UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2022/2023 Academic Session

July/August 2023

EEK374 Electrical Instrumentation and Measurement

Duration: 2 hours

Please check that this examination paper consists of **SEVEN (7)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **FOUR (4)** questions. Answer **ALL** questions.

...2/-

1. (a) Given expected voltage value across a resistor is 180 Volt. The voltage measurement is 174 Volt. Calculate,

(i) The absolute error

(10 marks)

(ii) The percentage of error

(10 marks)

(iii) The relative accuracy

(10 marks)

(iv) The percentage of accuracy

(10 marks)

(b) Resistance Temperature Detector (RTD) has a resistance of 25 Ω at 30 °C. When the temperature increases, the resistance of RTD will increase linearly and the relationship is expressed as follows:

$$RT = R30(1+\alpha\Delta T)$$
$$where\ \alpha 30 = 0.004/°C$$

A simple circuit as shown in Figure 1.1. is used to show the principle of RTD. Calculate the voltage output (*Vo*) at temperature 30°C and 100°C when the input voltage is 10 V.

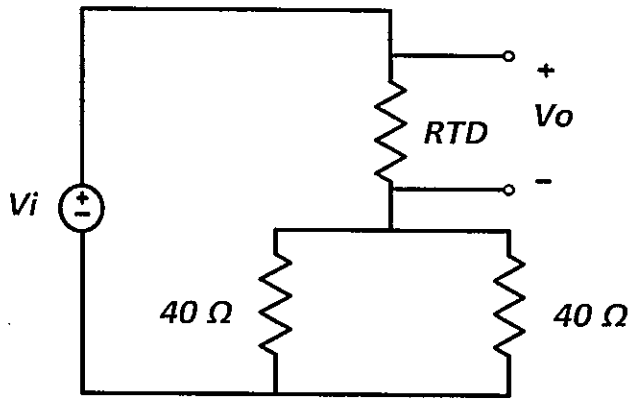

Figure 1.1

(30 marks)

...3/-

(c) Calculate the value of R_x in Figure 1.2. if $R_a=1600\ R_b$, $R_1=800\ \Omega$ and $R_1=1.25\ R_2$.

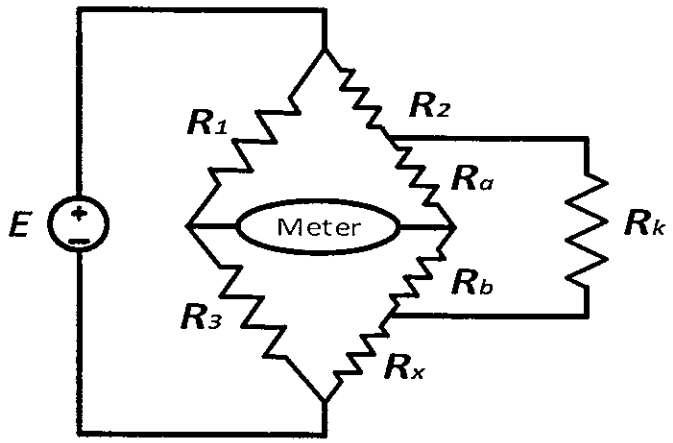

Figure 1.2

(30 Marks)

2. (a) Compare between measurement standard types in terms of scope, accuracy, and availability. And draw the relationship between standard and accuracy.

(30 marks)

(b) Figure 2.1 shows a voltmeter movement with an internal resistance, R_m of 50 Ω and maximum internal current 1 mA is to be used for measurement voltage at four different range: 0 – J_1 V, 0 – 50 V, 0 – 10 V and 0 – 1 V.

(i) Determine the sensitivity of the voltmeter?

(10 marks)

(ii) Find the value for resistors R_2, R_3 and R_4?

(15 marks)

(iii) Find the value of voltage selector J_1?

