

Calibrating Color-Critical Monitors for Accurate Image Rendering

A Special Report for Imaging Professionals



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Executive Summary

Imaging content professionals should no longer tolerate poor monitor conformance to image rendering standards. Monitor rendering deficiencies can be corrected very easily and accurately with an economical monitor calibration package that produces high accuracy monitor imaging with just a couple of mouse clicks.

Calibrating color-critical monitors for conformance to image rendering standards can be so quick, easy, and accurate that even a professional display calibration engineer would be hard pressed to produce higher accuracy image rendering to industry standards.

Introduction

Imaging professionals are often disappointed with their RGB or video monitors' non-standard color and tonal rendering when they are monitoring, evaluating, developing, grading or editing color-critical motion or still image content.

A monitor's imaging accuracy can be improved, often dramatically, by calibrating (precisely adjusting) the monitor. This can be done with a monitor calibration package that automates the process and allows workstation users to calibrate their computer monitors on their own, without engineering assistance.

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

Technology Review

Before we talk more about computer monitor problems or solutions, let's first review some technical concepts related to computer monitor rendering accuracy. When we evaluate the accuracy of a computer monitor, we first check the monitor's grayscale (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 BT.709 industry standard for HDTV images (fig. 2).

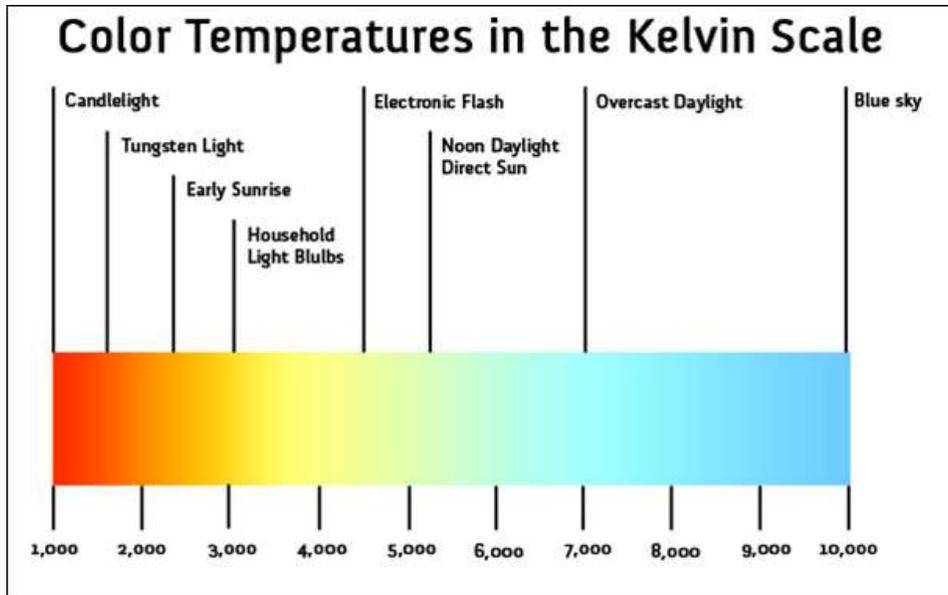


Figure 2: The color of a monitor's white and gray tones is sometimes specified with the Kelvin scale.

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 BT.709 standard.

We use a color meter to measure the color and amount of light (luminance) produced by a monitor when it renders 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 rendered color or luminance level, we often compare the measurement result to an ideal standard response and express the monitor's rendering accuracy in terms of the amount of error from the standard, expressed as delta Error (or delta E). An error of 0 delta E denotes perfect monitor color and luminance level rendering.

Monitor Accuracy Problems

Imaging professionals require their color-critical displays to render image content accurately with respect to their selected standard (e.g. BT.709/BT.1886). They are often dismayed, however, when their monitor images are either too dark or washed out. The colors may be too vivid or too

pale, some or all of the colors may be the wrong hue, or some image detail may be compressed.

These problems may not be obvious until they view the same image on another monitor or until they send color edited content off to another facility.

