# How Computer Monitors Work

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**Introduction to How Computer Monitors Work**


Because we use them daily, many of us have a lot of questions about our monitors and may not even realize it. What does "aspect ratio" mean? What is dot pitch? How much power does a display use? What is the difference between CRT and LCD? What does "refresh rate" mean?

In this article will answer all of these questions and many more. By the end of the article, you will be able to understand your current display and also make better decisions when purchasing your next one.

**Monitor Display Technology**

Often referred to as a **monitor** when packaged in a separate case, the display is the most-used output device on a computer. The display provides instant feedback by showing you text and graphic images as you work or play.

Most desktop displays use liquid crystal display (LCD) or cathode ray tube (CRT) technology, while nearly all portable computing devices such as laptops incorporate LCD technology. Because of their slimmer design and lower energy consumption, monitors using LCD technology (also called **flat panel** or **flat screen** displays) are replacing the venerable CRT on most desktops.

**Resolution** refers to the number of individual dots of color, known as **pixels**, contained on a

display. Resolution is expressed by identifying the number of pixels on the **horizontal axis** (rows) and the number on the **vertical axis** (columns), such as 800x600. Resolution is affected by a number of factors, including the size of the screen.

As monitor sizes have increased over the years, display standards and resolutions have changed. In addition, some manufacturers offer widescreen displays designed for viewing DVD movies.

### Common Display Standards and Resolutions

| Standard | Resolution | Typical Use |
|---|---|---|
| XGA (Extended Graphics Array) | 1024x768 | 15- and 17-inch CRT monitors<br>15-inch LCD monitors |
| SXGA (Super XGA) | 1280x1024 | 15- and 17-inch CRT monitors<br>17-and 19-inch LCD monitors |
| UXGA (Ultra XGA) | 1600x1200 | 19-, 20-, 21-inch CRT monitors<br>20-inch LCD monitors |
| QXGA (Quad XGA) | 2048x1536 | 21-inch and larger CRT monitors |
| WXGA (Wide XGA) | 1280x800 | Wide aspect 15.4-inch laptops<br>LCD displays |
| WSXGA+ (Wide SXGA plus) | 1680x1050 | Wide aspect 20-inch LCD monitors |
| WUXGA (Wide Ultra XGA) | 1920x1200 | Wide aspect 22-inch and larger LCD monitors |

In addition to the screen size, display standards and resolutions are related to something called the **aspect ratio**. Next, we'll discuss what an aspect ratio is and how screen size is measured.

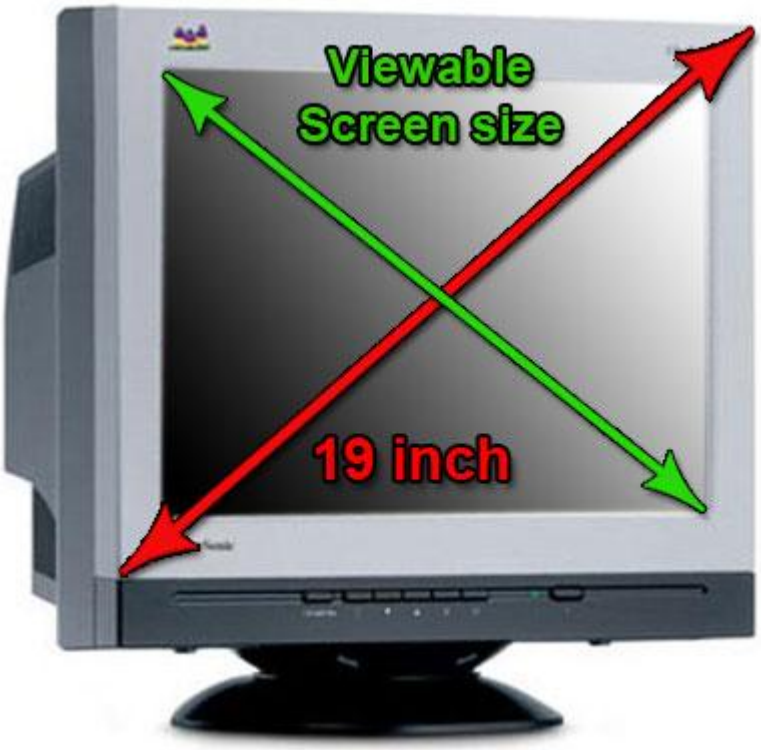
Aspect Ratio and Viewable Area

Two measures describe the size of your display: the **aspect ratio** and the **screen size**. Historically, computer displays, like most televisions, have had an aspect ratio of 4:3. This means that the ratio of the width of the display screen to the height is 4 to 3.

