Liquid crystal display having improved response time and image quality by optimizing driving voltage

Chen-Fu Mai[1]
Ying-Hsiang Tseng, and Chun-HSiu Liu
TFT Business Unit, Chunghwa Picture Tubes, Taiwan, R.O.C.
Tel: 886-3-480-5678-7816 ; E-mail:maicf@mail.cptt.com.tw

Abstract

By adjusting driving voltage, the image quality and optical characteristics have been improved. Based on the experiment results. Optical properties including viewing angle and color shifts at bias voltage 2.4 V are better than those of bias voltage 1 V.

1. Introduction

Recently, the extension of the digital TV market has becoming possible with the important technological progress realized in the LCD, FPD and projection technologies. Compared to other candidates, TFT-LCD TVs has the advantages of high resolution, lightweight, slim size and low power consumption. Many new and sophisticated technologies have been developed to widen the viewing angles, to increase the luminosity or improve the color rendering but they still come up short in terms of response time and image quality. [1]

A liquid crystal display has been realized by adjusting the driving voltage difference between the pixel electrodes and the common electrode. The gray scale can be changed. A liquid crystal display device includes a pair of substrate, i.e. a TFT substrate and an opposed substrate. The pair of substrates sandwich a liquid crystal layer. The TFT substrate has a picture element electrode, as showed in Fig. 1c. The picture element slits are disposed in picture element electrode. The opposed electrode or called common electrode is also designed with ribs within a display region. A height of the ribs is designed in a proper thickness. [2] The operation of multi-domain liquid crystal molecules in vertical alignment mode of an LCD panel was illustrated in Fig. 1a and b, respectively. Generally, the first gray is to represent the dark state and the driving voltage named as V9 and V10 are used to represent the driving voltage of first gray level. The 255 gray is used to show the bright state and the driving voltage named as V1 and V18 which are used to indicate the driving voltage of 255 gray level. [3~6]

The purpose of this paper is to adjust the first gray level voltage. Here the bias is used to describe the difference between V9 and V10. By proper adjusting the bias, the response time and image quality can be improved significantly.

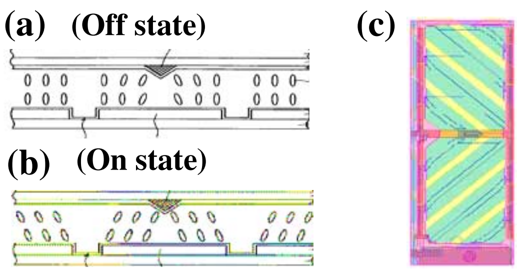

Figure 1: (a) & (b) (prior art) illustrate the arrangement of multi-domain liquid crystal molecules in vertical alignment mode of an LCD panel when a voltage is applied and not applied, respectively. (c) is pixel design diagram.

2. Experimental procedure

The gray scales from 0 to 255 levels can be performed through adjusting the driving voltage from V1 to V9, or V10 to V18. Here Vsh means the saturation voltage, i.e. the V1 or V18. In this paper, the V1 and V18 were set to a specific value. In order to achieve a better performance, various bias were evaluated to improve the optical characteristics and image quality.

2.1. Gamma Voltage

Table 1: The various driving voltage.

Voltage	Vsh=13.8 V bias=1 V	Vsh=13.8 V bias=2.4 V	Vsh=13.8 V bias=2.7 V
V1	13.813	13.824	13.895
V2	13.639	13.589	13.741
V3	11.555	11.488	11.369
V4	10.995	10.895	10.615
V5	10.386	10.181	9.468
V6	9.819	9.577	8.879
V7	9.383	9.273	8.407
V8	7.195	7.785	8.218
V9	6.865	7.765	8.154
bias	0.984	2.411	2.722
V10	5.881	5.354	5.432
V11	5.862	5.335	5.337
V12	4.907	4.779	5.069
V13	4.785	4.646	4.728
V14	4.505	4.438	4.570
V15	3.908	3.931	4.256
V16	3.279	3.297	3.650
V17	1.104	1.124	1.130
V18	0.960	0.975	0.976

The various driving voltage in this experiment was showed in Table 1. The saturation voltage was fixed at 13.8 V, bias voltage of 1, 2.4 and 2.7 were selected. The optical performance like contrast ratio and response time were evaluated by using the EZ-contrast made by French Eldim XL88.

