Computer Organisation

Learning Objectives

- To know the organisation of the computer components and their interconnections.
- To know the processors and their characteristics.
- To know the importance of memory devices and their roles in a computer.
- To explore RAM, ROM and differentiate each of them.
- To know about cache memory and how it improves the performance of a computer
- To know the secondary devices and their usage
- To know about the ports and interfaces so that external devices can be connected

3.1 Introduction

Computer organisation deals with the hardware components of a computer system. It includes Input / Output devices, the Central Processing Unit, storage devices and primary memory. It is concerned with how the various components of computer hardware operate. It also deals with how they are interconnected to implement an architectural specification. The term computer organisation looks similar to the term computer architecture. But, computer architecture deals with the engineering considerations involved in designing a computer. On the other hand, Computer Organisation deals with the hardware components that are transparent to the programmer.

3.2. Basics of Microprocessors

The CPU is the major component of a computer, which performs all tasks. This is realized by the microprocessor which is an Integrated Circuit. Microprocessors were first introduced in early 1970s. The first general purpose microprocessor, 4004 was developed by Intel Inc.

The microprocessor is a programmable multipurpose silicon chip. It is driven by clock pulses. It accepts input as a binary data and after processing, it provides the output data as per the instructions stored in the memory. A block diagram of a microprocessor based system is shown in Figure 3.1.

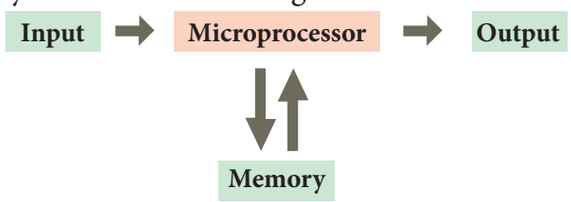

Figure 3.1 A Microprocessor - Based System

The microprocessor is made up of 3 main units. They are:

- **Arithmetic and Logic unit (ALU):** To perform arithmetic and logical instructions based on computer instructions.

- **Control unit:** To control the overall operations of the computer through signals.
- **Registers (Internal Memory):** They are used to hold the instruction and data for the execution of the processor.

Characteristics of Microprocessors

A Microprocessor's performance depends on the following characteristics:

a) Clock speed

b) Instruction set

c) Word size

a) Clock Speed

Every microprocessor has an **internal clock** that regulates the speed at which it executes instructions. The speed at which the microprocessor executes instructions is called the **clock speed**. Clock speed is measured in MHz (Mega Hertz) or in GHz (Giga Hertz).

b) Instruction Set

A command which is given to a computer to perform an operation on data is called an **instruction**. Basic set of machine level instructions that a microprocessor is designed to execute is called as an **instruction set**. This instruction set carries out the following types of operations:

- Data transfer
- Arithmetic operations
- Logical operations
- Control flow
- Input/output

c) Word Size

- The number of bits that can be processed by a processor in a single instruction is called its word size. **Word size** determines the amount of RAM that can be accessed by a microprocessor.

Speed Measurement

Hertz – abbreviated as Hz is the standard unit of measurement used for measuring frequency. Since frequency is measured in cycles per second, one hertz equals one cycle per second.

Hertz is commonly used to measure wave frequencies, such as sound waves, light waves, and radio waves. For example, the average human ear can detect sound waves between 20 and 20,000 Hz. Sound waves close to 20 Hz have a low pitch and are called "bass" frequencies. Sound waves above 5,000 Hz have a high pitch and are called "treble" frequencies.

While hertz can be used to measure wave frequencies, it is also used to measure the speed of computer processors. For example, each CPU is rated at a specific clock speed. This number indicates how many instruction cycles the processor can perform in every second. Since modern processors can perform millions or even billions of instructions per second, clock speeds are typically measured in megahertz or gigahertz.

3.3 Data communication between CPU and memory

The Central Processing Unit(CPU) has a Memory Data Register (MDR) and a Memory Address Register (MAR). The Memory Data Register (MDR) keeps the data which is transferred between the Memory and the CPU. The Program Counter (PC) is a special register in the CPU which always keeps the address of the next instruction to be

executed. The Arithmetic and Logic unit of CPU places the address of the memory to be fetched, into the Memory Address Register.

A bus is a collection of wires used for communication between the internal components of a computer.

The word in the RAM has the same size (no. of bits) as the Memory Data Register (MDR). If the processor is an 8-bit processor like Intel 8085, its MDR and the word in the RAM both have 8 bits.

The read operation transfers the data(bits) from word to Memory Data Register. The write operation transfers the data(bits) from Memory Data Register to word.

If 5V is applied at one end of a wire, the other end also can receive 5V. In the same way, the buses are wires, and the binary data are voltages (5V as 1 and 0V as 0), and these buses can simply pass the data as voltages from one end to other.

