Study on the Touch Screen Panel Based on the Light over Electro Phoretic Display

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Abstract

Different from the LCD that have two glass substrates on the top and the bottom, EPD have an advantage that is using the bottom glass substrate and the top e-ink sheet. So, it is impossible to apply R or C type TSP that need bottom and top glass plane. We successfully implemented the TSP (Touch Screen Panel) based on the light over the EPD (Electro Phoretic Display).

1. Introduction

The E-Paper based on many different methods has been developed such as electro powder, electro wetting, electro phoretic and electro chromatic display.

The advantages (can be the disadvantage) of the E-Paper for the publics are like that

1) It is very light and very easy to carry.
2) It doesn't need power consumption after making an image.
3) It is very cheap because of structure and simple function.
4) It needs no external light source.

As you can see, E-paper has many advantages (limitations) for the users' convenient and these advantages ask engineers implement more complicated devices without any space and cost charging.

One of method of reducing the cost and space is the unification of two or many different functions and that is the main reason why we have developed this device.

In this paper, we like to say about the integration of the EPD and the TSP in one device to reduce the cost, space and power consumption.

This integration is necessary for the sales of the public at the point of view on the cost and space problem.

2. Experimental

The experimental is done by this sequence. Each step's important factor and novel method will be discussed by this sequence too.

1) Panel Design
2) Board Design
3) Voltage Tuning
4) Algorithm Tuning

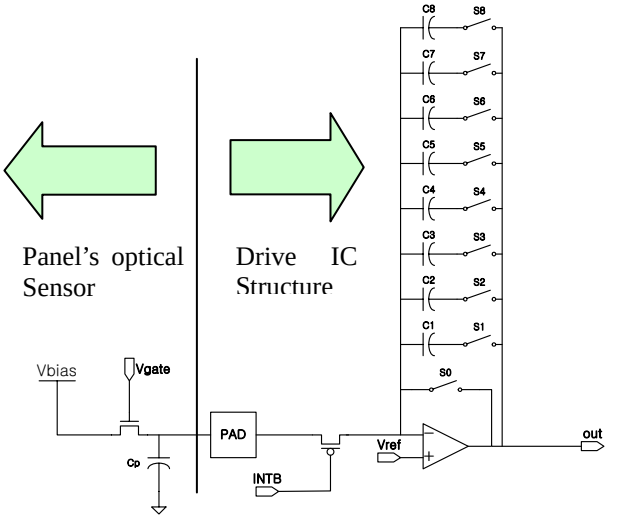

Fig. 1. Simple Circuit Diagram of the Optical Touch Sensor (From TL5104SR)

1) Panel Design

Fig 1 shows the optical sensor's circuit diagram of the TSP embedded EPD panel. That diagram is designed by the TLI and we have used the IC to drive the optical sensor.

The pixel design is almost same with the normal LCD TFT backplane except EPD's specific driving structure. In this paper, we have applied them to the EPD that have different characteristics and transmittance from the LCD panel. Those differences cause a different circumstance to drive the optical sensor as a respect of voltage and driving signal and algorithm.

TABLE 1. TFT SPECIFICATION (W/L)

Sensor TR	40 ㎛ / 4.0 ㎛

The output current is depended on the sensor transistor's W/L size. So we have implemented them within the adaptable range like a Table 1. These techniques are discussed in the LCD optical sensor.

Reduction of TFT's length and width can cause a shortage of the output current and then we can't find the exact change of optical sensor. We want to get the good sensitive as well as big difference of delta value (difference value between succession sensors of the light change detected position and undetected position).

Though the pixel design is little bit out of the range of best performance, we can handle the output using the voltage and signal.

With the proper optical sensor design, we have implemented another TFT for the EPD driving.

For driving an EPD and optical sensor, we need a gate driving module too. We added two gate driving circuits in the panel that is specific techniques that don't need an external gate drive ICs. Those things were shown in Fig 2.

2) Board Design

Before doing an experiment, we need a full system such as panel and sensor driving board. Even more we need an operational algorithm and switching pictures and PC interface. Those items show the sensor's proper activity. Fig 2 and Fig 3 show these specific system blocks.

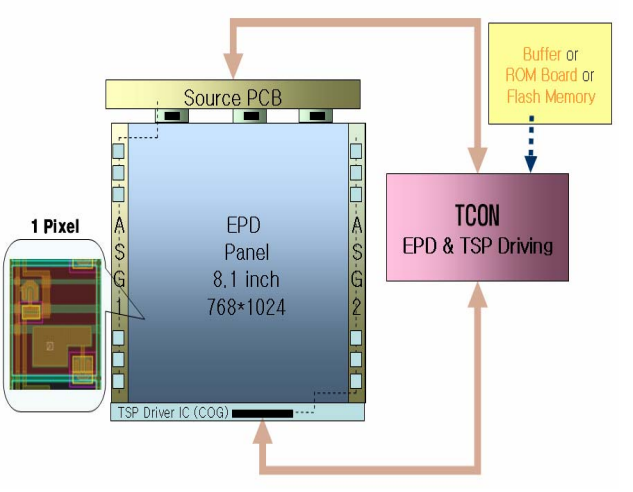

Fig. 2. Full System of Driving the EPD and TSP.

