A Research on Pixel Design of TDDI Infinity Display

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Abstract

As the full screen size of a TDDI solution grows, touch functions and display effects are bound to conflict. Based on the LTPS process, we can ensure that the display crosstalk problem of the TDDI infinity display and the flickering of the grayscale image are solved without affecting the touch function through optimization of the pixel design.

1. Introduction

In 2016, the mobile phone entered the era of full screen. When the full-screen market expanded rapidly, the new panel development adopted TDDI solutions, in line with the product strategy of panel manufacturers and driver IC manufacturers. Figure 1 shows IHS Markit's forecast of TDDI market demand in the next few years. It can be seen that this demand will reach its maximum growth rate in 2019.

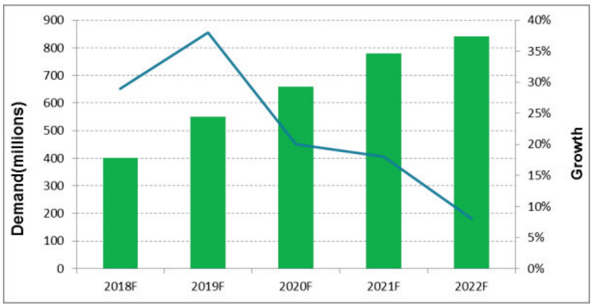


Fig.1 The IHS Markit's Forecast of TDDI Market Demand

Each panel manufacturer's TDDI solution is different. In the field of LTPS TFT, we have been working with driver IC manufacturers to develop TDDI full screen, as shown in Figure 2.

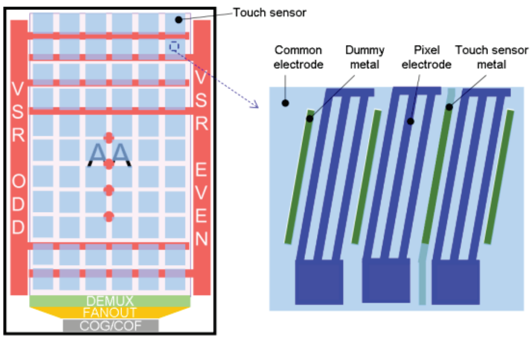


Fig.2 The Solution of TDDI

However, as the full screen size is increased from 6 inches to 6.5 inches, the aspect ratio is increased from 18:9 to 19.5:9, and the demand panel takes into account the display effect and the touch function, which restricts the pixel design. In particular, in order to improve the endurance capability of the mobile phone, the demand panel is compatible with the driving frequency of 30 Hz, and the performance of the gray-scale picture satisfies the non-flickering performance, and the higher requirements for the panel pixel design are put forward.

In order to occupy a place in the comprehensive screen panel market, we have studied the design and process aspects to ensure the display effect and touch performance of the panel.

2. Design Research

In the LTPS LCD, the flipping of the liquid crystal is affected by the electric field of the pixel, as shown in Figure 3. In the TDDI architecture, we added the metal trace of the touch sensor, as shown in Figure 4. The metal trace is not on the same layer as the common electrode. In order to ensure the uniformity of the display effect and the consideration of the viewing angle, the dummy metal in the same layer as the touch sensor is added, and in order to improve the touch Performance, we hollowed out part of the common electrode film layer above the touch sensor trace.

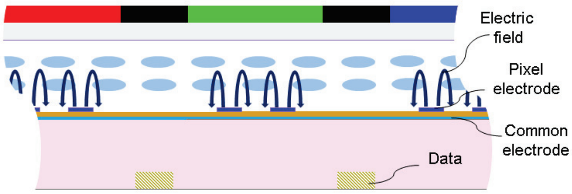


Fig.3 The Electric Field of the Pixel

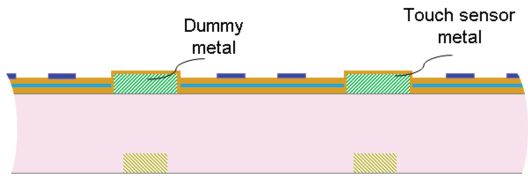


Fig.4 The Architecture of TDDI

With no significant changes in process conditions, as the panel size and aspect ratio increase, we find that the value of crosstalk in crosstalk image with a drive frequency of 60Hz and the value of flicker in 127 grayscale pattern with a drive frequency of 30Hz are deteriorating, as shown in Figure 5.

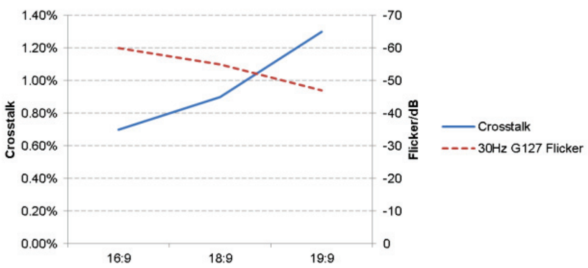


Fig.5 The Trend of Crosstalk and Flicker

Through research, we found that the dummy metal and other metals form coupling capacitors. These coupling capacitors include the coupling capacitance with the data line (C_d), the coupling capacitance of the common electrode (C_c), and the coupling capacitance of the pixel electrode (C_p). Due to the presence of the coupling capacitor, the dummy metal forms the induced voltage (U_{dum}) when the data signal changes. And the relationship is as shown in the following equation, U_{dum} is expressed as

$$U_{dum} \propto C_d/(C_d+C_c+C_p) \qquad (1)$$

U_{dum} is the cause of vertical crosstalk on the Crosstalk pattern and the 30Hz flicker of 127 grayscale pattern. The specific theory is as follows.

