AMOLED Fast Electrical Detection Technology and Compensation Data Processing

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Abstract

The electrical compensation scheme in the field of AMOLED (Active Matrix Organic Light Emitting Diode) has unique advantages. Compared with the traditional internal compensation circuit, the electrical compensation scheme can make the pixel circuit more concise, so that higher Pixels Per Inch (PPI) can be achieved. At the same time, it is more excellent in extending the life of the display and improving the display effect in real time. We use the current mode detection scheme, compared with the voltage mode detection technology, has a faster detection speed, in terms of compensation object is not limited to TFT Vth, but any factor caused by the driving TFT current difference, so it has higher technical advancement.

Author Keywords

Display panel; Electrical detection; Compensation algorithm; Fast detection;

1. Background

The electrical compensation technology originated in the field of large-size AMOLED, which can detect and compensate the Vth and mobility of the driving TFT, and can also detect and compensate the aging of OLED devices [1,2]. The electrical detection and compensation technology can monitor the voltage and current changes of OLED devices in real time, detect the signs of deterioration in time, and take corresponding compensation measures, so as to prolong the life of the display and further improve the durability of the display. The electrical compensation technology is divided into two steps: detection and compensation. The detection is divided into voltage mode and current mode. In terms of control mechanism, detection can be divided into real-time detection and non-real-time detection. The faster the detection speed, the better the chance of real-time detection. If the detection speed is slow, only non-real-time detection can be performed. Small AMOLED usually use an internal compensation pixel circuit to improve the backplane TFT Vth difference problem. However, due to the use of more TFT or capacitor components in the internal compensation, the routing space inside the panel becomes very tight when applied to higher PPI products, and it is difficult to achieve high PPI products [3]. This paper will study the external electrical compensation technology. We will use 3T1C pixel circuit, with external sensing circuit and control timing, cancel the internal compensation function and the corresponding TFT, and detect the current flowing through the driving TFT of each sub-pixel to realize the detection of current differences caused by factors such as Vth and mobility. This scheme reduces the number of TFTS in the pixel circuit, so as to achieve higher pixel density.

2. System Architecture

Electrical detection can be divided into voltage type and current type detection. Voltage-mode detection can obtain the Vth of driving TFT, but it usually has the disadvantages of slow detection speed and unable to obtain the absolute value. This paper studies the current-mode detection method, which has the characteristics of fast detection speed and high accuracy of detection data. The Driving circuit system includes driving part and Sensing part. The Driving part provides the control timing and image voltage output, and the Sensing part uses the integrator to integrate the current flowing through the D-TFT. The current information includes the mobility, Vth and other information of the D-TFT.

2.1 Pixel-wise Circuit

The pixel circuit discussed in this paper is a 3T1C circuit, as shown in Figure 1. T1 to T3 are N-type TFT, SW0 and SW1 are P-type TFT, and T1 is known as driven TFT(D-TFT) [4,5]. When detecting, the current flows through the D-TFT and enters the integrator. The integrator performs the reverse integration of the current to obtain the amount of charge. The amount of charge represents the difference of current flowing through each sub-pixel D-TFT.

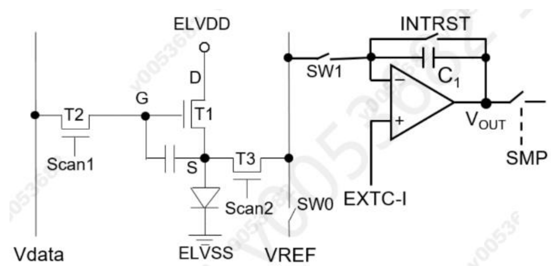

Figure 1. Pixel circuit

2.2 Display timing

The display timing of 3T1C pixel circuit is relatively simple, as shown in Figure 2. When scanning to the current line, SW0 is on, SW1 is off, T2 and T3 are on, Data voltage is written in point G through the T2 tube, and another determined voltage VREF is written in point S through the T3 tube, so that Vgs of T1 is equal to Vdata-VREF, and OLED emits light.