For widescreen LCD monitors, the aspect ratio is 16:9 (or sometimes 16:10 or 15:9). Widescreen LCD displays are useful for viewing DVD movies in widescreen format, playing games and displaying multiple windows side by side. High definition television (HDTV) also uses a widescreen aspect ratio.

All types of displays include a projection surface, commonly referred to as the screen. Screen sizes are normally measured in inches from one corner to the corner diagonally across from it. This diagonal measuring system actually came about because the early television manufacturers wanted to make the screen size of their TVs sound more impressive.

Interestingly, the way in which the screen size is measured for CRT and LCD monitors is different. For CRT monitors, screen size is measured diagonally from outside edges of the display casing. In other words, the exterior casing is included in the measurement as seen below.




**CRT screen size**

For LCD monitors, screen size is measured diagonally from the inside of the beveled edge. The measurement does not include the casing as indicated in the image below.


**LCD screen size**

## Multi-scanning Monitors

If you have been around computers for more than a decade, then you probably remember when NEC announced the **MultiSync** monitor. Up to that point, most monitors only understood one frequency, which meant that the monitor operated at a single fixed resolution and refresh rate. You had to match your monitor with a graphics adapter that provided that exact signal or it wouldn't work.

The introduction of NEC MultiSync technology started a trend towards **multi-scanning monitors**. This technology allows a monitor to understand any frequency sent to it within a certain bandwidth. The benefit of a multi-scanning monitor is that you can change resolutions and refresh rates without having to purchase and install a new graphics adapter or monitor each time.

Because of the differences in how CRT and LCD monitors are measured, a 17-inch LCD display is comparable to a 19-inch CRT display. For a more accurate representation of a CRT's size, find out its viewable screen size. This is the measurement of a CRT display without its outside casing.

Popular screen sizes are 15, 17, 19 and 21 inches. Notebook screen sizes are smaller, typically ranging from 12 to 17 inches. As technologies improve in both desktop and notebook displays, even larger screen sizes are becoming available. For professional applications, such as medical imaging or public information displays, some LCD monitors are 40 inches or larger!

Obviously, the size of the display directly affects resolution. The same pixel resolution is sharper on a smaller monitor and fuzzier on a larger monitor because the same number of pixels is spread out over a larger number of inches. An image on a 21-inch monitor with an 800x600 resolution will not appear nearly as sharp as it would on a 15-inch display at 800x600.

Analog and DVI Connections

To display information on a monitor, your computer sends the monitor a signal. The signal can be in analog or digital format.

## Analog (VGA) Connection

Because most CRT monitors require the signal information in **analog** (continuous electrical signals or waves) form and not **digital** (pulses equivalent to the binary digits 0 and 1), they typically use an analog connection.

However, computers work in a digital world. The computer and video adapter convert digital data into analog format. A **video adapter** is an expansion card or component that provides the ability to convert display information into a signal that is sent to the monitor. It can also be called a graphics adapter, video card or graphics card.

Once the display information is in analog form, it is sent to the monitor through a **VGA cable**. The cable connects at the back of the computer to an analog connector (also known as a D-Sub connector) that has 15 pins in three rows. See the diagram below:


| | | |
|---|---|---|
| **1**: Red out | **6**: Red return (ground) | **11**: Monitor ID 0 in |
| **2**: Green out | **7**: Green return (ground) | **12**: Monitor ID 1 in or data from display |
| **3**: Blue out | **8**: Blue return (ground) | **13**: Horizontal Sync out |
| **4**: Unused | **9**: Unused | **14**: Vertical Sync |
| **5**: Ground | **10**: Sync return (ground) | **15**: Monitor ID 3 in or data clock |

You can see that a VGA connector like this has three separate lines for the red, green and blue color signals, and two lines for horizontal and vertical sync signals. In a normal television, all of these signals are combined into a single composite video signal. The separation of the signals is one reason why a computer monitor can have so many more pixels than a TV set.

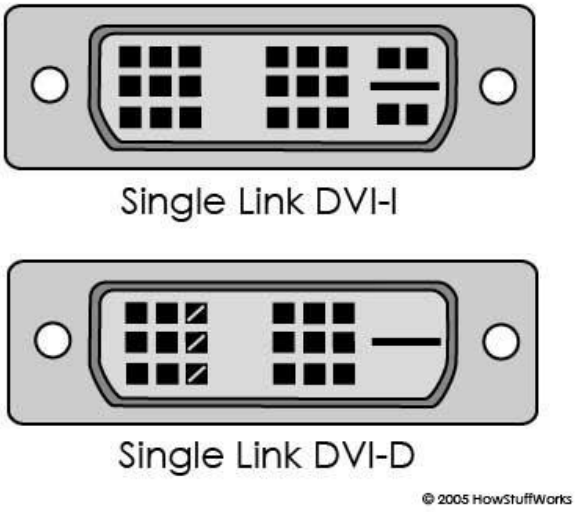
Because a VGA (analog) connector does not support the use of digital monitors, the **Digital Video Interface** (DVI) standard was developed.

