SENSORS

Safa A. Albarwary

INTRODUCTION TO MECHATRONICS

First Semester

18\ 01\ 2024

Outline

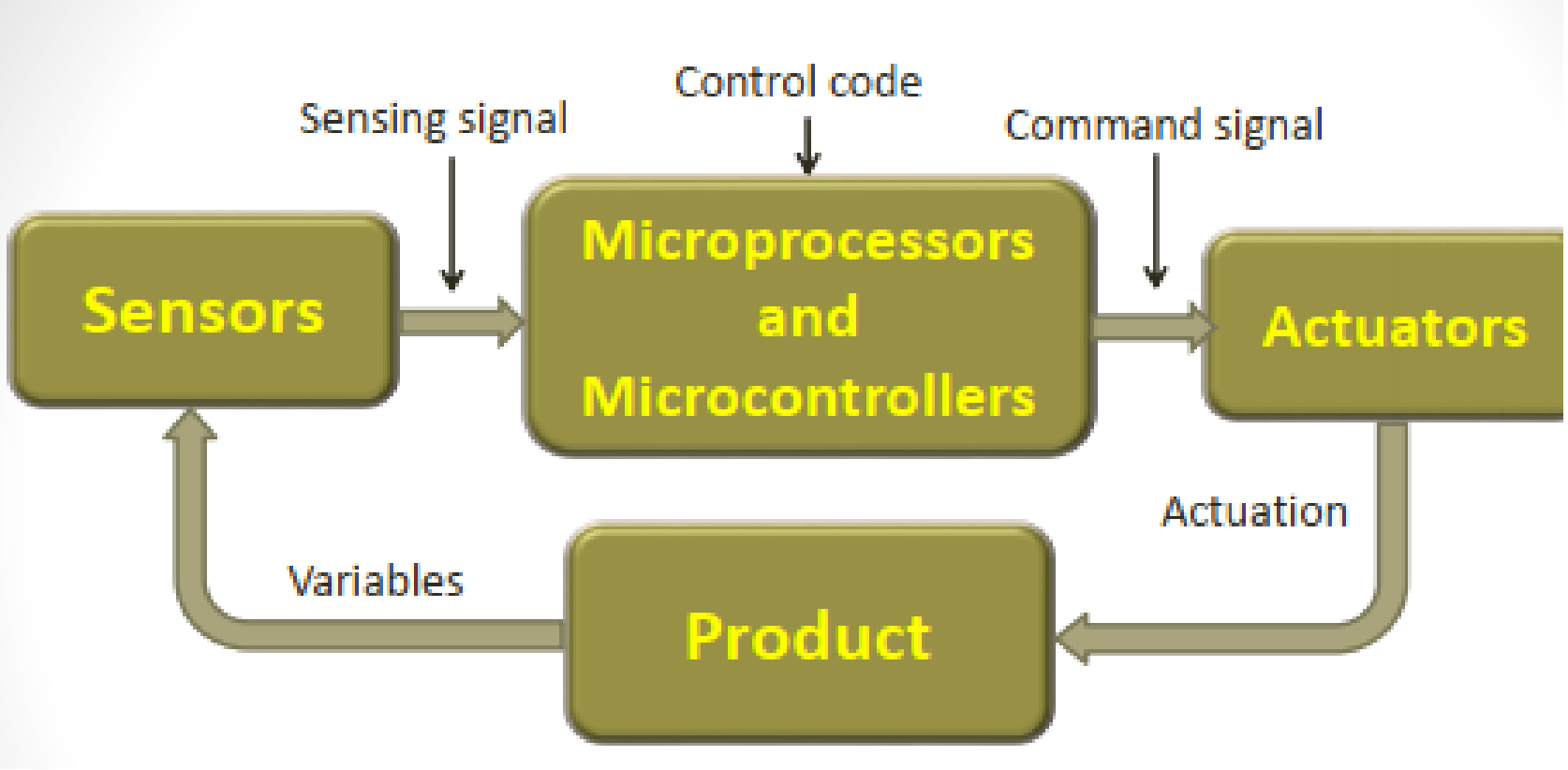
- Mechatronics Systems and Sensors
- What are sensors
- What are signal and its types
- Classification of sensors
- Analog and Digital Sensors
- Applications
- Sensors characteristics

Objectives

- **In this class the students will be introduce to the sensors, it's types, applications and characeristics.**

Mechatronic System

A mechatronics system is composed of mechanical parts, electric devices, electronics components, sensors, Actuators, hardware and it is operated and controlled under the supervisions and commands that are programmed through suitable software using microprocessors and microcontrollers.



Mechatronic System

Mechatronics System and Sensors

- A sensor is the Input of any Mechatronics system
- In the broadest sense, a sensor is a device, machine, module, or subsystem that senses changes or events in its surroundings and transmits the data to other electronics, most commonly a computer processor.
- Different types of sensors are often used in various electrical and electronic applications.
  - Sensors have evolved into a vital component of the embedded system. Chemical, pressure, temperature, position, force, fiber-optic sensors.
- Analog, and digital sensors are among the many types of sensors available.
- It is important to understand what is a "Signal" to be able to use the sensors effectively.

