Extremely Low-Power Consumption Design for LCD In-Cell Touch Panel

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Abstract

In-cell touch technology, as an important medium of human-machine interaction, is widely used in products such as mobile phones, tablets, notebooks, and so on. However, the addition of the vertical touch line (TP) in in-cell touch pixels leads to a decrease in pixel aperture rate and uneven display of sub-pixels with or without TP lines. In view of the characteristics of different sizes and resolutions of pixels, this paper innovatively re-arranges the layout of data line and TP line, such as placing the data line in the middle of sub-pixel, S-shaped data line routing, and dual TFT for one sub-pixel designs, to increase the overall transmittance of pixels while avoiding uneven display. Through the above-mentioned design to increase the transmittance, the panel power consumption can be reduced by 3% to 10%.

Keywords

In-cell touch, low-power consumption, aperture ratio

1. Introduction

In-cell touch technology, with the advantages of lightweight, high-precision, and good display performance, is widely used in products such as smartphones, tablets, notebooks, and so on. In order to integrate the touch layer into the LCD panel, as show in Figure1, the transparent common electrode is usually divided into different sensor pads and connected to the TDDI IC (Touch and Display Driver Integration) through a single touch trace (TP trace). The addition of TP trace in pixel lead to a decrease in pixel aperture ratio, usually requiring an increase in backlight brightness to compensate for the loss of transmittance, resulting in an increase in power consumption.

In view of the characteristics of pixels with different resolutions and manufacturing mask flows, this paper innovatively proposes some designs to improve the transmittance and reduce the power consumption of the LCD panel. The TP trace, setting in the same (second metal) layer with source (data) electrode, usually places near the data line or in the middle of pixel. The innovatively placed the data line in the middle of sub-pixel can increase the light efficiency of pixel by 3% to 4%. For the conventional 6-mask-flow in-cell touch pixel, there is no insulation layer between the source electrode layer and the pixel ITO layer. In order to place the data line in pixel, the pixel ITO is split into two halves, and the two parts of the pixel ITO are connected through two TFTs, which the aperture ratio of pixel can be increased by 4% to 10%. Moreover, in order to avoid uneven display caused by the presence or absence of TP lines in sub-pixels, dummy TP traces are usually set up, with three TP lines in one pixel (1P3T). The 2P3T (two pixel with three TP lines) pixel design, with S-shaped data and TP line routing design avoiding uneven display, can increase the aperture ratio of pixel by reducing the dummy TP. Through the above-mentioned design to increase the transmittance, the panel power consumption of different products can be reduced by 3% to 10%.

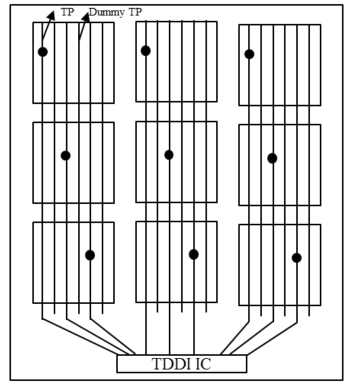

Figure 1. LCD In-cell touch panel design.

2. Result and discuss

In order to reduce the power consumption of in-cell touch panel, some new pixel designs are proposed below.

2.1 Pixel design 1

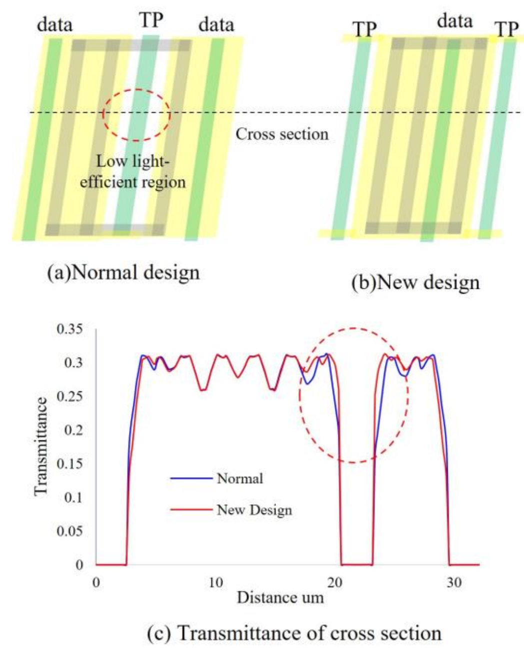

Figure 2. Pixel design 1 and transmittance of cross section.

