Introduction to IOT
Unit-1 (AIDS-309/AIML-309)

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AGENDA

Sensors

Part-3A

Agenda

- Introduction to Sensors
- Sensor terminology
- Understand the different classes of Sensors
- Sensor dynamics and specifications

Sensors in Laymen Terms

- Most systems use something to sense their physical environment.
- The human body is a system, it has many sensors built-in. The most known types are the nose, eyes, ears, skin and tongue.
- These natural sensors are used to sense different parameters, like light, sound, heat, and taste.
- In electronics, different artificial sensors are used to sense various physical parameters like light, sound, vibration, temperature, etc.
- A transducer is a device that converts energy from one form to another. In other words; transducer converts a particular physical parameter into a corresponding electrical/electronic signal.

Introduction to Sensors

- Sensors are crucial components in a wide range of applications, including the Internet of Things (IoT), as they provide the data necessary for devices to interact intelligently with their surroundings.
- At its core, a sensor is a device designed to detect changes in its environment and provide output in the form of analog or digital signals.
- They convert physical phenomena (like temperature, pressure, or motion) into electrical signals, which can be measured, recorded, and analyzed.
- Sensors are integral components of many technological systems, enabling them to “see,” “hear,” “feel,” “smell,” or “taste” their surroundings, often with greater precision than human senses.

