# *Microprocessors and Microcontrollers*

This report shall discuss the following topics:

- Topic 1: Microprocessors
- Topic 2: Microcontrollers
- Topic 3: Microprocessors vs Microcontrollers

## 1) Topic 1: Microprocessors

- Working of a Microprocessor
  - The microprocessor functions through a continuous loop known as the Instruction Cycle.
  - This happens billions of times per second, measured in Gigahertz.
  - Fetch: The Control Unit retrieves an instruction from the system's RAM. It uses the Program Counter (PC) to determine exactly which memory address to access.
  - Decode: The Instruction Decoder translates the binary code into specific signals that the microprocessor's internal hardware can understand.
  - Execute: The ALU performs the actual operation, like adding two numbers or moving data between registers.
  - Store: The result is written back into a register or stored in main memory for later use.
- Architecture and Components of a Microprocessor
  - A microprocessor is divided into several functional blocks that work together.
  - Arithmetic Logic Unit (ALU): The engine of the processor. It performs all mathematical calculations like addition, subtraction, etc., and logical operations like AND, OR, NOT.
  - Control Unit (CU): The conductor of the system. It decodes instructions from memory and generates timing signals to tell the ALU, registers, and other components how to respond.
  - Register Array: A set of high-speed internal storage locations.
  - Accumulator: Stores the intermediate and final results of ALU operations
  - Program Counter (PC): Holds the address of the next instruction to be executed.

- Instruction Register (IR): Temporarily holds the current instruction while it is being decoded.
- Flag Register: Contains status bits like Zero, Carry, or Sign that indicate the results of the last operation.
- System Bus**:** The communication lines (Address, Data, and Control) that connect the microprocessor to external memory and I/O devices.

## 2) Topic 2: Microcontrollers

- Working of a Microcontroller
  - A microcontroller typically follows a strict, never-ending loop.
  - Initialize: When powered on, it sets up its internal registers and prepares the I/O pins.
  - The Main Loop: It enters a cycle that repeats forever.
  - Sense: It reads the status of its input pins, e.g., Is the button pressed?.
  - Process: It runs the logic defined in its code, e.g., If button is pressed, wait 2 seconds.
  - Control: It updates the output pins based on that logic, e.g., Turn on the motor.
  - Interrupts: If a high-priority event occurs, like an emergency stop signal, the microcontroller can pause its main loop, handle the event immediately, and then return to where it left off.
- Architecture and Components of a Microcontroller
  - A microcontroller consists of several functional blocks interconnected by an internal bus system.
  - CPU (Core): The Brain that fetches, decodes, and executes instructions. It contains the ALU and control logic.
  - Flash Memory (ROM): Non-volatile memory where the firmware or program code is permanently stored.
  - SRAM (RAM): Volatile memory used to store temporary variables and data during program execution.
  - GPIO Ports: General Purpose Input/Output pins used to interface with the outside world, e.g., sensors, buttons, LEDs.
  - Timers & Counters: Specialized circuits for creating precise time delays, measuring pulse widths, or counting external events.

- Interrupt Controller: Manages interrupts, external or internal events that require immediate CPU attention, e.g., an emergency stop button press.
- ADC / DAC: Converters that translate Analog real-world signals, like temperature, into Digital numbers, and vice versa.
- Oscillator / Clock: The Heartbeat of the chip. It provides the timing signals that synchronize all operations.

## 3) Topic 3: Microprocessors vs Microcontrollers

- A microprocessor contains only the CPU. It requires external components like RAM, ROM, and I/O timers to function. It is designed for versatility and high-speed data processing.
- A microcontroller is an all in one computer on a chip. It has the CPU, RAM, ROM, and I/O ports all integrated into a single circuit. It is designed for specific, repetitive control tasks.
- In a Microprocessor system, the motherboard is filled with separate chips for memory and connectivity. This makes the system bulky but incredibly powerful.
- In a Microcontroller, the internal bus connects everything inside the chip, allowing it to be small enough to fit inside a smartwatch or a car key.