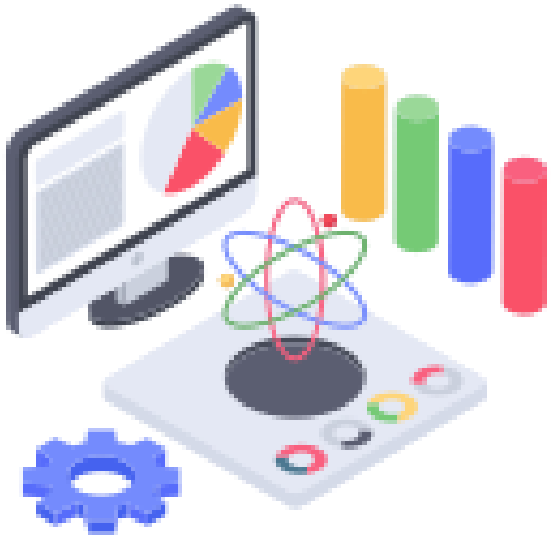


Computer Graphics

(UNIT 1)

Graphics

- Computer graphics can be defined as any sketch or drawing or a special network that pictorially represent something
- Graphics are 2 or 3 dimensional
- There are two types of graphics Raster and Vector graphics

Application of Graphics

- Education and training
    - We often use computer graphic models to help us learn about different things, like how things work
- Flight simulator
    - It helps in giving training to the pilots of airplanes
- Gaming
    - mobile or computer games are made using computer graphics
- Architecture
    - We can create Building designs and models with the help of computer graphics
- Use in biology
    - It is easy to understand biology concepts with the help of computer graphics
    - e.g. human body structure and its working
- Presentation graphics
    - bar charts, line graphs, pie charts and other displays showing relationships between some things
    - e.g. Financial Reports, Statistical Reports, Mathematical Reports

- Entertainment
    - Computer Graphics are now commonly used in making motion pictures, music videos and television shows.

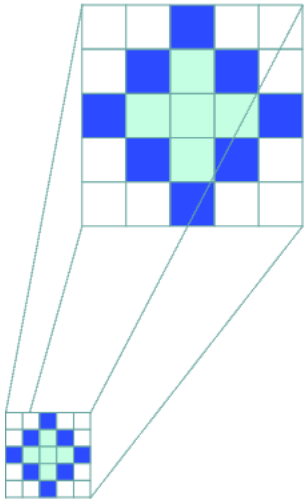
- Education software
    - Computer Graphics is used in the development of educational software for making computer-aided instruction.

Raster Graphics

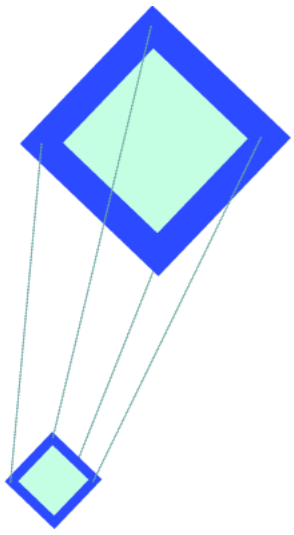
- Raster images use bit maps to store information.
- File extensions: .BMP, .TIF, .GIF, .JPG
- Also called as Bitmap image

Vector Graphics

- Making use of sequential commands or mathematical statements or programs which place lines or shapes in a 2-D or 3-D environment is referred to as Vector Graphics
- File extensions: SVG, EPS, PDF, AI, DXF



Raster Graphics



Vector Graphics

Interactive and Passive Graphics

Non-Interactive or Passive Computer Graphics:

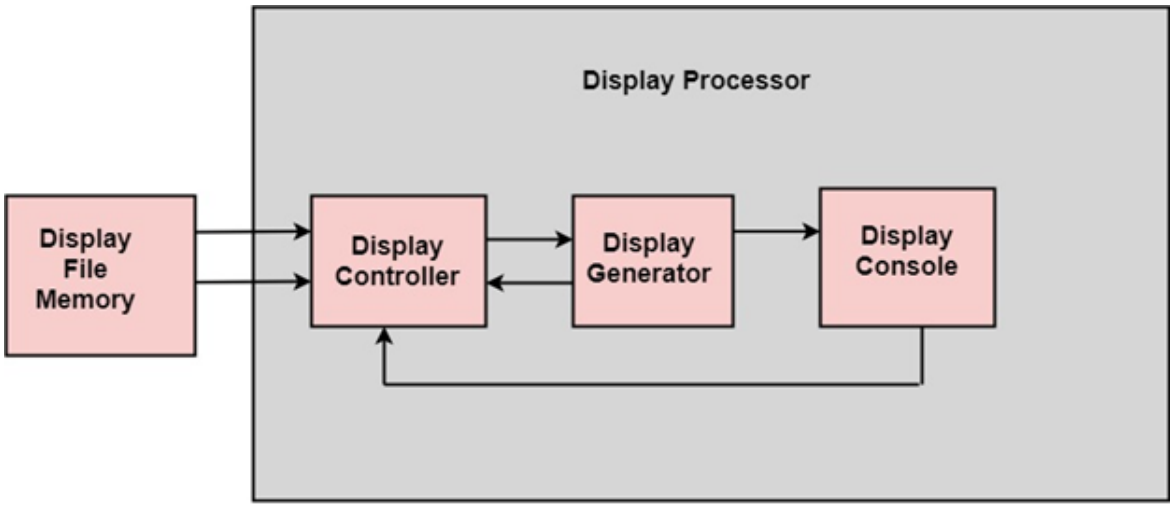
- In non-interactive computer graphics, the picture is produced on the monitor, and the user does not have any control over the image,
- i.e., the user cannot make any change in the rendered image
- e.g., Images shown on TV
- Non-interactive Graphics involves only one-way communication between the computer and the user

Interactive Computer Graphics:

- In interactive Computer Graphics user have some controls over the picture
- i.e., the user can make any change in the produced image.
- example of it is the ping-pong game.
- Interactive Computer Graphics require two-way communication between the computer and the user.