Examples of Mechatronics,

- Robot
- Autonomous Guided vehicle,
- Vehicle engines,
- Consumer products,
- Conveyor systems,
- Assembly systems,
- Cranes,
- Defense equipment,
- Air craft engines, etc)

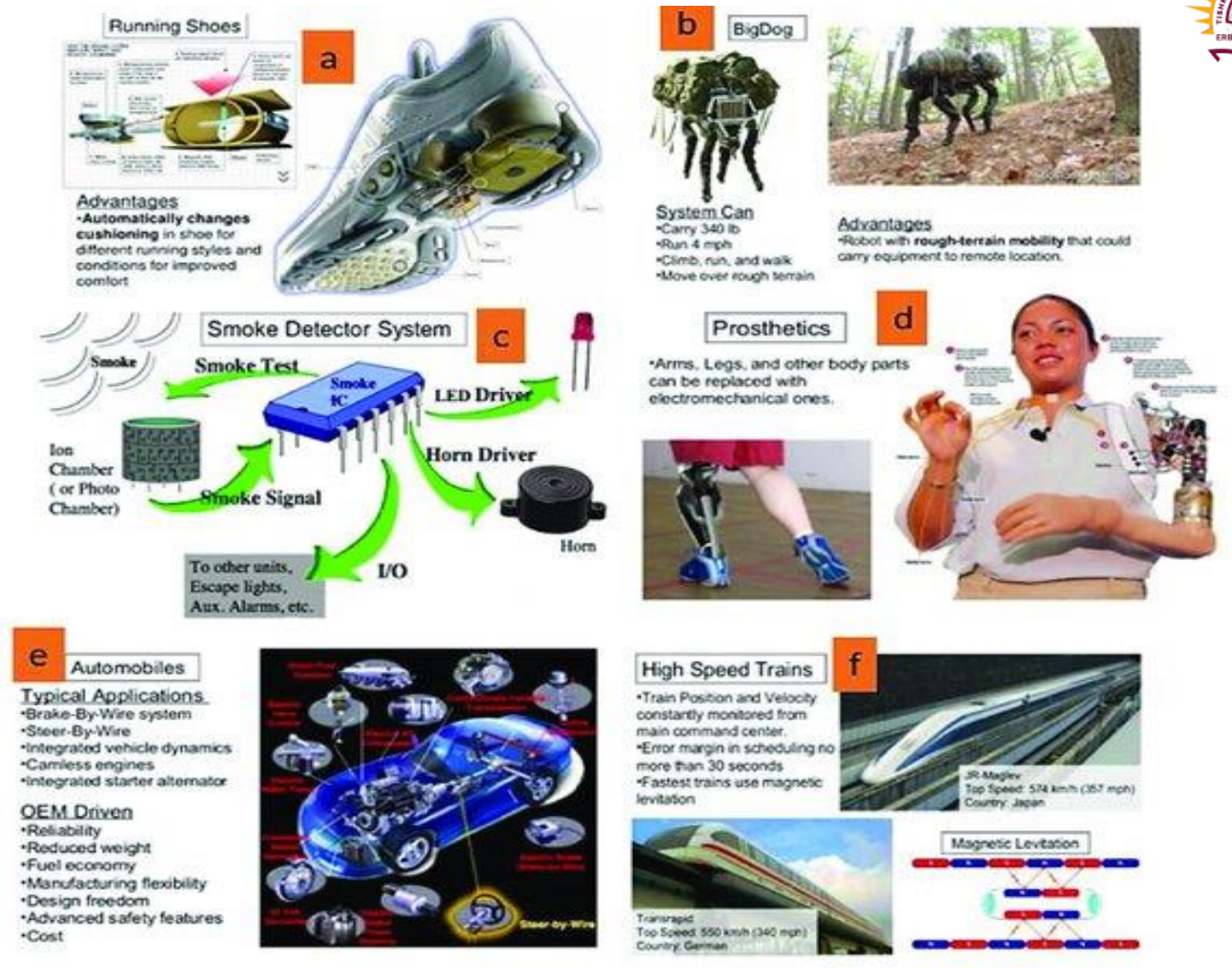


photo ref: (14) (PDF) Enviable roles of manufacturing processes in sustainable fourth industrial revolution – A case study of mechatronics (researchgate.net)

What is a SENSOR ?

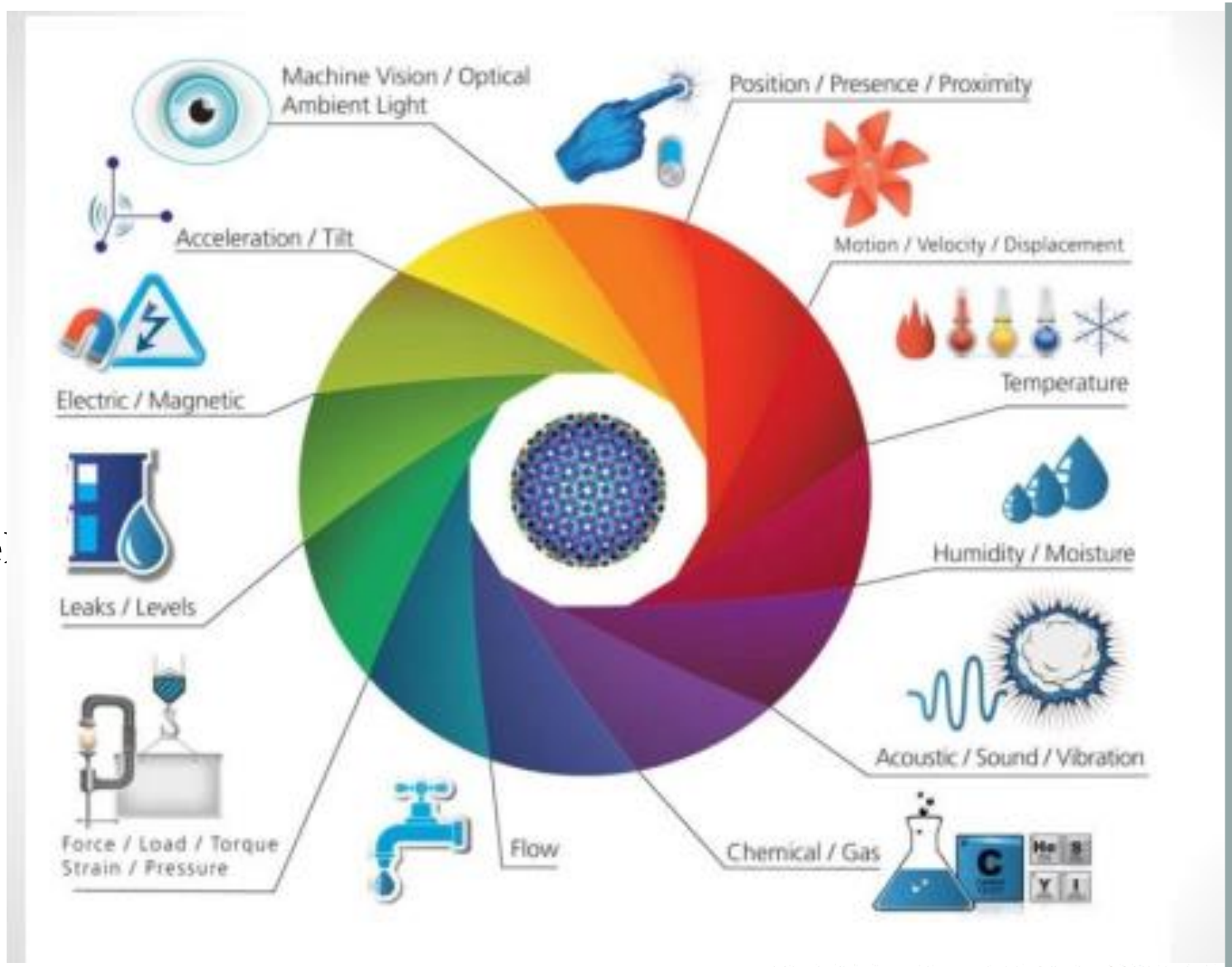
- It is a device that detects a change in a physical stimulus and turns it into a signal which can be measured or recorded by converting it into an electrical signal.
  - Technically, a sensor is a converter that converts physical signals, such as temperature, distance, or pressure into other signals, which makes it easier to make evaluations. This signal is usually an electronic signal, such as electricity Voltage, current, impedance, or oscillation frequency.
  - Sensors measure changes in physical quantities, **Input.** The changes occur in response to some excitation, for example heat or force and convert that into an electrical signal.
  - They perform an **Output** function are used to control some external device.