## DVI Connection

DVI keeps data in digital form from the computer to the monitor. There's no need to convert data from digital information to analog information. LCD monitors work in a digital mode and support the DVI format. (Although, some also accept analog information, which is then converted to digital format.) At one time, a digital signal offered better image quality compared to analog technology. However, analog signal processing technology has improved over the years and the difference in quality is now minimal.

The DVI specification is based on Silicon Image's **Transition Minimized Differential Signaling** (TMDS) and provides a high-speed digital interface. A transmitter on the video adapter sends the digital information to a receiver in the monitor. TMDS takes the signal from the video adapter, determines the **resolution** and **refresh rate** that the monitor is using, and spreads the signal out over the available bandwidth to optimize the data transfer from computer to monitor.

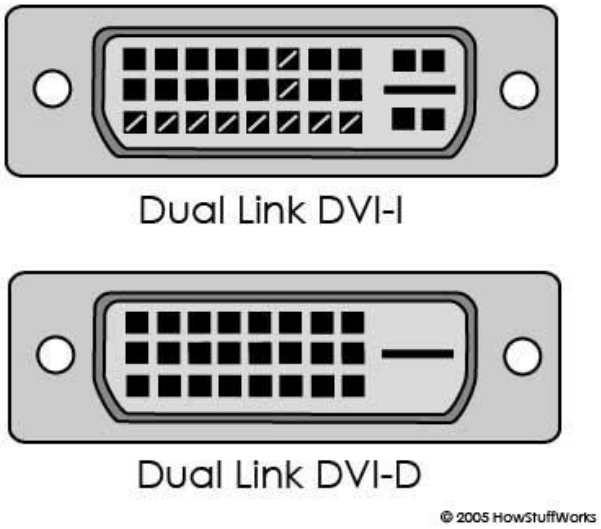
DVI cables can be a **single link cable** that uses one TMDS transmitter or a **dual link cable** with two transmitters. A single link DVI cable and connection supports a 1920x1080 image, and a dual link cable/connection supports up to a 2048x1536 image.




There are two main types of DVI connections:

- DVI-digital (DVI-D) is a digital-only format. It requires a video adapter with a DVI-D connection and a monitor with a DVI-D input. The connector contains 24 pins/receptacles in 3 rows of 8 plus a grounding slot for dual-link support. For single-link support, the connector contains 18 pins/receptacles.

- DVI-integrated (DVI-I) supports both digital and analog transmissions. This gives you the option to connect a monitor that accepts digital input or analog input. In addition to the pins/receptacles found on the DVI-D connector for digital support, a DVI-I connector has 4 additional pins/receptacles to carry an analog signal.




**DVI-D connectors carry a digital-only signal and DVI-I adds four pins for analog capability. Both connectors can be used with a single-link or a dual-link cable, depending upon the requirements of the display.**

If you buy a monitor with only a DVI (digital) connection, make sure that you have a video adapter with a DVI-D or DVI-I connection. If your video adapter has only an analog (VGA) connection, look for a monitor that supports the analog format.

Color Depth

The combination of the display modes supported by your graphics adapter and the color capability of your monitor determine how many colors it displays. For example, a display that operates in SuperVGA (SVGA) mode can display up to 16,777,216 (usually rounded to 16.8 million) colors because it can process a 24-bit-long description of a pixel. The number of bits used to describe a pixel is known as its bit depth.

With a 24-bit bit depth, eight bits are dedicated to each of the three additive primary colors -- red, green and blue. This bit depth is also called true color because it can produce the 10,000,000 colors discernible to the human eye, while a 16-bit display is only capable of producing 65,536 colors. Displays jumped from 16-bit color to 24-bit color because working in eight-bit increments makes things a whole lot easier for developers and programmers.

