53 (IE 502) TREN

2018

TRANSDUCER ENGINEERING

Paper : IE 502

Full Marks : 100

Time : Three hours

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

*Answer **any five** questions.*

1. *(a)* Define the gauge factor of a strain gauge. 2

(b) Prove that $G_f = 1 + 2\upsilon + \frac{\Delta\rho/\rho}{\Delta l/l}$, where G_f is the gauge factor, υ 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 $S_F = 2S_H$ where S_F and S_H are the sensitivities of full bridge and half bridge, respectively. 7

(d) A strain gauge of 350Ω nominal resistance is fixed on a structure member subjected to a strain of $500\,\mu m/m$. If the gauge factor is 2.1 what is the change in resistance of the gauge? 5

2. (a) Explain, with a proper diagram, the construction and the working principle of a LVDT. 8

(b) Draw the input-output characteristics of a LVDT and explain it. What is residual voltage and how it can be eliminated? 7

(c) A capacitive sensor of two parallel plates of overlapping area of $5.5\times10^{-4}\,m^2$ is immersed in water. The capacitance has been found to be $8.6\,pF$. Calculate the separation between the plates and the sensitivity of the sensor. Given: relative permittivity for water = 81 and permittivity in free space is $8.854\,pF/m$. 5

3. (a) Define the terms: charge sensitivity, voltage sensitivity and pressure sensitivity of a Piezoelectric transducer. Derive the different relations between them. 7

(b) Draw the block diagram and electrical equivalent circuit of a PZT based experimental setup. Derive the transfer function for the same. 8

(c) A barium titanate based piezoelectric transducer has a thickness of 3.2 *mm* and a voltage sensitivity of $12\times10^{-3}\,Vm/N$. Determine the output voltage when it is subjected to a pressure of $5.2\times10^{6}\,N/m^2$. 5

4. (a) Define the following parameters in connection photosensors: 6

(i) Noise Equivalent Power (NEP)

(ii) Detectivity (D) and

(iii) Quantum Efficiency (QE).

(b) What is the resistance of a Cu-3000 type RTD at $0°C$? Draw the schematic diagram for connection of a 3-wire and a 4-wire RTD and explain. 8

(c) For a certain thermistor, $\beta = 3100K$ and its resistance at $20°C$ is known to be 1050Ω. The thermistor is used for temperature measurement and the measured resistance is 2300Ω. Find the measured temperature. What will be the Thermistors' new resistance if the temperature is increased to $50°C$? 6

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

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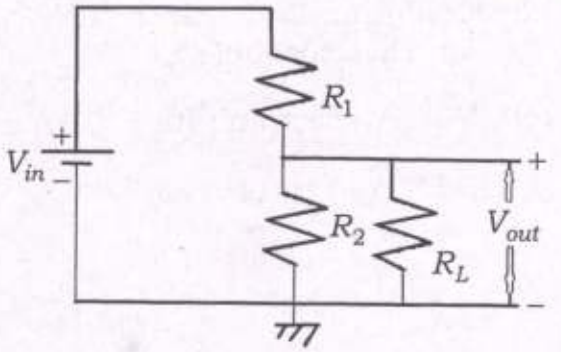
(b) Define the sensitivity of AD590 sensor. Explain how AD590 sensor can be used to measure temperature. 6

(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 $4.1\times10^{-6} Vm/A-Wb/m^2$. Determine the magnetic field strength. 4

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

6. (a) For the following *figure*, derive the expression of the output voltage (V_{out}) when load resistance *(i)* $RL \neq \infty$ and *(ii)* $R_L = \infty$. 8



Determine the value of V_{out} when $R_1 = 3k\Omega$, $R_2 = 2k\Omega$, $R_L = 1k\Omega$ and *(ii)* $V_{in} = 5$ *volts*.

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

(c) Explain, how a potentiometer can be used to measure linear and angular displacement. 8

7. Write short notes on ***any four*** of the following: 4×5=20

(a) RTD in Wheatstone bridge for temperature measurement

(b) Calibration of strain gauge

(c) Frequency response of a capacitive transducer

(d) Cold junction compensation technique for Thermocouple

(e) Villari effect and its application

(f) Eddy-current sensor.