Role of a sensor,

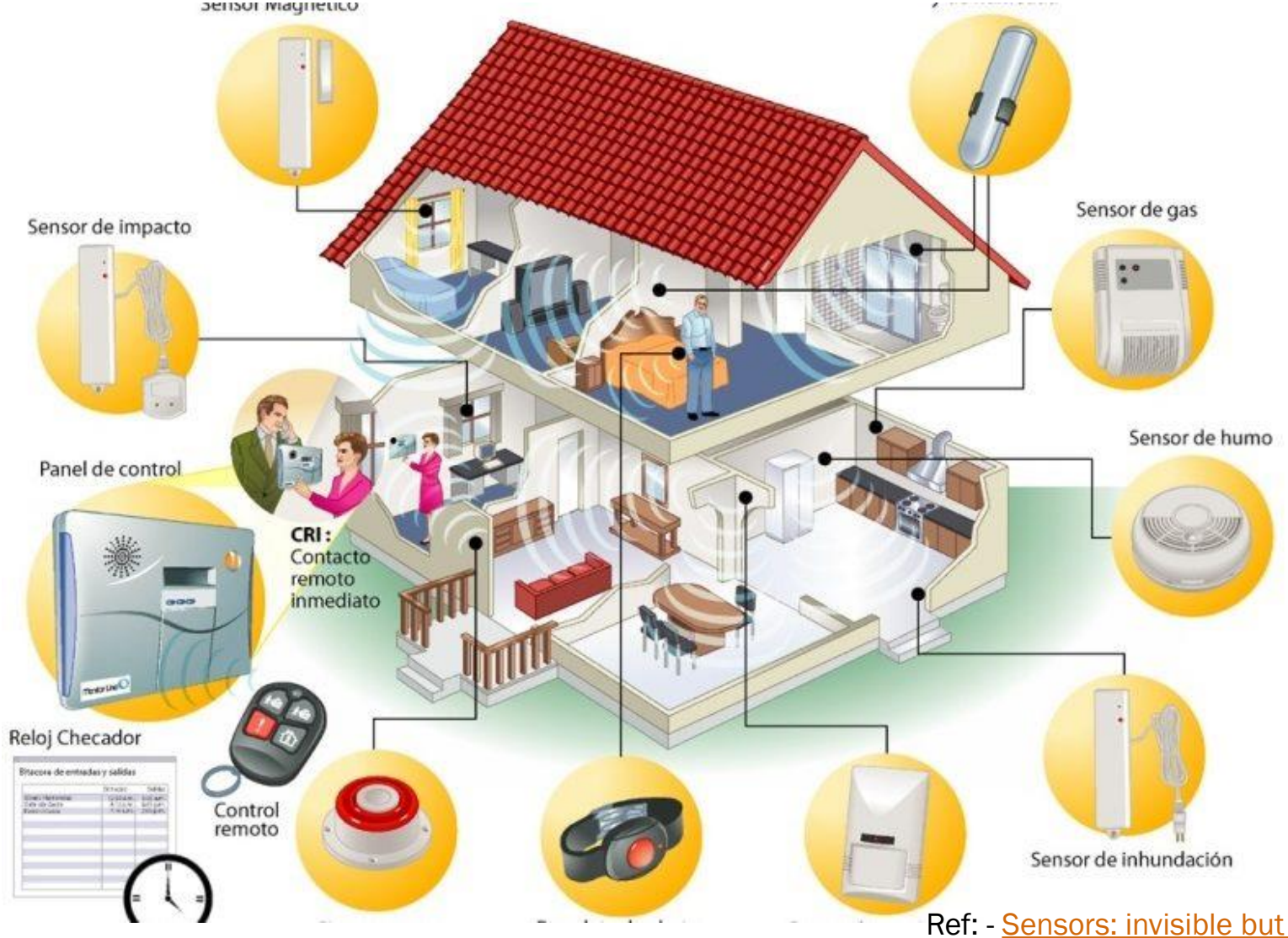
- Detection: detect the presence of an external phenomenon
- Selection: select or filter out a single property of the external stimulus
- Signal Processing: amplitude, power modulation, linearization, ADC conversion etc.
- Communication: pass the signal to the destination (control system, recording system, user)

Examples of sensors,

- Temperature sensors
- Displacement
- position
- motion and velocity sensors,
- Fluid sensors, liquid flow, liquid leve
- Light sensors … stc



Example: By sensation you can convert any system from normal one in to smart system .It's not just about design Smart Home Systems, it's the ability to convert the whole city into Smart city.



