Monitor Calibration

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ABSTRACT

Changing technology and evolving systems components, such as scanners or digitizers, printers, and film continue to become unique and dissimilar. When making an effort to be precise in studies, it is important to set and maintain standards, and align all devices along the image processing workflow. System calibration, the act of checking or adjusting one device to another, is designed to do exactly this. A system is calibrated when an image appears identical at all points through the work stream. An image should look identical, and possess identical characteristics (tone, shade, contrast) each time it is scanned, and wherever it is viewed. Monitor calibration procedures have been developed to ensure what is visible on screen is representative of scanned analog imagery. Described within this document are background information needed, and monitor calibration procedures designed by Eastman Kodak Company technical staff.

1. INTRODUCTION

Systems components are evolving rapidly, and technology is improving daily. Due to this, hardware and software in office settings change rapidly. Devices are switched, moved, changed, or updated. Along with device improvements, is component drift. For monitors this is usually due to phosphor or luminance decay; monitors are no longer capable of maintaining output levels. Drift over time, in all aspects of the processing chain may not be realized by the employee, it may be more noticeable by the customer.

Differences inherent in multiple products create a need to establish some standard for alignment. It is important that all components of a system speak the same language, and recognize and understand each other. Calibration compensates for individual component responses, achieving consistent, optimal image quality.

Monitor calibration is one step in this process. Ensuring reliable and repeatable output, calibrated monitors can be used to proof hardcopy output, and minimize data loss. This process optimizes monitor output range, including luminance, brightness, and contrast, and ensures output from scanner or network mechanisms can be visualized along the full spectrum. When office workspaces are calibrated together, output is consistent from product ingest to output, images will look the same from one display to the next, and one room to the next.

Adjustments in the past worked only with film exposure and processing. Now we can manipulate digitally even when the dynamic range of the scanner or digital input device is limited. This task is completed by using monitor front panel controls in conjunction with any instrument, such as a colorimeter or photometer that measures color, using numbers derived from CIE values.

Monitor calibration is not a new idea. In the past however, processes were very subjective, based on responses of the human visual system, matching colors on screen to print or adjusting contrast until some gray-level separation was achieved. Eastman Kodak introduces completely objective monitor calibration procedures for single-point calibrating, and dual-point calibrating monitors, distinguishable by monitor front panel controls. These procedures specify goals or aims, and define parameters for minimum and maximum luminance, and brightness and contrast that are applied to the graphics card of the monitor.

It is important to be aware that <u>if any part of the system is changed, it is no longer calibrated</u>. The steps defined below should be completed every time a monitor is purchased, installed, or moved to a new room, and repeated three to four times per year.

2. STEPS TO ENSURE OPTIMAL VISUAL IMAGE REPRESENTATION

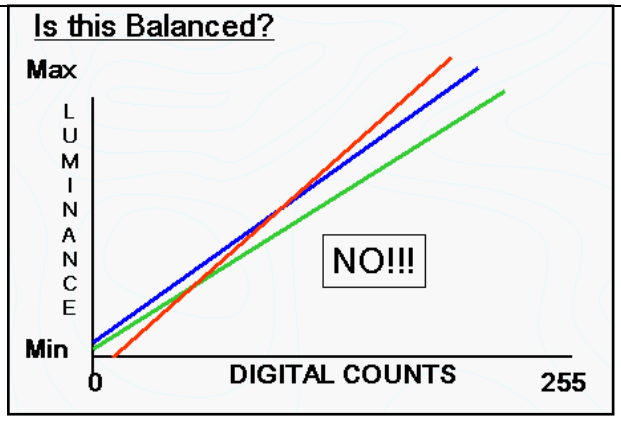
Set Display Properties:

It is important that monitors have the capability to display all colors in present in imagery. Ensure monitors' display properties are set correctly. Right click on the desktop, choose "Properties" and select "Settings". Once this menu is displayed, from the drop-down menu select "True Color (32-Bit)". In essence, this step sets the video board. The first setting will allow the monitor to display 256 colors, and is a representation of 2^8. High color, or 16 Bit = 2^{16}, is equal to 32,000 colors. True Color or 24 Bit = 2^{24}, or approximately16 million colors. The advantage to this setting is overwhelming.

