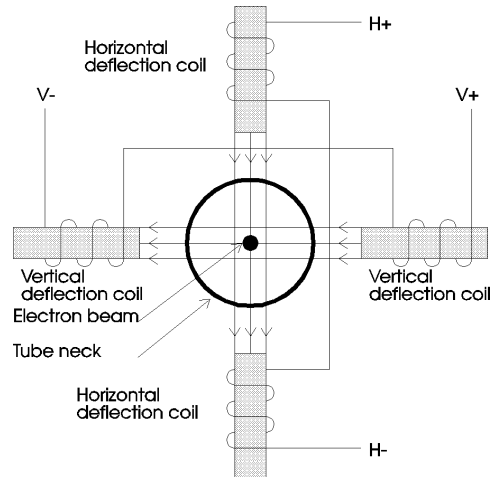


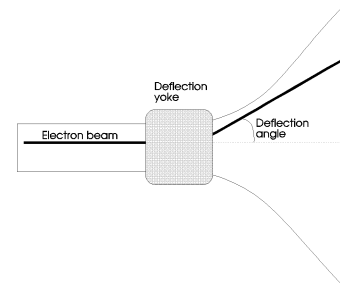
DEFLECTION

The beam is moved around the screen by magnetic fields generated by a deflection yoke. Starting in the top left corner the electron beam moves left to right across the 'raster' many times while it slowly moves top to bottom. When it strikes the front of the screen, the electrons collide with the phosphors creating light.

In magnetic deflection, two pair of deflection coils are mounted around the neck of the tube. The pair of coils above and below the electron beam cause horizontal deflection. Electrons move at a right angle to the flux lines (magnetic fields) created by the coils. The electron beam is bent at a right angle to the magnetic lines from the deflection coils.

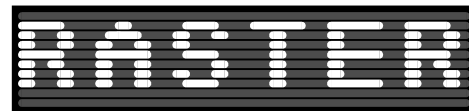


The amount that the electron beam is bent depends on the strength of the magnetic field caused by current passing in the wires that form the deflection coils. To get a beam to sweep from left through center and to the right a current ramp must start with a large negative current. As the current decreases the beam moves back toward center. When the current reaches zero the beam is in the center of the picture. For the right hand side of the picture the current ramps up in a positive direction.



Raster Scan CRT

Television sets and most computer monitors are raster scan. The electron beam scans the screen from left to right and top to bottom to create a raster on the screen. Characters are formed by changing the brightness of dots at the required points on the raster.



Stroke monitor

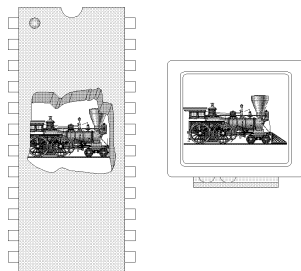
In the stroke character CRT the image is painted by the electron beam. There is no raster. This type of CRT is often used for computer aided design and other applications where line drawn images are used. The effect is much like a pen plotter.



Storage Tube CRT

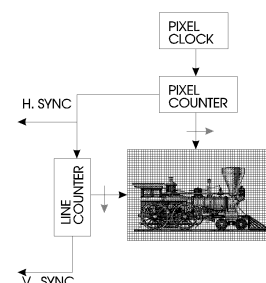
This type of display contains a special phosphor that maintains the image created by the electron beam. This means that the screen does not need to be refreshed as often as in other types of CRT's.

CRT CONTROLLER



The picture on a CRT monitor comes from a computer's memory. If you could see inside a computer memory chip; one would find a picture drawn with numbers. There is a number for each dot. The number determines that dot's intensity and/or color.

The picture is transferred from memory to CRT serially one pixel at a time. As the monitor scans across the tube the computer scans across memory. After the right hand



edge of the picture the computer resets the pixel counter, increments the line counter and generates a horizontal pulse to tell the monitor to start the next line. When the line counter reaches the maximum number it will be reset and a vertical sync pulse will be sent to the monitor. This will cause the monitor to get ready for the top of the next picture.

Computer memory needed for various formats

M Bytes of memory needed for:

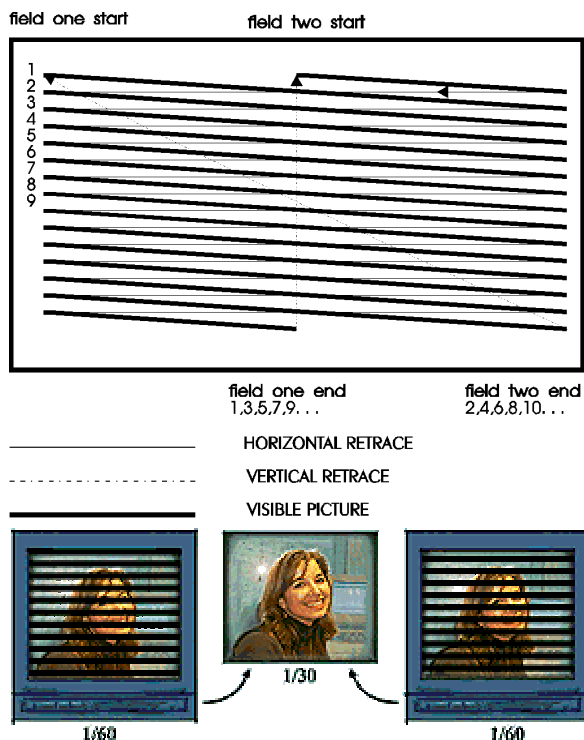
Tube size	Viewing area	Max. resolution	Working resolution	256 colors 8 bit color	65000 colors 16 bit color	16,000,000 colors 24 bit color
14"	12,5" - 13"	1024x768	640x480	0.5	1	2
15"	13,5" - 14"	1280x1024	800x600	1	2	2
17"	15,5" - 16"	1600x1200	1024x768	1	2	4
19"	17,5" - 18"	1600x1200	1280x1024	2	4	4
21"	19,5" - 20"	1600x1200	1280x1024	2	4	4
24"	21,5" - 22"	1900x1200	1600x1200	2	4	8

INTERLACE

The next diagram shows an example of an interlaced picture. The odd lines are scanned first omitting the even lines. Then the even lines are scanned to complete the picture frame.

The benefit of an interlaced picture is that the horizontal and video rate can be cut in half. This makes the video card in the computer much easier to build. The video amplifier and the horizontal deflection circuits in the monitor are also simpler. An interlaced picture as used in television, works well for pictures of flowers and trees or action shots. Generally an interlace picture is not excitable for data terminals or application where the viewer is close to the picture.

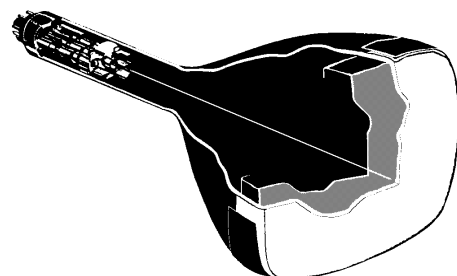
An example of where interlace does not work is the letter "E". The vertical bar in the letter is drawn both in the odd and even fields and thus gets updated 60 times a second. The three horizontal lines in the letter "E" reside in the odd field and only get drawn 30 times a second. This makes the right side of the "E" flicker.



CRT

The CRT or cathode-ray tube, was developed by Ferdinand Braun (a German scientist) in 1897. It did not appear in homes in TV sets until the late 1940s. It is surprising that a 100 year old invention is the mainstay of a computer industry that changes so rapidly.

