University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology Honours Degree
Level 4 (Semester I) Examination, June 2023
Academic year 2021/2022

Course Unit: ENT 4113 Mechatronics control and automation (Written)

Duration: 3 hours

- This paper contains **five (5)** questions on **six (6)** pages.
- Answer all the questions.
- Calculators are allowed to be used.

Q1) a) State the definition for the term 'sensor' (10 marks)

b) State the definition of a 'smart sensor'. (10 marks)

c) A rotary potentiometer can be used to measure the angle at which a robot arm rotates. The rotary potentiometer has three terminals and is named as shown in Figure 01(a) below. Consider that the rotary potentiometer has R_p resistance. As the robot arm rotates, the slider of the potentiometer rotates parallel to it. Derive values of R_{12} and R_{23} in terms of R_p and x after the slider has moved x distance (Figure 01(b)). (20 marks)

Where: R_P = Resistance between terminals 1 and 3

R_{12} = Resistance between terminals 1 and 2

R_{23} = Resistance between terminals 2 and 3

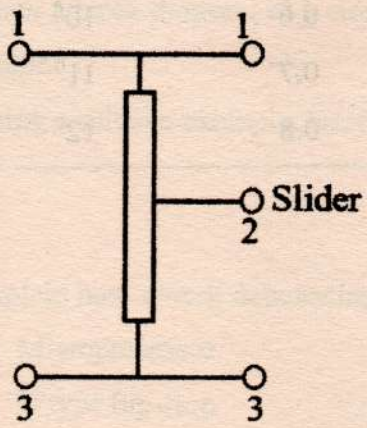


Figure 01 (a)

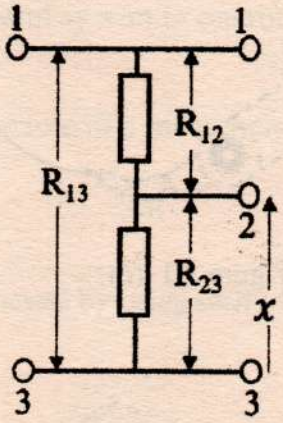


Figure 01 (b)

d) If a load R_L is parallelly across the R_{23}, calculate the new total resistance across terminals 2 and 3 (Consider this as R'_{23})? (10 marks)

e) Calculate the new total resistance between terminals 1 and 3 when the load R_L is attached as given in part (d) (Consider this as R'_{13}). (10 marks)

f) Consider the application of a constant input voltage (V_S) and the voltage across the load as V_L, derive the ratio between V_L and V_s using the terms R'_{23} , R'_{13} obtained from part (d) and part (e) respectively.

Note: $\frac{V_L}{V_S} = \frac{R'_{23}}{R'_{13}}$

Using the above ratio between V_L and V_s, hence show that;

$$\frac{V_L}{V_S} = \frac{x}{\left(\frac{R_P}{R_L}\right)x(1-x)+1}$$ (15 marks)

g) Using the derived equation in part (f), calculate the value of V_L. if $x = 0.5$, $R_p = 80$ kΩ, $R_L = 5$ kΩ, and $V_S = 6$ V. (15 marks)

h) If the robot arm length is 54 cm, calculate the distance (d) the tip of the robot arm has moved obliquely (Figure 01 (c)) by selecting an appropriate angle that matches the value calculated for V_L in part (g) from Table 01 below. (10 marks)

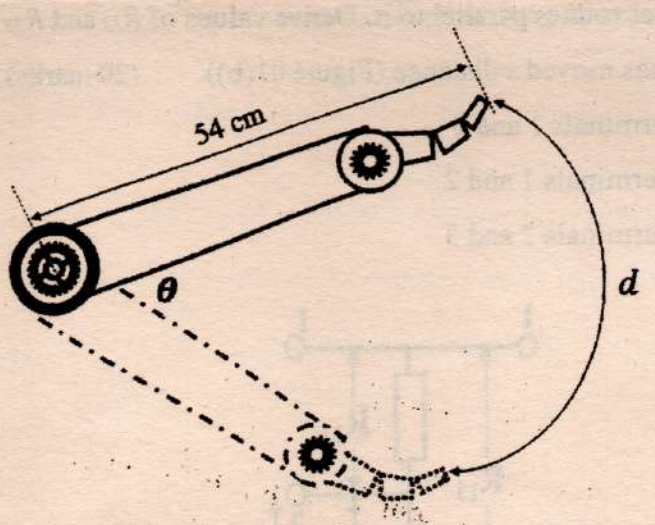


Figure 01 (c)

Table 01

V_L (V)	Angle θ (Degree)
0.4	8^0
0.5	9^0
0.6	10^0
0.7	11^0
0.8	12^0

Q2).

a) Draw the block diagram of the general architecture of a microprocessor system. (15 marks)

b) i) Define the term, "bus" used in microprocessors. (10 marks)

ii) Briefly explain the purpose of the three types of buses commonly used in microprocessors. (30 marks)

c) Briefly explain the purpose of the following units in microprocessors.

