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(54) **LIQUID CRYSTAL DISPLAY SOURCE DRIVER INTEGRATED CIRCUIT**

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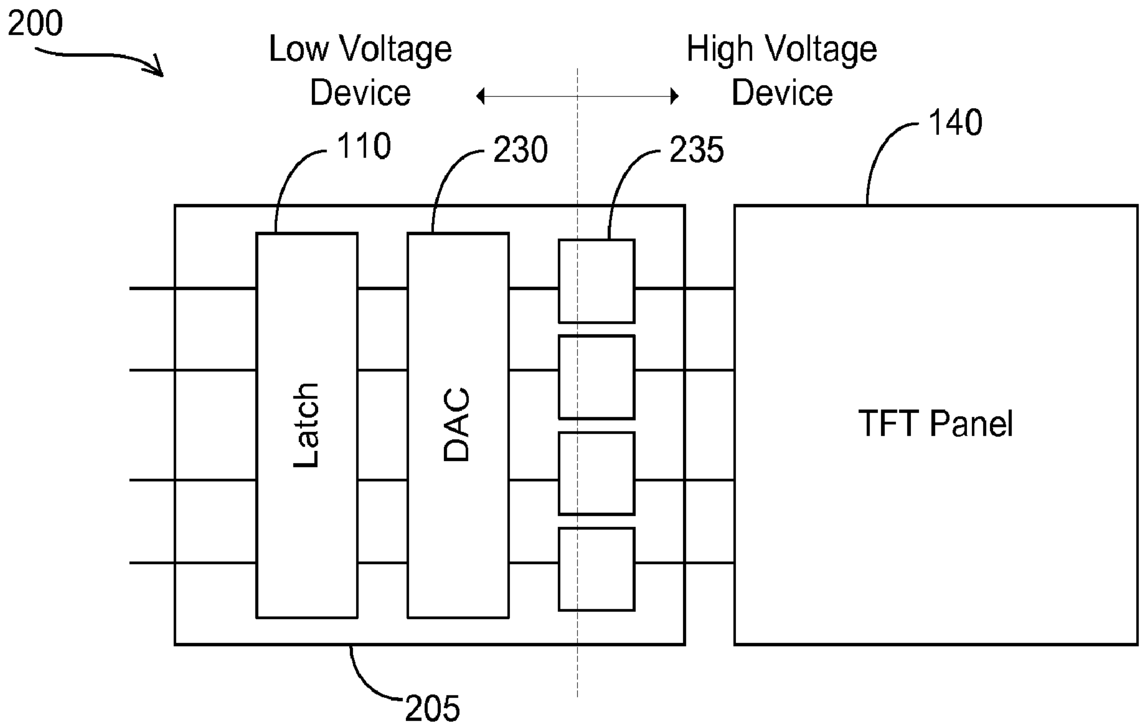
(57) **ABSTRACT**

A source driver eliminates the need for a level shifter and enables the use of a low voltage digital-to-analog converter by using an operational buffer that performs voltage amplification in addition to driving a TFT panel.