Ref: - Sensors: invisible but efficient IoT allies | PCT (uas.edu.mx)

Example: Sensors are used in the field of *automation* because they:

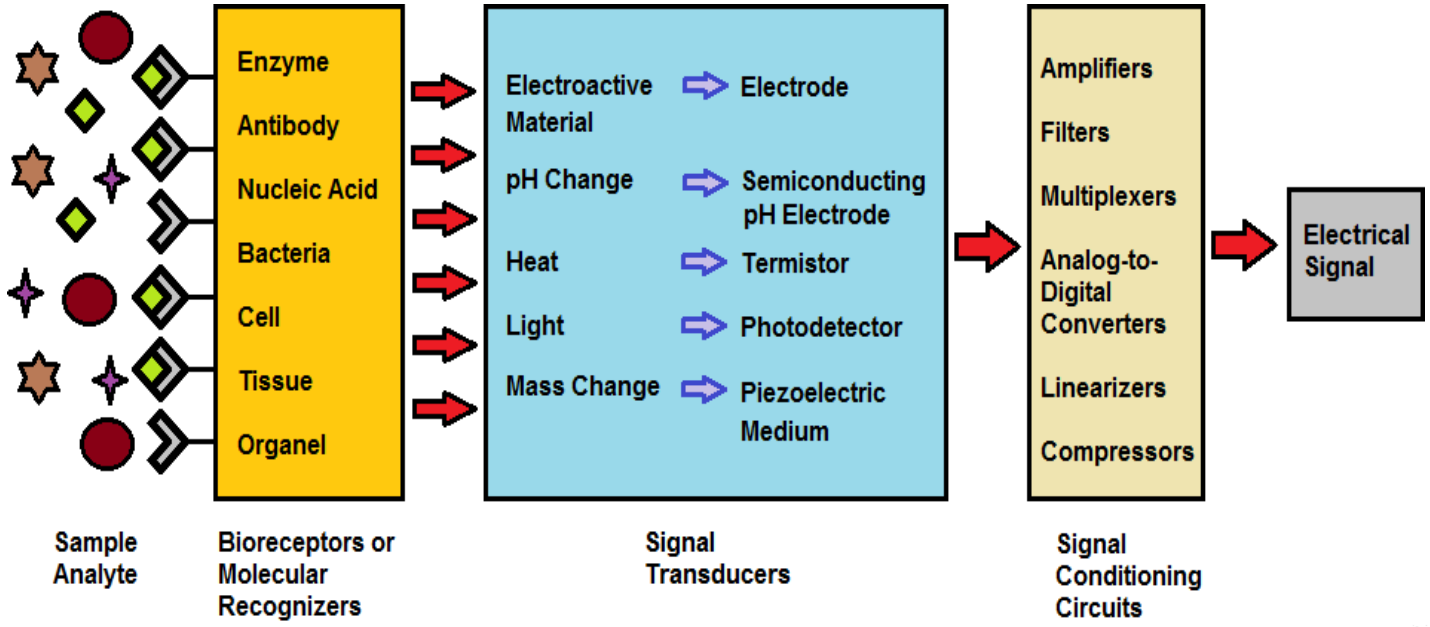
- In automation systems, errors such as tool damage can be signaled in advance.
- Locate the source of errors.
- Detection of wear tools.
- Provides measured values that can be continuously improved by control and regulation.
- For automated quality control.
- Monitor material management and assist in the automation of material flows.
- Product identification, which is the essence of automation.
- Signals of danger in the workpiece, e.g. increased contamination.
- Provide a more user-friendly working environment, such as monotonous and fatigued
- visual monitoring work, in hazardous environments monitoring and measurement work.

Ref: - Sensors: invisible but efficient IoT allies | PCT (uas.edu.mx)

BASICS – MEASUREMENT DEVICES

- Measurement devices perform a complete measuring function, from initial detection to final indication.
- Measurement system basic regions are:

1. Sensor – Primary sensing element
2. Transducer – changes one form of energy to another form energy
3. Transmitter – Contains the transducer and produces an amplified, standardized energy signal.



Signals and

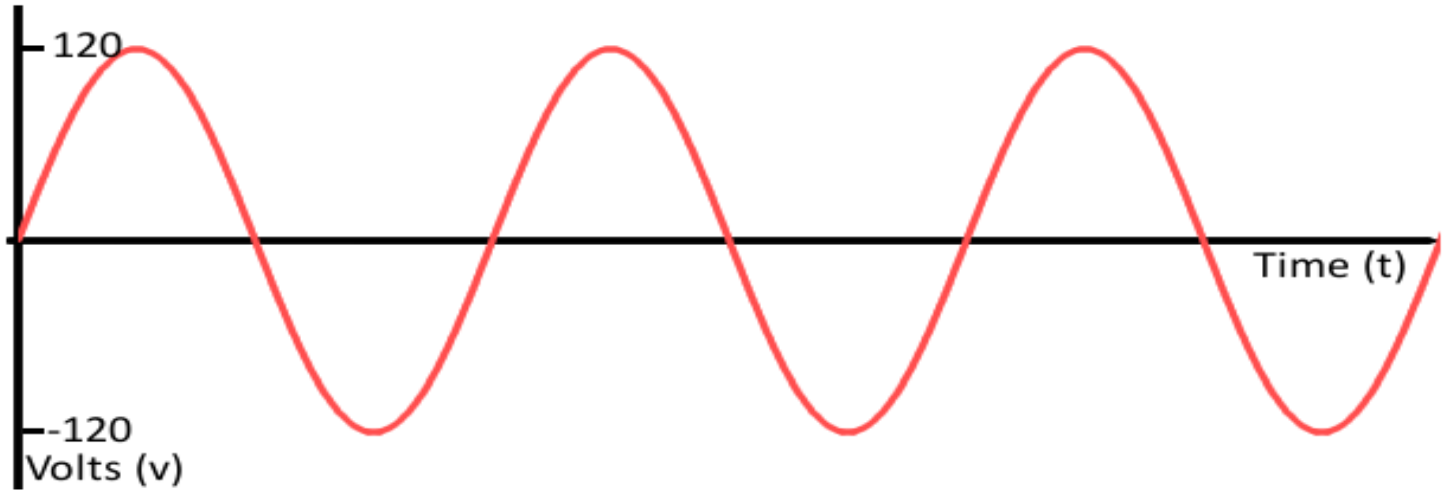
- A signal is an information conveyed between two electronic devices by fluctuating in the information value, (in most cases) voltage.

