

What is computer Graphics?

Computer graphics is an art of drawing pictures, lines, charts, etc. using computers with the help of programming. Computer graphics image is made up of number of pixels. **Pixel** is the smallest addressable graphical unit represented on the computer screen.

Introduction

- Computer is information processing machine. User needs to communicate with computer and the computer graphics is one of the most effective and commonly used ways of communication with the user.
- It displays the information in the form of graphical objects such as pictures, charts, diagram and graphs.
- Graphical objects convey more information in less time and easily understandable formats for example statically graph shown in stock exchange.
- In computer graphics picture or graphics objects are presented as a collection of discrete pixels.
- We can control intensity and color of pixel which decide how picture look like.
- The special procedure determines which pixel will provide the best approximation to the desired picture or graphics object this process is known as **Rasterization**.
- The process of representing continuous picture or graphics object as a collection of discrete pixels is called **Scan Conversion**.

Advantages of computer graphics

- Computer graphics is one of the most effective and commonly used ways of communication with computer.
- It provides tools for producing picture of “real-world” as well as synthetic objects such as mathematical surfaces in 4D and of data that have no inherent geometry such as survey result.
- It has ability to show moving pictures thus possible to produce animations with computer graphics.
- With the use of computer graphics we can control the animation by adjusting the speed, portion of picture in view the amount of detail shown and so on.
- It provides tools called motion dynamics. In which user can move objects as well as observes as per requirement for example walk throw made by builder to show flat interior and surrounding.
- It provides facility called update dynamics. With this we can change the shape color and other properties of object.
- Now in recent development of digital signal processing and audio synthesis chip the interactive graphics can now provide audio feedback along with the graphical feed backs.

Application of computer graphics

- User interface: - Visual object which we observe on screen which communicates with user is one of the most useful applications of the computer graphics.
- Plotting of graphics and chart in industry, business, government and educational organizations drawing like bars, pie-charts, histogram's are very useful for quick and good decision making.
- Office automation and desktop publishing: - It is used for creation and dissemination of information. It is used in in-house creation and printing of documents which contains text, tables, graphs and other forms of drawn or scanned images or picture.
- Computer aided drafting and design: - It uses graphics to design components and system such as automobile bodies structures of building etc.

- Simulation and animation: - Use of graphics in simulation makes mathematic models and mechanical systems more realistic and easy to study.
- Art and commerce: - There are many tools provided by graphics which allows used to make their picture animated and attracted which are used in advertising.
- Process control: - Now a day's automation is used which is graphically displayed on the screen.
- Cartography: - Computer graphics is also used to represent geographic maps, weather maps, oceanographic charts etc.
- Education and training: - Computer graphics can be used to generate models of physical, financial and economic systems. These models can be used as educational aids.
- Image processing: - It is used to process image by changing property of the image.

Display devices

- Display devices are also known as output devices.
- Most commonly used output device in a graphics system is a video monitor.

Cathode-ray-tubes

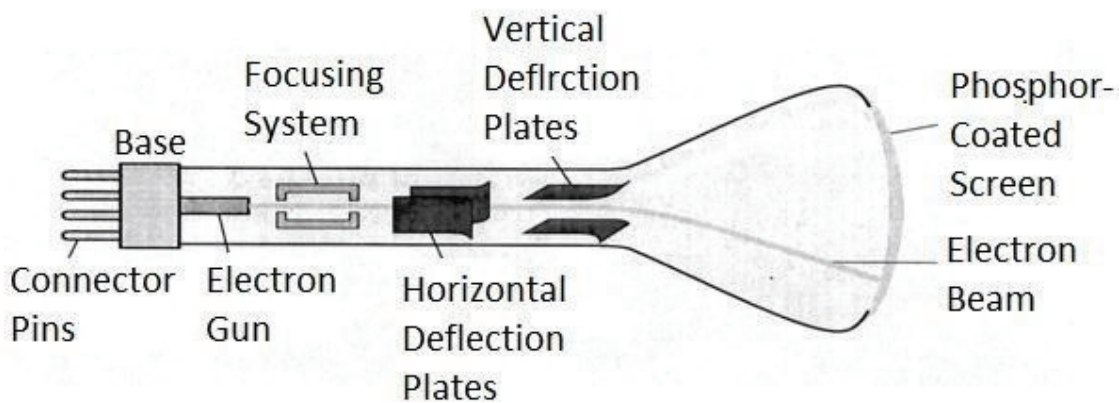


Fig. 1.1: - Cathode ray tube.

