CEN 511- 2023/2024

Question One

a) Discuss briefly term embedded systems as seen in autonomous systems, robotics, and industrial automation.

Answer:
An **embedded system** is a specialized computing system designed to perform dedicated functions within a larger system. It typically consists of hardware (microcontroller or microprocessor) and software optimized for a specific task.

- **Autonomous Systems:** Embedded systems control decision-making and navigation in self-driving cars, drones, and automated machines.
- **Robotics:** Robots rely on embedded systems for motion control, sensor integration, and real-time decision-making.
- **Industrial Automation:** Used in manufacturing for monitoring and controlling processes such as conveyor belts, robotic arms, and smart sensors.

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b) Why are computers seen as general-purpose machines and embedded systems as specialized or special-purpose computers?

Answer:

- **General-purpose computers** (e.g., laptops, desktops) can run multiple programs and perform a wide range of tasks.
- **Embedded systems** are designed for a **specific task** (e.g., washing machine controller, heart rate monitor). They are optimized for efficiency, reliability, and low power consumption.

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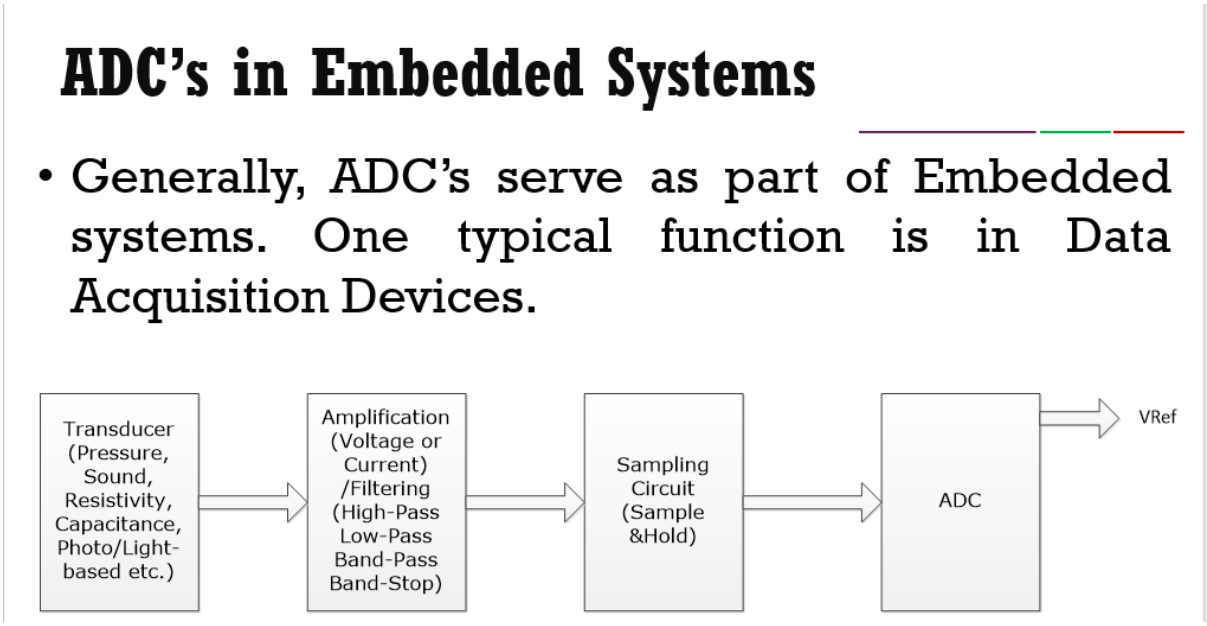
c) Identify three communication protocols used in the context of IoT.

Answer:

1. **MQTT (Message Queuing Telemetry Transport)** – A lightweight protocol used for IoT communication over unreliable networks.
2. **CoAP (Constrained Application Protocol)** – Designed for low-power devices in IoT applications.
3. **Bluetooth Low Energy (BLE)** – A wireless communication protocol suitable for short-range IoT devices.
4. **http**
5. **LoRanWAN 6. Wifi 7. NFC 8. websockets**

d) With the aid of a diagram, show the components of a typical data acquisition system.

Answer:



Question Two

a) A Microcontroller system with an 8-bit ADC is used to measure a physical signal/quantity with a voltage range of 0 – 5V.

i. What is the smallest voltage level that the microcontroller can measure?

Answer:
The smallest voltage level (resolution) is given by:

Resolution= Voltage Range / 2^n

For an **8-bit ADC**, the total levels = 2^8 = 256.