Monitor Calibration Solutions

Image accuracy problems like these are caused by the computer monitor rendering images inaccurately and can be solved by calibrating the monitor to conform to the appropriate image rendering standard for the current application. Monitor calibration can make a monitor conform very closely to the standard to which the images were created or to which the images are being graded, to enable accurate image rendering.

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 patterns 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 takes a single measurement of each of the selected test patterns. The software then calculates the color and luminance error (versus the selected target) for each of the test pattern levels 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 rendering accuracy.

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 marginal

accuracy, with an overall image rendering error of 4 to 6 delta E, compared to the selected grayscale target.

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 image rendering. This optimized monitor calibration algorithm typically results in an overall error well under 1 delta E, about a ten-fold increase in a monitor's image rendering accuracy, compared to the older single-pass calibration solutions.

Calibration software that uses this optimized algorithm makes multiple measurements and calibration data calculations for each of the selected test patterns, 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 characterize 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 image rendering accuracy, compared to legacy monitor calibration solutions. Professionals in the broadcast, graphics, and film industries can now calibrate their professional RGB and video monitors with automated calibration software that uses this optimized monitor calibration algorithm.



CalMAN ICC+ Computer Monitor Calibration Software

Until recently, all computer monitor calibration software calculated correction data after just a single-pass monitor measurement. They did not optimize the calibration correction data to compensate for display nonlinearities, they did not save monitor control settings for recall, and they did not create multiple profiles to target different rendering modes or different viewing environments.

Now, CalMAN calibration software - the same highly accurate calibration engine trusted by industry professionals for years to calibrate television displays - is available to imaging professionals with the revolutionary CalMAN ICC+ monitor calibration solution.

Only CalMAN ICC+ uses an advanced iterative calibration algorithm (measure/adjust, measure/adjust) to produce optimized correction data at each calibration point. This produces a ten-fold advantage in monitor image rendering accuracy over legacy monitor calibration software. Now you'll finally be able to see all the color details your images and computer monitor are able to offer.

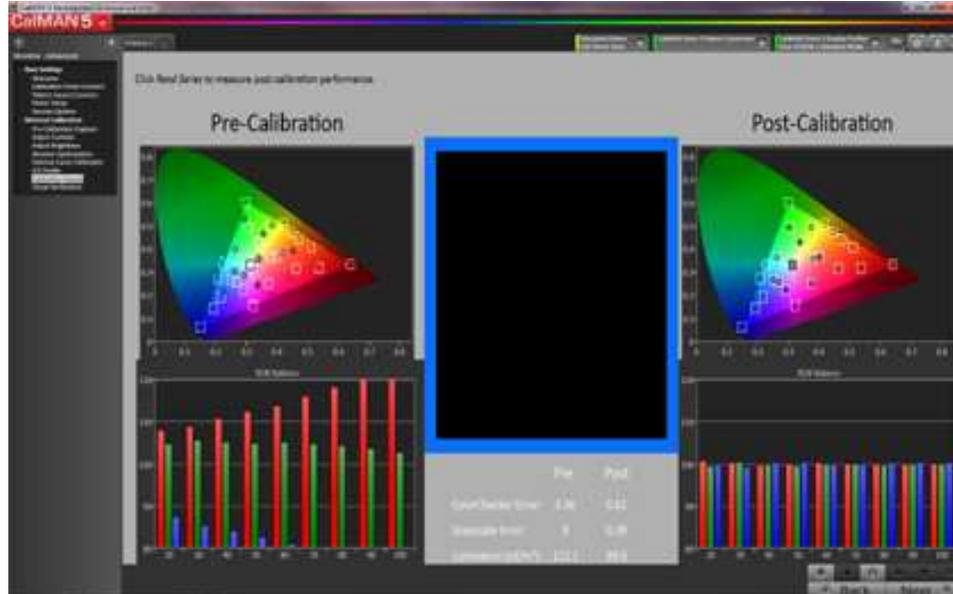


Figure 3: CalMAN ICC+ uses advanced calibration methods to produce improvements in monitor rendering accuracy that have been previously impossible with legacy calibration solutions.

