Apple Displays

Technology Overview
January 2003

Contents

Introduction

You've turned your head to get a better look at their vivid images on colleagues' desks. You've seen them outshine CRTs in computer stores. You've spotted their unmistakably elegant design in movies and on TV. In short, you've wished you could have one for yourself.

They're Apple flat-panel displays—and they're as stunning to work with as they are to see.

Packing millions of brilliantly colored pixels into a thin, lightweight design, Apple flat-panel displays offer a practical alternative to CRT monitors. All of these displays use active-matrix liquid crystal display (LCD) technology to produce bright, clear images that can be viewed easily from a wide range of angles.

There are three models in Apple's flat-panel display lineup. The two Apple Cinema Display models feature Apple's innovative widescreen format, which is ideal for professional customers working with multipage layouts and high-definition video, while the Apple Studio Display delivers a large workspace in a standard format for home and business users. All three offer the most advanced technology of any flat panel available today. In addition, these displays feature a simple single-cable design that provides power and video in one easy connector.

If you're buying a new Power Mac G4 computer, an Apple flat-panel display is a must-have accessory. If you already have a Power Mac and a CRT, consider upgrading to one of these space-saving displays. Or if you already use a flat-panel display, you can add a second one to your Power Mac for the ultimate in productivity. And if you have a PowerBook G4, an Apple flat-panel display can extend your workspace even further.[1]

Apple flat-panel displays: An integral component of your Macintosh experience.

Product Overview

Benefits of Apple Flat-Panel Displays

- Bright, accurate colors across a viewing angle of up to 170° both horizontally and vertically
- Support for a true 16.7 million saturated colors
- Sleek, elegant design
- Fast pixel response for crisp full-motion digital video playback
- Direct digital connection to Power Mac G4 computers for distortion-free images
- All-digital connection to the 15- and 17-inch PowerBook G4 computers through the optional Apple DVI to ADC Adapter
- Built-in two-port USB hub for easy connection of desktop peripheral devices
- Unique hinge design for effortless adjustment
- Power button to turn on, put to sleep, or wake your entire Power Mac G4 system with a single touch

Unique Benefits of Each Display

- The 23-inch Apple Cinema HD Display (1920-by-1200-pixel resolution) supports high-definition content for showing more of your work in stunning color.
- The 20-inch Apple Cinema Display (1680-by-1050-pixel resolution) shows more than two full pages of text and graphics, or DVD movies in wide format.
- The 17-inch Apple Studio Display (1280-by-1024-pixel resolution) provides workspace equivalent to that of a 21-inch CRT monitor.

Choosing an Apple Flat-Panel Display

Which Apple flat-panel display is right for you? Although individual needs can vary widely within a given application, here are some typical ways in which people can use the different models.

The 17-inch Apple Studio Display

The 17-inch Apple Studio Display, with its 1280-by-1024-pixel resolution, is an ideal alternative to a large CRT display. In fact, despite having only a fraction of the size, weight, and electrical consumption of a 21-inch CRT, this display provides the same amount of workspace.

A physical comparison between this display and a 21-inch CRT may at first seem questionable, but CRTs are increasingly difficult to use at higher resolutions. They are inherently less bright and less sharp than LCDs, and those problems are exacerbated with the smaller pixels used at higher resolutions. The superior visual quality of an LCD allows it to display more pixels in a smaller area without making you strain to see them.

- Small business users will appreciate being able to view more of a spreadsheet, personal finance report, or database record in applications such as Microsoft Office and Intuit QuickBooks.
- Gamers will love the bright colors and detailed game environments possible with the Apple Studio Display. The graphics cards available in Power Mac G4 computers allow games to be played at high resolutions with practically no degradation in frame rates.
- This display is ideal for home users surfing the web with Apple's new Safari software. With desktop workspace equivalent to that of a 21-inch CRT, you can have multiple browser windows open simultaneously. That means you can keep up on the latest news while you research colleges or shop online—without having to constantly toggle between windows.

The 20-inch Apple Cinema Display

The new Apple Cinema Display makes high-resolution, widescreen viewing more affordable than ever. Despite being two inches smaller diagonally than the Apple Cinema Display that it replaces, the 20-inch Apple Cinema Display provides even more workspace. This is a truly professional display that measures up to the most color-critical work. Leveraging the LCD technology used in the Apple Cinema HD Display, the Apple Cinema Display delivers superb color in resolutions up to 1680 by 1050 pixels. That's 1.7 million pixels you can put to work designing magazine layouts, editing film, or decoding a genetic sequence.