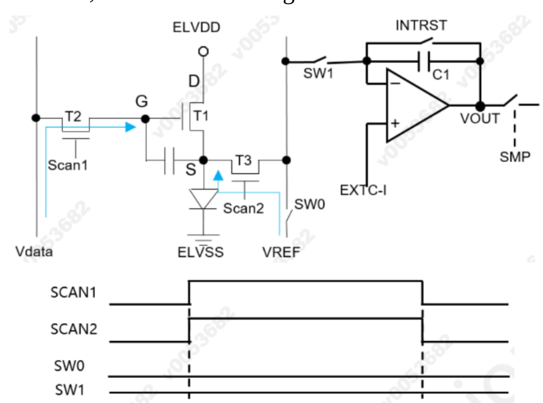

Figure 2. Display timing

2.3 Detection timing

The detection time sequence is divided into three stages, as shown in Figure 3. T1 stage switch SW0 conduction, SW1 off, T2, T3 conduction, G point through the T2 tube write Data voltage, S point through the T3 tube write another determined voltage VREF, to

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ensure T1 tube conduction. The setting of VREF voltage value can ensure that the OLED device does not emit light. T2 stage switch SW0 is disconnected, SW1 conduction, the current flows through the T1 tube, into the integrator for integration; T3 stage switch SW0 conduction, SW1 disconnect, the G-spot is written to the black state voltage, ensure that after completion of current line detection T1 tube conduction, to prevent the occurrence of voltage DROP ELVDD power - DROP (IR) phenomenon and influence in other lines of pixels detection [6].

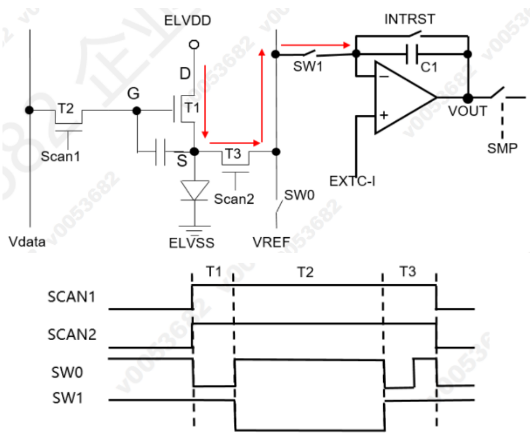
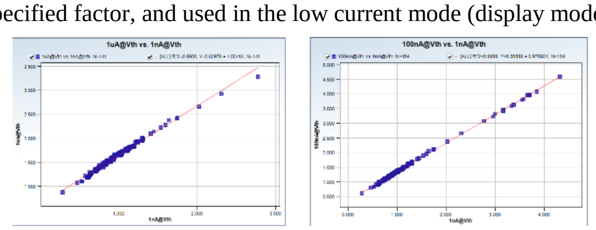


Figure 3. Detection timing

2.4 High current detection scheme

When the AMOLED module displays a low gray level, the current flowing through the D-TFT is small. If the same magnitude of current is used for detection, it is easy to be interfered, and it is difficult to obtain accurate data, and the signal-to-noise ratio is not good. The scheme in this paper is to use high current for detection, and then convert the data to the compensation data required for low current display. The feasibility of the scheme is verified by experiments. The TFT TEG is designed around the display. After the TEG and the display are produced together, the equivalent Vth data relationship of the TEG in the case of high current and low current is tested, as shown in Figure 4. Through the experiment, the equivalent Vth under the condition of high current and low current basically shows a good linear relationship, so the Vth can be obtained through the high current detection, multiplied by the specified factor, and used in the low current mode (display mode).