Simply put, **color bit depth** refers to the number of bits used to describe the color of a single pixel. The bit depth determines the number of colors that can be displayed at one time. Take a look at the following chart to see the number of colors different bit depths can produce:

| Bit-Depth | Number of Colors |
|---|---|
| 1 | 2 (monochrome) |
| 2 | 4 (CGA) |
| 4 | 16 (EGA) |
| 8 | 256 (VGA) |
| 16 | 65,536 (High Color, XGA) |
| 24 | 16,777,216 (True Color, SVGA) |
| 32 | 16,777,216 (True Color + Alpha Channel) |

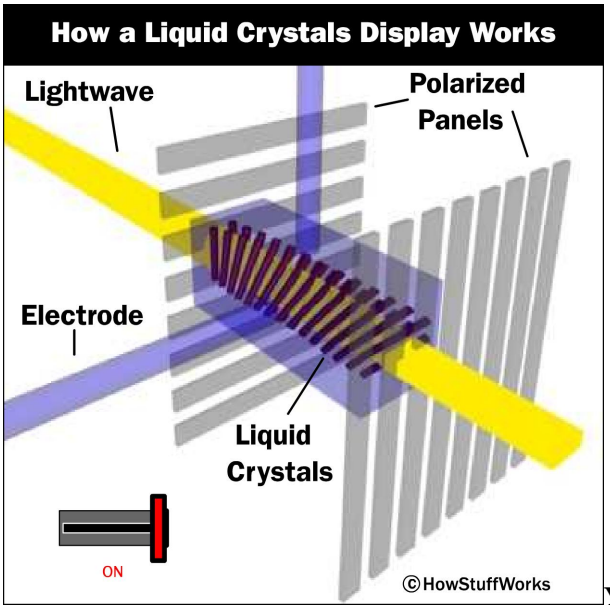
Notice that the last entry in the chart is for 32 bits. This is a special graphics mode used by digital video, animation and video games to achieve certain effects. Essentially, 24 bits are used for color and the other eight bits are used as a separate layer for representing levels of translucency in an object or image. Nearly every monitor sold today can handle 24-bit color using a standard VGA connector.

To create a single colored pixel, an LCD display uses three subpixels with red, green and blue filters. Through the careful control and variation of the voltage applied, the intensity of each subpixel can range over 256 shades. Combining the subpixels produces a possible palette of 16.8 million colors (256 shades of red x 256 shades of green x 256 shades of blue).

Now that you have a general idea of the technology behind computer monitors, let's take a closer look at LCD monitors, CRT monitors, and the general buying considerations for both.

LCD Monitors

Liquid crystal display technology works by blocking light. Specifically, an LCD is made of two pieces of polarized glass (also called substrate) that contain a liquid crystal material between them. A backlight creates light that passes through the first substrate. At the same time, electrical currents cause the liquid crystal molecules to align to allow varying levels of light to pass through to the second substrate and create the colors and images that you see.



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## Active and Passive Matrix Displays

Most LCD displays use **active matrix technology**. A **thin film transistor** (TFT) arranges tiny transistors and capacitors in a matrix on the glass of the display. To address a particular pixel, the proper row is switched on, and then a charge is sent down the correct column. Since all of the other rows that the column intersects are turned off, only the capacitor at the designated pixel receives a charge. The capacitor is able to hold the charge until the next refresh cycle.

The other type of LCD technology is **passive matrix**. This type of LCD display uses a grid of conductive metal to charge each pixel. Although they are less expensive to produce, passive matrix monitors are rarely used today due to the technology's slow response time and imprecise voltage control compared to active matrix technology.

Now that you have an understanding of how LCD technology works, let's look at some specific features unique to LCD monitors.

LCD Features and Attributes

To evaluate the specifications of LCD monitors, here are a few more things you need to know.

## Native Resolution

Unlike CRT monitors, LCD monitors display information well at only the resolution they are designed for, which is known as the native resolution. Digital displays address each individual pixel using a fixed matrix of horizontal and vertical dots. If you change the resolution settings, the LCD scales the image and the quality suffers. Native resolutions are typically:

- 17 inch = 1024x768

- 19 inch = 1280x1024
- 20 inch = 1600x1200

## Viewing Angle

When you look at an LCD monitor from an angle, the image can look dimmer or even disappear. Colors can also be misrepresented. To compensate for this problem, LCD monitor makers have designed wider viewing angles. (Do not confuse this with a widescreen display, which means the display is physically wider.) Manufacturers give a measure of viewing angle in degrees (a greater number of degrees is better). In general, look for between 120 and 170 degrees. Because manufacturers measure viewing angles differently, the best way to evaluate it is to test the display yourself. Check the angle from the top and bottom as well as the sides, bearing in mind how you will typically use the display.

## Brightness or Luminance

This is a measurement of the amount of light the LCD monitor produces. It is given in nits or one candelas per square meter (cd/m2). One nit is equal to on cd/m2. Typical brightness ratings range from 250 to 350 cd/m2 for monitors that perform general-purpose tasks. For displaying movies, a brighter luminance rating such as 500 cd/m2 is desirable.

