CS 401 COMPUTER GRAPHICS
Module 1

Basic concepts in Computer Graphics – Types of Graphic Devices – Interactive Graphic inputs – Raster Scan and Random Scan Displays

Basic concepts

- Computer graphics is the art of drawing pictures, lines, charts, etc on the computer screen.
- It is the use of computers to create and manipulate pictures on a display device.
- It comprises of software techniques to create, store, modify, represents pictures.
- To display a picture of any size on a computer screen is a very difficult process.
- It is simplified by using Computer graphics.
- Graphics on the computer screen are produced by using various techniques and algorithms.

INTRODUCTION

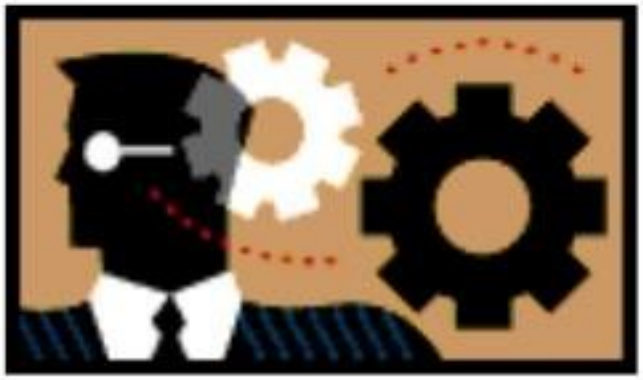
- ***Computer Graphics** is the pictorial representation or manipulation of data by a computer*

- ***Computer Graphics** refers to any sketch, drawing, special artwork or other material generated with the help of computer to pictorially depict an object or a process or otherwise convey information, as a supplement to or instead of written descriptions*"

Non-Interactive or Passive Computer Graphics

- *In non-interactive or passive computer graphics*, the picture is produced on the computer screen, and the user does not have any control over the image.
- The user cannot make any change in an image.

  Example: screen savers.
- In non-interactive computer graphics, users can only see the produced image.
- The produced image can not be changed by the user.
- It is one-way-communication between user and computer.



Gif Files

- In interactive Computer Graphics or active computer graphics, users can make some changes to the produced image.

- In simple users have some kind of control over the picture. Interactive

- Computer Graphics require two-way communication between the computer and the user.
- A User can see the produced image and make a change by
- sending his command by using the input device.

example : games

Interactive Computer Graphics
Video Games

INTRODUCTION

- **Every image or picture is in fact a graph and when different mathematical tricks are used to manipulate some change in its properties like shape, size, motion etc., through the help of computers then, the representation is nothing but computer graphics.**
- **A Picture is a fundamental cohesive concept in Computer Graphics. Each picture consists of points called pixels (Picture- element)**

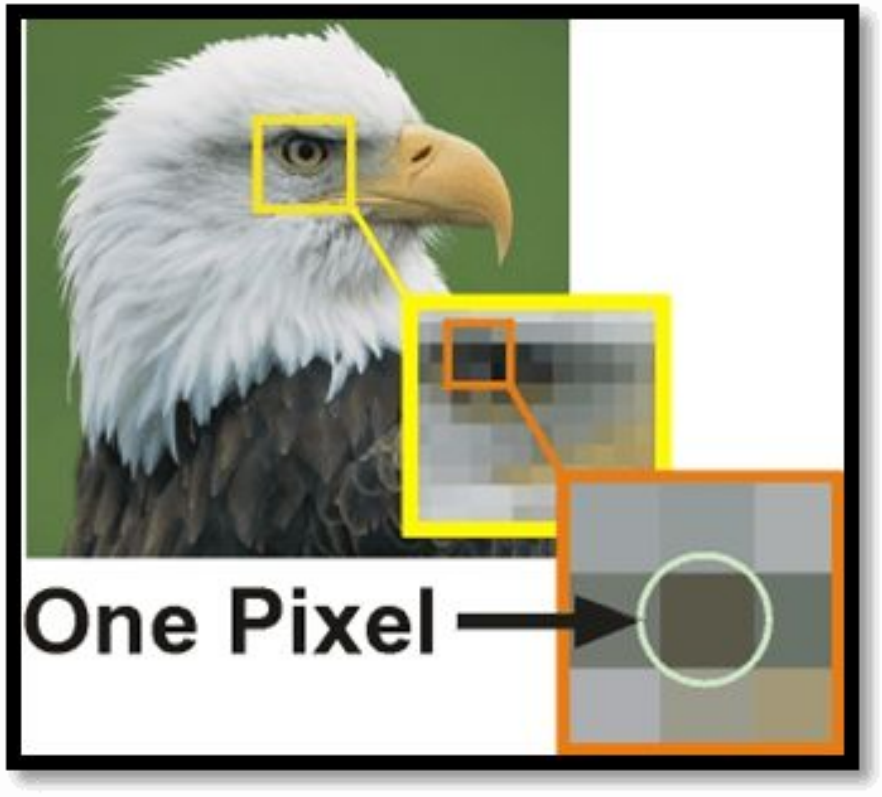
Pixel

- The full form of the pixel is "Picture Element.“
- It is also known as **"PEL."**
- Pixel is the smallest element of an image on a computer display, whether they are LCD or CRT monitors
- A screen is made up of a matrix of thousands or millions of pixels.
- A pixel is represented with a dot or a square on a computer screen.
- Each pixel has a value, or we can say a unique logical address.
- It can have only one color at a time.
- Colour of a pixel is determined by the number of bits which is used to represent it.

Pixel

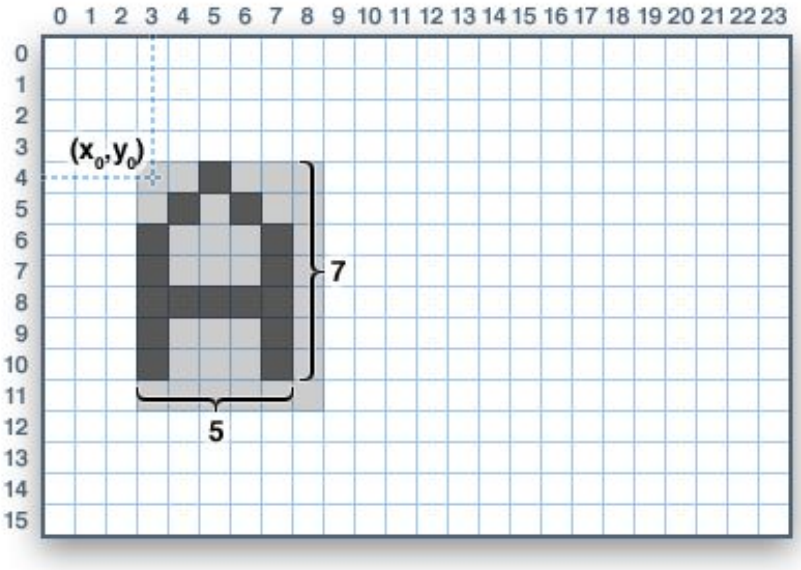
Computer screen contains 1000's of little dots called **Pixels** (picture element)

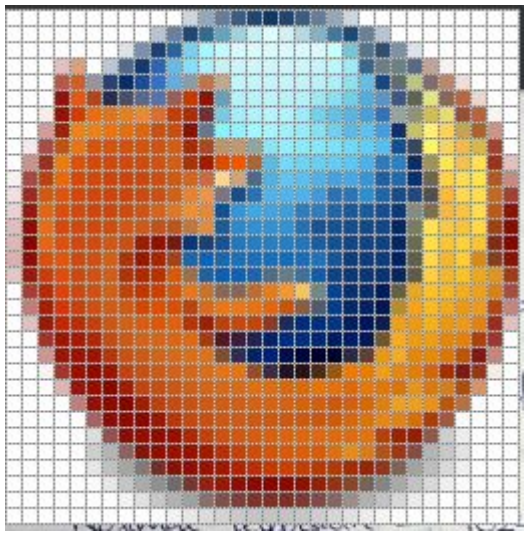
Pixel is the fundamental building block of picture

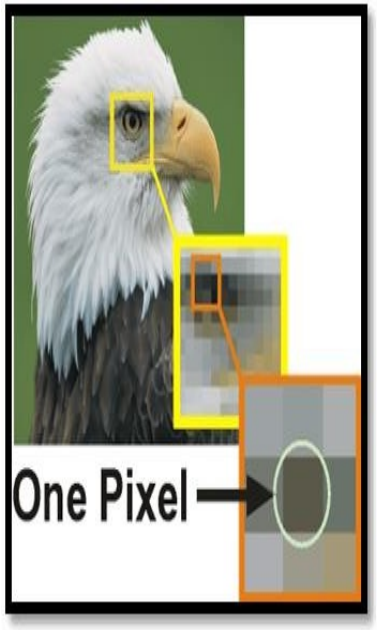


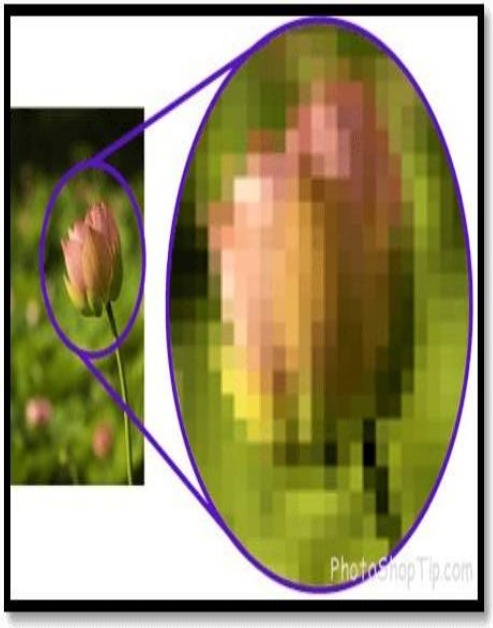
Pixel

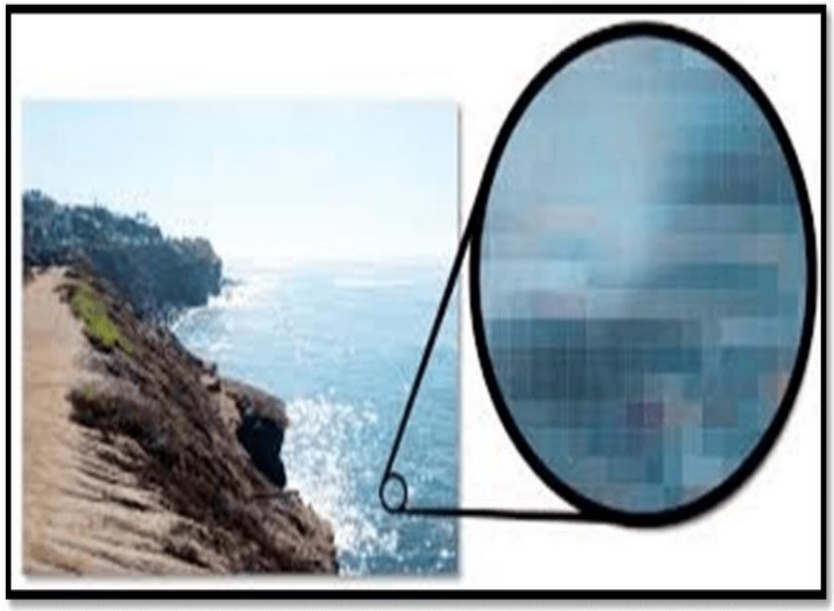
To display a picture, the computer be able to control the color of each pixels and need to know how to organize the pixels into meaningful shapes and image






One Pixel





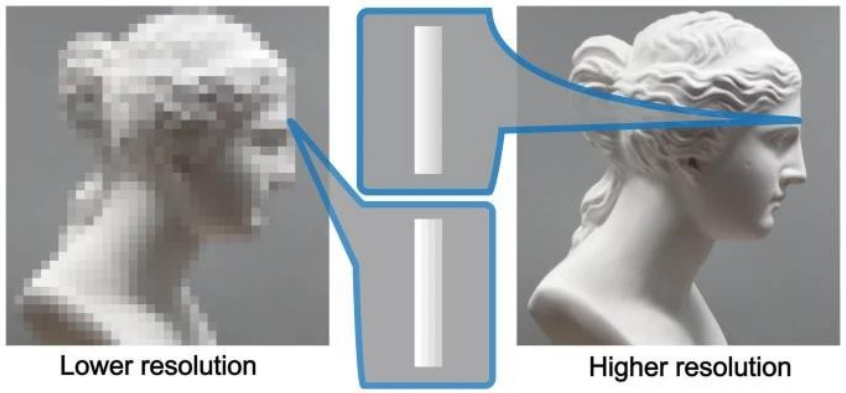
- Calculation of the total number of pixels
- Below is the formula to calculate the total number of pixel in an image.
- **For example:** let rows=300 & columns=200
  Total number of pixels= 300 X 200
  = 500

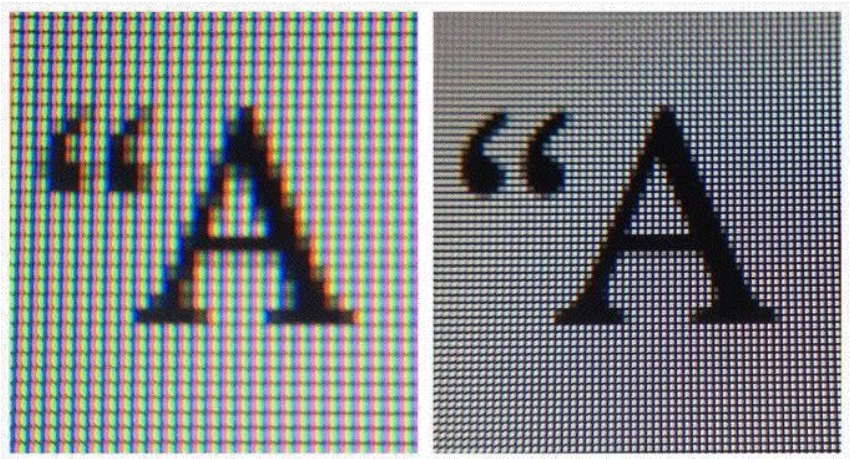
Bitmap / Pixmap

- A **Black-and-White System**: Each Screen Point is either ON or OFF, so only one bit per pixel is needed to control the intensity of screen positions.
- On a Black-and-White System with one bit per pixel, the **Frame Buffer** is called *BITMAP*.
- For system with multiple bits per pixel, the **Frame Buffer** is called *PIXMAP*.
- Sometimes, refresh rates are described in unit of cycles per second, or Hertz (HZ)

Resolution

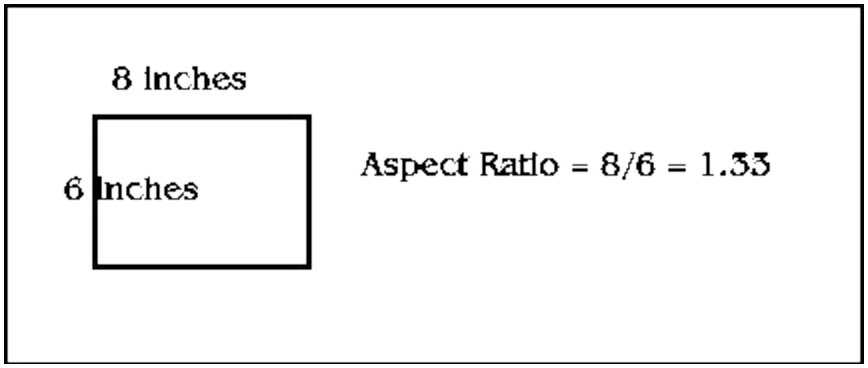
- Resolution is the number of pixels contained on a display monitor
- Resolution measures the number of pixels in a digital image or display.
- It is defined as width by height, or W x H, where W is the number of horizontal pixels and H is the number of vertical pixels.
- For example, the resolution of an HDTV is 1920 x 1080.


Lower resolution
Higher resolution



Aspect Ratio

- Aspect ratio is the ratio between width of an image and the height of an image.
- It is commonly explained as two numbers separated by a colon (8:9).
- This ratio differs in different images, and in different screens



WHAT IS AN INPUT DEVICE?

- An **input device** is any peripheral used to provide data and control signals to an information processing system.

LIST OF SOME INPUT DEVICES:

- Mouse
- Keyboard
- Trackball
- Space ball
- Joystick
- Digitizer
- Dials
- Button boxes

KEYBOARD

- IT is a device primarily used to enter TEXT STRINGS.

