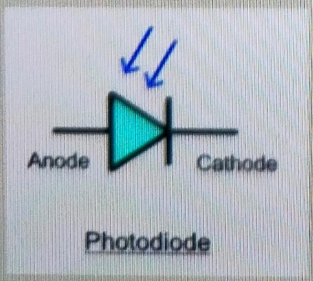
Chapter 5 – Sensors & Transducers

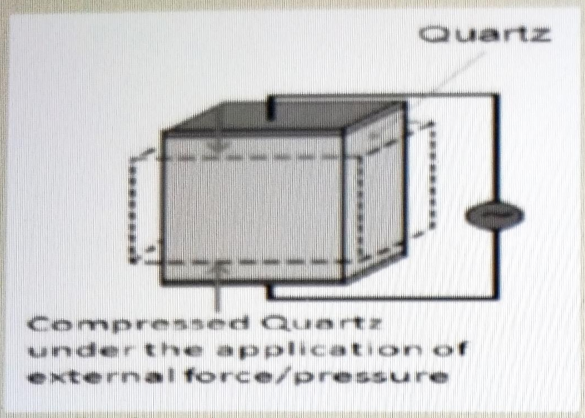
(Weightage – 13 Marks)

2 Marks Questions

1. **Define transducer and name two active transducers.**
   Answer:
   Transducer: Transducer is a device that converts one form of energy into another form of energy.
   Examples: (1) Photovoltaic cell (2) Thermocouple
2. **Define transducer and name two passive transducers.**
   Answer:
   Transducer: Transducer is a device that converts one form of energy into another form of energy.
   Examples: (1) Strain gauge (2) Thermistor
3. **Define Analog Transducer and give examples of it (any two)**
   Answer:
   Analog Transducer: An analog transducer is a device that converts the input signal into a continuous DC signal of voltage or current.
   Examples: (1) Strain gauge (2)LVDT
4. **State selection criteria of transducer.**
   Answer:
   1) Operating Principle: The transducers are selected on the basis of operating principle it may be resistive, inductive, capacitive, optical etc.
   2) Operating range: The range of transducer should be appropriate for measurement to get a good resolution.
   3) Accuracy: The accuracy should be as high as possible or as per the measurement.
   4) Range: The transducer can give good result within its specified range, so select transducer as per the operating range.
5. **Draw symbol of photodiode.**
   Answer:



6. **Draw constructional diagram of piezoelectric transducer.**
Answer:



7. **State the function of proximity sensors and photodiode.**
Answer:
Functions of Proximity Sensors:
1) Detect the presence of an object through change in the current in its coil.
2) Measure the small changes in movement through changes in current.

Function of Photodiode:

1) It converts the light energy into current or voltage in reverse bias condition.

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4 Marks Questions

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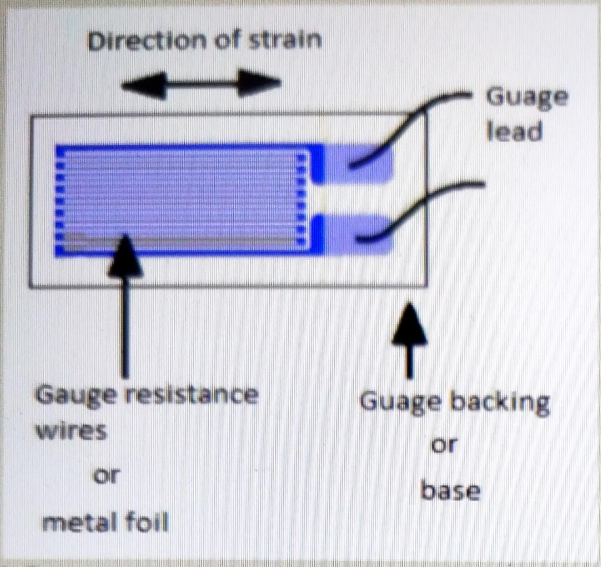
8. **Explain any four selection criteria of transducers for temperature measurement.**
Answer:
1) **Ambient temperature range**: It will impact on sensor accuracy as we can easily predict the ambient temperature effect on measurement taken from the sensor.
2) **Stability & control precision requirement**: If accuracy requirement is far better than 20F, use an RTD and if long term stability is required an RTD is better choice than Thermocouple.
3) **Speed of response** to temperature change requirement. Spring loaded temperature sensor and stepped thermo wells provide good speed of response.
4) **Cost:** Measurement failure most often results in production down time costs.

