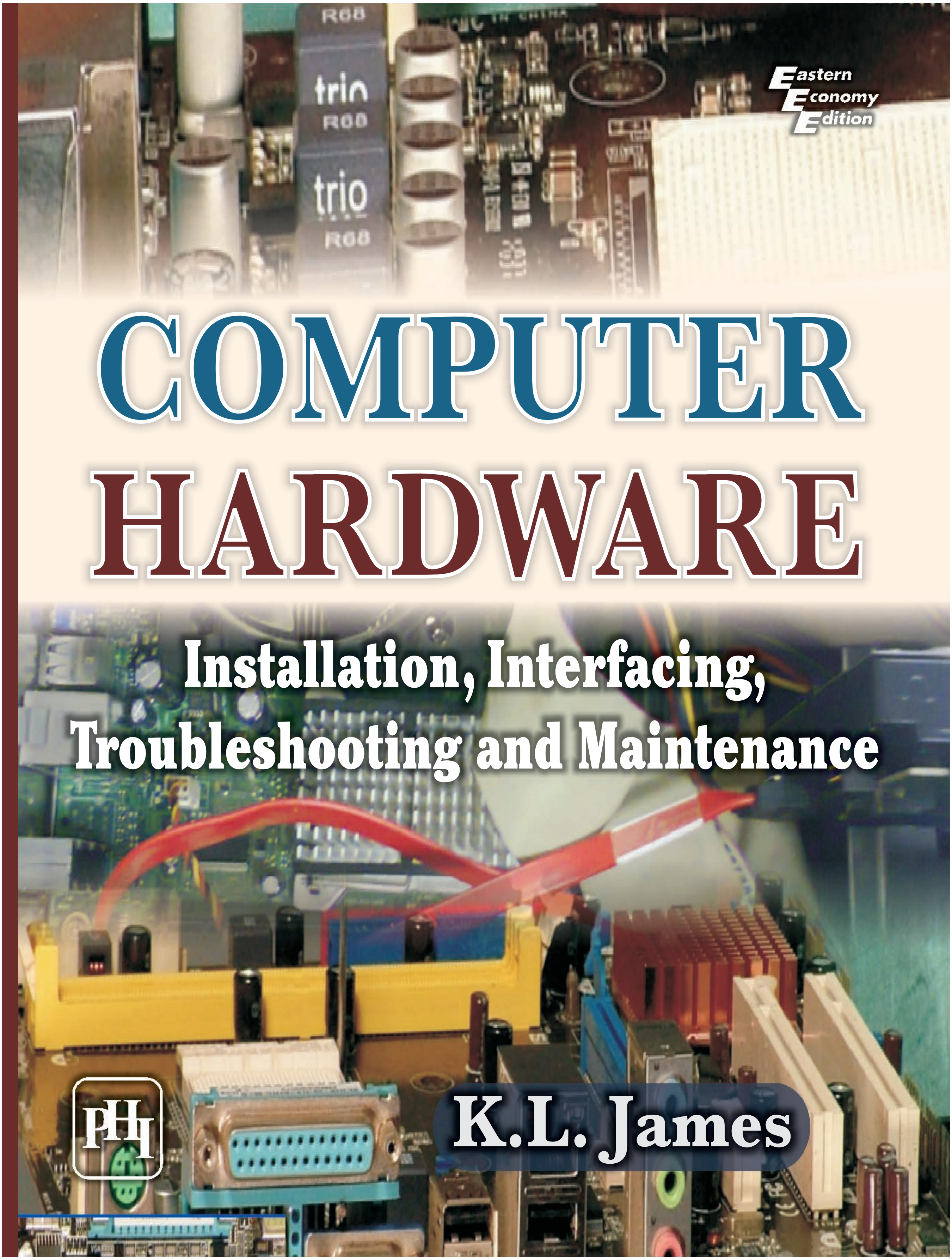

Eastern Economy Edition

COMPUTER HARDWARE

Installation, Interfacing, Troubleshooting and Maintenance

PHI

K.L. James

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2013

COMPUTER HARDWARE: Installation, Interfacing, Troubleshooting and Maintenance
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ISBN-978-81-203-4798-4

Published by Asoke K. Ghosh, PHI Learning Private Limited, Rimjhim House, 111, Patparganj Industrial Estate, Delhi-110092 and Printed by Raj Press, New Delhi-110012.

To

My Parents: *K.J. Lukose* and *Omana Lukose*
Wife: *Jainamma* and
Sons: *Jijo* and *Jacob*

Contents

Preface

Computers have transformed from a luxury to a necessity in recent times. There are almost no areas where the use of this device can be neglected. Increased capability, better portability, higher capacity and reduced cost make computers suitable for any area of activity. To satisfy the increased needs, computers of different configurations and varied capacities are currently available. Moreover, several peripheral devices suiting the different needs are connected and used with the computers. The selection of a particular type of computer system is dependent on several factors. But the basic factor considered is related to the specification of the computer hardware. Hence, in order to make a correct selection of computer hardware, it is necessary to have an idea about the different specification parameters associated with the computers and peripheral devices.

Several technologies have been developed for the computer systems. Also, these technologies are continuously changing. These are changing by leaps for almost all the computer components such as processor, memory, graphics unit, storage, monitor, mouse, keyboard and so on. With the introduction of new hardware components, the existing computer systems have become outdated and the new computers are arriving with the newly released and advanced hardware components. To make use of the added features of new hardware components, more and more new software versions with added utilities are released. Most of the new software versions find it extremely difficult to run in the existing hardware, since the existing systems lack the minimum system configurations essential for running the new software. This leads to a situation in which forced upgrading or complete replacement of the existing system becomes inevitable.

Upgrading a computer system is simply a process of replacing one or more hardware components with the other components having better features. But the actual process of upgrading is not as simple as it seems. Several steps are involved in upgrading the computer system like checking the compatibility of the system and the new hardware component, presence of a necessary device driver software suitable for the operating system as well as the correct installation and proper configuration of the hardware. Replacement of the existing computer system can be done by assembling a new computer system from scratch and then making it operational by installing the necessary operating system software in it. While performing all these different tasks, several doubts and confusions can arise to any person, both to a veteran and to a beginner in the field of computer hardware. Assembling a computer and properly configuring it do not mean that the system will function perfectly forever. Proper interfacing with the other devices is essential to increase the utility of the computer. Also, regular maintenance (both preventive and corrective) is necessary to keep the system healthy at all times. Proper troubleshooting steps must be followed for the correct identification of the associated faults and for taking suitable corrective action.

The book *Computer Hardware: Installation, Interfacing, Troubleshooting and Maintenance* is written with a view to provide sufficient guidelines and proper directions for assembling and upgrading of computer systems. It provides a detailed description of the different steps used for assembling desktop computers, interfacing with peripheral devices, installing new devices, preventive and breakdown maintenance and for troubleshooting. Details of configuring computers, installation and configuring of computer printers, document scanners and computer speakers are also available in the book. Systematic troubleshooting methods and details of maintenance required for the computer systems and peripheral devices are also included.

The book begins with an introductory chapter dealing with the basic hardware structure of computers. Different types of computers and their specification parameters are discussed in Chapter 1. Details about the front and rear panels and the overall component arrangements become clear by going through Chapter 2. Motherboards form the fundamental building block of any computer system. Chapter 3 provides a detailed discussion of the features and components of the motherboards. Different types of interfaces and connectors, troubleshooting and maintenance of motherboards and common motherboard problems and solutions are the other major topics included in this chapter. Chapter 4 discusses the different features and troubleshooting steps for two kinds of processing units, namely, central processing unit and graphics processing unit. The method of installing processors and the issues associated with the processor overheating are the other topics covered in this chapter. Fundamentals of storage and memory are discussed in Chapter 5. Features and specifications of different memory types, internal and external storage devices, their working are discussed in this chapter. Features of computer power supply units, uninterrupted power supply units, maintenance steps, battery maintenance tips and troubleshooting are the topics covered in Chapter 6. CRT monitors were common once but now, these monitors are replaced with TFT type monitors. Chapter 7 is devoted to a discussion of different types of computer monitors, their working, maintenance steps and troubleshooting process. Steps for the installation of monitors and the importance of different specification parameters are also available in this chapter. Keyboard and mouse are the commonly used computer input devices. Chapter 8 has a detailed discussion of the features, specifications and suggested solutions to common problems associated with these devices. Chapter 9 is highly useful for the computer assemblers. A step-by-step description of assembling a desktop computer supported with sufficient pictures, is available in this chapter. Configuring using BIOS parameters and installation of add-on cards are the other major topics covered in this chapter. Chapter 10 is entirely devoted to a discussion of different troubleshooting and maintenance steps for the computer systems. Replacing CMOS battery, clearing BIOS password, flashing BIOS are the other topics covered in this chapter. *Advice from the expert* is the major highlight of this chapter. Use of laptops has increased recently. Chapter 11 has a discussion of the general features of laptops, their maintenance and troubleshooting steps. The common computer output unit is the printer. Features of computer printers, installation steps, maintenance operations and troubleshooting methods are the topics covered in Chapter 12. Discussion of the details of MFD is also included in this chapter. Document scanners and audio speakers are also commonly used with the computers. Chapter 13 has topics covering the features, working, installation steps, maintenance and troubleshooting process associated with these two devices.

This book is highly beneficial for those who are interested in acquiring the necessary skills for the installation of computer hardware, their maintenance and troubleshooting methods. This book is written on the basis of the real experience acquired over the past several years. It provides enough confidence in solving common problems associated with the computer hardware.

K.L. James

Acknowledgements

A book of this nature can be written only with the support and help from different sources. I express my sincere gratitude to the God almighty for his grace, mercy and guidance extended throughout the preparation of this book. I am thankful to all my family members for their constant help and support. I am also extremely thankful to all at PHI Learning for their earnest efforts in bringing out this book beautifully in the present form and shape.

K.L. James

1

An Introduction to Computer Hardware

Computer is an electronic device that is widely used for several useful purposes. These are now commonly used in different places and can be seen everywhere. The omnipresence of computers is due to several reasons which are as follows:

(a) Solve different tasks in an easy manner
(b) Work tirelessly and speedily
(c) Have large storage capacity
(d) Able to work anywhere and at anytime
(e) Capable to search large databases and make instant retrieval of the required information.

These are some of the advantages of using computers. Different areas are getting benefited by the use of computers including business, education, communication, entertainment, media, heathcare, various industries and many more. Mainly, the two factors responsible for the widespread uses of computers are the size miniaturization and the increasing efficiency. Computers have changed their shape and size in past several years. Starting from the massive size of the first generation computers, they have been progressively narrowed to desktops then to laptops and now to the tablets. Despite the miniaturization in the size, their efficiency has been increased several times. This is primarily because of the computer hardware which has become more powerful with increased features and added abilities. Some of the hardware revisions of computers have modified the abilities of hardware components while certain others have done a complete makeover of the existing features thereby replacing the existing ones with better and newer ones. The reduction in hardware size with the ability of increased performance led to the development of different versions and forms of computer systems that are known to us by different names. Thus, we have mainframe computers, desktop computers, rack servers, blade servers, laptops, netbooks, notebooks, tablets and so on. The different versions of computer systems are aimed for suiting the needs of different types of users such as for home users, industry-oriented users, mobile users and so on.

In this chapter, we are making a quick study of the developmental stages of the computers from early periods to the present age alongwith a description of the basic structure and common features of different types of computers systems.

1.1 COMPUTERS THROUGH GENERATIONS

The history of computations and calculations dates back to some 5000 to 2000 years before the Christ. There are some evidences to prove that the polished stones were used as the calculating aids by the earlier people. They considered **abacus** as the starting tool in computations. Even today, some countries use abacus as the first calculating aid for children.

In the seventeenth century, Napier invented another computing tool called **computing rods** which later came to be called as **Napier's bones**. In course of time, several new tools and machines were developed for calculations. Some examples of such machines are Mechanical Adding Machine, Calculating Machine, etc.

During the eighteenth century, the binary system was developed. Two notable achievements during this period were the developments of Difference Engine and Analytical Engine. By the latter half of the nineteenth century, some machines were developed that were based on the principles of modern type of computers. An English mathematician **Charles Babbage** was the first to develop a machine that was capable of doing small calculations as well as to print outputs. Later on, Charles Babbage came to be known as the **father of computers**. He proposed a basic structure for the computers and this basic structure is still the same.

The world's first electronic computer was named **ENIAC**, which is an acronym for **Electronic Numerical Integrator and Calculator**. In February, 1946, the working of ENIAC was started at University of Pennsylvania. It was called the **first generation computer**. This first computer was much different from the new generation computers in size, shape, storage capacity and the speed of operation. It was made up of thousands of vacuum tubes and relays and a big room is occupied by it. This machine weighed several tones and the speed was also very slow. An enormous sound is produced by this machine during the operation and it got heated up quickly. Water had to be circulated through the cooling pipes around the machine to quench the heat generated during its working. Also, the machine might fail frequently. Moreover, it was difficult to operate the machine.

The vacuum tubes were later replaced by transistors, as a result of which machines began to diminish in their sizes. Unlike the computers made of vacuum tubes, transistor-based machines did not fail frequently or get overheated. Computers that were manufactured using transistors came to be known as **second generation computers**. Transistor-based computers began to be used by the middle of nineteenth century. Research was still continued for the achievement of better machines. The invention of integrated circuits was another remarkable endeavour in this field. This new technology had helped in the integration of a number of components into a single unit or few units. Use of integrated units further reduced the size and weight of the computers and thus the price of computers began to fall. Computers that were manufactured by this new technology came to be called as **third generation computers**. These new generation computers slowly began to replace the earlier ones. With the progress in the technology, the capacity of a single chip to integrate a number of components was also increased. Thus, a large number of different types of integrated circuits known as **SSI** (small scale), **MSI** (medium scale), **VLSI** (very large scale), etc. were developed which had further helped in the production of smaller and more powerful computers.

Computers based on microprocessors belong to the category of **fourth generation**. The main part of such computers is the microprocessor. The term *micro* is used to indicate small size. In a microprocessor, different components necessary for the functioning of the computer are assembled as a single and compact unit. Since, microprocessor is considered as the heart of such computers, they are also sometimes called as **microcomputers**. Unlike the computers of the first generation, microcomputers are very small in size and have less weight. These new generation computers can be placed on the top of the tables or desks and hence these types of computers came to be known as **desktop or tabletop computers**. The speed of operation of these new generation computers has also become improved considerably as compared to that of the computers of the previous generations.

1.2 BASIC COMPUTER HARDWARE STRUCTURE

Computers were initially designed as the devices for performing mathematical calculations. But the computers differ from the ordinary calculators in several ways. Storage of a large quantity of information is the major advantage of the computers. Also, the stored information can be retrieved at any stage and can be processed. Computers are able to perform several computations and logical operations in one go.

The basic hardware structure of computer systems was designed to satisfy all the increased requirements for storing and processing information on a large scale. Basically, the hardware structure of computer system is made up of four different essential basic units, namely, (a) input unit; (b) output unit; (c) storage unit; and (d) arithmetic logic unit.

All these basic units are interconnected so that the entire system can function in unison. The input unit intakes data or program and stores them in the storage unit. Different arithmetic and logical operations on the stored data are performed by the arithmetic logic unit. Results obtained after the computing processes are stored in the storage unit. The function of the output unit is to display the output or the results obtained. Figure 1.1 shows the basic hardware structure of computers. Apart from these four basic units, there is also a control unit which controls the functions of all the basic functional units.

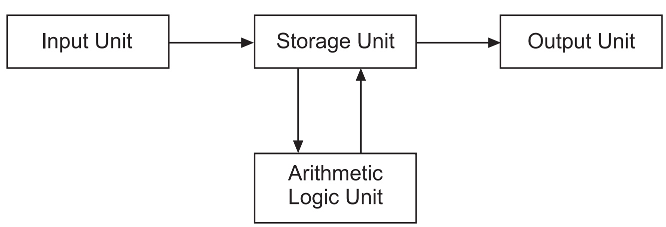


Figure 1.1 Basic hardware structure of a computer.

In the basic structure, as appears from the figure, different hardware components are arranged in a modular fashion to make a complete computer system. While constructing the computer system, the hardware units are manufactured in modules and these modular components are interconnected to get a complete computer system.

Different basic hardware components of any computer system include video display unit, keyboard, mouse, power supply, memory, storage, processor, motherboard and optional add-on cards for graphics, audio, networking, etc. The commonly used input devices are *keyboard* and *mouse*. *Game controllers*, *audio* and *video processors* also act as input devices. *Video display units* and *printers* are the most commonly used computer output devices. *Audio speakers* and some mechanical devices also function as the computer output devices. *Memory* and *storage* function as the storage units of the computer systems. *Central processing unit* performs different arithmetical and logical operations. *Motherboard* acts as the central connecting unit of the different components and this holds processor and memory. The *chipset* and the different electronic components in the motherboard are responsible for controlling and coordinating the functions of different component units of the computer system. All the modular hardware units of the computer system are interconnected in such a manner so that system can work in a proper way. Some of the components are externally connected while some are included within the casing. Internal components include memory, storage and the processing unit of the computer system. As the different units are modular, different types of computers can be assembled using the components having different specifications. Hence, to get an idea of the type of a computer system, it is necessary to specify the features of different basic hardware components that are used to complete that computer system.

1.3 HARDWARE AND SOFTWARE

The basic hardware structure of a computer system is already discussed. It is to be noted that simply connecting the different hardware components together does not create a working computer system. Its usefulness is determined by the way in which the instructions are executed by it. The set of instructions given for the working of computer systems is called **software**. Software is mainly divided into two types, namely, (a) system software and (b) application software.

System software is made up of instructions used for the management of the entire system such as for the management of memory, management of processor, management of device, file management and so on. System software is also known as **operating system**. *Windows*, *Unix* and *Linux* are the examples of operating systems. This type of software is the basic and essential component for any computer system. It is needed to make the hardware activate.

Application software is any software used for certain specific activity such as for word processing, image processing, speech processing, inventory management, data management, resource planning and for several other purposes. *Microsoft Word*, *Adobe® Photoshop®*, *Gimp* are the examples of application software. The application software works above the system software for which it is designed, i.e., the application software designed for Windows operating system cannot work on Linux operating system. Application software is found to be very useful and is widely used in different fields of industry, education, heathcare, etc. The relationship between the hardware, the system software and the application software can be easily understood from Figure 1.2.

Application Software (Word, Photoshop)
System Software (Linux, Windows)
Hardware

Figure 1.2 Relationship between hardware, system software and application software.

Earlier operating systems were single user type operating systems alongwith limited capabilities. Also, they were having command line interfaces. With the development of advanced hardware fabrication technology, the need for better system software emerged. Several modifications or revisions were made to the existing operating system software so as to develop the new operating systems. As a result, the new operating systems can fully utilize the advanced features of the new hardware. Now, these modern operating systems are multiuser and multitasking types and possess easy to use graphical interfaces. For using 32-bit and 64-bit buses, 32-bit and 64-bit operating systems also became common in due course.

1.4 DIFFERENT TYPES OF COMPUTERS

Although several companies had played different roles in the development and evolution of the computers, the part played by the American company **International Business Machine (IBM)** is worth mentioning. History of modern computers can be considered as the history of IBM itself. They were the first to introduce several computer related devices such as hard disks, floppy disks and various types of computers like super computers, personal computers, etc.

The first personal computer was introduced by IBM and the term **PC** was began to be used to refer **IBM PC**. Later on, another computer system, namely, **Apple** also entered the market. Apple computers are different from IBM PCs in certain ways. The main features of these computers are as follows:

(a) Hardware components of Apple computers are manufactured by Apple directly. So, there is more control on the hardware components of Apple computers by the manufacturer.
(b) These computer systems use specially designed accessories.
(c) Customization of components by the user is not possible in these systems. Also any upgrading, repair or replacement of components by the user is not practical for these systems.
(d) Apple computers work mainly on **Mac operating system** developed by Apple which performs well for the multimedia operations.
(e) These computers use their own applications for word processing, multimedia operations, mail management and other tasks.
(f) Apple computers are very costly.

IBM PCs are characterized as follows:

(a) IBM and IBM compatible computers are open products using open components.
(b) Here, users have liberty to choose the components suited used in these computer systems.
(c) Mainly, Windows or Linux based operating systems are used in these computers.

Computers can be classified under different groups based on their abilities, deployment purpose and constructional features. The earlier classification was based on the size of computers. During the earlier period, computers were classified as—(a) mainframe computers; (b) minicomputers and (c) microcomputers.

But with the change in time, the classification based on the size of computers is not relevant today. Nowadays, the general purpose personal computers are commonly and widely used and can be considered as the current computer types. As the name suggests, these computers are designed for general purposes such as for office use and personal activities. Internet browsing, e-mail sending and receiving, document preparation, multimedia file operations, game playing, software development are some of the functions that can be done by these computers. Due to its wide acceptance for personal use, this type of computer is also known as **personal computer** or **PC**. Ergonomic keyboards, easy to use mouse, multimedia features, network connectivity are some of the salient features of these computers but these are not much powerful. Personal computers are the primary choice of power users who do not require mobility.

Another type of computers common in business segments are the **server computers**. Server systems can be defined as the computers which satisfy the requests made by the client computers connected to them. A **client computer** is simply a general purpose personal computer or any other computer system that is connected to the server machine. Depending on the requirements, computing power of server computers can vary. Thus, we have the basic server model, middle level type model and high end type of server computers. High end server type computers are powerful giants capable of executing several tasks simultaneously at lightning speeds. The basic features of server computers are the large storage capacity and flexible configuration to scale with the increased needs. These computers are designed to get increased efficiency, lesser running cost and higher performance. In addition to this, RAID capability, virtualization ability are the other common features available with the server computers. Extensive system management capabilities available with such computers help in their easy and cost-effective administration and management. Server systems can be designed as single processor types or multiple processor types. Nowadays, the server computers possess advanced features for power saving, turning off processors when not required, etc. Different types of physical designs are used for servers and the models are known by their names like rack model, blade server, tower type, etc.

Certain computers are designed exclusively for playing games. These computers are designed in such a manner so that the computer remains strong enough to take the heavy loads of the games without getting the inside components overheated. These computers consist of powerful processors which are capable of handling the heavy loads of gaming. Also, gaming applications require more storage space. To support the functions of different hardware components, the motherboard used in these computer systems is also very powerful. Gaming keyboards, mouse, monitors, headsets are the other components used with gaming computer systems. High end Liquid Crystal Display (LCD) or Light Emitting Diode (LED) monitors supporting 3D (three-dimensional) technology are commonly used for gaming computers.

Another field for which the computers are commonly used is the graphic designing. Computers designed for this purpose use faster processor and these are having large memory. Graphics cards and additional hard drives are the other features included with such type of systems.

Figure 1.3 Desktop computer.

Apart from the above type of classification, computers are also classified depending on their physical design. Computers that are designed with their monitors placed on the top of desks or tables are known as **desktop computers** (Figure 1.3). Desktop computers are not portable. These computers are also known as personal computers. With the increased requirements, the necessity of better and improved systems with portability emerged. This led to the development of a variety of computers such as laptops, notebooks, etc. Now, these types of computers are widely used in different segments for different purposes.

Laptops are smaller than desktops and are portable systems. The entire system arrangement is made available as a single unit in a compact form (Figure 1.4). Laptops also possess the same hardware components that are used for making desktop systems but these components have small size. Small-sized memory, small hard disks and the absence of expansion slots are the features of laptop systems. These systems weigh less and consume less power resulting in less heat generation. Advanced technical features are incorporated in most of the laptops and hence, these systems show increased performance. DVD writer, built-in speakers, touch pad, webcam and Wi-Fi have become integral components of even the entry-level laptop systems. Multitasking ability available in the laptops helps users to engage in multitasking operations. These computers are powered using chargeable Lithium ion (Li ion) or Nickel Metal Hydride (NiMH) batteries. Lithium batteries are lighter and have longer life and hence these are commonly used for portable electronic devices. These batteries have best energy to weight ratio and slow loss of charge when not in use. Use of solid state devices, shrinking form factor, always on connectivity, better performance and affordable prices have made these portable systems, now, widely accepted. Due to the advancement in technology, even the entry-level smaller devices have turned into fully featured computer systems. Starting from the basic applications to the high end gaming, these portable devices not only help to do all the things that we were used to do traditionally on the desktops but also help to stay always connected using different connectivity options.

Figure 1.4 Laptop.

Notebooks are the computers smaller than the laptops. Touch pad, HD backlit display screen, integrated graphics are the features of these computers. These computers weigh around 2.0 to 2.5 kg. Still smaller computers are also available. Computers that are smaller than notebooks are known as **netbooks**. They are thinner and sleeker than the notebooks and are lighter in weight. These computers weigh around 1.0 kg. Netbooks are mainly used for browsing internet, checking e-mails, connecting in real time, watching movies and listening music. Lesser power consumption and long battery hours are the features of these systems. Less powerful processors are used in these systems due to which netbooks are not suitable for processor intensive jobs like ripping music or editing photos. Optical drives are not usually available with the netbooks. Due to smaller memory, these devices have limited multitasking ability. Keys of netbooks are smaller and lesser in number as compared to the keys available in desktop system keyboards. These have smaller screen size. Extreme portability, internet connectivity and suitability for the basic computing needs are some of the features of netbooks that make these gadgets essential for business community. These systems have embedded connectivity options including 3G support.

Computers that are smaller than netbooks are available in different form factors and with different screen sizes. These smaller computers are known as **tablet PCs** or **tablets**. Tablets are slightly larger than the mobile phones and PDAs but having the features of computers. They fulfill the functions of laptops as well as the smart phones at the same time. Tablets were introduced in 2001 by Microsoft. Nowadays, a number of tablets are available working on different operating systems. The widely used operating systems for tablets are *Google Android*, *Meego*, etc. Tablet developed by Apple Inc. is named as *iPad* and this tablet is working on special integrated chips named as *A4 chips*. Apart from iPad, Apple has also developed some other products, namely, *iPod* (portable multimedia player) and *iPhone* (internet and multimedia enabled phone). Apple iPad tablet is widely accepted in the market. Different peripheral devices can be connected to this device. Mobile processor, Wi-Fi and bluetooth based connectivity, auto focus front and back cameras, touch screen, lower power consumption, etc. are the major features of tablets. LED backlit display is used for the tablet displays. These are used for activities while on move. Browsing the internet, downloading files, playing audio/video files, checking e-mails, updating social networking sites, voice calls, playing games are the major functions where tablets find their applications. These support a number of audio and video file formats and multiple languages.

Figure 1.5 Smart phone.

Currently, tablets and netbooks are facing competition with the smart phones. Actually, smart phones are the fully featured mobile phones (Figure 1.5). The only difference is that these are having functionality similar to the personal computers. Smart phones have features above that of the normal phones and they support camera, radio, music players and different tools for viewing and editing documents and computer files. Smart phones have keyboards similar to that used in the computers and have touch screens to assist data viewing and manipulation. Smart phones can run a complete operating system software. Smart phones provide a standardized interface and platform for the application development also. These are also having customizable features to suit with the needs of different users.

1.5 FEATURES OF COMPUTER SYSTEMS

From the above discussion, it is clear that there are several features which distinguish one computer from the other. Actually, these different features determine the capacity, their performance and the software that can be run on the systems. The major features that make up different computer systems are given below in Table 1.1.

Table 1.1 General Features of Computers

Feature	Feature meaning	Typical values
CPU or processor	Memory that can be addressed by the system, speed of operation, performance, etc.	Dual-core, quad-core, core i3, i5, i7
Motherboard	Ability to support different components, performance, etc.	Intel original motherboard
CPU speed or processor speed or clock speed	Determines the speed of the system. Different clock speeds can be seen between the processor in their front side bus, RAM modules and PCI slots.	2 GHz
Chipset	Manufactured by different manufacturers, namely—Intel, AMD, etc. determines the performance of different control operations.	Intel 845 chipset
Bus	Affects the speed of operation. Determines the expansion cards that can be added to the system.	ISA, EISA, PCI, PCIe
BIOS	Low level system software that determines the machine's compatibility.	Award BIOS
Cache	Accelerates performance. Found in different types and is integrated with the processor.	2 MB L2
Memory	Temporary storage space, accelerates performance.	4 GB, 8 GB size DDR2, DDR3, etc.
Expansion slots	Expandability features.	Three PCI slots
Storage devices	Permanent storage spaces for data and program.	Hard disk, CD/DVD, Blu-ray disc
Optical drive	External storage ability	DVD-RW, Blu-ray burner
Interfaces	Interfaces for connecting devices.	Parallel, serial, mounted on board
Hard disk interface	Used to connect the hard disk to the system. Different interfaces have different speeds.	SCSI, SATA1, SATA2
Hard disk speed	Speed of accessing data from hard disk.	10000 rpm
Hard disk size	Determines internal storage capacity.	2 TB
Display size and resolution	Indication of the video displaying capability of the system.	SVGA, 1024 $\times$ 768 resolution with 0.28 mm dot pitch, 24-bit colours
Audio solution	For audio solutions.	Realtek
Speakers	Determines the type of audio output.	Built-in stereo type
Ports	Interfaces for connecting external devices to the computer.	Parallel port, serial port, USB port, audio jacks, MIDI port, LAN port, keyboard port, mouse port, game port, etc.
Networking	For connecting to computer networks.	Ethernet 10/100/1000, wireless LAN 802.11 b/g/n, bluetooth V2.1

Feature	Feature meaning	Typical values
Graphics cards	For increasing graphic ability.	NVIDIA GeForce, ATI Radeon
Keyboard	Input unit for typing data.	PS/2 keyboard
Mouse	Used as an input device.	PS/2 mouse
Headset, gamepad, joystick	For gaming purposes.	Logitech type
Power consumption	Indicates the power consumed by the system.	Maximum–110 W Normal–65 W Sleep–5 W
Power supply input	Indication of the input voltage level.	220 V–230 V AC
PC case	Determines the PC case size.	Rack, ATX type, etc.
Cooling system	Type of cooling used.	Liquid cooling
Preloaded operating system	States the features available.	Linux

1.5.1 Features of Desktop Systems

The features stated above are the overall general features of any computer system. By using components with better values or discarding certain components, it is possible to assemble a computer system suitable for the exact requirement of the user.

General features for a desktop computer and the typical values of components that make up the system are given in Table 1.2.

Table 1.2 Features of Desktop Systems

Feature	Typical values
Processor	Dual-core, quad-core, core i3, i5, i7 with integrated level 2 cache
Clock speed	2 GHz
Motherboard	Intel original
Chipset	Intel
Bus	PCI, PCIe
BIOS	Award
Cache	2 MB
Memory type and capacity	DDR2 2 GB
Expansion bays	Internal, external
Expansion slots available	PCI, PCI Express slots
Internal storage	Hard drive
Optical drive	SATA DVD, SATA Blu-ray writer
Hard drive interface	SCSI, SATA1, SATA2
Hard drive size (unformatted), speed	640 GB, 10 K
Display size and resolution	20″ SVGA, 1024 × 768 resolution with 0.28 mm dot pitch, TFT

Feature	Typical values
Ports	Parallel port, serial port, USB port, ports for microphone, headphone, RJ45, etc.
Networking	Integrated Ethernet 10/100/1000 with RJ45 Ethernet port, wireless LAN 802.11b/g/n, Bluetooth V2.1
Graphics chipset/cards	Integrated graphics, NVIDIA GeForce, ATI Radeon
Audio solution/channels	Realtek High Definition, 8 channels
Input devices	Keyboard, USB optical mouse
Power	300 W ATX

Apple iMacs are the special types of computer desktop systems. These are having a sturdy look and special design. LED backlit display, large glass multitouch trackpad, integrated battery, better performance are the salient features available with new Mac computers. These are having only a single power cable unlike the PC, which is having separate power cables for powering the monitor as well as the processing unit. The screen which encases the PC internal components suspends on a stand. This can be easily tilted along the axis. Different ports and power buttons are available either at the back or at the bottom. The keyboard is thin and small in size. These computers are having multimedia abilities and are fitted with internal speakers.

1.5.2 Features of Server Computers

As discussed earlier, server computers are designed for powerful performance. Hence, these types of computers need powerful processors. Multiple numbers of processors with multiple cores, high speed cache, high speed memory and support for multitasking operations are the general features necessary for the server computers. Since, these computers are designed for business processing applications, multimedia features are usually avoided for server type systems. Common features of server type systems with typical values are given in Table 1.3.

Table 1.3 Features of Server Computers

Feature	Typical values
Form factor/height	Tower/5U (rack mountable)
Processor	Six core with integrated level 2 cache
Number of processors (standard/maximum)	1–6
Clock speed	2 GHz
Cache	12 MB per processor socket
Bus	PCI, PCI Express
Memory	DDR2, DDR3, etc.
Expansion slots available	PCI and PCIe slots
Disk bays (total/hot swap)	Simple swap SATA, Serial Attached SCSI (SAS), hot swap SAS
Internal storage	Simple swap SATA, hot swap SATA/SAS

Feature	Typical values
Hard disk interface	SATA2
Hard disk speed	10000 rpm
Display	SVGA, 1024 × 768 resolution with 0.28 mm dot pitch
Ports	Parallel port, serial port, USB port, etc.
Power supply	670 W/920 W (1 or 2 numbers)
Hot swap components	Fans, hard disk drives, power supply
Networking	Integrated Ethernet 10/100/1000 with RJ45 Ethernet port
RAID support	Integrated, RAID 0,1
Operating system supported	Windows, Linux
Keyboard	IBM
Mouse	Optical

1.5.3 Features of Laptops

Laptops and tablets are made up of the same basic components that are used for the other types of computers but they are having reduced sizes to suit the overall size of these systems. Laptops and tablets have different features that are commonly grouped under different heads, namely (a) technical features; (b) build quality features and (c) ergonomics features.

The technical features include the processor type, number of processors used, RAM, display area and so on. Different build quality features include the quality of construction, location of interface ports, etc. There are several numbers of ergonomics features which include the size of keyboard and mouse, presence of status indicators, handling comfort, etc. The features of laptop computers and typical values for the feature are given in Table 1.4.

Table 1.4 Features of Laptops

Feature	Typical values	Feature	Typical values
CPU	Intel Core i7	Ports	USB, FireWire, Ethernet, DVI, etc.
CPU speed	2 GHz	Audio	Dolby stereo speakers
Motherboard chipset	Intel	Video	Intel HD graphics
Memory	DDR1, DDR2 4 GB	Battery life	8 hours
Internal storage	Hard drive	Networking	Wireless LAN 802.11 b/g/n, bluetooth, Wi-Fi
Internal storage capacity	500	Camera	1.3 megapixels
Hard disk interface	SATA1, SATA2	Operating system	Free DOS
Display, size, resolution	12.10 inch LED, 1280 × 800	Weight	1.1 kg
Graphics chipset	Intel	Dimensions (W × H × D)	16.4 × 1.46 × 10.87 inches (Width × height × depth)
Optical drive	DVD writer		

1.5.4 Features of Tablets

Apart from the features of laptops discussed above, the major feature of tablets is the touch screen computing facility. Touch screens provide a simpler and quicker user interface and help in avoiding the use of common mouse and keyboard. The other notable features of tablets are the reduced size and weight, small display type and size, networking features, etc. All these features make tablets suitable to use anytime and anywhere for chatting, watching TV, browsing the internet, downloading files and so on. Due to small screen size and higher resolution, the display of tablet screen appears like the page of a glossy magazine. General features of tablets and their typical values are given in Table 1.5.

Table 1.5 Features of Tablets

Feature	Typical values
CPU	Intel Atom
CPU speed	2 GHz
Memory type and capacity	DDR1, DDR2 1 GB
Internal storage	Hard drive
Internal storage capacity	500 GB
Hard disk interface	SATA1, SATA2
Display	9.7 inch LED multi-touch
Resolution	2048×1536
Optical drive	DVD writer
Ports	USB, FireWire, Ethernet, DVI, etc.
Speakers	Dolby stereo speakers
Video	Intel HD graphics
Battery life	8 hours
Connectivity	Wireless LAN 802.11 b/g/n, Wi-Fi, 3G, bluetooth V2.1
Camera	3 megapixels, built in front camera
Accessories	Mobile phone with earphones and speakers, GPS support
Weight	350 g
Operating system	Android

2

Disassembling Computers

In the previous chapter, we have discussed the computers and their basic structure. In this chapter, we will study more about some external features of the computer systems. It should be noticed that the mouse, keyboard and the display unit are connected using cables to different connectors available on the outside panel of the computer system. Instead of connecting these peripherals through wire, it is also possible to make use of wireless connectivity between the computer system and the different connected peripherals.

Apart from studying the different components assembled inside the computer chassis, a description of how the computer chassis can be opened and the different component units can be disassembled is also given here.

2.1 SAFETY INFORMATION

As we know that the computers are electricity-based devices. But the electrical current from power, telephone and communication cables can be hazardous. While working with the electrical devices such as computers, proper care must be taken to avoid the shock hazards. So, it becomes necessary to take several precautions while working with the computers, particularly during the assembling and disassembling processes. It is not advisable to connect or disconnect any cable or perform any installation, maintenance or reconfiguration when the system is switched on. Touching the surface of live electrical circuits can cause personal injury or equipment damage. Hence, before doing this, it would be better to disconnect the power cord from the power mains. Apart from the power cords, the other items should also be disconnected from the power supply before the device covers are opened. It is essential to check the different connecting points to make sure that the connections are actually disconnected and the cables are physically removed from the connections. It is always suggested to use suitable rubber mats while handling electrical devices for getting proper insulation. Also, due to the static electricity, chances of damage of computer system components become increased if they are placed without any adequate precaution. A wrist strap connecting the wrist of the user and the computer chassis can solve the risk associated with the static electricity. In case, the wrist strap is not available, the same effect can also be achieved by touching the chassis each time before handling any component.

Power cords of computer systems must be connected to a properly wired and grounded electrical outlet to ensure the safety of the user. When there is an evidence of fire, water or structural damage, then it is not safe and hence never attempt to turn on any equipment in that condition. It is advisable not to remove the cover of power supply units or any part that consists of hazardous voltage, current and energy levels. Usually, these systems do not contain any user serviceable parts. Thus, while connecting or disconnecting cables during installing, moving or opening covers of devices, proper sequences of steps must be followed to avoid the risk of danger.

In case of installation of laser products, do not attempt to remove the covers of the products. Removing the covers of laser products leads to the exposure of hazardous laser radiation. Also, there are no user serviceable parts inside these devices.

Only standard (best quality) tools and test equipment should be used for servicing purposes. Different electrical tools and equipment should be maintained in good operational conditions and these must be regularly inspected. Use of worn out or broken tools or equipment should be avoided. Also, the controls must be set correctly and only standard probe leads or accessories should be used for all the equipment. It is not advisable to work alone under hazardous conditions or near to the equipment that has hazardous voltages. If any electrical accident happens, then it would be the immediate first step to disconnect the power supply.

Before turning on the computer system after any maintenance or repair operation, it is very essential to replace all the opened covers of the computer system components. This is necessary to ensure the correct air flow inside the sealed component unit and hence to provide proper inside cooling. Operating a computer system for a long period of time while keeping the cover of any component unit open, can damage different components of the system and hence this is not to be attempted.

2.2 FRONT PANEL VIEW

Figure 2.1 illustrates the different controls, LEDs and connectors available on the front panel of a computer system. CD or DVD eject button, CD or DVD drive activity LED, diskette eject button, hard disk drive activity LED, power on LED, system error LED, USB ports are the common buttons available on the front panel. The use of each of these buttons is described below:

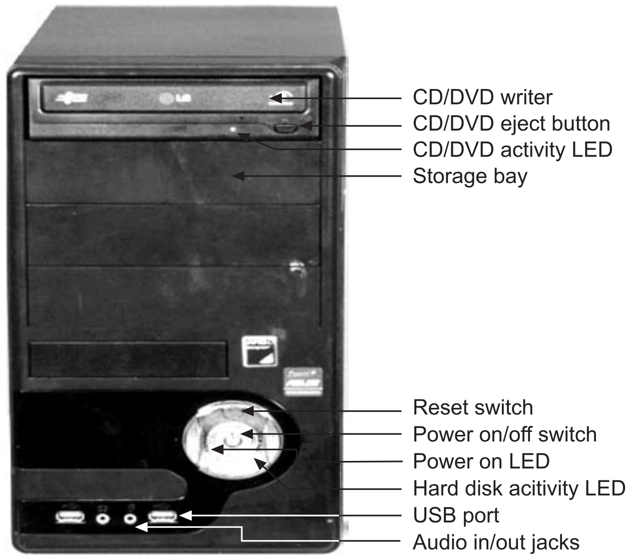


Figure 2.1 Computer: Front panel view.

(a) CD or DVD eject button helps to release a CD or DVD from the CD or DVD drive by opening the tray.
(b) CD or DVD activity LED when lit, indicates that the CD or DVD drive is in use.
(c) USB devices can be connected through USB port.
(d) When the system error LED is lit, it indicates that a system error has occurred. This indicator provides information about the possible component failures. It is commonly seen on the front panel of server computers but cannot be seen on the front panel of desktop systems.
(e) Flashing of hard disk activity LED indicates that a hard disk drive is in use.
(f) When the diskette drive activity LED is lit, it indicates that the diskette drive is in use.
(g) Power control button is used to turn the computer on and off manually. This switch toggles between these two conditions (i.e., on or off). No separate switching off operation using power control button is required in the computer systems, as the system becomes automatically switched off on shutting down of the operating system.
(h) When the power on LED is lit, it indicates that the CPU cabinet box is turned on. In case, it is off, shows that there is no power input or the power supply or the LED itself has failed. The new soft touch power button has replaced the main power switch that was used to turn the system on and off. The system can be turned off by pressing and holding this button for four seconds. Using the options available in the CMOS setup, the functions of this button can be modified.

2.3 REAR PANEL VIEW

Plug for connecting to power supply, connectors for keyboard and mouse, serial port, parallel port, USB port, etc. are some of the connectors that can be seen on the rear side of the CPU cabinet. These different connectors are as shown in Figure 2.2. The use of each of the connectors is described below:

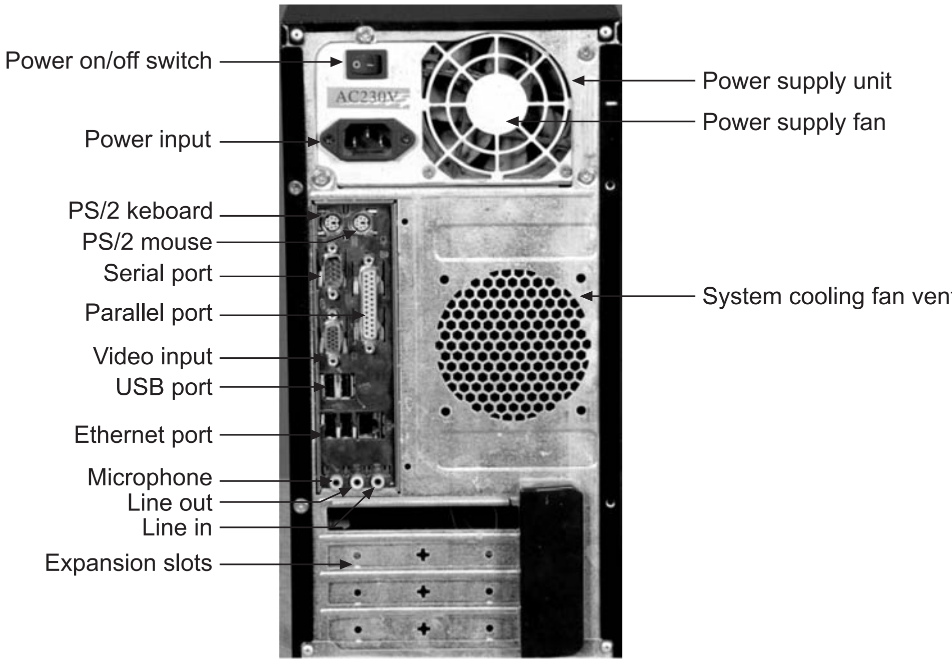


Figure 2.2 Computer: Rear panel view.

(a) The power cord is intended for supplying sufficient power to the computer system. One end of the power cord is connected to the input power connector on the rear panel. Its other end is connected to any suitable electrical outlet. When the power is switched on, the power LED glows and indicates the presence of electric power in the computer.

(b) Usually, two PS/2 (Personal System/2) ports can be seen on the rear panel. Mouse connector is the right PS/2 port and the left PS/2 port is for connecting the keyboard. Mouse connector is used to connect a mouse or other compatible PS/2 devices. Keyboard and mouse connectors are mini DIN connector types.

(c) Serial port, also known as **communication (COM) port**, is used to connect a 9-pin serial device. This is a D-sub 9-pin type connector. Earlier computer systems were having two serial ports indicated as COM1 and COM2.

(d) Parallel port is used for connecting a parallel device to the computer. This is a D-sub 25-pin type connector.

(e) Video input, also known as **VGA port**, is used to connect a video display unit to the computer. This is a D-sub 15-pin type connector.

(f) USB port connects USB devices to the computer. Usually more than one USB port is available in computer systems.

(g) Ethernet connector, also known as **LAN port**, is used to connect the computer to a network. RJ-45 connector crimped to a network cable can be connected to the LAN port. This connector is known as **Ethernet** 100/10base/T connector. Ethernet link status LED is present on the Ethernet connector. When this LED is lit, it indicates that there is an active connection with the Ethernet port. Ethernet transmit/receive activity LED is another LED available on the Ethernet connector and when this LED is lit, it indicates that there is some activity taking place between the computer and the network.

(h) Three audio ports, namely, line in, line out and microphone are used to connect audio speakers and microphone to the system. Line in and line out ports are used for connecting stereo line in signal and stereo line out signal respectively.

The different external connectors can be identified easily since the different connectors use standard colours, as stated in the Table 2.1.

Table 2.1 Colour Schemes used for External Peripheral Connectors of Computers

Connector	Colour
Analog VGA	Blue
Audio line in	Light blue
Audio line out	Lime
Monitor	White
Microphone	Pink
MIDI/Game	Gold
Parallel	Burgundy
PS/2 keyboard	Purple
PS/2 mouse	Green
Serial port	Turquoise
Speaker out/subwoofer	Orange
Speaker	Brown
USB	Black

The above discussed model of the computer system is known as the **tower model computer**. It is the most commonly used desktop computer model and is having a vertical layout and orientation.

Server type computers are available either as tower type model or as **rack type model**. Rack model systems are characterized by their horizontal layout and orientation and are installed in racks. For mounting the server computers, the racks consist of steel doors, keyboard tray and are fitted with castor wheels. More than one server computer can be mounted in the racks. To provide an effective cooling, racks are fitted with special cooling fans. Similar to the tower model computers, rack model computers are also having different connectors and interfaces on the front as well as on the rear panels. A typical rack model computer is shown in Figure 2.3.

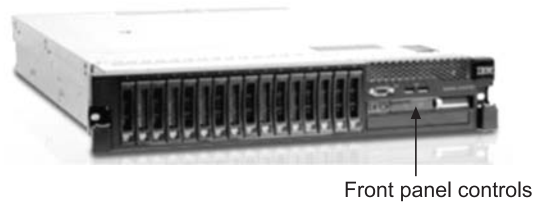


Figure 2.3 Rack model computer.

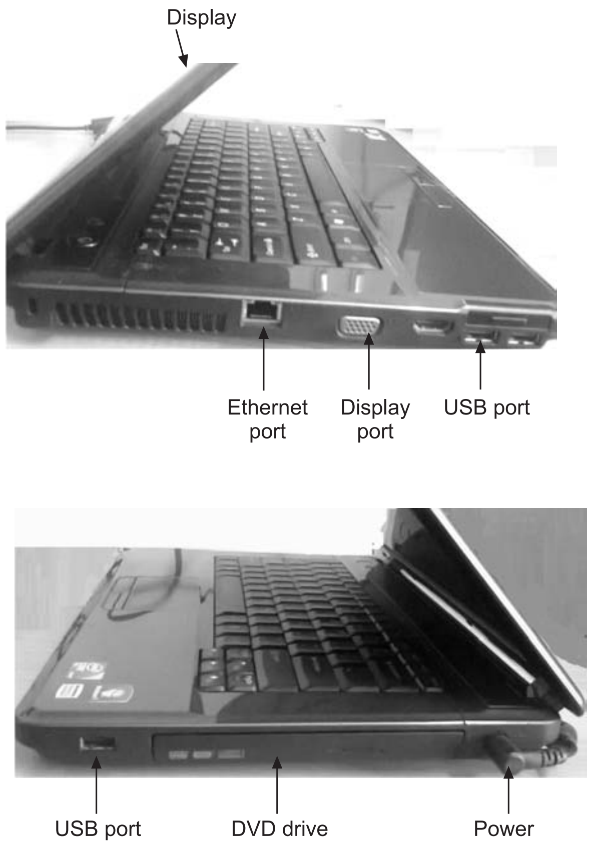


Figure 2.4 Laptop components.

Laptop and its variations are designed for suiting the needs of mobile users. These small-sized and less weighing computers can be used anywhere due to the feature of portability. Basically, there is not any difference between the components used in the desktop computers and laptops. Both are having the same type of hardware and the same software. But there are some differences exist in the design of these components. In laptops, the hardware size is less than that of the desktops. The different components that make up a laptop system are illustrated in Figure 2.4. Instead of mouse, different activities can be done through the touch pad. Display unit is permanently fixed to the processing unit and hence cannot be used separately. Different connectors and interfaces are fitted on the right, left and rear sides of the computer. The exact layout varies with different manufacturers.

2.4 INTERNAL ARRANGEMENTS

All the components necessary for the working of computer as well as the internal storage devices are housed inside the computer chassis. The different units are connected using cables or channels. Irrespective of the type of computer system, all the major components for any computer system are the same. These components are designed to perform different functions of a computer system such as input/output operations, storage, arithmetical logical operations, control functions, etc. The different components are assembled in such a way so that all of them work in unison to get the required output from the system. The exact layout of the component unit can vary with different systems.

All the peripheral devices connected to the motherboard, whether the internal components or the external components, make use of **controllers** for an effective communication between them. Controllers are also known as **interfaces**, **ports** or **adapters**. Thus, hard disk needs hard disk controllers, monitor requires graphics controllers and so on. The controllers perform the following functions:

(a) The main function of the controllers is to convert the data from the one form to the other. For example, graphics controllers convert the data from the digital format to the analogue format for displaying in the analogue display unit.
(b) Controllers help in the proper functioning of different connected devices by making their speeds to be matched with each other.
(c) Isolation of hardware from the software is another function of controllers.

Earlier systems made use of controllers in the form of add on cards fitted to different expansion slots in the motherboard. Currently, almost all the controller cards are integrated in the motherboard.

Computer uses different types of cables to connect to the devices like *parallel IDE*, *Serial ATA* and *SCSI* (such as tape devices) to the power supply and to the system board. One end of the signal cable is connected to the device and the other end is connected to the system board. Signal cables are typically flat cables. These are also called **ribbon cables** and these cables connect parallel IDE, Serial ATA, SCSI and diskette drives to the system board.

An **IDE signal cable** has three connectors. One of these connectors is attached to the drive, one is a spare and the third is attached to the primary or secondary IDE connector on the system board. The spare connector can be used to connect an additional IDE drive to the system. In fact, IDE signal cables are usually colour coded. The blue connector is attached to the system board. The black connector is attached to the master IDE device and the gray middle connector is attached to the slave IDE device. **Serial ATA (SATA) cable** has two connectors. One is connected to the Serial ATA drive and the other is attached to the system board. **SCSI cable** connects SCSI devices to the SCSI controller on the system board. Also, SCSI cable connects external SCSI devices to an optional SCSI controller.

Major power cables available inside the computer chassis are four-wire power cable type and these are used for the connection of inside devices to the power supply unit. Plastic connectors of different sizes are connected to the ends of different cables coming out of the power supply unit and these connectors can be plugged to different drives.

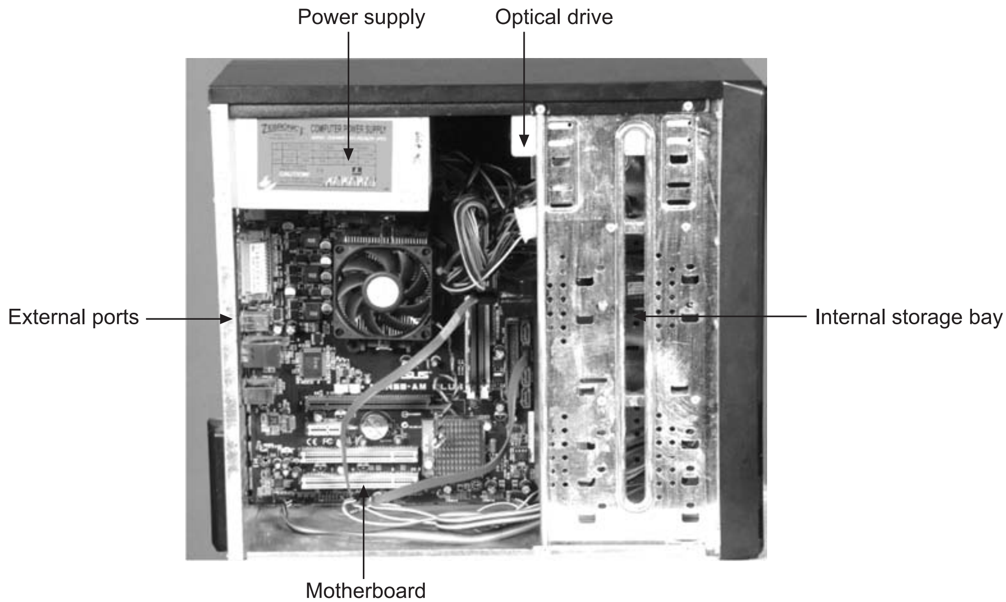


Figure 2.5 Computer: Internal arrangements.

The typical arrangement of the internal components of a computer system can be easily understood from the Figure 2.5. Although a computer chassis possess several internal components, yet these are arranged in such a compact and neat manner so that any cluttering or blocking of air circulation inside the chassis gets fully avoided. The motherboard is fixed on a back plate and is positioned at one side of the chassis. The position of the motherboard is so arranged such that the external connecting ports are easily accessible from the rear panel. The power supply unit is fixed usually at the top portion above the rear panel. Power supply unit used by computer is known as Switched Mode Power Supply (SMPS). These power supply unit converts the AC power supply to 5 V or 12 V DC supply to make it available for the use of different components inside the computer. Power supply units in different computer systems are having different power ratings depending on the requirement. Rating of power supply indicates the amount of power that can be handled by the system. The position of the power supply unit can be easily identified by the presence of the vent for fixing the cooling fan of the power supply unit. The internal storage hard disk, DVD drive, etc. are fitted in the opposite side of the power supply unit. DVD drive is commonly available in computer systems. Now, Blu-ray discs are slowly replacing DVDs. A number of drive bays are commonly provided in the chassis. Different expansion slots available in the motherboard are set below the position of external ports. When the expansion cards are inserted in the slots of the motherboard, then the connectors for external devices are easily accessible.

2.5 DISASSEMBLING THE COMPUTER

To view the internal arrangement and the organization of the components it is necessary to open the computer chassis. For this, the following steps are required to be followed:

(a) The first step is to turn off the system and all the peripheral devices connected to it.
(b) The power cords and all the external cables are disconnected from the chassis. Also, the cable from the adapter cards is disconnected.
(c) Chassis is made up of two side plates fitted on the two large sides of the frame of a rectangular box. Usually, thumb screws are used for fixing the side plates to the chassis frame. The side plate that is fixed away from the external connectors is to be removed for any maintenance operation or inspection of the components. To open the cover, the metal plate is unscrewed and then slided outwards. This removes the side plate from the chassis frame and the internal parts are now visible. The process of removing the side plate is illustrated in Figure 2.6.

Figure 2.6 Removing side plate of a computer chassis.

(d) To remove the motherboard from the chassis, it is necessary to remove all the add-on cards as well as the memory modules fitted in the expansion slots.
(e) To remove the memory module, the retaining clips are gently spread at each end of the memory socket. This step pops the memory module out of the socket.
(f) The module is held by the edges and then lifted away from the socket.
(g) To remove an expansion card, the screw is removed that make the card attach to the chassis.
(h) Holding on the metal bracket, the card is slowly lifted from the connector.
(i) From the rear of the chassis, on the slot cover is pressed. It is then grasped and pulled out from the expansion slot. The expansion card is stored at a safe place for future use.

(j) Once the connecting cables and expansion cards are removed, the motherboard becomes clearly visible. The screws are then located holding the motherboard in the base plate. After that, these are unscrewed, and the motherboard is taken out of the chassis. The process is illustrated in Figure 2.7.

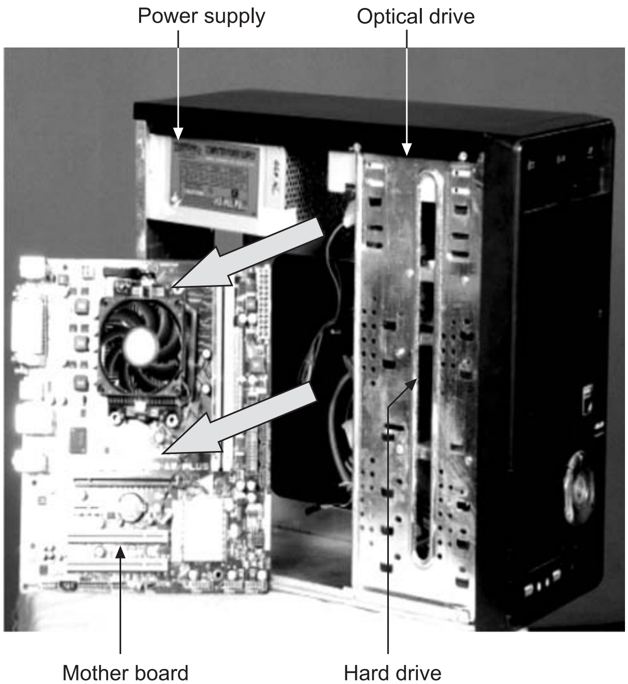


Figure 2.7 Removing motherboard of a computer.

In this way, all the components inside the chassis can be taken out. For disassembling a rack model type computer, the procedure is the same. Here, the top cover of the system is opened. For assembling the system after any maintenance operation, the reverse order of disassembling is followed. The detailed description of the assembling operation is given in the further chapter.

3

Motherboards

Motherboard is considered as the heart of the computer systems. Motherboard is also known by different names such as system board, main board, etc. Motherboard holds different components necessary for the proper and efficient working of the computer. All components of the computer system housed inside the cabinet as well as different external peripherals are connected to the motherboard. Motherboard provides communication channels for different devices that make up the computer system. Due to all these reasons, the role of motherboard in the proper functioning of a computer system becomes very significant.

With the introduction of new and advanced technologies, the existing computing platforms are refreshed and revisions are introduced in a continuous manner. Platform revisions include the introduction of new chipsets, use of new CPUs, faster memory, better graphics processing units and so on. Due to these revisions, features associated with the motherboards are continuously changing.

In this chapter, we will study the details of different features of the motherboards and uses of different components associated with the motherboards.

3.1 FEATURES OF MOTHERBOARDS

Different types of computer systems require different types of motherboards having different capacities and varied features. But all the different motherboards share some common features or in other terms it can be said that motherboards are having certain similar characteristics which determine their support for memory module types, type of hard disk storage that can be used, external and internal peripheral devices that can be connected, power saving and other management functions. Support for chipsets, configuring using BIOS options, overclocking abilities are some other features associated with the motherboards. The overall performance of a computer system is determined by the ability of the motherboard used. Reliability, compatibility and expandability features of computer systems are also determined by the features associated with the motherboard used.

Earlier motherboards were bigger in size than the present age motherboards. Also, the earlier motherboards were having very limited capabilities. Additional electronic circuits, which are also known as **add-on cards** or **expansion cards**, were used by those motherboards for enhancing their abilities for graphics, audio and other features. Electrolytic capacitors were used in the manufacture of earlier motherboards and these capacitors were not durable. Currently available motherboards have gone through several stages of transformations before the achievement of the present shape and features. Increased power, increased energy efficiency and compactness of the motherboards is the ultimate result of those transformations. Now, the modern motherboards make use of durable solid state capacitors instead of electrolytic capacitors. They have integrated or onboard abilities for graphics, audio as well as networking operations. Hence the use of add-on cards is avoided in the new motherboards which already consist of different varied features. Additional controllers for certain special operations are used as add-on cards with the new motherboards and are fitted to the expansion slots of the motherboard. Ability to overclock CPU, GPU chips and RAM speeds for increasing performance is another feature available with several new motherboards. Apart from these, special features such as antiradiation shielding that lowers the generation and emission of harmful radiation, antisurge protection that increases the components and systems longevity, are also incorporated in the modern motherboards. Moreover, increased performance, multitasking operations, fast downloading mechanisms are some salient features of the new motherboards.

It is clear from the above discussion that different motherboards have different features and abilities which are used in different computer systems such as desktops, servers and laptops. We know that the desktop systems are used by a single user at any time whereas the server systems are used by hundreds of users at a particular time. Due to their increased usage, server systems are designed so as to withstand the increased loads created by multiple simultaneous users. As increased reliability and availability are required conditions for the server computers, server motherboards are having provisions for using more than one processor and multiple hard disks to provide better and sustained outputs during all the time. To prevent data loss due to disk failures, provisions for the use of redundant array of storage disks, known as **RAID**, is also available in server class motherboards. Usually, onboard RAID chips or RAID controller integrated in the chipset of server motherboards support the different RAID levels. Laptops use small-sized motherboards with low capacities and low power consumption. As the laptops are designed for increased mobility, provisions for expandability are limited in laptop motherboards.

From the above discussion, it is very clear that an understanding of the features of different motherboards is essential to specify and select a motherboard suitable for a specified type of computer system. The major features associated with a typical motherboard alongwith their meaning and some typical examples are given in Table 3.1.

Table 3.1 Motherboard Features Summary

Feature	Meaning	Typical example
Form factor	Indicates the size of motherboard	ATX, Micro ATX
Processor supported	Determines the make and model of supported processors	Intel processor in the LGA 775 package
Number of processors supported	Determines the speed of computations and hence, performance	1, 2, etc.
Memory	Size of memory that is supported	240-pin SDRAM Dual In-line Memory Module (DIMM) sockets.
Chipset	Features supported by the motherboard	Intel chipset, ATI Radeon northbridge ATI IXP 450 southbridge
Graphics	Graphics ability	Integrated type/ATI Radeon graphics with support for external graphics via PCI Express connector
Multi GPU support (SLI/ crossfire)	Support for increased graphics ability	Available
Front side bus speed	Speed of operation	2000 MHz
Video output	Video interfaces supported	D-sub/DVI/HDMI/DP
Memory slots available	Memory expandability possible	8 GB/4 numbers
Storage interface	Support for storage devices	4 SATA, 1 PATA ports
RAID support	Support for built in RAID	Available
LAN ports/Wi-Fi ability	Support for networking features	PCI LAN integrated fast Ethernet
Audio	Audio features supported	ATI Radeon chipset, High Definition Audio interface
Expansion capability	Additional boards adding capability	2 PCI bus connectors, PCI Express connector
Peripheral Interfaces	Additional devices adding capability	Eight USB ports, four Serial ATA (SATA) channels, Two IDE interfaces (four devices), VGA connector, parallel port, serial port, PS/2 keyboard and mouse ports
BIOS features	Added abilities	Intel BIOS, Rapid BIOS Boot, Built-in flashing
Back panel I/O ports	External devices supported	Parallel, Serial, VGA, USB keyboard, USB mouse, RJ45
Internal I/O connections	Internal devices supported	CPU fan, ATX Power, audio
Power management	Power managing features	Support for Advanced Configuration and Power Interface (ACPI), Suspend to RAM (STR), Wake on USB, PCI, PCI Express, PS/2, LAN

3.2 COMPONENTS OF MOTHERBOARD

Different components of a motherboard include electronic components in the form of integrated circuit chips such as CPU, BIOS, etc. Memory, CMOS battery, different sockets, pins and connectors for different peripheral devices like video, display, keyboard, floppy drives and hard disks are also present in a motherboard. The different components are mounted on the surface of the motherboard. The process of mounting the components on motherboard surface is known as **Surface Mount Technology (SMT)**. In computer motherboards, the components are mounted on one side of the board only.

Motherboard is connected with all the parts of the computer system directly or indirectly through buses or cables. It also handles and controls various data transactions between the CPU and other peripherals connected to it. Early motherboards used discrete components for different control operations and hence, were difficult to design, manufacture and repair. The different included motherboard components performed different control operations such as generation of timing signals, regulating power supply for use of different components and so on.

The modern motherboards use integrated chipsets instead of discrete components. Integrated chipsets incorporate the equivalents of many chips into a single module such as a Very Large Scale Integration (VLSI) module. Chips integrate millions of transistors in a very small area. Chipsets are made of application specific integrated circuits to minimize the number of integrated circuits. Use of application specific integrated components reduces the use of several components in the motherboard. This also improves failure of resistance ability, eases troubleshooting process, reduces manufacturing cost, speeds up operations and minimizes power consumption. Due to the availability of all these features, the overall performance of new generation motherboards has increased considerably.

A list of components that are available in a typical desktop motherboard and the use of different components are explained in Table 3.2.

Table 3.2 List of Components in a Desktop Motherboard and their Uses

Component	Use
Power connector	Connects the 12 V power supply to the motherboard.
CPU socket	Surface mount, Zero Insertion Force (ZIF) socket is used for plugging the processor.
Northbridge controller	Acts as memory controller and integrated graphics interface.
Southbridge controller	Acts as controller chip for audio and connecting ports.
DIMM sockets	Used for connecting main memory modules.
I/O chipset	Chipset for controlling keyboard, mouse operations, etc.
IDE connector	For connecting cables from IDE devices.
BIOS	Programmable chip for configuring the system.
Battery holder	For holding CMOS battery.
Internal ports	Internal connectors for devices.
Expansion slots	Slots for fixing add-on cards.
Ethernet controller	Chip for controlling networking operations.
Ports for external devices	Include PS/2 ports, parallel, serial, LAN, video, USB ports, line in, line out and microphone jacks.

The arrangement and layout of different components in a typical motherboard is shown in Figure 3.1.

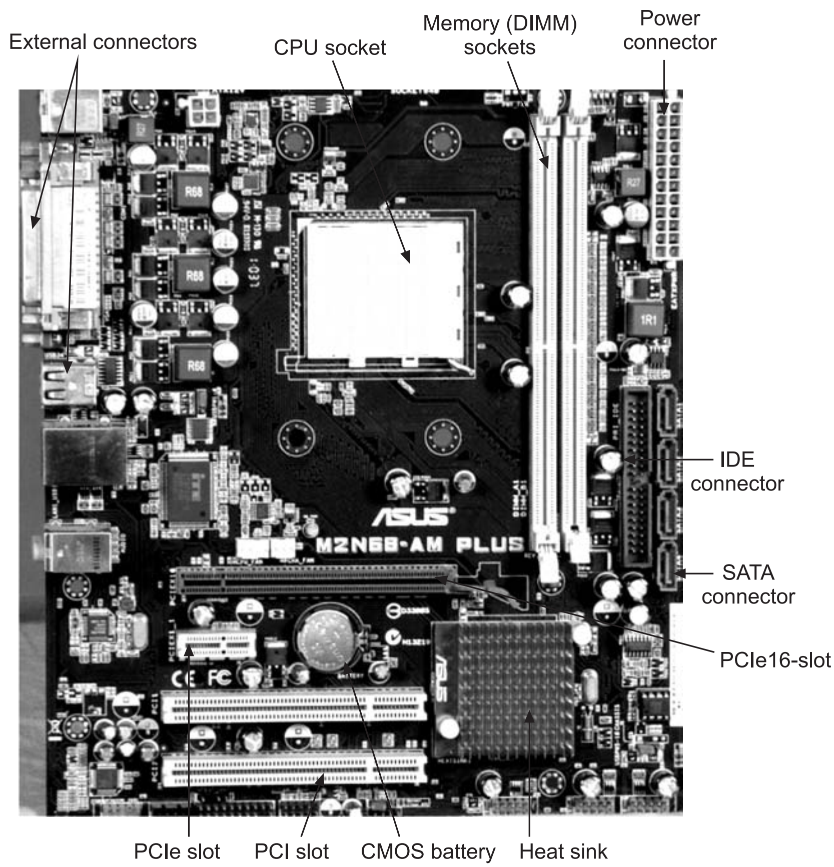


Figure 3.1 Layout of components in a typical motherboard.

Positions of various components that make up the motherboard are defined by the layout of the motherboard. Different manufacturers use different layouts. Also, motherboards used for different types of computer systems such as desktops, servers or laptops have different layouts. The layout of components in motherboards is very significant and this is one of the factors affecting the performance of the computer system, as an improper layout of components leads to certain signal integrity problems.

Different components included in the motherboard require different voltage levels for their proper functioning. BIOS chip, real time clock, keyboard controller and memory modules work on 5 V while cache, chipset etc. require 3.3 V. Central processing unit requires varying voltage levels. The power supply unit provides a fixed voltage level to the motherboard and with the help of some regulator circuits, the voltage level is suitably varied. Regulators also help to smooth out the voltage levels, as voltage fluctuations can occur while executing certain instructions during the working of the system. Voltage regulators are made using electronic components like resistors and capacitors. Resistors help in reducing the voltage levels while capacitors help to smoothout the output voltage level.

Earlier motherboards used some jumpers to set different voltage levels on which the processors used to work. In this system, when certain jumper pins got shorted, the circuit was routed through a particular set of resistor and capacitor components. The ratings of the components in the circuit route could be set to different values for getting the required different output voltage levels. Due to these varied reasons, a proper layout of the components has made the size of the motherboards compact and has increased their efficiency. A typical layout of the different components in a motherboard can be seen in Figure 3.2.

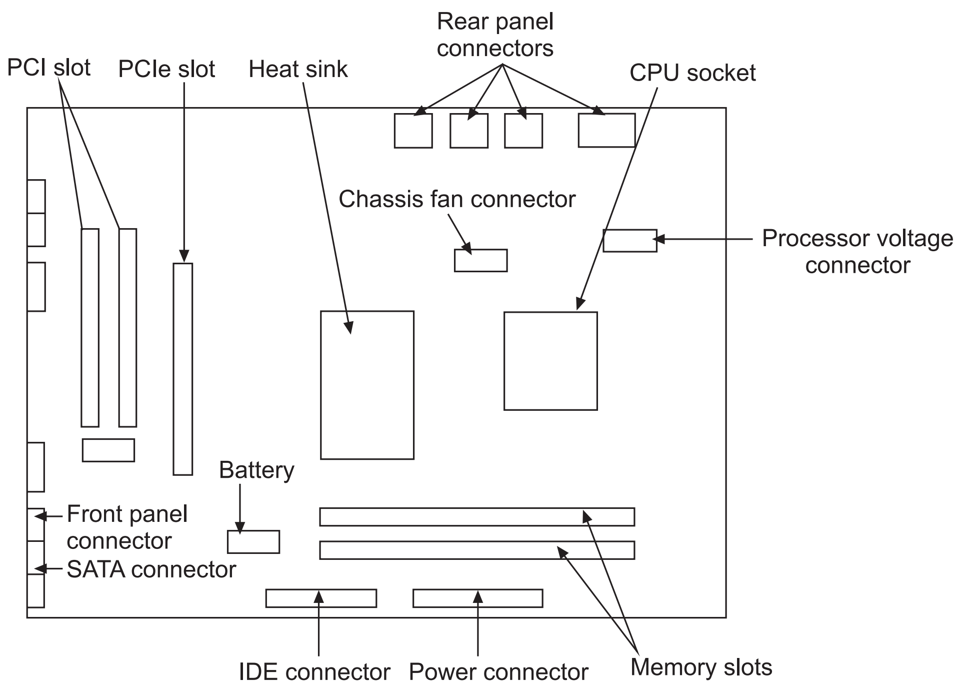


Figure 3.2 Typical motherboard layout.

3.3 FORM FACTOR OF MOTHERBOARDS

Motherboards used in different computer systems support different features and their included hardware components possess different layouts. Also, the motherboards manufactured by different companies show some differences in their designs and in the layout of their components. But all the motherboards are made up of the same components. The different design specifications of motherboards are broadly referred to as the **form factor** of the motherboards.

Earlier motherboards were larger in size. This large size was needed for adding a large number of memory chips, which were then available only in small capacities. But now, the situation has changed. Memory chips having large capacities are available as single small-sized modules. Hence, smaller motherboards have become common for different computer systems.

Motherboards are now available in two different form factors, namely, Advanced Technology (AT) and Advanced Technology Extended (ATX) form factors. Variants of ATX type, namely, mini ATX and micro ATX are also available. AT form factor boards are 21.6 cm × 25 to 28 cm size, ATX has size of 30.5 × 20 cm. Micro ATX form factor motherboard is smaller than ATX type motherboard. Micro ATX type motherboard is having size of 21.84 cm × 24.38 cm and is now commonly used for the desktop systems. Depending on the form factor of the motherboard used, different types of computer cabinets or chassis suitable to hold the motherboards are also available.

Earlier motherboards and computer chassis were designed using AT technology. Later, in 1995, Intel designed the ATX specification for motherboards. Nowadays, ATX is considered as the standard for the motherboard design. Several issues which were related to cable clutter, processor cooling etc., which were common in old AT motherboards, were addressed in the new ATX design of motherboards. The main difference between AT and ATX technologies lies in the power supply connection used. The AT style computers had their power button directly connected to the power supply of the system and hence, it was needed to use the power button to turn the system off. But ATX style computers do not have the power button connected directly to the power supply. This allows users to turn off the computer directly through the operating system. Also, AT motherboards were having two similar power connectors which could be connected wrongly causing irreparable damages to the motherboards. On the other hand, ATX motherboards have a single-keyed power connector which is impossible to connect wrongly. Also, most external interfaces like 25-pin parallel port and RS-232 serial port are being replaced with new interfaces such as FireWire and eSATA ports in newer ATX motherboards.

Development and revision in design aspects of motherboards led to the development of compact and efficient motherboards. Small form factor computers are compact and have space saving design. Most of the expansion slots are removed from the compact motherboards. These systems usually have space for a single optical drive, a single hard drive and one or two expansion slots. These computers consume less power due to their compact size and the reduced number of components and hence there is less heat generation. Compact motherboards have all the components integrated into the board. The small form factor design allows motherboards to be incorporated in small-sized cabinets, thereby making them easily portable.

3.4 PROCESSOR SUPPORT

The most important part of any motherboard is the central processing unit which is also called as the **processor** or **CPU**. CPU is a complex component consisting of several millions of transistors integrated in a small area in the form of a chip. CPU executes instructions from applications and processes data. The central processing units are manufactured by different manufacturers like Intel, AMD, etc. Different central processing units are having different features. CPUs are identified by their brand names and clock speeds. The processing unit is fitted in the CPU socket on the motherboard. In earlier motherboards, the processor units were soldered into the motherboard. Hence, their replacement was difficult. Later on, sockets for holding processors were introduced in the motherboards. Now, the processors are fabricated by encasing in the flat ceramic or plastic packages with pins extending outwards. The extending pins of processors can be inserted into the socket in the motherboard. In this way, processors can be easily fitted in the sockets and can be locked correctly and firmly. This design helps in the easy removal and replacement of the CPU, if required. The design of CPU socket differs with the type and brand of the CPU. A particular processor can be plugged into a particular socket only. Intel processors use a particular type of socket while AMD processors can fit into another type of socket. Hence, separate motherboards are needed for using the processors manufactured by different manufacturers. Also, depending on the type of production technology used for the processor, different CPU socket are used.

Earlier Intel processors, namely, *Pentium* and *Celeron* were plugged into long 242-contact slot connectors on the motherboards. These processors were kept in position with the help of retention brackets mounted on the motherboards. This is similar to the installation of memory modules. But new processors are having a rectangular shape and these new processors make use of a different type of processor socket for plugging into the motherboard. A typical type of CPU socket used in new motherboards is shown in Figure 3.3.

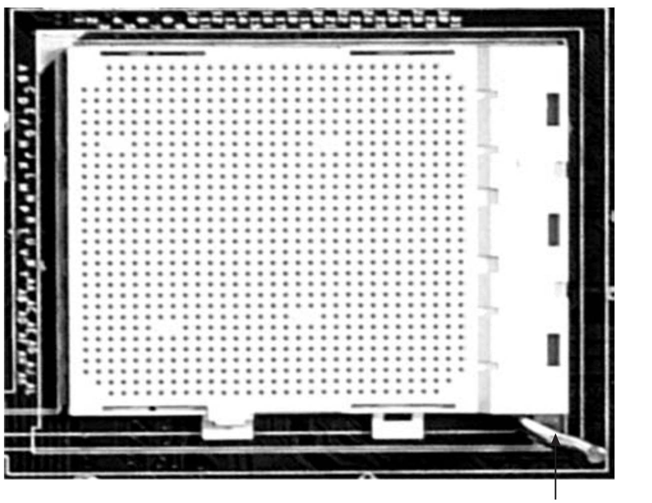


Figure 3.3 A typical CPU socket.

The method of fitting the processor into socket varies with different types of sockets. While using the CPU sockets, the pins of the processor are aligned with the holes in the socket and these are placed in the correct position. This type of socket design is known as **Zero Insertion Force (ZIF) socket**. While using this type of socket (as shown in Figure 3.3), the processor chip is locked and is firmly fitted on the motherboard with the help of a locking mechanism consisting of a locking lever that fits correctly in the rectangular frame enclosing the processor chip.

In another design, a lid and a locking lever are available for fixing the processor firmly in its socket. Such a type of CPU socket can be seen in Figure 3.4. While using such type of socket, after correctly inserting the processor into the socket, the top lid is closed and the lever is lowered which is then locked in the position. Locking the processor in the correct position makes an electrical connection between the processor pins and the motherboard. The locking mechanism includes a heat sink with a cooling fan fitted above it. The processor is fitted to the motherboard with the help of screws piercing through the four corners of the frame. Once the processor is firmly fixed, the connection between the processor and the motherboard is established.

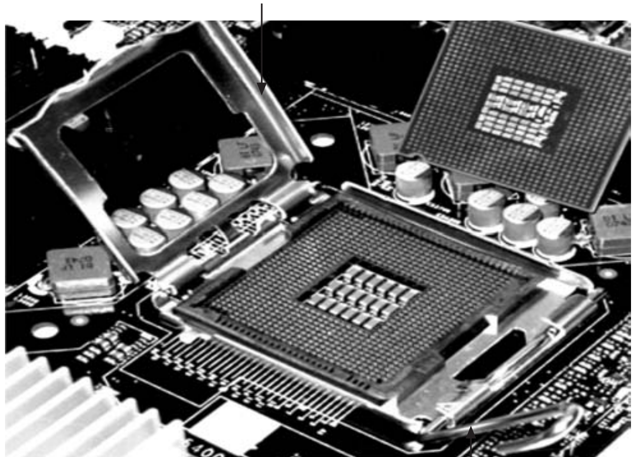


Figure 3.4 CPU socket with lid and locking lever.

Heat is produced from different electronic components of a computer system such as from graphics cards, central processing unit and chipsets during their working. With the performance of the components scaling up in leaps and bounds, the heat produced is also increased to great extents. Although the heat generating components are designed to withstand high temperature, overheating of the components reduces their life. Overheating also reduces the performance of the components and increases the chances of their instability and crashing. So, to reduce the generated heat, all the heat generating components are provided with efficient cooling mechanisms. The cooling mechanism usually consists of copper heat sinks and cooling fans of different sizes fitted above the component. The speed of the cooling fan is controlled with the help of thermal sensors fitted on the motherboards.