APLLICATIONS:

- Used to enter Text Strings
- Short cuts to many Functions

In Graphics:

- Used to provide screen coordinates
- Menu selection
- Gaming controls
- And FOR entering many graphics function

KEYBOARD

LATEST TYPES:

MOUSE

- Hand-held BOX used to position the screen cursor
- Wheels or Rollers(now-a-days Laser lights) on the bottom are used to record the position of the screen
- Generally there are two or three buttons, used for operations like recording of the cursor positions or invoking of a function
- In order to increase the number of INPUT parameters, additional devices can be included
- The Z-MOUSE is an example of this

Z-MOUSE

KEY FEATURES:

- **Has three buttons, a thumbwheel on the side, a trackball on the top and a standard mouse ball underneath**
- **This provides SIX degrees of freedom to select the positions, rotations ETC**
- **Allows 3D viewing**

Applications:

10. **Animation**
11. **Auto CAD**

And many more areas

TRACKBALL AND SPACEBALL

TRACKBALL

- It is a 2D positioning device
- It consists a ball held by a socket containing sensors to detect the rotation of ball about TWO axis
- User rolls the ball to move the cursor
- They are often mounted on devices such as keyboards, Z-mouse ETC

SPACEBALLS

- It provides SIX degrees of freedom
- It is a fix device
- Movement detection is done using strain gauges
- Cursor can move in any direction
- It is more efficient then trackball

APPLICATIONS:

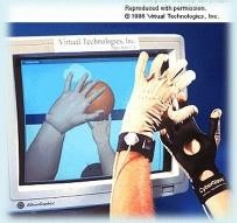
- Used in CAD workstations
- In animation
- Sometimes on special Workstations such as the radar consoles in air-traffic control room
- In Gaming consoles
- People with a mobility impairment use trackballs as an assistive technology input

JOYSTICK

JOYSTICK

- Consists of a stick pivoted on a base
- Used to steer the screen cursor
- It also has one or two PUSH buttons as input switches to perform certain actions
- Most joystick are 2D, but 3D do exist
- Distance moved from the CENTER position corresponds to the screen cursor movement in that direction

DATA GLOVE



DATA GLOVE

- Used to grasp a "virtual" object
- Uses sensors to detect the Hand and finger motion
- Electromagnetic coupling between signals provides information about the position and orientation of the HAND

APPLICATIONS:

- In 3D animation movies
- Visual effects
- Gestures can be categorized into useful information, such as to recognize Sign Language or other symbolic functions
- 3D Virtual environment Games

DIGITIZERS

DIGITIZERS

- Common device for drawing, painting, or interactively selecting coordinate positions on an object
- Typically, it is used to scan an Object and to input discrete coordinate positions

ONE TYPE of Digitizer is the Graphics Tablet

GRAPHICS TABLET

- A **graphics tablet** is a computer input device that allows one to hand-draw images and graphics, similar to the way one draws images with a pencil and paper. These tablets may also be used to capture data or handwritten signatures
- The common drawing TOOLS used to draw are **HAND CURSOR** and **STYLUS**
- A **STYLUS** is a pencil-shaped pointing device

GRAPHICS TABLET

- This Digitizing system uses electromagnetic resonance to detect the 3D positions of the STYLUS
- This allows one to produce different shades of brush strokes with different pressure on its surface
- Acoustic Tablets use sound waves to detect the position of the STYLUS

IMAGE SCANNERS

IMAGE SCANNERS

- In computing, a **scanner** is a device that optically scans images, printed text, handwriting, or an object, and converts it to a digital image
- When the scanning is performed, the gradation of gray scale or colors are recorded and stored in an array
- Once scanned, any kind of transformations can be applied to the object image

LIGHT PENS

LIGHT PENS

- A **light pen** is a computer input device in the form of a light-sensitive wand used in conjunction with a computer's CRT TV set or monitor
- Allows the users to point to displayed objects and to draw objects on screen
- The position points are highly accurate and sensitive
- It generates electrical pulse which records the position of the electron beam
- Not very much popular

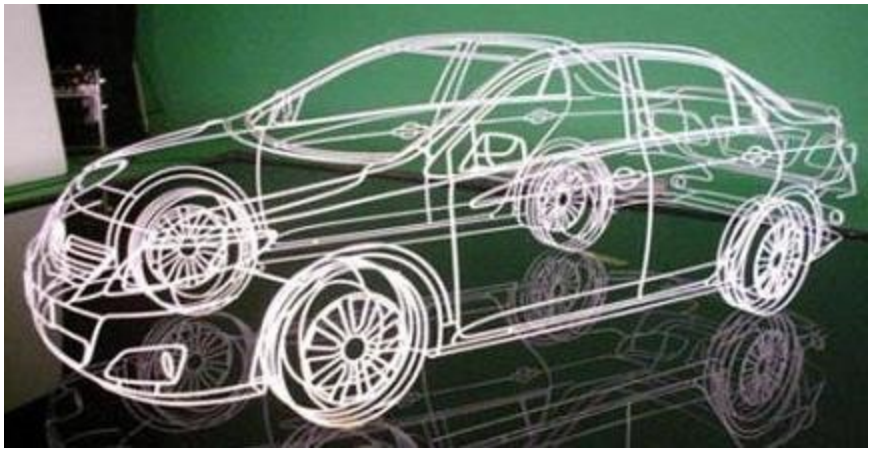
APPLICATIONS OF CG

Computer graphics is used in a lot of areas such as

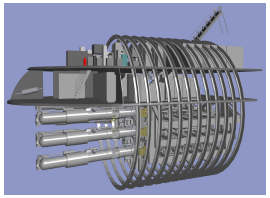
- science, engineering,
- medicine, business,
- industry, government,
- art, entertainment,
- advertising,
- education and training

1. COMPUTER AIDED DESIGN

- Computer graphics is used in the design of engineering and architectural systems such as buildings, automobiles, aircraft, watercraft, spacecraft, computers, textiles etc.



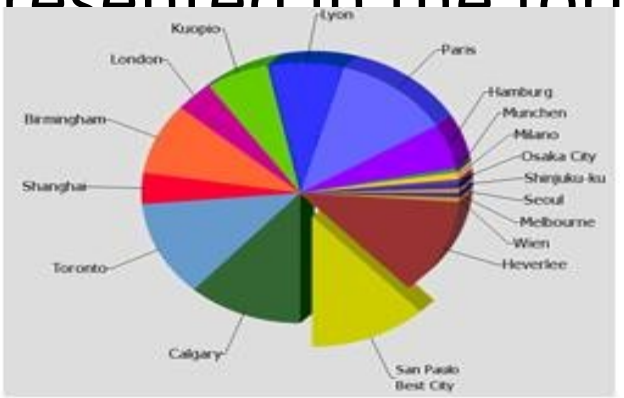
Computer Aided Design



- CAD methods are now routinely used in the design of buildings,automobiles,aircraft,watercraft.
- Animations are often used in CAD
- Circuits and networks for communications are constructed using graphics
- Wireframe displays also allow designers to quickly see the effects of interactive adjustment to design shapes.
- Architects use graphics to lay out floor plans etc.

2. PRESENTATION GRAPHICS

- It is an area of computer graphics in which slides are designed to be used with projectors.
- It is used to summarie financial, statistical, mathematical, scientific and economic data for reports.
- The data can be represented in the form of bar charts and grapl



3. COMPUTER ART

- Computer graphics techniques are used in fine art and commercial art applications.
- Artists use a variety of techniques such as paint packages, special hardware, CAD packages and animation packages for designing objects.
- Some examples software are Paint and Photoshop.

4.ENTERTAINMENT

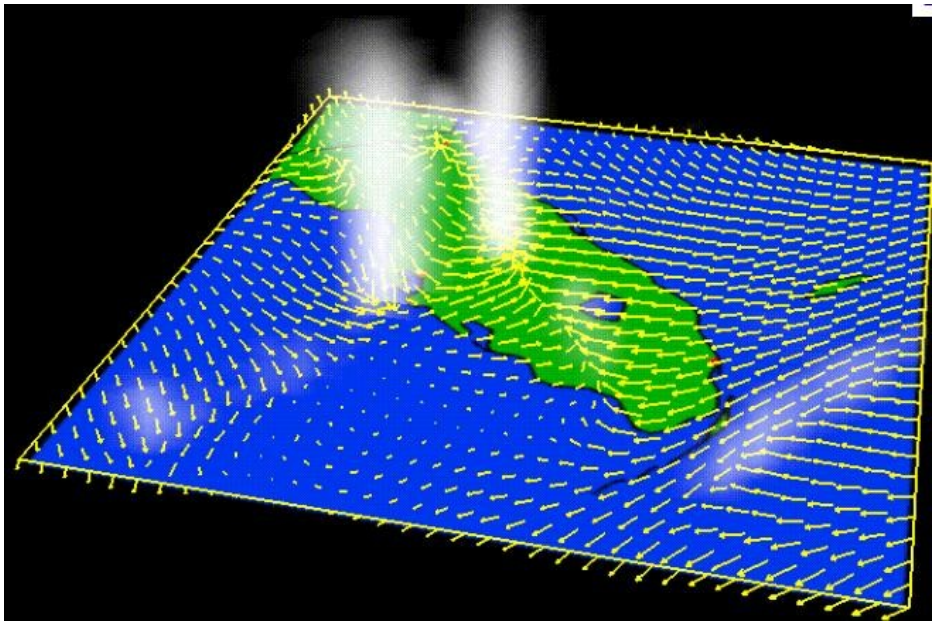
- Computer graphics methods are used in making motion pictures and television shows.
- Music videos use graphics in several ways. Graphics objects can be combined with live action

5 .EDUCATION AND TRAINING

- Computer generated models are used as financial aids.
- Virtual reality systems are used for training ship captains, aircraft pilots and heavy equipment operators.
- Flight simulators are used for training aircraft pilots.

6 .VISUALIZATION

- Scientists, engineers often need to analyze large amount of information to analyze certain processes.
- Satellite cameras collect thousands and even millions of images faster than they can be interpreted by human beings.
- But if these data are converted to visual form, trends can be analyzed. This is referred to as visualization



7 .IMAGE PROCESSING

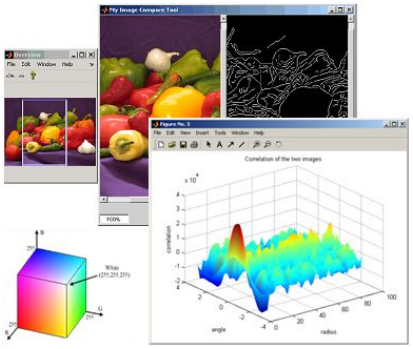
- Image processing apply techniques to modify or interpret existing pictures.
- Two applications of image processing are
- improving picture quality and machine perception of visual information.
- Medical applications widely use image processing techniques for surgery, tomography and for picture enhancements.

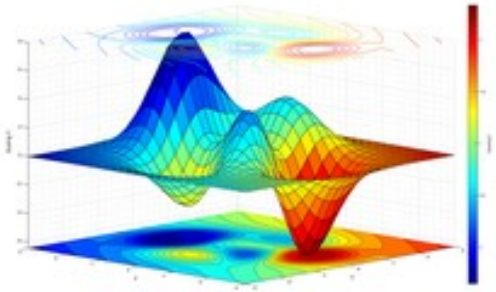
Digital Image Processing

Two principal applications of image processing are

a. improving picture quality
b. machine perception of visual information

used extensively in art applications, in analyzing satellite photos, Medical applications etc





8. GRAPHICAL USER INTERFACES

- Nowadays all operating systems provide graphical interfaces.
- They contain a number of windows.
- User can interact with the computer system by making some clicks instead of typing commands

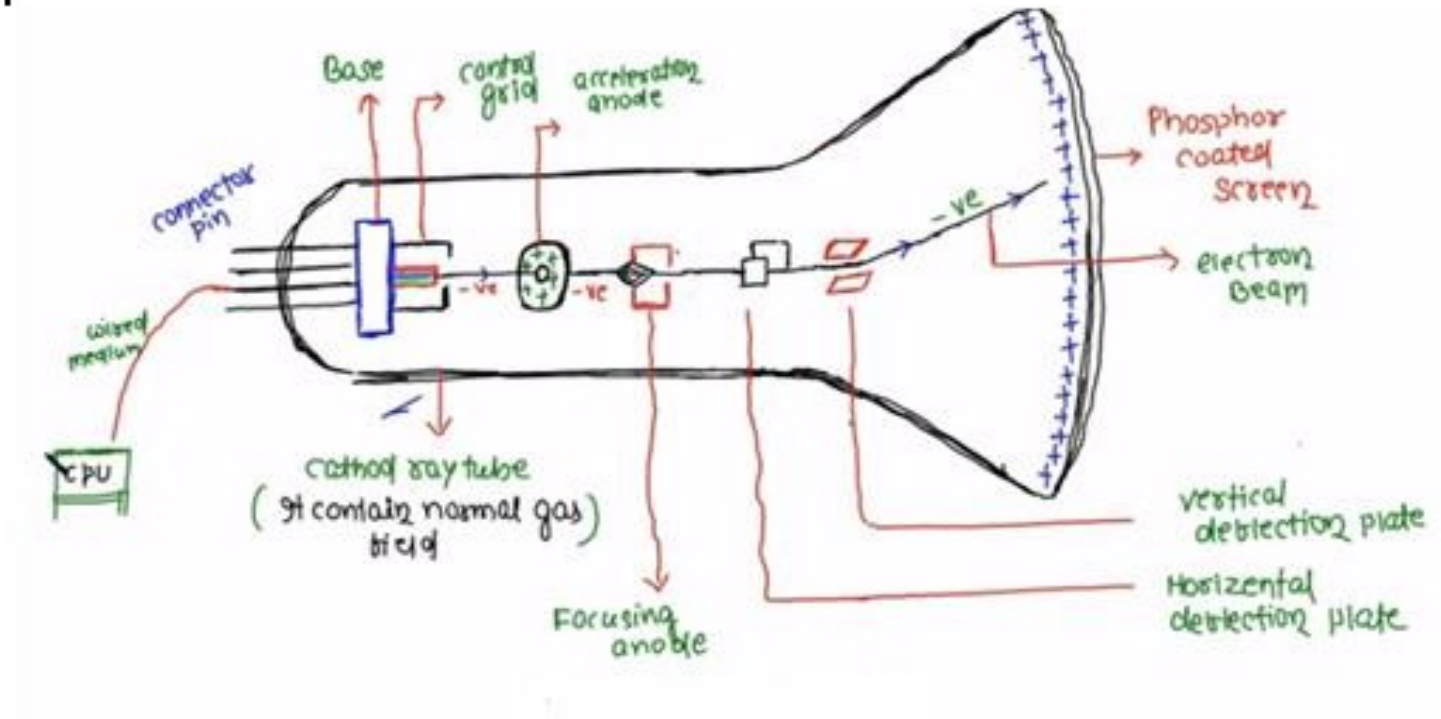
VIDEO DISPLAY DEVICES

- Primary output device in a graphics system is a video monitor.
- The operation of most video monitor is based on the standard Cathode Ray Tube(CRT)

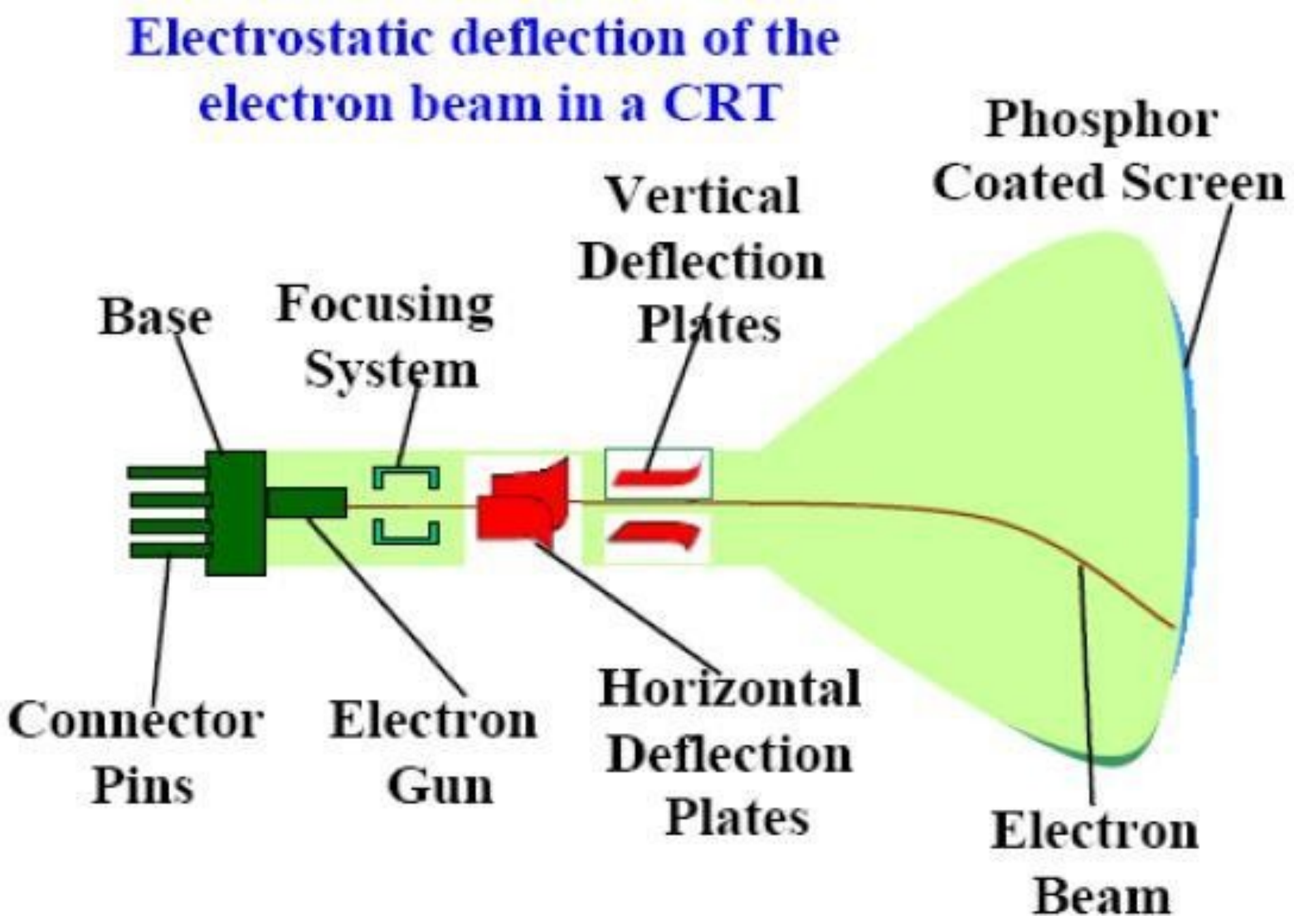
Cathode Ray Tube (CRT)

TYPES OF GRAPHIC DEVICES

- VIDEO DISPLAY DEVICES



Electrostatic deflection of the electron beam in a CRT

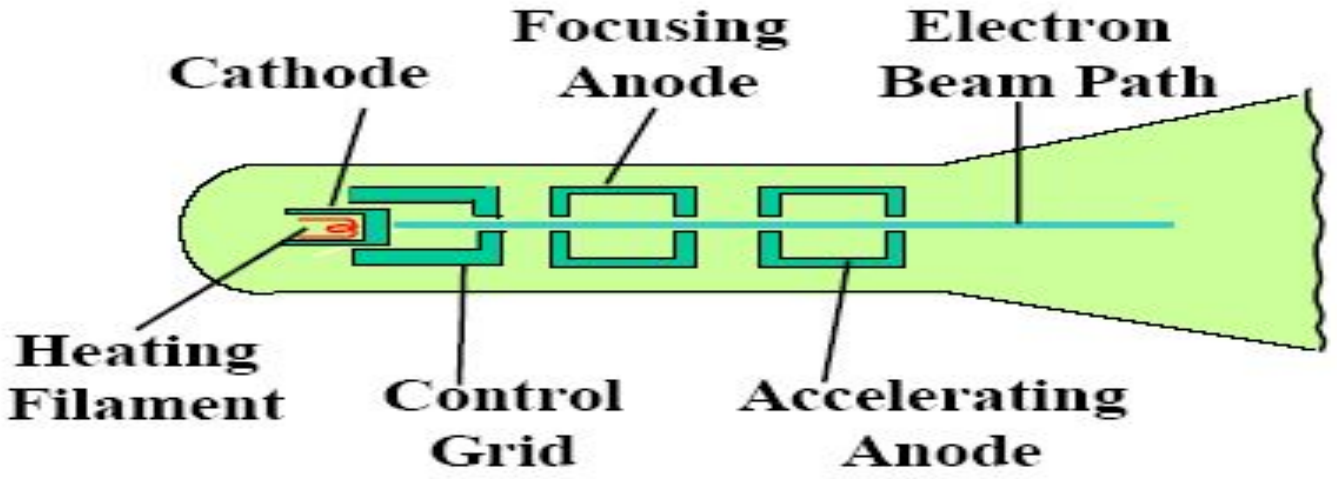


- The electron gun emits a beam of electrons called cathode rays.
- This electron beam passes through the focusing and deflection systems.
- When the beam strikes a position on the screen, the phosphor emits a small spot of light at that position.
- The light emitted by phosphor disappears very rapidly
- One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same positions.
- Such a type of display is called a refresh CRT.