A Cathode Ray Tube is a sealed glass bottle with no air inside. It begins with a slim neck and tapers outward to forms a 'screen'. It is coated on the inside with phosphor that emits light when excited. Different phosphors emit different colors of light. For color tubes the inside has a matrix of thousands of tiny phosphor dots. The dots are arranged in groups of three (red, green and blue).



In the neck of the CRT is the electron gun, which is composed of a cathode, heat source control elements and focusing elements. Color monitors have three guns, one for each phosphor color. Heater from a filament is needed to boil off electrons (negatively charged) from the cathode. Control grids block/allow electrons to leave the cathode. Focus elements create 'lenses' that focus the electron beam. The electrons are drawn toward the phosphor dots by a positively charged anode, located near the screen.

CRTs have advantages: large viewing angel (190^0), very large contrast ratio (300:1), bright pictures and long life.

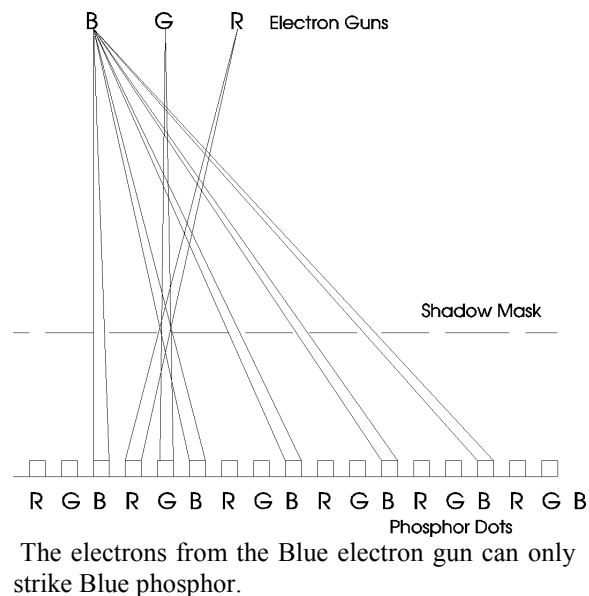
Electron beam

The heart of a CRT tube is the flow of electrons from the gun in the back of the tube to the phosphor in the front of the tube. Electrons excite the phosphor, producing light. Formation of the electron beam is one of the most important aspect of CRT technology. The aim is to create a well focused beam that can address smaller individual dots.

SHADOW MASK

The electron gun resides in the back of the tube. A stream of electrons strike the phosphor coating on the inside of the tube. In color CRT's the beam passes through holes in a metal plate called a shadow mask. The purpose of the mask is to keep the electrons beams precisely aligned with the tri-color phosphor dots. The size and spacing of these holes are called the CRT's dot pitch. The smaller the holes the smaller the dot pitch and the sharper the image. The holes in most shadow masks are arranged in triangles, with the exception of Sony Trinitron CRTs that use slots.

The purpose of the shadow mask is to keep an electron beam from striking the wrong phosphor.

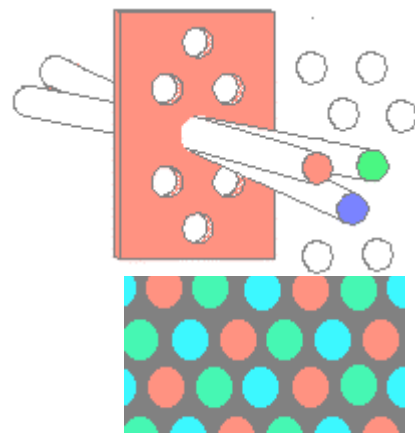


There are four different types of masks. Shadow Mask, Aperture Grill, Slot Mask and asymmetrical dot mask.

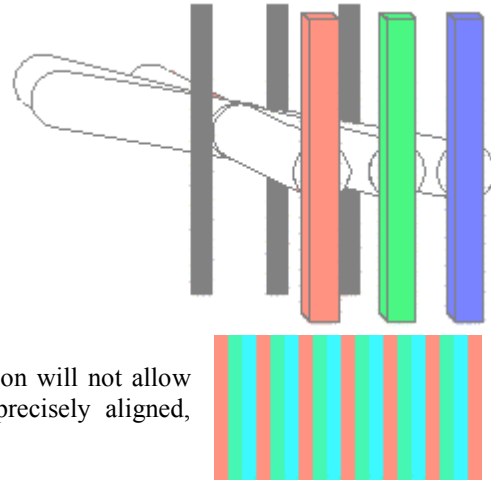
Shadow Mask

This is a very popular technology. It is made up of a screen laying just before the phosphors. A shadow mask has evenly spaced holes in the mask through which the red, green, and blue electron guns aim, helping the guns hit the right phosphor dots. The phosphor dots are also spaced evenly, so each triad of red, green, and blue dots forms an equilateral triangle. The center-to-center distance of 3 dots of the same color also form an equilateral triangle. Diagonal and vertical measurement of the pitch are equal. A shadow mask will absorb about 80% of the electrons.

Stripe Mask or Aperture Grill



This technology is used by Sony in their Trinitron tubes and Mitsubishi in their Diamondtron tubes. The aperture grill consists of vertical wires pulled very tight. Because the mask has less metal in it more of the electrons hit the phosphor. The phosphor is also placed in vertical stripes not dots. A higher percentage of the area is covered by phosphor. The result is a brighter picture with good color saturation. Darker tinted glass can be used which gives a higher contrast ratio.

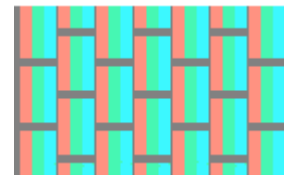


Shadow mask systems suffer from heat build-up causing the mask to expand and altering its shape. Aperture Grilles remains mostly unaffected. A strong vertical tension will not allow the grille to expand horizontally. The beams remain precisely aligned, ensuring color purity.

The pitch is given as stripe pitch, the center-to-center distance between two stripes of the same color.

Slot Mask

This technology is used by NEC by the name of Cromaclear. It is a combination of Shadow Mask and Aperture Grill technologies. The phosphor dots are elliptical (tall and thin). This design yields individual oval dots instead of round dots on the screen, which makes the image brighter than a standard dot mask. Because the mask is a single piece, it doesn't need horizontal wires to hold a grille in place. Slot mask is measured as stripe pitch, but the pitch is measured at the mask, not the phosphors. All other masks measure the phosphors. The mask holes will always be tighter together than the phosphors.



Asymmetrical dot mask

The dots on the screen are arranged so that unlike a standard dot mask, vertical and diagonal pitches are different. The triangle formed by any given dot with the two closest dots of the same color in the line above and below forms an isosceles triangle (with only two equal sides), rather than an equilateral triangle.

Comparing Pitch Numbers

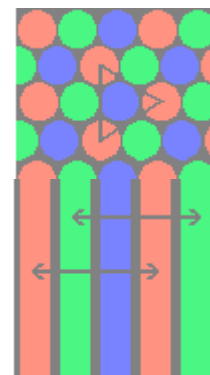
When comparing pitches of other monitors to a standard shadow mask monitor, the general rule of thumb is to multiply the shadow mask dot pitch by 0.866 to get a fair comparison. For example: a 0.26 mm dot pitch $\times 0.866 = 0.22$ mm is a fair comparison to a 0.25 mm stripe pitch, or mask pitch. This is a fair comparison because dot pitch is given in diagonal or vertical measurements. Stripe pitch and mask pitch is measured horizontally.

A quality color CRT with a 0.25-mm dot pitch can resolve the equivalent of 100 dpi ($25.4/0.25$). A monochrome CRT, which does not have a shadow mask, is limited by the ability of the electron optics and video bandwidth to form a pixel.

