Journal of Information Display
Vol. 12, No. 2, June 2011, 85–87

A new contrast ratio measurement method using image patterns

Dongwook Choi*, Sun A Yang, Jaewoo Bae, Seungbae Lee and Ho-Kyoon Chung

Research Institute, Samsung Mobile Display, Kiheung-Gu/Yongin-Si, Gyunggi-Do, Korea

(*Received 11 November 2010; Revised 6 January 2011; Accepted for publication 11 January 2011*)

The contrast ratio is one of the most important performance parameters for display devices. The general method of measuring the contrast ratio is to determine the ratio of the full-screen white pattern to the full-screen black pattern, according to the Video Electronics Standards Association standard. Real TV images seldom have these images, however, and the conventional method does not reflect the true performance of the display in actual use. In this paper, a new contrast ratio measurement method that uses image patterns is proposed, to demonstrate that active matrix organic light-emitting diode TVs have a higher contrast than LED (LCD) TVs.

Keywords: contrast ratio, test method, image quality, TV contents, load ratio, dimming, test pattern

1. Introduction

The rapid development of display technology has brought about serious competition among different technologies and display manufacturers. Therefore, the image quality of the display has become more critical than ever for proving the superiority of displays. The numerical values that are now being used to evaluate image quality, however, do not represent true human perception [1,2]. This contradiction is shown in the contrast ratio, one of the important parameters of display image quality. Since the contrast ratio is measured without considering human perception, however, it can be misleading, because it does not represent the clarity of the display that viewers perceive. The contrast ratio is defined as the ratio of the brightest luminance to the darkest luminance. Full-screen white patterns and full-screen black patterns are generally used to measure it. This method is based on the VESA (Video Electronics Standards Association) Flat Panel Display Measurements Standard v. 2.0 2001-6 [3] (Figure 1).

Images that have complete 100% and 0% load ratios, however, such as full-screen white patterns and full-screen black patterns, are rarely seen on TV. Since the luminance of images depends on their load ratio, even if they have the same gray scale, the full-screen patterns cannot represent the contrast quality. For instance, in the case of the LED BLU (backlight unit) LCD TV that has a dimming function, when the BLU is fully off in a full-screen black pattern, its black luminance differs from the black luminance in an actual image. In other words, the black level in actual images completely differs from the level shown in a full-screen black pattern, despite having the same 0 gray signal. In AMOLED (active matrix organic light-emitting diode) TVs, the full-screen black luminance and the black luminance in actual images also differ due to reflection (Figure 2).

To evaluate the contrast quality, the test method must consider how viewers actually perceive. Moreover, a new test pattern for representing human perception of contrast quality is needed. The new pattern has to have a specific load ratio for reflecting viewers' perception. According to the average picture level (APL) histograms of a test disc and the master video of the International Electrotechnical Commission (IEC), the average load ratio of TV contents is close to 33.6% in the gray scale [4] (Figure 3). This indicates that the new test pattern has to include an approximately 30–40% load in the gray scale. In this paper, a test pattern for the contrast ratio that considers the viewers' perception is proposed based on the data from the IEC.

2. Experiments and results

2.1. Luminance fluctuation with the load ratio

As shown in Figure 2, even if the gray scales are identical, the luminance can fluctuate with the load ratio. Therefore, it is necessary to analyze how the luminance fluctuates with the load ratio for each type of device. Thus, the luminance values of two patterns were measured – one pattern consisted of a black box with a white background, and the other pattern had a white box with a black background – while the box sizes of an LCD TV (LED BLU) and an AMOLED TV were changed (Figure 4).

*Corresponding author: Email: bran61.choi@samsung.com

ISSN 1598-0316 print/ISSN 2158-1606 online

DOI: 10.1080/15980316.2011.567819
http://www.informaworld.com

$$C = L_W / L_B$$

Figure 1. General contrast ratio measurement pattern (VESA Flat Panel Display Measurements Standard v. 2.0 2001-6).

$$L_{fb} \neq L_{rb}$$

Figure 2. Black luminance difference with images.