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

Incredibly Simple Calibration

CalMAN ICC+ makes it incredibly simple to calibrate your computer monitor. Two calibration workflows are provided with CalMAN ICC+, Standard and Advanced. With the Standard Monitor Calibration workflow (fig. 4) you place a color meter on your monitor screen, then with just two mouse clicks (the first assures proper meter position) you unleash the power of the CalMAN AutoCal calibration process to automatically calculate the optimum calibration data for your monitor and save it to your computer.

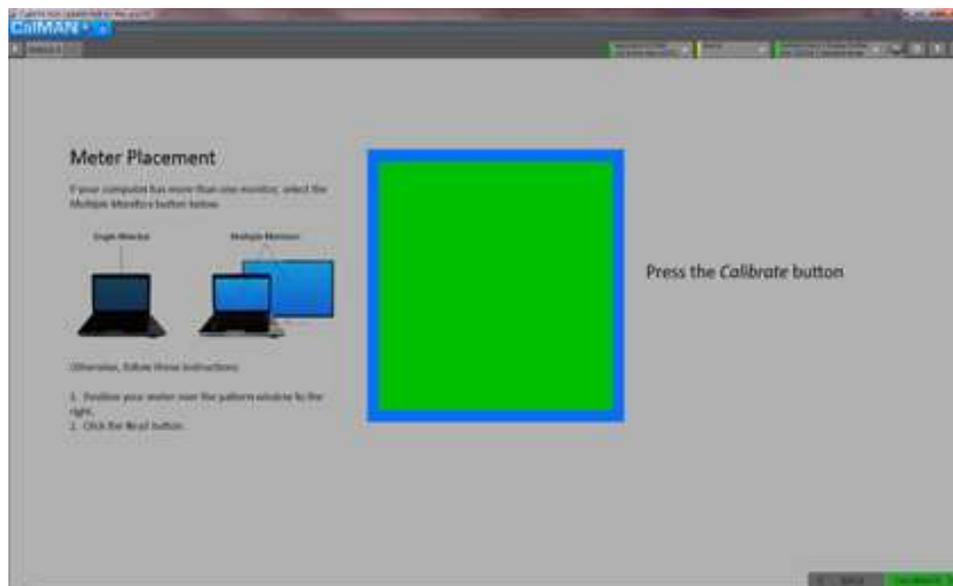


Figure 4: The CalMAN ICC+ Standard workflow has just two steps, automatically check your meter placement, then click the Calibrate button to perform a full optimized calibration.

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

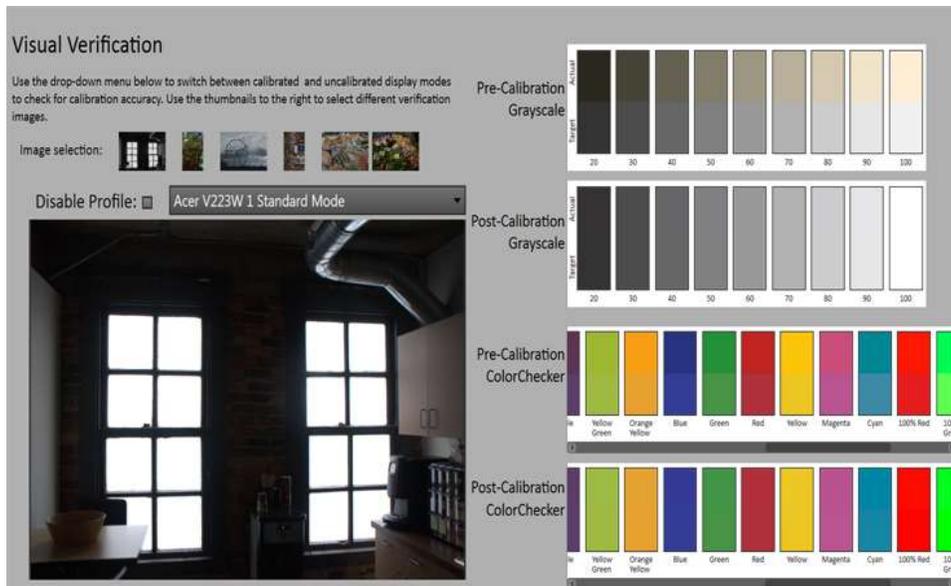


Figure 5: When a monitor calibration is complete, CalMAN ICC+ shows you how well the monitor matched the rendering standard, both before and after calibration.