Dot Pitch

The distance between two dots of the same color in mm usually measured diagonally. For masks which use stripes rather than dots, the pitch equals the horizontal distance. Dot pitch is the spacing of the holes or slots in the shadow mask.

The dot/slot/line pitch of TV grade CRTs are very large. Small TV sets may run .60mm, a 19 inch set may have .75mm dot pitch. A large 25 inch TV grade tub will



reach .9mm. Computer grade monitors will typically run in the .25 to .28 range with some as fine as .22mm.

Color

The electrons strike the phosphor coating on the inside of the screen. (Phosphors are materials that glow when struck by electrons.) In color monitors three different phosphor materials are used; red, green and blue. The stronger the electron beam the brighter the glow from the phosphor. If red, green and blue adjacent phosphor dots are excited with the same amount of energy then the results is white light. To get different colors, the intensity of each of the three beams is varied.

PERSISTENCE

The entire picture is not present on the CRT tube at one time. Only one "dot" or pixel is being struck by the electron beam at a time. After a beam leaves a phosphor dot, the dot continues to glow briefly, this is called persistence. The persistence of the phosphor denotes the length of time the phosphor continues to glow. For the image to remain stable, the phosphors must be repeatedly scanned by the electron beam at a rate faster than the response of the eye.

Phosphor Selection

For monochrome CRTs the screen is comprised of a smooth, continuous coating of phosphor which has been applied to the inside of the glass faceplate. A thin film of aluminum is then applied to the phosphor. This coating protects the phosphor from direct electron bombardment while transmitting the energy from the electron beam to the phosphor crystals. When excited by the electron beam, the phosphor crystals emit light. The aluminum coating reflects light that would otherwise be lost.



The design criteria for selecting a phosphor must take into consideration the effects of beam current on spot size and the ability of the electron gun to contain the beam bundle (maintain focus). Additional consideration must be given to the refresh rate for flicker free images.

Smear and tailing are characteristic of scrolling information on a display with phosphor having too long of a persistence. Interlaced displays gain resolution with higher line counts by utilizing long persistent phosphors to prevent flicker at the expense of smearing. However, current display technology in combination with high efficiency, fast phosphors provide a stable image above 76Hz vertical refresh rate without tailing or smearing.

Transmittance Values

Monochrome CRTs are commonly available with two transmittance values. Standard, which is 42%, and Dark, which is 30%. The use of darker glass will enhance the contrast and works best with white characters on a black background. Dark glass is less effective on reverse video applications and will put a heavier load on the electron gun.

Anti-reflective Panel

This is a specially panel attached on CRT surface to prevent surface glare. Without affecting the CRT, the panel can minimize glare from the surface and block Electromagnetic interference from the CRT. However because of its high cost, it is only applied to expensive high-resolution monitors.

Anti-reflective Coating

Using the same theory applied to AR-Panel, different types of layer are coated on CRT surface to reduce glare without affecting the focus. It is also known as Multi-layer Coating.

Anti-Static Coating

This is a coating on CDT surface with special chemicals to prevent static when a monitor is impressed to power sources. To acquire MPR II, Anti-Static Coating must be applied.

Mechanical Etching

This is the method of treatment of CRTs in highresolution applications where anti-glare is required and resolution is critical. This process provides greater attenuation of reflected images than Chemical Etching and less defocusing of the displayed image.

Electrostatic Film (ESF)

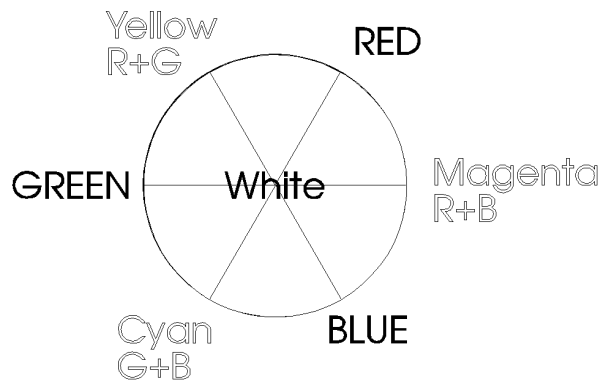
The ESF treatment utilizes a coating commonly referred to as SiO₂ (Silicon Dioxide). This treatment provides the attributes of chemical etching along with static dissipative properties

Notched Filter Panels

Notched Filter Panels are used for applications which require "Sun light readable" displays, such as those in FAA control towers and aircraft displays. Narrow energy spectrum phosphors are used with these panels. Notched Filter panels are typically a laminated configuration utilizing a dyed laminate between two glass substrates.

COLOR

To display colors, monitors add light; red green and blue. If red, green and blue light is mixed together, we get white light. When white is required on the screen, three electron guns hit the red, green and blue dots on the inside of the screen, which in turn glow together and produce white light.



Color wheel showing primary colors.

HUE

The HUE is the color (or tint). Has nothing to do with how bright the color is.

SATURATION

Saturated colors are intense. Pale colors have little saturation. The word saturation indicates how little white there is in the color. A fully saturated color has no white. Colors that can be fully saturated are: red,

yellow, green, cyan, blue, and magenta. A vivid red is fully saturated. Pink is red plus white. Pink is a desaturated red.

LUMINANCE

The luminance indicates the amount of light intensity. Luminance is not effected by the color of the light. Different colors have shades of luminance, some colors appear brighter than others. A picture of a yellow candle flame may appear to be brighter that a cyan (blue green) flame. A light meter will indicate that both pictures have the same light level or luminance.

WHITE

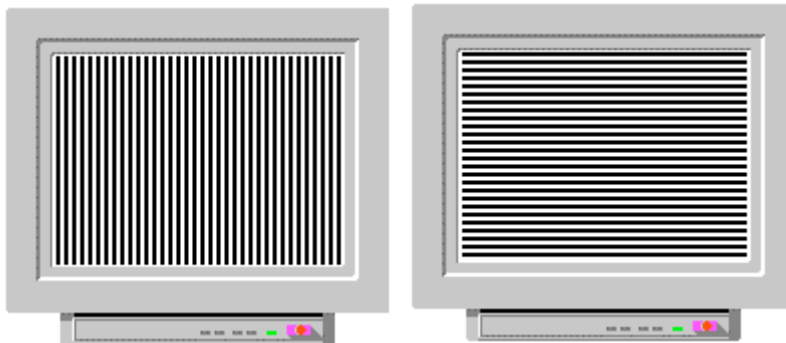
White light can be considered a mixture of red, green and blue in the proper mixture. Just as a prism brakes white light into a rainbow; a rainbow of colors can be mixed into white light.

The reference white for television is 6500K. This bluish white color was chosen to simulate daylight. The symbol K indicates degrees Kelvin where 0K equals -273°C (absolute zero).

Resolution

The resolution refers to the sharpness, or detail of a picture, and is a function of beam size and dot pitch. Resolution is the number of dots which make up the width and the height of the picture. A monitor with a resolution of 640x480 has 307,200 dots. It is obvious that the resolution must match the sizes of the monitor, the electron beam diameter and the dot pitch of the shadow mask. If the 307,200 dots were put into a 2cm square then the human eye could not see individual pixels. If 300,000 very small pixels were put on a very large screen then your eye would find little dots surrounded by a vast black void. The diameter of the electron beam should be about the size so the pixels just touch each other but do not over lap badly.

The maximum resolution of a color monitor is set by the density of the shadow mask. Most monitors specified the 'top end resolution' at or slightly beyond the density of the dot pitch.



