Display Devices

Terminologies

Pixel

The **smallest number of phosphor dots that the electron gun can focus** on is called a **pixel**, it comes from the term **picture element**. Each pixel has a **unique address**, which the computer uses to locate the pixel and control its appearance. Some electron guns can focus on pixels as small as a single phosphor dot.

Fluorescence / Phosphorescence

When the electron beam strikes the phosphor-coated screen of the CRT the individual electrons are moving with the kinetic energy proportional to the acceleration voltage.

Some of this energy is dissipated as heat but the rest is transferred to the electron of the phosphor atoms making them jump to *higher quantum energy levels*

In returning to their previous quantum levels these excited electrons give up their extra energy in the form of light at frequencies that is colors predicted by the quantum theory

Any given phosphor has several different quantum levels to which electrons can be excited each corresponding to a color associated with return to an unexcited state

Further, electrons on some levels are less stable and turn to the unexcited state more rapidly than others.

A phosphors fluorescence is the light emitted as these very unstable electrons lose their excess energy whole 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

Since fluorescence usually last just a fraction of a microsecond the most of the light emitted is phosphorescence for a give phosphor

Persistence

A phosphor's persistence is defined as the time from the removal of excitation to the moment when phosphorescence has decay to 10 percent of the initial light output

The range of persistence of different phosphors can reach many seconds

The phosphors used for graphics display devices usually have persistence of 10 to 60 micro seconds

A phosphor with low persistence is useful for animation and a high persistence phosphor is useful to highly complex static pictures

Refresh rate

The refresh rate is the number of times per second the image is redrawn to give a feeling of un-flickering pictures and it is usually 50 per second

As the refresh rate decreases flicker develops because the eye can no longer integrate the individual light impulses coming from a pixel

The refresh rate above which a picture sops flickering and fuses into a steady image is called the critical fusion frequency (CFF)

The factors affecting the CFF are:

i. Persistence: longer the persistence the lower the CFF But the relation between the CFF and persistence is non linear

ii. Image intensity: Increasing the image intensity increases the CFF with non linear relationship

iii. Ambient room light Decreasing the ambient room light increases the CFF with nonlinear relationship

iv. Wave lengths of emitted light

v. Observer

Horizontal scan rate:

The horizontal scan rate is the number of scan lines per second The rate is approximately the product of the refresh rate and the number of scan lines

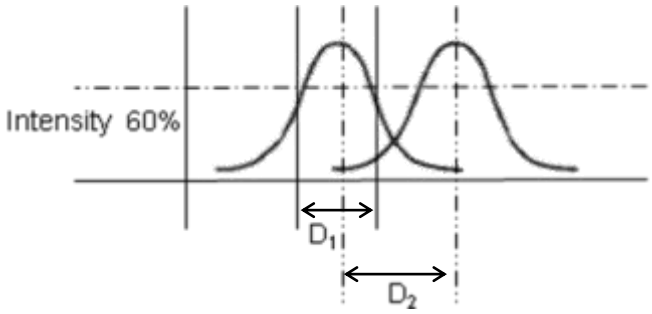
Resolution

Resolution is defined as the maximum number of points that can be displayed horizontally and vertically with out overlap on a display device

A monitor's resolution is determined by the **number of pixels on the screen**, expressed as a matrix. The more pixels a monitor can display, the higher its resolution and the dearer its images appear. For example, a resolution of 640 X 480 means that there are 640 pixels horizontally across the screen and 480 pixels vertically down the screen. The **actual resolution** is determined by the video controller not by the monitor itself—most monitors can operate at several different resolutions e.g. 800 x 600, 1024 x 768, 1152 x 864, 1280 x 1024. As the **resolution increases, the image on the screen gets smaller**.

Factors affecting the resolution are as follows

i. Spot profile The spot intensity has a Gaussian distribution as depicted in figure. So two adjacent spots on the display device appear distinct as log as their separation D2 is greater than the diameter of the spot D1 at which each spot has an intensity of about 60 percent of that at the center of the spot



ii. Intensity: as the intensity of the electron beam increases the spot size on the display tends to increase because of spreading of energy beyond the point of bombardment

This phenomenon is called *blooming* Consequently , the resolution decreases.

