

Unit 4, Transducer II

Peizo-electric Transducer, Optoelectronic transducers: LDR, Chemical sensors: PH sensor, Gas sensor (Fundamental aspects), Humidity sensor.

Introduction

- **A transducer is a device that converts one form of energy or physical attribute to another form.**
- **Most of the transducers either converts electrical energy into mechanical displacement and/or converts some non-electrical physical quantity, such as temperature, light, force, sound etc., into an electrical signal.**

Classification of Transducers

- **Two Main Groups:**
 1. **Active transducers, and,**
 2. **Passive transducers.**

Active Transducer

The active transducers are self generating type of transducers. They develop an electrical parameter, i.e., Voltage or current, which is proportional to the quantity under measurement.

Commonly used types of active transducers are;

1. Photovoltaic
2. Thermoelectric
3. Piezoelectric
4. Electromagnetic.

Passive Transducer

The passive transducers do not generate any electrical signal by themselves. To obtain an electrical signal from these transducers, an external power is essential. They depend on the change in electrical parameter (R, L & C). They are also known as externally power driven transducers.

- They can be subdivided into the following commonly used types;
- **Variable Resistance: Photoconductors, Strain gauges, and Thermistors.**
- **Opto-electronic : - Light Dependent Resistor (LDR)**

Piezoelectric Effect

- when opposite faces of a thin slice of certain crystal are subjected to a mechanical force, then opposite charges are developed on the two faces of the slice.
- The magnitude of the electric potential between the two faces is proportional to the deformation produced.
- At the same time the polarity of the potential produced across the faces get reversed, if the direction of force is reversed.
- Conversely, if the varying potential is applied to the axis of the crystal, the dimensions are changed and the crystal deforms.

- **This phenomenon is called Piezoelectric Effect,**
- **The material exhibiting this effect are called Piezoelectric Materials.**
- **The materials are Quartz, Rochelle salt, Tourmaline, and ceramic barium titanate.**
- **The Rochelle salt shows greatest piezoelectric activity.**

Piezoelectric Transducer

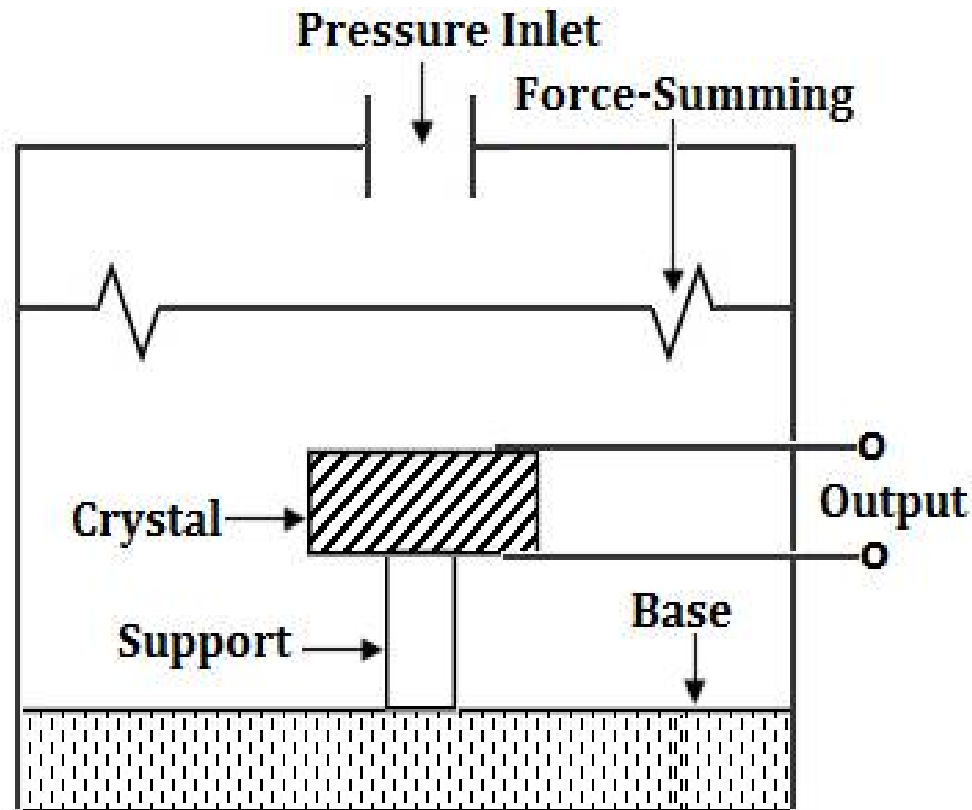


Fig - A, Piezoelectric Transducer.