(15 marks)

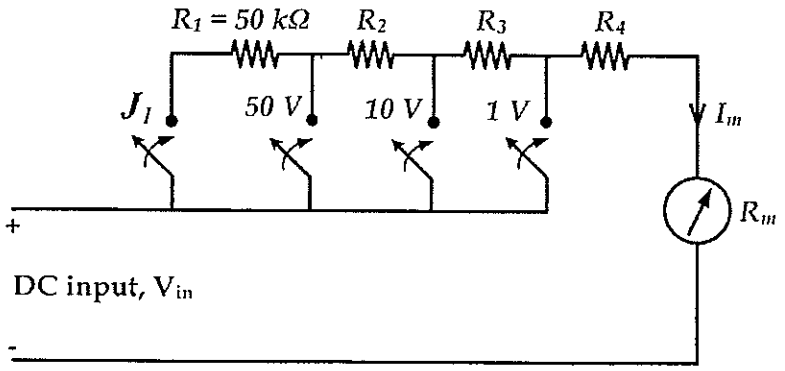

Figure 2.1: Multirange Voltmeter

(c) A parallel-plate capacitance type sensor has the following specifications:

- Area for each metal plate is 30 cm^2 (with 3 cm width and 10 cm length)
- Distance between the metal plates is 0.5 mm
- Dielectric constant of a ceramic type dielectric material, k= 1000
- Vacuum permittivity is 8.854×10^{-12} F/m

(i) Based on the given basic specifications, draw the design of the sensor for displacement measurement if the surface area of the metal plates changes according to the displacement.

(10 marks)

(ii) What is the relationship on capacitance if the plate area is increasing?

(10 marks)

(iii) What is the capacitance value if the distance between plates is increased to 1 mm.

(10 marks)

...5/-

3. (a) An analog-to-digital converter (ADC) has 7-bit resolution, and its input range is from 0 to 6 V.

(i) Calculate the smallest voltage step that the ADC can resolve.

(10 marks)

(ii) Calculate the quantization error of the ADC.

(15 marks)

(iii) Calculate the rms value of the quantization error.

(15 marks)

(b) The ADC in Question 3.(a) is used in the design of a microcontroller-based temperature monitoring system as shown in Figure 3.1. The measurement range of the temperature sensor is from -20°C to 150°C. Answer the following:

(i) Explain in detail how the system works.

(15 marks)

(ii) What are the advantages of using a microcontroller compared to a PC as the main control unit in the design?

(15 marks)

(iii) If the sensor can linearly convert the temperature to a voltage signal ranging from 0 to 3.0 V, calculate the smallest change in temperature value that the system can detect.

(20 marks)

(iv) Suggest two ways to improve the accuracy of the system without changing the temperature sensor.

(10 marks)

...6/-

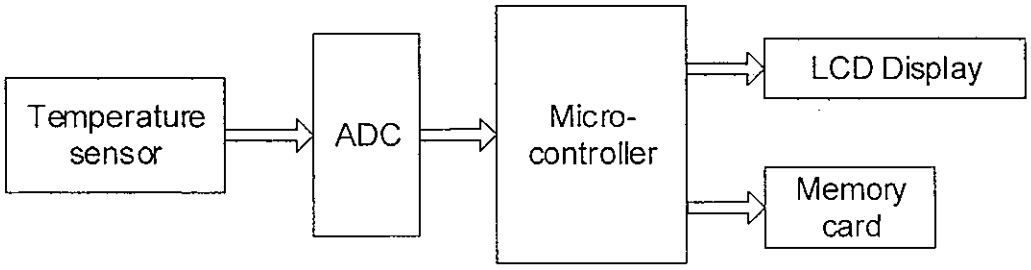

Figure 3.1

4. (a) Draw the block diagram of a data acquisition (DAQ) system and explain the functions of each block.

(30 marks)

(b) Explain five factors that need to be considered when selecting a DAQ device.

(20 marks)

(c) Design a microcontroller-based instrument that can measure the rms voltage and current of an AC signal. The instrument should have an LCD panel to display the measurement data and the data can be transferred to a computer. Your answer should include the system block diagram and software flow chart. Explain how the rms voltage and current can be calculated from the digitized voltage and current values read by the ADC in the microcontroller.

(50 marks)

ooOooo

...7/-

APPENDIX A

Course Outcomes (COs) – Programme Outcomes (POs) Mapping

Question	Course Outcome (CO)	Programme Outcome (PO)
1	1	1
2	2	2
3	2	2
4	3	3