Average Current Controlled X-Y Channel Driving White LED Backlight System for 46" LCD TV

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Abstract

A novel white-LED (light emitting diode) backlight system for 46"LCD TVs which involves the average current controlled X-Y channel driving method is proposed, which is composed of 1 converter and row and column channel switches. In the conventional X-Y channel driving driven with a constant voltage source, the driving current of LED increases because the threshold voltage of LED decreases when LED temperature goes up. To maintain the luminance of backlight constant, the average current controlled X-Y channel driving will be employed. Finally the results are confirmed by experimental results.

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: white light-emitting-diode (white-LED) array is the substitutive solution. White-LED backlight is much better than fluorescent lamp in the means of high dimming ratio, long lifetime, and fast response [2]. Up to the present, many approaches, such as channel drive, cluster drive, and pixel drive using the fast response and high dimming ratio characteristics of white-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. The conventional cluster driving normally uses current controlled system because the luminance of LED is proportional to the current flowing through LED at same junction temperature. Otherwise, conventional X-Y channel driving is applied to constant voltage source [3-4]. The threshold voltage of LED depends on temperature, so any temperature change results in a unwanted change in driving current [5]. Consequently, the LED backlight gets brighter after long time operation of LED because the increased driving current of LED due to increased junction temperature makes the luminance higher. In this paper, the average current controlled X-Y channel driving is proposed to make the constant and uniform luminance of LED backlight.

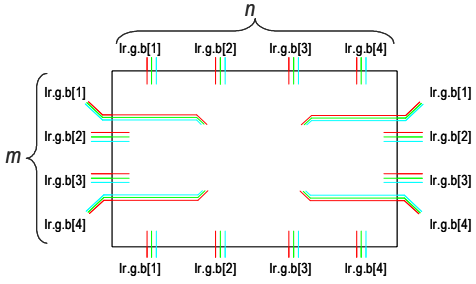

Figure 1: Cluster driving system

2. Proposed LED Backlight System

2.1 Conventional X-Y channel driving system

In conventional X-Y channel driving system, the LED backlight composed of m(= # of row division)*n(= # of column division) LED blocks is driven with a constant voltage. And each X(Row) and Y(Column) channel has a switch to control the turn-on time of the current flowing through the channel LED. The switching signal created by dimming algorithm described at previous paper[3-4] makes the local dimming suitable for the target image. As a result, each block of backlight is controlled by a certain different combinations of row and column channels. The conventional cluster driving method is composed of m * n converters and individual converters drive corresponding divisions. On the other hand, the X-Y channel driving system is composed of 1 converter and m + n switches. The conventional X-Y channel driving method can reduce the driving hardware and product cost and the performance of local dimming (reduction of power consumption, increase in dynamic contrast ratio) is similar as that of cluster driving. However, there are two drawbacks to the conventional X-Y channel driving system driven with a constant voltage. Firstly, the threshold voltage of LED depends on temperature, so any temperature change results in a significant change in current. Consequently, the luminance of LED is changed corresponding to current variation. Secondly, the luminance difference among LED blocks is large because the LED current of each block at same driving voltage is different. To make the luminance of LED backlight constant and uniform, the novel LED backlight is proposed in this paper.

