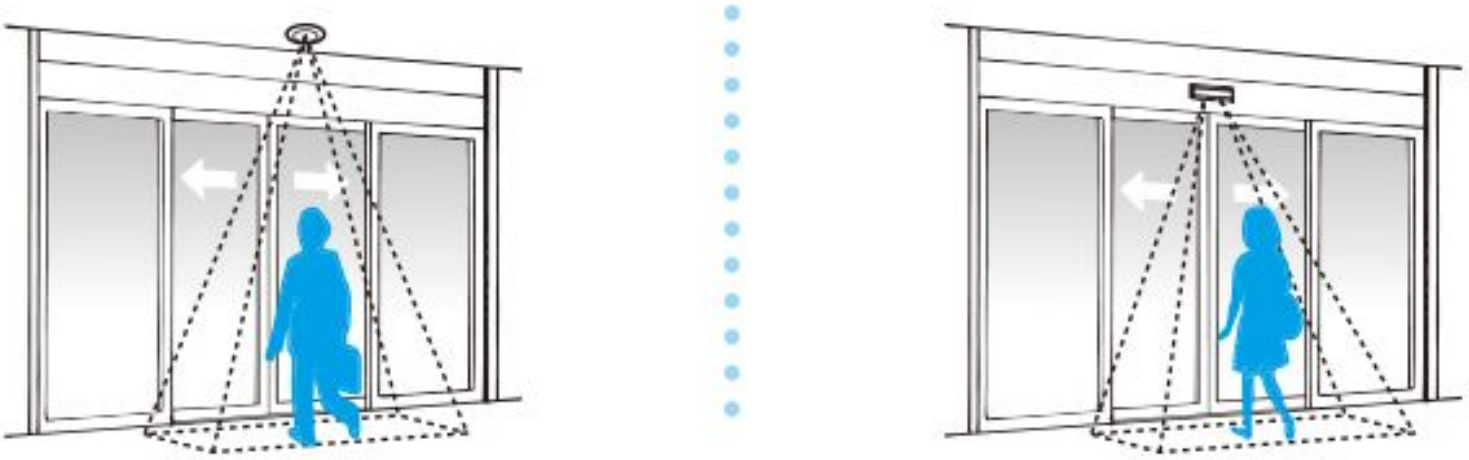
Smart sensor systems

Introduction:

- Many industries in which automation can be applied - manufacturing, transportation, and energy production.
- With automation, productivity, quality, and efficiency can be improved.
- For automation, it is essential to use a variety of technologies, including sensors to keep automated processes in operation at all times.
- The key to the automation industries lies in the collection of data and information.
- Sensors play a key role in the automation process.
- It collect data and provide basic data support for the construction of the automation.
- Sensors play an essential role by detecting and measuring a wide range of parameters such as temperature, pressure, humidity, flow rate, motion, and position.
- These physical signal are converted into an electric signal by these devices, which provide information in real-time to the control system, which enables smart and automated production to be carried out.
- The functions of sensors – Control, efficiency and safety.
- Different types of sensors used in automation: Proximity sensors, Vision sensors, Ultrasonic sensors, Position sensors, Photoelectric sensors, Temperature sensors, Inclination sensors, etc.

