Refresh and raster scan display system

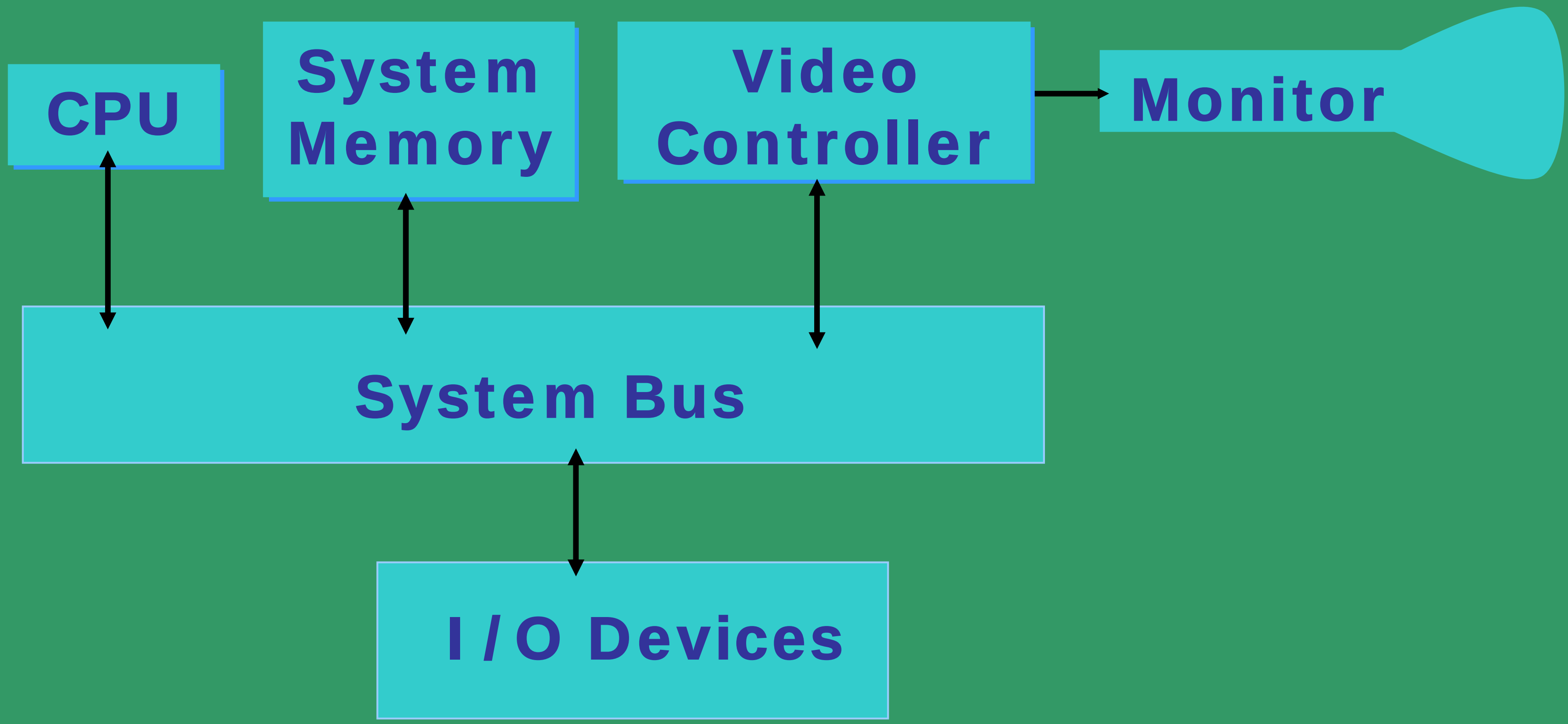
- Used in television screens

- Unlike DVST and random-scan which were line-drawing devices, refresh CRT is a <u>point-plotting device</u>

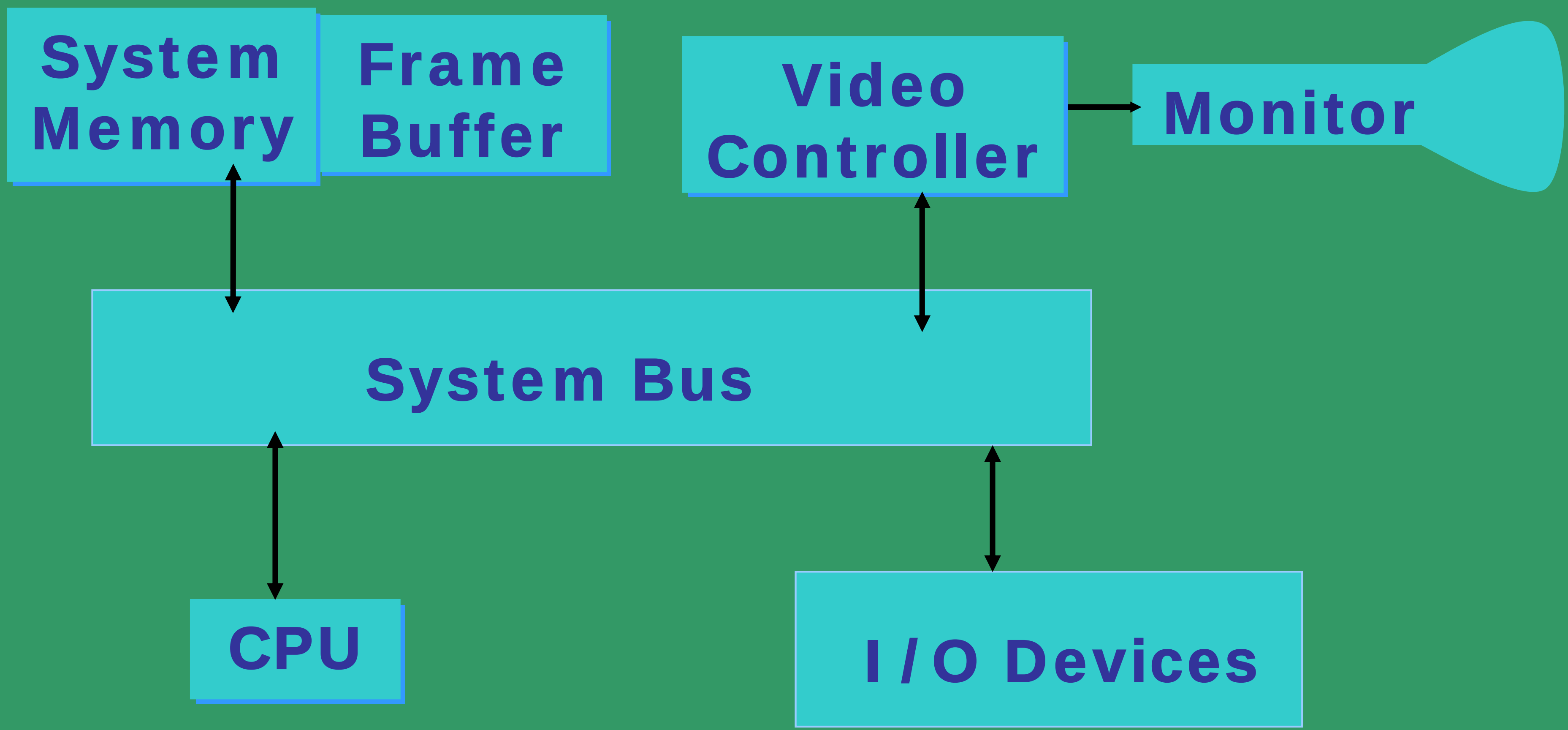
- Raster displays store the display primitives (lines, characters, shaded and patterned areas) in a refresh buffer