3. Results and Discussion

3.1. The optical of various bias voltage

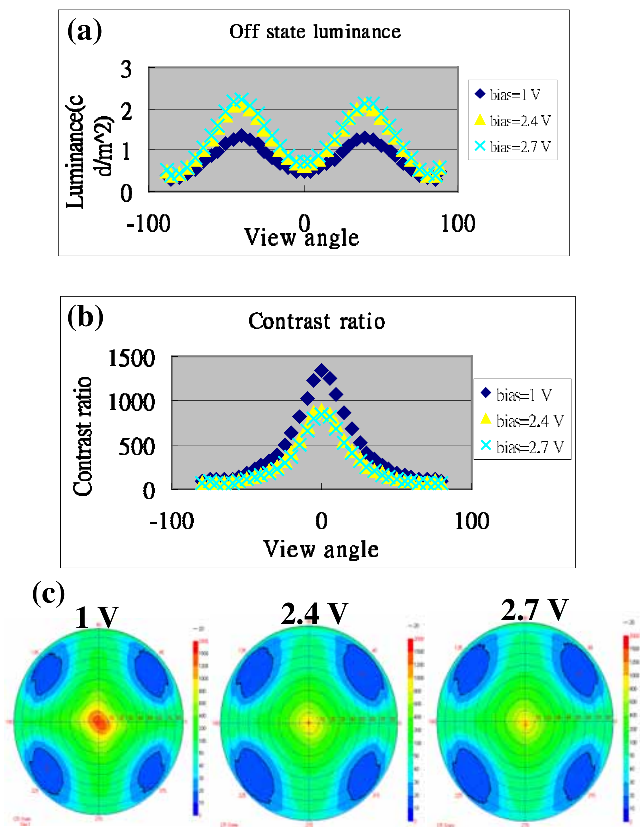

Figure 2: (a) showed the luminance of the panel at dark state. (b) the CR at various bias voltage. (c) the iso-contrast performed for various bias voltage.

As can be seen in Fig. 2, along with increasing bias voltage the luminance of dark state was increased. And the light leakage became serious at the view angle about 50 and –50 degree. Due to the contrast ratio is defined as the ratio of white state luminance divided with dark state luminance. Therefore, with increasing the bias, the contrast ratio would be decreased. The contrast ratio versus view angle for various bias voltage are showed in Fig. 2b. The tendency of contrast ratio changed was verified.

The contrast ratio view cone (or iso-contrast graph) under various bias voltage are showed in Fig. 2c. As can be seen in Fig. 2c the area of contrast ratio under 20 for bias voltage at 1 V is smaller than those of 2.4 V and 2.7 V. Therefore, the contrast ratio in oblique direction at bias voltage 1 V is better than those of 2.4 V and 2.7 V, respectively.

3.2. Response time

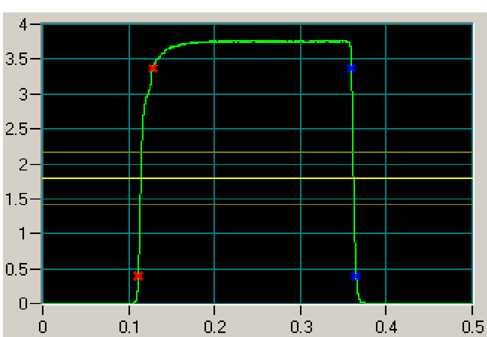

Figure 3: Waveform of response time.

Table 2: Response time of different bias voltage.

Voltage	Tr	Tf	Ttotal
bias= 1 V	17.1	6.8	23.9
bias= 2.7 V	14.1	7.2	21.3

The response time under the bias voltage of 1 V and 2.7 V are showed in Table 2. A schematic waveform for measuring the response time is showed in Fig. 3. The Tr means the raising time and Tf means the falling time. As can be seen in Table 2, with increasing the bias voltage, the response time would be shorten ~ 3 ms.

