

Calibrating Computer Monitors for Accurate Image Rendering

A Special Report for Consumers



SpectraCal, Inc.

17544 Midvale Avenue N.

Shoreline, WA 98133

(206) 420-7514

info@spectracal.com

<http://color.spectracal.com>

SpectraCal

Executive Summary

Poor quality image rendering on a computer monitor can be corrected very easily and accurately with an economical monitor calibration package that produces professional quality monitor performance with just a couple of mouse clicks.

Calibrating your monitor for accurate image rendering can be so quick, easy, and accurate that even a professional display calibrator would be hard pressed to give you more detailed, life-like monitor images.

Introduction

Consumers are often disappointed with the poor color and tonal reproduction produced by their computer monitor when rendering photo, web, and video images. A monitor's image rendering performance can be improved, often dramatically, by calibrating the monitor. This can be done either by a professional calibrator, or with a monitor calibration package that simplifies the process and allows consumers to calibrate their computer monitor on their own.

A number of monitor calibration packages are available, each of varying features, quality, and ease of use. This report examines the differences between these computer monitor calibration solutions, which allow consumers to improve the image rendering performance of their computer monitors.

Technology Review

Before we talk more about computer monitor problems or solutions, let's first review some technical concepts related to computer monitor performance. When we evaluate the performance of computer monitors, we first check the accuracy of the monitor's white balance (the monochrome images upon which all image colors are painted), since the image colors can't be right if the background grayscale is wrong (fig. 1).



Figure 1: A monitor's grayscale tonal range is the foundation for all image colors. If the grayscale coloration or tonal steps are wrong, then all image colors will be wrong.

We sometimes specify the particular color of the monitor's white and gray tones in terms of color temperature, specified on a scale from about 3000 Kelvin (very yellow/red) to 10,000 Kelvin (very blue), with 6500 Kelvin being the neutral white/gray color specified by the industry standard sRGB specification for photo and web image reproduction (fig. 2).

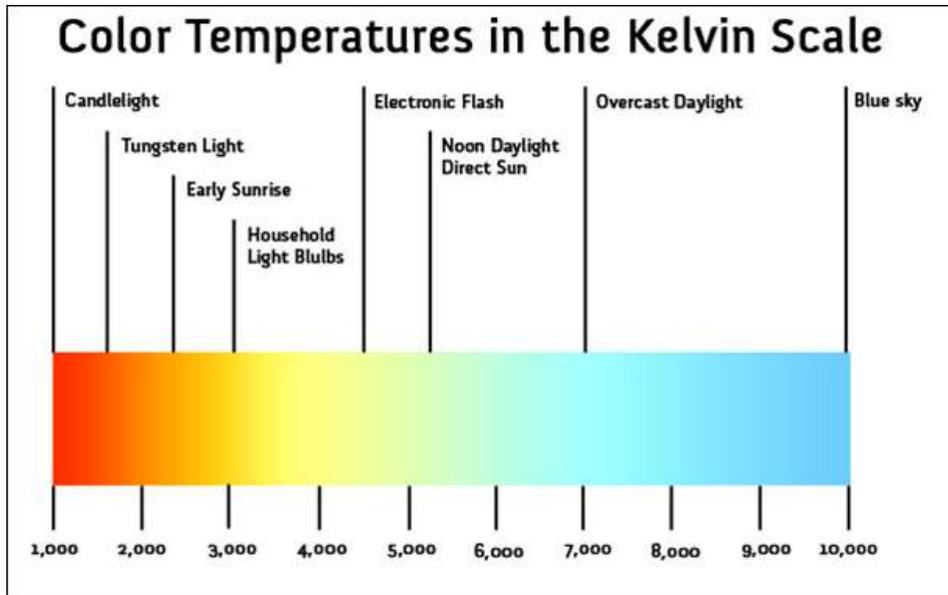


Figure 2: The color of a monitor's white and gray tones is sometimes specified with the Kelvin scale.

Instead of color temperature, though, we often use the more precise D50, D55, D65, and D75 standard daylight illuminant specifications to indicate a desired monitor white point, such as the D65 white/gray color specification for the sRGB standard.

