controller).

It also consists of a thermistor which is a variable resistor that changes in resistance with respect to temperature. these are are made up of ceramics and poly ceramics, in order to provide larger changes in the resistance by just small changes in the temperature we added these ceramics.

Applications
fuel management, chemical management, weather stations

PIR SENSOR

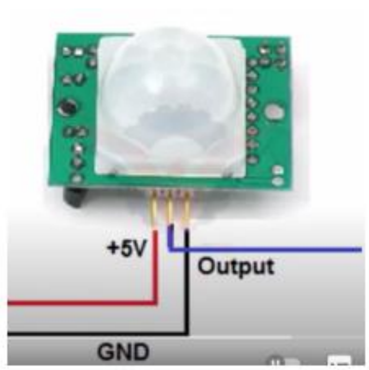
- A passive infrared sensor is a electronic sensor thst measures infrared light radiant from objects in its field of view.
- PIR sensors are commonly used in security alarms and automatic lighting applications.
- PIR sensors detect general movement, but do not give information on who or what moved.

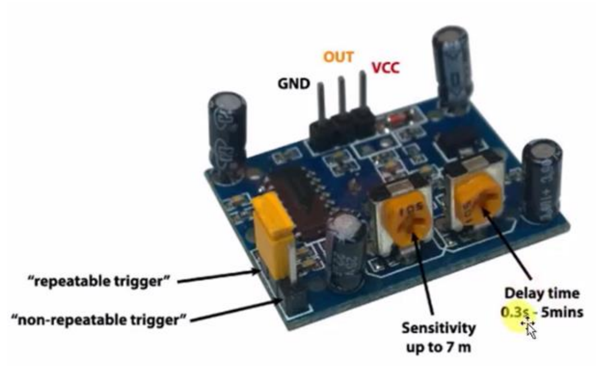
Pin Description

Pin 1 corresponding to the drain terminal of the device, which connected to the positive supply 5V DC.

Pin 2 corresponds to the source terminal of the device, which connects to the ground terminal via a 100K or 47K resistor. The pin2 is the output of the sensor.

Pin3 of the sensor connected to the ground.





PIR Working

There are two potentiometers one is delay and another one is sensitivity.

Delay: You have the flexibility to configure the duration for which you wish to receive the output, ranging from 0.3 seconds to 5 minutes.

Sensitivity: You have the ability to adjust the detection range of the object, with the option to set it up to 7 meters.

When the jumper is set to low, the output will be triggered once, and then the sensor will be deactivated.

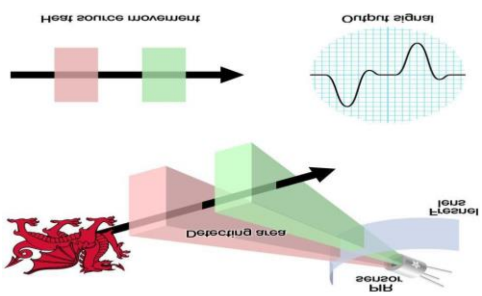
When the jumper is set to high, you'll receive repetitive output corresponding to the fixed time interval you've set.

The PIR sensor itself has two slots in it, each slot is made of a special material that is sensitive to IR.

When the sensor is idle, both slots detect the same amount of IR. The ambient amount radiated from the room or walls or outdoors.

When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves.

When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected.



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UNIT – 2

Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal.

The HC-SR04 is a type of ultrasonic sensor which uses sonar to find out the distance of the object from the sensor.

It provides an outstanding range of non-contact detection with high accuracy & stable readings.

It includes two modules like ultrasonic transmitter & receiver.

This sensor is used in a variety of applications like measurement of direction and speed, burglar alarms, medical, sonar, humidifiers, wireless charging, non-destructive testing, and ultrasonography.