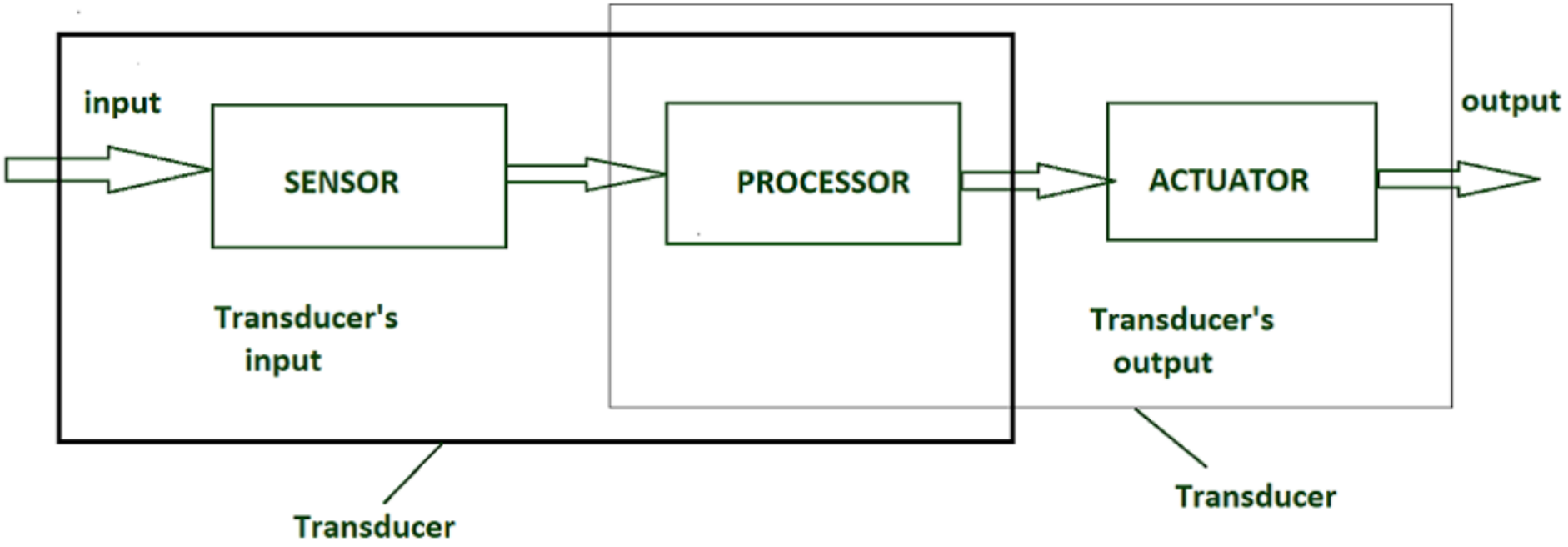
Introduction to Sensors

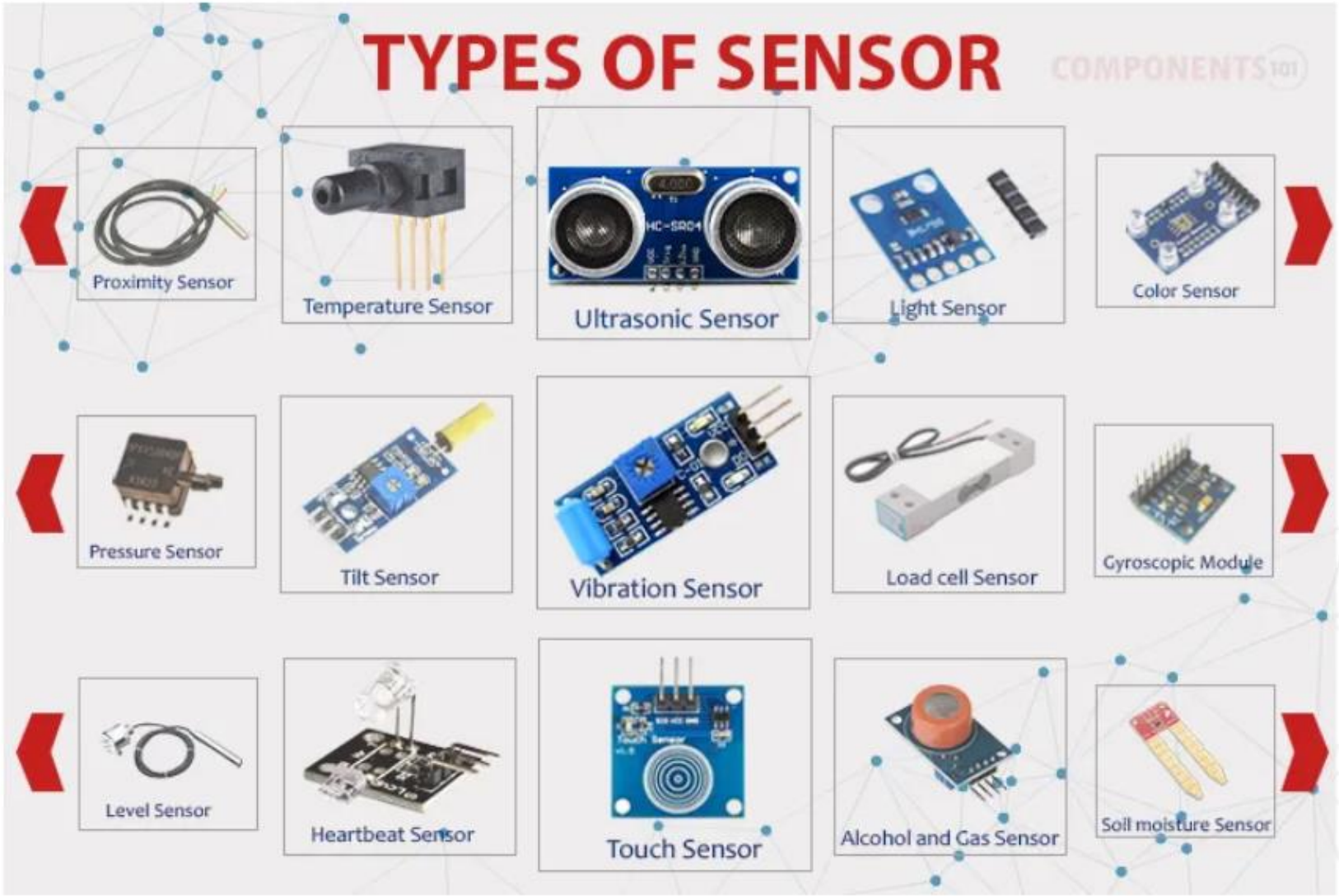
- A Sensor is a characteristic of any device or material to detect the presence of a particular physical quantity.
- The output of the sensor is a signal, which is converted to human readable form.
- It performs some function of input by sensing or feeling the physical changes in the characteristics of a system in response to stimuli.
- Sensors are the devices that can detect and response to changes in the environment.
- These changes can be in form of light, temperature, motion, moisture or any other physical property.