- It is an evacuated glass tube.
- An electron gun at the rear of the tube produce a beam of electrons which is directed towards the screen of the tube by a high voltage typically 15000 to 20000 volts
- Inner side screen is coated with phosphor substance which gives light when it is stroked by electrons.
- Control grid controls velocity of electrons before they hit the phosphor.
- The control grid voltage determines how many electrons are actually in the electron beam. The negative the control voltage is the fewer the electrons that pass through the grid.
- Thus control grid controls Intensity of the spot where beam strikes the screen.
- The focusing system concentrates the electron beam so it converges to small point when hits the phosphor coating.
- Deflection system directs beam which decides the point where beam strikes the screen.
- Deflection system of the CRT consists of two pairs of parallel plates which are vertical and horizontal deflection plates.
- Voltage applied to vertical and horizontal deflection plates is control vertical and horizontal deflection respectively.
- There are two techniques used for producing images on the CRT screen:

1. Vector scan/Random scan display.
2. Raster scan display.

Vector scan/Random scan display

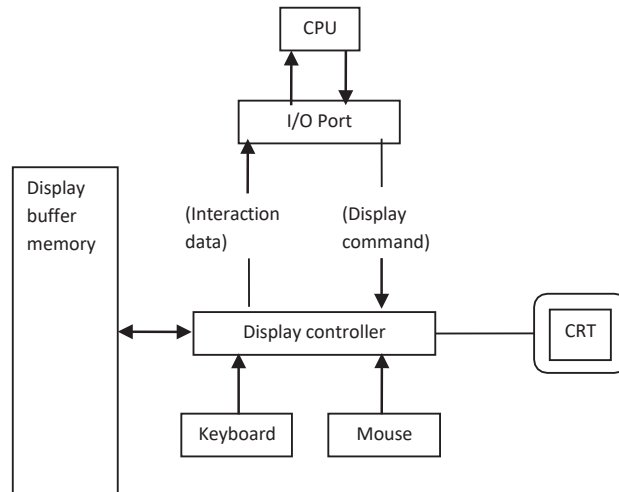


Fig. 1.2: - Architecture of a vector display.

- Vector scan display directly traces out only the desired lines on CRT.
- If we want line between point p1 & p2 then we directly drive the beam deflection circuitry which focus beam directly from point p1 to p2.
- If we do not want to display line from p1 to p2 and just move then we can blank the beam as we move it.
- To move the beam across the CRT, the information about both magnitude and direction is required. This information is generated with the help of vector graphics generator.
- Fig. 1.2 shows architecture of vector display. It consists of display controller, CPU, display buffer memory and CRT.
- Display controller is connected as an I/O peripheral to the CPU.
- Display buffer stores computer produced display list or display program.
- The Program contains point & line plotting commands with end point co-ordinates as well as character plotting commands.
- Display controller interprets command and sends digital and point co-ordinates to a vector generator.
- Vector generator then converts the digital co-ordinate value to analog voltages for beam deflection circuits that displace an electron beam which points on the CRT's screen.
- In this technique beam is deflected from end point to end point hence this techniques is also called random scan.
- We know as beam strikes phosphors coated screen it emits light but that light decays after few milliseconds and therefore it is necessary to repeat through the display list to refresh the screen at least 30 times per second to avoid flicker.
- As display buffer is used to store display list and used to refreshing, it is also called refresh buffer.