HC-SR04 Ultrasonic Sensor Pin Configuration

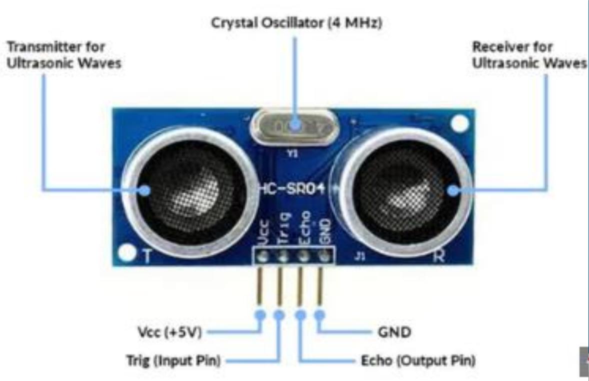
This sensor includes four pins and the pin configuration of this sensor is discussed below.

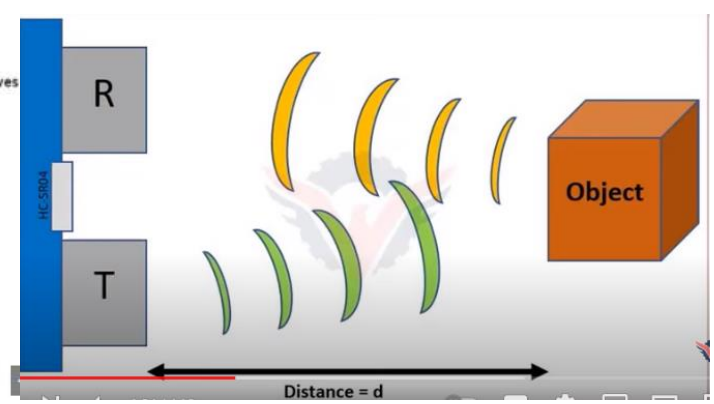
Pin1 (Vcc): This pin provides a +5V power supply to the sensor.

Pin2 (Trigger): This is an input pin, used to initialize measurement by transmitting ultrasonic waves by keeping this pin high for 10us.

Pin3 (Echo): This is an output pin, which goes high for a specific time period and it will be equivalent to the duration of the time for the wave to return back to the sensor.

Pin4 (Ground): This is a GND pin used to connect to the GND of the system.





Features:

The power supply used for this sensor is +5V DC

Dimension is 45mm x 20mm x 15mm

Quiescent current used for this sensor is <2mA

The input pulse width of trigger is10uS

Operating current is 15mA

Measuring angle is 30 degrees

The distance range is 2cm to 800 cm

Resolution is 0.3 cm

Effectual Angle is <15°

Operating frequency range is 40Hz

Accuracy is 3mm

Description

The HC-SR04 Ultrasonic sensor comes with four pins namely Vcc pin, Trigger pin, Echo pin, & Ground pin. This sensor is used to measure the accurate distance between the target and the sensor. This sensor mostly works on the sound waves.

When the power supply is given to this module, it generates the sound waves to travel throughout the air to hit the necessary object. These waves strike and come back from the object, then collects by the receiver module.

Here both the distance as well as time has taken is directly proportional because the time taken for more distance is high. If the trigger pin is kept high for 10 µs, then the ultrasonic waves will be generated which will travel at the sound speed. So it creates eight cycles of sonic burst that will be gathered within the Echo pin. This ultrasonic sensor is interfaced with Arduino to gauge the necessary distance between sensor & object. The distance can be calculated using the following formula.

$S = (V \times t)/2$

Where the ‘S’ is the required distance

‘V’ is the sound’s speed

‘t’ is the time taken for sound waves to return back after striking the object.

The actual distance can be calculated by dividing its value with 2 as the time will be twice once the waves travel and get back from the sensor.

Applications:

The applications of HC-SR04 sensor include the following,

This sensor is used to measure speed as well as the direction between two objects

It is used in wireless charging

Medical ultrasonography his is used to detect objects & avoid obstacles using robots such as biped, path finding, obstacle avoidance, etc.

Depth measurement

Humidifiers

This sensor is used to plot the objects nearby the sensor by revolving it

Non-destructive testing

By using this sensor depth of pits, wells can be measured by transmitting the waves through water.

