

Monitor Terminology and Specifications

Bandwidth: This is a measure of the total amount of data that the monitor can handle in one second, and is measured in megahertz (MHz). The bandwidth of a monitor is limited by the design of the video amplifiers. It is generally desirable to match the bandwidth of the monitor with the dot clock of the video controller to take full advantage of both devices. see dot clock. see 'How do I calculate the minimum bandwidth required for a monitor?'

Dot Clock: This is the clock frequency (in MHz) used by the video controller chip, sometimes termed pixel rate. Many newer graphics processors have variable dot clocks, but usually only the highest is quoted in specifications. It is a measure of the maximum amount of throughput that a video controller can sustain. A higher dot clock generally means that higher screen addressabilities, colour depths and vertical refresh rates are possible. If you want to know the approximate maximum dot clock for your video card and it isn't specified, you can calculate an approximate value (which tends to overestimate) as outlined in "How do I calculate the minimum bandwidth required for a monitor?"

Horizontal Scan Rate (HSR): This is a measure of how many scanlines of pixel data the monitor can display in one second. The electron gun has to scan horizontally across the screen and then return back to the beginning of the next line ready to scan again. It is controlled by the horizontal sync signal which is generated by the video card, but is limited by the monitor. If too much data (i.e. too high a horizontal pixel addressability) is sent to the monitor, it exceeds its ability to modulate the electron gun, and the signal will be displayed incorrectly and/or the monitor may be damaged. VGA and SVGA monitors must have a minimum HSR of 31.5 kHz to be able to display the corresponding horizontal resolutions. Now we begin to see how the vertical refresh rate and the horizontal scan rate are related.

Refresh Rate (also Vertical Refresh Rate or Vertical Scan Rate): This measures the maximum number of frames that can be displayed on the monitor per second at a given pixel addressability (resolution). It is controlled by the vertical sync signal coming from the video card. The vertical sync tells the monitor to position the electron gun(s) at the upper left corner of the screen, ready to paint another frame. The maximum rate for a given monitor is dependent on the frequency capability of the vertical deflection circuit and the pixel addressability, since higher addressabilities require a higher horizontal scan rate. For example, a monitor which can provide 72Hz refresh rate at 800x600 may only be capable of 60Hz refresh at 1024x768. In order to be considered a VGA or SVGA monitor, the unit must provide a minimum vertical refresh rate of 60Hz. In general, higher is better, but there is no point in paying more for a video card and monitor which are capable of higher refresh rates if you won't notice a difference.

60 Hz is adequate for most people, but others are bothered by flicker and prefer 72 Hz or faster to reduce eye strain. The minimum acceptable refresh rate for you may also depend on the screen resolution and monitor size. In general, higher addressabilities require higher refresh rates to prevent flicker from becoming noticeable.

A monitor's maximum vertical refresh rate is limited by how fast it can direct the electron beam over all of the picture elements on the monitor. This involves moving the electron beam in the same manner as you would read the words in a book, left to right, top to bottom. It is limited by the maximum HSR, which determines the maximum horizontal pixel addressability the monitor can display and the number of scanlines (i.e. vertical addressability). For example, to display a screen with an addressability of 640 pixels horizontally and 480 vertically, a monitor with a HSR of 31.5kHz would take $480/31.5k = 15.2$ ms to scan the entire screen once. In one second, this monitor could be refreshed $1000ms/15.2ms = 65.6$ times. However, the vertical sync - movement of the electron gun

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to the upper left corner of the screen - requires some time, so the resulting vertical refresh rate is only 60 Hz.

Built into the HSR and vertical refresh rate are the horizontal and vertical blanking intervals, respectively. During horizontal blanking, the electron beam is moved back across the screen from the right end of one scan line to the beginning of the next scan line on the left of the screen. This occurs once for each scan line displayed. The vertical blanking interval occurs after the last scan line is displayed, and the electron beam is directed back to the upper left corner of the screen to begin displaying the next screen image.

Interlacing: Interlacing is a holdover from television standards which use it as a way of putting more information on the screen than would otherwise be possible. Original television technology could handle thirty full frames of video per second. However, a 30 Hz refresh rate results in highly annoying flicker, so the video signal is divided into two fields for each frame. This is accomplished by displaying first the odd scanlines (i.e. 1,3,5, etc.) for 1/60 of a second, and then displaying the even scanlines for the next 1/60 of a second. Your brain can integrate the two fields, and the result is a higher effective resolution and lower flicker. Ideally however, you want to display a frame of video information at full resolution - i.e. have one horizontal scanline for each horizontal line of pixels and display it at a high enough refresh rate that flickering is not an issue.

