Areal Selective 2-bit Dimming of Mercury-free Flat Fluorescent Lamp for LCD Backlight

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Abstract

We proposed a new Mercury-free Flat Fluorescent Lamp (MFFL) for LCD backlight which shows a wide, stable operating voltage margin, high luminance and efficiency. In this paper, we expanded the single cell with 4 inch diagonal size into the multi-cell for the large size LCD-TV backlight application, examined its operating characteristics and proposed a driving scheme for 2-bit areal selective dimming control.

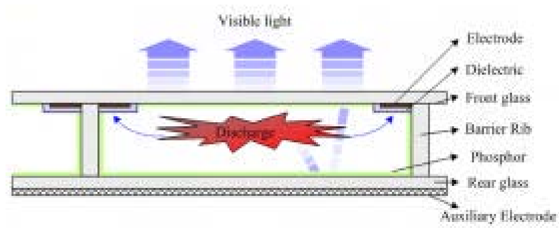
1. Introduction

The LCD has been one of the main display devices in wide application areas including mobile display, computer monitor and digital TV since the LCD was successfully developed and mass-produced for laptop PC in early 1990's.

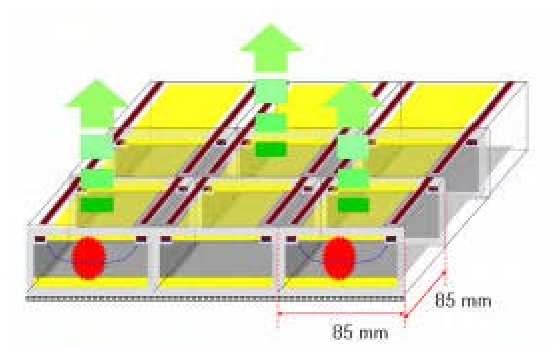
However, as the LCD extends its application area to the large size TV, the conventional backlight system with Cold Cathode Fluorescent Lamp (CCFL) is facing several technical problems as the length of a fluorescent lamp and the number of lamps for one LCD unit increases accordingly. Also the use of Mercury causes environmental concerns and its severe temperature dependency of luminous characteristics is another drawback [1-3].

Particularly, the future backlight for LCD are expected to have abilities such as the intelligent brightness variations for the low gray-scale expression, the areal selective dimming for the high contrast ratio and better picture quality and the low power consumption.

We reported a new Mercury-free Flat Fluorescent Lamp (MFFL) which showed high luminous efficiency and wide voltage driving margin [4]. In this work, we studied its discharge characteristic for dimming control and are suggesting a way to achieve an areal selective 2-bit dimming of multi-cell structured large lamp.



(a) Cut-away view of a unit cell



(b) Cut-away view of the multi-cell

Figure 1: Structure of the multi-cell MFFL

2. Experiment

Figure 1 shows the structure of dielectric barrier discharge flat fluorescent lamp using the Xenon and Neon rare gas with no Mercury. The cut away view of a unit cell is shown in Figure 1-(a), and that of the multi-cell MFFL is illustrated in Figure 1-(b). The parallel-running, main electrodes are separated by 70mm and covered by 80 μm dielectric material. The auxiliary electrode is located on the opposite plate and used as the data electrode for the selection of cells. The barrier rib height is 3mm. Ne-Xe(4%) mixture with the gas pressure of 120-torr was used as the discharge gas.

3. Results

Discharge takes place in the space between the two glass plates. The Xenon gas is then excited in the form of Xe* and Xe_2* and 147nm and 173nm of vacuum ultraviolet radiation is emitted when the transition from the excited state to the ground state [5].

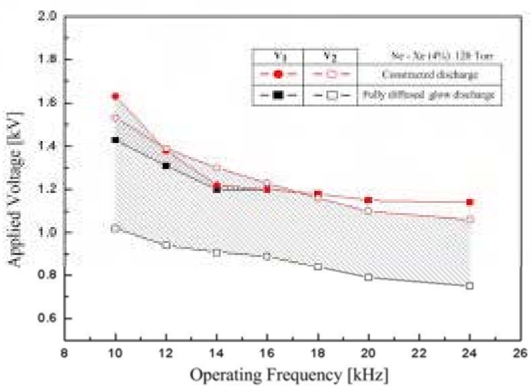


Figure 2: Operating voltage margin

3.1 Discharge characteristics of MFFL

In general, an increase of the distance between two electrodes causes the discharge voltage to increase. As shown in Figure1-(a), we obtained the low voltage operation by the help of the auxiliary electrode placed near to the main electrode on the opposite glass plate. However, the discharge condition is varied by the voltage conditions applied to the auxiliary electrode.