Embedded system

Burglar alarms

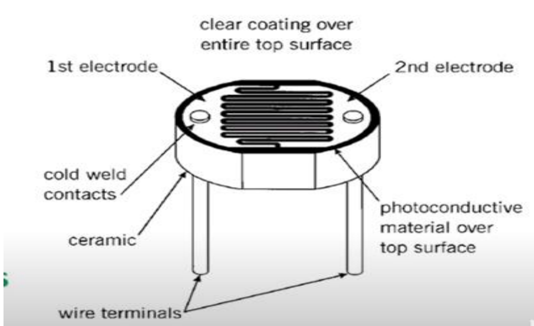
LDR (Light Dependent Resistor)

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation.

LDRs are light sensitive devices also called as photo conductors, photo conductive cells or simply photocells.

LDR are made up of semiconductor materials to enable them to have their light sensitive properties.

The popular material used for these photoresistors is cadmium sulphide.

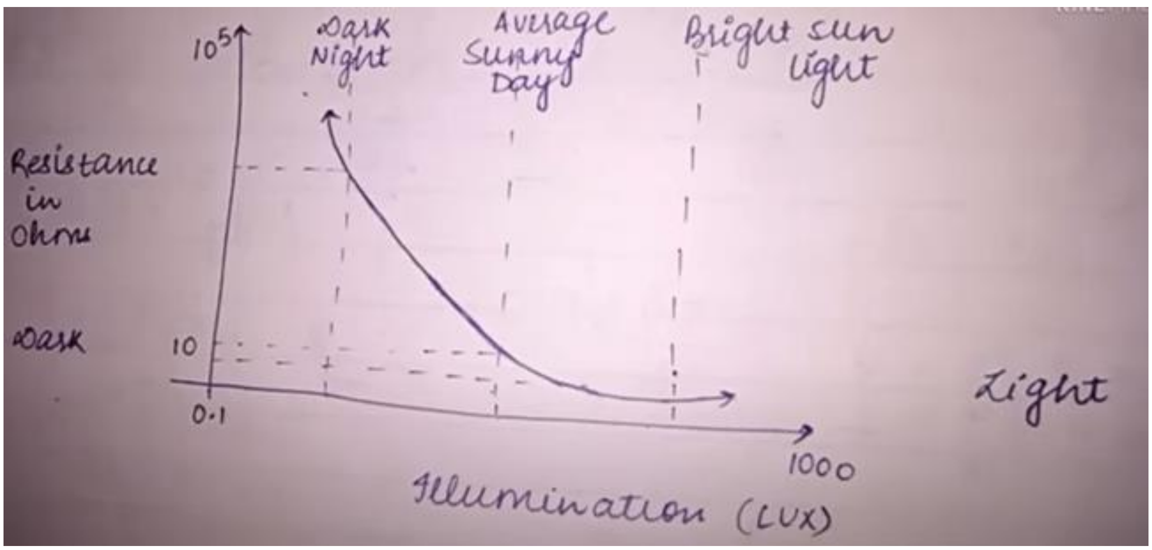


Description:

An LDR or photoresistor is made of semiconductor with a high resistance, it has a high resistance because their are few electrons that are free and able to move the vast majority of the electrons are locked into the crystal lattice and unable to move. therfore in this state there is high resistance.

As light falls on the semiconductor the light photons are absorbed by the semiconductor lattice and some of their energy is transffered to the electrons. this is some of them sufficient energy to break free from the crystal lattice so that they can conduct electicity.

As more and more light shines on the LDR semiconductor more elctrons are released to conduct electricity and the resistance falls further.



Applications

Street lights

Alarm clocks and many more.

INTERNET OF THINGS

UNIT – 2

ACTUATOR

An autator is a component of a machine or system that moves or controls the mechanism or the system.

