Crosstalk Improvements for STN LCD

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Among FPD technology, STN LCD has quite a long development history. Because of its maturity and its low fabrication cost, STN LCD dominates the display market of most handheld applications such as game console, cellular phone, PDA and many other products that require small size display. Following the development of information technology, the display requirements become stricter, with higher resolution, faster response and smaller in pixel pitch. The requirements of displaying unit are even harsh for color display. Nevertheless, color STN display has been developed and adopted into the display market. Compare to the active matrix display, STN LCD has to face another difficulty – the crosstalk problem. Crosstalk in general is a visible defect that occurs because of the interference by adjacent pixels. It is just like a translucent tail that is pattern dependent and will appear in some of the pictures only. Unfortunately, display quality will be greatly degraded with this phenomenon as shown in Fig.1.

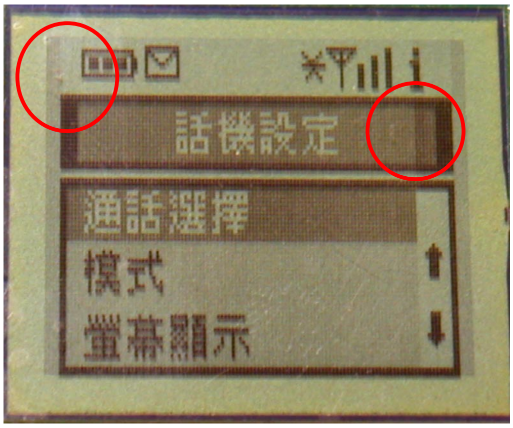


Fig.1 Example of a crosstalk display

"How does crosstalk occur?"

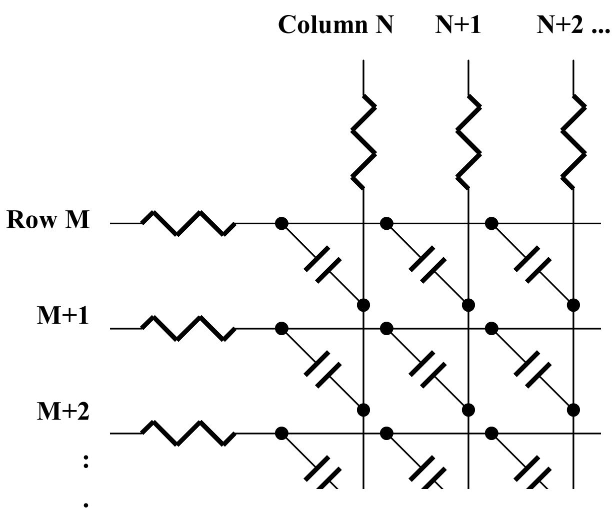


Fig.2 Electrical model of a LCD panel

Causes of crosstalk can be divided into two categories, the panel characteristic and the driver IC performance. Fig.2 shows the electrical model of a LCD panel. Each capacitor is one display element defined as a pixel and the resistors on each line depict the ITO resistance.

To turn the pixels on, a voltage has to be applied across the capacitors. The root mean square (RMS) voltage across the capacitors determines the darkness for the pixels. Since the pixels in the same column are driven by one signal line, the voltage across one pixel will be affected by the other pixels at the same column. When the voltages across different pixels in the same row are different, crosstalk can be observed.

"How to measure crosstalk?"

Since crosstalk is pattern dependent and therefore special test patterns are required to check the existence of crosstalk. Figure 3a and 3b show two patterns that can be

