

CALIBRATION AND OPERATION OF
PANASONIC PLASMA MONITORS
JULY 2009

Overview

Plasma video monitors provide high-resolution images with excellent contrast and dynamic range, low black levels, and saturated colors over very wide viewing angles. The performance of a calibrated plasma monitor is very close to that of a calibrated reference CRT monitor.

However, plasma monitors perform best after calibration, as opposed to simply being used with their factory settings. The user menu provides several tools to effect calibration, each of which will be discussed in this paper as part of a step-by-step calibration process.

Plasma imaging technology

To obtain the best results from a plasma monitor, it's useful to understand the underlying process that produces electronic images. Plasma display panels (PDPs) contain thousands of tiny pixels, each of which contains a red, green, or blue color phosphor coating.

Electrodes on the front and back of each pixel are used to discharge electricity through the pixel. A mixture of neon and xenon gas within the pixel is stimulated by this discharge, and emits a broad spectrum of electromagnetic energy, including a burst of ultraviolet (UV) light.

Initially, a high-voltage charge primes the pixels to be addressed, followed by lower voltage pulses that address pixels, line-by-line. A third, higher discharge voltage then sustains all pixels turned on during the second discharge cycle.

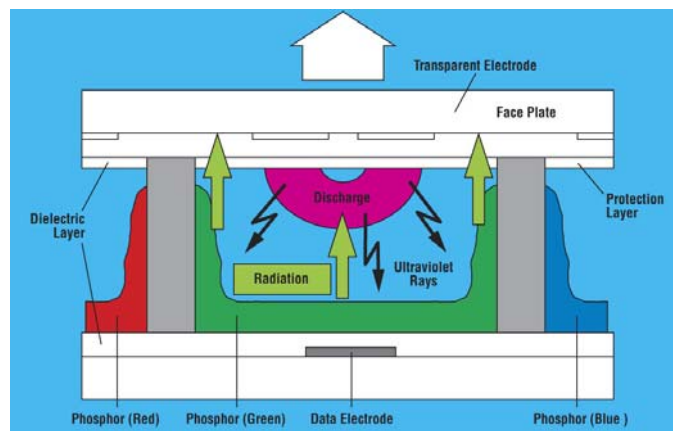


Figure 1. Cross-section of a plasma pixel.

Because the response of the pixel is binary, i.e. on or off, grayscale images of varying intensity can only be created by using rapid on-off cycling, with the grayscale value derived from the ratio of 'on' to 'off' cycles within a specific time interval. The human eye integrates these rapid pulses into lighter or darker shades of gray and color.

This technique is known as pulse-width modulation, and while it can be considered a digital imaging process, the response of the color phosphors to UV stimulation is very much analog in nature.

As you might expect, the continuous charge/discharge cycle creates heat within the pixels. Plasma technology has come a long way in power efficiency since the first color plasma monitors were introduced in 1993, and today's plasma monitors are much more efficient and run cooler than even models from ten years ago.

Still, plasma technology (like CRTs) employs current-limiting circuitry to minimize heat and premature aging of the color phosphors. As a result, peak brightness readings on plasma monitors will vary considerably between those taken with a small white area test pattern and a full white screen. Full screen readings will always be much lower than small area readings because of this feature, which is incorporated into every plasma monitor by all plasma manufacturers to limit power consumption.

Monitor Calibration- Readings

To calibrate a plasma monitor, you will need (at the least) a colorimeter, either contact or non-contact types. (Handheld meters can also be used with contact sensors.) More advanced color-sensing devices such as spectroradiometers and photometers can be used, although these are commonly used for extremely precise measurements of narrowband single-color intensity and hue values from electronic displays.

There are numerous bi-stimulus and tri-stimulus colorimeters available for reasonable prices. These systems usually consist of a sensor head that connects to a notebook or desktop PC via USB connections, plus applications software to log and interpret the readings.



