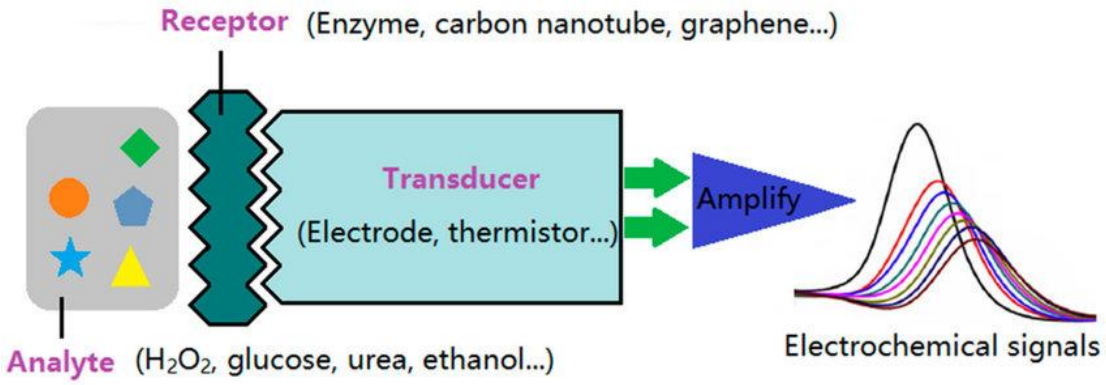
Sensor: A sensor is a device that detects and responds to some type of input either in the form of the physical or chemical component. The input can be light, heat, motion, moisture, pressure, chemical, biological or any number of other environmental phenomenon. The sensors can be divided into three types: Electrochemical, thermometric and optical sensors majorly.

1. **Electrochemical sensors:** Electrochemical sensor in particular a class of chemical sensor in which an electrode is used as a transducer element in the presence of an analyte. Electrochemical sensors made up of three essential components: a target electroactive analyte, a receptor that interacts with the sample analyte and a transducer to convert the reaction into a measurable electrical signals. The electrochemical sensors again can be divided into three types such as conductometric, potentiometric and amperometric based on the signal measuring method with respect to the concentration of the analyte.



Construction and working mechanism of Gas sensor as an electrochemical sensor:

The gas sensor which is an electrocheical sensor consist of following components

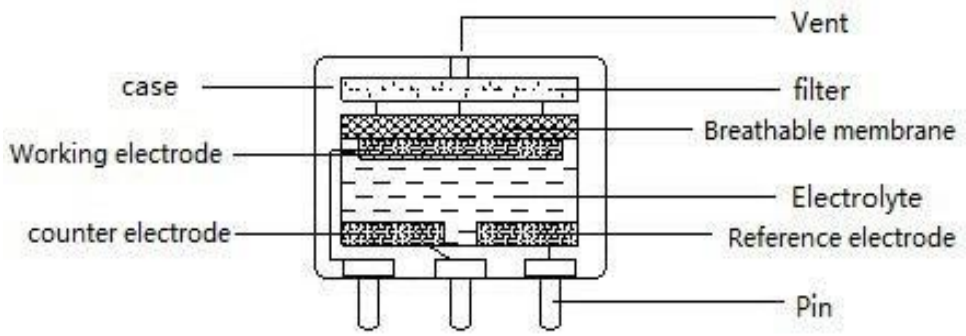
1. **Filter:** A porous (or) scrubber filter installed in front of the sensor to filter out unwanted gases and gas impurities. Ex: activated carbon based filters

2. **Breathable membrane:** Also called as hydrophobic membrane used to cover the working (or) sensing electrode surface and it can control the molecular weight of the gas reaching to the electrode surface. Ex: Porous Teflon.

3. **Electrode system:** A three electrode system is used like working, counter and reference electrodes in the fabrication. The working electrode material should be a catalytic material that can perform semi-electrolytic reactions over a long period of

time. Ex: high sensitive Pt, Au or transition metal electrodes or modified electrodes for better sensitivity.

4. **Electrolyte:** The electrolyte must be able to carry out the electrolysis reactions and effectively transfer the ionic charges to the electrodes. Ex: polymer based electrolytes.



The electrochemical gas sensor works by reacting with the measured gas/analyte and generating an electrical signal proportional to the concentration. The gas diffused through the filter and breathable membrane reaches and reacts with the sensing electrode and the sensing electrode can adopt an oxidation or reduction reactions. These reactions are catalyze by electrode material designed for the gas being measured. Through the resistor connected between the electrodes, a current proportional to the concentration of the gas to be measured will flow between positive and negative electrodes. The amount of current generated will be directly proportional to the concentration of the gas reached to the sensor.

$$SO_2 + 1/2\ O_2 \leftrightarrow SO_3$$ (oxidation reaction at 0.7 V)

$$NO_2 \leftrightarrow NO + 1/2\ O_2$$ (reduction reaction at 0.45 V)

Advantages:

1. Detection speed is fast, very simple and convenient.
2. The cost is relatively low
3. Analyze proteins and useful n drug development and disease treatment.