## Contrast Ratio

The contrast ratio rates the degree of difference of an LCD monitor's ability to produce bright whites and the dark blacks. The figure is usually expressed as a ratio, for example, 500:1. Typically, contrast ratios range from 450:1 to 600:1, and they can be rated as high as 1000:1. Ratios more than 600:1, however, provide little improvement over lower ratios.

## Response Rate

The response rate indicates how fast the monitor's pixels can change colors. Faster is better because it reduces the ghosting effect when an image moves, leaving a faint trial in such applications as videos or games.

## Adjustability

Unlike CRT monitors, LCD monitors have much more flexibility for positioning the screen the way you want it. LCD monitors can swivel, tilt up and down, and even rotate from **landscape** (with the horizontal plane longer than the vertical plane) to **portrait mode** (with the vertical plane longer than the horizontal plane). In addition, because they are lightweight and thin, most LCD monitors have built-in brackets for wall or arm mounting.

Besides the basic features, some LCD monitors have other conveniences such as integrated speakers, built-in Universal Serial Bus (USB) ports and anti-theft locks.

### LCD Terms

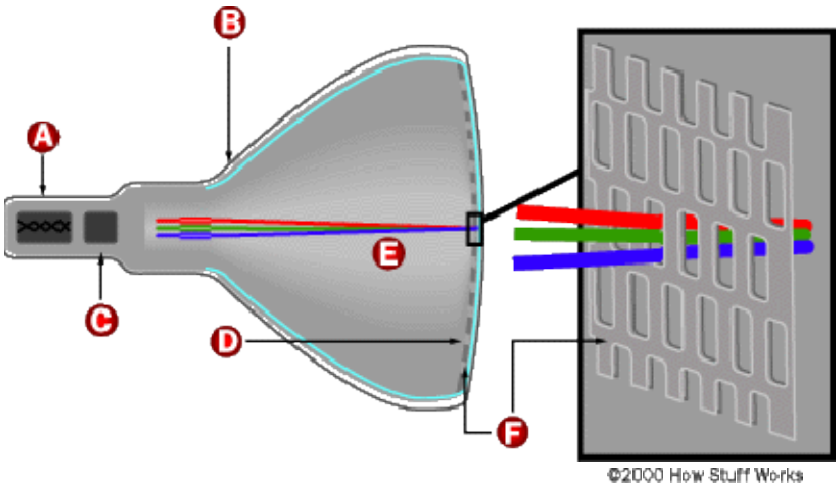
- **Bezel** - This is the metal or plastic frame surrounding the display screen. On LCD displays, the bezel is typically very narrow.
- **Contrast ratio** - The difference in light intensity between white and black on an LCD display is called contrast ratio. The higher

the contrast ratio, the easier it is to see details.

- **Ghosting** - An effect of slower response times that cause blurring of images on an LCD monitor, it's also known as **latency**. The effect is caused by voltage temporarily leaking from energized elements to neighboring, non-energized elements on the display.
- **Luminance** - Also known as **brightness**, it is the level of light emitted by an LCD display. Luminance is measured in **nits** or **candelas** per square meter (cd/m2). One nit is equal to one cd/m2.
- **Native resolution** - This actual measurement of an LCD display, in pixels, is given in horizontal by vertical order.
- **Response time** - The speed at which the monitor's pixels can change colors is called response time. It is measured in milliseconds (ms).
- **Stuck pixels** - A pixel that is stuck either 'on' or 'off', meaning that it is always illuminated, unlit, or stuck on one color regardless of the image the LCD monitor displays can also be called a dead pixel.
- **VESA mount** - With this, you can mount a monitor on a desk or wall. It meets recommendations of the Video Electronics Standards Association (VESA).
- **Viewing angle** - It's the degree of angle at which you can view the screen from the sides (horizontal angle) and top/bottom (vertical angle) and continue to see clearly defined images and accurate colors.

CRT Monitors

A CRT monitor contains millions of tiny red, green, and blue phosphor dots that glow when struck by an electron beam that travels across the screen to create a visible image. The illustration below shows how this works inside a CRT.



Display History 101

Displays have come a long way since the blinking green monitors in text-based computer systems of the 1970s. Just look at the advances made by IBM over the course of a decade:

- In 1981, IBM introduced the Color Graphics Adapter (CGA), which was capable of rendering four colors, and had a maximum resolution of 320 pixels horizontally by 200 pixels vertically.
- IBM introduced the Enhanced Graphics Adapter (EGA) display in 1984. EGA allowed up to 16 different colors and increased the resolution to 640x350 pixels, improving the appearance of the display and making it easier to read text.
- In 1987, IBM introduced the Video Graphics Array (VGA) display system. The VGA standard has a resolution of 640x480 pixels and some VGA monitors are still in use.
- IBM introduced the Extended Graphics Array (XGA) display in 1990, offering 800x600 pixel resolution in true color (16.8 million colors) and 1,024x768 resolution in 65,536 colors.