9. Describe strain gauge with labelled diagram.

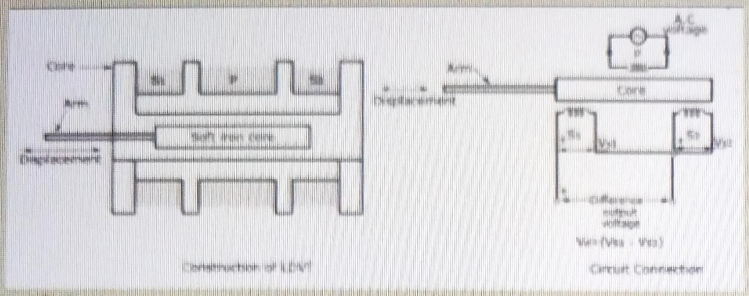
Answer:



1) A Strain gauge is a sensor whose resistance varies with applied force.
2) It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured.
3) When external forces are applied to a stationary object, stress and strain are the result.
4) The foil type strain gauges are very common in which a resistive foil is mounted on a backing material.
5) Metal foil gauges use similar materials to wire strain gauges.
6) The sensing elements of foil gauges are formed from sheets less than 0.005 mm thick by photo etching processes, which allows greater flexibility with regards to shape.
7) The resistance of the foil changes as the material to which the gauge is attached undergoes tension or compression due to change in its length and diameter.
8) This change in resistance is proportional to the applied strain. As this change in resistance is very small in magnitude so its effect can be only sensed by a Wheatstone bridge.
9) When strain is applied to the strain gauge, the resistance of the strain gauge sensor changes, the Wheatstone bridge becomes unbalanced, a current flows through the voltmeter.
10) Since the net change in the resistance is proportional to the applied strain, therefore, resultant current flow through the voltmeter is proportional to the applied strain. So, the voltmeter can be calibrated in terms of strain or force.

10. Describe LVDT with labelled diagram

Answer:

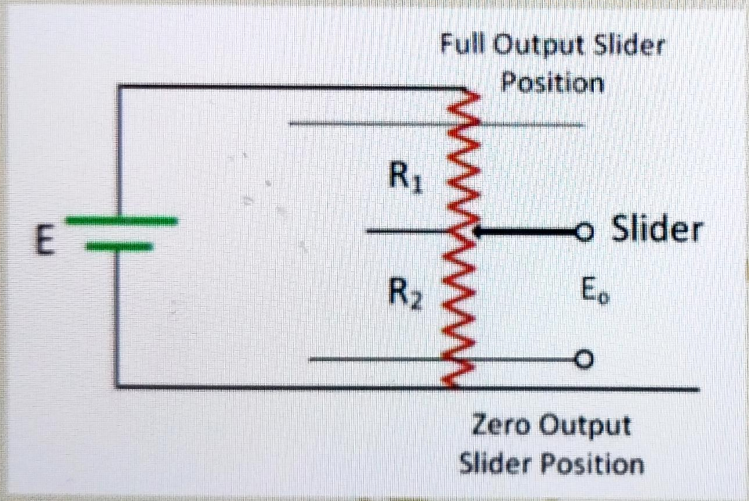


Working:

1) LVDT is the example of inductive transducer, in LVDT any physical displacement of the core cause the voltage of any secondary winding to increase while simultaneously reducing the voltage in the other secondary winding.
2) The difference of the two voltages appears across the output terminal of the transducer and gives a measurement of the physical position of the core.