Introduction to Sensors

- The sensor converts these physical changes into signal that can be measured.
- Sensors play an important role in IoT which will make an ecosystem for collecting, analyzing, and processing data about a specific environment so that it can be monitored, managed, and controlled more easily and efficiently.
- Sensors bridge the gap between the physical world and the logical world.
- **Transducer** : It converts the signal from one physical form to another physical form. it is also called energy converter. For example, microphone converts sound to electrical signal . It is based on the principle of conservation of energy.

Sensors


input
SENSOR
PROCESSOR
ACTUATOR
output
Transducer's
input
Transducer's
output
Transducer
Transducer


TYPES OF SENSOR
COMPONENTS101
Proximity Sensor
Temperature Sensor
Ultrasonic Sensor
Light Sensor
Color Sensor
Pressure Sensor
Tilt Sensor
Vibration Sensor
Load cell Sensor
Gyroscopic Module
Level Sensor
Heartbeat Sensor
Touch Sensor
Alcohol and Gas Sensor
Soil moisture Sensor

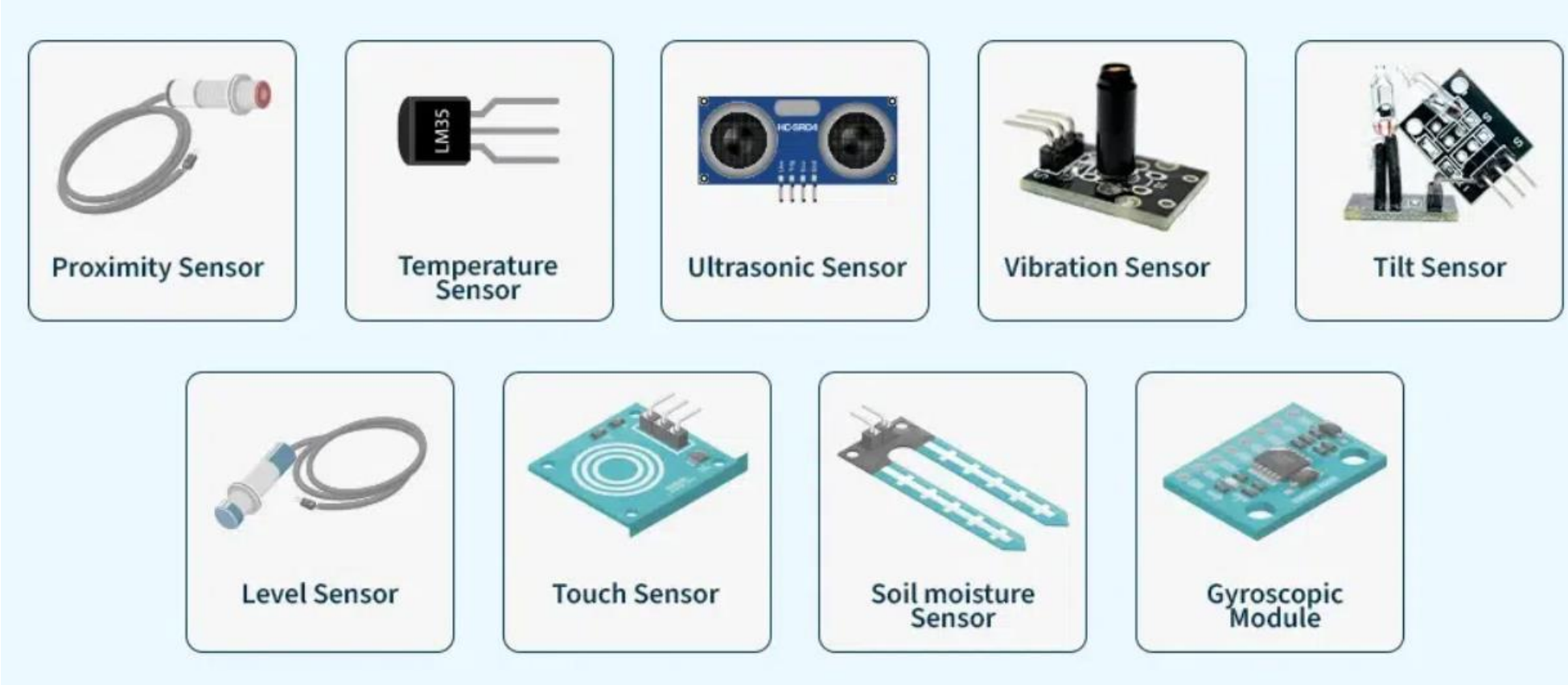
Distinction between Sensors and Transducers