(a) 1uA/1nA Vth relationship (b) 100nA/1nA Vth relationship

Figure 4. Different currents in DTFT saturation region correspond to Vth relation

3. Compensation algorithm

The current integrator converts the current value into a charge value, and the difference of the charge value reflects the difference of the current value flowing through each sub-pixel. The compensation scheme is a cyclic iterative way, and the iteration is stopped when the charge values obtained by all pixels are basically consistent. When the difference of the detected charge values is less than a certain threshold, the current flowing through each sub-pixel D-TFT is considered to be basically the same, and the display will obtain a good display effect.

The detection data in this paper is 16-bit wide, and the full scale integrated charge is 4.8pC. According to the formula

$$Q = I * t$$

if the integration time is 40 us, the maximum integration current is 120nA, which can meet the current requirements of low and medium gray-scale detection. After the detection is completed, the charge data needs to be preprocessed, such as sub-pixel order rearrangement, singular point determination, parity data correction, etc. After preprocessing, the data are sent to the compensation algorithm module.

The current-mode electrical detection can only obtain the current value difference of pixels, and can't directly obtain the Vdata compensation value of pixels. Therefore, the current-mode compensation technology needs to be added to the look-up table LUT. The LUT records the mapping relationship between the current difference value of each sub-pixel and ΔVdata. The accuracy of this LUT determines the accuracy and effect of electrical compensation, so it is very important. In order to improve the accuracy of the lookup table LUT, this paper uses a loop iteration method to improve the accuracy of the lookup table. We detect all pixels for the first time to obtain the charge of all pixels. The most frequent value in this data is defined as the base charge, and the corresponding △Vdata of this data is defined as 0V, and the corresponding pixel is defined as the base pixel. These base pixels are used as the target to compensate the other pixels. The charge amount Cth is defined as the judgment threshold of whether compensation is needed. If the difference ΔC between the detected charge and the reference charge is greater than Cth, it needs to be compensated. If ΔC is less than Cth, no compensation is needed. Define the compensation step of Vdata as Vstep. If the difference ΔC between the detected charge and the reference charge is greater than 1*Cth and less than 2*Cth, then ΔVdata is 1*Vstep. If ΔC is greater than 2*Cth and less than 3*Cth, then ΔVdata is 2*Vstep, and so on. However, it should be noted that Vstep is not a fixed value, and different values need to be set according to the Gamma bound interval of the gray level value. For example, Vstep1 is set under the 32 gray level, Vstep2 is set from 32 to 64 gray level, and Vstep3 is set above 64 gray level. The detection compensation process is shown in Figure5.

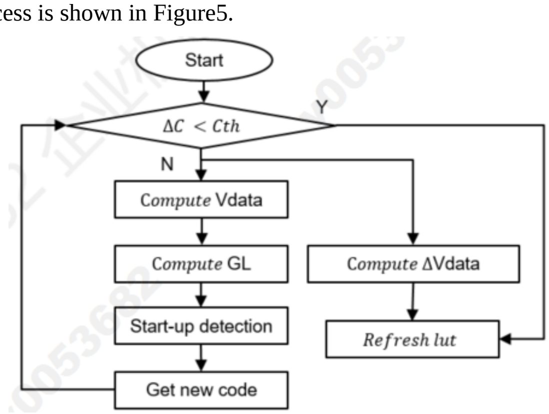


Figure 5. Loop iteration compensation schematic diagram

Firstly, the GL0 grayscale image is displayed in full screen. After the first full screen detection, the reference charge is calculated by counting the detected charge of each pixel. The difference between the charge of each pixel and the reference charge is calculated to obtain ΔC. For the pixel whose ΔC was greater than the compensation threshold Cth, ΔVdata1 and compensated Vdata1 were calculated, and then Vdata1 was converted to gray scale value GL1 according to the Gamma setting. The above processing is carried out for each sub-pixel of the full screen to make ΔVdata equal to ΔVdata1, and save it into the LUT table.

