53 (IE 502) TDEN

2018

TRANSDUCERS ENGINEERING

Paper : IE 502

Full Marks : 100

Time : Three hours

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

Symbols have their usual significance.

*Answer **any five** questions.*

1. *(a)* Define the gauge factor of a strain gauge. Deduce the expression for the gauge factor of a strain gauge $G_1 = 1 + 2v + \frac{\Delta\rho/\rho}{\Delta l/l}$, where G_1 is the gauge factor, v is the Poisson's ratio and $\frac{\Delta\rho/\rho}{\Delta l/l}$ is the change in resistance due to piezo-resistive effect. 2+6

(b) In strain gauge based measurement system, prove that $S_H = 2S_Q$ where S_H and S_Q are the sensitivities of half bridge and quarter bridge, respectively. 8

(c) A strain gauge of $120\,\Omega$ nominal resistance is fixed on a structure member subjected to a strain of $850\,\mu m/m$. If the gauge factor is 2·0, determine the change in resistance of the gauge ? 4

2. (a) Explain the working principle of variable area type capacitive sensor. 5

(b) Explain with a schematic circuit diagram how the differential displacement can be measured using parallel plate type capacitive sensor. 10

(c) A capacitive sensor of two parallel plates of overlapping area of $8{\cdot}2\times10^{-4}m^2$ is immersed in water. The capacitance has been found to be $15pF$. Calculate the separation between the plates and the sensitivity of the sensor. Given : relative permittivity for water =81 and permittivity in free space is $8{\cdot}854\,pF/m$. 5

3. *(a)* Explain the working principle of piezoelectric transducer. 5

(b) Draw the electrical equivalent circuit of a piezoelectric transducer based measurement setup and derive the transfer function. 10

(c) A piezoelectric crystal has a thickness of 5·6*mm* and a voltage sensitivity of $0.08 Vm/N$. Determine the output voltage when it is subjected to a pressure of $4{\cdot}4 \times 10^6 N/m^2$. 5

4. *(a)* What is Pt100 RTD ? Write down the R-T relationships for RTD and draw it's R-T characteristics.

A Pt100 sensor is used to measure the temperature of a chamber. What is its resistance under a $-180°C$ temperature ? If the chamber's temperature is increased to $+180°C$, what is the sensor's new resistance ? Assume the temperature coefficient of RTD is $3{\cdot}969 \times 10^{-3} \Omega/\Omega/°C$. 6+6

(b) State law of intermediate temperatures and law of intermediate metals. 8

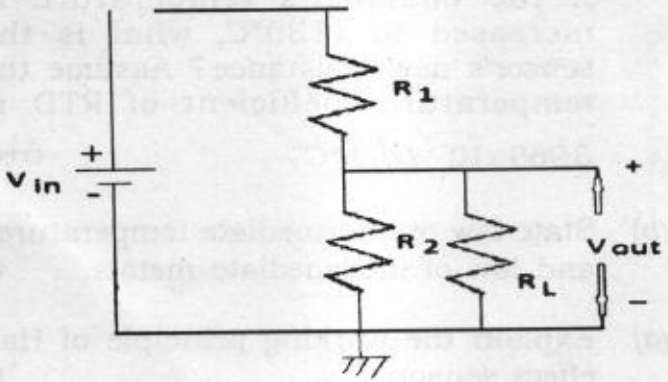
5. *(a)* Explain the working principle of Hall effect sensor. 8

(b) Explain how Hall sensor can be used to measure the RPM of a rotating object. 6

(c) An Hall effect element used for measuring a magnetic field strength gives an output voltage of $12.8mV$. The element is made of silicon and is $3{\cdot}2mm$ thick and carries a current of 4A. The Hall coefficient for Si is $5{\cdot}34 \times 10^{-6}$ $Vm/A\text{-}Wb/m^2$. Determine the magnetic field strength. 6

6. (a) Explain the operation of a potentiometer. Mention it's merits and demerits. 5+5

(b) For the following figure, derive the expression of the output voltage (V_{out}) when $R_1 \neq \infty$: 10



7. *(a)* Explain the principle of operation of an eddy current sensor. Give one application. 10

(b) Explain the principle of operation of electro-magnetic flow meter (EMFM) / ultrasonic flowmeter (UFM). 10

8. Write a short note on ***any four*** of the following : 4×5=20

(a) Angular displacement measurement

(b) Thermistor and its applications

(c) Liquid level measurement using capacitive transducer

(d) Cold junction compensation technique for thermocouple

(e) Pyro-electric sensor

(f) Construction of LVDT.