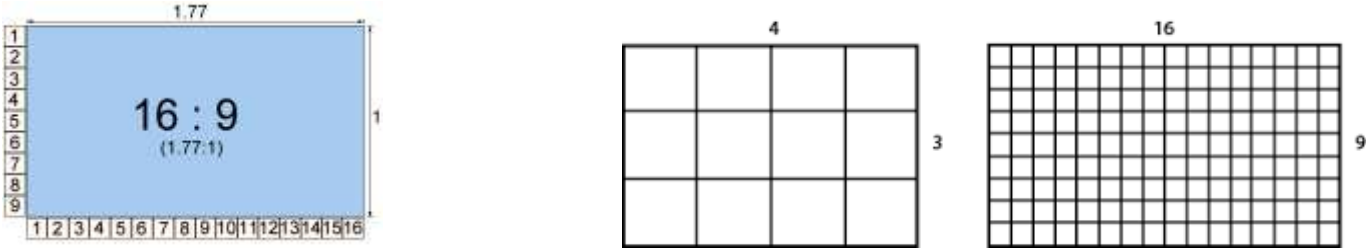
Thus it is noted that resolution is no necessarily a constant and it is not necessarily equal to the resolution of a pix-map, which is allocated in a buffer memory

Aspect Ratio

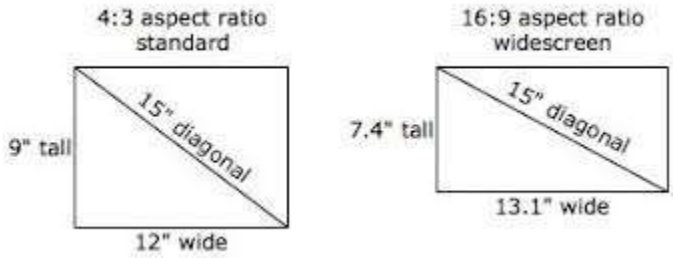
The ratio of horizontal points to the vertical points necessary to produce length of lines in both directions of the screen is called Aspect Ratio.

Aspect Ratio = Number of Horizontal Points / Number of Vertical Point

For example 4:3, 16:9



If the total resolution of the screen is 800 x 600 then the display has an aspect ratio of
Aspect Ratio = 800/600 = 4/3 = 4:3



Old TVs used to have an aspect ratio of 4:3 so they used to be square in shape
Modern TVs like LED, LCD have an aspect ratio of 16:9 so they are rectangular in shape
So a 15 inch CRT monitor has more height that a 15 inch LED monitor

Color CRTs

Color depends on the light emitted by phosphor.

Two type:

i. Beam Penetration Method

ii. Shadow Mask Method

I. Beam Penetration Method:

Two different layers of phosphor coating used Red (outer) and Green (inner)
Display of color depends on the depth of penetration of the electron beam into the phosphor layers

i. A beam of slow electrons excites only the outer red layer

ii. A beam of very fast electrons penetrates thru the red phosphor and excites the inner green layer

iii. When quantity of red is more than green then color appears as orange

iv. When quantity of green is more than red then color appears as yellow

Screen color is controlled by the beam acceleration voltage.

Only four colors possible, poor picture quality

ii. Shadow Mask Method

The inner side of the viewing surface of a color CRT consists of closely spaced groups of red, green and blue phosphor dots.