Raster scan display

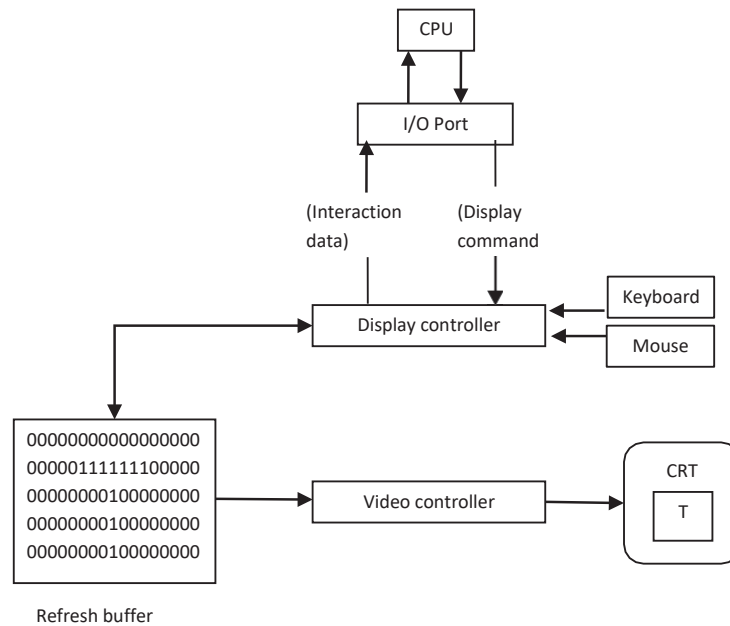


Fig. 1.3: - Architecture of a raster display.

- Fig. 1.3 shows the architecture of Raster display. It consists of display controller, CPU, video controller, refresh buffer, keyboard, mouse and CRT.
- The display image is stored in the form of 1's and 0's in the refresh buffer.
- The video controller reads this refresh buffer and produces the actual image on screen.
- It will scan one line at a time from top to bottom & then back to the top.

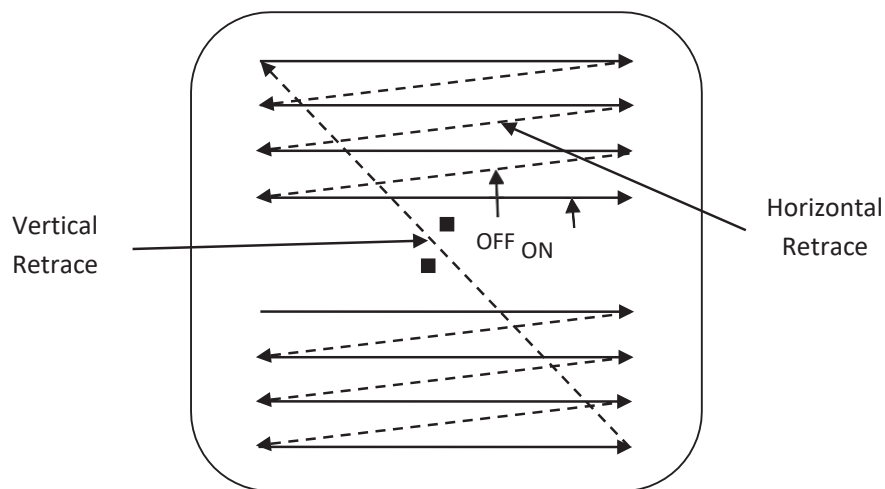


Fig. 1.4: - Raster scan CRT.

- In this method the horizontal and vertical deflection signals are generated to move the beam all over the screen in a pattern shown in fig. 1.4.
- Here beam is swept back & forth from left to the right.
- When beam is moved from left to right it is ON.

- When beam is moved from right to left it is OFF and process of moving beam from right to left after completion of row is known as **Horizontal Retrace**.
- When beam is reach at the bottom of the screen. It is made OFF and rapidly retraced back to the top left to start again and process of moving back to top is known as **Vertical Retrace**.
- The screen image is maintained by repeatedly scanning the same image. This process is known as **Refreshing of Screen**.
- In raster scan displays a special area of memory is dedicated to graphics only. This memory is called **Frame Buffer**.
- Frame buffer holds set of intensity values for all the screen points.
- That intensity is retrieved from frame buffer and display on screen one row at a time.
- Each screen point referred as pixel or **Pel (Picture Element)**.
- Each pixel can be specified by its row and column numbers.
- It can be simply black and white system or color system.
- In simple black and white system each pixel is either ON or OFF, so only one bit per pixel is needed.
- Additional bits are required when color and intensity variations can be displayed up to 24-bits per pixel are included in high quality display systems.
- On a black and white system with one bit per pixel the frame buffer is commonly called a **Bitmap**. And for systems with multiple bits per pixel, the frame buffer is often referred as a **Pixmap**.