For the conventional in-cell touch pixel design as shown in the figure 2a, the TP trace crosses the center of the sub-pixel, and in order to reduce the capacitive load between the TP trace and the transparent common electrode, the overlapping transparent common electrode is partially hollowed out. As shown in the graph of the relationship between transmittance and position in Figure 2c, the electric field strength of the pixel electrode and the common electrode in the hollowed-out part decreases, so that the rotation angle of the liquid crystal is smaller than that in the normal area, resulting in lower light efficiency. The new design places the data line in the middle of the pixel, as shown in the

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figure 2b, and places the aforementioned low efficiency area at the edge of the sub-pixel where obscured by the black matrix, which can improve the overall light efficiency of the pixel by 3% to 4%.

2.2 Pixel design 2

For the 6-mask-flow in-cell touch pixel, the TP trace cannot be designed in the middle of the sub-pixels because there is no insulation layer between the source electrode layer and the pixel ITO layer. As shown in Figure 3a, the TP trace is placed next to the data line, and their spacing S1, which covered by the black matrix. The opaque areas of the sub-pixels are d1, d2 and S1, which causes a loss of aperture ratio for the sub-pixel. As shown in Figure 3b, in order to place the data line in the middle of sub-pixel, the pixel ITO is split into two halves, and the two parts of the pixel ITO are connected through two Sub-TFTs, the opaque areas of the sub-pixels are d1 and d2 without S1. For notebook 16-inch WU pixel design, and the aperture rate can be increased by 10%. Besides, for pixels of different resolution products, the transmittance improvement range is 5% to 10%.

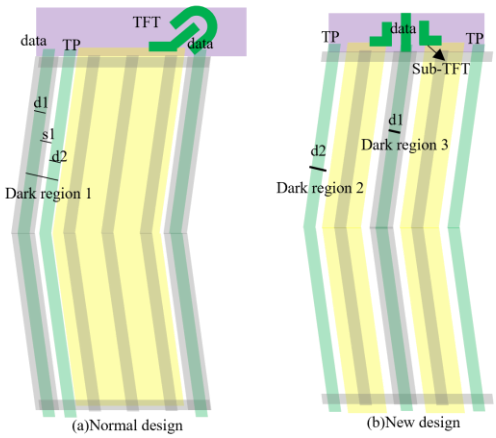

Figure 3. Schematic diagram of Pixel design 2.

2.3 Pixel design 3

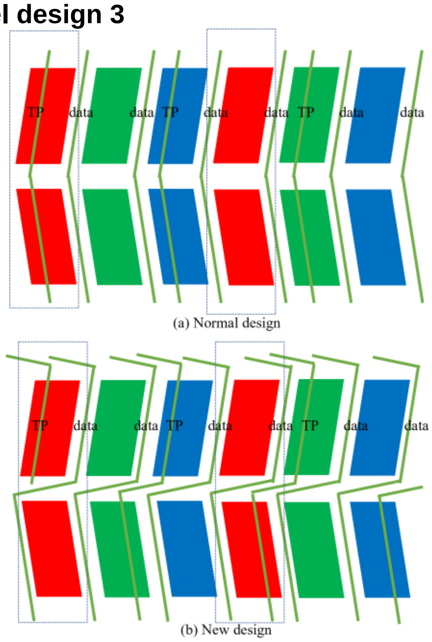

Figure 4. Schematic diagram of 2P3T pixel design

In order to avoid uneven display caused by the presence or absence of TP lines in sub-pixels, dummy TP traces are usually set up, with three TP lines in one pixel (1P3T). The dummy TP line occupies the aperture area, causing the light transmittance of the panel to decrease. Besides, design of one TP line in one pixel (1P1T) is also commonly used. However, the insufficient number of TP lines leads to a decrease in touch sensitivity.

As show in Figure 4a, the 2P3T (two pixel with three TP lines) design, which simply reduces the number of TP lines by half, has the problem of alternating vertical light and dark lines on the display. For example, the 2P3T design shows one of the R sub-pixels contains TP lines, and the other does not in the in a repeating unit of two pixels, resulting uneven display of alternating bright and dark vertical stripes Mura. To solve this problem, the data line is wound in an "S" shape, so that the TP line can alternately pass-through adjacent columns of sub pixels. As shown in Figure 4b, each column of RGB sub pixels has one row with TP lines and the other row without, so the display performance of each RGB column is the same, thus avoiding uneven vertical display caused by a decrease in the number of TP lines. For the pixel design of 11.45-inch QHD tablet product, from 1P3T to 2P3T design, the transmission can enhance 7%.

3. Conclusion

According to the characteristics of the in-cell touch pixel design for products with different process flow, corresponding transmittance improvement designs are proposed to reduce power consumption. Optimizing TP and Data line layout , reducing dummy TP trace to improve aperture rate. Novel pixel and common electrode line/space designs improve light efficiency. These designs which can be combined for different products can reduce the overall power consumption of LCD panel by 3%-10%.

4. References

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