New motherboards make use of special heat sink designs to increase the speed of heat dissipation. The heat sink comprises of towers of aluminum fins with copper heat pipes running through them. Also, copper heat pipes are laid between the heat generating components. The typical arrangement of copper heat pipes can be seen in Figure 3.5. The tip of each heat pipe is having a set of tiny fins neatly arranged so as to enable speedy heat dissipation. The heat pipes do not come in direct contact with the CPU but pass through a copper block on the top of the CPU. The cooling kits are designed for different types of sockets such as for Intel *LGA 775, 1155* (Sandy Bridge), *1156, 1366 Sockets and AMD socket AM2, AM2+* and *AM3.*

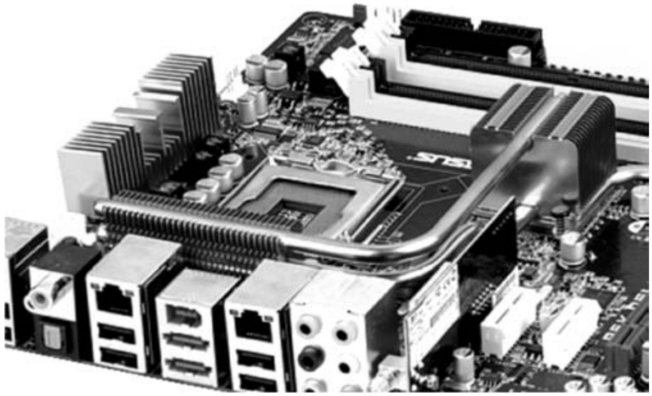


Figure 3.5 Arrangement of copper heat pipes for motherboard cooling.

The cooling fan used for the processor is connected to the processor fan connector on the motherboard. The fan connectors are indicated on the motherboards. Figure 3.6 displays the location of the CPU fan connector in the motherboard along with the enlarged view of the fan connector. From the connector socket, the CPU cooling fan gets + 12 V power supply for its working. In the modern motherboards, this processor cooling fan connector is having four pins. But in the earlier motherboards, there were only three pins for the CPU cooling fan connection. A fan with three pin connector can be used with new motherboards also but it cannot make use of the onboard speed control available with the motherboards. So, these fans always spin at full speed. The signal voltages for different pins of a CPU fan connector are given in Table 3.3.

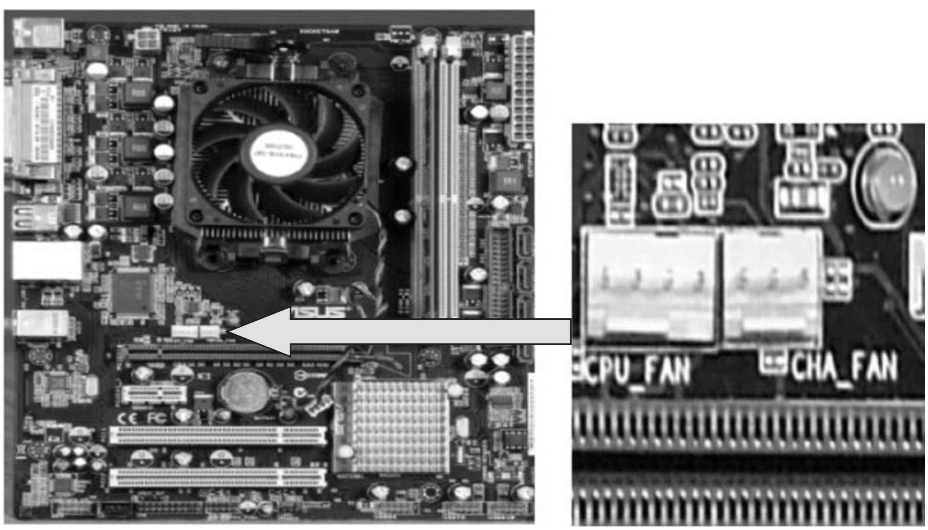


Figure 3.6 Location of CPU and chassis fan connectors and their enlarged views.

Table 3.3 CPU Cooling Fan Connector Pin Voltage

Pin	Signal name
1	Ground
2	+ 12 V
3	Ground
4	Fan control

Cooling fans fitted to a computer chassis are also common in the computer systems. More than one fan located at different places in the cabinet, can be seen in the new systems. Cooling fans help to dissipate the heat generated inside the chassis. The chassis cooling fans are of around 4.2 W rating and works on 12 V supply. Cooling fans are available in different sizes suited for different types of motherboards. Chassis fan cables can be connected to the chassis fan headers located close to the CPU fan header on the motherboard.

3.5 MOTHERBOARD CONTROLLER

The overall performance of a motherboard is determined by the chipset, also known as **the motherboard controller**. Chipset is a group of integrated chips that are designed to work together. It is the chipset that offers different features to a motherboard. Chipset is considered as the heart of a motherboard. The motherboard is built around a chipset that supports a specific class of processors and specific type of memory. The performance of a system is determined by the timely transfer of data without errors and it is the chipset that performs this function. Earlier motherboards used different controller chips but these are all integrated into a single chip in the new motherboards. Chipsets are available in packaged forms and are fitted in the motherboards. Nowadays, the common package form used for different chipsets is the *plastic quad form package*.

The overall structural organization of the chipset in a motherboard alongwith the way in which it is connected to the other components in the motherboard is illustrated in Figure 3.7. Motherboard chipset performs several functions such as controlling the communication between the processor and different external devices. Communication between the chipset and the processor takes place through the front side bus. Chipset controls the transfer of data between memory and the display system. It enhances the power of a computer with the help of onboard audio, video, networking and graphics facilities. It provides interfaces to processor, memory, buses, BIOS, input/output interfaces and ports. It also provides integrated graphics capabilities for supporting 2D and 3D graphics, thereby enhancing display capabilities of the motherboards. Certain chipsets support two separate, mutually exclusive graphics options. These two options are the integrated graphics controller and the add-on graphics controller. When the add-on card is installed, the integrated graphics controller is disabled. The support for Accelerated Graphics Port (AGP) and audio features help motherboards to deliver realistic 3D photo and enhance sound quality for seamless multimedia experience. Chipset also gives support to SATA, Ethernet, USB and other external interfaces. There are several manufacturers of the motherboard chipsets. Intel motherboards use chipsets manufactured by Intel themselves. Other chipset manufactures are VIA, Ali, SiS, etc.

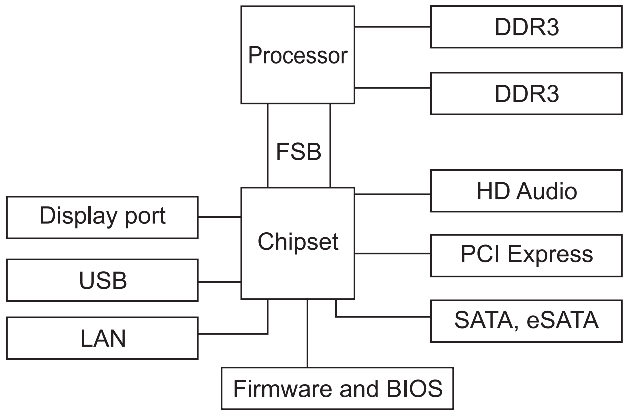


Figure 3.7 Structural organization of motherboard chipset.

Computer chipsets are manufactured by combining two types of integrated chips known as **northbridge** and **southbridge chips**. These two integrated chips are designed to work together. The connection between the two chips is through a bus. Figure 3.8 illustrates the arrangement. Northbridge chip links the CPU with high speed components like memory and graphics controller. The overall performance of a motherboard is basically dependent on northbridge chip, as all the communication between the processor and memory is controlled by this chip. The memory controller chip in northbridge controls the data traffic through the memory bus. Front side bus (FSB) connects the CPU with the northbridge chip. This is the way through which the CPU communicates with the other parts of the motherboard. The data and instructions are transferred between the CPU and other parts through this bus. Hence, a higher bandwidth is always necessary for this bus.

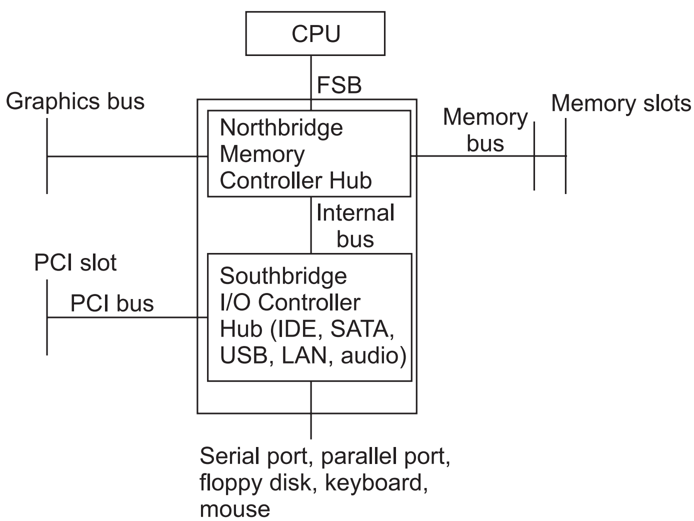


Figure 3.8 Internal arrangement of chipset.

The second part of the chipset is the southbridge chip. If northbridge chip is responsible for the coordination and data transfer between the system and high speed devices such as processor and main memory, southbridge chip is responsible for the data transfer between the low speed peripherals of the system, BIOS and other interfaces such as USB, SATA, etc. Peripheral Component Interconnect (PCI) bus connects the chipset with video card, audio card, network card and so on. This type of chipset architecture is the most commonly used **chipset architecture**.

Another type of architecture used for several chipsets is the **hub architecture**. In this architecture, a hub is available which controls the data flow between the core components of the system. Flow of instructions and data between the processor and memory is through an external bidirectional bus called Front Side Bus (FSB). The memory controller in the chipset acts as the connection hub between the different buses in the motherboard.

Several revisions to chipset architecture were made to improve the ability of chipsets. A new micro architecture is used by Intel in their chipsets that are used in the motherboards designed for the use of multi-core processors. Intel has named this new motherboard architecture as *Nehalem architecture*. As can be seen in detail later, multi-core processors are made up of more than one processor core with its own dedicated cache memory. The entire system is fabricated as a single unit. Details of the new architecture are clear from Figure 3.9. This new architecture is known as **QPI architecture**. In this architecture, the FSB (used in the earlier architectures) is replaced by a new bus known as **QuickPath Interconnect (QPI)**. QPI is similar to the HyperTransport technology used in AMD processors. QPI is a point to point interface connecting different cores of the multi-core processor. Also, it connects the CPU to the motherboard chipset and allows CPU to communicate with USB, SATA, PCIe components, etc. The new QPI bus provides a bidirectional link. It also offers a high data transfer speed as compared to the earlier architecture.

Another difference incorporated in the new architecture is the integration of memory controllers in the processor itself. In the earlier architecture, the memory controller was integrated in the chipset. This new architecture dedicates specific areas of system memory to each processor core.

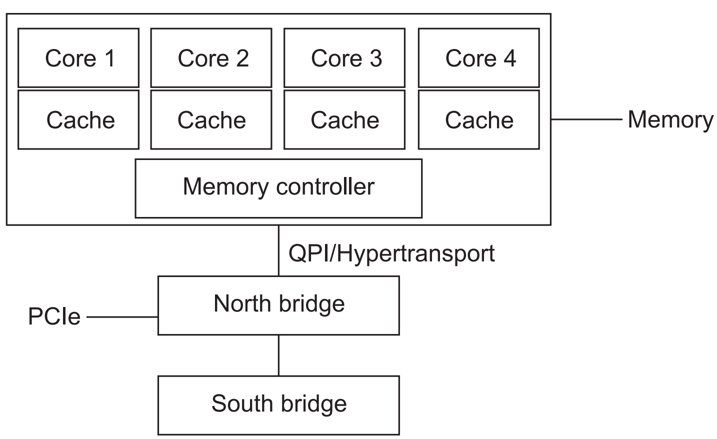


Figure 3.9 New architecture used by Intel chipset.

Heat dissipation is common with chipsets also and hence, chipsets require sufficient cooling for their proper working. Mainly, a heat sink is attached to the chipsets for dissipating the heat. In the modern motherboards, chipsets are cooled using copper heat pipes. These pipes are having much superior cooling capabilities than that of the traditional heat sinks. Facility to provide water cooling for chipsets is another feature available in several new generation motherboards.

3.6 MEMORY SUPPORT

Memory is necessary for the computers to store applications, instructions and data that are created or used during processing. Depending on the requirements, different types and sizes of the memory are used.

Computer memory is in the form of modules and these are fitted in memory slots of the motherboard. Different types of memory modules require different types of slots for their proper fitting in motherboards. The slots in the motherboards for fitting memory modules are currently known as **Dual In-line Memory Module (DIMM) slots**. Earlier memory module slots used were known as **Single In-line Memory Module (SIMM) slots**. Usually, motherboards have more than one DIMM slot. Memory modules having different capacities are available and can be fitted in any of the available DIMM slots in the motherboards. The layout of the DIMM slot in a typical motherboard alongwith its expanded view is shown in Figure 3.10.

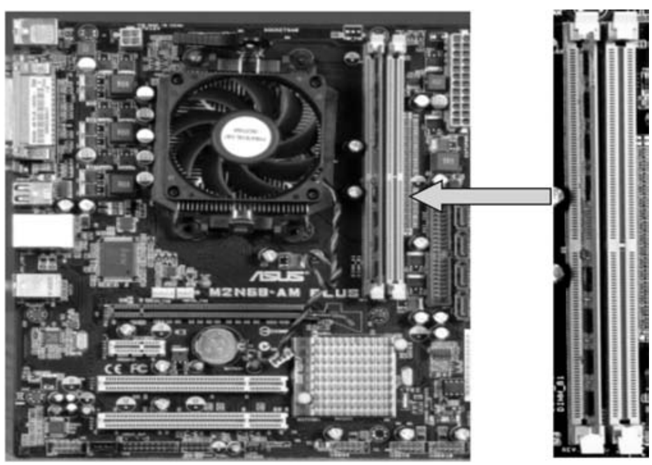


Figure 3.10 DIMM slot in the motherboard and its expanded view.

Memory slots consist of the standard sizes and operate on the standard frequencies. The current standard used is the **Double Data Rate 3 (DDR3)** standard. In this standard, the DIMM slot in the motherboard is having 184 pins for fixing memory modules. The modules are fitted firmly in the DIMM slots in an easy manner with the help of latches at the two ends of the slot. To remove the memory module from its slot, the latches on both the ends are released and are moved outwards. The module is then lifted upwards. A detailed discussion of the memory is available in further chapters.

Sometimes, the computer systems are appeared to work slowly. A simple solution to increase the speed of a computer system is to increase its memory. Increasing memory helps to open more files simultaneously. But memory can only be increased with limit. The number and type of free memory slots available in the motherboard for inserting memory modules is a major deciding factor in this regard.

3.7 GRAPHICS SUPPORT

Central processing units are mainly designed to do different arithmetical and logical operations. CPU also performed different graphics operations in the earlier computer systems. Increased graphics processing requirements of the computer systems necessitated the design and use of processors for exclusive graphics operations. This led to the development and use of graphics processors or Graphics Processing Units (GPU). Use of a separate graphics processing unit relieves the CPU from doing different tasks related with the graphics like rendering, transformation, lighting and so on. Graphics processing units are available as add-on cards or are integrated (on-board) with the motherboard. The on-board graphics chip available with the motherboards can handle only low-level graphics operations. A separate graphics card is not needed for the motherboards having on-board graphics chipset or when gaming is not the major requirement. But, if the motherboard is not having the built-in graphics chipset, then a graphics card is essential to get displayed on the monitor.

New generation computers require the increased use of graphics processing abilities. Entertainment and educational software are now heavily dependent on graphics environments. Also, the high-end graphics capabilities are needed to view graphics on high definition screens. For these purposes, the standard on-board graphics processing unit is not sufficient. Add-on cards upgrade the functions provided by the integrated graphics units. These cards are fitted in graphics slots available in the motherboards and draw the required power from the slot. Cooling is provided by the heat sink as well as by the cooling fans fitted to the graphics unit. Rear panel of add-on graphics cards provide support for different types of video outputs. Initial level motherboards do not provide support for high-end graphics cards. The graphics cards are available from manufacturers like NVIDIA or ATI. For using medium range or high-end graphics cards, it is beneficial to go for the motherboards that support Scalable Link Interface (SLI) or CrossFire options. Opting for high-end graphics cards requires a higher rated computer power supply unit.

3.8 BIOS

BIOS is an acronym for Basic Input/Output System. It is another important component of the motherboards. This consists of the basic input/output instructions and the information is stored in integrated chips as read only information. The instructions in BIOS are executed when the computer is powered on. As stated earlier, computer requires an operating system to do some basic tasks for its proper working. For a computer to run an operating system, a bootstrap program is required. This program is loaded from a known memory location and provides enough information to access the device in which the operating system is loaded.

Once this device is accessed, the computer can copy the operating system files to its memory. The vital information to access the device is stored in the BIOS chip of the computer systems. Apart from this, BIOS is responsible for coordinating the functions of CPU and chipsets. Thus, it influences the hardware compatibility in a greater way. It is available in the form of small chips by different manufacturers like Award, Phoenix, AMI (American Mega trends Inc.). These chips are upgradeable and are available either as surface mountable type chips or socket fitting type chips.

BIOS provides different facilities like built-in setup, diagnostics, setting boot up passwords to computers, etc. It conducts Power On Self Test (POST) of the computer components during the starting and executes the BIOS setup program. Configuring for different buses in the motherboards and executing different auto-configuration utilities and video BIOS are also done by BIOS. BIOS chips are having a range of new features and with the help of these features, it is possible to configure the system differently. The BIOS setup utility records different settings and information of the computer system such as system date and time, type of different hardware installed and their configurations. The information stored by BIOS is utilized by the computer during its booting process to initialize the different components connected to the system. The information is also used for coordinating the different functions of the connected components. After initializing the components, the control of different hardware components is transferred to the operating system. BIOS set up can be modified at the booting time of the computer systems through the access of different configuration patterns by pressing the designated key at the booting time. The newly set values can be stored in the BIOS chip by selecting the options for saving the values. The storage of configuration values in the BIOS memory is made possible with the help of power obtained from a button cell battery. The battery used for storing BIOS configuration information in the BIOS memory is known as **CMOS battery**. Security features provided in BIOS set up configuration utility can be used to restrict unnecessary access to the BIOS settings. The security utility allows setting up a supervisor password and a user password for accessing the BIOS configuration setup. The supervisor password provides unrestricted access to view and change all the configuration options. The password once set can be reset or can be cleared.

During earlier periods, BIOS program was stored in *Read Only Memory* (*ROM*) chips which were impossible to modify after their storage in the chip. Later on, the BIOS came to be stored in *Electrically Programmable Read Only Memory* (*EPROM*) chips. EPROM chips type of BIOS helped in the modification of the stored program, if required. Now, BIOS is stored in the *Serial Peripheral Interface* (*SPI*) flash component. The advantage of such storage is that the BIOS can be updated using a software. The process of updating BIOS is termed **BIOS flashing**. This process helps to overwrite the BIOS memory with new program. It is also helpful for upgrading motherboards or for rectifying defects in BIOS. Auto-configuration utility in the BIOS automatically detects and configures any IDE or SATA device connected to the motherboard. It is not necessary to run the BIOS setup program after installing any internal device such as Serial ATA or IDE device. Also, add-on cards connected to the computer in the PCI/PCI Express slots are automatically detected and the different resources (IRQs, DMA channels, and I/O space) are automatically configured by the system.

BIOS chip is usually located near the memory socket in the motherboard. Certain BIOS chips are marked on their top surface. Two types of BIOS chips found in motherboards are shown in Figure 3.11.

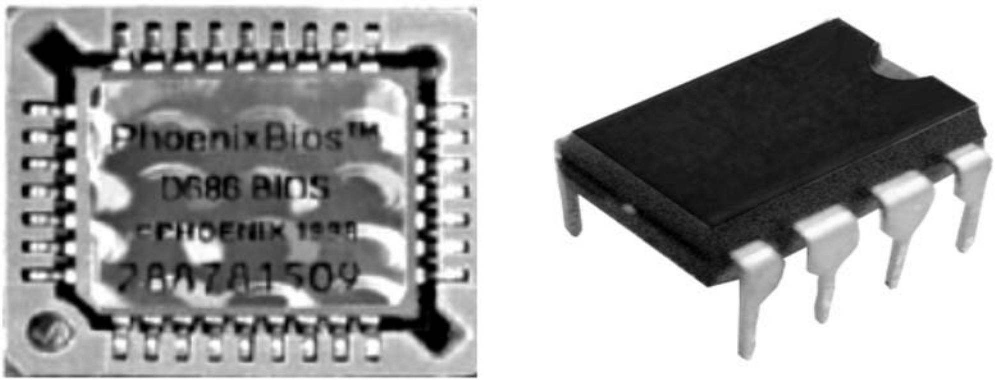


Figure 3.11 BIOS chip.

3.9 IDE AND SATA CONNECTORS

Different data devices connected to the motherboard require two cable connections. One cable is for supplying the necessary low voltage electric power for their operation and the other is for the transfer of data between the components. Electric power is supplied from the computer power supply unit. Data cables from devices are connected to the appropriate slots in the motherboard. The data slots in the motherboard are also known as **channel interfaces**. Two common interfaces used in the computer systems for connecting internal devices are **IDE** and **SATA interfaces**. These interfaces handle the exchange of information between the processor and other peripheral devices such as hard disk drives, optical drives, etc. IDE is an acronym for Integrated Device Electronics and SATA stands for Serial Advanced Technology Attachment. IDE is an earlier type of internal interface. It is also known as **PATA (Parallel ATA) interface**. Parallel ATA has reached its throughput limit. Hence, now Parallel ATA is replaced by Serial ATA interface. Another common internal interface used for hard disks and other data devices is known as **SAS (Serial Attached SCSI) interface**. This interface offers a higher throughput and provides a better performance. SAS allows connecting 128 devices using a single channel. SATA and SAS interfaces have become prominent industry standards for the storage devices. These are serial technologies and have replaced the earlier Parallel ATA and SCSI (Small Computer System Interface) interfaces. SATA is used in optical drives and hard disks while SAS is used in enterprise storage solutions.

IDE devices use IDE interfaces while SATA devices use SATA interfaces. IDE interfaces use ribbon type cables for connecting the device to the motherboard. Each IDE ribbon cable can connect the IDE channel interface with two IDE devices. When two devices are connected using a single IDE cable, jumpers or switches in the devices are configured to set these device as a master device and a slave device. Since, two devices can be connected using a single IDE cable, the IDE cable is having three connectors. Two connectors are separately fitted at the two ends of the cable (one connector at each end) and the third one is fitted in between the end connectors. The arrangement of the cable is clear from Figure 3.12. The end connectors of the cable must be connected to the devices in a correct way for their proper working. First pin of the device connector must be connected to the first pin of the cable end connector. First cable of the IDE ribbon cable is coloured and hence, it can be easily identified. The first pin of the device connector is usually indicated on the device itself.

Figure 3.12 IDE cable.

SATA interface uses SATA cables which are narrower than IDE cables. The picture of a SATA cable is shown in Figure 3.13. These cables are having one connector each at their two ends. One end connector is for connecting to the device and the other end connector is for connecting to the motherboard. End connectors are not interchangeable. These cables can connect only one device to the motherboard.

Figure 3.13 SATA cable.

IDE connectors on the motherboard are 40-pin connectors. The connectors can be identified easily as these are labeled on the motherboard. Early motherboards were having two IDE connectors called as primary and secondary IDE connectors. But, new motherboards are having only one IDE connector. SATA connectors on the motherboards are smaller type connectors. More than one SATA connector can be seen in new motherboards. IDE and SATA connectors in a typical motherboard alongwith their expanded views are shown in Figure 3.14.

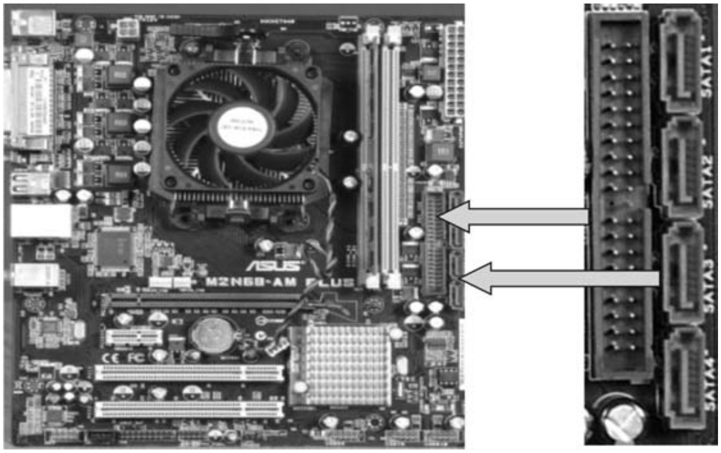


Figure 3.14 IDE and SATA connectors on the motherboard (Magnified).

Apart from the disk controllers discussed above, third party disk controller cards can also be used with the motherboards. Such type of card is known as **host bus adapter (HBA)**. This card can fit into a spare expansion slot such as PCI slot on the motherboard. This type of adapter provides the necessary ability to work with new disks that are not supported by the motherboards. SATA bus has become an interface for connecting mass storage devices to the host bus adapters. New versions of SATA standards offer increased data transfer speeds. SATA 1.0 can transfer data at the speed of 1.5 Gb/s, SATA 2.0 can transfer data at 3 Gb/s, and SATA 3.0 can transfer data at 6 Gb/s. SATA 3.0 standard is more beneficial for Solid State Drives (SSD) than the hard drives, as these have the ability to utilize the interface bandwidth.

3.10 POWER SUPPLY CONNECTORS

A motherboard requires two power connections from the power supply unit. One is the main power connector and the other is the microprocessor power connector. Failure to connect any of the connectors to the motherboard results in a damaged motherboard or non-functioning of the system. Microprocessor power connector is a 2×2 pin, 12 Volt connector. The main power connector in the motherboard can be either AT (2×6 pin) or ATX (2×12 pin) type. Thus, AT and ATX power supply units make use of different types of power connectors on the motherboard. The main power connector socket is usually placed near one side of the motherboard, as seen in Figure 3.15. The expanded view of the motherboard connector (ATX type) can also be seen in the figure. The connector from the power supply unit can fit into the connector of the motherboard by only one way. To make connection, first align the end connector from the power supply unit with the connector on the motherboard. Gently press the connector down and finally fix the connector firmly. The processor power connector is usually marked on the motherboard and is commonly placed near the shorter side of the motherboard. See Figure 3.15 for the layout and the expanded view of the processor power connector.

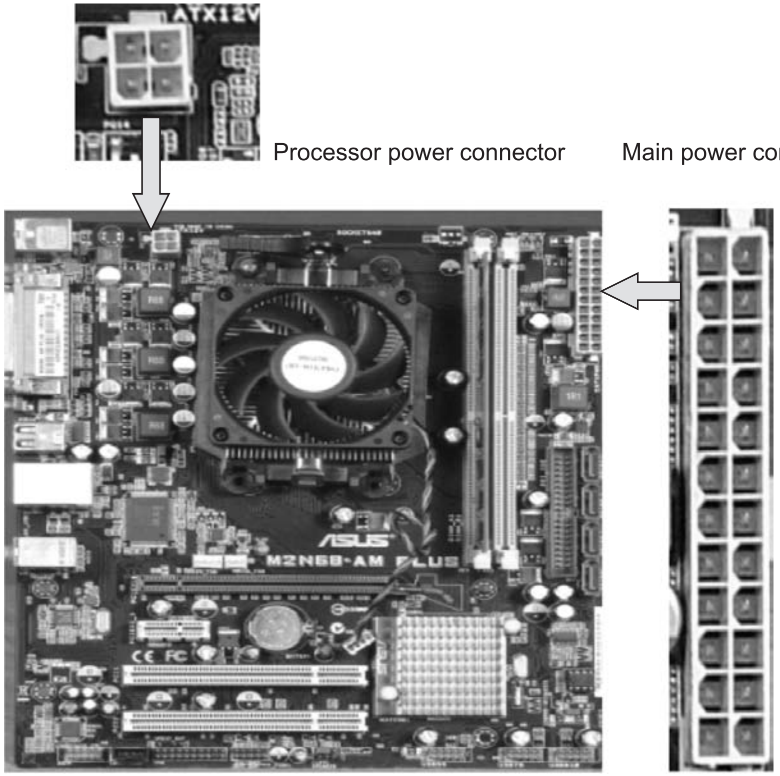


Figure 3.15 Layout of the power and CPU connectors on motherboard and their expanded views.

3.11 EXTERNAL DEVICES INTERFACES

Computer interfaces, so far discussed, are used for connecting internal devices. New motherboards provide a number of on-board interfaces for connecting external devices also. These external interfaces are known as **ports**. The most common ports for external devices are mouse port, keyboard port, parallel port, serial port, monitor or display port, LAN or RJ45 port and connectors for speaker and microphone. Some other interfaces common in new motherboards include external SATA (eSATA), USB and FireWire ports. Most of these interfaces are arranged in the back panel of computer systems. Earlier motherboards used separate add-on cards for adding these interfaces. But all these interfaces are integrated in the new generation motherboards. The main disadvantage of these integrated motherboards is that if any of the interfaces fails and cannot be repaired, then the motherboard is to be replaced. Some of the USB ports are routed to the back panel while some are routed to internal headers through IC chip. USB support requires an operating system as well as the drivers that fully support USB ports. The arrangement of different common external interfaces of a typical motherboard is shown in Figure 3.16.

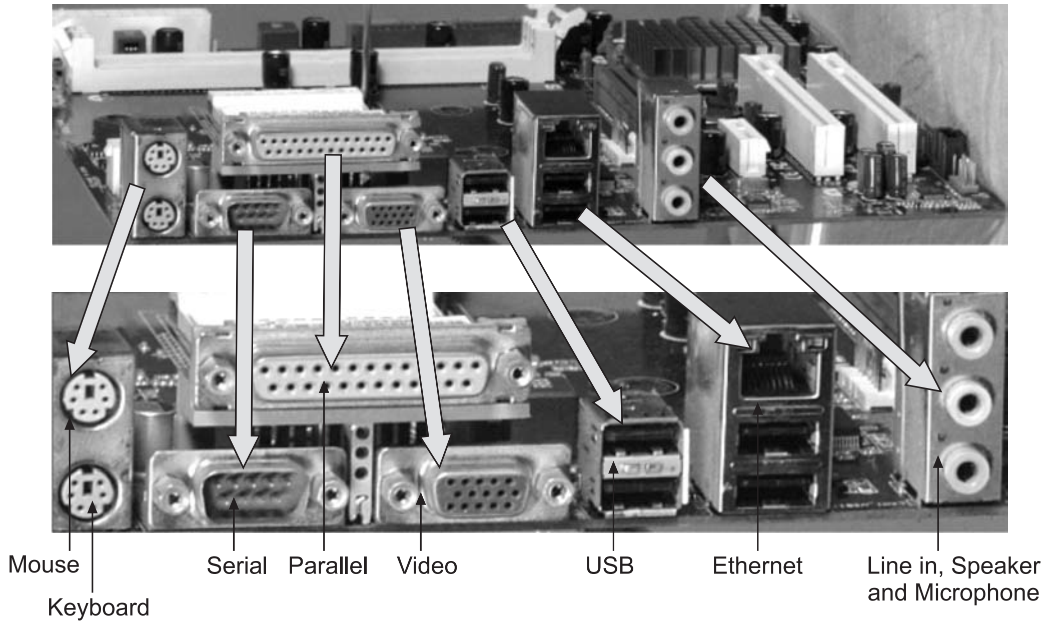


Figure 3.16 Motherboard: Common external interfaces and their expanded view.

Two most common ports available in earlier computer systems were serial ports and parallel ports. Serial port was also known as **communication or COM port**. One bit at a time was transferred by it and hence, this had a slower data transfer speed. The 9-pin connector on the motherboard was connected to the serial port. A magnified view of the serial port header in a motherboard is as shown in Figure 3.17.

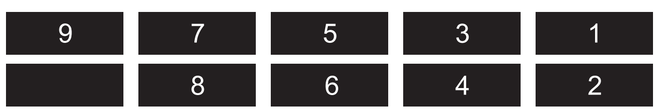


Figure 3.17 Serial port header in motherboard.

Out of the nine signals, majority of the signals were used for controlling the different data transfer operations. Table 3.4 illustrates the signal assignments for different pins of a serial port header. Incoming and outgoing serial data signals are through pins 2 and 3. The purpose of other signals is clear from the table.

Table 3.4 Serial Port Header Signal Names

Pin	Signal name	Pin	Signal name
1.	DCD (Data Carrier Detect)	2.	RXD#
3.	TXD#	4.	DTR (Data Terminal Ready)
5.	Ground	6.	DSR (Data Set Ready)
7.	RTS (Request to Send)	8.	CTS (Clear to Send)
9.	RI (Ring Indicator)	10.	No connection

Parallel port made the uses of eight data lines and hence, were able to transfer eight bits (one byte) at a time and offer a fast data transfer rate. The parallel port could be BIOS configured into different modes such as Standard Parallel Port (SPP) mode, Enhanced Parallel Port (EPP) mode, and high speed Extended Capabilities Port (ECP) mode. The parallel port is often called as **Centronics port**. The pin arrangement for the parallel port header in motherboard is as shown in Figure 3.18.

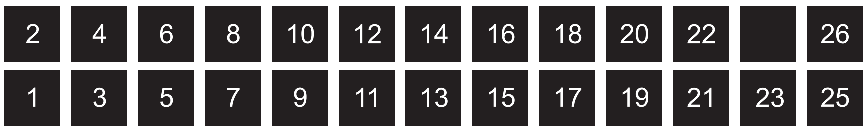


Figure 3.18 Parallel port header pin arrangement.

Signal assignment for different pins of a parallel port header is as given in Table 3.5. Data signal is passed through 8 lines indicated as D0 to D7. Strobe is a low pulse signal that acts to make the flow of data through the eight data pins of the parallel port. Out of the different controlling signals, some signals are for input from the printer to the computer and some are for input from the computer to the printer.

Table 3.5 Parallel Port Pin Signals

Pin	Signal name	Pin	Signal name
1.	Strobe	2.	AFD (Auto Feed)
3.	D0	4.	ERR (Error)
5.	D1	6.	INIT (Initialize)
7.	D2	8.	SLIN (Select Input)
9.	D3	10.	Ground
11.	D4	12.	Ground
13.	D5	14.	Ground
15.	D6	16.	Ground
17.	D7	18.	Ground
19.	ACK	20.	Ground
21.	BUSY	22.	Ground
23.	PE (Paper Entry)	24.	No pin
25.	SLCT	26.	Ground

Universal Serial Bus or USB ports are created by keeping in mind the limitations posed by serial and parallel ports. USB has become an interface standard for adding external plug and play (PnP) devices to the computer systems. These are bidirectional, dynamically addressable serial interfaces. USB was launched in 1996. Now, it has become the common standard used for the connection between external devices and the host controller for transferring data between them. It has replaced a variety of other interfaces such as serial port, parallel port, etc. A single USB port can take as many as 127 numbers of USB powered devices and most of the devices can work without any additional driver support other than that required for the USB port. These ports can house several devices including mouse, keyboard, digital camera, mobile phone, printers, flash drives, external hard drives and several utility devices. USB ports consist of three cables—two for power (one with + 5 volts and the other for providing earth) and the third twisted pair for carrying data. USB devices support plug and play, power management and hot plugging features. The pin arrangement of a typical USB header in the motherboard is shown in Figure 3.19. It is clear from the figure that the header is having nine pins.

Figure 3.19 USB port header pin arrangement.

Signal names for each USB port header is given in Table 3.6. Each USB header can be used to connect two USB devices.

Table 3.6 USB Port Header Signals

USB Port A		USB Port B	
Pin	Signal name	Pin	Signal name
1.	Power (+ 5 V)	2.	Power (+ 5 V)
3.	D –	4.	D –
5.	D +	6.	D +
7.	Ground	8.	Ground
9.	Key	10.	No connection

The currently used USB standard is USB 3.0 which was released in 2008. The standard is having a data transfer speed of 5 Gb/s. This is 10 times faster than USB 2.0 standard and offers better connectivity. A number of technical modifications are made in USB 3.0 as compared to USB 2.0 standard. The speed of USB 3.0 is increased by adding more parallel lines in USB 2.0. USB 2.0 is having four wires used for the power supply and data transfer while USB 3.0 uses eight parallel wires. USB 3.0 is a full duplex which means that it is able to transfer a bidirectional data, i.e., in both directions, while USB 2.0 is a half duplex which means that it can transfer the data in single direction only. A comparison of the major features of USB 2.0 and USB 3.0 standards is available in Table 3.7.

Table 3.7 Comparison of Features of USB 2.0 and USB 3.0 Standards

Feature	USB 2.0	USB 3.0
Code name	High speed	Super speed
Transfer speed	480 Mb/s	5000 Mb/s
Minimum voltage	4.4 V	4 V
Power output	100 mA	900 mA
Mode of operation	Half duplex	Full duplex

Opting for a faster means of data transfer is more important to save time, thereby speeding up the system. Manufacturers are concentrating on products that can transfer data through faster

I/O ports such as FireWire or eSATA because USB has some limitations for data transfer speeds. The USB 2.0 standard port can transfer data at a maximum speed of 480 Mb/s. This causes a bottleneck between the computer and the hard drive, as hard drives have a transfer speed ranging from 480 Mb/s to 800 Mb/s. Because of this limitation of USB 2.0 standard, FireWire port has turned to become a serial bus standard for high speed data transfer. FireWire has two variants known as FireWire 400 and FireWire 800 standards. The top speeds for FireWire 400 and FireWire 800 standards are approximately 400 Mb/s and 800 Mb/s respectively. For data transfer between a computer and an external storage drive, the common interface used is eSATA interface. Connecting a hard drive to eSATA port is similar to connecting an external hard drive directly to the SATA port of the motherboard.

Support for parallel port and serial port is not available in new motherboards and hence, these ports cannot be seen in new motherboards. Since, several peripheral devices are having USB interfaces, the number of USB ports supported by new motherboards has increased. Some other new interfaces such as DMI, HDMI, FireWire, etc. are also emerged. The arrangement of the different external device interfaces of a typical new generation motherboard is shown in Figure 3.20. Details of the new external interfaces are discussed later in this chapter.

Figure 3.20 New generation motherboard external interfaces.

A comparison of the data transfer speeds of some common computer interfaces is illustrated in Table 3.8.

Table 3.8 Comparison of Data Transfer Speeds of Different Computer Interfaces

Interface	Speed in Mb/s
ATA 133	1330
SATA 1	1500
SATA 2	3000
SATA 3	8000
eSATA	3000
USB 2.0	480
USB 3.0	5000
FireWire 400	400
FireWire 800	800

3.12 AUDIO SYSTEM

On-board support is provided in several motherboards for audio support including stereo-type audio. Different motherboards use different types of audio systems. The on-board audio subsystem consists of an integrated chip and audio codec and back panel audio connectors. These are connected to the on-board audio headers and connectors. Audio connectors allow receiving audio input from different sound sources. The pin assignments for different audio signals are different. The front panel audio connector in the motherboard is connected to the output using suitable audio cables. The header is located near the edge of the motherboard. Pin layout of a High Definition (HD) audio front panel header is illustrated in Figure 3.21.

Figure 3.21 Front panel audio header pin arrangement.

Table 3.9 provides the pin assignments and signal names for HD audio front panel header. The pin assignment is different for different types of audio systems.

Table 3.9 Pin Assignments and Signal Names for HD Audio Front Panel

Pin	Signal name	Pin	Signal name
1.	Port 1L (Microphone)	2.	GND
3.	Port 1R (Microphone)	4.	PRESENCE#
5.	Port 2R (Headphone)	6.	SENSE1_RETURN
7.	SENSE_SEND	8.	No pin
9.	Port 2L (Headphone)	10.	SENSE2_RETURN

The different audio jacks in the panel used for line in, line out and mic in connections are separately colour coded and hence, these can be easily identified.

3.13 LAN SYSTEM

The local Area Network (LAN) subsystem includes the integrated chip, Gigabit Ethernet Controller for operation at 10/100/1000 Mb/s, RJ45 LAN connector with integrated status LEDs. The subsystem features CSMA/CD protocol engine and LAN connect interface between the integrated chip and the LAN controller. The LAN is formed by connecting networking cables having end connectors (patch cords) to LAN port (RJ45 connector) of the motherboard. The port is having two LED indicators to display the working status. Table 3.10 describes the LED states when the board is powered up and the LAN subsystem is functioning.

Table 3.10 LAN Connector LED States

LED	LED Colour	LED State	Meaning
A	Green	Off	LAN link is not established
		On	LAN link is established
		Blinking	LAN activity is occurring
B	N/A	Off	10 Mb/s data rate
	Green	On	100 Mb/s data rate
	Yellow	On	1000 Mb/s data rate

3.14 BUSES AND EXPANSION SLOTS

Information is transmitted between different components connected to the motherboard through buses. Bus acts as the communication channel or data highway between different components of the motherboard. Speed of working of computer systems is dependent on the speed of bus. Bus is made up of a series of wires. Depending on the number of wires used, buses are of different types such as 16-bit, 32-bit, 64-bit buses, etc. The transfer rate of a 32-bit bus is twice as that of a 16-bit bus. Similarly, the transfer rate of 64-bit bus is twice as that of a 32-bit bus. Buses used in desktop computers are known by different names such as *Industry Standard Architecture (ISA), Enhanced Industry Standard Architecture (EISA), Micro Channel Architecture (MCA), Video Electronics Standards Association (VESA), Local bus, Peripheral Components Interconnect (PCI), Peripheral Components Interconnect Express (PCIe),* etc. Initially, **Personal Computer Memory Card International Association (PCMCIA) bus** was introduced as a specification for credit card-sized memory expansion cards, which was extended for different card types. New Buses are faster as compared to earlier buses and these offer better capabilities such as plug and play, automatic configuring ability, etc. A comparison of the features of different buses can be obtained from Table 3.11.

Table 3.11 Comparison of Features of Different Buses

Bus standard	Data width in bits	Speed in MHz	Transfer rate in Mb/s	PnP feature
ISA	16	8	8	N
EISA	32	8	33	N
MCA	32	20	80	N
VLB	32	33	132	N
PCI 32	32	66	264	Y
PCI 64	64	66	528	Y

Motherboards usually have several expansion slots for fitting the expansion cards. These cards provide added abilities to the computer systems which can be used for several purposes. In short, expansion slots provide an easy way to expand the abilities of a motherboard by adding additional cards. Access for power, data, addresses and control buses is available in expansion slots. This feature helps expansion cards to be fitted in any of the available expansion slots and to easily configure it for use. Expansion slots available in motherboards are of different types. Earlier motherboards were having 8-bit expansion slots. But current motherboards are having expansion slots of 16 bits and 32 bits wide.

As the expansion slots were 8-bit wide in earlier motherboards, add-on cards used with them were also 8-bit wide. These 8-bit expansion cards were known as **ISA (Industry Standard Architecture) 8-bit cards**. These cards were slower and less efficient. These cards were having one little tab protruding from the lower end that matched exactly with the 8-bit slot on the motherboard. This protruding tab was inserted in the slot for fixing it to the motherboard.

Later on **ISA 16-bit cards** were evolved. 16-bit cards moved twice the data as quickly as the earlier 8-bit cards used to do. 16-bit cards were having two tabs protruding from the lower portion that got fitted firmly in the two portions of the 16-bit expansion slot on the motherboard.

EISA cards came later. These are 32-bit cards and they were fitted firmly in EISA slots of the motherboards. Another type of cards known as **MCA cards** were intended for using MCA slots in motherboards. MCA card was developed by IBM. Another expansion card released was the **VESA card**. VESA cards were larger than the earlier cards and these were fitted into VESA expansion slots. The connecting edge of VESA cards has three tabs and hence, these cards can be easily identified.

Increased bit size of slots means a higher transfer rate and hence, improved performance. New motherboards have expansion slots like *PCI*, *Accelerated Graphics Port* (*AGP*), *Communication and Networking Riser* (*CNR*), etc.

PCI was introduced during the earlier years of 1900s. This standard was having a data transfer speed of 133 Mbps. It was later replaced by another standard known as **PCI Express** or **PCIe standard**. This is a faster interface and having a data transfer speed of 250 Mb/s. This bus provides a better throughput and is having a higher performance. PCI is a shared bus while PCIe is a point-to-point link. An advanced version of PCIe is available and this is known as **PCIe-16X** and is having a data transfer speed of 400 Mb/s. Separate buses used to transfer data between the graphics cards and the processor are known as **AGP buses** which are having a separate colour in the motherboard. AGP is a modified PCI bus exclusively reserved for graphics use. It provides a faster throughput for streaming videos and 3D displays. Different steps for fitting add-on cards to the expansion slot of the motherboard are discussed later.

From the above discussion, it is clear that the expansion slots in motherboards have different lengths and can be identified easily. The add-on cards are inserted to these expansion slots to provide additional abilities to the motherboard. These cards are designed for a particular slot and cannot be used in another slot. The new motherboards are having PCI, PCIe and AGP expansion slots. When these cards are installed in the motherboard slot, the auto-configuration utility in the BIOS automatically detects and configures the resources such as IRQ, DMA channels, and I/O space for expansion cards. The arrangement of different expansion slots in a typical motherboard is given in Figure 3.22.

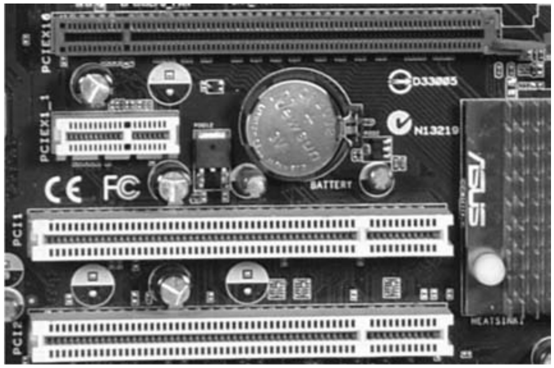


Figure 3.22 Different expansion slots in a motherboard.

3.15 SPEAKER AND BATTERY

A speaker can be seen fixed to the computer chassis in earlier systems. This speaker is having only a limited ability. In new generation motherboards, the speaker is mounted on the motherboard as an integrated item. It provides audible error code (beep code) information during the Power On Self Test (POST) process.

CMOS RAM is a special type of RAM seen in motherboards and this RAM stores the configuration data of the computer system. This is a volatile type of memory. A battery on the motherboard keeps the configuration values safely in CMOS RAM. Computer system is having a built-in clock that always updates the current time and date even when the computer is turned off. This clock (time-of-day clock) is known as **real time clock (RTC)**. Besides the clock, the motherboard maintains a hundred year calendar. A button cell type battery fitted on the motherboard battery holder updates the clock and date always. A retention clip in the battery holder keeps the battery in position. The layout of the battery holder and its magnified view are shown in Figure 3.23.

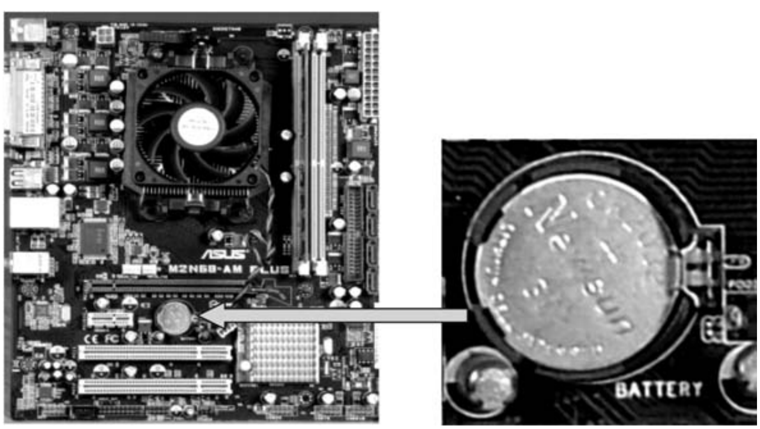


Figure 3.23 CMOS battery in motherboard and its magnified view.

The CMOS RAM needs to be updated only when there is a change in the configuration settings or when the battery is deteriorated. In the latter case, it has to be replaced. Steps for replacing the battery are discussed later. CMOS battery is a lithium battery which can explode if misused, mishandled or disposed. Throwing or immersing battery into water, exposing the battery to heat above 100°C, repairing or disassembling of the battery, etc. are some of the activities that must be avoided.

3.16 FRONT PANEL HEADERS

Front panel of a computer system is made up of power and reset switches and some light emitting diodes. System power indicator is green-coloured LED which lights up when the system is turned ON. Another LED in the front panel, is the hard drive activity LED and this LED is yellow-coloured. Pin layout of the front panel header on the motherboard is shown in Figure 3.24.

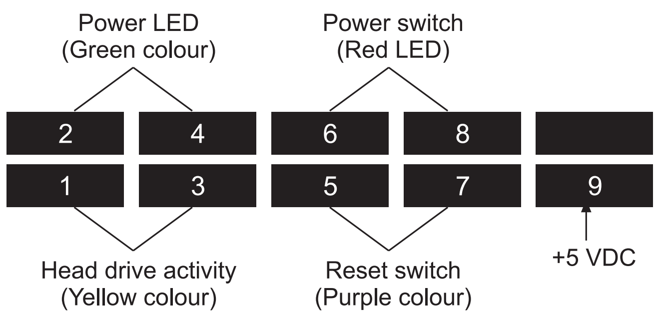


Figure 3.24 Pin layout of the front panel LED indicators.

The pin assignments and description of the front panel headers in the motherboard is illustrated in Table 3.12.

Table 3.12 Pin Assignments of Front Panel Header

Pin	Description	Switch/LED
1.	Hard disk LED + 5 V	Hard drive activity LED
3.	Hard disk active LED	
5.	Ground	Reset switch
7.	Reset switch	
9.	Power + 5V	Power
2.	Front panel green LED	Power LED
4.	Front panel yellow LED	
6.	Power switch	ON/OFF switch
8.	Ground	
10.	No pin	

Pins 1 and 3 of the header are connected to an LED that provides a visual indication about the data that is being read or written by hard disk. Pins 5 and 7 are connected to the reset switch. The reset switch is opened under the normal conditions. When the switch is closed, the motherboard resets, thereby rebooting the system. Pins 2 and 4 are connected either to a single or dual-coloured LED. The LED gets lit when the computer is powered on. Pins 6 and 8 are connected to the front panel power switch.

3.17 SYSTEM BOARD JUMPERS AND LED

Jumpers were very common in earlier motherboards. A jumper unit is made up of three small pins with a bridging cap which can be placed over any two pins at a time. The jumper pin can be completely removed and a third setting can also be configured. Earlier motherboards were having a number of jumper blocks for setting different configurations such as for clearing the CMOS data, thereby clearing the power on password, forcing power on of the system, etc. Earlier motherboards were designed for different types of CPUs manufactured by different manufacturers. In such motherboards, the CPU selection was done by configuring jumper settings. Configuring jumper settings also helped to set cache memory size of the motherboard, selection of CPU type, its speed and voltage. Some earlier motherboards also used thumb switches for setting different configuration values. But new motherboards do not use jumpers for setting configuration values. These motherboards use interfaces available in BIOS through which different system parameters can be configured as per the requirement.

Some of the components used for assembling computer systems are having their own fault identifying as well as status indicating LEDs. Motherboards are provided with a number of fault diagnostic LEDs which are common in the motherboards of server type computers. The diagnostic LED on the system board is lit when an error occurs in the system board and this indication is used to isolate system errors. System error LED fitted on the front panel of some server systems can also be used to identify errors caused. Besides the fault diagnosing LEDs on the motherboards, computer systems are also having LEDs fitted on the front panel also. In Figure 3.25, the location of the system board jumper and fault diagnosing LED are indicated alongwith their expanded views.

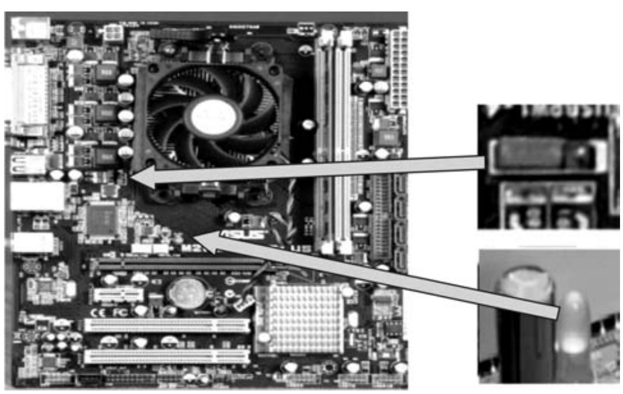


Figure 3.25 Location of system board jumper and LED and their expanded views.

3.18 I/O ADDRESSES AND INTERRUPTS

Different ports and controllers in motherboards are identified by their unique addresses. The uniqueness of addresses makes it helpful in identifying the required port correctly and to send the data to that port, like the addresses used in the memory. Also, each internal device that makes up the computer system is assigned a unique address. Thus, serial port, parallel port, audio port, keyboard controller, real time clock, interrupt controller, IDE channels, etc. are having unique addresses. Usually, a range of addresses is reserved for each type of device. This unique address is known as the **I/O address** which helps the CPU to communicate with different devices correctly. Different addresses are having different byte sizes and the address size can vary from 1 bit to several bytes. The I/O addresses used by some common devices of a typical computer system are given in Table 3.13.

Table 3.13 I/O Addresses Used by Some Common Devices of a Computer

Device	I/O address
Timer	40–5F
Keyboard	60–6F
Serial port 1	3F8–3FF
Serial port 2	2F8–2FF
Parallel port	378–37F
Real time clock	70–7F
Hard disk controller	1F0–1F7

Interrupt is a signal used by peripheral devices such as disk drives, printers, etc. to turn the attention of CPU on the device. IRQ is a dedicated hardware channel over which devices can send interrupt signals to the CPU. Suppose, the computer is busy in reading the input from the keyboard and if a port needs to input data, an interrupt from the port causes the computer to suspend the servicing of the keyboard and turns its attention for servicing the port. After servicing the port, the computer resumes the suspended job. Each device has a particular IRQ. If more than one device shares the same IRQ and all the interrupt shared devices are active at the same time, a conflict occurs. This creates instability problem to the system. 8-bit system has eight interrupt lines while 16-bit system has 16 interrupt lines. Modern systems have additional number of interrupt lines. Some interrupts are reserved for internal devices while some are available for using with expansion cards. Interrupt that is reserved for a device becomes free to use only when that device is not installed. Each IRQ line is identified by a number starting from zero such as IRQ0, IRQ1, etc. The interrupt IRQ0 is having the highest priority. Interrupts with higher numbers are having lower priorities. To handle interrupts correctly, interrupt controllers are used in the motherboards. IRQ connections are made available in expansion slots at a particular pin and the expansion card can identify the interrupt from the signal available at the pin in the expansion slot.

There are sixteen interrupt requests under the normal conditions. Some are reserved for specific devices. Sharing of interrupts for different devices is possible. Also, the reallocation of interrupts can be done, if required. System information gives a list of all hardware devices that are mapped to IRQ in the system. The sixteen IRQ and their functions are given in Table 3.14. Advanced Programmable Interrupt Controller (APIC) option in BIOS makes available to the twenty four interrupt requests of the system. APIC in motherboards offers facility for adequate interrupt sharing also. To make use of this feature, the option in BIOS is to be enabled. Use of advanced features in BIOS also helps in avoiding interrupt conflicts.

Table 3.14 IRQ and Corresponding Functions

IRQ	Function	IRQ	Function
0	System timer	8	CMOS real time clock
1	Keyboard controller	9	PCI
2	Second interrupt controller	10	PCI
3	Communication port 1	11	PCI
4	Communication port 2	12	PS/2 Mouse
5	PCI	13	Numeric processor
6	Floppy	14	IDE
7	Parallel port 1	15	Ultra ATA

System allocates its resources such as memory, IRQ, port, addresses and so on to different devices connected to it for its proper working. Sometimes, it can happen that the allocation of resources is done in an overlapped manner. This makes different devices to use the same resources simultaneously which results in hardware conflicts. The hardware conflicts in a computer system can occur due to a number of reasons, especially while adding new devices to the system. When a new device is added, the operating systems automatically detect them and properly allocate the available resources. Sharing of resources by more than one device depends on the capabilities of the hardware and the operating system.

Hardware conflicts can be identified by analysing different symptoms such as hardware locking and system freezing, frequent data corruption while writing data, slow I/O response, incomplete printing, non-working of hardware, etc. Different troubleshooting steps associated with the hardware conflicts include removing devices that are not in use, reallocating IRQ, etc.

3.19 MANAGEMENT FEATURES

New motherboards are having several hardware and power management features. The hardware management features include the abilities for speed monitoring and control for the cooling fan as well as thermal and voltage monitoring. Fan speed controllers and sensors are integrated into the legacy I/O controller. Thermally monitored closed loop fan control helps in adjusting the speed of the fan according to different thermal conditions.

Power management is implemented in the system using software support or hardware support. Software support is through the Advanced Configuration and Power Interface (ACPI) feature due to which the operating system directly controls the power management and Plug and Play functions of the computer. The use of ACPI with the motherboard requires an operating system that provides full ACPI support. Hardware support for ACPI is through power connectors, fan headers, LAN wake up capabilities, standby power indicator LED, etc. Surge protection feature of computer power supply unit provides enough support to the system from power surges. Fan headers support closed loop fan control that can adjust the fan speed according to the thermal conditions. All fan headers have a + 12 V DC connection. LAN wake up capabilities enable remote wake up of the computer through a network. The LAN subsystem monitors the network traffic and powers up the computer when data packets are detected. The standby power indicator available in the motherboard becomes lit when standby power is present in the board, even when the computer is turned off. When this LED is lit, then it indicates that the standby power is present at the memory module sockets and the PCI bus connectors. Under such conditions, disconnect the power cord before installing or removing any device connected to the board. Failure to do so can damage the board alongwith the attached device.

3.20 SELECTION OF MOTHERBOARDS

The overall performance of a computer system is determined by the ability of the motherboards. Motherboards house different components such as CPU, RAM and other components. Currently available motherboards have varied features and abilities. While selecting motherboards, it is necessary to consider different factors such as CPU support, support for chipsets, RAM support, expansion slot available, storage capacity, connectivity features and price. Different types of CPUs are now available such as single-core, multi-core, etc. The selected motherboard must have the right socket for accommodating the desired processor. The chipset used in the motherboard determines the type of CPU as well as the type of RAM that can be used. Hence, the chipset that is accommodated in the motherboard is a determining factor for selecting motherboards. The availability of DIMM slots determines the amount of memory (RAM) that can be used with the motherboard. RAM expandability depends on the availability of free DIMM slots. The number and type of expansion slots available in the motherboard is another important factor considered for selecting motherboards. Upgrading ability of a system is based on the availability of expansion slots. Storage type and capacity supported by the motherboards is another deciding factor in the selection process. The modern motherboards offer SATA ports for connecting storage devices. Increased number of available SATA ports enables the connection of more SATA devices. Now, the connection to the external devices is done by using USB, LAN and FireWire ports. Availability of more ports helps in connecting more external devices. Hence, motherboards with more USB, FireWire, eSATA ports are better. Support for RAID facility, high definition audio, availability of fault indicator LED are some other features that must be considered while selecting motherboards.

3.21 USING MODEM CARDS

Nowadays, the computers are commonly used for running business as well as for domestic applications. Due to this, a large range of accessories and expansion cards are available for them. Expansion cards are fitted to free expansion slots of the motherboards and hence, these cards are known as **plug in** or **add-on cards**. The commonly used expansion cards with motherboards are *modem*, *Ethernet card* and *graphics card*. Expansion cards do not require casing or power supply and do not take up any desk space or need any extra cable for their connection. This is the main difference between the external devices and the expansion cards. The disadvantage of these internal expansion cards is the generation of heat. Also, when fitted inside the cabinet, most add-on cards do not provide any visual indication to the outside world for displaying their working or operating status.

Modems are of different types. Modem speed is measured using V standard. The main V standard representing modem speeds are given in Table 3.15.

Table 3.15 Different Modem Standards

Modem standard	Speed (in b/s)
V.21	300
V.22	1200–2400
V.32	14400
V.34	28800–33600
V.90	56000 (or 56 kb/s)

3.22 USING GRAPHICS CARDS

While working in graphics modes, everything is displayed on the computer monitor using dots. Even the text matter is displayed on the screen using dots. The details of dots are stored in the computer memory. Whenever there is a change in the display, the system has to redraw the thousands of dots that make up the display. If the resolution is high, then the number of dots to be redrawn also increases. Earlier computers used the CPU for redrawing the dots in the display. Using the processor for displaying dots on the screen makes it unavailable for doing mathematical calculations. This is the main reason that has led to the development and use of graphics cards in the computer systems.

Graphics cards are also known as **graphics accelerators** or **accelerated graphics cards**. These are plugged into special expansion slots of the motherboard that are known as **Accelerated Graphics Port (AGP).** Graphics cards are used in the computers that are commonly used for gaming applications. Graphics cards are fitted with their own processor and memory. The processor of graphics cards are specifically designed to perform different graphics functions. Use of graphics cards or graphics processing units relieves the CPU from doing different tasks related with the graphics. These cards are essential for 3D modeling applications and for handling video films and pictures.

Graphics cards are available in two forms. One is the programmable type and the other is the fixed type. Fixed type cards are less expensive and can perform only certain fixed functions as programmed, while the programmable type graphics cards can be programmed as per the requirement.

Graphics cards used with the computer systems are of different types and are suited for different purposes and needs. Also, these cards have different features and different abilities.

Graphics cards have turned into complex systems in themselves. Now, a graphics card has become a mini motherboard with its own Graphics Processing Unit (GPU), memory, separate heat sink and cooling fan. The arrangement of the different components of a typical graphics card can be seen in Figure 3.26.

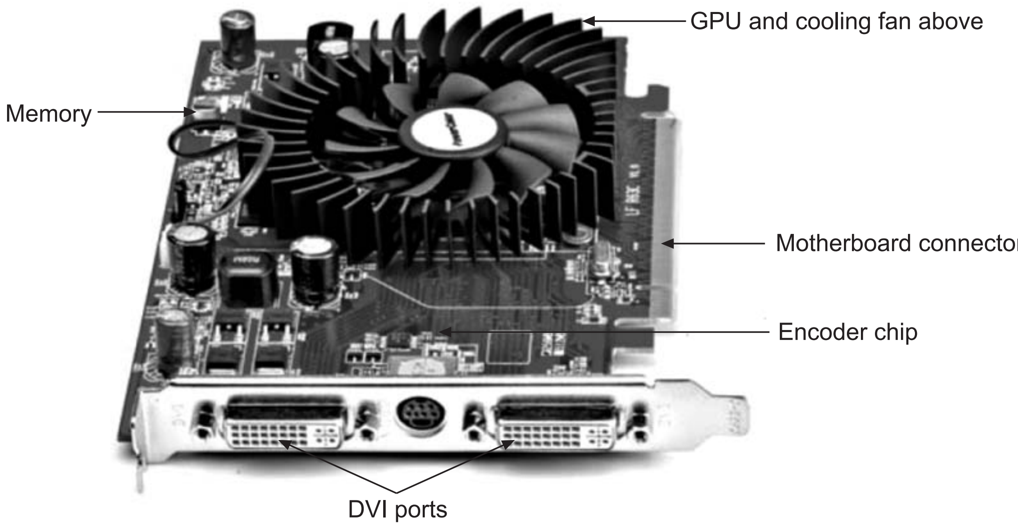


Figure 3.26 Components of a typical graphics card.

The GPU is fixed in the graphics card permanently and cannot be removed. Several manufacturing processes are used in the manufacture of GPU. Billions of transistors are compactly packed in the small GPU die. GPU is very powerful and is dedicated to the exclusive processing of graphics data. It provides all the number crunching abilities required to render the complex graphics at high speed.

Video memory is another important component of the graphics card. It stores commonly required fonts, icons and images, etc. for easy retrieval. This also stores different display frames before sending them for display. Graphics cards have memory with better clock speeds. For a lag-free gaming experience, increased memory of the order of 4 GB to 8 GB is required.

GPU displays graphics scenes by converting the graphics data and using the data for displaying each pixel element on the screen. This data conversion is achieved with the help of a digital to analogue converter (DAC). GPU has to process the data every time when the display is refreshed. Separate DAC is used to convert each RGB component of colour display.

BIOS chip and video controller are the other two components seen in the graphics cards. Graphics processors are cooled by variable speed fans. The speed of these cooling fans is tweaked by the thermal sensors. Several utilities can be downloaded from the Internet for tweaking cooling fans.

Different graphics cards differ in the core speed, stream processor type, memory type, output ports available, etc. The graphics processing unit used in the card determines the name of the graphics card. New generation graphics cards are very powerful and provide different visual effects and realism to the displayed scenes. These graphics cards can handle different graphics effects easily including the support for 3D graphics. Now the modern graphics cards generate realistic environments and experiences. These cards support several advanced features such as dynamic colour adjustments, dual stream decoding and so on. The modern graphics chips used in mobile devices supports high definition videos also. Performance of the graphics card is measured in frames per second (fps) unit. The common features associated with the graphics cards and their typical values are provided in Table 3.16.

Table 3.16 Features of Graphics Cards

Feature	Value
GPU (chipset) make	GeForce
Manufacturing process	90 nm
Clock speed	630 MHz
Core architecture	128 bits
Memory type	GDDR3–512
Memory speed	550 MHz
Memory bus width	128 bits
Maximum resolution	2048 × 1536
Internal interface	PCIe/AGP
Shader units	48 pixels, 8 vertices
Back panel interface	D-sub
GPU cooling type	Active
GPU overclocking	Allowed

Computers that are used for intensive graphics applications combine the powers of more than one graphics card. Different technologies are available for this combination. **Scalable Link Interface (SLI)** is one such technology that combines the powers of two or three graphics cards by linking them together on the same motherboard. Such graphics cards stack two cards one above the other with a common PCIe interface. The two cards communicate internally through SLI. **CrossFire X** is another technology that does the same job. Using this technology, it is possible to combine up to four graphics cards in a single PC. The hardware requirements for both the technologies are different. Also, the motherboards compatible with the concerned technology are required to support this feature.

3.23 EXTERNAL INTERFACES AND CONNECTORS

It is clear from the above discussion that the internal as well as the external devices are connected to the motherboard using different varieties of connectors or interfaces. An interface is defined as a point of interaction or communication between the components or devices that work through an input/output system and use a protocol. The aim of using interfaces is to bring seamless interaction between the connected devices. Primarily, there are two types of interfaces in the computer systems. These are hardware interfaces and software interfaces. Here, the details of the hardware interfaces are given only. Several new interface standards are introduced recently and these interfaces are replacing the outdated ones. Introduction of new interface standards leads to the use of modern types of ports for connecting devices.

Hardware interfaces used with computer systems are of two types, namely, (a) serial standard interface and (b) parallel standard interface. Serial interfaces can transfer one bit at a time over a communication channel whereas parallel interfaces can transfer multiple bits at a time. Parallel interfaces offer better performance in comparison to the serial interfaces. But, nowadays, the serial interfaces are preferred due to the difficulties in the synchronization of bit transfer at high data rates and clock frequencies for parallel data transmission. Also, due to technological advancement, serial transmission has become much faster and several new bus architectures such as USB, PCI Express, SATA have become industry standards.

There are different types of hardware interfaces that can be differentiated on the basis of the type of cables used such as co-axial cables, flat cables, standard wires, etc. and the termination method used in the cable such as soldering, welding, crimping, wrapping, etc. Different characteristics associated with the hardware interfaces include speed, quality of data transmission, compatibility and adherence to the standards. Different connectors used with the computer motherboards are in the standardized form. Due to the standardization, the same connector can be used for connecting several devices. Alongwith the standardization, these interfaces are also having plug and play capability.

For the proper working of external devices connected to the computer, the data must be transferred properly between the devices. Connection to external devices is done through sockets or ports. Computers are having different types of ports. Only two types of ports were available in the earlier computer systems, as discussed in Section 3.11. These were serial port and parallel port. Serial port was a general purpose connector and was used for connecting modems, mouse, etc. It was an industry standard port known as RS-232 port. This port made the use of one line to send data, another line to receive data and several lines for controlling the flow of data. Parallel port was commonly used for connecting printers. The data transmission of parallel port was eight times faster than the serial port transmission. The major drawback with the parallel port transmission system was the crosstalk between the adjacent wires of the connecting cable due to voltage leak. Because of this reason, the length of parallel cables was limited to three meters. In the new motherboards, these two ports are replaced by USB interfaces. Serial interface used thumb screws for firmly fixing the connector while parallel interface was firmly fixed with the help of end clips. Figure 3.27 displays a serial port interface and cable end connector while Figure 3.28 shows a parallel port interface and cable end connector.

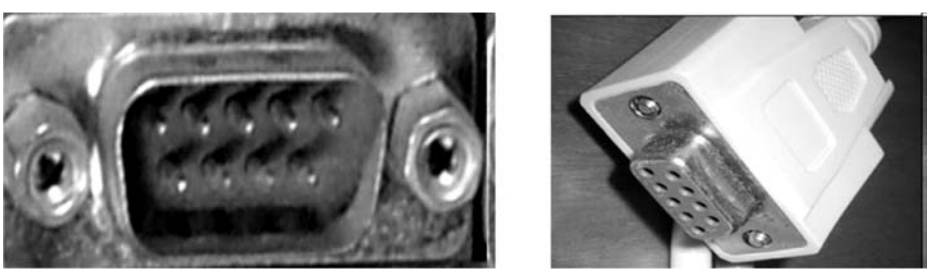


Figure 3.27 Serial port and cable end connector.

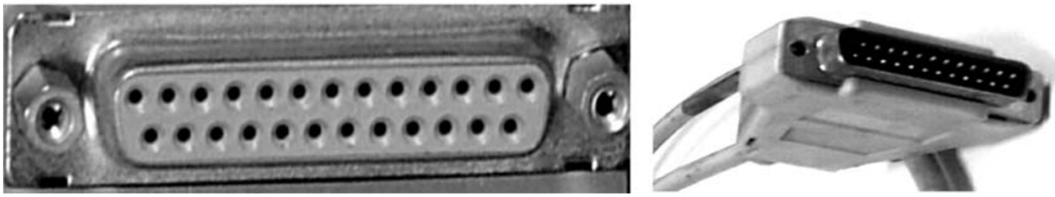


Figure 3.28 Parallel port interface and cable end connector.

The common type of display interface available is the **D-subminiature**, also known as, **D-sub connector**. This is the interface for connecting analogue CRT monitors. This interface is also called **VGA** or **SVGA interface**. The cable connector and the interface are shown in Figure 3.29. For LED type monitors, the connector used is named as **Digital Visual Interface (DVI) connector** which has superior features as compared to D-sub connectors. DVI interface is a digital type interface. Figure 3.30 displays more details about DVI cable connector and the motherboard interface. The number of connecting pins for D-sub interface is much lesser than DVI.

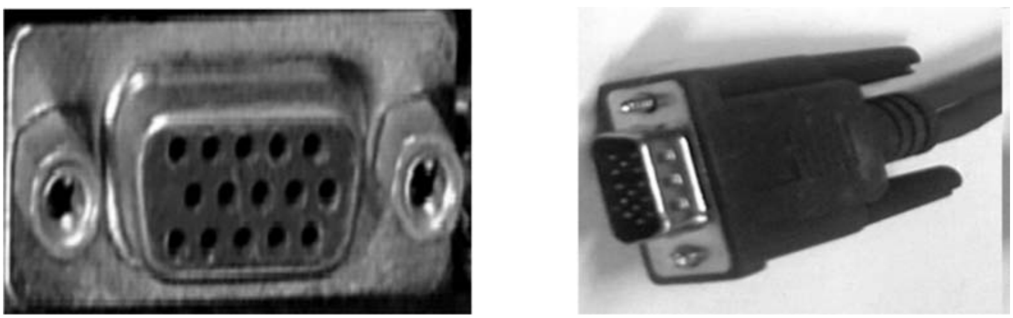


Figure 3.29 D-sub port and connector.

Figure 3.30 DVI cable connector and interface.

A modified version of DVI is **HDMI** which is the acronym for **High Definition Multimedia Interface**. This is a single media interface that has the capability for audio/video output through a single cable and this interface is commonly used for high definition display devices. It transmits uncompressed digital streams. It is a digital substitute to analog interfaces like coaxial and composite cables and is used to connect set-top boxes, Blu-ray and HD disc players, and other audio/video receivers to compatible audio and video devices like televisions and computer monitors. The interface can be identified from its shape. Figure 3.31 displays an HDMI interface and cable connector.


Figure 3.31 HDMI interface and connector.

Unified Display Interface (UDI) is an interface aimed at computer monitor manufacturers as well as video card manufacturers. This interface connector is thinner than the other types of video interfaces. The new video interface connectors are smaller and can support long connection cables. These are hot pluggable types. Another advantage of the new interfaces is that these have interlocking switches that clock into position during installation, thereby making the installation process easier. New interfaces are also having increased bandwidths.

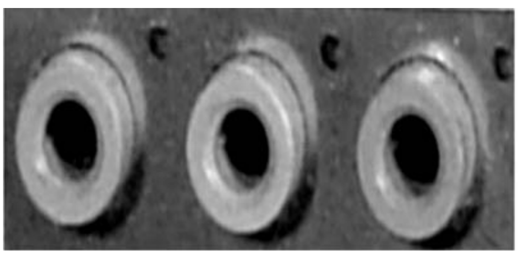



Figure 3.32 Component video interface and connectors.

Component video interfaces found in several video DVD players and television sets are shown in Figure 3.32. The interface inputs three analogue video signals, each for the three primary colours. The interface does not carry audio with the cables. Now, these are replaced by **composite video interfaces**. This interface combines all the three cables into a single cable and hence, this type of interface is made up of only one connector only. This type of interface can be seen in several VCD/VCRs, DVD players, TVs, camcorders and in certain graphics cards.

A type of video interface commonly seen in digital camcorders, DVD players and some graphics cards is the **supervideo** or **S video**. This interface is similar to the composite video output, but is provided with two separate video signal lines for luminance and chroma. This interface does not carry audio on the same cable. This type of interface can be seen in Figure 3.33.

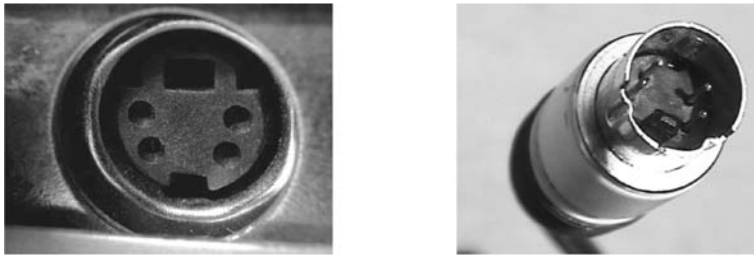


Figure 3.33 Supervideo interface and connector.

Interfaces used for communications and networking purposes are RJ11 and RJ45 interfaces. RJ11 is used for telephone connections while RJ45 is used in twisted pair Ethernet connections for networking computers. The two connectors appear identical. RJ11 connector is smaller than RJ45 connector. The two interfaces are having 6 and 8 pins respectively. Figure 3.34 shows the picture of RJ45 connector and the motherboard interface.

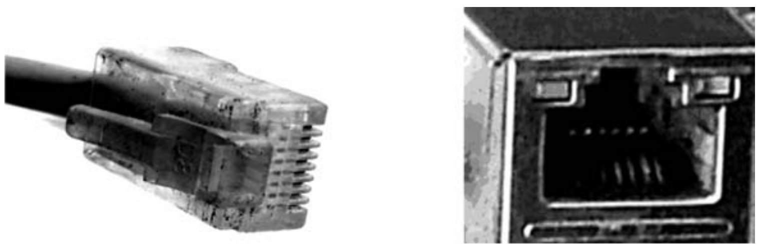


Figure 3.34 RJ45 connector and port.

The common interface used in the earlier motherboards for keyboard and mouse are the PS/2 interfaces. The keyboard interface is coloured purple while mouse interface is coloured green. These two interfaces are fitted side by side and usually appear on the rear panel. In appearance, these interfaces look similar to the supervideo interface.

FireWire interface is another interface and is used for high speed data transfer such as for importing video from camcorders or hard drives. These are speedily replaced by USB interfaces. Another common interface similar to SATA interface is **External Serial Advanced Technology Attachment (eSATA)** interface. As the name suggests, this interface is used to connect an external device directly to the motherboard. The cable connector and motherboard interface are shown in Figure 3.35.

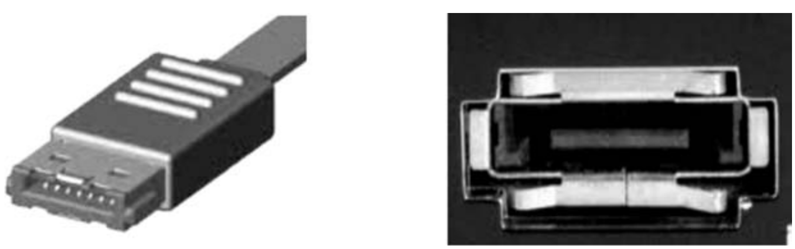


Figure 3.35 eSATA connector and port.

Nowadays, **USB**, **mini-USB** and **micro-USB interfaces** are the commonly used interfaces for connecting devices to the computer. Mini-USB interface is identical but smaller than the normal USB interface but larger than the micro-USB interfaces. Keyboard, mouse, printer, scanner, modem, storage devices are connected to the computer using USB interface. Smaller devices such as cameras make use of mini-USB interface while micro-USB is used by much smaller devices such as mobile phones. USB interfaces are having two types of connectors which are known as type A and type B. The connectors provide an upstream connection to the host and downstream connection to the device. The type A connector is used for connecting to the host while type B connector connects to the device. Interchanging of end connectors is not possible and hence, the cable can be connected in one way only. The maximum length of USB cable is five meters.

Type A USB cable connector and the USB port of the computer can be seen in Figure 3.36.

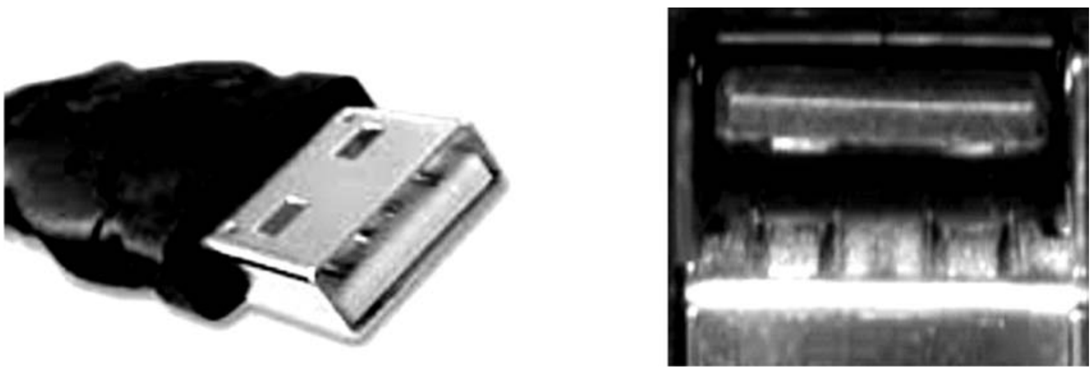


Figure 3.36 USB A type cable connector and port.

3.24 TROUBLESHOOTING AND MAINTENANCE OF MOTHERBOARDS

Earlier motherboards used different add-on cards for controlling disk drives and video display. But new motherboards integrate the different controller cards with them. Use of Surface Mount Technology (SMT) in the manufacture of motherboards helps in improving system reliability and reducing the size of motherboards and hence, the systems also get improved. This technology reduces the number of joints in the motherboards by bonding different chip level components into the motherboard rather than bonding different discrete components separately into the motherboard. Use of this technology helps in reducing power consumption of motherboards and improving their reliability. But these types of motherboards are difficult to repair and hence, get serviced.