Display Processor

- It is interpreter or piece of hardware that converts display processor code into pictures
- Parts of Display Processor
  - Display File Memory
  - Display Processor
  - Display Generator
  - Display Console

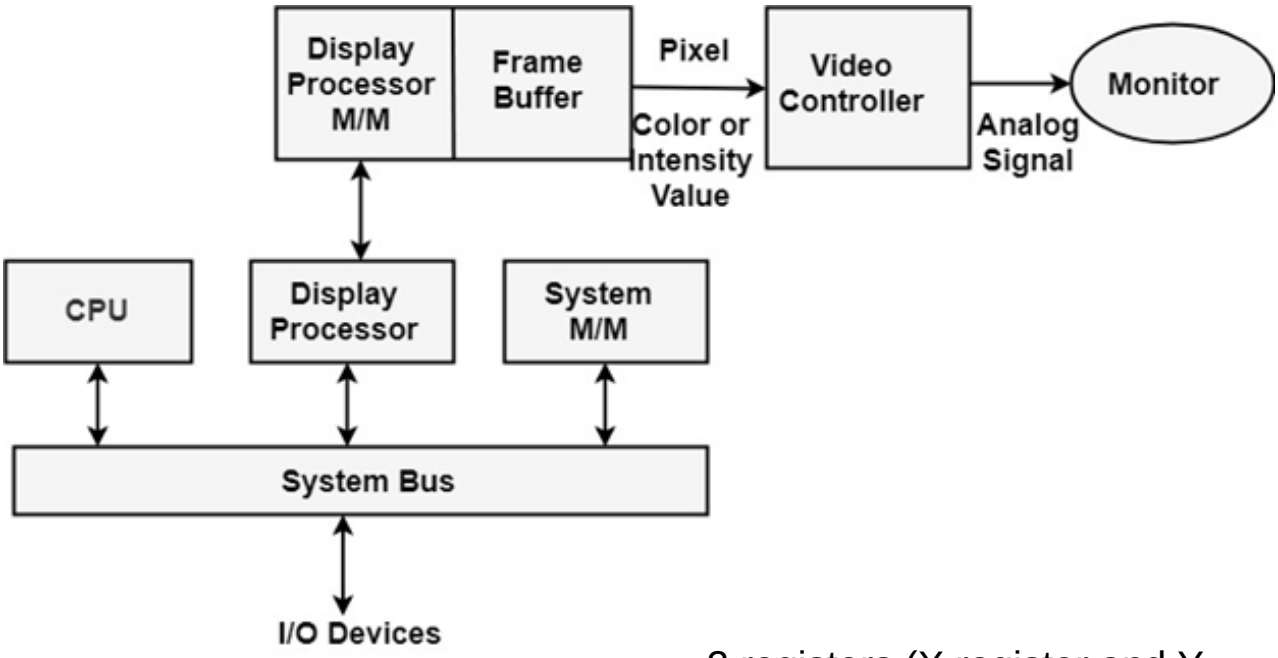


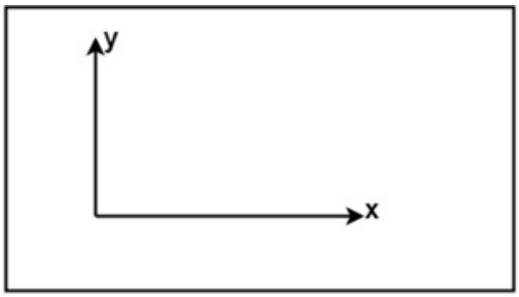
Block diagram of Display System

- **Display File Memory:** It is used for generation of the picture. It is used for identification of graphic entities.
- **Display Controller:** It handles interrupt, It maintains timings, It is used for interpretation of instruction.
- **Display Generator:** It is used for the generation of character. It is used for the generation of curves.
- **Display Console:** It contains CRT, Light Pen, and Keyboard and deflection system.

Working Display Processor

- The video controller in the output circuitry generates the horizontal and vertical drive signals so that the monitor can sweep. Its beam across the screen during raster scans.