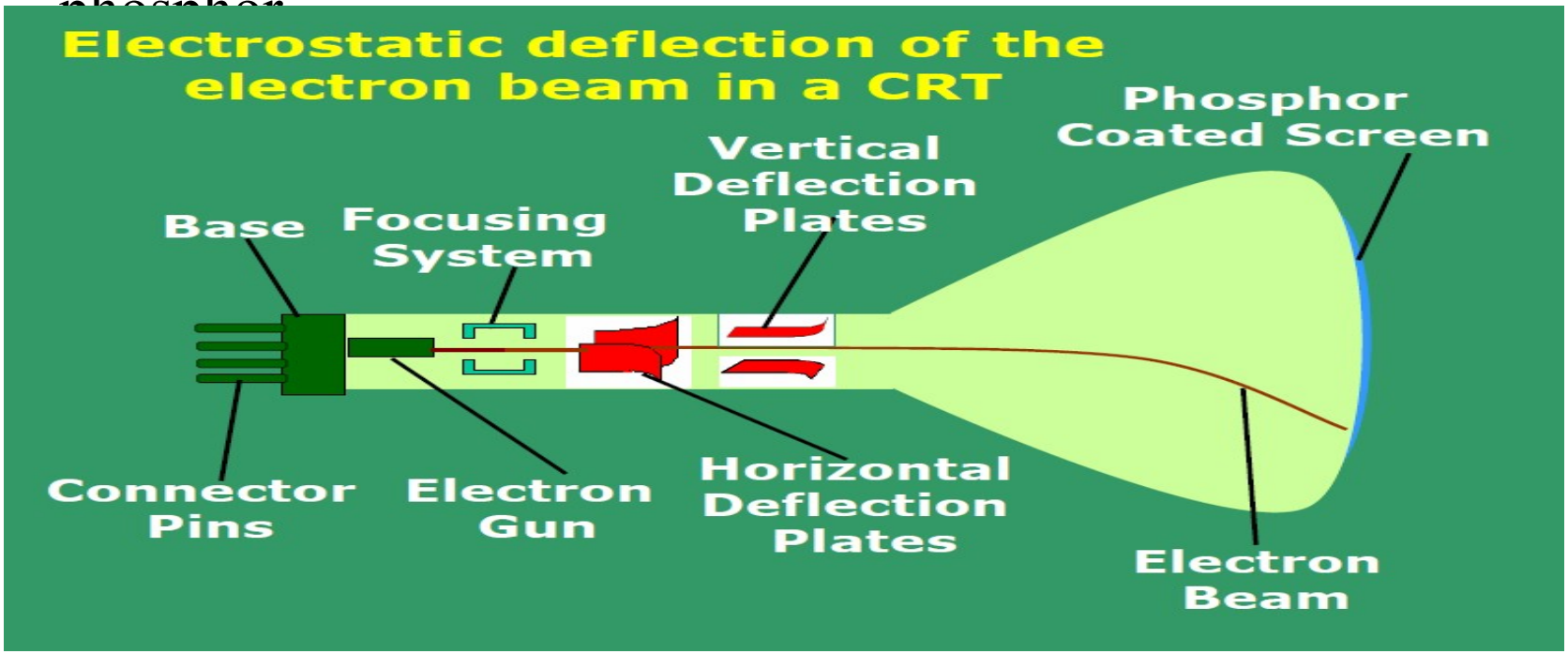
Working

- Beam passes between two pairs of metal plates, one vertical and other horizontal.
- A voltage difference is applied to each pair of plates according to the amount that the beam is to be deflected in each direction.
- As the electron beam passes between each pair of plates, it is bent towards the plate with the higher positive voltage.
- In figure below the beam is first deflected towards one side of the screen. Then, as the beam passes through the horizontal plates, it is deflected towards, the top or bottom of the screen.
- To get the proper deflection, adjust the current through coils placed around the outside of the CRT loop.
- The primary components of an electron gun in a CRT are the heated metal cathode and a control grid. Heat is supplied to the cathode by directing a current through a coil of wire, called the filament, inside the cylindrical cathode structure. This causes electrons to be "boiled off" the hot cathode surface.

- In the vacuum inside the CRT envelope, the free, negatively charged electrons are then accelerated toward the phosphor coating by a high positive voltage.
- The accelerating voltage can be generated with a positively charged metal coating on the in- side of the CRT envelope near the phosphor screen, or an accelerating anode can be used,
- as in Fig. below. Sometimes the electron gun is built to contain the accelerating anode and focusing system within the same unit.

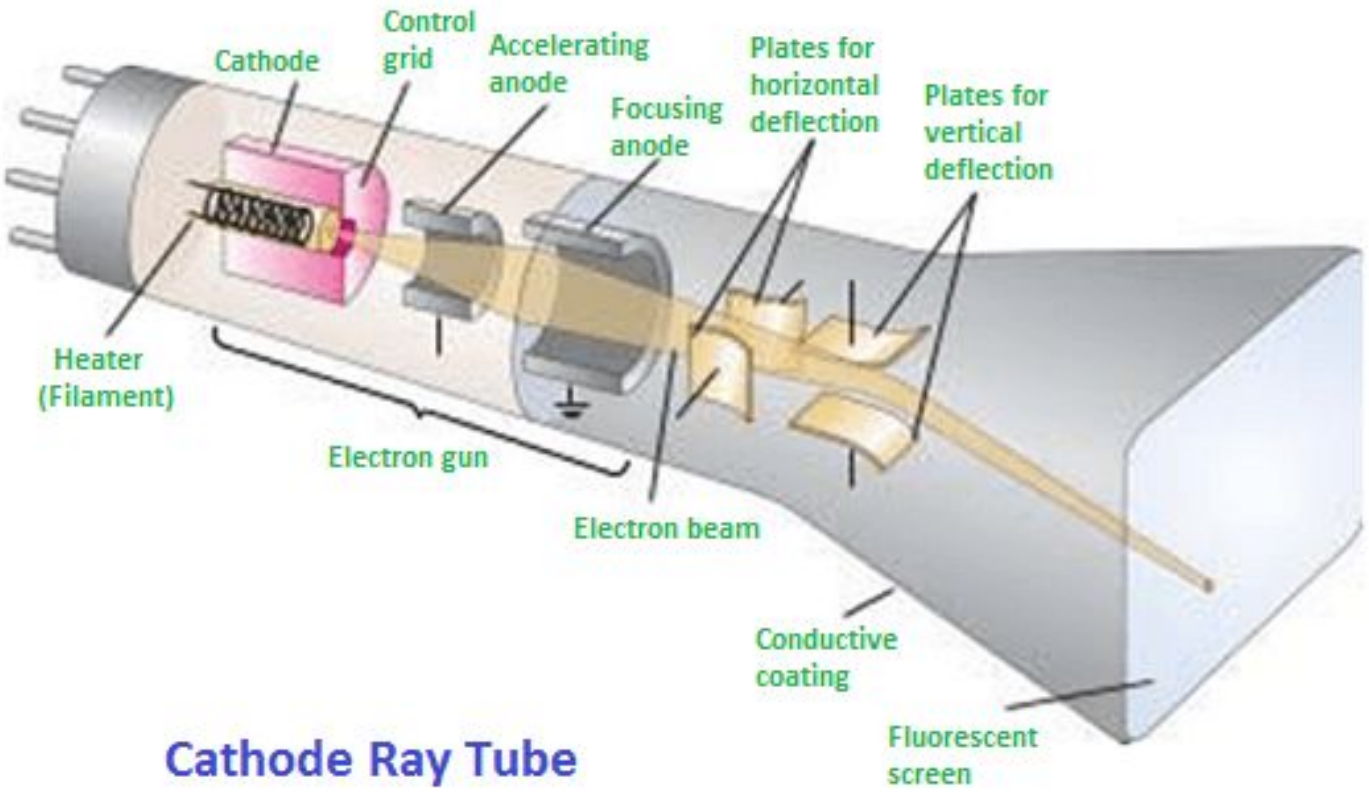


- The free negatively charged electrons produced from the cathode are accelerated toward the phosphor coating by a high positive voltage generated from accelerating anode.
- Control grid is used for controlling the intensity of this electron beam.
- The focusing system is to make the electron beam to converge into a small spot in the screen as it strikes the phosphor.



- The deflection of the electron beam is controlled by either magnetic or electric fields
- phosphors have persistence. That is how long they will continue to emit light after the CRT beam is removed.
- Lower persistence phosphors require higher refresh rates to maintain a picture o the screen without flicker.

Cathode Ray Tube (CRT)



- As with focusing, deflection of the electron beam can be controlled either with electric fields or with magnetic fields.
- Cathode-ray tubes are now commonly constructed with magnetic deflection coils mounted on the outside of the CRT envelope, as illustrated in.
- ln first Figure. Two pairs of coils are used, with the coils in each pair mounted on opposite sides of the neck of the CRT envelope. One pair is mounted on the top and bottom of the neck and the other pair is mounted on opposite sides of the neck.
- The magnetic field produced by each pair of coils results in a transverse deflection force that is perpendicular both to the direction of the magnetic field and to the direction of travel of the electron beam.
- Horizontal deflection is accomplished with one pair of coils, and vertical deflection by the other pair. The proper deflection amounts are attained by adjusting the current through the coils.
- When electrostatic deflection is used, two pairs of parallel plates are mounted inside the CRT envelope. One pair of plates is mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control horizontal deflection

Persistence

Besides color a major difference between the different kinds of phosphor is their persistence. Persistence means how long they continue to emit light after the CRT beam is removed

Resolution

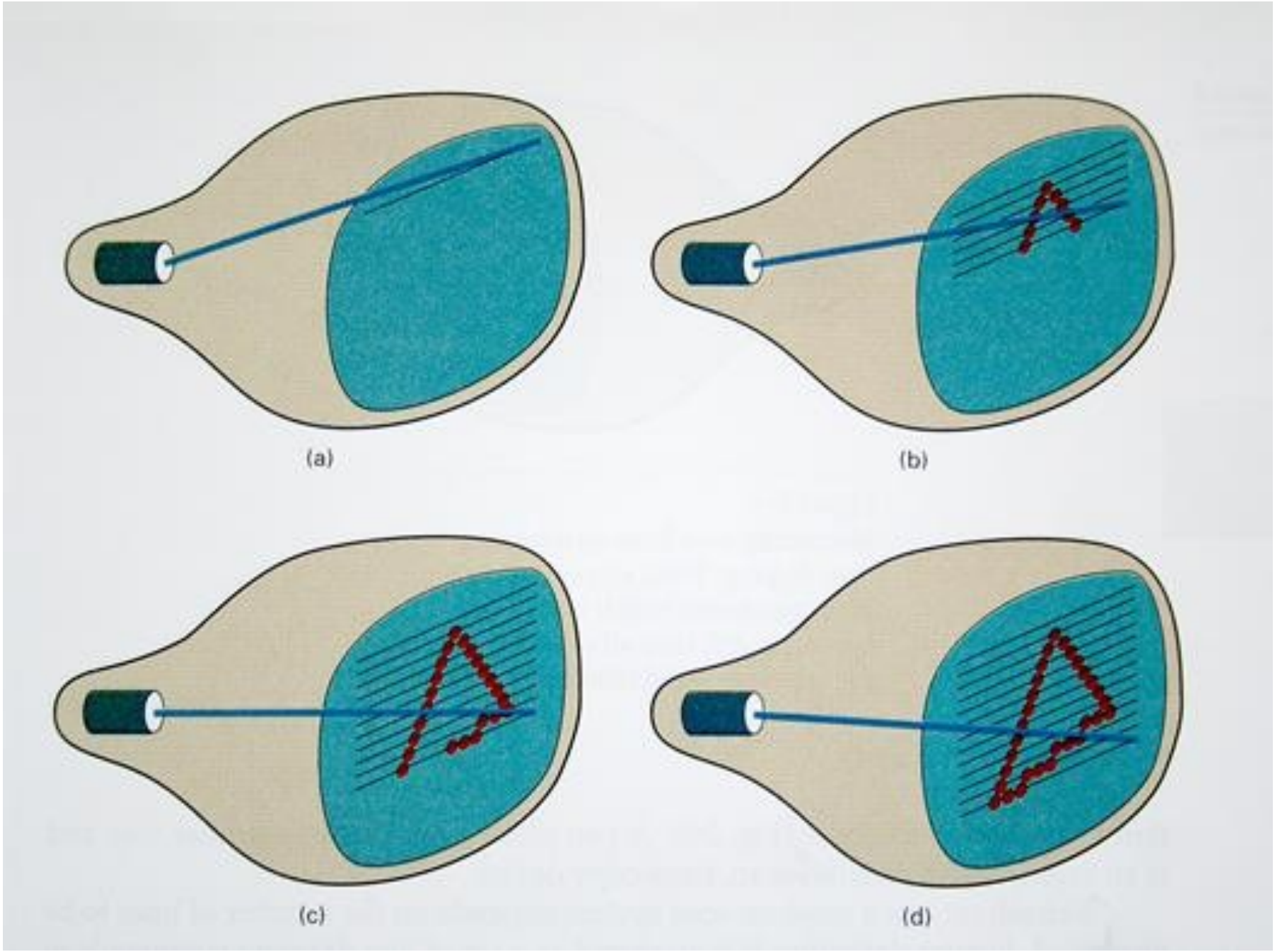
The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution. A more precise definition of resolution is ***the number of points per centimeter that can be plotted horizontally and vertically***, although it is often simply stated as the total number of points in each direction. This depends on the type of phosphor used and the focusing and deflection system.

Aspect Ratio

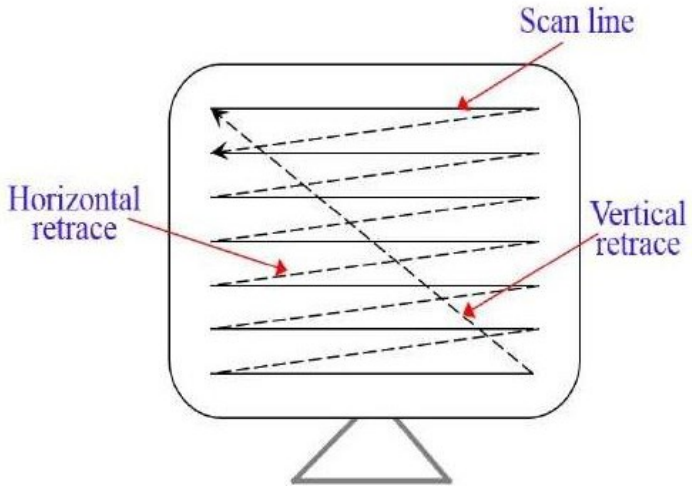
Another property of video monitors is aspect ratio. This number gives ***the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen***. (Sometimes aspect ratio is stated in terms of the ratio of horizontal to vertical points.) An aspect ratio of 3/4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points

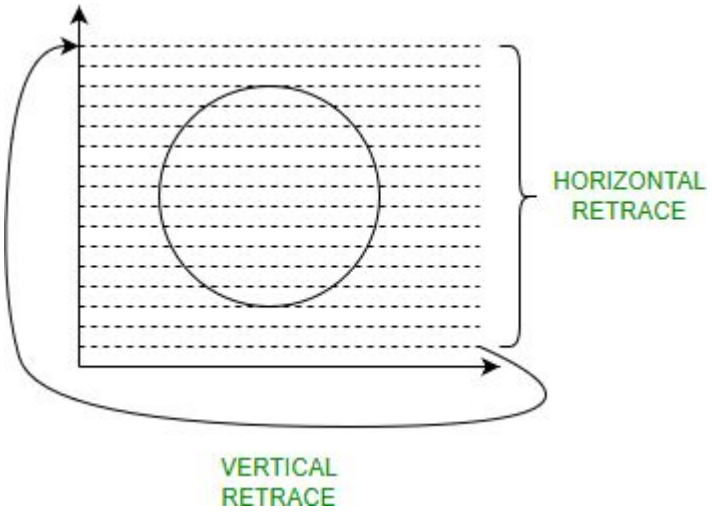
RASTER SCAN DISPLAY

- Raster Scan Displays are most common type of graphics monitor which employs CRT.
- It is based on television technology.
- In raster scan system electron beam sweeps across the screen, from top to bottom covering one row at a time.
- A pattern of illuminated pattern of spots is created by turning beam intensity on and off as it moves across each row.
- A memory area called refresh buffer or frame buffer stores picture definition.
- This memory area holds intensity values for all screen points. Stored intensity values are restored from frame buffer and painted on screen taking one row at a time


(a)
(b)
(c)
(d)

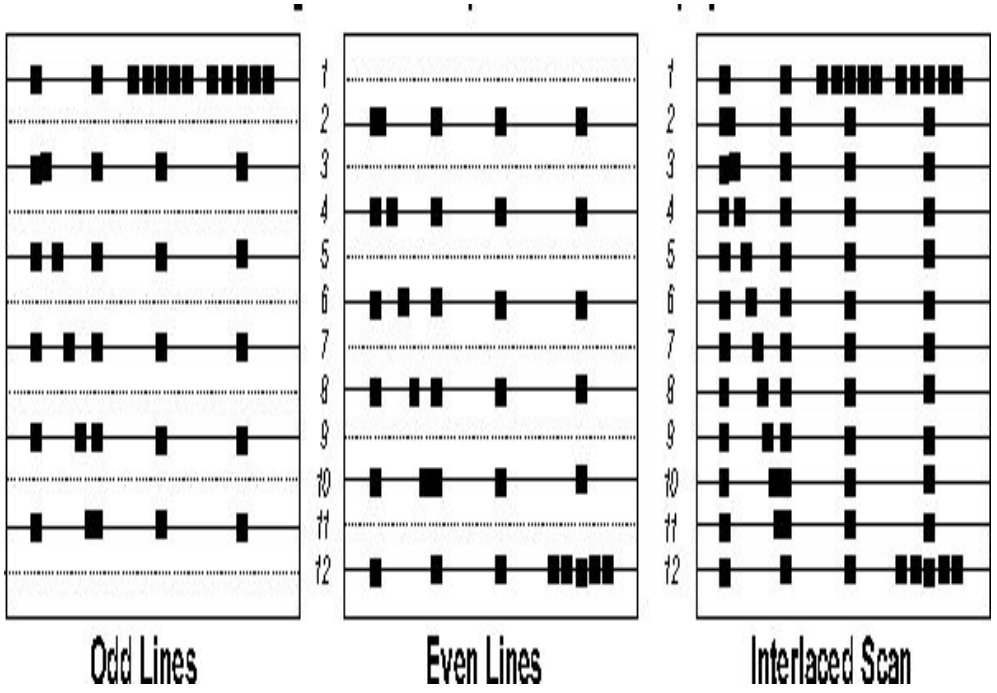
- In raster scan systems refreshing is done at done at a rate of 60-80 frames per second.
- Refresh rates are also sometimes described in units of cycles per second / Hertz (Hz).
- At the end of each scan line, electron beam begins to display next scan line after returning to left side of screen.
- The return to the left of screen after refresh of each scan line is known as horizontal retrace of electron beam.
- At the end of each frame electron beam returns to top left corner and begins the next frame