3.4 Types of Microprocessors

Microprocessors can be classified based on the following criteria:

- The width of data that can be processed
- The instruction set

3.4.1 Classification of Microprocessors based on the Data Width

Depending on the data width, microprocessors can process instructions. The microprocessors can be classified as follows:

- 8-bit microprocessor
- 16-bit microprocessor
- 32-bit microprocessor
- 64-bit microprocessor

3.4.2 Classification of Microprocessors based on Instruction Set

The size of the instruction set is important consideration while categorizing microprocessors.There are two types of microprocessors based on their instruction sets.

- Reduced Instruction Set Computers (RISC)
- Complex Instruction Set Computers (CISC)

Examples of RISC processors are Pentium IV, Intel P6, AMD K6 and K7.

Examples of CISC processors are Intel 386 & 486, Pentium, Pentium II and III, and Motorola 68000.

3.5 Memory Devices

A memory is just like a human brain. It is used to store data and instructions. Computer memory is the storage space in the computer, where data and instructions are stored. There are two types of accessing methods to access (read or write) the memory. They are sequential access and random access. In sequential access, the memory is accessed in an

orderly manner from starting to end. But, in random access, any byte of memory can be accessed directly without navigating through previous bytes. Different memory devices are arranged according to the capacity, speed and cost as shown in Figure 3.6.

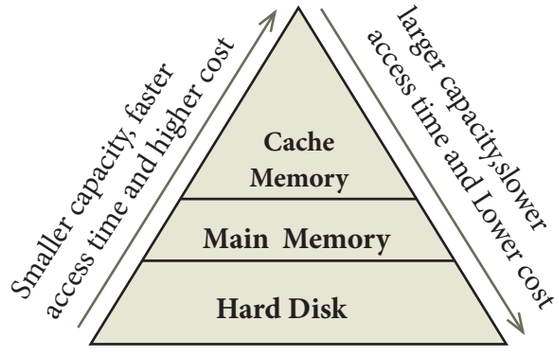

Figure 3.6 Memory Hierarchy

3.5.1 Random-Access Memory (RAM)

The main memory is otherwise called as **Random Access Memory**. This is available in computers in the form of Integrated Circuits (ICs). It is the place in a computer where the Operating System, Application Programs and the data in current use are kept temporarily so that they can be accessed by the computer's processor. The smallest unit of information that can be stored in the memory is called as a bit. The memory can be accessed by a collection of 8 bits which is called as a byte.

RAM is a volatile memory, which means that the information stored in it is not permanent. As soon as the power is turned off, whatever data that resides in RAM is lost. It allows both read and write operations.

3.5.2 Types of RAM

There are two basic types of RAM

- Dynamic RAM (DRAM)
- Static RAM (SRAM)

These two types differ in the technology they use to hold data. Dynamic RAM being a common type needs to be refreshed frequently. Static RAM needs to be refreshed less often, which makes it faster. Hence, Static RAM is more expensive than Dynamic RAM.

3.5.3 Read Only Memory (ROM)

Read Only Memory refers to special memory in a computer with pre-recorded data at manufacturing time which cannot be modified. The stored programs that start the computer and perform diagnostics are available in ROMs. ROM stores critical programs such as the program that boots the computer. Once the data has been written onto a ROM chip, it cannot be modified or removed and can only be read. ROM retains its contents even when the computer is turned off. So, ROM is called as a non-volatile memory.

3.5.3.1 Programmable Read Only Memory (PROM)

Programmable read only memory is also a non-volatile memory on which data can be written only once. Once a program has been written onto a PROM, it remains there forever. Unlike the main memory, PROMs retain their contents even when the computer is turned off.

The PROM differs from ROM. PROM is manufactured as a blank memory, whereas a ROM is programmed during the manufacturing process itself. PROM programmer or a PROM burner is used to write data to a PROM chip. The process of programming a PROM is called burning the PROM.

3.5.3.2 Erasable Programmable Read Only Memory (EPROM)

Erasable Programmable Read Only Memory is a special type of memory which

serves as a PROM, but the content can be erased using ultraviolet rays. EPROM retains its contents until it is exposed to ultraviolet light. The ultraviolet light clears its contents, making it possible to reprogram the memory.

An EPROM differs from a PROM, PROM can be written only once and cannot be erased. EPROMs are used widely in personal computers because they enable the manufacturer to change the contents of the PROM to replace with updated versions or erase the contents before the computer is delivered.

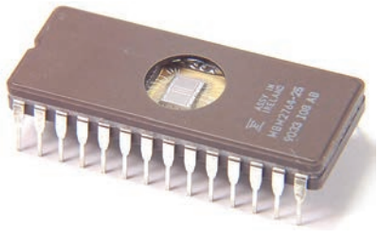

Figure 3.7 Erasable Programmable Read Only Memory

Most of the EPROM chips have a transparent area at the top surface which is covered by stickers. If it gets removed, the ultraviolet light in the sunlight may erase the contents.