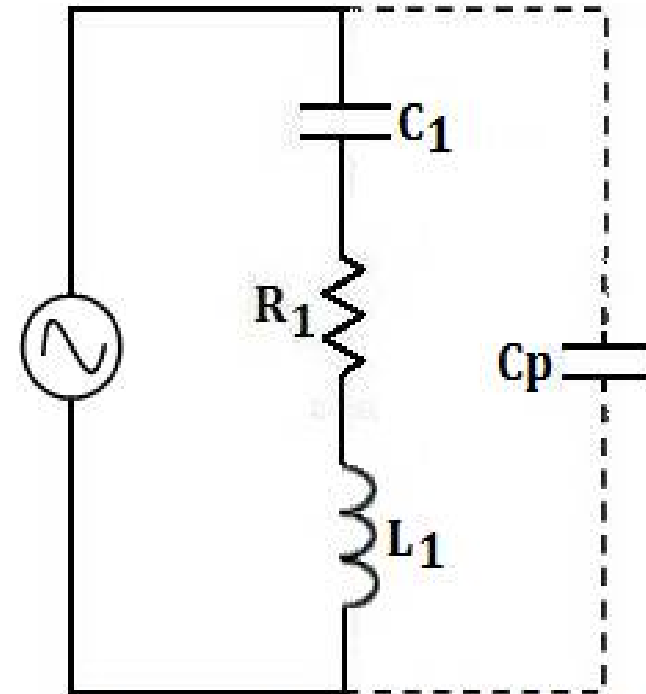


Fig - B, Equivalent CKT of Crystal.

$$E = \frac{Q}{C_p}$$

where Q=Charges generated, &
Cp = Shunt capacitance

Advantages of Piezoelectric Transducer

- **Excellent frequency response.**
- **High output with negligible phase shift.**
- **Rugged construction and small size.**

Disadvantages of Piezoelectric Transducer:

- **Voltage will be generated as long as the applied pressure changes.**
- **Piezoelectric crystals are water soluble, hence, in a high humid environment gets dissolved.**
- **Temperature sensitive.**
- **Can be used for dynamic measurement only.**

Optoelectronic Transducers: LDR

- **Light Dependent Resistor (LDR)**
- **Also known as Photo resistors.**
- **light sensitive devices**
- **Most often used to indicate the presence or absence of light,**
- **Or to measure the light intensity.**

Optoelectronic Transducers: LDR

- **Principal:**

The resistance of certain semiconductor material decreases when they are exposed to radiations.

In other words, such materials have high dark resistance and low irradiated resistance.