Computer systems do not function properly if the component connectors are not firmly fixed in the slots of the motherboard. Removing and fixing the components again can solve majority of faults and make the system working. This corrective step is to be applied before proceeding to any further troubleshooting step.

The major troubleshooting steps are as follows:

(a) First of all, the data and power cables connected to the components are removed and then they are firmly fixed again. If the problem is not solved, then move to the second step.
(b) Other components connected to the motherboards, namely, processor, RAM, add-on cards, if any, etc. are removed in the second step.
(c) After cleaning the components and removing dust and contaminants deposited on the gold contacts of the add-on cards or memory, the processor and the RAM are firmly fixed in their respective slots. A cotton cloth or an eraser can be used for cleaning purpose. While cleaning, it is essential to hold the card by its side only. Touching on the contact edges is to be avoided.
(d) After fixing the expansion cards and memory modules in the motherboard, the cables are connected to the system and it is switched on again.

This process will solve majority of the problems.

An idea of the fault of motherboard can be obtained by making a close physical observation of the motherboard. Motherboards are manufactured as the multilayered boards with large components density. Even minor cracks in the motherboards can make them faulty. Similarly, cracked component chips, decoloured capacitors, etc. can be the prospective causes for motherboards failure. Capacitors store electricity for other components on the motherboard and discharges when required. Solid capacitors contain solid organic polymers while electrolytic capacitors use liquid electrolyte. Electrolytic capacitors bulge or swell and leak fluid due to several causes, thereby damaging the motherboards. As the solid capacitors do not contain liquid, they do not explode or leak. Besides this, several weak components in the motherboards can fail due to heat. Also, edge connectors of cards or pins of chips can corrode and can stop working. These faulty components are to be removed from the motherboards and must be replaced with the new components of similar types. Cold testing of ICs and capacitors are helpful in diagnosing the problem. In some cases, chips in the sockets creeps out because of the expansion and contraction. Bad solder can make the joints disconnect or can cause short circuits also.

Device drivers are essential for making use of the abilities associated with different components of the motherboards. Due to the corrupted device drivers, the components systems fail to work properly. Audio, video, graphics, networking and other on-board functions of the motherboard are controlled by device drivers. Using updated device driver versions helps in getting better performance from the device. Driver software can be updated by downloading the files from the internet and then installing on the system. Usually, the rebooting of the system is necessary to take effect of the installed driver software. Certain operating systems provide an option for roll backing the driver software for a previous working state also.

Setting the proper BIOS configuration also affects the working of the motherboards. On navigating to the advanced section of the BIOS, a number of options are available for enabling or disabling on-board functions of the motherboards. If the on-board functions are not proper, an examination of the BIOS setting is necessary before proceeding further. If the on-board functions are in disabled states, these functions will not work. In such cases, after enabling the operations in the BIOS, save the changes and then restart the machine. In some extreme conditions, a situation can arise to revert back to the previous BIOS settings which is not very hard. For this, restart the system and move to the BIOS setup utility. Different options arise which help to restart the machine with the default BIOS settings.

3.25 MOTHERBOARD: COMMON PROBLEMS AND SOLUTIONS

Some of the common motherboard problems and the suggested solutions are given in Table 3.17.

Table 3.17 Motherboard: Common Problems and Suggested Solutions

Problem	Solution
The system powers on, beeps and stops	Check the motherboard for any fault. Replace the motherboard.
The power switch is not working	Ensure that the connection to the power switch is made properly and firmly.
Unable to use the USB port	Enabling the USB port in the BIOS solves the problem.
USB devices are not detected	Enabling the USB port in BIOS solves this problem. Install the device driver software and restart the computer. If the device is still not working, check the device.
Graphics card is not working	Take out the card from the expansion slot. Clean the connecting edge and fix again. Restart the machine. If the graphics card is not working, replace the card.
Cooling fan in the chassis is not working	Ensure that the power connector of the fan is firmly fixed to the motherboard. Replace the cooling fan, if found defective
Motherboard is having only PS/2 port and hence cannot plug a USB mouse.	USB mouse can be connected to PS/2 port with the help of a USB to PS/2 adapter.
Motherboard is getting overheated	Remove dust and contaminants deposited on the surface of components. This will solve the problem.
Much sound during the working of computers	Sound due to the spinning of cooling fan can be eliminated by cleaning the dust deposited on it.
A new device connected to the computer is not detected	Install the device driver software for the working of the new device.

4

Processing Units

While dealing with the computer systems, features and details of the two types of processor units are discussed. One is the central processing unit and the other is the graphics processing unit. The former is an essential component present in all motherboards, while the latter is not common in all the computer systems. The graphics processing units are present in optional graphics cards which are present in certain special purpose computers only. Different types of computer systems make use of different types of central processing units. Desktops use a particular type of CPU while laptops use another type of it. Servers use another type of CPU which is more powerful, while the tablets use a less powerful one. CPU with multiple cores is now commonly and widely used. The selection of the CPU is mainly dependent on the type of applications that are to be run by the computer system, performance required, etc. In this chapter, the details about the different types of CPU used in computer systems, CPU features and its developmental stages are given. Apart from this, a discussion of the features of graphics processors is also included in this chapter.

4.1 PROCESSOR FEATURES

The basic structural details of computer systems were already discussed in the earlier chapters. Besides the four basic units available in the computer systems, there is also a control unit which controls the operations of all the other components of the computer system. The control unit directs the computer system to carry out different instructions. Communication between memory and other units of the computer is controlled by the control unit. This unit decides the circuits to be activated for executing different instructions. It also coordinates the activities of other units including the peripherals and storage devices linked to the computer. The operation of the control unit is spread throughout the computer system. The control unit together with the arithmetic logic unit is known as **central processing unit** or **CPU** of the computer system. It is considered as the brain of computer systems. With the development of the integrated chips, the CPU is incorporated inside a single micro chip.

The central processing unit or the processor is an integrated circuit (IC) and this forms the central data processing unit of any computer system. The processor used in computers is also known as microprocessor due to its small size. Processors have undergone several design advancements before the achievement of their present shape and size. Due to different transformations, the new processors are more compact, efficient and economical.

Processors in the computer systems receive data from input units, process the data and output the computed values. Different activities are done by the processor based on the instructions given to them. Processors are made up of registers, instruction decoders, data bus, address bus, arithmetic logic unit (ALU) and cache memory. Each component of the processor performs a certain function. Registers store different data such as values of variables, location or address of data, etc. Instruction decoders decode the instructions for executing them. Through data bus and address bus, the values of data and address locations are moved from one place to another. Different arithmetical and logical operations are done by ALU. Cache memory basically acts as the data repositories for storing frequently used data and instructions, thereby enabling their speedy access.

With the increase in size of the program and data, the requirements of memory has increased to many folds. The increase in the processing speed of the processors over the past several years far outstripped the speed of memory. But the increased processor speed cannot be fully utilized, as the time to access data and instructions from memory cannot be increased. The concept of cache memory was evolved to bridge the performance which was a bottleneck between

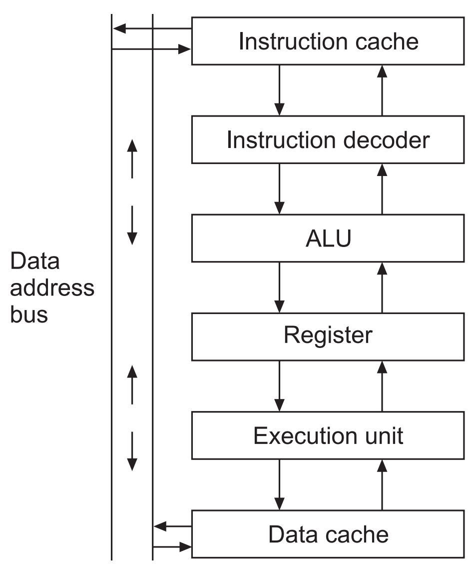


Figure 4.1 Basic structure of CPU.

the processor and the memory. Cache memory is a small memory which stores instructions, data and intermediary computed values. Instead of pulling the frequently accessed data and instructions from the main memory (RAM) or the hard drive, the CPU pulls it from the cache memory. A larger cache size means more data and instructions can be stored in it. This also makes the execution of commands faster, as the CPU can access the required command direct from the cache. New processor architectures provide separate cache for data and instructions. The different functional units that make up the CPU and their interlinking in the new processor architectures are shown in Figure 4.1.

Cache memory available with the new processors is of different types. This memory is arranged in a hierarchical structure that are named like *level 1 (L1), level 2 (L2)*, *level 3 (L3)* etc. The different memory levels are having different capacities speeds. Memory with higher speed is costlier than that with lower speed. The lower cache levels are smaller in size with increased speed and are placed closer to the processor while higher cache levels are larger in size and are located away from the processor. The arrangement of different memory levels is shown in Figure 4.2.

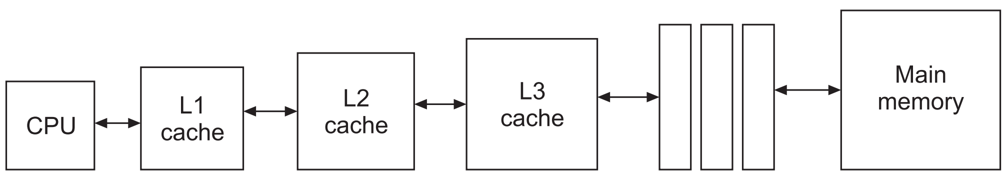


Figure 4.2 Different levels of cache memory.

In earlier processors, the cache memory was accommodated outside the processor in the motherboard. This memory was known as **external cache**. The modern processors are having the cache integrated into the processor chip. Such type of cache memory is known as **on-die cache**. Also, the new processors are having extra buffers which help in increasing the performance and efficiency of the processor and can be used for different purposes. The cache integrated inside the chip runs at the clock speed of the processor. The processor core is connected to cache memory and to the other components inside the processor chip using a bus known as **system bus** or **Front Side Bus (FSB)**. Performance of the processor is dependent on the speed as well as the width of the system bus. Higher width of FSB means more data can be transferred in each cycle. Also, the data transfer rate increases with the increase in the speed of system bus. The system bus is a feature of Intel processors only and it is absent in AMD made chips. Chips manufactured by AMD are designed with a different type of architecture.

The performance of the computer system is mainly dependent on the performance and abilities of the processor. Several features are associated with the processor and different factors affect its performance. These factors are CPU speed, word size, data path width and addressable memory. CPU speed indicates the number of operations that can be executed per second. It is also known as **clock speed** or **clock rate**. The unit of clock speed is hertz (Hz). The processor runs at a fixed clock speed and this speed is regulated by the pulses of a quartz crystal. For executing instructions, CPU requires a particular number of clock cycles. This is the speed at which the CPU communicates with various elements within the computer. Applications can run faster and better when faster processors are used. Earlier processors were having speeds indicated in units of megahertz (MHz). But new generation computer processors are having higher CPU speed which is indicated in higher units like gigahertz (GHz). The relationship between different speed units is given below:

Megahertz (MHz) = one million hertz
Gigahertz (GHz) = one billion hertz

Word size of a processor indicates the largest numeric number that can be handled in one operation by the processor. This varies from a single byte to several bytes. A large word size means that fewer operations are necessary to perform the required operation which results in a faster throughput. Also, the availability of more physical addressable memory locations is indicated by the large word size. The memory that can be addressed by the processor cannot be increased without any limit. A particular processor chip can address only a certain fixed amount of memory only. The number of memory locations that can be addressed by the processor is determined by the data path or bus width. Data path width determines the rate of transfer of data between the components. A wider data path means more data can be moved in less time. Hence, the speed of operation is high. Higher data path increases the efficiency of CPU. An 8-bit bus can address 2^8 (or 256) memory locations. Modern processors are having bus widths of 32 bits and 64 bits. 32-bit bus can address up to 2^{32} memory locations or 4 GB memory. A 64-bit processor can address up to 2^{64} memory locations. Processors with higher data path widths offer better performance and capacity. To achieve the advantages of higher data path size, the motherboard and registers must have the increased bus width also.

Processors are manufactured by integrating millions of transistors and other electronic components in a small area, in a packaged form. Different types of packages are used by different manufacturers for the manufacture of different processor chips. Packages used by AMD and Intel are shown in Figure 4.3. Earlier types of packages were named as *flatpack*, *Pin Grid Array* (*PGA*), *surface mount types*, etc. Flatpack is having flat solder leads placed along all its four sides. Pin grid array has concentric set of pins on the bottom of the pack. This array can be of different types such as *Organic Pin Grid Array* (*OPGA*), *Ceramic Pin Grid Array* (*CPGA*), etc. Organic pin grid array packaging is made up of fibre glass or resin, while ceramic is used in ceramic pin grid array packaging.

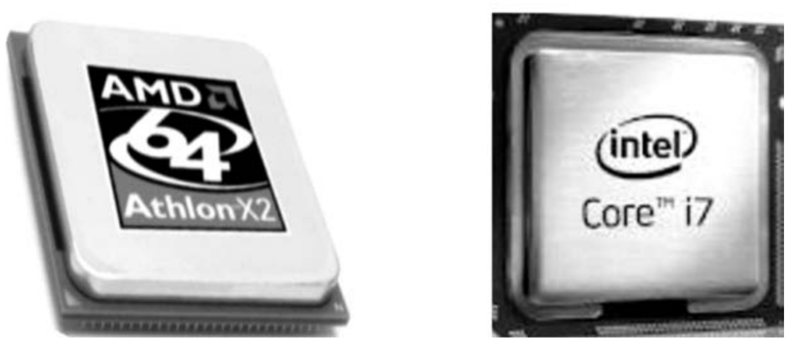


Figure 4.3 AMD and Intel processor packages.

CPU is mounted on the motherboard in specially designed CPU sockets. The purpose of the socket is to provide an adequate support to the CPU and the cooling fan fixed on its top side. Moreover, it also ensures that the processor chip is firmly and correctly plugged on its position and it is making proper connection with the motherboard. Depending on the CPU type selected, different types of CPU sockets are used in the motherboards. The design aspects of the CPU sockets vary with the processor used. Any type of processor cannot be accommodated in any of the sockets in the motherboard. A particular CPU can only be accommodated in the particular socket designed for it. The different CPU sockets are named as *PGA socket*, *LGA socket*, etc. Different variants of the socket types are indicated using numbers alongwith the socket name. For Intel processors, different CPU sockets are known by names like *LGA 771*, *LGA 775*, *LGA 1156*, etc. For AMD processors, the sockets used are known as *Socket 478*, *Socket 563*, *AM2*, etc. Manufacturers release new processors enclosed in the new type of packages. This makes it necessary to use new motherboards for using new types of processors.

Apart from the use of new sockets, new processors are designed to support only new memory types, new chipset, etc. New processors support the new DDR3 memory only. *Nehalem architecture* used for Intel-based chips have three memory channels using which the memory controllers address the DDR3 modules. Also, memory controllers are integrated in the new processor chips and these do not form part of the chipset on the main board. Virtualization support is another feature of the new processors. These processors are optimized for running multiple operating systems simultaneously.

4.2 DEVELOPMENTAL STAGES OF CPU

Processors are manufactured by different companies. Different processors are having similar features and all of them work identically. Through the past several years, the computer processor chips have passed through several stages of improvement processes. Earlier computer processors were having less computing power and lower efficiency as compared to the new generation processor units. The first microprocessor chip developed was the **Intel 4004 chip** in 1971. This was a 4-bit chip running at a low speed. It was not much powerful and was commonly used in calculators. Researches for the development of better and powerful processor chips were continued. The result was the development of a series of 8-bit processor chips by Intel. The new 8-bit chips series developed were named as **8080**, **8086** and **8088** *chips*. *Intel 8088 chip* is the first processor chip used in home computers. The computer that used this chip was named *Altair 8800*. The new chip worked faster than the earlier Intel 4004 chip. Researches were still continued for the achievement of better processors and **Intel 80286**, a 16-bit chip was made available by Intel in 1982. After three years, another powerful processor chip was released by Intel, known as **Intel 80386** which was a 32-bit chip and had better features such as multitasking. Another processor chip known as **Intel 80486** was released in 1989 and this was more powerful than the previous ones. Intel 80486 was a 32-bit chip. This chip was followed by another better processor known as **Intel Pentium processor**. **Intel Itanium processor** is a 64-bit processor which was released in the year 2001. These processors can work with numbers that are up to 64 bits long and hence, these are suitable in places where data intensive applications are to be executed. These processors are made up of registers and buses having 64 bits width.

Each new processor developed by Intel offered added abilities and better features such as increased speed and less power consumption. Intel also delivered different processor versions having name extensions such as *SX*, *DX*, etc. for certain earlier processors. The different versions were having different features. To enhance multimedia abilities, **MMX processors** were also developed by Intel. Pentium processors were released in different versions such as *Pentium II* (*PII*), *Pentium III* (*PIII*), *Pentium IV* (*PIV*), etc. Another version named as *Pentium M* was released later for using with mobile systems. The enhanced abilities of advanced processors are helpful in satisfying the increased needs of different areas such as education, entertainment, training and research. Intel processors are widely known and these are commonly accepted. Computer processors created by AMD such as **Athlon**, **Semptron**, etc. are also used in the computers alongwith Intel processors. AMD processors are also evolved through different stages of development. **AMD Athlon** released in 1999 was a 32-bit processor. AMD also released 64-bit processors. Apart from Intel and AMD, another processor chip manufacturer is Motorola. *Macintosh* computers mainly use processor chips manufactured by *Motorola* company.

Earlier processor chips were designed for performing different simple mathematical operations such as addition, subtraction, multiplication, division, etc. To perform intensive computing types operations in earlier computers, another chip was added in the motherboards to relieve the processors from the task of doing different number crunching operations. This additional chip included in the motherboards was known as **math coprocessor**. This chip was designed to work alongwith the main processor so as to boost the system performance. Math coprocessors were designed to perform complex mathematical operations such as trigonometric operations, complex variables operations, exponents operations, fractional number operations and so on. Presence of math coprocessor helped in making the mathematical computations faster. The first math coprocessor chip developed by Intel was **8087 chip**. Later on, the math coprocessor chip versions were known by names such as **80287**, **80387**, etc. For each processor in the 8086 family, Intel developed several other math coprocessor chips also. These chips are plugged into the empty socket located near the processor socket. New computer processors are designed with the integrated math coprocessors and hence, math coprocessors cannot be seen as separate chips in the new motherboards.

Modern computer processors with 32-bit and 64-bit architectures have replaced the earlier lower bit processor architectures. The new generation processors are having features such as higher clock frequency, increased processor efficiency, faster and efficient cache system and higher bandwidths. Some major techniques used to increase the performance of the microprocessors include the use of increased cache memory, parallel operations, Reduced Instruction Set Computing (RISC), Complex Instruction Set Computing (CISC), faster clock pulses, etc. Use of the latest processors in the computers provides several advantages in their working. Since, the new generation processors are very powerful, they enhance the productivity of users with the help of collaboration software, network integrated business applications, knowledge management applications, smart agents and enhanced multimedia capabilities. New generation processors also help to reduce the time, thereby reducing the cost of their ownership.

Notebooks and other portable devices use special types of processors. These processors are designed to reduce overheating and battery loss. The mobile processor released by Intel is named as *Centrino*. AMD has the mobile processor named as **Turion** Low power mobile processor specifically designed by Intel for mobile Internet devices such as laptops, notebooks, etc. is *Intel* **Atom** *processor*. It is one of the smallest processors with the least power consumption.

4.3 TOWARDS MULTIPLE CORE PROCESSORS

Processors make use of different techniques so as to increase their operational performance. One technique used for increasing the performance of processors is to include more number of transistors within the chip. Another method used is to increase the clock speed of processors. Normally, increasing the number of components makes the chip size large. More number of components can be accommodated in the same chip size by reducing the size of components. But the component size cannot be reduced beyond a limit, since the smaller components are having reduced efficiencies. Also, the switching process of small components leads to higher heat dissipation, thereby heating the system enormously. The same result appears in case of increasing the clock speeds of processors beyond a limit. On increasing the clock speed of processors switching speed also increases, which finally leads to an increased heat dissipation.

To avoid these difficulties, processors were begun to be designed using multiple cores. Adding more cores in a processor chip makes a way for its increased performance. Now, the multiple core processors are having more than one core fabricated in the same chip. The operating system of the computer treats each core as a separate processor. Each core of the processor can have separate cache memory or a shared cache memory for different cores. The architecture of a multi-core processor with two cores and shared cache is shown in Figure 4.4.

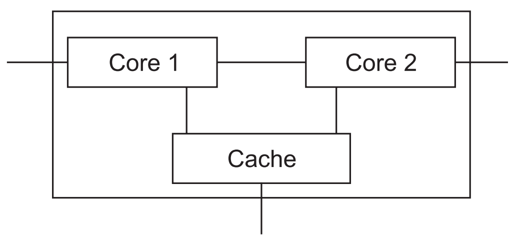


Figure 4.4 Two core processor architecture.

Traditional microprocessors from Intel 8080 to Athlon and Pentium are all single-core processors. After Pentium, Intel started releasing multi-core processors. Dual-core processors were the first type of processors that were released under multi-core processor series. Dual-core processors are having two cores. These are, basically, made up of two processors residing side by side as a single unit. Later on, quad-core processors made up of four cores were released. Six core and eight core processors were also made available. Going beyond four cores becomes complicated and the interprocess communication becomes complex. Due to this, the cost escalates too much.

Multiple core processors provide the benefits of increased performance due to increased transistor count. The problems associated with the running of multi-core processors at higher clock speed is avoided, as the cores in multiple core processors run at lower clock speed as compared to the single-core processors. The increase in parallelism makes up the loss in the clock speed for the overall increased performance of the processor. This type of core architecture allows a processor to execute as many independent threads as the number of included cores, simultaneously. *Thread* is a term used to indicate a part of a program in execution. When a program is executed, it creates one or more threads doing different tasks. The new core architecture is capable of executing several threads simultaneously.

Earlier generation multi-core processors were having common cache for different cores. In *Intel Pentium D* processor, there was no common cache for different cores. In this processor, each core was having a separate cache exclusively for its use. The architectural arrangement of the processor is shown in Figure 4.5. In this architecture, if core 1 wanted to communicate to core 2, the message was taken out of the first core using the slow bus, then it was transferred to the second core. Communication between the cores was made through the front side bus. A drawback of this type of separate cache architecture was the overflowing of cache during the active state of some cores which led to some performance degradation in the working of cores. Due to this, the concept of separate cache for each processor was changed. The new architecture just pools in all the cache and connects the processor cores to it, using a bus. This architecture ensures that the cores can communicate to each other at much higher speeds. Intel uses the name *Smart Cache* for this shared cache. This architecture helps in the better utilization of the cores when one of the cores is relatively less loaded. But this requires the addition of a memory controller for an effective management of the memory between different cores of the processor.

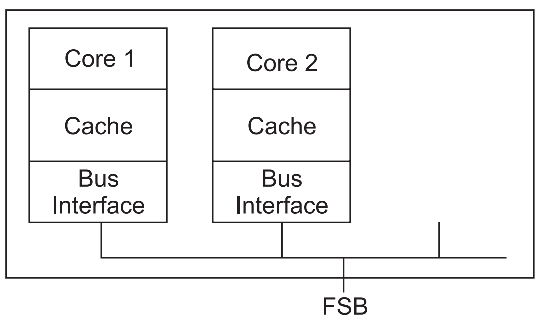


Figure 4.5 Multi-core processor with separate cache.

A variant of the dual-core processor architecture used by Intel is the **Core Duo** *architecture*. The code name used by Intel for this type of processor is **Yonah**. Single-core and dual-core processors are also fabricated using this architecture. Single-core processor using this architecture is known as **Core Solo**. Cache for instruction and data are provided in the chip die. A common high speed level 2 (L2) cache is shared by both the cores using a special technology and this allows dynamic allocation of cache to different cores as per the requirements. Dynamic allocation makes it possible to allocate the entire cache to one core when the second core is remaining idle. Also, the data can be shared by the two cores. The data can be modified by one core and can be utilized by the second core. Sharing cache avoids the storage of data in multiple locations in the memory. Data traffic through the bus and the latency can be reduced due to the sharing process.

Efficient power management is another feature of Core Duo processors. The processor can move to different power consumption levels depending on the activity of each core. This means that if only one core is required, the second core can enter into idle state to save power. The processor is based on a whole new fabrication process and is thinner than the earlier processors. The processor is faster and uses lesser power.

Simply putting multiple cores into a processor chip do not help in increasing the performance of processors. For increased performance, the way in which the different cores interact is very much significant. Presence of multiple cores does not mean that the cores are doing things independently and are processing completely different streams all the time. There might be some conditions when they would need to work on the same data. This means that each core has to make an effective communication between the other cores. Different manufacturers have found to use different architectures for multi-core processors. In case of AMD processors, different cores can access the common cache and all cores are able to interact with each other at core speeds. The link that enables the direct connection of different components with the processor is known as **HyperTransport Link**. The architecture based on the HyperTransport Link is known as **Direct Connect Architecture (DCA)**. This architecture ensures that the precious clock cycles are not wasted while the system waits for the slow bus. Communication between different cores of the processor is achieved by connecting different cores.

Use of multiple core processors improves speed and performance and aid multitasking operations. The performance of multi-core processors is high with the same amount of power. Use of multiple core processors helps in reducing the number of processor units, especially in server computers. This helps in reducing the size and complexity while designing the powerful computers. Multiple core processors developed by Intel are generally known as **Core i series** and these are known by names like *Intel Core i3*, *Intel Core i5*, *Intel Core i7*, *Intel Core i9*, etc. These processors are 64-bit processors. Each type of processor makes use of a different type of socket for getting plugged to the motherboards. Core i3 processors are having two cores, Core i5 and Core i7 are having four cores and Core i9 is having six cores. These different processors have different clock speeds and different cache memories. Clock speed and cache memory increase from Core i3 to Core i9 processors.

In context of the processor fabrication technology used, different types of fabrication architecture are common in processor fabrication. Processor manufacturers use different code names to denote different types of fabrication architecture. Multiple core processors of Intel are manufactured using an architecture known as **Nehalem architecture**. This architecture differs from earlier processor architectures. Each upgrade of this architecture results in a different code name or a different motherboard socket and a different design. Each improved processor offers more elements for processing and communications and hence, offers more powerful performance.

Higher cache memory, increased speed, higher word size and better performance are the major features associated with the multiple core processors. Hyper-threading and on-die memory controllers are the other notable features of multiple core processors. Hyper-threading allows to perform different tasks faster, thereby increasing the efficiency of the processor. Executing different applications by different cores is made possible using suitable instruction codes. However, a single threaded application does not get any benefit while running in a multi-core processor system. Users running more than one application at a time are benefited in terms of performance while using multi-core processors.

4.4 PROCESSOR ARCHITECTURAL DETAILS

It is clear from the above discussion that different processors differ in their architecture, manufacturing process and the number of cores. *Intel Pentium D* processors were based on the older **Netburst architecture** using the 90 nm fabrication process. The older *Core Duo* and *Core 2 Duo* were based on **Core architecture** and were fabricated using the 65 nm process. Newer *Core 2 Duo* processors are made using a leaner 45 nm process. The *Core 2 Quad series* processors are made up of four cores. The *Core i7 series* processors are having a brand new *microarchitecture* with four cores and are fabricated using 45 nm process.

Different processes and technologies are used in the manufacturing of microprocessors. Originally, the technology used was the 800 nm technology. During the course of time, the technology got changed and this was replaced by 90 nm technology. The currently used architecture is the **Core microarchitecture**. This architecture, during the earlier period, developed 65 nm processors which were followed by 45 nm processors. Intel Atom processor is manufactured using 45 nm process. New microprocessors are manufactured using 32 nm manufacturing process. From the names of manufacturing technologies itself, it is possible to get an indication of the size of the processor chips. Use of reduced process technologies (with less nm) aims to shrink the included components in the processor and to pack the components very close to each other. It has been discussed earlier that each processor chip is made up of several millions of transistors packed in a single die having a small area. These processor chips include different sizes and types of cache memory such as L1, L2 and L3 types. The use of new technologies helps in increasing the performance of the microprocessors and hence, reducing the energy consumption, thereby causing less heat dissipation. These new processors are of single socket types with multiple core processors with increased L3 cache. Increased cache helps in reducing the traffic between the CPU and the processor. High definition graphics is integrated with the new processors. Use of hyper-threading technology helps in multitasking by allowing different processing cores to run multiple threads, thereby providing an efficient performance. In multi-core processors, Simultaneous Multi Threading (SMT) doubles the number of threads that can be run simultaneously by each processor. Microarchitecture hyper pipelined technology increases pipeline depth leading to an increase in the processors performance and frequency capability. This architecture also eliminates the bottlenecks arising in the performance of the processor. Direct audio and video abilities provide richer user experience. New processors are also getting smarter and efficient by self-controlling power consumption, by shutting down or reducing power consumption during the time of inactivity. Turbo boost technology automatically boosts its performance in the emergency situation.

Another *Intel Core i5* processor, code named as *Clarkdale*, is having an architecture named as **Westmere architecture**. This architecture is based on dual-core CPU and is fabricated on 32 nm fabrication technology. This desktop processor is meant to be highly power efficient and produces lesser heat. It can work at increased clock speeds during overclocking. The processor goes into overclocking mode automatically as per the requirement of the running applications.

Also, an on-chip graphics processor unit is included with the processor. This feature facilitates better graphics output, thereby enabling the user to play high-end graphics without plugging in any additional graphics cards. The processor connects through an LGA 1156 socket which was used to connect the previous Lynnfield processors.

4.5 PROCESSOR SPECIFICATIONS

Several specification parameters are associated with the processors. The major parameters affecting the performance of the processors are the number of registers, clock frequency, FSB speed and the amount of cache memory. Some of the common parameters and their typical values are given in Table 4.1.

Table 4.1 Processor Specification Parameters and Typical Values

Parameter	Typical Value
Manufacturing process	45 nm
CPU socket	LGA 775
Clock speed	2.5 GHz
FSB speed	1066 MHz
Multiplier	9.5
Number of cores	2
L2 cache	3 MB
L3 cache	4 MB
Virtualization support	Yes
Thermal design power	65 W

4.6 INSTALLING AND UNINSTALLING CPU

Static electricity can damage electronic components including the processor chip and the motherboard. So, every precaution must be taken before touching any electronic component to avoid any damage due to static electricity.

(a) Before touching the processor, first of all the anti-static wrist strap must be tied on the hand.

(b) CPU sockets in the motherboard are of different types. Here, only the latched type CPU socket is discussed. In this type of CPU socket, the released lever on the processor socket is unlatched at first and then it is turned to the vertical position.

(c) Now, the new processor is taken out of its pack. It should be checked that no pins of the processor are bent or distorted.

(d) After that, the processor is aligned with the socket. For proper alignment of the processor with the socket, indications are shown on the processor surface such as cut marks. The bottom side of the processor, where thousands of contact pins are arranged systematically in an array, can be seen in Figure 4.6. Figure 4.7 displays the surface of the CPU socket in the motherboard. Methods used for ensuring proper alignment of the processor pins with the connecting points in the CPU socket can be easily understood by studying these two figures.

(e) Now, to install the processor, it is slowly placed above the socket in the correct alignment and then gently inserted in the socket. No force is needed to be applied to insert the processor in the socket. The CPU fits in only one correct orientation. Forcing the CPU into the socket can damage the CPU pins as well as the socket.

(f) Once the CPU is correctly seated in the socket, the released lever is pulled very gently and firmly and the processor is locked on its place.

To uninstall the processor from the socket, the reverse operation is to be done.

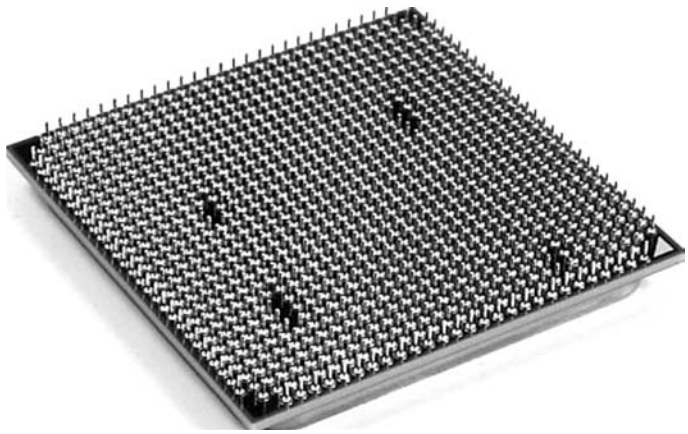


Figure 4.6 Rear side of the processor containing contact pins.

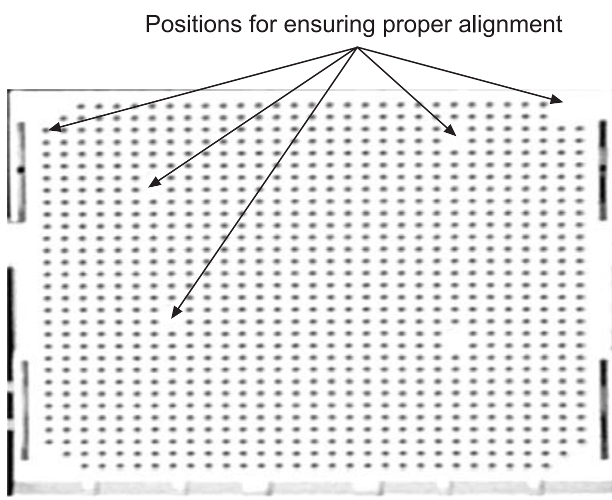


Figure 4.7 CPU socket surface in the motherboard.

4.7 CPU OVERHEATING ISSUES

Processor chips are made up of several thousands of electronic components such as capacitors and transistors assembled in a small area. These chips get heated up during their working. Increased heat generation reduces the efficiency as well as the durability of the electronic components. Cooling provisions such as heat sinks, cooling fins and cooling fans are provided for the easy dissipation of heat. Cooling of CPU is done with the help of CPU coolers. CPU cooling kits are designed for effective cooling during overworking and overclocking of the CPU. The CPU cooler includes a heat sink and a fan module fitted on the top. The removable fan module eases the installation and cleaning of the heat sink and fans. Apart from the cooling fans, new processors are provided with copper heat pipes to dissipate the generated heat.

For installation in motherboards, the heat sink and the cooling fan provided with the processor are to be used. If the fan or the heat sink is damaged, components of the same type can be used as the replacement. Two models of CPU cooling fans and heat sinks can be seen in Figure 4.8.

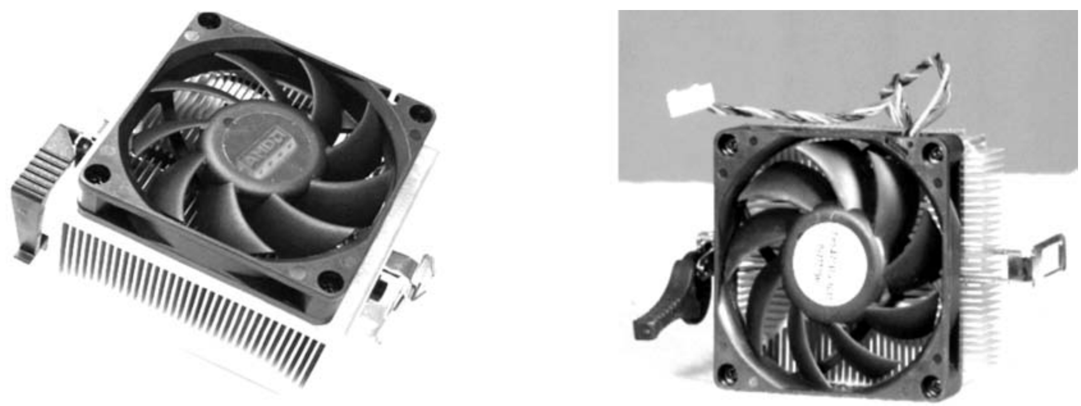


Figure 4.8 Two types of CPU cooling fans and heat sinks.

Before installing the heat sink, a thermal compound is applied above the processor surface. The heat sink is then aligned horizontally above the processor. After this, it is firmly fitted and its position is locked. The method of locking the heat sink depends on the design used. After properly installing the fan, the power cable from the fan is connected to the fan connector in the motherboard.

While installing the heat sink, it is necessary to make sure that it is not touching the socket or the motherboard, as the generated heat can damage it. Usually, the heat sink is fitted above a holder made of some non-conductive material. The holder is, first, fitted firmly to the motherboard using screws at the four corners of the holder, as seen in Figure 4.9. The screws are properly fixed with the help of a back plate placed below the motherboard. The heat sink is fixed on the holder and it must be ensured that the heat sink is not in contact with the motherboard.

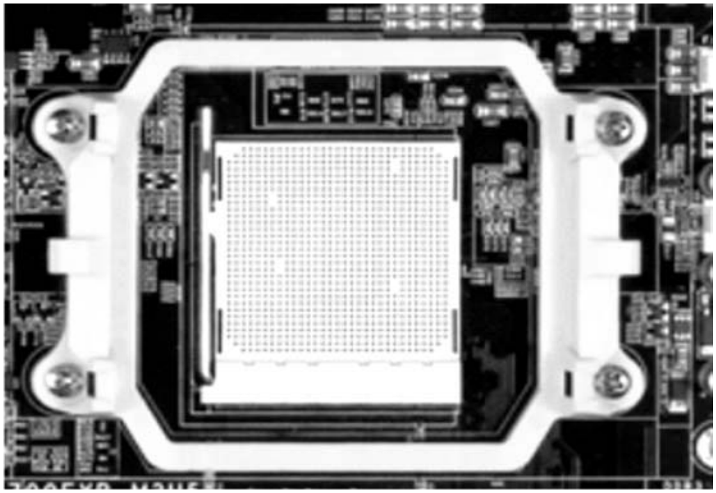


Figure 4.9 Holder for fixing CPU heat sink.

Despite all these arrangements, sometimes the CPU gets overheated. Due to this the system components stop functioning or get damaged. Rebooting of the system is an indication of overheating. Several reasons can be stated for CPU overheating. Running heavy applications such as gaming applications and media player software can cause the overheating of CPU. The working condition of the existing cooling system is to be checked, if an overheating is detected. The air vents must be cleaned and made dust-free to maintain free air circulation inside the cabinet. If required, more cooling fans are to be fitted. Cleaning the top of the processor, applying a fresh layer of heat sink compound and firmly fixing the heat sink without any air gap between the processor and the heat sink, helps in reducing the trouble caused due to CPU overheating.

Another method employed to cool the computer systems during their working is the use of liquid cooling or water cooling systems. The extra cooling provided by the liquid cooling is conducive for overclocking as this cooling lowers the inside temperature. The speed of cooling made by liquid cooling system is better than the air cooling system. Different types of liquid coolers are now available. The cooling system consists of a cooling kit made up of coolant, radiator and a pump. The pump provides the necessary force for circulating the coolant through the cooling system. The coolant is stored in a reservoir and is circulated through cooling pipes. The heat is transmitted to the radiator while the coolant is circulating through it and thus, the heat is dissipated. Due to this process, the temperature of the coolant is reduced. The process continues and the temperature is kept to an optimum level by this method.

4.8 PROCESSOR: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the processors and their suggested solutions are given in Table 4.2.

Table 4.2 Processor: Common Problems and Suggested Solutions

Problem	Solution
The computer produces continuous beep during booting	This is an indication that the processor is not working correctly. Make sure that the processor is seated correctly in the socket. Ensure that there are no broken or bend pins on the processor. If there are such types of pins, replace the processor.
The processor is getting overheated	Wipe or clean the processor surface with a clean cotton cloth to remove the dust. Apply a coating of the thermal paste on the exposed area of the CPU. Ensure that there are no contaminants on the surface of the CPU. Fix the heat sink and cooling fan firmly. Ensure that the cooling fan is working properly at the correct speed.
The system freezes during its working	This can be a problem due to overheating of the processor.

4.9 GRAPHICS PROCESSING UNITS

Graphics processing units have undergone several metamorphoses through several years. Currently available graphics processing units are richly featured and these provides several advanced facilities such as higher performance and three-dimensional abilities.

Graphics processing units are made up of several cores of shader and texture units. Shaders are of two types, namely, vertex shaders and pixel shaders. These are responsible for creating effects such as High Dynamic Range (HDR) lighting suitable for the games. Vertex is the corner of a triangle that is connected to another triangle in a polygon. Polygon (such as rectangle or triangle) form the building blocks of all three-dimensional objects. Each vertex has some characteristics such as its weight, colour, texture, etc.

Vertex shaders are capable of producing certain realistic experiences such as waves rippling in a pool, stretching and wrinkling of clothes, etc. **Pixel shaders** can produce smoke and fire effects, reflection of light in water and other surface effects. These shaders are responsible for colouring, shading individual pixels in each frame. This type of creating graphics effects produces a natural look to the materials and surfaces.

Table 4.3 Specification Parameters of GPU

Parameter	Typical value
Manufacturing process	45 nm
GPU (chipset) make	GeForce
Core speed	700 MHz
Maximum resolution	2048 × 1536
Vertex shader	8 vertices
Pixel shader	48 pixels
Power consumption	250 W
Overclocking	Allowed

Characteristics of GPU depend on the core speed of the processing unit. Faster the core speed, faster is the GPU. Pixel and vertex shaders are responsible for the smooth display of graphics. Hence, the number of pixels and vertex shaders affects the performance of the graphics system. Increased number of pixels and shader units makes the display better. New graphics systems are having unified shader models instead of separate vertex and pixel shaders. Similar to the central processing units, graphics processing units are also fabricated using different technologies such as 45 nm, 32 nm and so on. GPU are manufactured by several manufacturers. Different specification parameters of a GPU are given in Table 4.3.

Graphics processors are designed for different graphical operations and for doing graphics intensive tasks. Intensive graphics based operating systems are currently in use and these operating systems make use of the processing capabilities of GPU for creating graphic interfaces including 3D effects. GPU is needed for rendering graphics such as visual effects and animation. Advanced GPU provides several abilities beyond 3D effects. This unit is also called **Visual Processing Unit (VPU)** and it provides abilities to crunch difficult tasks at greater pace.

5

Memory and Storage

Memory is essential for the working of a computer system to store the data and instructions. Also, it is one of the performance enhancing components of the computer system. It is an important factor that determines the speed of a computer. Memory forms the workspace for the processor. In computer systems, the terms *memory* and *storage* are used with different meanings. Memory refers to the temporary storage while the term storage is used for the permanent storage. Several types of memory and storage are currently available that include main memory, cache memory, registers, optical storage, tape system, etc. All these types differ in their capacity, access speed and cost. Memory and storage have evolved through several stages of their development. In this chapter, a detailed description about the memory and their features as well as different types of common storage devices used in the computer systems is given.

5.1 FEATURES OF COMPUTER MEMORY

Bit is the basic unit of computer memory. For specifying large memory values, this basic memory unit is not sufficient and higher memory units are required. Byte is a higher unit of computer memory. One byte is equivalent to eight bits. One byte of memory is sufficient to store any character that can be represented in ASCII code. With the use of improved technology and the development of integrated chips, the memory capacity of currently used devices has increased several times. Higher units of computer memory are measured in units such as kilobyte (kB), megabyte (MB), gigabyte (GB), etc. The relationship between the higher memory units and byte is as given below:

1 kilobyte (kB) = 1024 bytes
1 megabyte (MB) = 1,048,576 bytes
1 gigabyte (GB) = 1,073,741,824 bytes

But for convenience, 1000 is taken as the multiplying factor. Hence, the relationship between different memory units can be written as follows:

1 kilobyte (kB) = 1000 bytes
1 megabyte (MB) = 1000 kilobytes
1 gigabyte (GB) = 1000 megabytes
1 terabyte (TB) = 1000 gigabytes
1 petabyte (PB) = 1000 terabytes
1 exabyte (EB) = 1000 petabytes
1 zettabyte (ZB) = 1000 exabytes
1 yottabyte (YB) = 1000 zettabytes

CPU works several times faster than the speed of the memory. But, if the memory is slower, the CPU has to wait till the data is made available to it for processing. This slows down the working of the system. Several measures are taken to increase the speed of system. Quicker and expensive memory devices are used for the immediate CPU needs resulting in the increased speed of CPU. Whereas slower and less expensive devices are used for storing data that are not immediately required. All the different storage devices work in a coherent manner so that the entire devices work in unison. Several manufacturers use *interleaved memory designs* to speed up the memory. In this design, the memory is split into different banks. This design helps in the better management of memory. Another technique used is the *paged memory*. Here, the memory is arranged in small units known as pages. This is a modified version of the interleaved design. Use of *cache memory* has become common in CPU for speeding up operations. CPU cache is a high speed memory that stores the information that is often needed or recently accessed. Cache acts as a storage buffer to store data temporarily. Cache memory uses fast memory chips and these are also very expensive. This memory is directly accessible by the CPU. Another method used by several manufacturers is the use of different combinations of storage devices such as fast registers, cache memory, etc. Use of combined storage devices helps to reduce the exclusive use of fast memory in the computer systems.

Several features determine the ability of memory. An important feature associated with the computer memory is access time which determines the speed of memory and hence, the speed of the system. A method of increasing the speed of systems is to use fast memory. But fast memory is expensive. Memory access time is measured in smaller time units known as nanoseconds (ns). Computers use memory chips having a speed of 70 ns or less. Peak data bandwidth or throughput is another measure for memory performance. This is a measure of data transfer speed. The data transfer speed is actually the product of memory speed, number of byte transferred per channel and the number of channels available.

5.2 TYPES OF COMPUTER MEMORY

Different types of memories are used in the computer systems and these are known by different names. Computer memory can be classified on the basis of different features. Based on the access speed, computer memory is of two types—one is the primary memory and the other is the secondary memory. The term *memory* is commonly used to refer primary memory and the term *storage* is used to refer secondary memory. **Primary memory** is fast and is costly. It is also called as **main memory** or **Random Access Memory (RAM)**. CPU can directly access the data stored in the primary memory. The speed of a system increases with increase in RAM capacity. A large RAM means more files can be loaded in the temporary storage. Loading more files in memory helps the CPU to access the required files at a fast speed. Different applications require different amounts of minimum RAM availability for their proper functioning. Performance of RAM is measured by its type and speed.

Graphics cards make use of another type of memory known as **video memory** or **Video RAM (VRAM)**. The video memory has also gone through several stages of transformations. **Synchronous Graphics RAM (SGRAM)**, **Windows RAM (WRAM)** were the earlier types of video RAM. The current standard is GDDR5 that offers increased bandwidth and consumes less power. These memory modules can be found in graphics and gaming cards.

Secondary memory is cheap and this memory is used for the permanent storage of data and applications. This memory also stores the instructions that are to be executed by the system. The access of CPU to secondary memory is through input/output channels. As the CPU does not have a direct access to the secondary memory, CPU cannot execute the code stored in the secondary memory. Therefore, the code is copied to the primary memory from the secondary memory so that the CPU can execute the code. Hard disk is the common secondary memory used in the computer systems which is available as internal type and external type. Other common storage devices used with the computer systems include flash memory, CD, DVD and tape drives.

Depending on the nature of the storage used, computer systems make use of two types of memories. One type of memory is the **volatile memory** and the second type of memory is the **non-volatile memory**. RAM is a volatile type memory in the sense that whatever stored in the RAM is lost, when the electric power is off. There are two types of RAM—one is the Dynamic RAM (DRAM) and the other is the Static RAM (SRAM). **Dynamic RAM** can be programmed and the information stored in it can be changed. It is having low power consumption and large cell densities but low access speed. It is made up of transistor capacitor pairs. Capacitor can remain either as charged or as discharged. Using the two states of capacitors, it is possible to represent the two binary digits, namely, zero and one. Data is represented by charging (applying a high voltage) or discharging (applying a low voltage) the capacitor. Capacitors lose their charge quickly. So, this type of memory requires to be refreshed in every few milliseconds. Due to this feature, the term *dynamic memory* is used to refer to this type of memory. This term is used to indicate the refresh process of capacitors. **Static RAM** is made up of transistors and is optimized for speed. This type of memory works in the form of latches and hence, these do not require refreshing or rewriting. These are faster but have low cell densities. So, it is costly. This type of memory is used as cache memory in the computer systems.

For working with the CPU having increased clock speed, the speed of RAM chips must also be increased proportionally. Memory that is synchronized with the system bus is known as **Synchronous Dynamic RAM (SDRAM)**. This memory can work at the system bus speed (FSB speed). The earlier DRAM type named as *EDO* (*Extended Data Out*) *DRAM* was not a synchronous type memory. Another fast DRAM used in the earlier computer systems was the

Rambus DRAM (*RDRAM*), manufactured by Rambus. All these different memory standards did not provide the ideal throughput between memory and CPU. The concept of dual-channel RAM setup was evolved for evading the bottleneck between the RAM and the CPU. RAM modules in a dual-channel setup can communicate with the memory controllers at double speed, due to their increased bandwidth. Memory controller in the chipset acts as a controller for the data transfer between CPU and memory. This type of memory is known as **Double Data Rate SDRAM (DDR SDRAM)**.

Use of multiple core and multiple threaded processors required to transfer the data at a fast rate for fast processing. As the number of cores in processors was increasing, the volume of data traffic between the processor and the main memory was also increasing. For the effective management of this increased data traffic, the need for the faster memory was also increased. This led to the adding of improved memory modules such as *DDR1*, *DDR2*, *DDR3*, etc. to SDRAM family. These new memory modules are designed as card types and these offer a hassle-free operation. These card types memory modules are known as **Dual In-line Memory Module (DIMM)**. These modules have improved heat dissipation abilities and universal compatibility. These memory modules are having better performance and consume less power. Also, the speed of new memory modules is higher as compared to the earlier memory modules.

Different types of RAM modules can be identified by their shapes and the position of notches on their motherboard connecting edge. Currently, the memory used in computer motherboards is DDR3 type memory. DDR3 DIMM exactly looks like DDR2 DIMM and both are having the same physical size but the notches appearing on the motherboard connecting side are in different positions. Hence, DDR3 offers no backward compatibility with DDR2, since it impossible to insert DDR3 module in the slot of DDR2 module. Hence, interchanging of DDR2 and DDR3 modules is not possible. The structure of DDR1, DDR2 and DDR3 memory modules is illustrated in Figure 5.1.

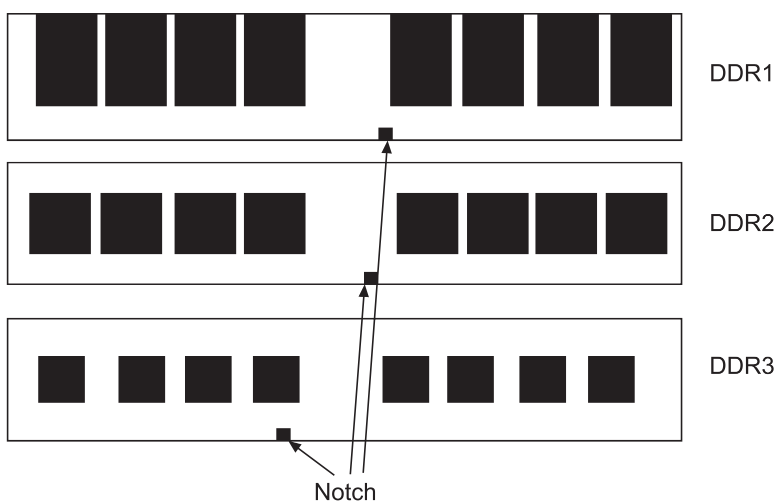


Figure 5.1 DDR1, DDR2 and DDR3 memory modules.

DDR1, DDR2 and DDR3 memory are available in different capacities such as 1 GB, 2 GB, etc. The different members of SDRAM memory family are having the same clock rate as the SDRAM but the data transfer speed is increased using the double sampling method. DDR2 is available at speed of 667 to 800 MHz whereas DDR3 memory is rated at 1066 MHz to 1333 MHz. Due to this increased speed, the data transfer rate of DDR2 and DDR3 has increased. For memory working at 400 MHz in dual-channel mode, the bandwidth is equivalent to 400 MHz × 8 Bytes × 2 Channel, which is turn, is equal to 6400 MB/s or 6.4 GB/s. The data transfer speeds of DDR2 and DDR3 modules are 6.4 GB/s and 10.6 GB/s respectively. DDR3 has the capacity of fetching 8 bits of data in a clock whereas DDR2 can fetch only half of the data, i.e., 4 bits per clock. Due to the increased speed, DDR3 memory has become the choice for high performance graphics applications. Another feature of DDR3 is its higher energy efficiency. DDR3 runs on 1.5 V whereas DDR2 requires 1.8 V for its operation. Thus, power consumption of DDR3 is much less. Due to the higher clock speed of DDR3, its latency (wasted clock cycles) is also higher and this is considered as its drawback. Increased DIMM capacity, small page size, higher memory throughput make DDR3 very suitable for multi-core servers. New motherboards accept only DDR3 memory. A comparison of the major features of DDR family memory modules is given in Table 5.1.

Table 5.1 Features of Different Memory Modules

Feature	DDR1	DDR2	DDR3
Operating voltage	2.5 V	1.8 V	1.5 V
Buffer	2 bit	4 bit	8 bit
Speed	400 MHz	800 MHz	1800 MHz
Module	184 pin DIMM	240 pin DIMM	240 pin DIMM
Capacity	1 GB	2 GB	8 GB

Non-volatile memory is also known as **Read Only Memory (ROM)**. This type of memory is used for the permanent storage of data and programs. Whatever stored in this type of memory remains permanent even when the electric power is turned off. Read only memory devices are of two types. In one type, the stored content can be erased while in the second type the stored content cannot be erased. Hard disks, floppy disks, thumb drives are the examples of first type of storage devices. This type of memory devices is used as the secondary memory or storage of computer systems. Here, the stored content can be erased and new content can be stored. Earlier types of BIOS chip used for booting computer systems are the examples of the second type of ROM. This is a permanent storage and cannot be erased. There are ROM chips that can be programmed and then these contents can be retained. These chips are known as **Erasable Programmable ROM (EPROM)**. There are different methods of erasing the contents of chips. Ultraviolet rays can be used for this purpose. Also, using electric power, certain ROM chips can be erased and reprogrammed. Such chips that are electrically erasable and programmable are known as **Electrically Erasable Read Only Memory (EEPROM)**.

Earlier computer systems were having limited memory. Those systems used vacuum tubes and magnetic core memories. Core memories made the use of iron cores for storage purposes.

Data was stored in core memories in the form of magnetic patterns on the surface. Now, the magnetic core memories are replaced with semiconductor memories which are available in the form of electronic integrated chips. These are made up of fast switching components and can hold the information of the order of millions of bits. Semiconductor memory is having low access speed of the order of nanoseconds. These are made up of millions of tiny capacitors that can hold charge to represent the two binary digits, namely, zero and one. As the capacitors cannot keep the charge for an unlimited time, these have to be refreshed at regular intervals. On the basis of manufacturing style used for the memory chips, these are grouped under different names such as *Single In-line Package* (*SIP*), *Dual In-line Package* (*DIP*), *Single In-line Memory Module* (SIMM), *Dual In-line Memory Module* (DIMM), etc. Different chips address different amounts of memory. The different memory modules can be identified by their appearance. DIP is a rectangular package that holds an integrated circuit. DIP has a total of two parallel rows of legs along both the long sides of the rectangular package, with one row on each side. SIP is also a rectangular chip with all pins appearing in a straight line on one side of the package only. These are the earlier types of memory used in computer systems. These types of memory are soldered into the motherboard and hence, upgrading the memory is difficult. SIMM is a strip of high capacity memory chips arranged in a tiny circuit board that plugs into SIMM sockets on the motherboards. DIMM appears similar to SIMM but it is faster than SIMM. DIMM is a 168-pin, 3.3 V dual in-line memory module. The modern motherboards make use of DIMMs in different capacities as Random Access Memory (RAM). These motherboards usually have two or more DIMM slots for connecting memory modules.

5.3 WORKING OF COMPUTER MEMORY

Digital data is stored in the computer memory or in the storage by converting it into binary digits. The memory of a computer behaves like a set of switches. These switches can be set into two different states, namely, on state and off state and the switches can remain set for the time during which the power is available. Each state of the memory switch represents a binary digit and hence, can store one binary digit. The space required to store one binary digit is known as **bit**. The basic storage element that can store one bit of information is known as a **cell**. Therefore to store one byte of information 8 cells are needed. To represent one kilobyte, 8192 cells are needed. In this way, 8,388,608 memory cells are needed to represent a memory of 1 megabyte capacity.

Large memory units are formed by arranging the cells in a two dimensional array or grid of cells arranged in rows and columns. Each cell of memory grid is having an address and this address helps in identifying each cell individually. The organization of cells for a typical memory grid of 1024 bits is shown in Figure 5.2. To accommodate 1024 bits, the grid is formed with 32-bit row and 32-bit column sizes. Each cell in the grid is identified by using a number pair representing the row number and the column number of the grid array. Separate signals are used for identifying the row number and column number and these are known as **Row Address Strobe (RAS)** and **Column Address Strobe (CAS)**. As CAS and RAS need to represent numbers up to 32, these are designed with 5 bits wide. CAS and RAS can be seen as physical signal pins on the memory modules. Large memory storage is achieved with the help of several chips working together. Memory modules are controlled with the help of memory controllers which are responsible for handling the signals going from CPU to the memory. To read or write data to the memory chip correctly, the signals, namely, chip select, data bus, read or write select, row and column address decoder are necessary. The address bus links different memory units. Each memory unit is addressed by setting the address in the address bus. The data bus carries data between the memory and the other components of the computer.

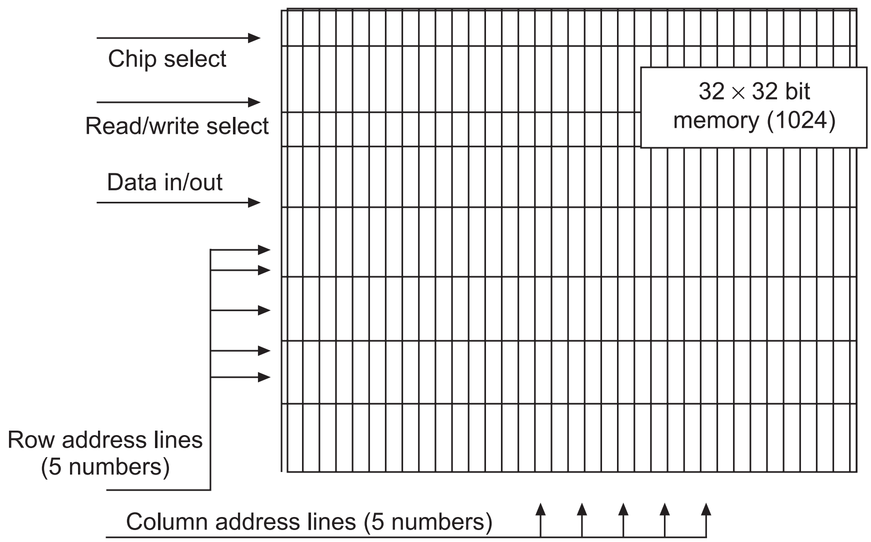


Figure 5.2 Organization of memory.

When the CPU sends signals to the memory, the memory controller, first, accesses the row by putting an address on the address pins and activating the RAS signal. Then, the CPU waits for a few clock cycles before sending the CAS signal. This delay between the sending of the two signals is known as the **RAS to CAS delay**. Then, the CPU waits for a few clock cycles before sending data. This delay is known as **CAS latency**. Latency means the time delay in accessing memory from the time when a request is made on the CAS and RAS pins. CAS latency can be stated as the maximum time taken (in clock cycles) for the RAM to commence sending data. Memory is usually having CAS latencies denoted as *CAS 2*, *CAS 3*, etc. CAS 2 latency indicates a delay of two clock cycles whereas CAS 3 latency denotes a delay of three clock cycles. Lower CAS latency means a faster data access.

5.4 MEMORY MAP

For the proper working of a computer system, it has to load different types of files to its memory. These different types of files that are loaded in the memory include operating system files, device driver files, different controller files, BIOS setup files, application files and so on. Also, a computer reserves some memory space for certain specific purposes such as for the use of video buffer, loading ROM details, etc. Computer loads the required files in an ordered manner in specific locations. It allocates different amounts of memory for different purposes. Memory map is a listing of how the memory is allocated for different purposes. Memory map details are stored in a firmware in motherboards and these details are used during the booting time of computers. Different motherboards are having different memory maps. Memory allocation for different purposes are done by specifying the address range of memory commencing from the start address. At the bottom portion of the memory lies the BIOS area for loading BIOS details. This is followed by other memory partition spaces for loading operating system files and system driver files. Certain amount of memory is reserved for the use of video details and for loading different controller files. A typical memory map is given in Table 5.2.

Table 5.2 Typical Memory Map

Address Range (Hex)	Size	Use
000000–0004FF	1280 B	BIOS area
000500–09FFFF	640 kB	Operating system files, Device drivers
0A0000–0BFFFF	128 kB	Video buffer
0C8000–0CFFFF	32 kB	Reserved
0D0000–0EFFFF	128 kB	Controller files
0F0000–0FFFFF	64 kB	BIOS set up utilities

5.5 INSTALLING AND UNINSTALLING MEMORY MODULES

Sometimes, it is required to increase the memory of computers. Adding more memory to the vacant memory slots can increase the available memory. Replacing the existing memory module with a larger capacity module can also increase the memory capacity. While installing new memory modules, it is necessary to ensure the compatibility of the new module with the chipset and the bus speed of the motherboard.

The normal method of fitting the memory module include the sliding of the memory module into the memory slot with the locks kept wide apart present on either ends of the slot. After properly and securely fitting the module, the end locks are closed. This keeps the memory module correctly in the slot. The method of installing a DIMM memory module is shown in Figure 5.3. The earlier SIPP memory did not contain any locking mechanism to prevent the vibrations from its position.

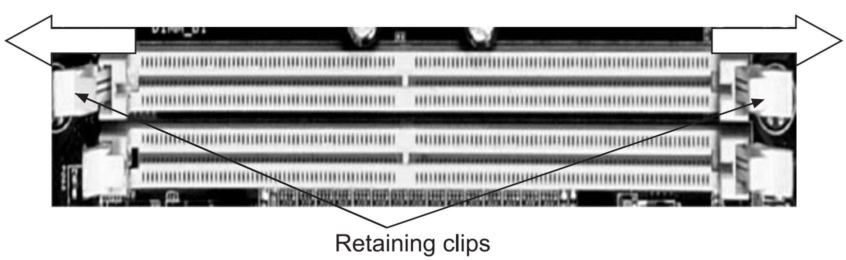


Figure 5.3 Installing memory module in memory slots.

To uninstall a memory module, first of all, the end locks are released by moving the locks away from their positions. After that, the module is slowly lifted from its position. In this way, the module can be taken out of its slot.

5.6 MAINTENANCE AND TROUBLESHOOTING

Memory problems are difficult to trace. Problems associated with the memory appear to be caused by other components of the computer system. Problems such as the failure of computer systems from booting, appearance of Blue Screen Of Death (BSOD), frequent rebooting, out of memory error, slow performance of the system and so on can be due to the problems associated with the computer memory modules. It is difficult to attribute the cause of the problem at the first instance itself, since the problems can happen due to several other reasons also. Moreover, the reasons for different errors cannot be specifically displayed.

Different types of RAM modules are available. But motherboards can support only a particular type of RAM module. For effective working, the speed of RAM modules must match with the speed supported by the motherboard. Due to speed mismatch between memory modules and the motherboard, it is not possible to get optimum performance expected from the memory. Use of a right type of memory modules can help in avoiding any speed mismatch error. As the performance of the system depends on the size of RAM used, a higher memory is preferable for better performance.

Memory modules do not work if the module is not properly installed in the slot. Dust deposited on the connecting edge causes the undetection of the memory module. Removing the module from the slot, cleaning the connecting edge and then inserting the module back to the slot will solve the problem.

5.7 MEMORY: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the computer memory and the suggested possible solutions are given in Table 5.3.

Table 5.3 Memory: Common Problems and Suggested Solutions

Problem	Solution
The amount of memory displayed by the system is less than the actual installed physical memory.	Make sure that all the modules are seated correctly. Also, make sure that the modules installed are of correct types.
Memory is not detected	Defective memory module. If the module is not properly installed, it is not detected.
The system powers on but there is no display	The problem may be because of faulty RAM modules or the incorrect seating of modules. Remove the module, clean the connecting edges and reinstall correctly.
The computer emits beep code and does not boot.	Check the RAM modules. Remove the modules, clean the connectors and reinsert. This will solve the problem.
Display of memory failure error.	Check the RAM modules. Remove the modules, clean the connectors and reinsert. This will solve the problem.

5.8 STORAGE DEVICES

Storage solutions that are currently available in computer world, are of different types and these vary from Direct Attached Storage (DAS) solutions to Network Attached Storage (NAS) solutions. Use of disaster recovery methods and business continuity planning has boosted the demand for better and reliable storage solutions. Storage used with the computer systems can be either internal storage or external storage type. The most common internal storage used in the computer systems is the **hard disk** which is also known as **fixed disk**. Hard disks store data on magnet-coated surfaces in the form of magnetic patterns. Commonly used external storage devices include hard disks, DVD, magnetic tape, flash drive, etc. External storage devices are connected to the computers through USB, FireWire or other interfaces. Data transfer to external hard disks is faster than data transfer to the optical devices. External hard disks are reliable and cheaper. **Optical storage** has become a common storage technology in the recent years. This technology makes use of laser beams for storing data and files in the medium. CD, DVD, Blu-ray are the examples of storage devices that are using optical storage technology. Storage devices are available with different storage capacities. A large storage means more applications and files can be stored in it. Capacity of the modern hard disks is measured in higher units such as gigabytes (GB), terabytes (TB), etc.

5.9 HARD DISKS DETAILS

Hard disks are made up of several rigid circular platters. Both sides of the circular platters are coated with a special type of magnetic material that can store data in the form of magnetic patterns. The platters are mounted on a spindle which can rotate at a high speed with the help of an electric motor. Each platter in the hard disk is having a read/write head attached to it. Several movable heads read data from all the platters as well as write data to them. The entire arrangement is stored in a sealed case. The circular platter is divided into concentric circles known as **tracks**. Each track is divided into several partitions known as **sectors**. Each sector holds 512 bytes of data. Sector is the smallest accessible unit of platter. A group of sectors is termed as a **cluster**. The number of sectors available on the inner track is lesser than that on the outer tracks. A combination of sectors and tracks of all vertical platters is known as a **cylinder**. The number of sectors forming a cluster is the minimum space allotted by the operating system for storing a file on the disk and this size varies with the capacity of the operating system. Data is stored in sectors, tracks and cylinders and in both sides of the platters. The arrangement of tracks and sectors is as shown in Figure 5.4. The total capacity of disk can be calculated when the details of tracks and sectors are known. The storage capacity is calculated using the following equation:

Storage capacity = Number of sides × Heads × Surface × Number of tracks × Number of sectors × 512 bytes.

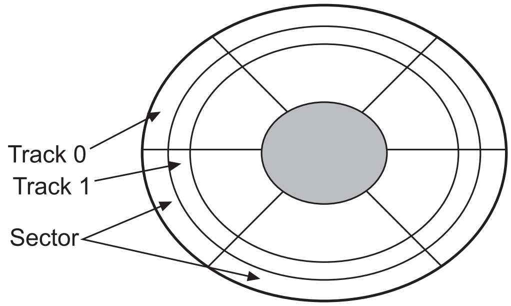


Figure 5.4 Arrangement of tracks and sectors in hard disks.

The constructional details of a hard disk can be understood from Figure 5.5. Different hardware components that make up the hard disk include platters, spindle, read/write head, actuator, actuator arm and face plate. Each component of the hard disk performs specific tasks. Any process on the magnetic disk surface such as read, write, erase, record or playback data on the magnetic medium is done by the read/write head which is fitted at the end of the actuator arm. The process of reading from or writing to the sectors involves two steps. First, the read/write head is moved to the desired track. The position of the head is controlled by a device known as **actuator**. The head waits until the required sector comes under it. In second step, the spindle is rotated by the electric motor (stepper motor) that makes the sector to take position below the head correctly. When the desired sector comes under the head, the reading or writing takes place. The read/write head never makes contact with the platter surface.

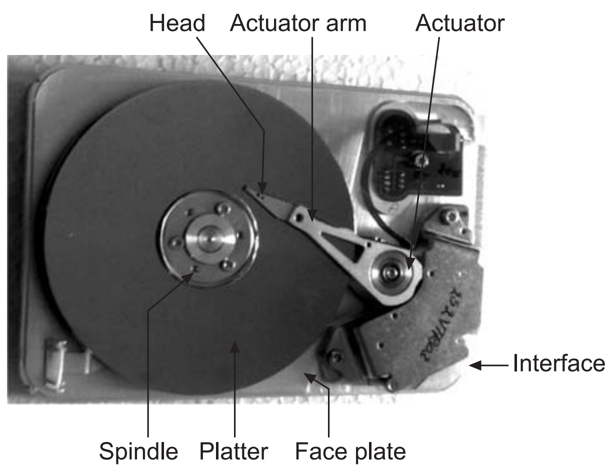


Figure 5.5 Parts of a hard disk.

A computer file need not to be stored in continuous sectors and tracks of hard disks. The file is stored in different sectors along different tracks and cylinders. To correctly locate the file, computer makes use of two information, namely, directory entry and File Allocation Table (FAT) entry. The directory entry provides the name of the file. This entry consists of the file name, file type extension, its attribute, date and time of last update, starting cluster number and the file size. FAT provides the list of sectors in which the file is stored. This is in the form of a double linked list.

5.10 WORKING OF HARD DISKS

Basically, the recording process involves magnetizing the surface of the spinning disk with a set of signals corresponding to the data that is to be recorded. Electronic circuits convert the electrical signals into magnetic pulses for recording on the surface of the disk. The process of recording on to the disk is known as **disk writing**. Reading is done using the reverse process. The recorded magnetic pulses are converted to electrical signals and these electrical signals are then converted to meaningful data.

There are different methods for coding electrical signals to magnetic patterns. Frequency Modulation (FM) and Modified Frequency Modulation (MFM) were the two common methods used for recording data to hard disks. Now, these earlier coding schemes have become obsolete. These are replaced by a new coding scheme known as **Run Length Limited (RLL) coding scheme**. RLL coding scheme is being used in different optical media also. The necessary coding circuits are included in the hard disk mechanism and new hard disks can use any of these methods. The emerging technology makes the use of perpendicular recording for data storage. The new technology replaces the traditional longitudinal recording technology. Perpendicular recording offers greater storage density.

5.11 FEATURES OF HARD DISKS

First hard disk was designed and introduced by IBM in 1950. Earlier hard disks were larger in size and were having reduced storage capacity. These were originally called as **fixed disks** or **Winchesters**. Later on, these storage devices were named as hard disks. A hard disk requires hard disk controller for the proper storage and access of data. Separate circuits in the form of add-on cards were used as hard disk controllers in earlier motherboards. In new motherboards, the controller is integrated with the motherboards.

Everything from the boot up time of the operating system to the startup time taken by an application is directly affected by the performance of the hard disk. It is measured using different parameters such as access time and spindle speed. Spindle speed is the speed at which the platter rotates. A faster spindle speed indicates a faster data access. The spindle rotates faster than read/write heads. The read/write head delays (for a short time) to move to the correct sector in the track where the data is available. This time delay is known as **latency** and is measured in milliseconds. Access time is the time taken to find the required data from the disk. For this, the head has to move to the correct sector in the correct track. Seek time is the time required for the read/write heads to move between the tracks. A lower seek time means better performance. It is also measured in milliseconds. Access time is dependent on seek time and latency and is the sum of these two parameters.

The maximum speed at which the data is transferred to and fro from the memory is known as **bust transfer rate**. Time taken for continuous reading or writing data is known as **data transfer speed** and is measured in megabytes per second. The speed at which the spindle rotates is the speed of hard disk and is measured in rotations per minute (rpm). Earlier, we had hard disks rotating at 7200 rpm while new generation hard disks have rotating speeds of the order of 10000 rpm and 15000 rpm. The diameter size of currently used platters is 3 inch and 3.5 inch. The trend is towards the use of less form factor platters. Less form factor platters means faster read/write operations, better access time and reduced power consumption. These platters are having increased storage capacity. This is made possible due to the increased data storage density achieved by using advanced technology. Also, the increased storage density helps in the use of less number of platters, thereby reducing the overall size of hard disks even for the higher capacity hard disks.

Internal buffer or cache of the hard disk acts as a temporary storage and this helps in speeding up the hard disk operation. A larger cache makes the system faster. The difficulty with this type of design (using internal buffer) is that the hard disk controller meant for one type of hard disk cannot work in another type of hard disk. The basic concept of Integrated Drive Electronics (IDE) is emerged with a view to combine the hard disk and the hard disk controller as a single unit. This type of combined or integrated interface came to be known as **IDE interface**. This type of interface was used for the first time in the earlier AT type computer systems. The original name for IDE interface was AT Attachment (ATA) means that the interface was developed for AT type computers. Later on, this type of interface was used for different computer systems and began to be used for connecting other storage devices such as optical drives. SATA is a modified version of ATA/IDE standard. SATA standards offer easy management ability at lower costs with comparable speeds.

Faster storage devices are having higher cache memory, faster spindle speeds and solid state (flash memory-based) drives. Flash drives are the fastest available storage media as they have static parts due to which the access time for data read and write operations is reduced. A method used for clubbing or coupling two or more hard drives to create a better performing or higher capacity storage medium is **Redundant Array of Inexpensive Disks (RAID)**. Use of RAID helps in reducing the Mean Time Between Failures (MTBF) of the storage systems. MTBF of an array of disks is equal to the MTBF of an individual drive divided by the number of drives in the array. RAID is implemented at different levels. RAID 0 is the method of striping the data into an equal number of segments. The different data segments are stored in different drives at the same time. RAID level 0 is not redundant. This RAID level helps in speeding the data read and write processes, thereby achieving higher data throughput speeds. This RAID level is achieved by using software or hardware methods through the on-board RAID controller or through the operating system. Opting for RAID 0 is beneficial when data transfer speed of a storage drive is important. Although RAID 0 gives better performing storage solution, there is a risk of losing data when one of the hard drives fails, as there is no redundancy of storage. To take the advantage of the performance of RAID, other RAID levels such as RAID 10 or RAID 5 can also be opted. In these RAID levels, the risk of data loss is lower because data is striped as well as mirrored. The stripping of data and mirroring operations are done with the help of controller units known as **RAID controller units**. These are available in the form of add-on cards or are integrated in the motherboard of the computer. In order to avoid the risk of losing data from hard disks when the system is switched off, hot swappable or hot pluggable type hard disks help in replacing hard disks while the system is in powered on state.

5.12 INSTALLING HARD DISKS

Hard disks make use of different types of interfaces for connecting to the motherboards. Two common hard disk interfaces currently used with desktop computers are *IDE* and *SATA* interfaces. IDE interface makes use of IDE ribbon data cables to connect hard disk to the motherboard while SATA interface devices use SATA cables for connecting hard disks to the motherboards. Nowadays, SATA interface is mainly used as a hard disk interface. Earlier motherboards had *SCSI* interfaces only, while the new motherboards are having both types of interfaces.

Cable length supported by IDE interfaces is short and hence, this interface is used as an internal solution. IDE devices use ribbon cables for connecting different devices to the motherboard and also to the other IDE devices. These cables have 40 or 80 small wires arranged in a parallel (flat) manner. IDE cables are having three connectors, as shown in Figure 5.6. The connectors are provided at the ends of the cable for connecting to the motherboard or to the other devices. The third connector is available nearly at the two-third length from the one end. To maintain signal integrity, the maximum cable length allowed is forty-six centimeters. The wire at one side of the ribbon cable is coloured which is connected to the first pin of the IDE connector. Cable key (a small projection) on the middle of the cable end connector prevents the cable from wrongly connecting it to the motherboard.

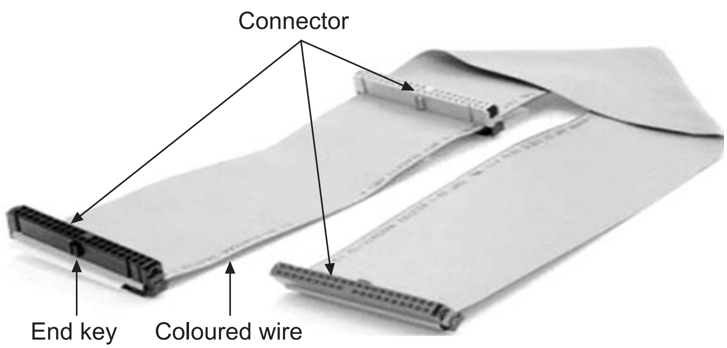


Figure 5.6 IDE ribbon cable and end connector.

Hard disks have two connectors on their front panel. One is for connecting the power cable from the power supply unit and the other is for connecting the data cable. These two connectors are arranged side by side. Two IDE devices can be connected using a single IDE channel. When two devices are connected in the same cable, one device is assigned the master status and the other is assigned the status of slave. Only then, the system can work correctly. This configuration of the device is done by suitably setting the jumper pins on the device. Jumper pins are also provided on the front of the hard disk. The entire arrangement is clear from Figure 5.7. Data for the two connected devices pass through the same channel but with two different frequencies. Master device uses the higher frequency while the slave device uses the lower frequency. So, there is no clash in the data transfer between the connected devices. Connectors at the ends of channel can be interchanged for connecting to device or to the motherboard.

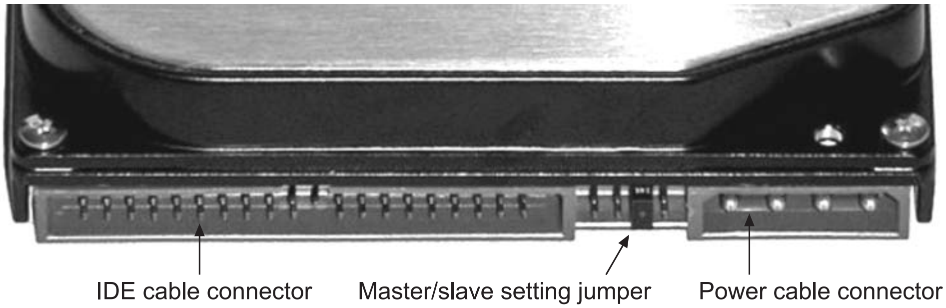


Figure 5.7 Front panel of IDE hard disk.

The installation process involves three steps which are as follows:

Step I The hard disk is fitted to the bottom empty bay on the computer chassis using screws.

Step II The data cable is connected between the hard disk and the motherboard.

Step III The power cable from the power supply unit is connected to the hard disk.

The method of connecting data and power cables is illustrated in Figure 5.8.

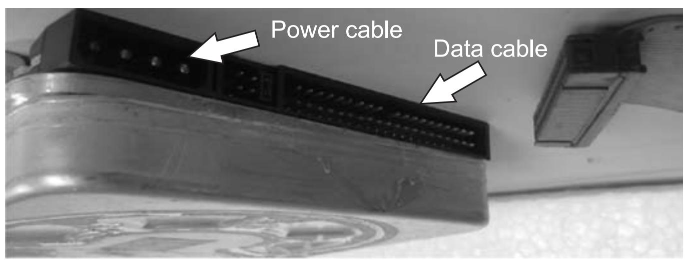


Figure 5.8 Connecting data and power cables to IDE hard disk.

Two different ATA types are available, namely, *Parallel ATA* or *PATA* type and *Serial ATA* or *SATA* type. SCSI is another type of interface and is a fast standard for accessing data. This is an advancement of ATA and IDE interfaces. Earlier SCSI supported up to eight devices. But current SCSI standard supports up to fifteen devices including printers, plotters and scanners. The current interface standard used with the computer systems is Serial Advanced Technology Attachment (SATA) interface. IDE uses parallel signaling whereas SATA uses serial signaling technology. SATA cables used for connecting hard disk to the motherboards are thinner and are having thinner end connectors. SATA offers fast data transfer rates and better reliability than the IDE cables. SATA cables are longer and allow connecting more distant devices (up to 1.5 metres) without any signal interference. SATA is available in two types, namely, SATA1 and SATA2. SATA1 is having a data transfer rate of 150 MB/s whereas SATA2 is having a data transfer rate of 300 MB/s. The method of connecting power and data cables to a SATA type hard disk is illustrated in Figure 5.9.

