Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

MAKE UP EXAMINATIONS, JANUARY 2023

MEASUREMENTS AND INSTRUMENTATION [ELE 3153]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 04 JAN 2023** **Max. Marks: 50**

Instructions to Candidates:

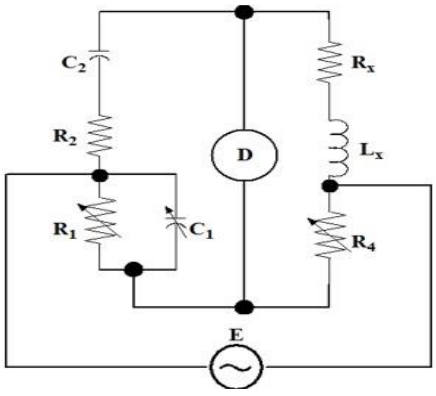
- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. Calculate the shielding effectiveness of a sheet of 2mil copper foil, at 100 MHz. Given, the copper conductivity as $\sigma = 5.7 \times 10^7$ S/m and 1mil = 0.0254 mm. ***(03)***

1B. A 820Ω resistance with an accuracy of ± 10% carries a current of 10mA. The current was measured by an analog ammeter on a 25mA range with an accuracy of ±2% of full scale. Calculate the power dissipated in the resistor and determine the accuracy of the result. ***(03)***

1C. Inductance of moving coil ammeter with full scale deflection of 90° at 1.5A is given by an expression $L=(200+40\theta-4\theta_2-\theta_3)$ μH, θ is deflection in radians from zero position. Estimate angular deflection of pointer for a current of 1A ***(04)***

2A. An AC Bridge as shown in the **Figure**, is used to measure an unknown inductance L_x, which has inherent resistance R_x. The bridge parameters are $R_1 = 20k\Omega$; $R_2 = 50k\Omega$; $C_2 = 0.0037\mu F$. The operating frequency $\omega = 10^5\ rad/sec$. C_1 is adjustable from 10pF to 150pF and R_4 is adjustable from 0 to 10kΩ. Derive expressions for R_x and L_x to show that resistive and reactive balance are independent of each other. Further through appropriate analysis, determine the largest values of R_x and L_x that can be measured with given parameters. ***(03)***



2B. A capacitive transducer is made up of two concentric cylindrical electrodes. The outer diameter of the inner cylindrical electrode is 4 mm. The inner diameter of the outer electrode is 4.1 mm. The length of the electrodes is 25 mm. The dielectric medium is air and its breakdown strength is 3 kV/mm. Calculate the change in capacitance if the inner electrode is moved through 3 mm. Calculate the dielectric stress when a voltage of 100 V is applied across the electrodes. Is it within safe limits? ***(03)***

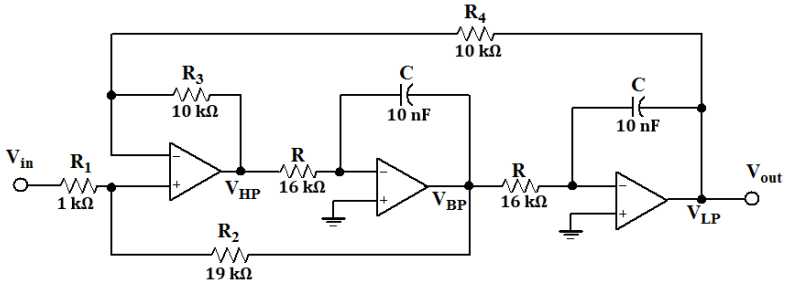
2C. Explain with neat schematics and accompanying sample plots, how capacitive transducers can be used for sensing applications by variations in: ***(04)***