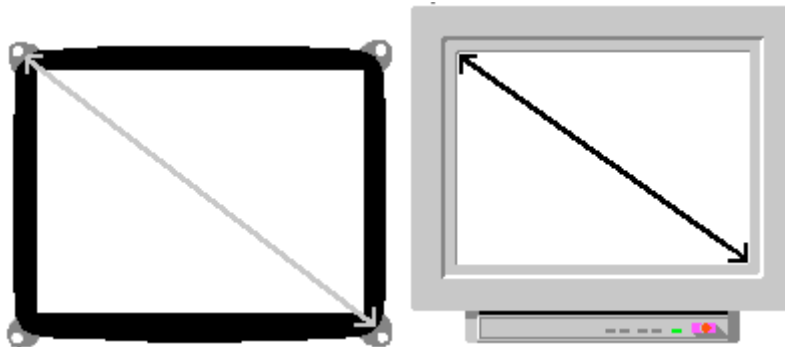
Graphics Formats

Date	Standard	Description	Resolution	No. colours
1981	CGA	Colour Graphics Adaptor	640 x 200 160 x 200	None 16
1984	EGA	Enhanced Graphics Adaptor	640 x 350	16 from 64
1987	VGA	Video Graphics Array	640 x 480 320 x 200	16 from 262,144 256
1990	XGA	Extended Graphics Array	800 x 600 1024 x 768	16.7 million 65,536
	SXGA	Super Extended	1280 x 1024	65,536

		Graphics Array		
	UXGA	Ultra XGA	1600 x 1200	65,536

Viewable size

Screen size is the measurement of the picture tube diagonally from one corner to another. Manufacturers publish the viewable screen sizes, in addition to the Cathode Ray Tube (CRT) sizes of their monitors. The CRT size is the actual size of the picture tube. The viewable screen size is the usable screen area. Because the picture tube is enclosed in the plastic casing, the viewable screen size is slightly smaller than the CRT or actual screen size.



Pixel

A pixel is the smallest piece of the screen that can be controlled individually, each pixel can be set to a different color and intensity.

Bit Depth Color Depth

The number of colors (or shades of gray) used to represent the image. Typical values are 4, 8, 16, and 24-bit color, allowing 16, 256, 65,536 and 16,777,216 colors. "True Color" with it's 16.8 million different colors is about as many as the human eye can distinguish.

Grayscale

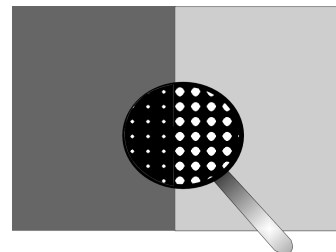
Shades of gray that represent light and dark portions of an image. Color images can also be converted to greyscale where the colors are represented by various shades of gray

Luminance

The amount of light intensity; one of the three image characteristics coded in composite television (represented by the letter Y). May be measured in lux or foot-candles. Also referred to as Intensity.

Halftone

An image type that simulates grayscale by varying the sizes of the dots. Highly bright areas consist of large dots, while lighter areas consist of smaller dots.



Gamma

A mathematical curve representing both the contrast and brightness of an image. Moving the curve in one direction will make the image both darker and decrease the contrast. Moving the curve the other direction will make the image both lighter and increase the contrast.

Chroma, Chrominance

The color portion of a video signal that includes hue and saturation information. Requires luminance, or light intensity, to make it visible.

Trichromatic

The technical name for RGB representation of color to create all the colors in the spectrum.

YUV

A color encoding scheme for natural pictures in which luminance and chrominance are separate. The human eye is less sensitive to color variations than to intensity variations. YUV allows the encoding of luminance (Y) information at full bandwidth and chrominance (UV) information at half bandwidth.

Uniformity

When a monitor has uniformity, its screen has uniform brightness level over the entire screen and causes no discomfort to users. Purity is one of the determinants of uniformity and temporary un-uniformity can be corrected by degaussing. Also, we can think of 'Brightness Uniformity' and 'White Uniformity'.

1. Brightness Uniformity

Most CRTs would have different brightness level on different spots of the screen. Brightness uniformity is the ratio of brightness on the brightness spot to that of the darkest spot.

2. White Uniformity

White uniformity indicates the difference in brightness of white color on a full white pattern display. It is the ratio between the maximum brightness and the minimum brightness.

Purity

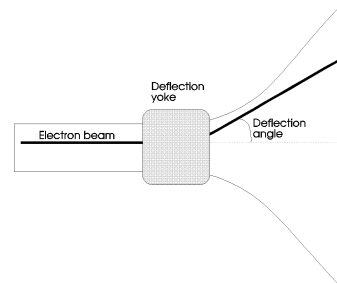
Poor purity comes from part, or all of, an electron beam striking the wrong color phosphors. To achieve good purity each of the R, G, B electron beams must land correctly on the R, G, B phosphor dots. This involves the interrelations between the electron guns, Shadow Mask holes, and the phosphor dots.

Pixelisation

Graininess in an image that results when the pixels are too big.

Deflection Angle

The maximum angle the beam makes with respect to the gun axis when lighting a corner of the display. A 110 degree tube is shorter than a 90 degree tube. This is the advantage of higher deflection angle CRTs. On the negative side, high deflection angles means higher deflection power. They are more difficult to converge, maintain focus, purity, and keep uniform brightness. Geometric errors are more challenging. Yoke design is also difficult.



Years ago 60 degrees was high tech. For TV CRTs 110 degrees is about the practical limit now. For color monitors 90 degrees seems typical.

CRT Aspect Ratio

Nearly all CRTs have a 4:3 aspect ratio (H:V). With HDTV there are now tube with aspect ratios near 16:9.

The very first TV sets may have been using a round tube for a rectangular picture. Hollywood's first transmission format specs was 4:3. Rectangular CRTs for TV use had been developed as early as 1939, with the first American rectangular tube to enter production in late 1949.

("The Cathode Ray Tube: Technology, History, and Applications" Peter Keller)

Refresh Rate

Expressed in Hertz (Hz), in interlaced mode this is the number of fields written to the screen every second. In non-interlaced mode it is the number of frames (complete pictures) written to the screen every second. Higher frequencies reduce flicker, because they light the pixels more frequently, reducing the dimming that causes flicker. Also called vertical frequency. The vertical rate of the monitor. How often the picture is drawn on the screen. Refresh rates have moved away from the standard 60 Hz to 75 and 80 Hz.

Overscan

TVs are set up to generate a picture which is 10-15 percent large than the visible face of the CRT. Years ago this was done to make the design easier. Component tolerances, power line voltage changes and poor high voltage regulation would be masked. The fact that the edge of the picture was not straight and true was hidden. With today's components and quality designs there is almost no reason to have any more than a couple of percent overscan.

Underscan

Computer monitors are usually set up for no overscan, the entire image is visible. To get the biggest picture possible many users push vertical and horizontal size out to just touch the edge of the bezel. The edge of the picture does not perfectly match the bezel. The closer the picture is to the bezel the more acute the errors appear.