- Signal classification:
  1. Pneumatic signal – Pneumatic Signal is pressure of a gas (or air) in a pipe, instead of electrical current.
  2. Hydraulic signal -Hydraulic signals are self-propagating changes in water (fluid) pressure.
  3. Electric signal - An electrical signal is a *voltage* or *current* which conveys information, usually it means a voltage

- Electrical signals has the following two types:
  1. **Analog Signals**
  2. **Digital Signals**

Analog Signals

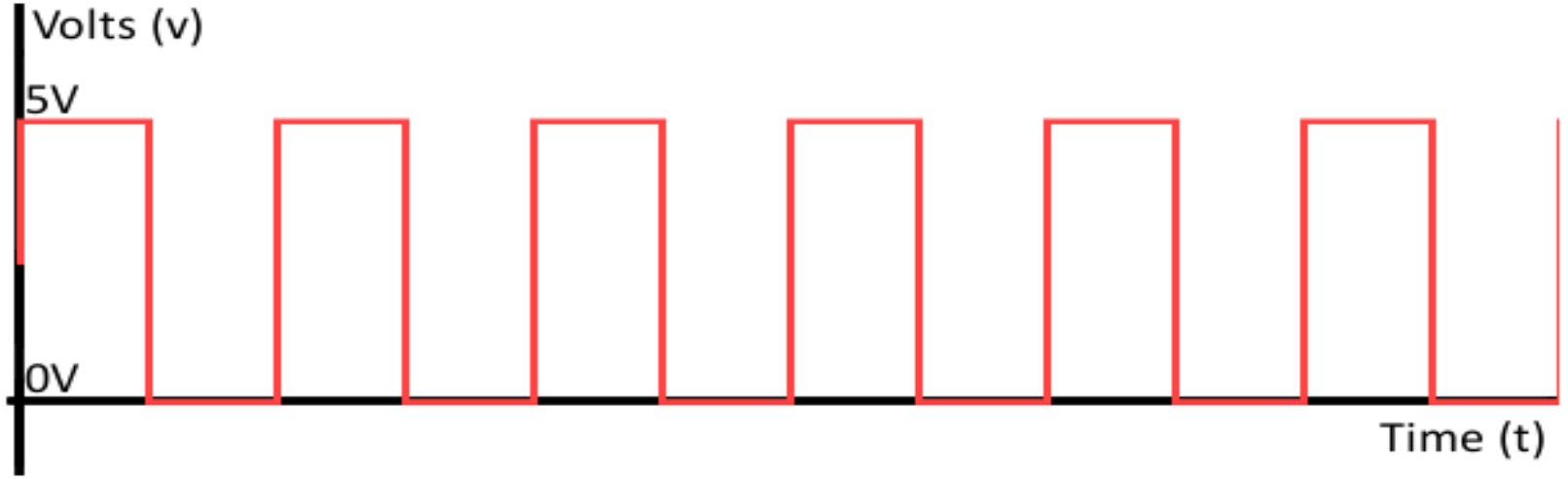
- Analog signals are continuous signals, meaning they are time-varying signals that reflect a quantity (e.g., current, voltage, or power) that changes over time.
- When look at an analog signal graph, its obviously a continuous plot with a defined value at each time point.
  - Human speech is the best example of analog signals. When look at the graph of an audio signal, notice that it's a continuous signal with a value at each time point.



Graphical representation of analog signals

Digital signals

- A digital signal represents data as a sequence of discrete values; it can only take on one of a finite number of values at any given time.
- Digital signals are discrete signals with only two possible values: high and low (1 and 0).
- By looking at a digital signal graph, can observe a square wave that varies between two points and doesn't take any other value.
  - A digital signal is a **binary signal** that can only take one of two values: 1 or 0.