i. Distance between the plates

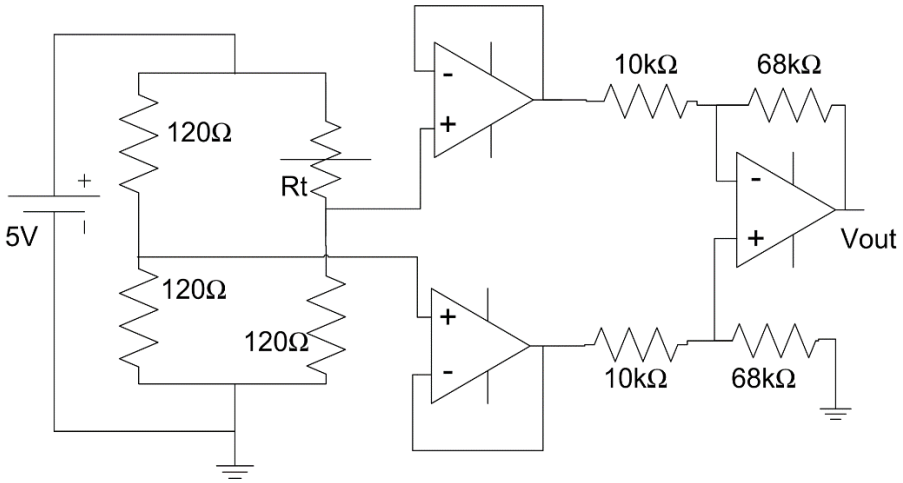
ii. Overlapping area

3A. Mention any two functions of signal conditioning circuit. Design a signal conditioning circuit for a temperature transducer such that the measurements of 0°C to 100°C are represented as 0V to 5V. The characteristic of the temperature transducer is given by the equation $Vt = (-10^{-3})T$, where Vt is transducer output voltage (V), and T is temperature in °C ***(03)***

3B. A state variable filter circuit design is as shown in the Figure. Analyze the circuit and determine the transfer function of a low-pass filter $\left(\frac{V_{LP}}{V_{IN}}\right)$ from the design. Also, determine the cutoff-frequency and quality factor of the design. ***(03)***



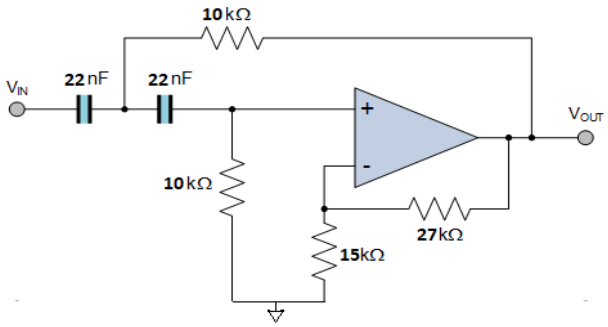
3C. A startup company with an expertise in biomedical equipment, have developed a prototype of exoskeleton to support the movement of disabled person. As part of the project, a group of interns have developed a measurement setup to sense the stretching ability of the limbs with the help of strain gauge. 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 shown below. 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. ***(04)***



4A. What is the importance of signal isolation in measurements and instrumentation? Explain the working of Optical isolation with help of neat circuit diagram. ***(03)***

4B. With the help of neat schematic, prove that, for a R-2R Ladder Network DAC with a digital input value of 0001, an equivalent analog voltage of (–Vs/16) is produced. Draw the schematic with appropriate circuit connections. Assume Vs as reference/source voltage. ***(03)***

4C. As an intern in an analog systems design company, you are asked to analyze the signal conditioning circuit developed by the system-design engineer for a specific transducer. The circuit is shown below. Analyze the circuit and determine the DC gain, cut-off frequency, quality factor and draw the frequency response characteristics of the developed circuit. ***(04)***



5A. Design an 3 bit Flash ADC with Vref=10V, Assume suitable value for R and find the equivalent digital output for an analog input of 5.5V ***(03)***

5B. Describe exhaust after treatment system in vehicles and comment on the importance of such a system. List and explain the specific usage and importance of any two sensors used in a Denoxtronics system. List any two existing Emission Standards/Norms in India to be followed considering impact on environment from vehicle emissions. ***(03)***

5C. A piezo shock sensor is connected to the back wheel of an F1 race car and it records a maximum possible shock of 100g (1g = 9.81 m/s") during the trial test. The electrical signals from the shock sensor is fed to a charge amplifier configured in the voltage mode. The critical sensor parameters are defined as: crystal capacitance = 60pF while the crystal resistance = 1GΩ. The shock to charge relation is determined to be as 0.6283 pC/g. The connecting cable capacitance is 2.83pF. Design a suitable signal conditioning platform such that for zero to maximum shock input, the output should be limited to 0—5V for a fixed pass band of 5 —159Hz. Assume the feedback capacitance to be 1uF ***(04)***