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 current controlled X-Y channel driving method is proposed in this paper. There are two problems related to the LED current in the conventional X-Y channel driving driven by a constant voltage source. To solve these problems, a real time current sensing system is applied to the conventional one and the time-division current sensing method is employed.

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, block 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 block driving as shown in Fig 1 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 shown in Fig 2 is applied to constant voltage source [3-4]. This causes two problems. First, the threshold voltage of LED depends on temperature, so any temperature change results in an unwanted change in driving current. [5] Consequently, the LED backlight gets brighter after operating LED for long time because the increased driving current of LED due to increased junction temperature raises the luminance. Second, there is luminance difference among LED blocks

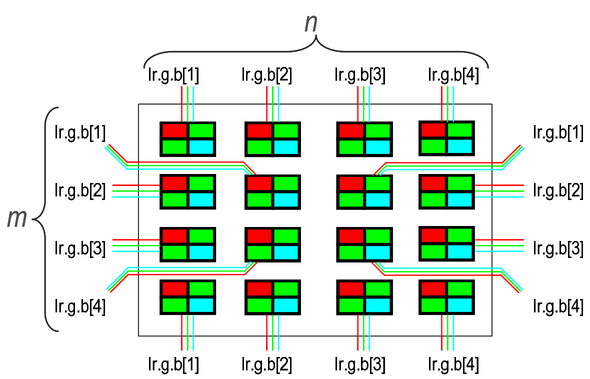

Fig 1. Conventional block driving

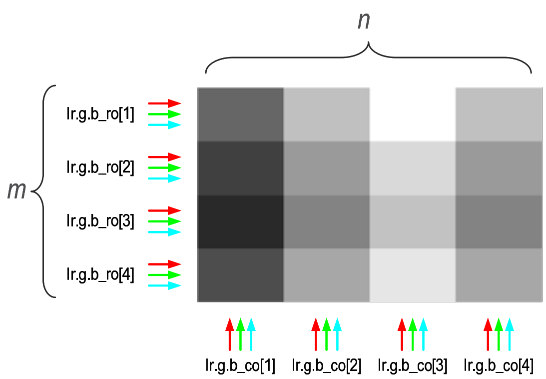

Fig 2. Conventional X-Y channel driving

because the LED current of each block differs from one another at same driving voltage.

In this paper, to avoid these problems, the real-time current sensing system is applied to the conventional X-Y channel driving system and the time-division current sensing is also employed.

2. Conventional X-Y channel driving system

In the conventional X-Y channel driving system, the LED backlight composed of m*n (m: # of row division, n: # of column division) LED blocks is driven with a constant voltage source. 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.

While the conventional block driving system has m*n individual converters which drive corresponding divisions, the conventional X-Y channel driving system is composed of 1 converter and m + n switches. It is available for the conventional X-Y channel driving method to reduce the driving hardware and product costs and to make the performance of local dimming (reduction of power consumption, increase in dynamic contrast ratio) similar as that of block driving. However, there are two drawbacks to the conventional X-Y channel driving system driven with a constant voltage source. The first one is that the threshold voltage of LED depends on the junction temperature, so any temperature change results in a significant change in current. Consequently, the luminance of LED is changed corresponding to current variation. The second drawback is that the luminance difference among LED blocks is large because the LED current of each block differs from one another at same driving voltage. To solve these problems, the real-time current sensing system is applied to the conventional one and the time-division current sensing is employed to achieve the constant and balanced driving current of each LED block in this paper.

3. Proposed current controlled X-Y channel driving system

The real-time digital current-sensing channel switch duty-cycle controller is integrated in conventional X-Y channel driving system as shown in Fig 3 to make the driving current of each LED constant and balanced. The real-time digital current sensing system is composed of 4 parts: sensing resistor (R_{sen}), current sensing amp, ADC and FPGA. It is available to get the current characteristics information of each block LED