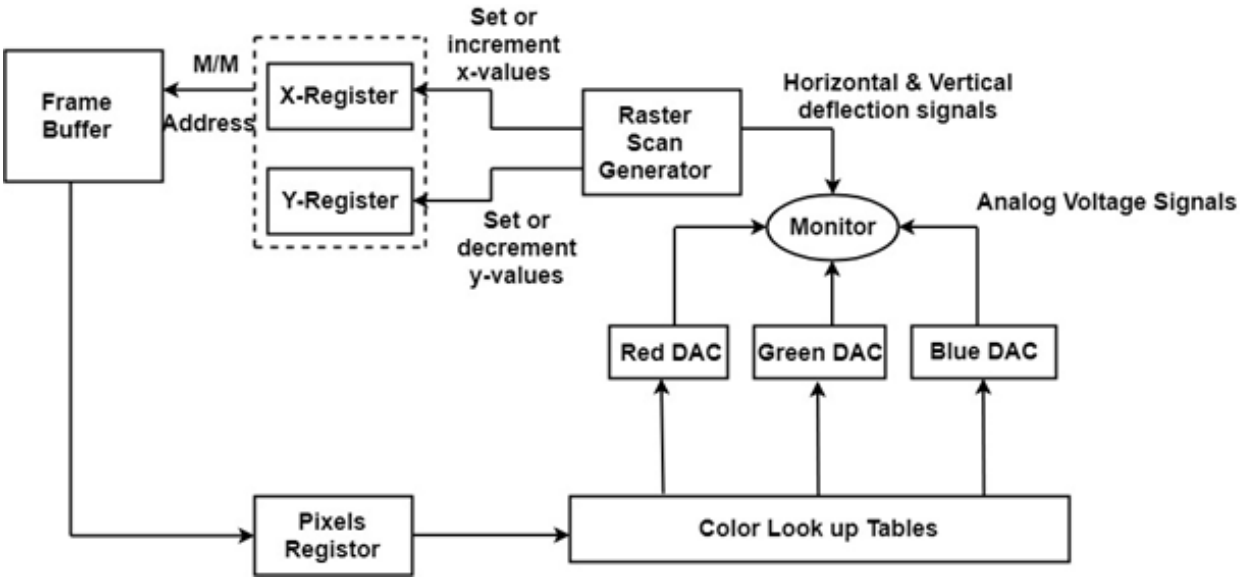




- 2 registers (X register and Y register) are used to store the coordinate of the screen pixels.
- The origin is at the lowest left corner of the screen as in a standard Cartesian coordinate system.

- The values of x and y at initial is 0 and ymax respectively
- frame buffer is used to store the color value of each pixel according to its position.
- The controller receives this color value from the frame buffer, breaks it up into three parts (R-G-B)

- And sends each element to a separate Digital-to-Analog Converter (DAC).
- This process is repeated for each pixel along the top scan line, each time incrementing the X register by Y.
- As pixels on the first scan line are generated, the X register is incremented through Xmax.
- Then x register is reset to 0, and y register is decremented by 1 to access the next scan line.

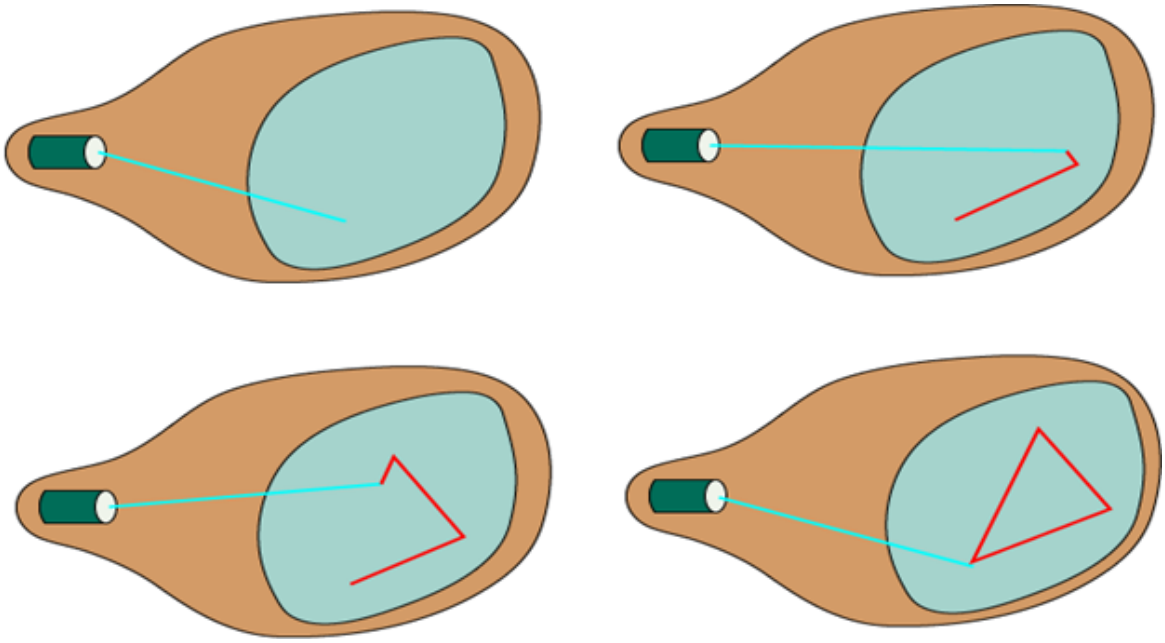


- For a display system employing a color look-up table frame buffer value is not directly used to control the CRT beam intensity.
- It is used as an index to find the three pixel-color value from the look-up table. This lookup operation is done for each pixel on every display cycle.

Types of Scans

1. Random Scan Display

- Random Scan System uses an electron beam which operates like a pencil to create a line image on the CRT screen
- The picture is constructed out of a sequence of straight-line segments
- Each line segment is drawn on the screen by directing the beam to move from one point on the screen to the next, where its x & y coordinates define each point.
- Random-scan monitors are also known as vector displays
- Advantages -
    - Produce smooth line drawings.
    - High Resolution
- Disadvantages -
    - Random-Scan monitors cannot display realistic shades
    - Cannot Draw 3d diagrams



