1 Hardware Concepts

Learning objectives

After learning this chapter the students will be able to:

❖ understand functional units of computer

❖ learn about various input devices

❖ learn about various output devices

❖ learn about secondary storage devices

❖ understand data and instruction flow using communication buses and ports

Our present day life is so automatic that most of the tasks are accomplished with a click of a button. Washing has been taken over by washing machines, cooking by microwaves, conventional banking has been replaced by ATMs etc. In every sphere of life, machines dominate human efforts. Have you ever wondered what mechanism works behind these machines? In fact, in all these machines, a click of button starts a process inside the machine which sometimes can be very complex one. It does exactly what is required as it follows a predefined work flow based on which button has been pressed. Let us take the case of cash withdrawal from a bank ATM. The user is required to press only a few buttons to authenticate his identity and the amount he wishes to withdraw. Then within seconds the money pops out of the ATM. During this process, the inside working of bank ATM is beyond imagination of the user. Broadly speaking, the ATM receives certain data from the user, processes it and gives the output (money). This is exactly what a computer does. Formally, a computer can be defined as follows:

A computer is an electronic device that processes input data and produces result (output) according to a set of instructions called program.

A computer performs basically five major functions irrespective of its size and make.

❖   It accepts data or instructions by way of <u>input</u>

❖   It <u>stores</u> data

❖   It <u>processes</u> data as required by the user

❖   It <u>controls</u> operations of a computer

❖   It gives results in the form of <u>output</u>

In order to carry out the operations mentioned above the computer allocates the task among its various functional units.
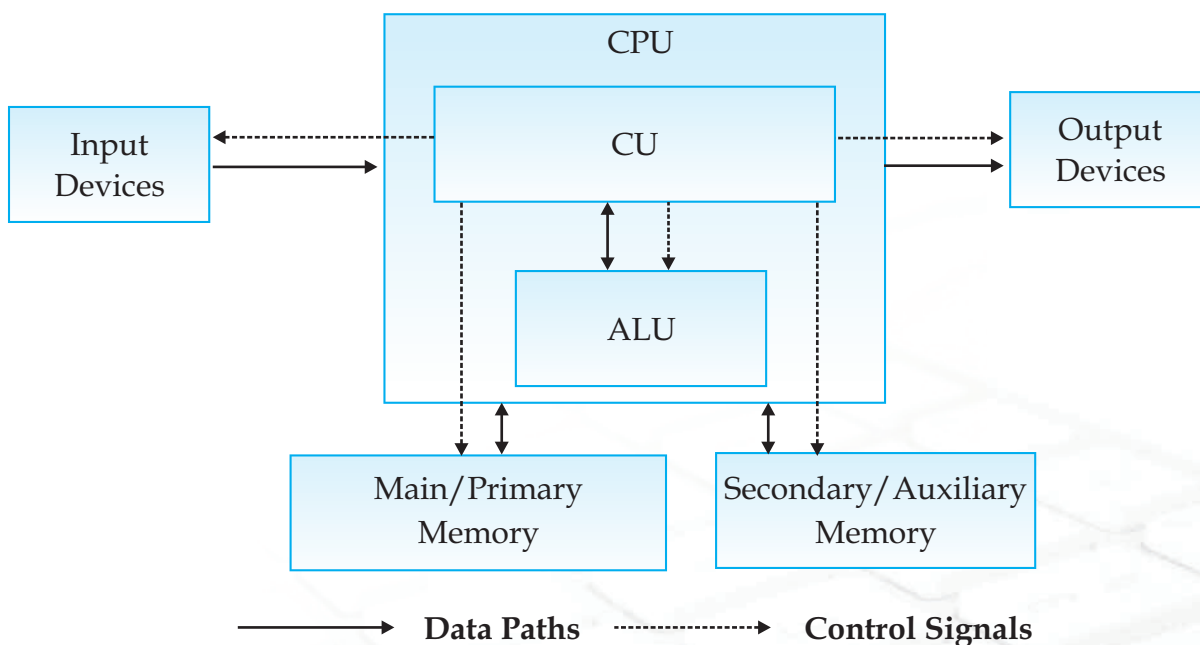

