1

COMPUTER INPUT DEVICES

INTRODUCTION

Data can be fed into computer through input devices. The various input devices are :

1. Keyboard
2. Mouse
3. Digitizer
4. Joystick
5. Light pen
6. Scanner

1. IBM PC Keyboard : It is like a typewriter keyboard and is the most commonly used input device.

(a) The three primary keyboard types created by IBM are :

83 key PC and XT keyboard

84 key AT keyboard

101 key enhanced keyboard

(b) The code produced is normally ASCII.

(c) The various types of keyswitches used for keyboard are : Mechanical keyswitch, Capacitive keyswitch and Hall effect keyswitch.

(d) A user can prevent entry from the keyboard using the keyboard lock facility.

Principal of operation of keyboard : The keyboard hardware interface logic is consisting of following sections :

(a) Shift register (Serial to Parallel Converter).

(b) Logic for interrupt generation.

(c) Port for scanning the code.

The various keyswitches are organised in the form of a matrix. A eight bit counter is required for scanning a 16 × 16 matrix.

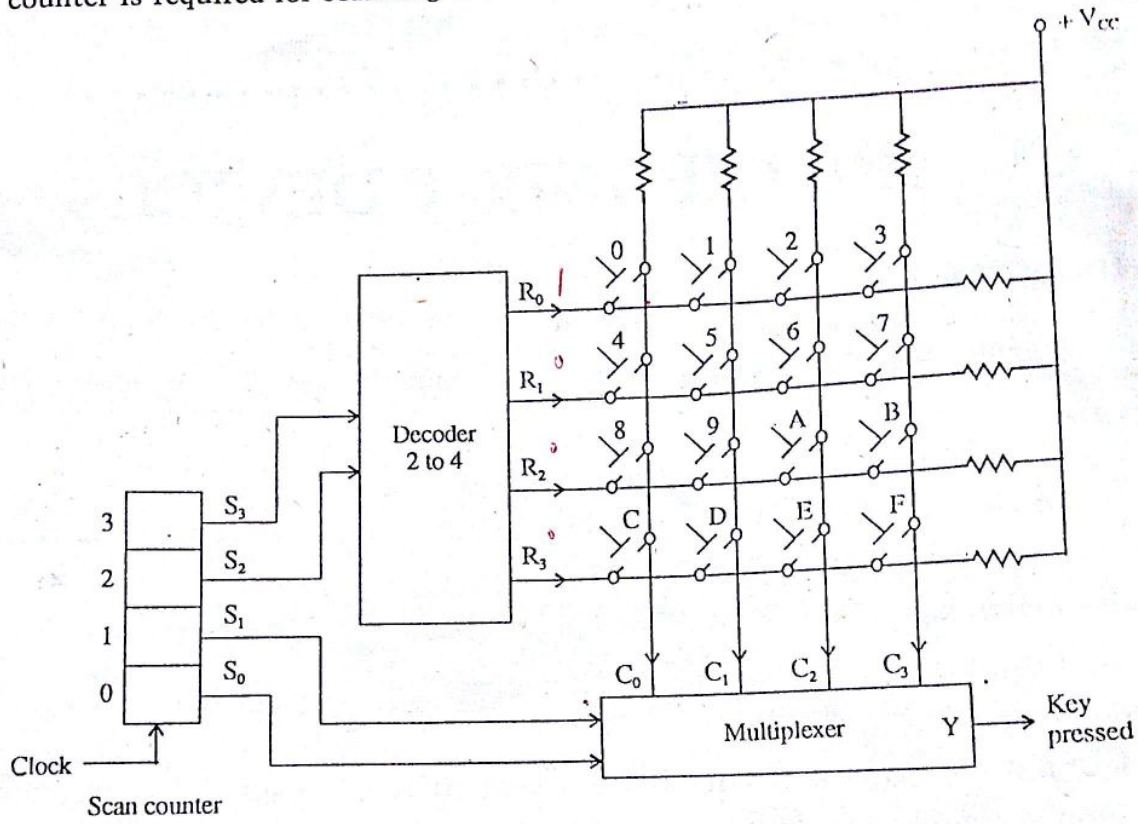


Fig. 1.1 Scanning hardware for a 4 × 4 keyboard matrix

In Fig. 1.1, four bit scan counter is used. The MSB of scan counter S3 and S2 are input to a decoder so at a time only one row will be low and the other will be high and the LSB's of scan counter S1 and S0 are select signals of 4 × 1 multiplexer. Whenever the status on Y is low it indicates a key is pressed and the scan code of that key is present in the counter. Let us consider key pressed is 1.

Now initially the counter outputs 0000 so row 0 is activated and status of columns is C0 = 1, C1 = 0, C2 = 1, C3 = 1. Now S1 = 0 and S0 = 0

Therefore, Y = C0 = 1, so the key pressed is not detected, now the counter is advanced by 1, the counter produces a count of 0001, again row 0 is activated, the status of columns is C0 = 1, C1 = 0, C2 = 1, C3 = 1.

As S1 = 0 and S0 = 1.

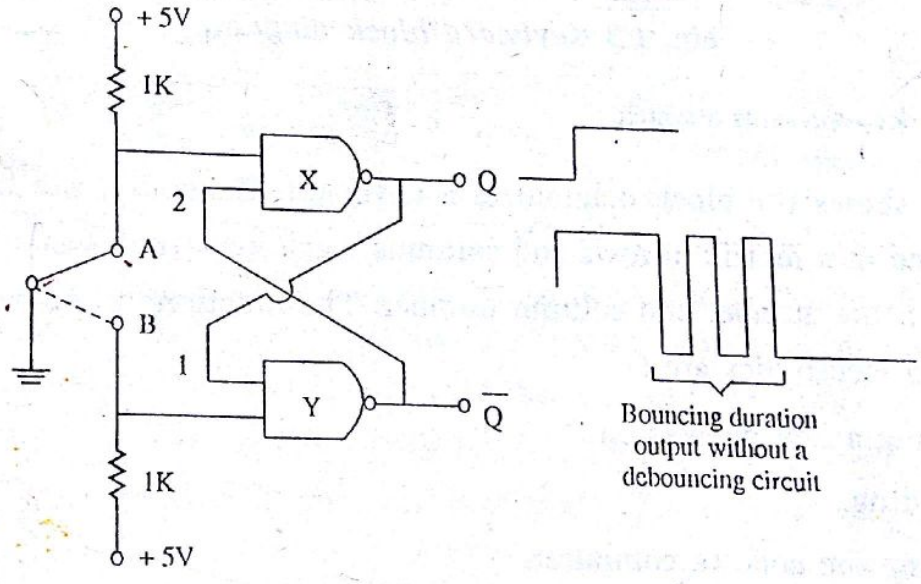
Therefore, Y = C1 = 0, a zero is detected on Y so the status of counter is scan code of key, so now a interrupt is generated by the system and the status of the counter is read.

The various scan codes for the various keys in the above figure are :

Key	Scan code	Key	Scan code
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

Key debouncing circuit : When matrix is scanned there are chances, that wrong status of key is sensed due to the bouncing effect. When a key is pressed the key bounces for a few milliseconds thus making and breaking the contact, this is called as bouncing. The circuit which takes care of the bouncing effect is called as a debouncing circuit.

The bouncing effect can be taken care of by means of a hardware or a software.



(a) Output with a debouncing circuit (b) Output without a debouncing circuit

Fig. 1.2

When the switch is thrown in position A, the input to the NAND gate X is input A = 0, input 2 = X, so the Q output is 1 and $\overline{Q}$ output is 0.

Now, even if the key bounces both the inputs to the NAND gate Y are at logic 1 and so $\overline{Q}$ = 0. Therefore, the Q output is one, so a RS flip flop takes care of the bouncing effect of the key.

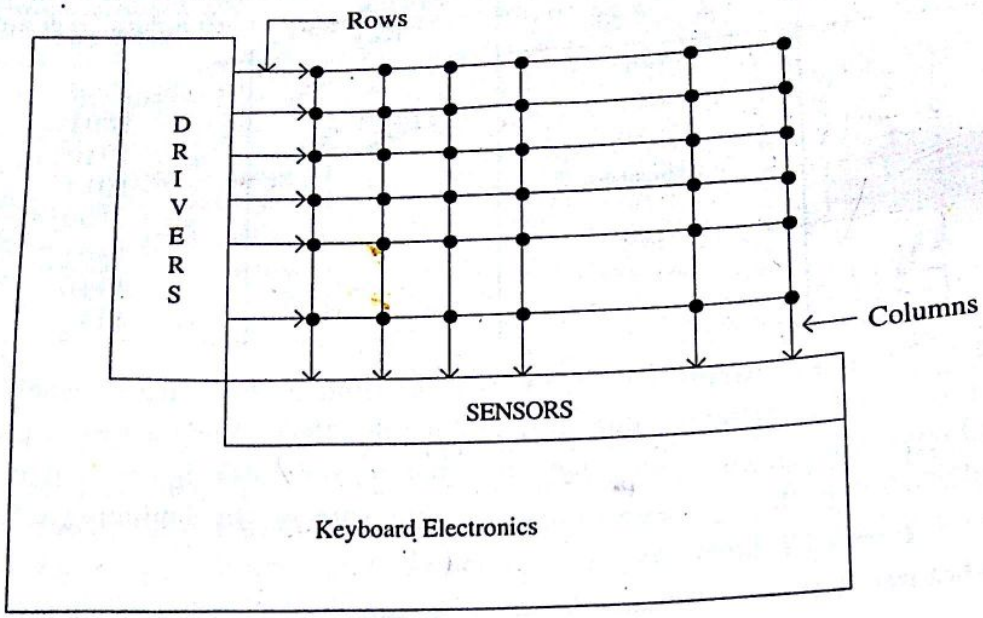


Fig. 1.3 Keyboard block diagram

Note : Each dot represents a switch.

Fig. 1.3 shows the block diagram of a keyboard. Generally, the keyswitches are connected in a matrix of rows and columns. Each keyswitch has a fixed set of coordinates : row number and column number. The functions to be performed by the keyboard electronics are :

1. Sensing a key depression.
2. Encoding.
3. Sending the code to computer.

A standard technique known as scanning is followed by the keyboard electronics. The rows are used as inputs to the matrix. The keyboard electronics sends signals to the matrix through the rows. The columns are used as outputs from the matrix. The columns lines are sensed by the electronics circuits.

Types of keyboard : There are two types of keyboards,

(a) A serial keyboard.

(b) A parallel keyboard.

(a) A serial keyboard : A serial keyboard sends the data, bit by bit, in a serial fashion as shown in Fig. 1.4. The computer converts the data into a parallel byte.

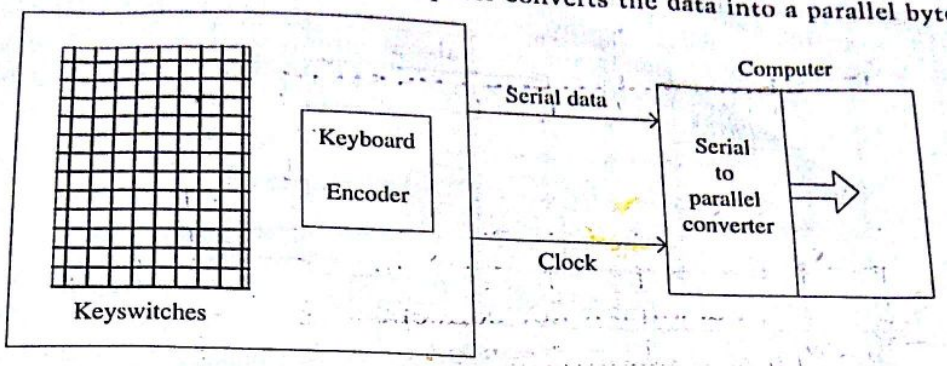


Fig. 1.4 Serial keyboard

(b) Parallel keyboard : A parallel keyboards sends the data as a byte in parallel form; all the bits are sent simultaneously on different lines (wires). The cable between the keyboard and the computer should have more wires in a parallel keyboard as shown in Fig. 1.5.

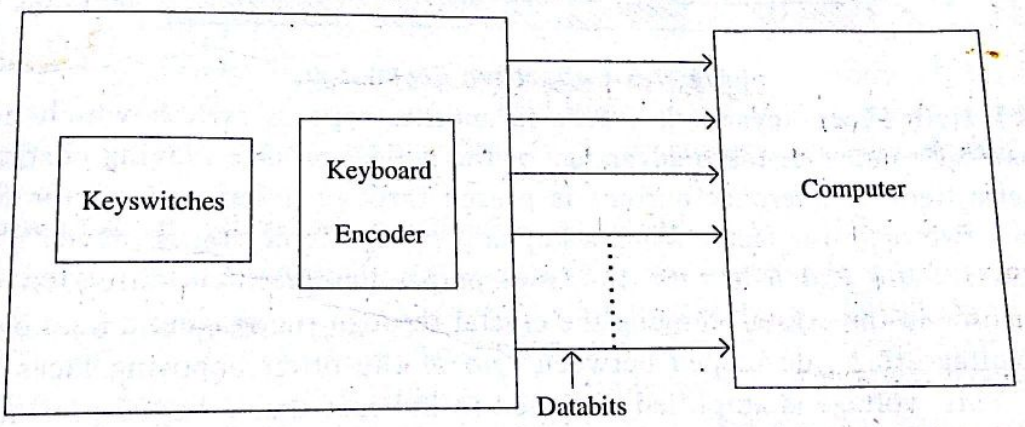


Fig. 1.5 Parallel keyboard

Types of keyswitches : There are different types of keyswitches used in keyboards.

(a) Capacitive keyswitch.
(b) Hall effect keyswitch.
(c) Opto-electronic keyswitch.
(d) Membrane keyswitch.
(e) Mechanical keyswitch.

(a) Capacitive keyswitch : As shown in Fig. 1.6, a capacitive keyswitch has two small metal plates on the printed circuit board and another metal plate on the bottom of a piece of foam. When you press the key, the movable plate is pushed closer to the fixed plate. This changes the capacitance between the fixed plates.

Sense amplifier circuitry detects this change in capacitance and produces a logic level signal that indicates a key has been pressed. The big advantage of a capacitive switch is that it has no mechanical contacts to become oxidized or dirty. A small disadvantage is the specialized circuitry needed to detect the change in capacitance. Capacitive keyswitches typically have a rated lifetime of about 20 million keystrokes.

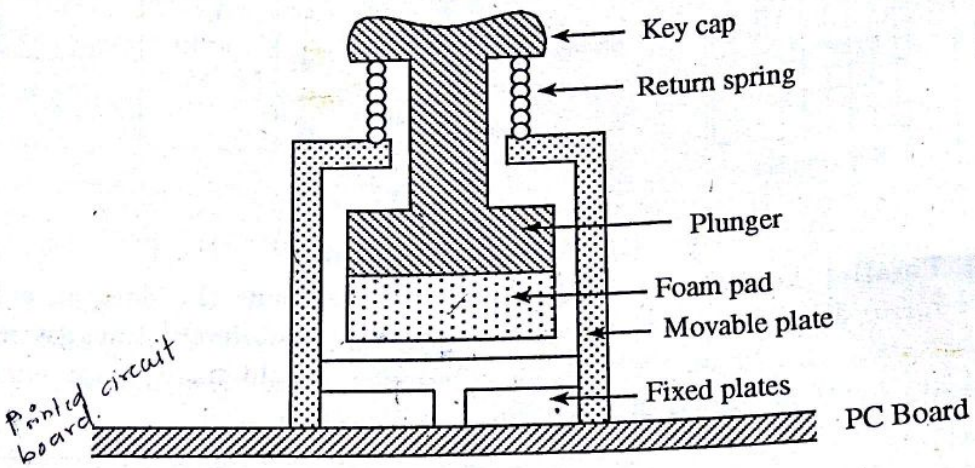


Fig. 1.6 Capacitive keyswitch

(b) Hall effect keyswitch : This is another type of switch which has no mechanical contact. It takes advantage of the deflection of a moving charge by a magnetic field. A reference current is passed through a semi conductor crystal between two opposing faces. When a key is pressed, the crystal is moved through a magnetic field which has its flux lines perpendicular to the direction of the current flow in the crystal. Moving the crystal through the magnetic field causes a small voltage to be developed between two of the other opposing faces of the crystal. This voltage is amplified and used to indicate that a key is pressed. Hall effect keyboards are more expensive because of the more complex switch mechanisms, but they are very dependable, and have typical rated lifetimes of 100 million or more keystrokes.

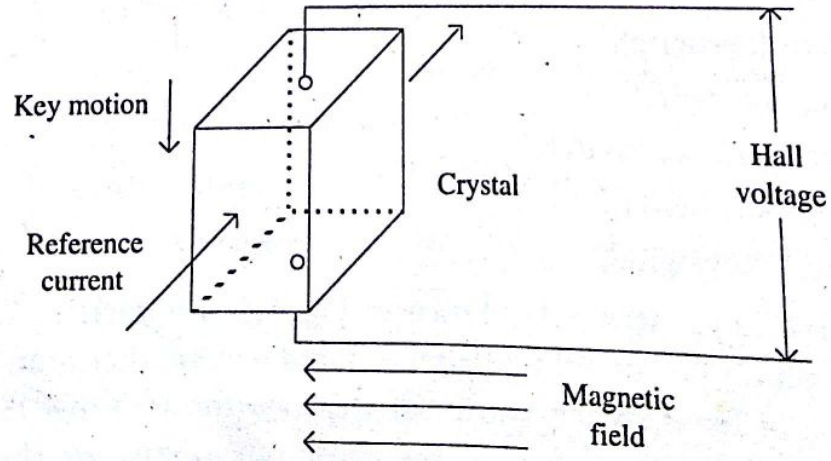


Fig. 1.7 Hall effect keyswitch

(c) Opto electronic switch : Switches are based on optical and electronic device. As shown in Fig. 1.8, this type of switches have a LED which generates light when proper electric power is applied. Opposite to the LED, a photo-transistor is used. The property of photo-transistor is such that it allows the current flow in the circuit, as long as light is applied to it. When the light following to the photo-transistor is removed, it will no longer allow the current to pass through it.

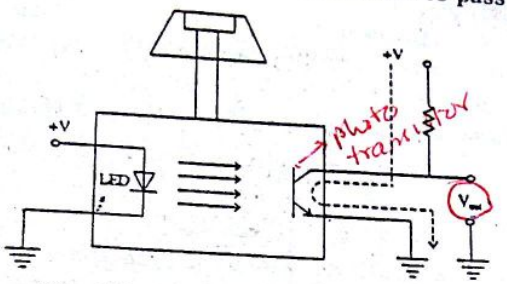


Fig. 1.8 Opto electronic switch

In this type of switch, when the key is not pressed, the light from LED falls onto the photo-transistor. This makes the current to flow through the photo-transistor and produces a very low voltage at the output V_{out}.

When the key is depressed, the light emitted from the LED is blocked. This will stop the current flow through the phototransistor and forces the photo-transistor to a cut-off condition. In this condition the current can not flow through the photo-transistor and a different value will be produced at the output V_{out}.

These two V_{out} values are interpreted by the keyboard circuit as two different logical conditions key being open and key being close.

(d) Membrane keyswitch : These switches are really just a special type of mechanical switch. They consist of a three-layer plastic or rubber sandwich as shown in Fig. 1.9. The top layer has a conductive line of silver ink running under each row of keys. The middle layer has a hole under each key position. The bottom layer has a conductive line of silver ink running under each column of keys. When you press a key you push the top ink line through the hole to contact the bottom ink line. The advantages of membrane keyboards is that they can be made as very thin, sealed units. They are often used on cash registers in fast food restaurants, on medical instruments, and in other messy applications. Lifetime of membrane keyboards varies over a wide range.

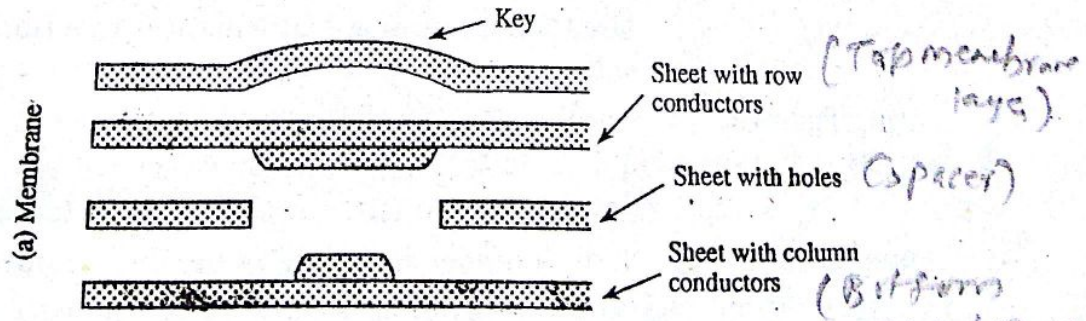


Fig. 1.9 Membrane keyswitch

(e) Mechanical keyswitch : In mechanical switch keys, two pieces of metal are pushed when you press the key. The actual switch elements are often made of a phosphor-bronze alloy with gold plating on the contact areas. The keyswitch usually contains a spring to return the key to the non pressed position and perhaps a small piece of foam to help damp out bouncing. Mechanical switches are relatively inexpensive, but they have several disadvantages. First, they suffer from **contact bounce**. A pressed key may make and break contact several times before it makes solid contact. Second, the contacts may become oxidized or dirty with age so they no longer make a dependable connection. Higher quality mechanical switches typically have a rated lifetime of about 1 million keyswitches.

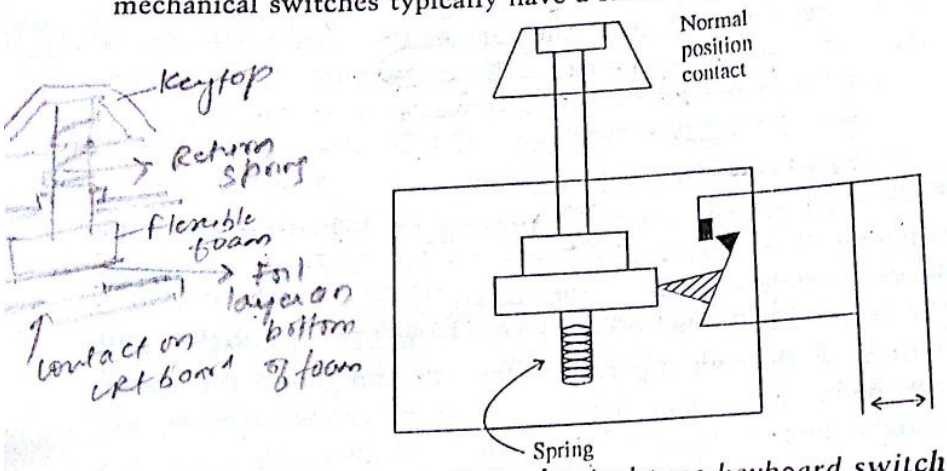


Fig. 1.10 Mechanical type keyboard switch

Function of keys on the keyboard : Generally keyboard available in the market have 101 keys but now-a-days keyboard with 104, 108 keys are also available in the market.

