Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, DECEMBER 2023

MEASUREMENTS AND INSTRUMENTATION [ELE 3153]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 06 DECEMBER 2023** **Max. Marks: 50**

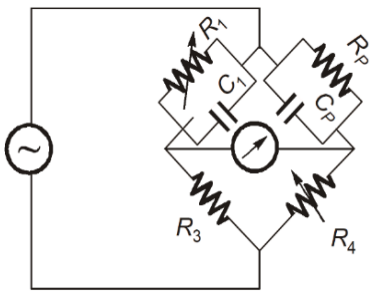
Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. In a series of successive measurements in an experiment, the readings of the period of oscillation of a simple pendulum were found to be 2.63s, 2.56 s, 2.42s, 2.71s and 2.80s. Calculate (i) the mean value of the period of oscillation (ii) the absolute error in each measurement (iii) the mean absolute error (iv) the relative error ***(02)***

1B. Explain any four static characteristics of a measuring instrument with example. ***(04)***

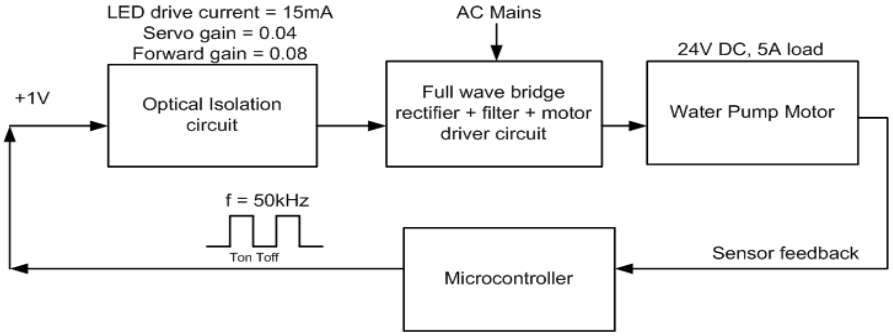
1C. The parallel resistance-capacitance bridge shown below has $C_1 = 0.1\ \mu F$ and $R_3 = 10\ k\Omega$. The bridge is balanced at a supply frequency of 100 Hz for $R_1 = 375\ k\Omega$, $R_3 = 10\ k\Omega$ and $R_4 = 14.7\ k\Omega$. Determine the dissipation factor of the parallel combination of C_p and R_p.



(04)

2A. The inductance of the coil in a moving iron instrument is given by the following expression: $L = (10 + 5\theta - \theta^2)\ \mu H$, where θ is the deflection in radian from zero position. The spring constant is $12 \times 10^{-6} N - m/rad$. From appropriate explanations of the involved fundamentals, determine the deflection for a flowing current of 5 A. ***(02)***

2B. An opto-isolated DC motor control scheme is to be implemented for a water pump module, newly to be launched. The driver output is fixed at +24V DC, 5A load and its MOSFETS have their gate driving voltage of +3V from the optical isolation circuit. The designed algorithm ensures an input voltage of +1V to the electronic module. Further, assume the LED drive current to be 15mA with servo and forward gains being 0.04 and 0.08 respectively. The overall block schematic is shown below. Accordingly design appropriate optical isolation and an active filter circuit with a gain of 10. Also ensure appropriate isolation as well as elimination of noise below 2.2 kHz from rectified AC input thereby enabling the module to pump water effectively. Explain the chosen design and justify the selection of the passive components in the design as well. ***(04)***



2C. Shock sensors are widely used in detecting abnormal vibrations in industrial motors. They behave like piezoelectric sensors. In the application here, the motor runs at variable speeds and the maximum shock sensed is 50G. The electric signals from the shock sensor is fed to a charge amplifier configured in its charge mode. The charge source is defined to be $0.35pC/G$, while the shunt resistor and capacitor were defined to be $10G\Omega$ and $390pF$ respectively. The cable length used here was 1 meter. The insulation material used in the cable is Polytetrafluoroethylene (PTFE) whose dielectric constant is 2.1 and the cable capacitance is $100pF$. The analog platform is designed in such a manner that for zero input, the voltage output too should be zero. The resonant frequency of the shock sensor is $28kHz$. Design the analog signal conditioning platform (amplifier along with the active filters) such that voltage output for a fixed pass band of 160 Hz to 2 kHz is obtained. ***(04)***