Introduction – Automated door system

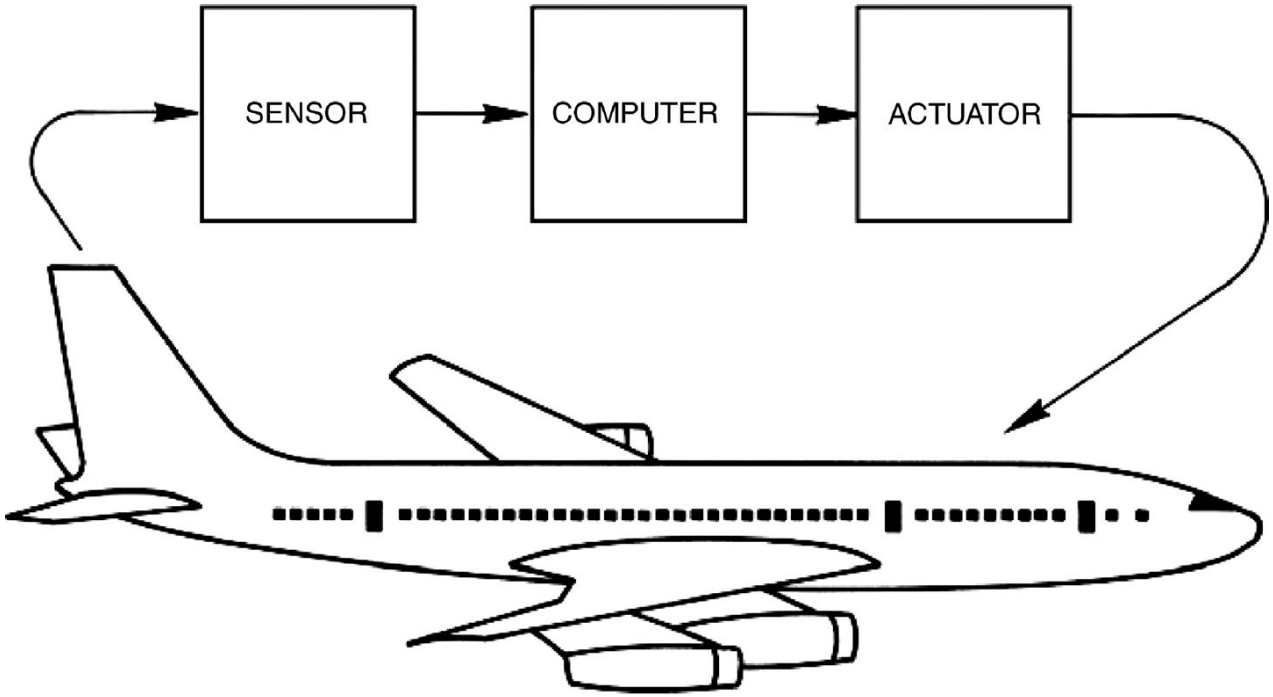


The door will be opened by detecting the reflection of infrared rays from objects.