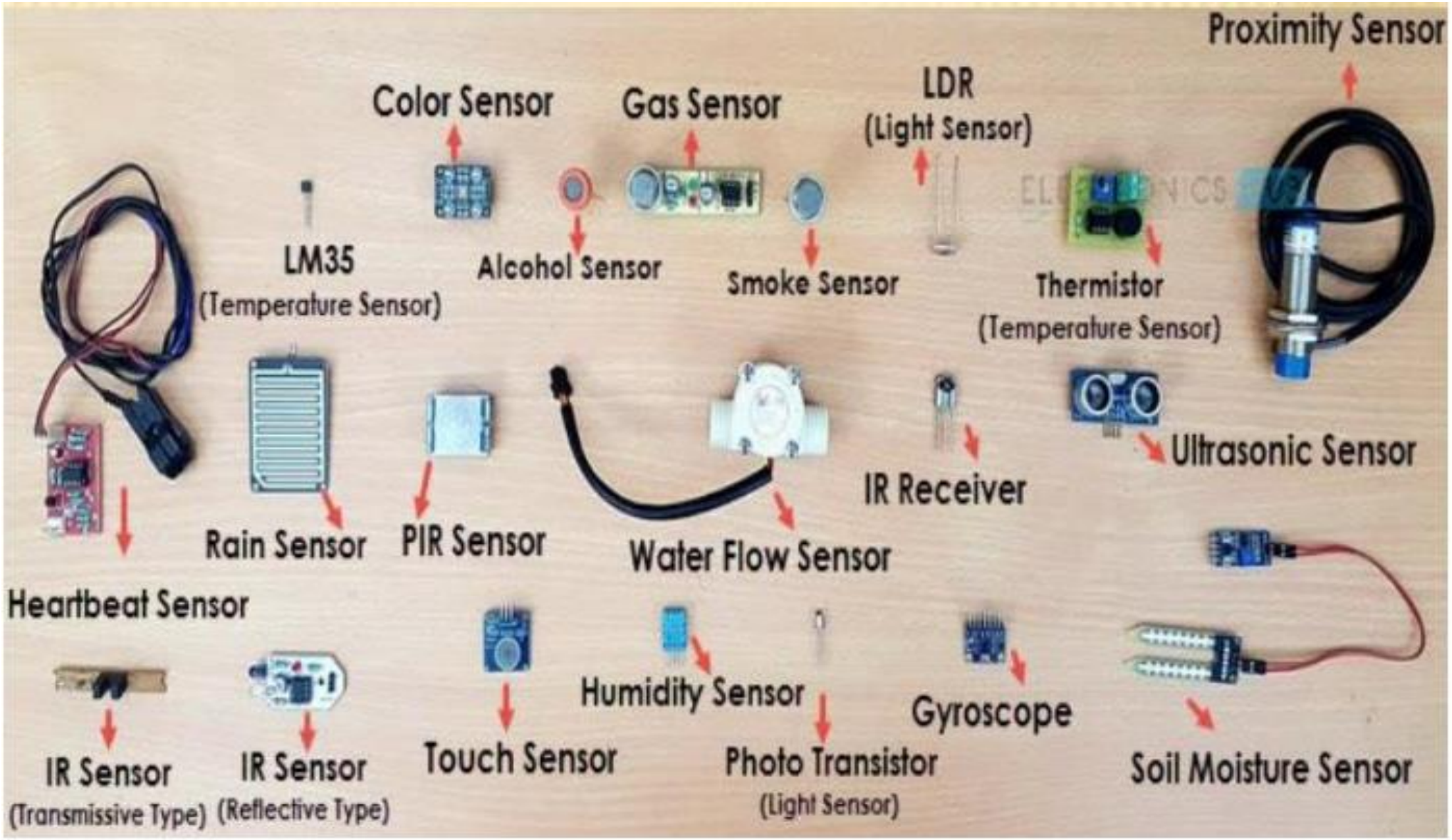


Graphical representation of digital signals

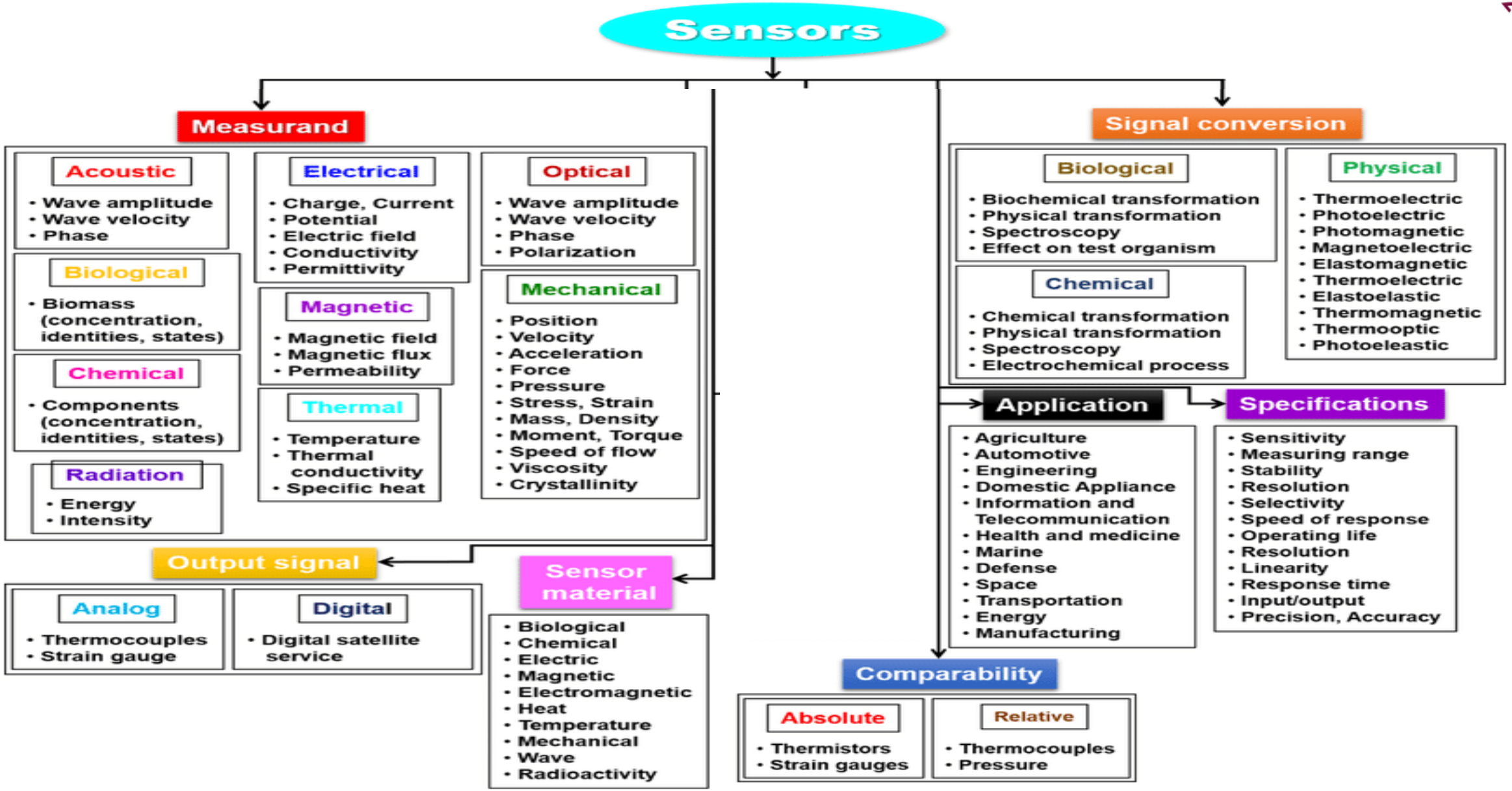
Analog vs. Digital Signals

Analog Signals	Digital Signals
Continuous Signals are present.	Discrete signals.
Represented by sine waves.	Represented by square waves.
A continuous range of values.	Discontinuous values.
Only used in Analog Devices.	Suited for digital electronics like computers and mobile phones.
Records sound waves as they are.	Converts into binary waveform.
The human voice and natural sound are some examples.	Computers and optical devices are some examples.

Examples of sensors

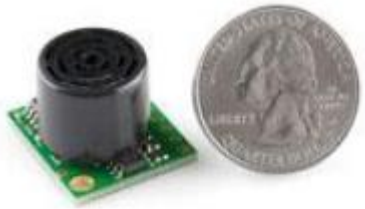


General Sensors Classification



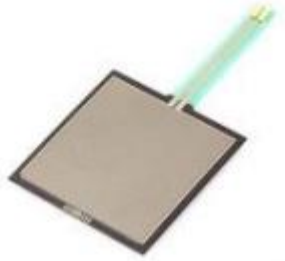
Applications of Analog sensors

- Many devices use analog signals, and sensors, in particular, provide an analog signal or voltage that varies depending on what is being sensed, such as *light, heat, humidity*, and so on.
- Sensors with analog outputs include different types such as (Speakers, Ultrasonic distance sensors, Light sensors, Ultraviolet light sensors, Flex sensors, etc).



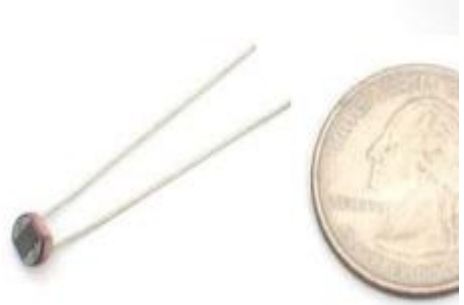
- Proximity sensors measure the distance from the sensor to an obstructing object in front of the sensor. There are two types, *Infrared and Sonar Proximity sensors*