3.5.3.3 Electrically Erasable Programmable Read Only Memory (EEPROM)

Electrically Erasable Programmable Read Only Memory is a special type of PROM that can be erased by exposing it to an electrical charge. Like other types of PROM, EEPROM retains its contents even when the power is turned off. Comparing with all other types of ROM, EEPROM is slower in performance.

3.5.4 Cache Memory

The cache memory is a very high speed and expensive memory, which is used to speed up the memory retrieval process. Due to its higher cost, the CPU comes with a smaller size of cache memory compared with the size of the main memory. Without cache memory, every time the CPU requests the data, it has to be fetched from the main memory which will consume more time. The idea of introducing a cache is that, this extremely fast memory would store data that is frequently accessed and if possible, the data that is closer to it. This helps to achieve the fast response time, Where response Time, (Access Time) refers to how quickly the memory can respond to a read / write request. Figure 3.8 shows the arrangement of cache memory between the CPU and the main memory.

Figure 3.8 Cache Memory Arrangement

3.6 Secondary Storage Devices

A computer generally has limited amount of main memory which is expensive and volatile. To store data and programs permanently, secondary storage devices are used. Secondary storage devices serve as a supportive storage to main memory and they are non-volatile in nature, secondary storage is also called as Backup storage

3.6.1 Hard Disk

Hard disk is a magnetic disk on which you can store data. The hard disk has the stacked arrangement of disks accessed by a pair of heads for each of the disks. The hard disks come with a single or double sided disk.

3.6.2 Compact Disc (CD)

A CD or CD-ROM is made from 1.2 millimeters thick, polycarbonate plastic material. A thin layer of aluminium or gold is applied to the surface. CD data is represented as tiny indentations known as

"pits", encoded in a spiral track moulded into the top of the polycarbonate layer. The areas between pits are known as "lands". A motor within the CD player rotates the disk. The capacity of an ordinary CD-ROM is 700MB.

Fig 3.9 Compact Disc

3.6.3 Digital Versatile Disc (DVD)

A **DVD (Digital Versatile Disc or Digital Video Disc)** is an optical disc capable of storing up to 4.7 GB of data, more than six times what a CD can hold. DVDs are often used to store movies at a better quality. Like CDs, DVDs are read with a laser.

The disc can have one or two sides, and one or two layers of data per side; the number of sides and layers determines how much it can hold. Double-layered sides are usually gold-coloured, while single-layered sides are usually silver-coloured, like a CD.

Fig 3.10 Digital Versatile Disc

3.6.4 Flash Memory Devices

Flash memory is an electronic (solid-state) non-volatile computer storage medium that can be electrically erased and reprogrammed. They are either EEPROM or EPROM. Examples for Flash memories are pendrives, memory cards etc. Flash memories can be used in personal computers, Personal Digital Assistants (PDA), digital audio players, digital cameras and mobile phones. Flash memory offers fast access times. The time taken to read or write a character in memory is called access time. The capacity of the flash memories vary from 1 Gigabytes (GB) to 2 Terabytes (TB). A sample of flash memory is shown in Figure 3.11.

Figure 3.11 Flash Memory

3.6.5 Blu-Ray Disc

Blu-Ray Disc is a high-density optical disc similar to DVD. Blu-ray is the type of disc used for PlayStation games and for playing High-Definition (HD) movies. A double-layer Blu-Ray disc can store up to 50GB (gigabytes) of data. DVD uses a red laser to read and write data. But, Blu-ray uses a blue-violet laser to write. Hence, it is called as Blu-Ray.

Fig 3.12 Blu- Ray Disc

3.7 Ports and Interfaces

The Motherboard of a computer has many I/O sockets that are connected to the ports and interfaces found on the rear side of a computer (Figure 3.13). The external devices can be connected to the ports and interfaces. The various types of ports are given below:

Serial Port: To connect the external devices, found in old computers.

Parallel Port: To connect the printers, found in old computers.

USB Ports: To connect external devices like cameras, scanners, mobile phones, external hard disks and printers to the computer.

USB 3.0 is the third major version of the Universal Serial Bus (USB) standard to connect computers with other electronic gadgets as shown in Figure 3.13. USB 3.0 can transfer data up to 5 Giga byte/second. USB3.1 and USB 3.2 are also released.

Figure 3.13 USB 3.0 Ports

VGA Connector: To connect a monitor or any display device like LCD projector.

Audio Plugs: To connect sound speakers, microphone and headphones.

PS/2 Port: To connect mouse and keyboard to PC.

SCSI Port: To connect the hard disk drives and network connectors.

