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

Daeyoun Cho*[*], *Won Sik Oh*[*], *Kyu Min Cho*[*], *Gun Woo Moon*[*], *Byungchoon Yang*[#] *and Taeseok Jang*[#]

[*]Display Power Circuit Lab, KAIST, Daejeon, South Korea

[#]LCD Development Center, Samsung Electronics, Asan, South Korea

TEL:82-42-869-3475, e-mail: gwmoon@ee.kaist.ac.kr

Keywords : LED backlight, local dimming, X-Y channel driving, dimming algorithm

Abstract

This paper proposes a novel RGB-LED (light emitting diode) backlight system, for 32" LCD TVs, accompanied by a new X-Y Channel driving method in which its row and column switches control the individual division screen. This proposed driving method is able to produce division driving effects such as image improvement and reduced power consumption. Not only that, the number of driver needed in this method, that is 3 power supplies with 3(m+n) switches, is much fewer than that of cluster driving method, that is 3*(m*n) driver.*

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

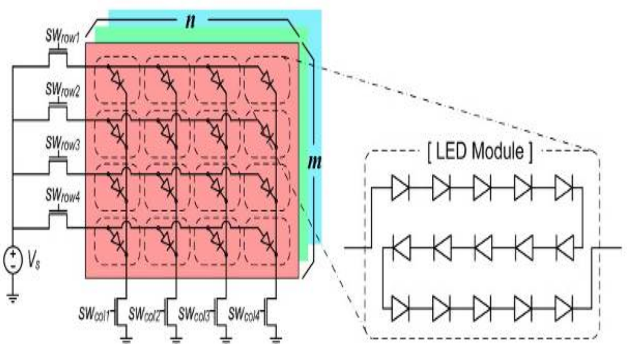


Fig. 1. Duty-duty controlled X-Y channel driving

RGB-LED (light emitting diode) backlight system for 32"LCD TVs which involves the X-Y channel driving method that utilizes row and column switch to control the individual division screen.

Throughout the X-Y channel driving method, image improvement and lower power consumption are successfully obtained, and less number of drivers (3 power supplies with 3(m+n) switch: m=# of rows, n=# of columns), fewer than that of cluster driving method (3*m*n drivers) in implementation is possible as well.

2. X-Y Channel Driving Method

X-Y channel driving method is new local driving method of LED backlight. LED is consisted of passive matrix structure shown in figure1, and three external power supplies are required as the current source of each RGB-LED in the proposed system. Each X(Row) and Y(Column) channel has a switch to control the turn-on time of the current flowing through the LED. The switching signal created by dimming algorithm described at section 3 makes the local dimming suitable for the target image. As a result, each cluster backlight is controlled by a certain different combinations of row and column channels. The proposed system can reduce the driving hardware and the performance of local dimming is similar as that of cluster driving. A conventional cluster driving method is composed of 3*m * n converters (m: # of row division, n: # of column division, 3: R, G, B LED) and individual converter drives each division backlight. On the other hand, the X-Y channel driving method, driving system is composed of 3*(m + n) switches with three converters.

The X-Y channel driving method provides cost reduction and similar performance of cluster driving, however, the dependency among clusters disturbs the power saving. Next, in section 3, the 2-D channel driving dimming algorithm is to be proposed.

3. Dimming Algorithm

3.1. 2-D Channel Driving 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

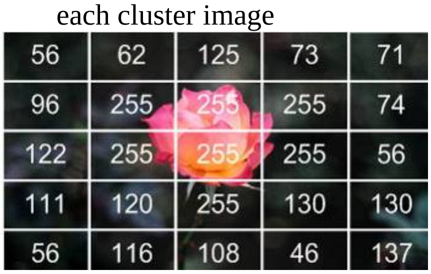


Fig. 2. MLD search

2. Determine the duty ratio of row switch.

$$D_{row,i} = [Max(MLD_{Row,i})/255]^{\gamma} \quad (1)$$

3. Determine the duty ratio of column switch.

$$D_{col,j} = [Max(MLD_{column,j})/255]^{\gamma} \quad (2)$$

4. Determine the luminance of backlight.

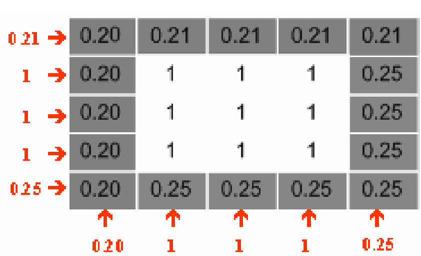


Fig. 3. Control of luminance of backlight

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

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

(cv: original image data, cv': modified image data) (3)

Fig. 4. Modified image to preserve the lightness

3.2. 2-D Channel Driving algorithm with Separated Color Control

Using 2-D channel driving algorithm, as described in section 3, the MLD is determined in unified RGB image data domain while the separated values of MLD_{Red}, MLD_{green} and MLD_{Blue} can be acquired at each color domain via 2-D channel driving algorithm with separated color control with higher power saving effect. As Each MLD of RGB can be applied to previous algorithm, the dimming backlight shown in figure 5 and the modified image data by formula (4) can be achieved.