Figure 2. A notebook PC-based colorimeter with contact sensor. (Photo courtesy Datacolor)

The readings and compiled data points should include monochromatic (white) luminance values (either in candelas per square meter (metric) or foot-Lamberts (English), color luminance and hue values, also expressed as x,y coordinates on the 1931 and 1976 CIE charts, and color temperature values, expressed in Kelvins.

It is also extremely helpful to have the colorimeter's software plot histograms for luminance response vs. driving voltage (gamma), color temperature tracking at different luminance values, and tracking of red, green, and blue levels at different luminance values. These plots are essential to determine the plasma monitor's gamma response before and after calibration.

The calibration software should also generate a color gamut chart for the display. This chart will show the operating color gamut of the plasma monitor, compared to a standard gamut such as the ITU BT.709 standard color space for digital TV. Such a chart is essential for fine-tuning hue and luminance values for primary colors to conform to different standard color spaces (where such fine-tuning controls are available).

Monitor Calibration – Test Patterns

Your calibration will also require a precision test pattern generator with the appropriate analog or digital signal interface, such as component YPbPr, RGB, HDMI, DVI, or SDI/HD-SDI. This generator should contain test patterns for:

- (1) Grayscale adjustments (full black and white, 50/50 black white fields, small area windows in steps of at least 10 IRE, and checkerboard black/white test patterns)
- (2) Color adjustments (full and small area 100% red, 100% green, and 100% blue, plus cyan, yellow, and magenta)
- (3) Pixel clock and image position adjustments (crosshatch and over/underscan patterns, fine text patterns)

You may also find additional test patterns to be useful, including luminance and chrominance multiburst patterns to show frequency response of the plasma monitor and any associated image processing/switching electronics.



Figure 3. Allow a 1-hour warm-up cycle for any new plasma monitor before calibration.

Calibration Steps

A 250-hour pre-aging cycle is strongly recommended for all new Panasonic plasma monitors. This pre-aging cycle is built in to Series 11 and later models, and is accessible from the menu.

After the panel has been aged, the first step is to turn on your plasma monitor and let it warm up. This brief idling period will stabilize the monitor and result in a more accurate calibration. A full-screen, 50% white test pattern should be used during this idling period. Do not use a 100% white test pattern.

Before calibration, you should select Standard or Cinema modes from the list of factory image presets. The Dynamic preset will present the brightest images, but the gamma response of the display is very non-linear in this mode, typically resembling an S-curve. This means the display comes slowly out of black, then rises too quickly towards white before clipping the highest levels of white. Choose a gamma setting of 2.2 for initial calibration.

Disable any image enhancements such as dynamic gamma and AGC modes. These will have a negative impact on gamma performance.

The only significant difference between Standard and Cinema modes will be the starting point for color temperature adjustments. In Standard mode, the color of gray is set by the factory to $\pm 7500\text{K}$, while in Cinema mode, it is much lower, ranging from 5800K to 6000K. There is enough range in the Red/Green/Blue high and low adjustments to raise or lower the measured color temperature to the normal 6500K target for video imaging.

One suggestion is to calibrate both presets and use Standard as a video (2.2 gamma) viewing mode, while Cinema (2.5) gamma can be used to preview content mastered for digital cinema projection. A third factory preset mode (Monitor) presents images that are much dimmer, but are supposed to emulate SMPTE theater brightness levels – approximately 14 ft-L, or 50 cd/m².