Scan line
Horizontal
retrace
Vertical
retrace


HORIZONTAL
RETRACE
VERTICAL
RETRACE

INTERLACING

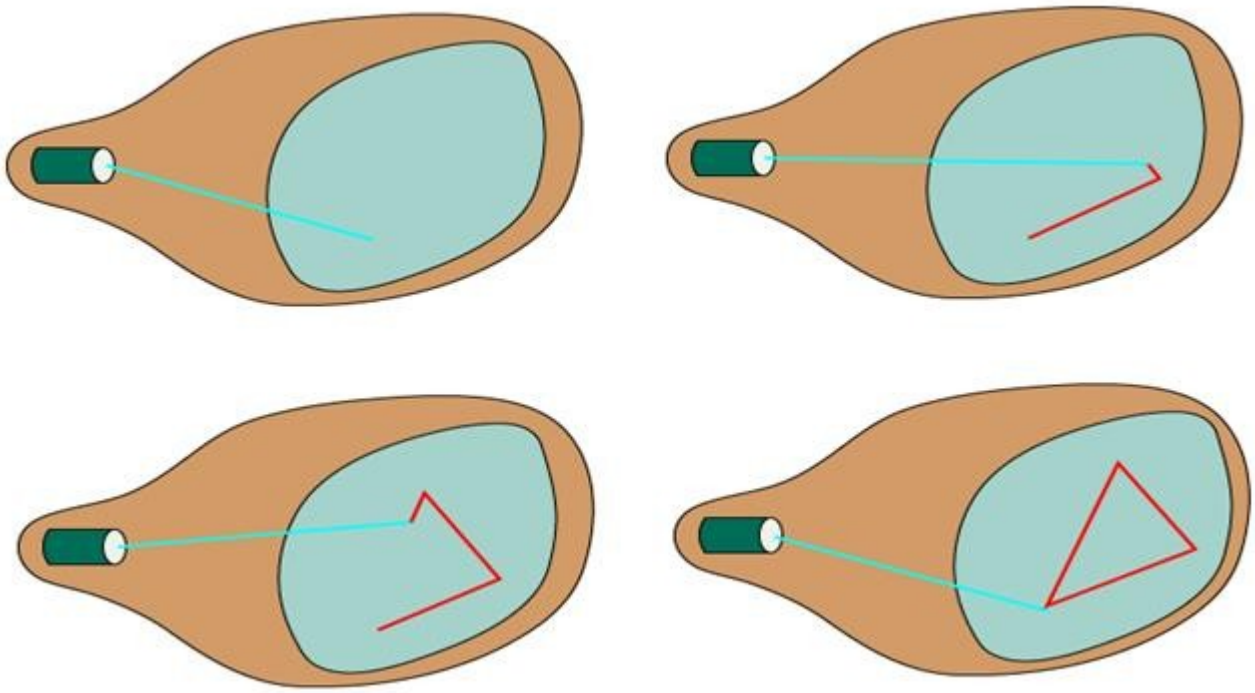
- Interlacing is where the horizontal lines of a video display are updated on odd and even lines alternately.
- One frame (the picture for one time interval) would update the odd lines and the next one would update the even lines.
- This means for a given data rate (the speed at which pixels can be updated) the video update can be faster, but at the expense of vertical resolution (only half of the lines change on every frame).



- *Advantages:*
- Realistic image
- Million Different colors to be generated
- Shadow Scenes are possible.
- *Disadvantages:*
- Low Resolution
- Expensive

RANDOM SCAN DISPLAY

- In **Random-Scan Display** electron beam is directed only to the areas of screen where a picture has to be drawn.
- It is also called vector displays, as it draws picture one line at time.
- It can draw and refresh component lines of a picture in any specified sequence.
- Pen plotter is an example of random-scan displays.
- The number of lines regulates refresh rate on random-scan displays.
- An area of memory called **refresh display files** stores picture definition as a set of line drawing commands.
- The system returns back to first line command in the list, after all the drawing commands have been processed.



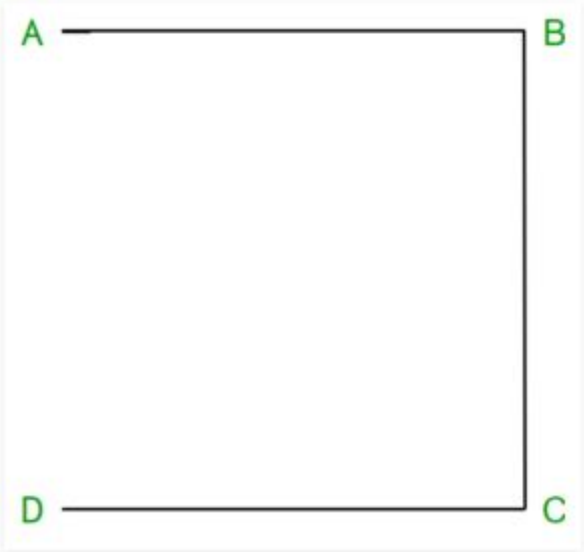
- High-quality vector systems can handle around 100, 00 short lines at this refresh rate.
- Faster refreshing can burn the phosphor.
- To avoid this every refresh cycle is delayed to prevent refresh rate greater than 60 frames per

Suppose we want to display a square ABCD on the screen. The commands will be:

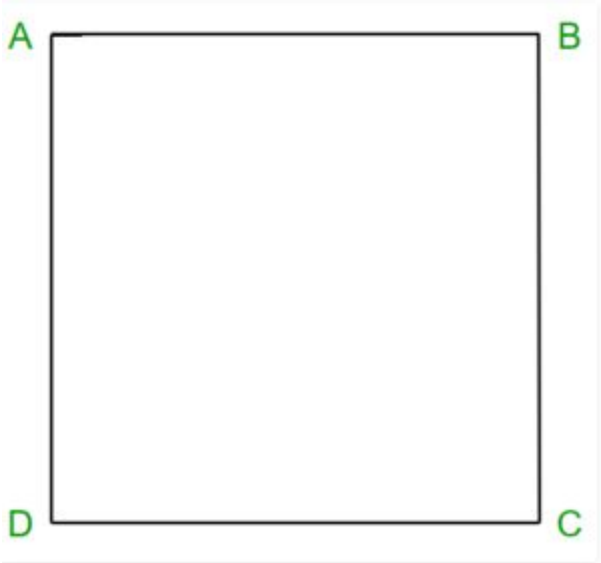
- Draw a line from A to B

- Draw a line from B to C

- Draw a line from C to D



- Draw a line from D to A



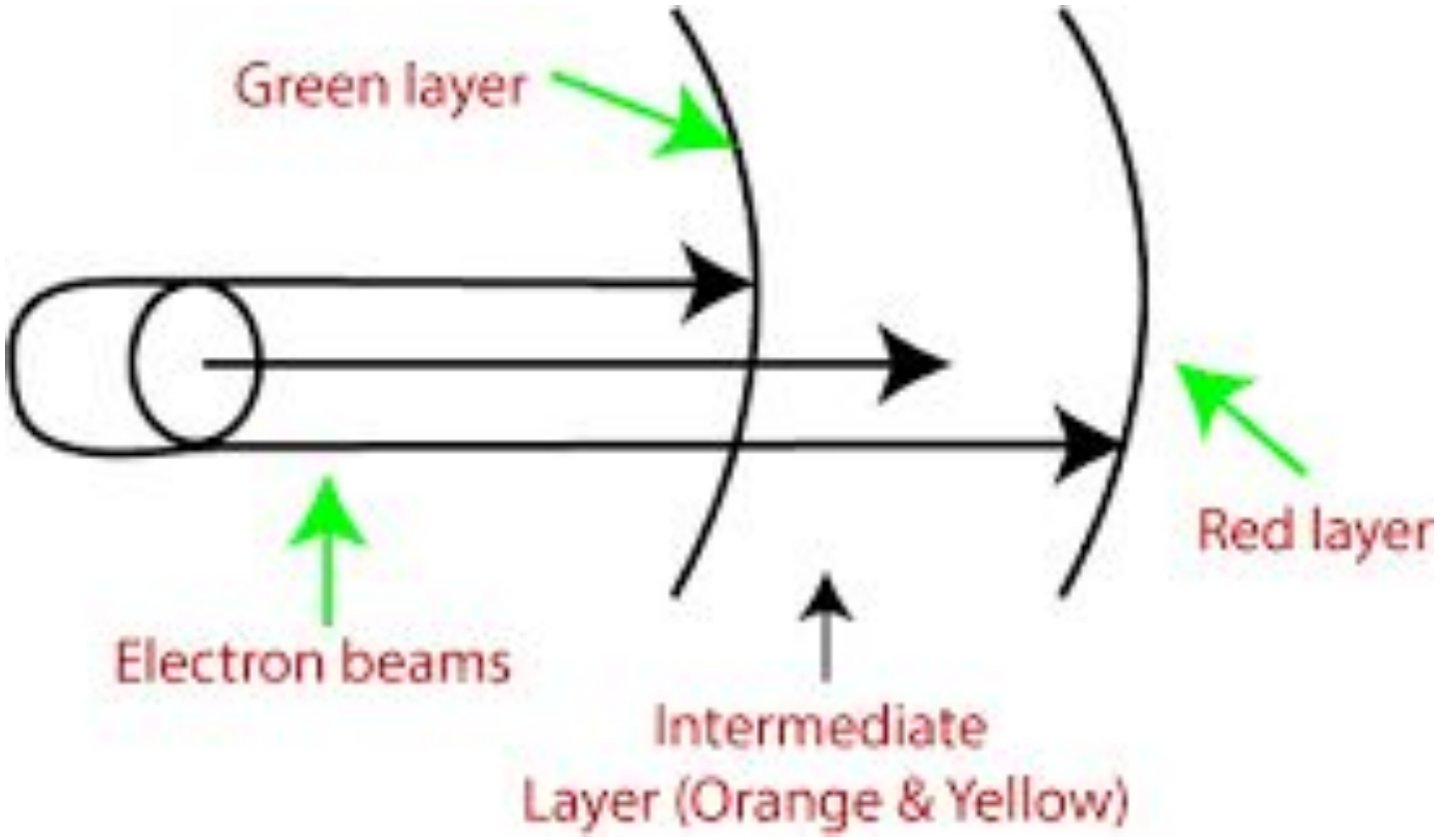
Raster	Random
The e beam scans the screen only 1 line at a time from top to bottom.	The e beam is directed only to the parts of the screen where the pic is to be drawn
(ii) Pic def are stored in frame buffer.	(ii) Pic def are stored in display
(iii) Pic def are stored in form of intensity values	(iii) Pic def are stored in form of set of line drawing commands.
(iv) It produce jaggedness	(iv) It produce smoothness
(v) Has low resolution	(v) Has high resolution
(vi) Used for realistic images	(vi) Used for line drawing applications

Color CRT Monitors

- A CRT monitor displays color pictures by using a combination of phosphors that emit different **COLOR** lights.
- Methods:-

1. Beam Penetration

2. Shadow Mask


Green layer
Red layer
Electron beams
Intermediate
Layer (Orange & Yellow)

Beam Penetration Method

- Used with Random Scan monitors.
- Two layers of phosphor (red and green) are coated onto the inside of the CRT screen.
- The display color depends on how far the electron beam penetrates into the phosphor layers.
- The speed of the electrons, and the screen color at any point, is controlled by the beam acceleration voltage.

Beam Penetration Method (contd.)

- Only 4 colors are possible (red, green, orange, and yellow).
- Quality of pictures is not as good as with other methods.

SHADOW MASK METHOD

- Shadow Mask Method is commonly used in Raster-Scan System because they produce a much wider range of colors than the beam-penetration method.

- It is used in the majority of color TV sets and monitors.
- Construction: A shadow mask CRT has 3 phosphor color dots at each pixel position.

- One phosphor dot emits: red light
- Another emits: green light
- Third emits: blue light

- This type of CRT has 3 electron guns, one for each color dot and a shadow mask grid just behind the phosphor coated screen.

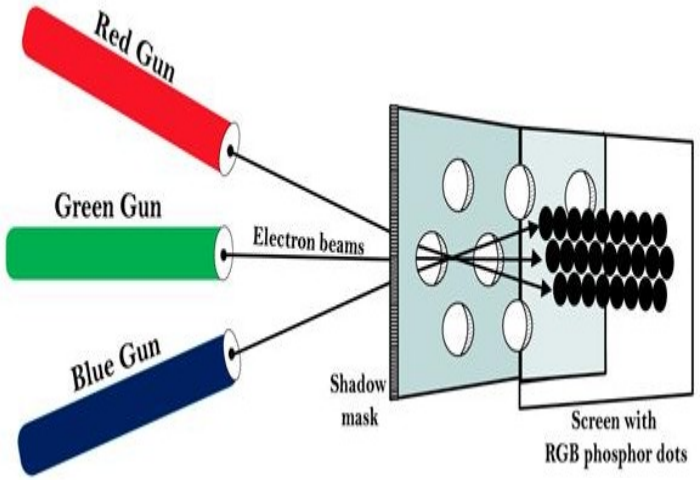
- Shadow mask grid is pierced with small round holes in a triangular pattern.

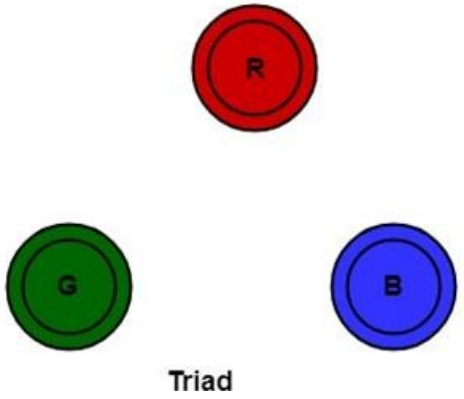
- Figure shows the delta-delta shadow mask method commonly used in color CRT system.

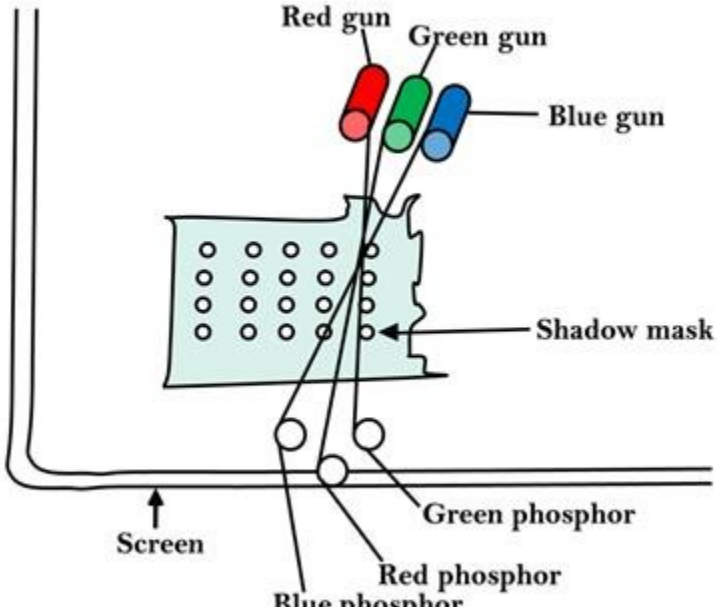
Explain the working of a delta-delta shadow mask CRT. (4)

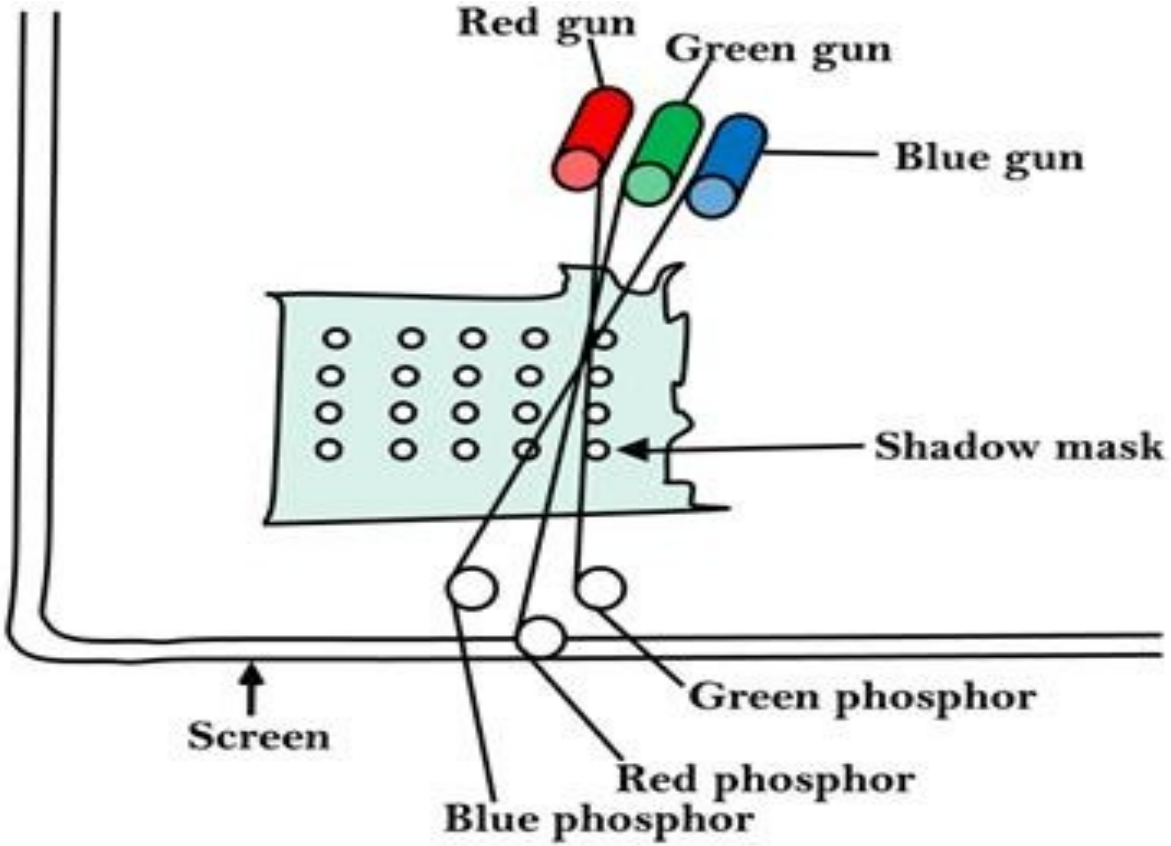
1 DELTA DELTA

)