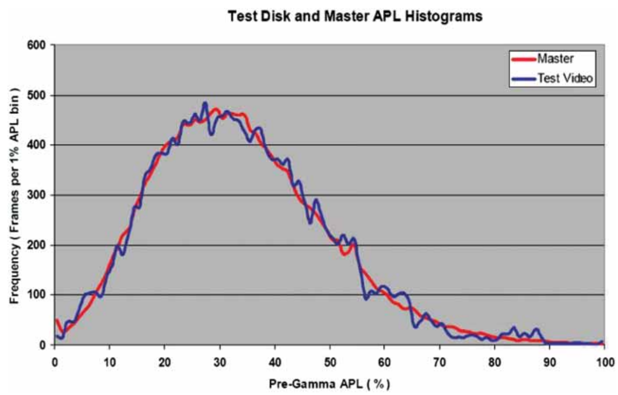

Figure 3. Dynamic broadcast-content video signal APL (IEC 62087: Methods of measurement of the power consumption of audio, video, and related equipment).

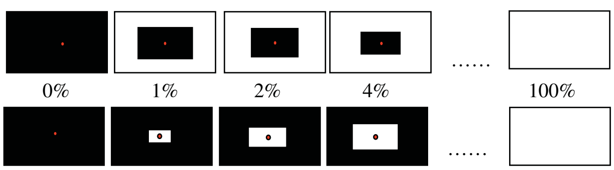

Figure 4. Measured patterns for the analysis of luminance fluctuation with load ratio fluctuation.

Figure 5 shows the results of the test. The two types of LCD TVs showed similar results, in that both the white and black luminance values fluctuated rapidly under a load ratio of 9%. This may have been caused by the dimming function, which controls the BLU in a specific load ratio range, which could be 0–9% depending on the results of the test. Given that the dimming function was activated under 9%, the contrast ratio below and above 9% would differ. In the AMOLED TV, the black luminance stayed almost constant with the load ratio. On the other hand, the white luminance tended to increase as the load ratio decreased due to the peak luminance control, which is a property of a self-emissive display [5].

2.2. New test pattern for the contrast ratio

According to the test results, it was found that the luminance fluctuation tendency can vary with the device type. Thus, an objective-datum load ratio for a contrast ratio test pattern must be determined. As mentioned in the Introduction, the average load ratio of TV contents can be the datum load ratio for this pattern. It is in the range of 30–40%. From this supposition, a pattern was proposed, as shown in Figure 6. The pattern had a load ratio of about 38–42% and consisted of 4% dimensions of white and black boxes with a 40% gray-scale background. Because this pattern is considered characteristic of a standard video for power consumption measurement that is relevant to TV contents all over the world, it can serve as a proper pattern for reflecting what viewers are actually seeing.

2.3. Results

With the proposed pattern, the contrast ratio of each device was measured to compare the results with a conventional contrast ratio through a full-screen pattern. In the results given in Table 1, the black luminance increased regardless of the device type, but the amount of increase differed according to the device type. In the AMOLED TV, the black luminance increased by a factor of 8. The black luminance of the LCD TV increased significantly, however, by 100–400 times. In contrast, the white luminance of the LCD

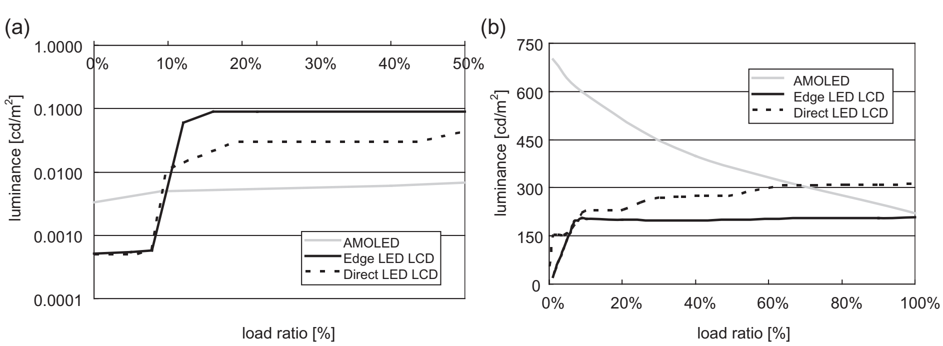

Figure 5. Luminance fluctuation with the load ratio fluctuation. (a) Black luminance fluctuation and (b) White luminance fluctuation.

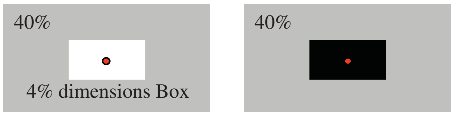

Figure 6. Proposed new contrast ratio test pattern.

