# 11th Task in Embedded Systems

## 🔷 What is a Microcontroller Unit (MCU)?

A **Microcontroller Unit (MCU)** is a small computer built into a single chip that is designed to perform **one specific task** — like controlling a washing machine, a car sensor, or a robot arm.

Unlike a regular computer, it doesn't need an operating system or large memory. Everything is built-in:

- A processor (CPU)
- Memory (RAM, Flash)
- Input/Output pins

**Example:** ATmega32, STM32, PIC16F877A, ESP32

## 🔷 MCU Architecture

An MCU is made of several main components:

1. **CPU (Central Processing Unit)**
   Executes instructions like calculations and logic operations.
2. **Memory**

- RAM: Temporary memory for variables during program execution
- Flash: Permanent memory for storing your code
- EEPROM: Permanent, re-writable memory (good for settings like passwords)

3. **I/O Ports**
   Connect the MCU to buttons, sensors, LEDs, etc.
4. **Timers and Counters**
   Used for delays, measuring time, PWM signals, etc.
5. **Peripheral Interfaces**
   Communication methods like:

   **-UART** (serial communication)

   **-SPI** (fast data exchange)

   **-I2C** (connect multiple devices on 2 wires)

6. **Interrupt System**
   Allows the MCU to react to external events **immediately**, like when a button is pressed.

## 🔷 MCU Clock System

The MCU needs a **clock signal** to work. It determines how fast instructions are executed.

**Types of Clock Sources:**

- **Internal RC Oscillator**: Built-in, not very accurate
- **External Crystal Oscillator**: Very accurate timing
- **PLL (Phase Locked Loop)**: Increases the clock speed internally

Example:
If your clock is **8 MHz**, that means it runs **8 million cycles per second**.

## 🔷 MCU Memory Mapping

Memory in a microcontroller is **divided into sections**. Each section has a specific purpose.

**Memory Type:**

- Flash : Stores program/code
- SRAM : Stores variables and temporary data
- EEPROM : Stores permanent settings
- Register Space : Controls internal modules like ports and timers

## 🔷 MCU Bus Interfaces

A bus is a pathway for data and control signals inside the MCU.

**Bus Type:**

- Data Bus : Transfers actual data
- Address Bus : Selects the memory location
- Control Bus : Sends control signals like "read" or "write"

## 🔷 AMBA – Advanced Microcontroller Bus Architecture

**AMBA** is a standard set by ARM for high-speed internal communication between MCU components.

It includes:

1. **AHB (Advanced High-performance Bus)**: Fast communication between memory and CPU.
2. **APB (Advanced Peripheral Bus)**: Slower bus used for simple peripherals like GPIO or timers.
3. **AXI (Advanced extensible Interface)**: More advanced, used in modern SoCs.

## 🔷 Reading MCU Datasheets & Specifications

The **datasheet** is your guidebook for any microcontroller.

- **Pin Configuration**: What each pin does
- **Block Diagram**: Shows how components inside the chip connect
- **Memory Map**: Location of registers, RAM, flash
- **Peripherals**: Features like timers, ADCs, UARTs
- **Electrical Specs**: Voltage ranges, current limits
- **Instruction Set** : for assembly programming