

BACHELOR OF POWER ENGINEERING EXAMINATION, 2011

(4th Year, 1st Semester)

SENSORS & TRANSDUCERS

Time : Three Hours

Full Marks - 100

Answer any **Five**

1. a) Define linearity and sensitivity of a sensor.

b) A sensor has a characteristic defined by

$$G(s) = \frac{0.2}{(0.001s + 1)}, \text{ calculate the cut-off frequency.}$$

c) If the sensor is used to measure a periodic displacement with a frequency of 100 Hz. and an amplitude 1mm what should be the amplifier gain if the amplifier supply voltage is Volts.

±5

d) What will happen if the frequency of the oscillations increase? 4+6+6+4

2. a) A disc is rotating at a certain rpm. If an 8 bit shaft encoder is used to sense position as well as speed, what is the resolution with which position can be sensed?

b) With what resolution can you sense the speed, assuming that the shaft is decoded using a laser stylus and the processing time is negligible.

c) If the disc rotates at 3600 rpm what is the maximum decoding and processing time if the net angular

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displacement has to be detected with the resolution in 2a. 5+8+7

3. a) Derive an expression for sensitivity of a piezo-resistive crystal subjected to a strain.
- b) Assuming appropriate resistance and capacitance deduce an expression for the output from the sensor subjected to time varying displacements.
- c) What are the different configurations in which a piezo-resistive sensor can be used? 7+7+6
4. a) With suitable assumptions design a circuit with LM-335 capable of measuring temperature in the range 0 to 100°C.
- b) Derive an expression for level measurement in a cylindrical vessel filled with a non-conducting fluid using a capacitive transducer. 10+10
5. a) Explain the principle of temperature measurement using infra-red thermometry.
- b) Deriving necessary expressions for measurement of temperature using a 3-wire Pt 100, design a bridge circuit for temperature measurement within a range $\Delta T^{\circ}\text{C}$. 10+10
6. a) The emitted radiation from a piece of metal is measured and the temperature is found to be 1065°C. Assuming a surface emissivity of 0.82. It was later found out that the

true emissivity is 0.85. Calculate the error in temperature measurement.

- b) A thermocouple circuit uses chromel-alumel thermocouple which gives an emf of 33.3 mV when measuring a temperature of 800°C with a reference temperature of 0°C. The resistance of the meter coil R_m is 50Ω and a current of 0.1mA gives a full scale deflection. The resistance of the junctions and leads together is 12Ω. Calculate (i) the series resistance R to obtain a full scale deflection for a temperature of 800°C and (ii) temperature error due to a rise of 10° in the resistance R_m assuming $\alpha=0.00426/^{\circ}\text{C}$. 10+10
7. a) Derive an expression for Doppler shift due to scattering using a Laser-Doppler velocimeter.
- b) Represent the schematic using a suitable diagram and state the requirements for the detector. 15+5
8. a) With a suitable sketch derive an expression for fluid velocity measurement using an ultrasonic probe. 10
- b) How is P_H measured? 10