- While sensors detect changes in the physical world and provide feedback, transducers convert physical quantities into electrical signals or vice versa.
- Sensors require power for operation, while transducers can function without external power sources.

Key Characteristics of Sensors

1. **Accuracy:** The degree to which the sensor's measurement corresponds to the actual value.
2. **Sensitivity:** The ability of the sensor to detect small changes in the measured quantity.
3. **Range:** The span of values over which the sensor can accurately measure.
4. **Resolution:** The smallest change in the measured quantity that the sensor can detect.
5. **Response Time:** The time it takes for the sensor to respond to a change in the measured quantity.
6. **Linearity:** The degree to which the sensor's output is directly proportional to the measured quantity.

Types of Sensors



Types of Sensors and Their Applications

1. Temperature Sensors:

Usage: Measure temperature changes.

Applications: Thermostats, weather monitoring systems, industrial processes, medical devices.

2. Pressure Sensors:

Usage: Measure pressure of gases or liquids.

Applications: Weather forecasting, automotive industry (tire pressure monitoring), industrial machinery.

Types of Sensors and Their Applications

3. Proximity Sensors:

Usage: Detect the presence or absence of an object or its distance from the sensor.

Applications: Mobile phones, parking sensors, industrial automation.

4. Accelerometers:

Usage: Measure acceleration forces.

Applications: Smartphones (screen orientation), fitness trackers, vehicle dynamics.

Types of Sensors and Their Applications

5. Light Sensors:

Usage: Detect light intensity.

Applications: Smartphones (automatic screen brightness adjustment), outdoor lighting systems, photography equipment.

6. Motion Sensors:

Usage: Detect movement.

Applications: Security systems, automatic doors, gaming consoles.

Types of Sensors and Their Applications

7. Humidity Sensors:

Usage: Measure the moisture level in the air.

Applications: HVAC systems, weather stations, agricultural monitoring.

8. Gas Sensors:

Usage: Detect the presence of gases in the environment.

Applications: Air quality monitoring, industrial safety, medical diagnostics.

Types of Sensors and Their Applications

9. Magnetic Sensors:

Usage: Detect magnetic fields.

Applications: Compass navigation, industrial applications, consumer electronics.

10. Sound Sensors:

Usage: Detect sound levels or specific audio frequencies.

Applications: Voice recognition systems, hearing aids, security alarms.

Types of Sensors

1. **Temperature sensors:** Monitoring temperature of used devices in industrial applications. it is used to measure temperature. this can be air temperature, liquid temperature or the temperature of solid. It can be analog or digital. In an Analog Temperature Sensor, the change in the Temperature correspond to change in its physical property like resistance or voltage. LM35 is a classic Analog Temperature Sensor. In Digital Temperature Sensor, the output is a discrete digital value, DS1621 is digital sensor which generates 9 bits temperature data.

2. **Accelerometer sensors:** It measures the rate of change of velocity and this sensor generate magnitude and acceleration of the acceleration. It is used in car electronics, ships, and agricultural machines.

Types of Sensors

3. Alcohol sensors: as the name suggests it detects alcohol. Usually, alcohol sensors are used in breathalyzer devices, which determine whether the person is drunk or not. Law enforcement personnel uses breathalyzers to catch drunk-and-drive culprits.

