

## LCD POWER MANAGEMENT ON HIGH SPEED BUFFER AMPLIFIER FOR LARGE SIZE DISPLAY APPLICATIONS

Sumit Jain<sup>1</sup>, Prof. Aman Saraf<sup>2</sup>

<sup>1,2</sup> Department of Electronics and Communication,  
Radharaman Institute of Technology and Science, Bhopal (M.P.)

### ABSTRACT

The circuit offers enhanced slewing capabilities with limited power consumption by exploiting a slew detector which monitors the output voltage of the input differential amplifier and outputs an additional current signal providing slew-rate enhancement at the output stage. Post-layout simulations show that the proposed buffer can drive a 1000pF column line load with 8.5-V/ $\mu$ s slew-rate and 0.6- $\mu$ s settling time, while drawing only 8- $\mu$ A static current from a 1.2-V power supply.

*Index Terms:* LCD driver, source driver, buffer amplifier

### I. INTRODUCTION

As the display resolution increases, the load capacitance of buffer amplifier increases, whereas the required settling time decreases. Beside that, large number of buffer amplifiers built into a single chip creates power dissipation problem. Consequently, a high driving capability buffer amplifier with low static power consumption is indispensable [1]. In order that the TFT-LCD displays beyond 512 gray levels, each color, each gray level is required to be less than 6.4 mV for a 1.2.V full scale. Therefore, the output buffer must have an offset voltage less than  $\pm 3.2$  mV [2]. There are many works on LCD drivers [2-3]. As reported in [4-5], the static power consumption of a folded-cascode amplifier is larger than that of a telescope-cascode one for more current summing circuits and tail current. Also the maximum efficiency of a folded-cascode amplifier is less than 50 percent [6], and thus has poor driving

capability. The offset voltages of the folded-cascode operational amplifiers described in [1], [4], are 10 mV and 12.2 mV, respectively. These reported offset voltages are too high that will create incorrect activation for gray level above 512. As mentioned in [1], [7], a buffer with complementary differential pair is able to deliver larger current and thus have better driving capability. In order to achieve higher driving capability with low static power and low offset voltage, we design a newly developed telescope-cascode based buffer amplifier with complementary differential input stage for low power and high resolution applications. Low offset voltage and high driving capability are attained further by a designed pair of auxiliary driving transistors.

### II. CIRCUIT AND OPERATION

The designed buffer amplifier with two complementary differential input amplifiers is shown in Fig.1. The circuit was formed by a common-source push-pull stage, the open-loop amplifier transfer function, can be derived by interrupting the feedback loop in Assuming and yields, in the most general case, the following expression:

$$A_V(s) = A_0 \frac{\left(1 + \frac{s}{\omega_Z}\right)}{\left(1 + \frac{s}{\omega_{P1}}\right) \left(1 + \frac{s}{\omega_{P2}}\right) \left(1 + \frac{s}{\omega_{P3}}\right)}$$

where  $A_0$  is the DC open-loop gain expressed by

$$A_0 = g_{m1}R_{o1}g_{m2}R_{o2}$$

while,  $\omega_{P1}$ ,  $\omega_{P2}$  and  $\omega_{P3}$  are the frequencies of the three amplifier real poles, which are, respectively, given by

$$\omega_{P1} = \frac{1}{(R_{o2} + R_C)C_L} \approx \frac{1}{R_{o2}C_L}$$

$$\omega_{P2} = \frac{1}{R_{o1}C_{o1}}$$

$$\omega_{P3} = \frac{1}{(R_{o2}||R_C)C_{o3}} \approx \frac{1}{R_C C_{o3}}$$

And  $\omega_Z$  is the frequency of the left-half plane zero introduced by the compensation resistor  $R_C$ , which is given by

$$\omega_Z = \frac{1}{R_C C_L}$$

Simulations are performed to estimate the amplifier offset voltage for different common-mode input voltages. A mean value of 1.2 mV and a maximum value of 5.6 mV are found, with a standard deviation lower than 800 nV. To further demonstrate the effectiveness of the present output buffer, and provide a performance comparison other previously adopted solutions, a numeric figure of merit is here introduced for the first time, relying on the main performance parameters of an LCD output buffer. Its basic definition is

$$FOM = \frac{C_L}{T_S \cdot I_{DD}}$$

Mn and Mp, offers good swing characteristics. In order to increase the driving capability, a pair of auxiliary driving transistors, MAp and MAn, are introduced and controlled by two comparators, nCMP and pCMP. The added comparators are merged with the original differential amplifiers to further reduce the power dissipation. Buffer Square buffer amplifier 1 shows the detailed circuit of the buffer amplifier. The transistors form the complementary telescope-cascode differential stages.

