Design of Integrated a-Si:H Gate Driver Circuit with Low Noise for Mobile TFT-LCD

Yong-hui Lee*, Yong-ju Park*, Jin-oh Kwag*, Hyung-guel Kim*, Junsin Yi[1]
***Mobile Display Development Team, LCD Business,**
Samsung Electronics CO., LTD, San #24, Nongseo-Dong, Giheung-Eup,
Yongin-City, Gyeonggi-Do, 449-711, Korea
[1] Sungkyunkwan University, 300 Chenchen-Dong, Changan-Gu, Suweon-City,
Kyenggi-Do, 440-746, Korea
Phone: 82-31-209-4637 , E-mail: huidong@samsung.com

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Abstract

This paper investigated a gate driver circuit with amorphous silicon for mobile TFT-LCD. In the conventional circuit, the fluctuation of the off-state voltage causes the fluctuation of gate line voltages in the panel and then image quality becomes worse. Newly designed gate driver circuit with dynamic switching inverter and carry out signal reduce the fluctuation of the off-state voltage because dynamic switching inverter is holding the off-state voltage and the delay of carry signal is reduced. The simulation results show that the proposed a-Si:H gate driver has low noise and high stability compared with the conventional one.

1. Introduction

An active matrix liquid crystal displays (AMLCDs) is used to most of application that need display from mobile devices to large size TV. Recently mobile devices like cellular phone, PDA, digital camera, MP3 player, and portable game machine became 'necessaries of life' along with elevation of communication environment and miniaturization and low-cost of recording media.

According to these circumstances, mobile displays have developed greatly in the sides of colorfulness, resolution, brightness and color reproducibility for the latest several years. The higher the resolution is, the more difficult it would be to compose many external connections in the peripheral regions of panel. To overcome this problem, an gate driver integrated a-Si:H TFT-LCD can be a solution for high resolution mobile display[1]~[4].

Amorphous silicon thin film transistor technology has been the dominant backplane technology for active matrix liquid crystal display because of its low manufacturing cost, compatibility with large area process and uniform device characteristics.

However, there are two important properties designing integrated circuit using a-Si:H TFT. One is the low mobility and high threshold voltage. The other is the shift of threshold voltage with increasing both operation time and gate voltage[5]~[7].

To overcome the inefficiency of a-Si:H TFT due to its low mobility, bootstrapping is used for a-Si:H gate driver circuit. But, in this conventional a-Si:H gate driver circuit, the fluctuation of the off-state voltage causes the fluctuation of gate line voltages in the panel and then image quality becomes worse[8],[9].

The purpose of this paper is to propose newly designed a-Si:H gate driver circuit with low noise and high stability by adding a carry out stage and a dynamic switching inverter for mobile TFT-LCD.

2. Results and discussion

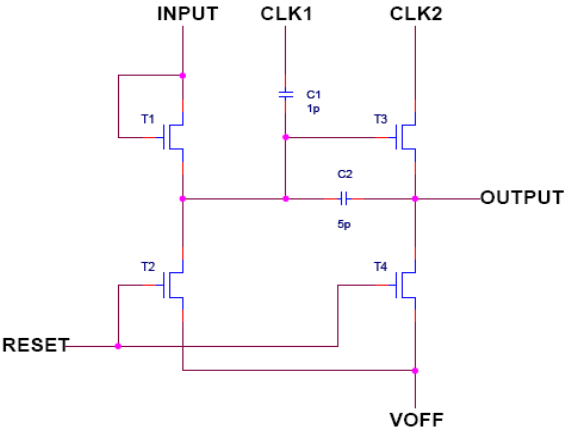

Fig 1. The schematic of the conventional a-Si:H shift register

Fig 1 shows the schematic of the conventional shift register employing a-Si:H TFT, which is composed of four transistors (T1, T2, T3, T4), two capacitors (C1, C2), two clock pulses (CLK1, CLK2), the previous stage output signal (INPUT) and the next stage output signal (RESET). It used the bootstrapping capacitor (C2) in the gate input signal node to overcome the inefficiency of a-Si:H circuit due to its low mobility [10].

