

REPORT ITU-R BT.2129

**User requirements for a Flat Panel Display (FPD) as a Master* monitor
in an HDTV programme production environment**

(2008)

Introduction

Flat panel displays will replace CRT based master monitors in TV programme production, and monitoring, it is therefore urgent that a set of user requirements be addressed. Flat panel displays have recently shown display performance closely emulating that of the CRT, as with most technologies the performance characteristics improves over time. It is the aim of this Report to be technology agnostic, although it should be remembered that certain technologies have characteristics that can not be ignored.

As of this writing, technologies such as Plasma, LCD, and FED may all be contenders for consideration as Master monitors. In all cases, commercial products may well vary in their performance, generally based on price.

In developing this Report the following assumptions are being made:

- 1 A master monitor is a measuring instrument of image quality in TV programme production. The purpose of a monitor is to faithfully and reliably display the signal as it is, and it must not attempt to “enhance” or otherwise alter the image. To do this, the input signal should be subjected to as little signal processing as possible.
- 2 A FPD will be used in the same way as a CRT master monitor in daily operation of TV programme production.
- 3 The focus of this Report is the display of HDTV images.
- 4 Recommendation ITU-R BT.709 was developed based on the assumed characteristics of CRT monitors (ex. colour gamut, gamma characteristics). Master monitors play a critical role of being utilized as a measuring instrument which displays the image in accordance with the specification of Recommendation ITU-R BT.709. FPD when used as a master monitor should have the same or similar characteristics as those of the CRT.
- 5 The input signals should have 10 bit pixel depth.

* The term Master monitor is also called Reference monitor, or Grade 1 monitor in different regions.

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1 User requirements – Image quality

In reviewing the user requirements, the reader should be cautioned that the parameter values noted are a moving target and the performance will no doubt be improved over time.

1.1 Peak luminance/all-white luminance

When a luma signal of level 940 (100% white) is input, the display should be adjusted so that the peak luminance on the screen can be set at any luminance level within the range of 100 to 250 cd/m².

When a luma signal of level 64 (black) through 1 019 (109% white) is input, grey scale tracking should be performed on each level between level 64 and 1 019.

The above conditions must be met for a colour temperature of 6 500 K (D65) (in some regions the above conditions must be met for a colour temperature of 9 300 K (D93)).

ABL (Automatic Brightness Limiter) function if provided should be disabled.

1.2 Black

When a luma signal of level 64 (black) is input, the luminance level on the screen should be less than 0.01 cd/m².

Measurement for this item must be conducted after adjustment of the display using the PLUGE test signal specified in Recommendation ITU-R BT.814, in case of LCD monitors, neither automatic nor manual control of backlight intensity should be active during the measurement of black level. This measurement may prove to be difficult under some conditions.

1.3 Contrast ratio

Contrast ratio should be more than 350:1.

The FPD is adjusted using the PLUGE test signal as specified in Recommendation ITU-R BT.814 so that the luminance setting of the 100% white part on the screen becomes 100 cd/m². Then, contrast ratio is measured as the ratio between the luminance of the part displaying 100% white (luma signal of value 940) on the screen, and that corresponding to displaying only the black level (luma signal of value 64) in a completely dark room when the signal specified in Recommendation ITU-R BT.815 for measurement of contrast ratio is input. Neither automatic control nor manual control of backlight intensity should be active during the measurement of contrast ratio.

1.4 Gamma characteristics

The gamma characteristics (electro-optical transfer characteristic) of the display should be equivalent to those of a reference CRT. The value for Gamma is still under discussion, the intent is that the final value should emulate the CRT or at minimum produce image characteristic that closely match the CRT.

Appendixes A and B – These appendixes reflect the finding of two industry bodies that have been investigating this issue. This information should be considered informative. It is expected that further information will be available in 2008/2009.

1.5 Tone reproduction (Grey scale)

Grey scale tracking in R , G and B components should be performed with no less than 10-bit precision. Grey scale tracking between colour channels shall be within ellipses defined:

$$\pm 0.0010 \Delta u', \pm 0.0015 \Delta v' \text{ (CIE 1976 chromaticity differences) for luminances from } 1 \text{ cd/m}^2 \text{ to } 100 \text{ cd/m}^2 \text{ and deviation from grey should not be visible for luminances below } 1 \text{ cd/m}^2.$$

The suggested tolerances may need further definition in the range above reference white up to the limit of 109% white (1019).

1.6 Colour gamut

The FPD should display images with the colour gamut specified in Recommendation ITU-R BT.709.

