Multi-Channel LED Driver with Power Optimization Feedback Control Technique

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Abstract

This paper proposes LED driver to minimize power consumption due to LED forward voltage difference and temperature rising. Compared to conventional LED driver, the proposed driver had excellent stability, brief structure and linear output voltage of DC-DC boost converter. With the channel current set at 100mA, the on/off switchover was controlled by means of the PWM control signal in the simulation and actual installation. As a result, it turned out that the normal LED current value of 100mA was produced according to the input PWM control signal.

Keywords: *LED, BLU, Control Function, Driver.*

1. Introduction

As the demand for low electricity-consuming and environment-friendly green industry is increasing recently, active is the development of technology for LED BLU as an LCD luminous source to replace existing mercurial CCFL, which features the excellent color representation, high reliability, prompt response, and low electricity consumption. In addition to such basic features of LED, methods to reduce the electric consumption of BLU are being developed to control the power output of the switching converter with the optimal voltage necessary for the LED unit [1, 2].

An LED backlight device consists of the boost converter that supplies LED strings with the voltage of rating and the constant current driving section that maintains the light of each LED string stable. To minimize the electric consumption at the constant current driving section, the voltage drop at the channel constant current driving section of each LED string must be kept minimized. Due to such factors as difference in VF of high output LED applied to LED strings and characteristic changes at different temperatures, the voltage drop at the constant current driving section of each channel of the LED backlight device results in difference between channels. When excessively high voltage is input, the voltage drop at the channel constant current driving section is accelerated, which requires more electric consumption. In contrast, when excessively low voltage is input, the constant current driving becomes impossible. Thus, to realize an LED backlight device with excellent electric consumption efficiency, the output voltage of the boost converter must be controlled to the extent that the constant current driving is possible by minimizing the electric consumption at the channel constant current driving section and by managing the voltage of each channel to the lowest [3].

2. The Structure and Operation Principle of BLU Driver

To minimize electric consumption at an LED backlight device, the voltage drop at the channel current source of each LED string must be kept minimized. However, due to such factors as difference in VF of high output LED applied to LED strings and characteristic changes at different temperatures, the extent of voltage drop may be different at each channel constant current resource. Therefore, to manage the optimal electric consumption at an LED backlight device, the voltage at both sides of the constant current source connected to LED strings must be kept minimized to extant that the constant current is available, which minimizes the power supplied to LED strings[4, 5]. Unless the loss of electric power, the most important element in LED operation of an LCD backlight system, is kept minimized, the problem of heat generation may weaken the system competitiveness to a large degree. In order to optimize the electric consumption of an LED backlight device, this study attempts to design an LED driver that can reduce electric power supplied to LED strings by controlling the boost converter output and by minimizing the voltage at both sides of the constant current source that is connected to LED strings as long as the constant current is still available [6].

Figure 1 demonstrates the feedback controlling method of an LED backlight device that adopts the LED driver with the electric consumption optimizing functions proposed in this study. To keep the electric consumption lower than in existing methods, the voltage drops at both sides of the current source of LED strings are compared in order to increase the boost voltage when it goes down below the lower limit so that the necessary voltage can be maintained.

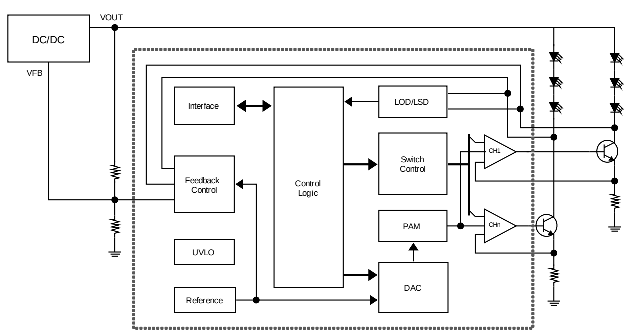

Figure 1. Functional Block Diagram

3. The Design and Simulation of BLU Driver Block

The most important element to be addressed with regard to LED operation of LCD backlighting system is the loss of electric power. Unless this is not kept minimized, the problem of heat generation may weaken the system competitiveness to a large degree.

This study aims to design an LED driver that controls the output of the boost converter for the optimization of voltage at both sides of the constant current source for LED string operation, in order to maximize the power consumption efficiency of an LED backlight device.