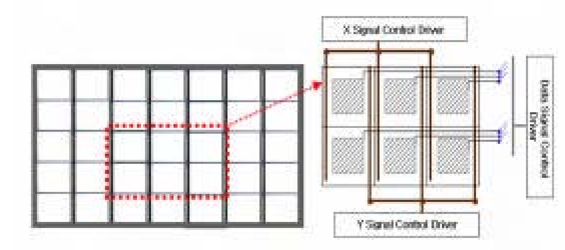


Figure 3: Electrode connection for the 3x2 multi-cell

Figure 2 shows the operating voltage margin change as the conditions of the applied voltage to the auxiliary electrode changes. When the voltage level V_1 was applied, the voltage margin was very narrow, but when the voltage level V_2 is applied, a fully extended glow discharge was obtained for the wide frequency range with about 400V margin. We will make use of this property to decide the areal selective On/Off state of the chosen cell in the large sized, multi-cell MFFL. Figure 3 shows the interconnection for 3x2 multi-cell blocks using the independent address signal control method. In which the parallel two electrodes are driven by common pulse generator (inverter) respectively.

3.2 Areal Dimming Control

Figure 4 shows the driving voltage waveform for the areal selective 2-bit dimming in the multi-cell MFFL. One subfield consisted of three periods; the

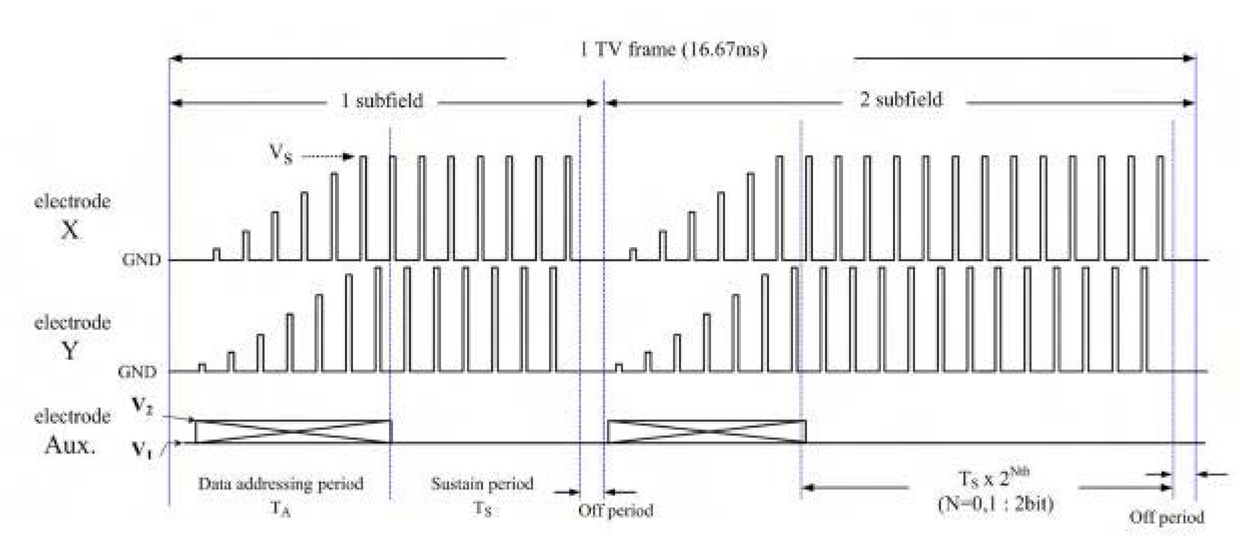


Figure 4: Drive waveforms for the areal selective 2-bit dimming

data addressing period (T_A), the sustain period (T_S) and the off period. During the addressing period (T_A), the V_2 is applied to the auxiliary electrode to be the on cell and the V_1 is applied to the auxiliary electrode to be the off cell. Ramp voltage prevents the discharge from going to unstable contracted discharge. In the period T_S, operating voltage Vs is selected among the bi-stable voltage range as shown in Figure 2. The sustain pulse train were set to display the selected luminance level by the association with pulse number and pulse width modulations, so that the luminance level can be variable in any different level according to image variation. So the sub-field method was used to give different luminance levels from a TV frame to the subsequent one with the areal selectivity. During the off period, driving voltage does not apply to any electrode. Discharge occurred in the previous subfield is terminated. In case of 2 sub-field driving with the 2^0, 2^1 luminance weightings as shown in Figure 4, a total of 4 luminance levels would be available.