Difference between random scan and raster scan

Base of Difference	Raster Scan System	Random Scan System
Electron Beam	The electron beam is swept across the screen, one row at a time, from top to bottom.	The electron beam is directed only to the parts of screen where a picture is to be drawn.
Resolution	Its resolution is poor because raster system in contrast produces zigzag lines that are plotted as discrete point sets.	Its resolution is good because this system produces smooth lines drawings because CRT beam directly follows the line path.
Picture Definition	Picture definition is stored as a set of intensity values for all screen points, called pixels in a refresh buffer area.	Picture definition is stored as a set of line drawing instructions in a display file.
Realistic Display	The capability of this system to store intensity values for pixel makes it well suited for the realistic display of scenes contain shadow and color pattern.	These systems are designed for line-drawing and can't display realistic shaded scenes.
Draw an Image	Screen points/pixels are used to draw an image.	Mathematical functions are used to draw an image.

Color CRT monitors

- A CRT monitors displays color pictures by using a combination of phosphors that emit different colored light.
- It produces range of colors by combining the light emitted by different phosphors.
- There are two basic techniques for color display:
 1. Beam-penetration technique
 2. Shadow-mask technique

Beam-penetration technique

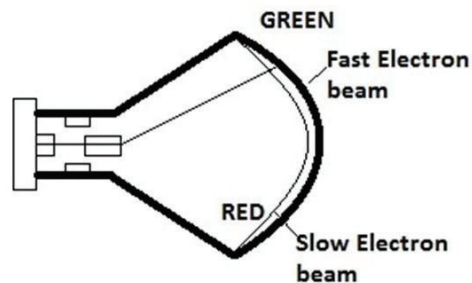


Fig. 1.5: - Beam-penetration CRT

- This technique is used with random scan monitors.
- In this technique inside of CRT coated with two phosphor layers usually red and green. The outer layer of red and inner layer of green phosphor.
- The color depends on how far the electron beam penetrates into the phosphor layer.
- A beam of fast electron penetrates more and excites inner green layer while slow electron excites outer red layer.
- At intermediate beam speed we can produce combination of red and green lights which emit additional two colors orange and yellow.
- The beam acceleration voltage controls the speed of the electrons and hence color of pixel.
- It is a low cost technique to produce color in random scan monitors.
- It can display only four colors.
- Quality of picture is not good compared to other techniques.

Shadow-mask technique

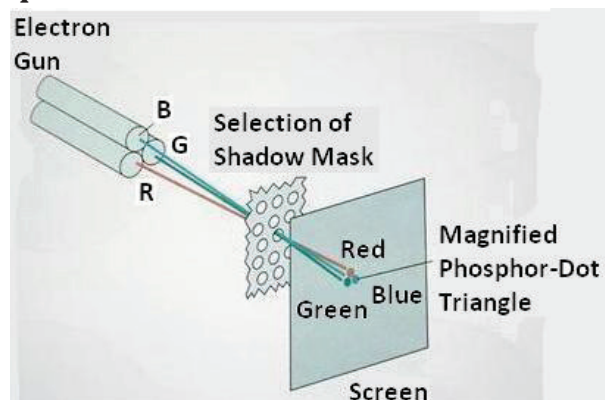


Fig. 1.6: - Shadow-mask CRT.

- It produces wide range of colors as compared to beam-penetration technique.
- This technique is generally used in raster scan displays. Including color TV.
- In this technique CRT has three phosphor color dots at each pixel position. One dot for red, one for green and one for blue light. This is commonly known as **Dot Triangle**.
- Here in CRT there are three electron guns present, one for each color dot. And a shadow mask grid just behind the phosphor coated screen.
- The shadow mask grid consists of series of holes aligned with the phosphor dot pattern.
- Three electron beams are deflected and focused as a group onto the shadow mask and when they pass through a hole they excite a dot triangle.
- In dot triangle three phosphor dots are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.
- A dot triangle when activated appears as a small dot on the screen which has color of combination of three small dots in the dot triangle.
- By changing the intensity of the three electron beams we can obtain different colors in the shadow mask CRT.