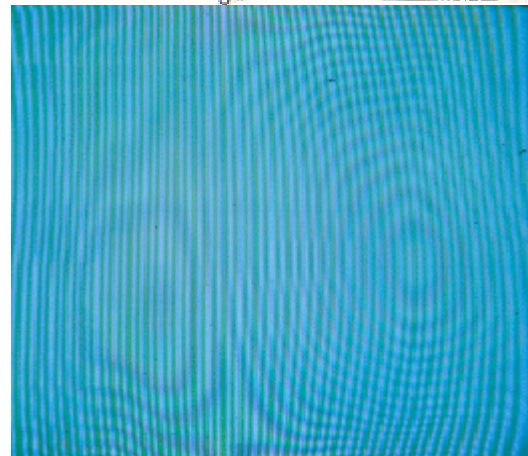
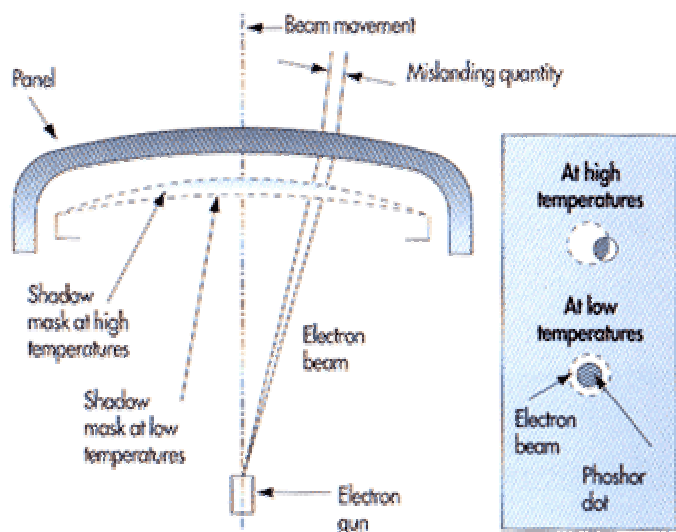
Doming

The shadow mask inside the CRT is a thin sheet of steel or InVar positioned about a half an inch behind the phosphor screen. The shadow mask is susceptible to thermal expansion. In areas of high beam current the shadow mask will deform, shifting the position of the holes or slots in the shadow mask. Individual phosphor dot may be spaced as little as .13 mm apart (for a .22 mm dot pitch CRT). Very little movement in the shadow mask cause the electron beam to strike the wrong color phosphors. The results is poor color purity and discoloration.

InVar shadow masks can sustain two to three times higher current density than steel shadow masks without noticeable problems.

Trinitrons are resistant to small area doming because the wires are under tension. The suspension components can still expand result in color purity with an overall bright picture.

Moiré



At low resolution there will be no moiré effect. Each pixel may extend over several holes in the shadow mask. As the resolution goes up the number of pixels may approach the number of shadow mask holes. Individual pixels no longer cover enough phosphor dots to ensure that they are constant brightness or constant color. The average of all the pixels in an area will still be expectable.

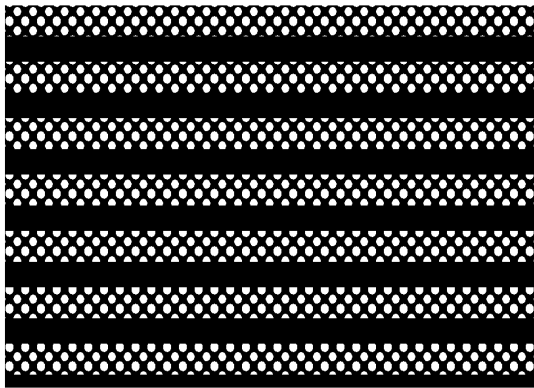
Moiré appears as wavy lines, contour lines, or light and dark bands often seen in areas of constant brightness. These may be very fine or 2 cm large and changing across the screen. Tubes with good focus will have worse moiré.

There are two sources of moiré. Video moiré is caused by the video pattern (horizontally) verses the dot pitch. Raster moiré is the spacing of scan lines verses the dot pitch. Trinitrons, which do not have a vertical dot structure should not have interference of this sort from the raster lines will have interference from the horizontal pixel structure.

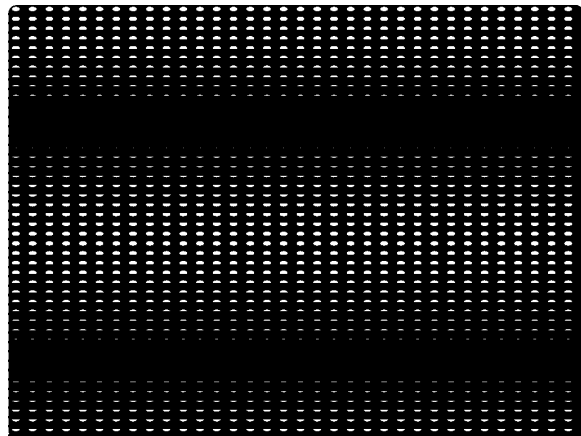
You can test for moiré by slowly adjusting the vertical size and horizontal size. If it is moiré, you should see the pattern change in location and frequency. Changes to vertical and horizontal position will change the moiré patterns very little. They will not remain locked to the moving image.

Some monitors have a Moiré control or switch. Generally this control causes every other picture to be moved very slightly. Generally the movement is 0 to .5 pixels. A similar effect is to slightly de-focus the picture.

A similar effect may be bad video cable termination creating reflections and ghosting.



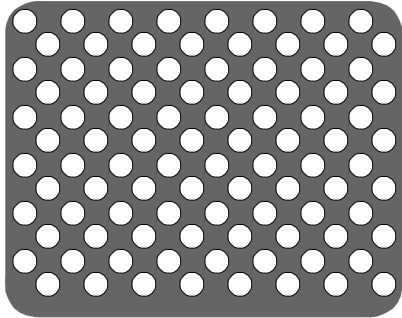
An example of large beam with fine shadow mask.



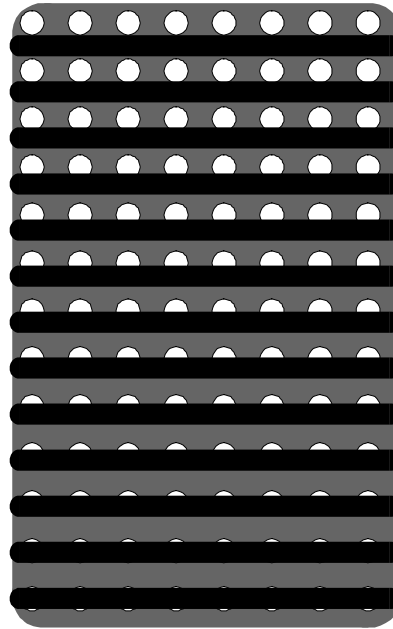
An example of a beam thats 4% different than the mask size.

The image to the right is an expanded piece of the one above it. The purpose is to show moiré.

Real shadow masks are more like this:



Which helps reduce the moiré problem.



Jitter, Swim & Drift

Jittering refers to any rapid and minute trembling of the dots on a monitor caused by noise generated from either mutual interference between monitor power, bias, video, PCB Pattern constituting Micro-Processor circuit, or improper grounding. Jitter refers to the fastest trembling at over 30Hz rate. Between 1Hz and 30Hz is called Swim. Slow trembling of less than 1Hz is called Drift. All monitors have an element of jitter at different scale. Although it may not be recognized by end-users since it is very minute, jittering may cause eye weariness and should be regulated. In Part 3 of ISO 9241, an Ergonomics regulation, diagonal movement of dots must be less than 0.1 mm.

HORIZONTAL SWITCH/DAMPER DIODE

On the right hand side of the screen, the H. switch transistor conducts current through the deflection yoke. This current comes from the S correction capacitors, which have a charge equal to the effective supply voltage. The damper diode allows current for the left hand side of the screen to flow back through the deflection yoke to the S capacitors.

FLYBACK CAPACITOR

The flyback capacitor connects the hot side of the yoke to ground. This component determines the size and length of the flyback pulse. 'Tuning the flyback capacitor' is done to match the timing of the flyback pulse to the video blanking time of the video signal. The peak flyback voltage on the horizontal switch must be set to less than 80% of the V_{ces} specification. The two conditions of time and voltage can be set by three variables (supply voltage, retrace capacitor and yoke inductance) .