Construction: LDR

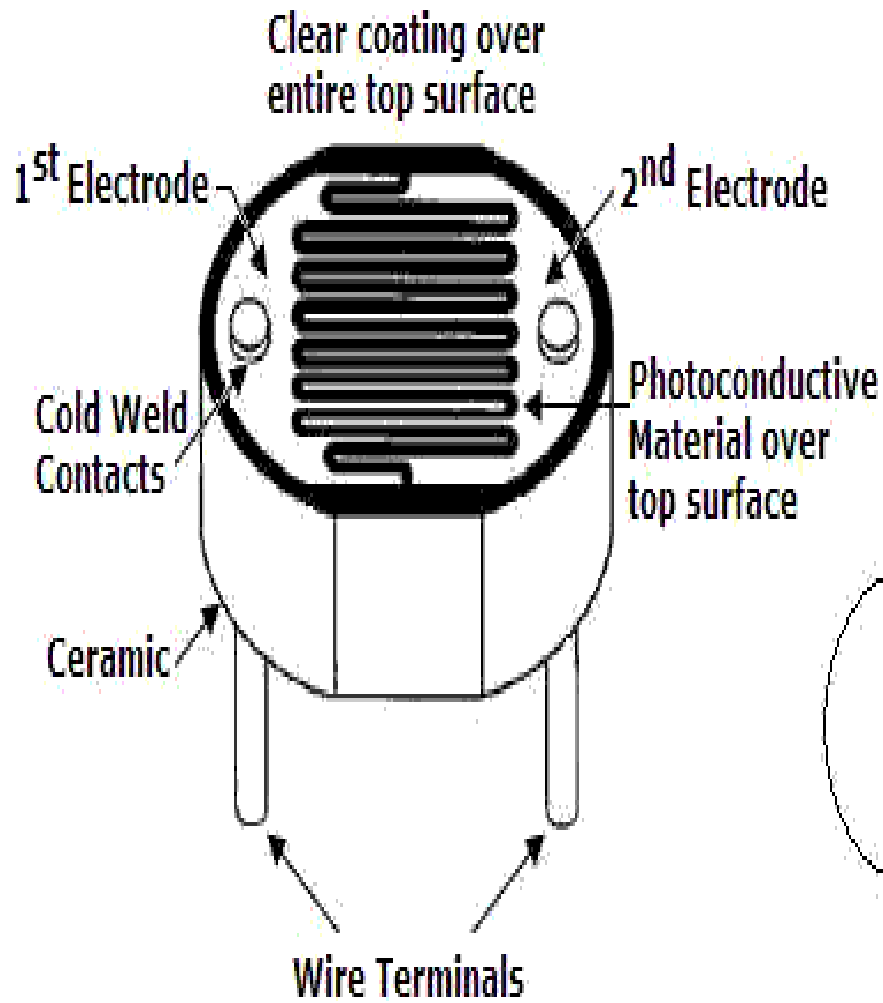


Fig. A. LDR



Fig. B. Symbol.

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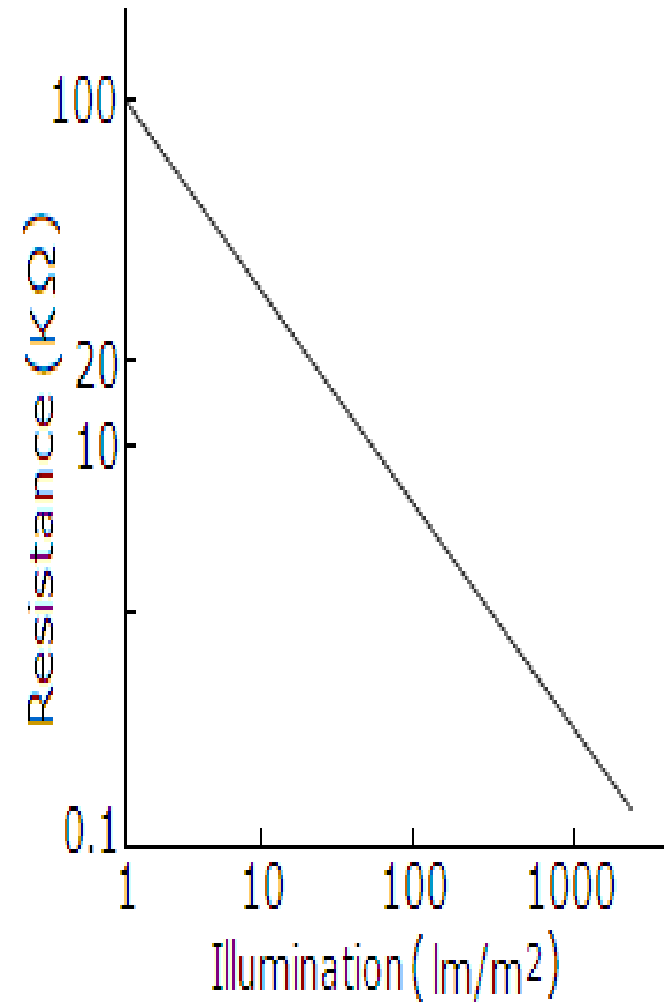


Fig. C. Illumination Characteristics.

pH Meter

- A very important measurement in many liquid chemical processes is that of pH: **the measurement of hydrogen ion concentration** in a liquid solution.
- A solution with a low pH value is called an "acid," while one with a high pH is called a "caustic." The common pH scale extends from **0 (strong acid)** to **14 (strong caustic)**, with **7** in the middle representing pure water (**neutral**).

