Antiferroelectric Liquid Crystal Display with High Image Quality

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Abstract
The antiferroelectric liquid crystal display (AFLCD) is unique display that can show the perfect moving image using the passive matrix driving scheme. We optimized the driving waveform and introduced the dual driving method. Also, by improving this driving method and using line inversion method, we realized AFLC display with high image quality, which has 160(RGB)x240, 32768colors, crosstalk free and flicker free. The contrast ratio is greater than 60:1, and the brightness is above 200cd/m².

1. Introduction
Recently, super-twisted nematic liquid crystal displays (STN-LCDs) are used for small-sized mobile phones widely as personal digital assistant (PDA), cellular phone. Thin film transistor liquid crystal displays (TFT-LCDs) are used as display monitors since those characteristics are rapidly approaching cathode ray tube (CRT) displays from the viewpoint of cost, image quality, and viewing angle due to many kinds of innovation.[1, 2]

But the change of the market toward the IMT2000 demands a moving image displays. The response time of STN-LCD (hundreds msec) and TFT-LCD (tens msec) cannot satisfy the demand of this market. AFLCD has not only fast response time within 1ms but also a number of important advantages, wide viewing angle characteristics of in-plane switching, continuous gray scale and the production cost.[3] It has the same manufacturing process with STN-LCD. In spite of all these attractive features, there are still no commercial AFLC devices available on the market. The main reasons for this are difficult cell gap control, bad contrast ratio and operating temperature range. In this work, we discuss some methods to get high image quality in AFLCD.

2. Design of AFLCD Panel
Color AFLCD panels (2.8 inch, 160(RGB) x 240, 32768 colors) have been prepared. The cell gap of the panel provided with patterned spacer was about 1.8μm and the antiparallel rubbing of the polyimide alignment layers was used.

3. The Driving Method
The driving scheme of AFLCD that shows in Figure 1 comprises three parts, selection(1), nonselection(2), and reset period(3). In order to remove DC effect, the waveform with opposite polarity is driven in each frame. The basic driving mechanism of the scan waveform is a method of maintaining the brightness in the non-selection period by hysteresis characteristics, after selecting a specified brightness in the selection period.

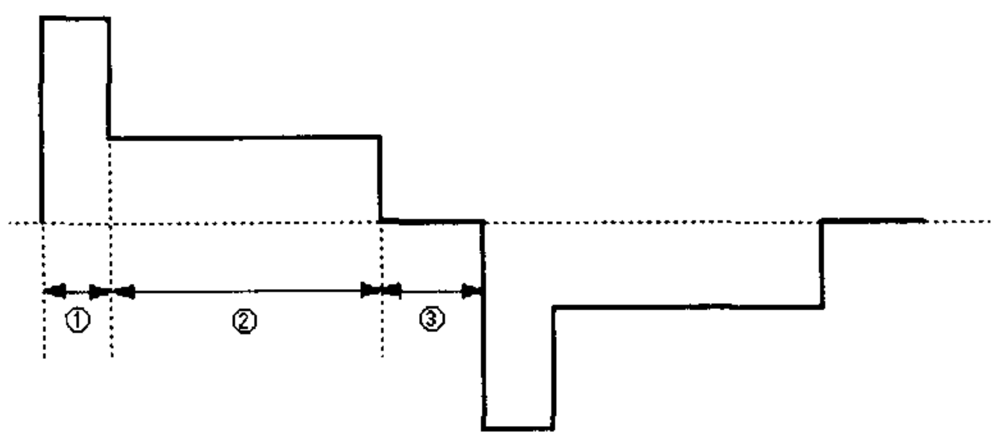

Figure 1. Scan waveform in AFLCD. Part (1) is selection, part (2) is nonselection and part (3) is reset period.

3.1 The Reset Time
The falling time from F to AF phase is slower than rising one because the falling follows the relaxation. When the falling time is slow, there are image sticking in the display. The reset period in the end of the waveform can remove this image sticking and improve the contrast ratio because of the early starting for AF phase. On the other hand, when the reset time is too long, the contrast ratio is worse because of the

bad transmission during the reset time. Therefore we chose the optimum reset time for the liquid crystal. Figure 2 shows the reset time dependence on the contrast ratio for the several liquid crystals.