A to Z	:	Used for entering the alphabets.
0 to 9	:	Used for entering the digits.
F1, F2, ...	:	These are function keys performing special functions like F1 for file, F2 for edit etc.
Up, down, left and right arrow keys	:	Used for moving the cursor up, down left or right by one position.
+, –, *, /	:	Used for performing mathematical functions like addition, subtraction.
Pgup/Pgdown	:	Used for moving the cursor up or down by one page.
Caps Lock	:	If caps lock is on when whatever we type on keyboard is typed in capital letter or else in small letter.
Num Lock	:	If the number lock key is on then numeric pad on right hand side of keyboard works as numeric pad else it does another function written below the number on the key.

2. Mouse : It is an input device. It's technical name is puck and because of its shape the term mouse is used.

The mouse is consisting of the following components :

(a) A roller ball which signals movement to the system.

(b) Two buttons (except Macintosh mouse which comes with only one button) for making the selection.

(c) Cable for connecting mouse to the system.

(d) Connector for interfacing mouse to the system.

Working or Principle of operation : The working of mouse is shown in Fig. 1.11. A small rubber ball protrudes through the base of the device. This ball is resting against two rollers one for translating the X axis movement and the other for the Y axis, the rotation of the rubber ball is transmitted to these two rollers, which are positioned at right angles to one another. The rubber ball is kept in contact with rubber by means of a spring loaded rubber. The amount and direction of rotation transmitted to each roller varies, depending upon the direction of movement of the mouse. Each roller is driving a rotary encoder. A rotary encoder is a small wheel which is containing perforations. The light from light emitting diode is passed through this perforations and is interrupted as the wheel rotates. The interrupted light beam is converted into electrical pulses by means of a photo detector.

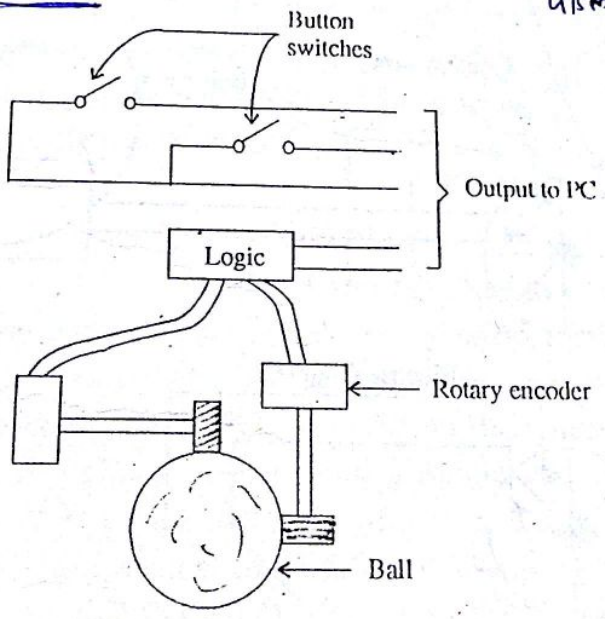


Fig. 1.11 Mouse (optomechanical)

These are interpreted by the mouse controller to determine the amount of movement in X and Y axis. This information is transmitted to the PC, for further processing.

The mouse buttons control a voltage the status of this is available on the pins of mouse connector and is detected by a software.

Types of mouse : The mouse has one, two or three buttons on the top. Three types of mouse are available :

(a) Mechanical mouse : As a mechanical mouse is moved across a flat surface, a ball (made of rubber or rubber covering over a steel ball) from the underside of the mouse starts to rotate in the direction of the movement.

As the ball rotates, it touches and turns two rollers touching the ball inside the mouse. These rollers are mounted at a 90 degree angle to each other. One roller is used for the back and forth movements of the mouse, which corresponds to vertical movements of the cursor on screen while the other roller is used for horizontal movement of the cursor on the screen.

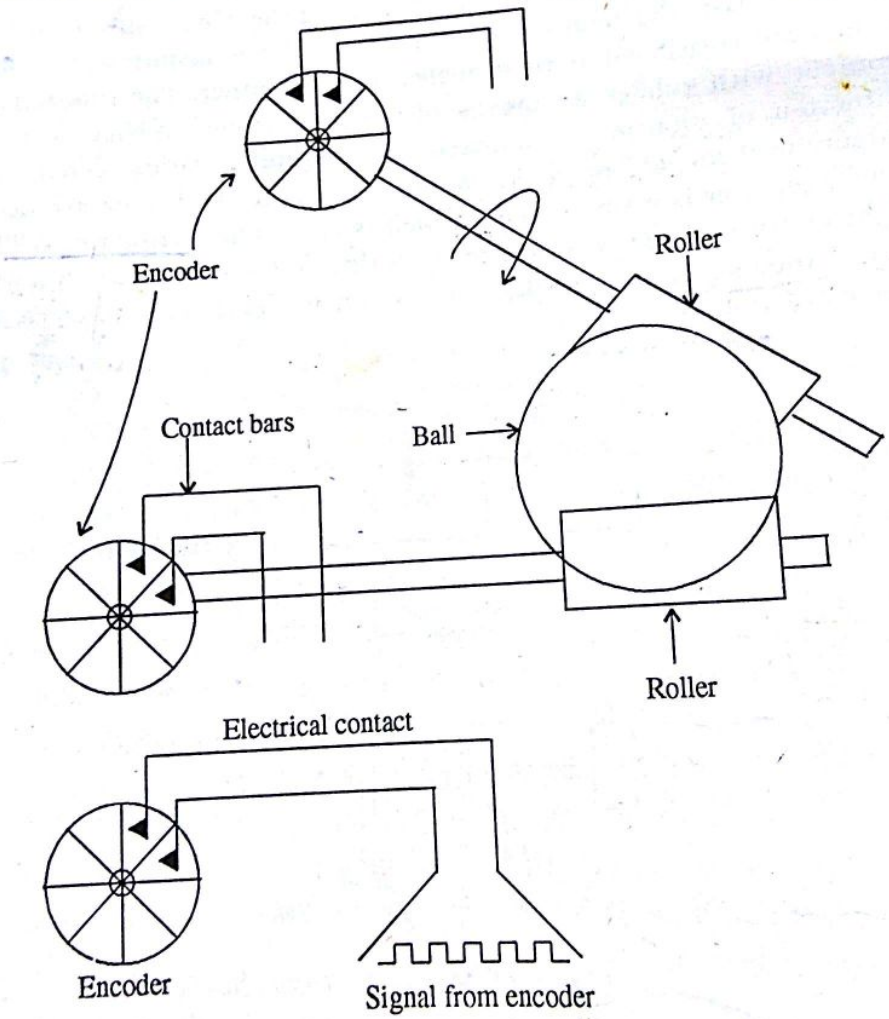


Fig. 1.12

Each roller is attached to an encoder which is wheel like structure. As the roller turns, these encoders rotate with them. Two pairs of contact bars touch the small metal contact points provided on the rims of each of these encoders. Each

edge, border

time a contact bar touches a point, an electrical signal is generated. The signal generated by these rollers are sent serially to the PC over the mouse's tail like cable. The mouse driver software converts these signals into the distance, direction and speed necessary to move the screen cursor. Also pressing of any of the mouse buttons sends a signal to the PC.

(b) Optomechanical mouse : Basic construction of optomechanical mouse is same as that of the mechanical mouse. Only difference is in the sensing circuit i.e. a combination of LED (Light Emitting Diode) and photo detectors is used to sense the distance travelled by the mouse.

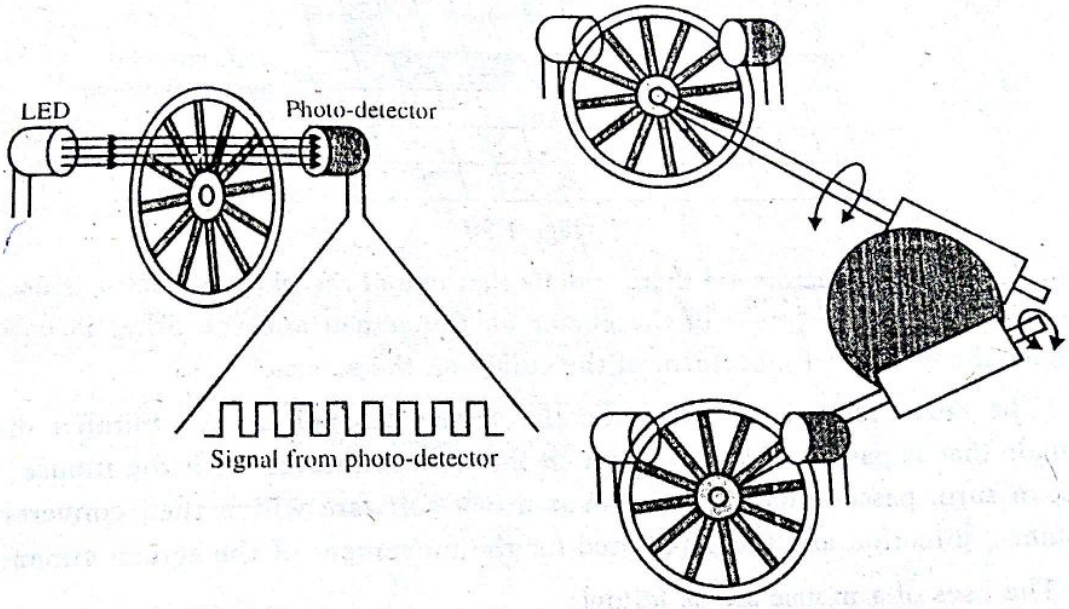


Fig. 1.13

In this mouse also there are two rollers as similar to the mechanical mouse. Each roller is connected to a wheel. There are small openings on the rim of each wheel. As the wheel rotates a pair of LED and photo detectors detect the number of openings passed between them. Each opening on the wheel allow the light from the LED to fall on the photo detector and generate an electrical signal. Then these signals are passed to the PC, in turn, it passes them to mouse driver software which then converts them into distance, direction and speed required for the movement of the screen cursor.

(c) Optical mouse : In this type of mouse, a light source and photo detector is used with a special mouse pad.

When the optical mouse is moved on this special pad, light from the light source gets reflected from the pad and special photo detector inside the mouse detect the horizontal and vertical movements.

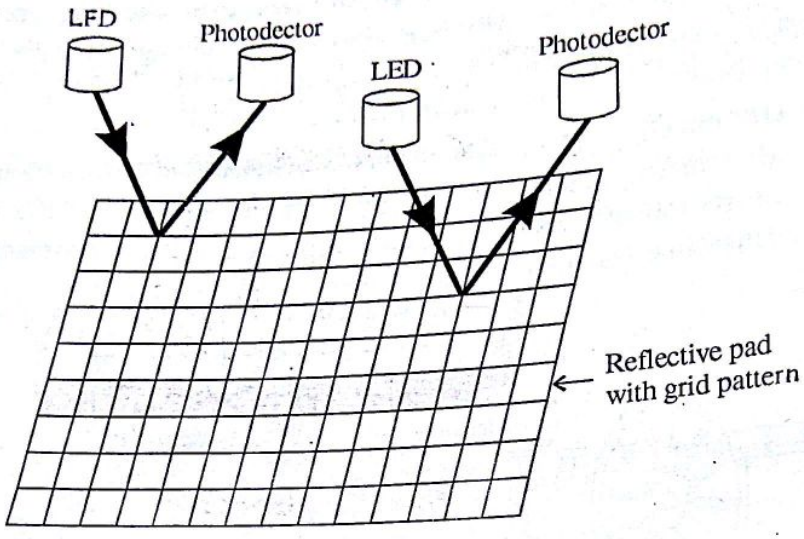


Fig. 1.14

Two photo detectors are there, among that one of the photo detector is used to detect vertical movement of the cursor on the screen and the other is used to detect the horizontal movement of the cursor on the screen.

The movement of the cursor on the screen depends on the number of the signals that is passed to the PC through the wire connected with the mouse. The PC, in turn, passes them to the mouse driver software which then converts the distance, direction and speed required for the movement of the screen cursor.

The uses of a mouse are as follows :

(a) It is used as a pointing device, objects can be easily dragged and dropped to another location by means of a mouse.

(b) It is very useful in making menu selections.

(c) It is useful in computer aided design for drawing diagrams and pictures.

(d) To use scroll bar to scroll windows clicking on the scroll bar below acts as page down and clinking on the scroll bar above acts as page up.

Due to its accuracy, speed, simple to use and low cost mouse is the widely preferred pointing device. It is also known as "X-Y position indicator for a display system".

3. Digitizer : It is a input device. It transforms the graphical representation of a picture into digital representation. Digitizer is also known as a graphics tablet. It is consisting of a flat surface like a drawing pad and a reading device which may be a stylus or pen, a push button cursor or puck.

A grid pattern of horizontal and vertical lines are present below the flat surface, the reading device is used to trace over the lines in drawing or a graphical representation. The digitizer then sends numeric description about these lines to the computer for further processing. It is very useful in CAD applications. It is available in many sizes in the market.

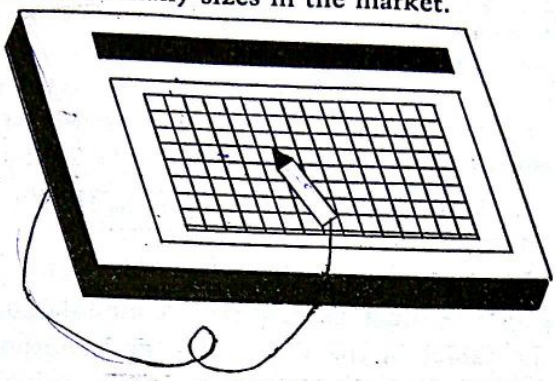


Fig. 1.15 Digitizer

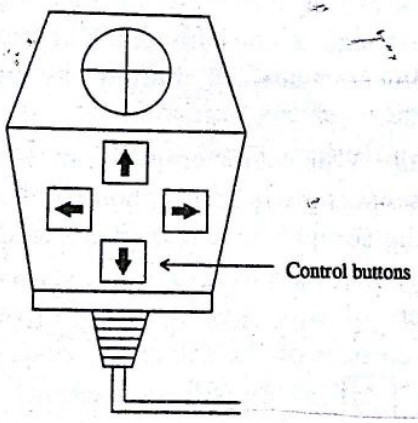


Fig. 1.16 Puck or Cursor

Digitizer tablets types : Digitizer tablets types are :

(a) Wire mesh tablet (electromagnetic induction)

(b) Voltage gradient tablet

(c) Sylvania tablet

(d) Acoustic tablet

(e) Pressure-sensitive tablet.

(a) Wire mesh tablet (electromagnetic induction) : The electromagnetic induction technique is commonly employed in digitizers. The position of the stylers is detected in this case by a matrix of wires embedded in the surface of the tablet, so that when pulse trains are applied to individual X and Y wires, the stylus can sense the pulses due to capacitive linkage to those X, Y wires closest to the stylus. Pulses can be applied to groups of wires using Gray code so that adjacent wires receive a unique sequence of pulses that differ by only one digit. The X and Y planes need to be separated by a sheet of Mylar.

(b) Voltage gradient tablets : This tablet is made of a resistive (partially conducting) material such as **Teledeltos** paper. A voltage potential is developed across the tablet in the X-direction and the X-co-ordinate of the stylus position obtained from the voltage measured at the stylus tip. Similarly, the Y-co-ordinates is obtained from a voltage potential developed across the tablet in the Y-direction. The X and Y voltage potentials are applied at different time intervals. Linear equipotentials need to be formed and this can be achieved by connecting the voltage signals to the sides of the tablets at several points through diodes. The diodes provide a means of connecting the voltage source to the edges of the tablet whilst not affecting the linear resistance between opposite edges.

The voltage-gradient method is not suitable for tracing drawings because the stylus needs to be in contact with the tablet to operate.

(c) Sylvania tablets : The Sylvania tablet is the name given to a commercial tablet based on using a conducting material. A modulated high-frequency signal is applied across the tablet in the X-direction and another modulated signal of different frequency applied to the Y-direction. The stylus picks up the signals. The modulating signals are derived and the phase shift of each in relation to master signals give the X and Y co-ordinates. The stylus need not actually be in contact with the conducting surface due to the use of the high frequencies (approximately 100 KHz).

(d) Acoustic tablets : This tablet employs an ultrasonic sound source in the stylus and two sound sensors (strip microphones) along two adjacent ends of the tablet, which pick up the sound emitted in the X and Y directions. Measurement of the time delay from emitting the sound and receiving the sound gives the co-ordinates. Earlier tablets of this type used an ultrasonic transmitter and four separate sensors at the corners of the tablet.

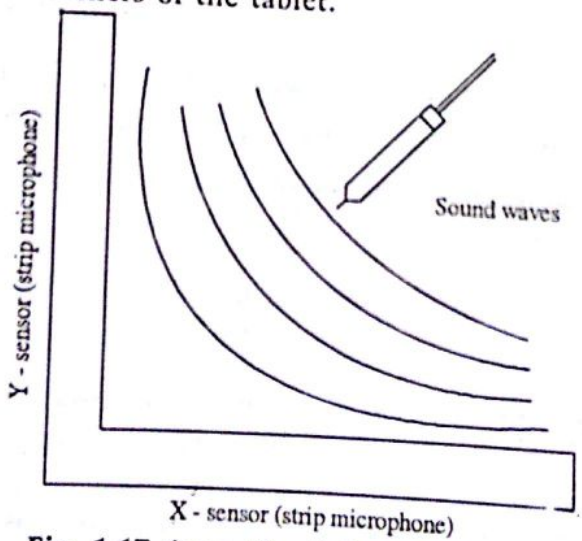


Fig. 1.17 Acoustic digitizer tablet

An acoustic digitizer tablet designed for digitizing drawings is typically 35 cm × 35 cm with a resolution of 0.25 mm, reproducibility of 0.1% of full scale and a data transfer rate of 140 points/seconds.

(e) Pressure-sensitive tablets : In this tablet pressure is applied at the required co-ordinates on the top surface of the tablet. This causes an electrical contact to be made between a particular X wire and Y wire of a matrix of X wires (parallel to the X axis) and Y wires (parallel to the Y axis) embedded in the tablet. The electrical contact thus identifies the location of the pressure point.

4. Joystick : It is an input device used in applications where high accuracy is not required. It has a electromechanical lever that, when manipulated moves the cursor. A joystick is basically a stick mounted on a spherical ball which moves in a socket. The stick can be moved left or right, forward or backward. Fig. 1.18 shows the diagram of a joystick.

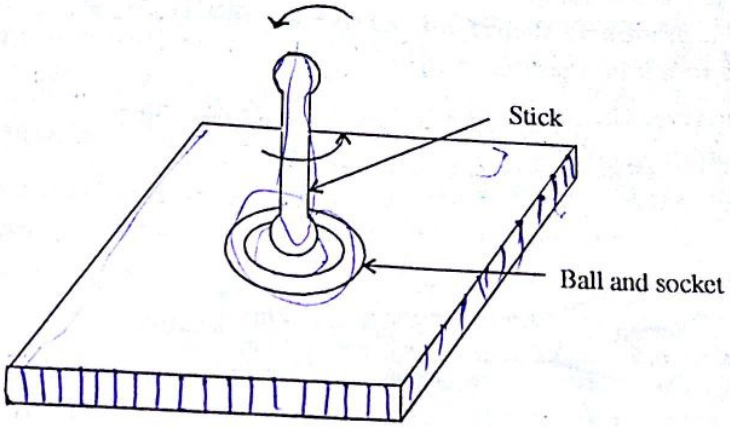


Fig. 1.18 Joystick

Potentiometers are used to sense the movements.

Non movable joystick : The distance that the stick is moved in any direction from its centre position corresponds to screen-cursor movement in that direction. Potentiometers mounted at the base of the joystick measure the amount of movement, and springs return the stick to the centre position when it is released. One or more buttons can be programmed to act as input switches to signal certain actions once a screen position has been selected.

In another type of movable joystick, the stick is used to activate switches that cause the screen cursor to move at a constant rate in the direction selected. Eight switches arranged in a circle, are sometimes provided so that the stick can select any one of eight directions for cursor movement. Pressure sensitive joysticks, also called isometric joysticks, have a nonmovable stick. Pressure on the stick is measured with strain gauges and converted to movement of the cursor in direction specified.

Principle : A hardware is present to record the (x, y) co-ordinates in buffer registers corresponding to the location of the device then x and y co-ordinates are read from the buffer.

Uses of joystick :

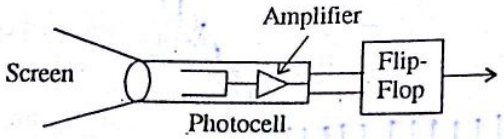
(a) It is used for playing games with computer.

(b) It is used to control the cursor on the CRT screen.

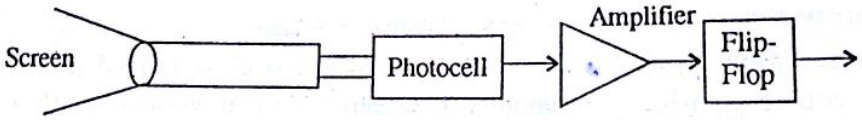
(c) It is used for creating different shapes.

5. Light pen : It is a input device and one of the most important picking device. The light pen contains a photo sensor and an optical system which detects the presence of light. The photo sensor and optical system is mounted in a pen shaped case and it can be pointed at any point on the screen. On the pen case a switch is present which controls a window to let the light fall on the lens or closes the electrical path from the photo sensor to the amplifier. The photo sensor output is amplified, shaped and fed to a flip flop whose status is 1, when the pen is pointed to a bright source of light.

Whenever the status of flip flop is 1 the computer is interrupted and it reads the co-ordinates of point where light pen is touched. The light pen is connected to the computer through a cable.



(a) Light pen using hand held photocell



(b) Light pen using optic fibre pipe

Fig. 1.19 Light pen

Fast response light pens can be made using a photomultiplier tube but they are bulky. Light pens using photo diode are cheap but their response is poor.

Uses of light pen :

(a) One can use a light pen instead of keyboard to request further information.

(b) They are used to provide a quick response to operator inquiries.

(c) It is used as input device in CAD applications.

(d) It is used to write or sketch on the screen of a cathode ray tube.

6. Scanner : It is an input device. It is very useful in a multimedia project. Scanners are of two type flat bed and hand held. The gray scale and colour flat bed scanner provide resolution of 300 or 600 dots per inch (dpi). Hand held scanners are useful for scanning small images and text but not so useful for multimedia.

For better reproduction of the original image it is always better to scan the image at the highest possible resolution but the hard disk space required in such cases is more. Scanners allow to use optical character recognition software (OCR), such as Omni page or Perceive to convert printed matter to ASCII text files.

Scanners are used in DTP, make electronic images of photos, advertisements, cartoons etc.