Figure 1.1 *Block diagram of functional units of a computer*

The above diagram describes the basic layout of a computer. A computer receives data and instructions through "Input Devices" which get processed in Central Processing Unit, "CPU" and the result is shown through "Output Devices". The "Main / primary Memory" and "Secondary / Auxiliary Memory" are used to store data inside the

computer. These are the basic components that each computer possess. Each of these components exists in various types and variety that differ in shape, size, usage and performance. The user makes a choice according to his specific requirement. Now we will discuss each component in detail.

Input Devices

These are used to enter data and instructions into the computer. Let us discuss some of them.

Keyboard

This is the most common input device which uses an arrangement of buttons or keys. In a keyboard each press of a key typically corresponds to a single written symbol. However some symbols require pressing and holding several keys simultaneously or in sequence. While most keyboard keys produce letters, numbers or characters, other keys or simultaneous key presses can produce actions or computer commands.

In normal usage, the keyboard is used to type text and numbers while in a modern computer, the interpretation of key press is generally left to the software. A computer keyboard distinguishes each physical key from every other and reports the key-presses to the controlling software. Keyboards are also used for computer gaming, either with regular keyboards or by using keyboards with special gaming features. Apart from alphabet keys (26 keys), there are several other keys for various purposes such as

❖ **Number keys** - The 10 number keys 0-9 are there on each keyboard. Sometimes, there are two sets of these keys.

❖ **Direction keys** - There are four direction keys : left, right, up and down which allow the curser to move in these directions. Unlike alphabet and number keys, these keys do not display any thing.

❖ **Function keys** - There are generally 12 functions keys F1-F12. These keys have special tasks and the tasks may change from program to program. Just like direction keys, these too do not print anything.

❖ **Other keys** - There are several other non-printable keys for various different purposes. These include caps lock, tab, ctrl, pause, delete, backspace, spacebar, shift, enter etc which are used for special purposes.
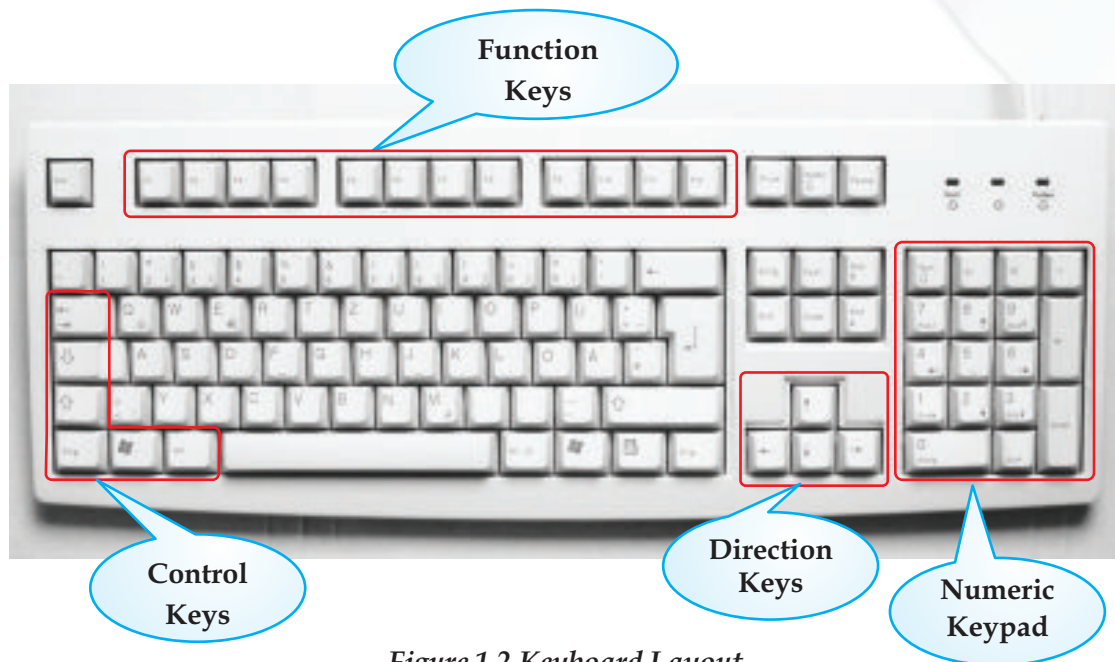
Figure 1.2 Keyboard Layout

