

Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.TECH (EE)/SEM-1/CIM-102/2010-11**

**2010-11**

**ELECTRICAL SENSORS AND TRANSDUCERS**

Time Allotted : 3 Hours

Full Marks : 70

*The figures in the margin indicate full marks.*

*Candidates are required to give their answers in their own words  
as far as practicable.*

Answer **Group-A** and any *two* from each **Groups B and C**.

**GROUP – A**

**( Multiple Choice Type Questions )**

Answer *all* the question.

1. Choose the correct answer with a brief justification :

$$7 \times 2 = 14$$

- i) The magnitude of the signal in current telemetry is

- a) 0 – 20 mA a.c.
- b) 0 – 20 mA d.c.
- c) 4 – 20 mA a.c.
- d) 4 – 20 mA d.c.



- ii) The material of the former on which the three windings of the LVDT are wound is
- a) Brass                                      b) Nickel
- c) Strong cardboard                      d) Silicon steel.
- iii) The arms  $AB$ ,  $BC$ ,  $CD$ ,  $DA$  of a Wheatstone Bridge contain identical strain gauges ( gauge factor  $G$  ), which are bonded to a structure such that arms  $AB$  and  $CD$  experience compressive strain, and arms  $BC$  and  $DA$  experience tensile strain (  $\sigma$  ). If the bridge supply voltage is  $V$  and the temperature variation is considerable, the output of the bridge will be
- a)  $GV \sigma$                                       b)  $GV \sigma/2$
- c)  $GV \sigma/4$                                       d) 0.
- iv) A sensor has appreciable hysteresis. Which of the performance characteristics the sensor is likely to possess ?
- a) Good resolution
- b) Unsatisfactory fidelity
- c) Constant gain
- d) Good phase sensitivity.
- v) A transducer with a demodulator is likely to be
- a) sluggish
- b) fast
- c) accurate
- d) of constant output.



- vi) Which of the following signal transmitters has poor immunity to noise ?
- a) Analogue current
  - b) Analogue voltage
  - c) Digital
  - d) Optical.
- vii) Guard rings used in capacitive transducers improve their
- a) range
  - b) sensitivity
  - c) accuracy
  - d) immunity to EMI.

**GROUP – B**

2. a) A diaphragm pressure gauge needs a secondary transducer to obtain electrical output as a function of the pneumatic pressure input to the gauge. Explain with sketches the possible schemes using the following methods :
- i) Potentiometric
  - ii) Piezo-electric
  - iii) Optical
  - iv) Strain gauge
  - v) Capacitive.

Compare the merits, demerits and suitability of application of the methods.

6



- b) Compare a thermistor with an RTD for temperature measurement in respect of the following :

- i) Materials
- ii) Performance characteristics *e.g.* linearity, sensitivity, range, accuracy, dynamic response
- iii) Signal processing
- iv) Suitability of applications. 5

- c) Four strain gauges ( $R = 120 \Omega$  each, Gauge factor = 2.1) are bonded onto a cantilever beam ( $L = 25$  cm,  $w = 6$  cm,  $t = 3$  mm) load cell half way along the cell and a force  $F = 0.5$  N is applied at the free end of the beam. Young's modulus  $E = 70 \times 10^9$  Pa. The strain gauges are connected in push-pull and the bridge supply voltage is 12 V. Calculate its output.

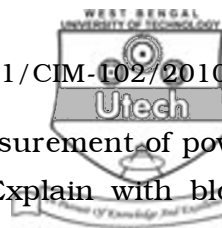
Given : strain =  $\frac{6 F L}{E b t^2}$  . 3

3. a) Obtain the sensitivity of a capacitive transducer with solid dielectric of constant thickness but variable permittivity and constant air gap between two parallel plates. Suggest its industrial application and limitations of use. 5

- b) Determine the displacement sensitivity ( $\delta C / \delta d$ ) of a capacitive transducer of two parallel plates of diameter 2 cm each, separated by an air gap ( $d$ ) of 0.25 mm. Deduce the formula used. Is it different from the

normalized displacement sensitivity  $\left\{ \frac{\left( \frac{\delta C}{C} \right)}{\left( \frac{\delta d}{d} \right)} \right\}$  ? What

arrangement is to be made in the capacitor system and its bridge circuit so as to obtain a higher sensitivity ? 4



- c) What are the problems in digital measurement of power frequency ? How is it overcome ? Explain with block diagrams. 5
4. a) Obtain sensitivity  $\left( \frac{\delta L}{\delta g} \right)$  of an inductive transducer with ferromagnetic core and small variable air gap (  $g$  ). Show how a push-pull configuration can be designed to improve upon its performance. 5
- b) Draw a neat sketch of cross-sectional views of a linear variable differential transformer (  $LVDT$  ), labelling its parts and materials used, and briefly explain its operating principle. Also show the output circuitry explaining how phase sensitive output and zero error adjustment is achieved. 5
- c) Obtain the expression for eddy current damping produced by a copper sleeve moving in a stationary magnet. 4
5. Write brief notes on the following : 7 × 2
- Sensitivity and accuracy of digital instruments
  - Loading effect in instruments and the remedial measures
  - Use of a thermistor for measurement of flow of a liquid
  - Specifications of a transducer
  - Digital wattmeter for high voltage power measurement
  - Calibration of an instrument
  - Strain gauge rosettes.



**GROUP – C**

6. a) Explain the phenomenon how charges develop on two faces placed across a piezoelectric crystal with a force applied on it.

Define  $d$ -constant and  $g$ -constant of a piezoelectric crystal. 7

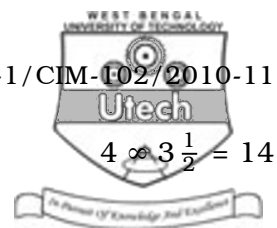
- b) Sketch a magnetostrictive type transducer for measurement of force. What materials are used for this transducer ? On what principle does this transducer work ? Explain with diagram. How is the output of the transducer obtained ? 7

7. a) Discuss different types ( both analogue and digital ) of data logging, display and storage device. What are the advantages of digital data display and storage device over analogue and vice versa ? 7

- b) Discuss recording and playback operation of magnetic tape recorder with neat sketch. 7

8. a) What are the functions of telemetry in industrial instrumentation ? Name different telemetry systems. Discuss current telemetry system. 6

- b) What is the need for modulation in signal transmission ? What are the different techniques of modulation ? Derive the equations for modulation index and total power in modulated wave in amplitude modulation. 8



9. Write short notes on the following :

- a) Charge amplifier
- b) Bridge amplifier
- c) Smart sensors
- d) Data acquisition system.

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