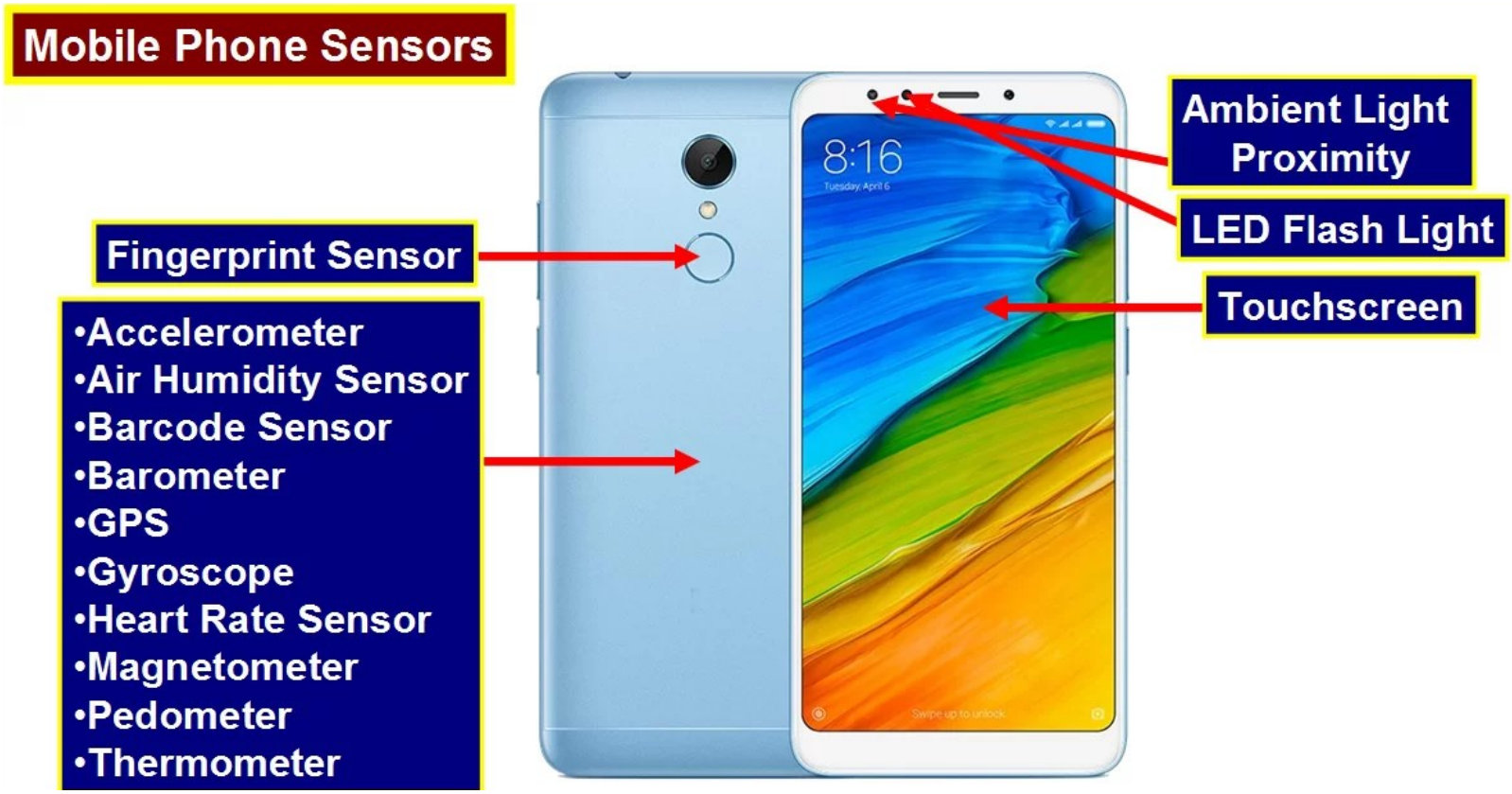
Simple car door monitoring arrangement

Every door in a car is supplied with a sensor that detects the door position (open or closed). In most cars, the sensor is a simple electric switch. Signals from all door switches go to the car's internal processor (no need for an ADC as all door signals are in a digital format: ones or zeros). The processor identifies which door is open (signal is zero) and sends an indicating message to the peripheral devices (a dashboard display and an audible alarm). A car driver (the actuator) gets the message and acts on the object (closes the door) and the sensor outputs the signal "one".

Introduction – Automated pilot system



Introduction – Smart phones



Motion Sensors

Motion sensors are useful for monitoring device movement, such as tilt, shake, rotation, or swing.

Environmental Sensors

The Environmental Sensors are used to detect temperature, humidity, heat losses.

Position Sensors

The Android smartphone provides two sensors that let you determine position of device- geomagnetic field sensor with combination of accelerometer sensor.

Ambient Light Sensor

This sensor works in controlling brightness level of screen.

Proximity Sensor

They are available in almost every smartphone at top of the screen. Infrared light flows through this sensor. When any physical object comes in contact with this light, it detects it and reacts towards it. For example, when you talk on your phone and place your phone on your ear, infrared light detects physical object i.e, your ear. Sensing that, screen's light automatically goes off. This saves both battery life and prevents accidental screen touches.

Accelerometer Sensor

It helps phone to check its orientation. For Example, if you rotate your phone in landscape mode, then all icons present on screen also moves to landscape mode, and when you want you can change it into portrait mode, this is because of these sensors.

Gyroscope Sensor

Virtual Reality is possible only because of these types of sensors. If you buy VR head set, put your phone inside, then that is only possible because of gyroscope sensors. Even 360 degree pictures or videos and AR (Augmented Reality) is possible only because of these sensors. These sensors helps phone to know that which axis (Angles and Directions) it is using at that point of time in very precise manner. Basically, it adjusts contents of phone according to user.