Each group is called a *triad*

A thin metal plate perforated with many small holes is mounted close to the inner side of the viewing surface. This plate is called *shadow mask*

The shadow mask is mounted in such a way that each hole is correctly aligned with a triad in color CRT

There are three electron guns one for each dot in a triad

The electron beam form each gun therefore hits only the corresponding dot of a triad as the three electron beams deflect

A triad is so small that light emanating from the individual dots is perceived by the viewer as a mixture of the three colors

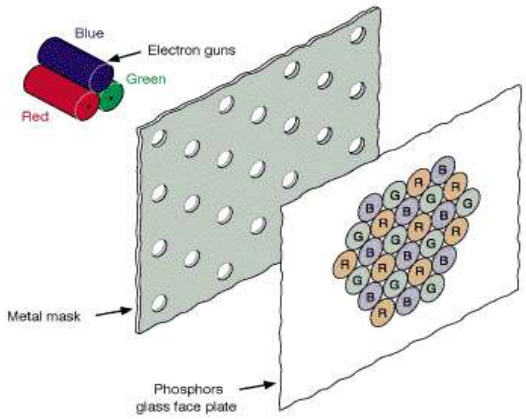
Thus, a wide range of colors can be produced by each triad depending on how strongly each individual phosphor dot in a triad is excited.

Two types:

a. A Delta –Delta CRT

A triad has a *triangular (delta) pattern* as are the three electron guns

Main drawback of this type of CRT is that a high precision display is very difficult to achieve because of technical difficulties involved in the alignment of shadow mask holes and the triad on one to one basis



b. A Precision Inline CRT

A triad has an *in-line pattern* as are the three electron guns

The introduction of this type of CRT has eliminated the main drawback of a Delta-Delta CRT

But a slight reduction of image sharpness at the edges of the tube has been noticed

Normally 1000 scan lines can be achieved

The necessity of triad has reduced the resolution of a color CRT

The distance between the center of adjacent triads is called a *pitch*

In very high resolution tubes, pitch measures 0.21 mm (0.61 mm for home TV tubes)

The diameter of each electron beam is set at 1.75 times the pitch

For example if a color CRT is 15.5 inches wide and 11.6 inches high and has a pitch of 0.01 inches

The beam diameter is therefore 0.01 x 1.75 = 0.018 inches

Thus the resolution per inch is about 1/0.018 = 55 lines

Hence the resolution achievable for the given CRT is 15.5 x 55 = 850 by 11.6 x 55 = 638

The resolution of a CRT can there fore be increased by decreasing the pitch

But small pitch CRT is difficult to manufacture because it is difficult to set small triads and the shadow mask is more fragile owing to too many holes on it .

Besides the shadow is more likely to warp from heating by the electrons

Hard Copy Devices (Output Hardware)

Printers

Printed output is referred to as hard copy and do not require electric power as they are printed on papers to read after printing and provide permanent readable form information

According to how they print printers can be of different types:

- Character printers prints one character of a text at a time
- Line printer prints one line of the text at a time
- A page printer prints one page of the text a t a time

According to the technology used printers produce output by either impact or non impact methods

Impact printers

Impact printers press the formed character faces against an inked ribbon onto paper

Character impact printers often have a dot matrix print head containing a rectangular array of protruding wire pins with a number of pins depending on the quality of the printer

Individual characters or graphics patterns are obtained by retracting certain pins so that the remaining pins form the pattern to be printed.

Non-Impact Printers

Non impact printers use laser techniques, ink-jet sprays etc to get images onto paper.

Ink-jet Devices

Ink-jet methods produce output by squirting ink in horizontal rows across a roll of paper wrapped on a drum.

When a heater is activated a drop of ink is exploded onto the paper

The print head contains an ink cartridge which is made up of a number of ink filled firing chambers each attached to a nozzle thinker that n a human hair

