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HD Monitor Calibration - SMPTE, ARIB, and White Balance

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I haven't spent a whole lot of time revisting old entries on this site. The most widely read post here was one written January 8, 2008 about HD Monitor Calibration using ARIB Bars. It's one of the only articles on the net that specifically addresses working with ARIB which is the reason for the traffic. Because of its continued use, I feel an overhaul probing a little deeper into the topic is beneficial to anyone referencing it.

In the original article, the emphasis was on using ARIB or SMPTE color bars to properly set your HD display's Brightness (black level), Contrast (white level), and Chroma (color saturation). I made the mistake of labeling this "calbration". What this assumes is that the most important component of display calibration, White Balance / Color Temperature, has already been set correctly. Color bars and color fields do nothing to tell you if your display's whites are truly white. White Balance or setting your monitor's Red, Blue, and Green Gain levels to the correct outputs to create a pure, chroma-free white is the most critical aspect of monitor calibration. The main reason I'm re-addressing this topic is that if your display's white is off, "calibrating" it with a test signal such as color bars doesn't mean a whole lot. Color bars will help you find the correct white, black, and color saturation levels but if 100% white input isn't output as 100% chroma-free white, your display is out of alignment.

First, a re-cap:

This post is in regards to HD monitor calibration only. There are several issues relating to standard definition video and monitoring that do not apply to HD:

1. NTSC Setup, or 7.5 IRE (%) Black Level. Setup is for standard definition only. The black portion of HD test signals hit 0 IRE (%) on the waveform.

2. Phase: There is no Phase control for digital HD monitoring. Only CHROMA (saturation) affects picture as Phase relating to monitoring is an analog issue only.

COLOR BAR TEST SIGNALS:

Many cameras and recording decks generate color bars - either the HD **SMPTE** (Society of Motion Picture and Television Engineers) version, which is this:

Or the newer HD specific version, **ARIB** (Association of Radio Industries and Businesses):

Correct use of these test signals will help you set your monitor's brightness, contrast, and choma levels. You can use either one of these interchangeably and one is not necessarily more accurate than the other. The process of using either of these color fields is virtually identical.

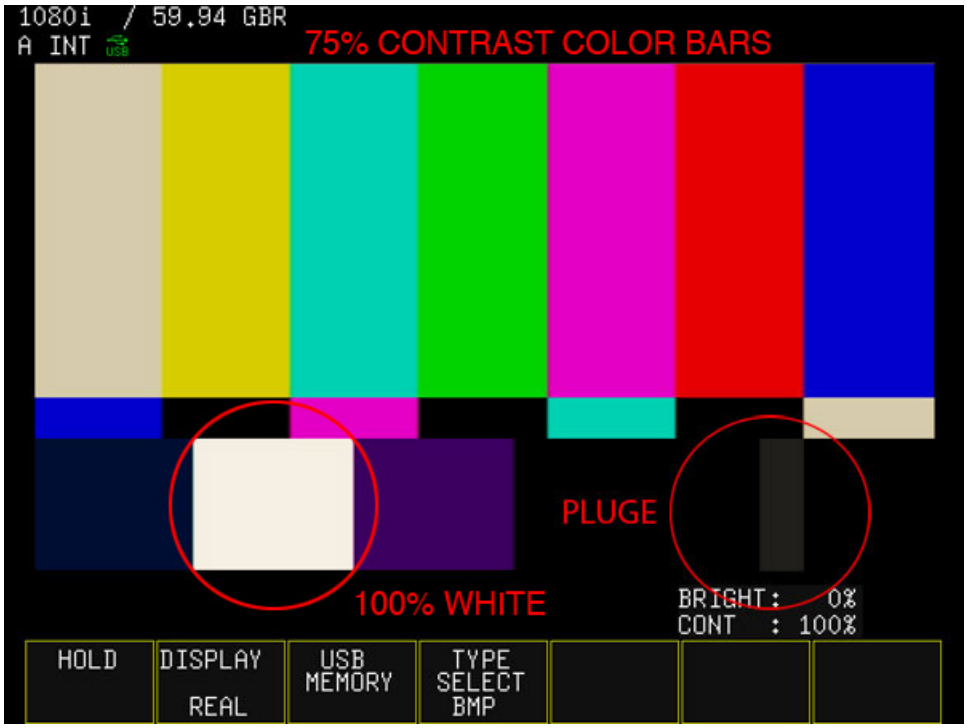
WHITE BALANCE AND GAMMA:

This post is only concerned with display calibration for **Rec709**, which is **for now**, the standard colorspace for HD broadcast. Rec709 uses a defacto gamma of 2.2 and a white point of D65 (Daylight 6500 kelvin). Very recently the **ITU** released **Rec1886** which specifies a gamma of 2.4. The topic of which gamma is the "correct" one is much larger than this post so for simplicity, let's assume we're all using the widely implemented gamma of 2.2. Many monitors have preset choices for both gamma and white balance. In this standard Rec709 calibration scenario, you're going to set your gamma to 2.2. For white balance, you may find choices such as D50, D65, and D93 but not all monitors will actually allow you to manually adjust Red, Blue, and Green Gain to create your own custom white point. If you do have a monitor that allows for custom alignment, the only way to do this is with an external probe that will measure the output levels and help you find the correct RGB mix to display a pure, chroma-free white. Additionally some displays, namely OLED's and newer LCD's, also require an adjustment for Bias which is similar to Black Balance to produce neutral, chroma-free dark tones. If your display does not allow for a manual RGB White and Bias, set White Balance to D65 and move on to the next step. Your monitor cannot be truly aligned beyond what was deemed "calibrated" at the factory.

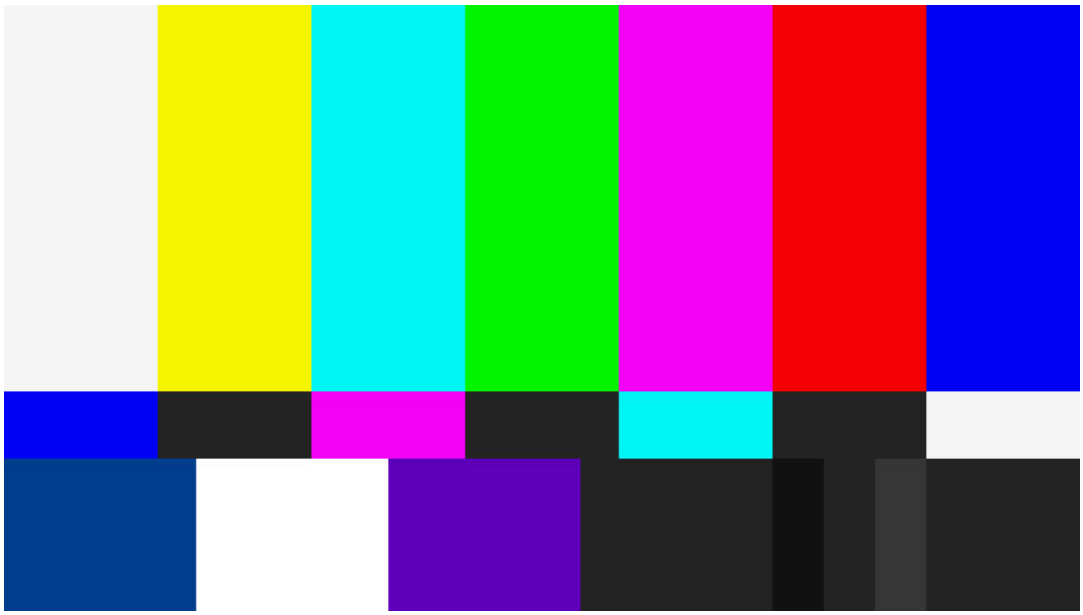
AN ANALYSIS OF THE HD SMPTE COLOR FIELD:

The components of this test signal are 75% Contrast Color Bars (Yellow, Cyan, Green, Magenta, Red, Blue), 20% Blue Chip, 10% Purple Chip, 75% Contrast White Chip, 100% Contrast White Chip, 0% Black chips, and The Pluge. When using this test signal to set Brightness, Contrast, and Chroma, all you really need to concern yourself with are the 75% Color Bars, 100% White Chip, and Pluge. The 20% Blue Chip and 10% Purple Chip fall along the **IQ Line** on the Vectorscope for verification that the color information in the test signal is accurately centered on the scope.