The Power of CalMAN ICC+ AutoCal

The extreme calibration power of CalMAN ICC+ is contained in its AutoCal grayscale calibration algorithm. CalMAN ICC+ AutoCal creates an exceptionally accurate monitor calibration file by repeatedly adjusting and optimizing each monitor calibration point. It repeats the process until the exact grayscale color and luminance output that is specified by the selected standard is achieved.

The CalMAN AutoCal iterative grayscale calibration process:

1. Measures the color and luminance level of a monitor's screen output, first with a 100% white test pattern.
2. Calculates the color and luminance error for the test pattern (per the selected standard) and writes calibration correction data to the computer's monitor calibration file for that test pattern.
3. Re-measures the corrected test pattern 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 pattern until the screen output measures exactly what the selected standard specifies.

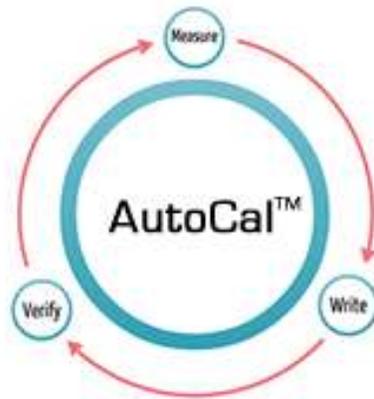


Figure 6: CalMAN AutoCal uses a measure/write/verify calibration optimization cycle to fully correct all monitor image rendering characteristics.

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

This CalMAN ICC+ advanced AutoCal monitor calibration algorithm is completely automated and produces professional quality monitor calibrations in just minutes. The typical calibrated monitor accuracy of under 1 delta E with CalMAN ICC+ is typically ten times more accurate than with legacy monitor calibration software.

CalMAN's AutoCal gives you more accurate monitor image rendering than even an experienced calibrator can typically obtain with hours of manual calibration work. CalMAN ICC+ is the only monitor calibration solution that optimizes each calibration data point to achieve ultimate monitor image rendering accuracy.

Legacy Monitor Calibration Solutions

Legacy monitor calibration solutions, on the other hand, don't verify the accuracy of individual calibration points. 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 patterns ranging from 100% white to black, plus fully saturated red, green, and blue test patterns.
2. Calculate the color and luminance error for each of the test patterns (per the selected standard) and write calibration correction data to the computer's monitor calibration file for all of the test patterns.
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 calibrated monitor's image rendering accuracy and means that monitor images won't be as accurate and life-like as they would otherwise be.

Incredibly Flexible Calibration

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

Calibration 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 calibration profile when the computer starts up and it allows you to quickly switch between multiple ICC+ profiles that you may have optionally created with CalMAN ICC+. For example, you may have created profiles for different color white points, different gamma performance, or different room lighting levels.

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

Summary

CalMAN ICC+ offers the most advanced monitor calibration technology available that produces the highest accuracy image rendering possible for each of your computer monitors. CalMAN ICC+ is the only monitor calibration solution that optimizes each calibration data point to achieve ultimate image rendering accuracy.

No more wrong colors, wrong grayscale tones, or compressed image detail. Now your color-critical monitors can be optimized to their optimum rendering accuracy with the simple to use, revolutionary CalMAN ICC+!

Next Step

Click [here](#) to see how easily you can get the amazing CalMAN ICC+ monitor calibration technology, included in a number of professional CalMAN calibration packages, to start calibrating your color-critical monitors to their ultimate in rendering accuracy.

Click [here](#) to see how you can get the CalMAN ICC+ monitor calibration technology in the dedicated CalMAN RGB Computer Monitor Calibration Software, with a bundled C3 Colorimeter.

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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 ICC+ computer monitor calibration:

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