i) Arithmetic and Logic Unit (ALU)

ii) Registers

iii) Control Unit (15 marks)

d) State the three main modes of data transmission used in serial communication and briefly explain the operation of each mode. (30 marks)

Q3).

a) State the main difference between open-loop control and closed-loop control system. (20 marks)

b) State one advantage **and** one disadvantage of using each of the followings:

i) open-loop control

ii) closed-loop control (20 marks)

c) Draw a block diagram of an open-loop control system for an electric heater. (20 marks)

d) Draw a block diagram of a closed-loop control system to control the speed of the DC motor. (20 marks)

e) Using a suitable example, briefly explain the role of a snubber circuit. (20 marks)

Q4).

a) Explain how switch debouncing can be achieved by using each of the following.

i) Microprocessor

ii) D type flip-flop (20 marks)

b) Briefly explain the operation of each of the following filters.

i) Low-pass filter

ii) High-pass filter

iii) Band-pass filter

iv) Band-stop filter (20 marks)

c) The Resonant frequency (f_R) and Bandwidth (Bw) of a band-pass filter can be calculated using the following equations.

$$f_R = \sqrt{(f_1 \times f_2)}$$

$$f_1 = \frac{1}{2\pi R_1 C_1}, \quad f_2 = \frac{1}{2\pi R_2 C_2}$$

$$Bw = f_2 - f_1$$

Where:

$R_1, R_2 = Resistance$

$C_1, C_2 = Capacitance$

$f_1, f_2 = Frequency$

i) Calculate f_R and Bw values for the band-pass filter shown in Figure 02(a).

(30 marks)

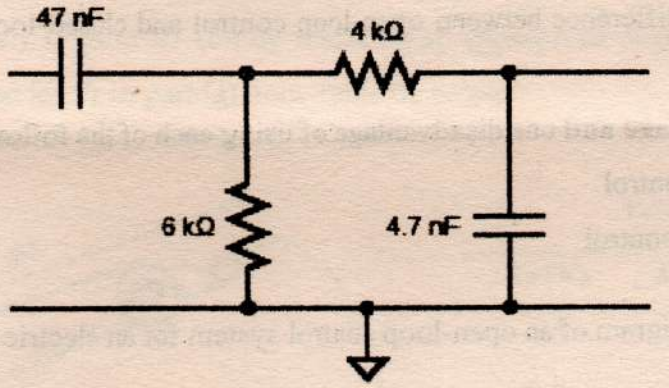


Figure 02 (a)

ii) The RC band-pass filter shown in Figure 02(b) uses two 8 kΩ resistors. Calculate the necessary values for C_1 and C_2, to achieve f_R of 4 kHz and a Bw of 4 kHz.

(30 marks)

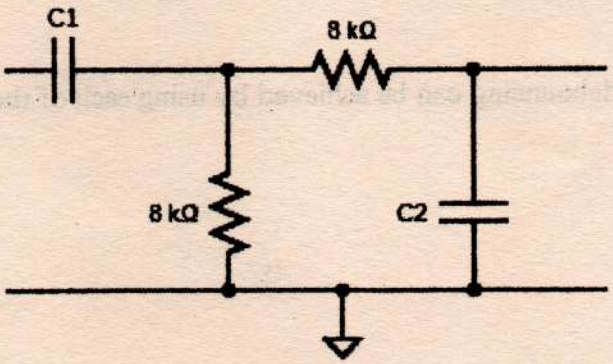


Figure 02 (b)

5) When you are given to design a system for a greenhouse, you will have to use a microcontroller, several sensors, and several actuators. A battery is also connected to the system for continuous operation in case of power failure. Each battery has a capacity of the battery is 5000 mAh. Its charger is capable of providing a maximum of 2000 mA. One of the batteries is used for the data transformation, and 7 mAh is consumed every time when it sent the data and goes idle. Consider that there is no power consumption in idle, when reading data and processing the data.

a) Calculate the time (hours and minutes) taken to fully charge the battery when its charge level is zero. (15 marks)

b) Calculate how many times can the device send data when the battery is fully charged. (15 marks)

c) Additional another 3.7 V battery is connected to a load resistance 200 Ω. Consider that the battery does not have internal resistance.

   i) How much current is flowing through the circuit? (10 marks)

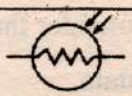
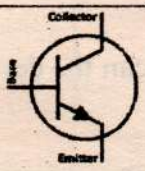
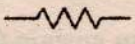
   ii) How long this battery can sustain this current? (10 marks)

d) List down the four factors that you should consider when selecting a suitable microcontroller to design a system for a greenhouse. (20 marks)

e) If the user wants to design the door to open automatically when someone comes near the door, propose a suitable sensor and the actuator you would use. (10 marks)

f) Draw a circuit diagram using the given components in table 02 (page 06), to detect the unauthorized entrance to the greenhouse. If an unauthorized entrance has happened, the LED should turn ON. (20 marks)

Table 02

Component	Symbol
Battery (7V)	
LDR	
LED, Laser light	
NPN transistor	
Potentiometer	
Resistor (330 Ω)	

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