Unit-5: Sensors & Transducers

❖ Syllabus

Unit –V Sensors and Transducers	5a. Differentiate between the given type of sensor and transducer	5.1 Working of sensors and transducers 5.2 Selection criteria for transducers 5.3 Active and passive transducers
Unit	**Unit Outcomes (UOs) (in cognitive domain)**	**Topics and Sub-topics**
	5b. Explain selection criteria of a transducer for the given application. 5c. Describe with sketches the working of photodiode and photo transistor as control device for the given application. 5d. Describe the steps to measure the temperature of a given metal using the given transducer.	5.4 Inductive, capacitive, resistive pressure and Piezoelectric transducer 5.5 Photodiode and phototransistor transducers 5.6 Thermocouple and Proximity sensors.

❖ Transducers

The transducers is a device, which can transform energy from one form to another form.

Function of transducer:

1) **To detect or sense the parameter, magnitude and also any change in the physical quantity.**
2) **To provide a proportional electrical output signal.**

Selection Criteria:

- **Nature of measurement required**
- **Accuracy required**
- **Speed response of sensor**
- **Signal conditioning requirement**
- **Reliability of sensor**
- **Cost of sensors**
- **Output power of sensor**
- **Linearity of sensor**
- **Nature of output (analog/digital)**
- **Maintainability of sensor.**

Classification of transducers:

1) Primary & Secondary transducers	**2) Passive & Active transducers**
3) Analog & Digital transducers	**4) Mechanical & Electric transducers**

Primary & Secondary Transducer

1. Primary Transducers

The transducer which senses or responds to the phenomenon or the change in a physical into non electrical phenomenon is called a primary transducer

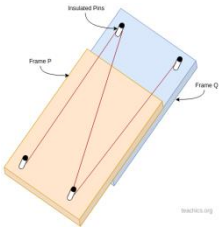
The examples of primary transducers are Bourdon tube, strain gauge, etc

2. Secondary Transducers:

The transducer which senses or responds to a physical phenomenon and converts it into an analogous electric quantity is called a secondary transducer

The few examples of secondary transducers are LVDS, photo diode, thermocouple, quartz crystal etc.

Passive and Active Transducers



1. Passive Transducers

The transducer which drives the power required to transduction from auxiliary power source is called a passive transducer. This type of transducer requires secondary source of energy

2 Active Transducers:

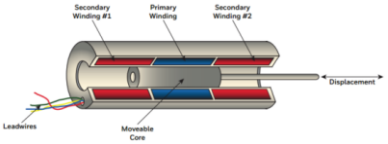
The transducer, which do not require auxiliary power sources to produce electrical analogous output is called an active transducer

The typical examples of active transducer are tacho-generator, thermocouple photo voltaic cell, quartz crystals, etc.

Analog and Digital Transducers

1. Analog Transducers:

The transducer, which converts the input quantity into an analog output as a continuous function of time is called a analog transducer



The typical examples of analog transducers are strain gauge Bourdon tube, LVDT thermocouple etc

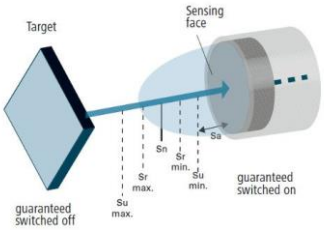
2. Digital Transducers:

The transducer, which converts the input quantity into an electrical output in the form of pulses is called a digital transducer.

Applications of Transducer:

1. Measurement of weight force and torque
2 Measurement of mass, volume and area
3. Measurement of speed and acceleration
4. Measurement of temperature
5. Measurement of pressure and differential pressure
6. Measurement of flow and liquid level
7. Measurement of density and velocity
8. Measurement of moisture current and humidity
9. Measurement of conductivity
10. Measurement of force and displacement

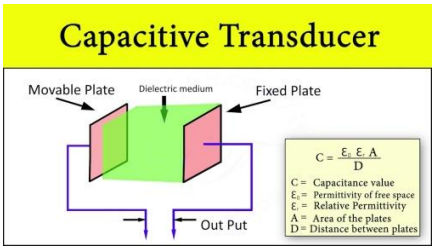
Inductive Transducers



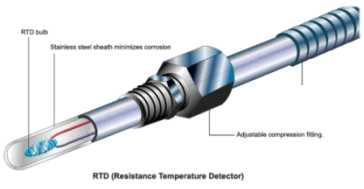
The transducer that converts the measured into change in induce (self-inductance and mutual inductance) which can be calibrated in terms of the measured is called an inductive transducer.
Eg: Inductive proximity transducer, LVDT

Capacitive Transducers

The transducer that converts the parameters to be measured into change in capacitance, which can be calibrated in terms of measurand is called a capacitive transducer.
Eg: VCDT(variable capacitance displacement transducer), CLLT(capacitance liquid level transducer



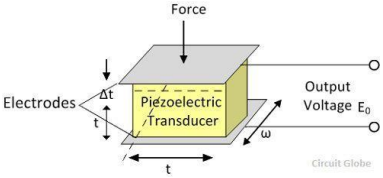
Resistive Transducer:



The transducer that converts the parameters to be measured into change in resistance, which can be calibrated in terms of measurand is called a capacitive transducer.
Eg: strain gauge, resistance temperature detector etc.