2. Raster Scan display

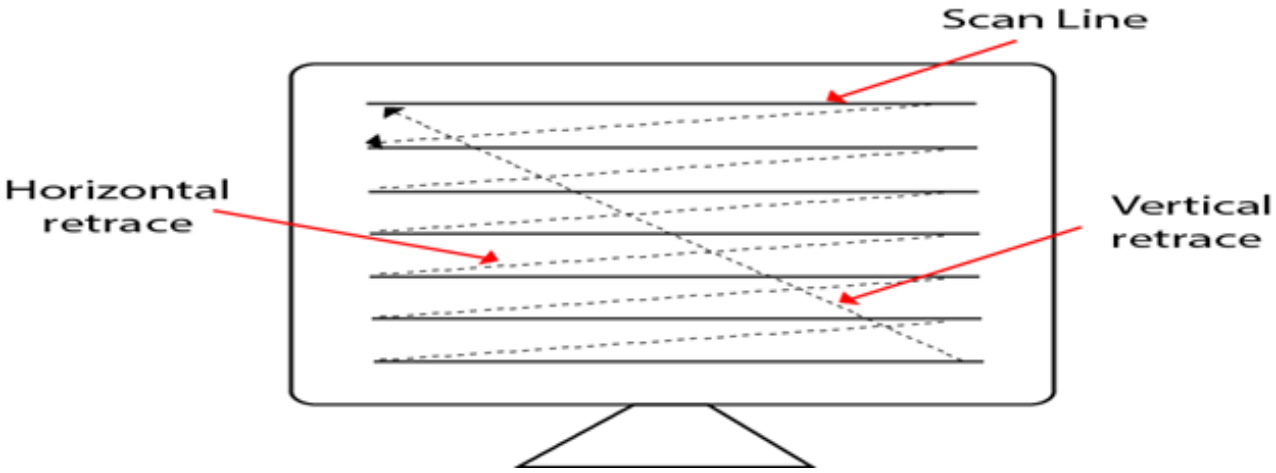
- A Raster Scan Display is based on intensity control of pixels in the form of a rectangular box called Raster on the screen
- Information of on and off pixels is stored in refresh buffer or Frame buffer.
- e.g., Televisions in our house
- Raster Scan provides a refresh rate of 60 to 80 frames per second.
- Advantages:
    - Realistic image
    - Million Different colors to be generated
    - Shadow Scenes are possible

- Disadvantages:
    - Low Resolution
    - Expensive

Types of Scanning or travelling of beam in Raster Scan

- **Interlaced Scanning** :-
    - In Interlaced scanning, each horizontal line of the screen is traced from top to bottom.
    - Due to which fading of display of object may occur
    - interlaced display provides refresh rate of 60 frames per second

- **Non-Interlaced Scanning** :-
    - In this first of all odd numbered lines are traced or visited by an electron beam
    - in the next cycle all the even numbered lines are traced
    - non interlaced display provides refresh rate of 30 frames per second



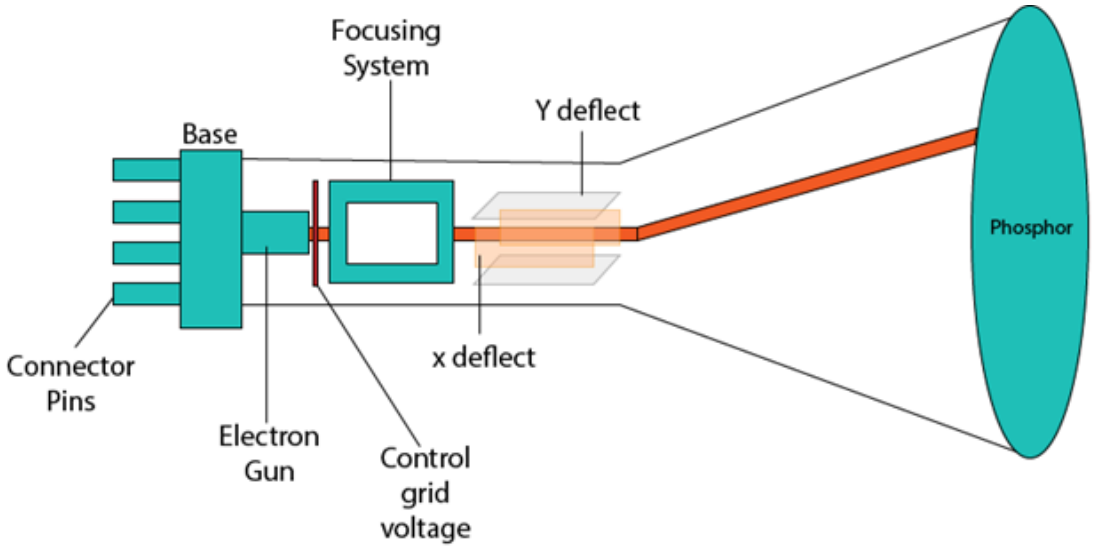
This figure shows the horizontal and vertical tracing used in Raster Scan

.....

Random Scan	Raster Scan
High Resolution	Low Resolution
More expensive	Less expensive
Easy to modify	Hard to Modify
Refresh rate depends on Resolution	Refresh rate does not depend on Resolution

CRT (Cathode Ray Tube)

- CRT stands for Cathode Ray Tube.
- CRT is a technology used in traditional computer monitors and televisions.
- The image on CRT display is created by firing electrons from the back of the tube of phosphorus located towards the front of the screen.
- Once the electron heats the phosphorus, they light up, and they are projected on a screen. The color you view on the screen is produced by a blend of red, blue and green light.



