Sensors & Transducer

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Overview

- Types of Sensors
- Resitance strain gauges
- Resistive Potentiometer & errors
- Thermocouples ,
- RTDs ,
- Thermistors
- Piezoelectric sensors
- Inductive Transducers
- Capacitive Transducers
- Applications of sensors in Industry

What is Sensor & Transducer

• Sensor is a device that produces an output signal for the purpose of sensing of a physical phenomenon

• This signal must be produced by some type of energy, such as heat, light, motion, or chemical reaction.

Sensor:

– converts a physical parameter to an electrical output (a type of transducer, e.g. a microphone)

Transducer:

– a device that converts energy from one form to another

Actuator:

• converts an electrical signal to a physical output (opposite of a sensor, e.g. a speaker)

Types of Sensors

- Classification of Sensors

1. Active and Passive Sensors
2. Analog and Digital Sensors

- The sensors are also classified into the following criteria:

1. Primary Input quantity (Measurand)
2. Transduction principles (Using physical and chemical effects)
3. Material and Technology
4. Property
5. Application

Types of Sensors

- **Active Sensors**: The type of sensors that produces output signal without the help of external excitation supply. The own physical properties of the sensor vary with respect to the applied external effect. Therefore, it is also called as Self Generating Sensors. Any sensor which requires to input energy to the environment in order to retrieve the measurement is active.
- Examples: Photovoltaic cells, Thermocouples, Piezoelectric device.

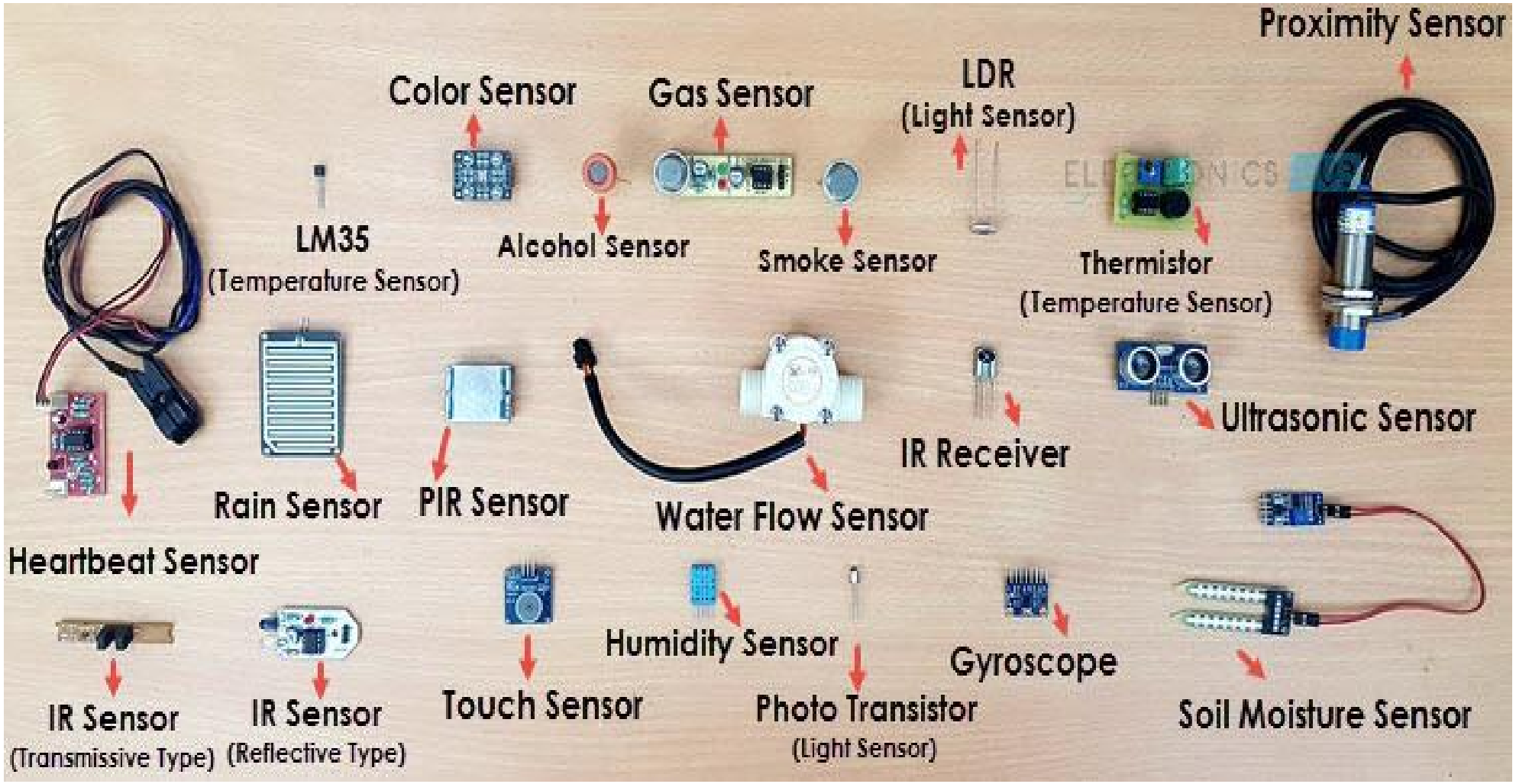
- **Passive Sensors**: The type of sensors that produces output signal with the help of external excitation supply. They need any extra stimulus or voltage. Sensors are able to retrieve a measurement without actively interacting with the environment.
- Example: Strain Gauge, Magnetometer, Barometer.

