UNIT 1:

MICROPROCESSOR ARCHITECTURE AND OPERATION

Module: Mechatronics Embedded Systems

Module Code: MTT05209

2.0 Introduction

In embedded systems and digital electronics, processing and control operations are performed using programmable electronic devices called microprocessors.

A microprocessor acts as the “brain” of a digital system because it:

- Processes data
- Executes instructions
- Performs calculations
- Controls system operations

This unit introduces:

- Microprocessor systems
- 8085 and 8086 microprocessors
- Internal architecture
- Registers
- Memory organization
- Instruction execution
- Addressing modes

These concepts form the foundation for:

- Embedded systems
- Microcontroller programming
- Industrial automation
- Computer systems

2.1 What is a Microprocessor?

Definition

A microprocessor is a programmable electronic device that performs:

- Arithmetic operations
- Logical operations
- Data processing
- Control operations

according to instructions stored in memory.

It acts as the CPU (Central Processing Unit) of a computer system.

Functions of a Microprocessor

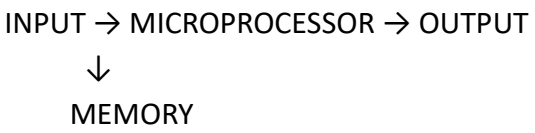
A microprocessor performs:

1. Data processing
2. Arithmetic calculations
3. Logical operations
4. Decision making
5. System control

Applications of Microprocessors

Application Area	Example
Computers	Desktop computers
Industrial control	Automation systems
Communication	Routers
Medical systems	ECG machines
Robotics	Robot controllers

2.2 Basic Block Diagram of a Microprocessor System



Explanation of the Blocks

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1. Input Unit

Used to enter data into the system.

Examples:

- Keyboard
- Sensors
- Switches

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2. Microprocessor

Acts as the brain of the system.

Functions:

- Executes instructions
- Processes data
- Controls operations

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3. Memory Unit

Stores:

- Programs
- Data
- Instructions

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4. Output Unit

Produces final result.

Examples:

- Display
- Motor
- Printer

2.3 Introduction to 8085 Microprocessor

Definition

The 8085 is an 8-bit microprocessor developed by Intel.

It can process:

- 8-bit data at a time

and uses:

- 16-bit address bus

NOTE:

What is a "bit"?

A **bit** is the smallest unit of data in a computer.

It can only be: 0 or 1

Think of it like a **light switch**:

- OFF = 0
- ON = 1

So:

- 1 bit = one switch
- 8 bits = 8 switches together

"11111111 is the maximum 8 binary bits"

An **8-bit microprocessor** works with **8 binary digits (bits)** at a time.

Each bit can be:

- 0 or 1

So the **largest possible 8-bit number** is: 11111111

How to calculate its value

Binary works in powers of 2:

Bit positions: 7 6 5 4 3 2 1 0
Values: 128 64 32 16 8 4 2 1

Now add all the 1s:

1 1 1 1 1 1 1 1
= 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1
= 255

✅ **Final result**

11111111=255

So:

- **8-bit maximum value = 255**

Why not bigger than 255?

Because with 8 bits:

- You only have **8 switches**
- Each switch is ON or OFF
- So maximum combinations = 2^8 = 256 values

Features of 8085

- 8-bit processor - handles 8 bits of data at once
- 16-bit address bus - carries memory location, it can reach 65536 locations = 64 KB memory
- 8-bit data bus - carries actual data
- Single +5V power supply
- Supports interrupts - It means the 8085 can **pause** its current task to immediately handle a high-priority event (like a button press or sensor signal), then **resume** the original task.
- Low cost

2.4 Architecture of 8085 Microprocessor

Main Components of 8085

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1. Arithmetic Logic Unit (ALU)

Performs:

- Addition
- Subtraction
- Logical operations

Examples:

- AND
- OR
- XOR

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2. Control Unit

Controls all operations of the processor.

Functions:

- Fetches instructions
- Decodes instructions
- Executes instructions

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3. Registers

Registers are temporary storage locations inside the microprocessor.

