Using Monitor Curves and Printer Curves

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Updated: 12-Jan-2016

Background

Monitor and Printer Curves are a feature of Picture Window Pro created to help you deal with some of the shortcomings of monitor calibration and color management. In an ideal world, printing an image you see on your monitor would produce an exact copy. In reality, even if you calibrate your monitor and use color management and the right monitor and printer profiles, your prints can come out looking dark, dull, and sometimes with a color cast. There are several reasons for this, some of which can be corrected and some of which are fundamental limitations of printing technology. Monitors and printers have very different characteristics and unfortunately translating images from one to the other in a satisfying manner can be complicated.

Dynamic Range

Dynamic range is the ratio between the brightest white and the darkest black a device can produce.

The dynamic range of a good quality print is about 100 : 1. This means white paper reflects about 100 times as much light as the same paper printed all over with black ink. The dynamic range varies somewhat with the printer, paper and ink, with high quality, glossy prints doing a little better and laser printer output on copy paper doing worse. By comparison, good flat screen monitors have dynamic ranges of 1000 : 1 or better.

In short, there is a *huge* amount of dynamic range compression going on when you print an image. All the color management system can do is to make sure the transition between full black and full white follows the same curve.

Gamma

The video standard for gamma is 2.2 while the prepress standard is 1.8. Both of these standards are in common use so the situation can be confusing. Printing a gamma 2.2 image as though it has gamma 1.8 produces a lighter print. Printing a gamma 1.8 image as though it is gamma 2.2 produces a darker print. Be careful in your printer settings to set your printer gamma to match the gamma of your working color space. Often the gamma setting is buried under *Advanced Settings* or something similar. Color color spaces such as *sRGB*, *Adobe RGB*, *NTSC*, etc. are all based on gamma 2.2.

Print Viewing Light

It matters a great deal what light you use to view your prints. Illuminants are characterized by their overall brightness and by their color spectrum. Brightness is measured in units called lux. The color spectrum varies with the way the light is produced. It can be summarized by color temperature or by a color rendering index (CRI), but these are just simplifications. Standard fluorescent lights, for example, have a very uneven spectrum and often render colors poorly, depending on the spectral absorption curves of the dyes or pigments used to make the print.

Color management systems assume you view prints under ideal conditions – typically using a D50 (color temperature 5000°K with a daylight spectrum) light source with a brightness of around 2000 lux. This is very bright. For example, I happen to have a lux meter and used it to measure the typical light levels on my desk which has good north light exposure. It measures around 200 lux, at 10AM in the morning. This goes up to around 700 lux and gets much yellower when I turn on my 150W halogen desk lamp a little over a foot away from the sensor. I also have a commercial viewing booth with a D50 light source and adjustable brightness. Prints generally look pretty good in the viewing booth with the light turned all the way up. However, in the much dimmer light you are likely to encounter in a room where a framed print will be hanging, most prints look muddy and have poor or very little shadow detail.

Monitor Brightness Control

Most monitor calibration software does not tell you how to set the brightness control on your monitor. If you set it as high as it will go, you get the best dynamic range and images with look better on the screen, but this

increased dynamic range widens the gap between monitor and printer and makes it harder to get prints to match. If you lower the brightness, on-screen images may look worse but will match prints more closely.

White Point

If monitor white does not match the color of the paper the print is made on as viewed under given lighting conditions, then the print will appear to have a color cast with respect to the monitor. In a typical room, lighting varies wildly depending on the time of day and what mixture of natural and artificial lighting is in use. Fortunately, the visual system is quite good at adapting to different types of lighting so this kind of mismatch is not usually too obvious.

Normally, you specify the desired monitor white point when you calibrate your monitor, although some monitors also have controls to adjust the relative brightness of the red, green and blue channels as well.

Ambient Light and Reflections

Too much ambient light or light reflecting off the screen will wash out the monitor display. Ideal conditions for viewing a monitor are subdued, neutral room lighting.