4. Radiation sensors: Radiation Sensors/Detectors are electronic devices that sense the presence of alpha, beta, or gamma particles and provide signals to counters and display devices. Radiation detectors are used for surveys and sample counting.

5. Image sensor: it is used for distance measurement, pattern matching, color checking, structured lighting, and motion capture and it is also used in different applications such as 3D imaging, video/broadcast, space, security, automotive, biometrics, medical, and machine vision.

Types of Sensors

6. Position sensors: Position Sensors are electronic devices used to sense the positions of valves, doors, throttles, etc. and supply signals to the inputs of control or display devices. Key specifications include sensor type, sensor function, measurement range, and features that are specific to the sensor type. Position sensors are used wherever positional information is needed in a myriad of control applications. A common position transducer is a so-called string-pot, or string potentiometer.

7. Gas sensors: It measures and detects concentration of different gases which is present in the atmosphere or any other environment.

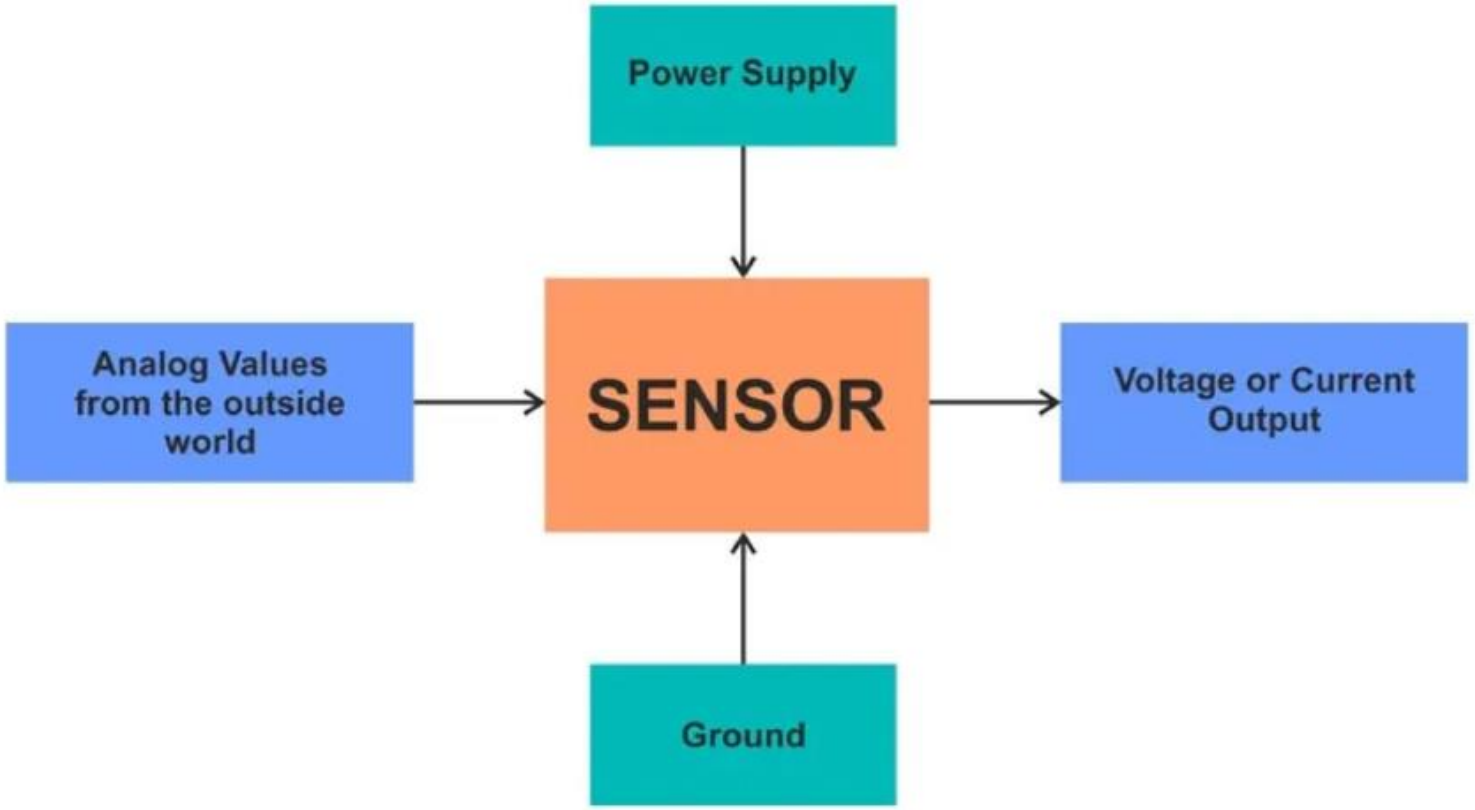
8. Torque sensors: This sensor is used for measuring the rotating torque and it is used to measure the speed of the rotation.