- With Apple's new Final Cut Express software, you can deliver a professional-quality business video, or edit footage from a family event. The wide-format design of the Apple Cinema Display allows you to see both your source and destination video windows simultaneously, plus more of your timeline than on a standard rectangular screen.
- Scientific research demands high resolution and responsiveness from a computer display, both of which are specialties of the Apple Cinema Display.
- Page layout is a snap with the Apple Cinema Display. You can view a two-page spread and keep tools and palettes handy at all times in applications such as Adobe InDesign and QuarkXPress. And the digital design ensures that the colors you see onscreen are the colors you'll get on paper.

The 23-inch Apple Cinema HD Display

The 23-inch Apple Cinema HD Display delivers an amazing 1920-by-1200-pixel resolution—enough to support high-definition video content with room to spare. Even with such a wide viewing space, text remains sharp and distortion-free, and colors are vivid from edge to edge. The Apple Cinema HD Display is perfect for editing video or enhancing large graphics, permitting high-performance image manipulation in gorgeous, richly saturated colors.

- Graphics and publishing professionals won't find a display better suited to their needs than the 23-inch Apple Cinema HD Display. It provides ample room to view two full pages of graphics and text simultaneously, along with all the tools and palettes needed to edit, format, and composite their work. In conjunction with the ColorSync calibration system that's built into the Mac OS, the Apple Cinema HD Display ensures accurate, consistent colors.
- Video editors using Apple's Final Cut Pro software can view more video and timeline windows on the Apple Cinema HD Display. Its wide-format screen can display a high-definition video with ease, or show two standard-definition videos at full size simultaneously.
- Scientific and technical users will appreciate being able to visualize more of their work in applications such as Mathematica and BLAST—the more of an image they can see, the more easily it can be analyzed.
- Business professionals will appreciate the widescreen format that allows them to view a calendar, email, and web browsers all at the same time. And when the work is done, the Apple Cinema HD Display provides a great canvas on which to watch the latest DVD movie releases.

LCD Benefits

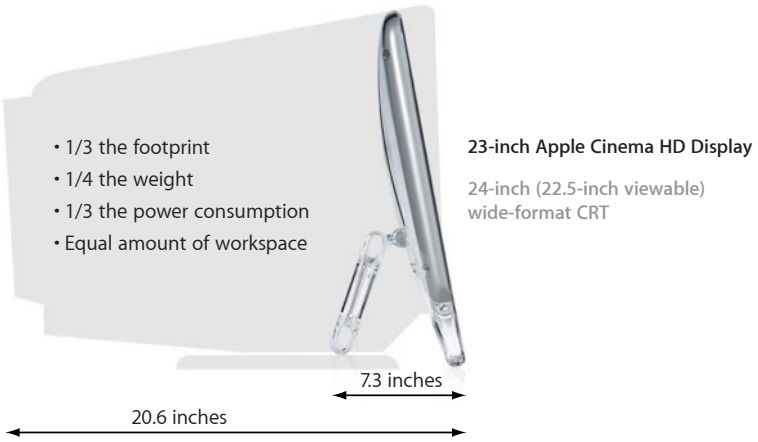
It's a fact that cathode-ray tube (CRT) monitors are quickly being surpassed in popularity by liquid crystal displays (LCDs). Apple pioneered the move to LCD technology two years ago with an award-winning lineup of all-digital active-matrix flat-panel displays, which provide the following advantages over CRTs:

- A thin, light form factor
- Excellent visual and color quality
- Low power consumption

This section focuses on the benefits offered by today's best active-matrix thin film transistor (TFT) flat-panel displays, such as those offered by Apple.

Thin, Light Form Factor

The first thing you notice about any LCD display is its slim and light design. Using two thin sheets of glass to enclose the liquid crystal material allows a flat-panel display to have a dramatically smaller desktop "footprint" when compared with a conventional monitor and its bulky cathode-ray tube. In fact, a flat-panel display averages about one-third the desktop space and weight of a comparable CRT. With a smaller footprint, LCD displays allow more desktop computers to be set up in places where they may not have previously fit, such as crowded audio and video studios as well as home, office, and school environments.



The 23-inch Apple Cinema HD Display has one-third the footprint, is nearly one-fourth the weight of a bulky 24-inch CRT display, and consumes just one-third the power.

