GREYSCALE & COLOUR CALIBRATION FOR DUMMIES (OLD VERSION)

Author	Message
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HEADS UP! AN UPDATED GUIDE IS AVAILABLE!

See: CHROMAPURE GRAYSCALE & COLOR CALIBRATION FOR DUMMIES

As of January 2014, an updated guide that focuses primarily on the calibration of newer display technologies such as digital projectors and flat panel TVs is also available. It includes information on the finer controls offered by these newer display devices, especially in the areas of gamma and color calibration.

This older 2008 guide will remain for historical reasons.

Kal

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Written by Kal, Editor CurtPalme.com Home Theater
***Last updated December 27, 2012** (Fixed a few broken links)*

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This guide is also available in Chinese: ä¸æ–‡ç‰ˆåœ¨æ¤ www.isf.com.tw

Is this guide for me?

This guide is for the home theater enthusiast who wants to get the ***absolute best*** picture out of any TV or projector. It will show you how to obtain the most accurate colours possible on any display regardless of what sort of technology it uses (Plasma, LCD, DLP, SXRD, LCOS, CRT, etc.). It doesn't matter if it's a 20 year old analog model or the most recent digital projector or TV. They will all benefit from calibration:

No prior knowledge or understanding of greyscale or colour calibration is required. In fact, you may not even know what "greyscale calibration" is at all! That's fine! I'll explain why it's important along with exactly what tools are needed and how to use them. Read on and learn why proper greyscale and colour calibration is regarded as one of (if not ***the***) most important actions that should be performed on all TVs or projectors for optimal picture quality.

Countless number of calibration guides have been published prior to this one. Some of them quite good. The problem I found is that most assume that the reader already has the required equipment and knows exactly how to use it. Most guides also assume that the reader has a good understanding of terms like D65, stimulus, CIE, etc. Some even provide links to highly technical documents as "required reading". Yes, many of these documents are very informative, but not everyone wants to earn a doctorate in colorimetry so that they can set their greyscale and colours properly.

Our guide takes a step backwards and makes the assumption that the reader has absolutely no knowledge of greyscale or colour calibration. In fact, this guide assumes that the reader doesn't even *know* what greyscale or colour calibration means! I explain what it is, why it's important, list the tools needed, where to get them, and walk you through the process from start to finish.

I hope you find it useful!

Kal
Editor, **CurtPalme.com** Home Theater
Founder, **TheElectricBrewery.com**: A step by step guide to building your own brewery ...

*Disclaimer: Those not comfortable with a do-it-yourself approach to calibration should consider hiring a pro. For those that wish to do the calibration themselves or want to learn exactly what a pro calibrator does, this guide is for you. Whether you attempt this yourself or hire a professional, please consider having your display calibrated. You will be astounded by the resulting difference in picture quality. You may want to also consider using one of our **ChromaPure** video calibration software packages which we carry at exclusive CurtPalme.com prices. Think of **ChromaPure** as an interactive software version of this guide. In fact, our guide was written based on the workflow process used in **ChromaPure**. You simply follow the on-screen instructions. Much easier! ChromaPure also supports completely automated calibration which allows anyone with little or no training in video technology to fully calibrate their display with almost no user input. Just setup a few simple options, click Auto-Calibrate, and then just go have a cup of coffee while the process completes. In less than 10 minutes your display will be full calibrated to professional standards. The package of tools does all the work for you.*

Testimonials

"***Excellent paper on calibration, well done.*** *I come from a deep training background myself and if my instructors felt they would be out of business by sharing their knowledge then I guess we would not* *have a single school or university open today. It is my opinion that nobody has a patent on knowledge. Keep up the great work."* - Richard Stokes of **www.finelytuned.ca**, ISF Certified Video Calibrator and Trainer / LucasFilm THX Certified Surround Sound System Calibrator

"Your Greyscale guide was great. A novice like me needed to know what sensor to buy and what patterns and software to use. Your guide not only covered that but also how to use the software. ***Even though I'm a beginner, I got the job done. My picture is now outstanding.*** *Tonight we had a bunch of people over to watch the Olympics in High Definition. Everyone was in awe over how good this picture was!* ***When I first put up this Sony G90 projector, the picture was good, but now it is terrific.*** *I wish that I had done a proper color calibration for my [prior] Sony G70 which I enjoyed for seven years, with what I saw as an excellent picture. But it was no comparison to this [calibrated] G90."* - Ray

*"**I could not believe how far out my settings were. I've used calibration discs before and THOUGHT I was close, NOT!** ...after going through the process outlined by Kal it is immensely better and I must say, **the image is so much more realistic it's not even funny.**"* - ExCavTanker

*"**... an incredible piece of technical writing.**"* - Greg K.

*"Thank you, Thank you, Thank you!!! **This is THE defacto article for setting greyscale** for those of us that are not afraid to venture into the service menu but never knew exactly how all the pieces went together (hardware, software and the process). I used to say there are two great things from Canada; hockey and beer, and now I have to add this guide to the list. I'm getting excited about correcting my greyscale along with the satisfaction of doing it myself!!!!!"* - Derek G.

*"**You have managed to bring greyscale calibration to the masses...** Thank you very much... I came across your guide a week ago and immediately ordered an eye-one. I downloaded the ColorHCFR software and loaded it onto my laptop, got out the tri-pod and the DVE disc and **within about an hour had my Z4 calibrated and learnt a lot about my set-up in the process.** Your guide is targeted precisely at folks like me and I'm very glad you took that approach of assuming the reader doesn't know the important of greyscale calibration nor any of the 'jargon' used when talking about it. I can't express my appreciation enough!"* - Monomer

*"Thank you very much for this guide. I just got done calibrating my grayscale with my i1 Display LT (Lite). **My HC3000 DLP projector looks amazing** ... amazing how well it worked. I enjoyed calibrating the display much more than I would have enjoyed hiring someone to do it for me."* - Jedirun

*"What a great job you did with this guide. It is so rare to find someone who actually knows what they are talking about who is also willing to share their information. Especially with so much detail. I appreciate all of the time and effort that you spent in putting this together. After having only read through the first section **I was 100% sure that the information you were giving was accurate and well put together.** As a fellow AV professional it is refreshing to know that there really are others out there who care enough about the industry to share what they know for the betterment of the business."* - Bill Allen

*"Thanks very much for the guide; **it was enormously helpful and the process was even fun!**"* - Curttard

*"**This guide is GREAT for amateurs and pros alike. Trust me: Follow the steps and you'll be AMAZED**, even if you only do the gray scale calibration."* - Joel

*"I'd like to echo the manys thanks for your guide. **It has opened new doors and answered so many questions I had.** I'm happy to not only be able to calibrate my own DLP but experiment and tweak the settings to my satisfaction and for that I'm very grateful."* - Warren

*"I've done a few calibrations following your guide Kal - **absolutely excellent - nothing made sense to me before this!**"* - Stephen

*"**You have done a great service for both mainstream customers as well as serious professional calibrators.** GREAT WORK!!!"* - Jeremy Kipnis of **Kipnis-Studios.com** and **VideoCalibration.com**

"How many projector owners have no proper calibration and people already 'happy' with it? Kal, I hope that your well made and excellent guide on grayscale calibration can let those people start to check their own (badly/not) calibrated projectors and discover how good a picture it can throw after a color calibration!" - John

*"I'm sure that you are by now pretty sick of people thanking you, kissing your feet in the street, begging to have your babies etc., but I just had to post saying thank you. **You guide encouraged me to buy an eye one last week and calibrate my VW60. What a difference! It's also great to have some understanding of all the graphs and terminology I've been viewing (and totally confused by) for all these years.** Keep those feet washed, if I ever meet you, I'm likely to do some kissing."* - Irish_Comer

Introduction

If you've spent $1,000 or more on a TV or projector, chances are you're serious about home theater. What many people don't know about projectors and TVs in general is that they require calibration in order to produce a close to accurate representation of the video signal being displayed. One of the most effective ways to get theaterlike pictures is to have the display professionally calibrated. The most important component of professional calibration (and one that requires special gear) is the greyscale and colour calibration.

The main downside to professional calibration is the price: It typically runs anywhere from $350-$450 for a simple TV to more than $1,000 for a complex home theater setup. Worth every penny of course but not inexpensive! Another downside is that for optimal results calibration must be performed as equipment is changed, as components age, and in the case of digital projectors, as the bulb ages. The colours displayed by digital projectors tends to change dramatically over the 1,000 - 2,000 hour lifespan of the bulb. It is not uncommon for a videophile with a digital projector to calibrate their greyscale every 100 - 200 hours (especially when the bulb is new). CRT displays are considerably more stable in this respect: The colour temperature does not shift much over the 10,000 - 20,000 hour lifespan of the typical CRT tube.

The good news is that in the last few years greyscale and colour calibration has become affordable for the average do-it-yourself home theater enthusiast as the equipment prices have come down drastically and quality has improved greatly. Someone looking to calibrate their display can now do it themselves with very good results for minimal investment. This guide will walk you through the steps required to perform this calibration with the assumption that you know absolutely nothing about colour calibration to begin with. Not only is it easy to do, doing it yourself is very rewarding and a learning experience!

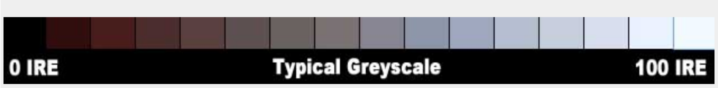
We'll start with greyscale calibration first as it's the most critical and easy to accomplish step, and then move on to colour calibration as a final (optional) step.

What is greyscale calibration?

Performing greyscale calibration is the act of adjusting your display to make sure that from black (0 IRE) to white (100 IRE) the display shows as close to the correct shade of grey as possible without the intrusion of unwanted colours.They cannot be slightly reddish, bluish, or greenish. This is done with the aid of a colour measuring meter. A meter must be used as our eyes are a horrible tool for measuring colours.

Greyscale calibration equalizes the colour of grey at various light levels, from very dark (0 IRE) to very bright (100 IRE), to the standard colour temperature of 6500 degrees Kelvin or 6500K. The 6500K colour temperature is "pure" in that it does not contain any colour information. It is purely black or white or a shade of grey in between. 6500K is often referred to as 'Daylight' as it is the colour temperature measured at noon in North America. Assuming the monitor you're using right now is fairly accurate in terms of greyscale, a perfect greyscale looks something like this:

Unfortunately most displays at their default settings have too much red in the darker areas and too much blue in the lighter areas such that their greyscale looks more like this:



What is colour calibration?

Colour calibration is the next step and comes after doing greyscale calibration. Colour calibration ensures that the raw or "primary" colours used to create all colours are correct.

Many displays have incorrect primary colours often with greens that are too yellow, reds that are too orange, or simply colours that are too saturated and incorrect. Below is an example from a projector with overly saturated green which causes grass to have an almost neon-like glow to it at times:

Photo courtesy of Tom Huffman. Thanks Tom!

Proper colour calibration has the greyscale as its foundation. Accurate colours are not possible unless the greyscale is also accurate.

If we compare this to painting with a brush, greyscale calibration ensures that the proper amounts of paint are mixed together to get the colours we need, while colour calibration is ensuring that we have the right base colours to mix in the first place. For example: If your bucket of red paint isn't perfectly "pure" red, no matter how you mix in the other primary colours you'll never you'll never be able to get that red any more correct.

Why should I do greyscale & colour calibration?

Calibrating both the greyscale and colours will greatly improve your display's ability to not only produce black and white accurately but every other colour in between. It will also improve the contrast and allows your display to operate closer to its optimal levels thus prolonging its operating life.

Without proper greyscale and colour calibration the image quality is far from perfect and results in incorrect colours, poor shadow details (loss of darker details), reduced contrast and lack of image 'punch'. The picture is simply not very engaging nor is it lifelike. Movies are created and meant to be displayed at 6500K colour temperature, so if your TV is calibrated properly to 6500K, you're that much closer to seeing what the director intended.

A common misconception is that you can achieve proper greyscale and colours by using the standard display controls such as hue, colour, and contrast. Not true. These controls have little to no effect on greyscale or colour in the ways we want. To do greyscale calibration you need to adjust the amount of primary colours (red, green, blue) at each level of brightness from black to white. To adjust the primary colours you need to go into further adjustments of the 'pure' primary colours. Most advanced TVs or projectors have menus where greyscale controls are offered. Some also have controls for adjusting the primary colours. These are the controls that we will be adjusting with the help of a meter and specialized software using this guide.

Some people will try and claim to do accurate greyscale and colour calibration by eye but the human eye is actually a very poor tool for measuring light output or colours. The results will be far from ideal. Someone who's been using a meter may get pretty good at doing it by eye after many years, but then they've had years of experience with a meter. A bit of a catch-22 as if you already have a meter, why not keep using it?

Why is greyscale & colour calibration needed at all?

This is a very good question and a valid complaint that most consumers have (or should have).

This question is best answered by answering some of the most common questions related to greyscale & colour calibration:

Why isn't my TV perfectly calibrated at the factory by the manufacturer? Why is this something I have to do myself or pay someone to do??

Unfortunately manufacturers do not seem interested in making sure their displays conform to the agreed upon and accepted colour standards used by television broadcasting and movie studios. In fact, they do quite the opposite and on purpose! In an attempt to sell more TVs, manufacturers are constantly trying to come up with "brighter blues" and "more vivid reds" than their competition. Similar to how laundry detergent manufacturers add blue dye to their soap to make whites "whiter", TV manufacturers are pushing colours to make *their* TVs seem more enticing to the buyer on the showroom floor full of different brands. How's a consumer to decide which TV to buy when faced with a wall of seemingly similar displays? Why, you pick the brightest one, or the one with the most vivid colours of course. Right? ***Wrong!***

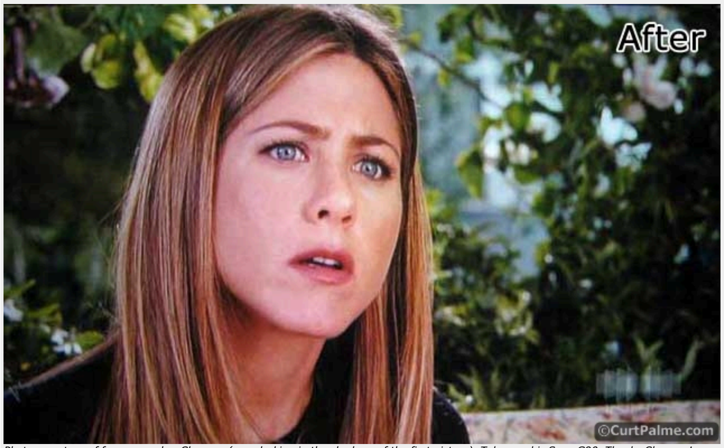
What you, the consumer, need to understand is that there is only ONE correct way to display colours: By following the industry wide recognized colour standards used for standard definition (SD) and high definition (HD). Everything else is simply wrong. Movies and TV shows are all meticulously created to adhere to these industry colour standards that have existed for years. For a TV or projector to reproduce what the director intends the audience to see, it has to follow these standards. No matter what the sales guys and manufacturers tell you, any TV that expands the colour range to go outside the bounds of the accepted industry colour standards is displaying **incorrect colours**! It is truly that simple and black and white. There are no tricks to this: The TV is either following the standards or it isn't. Remember this next time you go TV shopping! For more information on how manufacturers are purposely screwing up TVs and other displays to trick our brains into choosing their products, watch the first few chapters of the excellent **Digital Video Essentials: HD Basics (Blu-ray)** test disc.

My TV has a 6500K or THX setting so I don't need greyscale calibration. I simply choose this option and I automatically have a perfectly calibrated TV. Right?

Unfortunately, no. It's not that simple. Choosing the 6500K colour temperature or THX option in the TV/projector setup menu is a step in the right direction and I thank the manufacturers that include this option. Unfortunately this option is rarely anywhere near accurate across the entire greyscale. It also does not take into account the rest of the equipment being used (including the screen), or the age/wear on the TV or bulb. Later on we'll be looking in detail at the greyscale tracking of a $30,000 USD CRT projector (a Barco Cine 8 Onyx) with the greyscale setting set to 6500K just to show you how far off it is. We'll do the same for your display so you can see for yourself how far off your display is as well. For now however, we'll show a couple of quick before and after screenshots taken from an even more expensive CRT projector: The $40,000 USD Sony G90 CRT projector, regarded by many as one of the finest display devices ever created.

Here is a screenshot of a $40,000 USD Sony G90 with the greyscale settings set to the factory default 6500K setting:

Now here is the same projector after a proper greyscale calibration:



Photos courtesy of forum member Clarence (seen lurking in the shadows of the first picture). Taken on his Sony G90. Thanks Clarence!

Assuming the monitor you're currently using has a reasonably correct greyscale, the second screenshot should look a lot better than the first. Notice how in the second shot Jennifer Aniston's face no longer has a red/blue tint and how the colours are more vibrant, the contrast better. The image simply has a lot more "pop" to it. With proper greyscale calibration the image has a lot more "punch" to it and will often have a practically 3D look to it. Colours are more natural and shadow details are also more apparent. The entire picture is also brighter, without even having changed the contrast setting! As mentioned previously, the Sony G90 is a professional grade CRT projector with an MSRP of $40,000 USD, but even it was far from perfect at the default factory settings for 6500K! Most displays are considerably worse.

Correct greyscale can only be truly appreciated when the before & after picture is seen in person, not by viewing screenshots as you lose a lot of the details with digital cameras and viewing through another display. You may find that your projector or TV looks fine today but until you've actually seen what it's ***really*** supposed to look like, you simply won't know how much you've been missing. You will quite literally think you're looking at a completely different display after you've completed your greyscale calibration.

I don't have Blu-ray or high-definition. My TV/projector isn't 1080p capable. I just watch regular DVDs or regular TV. Is calibration still worth it?

The answer is a resounding: **Yes!**

Proper video calibration has nothing to do with the latest technologies like high definition or Blu-ray. Regardless of image resolution used by your source devices (Blu-ray, HDTV, 480i DVD or TV) proper calibration will ensure that you are seeing the best possible image.

While HD content shown through HDMI cabling will provide you the best image quality available today (and should be used whenever possible), standard definition content shown through composite, S-video, or component cabling will still benefit greatly from proper greyscale & colour calibration. (For more information on the various connection types and which ones are best, see our **FAQ: Hooking it all up** guide).

Video calibration has been around since the dawn of television. It's not a new concept. It will also continue to be useful far into the future as new technologies and content are invented. Wherever there are movies and television, calibration will always be required.

Interested in doing the greyscale and colour calibration ? Let's get to it! It's easier than you think!

What tools do I need?

You're going to need a few items to set greyscale properly on your projector/TV:

- ### A Meter
  A meter is needed to measure light and colour levels. See our **FAQ: Which meter is right for me?** for a comparison of the various popular models. The Eye-One Display 2/LT, Eye-One Pro, and Spyder 2 will work with our guide. Most home users not looking for absolute perfection will likely be happy with the Eye-One Display sensor which is available in the **Eye-One Display 2** or **Eye-One Display LT (Lite)** packages. Both packages use the same sensor. The more expensive Display 2 package comes with useful software for digital photographers but we won't use that software here however. Those looking for a professional grade solution that will not only be more accurate but will remain accurate longer, should consider the **Eye-One Pro** instead. It's the meter that many pros use*****. The **Spyder 2** is also available for the budget conscious user though make sure to read our **Eye-One vs. Spyder2** comparison first.

****While most pros use the Eye-One Pro meter, they do not use the free ColorHCFR software that is featured in our guide. It's not that it's bad software, it's just that it's missing***

features that pros look for such as reporting, profiling, tips/guides, advanced meter support, and so on. The ColorHCFR software used in this guide simply takes measurements from your meter and plots them out on a graph. It doesn't explain what's going on, what you should do, or what the results mean. It's up to you to figure all that out (with help from this guide of course).

Instead, professionals typically opt for the more advanced software like ChromaPure. Think of ChromaPure as an interactive version of our guide taken much farther. Our guide here is actually based on the workflow process designed by Tom Huffman, the author of ChromaPure. When you use ChromaPure, our guide here is no longer needed. Completely automated calibration is also supported. ChromaPure supports all of the popular meters listed above and then some. We feature ChromaPure here at special CurtPalme.com discounted prices too. More info »

Confused about meters? See our FAQ: Which meter is right for me?'

- ## A Test Disc with greyscale patterns

  You'll need a test disc with 0 to 100 IRE window patterns. I recommend the Digital Video Essentials: HD Basics disc (in **Blu-ray**) as it's the most up to date and the least expensive. Our guide will show you exactly where to find the patterns needed using either of these discs. Both **DVE (standard DVD version)** and **Avia II** will work too, but the disc menus are different so you'll have to look at our pictures and find the patterns yourself. I ***do not*** recommend using the original Avia DVD as the greyscale patterns are incorrect! (The authors have admitted to this).
  Canadians and other non-US citizens: **Amazon.com** ships worldwide and it's usually cheaper than buying locally. No duties/taxes for Canadians either!

Buy from amazon.com

- ## A Tripod

  You'll need a tripod for holding the sensor in front of the screen for projector/screen based setups. Not needed for direct-view TVs or rear projection TVs. Make sure the tripod extends to at least the middle of your screen. Just about any tripod will work as the meters are small and light.

Buy from amazon.com

- ## A Windows PC* for running the software

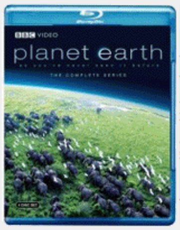
  A laptop preferred for portability but just about any computer will do as the speed and storage capacity are not important.

Buy from amazon.com

**A Mac will work too. Mac users will be happy to learn that at least one user has reported having successfully used the Windows ColorHCFR software from this guide together with the Eye One sensor on a Mac G3 (iBook) running Mac OS 10.2.8 under Virtual PC 6.1.2.*

- ## Some of the best looking movies to test out your results!

  You're going to want to show off your newly calibrated display! What better way than with 1080p (Full HD) Blu-ray discs from our **Release List & Must-Have Blu-ray Titles**! It's updated weekly and includes a short list of the absolute best movies that home theater has to offer in terms of audio and video quality. Every movie collection should include a handful of these movies! Here are some titles that achieved the elusive 5-star video rating to get you started ...



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Display controls you will need to use

Most CRT and digital projectors or TVs as well as LCD, DLP, and Plasma flat panel displays have the necessary controls to have their greyscale calibrated. In your projector or TV we will be adjusting four controls to set greyscale correctly. It's important that you locate these controls and be familiar with them:

- **Brightness:** The control used to adjust black level. Setting brightness too low will cause darker details to be lost into black (called 'black crush'). Setting brightness too high will cause the black to appear grey. Brightness affects all colours at the same time.
- **Contrast:** The control used to adjust white level or peak light output. Setting contrast too low will result in a dim picture. Contrast set too high can cause lighter details to be lost into white (called 'white clipping') or blooming/smearing. Contrast affects all colours at the same time. Some manufacturers call it 'Picture'.
- **RGB LowEnd:** The control used to adjust the amount of individual Red, Green, or Blue colour in the darker end of the black to white scale. Think of it as an individual brightness control for each colour. Manufacturers all use a different name for this control though 'Cut', 'Cutoff' and 'Bias' are the most common terms used. I will refer to this control as 'RGBLowEnd' in this guide to avoid any confusion.
- **RGB HighEnd:** The control used to adjust the amount of individual Red, Green, or Blue colour in the lighter end of the black to white scale. Think of it as an individual contrast control for each colour. Manufacturers all use a different name for this control though 'Drive' and 'Gain' are the most common terms used. I will refer to this control as 'RGBHighEnd' in this guide just to avoid any confusion.

All displays have brightness and contrast controls. If your projector or TV has RGBLowEnd and RGBHighEnd controls for Red, Green, and Blue, then you will also be able to calibrate your greyscale.