We use a color meter to measure the color and amount of light (luminance) produced by a monitor when it reproduces various reference test images/patterns. The color meter may be a very expensive, lab grade spectroradiometer or it may be a more affordable colorimeter, which can still be very accurate.

When we measure a monitor's reproduced color or luminance level, we often compare the measurement result to an ideal standard response and express the monitor's performance in terms of the amount of error from the standard, expressed as delta Error (or delta E). A performance error of 0 delta E denotes perfect monitor color and luminance level reproduction.

Monitor Accuracy Problems

Consumers expect their photos, web images, and videos to be rendered on their computer monitors with lifelike colors and tonal details that accurately reproduce the original images. Often, however, they are dismayed when they view photos of family and friends on their computer monitor, for example.

The photos often don't look like the original real-life images that they shot and they don't look like the photos did on their camera. The monitor images may be too dark or they may be washed out. The colors may be too vivid or too pale, or all the colors may be entirely the wrong shade.

These same problems occur with web images and with YouTube videos or feature films. Enthusiasts who use photo or video editing software to edit photos or create videos often find that when they send their carefully edited images to friends, or load them to a web site, the photos or videos have poor color or tonal characteristics.

Monitor Calibration Solutions

Computer image problems like these are caused by the computer monitor inaccurately rendering images and can be solved by calibrating (adjusting) the monitor to conform to the industry standard sRGB specification for photo and web image reproduction. Monitor calibration can make a monitor's image rendering performance conform very closely to the sRGB standard to which the images were created, to enable accurate image reproduction.

Both PC and Mac computers provide for calibration and ICC Profile data to be written to dedicated computer files. The computer uses this data to pre-correct its red, green, and blue image output signals that it sends to an attached monitor, compensating for inaccuracies in how the attached monitor renders the image data it receives.

To create this monitor correction data, calibration software measures the monitor's screen output with a color meter while displaying various test images on the monitor (typically full red, green, blue, white, and various shades of gray). The software then performs calculations to create calibration correction data and ICC profile data for the monitor, and writes the data to the dedicated monitor calibration files on the host computer system.

Single-Pass Calibration Solution

There are two fundamentally different calculation algorithms used in the industry to automatically create monitor calibration data.

Legacy monitor calibration software has traditionally taken a single measurement of each of the selected test images. The software then calculates the color and luminance error (versus the sRGB standard) for each of the test images and writes calibration correction data to the computer's monitor calibration file. It also writes ICC Profile data to the monitor's ICC file to document the monitor's final color and luminance performance.

This single-pass method of creating monitor calibration data assumes that the monitor will respond in a linear manner to the image correction data that the software writes to the monitor calibration file. Since monitors are never perfectly linear, however, this calibration method typically results in an overall monitor performance error of 3 to 5 delta E, compared to the sRGB standard.

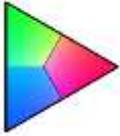
Optimized Calibration Solution

The other, newer monitor calibration method fully optimizes each data point that the calibration software writes to the calibration data file, to compensate for a monitor's nonlinear performance. This optimized monitor calibration algorithm typically results in an overall error of 0.3 to 0.4 delta E, a ten-fold increase in a monitor's image rendering accuracy, compared to the older calibration methods.

Calibration software that uses this optimized algorithm makes multiple measurements and calibration data calculations for each of the selected test images, generating calibration data with each verification measurement that is successively more accurate. This iterative process allows the calibration software to create color correction data that fully compensates for a monitor's nonlinear input signal response.

Since the calibration software is able to learn the monitor's non-linear response characteristics after a few data-write/measurement-verify cycles, most of the remaining calibration points can be fully optimized with only one or two calibration data calculations.

This new monitor calibration algorithm allows optimized software to complete a monitor calibration with a ten-fold increase in performance accuracy, compared to legacy monitor calibration solutions. Professionals in the broadcast, graphics, and film industries calibrate their professional RGB and video monitors with automated calibration software that uses this optimized monitor calibration algorithm.



CalMAN RGB Monitor Calibration Software

Until recently, however, professional accuracy computer monitor performance has been out of the reach of consumers and enthusiasts, primarily due to the unavailability of an affordable monitor calibration package with a highly accurate color meter and professional quality monitor calibration software. Recent availability of the highly accurate, yet very affordable, SpectraCal C3 Colorimeter (fig. 3) has changed that status quo.