The electrodes used for pH measurements are as follows;

- **Differential Electrode**
- **Hydrogen electrode**
- **Calomel electrode**
- **Quinhydrone and antimony electrode**
- **Glass electrode**

pH Measurement Using Hydrogen Electrode

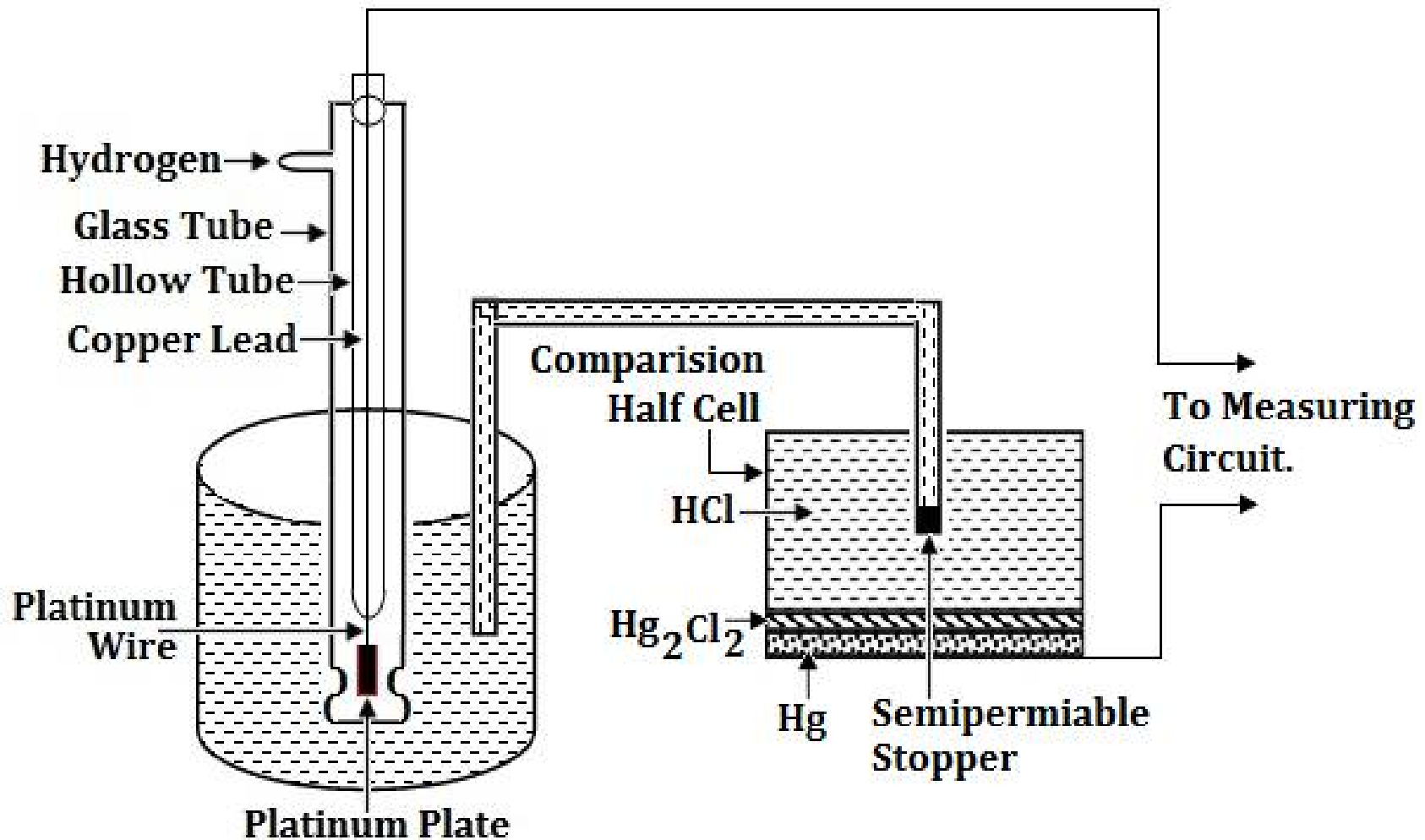


Fig - pH Measurement Using Hydrogen Electrode.