Color Gamuts

The color gamut of a device is simply the range of colors in can reproduce. This is most accurately represented as a 3-dimensional surface in some color space such as Lab but is also sometimes simplified as a 2-dimensional diagram that just considers color of full brightness.

To give an oversimplified generalization, monitors and printers both reproduce unsaturated colors well. Monitors are better at displaying bright, saturated colors while printers are better at dark saturated colors. When a color management system attempts to convert and image in the monitor color space to the printer color space, it needs to desaturate bright, saturated colors that fall outside the printer gamut. In an attempt to access some of the printer's best dark, saturated colors, it may also increase the saturation of dark, saturated colors. Gamut mapping remains something of a proprietary art.

There is one particular quirk of the visual system which can come into play called the Abney Effect. It turns out that as you gradually desaturate blue light, it starts to look purple as illustrated below in the third and fourth squares. There is also a similar but much more subtle effect with red light.
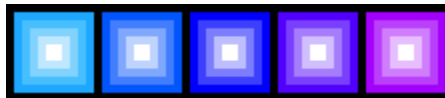
For this reason, sometimes blues that are too bright and saturated for the printer to reproduce are shifted towards purple in the print.

There is not much you can do about the gamut mismatch problem except make several proofs before you print and tweak specific colors using the Selective Color Correction transformation until you get a print you are happy with.

Monitor Curves and Printer Curves

Monitor Curves are a set of color curves that Picture Window Pro applies to all images displayed on the monitor. Monitor Curves are only enabled when the Monitor Curves dialog is active. This dialog is accessed via the File/Monitor Curves... command from the main menu. When you close the dialog, normal display is restored. While you are creating monitor curves, you can also toggle their effect on an off with the On/Off button at the top left of the dialog box.

Printer Curves are a set of color curves that Picture Window Pro applies to images just before they are printed. You can select which printer curve, if any, to use from the Print dialog. As soon as you select a set of printer curves in the Print dialog box, the print preview is updated so you can see the effect of the curves.

Two Basic Strategies to Deal with the "My Prints are too Dark" Problem

There are two different approaches to dealing with the twin problems of dynamic range mismatch and dimmer-than-optimal viewing light.

Darken the Monitor

In this approach, you start by making a test print and then compare it to the version on the screen. If you have a laptop computer, you could move it to the locating where the print will be viewed. What makes this tricky is that too much ambient light on the screen affects the display so you need to try to illuminate the print but not the monitor. A good test image will include a full range of tonalities as well as areas of shadow detail. If you don't have a photographic image to use, you can use the step wedge distributed with Picture Window Pro.

Next you create and save a set of Monitor Curves that darken the image so it looks as much like the print as you can get it. Rather than use Monitor Curves to darken the image or possibly in addition to using Monitor Curves, you can also dial back the monitor brightness control if your monitor supports this. If you lower the monitor brightness however, everything will look darker, including output from other programs. You might opt for a combination of these two methods, turning your monitor down a little and using Monitor Curves to provide the rest of the required darkening. Or, if you have two monitors, you could keep one of them darker than the other and use it to prepare images for printing.

In addition to adjusting the brightness curve of the monitor you can also adjust the color. This feature can be used to correct color casts, even if they are different for different parts of the tonal scale.

Once you have established a match between the monitor and the print, as long as you leave the Monitor Curves dialog open, you can use these settings to edit images and prepare them for printing being more confident that they will print the way they look on the screen.

One disadvantage of this approach is that you end up with two or more versions of each image you want to print – one optimized for viewing on-screen and one optimized for printing for each set of viewing conditions. This reflects the reality that optimally you need to print differently depending on the viewing conditions. If you are making a limited number of prints and want the best results you can get, this is the way to go.

Lighten the Print

If you don't want to re-edit your images with a darkened the monitor, your other option is to lighten the image just before you print it instead. You do this by selecting the inverse of the monitor curve you created above as a printer curve. An inverse monitor curve is one that undoes the effect of the monitor curve, lightening just as much as the monitor curve darkens. Conveniently, when you save a monitor curve, an inverse monitor curve is also automatically saved in the printer curves folder and becomes available as a selection in the Print dialog. While this approach lets you keep your monitor bright and work with a single copy of the image, lightening does not increase the dynamic range of the printer, so the print will have less punch than the on-screen image. If you are making lots of prints and don't want to fine tune each image individually, this is the way to go.