Since different manufacturers use different names for the RGBLowEnd and RGBHighEnd controls, refer to your user manual and look for a section on "greyscale", "white balance", or "colour temperature" adjustment to see what they're called for your display. If you own a CRT projector, you can access your user manual in the **Tech Tips** section of our main site.

The more popular names typically used for the two controls are:

RGBLowEnd: Bias, Offset, Cuts, Cutoff, Sub-brightness, RGB brightness
RGBHighEnd: Drive, Gain, Sub-contrast, RGB contrast

To make things even easier for CRT projector owners, below are the names used by various CRT projector manufacturers for RGBLowEnd and RGBHighEnd:

- **Ampro:** Sub-Brite, Sub-Contrast
- **Barco:** Cutoff, Drive
- **Dwin:** Level, Gain
- **Electrohome ECP:** G2, Drive
- **Electrohome Marquee/Madrigal:** G2, Drive
- **NEC PG/Runco:** B, W
- **NEC XG/Runco:** BLK, WHT
- **Runco:** Use our **Runco cross-reference table** to see who built your Runco projector and then refer to the other manufacturers listed here.
- **Seleco:** Black, White
- **Sony:** Bias, Gain

That's it for the introduction. On to greyscale calibration!

Last edited by kal on Sat Jan 16, 2021 3:43 pm; edited 310 times in total

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Forum Administrator

Joined: 06 Mar 2006
Posts: 17867
Location: Ottawa, Canada

TV/Projector: JVC DLA-NZ7

offline

Link   Posted: Sat Apr 26, 2008 7:47 pm   Post subject: quote

Performing the Greyscale & Colour Calibration

Part 1: Installation and Setup

Ok! Let's get started! First, some important rules:

- For front projector setups make your room as dark as possible and preferably pitch black (just like when you're watching a movie), making sure to not have any stray light hitting the screen. This includes the laptop or computer monitor as well. Point it away from the screen and turn the laptop or PC monitor's brightness down.
- Let your projector/TV warm up for at least 30 minutes before doing a greyscale calibration. It will take time to stabilize. Important: If you're using a Plasma display, make sure to let the sensor warm up **on** the display for a good 30 minutes as the plasma will get warm and you want the sensor to stabilize to the same temperature.

STEP 1.1: The software we will be using to measure our greyscale is called 'ColorHCFR'. The first step is to download and run the **ColorHCFR software v2.0.1 installation package** (8mb) and choose all of the default installation options. Make sure that your PC is set to 32 bit colour depth too otherwise some of the graphs may not display properly. To check this on Windows XP right-click on your Desktop, select "Properties", then the "Settings" tab, and make sure "Highest (32 bit)" is set in the "Color quality" drop-down list.

*Note: The latest version of ColorHCFR is always available on the **official ColorHCFR page**, but as these instructions are written for ColorHCFR Release 2.0.1 (May 2008 timeframe) I cannot guarantee that the screenshots and instructions in our guide will still continue to work if you use a newer version of the software.*

STEP 1.2: Install the sensor software using all of the default options. All we're interested in is the one driver (*.dll) file. To make sure you're using the latest version of the driver I recommend you do not use the CD that came in the box but instead visit the manufacturer website:

Spyder2 users only: The Spyder2 software can be downloaded at **http://spyder.datacolor.com**. The whole 100mb+ package must be downloaded and installed (you must register and log in to their site before you can download software updates).
Eye-One users only: The Eye-One software can be downloaded at **http://www.xrite.com**. Only the **i1Diagnostics** software needs to be downloaded and installed.

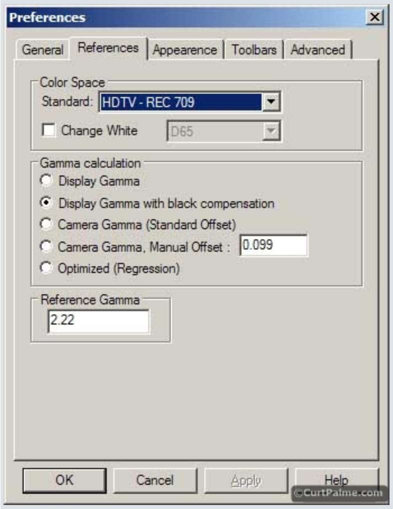
STEP 1.3: Copy the sensor driver to where you installed ColorHCFR (it must be in the same directory as ColorHCFR.exe):

Spyder2 users only: Copy the "CVSpyder.dll" file from **\Program Files\Colorvision\Spyder** to **\Program Files\ColorHCFR**. As of this writing, the latest "CVSpyder.dll" file is at version 4.2.0.1 (86,016 byte file dated October 12, 2006).
Eye-One users only: Copy the "EyeOne.dll" file from **\Program Files\X-Rite\i1Diagnostics** to **\Program Files\ColorHCFR**. As of this writing, the latest "EyeOne.dll" file is at version 3.4.0.131 (3,203,072 byte file dated June 26, 2007).

STEP 1.4: Launch the ColorHCFR software. You will see the main work window come up:

STEP 1.5: We need to tell ColorHCFR what color space or "gamut" we're working in. The color space is the range of colours that we expect our sensor to see and standard definition (SD) and high definition (HD) have different ranges. The HD range is slightly 'bigger' than SD, allowing for more vivid colours (more on this later).

Choose the "Advanced -> Preferences" menu option, and click on the "References" tab to see:



If you are using a Blu-ray test disc, set the "Color Space - Standard" option to **HDTV - REC 709**.
If you are using a Standard DVD test disc that is in NTSC format, set the Color Space - Standard option to **SDTV - REC 601 (NTSC)**.
If you are using a Standard DVD test disc that is in PAL or SECAM format, set the Color Space - Standard option to **PAL/SECAM**.

Click "Ok" to close the window.

Note: How you set this option actually doesn't matter at all for greyscale calibration. This is simply useful for seeing how close your display's Red/Green/Blue "primary" colours will measure to the perfect values set by the SD or HD standards (we'll discuss measuring primaries and what they mean later). Setting your greyscale using a Blu-ray disc in a machine that plays both SD DVD and HD Blu-ray discs will work for playing back both standard DVDs and Blu-ray discs. There's no reason to set greyscale differently for SD and HD as the greyscale reference target we're going to try and achieve is the some for SD and HD. Different sources may have *very* slight differences in the signals but they're subtle enough to ignore. I don't find it worth having different greyscale settings for different sources. Set greyscale using your best source (usually your DVD or Blu-ray player) and be done with.

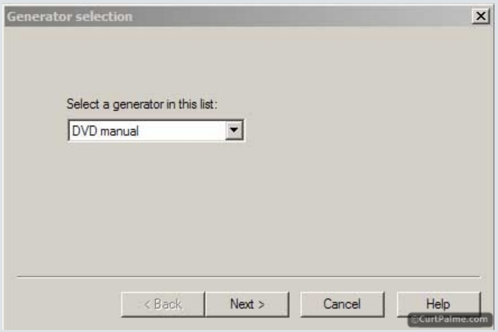
STEP 1.6: Take the sensor out of the box and plug it into a free USB plug on your PC. Both the Eye-One and Spyder2 have a removable cover that contains a filter or diffusor.

Here's the Spyder2 cover/filter:

Here's the Eye one diffusor:

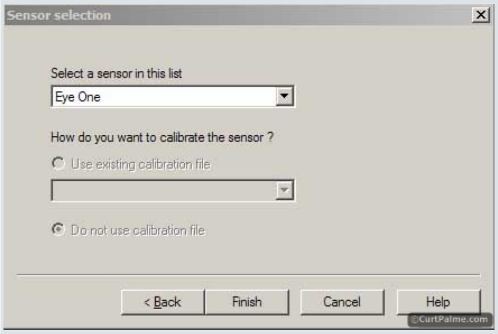
Spyder2 users only: Keep this cover/filter on for all display types including front projector setups with a screen.
Eye-One users only: Remove the diffusor for all display types. It is only used to measure ambient light with the Eye-One software. We will never use it with our ColorHCFR software. The Eye-One Pro meter does not have a diffusor.

STEP 1.7: Start a new calibration file in ColorHCFR. This file will store all of your "BEFORE" calibration readings so that we can compare them with our "AFTER" calibration readings. Choose the menu option "File -> New" to start a new calibration file in ColorHCFR and pick "DVD Manual" to tell ColorHCFR that you will supply the test patterns using an external test disc.

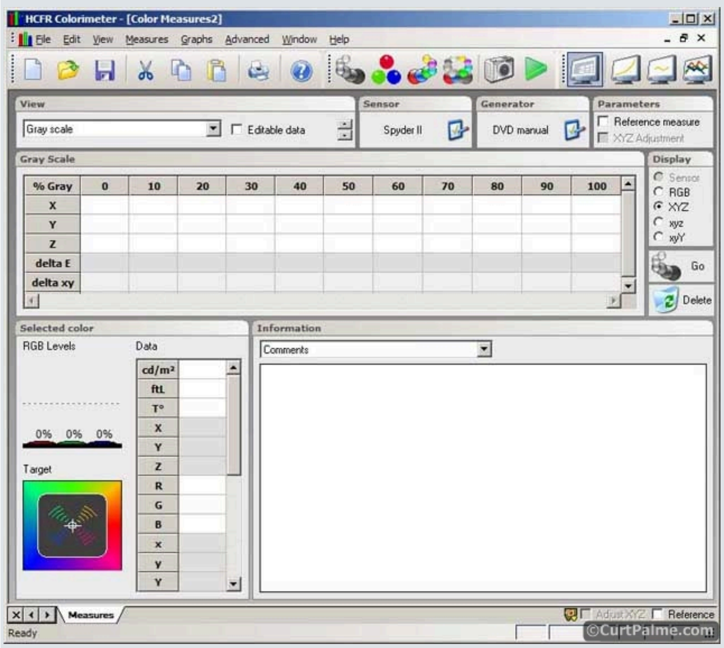


Click "Next".

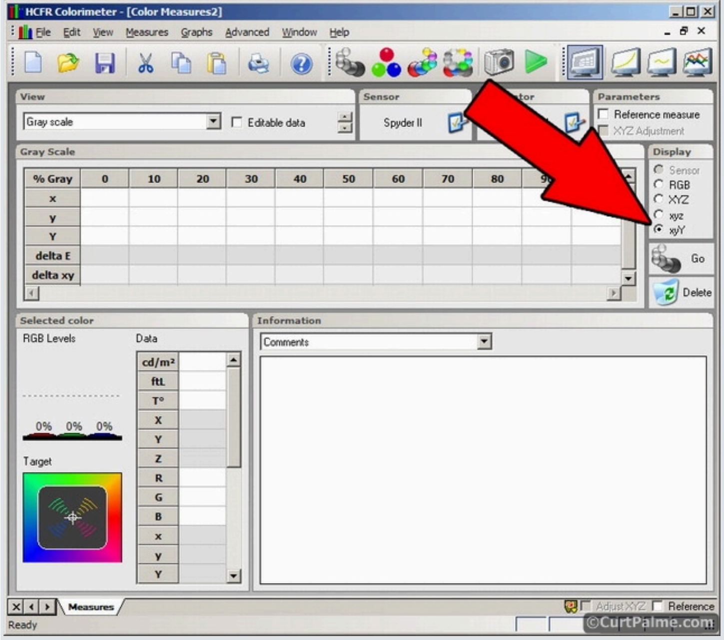
STEP 1.8: Pick "Eye One" or "Spyder II" as the sensor type from the list of available options.



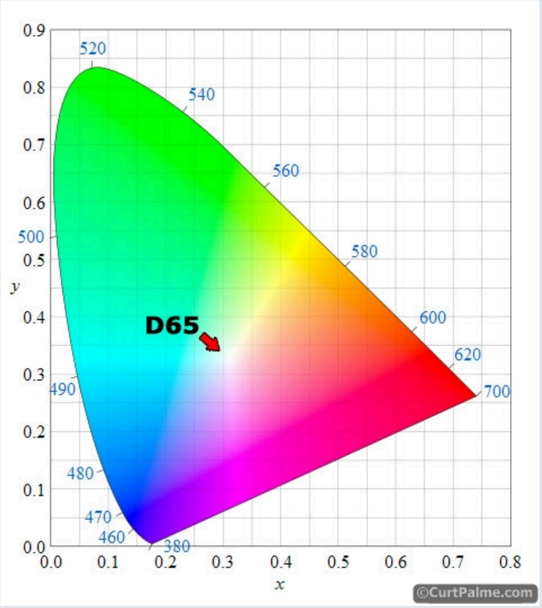
Click "Finish" and you will see a new window open up with a ton of new information (only some of which we will actually use):



STEP 1.9: We will be displaying data in xyY mode as it is the most common way to map colours. In the "Display" window on the right, select the "xyY" option:



While we're only interested in measuring peak light output (The 'Y' luminance value) right now, some explanation of xyY is probably helpful at this point. Take a look at the diagram below:

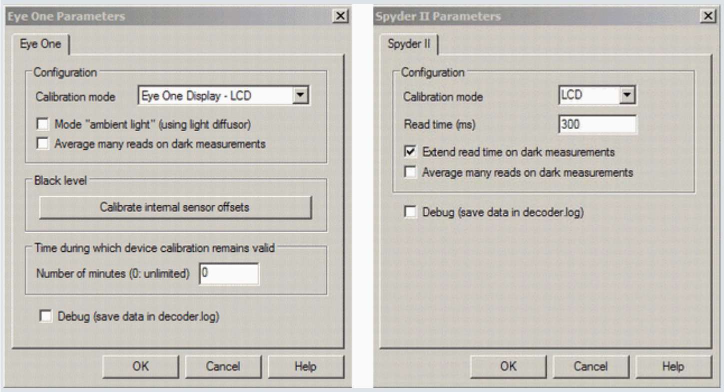


This graph represents an internationally agreed method of mapping all the colours or "colour space" that the human eye can see. It's called the CIE 1931 colour space. It was created by the "**C**ommission **I**nternationale de l'**E**clairage" or "CIE" (French for "International Commission on Illumination") in 1931. Hence the name "CIE 1931". Makes sense to me!

By changing the x and y values we can map to any possible colour visible to the human eye. The Y value is the brightness (or luminance) of the colour and while not shown on the graph, it could be represented by a third axis that comes out of the page (or screen as you're likely reading this online). What we will be doing later is taking readings by varying the "Y" value from black (0 IRE) to white (100 IRE) and trying to adjust the color to make it fall right at the middle white point, called D65. D65 represents the location where there is no colour component at all: It's purely black, white or a shade of grey in-between. The x,y coordinates for the D65 point are x=0.313, y=0.329. These are the magical numbers we will be trying to achieve by taking measurements with our meter.

Make sense? Don't worry if it's confusing. You don't really need to understand all this to calibrate your greyscale, but knowing the background helps understand what the ColorHCFR software is doing. For now however we're just going to measuring the luminance or total light output, so all we care about for now is the Y reading.

STEP 1.10: We want to now make sure we have the sensor settings are set properly. These vary by sensor type. Choose the menu option "Measures -> Sensor -> Configure". Users should set their settings as shown below depending on which sensor they are using (Eye-One or Spyder2).



Ensure that the "Calibration Mode" is set to "LCD" for all types of display types **except** for the following situations:

- Users with CRT direct view (tube) displays should select "CRT". This is for both the Eye-One and Spyder2 sensors.
- Users with CRT rear-projection and CRT front-projection displays should select "LCD". This is for both the Eye-One and Spyder2 sensors. If you run into issues such as finding that the software locks up or takes very long (30-60 seconds) to take readings sometimes, you may want to try "CRT" mode instead. We're still trying to figure out the logic behind all this and which is the best mode to use

- for CRT rear/front projectors - sorry!
- Users with Plasma displays using an Eye-One sensor should select "Plasma". There is no "Plasma" option for Spyder2 users - use "LCD" instead.
- Those using the Eye-One Pro meter should choose "Eye One Pro" as the display type.

Even if your display doesn't use LCD technology, the "LCD" option is the right one to use with other digital displays such as SXRD, LCoS, DLP, etc. CRT and Plasma technologies as well as the Eye-One Pro meter are the only possible exceptions where something other than "LCD" may be used.

Spyder2 users only: The read time is how long the sensor will remain on to take a reading and only exists with the Spyder2. (The Eye-One reads correctly without having to set the read time). Darker test patterns require longer read times otherwise the readings will not be correct. For patterns above 20 IRE, the default 300 ms is long enough. For 20 IRE and under, 1000 ms or even 2000 ms is sometimes required. Since we're going to measure a bright pattern first, we'll set it to the 300 ms default value.

Eye-One users only: You'll need to calibrate the sensor otherwise ColorHCFR will pop up a window asking you to do this before you take your first readings. You may want to set the "Time during which device calibration remains valid" to 0 to make sure that we don't have to redo a calibration during this session, especially when you're only just initially dialing things things in. When you go to take final critical readings, you may want to manually recalibrate again to ensure everything is perfect. Or you may want to set the time to, say, 10 or 20 minutes if you really want to make sure you're always perfectly calibrated. You'll have to calibrate next time you start up ColorHCFR or unplug/replug the Eye-One too of course. Calibration is done two different ways depending on which display type you selected previously:
LCD or Plasma: Click "Calibrate internal sensor offsets" and place the sensor on a flat non-porous opaque surface. A black surface is preferred. The inside of a black DVD case works great. Make sure it's flat and no extra light is getting in there! Select "OK" to calibrate.
CRT: The sensor needs to measure your CRT refresh rate. Display a bright white (preferrably 100IRE) test pattern from your test disk (see the steps directly below on how to do this) and click "Calibrate internal sensor offsets". For CRT tube displays simply stick the sensor to the TV tube. For CRT rear/front projectors hold the sensor close to and in front of the screen or use your tripod as mentioned below. The orientation doesn't have to be perfect, the sensor simply needs to be able to measure the refresh rate. Select "OK" to calibrate. Ignore the bright white window that pops up on your PC/laptop - You do not want to stick your sensor on your PC/laptop display!

Click "Ok".

STEP 1.11: We now need to orient the sensor correctly.

If you're using a direct-view display (digital or CRT) including rear projection TVs, you've got it easy! Simply hang the sensor flat on the display as shown below (there's a counterweight on the cable to keep it in place). Make sure it's nice and flat against the display surface. If you can't get it to lie flat against the display surface, you can gently hold it in place with your hand. If you're using a Plasma display, make sure to let the sensor warm up **on** the display for a good 30 minutes as the temperature change will affect the readings. If you're using the Eye-One sensor I would recommend re-doing the sensor calibration again after the 30 minute warmup.

That's it for sensor orientation if you're using a direct-view display - Ignore the rest of Part 1 and skip over to Part 2!

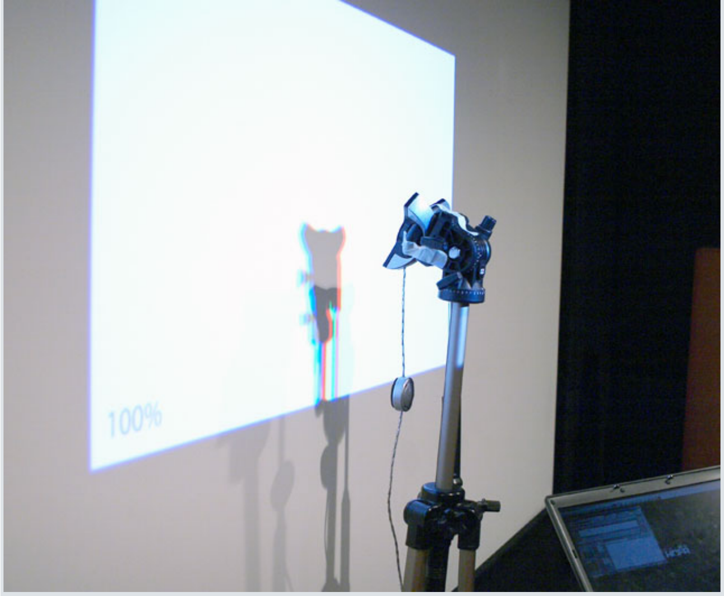
For front projector setups with screens there's a bit more work involved: we need to position the sensor so that it's perfectly square to the screen. We do this by adjusting the position until the light reading we get is at a maximum. Attach the sensor to the tripod with some masking tape, rubber bands, or the **free Spyder2 tripod mount** (if you're using a Spyder2). It doesn't have to be a good solid mount. It just needs to not move or shift while you take readings. I use a couple of pieces of regular masking tape. Works great.

Forum member Andrew Low sent us this tip: A standard 1/4â€³-20 nut will screw onto a standard tripod mount. Simply glue the nut to the Spyder2 as follows:

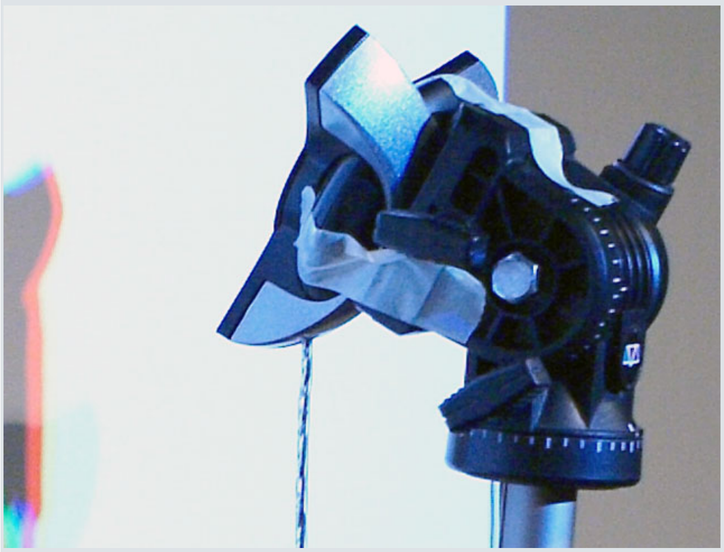
Another option is to use a universal mount as found in our **universal projector kit**:

This mount will hold any of the meters mentioned in this guide without having to use tape or alter the meter in any way. For complete information on this kit or to order, **click here**.

Using your tripod, place the sensor 3-4 inches from the screen, slightly below center, and titled upwards facing the screen as shown here for the Spyder2:



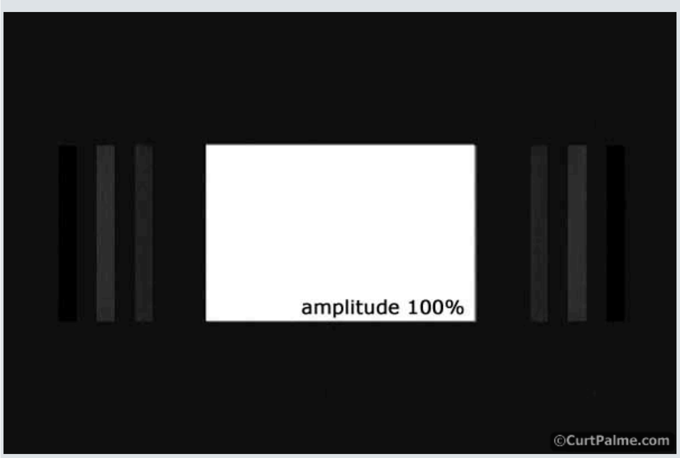
A closeup:



The Eye-One probe attaches in a similar manner to the Spyder2 probe. Simply use masking tape or something similar to hold it to the tripod such that the little suction cups on the underside of the probe face the screen.