Types of Sensors

- **Analog Sensors**: The sensor that produces continuous signal with respect to time with analog output is called as Analog sensors. The analog output generated is proportional to the measured or the input given to the system. Generally, analog voltage in the range of 0 to 5 V or current is produced as the output. The various physical parameters like temperature, stress, pressure, displacement, etc. are examples for continuous signals.

- **Digital Sensors**: When data is converted and transmitted digitally, it is called as Digital sensors. Digital sensors produce discrete output signals. Discrete signals will be non- continuous with time and it can be represented in “bits” for serial transmission and in “bytes” for parallel transmission. Digital output can be in form of Logic 1 or Logic 0 (ON or OFF). A digital sensor consists of sensor, cable and a transmitter. The measured signal is converted into a digital signal inside the sensor itself without any external component. Cable is used for long distance transmission.

Pictorial Discription of Sensors

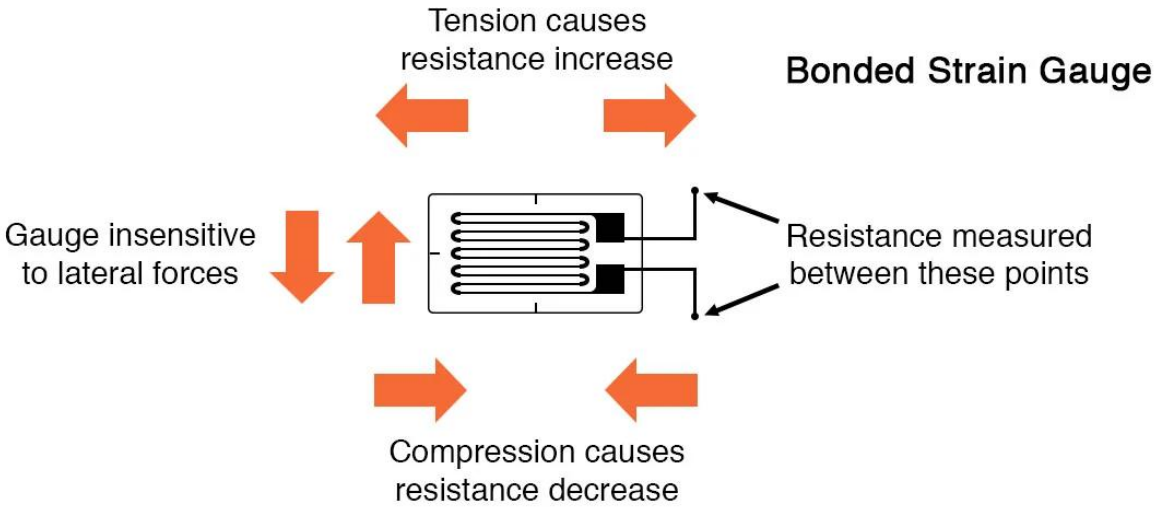


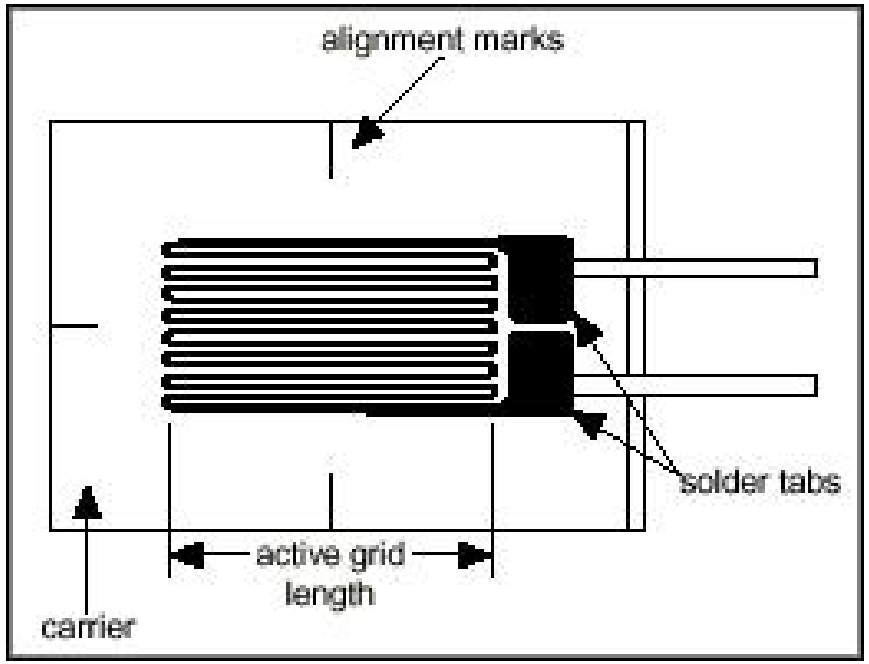
List of sensors

- Light Sensor
  1. IR Sensor (IR Transmitter / IR LED)
  2. Photodiode (IR Receiver)
  3. Light Dependent Resistor
- Temperature Sensor
  1. Thermistor
  2. Thermocouple
- Pressure/Force/Weight Sensor
  1. Strain Gauge (Pressure Sensor)
  2. Load Cells (Weight Sensor)
- Bio-Sensor
- Chemical Sensor

Resitance strain gauges

- The strain gauge is a passive, resistive transducer which converts the mechanical elongation and compression into a resistance change.
- This change in resistance takes place due to variation in length and cross sectional area of the gauge wire, when an external force acts on it.





Potentiometer

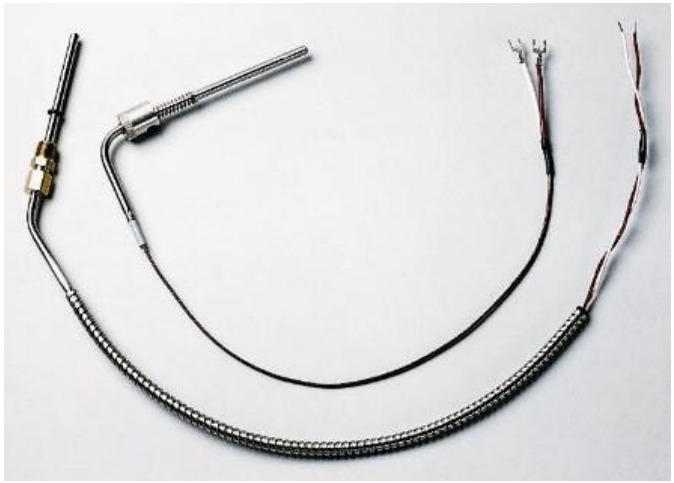
- resistance of a material given by $R \propto \frac{l}{A}$
  - ρ – resistivity of material
  - l – length
  - A – cross-sectional area of material
- change in the length changes the resistance of the material