Then the screen body displays the GL1 screen (some pixels are grayscale GL0, some pixels are grayscale GL1 with compensation), and the second full-screen detection is initiated. After the detection, the detected charge of each sub-pixel in the full screen is obtained, and it is again differentiated with the reference charge to obtain ΔC. For the pixel whose ΔC is greater than the compensation threshold Cth, ΔVdata2 and compensated Vdata2 are calculated, and then Vdata2 is converted to gray scale value GL2 according to Gamma setting. The ΔVdata1 and ΔVdata2 were superimposed to obtain ΔVdata, which was stored in the LUT table. After several iterations in this way, the accuracy of ΔVdata stored in LUT form is getting higher and higher, and the compensation effect is getting better and better. Generally, 3-5 times can achieve better compensation effect.

In the experiment, we find that the measured charge value can indeed reflect the bright and dark characteristics of the screen. As shown in Figure 6, if we take a row of data in the screen for observation, we can see that the data on the left and right sides of the screen are larger, that is, the current value of D-TFT is larger, which is consistent with the phenomenon that the left and right edges of the actual screen are brighter and the middle position is darker. From the full-screen data, the data in the middle area is small, which is consistent with the Mura phenomenon in the middle area presented by the actual screen body.

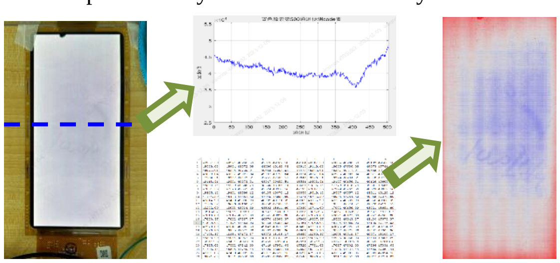
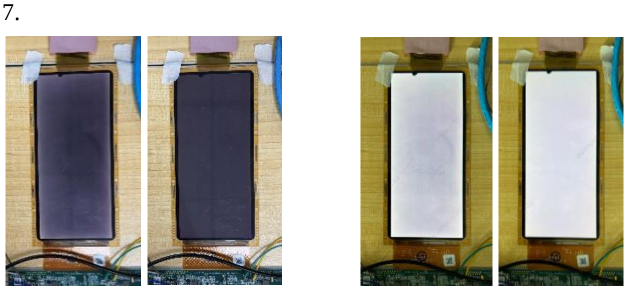


Figure 6. Data and display matching diagram

4. Practical effect

We verified the compensation method in an AMOLED display, and the photos before and after compensation are shown in Figure 7.



(a) Grayscale 32 (b) Grayscale 96

Figure 7. Before and after compensation diagram

From the comparison of photos before and after compensation, it can be seen that the electrical compensation scheme adopted in this paper has a significant improvement effect on Mura caused by the characteristics of the backplane (uniformity, light aging, etc.). We evaluated the improvement of brightness uniformity for each gray scale, and the data are shown in Figure 8. After compensation, the brightness uniformity is greatly improved, and the improvement range is greater at low gray levels, and a better display effect is obtained.

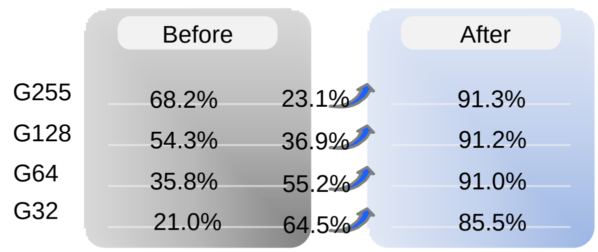


Figure 8. Comparison of uniformity before and after compensation

5. Conclusion

The current mode compensation technology discussed in this paper can obtain better compensation effect, and provide a feasible scheme for achieving high PPI and improving brightness uniformity. However, there is still room for improvement in the optimization of compensation algorithm, and further research is needed. In the future, this scheme can be applied to the development of real-time detection function, expand the aging compensation function of OLED devices, etc.

6. References

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