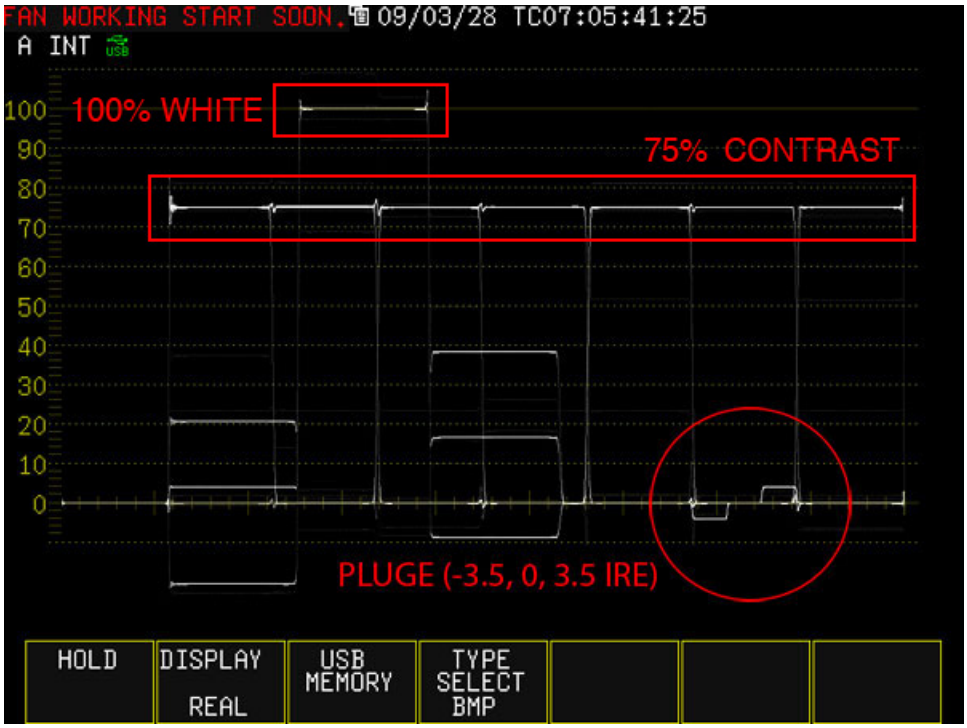
The Pluge will help you set your Brightness (Black Level). It consists of a -3.5% (IRE) chip on the left, 0% chip in the middle, and 3% chip on the right.



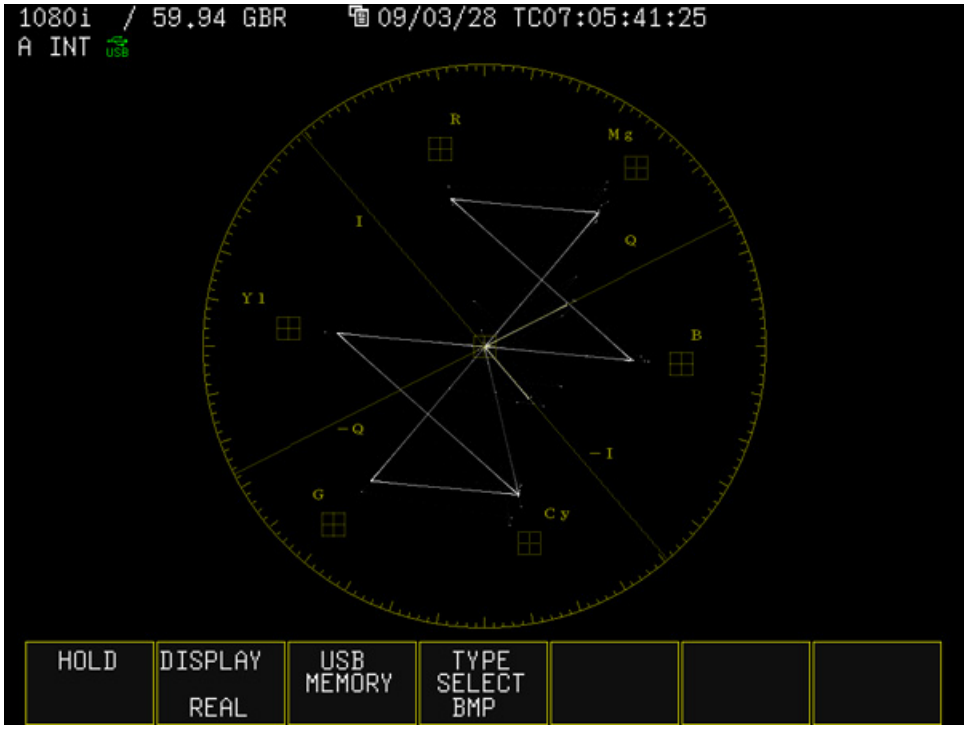
Here are SMPTE Color Bars with lifted blacks so you can see the pluge better:



Here's the same signal's luma waveform. This helps to see where everything in the field is hitting in terms of level, particularly the pluge.