Figure 3: The SpectraCal C3 Colorimeter supports all popular flat-panel technology with accuracy, speed, and low light sensitivity previously unavailable in its price range.

Now, CalMAN calibration software - the same highly accurate calibration software trusted by broadcast and film industry professionals for years - is finally available to consumers in the very affordable CalMAN RGB Monitor Calibration Software package, with the highly accurate C3 Colorimeter.

Click [here](#) to see some of the world's leading technology companies who trust CalMAN software for their display calibration.

Only CalMAN RGB uses an advanced AutoICC iterative calibration algorithm (measure/adjust, measure/adjust) to produce optimized monitor calibrations with a ten-fold advantage in monitor performance accuracy over legacy monitor calibration software. Now you'll finally be able to see all the color details your images and computer monitor have to offer.

Incredibly Simple Calibration

CalMAN RGB makes it incredibly simple to calibrate your computer monitor. Two calibration workflows are provided with CalMAN RGB, Standard and Advanced. With the Standard Monitor Calibration workflow (fig. 4) you place the C3 Colorimeter on your monitor screen, then with just two mouse clicks (the first assures proper meter position) you unleash the power of the

CalMAN AutoICC calibration process to automatically calculate the optimum performance calibration data for your monitor and save it to your computer.

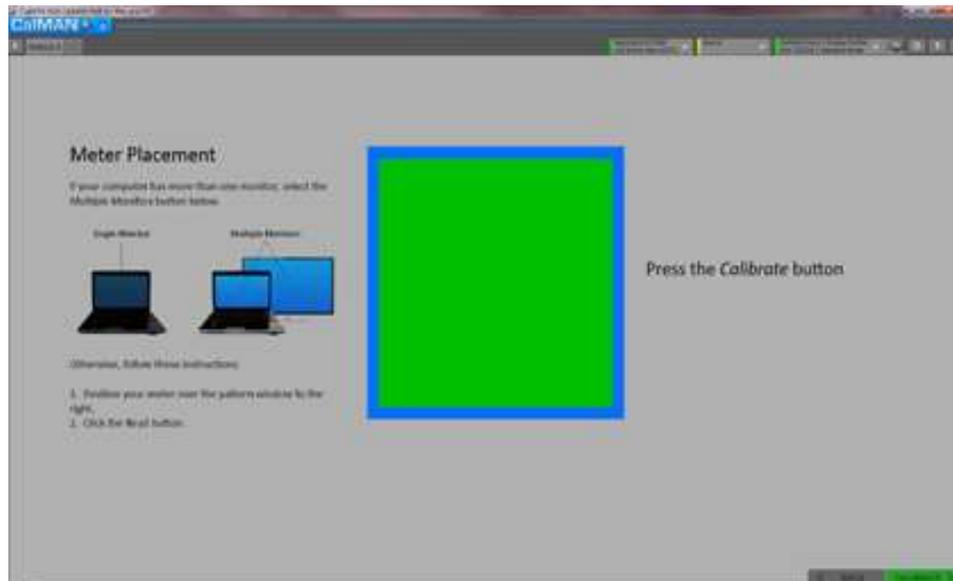


Figure 4: The CalMAN RGB Standard workflow has just two steps, automatically check your meter placement, then click the Calibrate button to perform a full optimized calibration.

That's it – your monitor performance is completely optimized with just two mouse clicks! CalMAN RGB even shows you a comparison of the monitor's grayscale performance before and after calibration (fig. 5). Plus, CalMAN provides an internal test pattern source that automatically switches test images, so no external generator hardware is required. Calibrating your monitor for accurate image rendering is so quick and easy – CalMAN RGB does all the work for you!

