Development of high image quality and low power consumption TFT-LCD with Data Rendering Innovation Matrix (DRIM)

Kwang Pyo Hong, Jun Ho Lee, Hyeun Joong Yoon, Jin Young Chun, Bong Yeol Ryu, Jung Mok Jun, Jung Yeal Lee

Research Center, BOE HYDIS TECHNOLOGY CO., LTD., San 136-1, Ami-ri, Bubal-eub, Ichon-si, Gyeonggi-do, 467-701 Korea, +82-31-639-8260, hkp0105@boehydis.com

Abstract

High energy-efficiency TFT-LCD supporting a good image quality is developed with Data Rendering Innovation Matrix Technology. The innovative matrix consists of octal sub-pixels and sub-pixel rendering technology enhanced the light efficiency; up to 30%, and reduces the number of column drivers for the same resolution by a third.

1. Introduction

Recently, some papers related to a new pixel layout to improve brightness, image quality and energy-efficiency have been continually reported [1-7]. Such studies are desirable in respect that the light efficiency of TFT-LCDs is very low; typically just 5% of back light brightness. Furthermore, high resolution and low cost have been required continuously.

In this paper, to increase the brightness and resolution of TFT-LCD, we used a new pixel layout with the sub-pixel rendering technology. The applied sub-pixel rendering technology is the PenTile™ technology, which is called DRIM (Data Rendering Innovation Matrix) by us. This technology has already been introduced in SID'02 [7]. This sub-pixel rendering has many benefits such as high brightness, low power consumption, and improved image quality [2]. Power and brightness benefits arise because the sub-pixels are larger and aperture ratio increases. Image quality is improved because higher resolution for a given number of sub-pixels can be achieved.

2. DRIM Sub-pixel Architecture

Figure 1 shows the comparison of the conventional RGB stripe and DRIM L6 sub-pixel arrangement. To increase aperture ratio, the pixel arrangement is designed to be the repeated octal sub-pixels. Green sub-pixels are designed to be the same pixel density to that of the RGB stripe. On the other hand, red and blue sub-pixels are half the pixel density of the RGB stripe panel with same resolution based on the fact that human vision are more sensitive to green color than red and blue color. These sub-pixels including the dark area so-called "black matrix" between sub-pixels allow high aperture ratio and only two third of the number of sub-pixels and column drivers. This design is the more efficient sub-pixel design than any other new pixel layouts or an white-added pixel type in text and color expression.

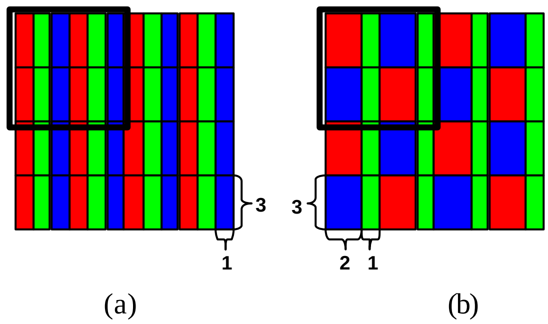

Figure 1. The sub-pixel structure.
(a) RGB stripe (b) DRIM L6

Figure 2 shows two simple examples of the sub-pixel rendering. Green sub-pixels in DRIM L6 coincide with those of the RGB stripe. Thus, they can be expressed directly to DRIM layout without a special data rendering process.

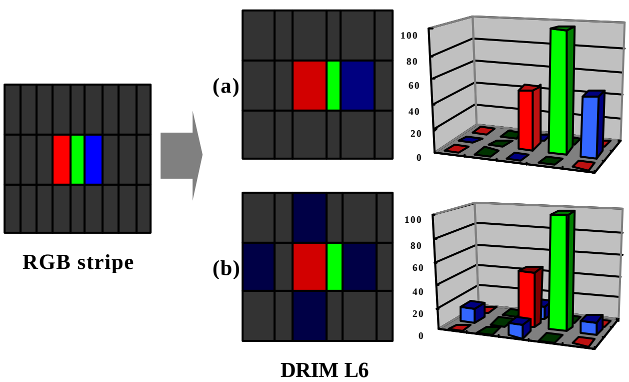

Figure 2. An example of the sub-pixel rendering.

On the other hand, red and blue sub-pixels sometimes are not placed at a suitable position because of half density. In the case of (a), a green sub-pixel is always centered with full luminance on red and blue sub-pixels used two times with half luminance. This is good for character expression. In the case of (b), when red (blue) and green sub-pixels play a role in center with half and full luminance respectively, Blue (red) sub-pixels are used four times with quarter luminance at surrounding. This is advantageous to a photograph or moving picture.

3. Sub-Pixel Rendering Hardware System

Figure 3 shows the DRIM driving system outline. A computer generates a conventional 1024*768 XGA RGB data. The sub-pixel rendering hardware has the FPGA as a scaling graphics controller, DVI input and LVDS output connected to a timing controller board. This system rearranges RGB data to odd and even row data; RGBGRGBG and BGRGBGRG respectively, in two third resolution of XGA (1024*768*2).

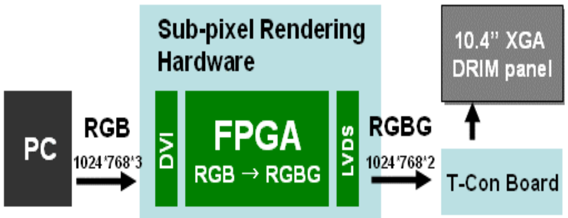

Figure 3. The DRIM driving system.

