BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
K.K. BIRLA GOA CAMPUS
First Semester, 2022 - 23
Course: INSTR F312 (Transducers and Measurement System)

Midterm Test, Regular [Closed Book] Date: 4.11.2022
Weightage: 35 %, Marks: 70 Duration: 90 Min

Note: 1. All questions are compulsory. 2. Make assumptions wherever necessary.

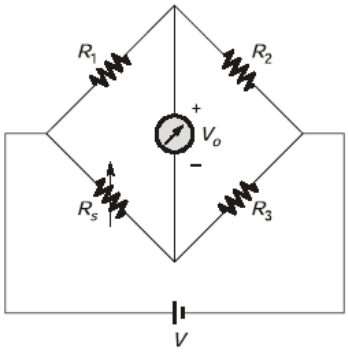
Q.1 (a) A sensor has a transfer function of 5 mV/ ^{o}C and an accuracy of ± 1%. If the temperature is known to be 60 ^{0} C, what is the expected output voltage. Now if the output voltage was first amplified by an amplifier of gain 15 ± 0.25 and then measured by a meter of range 0 to 2 V and accuracy of ± 1.5% FS, find the worst case of accuracy in the measured value. [5]

(b) An instrument has an accuracy of ± 0.5% FS and measures resistance from 0 to 1500 Ω. What is the resistance range in an indicated measurement of 397 Ω. Find the accuracy in the measured value of resistance. [4]

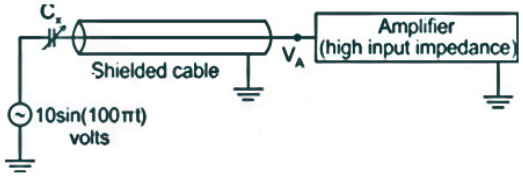
(c) A resistance potentiometer is used for position measurement. R_p and R_m are the resistance of potentiometer and load respectively. Maximum non-linearity of 1% was found when driving a load of 12 kΩ during the measurement. Find the maximum value of resistance of potentiometer. [4]

(d) Explain the effect of gauge length on the strain gauge performance. [3]

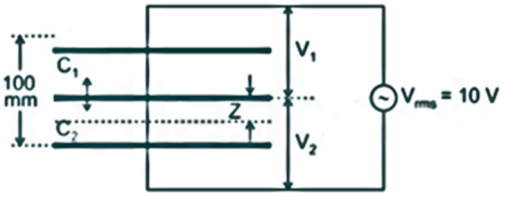
Q.2 (a) A strain gauge forms one arm of the bridge shown in figure below and has a nominal resistance without any load as R_s=240 Ω. The other bridge resistances are R_1=R_2=R_3=240 Ω. The maximum permissible current through the strain gauge is 25 mA. What is the output voltage V_0 in mV, when the bridge is excited by maximum permissible voltage and the strain gauge resistance is increased by 1.5 % over the nominal values? [6]



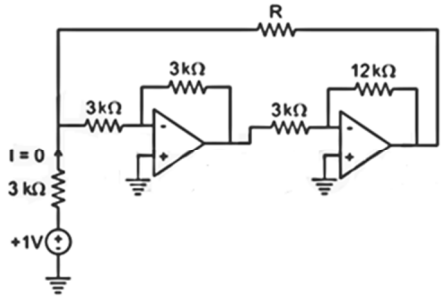
(b) The capacitance C_x of a capacitive transducer is (1000 X) pF, where X is the input to the transducer. The transducer is excited by a voltage of 10sin (100πt) V, as shown in figure below. The other terminal of the transducer is connected to the input of a amplifier through a shielded cable, with shield connected to ground. The cable capacitance is 100 pF. Draw the electrical equivalent circuit. Calculate the peak of the voltage V_A at the input of the amplifier when X=0.1. [6]



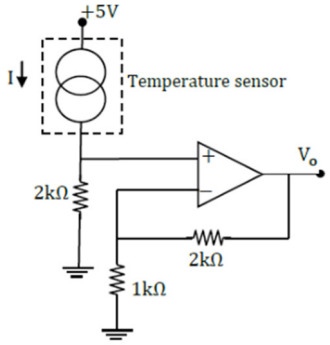
(c) A differential capacitive transducer with a distance between the extreme plates of 100 mm is shown in figure below. Derive the expression for differential voltage, ΔV. Calculate the differential voltage for a downward displacement of 10 mm of the intermediate plate from the central position. V_1 and V_2 are RMS voltages [6]



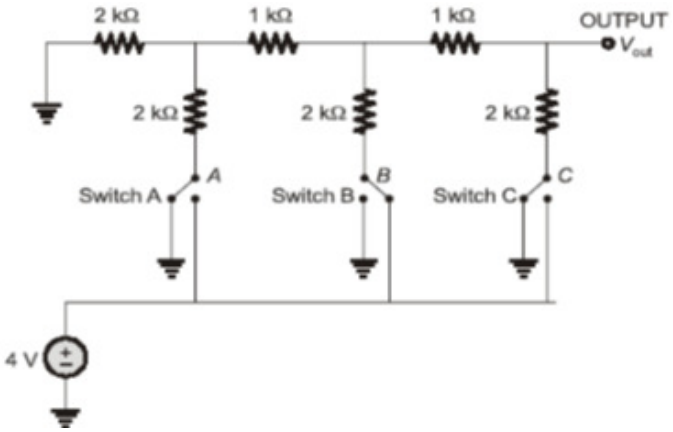
Q.3 (a) In the circuit shown below, all OPAMPS are ideal. What should be the value of resistance R, so that the current I = 0 A. [5]



(b) The temperature sensor shown in the figure below is used to measure the temperature of hot air. The output voltage V_0 is 2.1 V. The current output of the sensor is given by I=T μA where T is the temperature in K. Assuming the op-amp to be ideal, Calculate the temperature of the hot air in ℃ . [5]



(c) A resistor ladder digital to analog converter receives a digital input through switch in the circuit having the state as shown in the figure below. For this digital input, calculate the Thevenin voltage V_{th} and Thevenin resistance R_{th} as seen at the output node. **[5]**



Q.4 (a) Design a passive RC high pass filter with a cutoff frequency of 500 Hz using a 220 pF capacitor.
(i) What is the value of the resistor?
(ii) If the filter is loaded with a resistor whose value is the same as the resistor in (i), what is the transfer function of this loaded filter? (iii) What is the cutoff frequency of the loaded filter from part (ii)? [6]

(b) A linear control valve operates from fully closed to fully open when the input voltage varies from 0 V to 5 V. The valve is control using a 6 bit DAC. Find the required reference voltage to obtain a full open valve. Also calculate the percentage of the valve opening for a 1-bit change in the input word. [5]

(c) An ADC is used to encode pressure data. The input signal is 666.6 mV/psi. (i) Find the number of bits necessary for the ADC to ensure a resolution of 0.5 psi (ii) Find the maximum measurable pressure. Take reference as 10 V. [5]

(d) Discuss in details the design considerations of a RC filters for practical application. [5]

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