W/D/TY

Reg. No: BCT0029

VIT®
Vellore Institute of Technology

Final Assessment Test – April 2025

Course: **BCSE311L - Sensors and Actuator Devices**

Class NBR(s): **1970/1974**

Slot: **B1**

Time: **Three Hours**

Max. Marks: **100**

- **KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE**
- **DON'T WRITE ANYTHING ON THE QUESTION PAPER**

Answer ALL Questions

(10 X 10 = 100 Marks)

1. **Analyse** in detail the artificial sensing and actuating capabilities of a driverless car as per the given criteria:-

   • What • Why • How • Where • When

   and using your analysis demonstrate systematically how such a system could learn and adapt in Indian roads for the optimal performance.

2. In a glass manufacturing unit, a boiler has been independently measured to be at 85 °C for the optimal operation and five thermistors are used to measure temperature readings.

   ✓ Which thermistor is most likely to be chosen for the use in the future?
   ✓ Which has the best accuracy and precision?
   ✓ Provide suitable justifications and working mechanism and its characteristics.

   Sample Measurements (°C)

   - Thermistor-1: 81, 91, 92, 102, 88
   - Thermistor-2: 90, 92, 93, 90, 91
   - Thermistor-3: 90, 91, 92, 92,94
   - Thermistor-4: 97, 91, 108, 105, 101
   - Thermistor-5: 86, 87, 82, 84, 85

3. Analyse how the key performance characteristics of temperature sensors, such as accuracy, response time, sensitivity, and stability, affect their suitability for chemical plant temperature monitoring and does it impact sensor choice for safety and efficiency.

4. A wire-wound RTD sensor is made of pure platinum wire, 0.01 mm in diameter, to have a resistance of 25 Ω at °C. Assume here that the TCR is constant with temperature.

   [conductivity as $\sigma_{0=} 5.8 \times 10^7$ S/m at 20°C $TCR\ of\ copper\ \alpha = 0.0039$]

   - Find the necessary length for the wire.
   - Find the resistance of the RTD at 100°C.
   - Find the sensitivity of the sensor in ohms/degree Celsius [Ω/°C].

5. **Analyse** the working principle of an Active Far Infrared (AFIR) sensor, and **discuss** its advantages and limitations in industrial safety systems, such as fire detection. How do these factors influence the selection and performance of AFIR sensors in this application?

6. **Analyze** and **identify** the factors that influence the quality and integrity of data transmission in an optical link. Discuss how each factor impacts signal strength, accuracy, and overall system performance.

7. Analyze and illustrate various usage of Brush less DC motor and stepper motor.

8. **Examine** the key issues, challenges and considerations in developing a Tire Pressure Monitoring System (TPMS) using the required sensors.

   Design a TPMS that prioritizes and enhance the following aspects:-

   - Vehicle safety
   - Fuel efficiency
   - Tire longevity

9.a) For navigation and obstacle identification, autonomous underwater vehicles (AUVs) rely on ultrasonic sensors. The AUV starts with a sound pressure of 5 Pa and sends out a signal at 100 kHz.

It must detect objects 20 meters away in shallow water where:

✓ Pressure: 1 atm

✓ Attenuation at 100 kHz in water: 0.2 dB/m

✓ Minimum detection threshold: 1×10^{-5} Pa

✓ Efficiency factor ≈ 0.85 per additional hydrophone

Answer the followings:-

- Convert attenuation (dB/m) to Np/m.
- Compute sound pressure at 20m.
- Determine if detection is feasible.
- If attenuation is high, suggest an alternative frequency and compute and justify its impact.
- Propose any two system modifications with numerical justifications.

OR

9.b) A high-altitude weather balloon is equipped with a Surface Acoustic Wave (SAW) pressure sensor to monitor atmospheric pressure as it ascends to 30 km altitude, where the pressure drops to 1 kPa.

The sensor has:

✓ Resonance frequency: 500 Mhz

✓ Maximum strain limit: 1000 microstrain (corresponding to 10^6 Pa (9.87 atm))

✓ Temperature sensitivity: 10^{-4}/ °C

✓ Temperature fluctuations: ±5°C due to varying solar radiation exposure.

Answer the followings:-

- Compute the maximum frequency shift due to strain.
- Determine the sensor's sensitivity in Hz/microstrain.
- Calculate the frequency shift caused by a 5°C temperature variation.
- Discuss whether the sensor can accurately measure pressure variations at high altitude.
- Propose any two system modifications to improve the reliability of the SAW sensor and provide numerical justifications for their effectiveness.

10.a) **Provide** in-depth analysis with detailed explanation for the electrochemical sensors by applying the given terms:-

★ Sensitivity and Accuracy
★ Speed of Response
★ Environmental Effects
★ Energy Efficiency
★ Application selectivity

OR

10.b) **Provide** a in-depth analysis with detailed explanation for the Acoustical thermo-mechanical sensors by applying the given terms:-

★ Sensitivity and Accuracy
★ Speed of Response
★ Environmental Effects
★ Energy Efficiency
★ Application selectivity

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