Design of Mini-LVDS Output Buffer using Low-Temperature Poly-Silicon (LTPS) thin-film transistor (TFT)

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Abstract

Mini-LVDS has been widely used for high speed data transmission because it provides low EMI and high bandwidth for display driver. In this paper, a Mini-LVDS output buffer with LTPS TFT process is presented which provides sufficient performance in the presence of large variation in the threshold voltage and mobility and kink effect.

1. Introduction

System on Glass (SOG) is the ultimate goal of flat panel display for low cost and high performance. However the circuit integration level is quite limited because of poor characteristics of LTPS TFT. The electrical properties of LTPS TFT can change sharply according to the grain boundaries of poly-Si substrate. LTPS TFT shows threshold voltage and mobility variation and kink effect. Therefore analog circuit design has been a great challenge due to non-uniform electrical characteristics of LTPS TFT. [1-3]

TFT-LCD display system interface is shown in Fig. 1. The graphic data in timing controller (T-CON) is transmitted to the source driver through Mini low-voltage differential signaling (Mini-LVDS) output buffer. Due to the reduced sensitivity to noise, low electro-magnetic interference (EMI) and low power dissipation, Mini-LVDS has been widely used to transmit and receive digital data in TFT- LCD display system interface. [4]

A conventional Mini-LVDS output buffer is implemented as shown in Fig. 2. In LTPS TFT technologies, it is difficult to design a reliable current source and common-mode feedback (CMFB) circuit due to the large variation and non-linearity of electrical characteristics of LTPS TFT. In addition, it is difficult to meet the electrical specification of Mini-LVDS with the conventional output buffer because threshold voltage of TFT is generally larger than 1V. Therefore, it is more favorable not to use NTFT current source and switching NTFT to meet the electrical specification.

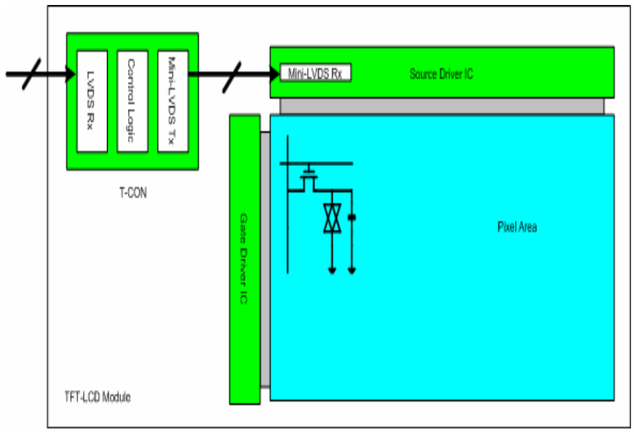


Fig.1. Conventional TFT-LCD display system Interface.

In this work, we have developed the Mini-LVDS output buffer which meets the electrical specification of mini-LVDS in LTPS TFT process. The proposed output buffer satisfies the electrical specification in LTPS TFT process and also reduces glitches during the transition period. The operating principle and experimental results are described in the following.

2. Proposed Mini-LVDS output buffer

A conventional Mini-LVDS output buffer is implemented as shown in Fig. 2. When D signal goes from Low to High, the transistors M_2 and M_3 transistors turn on and M_1 and M_4 turn off. Then the current I flows through M_2 and M_3 and output swing voltage becomes $2*I*R_T$. The output common-mode level, V_{OCM}, randomly changes due to the PVT variation. Therefore, additional common-mode feedback circuitry is required to maintain the stable common-mode level by adaptively changing bias voltage of NMOS current source. [4-5]

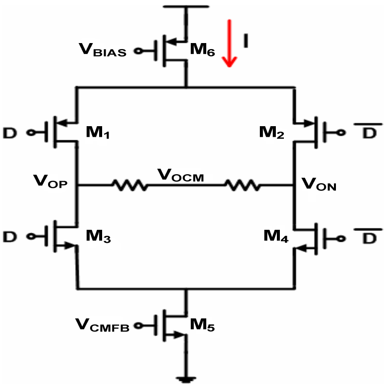


Fig. 2. Conventional Mini-LVDS output buffer.

With LTPS TFT, it is difficult to realize a reliable current source due to the kink effect, and the random variation in the threshold voltage and mobility. Moreover, because the common-mode level of the output voltage can be as low as 1 V and the threshold voltage of n-type TFT is larger than 1 V, it is impossible for the current source transistor M_5 to operate in the saturation region.