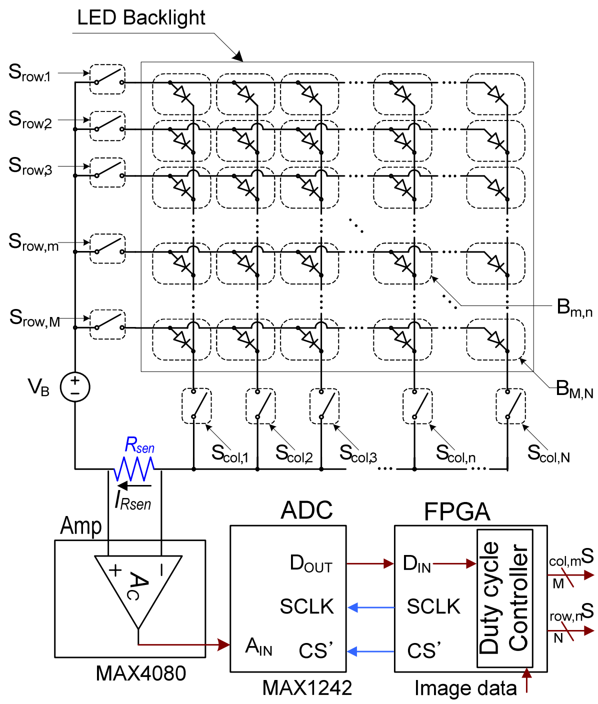

Fig 3. Proposed real-time digital current controlled X-Y channel driving system

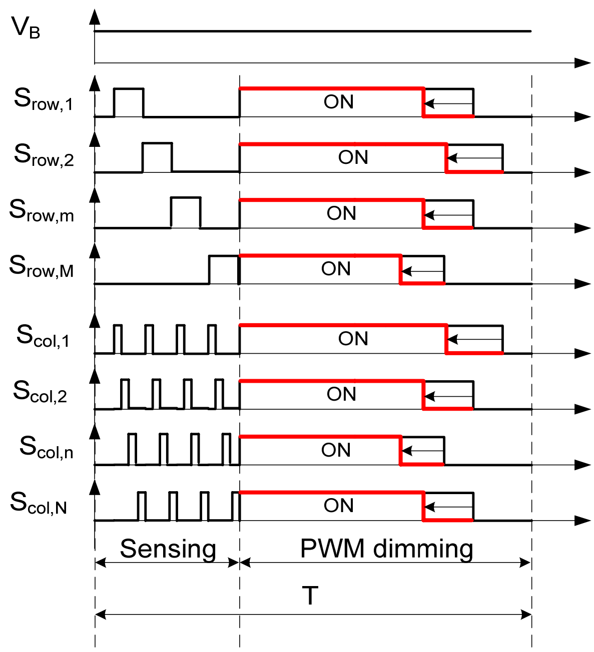

Fig 4. Key-waveform of proposed system [time-division current sensing]

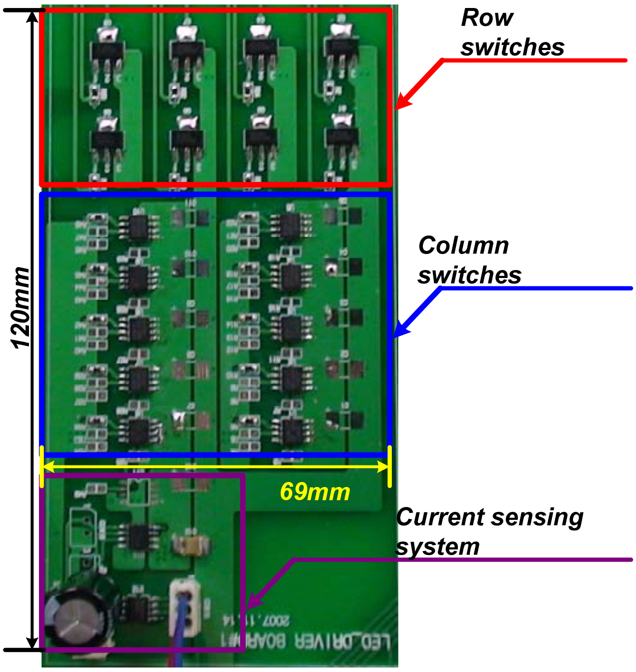

Fig 5. Prototype of proposed system

with the single current sensing system to which the time-division current sensing method as shown in Fig 4 is applied. The product cost can be reduced by this sensing method. However, it causes the insufficient effect to luminance of LED backlight.

The prototype of proposed system is implemented with specifications of V_B=40V, $S_{row,1}$~$S_{row,M}$: IPS7091, $S_{col,1}$~$S_{col,N}$: IPS2041, switching frequency=600Hz, current sense amp: MAX4080, ADC:MAX1242, and FPGA:Altera FLEX. Fig 5 shows a sample of a proposed driver for the 46" white LED backlight as shown in Fig 6.

Fig 7 shows the waveform detected by photo sensor amp (Hamamatsu) with input current waveform of LED driver. From the Fig 7, the current sensing time (=5ms) reduces the luminance of LED backlight because the input current of LED is reduced from 4.8A to 60mA during the current sensing time. The current sensing time is determined by three factors-the current settling time of LED, the minimum required time for the AD-conversion and the number of LED blocks. Fig 8 shows the current settling time (60us) of LED corresponding to the gate signal of channel switch, the minimum AD-conversion time of MAX1242 is 12.74us[10] and the number of LED block is 80. Consequentially, the current sensing system needs about 5ms to get the current value of all the blocks. By reducing the current sensing frequency (60Hz ➔ 6Hz) or the number of blocks measured continuously (80➔10), we can solve this problem.