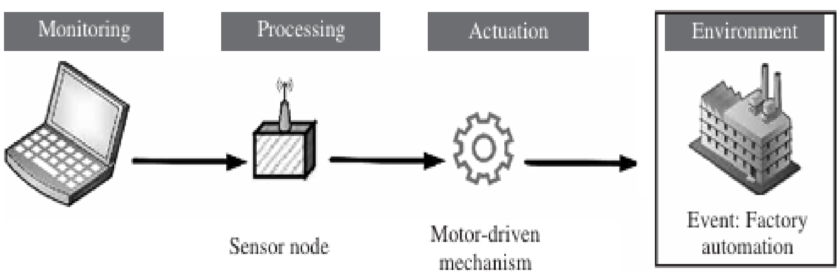
A actuator is a device which takes input as electrical signal or energy and produces physical phenomenon like force or motion

In general Actuators are used as output devices to produce any physical phenomenon

Actuators requires a control signal and a source of energy.

A control system can be simple(mechnical or electronic system, software based, human or a robot.

Examples of actuators are solenoids, electric motors, hydralic and pneumatic cyclinders and motors.



A remote user sends commands to a processor. The processor instructs a motor controlled robotic arm to perform the commanded tasks accordingly.

The processor is primarily responsible for converting the human commands into sequential machine-language command sequences, which enables the robot to move.

The robotic arm finally moves the designated boxes, which was its assigned task.

ACTUATOR TYPES

1) Hydraulic
2) pneumatic
3) electrical
4) thermal/magnetic
5) mechanical
6) soft and
7) shape memory polymers you also have Linaer and Rotatory types of actuators.

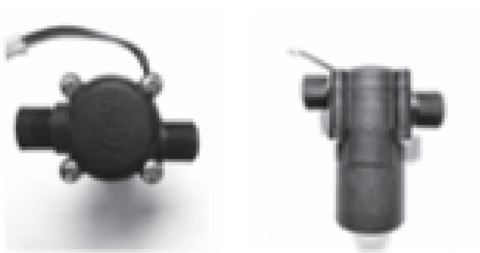
Hydraulic actuators

A hydraulic actuator works on the principle of compression and decompression of fluids.

These actuators facilitate mechanical tasks such as lifting loads through the use of hydraulic power derived from fluids in cylinders or fluid motors.

The mechanical motion applied to a hydraulic actuator is converted to either linear, rotary, or oscillatory motion.

They use hydraulic fuel as a driving force.



Hydralic generators

Pneumatic actuators

A pneumatic actuator works on the principle of compression and decompression of gases.

These actuators use a vacuum or compressed air at high pressure and convert it into either linear or rotary motion.

Pneumatic rack and pinion actuators are commonly used for valve controls of water pipes.

Pneumatic actuators are considered as compliant systems.

The actuators use pneumatic energy to quick response to starting and stopping signals. Small pressure changes can be used for generating large forces through these actuators.

Pneumatic actuators are responsible for converting pressure into force.

<u>Electric actuators</u>

DC Motors: the stator is a set of fixed permanent magnets, creating fixed maganetic feild while the rotar carries a current.

through brushes and commytators the direction of current is changed continously, causing the rotor to rotate continously.

AC Motors : these are similar to DC motors except that the rotar is permenant magnet stator houses, the windings and all commutators and brushes are eliminated.

Solenoids: solenoid valves control the flow of water in pipes in response to electrical signals.

stepper motor and relays are also electric autuators.

This class of actuators is considered one of the cheapest, cleanest and speedy actuator types available





RELAY DC Motor SELONIOD STEPEER MOTOR AC MOTOR

<u>Thermal or magnetic actuators</u>

Thermal or magnetic energy is used for powering this class of actuators.

Thet are very compact, lightweight, economical and with highpower density.

One classic example of thermal actuators is shape memory materials (SMMs) such as shape memory alloys (SMAs).

These actuators do not require electricity for actuation. They are not affected by vibration and can work with liquid or gases. Magnetic shape memory alloys (MSMAs) are a type of magnetic actuators.

Mechanical actuators

Mechanical actuators convertes rotary motion into linear motion to execute some movement.

Mechanical actuators requires gears, rails, pulleys, chains, and other devices to operate.

Rack and pinion are example of Mechanical actuators.

Similarly, the mechanical switches shown below uses the mechanical motion of the switch to switch on or off an electrical circuit.

These actuators can be easily used in conjunction with pneumatic, hydraulic, or electrical actuators. They can also work in a standalone mode.

