

COMPUTER GRAPHICS

Main details covered in these lectures include: –

Introduction to computer graphics, – Advantage and application of computer graphics, – Display devices, – CRT Cathode Ray Tube. CRT advantage and disadvantage

INTRODUCTION

- Computer graphics It is often abbreviated as CG, is an art of drawing pictures, lines, shape, charts, etc. Using computers with the help of mathematical algorithms programmed.
- It is the science that merge between theory and technology to produce an image with lines, or an number of composed shapes. Computer graphics image is made up of number of pixels. Pixel is an abbreviation of (picture element) it is the smallest addressable graphical unit represented on the computer screen .
- CG developed since the last 20 years. Computer is information processing machine and communication. 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.
- In computer graphics picture or graphics objects are presented as a collection of discrete pixels. The user can control intensity and color of pixel which decide how picture look like. The process of representing continuous picture or graphics object as a collection of discrete pixels is called Scan Conversion.

FEW TERMS

- Photo: It is any image captured by digital camera or by mobile or with the classical camera.
- Picture: is the old name of image. Image: addressed all type of image (still or video).
- Pixel: pixel can be specified by its row and column numbers. It can be simply black and white system (monochrome) or color system. In B/W system each pixel is either ON or OFF, so only one bit per pixel is needed.

APPLICATION OF COMPUTER GRAPHICS

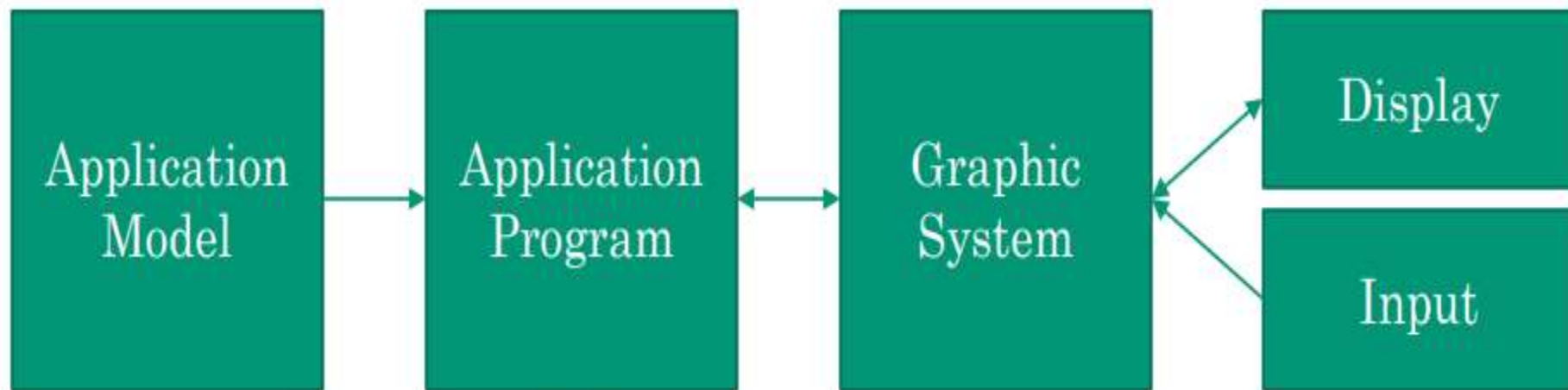
- Computer Graphics has various applications, some of which are listed below
- 1. Computer graphics user interfaces GUIs – A graphic, mouse oriented paradigm which allows the user to interact with a computer.
- 2. Business presentation graphics – "A picture is worth a thousand words".
- 3. Cartography – Drawing maps.
- 4. Weather Maps – Real-time mapping, symbolic representations.
- 5. Satellite Imaging – Geodesic images.
- 6. Photo Enhancement – Sharpening blurred photos.
- 7. Medical imaging – MRIs, CAT scans, etc. - Non-invasive internal examination.
- 8. Engineering drawings – mechanical, electrical, civil, etc. - Replacing the blueprints of the past.
- 9. Typography – The use of character images in publishing - replacing the hard type of the past.
- 10. Architecture – Construction plans, exterior sketches - replacing the blueprints and hand drawings of the past.
- 11. Art – Computers provide a new medium for artists.
- 12. Training – Flight simulators, computer aided instruction, etc.
- 13. Entertainment – Movies and games.
- 14. Simulation and modeling – Replacing physical modeling and enactments
- 15. Image Enhancement - Sharpening blurred photos.

