

POYNTON'S VECTOR 11 AMOLED displays

I recently attended the Hollywood Post Alliance (HPA) Tech Retreat; I presented a half-day seminar, *Studio Reference Displays*. Some of the topics that I discussed will be familiar to readers of *Poynton's Vector*. In Issue 5, I described how I am retraining myself to use the phrase *studio reference display* instead of *broadcast video monitor*. In issue 6, I lamented the demise of the CRT as a reference display. However, things are looking up. At HPA, Dolby (again) demonstrated their Professional Reference Monitor, which incorporates a spatially modulated backlight (which in Asia would probably be called local dimming). They have demonstrated it at previous events; this time, it's close to commercial availability.

Considering the part number prefix *BVM* (*broadcast video monitor*), Sony apparently didn't take to heart my suggestion to adopt anew acronym. See Issue 5.

As exciting as the Dolby display was Sony's demonstration of a 24.5-inch AMOLED studio reference display. It has a part number, BVM-E250, and it is expected to be commercially available in May, for a few tens of thousands of dollars. It comes from a new factory that has been quoted as requiring an investment of \$200M (US). Clearly, Sony can't recoup that investment from professional markets alone: We can expect this display technology to be introduced into consumer electronics.

About 3 years ago, shortly after discontinuing CRTs, Sony introduced the BVM-L230 reference display. The L230 comprised an LCD panel with an RGB LED backlight unit. The introduction event took place in a dark room where two L230s were placed alongside a reference-grade CRT BVM; all were displaying the same picture. The visitor was challenged to identify which was the CRT. You could argue that the source material was carefully chosen, but in my opinion the Sony engineers quite successfully managed to get the L230 to mimic CRT behaviour. However, the L230 emitted about 0.15 nt when driven with reference black signal level (equivalent to a contrast ratio of about 700:1): The blacks weren't very black, and studio users weren't too impressed. The L230 model didn't do very well, and it was shortly followed by a somewhat improved model – the BVM-L231 – which still didn't produce blacks adequately dark for mastering content.

Sony's 3-display setup was repeated at HPA for the E250 demonstration; however in this case it was interesting that Sony made no attempt to mimic the studio CRT black level of about 0.03 nt (a contrast ratio of about 3000:1): When the video signal goes to reference black level, an AMOLED emits no light; the display is pitch black. The AMOLED images were quite different from those on the CRT.

The luminance produced by code 0 is relevant to the appearance of displayed pictures. Code 1 is also relevant. Let's compute:

Eq 11.1
$$\left(\frac{1}{255}\right)^{2.2} \approx 0.000\,005\,077 \approx \frac{1}{197\,000}$$

Eq 11.2
$$\left(\frac{1}{219}\right)^{2.4} \approx 0.000\,002\,415 \approx \frac{1}{400\,000}$$

Eq 11.3
$$\left(\frac{1}{858}\right)^{2.4} \approx 0.000\,000\,091 \approx \frac{1}{11\,000\,000}$$

The first equation calculates the relative luminance expected from the 8-bit sRGB code value used in personal computers, assuming 2.2-gamma and no ambient light. Code 1 (on a scale of 0 to 255) has equivalent contrast ratio of about 200 000:1. In any reasonable viewing environment, no one could be expected to see that light.

The second equation calculates the relative luminance expected from the HD or SD 8-bit code values typical of consumer equipment, assuming 2.4-gamma, and again assuming no ambient light. Code 1 (now on a scale of 0 to 219) has equivalent contrast ratio of about 400 000:1. Again, no one could be expected to see code 1.

The third equation calculates the relative luminance expected from 10-bit studio video coding, with the same assumptions. Equivalent contrast ratio is 11 million to 1. Again, no one can see code 1.

Digging deeper into the visibility of video signal codes, we can ask, what is the ratio of luminances produced by codes 1 and 2?

Eq 11.4
$$\frac{\left(\frac{2}{219}\right)^{2.4}}{\left(\frac{1}{219}\right)^{2.4}} = 5.278; \quad \frac{\left(\frac{22}{219}\right)^{2.4}}{\left(\frac{21}{219}\right)^{2.4}} = 1.118; \quad \frac{\left(\frac{219}{219}\right)^{2.4}}{\left(\frac{218}{219}\right)^{2.4}} = 1.011$$

At the left is the answer for the 8-bit consumer video situation. The luminance ratio between the first two codes is about five to one: Going from code 1 to code 2 multiplies the luminance by five. At first glance, that factor is surprisingly large; however, it turns out to be entirely consistent with the behaviour of vision at very low luminances. As code value increases, the ratio diminishes; at code 22 (about 10% video level), the luminance ratio between adjacent video codes is about 1.1, and at reference white, the ratio has fallen to about 1.01 (the nominal one percent *Weber contrast* of vision science).

The traditional power law of video is well matched to perception, even at eight bits. But, home theatre calibrators know that 8-bit plasma panels – the very early ones – performed very poorly, exhibiting severe banding artifacts. Why? They were 8-bit *linear light* devices. The luminance ratios between adjacent panel driving codes didn't match visual perception. The solution for PDPs was to increase the bit depth driving the panel – and to add spatial and/or temporal dither.

For AMOLED displays, one open question is this: What is the native "law" by which the OLED driving codes are translated to luminance? I could tell from examining the BVM-E250 images that its characteristic wasn't linear. However, it's highly unlikely that AMOLEDs exhibit the power-function behaviour of CRTs. When I find out, and piece together the implications for image quality, I'll let you know! 🎲

Here I use video code level 0 for reference black and code 219 for reference white. You might be expecting codes 16 and 235, but those are *interface* codes. Calculations such as mine are greatly simplified if the interface offset of +16 is first subtracted. See Issue 4.

POYNTON, CHARLES (2009), "Perceptual uniformity in Digital Imaging," in *Proc. Gjøvik Color Imaging Symposium* (GCIS 2009): 102–109.