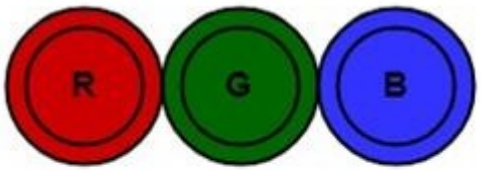

Red gun
Green gun
Blue gun
Shadow mask
Green phosphor
Screen
Red phosphor
Blue phosphor

WORKING

- **Working:** Triad arrangement of red, green, and blue guns.
- The deflection system of the CRT operates on all 3 electron beams simultaneously;
- the 3 electron beams are deflected and focused as a group onto the shadow mask, which contains a sequence of holes aligned with the phosphor- dot patterns.
- When the three beams pass through a hole in the shadow mask, they activate a dotted triangle, which occurs as a small color spot on the screen.
- The phosphor dots in the triangles are organized so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask

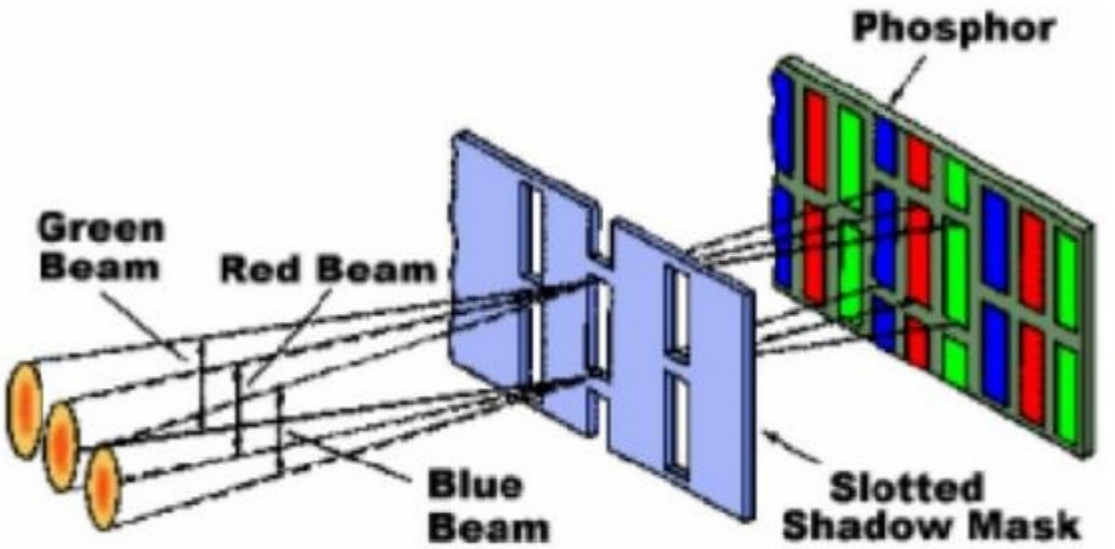
IN-LINE METHOD

- Another configuration for the 3 electron guns is an Inline arrangement in which the 3
- electron guns and the corresponding red-green-blue color dots on the screen, are aligned along one scan line rather of in a triangular pattern.
- This inline arrangement of electron guns in easier to keep in alignment and is commonly used in high-resolution color CRT's.

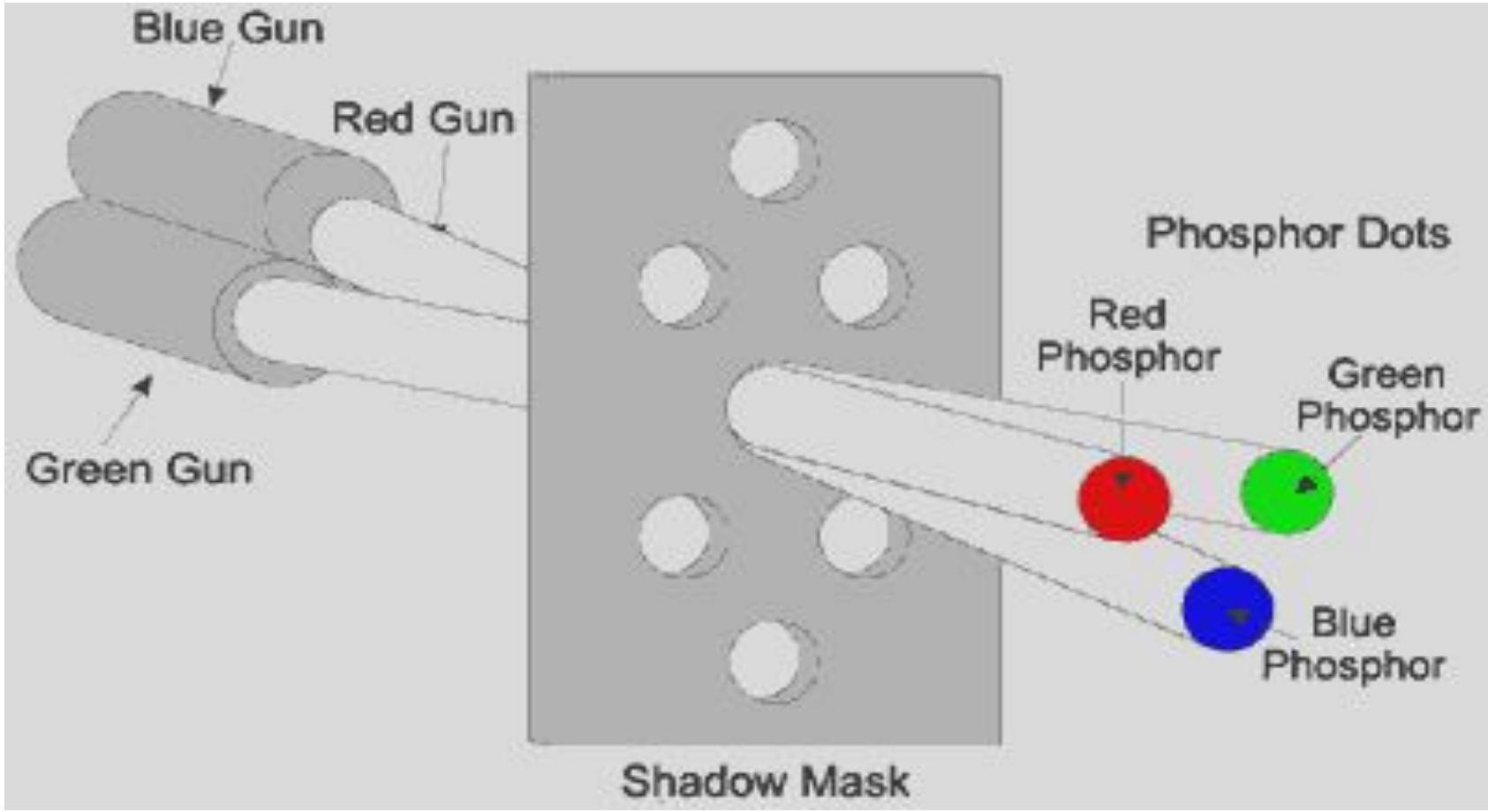


In-Line

Shadow Mask – Inline Method



Shadow Mask CRT



Q Consider 3 diff raster systems with resolutions of 640 x 480, 1280 x 1024, 2560 x 2048

(a) What is the size of frame buffer (in bytes) for each of these systems to store 12 bits/pixel.

Ans: Because 8 bits constitute a byte, frame buffer size of the systems are $640 \times 480 \times \frac{12}{8}$

$$= \frac{460800}{1024}$$

$$= 450 \text{ kb}$$

$$\left(1280 \times 1024 \times \frac{12}{8}\right) \div 1024$$

$$= 1920 \text{ kB}$$

$$\left[2560 \times 2048 \times \frac{12}{8}\right] \div 1024$$

$$= 7864320 \div 1024$$

$$= 7680 \text{ KB}$$

(b) How much storage for bytes is required for each of them if 24 bits/pixel are to be stored?

Similarly each of the above results are doubled for 24 bits of storage/pixels.

$640 \times 480 \Rightarrow \dfrac{640 \times 480 \times \frac{24}{8}}{1024} = 900$

$1280 \times 1024 = \left[1280 \times 1024 \times \frac{24}{8}\right] \div 1024$

$= \underline{3840}$

$2560 \times 2048 = \left[2560 \times 2048 \times \frac{24}{8}\right] \div 1024$

$= \underline{15360}$

Advantage:

1. Realistic image
2. Million different colors to be generated
3. Shadow scenes are possible

Disadvantage:

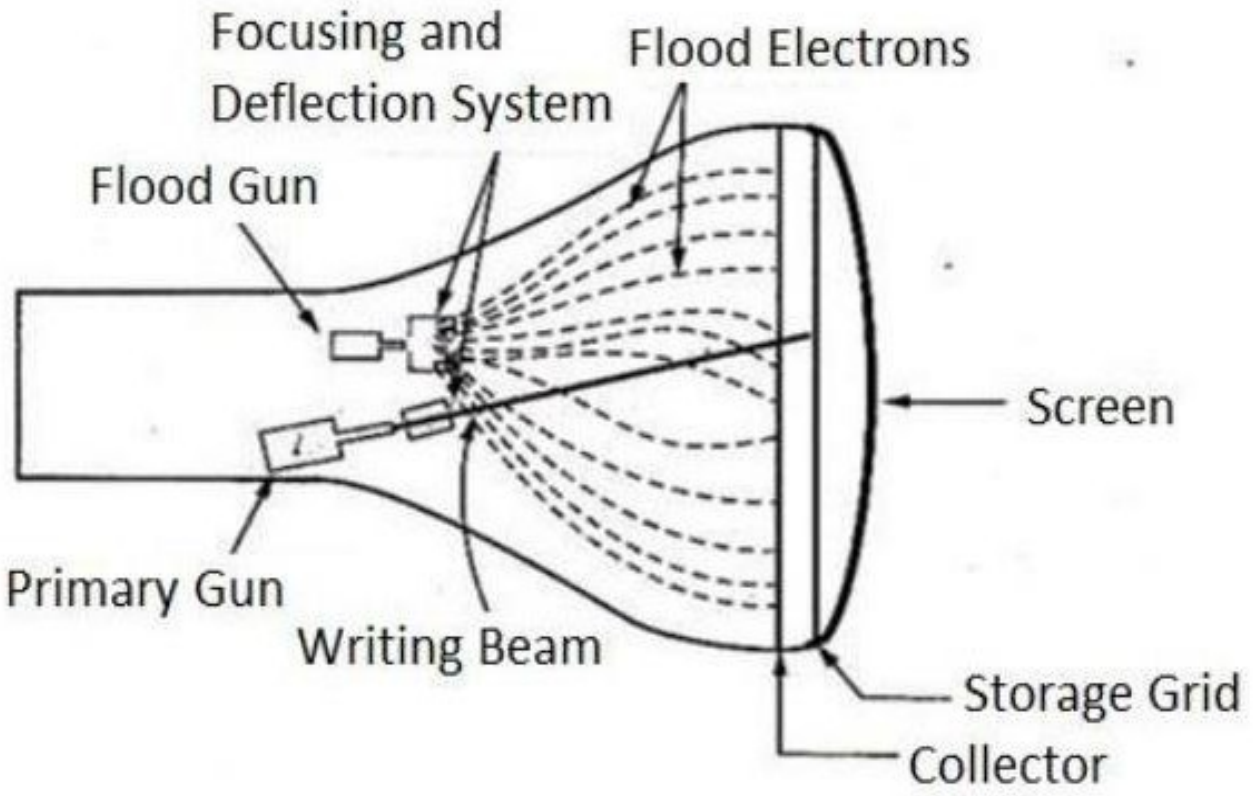
1. Relatively expensive compared with the monochrome CRT.
2. Relatively poor resolution
3. Convergence Problem

Direct View Storage Tubes

Two types of electron guns are used in DVST

- **Primary gun** – used to store the picture pattern
- **Flood gun** – maintains the picture display

Direct View Storage Tubes



- In raster scan display we do refreshing of the screen to maintain a screen image.
- DVST give an alternative method for maintaining the screen image.
- Moreover, Direct View Storage Tubes (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 attracted towards the collector.
- Also, 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 \attracted to the postpositive large 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 smoothens out the flow of flood electrons.

The advantage of DVST -Direct View Storage Tubes

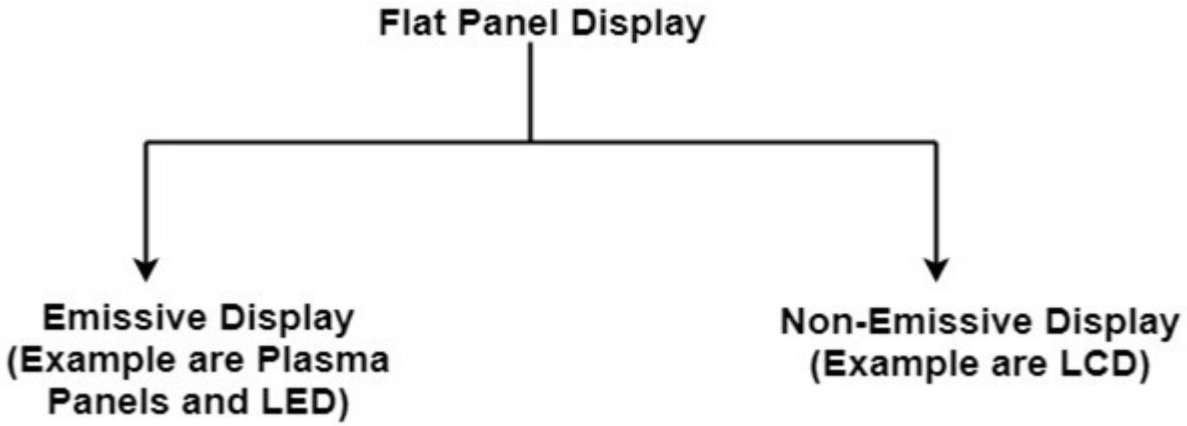
- Refreshing of CRT is not required.
- Moreover, Very complex pictures can be displayed at very high resolution without flicker.
- Flat screen.

Disadvantage of DVST: Direct View Storage Tubes

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

Flat Panel Display

- The Flat-Panel displays are video devices that have reduced volume, weight and power requirement compare to CRT.
- **Example:** Small T.V. monitor, calculator, pocket video games, laptop computers, an advertisement board in elevator.



Emissive Display: The emissive displays are devices that convert electrical energy into light. Examples are Plasma Panel, thin film electroluminescent display and LED (Light Emitting Diodes).

Non-Emissive Display: The Non-Emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. Examples are LCD (Liquid Crystal Device).

PLASMA PANAL DISPLAY

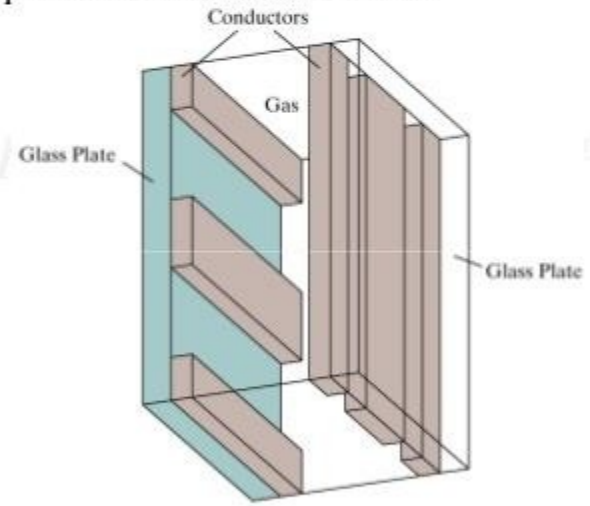
- Plasma-Panels are also called as Gas-Discharge Display. It consists of an array of small lights. Lights are fluorescent in nature.
- The essential components of the plasma-panel display are:

- **Cathode:** It consists of fine wires. It delivers negative voltage to gas cells. The voltage is released along with the negative axis.
- **Anode:** It also consists of line wires. It delivers positive voltage. The voltage is supplied along positive axis.
- **Fluorescent cells:** It consists of small pockets of gas liquids when the voltage is applied to this liquid (neon gas) it emits light.
- **Glass Plates:** These plates act as capacitors. The voltage will be applied, the cell will glow continuously.

PLASMA PANAL

Plasma Panel (Conti…)

- By applying high voltage to a pair of horizontal & vertical conductors, a small section of the gas at the intersection of the conductors break down into glowing plasma of electrons and ions.



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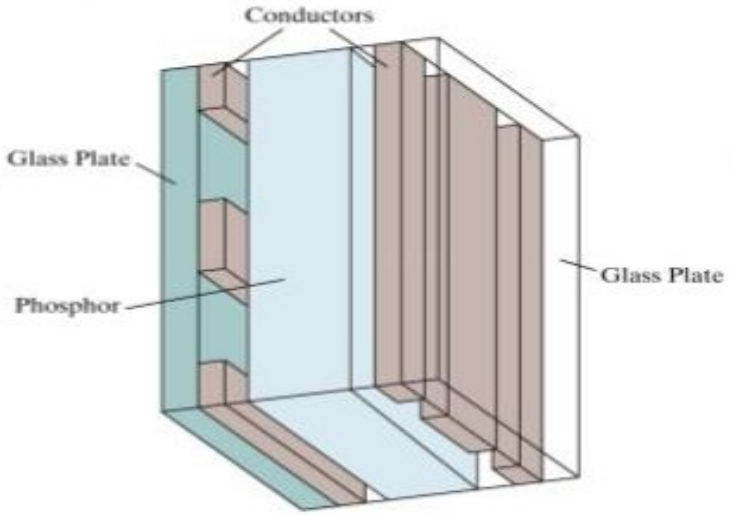
TU, CSED

- *Advantage:*
- High Resolution
- Large screen size is also possible.
- Less Volume
- Less weight
- Flicker Free Display
- *Disadvantage:*
- Poor Resolution
- Wiring requirement anode and the cathode is complex.
- Its addressing is also complex.

THIN FLIM ELECTROLUMINSCENT DISPLAY

Thin Film Electroluminescent

- The region between the glass plates is filled with a phosphor, such as zinc sulfide doped with manganese.



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Light Emitting Diode (LED)

- A matrix of diodes is arranged to form the pixel positions in the display, and picture definition is stored in a refresh buffer.

