New X-Y Channel Driving Method for LED Backlight System in LCD TVs

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Abstract

This paper proposes a novel RGB-LED (light emitting diode) backlight system, for 32” LCD TVs, accompanied by a new X-Y Channel drive method in which its row and column switches control the individual division screen. This proposed driving method is able to produce division drive effects such as image improvement and reduced power consumption. Not only that, the number of converter needed in this method, that is 1 with 4*(m+n) switches, is much fewer than that of cluster drive method, that is 4*(m*n).

1. Introduction

Thin-film-transistor liquid-crystal-displays (TFT-LCDs) have the largest market share of displays. Conventional backlight for LCD uses the fluorescent tube such as CCFL (Cold Cathode Fluorescent Lamp), EEFL (External Electrode Fluorescent Lamp), and FFL (Flat Fluorescent Lamp). However, due to the RoHS Directive’s limited permission of mercury (Hg) use [1], a new LCD employed with environmentally friendly backlight system is now required: tricolor red-green-blue light-emitting-diode (RGB-LED) array is the substitutive solution. RGB-LED backlight is much better than fluorescent lamp in the means of wide color gamut, tunable white point, high dimming ratio, long lifetime, and fast response [2]. Up to the present, many approaches, such as channel drive, cluster drive, and dot drive using the fast response and high dimming ratio characteristics of RGB-LED, have been achieved. However, due to the fact that these approaches result in huge increase in the number of converters needed for large number of division, better improvement on image enhancement and power saving have been remained unfocused.

This paper discusses a proposal related to the novel RGB-LED (light emitting diode) backlight system for 32"LCD TVs which involves the X-Y channel drive method that utilizes row and column switch to control the individual division screen.

Throughout the X-Y channel drive method, division drive effects such as image improvement and lower power consumption are successfully obtained, and less number of converters, fewer than that of cluster drive method shown in Figure 1, in implementation is possible as well.

2. X-Y Channel Driving Method

2.1 X-Y Channel Driving Method

X-Y channel driving method is a new division driving method. A conventional cluster driving method, is composed of m * n converters (m: # of row division, n: # of column division) and individual converter drives each division backlight. On the other hand, the X-Y channel driving method, driving system is composed of m + n switch and one converter. Each

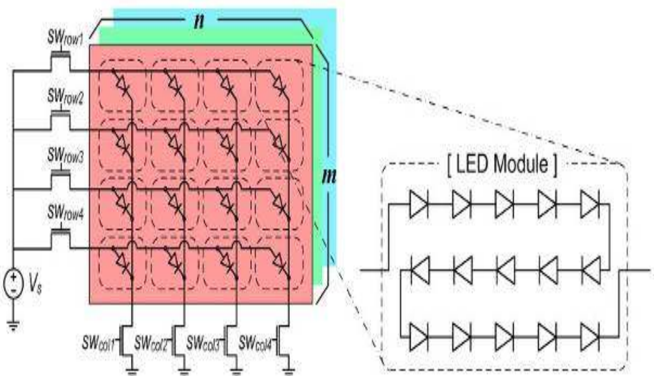

Fig. 1. Duty-duty controlled X-Y channel driving

cluster backlight is controlled by a certain different combinations of row and column channels. In this paper, a mechanism for adjusting the brightness level of cluster backlight is to be discussed.

2.2 Dimming Algorithm

To drive division backlight with X-Y channel driving method, a new algorithm is needed as follows with two major procedures, selecting brightness level of each division backlight, and modifying the image information to preserve the lightness.