Soft actuators

Soft actuators (e.g., polymer-based) consists of elastomeric polymers that are used as embedded fixtures in flexible materials such as cloth, paper, fiber, particles, and others.

The conversion of molecular level microscopic changes into tangible macroscopic deformations is the primary working principle of this class of actuators.

These actuators have a high stake in modern-day robotics. They are designed to handle fragile objects such as agricultural fruit harvesting, or performing precise operations like manipulating the internal organs during robot-assisted surgeries.

Shape memory polymers

Shape memory polymers (SMP) are considered as smart materials that respond to someexternalstimulusbychangingtheirshape, andthenreverttotheiroriginalshape once the affecting stimulus is removed .

Features such as high strain recovery, biocompatibility, low density, and biodegradability characterize These materials.

SMP-based actuators function similar to our muscles. Modern-day SMPs have been designed to respond to a wide range of stimuli such as pH changes, heat differentials, light intensity, and frequency changes, magnetic changes, and others.

Photopolymer/light-activated polymers (LAP) are a particular type of SMP, which require light as a stimulus to operate.

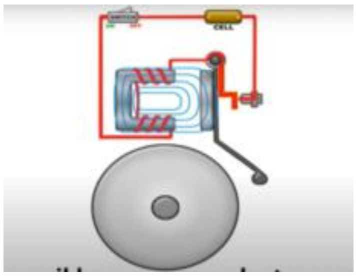
Electric Linear Actuator

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, locking doors, and braking machine .

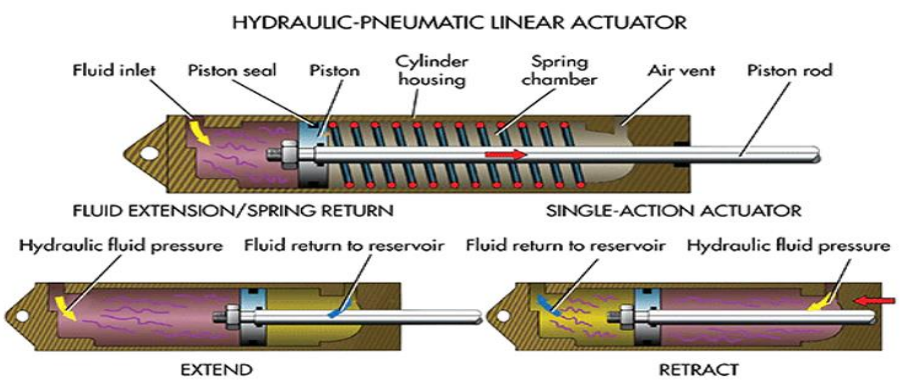


Fluid Power Linear Actuator

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.