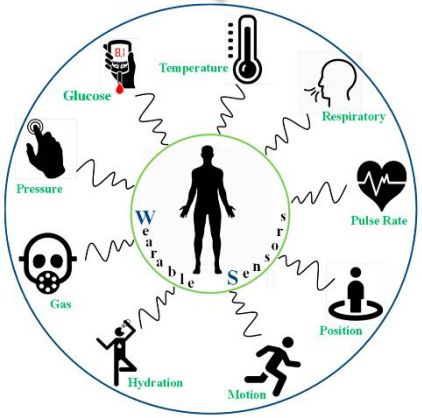
Compass Sensor –

Compass sensor is very normal and available in every phone, helps in detecting direction like normal compass do.

Smartphones

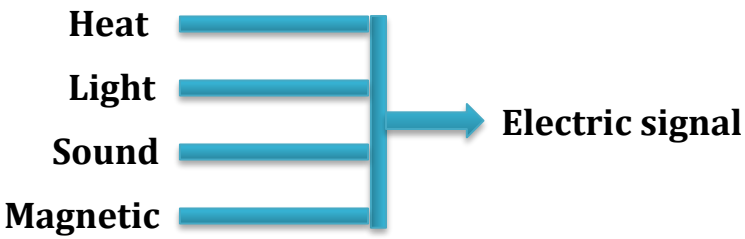
Aviation

Space craft

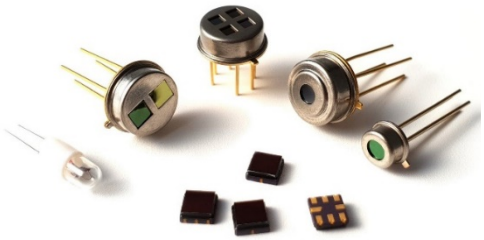


Health Care

What do you understand about sensors?