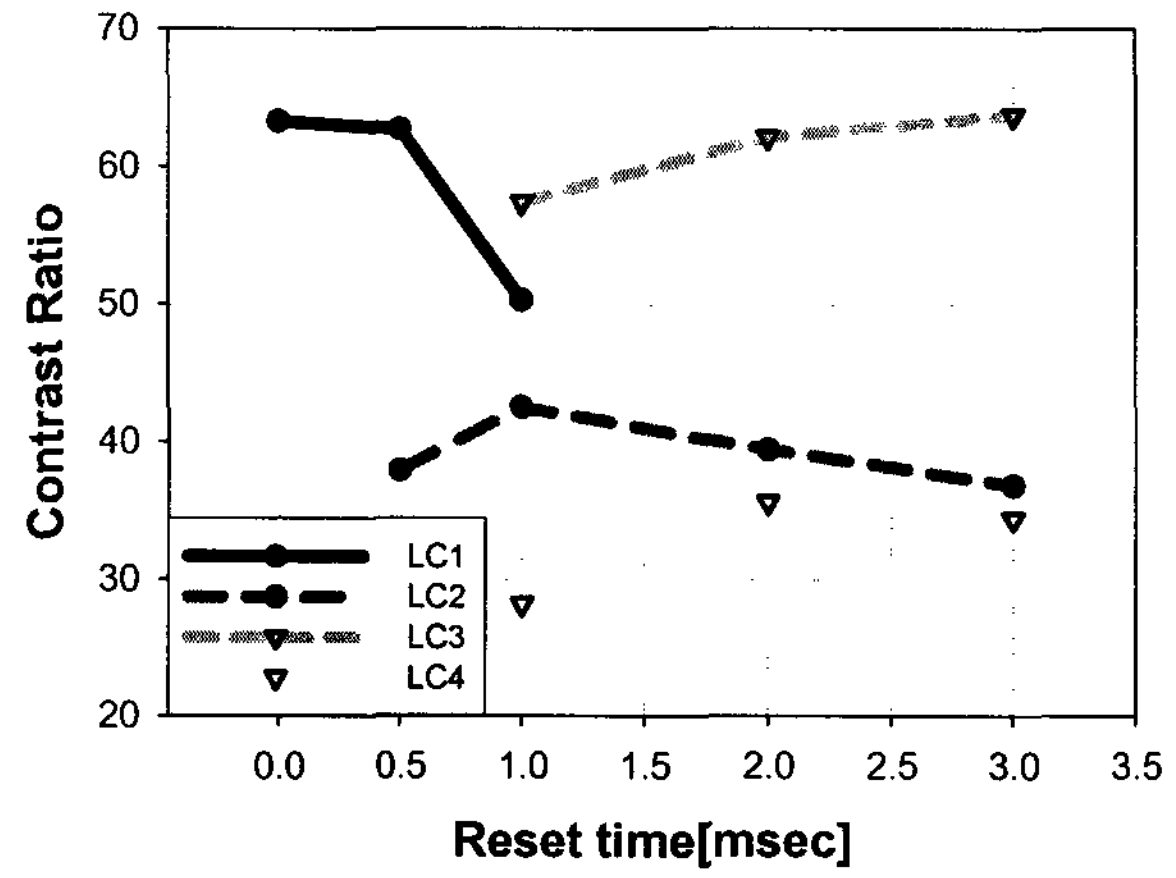

Figure 2. The reset time dependence on the contrast ratio for the several liquid crystals at 25°C.

3.2 Flicker and The number of scan line

The flicker occurs in the display that is driven with 60Hz frame frequency, because the two phases +F, -F are not complete symmetric each other and the display flickers with 30 Hz. In order to remove the flicker, the frame frequency was increased up 120Hz. However, the short time of the selection period decreases the brightness and the contrast ratio.