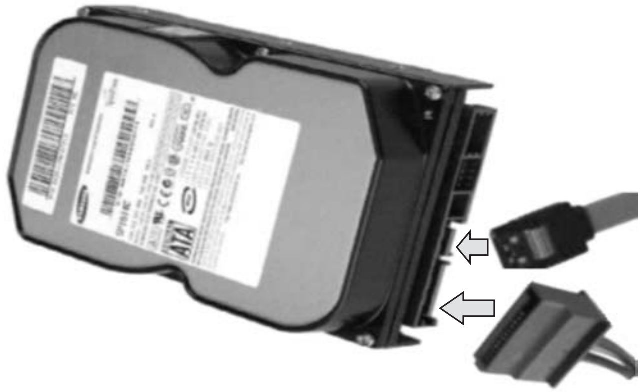


Figure 5.9 Connecting data and power cables to SATA hard disk.

5.13 SELECTING HARD DISKS

Upgrading of hard disks is required due to different reasons such as for increasing the storage capacity or for increasing the speed of data access. While purchasing hard disks, different factors are to be considered such as drive type, namely, IDE, SATA, etc., storage capacity of hard disk, physical size, average access time and data transfer rate.

Modern hard disks are manufactured using advanced technologies. These are having small size and large storage capacity. These have the abilities to eliminate hasty movements of the actuator. These make less noise and low power consumption. Better shock tolerance ability to withstand shocks during travel is another feature of modern hard disks. Also, modern hard disks have inbuilt abilities to report the device status at any time. This feature is known as Self Monitoring and Reporting Technology (SMART) which monitors the hard disk for any discrepancy and reports the status.

5.14 HARD DISK SPECIFICATIONS

Hard disks are evaluated by their features. Different major specification features include capacity, interface, spindle speed, interface, etc. Table 5.4. illustrates the major specification features associated with the hard disks. Mean Time Between Failures (MTBF) is an indication of the reliability of hard disks. Higher value of MTBF indicates more stability for the hard disk.

Table 5.4 Specification of Hard Disk

Feature	Typical value
Capacity	500 GB (Unformatted)
Internal buffer	32 MB
Interface	SATA
Form factor	3.5 inch

Feature	Typical value
Spindle speed	10000 rpm
Swap	Hot swappable
Single track seek time	0.5 ms–0.7 ms
Average seek time	3.7 ms–4.2 ms
Maximum seek time	8 ms–9 ms
Maximum rotational latency	4 ms
Average rotational latency	2 ms
Disk to read buffer data transfer rate	70 Mb/s maximum
Interface data transfer rate	3 Gb
Idle mode acoustics	27 dBA
Seek mode	35 dBA
Power dissipation idle	8 W
Power dissipation sleep	1 W
Read/write power dissipation	10 W
MTBF	1 million hours

5.15 PARTITIONING AND FORMATTING HARD DISKS

To use a hard disk for data storage, it must be prepared to store the data. The preparation of hard disk for storing data is done by low level formatting, partitioning and high level formatting. All the steps are done using special software developed for the purpose. **Low level formatting** is done at the low level framework and this is done at the manufacturing stage itself. Low level formatting creates tracks and sectors on the hard disk. **Partitioning** is the process of dividing a hard disk into a number of logical portions. Dividing a large hard disk into a number of parts helps in the easy management of the storage space. Partitions are of two types, namely, primary partition and extended partition. Every hard disk has at least one partition known as the **primary partition**. Partitions other than primary partition are known as **extended partitions**. Hard disks with large capacities are partitioned into more than one partition. A maximum of four primary partitions are allowed in hard disks. If a primary partition is marked as extended partition, more than four partitions can be created. Each partitioned part of the extended partition is termed as a **logical drive**. Usually 25 logical drives can be created from a hard disk. Each partition is identified using separate drive letters such as C, D, E, etc. After partitioning the hard drive, the drive is high level formatted. **High level formatting** writes the file storage structure into sectors. This process prepares the drive for holding data. Partitioning and formatting are done using separate software developed for the purpose.

Hard disks are formatted in different ways. Formatting process determines the type of file systems that can be used by the operating system. Different file systems are having different features such as the maximum file size supported, maximum number of folders and subfolders that can be created, etc. In short, performance of the operating system is dependent on the file system used by it. Different operating systems make use of different types of file formats and hence, they use different types of hard disk formatting. Linux operating system makes use of a file system known as extended file system. Hard disks are formatted in two ways, namely, New Technology File System (NTFS) and File Allocation Table (FAT32) formats by Windows-based operating systems. NTFS is a better file format as compared to FAT32, as NTFS surpasses the limitations in maximum file size and security provided by FAT32 file system. Reformatting of hard disks enables the conversion of one type of format to another. Reformatting a hard disk deletes all the data stored in the hard disk and hence, the entire data is lost. So, before attempting to reformat a hard disk, it is necessary to backup all the necessary data. In Windows-based systems, to format a hard disk partition, the partition is right clicked. This step displays a popup window having a set of options on the screen. Now, the option is selected to format the disk. This opens the *Format Disk* window, as shown in Figure 5.10.

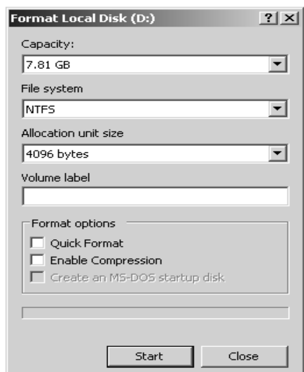


Figure 5.10 *Format Disk* window.

Option for selecting the file system is available as a drop down menu. Here, the *NTFS* file system is to be selected. In the format options, the *Quick Format* option is selected and then the *Start* button is clicked. This step starts the formatting of selected disk. Depending on the size of hard disk the time for formatting can vary.

5.16 MAINTENANCE AND TROUBLESHOOTING HARD DISKS

Hard disk is the most important component of the computer system because it is the common storage device used by them. Failure of hard disk leads to the loss of valuable data and files stored in that. Hence, regular maintenance of hard disks and backing up of vital data are essential to keep the data and files safe. Depending on the requirement, a proper data backup strategy must be formed for data backing up.

There are several reasons for the loss of data stored in the hard disks. Common causes of data loss are virus attack, accidental deletion and physical damage. Regular maintenance step involves checking the hard disks for any virus attacks and physical testing such as formation of bad sectors. Regular scanning the storage device using virus scanners, removing temporary and unwanted offline files and folders as well as the health checking helps in keeping the hard disks healthy. Several third party utilities and tools are available for these tasks. Most operating systems have several tools for these purposes installed during the installation of operating system itself. Several tools for these purposes can be downloaded from the Internet also. In Windows-based operating system, to check any of the hard drive partition, the drive is right clicked and *Properties* option is selected, from the displayed pop up window. This step displays the *Properties* window with five tabs. Now, the *Tools* tab is to be opened. In the new window displayed, there are options for checking for errors in the hard drive. This window is shown in Figure 5.11.

Figure 5.11 Option for checking hard disk for errors in Windows operating system.

To check for any error in the hard disk volume, the button is clicked for this purpose. This step commences the checking of hard disk errors. Bad sectors of hard disks are suitably marked. In this way, different hard drives can be checked for errors. Other options available are for backing up the drive and for defragmenting the drive.

Internal hard disks are fragile and easily get damaged. These are not designed for repeated attaching and detaching from the computer system. Extreme care must be taken during the transportation of this type of hard disk as well as during its installation, as these are extremely sensitive to physical shocks. While installing the hard disk, it is to be firmly fitted to the chassis drive bay using screws so that the disk is not affected by any physical shock during its transit. Even a slightest shock can damage the hard disk. Mishandling the hard disk or causing physical shocks can make the platter physically hit on the read/write heads, thereby damaging these heads and making the reading/writing operations impossible. When the collision occurs, particles from the hard disk surface get accumulated on the platter surface. This creates friction between the head and the platter surface, thereby increasing the temperature due to which additional bad sectors are formed on the hard disk. As the storage capacity of hard disks increases, the likelihood of collision between the head and the disk platters increases, since these two come closer in that condition. It is not advisable to open the hard disk cover because even a small dust particle entering inside the drive can destroy the disk. Always handle the hard disk by its side. Never touch the underside of the drive which is having the electronic circuit. Enabling SMART from BIOS provides necessary warnings whenever the hard disk is about to fail.

5.17 HARD DISK: COMMON PROBLEMS AND SOLUTIONS

Some of the major problems associated with the hard disks and the suggested possible solutions are given in Table 5.5.

Table 5.5 Hard Disk: Common Problems and Suggested Solutions

Problem	Solution
All drives of hard disk are not recognized	Check power cable. Replace the cable. Replace the hard disk.
Data cable is not fitting correctly	Use only the recommended cables for connecting the disk to the system. Align the cable with the connector pin properly.
Random error messages and crashing. Hard disk is detected but not usable	Hard disk is damaged. Replace it with a new one.
Sudden data loss or missing partitions and boot errors	Hard disk is damaged. Replace it with a new one.
Drive is making a noise during working	This is due to virus attack on boot sector or corrupt file allocation table or damaged head actuator mechanism. Replace the hard disk.
Display of *Invalid Media type* error	This problem occurs when trying to access an unformatted and unpartitioned hard disk. Partitioning the hard disk and formatting of it solve the problem.
Hard disk is not detected in BIOS	Check whether the power cable is connected properly and firmly. Remove the cable and connect again. If the problem is not solved, check the cable and replace it with a new one. Check the power supply unit and ensure that the correct voltage level is available for the hard disk. Also, check data cable for its proper working. Check the hard disk.
The computer cannot detect the two hard disks connected in the same IDE channel.	Check the jumper settings of the hard disk and ensure that one device is set to the master and the other to the slave mode.

5.18 SOLID STATE DRIVES

Due to the reduction in the size of the computers, the necessity of a compact, efficient, low power consumable and reliable memory was emerged. The bulky and fragile nature as well as the limitation in the reduction of size of electromechanical hard disks led to the use of flash disks as memory devices. Flash disks or flash drives emulate hard disks. These are made up of a number of flash memory integrated chips mounted inside a computer system. These are resilient and quicker. Flash drives are finding their applications in the laptops and desktops. These are generally known as **Solid State Drives (SSD)**.

Solid state drives are rather new in the field of computer storage. These devices are aimed as the replacements for the traditional magnetic hard disk drives which are having spinning platters and mechanical heads. SSD are flash-based devices. These are made using NAND flash memory. As these have no moving parts, SSD offers better reliability over the magnetic hard disk drives and these can withstand mechanical failures arising from the vibrations or shocks. Based on the constructional aspect, solid state drives are of two types. One is the Single Level Cell (SLC) type in which each memory bit holds one bit of data and the second type is the Multi Level Cell (MLC) type that can hold two bits of data in duplex mode.

Magnetic devices can get damaged due to scratches formed on the magnetic surface by the read/write head. Damaging the drives means loss of files stored in the drive. But solid state devices can withstand such damages. Also, to ensure accurate data transfer, SSD is having a built-in ECC (Error Correction Code) feature. Solid state devices have other features such as better readability and reduced power consumption. Reduced power consumption results in increased battery life. Solid state devices offer fast read/write operations than the traditional magnetic hard disks and have increased storage capacity. The increased speed of the solid state devices is because of the fact that there is no time involved in moving the read/write heads (seek time) and the time taken to bring the desired data under the head (latency time) is less. Flash-based devices are having the data access speed of the order of nanoseconds (ns) while the hard disks access data of the order of milliseconds (ms). Reduced access time (latency) helps in the speedy booting of the system as well as provides a better responsiveness while using the solid state devices. High performance and better reliability are the other features of these types of devices. These devices are having SATA interface and 2.5 inch form factor. These can be easily installed in the notebooks as well as in the desktops. Use of solid state devices help in getting ultraperformance from the computer systems. A comparison of the features of solid state devices and the conventional magnetic storage devices is given in Table 5.6.

Table 5.6 Comparison of Features of Solid State and Magnetic Storage Devices

Feature	SSD	Magnetic
Mechanism	Flash memory	Magnetic
Power consumption	2.6 W	5.6 W
Shock resistance	Better	Good
Acoustic noise	Silent	Noisy
Average access time	0.3 ms	15 ms

5.19 INSTALLING SOLID STATE DRIVES

Solid state drives deliver the advantages of flash disk technology using serial ATA (SATA) interfaces. In computer systems, these devices are fitted to SATA connectors of the motherboards. To install the SSD, following steps are to be done:

(a) First of all, the system is unplugged and then the cabinet is opened.
(b) Now, the solid state drive is fitted into the vacant bay. Since SSD is smaller, it is to be fitted using a metal bracket.

(c) After that, the SATA cable is connected between the connector on the motherboard and the device. Also, the power cable from the power supply unit is connected to the solid state drive. It should be ensured that the connectors are firmly fixed.
(d) Now, the cabinet is closed and then the system is turned on. On doing this, the Windows-based operating system detects the newly added drive.

Driver software for the device can be installed for its proper working. Working of the SSD in Linux depends on the availability of the driver software in Linux version used for installation. Once the drive is installed the operating system can be loaded and the system can be booted from it.

5.20 OPTICAL STORAGE DEVICES FEATURES

Optical storage devices store data and files and retrieve them using laser beams. Optical storage devices are widely used as secondary storage devices. Compact Disc (CD) is the earlier form of optical storage device. These are circular in shape with diameter of 12 cm and having storage capacity of 700 MB or above. A small version of CD known as **Mini CD** is having lesser diameter of 8 cm or 6 cm. These are having a lesser storage capacity of 120 MB. Optical storage devices use a reflective layer inside a plastic disc to record data. Recording is done in a spiral manner starting from the inside of the disc towards outside. The data that is to be stored in the medium is encoded as a series of patterns. A laser beam is used to burn pits in the reflective layer and the data is encoded as burned and unburned patterns on the reflective layer. Hence, the writing of CD is known as **burning**.

CD media are available in different forms such as CD ROM, CD-R, CD-RW, etc. CD ROM is a read only CD medium. It is possible to read the contents of this type of CD. But the content cannot be erased or edited. Also, new files cannot be written to this type of CD. CD-R is a writable type of CD which allows writing of files to it, only once. Erasing of files or rewriting is not possible. It is possible to read the contents stored in such type of CD. CD-RW is another name for rewritable CD. Files can be written to such CD, the content can be erased and new files can be added to it.

Now, CD medium is replaced by Digital Versatile Disc (DVD). These appear similar to CDs. But the storage capacity of DVD is high. The storage in DVD is done in closely-spaced tracks. The distance between the tracks in DVD is very small as compared to CD. Also, the pits created by the DVD laser beam are smaller and hence, more pits can be created in a given space. All these make the storage capacity of DVD much higher than that of CD. A comparison of the storage features of CD and DVD is given in the Table 5.7.

Table 5.7 Comparison of Features of CD and DVD

Feature	CD	DVD
Distance between tracks	1600 nm	740 nm
Length of pit	830 nm	400 nm

DVD is also available in different forms such as DVD ROM, DVD-R, DVD-RW, etc. DVD ROM is available in different types such as single-sided or double-sided and single layer or double layer. Each side of a DVD is having the capacity for single layer or double layer recording. Double layer DVDs are having double capacity than the single layer DVD. The storage capacity of a single-sided single layer DVD is 4.7 GB. Single-sided double layer DVD is having a storage capacity of 8.5 GB while a double-sided double layer DVD has the storage capacity of 17 GB. DVDs are fast and provide a faster response as compared to CDs.

In DVDs, the discs spin thrice the speed of the discs in CDs. CD can be used in DVD drives also. The standard interfaces used for CD drives such as SCSI, IDE, SATA, etc. can be used as interfaces for DVD drives also. This makes the installation of DVD drives easier. The new standard used to cater to the increased speeds of optical drives is *FireWire standard*. This standard is supported by several operating systems.

CD or DVD writers are necessary for burning data to the media and for reading from the media. The drives are fitted to the front side of computer chassis. Currently available writers are of multi drive types that support both CD and DVD. External multi drives are also available which are portable. These are connected to computers through interfaces available with the drive and computer. Currently available external drives are hot pluggable devices, i.e., these can be plugged to the computer systems without making them shutting down. The front panel of the drives is having a small button for opening and closing the drive. By pressing this button, it is possible to eject the disk tray as well as to close the tray. It is shown in Figure 5.12. Read/write operations in the optical drives are indicated by the blinking of LED status indicator. Another feature available in the front panel of optical drives is the emergency eject hole. This feature helps in ejecting the tray manually when the eject button fails to function. Physically, the drives are having a read/write heads same as in the case of magnetic drives, for doing read/write operations. Optical drives are fitted with two motors. One is the spindle motor that rotates the drive and the second is the tracking motor that moves the head assembly unit along the surface during the reading and writing process. The power input required for the motor is 5 V and 12 V which can be obtained from the SMPS.

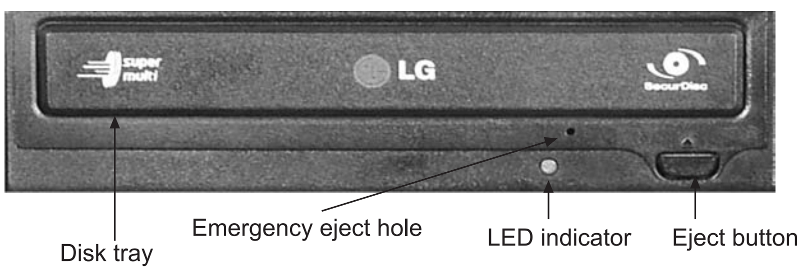


Figure 5.12 Multi drive for fitting to computer cabinet—Front panel.

The speed of an optical drive is indicated using three numbers. For example, a typical speed specification can be written as 40X, 32X, 48X. These three numbers indicate the speed of writing to a CD-R disc, rewriting a CD-RW disc and reading from a CD respectively and the speed specification is stated in this sequence. Of the three values given, the highest of the numbers is the CD read speed which appears as the last value, the middle number is the CD-R write speed that appears as the first parameter and the lowest number is the CD-RW rewrite speed and this is placed in the middle position, while stating the speed spacification. The spinning of CD is indicated in unit X. A regular audio player can play a CD in 74 minutes. This speed is called 1X. The unit 1X is equivalent to the transfer rate of 150 kB/s. Thus, we are having CD or DVD having speeds like 24X, 52X, etc.

Buffer size or cache associated with DVD drives is an important feature used to prevent burning failures. For proper writing, a steady stream of data flow during the writing time is necessary. If there is not enough data available, the writing process stops and the CD or DVD becomes useless. Steady data availability is ensured by the cache or buffer memory available with CD or DVD drives. A higher cache gives better results. Buffer acts as a temporary storage space before sending data for writing to discs.

5.21 WORKING OF OPTICAL STORAGE DRIVES

The hardware components that make up an optical drive are shown in Figure 5.13. The optical drive is essentially made up of a motor (mounted internally) that can rotate the optical medium. The motor ensures that the laser beam scans the surface of the optical disc at constant speed. A laser beam from the laser assembly (mounted on the system) moves outward from the centre of the medium with the rotation of the medium. The laser beam is moved precisely to the desired location by the tracking motor. The heart of optical storage drives is the drive lens. The lens reads data from discs as well as writes data to discs. For connecting to the system as well as to power the device, suitable data and power interfaces are available with the device. The earlier data interface used was *IDE ATAPI* (*Advanced Technology Attachment Packet Interface*). This interface is used between the CPU and optical drive. It helps in controlling the optical drive using additional commands. Now, the interface used with optical drives is the *SATA* interface.

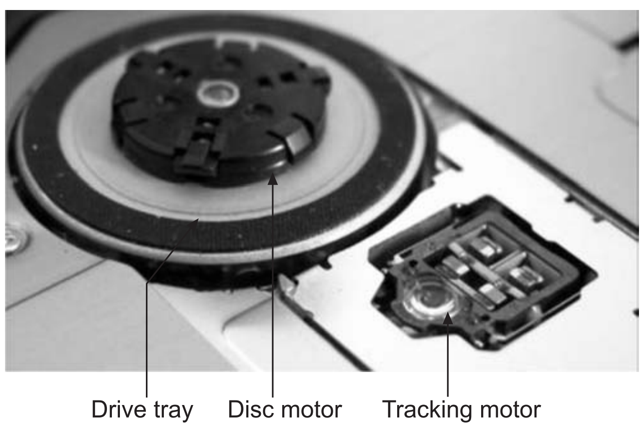


Figure 5.13 Constructional details of optical drive.

Optical discs are made of polycarbonate materials. On the medium surface of the photoresist material, a high intensity laser beam is applied for short duration of time which results in melting the surface to form pits. In this way, pits are created on the surface. Marks created by burning pits are used to represent *zero* and flat surfaces are used for representing *one*. These marks represent data and are read using laser beam. The recording takes place in circular tracks starting from the centre of the medium towards the outer side. During the reading process, the intensity of laser beam applied is less whereas during the writing process the laser intensity is high. The logic board mounted on the lower portion of the writer controls the changes in light intensity levels, moves the laser head assembly, controls the flow of data, writes at the selected speed and controls other operation.

Earlier types of optical media were read only types and a physical modification of the surface was made during the recording stage. Due to the physical damage caused on the surface during recording, it was impossible to erase the contents and to reuse the medium. Later on read/write optical storage came into existence. In the read/write optical media any physical damage of the medium is not created. In this case, a reflective coating of material layer is made on the surface. Laser beam creates regions on the surface of the medium which can reflect laser beam but cannot reflect the laser. In this way, two states are created for storing the binary data. The cross sectional view of the disc is shown in Figure 5.14.

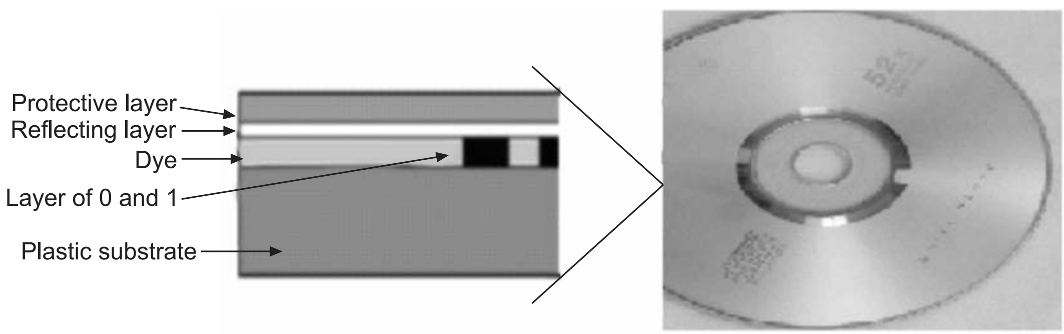


Figure 5.14 Optical disc cross section—Expanded view.

The functioning of optical writer devices involves transferring data from one source to another. The efficiency of this process depends on the speed of reading, transferring and writing data. The best performance is obtained when the speeds of the above three process become same. But in practical situations, this type of ideal situation is difficult. If the medium is not of good quality, then the reading speed gets slowed down and this causes gaps in the written medium making it useless. To prevent this, buffer memory is used with optical writer devices. This memory helps to collect the data and transfers it at a higher speed for continuous writing to the medium. The buffer memory varies and depends on the speed at which the data is read. If the reading is slower, more buffer memory is required. Gaps that are appearing on the optical writer devices when the buffer gets empty are known as **buffer under run error**. This error makes the medium useless. There are several factors affecting the speed of writing data to the storage and reading data from them. These different factors include the speed of rotation of the disk, temperature, type of media, power of laser beam, spacing and size of data pattern with respect to the speed of the medium, etc.

5.22 INSTALLING OPTICAL DRIVES

Different types of interfaces are used for connecting optical drives to the motherboards. Two common optical drive interfaces currently used are *IDE* and *SATA* interfaces. Similar to hard disks, IDE interface makes use of IDE ribbon data cables to connect the drive to the motherboard while SATA interface devices use SATA cables for connecting optical drive to the motherboards. Nowadays SATA interface is mainly used as the optical drive interface.

As stated earlier, IDE ribbon cables are having three connectors. A hard disk and an optical drive can be connected to the motherboard using the same IDE cable. In such case, one device is configured as the master and the other as the slave device.

Similar to the hard disks, two connectors are available for optical drives also. One connector is for connecting the power cable from the power supply unit and the other is for connecting data cable to the motherboard. These two connectors are arranged adjacent to each other. There are five steps for installing an optical drive.

(a) First of all, the closing tab on the top position of the front panel of the computer chassis is removed for getting space to insert the optical drive.
(b) After that the drive is inserted into the empty slot created, with the front panel of the drive accessible easily from outside and then firmly fitting in the bay.
(c) Now, the data cable is connected between the port of the device and the motherboard.
(d) In the next step, the power cable from the power supply unit is connected to the power input of the device.
(e) The last connection is an optional one and this is the connection for audio. The rear panel connectors of an IDE and a SATA type optical drives are displayed in Figures 5.15 and 5.16.

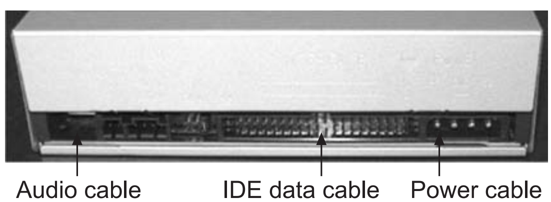


Figure 5.15 Rear panel of IDE optical drive.

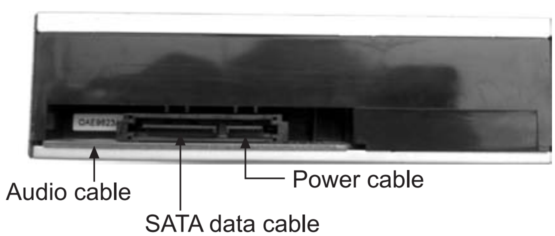


Figure 5.16 Rear panel of SATA optical drive.

5.23 SPECIFICATIONS FOR MULTI DRIVES

Major specifications related to multi drives are associated with different speeds such as the speed of reading from discs, writing to discs and rewriting speeds. The type of interface used is also another specification parameter used with multi drives. Overburning is a feature that makes a disc burn beyond its normal capacity. This feature is supported by several disc burning softwares. The specification parameters and typical values of multi drives are given Table 5.8.

Table 5.8 Specification of Multi Drives

Feature	Typical value
Supported discs	CD-R (single/dual), CD-RW, DVD-R (Single/double layer), DVD-RW
Read speed	32X
Write speed	8X
Rewrite speed	4X
Interface	USB
Cache	4 MB
Burning software	Nero
CPU utilization	10 %
Access time	80 ms
Power requirement	5 V DC
MTBF	60,000 power on hours

5.24 DISC BURNING SOFTWARE

New versions of Windows-based operating systems and Linux operating system are having built-in utilities for writing to optical disks. Files can be written to discs and can be read from them easily. Selecting the option for any disc operation launches the wizard for that operation and the process can be finished easily in a few mouse clicks. Most optical drives are accompanied by a bundle of applications for several uses such as for data backing up and for copying files. *Nero* is one of the easiest and most reliable CD/DVD recording packages to help store data, music, and video on CD or DVD. The application supports different file formats and can be used for different purposes. The application is to be installed in the computer for any operation on the optical media. After installing the application, launch the application. This step opens the initial screen of the application. The opening window is shown in Figure 5.17.

The type of the optical medium such as CD or DVD can be selected from the drop down list appearing at the top of the screen. Different options that are possible using the application are grouped under six heads. The six groups are represented with the help of six icons appearing at the top of the opening window. These six groups are labelled as *Favorites, Data, Audio, Photo and Video, Copy and Backup* and *Extras*. When the mouse cursor is placed above any of the icons, the options in the selected group are displayed on the window.

Figure 5.17 Opening screen of Nero application.

In Figure 5.17, the options available under the *Favorites* group are making data CD, data DVD, audio CD, video CD, copying CD and DVD. Clicking any of the options opens new window and the activity proceeds in an interactive manner. The required activity can be completed easily. When the option for making data CD or DVD is selected and then another window is opened. Here, it is possible to select the files or folders that are to be copied to the medium. Any number of files within the storage capacity of the medium can be selected for copying to it.

The option under *Data* group helps in creating bootable CD. Once a bootable CD is created, it can be used for booting the system. Copying audio tracks is possible on selecting the group *Audio*. Similarly, different options related to video files are available in the *Photo and Video* group. Options for backing up the disk and restoring from backup are available in the *Copy and Backup* group. A wizard facility available for scheduling the backup operation helps in backing up files automatically as per the set schedule. It is possible to select the files for backing up and the destination where the backup is to be stored. Making copies of optical discs is another option available in this group. The last group in the menu provides some added utilities. This includes erasing the contents from the optical medium, scanning the surface of the medium for testing the quality, creating label cover, etc.

5.25 TROUBLESHOOTING AND MAINTENANCE

As the recording in optical discs is not done by magnetizing the surface, optical media are not damaged by magnetic fields or X-rays. But mishandling or exposing the media to extreme hot and humidity conditions for a long time can damage it. To keep the disc away from dust and scratches, the medium is to be stored in safe places in a covered manner. Touching the surface of the disc is to be avoided, as finger prints formed on the surface can prevent the correct reading and writing operations. The medium is to be handled by holding its edges only.

Different maintenance operations help in keeping the optical burners in good condition and extending their lives. The drive must be kept clean and dry always. Due to the deposition of dust, the optical drive can behave erratically due to which the drive come out automatically after a while or may refuse to eject. A soft and dry fabric dipped in isopropyl alcohol or spirit should be used for removing dust from the drive. Lens is an important part of optical drives. Dirty or misaligned lens can make the optical writer behave inconsistently. So, a lens cleaner should be used at least once in a month for cleaning the lens. Lens cleaner kit includes a cleaning disc and a cleaning solution. The cleaning disc must be held with the label side downwards and one drop of the cleaning solution is dropped to wet the cleaning brush fixed on the surface of the disk. Now, the cleaning disc is inserted in the drive like other discs. Simply playing the video test files included in the disc starts the lens cleaning process. After the completion of cleaning process, the disc is taken out of the tray and stored in its pack safely for later use.

Sometimes, the optical drive refuses to eject. There are several reasons for this type of behaviour. Dirty sense switch, bad connection of the optical drive, stretched motor belt, defective motor, poor or gummy lubricants, mechanical damage, logic circuit problem are the common causes for this type of behaviour. Under such conditions, it is not advised to force the drive tray out from its container. If there is some difficulty in opening the tray, a manual ejection of the drive is to be attempted. For ejecting the tray manually, a straightened paper clip can be used. Now, the small hole is located below the LED on the front panel of the drive. The straightened paper clip is inserted into the hole and then pushed straight and in a firm manner. This makes the drive to eject making the tray to come out. This process is to be tried only in emergency situation. Closing the disc tray of the drive manually by pushing it through hand is similar to give extra force to the tray which causes its misalignment. It is to be avoided. The tray must be closed by pressing the button on the panel only which helps in preventing any kind of misalignment in the drive mechanism.

Sometimes, the drive takes a long time to complete the read/write operations. If this happens for a single disc only, then this delay may be due to defective optical medium inserted in the drive or due to its dirty or scratched surface. But, if it happens commonly for several discs, the reason is due to defective or damaged objective lens. Faulty motor, damaged chip or connecting cable can also cause this type of error.

Buffer under run error is an error happening during the writing of optical discs. Optical burners require an uninterrupted data stream for proper and successful writing to the medium. This type of error occurs due to several reasons which may be the interruption in the continuous stream of data, interruption caused by another application in the writing process or the high writing speed. Writing to the medium at a lower speed solves this type of problem. Also, while writing to the medium any other running applications must be closed. Downloading or browsing the internet while writing to disks is to be avoided. Disabling screen savers and power management features are other desirable steps that help in avoiding this type of error.

5.26 OPTICAL DRIVE: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the optical drives and their suggested solutions for solving the problem are given in Table 5.9.

Table 5.9 Optical Drive: Common Problems and Solutions

Problem	Solution
CD or DVD drive is not recognized.	Check that all connections are correct. If the problem still exists, replace the cable and check again. If the problem is not solved, replace the drive.
CD/DVD is not working correctly	First make sure that the CD or DVD is not damaged. Clean the drive and the laser head. Run a diagnostic program. Replace the cables and check. If the problem still exists, replace the drive.
Data is not properly written to the disc.	Finger print, dust or smudge on the surface of the medium can scatter the laser beam used for burning data. Scattered laser beam is having lesser strength and hence, data is not properly or correctly written to the disc. Before start recording data, it is important to make sure that the surface of the disc is clean and is free from dust and smudges. Also, do not touch the surface of the disc during its handling.
Drive reads the data very slowly.	This happens when the laser pickup assembly is weak. Clean the lens using a lens cleaner. This will solve the problem.
The driver ejects and reloads the disc during its working.	This is a mechanism used to clear buffer memory of the disc drive. Drive with a large buffer memory does not show this type of error.
CD/DVD tray is not working.	Make sure that the system is turned on. Insert the end of a straightened paper clip into the manual tray release opening. Replace the cable and check the working. Replace the drive.
It requires to apply too much pressure on the front panel switch of the drive.	Check the working of the front panel switch. If required, replace the switch.
It takes too long time to open the tray	Check the motor, drive belt and gear wheels.
Disc fails regularly	This is because of the poor quality of the material used for the disc. Using good quality media solves this problem.
Audio disc is not working properly.	Check the disc and ensure that the disc is not faulty. Try to use another audio disc. If the problem still exists, make sure that the volume of the player is set to high and that *Mute* option is not selected. Open the computer cabinet and ensure that the cable connection to the audio port is firmly fixed. Replace the drive.

Autorun facility provided by different operating systems helps to play the contents of the optical disc automatically. When the operating system detects the presence of the disc in the drive, it searches for a file called *Autorun.inf* in the medium. If the file exists, the commands of the file are executed. If the file is not available in the disc, other methods are used to view the contents of the disc. The autorun facility can be disabled.

5.27 BLU-RAY DISCS

Blu-ray also known as Blu-ray disc is the new generation optical disc format developed by Blu-ray Disc Association (BDA) consisting of the major manufacturers. This device works in the same way as any other optical drive. Superior picture quality and high image resolution are the major features of Blu-ray format. This technology is used for recording media, games and music. The format was developed for recording, rewriting and playing of High Definition (HD) video as well as for storing large amount of data. The format offers five times the storage capacity of traditional DVDs and can store 25 GB on single layer discs and 50 GB on double layer discs. The current DVD technology is based on red laser to read and write data. CD makes use of infrared laser for read/write operations. Blu-ray format uses blue-violet laser and hence, the technology came to be known as **Blu-ray technology**. Blue laser allows a higher density in storage. This accounts for the large storage capacity of Blu-ray discs. The advantage of using blue-violet laser is that it has a shorter wavelength (405 nm) than that of the red laser (650 nm) or infrared (780 nm) beams. Light waves having a lower wavelength cause a smaller laser beam. This feature makes blue laser to focus laser spots with great precision. Due to this, data can be packed more tightly in less space while using Blu-ray discs. Track width in Blu-ray discs is 0.32 micron which is much less than that used by DVD (around 0.74 micron). These factors are helpful in providing increased storage capacity for Blu-ray discs. Also, Blu-ray technology is having higher speed in reading and writing data as compared to DVD. Blu-ray discs are backward compatible with DVD. These are available in different types such as write once (BD-R), rewriteable (BD-RW), etc. and are having different speeds like 1X, 4X, 6X, etc. The method of reading and writing in Blu-ray discs is similar to that used for CD or DVD. Due to this, Blu-ray writers are backward compatible with CD or DVD burners. However, a Blu-ray disc player or recorder is necessary for using Blu-ray discs. CD or DVD writers or players cannot be used for recording or playing Blu-ray discs. A comparison of the different features of different optical discs is given in Table 5.10.

Table 5.10 Comparison of Features of Optical Discs

Feature	CD	DVD	BD
Laser	780 nm (Red)	650 nm (Red)	405 nm (Blue)
Track pitch	1.6 microns	0.74 micron	0.32 micron
Thickness	1.2 mm polycarbonate layer	Two 0.6 mm polycarbonate layers	1.1 mm polycarbonate layer

5.28 EXTERNAL STORAGE DEVICES

In certain circumstances, external storage solutions are required. There are different types of external storage devices with different storage capacities and different form factors. Commonly used external storage devices are Solid State Drives (SSD) equipped with USB ports. **USB flash drive** is one of the devices that belong to this category. These are miniature solid state storage devices having the advantages of a portable personal hard drive with different storage capacities of several terabytes. These devices offer high data transfer speeds of several gigabytes per second. The drag and drop facility and their use with computer systems having USB ports make them widely acceptable. These devices offer the advantage of running applications from the drive without copying to the hard drive. No separate power supply is required for this type of devices. These are powered through USB ports. Well protected enclosures help in protecting these devices from any physical damage. LED indicators provide an indication of the system status and data traffic. Software available helps in the automatic and continuous backing up of data and files. The devices are compatible with different operating systems and work similar to the hard disks.

Flash memory is the commonly used external solid state memory device. This type of memory is also known by other names like thumb drive, USB drive, etc. A typical flash memory is shown in Figure 5.18. This type of memory is made on a circuit board which contains a host controller (known as USB host controller), flash memory and oscillator. The host controller is in the form of a magnetized chip and controls the storage of data. The chip also interfaces the memory with external devices such as USB ports. Flash memory stores information in blocks. The capacity of flash memory depends on the number of blocks and the individual sizes. Each block is made up of transistors. The transistors used in flash memory are either NAND type or NOR type. Flash memory is available in different memory capacities. As these are light weight type devices, these are extremely portable.

Figure 5.18 Flash memory.

The major specification parameters of a typical flash memory are given in Table 5.11.

Table 5.11 Features of Flash Memory

Parameter	Value
Capacity	8 GB
Weight	10 g
Dimension	50 mm
Interfaces	USB
Type	NAND

In Windows-based operating system, when a USB device is plugged into the USB port, then an icon appears on the notification area. Before physically removing the USB device from the port, it is essential to stop the device. For this, the device icon is right clicked on the notification area. This step displays a popup menu. The option to safely remove the device is selected from the displayed list. This process stops the connected USB device and a message for safely removing the device appears on the screen. Now, the USB plugged device can be safely removed. In Linux operating system also, the USB device is to be stopped before removing it. This option can be selected from the main menu of Linux operating system. Removing the device from the USB port when the busy indicator is blinking or during computer start up time can damage the device. Hence, this is not to be done.

Another common external storage device is the **external hard disk**. These are fitted to USB or FireWire port. The advantage of using external hard disks is that it is portable. Also, it is not necessary to open the computer chassis to connect the hard disk to the computer. It is also not necessary to find any connector in the motherboard for fitting the cables of the external hard disk. All that is required is to connect the data cable to the external USB or FireWire port and to use it. External hard disk is simply a hard disk that is fitted to a case and having a small circuit board to control its operations. These are having a power connector with a necessary adaptor for connecting to the power supply. Small models do not have power supply cables and these are powered through the USB or FireWire connection. USB interfaces offer a high speed data transfer. Protection from buffer under run error is common in these types of devices.

6

Power Supply and UPS

Power supply unit is an essential component of a computer system. It supplies power to different internal components of a computer including the add-on cards that are plugged to expansion slots. Power supply units convert the current received from the mains to a form that can be used by the components of computers. Computer systems can be powered either directly from the mains power supply or through uninterrupted power supply units. Powering computers directly from the mains power supply has several drawbacks. So, computers are powered through battery backed uninterrupted power supply units. This chapter discusses the features of computer power supply units and uninterrupted power supply units.

6.1 COMPUTER POWER SUPPLY UNITS

Computers require low voltage direct current (DC) for their working. Power supply unit of computer converts 230 V alternating current (AC) supply from mains to 5 V and 12 V DC for computers to work. The process of conversion involves reducing the mains supply voltage to a lower voltage and then transformation of AC supply to DC supply. The power supply unit also helps in control and regulation of the supply to prevent value variations and to set the output to the precise level. The major components of the power supply units consist of a transformer, bridge rectifier unit and regulator circuits. The basic block diagram of a power supply unit is shown in Figure 6.1.

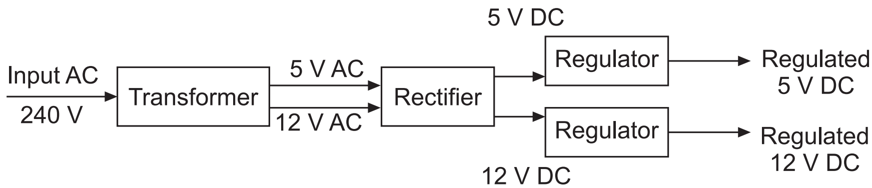


Figure 6.1 Basic block diagram of computer power supply unit.

Transformers are used to step down the voltage from 240 V input to 5 V or 12 V output level. Conversion to direct current for operating computers is achieved by using high frequency switching process. The alternating voltage is switched off and on several thousand times per second to get the direct voltage. Hence, the power supply units used in the computer systems are known as **Switched Mode Power Supply (SMPS)**. The regulators help in setting the output value to the precise level. The different output voltage levels from the SMPS are + 5 V, – 5 V, + 12 V and – 12 V with common ground point and zero voltage.

The voltage conversion process heats up the power system unit and hence, the system is to be cooled. The commonly used method for dissipating the heat generated consists of the use of cooling fans. The cooling fan sucks out hot air from the case. SMPS has its own cooling fan and is fitted inside the unit.

These units are fixed inside the computer cabinets. The power supply units are available in different sizes and ratings suited for different types of computers. The different ratings for the power supply are required because this unit supplies power to different peripheral devices connected to different expansion slots of the motherboard such as internal modem, graphics cards, etc. Bays of different sizes for fixing different internal devices are available in computer cabinets. Devices fitted in the bays are powered from the same computer power supply unit. As the number of connected devices increases, power requirements of the devices also increases leading to an increased necessity for the high rated power supply units. Usually, computer cabinets are bundled with 400 W power supply unit. This power is sufficient to power the basic components, two optical drives, a hard drive, USB ports and audio jacks.

6.2 FEATURES OF SMPS

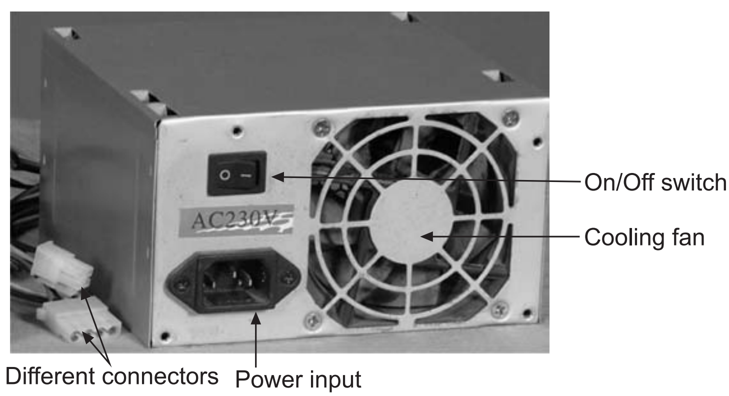


Figure 6.2 Parts of a computer SMPS.

As shown in Figure 6.2, cooling fan, on/off switch, power input connector and a number of molex connectors fitted at the ends of output cables are its important parts. The power supply unit is fitted inside the computer chassis with the cooling fan vent and power switch facing outwards at the rear side of the chassis. The purpose of cooling fan is to dissipate the heat generated inside the power supply unit. A power cable connects the computer power unit to power supply mains. The connection to mains is made at the power input connector. The on-off switch was commonly available in earlier type SMPS units. ATX type SMPS units usually do not have the on/off switch. The output wires from the SMPS are colour standardized and contain red, yellow and black-coloured wires. The earth wire is coloured black. The red and yellow wires give output voltages of 5 V and 12 V respectively. The output wires are having different types of end connectors suitable for connecting to different devices. Different voltage level exists for different end connector terminals. The different types of output cable end connectors for a computer SMPS unit is illustrated in Figure 6.3.

(a) Of the different connectors shown in the figure, the one with 2×2 pin layout having 12 V power output provides enough power to the processor. This connector is connected to the motherboard.
(b) The ATX power supply main connector is having 2×10 pins and this is the largest connector of the SMPS unit. Power to different components of the motherboard is provided by this connection.
(c) The 12 V power connectors for powering different internal devices have four pins arranged in a single row. These connectors are known as **molex connector**. Computer SMPS unit has more than one molex connector.
(d) The fourth type of connector commonly seen in old SMPS is the power connector for floppy drives.
(e) SATA power cable is different from traditional four pin connectors. It is the fifth type of connector which is usually coloured black. More than one SATA power connector is available in new SMPS units.

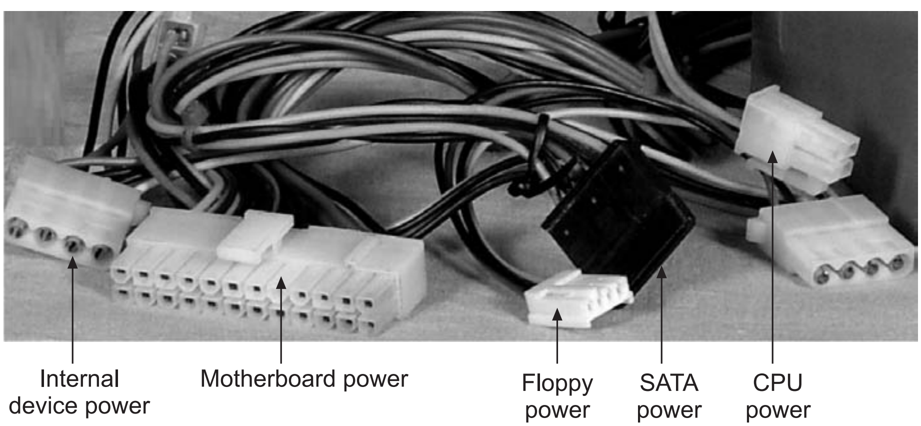


Figure 6.3 Output cable end connectors of computer SMPS unit—Enlarged view.

6.3 TYPES OF SMPS

Two types of computer SMPS units are available. One is the **AT type SMPS** and the other is the **ATX type SMPS**. These two types differ in the number and type of output connectors and the availability of on and off switches. AT and ATX classifications of SMPS has no relationship with the motherboards of AT an ATX types. ATX SMPS is used for powering ATX form factor motherboards. The main connector of ATX Power supply is having 20 (2×10) pins. The voltage levels in the connector pins are given in Table 6.1.

Table 6.1 Voltage Levels in Main Connector Pins of ATX Power Supply

Pin	Signal	Pin	Signal
1.	+ 3.3 V	11.	+ 3.3 V
2.	+ 3.3 V	12.	– 12 V
3.	Ground	13.	Ground
4.	+ 5 V	14.	Power supply remote on/off
5.	Ground	15.	Ground
6.	+ 5 V	16.	Ground
7.	Ground	17.	Ground
8.	Power good	18.	– 5 V
9.	+ 5 V SB	19.	+ 5 V
10.	+ 12 V	20.	+ 5 V

The main connector of AT type SMPS unit is having 24 (2×12) pins. Different voltage ratings of the pins are given in Table 6.2.

Table 6.2 Voltage Levels in Main Connector Pins of AT Power Supply

Pin	Signal	Pin	Signal
1.	+ 3.3 V	13.	+ 3.3 V
2.	+ 3.3 V	14.	– 12 V
3.	Ground	15.	Ground
4.	+ 5 V	16.	Power supply remote on/off
5.	Ground	17.	Ground
6.	+ 5 V	18.	Ground
7.	Ground	19.	Ground
8.	Power good	20.	No connection
9.	+ 5 V SB	21.	+ 5 V
10.	+ 12 V	22.	+ 5 V
11.	+ 12 V	23.	+ 5 V
12.	2×12 V connector detect	24.	Ground

Microprocessor power connector is a 2×2 pin connector. The voltage levels in the pins of the connector are given in Table 6.3.

Table 6.3 Voltage Levels in Microprocessor Power Connector Pins of SMPS

Pin	Signal	Pin	Signal
1.	Ground	3.	+ 12 V
2.	Ground	4.	+ 12 V

6.4 INSTALLING SMPS

Main power connection and microprocessor power connection are connected to different connectors of the motherboard. Connectors from the power supply unit are designed to fit motherboard connectors in one direction only. This is made possible by the presence of raised key on the side of the cable end connector. To install the SMPS, following steps are to be done:

(a) First of all, the SMPS unit is correctly oriented in the computer chassis with the fan vents facing outwards.
(b) Power connection from the mains supply can be easily connected to the power input socket of the SMPS in this position.
(c) Now, the SMPS is firmly fixed to the chassis using screws.
(d) To connect the SMPS to the motherboard, the power connection cables from the power supply are first oriented to the connector in the motherboard correctly and then the connector is pressed down firmly and slowly until they firmly fit into the slot.
(e) After connecting the main power connector, the above steps are repeated to connect the 4-pin connector for providing sufficient power to the CPU. Both the connectors must be connected to the motherboard before powering on the system.

It is necessary to ensure that the ATX 12 V power supply can provide at least 15 A on the 12 V lead and at least 2 A on the + 5 V standby lead. The minimum recommended power rating for computer power system is 300 W or above. If the power supply is inadequate, then the system can experience instability.

6.5 SPECIFICATION FOR SMPS

The different specification parameters for computer SMPS unit is given in Table 6.4.

Table 6.4 Specification for Computer SMPS Unit

Feature	Typical value
Standard	ATX 12 V
Power	600 W
Connectors	PCI, SATA, Molex
+ 12 V rails	4 numbers
PCIe connectors	2×8 pin
Fan diameter	140 mm

6.6 MAINTENANCE AND TROUBLESHOOTING

There is no maintenance required for the power supply unit. The only moving parts of power supply units are fan and power switch. If the fan is not working, it has to be replaced. Working of computer without a rotating cooling fan can damage or destroy the system due to the heat generated inside it.

To check the AT power supply unit, the output is connected to load such as CD drive. Now, the power supply is connected to the mains and then it is switched on. The working of the fan indicates that the power supply is working. The output voltage from the output wires can be checked to further ensure its working.

To check the ATX power supply unit, a green output wire is connected to a black wire. After that, the power supply unit is connected to the mains and then it is switched on. If the fan starts rotating, it indicates that the power supply unit is working. The output voltage from different output wires can be checked using a multimeter. If the output voltages are as indicated in the table, the SMPS is in working condition.

If the SMPS fails to work, the fault may be in any of the component units. The entire SMPS can be considered as a union of different units such as fuse, surge arrestor, line filter, rectifier, etc. The fault finding step involves the checking of each component unit and ensuring that the units are properly working and are giving proper outputs. Knowledge of electronics testing is essential for this. It is necessary to ensure that different capacitors in the circuit board are in working condition. A close observation of the capacitors for leakage or bulging is helpful in identifying the faulty components. If the power supply unit is continuously switching on and off then the damaged capacitors are responsible for it. Defects in certain components of the board can make the power supply unit getting overheated during its working. Due to this, the computer switches off. This problem can be solved by locating the overheated component and replacing it with a good one when the computer is in switched off state. Much care and precaution are to be taken before opening the case of SMPS unit. SMPS manufacturers do not support the opening of the SMPS case by persons having no experience in this field.

6.7 SELECTING SMPS AND COMPUTER CABINETS

SMPS with a steady power supply and having the correct power rating is necessary for the smooth running of computer system. Usually, computer SMPS units are available mounted along the computer cabinets. Cabinets are available in different form factors and in vertical and horizontal orientations. Depending on the orientation, the position of the SMPS unit inside the cabinet varies. However, SMPS is fitted with its air vent facing outwards on the rear side of the cabinet. Cabinet consists of one or more cooling fans fitted to it which can be of different sizes.

Cabinets with adequate ventilation provided with fixtures for mounting fans are preferred. Provision for rear and front vents is another desirable feature associated with the computer cabinets. An additional fan on the cabinets provides more air flow and makes the hardware run smoother, thereby increasing the life of components. A large cabinet provides enough space for air circulation as well as allows easy access to hardware, whenever required. Provision of enough drive bays helps in fixing more drives inside the cabinet. Screw mounted blanking plates that cover the unused bays are better, as these bays can be easily removed as well as replaced in the correct manner, thereby preventing unnecessary exposure to dust. Cabinets with thumb screws and slide out panels are easy to handle. To keep different components free from moisture, it is preferable to keep a packet of silica gel inside the cabinet.

6.8 SMPS: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the computer SMPS units and the suggested solutions are given in Table 6.5.

Table 6.5 SMPS: Common Problems and Suggested Solutions

Problem	Solution
Computer does not boot when started.	Check whether the SMPS is faulty or working. This is done by checking the rotation of cooling fan on the SMPS unit. If the fan rotates, the SMPS is working. Check for other causes.
SMPS does not start.	Check the wall socket for power. Check the power cable. Replace the cable and try again.
Pressing the front panel switch does not switch on the computer.	Check whether the connection from the motherboard to the panel switch is firm and is fixed correctly. Replace and fix the connection and try again. If the switch is defective, replace the switch.
The system powers on after a couple of trying	Ensure that the power on switch is not faulty. Replace the SMPS.
The system powers on but nothing happens after that.	This may be because enough power is not available for the hard disk. Check the power cable connection to the hard disk.
A whistling noise arises when the computer starts.	The noise may be due to dust deposits in the fan of the power supply unit. Disconnect the system and clean the fan. This will solve the problem.
The computer freezes or reboots during working.	One reason for this problem is related to the overheating of SMPS. Clean the fan from dust deposits. If the problem still exists, it indicates that the SMPS is failing.
SATA power cable is not available in the SMPS output cables.	This is common with old SMPS units. Using IDE to SATA power adapters help in solving the problem.
The working computer restarts after an additional hard disk is connected.	The SMPS may not be having the necessary capacity to power the newly added component. Replacing the SMPS with a higher rated unit can solve the problem.

6.9 UNINTERRUPTED POWER SUPPLY

Uninterruptible Power Supply (also called as UPS) has become an indispensable item for powering computer systems. This is because of the increased dependence of the world on computers and other electronic devices for communications and computations. Also, changing the mode of activities from offline to online makes the connecting devices always powered on. If a server running online activities turns off, it takes time to start its normal functions again. During this time, the connection between the server and the client is lost, thereby affecting the business of the enterprise. In a competitive market, availability is very important. A reliable UPS provides continuous power for different systems and keeps them up and running continuously for hours, whenever there are power failures so that the customers would stay connected always. Nowadays, UPS is widely used for operating computers, communication equipment, medical equipment, computerized instruments and so on where the interruption of power even for a few seconds, is considered very critical. The UPS functions like an inverter converting DC voltage stored in the rechargeable batteries to AC voltage. The batteries are charged when input power is available and are kept ready to be used when there is power failure. A basic inverter supplies unfiltered power whereas UPS removes spikes and surges and supplies refined stable power. UPS is available in different capacities for powering different computer systems, i.e., from a single computer to an entire building.

Several problems are arised on connecting the computer systems directly to the mains power supply units. If the computer is powered directly from the mains power supply, variations in the line voltage seriously affect the computer system or even cause its damage. Data loss and file corruption can also happen due to input power voltage fluctuations. Line noise, surge, lightning, brownout, blackout are the major causes that affect computer systems when they are directly connected to the mains power supply. A perfect sine wave output current supply cannot be obtained directly from any power source.

Line noises are due to variations in supply voltages. Power supply usually contains line noises that are created due to the working of other equipment connected to it. The line noise is technically referred to as Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) disrupting the smooth sine wave power output. **Surges** also affect a smooth power output. It is a momentary sudden rise in the supply voltage due to the working of certain machines such as welding machines or motors connected to the line or due to problems in electrical networks. This momentary sudden shooting up of voltage can damage the electronic components. Surges can make the computers permanently damaged. Due to lightning also, the voltage in electric lines can fluctuate in a wide range. This wide variation in supply voltages can also damage the computer systems, if they are directly connected to the mains electric power supply. **Brownout** is the phenomenon occurred when the supply voltage falls below the operating voltage of the connected equipment. This is also called **sags**. This is the most common type of power problem and accounts for the majority of power disturbances. Falling of the supply voltage level below the normal operating voltage level of computer system makes the system switched off. Sags also results in frozen keyboards, unexpected system crashes and results in reducing the life of electrical equipment. Power supply failure is known by the term **blackout**. A sudden blackout damages the system, corrupts computer files and hence, there is a loss of data and computer files. Sudden blackout can also cause computer hard disks to develop bad sectors, thereby damaging them.

Thus, it is clear that commercial power supply is not at all capable of providing clean and consistent electric power demanded by the electronic equipment. To avoid all the above difficulties associated with the mains power supply, computer systems are powered through UPS that not only conditions the power supply but also provides necessary backup power during the failure of mains power supply with the help of battery backup.

A number of technologies are used in the manufacture of UPS. Digital Signal Processing (DSP) technology offers several advantages. This type of UPS has a long life, as the signaling is done at a low voltage. But the design and implementation cost is high. This type of UPS is having a small number of components and hence, has an increased life. DSP controller offers better functions including the ability for controlling and sensing input and output voltages, controlling battery charger and so on. Higher uptime, increased reliability, faster response time, ability to work at a low voltage, easy setup and risk-free operations are the other features of this type of UPS. Another technology used in the manufacture of UPS is Insulated Gated Bipolar Transistor (IGBT) technology. Enabling IGBT to work at high capacities helps to increase the overall system reliability, power efficiency, power density and to get a near perfect output. These types of systems replace bulky transformers, relays and mechanical switches with smaller functional equivalents.

6.10 WORKING OF UPS

A line diagram showing the major components of UPS is given in Figure 6.4. UPS is made up of charger or converter, battery and inverter. Charger or converter converts the incoming AC to DC. The converted DC is stored in the battery which is then converted to AC by the inverter for the use of equipment. Facilities for conditioning the power and controlling the operations of components are also included with the UPS.

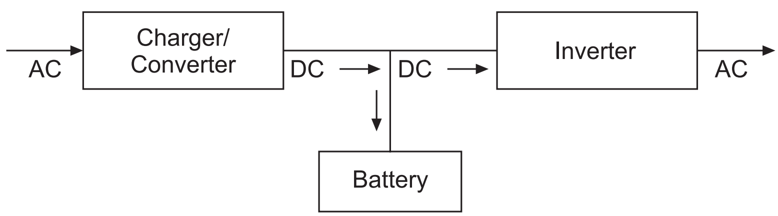


Figure 6.4 Components of UPS.

Working of UPS is controlled with the help of a microprocessor. The microprocessor senses the failure of AC power, switches between the mains and battery power sources and monitors battery status.

6.11 TYPES OF UPS

Mainly, two types of UPSs are available, namely, offline UPS (or standby UPS) and online UPS. Different levels of protection are offered by the different types of UPSs. The cheapest UPS available is the offline UPS and this is the widely used UPS type.

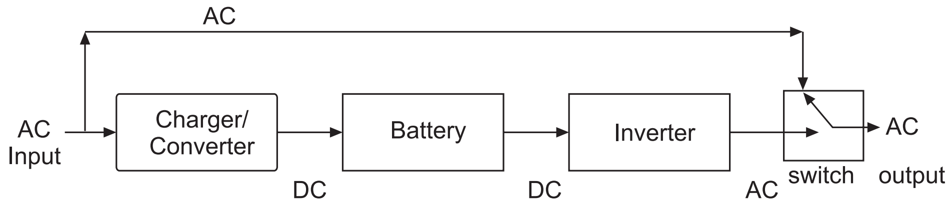


Figure 6.5 Working of offline UPS.

The working of an offline UPS is clear from Figure 6.5. The **offline UPS** is made up of a power conversion unit, battery, inverter and a changeover switch. The input AC power is converted to DC using the charger or converter. The converted DC is used to charge the battery. The DC from the battery is given as the input for the inverter that converts this DC to AC. A control circuit controls the operations of the components. The input AC power is used to charge the battery as well as to provide output power. Under normal conditions, the output is given direct from the input supply. When the mains supply fails, the changeover switch connected shifts its position from the input AC supply to the output terminal of the inverter and the power is supplied from the battery through the inverter. When the power supply is restored, the changeover switch shifts its position back to the direct power line. During the changeover period, the computer fails to get power. But the computer can run for a short period of the order of 10 to 15 milliseconds using the charge stored in the capacitors present in its power supply. Before the capacitor is fully discharged, the changeover process of the UPS is completed and the power supply is restored. Circuits for power conditioning and surge protection are also included with this type of UPS. The major difficulty with this type of UPS is the time necessary to make the changeover from one position to the other. This changeover time is of the order of microseconds. In the server type computers, this tiny changeover time is critical and hence, this type of UPS is not used with the server computers. For servers and other types of systems where a tiny changeover power disruption is critical, online types of UPS are used.

Nowadays, a variant of the offline UPS commonly used for the computer systems is known as **line interactive UPS**. The working of this UPS is similar to the offline UPS but the line interactive type offers better performance and higher protection. The changeover time of this type of UPS is much less than that of the offline UPS.

Online UPS is the ideal and the best UPS that offers complete protection from surges, line noise, brownouts and blackouts. In online UPS, the inverter supplies full load all the time, which in turn, enables the UPS to regenerate the complete output every time. This type of UPS always runs from the battery. Due to this, there is no transfer time or changeover time in the event of failure of the mains supply. Also, there is no need for activating any changeover switch in the event of brownout or failure of mains supply. In this case, any voltage fluctuation affects the battery charging voltage only and not the output. For high uptime of systems, online UPS is the correct choice. A line diagram of the online UPS is given in Figure 6.6.

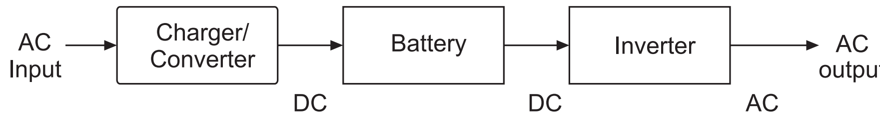


Figure 6.6 Online UPS line diagram.

Online UPS supplies conditioned clean power due to double conversion, i.e., from AC to DC and then from DC to AC. Thus, the online UPS is also known as **double conversion UPS**. Due to the double conversion process, this type of UPS fully protects the load from all power problems taking place in the electrical networks. Also, the online UPS provides true output voltage regulation during sags and brownouts without battery involvement, which in turn, increases the battery life and reserves the battery capacity for blackouts. As the inverter is always working in the online mode, it is not vulnerable to thermal shocks or stress, which is a characteristic of offline UPS when the power supply is suddenly switched to the inverter. The major drawback is the loss of energy in the form of heat during the double conversion process. **Delta control online UPS** are developed with a view to minimize the loss of power in the form of heat during the conversion process. This UPS makes the use of delta converter instead of the battery charger. In this type of UPS, a part of the output is fed from the mains line alongwith the battery output. Due to the use of transformer, inverter and the associated circuits, the size of online UPS is larger than the offline UPS.

6.12 FRONT AND REAR PANELS

Like other equipment, UPS is also having a number of control switches on the front panel. The type and the number of control switches vary with models and capacity. These include on/off switch of the UPS and a display panel. The on/off switch acts as a toggle switch. The UPS can be put to on and off states using this switch. The display panel displays the working status of the UPS at any time. The different displayed messages can vary with different UPSs. The common display messages include load percentage, input voltage, battery conditions, etc. Several status indicators are also available in the front panel of the UPS. These indicators include audible type indicators as well as visual LED indicators. The number of indicators differs with different UPSs. Line on indicator, battery on indicator, overload indicator, load status indicator, battery status indicator are some of the common visual indicators available in several UPSs. Audio indicators produce audio signals at appropriate time such as when the mains supply fails, battery voltage falls to an extremely low level, etc. New UPSs are available with software control for different control and monitoring operations and this software helps in the proper diagnosis and controls the operations. Some of these new UPS units offer facility for monitoring their working status remotely through a network. Figure 6.7 provides the details of the front and rear panels of a typical UPS unit.

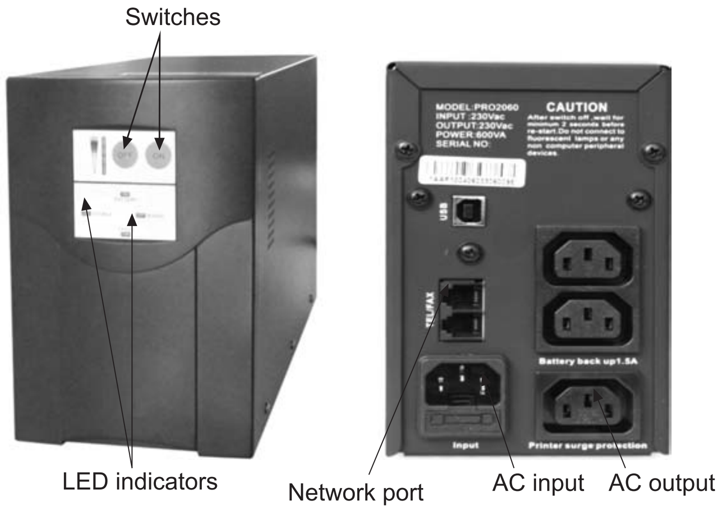


Figure 6.7 Front panel view and rear panel view of UPS.

There are no control switches or indicators on the rear side of UPS. Connections for input power and external load are provided on the rear side of the UPS. Low rated UPS is having internal batteries and these are enclosed within the UPS case. External batteries are common for UPS with higher ratings. Connection to the battery bank is through the connectors on the rear side of the UPS. The number of batteries in the battery bank can vary and it depends on different factors such as the backup time required, capacity of battery, etc. For cooling purposes, cooling fans are fitted internally in the UPS. Number of cooling fans can be more than one. Air vents for cooling fans can be seen on the rear side of the UPS.

6.13 UPS FEATURES AND SPECIFICATIONS

UPS are available with different capacities and are having different features. Rack mountable UPS and standalone UPS are commonly used with the computer systems. The **rack mountable UPS** is mounted on the computer rack alongwith the computer. Capacity of UPS is indicated in voltampere (VA) unit that indicates the apparent load which is supported by the UPS. The actual load in watt units (W) that is supported by the UPS is less than its voltampere (VA) rating. Thus, the watt rating determines the actual power that can be supplied by the UPS while voltampere rating is used for sizing of wiring and circuit breakers. The ratio of watt to voltampere rating is called as **power factor** and is expressed as a number like 0.8 or as percentage like 80 %. The UPS selected for a computer system must have the required rating for running the system. Single phase and three phase type UPS are available. Low power rated UPS are single phase type. UPS with power rating above 5 kVA is available as three phase type only. Normal working voltage of a computer system is 230 V with frequency of 50 Hz. So, the output required from UPS must be 230 V at 50 Hz frequency. The UPS must also have a pure sine wave output. The other features expected from any UPS are overload protection, automatic recovery from overloads and short circuits, etc. The recovery time must be small of the order of microseconds. The UPS must be capable of working on a range of frequencies below and above the normal value. The same is applicable in case of voltage also, i.e., the UPS must work on a range of voltages below and above the rated input voltage. Excellent power conditioning is another characteristic of the UPS. The power conditioning eliminates any noise from the output supply. Battery backup time and switching or transfer time are the other two important quality parameters of any UPS. Backup time is defined as the time for which the UPS can provide power from the battery for a given load. Extended battery life and extended backup time are essential for any UPS. Extended backup time is obtained with the help of external batteries connected to the UPS. Switching time or transfer time is the time taken by the UPS to switch to battery when the mains power supply fails. Panel display of parameters such as remaining backup time, battery condition, etc. is another feature necessary for a UPS. Cooling is necessary for UPS to dissipate the generated heat inside the case. Cooling fans are the common means used for cooling the internal components of UPS. Some of the general parameters and typical values of UPS are given in Table 6.6.

Table 6.6 General Features of UPS

Parameter	Typical value
Capacity	1 kVA, single phase input/output
Input voltage	170–270 AC single phase
Input frequency	50 Hz +/– 3 %
AC output voltage	220–230 V +/– single phase
Output frequency	50 Hz +/– 1 %
Output waveform	Sine wave
Transfer time	Less than 5 ms
Battery type	Sealed Maintenance Free (SMF) type 12 V, 7 AH
Backup time	15 to 30 minutes
Output protection	Over/under voltage, overload
Battery protection	Over/under voltage battery
Audio alarm	Battery low and overload
Visual indications	Mains on, battery low, inverter on
Operating temperature	0°–50°
Cooling	Air cooling

Online UPS is manufactured by incorporating several additional features to enhance the quality of output and to increase reliability. So, more specification parameters are taken into consideration while selecting online type UPS. The major features considered for the online UPS are given in Table 6.7. Currently available UPSs are having features such as IGBT technology with high frequency switching, high efficiency, reduced operating cost, continuous operation, pure sine wave output, complete isolation from mains power lines, protection from bad power due to spike surges, RFI or EMI, active power factor correction, microprocessor controlled operation, increased reliability, double conversion technology, etc. Output isolated transformer helps to segregate the input and output completely in the inverter mode, thereby providing a safe neutral line to the load. Communication software bundled with the device controls the

UPS and turns it off when the utility fails. This also allows testing major operating conditions of the UPS in a remote manner. Redundant power protection is another feature available in several UPSs.

Table 6.7 Specification Parameters of Online UPS

Parameter	Typical value
Capacity	1 kVA, single phase input/output
Input voltage	170–270 AC single phase
Input frequency	50 Hz +/– 3 %
Converter technology	IGBT rectifier technology
Input power factor	> 0.8 PF
Inverter	
DC input voltage	24 V to 192 V
Switching device	IGBT/MOSFET
AC output voltage	220 V – 230 V +/– single phase
Output frequency	50 Hz +/– 1%
Output waveform	Pure sine wave
Efficiency	AC to AC 90 %
Harmonic distortion	THD < 5 %
Overload capacity	125 % for 1 minute
Display	LCD for load percentage, input, output
Output protection	Over/under voltage, overload
Battery protection	Over/under voltage battery
Audio alarm	Battery low and overload
Visual indications	Mains on, battery low, inverter on
Operating temperature	0 degrees – 50 degrees
Cooling	Forced air cooling
Audible noise	< 45 dB

6.14 UPS BATTERIES

Battery is an electric storage device and is used in industrial, automotive and traction areas. Batteries used with UPS are of different types and having different capacities. The energy that can be saved in the battery is determined by its capacity. Battery is considered as the heart of UPS. More energy can be saved in more powerful batteries and hence, such batteries provide a longer backup time. Large plates of battery cells indicate a large capacity. Lead acid batteries are used with UPS and these differ from automobile batteries. Automobiles use flood cell batteries having sulphuric acid as the liquid component. Batteries used with UPS are tubular batteries or Sealed Maintenance Free (SMF) batteries, as shown in Figure 6.8. SMF batteries are environment friendly and can be directly used in the office environment. These are self-contained, safe, free from maintenance and are widely used.

Figure 6.8 SMF battery and tubular battery.

The capacity of battery is indicated in units known as ampere hour or AH. This is an indication of the ampere load that is supported using the battery for one hour. SMF batteries are of three types which are as follows:

(a) Small SMF batteries have capacities ranging from 4 AH to 17 AH and these are used for micro and mini UPS with capacities ranging from 0.5 kVA to 2 kVA and provide battery backup for 5 minutes to 20 minutes.
(b) Medium SMF batteries have capacity ranging from 26 AH to 200 AH and are used with UPS having capacities from 1 kVA to 80 kVA and provide battery backup for 30 minutes to 6 hours.
(c) Large SMF batteries are used with UPS above 80 kVA rating.

Batteries of UPS can be either fitted inside or can be connected externally. The factors considered for selecting batteries include power load to be supported, backup time required and operating conditions. Under normal working conditions, the UPS supplies power loads and charges the batteries connected to it from the mains. During brownout conditions, when the voltage falls down, the UPS supplies the loads from the mains as well as from the batteries. In the absence of mains supply, the entire load is supplied from the batteries that makes them discharged. It is observed that a deep discharge (below 80 %) of the battery reduces its life by twenty-five percent. In the presence of mains supply, the battery is charged as well as the load is supplied by the mains.

Each battery is made up of six cells, each cell having an individual output voltage of 2 V DC. Thus, the battery bank provides an output voltage of 12 V DC. Forming a battery bank with six cells is only for convenience and battery banks with voltage ratings of 2 V, 4 V and 6 V capacities are also available. A number of batteries can be connected in series to get higher voltage ratings and these can also be connected in parallel to get a higher capacity. The battery banks are connected in the correct polarity to the UPS. The polarities of UPS are marked on connecting terminals of the UPS. To reduce power loss caused in the connecting wires, the battery banks are kept within one meter from the UPS. There are some steps that must be followed for connecting the battery to the UPS.

(a) First of all, touch the red wire to the positive terminal of each battery so as to charge the capacitor inside the UPS slowly to avoid heavy spark. And then the battery negative is connected to the negative terminal of the UPS using the black wire and the red wire is connected to the positive terminal of the UPS.

(b) After connecting the UPS, it is switched on. It must be ensured that the inverter is working properly. If it is working, then the UPS is switched off.
(c) Now, the input terminals are connected to the mains with correct polarity.
(d) After that the mains supply is switched on. The power indicator LED must glow during this time. The UPS is also switched on and the output voltage level is to be checked.
(e) Now, the load is connected to the UPS step by step.

Operating with improper polarity and earthing can result in severe damages to the UPS and the connected equipment.

6.15 TIPS ON BATTERY CARE

There are no user serviceable parts inside the UPS. Fuse unit provided in the UPS is to be replaced with another one having the same rating, whenever its replacement is required. Proper maintenance of the battery helps in providing long life to it. Terminal corrosion, dirt and moisture can cause loss of power and can make the battery weak. The top of the battery must be kept clean and dry and the vent plugs must be secured. All electrical connections must be properly secured. Petroleum jelly must be applied to the terminals. The cells lose water during their use. The water level must be maintained to the marked indicator by adding demineralized or distilled battery water. Acid must not be added to it. The life of battery depends on the number of times the batteries are charged and discharged. So, in case of frequent power interruptions, the life of battery is considerably reduced. For better performance, it is necessary to keep the UPS in 'on' condition and to charge the batteries. Leaving the batteries unused for days can lead to the failure of batteries. The time for full-charging of batteries depends on the ampere hour rating of the battery. Switching off the input power to UPS slowly discharges the battery and reduces its life.

6.16 UPS: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the UPS, their possible causes and the suggested solutions are given in Table 6.8

Table 6.8 UPS: Common Problems and Suggested Solutions

Problem	Possible cause	Solution
UPS does not turn 'on'	Main switch is in 'off' position. No input power supply. Fuse is blown. Loose contact in the input socket. Input voltage is low or above the operating range.	Turn the mains switch 'on'. Check input voltage. Check UPS fuse. Check for loose contact.

Problem	Possible cause	Solution
UPS works on battery when the mains is on.	Incoming mains voltage is low.	Check the incoming voltage
UPS works on battery.	No input power.	Check the incoming voltage
Low battery indication.	Weak battery.	Replace batteries. Tight the battery connections.
Overload indicator display.	Overload. High temperature.	Reduce UPS load.
Less backup time.	Battery is not fully charged. Battery is out of order. Charger is defective. Loose connection in battery terminals.	Recharge batteries. Replace batteries. Check charger. Check for loose connection. Check battery water level.

7

Computer Monitors

The widely used computer output unit is the display unit, simply called as **monitor**. Earlier computers used CRT types of monitors. But now, these are replaced with less power consumable LED monitors. This is mainly due to the change in display technologies from the earlier green text blinking monitors to the modern LCD displays. Currently, LCD and LED monitors are used as computer output devices. Touch screens are also commonly used as output devices for tablets and smart mobile phones. This chapter includes the description, features and troubleshooting steps associated with different types of computer monitors.

7.1 FEATURES OF MONITOR

Monitor produces display on the screen by lighting small elements or points on the screen. The smallest element of a picture that can be displayed on the screen is termed as **pixel**. It is the short form for **picture element**. A single pixel is created by illuminating several adjoining points of light on the display unit. Pixel size is determined by the size of the light beam spot or electron spot falling on the screen. The number of pixels or dots per inch that can be handled in the screen is known as **resolution** of the screen which determines the fineness of details that can be distinguished in the image. If the pixel size is smaller, it means that the resolution of the display unit is better. Most computer monitors use 72 or 75 pixels per inch. Resolution is specified by the number of pixels in a line multiplied by the number of horizontal lines. Hence, monitor resolution and its size are directly linked. A big-sized monitor helps in getting a higher resolution which means more space is present on the display unit and thus more windows can be opened simultaneously. 800×600, 1024×768, etc. are the common pixel resolutions available for the computer monitors. In the monitors with lower resolutions, images are displayed with its edges, curves and diagonal lines appearing in a staircase manner. This effect is known as **aliasing**. It can be minimized by using monitors with higher resolutions.

Another feature associated with the computer monitors is the **dot pitch**. Dot pitch is defined as the shortest distance between two phosphor dots of the same colour displayed on the screen. The method of determining dot pitch value can be understood from Figure 7.1. Sometimes, the variants of dot pitch such as horizontal dot pitch and vertical dot pitch are also stated while specifying the features of computer monitors. Horizontal dot pitch gives the horizontal measurement while vertical dot pitch specifies the vertical measurement of distance between two phosphor dots of the same colour displayed on the screen. A smaller dot pitch means better resolution of the monitor and hence, this type of monitor produces sharper images. High dot pitch gives a coarse and grainy image. A dot pitch of 0.28 mm or less provides sharper images. The ideal dot pitch for computer monitors is 0.26 mm or less.

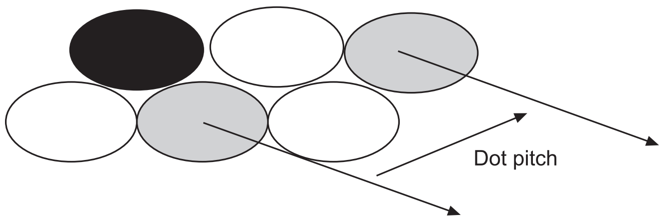


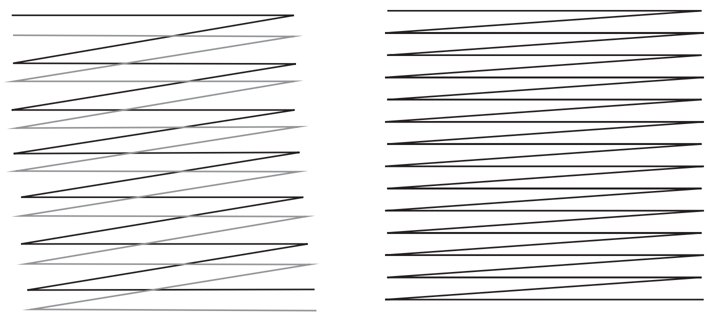
Figure 7.1 Dot pitch measurement.

Size of the computer monitors is measured from corner to corner and it is represented in terms of inch. The real screen dimension that users can see is measured diagonally. The viewable display size of a monitor is always less than the screen size of the monitor, especially for CRT monitors. For example, the viewable display size of a 17 inch CRT monitor is only about 16 inches. It depends on the useful screen size of the cathode ray tube and the opening of the monitor's front cabinet. But for LCD monitors, the viewable area is the same as its diagonal measurement.

In CRT monitors, the electron gun has to scan the display surface from top to bottom repeatedly to provide a consistent display. Refresh rate indicates the number of times the entire screen is refreshed per second. If the refresh rate is 85 Hz, the screen is refreshed or scanned 85 times per second. A higher refresh rate means better image stability and less flickering that helps users to work for long hours in front of a CRT monitor without causing eye fatigue and stress. The refresh rate can be set to different levels by modifying the display properties of the monitor. A lower refresh rate as well as electrical interferences cause flickering in the displayed picture, which in turn, causes eye strain and viewing fatigue in the long run. In LCD monitors, each pixel is individually controlled and hence, flickering is eliminated. The minimum recommended refresh rate for CRT monitors is 72 Hz.

