Department of Avionics,
Indian Institute of Space Science & Technology, Trivandrum
Instrumentation and Measurement AV222
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Tutorial No. 1

Q. 1. . Determine the input and output range, input and output span and sensitivity of the pressure transducer shown in Fig. 1.

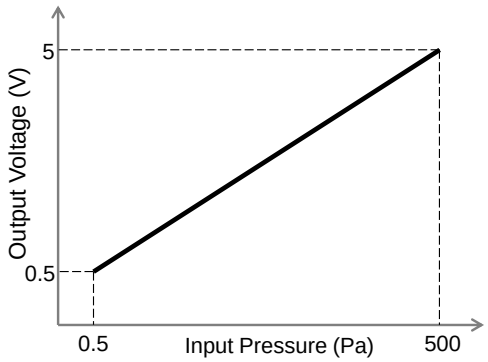

Fig. 1

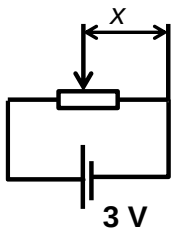

Fig. 2

Ans: Input Range = 0.5 - 500 Pa, Output Range = 0.5 – 5 V, Input Span = 499.5 Pa, Output Span = 4.5 V, Sensitivity = 9 mV/Pa

Q. 2. A potentiometric arrangement shown in Fig. 2 is used to sense displacement (*X*) of range 30 cm. A wire-wound potentiometer of 300 turns is used. Sensitivity of the circuit is 10 mV/mm. Determine the input and output resolution (assume that the wiper can touch only 1 turn at a time) of the sensor.

Ans: Input Resolution ≈ 0.1 cm, Output Resolution = 0.01 V

Q. 3. A voltmeter with a range of 2 – 10 V reads a voltage 5.2 V. True value of this voltage is 5.4 V. Determine the % error in terms of reading and full-scale span.

Ans: Error (Reading) = -3.7 %, Error (Full-Scale) = -2.5 %

Q. 4. A wire-wound potentiometer of (N =) 101 turns is used to realize a linear displacement sensor of range 0 to 5 mm. The wiper of this potentiometer can touch at the most 2 turns at any position. This arrangement is excited by a +5 V DC source. Derive and compute the values of minor and major output resolution pulses as the wiper transits from 50th to 51st turn (give proper reasoning).

Ans: Minor Resolution Pulse = 24.7 mV, Major Resolution Pulse = 25.3 mV

Q. 5. A current of 2.5 A is to be measured. Which one of the following ammeters you would prefer?

(a) 0 - 5 A, Class-1, (b) 0 – 3 A, Class 2

Ans: (a) is better

Q. 6. Voltage (V), current (I) and resistance (R) associated with a circuit element are measured with limiting error of 1 %. Calculate which of the expressions (I^2R, VI, V^2/R) is best for the calculation of power.

Ans: VI method

Q. 7. In Fig. 3, Ammeter A (0-10 mA, 100 Ω) and Voltmeter V (0-10V, 100 kΩ) is used to measure the value of an unknown resistance R_x. Find the position at which switch needs to be placed to get minimal error when (a) Rx < 100 Ω, (b) Rx > 100 kΩ. Justify your answers.

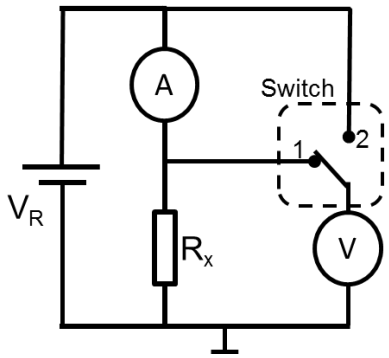

Fig. 3

Ans: case (a) → position 2, case (b) → position 1

Q. 8. The following values were obtained from the measurements of the value of a resistor:
147.2 Ω, 147.4 Ω, 147.9 Ω, 148.1 Ω, 147.1 Ω, 147.5 Ω, 147.6 Ω, 147.4 Ω, 147.6 Ω, 147.5 Ω
Calculate (a) arithmetic mean, (b) standard deviation and (c) probable error of the above measurements.