The inputs of these stages are connected in parallel. Each of them drives one half of the common-source push-pull stage. The figure shows the biasing current source, consist of are two sets of comparators and is the auxiliary driving transistor. The amplifiers without and with auxiliary driving transistors are loaded with a 1000pF capacitor. It can be observed in the figure that the charging capability is greatly

improved for the latter one. The settling times being defined as the time required for the output signal reaching within 0.2% of the final voltage, the simulated settling times shown. The rising edges of curves A and B, represented for the cases without and with auxiliary driving transistors, are 3.1 $\mu$ s and 0.4  $\mu$ s, Defining R8A(B) and R9A(B) as the channel resistances of the output transistor and the auxiliary driving transistor respectively, the output response of the rising edge can be expressed where VI and VF are the initial and final values of the output voltage, respectively.

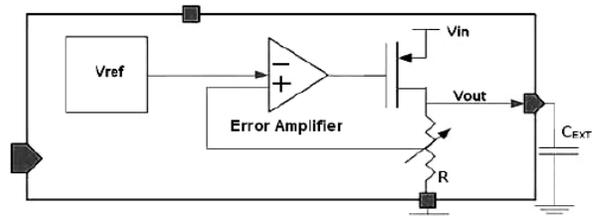


Fig.1: Block diagram of Amplifier

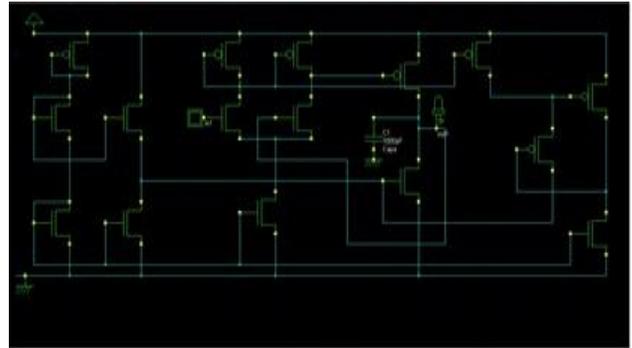


Fig.2: Circuit Diagram of Buffer Amplifier

The positive slew-rate can then be expressed as Transistors and of the input differential pair are active when  $V_{in}$  reaches the center of the supply voltage.

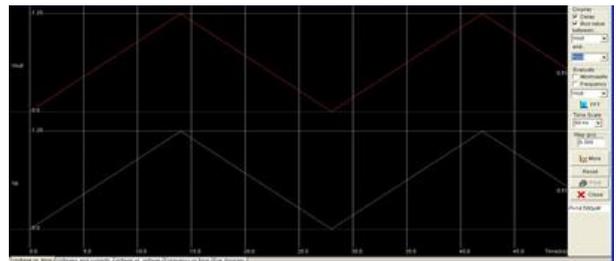


Fig. 3: Output Triangular Wave Buffer Amplifier

We choose longer length for transistor to reduce the channel length modulation and to

the systematic offset. For the input differential amplifier, the W/L of is chosen the same value as that of but the aspect ratio of is designed smaller.

Transistors are designed to have the same sizes. The currents of and can be expressed as From the above equations, it can be observed that the slew From the above equations, it can be observed that the slew rate can be increased by reducing  $\tau_p$ , i.e., reducing the channel resistances of the output stage, R8B and R9B, if load capacitance is constant. In a similar way, we can increase the negative slew-rate by reducing the

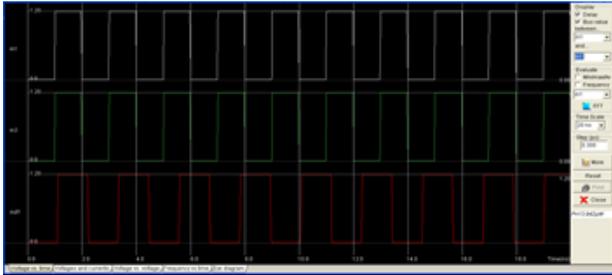


Fig.4: Output Square Wave Buffer Amplifier

Channel resistances of R8A and R9A Fig. 2 shows the simulated slew rates versus load capacitances (500 pF-5 nF) with 3 V output voltage. Simulated result shows a possible slew rate higher than 18 V/ $\mu$ s for load capacitance less than 1000pF. The figure shows the simulated offset voltages versus input circuit diagram of the proposed buffer amplifier.

