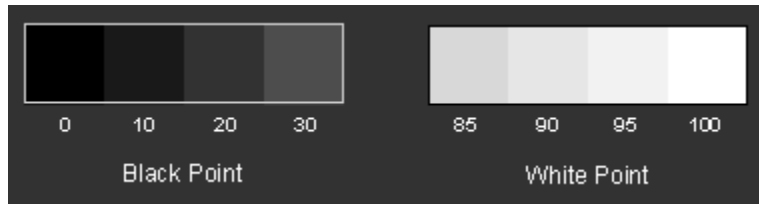
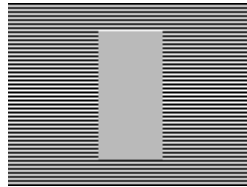


Monitor Calibration

by [Thomas Niemann](#)



Do the patches marked 0 and 10 in the grayscale appear to be the same? If they do then you need to calibrate your monitor black point. Do the patches marked 95 and 100 appear to be the same? If they do then you need to calibrate your monitor white point. If the patches have a color tint, you can correct problem by calibrating monitor gamma for each color channel individually.



Stand ten feet from your monitor and examine the above figure. If the smooth patch is darker or lighter than the background then you need to calibrate monitor gamma.

You can calibrate black and white points without any special software. To adjust monitor gamma, you'll need special software such as Adobe Gamma. It takes just a few minutes to make these adjustments. As a reward, you will view images on the web as they were designed to be viewed. If you're a web designer, or share images with others, then it's imperative that you calibrate your system to a standard. For the web, use the [sRGB standard](#).

Be sure your display is configured for 24-bit color. With 16-bit color there is not enough color depth to calibrate properly. Let your monitor warm-up for at least 15 minutes before calibration.

To view contents offline, download this PDF file (200k). It's intended for printed output, so you'll have to go online to click on links and properly view the images.

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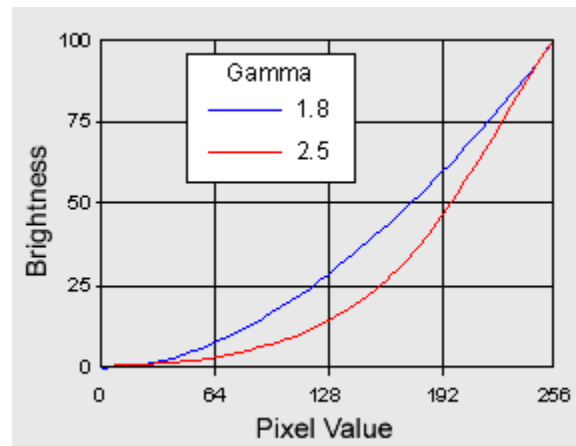
All graphics were made with [Fireworks](#). 

Calibration Theory

When you adjust monitor gamma, you change the tonal value of midtones on your display. Gamma relates pixel values to brightness according to the following formula:

$$\text{brightness} = C \cdot (\text{pixel value})^{\text{gamma}}$$

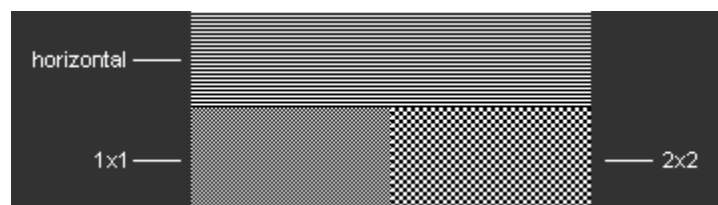
where C is a constant. Displays for Macintosh computers operate at a gamma of 1.8, while older PC monitors function at a gamma of 2.5. The following graph illustrates brightness vs. pixel value for gammas of 1.8 and 2.5. Notice that, for the same pixel value, the display on a Macintosh is brighter than a PC. Here is the [source code](#) used to create the graph.