Types of Registers

Register	Function
Accumulator	Stores data for ALU

Register	Function
Program Counter	Stores address of next instruction
Stack Pointer - The **stack pointer (SP)** is a **16-bit register** in the 8085 that always holds the **memory address** of the **top of the stack** (the last stored byte). When you push or pop data, the CPU automatically updates SP so it always "points" to the correct stack location.	Points to stack memory -
General Registers	Temporary data storage

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4. Timing and Control Unit

Controls timing signals for operations.

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5. Interrupt Control

Handles urgent external signals.

Example:

- Emergency input signal

2.5 Buses in Microprocessor Systems

A bus is a communication pathway used to transfer data and signals.

Types of Buses

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1. Address Bus

Transfers memory addresses.

8085 has:

- 16-bit address bus

Therefore, it can access:

$2^{16} = 65536$

memory locations.

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2. Data Bus

Transfers actual data.

8085 has:

- 8-bit data bus

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3. Control Bus

Transfers control signals.

Examples:

- Read signal
- Write signal

2.6 Memory Organization

Memory stores:

- Instructions
- Programs
- Data

Types of Memory

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1. RAM (Random Access Memory)

Temporary memory.

Characteristics:

- Volatile - **Volatile** means RAM loses all stored data immediately when power is turned off.

- Data lost when power OFF

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2. ROM (Read Only Memory)

Permanent memory.

Characteristics:

- Non-volatile
- Stores permanent programs

Memory Map

8085 can access:

- 64 KB address memory

because of 16-bit addressing.

2.7 Instruction Cycle

An instruction cycle is the process followed by a microprocessor to execute instructions.

Stages of Instruction Cycle

FETCH → DECODE → EXECUTE

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1. Fetch

Processor retrieves instruction from memory.

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2. Decode

Instruction meaning is interpreted.

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3. Execute

Required operation is performed.

Example

Instruction:

ADD B

Meaning:

- Add contents of register B to accumulator.

2.8 Introduction to 8086 Microprocessor

Definition

The 8086 is a 16-bit microprocessor developed by Intel.

It processes:

- 16-bit data at a time

Features of 8086

- 16-bit processor
- Faster than 8085
- 20-bit address bus
- Larger memory capacity
- Improved performance

Memory Capacity of 8086

8086 uses:

- 20-bit address bus

Therefore memory capacity is:

2^{20} =1048576

bytes = 1 MB memory.

2.9 Architecture of 8086

8086 has two major sections:

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1. Bus Interface Unit (BIU)

Functions:

- Fetches instructions
- Handles memory access
- Transfers data

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2. Execution Unit (EU)

Functions:

- Decodes instructions
- Executes operations

2.10 Addressing Modes

Addressing modes define how data is accessed.

Types of Addressing Modes

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1. Immediate Addressing

Data is directly included in instruction.

Example:

MOV A, 25H

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2. Register Addressing

Data stored in registers.

Example:

MOV A, B

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3. Direct Addressing

Instruction contains memory address directly.

Importance of Addressing Modes

They help:

- Access data efficiently
- Reduce instruction size
- Improve processing speed

2.11 Difference Between 8085 and 8086

Feature	8085	8086
Data Size	8-bit	16-bit
Address Bus	16-bit	20-bit
Speed	Lower	Higher
Memory Capacity	64 KB	1 MB
Performance	Moderate	Better

Advantages of Microprocessors

1. Fast data processing
2. Programmable operation
3. High accuracy
4. Automation support
5. Used in many applications

Disadvantages of Microprocessors

1. Requires external memory
2. Higher power consumption

3. Complex interfacing

Applications of Microprocessors

- Computers
- Industrial automation
- Communication systems
- Robotics
- Medical systems

Summary

In this unit, we studied:

- Introduction to microprocessors
- 8085 architecture
- 8086 architecture
- Registers
- ALU
- Buses
- Memory organization
- Instruction cycle
- Addressing modes

Microprocessors are very important in:

- Embedded systems
- Automation
- Robotics
- Communication systems
- Computer engineering