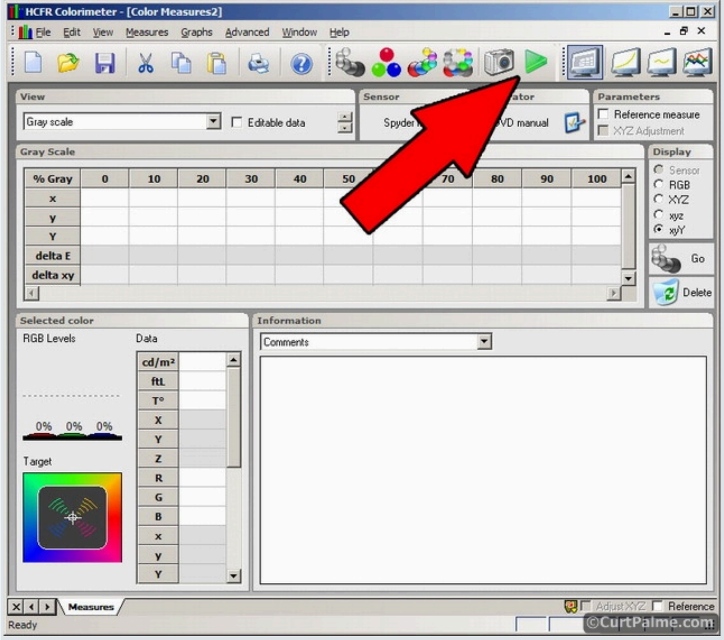
If your projector is floor mounted you'll have to put the sensor off the side a bit and angle towards the center of the screen instead. Exact placement isn't critical at this point as we will be fine-tuning it in the following steps.

STEP 1.12: We're going to put on the brightest test pattern and tweak the sensor positioning to maximize the Y reading thus ensuring that our placement is perfect. Start up your **Digital Video Essentials: HD Basics** test disc and skip to the 100 IRE window pattern by choosing the disc's menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "Window 100% w/ new PLUGE". 100 IRE means that the pattern is 100% white and 'window' means that this pattern only uses a small portion of the screen (typically 10-18%). It looks like this:

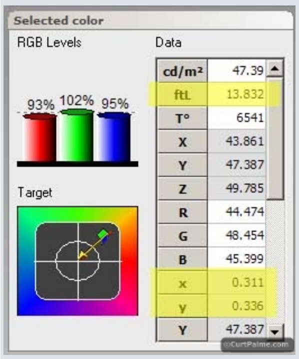


If you used a different test disc, your pattern may or may not have the darker PLUGE grey bars on the sides. That's fine.

STEP 1.13: Click on the green triangle to start taking continuous readings:



The sensor will now start taking x, y, and Y readings and report them back every few seconds. You should see the data in the "Selected Color" window in the lower left updating:



The only reading that we are concerned with now is the Y (luminance) value. The software conveniently takes the Y reading and converts it to ftL for us. In this example we're seeing a Y value of 47.387 (which translates to 13.8 ftL).

STEP 1.14: Keeping your eye on the ftL reading adjust the sensor position in all 6 degrees of motion (closer/farther from the screen, left/right, up/down). Do this slowly and systematically (one axis at a time) while you wait for the data to update. For example, rotate the sensor in one direction a few degrees at a time and wait for the ftL reading to update. Keep rotating and waiting for a reading. If the reading goes down, rotate the other way. Do this until you get the maximum value possible and then adjust the tilt, followed by the distance to the screen, etc. By only adjusting one axis at a time ensures you get the best position as quickly as possible. This whole process will take you a few minutes. Keep adjusting until you get the highest ftL reading possible. This is the position we're going to want to use. Don't touch or move the sensor from now on. If the sensor is moved you'll have to start the process over again as your Y readings would not be consistent.

The maximum light output reading also ensures that the sensor is not seeing its own shadow (which is darker than the rest of the white image). If the sensor was seeing any port of its shadow, the Y reading would simply drop.

By maximizing the light output reading we are ensuring that the position is exactly square to the projector and we are getting the most accurate readings possible. That said, the x,y (colour) readings I took with the sensor during my tests did not vary as I moved the sensor around slightly, only the Y (luminance) reading varied, so placement is not overly critical for proper greyscale calibration.

Congrats! You've now placed the sensor perfectly!

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Last edited by kal on Fri Jan 15, 2021 3:18 pm; edited 59 times in total

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kal
Forum Administrator

Joined: 06 Mar 2006
Posts: 17867
Location: Ottawa, Canada

TV/Projector: JVC DLA-NZ7

offline

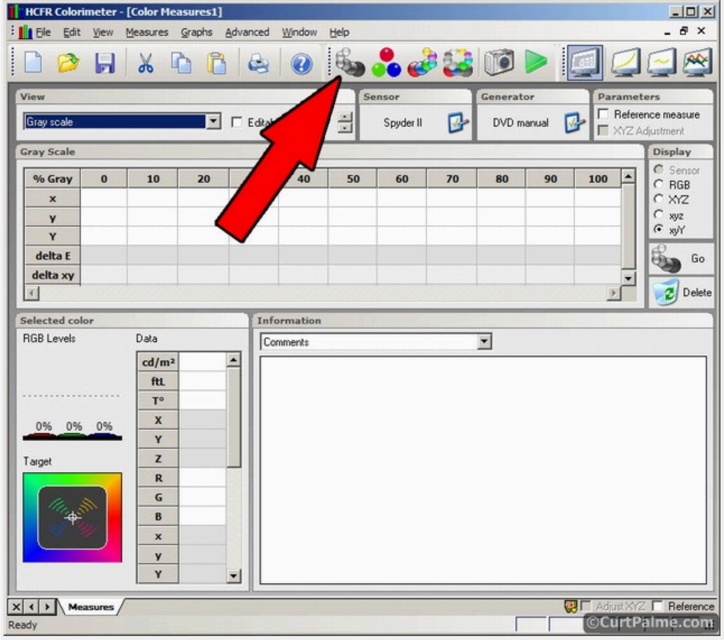
Link Posted: Sat Apr 26, 2008 7:48 pm Post subject: quote

Part 2: So just how bad *is* my greyscale anyway?

Before we start calibrating, we should run through and see how far off our current greyscale actually is. This way we will have a good before/after comparison. You'll have ColorHCFR take readings from 0 to 100 IRE and we'll explain what the graphs mean by using my Barco Cine 8 Onyx CRT projector readings as an example.

STEP 2.1 (Spyder 2 users only): The Spyder2 sensor has issues reading light input at low IRE values like 10 and 20 IRE so we'll need to turn up the read time to 2000 ms while we take our readings. To do this, choose the menu option "Measures -> Sensor -> Configure" and set the "Read Time" to 2000 ms. Click "Ok".

STEP 2.2: Click on the "Measure Grey Scale" button in ColorHCFR to start the process:



The ColorHCFR software will now ask you to display window patterns from 0 to 100 IRE in 10 IRE steps, one at a time, pausing at each one so that the sensor can take a reading. Cue up the first pattern on the **Digital Video Essentials: HD Basics** test disc. The 0 IRE pattern can be found by choosing the disc's menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "Video Black w/ new PLUGE". The subsequent patterns are in the chapters that follow.

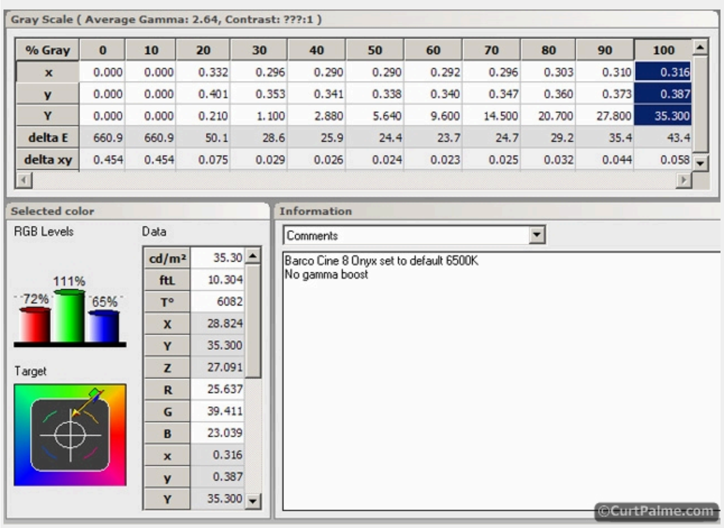
Follow the steps as indicated by ColorHCFR and run though the patterns one at a time waiting while ColorHCFR takes a reading. The **Digital Video Essentials: HD Basics** window patterns are in 5 IRE increments so you'll have to skip twice between each step. The IRE value is displayed as a percentage in the test pattern. For example, 50 IRE is displayed as "amplitude 50%" so it's easy to not get lost.

Once completed, you will have a full set of data for greyscale. On the Spyder2 you may get a "no data from sensor" error at 0 IRE. Don't worry. 0 IRE is so black that there's usually nothing much to see anyway. You won't however be able to plot graphs until there is data in all the columns so simply click the "Editable Data" checkbox and enter 0, 0, 0 for the x, y, Y values in the 0 IRE column. Zero light output is actually what most displays should put out at 0 IRE so this is accurate. If your light output is pretty low at 10IRE you may get the same error as well, especially if you don't use something to boost your gamma (more on this later). If that's the case simply enter the values from the 20 IRE column into the 10 IRE column for now. Don't enter zero's into any fields other than the 0 IRE column. There's a bug in ColorHCFR that doesn't allow you to re-edit a field once you've entered in a zero.

STEP 2.3: Save your "before" greyscale calibration readings by choosing the menu option "File -> Save". The ColorHCFR software will want to save the file as "Color.chc". I suggest using a name like "Color_before.chc" to make it more obvious that these this is your greyscale before calibration.

I've run through and done a set of readings using my Barco Cine 8 Onyx CRT projector set to default settings including the default 6500K colour temperature. I've also turned our gamma boost off on my **RTC2200** external box to get a more typical set of readings that you will encounter with most displays. This box (and **others like it**) are used to provide a gamma boost to produce better shadow details, something that pretty much all displays require to some degree or another, especially CRT based displays. More information on how gamma boost works as well as before & after screenshots showing why it's needed can be found in this thread: **Gamma Correction: What is it? Why is it needed?**

Here are the readings from my projector set to the default 6500K colour temperature:



Gray Scale (Average Gamma: 2.64, Contrast: ???:1)

% Gray	0	10	20	30	40	50	60	70	80	90	100
x	0.000	0.000	0.332	0.296	0.290	0.290	0.292	0.296	0.303	0.310	0.316
y	0.000	0.000	0.401	0.353	0.341	0.338	0.340	0.347	0.360	0.373	0.387
Y	0.000	0.000	0.210	1.100	2.880	5.640	9.600	14.500	20.700	27.800	35.300
delta E	660.9	660.9	50.1	28.6	25.9	24.4	23.7	24.7	29.2	35.4	43.4
delta xy	0.454	0.454	0.075	0.029	0.026	0.024	0.023	0.025	0.032	0.044	0.058

Selected color — Data

cd/m²	35.30
ftL	10.304
T°	6082
X	28.824
Y	35.300
Z	27.091
R	25.637
G	39.411
B	23.039
x	0.316
y	0.387
Y	35.300

So how well does this projector do at the default 6500K setting with gamma boost off? Well, to put it bluntly, it sucks. From 0 to 100 IRE none of the x,y values are anywhere near the x=0.313, y=0.329 D65 target values. I also didn't manage to get any readings at 10 IRE as the image was simply too dark. In the picture above I've selected the 100 IRE column (highlighted) to see how close the respective Red/Green/Blue levels are. If you look at the little bar graphs in the bottom left, we see that is Red is 72%, Green is 111%, and Blue is 65%. They should all be close to 100%, so the colours are obviously completely unbalanced at 100IRE. If we check some of the other IRE values, we see that they're all off as well. We're getting a maximum of 10.3 ftL of light output at 100 IRE (the target we'll aim for later is between 12-16 ftL) which actually isn't that bad as that the room is light controlled with black walls/ceiling around the screen so the perceived brightness is higher. (You can see pictures of the room in my **Home Theater Photo Album**).

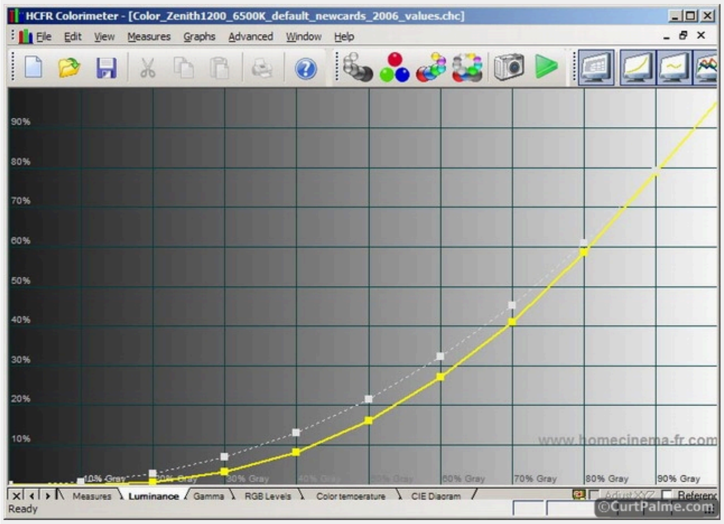
Ok, so the numbers are off and the image looks pretty off bad at the default 6500K setting, but what does all this data mean? Most of the interesting information can be seen in the graphs accessible in the "Graphs" menu. Let's run through them one at a time using my Barco Cine 8 Onyx CRT projector data and see what the graphs look like, what they mean, and where they should actually be. Do not make any adjustments to the display just yet. Instead, read and understand what the graphs mean. We'll do the adjustments systematically a bit later one.

You can load up the graphs for your own projector by selecting them one at a time in the "Graphs" menu and follow along. If you'd like to see my Barco Cine 8 Onyx graphs you can download my **Barco Cine 8 Onyx ColorHCFR measurements (before calibration)**. If you have ColorHCFR installed the file will load up directly in ColorHCFR. You can have more than one set of measurements loaded in ColorHCFR so you can look at both graphs at once if you like.

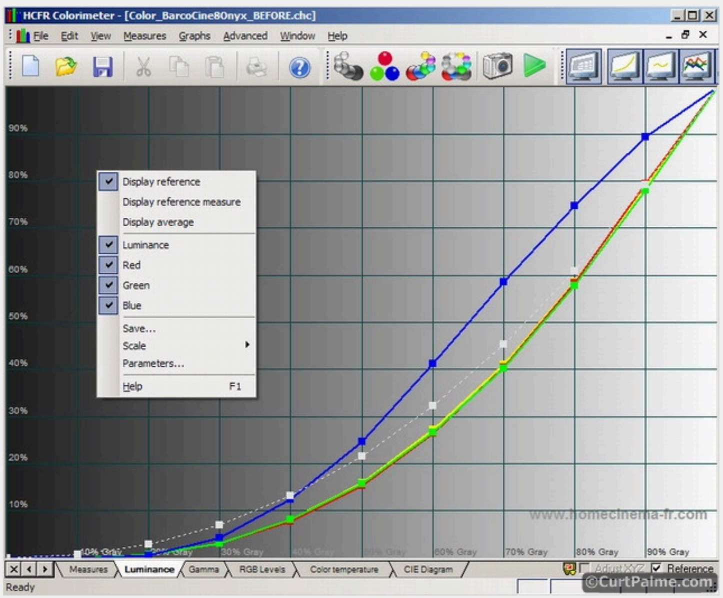
All of the graphs in ColorHCFR are customizable and interactive. Right click on any of the graphs to pull up extra options. You may also hover over data points within graphs for more information on exactly what you're looking at.

Graph 1 - Luminance (or light output):

The Luminance graph shows us how much light output we have at each 10IRE step. This is the Y value and is graphed as a function of IRE level (X axis) vs. percentage of total light output (Y axis) relative to the maximum measured at 100 IRE.



The white line is the target we're trying to achieve. The yellow line is the actual values of my projector. So you can see that we're consistently under the target which means that at every point between 0 and 100 the image isn't bright enough. The yellow line is actually an average of the red, green, and blue. If you right click on the graph and enable the separate red, green, and blue lines we'll get a better idea where the problem is.



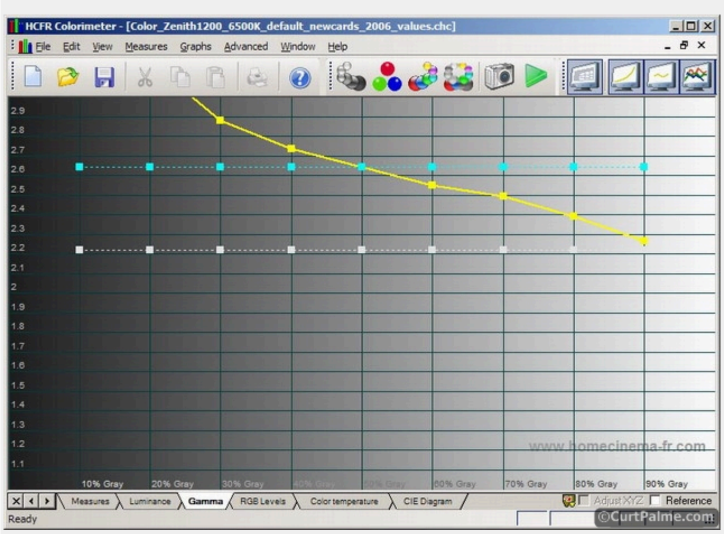
As you can see, both red and green are below the target along most of the curve while blue starts off below and then goes much too high above ~40 IRE. We want all three colours to move exactly along the yellow reference line.

Light output is affected by all four of the brightness, contrast, RGBLowEnd and RGBHighEnd controls in your display. We set these 4 items correctly using the steps later on in the guide and hopefully our curve will fall in line a bit better. Light output is also directly related to something called 'gamma'. Reduced light output like we're seeing here is because the gamma isn't correct. Later on we'll show you how to adjust gamma.

Graph 2 - Gamma:

Gamma (or more accurately the gamma correction value) controls the overall brightness of an image or how fast the brightness curve comes out of black. The higher the gamma value the slower the signal comes out of black as the brightness increases. An average gamma value that is too high will result in a picture that is brighter with deeper blacks but also show less information in dark scenes. Our previous Luminance graph is proof of this. An average gamma value that is too low will produce an image that is less bright image with too much brightness in the dark scenes which gives a flat/washed out look.

Here is our graph of gamma from 0 to 100 IRE:



The target value for average gamma we are trying to achieve for our display is 2.2. The ColorHCFR software tries to target 2.2. The ideal target is to match a properly calibrated (telecine) mastering reference monitor used by the movie studios. These monitors are designed for a ruler flat 2.20 response.

A gamma value of 2.2 gives us a perfect balance: Plenty of brightness and excellent shadow detail. If your room is pitch black with very little light reflection and you have a display with a very high contrast ratio (such as a CRT projector) then you may find values up to as high as 2.5 to be acceptable (the debate of 2.2 vs 2.5 gamma is a huge raging debate amonst calibrators). In most cases however closer to 2.2 is likely going to look better and is what you should try and aim for. Remember that lower numbers mean more gamma/brightness. Later on when you remeasure your greyscale I'll suggest that you try and target 2.2. For what it's worth, I've tried both 2.5 and 2.2 and prefer something closer to 2.2 in my light controlled home theater powered by a CRT projector. If you have a means of adjusting gamma (see below), I recommend you try both and decide yourself. Either way you should not go over 2.5 or below 2.2.

A gamma that is too high like mine means that our overal brightness will be better and we'll have deeper blacks, but at the expense of losing details in the darker scenes. In our example, my gamma for each point from 0 to 100 IRE can be seen by the yellow line and ranges from something so high (beyond 3) it's off the graph, down to 2.27. The average gamma (cyan line) is 2.64 which is too high compared to the 2.2 target. The especially high values in the dark areas mean that in my setup I'm completely losing shadow detail which is typical of all CRT displays. This needs to be fixed by adjusting the gamma control within the display or by adding a a gamma boost box to the signal as most displays do not have an internal gamma adjustment option. (No CRT projector has the required type of gamma boost adjustment that we require built in).

As mentioned previously, I use an **RTC2200** external box to add a gamma boost which helps me achieve the proper target numbers. This box as well as many high end scalers (Lumagen, Crystalio), **Moome HDMI cards and converters**, and the X-Vue **Box1020**, **Box1021** and **Box1040** RGB/Component converter products all have adjustable gamma boost features built in. If all you want is gamma boost in the least expensive package, then check out the **GammaX** dongle.

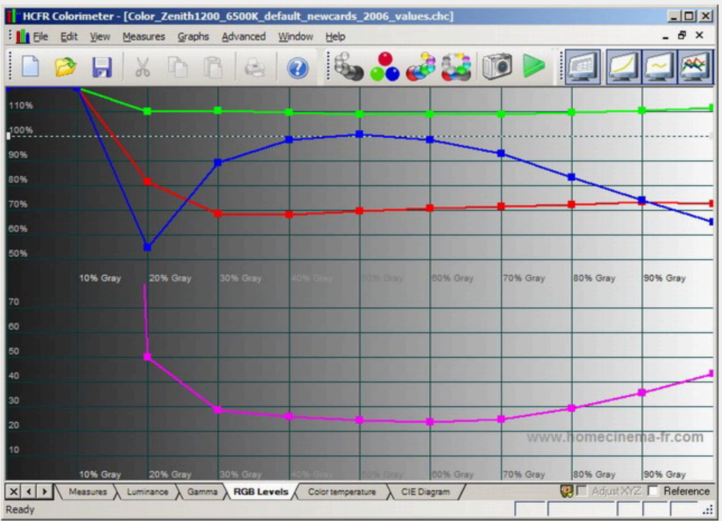
Videophiles look for this gamma boost feature as it is a critical one to have in order to obtain a proper gamma curve. Without one of these devices in your signal chain, many displays will not track gamma properly and you'll end up with a dull/lifeless image with a lack of shadow details. More information on how gamma boost works and before & after screenshots showing why it's needed (especially on CRT displays) can be found in this thread:**Gamma Correction: What is it? Why is it needed?**

Later on we'll add the **RTC2200** box back into the signal chain to see the difference it produces and explain how and when you should be adjusting your gamma (if you have such an adjustment available).

If your gamma is above 2.2 you'll want to look at adding one of these devices with adjustable gamma boost to your setup.

Graph 3 - RGB Levels:

The RGB levels graph shows two difference things:



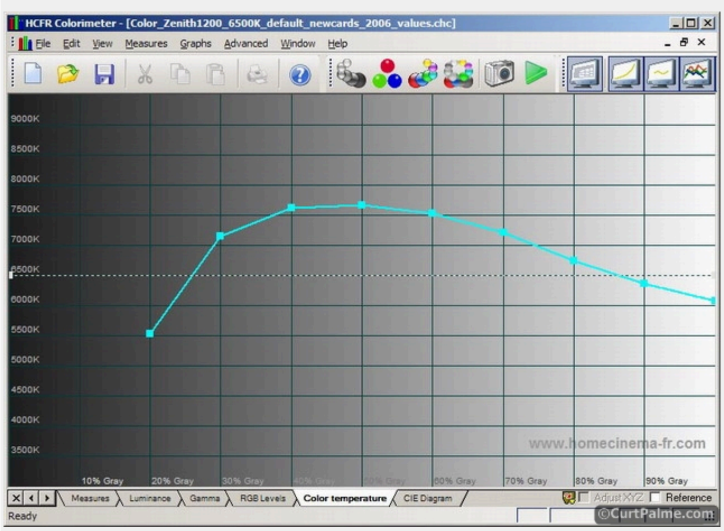
The top part of the graph shows us how close the red/green/blue colours each are to the target value of 100% from black (0 IRE) to white (100 IRE). When greyscale is set perfectly, all 3 coloured lines should be on top of each other at the 100% value creating straight lines from left to right. As you can see from my graph below it's far from perfect: Green is too high everywhere and (around 110% average), red is too low everywhere (around 70% average), and blue is close to perfect from 40-60 IRE but then drops too low on either side. This results in a picture that is too green in the dark and light areas and too blue-green in the mid-brightness areas. Later on we'll be adjusting our RGBLowEnd and RGBHighEnd controls to try and make this graph flatter for all 3 colours.