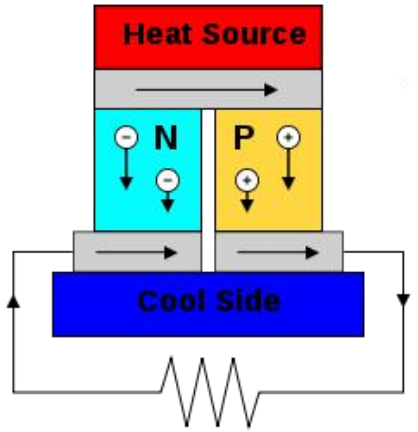
- potentiometer (pot) is a variable resistor
- pot wiper mechanically coupled to object whose displacement must be measured movement (linear or rotation) of object causes change in resistance

Thermocouples

A thermocouple is a temperature-measuring device consisting of two dissimilar conductors that contact each other at one or more spots. It produces a voltage when the temperature of one of the spots differs from the reference temperature at other parts of the circuit.

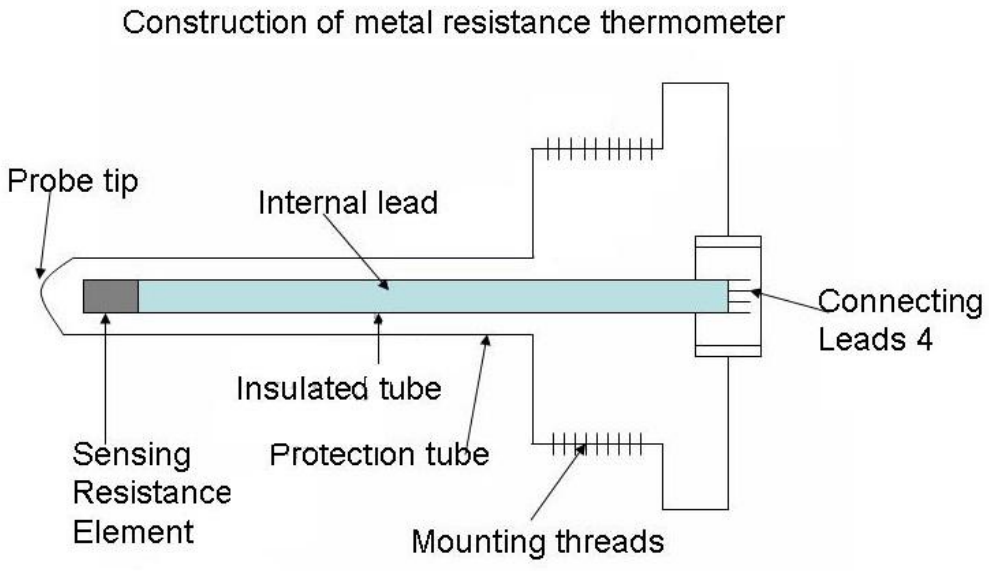
- A thermoelectric circuit composed of materials of different Seebeck coefficient (p-doped and n-doped semiconductors), configured as athermoelectric generator. If the load resistor at the bottom is replaced with avoltmeter the circuit then functions as a temperature-sensing thermocouple.

