Ref. No.: Ex/ET/T/424/2018

B.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING
FOURTH YEAR, SECOND SEMESTER EXAMINATIONS 2018

INSTRUMENTATION & MEASUREMENTS

Time – Three hours | Full Marks: 100

Answer **ALL the Five** Questions.
All question carry equal marks.

Marks [5+9+6]

Q.1 (A) (a) Explain the step response of first- and second- order elements.

(b). A force sensor has a mass of 0.5 kg, stiffness of 2×10^2 N/m and a damping constant of 6.0 N s/m.

(i) Calculate the steady- state sensitivity, natural frequency and damping ratio for the sensor.

(ii) Calculate the displacement of the sensor for a steady input force of 2 N.

(iii) If the input force is suddenly increased from 2 to 3 N, derive an expression for the resulting displacement of the sensor.

(c) Give an example to explain the measurement error produced due to loading effect.

(OR)

[11+ 9]

Q.1 (B) (a) Consider a mass-spring-damper model as an elastic force sensing element. Develop the differential equation of the system and evaluate its undamped natural frequency, damping ratio and transfer function in terms of the system parameters.

(b) An elastic force sensor has an effective seismic mass of 0.1 kg, a spring stiffness of 10 Nm^{-1} and a damping constant of 14 Nsm^{-1}.

Calculate the following quantities:

(i) Sensor natural frequency (ii) sensor damping ratio (iii) transfer function relating displacement and force.

[8+8+4]

Q.2 (A) (a) Describe with diagram the principle of operation of metal and semiconductor resistive strain gauges. Define gauge factor of a strain gauge. Explain how ambient temperature variations can affect the strain measurements.

(b) Explain with diagram the principle of operation of electromagnetic and thermoelectric sensing elements.

(c) A platinum resistance sensor is to be used to measure temperatures between 0 and 200^0 C. Given the resistance $R_T = R_0 (1 + \alpha T + \beta T^2)$ and $R_0 = 100.0$, $R_{100} = 138.50$, $R_{200} = 175.83\ \Omega$, calculate: (i) the values of α and β.

(OR)

[12+8]

Q.2 (B) (a) What is LVDT? Explain its principle of operation and areas of applications. Why do we need a phase-sensitive detector (PSD) with LVDT? Explain the operation of PSD .

(b) A variable reluctance sensor consists of a core, variable air gap and an armature. The core is a steel rod of diameter 1 cm, relative permeability 100, bent to form a semicircle of diameter 4 cm. A coil of 500 turns is wound on to the core. The armature is a steel plate of thickness 0.5 cm and relative permeability 100. Assuming the relative permeability of air 1.0 and the permeability of free space = $4\pi \times 10^{-7}$ Hm^{-1}, calculate the inductance of the sensor for air gaps of 1 mm and 3 mm.

[Turn over

[12+8]

Q.3 (A) (a) Explain the theory of operation of restriction type (orifice plate) differential pressure flowmeter. Explain how to connect a differential pressure transmitter to measure the mass flow rate of a fluid using the flowmeter.

(b) An orifice plate is to be used in conjunction with a differential pressure transmitter to measure the flow rate of water in a 0.15 m diameter pipe. The maximum flow rate is 50 m^3 /hour, the density of water is 10^3 kg m^{-3} and the viscosity is 10^{-3} Pa.s.

(i) Explain why an orifice plate meter is suitable for this application.

(ii) Estimate required orifice plate hole diameter if the transmitter has an input range of 0 to 1.25×10^4 Pa.

(OR)

[14+6]

Q.3 (B) (a) Describe with diagrams the principle of operation of non-restriction type cross-correlation ultrasonic flow meter. Develop the theoretical cross-correlation function for the flowmeter.

(b) A cross-correlation flowmeter consists of two transducers, spaced 0.15 metres apart, detecting random fluctuations in density. The velocity of flow is 1.0 m s^{-1} and the fluctuations contain frequencies up to 100 Hz. State whether the flowmeter is suitable for this application.

[10+(4+3+3)]

Q.4 (A) (a) Explain how noise and interference signals can affect a measurement system performance. Explain a suitable method to improve the signal-to-noise ratio of a measurement signal buried in noise.

(b) A sinusoidal signal of amplitude 1.4 mV and frequency 5 kHz is buried in Gaussian noise with zero mean value. The noise has a uniform power spectral density of 100 pW/ Hz upto a cut-off frequency of 1 MHz.

(i) Find the total power, r.m.s. value and standard deviation for the noise signal.

(ii) What is the signal-to-noise ratio in dB?

(iii) The combined signal is passed through a band-pass filter with centre frequency of 5 kHz and bandwidth 1 kHz. What improvement in signal-to-noise ratio is obtained?

(OR)

[12+8]

Q.4 (B) (a) Explain the meanings of series mode interference and common mode interference and explain with suitable example how such interfering signals can adversely affect the performance of a measurement system. What is meant by multiple earth? How its adverse effects are observed in measurement circuits? Give examples to explain the situation.

(b) A thermocouple giving 10 mV dc output voltage is connected to a high impedance DVM some distance away. A difference is potential exists between earth at the thermocouple and earth at the voltmeter. . Using the equivalent circuit given in Fig.1, Calculate (i) the rms values of the series-mode and common-mode interference voltages at the voltmeter input.

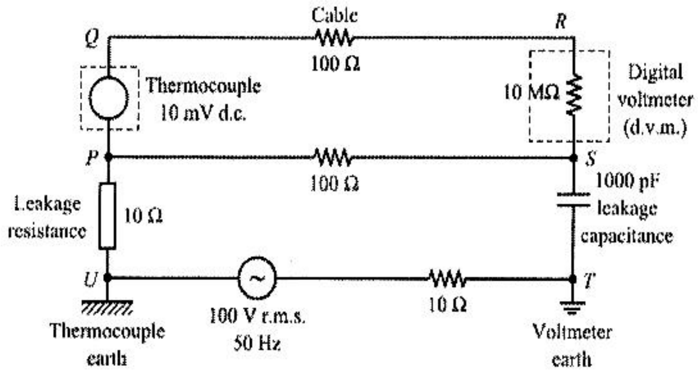

Fig.1

[14+6]

Q.5 (A) (a) Explain the principle of operation of a microprocessor based automated data acquisition system with arrangements of multiplexing of sensor signals, data logging and remote transmission of measurement data.

(b) Explain with diagram the principle of operation of instrumentation amplifiers. Enumerate the design considerations of the amplifier for extracting low-level sensor signal buried in noise.

(OR)

[10+10]

Q.5 (B) Write short notes on any ***TWO*** of the following:

(a) Electrical capacitive transducers and their industrial applications.

(b) The principle of correlation method in improving the signal-to-noise ratio

(c) The principle of design of a gas chromatograph instrument

(d) Optical pyrometer for high temperature measurement.

(e) UV-Visible- NIR spectrophotometer for chemical analysis.