



# Display Calibration With Open Source Software

A Tutorial for Photographers

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## Introduction

This document deals with monitor calibration and color profiling by means of open source software. This procedure allows people to share a common reference for visualizing images on different means (monitors, printouts, ...). An extensive explanation on color management is provided [here](#).

The operating system taken as a reference here is Linux, but the same procedure applies to all the platforms supported by [ArgyllCMS](#). The procedure described below makes use of a colorimeter.

This tutorial is partly based on [this](#) howto and on the [ArgyllCMS documentation on display calibration](#). The purpose of this tutorial is to integrate the website with additional information and to make the complex procedure named “monitor calibration” easier to understand. For this reason, some explanations may appear simplistic: please, refer to the documentation given as a reference for more precise information (including mathematical formulas). All the information explained in this document are presented as understood by the author while calibrating different displays.

## The Theory

In this section we give a brief explanation of what is commonly known as “display calibration”. Actually, this procedure is composed by two different steps (often hidden by commercial calibration softwares), the calibration and the color profiling.

Monitor calibration is a procedure by which the monitor is taken to a known state. This is the state used by the operating system and by non color-managed applications (i.e., applications that do not support the use of color profiles). This will allow you to view images in a “good enough” way in most of the cases. Of course, color accuracy is provided only by color managed applications. There are a number of different “known states” available, but the most suitable one for photography is sRGB. In this case the monitor is calibrated to a temperature of 6500K, gamma 2.2, and the sRGB calibration curve. The higher the gamma, the “darker” (different color levels are less spaced one among the other) the monitor will appear. On some laptop displays (or, anyway, low contrast displays) a gamma of 2.2 is not well supported and many color levels (usually the darker ones) will appear as if they were the same. In this case, a gamma of 2.0 can be used, trading some precision for usability. In the same way, on some low quality monitors (or on some laptop monitors) it may be impossible to reach a good calibration with a 6500K temperature; in this case, you may choose not to specify any temperature: *dispcal* will use the native one of you monitor as a reference. A luminosity of the white level (i.e., the brightness of the display) of 100cd/m<sup>2</sup> is usually considered as a reference value considered. Actually, this level should be tuned also by considering the lightning condition of your room. 100cd/m<sup>2</sup> is a suitable value for an almost-dark room. If your



monitor has the auto-brightness feature, calibrate the monitor to  $100\text{cd/m}^2$  with this feature disabled, then re-enable it. Otherwise, do not specify any target luminosity and adjust it with your monitor controls in the first step of *dispcal* (you may use a [gray scale](#) for this).

Color profiling is a procedure by which a correspondence between reference color patterns and colors shown by the display. This procedure allows the monitor to visualize colors as intended. Of course there is some tolerance due to the monitor (it may not be able to resolve all the possible colors in the sRGB profile) and to the graphic card.

Once the calibration and color profiling procedures are finished, an ICC file is created. This file contains both the calibration information and the color profile. As we will show in the following sections, the calibration profile is loaded in the graphic card lookup table (LUT); the color profile part, instead, is loaded only by color managed applications. The LUT is used to translate the colors generated by the applications into the ones visualized by your monitor. You can see the LUT as a table with an entry for each of the colors your graphic card can handle. The table contains two column: the color value requested and the one that should be used to obtain a result that corresponds to the calibration.

The following sections describe how to perform calibration, color profiling, and how to load the profiles.

## Calibration

Calibration can be performed by using *dispcal*. This tool is a part of the [ArgyllCMS](#) suite. This part of the process requires some intervention by the user. In fact, the tool shows a text interface that helps you in tuning your monitor by using the monitor controls to start calibration from a suitable state. This part of the process cannot really be documented well, as actions to be taken really depends on the specific display and graphic card. We had really different experiences with different monitors: on one display the best thing has been to set the temperature control to 6500K and a brightness slightly higher than the desired one ( $110\text{cd/m}^2$  instead of  $100\text{cd/m}^2$  – menu entry n. 3 of *dispcal*) and then let *dispcal* do its work. On another monitor, the best solution has been to use the monitor controls to reach the temperature tuning required by *dispcal* (menu entry n. 2) and then to proceed to the calibration.