There are two methods of writing pictures on display devices. One is the interlaced type display and the other is the non-interlaced type display. The difference between these two types of display methods can be understood from Figure 7.2.

In earlier generation CRT monitors, a picture is written on the screen by initially writing all even lines and subsequently writing all odd lines of the picture on the screen. Due to this, the complete picture is considered to be composed of two interlaced half pictures or fields. With interlacing, a vertical or field frequency of 50 Hz means a picture or frame frequency of 25 Hz. Television pictures are also transmitted as interlaced signals. The electron beam first scans the screen once to give half of the picture or field. The process is repeated to draw the next half so as to produce the complete picture. The speed of drawing is known as the **vertical scan rate**. It is expressed in hertz (Hz). The **vertical scanning frequency** is also known as **refresh rate**. **Horizontal scanning frequency**, also called **line frequency**, is the number of video lines written on the screen every second (from left to right). This frequency is expressed in kilohertz (kHz.). The higher horizontal scanning frequency produces a better resolution.



(a) (b)

Figure 7.2 (a) Interlaced display and (b) non-interlaced display.

The method of writing a picture on the screen in non-interlaced type display is by writing successive video lines of the picture such that a full frame is written onto the screen in one vertical sweep of the beams. In this type of display, a vertical frequency of 50 Hz means a picture or frame frequency of 50 Hz. At any given resolution, non-interlaced modes are preferable over the interlaced modes. But the non-interlaced mode is more expensive. New generation computer monitors use non-interlaced method of drawing. These computer monitors work at frequencies of 50 Hz to 80 Hz. If the frequency is low, then a flicker effect occurs making the display uncomfortable. Generally, a scan rate of 70 Hz and above produces a flicker free display. The unit of frequency is named after the famous physicist Heinrich Hertz (1857–1894). One hertz (Hz) is equal to the completion of one cycle per second.

The ratio between the brightness of the brightest and the darkest parts of a picture is known as **contrast ratio**. A higher contrast ratio produces better display. LCD monitors have a contrast ratio of around 1000 : 1. The darkest part of a picture is set by the brightness of the unexcited phosphor. This is governed by the degree with which ambient light is reflected. Therefore, in the condition of high ambient light levels, the contrast gets reduced.

Another ratio associated with the screen display is the **aspect ratio**. This ratio describes the relationship of screen width to the screen height. Conventional displays use 4 : 3 aspect ratio whereas widescreen displays are having an aspect ratio of 16 : 9. Movies usually look better in wide screen displays because movies are filmed in such an aspect ratio. **Colour depth** of monitors is the number of colours that a monitor can display and it is determined by the ability of the video card used. Sixteen bit colour depth is the recommended value for CRT monitors. A measure of the speed with which data is transferred between the video card and the subsequent processing circuitry is known as **dot rate**. It is represented in megahertz (MHz).

Computer monitors are specified by stating the colour depth of the display which is indicated in bits per pixel. This refers to the number of grey shades or colours which a monitor can display. A higher colour depth indicates the availability of more colours. An eight bit system can display 2^8 grey shades or colours while a sixteen bit system has the capacity to display 2^{16} grey shades or colours. A computer monitor requires to store all the information in the memory that correspond to all the pixels in the display. With the increase in pixel resolution, more information is to be stored. The information is stored in a special memory known as **Video RAM (VRAM)**. The amount of video memory determines the amount of colours that can be displayed on the computer screen. To provide a resolution of 1600 × 1200 pixels in 256 colours, a minimum VRAM of 2 MB is required. For graphics designing as well as for photographic manipulations operations, higher video memory of the order of 4 MB, 16 MB and so on are used in the computer systems.

Monitors can make use of different types of video inputs. These types determine the type of video sources that can be used with the display devices. Some of the common video sources that are used with monitors include *VGA*, *DVI*, *HDMI* and so on. Video Graphics Array (VGA) is an analogue RGB connection which can be used for computer output. Digital Visual Interface (DVI) offers high quality display and is used for HDTV tuners and computer outputs. High Definition Multimedia Interface (HDMI) offers high quality and is used for high definition TV as well as for computer outputs.

7.2 CRT MONITORS

CRT monitors are of different types. Earlier computers used CRT type monitors which were having the ability to display in black and white shades only. Later on, CRT colour monitors are evolved. Due to analogue nature, CRT monitors deliver true colours and higher resolution with lower dot pitch. The front view of a typical CRT monitor can be seen in Figure 7.3.

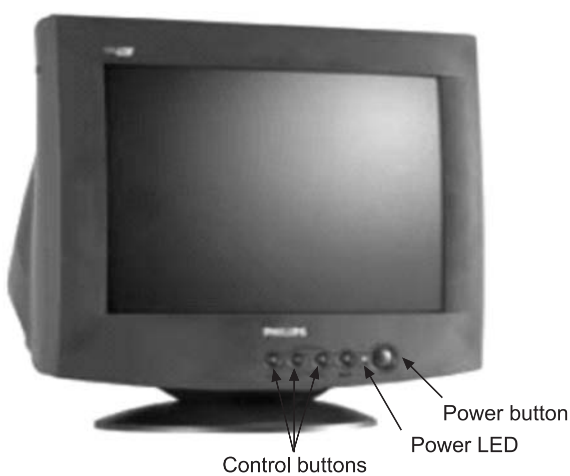


Figure 7.3 Front view of a CRT monitor.

Different front panel controls available with CRT monitors help to perform different monitor feature adjustments. Power button is used for switching on/off the monitor. This switch acts as a toggle switch. The power status of the monitor is indicated by the power indicator LED. This indicator lights up green indicating the normal working of the monitor. Using the menu button, different menu items can be selected and can be displayed on the screen. Pressing the arrow buttons helps to move through the different menu options displayed on the screen. The indicated option is selected by pressing the select button. Using different options available, it is possible to set the brightness, contrast, horizontal and vertical sizes of the screen display and other parameters. Power cable is connected to the power connector on the rear side of the monitor. Connection to the video port of the computer is given using the data cable connected on the rear side of the monitor. Data cable of CRT monitors is having an analogue data cable connector which is a 15-pin D-sub connector. The different pin arrangement for this type of connector is as shown in Figure 7.4.

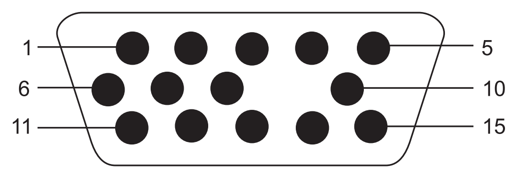


Figure 7.4 D-sub analogue data cable connector pin arrangement of CRT monitors.

The signal assignments for the pins of D-sub connector are given in Table 7.1.

Table 7.1 Signal Assignments of Pins of D-sub Data Cable Connector of CRT Monitor

Pin No.	Assignment	Pin No.	Assignment
1.	Red video input	9.	No pin
2.	Green video input	10.	Logic ground
3.	Blue video input	11.	Identical output—connected to pin 10
4.	Identical output—connected to pin 10	12.	Serial Data Line (SDL)
5.	Ground	13.	Horizontal synchronization/H + V
6.	Red video ground	14.	Vertical synchronization (VCLK for DDC)
7.	Green video ground	15.	Signal Clock Line (SCL)
8.	Blue video ground		

7.3 WORKING OF CRT MONITORS

CRT monitors use cathode ray tube displays. Constructional details of a cathode ray tube monitor are shown in Figure 7.5. Cathode ray tube is a general term used to describe all tubes in which one or more electron beams emitted by a cathode are periodically scanned across a phosphor screen by means of some deflection circuitry. Colour monitors use three electron guns (one for each of the three primary colours, namely, red, green and blue) to scan the screen and to fire a stream of electrons on the screen in proportion to the intensity of the signal received from the digital to analogue circuit from the computer. This circuit compares the digital values sent by the computer with the value stored in the look up table to determine the voltage levels required to brighten a single pixel on the monitor screen. Depending on the pixel resolution of the monitor, the number of values stored in the look up table varies. As the electron strikes on the phosphor coating present on the screen, light is emitted. The working is clear from Figure 7.5. Phosphor is the generic name for the class of substances that exhibit luminescence. To produce a picture on screen, phosphors are deposited on the inner surface of the picture tube screen and these are excited by the striking electron beam to show luminescence. Typical examples of phosphors are P22 medium short persistence phosphor and EBU high colour saturation phosphor. Different types of phosphor materials are used for red, green and blue colours. By using different voltage levels for each colour, different grades of colours can be produced on the screen. If the intensity levels for the three colours are equal, white colour is displayed on the screen.

Due to the bombardment through electron beam, monitor screens become electrically charged when in use. Electrically charged screens surfaces can attract dust particles. An antistatic coating, which is a conductive coating deposited on the screen (or on a glass panel immediately in front of the screen), conducts away the charge and prevents screen dust built-up.

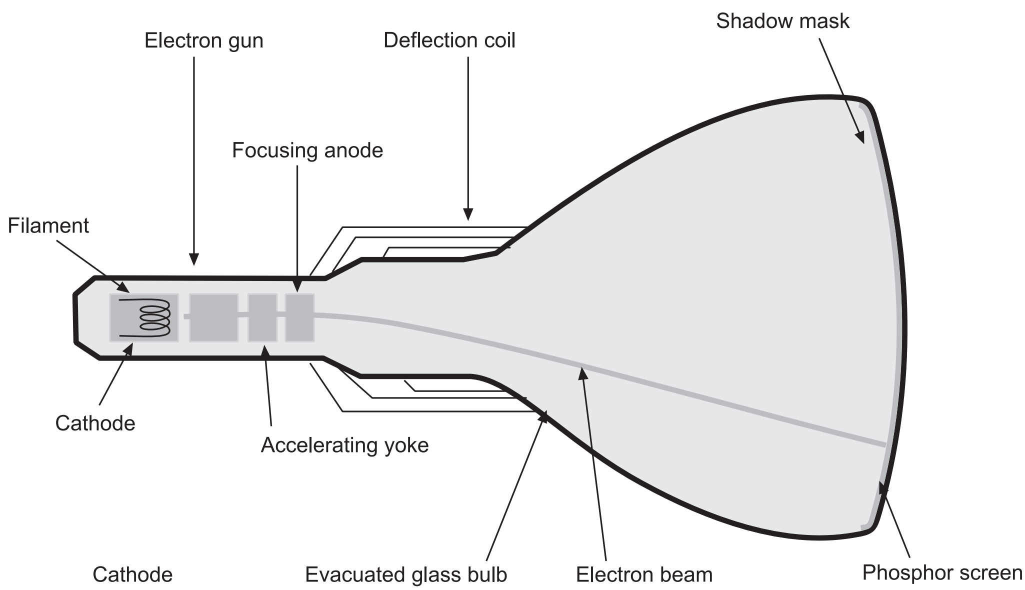


Figure 7.5 Working of a CRT monitor.

As stated above, to produce images in the monitors, an integrated circuitry is essential for generating the necessary electrical signals based on the image signals received. This circuitry is known by different names such as *video controller*, *display adapter*, *graphics card* or *graphics* *adapter*. Earlier computers had the circuitry fitted to the motherboard in the form of *add-on cards*. The expansion card is equipped with a character or graphic generator and video memory. The video memory maps to the screen. A microprocessor scans the video memory and translates bit information of the computer into video signals that can be displayed on the monitor. The expansion cards comply with various standards that determine the nature and quality of the display. Different computers use different types of graphics cards. Computer display unit is connected to the system through the graphics adapter. Common graphics adapters are *EGA*, *VGA*, *SVGA*, *XGA*, *VESA*, etc. Enhanced Graphics Array (EGA) was the earlier type of graphics card. Video Graphics Array (VGA) was introduced in 1987. VGA offered still higher resolution than EGA. The resolution offered was 640 × 480 pixels for graphics and 720 × 400 pixels for text, and a colour palette having 256 colours. VGA could emulate earlier types of adapters. Super VGA (SVGA) was devised by VESA in 1989 that offered a resolution of 800 × 600 pixels. Extended VGA (EVGA) was introduced by VESA in 1991 which offered a top resolution of 1024 × 768 pixels. Currently used high end graphics adapters offer top resolutions from 1280 × 1024 to 1600 × 1280 pixels. The modern motherboards do not have separate add-on graphics cards. These have graphics cards integrated with them. The chipset used for graphics operations and the memory available for graphics operations determine the speed and resolution of the display unit. Increasing the video memory helps in displaying the image having more colours with better resolution.

7.4 SPECIFICATIONS FOR CRT MONITORS

The common specifications related to CRT monitors are given in Table 7.2.

Table 7.2 Specification of CRT Monitors

Parameter	Value
Size and deflection	15 inch (38 cm), (35 cm viewable) 90° deflection angle
Dot pitch/Grille pitch	0.28 mm
Horizontal pitch	0.24 mm
Tube type	Shadow mask, flat square, antiglare, antistatic
Horizontal synchronization	30 kHz to 70 kHz
Vertical synchronization	50 Hz to 120 Hz
Display colour	Unlimited
Maximum resolution	1280 dots, 1024 lines
Active display	Horizontal – 267.0 ± 4 mm Vertical – 200.0 ± 4 mm
Video dot rate	65 MHz
Input impedance—Video	75 ohm
Input impedance—Synchronization	2.2 kΩ
Input signal levels	0.7 Vpp
Sync polarities	Positive and negative
Power supply	A.C. 100 V to 240 V, 50 Hz to 60 Hz
Power consumption	75 W (maximum)

7.5 SETTING UP CRT MONITORS

Setting up a CRT type computer monitor involves the following steps:

(a) A monitor is packed with the swivel or tilt stand separately. So, the first step is to fit the stand which is very easy. For this, the hooks are aligned on the swivel stand with the matching slot on the base of the monitor. Now, the hooks are inserted into the slot. The stand is slided towards the front of the monitor until the latches click into the locked position. After that the monitor is placed correctly on the level surface.

(b) After fitting the stand, the next step is to connect the signal cable to the computer. For this, the end of signal cable from the monitor is connected to the video port of the computer. The signal cable end connector is shown in Figure 7.6. The connector should not be forced to the video port, as this can damage the pins. After connecting it properly, the thumb screws are tightened to secure the connection.

(c) Now, the power cord is connected to the power socket present on the back side of the monitor. The power cord from the monitor is then plugged to the electrical outlet.

(d) After that, the computer is switched on and the power switch of the monitor turned on. If the monitor displays an image, the installation is complete.

Figure 7.6 Power cord and CRT monitor signal cable end connector.

A number of buttons are provided on the front panel of the monitor. Using these buttons, the different display properties of the monitor can be controlled. Buttons for adjusting brightness, contrast, horizontal and vertical positions, controlling geometry of the image are usually provided in the monitors. The working of these buttons varies with different types of monitors. The control buttons can be used to obtain optimum display quality. When a control button is pressed, it fires up *On Screen Display* (OSD) feature of the monitor, thereby displaying a menu on the screen. The menu is built into the monitor memory. Using the other control buttons, it is possible to navigate through the different options in the menu and the required one can be selected by pressing the select button. Thus, it is possible to control the size, shape and position of the image appearing on the screen. The newly set values for different feature parameters can be saved by taking them into effect. One button available in the front panel of the CRT monitors is for degaussing operation. Actually, the operation of the CRT monitors is affected by the influence of nearby electrical equipment and this results in a distorted image displayed on the CRT screen. Then, the degauss operation demagnetizes the electron gun and compensates the distortion caused. In new monitors, degaussing is done by selecting the displayed menu on the screen.

7.6 TROUBLESHOOTING AND MAINTENANCE

A high voltage exists inside a computer monitor, especially inside a cathode ray tube monitor. To avoid shock hazards, the cover of monitor should not be removed when it is working and without taking adequate proper precautions. There are no user serviceable components inside the cover. In case of any repair, the cover must be opened only by the qualified service personnel, since there is a danger of exposing to shock hazards. Careless handling of internal components can be fatal. The monitor should not be connected or disconnected during an electrical storm. The monitor must be disconnected from the power supply if it is not to be used for a long period of time. Also, the magnetic materials should not be brought near the picture tube.

Misalignment of one or more of the three beams due to passing through wrong aperture in the shadow mask and striking a phosphor dot in the wrong triad creates **convergence error**. This error is expressed in millimeter (mm) often at three well-defined points on the screen such as at the centre of the screen, at the corner of the screen and midway between these two points. Special convergence error correction coils in the deflection yoke are usually used for correcting this error.

Demagnetizing the shadow mask and the associated metal parts of a picture tube when the monitor is switched on, to minimize picture distortions is known as **degaussing**. This is usually accomplished by means of a special degaussing coil. A decaying alternating current is passed through the coil to generate an alternating magnetic field that gradually decays to demagnetize the tube. Some monitors offer a manual degaussing facility that can be activated at any time.

A very rapid variation in picture intensity is caused by the finite time required for the electron beam to scan a picture onto the screen. Due to this, two kinds of flicker, namely, line flicker and frame flicker occur. **Line flicker** is caused by the electron beam scanning in each line of the picture. **Frame flicker** is caused by the frame repetition rate of 50 frames per second. This flicker is noticeable with GUI and DTP software and can be very disturbing. The flicker causes eye strain, headache, visual blurring, stress, etc. to the users. The problem can be eliminated by increasing the refresh rate (number of frames/second) of the monitor to a value above 70 Hz.

Appearance of a repetitive wavy pattern, which is superimposed on the screen as ripple images, is called **moire effect**. This effect can be minimized by changing resolution or by changing the horizontal and vertical sizes. Cancellation feature available with some monitors can be effectively used in this regard.

The following instructions must be followed while connecting and using a computer monitor:

- The monitor without stand should not be operated. It must be operated in the specified power supply type as per the specifications.
- Broken power plugs and cables are to be avoided, as they can cause shock or fire hazard.

- The power cord must be connected to a properly grounded power outlet.
- Any equipment to which the monitor is connected must also be connected to a properly wired and grounded power outlet. It should be ensured that the plug is completely inserted into the socket and no bare pins of the plug are exposed.
- To avoid the risk of shock or permanent damage, the monitor should not be exposed to rain or excessive moisture.
- Nothing is to be placed on the top of the monitor cabinet, as this may prevent the proper cooling of the monitor's electronic components.
- Slots and openings in the cabinet are provided for ventilation. To ensure reliable operation of the monitor and to protect it from overheating, it is to be ensured that these openings are not blocked or covered.
- Placing the monitor on an unstable surface is to be avoided. If it falls, then it may injure the user as well as can cause damage to the equipment.
- The monitor cabinet should be cleaned regularly with a cloth. Before this, it must be ensured that the monitor is disconnected from the power supply.
- Use of severe spray cleanser or an alcohol or ammonia based liquid for cleaning the monitor cabinet should be avoided. Instead, a slightly damp cloth can be used for this purpose.
- Leaking liquid on monitor and scratching the screen with hard things result in the damage of chassis and the components.

7.7 CRT MONITOR: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with CRT monitors and the suggested solutions are given in Table 7.3.

Table 7.3 CRT Monitor: Common Problems and Solutions

Problem	Solution
No picture is shown. Power LED is not lit.	Make sure that the power cable is plugged into the power outlet and to the socket on the back of the monitor. The power cord must be firmly connected to the monitor. Power button of the monitor must be in the 'on' position. There must be power supply in the outlet. Switch off and then switch on the monitor. If the problem still exists, replace the monitor.
No picture is shown. Power LED is yellow.	Make sure that the monitor cable is properly connected to the computer and the computer is turned on. Ensure that the monitor cable has no bent pins in the connector. Press any key on the keyboard to wake up the computer from power saving mode.

Problem	Solution
No picture is shown. Power LED is green.	Make sure that the computer is switched on. Ensure that the brightness and contrast controls are set correctly and not at low levels. Also, check whether the monitor video signal cable is properly connected to the computer. Ensure that the monitor video signal cable has no bent pins in the end connector.
The display is not appeared on the monitor when it is switched on.	Make sure that the monitor cable is properly connected to the computer. Ensure that the monitor has no bent pins in its end connector.
Colours displayed appears blotchy.	The picture may need degaussing. Remove any nearby magnetic object.
One or more colours are missing in display.	Make sure that the monitor cable is properly connected to the computer. Ensure that the monitor cable has no bent pins in the connector.
Picture is too light or too dark	Adjust the brightness and contrast controls.
Picture is too large or too small.	Adjust the horizontal and/or vertical size and zoom levels.
Picture is not sharp.	Adjust contrast level.
Picture is unstable.	Increase refresh rate.
Picture is unreadable, wavy, rolling and distorted with dark or shadowed areas.	Check the presence of other devices such as transformers, fluorescent lights, etc. nearby which can create magnetic fields making the screen jitter, wavy, distorted, unreadable or rolling. Keep monitor away from the vicinity of the objects producing magnetic effects.
Monitor flickers.	Install the correct driver for the video card. All electrical devices including mobile phones are to be placed away from the monitor. Adjust the refresh rate to 75 Hz or above.
Wrong characters are appearing on the screen.	Check the BIOS settings to ensure that the correct language is set. Check the monitor cable and make sure that the cable is fixed firmly.
The screen is having a bluish, greenish or purplish tint.	This is due to a break in one of the three colour signals between the video card and monitor. Check the signal cable for any break. Replace the cable. If the problem still exists replace the monitor.
The image appears and disappears randomly	Check the cable connections and the video card. Replace it, if necessary.
Not Enough Video Memory error message appearing on the screen.	Increase the virtual memory.

7.8 LCD MONITORS

CRT monitors are bulky and have high rate of power consumption. But these are easy to manufacture and are durable. Also, the image quality is good. To increase the display size, the length of CRT has to be increased, which further makes them bulky and heavy. CRT monitors are replaced by Liquid Crystal Display (LCD) monitors that use transmitting devices that make the use of ambient light to produce the image. Liquid crystal is a crystalline substance close to the liquid state and is sensitive to electric current. In LCD monitors, liquid crystals are compactly placed between thin polarized sheets. On applying different voltage levels to the liquid crystals, the required display is produced having different colours with varying intensities.

LCD monitors are made up of LCD panels. These panels are used in different types of digital devices such as digital watches, flat screen monitors, television sets and so on. LCD panels used earlier were having black and white colours and were smaller in size. LCD monitors are more compact in size and occupy one-third of the space occupied by CRT monitors. LCD monitors generate less heat and consume less power. These are more stylish than the CRT monitors. These are crisper and have better performance. These monitors have zero radiation effect and do not possess screen flicker, thereby ensuring lesser or no eye strains during the long hours of working. LCD monitors are required to be updated when the display changes. The speed at which the updates are made is called **response time** of the monitor. Better monitors are having lesser response time, as this reduces the blurring effect as well as ghosting effect on the screen. A response time of 5 ms is ideal for LCD monitors but a lower response time is preferred for multimedia and animation applications. LCD monitors have wide screen form factor, greater viewing area, better picture quality and superior efficiency. These monitors offer more brightness than the CRT monitors. Moreover, these monitors are not affected by any magnetic interference while the CRT monitors are adversely affected. Automatic picture adjustment feature of LCD monitors helps in the automatic adjustment of display when the monitor is set at different refresh rates. Pivot display feature of the monitors helps to change their orientation easily such as from landscape to portrait mode. Built-in speakers and headphone jacks are now commonly available in the LCD monitors.

There are different types of LCD displays. **Active LCD**, or Thin Film Transistor (TFT) display is extensively used for display purposes. TFT technology is used to create thin and flat colour screens for computer monitors and digital cameras. This display has better image quality which is not possible with other LCD type displays. Regarding the constructional details of TFT monitors, these are made up of tiny switching transistors arranged like a matrix, in a glass substrate. A particular pixel is lighted up by applying power to the corresponding capacitor at the required position. Similar to the method used for identifying memory cells, to identify the correct pixel position of the pixel, row and column positions are used. The charged capacitor holds the charge till it is refreshed in the next cycle. By carefully controlling the applied voltage levels, it is possible to control the amount of light that is passed, which in turn, makes it possible to create different shades of grey levels on the screen. Colour LCD monitors make use of three subpixels with red, green and blue filters to create each colour pixel. By controlling the voltage levels, it is possible to create different colour shades. A palette consisting of 16.8 million colour shades can be set by combining all the three shades. Active matrix LCD monitors are free from ghost effect. This effect occurs when the display is forced to refresh its output faster than it is able to do. Ghost effect is common in passive matrix LCD monitors and this is the major drawback of passive type LCD monitors.

There are several lacking features associated with the LCD monitors. Resolution of CRT monitors can be varied. But LCD monitors are having fixed resolutions. The image quality of LCD monitors is not as impressive as that obtained from CRT monitors. If the LCD monitor runs in any resolution other than its native resolution, then it would lead to a drop in its performance or quality. The views from LCD monitors can vary with different viewing positions or angles as well as with the distance from the monitor. But this is not the case with CRT monitors. Usually, it is possible to adjust the angle of the monitor from –5° towards the user to 20° away from the user, as shown in Figure 7.7. There is a maximum angle (or viewing angle) which allows a viewer to view the display in LCD monitors without any deterioration in the display quality. Having a higher viewing angle is a feature of a better monitor.

Figure 7.7 Possibility of the adjustment of viewing positions in an LCD monitor.

As stated earlier, each pixel of the LCD monitor is made up of tiny switching transistors. With the increase in resolution and size of the display, the number of transistors to be used in the display increases. This makes LCD displays prone to dead pixels or bad transistors. **Dead pixels** are the pixels on the screen that do not function. These pixels always remain in the 'on' position or 'off' position. As these pixels remain at the same place all the time, these pixels can be easily spotted. Dead pixels appear as black dots on the display. These pixels are produced during the manufacturing process and are not repairable. With large-sized LCD displays, the chances of formation of dead pixels is higher. But this type of problem does not arise in case of CRT monitors. The inherent problem of limited viewing angle and the hazy displays are the other drawbacks of LCD monitors. Several transistors are used for manufacturing TFT displays. If any of the transistors is dead, it affects the visual effect created on the screen.

Plasma materials are used in place of liquid crystals to produce display devices which are known as **plasma displays**. These displays are similar to LCD in physical characteristics and have slim, compact and sleek design. Some of the normal symptoms common with this type of monitors include the flickering of screen during the initial use due to the nature of the fluorescent light. To remove the flicker effect, the monitor is first turned off and then powered on again. Slightly uneven brightness can appear on the screen depending on the desktop pattern used. When the same image is displayed for long hours, an afterimage of the previous screen may remain that can be disappeared by turning the monitor off.

The front and rear views of the LCD monitor is shown in Figure 7.8.

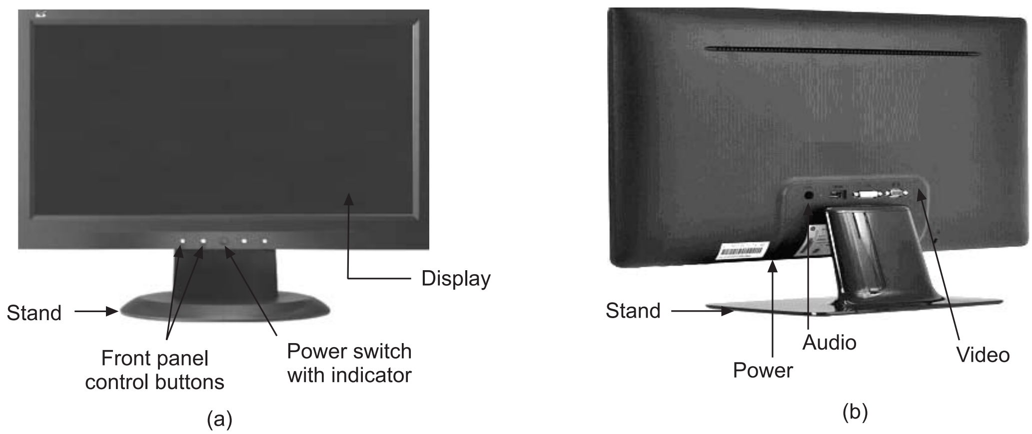


Figure 7.8 (a) Front view of an LCD monitor and (b) Rear view of an LCD monitor.

The front panel is having a set of control buttons for different operations. Different configuration settings of the monitor are done using these control buttons on the front panel. The power switch helps to switch the monitor on and off. The display of LED indicator helps in understanding the availability of power supply in the monitor. Different connecting ports are located on the rear side. Screw holes for wall mounting the monitor are common in LCD monitors.

7.9 INSTALLING LCD MONITORS

LCD monitors are packed and are made available with a separate base or stand. The first step is to fit the stand to the monitor. This is an easy step and can be done without any difficulty. A successful connection is usually indicated by a click sound. After fitting the stand, it can be placed on the table.

Like the CRT monitor, this type of monitor also requires a power connection using a power cable as well as a signal cable connection using a data cable. Following steps are to be done for the connection:

(a) For signal cable connection, one end of the signal cable is plugged to the VGA input socket of the LCD monitor and the other end is plugged to the VGA port on the rear panel of the computer. New monitors are provided with DVI or HDMI ports also. Applying force for connecting the cable is to be avoided.
(b) After fixing the cable, the screws at the both ends of the cable connector are tightened.
(c) Now, one end of the power cable is plugged to the AC input of the LCD monitor and the other end is plugged to the power outlet. It is to be ensured that proper grounding is available for the power outlet.
(d) After that, one end of the audio line is inserted in the audio-in socket present on the base of LCD monitor and the other end is inserted in the audio output of the computer. The different connector sockets can be seen in Figure 7.9.

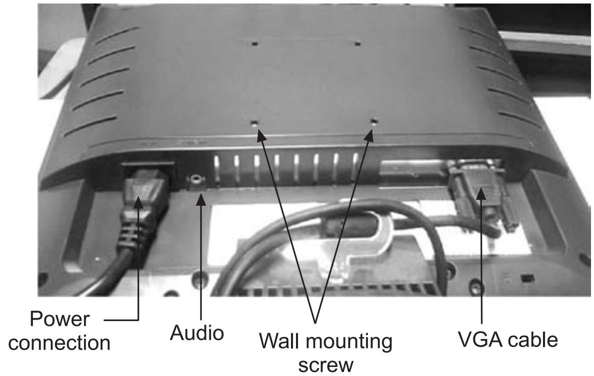


Figure 7.9 Connecting cables on the rear side of the LCD monitor.

(e) For optimal viewing, it is recommended to adjust the angle of the monitor as per the preference of the user. While changing the angle, touching or forcing the screen can damage the LCD screen and hence, this is to be avoided. By holding the frame of the screen, the viewing angle can be changed.
(f) After connecting the cables, the power button available on the front panel is pressed to turn the monitor on. The power indicator then lights up in green colour indicating the power 'on' status.

Different display parameters are controlled with the help of control buttons available on the front panel of the monitor. Usually, a menu button is available on the front panel and on pressing which a new window called **On Screen Display (OSD) window** is opened. In this window, a number of options are displayed. The options appear on the screen as icons. The option menu is known as **On Screen Display (OSD) menu**. Navigating through the menu option items is possible by pressing the navigation buttons. The desired option can be selected from the menu and the selection can be set by pressing the button. In this way, it is possible to adjust luminance (contrast, brightness), image set up (focus, clock), image position (horizontal, vertical), colour temperature (warm, cool), auto-configuration mode, OSD set up position, language for OSD and so on. The facility of locking the control settings helps to prevent the changes in the once-set control values by the other users.

The 15-pin D-sub connector is the analog connector used to connect the monitor to the display port on the computer. A typical display unit generates the display information in digital form and is stored in the frame buffer. This digital data is converted to analog form and then again converted to digital form in the monitor. The pin arrangement of this type of connector is shown in Figure 7.10.

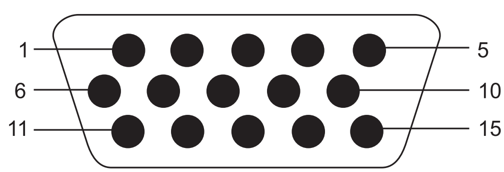


Figure 7.10 LCD monitor D-sub connector.

The pin assignments for the LCD D-sub connector are given in Table 7.4.

Table 7.4 Pin Assignments for Digital D-sub Connector

Pin No	Assignment	Pin No	Assignment
1.	Red video input	9.	+ 5 V
2.	Green video input	10.	VGA-CON
3.	Blue video input	11.	RXD
4.	TXD	12.	DDC serial data
5.	Ground	13.	Horizontal synchronization
6.	Red video ground	14.	Vertical synchronization
7.	Green video ground	15.	DDC serial clock
8.	Blue video ground		

Due to this conversion operation, some signal loss arise. To get a better display, it is now common to use digital interfaces. The DVI interface is developed to eliminate the conversion loss, as there is no signal conversion between the analogue and digital forms while using this interface. Due to this, DVI interface helps in getting better quality displays.

7.10 SPECIFICATIONS FOR TFT MONITORS

A majority of the specification parameters of TFT monitors match with the specifications of CRT monitors. However, there is some difference in certain parameters. General specifications related to the TFT monitor are given in Table 7.5.

Table 7.5 Specification for TFT Monitor

Parameter	Typical value
Screen size (Diagonal)	19 inch
Driving system	TFT colour LCD
Dot pitch/Grille pitch	0.28 mm
Horizontal pitch	0.24 mm
Display colour	Unlimited
Audio output	2.0 W RMS per channel
Maximum resolution	1600 × 1200 pixels
Horizontal scanning frequency kHz	82
Vertical scanning frequency kHz	85
Aspect ratio (width to height ratio)	4:3
Response time	5 ms
Brightness	300 cd/m^2
Viewing angle	170°/160°
Contrast ratio	1000 : 1
Video input	DVI
Power supply	AC 100 V – 240 V, 50 Hz – 60 Hz
Power consumption	Less than 20 W in power 'on' state. Less than 2 W in standby mode.

Factory preset resolution levels of TFT monitors are given in Table 7.6.

Table 7.6 Resolution Table for TFT Monitors

Mode	Resolution (Hz)	Horizontal frequency (kHz)	Vertical frequency (Hz)
VGA	640 × 480 @ 60	31.469	59.940
VGA	640 × 480 @ 72	37.861	72.809
VGA	640 × 480 @ 75	37.500	75.000
Dos-mode	720 × 400 @ 70	31.469	70.087
SVGA	800 × 600 @ 56	35.156	56.250
SVGA	800 × 600 @ 60	37.879	60.317
SVGA	800 × 600 @ 72	48.077	72.188
SVGA	800 × 600 @ 75	46.875	75.000
Mac-mode	832 × 624 @ 75	49.725	74.500
XGA	1024 × 768 @ 60	48.363	60.004
XGA	1024 × 768 @ 70	56.476	70.069
XGA	1024 × 768 @ 72	57.500	72.074
XGA	1024 × 768 @ 75	60.023	75.029
XGA	1024 × 768 @ 75	47.712	74.927
WSXGA	1366 × 768 @ 60	47.765	59.85

7.11 MAINTENANCE AND TROUBLESHOOTING OF LCD MONITORS

A number of maintenance steps are to be followed for increasing the life of LCD monitors. It is important to keep the monitor screen always clean. The monitor must be kept free from dust and stains. For cleaning the surface, suitable soft cloth can be used. The use of chemically aggressive cleaning agents or solvents is to be avoided, as these can damage the coatings on the surface. Applying pressure on the surface is not advisable, as this can damage the display. Adjusting brightness, contrast and resolution to suitable levels can reduce eye strain. Also, setting the lighting level too bright is to be avoided. Clock and focus adjustments are the other two controlling parameters associated with the LCD monitors. Clock controls the number of pixels scanned by one horizontal sweep. If the frequency is not correct, the screen shows vertical stripes and the picture does not have the correct width. Focus adjusts the phase of the pixel clock signal. A wrong phase adjustment makes the picture to become distorted. For proper display, it is necessary to set these two parameters at suitable levels.

If the computer is not going to be used for a long time, then the system should be kept powered off. An image can be burned into the LCD panel, if it is displayed for a long time. During the manufacturing of LCD panels, there are possibilities of individual liquid crystal cells to become permanently on or off. This condition creates some tiny coloured or black dots on the screen that never change. These pixels are the dead pixels and their appearance is a manufacturing defect. Replacing the panel is the only solution for it. There are two methods for checking the presence of dead pixels which are as follows:

(a) In the first method, a totally white screen is run and the stray black dots are searched on the screen. The stray black dots that appear on the screen are dead pixels.
(b) After this, the second method is applied in which a black screen is run and the stray white or coloured dots are searched on the screen. The stray white or coloured dots that appear on the screen are dead pixels. A few dead pixels do not normally impact the display but too many dead pixels can create irritation to the eyes.

7.12 LCD MONITOR: COMMON PROBLEMS AND SOLUTIONS

There are certain problems that affect the working of LCD monitors and these can be solved using suitable methods. In Table 7.7, a list of some common problems associated with the LCD monitors and their possible solutions are given.

Table 7.7 LCD Monitor: Problems and Suggested Solutions

Problem	Solution
Power indicator LED is off.	Make sure that the power button is on. Check the power cord.
No signal message appears on the screen display.	Check whether the signal cable is properly and firmly connected and is not damaged. Also, ensure that the pins at the connector are not bent.
Fuzzy display as well as ghosting and shadowing problem.	Adjust contrast and brightness controls. Check video cable.
Flicker display and presence of wave pattern.	Move any nearby electrical device. Set the correct refresh rate to set the resolution.
Missing of the primary colour in the display.	Ensure that none of the pins in the video cable is bent. Replace the video cable. Replace the monitor, if required.
Screen image is not sized properly.	Adjust the horizontal and vertical positions
Poor brightness and contrast.	Adjust the parameters using OSD. If not succeeded, replace the monitor.
Appearance of permanent marks at fixed place.	The pixels are dead. Replace the monitor.

7.13 LED MONITORS AND TOUCH SCREENS

Light Emitting Diode (LED) is an electronic device that lights up when electricity passes through it. This is a semiconductor light source and is used in several devices as indicator lamps. LED performs a variety of jobs like displaying numbers on digital clocks, notifying that a device is in 'on' state by emitting light indicator and displaying images when combined together. LED is similar to light bulbs. But it does not have the filaments that burn out as in the case of a bulb. Light is emitted in LED due to the harsh movement and collision of electrons within the diode. These diodes emit different types of light with visible, ultraviolet and infrared wavelengths. The power consumption of LED is low. Long life, compact size, vibration immunity, low operational voltage and precise control over the intensity are the major features of LED monitors. These are bright, scalable, flexible, long lasting and energy efficient. These have accurate colour reproduction ability, thinner panel design and high brightness. Less flicker and breaking during the movement give a better viewing experience with this type of monitors. The technology used in LED monitors is known as **backlight technology**. This technology makes use of separate coloured diodes in the backlight to produce pure red, green and blue primary colours for better colour reproduction, higher output and longer operational life. LED backlit monitors consume less power than the conventional LCD monitors. LED technology is used in the monitors that are targeted at graphics designers, professional photographers and gamers. Tiny LEDs are used to illuminate LCD pixels. LED turns on and off independently to produce the required display on LCD panel. Earlier generations of LED emitted low intensity red light. Use of the new and advanced technology helps in the development of a number of different versions of light emitting diodes.

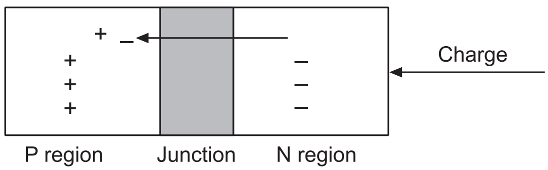


Figure 7.11 LED semiconductor chip.

The most important component of an LED is the semiconductor chip. The constructional details of the semiconductor chip can be seen in Figure 7.11. This semiconductor chip consists of two regions separated by a junction. Sides of the junction are named as **p-junction** meaning positive side and **n-junction** meaning negative side. The positive region is made up of positive electric charge whereas the negative region is made up of negative electric charge. The junction in the semiconductor acts as a barrier to the flow of charges. A certain amount of voltage is required for the flow of particles from the p-region to the n-region across the junction and vice versa. After the voltage is applied and the negative electrons are in the p-region, they immediately attract the positive charge. Once the electron is close enough to a positive charge in the p-region, they recombine. After several recombinations, the electric energy is converted into electromagnetic energy which is emitted in the form of light. Almost all the diodes release light, but only some of them do it efficiently. This is because in most of the diodes, the semiconductor material absorbs the light energy. But light emitting diodes release light energy outwards. These diodes are placed in a bulb and due to this, light propagates in a particular direction. These diodes can be mounted on almost every electrical circuit.

Nowadays, the touch screen is commonly used for the display of outputs in information kiosks, ATMs, mobile phones, tablet computers and so on. Touch screens function similar to the other display devices but make the use of touch-based interactions. Different technologies are used for touch screens and all of them use three main components, namely, the touch sensitive surface, the controller and the associated software, as shown in Figure 7.12. The touch sensitive surface is an extremely durable and flexible glass or a responsive surface which is placed over the display area of the screen. A single touch on the surface of the screen can make a change in the signal or the electric current passing through it. This change in the signal helps the controller to identify the location of the touch made on the screen. The controller is an electronic circuit which acts as an intermediary agent between the screen and the computer. The controller interprets the electrical signal of the touch event to the digital signals that can be understood by the computer. The whole process is controlled using the associated software.

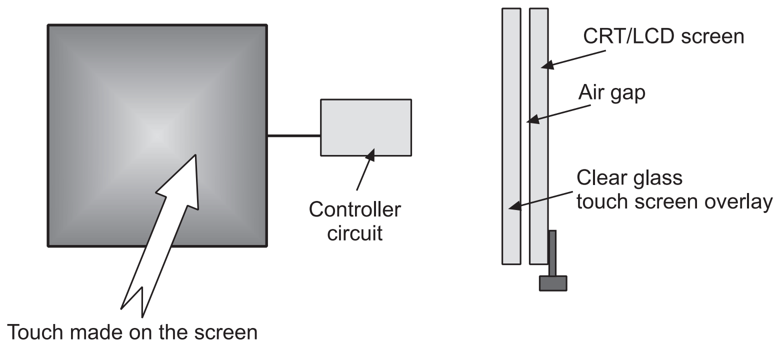


Figure 7.12 Touch screen components.

The touch screen sensor technologies commonly used are resistive touch screen, capacitor touch screen, surface acoustic wave and so on. **Resistive technology** is an old type of technology and is not durable. This technology makes use of touch screens made of two glass or acrylic layers placed together. One layer is having a thin coating of conductive material while the other is provided with a resistive material coating. During operation, the electricity passes through the conductive surface. When a touch is made on the screen, the two layers are pressed together and a change in the flow of electricity occurs due to the resistance created by the resistive layer. This change is noted and is used for locating the position of the touch made on the screen.

Capacitive touch screens are commonly used for the computers and medical imaging systems. This type of touch screens use a glass panel having a coating of charge storing material on its surface. When a touch is made on the screen, a small amount of charge is drawn at the point of contact. The circuits located on the sides of the screen measure the difference in charge and this information is used for locating the position of the touch made on the surface.

Surface acoustic wave touch screens function by using ultrasonic waves that pass over the screen. When a touch is made on the surface of the screen, there is a change in the frequency of the sound passing across the screen. Electronic circuits identify this change and locate the position of the touch made on the screen.

8

Keyboard and Mouse

Keyboard and mouse are the two commonly used computer input devices. Certain other input devices that are commonly used for gaming purpose include feedback wheel, rumblepad, gamepad, joystick, etc. But these are not commonly applicable for day-to-day use. Keyboard and mouse are of different types. Gaming keyboards allow to program complex commands to a single key. Mouse that is specially designed for gaming purposes has programmable buttons that can detect even the small movements with better accuracy. Game pads and joysticks are also available from different manufacturers. In this chapter, the use of keyboard and the mouse as computer peripherals as well as their features are discussed in detail.

8.1 TYPES AND FEATURES OF KEYBOARDS

Keyboard acts as an interpreter between the user and the computer. Different keyboards are made up of keys that are classified under different groups. There are different types of keyboards such as basic keyboard, gaming keyboard, ergonomic keyboard, etc. Basic keyboard is commonly used for normal operations such as to type various types of documents, control audio properties, input data, etc. Gaming keyboards are having extremely simple functions. Some of these keyboards are having backlit keys, programmable buttons, media centre controls and so on. The keys of gaming keyboards are more responsive and the tactility is felt better as compared to the normal keyboards. Ergonomic keyboards are designed in a way so as to make their usage even more comfortable. These keyboards have a peculiar shape in which different groups of keys provide an ease for typing. Certain keyboards have positional flexibility, i.e., they can be adjusted to fit the needs of the user. This keeps the wrists and body parts free from damage. One touch control to access different applications, spill resistance that enables the easy draining of liquid spilled over the keyboard and adjustable tilt legs are the salient features available in the new keyboards.

Keyboards are indicated by stating the number of keys such as 101-key type, 104-key type, etc. A standard keyboard consists of 104 keys and allows easy input of letters and numerals alongwith a set of function keys. The layout of a standard keyboard can be seen in Figure 8.1. Different keys in the keyboard are classified into three groups, namely, typing keys, numeric keys and control keys. **Typing keys** include the different characters of the alphabet. Documents are typed using these keys. **Numeric keys** are positioned at a particular place on the keyboard and these keys enable the data entry of numerals easily. Generally, these keys are placed on the right side of the keyboard. **Control keys** are the special keys on the keyboard that are used for certain special purposes. Different control keys include *Function* keys, *Home*, *End*, *Insert*, *Delete*, *Page Up*, *Page Down*, *Alt*, *Esc* key, etc. The *Function* keys are arranged on the top position of keyboards. Other control keys are laid on the right and left sides of the keyboard. Keyboard LED indicators display the status of three toggle keys, namely, *Num Lock*, *Caps Lock* and *Scroll Lock*. These three LED indicators are available in a normal keyboard. When the *Num Lock* LED indicator is lit, then under such condition, the pressing of the numeric key displays the corresponding numeral, on the screen. When the *Caps Lock* LED indicator is lit, the pressing of the alphabetic character keys displays them in upper case only. Scrolling of the long screen contents on the screen can be paused by pressing the *Scroll Lock* key. Pressing again the above key resumes the scrolling process. **Space bar** is the longest key in the keyboard which is present at the bottom. **Windows logo key** makes the different Windows operating system based activities easier. For the easy movement of screen cursor, four **cursor keys** are provided on the right side of the keyboard. These keys help to move the cursor along the four directions on the screen. The increased usage of the computers for different purposes has made the keyboards to become more complex leading to the emergence of specialized keyboards to serve specialized purposes.

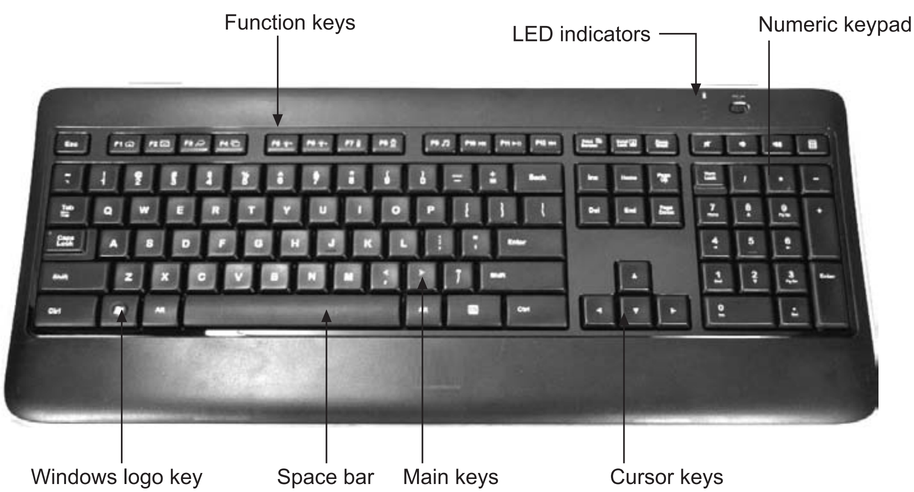


Figure 8.1 Standard keyboard layout.

Multimedia keyboard is a modified version of the standard keyboard. It is basically a keyboard having additional multimedia and internet keys to control media playback and internet surfing. These keys help in providing an easy access to the frequently used programs. The **web browser keys** on a multimedia keyboard helps in the easy surfing of the internet. Back, forward, stop and refresh buttons are usually present in such keyboards. **Key buttons** to access *Bookmark Favorites*, *Search* and the *Homepage* of the browser are also available in such keyboards. **Audio volume control button** is another handy function available with the above type of keyboard.

Gaming keyboards have some features that enable easy gaming operations. A good gaming keyboard provides superior accuracy and improved responsiveness. Normal keyboards cannot handle more than three keystrokes at a time. Multiple rapid keystrokes occurring simultaneously in the normal keyboards can result in a missed key press called **ghosting**. Anti-ghosting feature available with the gaming keyboards help these keyboards to handle more simultaneous keystrokes without any loss. Programmable keys to store macros which enable a single key press to execute a series of input commands are the other features of gaming keyboards. There are many gaming keyboards available that also allow the programming of any/every key on the keyboard. Some gaming keyboards consist of ports for plugging in pen drive, USB mouse and audio ports. Backlight keys of these keyboards enhance gaming and typing experiences. Windows logo key provides a quick access to different menus from the keyboard. The pressing of the logo key alongwith a shortcut key helps in using several Windows functions easily.

A keyboard simply consists of a small processor and a simple circuitry that carry information to the system. The main portion of the keyboard circuit is the **key matrix**, as shown in Figure 8.2. In the key matrix, a special position is available below each key. On pressing a key on the keyboard, the position below the key gets pressed. This makes a contact due to which the circuit gets completed and a small current passes through the circuit. The processor available in the keyboard receives the current and processes the received signal. Then, the processor is able to identify the key pressed. A character map is used to identify the key which is pressed and that key is displayed on the display device. The key matrix can also identify the simultaneous pressing of more than one key on the keyboard. For example, whether a particular key is pressed alone or is pressed alongwith another key such as the *Shift* key to display an uppercase letter, are both get identified.

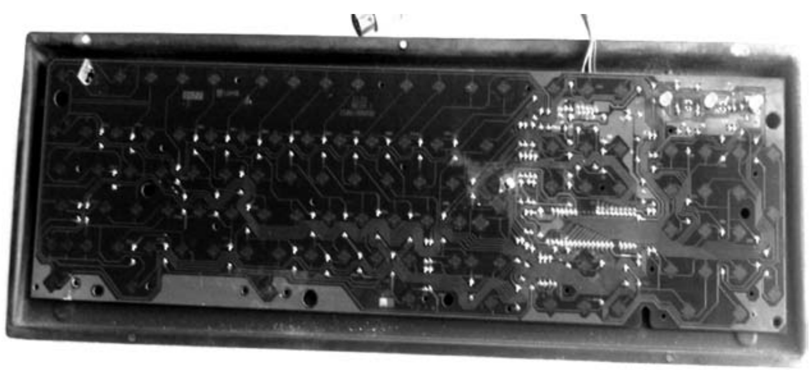


Figure 8.2 Key matrix of a keyboard.

8.2 KEYBOARDS INTERFACES

Keyboards are designed to work at + 5 V DC. The operating current is less than 150 mA. Different types of interfaces are used with the keyboards. The interfaces include PS/2, USB, etc. The standard connector for desktop PCs is a PS/2 port, usually colour-coded as purple. The connecting port in the computer is available in the rear panel. The PS/2 and USB connectors of the keyboard can be seen in Figure 8.3.

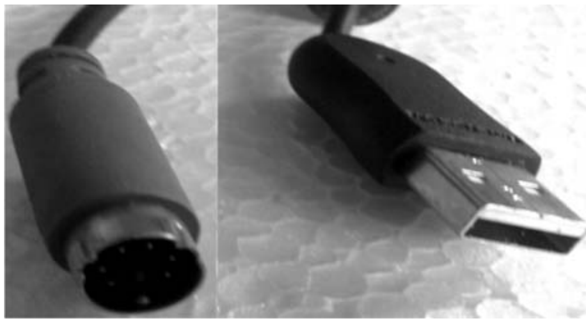
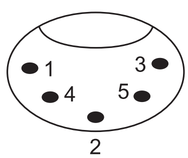


Figure 8.3 PS/2 and USB keyboard connectors.

PS/2 connector of the keyboard is a five pin DIN connector. Different voltage levels available at the pins of the DIN connector are given in Table 8.1.

Table 8.1 DIN Connector and Pin Arrangement

DIN connector	Pin No.	Signal
	1.	Clock
	2.	Data
	3.	Not used
	4.	Ground
	5.	+ 5 V DC
	Shell	Ground

Later on, mini DIN connector with reduced connector sizes has emerged. The modern keyboards have USB connectors that can be used for a wide range of peripheral devices and these connectors have emerged as a standard interface. Nowadays, the popularity of USB devices and USB ports makes the USB keyboards highly usage with the laptops, desktops and the tablet PCs alike. The wireless keyboards also require a USB port for the wireless dongle. The wired keyboards use power from the system while the wireless keyboards are powered using the batteries.

8.3 INSTALLING KEYBOARDS

As stated above, keyboards are having two types of connectors, namely, USB and PS/2. The USB keyboard requires a USB interface and the PS/2 keyboard requires a PS/2 interface on the computer panel. Depending on the interface used, the PS/2 keyboard is connected to the PS/2 port and the USB keyboard is connected to the USB port of the computer panel, as shown in Figure 8.4. Before connecting the keyboard to the system, the system must be switched off. Then, the keyboard connector is connected to the keyboard port on the computer panel. It should be ensured that the connector is firmly fixed in the port. Now, the system is turned on after connecting the keyboard. The three LED indicators on the keyboard must blink during the booting time indicating that the keyboard is ready to be used. To adjust the height of the keyboard, its legs can be pulled out or pushed in. The keyboard legs are designed to accommodate different body sizes, chairs and desks. The height adjustment of the keyboard is done to minimize the bending of wrists while typing.

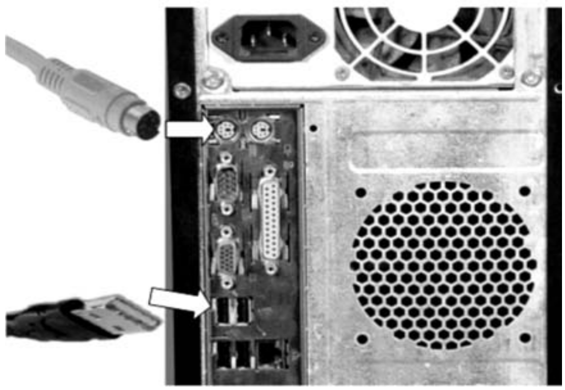


Figure 8.4 Connecting keyboard to the computer rear port.

8.4 KEYBOARDS USAGE GUIDELINES

Several guidelines are provided to avoid fatigue and discomfort while working on the computer keyboards. These guidelines are often called as **healthy computing guidelines**. These guidelines are derived to make the user more comfortable and productive while working on the computer keyboards. Working in a comfortable position can itself improve the productivity and help in avoiding any discomfort or fatigue. Certain guidelines that help in reducing the risk of experiencing pain or injury while working with the computer keyboards are as follows:

(a) While working or playing with the computers, it is important to avoid awkward postures and to remain in a comfortable position.
(b) Adjust the height of the chair so that the forearms of the user are placed on the keyboard comfortably during typing. A chair that supports the lower back is preferred. Certain keyboard models are having palm rests for resting the wrists. It must be ensured that the eyes of the user are in the same level with the top of the screen.
(c) Keep the keyboard close to the user to avoid stretching to reach it. A good and relaxed posture must be maintained while working with the keyboard.
(d) Enough work space must be available for the user to remain in a comfortable position.

(e) Avoid hitting the keyboard with excessive pressure.
(f) Frequent rests from typing should be taken at different intervals.

8.5 MAINTENANCE AND TROUBLESHOOTING

From the above discussion, it is clear that the keyboard forms an integral part of a computer system. Dust can gather on the surface of the keyboard. So, it is better to keep it covered, when it is not used. The keyboard must be cleaned regularly for its proper working but only when it is powered off. A small paint brush can be used for removing dust and dirt accumulated between the keys of the keyboard. A vacuum cleaner can also be used for sucking in or blowing out dust accumulated beneath the keys of the keyboard. Blowing hard to the keyboard helps in blowing away the dust and debris built up between the keys of the keyboard. A soft cloth dipped in a mild cleaning solution can also be used for cleaning purpose. Use of the stray solutions is to be avoided for cleaning the keyboard surface, as its use can ooze out the keys and may result in a short circuit that can lead to a permanent damage of the circuit board. Also, the use of strong detergents is to be avoided as the solvent can damage the rubber and plastic surfaces.

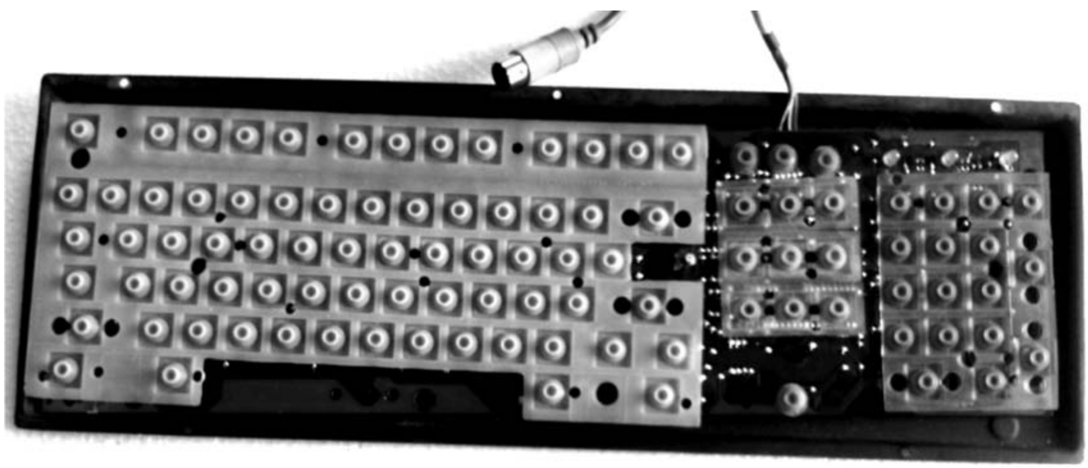


Figure 8.5 Arrangement of rubber bushes under different keys of keyboard.

Dust accumulated on the underside of the keys of the keyboards causes them to get jammed, which in turn, causes certain keyboard errors. To correct the fault, proper cleaning of the underside of the keys is required. For this, the first step is to unplug the keyboard from the computer cabinet. Turning upside down of the keyboard and providing a gentle tapping on the surface can help in removing any particles caught in between the keys. It is recommended to remove all the keys from the keyboard and then clean them with some detergent and water. Mapping the keyboard layout on a piece of paper before removing the keys helps its reinstallation process much easier. To remove the key from its position, a flat screw driver can be used. The tip of the screw driver is inserted under each key. Then, the screw driver is gently pushed up until the key pops out of its position. Once the key comes out of its position, it can be taken out. Extreme care must be taken while removing the keys so as to avoid any possible damage to the keys. After removing all the keys, every slot must be inspected where the keys were placed in the keyboard and the dirt or dust accumulated in the slots must be cleaned. To clean the slots, a hard bristle brush is used to get rid of any dust. The rubber cups in the board are responsible for the switching action inside the keyboard. Arrangements of rubber bushes under different keys can be seen in Figure 8.5. While cleaning the slots, it should be ensured that the rubber cups are not damaged. After cleaning all the keys these should be wiped with a clean and dry soft cloth until they are completely dry. To fix the key back to its position, the key is first selected and then aligned properly on the surface. The key should be pressed down until it is properly and firmly fixed in its position. The process is repeated until all the keys are fixed on the keyboard. The mapping diagram of keys prepared earlier can be used as a reference for locating the correct position of each key. Now, the keyboard and the keys are left idle for nearly two hours so as to make it properly dried. After that, the keyboard is connected back to the computer port for working again.

Sometimes, it may happen that some liquid material can spill over the keyboard. The following steps are to be taken under such condition:

(a) First of all, the system must be turned off immediately and the keyboard is to be disconnected from the system.
(b) The liquid is to be drained from the keyboard by turning it upside down and shaking it well.
(c) A thorough cleaning of the keys and the internal parts are the next steps to be done.
(d) Now, the keyboard is allowed to dry completely and then all the keys are fixed in the keyboard firmly.
(e) The keyboard is again connected to the computer and then it is switched on.

Powering on the keyboard when its components are in wet state, can damage the keyboard and this is not to be attempted. If the keyboard does not work after these steps, it is necessary to replace the keyboard.

Some keyboard devices require special software other than the driver software for their proper running. The device cannot work at all or some of its features may not work correctly if the software is not installed. The special software is usually provided by the manufacturer alongwith the keyboard. The instructions of the manufacturer are to be followed to install the software. After installing the software, the rebooting of the computer system is necessary for the new software to take effect. Sometimes, it is required to upgrade the device driver software. If the device driver gets corrupted, the software is to be reinstalled. In Windows-based operating systems, the upgrading and installation of the device driver software is done through the *Device Manager* option available from the *Control Panel*. The *Control Panel* window is opened and the keyboard icon is then double clicked. This opens the *Keyboard Properties* window having two tabs. Now, the *Hardware* tab is opened and the *Properties* button is then clicked. This launches a new window, as shown in Figure 8.6. The working status of the keyboard is displayed in this window.

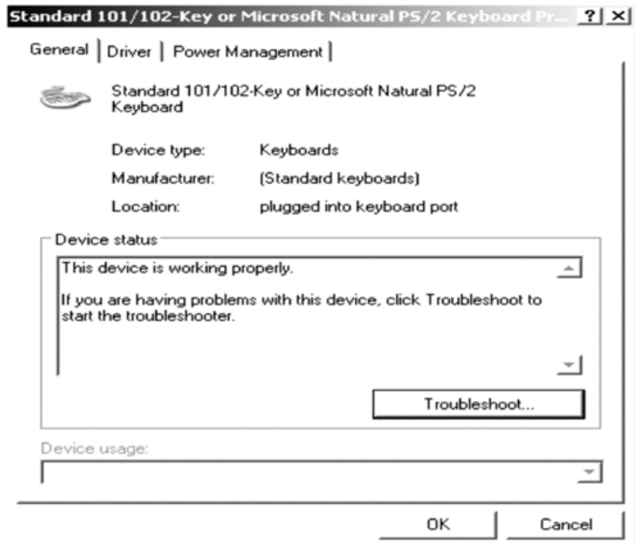


Figure 8.6 Checking the working status of keyboard.

Opening the tab labeled *Driver* displays a new window. Buttons are provided in this window for updating device driver and for uninstalling the driver. Clicking the button for updating the driver file launches the *Hardware Update Wizard* which searches for device driver files from the internet or from the selected location. Updating the driver with the new driver files can be completed with some mouse clicks and this completes the installation of the device driver files. If a new device driver is to be installed, the first step is the uninstallation of the already installed device driver file. If the computer is started with the device driver uninstalled, the system launches the *Found New Hardware Wizard* that acts interactively and helps in the installation of the new device driver files. The rebooting is necessary to take effect of the new device driver file.

8.6 KEYBOARD: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the keyboards and the suggested solutions are given below in the Table 8.2.

Table 8.2 Common Keyboard: Problems and Suggested Solutions

Problem	Solution
Computer does not take input from the keyboard.	Make sure that the keyboard is connected to the computer. Disconnect the keyboard from the keyboard port and then reconnect. Check the BIOS settings. Replace with a working keyboard and check again. If the problem is solved, the former keyboard is found to be faulty. Otherwise, the fault lies with the keyboard port.

Problem	Solution
All or some of the keys of the keyboard are not working.	Make sure that the keyboard cable is securely connected. For PS/2 keyboard, the keyboard and mouse cables are not to be reversed. In case of USB keyboards run the *Configuration/Setup Utility* program and enable the port. Check with another keyboard. If the problem still exists, check the working of the motherboard.
Displaying the keyboard error message during system booting.	This is due to some keys getting pressed down. Make sure that not any key in the keyboard is pressed down while the system is booting.
Keyboard not found error is displayed on the screen.	The error message is displayed if the keyboard is not properly connected. Unplug the keyboard and then plug again firmly. This step will solve the error.
Intermittent failure of the keyboard is detected.	Check the keyboard cable or connecting port for errors. Replace the defective component.
Multimedia keys in the keyboard are not working.	Use of the correct keyboard software will solve this problem.
USB keyboard is not working.	Enable the settings for USB ports in the BIOS.
Some keys are remaining pressed on the keyboard.	The problem is mainly due to the dust and debris getting deposited beneath the keys. Removing the keys and cleaning their under surfaces will solve the problem.
Some keys are not generating any keystroke.	The problem is mainly due to the dust and debris getting deposited beneath the keys. Removing the key and cleaning their under surfaces will solve the problem.
Repeating characters appear when pressing some keys.	If the problem appears for several keys, the problem is associated with the typematic settings of the keyboard. Correctly setting the configurations will solve this problem. If the problem appears for one key only, proper cleaning will solve the problem.
When a key on the keyboard is pressed, something different appears on the screen	The error is because the keyboard layout is set to a wrong region in its configuration settings. Correcting the layout settings will solve the problem.

8.7 DIFFERENT MOUSE TYPES

With the wide acceptance of graphics-based user interfaces, mouse has become an indispensable computer input device. Mouse also forms one of the most important peripherals for playing computer games Mouse senses the movement of the user hands and translates them into an equivalent movement on the computer monitor. The notable feature of a mouse is that it synchronizes almost perfectly with the human eye-hand coordination.

Computer mouse are of different types, namely, mechanical mouse, optical mouse, wireless mouse, etc. **Mechanical mouse** is also called as **scroll mouse**, since it uses a scroll ball fitted on its lower side to sense the mouse movement. The earlier mouse used was scroll mouse that was having two buttons fitted on its upper part. These are now replaced by optical mouse. Currently used standard optical mouse is having two buttons and one scroll wheel. By turning the scroll wheel using the finger tip, a corresponding movement of the cursor can be created on the screen. The buttons of the mouse are known as **left button** and **right button**. Clicking the buttons help in performing different tasks, as configured. Optical mouse senses the position and the movement with the help of an LED. This mode of sensing the position is called **tracking**. Optical mouse is better than scroll mouse and is more accurate. Apart from the above types, wireless mouse is another type of mouse currently in use. Wireless methods are used by the wireless mouse for making connection to the computer. The standard mouse is adequate for the normal operations. For gaming purposes, an extra bit of performance is obtained with the help of a gaming mouse. Different types of mouse can be seen in Figure 8.7.

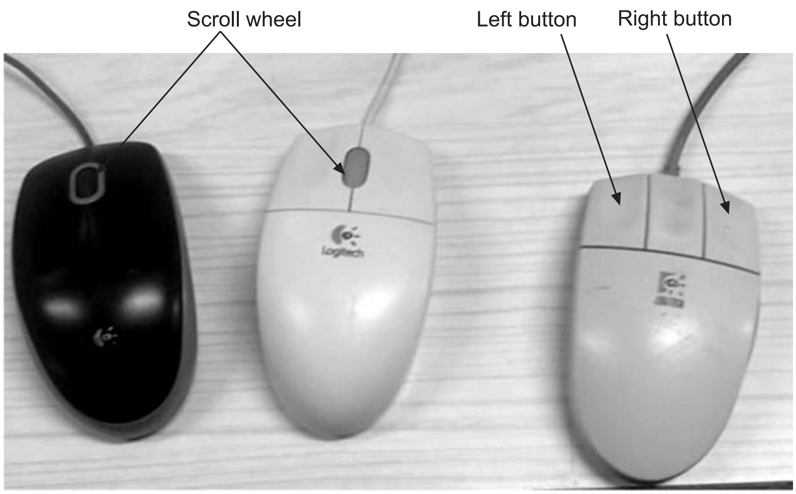


Figure 8.7 Mouse types.

8.8 WORKING OF MOUSE

The main component of a scroll mouse is **roller** which is a rubber ball fitted on its underside. The roller converts the movement of the mouse into an equivalent pointer movement on the computer screen, along the x and y directions. The other components of the scroll mouse are x and y sensors, x and y lasers, x and y wheels and buttons. The continuous signal generated by the mouse movement is broken by the wheel into discrete signals which are converted to a digital form. This conversion is done by the sensors. Mouse buttons are used for performing tasks such as single clicking, double clicking, etc. Two types of laser beams are generated by x and y lasers. The x and y wheels are slotted equally such that as the wheel moves, they allow or block the passage of the laser beams generated by the x and y lasers. The control chip converts the data into digital data to be used by the computer. Gaming mouse is having more than two buttons. A scroll wheel which moves along the x and y axes, weight tuning and tracking mechanism working on laser beams are the other components. The laser mouse works very well and in extremely precise manner on a huge array of surfaces. The additional buttons are great to save extra functions and macros for instantaneous use.

The different components that make up an optical mouse are given Figure 8.8. The working of an optical mouse is similar to the scroll mouse. Optical mouse consists of a main component known as the **optical eye** which is an LED placed beneath the mouse and is used to scan the surface. Another component embedded with the optical mouse is the **microcamera** which takes the pictures of the surface that are scanned. The digital signal processor in the optical mouse receives the images captured by the camera. Once all the images are received, it compares the pictures and looks for any difference between them. Even the minutest differences can be easily picked up. This helps the processor to determine the exact distance and speed covered by the mouse. Then the coordinates are measured and are sent to the computer. This makes the mouse pointer to move to a particular location on the screen according to the movement of the mouse. The digital signal processor which was placed in the first optical mouse created by Microsoft, could take in 18 million instructions per second. The first optical mouse was manufactured by Microsoft and it could scan the surface around 1500 times per second. Gaming optical mouse has advanced cameras embedded for the better mouse reaction.

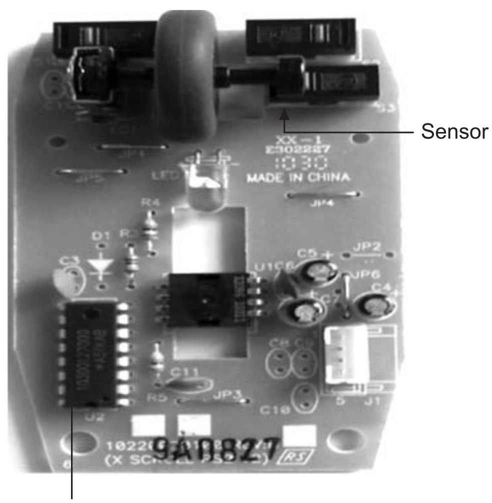


Figure 8.8 Components of an optical mouse.

8.9 FEATURES OF MOUSE

Now, the optical mouse has become the standard. This mouse is preferred over the mechanical mouse due to several reasons. Optical mouse is not having moving parts and hence, there are less chances of failure. Dirt and debris cannot get accumulated within an optical mouse and hence, no maintenance is required for them. Optical mouse can run smoothly on almost any surface, so there is no need of using mouse pads.

There are several factors that affect the accuracy of an optical mouse. One of them is the **resolution** that can be defined with respect to an optical mouse as, the number of pixels the optical sensor and lens can view per inch while the mouse is being moved. If the resolution is higher, then less mouse movement is required to get an accurate response. Common resolution of the mouse is around 700 to 800 dots per inch (dpi). Gaming mouse has a higher resolution as compared to the normal mouse and it offers smoother and more accurate responses. It is more specialized and hence, is more expensive than the other types. Gamers expect a better response time and a higher performance. Generally, a gaming mouse consists of an enhanced resolution with multiple DPI settings. The lower DPI settings are good for the fine control and increased sensitivity while the higher DPI settings are used for faster and less accurate movements. Programmable buttons are another key feature available in a gaming mouse, with certain mouse offering several keys that can be programmed to replace keystrokes or macros. Some gaming mouse are available with on-board memory also.

8.10 MOUSE INTERFACES

The common interfaces for wired type of mouse are PS/2 interface and USB interface. These interfaces can be seen in Figure 8.9. A wireless mouse makes use of the radio frequency and the infrared and bluetooth technologies as interfaces. This type of mouse is handy and is not required for the desktop systems. A wired mouse is better, as it never runs out of batteries or loses signals. The advantage of a wireless mouse over the wired one is that it gives greater mobility and reduces the clutter of wires going into the computer. If it is required to operate a computer from a distance, then a wireless mouse is suitable. The major drawback of this type of mouse is that its limited radius of operation and run on batteries.

Figure 8.9 PS/2 and USB mouse interfaces.

As stated above, the mouse connector can have either a USB or a PS/2 interface. A USB mouse requires a USB interface while a PS/2 mouse requires a PS/2 interface on the computer panel. Depending on the interface used, the PS/2 mouse is connected to the PS/2 port and USB mouse is connected to the USB port of the computer panel, as shown in Figure 8.10. Before connecting the mouse to the system, the system must be switched off. Now, the mouse connector is connected to the mouse port on the computer panel. It must be ensured that the connector is firmly fixed in the port. After making the connection, the system is turned on. The LED on the rear side of the mouse should be indicating that the computer is turned on and the mouse is ready to be used.

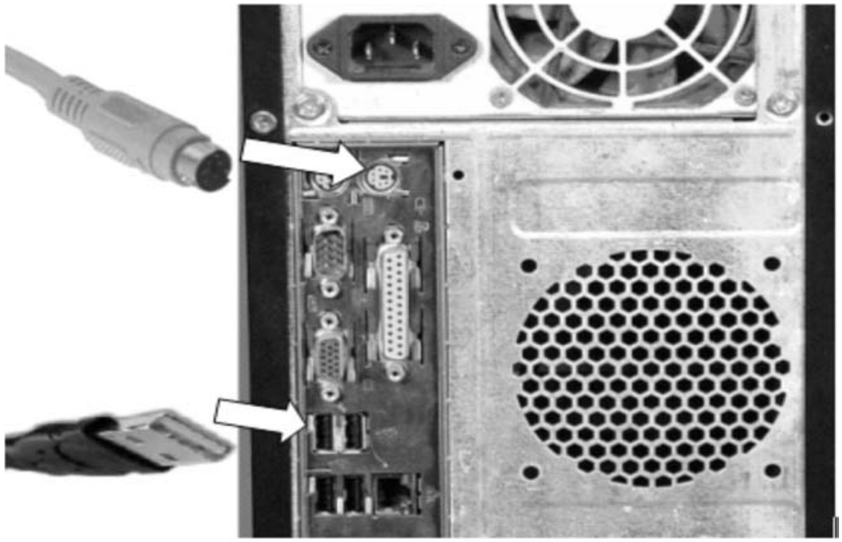


Figure 8.10 Connecting mouse interfaces to computer rear panel.

8.11 MAINTENANCE AND TROUBLESHOOTING

Proper working of a mouse is affected by different factors. In some cases, the mouse pointer functions in an abnormal manner. The pointer jumps to one corner of the screen. This phenomenon is called **leaping mouse**. Several reasons can be attributed to this type of mouse behaviour. Loose connectivity, corrupted driver software or dusty internal parts of the mouse are the major reasons for this type of mouse behaviour. For checking connectivity issues, first of all, it should be ensured that the mouse has compatible interfaces with the motherboard. Also, the pins in the PS/2 end connector are to be checked for any damage and it is to be made sure the connector is firmly fixed to the mouse port.

Continuous use of the mouse makes the dust getting accumulated inside the roller panel of a scroll mouse. The inside cleaning of the panel and the roller surface is essential for the proper working of the mouse. For cleaning a roller mouse, first of all, the system is turned off and the mouse is unplugged. Then, the mouse is turned upside down and the cover is unlocked by it rotating in the anticlockwise direction. The cover and the roller can be taken out. The process is clear from Figure 8.11. Now, the roller is cleaned by gently rubbing the surface using a wet cotton cloth. Also, the inside sensors are cleared carefully. The roller is placed back after it has become completely dry and then the cover is turned clockwise to lock the cover in its position. Then, the mechanism is allowed to become dry. After that, the mouse is plugged back to its port and the system is turned on. It is not advisable to use sharp objects to clean the inner side of the mouse mechanism, as these objects can damage its internal components. In optical mouse, the dust gets accumulated over the optical sensor and prevents it from proper functioning. So, cleaning the optical sensor is essential for the optical mouse. There is no need of cleaning the mouse internal mechanism, in the case of optical mouse.

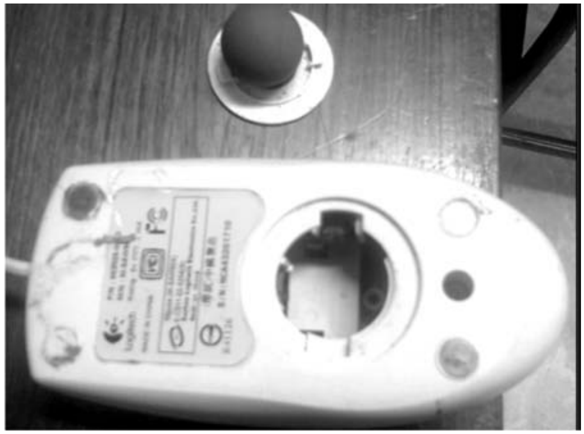


Figure 8.11 Unlocking the mouse cover and taking the roller out.

Different mouse configuration options in Windows operating system are done from the *Control Panel*. From *Control Panel*, the *Mouse* option is selected by double clicking on it, that opens *Mouse Properties* window in which a number of tabs are displayed. Clicking each of the tabs displays a number of configuration options for setting different properties. A typical window displayed is shown in Figure 8.12. Switching between the right and left key buttons of the mouse, adjusting the double click speed to slow or fast levels and turning on or off the click lock are the properties that can be controlled from the options in *Buttons* tab. The appearance of the mouse pointer is customized on the screen by using the options available in the *Pointers* tab. Some other configurations options are available from the other tabs also.

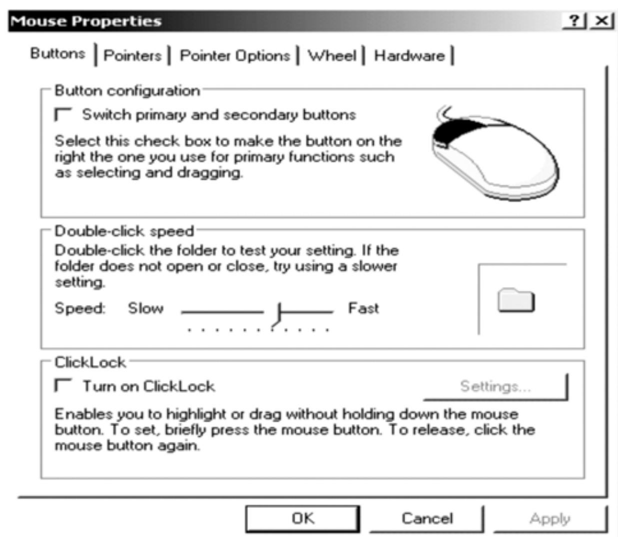


Figure 8.12 *Mouse Properties* window.

Corruption in the mouse driver software can affect its proper functioning. Uninstalling and reinstalling the device driver can solve majority of software driver related issues. In Windows-based operating system, the device driver is updated through *Control Panel*. After opening the *Mouse Properties* window, the *Hardwa*re tab is opened and the *Properties* button is clicked. This opens a new window with two tabs. Now, the *Driver* tab is opened which displays a new window, as shown in Figure 8.13. The options available are for displaying driver details, updating driver, rolling back driver and uninstalling driver software. For updating the driver, the *uninstall* button is clicked. This step uninstalls the driver. Now, the option to update the driver is selected. This step launches the *Hardware Update Wizard*. The location of the driver can be selected from the options. Clicking the *Forward* button helps in navigating through different options and the installation can be completed in few steps in an interactive manner. If the device does not function properly even after updating the driver, it is possible to rollback the driver to the previous one.