Whenever a key is pressed, a specific signal is transmitted to the computer. The keyboard uses a crossbar network to identify every key. When a key is pressed, an electrical contact is formed. These electric signals are transmitted to a microcontroller in a coded form to the computer describing the character which corresponds to that key. The theory of codes in itself is a vast field of study. However, in Appendices I, II, III and IV we have discussed the most common codes namely BCD, ASCII, ISCII and Unicode.

All programs and software were mostly text-based. With the subsequent GUI based operating systems, more application based software were evolved and in addition to keyboard, more sophisticated input devices were also evolved such as mouse, joystick, scanner etc. We discuss these devices below.

Mouse

Figure 1.3 Mouse Buttons

A mouse is a pointing device that functions by detecting two-dimensional motion relative to its supporting surface. The mouse's motion typically translates into the motion of a cursor on a display, which allows for fine control of a Graphical User Interface. A mouse primarily comprises of three parts: the buttons, the handling area, and the rolling object.

By default, the mouse is configured to work for the right hand. If you are left-handed, the settings can be changed to suit your needs. All mouse do not use the same mechanical operation but all of them accomplish the same task. Some of them use a tracking ball at the bottom and some of them use a type of light beam to detect the motion of mouse. Laptops are equipped with a small flat surface or sometimes with a very short stick for performing same job as mouse. Using left button of mouse different operations like selection, dragging, moving and pasting can be done. With the right button we can open a context menu for an item, if it is applicable.
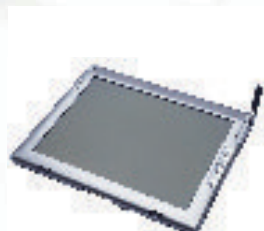
Other input devices

Light Pen

It is a light sensitive stylus attached to a video terminal to draw pictures or to select menu options.

Touch Screen

This device allow interacting with the computer without any intermediate device. You may see it at as KIOSKS installed in various public places

Graphics Tablet

This device is used to enter data using a stylus. Most commonly it is used to enter digital signatures.

Joystick

It is an input device consisting of a stick that pivots on a base and translates its angle or direction as data. Joysticks are often used to control inputs in video games.

Microphone

It is used to input audio data into the computer. They are mainly used for sound recording.

O C R (Optical Character Reader)

It is used to convert images of text into machine editable text. It is widely used to convert books and documents into electronic files, to computerize a record-keeping system in an office, or to publish the text on a website.

Scanner

It is a device that optically scans images, printed text or an object and converts it to a digital image.

Smart card reader

It is used to access the microprocessor of a smart card. There are two broad categories of smart cards - Memory cards and microprocessor cards. Memory cards contain only non-volatile memory storage components, and some specific security logic. Microprocessor cards contain volatile memory and microprocessor components. The card is made of plastic, generally PVC. Smart cards are used in large companies and organizations for strong security authentication.

Bar Code Reader

This device read the bar code as input data. It consists of a light source, a lens and a light sensor which translates optical impulses into electrical signals. Also it contains decoder circuitry which analyzes the barcode's image data and sends the barcode's content to the scanner's output port.

Biometric Sensors

It is used to recognize individuals based on physical or behavioral traits. Biometric sensor is used to mark attendance of employees/students in organizations/institutions. It is also popular as a security device to provide restricted entry for secured areas.

Web Camera

This captures video as data for computer with reasonably good quality. It is commonly used for Web Chats.

Figure 1.4 Other Input Devices

Central Processing Unit

It is responsible for processing the data and instruction.