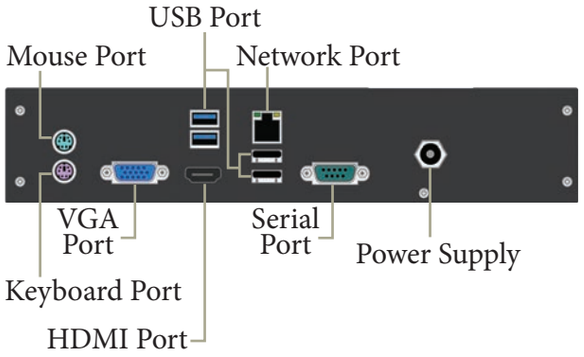

Fig 3.14 Ports and Interfaces

High Definition Multimedia Interface (HDMI)

High-Definition Multimedia Interface is an audio/video interface which transfers the uncompressed video and audio data from a video controller, to a compatible computer monitor, LCD projector, digital television etc.

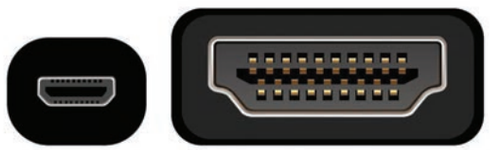

Figure 3.15 HDMI Ports

Activity

Student Activity

- Identify the components of a computer
- Connecting external devices like printer/LCD projector.

Teacher Activity

- Show the components of a computer
- Display different ROM ICs
- Display the flash memory
- Demonstrate various ports and their usage

Evaluation

Part – I

Choose the correct answer

1. Which of the following is sadi to be the brain of a computer?
   (a) Input devices
   (b) Output devices
   (c) Memory device
   (d) Microprocessor
2. Which of the following is not the part of a microprocessor unit?
   (a) ALU (b) Control unit
   (c) Cache memory (d) register
3. How many bits constitute a word?
   (a) 8
   (b) 16
   (c) 32
   (d) determined by the processor used.
4. Which of the following device identifies the location when address is placed in the memory address register?
   (a) Locator (b) encoder
   (c) decoder (d) multiplexer
5. Which of the following is a CISC processor?
   (a) Intel P6 (b) AMD K6
   (c) Pentium III (d) Pentium IV
6. Which is the fastest memory?
   (a) Hard disk
   (b) Main memory
   (c) Cache memory
   (d) Blue-Ray disc
7. How many memory locations are identified by a processor with 8 bits address bus at a time?
   (a) 28 (b) 1024
   (c) 256 (d) 8000
8. What is the capacity of 12cm diameter DVD with single sided and single layer?
   (a) 4.7 GB (b) 5.5 GB
   (c) 7.8GB (d) 2.2 GB
9. What is the smallest size of data represented in a CD?
   (a) blocks (b) sectors
   (c) pits (d) tracks
10. Display devices are connected to the computer through.
    (a) USB port (b) Ps/2 port
    (c) SCSI port (d) VGA connector

Part – II

Very Short Answers

(1) What are the parameters which influence the characteristics of a microprocessor?

(2) What is an instruction?

(3) What is a program counter?

(4) What is HDMI?

(5) Which source is used to erase the content of a EPROM?

Part-III

Short Answers

(1) Differentiate Computer Organisation from Computer Architecture.

(2) Classify the microprocessor based on the size of the data.

(3) Write down the classifications of microprocessors based on the instruction set.

(4) Differentiate PROM and EPROM.

(5) Write down the interfaces and ports available in a computer.

(6) Differentiate CD and DVD

(7) How will you differentiate a flash memory and an EEPROM?

Part-IV

Explain in Detail

(1) Explain the characteristics of a microprocessor.

(2) How the read and write operations are performed by a processor? Explain.

(3) Arrange the memory devices in ascending order based on the access time.

(4) Explain the types of ROM.

Computer hardware	The physical parts or components of a computer, such as the CPU, mother board, monitor, keyboard, etc.
Intel	Intel Corporation is an American multinational corporation and technology company involving in hardware manufacturing, especially mother board and processors
Silicon chip	Silicon chip is an integrated , set of electronic circuits on one small flat piece of semiconductor material, silicon.
Multipurpose	Multipurpose is several purpose
Address bus	Address bus is a collection of wires that carry the address as bits
Data bus	Data bus is a collection of wires to carry data in bits
Control bus	Control bus is a control line/collection of wires to control the operations/functions
Arithmetic operations	Arithmetic operations are the mathematical operations on data like add, subtract etc
Data Transfer	Data Transfer means moving data from one component to another
Logical operations	Logical operations are the operations on binary/Boolean data like AND, OR , NOT
Bidirectional	Bidirectional means both the directions/ways
Unidirectional	Unidirectional means only one direction
Access time	Access time is the time delay or latency between a request to an electronic system, and the access being completed or the requested data returned