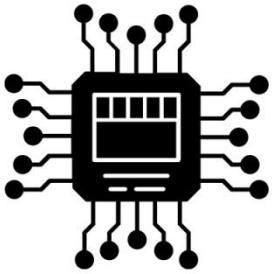


قـســـــــــم علوم الذكاء الاصطناعي

DEPARTMENT OF ARTIFICIAL INTELLIGENCE

SUBJECT:

Microprocessor

CLASS:

SECOND

LECTURER:

Dr. Abdulkadhem A. Abdulkadhem

LECTURE: (1)

Introduction to microprocessors

Course Syllabus: Microprocessors

This course introduces the fundamental concepts of microprocessors with a primary focus on the Intel 8086 architecture and assembly language programming. The course covers microprocessor organization, programming models, instruction sets, addressing modes, and hardware interfacing concepts. Emphasis is placed on understanding internal architecture, register organization, instruction execution, and memory interfacing to enable students to design, analyze, and program microprocessor-based systems.

Weekly Course Outline

- **Week 1:** Introduction to Microprocessors
  Overview of microprocessors, evolution, applications, and basic system components.
- **Week 2:** Microprocessor Architecture
  General microprocessor architecture, functional units, and system organization.
- **Week 3:** Microprocessor Programming
  Introduction to assembly language programming concepts and program structure.
- **Week 4:** Microprocessor Registers
  Internal register organization of the 8086, including general-purpose, segment, pointer, and flag registers.
- **Weeks 5–6:** Addressing Modes
  Addressing modes of the 8086 microprocessor and effective address calculation.
- **Weeks 7–8:** Data Movement Instructions
  Data transfer instructions, stack operations, and string manipulation basics.
- **Weeks 9–10:** Arithmetic and Logic Instructions
  Arithmetic operations, logical instructions, flag effects, and basic computational examples.
- **Weeks 11–12:** Program Control Instructions
  Branching, looping, procedure calls, interrupts, and program control flow.
- **Weeks 13–14:** 8086 Hardware Specifications
  Pin configuration, bus structure, timing diagrams, and minimum/maximum modes.
- **Week 15:** Memory Interfacing
  Memory organization, address decoding, and interfacing memory devices with the 8086.

References

1. Abel, P., *IBM PC Assembly Language and Programming*, 4th Edition, Prentice Hall, 1998.
2. Thorne, M., *Computer Organization and Assembly Language Programming*, 2nd Edition, Benjamin/Cummings, 1990.

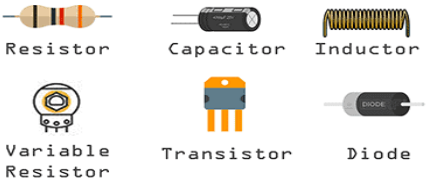
1. Introduction to Electronic and Logic Circuits

Modern digital systems are built using **two** fundamental types of circuits: **Electronic Circuits** and **Logic Circuits**. Understanding the distinction between these circuits is essential before studying microprocessors.

1.1 Electronic Circuits

Electronic circuits are constructed using basic electronic components such as:

- Transistors
- Resistors
- Capacitors
- Diodes

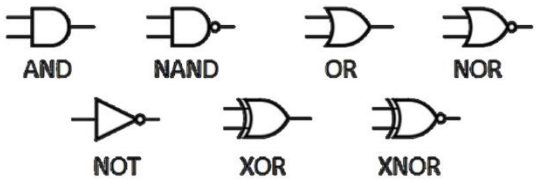


These circuits operate over a wide range of voltages (e.g., 1V, 2.1V, 3.3V, ±12V) and primarily deal with **analog signals**, which vary continuously over time.

1.2 Logic Circuits

Logic circuits form the foundation of digital systems. They are built using **logic gates**, such as:

- AND, OR
- NAND, NOR
- XOR, XNOR
- NOT



Logic circuits process **digital signals**, which represent discrete binary values (0 and 1).

2. Integrated Circuits (ICs)

An **Integrated Circuit (IC)** is a miniaturized electronic circuit in which electronic and logic components are fabricated on a single semiconductor chip.

Characteristics of ICs:

- Compact size
- High reliability
- Low power consumption
- High processing speed

Due to their fragility (هشاشة), ICs are typically enclosed (تغلف) in protective plastic or ceramic packages with metallic pins to facilitate connection to circuit boards.

Microprocessor


Integrated Circuit

3. Microprocessor Definition

A **microprocessor** is defined as:

A computer's Central Processing Unit (CPU) implemented on a single integrated circuit.

A digital computer that uses a single microprocessor as its CPU is referred to as a **microcomputer**.

The microprocessor is:

- Programmable
- Multipurpose
- Clock-driven
- Register-based

It reads binary instructions from memory, processes binary data according to these instructions, and produces results as output.