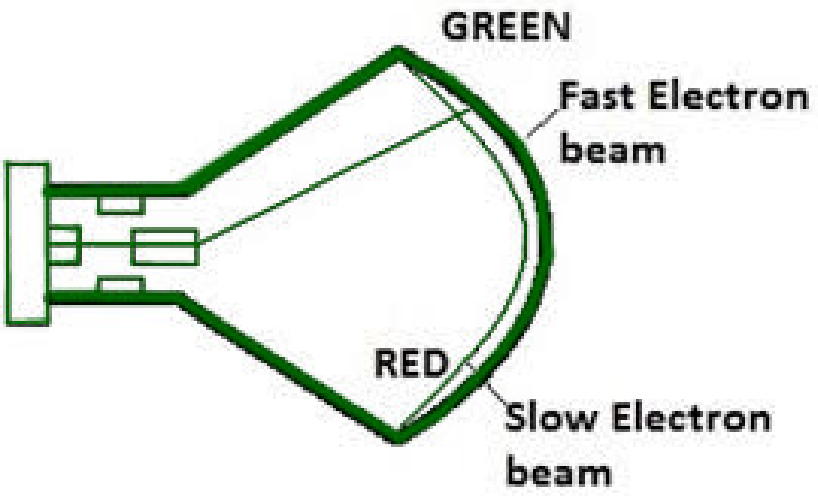
- **Electron Gun**: This part makes a bunch of electrons using a hot wire and sends them in a focused beam towards the screen.
- **Control Electrode:** This helps to switch the electron beam on and off when needed.
- **Focusing System:** This part ensures that the electrons are concentrated into a tight beam for a clear picture.
- **Deflection Yoke:** It guides the electron beam to different parts of the screen, making the picture by using electric or magnetic fields.
- **Phosphorus-coated Screen**: The screen has a special coating that lights up when the electron beam hits it, creating the visible image you see on the screen.

Color CRT Monitors

- The CRT Monitor display by using a combination of phosphors. The phosphors are different colors. There are two popular approaches for producing color displays with a CRT are:
    - Beam Penetration Method
    - Shadow-Mask Method

1. Beam Penetration Method

- used with random scan method
- CRT screen is coated with two layers of phosphor red and green and the display color depends on how far the electron beam is penetrated
- this method only produces four color (red, green, orange and yellow)
- **Advantages** : inexpensive
- **Disadvantages** : only four colors are possible, less quality



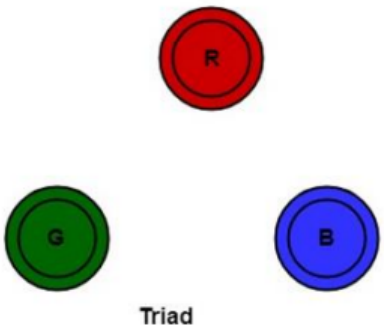
2. Shadow Mask Method

- Uses raster scan method
- Used in color TV and monitors
- A shadow mask CRT has 3 phosphors color dots at each pixel
    - Phosphors which emits red light
    - Phosphors which emits green light
    - Phosphors which emits blue light
- There are 3 electron guns for each color dot

There are 2 types of arrangements of the phosphor color dots

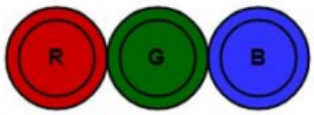
- Triad arrangement
- inline arrangement

- In a CRT with a triad arrangement, the screen is coated with tiny dots of red, green, and blue phosphors.
- These dots are grouped together in triangle called triads.
- When electrons from the cathode ray strike these phosphor dots, they emit light.
- By varying the intensity of the electron beam hitting each phosphor dot, different colors can be produced on the screen.



Triad

- In inline arrangement the phosphor dots are arranged in lines or stripes on the screen
- 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

Direct View Storage Tubes (DVST)

- DVST stands for Direct View Storage Tubes
- It works just like CRT
- It uses electron gun to draw picture and has phosphor coated screen to display images
- the phosphor used in DVST is of high persistence
- DVST does not have a refresh buffer or a frame buffer
- No refreshing is required in DVST so the picture drawn in DVST stays for few minutes before fading

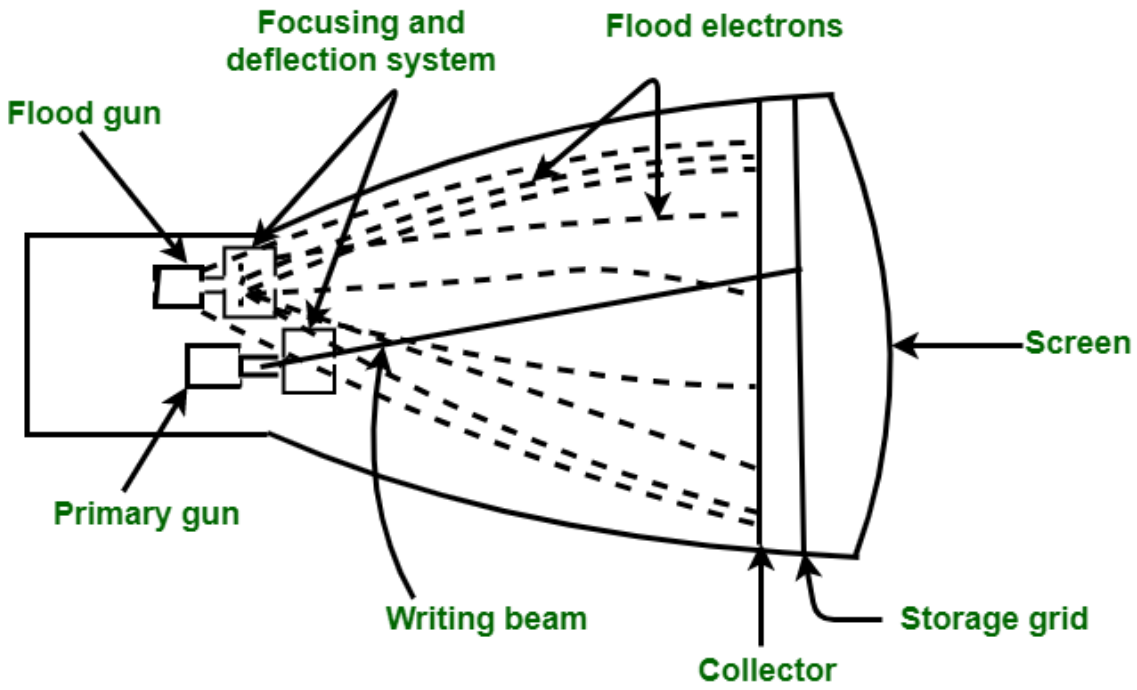
- **Electron guns**
    - Two electron guns are used in DVST
    - Primary Gun and Flood Gun.
    - Primary gun is used to store picture pattern.
    - Flood gun is used to maintain picture display on phosphor coated screen.