Direct-view storage tubes (DVST)

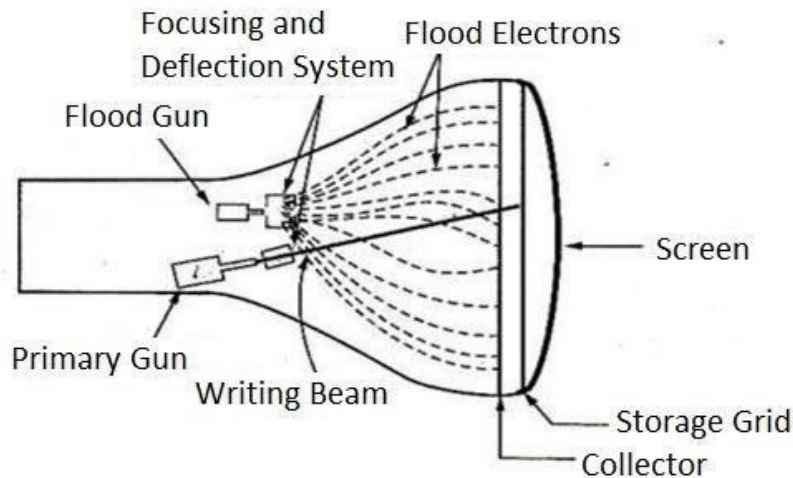


Fig. 1.7: - Direct-view storage tube.

- In raster scan display we do refreshing of the screen to maintain a screen image.
- DVST gives alternative method for maintaining the screen image.
- DVST uses the storage grid which stores the picture information as a charge distribution just behind the phosphor coated screen.
- DVST consists two electron guns a primary gun and a flood gun.
- A primary gun stores the picture pattern and the flood gun maintains the picture display.
- A primary gun emits high speed electrons which strike on the storage grid to draw the picture pattern.
- As electron beam strikes on the storage grid with high speed, it knocks out electrons from the storage grid keeping the net positive charge.
- The knocked out electrons are attracted towards the collector.
- The net positive charge on the storage grid is nothing but the picture pattern.
- The continuous low speed electrons from flood gun pass through the control grid and are attracted to the positive charged area of the storage grid.

- The low speed electrons then penetrate the storage grid and strike the phosphor coating without affecting the positive charge pattern on the storage grid.
- During this process the collector just behind the storage grid smooth out the flow of flood electrons.

Advantage of DVST

- Refreshing of CRT is not required.
- Very complex pictures can be displayed at very high resolution without flicker.
- Flat screen.

Disadvantage of DVST

- They do not display color and are available with single level of line intensity.
- For erasing it is necessary to removal of charge on the storage grid so erasing and redrawing process take several second.
- Erasing selective part of the screen cannot be possible.
- Cannot used for dynamic graphics application as on erasing it produce unpleasant flash over entire screen.
- It has poor contrast as a result of the comparatively low accelerating potential applied to the flood electrons.
- The performance of DVST is somewhat inferior to the refresh CRT.

Flat Panel Display

- The term flat panel display refers to a class of video device that have reduced volume, weight & power requirement compared to a CRT.
- As flat panel display is thinner than CRTs, we can hang them on walls or wear on our wrists.
- Since we can even write on some flat panel displays they will soon be available as pocket notepads.
- We can separate flat panel display in two categories:
 1. **Emissive displays**: - the emissive display or **emitters** are devices that convert electrical energy into light. For Ex. Plasma panel, thin film electroluminescent displays and light emitting diodes.
 2. **Non emissive displays**: - non emissive display or **non emitters** use optical effects to convert sunlight or light from some other source into graphics patterns. For Ex. LCD (Liquid Crystal Display).

Plasma Panels displays

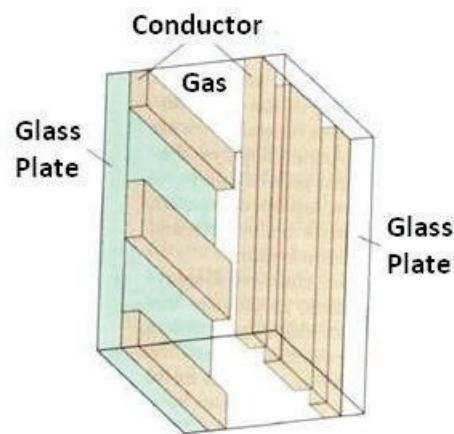


Fig. 1.8: - Basic design of a plasma-panel display device.