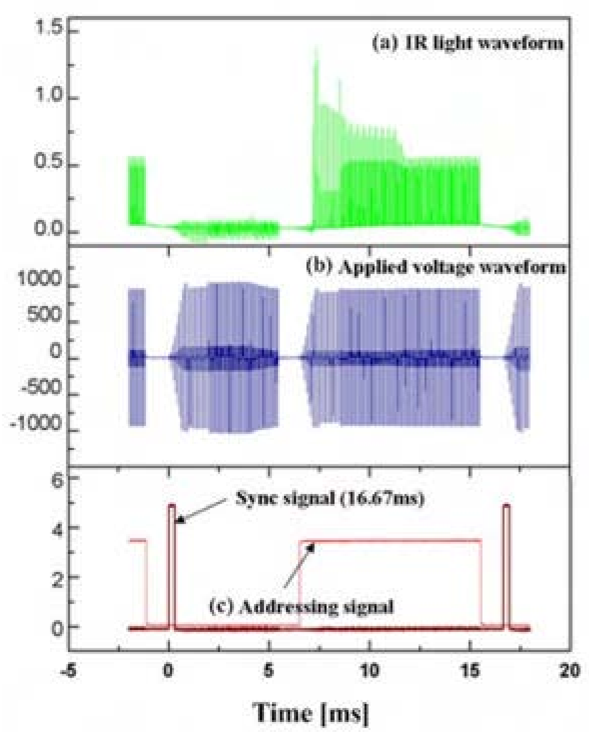


Figure 5: Operating waveforms and driving signal Infra Red light waveform (a), proposed driving waveform (b) and gate signal for addressing(c).

Figure 5 shows the operating waveform and the result of sub-field driving method. Figure 5-(b) shows

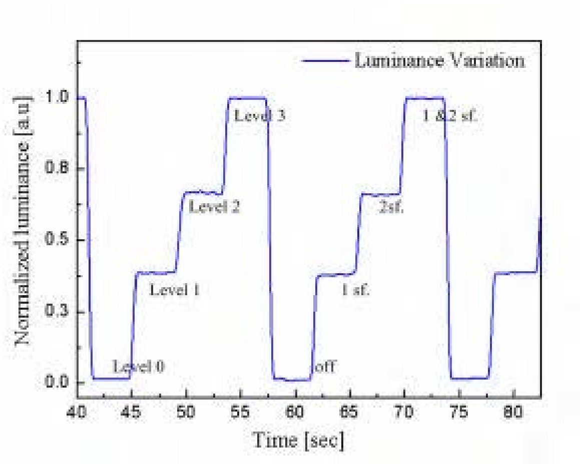


Figure 6: Luminance variation on the proposed sub-field driving method

the applied voltage waveform measured by differential voltage probe between two main electrodes. During the 1st subfield, when we give the turning off signal to the auxiliary electrode like Figure 5-(c), so there is no light emission, even though sustain pulse is applying. And if we give the turning on signal during the 2nd subfield then the lamp starts to emit as shown in Figure 5-(a).

Therefore we could achieve 4 different luminance levels through the selective switching On and Off in a TV frame in newly proposed driving method as shown in Figure 6. These luminance levels can be adjusted by the input image signal.

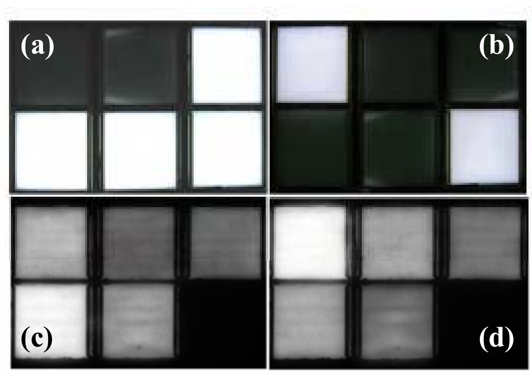


Figure 7: Luminance variation of the 3x2 multi-cell MFFL

Figure 7 shows the various examples when the sub-field driving method was adopted in the multi-cell MFFL. These images are captured by Intensified CCD camera during one TV field. In Figure 7-(a), the 4

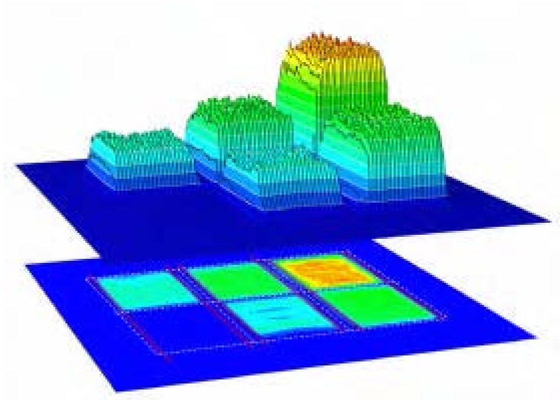


Figure 8: Areal selective dimming in the 3x2 multi-cell MFFL

cells are turned on at the luminance level 3, and Figure 7-(b) shows the emission image when 2 cells are turned on at luminance level 2, and Figure 7-(c) and 7-(d) show the gradation images displaying 4 kinds of luminance levels. It was possible to make a different luminance level in a TV frame by frame.

Figure 8 shows the replotted 3-D graph during the one TV frame, which show different luminance levels in each cell.

4. Conclusion

We propose a new driving method for the areal selective 2-bit dimming of a multi-cell structured MFFL that will allow a significant improvement of the gray scale expression capability, the contrast ratio and the power reduction of LCD.

5. References

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