ABL or AUTOMATIC BRIGHTNESS LEVEL

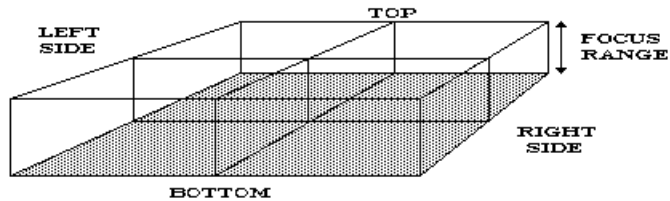
Most monitors are capable of displaying a small very bright area, but can not display a large very bright area. If the current from the high voltage supply is too high the monitor will reduce the brightness level.

X-RAY SHUT DOWN

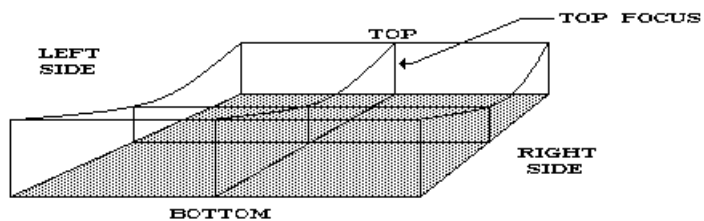
X-ray shut down is a function much like ABL limits. If there is too much power going into a CRT tube there is a possibility of generating X-ray radiation. Some CRT monitors monitor the voltage and/or the current going into the CRT tube. If dangerous power levels exist the monitor will shut down.

FOCUS

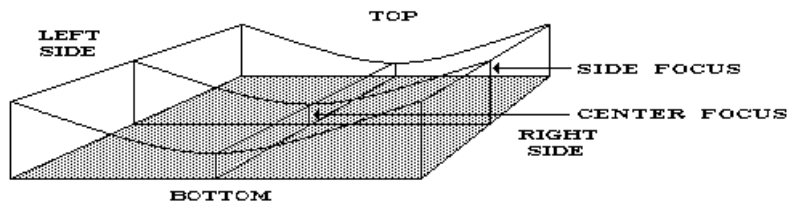
All monitors have the ability to set a focus voltage. The voltage is DC and will be the same for all areas of the picture.



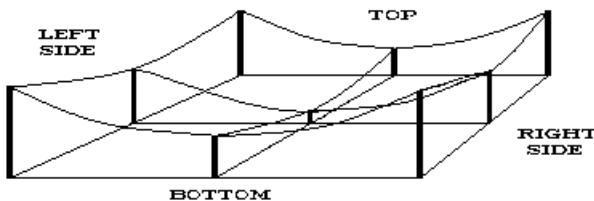
The vertical focus modulation sets the focus voltage for the top and bottom of the picture.

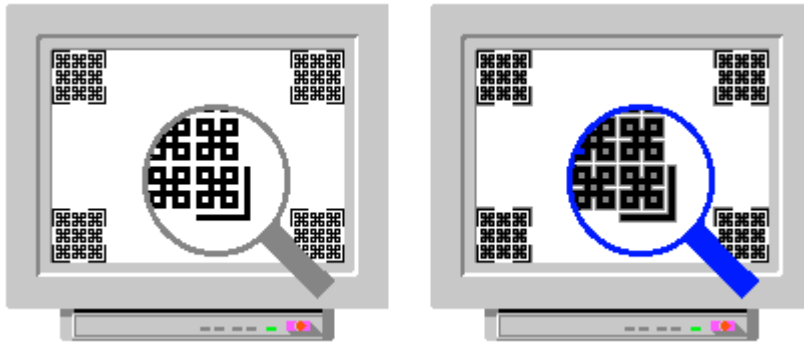


The horizontal focus modulation sets the focus voltages along the side of the picture.



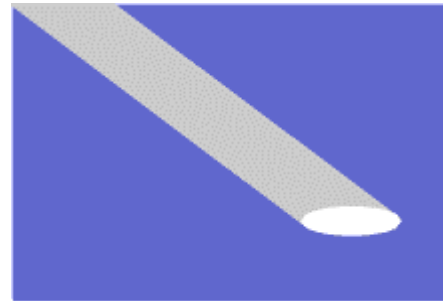
When both top and side focus voltages are adjusted the focus voltage is a complex wave form containing horizontal and vertical frequencies.



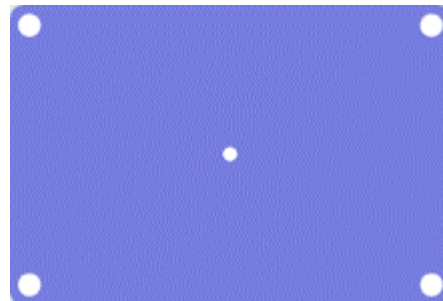


Elliptical Beam

The electron beam leaving an electron gun will normally be spiracle in shape. If the gun was at the radius of curvature of the faceplate then the spot at the faceplate would be round. The problem is that most CRTs are short, the gun is very close to the face plate. This causes the electron beam to strike the phosphor at a non right angle. The corners will have an elliptical shaped spot landing pattern.



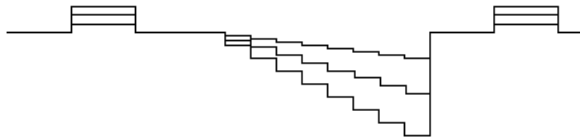
A Dynamic Quadropole Lens found in some electron gun enables the beam to be made elliptical as it leaves the gun. Naturally the quadropole lens will distort the beam in a direction that is at a right angle to the normal elliptical effect. The addition of the two elliptical effects will result in a round but larger spot. The beam's spot shape, and therefore picture sharpness, remain the same all over the screen.



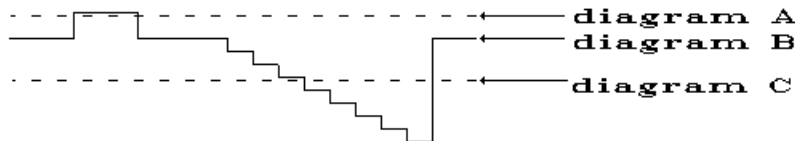
CONTRAST & BRIGHTNESS

The contrast and brightness controls plug into the video board and adjust how the picture looks on the screen. The words "contrast" and "brightness" come from the television industry and are misnamed (in my opinion). In a television the "contrast" control does change the distance from black to white and the 'brightness' appears to change how bright the picture is. On a non-gray scale monitor, where the picture is black or white with no gray, the two controls are nearly impossible to tell apart. Over most the range they will do the same job. In critical applications like a gray scale & color monitor the controls function much differently then the names imply.

Below is the video wave form on the cathode of the CRT. The highest portion of the wave form represents the blackest part of the picture. As the wave goes lower the picture gets brighter. The three lines represent three different settings of the contrast control. The black level (at the top) stays stationary while the bright portions of the picture change intensity with the contrast control. If the user wants to make the picture 'brighter' or 'dimmer' then the contrast control should be adjusted not the brightness control.

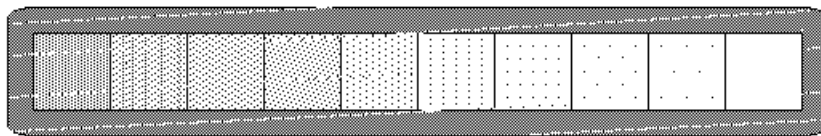


The 'brightness' control refers to the intensity of the black part of the picture.