4. Main Components of a Microprocessor (CPU)

The **Central Processing Unit (CPU)** supervises and controls all operations of a computer system. It performs arithmetic and logical operations and manages data flow between system components.

The CPU is divided into three main units:

1. Arithmetic and Logic Unit (ALU)
2. Control Unit (CU)
3. Registers

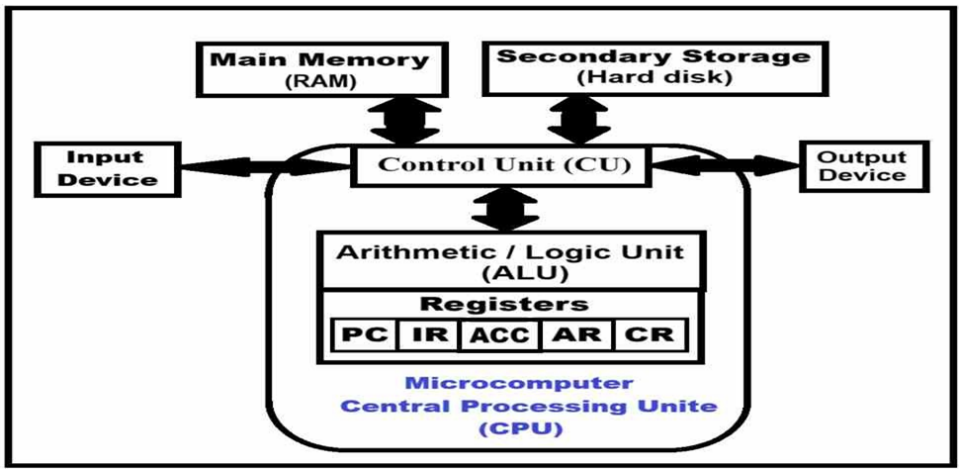


Figure 1: Main Components of the Central Processing Unit

4.1 Arithmetic and Logic Unit (ALU)

The ALU performs all data processing operations, including:

- Arithmetic operations: addition, subtraction, multiplication, division
- Logical operations: comparison, sorting, and bitwise logic

4.2 Control Unit (CU)

The Control Unit acts as the **central nervous system (الجهاز العصبي المركزي)** of the computer. It coordinates and controls all system operations by issuing control signals. فهي تُنسق وتتحكم في جميع عمليات النظام عن طريق إصدار إشارات التحكم.

Main functions of the CU include:

1. Controlling input and output devices
2. Managing data transfer to and from memory
3. Routing(توجيه) data between memory and ALU
4. Directing the execution of program instructions

4.3 Registers

Registers are **high-speed storage locations within the CPU** used to temporarily hold data and instructions currently being processed.

At a conceptual level, a generic CPU may include the following functional registers:

- **Instruction Register (IR):** Holds the currently executing instruction

- **Program Counter (PC):** Holds the address of the next instruction to be executed
- **Address Register (AR):** Temporarily stores memory addresses
- **Data Register (DR):** Temporarily stores data transferred between CPU and memory
- **Accumulator (ACC):** Stores intermediate arithmetic and logic results

Note: These registers represent a *functional abstraction* of CPU operation. In the **8086 microprocessor**, these functions are implemented using different programmer-visible and internal registers, which will be discussed later.

Exam Note: Register functions are frequently asked in theoretical exams.

5. Basic Operations of a Microprocessor

A microprocessor performs three fundamental operations:

1. **Arithmetic and logical processing** using the ALU
2. **Data transfer** between memory locations
3. **Decision making and branching**, allowing the program to change execution flow

6. Instruction Fetch–Execute Cycle

The microprocessor executes instructions through a well-defined sequence known as the **Instruction Cycle**:

1. Program instructions are loaded into memory
2. **Fetch:** Instruction is fetched from memory into IR
3. **Decode:** Instruction is decoded to identify operation and operands
4. **Execute:** Operation is performed
5. Results are stored or sent to output devices

Registers temporarily store data during this process, while the ALU performs computations.

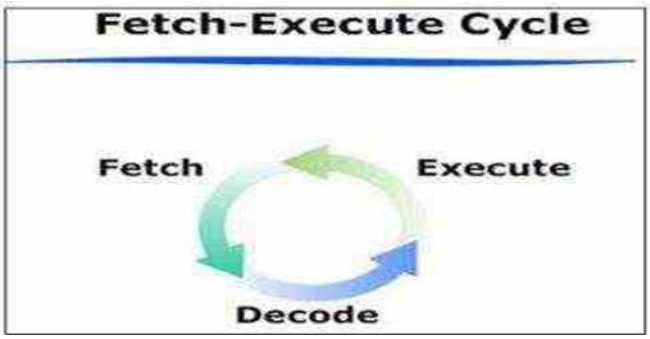


Figure 2: Instruction Fetch–Decode–Execute Cycle

Exam-Oriented Question

How does the CPU fetch and execute instructions?