- Refresh buffer (also called frame buffer) stores the drawing primitives in terms of points and pixels components

Architecture of a simple raster graphics system



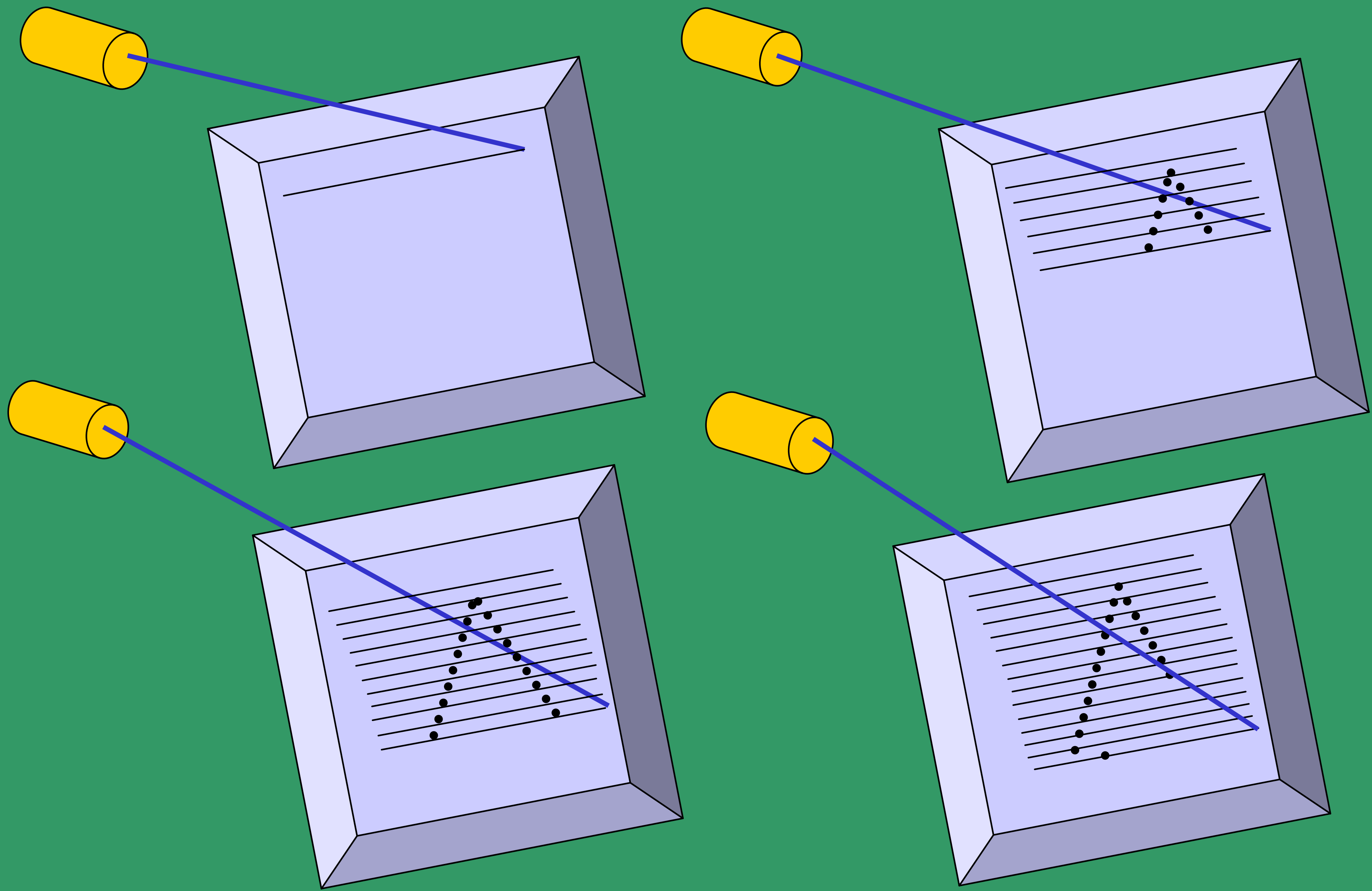
Architecture of a raster system with a fixed portion of the system memory reserved for the frame buffer



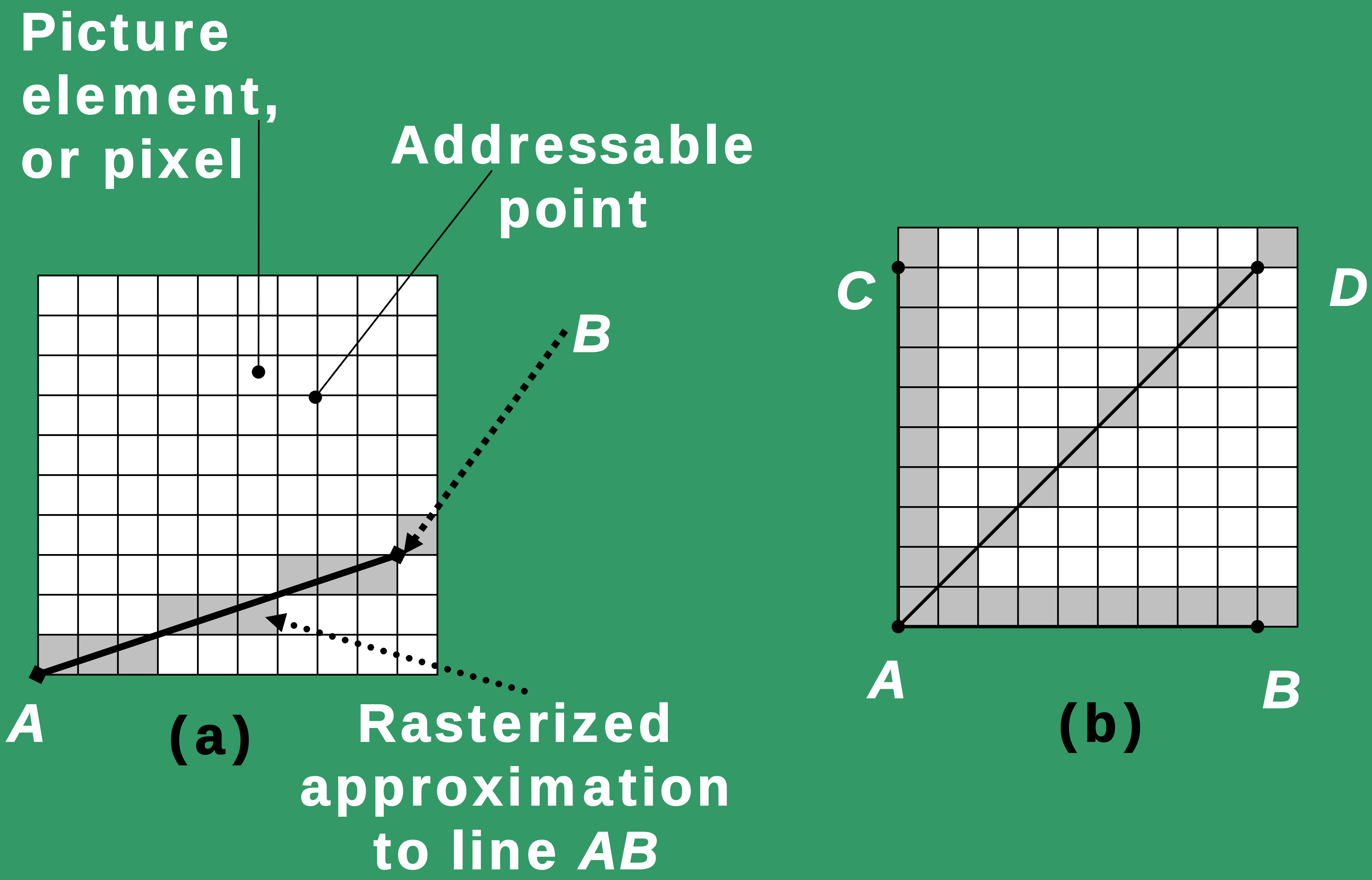
Refresh and raster scan display system (contd.)