11. Draw a sketch and describe the working of resistive transducer.

Answer:



1) The measurement of the physical quantity is quite difficult.
2) The resistive transducer converts the physical quantities into variable resistance which is easily measured by the meters.
3) The process of variation in resistance is widely used in the industrial applications.
4) The resistive transducer can work both as the primary as well as the secondary transducer.
5) The primary transducer changes the physical quantities into a mechanical signal, and secondary transducer directly transforms it into an electrical signal
6) The resistive transducer element works on the principle that the resistance of the element is directly proportional to the length of the conductor and inversely proportional to the area of the conductor.

$$R = \frac{\rho L}{A}$$

6 Marks Questions

12. Identify active and passive transducer from the following transducers:
(i) Capacitive transducer
(ii) Photovoltic cells
(iii) Piezoelectric transducer
(iv) Strain gauge
(v) Thermocouple
(vi) Thermisters
Answer:
(i) Capacitive transducer-passive transducer
(ii) Photovoltaic cells- active transducer
(iii) Piezoelectric transducer–active transducer.
(iv) Strain gauge-passive transducer
(v) Thermocouple- active transducer
(vi) Thermisters- passive transducer

13. i) Compare
1) Active and Passive transducer
2) Analog and digital transducer.

ii) Differentiate following transducer in active and passive.

1) Strain gauge
2) Photovoltaic cell
3) Thermocouple
4) Thermistor

OR

Differentiate active and passive transducer on the basis of any four points. (4 Marks)

Answer:

Sr. No.	Parameters	Active Transducer	Passive Transducer
1	Working Principle	Operate under energy conversion principle	Operate under energy controlling principle
2	Example	Thermocouple, Piezoelectric Transducer etc.	Thermistors, Strain Gauges etc.
3	Advantage	Do not require external power supply for its operation.	Require external power supply for its operation.
4	Application	Used for measurement of Surface roughness in accelerometers and vibration pick-ups.	Used for measurement of Power at high frequency.

Sr. No.	Analog Transducers	Digital Transducers
1	Output of these transducers are analog in nature	Output of these transducers are in the form of pulses
2	Convert the input quantity in analog Output	Convert the input quantity in digital output
3	e.g. Strain gauge, Potentiometer	e.g. Rotary encoder

1) Strain gauge – Passive Transducer
2) Photovoltaic cell – Active Transducer
3) Thermocouple – Active Transducer
4) Thermistor – Passive Transducer

14. List four types of electrical pressure transducers and describe one application of each one.

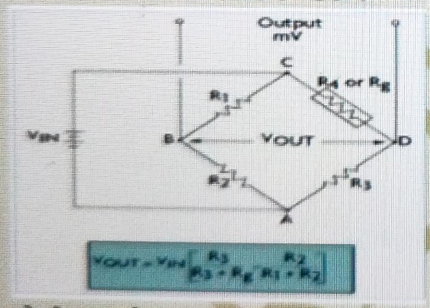
Answer:

Types of electrical pressure transducers:

1) Strain gauge pressure transducers
2) Potentiometer pressure transducers
3) Piezoelectric pressure transducers
4) Reluctance pressure transducers

1) Application of Strain gauge pressure transducers:

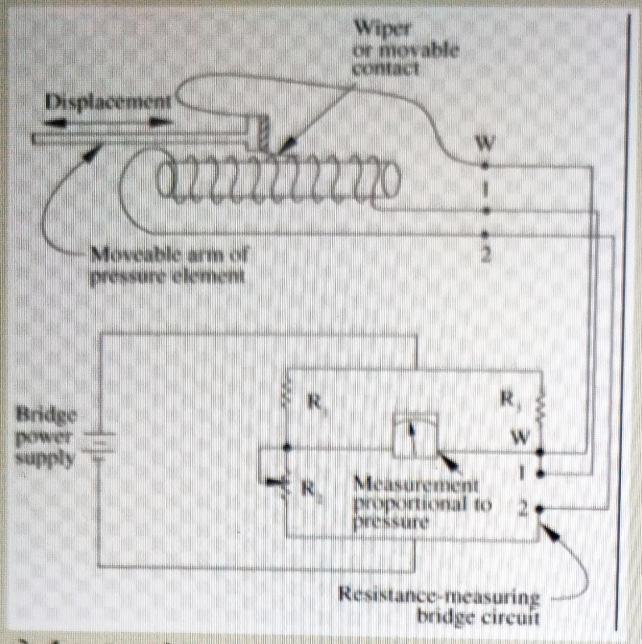
In measurement of strain:



a) In order to measure strain with a bonded resistance strain gauge, it must be connected to an electric circuit that is capable of measuring the minute changes in resistance corresponding to strain.
b) Strain gauge transducers usually employ four strain gauge elements that are electrically connected to form a Wheatstone bridge circuit.
c) The Figure shows a typical strain gauge diagram. A Wheatstone bridge is a divided bridge circuit used for the measurement of static or dynamic electrical resistance.
d) The output voltage of the Wheatstone bridge is expressed in millivolts output per volt input.

2) Application of Potentiometer pressure transducers

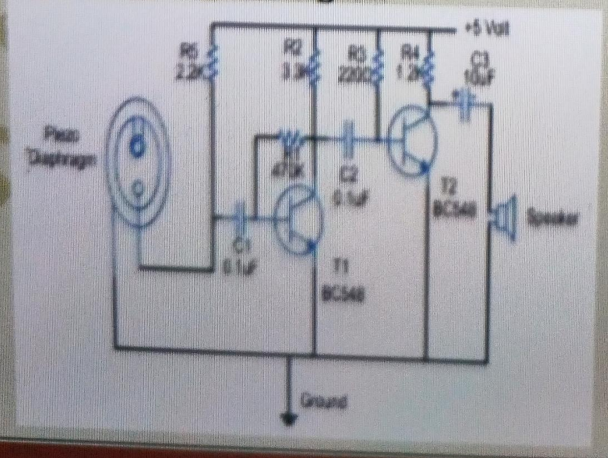
In pressure measurement:



a) A potentiometric consists of a wire wound resistor with removable slide attached to it.
b) Moving the slide will change the amount of resistance of the potentiometer.
c) When the potentiometer is connected in an electronic circuit any movement of the slide on the potentiometer will change the resistance in the circuit.
d) The circuit configuration most often used to make accurate measurement is the Wheatstone bridge. I
e) n a Wheatstone bridge, the bridge has two parallel legs. Each leg has two resistors in series.
f) A voltage source has connected to the bridge so that current will follow through each leg.
g) In a typical bridge, there is another circuit installed here. When the resistance of all four resistor is exactly equal the current flow through each leg is equal. In this condition, the bridge is balanced.

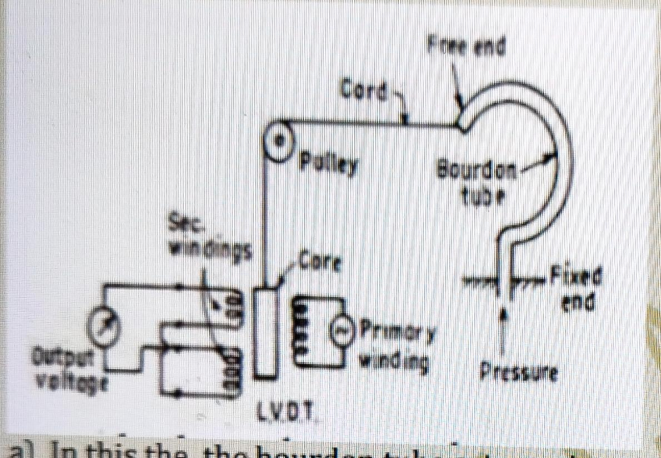
3) Application of Piezoelectric pressure transducers