The terms **anode** and **cathode** are used in electronics as synonyms for positive and negative terminals. For example, you could refer to the positive terminal of a battery as the anode and the negative terminal as the cathode.

In a cathode ray tube, the "cathode" is a heated filament. The heated filament is in a vacuum created inside a glass "tube." The "ray" is a stream of electrons generated by an electron gun that naturally pour off a heated cathode into the vacuum. Electrons are negative. The anode is positive, so it attracts the electrons pouring off the cathode. This screen is coated with **phosphor**, an organic material that glows when struck by the electron beam.

There are three ways to filter the electron beam in order to obtain the correct image on the monitor screen: shadow mask, aperture grill and slot mask. These technologies also impact the sharpness of the monitor's display. Let's take a closer look at these now.

CRT Features and Attributes

To evaluate the specifications of CRT monitors, here are a few more things you need to know:

## Shadow-mask

A **shadow mask** is a thin metal screen filled with very small holes. Three electron beams pass through the holes to focus on a single point on a CRT displays' phosphor surface. The shadow mask helps to control the electron beams so that the beams strike the correct phosphor at just the right intensity to create the desired colors and image on the display. The unwanted beams are blocked or "shadowed."

## Aperture-grill

Monitors based on the Trinitron technology, which was pioneered by Sony, use an **aperture-grill** instead of a shadow-mask type of tube. The aperture grill consists of tiny vertical wires. Electron beams pass through the aperture grill to illuminate the phosphor on the faceplate. Most

aperture-grill monitors have a flat faceplate and tend to represent a less distorted image over the entire surface of the display than the curved faceplate of a shadow-mask CRT. However, aperture-grill displays are normally more expensive.

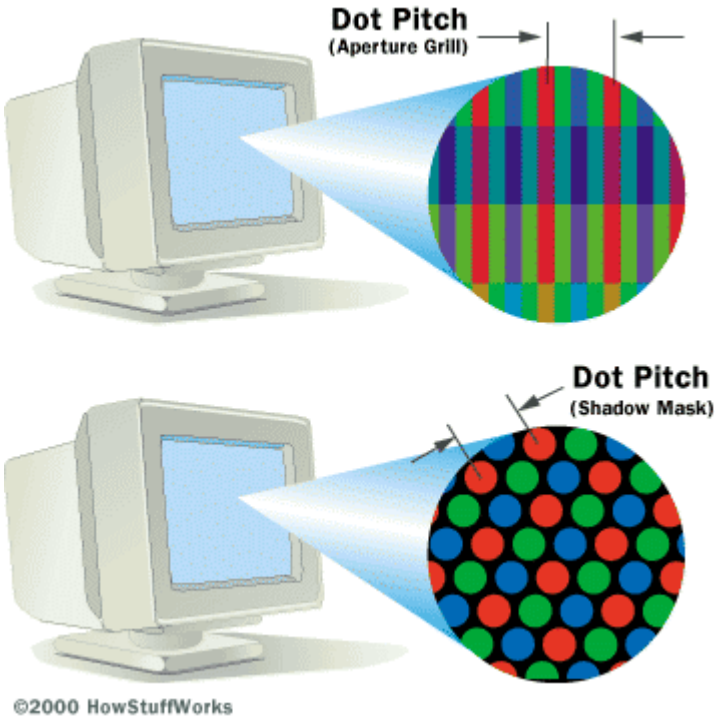
## Slot-mask

A less-common type of CRT display, a **slot-mask tube** uses a combination of the shadow-mask and aperture-grill technologies. Rather than the round perforations found in shadow-mask CRT displays, a slot-mask display uses vertically aligned slots. The design creates more brightness through increased electron transmissions combined with the arrangement of the phosphor dots.

## Dot pitch

**Dot pitch** is an indicator of the sharpness of the displayed image. It is measured in millimeters (mm), and a smaller number means a sharper image. How you measure the dot pitch depends on the technology used:

- In a shadow-mask CRT monitor, you measure dot pitch as the *diagonal distance* between two like-colored phosphors. Some manufacturers may also cite a horizontal dot pitch, which is the distance between two-like colored phosphors horizontally.
- The dot pitch of an aperture-grill monitor is measured by the *horizontal distance* between two like-colored phosphors. It is also sometimes are called **stripe pitch**.