Visual Quality

Today's best LCDs deliver about twice the brightness, sharpness, and contrast of a CRT display. They are also flicker-free and resistant to many of the environmental factors that affect the visual performance of CRTs.

Brightness and contrast

Active-matrix LCD displays are twice as bright as comparable CRT displays. A designer who uses a CRT must make a tradeoff between brightness and sharpness. If the CRT screen is made brighter, the text typically becomes less sharp. That's because CRT technology is based on phosphors emitting light after they've been excited by an electron beam. The more energy in the electron beam, the more the phosphors will glow. Unfortunately, as a given phosphor glows brighter, it becomes harder to distinguish it from neighboring phosphors. The result is that adjacent pixels become less distinct and therefore less sharp.

Flat-panel displays don't suffer from this limitation. They simply turn each pixel on and off using transistors directly in the screen that activate the liquid crystal layer with electricity. This means an LCD can be made very bright without reducing the clarity of text or graphics. A key benefit of a bright screen is that it allows you to view fine details and subtle color differences onscreen even in well-lit standard office and home environments.

Another benefit of increased brightness is better contrast ratio. Contrast ratio is defined as the ratio between the whitest white and the blackest black on a display—its dynamic range, if you will. Because flat-panel displays are brighter, they can create brighter whites, thus instantly increasing the contrast ratio. On the other hand, the glass surface of a CRT screen tends to scatter the ambient light of well-lit environments, further reducing the contrast ratio and washing out colors. An LCD does not exhibit this effect, so it displays blacker blacks in standard office illumination settings. You can see the difference by comparing an LCD and CRT monitor side by side when they're turned off.

Sharpness

In a CRT, the energy from the electron beam hitting the phosphors creates light, which fades after the beam sweeps to other parts of the screen. The sharpness of a CRT is determined by the size of the area excited by the electron beam. To minimize the apparent flicker of the phosphor being excited and fading, a good CRT monitor updates each part of the screen at an incredibly fast rate—75 times a second or more. However, at those speeds it's difficult to control the spot size of the electron beam and therefore to create a sharp transition between black and white areas. So a high refresh rate and a sharp image are difficult to implement simultaneously at high resolutions.

An active-matrix digital display isn't subject to the physical limitations of an electron beam being swept across the screen. Each pixel is physically separated from the others and has an electronic switch that can be turned on or off independently. A black pixel can be adjacent to a white pixel with no difficulty. The result is an incredibly sharp display.

Another factor in the sharpness of LCD displays is simple geometry. The electron beam emanates from the center of the cathode-ray tube, so at the edges of the screen, it hits the phosphors at a noticeable angle, not straight on. The beam's footprint becomes oval rather than circular, causing inevitable clarity problems at the edges of the CRT screen. This problem is even more dramatic in wide-format CRTs, because the electron beam must be deflected at an even greater angle to reach the edges and corners. LCDs, by comparison, have no beam hitting the screen edges at an angle, and therefore no geometry problems. The pixels at the edge of an LCD are as crisp as the ones in the center.

Lack of flicker

It is a widely accepted belief that watching a flickering monitor for an extended period can cause eyestrain and associated headaches. Modern CRT displays with high refresh rates have minimized flickering in their images. LCDs, however, offer an inherent advantage in this regard: They have no electron beam rapidly "painting" an image on the screen line by line. Each and every pixel on an LCD is simply turned on and off independently whenever needed.

Color Quality

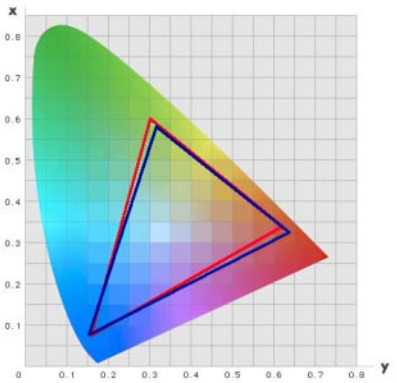
For many Mac users, color quality is a critical factor—one that affects their very livelihood. Traditionally, CRTs have been an important link in the color proofing system for content ultimately destined for print, web, or video distribution. So flat-panel displays must provide equal or better results in these color-critical applications if media professionals are to accept them.

What makes a great color display? A monitor must be able to display a broad color gamut that is consistent from edge to edge and over time—no matter where it's located. In short, it must provide accurate, predictable, and consistent colors.

Apple pioneered the shift to all-digital flat panel displays in 2001, once we believed that LCD technology was up to the task of providing a great color viewing environment for our customers.