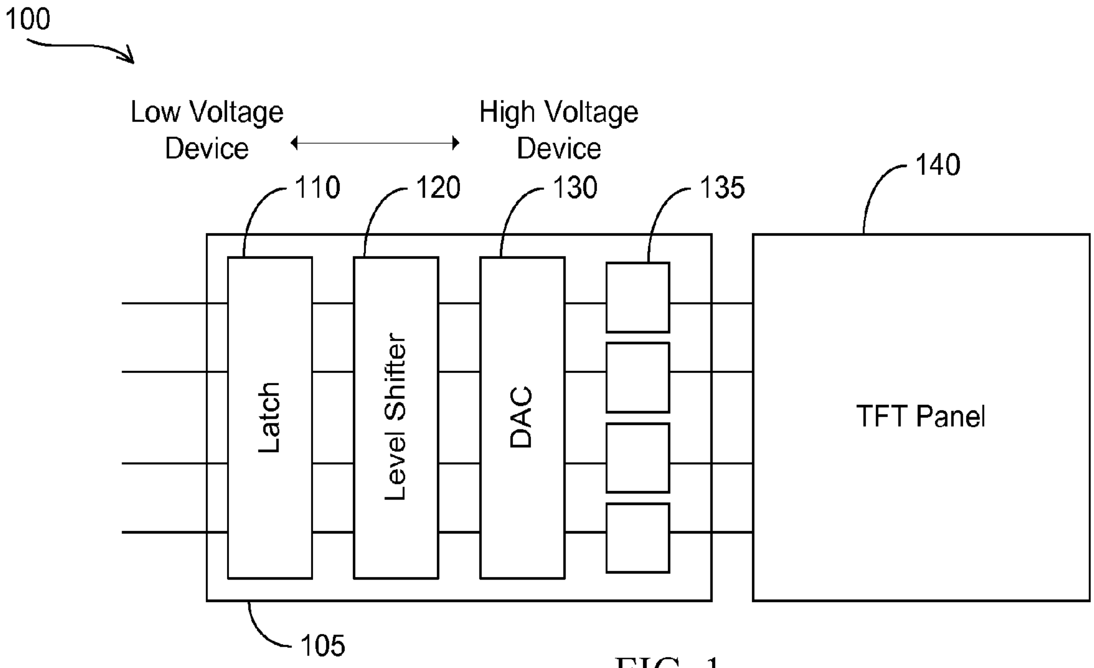


FIG. 1
Prior Art

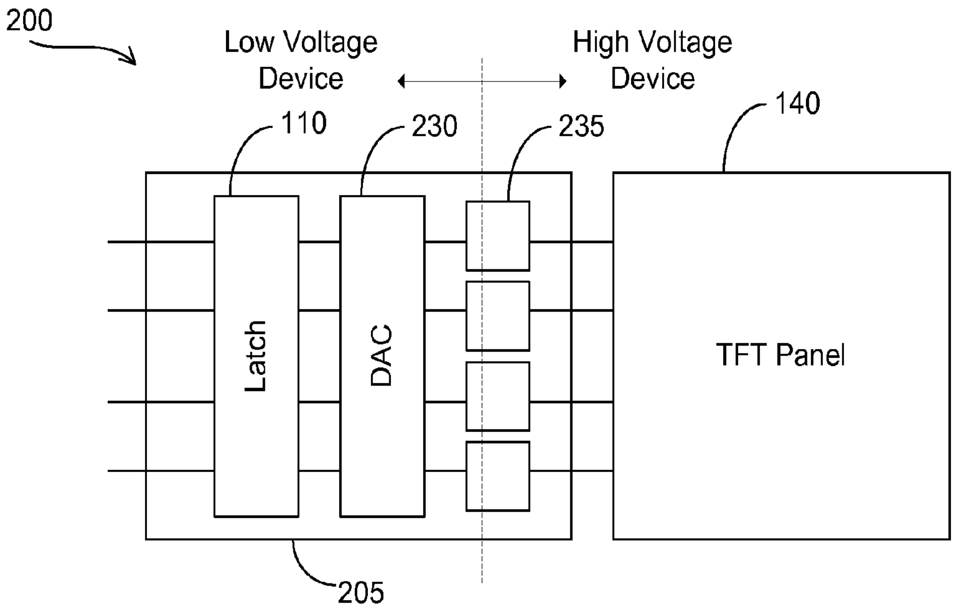


FIG. 2

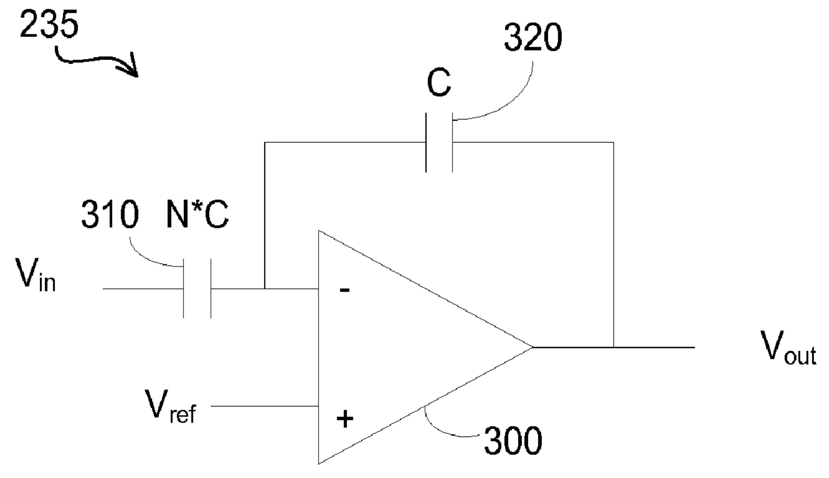

235
320
C
310 N*C
Vin
-
+
Vref
Vout
300

FIG. 3

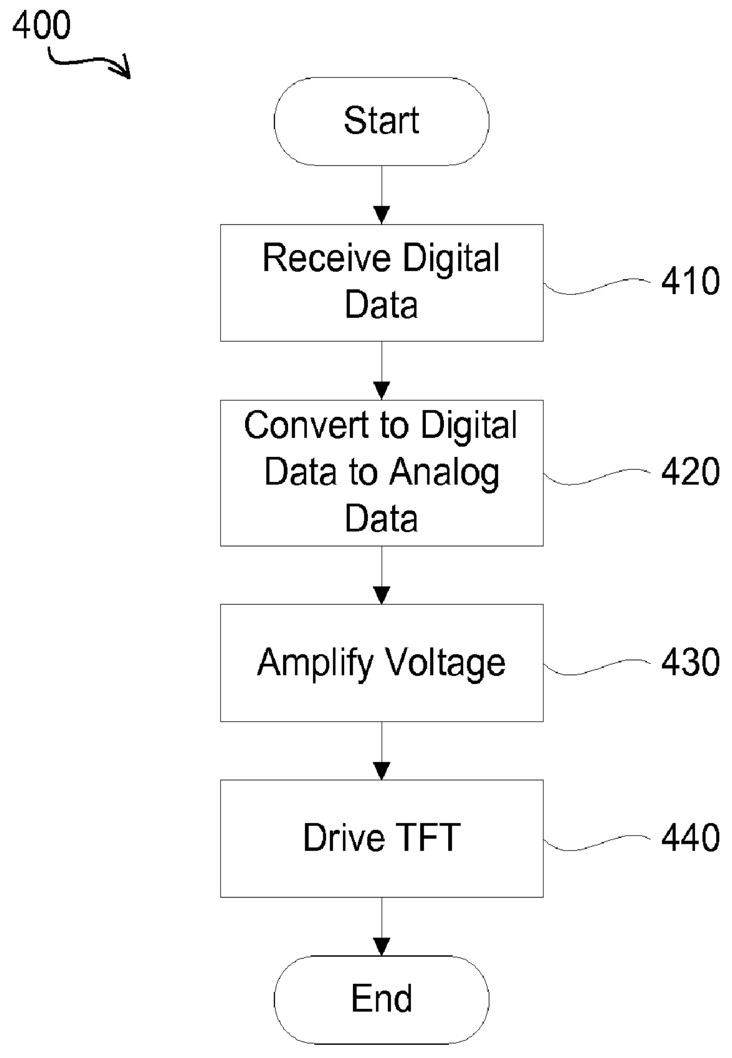

400
Start
Receive Digital Data
410
Convert to Digital Data to Analog Data
420
Amplify Voltage
430
Drive TFT
440
End

FIG. 4

LIQUID CRYSTAL DISPLAY SOURCE DRIVER INTEGRATED CIRCUIT

TECHNICAL FIELD

[0001] This invention relates generally to liquid crystal displays (LCDs), and more particularly, but not exclusively, provides a source driver integrated circuit for use in a liquid crystal display.

BACKGROUND

[0002] LCD source drivers (also referred to as column drivers) are a critical component in the LCD application. Source drivers supply video data signals to data lines connected to the source of Thin Film Transistors (TFTs) at each pixel of an LCD. A good LCD driver design is crucial. In the conventional LCD source driver approach, as shown in FIG. **1**, the input digital data is latched into a data latch **105**. Through a voltage level shifter **120**, the digital data is shifted to a high voltage level. Then it goes through a digital-to-analog converter (DAC) **130** to generate a high voltage analog signal level. This signal then drives an operational buffer **135** towards a TFT LCD panel **140**.