Resolution = 5V / 256 = 0.01953V

So, the smallest voltage level the microcontroller can measure is **19.53mV**.

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ii. How many voltage levels (resolution) can the microcontroller accurately measure?

Answer:
Since it's an 8-bit ADC, it can measure **256 discrete voltage levels** (from **0 to 255**).

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iii. If the ADC gives an output of 1100 00112_22, what is the voltage range of the physical quantity? (Reference voltage = 5V)

Answer:
First, convert **1100 0011** to decimal:

$11000011_2 = 195$

Now, calculate the voltage using:

V= (ADC Output / Levels) × Reference Voltage

V= (195 / 256) × 5V = 3.81V

So, the voltage range is **3.81V**.

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b) Discuss the features of one serial communication protocol used in Microcontroller systems.

Answer:
UART (Universal Asynchronous Receiver-Transmitter)

- UART: Stands for Universal Asynchronous Reception and Transmission (UART)
- A simple serial communication protocol that allows the host communicates with the auxiliary device. UART supports bi-directional, asynchronous and serial data transmission.
- It has two data lines, one to transmit (TX) and another to receive (RX) which is used to communicate through digital pin 0, digital pin 1. TX and RX are connected between two devices. (eg. USB and computer).
- UART can also handle synchronization management issues between computers and external serial devices.

c) List four typical features of a Microcontroller system.

Answer:

1. **Number of inputs and outputs (Ports)**
2. **Program memory size**
3. **Data RAM size**
4. **Nonvolatile data memory(ROM)**
5. **Maximum clock speed**
6. **Range of interfaces**

Question Three

a) Consider two common cathode seven-segment displays connected to a PIC microcontroller on Ports B and C.

i. What is the value (in binary or hexadecimal) to enable both ports to write to the displays?

Answer:
If all segments are enabled, the value depends on the **seven-segment encoding scheme**. For **common cathode**, segments are activated with logic **1**.
Example for displaying **"88"**:

- **Port B:** 0x7F (binary: 0111 1111)
- **Port C:** 0x7F (binary: 0111 1111)

ii. What register is used to enable Port B and Port C as output ports?

Answer:
The **TRISB** and **TRISC** registers control port direction:

TRISB=0x00,

TRISC=0x00 (Setting them to **0** configures the ports as output.)

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iii. What value sent to each port would display the last two digits of a matriculation number?

Answer:
Depends on the **7-segment encoding table**.

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b) The circuit in (a) is modified so that eight switches input a value.

i. What is the value (binary/hex) to enable one port to read from switches and another to write to the display?

Answer:

- Set one port as input (e.g., **TRISB = 0xFF**)
- Set the display port as output (e.g., **TRISC = 0x00**).

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c) Arduino sketch programs in embedded C come with two methods.

i. List these two methods.

Answer:

1. **setup()** – Runs once at the beginning.
2. **loop()** – Runs continuously after setup().

ii. Explain how both methods work.

Answer:

- **setup():** Used to initialize configurations (e.g., pin modes, serial communication).

- **loop():** Contains the main code that executes repeatedly.

Question Four

a) Write an Arduino program to control a traffic light.

```
void setup() {
  pinMode(2, OUTPUT); // Red
  pinMode(3, OUTPUT); // Yellow
  pinMode(4, OUTPUT); // Green
}

void loop() {
  digitalWrite(2, HIGH); delay(6000); // Red for 60 sec
  digitalWrite(2, LOW);
  digitalWrite(3, HIGH); delay(10000); // Yellow for 10 sec
  digitalWrite(3, LOW);
  digitalWrite(4, HIGH); delay(60000); // Green for 60 sec
  digitalWrite(4, LOW);
}
```

Question Five

a) Explain the timer interrupt system in a PIC microcontroller.

Answer:
Timers generate **interrupts** to execute tasks at regular intervals without blocking main code execution. It is used in **delays, PWM, and real-time applications**.

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b) Why are oscillator circuits important to microcontrollers?

Answer:
Oscillators provide the **clock signal** for microcontrollers, ensuring accurate timing for operations.

List and describe four oscillator operating modes.

1. **XT (Crystal):** Uses an external crystal for stable timing.
2. **HS (High-Speed):** Used for fast execution speeds.

3. **RC (Resistor-Capacitor):** Uses external resistor-capacitor for low-cost applications.
4. **LP (Low Power):** For low-energy applications like battery-powered devices.