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

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

$$B(i,j)' = B(i,j) \times \frac{255}{\max(MLD_{B,Row,i}, MLD_{B,.Column,j})}$$

(R,G,B: original image data, R',G',B': modified image data) (4)

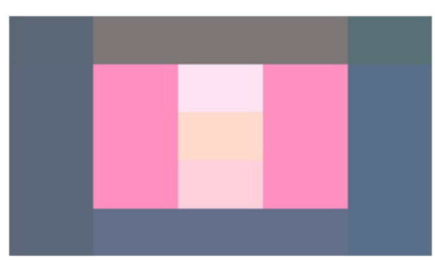
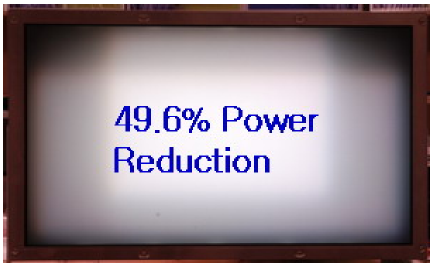
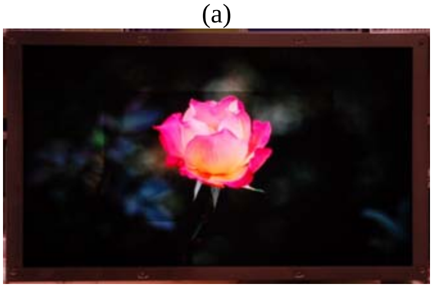


Fig. 5. Luminance of backlight (Separated color control)

4. Experiment Results



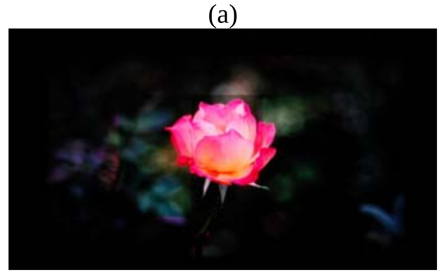
(a)



(b)

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

(a)



(b)

Fig. 7. (a)Backlight dimmed by X-Y channel driving method with separated color control (b)Image output of total system

4.1. Overall System with 2-D Channel driving algorithm

The brightness of each block backlight is determined by the analytical algorithm discussed in section 3. 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 1st and 5th column and the 1st and 5th 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 section 3.

In terms of power consumption, the experiment result shows that the power consumption is reduced to about 50.4 % as predicted. The total result of the system is shown in Figure 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 overall system is well-displayed as shown in Figure 6(b).

4.2. Overall System with 2-D Channel driving algorithm with separated color control

The overall system is the same as that of 4.1 except the switching signal. In 4.1, same PWM switching signal enters switches and controls the current of RGB LED. However, at this time, the three switching signals control the current of each R, G, B LED channels separately. The brightness of backlight controlled by the X-Y channel driving method with separated color control is shown in Figure7 (a), and the image output of the overall system is well-displayed as shown in Figure 7(b). Comparing with the system in 4.1, the power consumption of the system with separated color control has reduced 15.3 % more.

5. Conclusion

Image improvement and reduced power consumption are typical division driving 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 driving method.

Acknowledgment

This work is supported by Samsung LCD Business, Korea, under Display Research Center Program.

Reference

[1]http://www.rohs.gov.uk/
[2]LED-backlight feedback control system with integrated amorphous-silicon color sensor on an LCD panel, Ki-Chan Lee, Seung-Hwan Moon, Brian Berkeley, Sang-Soo Kim
[3]New X-Y Channel Driving Method for LED Backlight System in LCD TVs, Daeyoun Cho,

Won-Sik Oh, Gun-Woo Moon, San-Gil Lee, Mun Soo Park, ASID07
[4]Colorimetry, Fundamentals and Applications, Noboru Ohta, Alan R. Robertson
[5]RGB-LED Backlights for LCD-TVs with 0D, 1D, and 2D Adaptive Dimming, T.Shirai, S.Shimizukawa, T.Shiga, and S.Mikoshiba, SID06
[6]Backlight Local Dimming Algorithm for High Contrast LCD-TV, Hanfeng Chen, Junho Sung, Taehyeun Ha, Yungjun Park and Changwan Hong, ASID06, 8-12 Oct, New Delhi
[7]Brightness Preservation for LCD Backlight Dimming, Louis Kerofsky, Scott Daly, Sharp Laboratories of Amerca
[8]A Programmable Gamma Reference Buffer with Integrated Backlight Control , Rick Orlando, Kames Larimer, Trevor Blyth and Pat Madden
[9]HEBS: Histogram Equalization for Backlight Scaling, Ali Iranl, Hanif Fatemi, Massoud Pedram, DATE'05