A combination of parameters that may be used to obtain a sRGB calibration is the following:

```
dispcal -t6500 -gs -b 100 -q h -v -y l <filename>
```

The `-t6500` parameter tells *dispcal* to calibrate the monitor to a color temperature of 6500K; `-gs` tells *dispcal* to use a sRGB curve (gamma 2.2); `-b100` tells *dispcal* to use a white level of  $100\text{cd/m}^2$ ; `-qh` tells *dispcal* to do a high-quality calibration; `-y l` identifies a LCD monitor; `-v` tells *dispcal* to be verbose.

A high-quality calibration may take a long time (time really depends on the colorimeter and on the monitor/graphic card; on my configuration it took more than one hour) and may not be necessary, especially on low-quality monitors. Thus, the medium-quality calibration can be effectively used in these cases.



## Color profiling

Color profiling is performed by means of *dispread* another tool of the ArgyllCMS suite. Tough, this tool requires color patterns to be generated first. This operation can be done by typing:

```
targen -v -d3 <filename>
```

`-d3` tells *targen* to generate patches in the RGB space. The default of *targen* is to generate 836 color patches and 0 gray patches. To shorten the time required to generate the color profile, you may lower the number of patches to 500, by adding the parameter `-f500`.

After the generation of the patches, *dispread* can be run by typing:

```
dispread -v -y 1 -k <dispcal_outfile.cal> <outfile>
```

`-y1` tells *dispread* that we are considering a LCD monitor; `-k <dispcal_outfile.cal>` provides *dispread* a monitor calibration profile. If you skipped the calibration step, also skip this option.

At the end of the process, the final monitor profile can be generated by typing:

```
colprof -v -A "producer" -M "model" -D "date" -q u -as  
<filename>
```

`-A` identifies the producer of the monitor; `-M` the monitor model; `-D` identifies the creation date of the profile. `-qu` makes *colprof* generate an ultra-quality profile; `-as` specifies the type of algorithm to use for profile generation (*shaper+matrix* in this case).

## Verifying the Profiles

Once calibration and color profiles are generated, they can also be verified. The simplest thing you can do is to try loading the calibration profile into your video card LUT. You can do this by typing:

```
dispwin <profile.icc>
```

You can verify that the LUT has been correctly loaded by typing:

```
dispwin -V <profile.icc>
```

You can also run some tests to check whether the profiles are good or not. The simplest test you can run is:

```
dispcal -r
```

This will check the calibration against a couple of color patches and will tell you some information about your calibrated monitor. `-R` can be used, instead, to have information about the non-calibrated display.

*Dispcal* can also be used to verify the loaded calibration curves. You can do this by typing

```
dispcal -E
```



## Loading the Profiles

As explained earlier in this document, the ICC file contains two profiles: the calibration and the color ones. These two profiles are loaded at different times by different applications.

### Loading the Calibration Profile

The calibration profile can be loaded by typing

```
dispwin -I <profile.icc>
```

Profiles can be loaded at boot time with different methods, depending on the operating system considered. Under Linux, the best way is to write a small script and to place it in the directory named: `/etc/X11/xinit/xinitrc.d/`. Scripts in this directory are automatically run by Xorg during its startup phase. You can call the script as you wish; in this document we call it `calibrate-display.sh`. This simple script should contain the following two lines:

```
#!/bin/bash  
  
dispwin -I <profile.icc>
```

### Loading the Color Profile

This operations strictly depends on the application considered. In this document we provide references to load color profiles in some common color-managed applications, namely The GIMP (>=2.4) and Mozilla Firefox 3.x.

A color profile can be loaded in the GIMP as explained [here](#).

A color profile can be loaded in Firefox as explained [here](#).

## Conclusions

Monitor calibration is a complex procedure. While many commercial programs – especially the ones thought for non-professionals - try to hide this complexity, open source programs expose it. As usual, this is both an advantage and a disadvantage: by using ArgyllCMS you have a great degree of flexibility, but you must understand how the calibration process works. Hopefully, this small tutorial will contribute to make this complex procedure more understandable.

## References

- ArgyllCMS website: <http://www.argyllcms.com>
- Use ColorVision Spyder to produce an ICC monitor profile under ArgyllCMS / Linux: <http://jcornuz.wordpress.com/2007/11/18/use-colorvision-spyder-to-produce-an-icc-monitor-profile-under-argyllcms-linux/>