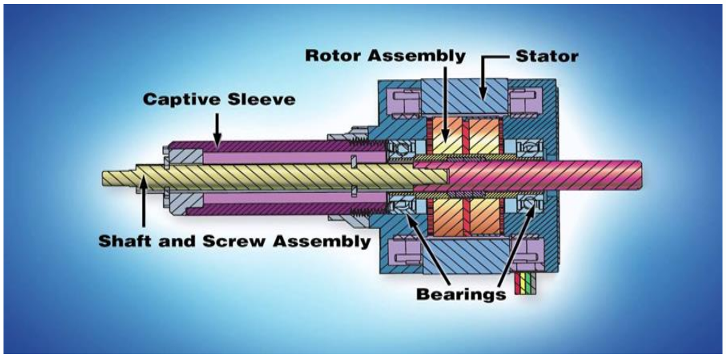


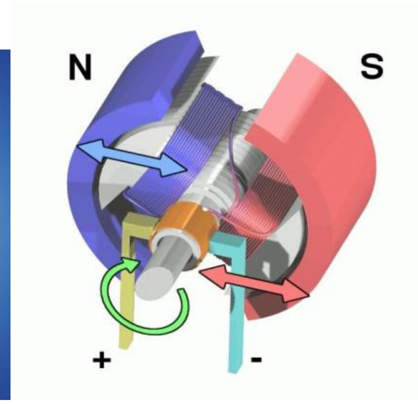
Electric Rotary Actuator

Powered by electrical signal

Converts electrical energy into rotational motion

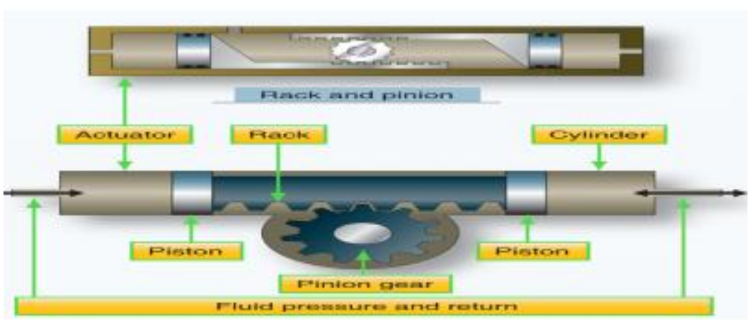
Applications including quarter-turn valve windows and robotics





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.

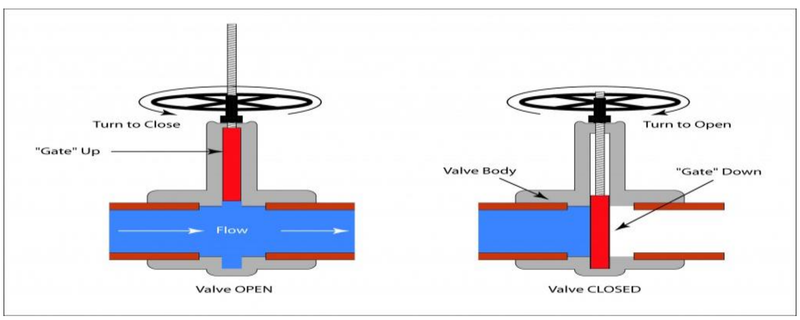


Manual Linear Actuator

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 work pieces

Manual Rotary Actuator

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



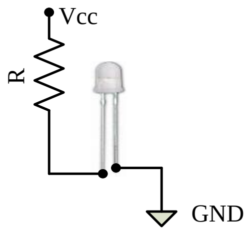
INTERNET OF THINGS

UNIT – 2

ACUTAORS : LED, Pi CAMERA, SWITCH

I/O Devices - Light Emitting Diode (LED)

- Light Emitting Diode (LED) is an output device for visual indication in any embedded system
- LED can be used as an indicator for the status of various signals or situations. Typical examples are indicating the presence of power conditions like 'Device ON', 'Battery low' or 'Charging of battery' for a battery operated handheld embedded devices
- LED is a p-n junction diode and it contains an anode and a cathode. For proper functioning of the LED, the anode of it should be connected to +ve terminal of the supply voltage and cathode to the –ve terminal of supply voltage
- The current flowing through the LED must limited to a value below the maximum current that it can conduct. A resister is used in series between the power supply and the resistor to limit the current through the LED

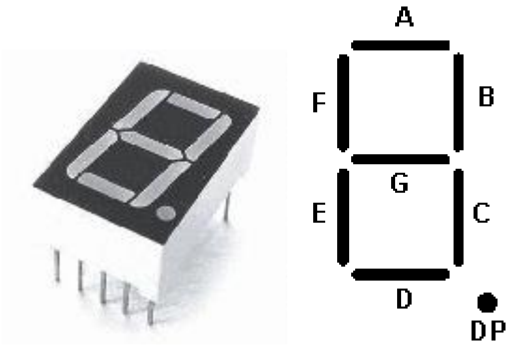


7-Segment LED Display

- The 7 – segment LED display is an output device for displaying alpha numeric characters
- It contains 8 light-emitting diode (LED) segments arranged in a special form. Out of the 8 LED segments, 7 are used for displaying alpha numeric characters
- The LED segments are named A to G and the decimal point LED segment is named as DP
- The LED Segments A to G and DP should be lit accordingly to display numbers and characters

- The 7 – segment LED displays are available in two different configurations, namely; Common anode and Common cathode

- In the Common anode configuration, the anodes of the 8 segments are connected commonly whereas in the Common cathode configuration, the 8 LED segments share a common cathode line