Figure 1.5 CPU

This unit can be divided into three sections:

❖   Control Unit

❖   Arithmetic and Logical Unit (ALU)

Control Unit

This unit coordinates various operations of the computer like,

❖   It directs the sequence of operations

❖   It interprets the instructions of a program in storage unit and produces signals to execute the instructions

❖   It directs the flow of data and instructions in the computer system

Arithmetic and Logical Unit

This unit is responsible for performing various Arithmetic operation of addition, subtraction, multiplication, division and relational operations such as equal to , greater than , less than, greater than or not equal to and logical operation etc.

Primary Memory Unit

The main or primary memory stores information (instruction and data)

The memory unit is divided into :

❖   Random Access Memory (RAM)

❖   Read Only Memory(ROM)

RAM

Random Access Memory is used for primary storage in computers to hold active information of data and instructions.

Figure 1.6 RAM (Random Access Memory)

ROM (Read Only Memory) is used to store the instructions provided by the manufacturer, which holds the instructions to check basic hardware interconnecter and to load operating system from appropriate storage device.

Figure 1.7 ROM (Read Only Memory)

Units of Memory

The elementary unit of memory is a bit. A group of 4 bits is called a nibble and a group of 8 bits is called a byte. One byte is the minimum space required to store one character.

Other units of memory are:

1 KB(Kilo Byte)	$= 2^{10}$ bytes	$= 1024$ bytes
1 MB(Mega Byte)	$= 2^{10}$ KB	$= 1024$ KB
1 GB(Giga Byte)	$= 2^{10}$ MB	$= 1024$ MB
1 TB(Tera Byte)	$= 2^{10}$ GB	$= 1024$ GB
1 PB(Peta Byte)	$= 2^{10}$ TB	$= 1024$ TB

Output Devices

These are used to display results on video display or are used to print the result. These can also be used to store the result for further use.

Output Devices

Monitor or VDU

It is the most common output device. It looks like a TV. Its display may be CRT, LCD, Plasma or touch sensitive.

Speakers

These are used to listen to the audio output of computer.

Printers

These are used to produce hard copy of output as text or graphics.

Dot Matrix Printer

This printer prints characters by striking an ink soaked ribbon against the paper. These can be used to generate carbon copies also.

Inkjet/Deskjet/Bubblejet printers

These all are low cost printers which use a controlled stream of ink for printing.

Laser Printers

These printers use laser technology to produce printed documents. These are very fast printers and are used for high quality prints.

Plotters

These are used to print graphics. It is mainly used in computer-aided designing.

Figure 1.8 Other Output Devices

Communication Bus

In computer architecture, a bus is a system that transfers data between computer components or between computers.

Address Bus

This is a system of bus, which is used to specify the address of a memory location. The width of a bus determines the number of memory locations that can be addressed. For example a system with 64-bit address bus can address 2^{64} memory locations.

Data Bus

This system of bus is a medium, which transfer the data from one place to another in a computer system.

Control Bus

This system of bus carries the signals that give the report about the status of a device. For ex one wire of bus indicates whether the CPU is currently reading or writing from the main memory.
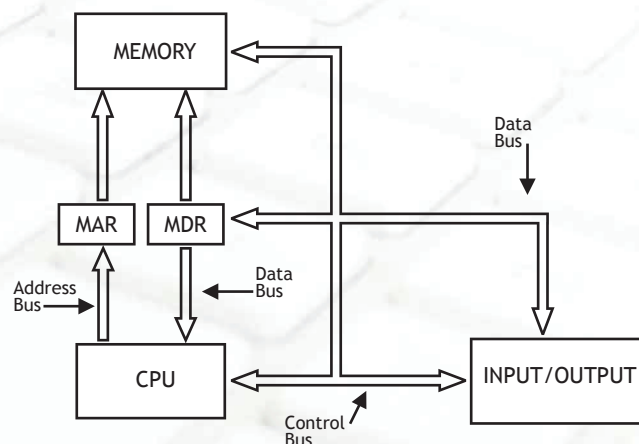
More about communication bus