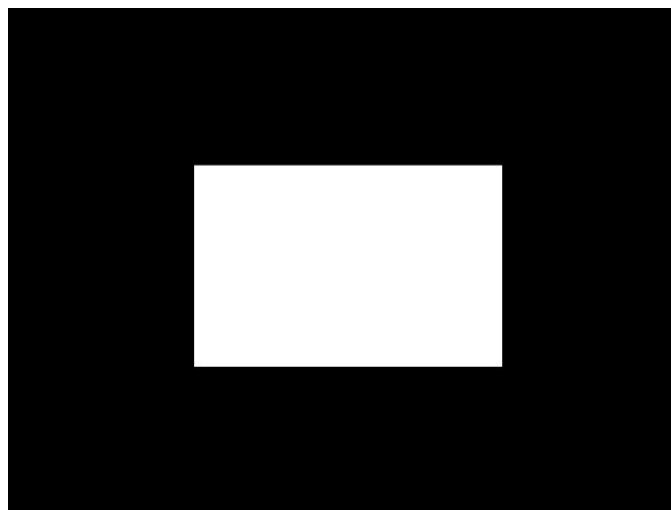


Figure 4. A small-area 100% white window, used for peak brightness calibration.

Adjusting Dynamic Range – White Level

While plasma monitors are capable of very high luminance readings from small area 100%-white windows (over 180 cd/m² or 52 ft-L), their gamma performance is not stable at such high brightness levels.

A good target is a peak small-area brightness reading of 100 cd/m², which is equivalent to 29.23 ft-L. The colorimeter is set to take a simple luminance reading, and a small area 100%-white test pattern is used to set peak brightness. Note that the monitor's Picture (Contrast) adjustment is used here, not the Brightness (black level) adjustment.

Although 100 cd/m² is a useful level, plasma monitors are capable of higher peak brightness levels while maintaining stable gamma performance. In practice, a maximum brightness value of 120 to 130 cd/m² can be used (35 to 38 ft-L) before gamma performance begins to suffer. However, this peak brightness level is much higher than that recommended for professional video monitors by standards organizations such as SMPTE.



Figure 5. PLUGE pattern, showing logarithmic grayscale (right) and 5% white bar (left).

Adjusting Dynamic Range – Black Level

The next step is to set the display's black level. This is done with the Brightness (black level) adjustment and a suitable test pattern that conforms to the black set-up level of the content being displayed. Black can be set either at 0 IRE (0 on a 0-255 RGB scale), or 7.5 IRE (16 on a 0-255 RGB scale).

A PLUGE test pattern is generally used to set black level. This pattern consists of a four-step logarithmic grayscale on the right, and two black bars that represent levels above black that measure 2.5 and 5%, respectively, when generated from an RGB video card.

When originating from a true video pattern generator, the 2.5% bar is actually below black, as the value of video black is 7.5 IRE. So the black setting on your plasma monitor is dependent on your video/RGB source and the value of black setup.

Note that the white (contrast) setting is not touched during this part of the calibration. What you are doing is setting the upper and lower limits of the monitor's dynamic range, i.e. the lowest level of black and the highest level of white. Make sure that any image enhancements are turned OFF in the image adjustment menu, such as dynamic contrast and picture AGC. These will cause the levels of black and white to vary dynamically with content.

Measuring Dynamic Range And Gamma

At this point, it's a good idea to measure the dynamic range and gamma of the plasma monitor. This can be done in 10 IRE steps with software that plots the resulting gamma curves automatically. The resulting plot will show the lowest luminance level (black), the highest level (white), and how the display comes out of black. Software such as ColorFacts will have "wizard" applications to run these measurements automatically.

The goal is emulate the performance of CRTs and come as closely as possible to standard gamma curves, such as 2.2 for video and 2.6 for digital cinema. Although individual gamma correction for red, green, and blue channels is not included in the standard picture menu, adjusting the black level setting in combination with one of the gamma presets will result in a slightly steeper or shallower climb out of black.

