

Evaluating Color Performance in a Professional Monitor



This buyer's guide reviews why your monitor matters, and what to look for when purchasing a professional-grade monitor to enhance your creative work.

— Kenneth Mau, 09/28/16

Introduction

Professional-grade monitors are distinguished by the ability to deliver a greater range of colors, along with other color-enhancing technologies, which results in a more accurate on-screen representation of images. These capabilities are ideal – and often critical – for those whose work depends on image accuracy, such as graphic designers, video/photo editors, and CAD/CAM engineers. They're also desirable to anyone who seeks to achieve the best possible results from their technology.

Working with and editing images onscreen with a less-than-accurate monitor delivers output that won't represent the original image files. Another way to look at it: if you're making adjustments to an image that isn't really the image you shot or designed (in terms of color), any changes you make to these incorrect colors can make what you're trying to fix worse. In today's digital world, the monitor is a critical component of the photographic and graphic design process. It's also the visual doorway into a world of content for anyone with a passion for perfection – whether viewing home videos or surfing the Internet.

Monitors marketed under the moniker “professional” have traditionally come with a price tag that puts them out of reach for anyone other than those whose displays are funded by their company, or freelancers and enthusiasts with the deepest of pockets. Recently, moderately priced color-critical monitors with professional-level specs have become available.

Part 1: Digital Color Basics

The science of digital color is quite complex. Add in digital devices that mathematically encode and decode color, and don't always (or even usually) match up, and things get even trickier. Following are some of the terms you're likely to encounter as you weigh the merits of professional monitors.

Color Gamut

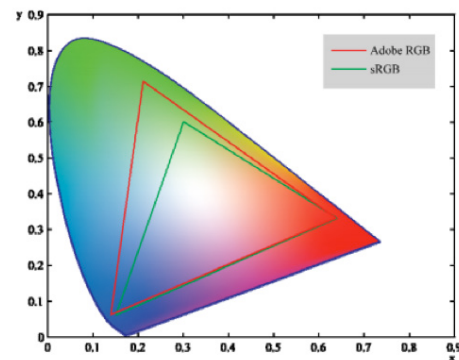
So closely related that they are often used interchangeably in marketing materials, the terms color gamut and color space both refer to specific sets of colors that can be seen or reproduced. The term “gamut” refers to a complete range of something compared to its reference range. A color gamut is the complete range of colors visible to the eye; represented in a photograph, illustration or painting; or produced by a camera, monitor, printer or other digital device. Different technologies and devices have different color gamut capabilities. And because devices have different gamuts, things get complicated. On its own, the color data assigned by one device is essentially meaningless to other technologies with which it shares its image files, be they a camera, editing software, monitor or printer. To address this issue, digital devices map colors into color spaces, which gives meaning to the color values.

In nature, the number of possible colors is virtually infinite. Color spaces represent defined sets of colors within this infinite palette. They are derived using abstract mathematical models. Wider color spaces contain more colors, while smaller color spaces have fewer colors. The human eye can see around 10 million colors, which is the physical limitation of our color space. Different digital devices are designed to work within different color spaces.

While in theory a virtually infinite number of color spaces can be defined, a handful of standards guide digital photographic, video, graphic design and color processing technologies. The CIE L*a*B* space defines the visible human spectrum and is represented by the “horseshoe” shaped graph shown here. The sRGB and Adobe RGB color spaces are well known digital color spaces, which are defined graphically as triangles within the CIE space.

"A color gamut is the complete range of colors visible to the eye; represented in a photograph, illustration or painting; or produced by a camera, monitor, printer or other digital device."

- sRGB is a least-common-denominator color space standard used in a large number of applications, including the Internet.
- Adobe RGB is a well-known standard among graphic designers, photographers and other creative professionals and is used as an editing space.
- NTSC, EBU, Rec.709, and Rec.2020 are common color spaces used for video, film and TV broadcasting.