In detection of audio signal:



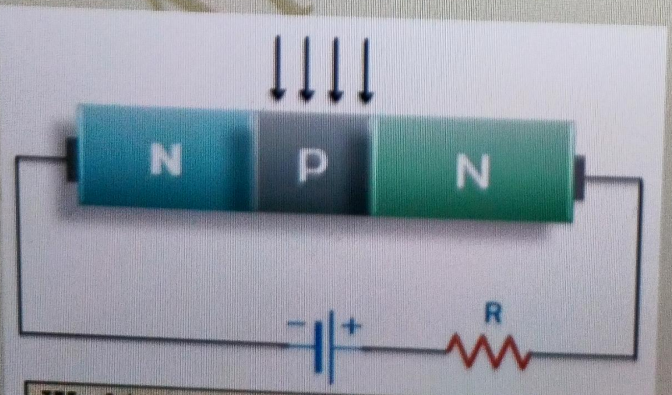
a) The following circuit shows the piezoelectric sensor circuit diagram.
b) The components required for this circuit are four resistors, speaker, two NPN transistor, capacitor, and piezo diaphragm.
c) The generation of the electrical signal in the piezo diaphragm is when it is subjected to the pressure variation due to the sound in the vicinity.
d) The output of the piezo-diaphragm is supplied to the two transistors of T1 & T2 (BC548) and the two transistors are known as a Darlington pair, it has a very high current.

4) Application of Reluctance pressure transducers
Measurement of fluid pressure in bourdon tube:



a) In this the, the bourdon tube act as primary transducer and LVDT which follows the output of bourdon tube act as a secondary transducer.
b) The bourdon tube senses the pressure when liquid enters into it, it will bend depending upon the pressure of the fluid and converts it into a displacement.
c) This set up is used for measurement of pressure which is converted into electrical signal by LVDT.

15. Explain the working principal of phototransistor and photodiode with neat sketches.
Answer:
Working principal of phototransistor:



Working structure of Phototransistor

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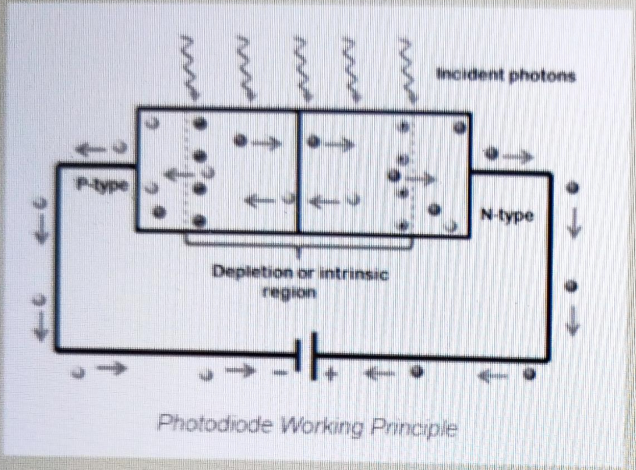
1) The operation of a phototransistor depends on the intensity of radiation falling at its base region.
2) Its working is almost similar to a normal transistor, however; the variation lies in the input current that drives the circuit.
3) And in the case of a phototransistor, the incident light generates driving current.

Working principal of photodiode:



Photodiode Working Principle

1) The working principle of a photodiode is, when a photon of ample energy strikes the diode, it makes a couple of an electron-hole. This mechanism is also called the inner photoelectric effect.
2) If the absorption arises in the depletion region junction, then the carriers are removed from the junction by the inbuilt electric field of the depletion region.
3) Therefore, holes in the region move toward the anode, and electrons move toward the cathode, and a photocurrent will be generated.
4) The entire current through the diode is the sum of the absence of light and the photocurrent.
5) So the absent current must be reduced to maximize the sensitivity of the device.