Table 1. Contrast ratio comparison with patterns.

Device	Full black (cd/m^2)	Box black (cd/m^2)	Relative change (%)
Black luminance comparison			
AMOLED	0.0005	0.004	800
Edge LED LCD	0.0005	0.06	11,316
Direct LED LCD	0.0005	0.2	40,000
Device	Full white (cd/m^2)	Box white (cd/m^2)	Relative change (%)
White luminance comparison			
AMOLED	194.8	549.3	282
Edge LED LCD	189.7	201.5	106
Direct LED LCD	296.4	306.3	103
Device	Conventional contrast ratio	New contrast ratio	Relative change (%)
Contrast ratio comparison			
AMOLED	389,600 : 1	137,000 : 1	35.1
Edge LED LCD	357,000 : 1	3300 : 1	0.9
Direct LED LCD	592,800 : 1	1500 : 1	0.3

Note: Relative change = New CR/conventional CR.

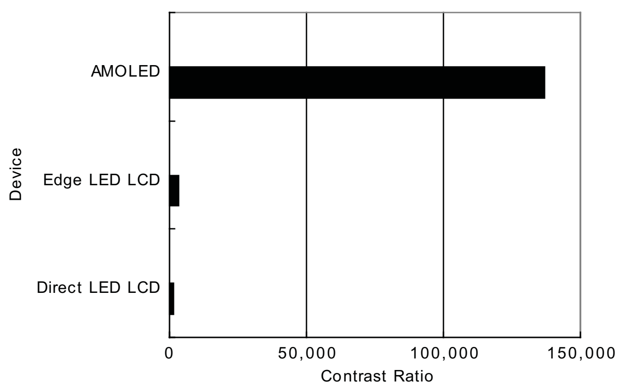

Figure 7. Contrast ratio considering the image pattern for each device.

TV remained at nearly the same level, but was nearly tripled in the AMOLED TV due to the decrease in the load ratio. As the luminance changed, the contrast ratio also changed. The LCD TV showed a contrast ratio at the high end of 300,000–600,000:1 through a full-screen pattern. The result was approximately 1000–3000:1, however, through the new pattern due to the increase in the black luminance, and the contrast-relative change for this TV was less than 1%. In the AMOLED TV, the contrast ratio was also reduced because the black luminance increased. Given that the amount of the increase in the black luminance was much less than that for the LCD TV, and given the increase in the white luminance,the contrast ratio of the AMOLED TV remained at 137,000:1, which is about 50 times higher than that of the LCD TV, even though its relative contrast ratio change was 35.1% (Figure 7).

According to the test results, the contrast ratio specifications varied with the test pattern. Through a pattern that was considered an image pattern, the AMOLED TV showed a much higher relative contrast ratio than any other compared TVs, which implies that AMOLED TVs create the clearest actual image among all new-generation TVs.

3. Conclusion

The contrast ratio, which is one of the most critical image quality parameters for displays, was measured thus far through a full-screen white pattern and a full-screen black pattern. This method, however, does not properly represent the contrast quality that the viewers actually perceive due to the use of a test pattern rather than the images that are actually observed. Therefore, a new test pattern that is based on an image pattern created from the average load ratio of the TV contents was proposed, and the contrast ratios of different devices were analyzed with the new pattern. The results showed that the contrast ratio specifications, as published for viewers, and the contrast ratio that viewers actually perceive are very different in some devices.

As the contrast ratio is a critical parameter of image quality, objective specifications have to be published for viewers. This proposal assists with the creation of more objective specifications. In the future, an image quality test method that considers what the viewers actually perceive has to be developed for objective image quality specifications. It is hoped that this paper will lead to the development of a standard image quality test method that takes human factors into account.

References

[1] E.J. Lee and S.B. Lee, J. KIEE **23** (2009).
[2] S.B. Lee, Korean Inst. Illum. Electr. Installation Eng. **21** (5), 13 (2007).
[3] VESA, *Flat Panel Display Measurements Standard Version 2.0* (2001).
[4] IEC 62087, Methods of measurement for the power consumption of audio, video and related equipment (TA1) 2008.
[5] H. Kageyama, H. Akimoto, and Y. Shimizu, J. SID **13** (5), 447 (2005).