The function of the scanner is to obtain an electronic image of the character to be read, in a form which is suitable for the recognition process. The text, images or any data can be directly entered into computer memory with the help of scanners. There are two types of scanners in use : (a) Optical scanners (OCR/OMR) and (b) Magnetic-ink character reader (MICR).

(a) Optical scanners : The optical scanner scans the information recorded on paper. It employs light source and sensors to read the information. The common used optical scanners are :

(i) Optical Character Reader (OCR) : These scanners scans only printed or type written characters (alphabetic and/or numeric).

(ii) Optical Mark Reader (OMR) : These scanners scans hand printed characters (alphabetic and/or numeric) as well as marks that are put in predefined areas of the document.

Block diagram of OCR/OMR machine :

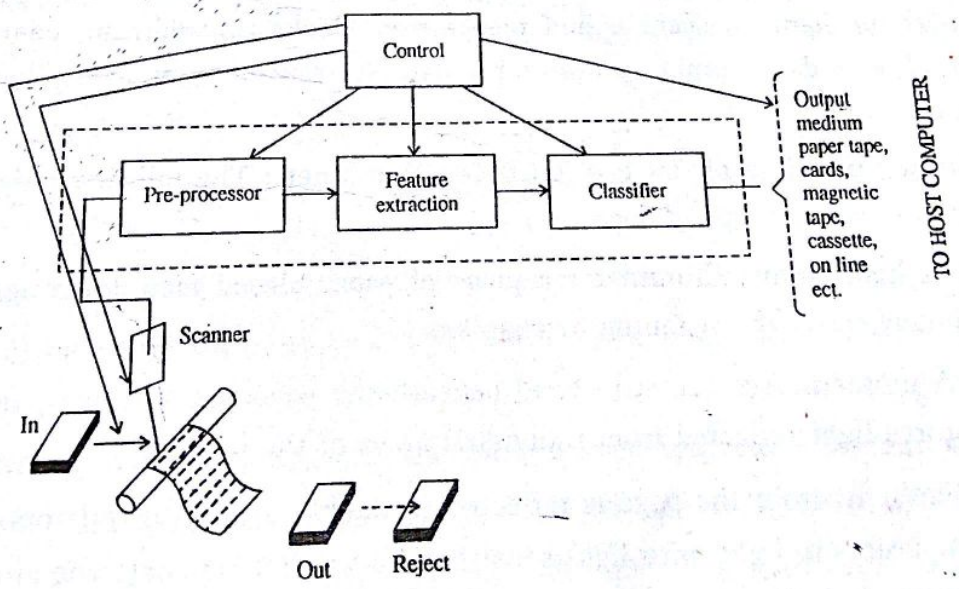


Fig. 1.20 Block diagram of OCR/OMR machine

Recognition process in OCR/OMR machine : As shown in Fig. 1.20, the recognition process can be thought of as comprising three stages : pre-processing, feature extraction and classification. There are several recognition techniques in use and these determine the functions performed by each stage.

(i) Pre-processing : This stage normalizes the character before feature extraction. Operations that may be performed are : adjusting the width and height to standard size and also centring of the character. This can be done after scanning or, where CRT scanning is used, a preliminary quick scan can be used to determine the size and location of the character and the parameters of the main scan are then adjusted accordingly. With hand-printed characters it may be desirable to correct for character skew and rotation due to individual hand-printing styles.

(ii) Feature extraction : This stage identifies a set of characteristics or features in the character which allow it to be distinguished from other characters in the set.

(iii) Classification : This stage identifies the scanned character. A set of reference features, extracted for each member of the reference characters set, is stored in optical reader machine. The set of features extracted from the scanned character is then compared with those of each of the reference characters until a match is obtained, thus identifying the character. In practice short cuts are taken in this comparison process.

Control : This function directs the timing and sequencing of the paper – transport mechanism, scanner and recognition blocks. In addition, control is exercised over data output to a suitable data storage medium or on-line to a computer.

Working principle of flat bed (OCR/OMR) scanner : The following steps are involved to scan any type of document.

(i) A light source illuminates a piece of paper placed face down against a glass window above the scanning mechanism.

(ii) A motor moves the scan head beneath the page. As it moves, the scan head captures light reflected from individual areas of the page.

(iii) The light from the page is reflected through a system of mirrors. A lens focuses the beams of light onto light-sensitive diodes that translate the amount of light into electrical current.

(iv) The more ligh
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(v) An analog to
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(vi) If the scan
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green or blue filter

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(iv) The more light that's reflected, the greater the voltage of the current. Black or white spaces reflect more light than black or coloured letters or images.

(v) An analog to digital (A – D) converter converts each analog reading of voltage as digital pixel representing the scanned area.

ADC on a monochrome scanner stores only 1 bit per pixel, either on or off, representing, black or white.

(vi) If the scanner is a colour scanner then the scan head makes three passes under the images and the light on each pass is directed through a red, green or blue filter before it strikes the original image.

The reflected signals from these three pass are converted into digital information and stored to represent red, green and blue colour value of the scanned area on the page.

(vii) This digital information is sent to software in the PC, where the data is stored in a format with which a graphics program or Optical Character Recognition (OCR) work.

Scanning the scanner : A flat-bed scanner uses a light source, a lens, a charge coupled device (CCD) array and one or more analog to digital converters (ADCs) to collect the optical information about the object to be scanned and transforms it to a computer image file.

A CCD is a miniature photometer that measures incident light and converts that measured value to an analog voltage.

The CCDs elements are all in one row with one element for each pixel in a line. If you have 300 CCD elements for each inch across the scanner, you can have a maximum potential optical resolution of 300 pixels per inch (PPI) or dots per inch (DPI).

Resolution of scanner : It is also called optical sampling rate that is the number of samples captured in the x-axis by scanner. It is depend upon the width of the scanned area and the number of elements in the CCD.

Interpolation : Interpolation means the scanner or scanning software generates data based on the real, captured data.

The true optical resolution is known also as horizontal resolution and Y-direction sampling rate measurement is known as mechanical resolution or vertical resolution. The vertical resolution figure is typically double than the optical resolution.

CIS technology in scanner : The Contact Image Sensor (CIS) are used in new flat-bed scanner. CIS scanners deploy dense banks of red, green and blue LEDs to produce white light and replace the mirrors and lenses of a CCD scanner with a single rows of sensors placed extremely close to the source image CIS scanners uses the single chip that handles many data processing functions.

Scanner specifications : The following points should be considered for scanner. The normal scanner has the following configurations :

1. Resolution : 600 × 1200 dpi
2. Maximum resolution : 9600 × 9600 dpi
3. Maximum scan area (W × H) : 8.5" × 11.7"
4. Bit depth : 36 bits/pixel with BET
5. Interface : SCSI, USB
6. Transparency adopter : Inbuilt.

(b) Magnetic character readers (MCR) scanner : Characters are printed using ink loaded with iron oxide. The printed document is passed through the reading machine which first magnetizes the characters and then passes the document under a small coil. The magnetized characters induce a voltage signal in the coil from which the character is decoded.

A special printer is used to print the characters on documents.

This method has found widespread use in banks (for example, on cheques) because of its security and reability. The method is secure because characters are not easily altered without the special printer. Reability is obtained because ordinary dirty marks and other blemishes which might cause errors in an optical character reader are less likely to cause errors here because they are generally non-magnetic.

Reability and simplicity of the recognition process is also enhanced by using stylized fonts. Two MICR fonts in widespread use are E13B and CMC7.

(i) E13B font : This font originated in the United States and is now also used in Britain. (see figure) The font includes the ten numerals, four special characters to specify data fields, but no alphanumeric characters. The special characters signify : 'dash', 'blank-branch', 'amount', 'on us' respectively.

A thin vertical slice of each character is scanned, which produces a signal amplitude that is proportional to the quantity of magnetized ink in the slice, as shown in Fig. 1.21. The signal is unique to each character, which is therefore easily identified.

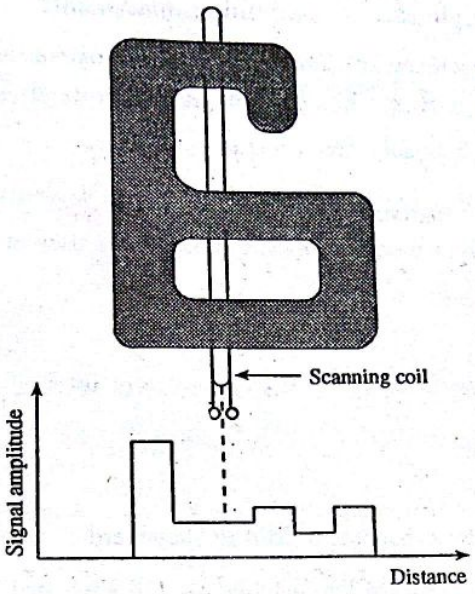

Fig. 1.21 Reading of E13B character

(ii) CMC7 font : This font, (see figure), is in widespread use on the continent. Numerals, special characters, and also alphabet characters are included. The coding principle is different from that of E13B font. In this case each character is made up of seven vertical magnetic ink bars. The six spaces between the bars are binary valued : narrow (binary 0) and wide (binary 1). This creates a six-bit code which allows a maximum of 64 possible characters to be represented. CMC7 uses 41 of these. The magnetic character reader again scans a think vertical slice of the character, but measures the time between the bars and from this the character is decoded. The method is therefore insensitive to the length of each bar, (provided each bar is not too short). This allows pieces to be cut out of the bars to allow the character to be visually readable as shown below.

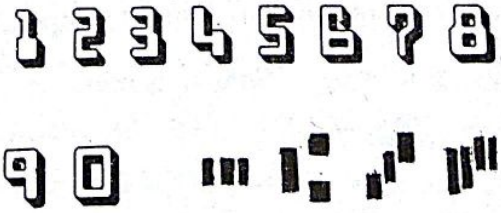

Fig. 1.22 The CMC7 magnetic character font

QUESTIONS • 1

1. What are the various input devices?
2. Explain how a keyboard works with necessary diagram.
3. Keyboard with how many keys are available in the market and give the different type of keyswitches?
4. Explain the key debouncing circuit and what is its use?
5. Discuss constructional details of mouse and explain its working.
6. What are the different types of mouses and give the uses of mouse?
7. Write short notes on :
   (a) Digitizer
   (b) Light pen
   (c) Joystick
   (d) Scanner.
8. Explain functional block diagram of IBM PC keyboard.
9. Explain the different types of keyswitches used in keyboard.
10. Explain in brief different types of digitizer tablets.
11. Explain OCR/OMR scanner recognition process with block diagram.
12. Explain the working principle of flat bed (OCR/OMR) scanner.
13. Explain the magnetic ink character reader scanner.
14. Give constructional detail of Joystick. Discuss its uses.
15. Describe the operating principle of any one of the scanner studied by you.
16. Give constructional detail of Mouse. Discuss its uses.
17. Draw block diagram for keyboard interface and explain the same. *OR* Explain how a keyboard works with necessary diagram.
18. Explain the functioning of different keys on the keyboard.
19. Give constructional details of light pen. Explain its operating principle.
20. Explain the working of light pen. Mention its uses.
21. Discuss the used of digitzer.

2

COMPUTER PERIPHERALS

The various output devices which are used in a computer are monitor, printer, recorder etc.

2.1 SCANNING

CRT display is used to display numbers, letters and graphics. Image can be produced on the CRT screen using two techniques :

1. Random Scan Display
2. Raster Scan Display.

1. Random Scan Display : It is also called as vector scan. In this type of display the electron beam is directed only on those parts of the screen where the picture is to be drawn. The monitor draws one line of picture at a time.

2. Raster Scan Display : In this type of display the horizontal and vertical deflection signals are generated to move the beam back and forth across the screen like a raster. The retrace portion of the raster scan is blanked. Thus the picture is created on the screen as a set of points, starting from top of the screen and picture definition is stored as a set of intensity values for all the screen points and these stored values are drawn on the screen one row at a time.

Resolution and frequency : Resolution tells the amount of details that a monitor can give. Resolution is expressed in terms of the number of horizontal and vertical picture elements as pixels contained in the screen.

A pixel is any one point on the tube that includes in color monitors one red phosphor dot, one green phosphor dot and blue phosphor dot. The sharpness and details of the picture presented on the screen depends upon the resolution. In color monitors the resolution depends upon the dot pitch, dot pitch is the distance in millimetres, between phosphor triads. If dot pitch is less the picture elements are closer and thus producing sharp picture.

Lower resolution picture takes less time to draw than higher resolution picture. The picture can be drawn in the same time in higher resolution monitor by increasing the horizontal frequency.

The speed at which scanning occurs is called as horizontal frequency.

2.2 CRT

A monitor contains a cathode ray tube (CRT), hardware to control the electronic beam and power supply. A CRT is used to display numbers, letters and graphics. CRT is consisting of an evacuated glass tube, conical in shape with a phosphor coating on the inside of large screen end and electron gun at the narrow end. The gun fires a narrow beam of electrons at the screen when the beam strikes the phosphor, light is limited.

Fig. 2.1 shows the diagram of CRT.

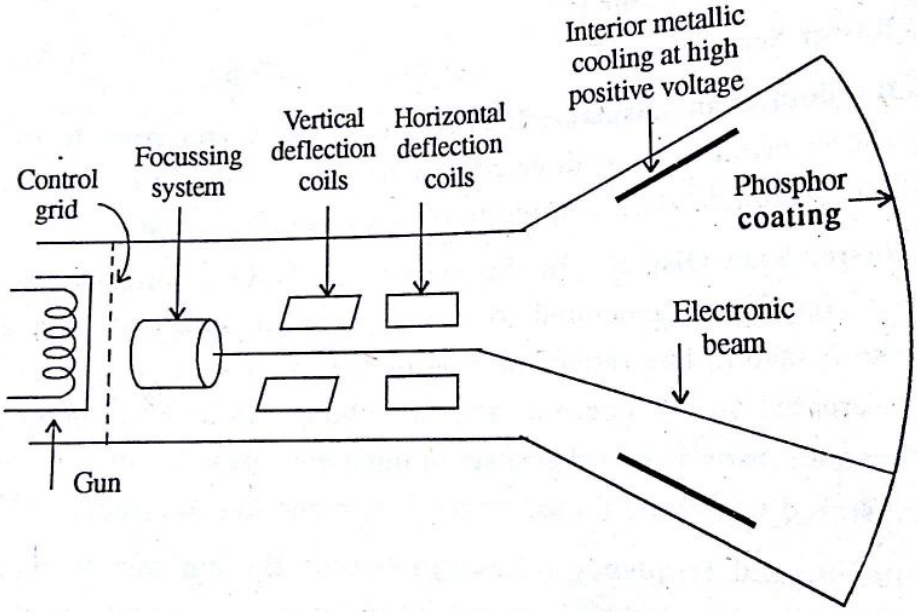

Fig. 2.1 CRT (monochrome)

The CRT display used in PC's are called as raster displays because the picture or text produced on the screen by a beam of electrons repeatedly scans across the screen to form a uniform pattern of closely spaced horizontal line, which covers the entire screen.

The working principle of color video displays is the same as that of monochrome displays. Three separate electron guns are used – red, green and blue. The screen is coated with a pattern of rectangular or phosphor dots. One

third of dots uses phosphor which glows red when hit by a electron beam, one third uses phosphor that glows green and remaining one third uses phosphor that glows blue. By varying the intensity of red, green and blue electron beams, the color of the dot can be changed into any color.

Fig. 2.2 shows electron beam and screen for a color CRT.

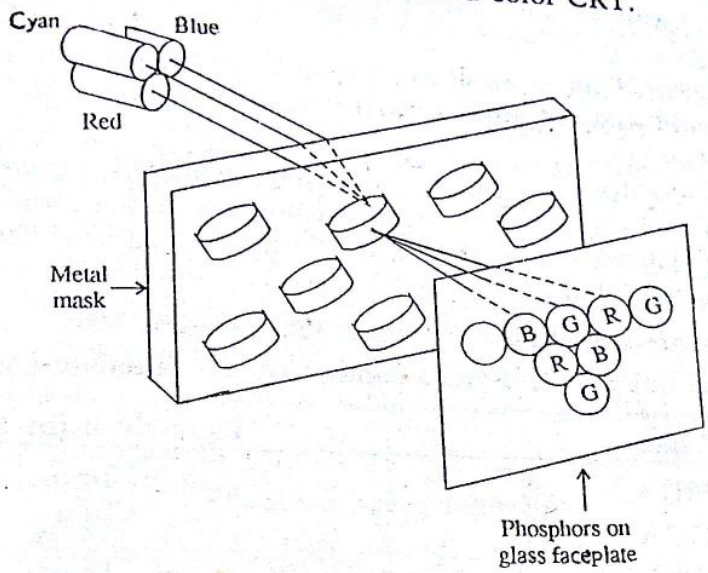

Fig. 2.2 Electron beam and screen for color CRT

There are two types of monitors, Digital and Analog. The display on the screen is controlled by the signals which are coming from the Adaptor. If the signals coming from the monitor are digital then that monitor is known as a digital monitor. So each signal is either on or off. Analog monitors are controlled using variable voltages. We can get a infinite range of colors with analog monitors because the signals which controls the red, green and blue electron guns can be infinitely variable. Whereas with digital monitor only 16 colors are possible and hardware inside is simple and cheaper than Analog monitor.

2.2.1 Monitor Specifications

The following points should be considered while selecting a new monitors :

1. **Resolution** : A monitor's resolution describes the number of potential pixels. The monitors is capable of displaying. The value is given as

resolution = The total horizontal pixels × the total vertical pixels.

2. **Interlaced or Non Interlaced mode :**

Interlacing : Information on a monitor is displayed by an electron gun scanning the phosphor inside of the display. The gun scans from top to bottom, left to right with each complete scan displaying a "frame".

In interlaced mode, the image is to be scanned in two passes known as even pass and odd pass. In first pass the electron gun scanning will skip every next line on the second pass, it will scan the lines it missed during the first lines, thus creating the full image in two scans instead of one.

Non interlacing : It is the opposite of interlaced display i.e. all the lines are scanned or displayed in one pass instead of the two passes required in the interlaced display.

3. **Frame rate :** This is used to show the number of times a screenful of information is produced per second on the monitor. Higher the frame rate, less flicker problem you get.

4. **Video bandwidth :** It is the highest input frequency a monitor can handle and helps in determining the resolution capabilities of the monitor and unit is megahertz (MHz). Higher the video bandwidth, image quality is better.

The bandwidth is calculated as

Bandwidth = horizontal pixel × vertical pixel × frame rate.

The table list same standard video Bandwidths for different display cards.

Video	Bandwidth (in MHz)
MDA	16.3
CGA	14.3
EGA	16.3
VGA	25-28
8514/A	44.9

5. **Horizontal scanning frequency :** The frequency at which the monitor repaints the horizontal lines that make up an image is called horizontal scanning frequency. It is measured in KHz (Kilo hertz).

6. **Vertical scanning frequency :** The frequency at which the monitor repaints the whole screen, is called vertical scanning frequency. It is also called as vertical refresh rate and it is measured in Hz (Hertz).

7. **The dot pitch or slot pitch :** It is simply a measurement of the distance between dots or slots on the CRT. This measurement is independent of the size of the tube or the size of the displayed image.

8. **Screen size :** Most computer displays are rated by their screen size. Different size of monitors are available as 15 inch monitor, 17 inch monitor, 14 inch monitor etc.

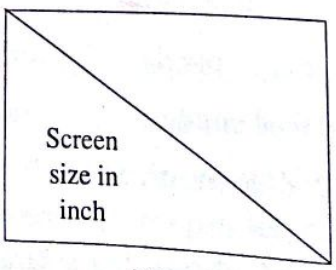

Fig. 2.3

2.2.2 CRT Display Basics

The Fig. 2.4 shows the block diagram of the CRT controller in a PC.

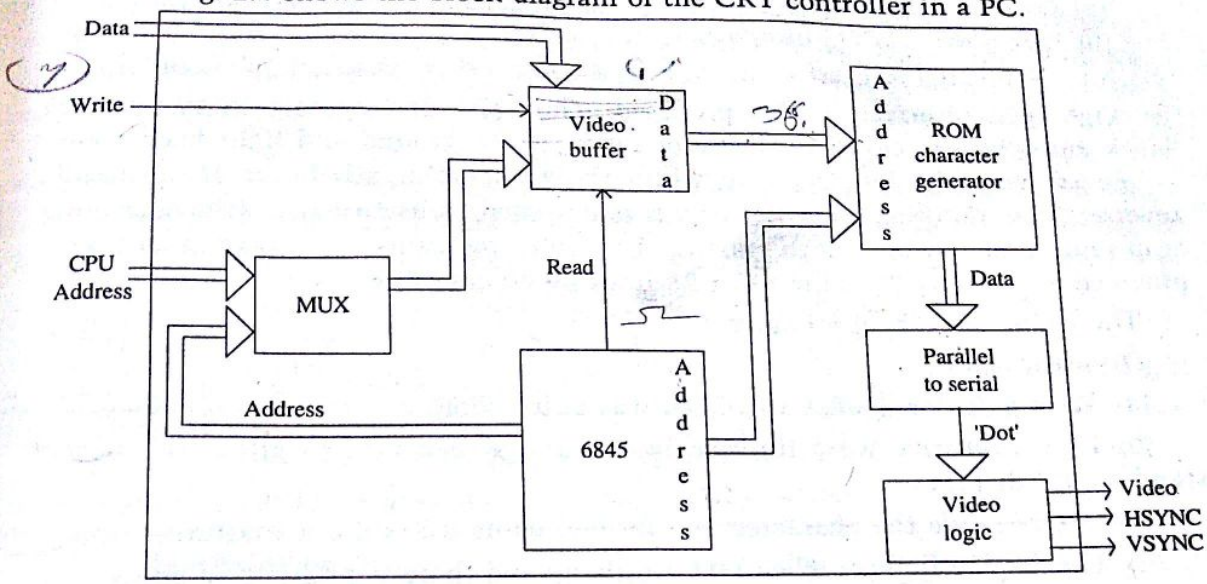

Fig. 2.4 Display adaptor

The display adaptor contains video RAM, 6845 CRT controller IC character generator ROM, parallel to serial shift registers, multiplexers and video logic as major blocks.

The basic CRT controller principle is some in almost all display adaptors. The CRT controller has video buffer memory with dual port access means it can be access either by CPU or 6845 CRT controller. The message or pattern to be displayed is first stored in the video buffer by the CPU (program). The CRT controller (6845) reads the data from the video buffer and also generates appropriate address signals for the character generator ROM which gives the dot patterns for the characters. The video buffer memory (screen memory) contains the text to be display in ASC II format. The dot pattern generated by character generator is in parallel form. This parallel dot pattern is converted into serial form by parallel to serial shift register (PISO). These serial dots pattern are processed by video process logic and sent to CRT display along with SYNC signals (HSYNC, VSYNC). The 6845 CRT controller generates SYNC signals such as HSYNC, VSYNC. The video process logic sends video, HSYNC, VSYNC signals to the CRT and appropriate character are displayed on the CRT screen.