And Vectorscope. You can see that each of the color bars lines up perfectly with thier targets indicating that these are pure, undiluted primary and secondary video colors. If this was a 100% contrast color field, the vectors would land perfectly in their little targets; R = Red, Mg = Magneta, B = Blue, Cy = Cyan, G = Green, Yl = Yellow.



SETTING BRIGHTNESS, CONTRAST, AND COLOR WITH HD SMPTE BARS:

1. Set your gamma to 2.2 and White Balance to D65. Set your Brightness, Contrast, and Chroma to their default levels. If you have a display that can be custom white balanced, make sure that you're aligned before starting this. If you're working with a facility on a project, they can send a technician with a probe to you and he can do it for you. Or you can talk to you manufacturer and get a list of recommended probes for use with your display along with x,y (Color Temperature), and Y (Luminance) targets so you can do it yourself. Once you're there, send the HD SMPTE test signal to your monitor via HD-SDI. This is best done in a dark environment so if you're outside or in an unshielded location, try and keep as much ambient light and direct light off the display as you can.

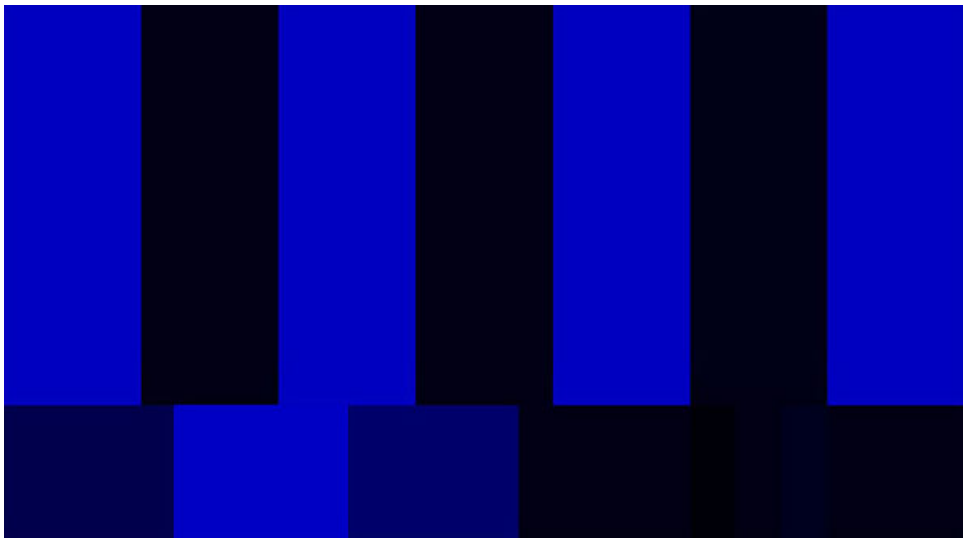
2. Everyone has their own way of doing this. All I can say is that I feel that I've had pretty good results with this method which involves jumping back and forth between the different adjustments to find just the right levels. I start with Contrast which is the most subjective. Looking at the 100% white chip, turn the contrast up until it visually stops getting any brighter. Now back it off a little bit. This will be different on every display and really the smart way to do is with a probe that reads Luminance level.

3. By default, increasing Contrast will also somewhat raise the black level. Now use the pluge and set your Brightness so that the left (-3%) pluge chip disappears into the surrounding 0% black field. The right chip which reads 3.5% on the waveform should be just barely visible.