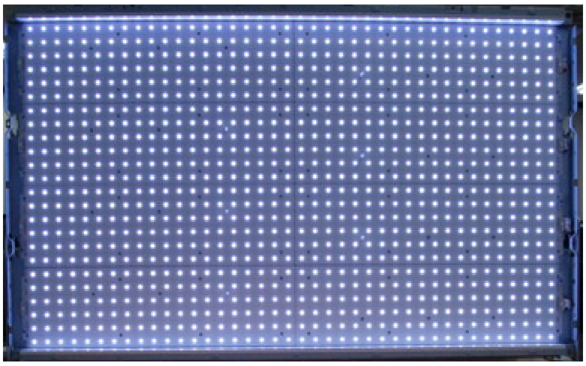

Fig 6. 46" white LED backlight (80blocks, 960EA white LEDs)

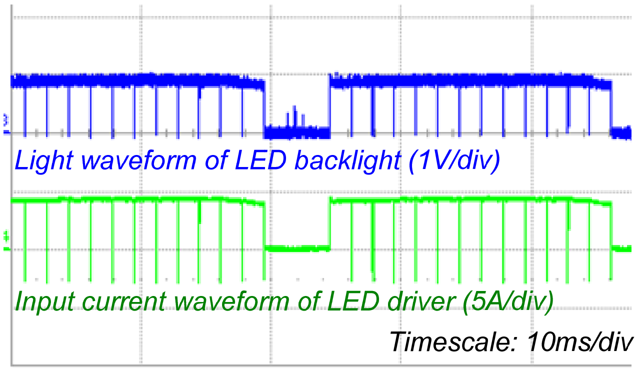

Fig 7. Light waveform of LED backlight and input current waveform of LED driver

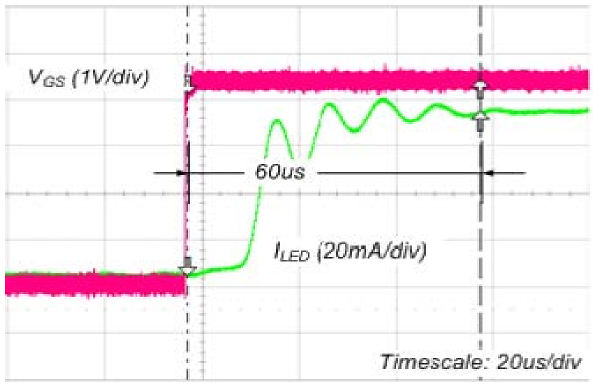

Fig 8. LED current settling time corresponding gate signal @block LED current~60mA

The driving current of LED waveform is shown in Fig 9. It shows the transient response corresponding to increasing LED current. The average current of all LED blocks remains constant by controlling the on time of channel switch with the measured current information about all LED blocks.

By the experiment results, the X-Y channel driving system with the average current control has the merits of conventional X-Y channel driving system, such as

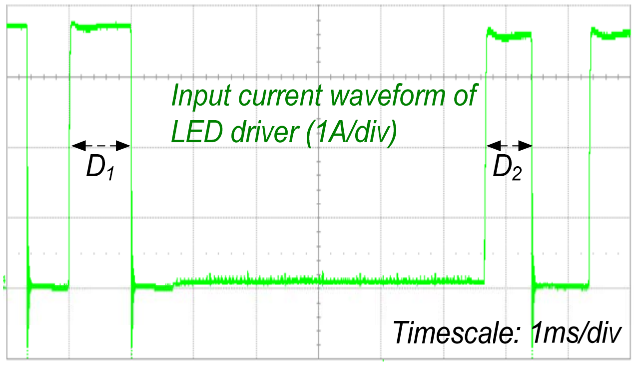

Fig 9. Transient response corresponding to increasing input current of LED driver

lower production cost, comparable image improvement and reduced power consumption when comparing with those of conventional block driving system. Also, the LED backlight driven by this system can have the constant luminance at same temperature.

4. Conclusion

The conventional X-Y channel driving system can achieve the comparable image improvement and reduced power consumption with much fewer converters than that of conventional block driving method. However, the luminance is varied by the temperature change of LED in the conventional X-Y channel driving system driven with constant voltage source. This problem can be solved by applying the real-time current sensing system to the conventional one and to employing the time-division current sensing to achieve the constant driving current of all the LED blocks.

5. Acknowledgements

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5. References

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