Gamma and Gamma Correction

Experts in the field agree that while gamma is a complex and confusing concept, a basic understanding of it is critical to achieving the best results from your photographic and/or design efforts as it greatly affects how digital images look on a monitor.¹ The term Gamma has several different meanings; when it comes to working with digital devices, gamma is defined as a mathematical operation used to code and decode brightness (aka “luminance”) values. The goal of Gamma is to make a digital image that looks as good as possible. Here’s one pro’s viewpoint:

“Gamma is an important but seldom understood characteristic of virtually all digital imaging systems. It defines the relationship between a pixel's numerical value and its actual luminance. Without gamma, shades captured by digital cameras wouldn't appear as they did to our eyes (on a standard monitor). It's also referred to as gamma correction, gamma encoding or

gamma compression, but these all refer to a similar concept. Understanding how gamma works can improve one's exposure technique, in addition to helping one make the most of image editing."²

There are three types of gamma involved in digital images: image gamma, display gamma and system gamma. How these gammas work is beyond the scope of this article. Suffice to say that every digital device has its own gamma characteristics, and translating the image gamma into what you see on your monitor screen is the purview of the display gamma. Display gamma is used by monitors to adjust the output of an image. Higher display gammas result in darker images with greater contrast. Since the mid-20th century, industry experts have agreed that a display gamma of 2.2 delivers the right perceptual relationship between tones, and today, most monitor manufacturers develop displays with a pre-set native 2.2 gamma.³

Color Depth

Also called pixel depth, color depth refers to the number of bits-per-pixel a computer monitor uses to represent a specific color: the more bits-per-pixel, the higher color variety. The earliest graphics cards and monitors supported 1-bit color, for a monochrome (typically black and white) display. General use monitors tend to be promoted as offering 24-bit (8-bit color, times three color channels) for 16,777,216 colors. While this sounds good, there's more to the story. Most of these less-than-pro-level monitors deliver the 16.7M colors by supporting 6 bits plus 2 bits more using FRC (frame rate control). Professional-grade monitors, on the other hand, deliver true 8-bit or 10-bit using 8-bit plus 2-bit FRC, both of which deliver greater color accuracy.

Part 2: What to Look for in a Professional Monitor

Monitors on the market today offer a variety of features and technologies. When it comes to maximizing the beauty and accuracy of anything you view on your screen, several key features impact color performance and image quality. Chief among these are:

- Full sRGB / Adobe RGB color spaces
- Gamma preset options
- A powerful 3D Look up Table (LUT) / color engine
- Low Delta E
- Screen uniformity compensation
- Premium panel technology
- Hardware calibration ready

Below is a summary of what to look for in each of these areas.

Color Reproduction Capabilities: Gamut, Color Space and Color Depth

As discussed above, a monitor's color gamut is the range of colors it can produce. In terms of pure color theory it is an entirely different thing than a color space. In terms of monitor marketing materials, not so much, so it's important to be aware that you'll probably see the terms "color gamut" and "color space" used interchangeably. While the term "wide color gamut" may be accurate to describe a particular professional monitor, it's also an imprecise term. Color spaces on the other hand are specific, standardized sets of color and are a highly useful way to understand the color capabilities of a particular monitor.

"when you view photos in a color space smaller than the one with which they were shot, the missing color data will reduce the level of detail and result in muddier, less vivid colors."

No monitor can display colors that are outside of its available color space(s). For example, a monitor that covers only the sRGB space can't display all of the colors in the larger Adobe RGB space. For example, if you're working with an image captured by a camera that used the Adobe RGB space, and you view the images on an sRGB display, the saturated colors that fall outside of the sRGB gamut will still exist as encoded data but you won't be able to see them. Likewise, if your image is shot on a camera set to capture images using the sRGB color space but your general-purpose display only covers part of this color space, when you view these images they'll be missing colors. In short, when you view photos in a color space smaller than the one with which they were shot, the missing color data will reduce the level of detail and result in muddier, less vivid colors.

Gamma Adjustment Features

Most displays are shipped with a native display gamma of 2.2. Good professional-grade monitors allow gamma to be easily adjusted for fine tuning. While the correct term for this is monitor gamma calibration, you'll also see information refer to it as gamma correction. Those who work regularly in digital color professions agree that it's a critical function; here's how one pro puts it:

"Gamma correction matters if you have any interest in displaying an image accurately on a computer screen. Gamma correction controls the overall brightness of an image. Images which are not properly corrected can look either bleached out, or too dark... Varying the amount of gamma correction changes not only the brightness, but also the ratios of red to green to blue."⁴

sRGB

- Least-common-denominator standard
- Wide usage, including the Internet

Adobe RGB

- Covers more colors than sRGB
- Most-used standard among graphic designers, photographers and other creative professionals
- Widely used with Photoshop & other editing software