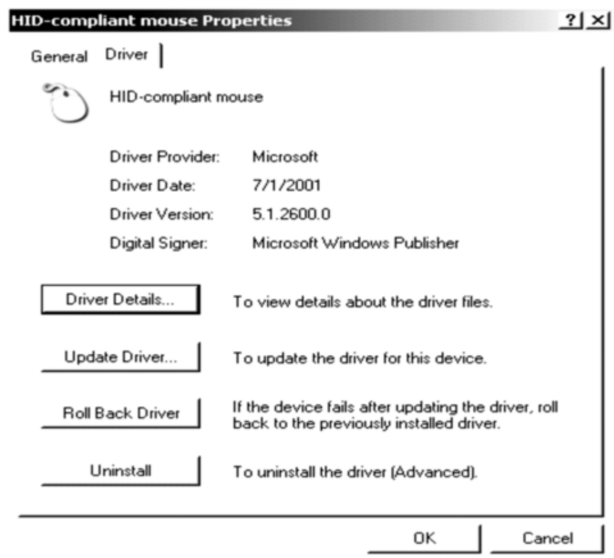


Figure 8.13 Window displaying *Mouse Driver Details*.

Linux operating system also offers the facilities for customizing mouse properties. For this, the menu *System* is opened and the option *Preferences* is selected. The drop down window displayed lists *Keyboard* and *Mouse* alongwith the other items. On selecting *Mouse*, a new window is displayed and then the different properties can be set.

8.12 MOUSE: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the mouse and the suggested solutions are given in Table 8.3.

Table 8.3 Mouse: Common Problems and Suggested Solutions

Problem	Solution
The mouse or the pointing device is not working.	Make sure that the mouse cable is securely connected. For PS/2 mouse, the keyboard and the mouse connectors must not be reversed. Run the *Configuration/Setup Utility* program and enable the USB port while using the USB mouse. If the problem is not solved, check the mouse by replacing the mouse. If the problem still exists, replace the motherboard
Double clicking the mouse button does not initiate any action.	This may be due to fast or slow clicking. Change the mouse configuration settings.
USB mouse is not working.	Enable the settings for USB ports in the BIOS
Mouse pointer is jerking on the screen.	This problem is due to dust deposits in the mouse mechanism. Cleaning the mechanism will solve this problem.
Mouse movement is sluggish.	Cleaning the mouse mechanism will solve this problem.

9

Assembling and Configuring Computers

When we think about purchasing a computer, then two choices arise. First choice is going for a branded computer and the second choice is purchasing an assembled computer. Branded computers and assembled computers are having their own advantages and disadvantages. A branded computer has specifications fixed by the manufacturer. On the other hand, an assembled computer is designed using the specifications requested by the purchaser. Better technology, service support, lower cost of ownership and reduced maintenance costs are the major driving factors for the purchase of branded systems. Different components that make up a branded computer system are thoroughly tested and these are connected in such a way so that they work together perfectly to get the optimum result. A branded system has better finish and fit. Whereas, an assembled computer is made by combining different components obtained from different sources. The performance of an assembled computer is badly affected if its components fail to work together perfectly. A final decision on the choice of the type of computer is made by considering different factors such as cost, required configurations, type and nature of use and the applications that are to be run in the computer. This type of choice is applicable in the case of desktop computers only. Laptops, notebooks and even server computers are manufactured and marketed with some standard specifications. Any configuration modification by the user is difficult for these types of systems. At the most, the user can replace the hard disk or the memory or something like that. In this chapter, different steps involved in assembling a desktop computer and in configuring the system are discussed. This chapter also describes the steps for installing the I/O shield, fixing motherboard, adding processor, memory, add-on cards, connecting IDE and SATA devices, connecting devices to different internal and external connectors, connecting power supply cables, etc. Irrespective of the configuration of the system that is going to be assembled, the basic principles underlying the assembly and the overall construction steps will remain the same.

9.1 CAUTION AND SAFETY

A desktop computer is easy to assemble. Also, changing the components of a desktop system or upgrading its components is not a difficult task. The high level technical skills are not required for this work. It just involves putting the various components and connectors together at the right place in a correct manner. Usually, user's manual is provided by the manufacturer on purchasing the chassis, motherboard, processor or other important components. This manual must be studied to understand the features as well as the methods of using the product. Before assembling the system, different cables and the components are checked for any damage. The components are to be kept away from dust, dirt and humid conditions. All precautions and warnings must be observed and all the steps are performed according to the correct sequence during the operation. Non observance of precautions or changing the order of doing operations can damage the components as well as can cause injury to the user. To avoid any injury, proper care must be taken while dealing with the sharp pins of connectors and printed circuit assemblies, rough edges and sharp corners of the chassis and the other components. Always be careful to avoid the damaged connecting wires and cables, as these can cause short circuit.

The essential components for building a computer include computer cabinet (also called as computer chassis) and power supply, motherboard, processor, thermal grease, processor heat sink and cooling fan, hard disk, memory, optical drive, keyboard, mouse, data and power cables for hard disk and optical drive. To make the assembling easy, a number of tools are also required. Cross head and flat screw drivers, pliers, antistatic wrist strap and a multimeter for measuring voltage conditions are some tools that can make the assembling process easier. Some of the essential tools can be seen in Figure 9.1. Once all the required items are ready, the building of a computer system can be started.

Figure 9.1 Tools for assembling a computer system.

Static electricity present in the human body can damage the different electronic components such as motherboard or memory and make them completely useless. Hence, it is necessary to ensure that static electricity is not present in the user's body while handling the different components. In case, the static electricity is present, it is advisable to wear a wrist strap by the user. One end of the wrist strap is fixed to the wrist of the user and the other end is connected to a grounded object. For proper wearing of the strap, about 30 cm of the band end is unwrapped and the adhesive side is wrapped around the wrist of the user. The rest of the strap is unrolled and then the linear is removed from the copper tape. After that, the copper tape is attached to an electrical ground or the metal frame of the equipment. The proper way of wearing a wrist strap is shown in Figure 9.2. If the wrist strap is not available, touching a grounded object before handling the components also helps in discharging static electricity.

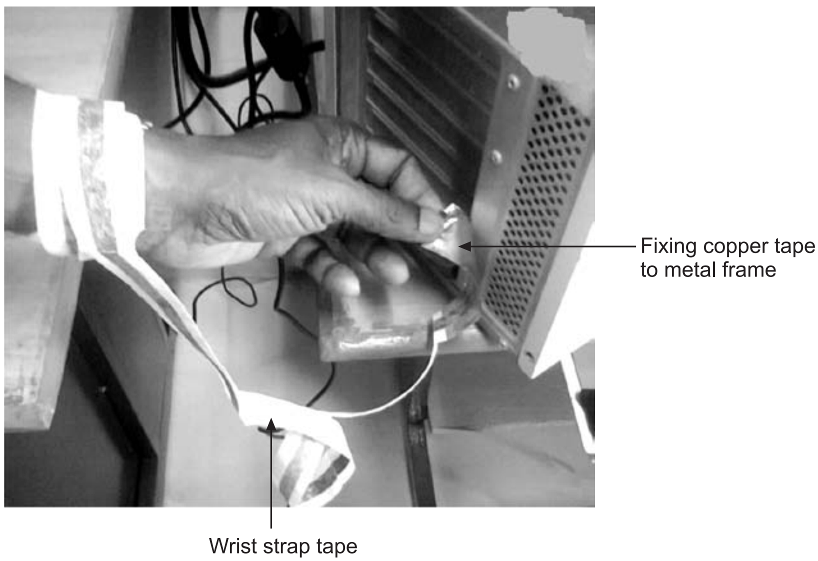


Figure 9.2 Setting up the wrist strap.

9.2 SETTING UP THE CABINET

Selection of a suitable cabinet or chassis for fitting the components of a computer system is mainly dependent on the form factor of the motherboard. The selected cabinet must have plenty of rooms for fitting the motherboard safely as well as for enough air circulation inside. The cabinet must have provisions for fitting enough cooling fans, preferably more than one. Grills must be available on the cooling vents. Earlier models of chassis were having a small loudspeaker fitted to the front side of it. The loudspeaker was used to provide warning beeps during the staring time of the computer. Leads were also provided with the loudspeaker for connecting it to the motherboard. But the modern motherboards are having integrated or on-board loudspeaker and hence, a separate speaker cannot be found with the new model cabinets. Both the sides of the chassis are kept closed by separable side plates. These side plate can be separated by loosening the thumb screws. A chassis with the side plate removed is shown in Figure 9.3.

Figure 9.3 A computer chassis with the side plate removed.

The desktop motherboard package comes with an I/O shield or a back plate. The I/O shield is used to block radio frequency transmission and to protect different internal components and printed boards from dust and foreign objects. This shield maintains the correct airflow within the chassis and also helps to connect different connectors from the external devices in an easy manner. The I/O shield is to be installed on the chassis before installing the motherboard. It is installed in the window provided on the rear side of the computer chassis. The location of the window for installing the I/O shield is clear from Figure 9.4. If an I/O shield is already present in the chassis, this is to be removed. The shield available with the motherboard alone must be used for assembling the computer, since the I/O shield coming with the motherboard is designed to match the exact orientation of different ports on the motherboard.

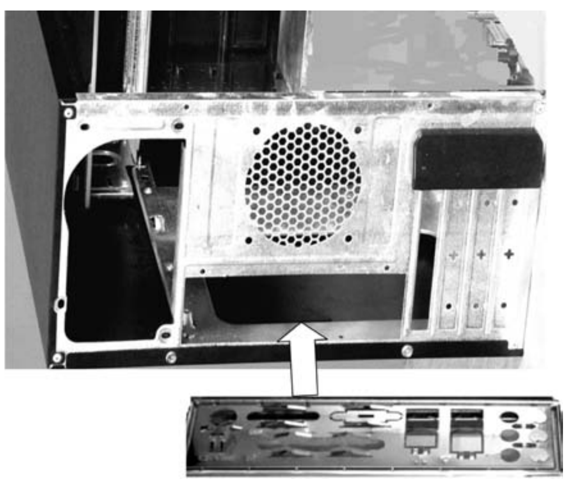


Figure 9.4 Fixing I/O shield on the cabinet.

To install the shield, first of all, the side plate located away from the I/O shield window is to be removed. After this, the shield is placed inside the chassis correctly in the window and it is firmly pressed into the right place so that the shield fits tightly and securely on the I/O shield window of the chassis. An idea of the process can be obtained by studying the Figure 9.4.

Now, the I/O shield is fixed to the chassis correctly. It is necessary to ensure that the motherboard, when fixed, is not in contact with the metallic parts of the computer chassis, as this type of contact can damage the motherboard components. The motherboard is seated on two or more standoffs fixed on the chassis metal surface. Standoffs are fixed to the matching screw holes on the surface of the chassis with the help of pliers. The process of fixing the standoffs is clear from Figure 9.5.

Figure 9.5 Fixing standoffs to metal plate on the chassis.

The cooling mechanism is essential for the internal cooling of different components. In the new computer chassis, provisions for fixing more than one chassis fan, usually on the rear side as well as on its side opposite to motherboard, are made. Certain systems are having separate intake and exhaust fans. In such cases, the fans are arranged in a push-pull manner to draw the cool air through the fins and blow out the hot air. The fans available in the power supply units are of different sizes. Large fans are having better performance and a higher capacity. More air can be circulated by the large fans at a low speed. Hence, these types of fans support less noise. To prevent dust from entering the internal mechanism, air filter and steel mesh are fitted on the air vent. The main drawback of the cooling fans is the noise generated during their working. The chassis fan is fixed inside the chassis on the air vent through the screw holes provided in the chassis as well as in the fan. This is shown in Figure 9.6. To fix the fan, the chassis fan is correctly aligned in its position inside the chassis with the mounting screw holes aligned properly. Using these screws, the fan is then tightened firmly in the slot.

Figure 9.6 Chassis fan.

9.3 INSTALLING POWER SUPPLY UNIT

The computer cabinets are available with the power supply unit fixed to them. The power supply unit can also be purchased separately. Different power supply units are having different capacities. The power rating required for a power supply unit of a system is decided by the total power requirements of the different components used in the computer. If the power supply unit is purchased separately, then it is to be fixed on the top rear corner window of the cabinet. The screw holes for fixing the power supply unit to the chassis as well as the air exhaust slots for the cooling fan are provided in the cabinet at the place where the power supply unit is to be fixed.

To install the power supply unit, following steps are to be done:

(a) First of all, the power supply unit is inserted inside the chassis and then the screw holes of the chassis are aligned with the screw holes of the power supply unit. The insertion of the power supply unit should be done in a manner so that its socket for connecting to the mains power supply is facing outwards. Some power supply units are available with a rubber padding that fits between the cabinet and the power supply unit, thereby helping to absorb any vibration. This helps in reducing noise levels.

(b) After placing the power supply unit in its place, the screws are inserted in the holes from outside (one by one) and each one is tightened gently. The arrangement is clear from Figure 9.7.

Figure 9.7 Fixing power supply unit in the chassis.

The connectors of the power supply unit used to connect with the motherboard are available in two types, namely, AT power connector and ATX power connector. The main difference between these two types of power supply units lies in the number of connecting pins. The selection of the power supply unit must be done in a way so that it would suit the motherboard connector. The connections from the power supply unit are provided to the different devices only after the components are properly fixed.

9.4 INSTALLING CPU

The user manual, a set of necessary cables and a driver software CD are provided alongwith the motherboard. Earlier motherboards required the setting and configuring of several jumpers for proper functioning of the computers. Jumpers are the little pins found on the motherboards and on the expansion cards which allow to change different configuration settings manually. But the new motherboards are designed without jumpers and these are configured through the settings in BIOS. Before fixing the motherboard in the chassis, it is to be made ready by installing the CPU in its socket and the memory in its slots. The installation of the processor, heat sink, processor cooling fan and the memory are to be done before mounting the motherboard on the cabinet, as sufficient space is required for easy movement while fixing the various components in the motherboard. Different processors follow different methods for their fixing on the motherboards. The instructions in the user manual must be followed for installing the processor.

To install the CPU, following steps are to be done:

(a) First of all, the CPU socket is located on the motherboard. Depending on the type of the processor, the socket design can vary.
(b) AMD as well as Intel processors are fitted on the motherboard sockets with the help of retention levers.
(c) While using this type of socket, as the first step, the load lever is released from the retention tab and then the lever is lifted up. To release the load lever, the lever is pressed down and then it is moved away from the socket.
(d) After lifting up the lever, the load plate that is placed above the socket is lifted.
(e) Usually a cap can be seen placed on the socket, attached to the load plate, to prevent the socket pins from getting damaged. For installing the CPU, it is necessary to remove the socket cap from the load plate.
(f) Now, the processor is removed from the protective processor cover. The processor must be handled only through its edges. Touching the bottom of the processor or holding the processor at its bottom is to be avoided.
(g) After removing the cap from the socket load plate, the CPU is correctly placed on the CPU socket present on the motherboard. Only a single position is provided in the socket to make the CPU properly fitted. It must be ensured that the cutouts in the processor chip are aligned with the notches on the socket.
(h) Now, the processor is lowered straight down to the socket without its tilting or sliding. As a result, the processor acquires its correct position in the socket without taking the help of any external force. This type of socket is also called **Zero Insertion Force**

(ZIF) socket because no force is required for inserting the chip into the socket. Forcing the CPU to the socket may damage the processor chip pins and hence, this is to be avoided.

Certain processor chips are also available having a mark on their edges to indicate the correct position. This distinctive mark on the chip must be aligned with a particular position on the socket such as on the left bottom portion of the socket. The method of installing the CPU in the motherboard socket is shown in Figure 9.8.

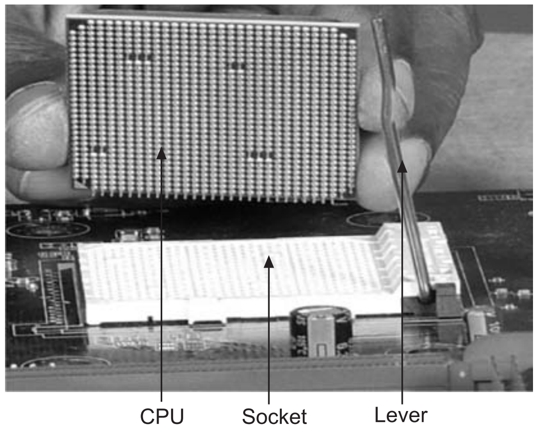


Figure 9.8 Installing the CPU in its socket.

(i) After correctly placing the CPU chip in its position, the load plate is pressed down (if available), and the socket lever is closed and locked.
(j) Now, the processor is firmly and securely fixed on its socket present on the motherboard. This can be made clear from Figure 9.9.

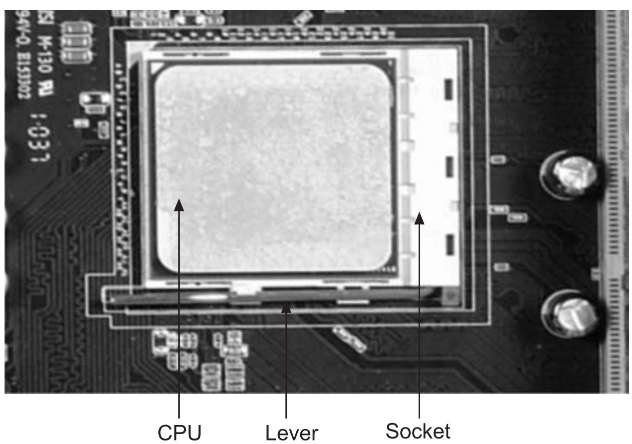


Figure 9.9 CPU fixed in the motherboard socket.

9.5 INSTALLING HEAT SINK AND COOLING FAN

After fitting the processor, the next step is the fitting of a CPU heat sink and a processor fan. Fitting of the heat sink and processor fan is essential to prevent the overheating of the processor, as it can damage the processor as well as the motherboard. All the processors packing consist of a compound known as **thermal paste**. This paste is applied on the above surface of the CPU to make the heat sink fitted above the CPU. Only a small amount of paste is needed to be applied above the CPU, as shown in Figure 9.10. Applying too much or too little paste on the CPU can damage it. The thermal paste also increases the efficiency of the heat sink by filling up the gap present between the CPU and the heat sink.

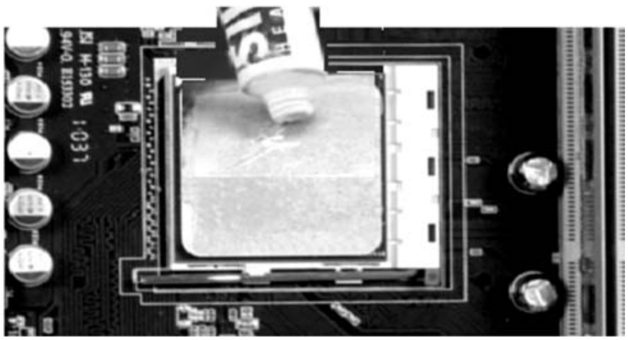


Figure 9.10 Applying thermal paste on the processor surface for fixing heat sink.

Desktop motherboard is usually provided with the mounting holes for fitting the processor cooling fan. Depending on the design of the processor, the type of the cooling fan varies. Also, the fitting steps of the cooling fans differ with the different types of processors. A typical CPU cooling fan can be seen in Figure 9.11. In this type of fan, the mounting screws provided with the cooling fan are forced down to the mounting holes present on the motherboard and are then locked in their positions. Before locking the screws, it is to be ensured that the fan is seated properly in its position.

Figure 9.11 Typical CPU cooling fan.

In certain models, the cooling fan is fixed on a special type of CPU fan holder. In such type, first of all, the holder is fixed in the position using the screws fixed at the four sides. Such type of cooling fan holder fixed on the motherboard can be seen in Figure 9.12. In this model, the cooling fan is firmly fixed in its position with the help of two locking clips available on its sides using the two projecting tabs on the fan holder. The arrangement can be made clear from Figure 9.13.

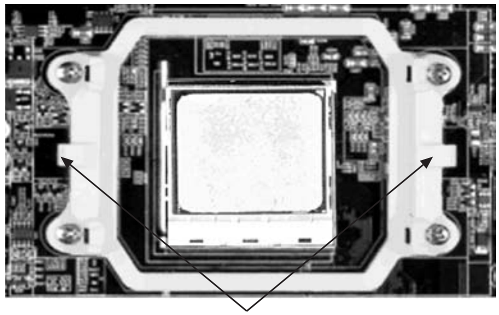


Figure 9.12 CPU cooling fan holder fixed on the motherboard.

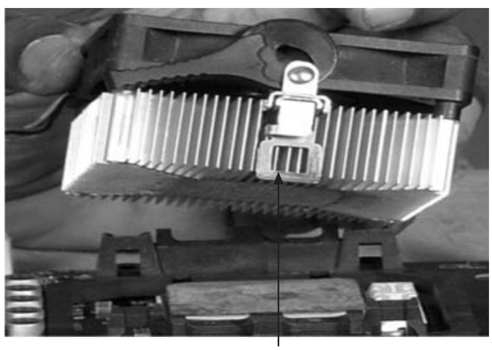


Figure 9.13 Fixing CPU cooling fan on the motherboard.

After fixing the fan, the next step is to give the necessary power connection to the cooling fan. The fan is powered from the connector in the motherboard. The fan connector is marked on the motherboard and is usually located near the memory slots. The position can be clearly understood from Figure 9.14. The processor cooling fans with 3-pin or 4-pin motherboard connectors are available and either type can be used. The fourth pin in the connector is aimed to control the speed of the fan rotation with the help of temperature sensors. The fans with 3-pin connector cannot use the on-board fan control and hence, they always rotate at full speed. The fan power cable is connected to the corresponding connector on the motherboard.

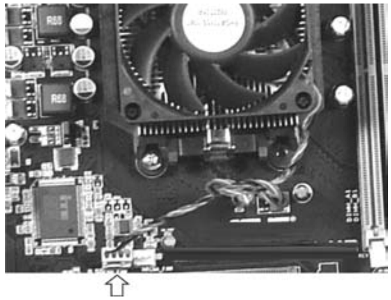


Figure 9.14 Connecting CPU cooling fan connector to the motherboard.

9.6 INSTALLING MEMORY MODULE

To install a memory module in the DIMM slot, following steps are to be done:

(a) The first step is the opening of latches on both sides of the slot and then these are moved outwards completely.
(b) In the second step, the memory module is aligned in the slot correctly.
(c) The slot in the motherboard for connecting the memory module is divided into two parts by a small notch. A similar notch can be seen in the connecting edge of the memory module also. The proper way for installing the memory module in the slot is to align the notch on the module with the notch in the memory slot of the motherboard. This process can be cleared from Figure 9.15.

Proper alignment of the notches makes the module to get inserted in the slot only in a single correct way. For this, the module is pushed down to the slot gently and then it is pressed down firmly by applying pressure on both the edges so that the module seats firmly in the slot. The retaining clips snaps into the locked position when the module is firmly seated in the connector.

(d) The latches on both sides of the slot are then levered upwards and are latched to the edges of the memory module.

Depending on the requirements of the memory and the availability of slots, more than one memory module can be installed in the free memory slots of the motherboard.

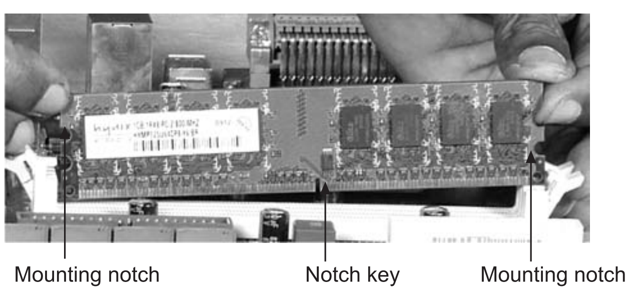


Figure 9.15 Fixing memory module in DIMM slots of motherboard.

9.7 MOUNTING MOTHERBOARD

After fixing the above components in their respective positions, the motherboard is ready for mounting in the computer chassis. Mounting screws for motherboards are provided alongwith the chassis. To mount the motherboard on the chassis, as the first step, the motherboard is properly placed inside the chassis. For this, the chassis is placed on a flat surface with the side plate removed and the window facing upwards. The insertion of the motherboard into the chassis should be done slowly and carefully, as shown in Figure 9.16. While inserting the motherboard, it is properly aligned such that the different external connectors in it get aligned with the respective slots of the already fitted I/O shield on the chassis. The I/O shield edge springs can damage the ports of the motherboard. So, it is necessary to be very cautious while inserting the motherboard on the chassis. It is very important that the motherboard circuits must not touch any metal part of the cabinet. The contact of the motherboard parts with the metal cabinet may cause the short circuit and possibly can damage the motherboard. This can be prevented by using spacers. After placing the motherboard in the cabinet in correct alignment with the I/O shield, all the screws are inserted in the slots one by one and each on is gently tightened.

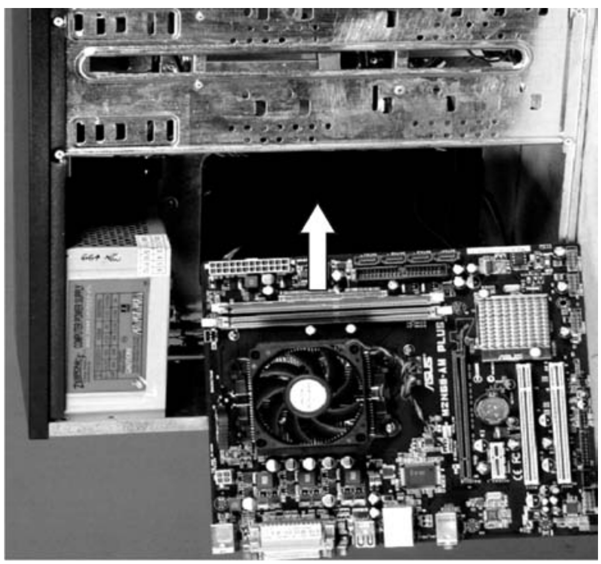


Figure 9.16 Inserting motherboard into the chassis.

9.8 INSTALLING HARD DISK

The following steps are to be done to install the hard disk.

(a) The first step is to fix the hard disk in the drive bay of the computer chassis using screws. Normally, hard disks are fitted at the lowest drive bay of the chassis. The drive bay has slots through which the hard disk can be freely moved without any difficulty.

(b) The drive is mounted in the bay and its position is slowly adjusted so as to make the position of the screws match with the slots in the mounting plate.
(c) The hard disk is fitted to the bay using small screws with its rear panel facing towards the motherboard.
(d) The screws are first tightened manually using a small screw driver. Use of long screws or applying much pressure while tightening can damage the hard disk. A hard disk firmly fitted to the bay of the chassis using screws is shown in Figure 9.17.
(e) After firmly fixing the hard disk, the data cable is connected to the hard disk and to the motherboard and then the power cable from the power supply unit is connected.

The data cable can be a flat ribbon IDE cable or a SATA cable. The power cable is a four-strand type cable. The hard disks require two supply voltages, i.e., 12 V for the motor and 5 V for electronic circuitry. Both the voltages are supplied through the same power cable. The different cables can be fitted in one way only and these cables get locked in their positions.

Figure 9.17 Hard disk fitted to the chassis using screws.

While using IDE interface, the IDE cable connector is plugged into the hard disk IDE connector. Any of the end connectors in the cable can be connected to the hard disk. If the cable end connector is coloured, then the blue connector is used as the host connector and the black or grey connector is used for connecting to the hard disk. The ribbon cable connectors are keyed so that they can be installed only in a correct way on the device connector. The coloured wire on one side of the ribbon cable indicates the first wire which is connected to pin 1 on the drives and on the board.

If more than one device is to be connected in the IDE cable, the jumper settings must be set in the device so as to bring the devices in master and slave modes. If this is not done, then the computer system becomes unable to recognize the devices. Also, the master device is to be connected to the end of the cable. If only one device is connected in the IDE cable, it must be configured as a master device. After connecting the cable to the hard disk, the IDE cable is plugged into the primary IDE channel on the motherboard. The primary channel is indicated by a marking on the motherboard. Earlier motherboards were having two IDE connectors known as **primary** and **secondary IDE channels**. In such motherboards, two hard disks could be connected by using two cables. One hard disk was connected to each of the IDE connectors. In that case, both the hard disks were configured as the master hard disks.

SATA hard disks are connected using SATA cables which are different from the IDE cables. While using SATA hard disk, the hard disk is connected to the motherboard using a SATA data cable. The SATA power cable from the power supply unit is used to connect the hard disk to the power supply unit. After connecting the data cable, a power cable from the power supply is plugged into the power connector on the hard disk. The power connector too, can only be inserted in only one way.

It is very important that the data cables are connected properly before connecting the power cable. When the computer is started for the first time, the BIOS automatically detects the hard disk. If the device is not detected automatically, the *Hard Disk Auto Detect* feature in the BIOS setup utility is used to detect the hard disk.

9.9 INSTALLING OPTICAL DRIVE

The steps followed to install an optical drive are given below:

(a) First of all, the blanking panel is removed from the front side of the computer chassis. These panels are made up of plastic and can be easily removed. For this, the middle of the panel is pressed firmly that make it bend and using the sharp edge of a screw driver, the panel can be removed. This leaves a blank space on the front side of the chassis for fitting the optical drive.
(b) Now, the drive is slowly inserted in the drive bay with the tray opening gate facing outwards, as shown in Figure 9.18.
(c) After that, the drive is firmly fixed in the bay using mounting screws, as done in the case of hard disk.
(d) Depending on the type of interface, the data cable used for the device is either IDE type or SATA type.

If an IDE hard disk is already installed and the second connector in the cable is free, it can be connected to the device if the installed drive is IDE type. Otherwise, a new cable is to be used. The choice of the data cable is dependent on the interface of the optical drive. The connector ends are plugged to the IDE channel or SATA connector in the motherboard and to the drive connector. It is to be ensured that the cable is connected in the correct way.

(e) Now, the free power cable from the computer power supply is plugged to the power connector of the drive.
(f) The audio cable supplied with the drive is used for connecting the drive to the audio connector in the motherboard.
(g) When the computer is started for the first time, the optical drive is automatically detected during the booting time. If the drive is not detected, the BIOS setup utility is used to configure the drive.

Figure 9.18 Fitting an optical drive in the chassis: Front view and side view.

9.10 CONNECTING MOTHERBOARD POWER SUPPLY CABLES

AT power connector is a 24-pin connector and it is having two parts. Each part of the cable connector contains twelve pins. Of the different cables to the cable connector from the power supply unit, two are in black colour. The black wires are oriented together and then the cable end connectors are connected to the motherboard, as shown in Figure 9.19. After placing the cable end connector on the motherboard connector, it is gently pushed downwards until the connector gets fitted firmly. The key-lock provided on the side of the cable connector helps in fixing the connector to the motherboard firmly. All the connectors can be fitted in one way only. ATX and AT connectors can be seen in Figure 9.19. ATX power connector is a single 20-pin connector incorporating + 5 V and + 12 V with optional 3.3 V signals. The twenty pins of the connector are laid out in two rows with ten pins in each row. When an ATX cable end connector is plugged to an AT motherboard socket, four pins at the extreme ends of the motherboard socket remain open, as shown in the Figure 9.19.

Figure 9.19 AT and ATX power connectors connected to the motherboard socket.

One more connection from the power supply unit to the motherboard is required. This is the processor power supply connection. The four-pin connector from the power supply is, first, gently connected to the connector in the motherboard. When it is correctly oriented, then the connector is fixed firmly. The connector can be fixed in one way only. It is shown in Figure 9.20.

Figure 9.20 Connecting power supply to CPU.

9.11 CONNECTING TO FRONT PANEL

The front panel usually consists of a power switch, power LED indicator, reset switch and a hard disk active indicator. All these items are to be connected to the respective connectors in the motherboard. Position of the different connecting points in the motherboards can vary with the different motherboards. Hence so, by using the manual, different connections are made in the motherboards. Generally, the connection points are clearly marked in the motherboards and the cable end connectors are labeled, as shown in Figure 9.21. The cable end connector is correctly placed on the motherboard connecting pins. Then, the connector is firmly pressed down so that the cable connector gets fixed on the motherboard connector firmly. Connections for the LED indicators are having specific orientation and they function only when the connection are made in a correct way. If the LED does not lit during its operation, reconnecting by interchanging the connection wires makes it working. Making wrong connections can damage the motherboard as well as the components. There is no need of making any connection to the motherboard from the rear panel, since all the external connectors in the rear panel are directly mounted on the motherboard itself.

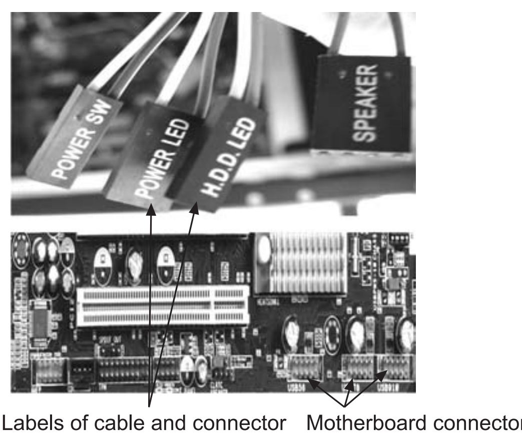


Figure 9.21 Connecting front panel cables to the motherboard.

9.12 CONNECTING MOUSE, KEYBOARD AND MONITOR

The connection of the external peripherals to the different ports present on the rear panel of the computer is the next step in the process of assembling a computer system. The cabinet is closed before making connections to the rear panel. Before closing the cover, all the connections are again checked and it is confirmed that all the connections are done correctly. All the loose hanging wires inside the chassis are tied up as a bunch, as this bunching assists in the proper air circulation, thereby preventing the system from getting overheated. It is shown in Figure 9.22. Any loose cable inside the cabinet can touch the cooling fan and due to this, the fan can stop its rotation. Non-working of the cooling fan results in the overheating of motherboard components. After doing all these activities, the chassis cover is closed and it is tightly screwed to the frame. Before closing the cover, it is necessary to ensure that no screws or other components are left free inside the cabinet.

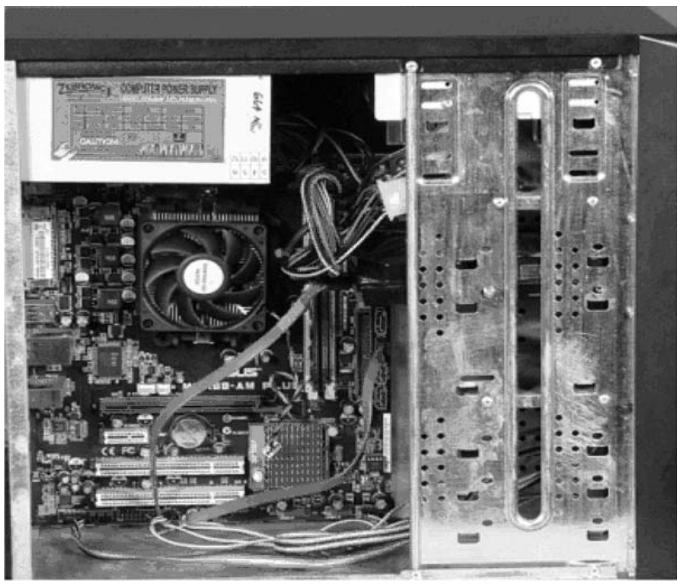


Figure 9.22 Arrangement of the components inside the cabinet.

The mouse and the keyboard are connected to the mouse port and the keyboard port respectively, present on the rear panel. Since, the connectors for mouse and keyboard appear similar, there are chances for these connectors to get interchanged. Different colours are used in the PS/2 connectors for distinguishing these two connectors. The signal cable of the monitor is connected to the video port on the rear panel. The video cable is then firmly fixed using the thumb screws in the connector. All the different connector cables can be connected to the ports in one way only. Different audio devices such as speaker, head phone and microphone are connected to the respective audio jacks, if required. Different colour codes used for the audio device connectors help in connecting the peripherals to the correct port on the rear panel. The process of making connections to the different ports can be easily understood from Figure 9.23.

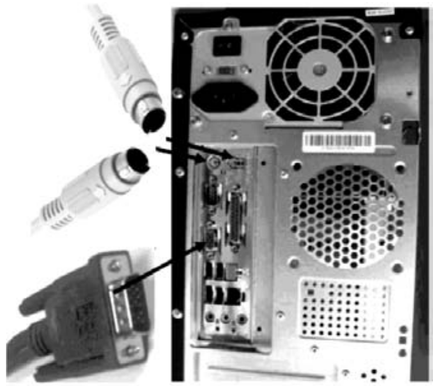


Figure 9.23 Connecting mouse, keyboard and monitor to chassis.

9.13 SWITCHING ON THE COMPUTER

Once all the connections are made, the assembling of the computer is completed, as shown in Figure 9.24. Now, the system is to be switched on. For this, the computer chassis and the monitor are connected to the mains power supply and then the power is switched on. The monitor power switch as well as the chassis power switch is switched on. In the presence of the power supply, the indicators on the front panel of the chassis as well as the monitor become lit. Now, after waiting for few seconds, the monitor is checked for any display. Some startup messages appear on the monitor. LED indicators on the keyboard as well as on the optical mouse also get lit.

Figure 9.24 Computer is ready for switching on.

If all the connections are correct, the assembled system generates a single beep sound. This beep sound is a signal code and this code is known as **BIOS beep code**. If any of the components makes a problem, then the system stops its working during the starting time itself.

BIOS beep codes can be used as an indicator to know the reasons for the failure. A list of beep codes and their meanings are given in Table 9.1. System hanging or a long delay in starting indicates system instability. This problem can be due to some loose cable connections. Checking the connections and firmly fitting the cables to connectors solve this problem.

Table 9.1 BIOS Beep Codes and their Description

BIOS beep code	Meaning
One long beep.	Memory problem.
One continuous beep followed by two short beeps.	Video error.
One continuous beep followed by three short beeps.	No VGA detected.
One continuous beep followed by two short beeps then a pause (repeated).	No memory detected.
One continuous beep followed by four short beeps or four short beeps only.	Hardware failure.
Long and short beeps.	CPU error.

9.14 CONFIGURING BIOS

The next step is to properly configure the system. Different specification configuration settings were done by setting different jumpers in the earlier motherboards. But in the new motherboards, different configuration settings such as clock speed are automatically detected without configuring jumpers. All configuration settings are done by the system automatically. However, if it is required to modify any configuration setting, the *Configuration Utility* can be used. To start the *Configuration/Setup Utility* function, watch for a message appearing on the monitor screen such as *Press F1* or *F2* or *Del key for Configuration/Setup*. The exact key to be pressed varies with the BIOS used. The indicated key on the monitor screen is then pressed and this opens the BIOS main menu.

The *Configuration/Setup Utility* program forms a part of the BIOS code. This utility can be used for changing interrupt request (IRQ) settings and the startup drive sequence, configuring port assignments, enabling USB keyboard and mouse support, resolving configuration conflicts, settling different hardware parameters and security passwords, etc. Different aspects of the motherboard and its performance can be controlled through the options available in the BIOS.

Different BIOS menu options are arranged in the form of a hierarchical menu structure. These options are grouped under different heads. *Standard CMOS setup*, *Advanced CMOS setup*, *Advanced chipset setup*, *Power management setup*, *PCI/PnP setup*, *Peripheral setup*, *CPU configuration setup* are the common main menu of BIOS setup utility. Using the options of *standard CMOS setup*, it is possible to set common parameters such as date, time, disk types, etc. Capacity of the hard disks and their types are also set using the options in this menu. *Advanced CMOS setup* options help to change the boot disks, change the access methods of peripherals and so on. *Advanced chipset* options enable to customize the features of chipsets. *PCI/PnP setup* has options to configure PCI devices as well as plug and play devices connected to the system. Using power management options different power management features can be enabled. *Peripheral setup* options provide facilities for configuring USB support, on-board audio, on-board serial and parallel ports, IR devices and so on. *CPU configuration setup* helps in configuring the processor.

Advanced CMOS setup menu has the option for choosing the first boot device. At this stage, there is no operating system installed in the hard disk of the assembled system. So, the hard disk of the system is empty. The next step is to load the operating system to the hard disk. For this, the computer system is started using an operating system CD in the optical drive and the operating system files are then copied to the hard disk of the computer. Using the configuration option in the BIOS setting, it is possible to temporarily redefine the first startup device, without changing any other settings. So, to boot from a CD or DVD loaded in the optical drive, the option for the first boot device is changed as CD drive in the menu. The configuration changes are then saved and then an exit from the *Setup Utility* is made. On starting the computer next time, if there is an operating system CD or DVD in the optical drive, then the computer boots from the optical drive.

9.15 INSTALLING OPERATING SYSTEM

A computer requires an operating system to control and coordinate its different functions. Any operating system can be loaded to the hard disk of the computer. Selection of an operating system is determined on the basis of the processor and RAM capacity, requirements of the user, storage space available, etc. To load an operating system, the following steps are done:

(a) First at all, the DVD medium containing the operating system files is inserted into the optical drive.
(b) In the BIOS set up, the first boot drive is changed as CD or optical drive and the machine is then restarted.
(c) The machine boots from the optical drive and tries to copy the operating system files to the hard disk.
(d) The instructions appearing on the screen are to be followed such as select the language, select the keyboard layout and country, etc. Many operating systems require to set the country or region as well as the current time.
(e) Now, the *Forward* button is clicked so as to install the operating system in the hard disk of the computer.
(f) After successfully finishing the installation of the operating system, the computer restarts and boots from the hard disk.
(g) Now, the operating system medium inserted in the optical drive can be removed. During the booting process, the BIOS controls the Master Boot Record (MBR) which is stored in the first sector of the hard disk and the first 446 bytes in the hard disk contain the boot loader information.

To use the features integrated with the motherboard, it is necessary to install the driver software for different motherboard components such as audio device, graphics accelerator, networking system, etc. The device driver medium containing the driver software for different motherboard components is usually provided with the motherboard by the manufacturer. Linux operating system installs almost all the device driver software while installing the operating system and hence, there is no need for separate installation of the device driver software in the case of Linux operating system.

9.16 INSTALLING DEVICE DRIVERS

The device driver medium contains driver software for chipset, LAN, audio/video components. Installation of the device driver software is essential for the working of different components of the system. The steps to install the driver software are as follows:

(a) First of all, the driver DVD is inserted in the optical drive. If the autorun feature is enabled, the above step displays the opening page of the installer utility. The display of the opening window varies with different motherboard manufacturers. In case of device driver installer for Intel motherboards, the opening window shows a number of options on its left side. Status details of the driver components are displayed on the right side.
(b) Selecting the driver by checking the check box activates the *Install* button at the bottom.
(c) Clicking the *Install* button initiates the installation of the selected device driver in the hard disk.
(d) A rebooting of the system is necessary to bring the installed driver software into effect.

More driver software can be selected by repeating the above process.

9.17 INSTALLING ADD-ON CARDS

Usually, the motherboards have different expansion slots for installing add-on cards or the expansion cards. The number of expansion slots is determined by the specification of the motherboard. The steps to install an add-on card are as follows:

(a) First of all, the blanking plate is removed from the chassis corresponding to the slot where the add-on card is to be fixed. Usually, the blanking plates are held in their place by small spot welds. The blanking plates are removed by pressing the slot cover, grasping it and then pulling it out of the expansion slot.
(b) Add-on cards are generally available in the special static-protective packages. The add-on card is to be taken from its static-protective package. It must be avoided to touch the components and gold edge connectors on the adapter.
(c) The edge connector of the add-on card is then placed on the expansion slot and here, it must be ensured that the card is seated correctly in the slot.
(d) Now, the card is gently pushed into the slot and then it is fixed firmly. Applying too much pressure can lead to the damage of the card and the motherboard and it is to be avoided. The card must be completely seated in the connector and the card retention notch must snap into the correct place around the retention mechanism pin.
(e) While installing the add-on card on the motherboard, it should be ensured that the card is fully seated in the connector slot before the system is turned on, as an electrical

short may result across the connector pins when the condition is not fulfilled. It may also result in the damage of certain desktop board components.

(f) Once the card is properly seated, the metal bracket on the card is secured to the system chassis using a screw.

(g) In case, the cables are required to connect with the adapter, the connection are to be done properly.

(h) The cables are then routed so that they do not block the flow of air from cooling fans.

(i) If any of the vacant expansion slots is remaining open, then these are covered. This maintains the electronic emission standard and ensures a proper ventilation of internal components.

(j) After that, the chassis cover is closed and it is screwed firmly on the chassis frame. Usually, the required device driver software for the added card is to be installed in the computer for its proper working.

(k) When the computer is switched on for the first time after adding a new expansion card, the system prompts for device driver files.

(l) The DVD containing the device driver files can then be inserted in the drive and the installation can be done.

For removing an expansion card, the screw holding the card in its position is removed and then the card is pulled upwards to remove it from its socket. If there is any difficulty in the removal of card, a screwdriver can be inserted under the top bracket and can be slowly raised until the card is released from the slot. Once the card is released from the slot, it is pulled out, thereby removing the card.

Add-on graphics cards are inserted in the AGP expansion slots in the motherboards. To insert the graphics card, first of all, the chassis is opened carefully. Now, the back plate on the chassis is removed corresponding to the expansion slot. The graphics card is inserted in the AGP slot and is then fixed in the slot firmly. To prevent the movement of the expansion card, screws are used to fix the card firmly on the chassis. After that, the chassis is closed. The monitor is connected to the output port of the graphics card and the system is switched on. Windows operating system detects the presence of a new hardware component during its booting and the system searches for the device driver required for the new hardware and then installs the driver software. If the driver software is not detected, the system prompts for the insertion of the driver software medium in the drive which is then inserted to proceed the installation process without any difficulty.

Another common add-on card used in the computers is the **network adapter card**. These types of cards are featured with universal support, plug and play installation, built-in network connector, activity LED indicator, etc. A typical network adapter can be seen in Figure 9.25.

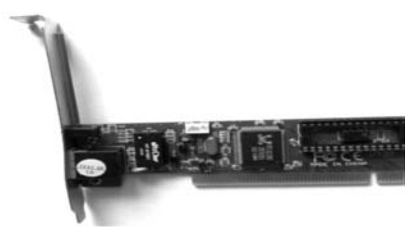


Figure 9.25 A typical network adapter.

Usually, the device driver software for the network card is supplied by the manufacturer. To install the adapter, first of all, the device driver is to be installed in the computer. If the software is in the DVD, then the driver DVD is to be inserted in the optical drive. Clicking the option for the installation of the software starts installing the device driver software in the computer. After installing the software, the computer is switched off and the chassis is opened to install the adapter card. After that, the chassis cover is closed and the system is powered on. If the BIOS is plug and play compliant, the adapter card is automatically configured. Otherwise, a manual configuring through the BIOS utility is required.

Another expansion card commonly found in server machines is the **RAID controller card**. It supports different RAID levels such as RAID 0 (data stripping), RAID 1 (drive mirroring), RAID 5 (drive stripping with distributed parity), etc. In data stripping, the data is striped across all the drives without any redundancy. This enables a fast data access. But the data is lost, if any of the drives fails. In data mirroring, the data is written simultaneously in several disks. Data stripping with distributed parity enables the reconstruction of data, if a drive fails. The installation of the RAID controller card is similar to the installation done for the other expansion cards.

9.18 COMPUTER SYSTEM: COMMON PROBLEMS AND SOLUTIONS

In this section, some of the common problems associated with the computer systems and their possible solutions are discussed. Table 9.2 provides the details in an easy usable format.

Table 9.2 Computer System: Common Problems and Suggested Solutions

Problem	Solution
BIOS fails to detect hard disk, DVD, etc.	The common reason for this problem is the loosely connected cables to devices. Disconnect the cables and fix them firmly. If this does not work, use another set of cables and try again. If the problem still exists, replace the components.
There is change in the time and date settings in the system.	The CMOS battery is powering the clock. Change in the time and date settings is an indication of failing CMOS battery. Replace it.
The computer restarts during the midst of working.	This problem can be due to overheating of the system components. Cleaning the accumulated dust from the components, adding more cooling fans, using better memory coolers help in solving this problem.
The add-on network card is not working.	Ensure that the appropriate driver is loaded and the proper grade of cable is used for the network connection. Firmly fix the connectors and check again.

10

Troubleshooting and Maintenance

A working computer system can fail all of a sudden without giving any warning indications or it can develop some troubles during the course of its working. The failure of the computer can be due to a hardware problem or a software problem. Sometimes, the failure of the computer system can be due to a combination of several faults. In the case of hardware faults, any of the associated components of the system can develop faults at any time. The best way to keep the computer healthy in hardware aspects is to maintain the hardware components properly. With respect to software, the reasons for computer faults can be wide and varied. The computer can fail if the operating system or any of the associated files get corrupted or any of the applications become non-working. The symptoms of failure can range from minor problems such as margin alignment problem in print output from a printer to some other major disasters such as the system does not even load the operating system at all. A correct troubleshooting process helps in identifying the problem and provides a correct maintenance operation.

In this chapter, some of the common problems, troubleshooting methods, suggested solutions and the maintenance steps that can be taken to ensure proper health of the system are discussed. Even if a particular problem faced by the reader is not covered, this chapter provides some basic ideas about the general techniques that can be followed for troubleshooting and tackling repairs. The chapter also provides suitable suggestions in solving some of the common hardware problems and gives the necessary directions to keep the system in a proper working condition.

10.1 SAFETY PRECAUTIONS

While working with the computer system, several safety precautions must be followed to ensure the safety of the users. Several hazards can occur while working with various computer components. The primary voltage provided on the devices can cause a serious or fatal electrical shock. A damaged CRT face or a bulging capacitor on the circuit board can create explosive hazards. Moreover, a loose or missing hardware can lead to the mechanical hazards. The computer must be operated in the specified voltage levels only. To protect the devices from any damage due to electricity, proper electrical earth wiring must be ensured. For the proper and safe working of the connected components, the resistance between the external ground pin and the frame ground must be 0.1 ohm or less. A voltmeter must be used to check the ground continuity resistance.

Before inspecting the system for defects, the power must be turned off and the power cord should be disconnected from the mains supply. For the safety of the person doing the maintenance of the system as well as to ensure proper working, the following rules must be followed during disconnecting and reconnecting the computer components:

(a) For disconnecting the devices, everything must be turned off and then the power cords are removed. After that, the signal cables from the connector are removed.
(b) For making the connections, first of all, the signal cables are attached to the connectors. After that, the power cords are connected to the outlet and then the devices are turned on.

Static electricity present in the human body can seriously damage the computer components. So, necessary protective measures must be taken to avoid the damages due to static electricity. To prevent the build up of static electricity, it is necessary to limit the movement of the people. It is not advisable to touch the exposed circuitry of the adapters and memory modules. These items must be handled by holding them by edges or connectors only. While installing a new item, a contact must be made between the static protective package of the item and an unpainted metal surface for at least two seconds so as to nullify the static electric charge. It is possible to provide the electrostatic discharge protection by wearing an antistatic wrist strap and attaching it to a metal part of the computer chassis.

10.2 CONFIGURING USING BIOS PARAMETERS

BIOS utility displays the system parameters and provides the facilities to set different configuration parameters of the computer. *AMI BIOS*, *IBM BIOS*, *Award* and *Phoenix BIOS* are the different BIOS commonly used in the computer systems. The different BIOS configuration parameters are stored in a special memory chip known as *CMOS RAM*. These different configuration parameters remain in this RAM even when the system is turned off. This is made possible because of the power backing up provided by the CMOS battery to the RAM. The stored data is used by the system for its configuration during its booting time. The settings in BIOS determine the performance of the computer system. Configuring the system using incorrect values results in unstable system which leads to the crashing of the system. Therefore, to get optimum performance from a computer system, it is necessary to configure the computer using the correct BIOS parameters. Apart from the basic settings, BIOS offers a range of options that can make the computer system faster or easier to be used. If the BIOS got corrupted due to any reason, the system can be configured and booted using the default values or the last good configuration values stored in the BIOS. Several problems associated with the computer systems can be corrected by setting the correct BIOS parameters.

For all configuration purposes, it is necessary to enter into the BIOS set up utility. An assigned key such as *F2* or *Del* on the keyboard is pressed while booting, to display the BIOS main menu. The different configuration settings are arranged in groups under different menus. The features used in the configuration menu of different BIOS are more or less consistent. In some cases, the same options may appear under different groups for different BIOS chips. Certain computer manufacturers also make use of customized BIOS interfaces. The main menu of BIOS usually displays the configuration details of the components that are used in the computer system. The configuration details are detected automatically during the booting time of the computer by a self test conducted by the BIOS. Different BIOS set ups make use of different methods of navigation through the options displayed. Some of them follow a direct movement through the menu options while certain others need some extra searching methods to find the required option. In a typical case, to navigate through the BIOS menus, the following keys given in Table 10.1 are used.

Table 10.1 Navigating Keys of BIOS Menu

Key	Function
Esc	Exit from the current menu.
Up arrow key and *Down* arrow key	Move upwards and downwards through the menu.
Right arrow key and *Left* arrow key	Move right and left directions in the menu.
Enter	Select the option.
Plus (+) key and *Minus* (–) key	Scroll through the available options.
F9	Load default values.
F10	Saves the current configuration and exit.

The selected item of the menu is usually indicated using a highlighted display. By making the use of cursor arrow keys, it is possible to move through the displayed list of options. Whenever more than one option is available for any parameter, changing to other values of the parameters is possible by pressing the *Up* arrow key or *Down* arrow key. Usually, the available options are displayed in a pop-up dialog box. The displayed option can be selected by pressing the *Enter* key. The pressing of the *F10* key saves the selected option and exits from the BIOS menu. On pressing *F9* key, default stored values are loaded. The pressing of the *Esc* key makes the BIOS to exit without saving the changes made, if any.

The usual first level menu items of the BIOS application are named as *Main, Advanced, Security, Power* and *Exit*. On selecting the *Main* menu, basic features of the computer system are displayed. This menu is also known as Standard configuration menu. The details available in this menu include the BIOS version, type and speed of the processor used by the system, system bus speed, system memory speed, size and type of the memory. Most of the parameter values are detected automatically by the system and hence, the user cannot make modifications to the displayed values. Processor name, BIOS version, etc. are the examples of this type of configuration menu which are detected but cannot be changed. But there are some other parameter values that can be changed by the user. The default date and time of the system is such a type of parameter whose values can be changed by the user. By selecting some menu items, a new window is opened that displays a further set of options or values to be selected.

Selecting *Advanced* menu displays the advanced features of the computer system and this menu offers the facilities for modifying different advanced features of the computer. Configuration settings during the computer boot time such as keeping the number lock in 'on' state, controlling the speed of CPU fan, etc. are done from this menu. The other configuration options include the configuring of different peripheral devices attached such as IDE and SATA devices, parallel, serial and USB ports, video configuring, configuration of the features of chipset, etc. Different on-board controllers in the motherboard can be enabled or disabled using the options available in this menu. Hard disks and ports are detected automatically and the details are displayed by the system. Enabling the *Self Monitoring Analysis and Reporting Technology* (SMART) function available in the BIOS menu can help in providing a suitable advance warning of the failures of hard disks. Certain BIOS displays the particular features of the system such as the machine type and its identification number. Enabling and disabling of different ports is another facility available in this menu.

Selecting *Boot* menu option opens the facility for configuring the priority for booting devices attached to the computer. Any device such as CD or DVD, hard disk, network, etc. can be configured to act as the first boot device. Setting BIOS password, changing passwords are the common options available in *Security* menu. By using this option, it is possible to set a password to the BIOS. Once the password is set, the access to different configuration options is possible only if the password is given. The password once set can be erased or changed later, if required.

Different features for power management are available in *Power* menu. When the system is inactive, then it can be changed to power saving mode using the options available in this menu. The advantage is that the system then consumes only the minimum power necessary for its working during the inactive time, thereby saving the power. This is achieved by reducing the clock speed when the processor is not busy. Less power consumption means less heat dissipation. This results in slow running of the cooling fans making a quiet operation. A number of options for monitoring and controlling the temperature levels of the components are also available in the new BIOS versions. Options for returning to the normal mode can also be set using the parameters provided in the menu. After modifying the parameter values, these can be saved in BIOS. The system uses the saved values during the next booting of the system to configure the booting process as well as to set the values for different parameters.

10.3 POWER ON SELF TEST

When the computer is powered on, the BIOS performs a series of initialization and diagnostic tests known as **Power On Self Test** (POST). This is a test for error reporting during the booting of computers. POST checks registers, memory, flags, ROM, DMA, video, keyboard and determines the details of the peripheral devices connected to it. Then, the BIOS proceeds to load the operating system, if no error is detected. The process of loading the operating system is known as **booting**. If there is an error, POST reports the error in three ways—by using beep code sound, by displaying error messages on the monitor and by creating error logs. A beep code is a combination of short or long beeps or a series of short beeps that are separated by pauses. One beep at the end of POST indicates a successful completion of POST. If no beep is heard at the end of POST, the computer may be having a power problem or a fault with the motherboard or a fault with the speaker. The beep codes of the computer system are dependent on the BIOS used and these vary with different BIOS versions. The beep codes are intended to provide some ideas regarding the location of the fault occurred and it need not provide the exact reasons for the fault.

As stated earlier, beep codes are not standardized and different manufacturers use different beep codes for indicating different problems. A typical **IBM BIOS** gives beep indications as follows:

(a) One long beep followed by two short beeps indicates a faulty video card or the absence of a video card. It also indicates that an external ROM module does not properly checksum to zero.
(b) Three beeps indicate the failure of memory.
(c) A long siren indicates an overheating of the processor. These are mainly related to hardware faults.
(d) A recoverable error is indicated by the display of an error message on the monitor after the POST operation.

A list of different error messages displayed by IBM BIOS and the corresponding descriptions are given in Table 10.2.

Table 10.2 IBM Error Codes and Descriptions

Code	Description
02×	Power supply errors
1××	System board errors
2××	RAM errors
3××	Keyboard errors
4××, 5××	Monitor errors
6××	Disk drive/controllers errors
9××	Printer adapter errors
14××	Printer errors
17××	Hard disk controller errors

The **Phoenix BIOS** makes use of another type of beep codes for fault indication. A description of the beep codes and suggested actions to correct the detected problems are given in Table 10.3. A single problem can create more than one error message. When this occurs, the cause of the first error message should be corrected. Usually, the other error messages do not occur next time, when the POST runs. Also, the same error can occur due to more than one fault. In such cases, the first fault is corrected and then the machine is restarted. If the problem still exists, then the next corrective action is done to proceed further. In this way, the fault can be corrected and the system can be made operational.

Table 10.3 Phoenix BIOS Beep Codes and Suggested Action

Beep code	Description	Action
1-1-3	CMOS test failed	Check battery and replace it, if needed.
1-1-4	BIOS ROM checksum failed	Recover BIOS code and replace the system board.
1-2-1	Programmable timer failure	Replace the system board.
1-2-2	DMA failure	Replace the system board.
1-2-3	DMA failure	Replace the system board.
1-2-4	RAM refresh failed	Replace RAM and the system board.
1-3-1	RAM test failed.	Replace RAM and the system board.
2-1-2	System board registers failed	Replace the system board.
2-1-3	System board registers failed	Replace the system board.
2-1-4	System board registers failed	Replace the system board.
2-2-2	Keyboard controller failed	Check keyboard and connection. Replace the keyboard and the system board.
2-2-3	CMOS checksum failure	Replace the battery and the system board.
3-3-3	No operational memory	Check memory and connection. Replace DIMM and the system board.

With the help of visual indications also, it is possible to get an idea about the reasons of the failure of the system. Light emitting diodes in the motherboard, especially in server systems, are lit when an error is detected. Such types of LEDs are commonly available in the new motherboards. These different light emitting diodes indicate the failure of system fans, DIMM, etc. By using the LED indications, the fault can be identified as well as can be corrected. Each error LED is lit to indicate a problem with a specific component only. Once the problem is rectified, the LED does not lit again during the next time booting of the system. Apart from using the above types of built-in hardware diagnostic methods, different diagnostic applications also help in identifying the errors and correcting the problems. The applications for fault diagnosis can be downloaded from the Web and can be used.

10.4 DEVICES AND DRIVERS

Many of the computer hardware problems can be due to the problems associated with the device driver applications which are the background applications that control the working of different devices connected to the computer. Every device connected to the computer system has a device driver application installed in the system. The device driver must function properly and correctly for making the use of connected devices. Printers, monitors, scanners, networking cards, audio devices, etc. all have an associated device driver application. Different operating systems install device drivers automatically for many common devices. When a device is to be connected to the computer, the device driver application supplied alongwith the particular device must be installed for its proper working.

The details of the device drivers installed in the system are displayed in the *Device Manager* utility available in Windows-based operating systems. *Device Manager* also acts as the central point in modifying hardware settings and for updating the associated device drivers. When opened, the utility displays a window in which the details of the installed hardware items, associated device drivers and resources are displayed in the form of a tree structure. The typical display window is shown in Figure 10.1.

From the list displayed in the *Device Manager* window, it is possible to identify the hardware problems due to device driver applications. Usually, three types of problems can be identified from this window which are as follows:

(a) A device highlighted with a yellow exclamation mark is in conflict with another hardware device and hence, the device does not work properly.
(b) A device indicated with a red cross mark shows that the device is disabled or removed and hence, the device does not work.
(c) Some of the devices can be seen included under the group named *Other Devices*. These devices have no device driver software installed in the computer system and hence these do not work.

A disabled device can be enabled by right clicking on the disabled device and selecting the option to enable the device, from the displayed pop-up option. A rebooting of the system is necessary to bring the effect of the change made and to ensure the proper working of the device. If enabling of the device and the rebooting the system do not make the device working, then in the next step the driver software is uninstalled. After that, it is installed again. Uninstalling of the driver can be done by right clicking on the device and selecting the option for uninstalling, from the displayed pop-up window. After uninsttalling, a restarting operation makes the operating system to detect the connected device and to load the driver automatically or to prompt to provide the location where the driver software is available or to insert the driver medium in the optical drive. This works only if the device is connected properly and is powered on. The installation steps are interactive and can be completed easily.

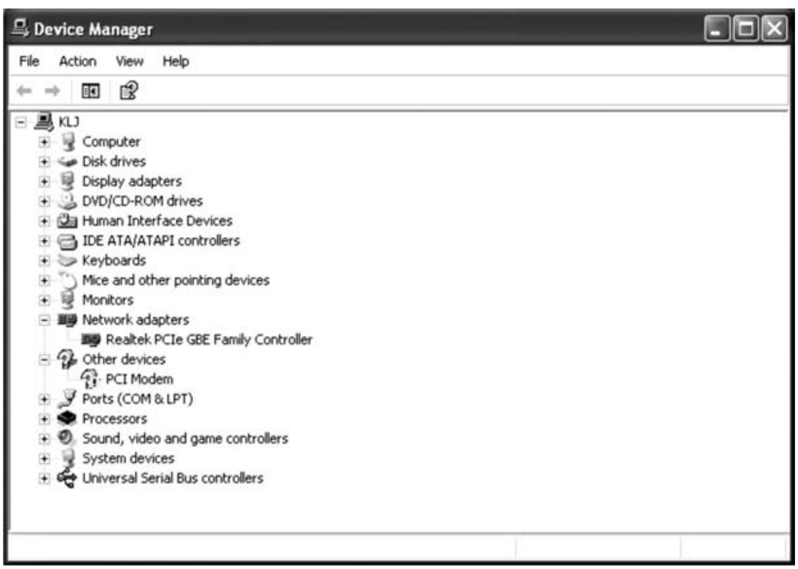


Figure 10.1 *Device Manager* window.

Sometimes, it becomes necessary to update the device driver software to the latest version. If a device of another manufacturer is installed, the need for using another device driver arises. Updating the device driver is possible by selecting the *Update driver* option from the pop-up menu displayed, when the device is right clicked. This opens the *Hardware Update Wizard* window, as shown in Figure 10.2. Windows operating system searches for the updated software version from the hardware installation optical medium or it is searched the Web. The system must be connected to the internet for searching through the Web. If a DVD containing the updated software is available, then it can be used for device driver installation. A suitable option from the list displayed at the bottom of the wizard window is selected that activates the *Next* button. On clicking the button, the next window is opened. The process is interactive and the updating process can be finished easily within a few mouse clicks. Restarting of the computer system is necessary for the change to being into the effect.

Figure 10.2 *Hardware Update Wizard* window.

10.5 WORKING WITH WINDOWS REGISTRY

Windows registry is an integral part of the Windows-based operating systems. Registry stores the settings of the operating system alongwith the details of hardware and software that are installed in the system. This is a large database used to store the necessary information for the proper working of Windows-based computer systems. Information stored in the registry controls the behaviour of these type of computer systems. Registry information is used by the computer to store the user preferences and the system settings such as the application which is to be used for opening a file, applications that are to be launched during the starting time, passwords of the users, etc. When the computer system is running, values stored in the registry is constantly accessed and changed. Also, when the new software is installed, several modifications are made in the registry values. Bugs or incorrect registry entries can instantly make the Windows system completely unusable. Displaying unwanted dialog boxes and messages during the working of computers, software hesitating to open or close, unpredictable system behavior, etc. can be due to the bad or corrupted registry values.

By default, there are registry editor tools available in the Windows operating system as well as in several third party applications for editing the values stored in the registry. Apart from editing values, these tools also help for registry backing up and its restoration. Launching the *Windows Registry Editor* tool displays the opening window, as shown in Figure 10.3. The window has two panes similar to the panes of the *Windows Explorer* application. The left pane displays the navigation map in a tree structure and the user can move through the keys. A plus sign on the left side of a key indicates that there are subkeys below the key. Clicking the plus sign expands the tree and opens further keys under the selected one. The right pane displays the values stored in the selected key on the left pane. The right pane is split into three columns and the labels are named as *Name, Type* and *Data*. The values are of various types such as string value, binary value, DWORD and expandable string.

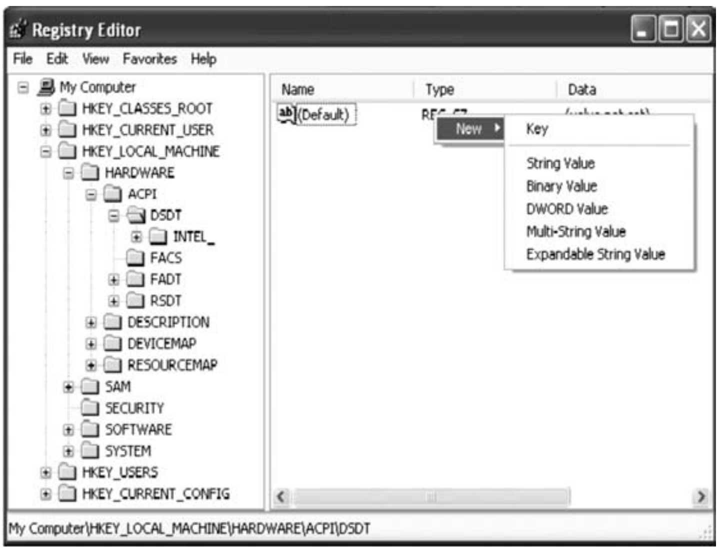


Figure 10.3 *Windows Registry Editor* window.

Different information in the registry is stored in an organized manner. There are five main registry keys under which the different configuration values are stored in several subkeys. The main keys can be seen displayed on the left pane. The five main keys are *Hkey_Classes_Root* (*HKCR*), *Hkey_Current_User* (*HKCU*), *Hkey_Local_Machine* (*HKLM*), *Hkey_Users* (*HKU*), and *Hkey_Current_Config* (*HKCC*). The above keys control the settings of the different allocation and registration settings, manages user related settings, system wide configurations, desktop settings and the current hardware profile respectively. The number of subkeys under a main key varies. Values stored in the subkeys control the different settings. The values in the key can be changed and the changes are brought into the effect only after rebooting of the system.

Configuring of the *Current User* key helps to set the system as per the user preferences. The key can be configured to display the programs that the user access often, enable the command line autotyping, control the position of the desktop icons, change the file association applications, hide the drives, disable or enable the right mouse clicking effects, etc. Different configuration values of the local system are set using the values stored in the *Local Machine* key. The values help to set or remove the passwords, change the configuration information, get a product key, remove or uninstall the information, enable or disable the sharing properties and so on. The user can change keys and values, import or export registry keys, load or unload registry hives and so on. To add a new key, the registry key is clicked under which the new value is to be added. Selecting the *New* option from the *Edit* menu, displays a pop-up menu, which in turn, displays a number of options. The user can select the required option and can proceed further. The process is simple and can be completed easily. In this way, it is possible to modify, delete or rename the different registry keys and the key values. Exporting registry values to files or importing values from files are the options available from the *File* menu of the *Registry Editor*. To make operations easier, necessary help facilities are also available with this tool.

When a new application is installed, the details are added to the registry data. So, the size of the registry increases. The bigger size of the registry indicates the more time requirements for getting the required information from the registry. Proper uninstalling of the installed software removes all the application specific information such as the product ID, recently accessed files, etc., added in the registry. If the software is removed by deleting the folders in the system that contains the software, then the application specific information created in the registry does not get removed. Also, several unwanted values and keys remain in the registry database. To make the registry size compact, the registry is to be cleaned occasionally. Manual cleaning of registry is time-consuming and tedious and hence, is difficult. Also, deleting wrong registry key values or setting the values wrongly make the system badly damaged. To make the registry cleaning easier, there are applications developed for this purpose and such applications can be used.

By storing the configuration information centrally in the registry, the administration and configuration of the system is made easy. The disadvantage of this type of arrangement is that any incorrect setting in the registry value can disable the working of the system. Hence, when trying to edit the registry values, it is necessary to follow some good practices to protect the system from any damage. A backup copy of the registry values is to be prepared and stored before modifying them, since the backup copy can be restored if any inconsistency occurs during the modification of the registry value. As the registry values used by different Windows versions are different, replacement of one registry version with another is not to be attempted. Several tools and applications that provide easy to use user interfaces are available which provide an easy method for modifying registry values.

10.6 PERFORMANCE IMPROVING STEPS

Performance of the computer systems can be increased by using several performance improving steps. Some of the hardware related activities for improving the system performance are stated here. Basically, the settings in BIOS affect the performance of the computer systems. Using optimum values in BIOS helps in improving the performance of the computer systems. Enabling memory cache in BIOS is an effective step to get a better performance from the system. Setting CAS value to its lowest and the bus speed to its highest in BIOS are the other methods for improving the system performance. Setting the correct booting device and quick POST option in the BIOS setup helps in shortening the boot process. This step saves several seconds during the boot time of the system. Enabling the fast boot option available in different BIOS can also save time during the booting process. This step bypasses certain areas of automatic hardware recognition. Hard disks with large spindle speed, increased storage capacity and buffer size can increase the speed of operation to a large extent. Regular scanning of the hard disks for error correction, defragmenting disks, enabling DMA from BIOS settings are the other ways to increase the system performance. Using the latest and updated versions of the driver applications also helps in increasing the speed of the computer systems.

Computers and monitors produce heat during their working. Computer is fitted with the cooling fans that pull in fresh air and force out hot air from the cabinet. Cooling fans and heat sinks are fitted to the processors to dissipate the generated heat during its working. To make the cooling process easier, air vents are also provided with the computers. The monitor also consists of several vents to let in cool air. Blocking the air vents causes overheating and this can result in malfunctioning or damaging of the components. Providing enough air circulating paths around the computer and monitor also helps in easy heat dissipation. Computers are to be placed in a way in which they are designed to be used. Placing computers on surfaces in such a way so as to block the free movement of air can damage the computer and hence, this is not advisable.

Keeping the display settings of the monitor to a lower colour bit level such as 16-bit or 256 colours instead of high bit colours such as 24-bit can be tried to increase the speed of the system. A lower bit rate is acceptable in most of the cases. The presence of innumerable fonts in the system makes the system slow. Thus, the removal of unnecessary fonts from the system can be helpful in speeding up the system. Several temporary files are created during the working of computer applications. Normally, all these temporary files are removed when the application quits. But in certain cases, the temporary files are not removed. Clearing the temporary files increases the availability of free disk space. To view the presence of temporary files in Windows based systems, *Start* button is to be clicked and then *Run* option is to be chosen. Now, *%temp%* is typed and then *OK* button is clicked. This step opens another window and the list of temporary files is displayed. The listed files can be deleted to free the hard disk space. Built-in applications for cleaning disks are available in several operating systems and these can be used for cleaning hard disks. Several applications are started during the startup time of the computer systems. Some of the applications are not essential for the normal working of computers. Disabling these types of applications can increase the performance of the system to some extent. Different operating systems have tools installed by default to identify as well as to enable and disable the applications during startup time of the computers. Disabling services that are not required for the normal working of computer systems can also increase the performance of the computer systems. These operations can be done with the help of tools available with the operating system.

Sometimes, computers take a long time to get ready, when switched on. Lots of icons cluttered on the desktop can make the system slow in getting started. Also, some computers take a long time to download files from networks. There are several reasons for this slow speed. An easy way to increase the speed of the operations of computer systems is to add more memory. Increased memory (RAM capacity) increases the temporary memory available to the system. Hence, the speed of the operation of computer system can be improved. Increased RAM makes swift starting of the applications, fast scrolling through the pages of documents and fast switching between different tasks. If the hard disk storage space is less, then the system takes more time for storing files. Applications and files that are not used, are to be deleted to make the available disk space free, thereby making more free storage space. Availability of increased storage helps in the speedy storage of files as well as their retrieval. If the files are stored in fragmented state in storage, it will take more time to read files as well as to write files to the storage. Defragmentation process helps in storing the fragmented files in adjacent blocks in storage. This enhances the speed of reading and writing of files.

10.7 OVERCLOCKING THE SYSTEM

Certain components included in the computer systems are designed to work in certain frequencies. But in practical, most of the components works in lower frequencies than their rated frequencies. **Overclocking** is a process of increasing the working frequencies of different components of the computer above the factory set values. Different computer components whose frequencies can be increased are memory, CPU, RAM, GPU, video memory and different buses of the motherboards. A steep hike in the frequency affects the stability of the system and hence, this is not to be done.

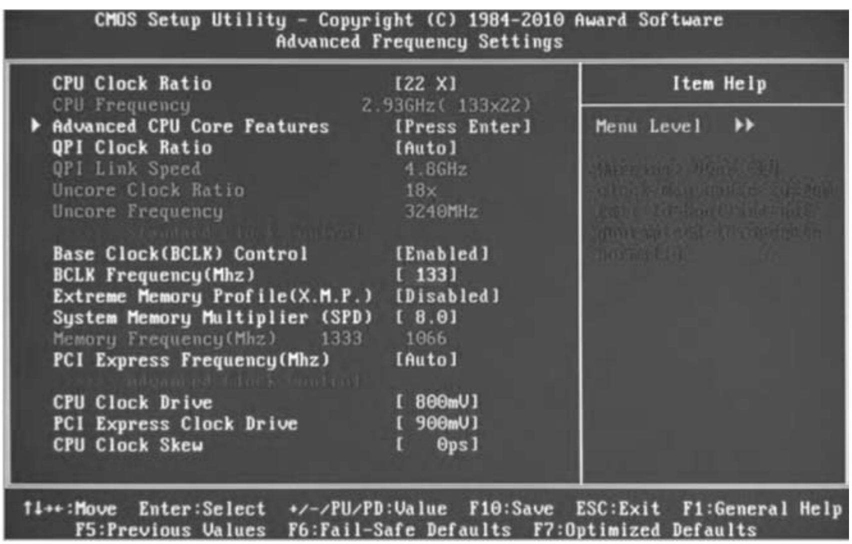


Figure 10.4 BIOS utility for CPU overclocking.

The usual method of overclocking the component is to increase the frequency in small steps. There are several tools, utilities and methods for overclocking the CPU. Certain motherboards are having an overclock button pressing which the CPU starts to calculate its speed and applies in the BIOS to make the CPU run with an overclocked speed. The simplest and the easiest way of overclocking is to change the frequency settings in the BIOS. For overclocking through BIOS, first of all, the overclocking/frequency settings section in the BIOS set up is opened and then BCLK (Base Clock Control) parameter is located from the options, as shown in Figure 10.4. Increasing the value of this parameter will step up the speed of the CPU and memory, thereby increasing their performance. While increasing the speed of CPU, it must be ensured that the memory runs at its rated speed by adjusting the memory ratio.

The CPU speed is actually the product of the bus speed of motherboard (FSB) and the CPU multiplier. The multiplier of a CPU is a locked value and cannot be increased. In order to overclock CPUs with a locked multiplier, it is necessary to increase the FSB, which in turn, increases the speed of RAM. Therefore, a good motherboard that can handle the high FSB speeds and a high end memory is necessary to overclock the CPU.

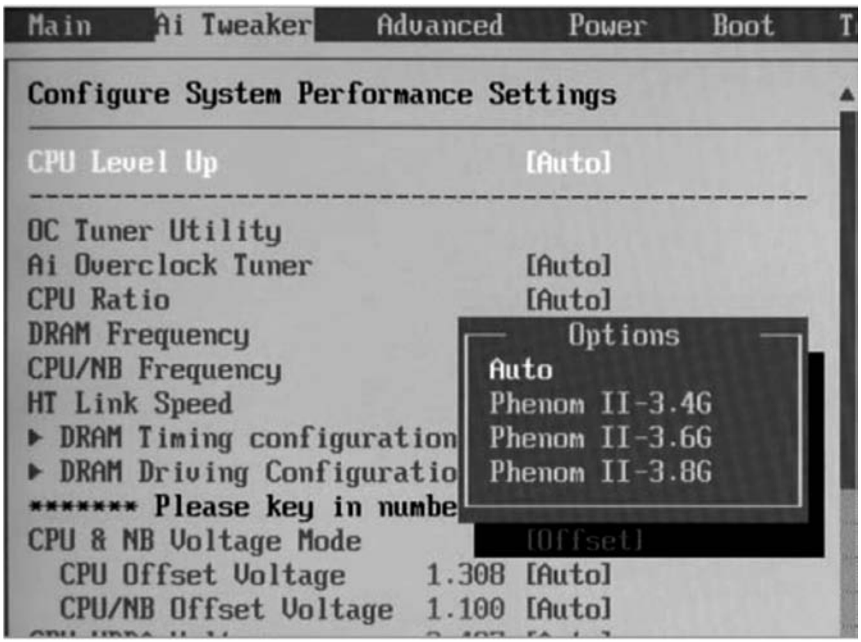


Figure 10.5 Selecting CPU frequency values from BIOS setup utility.

Automatic overclocking feature provided by certain motherboards help to overclock the CPU in an easy way. To use this method, first of all, the BIOS is opened and then CPU frequency parameter is to be chosen. The required speed is then selected from the preset values for the CPU frequency. The preset values ensure that the CPU and the motherboard run at optimal speed so as to maintain the system stability. As seen from Figure 10.5, three values are provided as preset values for *Phenom II* processor. Selecting a higher value makes the processor to run at increased value. In this way, the CPU can be overclocked.

Overclocking beyond an optimum value is not advisable. The extent of overclocking is decided by the capacity of the weakest component in the system. Overclocking of 10 % is the normal overclocking limit for RAM, motherboards and processors. Too much overclocking creates too much stress on the components. This produces a large amount of heat and results in overheating which finally leads to the reduction in the life of the components. Overheating forces the components to reduce their speeds. Instability and restarting the system are the ultimate effects of overheating. Accumulation of dust on computer components decreases their heat dissipation abilities, thereby causing overheating and hence, reducing their life span. Cleaning the accumulated dust from the components and providing enough air flow helps in the easy heat dissipation, thereby cooling the components. Use of the CPU and memory coolers having good quality also help in reducing the heat generated. The addition of more fans to the chassis helps in dissipating the generated heat, thereby preventing them from getting overheated. Using good thermal paste between the CPU and heat sink helps in easy conduction of heat to the heat sinks and thus, helps in the easy dissipation of heat. Using these different methods for heat dissipation helps in preventing the overheating of computer components in an overclocked system.