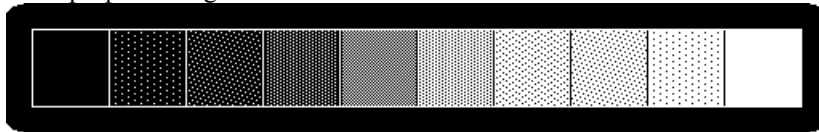


The brightness control should only be used to set the background to just disappear. This control should not be used to change the overall brightness. The next diagrams refer to three possible levels of brightness settings.

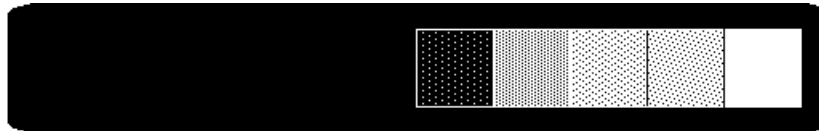
In A the background appears gray. Blacks are not black. The retrace lines appear in the background. Picture quality is poor.



At level B the background has just disappeared. Blacks are black. Low level grays can still be seen. This is the proper setting.



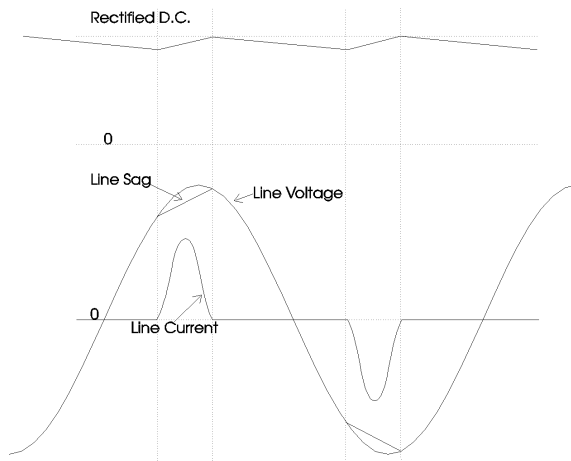
Level C results in the loss of many of the low levels of gray. Black is black but half of the gray levels are also black.



POWER FACTOR CORRECTION

This is an optional pre-regulator that sits before the normal power supply.

Off-line switching power supplies use a bridge rectifier and filter capacitor. The large filter capacitor charges to the peak AC line voltage. This capacitor alone supplies all the power during most of the power line cycle. The capacitor receives power off the power line only during the peaks of the voltage. The line current is not sinusoidal but a pulse. Input power factor is only .65 and there is high harmonic content (noise) on the power line. The RMS line current is twice the equivalent sine wave current. A 120v 15A circuit breaker may not be able to deliver 1kW with out tripping. About twice as much power could be supplied if the load looked 'resistive'. For these reasons, high power factor supplies are becoming popular.



The power factor correction pre-regulator is inserted between the input rectifier and the bulk filter capacitor. The pre-regulator is programmed to draw a sinusoid current in phase with the line voltage. The harmonics on the power line will be reduced to <3%. The power factor will increase from .65 to .98. The power supply will work from 90V. to 270V without a 110/220 switch. A smaller bulk capacitor can be used, it will have a lower RMS charging current resulting in improved capacitor reliability. The bulk capacitor voltage is crudely regulated. This allows the main switcher to only deal with 10 volts of input voltage variations. The main switcher can be simplified.

DDC

The acronym DDC means "Display Data Channel" and it is a standard created by VESA (Video Electronics Standard Association). This is how a monitor and the video card can communicate. It allows you to control a monitor from the PC. In the case of 'Plug & Play' the graphics adapter gets from the monitor all the information about its features and make.

DDC is based on the I2C architecture developed by Philips and Digital. I2C uses two bidirectional signal and a ground wire. Data is passed bidirectionally on the data line under the control of the clock line. Generally there is a 'bus master' and one or more 'bus slaves'. Provisions are in place for more than one bus master but only one can talk at a time.

There are three different DDC levels:

DDC1: it is used by the monitor to send configuration information (EDID) to the PC. It uses V. sync as the data clock.

DDC2B: it uses the I2C bus to read the configuration data from the monitor. This is many times faster

DDC2AB: it is based on the bidirectional communication between the monitor and the PC and it handles the control through the commands provided by the ACCESS.BUS protocol.

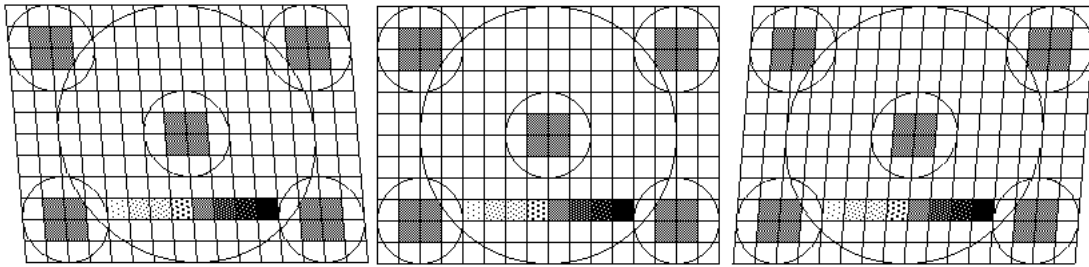
Plug and Play Compatibility

Developed by Microsoft, "Plug and Play" was developed to simplify hardware installation. The basic idea behind Plug and Play is to design and develop hardware peripherals that can communicate with the operating system, identify the hardware's requirements, and functions to the system. Upon recognizing the new device, the operating system will install the necessary components to make it work as part of the system.

Power Management

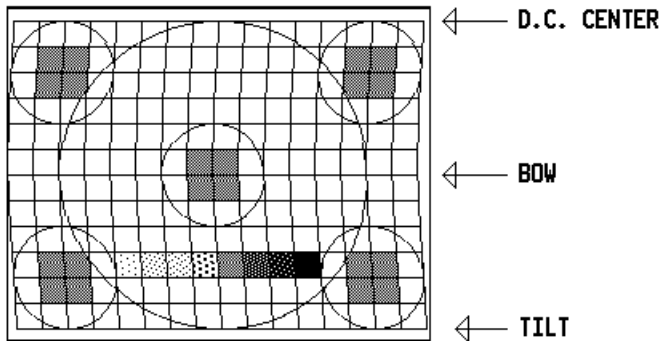
Due to the increasing demand on power to display a higher number of pixels, monitors have adopted a power management scheme based on EPA Energy Star specifications. DPMS (Display Power Management Signaling) is a standard of the VESA consortium; it refers to the power management modes you can apply when the monitor is idle and it has three different modes. That is "Stand-by", "Suspend" and "Shut down".

Tilt



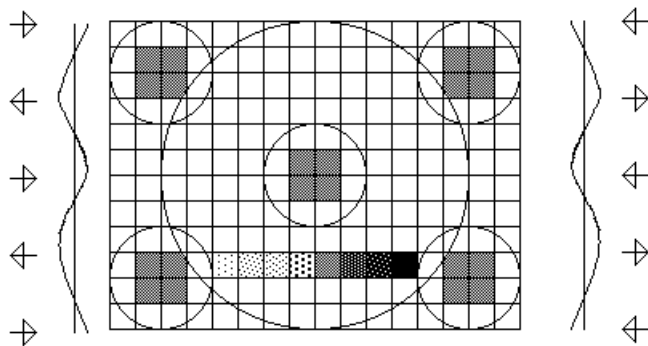
Bow

Moves the center of the picture left/right. Used to balance left and right PIN on the yoke.

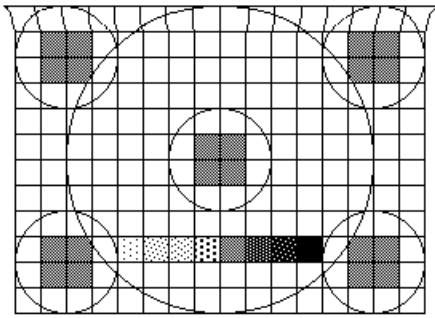


Cupids Bow

Horizontal correction for second order errors in Horizontal Pin.