- Accelerometers sense motion and are used to detect changes in position, tilt, and orientation.



- Pressure sensors Measure the amount of pressure, for example of a finger press, or the weight of someone standing on a surface.

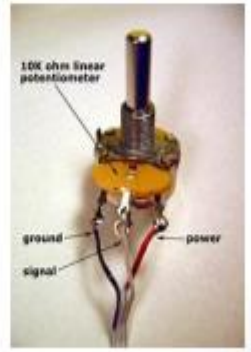
- Light sensors, Detect the amount of light striking the sensor, which is called a photocell, photoresistor.



- Temperature sensors, measure the air temperature in Fahrenheit or Celsius.

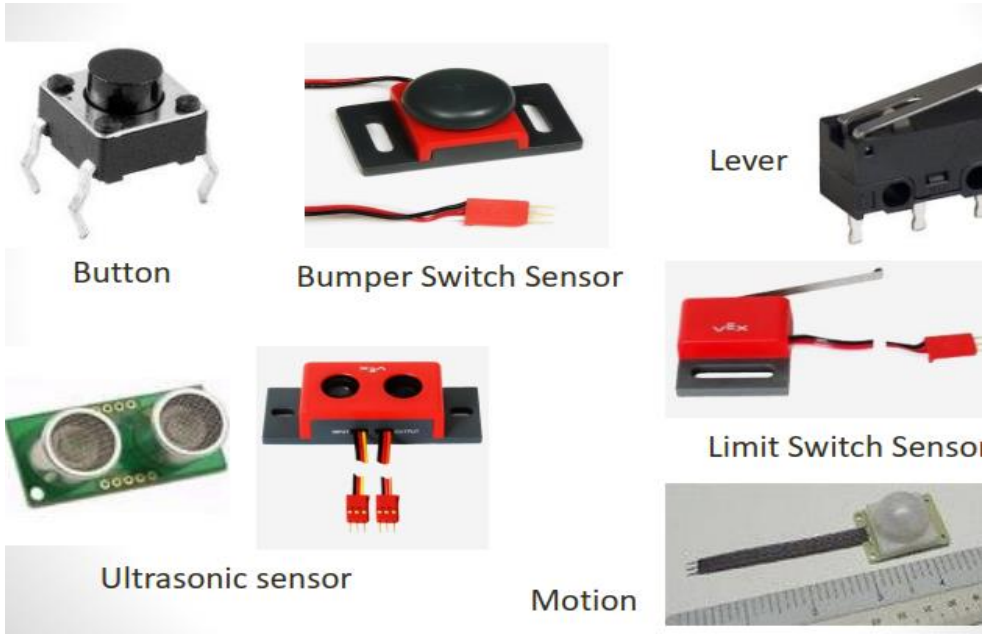
- Ribbon sensors, Measure the position of a finger touch across a surface.

- Potentiometers, Measure rotation or linear travel, and are used in car stereos, dimmers, equalizers, etc



Applications of Digital sensors

- The typical disadvantages of analog sensors have been overcome with the development of digital sensors.
- Following are the applications of digital sensors:
  - **Water and industrial processes** are the most common applications for digital sensors. *pH, redox potential, conductivity, dissolved oxygen, ammonium, nitrate, and turbidity* are among the characteristics they monitor.
  - These are implemented in **cell phones** and other **internet-connected devices**.
  - **In-game controllers** and computer components.
  - Used in the **healthcare profession.**
  - Personal **navigation equipment** is also equipped with this technology.