Color gamut

Earlier this century, a group of scientists and intellectuals who called themselves the Commission Internationale de l'Eclairage (CIE) had the goal of defining color. Using as much objectivity as is possible with this highly subjective topic, they developed a coordinate system for categorizing the world of colors. Theoretically, based on this system, every color we see can be described in terms of x, y coordinates for red, green, and blue components. Taking it one step further, every device that reproduces colors can also be described based on the x and y values of its red, green, and blue colors. The total number of colors prescribed by the two-dimensional plot of these x and y coordinates is often referred to as the device's "color gamut."

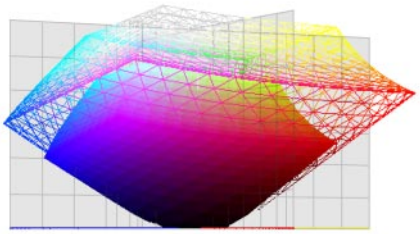


1931 CIE chromaticity diagram
The broad color gamut of the Apple Cinema HD Display is virtually the same as that of professional-quality CRT displays.

The first question in our comparison of LCD versus CRT color quality is whether the color gamut of today's best LCDs is as extensive as that of the CRT. The answer is yes. Plotting the x, y values for the red, green, and blue colors shows that the color gamut of an LCD is as large as that of a typical CRT. In other words, there are no longer any compromises in the total colors available when using a flat-panel display.

In addition to this two-dimensional color description, color has a third dimension: its brightness. As previously described, a flat panel substantially outperforms a CRT on the brightness axis. Adding this third dimension to our color comparison shows that the total volume of colors perceived from an LCD such as the Apple Cinema Display actually becomes larger than the volume of colors corresponding to a CRT.

While it's difficult to notice the impact of brightness on color when you view CRTs and LCDs independently, it's easy to see the difference when you put the two types of monitors side by side. You'll immediately notice that the LCD's colors appear more vivid and lifelike because its total color gamut is perceptually larger than that of the CRT. The benefit of this larger perceptual gamut is that you can use the LCD in normally lit settings such as offices and homes—with little reduction in the dynamic range of colors being displayed (that is, without the colors becoming washed out). A CRT in a darkened room will perform similarly to an LCD in this regard, but the LCD provides a greater color range in a room that isn't dark. Content creators who have been forced to sit in darkened rooms to do their work on a CRT will appreciate this difference.



Comparison of a typical 21-inch CRT and the Apple Cinema Display
The increased brightness of the Apple Cinema Display produces a much larger perceptual color gamut.

Uniform color

We described how important it is for a display to be capable of reproducing a large number of colors; that is, providing a large color gamut. Equally important is that it be able to display that broad color gamut over the entire screen, over a wide range of physical locations, and over time. Each of these concerns is an aspect of color uniformity—a goal that display manufacturers are constantly striving to improve.

Today's best LCDs, such as those in Apple's display family, offer excellent color uniformity over the entire screen, both from top to bottom and from side to side. An important reason why edge-to-edge color uniformity is possible with recent LCD designs is the development of wide-viewing-angle technologies. Users viewing the 23-inch Apple Cinema HD Display from a typical distance of 20 inches will be seeing the color in the corners of the display at an angle. Without wide-viewing-angle technology, the colors at those extreme locations would shift.

Viewing conditions can also vary widely around the globe. Terrestrial magnetism, heat, humidity, altitude, and local electromagnetic fields all play a role in causing an analog CRT display to become misaligned—leading to image degradation and color distortion. LCDs are immune from the negative impact of such worst-case viewing environments. Here are several real-world situations in which a CRT display could be adversely affected by environmental factors:

- Position your CRT in a north/south orientation. It will behave differently than when it's in an east/west orientation.
- Position your CRT near a pair of unshielded stereo speakers or in an office building next to an elevator shaft. You may see a dramatic change in screen colors because of magnetic field interference with the electron beam being fired at the phosphors.
- Tap the side of a CRT that uses an aperture grille mask and notice how the vibration of the grille distorts the image.
- Have a user in the Northern Hemisphere send an important color file to a client site in the Southern Hemisphere, or vice versa. The different terrestrial magnetism of the two hemispheres creates different effects on CRTs in the two locations.

In all of these real-world scenarios, LCDs would provide much more accurate and predictable colors than CRTs.

Another aspect of display color uniformity is how predictable it is over time. With extended use, every monitor will change. The goal for display manufacturers is to minimize the impact of these changes on the display's color performance. In this regard, the LCD again has an advantage over CRTs.