The bottom part of the graph shows our DeltaE. DeltaE is a numerical value of how far off the greyscale is from the target D65 values of x=0.313 and y=0.329 at each point we measured from 0 to 100 IRE. It will be impossible to achieve exactly 0.313/0.329 at each point so the goal is to try and keep DeltaE under 10 for each point. A DeltaE of 3 or under is so close to perfect that the human eye cannot detect the subtle imperfection. My points are from 23 to over 50 points away from the perfect D65 target. Whoever said a projector's 6500K value was accurate?

Graph 4 - Colour temperature:

The colour temperature graph is actually a pretty useless graph as it maps out where your point fall in terms of colour temperature (which is a line) instead of where they fall in relation to the more correct exact point of D65. Higher values (towards 9000K) are "supposed" to appear blue, while lower values (towards 3500K) are "supposed" to appear red.

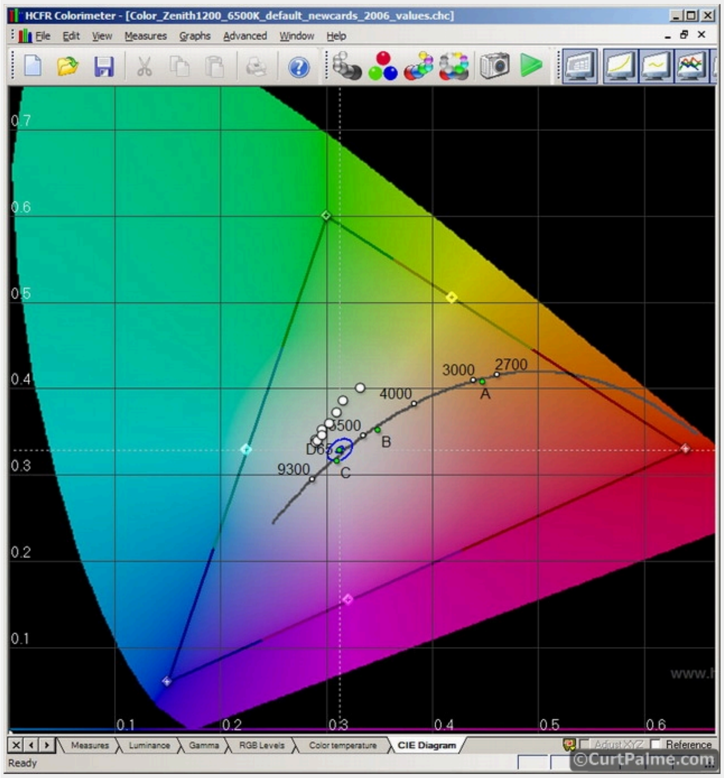
Here is my colour temperature graph:



Some magazines love to show this graph as it's easy for people to follow. They tell us that if the graph is perfectly flat with values of 6500K from black to white that the greyscale is therefore perfect. Not true. What you need to understand is that many points on the CIE diagram actually add up to a colour temperature of 6500K, but only one is correct: The D65 point where x=0.313 and y=0.329. You can have a display that measures 6500K across the board but still look incorrect. The previous RGB Levels graph and the upcoming CIE graph give us a far more accurate picture of what's actually going on. The less I say about the colour temperature graph the better. Just ignore it, it's truly useless. Don't make the beginner mistake of only posting your colour temperature graph in online forums. Without the other graphs or data for context, it's useless.

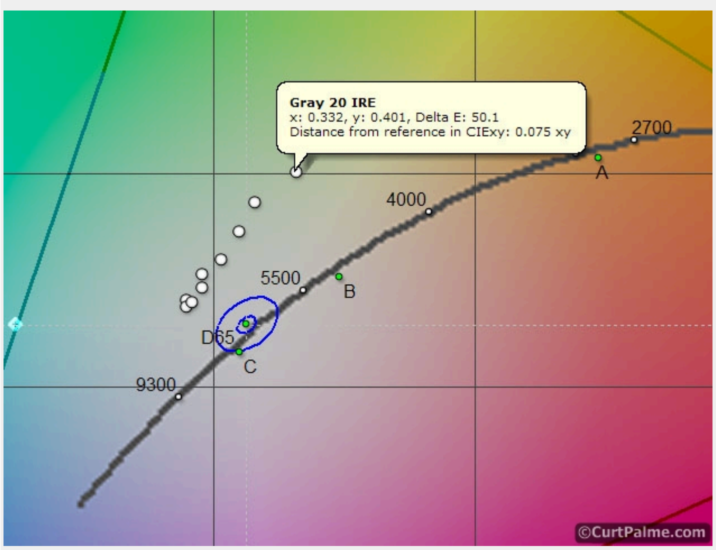
Graph 5 - CIE Diagram:

I talked about the CIE 1931 diagram previously and here we are again, this time displaying where our points from 0 to 100IRE fall on the diagram. As mentioned previously the CIE 1931 chart displays all the colours that are visible to the human eye.



We are trying to get our readings (represented by the little white circles) to fall exactly on the D65 point (where x is 0.313 and y is 0.329). The D65 point is hard to see here - it's right where the two white dotted lines cross. The little blue circle around the D65 point is the target area we want our readings to fall into. If we can get our white circles to land somewhere within the blue circle, our DeltaE values will be under 10 which is good enough. That is the goal we hope to achieve for all points from 0 from 100 IRE. Hard to see in this picture is another blue circle closer to the D65 point which represents a DeltaE of 3 is better. If you can acheive that, even better! As you can see we're not quite there with the default 6500K projector setting.

Below is a close-up that shows the DeltaE=10 and DeltaE=3 circles around the target D65 point a bit better. Also shown is how you can hover your mouse over any of the points to get more information about what you're looking at. In this case we're hovering over the IRE 20 reading which happens to be our worst point with a DeltaE of 50.1:



The black triangle on the CIE diagram represents the colour space we have to work with that we selected earlier (either Rec709 which is HD or Rec601 which is SD). This is the zone of colours that we hope our projector will be able to display. In our example the colour space triangle is the Rec709 (HD) colour space which is just a bit larger than the Rec601 (SD) colour space (not shown). The points at the tips of the colour space triangle are called 'primaries' as they represent the 3 primary (pure) red, green, and blue colours that make up all of the other colours available within the triangle. Later on in this guide I will show you how to measure your primary colours which will map out your own triangle of colours, effectively showing you the range of colours your display is able to reproduce. In an ideal world your display's colour range should map exactly to the SD or HD colour range such that the two triangles line up. In practice that's never the case.

It's important to undertand that setting your greyscale accurately will not guarantee that your projector or TV will display colours 100% accurately. How accurately a specific colour on your projector or TV matches the SD or HD defined colour depends not only on how accurate your greyscale is, but also on how accurate your display's primaries are to the SD or HD defined primaries. More on this later.

So now that we have an idea how bad our greyscale actually is, let's see if we can fix it!

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Last edited by kal on Tue May 14, 2013 2:25 am; edited 59 times in total

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TV/Projector: JVC DLA-NZ7

offline

Link Posted: Sat Apr 26, 2008 7:48 pm Post subject: quote

Part 3: Resetting our Settings

Before we start we'll have to reset some of the settings to default values.

STEP 3.1: On your display, set the RGBLowEnd and RGBHighEnd controls to their default values. If your display has a 6500K setting, you can do this by simply select it. If you've never played with the RGBLowEnd and RGBHighEnd controls in your display, chances are they're already at the the default values. Don't worry if you don't know any of the default settings. They're not critical as we'll be adjusting them anyway.

STEP 3.2 (CRT projector owners only): Set your blue tube's electronic focus to whatever produces the sharpest picture (you've likely already done this when you first set up the projector). If your CRT projector has an option to automatically defocus blue, turn it on. This will help with your greyscale in the brighter region (70-100 IRE).

STEP 3.3 (CRT projector owners only): Make sure your projector's G2 (aka 'Grid 2') for each tube is set up correctly. There is usually one G2 pot for each tube inside the projector. Check your owner's manual for the procedure used to set up G2. The G2 controls set the point at which each tubes 'turns on' or starts to emit light. It's important to get all 3 tubes to turn on at the same time to get proper greyscale in the darker regions. You can check that all 3 tubes are lighting up at the same time by slowing turning up the brightness while displaying the black (0 IRE) pattern on the **Digital Video Essentials: HD Basics** test disc. It's available by choosing menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "Video Black w/ new PLUGE". Make sure all 3 tubes light up at the same time. If you're not sure what this step means or uncomfortable sticking your hands in the projector, just leave the G2 pots alone. Odds are that the G2 is set pretty close to correctly.

Part 4: Setting White Level (Contrast)

The contrast setting controls the peak light output or luminance that your display will provide. As mentioned previously, setting contrast too low will result in a dim picture. Set contrast too high can cause lighter details to be lost into white (white clipping) or cause blooming/smearing. Contrast affects all colours at the same time.

To set contrast, some guides will tell you to display a test pattern with a 100 IRE white and just below 100 IRE white information and simply turn up the contrast to the highest point just before they both appear the same, or until the patterns appear thicker (start to 'bloom'). This is not the preferred method as (a) some displays will continue to display two distinct patterns even at 100% contrast, (b) obtaining a flat greyscale will be difficult if you increase contrast too high, and (c) having contrast too high can result in eye strain.

Instead, set contrast to give reasonable performance and light output for the room setup, light control, and type of display you are using. Light output is measured in foot lamberts or ftL and the target target ftL output depends on the display type. You should try and target the following:

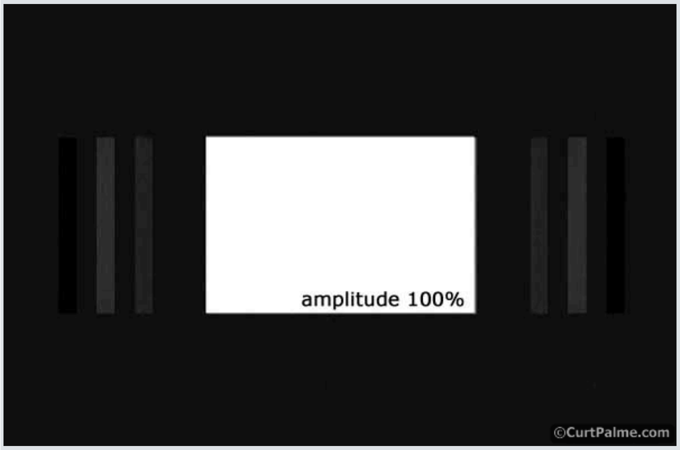
Projectors (CRT and digital): 12-16 ftL*
Direct view sets (CRT tube, Plasma, rear projection, flat panel, etc.): 30-40 ftL

**Given that CRT projectors have much better contrast ratios than most digital projectors, you can get good performance even at lower light output like 8-10 ftL if your room is well light controlled (reflections minimized). Lower performance CRT projectors may not be able to get as high as 12 ftL without softening or blooming, in which case you should back off the contrast to the point where the image is still sharp.*

STEP 4.1: Start a new calibration file in ColorHCFR. This file will store all of your "AFTER" calibration readings so that we can compare them with our "BEFORE" calibration readings already saved. Choose the menu option "File -> New" to start a new calibration file in ColorHCFR and pick "DVD Manual" followed by "Eye One" or "Spyder II" as the sensor type. Click "Finish".

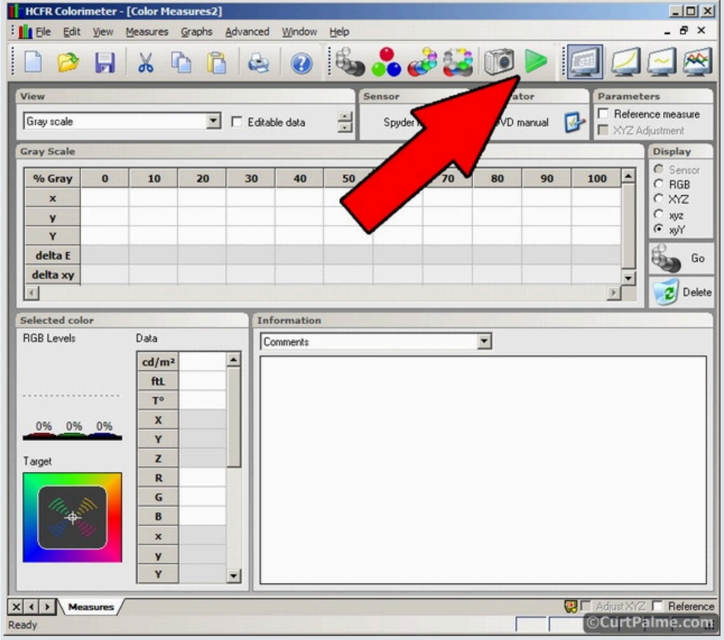
STEP 4.2 (Spyder2 users only): Make sure that the sensor read time is still set correctly (it does not change when you start new files but best to check). Choose the menu option "Measures -> Sensor -> Configure". Ensure that the "Read Time" is set to the 300 ms default value. Make sure the checkbox "Extend read time on dark measurements" is checked. Click "Ok".

STEP 4.3: Skip to the 100 IRE window pattern on the **Digital Video Essentials: HD Basics** disc by choosing menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "Window 100% level w/ new PLUGE". It looks like this:

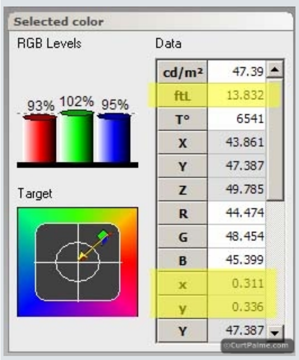


If you use a different test disc your pattern may or may not have the darker grey PLUGE bars on the sides. That's fine.

STEP 4.4: Click on the green triangle to start taking continuous readings:



You should see the data in the "Selected Color" window in the lower left updating every 3 seconds or so:



The only value that we are concerned with right now is the Y value. The ColorHCFR software conveniently takes the Y (luminance) reading and converts it to ftL (highlighted in yellow). In this example we're seeing a Y value of 47.387 or 13.8 ftL.

How many ftL are you getting? If it's now within your display's target range (12-16 ftL for projectors, 30-40 ftL for direct-view) then great! If it's below the range see if you can increase contrast, keeping in mind that going too high may introduce problems as well and not every projector may be able to do this especially if it's older or your screen is especially large. You will have to use your judgment here a bit and don't be too concerned if you cannot get readings quite as high as the minimum value.

If your readings are higher than the maximum value you may want to consider reducing the contrast. In a completely light controlled room even the minimum value will appear very bright.

Important: Remember that the target range is only valid if you're using a window pattern (typically 10-18% of the screen). This is especially true for CRT and Plasma based displays as the ftL light output for a fullscreen white pattern will not be nearly as high as a window pattern (it will typically only be half). The calibration will ***not*** be correct if you use fullscreen patterns on a CRT (RPTVs and front projectors) or plasma based display.

We've now set our initial contrast setting correctly. This reading will change as we set the other controls later so don't be too concerned about the exact value right now. Just get it in the ballpark.

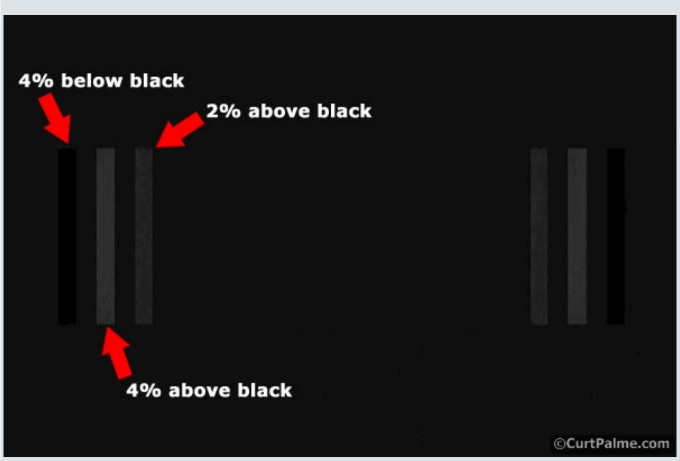
Part 5: Setting Black Level (Brightness)

The brightness control adjusts the black level on your display. In other words, it sets the level when the darkest objects become visible. As mentioned previously, setting it too low will cause darker details to be lost into black (black crush). Set too high will cause black to appear grey. Brightness affects all colours at the same time.

Setting brightness is pretty straight forward:

STEP 5.1: Every test disc has what's called a PLUGE pattern (which stands for "**P**icture **L**ine-**U**p **G**eneration **E**quipment" because of the equipment that used to be used to generate greyscale test patterns). They all have a blacker-than-black bar, a black bar (often just the background) and one or two just-above-black bar(s). Skip to the PLUGE pattern on the **Digital Video Essentials: HD Basics** disc by choosing menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "Video Black w/ new PLUGE".

The Digital Video Essential disc has one blacker-than-black bar and two just-above-black bars like this:



Note: The 4% below black (blacker-than-black) bar may not be visible on your setup. Not all setups will display blacker-than-black (or whiter-than-white) content. While your system will have a slightly reduced video range, you typically will not be losing out on anything if you cannot see this content.

Incidentally, all of the greyscale window patterns from 0 to 100 IRE on the **Digital Video Essentials: HD Basics** test disc have these PLUGE patterns to the left and right of the image. We use the one that is dark (0 IRE) to make the PLUGE pattern easier to see.

Adjust the brightness control on your display until the 2% above black bar is barely visible and the 4% below black bar is invisible. (The 4% above black is just there for reference). That's it! Simple! You're not supposed to see the 4% below black bar as it is content BELOW black. If you adjust brightness too high such that that 4% below black bar is visible, your black level will be too high and things that are supposed to be black will instead appear grey.

Using a traditional pluge pattern with a 2% black bar on a black background can often require subjective judgments about exactly where to set brightness. For advanced users that want a more objective way of doing this, try this:

- Set the contrast as in the previous section and record the Y value (light output) on the 100 IRE window pattern.
- **(Spyder2 users only)** Increase the sensor read time temporarily to 2000ms by going in the "Measures -> Sensor -> Configure" option.
- Display the 10 IRE window pattern.
- Adjust the brightness so that the Y reading of the 10 IRE window pattern measures as close as possible to 0.65% of the Y reading of the 100 IRE white pattern. For example: At 100 IRE we measured a Y value of 47.387. 0.65% of this is 47.387 x 0.0065, or a Y value of 0.308. We would therefore adjust the brightness until the Y value reads 0.308.
- This sets your gamma at 2.2 for the the 10 IRE window pattern which is typically the perfect gamma value as explained previously. In most cases this will be the correct setting for brightness. If your display has an unusually high or low gamma or a non-linear gamma, this method may give you the wrong result such that you can't see the 2% or 4% PLUGE bars (black clipping) or the black background is far too grey. In that case, adjust the brightness setting using the traditional method described previously using the PLUGE pattern.

We've now set our initial brightness setting correctly. This setting may change slightly as we set the other controls so we'll have to re-test later. As you're probably realizing, setting proper greyscale is very iterative as every control affects every other control!

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Link Posted: Sat Apr 26, 2008 7:48 pm Post subject: quote

Part 6: Adjusting Greyscale

Ok, now for the 'meat' of this guide: Adjusting the actual greyscale!

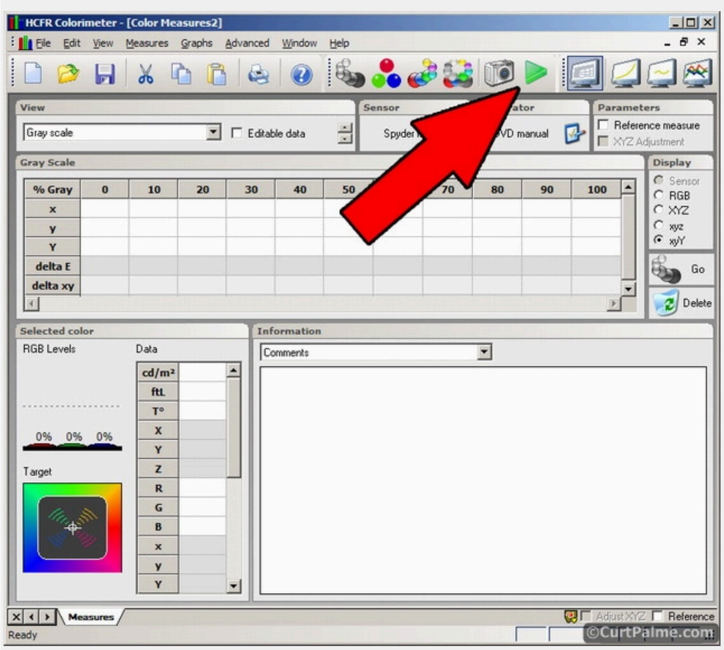
The basic concept behind adjusting greyscale is pretty straightforward: We alternate displaying a reasonably dark and light patterns and adjust the RGBLowEnd and RGBHighEnd controls until the x and y values are as close to the D65 point as possible. We then hope and cross our fingers that the rest of the greyscale from 10 to 100 IRE follows suite and tracks close to D65 as well.

Sound easy? Unfortunately it's not always that simple. Digital displays will usually track fairly well from black to white while CRT based displays often require some tricks to get a reasonably flat greyscale. By flat we mean something without a lot of dips or humps when we look at the resulting RGB graph described earlier. We'll walk you through the adjustment procedure and then give you some tricks you can use to help even out your greyscale.

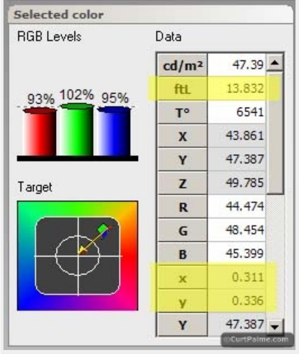
Here's a reminder of what the RGBLowEnd and RGBHighEnd controls actually do:

- **RGBLowEnd**: The control used to adjust the amount of individual Red, Green, or Blue colour in the darker end of the black to white scale. Think of it as an individual brightness control for each colour. We adjust this while displaying a dark pattern.
- **RGBHighEnd**: The control used to adjust the amount of individual Red, Green, or Blue colour in the lighter end of the black to white scale. Think of it as an individual contrast control for each colour. We adjust this while displaying a light pattern

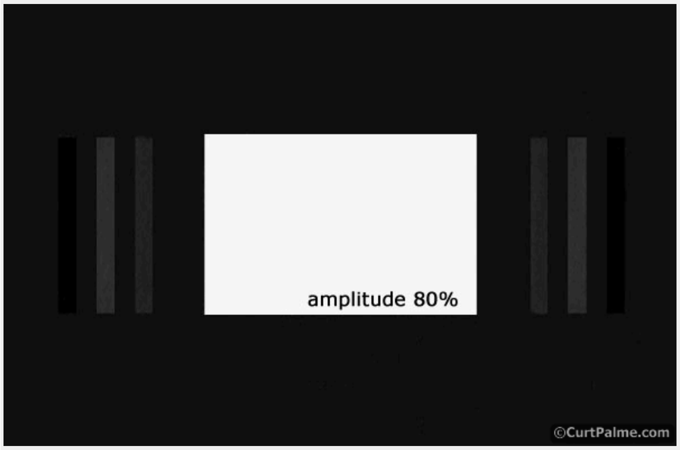
STEP 6.1: Click on the green triangle to start taking continuous readings:



The sensor will now start taking x, y, and Y readings and report them back every few seconds. You should see the data in the "Selected Color" window in the lower left updating periodically:



STEP 6.2: On your **Digital Video Essentials: HD Basics** test disc and skip to the bright 80 IRE window pattern by choosing the disc's menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "Window 80% w/ PLUGE". 80 IRE means that the pattern is 80% white and 'window' means that this pattern only uses a small portion of the screen (typically 10-18%). It looks like this:

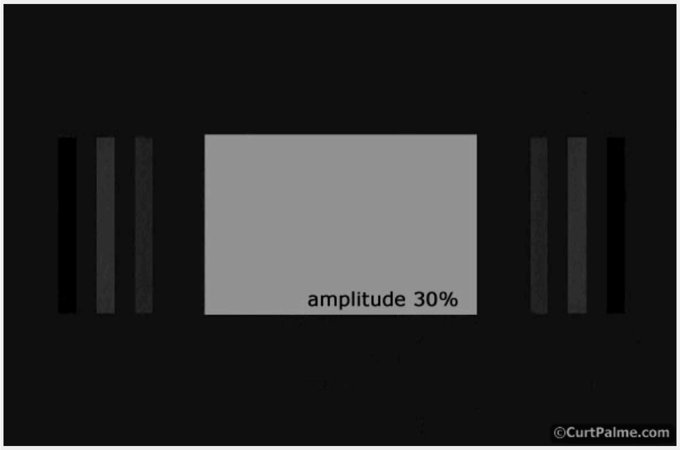


STEP 6.3: Adjust the red and blue **RGBHighEnd** controls on your display until all three RGB Level bars are at 100% or very close. You'll have to play around the first time to figure out which way to adjust the controls to add or remove red and blue as all displays work differently. Once all three are close to 100% you should be close to the D65 point (x=0.313 and y=0.329).