TABLE 1. The electrical specification of Mini-LVDS output buffer

	MIN	TYP	MAX
Differential swing ($\vert V_{OD}\vert$)	300 mV		600 mV
Common-mode voltage (V_{CM})	1 V	1.2 V	1.4 V

Fig. 3 depicts the proposed output buffer which employs the resistor R_s instead of switching n-type TFT and NTFT current source unlike the conventional one.

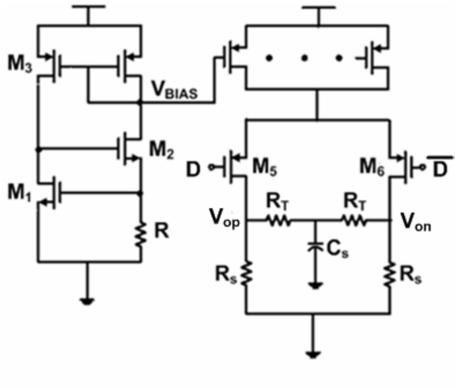


Fig. 3. The proposed Mini-LVDS output buffer.

However, PTFT M_5 and M_6 turns simultaneously off when input signals D and D change their value "LOW" → "HIGH" or "HIGH" → "LOW". This causes large glitch if the input signals D and D have large swing. Therefore, the input signals are level shifted to reduce the swing as shown in Fig. 4.

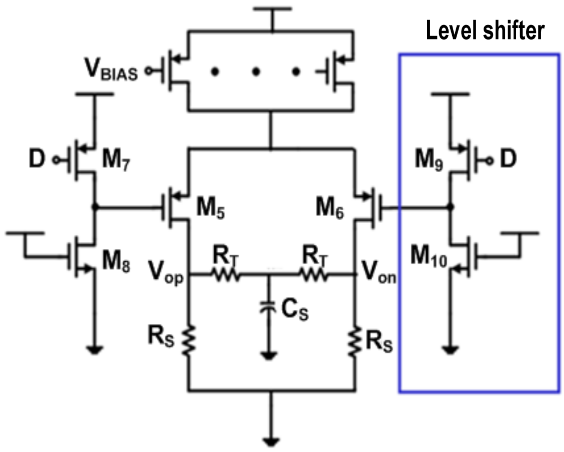
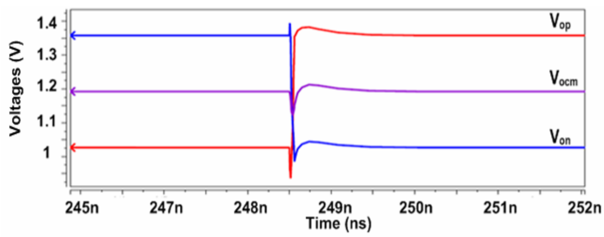
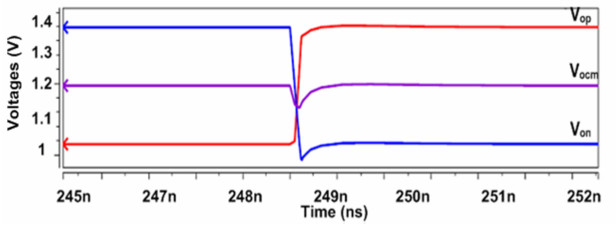


Fig. 4. The proposed Mini-LVDS output buffer with glitch-reduction level shifter.

As shown in Fig. 5, the level shifter decreases the glitch by about 50 % compared to the previous one. The glitch of Fig. 5 (a) is 90 mV and that of Fig. 5 (b) is 40 mV variations during the transition period.



(a)

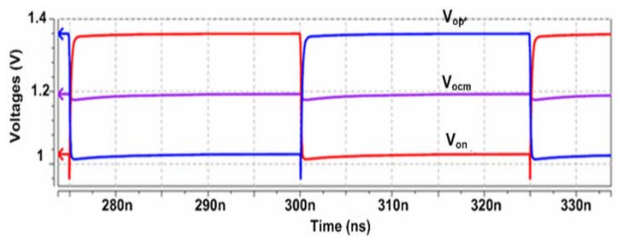


(b)

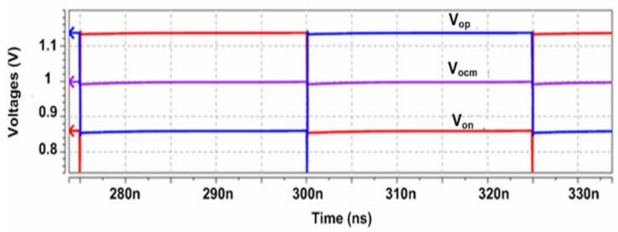
Fig.5. Simulation result of the proposed Mini-LVDS output buffer during transition (a) Without glitch-reduction circuit (b) With glitch-reduction circuit.

