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6 The demise of the CRT

Last month, I outlined my argument that the historical term "broadcast video monitor" is archaic and misleading; I proposed that we should say "studio reference display" instead. A more serious problem than terminology is that studio-grade CRTs are no longer available, having been discontinued by professional equipment manufacturers.

CRTs were heavy, bulky, and power hungry; alternatives to overcome those advantages have been sought for a long time. In the consumer market, many alternatives are available, primarily LCDs and PDPs.

Wikipedia (2010), *Restriction of Hazardous Substances Directive*, <http://en.wikipedia.org/wiki/Restriction_of_Hazardous_Substances_Directive>).

The direct cause of the withdrawal of CRTs from the studio market was the introduction, in 2003 in Europe, of regulations to minimize or eliminate the use of lead in electronic devices, an initiative known as *Reduction of Hazardous Substances* (RoHS, often pronounced "roze" or "ro-haws"). Lead is a hazardous substance; lead was very widely used in solder in all electronic devices. Solder without lead has a high melting point, and electronic products have to be reengineered to accommodate changes to the manufacturing process in order to use lead-free solder. In addition to lead in solder, CRTs used lots of lead in the glass tube itself, to absorb X-rays (and perhaps also to improve the optical properties of the faceplate). Presumably, studio CRT display manufacturers could have reengineered their CRT products to conform to RoHS standards. However, manufacturers apparently concluded that LCD displays achieving studio quality were right around the corner, so instead of reengineering their CRT-based products, they developed and commercialized what they deemed to be studio-grade LCDs.

Predictions of the performance of studio LCD displays were wrong. The first studio LCD products did not attain the visual performance of CRTs, and nearly all studio engineers agree that CRT performance is not reached even today in the latest models of LED-illuminated LCD studio displays. LCD contrast ratio isn't high enough (that is, blacks aren't dark enough), LCDs have poor luminance and colour uniformity on flatfields, and LCDs suffer viewing angle problems. Meanwhile, the gold-standard BVMs are aging and dropping, one by one, out of use. Studio engineers are faced with a vexing problem: On what display do you approve HD content?

The main purpose of a studio reference display is to mimic the best possible display in the consumers' premises. At first glance you may think that goal can be achieved by mastering on high-end consumer displays! However, even if consistency were to be achieved in consumer panels, there is a huge diversity in consumer-class signal processing. Also, consumer manufacturers are not motivated to provide faithful display of the image data; they are motivated to sell TV receivers. CE manufacturer seek to differentiate their products from those of their competitors. Consumer displays are inconsistent, so they cannot serve as reliable references for mastering.

Most studios are limping along at the moment with whatever BVMs remain operational, typically running at 80 nt white to extend the lifetime somewhat compared to the more desirable 100 nt. Some studios are mastering on the new breed of LED-backlit-LCD studio displays, but as I have mentioned most studio engineers declare these displays to have unsatisfactory performance. One prominent studio masters using a D-cinema grade DLP projector, set to BT.709 primaries; that's an excellent solution, although an expensive one. Some studios are now mastering using industrial-grade plasma displays, but custom colour-mapping machinery is required to bring the plasma gamma to a 2.4-power function; to bring the plasma primary colours into reasonably good conformance with BT.709; and to suppress any non-additive colour behaviour that may be found as a consequence of poor signal processing. Another complication is the luminance loading of plasma displays: When a full reference white flatfield is presented to the display, luminance drops according to a total power limit that corresponds to perhaps 35% of the small-field reference white.

I hope that acceptable studio-grade direct view displays become commercially available fairly soon. In the meantime, there's no viable technology-independent standard for a studio reference display. Disregard the potentially hundreds of variations of signal processing and display differences among consumer TV models, and consider a modest variation in consumer display and viewing conditions. Imagine three different consumer display luminances – say 100, 200, and 400 nt – and three different surround conditions – dark (1%), dim (5%), and average (20%). It is unreasonable to expect that programs should be mastered in nine versions, one for each of these conditions. Instead, content is mastered in one condition: 100 nt at 1% surround. That mastering condition should be built into a new studio standard. In my view, a display EOCF power ("gamma") of 2.4 is appropriate, and reference black video (code 16 at an 8-bit interface) should result in a luminance of about 0.03 nt.

A diversity of mastering displays are in use today, and it seems to me that no single display technology will dominate the future like the CRT did in the past. It remains a complex topic to determine how image appearance changes as a function of different display and viewing conditions, but it is clear to me that the HD community desperately needs a single, worldwide, technology-independent studio reference display standard. Your comments are welcome! ■