53 (IE 502) TREN

2019

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)* What do you mean by *Pt* 100 ? Write down the *R-T* relation for *Pt* RTD and draw its *R-T* characteristic.

   A given PRT probe has 100Ω and $\alpha = 0.00389$. $(\Omega/\Omega)/K$ at $0°C$. Calculate its sensitivity and temperature coefficients at $45°C$ and $80°C$. 4+6=10

   (b) Calculate β for an NTC thermistor that has 5000Ω at $25°C$ and 1245Ω at $60°C$. 4

Contd.

(c) Define the following terms for photo-resistive sensors : *(i)* Responsivity, *(ii)* Noise equivalent power (NEP), *(iii)* Detectivity *(D)* and *(iv)* % quantum efficiency (QE). 6

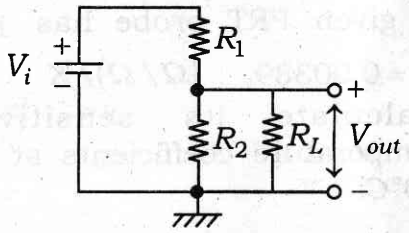
2. (a) Mention the advantages and disadvantages of a potentiometer. 4

(b) Explain, how a potentiometer can be used to measure angular displacement.

A potentiometer used for angular displacement provides 1.22 *volts* output voltage when angular displacement is 15° and 3.46 *volts* for angular displacement, 85°. Determine the angular displacement when the output voltage is 1.92*volts*. 5+4=9

(c) For the following figure, derive the **expression of the output voltage (V_{out})** when load resistance

(i) $R_L \neq \infty$ and *(ii)* $R_L = \infty$.



Determine the value of V_{out} when $R_1 = 6k\Omega$, $R_2 = 4k\Omega$, $R_L = 10k\Omega$ and $V_i = 9volts$. 7

3. (a) Define the gauge factor of a strain gauge. 2

(b) Prove that $G_f = 1 + 2\sigma + \frac{d\rho/\rho}{dl/l}$ where G_f is the gauge factor, σ is the Poisson's ratio and $\frac{d\rho/\rho}{dl/l}$ is the change in resistance due to piezo-resistive effect. 7

(c) Explain how dummy gauge can be used to compensate the effect of ambient temperature in strain gauge based measurement. 6

(d) A 120Ω strain gauge is fixed on a structure member subjected to a strain of $550\mu m/m$. If the gauge factor is 2.0, what is the change in resistance of the gauge ? 5

4. (a) Explain, with a proper diagram, the working principle of a differential capacitor. 8

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

(c) A capacitive sensor of two parallel. Mates of overlapping area of $4.5\times10^{-4}m^2$ is immersed in water. The capacitance has been found to be $7.8pF$. Calculate the separation between the plates and the sensitivity of the sensor. Given : relative permitivity for water = 81 and permitivity in free space is $8.85pF/m$. 5

5. (a) Define the terms : Charge sensitivity, Voltage sensitivity and Pressure sensitivity of a PZT. Derive the different relations among them. 7

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

(c) A barium titanate based PZT has a thickness of 4.2 mm and a voltage sensitivity of $9.2\times10^{-3}Vm/N$. Determine the output voltage when it is subjected to a pressure of $5.2\times10^{6}N/m^2$. 5

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

(b) An Hall effect element used for measuring a magnetic field strength gives an output voltage of $9.3mV$. The element is made of Silicon and is $5mm$ thick and carries a current of $4A$. The Hall co-efficient for S_i is $4.4\times10^{-6}Vm/A-Wb/m^2$. Determine the magnetic field strength. 4

(c) Explain how a diode/transistor can be used to measure temperature. 6

(d) What do you mean by Smart Sensors ? 4

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

(a) RTD in Wheatstone bridge for temperature measurement

(b) Calibration of strain gauge

(c) Construction and operation of LVDT

(d) Explain the law of intermediate temperature in thermocouple

(e) Eddy current sensor.