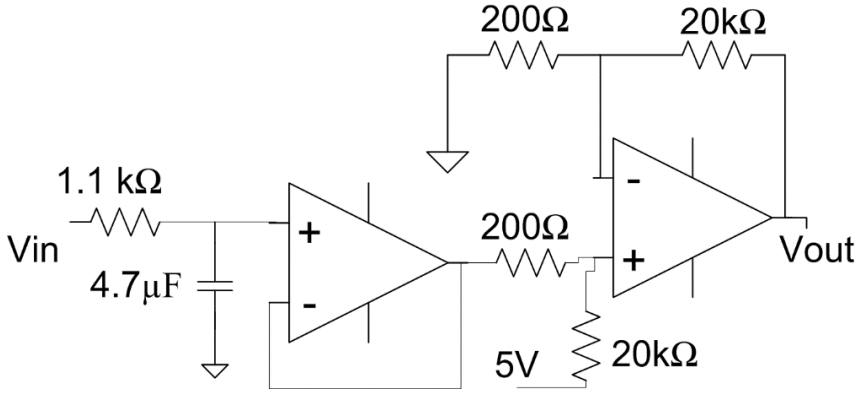
3A. Steel bar of rectangular cross-section ($2cm \times 1cm$) is subjected to tensile force of 20kN. A strain gauge is placed on steel bar. Find the change is resistance if the gauge factor is 2. In absence of axial load, the resistance is 120Ω. Young's modulus of elasticity of steel bar is equal to ($2 \times 10^8\ kN/m^2$). ***(02)***

3B. A thermistor has a resistance of 3980Ω at the ice point (0°C) and $794\ \Omega$ at 50°C. The temperature –resistance relationship is given as $R_t = a\ R_0 e^{b/T}$. Calculate the constants a and b. Calculate the range of resistance to be measured in case the temperature varies from 40°C to 100°C ***(04)***

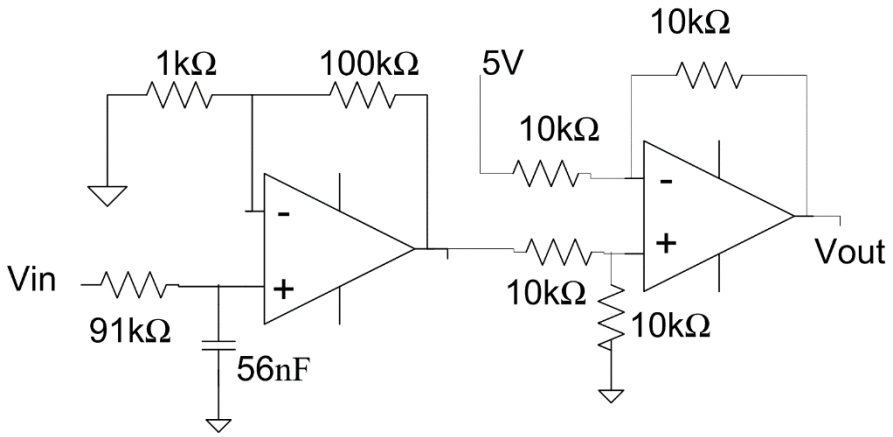
3C. The following designs were proposed to the testing and verification team of a company. The objective was to design a signal conditioning circuit with following specifications.

a. Input voltage 50mV to 100mV
b. Output voltage 0V to 5V
c. Flat frequency response for less than 31Hz

Evaluate the proposed Design A and Design B for the given specifications and select the correct design.