This difference is causing difficulty for online retailers. Customers view and order a red sweater, using a MAC, only to find a burgundy sweater in their mailbox! There's currently a push to standardize monitor display parameters so that everyone sees the same colors when viewing pages on the web. The standard chosen is the [sRGB standard](#) that specifies a gamma of 2.2.

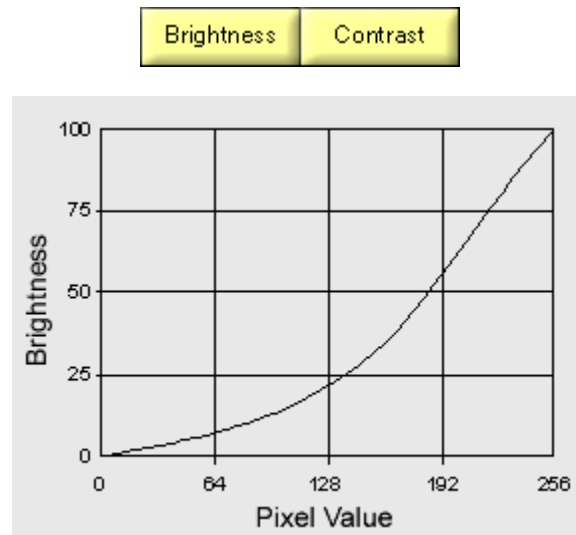
You can determine monitor gamma with a simple test. View a smooth gray patch against a background composed of black & white pixels. At a distance the black & white pixels merge to create a gray background. If half the pixels are black, and half are white, background brightness is 50%. Using the above graph, and 50% brightness, an RGB value of (174,174,174) would match with a gamma of 1.8, and (193,193,193) would match with a gamma of 2.5. View several patches, against a 50% background, to determine monitor gamma. Here is the [source code](#) used to determine patch values.

The CRT electron gun repaints the screen in horizontal strokes. When it encounters rapid changes in intensity, streaking can occur. Streaking is discoloration that occurs when the electron gun cannot switch on and off rapidly enough to keep up with changes in intensity between neighboring black and white areas.



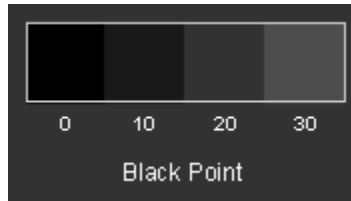
The above figure contains three 50% patches: horizontal lines, 1x1 pixels, and 2x2 pixels. In theory, they should all appear identical at a distance. View the 1x1 area with a magnifying glass, and you will see streaking on most monitors. This also occurs, but to a lesser extent, in the 2x2 area. For best results, use horizontal lines for the background.

In addition to calibrating gamma, you need to do black point and white point calibration. No special software is needed. Monitor brightness and contrast controls are the only tools you need for calibration. Pass your cursor over the yellow rectangles to view the effect of each control.



When you adjust brightness you are adjusting the 0-level signal, or vertical bias of the response. The goal is to make RGB value (0,0,0) correspond to 0% brightness, or black point. When you adjust contrast you are adjusting the video signal amplification, or slope of the response. The goal is to make RGB value (255,255,255) correspond to 100% brightness, or white point.

Black Point Calibration



You should be able to distinguish between the patches marked 0 and 10 in the above grayscale. Patch 0 should be perfectly black, matching the unscanned portion of your monitor, and patch 10 should be barely visible. In this section you will adjust monitor brightness so the black point is properly calibrated.

Adobe Gamma, and several web sites, attempt to adjust the black point with grayscale patches. However, the quality of monitor displays varies significantly, and attempting to read something out of low-valued patches is fraught with difficulties.

When the black point is properly set, an RGB value of (0,0,0) will appear as true black on your monitor. Increase the RGB value slightly and you should see a slight increase in intensity. The non-scanned area surrounding the displayed image is an ideal reference for the black point. The goal is to make display value (0,0,0) match the black of the non-scanned border.