1. Fetch instruction from memory into IR
2. Increment PC to next instruction
3. Decode instruction
4. Fetch operands (if required)
5. Execute instruction
6. Store result and repeat cycle

7. Terminology Used in Microprocessors

Here is a list of some of the used terms in a microprocessor.

- Instruction Set: It is the set of instructions that the microprocessor can understand (Ex: MOV, ADD, SUB...). The instruction set acts as an interface between the software and hardware.
- Bus: The bus is used for the transmission of data, address and control information. This transmission occurs in different elements of the microprocessor. The bus in this is basically of three types which are data bus, address bus and control bus.

This microprocessor has:

- ✓ A data bus (that may be 8, 16, 32 or 64 bits wide) that can send data to memory or receive data from memory.
- ✓ An address bus (that may be 8, 16, 32 or 64 bits wide) that sends an address to memory.
- ✓ An RD (read) and WR (write) line to tell the memory whether it should set or get the addressed location.
- ✓ A clock line that lets a clock pulse sequence the processor
- ✓ A reset line that resets the program counter to zero (or whatever) and restarts execution

- Word Length: It depends upon the (number of bits) of internal data bus, registers, ALU, etc. A 16-bit microprocessor can process 16-bit data at a time. The word length ranges from 4 bits to 64 bits depending on the type of the microcomputer. A processor with longer word length is more powerful and can process data at a faster speed as compared to a processor with shorter word length.

NOT: The power of the given microprocessor is measured in terms of bits.

- Clock Speed: It determines the number of operations per second the processor can perform. It is expressed in megahertz (MHz) or gigahertz (GHz). It is also known as Clock Rate.
- Data Types: The microprocessor has multiple data type formats like Decimal, Hexadecimal, Binary, signed and unsigned numbers.

8. Evolution of Microprocessors

Microprocessors have evolved through several generations based on word size and capability.

(4-bit → 8-bit → 16-bit → 32-bit → 64-bit → Multi-core)

Table 1: Evolution of Microprocessors by Generation

Generation	Year	Size	Example	Features
1st generation	1971-1972	4 bits	4004	Basic operation and it has limited memory and the control unit executes fetch, decode and execute instructions
2nd generation	1973	8 bits	Intel 8008 & 8080	Improved processing speed, better instruction sets
3rd generation	1978	16 bits	Intel 8086, Zilog Z800 and 80286	Its performance like minicomputers. Enhanced memory access, pipelining introduced
4th generation	1985-1994	32 bits	Intel 80386, 80486, Motorola 68020	Integrated FPU, cache memory, faster processing
5th generation	195-2005	64 bits	Intel Pentium, AMD Athlon, PowerPC G4	Super scalar architecture, advanced power management
6th generation	2006 up now	Multi-core	Intel Core i3/i5/i7/i9, AMD Ryzen, Apple M-series	Multi-core processing, AI acceleration, high energy efficiency

9. Introduction to Microcomputers

A **microcomputer** is a digital computer that uses a microprocessor as its CPU.
Microcomputers may be:

- General-purpose machines
- Special-purpose machines

Types include:

- Desktop PCs
- Tower PCs
- Laptops
- PDAs
- Embedded systems (Microcontrollers)

10. Microprocessor-Based Computer System

A microcomputer system consists of:

1. Microprocessor
2. Memory system
3. Input/Output system

These components are interconnected using buses.

