Novel Current Driving Circuit for Active Matrix Organic Light Emitting Diode

Yil Suk Yang, Tae Moon Roh, Dae Woo Lee, Woo H. Kwon, and Jongdae Kim

ABSTRACT—This paper describes a novel current driving circuit for an active matrix organic light emitting diode (AMOLED). The proposed current driving circuit has a lower power consumption and higher chip density for the AMOLED display compared with the conventional one because all elements operate at a normal voltage and are shielded from the high voltage of the panel. The chip size and power consumption of the current driving circuit for an AMOLED can be improved by about 30 to 40% and 10 to 20%, respectively, compared with the conventional one.

Keywords—Current driving circuit for active matrix organic light emitting diode, high voltage shield circuit.

I. Introduction

Generally, a source driver for a flat panel display (FPD) is an integrated circuit for transferring data to a panel for one frame period. Two types of source driving methods are a voltage driven method and current driven method, which strongly depends on the type of liquid crystal. The organic light emitting diode (OLED) display uses the current driving method for the source driver. The OLED-based displays have attracted considerable attention for FPDs because they have not only a wide view angle but also a low power consumption [1], [2]. They have many application fields such as mobile phones, micro-displays, TVs, and so on. [3]-[5]. This paper proposes a novel current driving circuit for an active matrix (AM) OLED in order to decrease the chip size and power consumption.

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II. Architecture of the Proposed AMOLED Driver Circuit

The block diagram of a conventional one-channel source driver for a current driven AMOLED display is shown in Fig. 1. The conventional one-channel source driver is composed of

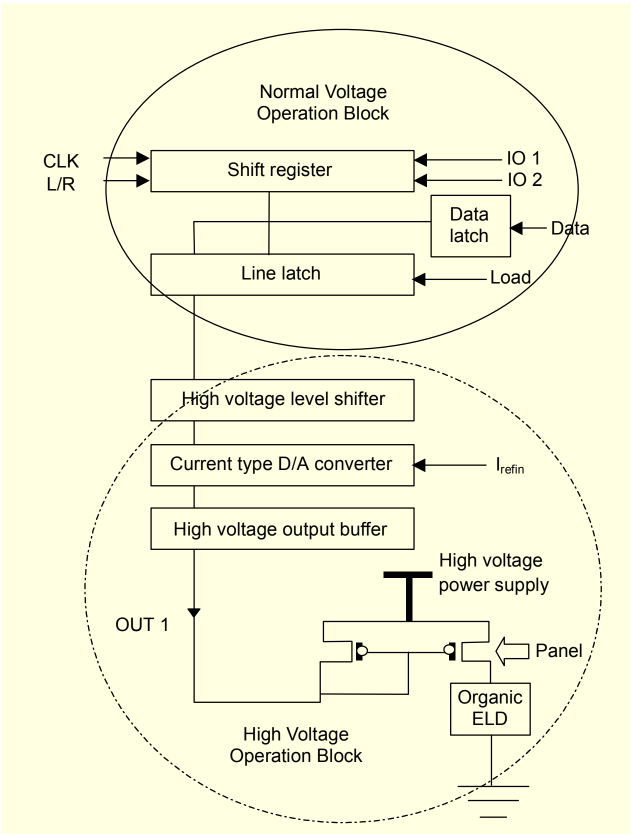

Fig. 1. Block diagram of a conventional one-channel AMOLED source driver with high voltage and normal operation block.

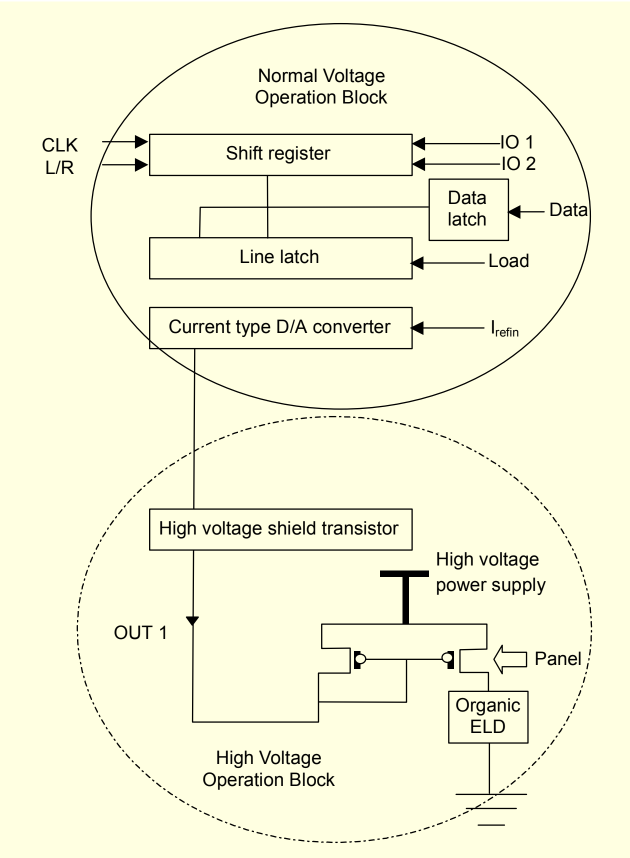

Fig. 2. Block diagram of the proposed one-channel AMOLED source driver. The high voltage level shift and the high voltage output buffer are omitted from the high voltage operation block.

a shift register, a data latch, a line latch at the normal voltage operation block, a level shifter, a current type digital-to-analog converter (DAC), and an output buffer circuit at the high voltage operation block. Also, the panel operates at a high voltage. The high voltage operation block occupies most parts of the total source driver chip because the high voltage devices for the source driver circuit need the larger area more than the low voltage devices. In addition, large power consumption happens at the high voltage operation block due to the leakage phenomena during the high voltage operation [6], [7].