COORDINATE REPRESENTATIONS

- 1. Cartesian coordinate specifications were used in Computer Graphics.
- 2. Any other type of coordinate values for a picture are must be converted to Cartesian coordinate before giving input to graphics package.
- 3. The conversion process of the World-coordinates description of the scene to one or more output device display are referred to as “Device Coordinates” or “Screen Coordinates”.
- 4. Generally a graphic system first converts the world-coordinates position to normalized device coordinates. In the range from 0 to 1 before final conversion to specific device coordinates.

INTRODUCTION CRT Monitor

- Computer graphics involves display, manipulation, storage pictures and experimental data for visualization using a computer.
- computer graphic system consists of host computer with support of fast processor , large memory ,frame buffer and Display devices (Monitors) Input devices (keyboards, mouse , joysticks) →Output devices (printers, plotters, LCD panel)



(Conceptual framework for interactive graphics)

ACTIVE & PASSIVE GRAPHIC SYSTEM

- Computer graphics system could be active or passive.
- Active: The user controls the display with the help of GUI using input device.
- Passive: The user can control nothing.
- Output Primitives for drawing pictures:
- Four basic output primitives for drawing pictures:
 - 1. Polyline: End-Point joint by line.
 - 2. Filled Polygon: The points are joint to create a closed region.
 - 3. Ellipse (Arc): Can be used to draw circles.
 - 4. Text: Font.

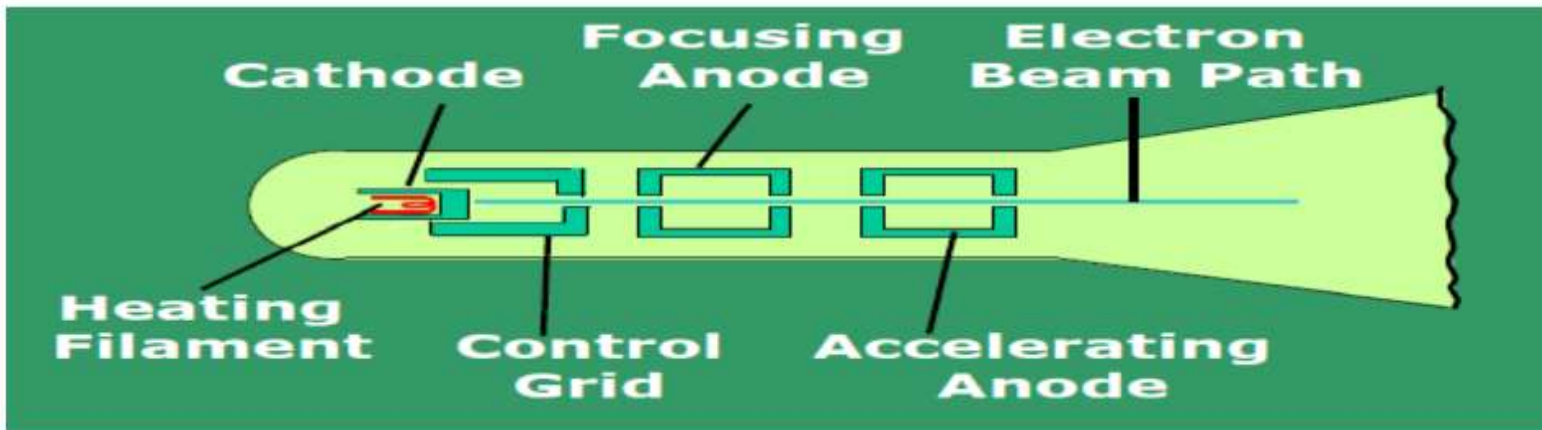
COMPUTER GRAPHIC DEVICES

- CRT (Cathode Ray Tube).
- EGA (Enhanced Graphics Adapter).
- VGA (Video Graphics Array).
- CGA (Color Graphics Adapter).
- SVGA (Super Video Graphics Adapter).
- Plotters. □ Printers (Laser, Data Matrix, Inkjet).
- Flat Panel Devices (LCD, LED).
- Input Devices (Keyboard, Mouse, Scanner).

