Total number of printed pages–6

53 (IE 502) TDEN

2021

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 are the materials used for RTDs ? Write down the R-T relation for *Pt*-RTD and draw its R-T characteristics. 4

   (b) A given *Pt*-RTD has $100\,\Omega$ and $\alpha = 0{\cdot}00389\,(\Omega/K)$ at $0°C$. Calculate its sensitivity and temperature co-efficients at $55°C$ and $90°C$. 6

   (c) Calculate β for an NTC thermistor that has $5\,k\Omega$ at $25°C$ and $1{\cdot}24\,k\Omega$ at $60°C$. 4

Contd.

(d) Define the following terms for photo-resistive sensors — 6

(i) responsivety

(ii) noise equivalent power

(iii) detectivity and

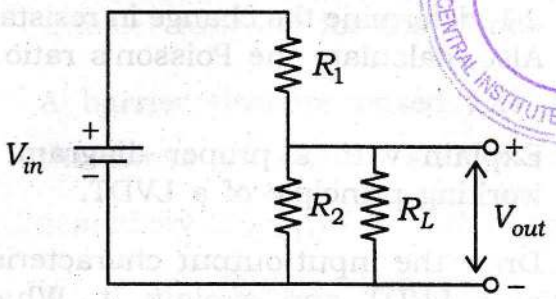
(iv) quantum efficiency.

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

(b) Explain how a potentiometer can be used to measure linear displacement. 5

(c) A potentiometer used for linear displacement provides 1·25 *V* output voltage when linear displacement is 15 *mm* and 3·45 *V* for 85 *mm*. Determine the linear displacement when the output voltage is 1·95 *V*. 4

(d) For the following figure, derive the expression of the output voltage (V_{out}) when load resistance (R_L) $\neq \infty$. 7



Also, determine the value of V_{out} when $R_1 = 10k\Omega$, $R_2 = 5k\Omega$, $R_L = 10k\Omega$ and $V_{in} = 10\ V$.

3. (a) Prove that $G_f = 1 + 2\nu + \left(\frac{\Delta\rho/\rho}{\Delta l/l}\right)$; where G_f is the gauge factor, ν is the Poisson's ratio and $\left(\frac{\Delta\rho/\rho}{\Delta l/l}\right)$ is the change in resistance due to piezo-resistive effect. 8

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

(c) A $350\,\Omega$ strain gauge is fixed as a metallic frame and subjected to a strain of $1500\,\mu m/m$. If the gauge factor is 2·1, determine the change in resistance. Also, calculate the Poisson's ratio. 6

4. (a) Explain with a proper diagram, 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 $5{\cdot}5\times10^{-4}m^2$ is immersed in water. The capacitance has found to be $8{\cdot}7\,pF$. Calculate the separation between the plates and the sensitivity of the sensor. [Given, relative permittivity of water = 81 and permittivity in free space = $8{\cdot}854\,pF/m$]. 5

5. (a) Define the terms: change sensitivity and voltage sensitivity of a PZT. Drive the different relationships between then. 7

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

(c) A barrier titanate based PZT has a thickness of 4·6mm and a voltage sensitivity of 8×10^{-3} $V\text{-}m/N$. Determine the output voltage when it is subjected to a pressure of $3{\cdot}5\times10^{6} N/m^{2}$. 5

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

(b) Explain with a proper diagram, the working principle of Eddy current sensor. 5

(c) Explain how a diode/transistor can be used to measure temperature. 5

(d) What do you understand by smart sensors? 4

7. Write short notes on : ***(any four)*** 5×4=20

(i) Capacitive sensor for moisture measurement.

(ii) RTD in Wheatstone bridge for temperature—measurement.

(iii) Calibration of strain gauge

(iv) Differential inductive sensor

(v) Law of intermediate metal in thermocouple.