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53 (IE 502) TREN

2017

TRANSDUCERS ENGINEERING

Paper : IE 502

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Question no. 1 is **compulsory** and answer **any five** questions from the rest.

1. i) Resistive type potentiometer can be used for
- a) displacement measurement
 - b) pH measurement
 - c) magnetic field measurement
 - d) none of the above.
- 1

Contd.

ii) Strain gauge is

- a) direction sensitive transducer
- b) direction insensitive transducer
- c) frequency dependent transducer
- d) all of the above. 1

iii) LVDT is a

- a) passive transducer
- b) active transducer
- c) step up transformer
- d) none of the above. 1

iv) Thermopile is a

- a) temperature detector
- b) viscosity sensor
- c) force sensor
- d) all of the above. 1

- v) The temperature range for thermistor is
- a) -30°C to $+30^{\circ}\text{C}$
 - b) -100°C to $+300^{\circ}\text{C}$
 - c) -200°C to $+3000^{\circ}\text{C}$
 - d) None of the above. 1
- vi) The gauge factor of grid material used in strain gauge will be
- a) always positive value
 - b) always negative value.
 - c) both positive and negative value
 - d) none of the above. 1
- vii) Inductive sensor can be used for
- a) differential pressure measurement
 - b) liquid level measurement
 - c) liquid flow measurement
 - d) all of the above. 1

viii) Piezoelectric transducer can be used for

- a) static pressure measurement
- b) dynamic pressure measurement only
- c) both a) and b)
- d) none of the above. 1

ix) Villari effect is related with

- a) resistive type sensor
- b) electromechanical sensor
- c) magnetic sensor
- d) none of the above. 1

x) Hall sensor is used for

- a) number of entry measurement in a seminar hall
- b) intensity of light measurement in a conference hall
- c) magnetic field strength measurement
- d) all of the above. 1

2. a) Define the gauge factor of a strain gauge. Give the classification of strain gauge. 2

b) Deduce the expression for the gauge factor of a strain gauge

$$G_f = 1 + 2\nu + \frac{\Delta\rho/\rho}{\Delta l/l}, \text{ where } G_f \text{ is the}$$

gauge factor, ν is the Poisson's ratio

and $\frac{\Delta\rho/\rho}{\Delta l/l}$ is the change in resistance

due to piezo-resistive effect.

6

c) In strain gauge based measurement system, prove that $S_F = 4S_Q$ where S_F and S_Q are the sensitivities of full bridge and quarter bridge, respectively.

6

d) A strain gauge of 350Ω nominal resistance is fixed on a structure member subjected to a strain of $500 \mu\text{m}/\text{m}$. If the gauge factor is 2.5, what is the change in resistance of the gauge? 4

3. a) Explain the working principle of reluctance type inductive sensor.

6

b) Explain, with a schematic circuit diagram how the differential displacement can be measured using parallel plate type capacitive sensor.

7

c) A capacitive sensor of two parallel plates of overlapping area of $4 \times 10^{-4} m^2$ is immersed in water. The capacitance has been found to be $11.6 pF$. Calculate the separation between the plates and the sensitivity of the sensor.

Given: relative permittivity for water = 81 and permittivity in free space is $8.854 pF/m$.

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4. a) Mention *four* piezoelectric materials. Explain the working principle of piezoelectric transducer.

2+4

b) Draw the electrical equivalent circuit of a piezoelectric transducer based measurement setup (Assume setup containing a piezoelectric transducer, measuring cable and a measuring instrument) and derive the transfer function for the same.

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c) A piezoelectric crystal has a thickness of 2.7mm and a voltage sensitivity of 0.06Vm/N . Determine the output voltage when it is subjected to a pressure of $2.4 \times 10^6\text{N/m}^2$.

4

5. a) Write down the R-T relationships for RTD and Thermistor. Draw their R-T characteristics. What do you mean by Pt-100 RTD?

2+2+2

b) A Pt-100 sensor is used to measure the temperature of a chamber and the R-T relationship is described by the Callendar-Van Dusen equation :

$$R_T = R_0 [1 + AT + BT^2 + C(T - 100)T^3]_{-200^\circ\text{C} < T < 850^\circ\text{C}}$$

where $A = 3.969 \times 10^{-3}$,

$B = -5.849 \times 10^{-7}$ and

$C = -4.232 \times 10^{-12}$ ($= 0$ for $T > 0^\circ\text{C}$).

What is its resistance under a -180°C temperature? If the chamber's temperature is increased to $+180^\circ\text{C}$, what is the sensor's new resistance?

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c) Define the following parameters in connection photosensors : (i) Noise Equivalent Power (NEP), (ii) Detectivity (D) and (iii) Quantum Efficiency (QE).

6

6. a) What is Hall effect? Explain the working principle of Hall effect sensor.

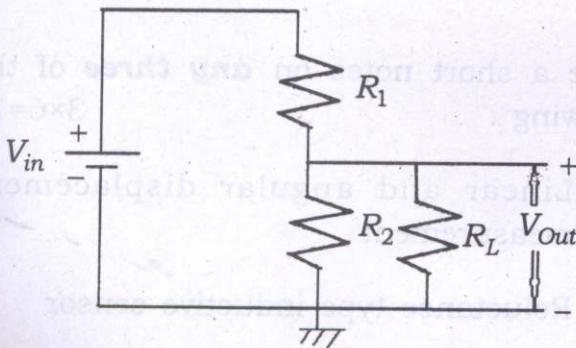
6

b) Explain how Hall sensor can be used to measure the RPM of a rotating object. 4

c) An Hall effect element used for measuring a magnetic field strength gives an output voltage of 9.6 mV . The element is made of silicon and is 3 mm thick and carries a current of 5 A . The Hall coefficient for Si is $4.1 \times 10^{-6}\text{ Vm/A-Wb/m}^2$. Determine the magnetic field strength. 4

d) What are the advantages and applications of smart sensors? 4

7. a) For the following figure, derive the expression of the output voltage (V_{Out}) when $R_L \neq \infty$:



Also find the output voltage (V_{Out}) when $R_L = \infty$. 7

b) Mention the merits and demerits of a potentiometer. 4

c) A potentiometer is used to measure the displacement of a moving object. The potentiometer is 25cm long, has a total resistance of 2500Ω and is operating at 4 Watt with a voltage source. It has linear resistance-displacement characteristics. Determine (i) Sensitivity of the potentiometer in *volts/cm* (without loading effect), (ii) loading error in the measurement of displacement at actual input displacement of 15cm, when the potentiometer is connected to a voltmeter having a resistance of 5000Ω . 7

8. Write a short notes on **any three** of the following : $3 \times 6 = 18$

a) Linear and angular displacement measurement

b) Reluctance type inductive sensor

c) Liquid level measurement using capacitive transducer

- d) Cold junction compensation technique for Thermocouple
 - e) Magnetic sensor and its application
 - f) Construction and operation of LVDT.
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