Printing gamma 2.2 images at gamma 1.8 is another way of lightening them, but it is not adjustable so it cannot accommodate different lighting conditions. Photoshop includes a set of grayscale profiles that can be used to lighten prints called *Dot Gain 10%*, *Dot Gain 15%*, *Dot Gain 20%*, *Dot Gain 25%* and *Dot Gain 30%* — the 10% profile lightens the least and the 30% profile lightens the most. Since a grayscale profile is just a curve, it is possible to mimic the action of these profiles with monitor and printer curves, and a set of monitor and printer curves that does just this is supplied with Picture Window Pro. If you don't want to go through the process of building monitor curves by hand, you can experiment with of these pre-built curves and use the one that provides about the right amount of print lightening.

One or the Other — Not Both

Make sure you use one approach or the other and don't try to combine them. If you optimize your images to look good with monitor curves in effect and also print using the corresponding inverse monitor curves, you will double correct and get prints that are too light.

Advanced Uses for Printer Curves

Having recently attended a workshop run by Don Messec, I have been experimenting with an alternative printing process. It involves printing an image on a polymer plate (reversed left to right), exposing the plate to a UV light source, developing it in a water bath, inking it, and finally printing it on an intaglio press. Because the image printed on the plate is only the first step in the process, it is necessary to compensate for changes in tonality introduced by the remainder of

the process. Thus there is a calibration phase where I created and printed test plates and measured the way they reproduced the tone scale. The inverse of this curve then needs to be applied to each image before it is printed on a plate, so I created a custom printer curve that does exactly that and placed it in the Printer Curves folder. Now I can apply the necessary correction curve when I print on a plate just by selecting my custom printer curve in the Print dialog box.

Should you need to manipulate them yourself, monitor and printer curves are stored in folders named *Monitor Curves* and *Printer Curves* located in Picture Window Pro's data folder. The data folder is located at:

C:\Users\<Your user name>\AppData\Roaming\Digital Light and Color\Picture Window.

How to Use the Monitor/Printer Curves Dialog Box

When you invoke Monitor/Printer Curves via the File/Monitor/Printer Curves command from the main menu, Picture Window Pro displays the Monitor Curves dialog box:
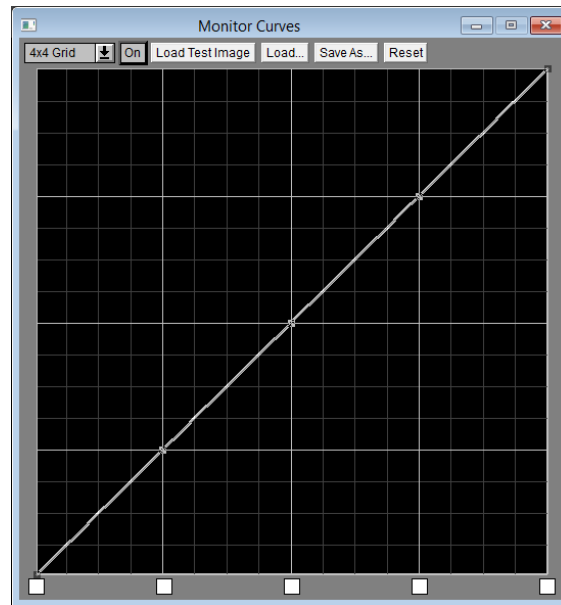
The name of the currently loaded monitor curves, if any, is displayed in the caption of the dialog box. An asterisk is displayed after the name if the curves have been modified since they were last loaded or saved. By default, the last set of monitor curves you loaded or saved is reloaded when you start.

