**Topic: Embedded systems**

Reading Time: 15 mins

**·        Note\* Highlight important/core points while reading**

·        Read the content and write the answers given in the document in your words, to get the solid grip on topic.

**Embedded Systems**

Embedded systems are specialized computing systems designed to perform dedicated functions within larger devices. These systems integrate different components to carry out specific tasks, such as processing data or controlling devices, efficiently and reliably.

**Types of Components in Embedded Systems**

1.      **Microprocessor**

* **Definition**: A microprocessor is an integrated circuit that functions as the central processing unit (CPU) of a computer, executing instructions and performing calculations. It does not have built-in memory or I/O (input/output) components.
* **Advantages**:
  + High processing power, capable of complex computations.
  + Versatile for use in various applications by changing software programs.
* **Disadvantages**:
  + Requires external memory and I/O components, increasing the system's size and complexity.
  + Higher power consumption, less suitable for battery-powered or compact devices.
* **Example Usage**: Desktop computers, servers, some industrial machines.

2.      **Microcontroller**

* **Definition**: A microcontroller is an integrated circuit that contains a CPU, memory (RAM, ROM), and I/O interfaces on a single chip. It is designed for low-power, dedicated applications.
* **Advantages**:
  + Compact and self-contained with built-in memory and I/O, making it ideal for simple, dedicated functions.
  + Low power consumption, suitable for battery-operated devices.
* **Disadvantages**:
  + Limited processing power compared to microprocessors, so not suitable for complex tasks.
  + Limited memory and storage capacity.
* **Example Usage**: Home appliances like washing machines and microwaves, where specific control functions are required.

3.      **System on Chip (SoC)**

* **Definition**: A System on Chip (SoC) integrates a CPU, memory, I/O ports, and often additional components like GPUs or wireless connectivity on a single chip. It combines the functionalities of both microprocessors and microcontrollers, optimized for compact devices.
* **Advantages**:
  + Highly efficient and compact, suitable for multifunctional and portable devices.
  + Supports complex functions due to integration of multiple components.
* **Disadvantages**:
  + Expensive and complex design, making it difficult to repair.
  + Often harder to upgrade individual components due to tight integration.
* **Example Usage**: Smartphones, tablets, modern smart home devices.

**Embedded Systems Examples**

1.      **Set-Top Box**

* **Description**: A set-top box is a device that connects to a television and enables streaming of digital television content. It often contains an SoC to handle multimedia processing, decoding signals, and connecting to Wi-Fi.
* **Advantages**: Enhances standard TV functionality; allows access to a variety of digital content.
* **Disadvantages**: Limited processing power for additional tasks; relies on stable internet.

2.      **Security Systems**

* **Description**: Security systems, such as alarm systems and surveillance cameras, use microcontrollers or SoCs to process sensor data, activate alarms, or connect to networks for remote monitoring.
* **Advantages**: Provides real-time monitoring and increases safety.
* **Disadvantages**: Potential vulnerability to hacking, dependency on power supply.

3.      **Lighting Systems**

* **Description**: Lighting systems, especially smart lighting, use microcontrollers to control brightness, color, and power on/off schedules. They may connect to networks for remote control.
* **Advantages**: Enhances convenience and energy efficiency.
* **Disadvantages**: Limited functionality if network connectivity is lost.

4.      **Vending Machines**

* **Description**: Vending machines use microcontrollers to handle customer inputs, dispense products, and manage payment transactions.
* **Advantages**: Provides automation and convenient service for customers.
* **Disadvantages**: Limited to predefined products and prices; maintenance required.

5.      **Washing Machines**

* **Description**: Washing machines contain microcontrollers to manage wash cycles, control water temperature, and adjust spin speed. They enable various preset modes based on fabric type.
* **Advantages**: Increases convenience with automation; conserves energy and water through optimized cycles.
* **Disadvantages**: Limited flexibility for custom programming; breakdowns can be complex to fix.

**Advantages and Disadvantages of Embedded System Components**

* **Microprocessor**:
  + **Advantages**: High processing power; versatile for different software applications.
  + **Disadvantages**: Requires external components; high power consumption.
* **Microcontroller**:
  + **Advantages**: Compact and low-cost; ideal for single-function applications.
  + **Disadvantages**: Limited in processing power and memory capacity.
* **System on Chip (SoC)**:
  + **Advantages**: Compact, powerful, suitable for multifunctional devices.
  + **Disadvantages**: Expensive, complex, harder to repair.