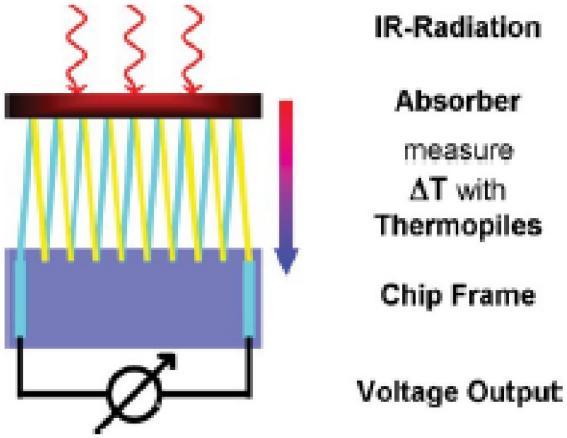


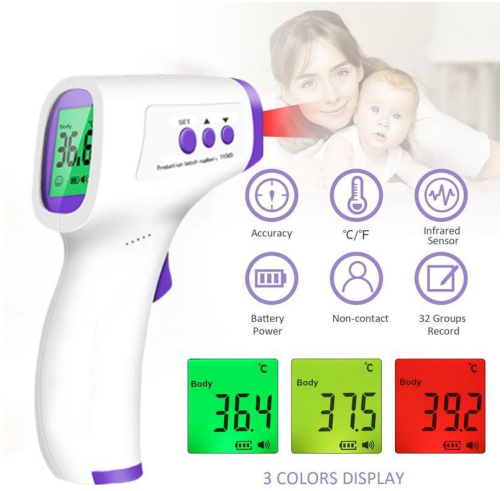
Sensors

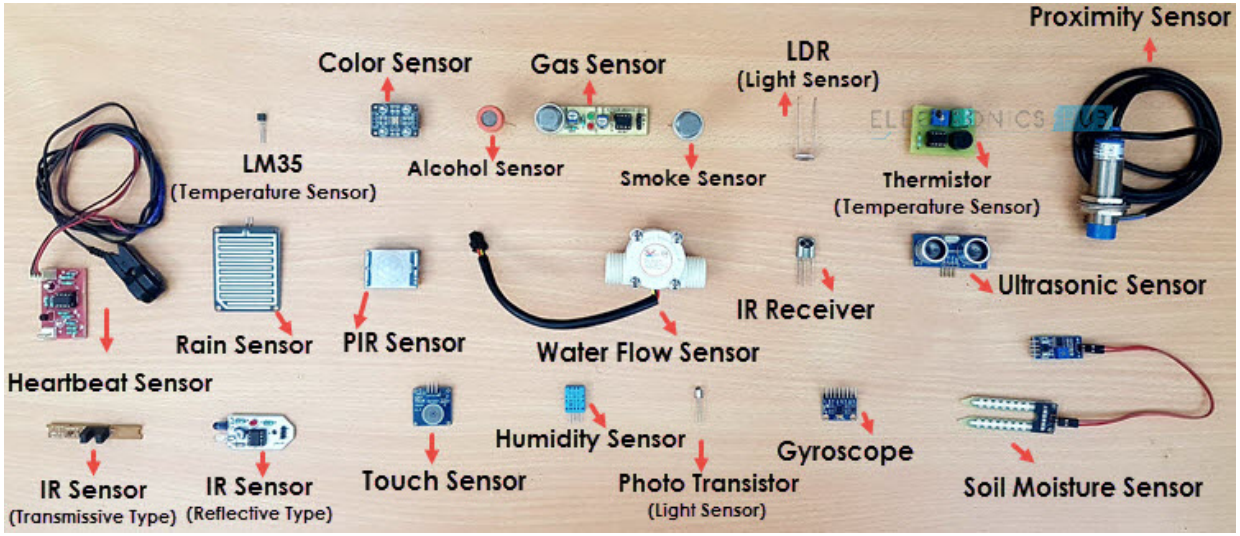


- Energy convertor
- It is a device that convert signals from one energy domain to electrical domain
- Energy transfer between objects of measurement to the sensors
- Transmission of energy can flow in both ways
  - the object to the sensors
  - the sensor to the object

Sensors







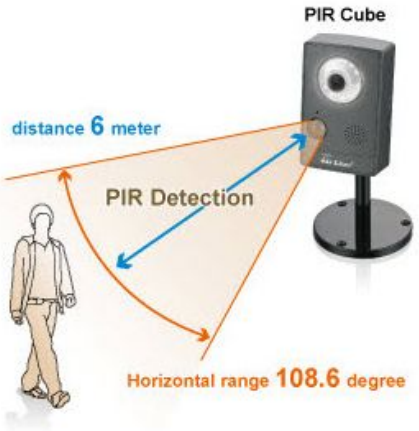
Sensors ⟷ **Detectors**

Detector is more often used to stress **qualitative** rather than quantitative nature of measurement.

Ex: PIR detector is used to indicate the presence of human movement only and other their functions such as directions.

Passive infrared sensor

- "Passive" means that the sensor does not actively participate in the process, meaning it does not emit the referred IR signals itself, but rather passively detects them coming from the human body.
- Radiation detected by the detector is converted into an electrical charge.



Smart sensors

- Sensors are devices that respond to physical stimulus heat, light etc and convert them into an electric signal where as smart sensors along with the above activity does more interactive send this sensed quantity to controller/processor for further actions.
- If we combine a sensor, an analog interface circuit, an analog to digital converter (ADC) and a bus interface in one housing, we get a smart sensor.

