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 carboard 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 Ω 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 $E = 70 \infty 10^{9}$ Pa. The strain gauges are connected in push-pull and the bridge supply voltage is 12 V. Calculate its output.

Given : strain = $6_{FL} / E^{2}_{bt}$. 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) Obtan 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 : $7 \infty 2$

a) Sensitivity and accuracy of digital instruments

b) Loading effect in instruments and the remedial measures

c) Use of a thermistor for measurement of flow of a liquid

d) Specifications of a transducer

e) Digital wattmeter for high voltage power measurement

f) Calibration of an instrument

g) 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 : $4 \times 3\frac{1}{2} = 14$

a) Charge amplifier

b) Bridge amplifier

c) Smart sensors

d) Data acquisition system.