- Entire screen is a matrix of pixels
- Each pixel brightness can be controlled
- Refresh buffer can be visualized as a set of horizontal raster lines or a row of individual pixels
- 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

Raster-scan display system draws a discrete set of points



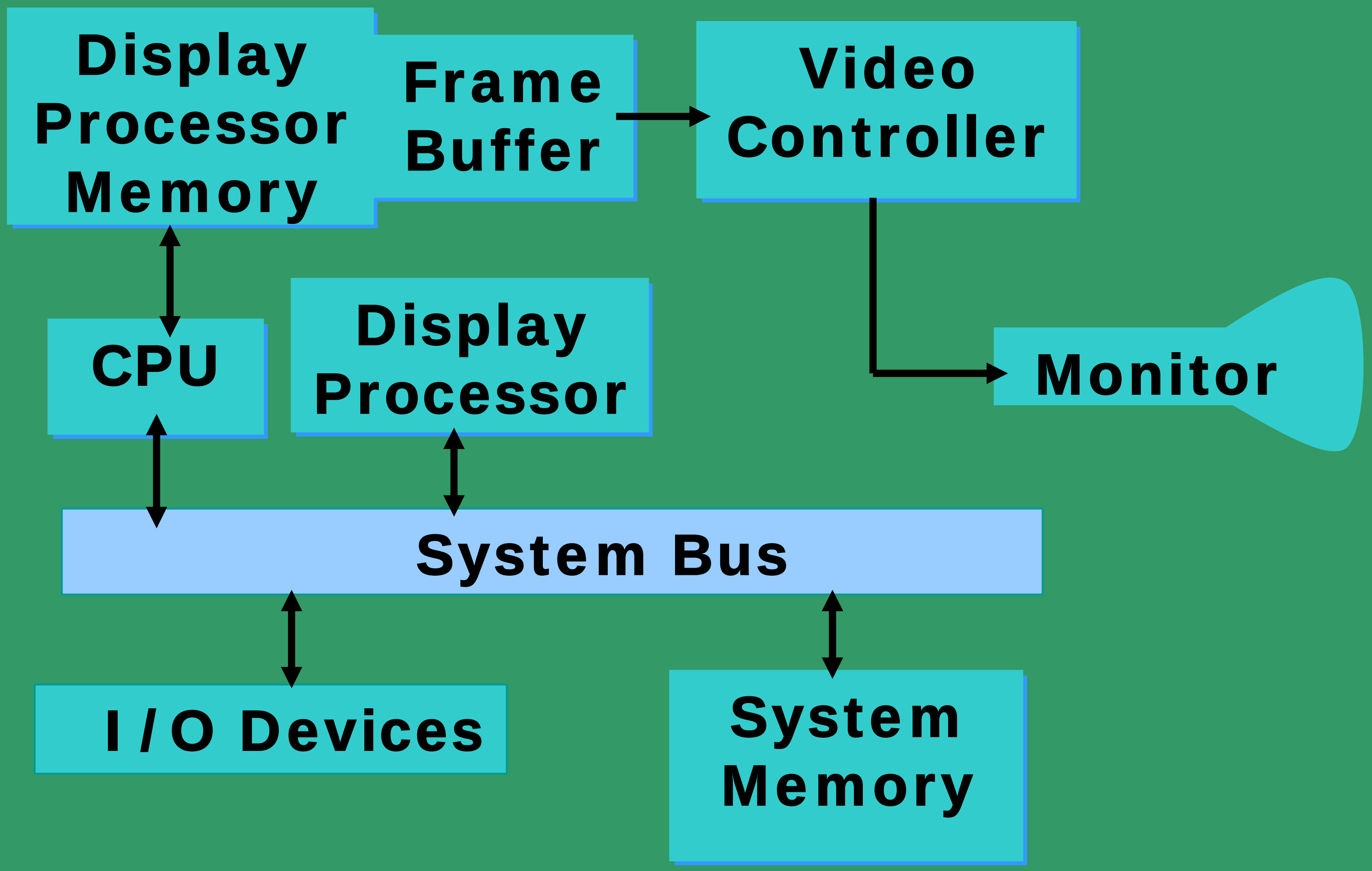
Rasterization: (a) General line ; (b) special cases



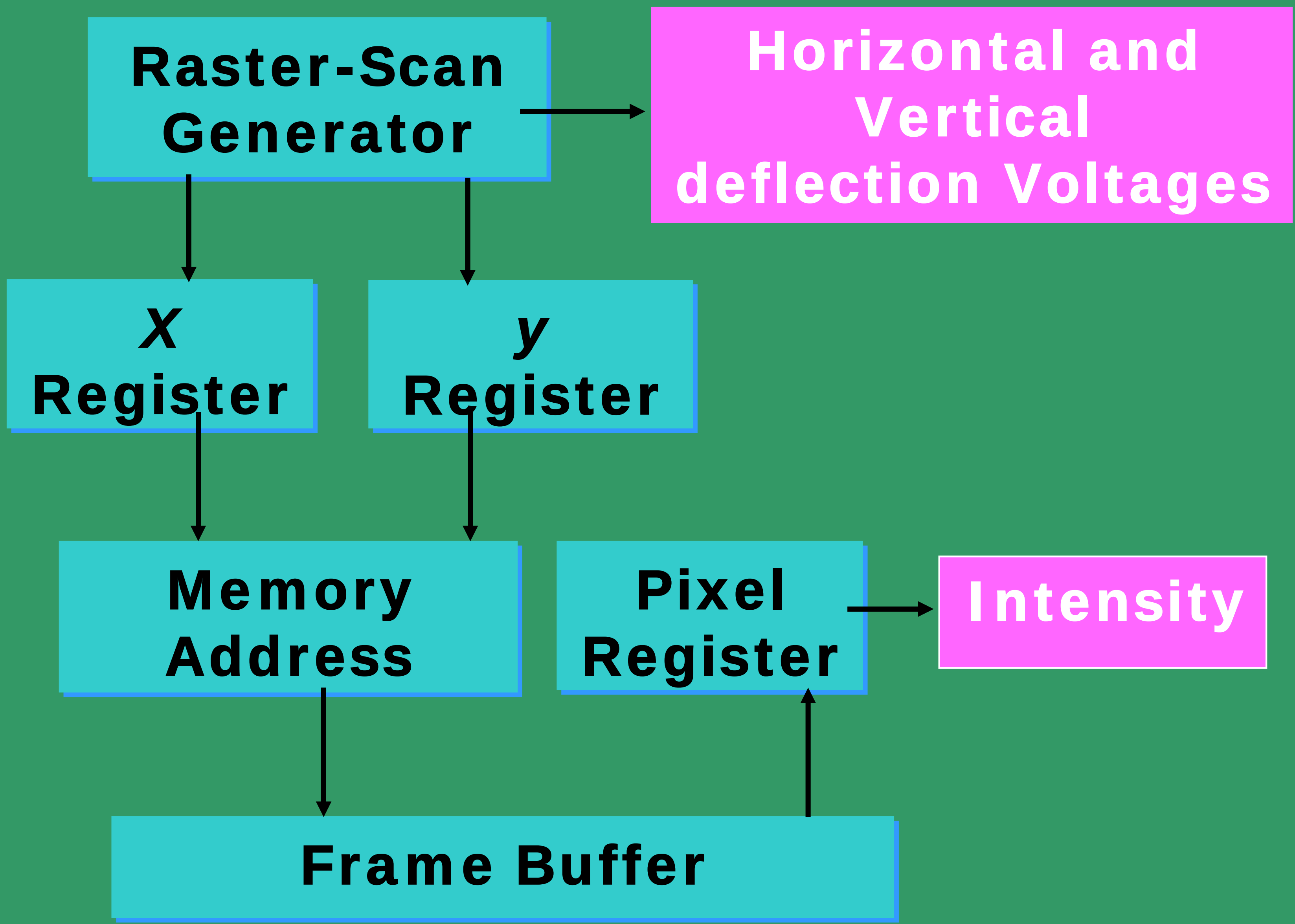
Refresh Rate, Video basics and Scan Conversion