3.3. Gamma curve & Visual evaluation

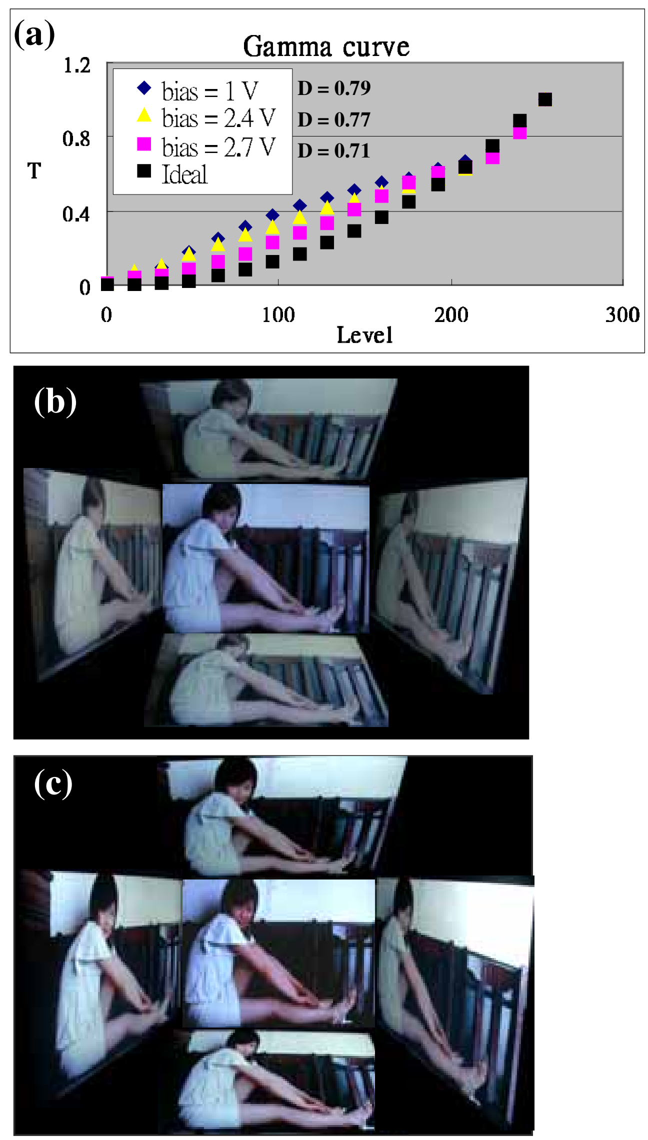

Figure 4: (a) gamma curve at Phi = 0 vs. Theta =60, (b) the visual evaluation result as bias= 1 V and (c) bias= 2.4 V.

Table 3: color coordinates and color temperature.

White		x	y	CT
bias = 1 V	0 °	0.273	0.328	9102
	60 °	0.292	0.348	
bias = 2.4V	0 °	0.276	0.319	9136
	60 °	0.288	0.344	
bias = 2.7V	0 °	0.271	0.325	9332
	60 °	0.290	0.346	

The color performance and gamma curve changes with various bias voltages are showed in Table 3 and Fig. 4a respectively. From Table 3, the higher bias voltage, the higher color temperature. It should be noted that the white point seen to be no difference during adjusting the bias voltage. As can be seen in Fig. 4a, the color shift performance is improved with increasing bias voltage. The D value was used to evaluated the color shift performance which was proposed by Kim et al. 〔7〕 As can be seen in Fig. 4a, the D value for bias = 1, 2.4 and 2.7 V are 0.79, 0.77 and 0.71 respectively. According to the calculation result of D value, the better color shift performance for bias 2.7 V can be realized.

The visual evaluation results are showed in Fig. 4b and c respectively. By comparing the Fig. 4b and c, the bias 2.4 V is more reddish than bias = 1 V. With bias voltage increasing, the picture wash out would be reduced. This is also agreed with the evaluation result of D value. There will be a better oblique visual performance and image quality at bias voltage 2.4 V and 2.7 V. The optimum driving voltage for the TFT LCD can be acquired through these measurement and evaluation results.

4. Conclusions

1. By increasing the bias voltage, the response time can be shortened for some extent.
2. By increasing the bias voltage, the D value would be reduced i.e. the color shift and wash out performance can be improved.
3. By proper adjusting the driving voltage, the optimum optical performance can be acquired.

5. Acknowledgements

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