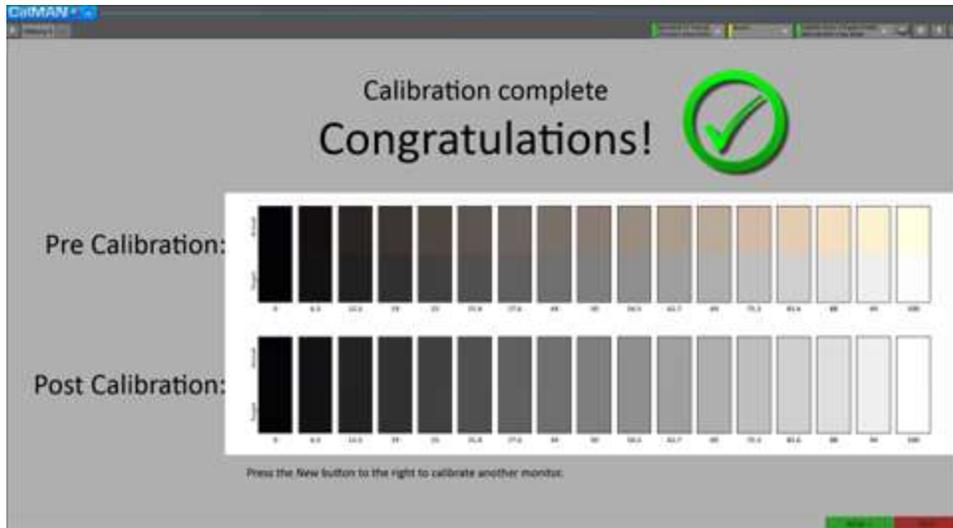


Figure 5: When a monitor calibration is complete, CalMAN RGB shows you how well the monitor matched the performance standard, both before and after calibration.

The Power of CalMAN RGB AutoICC™

The extreme calibration power of CalMAN RGB is contained in its AutoICC iterative calibration algorithm. CalMAN RGB AutoICC creates an exceptionally accurate AutoICC profile for the monitor by repeatedly adjusting and optimizing each monitor calibration point until the exact grayscale color and luminance output that is specified by the sRGB standard is achieved.

The CalMAN AutoICC iterative grayscale calibration process:

1. Measures the color and luminance level of a monitor's screen output, first with a 100% white test image.
2. Calculates the color and luminance error for the test image (per the sRGB standard) and writes calibration correction data for that test image to an exclusive CalMAN AutoICC™ profile.
3. Re-measures the corrected test image to verify the correction and evaluate the monitor's non-linear response to the calibration data.
4. Re-calculates calibration data to correct the monitor's non-linear calibration response.
5. Repeats this optimization cycle for the 100% white test image until the screen output measures exactly what the sRGB standard specifies.

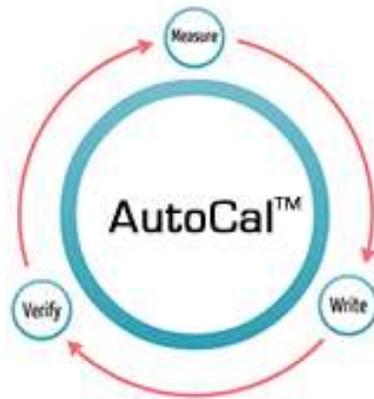


Figure 6: CalMAN AutoICC uses a measure/write/verify AutoCal calibration optimization cycle to fully correct all monitor performance characteristics.

6. Repeats this measure/write/verify calibration optimization cycle for each of the remaining grayscale calibration test images (i.e. 90% white, 80% white, 70% white, etc.). Since AutoICC has already learned the monitor's non-linear characteristics, these steps go very quickly.
7. AutoICC then measures the monitor's red, green, and blue primary colors and writes the color and luminance ICC Profile data to the monitor's AutoICC profile, to document the monitor's final color and luminance performance.

This advanced CalMAN RGB AutoICC monitor calibration algorithm is completely automated and produces professional quality monitor calibrations in just minutes. The typical calibrated monitor performance of 0.3 to 0.4 delta E with CalMAN RGB is ten times more accurate than with legacy monitor calibration software.

CalMAN RGB AutoICC gives you more accurate monitor image reproduction than even an experienced calibrator can typically obtain with hours of manual calibration work.

Legacy Monitor Calibration Solutions

Legacy monitor calibration solutions, on the other hand, don't verify the accuracy of individual calibration points, so they never compensate for the monitor's non-linear response to the image correction data that they calculate from their single-pass measurements.