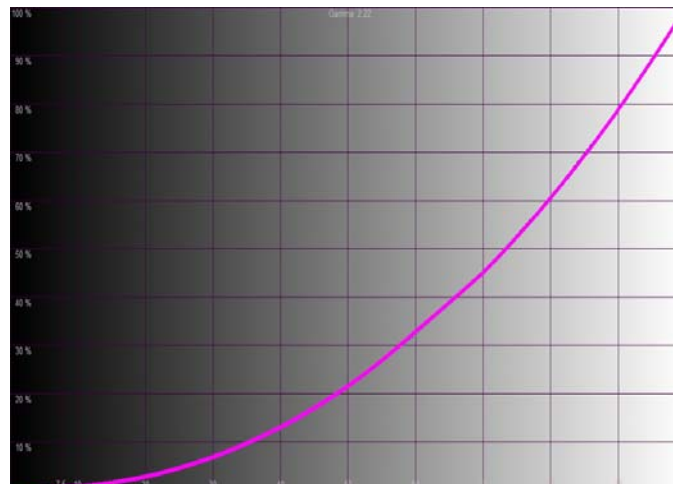


Figure 6. Luminance histogram for a TH42PF11UK, after calibration. Gamma calculates to 2.22.

The resulting gamma curves should arc correctly towards white with no evidence of clipping or white crush. If either is seen, the contrast control must be turned back to reduce peak brightness. Then, run a grayscale step measurement series again to verify consistent gamma performance.

Once a satisfactory gamma curve (or curves) has been achieved, the next step is to adjust the color of white.

Calibration Of Color Temperature

On CRT monitors, there are usually two sets of controls for adjusting color temperature. One set controls individual gain (contrast) for the red, green, and blue channels, while the other set controls bias (cut) for red, green, and blue. Gain (or High) is used to make adjustments in the upper end of the grayscale (40-100 IRE), while bias (or Low) is used below 40 IRE.

Because plasma uses a pulse-width switching mode to create images, there really aren't any gain and bias controls per se. Instead, there are High and Low settings for each primary color. Picture information is reproduced on a plasma display by the use of sub-field addressing, even though the voltages in the priming charge, addressing, sustain, and clearing cycles remain constant.

As a result, the Low adjustment has much less of an effect than the High adjustment for each primary color. Even so, it's still possible to get consistent tracking of a specific color temperature just above black to full white, with a variation of 250 Kelvin from 20 IRE to 100 IRE not unusual. This performance is consistent with evaluation-grade CRT monitors.



Figure 7. Small area windows at 20 IRE (left) and 80 IRE (right).

Setting High Color Temperature Values

To start, select a near-white small area window, such as a 70 or 80 IRE pattern. Attach the sensor to the screen so it is centered in the window. Next, launch the colorimeter software that reads out x,y coordinates for the color of white, using 6500K as the target value. Set the color temperature on the plasma monitor to Normal as a starting point – this will run a little on the cold side, above 7000 Kelvin.

Watching as the color temperature reading updates continuously, adjust the High controls for red, green, and blue individually to come as close as possible to the desired locus of .313x and .329y. There will be some interaction between these drive adjustments.

It's also very helpful to run an RGB level histogram simultaneously while making these adjustments. The histogram will show the levels of red, green, and blue change as you make adjustments to the white point. This makes the process more intuitive.

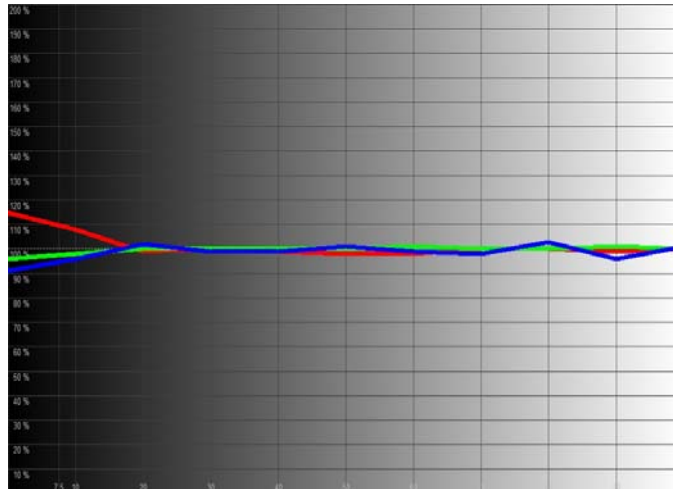


Figure 8. Color temperature histogram for a TH42PF11UK, showing RGB levels across the grayscale.