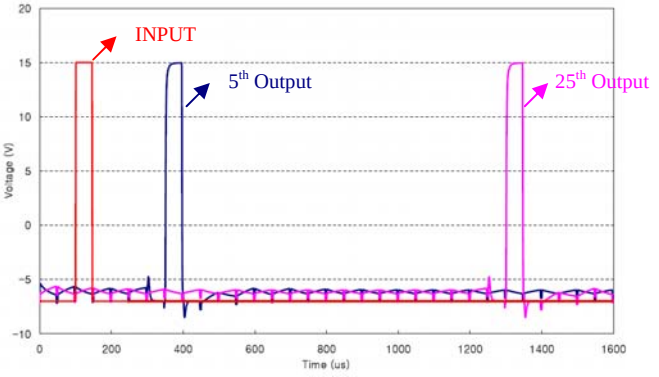

Fig 2. The SPICE simulation result of the conventional a-Si:H gate driver

Fig 2 is the SPICE simulation result of the conventional gate driver. The rising time of 5th and 25th output is 3.32us and 3.16us, respectively. Output waveform of each stage is normal except for the fluctuation of off-state voltage. The fluctuation of the off-state voltage causes the fluctuation of gate line voltages in the panel, and then image quality of LCD becomes worse.

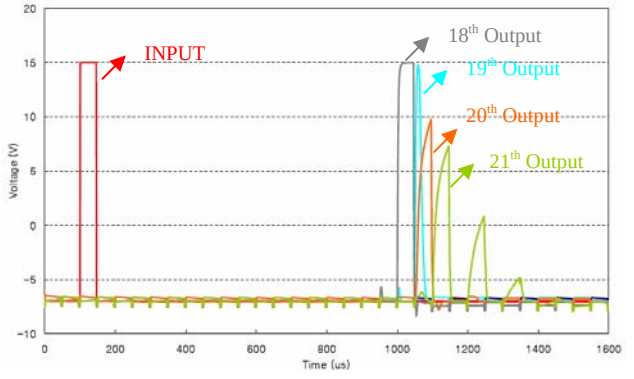

Fig 3. The SPICE simulation result of the conventional a-Si:H gate driver using Vth shift a-Si:H model

Fig 3 shows the SPICE simulation result of the conventional gate driver using Vth shift a-Si:H model. Each output waveforms from 1st to 18th stage is normal, but one from 19th to last stage is abnormal. This shift register could not operate normally.

Therefore, In order to reduce the fluctuation of the off-state voltage and abnormal operation, we proposed newly designed gate driver circuit with a dynamic switching inverter and carry out signal.

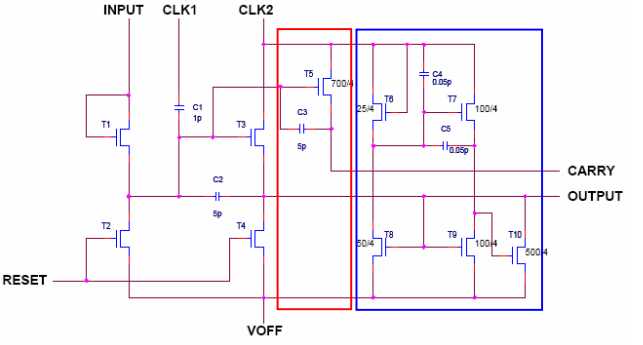

Fig 4. The schematic of newly designed a-Si:H Shift register

Fig 4 is the schematic of newly designed a-Si:H shift register, which adds a carry out stage and a dynamic switching inverter to conventional shift register. Carry out stage is composed of one transistor (T5) and one capacitor (C3). Dynamic switching inverter is composed of five transistors (T6 ~ T10) and two capacitor (C4, C5).