The available legacy calibration solutions:

1. Measure the monitor's screen output while displaying a number of neutral grayscale test images ranging from 100% white to black, plus fully saturated red, green, and blue test images.
2. Calculate the color and luminance error for each of the test images (per the sRGB standard) and write calibration correction data to the computer's monitor calibration file for all of the test images.
3. Write ICC Profile data to the monitor's ICC Profile data file.

Since single-pass monitor calibration solutions don't verify their calibration data, they can't optimize their data to compensate for monitor non-linearity. This limits the accuracy of the calibrated monitor's image rendering performance and means that reproduced images won't be as realistic and life-like as you would like.

Incredibly Flexible Calibration

CalMAN RGB also provides an Advanced Monitor Calibration workflow for enhanced monitor calibration flexibility.

You can use the Advanced Monitor Calibration workflow to:

- Calibrate multiple monitors on the host computer that is running CalMAN RGB.
- Calibrate multiple monitors on a remote target computer this is on the same local network as the host CalMAN RGB computer.
- Optimize DDC monitor controls (Contrast, Brightness, etc.) with software controls that are right on the CalMAN RGB page (so easy!).
- Select custom calibration target alternatives to sRGB.
- View expanded pre-calibration and post- calibration performance comparisons.
- View built-in visual calibration verification images (wow, look at that difference!).

AutoICC™ Profile Management

When monitor calibration is complete, CalMAN leaves a profile management utility resident on the computer, in the task bar. This task bar utility, called Client 3, automatically loads the current AutoICC profile when the computer starts up and it allows you to quickly switch between multiple AutoICC profiles that you may have optionally created with CalMAN RGB. For example, you may have created profiles for different color white points or for different room lighting levels.

Each AutoICC profile created by CalMAN RGB includes any monitor control adjustments you made with software DDC controls, white balance calibration data, and ICC Profile data. When you switch between AutoICC profiles, the computer monitor is completely readjusted for accurate performance under different viewing situations.

SpectraCal C3 Colorimeter

The SpectraCal C3 Colorimeter, provided as part of the CalMAN RGB Monitor Calibration package, is one of the most accurate, sensitive, and reliable colorimeters on the market. As a bonus, it also happens to be one of the most affordable.

The C3 Colorimeter pairs with the advanced CalMAN software to make the CalMAN RGB Monitor Calibration Software package the most accurate, easy to use, affordable monitor calibration solution on the planet.

Summary

CalMAN RGB offers the most advanced monitor calibration technology available and, paired with the SpectraCal C3 Colorimeter, provides an economical calibration solution that will produce professional quality images on your computer monitor. CalMAN RGB is the only computer calibration solution that uses an optimized calibration data algorithm to achieve ultimate accuracy monitor performance.

No more sickly looking colors on your photos, web graphics, videos, or games - now you can enjoy professional quality monitor performance while viewing all your beautiful computer images!

Next Step

Click [here](#) to learn more about SpectraCal's leadership in the professional display calibration industry and how CalMAN RGB provides professional level calibration quality with an affordable consumer package.

Click [here](#) to learn how you can own the amazingly affordable CalMAN RGB Monitor Calibration Package, including the high value SpectraCal C3 Colorimeter.

SpectraCal, Inc.

17544 Midvale Avenue N., Suite 100

Shoreline, WA 98133

+1 206 420 7514

www.spectracal.com

info@spectracal.com

About SpectraCal:

SpectraCal specializes in the tools and training necessary to achieve images representative of the content creator's intent for environments from low to high ambient light while achieving the colorimetry, contrast, and dynamic range necessary for the image to have the proper impact on the viewer.

SpectraCal CalMAN software was developed to support the display calibrator in the step by step process of screen optimization. The foundation of screen optimization through display calibration is to understand the elements in a display that require adjustment and how each element inter-relates to the others. From its inception, CalMAN has earned rave reviews and has become the preeminent display calibration software package on the market, compatible with virtually all color meters available today. As display technology evolves, CalMAN will continue to provide the first choice for display calibration solutions.

More Information:

For more information on how you can benefit with professional quality CalMAN RGB computer monitor calibration:

Visit <http://color.spectracal.com>,

email info@spectracal.com, or

call +1 206 420 7514.