Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 13036

M.E. DEGREE EXAMINATION, JANUARY 2015.

Elective

Applied Electronics

AP 7006 — SENSOR AND SIGNAL CONDITIONING

(Regulation 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. A given sensor has a specified linearity error of 1% of the reading plus 0.1% of the fall scale output. A second sensor having the same measurement range has a specified error of 0.75% of the reading plus 0.25% full scale reading. For what range of values is the first sensor more accurate than the second one?

2. What is natural damped angular frequency?

3. Differentiate the characteristics of metal and semiconductor strain gages in their Gage factor, Active grid length, measurement range and nominal resistance.

4. Draw the circuit of an instrumentation amplifier based on two op-amps.

5. List the different arrangements for movement sensing using Hall effect sensors.

6. Why are electrostatic and driven shields needed?

7. Define the law of Homogeneous circuits and intermediate metals.

8. If the integration time of a current integrator is selected to cancel power line interference for both 60 Hz and 50 Hz systems, and we accept a maximal amplitude error of 0.1%. Calculate the maximal frequency of the current to integrate.

9. Shortly comment on Quartz micro balances.

10. Calculate the NEP for a photodiode biased so that $I_D = 10nA, R_P = 100M\Omega$, $S = 0.5A/W$, when operating at 45°C and the noise band width is from 10 kHz to 100 kHz.

PART B — (5 × 16 = 80 marks)

11. (a) (i) In a measurement system, a first order sensor is replaced by a second order sensor with the same natural frequency. Calculate the damping ratio to achieve the same – 3dB attenuation at that frequency. (4)

(ii) Determine the portability that has the confidence interval $\hat{x}_n \pm \frac{\alpha}{\sqrt{n}}$ of including the lone value x. (12)

Or

(b) (i) The appropriate time constant of a thermometer is determined by immersing it in a bath and noting the time it takes to reach 74% of the final reading. If the result is 32 sec, determine the delay when measuring the temperature of a bath that is periodically changing 2 times per minute. (4)

(ii) Tabulate the outputs of a second order measuring system for different common test inputs. Also draw the second order system response to a unit step input, ramp input and sinusoidal input for different damping ratios. (12)

12. (a) (i) A given 500 Ω nickel RTD has $\alpha = 0.00618(\Omega/\Omega)/K$ at 0°C. It is used at temperatures around 100°C, so we use the model $R_T = R_{100}[1 + \alpha_{100}(T - 100^\circ C)]$. Calculate its sensitivity and temperature coefficient at 100°C and determine the resistance at 100° C. (8)

(ii) A PLO NTC thermistor has 10 kΩ, $\delta = 0.14$ mW/K in still air at 25°C and $\frac{R_{25}}{R_{125}} = 19.8$. Calculate the miximal drop in voltage across it when immersed in air at 35°C. (8)

Or

(b) (i) Model an NTC thermistor by two parameters in reduced temperature range. Draw the 'S' curves for the selected material. (8)

(ii) Obtain the alternative methods to detect the output voltage of a sensor bridge depending on power supply grounding. With neat circuit diagram, explain the operation. (8)

13. (a) (i) A given capacitive level sensor consists of two concentric cylinders with diameter 40 mm and 8 mm. the storage tank is also cylindrical, 50 cm in diameter and 1.2 m in height. The stored liquid has $\varepsilon_r = 2.1$. Calculate the minimal and maximal capacitance for the sensor and its sensitivity, when used in the storage tank. (6)

(ii) How is a LVDT applied for pressure and acceleration measurement? Explain with neat diagrams. (10)

Or

(b) (i) Mention the significance of carrier amplifiers for sensors. Illustrate the spectrum changes involved in the amplitude modulation of an excitation signal by a measurement signal and obtain SMRR. (10)

(ii) With the circuit to convert angles in synchro format into angles in revolver format, prove that if the primary resistances are balanced, so all those at the secondary windings. (6)

14. (a) (i) Draw a circuit to measure a temperature by means of a J type thermocouple and electronic compensation of the reference junction based on an NTC thermistor at ambient temperature. Design the circuit in order to have compensation in the range from 10°C to 40°C with an NTC thremistor having B=3456k and resistance 10k Ω at 25°C. (10)

(ii) What is pyroelectric effect? Derive the current responsivity for the same. (6)

Or

(b) (i) Calculate the power spectral density of the output noise of a buffer amplifier based on an op-amp as a function of the output resistauce of the signal source R_p. (4)

(ii) Derive the off set and drifts in op-amp used in chopper and low-drift amplifiers. (12)

15. (a) (i) What are the types of CCD imagers? Classify them and broadly comment on each type. (8)

(ii) A given photodiode has an equivalent output resistance of 20G Ω shunted by 10pf. In order to obtain an output voltage, we use a circuit with R = 100 k Ω and an op-amp. Calculate C to obtain a flat frequency response and determine the –3dB band width. (8)

Or

(b) Elaborate the construction of Incremental position encoders and explain its operation. Show the pulse multiplication to increase the encoder resolution. (16)