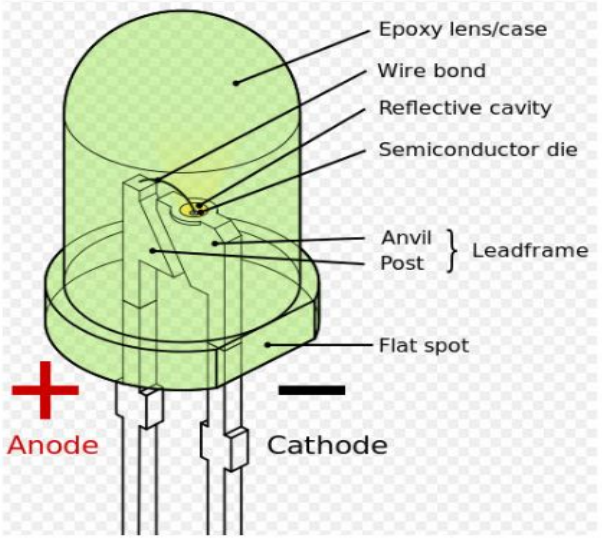
- Information is read from the refreshed buffer and converted to voltage levels that are applied to the diodes to produce the light patterns in the display.

Working principle of LED

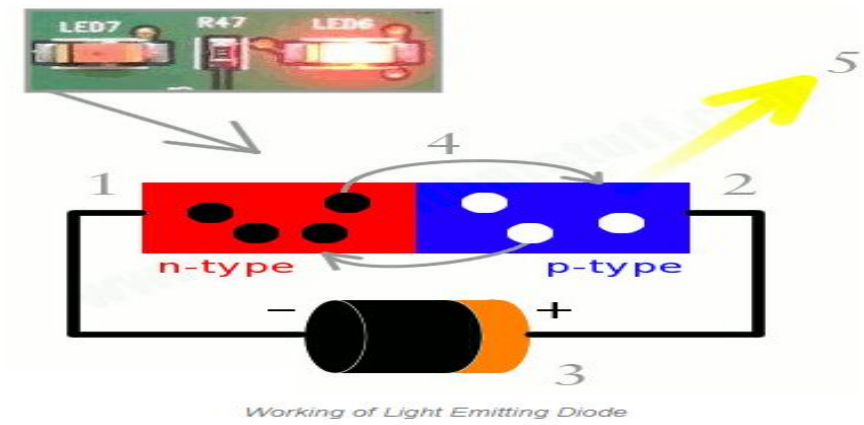
- The Light emitting diode is a two-lead semiconductor light source.
- In 1962, Nick Holonyak has come up with an idea of light emitting diode, and he was working for the general electric company.
- The LED is a special type of diode and they have similar electrical characteristics of a PN junction diode.
- Hence the LED allows the flow of current in the forward direction and blocks the current in the reverse direction.
- The lighting emitting diode is a p-n junction diode. It is a specially doped diode and made up of a special type of semiconductors. When the light emits in the forward biased, then it is called as a light emitting diode.

How does the Light Emitting Diode work?

- The light emitting diode simply, we know as a diode.
- When the diode is forward biased, then the electrons & holes are moving fast across the junction and they are combining constantly, removing one another out. Soon after the electrons are moving from the n-type to the p-type silicon, it combines with the holes, then it disappears.
- Hence it makes the complete atom & more stable and it gives the little burst of energy in the form of a tiny packet or photon of light.



Light Emitting Diode



Working of Light Emitting Diode

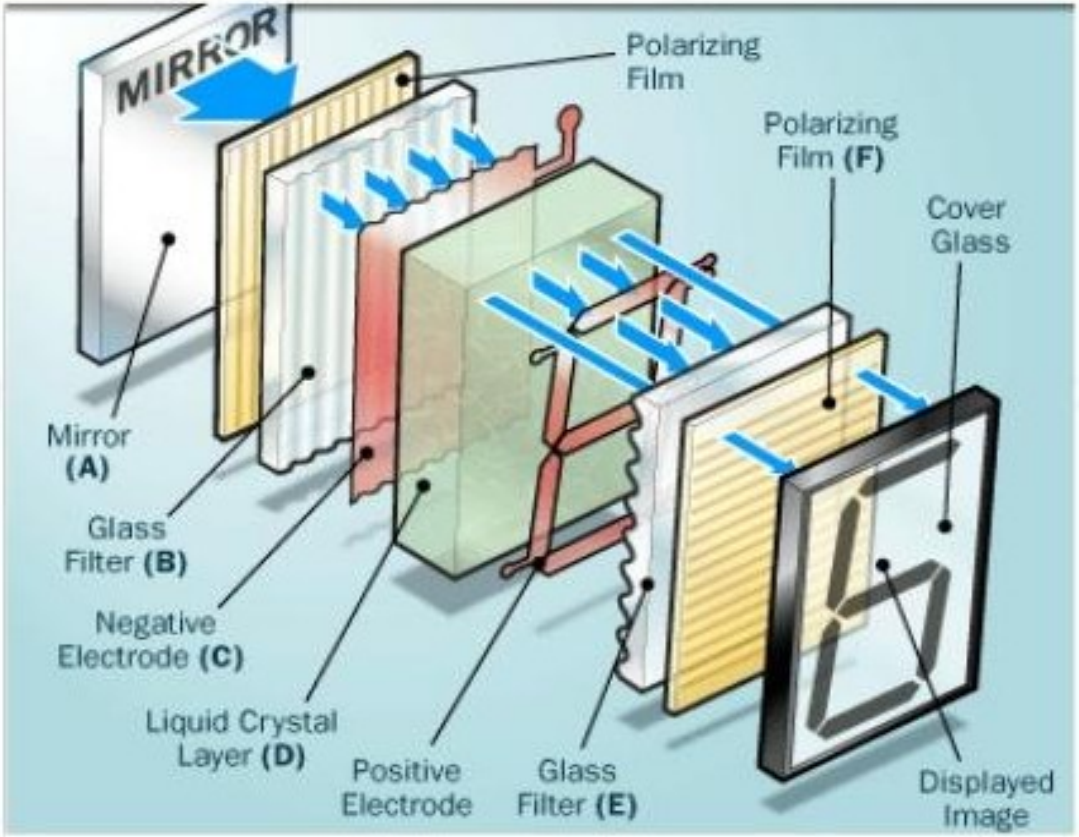
From the diagram, we can observe that the N-type silicon is in red color and it contains the electrons, they are indicated by the black circles.
The P- type silicon is in the blue color and it contains holes, they are indicated by the white circles.
The power supply across the p-n junction makes the diode forward biased and pushing the electrons from n-type to p-type. Pushing the holes in the opposite direction.
Electron and holes at the junction are combined.
The photons are given off as the electrons and holes are recombined.

NON-EMITTERS

Liquid Crystal Displays (LCD)

- Used in small systems, such as calculators, laptop computers.
- Produce a picture by passing polarized light (from the surrounding or from an internal light source) through a liquid-crystal material that can be aligned to either block or transmit the light.
- Two glass plates, each containing a light polarizer at right angles to the other plate, sandwich the liquid crystal materials.
- Rows of horizontal transparent conductor & columns of vertical conductors (put into glass plates)

LCD Display



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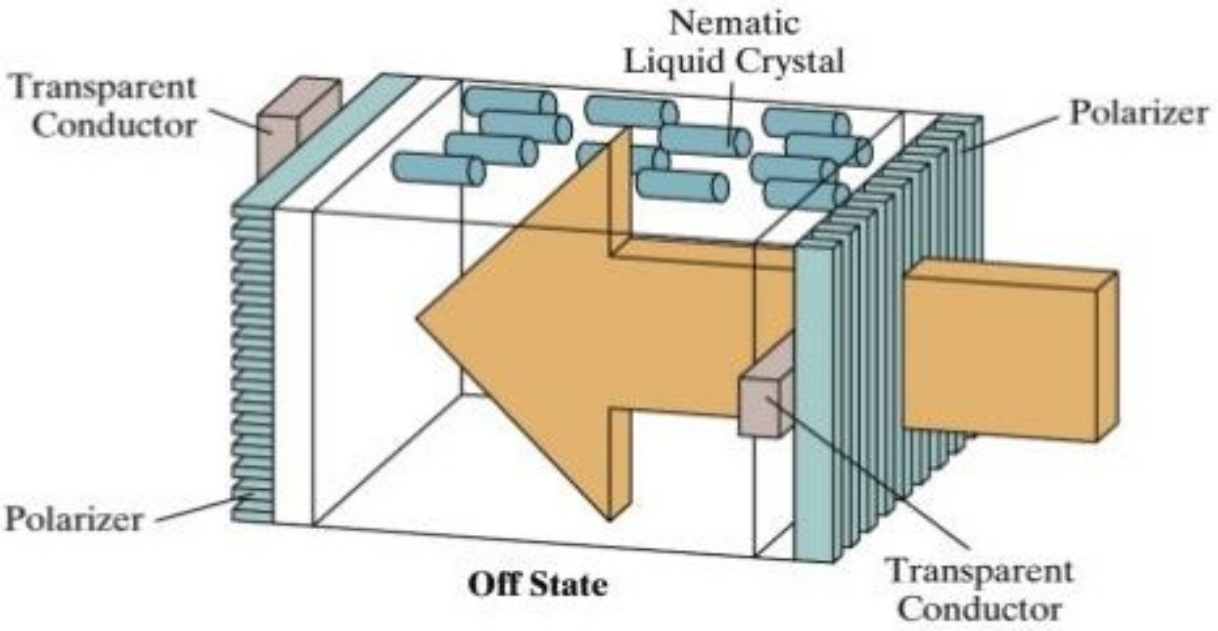
Off State

- To turn off the pixel, we apply a voltage to the two intersecting conductor to align the molecules so that the light is not twisted.



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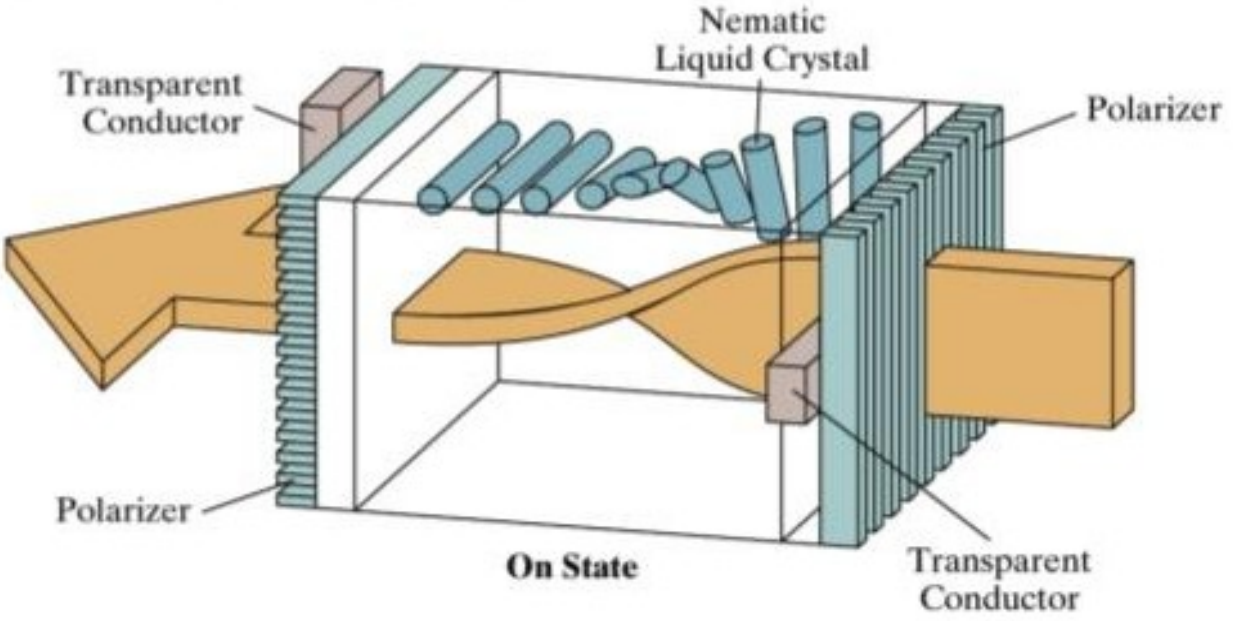
On State

- Polarized light passing through the material is twisted so that it will pass through the opposite polarizer.



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- LCD’S are commonly used in small systems, such as calculators andportable laptop computers

- It produce a picture by passing polarized light from the surroundings or from an internal light source

- through a liquid-crystal material that can be aligned to either block or transmit the light.

- The term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, as they flow like a liquid

- Flat-panel displays commonly use nematic (thread like) liquid-crystal compounds

- Two glass plates, each containing a light polarizer at right angles to the-other plate, sandwich the liquid-crystal material.

- Rows of horizontal transparent conductors are built into one glass plate, and columns of vertical conductors are put into the other plate.

- The intersection of two conductors defines a pixel position

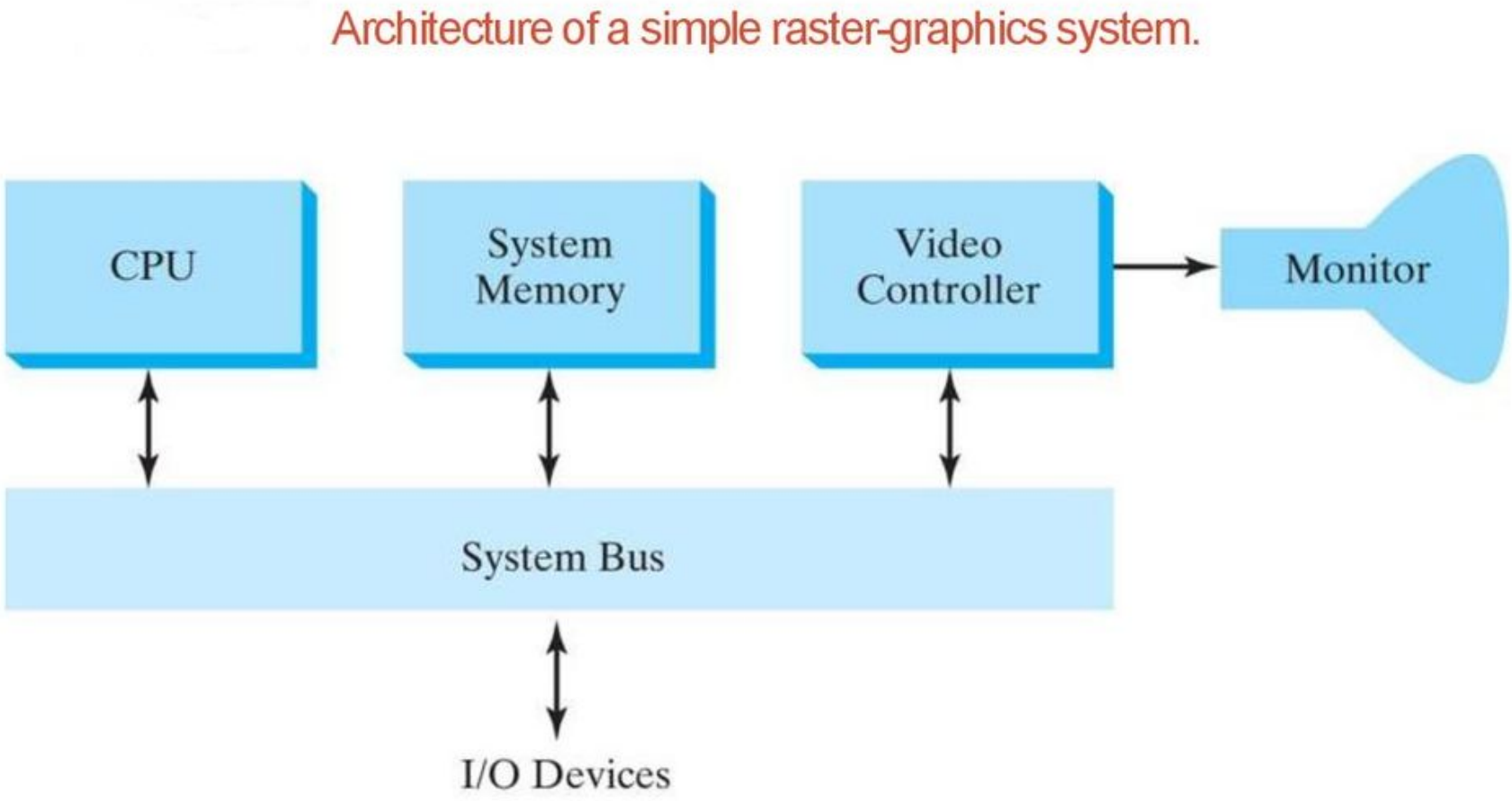
- In ON state, Polarized light passing through the material is twisted so that it will pass through the opposite polarizer.

- The light is then reflected back to the viewer

Raster scan systems

- Interactive raster graphics system typically employs several processing units.
- In addition to CPU, there is a special–purpose processor, called the **video controller** or **display controller**.
- In a simple raster graphics system the video controller accesses the frame buffer to refresh the screen
  - the frame buffer can be anywhere in the system memory

Raster scan systems

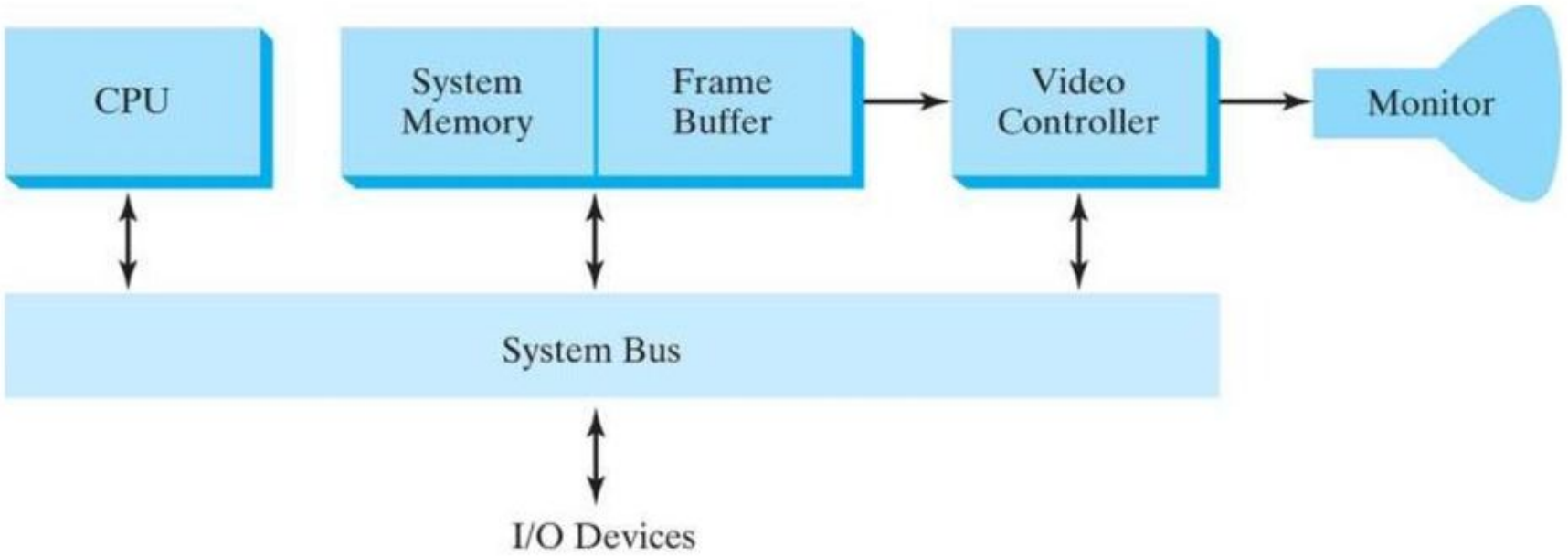


Raster scan systems

Video controller – special type of processor which control the operation of display device.
In commonly used raster systems a fixed area is reserved for the frame buffer, and the video controller is given direct access to the frame buffer memory.
Frame buffer locations & screen positions are referenced in Cartesian coordinates.