ph Sensor (Differential Electrode)

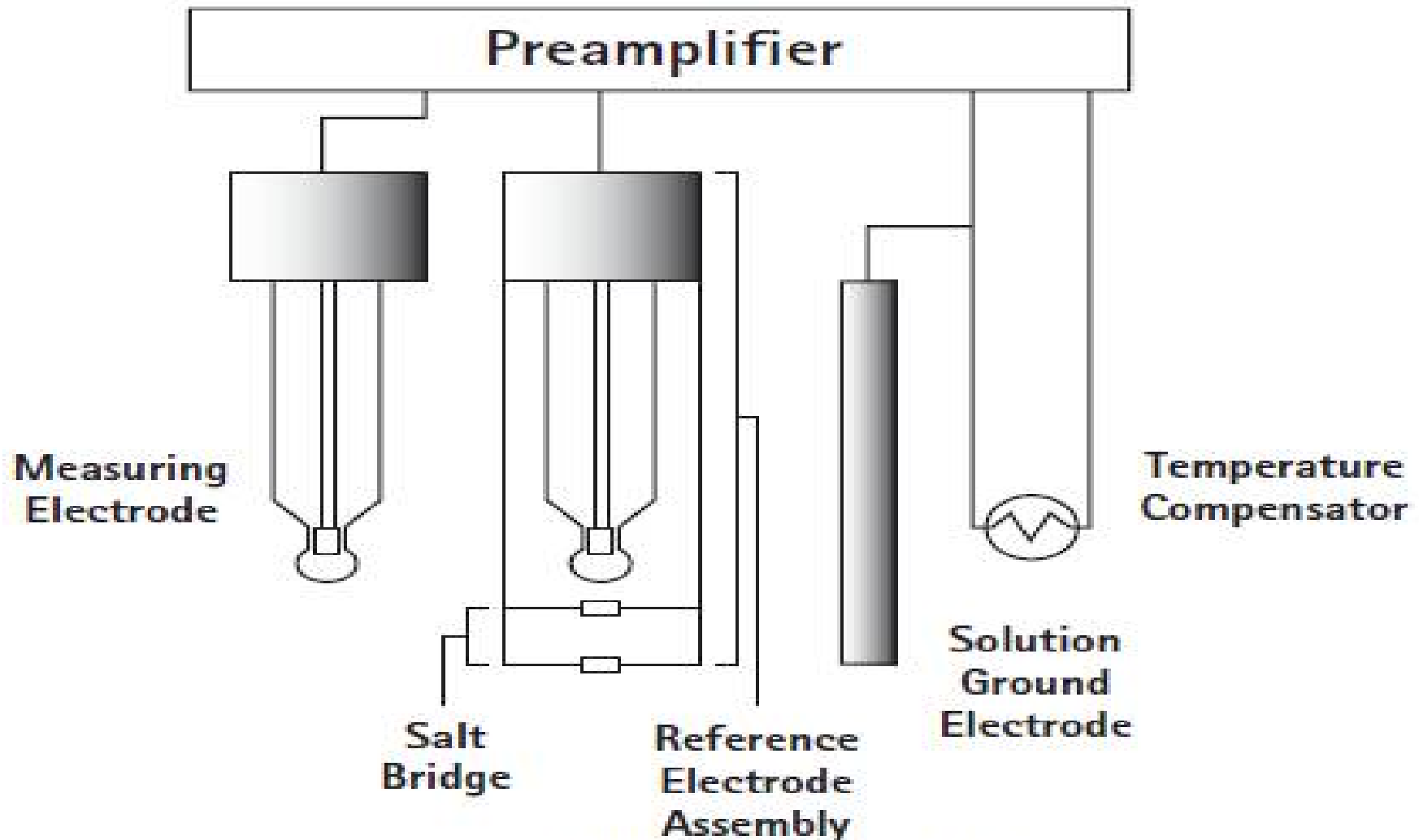


Fig - Differential Electrode Technique for pH Measurement.

ph Sensor (Differential Electrode)