### ****A-Rated Questions/Answers By Examiner****

**Q1: What is the main role of a microcontroller in an embedded system?**  
**Answer**: A microcontroller acts as a dedicated control unit in an embedded system, managing specific tasks like processing input from sensors or controlling devices, with integrated memory and I/O ports.

**Q2: How does an SoC differ from a microprocessor in terms of functionality?**  
**Answer**: An SoC integrates a CPU, memory, and other components like I/O interfaces and GPUs on one chip, allowing it to handle multiple complex functions, while a microprocessor requires additional external components.

**Q3: Why are microcontrollers ideal for use in washing machines?**  
**Answer**: Microcontrollers are compact and energy-efficient, making them suitable for controlling the wash cycles and water temperature in washing machines, providing dedicated control for these specific tasks.

**Q4: What are the advantages of using a System on Chip (SoC) in a smartphone?**  
**Answer**: SoCs are highly efficient and compact, integrating the CPU, memory, I/O ports, and often additional components like wireless connectivity or GPUs into a single chip. This integration allows smartphones to handle multiple complex functions, such as running applications, processing graphics, and enabling communication, all within a small, power-efficient form factor.

**Q5: How does the use of microcontrollers enhance the functionality of security systems?**  
**Answer**: Microcontrollers in security systems handle tasks such as processing data from sensors (motion detectors, cameras), activating alarms, and communicating with remote monitoring systems. Their compact size and low power consumption make them ideal for real-time processing, ensuring that security systems are responsive, efficient, and reliable while maintaining energy efficiency.

### Write your Answers on your Notebook and Verify it on Next Screen

**Q6: What is a primary disadvantage of using a microprocessor in embedded systems?**

**Q7: How does a microcontroller contribute to energy efficiency in embedded systems like lighting controls?**

**Q8: Why is a System on Chip (SoC) more suitable for smartphones than a microprocessor?**

**Q9: In what way does the use of embedded systems in vending machines improve service for customers?**

**Q10: What are some of the challenges in maintaining embedded systems such as smart home devices?**

**6. Answer:** A key disadvantage is that microprocessors require external memory and I/O components, which increases system complexity and power consumption, making them less suitable for compact or battery-powered devices.

**7. Answer:** Microcontrollers are designed for low power consumption, enabling them to efficiently manage power usage, such as adjusting brightness or turning lights on/off, which helps conserve energy in lighting systems.

**8. Answer:** An SoC integrates multiple components (CPU, memory, GPU, I/O) on a single chip, making it compact and power-efficient, ideal for the multifunctional and space-constrained requirements of smartphones.

**9. Answer:** Embedded systems automate processes like accepting payment, dispensing products, and providing real-time inventory updates, allowing vending machines to deliver products quickly and conveniently without human assistance.

**10. Answer:** Challenges include limited upgradability due to tightly integrated components (especially in SoCs), vulnerability to cyber threats, and potential difficulties in repair if a malfunction occurs, as components are not easily replaceable.

### ****Kindly Write down your answers on your Note book and than verifiy it with answers given at the end****

(a) State what is meant by the robot being automated.

................................................................................................................................................... ............................................................................................................................... [1]

(b) Give three characteristics of a robot.

1........................................................................................................................................................................................................................................................................................ 2............................................................................................................................................ .............................................................................................................................................. 3........................................................................................................................................... ..............................................................................................................................................   [3]

(c) The robot plants seeds and stops when it reaches a fence. It then turns and continues planting seeds. The robot uses sensors and a microprocessor to know when it reaches a fence.

................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ............................................................................................................................................. [6]

Explain how the robot uses sensors and a microprocessor to know it has reached a fence.

................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ............................................................................................................................................. [6]

(d) Give two advantages of the farmer using an automated robot to plant seeds.

1 ................................................................................................................................................ ................................................................................................................................................... ..................................................................................................................................................

2 ................................................................................................................................................ ................................................................................................................................................... ...................................................................................................................................................

                                                                                                                                                [2]

(e) Give two disadvantages of the farmer using an automated robot to plant seeds.

1 ................................................................................................................................................ ................................................................................................................................................... ...................................................................................................................................................

 2 ................................................................................................................................................ ................................................................................................................................................... ...................................................................................................................................................

                                                                                                                                                 [2]

(f) The robot is adapted to have machine learning capabilities.

Explain how this will improve the robot.

................................................................................................................................................... ................................................................................................................................................... ................................................................................................................................................... ............................................................................................................................................. [2]