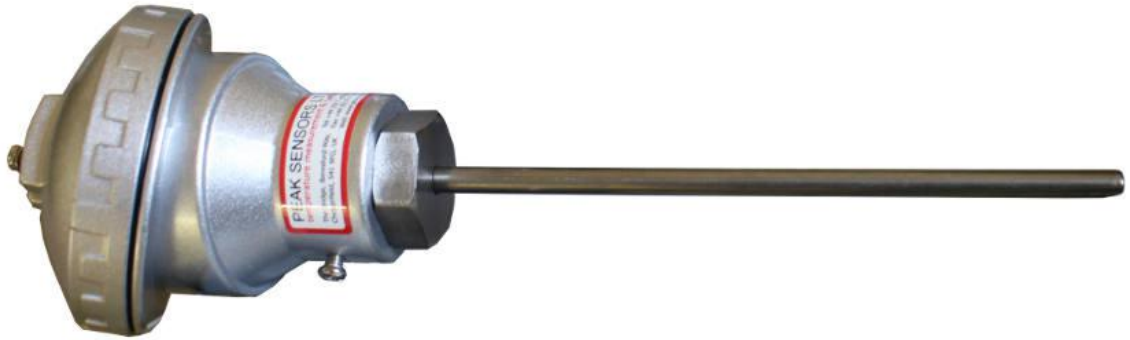




RTDs

- Resistance thermometers, also called resistance temperature detectors (RTDs), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. The RTD wire is a pure material, typically platinum, nickel, or copper. The material has an accurate resistance/temperature relationship which is used to provide an indication of temperature. As RTD elements are fragile, they are often housed in protective probes.
- RTDs, which have higher accuracy and repeatability, are slowly replacing thermocouples in industrial applications below 600 °C



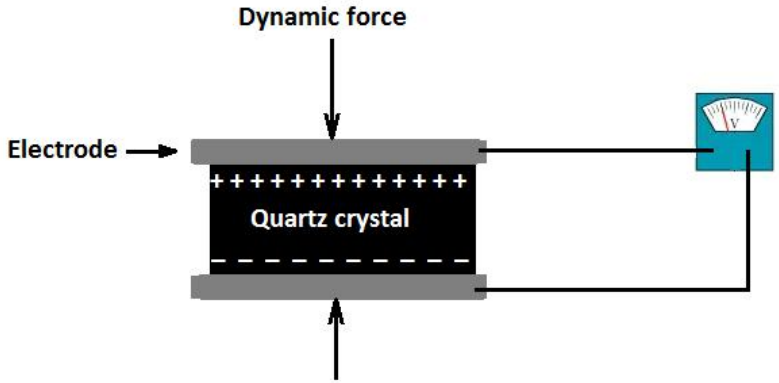


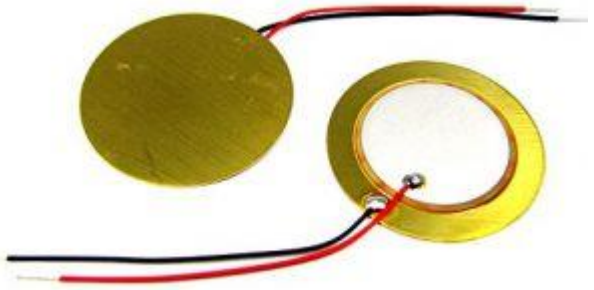
Thermistors

- A thermistor is a type of resistor whose resistance is dependent on temperature, more so than in standard resistors. The word is a combination of thermal and resistor. Thermistors are widely used as inrush current limiters, temperature sensors (negative temperature coefficient or NTC type typically), self-resetting overcurrent protectors, and self-regulating heating elements (positive temperature coefficient or PTC type typically).
- Thermistors are of two opposite fundamental types:
- With NTC thermistors, resistance decreases as temperature rises. An NTC is commonly used as a temperature sensor, or in series with a circuit as an inrush current limiter.
- With PTC thermistors, resistance increases as temperature rises. PTC thermistors are commonly installed in series with a circuit, and used to protect against overcurrent conditions, as resettable fuses.