Setting Low Color Temperature Values

Once you have calibrated the High settings, switch to a 20 or 30 IRE small area window and repeat the process, this time using the Low adjust controls for red, green, and blue. Note that you will likely see much wider swings in color temperature with incremental adjustments to each color channel. This is normal. You may not be able to get as close to D6500 in Low modes as you can with High settings.

Once again, an RGB levels histogram will move this process along much more quickly. It will also prevent you from making erroneous, gross corrections to one or more color channels as you work towards a neutral gray value. Also, the two sets of controls will interact with each other, and you will probably see that your High settings will need to be adjusted again after you have calibrated the RGB Low settings.

Measuring Color Temperature (Grayscale) Tracking

After you have completed your adjustments, run a grayscale tracking wizard to see just how closely your plasma monitor tracks to 6500K. You can also do this step-by-step, starting at black (typically 7.5 IRE on most generators) and moving to 10 IRE, then up to 100 IRE in 10 IRE steps. Some programs will plot gamma, color temperature tracks, and RGB histograms for you, all at the same time.

If you are satisfied with the results, you can move to another image preset mode that you'd calibrated for a different gamma curve, and repeat the High-Low RGB adjustment process. Don't be surprised to see large shifts in color temperature at both ends of the grayscale, as you select different gamma settings.

Save your settings after completion. They will be retained in memory even after the display is powered down. It's also a good idea to write down your settings and keep them with the owner's manual. If your colorimeter charts can be printed out, make a color copy and keep those on hand for reference when doing future calibrations.

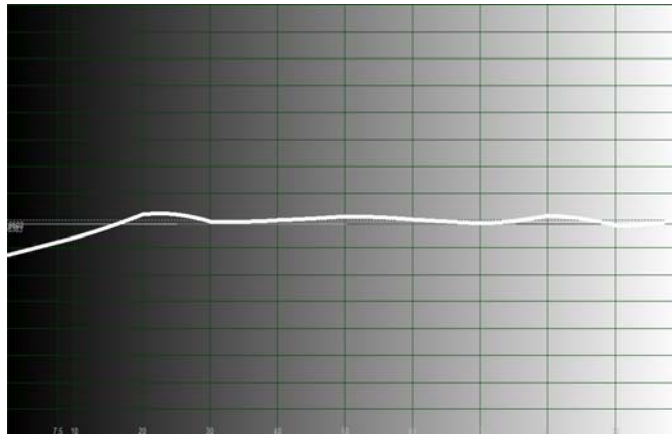


Figure 9. A color temperature histogram (white) for a TH42PF11UK, overlaid on the desired 6500K target line.

Calibration For Video Inputs

This calibration involves setting color saturation and hue for SD and HD input signals. Note that hue adjustments may not be possible with digital inputs, such as SDI, HD-SDI, and DVI/HDMI.

You will need a color bar test pattern to make this adjustment. Connect the test pattern generator to the input you want to use, in the same analog or digital signal format. Also, match the resolution of test pattern generator to that of the input signals you will be connecting to this input.

Bring up the color bar test pattern. Looking through a blue filter, adjust the plasma monitor's color saturation control until the long and short white and blue bar segments exhibit uniform intensity from top to bottom. Next, adjust the hue control until the short and long magenta and cyan bar segments are equal in intensity.

At this point, the saturation and hue levels are set correctly. Note that these are different adjustments than those made for color temperature and white balance.