CRT MONITORS

- The most commonly used display devices is the CRT Monitors.
- Types of CRT display devices:
 1. DVST (Direct View Storage Tube) The Simplest.
 2. Calligraphic or Random Scan display system.
 3. Refresh and Raster Scan display system.

How CRT works?



How CRT works?

- Heating Filament: Heat up the cathode elements of the CRT and that is what generates the electrons then the electrons move through 3 cylindrical element of a CRT.
- Control Grid: (Negative Charged) Control the intensity of the electron so the amount of the voltage at the control grid will allow a certain amount of the electrons to pass through.
- Focusing Anode: (Positive Charged) Responsible to focus the beam on to a particular point on the screen, and its similar to lens focusing.
- Accelerating Anode: (Positively Charged) The electrons should strikes the screen at very high speed. Till now the electron beam path is going straight after it has passed these 3 stages (intensity control, focusing control , acceleration). So the electron strike the center of the screen so we need horizontal and vertical deflections of the beam.
- How we implement the deflections of the point?
we need horizontal and vertical deflections of the beam.

MONITOR PROPERTIES

- Refresh Rate: It's the frequency at which a picture is redrawn on the screen.
- Persistence: The time it takes the emitted light from the screen to decay to 1/10 of its original intensity.
- Resolution: The number of the points per centimeter that can be plotted horizontally and vertically (1280x1024).
- Intensity: How much light will be produced.
- Aspect Ratio: Gives the ratio of vertical points to horizontal points necessary to produce equal length lines in both directions on the screen.

NOTES:

- Aspect ratio of $\frac{3}{4}$ means that a vertical line plotted with 3 points has the same length as a horizontal line plotted with 4 points.
- Lower persistence phosphors require higher refresh rate to maintain a picture on the screen without flicker.
- Phosphor with low persistence is useful for animation.
- Higher persistence phosphor is useful for displaying higher complex static picture.
- Monitors are usually constructed with a persistence in the range from 1 to 60 microsecond.

DVST

- a CRT with long persistence phosphor. Provides flicker-free display. No refreshing necessary.
- How it works:
- A slow moving electron beam draws a line on the screen.
- The electron beam is the basic component of a CRT.
- The DVST has a storage mesh in which the phosphor is embedded.
- Image is stored as a distribution of charges on the inside surface of the screen.
- Very limited interactive support

DVST -DRAWBACKS

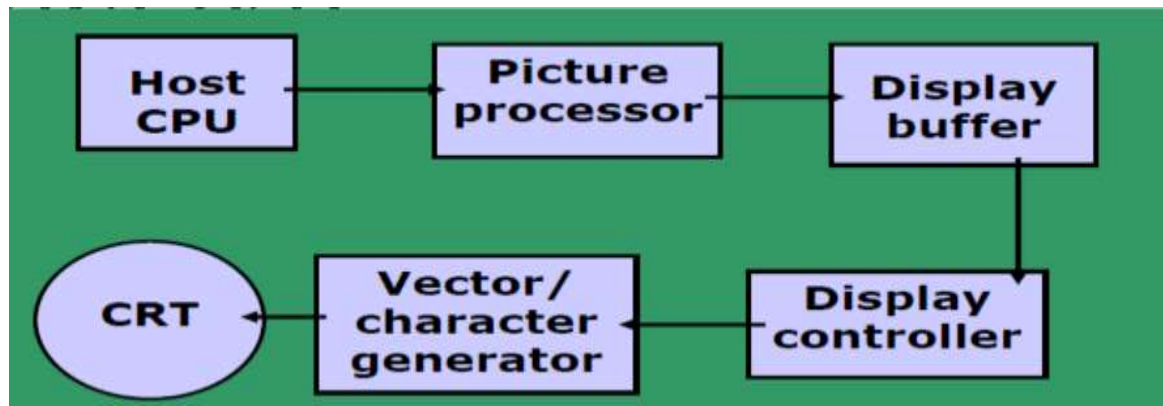
- Has very limited application.
- Modifying any part of the image requires redrawing the entire modified image.
- Change in the image requires to generate a new charge distribution.
- Slow process of drawing – typically a few seconds are necessary for a complex picture.
- Erasing takes about 0.5 seconds (All lines and characters must be erased).

