

# Research on a Method to Improve the Stability and Accuracy of LCD with Ambient Light Sensor

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## Abstract

To address the issue of poor accuracy when integrating light sensors into LCD for ambient light detection, this paper proposes a method to improve the stability and accuracy of a-Si LCD with ambient light sensor (LCD with ALS). The approach primarily involves designing different-sized TFT sensors, optimizing the light sensor driving circuit, refining light-sensing algorithms, and implementing driver IC differentiation to improve the precision of existing light-sensing measurements.

## Author Keywords

ambient light sensor(ALS); LCD with ALS; TFT; Amorphous silicon (a-Si); stability and accuracy

## 1. Introduction

In current amorphous silicon-based LCD display modules, the ambient light-sensing function (which automatically adjusts screen brightness based on ambient light levels) integrates TFT as light sensors within the panel. As shown in Figure 1, the TFT sensor is positioned between the Viewing Area (VA) and Active Area (AA). The implementation utilizes voltage-divider resistors on the Flexible Printed Circuit (FPC) for IC voltage detection, with the signal sampling design illustrated in Figure 2.

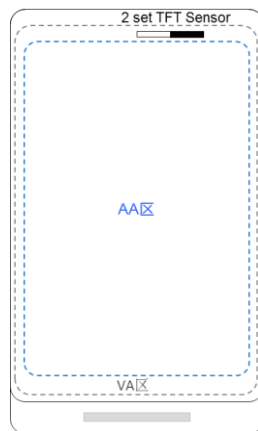


Figure 1. Schematic diagram of LCD with ALS

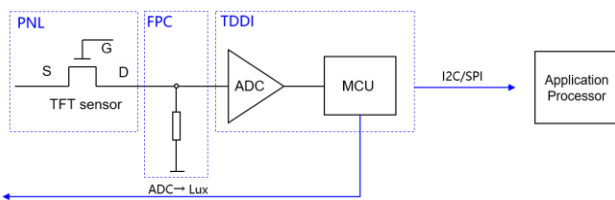


Figure 2. Schematic diagram of signal sampling design of LCD with ALS

As the light sensor of the LCD with ALS, the instability of TFT characteristics leads to the poor stability of the light-sensing data of the LCD with ALS. Simultaneously, factors including backlight conditions, temperature variations, light source types, driver IC performance, and light-sensing algorithms collectively affect the stability and accuracy of data acquisition in LCD with ALS. This paper proposes the following solutions to enhance the stability and accuracy of a-Si LCD with ALS: 1) Accuracy enhancement through TFT sensors with differentiated dimensions; 2) Parameter optimization of driving circuit based on TFT Sensor; 3) Algorithmic refinement for light-sensing data acquisition; 4) Comparative investigation of light-sensing accuracy via driver IC differentiation. Extensive experimental testing and comparative analysis under diverse environmental conditions have validated the feasibility of these approaches in improving both stability and accuracy of light-sensing data output.

## 2. Improvement solution of light sensing accuracy based on the size difference of TFT Sensor

As illustrated in Figure 2, when maintaining fixed source and gate terminal voltages in the TFT sensor, fluctuations in TFT channel resistance significantly compromise drain current stability. This phenomenon ultimately degrades the accuracy of light-sensing data by reducing the stability of ADC values output from TDDI (Touch and Display Driver Integration). The TFT channel resistance itself is subject to multiple influencing factors, with dimensional variations in TFT sensors exhibiting particularly pronounced effects on channel resistance values.

Experimental comparisons reveal that the response of TFT light-sensing sensors to ambient illumination is governed by both dimensional disparities in TFT sensors and optical filter characteristics. For TFT devices with varying dimensions, discrepancies in width-to-length (W/L) ratios induce distinct drain currents under identical illumination conditions, consequently generating differential response characteristics. Furthermore, light source identification accuracy critically impacts light-sensing data precision. This paper implements spectral energy distribution ratios of RGB components to discriminate between light sources, thereby enhancing spectral recognition capabilities.

Through extensive testing and comparative experiments, this paper has established a comprehensive experimental dataset. The empirical results demonstrate significant correlations between TFT sensor dimensions and light source identification accuracy. As shown in Figures 3~5, the analyzed measurement data from 10 display modules demonstrates that the vertical axis differentiates light sources (corresponding to distinct color-coded curves in the figures). The light source identification accuracy exhibits an inversely proportional relationship with the intersection density of these chromatic profiles - specifically, a

higher concentration of curve intersections between different light source signatures directly correlates with degraded discrimination precision.