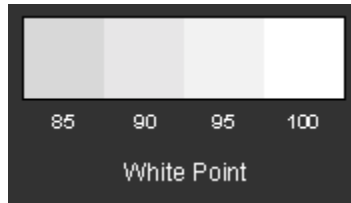
For adjustments to be accurate you need to use consistent lighting when viewing your monitor. The black point for a brightly-lit room will be higher than a dimly-lit room. After setting room lights to your standard, minimize any on-screen applications (including your browser). If there are bright-colored icons on your desktop, move them to a folder and minimize the folder. You can easily retrieve them later. It is very important that your screen be completely black.

Set the desktop background color to black (0,0,0). To set the background color in Windows, choose Start > Settings > Control Panel, double-click on Display, and click on the Appearance tab. You can verify the RGB value is (0,0,0) by double-clicking on the color patch to view the Color Picker dialog box.

Set brightness and contrast to 100%. Adjust the vertical dimensions of the screen so you can easily distinguish the border between the scanned and non-scanned areas. To make this adjustment, shrink the view vertically, or move the view up and down with your monitor controls. This will expose the non-scanned area. If you shrank the window 2" from the top, then the border between the scanned and non-scanned area should be 2" down on your screen.

Decrease brightness until the the scanned area blends with the non-scanned area. If there is a dialog box for monitor brightness, and it is distracting, mask it so it doesn't interfere with this step. Go back and forth until you've identified the point where the scanned area starts increasing in intensity. Lock the setting when the scanned area just starts to become visible.

White Point Calibration

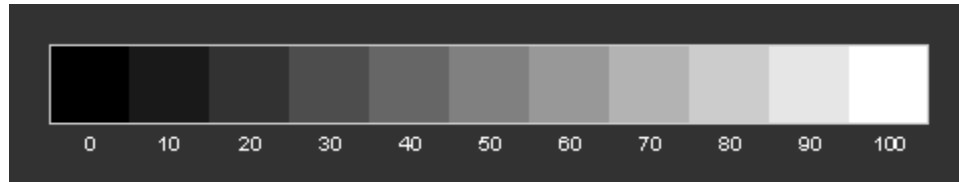


You should be able to distinguish between the 95% and 100% patches in the above grayscale. If they appear to be the same, then contrast is too high, and highlights are blocked. Most monitors work fine with contrast set at 100%. If you find this too bright, or highlights are blocked, decrease contrast and recalibrate the black point.

The sRGB standard specifies a color temperature of 6500°. Most monitors have provisions for setting color temperature using on-screen menus. You may find 6500° a bit warm. Feel free to adjust this value so that whites are white on your monitor.

Calibrating Monitor Gamma

You must use software to make gamma corrections. A change in gamma changes the shape of the brightness curve (see section on Theory). Most operating systems support a Color Management System (CMS) that allows you to control display gamma. An exception is NT4. If you're running NT4, you may want to upgrade to Windows 2000 for better color control. If you're using Adobe Photoshop, you can adjust gamma using Adobe Gamma. On a Windows computer, click on **Start > Settings > Control Panel**, and double-click on the Adobe Gamma icon. De-select the View Single Gamma Only checkbox, and adjust each color individually. As a double-check for Adobe Gamma, verify that there is no color tint in the following grayscale.



You can use the following chart to determine monitor gamma for your system. Stand ten feet from your monitor and choose the patch that blends with the background. For web use you'll want a gamma of 2.2, the [sRGB standard](#). The sRGB color space also works well [for inkjet printers](#).

If gamma is around 2.5, you're viewing the web through dark glasses. If gamma is near 1.8, images on the web appear too bright. You've probably got a MAC. If you're posting on the web, be sure to preview your work at a gamma of 2.2. Otherwise, they'll look great on your monitor, but too dark to the other 95% of the world.

As a final pass in Adobe Gamma, select View Single Gamma Only, and view this chart while making minor adjustments. As you move the gamma slider, you'll see the display darken and lighten. You are altering the look-up table (LUT) that controls monitor display. The RGB value of the smooth patches remains the same, but they're interpreted to a different brightness as you move the slider.