- **Phosphor Coated Screen**
    - In DVST the inner surface of CRT is coated with phosphor crystals is of high persistence that emit light when beam of electrons strike them

- **Storage Mesh**
    - It is thin and high quality wire that is coated with dielectric and is located just behind phosphor coated screen.
    - Storage Mesh stores picture to be displayed in form of positive charge distribution.

- **Collector**
    - This grid is located just behind storage mesh and purpose of this negatively charged grid is to smooth out flow of flood electrons.

- **Focusing And Deflection system**
    - Used to move the electrons which are emitted by the primary gun and Flood Gun to the perfect position



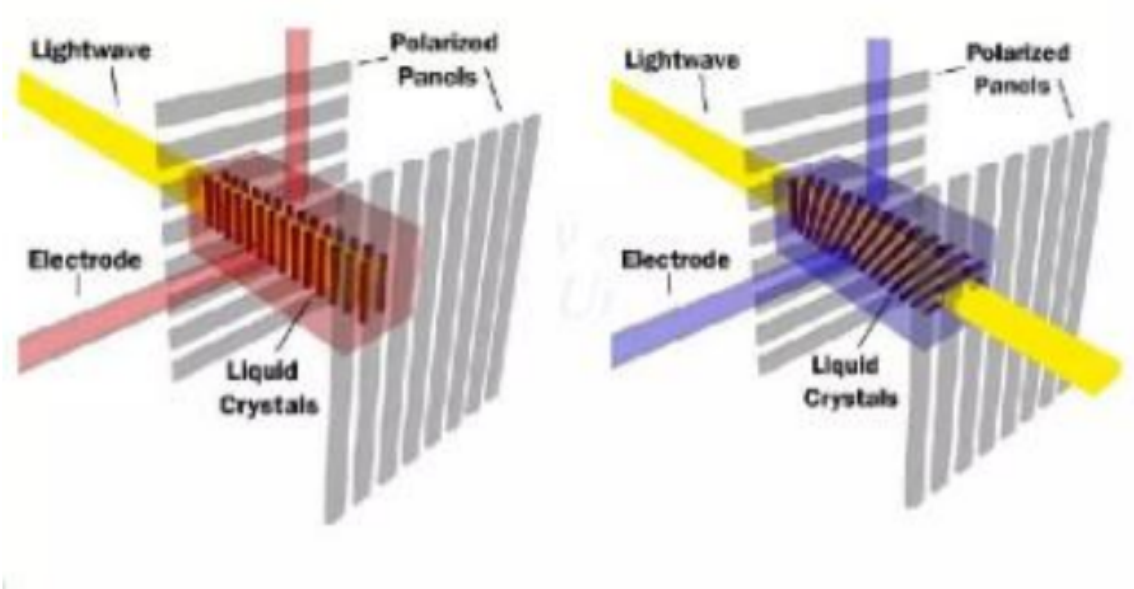
- **Advantages of DVST**
    - Refreshing is not required
    - Display complex pictures at high resolution without any flicker
    - No use of frame buffer or refresh buffer.

- **Disadvantages of DVST**
    - Dynamic graphic cannot be displayed such as animation.
    - These systems do not display colors.
    - To erase selected part of an image, entire screen needs to be erased and modified pictures needs to be redrawn.

LCD (Liquid Crystal Display)

- liquid crystal display (LCD) is a flat panel display that uses the the light emitting properties of the liquid crystal
- The liquid crystal uses backlight or reflector to produce images
- LCDs can display arbitrary images or fixed images
- Its called as Liquid crystal display as the compounds as a crystalline arrangement of molecules and flows like a liquid
- in LCD two glass plates each with light polarizer are placed which faces each other at right angle, sandwich the liquid crystals

- **Advantages**
    - low power consumption
    - small size
    - low cost
- **Disadvantages**
    - temperature dependent
    - no color capability
    - less resolution as compared to CRTs