- This is also called gas discharge displays.
- It is constructed by filling the region between two glass plates with a mixture of gases that usually includes neon.
- A series of vertical conducting ribbons is placed on one glass panel and a set of horizontal ribbon is built into the other glass panel.
- Firing voltage is applied to a pair of horizontal and vertical conductors cause the gas at the intersection of the two conductors to break down into glowing plasma of electrons and ions.
- Picture definition is stored in a refresh buffer and the firing voltages are applied to refresh the pixel positions, 60 times per second.
- Alternating current methods are used to provide faster application of firing voltages and thus brighter displays.
- Separation between pixels is provided by the electric field of conductor.
- One disadvantage of plasma panels is they were strictly monochromatic device that means shows only one color other than black like black and white.

Thin Film Electroluminescent Displays.

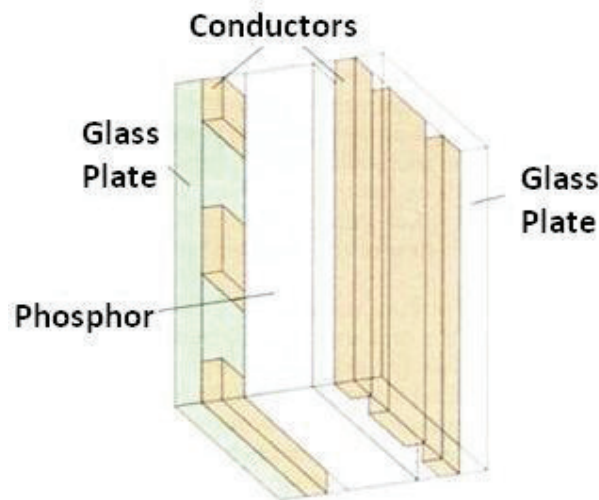


Fig. 1.9: - Basic design of a thin-film electro luminescent display device.

- It is similar to plasma panel display but region between the glass plates is filled with phosphors such as zinksulphide doped with magnesium instead of gas.
- When sufficient voltage is applied the phosphors becomes a conductor in area of intersection of the two electrodes.
- Electrical energy is then absorbed by the manganese atoms which then release the energy as a spot of light similar to the glowing plasma effect in plasma panel.
- It requires more power than plasma panel.
- In this good color and gray scale difficult to achieve.

Light Emitting Diode (LED)

- In this display a matrix of multi-color light emitting diode is arranged to form the pixel position in the display. And the picture definition is stored in refresh buffer.
- Similar to scan line refreshing of CRT information is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light pattern on the display.

Liquid Crystal Display (LCD)