3-1. Design of Bias Blocks

Band-gap Circuit is a block that generates the standard voltage regardless of the changes in input voltage or temperature. Figure 2 shows the designed reference voltage generation circuit. Although there may be various methods to generate the standard voltage, the circuit that can produce the most stable output despite changes in input power or temperature is the band-gap reference.

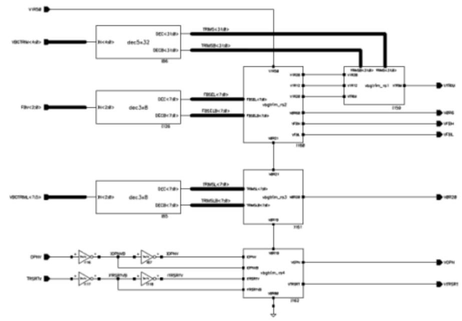

Figure 2. Reference Voltage Generation Circuit

As in the simulation results shown in Figures 3, the reference voltages to be used for the DAC and fault detection circuit were generated.

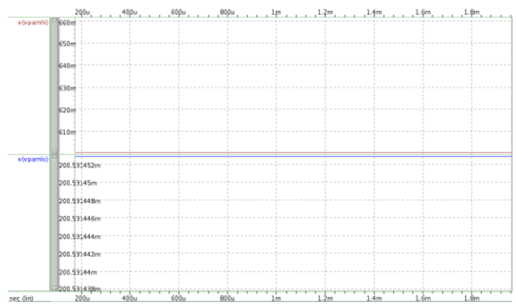

Figure 3. The Simulation Results of the Reference Voltage Generation Circuit

3-2. PAM Control Block Design

Figure 4 shows the VPAM circuit that generates VPAM voltage by means of 6 bit R2R DAC to for the analogue value of 64 step in accord with the start/stop bits.

The designed R2R DAC connects the switch to VH and VL reference in accord with the input code in the digital condition and has the VPAM output generated by means of the output buffer.

Figure 6 shows the entire circuit of the edge-type one-chip BLU Driver for the proposed LCD TV. As stated above, the designed circuit mainly consists of the digital block, standard voltage generation circuit, channel amp block, and feedback control block.

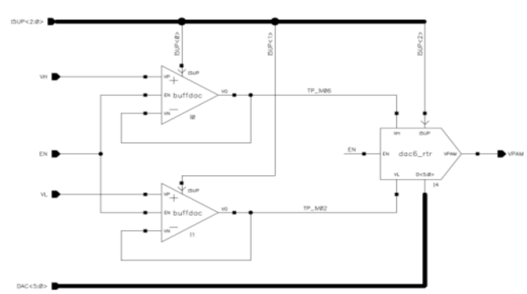

Figure 4. VPAM Generation Circuit

As in the simulation result, the voltage between 0.2V and 0.6V, which is the standard voltage range, is output appropriately in accord with the start/stop bits.

Figure 5 shows the simulation result of the VPAM output in accord with the start/stop bits

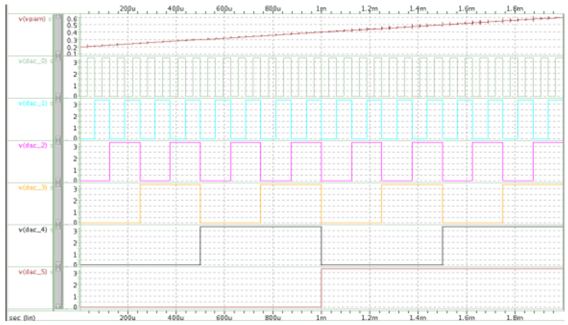

Figure 5. VPAM Simulation Result

To certify the performance of the finally designed BLU driver in Figure 6, the simulations was implemented by means of HSPICE after the booster converter and BLU driver were composed in a manner of feedback control. As to the conditions of the simulation, the channel current was set to 100mA, and the on/off was switched according to the PWM control signal.