Figure 1.9 Interconnection of CPU with Memory and I/O Units

Instructions to be executed by a CPU are retrieved from main memory, interpreted by it and executed. CPU is connected to main memory by a set of parallel wires called Address Bus, which carries address bits to the MAR (Memory Address Register) and the Data Bus, which carries data/instructions from CPU to MDR (Memory Data Register) of main memory. The control bus carries instructions to carry out operations such as Read/Write from or to memory and also input/output operations. Number of parallel wires is called bus width. If MAR has 24 bits(to address upto 16 MB memory) then the address bus width is 24. The size of data bus from memory to CPU equals number of bits in an instruction also called CPU word length. Most of the processors used in PCs have a word length of 32 bits and thus the data bus width is 32 bits. The instruction width of I A - 64 by Intel is 128 and thus the data bus width is 128 bits. The number of bits in the control bus is normally around 16. This connection of buses, namely Address bus, Data bus and Control bus is called - System Bus. The bus standards allow diverse manufacturers of various peripheral devices to design devices to easily connect to PCs.

The CPU, memory and integrated circuits to connect I/O units to the CPU and main memory are all mounted on what is called a motherboard. The motherboard also has a ROM where a program called BIOS (Basic Input Output System) is stored to control all the peripheral devices connected to a computer.

A motherboard has a set of connection points called ports to connect units such as disk, VDU, keyboard etc. In a parallel port databits are transmitted in parallel (16 or 32 bits simultaneously) to peripherals via a set of parallel wires (called ribbon cables). Serial ports transmit single bits serially, one after another. Faster peripherals such as hard disk are connected to parallel ports. Slower devices such as keyboard are connected to serial port. A standard serial port is known as Universal Serial Bus (USB)

Communication Ports

A communication port is mounted in a slot on the computer for easy plugging/unplugging of a peripheral device.

Serial Port

Through this port the information travels in and out one bit at a time. Serial ports come in the form of 9-pin or 25-pin male connector. These ports are often known as communication (COM) port. Mouse, modem etc. are connected using serial port though now mostly they are been replaced by USB port.

Figure 1.10 Serial Port Socket

Parallel Port

Through this port the several data signals are sent simultaneously over several parallel channels. Parallel ports come in the form of 25-pin female connector. These ports are used to connect printer, scanner etc.
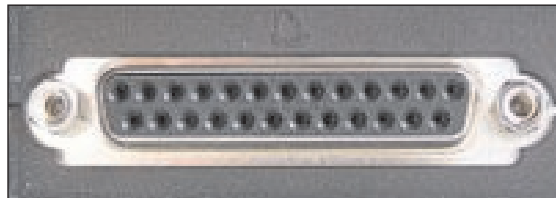

Figure 1.11 Parallel Port Socket

RJ 45 Port

This port is used for ethernet connections and can be used between computer and any networked device, such as a cable modem or a network hub. It is a 8 wire connector.

RJ 11 Port

This port is for connecting to a telephone line. It has six-wire conductors in it and is smaller than RJ45.

USB Port :

USB stands for Universal Serial Bus, used for short distance digital data communications. This port allows data transfer between devices with little electric power.

| RJ-11 Connector | RJ-11 Socket | RJ-45 Connector | RJ-45 Socket |

Figure 1.12 RJ11 and RJ45 Port Socket

Secondary Storage Devices

If we want to save data for future reference and retrieval then it needs to be saved in memory other than primary memory, which is called secondary memory, or auxiliary memory. Normally hard disk of computer is used as secondary memory but this is not portable so there are many other secondary storage media in use.

Hard disk

This is a high capacity storage device ranging from 1GB to Tera Bytes nowadays. Generally hard disks are sealed units fixed in the cabinet.
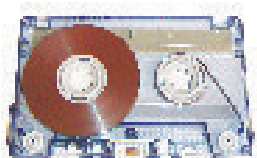
Floppy Disk

It is a data storage medium that is made up of a disk of thin, flexible magnetic material enclosed in a cover.

Compact Disk

Capacity of standard 120mm CD is 700MB. It is a thin optical disk which is commonly used to store audio and video data. Transfer speed is mentioned as muliple of 150 KB/s. 4x means 600 KB/s.