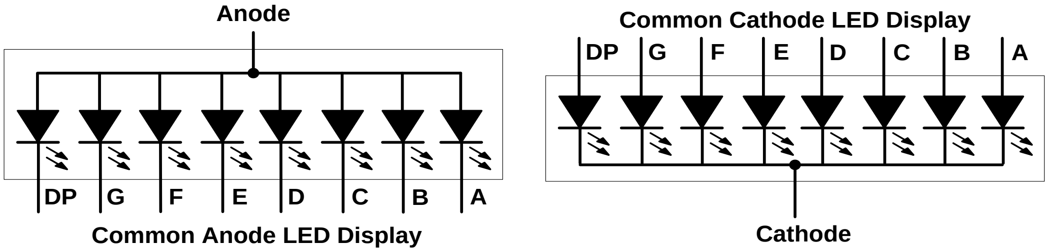


- Based on the configuration of the 7 – segment LED unit, the LED segment anode or cathode is connected to the Port of the processor/controller in the order 'A' segment to the Least significant port Pin and DP segment to the most significant Port Pin.

- The current flow through each of the LED segments should be limited to the maximum value supported by the LED display unit

- The typical value for the current falls within the range of 20mA

- The current through each segment can be limited by connecting a current limiting resistor to the anode or cathode of each segment



Push button switch

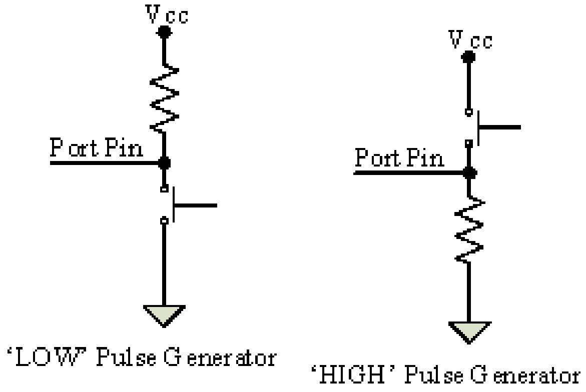
- Push Button switch is an input device

- Push button switch comes in two configurations, namely 'Push to Make' and 'Push to
- Break'

- The switch is normally in the open state and it makes a circuit contact when it is pushed or pressed in the 'Push to Make' configuration

- In the 'Push to Break' configuration, the switch is normally in the closed state and it breaks the circuit contact when it is pushed or pressed

- The push button stays in the ‘closed’ (For Push to Make type) or ‘open’ (For Push to Break type) state as long as it is kept in the pushed state and it breaks/makes the circuit connection when it is released
- Push button is used for generating a momentary pulse



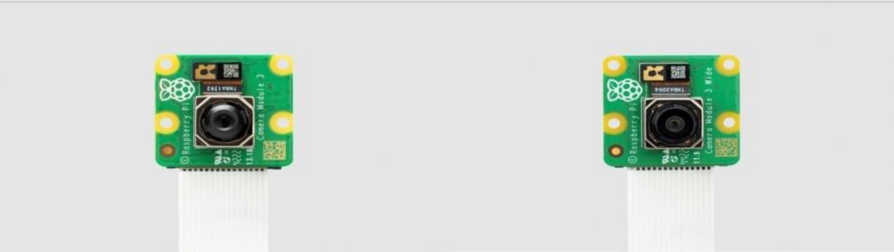
Pi Camera

There are now several official Raspberry Pi camera modules. The original 5- megapixel model was released in 2013, it was followed by an 8- megapixel camera Module 2 which was released in 2016.

The latest camera model is the 12-megapixel Camera Module 3 which was released in 2023. The original 5MP device is no longer available from Raspberry Pi

All of these cameras come in visible light and infrared versions, while the Camera Module 3 also comes as a standard or wide FoV model for a total of four different variants.