Piezo-Electric Transducer:

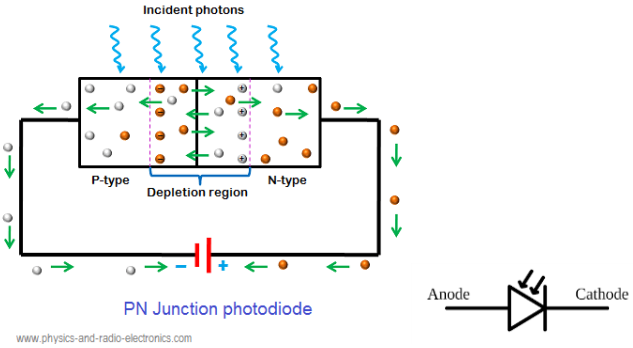
A device converting the mechanical (stress, i.e pressure) energy into the electrical energy is called a Piezo electric transducer



Piezo-electric Effect

When a mechanical stress, ie pressure is applied across the crystal, it becomes polarized and emf generated across the crystal in opposite faces. This phenomenon is called a Piezo-electric effect. This effect is reversible
Eg: 1 Rochelle salt 2. Quartz 3. $BaTiO_2$

P-N Photo-diode Transducer:



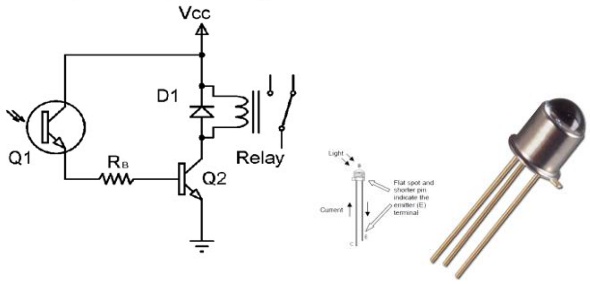
A two terminal P-N junction diode which operates in reverse bias, is called P-N photo diode.

A photo diode differs from a rectifier diode in the sense that its reverse current increases with the increase in light intensity at the P-N junction.

Applications:

1. It is used for photo detection.
2. It is used in object counting system.
3. It is used in demodulation.
4. It is used in fiber optic receivers.
5. It is used in logic circuit
6. It is used in light intensity (flux) meters.
7. It is used in photo-electric relays.
8. used in optical communication system
9. used in character recognition circuit.
10. It is used in encoders.
11. It is used in solar cell panels.

Photo-Transistor:

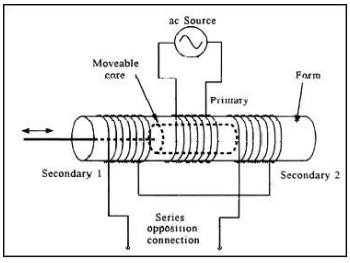


A bipolar photo sensitive solid state device having P-N junctions, in which excess electron-hole pairs are introduced by optical excitation is called photo transistor transducer.

Applications:

1. used in digital ON/OFF applications.
2. It is used in electro-optical shaft encoder
3. It is used in optical paper tap reader.
4. It is used in opto-electronic spring mass accelerometer,
5. It is used in burglar alarm, smoke detector, etc.

*LVDT:



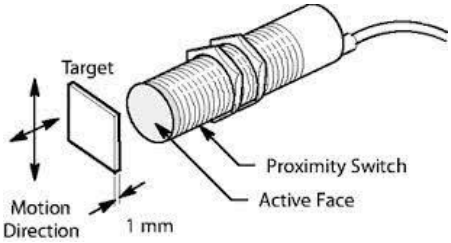
Linear Variable Differential Transformer, LVDT is the most used inductive transducer for converting a mechanical displacement or to translate linear motion proportionally into electrical signal.

- **LVDT works on the principle of Mutual Induction.**
- **The L.V.D.T. has a primary winding P and two secondary windings S1 and S_2 wound on a cylindrical former.**
- **Both the secondary windings have equal number of turns and identically placed on either side of primary winding.**
- **The soft ferrite core is placed inside the former.**

Thermocouple:

A pair of junctions of two dissimilar metals kept at two different temperatures is called a thermocouple.
A mechanical device, in which heat energy is converted into electrical energy, is called a thermocouple.
The emf generated in a thermocouple is called a thermo-electric emf, whereas the electric current flowing through a thermocouple is called a thermo-electric current.

Proximity Sensors



The switches which detect the presence or absence of an object without making any physical contact are called proximity switch sensors. They are also known as non-contact type electronic sensors.
These are solid-state devices that create an energy field for a beam to react to a distribution in that field.
The sensor (or switch) output is the basis for the monitoring and control of a manufacturing process

Types

1. **Inductive proximity sensors**
2. **Capacitive proximity sensors**
3. **Optical proximity sensors**
4. **Ultrasonic proximity sensors.**
5. **Pneumatic proximity sensors**
6. **Hall effect proximity sensors**

Applications

1. **Mining,**
2. **Machine-tool**
3. **Foundries.**
4. **Oil refineries,**
5. **Robotics,**
6. **Chemical plants,**
7. **Sheet metal fabrication,**
8. **Food processing.**
9. **Breweries.**