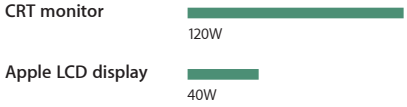
CRT displays work by having an electron beam excite inorganic phosphors, which in turn emit a red, green, or blue color. As the CRT ages, the ability of these phosphors to uniformly emit color deteriorates. The red, green, and blue phosphors age at different rates, which eventually produces a color shift.

An important parameter affecting the color on a display is the white point. We tend to think of white as an absolute color. But there are actually many hues of white—compare the "white" light of the sun, an incandescent light bulb, and a fluorescent light. The white point is important because it affects how you perceive all other colors on that display. Even more important is maintaining a consistent white point over time, because a white point that changes will throw off all the other colors on the screen. LCDs are excellent at maintaining a consistent white point, providing a predictable and uniform environment in which to view color images over time.

Even with the color consistency now possible with flat-panel displays, for the most color-critical work it's still important to carefully manage the performance of every device in the process—scanners, displays, printers, and so on. Because each device has different color reproduction capabilities, maintaining consistent colors in a given image from device to device is difficult without a systemic mechanism of color control. Hence the need for a high-quality color management system.

A color management system works by collecting information about every device and then using color correction to translate between the color characteristics of the different devices. Apple's own ColorSync is the industry's best means of managing color. It uses the industry-standard International Color Consortium (ICC) format for storing color information about different devices, known as the ICC profile. Creating a profile for a given device requires a calibrated measuring tool. The Eye-One spectrophotometer from GretagMacbeth is one such tool. It can measure CRT and LCD displays, photographs, slides, and printed output, ensuring better long-term color fidelity in a color-managed workflow.

Low power consumption:
A 200% cost savings



Low power consumption means increased savings over the life of the display.[2]

Low Power Consumption

Although visual quality is of paramount importance in selecting a monitor for your computer, cost of ownership is also a significant factor. Because LCDs use one-third the power that CRTs use, they have a lower cost of ownership.

CRT monitors need a lot of electricity to power the magnetic system used to deflect the electron beam across the entire screen and back 75 times or more per second. Instead of this electron beam, LCDs use a backlight and thin film transistors (TFTs) at each pixel location to drive the display mechanism. The backlight and transistors use only a fraction of the electricity needed to power a CRT. The net result of using a TFT active-matrix LCD is a dramatic saving in energy costs over time. That's good for the environment—and for your budget.

Apple LCD Benefits

From their precision color technology to their head-turning design, Apple flat-panel displays deliver sharp text and stunning colors from edge to edge. Not only do Apple flat-panel displays offer advantages over CRT displays, but they also offer advantages over competitors' LCD displays.

At Apple we believe that the display is a crucial part of your computing experience. That's why we pay as much attention to creating great displays as we do to creating great computers and great software. Whether you choose the 17-inch Apple Studio Display, the 20-inch Apple Cinema Display, or the 23-inch Apple Cinema HD Display, you'll enjoy a wide-viewing angle, fast responsiveness, a pure digital connection, and great integration with other components of your Macintosh system.

Wide-Viewing-Angle Technology

The heart of the tremendous color quality delivered by Apple flat-panel displays—and what distinguishes them from many other LCDs—is the technology used to extend the viewing angle. Without it, colors viewed off-axis can shift in color, contrast, gamma, or all three attributes. Off-axis color consistency is especially important in displays that have a wide aspect ratio, as pioneered in the Apple Cinema Display line. An inferior wide-viewing-angle technology could cause significant perceived variations between a color in the middle of the screen and the same color in the corner of a wide-format display.

The technology used in Apple flat-panel displays is the best in the industry at minimizing color shift at wide angles. LCDs that use other viewing-angle technologies can't measure up to the off-axis color performance of an Apple display.

Apple Displays and SWOP Certification

In January 2003, the Remote Director 2.0 proofing system from Integrated Color Solutions, Inc. (ICS) became the first display-based proofing system to be SWOP (Specifications for Web Offset Publications; www.swop.org) certified. The prestigious SWOP certification means Remote Director 2.0 can be used to approve jobs for press production onscreen without the need for hard-copy proofs, providing significant time and cost saving for print professionals. Certified systems are capable of producing proofs visually identical to the SWOP Certified Press Proof as defined in ANSI CGATS TR 001, *Graphic Technology—Color Characterization Data for Type 1 Printing*.