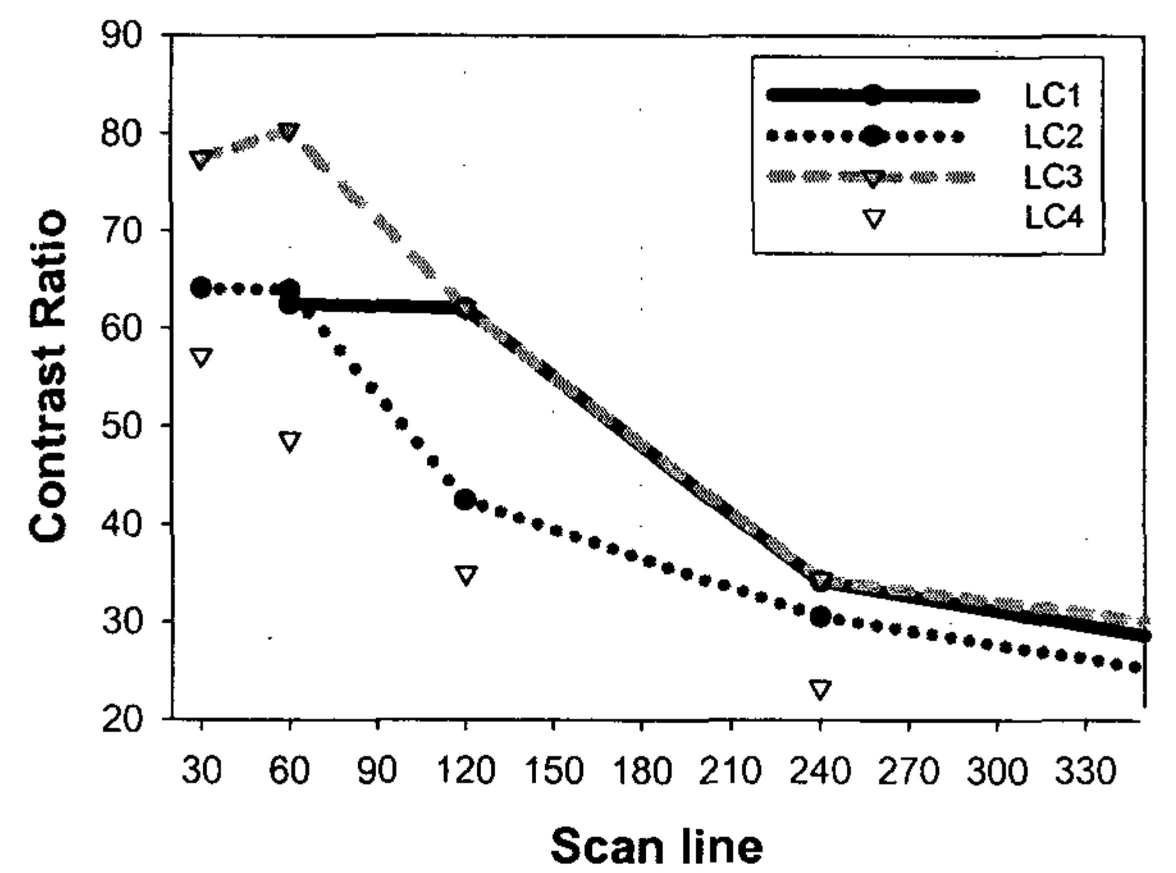

Figure 3. The number of scan line dependence on the contrast ratio

Figure 3 shows the scan line dependence on the contrast ratio. The contrast ratio increases as the number of the scan lines decreases because of long selection period. The contrast ratio of the display is saturated in the small number of scan line. In this case the display responds as like single pulse. We used the dual method that comprises two separated scan parts. This means that the line selection period become two times longer and it gives the effect of 120 scan lines instead of 240 lines. So the dual method compensates for loss of the contrast ratio from fast frame frequency.