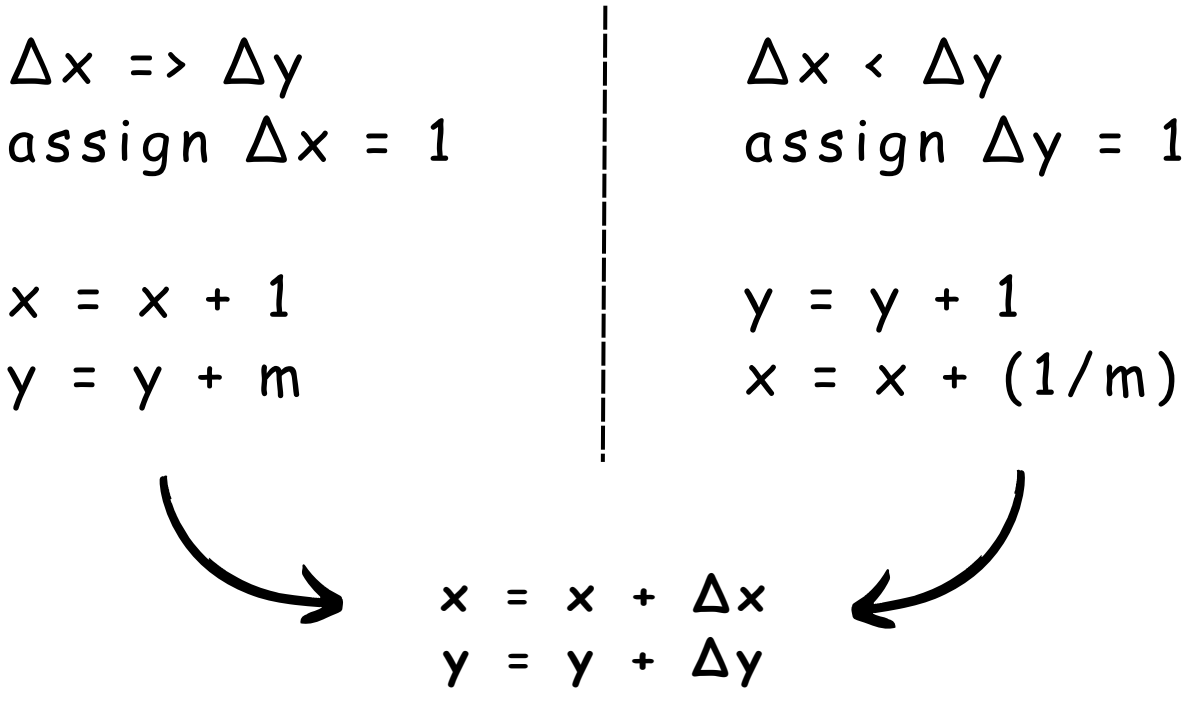
1 DDA (Digital Differential Analizer) Line Drawing Algorithm

- Step 1 : Find Slope $$m \equiv \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

- Find values of Delta Y (dy) and Delta X (dx)

$$\triangle y = y_2 - y_1 \qquad \triangle x = x_2 - x_1$$

- Check this conditions and repeat until we get final value



DDA (Digital Differential Analizer) Line Drawing Algorithm

- Advantage:
    - It is a faster method than method of using direct use of line equation.
    - This method does not use multiplication theorem.
    - It allows us to detect the change in the value of x and y so plotting of same point twice is not possible.
    - This method gives overflow indication when a point is repositioned.
    - It is an easy method because each step involves just two additions.

- Disadvantage:
    - It involves floating point additions rounding off is done. Accumulations of round off error cause accumulation of error.
    - Rounding off operations and floating point operations consumes a lot of time.
    - It is more suitable for generating line using the software. But it is less suited for hardware implementation.

2

Bresenham's Line Drawing Algorithm Code

- Step 1 : Find Slope $$m \equiv \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

- Step 2 : Find Decision parameter $P = 2\Delta y - \Delta x$

- Check this conditions and repeat until we get final value

```
if m < 1

  if P < 0

    x = x + 1
    y = y
    p = p + 2Δy


  if P => 0

    x = x + 1
    y = y + 1
    p = p + 2Δy - 2Δx
```

```
if m> 1

  if P < 0

    x = x
    y = y + 1
    p = p + 2Δx


  if P => 0

    x = x + 1
    y = y + 1
    p = p + 2Δx - Δy
```

Bresenham’s Line Drawing Algorithm Code

- Advantage:
    - 1. It involves only integer arithmetic, so it is simple.
    - 2. It avoids the generation of duplicate points.
    - 3. It can be implemented using hardware because it does not use multiplication and division.
    - 4. It is faster as compared to DDA (Digital Differential Analyzer) because it does not involve floating point calculations like DDA Algorithm.
- Disadvantage:
    - 1. This algorithm is meant for basic line drawing only Initializing is not a part of Bresenham's line algorithm.
    - So to draw smooth lines, you should want to look into a different algorithm.

3 Bresenham's Circle Algorithm

- Step 1 : Set Start Points

```
x = 0
y = r (radius)
```

- Step 2 : Decision parameter

```
P = 3 - 2r
```

- Check this conditions and repeat until

```
x => y
```

```
If P < 0

    P = P + 4x + 6
    x = x + 1
    y = y

If P => 0

    P = P + 4(x - y) + 10
    x = x + 1
    y = y - 1
```