Most processors are made to perform beyond the cooling capabilities of the cabinets in which they are placed. This causes numerous problems because of overheating. For proper cooling, different types of heat sinks can be used. Some heat sinks have rubber pads below them to handle the heating. Over a period of time, these rubber layers melt away and make them ineffective and useless. At that time, it is necessary to replace the heat sink. For this, the top of the processor is cleaned with a clean and dry cloth. Isopropyl alcohol is commonly used for this purpose. Then, the heat sink compound is applied to the flat portion of the processor and it is spread out evenly. After this, the fan is attached on the top of the processor. The fan must be placed straight over the layer of the compound in a manner so that full contact is made on the surface of the processor. After this, the fan are fastened with the clips.

10.8 DIAGNOSING GENERAL PROBLEMS

The general problems associated with the computer systems can be identified and corrected easily by following a methodical approach. The computer systems can fail due to faults of more than one component. The following steps must be followed to diagnose the problem:

(a) The first step in the methodical approach of diagnosing the fault involves identifying all the possible subsystems and causes due to which the observed fault can happen.

(b) The second step in this approach is to examine each of the subsystem one by one and then isolating the working subsystem from the problem check list and finally identifying the faulty component. The idea of methodical approach can be made clearer with the help of an example. Consider a case in which the computer system does not provide any display when it is powered on. The possible causes for this fault are as follows:

1. No mains supply is given or it is faulty.
2. Monitor is not turned on.
3. Fault in the power cable.
4. Faulty power supply unit.
5. Cables are not plugged in properly.

6. Fault in the data cable connected to the monitor.
7. Faulty monitor.
8. Faulty RAM.
9. Incorrect configuration settings.
10. Software error.

Following a methodical approach, the first step is to check whether the mains supply is available or not. Further examining the other possible causes needs be done only if the mains supply is available. Proceeding through the series of these one by one makes it possible to examine each of the causes and finally, the main fault is identified and then corrected. It is to be stated that doing different troubleshooting methods without any methodical approaches leads to the complications in the entire process and thus, it makes the fault rectifying process to get prolonged indefinitely.

Analyzing error logs is an effective method of identifying faulty hardware components. An error log file is created during the POST operation. The POST error log contains three most recent error codes and messages that were generated during the POST. The system event or an error log contains messages that were generated during the POST and all system status messages. An idea of the fault can be obtained by viewing this log file. The system event/error log is limited in size. When the log is full, new entries do not overwrite the existing entries. Each system event/error log entry appears on its own page. To move from one entry to the next, the arrow keys are used.

Diagnostic applications are the primary methods of testing major components of the computers. When such applications are executed by the computer, text messages and error codes are displayed on the screen and these are saved in the test log. A diagnostic text message or error code indicates that a problem has occurred. If the diagnostic programs do not detect any hardware error and the problem still exists, then a software error may be suspected. A single problem can cause more than one error message. Correcting the cause of the first error message usually clears the other errors. If the problem still remains, it is necessary to replace the components.

Power problems can sometimes be difficult to solve. This is because a short circuit can exist anywhere on any of the power distribution buses. A short circuit causes the power subsystem to shut down because of an overcurrent condition. To diagnose a power problem, following steps can be used:

(a) First of all, the system is turned off and all the power cords are disconnected.
(b) Loose cables and short circuits in the power subsystem are to be checked.
(c) The adapters as well as the cables and power cords of all internal and external devices are disconnected.
(d) Now, the AC power cord is reconnected and the system is turned on. If the system starts successfully, then the adapters and devices are to be replaced (one at a time) until the problem is solved. If the system does not start from the minimum configuration, then the components in the minimum configuration are to be replaced (one at a time) until the problem is solved. If the problem still exists, then these components must be suspected in an order, i.e., system board, memory module and the processor. If the

problem is solved when an adapter is removed from the motherboard and it recurs after reinstalling the same adapter, then the adapter must be suspected. If the problem recurs after replacing the adapter with a different one, then the system board is to be suspected.

To test the Ethernet controller, it must be ensured that the correct device driver is installed. Also it must be checked that the Ethernet cable is installed correctly and is securely attached. If the cable is securely attached and the problem still remains, the cable may be faulty. Testing of the cable or replacing the cable is necessary in this situation. Checking the Ethernet controller LED helps in getting more details about the fault. LED indicator helps to test whether there is a problem with the connector, cable or the hub. The Ethernet link status LED is lit when the Ethernet controller receives a link pulse from the hub. If the LED is off, the fault may be because of a defective connector or cable or a problem with the hub. The Ethernet transmit/receive activity LED is lit when the Ethernet controller sends or receives data over the Ethernet network. If the Ethernet transmit/receive activity light is off, the hub and the network are to be checked whether they are in working condition and that the correct device drivers are installed. The checking for the causes of the problem related with the operating system is helpful to solve the problem. Ensuring that the device drivers on the client and server are using the same protocol is another helpful step in solving network faults. If there is a networking problem and the computer passes all the system tests, then a network cabling problem external to the system must be suspected.

If the diagnostic tests cannot diagnose the failure and if the system remains inoperative, the problem can be a software problem. Corrupt data in CMOS memory or damaged BIOS code can cause these undetermined problems. To reset the CMOS data, the CMOS memory is to be cleared. If the BIOS code is damaged, flashing the BIOS can update the BIOS configuration values.

10.9 COMPUTER SYSTEM: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the computer systems and the suggested solutions to rectify the defect are described in Table 10.4.

Table 10.4 Computer System: Common Problems and Suggested Solutions

Problem	Solution
The computer does not start when switched on.	Ensure that the power cord is firmly connected to the power input socket on the rear side of the computer as well as to the mains. Make sure that there is power supply in the electrical outlet. If the computer is having a secondary power on/off switch on the rear side, ensure that this switch is turned on.
The monitor screen is blank.	Verify that the monitor signal cable is securely attached to the connector on the rear side of the computer. Ensure that the power cord of the monitor is firmly plugged into the monitor as well as to the electrical outlet and the monitor is turned on. Also, ensure that the brightness and contrast controls of the monitor are set correctly.

Problem	Solution
The computer does not respond to the keyboard.	Verify that the keyboard is securely connected to the keyboard connector. Also, ensure that the monitor is turned on and its brightness and contrast controls are set correctly. Make sure that no keys are stuck down.
The computer does not respond to mouse.	Verify that the mouse is securely connected to the mouse connector. Also, ensure that the monitor is turned on and its brightness and contrast controls are set correctly.
The computer cannot load the operating system.	Ensure that the first booting device is configured as hard disk. Verify that there is no disk in the CD/DVD drive or in floppy drive.
The computer beeps multiple times before the starting of operating system.	Verify that no keys in the keyboard are stuck down.
The computer restarts during its working.	Check that all cables are connected securely to the system and attached devices. When the computer is turned on, make sure that the fan is working. If there is no airflow from the fan, it is not working. This can cause the overheating of the system and make the system shut down. Clean the components from dust and debris.
A device connected to a port is not working.	Make sure that the device is compatible with the computer, the port is enabled and is assigned a unique address. Also, check that the device is properly connected and the correct device driver is installed.
The number of ports that are identified by the operating system is less than the number of ports installed.	Make sure that each port is assigned a unique address in the Configuration/Setup utility and none of the ports is disabled.
USB device connected to the computer does not work.	Make sure that the correct USB driver is installed and the configuration options are set correctly. Also, ensure that the operating system supports USB devices.
Ethernet networking is not working.	The correct device driver for Ethernet card is to be installed. Check the Ethernet controller LED. If the LED is off, there may be a defective connector or cable or a problem with the hub. Ensure that the hub and the network are operating and that the correct device driver is installed. If networking is done using add-on card, ensure that the card is fixed firmly and the connections are made correctly.

10.10 PREVENTIVE MAINTENANCE

Periodic checking of the health of computer systems and doing preventive maintenance can keep the system away from the possible breakdown. To check the health of different computer components, several applications and utilities are available. Some of the applications are bundled alongwith the operating systems and are installed automatically while installing the operating system.

The computers and its peripheral devices need a normal operating temperature. Proper cooling of the computer system is essential to dissipate the heat generated by the circuit boards and the power supply. The heat speeds up the corrosion. The working of cooling fans must be checked periodically. The dust sticks to the circuit boards and dust clogs are made in the area of cooling fans. As the dust coating acts as a thermal insulator, so these must be cleaned periodically. The air vents must be cleaned from dust for the free flow of air inside the chassis. Compressed air can be used for blowing out the dust from the vents and circuit boards. When the system is not in use, it is advisable to use the dust covers so as to protect the entire system from dust. Different types of dust covers suitable for the monitor, mouse, keyboard, CPU case, etc. are available. Water and other liquids must be kept away from the system and these may not be allowed to spill on the keyboard, CPU or on the other components of the chassis.

After using the computer, it is not to be switched off directly, without making a proper shutting down. Shifting or moving the system from one place to another is not to be attempted when the system is in the switched 'on' state. Also, opening the cover of the system or other components when the computer is in switched on position must be avoided. Using mouse without a mouse pad is not advisable. Storage media such as CD or DVD must be kept away from heat, dust, humid surroundings, magnetic field, direct sunlight, etc. Use of the spike arresters protects the computers from power surges. Proper electrical grounding is to be ensured for the system always. Changing the BIOS settings can prevent the system from booting and this is not to be attempted without proper knowledge and understanding of the BIOS configuration.

During the working of computer systems, several temporary files are created and these remain in the system, thereby occupying too much hard disk space. Files downloaded from the internet, old and outdated files, demo applications also consume much hard disk space. For smooth working of the computer systems, the hard disk must be cleaned regularly. It can be done by using the operating system bundled tools or the third party utilities. Cleaning process must be done carefully because deletion of the system files can prevent the system from its normal working. While deleting the files, it must be ensured that the particular files are not needed for the proper working of the system. Regular scanning of disks for hardware errors and defragmentation are necessary to ensure that disks are working in good condition. Infection of computers by viruses, trojans or spyware affects the performance of the computer systems. Due to the infection, the bandwidth gets chocked and the performance of the computer is reduced. Installation of antivirus software and regular scanning of the system for viruses are necessary to protect the system from virus infection. Also, the antivirus must be updated regularly to protect the system from new viruses. Having a working firewall helps to keep the system free from virus and spyware.

10.11 REPLACING CMOS BATTERY

A coin cell type battery powers the real time clock and CMOS memory of the computer system. When the computer is switched on, the standby current from the power supply extends the life of the battery. When the voltage of the battery falls below a certain level, the BIOS setup program settings stored in CMOS RAM is lost. Under such condition, the battery is to be replaced with an equivalent one. If the replaced battery is not appropriate, then it may lead to the explosion.

Battery replacement is an easy task. To replace the CMOS battery, all peripheral devices connected to the computer are first turned off. The power cord of the computer is to be disconnected and the computer cover is then removed. After that, the button cell battery is located on the motherboard. Battery is placed in the battery holder, as shown in Figure 10.6. The orientation of the positive and negative polarities of the battery must be noted. The battery retention clip is pushed aside and the battery is removed from the connector. The flat edge of a screw driver can be used for this purpose. Now, the new battery is inserted in the connector with the positive and negative polarities in the correct orientation. After replacing the battery, the computer cover is fixed and then the system is switched on.

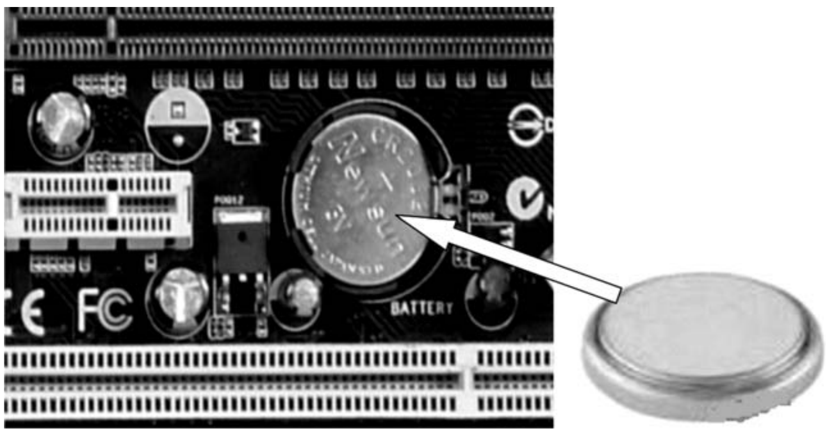


Figure 10.6 Replacing CMOS battery from the motherboard.

10.12 CLEARING BIOS PASSWORD

The BIOS setup utility helps to view and change the BIOS settings of the computer. BIOS setup program can be accessed by pressing the designated key in the keyboard, before the operating system begins to load. It is also possible to update the BIOS using the updating facility available with the BIOS utility. For this, the necessary update file is to be downloaded from the website of the motherboard manufacturer and then the updating process is made to run. By following the instructions displayed on the screen, it is possible to update the BIOS easily.

Configuration parameters in BIOS can be protected by setting suitable passwords by the users. Sometimes, it becomes necessary to clear the BIOS passwords. This becomes essential when the user forgets the password. Changing BIOS passwords is possible by clearing the contents of CMOS RAM. This clearing process clears the date, time and other system configuration parameters stored in the CMOS memory. Different methods are used by different motherboards for this. The first step for erasing CMOS memory is to turn off the computer and to unplug the power cord. After this, the computer cover is opened and the jumper is located on the motherboard for clearing the CMOS. It is located near the CMOS battery. Usually, the jumper cap on the motherboard is set in normal (in pins 1–2) mode for clearing the RAM, as shown in Figure 10.7. Now, the CMOS battery is removed carefully from the container. The configuration of the jumper block are changed to the configure mode (in pins 2–3). The cap is kept on pins 2–3 for about 5 to 10 seconds and then it is put back to pins 1–2. Now, the cover is fixed and the computer is switched on. Then, the computer is allowed to boot. After that, the BIOS setup options are opened. Different options can be selected and parameters can be set. Finally, the setup is saved and an exit is made so as to boot the system using the newly set parameters. Switching on the computer without the jumper cap in pins 1–2 causes the system boot failure.

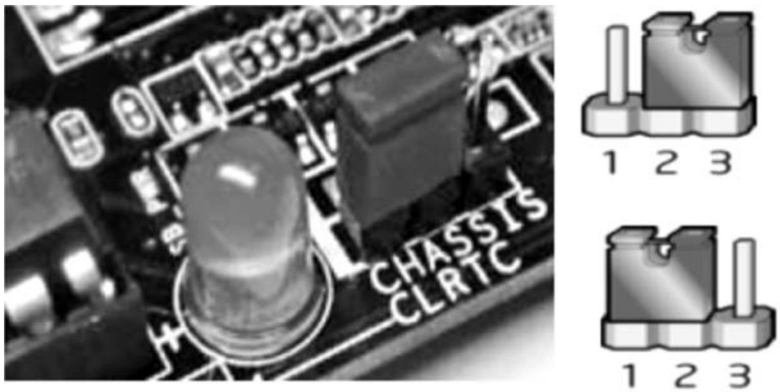


Figure 10.7 Position of jumper pins in motherboard and two positions of jumper pins.

In some motherboards, the password is to be cleared using the options available in the *Maintenance* menu in BIOS. In such motherboards, there is no need to remove the CMOS battery from its container. Here, first of all, the jumper caps are changed to pins 2–3 and then rebooting of the system is allowed. The computer boots and displays the setup options. Now, the *Maintenance* menu is to be selected from the list. Using the arrow keys *Clear Passwords* option is then selected. After that, the option is saved and an exit from the setup is made. This results in clearing the password. After this, the normal jumper position is restored by placing the jumper cap on pins 1–2 (normal mode). The cover is then fixed and the computer is turned on.

The new motherboards are jumperless. If the motherboard is not having the jumper, the BIOS RAM values can be reset to default by removing the CMOS battery. To clear the values, the computer is disconnected from the mains power supply. Now, the chassis cover is opened. After that, the button cell is located and then removed from the container. It is to be checked that any residual voltage holding the content of the BIOS memory is cleared by waiting for at least 10 minutes. Now, the battery is replaced and the system is then restarted. During the booting process, the BIOS values are opened and the system reconfiguration is done. This method does not usually work for notebooks, laptops and netbooks.

10.13 FLASHING BIOS

Flashing is a process of updating BIOS. It helps to increase the performance of the motherboard by increasing its stability. Flashing also provides support to the new hardware components. In some cases, flashing BIOS is recommended when certain bugs are identified by the manufacturer in the existing BIOS. Flashing the BIOS is risky and can be tedious. One wrong move can render the motherboard useless. It is necessary to ensure that there is no power failure during the time of flashing of the BIOS. Before flashing the BIOS, it is necessary to get the details of the current BIOS version used in the system. The details of the existing BIOS and its version are displayed on the screen during the booting time of the computer. From the details displayed and referring to the website of the manufacturer, it is possible to know whether any updating of the BIOS is required for the existing BIOS or not.

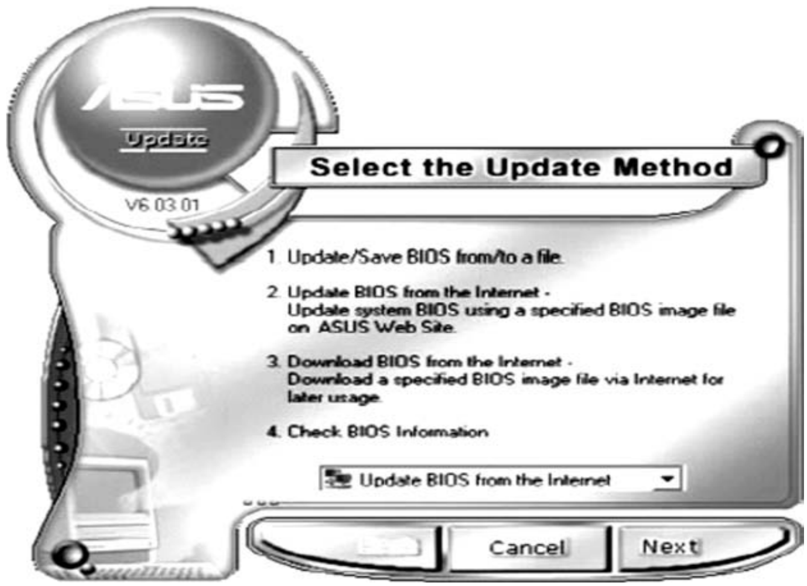


Figure 10.8 BIOS Flashing process—Opening window.

Different methods are used to update the BIOS. One method is the use of automatic BIOS updater software provided in the driver CD. This software searches for BIOS updates and automatically installs the latest ones. A BIOS flashing utility for flashing can also be found on the driver CD and this can be used for flashing the BIOS. The updated and the latest BIOS are usually available in the website of the manufacturer. The list of the new features available is also provided in the website. The details can be downloaded alongwith the utility for flashing BIOS. The utility can be executed. In the new motherboards, the facility for BIOS flash is available in the BIOS itself. In such cases, the downloaded BIOS is burned into a blank CD or DVD or is copied to a USB flash drive. The CD or DVD is inserted into the optical drive or the flash drive is plugged to the drive and the machine is switched on. Moving to the BIOS setup utility, the flash utility is launched that specify the location where the BIOS file is located. This step initiates the flashing process. The opening window of the flashing utility is shown in Figure 10.8.

The desired updating method is first selected from the displayed list and the *Next* button is clicked to proceed. In the next window, the nearest FTP site is selected for downloading the files and then the next screen comes. The BIOS version is then selected and the download button is clicked for downloading the files. To finish the update process, the instructions are to be followed. It is very important to note that motherboards become useless if the flashing process is interrupted.

ADVICE FROM THE EXPERT

Some of the common problems of the computers and their suggested solutions are discussed earlier in brief. But in some cases, it is worth to have an advice from the expert. In this section, detailed solutions are given by the experts for certain common computer problems.

Computer restarts during its working

There are several reasons for this type of behaviour. Some are related to hardware issues and some others are connected to the software problems. The connection to mains power supply may be loose and this is to be checked first. It must be ensured that the power from the UPS is clean without any spikes or voltage errors. Also, the working of the UPS or voltage stabilizer connected to the computer is to be checked. Another reason for the system turning off completely on its own is due to the problem in the SMPS unit. The SMPS unit may be dusty leading to its overheating, thereby turning the system off. An air blower is to be used to clean the dust from the inner side of chassis. The problem may also occur if the SMPS unit is weak or under rated. The power supply unit can be tested by replacing it with a good one. Shutting down of the system may also be due to the heating of the processor or the motherboard chipset above the normal temperature. It must be ensured that the processor fan is properly working, the air vents are not blocked by dust and the cooling fan is spinning at the correct speed. Also, it is to be made sure that the heat sink fitted to the chipset is not overheated. All the air vents, heat sink and the other hardware components such as motherboard, RAM, graphics card, etc. must be cleaned. Some of the cards may be loosely fitted. It is to be ensured that the cards are firmly fitted in their slots. All the cables and connectors are checked for the loose connections. A fresh coat of heat sink paste is applied between the processor and the heat sink and the fan assembly is clamped properly and firmly on the processor. The path of air inside the chassis should not be blocked by the cables and other offenders. The hard drive may have file allocation errors or bad sectors. The hard drive is checked for the errors and it is repaired if any error occurs. If the problems still exists after all these activities, it is necessary to check the motherboard. Motherboard faults can also restart the system during the midst of the computer working. Moisture conditions can dampen the inside of the computers and can develop corrosive and short circuiting effects. To remove the moisture, enough silica gel is placed inside the computer cabinet. The silica gel absorbs the moisture and makes the inside of the computer system dry.

Action of certain viruses can also result in restarting of the system. Cleaning the system from viruses solves this problem. Using updated antivirus and antispyware tools to scan and clean the system helps in removing the infected viruses. Missing of one or more files required by the operating system may cause the system to restart. Repairing or reinstallation of the operating system files help in solving the problem. Outdated device drivers and essential patches for the operating system can be the other reasons for this type of behaviour. Using the latest device drivers helps in solving the issue.

Computer takes a long time to start up, shut down or to do anything.

There are several reasons for the slow start up. One reason is that some of the applications that work on the background take a long time to be started up during the booting stage and to be closed at the shutting down time. To avoid this, the device drivers should be up to date and should not be corrupted. The system is cleaned from the viruses and spyware using suitable tools. Also, the drives are defragmented. Some of the startup programs are not necessary for the proper working of the computer system. But these programs try to load automatically during the startup time of the computer. Removing the unwanted startup applications can make the computer to boot at a faster speed. Also, any unwanted scheduled tasks that are affecting the working of the system are to be removed.

Computer becomes non-responsive during its working.

There are several reasons for this type of behaviour. This may be due to a software fault or a fault of the hardware. For this, the number lock button is pressed. If the button works, the fault is due to software. Rebooting of the system solves this problem. Another reason for the slow speed is the presence of spyware or virus in the system. Suitable tools are to be used to clean the system from virus or spyware. Formatting the hard disk and reinstallation of the software can make the system work speedy. Different hardware faults can also make the system stop working. One of the hardware faults is the difficulty in accessing the hard disk. A cable fault or the existence of bad sectors in the hard disk can make the system slow in its working. The hardware faults are to be identified using different diagnosing methods and then rectified for proper working of the system.

Computer has become very noisy during its working.

The noise from computers is created from cooling fans of the system. Cooling fans are attached with the processors, graphic cards and power supply unit. These fans help in the easy dissipation of heat produced in the system. The more heat generated makes the fans to rotate at higher speed making a louder noise. Laptops consume less power and hence, they dissipate less heat. So, only less cooling is required for them and due to this reason, the laptops are quieter in operation. Fans of different sizes are available. Large-sized fans have higher capacity and hence, lesser rotation is required to dissipate the developed heat, as compared to the small-sized fans. Also, the large-sized fans have quieter operations. Removing the dust deposits from the fans as well as oiling and greasing of the motor mechanism help in reducing the generated noise. Another way of making cooling more effective is the use of efficient heat sinks fitted to the heat dissipating components of the system. Any type of blocking of air vents makes it difficult to cool the inside components. This makes the fans to rotate at higher speed, thereby increasing the noise. Cleaning air vents regularly makes air circulation more efficient. This also makes cooling more effective and hence, the noise level can be brought down. A small noise is also created during the read/write operations of the hard disks. The new computers make use of hard disks made up of solid-state devices which do not have any moving parts. So, such types of hard disks do not produce any noise during their operations.

USB device is not recognized by the computer.

There are several reasons for this type of fault. The operating system may not be recognizing the USB port. Older versions of the operating systems do not support the USB ports. In Windows versions, updating the USB driver can solve the problem. For this, the *My Computer* icon is right clicked and *Properties* is selected. After that *Hardware* tab is selected and then the option *Device Manager* is chosen. This opens a window displaying the details of the hardware components, as shown in Figure 10.9. A question mark on the left of the device indicates that no driver is installed. Right clicking the device displays a window and the option for updating the driver can be selected and can be proceeded to install the driver.

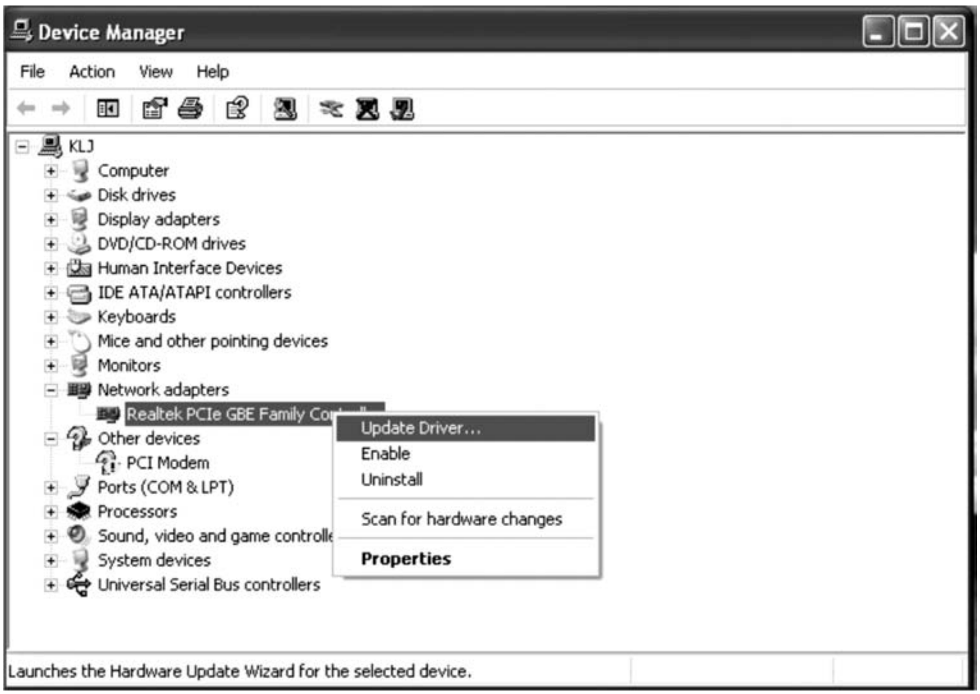


Figure 10.9 Updating device driver.

Computer displays a message stating that hard disk does not exist. Also the date and time displayed by the system is wrong.

This is an indication of dying CMOS battery. All the configuration settings are stored in the computer memory using CMOS battery. The issue can be solved by replacing the weak battery with a new one. For this, the values set for the different BIOS parameters are first noted and then the system is turned off. Now, the case of the cabinet is opened to locate the CMOS battery on the motherboard. Current computer systems use lithium/manganese dioxide battery that looks like a large watch battery. The battery is replaced with a new one. After that, the case is closed and the machine is restarted. Now, the setup parameters are typed and then saved in the BIOS. The changes made take the effect and the system starts normally.

Hard disk drive is not detected during the starting of computer on several occasions.

There are several reasons for this type of behaviour. This can be an indication of the failure of the hard disk. First of all, it is ensured that the hard disk is working properly. The formation of any bad sector in the hard disk is also checked. A loose connection in the data cable or power cable can cause the above error. So, the dirty sockets and connectors are cleaned and then the cables are connected firmly. Problems with the motherboard or a weak power supply unit can cause the above type of error.

Long beeps are arising during the booting of the computer.

Presence of long beeps during the starting time is an indication of faulty RAM modules. To correct the fault, as a first step, the RAM module is removed, the edge connector is cleaned. Now, it is inserted again in its slot and the system is rebooted. If the RAM module is completely dead, then no beep sound can be heard. In such case, the RAM module is to be replaced with another module.

Computer display turning illegible and getting transformed into gibberish.

This is a hardware related problem. The problem can be due to a failing memory. The condition of memory is checked. If the memory is good, the problem may be with the memory slots in the motherboard.

Computer switching off during working, after adding a new graphics card.

Inadequate power supply capacity is the reason for this new development. The power rating of the power supply unit is not sufficient to handle the power requirements of the newly added graphics card as well as the hard disk. Replacing the power supply unit with a high rated power supply unit solves the problem.

Computer fails to start in the morning.

There are several reasons for this type of fault. One of the reasons is the faulty or loose RAM slot. So, it is checked. Also, the connecting edge of the memory should not be corroded. In some cases, the power LED indicator appears lit but the system does not start. This can be due to a faulty power system. Absence of the correct voltage level also creates such a situation. So, the SMPS output voltages on different rails are checked using a multimeter. The SMPS unit is replaced, if required and then the system is checked.

Computer displays a checksum error during booting.

This is an error caused due to the failure of the CMOS battery on the motherboard. The CMOS battery cannot store the configuration settings in the BIOS. Replacing the battery, setting configurations and saving the configurations in the BIOS solve this error. If the problem still exists, it is necessary to replace the motherboard.

External USB hard disk that works in a desktop computer is not working when connected to the laptop.

First of all, it must be ensured that the USB port is properly configured and the power management option is properly set. One of the reasons may be that the USB hard disk may not be getting sufficient power when connected to the laptop. If the drive is having an additional power cable, then it may be used for the power connection.

It is necessary to view the list of applications that are set to run when the Windows operating system starts.

There are several places where this information is stored. Using the *msconfig* utility, the list can be obtained. The *Start* button is clicked and *Run* is selected. Now, *msconfig* is to be typed in the textbox and the enter key is pressed. After that, the *Startup* tab is clicked to view the full list of applications that are automatically started when the system boots. These startup programs consume memory and other resources. To stop any program from loading during starting, the box with the tick mark are clicked so as to make the mark disappeared. Now, the computer is restarted for the changes to bring into effect.

Steps for creating an autorun CD or DVD

Sometimes, it is necessary to create a CD or DVD with autorun feature. For creating an autorun CD or DVD, there must be a file named *autorun.ini* in the top folder. The file must have the following commands:

[*autorun*]
icon = test.ico
open = test.exe

The command *test.exe* is replaced with the name and location of the file that is to be executed when the CD is inserted into the drive. The file *test.ico* is the icon file that is to be used for the CD. When this type of CD is inserted into the drive, the file is automatically started. This feature is known as *autoplay*. To temporarily suspend this feature, the *Shift* key is pressed while inserting the CD in the drive and then the key is released when the light on the drive stops flashing.

Display of a message stating the presence of bad sectors in the hard disk during surface scanning of the hard disk.

A hard disk is a mechanical component and is liable to wear and tear during the operation. A bad sector is a portion of the surface of the hard disk that can no longer be used for storing data. This is an indication that the disk is demanding the replacement. All the required data in the hard disk is to be backed up. A bad sector in a new hard disk means a faulty product.

Data recovery from a CD or DVD which displayed a CRC error or which cannot read from the specified location, during the copying process.

For copying files from the CD or DVD, as the first step, the dust is cleared from the medium and the drive using a soft cloth. If there are stains on the surface of the medium, then the surface is washed using plain water or mild detergent. The disc must be dried before inserting it to the drive again. Trying to read from another disc of the same make and capacity before using the particular disc can provide better results. Softwares are available for downloading that can continuously read from the disc or to skip the damaged sectors and these softwares can be used for getting better results.

Failure of optical drives to read from the disc.

The optical drive cannot read the files, if the lens in the mechanism is dead or misaligned. Cleaning the disc using a lens cleaner can solve the problem. Manual cleaning of the disc drive can also be attempted using a cotton cloth piece dipped in a little isopropyl alcohol. If the problem still exists, it is necessary to replace the lens or the disc drive.

A program stops while working and an error message appears on the screen.

There are several reasons for this fault. The program might have crashed or might be performing some complex tasks. This can happen when the computer has not enough power to run the application, especially in the computers using less powerful processors.

Computer does not boot and it is stating the disc error or no disc.

The error is displayed because the computer cannot read from the disc from which the operating system files are to be loaded. It can also be happened due to some hardware faults, corrupt operating system files or an improper BIOS configuration. Switching off the system for few minutes and starting again may correct the fault.

Computer monitor displays no signal error.

The error message appears on the screen if there is no signal coming from the computer. It must be ensured that the data cable is correctly and firmly plugged into the port. The message can also appear if the monitor refresh rate is set to a high value. So, the refresh rate settings of the monitor are to be changed to a lower value.

DVD writer keeps ejecting the DVD from the drive.

The basic reason for this type of behaviour is that the DVD writer cannot identify any file in the DVD and there is difficulty in reading files from the DVD. Dirt getting deposited on the lens makes the reading of the media difficult. Cleaning the lens using a cleaner can solve the problem. Also, due to prolonged use, the laser head deteriorates its power and this causes difficulty in read operation. In such cases, replacement of the DVD writer is preferred.

There is no display appearing on the projector when the laptop is connected to an LCD projector.

LCD projectors and other computer monitors are treated as secondary display devices by laptops. Secondary display devices are to be enabled through different configuration steps to get display in the projector as well as in the other computer monitors.

During the midst of working, the computer monitor displays a blue screen with a message like Beginning dump of physical memory.

The blue screen appearing during the midst of working is commonly known as **Windows Blue Screen of Death**. This is a critical error and the error can be due to one or more reasons such as the corruption of data in RAM, incorrect settings in the BIOS, errors in hard disks, etc. All the components are to be checked while troubleshooting the problem. The RAM is checked and it must be ensured that the module is working in good condition. The default BIOS settings are loaded and the system is restarted to check the BIOS settings. Also, the hard disk is checked for any bad sector.

A large number of *CHK* files are seen in the root directory of Windows system.

This type of file is created when the Windows-based computer systems are not switched off in the proper manner. These files can be safely deleted. The system must be shut down properly through the interface.

11

Laptops
Troubleshooting and Maintenance

Due to portability and other features, the use of laptops has increased very much. There is some difference in the installation of the hardware components and their maintenance between the desktop systems and the laptops. Hence, the laptops need special attention for their maintenance and troubleshooting. The installation and common troubleshooting steps used for laptop systems as well as the common maintenance operations used for their proper working are discussed in this chapter.

11.1 FEATURES OF LAPTOPS

The smaller size of the laptops is aimed to increase their mobility. Their small size also helps in power conservation, since smaller components require less power. The desktop systems use separate keyboard and mouse while the laptops are having integrated keyboard and mouse. However external mouse and keyboard can also be connected to the laptop ports. Processor chips used with the laptops operate on low voltages and are having less clock speeds. Due to this feature, the heat dissipation in the laptop computers is also less. The fan and heat sink used with the laptops are thin and are small in size to suit the size of the laptop. The processors used in the laptops are having small pins and are plugged into small processor sockets in the motherboards. Due to this, changing the processor chip is difficult. In laptops, processors are seen fitted near the side of the motherboard. This feature enables in the easy heat dissipation.

Similar to the desktop systems, memory forms the workspace for laptops. Different types of memories are used for the laptops. The memory used in the laptop systems is small in size. Commonly used memory types for laptops are *Small Outline DIMM* (*SODIMM*), *Dual Data Rate Synchronous Dynamic RAM* (*DDR SDRAM*) and *Single Data RAM*. Laptops use small-sized hard disks as the storage devices. These hard disks have slow speed and less power consumption. Laptops have a single bay for connecting optical drive. The drives used with laptops can be hot swappable, warm swappable or cold swappable types. Hot swappable type helps in the removal and insertion of the drives without shutting down the system. Warm swappable type also helps in the removal and insertion of the drives without shutting down the system but there is a small delay exists in the starting of the operation. Cold swappable type devices can be removed and replaced only after shutting down the system. A rebooting of the system is necessary to start the operation of the attached devices.

Laptops use special graphics processing units. These are either integrated with the motherboard or are added as add-on cards. LCD technology is the display type used with the laptops. Usually, the display size is kept to the minimum size to suit the small size of the laptops. Active matrix LCD displays provide a better viewing experience as compared to the passive matrix display. The reflective and backlit lighting technologies are used for LCD fabrication. The backlit technology helps in operating laptops in low light environment. While working with the integrated mouse, cursor control is achieved by using the track ball, track point or the touch pad. These facilities perform the functions of mouse connected to the desktop systems.

Laptops are also having different input/output ports. Serial, parallel, networking, USB, PS/2, audio, firewire ports are the common ports available in laptops. Infrared (IR) port, monitor port, A/V port are also available in certain laptop models. Most of these ports can be seen on the left panel. Optical drive is fitted on the right side. Jacks for headphone and microphone and built-in speakers are available on the front side. Special keys for audio volume control, power status indicator and OneKey Rescue System are common in laptops. In the expansion slots available in the motherboard, add-on cards can be inserted. Batteries form the primary power supply unit of the laptops. In earlier times, nickel-cadmium and nickel metal batteries were used. These were less efficient with short lifespan. Currently, lithium ion batteries are used with the laptops. These are efficient and have long life. These are light weight types and there are no overvoltage and overheating problems with these types of batteries. Integrated camera for video communications, built-in antennae for wireless radio, built-in microphones

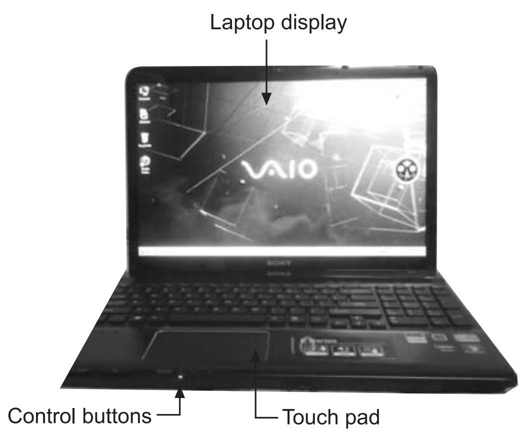


Figure 11.1 Components of a laptop.

are the other common features available with the new laptop computers. Kensington slot for attaching security lock, HDMI port for connecting HDMI devices such as TV, memory card slot are also available in certain laptop models. The major components of a typical laptop are shown in Figure 11.1, for a quick refreshing of memory.

The feature for backing up data and restoration is commonly available in several laptops. In order to make use of this facility, the hard disk is provided with a hidden partition by default to store the system image file and to restore the program files. If this feature is available, the displayed hard disk size of the laptops appears to be less than its actual size, as the hidden partition is excluded. The available hard disk size is dependent on the image file size and the size of the application. The backing up and restoration processes can be done easily by clicking on the suitable icons displayed. If the operating system cannot be loaded, the OneKey Rescue System can be used for restoring the system. If the operating system fails, the first step is to shut down the laptop. In the next step, the OneKey Rescue System key is pressed. This step initiates the restoration process. Instead of backing up on the hard disk partition, the backup can be taken in the other storage devices also. Restoration can be done from the backup created.

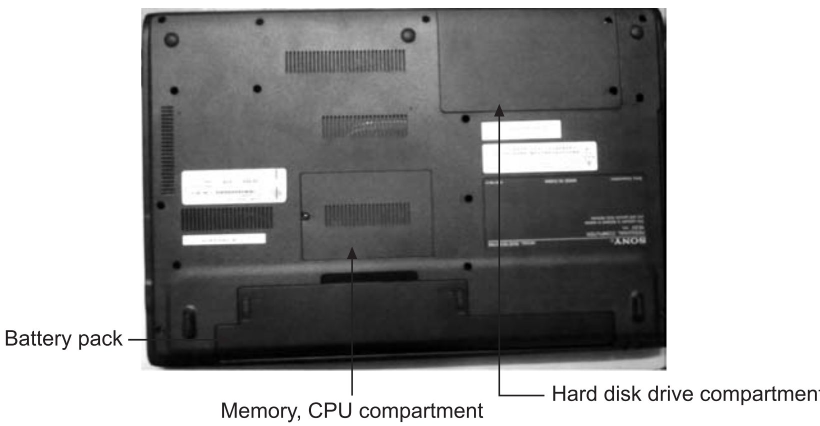


Figure 11.2 Bottom view of laptop.

The bottom view of a laptop computer is shown in Figure 11.2 in which the positions of different components necessary for the laptop are indicated. All the components that are required for the working of the laptop are fixed to the respective positions by opening the compartment windows. Depending on the model selected, the layout of components can vary.

11.2 USING LAPTOPS

For new laptops, the battery pack is supplied as a separate unit. Also, the battery is not fully charged. To start using the laptop, as the first step, the battery pack is inserted in the laptop. After inserting the battery to the slot, the next step is to connect the battery charger to the laptop. The picture of a typical laptop battery and battery charger can be seen in Figure 11.3. The output of battery charger is connected to the power jack of the laptop. The charger is then connected to the mains supply. Now, the mains power switch is turned on and then the power button of the laptop is switched on.

Figure 11.3 Laptop battery and battery charger.

The battery is automatically charged when the power is switched on. Charging time depends on the usage conditions. Indicators for low battery charge conditions are provided by some operating systems. In certain cases, some initial configurations settings are to be done for the proper working of the system. The ability to change to sleep mode is a salient feature of the laptops. This is useful when the laptop is not used for some time. Hard disks stop spinning when the laptop is changed to the sleep mode. When it is required to move the laptops, changing to the sleep mode is helpful in protecting the hard disks from possible damages. The laptop can be returned to its working state by pressing any key on the keyboard.

Instead of the mouse, touch pad is used in the laptops to move the cursor on the screen. The movement of the cursor is achieved by sliding the finger tips over the pad in the direction in which the cursor is to be moved. Left click button and right click button perform the same functions as that of a conventional computer mouse. The arrangement of the touch pad is shown in Figure 11.4.

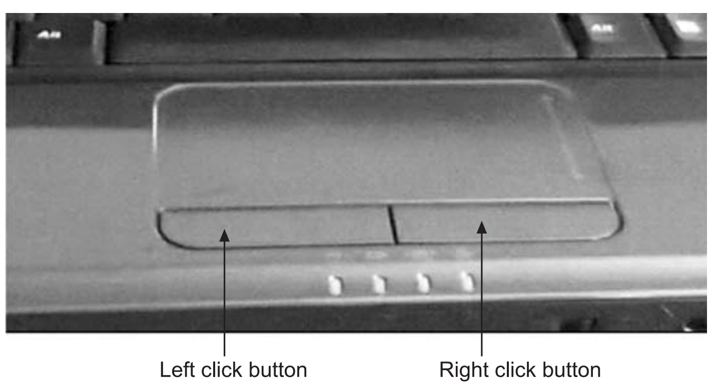


Figure 11.4 Touch pad buttons.

11.3 REPLACING LAPTOP BATTERY

Sometimes, it becomes necessary to replace the laptop battery. To replace the battery, first of all, the laptop is turned off. The battery charger as well as all the cables connected to the laptop are removed. The display is then closed and the laptop is turned upside down. Now, the battery pack compartment is located. The battery is held firmly in its position with the help of a battery latch. So, the battery latch is unlocked. Keeping the spring locked battery latch in the unlocked position, the battery pack is removed in the direction of the arrow, as indicated in Figure 11.5. After removing the battery, a fully charged battery is installed. After that, the latch is slided to the locked position. This completes the battery installation. Now, the laptop is turned over again. The battery charger and the cables are connected and the laptop is switched on.

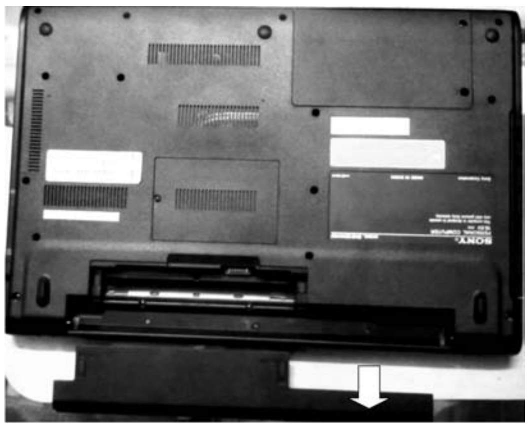


Figure 11.5 Removing laptop battery pack.

11.4 DISMANTLING LAPTOPS

A complete dismantling of the laptops is required only when there is problem with the system board. The actual dismantling process varies with different models. Typical steps for dismantling a laptop are stated below:

(a) Before start dismantling laptops, the attached power cord, battery charger and all the other devices connected to the laptop are disconnected. A small plastic panel fastened by screws is available on the base of the laptop. Using appropriate screwdriver, the screws can be removed and can be detached from the panel to expose the compartment in which the core components such as memory, heat sink and hard drive are located.
(b) As a next step, all the data cables are detached from the headers on the motherboard.
(c) After this, the screen is lowered and the laptop is flipped upside down and all the screws securing the upper and lower panels are removed.
(d) After removing all the screws, the two halves are separated carefully by using a flat screwdriver edge. The panels may not separate completely as the ribbon cables for the touch pad, LEDs and speakers are still connected to the motherboard.

(e) Now, the cables are also disconnected. The components are now visible, as shown in Figure 11.6.
(f) Each component is now disconnected and removed without any damage.

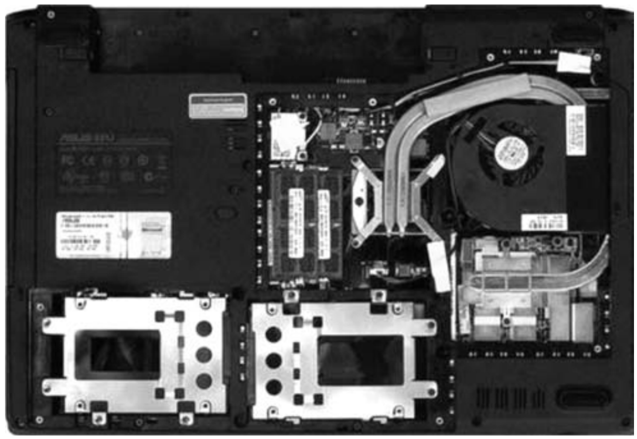


Figure 11.6 Laptop-Internal arrangement.

(g) The next step is to pull apart the laptop screen. For this, the data cable is detached from the header.
(h) The screws, clamps or latches that hold the screen in its position are then located.
(i) The latches and hinges are removed and the screen is separated from the body.

LCD screens require backlight unit for display which consists of cold compact fluorescent lamp (CCFL) and a lamp inverter circuit. The major reason for the failure of display in the LCD monitor is the failure of the backlight system. The power supply unit of LCD is integrated with the motherboard. In certain motherboards, this can be seen as an add-on card. While dismantling, proper care must be taken, since the components can get damaged easily. Only trained personnel need to attempt the dismantling operation.

Some of the internal components such as hard disk, memory and optical drive can fail. Many laptops arrange the internal components in separate slots such that the damaged component can be replaced by opening that particular slot only.

11.5 REPLACING HARD DISK DRIVE

Replacing the laptop hard disk is necessary to increase the storage capacity or when the hard drive becomes faulty. The bay and the connections of the hard disk are not designed in a way so as to make frequent changes in them. Hence, proper care must be taken while replacing the hard drive. Dropping the drive or applying too much pressure on it can damage it. Removing the hard drive while the laptop is in operating condition is to be avoided. Incorrect handling of the hard drive can lead to the permanent damage and hence, the data stored in it can be lost. The static electricity present in human body can damage the components. Touching a metal or grounded object helps in reducing the static electricity present in the body. The process is similar to the steps used for the desktop systems as discussed earlier.

To replace the hard disk drive, following steps are to be taken:

(a) As the first step, the laptop is turned of and all the connecting cables and battery pack are disconnected.
(b) The display is closed and the laptop is turned upside down.
(c) Now, the screws securing the slot cover are removed.
(d) After this, the cover of the hard drive compartment is removed.
(e) Usually, the components are securely fixed in their slots using tabs. So, the tab is pulled out, if any and the component is removed from the slot.
(f) Hard disk is usually fixed on a metal frame, as shown in Figure 11.7. The hard drive is detached from the metal frame.

Figure 11.7 Laptop hard drive in the compartment and hard drive taken out.

(g) A new hard drive which is of identical type can be fitted on the metal frame using screws.
(h) After this, the hard drive is put in the bay in correct orientation.
(i) The hard drive is then firmly pushed in its position.
(j) The compartment cover is closed and the battery pack is installed.
(k) The battery charger is connected and the laptop is switched on.

11.6 REPLACING MEMORY

The memory capacity of the laptops can be increased by installing double data rate Small Outline Dual In-line Memory Module (SO-DIMM) in free slots. Necessary precautions to protect the system from static electricity must be taken before attempting to make any repair.

To replace the memory, following steps are to be taken:

(a) First of all, the laptop is turned off and all the connecting cables are disconnected.
(b) The display is closed and the laptop is turned upside down.

(c) The battery pack and the screws that secure the memory compartment are removed.
(d) After this step, the cover of the compartment is removed making the memory visible.
(e) The memory module is held in its position with the help of latches at both ends of the memory slot. So, the latches are pressed out at both the ends. This removes the memory module from the slot.
(f) Now, the module is taken out slowly. It is shown in Figure 11.8.

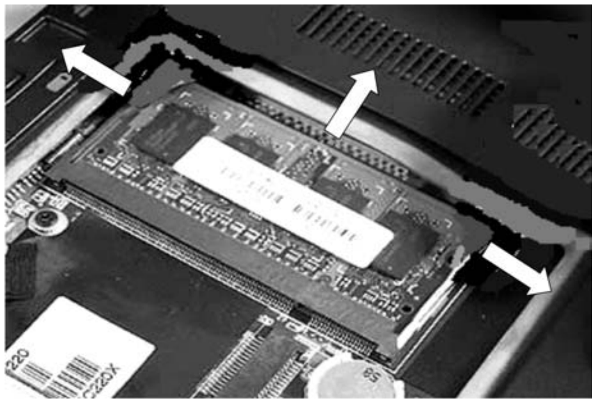


Figure 11.8 Removing memory from the memory slot.

(g) To insert a new memory module, the module is inserted with the connector ends facing towards the slot. It is to ensured that the end latches in the slot are kept wide apart.
(h) The module is firmly pressed in the slot until it snatches in the place.
(i) Now, the compartments are closed and the battery pack is installed.
(j) The battery charger is connected and the laptop is turned on.
(k) To ensure that the memory is correctly installed, the total memory is checked using the BIOS setup utility.

11.7 REPLACING OPTICAL DRIVE

The optical drive is fitted using screws on the laptop chassis frame. To replace the optical drive, following steps must be taken:

(a) As the first step, the laptop is turned off and all the connecting cables are disconnected.
(b) The display is closed and the laptop is turned upside down.
(c) The battery pack and the screws that secure the memory compartment are removed.
(d) After this, the cover of the compartment is removed making the screw holding the optical drive visible.
(e) Using a screw driver, the screw is removed and the optical drive is pulled out from the bay gently, as shown in Figure 11.9.
(f) Optical drive can be fitted to the bay by doing the tasks in the reverse order.

Figure 11.9 Pulling out the optical drive from the bay with the optical drive taken out.

11.8 LAPTOP: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the laptops and the suggested solutions are given in Table 11.1.

Table 11.1 Laptop: Common Problems and Solutions

Problem	Solution
Nothing is displayed on the display.	Make sure that the battery is connected properly and is working. Also, make sure that the laptop is powered on. Ensure that the memory is correctly installed and is working.
Only a cursor is displayed on the screen.	Restore the backed up files to the original settings using the recovery process.
Nothing is visible on the lower portion of the laptop display.	This can be due to loose connection in the data circuit or in the interfaces. Remove the interfaces and connect the cable firmly.
Flicker in the display while viewing full screen display.	This error may be due to low video memory. Increasing the video memory can solve the problem.
The screen appears dark.	This error is due to backlight display problem. Check the backlight unit.
The screen displays only white colour.	This may be due to error in the panel.
Laptop takes a long time to start. Also, the system switches on and off frequently.	The error is due to a fault in the power supply unit. Check the power supply unit. Overheating of the components is another reason for this fault. Clean the internal components. Make sure that the cooling fans are working properly and the air vents are not blocked.
Colour error in the display.	This error can be due to the panel voltage error. Check the circuit for hardware errors and replace the faulty components.

Problem	Solution
Laptop battery is getting charged normally and the system is working. But the battery charge indicator on the laptop keeps blinking orange instead of blue.	The blinking LED means that the battery is to be checked and possibly be replaced. Before that, take the battery out and check that its terminals and those in the battery compartment are properly cleaned and do not have any dirt or corrosion on them. Also, check whether the battery life has degraded considerably. Usually, a good battery gives around 3 to 4 hours of battery life depending on the model of the laptop and the usage. If the life of the battery is much less, then it is necessary to replace the battery.
Resetting the BIOS password of laptops.	To reset the password of the laptop BIOS, it is necessary to reset the CMOS settings, as in the case of desktop systems. To reset the CMOS, open the laptop and locate the CMOS battery and disconnect or remove it completely. Replace the battery back after waiting for around 20 to 30 minutes. This step resets the CMOS settings completely including the password. The position of CMOS battery varies with different models of the laptop.
The laptop is getting restarted often.	Restarting of the laptops is due to several reasons. There is a possibility of the fan slowing down due to a manufacturing defect or dust clogging which can cause the processor to overheat, thereby restarting the laptop. A damaged CPU fan mounting plate or broken latches can overheat the CPU. Ensure that the plate is intact and has no cracks or broken latches. Also, check whether the mounting plate screws are properly tightened to the motherboard. If the processor fan is not mounted properly or if there is minimal or no contact between the processor surface and the cooler, transfer of heat does not take place properly which results in overheating of the processor and hence, the system restarts. Also, make sure that sufficient layer of CPU coolant paste is added between the processor and the fan. The number of intake and exhaust fans installed should be more, for effective cooling.
Backup process fails.	Make sure that there is enough space in the partition used for backing up files.
A number appears when a letter is typed on the keyboard.	This can happen if the numeric key lock is in 'ON' state. Disable this feature.
DVD takes a long time to write to DVD.	This problem can be due to either a weak or dirty lens. Use an optical lens cleaner to clean the medium. This will solve the problem. Also, inspect the medium and make sure that the surface is not contaminated with dust.

Problem	Solution
No sound is heard from speakers.	Make sure that the mute function is off. Also, ensure that the volume is not set to low.
External device connected is not working.	Make sure that the necessary device driver files are installed and the device is configured properly. Ensure that the system is powered on and is working.

11.9 TROUBLESHOOTING AND MAINTENANCE OF LAPTOPS

Laptops are having the same components as that of the desktop systems. But the components of laptops are smaller than the desktops and hence, these can be damaged easily. Also, there are chances of getting scratches on the surface of laptops. So, it is necessary to be very careful while working on the laptop systems. It is not advisable to use laptop systems in the humid environment. Using laptops during the time of lightning storm can damage the computer. In order to avoid overheating of the inside components, it is necessary to provide enough ventilation. Also, the laptop should be kept away from magnets, activated cellular phones, electrical appliances, speakers, etc. Turning the display beyond 130 degrees should be avoided. The laptop must be carried safely. The different media are to be handled safely. The device should be switched off while connecting the external devices.

Laptops are powered by a battery pack. The battery charger consists of an electronic circuit and is used for charging the internal battery of the laptop. Laptop charger receives 230 V AC and converts it into DC so as to charge the internal battery. Rechargeable lithium ion batteries, which are designed for long life operation, are used with the laptops. Internal battery is the primary source of power for the laptop systems. Special electronic circuits are available in the charger which provide enough overvoltage, deep discharging and overheating protection. The entire unit is enclosed in special enclosures. An unsuitable power supply may damage the computer. Hence, the power cord, power adapter and the battery pack supplied with the system are to be used for the system only. Charging of the battery is to be done when the battery charge falls to a low level. This is usually indicated by the battery status indicator.

Sometimes, laptops may become faulty. If the laptop is not working, first of all, it must be ensured that the electric power is available. If there is no power incoming, it may be due to a problem with the battery or with the connecting cables. The power cable and the connector connected between the charger and the laptop are checked and it is ensured that the different cables are connected firmly and correctly. The cables are replaced with the new cables, if required and the system is tested. The battery power and output voltage are also checked. If the battery is not suitable, it is to be replaced with a new one and then it is checked again. If the laptop works after doing these steps, the problem may be with the battery charger. So, the charger must be checked for faults. The damageable components of the charger include fuse unit, surge corrector, capacitors, etc. Opening the battery charger or power adapter is dangerous. This may be attempted by trained personnel only. After opening the cover, the circuit is closely observed for any burned component or damaged capacitor or broken part. Replacing the damaged components makes the charger working. Also, the soldering done on the inverter transformer should be firm at all the terminals.

If the battery charger output is correct and the laptop is not working, the fault may be with the laptop. So, at first, the power on switch of the laptop is checked. It must be pressed down for few seconds. The process is to be repeated one or two times. If there are some indications of the laptop working, the problem may be in the power on switch of the laptop or in the battery compartment. The laptop cover is then removed and the battery connection is checked. A loose battery connection can create such problems. The connection terminals of the battery are cleaned or the battery is replaced, if required. This may solve majority of the problems. If this does not solve the problem, the contacts of the power on switch are checked. These must be cleaned and the laptop is switched on.

Graphics section of laptops can be either integrated with the motherboard or it can be an add-on card. If the LCD display of laptops is empty, this may be due to the problem in the display. If there is problem in the graphics unit, it is to be checked. The internal parts must be cleaned. Due to the heat generated during the working, the graphics card may not fix firmly on the slot. So, the graphics card are to be removed and then it is firmly fitted on the slot again. After that, the laptop is checked. The display trouble in laptops can be due to several reasons. The fault can be due to the damage of backlighting system or graphics system of the motherboard or due to some other reasons. A close preliminary observation helps in solving the problem in majority of the cases. As usual, the faulty item can be found by the process of eliminating working components. For this, an external display unit is connected and the display is checked. If there is display in the external monitor, the error is not due to motherboard graphics error. The next step is to check the video cable connecting the motherboard with the LCD. Checking the connectivity helps in ensuring that the cable is not faulty. Any loose connection at the connecting edges is to be corrected. If it is required to replace the cable, it must be done carefully without altering the existing layout and without damaging any other component. The backlighting system is made up of the electronic circuits consisting of different components and IC chips. The checking of this circuit involves finding the voltage levels available at different pins of the chip when the laptop is turned on. The IC used in the circuit is known from its label printed on its surface. The expected voltage levels available at different pins can be obtained from the IC manual.

If the LED indicators of the laptop are lit and the cooling fan is working, the problem may be with the hard disk. If the hard disk activity is taking place, the problem lies with the screen display. Due to the faults in the LCD screen, nothing is displayed. In such case, the screen display is closely examined. Due to the failure of backlight mechanism, the LCD screen displays the contents in a dimmed manner. To confirm the fault, the panel is tilted to and fro for one or two times, watching the display formed. During the tilting time, if a normal display is obtained on the screen, the error may be due to a fault in the lead switch used for detecting the flip condition of the screen. If normal display cannot be obtained, the problem lies in the backlighting unit of the laptop. The backlighting unit is made up of a cold compact fluorescent lamp (CCFL) and an inverter unit. These must be checked for faults. Also, the cable connecting the unit with the LCD screen is to be checked. If the above components are in working conditions, the fault lies with the LCD panel. It is not advisable to drop, scratch, hit or place heavy objects on the display panel. It is important to avoid making direct contact with the liquid crystal materials from the broken LCD, as it may be hazardous.

Fault in keyboard is another reason for the improper working of the laptop. Liquids spilled on the keyboard can flow down to the circuit board under the keys. The liquid can damage the motherboard or its components and can also create a short circuit problem. If the liquid is spilled over the keyboard of a laptop, the system is to be switched off immediately and the battery is to be removed. The keyboard must be placed upside down such that all the liquid drops are removed. Using a hot air blower, the components must be made dry.

Sometimes, RAM modules may not work correctly. RAM modules may be slightly dislodged from the slots. This creates some connection problem. So, in this case, the RAM modules are removed and are replaced firmly on the slot and then these are checked again. CMOS battery available in the laptops makes the time and date stored in the system correct. If the CMOS battery becomes faulty, it has to be replaced with a new one. In majority of the laptops, the CMOS batteries are soldered to the motherboard. Hence, the users cannot replace the battery. While replacing the battery, the polarities are to be checked. It is necessary to ensure that the CMOS battery is fitted correctly.

A working laptop can be switched off during the course of its working in an unexpected manner. This fault can occur in desktop systems also. In laptops, this may be due to a fault in the charger. In certain cases, an overload error on the laptop can make it switched off. But the majority of the faults in the desktop systems as well as in laptops are due to a higher temperature inside the computer. Too much heat is generated during the working of computer systems. The heat is dissipated with the help of cooling fans provided to serve this purpose. Due to the dust deposit, the vent holes get blocked, thereby making it difficult to dissipate the heat easily. Also, if the cooling fan is not working properly, then the heat dissipation will not be effective. All these factors increase the temperature inside the cabinet. Finally, the computer system stops working and then starts again. Regular cleaning of the vent holes and the cooling fan mechanism can prevent the problem. Cooling fans must be regularly checked for their working. Infection of the laptops with virus or spyware can also make the laptop behave like above. Removing the infected virus and spyware brings the laptop back to its healthy condition.

There are several reasons for the overheating of laptop systems. Overheating can be either application driven or hardware driven. Applications like games (that require graphics card) and the media player software can heat the laptop easily. Due to overheating, the laptop may change to a lock up state and even reboot repeatedly. Also, the components of the laptop may stop functioning properly and may even get destroyed. This overheating problem can be prevented using the following steps:

(a) The first and the most basic step is to examine whether the cooling system is working properly. The fans as well as the heat sinks are responsible for cooling down the system when it is overheated. Dust particles can reduce the rotational speed of the fan and can make the system overheated. Proper cleaning of the fan helps in reducing the generated heat.
(b) Another solution to the problem is to add an additional cooling fan. The fan helps to provide a free flow of air from the vents. Most of the fans are powered up by USB or by an adapter.
(c) The laptop must be kept away from intense heat, direct sunlight and stuffy environments.

For mobile devices, the ergonomics of devices is very important. Ergonomics is evaluated from the keyboard and pointing device in terms of the key size, button size, layout and tactile response. The keyboard and mouse are mostly used in the laptops. Key size, key spacing and the tactility must be good enough for the extended keyboard usage. Small or cluttered keys on the keyboard can slow down the typing speed and can also cause erratic typing, thereby causing strain in the fingers and palm.

The ideal place of the touch pad is at the centre of the space bar and the buttons should be placed on the bottom side. The position of the USB ports, audio jacks and the card reader are also important in selecting a laptop. These should ideally be placed on the sides rather than on the rear or the front. Dedicated volume control and switch for Wi-Fi and bluetooth are also very important considerations for the selection of a laptop. Also, the chassis must be good and sturdy enough to withstand rough usage that may happen while on move.

Cleaning the laptop screen often helps in removing dust and stains from the display. A soft damp cloth must be used to clean the surface. Isopropyl alcohol can be used to dampen the cloth. It is not advisable to use rough clothes for cleaning the surface, since this may leave permanent scratches on the surface. Before closing the display, it is to ensured that the display is completely dry. Sometime, the touch pad of the laptop may not work. In that case, it is needed to replace the non-working touch pad with another one having the same part number.

12

Computer Printers

A commonly used output unit of a computer is the printer. Printers have become a necessity for their applications in the business segments. There are different types of printers that can be used with the computers. These printers vary from tiny pocket printers to huge commercial printers. Computer printers for specific purposes are also available such as for home users, photographers and for professional printing. *Inkjet*, *dot matrix*, *laser*, *multifunction printers* are now commonly available. Each printer has its own advantages and disadvantages. In this chapter, the common types of printers, their features and special qualities are discussed.

12.1 TYPES OF PRINTERS

Different types of computer printers use different technologies in their manufacture. Variants of computer printers in several forms such as *photo printer* and *invoice printers* are also available, but these use the same basic technologies that are used with the other types of printers. The selection of a printer is based on the different factors that include the type of document to be printed, requirements for multiple copies or a single copy, size of the document, platform in which the application is running, extent of graphics available, print load and usage conditions, required quality, type of media used, colour printing or monochrome, etc. The printer is selected by considering the cost-effectiveness and performance quality.

Laser printers currently dominate in the business segments. The cost and the printing cost per page of the laser printers has become low and these factors make laser printers very attractive in the business segments. Inkjet printers were once used and now, these are replaced with laser printers. Cost of acquiring inkjet printers is less while the printing cost per page is high. Dot matrix printers are used in environments having high transaction processing. Lower cost and rugged nature of dot matrix printers make them ideal in such places. Multifunction device (MFD) is also accepted in the business segments. Besides printing, MFD offers other facilities such as scanning of documents, e-mail sending, fax facilities, etc.

Earlier laser printers were mono types having the capacity to print only in black and gray shades. Now, the use of colour laser printers has increased. There are several reasons for changing to the colour printers. The colour printing has become a necessity due to its increased advantages and impacts in the business segments. Nowadays, the colour laser printers have become affordable. Colour printing increases the appearance as well as the business value of the documents. The colour visuals provide a professional look and enhance presentation and communication abilities. Better quality and enhanced appeal are the other advantages of colour documents. Thus, the colour visuals are widely accepted among the people. The colour laser printers use four coloured inks for getting printouts. These colours are indicated as CMYK, used by the printing presses for colour printing. C is cyan (blue), M is magenta (red), Y is yellow and K is black. During printing, the coloured inks are laid out in the layers of dots that are combined to create the illusion of several colours. Inkjet colour printers use mechanical print heads and the head has to move four times to print the four colours. Colour laser printers use laser beams to spray the different colours onto the paper. So, the inkjet printers have four times the wear and tear as compared to the colour laser printers.

12.2 DOT MATRIX PRINTERS

Dot matrix printers are mainly used in places where multiple copies of documents are needed at low costs. These types of printers provide low cost of acquisition and low running cost. These are slow and noisy in operation. These printers are used in places where print quality is not of much importance. The important parts of a dot matrix printer are print head, ribbon, interface, power on/off switch, front panel controllers, roller etc. The different parts of a dot matrix printer are shown in Figure 12.1.

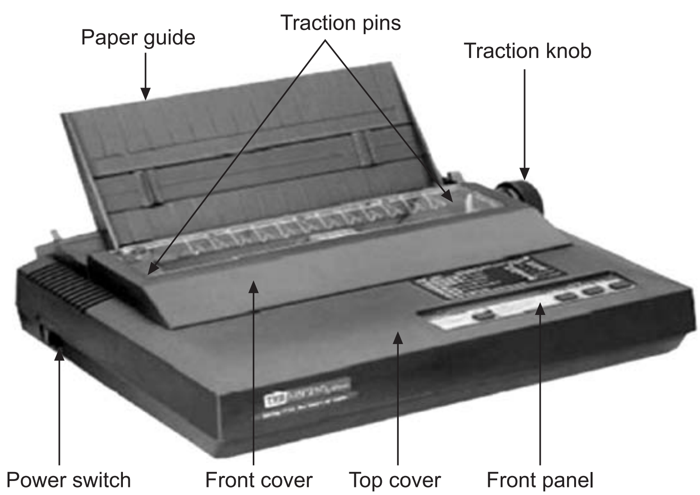


Figure 12.1 Parts of dot matrix printer.

The top cover of the dot matrix printer helps to reduce the sound produced during printing and it protects the printer from dust and dirt. The front cover protects the print head as well as the print ribbon. This cover needs to be exposed while changing the ribbon cassette or for loading the paper. The front panel has the buttons to load paper, pause/start printing, select font size and type, etc. Number of pins available in the printer head determines the print quality of the document, since every character or image is made up of dots produced by the metal pins on the printer head. Dot matrix printers are available either with 9 pins or with 24 pins. Printer with 24-pin print head is having a higher print quality than that produced by a 9-pin print head printer. Printer ribbon is a nylon strip impregnated with ink which gets transferred to the paper whenever the print head strikes on the paper.

Print ribbon can be replaced whenever required. Platen knob is used for manually loading the paper. There is a roller with sensors attached to it and it detects the paper when these make contact with the sensor. Traction pins are used to pull the paper during the printing process. The paper selector level selects the type of paper feeding method such as single sheet or continuous form. A lever for adjusting the paper thickness is also available with the dot matrix printers. Adjusting this lever widens or narrows the space between the print head and the platen. A wider gap accommodates thicker paper. The power switch is used to switch on and off the printer. The computer interface is necessary for connecting the printer to the computer. Earlier dot matrix printers used parallel and serial interfaces. Currently used interface is the USB interface. The control panel of the printer is located on the top right side of the printer. The control panel consists of a set of buttons for different operations and a number of LED indicators showing different status conditions. Different configuration settings are done by setting different options in the menu displayed in the control panel.

12.3 DOT MATRIX PRINTER SPECIFICATIONS

Dot matrix printers are manufactured with different specifications. Major specification features for dot matrix printers are given in Table 12.1.

Table 12.1 Dot Matrix Printer Specification

Feature	Specification
Printing method	Impact dot matrix
Number of pins	24-pin or 9-pin
Print direction	Bidirectional
Number of columns	80 or 132
Print speed	Draft 180 cps at 10 cpi
Character set, size	Different types
Print handling	Different types
Input buffer	256 kB
Interface	Centronics type parallel/USB
Power requirements	AC – 100 V – 230 V, 50–60 Hz
Power consumption	75 W

Feature	Specification
Operating temperature	30
Reliability, MCBF	7.5 million lines
Print head	150 million characters
Sound level	Low

Buffer size is an important feature of dot matrix printers. Buffer acts a temporary storage. A large buffer size makes a faster print output. Dot matrix printers make use of two types of paper feeding mechanisms. One is the **friction feed mechanism** and the other is the **tractor feed mechanism**. In the friction feed mechanism, the paper is pulled from the stack when required. Whereas, in the case of tractor feeding, the continuous sheets of paper are pulled through the spokes available at the two ends of the stationery. Multilingual printing is another feature available with the dot matrix printers.

12.4 INSTALLING DOT MATRIX PRINTER

The following steps must be taken to install a dot matrix printer:

(a) First of all, a flat stable surface free from heat, dust and humid conditions is chosen. Enough air circulation must be available around all the sides of the printer.
(b) After placing the printer in the chosen surface, the top and front covers are opened.
(c) The shipping restraints, if any, are removed from the inner side of the printer.
(d) Now, the ribbon cassette is taken from the pack.
(e) The print head is located and the ribbon cassette is installed over the print head, as shown in Figure 12.2. It must be ensured that the exposed ribbon is between the print head and the guides and the ribbon is not folded or damaged.
(f) Now, the print head is placed down firmly until it gets locked into its position. To adjust any slack in the ribbon, the ribbon knob is to be moved clockwise once or twice.

Figure 12.2 Dot matrix printer-Internal view.

(g) The power cord can be fitted only in one way. The other end of the power cord is connected to a properly earthed electrical outlet.
(h) The printer is connected to the computer using a data cable. Before this, the cable is connected to the port on the printer. The data cable interface can be a parallel interface or USB interface. The cable connection can be made only in one way.
(i) After firmly fixing the cable on the printer port, the other end is connected to the port on the computer system and the printer in switched on. If the printer is in working condition, switching on the printer makes the print head to move to the initial print position.
(j) Now, the printer driver software is installed in the connected computer and the settings are properly configured. Cut sheets or continuous stationery can be loaded and the printing can be started. Printing a test page helps to get the currently used configuration settings. Some configuration settings can be changed through the printer driver software and some other can be changed through the printer panel.

Dot matrix printers are provided with a built-in program for self testing the working of the printer. This program when executed prints all the characters including line and block graphics. Successful running of self test program ensures that everything is working correctly. Running self test is very easy and can be done without connecting the printer to a computer system. The self test application is run by turning on the printer and holding down one or two designated buttons on the printer control panel. The buttons used for the self test printing varies with different types of printers and this is usually indicated in the control panel.

12.5 MAINTENANCE AND TROUBLESHOOTING

By following several good practices while using a dot matrix printer helps in reducing its maintenance and increasing the life of the printer. It is advisable to not turn the print platen when the printer is in powered ‘on’ state, as it may damage the printer. Use of the stepper motor is preferred for this purpose. The print head becomes hot during printing. So, touching the print head immediately after a print process is to be avoided. Using draft mode for printing is economical for dot matrix printers. Changing printer ribbons as soon as they begin to fade is necessary, since the ink in the printer ribbon is used by the print head as a lubricant for the pins present in the head. The dried up ink causes undue wear and tear of the pins. The ribbon is placed in the ribbon cassette in a continuous loop. The cassette can be removed by slowly taking out from its position. New cassette can be fixed to its slot and can be used.

The dirt and dust are the common trouble makers for the dot matrix printers. Cleaning the inside of the printers is to be done occasionally. To clean the printer, as the first step, the printer in turned off. After that, the front and top covers are opened. A soft brush is used to remove the dust and paper particles from inside the printer mechanism. A vacuum cleaner or a blower can make the cleaning process very easy. The outside surface of the printer can be cleaned using a soft cotton cloth dampened with a mild detergent.

12.6 DOT MATRIX PRINTER: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the dot matrix printer and their suggested solutions are given in Table 12.2.

Table 12.2 Dot Matrix Printer: Common Problems and Suggested Solutions

Problem	Solution
There is no power supply to the printer when it is powered on.	Check whether the printer is turned on and the indicator LED is glowing. Check the input power supply. Check whether the power cable is connected properly and is working. Also check the configurations.
Power is turned on but the printer is not working.	Verify that the interface cable is properly and firmly connected. If the printer is not in online mode, make it online. If there is no paper, load paper.
Paper is not feeding correctly.	Use paper having the appropriate thickness only.
Printing is too light or too dark.	Adjust the paper thickness lever to lighten or darken the print. If the ribbon is old, replace it with a new one. Ensure that the ribbon is properly and correctly positioned.
Print quality is poor and the print appears smudged.	Adjust the paper thickness lever to lighten or darken the print. If the ribbon is old, replace it with a new one. Ensure that the ribbon is properly and correctly positioned.
Printing is erratic and wrong characters are printed.	Check the interface connection and make sure that the connection is tight. Check the configuration settings.
Lines are double spaced and overprinting of lines.	Set the correct configuration in the setup.
Graphics pattern appears garbled.	Use the correct emulation from the set up options.
Paper jams while loading.	Ensure that the paper guide panel and the paper select panel are set correctly.
Pin holes in continuous paper run out of perforations during printing.	Ensure that the paper path is straight and not skewed.
Printing garbled text.	Reinstalling the printer driver can solve this problem.
When trying to print, a message *Error writing to LPT1* is displayed on the computer screen.	Make sure that the printer is set online. Ensure that the data cable is firmly connected to the parallel port. Make sure that the cable is free from defects. Turn off the printer and restart. This will solve the problem. If the problem is not solved, uninstall the printer driver software and then reinstall. Restart the machine and try again.

12.7 INKJET PRINTERS

This is a non-impact type of printer. This type of printer uses liquid ink for printing. Inkjet printers are capable of printing photo-realistic prints on the paper. These printers are available with different print resolutions. New types of printers are provided with several additional features such as software for determining ink status in cartridges, paper jam, etc.

The components of inkjet printer are print head, ink cartridge, print head stepper motor and belt. Print head is the important part of inkjet printers. It is made up of several nozzles. The series of nozzles spray the liquid ink drops to the medium by using an electrostatic field. This is made possible with the help of some piezo elements placed at the back side of the ink reservoir which oscillates when subjected to the electrical voltage. Applying voltage causes the ink drop to come out of the nozzle and to spread on the paper. It is estimated that nozzles of inkjet printers open about 5000 times per second while printing. Different characters are formed by this method. Ink cartridge supplies the ink. The movement of the print head as well as the cartridge is controlled by the stepper motor. A belt helps to transfer the movement of the stepper motor to the print head. Paper is fed from paper feeder or paper tray. The feeding of paper is controlled by the paper feed motor. Necessary control circuit is used to control the different functions. The interface used for inkjet printers is USB or parallel.

The front view of an inkjet printer is shown in Figure 12.3. Similar to dot matrix printer, inkjet printer is also having a front panel with a small display and a number of buttons for different purposes. Depending on the model, the settings can be changed. The connector to electrical outlet and the interface to computer are provided on the rear side. The ink cartridge is installed by opening the top cover. Monochrome inkjet printers have only one ink cartridge while colour printers make use of four cartridges. Only cut sheets can be used for printing. The paper is fed through the paper tray.

Figure 12.3 Inkjet printer–Front view.

12.8 INKJET PRINTER SPECIFICATION

There are several specification parameters associated with the inkjet printers. Some of the common specification parameters are given in Table 12.3.

Table 12.3 Inkjet Printer Specifications

Parameter	Typical value
Technology used	Piezoelectric (on demand)/Thermal
Resolution	600 dpi
Print speed black	8 ppm
Print speed colour	8 ppm
Interface	USB
Paper tray capacity	50 pages
Memory	64 kB

12.9 INSTALLING INKJET PRINTER

The following steps must be taken to install an inkjet printer:

(a) As the first step, a flat level surface free from heat, dust and humid conditions is selected. Enough air circulation must be available around all the sides of the printer.
(b) After placing the printer in the chosen surface, shipping restraints are removed from inside of the printer. Inkjet printers are equipped with ink cartridge, connecting cables and driver CD.
(c) The power cord is attached to the connector in the printer. This cord can be fitted only in one way. The printer is connected to the computer using a data cable. Before this, the cable is connected to the port on the printer. The cable connection can be made only in one way.
(d) After firmly fixing the cable on the printer port, the other end is connected to the port on the computer system.
(e) Now, the ink cartridge is taken from its packet.
(f) The top cover of the printer is opened and the cartridge is installed correctly. The coloured cartridges of colour inkjet printers must be installed in the correct colour position. The colour positions are usually labeled, as shown in Figure 12.4.
(g) After installing the cartridges the printer can be powered on. The print head makes a movement and its position is adjusted to the initial print position.
(h) Now, the printer driver software is installed in the computer.
(i) Then, the settings are configured and a test print is made. If the test print is correct, the printer is installed correctly.

Figure 12.4 Colour cartridges installed in inkjet printer.

12.10 TROUBLESHOOTING AND MAINTENANCE

Inkjet printers are to be maintained properly for getting the best results. The proper alignment of the ink cartridge is necessary for proper working of the printer. This is essential while configuring a new printer or replacing the ink cartridge. When the cartridges are out of alignment, it results in abnormal or poor quality of printing. A suitable software for this purpose is available and it can be used. New inkjet printers use an automatic alignment mechanism to correct this problem. Ink cartridges are to be stored in the factory supplied containers in a cool and dry environment. If printing is not done for a long period, the ink gets dried causing the nozzle in the print head getting blocked, thereby preventing the printing process. The dust particles getting deposited on the print head also result in clogged prints. For smooth printing process, clearing the clogged print heads is essential. The new inkjet printers are provided with a feature for cleaning the print heads. Either this feature can be used or the head can be cleaned otherwise. While cleaning the print heads, proper care must be taken to avoid the damage of the print heads. The cleaning process involves taking the ink cartridge out and removing the blocking dry residue with the help of a wet cleaning kit. Cleaning the contact points of the cartridge and the printer using a cotton cloth dampened with isopropyl alcohol helps in clearing the smudges and dust deposits and getting good quality prints. Cleaning the inside rollers helps in preventing the paper jams. To prevent the drying of ink and its clogging in the print head, the printer must be always kept closed. It is not advisable to shake the ink cartridges, as bubbles can be created in the cartridge bottle that can stop the working of printers.