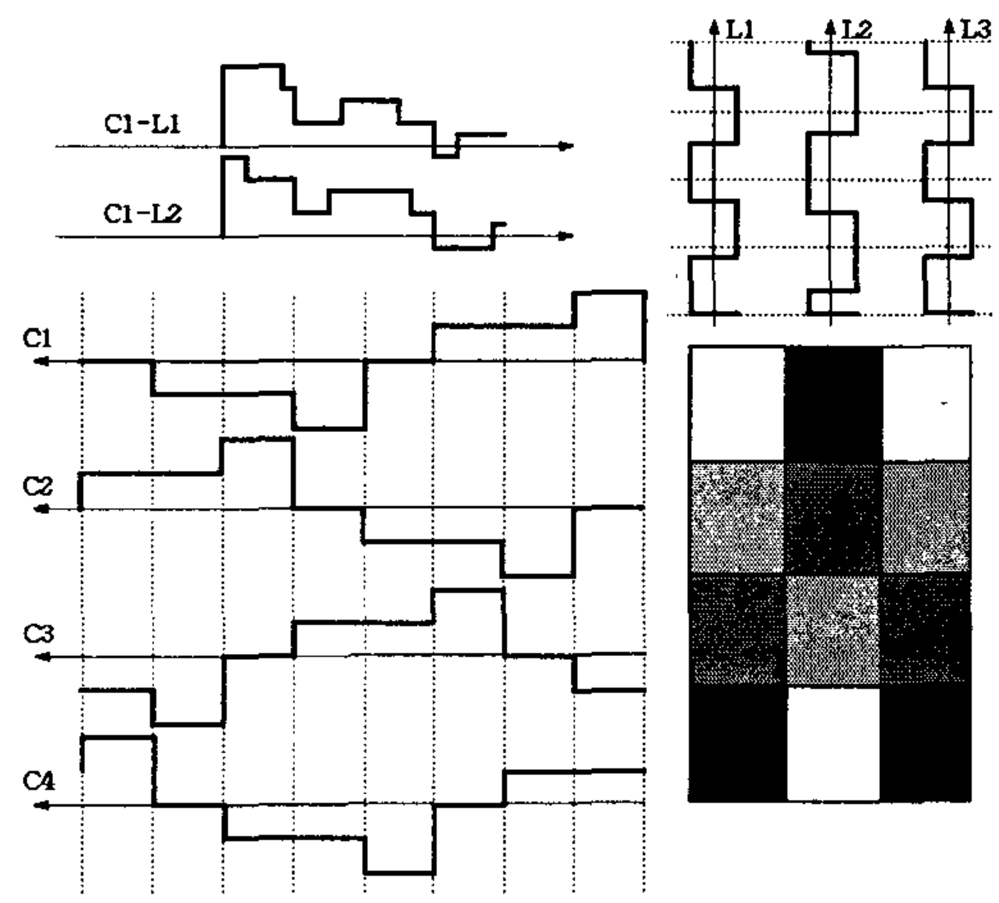

Figure 4. Driving Scheme with line inversion method. C1~C4 are line inversion method. L1~L3 show the data with pulse width modulation for gray scale.

3.3 The Crosstalk Free Driving Method

Researches on the crosstalk in STN-LCD have been undertaken. In the case of STN-LCD, the crosstalk occurs from both of the voltage change of the ON/OFF applied in data line and the capacitance change of dielectric anisotropy of liquid crystal according to ON/OFF state. The crosstalk from the data line relates to the frequency and it can be removed somewhat by the modulation signal. The crosstalk from the capacitance change occurs in the scan line.

In AFLCD, due to hysteresis characteristics in non-selection period, the crosstalk of a small voltage change as STN-LCD does not occur. But since scan voltage in non-selection period is not zero, the crosstalk occurs by actual voltage change according to data. Figure 4(C1~C4) shows the line inversion driving method that converts the polarity of the scan voltage in each line. This line inversion of the scan voltage maintains constantly the average voltage during the nonselection period. Then we can use the same duty ratio and whole selection period time. Therefore, we removed the crosstalk without any loss in the brightness and contrast ratio.

4. Conclusion

We realized AFLC display with high quality by the optimization of the driving waveform and introduction of the dual driving method. Crosstalk was removed by means of a line inversion method. Flicker also was removed from increase of the frame frequency. We drove 2.8 inch AFLCD panel which has 160(RGB)x240, 32768 colors, crosstalk free and flicker free. The contrast ratio of the display was greater than 60:1 and the brightness was above 200cd/m^2.

5. References

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