1. Find the maximum level data (MLD) in each cluster image.

Fig. 2. MLD search

2. Determine the duty ratio of row switch ($D_{row,i}$) $=(Max(MLD_{Row,i})/255)^{\gamma}$

3. Determine the duty ratio of column switch ($D_{col,j}$) $=(Max(MLD_{Column,j})/255)^{\gamma}$

Table 1. Duty Ratio of $SW_{row,i}$, $SW_{col,j}$

i \ D	$D_{row,i}$	$D_{col,i}$
1	$(125/255)^{2.2}$=0.21	$(122/255)^{2.2}$=0.20
2	$(255/255)^{2.2}$=1	$(255/255)^{2.2}$=1
3	$(255/255)^{2.2}$=1	$(255/255)^{2.2}$=1
4	$(255/255)^{2.2}$=1	$(255/255)^{2.2}$=1
5	$(137/255)^{2.2}$=0.25	$(137/255)^{2.2}$=0.25

4. Determine the luminance of backlight

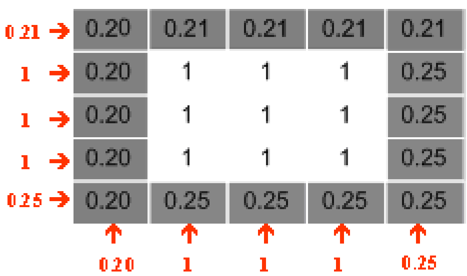

Fig. 3. Control of luminance of backlight

5. For lightness preservation, the image information should be modified.

$$cv(i,j)' = cv(i,j) \times \frac{255}{\max(MLD_{Row,i}, MLD_{Col,j})}$$

(cv: original image data, cv': modified image data)

Fig. 4. Modified image to preserve the lightness

2.3 Advantage of X-Y Channel Driving Method

Low cost: The number of converters can be reduced from 4 * (m * n) to 1, and the proposed system needs 4 * (m + n) switches to control the luminance of each row and column channel LED. (m= # of row channel, n = # column channel, 4: RGGB LED formation) As a result, it can save the cost.

Reduced power consumption: The X-Y channel driving method is more efficient in power consumption than the conventional. In Figure 3, the luminance of 16 blocks in overall is decreased to 0.20~0.25. Assuming that the power consumption of conventional backlight for each block equals to 1, then the power consumption of X-Y channel driving backlight averages out to be (1*9+0.20*5+0.21*4+0.25*7)/25=0.57. Therefore, it establishes that X-Y channel driving method lowers power consumption.

3. Experiment Results

3.1 Implementation of total system

The brightness of each block backlight is decided by the analytical algorithm discussed in Part 2.2. The output voltages of converter for red, green and blue LED strings are set to drive the desired current: the forward current of the blocks is set to 20mA. And 600Hz Pulse Width Modulation (PWM) signals made from dimming algorithm control the luminance of each cluster, Hence, in the X-Y channel driving method, the image information on the

1^{st} and 5^{th} column and the 1^{st} and 5^{th} row channels, whose average forward current is 4~5mA, should be modified, or it might make distortion on the displayed image of the screen due to the different current flow: a typical way of modification is shown in Part 2.2.

In terms of power consumption, the experiment result shows that the power consumption is reduced to about 57.3 % as predicted. The total result of the system is shown in Figure 5(fully on backlight system) and 6. The brightness of backlight controlled by the new X-Y channel driving method is shown in Figure6 (a). And the image output of the total system is well-displyed as shown in Figure 6(b).

4. Conclusion

Image improvement and reduced power consumption are typical division drive effects resulted from the proposed X-Y channel driving method. The number of converters required for implementation is also much reduced than that of the conventional cluster drive method.

Acknowledgment

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(a)

(b)

Fig. 5. (a)Fully-on Backlight (b)Image output on fully-on backlight

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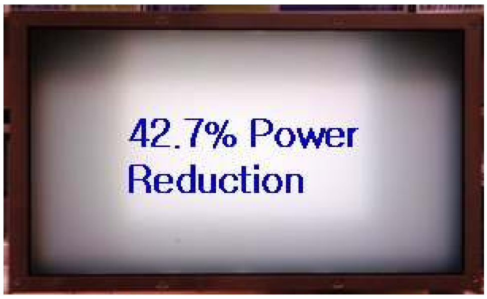

(a)

(b)

Fig. 6. (a)Backlight dimmed by X-Y channel driving method (b)Image output of total system