2.3 ADAPTORS

The function of generating the picture to be displayed is performed by the display adaptor. The display adaptors are of two types Monochrome display adaptor which supports alphanumeric text in black and white, color graphics adaptor which supports text and graphics in color.

1. CGA : It stands for Color Graphics Adaptor. It supports text and graphics in color. It provides three video interfaces :

(a) Composite video interface

(b) Direct drive (TTL) interface

(c) RF modulator interface for linking a home TV via external RF modulator.

Light pen interface is also provided. The CGA can operate in two modes black and white or color. In the color mode 16 foreground and light background colors are possible. In black and white three character attributes are available reverse video, blinking and intensity. It is designed to use a 15.75 kHz horizontal scan rate. It can be used with existing TTL color monitors. Two text modes were provided 25 lines by 80 columns or 25 lines by 40 columns.

The CGA has 16K of memory.

Disadvantages :

(a) With graphics display the CGA was quite poor.

(b) Its capabilities were limited by the design decision to allow the use of standard TV displays.

(c) In text mode the characters are formed using a 8 × 8 dot matrix.

(d) The display flickers when text strolls up and there is problem of snow.

The IBM PC color graphics adaptor board : Fig. 2.5 shows the IBM PC color/graphics adaptor board. This board uses the Motorola MC 6845 CRT controller device to do the overall display control. It produces the sequential addresses required for the display refresh RAM, the horizontal sync pulses, and the vertical sync pulses. The 16 kbyte display refresh RAM is dual ported. This means that it can be accessed by either the system processor or the CRT controller on a time share basis.

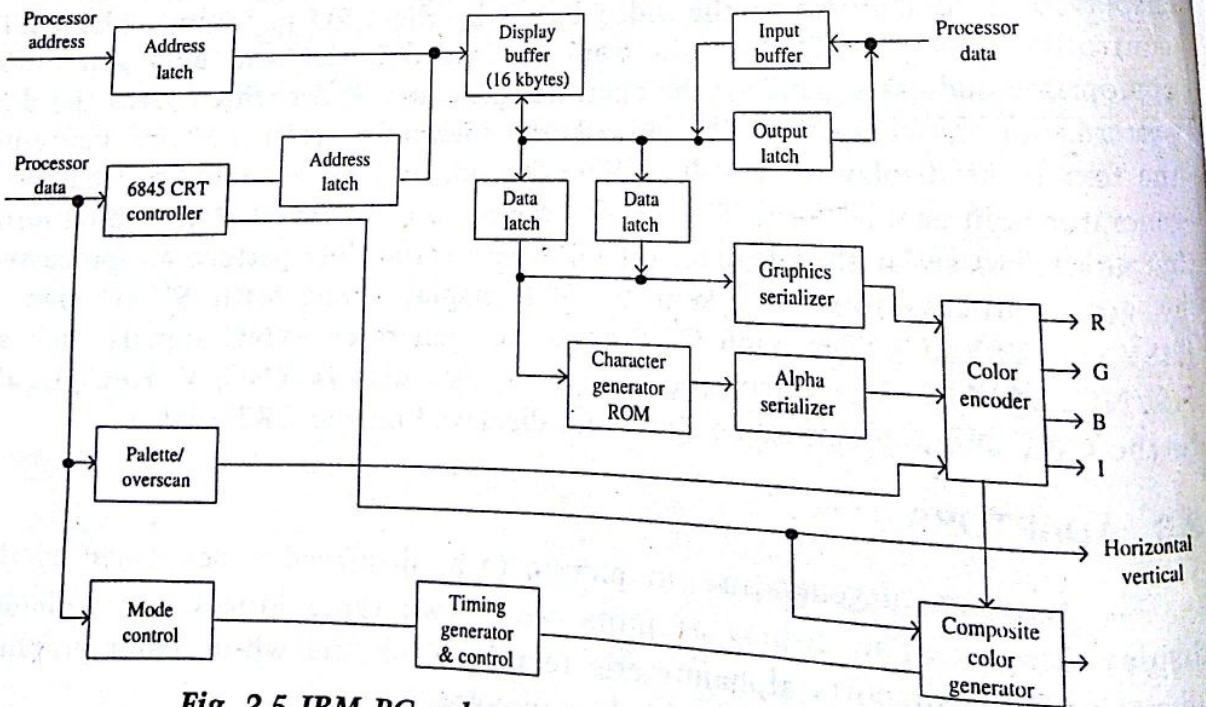

Fig. 2.5 IBM PC color graphics adaptor board block

This adaptor board
mode. In the characte
shift register (alpha se
scan lines. When ope
shift registers (graphic
color guns and for the

Resolution	Co
1. 320 × 200	
2. 640 × 200	
3. 320 × 200	
4. 640 × 200	

Pin configurati

(Female 9 - Pi

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1.
2.
3.
4
5
6

2. HGA :
supports high
Features o
(a) 720 ×
(b) 64 Kb
(c) Two
starting from
(d) Print
required for
HGA. It has
HGA pl
(a) Stan
(b) HG

This adaptor board can operate in either a character mode or a graphics mode. In the character mode it uses a character generator ROM and a single shift register (alpha serializer) to produce the serial dot information for display scan lines. When operating in a color graphics mode, the board uses separate shift registers (graphic serializer) to produce the dot information for each of the color guns and for the overall intensity.

CGA Summary

Resolution	Colours	Mode	Character	Vertical	Horizontal
1. 320 × 200	16	Text	40 × 25	60 Hz	15.75 kHz
2. 640 × 200	16	Text	80 × 25	60 Hz	15.75 kHz
3. 320 × 200	4	Graph	40 × 25	60 Hz	15.75 kHz
4. 640 × 200	2	Graph	40 × 25	60 Hz	15.75 kHz

Pin configuration of CGA Display Adapter Cable :

(Female 9 - Pin D - Subminiature, cable requires male)

Pin Number	Description
1.	Ground
2.	Ground
3.	Red
4.	Green
5.	Blue
6.	Intensity
7.	Reserved
8.	Horizontal Sync. (H Sync.)
9.	Vertical Sync. (V Sync.)

2. HGA : It was introduced in 1983. It is an advanced Graphics Adaptor. It supports high quality graphics, text and provides a parallel printer interface.

Features of HGA are :

(a) 720 × 348 resolution

(b) 64 Kb video buffer

(c) Two graphics pages with a facility to disable second graphics page starting from B 8000.

(d) Printer Port : The HGA is not supported by DOS. Therefore drivers are required for supporting this. Hercules graphics card plus is the later version of HGA. It has more memory. It supports RAM font mode.

HGA plus can operate in two modes :

(a) Standard HGA

(b) HGA plus with RAM font.

Additional features are :

(a) High speed

(b) The user can create and edit his own fonts.

(c) Contains a program to blank the screen when the system is not used thus increasing the life of the tube.

3. **VGA :** Video Graphics Array was introduced along with PS/2. It is similar in operation to the EGA but the advantages are resolution is more and it provides new BIOS functions. The memory supplied is 256 kb. The resolution is 640 × 480 pixels. It can display 256 out of a palette of 262, 144 colors on screen in lower resolutions if analog monitor is used. The adaptor senses whether a monochrome or color monitor is attached.

A proprietary gate array CRT controller device in a VGA based system allows you, to select the dot clock frequency, the number of horizontal scan lines, the vertical refresh rate, the amount of overscan etc. In order to produce 256 colors, a VGA system generates analog red, green and blue signals used by MGA, CGA, EGA adaptors.

As shown in Fig. 2.6 a 6 bit D/A converter, commonly called a video DAC, is used to produce each of the color signals. With 6 bit D/A converter each signal can have 2^6 or 64 possible values, so that total possible number of combinations for the three signals is 64 × 64 × 64 or 262,144 which we refer to as 256 K.

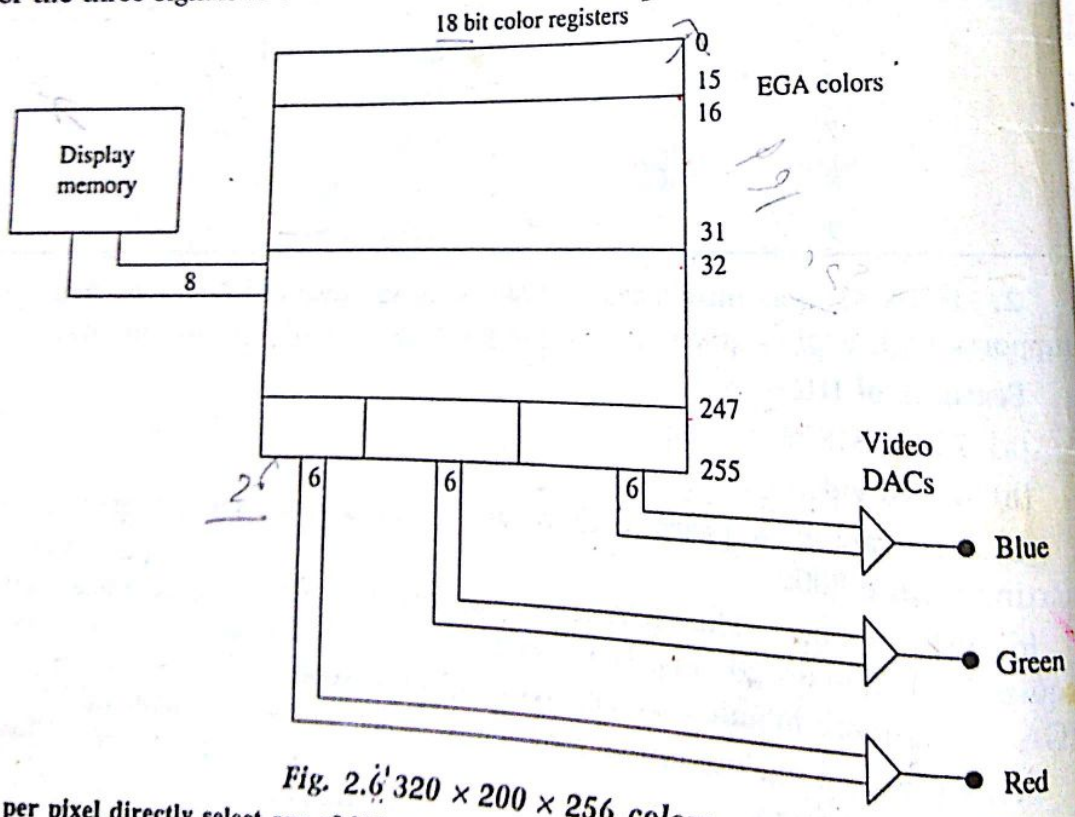

Fig. 2.6 320 × 200 × 256 colors

8 bit per pixel directly select one of 256 color registers.

As shown in Fig.
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number of colors tha

For each pixel a
D/A converters. Thi
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The 8 bit value
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the pixel value are
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registers. The low
used as the lower

Resolution	
1. 360 × 400	
2. 720 × 400	
3. 640 × 480	
4. 320 × 200	

Pin configura

(Female 15 -

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15.	

4. EGA
supports m
monochrome

As shown in Fig. 2.6, the 18 bit values for the colors to be displayed are stored in 256 color registers. Since there are only 256 color registers, the maximum number of colors that you can display at a time is 256.

For each pixel an 8 bit value is used to select the color register which drives D/A converters. This 8 bit value is produced in several different ways, depending on the selected display mode.

The 8 bit values for four successive pixels are stored in four memory planes. When an 8 bit pixel value is read from one of memory planes, the upper 4 bits of the pixel value are used directly as part of the color register address. The lower 4 bits of the pixel value from memory planes are used to address one of 16 palette registers. The lower 4 bits of the value from the addressed palette register are used as the lower 4 bits of the color register address.

VGA Summary

Resolution	Colours	Mode	Character	Vertical	Horizontal
1. 360 × 400	16	Text	40 × 25	70 Hz	31.5 kHz
2. 720 × 400	16	Text	80 × 25	70 Hz	31.5 kHz
3. 640 × 480	16	Graph	80 × 25	60 Hz	31.5 kHz
4. 320 × 200	256	Graph	40 × 25	70 Hz	31.5 kHz

Pin configuration of VGA RGB Display Adapter Cable :

(Female 15 - Pin D - Subminiature, cable requires male)

Pin Number	Description	Monochrome Use	Colour Use
1.	Red		Red
2.	Green	Monochrome	Green
3.	Blue		Blue
4.	Monitor ID bit-2		
5.	Ground	Self Test	Self Test
6.	Red Return		Red Return
7.	Green Return	Monochrome return	Green Return
8.	Blue Return		Blue Return
9.	Not used		
10.	Sync. Return	Ground	Ground
11.	Monitor ID bit-0		
12.	Monitor ID bit-1		
13.	Horizontal Sync.	Horizontal Sync.	Horizontal Sync.
14.	Vertical Sync.	Vertical Sync.	Vertical Sync.
15.	Reserved		

The user can create and edit his own fonts. These are called as RAM fonts. The user can define a maximum of four fonts of 256 characters but at a time only two fonts can be active. Split screen operation and hardware rolling is possible by the use of hardware registers. It has 256K dual part memory, two graphics controller handling processing. It has 16K video BIOS ROM and 71 progrmmable registers.

Hardware : It has programmable CRT controller which allow you to set the display mode.

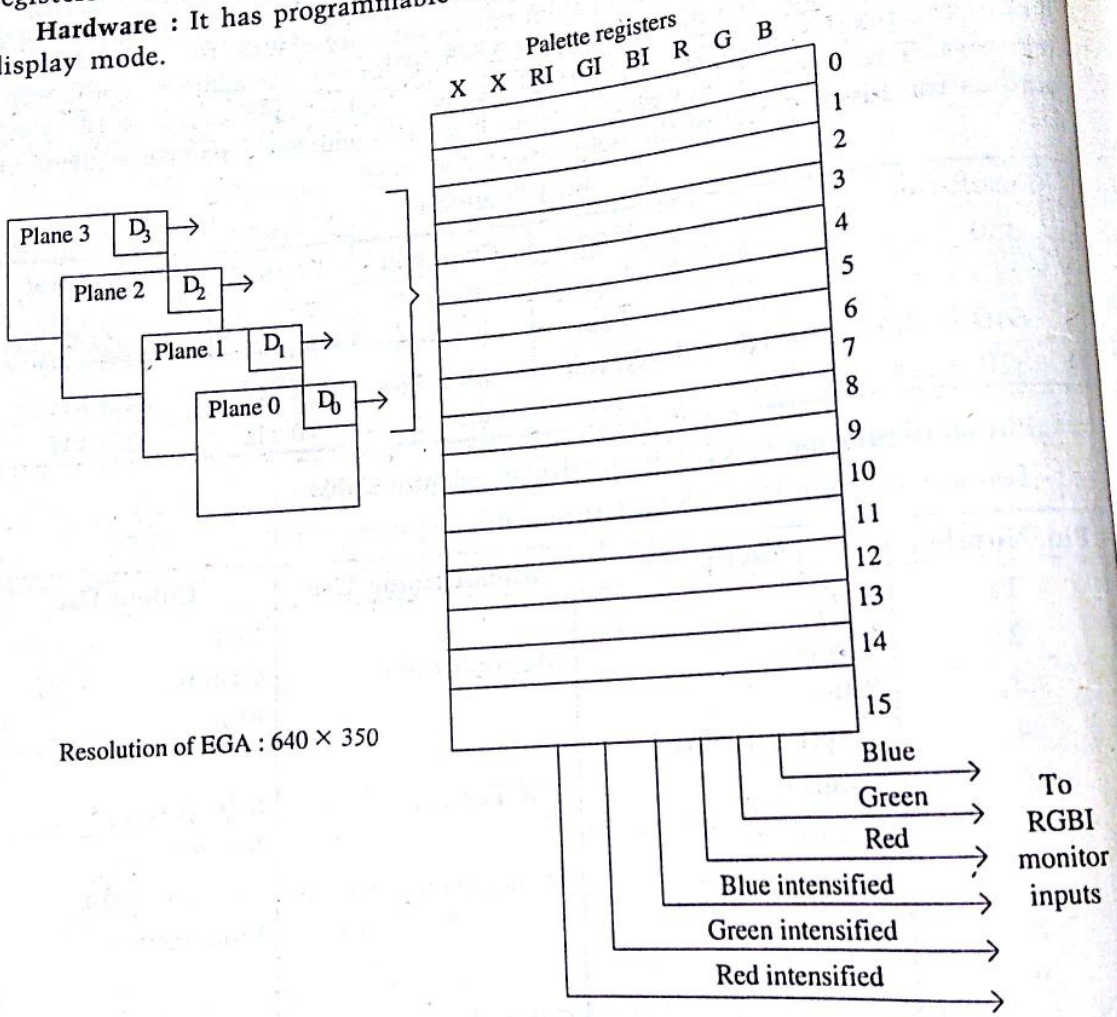


Fig. 2.7 Function of frame buffer and palette registers for the most commonly used EGA display

In this mode the frame buffer memory is configured as four planes. Each plane holds one of the 4 bits required to specify the color of each pixel. A 4-bit value read from the four planes is used to address one of the sixteen 8 bit palette registers. The lowest 6 bits from the addressed palette register are output to the color monitor.

Note : To work with this mode the monitor must have red-intensified, green-intensified, and blue-intensified inputs as well as standard red, green and blue inputs.

There are 64 possible combinations for 6 bit value in each palette register, but there are only 16 palette registers, only 16 of the 64 possible combinations can be stored at a time. The 16 values in the palette registers at any particular time then specify 16 colors from a palette of 64. During bootup the palette registers in an EGA are initialized with values which correspond to the 16 colors available on a CGA system, but you can load the palette registers with values which produce your favourite colors.

EGA Summary

Resolution	Colours	Mode	Character	Vertical	Horizontal
1. 320 × 350	16	Text	40 × 25	60 Hz	21.85 kHz
2. 640 × 350	16	Text	80 × 25	60 Hz	21.85 kHz
3. 640 × 350	4	Graph	80 × 25	50 Hz	18.43 kHz
4. 640 × 350	16	Graph	80 × 25	60 Hz	21.85 kHz

Pin configuration of EGA RGB display adapter cable :
(Female 9 - Pin D - Subminiature, cable requires male)

Pin Number	Description
1.	Ground
2.	Secondary Red
3.	Red
4.	Green
5.	Blue
6.	Secondary Green/Intensity
7.	Secondary Blue/Mono video
8.	Horizontal drive
9.	Vertical drive

5. MDA (Monochrome Display Adaptor) : The MDA uses 6845 IC as CRT controller. The CRT controller has video buffer memory with dual port access. The message or pattern to be displayed is stored in the video buffer by the CPU (program). The CRT controller reads the data from the video buffer and also generates appropriate address signals for the character generator ROM which gives the dot patterns for the characters. These are processed by video process logic and sent to CRT display along with SYNC signals. Thus the video buffer, character generator, CRT controller LSI and video process logic are the major blocks that constitute the CRT controller.

The MDA uses total 4 kb screen memory. In 2 kb memory, ASCII codes for the characters to be displayed are stored. In another 2 kb memory used to store an attribute code for each character. An attribute code specifies how the character is to be displayed. For example, with an underline or with increased or decreased intensity.

Now observe that there is a multiplexer in series with the address lines going to the character and attribute memories. This is done so that either the CPU or the CRT controller can access the display refresh RAM. The 6845 has 14 address outputs, so that it can address up to 16 kbyte display and attribute locations. To keep the display refreshed, the 6845 sends out the memory address for a character code and an attribute code. The character clock signal latches the code from memory for the character generator and the attribute code for the attribute decode circuitry. The character clock also increments the address counter in the 6845 to point to the next character code in memory. The next character clock transfers the next codes to the character generator and attribute decoder. The process cycles through all the characters on the page and then repeats. Now, when you want to display some new characters on the screen, you simply have the CPU to execute some instructions which write the ASCII codes for the new characters to the appropriate address in display RAM. When the address decoding circuitry detects a display RAM address, it produces signal which toggles the multiplexers so that the CPU has access to display RAM.

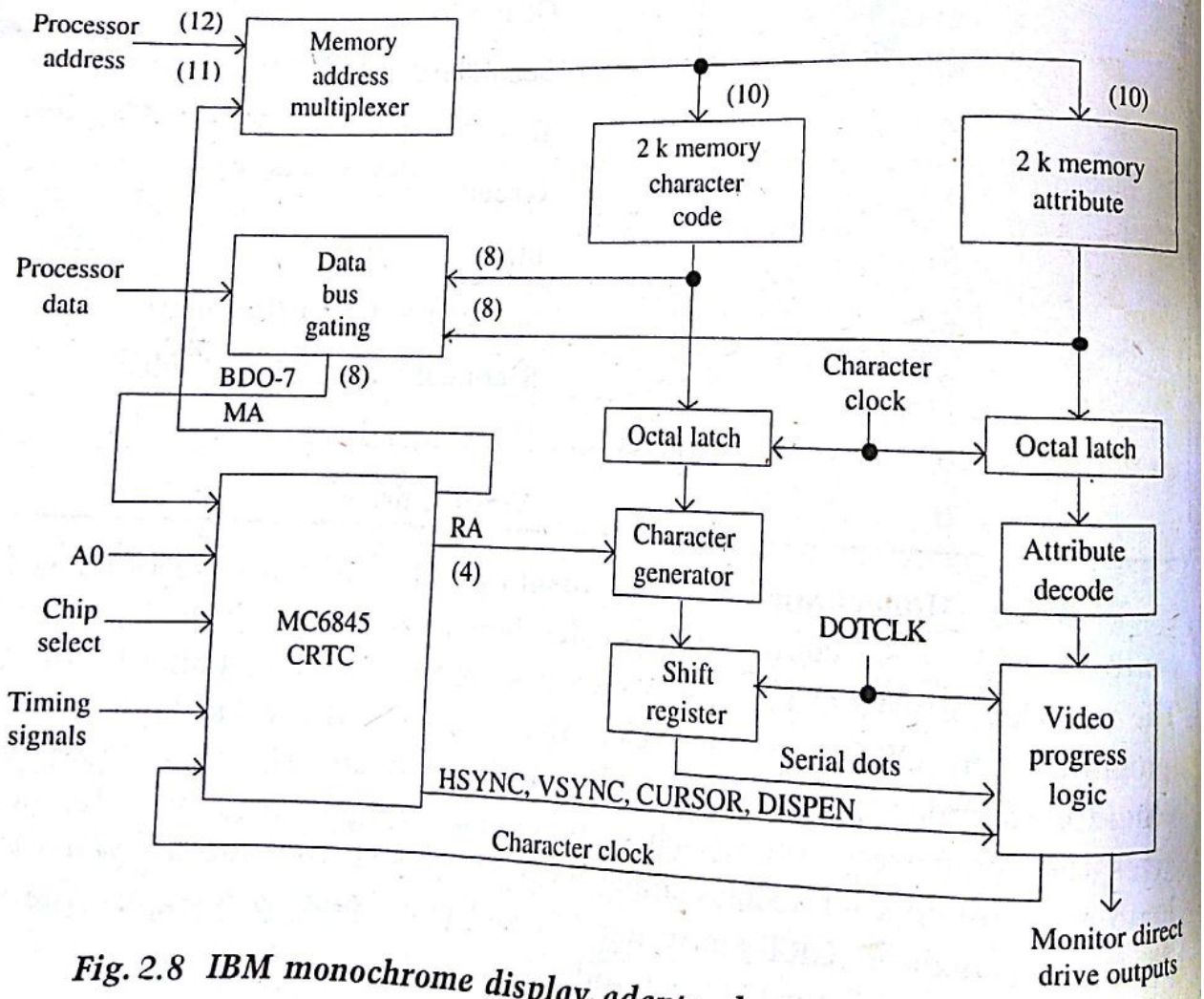


Fig. 2.8 IBM monochrome display adaptor board block diagram

MDA Summary

Resolution	Colours	Mode	Character	Vertical	Horizontal
720 × 350	4	Text	80 × 25	50 Hz	18.43 kHz

Pin configuration of MDA Cable :

(Female 9 - Pin D - Subminiture, Cable requires males)

Pin Number	Description
1.	Ground
2.	Ground
3.	Not connected
4.	Not connected
5.	Not connected
6.	Intensity
7.	Video
8.	Horizontal Sync. (H Sync.)
9.	Vertical Sync. (V Sync.)