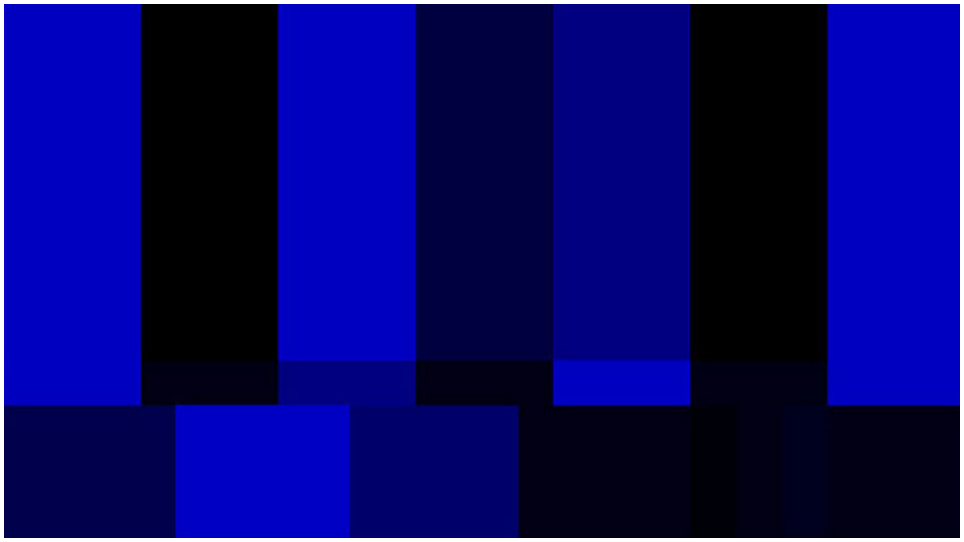
4. Now check your contrast again. Is the 100% white chip still hitting peak white? If you need to adjust, make sure to go back and check your pluge again. By going back and forth between these 2 adjustments, you should be able to arrive at a satisfactory black and white level.

5. Now check Chroma. Your monitor most likely has some sort of Blue Only feature. This is used to help you correctly set your color saturation level with Chroma. Turn it on and have a look.

If it looks something like this, you're in good shape.



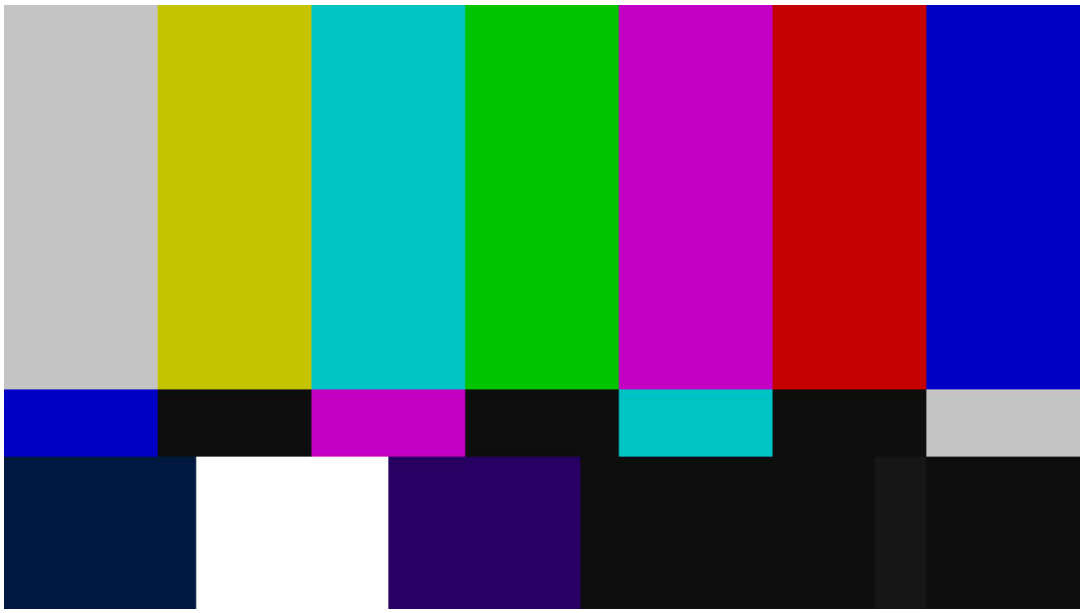
If you're looking at something like this:



Adjust the Chroma level on the display until you're looking at solid, alternating bars of equal value. The larger top portion of each individual bar needs to blend into the smaller section beneath it.