Magnetic Tape

In this magnetic coatings are stored as data on a thin tape. Earlier this medium was used for archive purposes.

DVD

Digital Versatile Disc or Digital Video Disc

This is an optical disc storage device. It can be recorded on single side or on double side. Its capacity may range from 4.7 GB to 8.5 GB

USB Drive

This is small, portable memory, which can be plugged into a computer with USB Port. They have capacity lesser than hard disk but much larger than a floppy or CD. They are more reliable also. They are also called pen drive.

Memory Cards

These are data storage devices mainly used with digital cameras, computers, mobile phones, music players, video game console etc. They offer high recordability with power free storage.


Figure 1.13 Secondary Storage Devices

Know more

As we know, the computer industry is ever growing and new hardware components keep coming in the market with enhanced features and capabilities. We should keep updating our information about these components by knowing about them from Internet and other possible sources. Some of the websites having these updates are www.allthingsd.com, www.arstechnica.com, www.cnet.com

Summary

❖ A computer is a machine, which takes input as data and instructions as input and performs computations based on those instructions to give some output.

❖ The main functional units of computer are - input devices, CPU, memory and output devices.
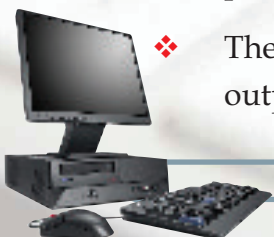
❖ There are various input and output devices for receiving input and for giving output.

❖ CPU is divided into ALU and CU.

❖ Primary memory is divided into RAM and ROM.

❖ Communication bus is used to transfer data between computer and peripherals.

❖ Different ports are used to connect peripherals to a computer.

❖ For future reference and permanent storage secondary devices are used.

Multiple Choice Questions

1) **When the electrical power is disrupted or cut off, data and programs are lost in**

    A. ROM

    B. hard disk

    C. RAM

    D. secondary storage

2) **Read Only Memory (ROM)**

    i.   Is volatile

    ii.   Is programmable

    iii. Is mounted on the mother board

    iv.   Contains the bootstrap loader

        A. i and iii

        B. i, ii and iv

        C. ii, iii and iv

        D. iii and iv

3) **CD-ROM stands for**

    A. Compactable Read Only Memory

    B. Compact Data Read Only Memory

C.　Compactable Disk Read Only Memory

D.　Compact Disk Read Only Memory

4)　**ALU is**

A.　Arithmetic Logic Unit

B.　Array Logic Unit

C.　Application Logic Unit

D.　None of the above

5)　**MICR stands for**

A.　Magnetic Ink Character Reader

B.　Magnetic Ink Code Reader

C.　Magnetic Ink Cases Reader

D.　None of the above

6)　**Which operation is not performed by computer**

A.　Inputting

B.　Processing

C.　Controlling

D.　Understanding

7)　**Pick the one that is used for logical operations or comparisons such as less than equal to or greater than.**

A.　Arithmetic and Logic Unit

B.　Control Unit

C.　Both of above

D.　None of the above

8)　**Which of the following is a secondary memory device?**

A.　Keyboard

B.　Disk

C.   ALU

D.   All of the above

9)   **The difference between RAM and Secondary Storage is that RAM is … and Secondary Storage is …**

A.   Temporary, permanent

B.   Permanent, temporary

C.   Slow, fast

D.   All of above

Exercises

1)   I saved my document on the hard drive 5 minutes ago. I have continued to work. Where is the latest copy of my work?

2)   Why is it necessary to use ROM in a computer?

3)   What is the function of a bus?

4)   Explain the block diagram of a computer.

5)   Pair the following equivalent units

10GB, 1GB, 1000MB, 10MB, 10^4KB, 10^7KB

6)   Suppose your uncle has to buy a computer and he has asked you for help. What all components and specifications would you suggest him. Make a table similar to the one given below (three entries are done to help you)

COMPONENT	SPECIFICATION
RAM	4GB
Hard Disk	260 GB
Monitor	17"