- Raster is stored as a matrix of pixels representing the entire screen area
- Entire image is scanned out sequentially by the video controller (one raster line at a time)
- The raster lines are scanned from top to bottom and then back to the top
- The intensity of the beam decides the brightness of the pixel
- At least one memory bit for each pixel (called bit-plane)

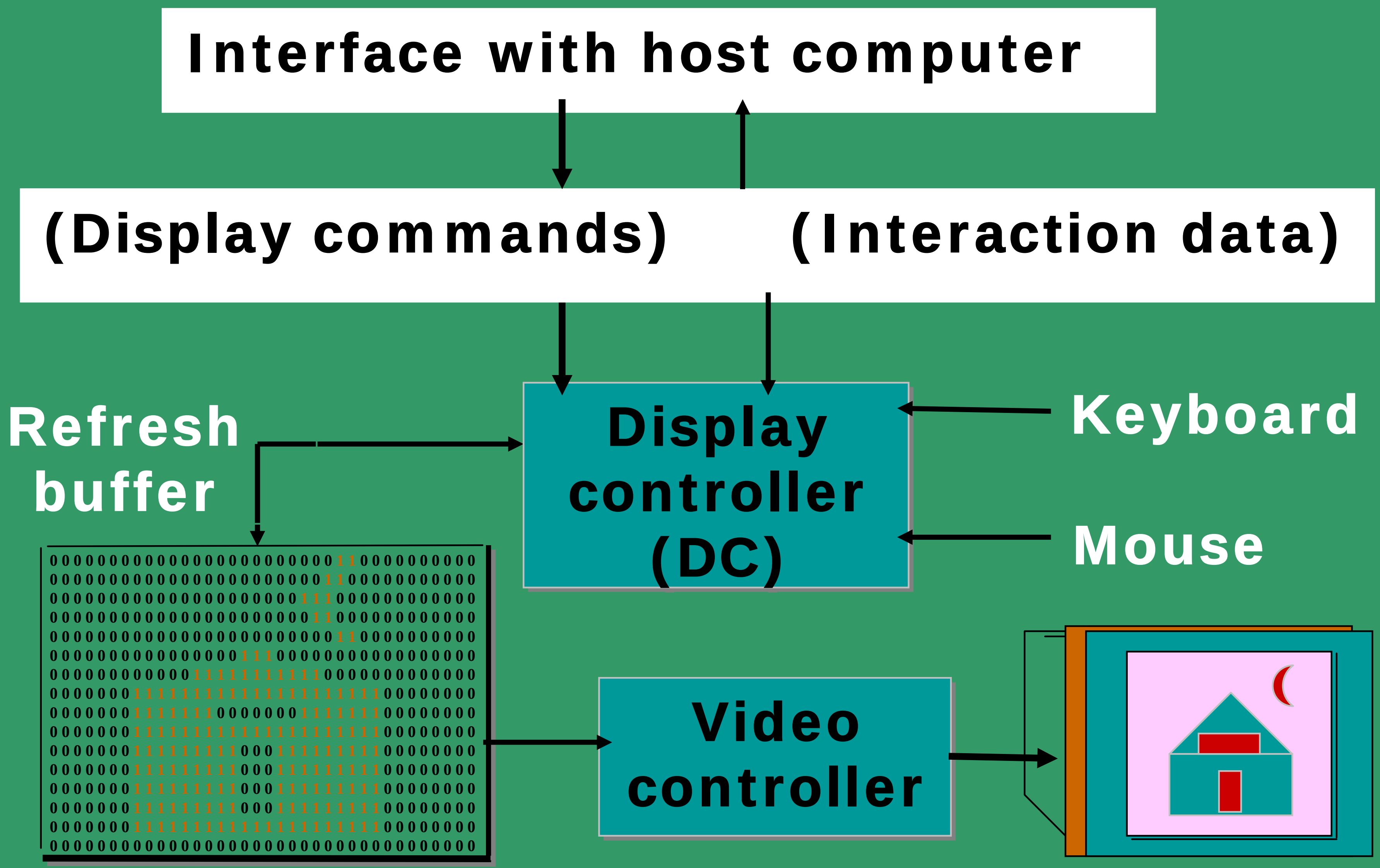
Architecture of a raster-graphics system with a display processor