We have used one board to operate an EPD_TSP Panel. As mentioned before, one of the EPD's advantage is portable display that user can easily read or see the panel's output under the sunlight circumstance. As the board's size is smaller, the user would feel more convenient and the power consumption is smaller too.

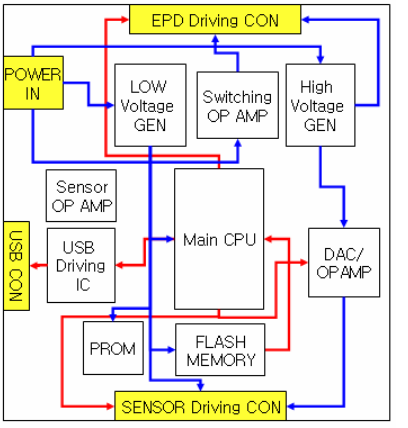

Fig. 3. Board Architecture with signal and power flow.

Board's block diagram was shown in the Fig 3. Some lines show the signal processing and the some lines show the power flow. Every important signal is controlled under the Main CPU because the exact timing is needed to show the clean image and to reduce the unnecessary power consumption.

To adjust an optimal sensor output, we need to change many things depends on the board and panel and external circumstances. For example, to increase

the sensor's output current, we can change the voltage as well as algorithms or gate on time. As the optical sensor's output is very sensitive to the applied voltage (Vbias, Vgate), we make it changeable.

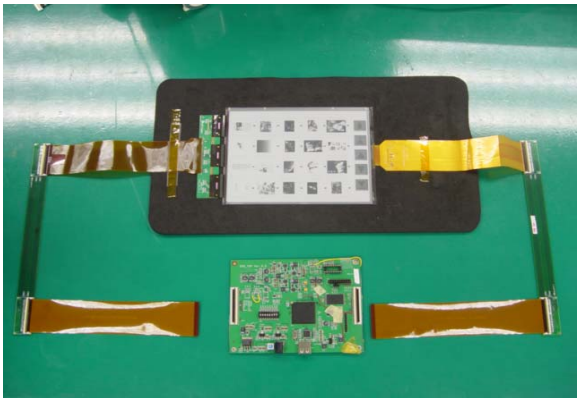

Fig. 4. Full Picture of EPD_TSP Panel.

Fig 4 shows the real board and panel's picture. As you can see in the Fig 4, panel need a two connector, upside for the EPD driving and downside for the sensor operation. Those interfaces are easily connected to the board.

3) Voltage Tuning

Before applying the algorithm to the real image test, we need to see the sensor's output. If the sensor's delta values are not enough to indicate the switching location, we can't define the switch position. And we need to know the finger's resolution compared to the panel's sensor resolution.

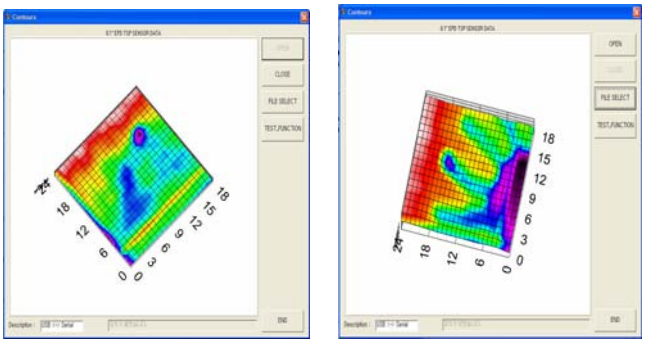

Fig. 6. Sample Test (Hand) Image of the PC interfaced (USB) panel output.

After implementing a system that is easily changeable by the changeable voltage generator, we have tuned voltages (Vbias, Vgate). To know the exact sensor's output, we have used a TLI sensor drive IC that embedded the ADC and it generates the digital output including a position data. We also want to know the real time output of the sensor, so we have connected to a PC to see the sensor's output by using a USB interface. Fig 6 shows the hand shape that block the external light source over the EPD Panel.

Fist image shows that one of fingers touch a panel and second one is full hand on the panel.

As you can see, the delta value is enough to be used for the switches and we have implemented the reference value in the panel by blocking the sensor with the BM (black mask). However the light is penetrated from the side to the TFT and it can't show the exact reference sensor array output. So we have used a first line of sensor as a reference. It indicates the external circumstance and we have changed the voltages (Vbias, Vgate) by DAC (digital to analog converter) and gain control methods.

4) Algorithm Tuning

One of the most different parts from the LCD optical sensor panel is the algorithm of the switching. Because EPD's response time is later than the LCD, we have to wait the finishing of operation after switches order the changing of the panel work. And another different thing is that EPD do not need a power after image making is finished. So we have to cut off the power after each operation.