CALLIGRAPHIS/RANDOM SCAN DISPLAY

- Also called Vector, Stroke, Line drawing displays.
- Very closed to old TVs.
- Characters are also made of sequences of strokes (or short lines).
- Vectored – electron beam is deflected from end-point to end-point.
- Random scan - Order of deflection is dictated by the arbitrary order of the display commands. Phosphor has short persistence – decays in 10-100 ms.
- The display must be refreshed at regular intervals – minimum of 30 Hz (fps) for flicker-free display.
- Refresh Buffer : memory space allocated to store the display list or display program for the display processor to draw the picture.
- The display processor interprets the commands in the refresh buffer for plotting.

CALLIGRAPHIC-

- The vector generator needs the intensity and the points coordinate values.
- The vector generator converts the digital coordinate values to analog voltages for the beam-deflection circuits.
- Scope of animation with segmentation – mixture of static and dynamic parts of a picture (it has a limited support of animation).
- Random-scan display system draws a set of lines in any order.

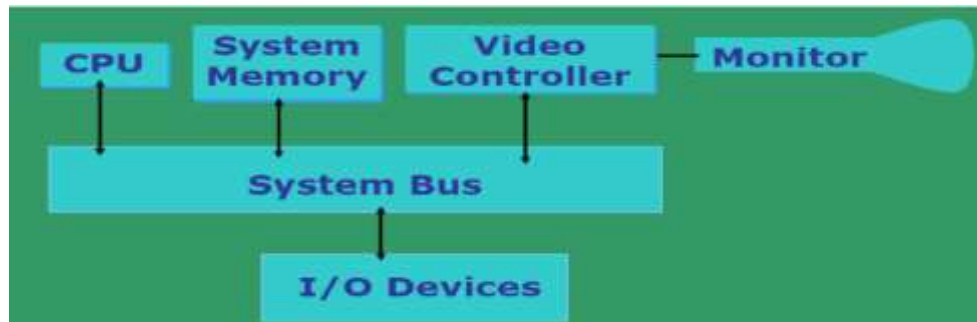


CALLIGRAPHIC-

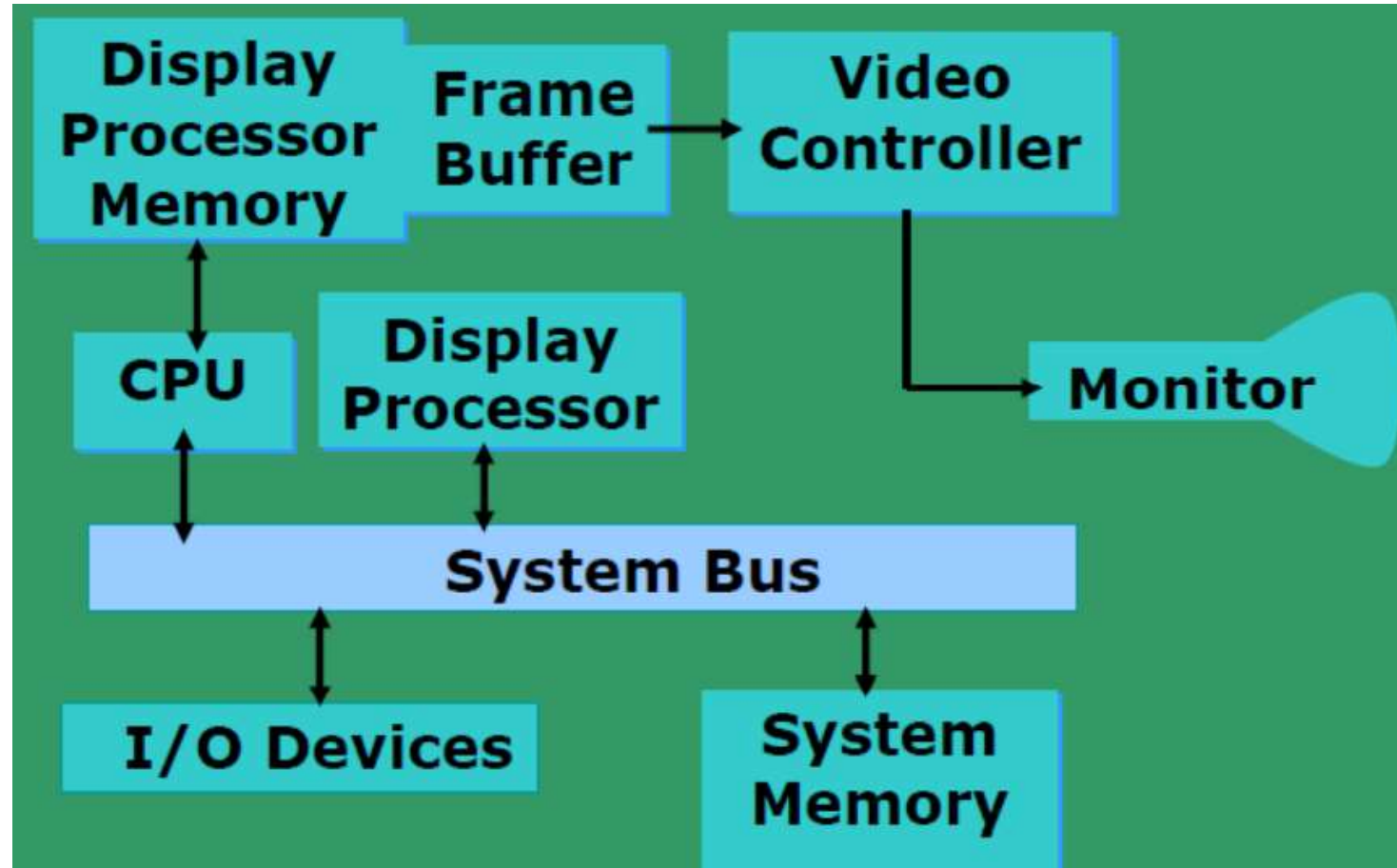
- Phosphor's Fluorescence is the light emitted as electrons (unstable) lose their excess energy while the phosphor is being struck by electrons.
- Phosphorescence is the light given off by the return of the relatively more stable excited electrons to their unexcited state once the electron beam excitation is removed.
- Phosphor's persistence is defined as the time from the removal of excitation to the moment when phosphorescence has decayed to 10% of the initial light output.
- Long persistence : several seconds.
- Short persistence : 10-60 ms.

RASTER SCAN DISPLAY SYSTEM

- Unlike DVST and random-scan which were linedrawing devices, refresh CRT is a point-plotting device.
- Raster displays store the display primitives (lines, characters, shaded and patterned areas) in a refresh buffer.
- Refresh buffer (also called frame buffer).
- Frame buffer: stores the drawing primitives in terms of points and pixels components.