Concurrently, this paper conducts comparative testing of TFT sensor dimensional configurations within the panel. By integrating multiple sensor sizes (A/B/C) on a single array substrate, the experimental design effectively eliminates inter-panel variations and driver IC discrepancies. As depicted in Figure 6, three TFT sensors with different sizes (A/B/C) are designed, and a variety of different size schemes can be obtained by connecting different sizes in series. At present, according to Figure 3~5, the light source identification accuracy of size C is the best. Subsequently, the size design scheme of TFT sensor will be determined by testing the light sensing accuracy and light source identification accuracy of TFT sensors with different sizes, so as to improve the accuracy of subsequent light sensing algorithm.

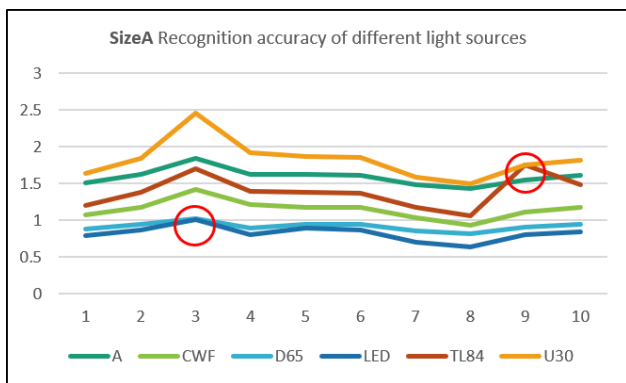


Figure 3. SizeA Identification accuracy of different light sources

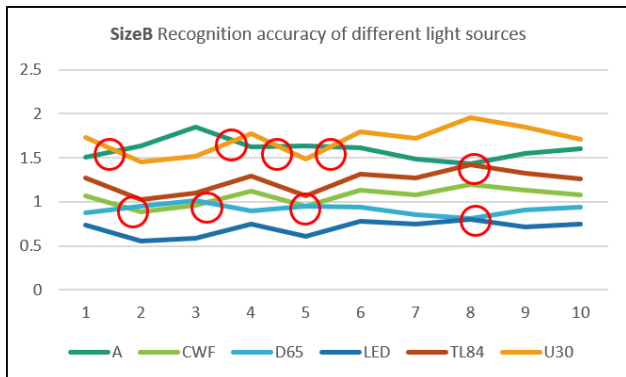


Figure 4. SizeB Identification accuracy of different light sources

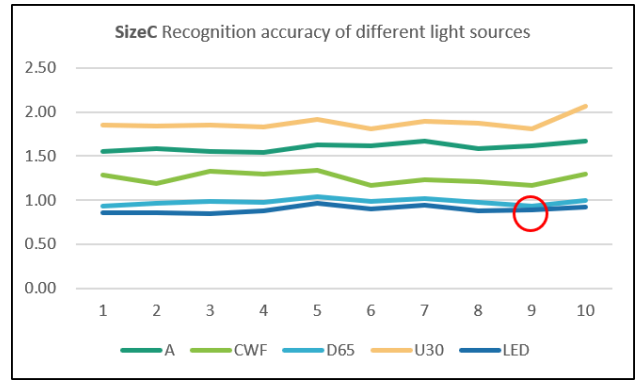


Figure 5. SizeC Identification accuracy of different light sources

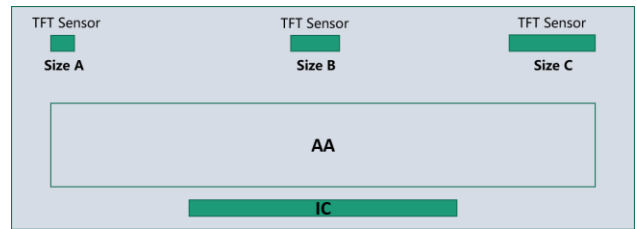


Figure 6. Schematic diagram of TFT sensor distribution with different sizes

### 3. Improvement solution of light sensing accuracy based on optimization of TFT Sensor driving circuit

Aiming at the design of the driving circuit for light sensing recognition, as shown in Figure 2, this paper optimizes the design of the TFT Sensor part of the driving circuit, compares and tests the different voltages set at the Source, Drain and Gate electrodes, and determines the best design solution for the stability of light sensing data acquisition through the ADC variation, data fluctuation difference, uniformity and final illumination data error in different high and low temperature environments.