Fortunately, modern monitor technology is capable of non-interlaced (NI) display at high vertical refresh rates. Many non-interlaced monitors can only work in non-interlaced mode up to a maximum pixel addressability, above which they revert to interlaced mode. For this reason, it is important that you ensure that the monitor you buy is capable of non-interlaced display at the maximum addressability and vertical refresh rate that you want to use. Typically, interlaced computer monitors refresh at about 87Hz, or 43.5 full frames per second. Interlaced displays can result in annoying flicker, especially noticeable with thin horizontal lines because the scanline is alternating between the line and background colours. It's very noticeable if you look at the top or bottom edge of a window on an interlaced monitor.

Dot Pitch: Images on a computer monitor are made up of glowing blobs of phosphor. On colour monitors, the smallest discrete picture element consists of three phosphor blobs, one each of red, green and blue. These elements are called dot triads. On most monitors the blobs are arranged in rows and columns, often with every other row staggered:

R G B R G B	R - Red
B R G B R G	G - Green
R G B R G B	B - Blue
B R G B R G	

So, in the above example, a shape like the following might be a dot triad:

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R G
 B
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The dot pitch is measured as the shortest diagonal distance between the centers of any two neighbouring dot triads. This is the same as the shortest diagonal distance between any two phosphor blobs of the same colour. As dot pitch decreases, smaller objects can be resolved.

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Resolution: First, the correct term that should be used in place of resolution for most computer video discussion is pixel addressability. This is because in actuality, when we talk about 'resolution' being say, 640x480, we are referring to how many pixels can be addressed in the video frame buffer. Resolution should actually be defined as the smallest sized object that can be displayed on a given monitor, and so is really more closely related to dot pitch. So, two definitions are given here. The first is technically more correct, while the second is the more common interpretation (though strictly incorrect).

The technically correct answer:

Resolution: The ability of a monitor to show fine detail, related mostly to the size of the electron beam within the CRT, but also to how well the focus is adjusted, and whether the video bandwidth is high enough. Note that the dot pitch of a CRT is generally an indication of the tube's resolution ability, but only because the manufacturers try to maintain a spot size enough larger than the dot pitch to prevent Moire' patterning from appearing.

The more mainstream usage:

This refers to the maximum number of pixels which can be displayed on the monitor at one time, and is expressed as (number of horizontal pixels) by (number of vertical pixels) i.e. 1024x768. While a higher maximum resolution is, in general, a good thing, keep in mind that as the resolution gets higher, the pixel size gets smaller. The resolution capability of a monitor puts practical limits on the maximum pixel addressability a user may want to use. You may notice that most addressabilities are in the ratio of 4:3. This is also a holdover from television technology which uses the same 4:3 aspect ratio. As a result, monitor size can be quoted with one diagonal measure, since the horizontal and vertical sizes can be calculated from the 4:3 ratio. In future, HDTV (High Definition Television) will use 16:9 (the same aspect ratio as used in movie theatres) and this may spill over into computer technology.

The following are recommendations:

Monitor Size	14"	15"	17"	20"
Resolution				
640x480	A	A	B	B
800x600	C	A	A	B
1024x768	D	C	A	A
1280x1024	D	D	C	A

Legend:

A - Optimal

B - Grainy, pixels become visible

C - Usable, but objects become small and fine detail becomes less distinct

D - Not Recommended, objects are difficult to see and fine detail can not be perceived

These are only recommendations. Personally, I can only afford a 14" NI monitor, and I run it at 1024x768. Objects are small, but my vision is 20/20 :-).

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Keep in mind that there is also a very wide variation in the quality of the images between manufacturers and between models. Many factors contribute to this variation including video amplifier bandwidth, sharpness of the electron beam (focus), dot pitch of the CRT shadowmask (or line pitch of a Trinitron's aperture grill), stability of the power supplies, bandwidth of the video card, quality of the cables, etc. Many monitors are able to operate (synchronize, and present an image) at pixel addressabilities beyond their resolution capabilities. When operated in this way, fine detail (single pixels) within the image may not be perceptible by the user.

Size: Monitor sizes are typically quoted in inches, and this is measured across the diagonal length of the monitor i.e. the longest possible measurement. Industry practice has been to list the size of the picture tube as the size of the monitor, but this has led to some problems. For example, a tube may measure 17" across the diagonal, but due to glass thickness and that the tube is encased in the monitor housing, the viewable area is only 15.5". So, just because two monitors are advertised as being the same size doesn't mean that they have the same viewable area.

Part of the source of this inconsistency is that the monitor _tube_ manufacturers do not specify image performance such as focus and convergence up to the extreme edge of the phosphor, so the image size is adjusted to that which the tube supplier specifies. (Many monitors today provide the possibility of adjusting the image size larger than this, but may neglect to tell the user to expect image quality degradation beyond the calibrated image size.)

Some users may have allowed themselves to think (or wish) that the size designation should refer to the image size, but this has never been true. Regardless, within the US, the Federal Trade Commission (the body which brought standardization to the TV industry with use of the "V" terminology) is working to produce a standard for computer monitors. Some vendors actually quote viewable area in addition to the tube size, but this is not provided by all vendors yet. Until then, caveat emptor - take a measuring tape with you when you go shopping.