Disadvantages:

1. Short lifespan
2. Electrolytic solution needs to replenish regularly

Applications:

1. Detection of toxic gases like nitrogen oxides, sulfur oxides, hydrogen sulfide, methane with high selectivity and sensitivity.
2. Detection of analytes in agriculture, food, oil industries as well as in environment and biomedical applications.
3. Humidity sensor: The sensor used to monitor relative humidity which coated with piezoelectric quartz crystal.

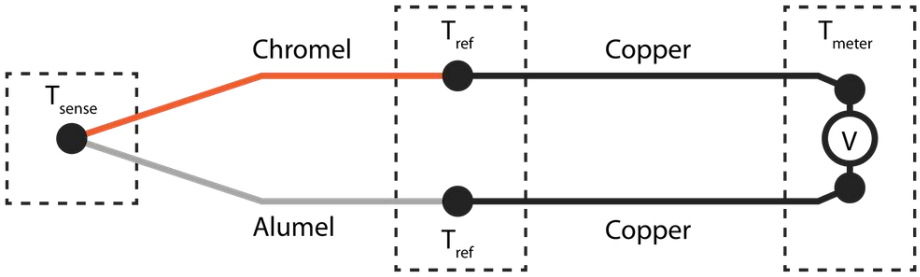
2. Thermometric sensor (temperature sensor):

The temperature sensor refers to a sensor that can sense the temperature and convert it into a usable output signals at the core part of the temperature measuring instrument. The five common types of sensors include thermocouples, Resistant temperature detectors (RTDs), thermistors, analog thermometer ICs and digital thermometer ICs.

Working principle:

Thermocouples: TCs will work on the principle called Seebeck effect where an electromotive force (voltage) is generated when two different conductors or semiconductors are connected to each other to form a loop. As long as the temperature applied to two nodes temperature gradient will be different and amount of voltage generated at both the ends can be measured to find out the temperature of the system.

Ex: A thermocouple made up of Ni-Cr (chomel) as +ve terminal and Ni-Al (Alumel) as -ve terminal connected in a loop to measure the system temperature.



Resistance temperature detectors:

RTD measures the temperature according to the rule that the resistance of the conductor or semiconductor changes with temperature. The temperature sensing element of resistance thermometrs are commonly made of metal wires such as Pt, Cu, Ni, Ge and Rh. Most of the RTDs are made up of Pt so often called them as platinum resistance therometers.

The resistance changes in 2 different ways:

Positive temperature coefficient

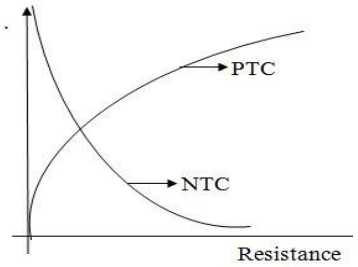
Temperature increases- resistance increases

Temperature decreases- resistance decreases

Negative temperature coefficient

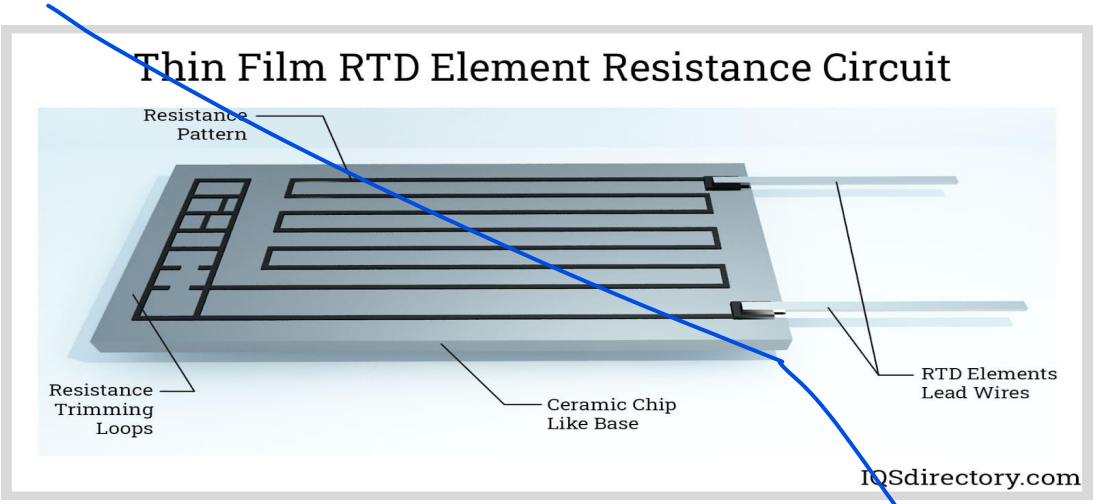
Temperature increases- resistance decreases

Temperature decreases- resistance increases



Thin Film RTD Sensors

Thin film RTD elements have a thin layer of metal placed on the substrate of a ceramic material. The film of metal is etched into an electrical circuit pattern that offers the necessary amount of resistance. Lead wires are attached, and a protective coating is applied to the substrate and element. Thin film RTD sensors are rugged, reliable, and resistant to shock and vibration damage.