Remote Director 2.0 uses an Apple Cinema Display or Apple Cinema HD Display along with a Power Mac G4 running Mac OS X version 10.2 "Jaguar." ICS chose Apple flat-panel displays because they are the only ones able to provide the luminance and color gamut ICS needs to create an onscreen proof that has the same brightness and feel as paper.

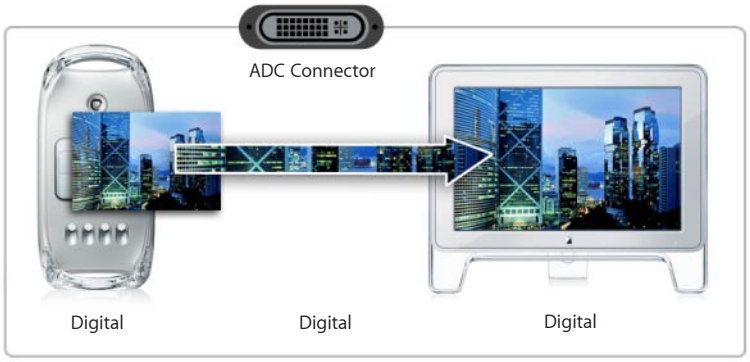
Pixel Response Time

For media professionals, the ability to render full-motion video or 3D graphics clearly enough to view precise details is key. Today's advanced LCDs such as the Apple flat-panel displays meet this demanding requirement.

The specification used by LCD manufacturers to define this ability is pixel response time. However, that specification doesn't tell the whole story. Fast pixel response when transitioning between black and white is important, but so is the response time for transitioning between midtones. A specification that measures only black to white transitions is insufficient. Apple LCD displays have been designed to offer fast pixel response across the entire spectrum, working well with fast-moving details in multi-hued images.

Digital Connection

Apple has maximized the sharpness of its flat-panel displays by using a pure digital signal to drive them. Some flat-panel displays still use an analog interface (typically VGA) in order to be more broadly compatible with graphics cards that don't support digital output. To create an analog signal from the digital data in graphics memory, the computer's graphics controller must perform a digital-to-analog (D/A) conversion. Because an LCD display is a digital device, the incoming analog signal requires conversion back to digital form (A/D). These two conversions (from digital to analog by the graphics card, then from analog to digital in the LCD monitor) inevitably lead to varying degrees of image degradation on the screen. This degradation can take many forms, including ghosting (fuzziness around the edges of images), color shifts, incorrect vertical and/or horizontal alignment of the viewable area, loss of vertical or horizontal synchronization, and brightness and contrast problems. Analog conversion problems become progressively worse as you move to monitors that have higher resolutions or use longer monitor cables.



The pure digital connection of the Power Mac G4 to the Apple flat-panel display ensures maximum visual quality.

To accommodate for the imperfections created by using an analog signal to drive a flat-panel display, manufacturers provide lots of hardware and/or software user controls. But those controls are hard to use, and they can only do so much. When driving a digital display with an analog signal, it is particularly difficult to maximize the display's dynamic range, and therefore its ability to reproduce a wide range of colors is inhibited. Maximizing the range requires accurately establishing both the black and peak white points of the analog signal and the analog to digital converter. Often either the black point or the white point is set incorrectly, resulting in a decreased dynamic range or clipping of colors.

Apple flat-panel displays are safe from those problems because they don't require any conversion. The pure digital Apple Display Connector (ADC) transmits a distortion-free digital signal from a digital location in the graphics card to a digital location on the display's screen. This digital connection gives you the full clarity and stability of liquid crystal technology—with sharp, clear pixels from edge to edge, and no flicker. Because there's no conversion, there's no need for special controls. You see high-quality images every time, automatically, without having to constantly adjust the picture.

The following chart lists the controls needed for an LCD with an analog interface and those provided with an Apple all-digital display. In this case, needing more controls is not desirable.

User controls needed on an LCD without an all-digital signal	User controls on Apple LCD displays
Monitor startup and sleep	System startup and sleep
Brightness and contrast	Brightness
Fine tracking and coarse tracking (synch)	
White and black balance controls	
Horizontal and vertical positions	

Stunning Design

In addition to providing outstanding visual performance, Apple displays are designed to be works of art for the desktop. When you look at an Apple flat-panel display, notice the crystal enclosure that makes the display appear to be floating on the desktop. Not only does this make the display stunning to look at, but it also makes your eyes focus on the screen rather than the enclosure. In addition, the color of the bezel has been carefully chosen to minimize interference with color appearing on the screen, providing a neutral reference point for viewing colors.