Design A

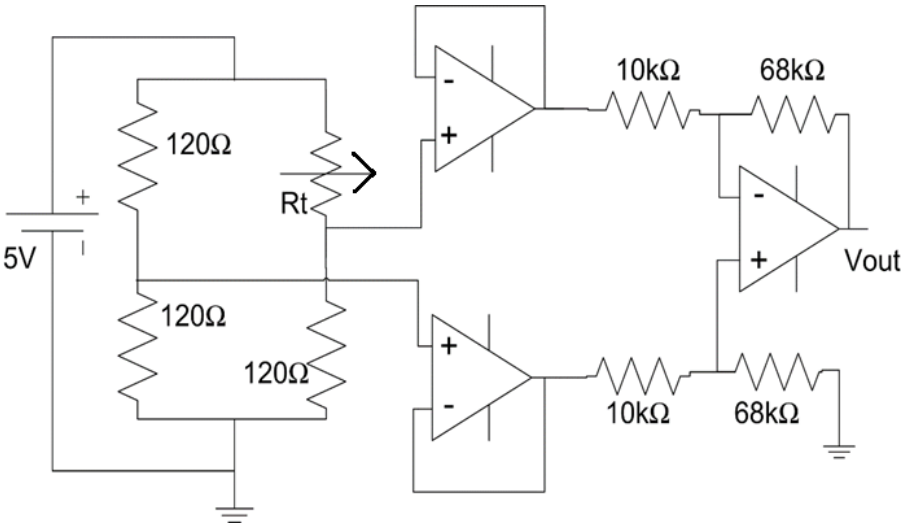


Design B ***(04)***

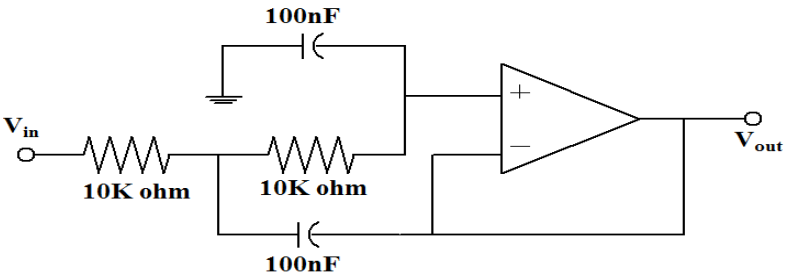
4A. Design an instrumentation circuit which provides an output voltage V_{out} related to input voltage (V_{in}) as $V_{out} = 3.5V_{in} + 5$. The available components are 35 kΩ (two in number) and 10 kΩ (three in number, two OPAMPS and a DC power supply of 5V. ***(02)***

4B. A startup company with an expertise in biomedical equipment, have developed a prototype of exoskeleton to support the movement of disabled person. As part of the project, a group of interns have developed a measurement setup to sense the stretching ability of the limbs with the help of strain gauge. The task given was to determine the resistance (Rt) produced by strain gauge during stretching and convert it to voltage in range of 0V to 5V (maximum stretching). The strain gauge with gauge factor of 2 is placed tactically such that change in length of strain gauge represents the stretching motion. The nominal resistance of strain gauge selected is 120Ω. The circuit connections developed is ***(04)***

shown in Figure. As an engineer in the firm, you are required to analyze the developed circuit and compute the output voltages for 'x' % change in length of the strain gauge due to stretching. The value of 'x' can vary from 10% to 50% in steps of 10% and the system is designed to operate only up to maximum of 50% change in length (considered as maximum possible stretching). Comment on the feasibility of the design and thereby approve or reject the design developed with appropriate justification.



4C. It is proposed to employ an active filter as depicted in Figure in an audio amplifier. From the fundamentals, derive the mathematical model of the proposed filter and identify its type. Further, determine the cutoff frequency/frequencies and the quality factor.



(04)

5A. For a supply excitation of +12 V, determine the digital output of a 2 bit flash A/D converter for an input voltage of 4 V. Draw the complete schematic assuming a 4:2 priority encoder to be incorporated. Consider the ladder resistances of 1kΩ. Determine the output of the encoder for an input of 4 V. ***(02)***

5B. With the help of neat schematic, prove that, for a R-2R Ladder Network DAC with a digital input of 1100, the equivalent analog voltage is –3Vs/4. Draw the schematic with appropriate circuit connections. Assume Vs as reference/source voltage ***(04)***

5C. Write a case study of any measurement and instrumentation system focusing on applications related to Environment and Sustainability. Draw the block diagram of its working and explain in detail the measurement part, signal conditioning part and the data display part. ***(04)***