Note that we only adjust red and blue. Green is typically the reference and should be left alone as adjusting the green RGBHighEnd control (and balancing the red and blue levels to match) has the same effect as simply adjusting the overall contrast.

Ok! So now the 80 IRE point is set correctly to D65! Don't get too excited, you're going to adjust it again very soon ...

STEP 6.4: On your **Digital Video Essentials: HD Basics** test disc and skip to the darker 30 IRE window pattern. It looks like this:



STEP 6.5: Adjust the red and blue **RGBLowEnd** controls on your display until all three RGB Level bars are at 100% or very close. Again, you'll have to play around the first time figure out which way to adjust the controls to add or remove red and blue as all displays work differently. Once all three are close to 100% you should be close to the D65 point (x=0.313 and y=0.329).

Again, we only adjust red and blue. Green is typically the reference and should be left alone as adjusting the green RGBLowEnd control (and balancing the red and blue levels to match) has the same effect as simply adjusting the overall brightness.

Ok! So now the 30 IRE point is also set correctly to D65!

STEP 6.6: There's a catch however: Adjusting the low end controls affects the high end as well, and vice versa. Go back to step 6.2 and check the 80 IRE reading. It's no longer at D65 is it? Keep going back and forth redoing steps 6.2 through 6.5 until both of the 30 and 80 IRE readings are fairly close to D65 (x=0.313 and y=0.329).

Some tricks that will help you achieve this:

- Adjusting RGBLowEnd does not have much of an effect on readings above 50 IRE so it will not affect 80 IRE much. Therefore adjusting RGBLowEnd usually does not require an adjustment of RGBHighEnd to compensate.
- Adjusting RGBHighEnd has a *large* affect across the entire greyscale. Adjusting RGBHighEnd will require an adjustment to RGBLowEnd to compensate. This is why we adjust the RGBHighEnd first.
- The red and blue levels interact: Lowering one raises the other and vice versa. In fact, as you've probably noticed, everything affects everything!
- If you're keeping your eye on the x/y readings, you'll note that the red controls affect x while the blue controls affect y.
- Getting a reading to hit that D65 point (x=0.313, y=0.329) takes some practice. Make small adjustments at a time and wait for the readings to update twice before making another adjustment. You need to wait twice as the sensor was in the middle of taking a measurement while you were making the first adjustment.

STEP 6.7: Once you have both the 30 and 80 IRE levels reading close to the magic D65 point, it's time to re-measure our entire greyscale from 0 to 100 IRE. We know that 30 and 80 IRE are close to D65, but what about the rest of the greyscale?

STEP 6.8 (Spyder2 users only): Turn up the read time to 2000 ms first by choosing the menu option "Measures -> Sensor -> Configure" and set the "Read Time" to 2000 ms. Click "Ok".

STEP 6.9: Click on the "Measure Grey Scale" button to start the process of taking an entire greyscale. The HCFR software will again ask you to display window patterns from 0 to 100 IRE in 10 IRE steps, one at a time, pausing at each one so that the sensor can take a reading. Cue up the first pattern on the **Digital Video Essentials: HD Basics** test disc. The 0 IRE pattern can be found by choosing the disc's menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "Video Black w/ PLUGE". The subsequent patterns are in the chapters that follow.

Follow the steps as indicated by HCFR and run though the patterns one at a time waiting while HCFR takes a reading just like before.

STEP 6.10: In the "Graphs" menu select "RGB levels graph" to see how things look from 0 to 100 IRE. So how are they? If all of the DeltaE values are under 3 then fantastic (but unlikely)! A DeltaE of 3 or under for every point means that there is absolutely nothing more you can really do or should bother doing. Your greyscale is so close to perfect that the human eye cannot cannot see the subtle errors. If all of your DeltaE's are seriously under 3 then you should also be buying a lottery ticket as the odds of this happening the first time around are, well, pretty improbable...

If your DeltaE values are all under 10 then you've actually done very well. Your greyscale is for all intensive purposes very close to accurate. If most of the points are between 3-10 then you may want to see if you can tweak things just a little bit to to see if you can obtain more accurate readings across the entire range or make things better in the critical 40-70 IRE range.

You've obviously noticed by now that we only have two sets of controls to adjust greyscale: One set of controls that affect the low end, and another that affect the high end. Part of the trick to adjusting greyscale is to figure out exactly where to make compromises if we can't get every reading from 10 to 100 IRE to fall exactly on the D65 point. It's primarily important to get the 50-70 IRE midrange correct, then the under 50 IRE low end correct, and finally the high end above 70 IRE. If you have to sacrifice somewhere, sacrifice the 70-100 IRE range as most of the content is under that range.

The low end (especially 20 IRE and below) is especially problematic on just about every display. In fact, contrary to what we've said before, you're almost better off using your eyes to judge the readings at 10 and 20 IRE as most sensors (including the more expensive ones) simply don't do a very good job of measuring light output at the low end. If your greys at 10 and 20 IRE look *reasonably* grey and 30 IRE measures close to D65 then good enough!

Some displays have other controls that you may be able to use to flatten out any peaks or valleys in your greyscale. Look for them in in your display's advanced menus or service menus. For example, here are some of the extra controls offered by the Barco Cine 8 Onyx CRT projector we use to achieve a flatter greyscale:

- **Blue gamma slope:** Boosts the amount of blue in the high end. Think of it as a RGBHighEnd multiplier for blue only. Used to boost the blue output in the higher end as the amount of blue typically drops off the higher you go with CRT projectors.
- **Blue breakpoint:** Controls the point along the greyscale where the blue gamma slope mentioned in the last point starts to have an effect. Lower numbers means that blue is boosted across the entire IRE range, higher numbers means that blue is only boosted at higher IRE's. These last 2 controls are very powerful at taming the blue output.
- **Red midlights:** Increases/decreases the amount of red around the middle of the IRE range.
- **Blue midlights:** Increases/decreases the amount of blue around the middle of the IRE range.

If your projector has extra greyscale controls available, but all means try them out to figure out exactly what they do and use them to flatten out your greyscale if needed. We can't go into any more details here as these extra features are very display specific.

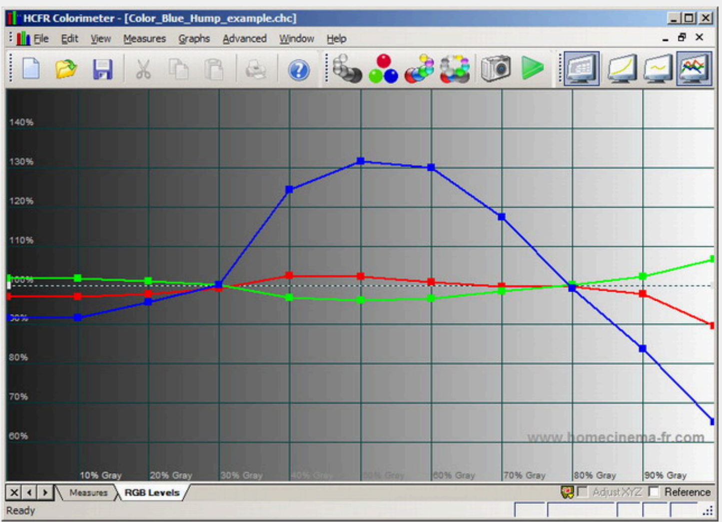
An important thing to keep in mind while you work on your greyscale is to understand that achieving an absolutely perfect greyscale is nearly impossible. You don't need to acheive a ruler flat greyscale for a fantastic looking image. Do not fret if you cannot achieve perfection. Just getting your greyscale closer will usually result in a picture that look incredibly better than before.

Another option you need to be aware of is that some of the newer higher end processors/scalers like the **Radiance** have what's called parametric greyscale calibration. This lets you fine tune the greyscale at any point from black to white (instead of just a 2 points) by adding your own boosts or cuts as needed (among other features). Very powerful indeed.

While you can often get close to perfection with the controls in the display itself, higher end processors/scalers are really the only way to get completely ruler flat greyscale as they offer multiple adjustment points instead of only two.

STEP 6.11 (CRT projector & CRT RPTV owners only): Obtaining a nearly flat greyscale with CRT projectors is tricker as by nature CRT tubes are not quite as linear as digital displays. This means that conversely, once you get a CRT projector dialed in the difference will likely be a lot more noticeable! One very common problem that arises on CRT projectors is called the 'blue hump'.

The amount of blue typically drops off as you move into the higher IRE values with CRT projectors. When calibrating for the 30 and 80 IRE points as you did above, the result will often look something like this on a CRT:



This is called the 'blue hump' as there is too much blue in the middle region from 30 to 80 IRE and often not enough blue elsewhere. If we adjust RGBHighEnd and RGBLowEnd for perfect levels around the 50 IRE point, the blue simply drops off even more at either end of the graph so we're not better off than before.

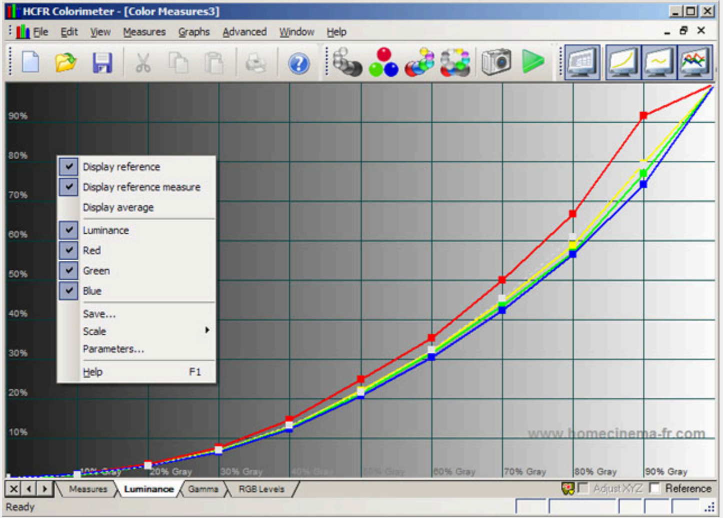
The solution is fortunately an easy one: Defocussing blue electronically. By defocussing the blue tube the blue light output will increase allowing us to lower the RGBLowEnd and RGBHighEnd values and thus creating a flatter greyscale. The defocussing *must* be done electronically and not by adjusting the blue lens. To adjust electronically either use the remote (on newer **electromagnetic** CRT projectors) or the blue focus pot (older **electrostatic** CRT projectors). See your user manual on how to access this control.

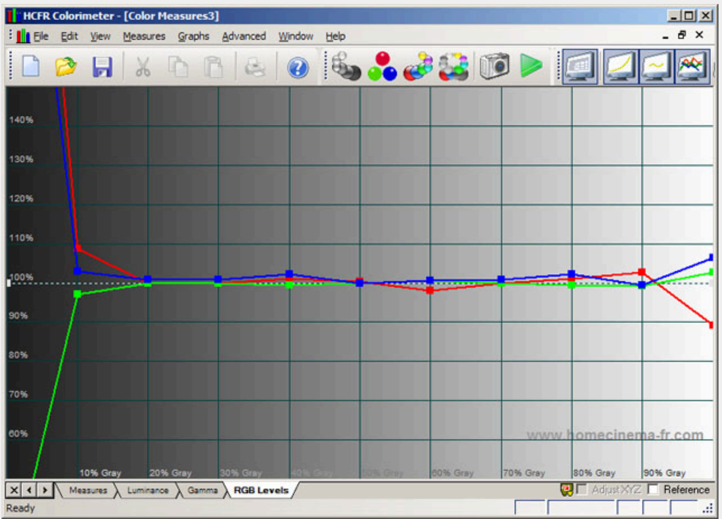
All CRT projectors will have a blue hump of some sort and defocussing the blue tube to some degree is a requirement. Some CRT projectors even have an option to automatically defocus blue for you: You set up the projector for the sharpest blue possible then flick a switch to defocus blue a preset amount automatically.

To lower the blue hump, defocus the blue tube just a little bit and start over at Step 6.2 and work your way through again. When you re-measure your entire greyscale again the hump should be lower. Defocus some more and try again if it's still not low enough. Do not be concerned if extreme amounts of blue defocus are required. While the defocussing may be visible when standing next to the screen, an even highly defocussed blue will not be visible by the viewer at typical seating distances (i.e.: 1.2-1.5 screen widths away) as our eyes have a horrible time focusing on blue.

STEP 6.12: A common problem with all displays if your contrast is set too high is 'running out' of a certain colour before the others as light output goes up beyond 80 IRE and approaches 100IRE. With digital displays the problem colour is typically red so we will use that as our example. Red light output will often hit a ceiling and stop increasing while contrast is turned up while green and blue output continue to increase. This causes a visible drop in red output in the 90/100 IRE points and looks something like this:

% Gray	0	10	20	30	40	50	60	70	80	90	100
x	0.339	0.317	0.312	0.312	0.312	0.313	0.311	0.312	0.312	0.315	0.301
y	0.187	0.323	0.328	0.328	0.326	0.329	0.329	0.328	0.326	0.329	0.325
Y	0.001	0.211	0.855	1.952	3.668	6.319	9.230	12.808	16.893	22.856	28.692
delta E	182.8	7.7	0.9	0.9	2.4	0.3	1.6	0.9	2.4	2.1	10.0





Why this happens (thanks for forum member Scott_R_K): In the early days of home theater many of the digital projector manufacturers were simply using slightly altered presentation projectors as home theater projectors. These projectors were intentionally built to produce higher blue and green outputs to produce a more vivid picture and higher light output as this is what was required for presentation situations: Light output was the primary concern at the expense of colour accuracy. The bulbs chosen for these projectors were also often very red deficient to begin with (something that a CC30R colour correction filter can help with - more on that later).

The only solution if you run out of red in at 90/100 IRE is to turn down your contrast. While displaying the 100 IRE pattern (see Part 4: Setting White Level) take continuous measurements and keep lowering the contrast until the x value (red) reads 0.313 or stops dropping. This will be the highest you can run your contrast and maintain a correct amount of red output in relation to green and blue.

If you have to reduce the contrast such that you're not longer within the target ftL light range for your type of display, you have a decision to make: Do you keep higher light output at the expense of having an incorrect upper IRE range? Or do you fix the upper IRE range at the expense of contrast ratio and light output? As is always the case, calibration requires deciding which trade offs to make to get the best picture for your particular set up. Try both and make the call.

While this sort of problem can also occur with green or blue, it's far less likely to happen on digital displays. Regardless, if you find one of the colours dropping off significantly above 80 IRE, try reducing your contrast to see if the problem resolves itself.

STEP 6.13: Since adjusting greyscale will affect previous settings we need to go back and recheck our contrast and brightness settings (see Parts 4 and 5). For contrast we want to ensure that we're still within the expected ftL range outlined in Part 4. You can do this quickly by simply looking at the ftL reading for the 100 IRE reading you did on your last full range measurement. Odds are your contrast setting will not need to be changed at all.

For brightness you want to make sure that you're not losing details into black (black crush due to brightness set too low), or that the colour black now appears grey (brightness set too high). You may have to change brightness by a notch or two at most.

If either of the contrast or brightness controls are changed, you should re-run another set of greyscale readings to make sure that the RGBLowEnd or RGBHighEnd controls do not need to be tweaked. With every iteration through this process, less and less adjustments will be required until everything finally stabilizes at the best you can achieve.

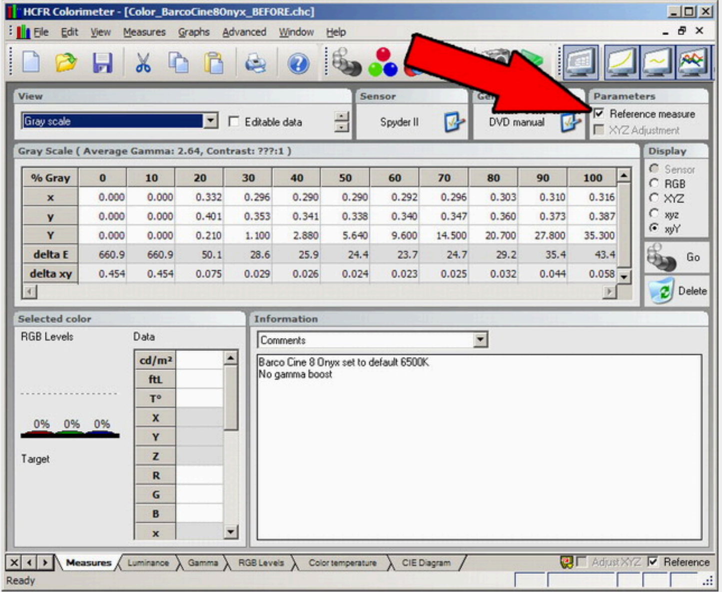
Congratulations! You've now calibrated your greyscale!

Part 7: So how does your greyscale look now?

We've gone through now and redone the greyscale on our Barco Cine 8 CRT projector so let's take a look at the before and after results. We first re-enabled the gamma boost on our Crescendo-Systems **RTC2200** box to boost up the signal (mostly in the lower end). This helps us obtain a better luminance curve for perfect shadow details.

We've also purposely left a few 'problem spots' in place in our results so that you can see something that's close to but not exactly perfect. This way we can comment on what still needs to be fixed and how to fix it (if even possible). Showing you graphs that perfectly track along the intended lines doesn't help anyone as we all know what you're *trying* to achieve. The hard part is *getting* there. Getting 80% of the way to perfection is the easy part. The last 20% is often impossible. The good news is that getting 100% of the way there isn't required to have a picture that looks considerably better than before.

ColorHCFR has a great feature to allow you to compare data from two files. By marking one set of data as the "reference measure", all other sets will be compared against that reference. To do this simply load your before and after data files, select the before file in the "Window" menu, and click on the "Reference Measure" as shown below:



Now re-reselect the "after" file in the "Window" menu. All data on the "after" graphs will now be shown in relation to the "before" readings you took. If you do not see the "before" data on the graphs, right click anywhere on the graph and make sure that the "Display reference measure" option is selected.

Raw data:

Below are our before and after raw data readings. Remember that our sensor only reads x, y, and Y. Everything else is derived by the ColorHCFR software. We're trying to hit the D65 target values of x=0.313/y=0.329, or at least a DeltaE of 10 or less (preferably 3 or less) for all points across the greyscale from 10 to 100 IRE.

Before:

Gray Scale (Average Gamma: 2.64, Contrast: ???:1)

% Gray	0	10	20	30	40	50	60	70	80	90	100
x	0.000	0.000	0.332	0.296	0.290	0.290	0.292	0.296	0.303	0.310	0.316
y	0.000	0.000	0.401	0.353	0.341	0.338	0.340	0.347	0.360	0.373	0.387
Y	0.000	0.000	0.210	1.100	2.880	5.640	9.600	14.500	20.700	27.800	35.300
delta E	660.9	660.9	50.1	28.6	25.9	24.4	23.7	24.7	29.2	35.4	43.4
delta xy	0.454	0.454	0.075	0.029	0.026	0.024	0.023	0.025	0.032	0.044	0.058

After:

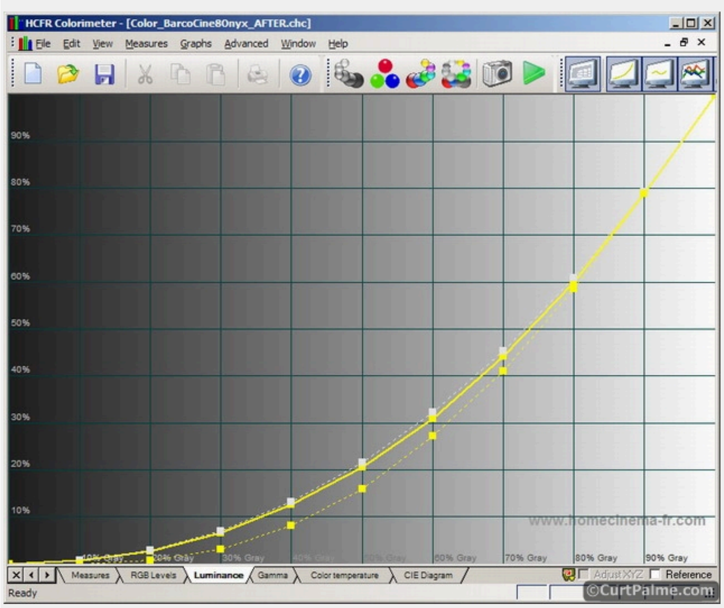
Gray Scale (Average Gamma: 2.27, Contrast: ???:1)

% Gray	0	10	20	30	40	50	60	70	80	90	100
x	0.000	0.351	0.317	0.309	0.312	0.313	0.314	0.314	0.313	0.312	0.311
y	0.000	0.396	0.337	0.327	0.329	0.330	0.331	0.332	0.332	0.333	0.336
Y	0.000	0.286	1.236	3.128	5.987	9.780	14.605	20.883	28.448	37.407	47.387
delta E	660.9	48.4	6.3	3.2	0.7	0.8	1.6	2.3	2.4	3.7	6.6
delta xy	0.454	0.077	0.009	0.004	0.001	0.001	0.002	0.003	0.003	0.004	0.007

Other than our 10 IRE reading, most of our after values are now very close to the D65 target of x=0.313/y=0.329. Not bad at all! 9 out of 10 readings have a DeltaE of 10 or less, and 5 are even within the magic DeltaE of 3 or less range (the critical 40-70 IRE range). Very good!

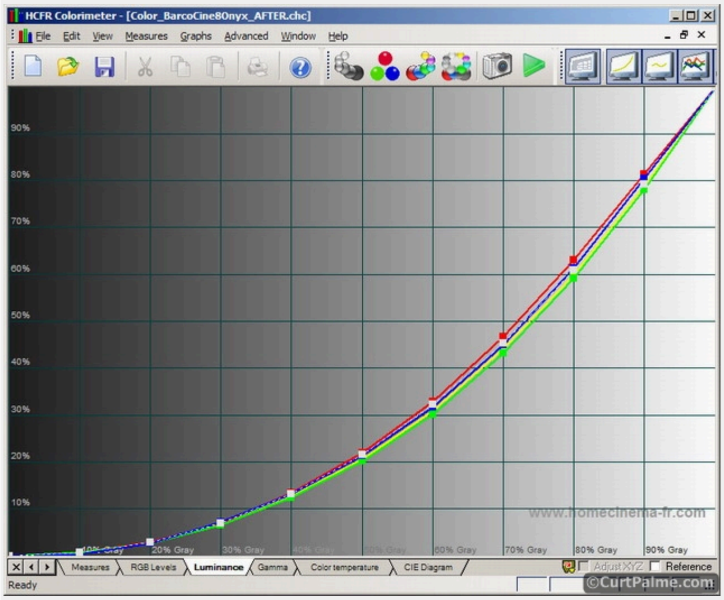
We also managed to get a reading at 10 IRE this time, mostly due to the gamma boost that we re-enabled on our **RTC2200** box. Our maximum luminance (Y) value has also increased from 35.3 (10.3 ftL) to 47.4 (13.8 ftL) resulting in a brighter punchier image. This fits perfectly within the 12-16 ftL range for a projector. It's interesting to note that the contrast setting for our projector did not change at all!