Another important design feature is the unique ratcheting hinge that requires very little pressure to tilt the monitor to a different position. This design allows you to effortlessly adjust the display so you view it at a downward angle, a position that puts less strain on your eyes and neck. In addition, the cable that carries the digital signals can pass straight through the rear foot, without interfering with the motion of the hinge. The hinge also provides a convenient means of securing the display with a cable lock.

Integration

For many PC manufacturers, the display is a peripheral device. For Apple, the display is designed to be an integral part of a complete Macintosh system. Our goal is to create systems that give you modular flexibility and all-in-one simplicity.

All Apple flat-panel displays have the following integrated features that deliver smoother performance, more consistent operation, and easier setup and use than other LCDs:

- **Apple Display Connector.** The ADC makes setting up any of the displays simple. A single cable with a quick-latch connector carries all the video, USB, and power signals from the computer to the display. Your desktop isn't cluttered with separate USB and power cables.

- **USB ports.** Conveniently located on a built-in hub, the USB ports make it easy to connect peripheral devices such as a keyboard, mouse, printer, storage device, or digital camera.
- **A single power button.** The power button on the front of the Apple display allows you to turn on, put to sleep, or wake your Power Mac G4 with a single touch.
- **Displays preference launch button.** The other button on the display automatically launches the Displays preference pane, so you can easily change resolutions or brightness.

Support for Dual Displays

Whether you have a Power Mac G4 or a PowerBook G4 computer, you'll enjoy the benefits of having an additional Apple flat-panel display. A second display dramatically increases the amount of "screen real estate" you have to work with, which is a boon to graphic designers, video editors, and other media professionals who must juggle multiple source documents, tool palettes, timelines, and more. It's also a great solution for PowerBook users who want a larger screen when they aren't on the road.

Power Mac G4 systems come with both ADC and DVI connectors. You can plug one Apple flat-panel display directly into the ADC port, and use an optional Apple DVI to ADC Adapter to create a pure digital connection to a second display.

The 15- and 17-inch PowerBook G4 computers have a DVI connector. Simply add an Apple DVI to ADC Adapter to attach any current Apple flat-panel display.

Product Details

Apple Displays

Apple's all-digital flat-panel displays are available in three sizes to meet the needs of every Power Mac G4 user.

Model	Apple Studio Display M7649ZM/B	Apple Cinema Display M8893ZM/A	Apple Cinema HD Display M8537ZM/A
Screen size and type	17-inch (viewable) active-matrix LCD	20-inch (viewable) active-matrix LCD	23-inch (viewable) active-matrix LCD
Maximum resolution	1280 by 1024 pixels	1680 by 1050 pixels	1920 by 1200 pixels
Viewing angle	170° horizontal; 170° vertical	170° horizontal; 170° vertical	170° horizontal; 170° vertical
Color support	16.7 million colors	16.7 million colors	16.7 million colors
Input/Output ports	Apple Display Connector; two-port, self-powered USB hub	Apple Display Connector; two-port, self-powered USB hub	Apple Display Connector; two-port, self-powered USB hub
Agency approvals	ENERGY STAR, TCO 95	ENERGY STAR, TCO 95	ENERGY STAR, TCO 95

System Requirements

- The Apple Studio Display requires Mac OS X v10.1.3 or Mac OS 9.2.2 or later, and one of the following systems:
  - Power Mac G4 with an Apple Display Connector
  - PowerBook G4 with a DVI port and an Apple DVI to ADC Adapter
- The Apple Cinema Display requires Mac OS X v10.2 or later, and one of the following systems:
  - Power Mac G4 with an NVIDIA GeForce2 MX, GeForce3, GeForce4 MX, or GeForce4 Titanium graphics card; or an ATI Radeon 7500, 9000 Pro, or 9700 Pro graphics card
  - PowerBook G4 with a DVI port and an Apple DVI to ADC Adapter
- The Apple Cinema HD Display requires Mac OS X v10.1.3 or Mac OS 9.2.2 or later, and one of the following systems:
  - Power Mac G4 with an NVIDIA GeForce2 MX, GeForce3, GeForce4 MX, or GeForce4 Titanium graphics card; or an ATI Radeon 7500, 9000 Pro, or 9700 Pro graphics card
  - PowerBook G4 with a DVI port and an Apple DVI to ADC Adapter
- A second Apple display can be used with a Power Mac G4 via the DVI port on the NVIDIA GeForce4 MX, GeForce4 Titanium, ATI Radeon 7500, Radeon 9000 Pro, or Radeon 9700 Pro graphics card and the Apple DVI to ADC Adapter.