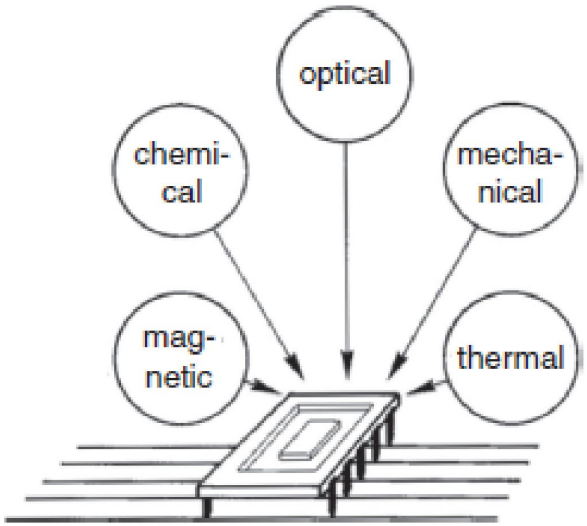
Sensors + Interface ⟶ **Smart sensors**

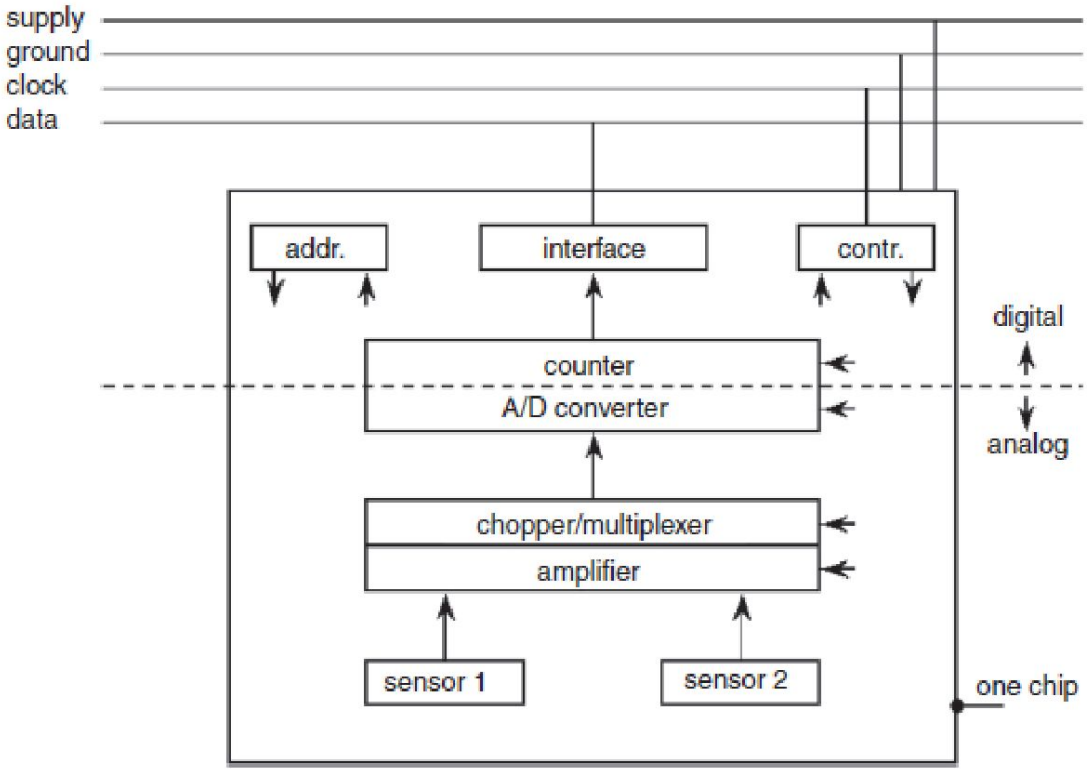
- In a single package, it is made up of a sensing element, a signal conditioning electronic, and a controller/processor that all function together.

- Smart sensors are identified as having decision making and communication present in a single system.

Integrated smart sensors

- If we integrate all functions from sensor to bus interface in one chip, we get an integrated smart sensor
- An integrated smart sensor should contain all elements necessary per node: one or more sensors, amplifiers, a chopper and multiplexers, an AD converter, buffers, a bus interface, addresses, and control and power management
- for realizing all functions on one chip we must first integrate a diversity of sensors on one chip.