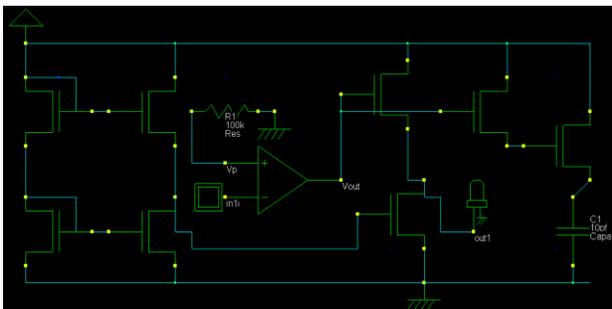


Fig.5: Circuit Diagram of Buffer Amplifier.

### III. RESULTS

The output buffer amplifier was fabricated using the TSMC 0.6 $\mu$ m CMOS process. Several measurements have been done here. The measured static current of the output buffer is 1  $\mu$ A from a 1.2 V supply voltage. The maximum offset voltage is 2.5 mV, and the slew rate is

higher than 18 V/ $\mu$ s for 1000pF load capacitance. The measured result of the proposed buffer amplifier is under a 50 KHz step input waveform with a 1.2 V amplitude and 1000pF load capacitance. It shows the measured and simulated settling times for various load capacitances with 1.2 V voltage swing. It is worth mentioned that the settling time is only 1.62  $\mu$ s even the load capacitance is up to 1000 pF. The performance of the proposed buffer amplifier is compared with the other reported circuits. It can be observed that the proposed buffer amplifier has a superior performance than that of the other circuits on slew rate, settling time, offset voltage, and static current.

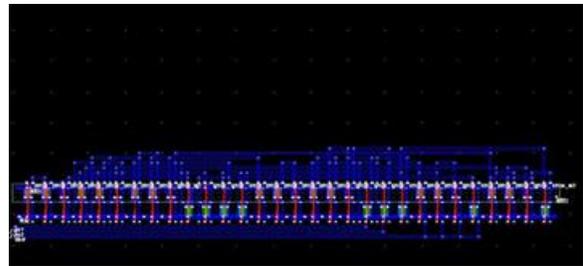


Fig.6: Buffer Amplifier

### IV. CONCLUSION

In this paper we design a LCD Power Management on High Speed Buffer Amplifier for Large -Size Display with low static power, and low offset voltage, which is suitable for the source drivers of high resolution LCD with gray levels above 512. The well designed telescopic-cascode based buffer amplifier consumes only 1  $\mu$ A static current and achieves 18 V/ $\mu$ s slew rate for 1000 pF load capacitance. Thus, the buffer amplifier is quite promising for high resolution flat-panel displays that require low static power, high driving capability and high accuracy Buffer amplifier for large -size LCD applications.

### REFERENCES

- [1].S.K. Kim, Y.-S. Son, and G.H. Cho, "Low-power high-slew-rate CMOS buffer amplifier for flat panel display drivers," Electron. Lett., vol. 42, no.4, 2006, pp. 214-215.P.-C.
- [2]. Yu, and J.-C. Wu, "A class-B output buffer for flat-panel-display column driver," IEEE J.

Solid-State Circuits, vol. 34, no. 1, 1999, pp.116–119

[3].C.-W. Lu, and K.-J. Hsu, “A high-speed low-power rail-to-rail column driver for AMLCD application,” IEEE J. of Solid-State Circuits, vol. 39, no. 9, 2004, pp. 1313-1320.

[4].C.-W. Lu, “High-speed driving scheme and compact high-speed low-power rail-to-rail class-B buffer amplifier for LCD applications,” IEEE J. of Solid-State Circuits, vol. 39, no. 11, 2010, pp. 1938-1947.

[5].Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill, NY, USA, 2001G. Nicollini, F. Moretti, and M. Conti, “High-frequency fully differential filter using operational amplifiers without common-mode feedback,” IEEE J. of Solid-State Circuits, vol. 24, no. 3, 1989,pp. 803-813.

[6].J.M. Carrillo, R.G. Carvajal, A. Torralba, and J.F. Duque-Carrillo, “Rail-to-rail low-power high-slew-rate CMOS analogue buffer,” Electron. Lett., vol. 40, no. 14, 2004, pp. 214-215

[7].R. L. Shuler and R. S. Askew, “Low offset rail-to-rail operational amplifier,” United States Application 20060097791, 2006.