To get better results, it is important to use the paper of a good quality always. The quality of the paper determines the amount of ink that is absorbed by the paper. It also determines the quantity of the ink bleeding on the surface of the paper or the amount of ink that is staying in the spot where the drop hits the paper. Another reason for getting poor prints is the use of wrong printer driver and incorrect configuration settings. Use of the right printer driver software as well as the correct configuration settings is helpful for getting better quality prints. It is necessary to allow the ink in the prints to dry completely so as to avoid any smudge appearing on the prints. The time taken by the ink to get dried depends on the quality of paper, temperature and humidity conditions.

12.11 INKJET PRINTERS: COMMON PROBLEMS AND SOLUTIONS

Some common problems associated with the inkjet printers and their suggested solutions are given in Table 12.4.

Table 12.4 Inkjet Printers: Common Problems and Suggested Solutions

Problem	Solution
Printer does not work.	Check whether the printer is turned on and the indicator LED is glowing. Check the input power supply. Ensure that the power cable and the data cable are connected properly and are working. Check the configurations. Reinstall the printer software and reconfigure the device. Print a demo page to ensure the working of the printer.
Paper is not feeding correctly.	Use the paper having appropriate thickness. Do not overload the tray.
White strips or bands are running across the prints.	The error can be due to the print nozzles getting blocked by dry ink or dust. The head cleaning utility available with the printer software can be used to clear the blocks. To ensure that the blocks are cleared, use the nozzle checking facility available with the software.
Faded or round edge prints are appearing in the prints.	This is an indication of low toner ink. Replacing the toner cartridge can solve the problem.
Appearance of light and dark horizontal lines and vertical lines in the prints.	This is due to the print heads getting out of alignment. The problem can be solved by adjusting the alignments.
Colours are missing in the prints and uneven ink flow.	The error can be due to the print nozzles getting blocked by dry ink or dust. The head cleaning utility available with the printer software can be used to clear the blocks. To ensure that the blocks are cleared, use the nozzle checking facility available with the software.
The printed text appears unintelligible.	Try to print a different document. If the problem still exists, it may be due to corrupted printer driver software. Reinstalling the driver software can solve the problem. If the problem is not solved, check the hardware.
Printer takes too much time to print.	This may be due to large file size. Reinstall the printer driver. In BIOS, under communication port, select parallel port and configure as ECP + EPP

Problem	Solution
Display of *Error writing to port* message on the computer screen.	Reinstall printer driver software. Check data cable and if needed replace the data cable. A conflicting port setting can display this type of error. Assign a new IRQ for the device.
When trying to print, a message *Error writing to LPT1* is displayed on the computer screen.	Make sure that the printer is set online. Ensure that the data cable is free from defects and is firmly connected to the parallel port. Turn off the printer and then restart. This will solve the problem. If the problem is not solved, uninstall the printer driver software and then reinstall. Restart the machine and try again.

12.12 LASER PRINTER FEATURES

Although the initial cost of laser printer is high as compared to the inkjet printers, yet the laser printers are economical than the inkjet printers in the long run. Also, there are no risks associated with the ink of the laser printers getting dried up in course of time, since the laser printers use toner in the form of dry powder rather than in liquid form, which is the case with inkjet printers. Laser printers work on the principle of laser and they use heat to fuse toner to the paper. These types of printers print faster. Better quality and lower cost of ownership are the other features of the laser printers. These printers are manufactured by different manufacturers and are available for different purposes. Different laser printers differ in their speed, print resolution, ability to use different types of print media, quality of printing, etc. The different components of a typical laser printer are shown in Figure 12.5

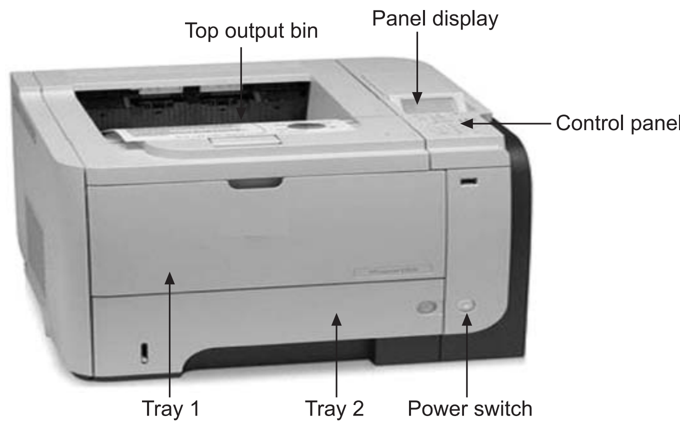


Figure 12.5 Laser printer—Front view.

The panel indicators provide indications of different working conditions of the laser printer. The common LED indicators available in several printers are online/error LED and toner saver LED. If the online/error light is green, the printer is ready to print. If the light is red, the printer is experiencing an error such as jammed paper, the open cover or the empty toner cartridge. Pressing the cancel button while the printer is receiving data, the online/error LED blinks red to cancel the printing. If there is no paper in the feeder, the online/error LED blinks red. If the printer is receiving data, the online/error LED slowly blinks green.

The interface for connecting the printer and power input socket are provided on the rear side. Paper jam release door is also available on the rear side. The rear view of a typical laser printer is shown in Figure 12.6.

Figure 12.6 Laser printer—Rear view.

12.13 WORKING OF LASER PRINTER

The technology used by laser printers is different from that used in the inkjet printers. Laser printers work on mechanism based on the static electricity. The internal component structure of a laser printer is shown in Figure 12.7. The figure provides an idea of the printing path followed in the laser printers. The major internal components include toner bin, photoconductive drum, fusing roller, mirror and laser mechanism. The toner bin stores the toner which is responsible for forming the image on the media. The toner is equivalent to the inks used in the ink printers. It is made up of pigments and plastic particles. Pigments give colour and plastic particles melt when heat is applied so that it gets fused to the paper. The drum is considered as the heart of the laser printer and it is the place where the image is stored in the form of electrostatic image and this is basically a revolving cylinder. The photoconductive drum has a tendency to get the positive or negative charge when the visible or infrared light strikes on the surface. The fusing roller is for applying pressure and heat to the paper. The mirror and the laser convert the digital data to an electrostatic charge on the drum.

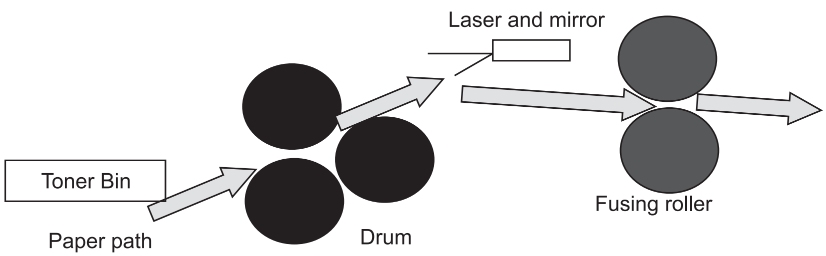


Figure 12.7 Printing path in laser printer.

Practically, the toner is stored in the toner cartridges. Mono laser printers have only one cartridge whereas colour laser printers use four cartridges—one with black and the rest with coloured (cyan, magenta and yellow) toner particles. During working, the photosensitive drum is positively charged with a high voltage. This is done with the help of a wire carrying electric current. The wire is known as **corona wire**. In certain printers, a charged roller is used for this purpose. A laser beam scans the surface of the photosensitive drum and discharges the positive charge from the surface. The movement of the laser beam is controlled by the on-board electronic circuit. The laser beam mechanism is made up of moving mirrors and sharp lenses so as to get the sharp laser beams. The places where the charge is discharged are decided by the document that is to be printed. Thus, an image of the document to be printed is created on the drum. Positively charged toner particles are attracted to the photosensitive drum and the toner particles affix themselves to the drum, in places where the charge is discharged by the laser beam. The drum attracts the toner particles to its surface exactly identical to the page that is to be printed. For this, the laser beam switches on and off several times depending on the document that is to be printed. A typical laser printer switches on and off millions of times every second. The faster the speed of switching on and off of the laser beam means a higher print resolution. A negative charge is applied to the sheet of paper and when the paper passes over the drum, it attracts the toner away from the drum to the sheet of paper. This transfers the image to the paper. When the paper is heated and pressure is applied by the fuser assembly unit, the toner particles get fused on the surface of the paper and make them to remain on the paper surface permanently. The fuser assembly is simply a metal roller coated with teflon, which is heated by quartz lamp. This produces an identical copy of the page to be printed on the sheet of paper. After printing, the pattern is cleaned off from the drum by the charged corona wire. After cleaning the drum, the process is repeated and the printer prints the next page. The entire process takes place in a fast and synchronous manner and thus, the printing takes place continuously. The buffer memory used with the printers helps to store the details of sufficient pages to ensure smooth continuous printing.

The entire printing process is controlled by the printer controller unit. This unit receives data through the printer interface. Laser printers communicate in a certain language known as **Printer Command Language** or **PCL** (used by HP machines) or **Postscript** (used by Adobe) or other graphical interfaces. The data received by the mechanism includes the size and type of the print media, details of the margin settings, input/output tray to be used, etc. The controller mechanism understands the language and sends suitable and necessary instructions to the printer hardware for printing the document.

12.14 LASER PRINTER SPECIFICATIONS

Print speed is an indication of how long the printer takes to print the document. This is the sum of the time taken by the printer to start printing the first page and the time taken to print the entire document. Print speed is measured in units of pages per minute (ppm). To measure the print speed, the time taken by the printer to start printing the first page of a multi-page document, the total time for printing the multi-page documents and the time taken for printing pages with partial graphics and full graphics are compared.

Several factors affect the time taken by a printer to print a document. The factors include the maximum printer speed, the use of the print media (such as transparencies, heavy paper, and custom size paper), processing and download time, complexity and graphics associated with the document, the speed of the computer, interface connection used, printer I/O configuration, operating system used and its configuration. Laser printers take some extra time to output the first page. This delay is because they need some time to heat up the system before start printing.

Print quality of the laser printers is measured by comparing the smallest readable font size that can be printed, quality of the graphics and the sharpness of printing. The ability to print different font sizes and different font types is a parameter that is evaluated in determining the print quality. Different test charts available help to check the ability of printers to precisely print the fine lines of various sizes and shapes. Gray scale test helps to determine the ability of printers to produce gradients while printing grayscale-based documents and graphics. The quality of the colour laser printers is evaluated using the printing of coloured documents. The ability of printers to print coloured documents crisply and using colour gradients make the printer better. The upgrading ability of the laser printers is another factor that requires a comparison. This is measured by comparing the supported RAM, networking features supported and accessories that can be used with the printer. Other features that worth comparing are the ease of setting up the printer and its configuration, remote administration abilities, support for the platforms and protocols and the accessories supported.

Print resolution is an important feature of any laser printer. This refers to the sharpness or clarity of printing. It is indicated in dots per inch (dpi). The higher print resolution means a better image quality and sharper prints. The printers with high print resolution are good for the documents consisting of graphics.

Maximum paper size that can be used with the printers and the range of paper weight are the other features associated with the laser printers. These printers use print media in a variety of sizes and weights such as plain paper, transparent paper, recycled paper, envelopes and labels for printing purposes. Some of the common specification parameters associated with the laser printers are given in Table 12.5.

Table 12.5 Laser Printer Specifications

Parameter	Typical value
Technology	Laser
Resolution (dpi × dpi)	1200 × 1200
Print speed black, colour	30 ppm
Paper size	A4, legal, custom
Paper weight	75 gsm
Memory	12 MB
Duplex ability	Available
Networking ability	Available
Input tray	2 numbers
Types of media	Plain, recycled, envelopes, etc.
Duty cycle	3000 pages per month
Weight	50 kg
Interface	USB

12.15 INSTALLING LASER PRINTER

New laser printers are equipped with a number of items in the package. The components that are included in the package involve the power cord, driver medium and the toner cartridge. These items can be seen in Figure 12.8.

(a) For installing a laser printer, first of all, a suitable level and a well-ventilated position is chosen to place the laser printer.

(b) Now, the toner cartridge is removed from its cover. The cartridge is gently shaken from the sides to make the toner evenly distribute inside the cartridge. To prevent any damage, the toner cartridge is not exposed to the light for more than a few minutes. The cartridge slots are then located inside the printer after which the handle is grasped and the cartridge is inserted in the printer until it snaps into the place.

(c) Now, the front cover is securely closed.

(d) After that, the tray is pulled out of the printer and a stack of paper is load in the tray. The loading is done by flexing or fanning and then straightening the edges by placing on a level surface. Now, the tray closed.

(a) (b) (c)

Figure 12.8 Laser printer package contents (a) Toner cartridge; (b) Power cord and (c) Driver medium.

(e) To print from a computer, the printer is to be connected to a computer using a parallel interface cable or a USB cable. To make the connection, it must be ensured that both the computer and the printer are in the 'off' state. Now, the end of the cable is connected to the connector in the printer and the other end is connected to the parallel port or USB port of the printer, depending on the interface available. The installation process can be understood from Figure 12.9.

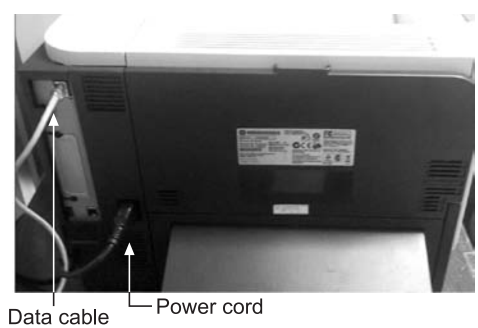


Figure 12.9 Data cable and power connections of laser printer.

(f) One end of the power cord is connected to the printer and the other end is connected to a properly grounded AC outlet.
(g) Now, the printer is turned on. To ensure that the printer is working properly, print a demo page that displays the current printer configurations using the buttons on the printer panel.
(h) The necessary printer driver software is included in the medium. To install the printer driver, the medium is inserted in the drive. The installation of driver starts automatically.
(i) The entire operation works in an interactive manner with the help of animations. The installation proceeds through different screens on clicking the forward button and finally finishing the installation process.
(j) After finishing the installation, a prompt appears for the printing of a test page. If required, a test page can be printed.

12.16 INSTALLING PRINTER ON NETWORKS

Network printers can be connected directly to a network and can be configured to allow all the computers on the network to print directly to it. For this, following steps are taken:

(a) First of all, the printer is connected directly to the network by inserting a network cable into the printer network port. The length of the cable must be less than 2 meters.
(b) Then, the printer is turned on and a configuration page is printed. The IP address assigned to the printer is displayed on this page. If the IP address is not present, the configuration page is to be reprinted after assigning an IP address.
(c) The driver medium is inserted in its drive and the installation process is then started.
(d) When the prompt for the network appears on the screen, then the IP address is provided to proceed further, thereby finishing the installation process. Instead of providing the IP address, if a search for printer option is selected, then the connected printers in the network are displayed. The required printer can be selected and the installation process can be finished.

To change the network address of the printer, the IP address from the configuration page is searched. If the printer is using IPv4, the IP address contains four digits separated by period character. IPv6 addresses make use of hexadecimal character combinations. The IP address is then typed in the address box of a Web browser which opens the embedded Web server. By opening the *networking* tab, it is possible to change the settings. The IP address of the device can be set manually or it can be configured automatically. In this case, the printer sharing need not be enabled.

The printer software is used for performing several jobs such as to cancel a print job, set different page sizes and to set the print quality for printing the document. The page size can be set to different available sizes in the drop down list and also can be set to a custom size. To accommodate the paper, the paper adjusters of the paper feeder are set to the desired size. The printer is designed to support the print media with specified weight, use of the specified tray and the manual feeder option. The paper used must have weight within the specified range. Usually, the whiter paper produces sharper and more vibrant images. Smoothness of the paper affects the crispness of printing. Damp, curled, wrinkled or torn paper can cause paper jams and poor print quality. Only cut sheets can be used and multipart papers cannot be used with the laser printers. The paper source can be set to different trays available such as tray 1 or tray 2. The paper type and print resolution can be set differently from the options. Different document effects that can be set include scaling to different sizes, printing watermarks, etc. Selecting the duplex print option helps to print on both sides of the paper. Setting the number of copies and printing in shades of gray are the other options that can be set using the options available in the printer software.

12.17 MANAGING LASER PRINTERS

Laser printers allow the printing of different configuration pages and status reports. Demo page, printer configuration page and the toner supply status page are the common pages that can be printed. In network printers, the embedded Web server enables to display different settings and status of the printer. If the toner is low, then faded and light areas appear on the printed page. When a print cartridge approaches is its end, prompts usually appear on the panel display for its replacement, if the feature is available. The printing can be continued with the current cartridge by redistributing the toner. But, it will lead to a situation when the prints no longer yield the acceptable print quality. Replacing the print cartridge corrects this problem. These can be replaced by opening the print cartridge door, removing the cartridge and then replacing with a new one. For this, the front or top cover is opened, depending on the design. The cartridge is then pulled out gently, as shown in Figure 12.10. The new cartridge is inserted in the correct orientation to the compartment. The cartridge is firmly fixed in its place. Now, the print cartridge door is closed after ensuring that the cartridge is firmly seated. Switching on the printer brings it to the ready sate. Certain laser printer models, especially colour laser printers make use of toner bottles. The method of replacing toner bottles is similar to that used for the other models.

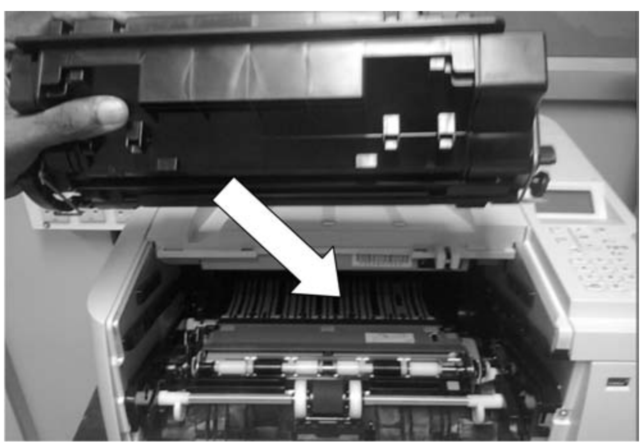


Figure 12.10 Installing new cartridge in laser printer.

Several laser printer management steps are necessary to keep the laser printer in good condition. Cleaning the printer cartridge area helps in producing better quality prints. To clean the area, the print cartridge door is opened and then the cartridge is removed. The print area and the cartridge cavity are wiped out using a dry cloth. After cleaning, the cartridge is replaced and the door is closed firmly. The power cord is then reconnected and the printer is turned on for use.

If toner specks and dots are visible in prints, cleaning the paper path helps in getting better quality prints. Cleaning prints are taken using a sheet of transparency. The cleaning process takes around two minutes to complete. The cleaning process is initiated by printing a cleaning page from the option available in the printer software. For a thorough cleaning, the process is repeated a number of times. Cleaning the pickup roller helps to prevent the difficulty in picking up the paper from the tray. The pickup roller is cylindrical in shape (as shown in Figure 12.11) and in several laser printer models, it can be removed easily from the printer. After removing the roller from its holding, it is scrubed using a piece of cloth soaked in water. Then, it is wiped out using a piece of dry cloth to remove any dust particle present on the surface. After cleaning the roller, it is fixed and the printer is started to be used. Different pickup rollers are available for different trays of the printer.

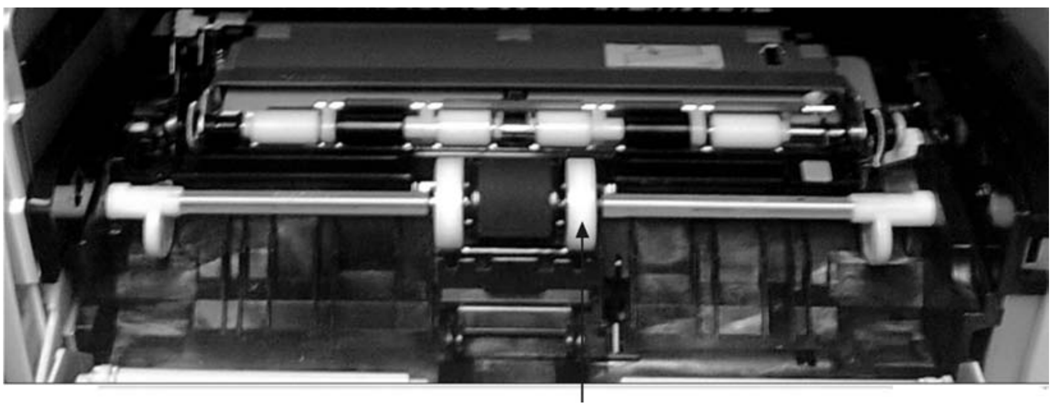


Figure 12.11 Pickup roller mechanism of laser printer.

12.18 MAINTENANCE AND TROUBLESHOOTING

Printers support a variety of paper and other print media. Use of the paper or other print media that are not supported by the printer can cause different printing problems such as poor print quality, increased paper jams and premature wear on the product. To get the best possible print quality, appropriate and high quality papers are to be used only. If any of the components is not installed correctly, it results in paper jams. Using paper with irregularities such as tabs or staples also cause paper jam. Attempting to load any feeder during printing as well as overfilling the feeder can cause paper jam. The use of paper with embossed lettering, perforations or texture that is too smooth or too rough is to be avoided. Preprinted forms must be printed with non-flammable, heat resistant ink that does not melt, vaporize or release hazardous emissions when subjected to the high fusing temperature of laser printers of the order of > 200°C for nearly 0.1 second.

The paper jams may occur in different areas such as internal area, output bin as well as in the input trays. If the paper jam happens, the printer stops working and the status is displayed on the panel display. To bring the printer back to its normal working state, it is necessary to clear the paper jam. For this, the button is pushed to open the print cartridge door and then the print cartridge is removed. If the jammed paper is visible, it is grasped with both hands and then pulled out slowly. The cartridge is replaced and the cartridge door is closed. If no paper is seen jammed inside the cartridge door, the jam release door is opened which is present at the back of the printer. Here, if the jammed paper becomes visible, then it is pulled out slowly. After this, the jam release door is closed and working is started. While clearing jams, it is advisable to not tear the jammed paper. Even a small piece of paper remaining in the printer may cause paper jams.

Printer does not work due to several reasons. For troubleshooting, it is necessary to determine where the fault has occurred and which part is not working. The fault regions may be the cable, printer or the power supply. As a first step, the power supply is checked. The printer is turned off and then it is turned on again and so as to check its working. A self test of the laser printer is done. It must be ensured that the printer is turned on and it is in online mode by observing the status of LEDs. The printer signal cable must be properly connected to the connector of the printer and to the ports of the computer. Necessary printer driver is to be installed for the working of the printer. The printer port is to be assigned correctly in the operating system as well as in the *configuration/setup utility* program. The printer cover must be closed and the toner cartridge must be installed properly for getting the prints. If the printer still remains non-working, the signal cable is replaced with a new cable and the test is done once again.

Several status alerts appear on the panel when certain problems occur. The alerts are displayed when the tray is empty, when there is paper jam inside the printer, when an incompatible toner cartridge is used, when the paper is of poor quality, etc. On clearing the fault displayed in the panel, the printer starts working.

12.19 LASER PRINTER: COMMON PROBLEMS AND SOLUTIONS

Some of the common faults associated with the laser printers and their suggested solutions are given in Table 12.6.

Table 12.6 Laser Printers: Common Problems and Suggested Solutions

Problem	Solution
Printer does not work.	Check whether the printer is turned on and the indicator LED is glowing. Check the input power supply. Ensure that the power cable and data cable are connected properly and are working. Check the configuration parameters. Reinstall the printer software and reconfigure the device. Print a demo page to ensure the working of the printer.

Problem	Solution
Paper is not feeding correctly.	Use the paper having appropriate thickness and quality. Do not overload the tray.
Light or faded print is appeared.	Print density option in the printer software is set to light or the economic mode is turned on. Change the settings and try again. Low toner cartridge supply can be another reason. Take out the toner cartridge, redistribute the toner and replace it.
Toner dots or specks are appearing in the prints.	Replace the cartridge, as it is an indication of defective cartridge. It may also be due to dirty paper path. So, clean the path.
Dropouts are appearing in the prints.	Replace the cartridge, as it may be due to defective cartridge. Avoid using poor quality media. Use better quality media.
Vertical lines are existing in the prints.	Replace the cartridge as it is due to defective print cartridge.
Grey background is appearing in the prints.	Defective toner cartridge. Replace the print cartridge. Density setting is high. Change the setting in the software.
Vertical repetitive defects appearing in the prints.	Toner cartridge may be damaged. Replace it. Also replace the fusing assembly, if damaged.
Appearance of toner smear.	Dirty media guides. Clean the guides. Defective print cartridge. Replace it with a new one.
Loose toner is appearing on the prints.	Clean the printer. Set the temperature to the correct value so as to low the fuser temperature..
Blank page printing.	The toner cartridge is out of toner. Replace the toner and try again. If the document page is blank, a blank page is printed. Hardware defect can also print a blank page. Make a testing by printing a configuration page. If the problem is not solved, replace the printer.
Slow printing.	Complexity of page is high. Media used is not the required one.
Pages do not print.	Data cable fault or printer fault. Check with a new data cable.
Network printer does not work.	It is due to connectivity problem. Protocol is not enabled in the printer software.
Regular paper jam.	Presence of too much paper in the tray or the paper debris is present inside the printer. Remove it.
Wrong text printing.	Loose or defective printer cable. Wrong printer driver software.

Problem	Solution
Out of memory error is displayed.	Check the settings and properties. Check the memory chip for loose contact or damage. If required, replace the memory. Use of large spool space requires more memory space. Clear the hard disk and release enough space.
When trying to print, a message *Error writing to LPT1* is displayed on the computer screen.	Make sure that the printer is set online. Ensure that the cable is free from defects and is firmly fixed to the parallel port. Turn off the printer and restart. This will solve the problem. If the problem is not solved, uninstall the printer driver software and then reinstall. Restart the machine and try again.

12.20 MULTIFUNCTION DEVICES (MFDS)

The multifunction devices provide facilities for copying, printing, scanning, sending e-mail, faxing over the internet and network scanning at the same time. These are the integrated devices that converge the functions of all the above different types of devices. The multifunction devices have emerged as the communication hub for the networked offices. These type of machines cost less in comparison to the total cost of different stand alone machines. These devices are compact and provide single print easy solutions. These are easy to use and fulfill the current office communication needs. The multifunction devices are available in different variants such as monochrome, colour, inkjet and laser. The different components of a typical multifunction printer are shown in Figure 12.12.

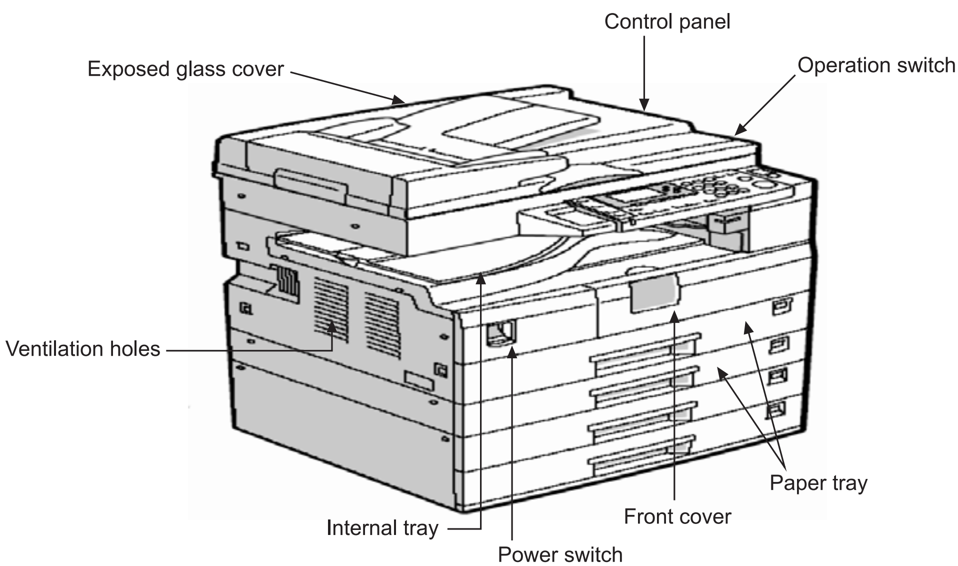


Figure 12.12 Multifunction device components.

Multifunction device engines are of two types such as copier-based devices or printer based devices. Copier-based devices have separate drum and toner cartridges, whereas the printer-based devices are integrated to form a single unit. Toner and drum have different duty cycles for copier-based devices. The advantage of having separate toner and drum is that if one of them is exhausted, it is needed to replace only the exhausted part only. In this type of device drum, duty cycle is always more than twice that of toner duty cycle. So, the running cost is less. In printer-based devices, the duty cycle of the unit is the same as that of the duty cycle of the drum. Inkjet and laser types multifunction printers are available. Ink multifunction printers are suitable for common uses. Both the types of multifunction devices cater to their own dedicated printing segments.

Most of the multifunction devices perform three functions, i.e., print, scan and copy. Fax-based machines are less popular. The features of these devices are determined by the features associated with the main unit as well as the printer and the scanner. Desktop type is the basic type of multifunction devices suitable for office purposes. Advanced devices with several value added features are used in commercial segments. Of the different features, the important feature is the print or the scan resolution of the device. The resolution of printer or scanner refers to the hardware ability of the device. The scanning resolution determines the ability to extract the minor details from the image or the document. Features such as copying speed, size of buffer, paper tray capacity, OCR ability are also considered while purchasing these devices. Two types of scanner technologies are available. One is the **flatbed type scanner** and the other is the **sheetfed type scanner**. Flatbed scanners offer greater convenience while scanning as compared to the sheetfed type scanners. The availability of Automatic Document Feeder (ADF) tray is another feature available in several multifunction devices.

12.21 MULTIFUNCTION DEVICE SPECIFICATIONS

The multifunction devices are having different specification parameters. The common specification parameters are given in Table 12.7.

Table 12.7 Multifunction Device Specifications

Parameter	Typical value
Type	Desktop
Printing engine	Printer-based/copier-based
Print resolution (dpi × dpi)	2400 × 600 dpi
Input buffer	64 MB
Input-output tray capacity	100 sheets
Duplex option availability	Yes
First page print time	6 seconds
Printing speed	32 ppm
Copying speed	38 ppm
Enlarge/Reduction ability	200 %/50 %

Parameter	Typical value
Type of media	Different types
Scanner type	Flatbed/Sheetfed
Scanning resolution	600 dpi
Size/depth of scanning	A4/24
OCR scanning capacity	Yes
ADF availability	Yes
Scanning standards used	TWAIN
Scanning resolution	1200 × 1200 dpi
Paper tray capacity	500 sheets
Computer connectivity	USB
Power consumption	450 W

12.22 INSTALLING MFD

The installation of MFD is similar to the other types of printers.

(a) The first step is to install the MFD in a level flat surface. Adequate ventilation must be available on all the sides of the device.
(b) The cartridge is taken out of the container.
(c) The front cover is opened and the toner cartridge is installed properly.
(d) The power cord is connected to the mains power supply.
(e) The data cable is connected to the interface of computer.
(f) When the printer is turned on, the computer detects the newly added printer and prompts for the printer driver medium. Otherwise the *Add Printer Wizard* can be launched. The wizard works in an interactive manner. Necessary printer driver files are copied and are installed in the computer by the wizard.
(g) The device installation can be finished within some mouse clicks. To check the installation, a test page can be printed.
(h) Depending on the feature, the device can also be connected to a network so that the users connected to the network can use the device.

12.23 MAINTENANCE AND TROUBLESHOOTING

The paper jams are quite a common problem with printers. Applying force to remove the jammed paper is to be avoided by all means. Every time a line is printed, the cartridge moves from its original position across the printer and then reverts to its initial position. Applying force causes the rollers to turn leading to the movement of the cartridge within the printer. This causes the paper to be crushed or to tear. Shutting off the printer and restarting it can also cause the cartridge to move, thus resulting in the tearing of the paper. During a paper jam, the printer and computer are left ‘on’. To remove the jammed paper, the rear access door is opened. The jammed paper can be seen through the rear door and the paper can be removed easily by pulling it out without affecting the rollers or touching any of the internal machinery. Pulling the paper out with too much force is to be avoided. If the paper is torn in many smaller parts, then it means that the paper has been crushed. In such case, a small brush should be used to remove the paper that is present between the rollers as well as to clear away the smaller scraps of paper that are scattered in the innards of the printer. Touching the roller and the inner components is to be avoided while clearing the paper jam.

12.24 MULTIFUNCTION PRINTER: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the multifunction printers and their suggested solution are given in Table 12.8.

Table 12.8 Multifunction Printer: Common Problems and Suggested Solutions

Problem	Solution
Printer does not work.	Check whether the printer is turned on and the indicator LED is glowing. Check the input power supply. Ensure that the power cable and data cable are connected properly and are working. Check the configurations. Reinstall the printer software and reconfigure the device. Print a demo page to ensure the working of the printer.
Display is not visible.	Ensure that the device is turned on. Make sure that the contrast level is appropriately set.
Document is not printed.	Ensure that there is paper in the tray. Check whether the MFD is turned on and the data cable is properly and firmly connected.
Printing does not start.	Make sure that the printer is set in the online mode and is properly configured. Check the data cables and ensure that the cable is firmly connected.
Paper is not feeding correctly.	Use the paper having appropriate thickness. Do not overload the tray.
Light or faded print is appeared.	Print density option in the printer software is set to light or the economic mode is turned on. Change the settings and try again. Low toner cartridge supply also results in faded prints. Take out the toner cartridge, redistribute the toner and replace it.
Printed copies appear dirty.	Image density is set too dark. Adjust image density. Check the toner cartridge. Replace it, if required.
Printed copies appear light.	Image density is set too light. Adjust image density.
Printing speed is very low.	This may be due to complex data in the document. Selecting lower resolution for graphics data can speed the printing.
Graphics are not printed correctly.	Install the correct device driver software.
Some characters are not printed or are printed differently.	Install the correct device driver software.
Frequent paper misfeeds.	The tray is overloaded. Avoid to use improper type of paper.

13

Scanners and Speakers

Two other peripheral devices commonly used with the computer systems are document scanners and audio speakers. These peripherals are commonly called as **scanners** and **speakers**. The scanners scan the documents and convert them to files that can be used by the computers. The audio digital files stored in the computer systems are heard with the help of audio speakers. In this chapter, details about the document scanners and audio speakers are given.

13.1 FEATURES OF SCANNER

Scanners are the devices that convert physical documents to digital files. This device is becoming very popular due to the increased need for the conversion of physical documents to the computer files. This conversion helps in transmitting the files electronically as well as to archive them and to edit them easily. Scanning the documents using OCR method helps to convert the physical documents into the editable text documents.

Different types of scanners are used in different environments. The most commonly used scanner is *flatbed scanner*. *Sheetfed scanner* and *drum scanner* are the other two types of scanners used. In the **flatbed type**, the scanning head moves past the document to be scanned that is placed on a glass plate, whereas in the **sheetfed scanner** the document moves past a stationary scanning head. Flatbed scanners are faster than the sheetfed type scanners.

The scanners are classified based on different features such as warm up time, scanning speed, scan resolution, scan depth, platform size, OCR capability, reduction or enlargement features, interface used, and so on. The **resolution** of scanning determines the scanning sharpness of the documents which is to be scanned. Different scanning resolutions are used for scanning the documents for different purposes. A higher resolution is necessary for scanning photographs. The higher scanning resolution means a sharper reproduction of the document. Another feature of scanner is the **scan depth** or **scan bit level**. Different scanners are capable of scanning at different bit levels or depth levels. A higher scan depth level or increased bit level means that the scanned document can be viewed using more number of colour shades or gray levels. As the scanning depth increases, the size of the scanned digital file also increases. In case of increased file size, more storage space is required and there is a need for increased transmission time through the computer networks. Increased file size slows down the printing and in some cases, makes the image impossible to print on low end printers. In order to avoid all these difficulties, usually scanning is done using an optimum scan depth after considering the size of the scanned file. The **platform size** of scanners determines the maximum size of the document that can be scanned using the device. Certain scanners scan up to A4 size documents while certain others can have the capacity to scan large-sized documents of A3 size and so on. **OCR capability** is a feature available with most of the new types of scanners. It enables to convert a physical document into an editable digital text file. Scanners are connected to computers using different interfaces. Earlier scanners used parallel or SCSI interfaces, while the new scanners make use of USB interfaces. Two common scanning compliant standards used with different applications are *TWAIN* and *WIA* interfaces. **TWAIN** interface is a universal standard designed to link the applications and different image acquisition devices such as scanners, cameras, etc. If an application is TWAIN compliant, the image scanned using the scanner can be brought directly into the application.

13.2 COMPONENTS OF SCANNER

The different major components of a flatbed type scanner are shown in Figure 13.1. The components that can be identified externally are scanner lid, signal and power interfaces on the rear side and buttons for performing different scanner operations. The scanner lid can be lifted up. The documents for scanning purposes are placed below the scanner lid in the scanner glass with the side to be scanned facing downwards. The light source and the scanner head are fixed below the scanner glass in a small compartment and the compartment is permanently sealed.

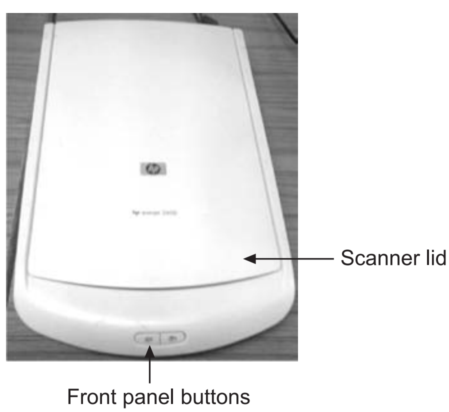
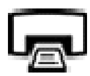


Figure 13.1 Flatbed type document scanner.

The buttons on the front panel are used for scanning, copying and scanning to PDF documents. The functions of different buttons can be understood with the help of icons marked on them. These buttons act as shortcuts to often used scanning functions. The purpose of different icon markings are described in Table 13.1. Apart from the use of buttons, the different scanner operations can be performed using the scanner software installed in the computer connected to the scanner.

Table 13.1 Front Panel Button Icons and their Purposes

Icon	Feature	Purpose
	Scan	Scanning
	Copy	Scanning and sending to a printer to get a copy
	Scan to PDF	Scanning and saving as a PDF file

13.3 SPECIFICATIONS OF SCANNER

The scanners are having a small number of specification parameters. The commonly stated specification parameters for scanners and their typical values are stated in Table 13.2.

Table 13.2 Scanner Specification Parameters

Feature	Typical value
Scanner type	Flatbed
Scanning element	Charge coupled device (CCD)
Interface	USB
Hardware resolution	1200 dpi
Power input	230 V AC

13.4 WORKING OF SCANNERS

The major internal components of a scanner are light sensitive diodes, a light source, lens, mirror and a stepper motor. The stepper motor moves the scan head across the document to be scanned. The light source generates the necessary light for scanning the documents. The document that is to be scanned is placed on the glass plate with the side to be scanned facing downwards. The glass plate used is larger than the size of the document that is to be scanned. The quality of scanning depends on the quality of the glass plate. If there is dust or smudge on the glass plate, the scanned image will not be clear. The light source used can be either a Cold Cathode Fluorescent Lamp (CCFL) or xenon lamp. Xenon lamp offers better performance as compared to CCFL. The light source lights up the area that is to scanned using pure white light. It is placed in the scan head alongwith the Charge Coupled Device (CCD). The light hits the document and the image is reflected off or transmitted to the diode through the object that is scanned. This process is done with the help of mirrors. Two or three mirrors are common in several scanners. The image is then focused on the CCD array using a lens. The CCD arrays are madeup of photosensitive cells that are having the capacity to sense the light energy and to convert this into the electrical signals. CCD is considered as the heart of the scanner. It measures the light intensity falling on them and converts the image in the form of electrical charge. The arrangement of mirrors and lens is very critical for the proper working of scanners. Mirrors and lens are to be placed correctly so that all the light is concentrated accurately on the CCD. Otherwise, some area of the scanned document is lost. An analogue to digital converter converts the received information into digital form and this is stored as a digital file in the computer. Each pixel of the scanned document is created by one CCD element of the array. The number of CCD elements forming the array is a factor that is determining the hardware or scanning resolution. For a scanning the resolution of 600 × 1200 pixels, 600 numbers of CCD are arranged in a horizontal fashion. The vertical resolution of 1200 denotes that the stepper motor is capable of moving at the rate of 1/1200th of an inch in a vertical fashion.

13.5 INSTALLING SCANNER

Installation of scanner is similar to the installation process done for the printers. The scanners are equipped with the power cables and data cables as well as with the scanner driver software medium. The following steps are to be taken for installing a scanner:

(a) First of all, the scanner is taken out from the packing and is placed on a flat surface having sufficient ventilation all around it.
(b) One end of the signal cable is connected to the scanner and the other end is connected to the port of the computer.
(c) To ensure the proper working, the signal cable available with the scanner must be used.
(d) The power cord is connected between the scanner and a well-grounded electrical outlet. The connections of the power cable and signal cable are shown in Figure 13.2.

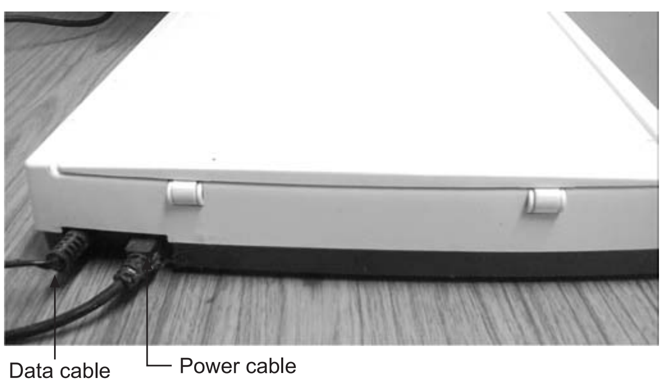


Figure 13.2 Connecting power cable and signal cable of a scanner.

(e) For the working of the scanner device, the scanner driver software is to be installed in the computer and the software is to be configured correctly. For this, the scanner is powered on first.
(f) After this, the computer is switched on.
(g) The plug and play feature available in new operating systems enables to detect the presence of the new connected device and the computer prompts for inserting the device driver medium in the optical drive. This step initiates the installation of the driver software.
(h) The installation process proceeds interactively and finishes easily.
(i) After installing and configuring the scanner, documents can be scanned and saved in the computer system as a digital file.

13.6 SCANNING PICTURES AND DOCUMENTS

Scanning the documents and converting them into digital files can be done in two ways. One way is to use the front panel buttons for scanning and the second way is to use the options from the scanning software installed in the connected computer. A document containing text matter can be scanned and saved as an editable digital file or as an image file unable to edit. To scan a picture, following steps are to be applied:

(a) The first step is to power on the scanner and to wait for a few seconds for its initialization.
(b) When the scanner is turned on, the carriage on the scanner moves forward and backward approximately 25 mm and the scanner lamp gets turned on.
(c) After this, the scanner lid is opened and the picture or the document is placed on the scanner glass facing downwards, as indicated by the reference marks on the scanner glass. It is shown in Figure 13.3.

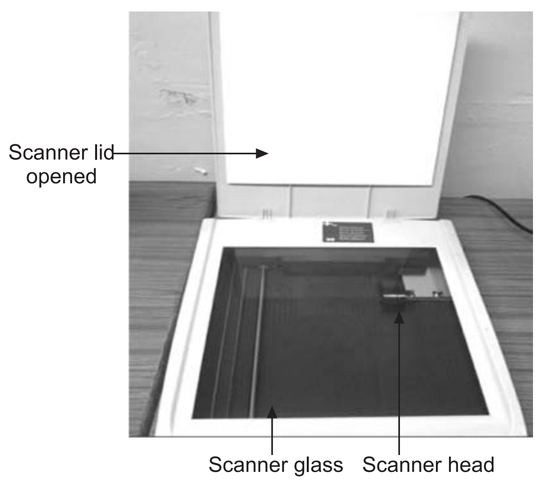


Figure 13.3 Scanner ready for scanning with its lid open.

(d) The lid is closed and then the scan button present on the front panel is pressed.
(e) A dialog box appears on the screen asking the type of scanning required. Since, the scanning is done for creating a picture file, the option for picture type scanning is clicked. Also, the location where the original matter is placed (such as scan originals from glass) is selected.
(f) Now, the scan option is clicked.
(g) In the preview that appears on the screen, the final area for scanning can be selected.
(h) The software saves the scanned document to a file in the specified subfolder. The subfolder is named with the current year and month, by default.
(i) The process can be repeated for scanning more pictures.
(j) The scanning software can automatically correct the pictures and restore faded colours in the old pictures. To turn the picture correction on or off, the options are selected from the menu of the scanning software. The preview option helps to get a preview of the scanned picture.

Different steps for scanning the text documents are same as described above. For text documents, the colour option is set as black and white. This is the ideal option for scanning black and white graphic text documents. Selection of this option is not advisable for the colour documents when the original style of documents is to be maintained. Using the *Scan to PDF* button on the front panel, it is possible to scan a text document or a picture and to save it in the form of a PDF file. When this option is used, the scanned text may not appear on the computer exactly as in the original text, especially if the original matter contains faint or smudged text. Some characters can be incorrect and some others can be missing. Comparing the scanned text with the original one and then making the necessary corrections is the ideal solution for this problem. Using the *Copy* button on the front panel, it is possible to scan a document and then send it directly to a printer to get a hard copy. Different scanner setting options help to print more than one copy, lighten or darken the intensities of printed copies, enlarge or reduce their size.

13.7 TIPS FOR SCANNING

For effective working of the scanners, the computer system must have the minimum system requirements as specified. Sufficient free space must be available in the hard disk of the computer system for storing files. To check whether a scanner is working, the *Scan* button is pressed for nearly five seconds, after powering on the scanner. If the scanner is working, the scanner carriage must move forward and backward. It is advisable to select the area for scanning instead of making a scanning of the complete document. This type of selective scanning helps in speedy scanning process. Using a high resolution for normal scanning purpose is to be avoided. The optimum level of the scanning resolution must be selected depending upon the nature of output required. Higher resolution is necessary only for high clarity images. The file format for saving the scanned image must be selected suitably. Images saved in *jpg* formats occupy much less space as compared to other image formats. For better results, a scanner is used having a white surface under the lid. The document that is to be scanned must not have wrinkles on its surface, as the appearance of wrinkles affect the quality of the scanned image.

Placing the items with sharp edges on the scanner is to be avoided, as this can damage the scanner. Also, the item must be free from glue, fluid materials or such type of things that can be transferred to the scanning glass.

13.8 MAINTENANCE OF SCANNER

While working with scanners, there are a number of activities that are to be done and there are certain other activities that are to be avoided for keeping the scanner in good condition. While operating the scanner, it is kept on a flat surface. Scanner must be kept away from direct sunlight, heat, water and moist environments. The cables supplied alongwith the scanner must be used for connecting to the computers as well as to the electrical power outlet. The scanner is unplugged before doing any work on the device. Occasional cleaning of the scanner glass gives good quality scans. Cleaning of glass is essential, if it contains finger prints, ink, dust or smudges, without using any type of cleaning solution. The cleaning of the scanner glass can be done using a piece of soft cloth sprayed with a mild glass cleaner. If too much glass cleaner is applied, it will flow to the edges of the scanner glass and then into the scanner mechanism and can damage the scanner mechanism. The scanner glass must be completely dry before its use. It is not desirable to unscrew the scanner glass from its place.

13.9 SCANNER: COMMON PROBLEMS AND SOLUTIONS

Some of the common problems associated with the scanners and their suggested solutions are given in Table 13.3.

Table 13.3 Scanner: Common Problems and Suggested Solutions

Problem	Solution
No power supply is coming to the scanner.	Ensure that there is power supply in the mains. Check the power cable. Check the scanner power switch. Ensure that the scanner is connected properly.
Scanner Initialization Failed or *Scanner Not Found* error message is displayed on the computer screen.	Turn off the scanner and computer. Disconnect and reconnect the signal cable. Restart and try again. If the problem still exists, check the cable for any kind of damage.
Scan comes out blurred.	Setting the scanning resolution to a high value will solve this problem.
Scanning is at high resolution and display of *Out of Memory* error.	Scanning at high resolution produces large-sized files. Making available enough free space will solve this problem.
Scanned picture does not display the original colour.	Setting the colour scan bit depth to an increased value can solve this problem.
Scanner does not work properly.	Connect the cables firmly and correctly. Restart the computer and the scanner. Reinstall the scanner software.

Problem	Solution
Scanner does not scan right away.	If the scanner has not been used for a while, the scanner lamp has to go through a warm up period before the beginning of scanning process. For scanner lamp to warm up, it takes some time after starting the software or pressing a scanner button for scanning to begin.
Scanner buttons appear to be not working.	Connect the cables firmly and correctly. Restart the computer and the scanner. Ensure that the scanner buttons are not set to disabled state in the scanning software.
Fuzzy scanned image is appeared.	The document for scanning must be placed in close contact with the scanner glass. Fuzzy image is created because the document is not placed in full close contact with the scanner glass.
Scanning takes place very slowly.	For scanning the documents as text files, scanning takes place at lesser speeds. In other cases, setting the scan resolution to a lower value can speed up the scanning process.
Scanner cannot be turned off.	If a separate power on/off switch is available, it can be used for turning off the device. If no switch is available, it is necessary to disconnect it from the mains power supply.
Scanner lamp does not turn off.	The scanner lamp turns off automatically after a period of inactivity.

13.10 COMPUTER SPEAKERS

Speakers are the electromechanical devices that convert electrical signals to audio waves. These systems are essential while playing movies or games, as these provide powerful and well-defined sound signals. Nowadays, different types of speakers are used with the computer systems. These different speakers differ in their power rating and output quality. Also, the speakers are fitted in cabinets having different shapes. *Desktop stereo speaker*, *laptop mono type*, *laptop stereo type*, *monitor stereo*, *keyboard stereo*, *surround sound* are some examples of different types of speakers used with the computers. Different speakers produce different types of acoustic experiences to the user. New types of speakers are able to create a realistic acoustic experience. The ability for convergence integrates a home entertainment system within the computer itself. New generation speaker systems provide support for surround sound standards such as *Dolby Digital* or *Digital Theatre System (DTS)*. Some of the typical speakers can be seen in Figure 13.4. Small types of speakers can be placed on the desktops while certain big type of speakers are fixed on stands or are mounted on the walls or placed on the floor. The speakers are having power on/off switch as well as volume control knob. A separate speaker is not necessary in the new computer systems, since it is integrated with the laptops, monitors and the keyboards.

Figure 13.4 Typical computer speakers.

13.11 WORKING OF SPEAKERS

The different components that make up a speaker system include diaphragm, magnet, voice coil, spider, etc. These components are marked in Figure 13.5. The core component of a speaker is a permanent magnet. A wire coiled around a metallic framework that surrounds the permanent magnet is known as spider. The voice coil is suspended by this corrugated component spider. When a current is applied to the voice coil, it oscillates and in this process, it compresses and expands the air immediately in front and behind it. This produces ripples in the air, which in turn, produces sound waves that can be heard. The entire assembly is enclosed in a metallic framework known as basket.

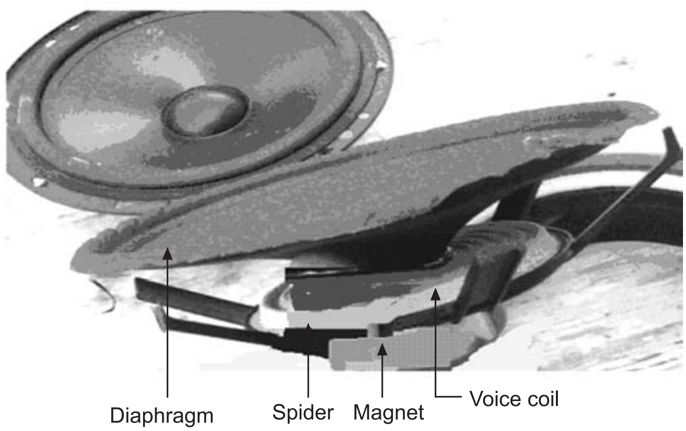


Figure 13.5 Components of speaker.

13.12 SPEAKER SPECIFICATIONS

The primary feature specification of the speaker is **power rating** of the speaker which is measured either using RMS rating or *Peak Music Power Output* (*PMPO*). **RMS power** is defined as the measure of the ability of the speaker to handle continuous power. This is the true technical measure of the ability of speaker to handle continuous power. Normally, 40 W RMS is an ideal choice for the audio systems. **Frequency response** is another feature of speakers. Speaker must function in a specific frequency range for effective working. Usually, the speakers are functioning in a frequency response range of 40 Hz–18 kHz. The important specifications associated with the speakers are given in Table 13.4.

Table 13.4 Specification of Speakers

Parameter	Typical value
Power rating	40 W RMS
Frequency response range	40 Hz – 18 kHz
Connectors	Front, rear, etc.
Controls available	Volume, bass, mute, etc.
Bundled accessories	Power adapter, speaker stands, etc.

13.13 ADDING SPEAKERS

Similar to the other peripherals connected with the computers, speakers also require two connections. One connection is the power connection to an electrical outlet and the second is the connection to the computers. Signal cables of the speakers are connected to the audio jacks present in the panel of the computer systems. Since, the computer motherboards integrate audio also, the necessary driver software for audio devices can be installed from the motherboard driver CD. Different operating systems provide facilities for controlling the sound and audio properties of connected devices. Windows-based operating system controls the properties of speakers by opening the window of sound and audio devices through the *Control Panel.* Double clicking the icon displays a window with a number of tabs, as shown in Figure 13.6. Options available when opening the tabs help to control the different associated speaker properties.

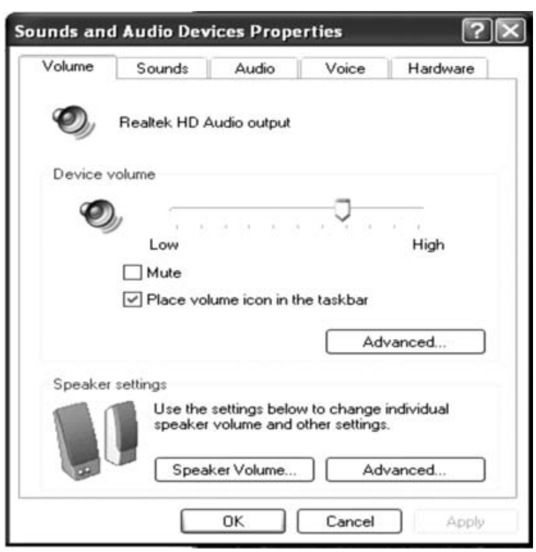


Figure 13.6 *Sound and Audio Devices Properties* window.

13.14 ADDING AUDIO CARDS

For audio conferencing and for gaming purposes, the built-in or on-board audio abilities of the motherboard are not sufficient, as these process only a limited features. For such purposes, an add-on audio card is used in the computer systems. Sound cards are also known as audio adapters. These cards are capable of generating clear and powerful audio. Many audio cards support several advanced features. The process of installing the audio card in computer systems is simple. This is similar to the process used for adding other add-on cards.

(a) As the first step, the system is switched off and then the chassis is opened.
(b) In the motherboard, any free expansion slot is located.
(c) The audio card is inserted in the free slot and it is screwed firmly.
(d) The cabinet is then closed and the computer system is switched on. The computer inspects the system and prompts for the installation of device driver software.
(e) The device driver medium can be inserted in the optical drive and the software can be installed easily.

Audio adapters offer several advanced features such as wave table synthesis, high bit rate recording depth and digital input and output connectors. Use of audio adapters helps in getting professional theatre quality music at reasonable rates. They offer facilities for enjoying theatre quality audio experiences with homely atmosphere. There are certain other specification features that are needed to be considered during the selection of audio cards. Some of these features include the number of supported channels, built quality, operational performance, support for common interfaces and so on.

13.15 SPEAKER: COMMON PROBLEMS AND SOLUTIONS

Some of the general problems associated with the speakers and their suggested solutions are given in Table 13.5.

Table 13.5 Speaker: Common Problems and Suggested Solutions

Problem	Solution
No power supply is coming to the speaker set.	Ensure that there is power supply in the mains. Check the power cable. Ensure that the speakers are connected properly and securely.
Power supply is coming to the speakers but no sound is coming from it.	Check the connection to different interfaces and ensure that all the connections are made properly and securely. Ensure that the volume is not set to mute.
Speakers are affected by too much interference from surroundings.	Check the presence of any other electronic device in the vicinity. Keep the speakers away from such devices.
No audio is coming when an audio CD is played.	Enable digital audio from CD/DVD from the settings.
Distorted sound is appeared while playing music.	Try another music file and ensure that the fault is not due to the fault in the associated file. Check the speakers.
Speaker volume is too low.	Check the volume control.

Appendix
I

Worksheet

After a thorough study of all the chapters of this book, it is time to test what you had studied from the book. Read the following questions and then complete the given worksheets:

1. Identify and name any eight parts from the front panel of a desktop computer shown in Figure A.1.

1.

2.

3.

4.

5.

6.

7.

8.

Figure A.1 Desktop computer—Front panel.

2. Name the parts of a laptop computer labeled as 1, 2 and 3 in Figure A.2.

Figure A.2 Laptop computer.

1.
2.
3.

3. Name the components of a typical motherboard which are labeled from 1 to 8 in Figure A.3.

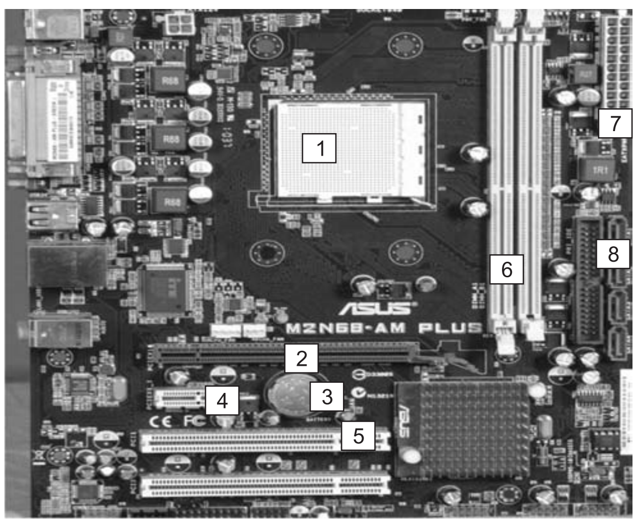


Figure A.3 Motherboard.

1.	4.	7.
2.	5.	8.
3.	6.	

4. Name the two types of cables shown in Figure A.4.

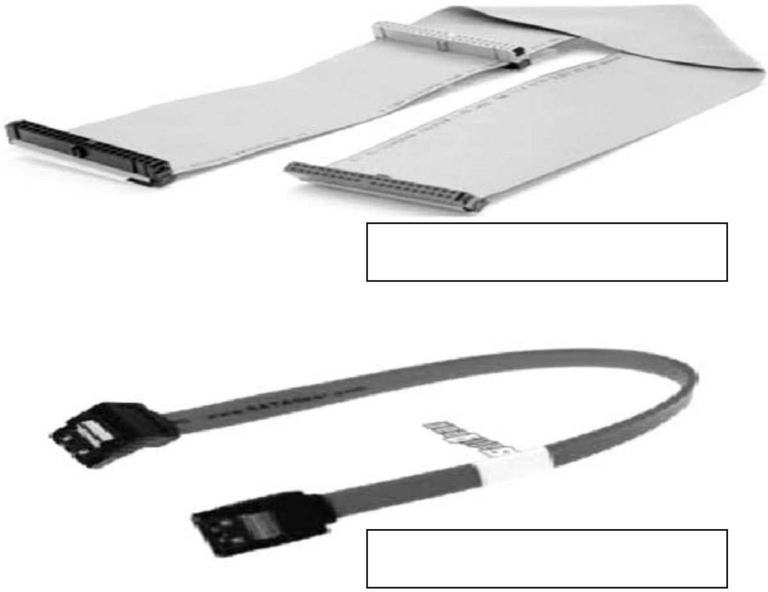


Figure A.4 Two types of cables.

5. Name the different ports of a motherboard shown in Figure A.5.

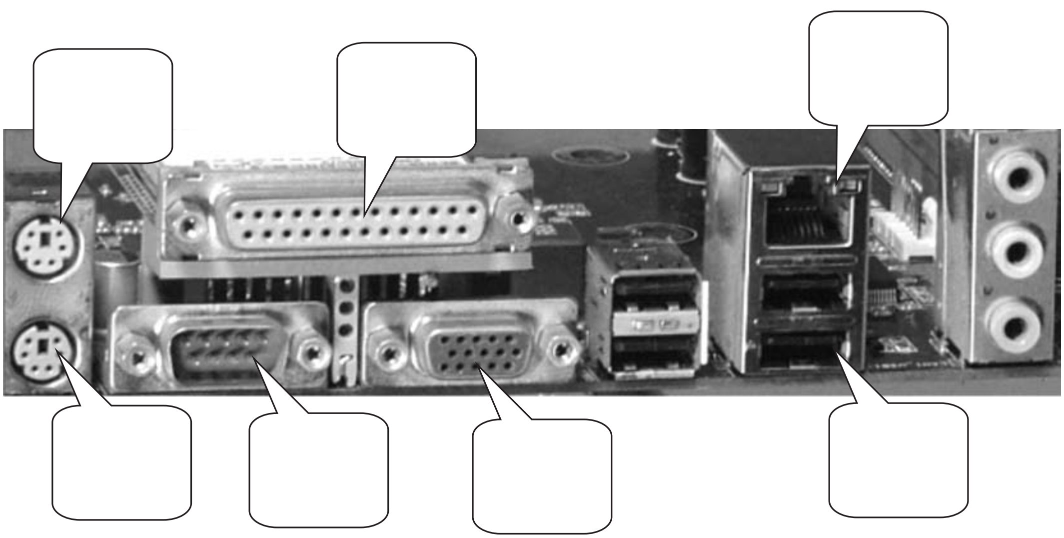
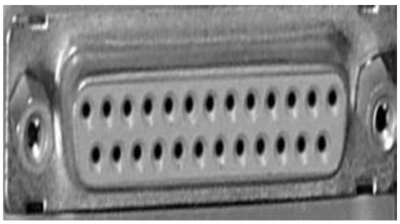
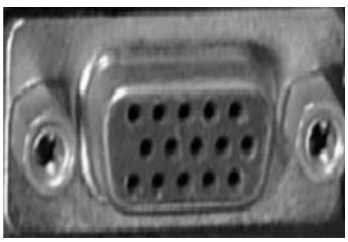


Figure A.5 Motherboard ports.

6. Match the ports shown in column A with the connectors shown in column B.

A	B
 1.	 (a)
 2.	 (b)
 3.	 (c)
 4.	 (d)
 5.	 (e)

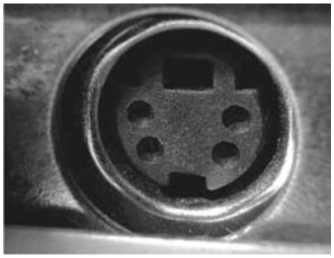
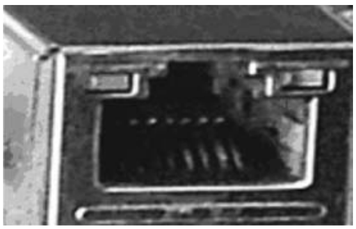
 6.	 (f)
 7.	 (g)

Figure A.6

1.   2.   3.   4.

5.   6.   7.

7. Name the different internal parts of the hard disk shown in Figure A.7.

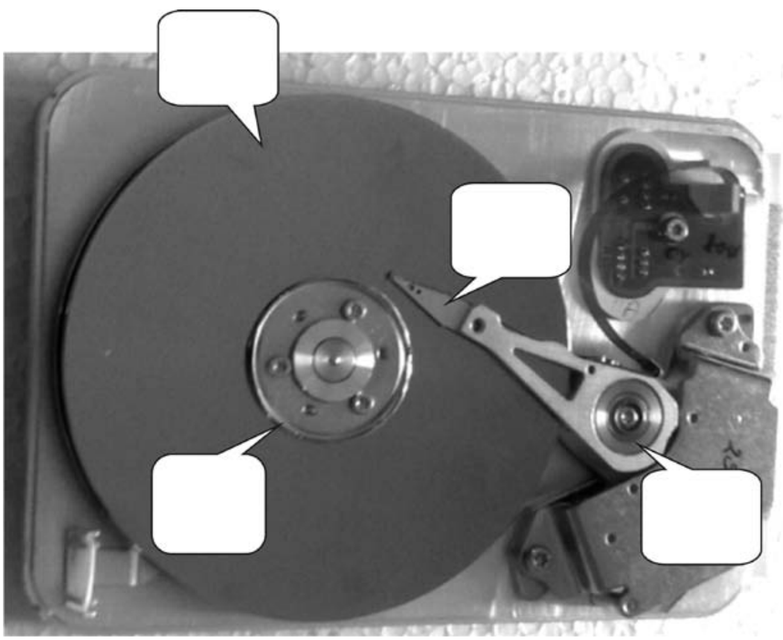


Figure A.7 Parts of a hard disk.

8. Identify the type of hard disk shown in Figure A.8.

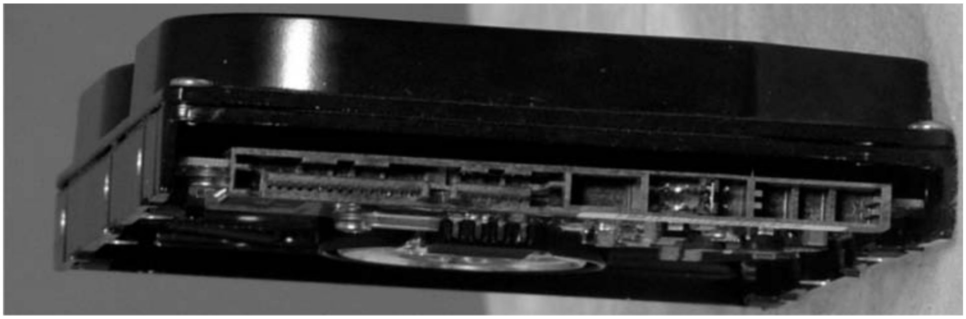


Figure A.8 Hard disk.

9. Name the devices to which the different connectors of a power supply unit, shown in Figure A.9, are connected.

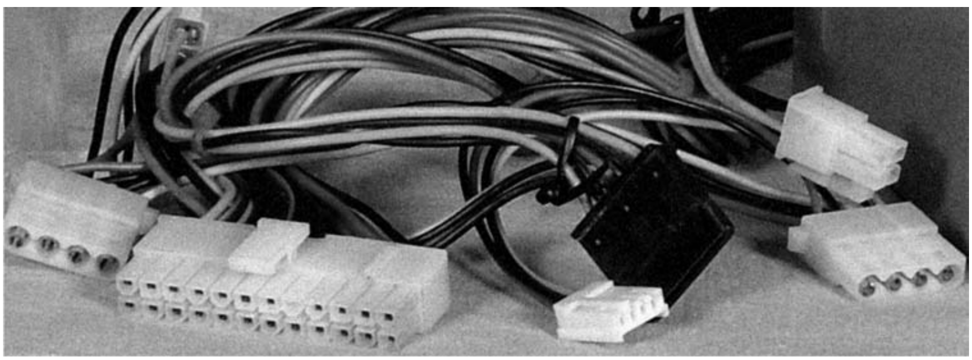


Figure A.9 Different connectors of a computer power supply unit.

10. Expand the following acronyms:

(a) IBM ....
(b) RAID ....
(c) LCD ....
(d) DVD ....
(e) PS/2 ....
(f) VLSI ....
(g) ATX ....
(h) FSB ....
(i) AGP ....
(j) DIMM ....
(k) SIMM ....
(l) DDR3 ....
(m) SLI ....
(n) POST ....

(o) BIOS ....
(p) IDE ....
(q) SMPS ....
(r) SATA ....
(s) SCSI ....
(t) USB ....
(u) PCIe ....
(v) CMOS ....
(w) DVI ....
(x) HDMI ....
(y) RISC ....
(z) ATAPI ....

11. Give the specifications for a general purpose desktop computer system.

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12. State the precautions to be taken before disassembling a computer system.

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13. State the different management features available in the new motherboards.

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14. Explain the features of DDR1, DDR2 and DDR3 memory.

15. State the problems that would exist when the computer system is operated directly from mains power supply.

16. Define the terms dot pitch, contrast ratio, interlacing, refresh rate and aspect ratio of the computer monitors.

17. State the common maintenance steps required for a keyboard and a mouse.

18. Mention the steps for installing an operating system in a computer.

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19. State the common problems associated with the laser printers and their solutions.

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20. State the steps for scanning a document using a flatbed scanner.

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Appendix II

Test Your Knowledge

Time allowed: 60 minutes

Choose the correct answer from the given options. After marking all the answers, check with the correct answers given at the end.

1. Arithmetic operations performing unit of the computer systems is
(a) VDU (b) mouse
(c) keyboard (d) CPU

2. Which of the following is an operating system?
(a) Microsoft Word (b) Windows
(c) Photoshop (d) Pentium

3. LED is a term associated with
(a) memory (b) hard disk
(c) display (d) mouse

4. Tablet computer introduced by Apple is known as
(a) iMagic (b) ipad
(c) ipod (d) itab

5. Dual core is a type of
(a) processor (b) hard disk
(c) CD (d) memory

6. CPU speed is indicated in units known as
(a) Hz (b) kHz
(c) MHz (d) GHz

7. Award is the name of
   (a) motherboard (b) processor
   (c) BIOS (d) memory

8. Cache is a term associated with
   (a) computer display (b) computer memory
   (c) operating system (d) power supply

9. A computer internal storage unit is
   (a) hard disk (b) RAM
   (c) DVD (d) BIOS

10. Wrist strap is used to
    (a) protect from static electricity (b) connect to hard disk
    (c) identify the person (d) measure the voltage level

11. RJ45 connector is used for
    (a) connecting the hard disk (b) connecting a printer
    (c) networking a computer (d) connecting a monitor

12. D-sub 25-pin connector is a
    (a) video connector (b) printer connector
    (c) network connector (d) mouse connector

13. A green-coloured PS/2 connector in the rear panel of a desktop computer is usually a
    (a) video connector (b) keyboard connector
    (c) mouse connector (d) speaker connector

14. The number of cores in a quad-core processor is
    (a) 1 (b) 2
    (c) 3 (d) 4

15. Computer power supply unit provides an output voltage of
    (a) 230 V (b) 12 V
    (c) 130 V (d) 6 V

16. Which of the following is considered as the heart of a computer system?
    (a) CPU (b) Memory
    (c) Motherboard (d) Hard disk

17. Type of capacitors used in new motherboards are
    (a) electrolytic (b) ceramic
    (c) embedded (d) solid state

18. Northbridge and southbridge are the types of
    (a) computer memory (b) computer chipsets
    (c) hard disks (d) motherboard

19. Zero Insertion Force is used to describe
    (a) a typical CPU socket (b) a force applied to fix the CPU
    (c) a type of chip (d) a type of internal force

20. Ethernet controller is used to
(a) control calculations (b) control display properties
(c) control CPU temperature (d) control networking operations

21. FireWire is the name of a
(a) computer port (b) computer virus
(c) tablet computer (d) computer game

22. A CPU manufacturer is
(a) IBM (b) AMD
(c) HP (d) Microsoft

23. The CPU fan connector works on
(a) 230 V (b) 6 V
(c) 12 V (d) 3 V

24. Memory slot in computer motherboard with 184 pins is known as
(a) DDR (b) DDR1
(c) DDR2 (d) DDR3

25. A graphics card manufacturer is
(a) IBM (b) HP
(c) NVIDIA (d) AMD

26. A thin hard disk cable with connectors at its both ends can only be the
(a) IDE cable (b) SCSI cable
(c) SATA cable (d) audio cable

27. Data transfer speed of USB 3.0 standard is
(a) 500 Mb/s (b) 1000 Mb/s
(c) 5000 Mb/s (d) 10000 Mb/s

28. 2×10 power connector of a motherboard indicates that the motherboard is
(a) AT type (b) ATX type
(c) small form factor type (d) micro form factor type

29. How many devices can be a connected to a USB port?
(a) 1 (b) 2
(c) 127 (d) 256

30. The I/O address of a computer keyboard is
(a) 30 (b) 40
(c) 50 (d) 60

31. Performance of graphics cards is indicated in units known as
(a) cycles per second (b) frames per second
(c) rotations per second (d) lines per second

32. Level 1, level 2, level 3 are different hierarchical levels of
(a) storage capacity (b) cache memory
(c) processor speed (d) server computer

33. Thermal compound applied on the processor helps to
(a) dissipate the heat easily (b) fix the processor firmly on motherboard
(c) protect the processor from wear (d) increase the performance

34. How many megabytes are found in one terabyte?
(a) 1000 (b) 10000
(c) 100000 (d) 1000000

35. DDR3 memory has a rating of
(a) 400 MHz (b) 800 MHz
(c) 1800 MHz (d) 2200 MHz

36. Each sector of a hard disk can store
(a) 512 bytes (b) 256 bytes
(c) 1024 bytes (d) 1000 bytes

37. Linux operating system makes use of
(a) FAT file system (b) NTFS file system
(c) compressed file system (d) extended file system

38. Error due to invalid media type of hard disks can be solved by
(a) replacing the data cable (b) replacing the hard disk
(c) replacing the power cable (d) formatting the hard disk

39. The unit X is used to measure the speed of
(a) hard disk rotation (b) spinning of optical disc
(c) memory capacity (d) processor speed

40. Buffer under run error is caused when
(a) the BIOS fails (b) the CPU fails
(c) the motherboard fails (d) the writing to optical discs fails

41. A transformer is used in the computer power supply unit to
(a) provide continuous power (b) protect from heavy current
(c) provide smooth output (d) provide low voltage

42. The rating of a normal SMPS unit of a desktop computer is
(a) 400 W (b) 230 W
(c) 12 W (d) 1000 W

43. The earth wire of an SMPS unit is coloured
(a) white (b) black
(c) yellow (d) red

44. The largest connector of SMPS is connected to
(a) motherboard (b) hard disk
(c) optical drive (d) front panel switch

45. SMF in SMF battery is
(a) Switched Mode Free (b) Single Mode Fiber
(c) Solid Multi Fiber (d) Sealed Maintenance Free

46. Which of the following technology is not associated with the UPS?
(a) IGBT (b) EMI
(c) Double conversion (d) DSP

47. UPS battery capacity is indicated in units of
(a) volt (b) ampere
(c) ampere hour (d) volt hour

48. The voltage of a UPS battery cell is
(a) 12 V (b) 6 V
(c) 2 V (d) 230 V

49. Blackout and brownout are the terms related to
(a) power supply (b) colouring schemes
(c) battery capacity (d) flash memory

50. The number of pixels that can be handled in a monitor is known as
(a) pixel capacity (b) screen size
(c) dot pitch (d) resolution

51. Cathode ray tube is used with
(a) TFT monitor (b) LCD monitor
(c) LED monitor (d) None of these

52. A memory used to store display information is
(a) ROM (b) VRAM
(c) DDRAM (d) SDRAM

53. Flickering of computer monitors can be eliminated by
(a) increasing refresh rate (b) increasing resolution
(c) increasing contrast ratio (d) increasing dot pitch

54. A type of LCD display is known as
(a) LED (b) plasma
(c) touch screen (d) TFT

55. Game pad is the name of a
(a) gaming software (b) hardware
(c) cloth (d) computer for playing games

56. DIN connector is usually associated with
(a) keyboard (b) modem
(c) printer (d) monitor

57. Scroll wheel can be seen in
(a) monitor (b) keyboard
(c) mouse (d) gaming device

58. LED of an optical mouse is known as
(a) optical eye (b) control button
(c) power indicator (d) sensor

59. Heat sink can be seen in desktop computers alongwith the
(a) chassis fan (b) motherboard
(c) CPU fan (d) SMPS fan

60. One long beep during computer start up indicates
(a) no error (b) hardware fault
(c) memory problem (d) CPU fault

61. Device driver is a type of
(a) hardware (b) software
(c) input device (d) tool like screwdriver

62. Add-on graphics card is fixed in
(a) AGP slot (b) PCI slot
(c) DIMM slot (d) IDE slot

63. Plug and play means
(a) easy gaming (b) easy fixing
(c) better performance (d) automatic configuring

64. The failure of the computer system to keep the correct date and time is due to
(a) hard disk failure (b) memory failure
(c) CPU failure (d) CMOS battery failure

65. BIOS setup utility can be activated by
(a) switching on the system (b) double clicking the mouse button
(c) executing the software (d) pressing the assigned keyboard key

66. Flashing is a process
(a) to clean BIOS (b) to replace BIOS
(c) to update BIOS (d) to shut down BIOS

67. Silica gel is used to
(a) clean the monitor (b) remove moisture
(c) dissipate the heat generated (d) fix the CPU firmly

68. Display of checksum error is due to
(a) CMOS battery failure (b) hard disk failure
(c) memory failure (d) CPU failure

69. Display unit can be cleaned by using
(a) ammonia (b) spirit
(c) isopropyl alcohol (d) silica gel

70. Touch pad can be seen alongwith the
(a) mouse (b) keyboard
(c) game machine (d) laptops

71. The major use of MFD is
(a) copying (b) testing
(c) troubleshooting (d) measuring

72. The number of toner cartridges used by the colour laser printers is
(a) 1 (b) 2
(c) 3 (d) 4

73. Number of pins available for a dot matrix printer is
(a) 12 (b) 18
(c) 24 (d) 30

74. Print speed of dot matrix printer is indicated in units known as
(a) rpm (b) ppm
(c) cps (d) dpi

75. Toner used by laser printers is in the form of
(a) liquid (b) powder
(c) gas (d) ribbon

76. Laser printers work on the mechanism of
(a) static electricity (b) impact method
(c) spraying ink (d) drawing letters

77. Resolution of printing is indicated in units known as
(a) cpi (b) dpi
(c) rpm (d) fps

78. Computer interface used by laser printers is
(a) serial (b) SATA
(c) IDE (d) USB

79. Vertical lines appearing in laser printer pages can be eliminated by
(a) replacing the cartridge (b) cleaning inside
(c) replacing data cable (d) restarting

80. The capacity of a CD medium is
(a) 500 MB (b) 700 MB
(c) 450 GB (d) 800 GB

ANSWERS

1. (d)	2. (b)	3. (c)	4. (b)	5. (a)	6. (d)	7. (c)	8. (b)
9. (a)	10. (a)	11. (c)	12. (a)	13. (c)	14. (d)	15. (b)	16. (c)
17. (d)	18. (b)	19. (a)	20. (d)	21. (a)	22. (b)	23. (c)	24. (d)
25. (c)	26. (b)	27. (c)	28. (b)	29. (c)	30. (d)	31. (b)	32. (b)
33. (a)	34. (d)	35. (c)	36. (a)	37. (d)	38. (d)	39. (b)	40. (d)
41. (d)	42. (a)	43. (b)	44. (a)	45. (d)	46. (b)	47. (c)	48. (c)
49. (a)	50. (d)	51. (d)	52. (d)	53. (a)	54. (d)	55. (b)	56. (a)
57. (c)	58. (a)	59. (c)	60. (c)	61. (b)	62. (a)	63. (d)	64. (d)
65. (d)	66. (c)	67. (b)	68. (a)	69. (c)	70. (d)	71. (a)	72. (d)
73. (c)	74. (c)	75. (b)	76. (a)	77. (b)	78. (d)	79. (a)	80. (b)

Index

COMPUTER HARDWARE

Installation, Interfacing, Troubleshooting and Maintenance

K.L. James

Computer Hardware: Installation, Interfacing, Troubleshooting and Maintenance is a comprehensive and well-organised book that provides sufficient guidelines and proper directions for assembling and upgrading the computer systems, interfacing the computers with peripheral devices as well as for installing the new devices. Apart from this, the book also covers various preventive and corrective steps required for the regular maintenance of computer system as well as the steps that are to be followed for troubleshooting.

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ISBN:978-81-203-4798-4

9 788120 347984

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