- 1.** The measuring electrode, which is sensitive to the hydrogen ion, develops a potential (voltage) directly related to the hydrogen ion concentration of the solution.
- 2.** The reference electrode provides a stable potential against which the measuring electrode can be compared.
- 3.** The differential electrode technique is expressed as:

$$E_{out} = [(E_m - E_g) - (E_r - E_g)]$$

ph Sensor (Differential Electrode)

where:

E_m = measuring electrode voltage

E_r = reference electrode assembly voltage

E_g = solution ground electrode voltage

After canceling the E_g term:

$E_{out} = E_m - E_r$

Humidity

- Humidity is the presence of water in air.
- Affect human comfort as well as many manufacturing processes in industries.
- Influences various physical, chemical, and biological processes.
- The humidity is generally expressed in terms of Absolute Humidity or Relative Humidity (RH).

- **Absolute humidity of a gas is defined as the mass of water vapour present in a unit volume of gas and is usually expressed in grams per cubic meter.**
- **The relative humidity compares the humidity with humidity of saturated air at the same temperature pressure.**
- **Relative humidity is defined as the ratio of mass of water vapour present in a given volume of gas to the mass of water vapour necessary to saturate the same volume of gas at the same temperature. Thus for dry air $RH=0.0\%$ and for saturated air $RH=100\%$.**