Extended Service and Support

Purchase the AppleCare Protection Plan to extend your service and support to up to three full years. The plan provides support for your Mac, the Mac OS, and many Apple consumer applications, so just one phone call can help resolve most issues. Power Mac and PowerBook customers can also enroll one display for coverage, provided that the display is purchased at the same time as the covered computer. For more information, visit www.apple.com/support/products or call 800-823-2775.

Technical Specifications

Following are the specifications for the 17-inch Apple Studio Display, the 20-inch Apple Cinema Display, and the 23-inch Apple Cinema HD Display.

Screen size (diagonal viewable image size)

- Apple Studio Display: 17 inches
- Apple Cinema Display: 20 inches
- Apple Cinema HD Display: 23 inches

Screen type

- Thin film transistor (TFT) active-matrix liquid crystal display

Resolutions

Apple Studio Display

- 1280 by 1024 pixels (optimum resolution)
- 1024 by 768 pixels
- 800 by 600 pixels
- 640 by 480 pixels

Apple Cinema Display

- 1680 by 1050 pixels (optimum resolution)
- 1280 by 800 pixels
- 1024 by 640 pixels

Apple Cinema HD Display

- 1920 by 1200 pixels (optimum resolution)
- 1280 by 800 pixels
- 1024 by 640 pixels
- 800 by 500 pixels

Display colors (maximum)

- 16.7 million

Viewing angle (typical)

- 170° horizontal; 170° vertical

Brightness (typical)

- Apple Studio Display: 200 cd/m^2
- Apple Cinema Display: 230 cd/m^2
- Apple Cinema HD Display: 200 cd/m^2

Contrast ratio (typical)

- 350:1

Pixel pitch

- Apple Studio Display: 0.264 mm
- Apple Cinema Display: 0.258 mm
- Apple Cinema HD Display: 0.258 mm

Screen treatment

- Antiglare hardcoat

User controls (hardware and software)

- System power on, sleep, wake
- Brightness
- Monitor tilt

Connectors and cables

- Apple Display Connector carries digital video, USB, and power
- Two-port, self-powered USB hub

Electrical requirements

- Input voltage: 24.5V to 28V DC carries digital video, USB, and power
- Maximum power when operating: 40W (Apple Studio Display); 60W (Apple Cinema Display); 70W (Apple Cinema HD Display)
- Energy saver mode: 3W or less

Environmental requirements

- Operating temperature: 50° to 95° F (10° to 35° C)
- Storage temperature: –40° to 116° F (–40° to 47° C)
- Operating humidity: 20% to 80% noncondensing
- Maximum operating altitude: 10,000 feet

Agency approvals

- FCC Part 15 Class B
- EN55022 Class B
- EN55024
- VCCI Class B
- AS/NZS 3548 Class B
- CNS 13438 Class B
- ICES-003 Class B
- ISO 13406
- MPR II
- IEC 60950
- UL 60950
- CSA 60950
- EN60950
- ENERGY STAR
- TCO 95

Size and weight

17-inch Apple Studio Display

- Height: 17.3 inches (43.9 cm)
- Width: 17.6 inches (44.7 cm)
- Depth: 6.9 inches (17.6 cm) minimum; 9.8 inches (24.9 cm) maximum
- Weight: 14.6 pounds (6.6 kg)

20-inch Apple Cinema Display

- Height: 17.3 inches (43.9 cm)
- Width: 21.34 inches (54.2 cm)
- Depth: 6.93 inches (17.6 cm) minimum; 10.43 inches (26.5 cm) maximum
- Weight: 18.9 pounds (8.6 kg)

23-inch Apple Cinema HD Display

- Height: 19.2 inches (48.8 cm)
- Width: 24.2 inches (61.4 cm)
- Depth: 7.3 inches (18.7 cm) minimum; 11.1 inches (28.0 cm) maximum
- Weight: 25.3 pounds (11.5 kg)

For More Information

For more information about Apple's family of all-digital flat-panel displays, please visit www.apple.com/displays.

[1]Requires Power Mac G4 or PowerBook G4 with DVI port. [2]Comparison based on cost of operating an Apple 17-inch flat-panel display and a typical 21-inch CRT display in California over a four-year period, as of January 2003.