6. If you find that you have to make some adjustments to Chroma, this could up slightly changing your overall contrast so turn Blue Only off and check the pluge and 100% white chip again. By tweaking back and forth between all of these adjustments, you will be able to find the most accurate settings your monitor can produce. Please note that some monitors don't have Blue Only but can display in Monochrome. The Chroma calibration process with Monochrome is identical to Blue Only.

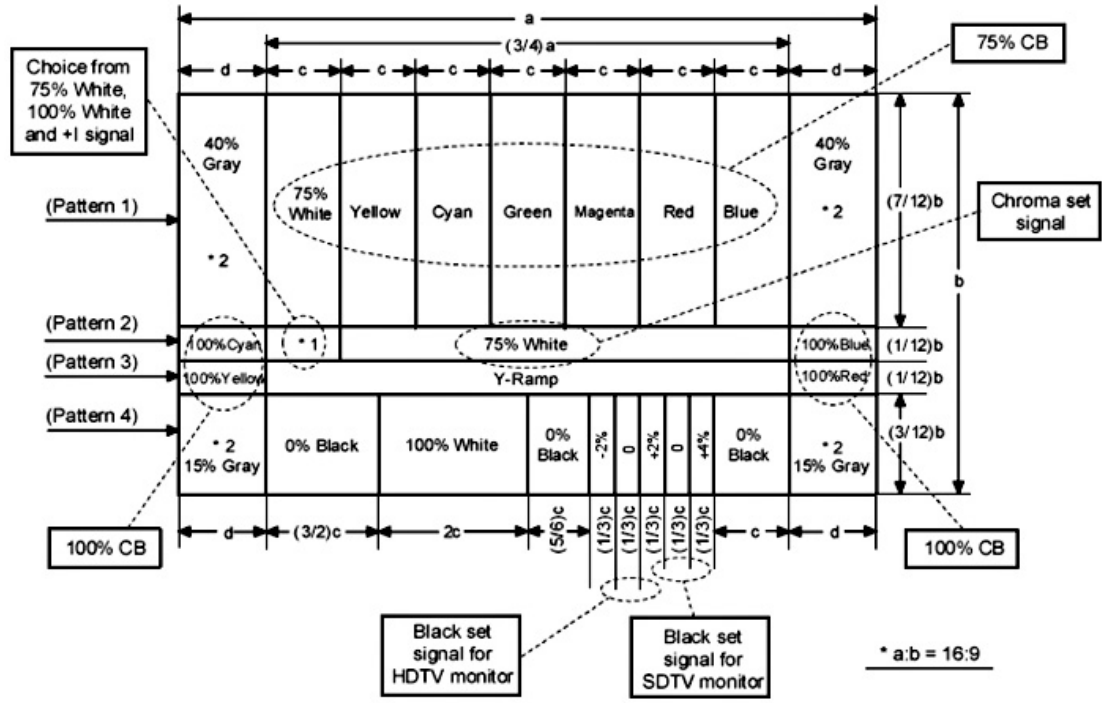
At the end of the process, you should be looking at something like this:



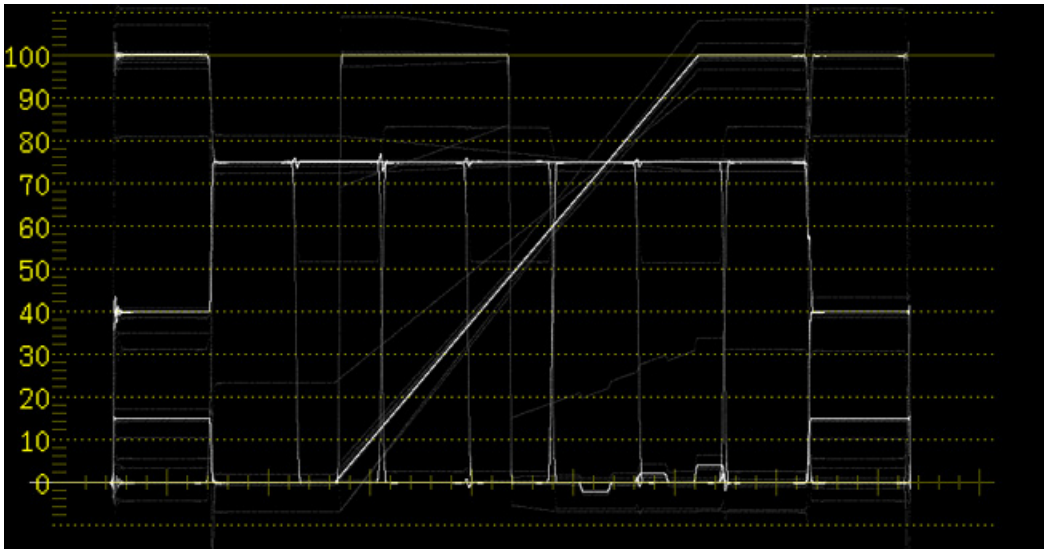
AN ANALYSIS OF THE ARIB COLOR FIELD:

This test signal has a greater variety of components than it's SMPTE relative. It contains the same 75% Contrast Color Bars, with the addition of neutral gray chips at various luma levels, and pluge with more steps (-2%, 2%, and 4%) that I suppose offer a bit more finesse for setting black level with Brightness.

Here's a handy diagram detailing what's what in the ARIB:



Here's the luma waveform of the signal. Note the 0%-100% gradient that ramps through the middle of the field and the pluge at -2, 2, and 4%.



SETTING BRIGHTNESS, CONTRAST, AND COLOR WITH ARIB BARS:

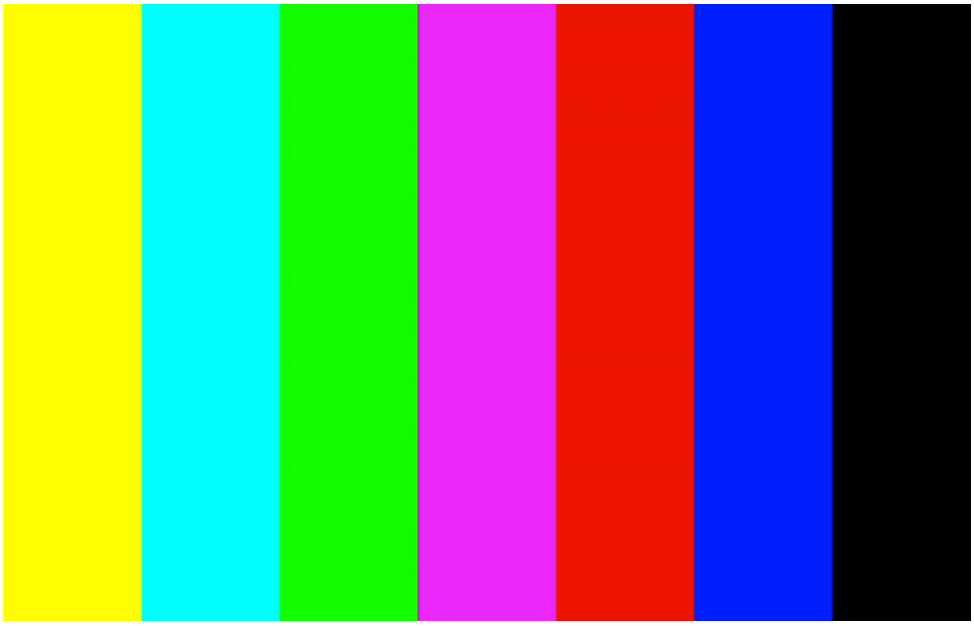
Though it looks radically different, on principle it's the same as the SMPTE. Follow the exact same steps outlined above when using this signal to arrive at correct Brightness, Contrast and Chroma levels.

The biggest difference is with the pluge. When using this signal, the middle (2%) and right (4%) pluge chips should be barely visible with the the -2% chip blending into the surrounding 0% black field.

When setting Chroma with Blue Only, this is what you should be looking at with the correct level:

And when you're all done, this is what you should be looking at:

SMPTE 100% COLOR FIELD:



Some recording decks will output these but very few cameras will. I don't think this is as useful a calibration signal as there's no pluge to help you set black level. It's good for checking saturation on displays or if for some reason you needed to check a 100% signal in a video system. This field contains the 3 primary video colors (Red, Green, and Blue) and 3 secondary colors (Yellow, Cyan, and Magenta) at 100% contrast along with a 0% Black Chip and 100% White Chip.

On the vectorscope, you can see the colors hit their 100% targets spot on.