Ans: Mean = 147.5Ω, σ = 0.3Ω, P = 0.1Ω

Q. 9. The value of two resistors was found using a standard measurement technique and repeated measurements. It was found that (1) the mean value of the resistors is 45 Ω and 48 Ω, (2) maximum deviation of the resistors from their mean values is 3 Ω. Calculate the effective resistance and its limiting error when the above resistors are connected in parallel.

Ans: limiting error = 1.5 Ω

Q. 10. Few 10 Ω resistors of standard deviation 10 % are available. It is required to realize a 30 Ω resistor using these 10 Ω resistors. Suggest the best connection from the different circuit connections shown in Fig. 4 (a) to (d).

Ans: (c) and (d) are best connections.

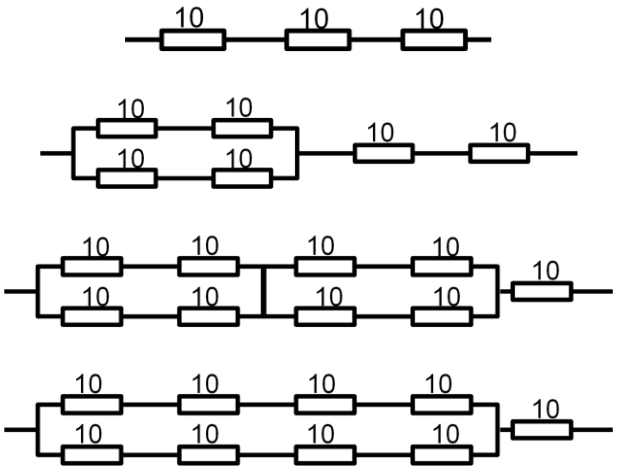

Fig. 4 (a) to (d)

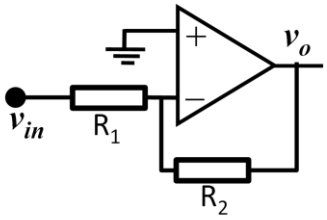

Fig. 5

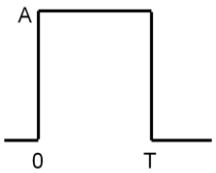

Fig. 6

Q. 11. Consider the circuit shown in Fig. 5. Mean and limiting error of the resistors and input voltage: R_1 = 100 ± 5 Ω, R_2 = 200 ± 8 Ω. Voltage v_{in} = 1 ± 0.1 V. Calculate the output and its maximum deviation (assume ideal opamp).

Ans: Output = -2 V, Limiting Error = 20.4 %

Q. 12. A resistor manufacturer received a customer's order for 100000 precision resistors of nominal resistance 10000 Ω, which were not to exceed 10025 Ω and not to be less than 9950 Ω. The manufacturer made a sample batch of 1000 resistors, and it was found that 80 resistors of this batch exceeded 10025 Ω. Assuming gaussian distribution, (a) predict the number of the remaining resistors which will confirm to the specifications, (b) predict the total number of resistors that the manufacturer needs to make to obtain 100000 resistors that satisfy customer's requirements. Assume the sample batch of 1000 resistors is representative in your calculations.

Ans: (a) 917, (b) 109171

Q. 13. A known current of 80 A was measured by an ammeter. If 40 % of the readings are within 0.8 A of the true value, determine the probability that readings can lie between - 79 A and 81.2 A. Determine the deviation (say, ΔI) for which only 0.26 % lie outside 80 ± ΔI.

Ans: Probability = 0.524, Deviation = 3σ = 4.63 A

Q. 14. A customer placed an order for 25000 pipes with below specifications to a vendor.
(a) Nominal diameter (d) = 0.400 m.
(b) Error Spec: 0.398 m < d < 0.401 m.
After manufacturing the 25000 pipes, according to above specifications, the vendor did a quality check and found that 2000 pipes were having diameter > 0.401 m. Assuming gaussian distribution, predict the number of remaining 23000 pipes that will be within customer specifications.

Ans: 22930