[0003] In this conventional approach, the digital-to-analog conversion is accomplished with high voltage devices. Usually the high voltage semiconductor devices are area consuming and take up much silicon area, thereby increasing cost and limiting area for other components.

[0004] As such, a new source driver is needed that consumes less area.

SUMMARY

[0005] Embodiments of the invention provide a source driver that eliminates the need for a level shifter and enables the use of a low voltage digital-to-analog converter by using an operational buffer that performs voltage amplification in addition to driving a TFT panel. As such, complexity and area is reduced, thereby reducing costs.

[0006] In an embodiment, the operational buffer comprises a transistor, a feedback capacitor and an input capacitor. The transistor has two voltage inputs and one voltage output. A first voltage input receives an input voltage and a second voltage input receives a reference voltage. The feedback capacitor has a capacitance C and is coupled to the voltage output and the first voltage input. The input capacitor has a capacitance equal to a multiple of the capacitance of the feedback capacitor and is coupled to the first voltage input.

[0007] In an embodiment of the invention, the source driver includes a latch that receives digital data, a digital-to-analog converter coupled to the latch that converts the digital data to analog data (voltage), and one or more operational buffers coupled to the digital-to-analog converter that amplifies the voltage and drives a TFT.

[0008] In an embodiment of the invention, a method of driving a TFT comprises receiving digital data; converting the digital data to voltage; amplifying the voltage using an operational buffer; and driving a TFT with the amplified voltage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Non-limiting and non-exhaustive embodiments of the present invention are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various views unless otherwise specified.

[0010] FIG. **1** is a block diagram illustrating a conventional LCD;

[0011] FIG. **2** is a block diagram illustrating a LCD according to an embodiment of the invention;

[0012] FIG. **3** is a block diagram illustrating an operational buffer of the source driver of FIG. **2**; and

[0013] FIG. **4** is a flowchart illustrating a method of using the source driver of FIG. **2**.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0014] The following description is provided to enable any person having ordinary skill in the art to make and use the invention, and is provided in the context of a particular application and its requirements. Various modifications to the embodiments will be readily apparent to those skilled in the art, and the principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles, features and teachings disclosed herein.

[0015] FIG. **2** is a block diagram illustrating an LCD **200** according to an embodiment of the invention. The LCD **200** comprises a source driver **205** coupled to a TFT panel **140**. For ease of illustration, other components of the LCD **200** (e.g., a gate driver) that are not relevant are not shown. The source driver **205** includes a latch **110** coupled to a DAC **230**, which is coupled to a plurality of operational buffers **235**. While four operational buffers **235** are illustrated, it will be appreciated by one of ordinary skill in the art that the source driver **205** can include many more operational buffers **235** (e.g., **384** buffers **235**).

[0016] Embodiments of the invention partition the functional blocks of the source driver **205** differently than the conventional source driver **105** (FIG. **1**). Low voltage to high voltage conversion is accomplished in the final Operational Buffer **235** instead of by the level shifter **120**. Instead of unit gain buffering that the conventional operational buffer **135** does, the Operational Buffer **235** needs to provide N times gain in addition to the buffering function. All the blocks before the buffer **235** become low voltage devices, thereby reducing complexity and area required. The DAC **230** comprises low voltage device now and saves silicon area. The digital level shifter **120** can be omitted to save silicon area further as the operation buffer **235** performs the amplification, as described further below.

[0017] FIG. **3** is a block diagram illustrating the operational buffer **235** of the source driver **205**. The operation buffer **235** comprises a transistor **300** with two voltage inputs (V_{in}, and V_{ref}) and one voltage output (V_{out}). Coupled to V_{in} is an input capacitor **310**. Coupled between V_{in} and V_{out} is a feedback capacitor **320**. The feedback capacitor has a capacitance C and while the input capacitor **310** has a capacitance of N*C.