Camera Module 3 (left) and Camera Module 3 Wide (right)

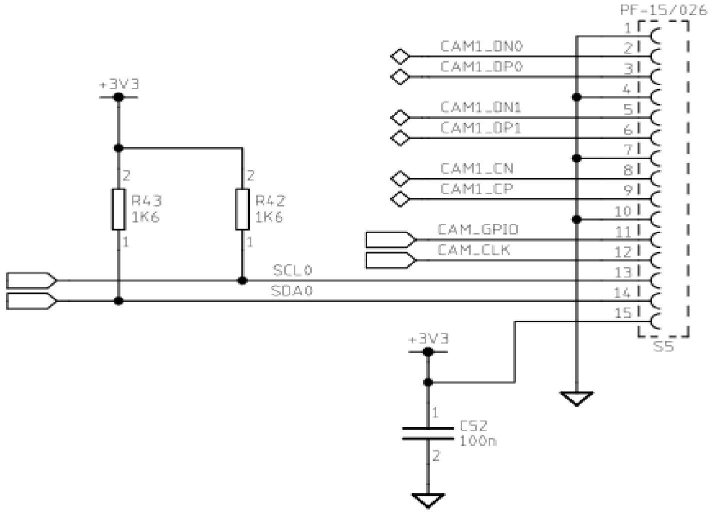


Connecting the Camera

- The flex cable inserts into the connector labelled CAMERA on the Raspberry Pi, which is located between the Ethernet and HDMI ports.
-
- The cable must be inserted with the silver contacts facing the HDMI port.
-
- To open the connector, pull the tabs on the top of the connector upwards, then towards the Ethernet port.
-
- The flex cable should be inserted firmly into the connector, with care taken not to bend the flex at too acute an angle.
-

- To close the connector, push the top part of the connector towards the HDMI port and
- down, while holding the flex cable in place.
-

Schematic of the Raspberry Pi CSI camera connector.



INTERNET OF THINGS

UNIT – 2

ACUTAORS CONSIDERATIONS

The following are some of considerations

- When choosing powered actuators, it's important to consider factors like how much weight they can handle, how far they can move, and how quickly they can do it.
- These factors have specific limits on things like speed and strength, so focusing on those limits can help find the right type of actuator for the job.
- Other considerations include the kinds of services available. Hydraulic actuators provide large forces in small sizes but need a source of hydraulic pressure.
- Air-powered ones use air that's easy to find in factories, but they tend to be bigger for the same amount of force.
- Electric actuators are easier to control and don't leak as much as other types. However, they can be more expensive at first. But they're a good choice for outdoor use since they don't have the risk of freezing like air systems do.
- Pneumatic actuators for valves have two types: double-acting and spring return.
- Double-acting means air pressure moves the valve both ways.
- Spring return means a spring helps move the valve in one direction, and air pressure is needed to overcome it.
- This matters because if air pressure is lost, a spring return valve will go back to its original position. Hydraulic actuators can work in similar ways.
- When it comes to moving things precisely, some linear actuators are made for super tiny movements using piezo crystals, which are great for really small-scale tasks like in optics or making semiconductors.
- Usually, though, actuators with belts or ball screws are used for positioning things with high accuracy, measured in thousandths of an inch. Linear actuators can also be used with hand controls, like in dental chairs.

Important Actuator Attributes

Mounting Configuration

This explains how the actuator connects to the device it moves. For valves, actuators either attach directly to the valve flange or use trunnion mounts to reach the valve stem packing glands.

Actuation Features

Selecting double acting or spring return here will choose the failure mode of the actuator upon loss of air or hydraulic pressure.

Output Torque

Output torque applies to both electric and fluid powered rotary actuators and describes the rotational force the actuator can apply to the valve to close it. It is usually expressed in in-lb. or Nm. (newton meter)

Maximum Extension/Retraction/Holding Force

These attributes apply to linear actuators and may sometimes be expressed as a single value such as maximum thrust force. They are usually given in lbf (pound foot) or N.

Maximum Speed

For powered actuators, this is the highest linear or rotational speed the unit can deliver. It is usually expressed as rpm for rotary actuators and as in/sec for linear devices.

Enclosure Protection Rating

Electrical enclosures are specified in accordance with NEMA (electrical motor standards) or IEC criteria for the environment and ingress protection.