Sensors Characteristics

- With regard to sensors types, each type fulfills different functions, but all of them count on the same characteristics that determine the sensor's quality.
- These characteristics are:

1. Range and Span
2. Error and Accuracy
3. Precision and stability
4. Linearity.
5. Sensibility.
6. Measure repetitiveness.
7. Resolution power.
8. Physic and chemical pollutants resistance.
9. Time of response.
10. Size.
11. Encapsulating.
12. Integrated electronics.
13. Processable exits.
14. Hysteresis

Range and Span,

Span: The arithmetic difference between the highest and lowest values of the input that being sensed.

Range: Lowest and highest values of the stimulus

Input full scale (IFS) = Span

Output full scale (OFS): Difference between the upper and lower ranges of the output of the sensor.

Example:

A sensors is designed for: −30 °C to +80 °C to output 2.5V to 1.2V

- Range: −30°C and +80 °C
- Span: 80 − (−30)=110 ° C
- Input full scale = 110 ° C
- Output full scale = 2.5V-1.2V=1.3V

Nonlinearity,

- Nonlinearity is defined as the maximum deviation from the ideal linear transfer function.
- Nonlinearity must be deduced from the actual transfer Function or from the calibration curve

Hysteresis,

- Hysteresis is the deviation of the sensor's output at any given point when approached from two different directions. Caused by electrical or mechanical systems – Magnetization – Thermal properties – Loose linkages.
  - **EXAMPLE**: If temperature is measured, at a rated temperature of 50 °C, the output might be 4.95V when temperature increases but 5.05V when temperature decreases.
  - This is an error of ±0.5% (for an output full scale of 10V in this idealized example).

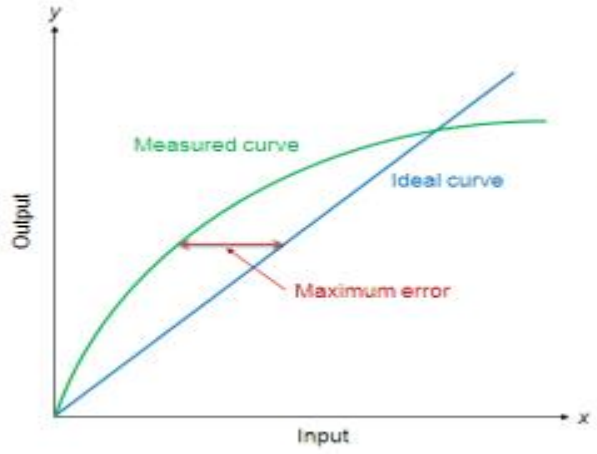


Fig. 2.1 Non-Linearity

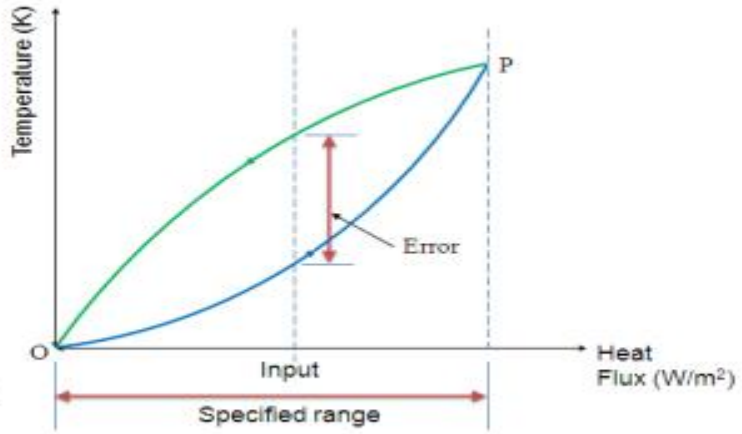
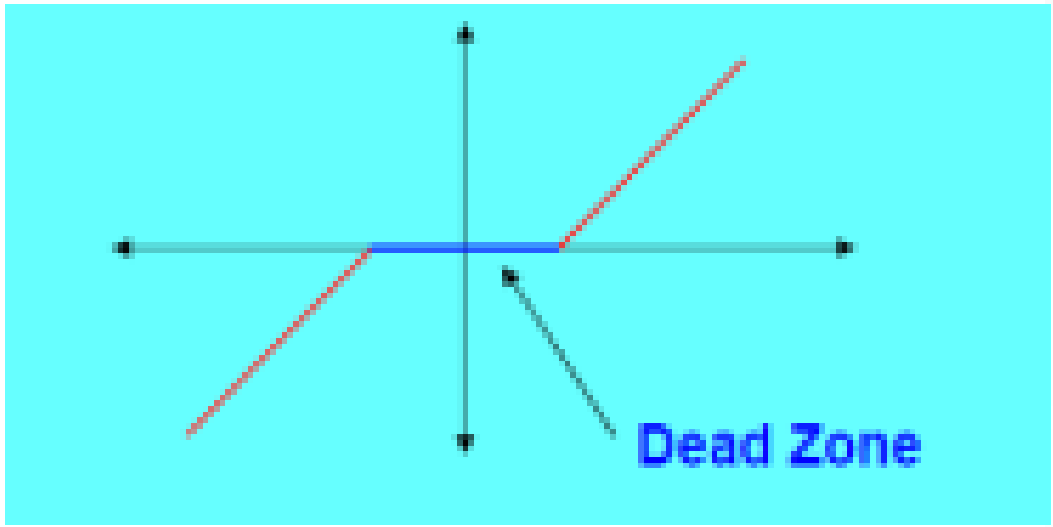


Fig. 2.2 Hysteresis

Dead-band,

- Dead-band: the lack of response or insensitivity of a device over a specific range of the input.
- In this range which may be small, the output remains constant.
- A device should not operate in this range unless this insensitivity is acceptable.



References

- Jacob Fraden, “Hand Book of Modern Sensors: Physics, Designs and Application” Fourth edition, Springer, 2010.