In Figure 6, there are two properties of the metal A, one is dummy metal, which is floating, storing passive signals. The other is touch sensor metal, which stores the signal that is the active signal provided by the IC. Therefore, when the data voltage changes, there is an induced voltage generated on the dummy metal, and the touch sensor metal acts as a shield. When the properties of the metal A on the left and right sides of the pixel electrode are different, the electric field above the pixel is only disturbed by the induced electric field on one side, which affects the rotation of the liquid crystal of the pixel, so that the brightness of the pixel cannot reach the target value. When the properties of the metal A on the left and right sides of the pixel electrode are the same, since the polarities of the adjacent data voltages are opposite, the interference of the electric field above the pixels is cancelled, and the brightness of the pixels is not affected. In the crosstalk picture of Fig. 7a, the data voltage variation causing the coupling effect is changed from 127 grayscale voltage to 255 gray scale voltage; in the 127 grayscale picture of Figure 7b, this change in data voltage causing the coupling effect is a change in the 127 grayscale voltage between each frame.

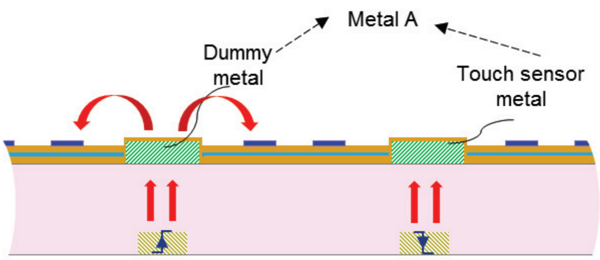
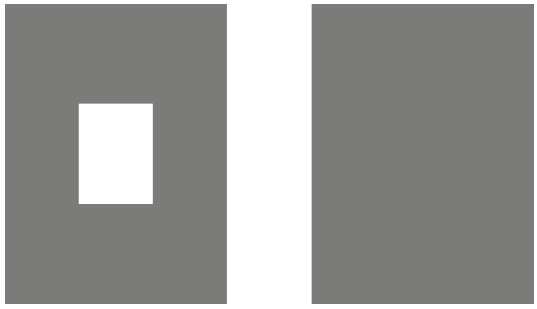


Fig.6 The Coupling Effect



a Crosstalk Pattern **b 127Gray Pattern**

Fig.7 The Experimental Picture

Therefore, we optimize the design of the area of the dummy metal and the hollowed-out area of the common electrode by simulation, and reasonably allocate the value of C_d, C_c and C_p.

3. Process Research

When we measured the in-plane uniformity of G127 Flicker driven by 30Hz, we found that it is regularly distributed on large sheets of glass. We have found that by adjusting the exposure process parameters and etching process parameters, performance differences in different regions can be reduced.

At the same time, we know that C_d, C_c and C_p will affect the value of crosstalk and flicker. Therefore, we change the relative position of the data metal layer, the touch sensor metal layer, the common electrode metal layer and the pixel electrode metal layer to change the performance of the panel. This can also be left to a more flexible range of designs. For example, by adjusting the relative distance between the pixel electrode layer and the touch sensor metal layer (D_{pt}), both crosstalk and flicker are subject to change, and the trend of change is uniform, as shown in Figure 8 and Figure 9.

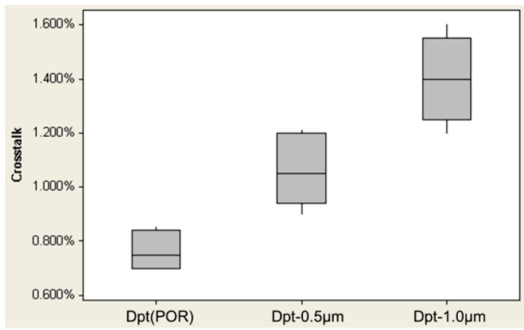


Fig.8 The Relationship of Crosstalk and D_{pt}

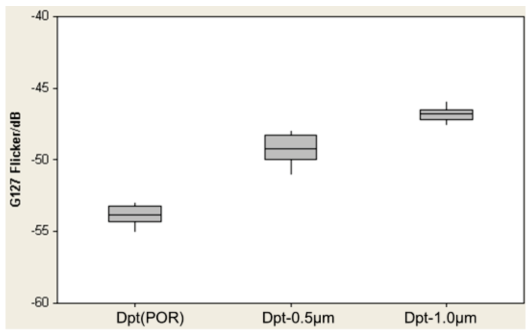


Fig.9 The Relationship of Flicker and D_{pt}

4. Result

Through our cooperation and efforts with various departments of the process, through the above research, the final product developed can meet both good display performance and reliable touch performance.

We designed a 6.53-inch full-screen with an aspect ratio of 19.5:9, with a crosstalk value of less than 1.2%, a 30Hz 127 grayscale Flicker value of less than -50dB, a TP SNR value of less than -45dB, and a viewing angle and TP performance that meet most of the customer requirements. Moreover, we also reduced the differences in display and touch functions of different batches of panels by optimizing process flow and process parameters.

Tab.1 The design specifications of 6.53

Item	Data
Display size	6.53"
TFT process	LTPS
Display type	SFT
Resolution	1080*RGB*2340
PPI	394
View angle	In spec
Crosstalk	<1.2%
30Hz G127Flicker	<-50dB
TP SNR	<-45dB
TP performance	In spec

5. Conclusion

In the past three years, in the mobile phone market, the proportion of comprehensive screens has become larger and larger. By optimizing the pixel design and adjusting the process parameters, we designed a more reliable panel to bring a better user experience to consumers. And the study can guide the design of panels with an aspect ratio of 20:9 or higher.

References

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