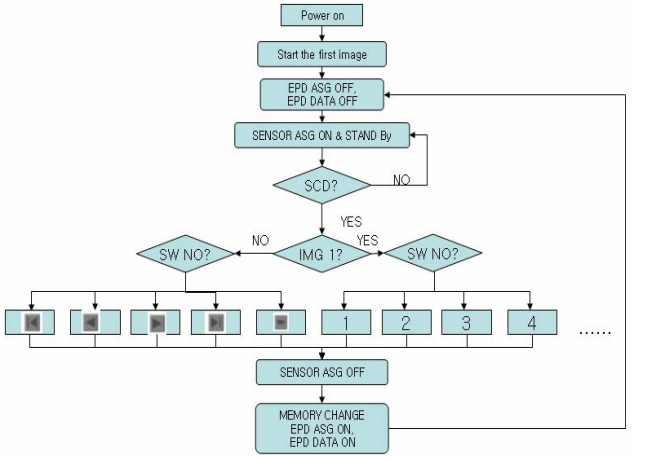

Fig. 5. Driving Algorithm.

Fig 5 shows the algorithm how to operate the sensor and TSP spontaneously without missing the switch operation and image defect.

After power on, we have booted the panel by changing to the initial picture (shown in Fig .7(1)).

And then display must wait the operation order (Stand By mode). We used a SCD (scene change detection) as operation order. If any change (the value

in the sensor output have been predetermined as the threshold in the voltage tuning) was detected, we regard is as a scene change order.

At that time, depending on the present image, we have operated differently. If the present panel is number one, we use the multi switches that is located upper part of the panel (shown in Fig .7(1)). If not, we wait to detect from the bottom 5 switches.

If no switching operation is detected, the board is sequentially in the stand-by mode.

3. Results and discussion

Fig 7 shows the sample images that have used in the panel's operation. We have inserted twenty one pictures to the memory and the some sample pictures are shown in the Fig 4.

There are two modes to operation as mentioned in the experimental 4).

One is to start with Fig 7(1) and we have predetermined switches' position as you can see in the bottom of each small picture in the Fig 7(1). If one of switches is pushed by finger, the panel was switched to that image.

The other is to work with the 5 big switches that pre-inserted in the picture.

The following sentence explained the switches operation.

 : go to the first picture (Fig 4(1)

 : go to the previous picture

 : go to the next picture

 : go to the last picture (Fig 4(2))

 : slide-show (automatically sequence)

These switches can not be operated at any time because the image is needed to be completed. As you can see in the Fig 5, there is a time interval between the image making and switch operational time.

The operation can be changed at the users convenient. For example, we can start or the stop the slide shows at any time. Our experiment is one of example how to drive and how to apply the TSP on the E-paper device

The optical sensor is very sensitive to the external circumstance. To reduce this effect on the panel, we have tried several different methods such as location of the predetermined switches and voltage magnitude and sensor driving time. Sensor's high sensitivity sometimes causes the mis-operation.

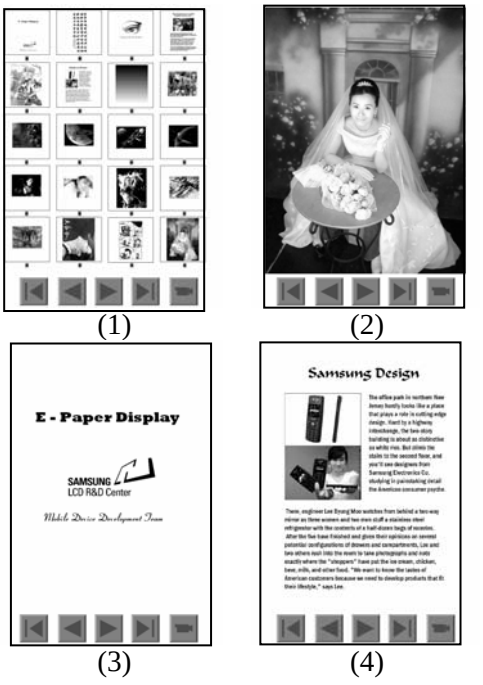

Fig. 7. Sample Images applied to the EPD_TSP panel & board.

4. Summary

As the TSP techniques are developed, the necessity on the FPD is increased. However, how much the sensor need to be operated well is not decided yet. So many devices suggested the sensitivity controllable by receiving a reference data.

We have implemented the EPD and TSP based panel in a system and we can get the good result in the room circumstance by adjusting many factors.

The one of different things from the LCD optical sensor is the switching algorithm that doesn't need to be real time and power must be cut down after image generation is done. In this paper, we suggested one of sample of cost reducing method on the E-paper techniques and how to use it as a switches.

5. References

1. W. den Boer, *SID'03 Technical Digest*, p1494 (2003).