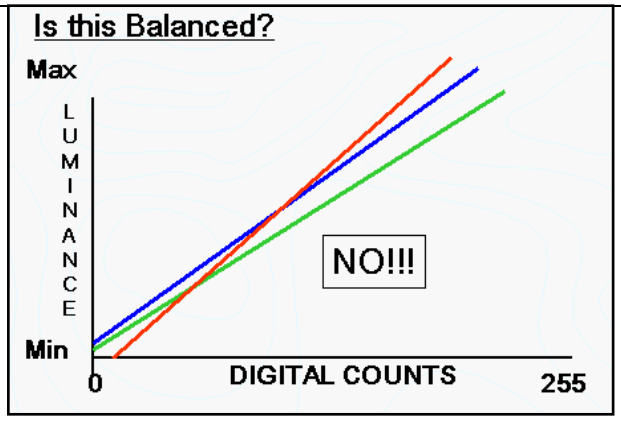
Decide Monitor Type:

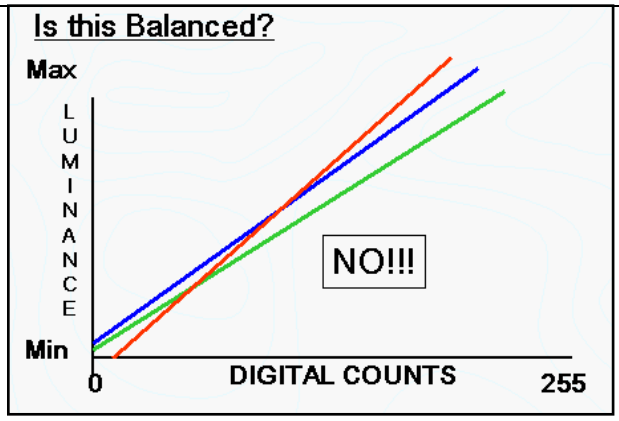
To obtain the optimum results from calibration, one must decide in which category their monitor falls (figure1). This can be determined by activating the display menu via monitor front panel controls. Compare menu display to figure (2) and (3). The single point calibrating monitor derives its name from the gamma curve of the aim applied to the graphics card. This curve can only be adjusted at one point. Eastman Kodak Company has determined the best location of this point to be the midpoint of the curve or 128 (on a 0-255scale). Single-point monitors typically have controls for brightness, contrast, and gain or Red, Green and Blue (R, G, B) sliders.

Fig.1 Simplified graphical representation of calibrations applied to monitor graphic card



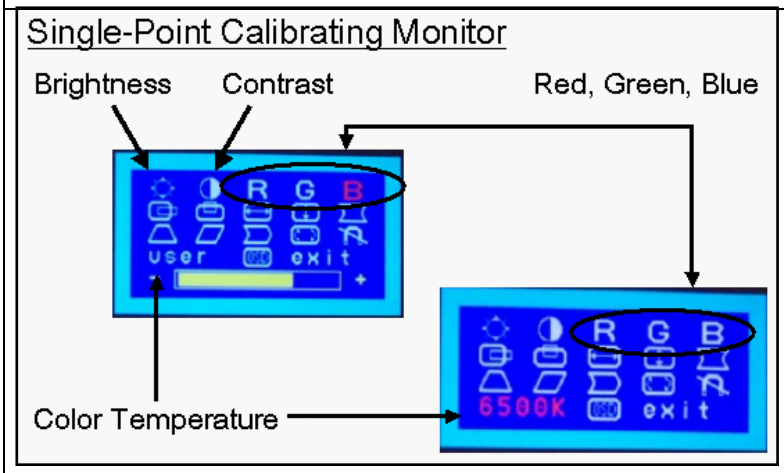
NOT Calibrated - Although this is a simplified representation of a monitor response, it is evident that minimum, midpoint and maximum, do not coincide. Single Point Calibration will only adjust monitor mid-tones. This is achieved by monitors having only brightness and contrast controls. Calibration should be performed with mid-level gray. Since color tracking is performed at the mid-level, color tracking in the highlights and shadow regions may exhibit a color cast. Dual Point Calibration and tracking is set at the top and bottom ends. It allows for adjustment along the entire dynamic range. Here Red, Green, and Blue are equally represented throughout digital counts. Shadows and Highlights would have detail, and would demonstrate shades well.