ProPhoto

- The largest defined space which no monitor is capable of displaying
- Used for document archiving & photo output
- Encodes nearly the whole range of colors detected by the human eye, and even encode colors that the eye cannot detect

Examples of typical gamma presets include:

- Gamma 1.8 – Enhances visibility and detail in dark scenes
- Gamma 2.0 – Enhances detail in dark scenes for soft, gentle scenes.
- Gamma 2.2 – Native preset for general use
- Gamma 2.4 – Enhances detail in bright scenes for vivid colors
- Gamma 2.6 – Highlights black and white scenes;
good for document viewing

The Power of LUTs

The best professional monitors include a powerful, hardware-embedded LUT. An acronym for “look up table,” LUTs enable monitors to adapt to deliver added color gradations as needed based on the image(s) displayed. They may also be referred to as part of the monitor’s “color engine” or “internal color processing” capabilities.

Look up tables apply complex mathematical calculations to optimally map color values by adjusting gamma. An easier way to conceptualize them is to think of a LUT as a dictionary that offers your monitor a set of colors to choose from when seeking to adjust color in relation to shifting luminance levels. Fortunately, this color correction happens automatically in monitors equipped with this functionality. (Not to be confused with custom LUTs that advanced pro users may create.)

LUTs are measured in bits, with a higher the bit level indicating a larger available color palette and more powerful color adjustment capabilities. Standard multi-purpose consumer monitors are typically 8-bit, providing a usable palette of 16.7 million colors. Professional color management monitors are equipped with a 10-, 12-, or 14-bit LUT, with this highest-level (14-bit) look up table delivering 4.39 trillion colors – for 260,000 times more color precision than an average consumer monitor.

Another indicator of a LUT’s capabilities is whether it is standard (1D) or 3D. Monitors equipped with a 3D LUT deliver more finely nuanced hues, smoother, highly blended gradations, and more vibrant, accurate colors than those with a more limited 1D LUT.

Delta E: The Lower the Better

Delta E is a metric for understanding how the human eye perceives color difference and is used to measure the color performance of monitors. Also written as ΔE - or dE, Delta E is the measure of change in visual perception of

two given colors. On a typical scale, the Delta E value will range from 0 to 100, with numbers less than zero indicating differences that are not perceptible to the human eye and 100 indicating colors that are exact opposites. Monitor manufacturers will state a Delta E number for models targeted to meet color-critical needs. This number is representative of how the color delivered by a particular monitor compares to the “perfect” color value – the lower the number the better the performance.

The human eye has a Delta E of around 1, so anything less than that is imperceptible. In fact, achieving a “perfect” Delta E in a monitor is impossible and even the most costly display will never have a Delta E of 0; these top-of-the-line professional displays can achieve Delta E of 1 or even slightly less. Next are the high-end, high price tag displays with a Delta E of <2. Many mid-range monitors marketed for photography and other color-conscious applications have a Delta E of <3 or <4. More recently, high-spec displays with Delta E of <2 have become available at a more moderate price point.

Screen Uniformity: Panel Technology and Compensation

Uniformity of color across the screen is critical to achieving the most accurate viewing and editing. The type of panel used in a monitor is an important factor in its ability to deliver the widest possible viewing angle for the best visual performance across the screen. The wider the viewing angle, the less image (and color) degradation as your view moves from the center of the screen. Outside of a display’s stated viewing angle, images can lose contrast, become blurry, faint, or poorly saturated. For the average home or business user, or those who rely on a laptop-sized screen, the impact of this reduced brightness and diminished contrast is generally negligible. For graphic designers and other color-conscious users, it reduces color accuracy for more challenging viewing, assessing and editing.

Premium panel technology such as SuperClear IPS technology, which offers the widest-available maximum viewing of 178-degrees up/down and right/left, is the gold standard panel technology for professional-level displays and the most widely recommended panel technology among this group.

Even with the highest quality premium panel, color uniformity will vary somewhat across the screen, with optimal color performance at the center of the screen. This is largely due to unavoidable variations in luminance across the screen. Imagine a screen divided into several equivalent sections. Because the brightness is different across the screen, the same color will appear somewhat different in each of these sections.