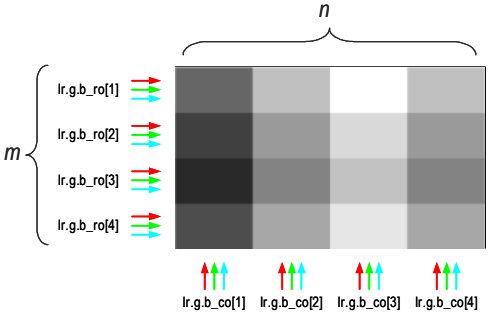

Figure 2: X-Y Channel driving system

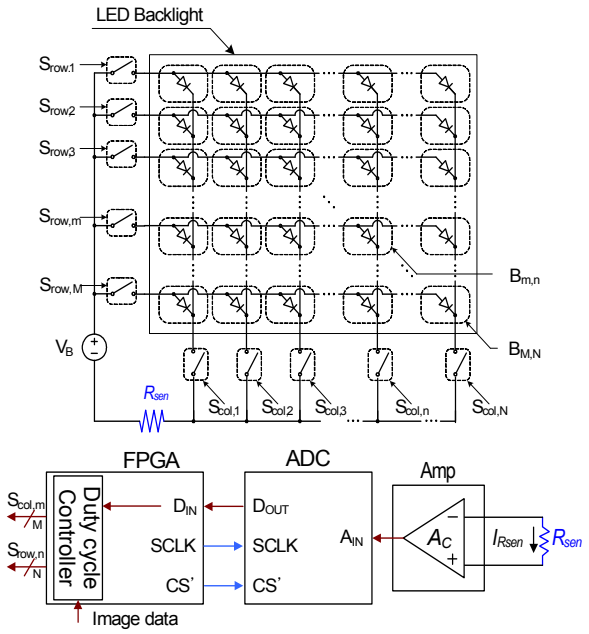

Figure 3: (a) Current controlled X-Y channel driving system

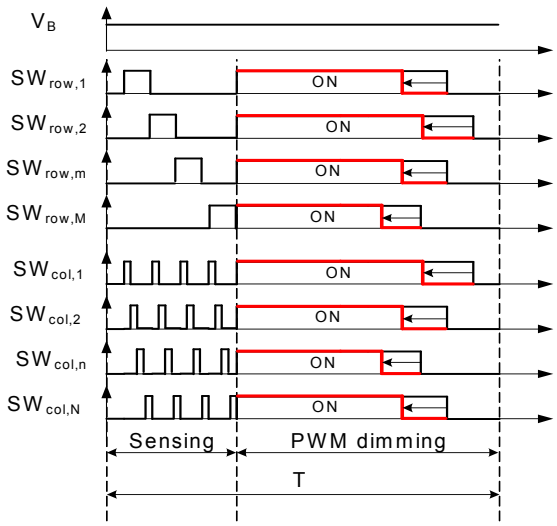

Figure 3: (b) Key waveform of proposed system

2.2 Average Current controlled X-Y channel driving system

To make the luminance of LED backlight constant and uniform, the digital current-sense channel switch duty-cycle controller is integrated in conventional X-Y channel driving system as shown in figure 3(a). The digital current sense part is composed of 4 parts: sensing resistor, current senses amp, ADC and FPGA. The channel switching signal is compensated by the ratio between the sensing current and reference one. The current sensing time is inserted once per 1.67ms (X-Y channel driving time: 600Hz). The timing diagram of channel switch control signal is shown in figure 3(b). The multiplexing driving during the sensing time as shown in figure 3(b) can achieve the current characteristics information of each block LED with one sensing part. The system can achieve the cost-saving because this method can share the current sensing part.

After the information about all block current is corrected, the average current of all block LED is balanced by controlling the duty ratio of channel switch or input voltage. However, there is still average current unbalance problem due to the characteristics of X-Y channel driving. The unbalanced luminance among LED blocks caused by unbalanced current is compensated by modifying the block image data.

2.3 Experiment Results

The target of experiment is the backlight composed of 10*8 blocks (1 block: 12 white LED) for 46" LCD TV. And the voltage source is determined to 39V. At room temperature, the driving current (@39V driving voltage) is 60mA. The driving frequency of channel switches is 600Hz. The implementation of 46" white LED backlight is shown in figure 4.