Graph 1 - Luminance (or light output):



The "before" readings are the yellow dotted line while the "after" readings are the solid yellow line. As you can see, we are much closer now to the intended target shown by the white dotted line. If we track perfectly to this line we will have a gamma of 2.2. While our after readings are better than before, we are still a bit low across the entire range. (It's hard to see in our little image but you zoom in or enlarge the image in the software to see better that we're actually below across the entire range). We may want to turn up the gamma boost on our **RTC2200** box just a little bit more and re-measure.

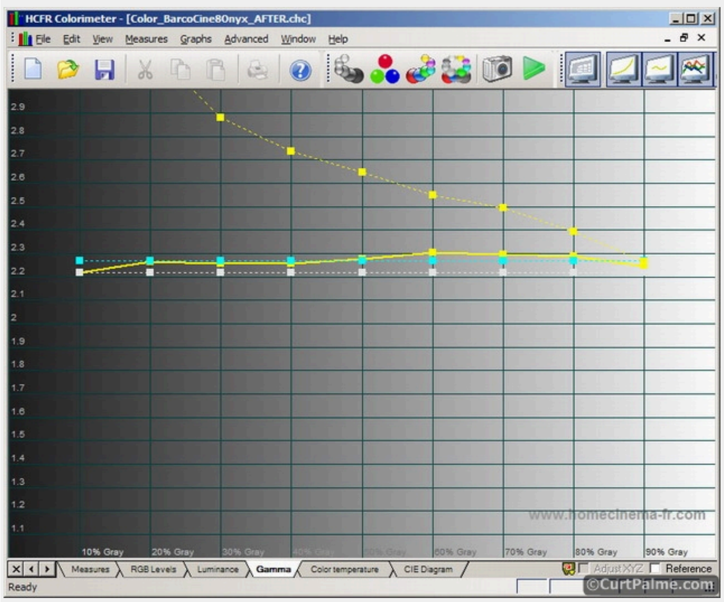
If we turn off the "before" readings and instead show the distinct red, green, and blue "after" values we see the following:



Red is above the target graph, green below it, and blue is almost exactly on. Not much really we can do here about this and they're not off by much and will change anyway when we tweak the gamma boost slightly. Displaying the colours separately is more informational than anything else. We adjust the greyscale as best we can and can use this graph to see how we're doing.

Graph 2 - Gamma:

Our gamma is much better now. Our average value (cyan line) dropped from 2.64 to 2.27 which is close to the 2.2 target.



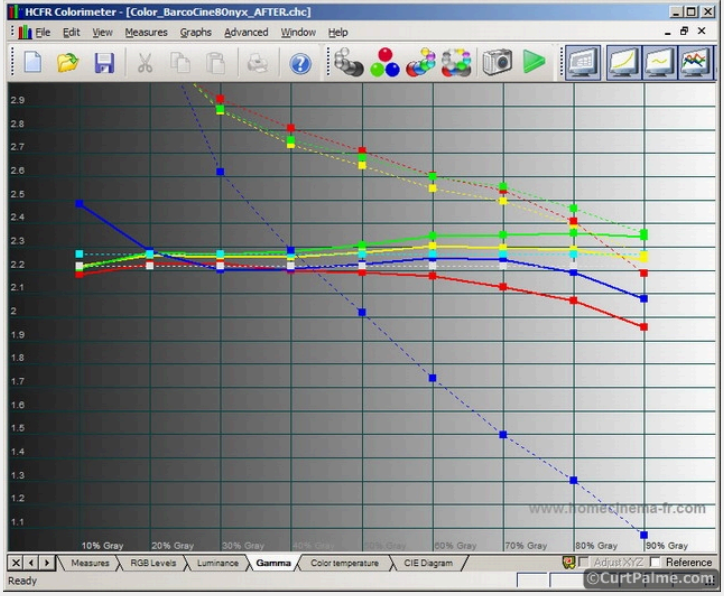
The solid yellow line is our "after" gamma while the dotted yellow line is the "before" gamma. Our new gamma now tracks much closer to the target white line which is gamma 2.2. Much better. Turning up the gamma boost slightly as mentioned previously will likely get our average very close to the 2.2 target. (Turning up the gamma boost reduces the gamma number).

Remember that the target value for average gamma we are trying to achieve is 2.2. The ColorHCFR software tries to target 2.2 by default. This range gives us a perfect balance: Plenty of brightness and excellent shadow detail. If your room is pitch black with very little light reflection and you run a display with very high contrast ratio (such as a CRT projector) then gamma as high as 2.5 may look ok too though 2.2 will likely look better.

In our case we use an **RTC2200** external box to add a gamma boost which helps us achieve the proper gamma numbers. This box as well as many high end scalers (Lumagen, Crystalio), **Moome HDMI cards and converters**, and the X-Vue **Box1020**, **Box1021** and **Box1040** RGB/Component converter products all have adjustable gamma boost features built in. If all you want is gamma boost in the least expensive package, then check out the **GammaX** dongle.

If your average gamma is above 2.2 you need a gamma boost. Since most displays do not have an internal gamma boost feature, adding a gamma boost using one if these boxes is the only way to achieve perfect gamma tracking from black to white. Without one of these devices in your signal chain, many displays will not track gamma properly and you'll end up with a dull/lifeless image with a lack of shadow details. More information on how gamma boost works and before & after screenshots showing why it's needed (especially on CRT displays) can be found in this thread:**Gamma Correction: What is it? Why is it needed?**

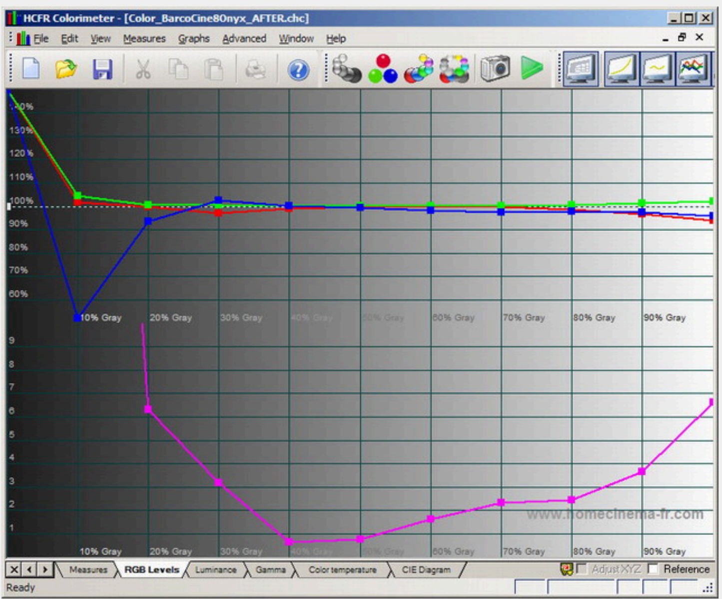
If we turn on the individual colours and see how they did both before and after, we really see how far off the before values were (represented by the dotted lines below):



The "before" blue gamma curve was especially off. Very typical.

Graph 3 - RGB Levels:

Our RGB levels are much closer to the target 100% across the greyscale from black to white:

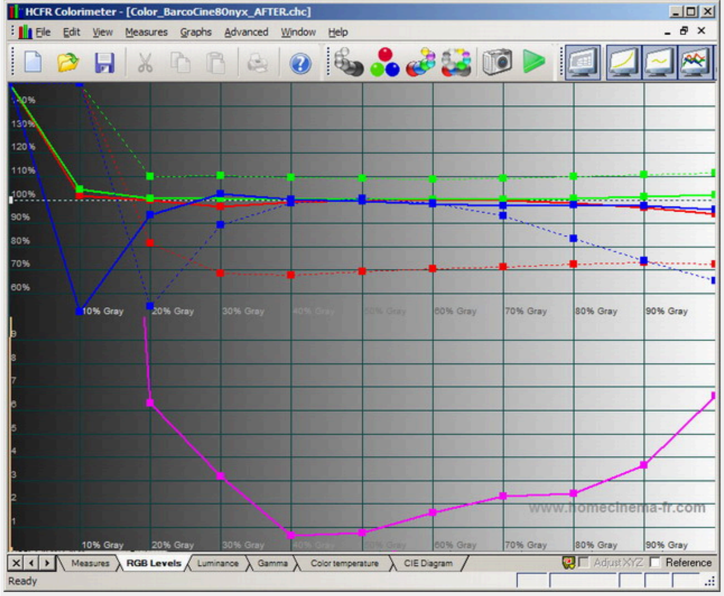


Every point except 10 IRE has a DeltaE of less than 7 which is great. Sometimes you have to sacrifice a high or low end to get the rest to be reasonably flat. In our case both red and green track very nicely at the low end, only blue is off and drops too low at 10 IRE. You can see the downwards curve that starts between 20 and 30 IRE.

The obvious solution is to simply increase the blue RGBLowEnd value to get more blue in the 0 to 50 IRE range. We tried, but doing this to help blue to raise up at 10 IRE also added a noticeable blue hump in the 20 to 50 IRE range. 10 IRE is very dark and while the DeltaE of 48 that we obtained at 10 IRE may seem large, it's a lot less noticeable in regular movie content than a 20-50 IRE blue hump.

This is a good example of where higher end processors like the **Radiance** with built in boosts or cuts could come in handy: We could use the scaler to only raise blue in the 0 to 20 IRE range and be done. It's again important to remember that while it's difficult to achieve perfection, something that is 80% better will still be an enormous improvement over what you had before. The blue dip in the lower IRE's may look bad on paper, but it is really not even noticeable to the eye and questionable if it's worth it for most people to purchase an advanced video processor to fix.

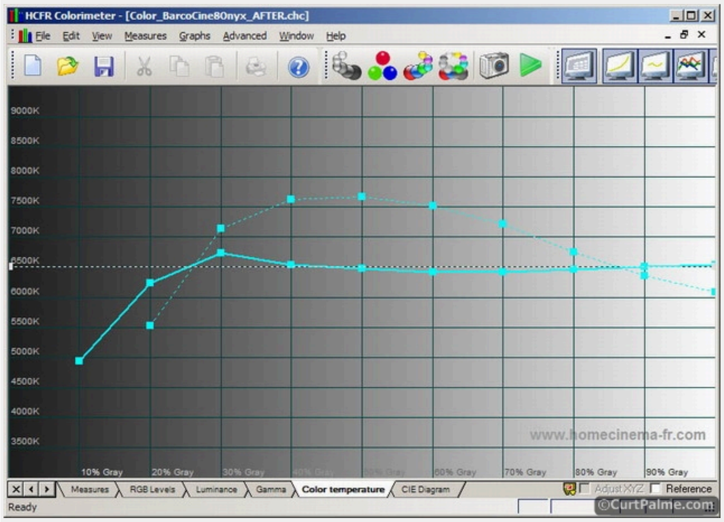
Let's see how the 3 RGB lines compare in terms of before and after:



A bit hard to read, but the dotted lines are the "before" measurements and the solid lines are the "after" measurements. Red is raised across the board to track well now, green has been lowered across the board and also tracks well. Blue no longer has the drop off at higher IRE, and the blue dropoff at lower IREs now only starts at around 20 IRE instead of 30. Better all around!

Graph 4 - Colour temperature:

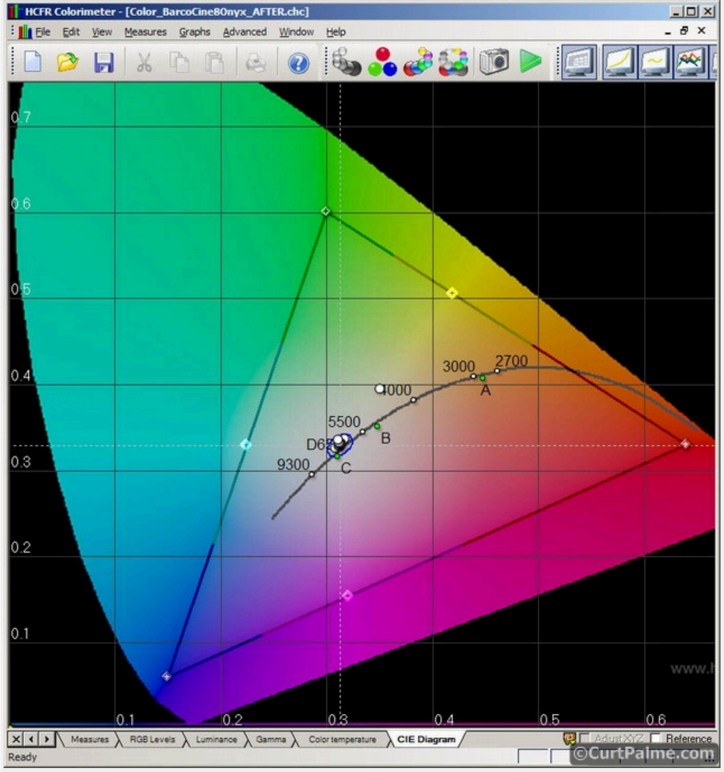
Here is our before and after colour temperature graph:



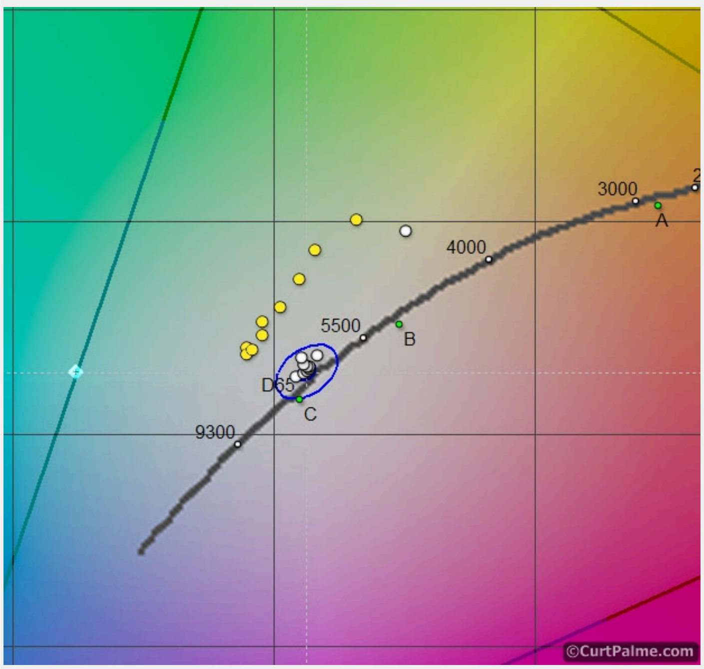
The dotted lines are the "before" measurements and the solid lines are the "after" measurements. Our "after" results are pretty close to 6500K across the entire range, but as mentioned before, this graph is somewhat useless as it doesn't take into account all variables. Ignore it and use the other graphs instead.

Graph 5 - CIE Diagram:

Below is our CIE diagram showing the "after" results. (For whatever reason, ColorHCFR doesn't display the "before" and "after" greyscale readings at the same time on the CIE chart).



Let's zoom in a bit and super-impose the "before" and "after" results onto the same graph to make the differences easier to see:



The "before" readings are the yellow circles above the target D65 point while the after readings are the white circles. As we already knew, we're a lot closer to the target D65 than before. Only the 10 IRE point is off. All of the other points fall well within DeltaE<10 blue circle and 50% are even within the DeltaE<3 circle (hard to see).

That's it for the before & after greyscale readings. Sit back and enjoy a movie or two and notice how much better the colours, detail, and image depth is now that everything is closer to perfection.

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Last edited by kal on Thu Dec 27, 2012 3:41 pm; edited 58 times in total

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kal
Forum Administrator
CurtPalme.com Lifetime Club Member
Joined: 06 Mar 2006
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TV/Projector: JVC DLA-NZ7

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Link Posted: Mon May 05, 2008 9:17 pm Post subject: quote

Part 8: Advanced Colour Management (Primaries & Secondaries)

This is the last and most advanced section of our guide. We will be explaining what primaries and secondaries are, how to measure them, and (on some displays) how to adjust them. We will then also give some hints on how to physically alter some displays for more accurate primaries by adding filters.

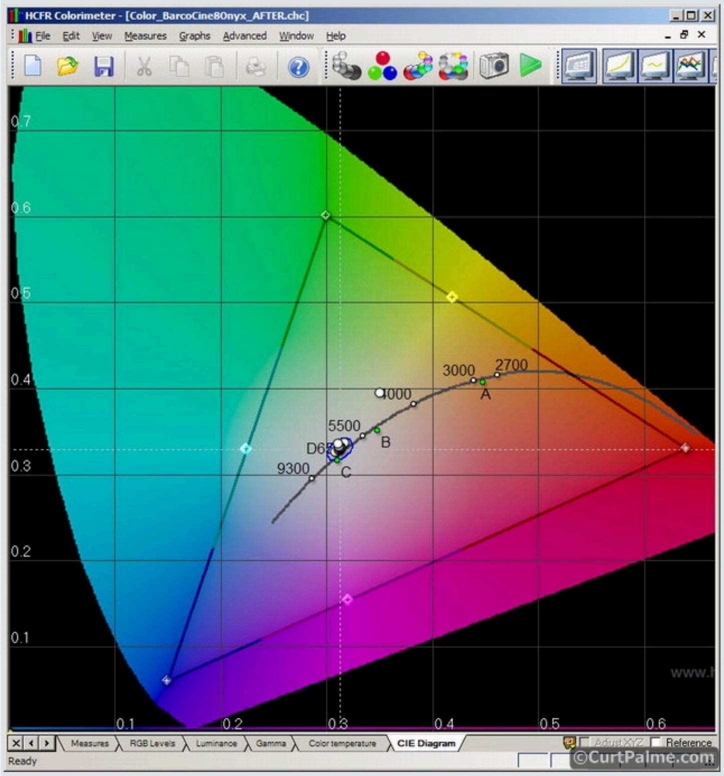
This section should be considered optional as most displays do not have the advanced color management system (CMS) required to set primaries and secondaries correctly. Even if your display does not have a CMS, at the very least you'll gain a better understanding of your display's colour reproduction by measuring your display's primary and secondary values and how it all fits in with greyscale.

If your display doesn't have a CMS, you can add one with an advanced video processor like the **Radiance**.

If you're unsure if your display has a CMS or other means of adjusting primaries or secondaries check your user manual, or start a new thread in our **Audio & Video Calibration** forum and ask!

What are primaries and secondaries?

Take a look at the CIE diagram from the previous section:



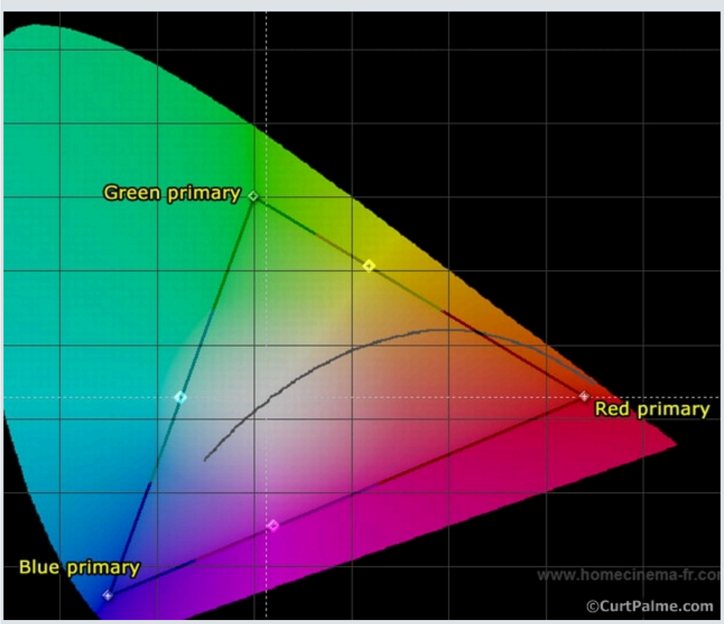
The white dots close to the D65 middle point are our greyscale measurements that we performed earlier. What we haven't talked about yet however is the black triangle in this diagram: It represents the colour space (or "gamut") that we selected.

This triangle is the range of colours that we expect (or hope) our display will be able to reproduce. A perfect display will only display colours inside the triangle and none of the colours outside. Standard definition (Rec601) and high definition (Rec709) have different ranges. The high definition Rec709 triangle is slightly 'bigger' than the Rec601 version as the three points are farther apart, thus allowing for more vivid colours in HD. One of the many benefits of HD over SD! It's not a huge difference, but it's certainly noticeable. The one in our diagram above is for Rec709.

You can try switching between the HD and SD colour space yourself in ColorHCFR to see the difference by choosing the "Advanced -> Preferences" menu option, selecting the "References" tab, and changing the "Color Space - Standard" option. You'll see how the triangle grows or shrinks slightly depending on the colour space selected.

Side note: What's interesting is how small the SD and HD colour spaces are actually in relation to the ***entire*** *range of visible colours in the CIE diagram. Remember that the entire CIE diagram represents the colours that we, as humans, can see. There are millions of colours visible to the human eye outside of the triangles that even HDTV television and Blu-ray still cannot begin to display as they are not part of any adopted standard like Rec601 or Rec709! Some day (likely quite some time in the future) a new colour space may be adopted as a standard that includes a wider range of colours. Broadcast TV and some future media disc (whatever replaces Blu-ray?) would likely be developed to use that new and expanded colour space for our home theaters.*

What are the primary points?



The points at the tips of the colour space triangle are called 'primaries' as they represent the 3 primary (pure) red, green, and blue colours that define how all other colours are created within the triangle. Your display creates every other colour within the colour space triangle by varying the amount of red, green, and blue. The size and shape of the triangle changes based on where these 3 points land. If your display's primary points do not land on the correct spots, every other colour will suffer to some degree (even if your greyscale is perfect).

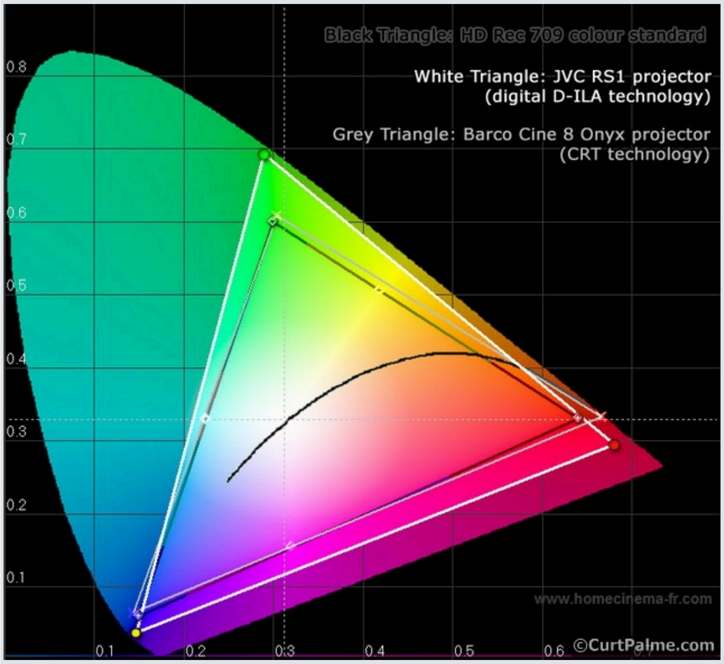
Here's a great great analogy by Forum member Gary Fritz to explain this:

"Your projector or TV must display the exact three primary colours as set by standards. If it doesn't, your colours will be wrong. Why? Think of your display as a blind paint-by-number artist. He's got 3 pots of paint (Red, Green, Blue), and he just paints whatever colour the signal tells him. If the video signal says to paint pure green, he goes to his green pot and uses that. If the signal has a yellow colour, he mixes red and green together. Now imagine what would happen if somebody swiped his green paint and substituted a pot of pink paint. He's a blind painter, so he can't correct for the bad colour. Obviously his greens would be wrong; grass would be pink. But in addition ALL colours that included any green would also be wrong. Since all colours except pure red, pure blue, and shades of pure magenta include SOME green, this means that ALL other colours will be wrong."