Raster scan systems

Architecture of a raster system with a fixed portion of the system memory reserved for the frame buffer.

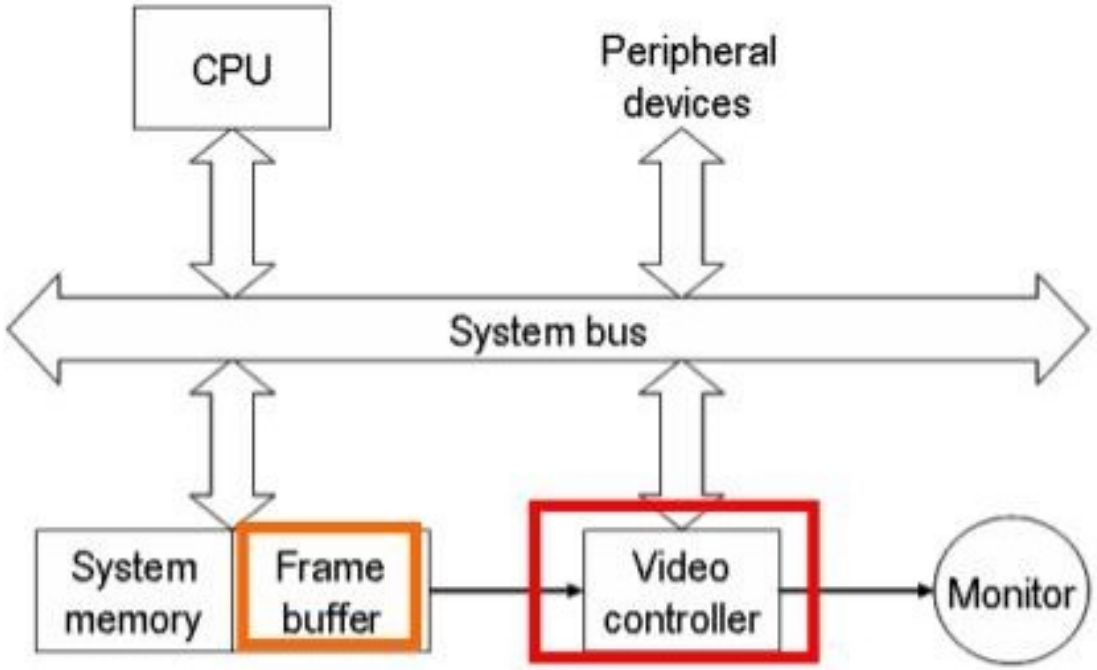


- In raster scan displays a special area of memory is dedicated to **Graphics** only. This memory area is called **Frame Buffer.**
- It holds the **set of intensity values** for all the screen points.
- The video controller retrieves the **stored intensity values from frame buffer** and displays them on the screen one row (**scan line) at a time** , typically 50 times per second.

3

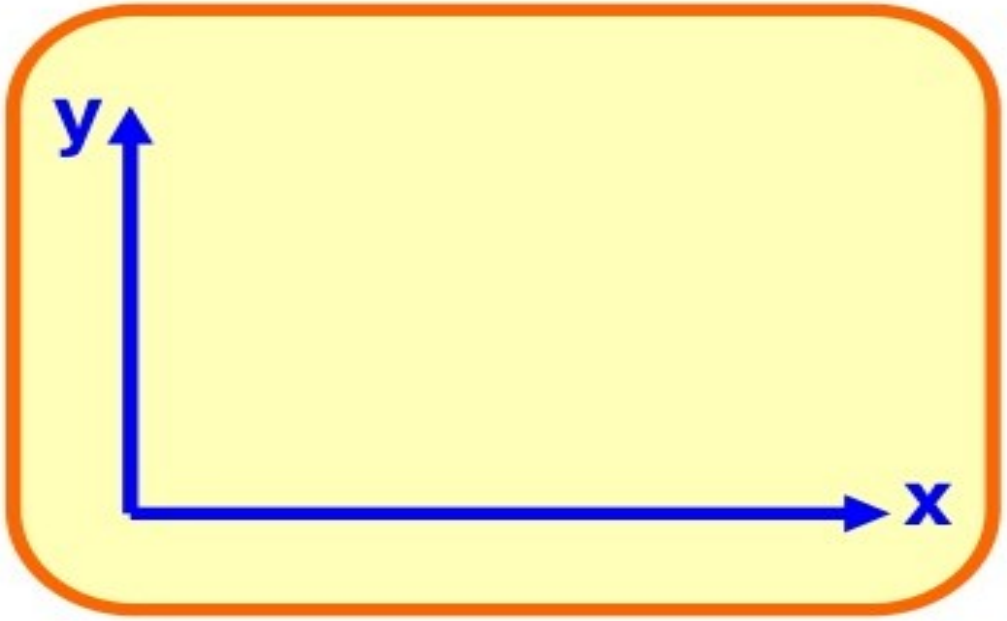
Video Controller

- A fixed area of the system memory is reserved for the frame buffer, and the video controller is given direct access to the frame buffer memory



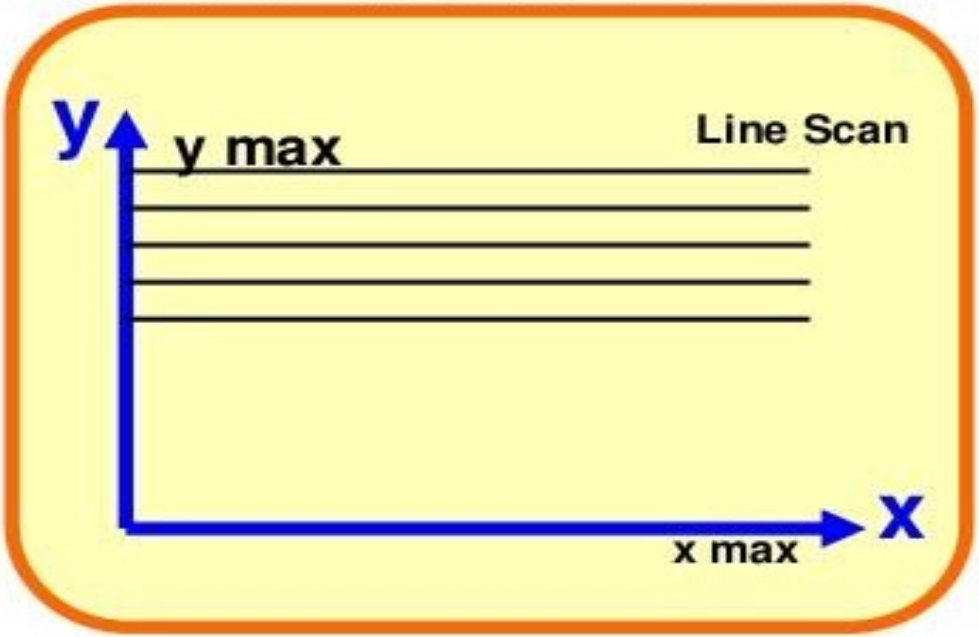
Video Controller

- **Frame buffer** location, and the corresponding screen positions, are referenced in Cartesian coordinates.

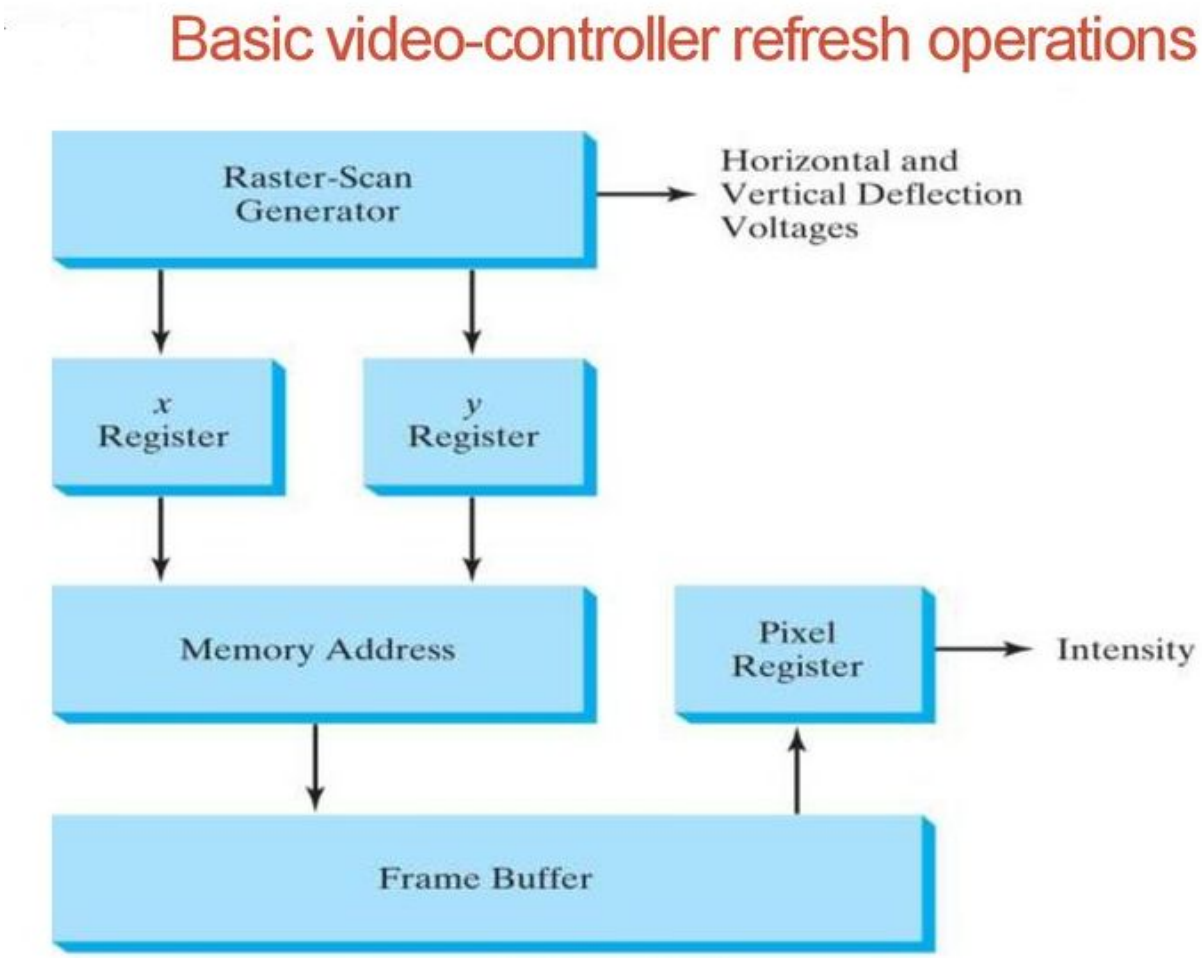


Video Controller

- **Scan lines** are then labeled from y_{max} at the top of the screen to 0 at the bottom. Along each scan line, screen **pixel** positions are labeled from 0 to x_{max}.



Raster scan systems



- Initially, the x register is set to 0 and the y register is set to y,The value stored in the frame buffer for this pixel position is then retrieved and used to set the intensity of the CRT beam.
- Then the x register is incremented by 1, and the process repeated for the next pixel on the top scan line.
- This procedure is repeated for each pixel along the scan line. After the last pixel on the top scan line has been processed, the x register is reset to 0 and the y register is decremented by 1.

- Pixels along this scan line are then processed in turn, and the procedure is repeated for each successive scan line.
- After cycling through all pixels along the bottom scan line (y = O), the video controller resets the registers to the first pixel position on the top scan line and the refresh process starts over.

- Since the screen must be refreshed at the rate of 60 frames per second, the simple procedure illustrated in above figure cannot be accommodated by typical RAM chips. The cycle time is too slow.
- To speed up pixel processing, video controllers can retrieve multiple pixel values from the refresh buffer on each pass.
- The multiple pixel intensities are then Stored in a separate register and used to control the CRT beam intensity for a group of adjacent pixels. When that group of pixels has been processed, the next block of pixel values is retrieved from the frame buffer.
- A number of other operations can be performed by the video controller, besides the basic refreshing operations.

- In color displays, 24 bits per pixel are commonly used, where 8 bits represent 256 levels for each color.
- It is necessary to read 24-bits for each pixel from frame buffer. This is very time consuming.
- To avoid this video controller uses Look Up Table (LUT) to store many entries of pixel values in RGB format.
- With this facility , now it is necessary to only read index to the Look Up Table from the frame buffer for each pixel.
- The specified entry in the Look Up Table is then used to control the intensity or color of the CRT.

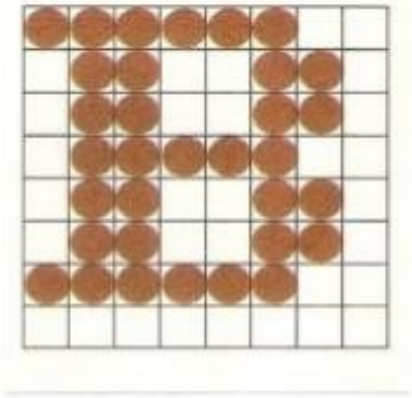
10

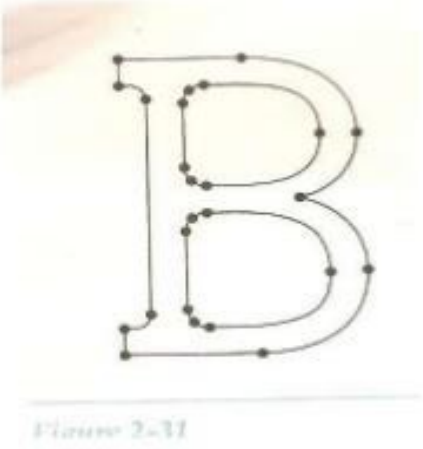
Raster-Scan Display Processor:

An important function of display process is to digitize a picture definition given in an application program into a set of pixel-intensity values for storage in refresh buffer.

- This process is referred to as **scan conversion**.
- The purpose of display processors is to relieve the CPU from graphics jobs.
- Display processors can perform various other tasks like: creating different line styles, displaying color areas, etc.
- Typically display processors are utilized to interface input devices, such as mouse, joysticks.

- Character defined with rectangular grids of pixel positions (rectangular grid pattern – frame buffer)





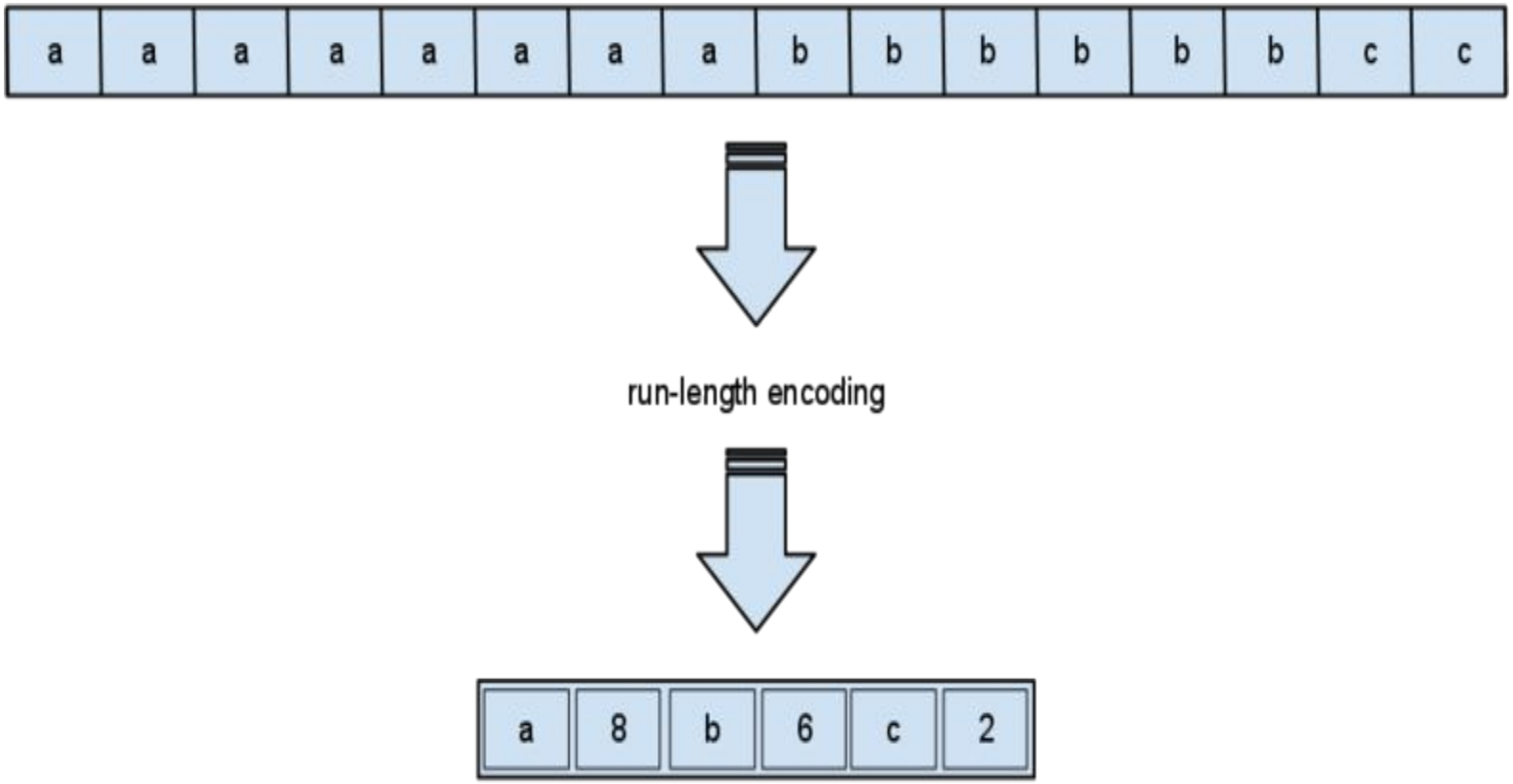
- Character defined as a curve outline (curve outlines, character shapes – frame buffer)