Piezoelectric sensors

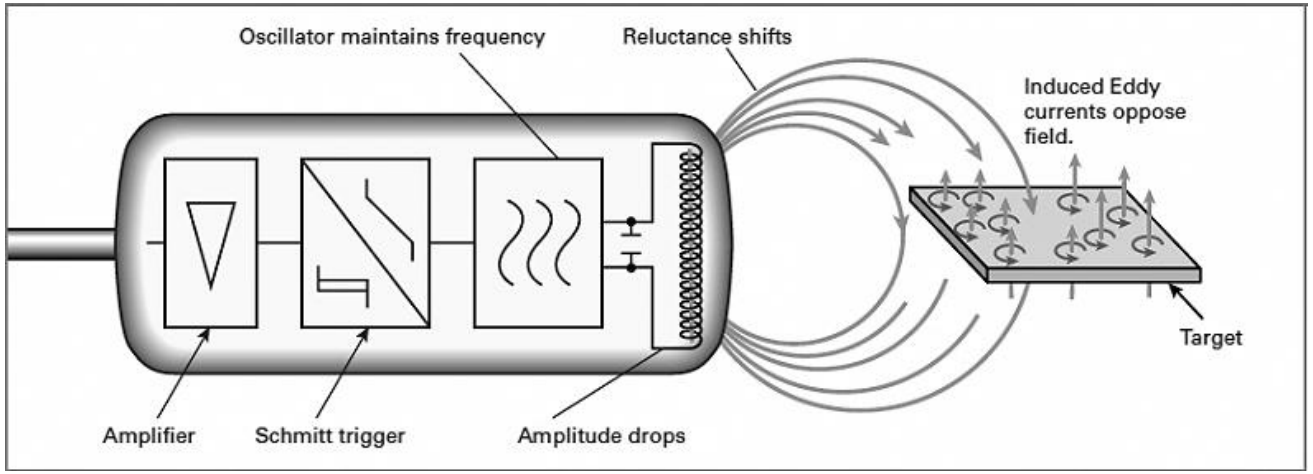
- A piezoelectric sensor is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. The prefix piezo- is Greek for 'press' or 'squeeze'.
- They have been successfully used in various applications, such as in medical, aerospace, nuclear instrumentation, and as a tilt sensor in consumer electronics or a pressure sensor in the touch pads of mobile phones. In the automotive industry, piezoelectric elements are used to monitor combustion when developing internal combustion engines. The sensors are either directly mounted into additional holes into the cylinder head or the spark/glow plug is equipped with a built-in miniature piezoelectric sensor





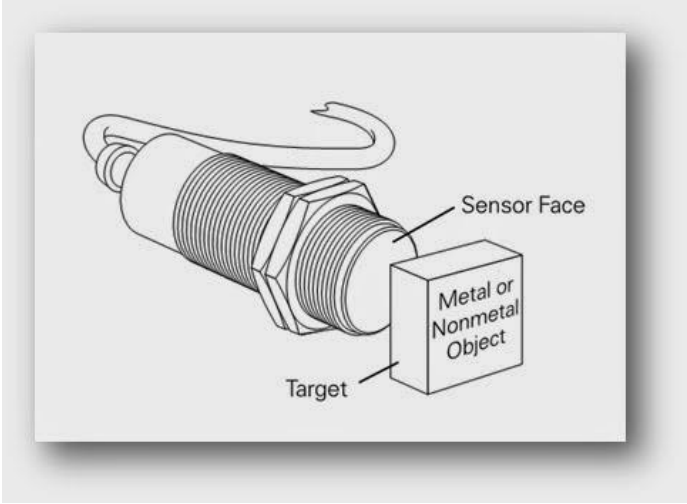
Inductive Transducers

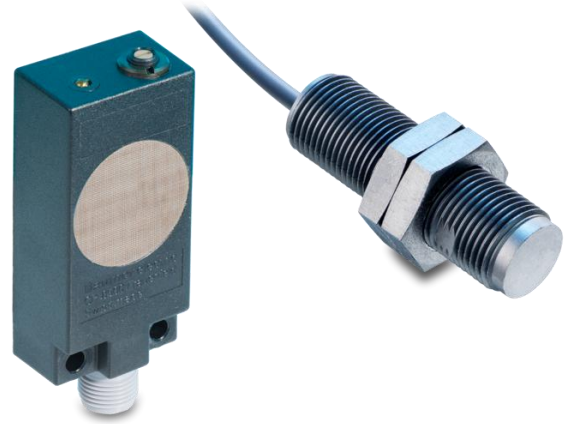
- An inductive sensor is a device that uses the principle of electromagnetic induction to detect or measure objects. An inductor develops a magnetic field when a current flows through it; alternatively, a current will flow through a circuit containing an inductor when the magnetic field through it changes.
- This effect can be used to detect metallic objects that interact with a magnetic field. Non-metallic substances such as liquids or some kinds of dirt do not interact with the magnetic field, so an inductive sensor can operate in wet or dirty conditions.