How close your display's primaries are to the Rec601 or Rec709 standards depends largely on the technology used by your display, how the manufacturer implemented it, and what controls they offer to adjust for aging or inconsistencies. A large percentage of digital displays are considerably off, while most CRT based displays are fairly accurate as CRT was the technology to which the standards were defined given that it was the only technology that existed at the time (20+ years ago). Movie studios typically still employ CRT type displays due to the colour accuracy and lack of colour drift (digital display bulb colour output drifts considerably over short times while CRT tube colour output tends to remain stable) . For more information watch the first few chapters of the **Digital Video Essentials: HD Basics** test disc.

A comprehensive colour management system (CMS) which provides separate controls for each of the colours is usually required to set primaries correctly.

Many new displays today artificially boost or shift how they create colours in order to be able to display colours outside the Rec601 or Rec709 range. They often do this on purpose to increase light output (by boosting green and blue) and/or to make the colours appear more 'vivid' or 'pleasing'. It's important to remember that this is completely incorrect! The end result is a picture that is not what the director intended for you to see. This can be shown using a real-world example using two different display technologies: Our Barco Cine 8 Onyx projector which uses CRT tube technology and the popular high-end JVC RS1 projector which uses digital D-ILA technology:



We would like both projectors to have primaries that fall exactly on the black triangle that is our target Rec709 (HD) colour space. The Barco primaries are pretty close: Green and blue are almost perfect while red is slightly over saturated (farther out than it should be) but it's reasonably close so no further correction is needed or warranted. If you really wanted perfection a colour processor could be added to correct this but we feel it's close enough. The imperfection in red will not be noticed in regular content as while it is over saturated, it isn't pushing to either side so red isn't tinted orange or purple - it's simply a little "too" red.

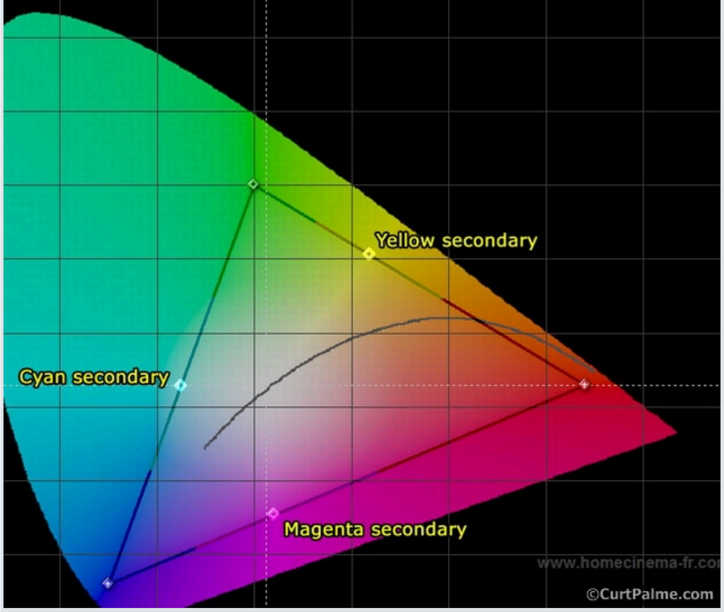
The JVC primaries on the other hand are much worse and the imperfections will most certainly be noticed when viewing regular content. The primaries are considerably outside the Rec709 (HD) standard which causes the colours to appear much too vibrant. This is especially true of the green primary which is also shifted to the left which gives the image a yellowish hue to all greens. The JVC does not have a colour management system (CMS) for altering the primaries so an advanced processor or other modifications are required if we wish to move the primaries to more accurate values.

So why isn't more vibrant colours a better thing? You may think that being able to display colours that are outside the standard is a *good thing* as it'll give you a broader range of colours. Unfortunately that's not true. While more vibrant colours may look pleasing in some cases (cartoons or other artificial content) it will not look correct for the other 90%+ of content that we are familiar with such as human faces or objects from nature we see every day (the sky, grass, and so on). Overly saturated colours will cause (for example) green grass to have an almost neon-like glow to it at times. Below is an example:

Photo courtesy of Tom Huffman. Thanks Tom!

The top photo is from the JVC RS1 digital projector mentioned earlier, the bottom photo is the colour correct version. Notice how much more saturated the colours are in the JVC RS1. Definitely not what the director intended and completely unnatural looking. Your greyscale may be set perfectly, but if the colour space of a display is too far outside the SD or HD defined standards, that grass is going to look bright neon-green. This is one reason why many people complain that many digital displays out of the box look 'cartoony' or 'fake'. Whenever you look to buy a new display regardless of technology, make sure to do some research into how accurate the primaries are and/or make sure some method to adjust the primaries and secondaries is offered in order to get them closer to the correct values. Don't ask the sales person on the show room floor how accurate the primaries are however - you'll only get a blank stare in return.

What are the secondary points?



Along the triangle edges we have the 'secondaries'. These secondary points are created by mixing predefined amounts of the two primary colours that are at either tip of the line: Green and Blue make Cyan, Green and Red make yellow, and Blue and Red make Magenta.

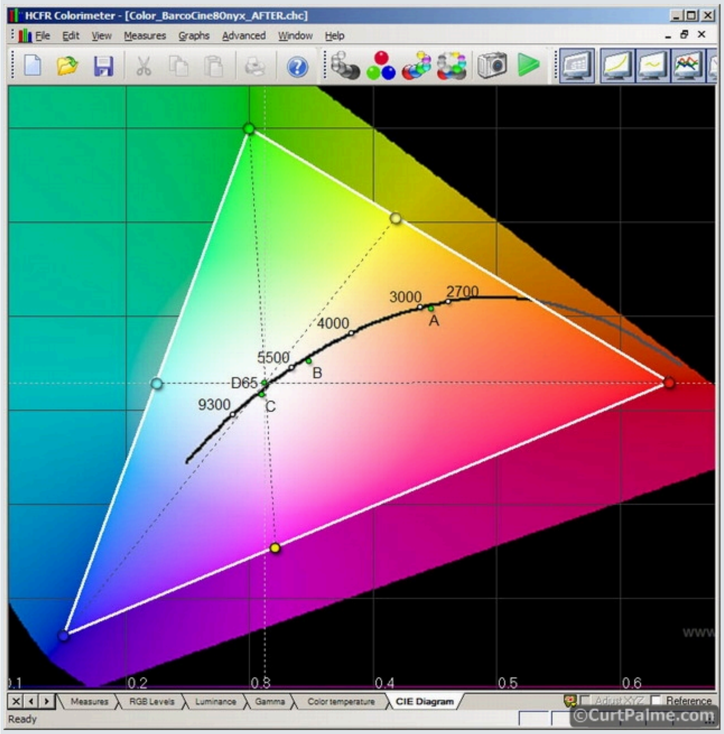
Secondaries can be moved by adjusting the 'tint' setting on your display. How well your secondaries measure is an indication of how accurate your primaries are to begin with, along with how well your display's colour decoder is at mixing the right ratios of primary colours together. Again, unfortunately the tint control found on all displays is pretty much useless as it affects all three secondaries at the same time. Adjusting tint to get one of the secondaries accurate usually results in the other two being even more inaccurate. A comprehensive CMS which provides separate tint controls for each of the colours is required to set secondaries correctly. In other cases we need to adjust to try and average out the errors over the three secondaries.

How do primaries and secondaries fit in with greyscale?

Having an accurate greyscale ensures that our display is able to always display a D65 (colour neutral) black and white image as the starting point. Remember that the D65 point is exactly in the middle of the CIE diagram where the two white dotted lines cross. How far out we map and in which direction to achieve a specific colour all depends on the accuracy of a display's primaries and secondaries. For colours on our display to be 100% accurate 100% of the time, all three things must be perfect: Primaries, Secondaries, and Greyscale.

If a display's greyscale is perfect but the primaries are too far out the colours will be too vibrant. If the primaries are not far out enough the colours will be subdued. If the primary are at all shifted such that the triangle appears twisted or warped in relation to the Rec601/709 standards, then the resulting colours may also have an incorrect tint (especially if the secondaries are off as well).

Below is a graph of a fictional display with perfect primaries and secondaries. The measured primaries and secondaries fall exactly on the Rec709 standard points such that the Rec709 points and resulting triangle can no longer be seen:

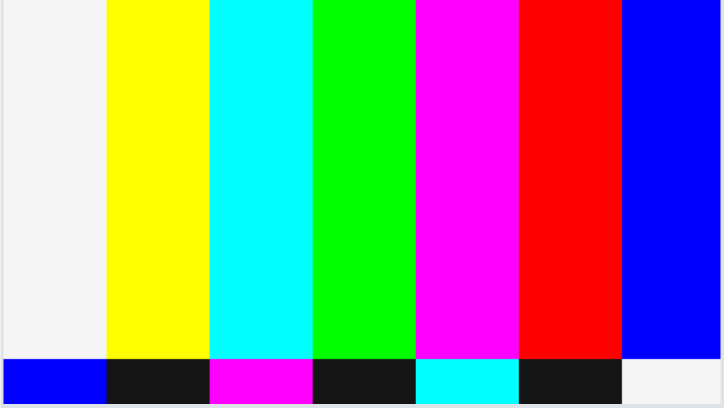


If we draw a line from each of the primaries through the D65 center point, you'll note that the line ends up crossing exactly through the secondary point on the opposite side of the triangle. This is a perfectly balanced and calibrated display. Very difficult to achieve in practice given limitations in display technologies and the fact that most display manufacturers do not seem compelled to provide the colour management system (CMS) required to achieve perfection.

In this part of the guide we will measure your primaries and secondaries and see how they relate to the perfect (expected) values. ColorHCFR will display a second colour space triangle on your CIE diagram so that you can see how your display behaves in relation to the expected Rec601 or Rec709 standards. We'll then give some tips to improve the results.

As with everything else in colour calibration, remember that everything affects everything! So enough background information! Let's start adjusting!

Step 8.1: We'll need to use a different test disc for this part of the guide. For a reason that completely eludes us, the **Digital Video Essentials: HD Basics** test disc does not include individual window patterns of the primary and secondary colours. Instead it only includes the generic SMPTE colour bars test pattern that includes all six colours in one test pattern. The top part of the pattern looks like this:



Why they would include greyscale window patterns and not individual primary/secondary window patterns is beyond us.

*Background information: SMPTE stands for **S**ociety of **M**otion **P**icture and **T**elevision **E**ngineers. The colour bars in the SMPTE test pattern are a known standard, so comparing this pattern as displayed to the known standard gives us an indication how the video signal has been altered by recording, transmission, or the display (and more importantly what compensation needs to be applied to that signal to bring it back to original state). It used to be broadcast after hours on TV but with shows on 24/7 these days you'll rarely see it displayed on TV.*

This SMPTE colour bars test pattern will work for some of our tests in this section of the guide but not for others. Ideally we want individual window patterns just like our previous grey window patterns, but this time with the primary and secondary colours instead. The test disc we're going to use to is AVS HD 709. It's free and can be downloaded here: **AVS HD 709**. It contains 10% window patterns of all the primary and secondary colours so that we can set our colour and tint and other optional colour management system (CMS) controls properly.

The caveat is that only a Blu-ray version of the AVS HD 709 disc are available and you will have to download and burn this test disc yourself. The test disc is burnt onto a regular blank DVD and then plays back as Blu-ray. As odd as it may sound, you do not require a Blu-ray burner to create a Blu-ray disc: Instead we are creating Blu-ray content but placing it on a standard DVD disc. A Blu-ray player is required for playback of course, but for burning pretty much any computer DVD burner and software will work. As of the latest version of this test disc, Chapters 1-7 contain the 100% saturated colour window patterns for the primary and secondary colours that we will be measuring.

Aside: The AVS HD 709 test disc actually includes patterns that may be used for this entire guide. While we would have liked to have used this test disc exclusively, not everyone is comfortable in burning their own discs or has a Blu-ray player. As well, AVS HD 709 is still work in progress which means the test patterns may still be reorganized as it matures requiring us to rewrite this guide with every change. Our search for the one inexpensive, all-inclusive, readily available test disc continues!

If you have a different test disc with 100% saturated 100 IRE window patterns for primary and secondary colours then that will work as well. **GetGrey** is one such popular (not free) test disc that will also work. The **ColorHCFR** developers also have their own test disc in PAL (European) format that can be used. The original Avia test disc includes individual patterns for the primary and secondary colours but they're full-screen instead of windowed, which will cause some problems on Plasma and CRT displays.

Some calibration discs will tell you that you can adjust tint and colour by looking through colour filtered gels. Do not use these. They simply do not work on all displays and are only a close approximation anyway. Best to use your meter.

Before proceeding any further, it is important that you have completed all of the previous steps in this guide, including setting contrast, brightness, and greyscale as best as possible.

Now on to the adjustments!

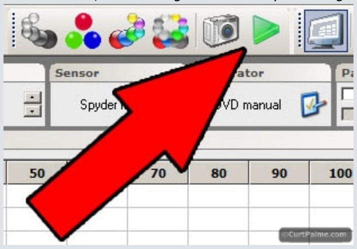
STEP 8.2: Adjusting the colour control

The colour control is a legacy control that exists from the days of 480i **composite** video (not to be confused with **component**). It adjusts the amplitudes or 'lightness' of all three primary colours at the same time. Since it affects all three primary colours at the same time, it is pretty much useless for precise calibration purposes. We'll adjust it anyway to ensure that it is at least as close to the correct value as possible.

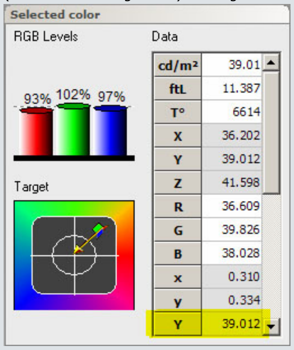
Since the colour control affects all three primary colour levels we pick one (red in our case) and adjust to that and hope that the others follow along. A comprehensive colour management system (CMS) is required to set all three correctly. If your display has a comprehensive CMS available, we will make these adjustments at a later step.

On some displays the colour control will not have any effect when using any input other than the low end 480i **composite** or **S-video** inputs. If you are using the RGB, component, DVI, or HDMI input on display and find that for your display the colour control does nothing or is not adjustable, skip the step. There is nothing you need to do.

- In ColorHCFR, start taking continuous xyY readings by clicking on the green arrow icon:



- Cue up your AVS HD 709 test disc and skip to the 100% white window pattern by selecting "10% Grayscale" -> "100% Gray window". 100% means that the window is at 100 IRE. Write down the Y (Luminance or brightness) reading as seen by the sensor:



- Skip to the 100% Red window pattern by selecting "100% Saturated Colors" -> "100% Red window".
- Adjust the colour control on your display until the Y reading is 21% of the 100% white window reading measured earlier. For example, if the Y value earlier was 39.012 as seen above, then 21% would be 39.012 x 0.21 = 8.193.

That's it! This will set the red colour level properly. Hopefully the Green and Blue levels will follow suite.

Note that adjusting the colour control will not alter the primary colour x/y coordinates. It only affects the amplitude or luminance of these colours. To adjust the x/y coordinates of primaries, physical alterations or an advanced colour management system (CMS) is required - more on this later!

STEP 8.3: Adjusting the tint control

The tint control is a legacy control that exists from the days of 480i **composite** video (not to be confused with **component**). Tint is used to adjust for hue errors in the three secondary colours. Since it affects all three secondary colours at the same time, it is pretty much useless for precise calibration purposes. We'll adjust it anyway to ensure that it is at least as close to the correct value as possible.

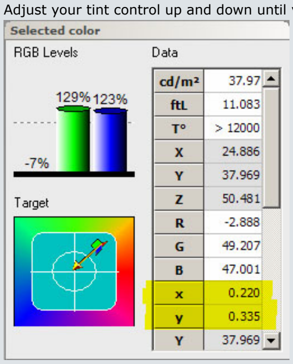
Since the tint control affects all three secondary colours we pick one (cyan in our case) and adjust to that and hope that the others follow along. A comprehensive colour management system (CMS) is required to set all three secondaries correctly. If your display has a comprehensive CMS available, we will make these adjustments at a later step.

On some displays the tint control will not have any effect when using any input other than the low end 480i **composite** or **S-video** inputs. If you are using the RGB, component, DVI, or HDMI input on display and find that for your display the tint control does nothing or is not adjustable, skip the step. There is nothing you need to do.

- Set your display's tint setting to the midpoint (default) setting.
- Ensure that ColorHCFR is still in continuous read mode. If not, click on the green arrow icon again.
- Cue up your AVS HD 709 test disc and skip to the 100% Cyan window pattern by selecting "100% Saturated Colors" -> "100% Cyan window".
- We want to try and achieve an x/y reading as close to perfect as possible for the colour Cyan based on what colour space you chose earlier in this guide. If you can't remember, check the "Advanced -> Preferences" menu option and click on the "References" tab.

  The **PAL/SECAM** cyan target is x=0.220 / y=0.329
  The **SDTV - REC 601 (NTSC)** cyan target is x=0.231 / y=0.326
  The **HDTV - REC 709** cyan target is x=0.225 / y=0.329

  Adjust your tint control up and down until you get as close to the x/y values as possible:



That's it!

Note that the Cyan points for the three different colour spaces are very close to one another. The DeltaE is less than 5 between any two of these points. Getting close to any of these will result is what we can consider a pretty accurate cyan secondary. If you had to adjust the tint considerably away from the midpoint to have it read close to accurate however, there's a good chance that the other two secondaries (magenta and yellow) will be off. The targets for magenta and yellow are:

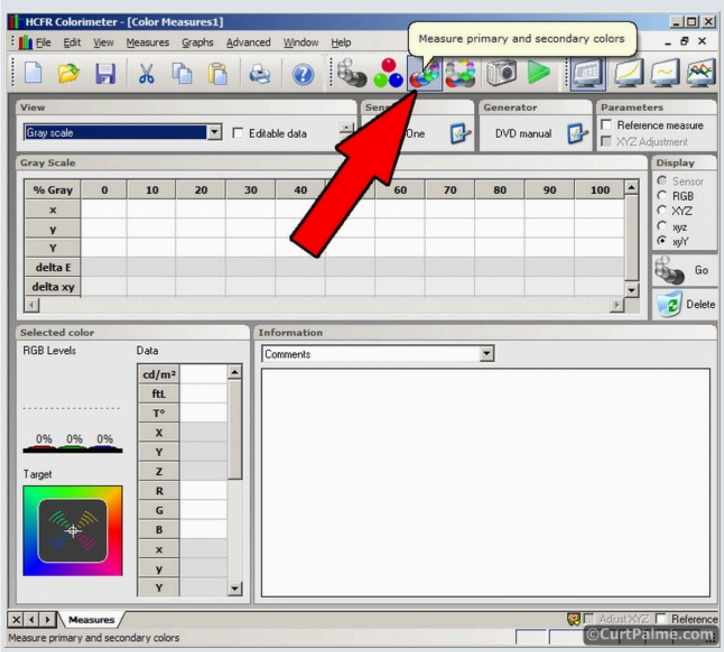
For **PAL/SECAM** the magenta target is x=0.327 / y=0.157 and the yellow target is x=0.417 / y=0.502
For **SDTV - REC 601 (NTSC)** the magenta target is x=0.314 / y=0.161 and the yellow target is x=0.421 / y=0.507
For **HDTV - REC 709** the magenta target is x=0.321 / y=0.154 and the yellow target is x=0.419 / y=0.504

Again, all three sets of points are fairly close to one another. In the next step we'll measure all three primary and secondary points so that you can see if the results are more or less balanced. We want the error (DeltaE) of the secondaries to be roughly the same for all three points. You may have to come back and re-adjust your cyan target if it turns out that the DeltaE for magenta or yellow are much larger than that of cyan. It's best to compensate by having all three secondaries off by approximately the same amount instead of having one perfect secondary at the expense of accuracy for the other two.

Ok! So now that the colour and tint controls are set properly, let's measure our primaries and secondaries and see how they look relative to the known standards.

Step 8.4: Measuring primaries and secondaries

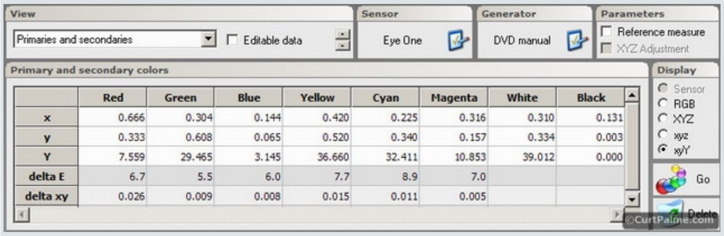
Measuring primaries and secondaries is actually very simple. We display the primary and secondary colours one a time and have ColorHCFR take measurements. Click on the "Measure primary and secondary colors" button:



The ColorHCFR software will now ask you to display primary and secondary (100% saturated) colours, one at a time, pausing at each one so that the sensor can take a reading. 100% saturated means that the brightness of the colour must be 100IRE or completely 'on'.

*While it is still best to use the AVS HD 709 test disc, those of you that simply want to measure your primaries and secondaries without performing the previous adjustments can use the SMPTE test pattern on the **Digital Video Essentials: HD Basics** test disc. You can do this by cueing up the "SMPTE 75% Color Bars w/ Gray Scale" pattern on the **Digital Video Essentials: HD Basics** test disc that includes all of the colours. It can be found by choosing the disc's menu option "Complete Program Menu" -> "Advanced Video Test Patterns" -> 1080p or 720p -> "SMPTE 75% Color Bars w/ Gray Scale". You will then have to move the sensor around to place it in front of the correct colour as requested by ColorHCFR. A bit of a pain for projector owners as if you want to re-measure your greyscale you will need to re-adjust the sensor position again perfectly as per earlier steps. Even though the colours in this pattern are at 75% saturation instead of 100%, this pattern is not recommended for CRT or Plasma displays* *as the brightness level may be different as compared to smaller windowed pattern. 3-tube CRT front and rear projection displays also may be affected by colour shift errors for the colours that are farther to the left or right on the image.*

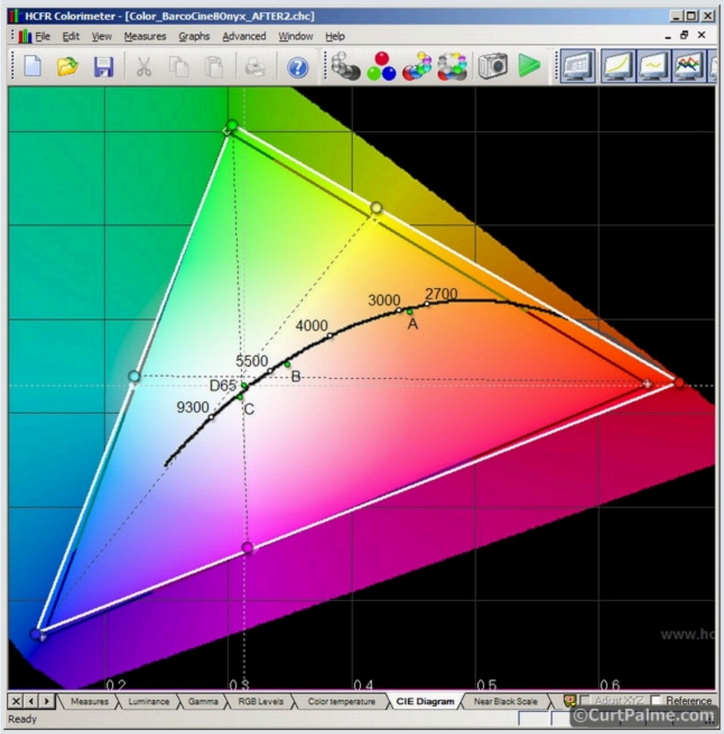
Once completed, you will have a full set of data for primaries and secondaries that looks like this:



	Red	Green	Blue	Yellow	Cyan	Magenta	White	Black
x	0.666	0.304	0.144	0.420	0.225	0.316	0.310	0.131
y	0.333	0.608	0.065	0.520	0.340	0.157	0.334	0.003
Y	7.559	29.465	3.145	36.660	32.411	10.853	39.012	0.000
delta E	6.7	5.5	6.0	7.7	8.9	7.0		
delta xy	0.026	0.009	0.008	0.015	0.011	0.005		

Similar to measuring greyscale, we hope to achieve a DeltaE for all six primary and secondary measurements of 10 or less with 3 being even better. In our Barco Cine 8 Onyx projector example you can see from our results above that all values are under 10 so we're happy!

