IDEC Chip Design Contest

A Low Area 10-Bit OLED Source Driver IC With a Capacitor-Ratio-Independent Switched-Capacitor Amplifier

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Introduction

OLED displays are widely used in smartphones and TVs due to their high efficiency, wide viewing angle, and fast response speed. However, increasing demands for higher resolution, refresh rate, and grayscale accuracy enlarge DDIC area and cost. In OLED source driver ICs, the DAC occupies a major portion of the area, while conventional switched-capacitor techniques suffer from capacitor mismatch, causing output errors and channel-to-channel variation. To address these issues, this work proposes a low-area 10-bit OLED source driver IC using a 6bit resistor-string DAC and a 4bit DAC-embedded capacitor-ratio-independent switched-capacitor amplifier, reducing DAC area while improving output uniformity.

Proposed Source Driver IC

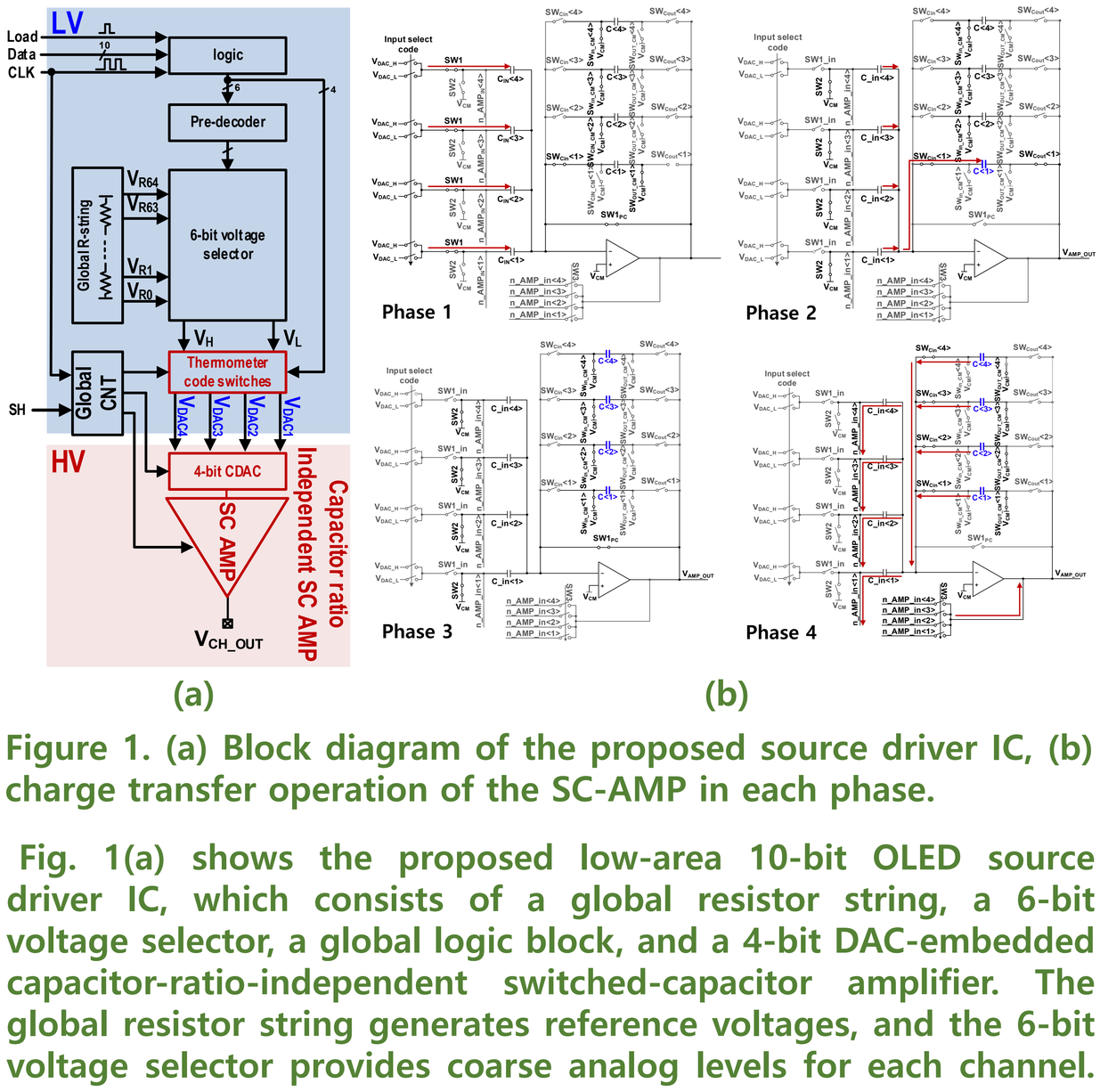

Figure 1. (a) Block diagram of the proposed source driver IC, (b) charge transfer operation of the SC-AMP in each phase.

