

Plasma versus LCD for Large Screen Monitors

Comparison of Four Top-of-the-Line Flagship Models from Panasonic, Samsung, Sharp and Sony

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Executive Summary

In this report we focus on examining the strengths of Plasma versus LCD displays because many consumers are not aware of a number of significant Plasma advantages. For this study, we focus on the HDTV and Signage market by comparing the top-of-the-line flagship models from Panasonic (TH-50PF10UK), the market leader for Plasmas, and Samsung (LN-T5281F), Sharp (LC-52D92U) and Sony (KDL-52XBR4), the market leaders for LCDs.

We believe that for HDTV and Signage monitors the quality of the image in terms of contrast, color accuracy and lack of artifacts is critical – and that these need to be maintained over a fairly wide viewing angle. What we found were significant color shifts in the LCDs even at small ± 15 degree viewing angles - and the effects are even larger for the new extended color gamut LCDs. We also noticed large increases in black level (up to 4:1) and the even larger decreases in contrast ratio (up to 8:1) for these LCDs at a moderate viewing angle of ± 45 degrees.

On the other hand, Plasma displays deliver very close to true (full) 180 degree viewing angles and there is very little change in brightness, contrast, hue, or color saturation over the entire 180 degree viewing area. The ramification of the LCD color shifts and black level and contrast ratio problems are:

- Even when viewers are seated close together side-by-side, each person will see a different picture with noticeably different coloration on an LCD
- The sweet spot for seeing the best picture on an LCD is only one person wide, even for these top-of-the line LCD HDTVs
- Presentation of customer logos or product details will vary with the viewing position
- Dark scene content details are easily lost due to the drop in contrast with increasing viewing angle
- Extended color gamut LCDs are not be the best choice today for color accuracy vs. viewing angle

Introduction

The four units were set up, calibrated, and compared side-side in a shoot-out configuration, simultaneously showing identical 1080p HDMI high quality all digital content. By exclusively using only top-of-the-line models for the market leaders we are assured of examining the state-of-the-art for each technology and each manufacturer.

Picture Quality and Viewing angle

The discussion that follows is based on viewing tests, which we document with screen photos on page 4, and via spectroradiometer measurements with results presented in the Figures and Tables below.

Plasma Viewing angle Performance: Plasma displays deliver very close to true (full) 180 degree (± 90 degree) viewing angles, the same as traditional CRT monitors. There is very little change in brightness, contrast, hue, or color saturation over the entire 180 degree viewing area.

LCD Viewing angle Artifacts: All LCDs show large viewing angle artifacts. Even when viewers are seated close together side-by-side, each person will see a different picture with noticeably different coloration in both hue and saturation, as well as variations in contrast and black level. This effect is due to the fact that for bright LCD sub-pixels the brightness decreases with viewing angle and for dim sub-pixels the brightness increases with viewing angle, leading to contrast reversal. Since this occurs independently for each of the red, green, and blue sub-pixels, it leads to a rather complex behavior of

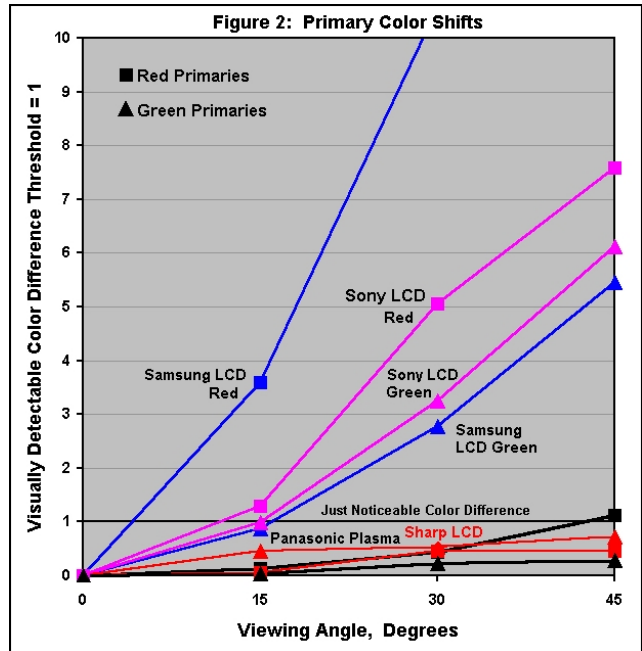
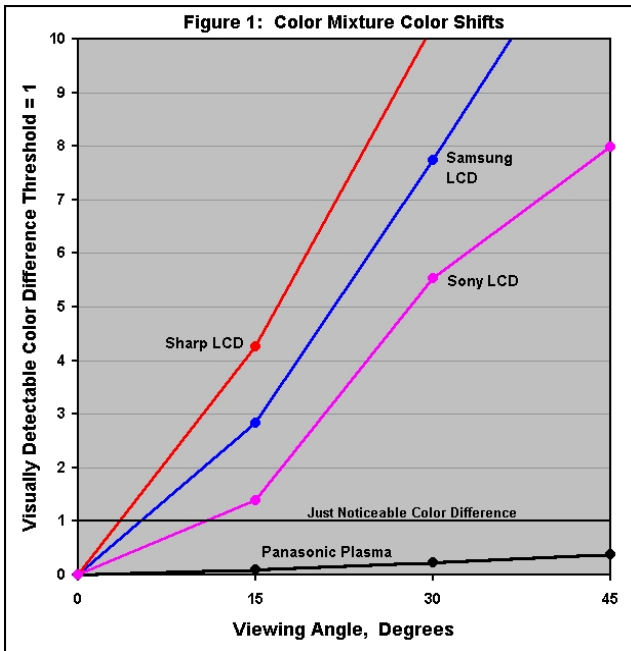
brightness and color variation with viewing angle. Color mixtures show the greatest variations, but displays are engineered so that things balance out for whites and grays. We found that:

- There are clearly noticeable differences at ± 15 degrees and large differences at ± 30 degrees. This is confirmed in both the viewing tests and spectroradiometer measurements.
- The sweet spot for seeing the best picture on an LCD is only one person wide, even for these top-of-the line LCD HDTVs.
- Both horizontal and vertical viewing angles matter. Someone sitting on the floor directly in front of a monitor will see a degraded picture, as will someone standing up looking downward at the screen. Sitting on the floor and off to the side is worst of all.

Manufacturer’s Published LCD Viewing angle Specifications: The wide (full) 176+ degree viewing angle (± 88 degrees) specifications published by LCD manufacturers have absolutely no bearing on the true acceptable viewing angles. This industry specification is based on where the contrast ratio falls to 10, which is unacceptably poor performance because these monitors have contrast ratios of about 1,500 when viewed face on. Furthermore, the eye is much more sensitive to variations in color than the luminance values used to determine the contrast ratio variation. While some pictures with very bright and saturated colors may be considered viewable at ± 45 degrees, more typical pictures that include a wide range of intensities, hues and saturations will appear significantly degraded at much smaller viewing angles.

Extended Color Gamut Effects: LCDs with extended color gamuts (Sony and Samsung units) show additional and much stronger viewing angle artifacts than LCDs with a standard HDTV color gamut. This is because the standard HDTV primary colors must be generated as color mixtures of the extended gamut primary colors, and those color mixtures then vary with viewing angle just like the other colors. As a result a much larger fraction of the HDTV color gamut shows a strong variation with angle. The Sharp unit does not have an extended color gamut and as a result performed much better with bright saturated colors than both the Sony and Samsung units.

Change in Color with Viewing Angle Data: Figure 1 shows the variation in color with viewing angle for each of the tested units.



The eye is more sensitive to reds and greens than blues, so we've picked a sample color with a mixture of 100% red and 50% green to measure and analyze, which is an orange color that has roughly equal luminance contributions from both red and green. The results are based on spectroradiometer measurements and presented in terms of MPCD (Minimum Perceptible Color Difference) or JNCD (Just Noticeable Color Difference), where 1 MPCD = 1 JNCD = $\Delta(u'v')$ = 0.0040 on the 1976 CIE Uniform Chromaticity Scale.

Figure 2 repeats the measurements and analysis for the pure saturated red and green HDTV primary colors in order to examine the effect of Extended Color Gamuts. Results indicate:

- All of the LCDs produce a noticeable color shift at 15 degrees, whereas the Panasonic Plasma display is visually indistinguishable from face on viewing to well beyond 45 degrees
- The LCDs with extended color gamuts show roughly the same color shifts for the primaries as in Figure 1, whereas the Panasonic Plasma and the Sharp LCD, which does not have an extended color gamut, show very small color shifts for the primary colors

Contrast Ratios and Black Levels

While Plasma displays deliver contrast ratios of 3,500 or more and produce very dark black levels, the best LCD panels can still only deliver (true native) contrast ratios of 1,000 to 2,000, which results in much higher black levels and a rather noticeable background glow under reduced ambient lighting. This can wash out the picture and is especially noticeable for images that include dim or darker content. But it gets much worse with viewing angle.

