**Exam.Code:0941**
**Sub. Code: 33866**

**2124**
**B.E. (Mechanical Engineering)**
**Fifth Semester**
**MEC-505: Mechatronics**

**Time allowed: 3 Hours** **Max. Marks: 50**

***NOTE: Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Part.***

*x-x-x*

**Question 1**:

(a) Why is impedance matching important in electrical circuits? Explain one practical scenario where impedance matching is critical.

(b) Why is the common emitter configuration widely used in amplifiers compared to the common base or common collector configurations? Discuss its advantages in terms of gain and input/output impedance.

(c) Why are semiconductor materials like silicon and germanium preferred over conductors or insulators for making electronic devices? Discuss the role of the bandgap in determining their suitability.

(d) Why would an inverting amplifier configuration be preferred over a non-inverting configuration in certain applications? Discuss its advantages in terms of gain control and phase inversion.

(e) Why are sample-and-hold circuits critical in analog-to-digital conversion? Explain their role in preserving signal accuracy during the conversion process.

[10 marks]

**Part A**

**Question 2.** A circuit consists of the following:
A 12 V voltage source connected in series with a 4 Ω resistor (R1) and a 2 Ω resistor (R2).Parallel to R2 is another branch containing a 6 Ω resistor (R3).

a. Determine the Thevenin equivalent voltage and resistance across the terminals of R3.

b. Replace R3 with a load resistor RL. Derive the value of RL that will maximize the power delivered to it (impedance matching principle).

c. Calculate the maximum power delivered to RL.

[10 marks]

**Question 3:**

a. Explain the working principle of a Zener diode in reverse bias and its role in voltage regulation.

b. Design a simple voltage regulator circuit using a Zener diode for an input voltage range of 12–18 V to provide a constant 9 V output. Explain the working of your design, and discuss the limitations of using a Zener diode for regulation in high-current applications.

c. Compare the behavior and applications of optoelectronic diodes (LEDs and photodiodes) in electronic circuits.

[10 marks]

**P.T.O.**

**Question 4:**

a. Explain the working principles of an inverting amplifier and a non-inverting amplifier using an operational amplifier. Derive expressions for their respective voltage gains.

b. Discuss how the limitations of a real operational amplifier (e.g., finite gain, input bias current, offset voltage) impact the performance of the designed circuit.

[10 marks]

## Part B

**Question 5:**

a. Explain the steps involved in deriving a simplified Boolean expression from a given truth table. Discuss how Karnaugh Maps (K-maps) help in minimizing Boolean expressions compared to algebraic simplification.

b. Design a combinational logic circuit that takes three inputs (A,B,C) and outputs 1 only when a majority of the inputs are 1. Provide the truth table, simplified Boolean expression, and a block diagram for your design.

c. Discuss the advantages and limitations of using NAND gates to implement any digital logic function.

[10 marks]

**Question 6:**

a. Discuss the working principles and structure of a Programmable Logic Controller (PLC). How does it differ from a traditional microcontroller?

b. Write and explain a ladder logic program to control a conveyor belt system where: The conveyor starts when a start button is pressed. It stops when a stop button is pressed or a proximity sensor detects an object. Include an emergency stop that overrides all other conditions.

c. Explain how a shift register can be implemented in ladder programming and its applications in industrial automation.

[10 marks]

**Question 7:**

a. Explain the working principles of cams and followers, and discuss their applications in mechanical systems. Illustrate your explanation with a diagram of a cam profile for uniform motion.

b. Compare and contrast belt drives and chain drives in terms of efficiency, maintenance, and applications in mechatronic systems.

c. Using an example, describe how kinematic chains are used to achieve complex motion in mechatronic systems, such as robotic arms or assembly line equipment.

[10 marks]

*x-x-x*