6. MGA : The Monochrome Graphics Adaptor (MGA) introduced by several clones is compatible to the HGA. It supports two modes of display.

(a) Text mode : 80 column by 25 line.

(b) Graphics mode : 720 column by 348 dots.

The 6845, being a character oriented CRT controller, is programmed for different character sizes in text mode and graphics. In the text modes the character is 9 dot wide by 14 scan lines tall. In the graphics mode, the bit mapped graphics "character cell" is 16 dots wide and 4 scan lines tall. The video buffer is 64 kbytes and is divided into two graphics pages of 32 kb each, as shown below :

page 0 from B0000 to B7FFF

page 1 from B8000 to BFFFF.

In text mode, address from B0000 to B0FFF is used to store character and attribute codes. The MGA usually supports a parallel interface for the printer. The MGA usually provides limited light pen logic. It is generally used by software routines to sense whether the MGA is currently in text or graphics mode.

Table : Display adaptors and screen memory

Sr. No.	Adaptor	Screen Memory
1.	MDA	4 k
2.	CGA	16 k
3.	HGA/MGA	64 k
4.	EGA	256 k
5.	PGA	320 k

2.4 LCD MONITOR

Most of the computers use CRT displays. CRT displays are bulky and fragile so that they are not suitable for Lap Top computers. Lap Top computers use liquid crystal display. The same type of display is used for calculators and digital watches.

The LCD's are compact, lightweight, durable and use little power. The disadvantage is that the LCD graphics capability is poor because the individual pixels aren't small enough give sharp definition. LCD can have a maximum resolution equal to that of a VGA resolution. They are very expensive even a 10 inch screen costs thousands of dollars.

The liquid crystal material is sandwiched between a pair of polarizers and transparent electrodes are deposited on either side of the sandwich. On one side the electrode lines are horizontal and on the other side the electrode lines are vertical. Applying a voltage between the horizontal electrode line and vertical electrode line creates electric field across the liquid crystal layer just at the intersection where particular line of electrodes cross. The polarizers are oriented with respect to each other in such a way that no voltage is existing across the liquid crystal, the polarized light transmitted by the first polarizer has its plane of polarization rotated by liquid crystal by an amount to pass through second polarizer. The polarization rotation angle differs from the zero field value depending upon the electric field thus causing part of light to be locked by second polarizer. The amount of light blocked depends on the applied voltage.

For creating text and graphics in an LCD display, the electrode intersections are scanned in a raster pattern.

2.4.1 Working Principle of LCD

In a LCD display each pixel is filled with a transparent material called liquid crystal. When energy is supplied, the liquid crystal material becomes polarised (i.e. it will pass/reflect light of a certain polarity only) and appear darker than its background.

A light source is used to produce light at the background. That light is passed through the polarizing filter. Then polarized light passes through a liquid crystal sandwitched between transparent column and row electrodes.

When current is pass
crystal twist and they ro
polarizing filter which is
the second polarizing fil
first polarizing filter, the
If you do not apply
incoming light and pas
you will get a dark or l

Types of LCD - Th

(a) Passive-matrix

In a passive ma
transmitted by transi
edge. Passive matrix
passive matrix color
and blue respective
have multiple cells
LCD the cell reacts

The twist in th
is more the twist i
as the charges are
screen into a top
This is called as

Active matrix
each cell has its
provided with a
Energy consump
matrix LCDs ar

Vertic
elect

When current is passing through the electrodes, the molecules of the liquid crystal twist and they rotate incoming light by 90 degree. Next we have another polarizing filter which is in 90 degree to the first filter. The light will pass through the second polarizing filter if the incoming light is rotated by 90 degrees by the first polarizing filter, then display shows the bright pixel on screen.

If you do not apply any current to electrode, liquid crystal would not rotate incoming light and pass them as it is. The second filter will block that light and you will get a dark or black pixel on display.

Types of LCD - There are two types of LCD :

(a) Passive-matrix LCD (b) Active-matrix LCD.

In a passive matrix LCD each cell is controlled by electrical charges transmitted by transistors according to row and column positions on the screen's edge. Passive matrix LCD is of two types – passive matrix monochrome and passive matrix color. In color LCD there are three cells per pixel for red, green and blue respectively. Monochrome LCD's do not have color filters, but they have multiple cells per pixel for controlling shades of gray. In passive matrix LCD the cell reacts to the pulsing charge and twists the light wave.

The twist in the light wave is directly proportional to the charge. If the charge is more the twist is more and vice-versa. Brilliance in passive matrix LCD is less as the charges are pulsed. To increase the brilliance vendors split passive matrix screen into a top half and bottom half, thus cutting the time between each pulse. This is called as a double scan LCD.

Active matrix LCDs are the best type of LCD displays. In active matrix LCD, each cell has its own transistor to charge it and twist the light wave. As the cell is provided with a constant charge the brilliance is better than passive matrix LCD. Energy consumption in active matrix LCD is more than passive matrix. Active matrix LCDs are costly and their manufacturing process is complicated.

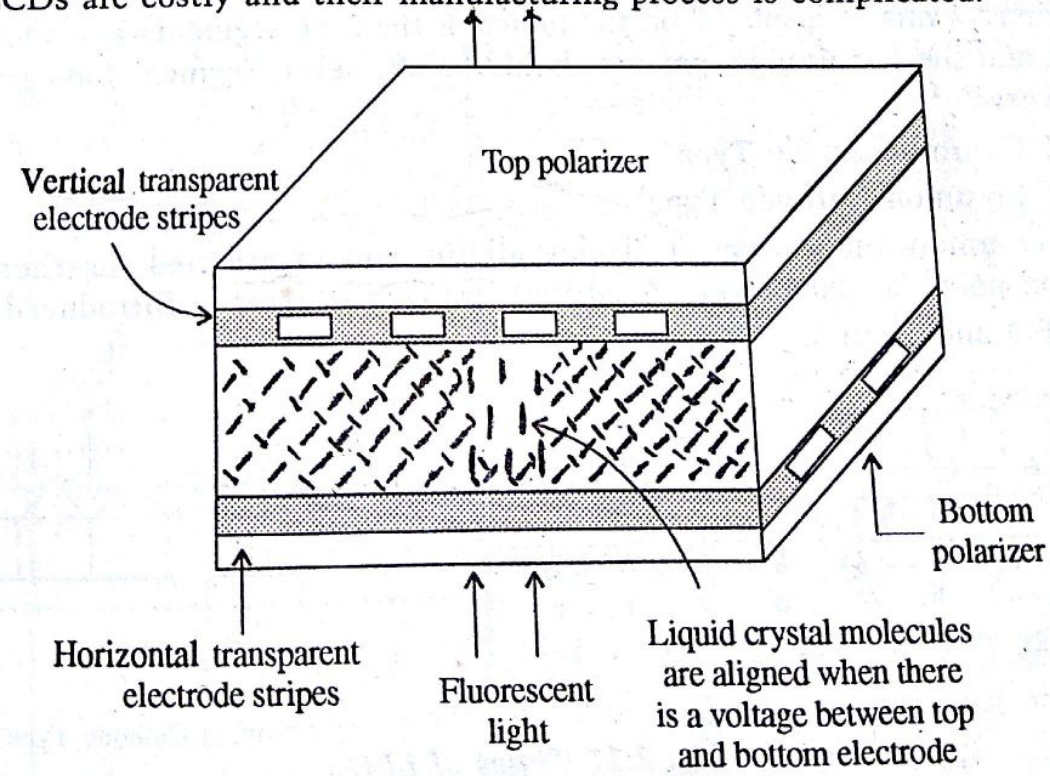


Fig. 2.9 Construction of LCD

Advantages and Disadvantages of LCD

Advantages :

(a) Power consumption is low.

(b) Cost is less.

Disadvantages :

(a) Turn on and Turn off is large hence they are slow devices.

(b) Their life span is less when used on DC.

(c) They occupy large area.

2.5 SEVEN SEGMENT DISPLAY

Seven Segment Display is the most popular display device used in digital systems. LED emits radiation due to recombination of free electrons with the holes at the function. By using elements like gallium, arsenic and phosphorus a manufacturer can produce LEDs that emit red, green and yellow light. LEDs are useful in testing instruments, digital systems etc.

Fig. 2.10 shows a seven segment indicator. It is containing seven segments a, b, c, d, e, f and g respectively.

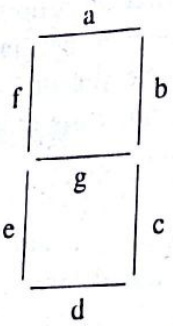


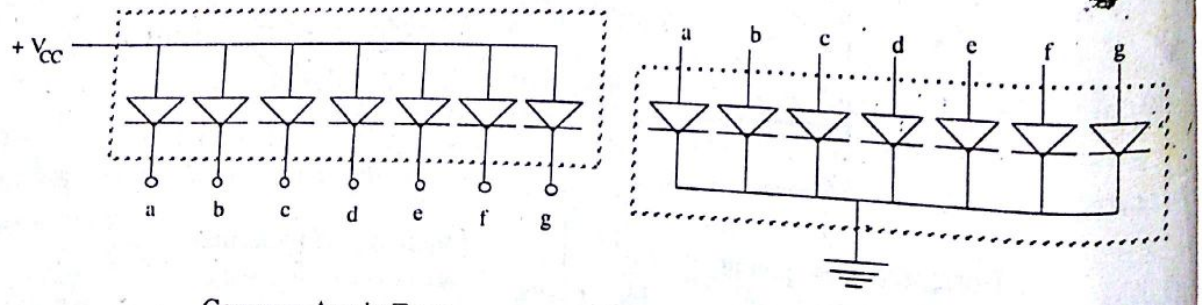
Fig. 2.10 Seven segment indicator

If one wants to display 7 on the indicator then the segments a, b and c should be on and the remaining segments should be off. Seven Segment Indicators are of two types :

(a) Common Anode Type

(b) Common Cathode Type.

In common anode type of display all the anodes are tied together and the common point is tied to V_{CC}. A current limiting resistor is introduced between each LED and ground.



Common Anode Type

Common Cathode Type

Fig. 2.11 Types of LED

In common cathode type of display all the cathodes are tied together and the common point is tied to ground. A current limiting resistor is introduced between each LED and V_{CC}.

A seven segment decoder-driver is used to drive a seven segment indicator. IC 7446 drives a common anode type of display. IC 7447 drives a common cathode type of display.

BCD to 7 Segment Converter :

It can be either 7446/7447. It is used to convert four bit BCD input to control the outputs for drawing a seven segment LED.

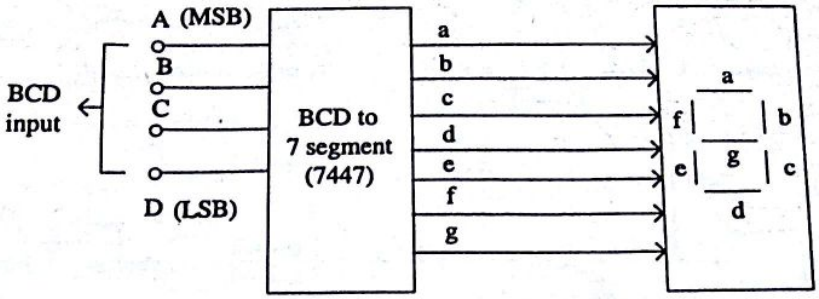


Fig. 2.12 BCD to 7 segment converter

Truth Table of a BCD converter for driving a common cathode type of display is as follows :

Truth Table :

Digit displayed	Inputs				Outputs						
	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	0	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	0	0	1	1

BCD to seven segment conversion can be realized using NAND gates als and the circuit is as follows :

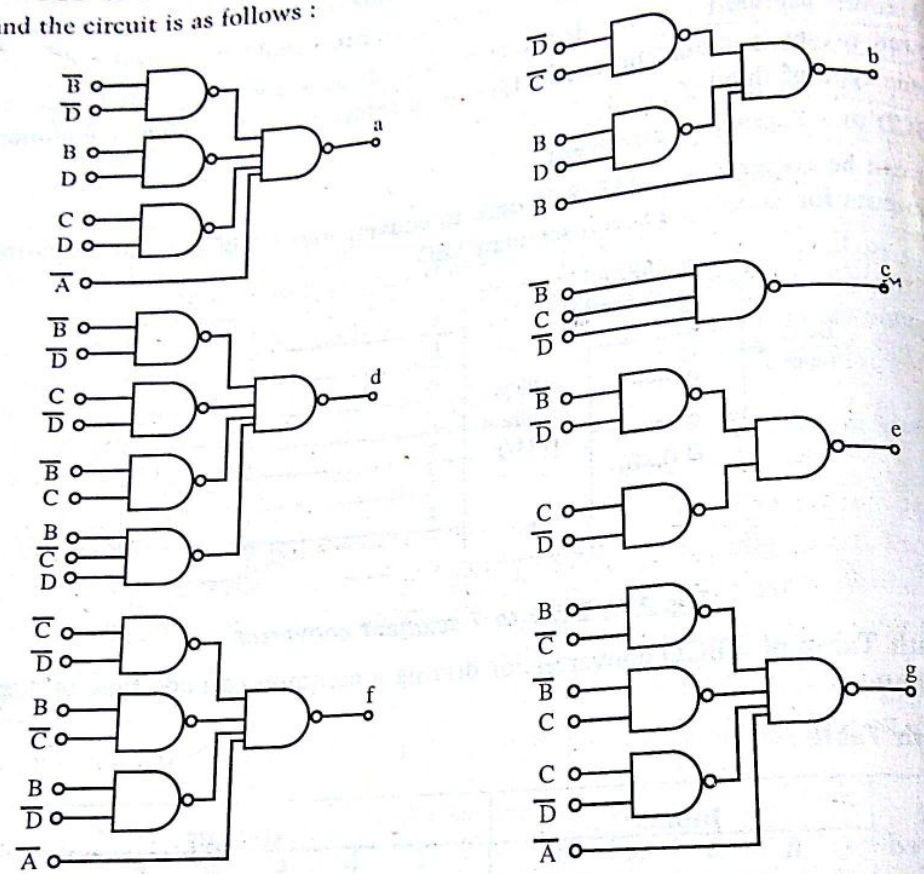


Fig. 2.13 BCD to seven segment using NAND gate

Advantages of LED :

(a) It occupies small area.

(b) LEDs are available which emit light of different colors.

(c) Intensity of light can be controlled by the current.

(d) Turn on and Turn off time is very small.

(e) It can withstand shocks and vibrations.

Disadvantages of LED :

(a) Power consumption is more.

(b) Not suitable for large area displays.

2.6 PRINTERS

It is an output devic
selecting a printer :

(a) Resolution of the
(b) Paper width sizes
(c) Speed of the prin
(d) Is graphics Mod
(e) Types and numl
(f) Type of feed m
(g) Cost of printer

Printers are of two

1. Impact printe
2. Non Impact

1. Impact Print

output media. The
squeeze ink from ri
Daisy wheel printe

Advantages :

(a) Design an
printers.

(b) As the im
produced by the

Disadvantage

(a) They are

2. Non Imp

carbon or pape
magnetization

Examples o

Advantages

(a) Soundl
(b) High q

Disadvan

(a) Multi
(b) They

2.6 PRINTERS

It is an output device. The following points should be considered while selecting a printer :

(a) Resolution of the printer

(b) Paper width sizes supported

(c) Speed of the printer

(d) Is graphics Mode supported by the printer

(e) Types and number of character font supported by printer

(f) Type of feed mechanism

(g) Cost of printer.

Printers are of two types :

1. Impact printers
2. Non Impact printers.

1. Impact Printers : These type of printers uses impact to create an image on output media. The impact printers smash a hammer against an inked ribbon to squeeze ink from ribbon onto the printing media. Examples of impact printers are Daisy wheel printers, Dot matrix printers etc.

Advantages :

(a) Design and functioning of this kind of printer is easy than non impact printers.

(b) As the image is produced as a result of impact multiple copies can be produced by the use of carbon paper.

Disadvantages :

(a) They are noisy in operation.

2. Non Impact Printers : In this type of printers the printer does not strike the carbon or paper but instead it uses ink spraying, heat process or electrostatic magnetization to produce the required image on the output media.

Examples of non impact printers are Ink jet, Laser etc.

Advantages :

(a) Soundless operation

(b) High quality output.

Disadvantages :

(a) Multiple copies cannot be produced in a single pass.

(b) They are costly.

Interfacing of Printer : Printer Interface can be done in two ways, serial or parallel. Selection of a particular type of interface depends upon the requirement and the location of the printer.

Serial Interface : If the printer is located far, one should go for the serial interface because the cost is less. The printer is connected to the serial port of the computer. The data moves serially one bit at a time so it is called as serial interface. Two lines are not enough for serial communication because some extra lines are required for hand shaking purpose. Serial communication is of two types :

1. **Synchronous Communication :** Data is synchronized with external clock signal and data is sent at fixed interval.

2. **Asynchronous Communication :** There is no clock signal to co-ordinate between transmitting and receiving end. Start bit indicates that after this bit data will be transmitted and stop bit indicates the end of data transmission.

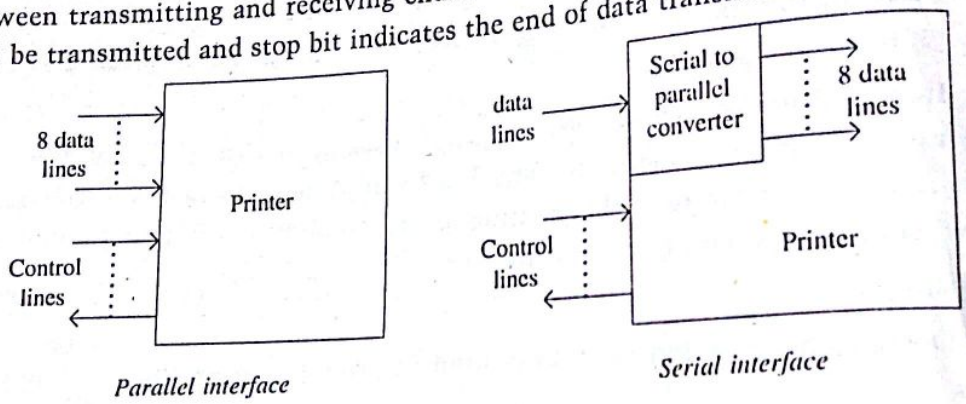


Fig. 2.14

Printer Characteristics : There are a wide variety of printers. They differ in different aspects like performance, price and quality. The main characteristics of the printers are listed below :

(a) Speed : Specified as CPS (Characters per second) or LPM (Lines per minute). It indicates how fast a printer works.

(b) Quality : Specified as RAFT, NLQ (Near Letter Quality) or LQP (Letter Quality Printer). This implies how good the shape of the printed character is.

(c) Character Set : Indicating the total number of data characters and control characters recognised by the printer.

(d) Interface : Specifying whether the printer receives characters from the printer in parallel form (one character at a time) or in serial form (one bit at a time).

(e) Buffer Size : Indicating how many data characters can be stacked in the printer buffer memory before printing.

(f) Print Mechanism : Specified as impact dot matrix, impact daisy wheel, impact golf ball, electrosensitive dot matrix, thermal dot matrix, band, belt, drum, train, chain, ink jet or laser.

(g) Print Mode : Specified as serial or parallel.

(h) Print Size : Specified as character size and number of characters per line (number of print columns).

(i) Print Direction : Specified as unidirectional, reverse, bidirectional logic seeking.

2.7 TYPES OF PRINTERS

1. Dot Matrix Printer : It is the most popular serial printer used with PCs. It has a print head that is pulled horizontally across the paper from left to right and back again by using a rubber belt and an electric motor. Dot matrix printer doesn't print a whole character but the character is generated from an array or matrix of dots which is usually 7 by 5.

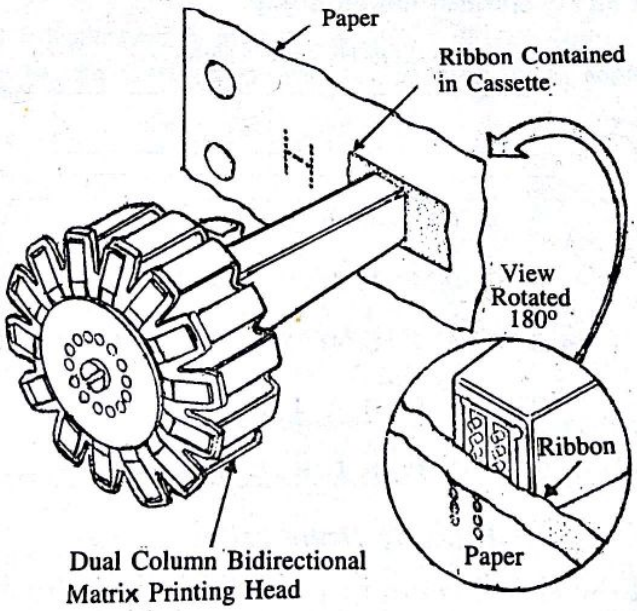


Fig. 2.15

Principle : The print head consists of pins which are arranged in a vertical column. The pins are operated electromagnetically and the character to be printed has dots in certain position of the matrix and the printer head moves column by column in the matrix. The required dots for a column are formed by striking appropriate pins then the printer head moves to the next column.

Centronics-702, HP-2635A are examples of dot matrix printer.

Advantages :

(a) It is very cheap.

(b) They can print alphabets other than English.

(c) They are impact devices, so they can use multi-part stationery.

Disadvantages :

(a) These are light duty printers. They cannot be used continuously for more than an hour.

(b) Quality is not so good

(c) Servicing a dot matrix printer usually costs more than buying a new one.