Capacitive transducer

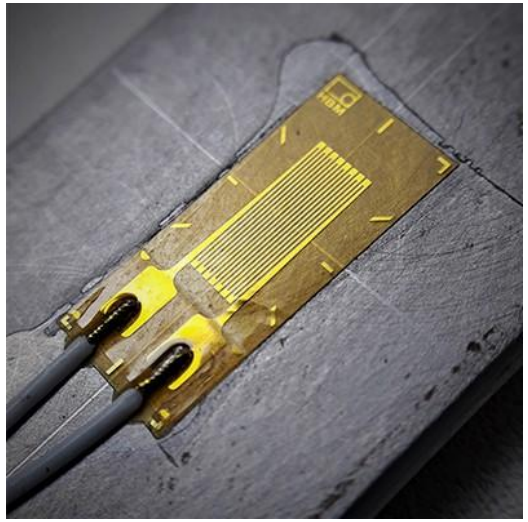
- The capacitive transducer or sensor is nothing but the capacitor with variable capacitance. The capacitive transducer comprises two parallel metal plates that are separated by the material such as air, which is called as the dielectric material. In the typical capacitor the distance between the two plates is fixed, but in variable capacitance transducers, the distance between the two plates is variable.
- In the instruments using capacitance transducers the value of the capacitance changes due to change in the value of the input quantity that is to be measured. This change in capacitance can be measured easily and it is calibrated against the input quantity, thus the value if the input quantity can be measured directly.

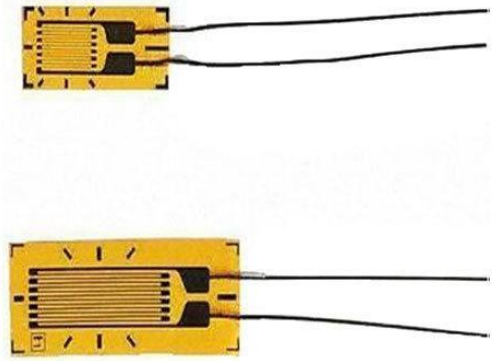




Strain guage

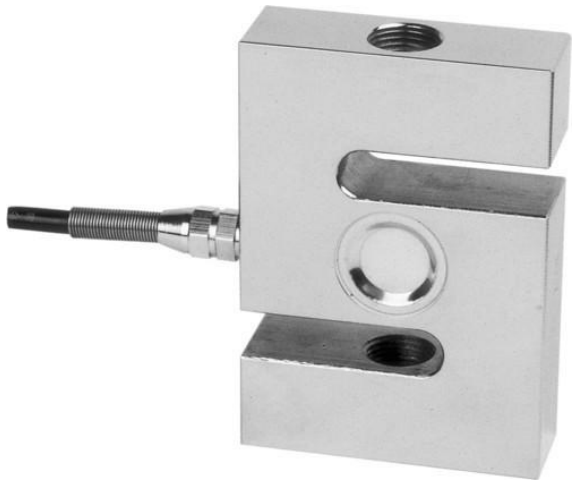
- A Strain gauge (sometimes refered to as a Strain gage) is a sensor whose resistance varies with applied force; It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. When external forces are applied to a stationary object, stress and strain are the result.
- .The most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate.
- As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the gauge factor.





Load cell

- A load cell is a force transducer. It converts a force such as tension, compression, pressure, or torque into an electrical signal that can be measured and standardized. As the force applied to the load cell increases, the electrical signal changes proportionally. The most common types of load cell used are hydraulic, pneumatic, and strain gauge.
- It is availalable in various shape and capacity



Applications of sensors in Industry

Laser rangefinders
Laser scanners/LIDAR
Laser alignment systems
Encoders
Spectrometers
Container scanners
Baggage scanners
Radiation detectors
Passenger counters
Volumetric flow controllers
Filter monitoring
Condition monitoring
Leak detection
Level sensing
Industrial printers
Cabin air pressure