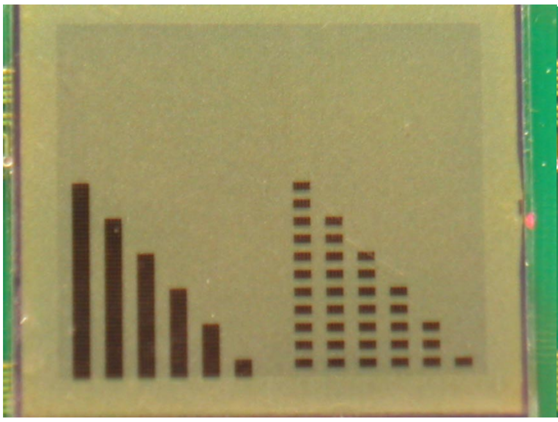


Fig.3a Test pattern for mono display

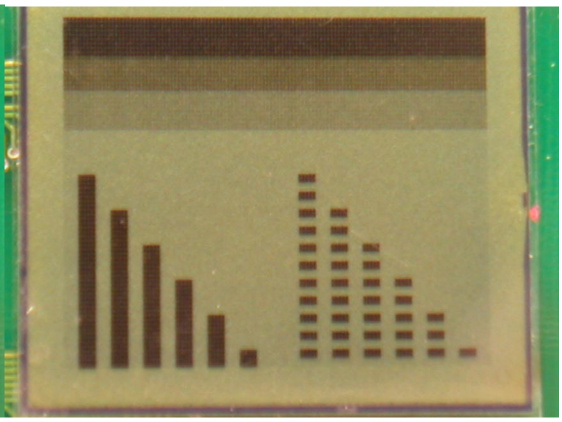


Fig.3b Test pattern for gray scale Display

used to check for crosstalk effectively. Bars with longer length will cause more crosstalk. The solid bars are more effective for driver related problems while the broken bars are more effective for panel related problems. For gray scale or CSTN LCD, rows of gray bars are required as they are more susceptible to crosstalk.

“Differences between mono and gray scale display?”

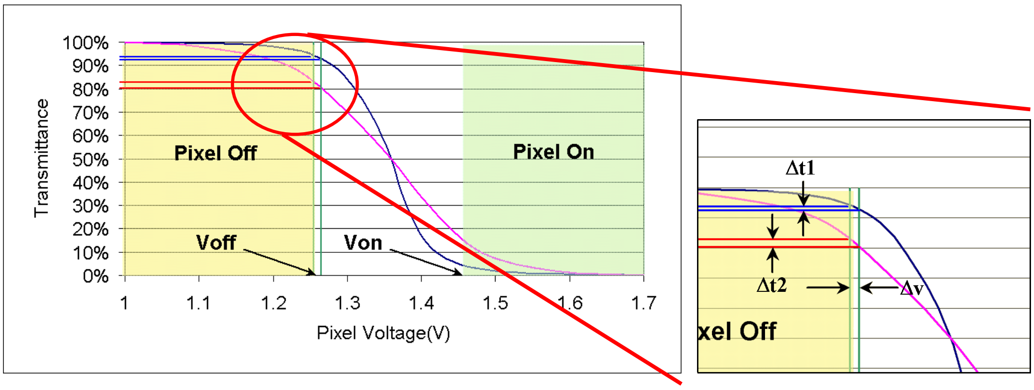


Fig.4a VT curve of mono STN displays

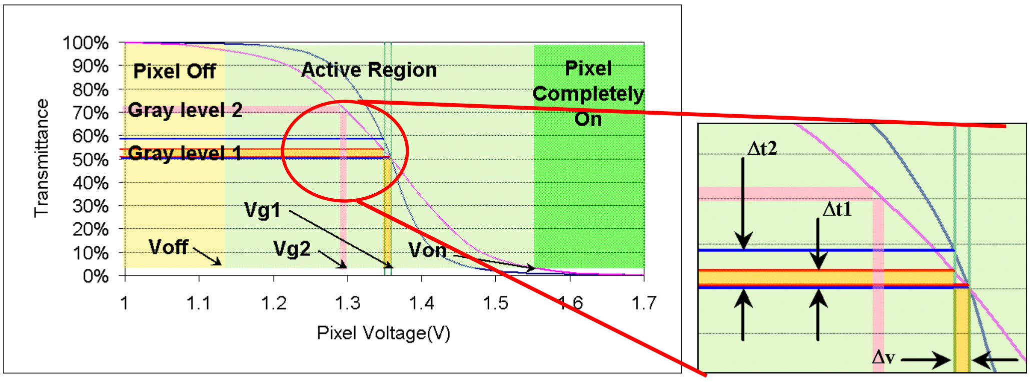


Fig.4b VT curve of gray scale or CSTN displays

Figure 4a and 4b shows the voltage and transmittance (VT) curve for a mono and gray scale displays respectively. Assuming the difference of RMS voltage between two adjacent pixels is Δv, it can be seen from Fig 4a that the difference in transmittance Δt2 is smaller than Δt1. Therefore a panel with stepper VT curve provides less crosstalk in mono STN. However, from Fig 4b, Δt2 is greater than Δt1 in gray scale or CSTN displays, it means gray scale or CSTN displays requires a panel with less steep curve. Fig 4b also shows crosstalk is more severe at the two gray scales than the black and white regions.