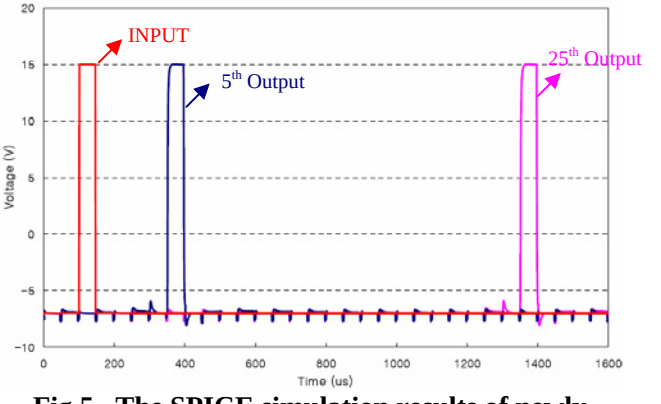

Fig 5. The SPICE simulation results of newly designed a-Si:H gate driver

Fig 5 shows the SPICE simulation result of newly designed gate driver. The rising time of 5th and 25th output is 3.06us and 2.92us, respectively. It is better

than the conventional gate driver. The fluctuation of off-state voltage is much smaller than one of the conventional shift register. Also, output waveform of each stage is normal.

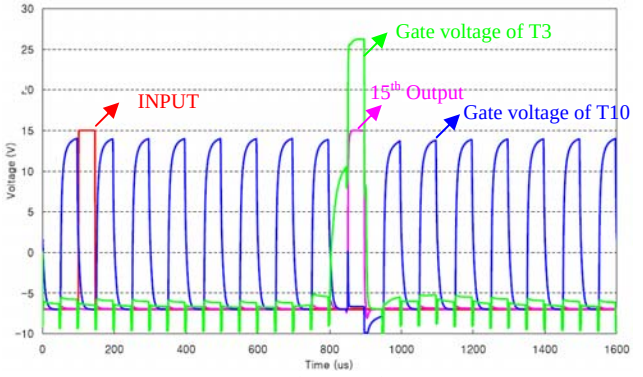

Fig 6. The output waveform of dynamic switching inverter (gate voltage of T10) in the 15th gate stage

Fig 6 shows the output waveform of dynamic switching inverter (gate voltage of T10) in the 15th stage. In on-state, gate voltage of T10 is pulled down and in off-state, it hold voltage of off-state.

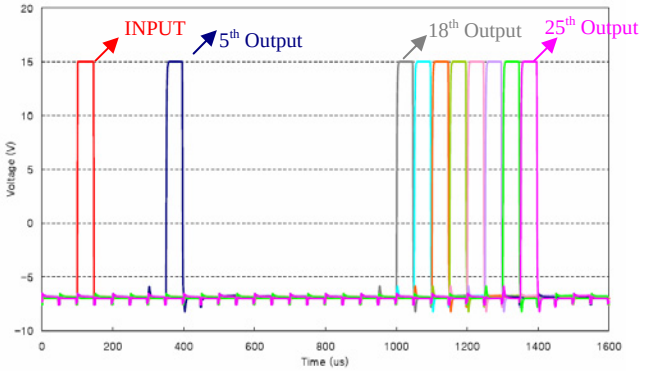

Fig 7. The SPICE simulation result of newly designed a-Si:H gate driver using Vth shift a-Si:H model

Fig 7 shows the SPICE simulation result of newly designed gate driver using Vth shift a-Si:H model. To prevent the distortion of the gate input signal as a result of resolution increased, we separated the gate input signal and the carry out signal. And to reduce the fluctuation of off-state voltage, we added dynamic switching inverter. Output waveform of each stage is normal. This shift register could operate normally although it was affected by time stress and gate voltage stress.

4. Summary

In this paper, we designed and verified new a-Si:H gate driver with low noise and high stability for mobile display by SPICE simulation. To reduce the noise and improve the stability, newly designed a-Si:H gate driver add a carry out stage and a dynamic switching inverter to the conventional one. As shown in simulation results, the noise is reduced and the stability is improved. If this circuit is applied in the large size TFT LCD the size of transistors and capacitors is optimized, because the gate load and the transfer characteristic of transistors could change.

5. References

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