Figure 2 is a block diagram of the proposed one-channel source driver for a current driven AMOLED display. The novel AMOLED source driver is composed of a shift register, a data latch, a line latch, a current-type DAC at the normal voltage operation block, and only a high voltage shield circuit at the high voltage operation block. The panel also operates at high voltage. The new source driver omits a high voltage level shifter and a high voltage output buffer from the conventional source driver. The high voltage output buffer is not needed for the proposed current driving circuit because the current drop does not occur in the current driving circuit. Moreover, the high voltage level shifter is not required in the proposed circuit due to the operation with the single normal voltage level. Therefore, the new source driver is leading to a dramatic decrease of chip area and power consumption.

The high voltage shield circuit transfers the output of the current type DAC to external source lines of the panel and shields the internal circuits of the chip from the high voltage of the panel. All circuit elements of the proposed AMOLED source driver operate at normal voltage due to the high voltage shield circuit. The high voltage shield circuit prevents the internal circuit with the normal voltage from contact with the high voltage panel.

There are two sorts of shield methods with a high voltage n-channel metal-oxide-semiconductor field effect transistor (MOSFET) and a high voltage p-MOSFET operating in the saturation region. Therefore, the output terminal of the proposed AMOLED source driver has a normal voltage. The chip size of the high voltage shield circuit with the high voltage n-MOSFET is more compact than that with the high voltage p-MOSFET because of the simple substrate connection in the layout. In this paper, the high voltage shield circuit with the high voltage n-MOSFET is implemented in order to improve the chip density and power consumption. Based on the 0.6 µm design rule, the total chip size of the conventional and proposed 3-channel source drivers for the full color display are 360 µm by 1542.8 µm and 320 µm by 1164.1 µm, respectively. The total chip size of the proposed AMOLED source driver can be reduced by 33% compared to the conventional one.

III. Simulation Results

The simulation result of the designed AMOLED source

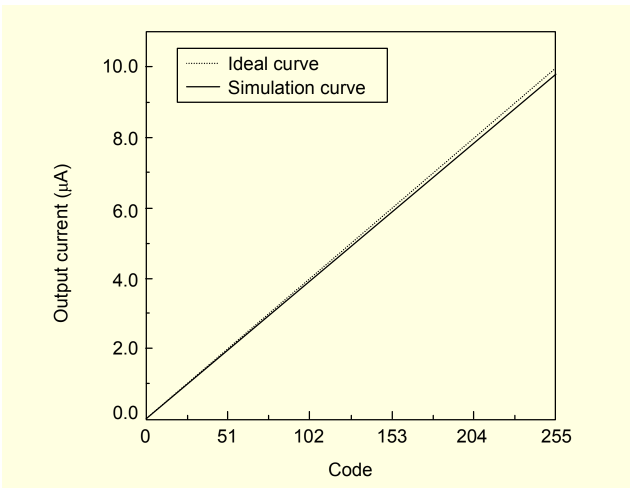

Fig. 3. Simulation results of the designed AMOLED source driver circuit with an 8-bit gray scale. The x-axis represents the input code. The y-axis represents the output current.

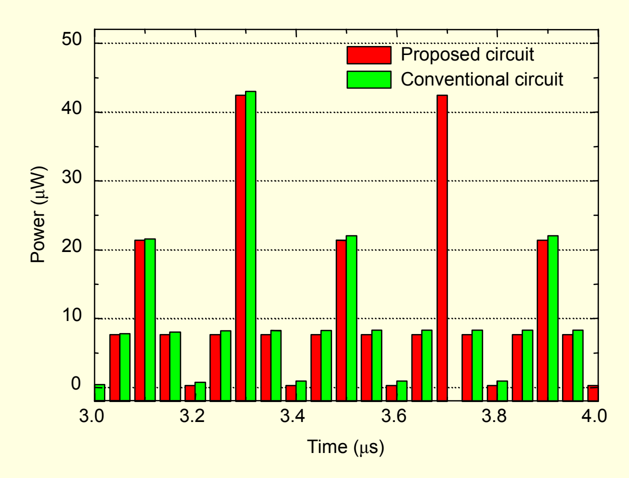

Fig. 4. Simulation results of the power consumption for the designed AMOLED source driver circuit with the full 8-bit gray scale operation.

driver circuit with an 8 bit gray scale is shown in Fig. 3. The input current is 10 μA, while the high and normal voltages are 10 V and 5 V, respectively. The maximum and minimum output currents are 9.84 μA and 0 nA. The ideal curve and the simulation curve have very good fitness.

Figure 4 shows the simulation results of the power consumption for the designed AMOLED source driver circuit with the full 8-bit gray scale operation. We estimate that the power consumption can be reduced by about 10 to 20% compared with the conventional current driving circuit because of the circuit element removal (level shifter and output buffer) and the single normal voltage operation.

IV. Conclusion

We introduced a novel current-driven AMOLED source driver to increase chip density and decrease the power consumption. All elements operate at a normal voltage in the proposed source driver and are shielded by the high voltage shield circuit from a high voltage panel. The proposed AMOLED source driver has no high voltage circuit blocks occupying the main area of the driver, thereby increasing the chip density. The chip size of the proposed AMOLED source driver can be reduced by about 30 to 40% compared with the conventional one. Further, the power consumption of the proposed AMOLED source driver can be reduced by about 10 to 20% compared to the conventional one. Also, the designed 8-bit AMOLED source driver circuit can be applied to the FPDs with VGA resolution.

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