Fig. 1(a) shows the proposed low-area 10-bit OLED source driver IC, which consists of a global resistor string, a 6-bit voltage selector, a global logic block, and a 4-bit DAC-embedded capacitor-ratio-independent switched-capacitor amplifier. The global resistor string generates reference voltages, and the 6-bit voltage selector provides coarse analog levels for each channel. The remaining fine conversion is performed by the proposed SC amplifier using only eight capacitors.

Fig. 1(b) illustrates the four-phase operation of the SC amplifier. In Phase 1, the input capacitors sample the selected voltages according to the digital input data. In Phase 2, the sampled charge is transferred and stored at the output side, and Phases 1 and 2 are repeated four times to realize 4-bit DAC operation. In Phases 3 and 4, the stored charges are used to generate the final amplified output voltage. Through this operation, the proposed amplifier reduces the dependence of the output voltage on capacitor ratio mismatch, thereby suppressing channel-to-channel voltage variation without requiring large or dummy capacitors.

Results

The proposed OLED source driver IC was designed in a 180-nm BCDMOS process and operates with 1.8-V and 5-V supply voltages for 10-bit output operation. According to the provided material, the output voltage range is 5 V. Since the source driver provides 1024 output levels in 10-bit operation, one least significant bit (LSB) corresponds to approximately 4 mV. In addition to the linearity characteristics, the offset voltage was also measured, showing an average value of 0.89 mV and a maximum value of 1.08 mV.

To evaluate the output accuracy of the proposed source driver IC, integral non-linearity (INL) and differential non-linearity (DNL) were used. INL represents the deviation between the ideal transfer characteristic and the actual transfer curve, whereas DNL indicates the output step error between adjacent digital codes. The provided material reports that the proposed circuit achieves an INL of 0.624 LSB and a DNL of 0.06 LSB. These results indicate that the proposed source driver maintains good linearity while employing a low-area capacitor-ratio-independent switched-capacitor amplifier structure.

Table 1. Performance of the proposed circuit

	This Work
Process	180nm
Gray-scale	10 bit
DNL	0.06 LSB
INL	0.62 LSB
Output range	0.5V to 4.5V
1-Horizontal time	3μs
Area per channel	3240μm² (135 × 24)
Normalized Area ratio	100%

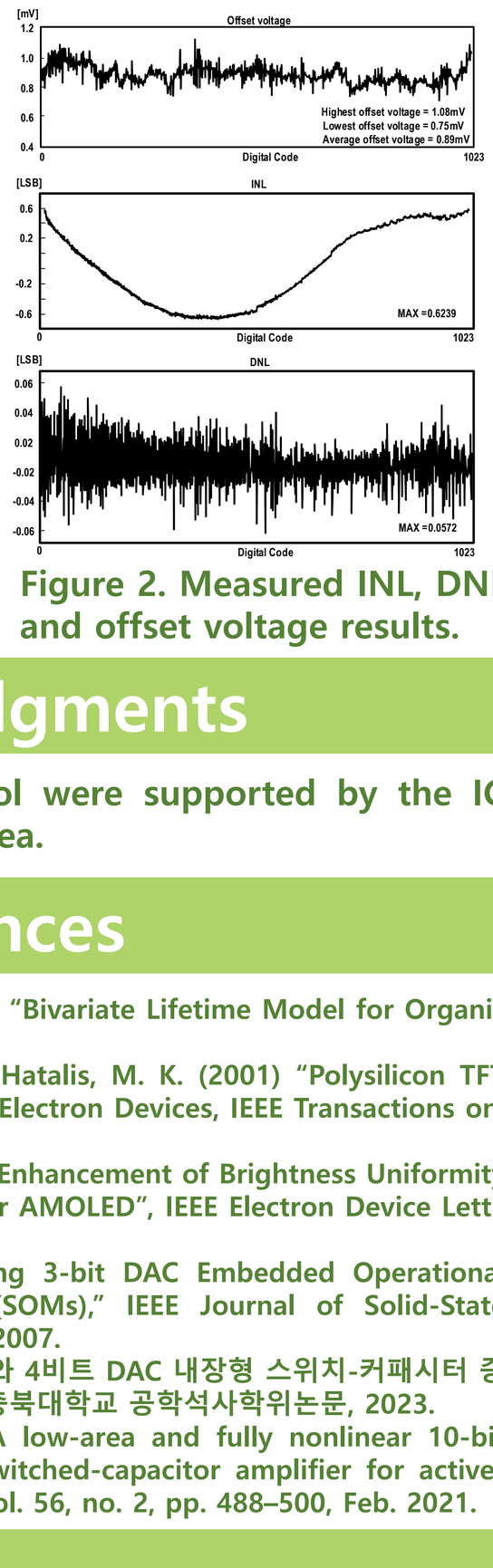

Figure 2. Measured INL, DNL, and offset voltage results.

Acknowledgments

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