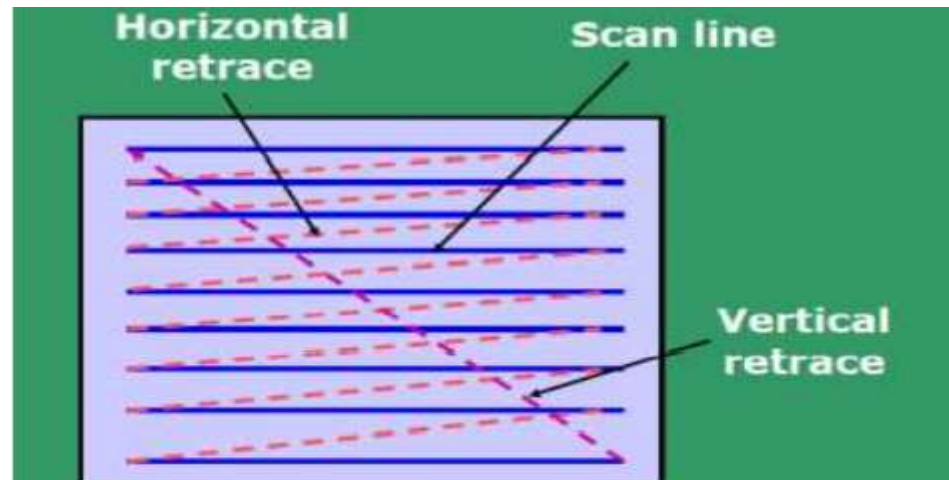


RASTER GRAPHIC SYSTEM WITH A DISPLAY PROCESSOR

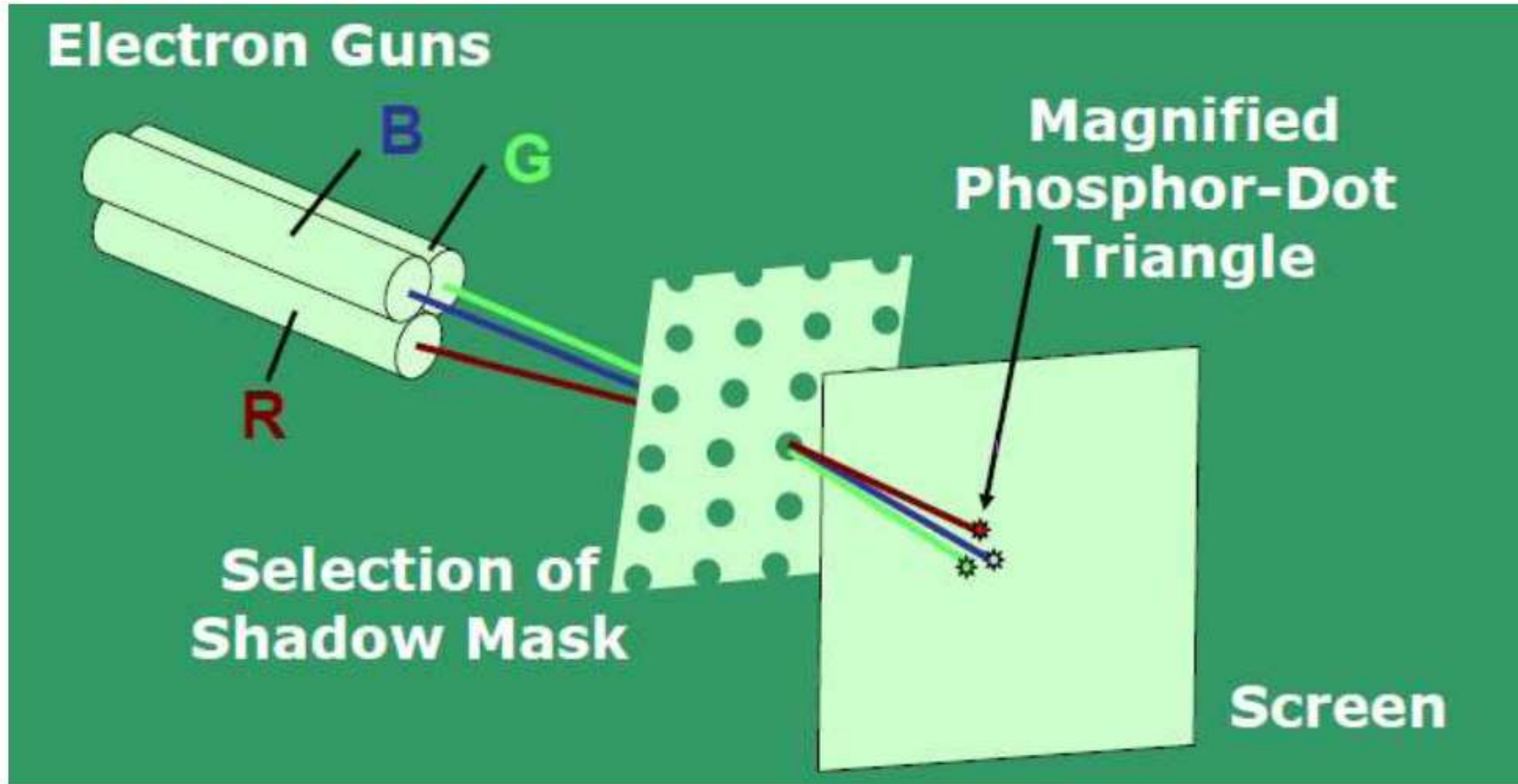


TERMINOLOGY-

- Bandwidth of the display: The rate at which the beam can be turned OFF to ON and vice-versa.
- EXAMPLE: For N pixels per scan line, it is necessary to turn the electron gun at a maximum rate of: $N/2$ times ON and $N/2$ times OFF; This will create alternate black and white lines on the screen.



OPERATION



RASTER SCAN DISPLAY SYSTEM--

- Entire screen is a matrix of pixels.
- Each pixel brightness can be controlled.
- Each point is an addressable point in screen and memory. Line cannot be drawn directly from one point to another.
- This causes the effect of 'aliasing', 'jaggies' or 'staircase' effect.
- Refresh/Frame buffer is also called Bit-plane.

EXAMPLE 1-RASTER SCAN DISPLAY

- For 512x512 raster display then 2^{18} bits are necessary in a single bit plane.
- Memory size required: 32 KB.
- $2^9 * 2^9 = 2^{18}$ b
- $\frac{2^{18}}{2^3} = 2^{15}$ B
- $\frac{2^{15}}{2^{10}} = 2^5 = 32$ KB
- Memory size required for N-bit plane gray level frame buffers:

N	Size in KB
3	96=(3*32)
8	256=(8*32)
24	768=(24*32)

EXAMPLE 2-RASTER SCAN DISPLAY

- For 1024x1024 raster display then 2^{18} bits are necessary in a single bit plane.
- Memory size required: 128 KB.