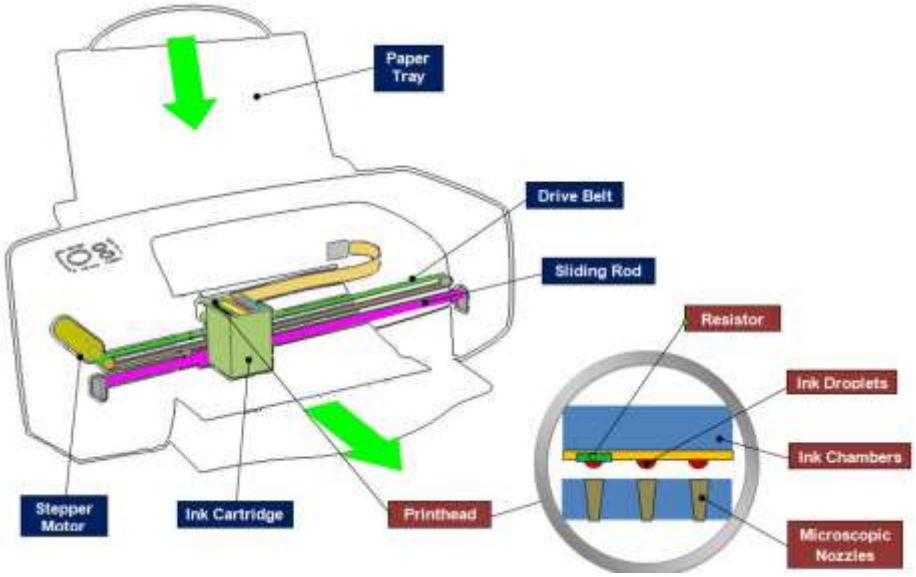
When an electric current is passed thru a resistor the resistor heats a thin layer of ink at the bottom of the chamber

Causing ink to boil and form a vapor bubble that expands and pushes ink thru the nozzle to form a droplet at the tip of the nozzle

The pressure of vapor bubble forces the droplet to move to the paper

A color ink jet printer employs four ink cartridges: one each for cyan, magenta, yellow and black

The ink of desired color can be placed at any desired point of the page in a single pass



Laser Devices

These are page printers

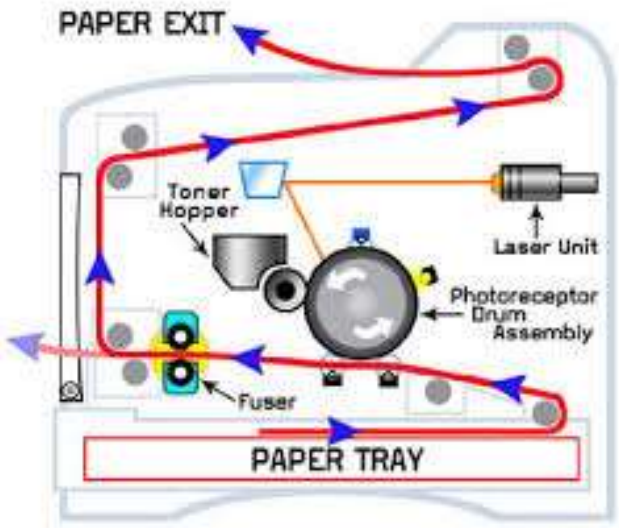
They use laser beam to produce an image of the page containing text graphics on a photosensitive drum which is coated with negatively charge photo conductive material

In a laser device a laser beam creates a charge distribution on a rotating drum coated with a photo electric material such as selenium. Toner is applied to drum and then transferred to paper. Just as the electron gun in a monitor can target any pixel, the laser in a laser printer can aim at any point on a drum, creating an electrical charge.

Toner, composed of tiny particles of oppositely charged ink, sticks to the drum in the places the laser has charged

With pressure and heat, the toner is transferred off the drum onto the paper.

The paper then moves to a fusing station where toner is permanently fused on the paper with page



Potters

Plotter is a device that draws pictures on paper based on commands from a computer

They are used to produce precise and good quality graphics and drawing under computers control

They use motor driven ink pen or ink jet to draw graphic or drawings

Drawings can be prepared on paper, Velluym or Mylar (Polyester film)

Drum plotters

A drum plotter contains as long cylinder and a pen carriage

Paper is placed over the drum and the drum rotates back and forth to give up and down movement

The pen is mounted horizontally on the carriage that moves horizontally along with the carriage left to right or right to left on the paper to produce drawings

The pen and drum both mover under the computer control to produce the desired drawing

Several pens with different color dinks can be mounted on the carriage for multicolor drawing

Inkjet plotters

Many plotters us ink jets in place of ink pens

The paper is placed on a drum and the ink jets with different colored ink are mounted on a carriage

Such plotters are capable of producing multicolor large drawings