Transducers

A sensor is different from a transducer in the sense that it is measuring.
The device that converts one type of energy or property into another type of energy or property.
Example: Loudspeaker

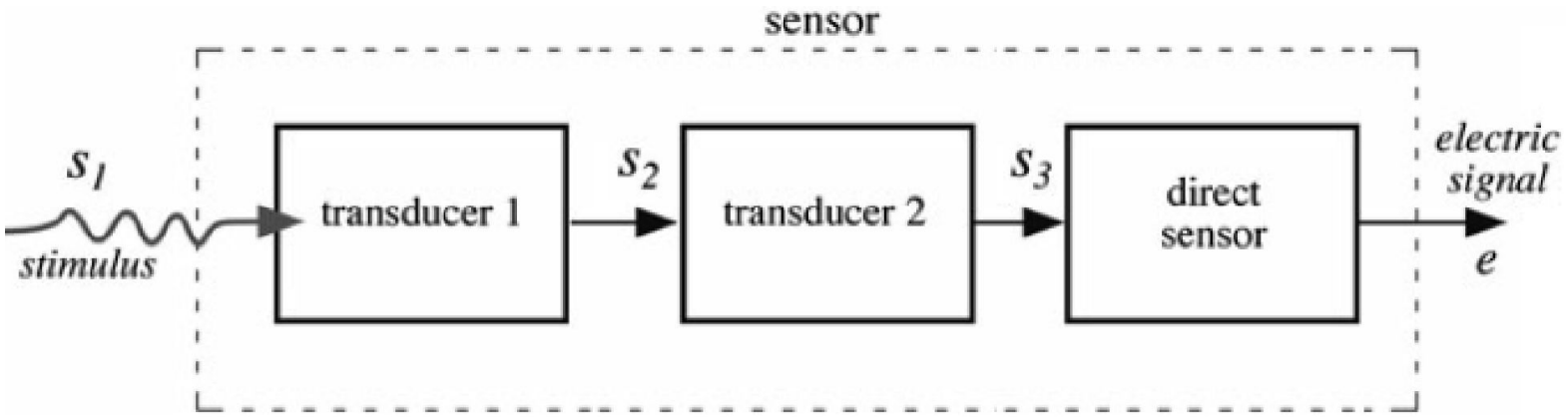
It converts an electrical signal into a variable magnetic field and, subsequently, into acoustic waves
In a variety of systems, transducers may be used as actuators.
actuator - opposite to a sensor—it converts electrical signal into generally nonelectrical energy.

When input is a physical quantity and output electrical → **Sensor**

When input is electrical and output a physical quantity → **Actuator**

Sensors and Actuators

- Sensor: an input transducer (i.e., a microphone)
- Actuator: an output transducer (i.e., a loudspeaker)



Transducers may be parts of a hybrid or complex sensor.
For example, a chemical sensor may comprise two parts:
The first part converts energy of an exothermal chemical reaction into heat (transducer) and another part, a thermopile, converts heat into an electrical output signal.
The combination of the two makes a hybrid chemical sensor, a device which produces electrical signal in response to a chemical reagent.
chemical sensor is a complex sensor—it is comprised of a nonelectrical transducer and a simple (direct) sensor converting heat to electricity.

Sensors classifications

- There are a wide variety of sensor classification schemes, ranging from the very simple to the very complex.
- Different classification criteria can be selected according to the purpose of the classification.
- Here are several practical ways to look at sensors.

1.Passive sensor: it does not need any additional energy source and directly generates an electric signal in response to an external stimulus. That is, the input stimulus energy is converted by the sensor into the output signal. Most of passive sensors are direct sensors as we defined them earlier. **Example:** a thermocouple, a photodiode, and a piezoelectric sensor.

2. Active Sensor: it requires external power for its operation, which is called an excitation signal. That signal is modified by the sensor to produce the output signal. **Example:** a thermistor is a temperature sensitive resistor. It does not generate any electric signal, but by passing an electric current through it (excitation signal) its resistance can be measured by detecting variations in current and/or voltage across the thermistor.

Sensor Classification: Depending on the selected reference, sensors can be classified into absolute and relative.

1. Absolute sensor: it detects a stimulus in reference to an absolute physical scale that is independent of the measurement conditions. **Examples:**

Thermistor is an absolute sensor, it is a temperature-sensitive resistor. Its electrical resistance directly relates to the absolute temperature scale of Kelvin.

An absolute pressure sensor produces signal in reference to vacuum – an absolute zero on a pressure scale.

