

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 (σ). 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.

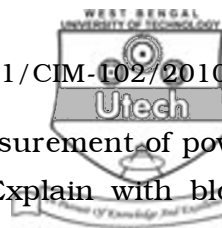
Given : strain = $\frac{6 F L}{E b t^2}$. 3

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 \times 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

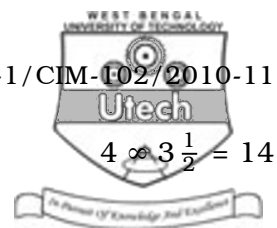
- b) Sketch a magnetostrictive type transducer for measurement of force. What materials are used for this transducer ? On what principle does this transducer work ? Explain with diagram. How is the output of the transducer obtained ? 7

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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