The controls along the top of the dialog box are:

Grid Size

This setting controls how many control points are placed along the curve. Legal values run from 1x1 to 10x10. The finer the grid, the more precisely you can control the curve, but the more work it takes to make adjustments. A setting of 1x1 gives you two control points, one for black and one for white. If you select 2x2 you get three control points with one added in the center for midtones. Using a 4x4 grid you get five control points as illustrated above.

On/Off

Holding down this button temporarily turns off monitor curves and restores the normal display. As soon as you release the button the monitor curves go back into effect. This gives you a quick way to see what the curves are doing.

Load Test Image

This button loads a test image of a step wedge (a series of graduated squares running in steps from black to white on a gray background) that you can use to help adjust monitor curves.

You can print this image and then compare the result to the on-screen version. Or use your own sample image as long as it has a good range of shadow detail and covers the entire tonal range.

Load…

This button lets you load a set of previously saved monitor curves from the Monitor Curves folder. This provides a quick way to select one of a set of commonly used curves.

Save As…

This button lets you save the current monitor curves for later re-use. Using named monitor curves files lets you create and save multiple monitor curves to correct for different lighting conditions.

When you save monitor curves, at the same time a copy of the inverse monitor curves (obtained by reflecting the curve about the diagonal line connecting the lower left and upper right corners) is saved as a printer curves file. Applying this inverse curve to an image has the opposite effect of the monitor curves. If the monitor curves darken the image, the inverse monitor curves lighten it; if the monitor curves add a yellow cast to the image, the inverse monitor curves add a blue cast (since blue is the complementary color to yellow). To be able to compute inverse monitor curves, the monitor curves must be monotonic; in other words the curve must increase steadily from left to right with no peaks or valleys. If this condition is not met, Picture Window Pro will display an error message.

Reset

This button resets the monitor curves. The new curve runs along the diagonal and thus does not affect the display. Any previous settings are lost.

Curve

You adjust the brightness curve by dragging control points up and down until an image on the screen matches a print of the same image viewed under the illumination it will be subjected to when exhibited. Control points toward the left side adjust shadows while control points toward the right side adjust highlights.
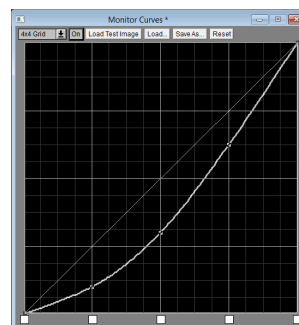
You can also adjust the color cast at each brightness level by clicking on the small square below the curve. This brings up a color picker you can use to adjust the color for the corresponding control point. As you adjust the color away from a neutral gray, the curve splits into three to show how each color channel is mapped (see below).
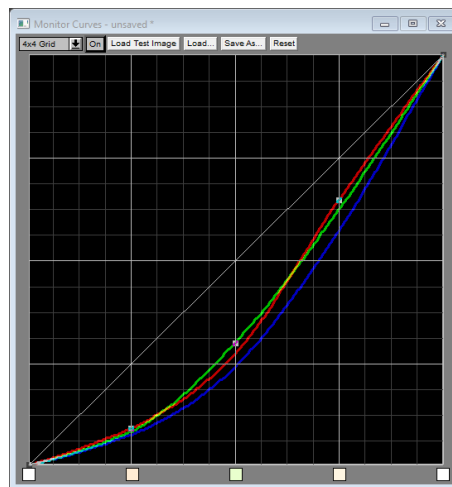
If you are using the "darken the monitor" method, the monitor curves should run from full black to somewhat less than full white so as to darken the entire tonal range. If you are using the "lighten the print" method, monitor curves should start at full black and end at full white, otherwise you will further limit the printer's dynamic range. Some sample monitor curves for the two methods are illustrated below:
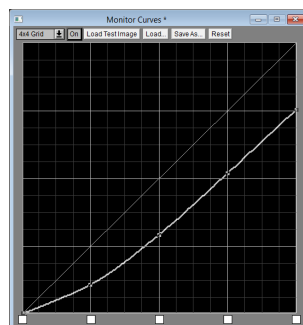
darken the monitor   lighten the print