- $2^{10} * 2^{10} = 2^{20}$ b
- $\frac{2^{20}}{2^3} = 2^{17}$ B
- $\frac{2^{17}}{2^{10}} = 2^7 = 128$ KB
- Memory size required for N-bit plane gray level frame buffers:

N	Display color	Size
1	Black & White	128 KB
8	256 color	1 MB
24	16 million color	3 MB

EXAMPLES-

Q: Consider three different raster systems with resolutions of 640 x 480 and 1280 x 1024, What size is frame buffer (in bytes) for each of these systems to store 12 bits per pixel?

640 x 480 x 12 bits / 8 = 450KB.

1280 x 1024 x 12 bits / 8 = 1920KB.

Q: Find out the aspect ratio of the raster system using 8 x 10 inches screen and 100 pixel/inch.?

Aspect ratio = width/height = $8 \times 100 / 10 \times 100 = 4/5$

Q: You have 3 guns each gun have 8 bit, and you have 256 color, find the memory size required in MB?

- Memory size required: 2 MB

- 2^{24} bits

- $\frac{2^{24}}{2^3} = 2^{21}$ B

- $\frac{2^{21}}{2^{10}} = 2^{11}$ KB

- $\frac{2^{11}}{2^{10}} = 2^1$ MB

TERMINOLOGY

- Refresh rate: is the number of times the image is drawn on the screen per second.
- Refresh rate to avoid flickering : 60 Hz
- Reducing refresh rate increases flicker and reduces the frame buffer size.
- Horizontal scan rate is the number of scan lines the circuit drives a CRT display per second
- Horizontal scan rate = refresh rate x number of scan lines