The smaller and closer the dots are to one another, the more realistic and detailed the picture appears. When the dots are farther apart, they become noticeable and make the image look grainier. Unfortunately, manufacturers are not always upfront about dot pitch measurements, and

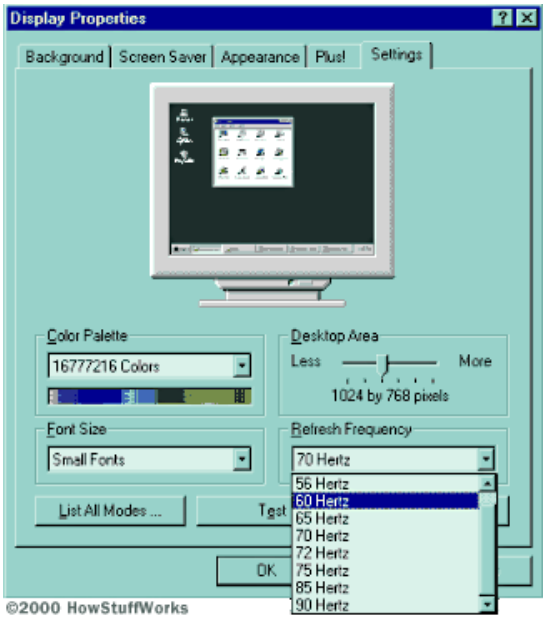
you cannot necessarily compare shadow-mask and aperture-grill CRT types, due to the difference in horizontal and vertical measurements.

The dot pitch translates directly to the resolution on the screen. If you were to put a ruler up to the glass and measure an inch, you would see a certain number of dots, depending on the dot pitch. Here is a table that shows the number of dots per square centimeter and per square inch in each of these common dot pitches:

| Dot Pitch | Approx. number of pixels/cm$^2$ | Approx. number of pixels/in$^2$ |
|---|---|---|
| .25 mm | 1,600 | 10,000 |
| .26 mm | 1,444 | 9,025 |
| .27 mm | 1,369 | 8,556 |
| .28 mm | 1,225 | 7,656 |
| .31 mm | 1,024 | 6,400 |
| .51 mm | 361 | 2,256 |
| 1 mm | 100 | 625 |

## Refresh Rate

In monitors based on CRT technology, the refresh rate is the number of times that the image on the display is drawn each second. If your CRT monitor has a refresh rate of 72 Hertz (Hz), then it cycles through all the pixels from top to bottom 72 times a second. Refresh rates are very important because they control flicker, and you want the refresh rate as high as possible. Too few cycles per second and you will notice a **flickering**, which can lead to headaches and eye strain.



Because your monitor's refresh rate depends on the number of rows it has to scan, it limits the maximum possible resolution. Most monitors support multiple refresh rates. Keep in mind that there is a tradeoff between flicker and resolution, and then pick what works best for you. This is especially important with larger monitors where flicker is more noticeable. Recommendations for refresh rate and resolution include 1280x1024 at 85 Hertz or 1600x1200 at 75 Hertz.

### Multiple Resolutions

Because a CRT uses electron beams to create images on a phosphor screen, it supports the resolution that matches its physical dot (pixel) size as well as several lesser resolutions. For example, a display with a physical grid of 1280 rows by 1024 columns can obviously support a maximum resolution of 1280x1024 pixels. It also supports lower resolutions such as 1024x768, 800x600, and 640x480. As noted previously, an LCD monitor works well only at its native resolution.

LCDs vs. CRTs

If you are looking for a new display, you should consider the differences between CRT and LCD monitors. Choose the type of monitor that best serves your specific needs, the typical applications you use, and your budget.

## Advantages of LCD Monitors

- **Require less power** - Power consumption varies greatly with different technologies. CRT displays are somewhat power-hungry, at about 100 watts for a typical 19-inch display. The average is about 45 watts for a 19-inch LCD display. LCDs also produce less heat.
- **Smaller and weigh less** - An LCD monitor is significantly thinner and lighter than a CRT monitor, typically weighing less than half as much. In addition, you can mount an LCD on an arm or a wall, which also takes up less desktop space.
- **More adjustable** - LCD displays are much more adjustable than CRT displays. With LCDs, you can adjust the tilt, height, swivel, and orientation from horizontal to vertical mode. As noted previously, you can also mount them on the wall or on an arm.
- **Less eye strain** - Because LCD displays turn each pixel off individually, they do not produce a flicker like CRT displays do. In addition, LCD displays do a better job of displaying text compared with CRT displays.

## Advantages of CRT Monitors

- **Less expensive** - Although LCD monitor prices have decreased, comparable CRT displays still cost less.
- **Better color representation** - CRT displays have historically represented colors and different gradations of color more accurately than LCD displays. However, LCD displays are gaining ground in this area, especially with higher-end models that include color-calibration technology.