3. Experimental results

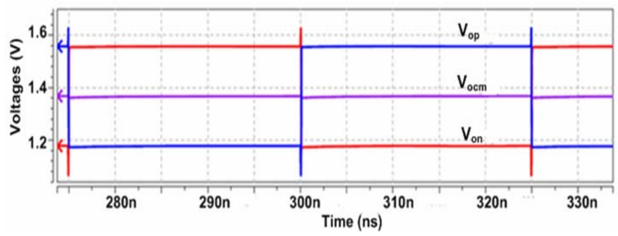
The Mini-LVDS output buffer has been developed with a 2um LTPS technology. To verify the operation of the proposed output buffer, SPICE simulation is performed in various conditions to see the effect of large variation of TFT characteristics. The operation frequency is 30 MHz and the supply voltage is 7 V. The simulated waveforms are shown in Fig. 6. As summarized in Table 2, the proposed output buffer satisfies the electrical specification of mini-LVDS in all corners.



(a)



(b)



(c)

Fig.8. Simulation result (a) Normal condition (b) V_{TH} +200mV and mobility -20% variation (c) V_{TH} -200mV and mobility +20% variation

The output of the proposed Mini-LVDS transmitter is received properly by the conventional Mini-LVDS receiver in Fig. 7 as shown in Fig. 8.

TABLE 2. Simulation results for each condition.

Condition	Common-mode voltage (V_{OCM})	Differential swing (V_{OD})
Normal	1.19 V	330 mV
V_{TH} +200mV and mobility -20%	1.0 V	309 mV
V_{TH} -200mV and mobility +20%	1.37 V	380 mV

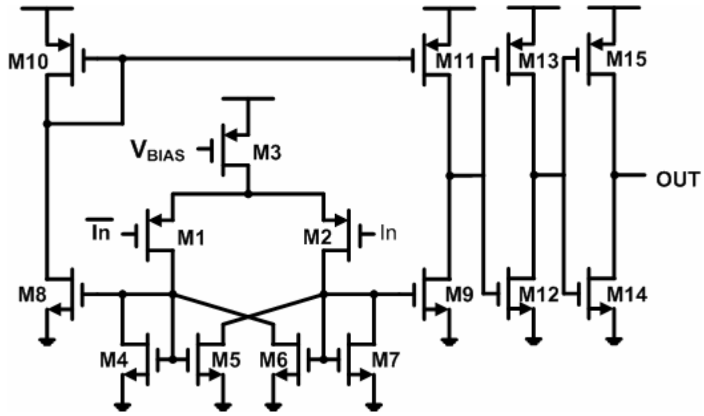


Fig. 7. Conventional Mini-LVDS receiver

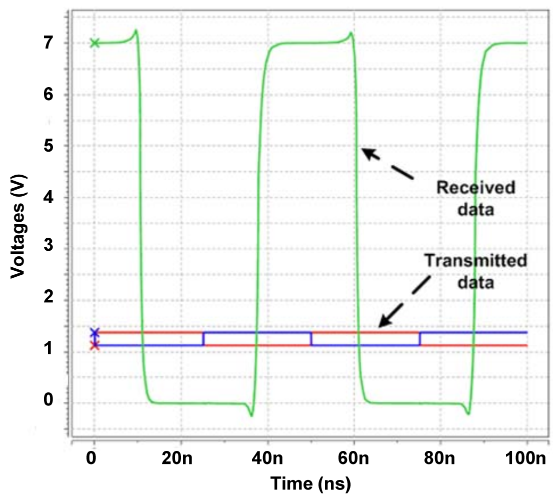


Fig. 8. Simulation result of the proposed Mini-LVDS output buffer and receiver

4. Summary

As a step towards system-on-glass, Mini-LVDS output buffer is developed with a LTPS TFT technology. The proposed buffer satisfies all the electrical specifications of Mini-LVDS.

5. Acknowledgements

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6. References

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