"What is the driver voltage requirement?"

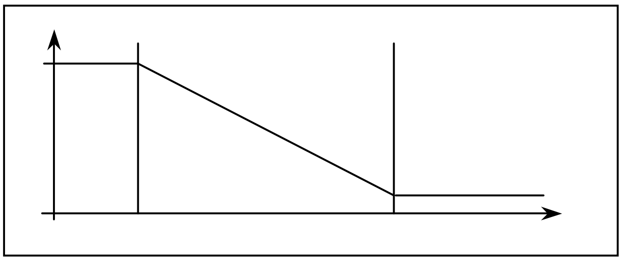


Fig 5a.   Linear VT curve

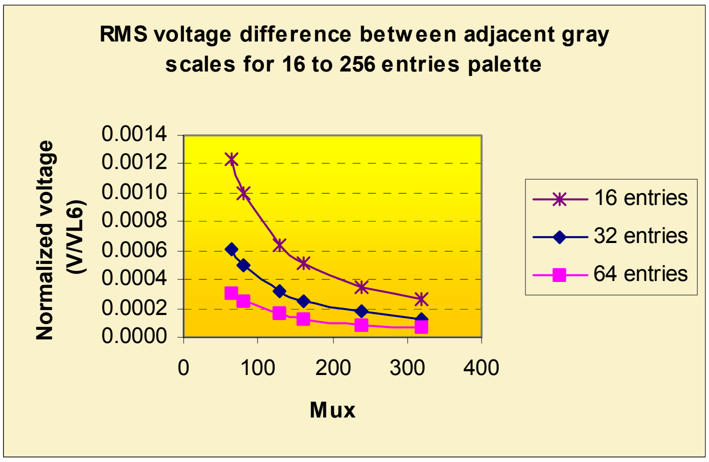


Fig.5b Driver voltage requirement

As mentioned in previous section, the ideal VT curve for a gray scale display should be linear as shown in Fig 5a.

Assume the gray levels are equally distributed within the on and off region, the RMS voltage between two gray levels are shown in Fig 5b. For example, a 4k-colors STN display, each of the RGB pixels need to display one out of 4-bits, or 16 levels of gray. If the display has 80 lines and the VLCD is 10V, then the RMS voltage difference between two gray levels is about 10mV. In order to make sure adjacent gray levels or colors can be identified, the crosstalk effect must be less than this voltage. As the display size or number of gray or color increased, the voltage requirement will be tightened.

"How the yield be influenced?"

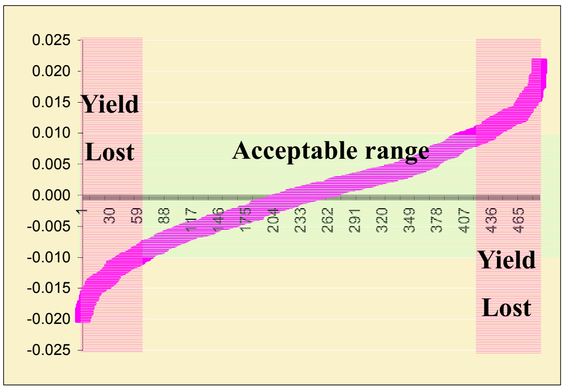


Fig.6 Distribution of voltage deviation

For an 80-lines, 16-levels per pixel display operating at 10V VLCD, Fig. 6 shows a simulation on the RMS voltage shift of 500 LCD driver ICs with random voltage offset at VL2 and VL5. From Fig 4b, over 28% will not be able to meet the requirement of 10mV as set in the previous section. In order to improve the yield, the output voltage levels for the LCD driver must be improved.

"Effect of panel loadings"

As shown in Fig. 7, the ITO resistance and LC capacitance on LCD affect the RMS voltage across a pixel.