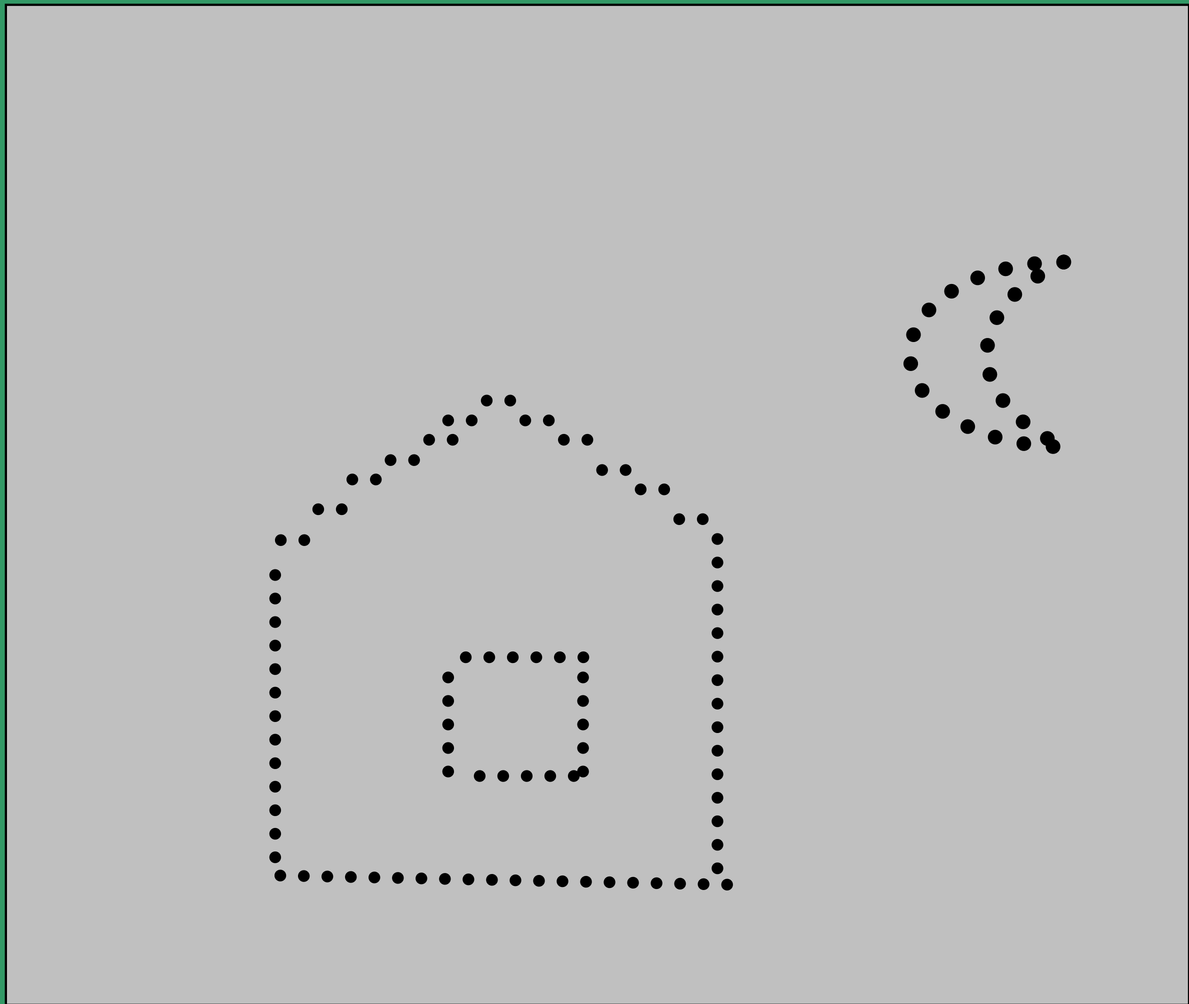
Basic video-controller refresh operations



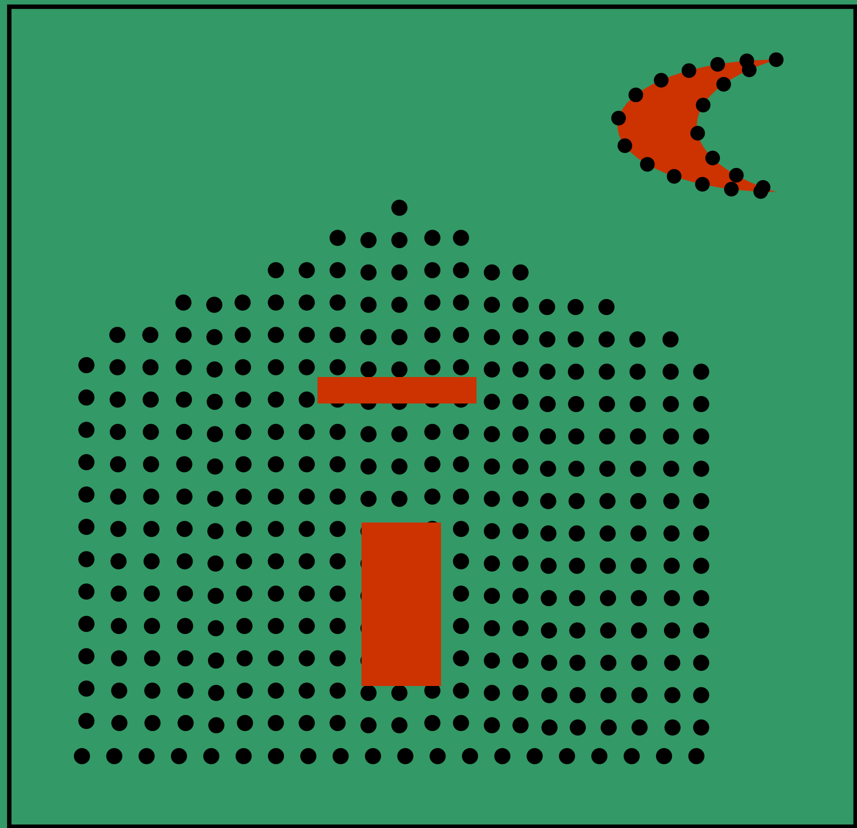
Architecture of a raster display



Raster scan with outline primitives



Raster scan with filled primitives



Refresh Rate, Video basics and Scan Conversion (contd.)

A typical example:

If one uses a 512x512 element raster display, then 2^{18} bits are necessary in a single bit plane. Memory size required: 32 KB

A DAC (digital-to-analog converter) is used to convert the bit value (0, 1) to analog signals for refreshing the screen

Memory size required for N-bit plane gray level frame buffers:

N	Size in KB
3	96
8	256
24	768

Refresh Rate, Video basics and Scan Conversion (contd.)

Refresh rate to avoid flickering – 60 Hz

If one uses a 1024x1024 high resolution CRT:

N	Display Color	Memory Size
1	Black & White	128 KB
8	256 colors	1 MB
24	16 million colors	3 MB
32	16 million colors	4 MB

Even 32 bits per pixel with 1280x1024 pixels raster are available.

Refresh Rate, Video basics and Scan Conversion (contd.)

- Refresh rate of a CRT is the number of times the image is drawn on the screen per second.
- Reducing refresh rate increases flicker.
- Horizontal scan rate is the number of scan lines the circuit drives a CRT display per second = refresh rate x number of scan lines
- Resolution of the screen depends on spot size
- CRT resolution is not a function of bitmap resolution
- For larger spot size, resolution decreases
- Horizontal resolution depends on spot size and beam switching (ON/OFF) speed

Refresh Rate, Video basics and Scan Conversion (contd.)

Bandwidth of the display:

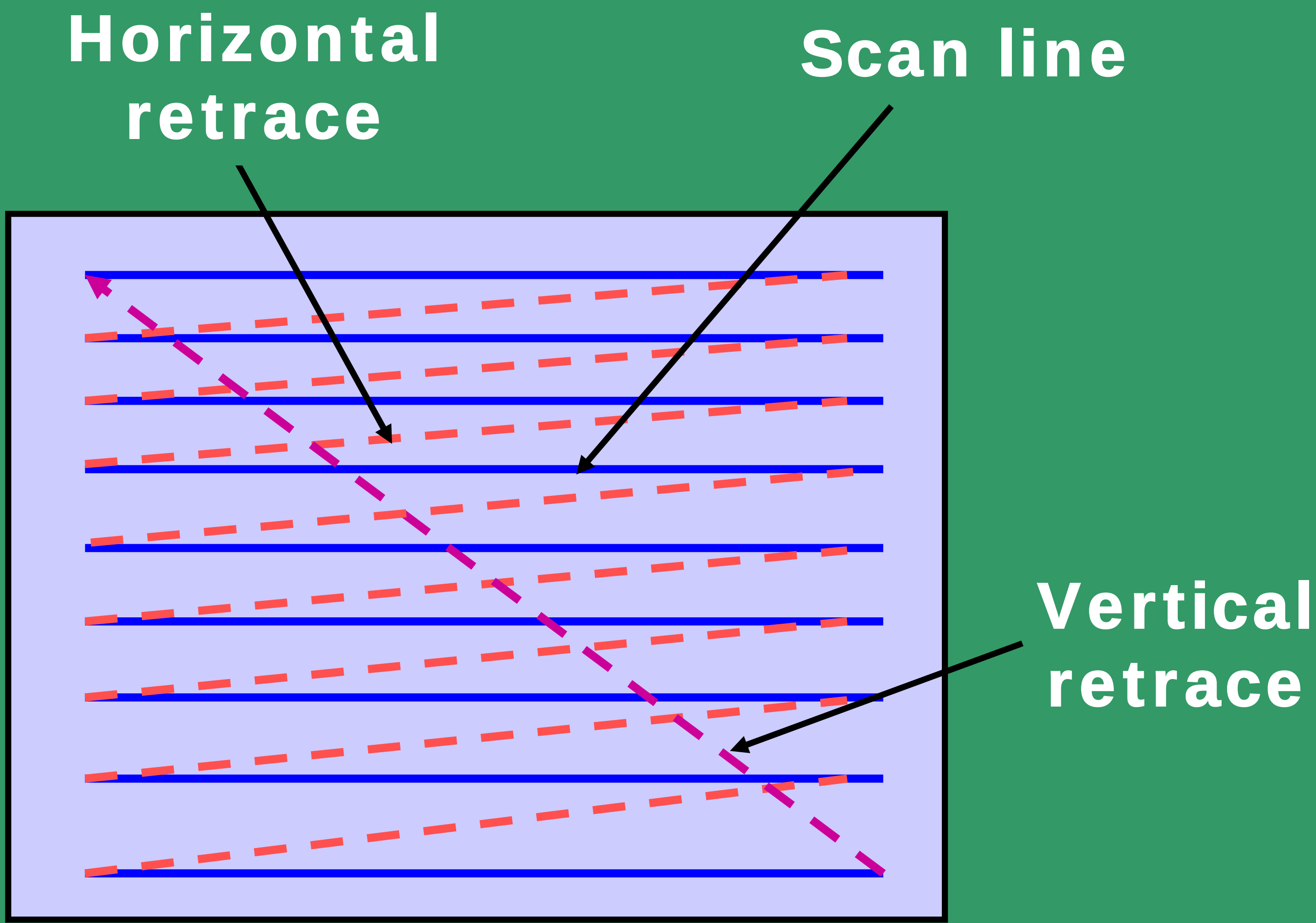
The rate at which the beam can be turned OFF to ON and vice-versa.

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.

Let us now look at some concepts of Video basics and Scan conversion.

Raster Scan



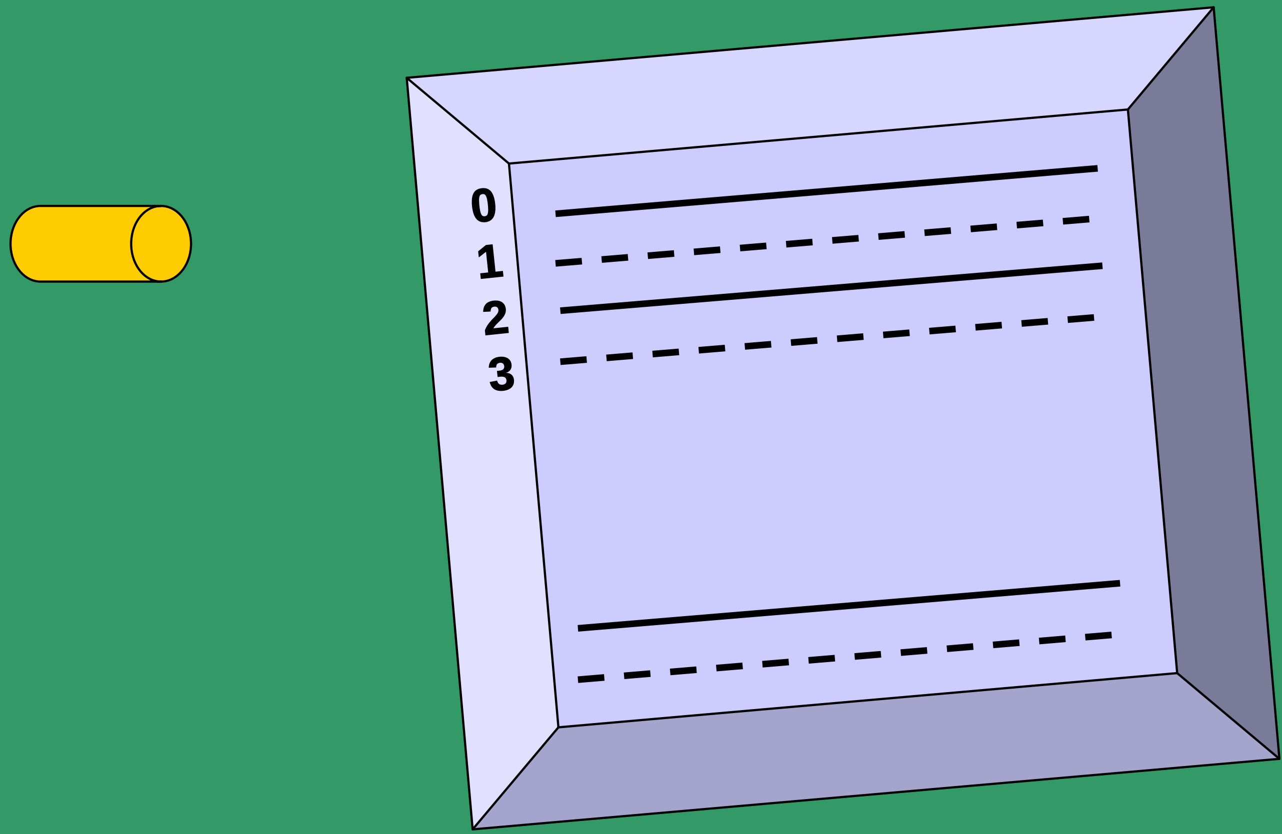
Refresh Rate, Video basics and Scan Conversion (contd.)

NTSC (American Standard Video) has 525 horizontal lines with a frame rate of 30 fps.