Dual-point calibrating monitors have controls for brightness, contrast, and bias and gain where each have R, G, and B sliders, Figure (3). The gamma curve for these types of monitors can be adjusted at multiple points, the minimum, midpoint, and maximum. This calibration matches the output of R, G, and B along the dynamic range.

Fig. 2: Single-Point monitor display menu controls



These are the type of controls for a typical single-point calibrating monitor. Notice the controls for brightness and contrast (top left). They each have an operable slider mechanism that displays once selected. There are also Color Temperature presets, including a "User" specified setting. This "User" setting allows the operator to independently adjust the Red, Green, and Blue bands.

Current Environment: Addressing Concerns

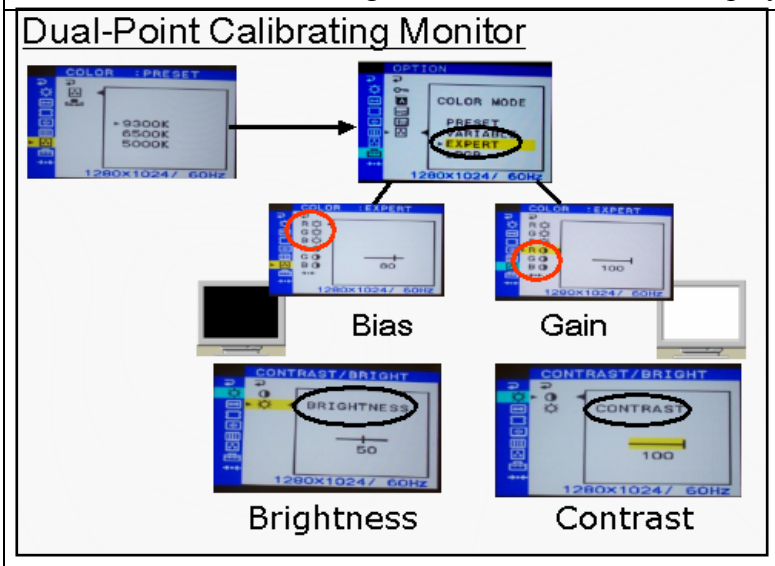
The first step is to evaluate the setting. It is crucial to know what is available, and to identify any constraints The key word is consistency; all light sources should have the same color temperature. Take measurement of *all* light sources in room with colorimeter measuring foot-lamberts, pointed towards light without blocking. Do this to ensure that all bulbs have the same color temperature. Note: Recommended room luminance is 1-2 foot candles.
The combination of multiple light sources (with differing color temperatures) will degrade image proofing. Each light source effects image viewing differently; some are too bright, blue, dim, or yellow. Avoid lights behind the user, which may reflect off the display. This can cause glare, and remove image detail.

It is best practice for image exploitation to locate monitors in rooms without windows, or block them if possible. Glare, or reflected illumination should not be noticeable on screen. Reflective sources could be monitors facing each other, tabletops, coffee mugs or anything with a shiny or reflective surface from which light could bounce.

Next, use the colorimeter to measure the color temperature of the monitor. Place the colorimeter puck at monitors' center to assess current settings with background set to gray (128,128,128). It should match the temperature of the ambient lighting.

Monitor Color Temperature based on ambient light
9300ºKelvin (K) Color monitors are shipped with this setting (not preferred)
5500 - 6500ºK: Daylight (preferred for color exploitation)
4000 - 6500ºK: Fluorescent lights

Fig.3: Dual-Point Monitor Display Menu Controls



These are the typical controls for dual-point calibrating monitors. Notice controls for preset color temperatures (mode), and an expert mode. This user definable setting allows both Bias and Gain, and brightness and contrast adjustment.