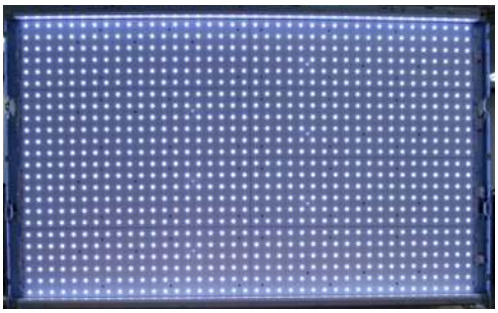

Figure 4: Implementation of 46" white LED backlight

The sensing time is determined by converting speed of ADC or current settling time. The minimum converting time of ADC which is used in out experiment is about 13us, and the current settling time of block LED is about 60us as shown in figure 5. The number of LED block is 80, so the whole sensing time requires 4.8ms. The sensing time affects the luminance variation. We can reduce the unwanted change in luminance with reduced frequency of sensing as shown in figure 6. .

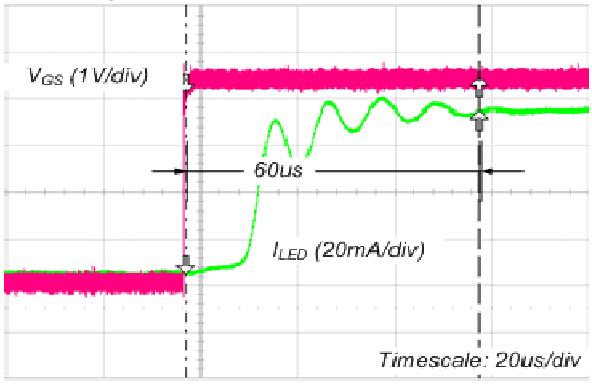

Figure 5: Current settling time of block LED

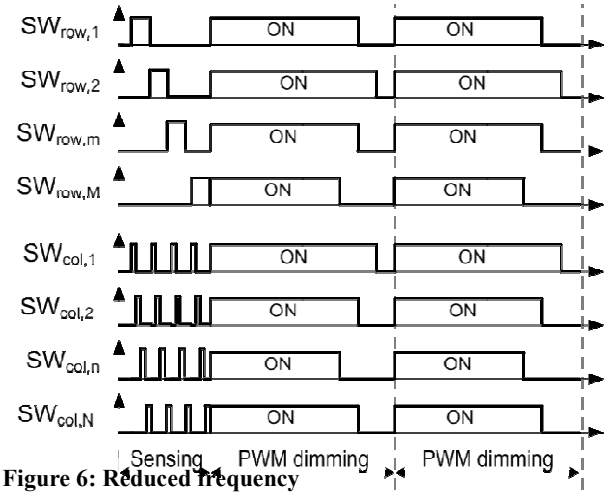

Figure 6: Reduced frequency

of sensing time (once/1min)

The figure 7 shows the change of input current of conventional and proposed system during 1 hour. The average forward current is compensated by controlling the on time of channel switches or the driving voltage.

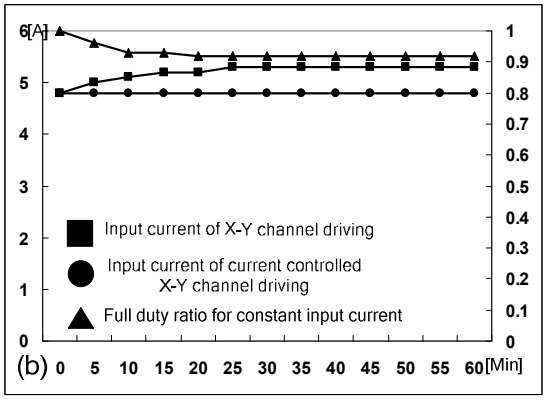

Figure 6: Change of input current and current control (full white control)

3. Conclusion

The conventional X-Y channel driving system can achieve the image improvement and reduced power consumption. The number of converters required for implementation is also much reduced than that of the conventional cluster drive method. However the luminance of conventional X-Y channel driving system is varied by the temperature change of LED because of constant voltage driving. And the luminance uniformity is not guaranteed because of different I-V characteristics among LED blocks. So the average current controlled X-Y channel driving is proposed, which can make the constant and uniform luminance by the change of duty cycle of channel switches or input voltage.

Acknowledgment

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