MANIPAL INSTITUTE OF TECHNOLOGY
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**III SEMESTER B.TECH. (MECHATRONICS)**

**End Sem Examination**

**SUBJECT: SENSORS AND TRANSDUCERS (MTE 2125)**

**Date: 12-12-2023**

**Time: 3 hours** **Exam time: 9.30 AM-12.30 PM** **MAX. MARKS: 50**

**Instructions to Candidates:**

- *Answer ALL the questions.*
- *Missing data may be suitably assumed and justified.*

| | M | CO/CLO | PO | LO | BL |
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| Q1(a). A 10,000-ohm variable resistance has a linearity of 0.1%, and the movement of the contact arm is 320°.<br>(a) Determine the maximum position deviation in degrees and the resistance deviation in ohm.<br>(b) If this instrument is used as a potentiometer with a linear scale of 0 to 1.6 V, determine the maximum voltage error.<br>$Non-linearity = \frac{Maximum\ Deviation}{full\ scale\ deflection}$ | 2 | 1 | 2 | 2 | 3 |
| Q1(b). Make use of Kelvin's Double Bridge circuit used to measure low resistances to derive the condition for balance. | 4 | 2 | 2 | 2 | 3 |
| Q1(c). How would you develop electrical safety measures for incorporating sensors and transducers, considering potential risks, and implementing precautionary steps at moderate complexity? | 4 | 5 | 6 | 9 | 3 |
| Q2(a). As a graduate trainee engineer in the defence industry, you are tasked with employing a sophisticated sensor for geospatial mapping of border areas covering a range from 1,000 hectares to 10,000 square kilometers. Elaborate working principles of the sensor, demonstrating a deep understanding of its mechanisms and optimizations within this complex operational context. | 5 | 3 | 2 | 2 | 5 |
| Q2(b). XYZ Chemicals produces a wide range of chemical products in the manufacturing industry. Their storage facility comprises many tanks, each containing a distinct chemical. The accurate temperature measurement in these tanks is essential for ensuring the safety of operations, effectively managing inventories, and maximizing production efficiency. As a manufacturing engineer, you are asked to install the sensor whose temperature range is - 60°C to 15°C. Explain the working principle and construction of the sensor with the help of a diagram in detail. | 3 | 3 | 2 | 2 | 5 |

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| Q2(c). Each ratio arm of a laboratory-type Wheatstone bridge has a guaranteed accuracy of ± 0.05%, while the standard arm has a guaranteed accuracy of ± 0.1%. The ratio arms are set at 1000 Ohms, and the bridge is balanced with the standard arm adjusted to 3154 Ohms. Determine the upper and lower limits of the unknown resistance based on the guaranteed accuracies of the known bridge arms. $$R = \left(\frac{P}{Q}\right) * S$$ $$\frac{\partial X}{X} = \pm\frac{\partial x}{x} \pm \frac{\partial y}{y}$$ | 2 | 2 | 2 | 2 | 3 |
| Q3(a). A parallel plate capacitive transducer uses plates of area 500 $mm^2$, separated by 0.2 mm. (1). Calculate the capacitance value when the dielectric is air having a permittivity of 8.85 x $10^{-12}$ F/m. (2). Calculate the change in capacitance if a linear displacement reduces the distance between the plates to 0.18 mm. Also, calculate the ratio of per unit change of capacitance to per unit change of displacement. | 4 | 3 | 2 | 2 | 3 |
| Q3(b). Explain the construction of the strain gauge with the help of a diagram and derive the condition of the gauge factor. Also, write the advantages and disadvantages of semiconductor-type strain gauges. | 3 | 3 | 2 | 2 | 2 |
| Q.3(c). A C-type bourdon tube made of Monel metal. The tube dimensions are $r$ = 36.5 mm, $x$ = 16 mm, $y$ = 3 mm, $t$ = 0.35 mm, and a is the circumference of the semicircular C section. Calculate the displacement of the free end if a pressure of 1500 kPa is applied. The modulus of elasticity for Monel metal is 180 $GN/m^2$. $$\Delta a = 0.05\frac{aP}{E}\left(\frac{r}{t}\right)^{0.2}\left(\frac{x}{y}\right)^{0.33}\left(\frac{x}{t}\right)^{3}$$ | 3 | 3 | 2 | 2 | 3 |
| Q4(a). ABC Electronics, a leading consumer electronics manufacturer, was in the final stages of developing a state-of-the-art audio amplifier. However, during the testing phase, the engineering team encountered intermittent signal anomalies affecting the device's performance. It was advised to use the device for troubleshooting, which allows engineers to capture and store waveforms for in-depth analysis. Identify the device and discuss in detail the working principle with the help of a suitable diagram. | 5 | 4 | 2 | 2 | 3 |
| Q4(b). Explain the non-inverting amplifier, which can amplify weak sensor signals to a level suitable for further processing without changing the signal's original characteristic in detail. | 3 | 4 | 2 | 2 | 2 |
| Q4(c). Construct the circuit diagram of the diaphragm and bellows pressure gauge used for the pressure measurement. | 2 | 3 | 2 | 2 | 3 |

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| Q5(a). Explain the data acquisition system with the help of a suitable block diagram. | 4 | 4 | 2 | 2 | 2 |
| Q5(b). Distinguish between the working principle of ultrasonics and resistive sensor-based level measurement in detail. | 4 | 3 | 2 | 2 | 4 |
| Q5(c). Explain the signal conditioning method utilized in minimizing high-frequency noise within the framework of process automation with the help of a circuit diagram. | 2 | 4 | 2 | 2 | 2 |