Types of Sensors

9. Optical sensors: it is also called photosensors which can detect light waves at different points in the light spectrum including ultraviolet light, visible light, and infrared light. it is extensively used in smartphone, robotics and Blu-ray players.

10. Proximity sensors: This sensor is used to detect the distance between two objects or detect the presence of an object. it is used in elevators, parking lots, automobiles, robotics, and numerous other environment.

11. Touch sensors: Touch sensing devices detect physical contact on a monitored surface. Touch sensors are used extensively in electronic devices to support trackpad and touchscreen technologies. They're also used in many other systems, such as elevators, robotics and soap dispensers.


Power Supply
Analog Values from the outside world
SENSOR
Voltage or Current Output
Ground

Sensors are mainly classified into two types: Digital and Analog

Feature	Digital Sensors	Analog Sensors
Signal Type	Digital (discrete)	Analog (continuous)
Signal Output	Discrete digital signal (usually binary)	Continuous analog voltage or current
Accuracy	Higher accuracy, less susceptible to noise	Generally less accurate due to noise and drift
Complexity	More complex due to signal processing	Simpler design and circuitry
Interference	Less prone to electromagnetic interference (EMI)	More prone to EMI

Feature	Digital Sensors	Analog Sensors
Cost	Usually more expensive due to additional components	Usually less expensive
Power Consumption	Can be higher depending on processing needs	Can be lower
Response Time	May involve delay due to digital processing	Typically faster
Data Transmission	Data can be transmitted in a more reliable form	Direct transmission of analog signals
Applications	Preferred in applications requiring precision and complex processing	Often used to simple, low cost applications

Classification of Sensors

The Sensor can be classified as:-

1. Based on Power Requirement
2. Based on Means of Detection
3. Based on the Conversion Phenomenon
4. Based on Output Type

Classification of Sensors

1. Based on Power Requirement

- **Active Sensors:** These Sensors require an external excitation signal or power source to work.
- **Passive Sensors**: These Sensors do not require any external power source and it can directly generate the output response.

2. Based on Means of Detection

- The Sensors can be according to detection method they use such as electrical, biological, chemical, or radioactive detection.

Classification of Sensors

3. Based on the Conversion Phenomenon

This classification is based on the input and output conversion

- **Photoelectric:** It Changes light to electrical signals.
- **Thermoelectric:** It Changes temperature difference to electrical voltage.
- **Electrochemical:** It Changes chemical reactions to electrical signals.
- **Electromagnetic:** It Changes magnetic fields to electrical signals.
- **Thermoptic:** It Changes temperature changes to electrical signals.

Classification of Sensors

4. Based on Output Type

- **Analog Sensors:** It produce an output signal which is usually in the form of voltage, current, or resistance, proportional to the measured quantity.
- **Digital Sensors:** It provide discrete or digital data as output.

How do Sensors work?

Sensors are known to react as per the changing physical conditions by bringing a change in their electrical properties. It has been observed that artificial sensors in most cases rely on electronic systems for analyzing, capturing, and relaying environment information.