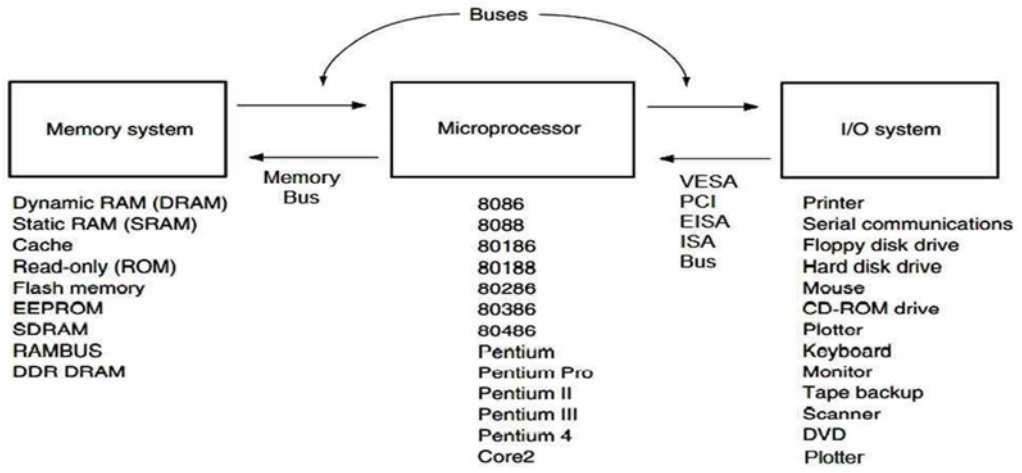


Figure 3: Block Diagram of a Microprocessor-Based Computer System

11. Memory System Overview

Memory unit in microprocessor is used to store information such as numbers, characters and so on. Storing information means that the memory has the ability to hold this information for processing or for later use. Programs that define how the computer work are also stored in the memory.
Memory can be divided into: primary storge that is used for temporary storage and it is normally of small size and secondary storage which is used for long term storage.

The primary storage is further divided into Read Only Memory (ROM) and Random Access Memory (RAM). The information stored in ROM are nonvolatile, that is the information is not lost when the power turned off. On the other hand, the information stored in RAM are volatile can be modified.

12. Input/Output System

The microcomputer system contains input and output (I/O) devices that allow the system to communicate with the external environment. Keyboard, mouse, joystick and microphone are examples of the input devices. On the other hand the most used output devices are printers, displays and speakers.

15. Summary (Exam-Focused)

Q1 Which type of circuits mainly deal with continuously varying signals?
A) Logic circuits
B) Digital circuits
C) Electronic circuits
D) Integrated circuits
 Answer: C

Q2 Which of the following is NOT a basic electronic component?
A) Transistor
B) Capacitor
C) Diode
D) Logic gate
 Answer: D

Q3 Logic circuits process signals in the form of:
A) Analog values
B) Continuous voltages
C) Binary values
D) Electrical noise
 Answer: C

Q4 Which logic gate produces an output of 1 only when both inputs are 1?
A) OR
B) NAND
C) AND
D) XOR
 Answer: C

Q5 An Integrated Circuit (IC) is best defined as:
A) A collection of discrete components
B) A programmable memory
C) A miniaturized circuit on a single chip
D) A digital computer
 Answer: C

Q6 Which is NOT a characteristic of ICs?
A) Compact size
B) Low reliability
C) Low power consumption
D) High speed
 Answer: B

Q7 A microprocessor is:
A) A complete computer
B) CPU on a single IC
C) Memory unit
D) Input/output device
 Answer: B

Q8 A computer using a single microprocessor as CPU is called:
A) Mainframe
B) Supercomputer
C) Microcomputer
D) Minicomputer
 Answer: C

Q9 Which of the following is NOT a feature of a microprocessor?
A) Programmable
B) Clock-driven
C) Register-based
D) Mechanical
 Answer: D

Q10 Which unit performs arithmetic and logic operations?
A) CU
B) Registers
C) ALU
D) Memory
 Answer: C

Q11 The Control Unit is responsible for:
A) Data storage
B) Arithmetic operations
C) Issuing control signals
D) Permanent storage
 Answer: C

Q12 Which CPU component acts as temporary high-speed storage?
A) RAM
B) ROM
C) Registers
D) Cache
 Answer: C

Q13 Which register holds the currently executing instruction?
A) PC
B) ACC
C) IR
D) DR
 Answer: C

Q14 The Program Counter (PC) holds:
A) Current data
B) Next instruction address
C) Operand value
D) Status flags
 Answer: B

Q15 Which register stores intermediate arithmetic results?
A) DR
B) AR
C) ACC
D) PC
 Answer: C

Q16 The instruction cycle consists of:
A) Fetch only
B) Decode only
C) Execute only
D) Fetch–Decode–Execute
 Answer: D

Q17 Which step comes immediately after fetching the instruction?
A) Execute
B) Store
C) Decode
D) Reset
 Answer: C

Q18 Which bus is used to transfer addresses?
A) Data bus
B) Control bus
C) Address bus
D) System bus
 Answer: C

Q19 RD and WR signals belong to:
A) Data bus
B) Address bus
C) Control bus
D) Memory
 Answer: C

Q20 Word length of a processor refers to:
A) Instruction size only
B) Number of registers
C) Number of bits processed at a time
D) Clock speed
 Answer: C

Q21 Clock speed is measured in:
A) Bytes
B) Hertz
C) Volts
D) Bits
 Answer: B

Q22 Which generation introduced the Intel 8086?
A) 2nd
B) 3rd
C) 4th
D) 5th
 Answer: B

Q23 Which generation introduced multi-core processors?
A) 3rd
B) 4th
C) 5th
D) 6th
 Answer: D

Q24 ROM memory is:
A) Volatile
B) Non-volatile
C) Programmable only
D) Used for temporary storage
 Answer: B

Q25 Which of the following is an input device?
A) Printer
B) Speaker
C) Display
D) Keyboard
 Answer: D