1.7 Colour temperature (White)

The FPD should display pictures with a reference white colour temperature of 6 500 K ($D65$)

$$\pm 0.0010 \Delta u', \pm 0.0015 \Delta v' \text{ (CIE 1976 chromaticity differences) or (in some regions of the world } 9\,300 \text{ K (} D93 \text{) is used)}^1.$$

1.8 Viewing-angle dependency

Deviations in reproduced colour on the screen should not be visible to a human observer when viewing the screen from an angle of up to $\pm 45^\circ$ horizontally and vertically in any direction from the perpendicular axis to the centre of the screen (see Appendix C).

As a guide to an acceptable numerical value, $\Delta u'$, $\Delta v'$ (CIE 1976 chromaticity differences) should be less than 0.01 for any of the colours within the Recommendation ITU-R BT.709 gamut.

As a guide to an acceptable numerical value, the luminance value should drop less than 10% for viewing angles within $\pm 30^\circ$ horizontally, vertically, and diagonally, and less than 20% for viewing angles within $\pm 30^\circ$ and $\pm 45^\circ$ horizontally, vertically, and diagonally.

The black level, when measured from viewing angles up to $\pm 20^\circ$ in any direction from the perpendicular axis to the centre of the screen, horizontally and vertically, $= \Delta u', \Delta v' = < 0.01$. When measured from viewing angles between $\pm 20 - \pm 45^\circ$ horizontally and vertically $= \Delta u', \Delta v' = < 0.02$.

1.9 Motion artefacts

Motion blur on FPD screens should be comparable to those of the CRT, or to a degree at which it cannot be detected. Work continues on decreasing the visibility of motion artefacts. Different FPD technologies require different solutions and produce different artefacts. In addition the refresh rate of FPDs may not be at the same rate as the native rate of the image. Care should be taken to ensure that no difference in motion rendition is introduced.

1.10 Screen resolution

The horizontal and vertical pixel counts on the screen must be equal to the number of active samples per line and the number of active lines per frame of TV system for R , G and B , respectively. The desire is to have a one to one pixel mapping without the use of image scalers. In some cases, scaling may be required in order for the image to completely fill the screen. End users are advised to determine the characteristics of the scaler before performing any critical evaluation.

¹ If the colour temperature is designed for either $D65$ or $D93$ only, the other colour temperature must be realized by signal processing. Under these circumstances, 10-bit precision may not be obtained.

1.11 Image scaling, de-interlacing and overscan

- a) Image scaling should be done in such a way as to avoid the introduction of artefacts, such as excessive ringing, aliases or banding, noise, etc.
- b) It is desirable that monitors display the image in the native interlace or progressive format that is present on the input interface. De-interlacing of interlace images, if equipped, should be able to be turned off.
- c) The default mode should be to display without overscan, that is, showing the full active image area right to its edges. This should be the optimal mode for scaling quality, and often may be one-to-one pixel mapping.
- d) Monitors should offer optional programmable overscan/underscan mode of up to 5%.

1.12 Uniformity

The luminance values measured at many points for each luma signal level on the whole screen should meet the following conditions when the signal of the grey level is input: (the maximum measured value – the minimum measured value)/the average value ≤ 0.10 . This measurement should be performed at a mid grey level, and white level.

1.13 Mura²

Mura should not be visually detected on the screen regardless of reproduced luminance levels or colour saturation. This artefact is not expected to be a problem however in the interest of completeness it is included in this Report.

1.14 Smear³ (vertical and horizontal crosstalk)

When the input signal has a rectangle of luma signal of value 64 (black) or 940 (100% white) near the centre and has a grey area in its surroundings (see Fig. 2), the difference in luminance between the horizontal and vertical belt-like portions and the other grey portions should not be greater than 0.5%.

1.15 Stability

- a) A 30-min warm-up period from a “cold” start should be allowed before any observations or measurements are taken.
- b) After this warm-up time, the measurements shall remain within the specifications given for 24 h.

1.16 Screen size

The screen size of the display is at the discretion of users, but may need to be larger (because of the target viewing distance of 3 times picture height) for adequate monitoring of HD. Production spaces

² “Mura” is a defect that looks like a small-scale crack with very small changes in luminance or colour. “Mura” is likely to be noticeable in the flat portions of images even if the size of the mura is very small.

³ “Smear” is a term for capturing devices with CCD, and it means the phenomenon that a vertical bright bar occurs when such strong light source as the sun or electric bulbs is shot. In case of CRT monitors, when a much brighter or darker spot than the surrounding area causes vertical or horizontal bars, this phenomenon is also often called as smear. The similar phenomenon is called as “crosstalk” for LCD and “image streaking” for PDP. Here, smear means the phenomenon that the data on one part of the display influences what is displayed elsewhere.