2. Line Printers : Line printers are of two types :

(a) Drum printers

(b) Chain printers

(a) Drum Printer : A drum printer is consisting of a cylindrical drum and characters to be printed are embossed on its surface. One complete set is embossed for each and every position on a line.

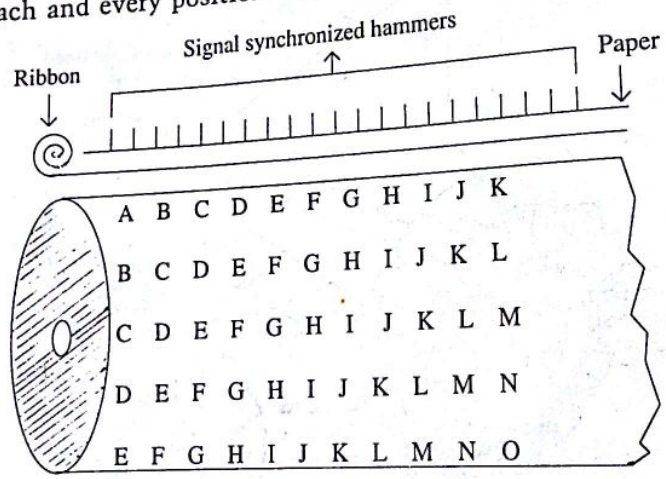


Fig. 2.16 Drum printer

The codes of all the characters to be printed are transmitted by the computer to the storage unit of the printer. A set of hammers one for each character in a line are mounted in front of the drum. A character is printed by striking hammer against embossed character on the surface. The ribbon and paper is placed between the drum and hammer. As the drum rotates the hammer waits and is activated when the character to be printed at that position appears in front of hammer. There should to a synchronization between the hammer and drum movement. The disadvantages are the drum is expensive and it has a fixed font.

(b) Chain Printers : It has a steel band on which character sets are embossed. The characters to be printed are sent to the print buffer. The band is rotated at a high speed and when the desired character comes in front of it the hammer strikes it.

Line printers can print continuously.

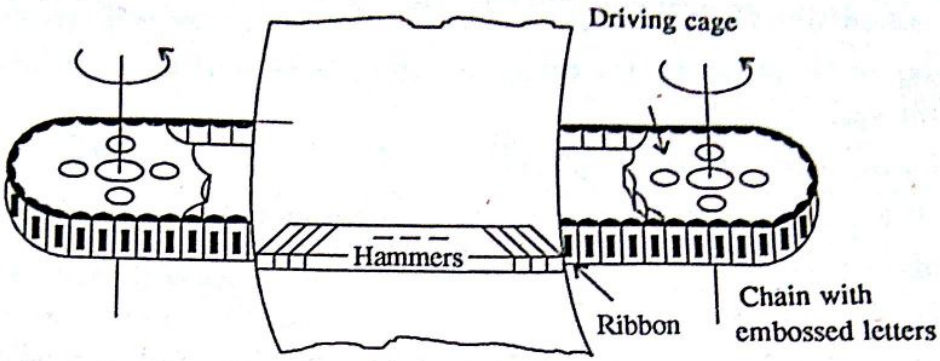


Fig. 2.17

3. Laser Printers : These are non impact printers. They are widely used in application where high quality printing is required. The main aim of developing a laser printer was to eliminate the mechanical motion in the printer.

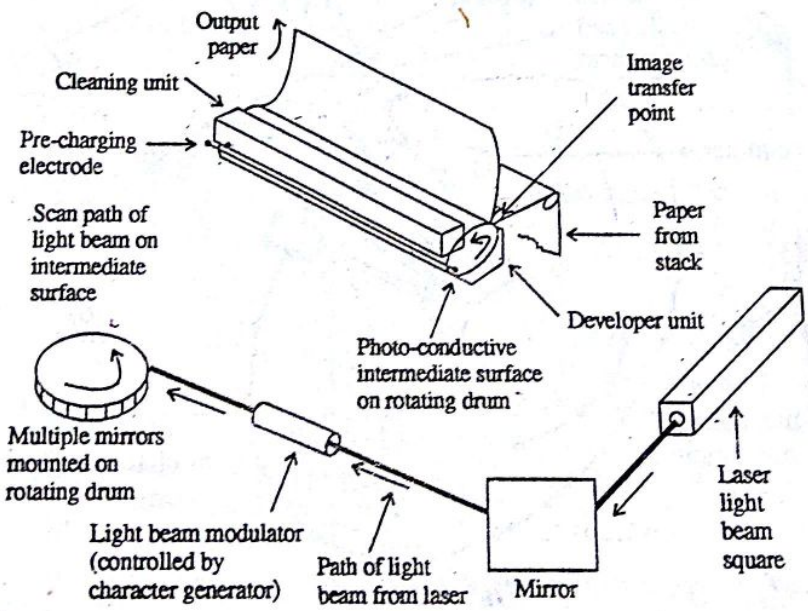


Fig. 2.18

Principle : It's operation is similar to a Xerox machine. Laser is used for creating image on a photosensitive drum. Laser is turned on and off when it sweeps back and forth across the drum. Toner is attracted to the charged areas of the drum and the inked image formed on the drum is electrostatically transferred from the drum to the paper and it is fused on to the paper using hot pressure rollers.

There are two types of laser printers :

Write-white and write black.

In write-white laser, the laser writes a negative image to the drum and the toner is attracted to the areas untouched by the laser beam. In write black laser the toner is attracted to the areas touched by the laser beam.

Advantages :

(a) Letter quality is excellent.

(b) Speed is high.

(c) Supports text and graphics.

(d) No mechanical motion is involved so it is quite in operation.

Disadvantages :

(a) Cost is more.

(b) Maintenance should be done by an expert preferably an engineer.

4. Daisy wheel Printers : It is impact printer.

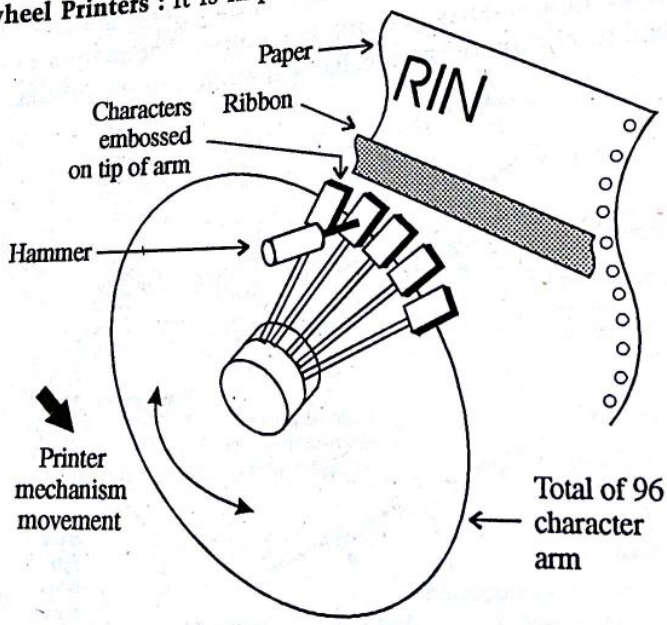


Fig. 2.19

Principle : Daisy wheel is a flat plastic or metal disk containing spokes wherein each spoke is containing a character embossed at the tip. It is mounted on a carriage which can move from left to right and also rotate. The characters to be printed are sent serially to the printer. The carriage positions itself so that the character strikes the ribbon, now the embossed characters strikes the ribbon and the impression is made on the paper.

Advantages :

(a) It gives true letter quality.

(b) Fonts can be easily interchanged.

(c) Supports multi-part stationery.

Disadvantages :

(a) They are slow and noisy.

(b) Maintenance is limited to replacing the ribbon or replacing the daisy wheel.

(c) Most of the manufacturers have stopped manufacturing daisy wheel printers.

5. Ink Jet Printers : It is non impact of printer. They are similar to dot matrix printers. The image is produced by squirting ink through an array of tiny nozzles. In ink jet printers the quality and resolution is directly dependent on the number of nozzles. The motive force for squirting the ink can be either a electromagnet or a piezo electric crystal. When a digital pulse of electricity is applied to the crystal it vibrates and causes the ink to squirt on the paper.

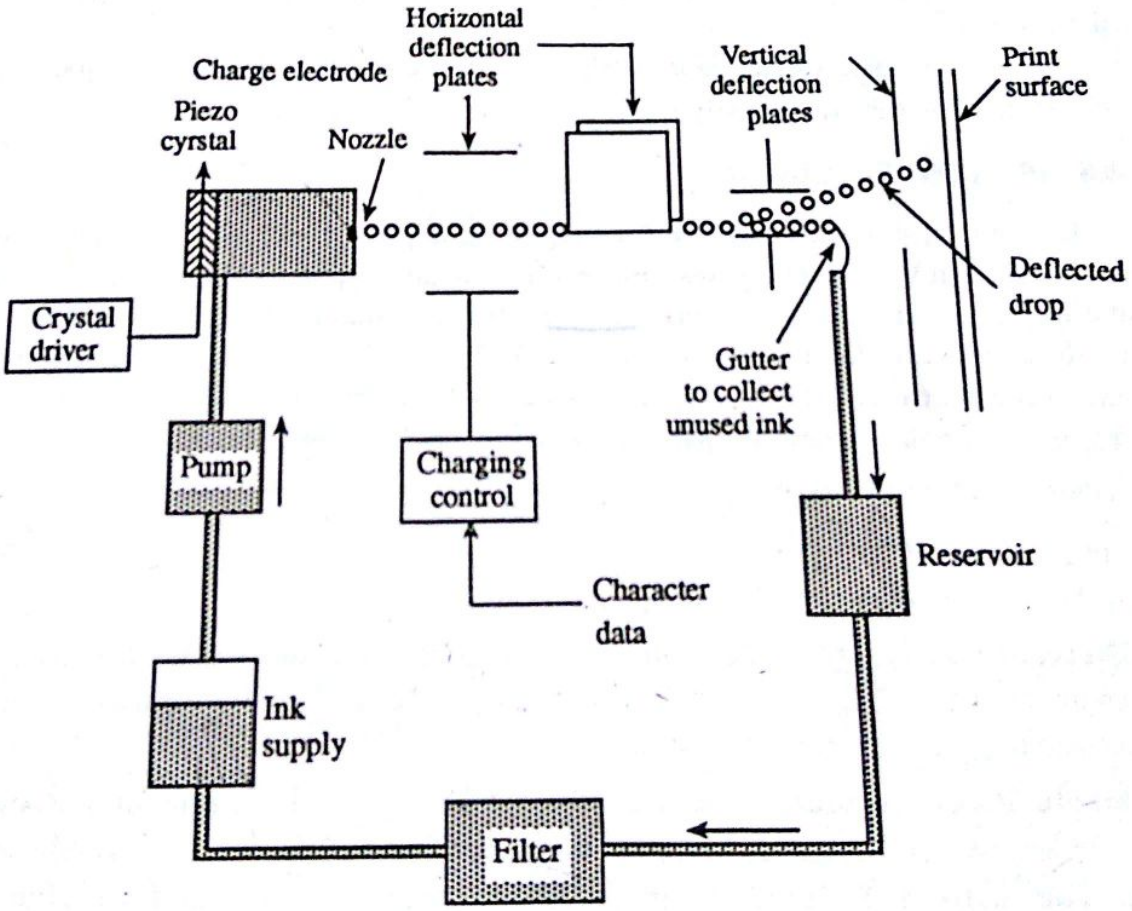


Fig. 2.20

Working :

(a) A ink filled cartridge is attached to head.

(b) The print head is made of small ink filled chamber, each attached to a nozzle which is smaller than human hair.

(c) Electrical pulse flows through heating elements which is usually a resistor located at the back of each chamber.

(d) The heat generated by the resistor heats thin layer of ink resulting in boiling of ink and thus formation of a small bubble of vapour.

(e) This bubble expands and a droplet of ink falls on the paper. Thus resulting in the formation of character by the dot matrix of these drops.

Advantages :

(a) They are silent in operation.

(b) It produces a output which is comparable in quality to that of a laser printer.

(c) Color printing can be done.

Disadvantages :

(a) Ink jet printers require periodic maintenance or else the ink gets logged in the nozzle.

(b) They require special paper with controlled absorbency for best results.

(c) Ink cartridges are costly than ribbon and don't last longer.

2.8 PLOTTER/RECORDER

It is an output used for creating graphs on paper. Plotter can be interfaced serially or parallel. Large plotters are driven using a Ethernet connection and the smaller ones can be driven using RS-232 interface. Manufacturers have adopted Howlett Packard Graphics Language (HPGL) as the standard language for controlling plotters. Colored output can be produced by using different types of inks, it can produce graph on paper as well as transparencies.

Plotters are of two types :

(a) Flatbeds or X-Y plotter

(b) Drum plotters or Roller beds.

Necessity of Recorder : It records electrical and non electrical quantities as function of time. The record can be examined and analyzed to obtain a letter understanding and control of process.

Single Point Recorder : In this one set indicates the value of measured variable and second indicates time it shows variation of measured variable with time. The instruments that record change of only one measured variable are called single point recorder.

Multi Point Recorder : As the name indicates it records changes of two or more variables. It is very useful in industry.

There are two types of recorder depending upon the tracing system used :

1. Curvilinear system
2. Rectilinear system

1. Curvilinear System : The stylus is mounted on central pivot and moves through an arc which allows full width chart making. If stylus makes full range recording then line drawn across chart is curved. In this type of system it is difficult to analyze the chart.

2. Rectilinear System : The line of constant time is perpendicular to time axis so this system produces a straight line across the width of chart ; it is easy to analyze the chart and the stylus is actuated by drive card to produce forward and reverse motion.

X-Y Plotter/Recorder : It is an instrument which gives a graphic record of relationship between two variables. In this type of recorder one recording stylus (pen) moves in the X direction while the other recording stylus (pen) moves in Y direction.

X-Y Plotter consists of servo systems driving recording pen in two axis through sliding pen and moving arm arrangement. Attenuators are used to bring input signals to levels acceptable by recorder.

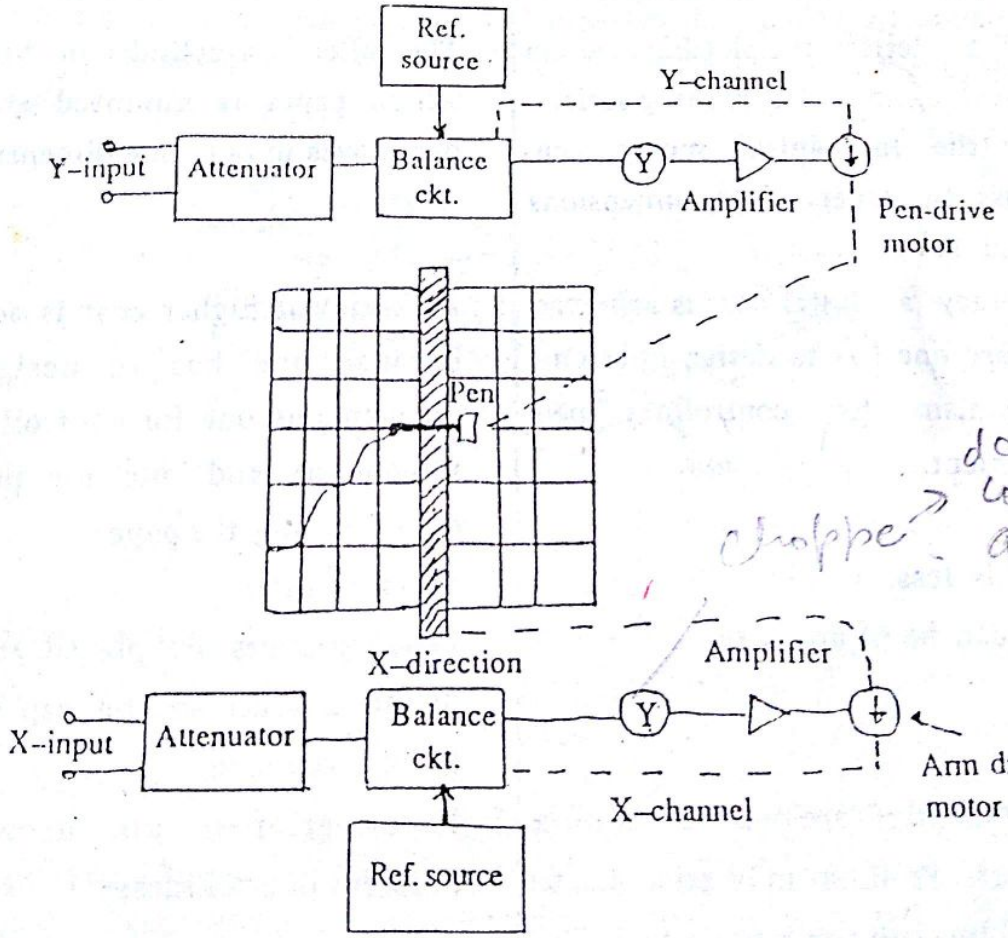


Fig. 2 21 X-Y plotter

A signal enters each of two channels. The signals are attenuated and then passed to balance circuit where it is compared with internal reference voltage. The difference is fed to chopper which converts DC signal to AC signal. The signal is then amplified to activate servometer which balances the system and hold it in balance as value of quantity being recorded changes.

The action takes place on both the axis and we get a record of one variable with respect to another.

Applications :

1. Plotting of characteristics of vacuum tubes, zener diodes, rectifiers and transistors etc.
2. Plotting stress–strain curves, hysteresis curves and vibrations amplitude against swept frequency.
3. Regulation curves of power supplies.

Speed : 1.5 m/s frequency response about 6 Hz for both the axes. Chart size is 250 × 180 mm. Accuracy is ± 0.3%.

X-Y Plotters	Drum Plotters
1. In X-Y Plotters the plotting medium is held against flat plotting surface and the mechanism moves pen across the paper in two dimensions X and Y.	1. The roller is a cylinder or drum on which paper is mounted and the pen moves in only one dimension.
2. Accuracy at lower cost is achieved because one has to design only one mechanism for controlling pen movement.	2. Accuracy at higher cost is achieved because one has to design two mechanisms one for controlling pen movement and one for precisely co-ordinating the paper.
3. Speed is less.	3. Speed is more.
4. Paper can be of any size.	4. Paper grippers are placed at a fixed distance apart so the paper has to be of fixed size.
5. Tape or magnets are used for holding the paper. Problem may arise due to the stickiness of the tape.	5. Paper grippers are used so no problem of stickiness.

Comparison between Prin

(a) The speed of laser pri limited to a single color and can draw in any color and t

(b) The accuracy of plo it comes to fine detail.

(c) Plotters can draw i paper in laser.

(d) Printers are raste faster than printer when is complicated.

Types of plotters : industry.

1. Flat-bed plotte
2. Drum plotter
3. Electrostatic p
4. Computer out

1. Flat-bed plot mounted on a statio moves on a track. T back and forth alo desired place over

2. Drum is mounted a and there ma the paper ba track. The p mechanism. roll of pape paper cutte

Comparison between Printer and Plotter :

(a) The speed of laser printer for graphic output is more than a plotter but it is limited to a single color and media cannot be larger than A size, whereas plotters can draw in any color and they can handle sheets upto B size.

(b) The accuracy of plotters is more than printers but laser printers lead when it comes to fine detail.

(c) Plotters can draw in solid colors rather than spotty digital dots fused to the paper in laser.

(d) Printers are raster based devices and plotters draw vectors. Plotters are faster than printer when the drawing is simple but they are slow when the drawing is complicated.

Types of plotters : There are basically four types of plotters widely used in industry.

1. Flat-bed plotter
2. Drum plotter
3. Electrostatic plotter
4. Computer output microfilm plotters.

1. Flat-bed plotter : A flat-bed plotter is shown in Fig. 2.22. The paper is mounted on a stationary table (the bed) and the pen is mounted on a carriage that moves on a track. The track moves over the surface of the paper. The pen moves back and forth along the track, thus allowing the pen to be positioned in the desired place over the paper.

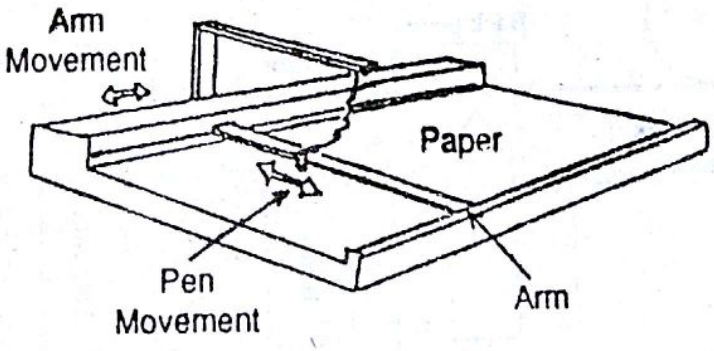


Fig. 2.22 Flat-bed plotter

2. Drum plotter : A drum plotter is shown in Fig. 2.23. In this case the paper is mounted around a drum. The paper interlocks with sprocket pins on the drum and there may be a vacuum chamber to hold the paper in place, the drum drives the paper backwards and forwards past a pen that is mounted on a stationary track. The pen is driven along the track on a carriage to complete the positioning mechanism. The advantage of drum plotter is to use to paper of long length. The roll of paper is often 50 meter long. The complete unit is quite compact. The paper cutter is used to cut the paper.

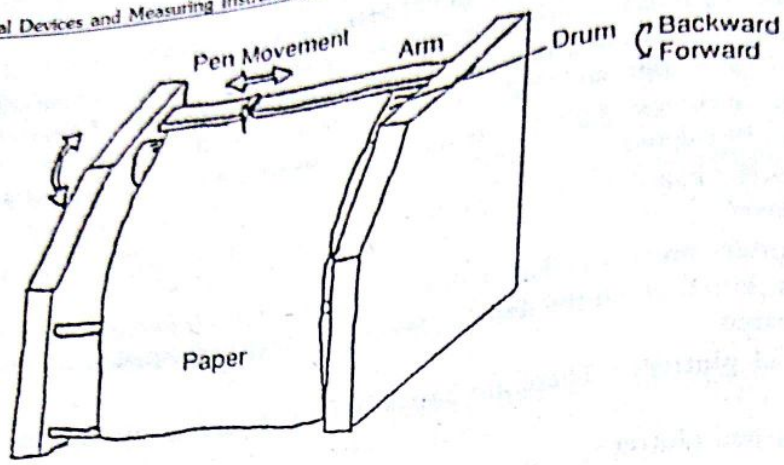


Fig. 2.23 Drum plotter

3. Electrostatic plotter : The electrostatic plotter is based on the same principle of electrostatic line printer. This plotter produces rows of dotes which can then approximate to continuous lines. Typically there are 1056 or 2112 style and a dot resolution in both horizontal and vertical or 40 or 80 dots/cm. Speed of operation is typically specified in the region of 10-100 mm/s vertically.