Applications:

1. **Motorsport and other vehicles** – ensuring motors do not overheat, surface plate temperature, exhaust gas temperature, oil temperature etc

2. **Industrial equipment** – most machinery used within industrial equipment and manufacturing will contain a temperature sensor for safety reasons.

3. **Medical Applications** – Temperature sensors are used for patient monitoring as well as within machines and devices for a range of medical procedures.

4. **Food and Beverage Industry** – temperature sensors are used within this environment as part of food safety standards, ensuring food is kept at the correct temperature.

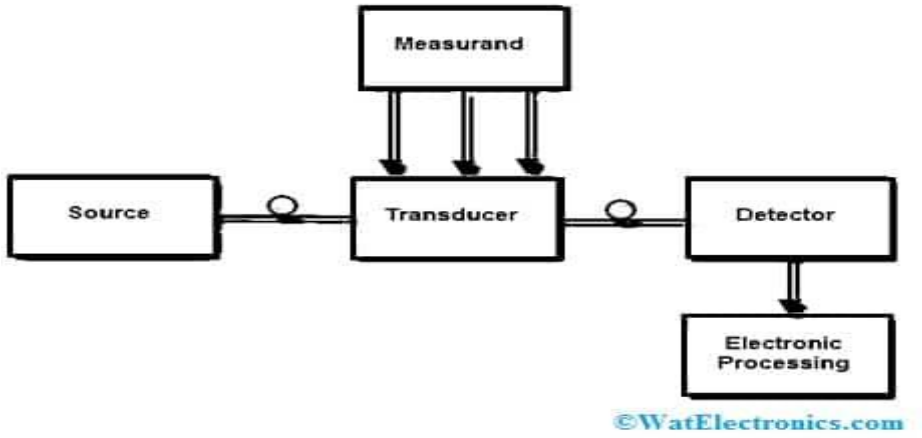
5. **Computers and devices**– temperature sensors are used within computers and other devices to ensure they do not overheat and become dangerous.

3. Optical sensors:

An optical sensor is a sensor that is used to convert the light rays into electronic signals. These sensors help in measuring the incident light's intensity & changing it into a readable form through an incorporated measuring device based on the type of sensor. Generally, this sensor is an essential part of a larger system which includes a light source, sensor, and measuring device itself.

Working Principle:

An optical sensor's detecting principle mainly depends on changes within the optical signal's characteristics. This sensor simply detects the polarization of light, wavelength, or frequency and changes it into an electric signal because of the photoelectric effect.



There are different types of optical sensors like Through Beam, Diffuse reflective & Retro-reflective sensors.

Through Beam Optical Sensors

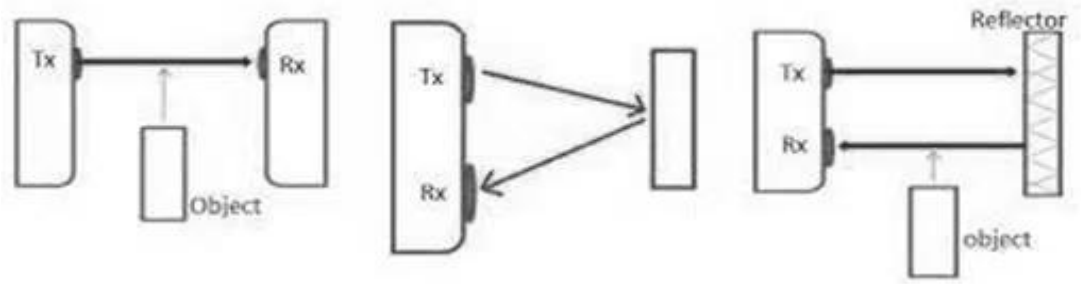
Through-beam optical sensor includes both transmitter & receiver which are arranged by pointing to each other so that they can create a directly light ray path. Once any object approaches in the middle of this path then the light intensity will be changed & thus object is detected.

Diffuse Reflective Sensor

This diffuse reflective sensor has both transmitter & receiver which are arranged parallel to each other. Once the transmitter generates a light signal then it is reflected through the object. This light reflection can be simply measured through the receiver.

Retro-reflective Sensor

This kind of optical sensor has both transmitter & receiver which are arranged within one housing. The transmitter generates a light ray which is reflected through the reflector & obtained by the receiver. If any object approaches in the middle of this light ray path, then it breaks. So the object at the receiver is detected based on the variation between the intensity of the light beam & other parameters.



Advantages

1. Sensitivity is high.
2. Inert chemically.
3. The dynamic range is wide.
4. It is capable to monitor a wide range of physical and chemical parameters.

Disadvantages

1. Optical sensors are expensive.
2. Vulnerable to physical damage
3. Susceptible to intrusion from ecological effects.

Applications

1. Optical sensors are used in smartphones for adjusting the brightness of the screen.
2. These are used in smartwatches to measure the heartbeat of the person.
3. These are used as water level indicators.
4. These are utilized in several commercial & research applications for process & quality control, metrology, medico technologies, remote sensing & imaging.