

Fifth Semester Examination – 2008

PRINCIPLES OF MEASUREMENT SYSTEMS

Full Marks – 70

Time – 3 Hours

Answer Question No. 1 which is compulsory  
and any **five** from the rest.

The figures in the right-hand margin  
indicate marks.

1. Answer the following questions : 2×10
  - (a) Is the "Sensitivity" a systematic characteristic of measurement system elements? Give reasons in one or two sentences.
  - (b) Write the conditions for which the measurement system is said to be complete and accurate.

- (c) Write the transfer function of a first order sensing element and a second order sensing element. Indicate the symbols used in the transfer functions.
- (d) How a periodic signal  $f(t)$  with period "T" can be expressed as series of sine and cosine signals. Indicate the average value, fundamental and harmonics of  $f(t)$ .
- (e) Write the flow, effort, impedance and stiffness variables of electrical and mechanical (translation) systems.
- (f) How to specify amplitude behaviour and frequency behaviour of a random signal?
- (g) List the origin or sources of external noises and interferences.
- (h) Define "reliability" of measurement systems. How to calculate "unreliability" from the knowledge of "reliability"?

- (i) Explain the basic principle of measurement of a hydrometer.
- (j) How will the pressure difference measured with a Venturi tube change if the volume rate of flow is doubled?

2. (a) The resistance  $R(\theta)$  of a thermistor at temperature  $\theta$  K is given by  $R(\theta) = \alpha \exp\left(\frac{\beta}{\theta}\right)$ . Given that the resistance at the ice point is  $9.00 \text{ K}\Omega$  and the resistance at the steam point is  $0.50 \text{ K}\Omega$ , find the resistance at  $25^\circ\text{C}$ . 4
- (b) The strain gauge has an unstrained resistance of  $100\Omega$  and gauge factor of 2.0. Non-linearity and dynamic effects are neglected. Resistance of the gauge is affected by ambient temperature as well as strain. Here, temperature acts as both an interfering input and modifying input. Given that temperature coefficient of

resistance =  $2 \times 10^{-5} / ^\circ\text{C}$  ( $\Delta\Omega / \Omega / ^\circ\text{C}$ )  
and temperature coefficient of linear expansion =  $1 \times 10^{-6} / ^\circ\text{C}$  ( $\Delta l / l / ^\circ\text{C}$ ). Draw the generalized model of the strain gauge element. 6

3. (a) Illustrate one method of compensating for non-linear effects of measuring elements, which will produce significant reductions in the overall system error due to non-linear effect. 4
- (b) The voltage output of a force sensing element is amplified by a high gain amplifier. The amplifier output is fed back to an element (e.g., a coil and a permanent magnet), which provides a balancing force to oppose the input force.
- (i) Derive the equation of the output voltage for the force transducer system, ignoring the effects of modifying input.

- (ii) Show that the system output depends only on the feedback gain and is independent of the sensor gain and amplifier gain. 6

4. (a) Define the following terms used in describing dynamic characteristics of measurement system,
- (i) Time Constant and 4
- (ii) Damping Ratio. 4
- (b) Explain the methods of dynamic compensation for open loop and closed loop systems. 6
5. (a) A Thevenin's equivalent circuit is connected to load impedance. Write the conditions in order to get maximum voltage transfer and maximum power transfer from the circuit to the load. 4

- (b) Explain the following with examples :
- (i) Process Loading
  - (ii) Bilateral transducer. 6
6. (a) Write the mathematical expressions of the following statistical functions :
- (i) Probability
  - (ii) Cumulative probability
  - (iii) Cumulative probability distribution function
  - (iv) Probability density function. 4
- (b) Explain the following methods of reducing the effects of noise and interference.
- (i) Using differential amplifier
  - (ii) Filtering
  - (iii) Using amplitude modulation. 6
7. (a) Define "mean time to fail" and "mean failure rate". How these are related to "reliability function" ? 4

- (b) Define "instantaneous failure rate". Derive the relation between "reliability" and "instantaneous failure rate". 6
8. (a) Describe the construction; and explain the theory and operation of barometer. Explain the factors that affect the reading given by a mercury barometer. 4
- (b) Draw the schematic diagrams and write the operations of "radiation pyrometer" and "disappearing filament pyrometer". Indicate the output and measurement ranges. 6