Display processor operation

- Generating various line styles (dashed, dotted or solid)
- display color area
- performing certain transformations
- manipulations on displayed objects
- To reduce memory
  - Frame buffer is organized as linked list
  - Encoding intensity information

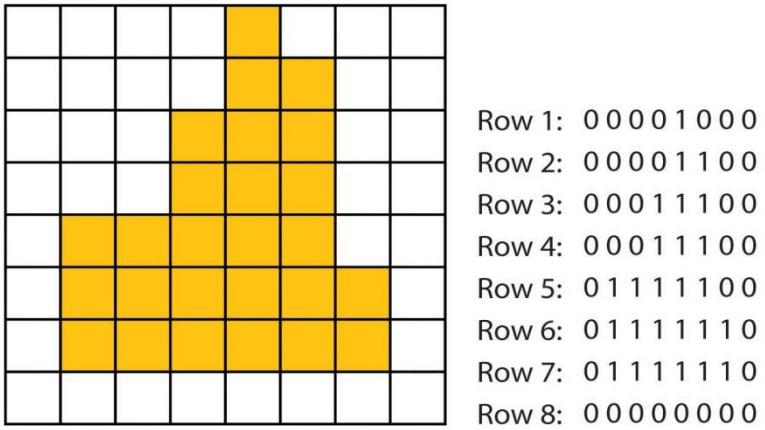
1. Run-length encoding

- Store each scan line as a set of integer pairs
- First number of each pair indicates intensity value
- Second number specifies the number of adjacent pixels on the scan line with that intensity value
- Advantage – save storage space if a picture is to be constructed with long runs of single color


a a a a a a a a b b b b b b c c
run-length encoding
a 8 b 6 c 2

2.Cell encoding

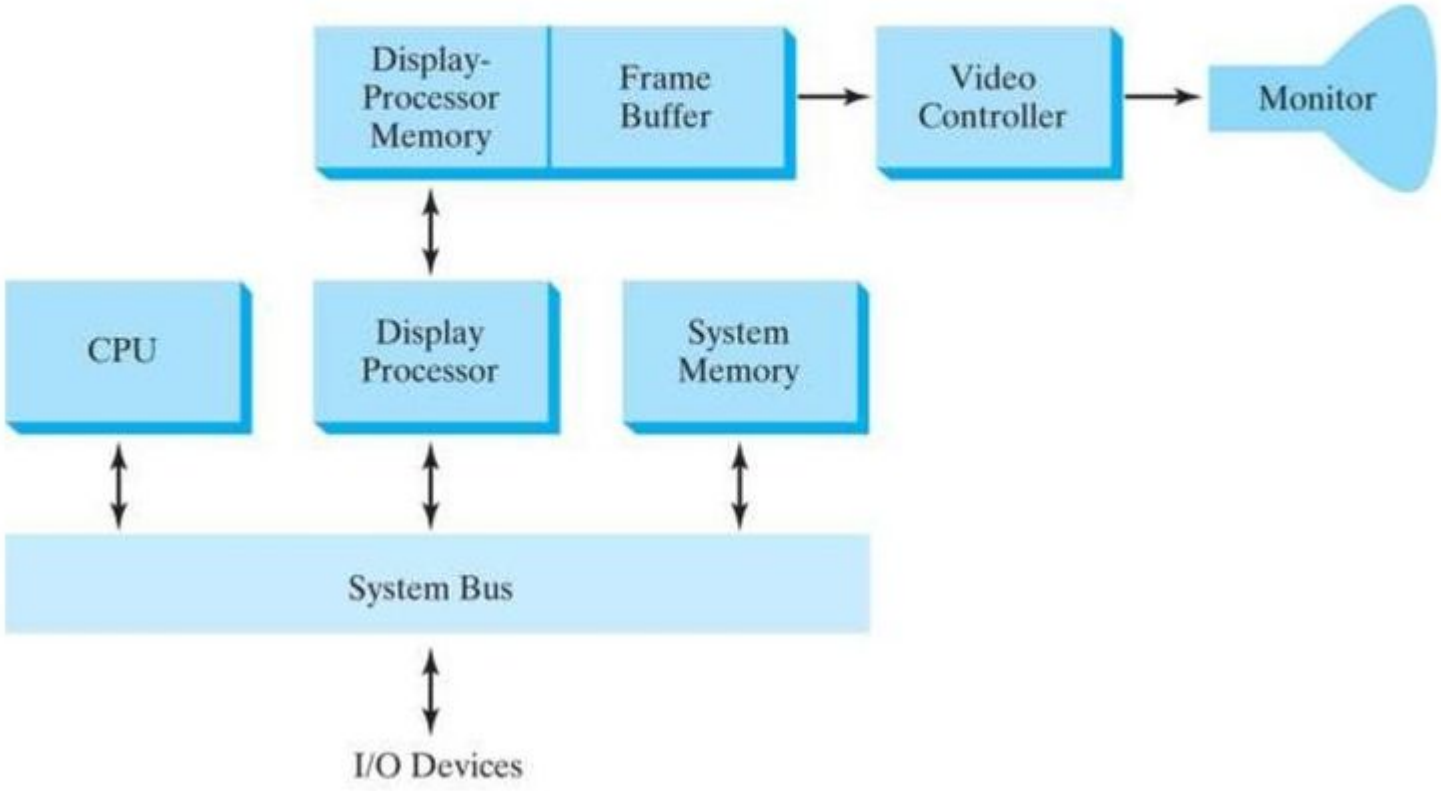
- Encode the raster as set of rectangular areas
- Disadvantage
  - Intensity changes are difficult to make
  - Storage requirements actually increase as length of runs decrease



This minimally intensive method encodes a raster by creating records for each cell value by row and column

Raster scan systems

Architecture of a raster-graphics system with a display processor.



Q1.suppose you have a raster system designed using an 8 inches × 10 inches screen with a resolution of 100 pixels per inch in each direction. what frame buffer size is required if 6 bits are stored per pixel in the buffer?

Solution:

Here, resolution = **8 inch X 10 inch**

First, we convert it in pixel then

Now resolution = **8 X 100 by 10 X 100 pixel = 800 X 1000 pixel**

1 pixel can store 6 bits

So, frame buffer size required = **800 X 1000 X 6 bits**

$$= \frac{800 \times 1000 \times 6}{8}$$

Bytes $= 6 \times 10^5$ bytes.

Q2 Consider two raster systems with the resolutions of 640 x 480 and 1280 x 1024.

a) **How many pixels could be accessed per second in each of these systems by a display controller that refreshes the screen at a rate of 60 frames per second?**

Ans. Since 60 frames are refreshed per second and each frame consists of 640 x 480 pixels, the access rate of such a system is (640 x 480) * 60 = 1.8432 x 107 pixels/second.
Likewise, for the 1280 x 1024 system, the access rate is (1280 x 1024) * 60 = 7.86432 x 107 pixels/second.

Q3 Consider three different raster systems with resolutions of 640 x 480, 1280 x 1024, and 2560 x 2048.

a. What size is frame buffer (in bytes) for each of these systems to store 12 bits per pixel?

pixel?

Because eight bits constitute a byte, frame-buffer sizes of the systems are as follows:
640 x 480 x 12 bits / 8 = 450KB;
1280 x 1024 x 12 bits / 8 = 1920KB;
2560 x 2048 x 12 bits / 8 = 7680KB;

b)How much storage (in bytes) is required for each system if 24 bits per pixel are to be stored?

Similarly, each of the above results is just doubled for 24 (12×2) bits of storage per pixel.

Q4.Consider two raster systems with the resolutions of 640 x 480 and 1280 x 1024. a. How many pixels could be accessed per second in each of these systems by a display controller that refreshes the screen at a rate of 60 frames per second?

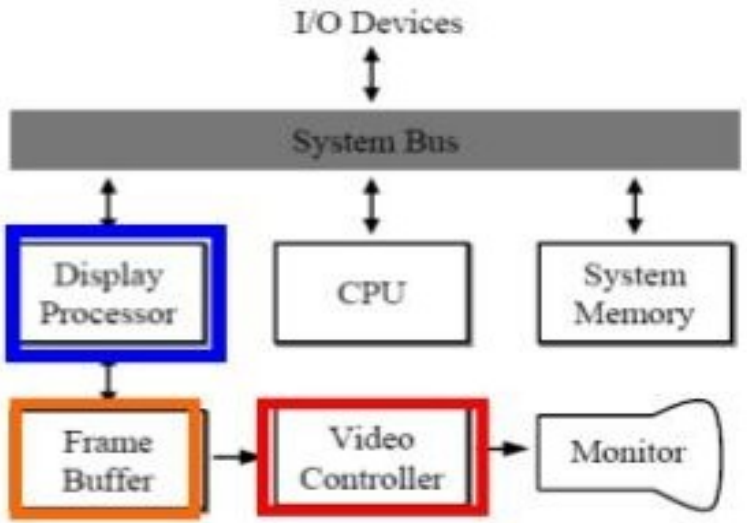
Since 60 frames are refreshed per second.
Each frame consists of 640 x 480 pixels,
- The access rate of such a system = (640 x 480) * 60 = 1.8432 x 107 pixels/second.
For the 1280 x 1024 system,
- The access rate is (1280 x 1024) * 60 = 7.86432 x 107 pixels/second.

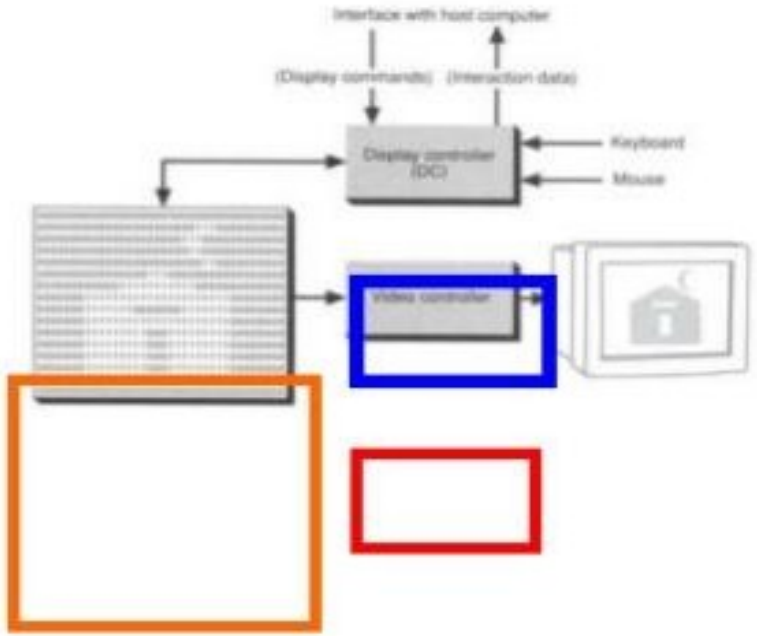
b. **What is the access time per pixel in each system?**

The access time per pixel = 1/ access rate.
The access time is around 54 nanoseconds/pixel for the 640 x 480 system,
The access time is around 12.7 nanoseconds/pixel for the 1280×1024 system.

Raster Scan Display Controller/Processor

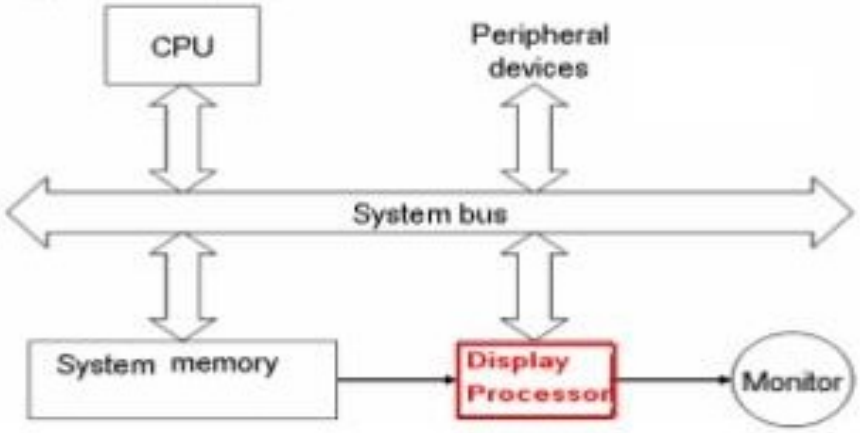
- A raster system containing a separate **display processor** (graphics controller, display coprocessor)
- The purpose of the **DP** is to free the CPU from the graphics chores.



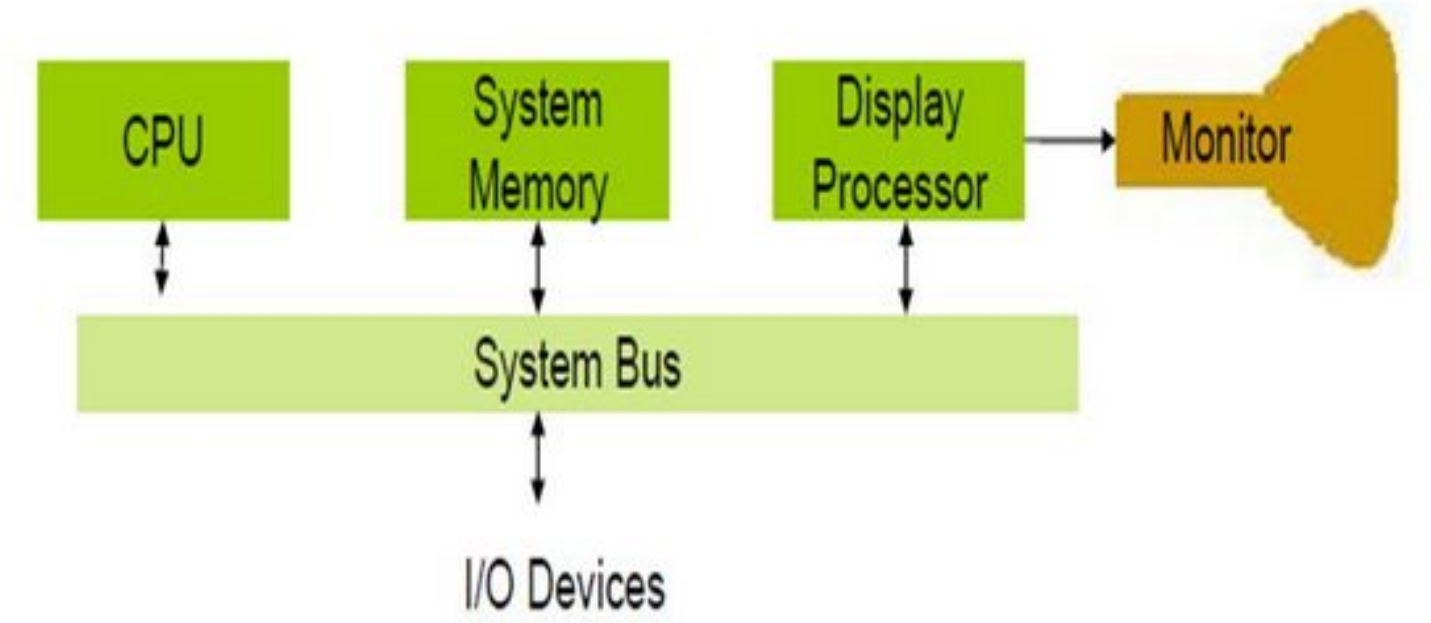


Random Scan System

- Graphic commands are translated by the graphics package into a display file stored in the system memory.
- This file is then accessed by the **display processor unit** (**DPU**)(graphic controller) to refresh the screen



Random scan systems



Random scan systems

- Application program is input & stored in system memory along with a graphics package
- Graphics commands in application program are translated to display file by graphics package & stored in system memory
- Display processor access display file to refresh the screen
- At each refresh cycle, display processor cycles through each command in display file

Random scan systems

- Display processor in random scan system is also called as display processing unit or a graphics controller
- Graphics patterns are drawn by directing e- beam along the component lines of the picture
- Lines are defined by values for their coordinate endpoints & input coordinate values are converted to x& y deflection voltages
- A scene is then drawn one line at a time by positioning the beam to fill in the line between specified endpoints

Differentiate between raster scan and random scan display systems. (4)

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.

Q. Differentiate between Raster Scan and Random Scan system. [10 marks][cusat ,Nov 2008]

Raster-scan system:-

1) raster displays have less resolution.
2) The lines produced are zig-zag as the plotted values are discrete.
3) High degree realism is achieved in picture with the aid of advanced shading and hidden surface technique.
4) Decreasing memory costs have made raster systems popular.
5) In this case, the electron beam is swept across the screen, one row at a time from top to bottom.
6) Picture definition is stored in a memory area called the refresh buffer/frame buffer.
7) Refreshing on raster scan displays is carried out at the rate of 60 to 80 frames/second.

Random scan system:-

1) random display has high resolutions since the picture definition is stored as a set of line drawing commands and not as a set of intensity values.
2) Smooth lines are produced as the electron beam directly follows the line path.
3) Realism is difficult to achieve.
4) random-scan system's are generally costlier.
5) Here CRT has the electron beam directly only to the parts of the screen where a picture is to be drawn.
6) Picture definition is stored as a set of line drawing commands in an area of memory referred to as refresh display file.
7)Random scan systems are designed to draw all the component lines of a picture 30 to 60 times each second

Key Term	Raster scan system	Random scan system
Resolution	Lower resolution	Higher resolution
Designed for	Realistic shaded scenes	Line drawing application
Picture definition store	Intensity values for all screen points	Line drawing instructions
Produce line	Jagged line form	Smooth line form

Questions

What do you understand by the aspect ratio and resolution of a display screen in a raster scan display? (4)

Write the flood fill algorithm for filling a polygon. (4)

Explain the working of a random scan display system with suitable diagram. (6)

Explain the working of a beam penetration CRT. (3)

A mouse is picked up and placed in another position. Whether the position of the mouse pointer change. Justify your answer. (2)

Explain the working of a light pen. (3)

Write the scan line algorithm for filling a polygon. (4)

Write a note on any two interactive graphics input devices.

Describe in detail about emissive and non-emissive flat panel displays.

Explain the working principle of a Refresh CRT monitor with suitable diagrams. (4)

Write the boundary fill algorithm for filling a polygon using eight connected approach. (4)

Explain the architecture of raster graphics system with suitable diagrams. (6)

Explain the working of Direct View Storage Tube (DVST). (3)