At present, through testing, it is found that the photoelectric variation is affected under different source voltages, as shown in Figure 7, thus affecting the sensitivity of light sensing data acquisition.

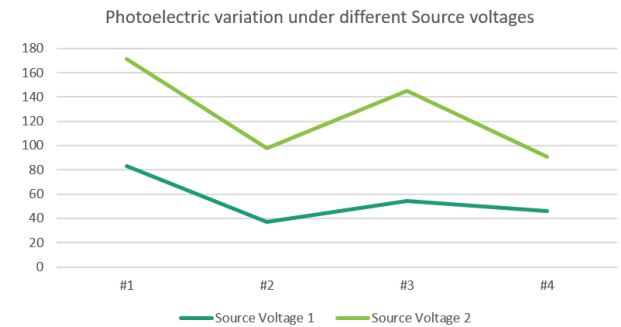


Figure 7. Comparison of photoelectric changes under different Source voltages

**4. Optimization solution of light sensing algorithm based on deleting excessive coupling data and adding floating-point value calculation**

The raw data obtained after the light sensing signal acquisition needs to be processed by the light sensing algorithm, and the ADC value is calculated to obtain the illumination value, which is reported to the AP. Based on the comparison of measured data, it is found that the coupling value of some modules is too large, which leads to abnormal calculated illuminance and the illuminance error exceeds Spec. This paper proposes an optimized light-sensing algorithm based on dynamic threshold constraints: 1) Constructing a Gaussian Mixture Model (GMM)-driven real-time anomaly detection module to automatically filter coupling noise under  $3\sigma$  criteria; 2) Implementing an adaptive resampling mechanism that triggers multi-cycle synchronous acquisition when data confidence levels drop below 95%. Experimental validation demonstrates that the proposed solution enhances the measurement accuracy of the light-sensing algorithm.

Through the comparative analysis of experiments, it is found that the data processing method of adding floating-point value calculation has a significant impact on the accuracy of light sensing algorithm. During the implementation of the algorithm, the processed data can realize the autonomous detection of low illumination environment. Moreover, after different data processing in different illuminance, the accuracy of light sensitivity detection in low illuminance can be effectively improved (as shown in Figure 8), the light sensitivity measurement error in low illuminance (5~10lux) can be reduced from 20% to less than 15%.

Actual illuminance /lux		0	1	5	10	20	40	80	160	320	640	1280	2560	5120
Error before data processing	#1	0%	0%	-20%	-10%	-15%	-13%	-10%	-3%	0%	4%	6%	6%	3%
	#2	0%	0%	-20%	-10%	-10%	-8%	-9%	-5%	-4%	-4%	-3%	-4%	-2%
	#3	0%	0%	0%	10%	10%	3%	-1%	-1%	-3%	-2%	-2%	-3%	-3%
	#7	0%	0%	-20%	-20%	-15%	-13%	-13%	-9%	-7%	-6%	-5%	-5%	-4%

Actual illuminance /lux		0	1	5	10	20	40	80	160	320	640	1280	2560	5120
Error after data processing	#1	0%	-20%	-14%	-7%	-10%	-9%	-9%	-3%	0%	4%	5%	4%	2%
	#2	0%	10%	-10%	-3%	-8%	-9%	-9%	-5%	-4%	-4%	-3%	-4%	-3%
	#3	0%	10%	4%	14%	4%	1%	-2%	-2%	3%	-2%	3%	-3%	-3%
	#7	0%	10%	-6%	-14%	-13%	9%	9%	7%	6%	-5%	4%	-6%	4%

**Figure 8.** Influence of data processing on the accuracy of light perception

**5. Optimal driving solution to improve accuracy and stability based on differential design of driving IC**

Different TDDI processes the light sensing signal output by TFT Sensor Drain electrode differently, which will also affect the stability and accuracy of the final measured illuminance value. In this paper, the stability and accuracy are tested by comparing the light sensing data collected by the same panel with different TDDI, and the best light sensing scheme is sought.

**6. Conclusion**

Aiming at the poor accuracy of a-Si LCD with ALS, this paper puts forward methods to improve the stability and accuracy of light sensing data acquisition in many aspects. At present, a large number of tests have been carried out and relevant data sets have been established, which can provide practical solutions for the stability of light-sensitive screens.

**7. References**

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