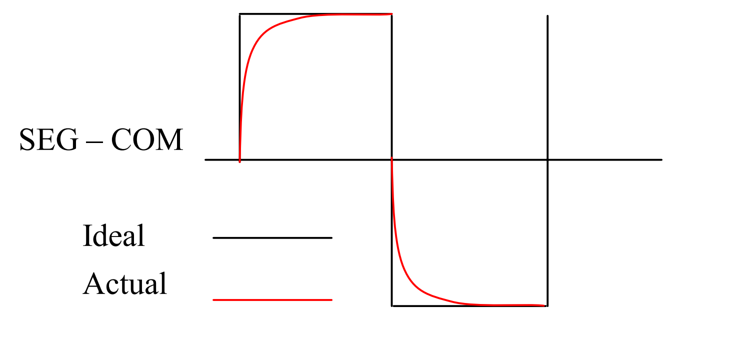
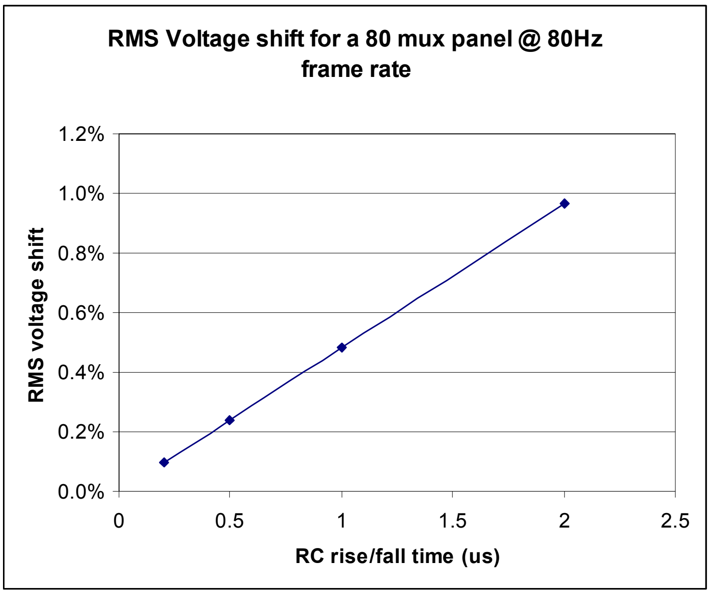


Figure 7. Voltage across non-selected pixel

The relationship between the RC rise/fall time and the change in RMS voltage is shown below. For a 1/10 bias panel with 10V VLCD, the peak-to-peak voltage as shown in Figure 7 is 2V. In order to meet the requirement of less than 10mV shift (0.5% of 2V) as mentioned before, the RC rise/fall time must be less than 1us.



"Solutions for crosstalk improvement"

To reduce display crosstalk, the panel RC loading is required to be as small as possible. Either reduce the capacitance or the ITO resistance can improve the crosstalk phenomenon. Especially in COG application, the ITO resistance and its layout are more circuital and the noise caused by ITO traces may be large enough to generate crosstalk. The optimization of VT characteristic is another method for minimizing crosstalk.

Besides the improvements mentioned above, crosstalk also could be reduced by using a driving method called N-line inversion provided in SSD1851 LCD driver IC from Solomon Systech Limited. N-line inversion allows polarity change in any N-lines as specified during software programming, which can be used to reduce crosstalk caused by panel loading. The mechanism is to reduce the number of lines that influence a pixel. For a 64-mux module, one ON pixel in a particular column may be influenced by 63 OFF pixels of that column. When 13-line inversion is used, the number of influence pixels is reduced to 12, a simple mathematics.

"Face the market, improve for the future"

In recent years, the use of color display in cellular phone market is obviously increasing. There is about 70% of the new color display using color STN and this figure keeps rising. Major handset manufacturers, such as Motorola, SonyErisson and Nokia have introduced series of color phone for next generation. The display market of cellular phone is switching from mono and gray scale to color display. In order to meet the market needs, the crosstalk problem of STN LCD must be solved. From IC design to panel manufacturing, many parameters will affect the final performance and thus contribution from each of the parties are necessary.