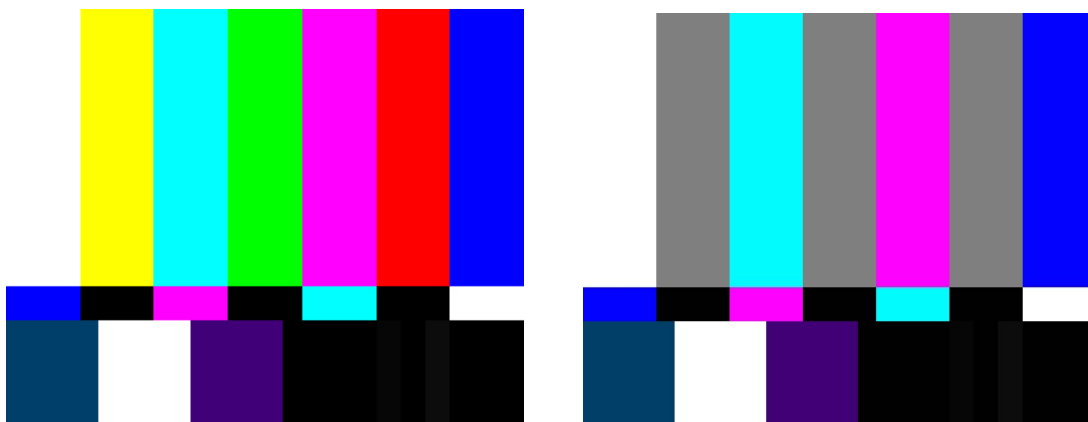


Figure 10. Full color bar pattern (left) and color saturation and hue adjustment bars highlighted (right).

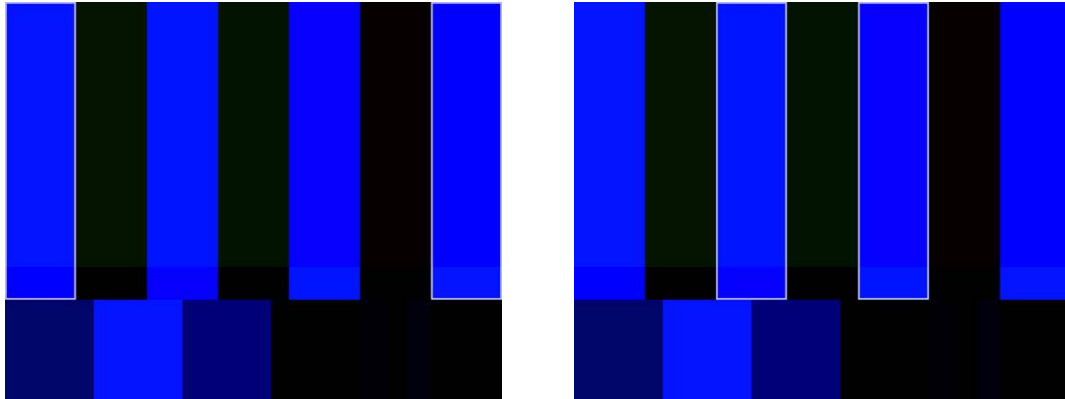


Figure 11. Outlined areas show bars to adjust for color saturation (left) and hue (right). When set correctly, the saturation and hue bars will have the same intensity from top to bottom.

Additional Measurements And Calibrations

Contrast: Using a checkerboard pattern, you can take an ANSI (average) contrast reading and calculate a realistic intra-scene contrast ratio. Log the eight white square readings; add them, and then take the average. Repeat this process for the eight black squares. Note that the black readings will take longer, due to the lower sensitivity of the measuring instrument.

Now, divide the average black reading into the average white reading to determine the ANSI contrast ratio. You can also calculate a peak intra-scene contrast ratio by dividing the lowest black reading into the highest white reading.

If a 50/50 white/black test pattern is available, you can calculate peak contrast that way. Take a measurement near the center on the white side, and then repeat on the black side. Divide the black into the white for the results. Sequential contrast readings involve measuring a quiescent screen (powered on, but no signal present) and then a 100% white, small area window. Divide the black reading into the white reading to get a sequential contrast calculation.

