भारतीय सूचना प्रौद्योगिकी संस्थान कोटा
INDIAN INSTITUTE OF INFORMATION TECHNOLOGY KOTA

B.Tech. (ECE), Semester – IV
End Term Examination, Even Semester 2023-24

Measurement and Instrumentation Technology (ECT204)
Marks: 40 (Weightage – 40%) **Time: 120 minutes** **Date: May 14, 2024**

Note: Attempt all questions in sequence.

Q1. Answer in brief. [2×11 = 22 Marks]

i. Name different components of a measurement system.
ii. Express the following derived units in terms of base SI units: Farad, Ohm.
iii. Mention at least four classification of instruments based on type and method of measurements.
iv. Define standards and calibration.
v. Mention the percentage of values that lie within a band around the mean in a normal distribution curve with a width of two and four times of standard deviations, respectively.
vi. Two resistors, with given nominal values ± uncertainty, R_1 (100 ± 0.1 Ω) and R_2 (50 ± 0.03 Ω) are connected in series and then in parallel. Calculate equivalent resistance (nominal value ± resulting uncertainty) for series and parallel connections.
vii. Derive the expression of gage factor for a strain gage with circular cross-section.
viii. Consider a full-bridge circuit having identical strain gages with nominal resistance equal to 130 Ω. If each strain gage cannot sustain power dissipation of more than 0.35 W, what is the maximum value of the input excitation?
ix. With the help of schematic diagram, explain the working principle of LVDT.
x. Design an active band-reject filter with following specifications: band-pass gain = 2 V/V. lower cut-off frequency = 100 Hz, upper cut-off frequency = 1000 Hz. Use OPAMP ICs 741, capacitors with 1 μF and resistors of appropriate values.
xi. A pressure sensor outputs a voltage varying as 100 mV/psi and has 2.5 kΩ output impedance. Design an OPAMP based signal conditioning circuit to provide 0 to 2.5 V as the pressure varies from 50 to 150 psi.

Q2. A piezoelectric transducer having a capacitance of 1000 pF and charge sensitivity of 40×10^{-3} coulomb/cm is connected to a CRO having resistance of 1 MΩ in parallel with 50 pF by a cable which has a capacitance of 300 pF.

i. Find the sensitivity of the transducer alone in V/cm.
ii. Find the overall sensitivity of the system in V/cm.
iii. Find the time-constant of the system.
iv. Find the maximum operating frequency in rad/sec so that the amplitude-ratio error is no worse than 5%. [1+1+1+3 = 6 Marks]

Q3. Two ideal op-amps are used to linearize the output of a single active arm Wheatstone bridge, shown in **Figure 1**. The resistance of the variable resistor is given by $R_v = R + \Delta R$, where $\Delta R > -R$.

i. Find an algebraic expression for $V_o = f(V_s, R, R_1, R_2)$.

ii. Let $V_s = 5$ V, $R = R_1 = R_2 = 1$ kΩ. Find the permissible range in R_v so that neither op-amp's output reaches ± 12V (saturation). [3+3 = 6 Marks]

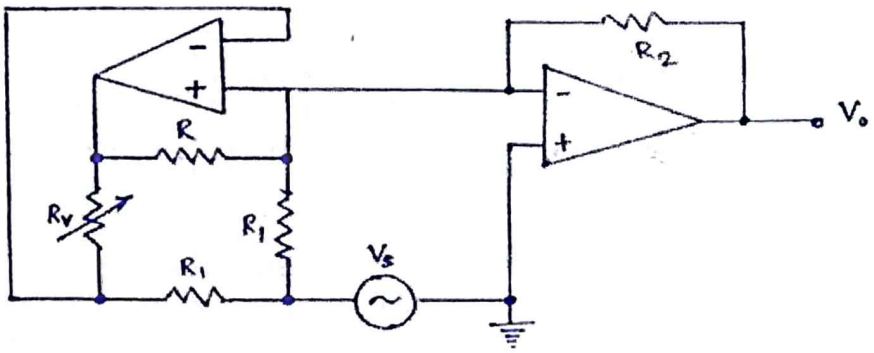

Figure 1

Q4. Consider a rectangular strip of gold sample with length L, width W, and thickness D (1 μm) as shown in Figure 2. A current I (100 mA) is passed along L, perpendicular to the cross-sectional area W×D. The face W×L is exposed to a magnetic field intensity B. A voltmeter is connected across the width to read the Hall voltage V_H. What is the magnetic field that can be recorded per micro-volt of Hall voltage?

Given: density of gold is 19.32 g/cm^3; 1 gm-atomic weight of gold (196.97 gm) contains atoms 6.0225×10^{23} (Avogadro number); gold is monovalent, meaning each atom contributes one conduction electrons. [6 Marks]

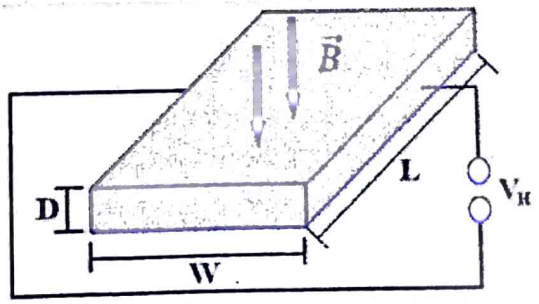

Figure 2

*** *Be Good, Do Good* ***