If we take a look at the CIE diagram we can see how these points look graphically in relation to the Rec709 colour space standard that we chose earlier:



What's interesting to note is that the our red point seems considerably farther away from the standard than the green or blue, but our DeltaE values for all three are all very close in value. Pay more attention to the DeltaE numbers than what you see on the CIE diagram until you become accustomed to reading a CIE diagram.

In the case of our Barco projector, little can be done to adjust primaries or secondaries. It does not have an advanced colour management system, nor do the colour and tint controls have any effect when displaying high resolution signals (above 480i) through the RGBHV input.

How are your secondary values? Is the cyan DeltaE much lower than the magenta and yellow DeltaE? If yes, we suggest jumping back to STEP 8.3 and re-adjusting your tint control to try and even out the error between the three secondaries.

Step 8.5: Advanced Colour Management System (CMS) adjustments

Some advanced displays have an advanced CMS available such that direct adjustments to all six primary/secondary colours can be made. Most displays (including all CRT projectors) do not have these adjustments. Skip this step if that is your case.

There are no standards for CMS control names. Typically controls exist for Saturation (or Colour), Tint, Hue, and Lightness (or Brightness/Value). We are going to adjust the Lightness, Hue, and Saturation in the steps that follow. If your display does have an advanced CMS you will have to refer to your user manual to find what names your specific display uses.

Keep in mind that CMS adjustments are indeed for advanced users only. You will likely find this part of the guide the most complex or confusing so do not fret if it takes you some experimentation to understand how the controls interact. When in doubt, revert back to the default settings or ask someone with the same display as you for some help. Internet forums are a wonderful resource for assistance.

In Step 8.2 we adjusted the red colour level. If your display has an advanced CMS available we can now do the same for green and blue as follows:

- Ensure that ColorHCFR is still in continuous read mode. If not, click on the green arrow icon again.
- Cue up your AVS HD 709 test disc and skip to the 100% white window pattern by selecting "10% Grayscale" -> "100% Gray window". Write down the Y (Luminance or brightness) reading as seen by the sensor.
- Skip to the 100% Green window pattern by selecting "100% Saturated Colors" -> "100% Green window".
- Adjust the CMS 'Lightness' control on your display for Green until the Y reading is 71% of the 100% white window reading measured earlier. For example, if the Y value earlier was 39.012 as seen above, then 71% would be 39.012 x 0.71 = 27.699.
- Skip to the 100% Blue window pattern by selecting "100% Saturated Colors" -> "100% Blue window".
- Adjust the CMS 'Lightness' control on your display for Blue until the Y reading is 8% of the 100% white window reading measured earlier. For example, if the Y value earlier was 39.012 as seen above, then 8% would be 39.012 x 0.08 = 3.121.

That's it for the first part. This sets the green and blue colour decoder adjustments correctly. We already adjusted red earlier using the universal 'colour' control.

The next part is to adjust the CMS 'Hue' and 'Saturation' controls for all six primary & secondary points. This will get our primary and secondary values hopefully as close to perfect as possible. Depending on which colour space you're using, the six reference points have the following x/y values:

PAL/SECAM:
Red primary: x=0.640 / y=0.330
Green primary: x=0.290 / y=0.600
Blue primary: x=0.150 / y=0.060
Yellow secondary: x=0.417 / y=0.502
Cyan secondary: x=0.220 / y=0.329
Magenta secondary: x=0.327 / y=0.157

SDTV - REC 601 (NTSC):
Red primary: x=0.630 / y=0.340
Green primary: x=0.310 / y=0.595
Blue primary: x=0.155 / y=0.070
Yellow secondary: x=0.421 / y=0.507
Cyan secondary: x=0.231 / y=0.326
Magenta secondary: x=0.314 / y=0.161

HDTV - REC 709:
Red primary: x=0.640 / y=0.330
Green primary: x=0.300 / y=0.600
Blue primary: x=0.150 / y=0.060
Yellow secondary: x=0.419 / y=0.505
Cyan secondary: x=0.225 / y=0.329
Magenta secondary: x=0.321 / y=0.154

Referencing the x/y values for the colour space you've chosen to use, follow these steps:

- Skip to the 100% Red window pattern by selecting "100% Saturated Colors" -> "100% Red window".
- Adjust the CMS 'Hue' and 'Saturation' control on your display for Red until the x/y values are as close to possible to the reference values listed above.
- Repeat these two steps for all of the other primary and secondary colours listed in the following order: Green, Blue, Yellow, Cyan, and Magenta.
- While making the adjustments that affect x/y, pay attention to the Y (Luminance) value as well. While only the x/y values should be changing, some displays have poorly implemented colour management systems that also affect the Y value. You may end up getting the correct x/y value and a CIE chart that looks right, but the light output may be completely incorrect which ends up making things worse than before you started! If the Y value starts changing dramatically, go back to whatever settings keep the Y values consistent.

That's it! Your primary and secondary values should now be as close as possible to the reference values. We recommend re-measuring the primary and secondary points again (as outlined in Step 8.4) to see how much closer your readings are.

Given that all of these controls affect all other controls that we adjusted previously, we recommend that you run through the entire guide again quickly and re-measure contrast, brightness, and greyscale, and so on. Until you can run through all of the steps in this guide without making any adjustments, you should always be going back to the start and re-measuring everything. With every successive pass, the adjustments should get smaller and smaller until there is nothing left to adjust.

Step 8.6: Additional hints and tips to achieving more accurate primaries

Below are some additional tricks and tips that you may use to physically alter your display for more accurate primaries and secondaries.

CRT Projectors:

Adjusting primaries in CRT projectors is possible in some models by replacing the lenses or tinting the CRT coolant glycol. This is done by using tinted lenses or glycol instead of clear. Getting a CRT projector's primaries closer to the targets is the only reason why some manufacturers chose to tint. Those that do not are primarily concerned with light output as while these modifications result in more accurate primaries, they do so at the expense of light output.

How can you tell if a CRT projector already has tinted lenses or tinted glycol? With your CRT projector off, shine a flashlight into the red and green lenses and take a look. Do the CRT tube surfaces you see appear white or are they tinted red and green respectively? If they are white then you do not have any tinting and your primaries are likely going to be off causing your green to be greenish/yellow and red to be reddish/orange.

By adding tinting we cause unwanted colours to be filtered out only allowing pure red and green to pass. The blue tube is never tinted as it is usually very close to begin with and blue light output is at a premium. Our Barco projector has tinted red and green lenses and this is the main reason why the primary readings are close to perfect.

So what can be done if your red and green are not tinted?

For lower end **air-coupled** CRT projectors you have three choices:

- If your lenses are labelled as HD8 lenses used by many Barco, Electrohome, Sony, and Ampro models you can replace them with tinted HD144 (or HD145) lenses by using the **Joustmods.com HD144/145 lens adapter kit**. The trick is finding used HD144/145 lenses. They are used on NEC PG and XG CRT projectors natively. The lenses themselves are often hard to come by separately, so buying a scrapped NEC CRT projector is one option. Ebay or our own **Buy & Sell** forum is another option. As an added bonus, HD144/145 lenses are also sharper than HD8 lenses (especially in the corners). Replacing the lenses is quick and easy task for anyone and should take about an hour at most.
- If your lenses are not HD8 you can replace the clear glycol coolant in front of the tube faces with tinted glycol. Unfortunately buying aftermarket tinted glycol seems impossible as it has never been sold directly by manufacturers. We've also never heard of anyone being able to source aftermarket tinted glycol. Enthusiasts have instead figured out how to tint clear glycol themselves. You can read about it in our **Tinting Glycol** guide. Tinting your own glycol is considerably more work than simply replacing the lenses as the projector likely has to be lowered and the tubes removed and stripped down. This is complex work for most people.
- While the following method is not recommended as a permanent solution, you can perform an inexpensive modification using **Rosco Calcolor filters** to see what more accurate primaries will look like. These filters are readily available on Ebay for less than $10. You want 4690 (Dark Red) and 4460 (Medium Green), though you may want to experiment with 4430 (Light Green) or 4660 (Medium Red) as well. Cut a piece of filter to fit on the front of your CRT tubes. Remove the red & green lenses, clean off the front glass of the CRTs with a good glass cleaner and a lint-free cloth, and mist a little cleaner onto the filter. Stick it onto the CRT glass and work out any bubbles. (You probably want to cover it with a tissue while you do this, so you don't get fingerprints on it.) The surface tension will keep the filter attached for a long time. Re-mount your lenses and re-calibrate your greyscale. Again, we don't recommend this as a permanent solution as while the colours will be a lot better, the image will be softer and there will likely be a 'haze' to the image. These filters are designed for tinting stage lighting, and not for optical clarity.

For higher end **liquid-coupled** CRT projectors your only option is to replace your clear red and green c-elements with tinted versions. Instructions can be found **here (Barco models)** and **here (Electrohome models)**. There is considerable work involved in changing the c-elements as once again the projector has to be lowered and the tubes removed to perform the operation safely.

Undertaking any of one of these procedures results in much more accurate primary colours and is worth the effort as is seen in this photo:

Photo courtesy of forum member Chris Johnson. Thanks CJ!

The left portion of the photo is a stock red tube without colour filtering and appears reddish/orange. The right portion has been filtered and does not exhibit a orange tint.

Below is a CIE chart showing before and after measurements on an Electrohome 8500 air-coupled CRT projector:

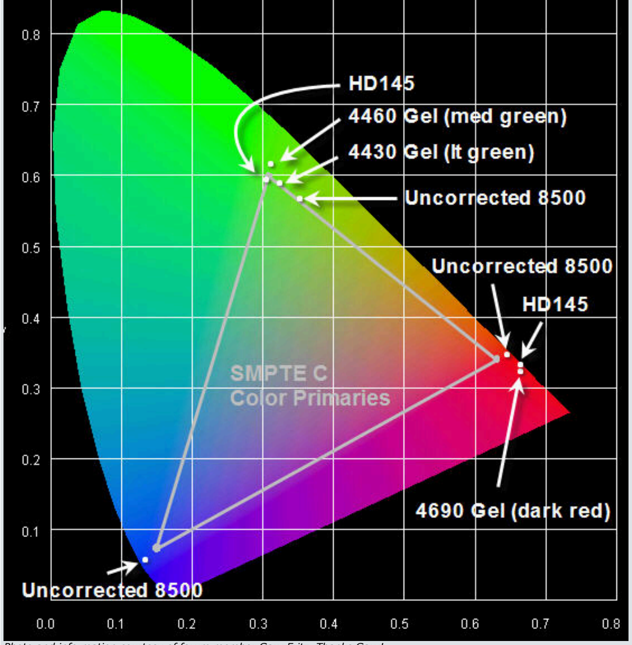


Photo and information courtesy of forum member Gary Fritz. Thanks Gary!

The 8500 does not have any filtering on the red and green lenses in stock form. Blue does not require any filtering as it is pretty close to the correct colour, just a bit more vivid than it needs to be. This (and blue's limited light output) is the reason why blue is never colour filtered. Green is way off, in a very "yellowish" direction. The first Rosco (4430) filter moved it a bit towards the correct value, and the second (4460) moved it a bit more. The HD145 lens moves it almost exactly onto the correct value, just where we want it. Surprisingly the uncorrected red measurement appears almost correct but it is somewhat into the 'orange/red' area. The HD145's and the red gel moved it farther out into the "intense red" area, but kept the right shade of red.

Other than the options listed above, using an external processor is the only other option. CRT projectors do not have colour management systems (CMS) advanced enough to allow for primary alteration. It is important to remember that external processing will not be able to increase the colour space of a projector. It can only reduce it. The more advanced processors will also allow you to alter secondaries.

Digital Projectors:

If the blue and green primaries on your digital projector are too far out causing the colours to be too vibrant, you can possibly tame them a bit by adding a filter in front of your lens. The CC20R, CC30R, and CC40R filters (for example) are popular choices. These are light filters that can be added into the light path in front of your digital projector. It limits the light output for certain colours (mostly blue/green) which can help with the black level and also has the effect of pulling in the blue and green primary points (red remains unaffected). The number represents the percentage of attenuation that is performed, so for example, a CC20R filter attenuates light output by 20%.

These filters are most affective at very dark picture levels. So if you find the dark parts of the image to measure too blue-green (probably due to an unfiltered bulb), consider applying a color correcting filter in front of the projector lens. They are available from photography supply stores such as **B&H Photo Video**. They will usually do a good job of color balancing the projector output at very dark picture levels. You will need to devise a way to mount the filter in front of the projector lens.

Since the filter reduces the bulb light output at low light levels, the color correcting filter gives you the added bonus of deeper blacks and an improved *calibrated* contrast ratio. Some extra information from forum member ChrisWiggles (author of the **Source Settings Guide**):

> **Quote:**
> The filter itself is passive, and will hace no inherent impact on contrast ratios. The reason to use a color filter on a digital display is that often a digital display will have too much blue or green, but using the gains in the digital projector to reduce the blue/green output can have the effect of reducing the contrast ratio since you have a limited on/off contrast ratio range for each primary. As you lower the gain of each primary control, you also will have to lower the global white level setting to stay below the display's white level clip point as the primary gains are lowered. This sacrifices contrast ratio. Using a colored filter achieves this without needing to sacrifice contrast ratio at all (or as much) since you may not need to adjust down the primary gains at all (or as much) in order to achieve proper greyscale. In this manner, a colored filter can have the end effect of improving your calibrated contrast ratio, but it in and of itself will not affect contrast ratio at all, except insofar as it helps during the calibration process.

Which filters to use and how to install and calibrate depends on the projector in question and beyond the scope of this guide. You will also be required to recalibrate your greyscale once such a filter is installed of course.

Another option is a high end processor to directly alter the primary and secondary values. External processing however will not be able to increase the colour space of a projector. It can only reduce it.

Direct View displays:

Direct view displays cannot be altered as there is no lens or screen between the display surface and the viewer so there is nothing that can be modified. Other than having your guests all wear sunglasses made out of filters as mentioned above, the only option is a video processor to directly alter the primary and secondary values. External processing however will not be able to increase the colour space of a projector. It can only reduce it.

Last edited by kal on Thu Dec 27, 2012 3:42 pm; edited 38 times in total

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Link Posted: Tue May 06, 2008 7:18 pm Post subject: quote

Closing Comments

I hope that this guide has helped you understand why proper greyscale and colour calibration is one of the most important enhancements required for proper movie reproduction. Directors, cinematographers, and motion picture colorists go to great lengths to ensure that the movies you watch on DVD or Blu-ray are reproduced with accurate colours. By doing your part and calibrating your greyscale and colours, you help ensure that what you see at home is a perfect match to what these professionals intended for you to see.

This guide came about as many of our **newsletter** readers have been asking about greyscale and colour calibration over the years. With reliable meters now under $150 and excellent free software like ColorHCFR available, it's a no-brainer that all HT enthusiasts have some sort of meter in their toolbox.

I hope you've found this guide useful!

Comments and feedback are appreciated. We've locked this thread to keep it clean, but you may post your questions or comments in our official **'Greyscale & Colour Calibration for Dummies' Q/A thread** or start a new thread in our **Audio & Video Calibration** forum.

Cheers! I hope you enjoy your greatly improved home theater!

Kal
Editor, **CurtPalme.com** Home Theater
Founder, **TheElectricBrewery.com**: A step by step guide to building your own home brewery ...

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If you found this guide useful please help support the creation and maintenance of guides such as this by making purchases using the Amazon.com, Amazon.co.uk or B&H Photo Video links provided. A small percentage of everything you purchase (not just these items) automatically goes to support this forum and guides at no extra cost to you. We thank you!

Also consider making a **donation to ColorHCFR** to help support its continued development.

Want to show off your newly calibrated home theater? See our **Blu-ray Release Dates & Must-Have Titles** for some movie ideas. Need to purchase home theater products? See our **products page**.

My latest publication is a step by step guide to building your own brewery. Now available as a downloadable e-book:

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Last edited by kal on Mon Apr 13, 2015 12:58 am; edited 25 times in total

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Link Posted: Fri May 09, 2008 8:31 pm Post subject: quote

Appendix A: Spyder2 and Eye-One Sensor Comparison

We own both the **Spyder2** and **Eye-One** sensor so we thought some comparison of the two would be in order.

The least expensive way to purchase the **Spyder2** sensor is in the **Spyder2 Express** kit.
The least expensive way to purchase the **Eye-One** sensor is in the **Eye-One Display LT (Lite)** kit.

The short answer:

If you're on a budget and need to decide between the two, buy the Eye-One sensor. We recommend you use it with **ChromaPure** to make your calibration even easier. For those that want to use our guide, it's available in both the **Eye-One Display LT (Lite)** and **Eye-One Display 2** packages. The more expensive Display 2 package comes which extra tools useful if you're into digital photography (we don't use these tools in this guide).

June 2009 Update: The Spyder 3 is now available as well. The same issues with widely varying results are apparent in the Spyder 3 as well so we cannot recommend purchasing a regular Spyder 3. Great hardware, it's just not properly calibrated at the factory (at all it seems) so you have no idea what you're getting.

The longer answer:

In our tests and speaking with various calibration experts we've concluded that: Approximately 1/3 of Spyder2 units are very accurate. The next 1/3 are slightly off. The last third are considerably more inaccurate. Unfortunately there's no way to know how your Spyder2 unit rates unless you have a known accurate meter to compare it against like an Eye-One. The Spyder2 we own is "reasonably good" above 30 IRE and off below 30 IRE when compared to our Eye-One. The results (in our case) were still much better than doing greyscale by eye (we tried) but your mileage may vary.

The Eye-One on the other hand is consistently accurate and readings do not vary between units from what we've read. Those of you that would never consider spending more than $70 on greyscale calibration may consider ordering the Spyder2. Those that want to do this right should order the Eye-One as it's the cheapest probe recommended by the pro's.

Stay away from the newer Spyder3 as the ColorHCFR software used by this guide does not support it (yet). June 2009 update: A newer version of ColorHCFR does now support the Spyder 3 but the same quality issues plague the Spyder 3 meters. You just don't know what you're getting.

Eye-One sensor advantages:

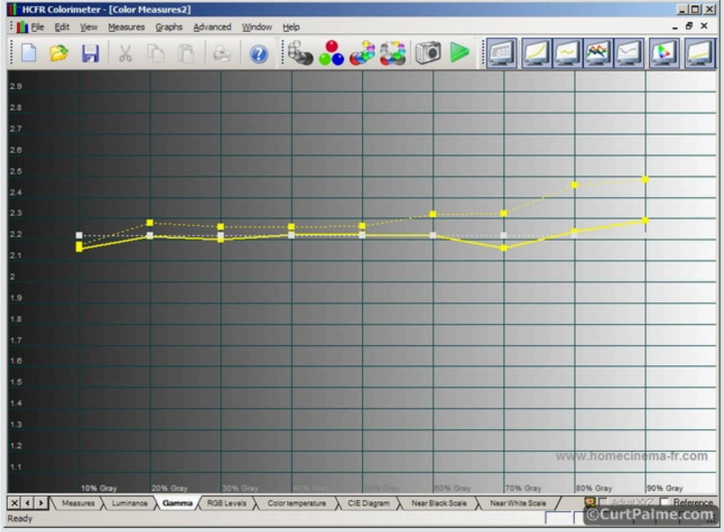
- They Eye-One is considerably faster at reading than the Spyder2. More than 3 times faster on average! In continuous read mode the data updates every second instead of every 3-20 seconds as with the Spyder2.
- The read time does not have to be adjusted with the Eye-one. It just always works correctly. It extends the read time at lower IREs for you automatically to get accurate readings. At lower IRE readings the Spyder2 returns inconsistent numbers unless you increase the read time manually. The end result is that you end up fussing with the read time with the Spyder2, or have it set so high that all readings are very slow which can be annoying. Even at 10 IRE the Eye-One only needs about 2 seconds instead of 20 seconds for the Spyder2. Given that you will likely perform hundreds of readings with your sensor over the course of a calibration, you will save time by using the Eye-One.
- The bundled Eye-One Display LT (Lite) software package used for calibrating computer displays/laptops is a lot nicer and polished than the Spyder2 software and lets you choose different colour temperatures and gamma depending on your needs. The Spyder 2 Express software gives you next to nothing. The Eye-One is a better choice is you wish to use completely automated calibration of PC monitor.
- The Eye-One is a lot more accurate. We calibrated our PC screens using the software bundled with both packages and the results simply do not track as correctly with the Spyder2 sensor (see below). With the Eye-One the result is perfect with great shadow detail. One of the reasons for the increased accuracy in the Eye-One is the fact that you must quickly calibrate it before use every time (by placing it on a flat surface and clicking the mouse). The Spyder2 doesn't have any sort of calibration so over time and in varying temperatures it will drift.

Spyder2 advantages:

- Price. At the time of this writing, the Spyder2 is available for approximately half the price of the Eye-One.

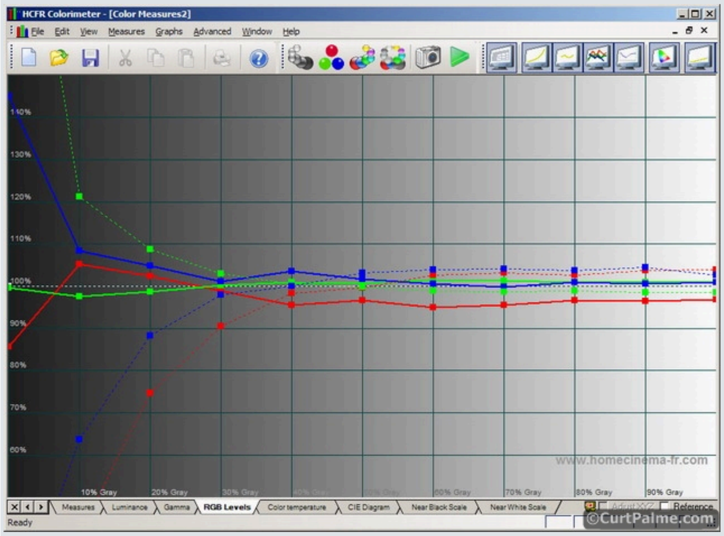
Here are some screenshots of a laptop's greyscale to show how the Eye-One does better than the Spyder2:

Gamma:



Solid yellow line is the Eye-One, dotted yellow is the Spyder2. The target we're trying to achieve is the white line. Notice how according to the Eye-One, we're actually very close to the 2.2 gamma target. The Spyder2 tells us that we're not that close and would end up compensating incorrectly.

RGB levels:



The solid lines are the Eye-One, the dotted lines are the Spyder2. Notice how our Eye-One does not have the same problem at 10-30 IRE as the Spyder2. The lines curve away from the 100% target for our Spyder the farther down you go. While most sensors are the least accurate in the lower IRE range the Spyder2 (or is it just our unit?) seems to be considerably more off and doesn't seem to be able to read accurately below 40 IRE.

We highly suggest the those looking to spend the time required to perform greyscale calibration skip over the less expensive Spyder2 and opt for the Eye-One sensor instead. The greater accuracy and time saved will be worth the price difference. The Eye-One is available in both the **Eye-One Display LT (Lite)** and **Eye-One Display 2** packages. The more expensive Display 2 package comes which extra tools for digital photographers (not needed here). Something to keep in mind.

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