Top Flair



S CAPACITOR

The S capacitors corrects outside versus center linearity in the horizontal scan. The voltage on the S cap has a parabola plus the DC horizontal supply. Reducing the value of S cap increases this parabola thus reducing the size of the outside characters and increasing the size of the center characters.

S Capacitor value: Too low: picture will be squashed towards edges.
Too high: picture will be stretched towards edges.

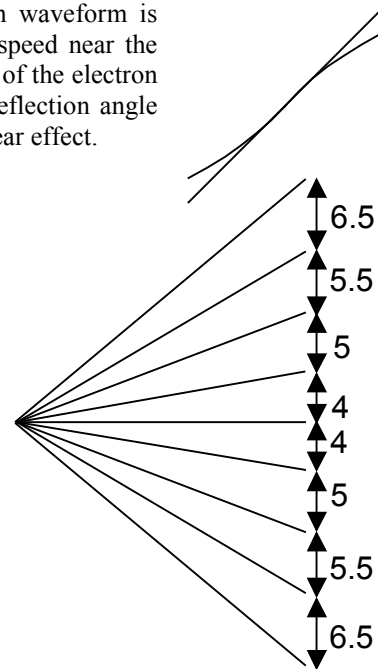
By simply putting a capacitor in series with each coil, the sawtooth waveform is modified into a slightly sine-wave shape. This reduces the scanning speed near the edges where the yoke is more sensitive. Generally the deflection angle of the electron beam and the yoke current are closely related. The problem is the deflection angle verses the distance of movement on the CRT screen does not have a linear effect.

In this example an electron beam is deflected with nine different current values. (4,3,2,1,0,-1,-2,-3,-4 amps) A current in the range of 0 to 1 amp causes the beam to move 4cms. Current changing from 3 to 4 amps causes 6.5cm movement. The yoke appears to be 1.5 times more sensitive at the edge of the picture.

The amount of S-correction needed is related to the flatness of the tube and the deflection angle. If the yoke is at the radius of the curvature of the tube then no S-correction is needed. As the yoke is pushed toward the face of the tube deflection angles get large. This problem is compounded by very flat tubs.

When the scan begins, at the left side of the picture, the voltage on the S-cap is low causing less voltage to be placed across the deflection yoke and the beam to move slowly. The yoke current is at the maximum value in the direction to charge the S-cap. As the beam moves toward the center of the screen the yoke current decreases and the voltage across the S-cap increases. The larger S-cap voltage will cause more voltage across the DY and the beam will move faster. By middle of the picture, the yoke current has run down to zero. The S-cap has charged to it's maximum value. The beam speed is at it's maximum. The current now reverses direction causing right side deflection. The current flows out of the S-cap through the DY. The S-cap voltage drops reducing the speed of deflection as the beam approaches the right edge. The voltage on the S-cap is varying by the right amount to compensate for the geometry error.

The S-cap value is very dependant on the scan rate. For multiscan monitors, S-caps must be selected for each scan range. These are only approximate corrections but good enough for most purposes. MOSFETs or relays switch in the correct S-cap for each range of scanning frequencies.

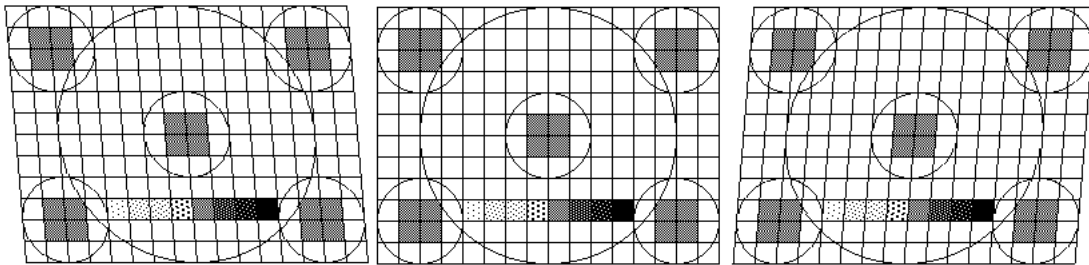


INNER PIN-CUSHION

Many CRTs, especially flatter ones, need geometry correction that goes beyond simple S-correction. Most tubes need inner pin-cushion correction, which is also called "dynamic S-correction". Some tubes need more S-correction only at the extreme edges, this is called "higher-order S-correction". This requires another resonant circuit, tuned to a higher frequency, which is more difficult to implement. Most sets will not have such circuit.

Tilt

Tilt is the dynamic adjustment of the DC centering. The centering may be adjusted differently down the page. The top may be shifted right 2mm and the bottom shifted left by 1mm. This is tilt. The top of the picture should be centered with DC centering. The bottom of the picture is set by Tilt. The center of the picture will move over 1/2 as far as the bottom.

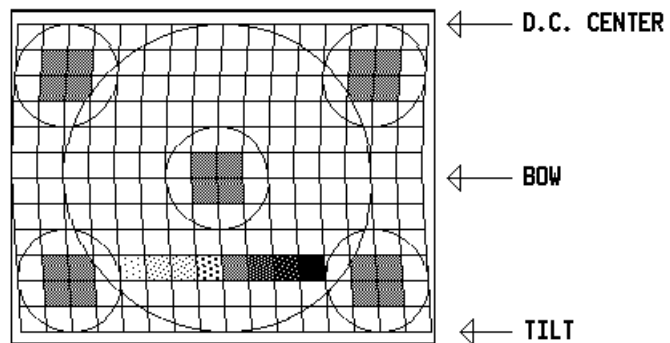


There is more than one method of correcting for tilt. In the above paragraph we talked about DC centering moving the raster. Another method is to use horizontal phase to reposition the picture within the raster. This method has a limited range. The H. phase can easily be moved too far and the picture will wrap around into horizontal blanking.

BOW

The BOW adjustment controls the amount of horizontal DC centering in the center of the picture. Tilt controls the horizontal centering of the picture at the bottom. The DC centering controls the raster centering over the entire picture. BOW should have little to no effect on the top and bottom of the picture. BOW should be set only after the top and bottom have first been adjusted.

It is possible to use H. phase to get limited bow correction.



NTSC, National Television System Committee

North America and Japan established NTSC color standards to make signals compatible with black and white transmissions. Backward compatibility was assured by transmitting the luminance and the chrominance combined in the signal. An NTSC set can display 525 scan lines at 30 (actually 29.97) frames per second, but non-picture lines and interlaced scanning methods make for an effective resolution limit of about 340 lines. Bandwidth is 4.2 MHz. The NTSC frame rate was established based on the 60 Hz rate of the U.S. electrical mains.

PAL, Phase Alternation Line-rate

PAL is the standard used in much of Europe or in places where the electrical current is 50 Hz. It displays 625 scan lines and 25 frames per second. It offers slightly better resolution with slightly more flicker. Bandwidth is 5.5 MHz.

Degauss

The ability to demagnetize the monitor. Magnetic fields from the earth and fields from other electric devices cause distortions in the image colors. Monitors usually run a degauss cycle automatically every time they are turned on. Some monitors have a manual degauss button.

The shadow mask or aperture grill must be made of magnetic material! This leads to the need for degaussing. The shadow mask and internal shielding hood forms a closed chamber where there is a near zero field. Degaussing is not to demagnetize the metal, but to create a magnetization that compensates for the earth's magnetic field. The sum of the two fields must be near zero.