[0018] Accordingly, the relation of output voltage to input voltage can be described as:

$$V_{out}=V_{ref}+N^*(V_{in}-V_{ref}) \quad \text{Equation 1}$$

[0019] Output voltage is amplified N times from the input voltage, where V_{ref} is a reference voltage can be chosen to achieve the desired output voltage level.

[0020] FIG. **4** is a flowchart illustrating a method **400** of using the source driver **205** (FIG. **2**). First, the latch **110** receives (**410**) digital data. The DAC **230** then converts (**230**) the digital data to analog data (i.e., voltage). The operational buffers **235** then amplify (**430**) the voltage and drive (**440**) the TFT panel **140**. The method **400** then ends.

[0021] The foregoing description of the illustrated embodiments of the present invention is by way of example only, and other variations and modifications of the above-described embodiments and methods are possible in light of the foregoing teaching. For example, the operation buffers **235** can be used in a gate driver IC or for other applications besides LCDs. Further, components of this invention may be implemented using a programmed general purpose digital computer, using application specific integrated circuits, or using a network of interconnected conventional components and circuits. Connections may be wired, wireless, modem, etc. The embodiments described herein are not intended to be exhaustive or limiting. The present invention is limited only by the following claims.

What is claimed is:

1. An operational buffer, comprising:

a transistor having two voltage inputs and one voltage output, wherein a first voltage input receives an input voltage and a second voltage input receives a reference voltage;

a feedback capacitor having a capacitance C, the feedback capacitor coupled to the voltage output and the first voltage input; and

an input capacitor having a capacitance equal to a multiple of the capacitance of the feedback capacitor, the input capacitor coupled to the first voltage input.

2. The operational buffer of claim **1**, wherein the first voltage input receives a voltage from a digital-to-analog converter.

3. The operational buffer of claim **1**, wherein the buffer amplifies an input voltage by the multiple.

4. The operational buffer of claim **1**, wherein the output from the voltage output drives a TFT.

5. A source driver for an LCD, comprising:

a latch;

a digital-to-analog converter coupled to the latch, and

a operational buffer coupled to the digital-to-analog converter;

the operational buffer comprising

a transistor having two voltage inputs and one voltage output, wherein a first voltage input receives an input voltage and a second voltage input receives a reference voltage;

a feedback capacitor having a capacitance C, the feedback capacitor coupled to the voltage output and the first voltage input; and

an input capacitor having a capacitance equal to a multiple of the capacitance of the feedback capacitor, the input capacitor coupled to the first voltage input.

6. The source driver of claim **5**, wherein the first voltage input receives a voltage from the digital-to-analog converter.

7. The source driver of claim **5**, wherein the buffer amplifies an input voltage by the multiple.

8. The source driver of claim **5**, wherein the output from the voltage output drives a TFT.

9. The source driver of claim **5**, wherein the latch and the digital-to-analog converter operate at a lower voltage than the operational buffer.

10. The source driver of claim **5**, further comprising a plurality of operational buffers coupled to the digital-to-analog converter.

11. A method of driving a TFT, comprising:

receiving digital data;

converting the digital data to voltage;

amplifying the voltage using an operational buffer; and

driving a TFT with the amplified voltage.

12. The method of claim **11**, wherein the operational buffer comprises:

a transistor having two voltage inputs and one voltage output, wherein a first voltage input receives an input voltage and a second voltage input receives a reference voltage;

a feedback capacitor having a capacitance C, the feedback capacitor coupled to the voltage output and the first voltage input; and

an input capacitor having a capacitance equal to a multiple of the capacitance of the feedback capacitor, the input capacitor coupled to the first voltage input.

13. The method of claim **12**, wherein the first voltage input receives a voltage from a digital-to-analog converter that performs the converting.

14. The method of claim **12**, wherein the buffer amplifies an input voltage by the multiple.

15. The method of claim **12**, wherein a latch performs the receiving and a digital-to-analog converter performs the converting, and wherein the latch and the digital-to-analog converter operate at a lower voltage than the operational buffer.

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摘要(译)

源驱动器消除了对电平移位器的需要，并且通过使用除了驱动TFT面板之外还执行电压放大的操作缓冲器，使得能够使用低电压数模转换器。