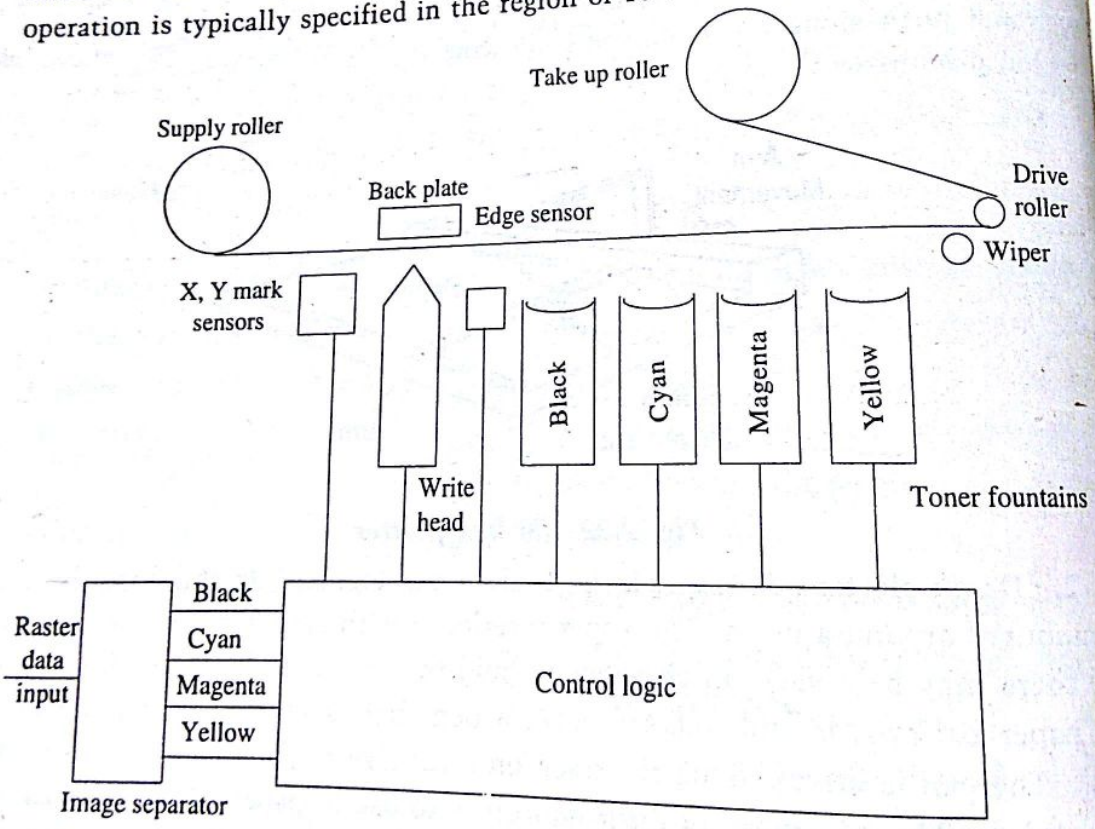


Fig. 2.24 Electrostatic colour plotters

The paper is steppe
so that picture to be pl
by vector as in the per
picture in the form of
direct memory access
are used in electrost
passing the plot med
different toner. Fig.
sensors are used t
registration marks c
These registration
correct the plotting.

4. Computer o
(COM) plotters re
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onto special film.

The film ma
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QUE

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2. Explain
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   (e) M
4. Differ
   (a) L
   (b)
   (c)
   (d)
5. Wha

The paper is stepped in only one direction as in the electrostatic line printer, so that picture to be plotted needs to be specified row by row rather than vector by vector as in the pen-on-paper plotters (Flat-bed plotter or Drum plotters). The picture in the form of rows of dots is transmitted to the electrostatic plotter via direct memory access DMA or programmed output. For colour plotting toners are used in electrostatic plotter. Hence colour plotting could be achieved by passing the plot medium through the plotter more than once, each time with a different toner. Fig. 2.24 shows the colour electrostatic plotter. The paper edge sensors are used to control the general skew. For more precise control, registration marks can be printed on the medium but outside the plotting area. These registration marks are sensed prior to each pass through the plotter to correct the plotting.

4. Computer output microfilm (COM) plotters : Computer output microfilming (COM) plotters record images onto photographic film which then can be stored, and read on a special reader. There are two method of forming the images. The first is by using a CRT to display the image, which is then photographed with a camera. The second is by using electron beam or laser beam to write directly onto special film. The incoming data control the CRT or writing device.

The film may be 16 mm, 35 mm, or 105 mm rolls or cartridges/cassettes. All the microfilm is viewed with a magnifying viewer (magnifying lens). The advantages COM plotter is that very low bulk of the output which allows easy duplication and distribution to many destinations. The speed of writing on film is fast, in order of 200-500 pages per minute (260 000 character/s).

QUESTIONS • 2

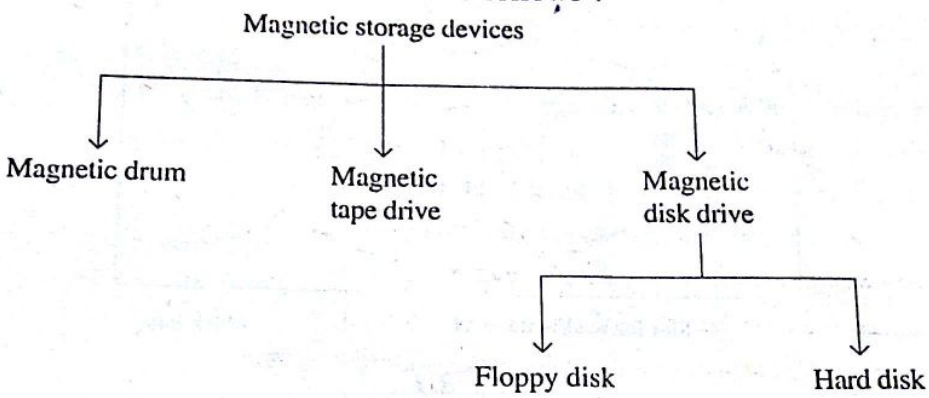
1. What is scanning and give the methods of scanning?
2. Explain the working of CRT.
3. What is adaptor and explain the following :
   (a) CGA (b) HGA
   (c) VGA (d) EGA
   (e) MDA (f) MGA.
4. Differentiate between the following :
   (a) LED and LCD
   (b) Active matrix LCD and passive matrix LCD
   (c) Printer and Plotter
   (d) Impact and non-impact printer
5. What factors should be considered while selecting a printer?

6. Write short notes on :
   (a) Dot matrix printer (b) Line printer
   (c) Laser printer (d) Daisy wheel printer
   (e) Plotter (f) X-Y Plotter/Recorder.
7. Draw and explain the block diagram of IBM PC Color Graphics Adaptor card.
8. Draw and explain the block diagram of IBM PC Monochrome Display Adaptor card.
9. Explain the printer characteristics.
10. Write short notes on LCD monitors.
11. Compare EGA and CGA systems.
12. Explain the difference between printers and plotters.
13. Explain the operating principle of LASER printer.
14. Explain the operational features of CRT monitor.
15. List printer specifications. Explain the working principle of Ink-jet plotters.
16. Explain the working principle of Video Graphics Arrays (VGA) system.
17. Explain the operational features of LCD monitor.
18. List monitor specifications. Explain Enhanced Graphics Adaptor (EGA) system.
19. Explain operating principles of X-Y plotters.
20. Explain the working principle of Daisy Wheel printers.
21. Discuss constructional detail of MOUSE. Mention its uses.
22. Discuss the operational features of any monitors.
23. Discuss the difference between plotters and printers. Give their specifications. Discuss their advantages.
24. Explain how a character is displayed on CRT screen.
25. Compare EGA and CGA system with respect to specifications and operation principle. Also discuss their advantages and disadvantages.
26. Explain the operating printers of any one of the plotters studied by you.
27. Explain the working of Dot-matrix printers.
28. Explain the working of Ink-jet plotters.
29. Explain operating principle of CGA systems.
30. Explain working principle of CRT monitor.
31. Discuss the factors affecting the choice of a printers.
32. List specifications of monitors.

3

DATA STORING DEVICES

Storage Devices : The data can be stored on magnetic devices. These magnetic storage devices are classified as follows :



3.1 FLOPPY DISK

The floppy disk is made of thin flexible plastic (Mylar) material circular shape. As the thickness of the Mylar is few thousands of a inch it is called as floppy. The information can be stored on single side or both sides of disk so depending on this a single sided and double sided disk is available. Depending on the recording technique used, they are classified as single density and double density diskettes.

The different sizes available :

(a) 8 inch disk which is used in older computers is presently obsolete.

(b) $5\frac{1}{4}$ inch disk capacity is 1.2 MB called as mini floppy.

(c) $3\frac{1}{2}$ inch disk capacity is 1.44 MB called as micro floppy.

Construction of floppy disk : The floppy disk is coated with magnetic material and enclosed in a protective jacket. There is a large slot on jacket through which head reads and write data on the disk.

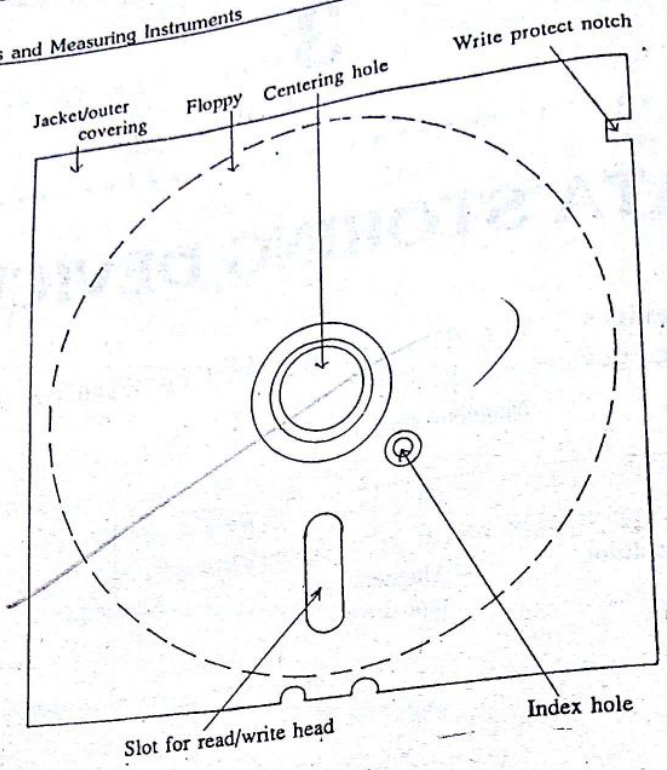


Fig. 3.1

A hole is provided at the centre called as the hub hole for clamping the floppy so that it can rotate easily without slipping. Near the centre a small hole is punched on the diskette called as index hole. This hole indicates the beginning of a track. Writing is done on the floppy disk only after sensing the index hole.

A write protect notch is provided if this notch is open writing on diskette is permitted. If this notch is covered by a paper or sticker then writing is not permitted.

Principle of working : Floppy is made of number of tracks and each track is divided into a number of sectors. Data is stored on the track bit by bit using electromagnetic techniques, the data is read (or stored) from (on) the disk. There are two heads, one for writing on the top side of the disk and the other on the bottom side of the disk. In a write operation the write data line is containing both clock pulses and data pulses. Current is passed through read/write head and flux transition is created for each clock or data pulse. In read operation emf is induced into the read head because of rotation of floppy disk which causes flux transitions. These induced emf is amplified and shaped by the amplifier circuit in FDD.

In a write operation the data pulses as well as the clock pulses are stored on the disk or else it becomes difficult to differentiate between no data and zero data.

Micro floppy : It is of the size $3\frac{1}{2}$" and its capacity is 1.44 MB. The 3.5" is so designed that one end is truncated which prevents improper insertion of the diskette.

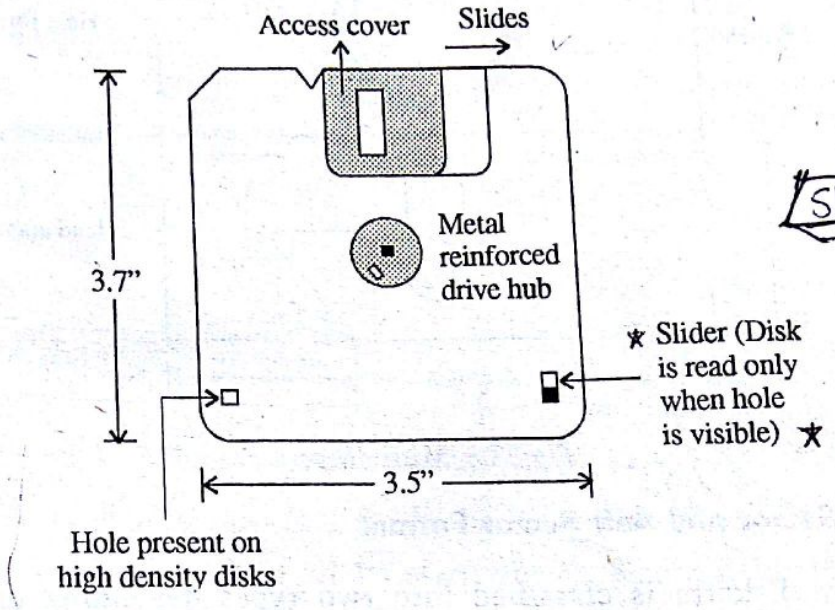


Fig. 3.2 Micro floppy

There is round plastic coated with magnetic material and is enclosed in a hard plastic jacket. It uses hole and plastic sides which performs the function of write protect. One can read/write if the hole is blocked by the slider. One can only read the data if the hole is visible. It uses a more finely grained medium with buffer magnetic properties so its capacity is more.

It uses a metal hub so the disk can be centered very easily. If one more hole is provided it indicates the diskette has double density.

Mini floppy : A mini floppy is of size of $5\frac{1}{4}$ inch floppy disk. A floppy diskette is an ultra thin plastic piece in circular shape. It is coated with a magnetic material and enclosed in a protective jacket. An oval access hole is made on the jacket so as to provide contact between the read/write head and the diskette. On floppy there is write protect notch. If this notch is kept as it is then you can write to the floppy, but if it is covered by the sticker then floppy becomes read only and you cannot write to it. When index hole of upper cover and miner floppy matches each other then there is first block/sector on read/write head slot. It is widely used in present day computers including PCs, PC-XTs, PC-ATs, etc.

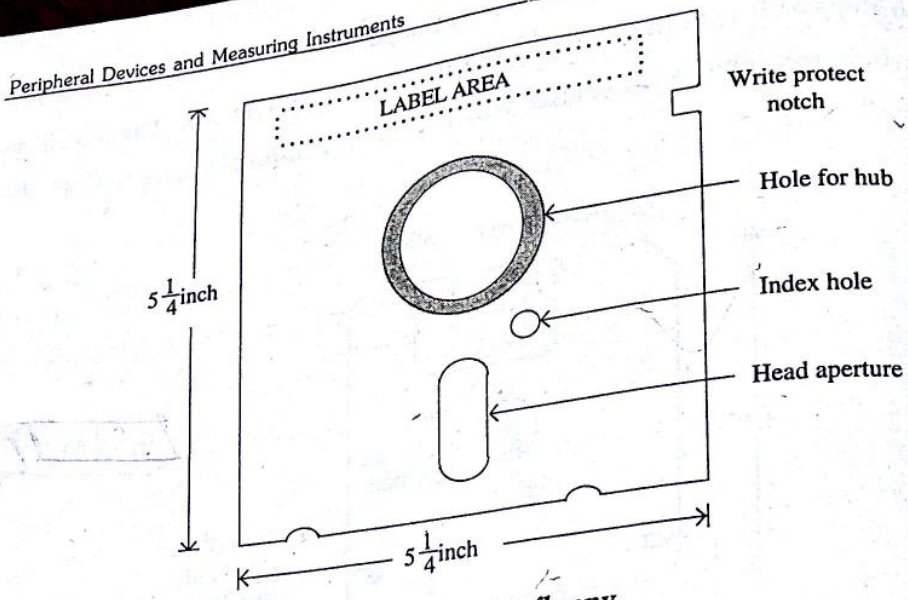


Fig. 3.3 Mini floppy

3.1.1 Hard Sector and Soft Sector Format

The floppy diskette is classified into two types depending on the sector organization.

1. Hard sectored floppy diskette
2. Soft sectored floppy diskette

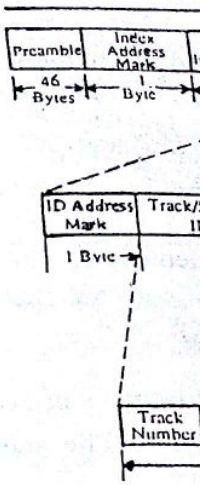
1. Hard sectoring : During the manufacturing process the number of sectors per track is decided. A sector hole is punched on the plastic disk to indicate the beginning of every sector. The total number of data types that can be stored on a track is more. It has become an obsolete method.

2. Soft sectoring : In this method the software decides the number of sectors per track. No holes are present on the diskette for giving sector information. New systems use soft sectoring. Less data can be stored.

3.1.2 Sector Formats and Error Detection in Floppy Disk

A hard sectored disk has 32 holes which are equally spaced around the disk. A hole indicates the starting of a sector. A photodetector is used for detecting the index holes.

A soft sectored disk has only one hole which indicates the start of all the tracks. Fig. 3.4 shows the disk format of a soft sectored floppy. In soft sectoring less amount of data is stored per track but this data is returned more reliably, compared to hard sectoring.



Each sector is
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It gives time fo
record data. Ano
field consists
redundancy byt
formed by add
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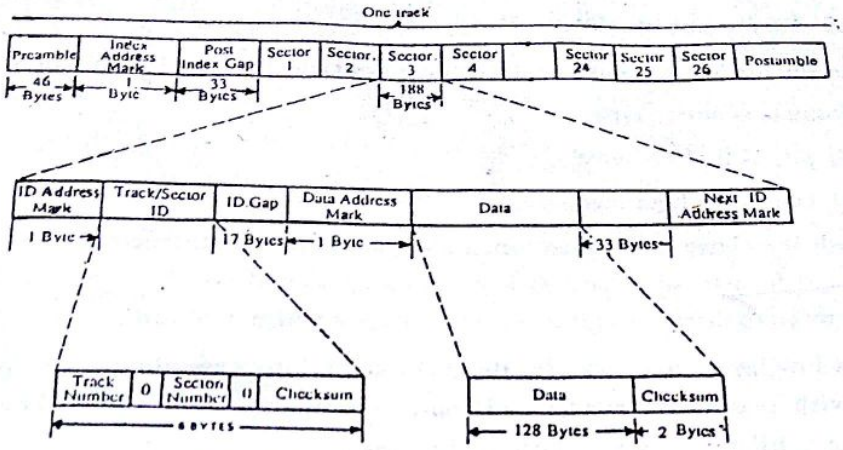


Fig. 3.4 Soft sectored floppy disk

Each sector is divided into four fields the ID record, ID gap, data field record and data gap. A 1 byte mark of all 1's starts the ID record field. The rest of this field gives complete track and sector address. The ID gap field is a buffer zone. It gives time for the system to verify an address and switch to write mode to record data. Another mark byte of 1's indicates the start of the data field. the data field consists of mark byte plus 128 bytes and two check sum or cyclic redundancy bytes which are used for checking errors in data. Check sum byte is formed by adding all the data bytes and ignoring carries over 2 bytes. The resultant 2 byte sum is stored in the 2 byte positions after the data. The read data is added and the sum is compared with the recorded check sum bytes. If no error is present in the recorded data then the two sums will agree. The errors can be checked by using cyclic redundancy check (CRC).

In this method the string of data bytes is divided by the constant. If the data contains no errors then division should give zero remainder.

Data can be written onto a disk and then read back immediately and tested for errors. If an error is detected the data can be written again and rechecked.

The data field is followed by record gap field which acts as a buffer between the end of one data field and starting mark of next sector. The gap gives time for the system to switch from write mode to read mode when it goes from writing data in one sector to reading the ID field of the next.

Transfer rate = 500 KB/sec.

$\therefore$ Transfer rate of 1 KB = $\frac{1}{500}$ = 2×10^{-3} sec.

Average time to read/write 1 KB of data neglecting read/write time

= Transfer rate of 1 KB + Average seek time + Average latency time

= 2 ms + 30 ms + 10 ms

= 42 ms

Advantages of floppy disk :

(a) Information can be directly encoded onto the disk.

(b) Bulky media is not used, so ease in handling and transportation.

(c) Used for storage, input and output.

(d) It is cheap.

(e) Density is high.

(f) It can be reused many times.

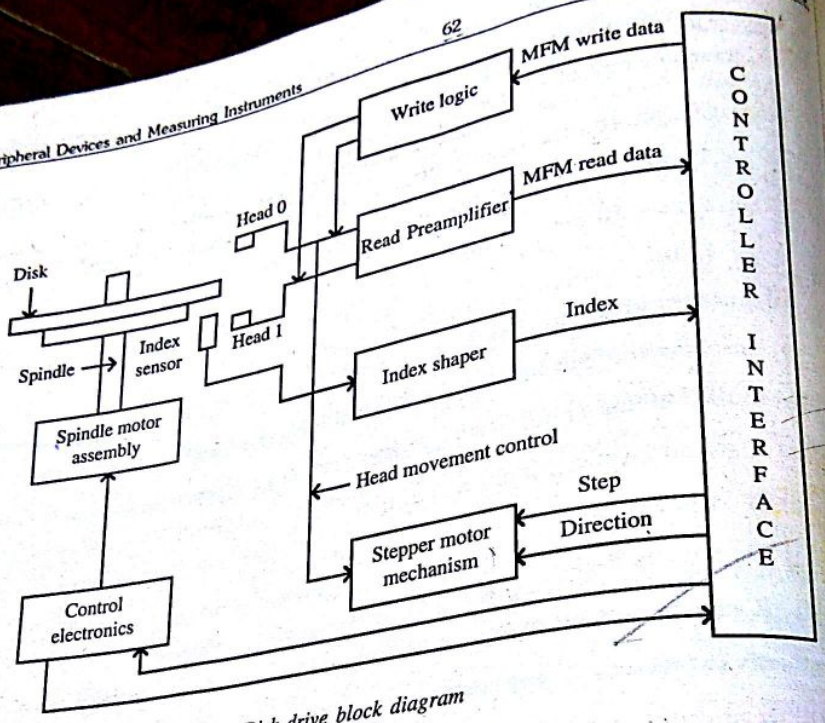
Disadvantages of floppy disk :

(a) It should be handled carefully.

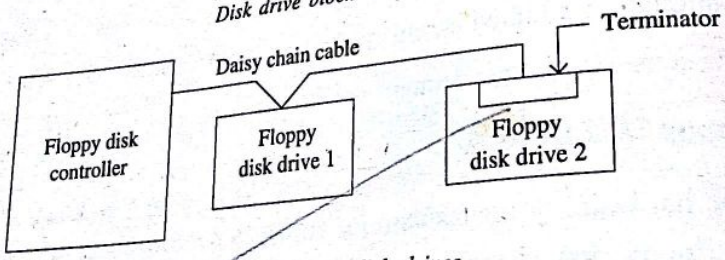
(b) It is sensitive to environment conditions heat, dust etc.

