Color STN (CSTN) LCD Driver Integrated Circuit with Sense Amplifier of Non-Volatile Memory

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Abstract—**This paper proposes a sense amplifier with non-volatile memory in order to improve the image quality of LCD by enhancing the matching of the driving voltages between the panel and driver. The sense amplifier having a wide sensing margin and fast response adjusts LCD driver voltage of display driver. The CSTN-LCD with the sense amplifier results improved image quality than that with conventional 6 bit column driver without it.**

Index Terms—**CSTN-LCD, column driver, EEPROM, sense amplifier**

I. INTRODUCTION

LCD is the dominant FPD (Flat Panel Display) technology with wide range of application such as cellular phone, PDA, notebook, monitor, digital TV and more due to its ability for displaying high quality images. The great amount of studies and researches have been made for the improvement of the gray scale of the driver and the resolutions of the panel, hence LCD became one of the most popular FPD technologies[1-2]. However, only increasing the gray scale and resolution is no longer sufficient to support the ever increasing demand of higher quality display.

To improve the image quality of LCD, the matching of the driving conditions between the panel and driver is an important key. This can be approached by compensating either gray scale of LCD or frequency of oscillator.

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This paper proposes to use the 1st approach, compensating the gray scale of LCD, using a sense amplifier which uses bias voltage generation in a column driver with EEPROM. The 6bit column driver with the sense amplifier with EEPROM is developed and tested on 1.5 inch 128×128 CSTN-LCD panel.

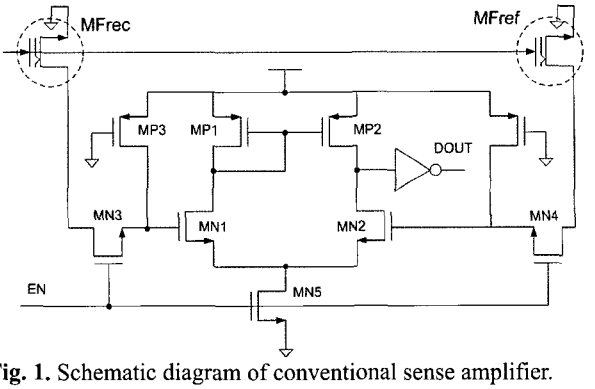

Fig. 1. Schematic diagram of conventional sense amplifier.

II. CONVENTIONAL SENSE AMPLIFIER

Conventional sense amplifier with non-volatile is shown in Fig. 1[3]. It consists of MFrec and MFref. There is MFrec for recording data and MFref for generating reference voltage of cell array. In the read operation, if threshold voltage of MFrec is higher than MFref, current of MN3, IMN3, decreases and gate voltage of MN3, VgMN3, increases. An increasing value of VgMN3 is amplified by sense amplifier. Therefore, sense amplifier output, DOUT, is low. The relationship regarding the threshold voltages can be expressed as below;

$$Vth\_ref = (Vth\_erase + Vth\_write)/2 \quad (1)$$

$$\Delta Vth = |Vth\_erase + Vth\_write|/2 \quad (2)$$

where, Vth_write is threshold voltage of recording MFrec, Vth_erase is threshold voltage of erasing MFref, Vth_ref is threshold voltage of MFref and ΔVth is voltage margin.

The conventional sense amplifier has problem which does not allow the voltage margin over ΔVth to be increased as shown in equation (1) and (2).

III. Column Driver with Proposed Sense Amplifier

In this paper, the bias voltage generator which adjusts CSTN-LCD drive voltage using memory system includes a sense amplifier. Fig. 2 shows that the bias voltage generator system consists of EVR (electric volume register) for storing the optimum panel value and EPD (EEPROM programming data) for storing the contrast offset value on each panel which is caused by process.

The proposed sense amplifier consists of a non-volatile memory (FT and FB) and a pair of sensing MOS (LT and LB) as shown in Fig. 3. Threshold voltages of FT and FB are the different input signals of the amplifier and drain voltages of LT and LB are output signal of the amplifier. This requires using two non-volatile memories per 1 bit. The voltage margin of the amplifier increases up to the swing range of the threshold voltage, FT. Hence, the amplifier provides faster data reading than that of the conventional sense amplifier using a separate amplifier.

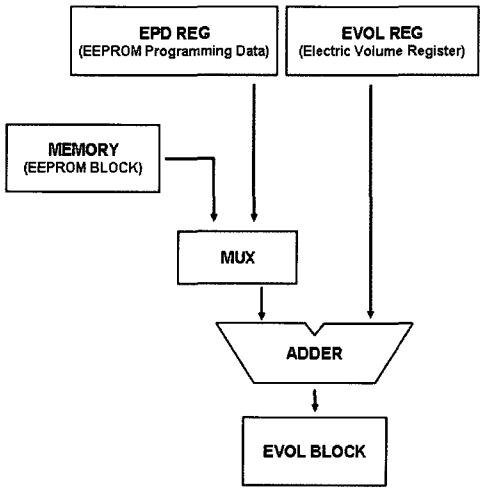

Fig. 2. Block diagram of the bias voltage generator which adjusts CSTN-LCD drive voltage using memory system.