2. Relative sensor: it produces a signal that relates to some special case. **Examples:**

Thermocouple is a relative sensor that produces an electric voltage, which is a function of a temperature gradient across the thermocouple wires. The sensor output signal cannot be related to any particular temperature without referencing to a known baseline.

A relative pressure sensor produces signal with respect to a selected baseline that is not zero pressure, for example, to the atmospheric pressure.

A sensor can also be viewed in terms of its specific properties.

Sensor specifications

Sensitivity	Stimulus range (span)
Stability (short and long term)	Resolution
Accuracy	Selectivity
Speed of response	Environmental conditions
Overload characteristics	Linearity
Hysteresis	Dead band
Operating life	Output format
Cost, size, weight	Other

Sensing element material

Inorganic	Organic
Conductor	Insulator
Semiconductor	Liquid gas or plasma
Biological substance	Other

Conversion phenomena

Physical	Thermoelectric Photoelectric Photomagnetic Magnetoelectric Electromagnetic Thermoelastic Electroelastic Thermomagnetic Thermo-optic Photoelastic Other	Chemical	Chemical transformation Physical transformation Electrochemical process Spectroscopy Other
		Biological	Biochemical transformation Physical transformation Effect on test organism Spectroscopy Other

Field of applications

Agriculture	Automotive
Civil engineering, construction	Domestic, appliances
Distribution, commerce, finance	Environment, meteorology, security
Energy, power	Information, telecommunication
Health, medicine	Marine
Manufacturing	Recreation, toys
Military	Space
Scientific measurement	Other
Transportation (excluding automotive)	

Stimuli

Stimulus	Stimulus	
Acoustic	*Mechanical*	Position (linear, angular)
Wave amplitude, phase		Acceleration
Spectrum polarization		Force
Wave velocity		Stress, pressure
Other		Strain
Biological		Mass, density
Biomass (types, concentration states)		Moment, torque
Other		Speed of flow, rate of mass transport
Chemical		Shape, roughness, orientation
Components (identities, concentration, states)		Stiffness, compliance
Other		Viscosity
Electric		Crystallinity, structural integrity
Charge, current		Other
Potential, voltage	*Radiation*	Type
Electric field (amplitude, phase, polarization, spectrum)		Energy
Conductivity		Intensity
Permittivity		Other
Other	*Thermal*	Temperature
Magnetic		Flux
Magnetic field (amplitude, phase, polarization, spectrum)		Specific heat
Magnetic flux		Thermal conductivity
Permeability		Other
Other		
Optical		
Wave amplitude, phase, polarization, spectrum		
Wave velocity		
Refractive index		
Emissivity, reflectivity, absorption		
Other		

Units of Measurements: The base measurement system is known as SI, which stands for Le Syste´me International d'Unite´s in French:

Quantity	Name	Symbol	Defined by. . . (year established)
Length	meter	m	. . .the length of the path traveled by light in vacuum in 1/299,792,458 of a second. . . (1983)
Mass	kilogram	kg	. . .after a platinum-iridium prototype (1889)
Time	second	s	. . .the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom (1967)
Electric current	ampere	A	force equal to 2×10^{-7} N/m of length exerted on two parallel conductors in vacuum when they carry the current (1946)
Thermodynamic temperature	kelvin	K	The fraction 1/273.16 of the thermodynamic temperature of the triple point of water (1967)
Amount of substance	mole	mol	. . .the amount of substance which contains as many elementary entities as there are atoms in 0.012 kg of carbon 12 (1971)
Luminous intensity	candela	cd	. . .intensity in the perpendicular direction of a surface of 1/600,000 m^2 of a blackbody at temperature of freezing Pt under pressure of 101,325 N/m^2 (1967)
Plane angle	radian	rad	(supplemental unit)
Solid angle	steradian	sr	(supplemental unit)

SENSORS APPLICATIONS

- Civil engineering, construction
- Domestic, appliances
- Distribution, commerce, finance
- Environment, meteorology,
- security
- Energy, power Information, telecommunication
- Health, medicine Marine
- Manufacturing
- Recreation, toys
- Military
- Space
- Scientific measurement
- Transportation