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Frame buffer architectures

A frame buffer is a large contiguous piece of computer memory which stores picture information to be displayed on computer screen. If only one memory bit, which is minimum, is used for each pixel in the raster display, then this amount of memory is referred to as bit-plane. If more than one bit is used for each pixel, then frame buffer is referred to as pixmap.

Figure 2.22, shows the architecture of a single-bit-plane black and white frame buffer raster display system, each pixel is represented by one-bit and has single bit-plane which yields a black and white, binary 0 and 1, display. The bit-plane or frame buffer is a digital device, and the raster display may be digital or analog. In most of the cases, the raster display is analog such as CRT. Hence to display picture information stored in frame buffer to CRT raster display a digital-to-analog conversion is required that's why a digital to analog converter (DAC) hardware device is used. All the picture information that are to be displayed on the screen are at first stored in a register (here the size of register is 1-bit which is essentially a single flip-flop). A 1024x1024 resolution of raster requires 2 10 x2 10 =2 20 bits=1MB memory space in frame buffer or bit-plane.

Frame buffer for gray level monochrome display
Additional bit-planes may be used in frame buffer to incorporate gray levels or colors. The intensity of each pixel on the CRT monitor is controlled by the corresponding pixel values in each of N-bit planes and the binary value from each of the N-bit planes is loaded in to corresponding positions in a register. The resulting binary number in the register at a time is a intensity level of a pixel to be displayed on the screen. The intensity level stored in register may have any value in between 0 to 2 N -1 which is converted in to its analogous voltage valueby the digital-to-analog converter. For gray images with 8-bits per pixel, there are 8-bit planes in frame buffer with 256 possible intensity levels in between 0 to 255.

Example 2.2: For a frame buffer having 3 bit-planes and a CRT monitor with resolution 1024x1024, the total number of intensity levels supported will be 2 3 =8 and memory space requirement for the frame buffer will be 3x1024x1024=3MB.

Figure 2.23: Frame buffer for monochrome gray level display
Further, look-up tables (LUTs) can be used in frame buffer architecture to support larger intensity levels in comparison to frame buffer. In this architecture (See Figure 2.24), a LUT is placed in between frame buffer and CRT raster. The resulting number retrieved through frame buffer and stored in register acts an index value to the LUT which stores the corresponding intensity value to be displayed on screen. If N is the number of bit-planes in frame buffer and the LUT is of W-bit wide, then 2 W intensity levels can be stored in LUT and out of 2 W only 2 N intensity levels are available at a time for W>N. This architecture allows one to store maximum number of intensity values of large range without increase in size of frame buffer.Frame buffer for color CRT

For implementing a color frame buffer, separate bit-planes for each primary color such as Red, Green, and Blue are used. Figure 2.25 shows frame buffer architecture for color CRT. These three primary colors, retrieved from individual frame buffer bit-planes are stored in separate registers which are in turn converted and combined at CRT to yield one of the possible 8-combinations of colors as listed in following Table 2.1. Further, additional bit-planes can be used for each of the three color guns. Color look-up tables (CLUTs) can be used to further expand the frame buffer to accommodate larger number of color intensity values. For N-bit planes per color with W-bit wide lookup table (2 3 ) N colors from a palette of (2 3 ) W possible colors can be shown at a time.

For a color monitor with 24-bits per pixel, 8-bits each for R,G, and B primary colors, there will be 8-bit planes each for every primary colors. The size of registers for each color planes will be 8-bits and similarly we require 8-bit DACs for each color channels.

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