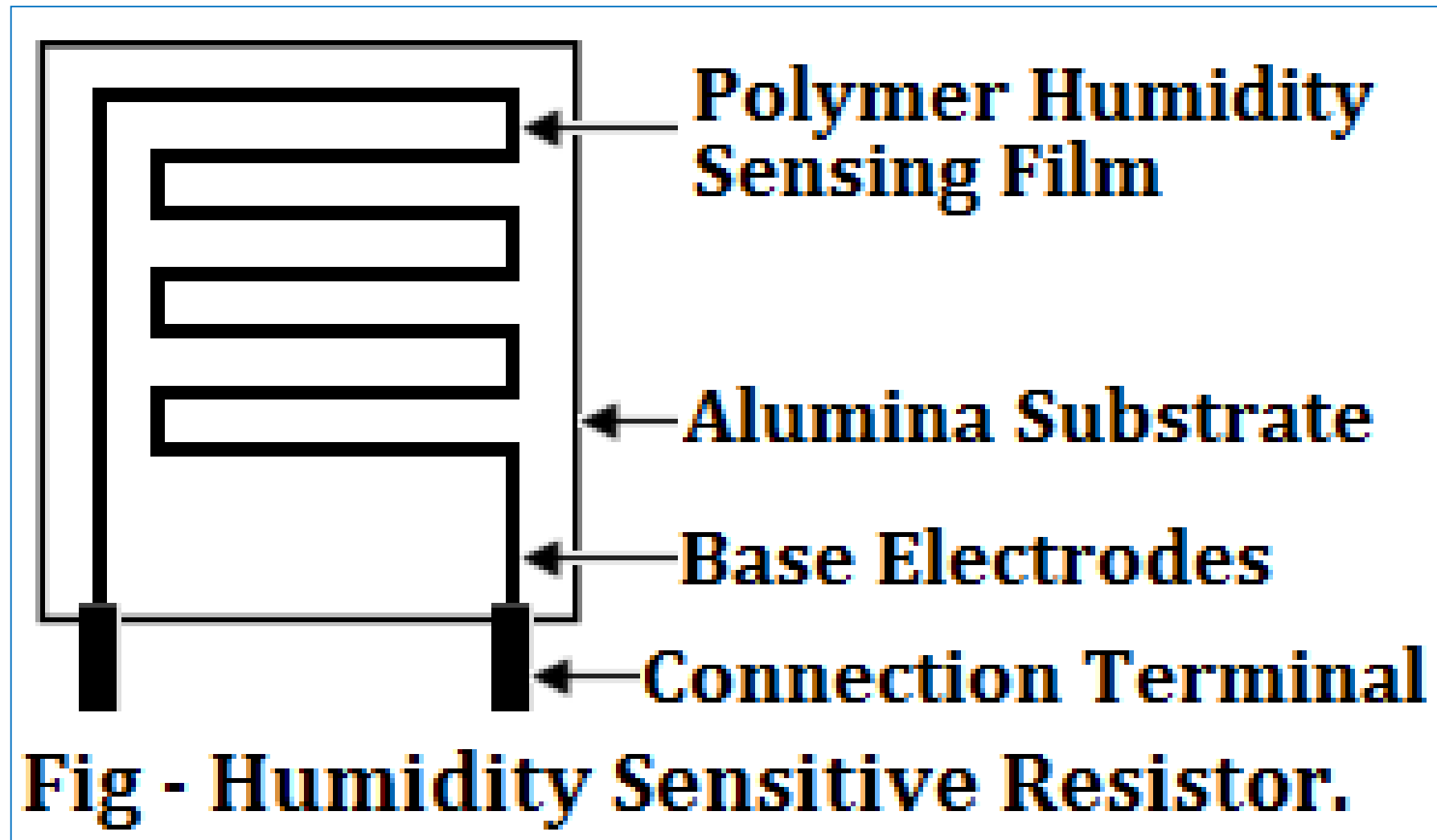
Sensing Principle

- Humidity measurement can be done using **dry and wet bulb hygrometers**, **hair hygrometer**, **dew point hygrometers**, and **electronic hygrometers**.
- The electronic hygrometers are often called **humidity sensors**.
- Electronic type hygrometers or humidity sensors: **Two categories**:
 1. **Capacitive sensing principle**,
 2. **Resistive effects**.

Humistor Hygrometer (Sensors based on Resistive effect)

- **Consist of thick film conductor of precious metals like gold, ruthenium oxide is printed and calcinated in the shape of the comb to form an electrode.**
- **Then a polymeric film (hygroscopic material) is applied on the electrode.**
- **The film acts as a humidity sensing film due to the existence of movable ions.**
- **As the relative humidity rises, the film becomes more conductive and the electrical resistance of the grid is lowered.**
- **It meets the industrial need of speed, versatility, accuracy, and high sensitivity. Such sensors are capable of detecting 1% change in relative humidity.**

Humistor Hygrometer (Sensors based on Resistive effect)



Sensors based on capacitive effect

Principle:

Hygroscopic **dielectric material** sandwiched between a pair of electrodes forming a small capacitor.

In absence of moisture, the dielectric constant of the hygroscopic dielectric material and the sensor geometry determine the value of capacitance.

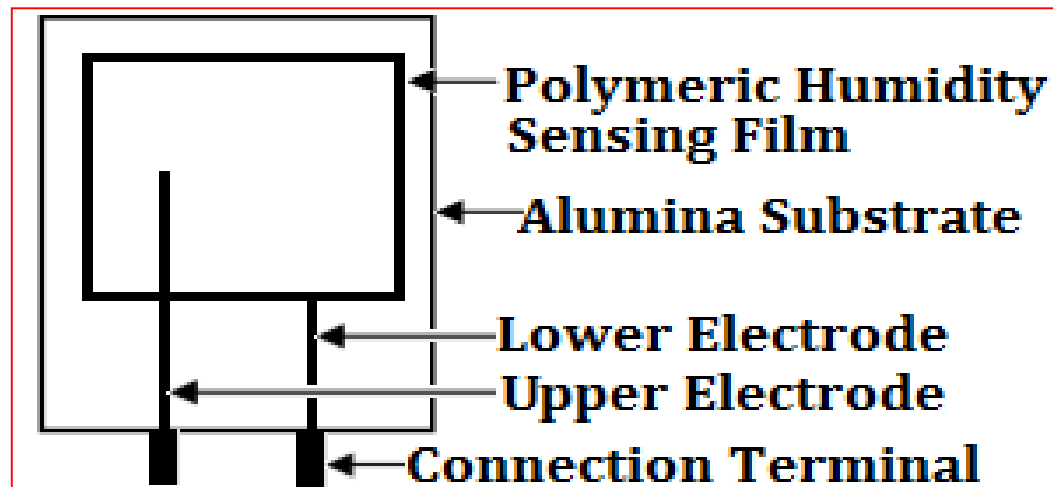


Fig - Humidity Sensors based on Capacitive Effect.

Gas Sensors (Detectors)

It measure and indicate the concentration of certain gases in an air via different technologies.