- **More responsive** - Historically, CRT monitors have had fewer problems with ghosting and blurring because they redrew the screen image faster than LCD monitors. Again, LCD manufacturers are improving on this with displays that have faster response times than they did in the past.
- **Multiple resolutions** - If you need to change your display's resolution for different applications, you are better off with a CRT monitor because LCD monitors don't handle multiple resolutions as well.
- **More rugged** - Although they are bigger and heavier than LCD displays, CRT displays are also less fragile and harder to damage.

So now that you know about LCD and CRT monitors, let's talk about how you can use two monitors at once. They say, "Two heads are better than one." Maybe the same is true of monitors!

**Dual Monitors**

One way to expand your computer's display is to add a second monitor. Using dual monitors can make you more productive and add a lot to your computing experience.

With two monitors, you can:

- View large spreadsheets
- Make changes to a web page's code on one monitor and view the results on the second
- Open two different applications, such as a Word document on one monitor and your web browser on the second

Besides two displays and two sets of the appropriate video cables, the only other thing you need is a video adapter with two display connections. The connections can be analog or digital; they need only to match the type of connections on the monitors. It does not matter what type of monitor you use; two LCDs, two CRTs, or one of each works fine as long as the video adapter has compatible connections.

If you don't have a video adapter with two connections, you can purchase one and replace your current adapter. This generally works better than simply installing another video card with a single connection. Combination cards also come with more features, such as a TV-out port.

In addition to verifying your hardware, you should also double-check your computer's operating system to be sure it supports the use of dual monitors. For example, Windows 98 SE, Me, 2000, and XP support multiple monitors.

If you really want to increase your screen real estate, especially for applications such as financial trading or 3-D design, you can even implement three or more monitors.

**Other Technologies**

## Touch-screen Monitors

Displays with touch-screen technology let you input information or navigate applications by touching the surface of the display. The technology can be implemented through a variety of methods, including infrared sensors, pressure-sensitive resistors or electronic capacitors.

## Wireless Monitors

Similar in looks to a tablet PC, wireless monitors use technology such as 802.11b/g to connect to your computer without a cable. Most include buttons and controls for mousing and web surfing, and some also include keyboards. The displays are battery-powered and relatively lightweight. Most also include touch-screen capabilities.

## Television and HDTV Integration

some displays have built-in television tuners that you can use for viewing cable TV on your computer. You can also find displays that accept S-video input directly from a video device. Additional features include picture-in-picture or picture-on-picture capability, a remote control and support for high-definition television (HDTV).

### VESA Brings Standardization

The Video Electronics Standards Association (VESA) is an organization that supports and sets industry-wide interface standards for the PC, workstation and consumer electronics industries. VESA promotes and develops timely, relevant, open standards for the display and display interface industry, ensuring interoperability and encouraging innovation and market growth.

In August of 1992, VESA passed the VESA Local Bus (VL-Bus) Standard 1.0. This standard had a significant impact on the industry, because it was the first local bus standard to be developed, which provided a uniform hardware interface for local bus peripherals. The creation of this standard ensured compatibility among a wide variety of graphics boards, monitors, and systems software.

Today, VESA is a worldwide organization that promotes and develops open display and display interface standards for interoperability. VESA is a formative influence in the PC industry and a contributor to the enhancement of flat panel display, monitor, graphics, software and systems technologies including home networking and PC theater.

Monitor Trends

## Display Port Standard

The Video Electronics Standards Association (VESA) is working on a new digital display interface for LCD, plasma, CRT and projection displays. The new technology, which is called Display Port, supports protected digital outputs for high definition and other content along with improved display performance.

According to VESA, the Display Port standard will provide a high-quality digital interface for video and audio content with optional secure content protection. The goal is to enable support for a wide range of source and display devices, while combining technologies. For example, the audio and video signals will be available over the same cable -- a smaller video connector will allow for smaller devices such as notebook computers, and the standard will enable streaming high definition (HD) video and audio content.

## Organic Light-Emitting Diode

Organic Light-Emitting Diodes (OLEDs) are thin-film LED (Light-Emitting Diode) displays that don't require a backlight to function. The material emits light when stimulated by an electrical current, which is known as **electroluminescence**. OLEDs consist of red, green and blue elements, which combine to create the desired colors. Advantages of OLEDs include lower power requirements, a less-expensive manufacturing process, improvements in contrast and color, and the ability to bend.

## Surface-Conduction Electron Emitter Displays

A Surface-Conduction Electron Emitter Display (SED) is a new technology developed jointly by Canon and Toshiba. Similar to a CRT, an SED display utilizes electrons and a phosphor-coated screen to create images. The difference is that instead of a deep tube with an electron gun, an SED uses tiny electron emitters and a flat-panel display.