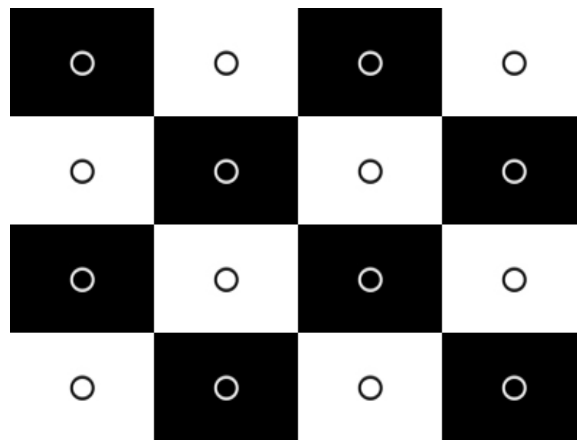


Figure 10. A 16-block checkerboard contrast test pattern, showing measuring points.

Tip: When measuring levels of black and also when running a grayscale wizard series to determine gamma performance, RGB histogram, and grayscale tracking, make sure that ambient light is kept away from the sensor as much as possible. One way to do this is to drape the front of screen with light-absorbent, largely opaque material, such as thick velvet stipple fabric. Cover the entire screen and the colorimeter sensor, then take your readings.

Frequency Response: You can use a luminance multiburst pattern to check frequency response up to 1920x1080 pixels. This will usually involve a pattern with a frequency above 30 MHz. It may also be one of any test patterns that start at lower frequencies and move upwards. The fine delineations between the black and white transitions should be visible at this frequency, particularly when using a digital video signal interface (SDI, DVI, HDMI).

Tip: Make sure the plasma monitor is in pixel-by-pixel (1:1) mode before checking frequency response with a 1920x1080 test signal. Otherwise, the multiburst test pattern will not appear correctly.

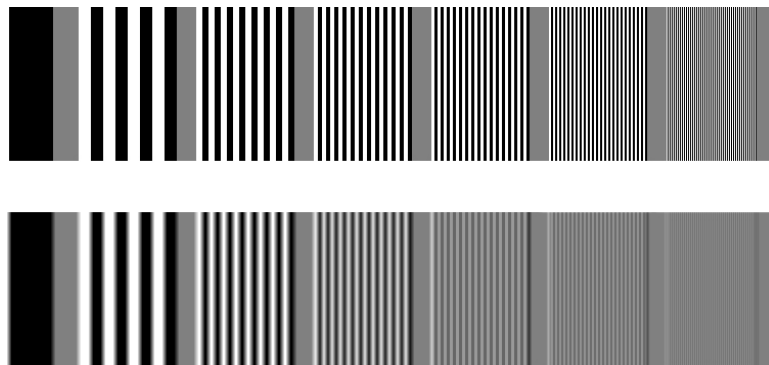


Figure 11. Luminance multiburst patterns, showing full frequency response (top) and high-frequency roll-off (bottom).

Brightness And Color Temperature Uniformity: You can measure the consistency of both brightness and color temperature across your screen with a colorimeter. Take measurements with a full white test pattern, allowing about five minutes for any AGC circuitry to settle. Divide the screen into nine imaginary sections and take a combined luminance and color temperature reading in each.

Add the readings and determine the average of all. Divide that by the brightest reading, which is usually the center reading. The result will be a fraction (less than 1), typically in the high 90% range.

Now subtract the lowest color temperature reading from the highest to measure the total shift across a full white screen. This shift should measure less than 250 Kelvin. Each time you recalibrate the monitor, run another series of nine combined brightness and color temperature uniformity readings to check for excessive differential aging of the phosphors. When operated at normal brightness levels, the phosphors should age at a consistent rate across the screen.

Tip: It is normal for many image adjustments to interact with each other. This effect is most pronounced when adjusting red, green, and blue High and Low settings, but you may also see interaction between contrast and brightness adjustments, particularly when setting black levels and measuring gamma curves.

