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B. Tech
CPEN 5302

Fifth Semester Examination – 2007

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) Write the mathematical expression of Gaussian Probability distribution function and define the symbols used in the expression.

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- (b) A 100 kilo ohm resistive potentiometer is used for the measurement of displacement. It has 50 turns and a movable sliding contact. Calculate the resolution of the potentiometer.
- (c) Define "Tolerance" in terms of statistical variations amongst a batch of similar elements.
- (d) Describe how the overall time constant is altered in open loop dynamic compensation using lead/lag circuits ?
- (e) What should be the load impedance in comparison to the network impedance in order to get maximum voltage transfer from the network to the load and in order to get maximum power transfer from the network to the load ?
- (f) What are the characteristics of a "Bilateral Transducer" ? Explain with examples.

- (g) What are the statistical functions used in order to specify amplitude behaviour and frequency/time behaviour of a random signal ?
- (h) Define "Johnson noise". Comment on the power spectral density of this noise.
- (i) If 150 faults are recorded for 200 transducers over 1.5 years with a mean down time of 0.002 years, calculate mean time between failures (MTBF) and mean failure rate.
- (j) A mercury barometer has a height reading of 760 mm of mercury. What is the atmospheric pressure in Pascal, if the density of mercury is 13600 kg/m^3 and acceleration due to gravity is 9.81 m/s^2 ?
2. (a) The input-output characteristic of a sensor is an ideal straight line equation. Define modifying input and interfering input.

Explain how these inputs change the input-output characteristic ? 4

- (b) A copper-constant and thermocouple has the following e.m.f. (E in micro volt) and temperature (T in °C) characteristic for an input temperature range of 0 to 400°C.

$$E(T) = 38.74T + 3.319 \times 10^{-2} T^2$$

- (i) Find the ideal straight line characteristic equation of the thermocouple.
- (ii) Obtain the non-linear correction function.
- (iii) Assuming a time constant of 10 second, show the generalized model (block diagram) of the thermocouple.

6

3. (a) With suitable examples to distinguish : 4

- (i) Range and Span
- (ii) Wear and Ageing.

- (b) Describe the following error reduction techniques in steady state of a measurement system : 6

- (i) Isolation
- (ii) Opposing environmental input
- (iii) Differential system.

4. (a) Define the following : 4

- (i) Time constant
- (ii) Damping ratio.

- (b) Derive the step response for the following types of sensing elements : 6

- (i) First order element
- (ii) Second order element (Critical Damping only).

5. (a) Mention the "Flow variables" and "Effort variables" for mechanical, electrical, fluidic and thermal systems. 4

(b) A potentiometer displacement sensor has a resistance of R_p ohm and a supply voltage of V_s volt. The voltage of the sliding contact is measured using a voltmeter of resistance R_L ohm. If 'x' is the fractional displacement, derive the expression of the output voltage in terms of 'x' for a loaded potentiometer. Show that the effect of loading a linear potentiometer sensor is to introduce a non-linear error into the system. 6

6. (a) Write the Fourier series of a periodic signal. What is the power due to n^{th} harmonic? 4

(b) 'N' numbers of observations of a random signal 'y' are recorded. The range of 'y' is divided into 'm' numbers of equal intervals.

(i) What is the probability of the signal value occurring in the j^{th} interval?

(ii) What is the cumulative probability that the signal value will occur in the first 'k' intervals?

(iii) Define the "Cumulative probability distribution function" and "probability density function" of the signal 'y'. 6

7. (a) Describe the failure patterns of 'repairable items' and 'non-repairable items'. 4

(b) Derive the relationship between reliability and instantaneous failure rate. 6

8. Write short notes on any *four*: 2.5×4

- (a) Atmospheric pressure measurement
- (b) Reynolds number
- (c) Rotameter
- (d) Bimetallic thermostat
- (e) Hydrometer
- (f) Level measurement of a closed vessel
- (g) Semiconductor resistance thermometer.

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