The best professional displays include a color uniformity compensation function to address these variations. While technologies vary by manufacturer,

they broadly work by selectively adjusting chromaticity and dimming brightness as needed to achieve greater uniformity across the screen. A typical specification identifying uniformity compensation through brightness adjustments is notated as $L_v < 5\%$, which indicates that variations in luminance will be controlled within 5%. By contrast, in typical general-use monitors, brightness can vary by as much as 30% or higher.

Color Calibration Capabilities

At its most basic, monitor calibration is any adjustment that impacts brightness, contrast and color reproduction. Making the adjustments to gamma discussed above is an example of calibrating your monitor. Many photography pros consider monitor calibration critical to being a digital photographer, and the exemplary comment below applies to other color-conscious work as well:

"The best professional monitors are capable of "hardware calibration," which enables colorimeters to deliver the most consistent, accurate results. "

"No photographer, whether they be amateur or professional, should work with images without having a calibrated monitor. It is a small investment that will ensure that every photograph you share online or send to a photo lab to be printed looks the way you intend it to. It does absolutely no good to create an image that looks beautiful to you and looks horrible to everyone else!"⁵

Standard consumer and business monitors have minimal functionality related to maintaining the accuracy of such adjustments. Pro-minded displays, on the other hand, include color space and gamma presets to facilitate easy, accurate adjustments.

The most accurate monitor calibration is achieved through the use of a color measurement accessory commonly called a "colorimeter" and its supporting software. A wide range of colorimeter features and price points are available, but all work in a similar manner by measuring and adjusting onscreen colors when placed on the screen. Using this approach delivers the most precise, consistent and accurate representation of original digital image files.

The best professional monitors are capable of "hardware calibration," which enables colorimeters to deliver the most consistent, accurate results. Calibration via software requires repetitive data recall and manipulation between the PC graphic card and monitor each time calibration is performed. Hardware calibration streamlines the process by allowing the colorimeter to modify the monitor's internal LUT and store calibration results on the monitor, for faster, more consistently accurate results.

Why calibrate?

- **Your eyes aren't perfect.** Age, gender, health and other factors affect how even those with perfect color vision see colors.
- **Monitors display color differently and change over time.** Calibrating regularly fine-tunes your display to known color reference standards and ensures consistency over time.
- **Image file colors are not true to life.** Even a slight red or blue cast can throw off your images.
- **Highlights & shadow details get lost.** Calibrating brings back fine details for more accurate viewing of your entire image.
- **Grays & whites aren't consistent.** This can cause shifts in color hues. Calibrating your produces neutral grays and whites and eliminates inconsistency.

Source: X-Rite Inc., the global leader in color trends, science and technology. http://xritephoto.com/ph_product_overview.aspx?id=1970&catid=149

Design Features

Beyond the color-critical features noted above, design bells and whistles can make working on your monitor easier, more efficient and more comfortable. Monitors with a frameless bezel design are ideal for those looking to maximize productivity and creative workspace with a dual- or multi-monitor set up. A swivel mount delivers added configuration options, while a flat matte finish will greatly reduce reflection for easier calibration and viewing. Ergonomic tilt, swivel, pivot and height adjustment capabilities will help maximize comfort. Advanced features can include an ambient light sensor for automatic screen brightness adjustments and presence sensors that automatically dim the backlight when you step away from your workspace.

Connectivity

Look for a variety of output ports (including USB, DisplayPort and HDMI) to enable easy connectivity with the devices you use today, along with the best likelihood of supporting those you'll use in years to come. USB 3.0 ports deliver the added bonus of device charging, while USB 3.1 Type C ports deliver charging plus audio for more streamlined, simplified set ups. The ability to “daisy chain” two or more monitors via DisplayPort delivers added flexibility. Content Mirroring Capability.

Conclusion

If your work, pastime or passion involves viewing and manipulating color images on a monitor, it may be time to invest in a monitor that will do your photos and designs justice – not to mention bringing added color quality to anything you view on your monitor. While multi-purpose monitors can be outstanding for a wide variety of basic tasks, these screens can't deliver consistent, color-accurate images. By investing in a display that's purpose-built for image editing you'll gain the color range, calibration capabilities and other color management features to view and edit with a greater degree of detail and color accuracy. Fortunately, today there are more budget-friendly options than ever for professional monitors with advanced features like a wide range of color spaces, preset gamma adjustments, 14-bit 3D LUTs and hardware calibration capabilities.

For more information, contact ViewSonic sales at salesinfo@viewsonic.com or visit www.viewsonic.com

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