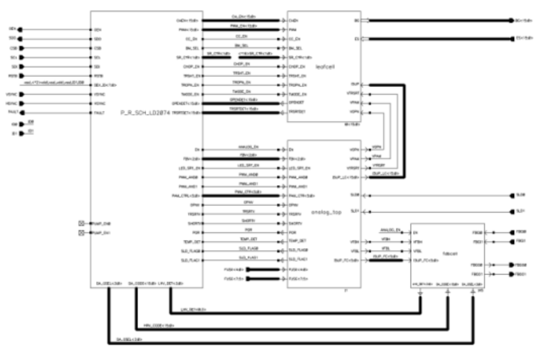

Figure 6. The Entire Circuit of the Proposed BLU Driver

Figure 7 shows the simulation result of the designed entire circuit. The LED current value of 100mA, which is normal, was output according to the input PWM control signal.

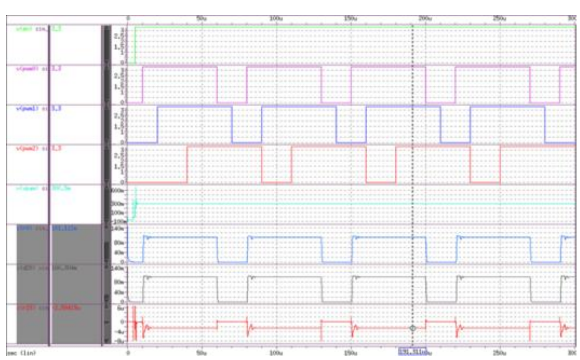

Figure 7. Top Simulation Result

Figure 8 shows the layout of the designed IC. The designed chip disconnects from the power source the guard ring and analogue/digital blocks to minimize the interference between the analogue block and digital block. The size of the designed chip is 2,300μm x 1.900μm.

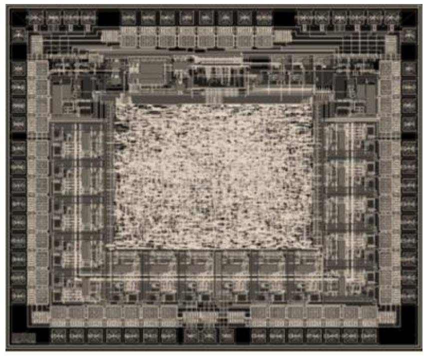

Figure 8. Proposed BLU Driver IC Layout

Figure 9 and 10 show the waves after the mounting of IC in Figure 9. As shown in the waves as a result of the mounting in Figure 10 and 11, the channel current of 100mA resulted in the normal action even when the duty rates were set to 90% and 10% respectively.

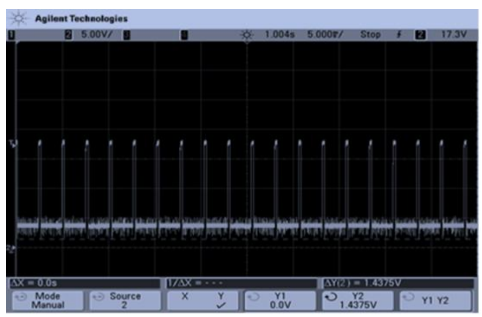

Figure 9. Waves Measured after the Headroom Voltage Mounting According to the Duty [Duty=90%]

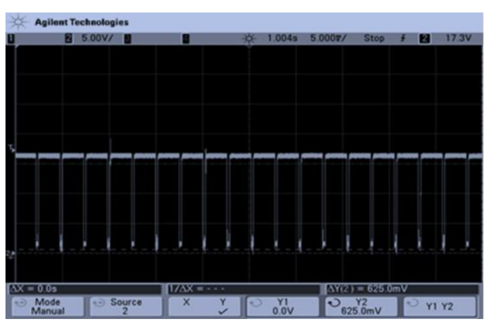

Figure 10. Waves Measured after the Headroom Voltage Mounting According to the Duty [Duty=10%]

4. Conclusion

This study proposes the LED driver circuit with the boost output voltage controlling function for the efficient power management of the LED backlight device, which has been one of the highlighted issues recently. The proposed circuit does not need any standard voltage generation circuit or comparator, and features the embodiment of the integrated circuit that requires only a relatively small area. In addition, the lineal boost output voltage control in consideration of such factors as difference in forward voltage of LED, characteristic changes at different temperatures, and power consumption during the operation enables the voltage at both sides of the constant current source to be kept minimized, through which a high reliability LED backlight device with excellent power efficiency can be embodied.

Acknowledgements

Funding for this paper was provided by Namseoul University.

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