Determine a Prescription:

The ambient lighting and monitor settings should correspond, color temperatures (ºK) should match. Identify any opportunities or constraints, and determine a calibration goal for your workstation(s) defining luminance and chromaticity output for each digital count input. Below is a table for a few of the most popular settings with correlated chromaticity coordinates, Table 1.
Dynamic range, the range from minimum luminance to maximum luminance, standards must also be maintained. Room lighting should not exceed one to two foot-candles. If the dynamic range of the monitor is too low, monitor will be in cut off causing the visual loss of data. Low points, or dark areas may appear entirely black and light areas may appear entirely saturated or completely white. Ranges of colors, and shadow details will be removed; thus decreasing functionality of the data.
To ensure that the monitor is capable of displaying all information in the shadow regions of imagery, the minimum luminance recommendation is 0.15-foot lamberts. The maximum luminance should fall within 25-35 foot lamberts.
Using a matrix to illustrate your prescription is an effective management tool. Below is an example, Table 2.

Table1. Popular Color temperatures and Chromaticity Coordinates

Color Temperature		**Chromaticity Coordinates** [1]	
		X	**Y**
9300K:	Monitor Delivered	0.285	0.293
4000K - 6500K:	Fluorescent Lights	0.341	0.351
5500K -6500K:	(D65) Overcast Daylight	0.313	0.329

[1] Chromaticity Coordinates are from the CIE Chromaticity Chart. These (X, Y) coordinates define particular white point reference for different settings.

Table 2. Prescription for 6500ºK

Prescription for Monitor and Ambient Lighting	
Monitor	
Color Temperature	6500K
Chromaticity Coordinates	X = 0.313, Y = 0.329
Minimum Luminance	0.15fL
Maximum Luminance	25-35 fL
Ambient Lighting	
Color Temperature	6500K
Luminance	1-2 fc

Single-Point Calibration Steps:

Once the appropriate prescription has been determined, begin the calibration process by setting the dynamic range of the monitor. With the background of the monitor still set to gray (128, 128, 128) and the colorimeter mounted on monitor screen, activate the monitor front panel controls. To set minimum luminance and bring the monitor out of cut off, highlight Brightness and adjust the slider until the colorimeter displays a reading of 0.15fL.
Next select Contrast, and manipulate this slider until the colorimeter reading falls within 25-35 fL. Now that the dynamic range has been set, adjust each R, G, and B slider until the colorimeter reaches the appropriate chromaticity coordinates, (X = 0.313, Y = 0.329 for 6500ºK). This will achieve your color temperature goal

Dual point calibration:

Change monitor background to Black = (0,0,0) and place the colorimeter puck on screen center. Activate the monitor front panel controls. Set the minimum luminance by adjusting the Brightness slider to where colorimeter reads 0.15fl. This brings the monitor out of cut-off. Select the bias controls (sun icon) and set each Red, Green and Blue BIAS slider to (X = 0.313, Y = 0.329). Be sure to double check measurements after settings. Adjustments are not independent of each other.
Next change monitor background to white (255,255,255) and set the maximum luminance. Set the contrast slider to 100% and check the luminance. It should be > 25fl. Set Red Gain to 100%; the symbol is a half full circle. To reach color temperature goal manipulate the Green and Blue Gain sliders to where colorimeter reads (X = 0.313, Y = 0.329). Be sure to recheck all work.

3. CONCLUSION

A system is calibrated when an image appears identical at all points through the work stream. An image should look identical, and possess identical characteristics (tone, shade, contrast) each time it is scanned, and wherever it is viewed. The ideal calibration is System Calibration. This implies calibration of every workstation within the data processing stream, from input to output device.
The goal of calibration is to render a device consistent and repeatable. Input and output values do not have to match, as long as you know and control the difference. Software can then adjust the relationship, so any given input produces a predictable output. We recommend system calibration for overall optimum equipment performance.

Monitor calibration adjusts dynamic range, and color temperature to ensure what is seen on the monitors' screen is representative of the analog imagery. We have described procedures for monitors within two categories, single-point and dual-point. Type is determined by on-screen display controls. These procedures specify goals or aims, and define parameters for minimum and maximum luminance, and brightness and contrast that are applied to the graphics card of the monitor.

4. REFERENCES

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