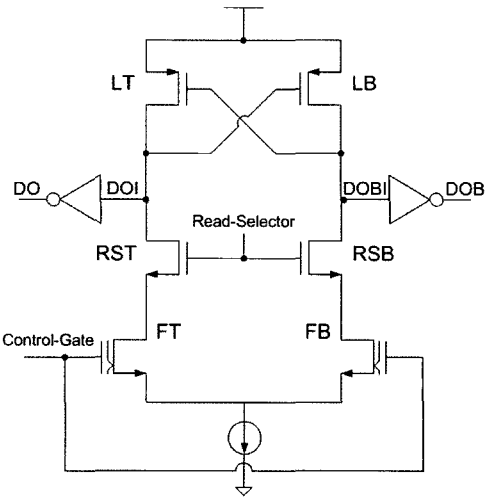

Fig. 3. Schematic diagram of proposed sense amplifier with EEPROM.

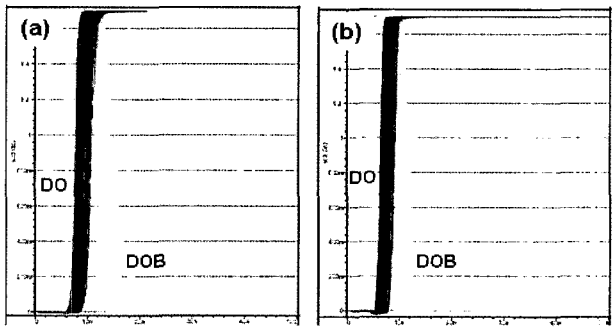

Fig. 4. Monte-Carlo simulation waveforms of proposed sense amplifier as a function of operating temperature; (a)90℃ and (b)-40℃.

IV. Simulation and Experiment Results

Electric performance of the proposed sense amplifier is verified by HSPICE simulation. Fig. 4 shows the simulated waveforms of the output nodes DO and DOB for the proposed sense amplifier in the case where 90℃ and -40℃. The output DO goes high while the output DOB turns to low. According to the simulations the sensing delay time is equal to 2ns.

The proposed sense amplifier with EEPROM is applied to a column driver for CSTN-LCD. The circuits are implemented in a 3.3V/18V 0.35um CMOS technology. Layout design of the proposed sense amplifier with non-volatile memory is shown in Fig. 5. As shown in Fig. 5 the layout design is compact and symmetric. It consists of EEPROM block, sensing PMOS block, protecting NMOS block and output buffer block.

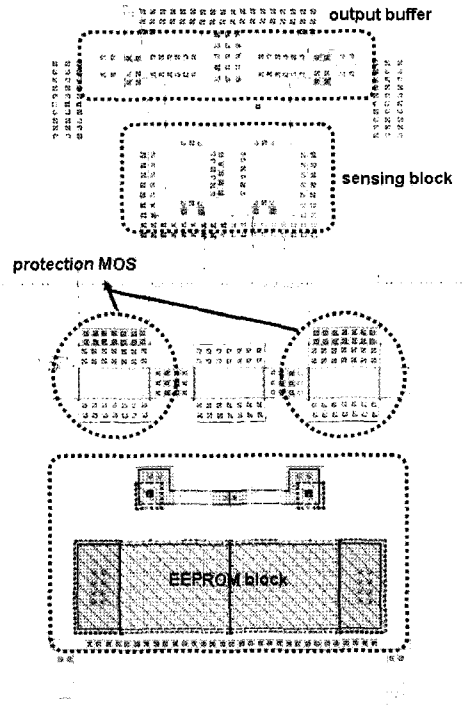

Fig. 5. Layout design of proposed sense amplifier.

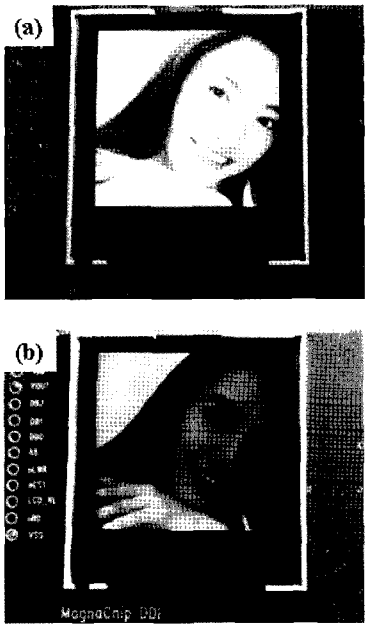

Fig. 6. Photograph of 1.5inch 128×128 CSTN-LCD panel operated by column driver; (a) without sense amplifier and (b) with sense amplifier.

We designed the 6bit column driver for CSTN-LCD using the proposed sense amplifier with EEPROM. The number of output channel is 396 for hand-held LCD system or hand-carrying information equipment application. The chip area is equivalent to the conventional CSTN-LCD column driver without a sense amplifier. Fig. 6 is the photograph of 1.5inch 128×128 CSTN-LCD panel operated by the column driver with the sense amplifier and without the sense amplifier. As shown in Fig. 8 (a) and (b), CSTN-LCD panel with the sense amplifier improves the image quality compare to the conventional CSTN-LCD panel without the sense amplifier.

V. CONCLUSIONS

In this paper, the sense amplifier with a wide sensing margin and fast response is proposed. In order to verify its functionality, 6bit column driver for CSTN-LCD using the proposed sense amplifier with EEPROM is presented, The circuits are fabricated in a 3.3V and 18V 0.35um process CMOS technology and the proposed sense amplifier with EEPROM was applied into the a column driver for CSTN-LCD. The column driver for CSTN-LCD with the proposed sense amplifier improves the image quality compare to the conventional column driver for CSTN-LCD without it.

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