3.1.4 Floppy Disk Drive

It is the hardware or mechanism for slowing or retrieving data from the floppy disk. The floppy disk drive is controlled by the floppy disk controller and is consisting of the following. The spindle motor is used to rotate the disk at 300 r.p.m. Spindle motor assemblies used in FDDs are of two types, belt driven or direct drive. In a belt driven spindle motor, a belt and a pulley is used to couple the spindle motor to the disk spindle. The direct drive FDDs uses a spindle motor whose shaft drives the head assembly directly. A read/write head is present for each surface. Both the heads are mounted on a common assembly so that both move together. The heads are moved forward or backward by head actuator mechanism. They come with two PCB's. On the logic board PCB the controller interface, read/write circuits, head positioning circuit and sensor electronics is present. Servo board PCB controls the spindle motor and makes it rotate at a constant speed of 300 rpm.



Disk drive block diagram



Interfacing floppy disk drives

Fig. 3.5

Floppy disk drive components : A floppy disk drive normally has two read/write heads, making the floppy disks double sided.

(a) Head actuator : The head actuator is a mechanical motor device that causes the heads to move in and out over the surface of a disk.

(b) Stepper motor : The stepper motor moves the head to and fro to access all the tracks.

(c) Spindle motor : The spindle motor spins the disk.

(d) Circuit board (PCB) : The circuit board (PCB) contains the circuity used to control the head actuator, read/write heads, spindle motors, disk change sensors, and any other components of the drive.

3.1.5 5.25 Inch Disk

Table giving physical

Disk Type
1. Tracks per inch
2. Bites per inch
3. Number of sides
4. Track width
5. Coercitivity
6. Media
7. Recording polarity
8. No. of Tracks

Storage Density
into a given area of
In case of floppy
1. Longitudinal
2. Linear densi

Longitudinal De
can be recorded or
tracks per inch (TP

Linear Density
to store data. This

Coercitivity/D
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For example
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3.5 Inch Dis

Disk T
1. Tracks Per
2. Bits Per Inc
3. Number o
4. Track widt
5. Coercitivi
6. Media
7. Recordin
8. No. of T

3.1.5 5.25 Inch Disk

Table giving physical disk specification :

Disk Type	360 KB Double Density	1.2 MB High Density
1. Tracks per inch	48	96
2. Bites per inch	5876	9646
3. Number of sides	2	3
4. Track width	0.330 mm	0.155 mm
5. Coercitivity	300	600
6. Media	Ferrite	Cobalt
7. Recording polarity	Horizontal	Horizontal
8. No. of Tracks	40 per side	80 per side

Storage Density : "Density" is a measure of information that can be place into a given area of recording surface.

In case of floppy disks, two types of densities exists :

1. Longitudinal density (TPI)
2. Linear density (BPI).

Longitudinal Density : Longitudinal density is expressed in how may tracks can be recorded on the floppy disk. This is usually expressed as a number of tracks per inch (TPI).

Linear Density : Linear density indicates the capability of an individual track to store data. This is usually expressed as bits per inch (BDI).

Coercitivity/Disk Sensitivity : The term coercitivity is made from the word "coerce", which means "to force" coercitivity of any magnetic energy required to force the magnetic particle of the media to change its orientation.

For example if a magnetic particle on the disk surface is oriented as NS, then the magnetic energy required to change its status to SN will be the coercitivity of the disk media.

3.5 Inch Disk Physical Specification :

Disk Type	720 KB DD	1.44 MB HD	2.88 MB ED
1. Tracks Per Inch (TPI)	135	135	135
2. Bits Per Inch (BPI)	8717	17434	34868
3. Number of sides	2	2	2
4. Track width	0.115 mm	0.115 mm	0.115 mm
5. Coercitivity	600	720	750
6. Media	Cobalt	Cobalt	Barium
7. Recording polarity	Horizontal	Horizontal	Horizontal
8. No. of Tracks	80 per side	80 per side	80 per side

3.1.6 Sensors in F.D.D.

The floppy drives had different sensors such as :

1. The write protect sensor which indicates whether floppy disk in the drive is write protected or not. It may be a micro-switch sensing the presence of a write protect tab on the floppy disks, or could be an LED light source and photocell combination to detect the presence of the write protect tab.

2. **Disk sensor :** Some drives have a disk sensor which determine the presence of a floppy disk in the drive.

3. **Media type sensors :** Similar to write protect sensor, the 3.5" high density drives have media type sensors which is used to detect whether the floppy disk used in it is double density or high density.

4. **Index sensor :** Index sensor generates a pulse each time the disk completes a revolution.

3.2 HARD DISK

The hard disk is the most widely used mass storage device for PCs. Without a hard disk it is of no use to go in for a 32 or 64 bit processor. On the hard disk all the programs and data are stored which can be accessed instantly thus making the system faster.

Construction of hard disk : The hard disk uses a rigid or hard substrate called as platter. One or more platters are mounted on a common spindle. A platter has two magnetic surfaces, top and bottom. It consists of a motor to drive the disk pack about its axis at a speed of 3600 rpm. A set of magnetic heads are also mounted. Initially ferrite heads were used, now-a-days thin film heads are used.

Information is recorded on both the sides of the disk, a spot is magnetized for storing 1 and it is non-magnetized for storing 0.

The outer surface of top and bottom disk cannot be used for storing information as they can't be accessed. Information is recorded on the circular tracks and the track is divided into sectors. The capacity of the hard disk depends upon the total number of usable surfaces, bytes stored per sector, sectors per track, tracks per surface and is given by the equation.

$$\begin{pmatrix}\text{Capacity}\\ \text{of hard}\\ \text{disk}\end{pmatrix} = \begin{pmatrix}\text{No. of}\\ \text{usable}\\ \text{surface}\end{pmatrix} \times \begin{pmatrix}\text{Bytes}\\ \text{stored}\\ \text{per sector}\end{pmatrix} \times \begin{pmatrix}\text{Sectors}\\ \text{per}\\ \text{track}\end{pmatrix} \times \begin{pmatrix}\text{Tracks}\\ \text{per}\\ \text{surface}\end{pmatrix}$$

Please see Fig. 3.6 on next page.

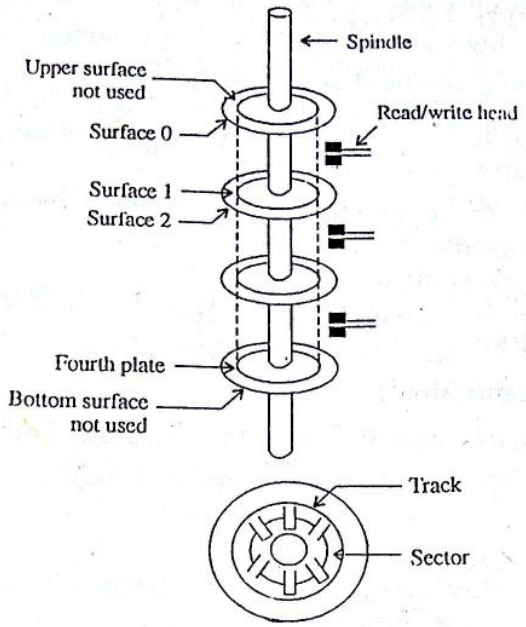

Fig. 3.6 Constructional details of hard disk

Types of hard disk :

1. **Removable and fixed :** In a removable hard disk, the disks can be removed and placed in a cupboard or other computer similar to a floppy. In a fixed hard disk the disks cannot be removed.

2. **Moving head and fixed head :** In moving head hard disk, the read/write head moves from one track to another track as controlled by the computer.

In fixed head hard disk, as the name indicates heads are fixed.

3. **Single head and dual head assembly :** In single head assembly there is one head for each surface. In a dual head assembly there are two heads for each surface.

4. **Winchester and non-Winchester :** Winchester was introduced by IBM in 1973, all the disks before 1973 were of non-Winchester type. The head in a Winchester disk is attached to airfoil. The head is kept floating a few microinches above the surface of the disk. So there is no wear of the disk surface.

Terms related to hard disk :

(a) **Seek time :** It is the time taken to position the heads over the required track. It depends upon where the arm assembly is when read-write command is received.

(b) Search or latency time : Time taken to locate actual data on a track. Once the head assembly is positioned the head corresponding to specified surface is switched. Once the head is switched it has to wait until the required record comes under the head. This average rotational delay is called latency time.

(c) Access time : It is the summation of seek time, latency time and the time for reading/writing on the disk.

(d) Average latency time : It is half the time, the read/write head requires for one revolution of the disk.

Hard disk drive organisation :

A hard disk consists of both electronic circuits and electromechanical subsystems. The electromechanical subsystems in a hard disk are :

1. Read/write head
2. Disks
3. Spindle motor
4. Positioning mechanism
5. Air circulation system
6. Air filters.

In a Winchester hard disk the sealed head disk assembly (HDA) consists of read/write heads, disks and band actuator assembly and air circulation system. The heads are either of the following two types :

(a) Manganese/Zinc ferrite head

(b) Thin film head.

There are many standard interfaces for the hard disk connection to the computer. Some of these are SMD, ST 506/412, SCSI, IPI, ESDI. Generally, microcomputers provide a ST 506/412 interface to the hard disk, though SCSI interface is also becoming popular now.

The data is sent or received on a separate cable to each drive. This cable is known as radial cable or data cable. The control signals are sent through a daisy chain cable. The cable carries control signals between the computer and the first hard disk. The same signals are extended to second HDD through another cable from the first HDD. This is known as daisy chaining.

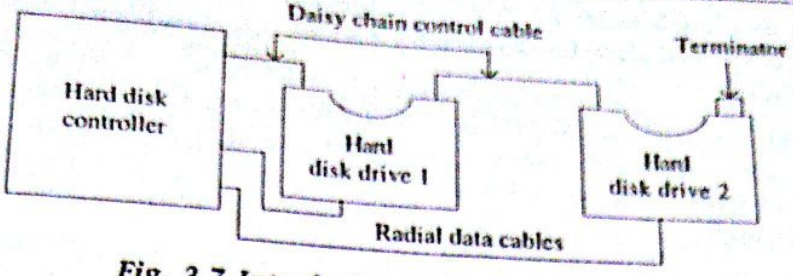

Fig. 3.7 Interfacing hard disk drives

The electronic circuitry consists of PCB, which incorporates drives control logic, motor control logics, interfacing, R/W logics etc.

3.2.1 Information Recording in Hard Disk

Information is stored in the hard drive using the same magnetic recording method, which is used to store songs on a audio tape or movies on a video tape.

Magnetic Recording : The magnetic recording on the disk surface is done by a magnetic read/write head, which is similar to the read/write head of an audio/video recording.

The read/write head of the disk drive is an electro-magnet whose polarity can be switched by changing the direction of the electric current through it.

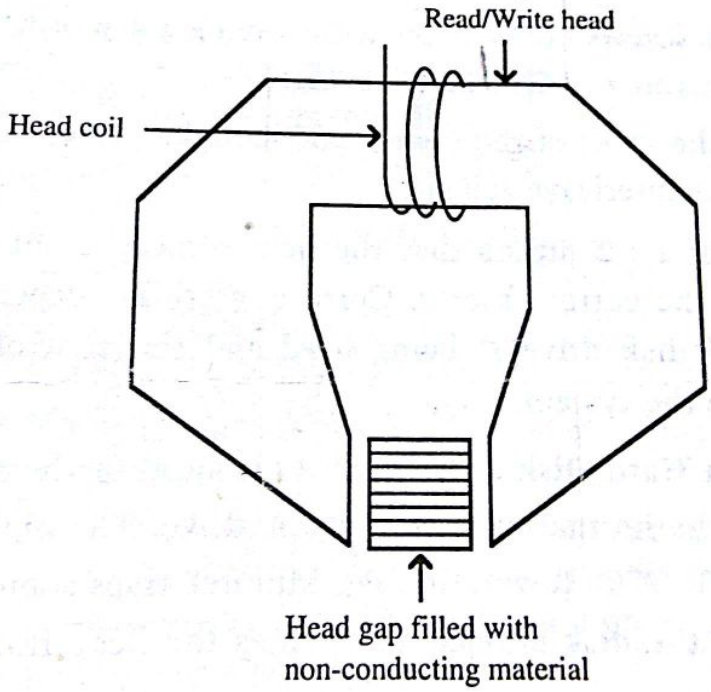

Fig. 3.8 Magnetic recording

When the current is passed through the coil, a magnetic field is generated on the head. When the magnetic reaches the head gap, the magnetic field pass through the disk media beneath the head gap and goes to the other side of the head.

Writing on a Disk Surface : When writing any information on the disk surface the principles of magnetic field around a coil of conductor wire, carrying electric current is at work.

The magnetic field produced by the head, forces the particles on the disk surface to align themselves along the axis of the applied field. The direction of the current through the head coil determines the orientation of the particles of the magnetic coating.

This direction of the current flow represents the information that is to be written on the disk surface, current flow in one side could be for storing binary digit 1 and flow in the reverse side could be storing binary digit 0.

Recording from Disk Surface : When the read/write head passes over the surface of the disk, an electric pulse is induced in the read/write head circuitry for each change in the orientation of the magnetic particle on the disk surface.

The state of this electric pulse tells the read/write head whether the information on the disk surface is a 0 or 1.

3.2.2 Interleave

If the secto...

3.2.4 Comparison between Floppy Disk Drives and Hard Disk Drives

Floppy disk drives	Hard disk drives
1. The head in the floppy disk touches the media surface during a read/write operation.	1. In the Hard disk drive, the read/write head does not touch the media surface during a read/write operation. It flies above the disk at a minute distance, called as flying height.
2. The FDD has a maximum of two read/write heads since the diskette has two surfaces.	2. The HDD has multiple read/write heads depending upon the number of plotter HDD contains. The each plotter has two read/write head respectively.
3. The head positioning mechanism in the FDD uses a stepper motor.	3. The HDD has two options for head positioning mechanism, (i) Stepper motor mechanism (open-loop disk drive). (ii) Voice coil servo mechanism (closed-loop disk drive). The voice coil servo mechanism is now a days mostly popular head positioning mechanism used in HDD.
4. The diskette in the FDD is rotated at low speed usually at 300 rpm or 360 rpm.	4. The plotters in the HDD are rotated at higher speed, usually at 2400 rpm or 360 rpm.
5. The number of tracks on a floppy disk is lesser- usually 40 or 80.	5. The number of tracks on HD is more that depends upon the size of the hard disk 14", 8", 5'/4" or 3'/2".
6. The track density is usually 48 TPI (Track per inch) or 96 TPI.	6. In a HDD, higher track density is possible, 1000 TPI is common.
7. The recording density BPI (Bits per Inch) is less because of low rotation speed.	7. The recording density (BPI) is higher because of high rotation speed.
8. The PC uses SA-450 interface for the FDDs. The SA-450 is the standard interface introduced by Shugart Associates.	8. The PC uses different interface standard for HDD such as SMD, ST 506/412, SCSI, IPI, ESDI.

3.3 TAPE DRIVE

The magnetic tape drive is similar to the audio tape recorders. Before the data on magnetic tape can be processed the tape must be placed in a machine called tape drive or tape transport. We can read/write data from the tape. Writing data on the tape destroys the previous tape contents.

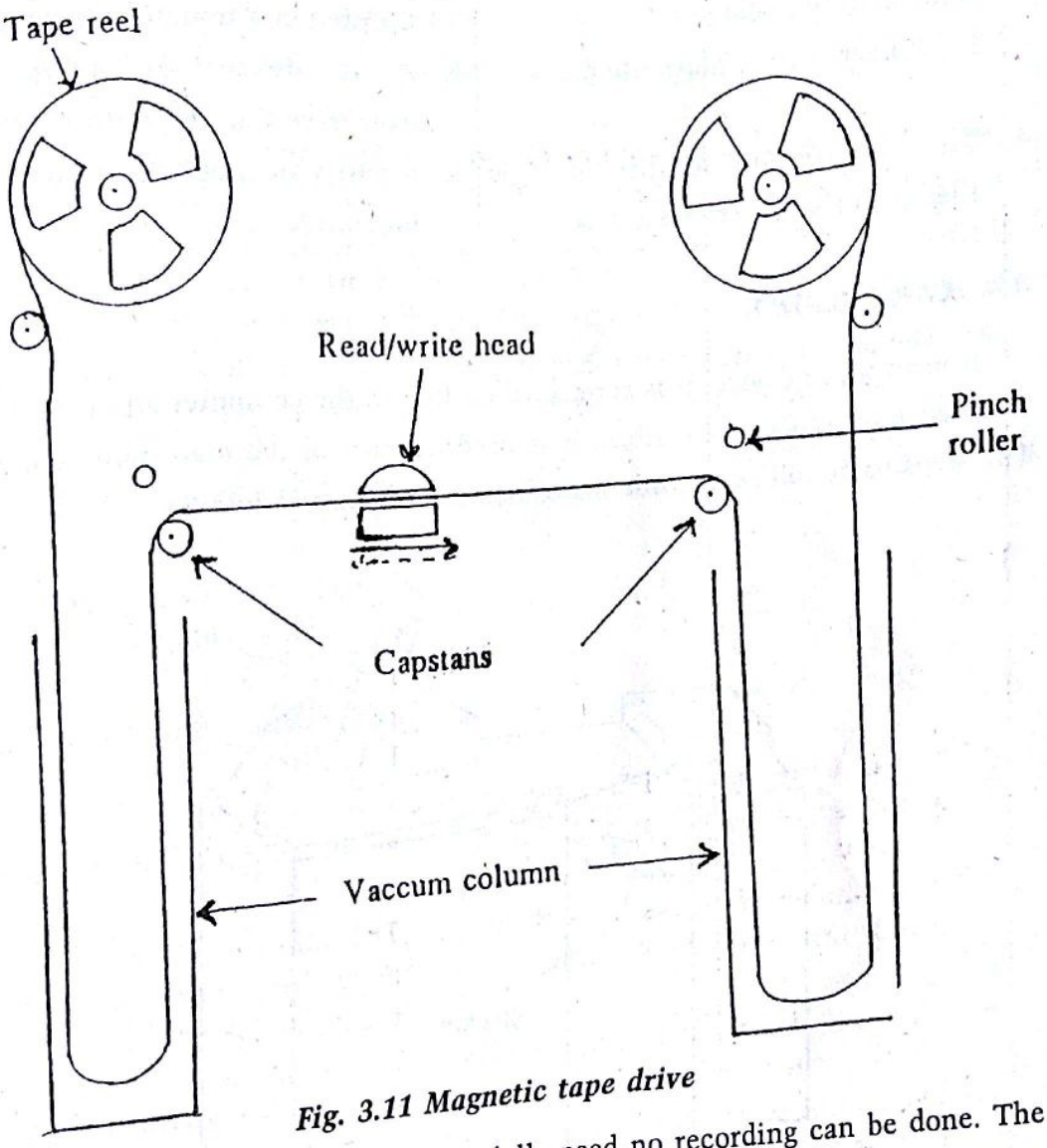

Fig. 3.11 Magnetic tape drive

When the tape is accelerated to its full speed no recording can be done. The distance traversed by the tape during this time is called as inter block gap (IBG). The beginning of the tape is indicated by a metal foil called a marker. When a write command is given, the block of data is written on the tape and after the IBG the next block of data is written. A metal foil is used again to indicate the end of tape. The data which is stored on the tape has to be accessed sequentially.

Comparison between tape drive and hard disk or floppy disk :

Tape drive	Hard disk/Floppy disk
1. Data cannot be accessed directly, it has to be accessed sequentially.	1. Data can be accessed directly or sequentially.
2. The data cannot be accessed and immediately updated.	2. The data can be accessed and updated in a few milliseconds.
3. It is cheaper than magnetic disks.	3. It is nearly 20 times more expensive than tape drive.
4. Easy to maintain security of tape files than files stored on a disk.	4. Security of files is less compared to tape drive.

3.4 CARD READER

It is an input device. It is connected on line to the computer and is very useful in batch processing applications. It is used in most of the mainframe computers. The steps to be followed while using a card reader are as follows.

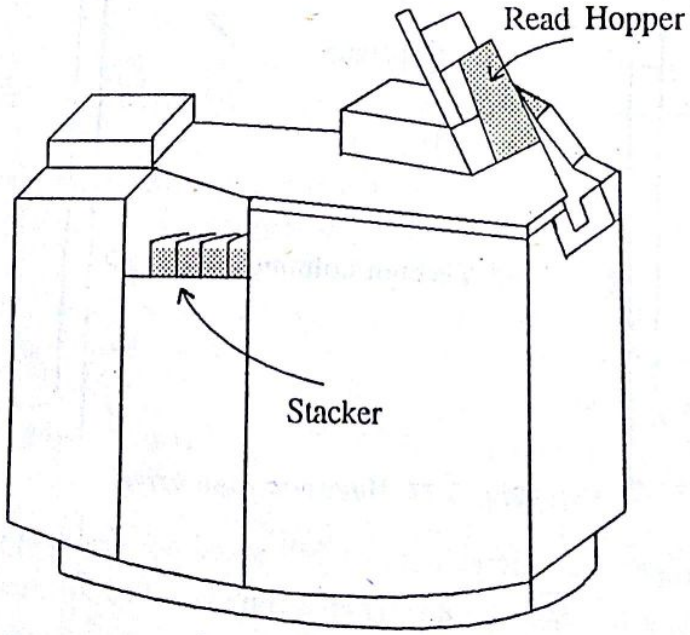

Fig. 3.12 Card reader

The program and data decks are placed in the read hopper of the card reader. The punched card is moved rapidly after the computer gives a command. The punch holes are read by two stations and compared to detect read errors, after comparing the punch holes are converted into signals and sent to the computer for storage. The punch holes can be sensed by photoelectric cells or by wire brushes. In brush type reader a card is passed between wire brush and metal roller. If there is a punch the brush makes electric contact with roller and signals the computer. Another wire brush is provided to check for comparison with the first wire brush, card readers using photoelectric cells are also available. These are faster and more accurate than wire brush type of readers. In a photoelectric card reader the light source is placed above the reading station as the cards pass one after the other, the light passing through holes of card is detected by photoelectric cells and send signals to the computer.

QUESTIONS • 3

1. Explain construction of mini floppy disk.
2. Explain construction of micro floppy disk.
3. Write short note on sector formats and error detection in floppy disks.
4. Write short notes on :
   (a) Floppy disk drive
   (b) Hard disk
   (c) Tape drive
   (d) Card reader.
5. Distinguish between the following :
   (a) Floppy disk and Hard disk
   (b) Hard sector and Soft sector
   (c) Tape drive and Hard disk/Floppy disk.
6. Describe the construction and working principle of Mini and Micro floppies.