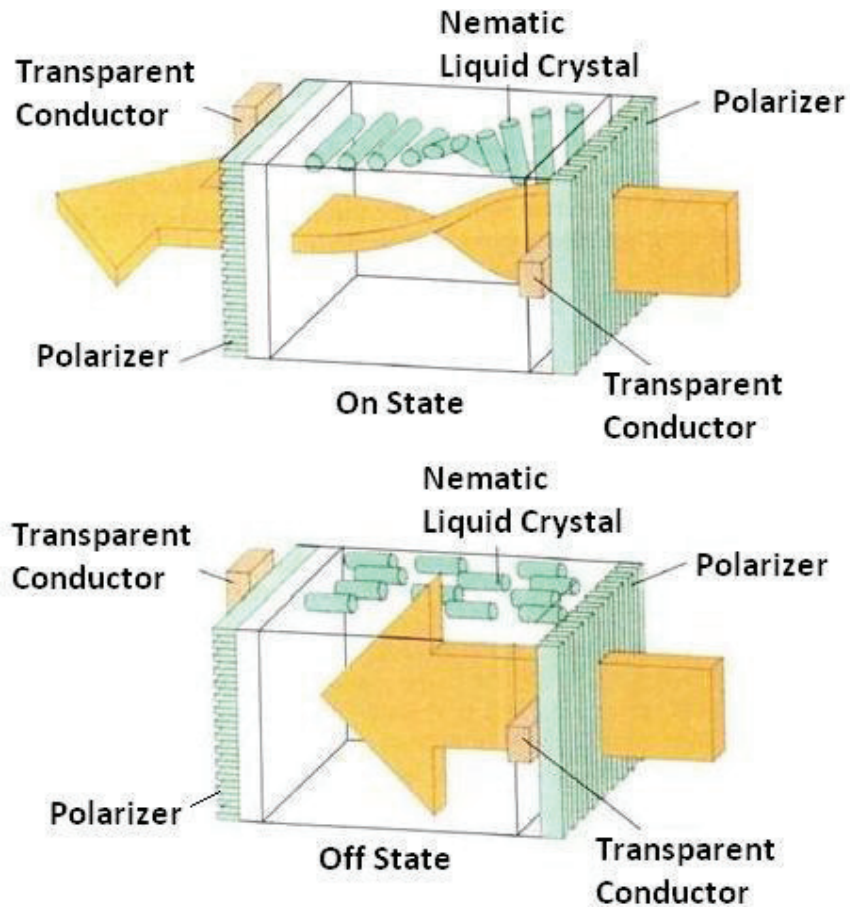


Fig. 1.10: - Light twisting shutter effect used in design of most LCD.

- It is generally used in small system such as calculator and portable laptop.
- This non emissive device produce picture by passing polarized light from the surrounding or from an internal light source through liquid crystal material that can be aligned to either block or transmit the light.
- The liquid crystal refreshes to fact that these compounds have crystalline arrangement of molecules then also flows like liquid.
- It consists of two glass plates each with light polarizer at right angles to each other sandwich the liquid crystal material between the plates.
- Rows of horizontal transparent conductors are built into one glass plate, and column of vertical conductors are put into the other plates.
- The intersection of two conductors defines a pixel position.
- In the ON state polarized light passing through material is twisted so that it will pass through the opposite polarizer.
- In the OFF state it will reflect back towards source.
- We applied a voltage to the two intersecting conductor to align the molecules so that the light is not twisted.
- This type of flat panel device is referred to as a passive matrix LCD.
- In active matrix LCD transistors are used at each (x, y) grid point.

- Transistor cause crystal to change their state quickly and also to control degree to which the state has been changed.
- Transistor can also serve as a memory for the state until it is changed.
- So transistor make cell ON for all time giving brighter display then it would be if it had to be refresh periodically

Advantages of LCD display

- Low cost.
- Low weight.
- Small size
- Low power consumption.

Three dimensional viewing devices

- The graphics monitor which are display three dimensional scenes are devised using a technique that reflects a CRT image from a vibrating flexible mirror.

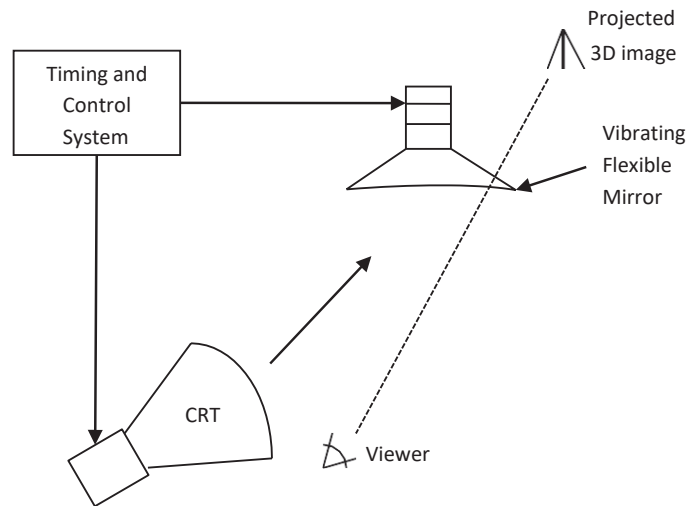


Fig. 1.11: - 3D display system uses a vibrating mirror.

- Vibrating mirror changes its focal length due to vibration which is synchronized with the display of an object on CRT.
- The each point on the object is reflected from the mirror into spatial position corresponding to distance of that point from a viewing position.
- Very good example of this system is GENISCO SPACE GRAPH system, which use vibrating mirror to project 3D objects into a 25 cm by 25 cm by 25 cm volume. This system is also capable to show 2D cross section at different depth.

Application of 3D viewing devices

- In medical to analyze data from ultra-sonography.
- In geological to analyze topological and seismic data.
- In designing like solid objects viewing and 3D viewing of objects.