4. Results

Table 1 summarizes the specification and comparison of the developed DRIM prototype panel and RGB stripe panel. The aperture ratio of the DRIM panel increase to 56% by about 18% compared with the RGB panel, which lead to high brightness and contrast ratio of 240 cd/m^2 and 800, respectively.

Item	Unit	RGB Panel	DRIM L6 Panel
Display mode		FFS/Normally black	←
Pixel pitch (H*V)	μm	68.5*205.5	G: 76.5*205.5 B&R: 129*205.5
Resolution		1024*768*3	1024*768*2
Color Gamut	%	45	←
Brightness	cd/m^2	180	240
Contrast Ratio	Center	600	800
Aperture Ratio	%	47.6	56.2
Transmittance	%	7.08	8.38
Cross-Talk (H/V)	%	1.27/0.64	0.97/0.54
Viewing Angle	Degree	80/80/80/80	←

Table 1. The specification and comparison of DRIM to RGB TFT-LCD panel

The sub-pixels of the DRIM panel are arranged with the repeated octal pattern. This evenly repeated pattern probably induces any combination of polarity not compensated, which cause a horizontal cross talk problem in the case of employing the "dot inversion" commercial source drive ICs [4]. However, the cross talk of the DRIM panel is below 1% not only in a normal test but also in using a vertical sub-line-skipped pattern intended polarity.

Item	Unit	RGB TFT-LCD	DRIM TFT-LCD
Brightness	cd/m^2	180	180
B/L Power	Watt	4.1	3.32
Average Panel Power	Watt	0.46	0.46
Total Power Consumption	Watt	4.56	3.78

Table 2. Power consumption and comparison of DRIM to RGB TFT-LCD panel

Table 2 shows the comparison of brightness and power consumption between DRIM and RGB panel. DRIM panel used only two third the number of source Drive ICs of 384 out channels compared to the RGB panel. Although the IC power consumption of the DRIM panel is advantageous, their panel power is much the same. This is the effect of Sub-pixel rendering using the maximum of sub-pixels potential. At the same brightness, the B/L power of DRIM panel is 3.32 W, which is reduced by about 23% and total power consumption is saved by 20%.

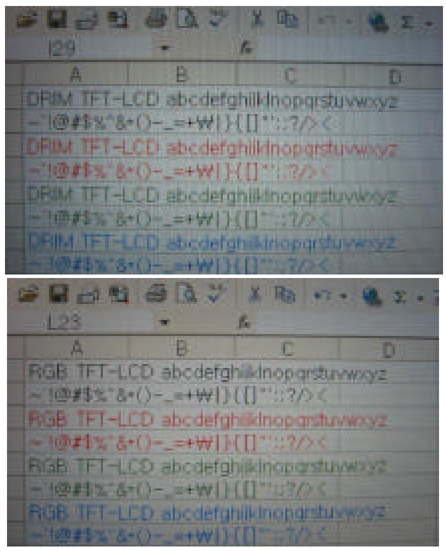

Figure 3. The character expression. RGB(top) and DRIM TFT-LCD(bottom)

In figure 3, we compare the character expression ability of DRIM panel with the RGB panel. The used character is Time New Roman font of 10 point in Microsoft Excel program. Although these images are taken through close-up, the expression ability of characters is almost the same. Figure 4 shows photographs of the RGB panel and the DRIM panel with sub-pixel rendering. This shows better image quality through high brightness and sub-pixel rendering.

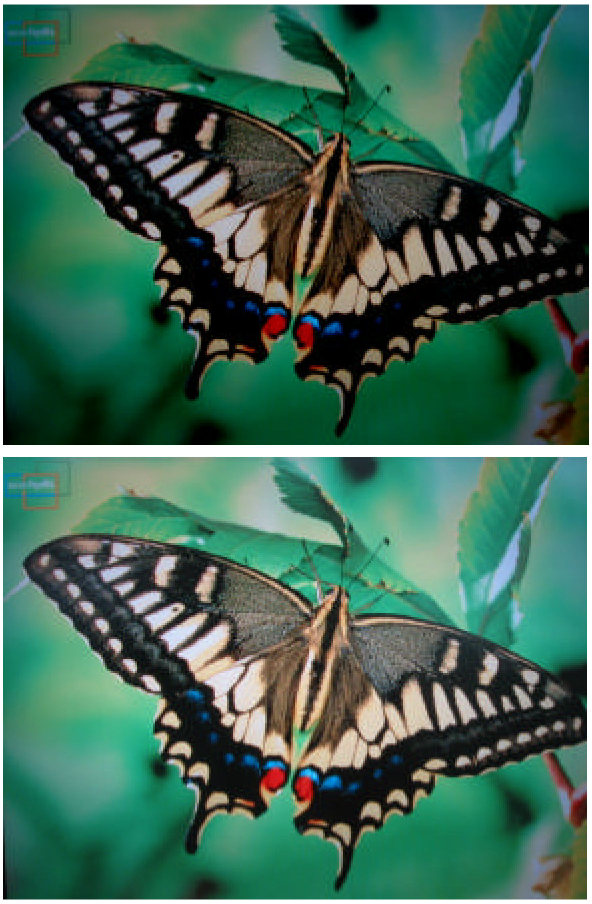

Figure 4. RGB(top) and DRIM(bottom) image comparison.

5. Conclusion

The developed DRIM TFT-LCD panel is 30% brighter than a reference RGB type. The number of source drive ICs is reduced to two third, which can save a manufacturing cost and extend 20% more a battery life time of potable applications such as notebook, mobile phone, PDA and LCD TV.

In the near future, we plan on developing SXGA+ 12.1 inch DRIM L6 panel and Timing Controller with a built-in rendering function.

6. Acknowledgements

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7. References

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