In simple words, it can be said that a sensor converts the stimuli such as sound, motion, heat, and light into electrical signals. These signals are passed through an interface that further converts these into a binary code passing them on to a computer to get processed.

Mostly, the sensors act as a switch and are used for controlling the flow of electric charges passing via the circuit. Switches form an important part of electronics as these are known for changing the state of the circuit.

The components present in sensors such as transistors, diodes, and integrated circuits or chips consist of semiconducting material. These materials are included in the sensor circuits so that they can be used as switches.

Mostly, sensors use radiation such as laser or light, infrared radio waves, or other waves such as ultrasonic ones for detecting the changes and objects present in the environment. This is possible if they have an energy source that assists them in emitting radiation in the direction of their target object.

This radiation is reflected back by the object and gets detected by the sensor; it is termed an active sensor. Passive sensors don’t send radiation or waves that are their own and detect what is being emitted by the target objects such as thermal infrared radiation, heat, or radiation from external sources like Sun reflected off the objects.

Sensor dynamics and specifications

In the context of the Internet of Things (IoT), sensors are crucial components that enable devices to collect data from their environment. Understanding sensor dynamics and specifications is essential for designing effective IoT systems.

1. Sensor Dynamics

Sensor dynamics refer to the behavior and response characteristics of a sensor over time as it interacts with its environment. This includes how a sensor responds to changes in the measured quantity and how quickly it can adapt to those changes.

Key aspects of sensor dynamics include:

- **Response Time:** The time a sensor takes to reach a stable reading after a change in the measured parameter. A fast response time is essential for real-time applications.
- **Sensitivity:** The degree to which a sensor's output changes in response to a change in the measured parameter. High sensitivity is crucial for detecting small variations.

Sensor dynamics and specifications

- **Linearity:** The relationship between the input (measured parameter) and output (sensor reading) should ideally be linear. Nonlinearity can introduce errors in measurement.
- **Hysteresis:** The difference in the sensor's output when the measured parameter is increasing versus when it is decreasing. Low hysteresis is desirable for accuracy.
- **Range:** The span of values a sensor can measure. The dynamic range is critical to ensure the sensor operates effectively across all expected conditions.
- **Resolution:** The smallest change in the measured parameter that can be detected by the sensor. Higher resolution allows for more precise measurements.

Sensor dynamics and specifications

2. Sensor Specifications

Sensor specifications provide detailed information about a sensor's capabilities and limitations. These specifications are essential for selecting the right sensor for a given IoT application.

Common sensor specifications include:

- **Accuracy:** The degree to which the sensor's measurements match the true value of the measured parameter. High accuracy is vital for applications requiring precise data.
- **Precision:** The consistency of the sensor's measurements over repeated trials. A sensor with high precision will give similar readings under the same conditions.
- **Drift:** The change in sensor output over time due to factors like temperature, aging, or environmental conditions. Low drift is important for long-term reliability.

- **Power Consumption:** The amount of power the sensor requires to operate. Low power consumption is critical in IoT applications, especially for battery-powered devices.
- **Operating Temperature:** The range of temperatures within which the sensor can operate effectively. This is important for sensors used in harsh or varying environmental conditions.
- **Calibration:** The process of setting or correcting a sensor's output to match a known standard. Some sensors may require frequent calibration, while others are factory-calibrated.
- **Noise:** Unwanted variations in the sensor's output that are not related to the measured parameter. Low noise levels are important for obtaining clear and accurate readings.
- **Environmental Resistance:** The sensor's ability to withstand conditions like moisture, dust, or chemicals. This specification is crucial for sensors used in outdoor or industrial IoT applications.

Application of Types Of Sensors

Given below are the Application of Types Of Sensors

1. **Automotive Industry:** They are used in the Automotive industry for monitoring engine temperature, speed and other parameters.
2. **Smart Homes:** They are used in the Smart Homes for detecting movements, Control HVAC and other measurements.
3. **Robotics:** They are used in the Robotics for object recognition, Tracking the position and measuring force.
4. **Transportation:** Sensors such as GPS , Load, and Speed sensors are used in transportation infrastructure.

THANK YOU