4 MidPoint Circle Algorithm

- Step 1 : Set Start Points

```
x = 0
y = r (radius)
```

- Step 2 : Decision parameter

```
P = 1 - r
```

- Check this conditions and repeat until

```
x => y
```

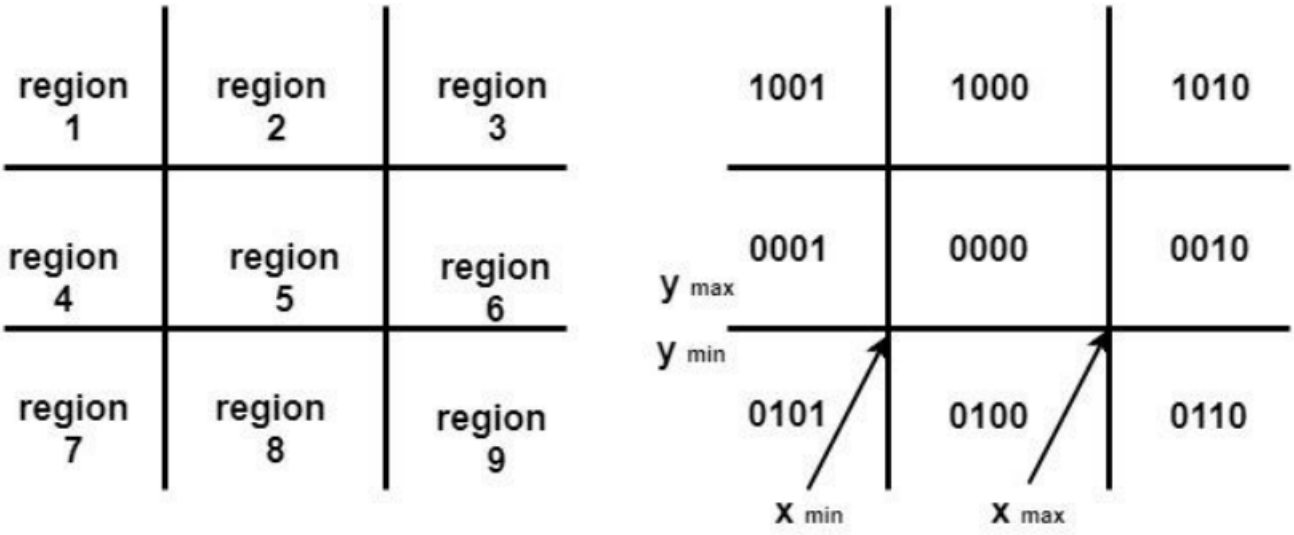
```
If P < 0

    P = P + 2x + 3
    x = x + 1
    y = y

If P => 0

    P = P + 2(x-y)+5
    x = x + 1
    y = y - 1
```

Point Clipping

- In computer graphics the screen acts as a 2-D coordinate system
- it is not possible that each and every point can be viewed on the screen
- we can only view the points which lies in a particular range form (0,0) to (Xmax, Ymax)
- Clipping is a process which identifies those portions which are inside this range and outside of the range
- In clipping we only show the points which lies in the range and the points which are outside of the range are discarded
- there are two types of clipping algorithm
    - **Cohen Sutherland Line Clipping Algorithm**
    - **Liang-Barsky Line Clipping Algorithm**

1. Cohen Sutherland Line Clipping Algorithm :

- In this algorithm we check if the line lies inside the screen or not
- the line lies in one of the following - Visible, Not Visible, Clipping Case
- **Visible**: Line lies in the range within the window
- **Not Visible**: Line lies outside the range of the window, such lines ill not be displayed
- **Clipping Case**: If the line is neither visible case nor invisible case. It is considered to be clipped case. the category of a line is found based on nine regions given below. All nine regions are assigned codes. Each code is of 4 bits. If both endpoints of the line have end bits zero, then the line is considered to be visible.



9 region

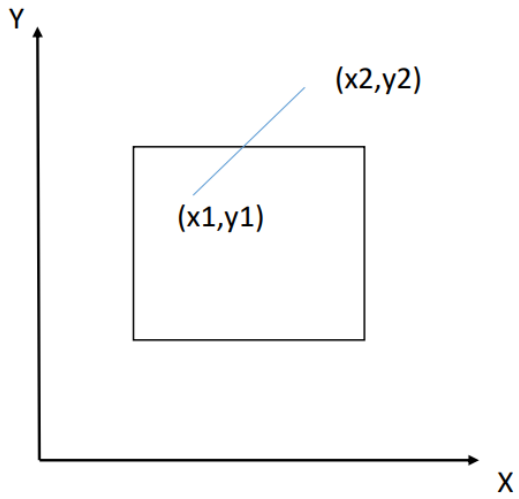
bits assigned to 9 regions

Advantages:

- It calculates end-points very quickly and rejects and accepts lines quickly.
- It can clip pictures much large than screen size.

2. Liang-Barsky Line Clipping Algorithm

- The Liang-Barsky algorithm is a line clipping algorithm.
- This algorithm is more efficient than Cohen–Sutherland line clipping algorithm.
- This algorithm is considered to be the faster parametric line-clipping algorithm.



$$x = x1 + t\,dx$$
$$y = y1 + t\,dy$$

$$xw_{min} <= x <= xw_{max}$$
$$xw_{min} <= x + t\,dx <= xw_{max}$$

$$t\,dx <= xw_{max} - x1$$
$$t\,dx >= xw_{min} - x1$$
$$t\,dy <= yw_{max} - y1$$
$$t\,dy >= yw_{min} - y1$$

$$t\,pk <= qk$$

$$-t\,dx <= x1 - xwmin$$
$$t\,dx <= xwmax - x1$$

$$-t\,dy <= y1 - ywmin$$
$$t\,dy <= ywmax - y1$$

$$P1 = -dx$$
$$P2 = dx$$
$$P3 = -dy$$
$$P4 = dy$$

Aliasing

- Aliasing is the result of sampling a continuous signal at certain intervals
- It occurs due to low sampling which creates a distortion of image
- Instead of smooth curves or transitions, we might see rough edges or strange patterns.
- Aliasing is especially noticeable when the signal has high frequencies, such as sharp edges, fine details, or rapid changes.

How to fix Aliasing?

- There are two main ways to fix aliasing in computer graphics:
    - increasing the resolution
    - applying anti-aliasing techniques.
- **Increasing the resolution** means using more pixels or samples to represent the image.
- This can reduce or eliminate aliasing artifacts, but it also requires more computational power and memory
- **Applying anti-aliasing techniques** means using algorithms that smooth out the edges and blend the colors of the image.
- This can improve the appearance of the image, but it also introduces some blurring and softening effects