Viewing aspect ratio is 4:3

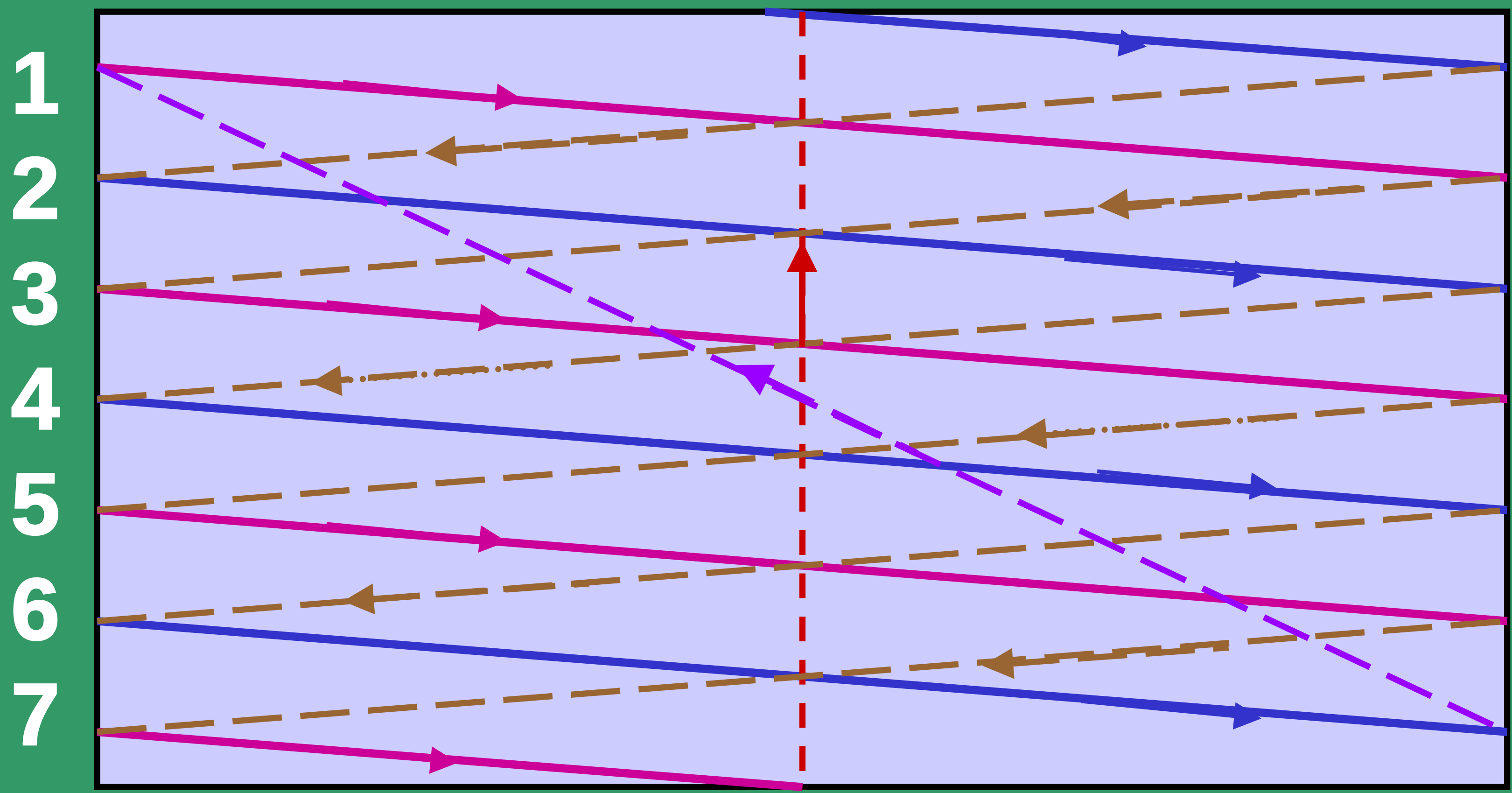
- Each frame has two fields, each containing half the picture.
- Fields are interlaced or interwoven
- Fields are presented alternately every other 1/60-th of a sec.
- One field contains odd scan lines (1,3,5,...)
- The other contains even scan lines (2,4,6,...)
- Two types of retrace after every field

Interlacing scan lines on a raster scan display; First, all points on the even-numbered (solid) scan lines are displayed; then all points along the odd-numbered (dashed) lines are displayed



Schematic of a 7-line interlaced scan line pattern.

The odd field begins with line 1. The horizontal retrace is shown dashed. The odd field vertical retrace starts at the bottom center. The even field vertical retrace starts at the bottom right.



Refresh Rate, Video basics and Scan Conversion (contd.)

Horizontal retrace - As the electron beam reaches the right edge of the screen, it is made invisible and rapidly returns to the left edge

- Time taken for horizontal retrace is typically 17% allotted for a scan line.
- After odd field scan conversion is complete, the beam is at the bottom center of the screen.
- After even field scan conversion is complete, the beam is at the bottom right of the screen.
- Odd field vertical retrace returns the beam (switched OFF) to the top center of the screen
- Even field vertical retrace returns it to the upper left corner of the screen

Refresh Rate, Video basics and Scan Conversion (contd.)

- Two fields are presented alternately for each frame. So we present 60 frames per second.

- In NTSC, generally 483 lines are visible.

- This is because, the vertical retrace after each field requires a time equivalent of 21 scan lines

- So for each field we have time to display: 262.5 *(=525/2)* – 21 = 241.5 lines.

- So with both fields together, we have: 241.5*2 = 483 lines to display.

- This is the reason for 42 (= 525-483) invisible lines.

Refresh Rate, Video basics and Scan Conversion (contd.)

- Let the time available for each scan line be T.
- Thus, we have: T * 525 * 30 = 1 sec.
- Thus, T = 63.5 μs/scan-line
- This includes the vertical retrace time.
- When we consider the horizontal retrace time, the actual time to display all pixels in a scan line (time to scan from left to right only):

T' = 0.83*T = 53 μs.

- Considering 4:3 aspect ratio, the number of pixels per scan line = 483*4/3 = 644
- Thus, time available for the beam to access and display a pixel = 82.3 ns (nano-second).

Refresh Rate, Video basics and Scan Conversion (contd.)

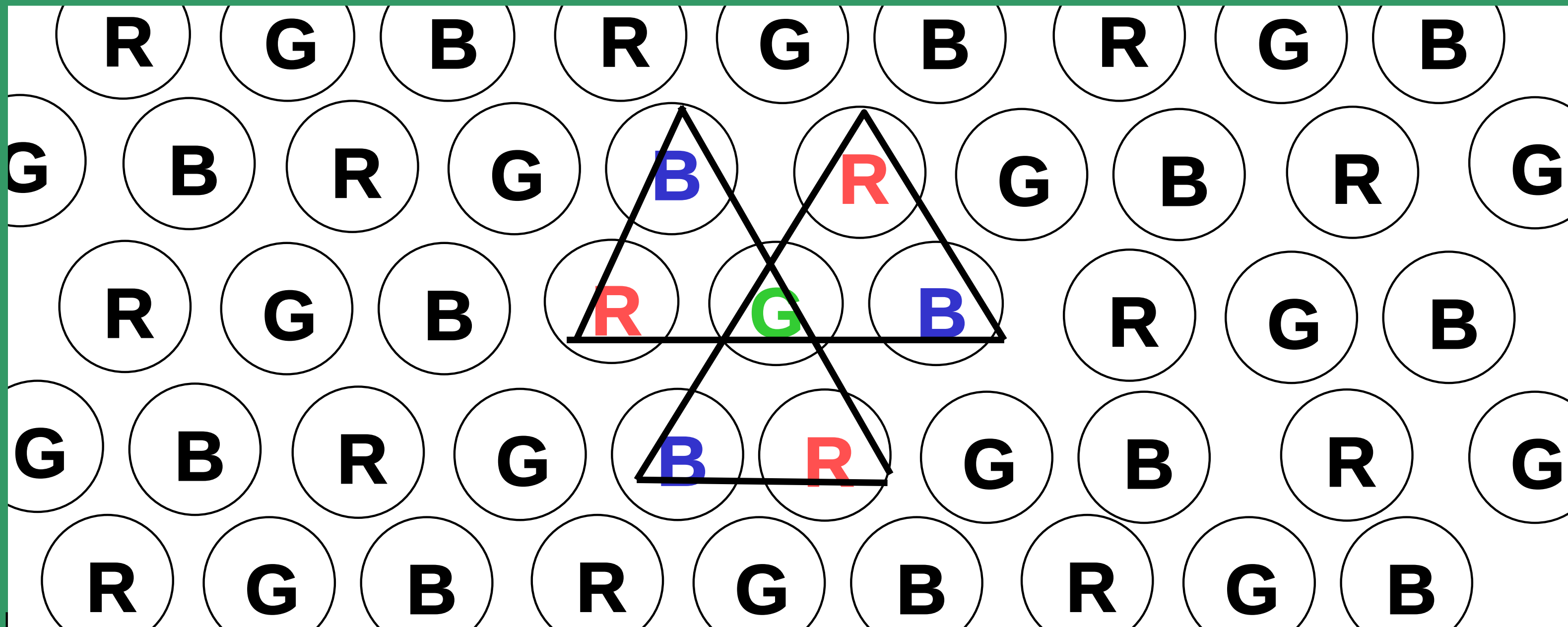
Some examples of pixel access times:

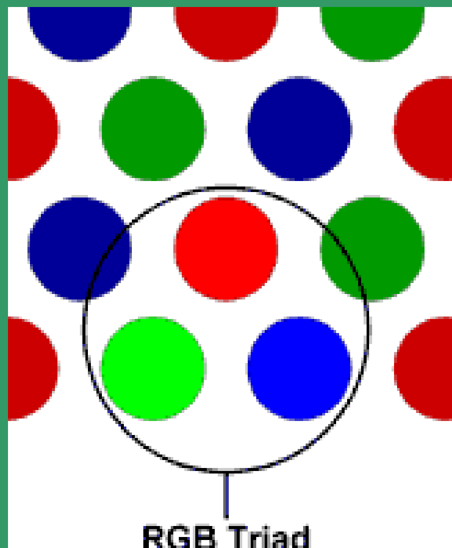
Frame Rate	Display Resolution	Pixel access time
30	512 x 512	105 ns
25	500 x 625	105 ns
60	1000 x 1000	26 ns
60	1024 x 1024	24 ns

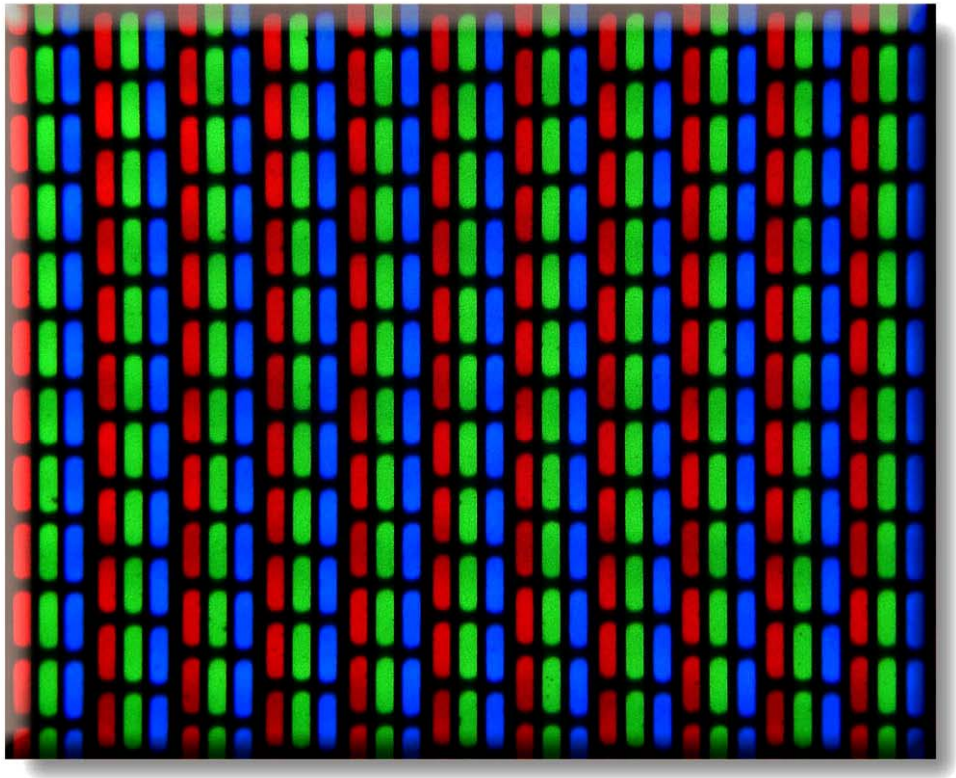
N-bit plane gray level Frame buffer

- Choice of the number of gray scales and colors depend on the value of N (bit plane size)
  - N = 1 – two colors (B&W)
  - N = 3 – 8 gray scales or colors
  - N = 8 – 256 gray scales or colors
  - N = 24 – 16 million colors
- For colored displays (raster-scan), three separate color guns must be used.
- Each bit/byte plane drives a color gun.

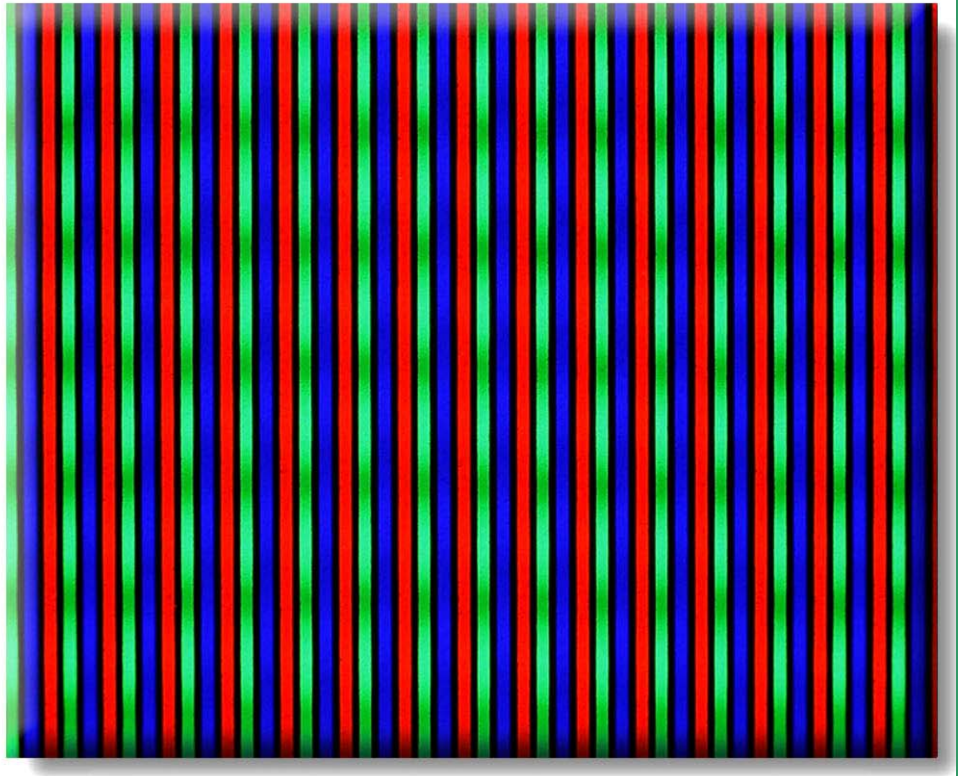
Phosphorus dot pattern for a shadow mask CRT







Shadow Mask



Aperture Grille