Contrast Ratio and Black Level Data: Tables 1 and 2 show the variation in contrast ratio and black level for each of the tested units at face-on viewing (0 degrees) and at a 45 degree viewing angle, which is a typical viewing angle for both HDTV and signage monitors.

Variation with Viewing Angle: Following the trend of the previous section, the contrast ratios and black levels for LCDs change dramatically with viewing angle, while they remain virtually constant for Plasmas. In fact, at 45 degrees the best of the LCDs has a contrast ratio of 467 while it is 3,502 for the Plasma. The black levels in Table 2 are all for the same peak white luminance of 200 cd/m².

Table 1: Contrast Ratio with Viewing Angle

	0 Degrees	45 Degrees
Panasonic Plasma	3,842	3,502
Samsung LCD	1,877	462
Sharp LCD	1,330	174
Sony LCD	1,344	467

Table 2: Black Level with Viewing Angle

	0 Degrees	45 Degrees
Panasonic Plasma	0.05 cd/m ²	0.04 cd/m ²
Samsung LCD	0.11 cd/m ²	0.28 cd/m ²
Sharp LCD	0.15 cd/m ²	0.61 cd/m ²
Sony LCD	0.15 cd/m ²	0.28 cd/m ²

Dynamic Backlights and Dynamic Contrast Ratios: A new trick for LCDs is to darken the backlight when the video signal is black or near black. Sony and Samsung use this technique. The backlight goes into a standby mode lowering the minimum black level by a factor of 10 or more, thereby increasing the contrast ratio by this same 10X amount. Sometimes it's called dynamic contrast. This does not change the black level or the contrast for any picture that is not all black, so it is meaningless for picture quality. The primary reason for including this feature is that the published contrast ratio goes from 1,500 up to 15,000 to 35,000 or more.

LED Local Dimming Backlights: LCD HDTVs with multi-zone LED dynamic backlights (such as the Samsung unit) can produce very dark black levels. When a portion of the image is relatively dark, the LEDs in that local area of the screen are dimmed, which lowers the black level in that area only. However, objectionable halos appear around bright objects that are embedded in dim or dark surroundings. Also, very dim or dark content is sometimes lost entirely and appears as pure black.

The Dynamic Contrast ratio for this technique is close to infinite when the LEDs are all shut down, but Samsung “conservatively” quotes 500,000:1, which is impressive but the halo artifacts are offensive.

Motion Smear

Motion smear is a well known problem with LCDs. It arises because the liquid crystal is unable to change its orientation rapidly enough when the picture changes, and is most noticeable with moving objects, which appear smeared. The Plasma units have pixels that are digitally switched at frequencies that are much higher than the frame rate, and so do not show any motion smear. Motion smear on the tested LCDs was noticeable only occasionally with both moving text (such as news and stock tickers) and during camera panning (such as many sporting events).

Screen Photos from the Viewing Tests

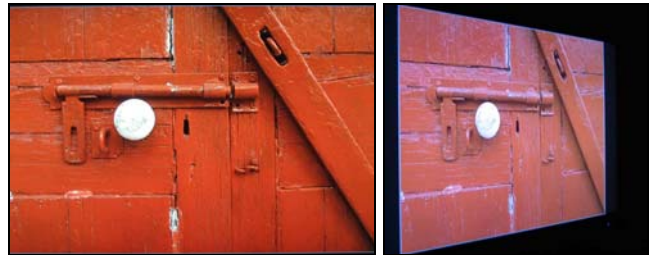
These screen photographs demonstrate the change in color with viewing angle for each of the test units. When viewed in person the differences are much more pronounced than they appear here in these printed thumbnails.

Red Door – On-axis color is good, but shifts to orange in off-angle Sony LCD (Photograph - Don Cochran)

Panasonic - PDP



Sony - LCD



Girl with Painted Face – Notice the change in the skin color in the off-axis LCD (Photographer Steve Kelly)

Panasonic - PDP

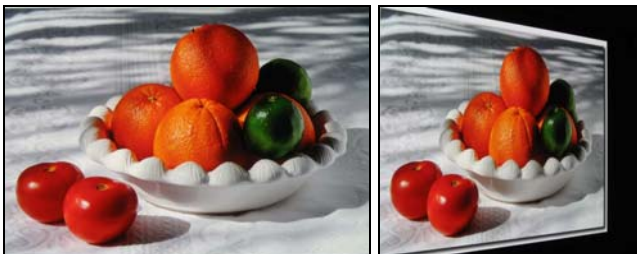


Sharp – LCD



Spanish Oranges – Notice the oranges change color and look like pinkish grapefruits in the off-axis LCD (Photographer Sergio Parisi)

Panasonic - PDP



Samsung - LCD

