Vidyavardhini's College of Engineering and Technology, Vasai (West)

First Year Engineering

Academic Year: 2024-2025

Problem Set 3: Transducers

Subject: BSC2023/EP **Date: 24/02/2025**
Max Marks: 10 **Submission Deadline: 07-03-2025**

CO3: To learn the foundation of transducers in the area of measurements.

1. A thermistor has a resistance of 10 kΩ at 25°C and 6 kΩ at 50°C. Calculate the temperature coefficient of resistance.

   Solution: The temperature coefficient (α) is given by:

   $$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

   $$\alpha = \frac{6000 - 10000}{10000 \times (50 - 25)}$$

   $$\alpha = \frac{-4000}{250000} = -0.016 \text{ per } ^\circ C$$

2. A resistive temperature detector (RTD) has a resistance of 120 Ω at 0°C. If its temperature coefficient is 0.00392/°C, determine its resistance at 50°C.

   Solution: The resistance at temperature T is given by:

   $$R_T = R_0(1 + \alpha T)$$

   $$R_{50} = 120(1 + 0.00392 \times 50)$$

   $$R_{50} = 120(1.196) = 143.52\Omega$$

3. An inductive transducer has an inductance of 10 mH and operates at a frequency of 1 kHz. Determine the reactance.

   Solution: Inductive reactance is given by:

   $$X_L = 2\pi f L$$

   $$X_L = 2\pi \times 1000 \times 10 \times 10^{-3}$$

   $$X_L = 62.83\Omega$$

4. A potentiometer has a total resistance of 5 kΩ and a supply voltage of 10V. If the wiper is at 60

   Solution: The output voltage is:

   $$V_{out} = \text{Position fraction} \times V_{supply}$$

   $$V_{out} = 0.6 \times 10 = 6V$$

5. A strain gauge has an initial resistance of 120 Ω. When a strain is applied, its resistance changes to 122.4 Ω. If the gauge factor (GF) is 2, determine the strain.

   Solution: The strain (ε) is given by:

$$\varepsilon = \frac{\Delta R}{R} \times \frac{1}{GF}$$

$$\varepsilon = \frac{122.4 - 120}{120} \times \frac{1}{2}$$

$$\varepsilon = \frac{2.4}{240} = 0.01 \text{ or } 1\%$$

   Extra Questions

6. An LVDT produces an output voltage of 2.5V for a displacement of 5 mm. Determine the sensitivity of the LVDT.

   Solution: Sensitivity is given by:

$$S = \frac{V_{out}}{\text{Displacement}}$$

$$S = \frac{2.5V}{5mm} = 0.5V/mm$$

7. A piezoelectric transducer generates a charge of 4×10^{-6} C when subjected to a force of 200 N. Determine its charge sensitivity.

   Solution: Charge sensitivity (S_c) is given by:

$$S_c = \frac{Q}{F}$$

$$S_c = \frac{4 \times 10^{-6}C}{200N}$$

$$S_c = 2 \times 10^{-8}C/N$$

8. A photodiode generates a current of 20 μA when exposed to light intensity of 5 mW/cm^2. Determine its responsivity.

   Solution: Responsivity (R) is given by:

$$R = \frac{I}{P}$$

$$R = \frac{20 \times 10^{-6}A}{5 \times 10^{-3}W}$$

$$R = 4 \text{ A/W}$$