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Lee (43) **Pub. Date: Jul. 19, 2007**(54) **ACTIVE MATRIX ORGANIC LIGHT
EMITTING DIODE DISPLAY AND DRIVING
METHOD THEREOF****Publication Classification**(51) **Int. Cl.**
G09G 3/30 (2006.01)(52) **U.S. Cl.** **345/76**(76) Inventor: **I-Shu Lee, Taoyuan (TW)**

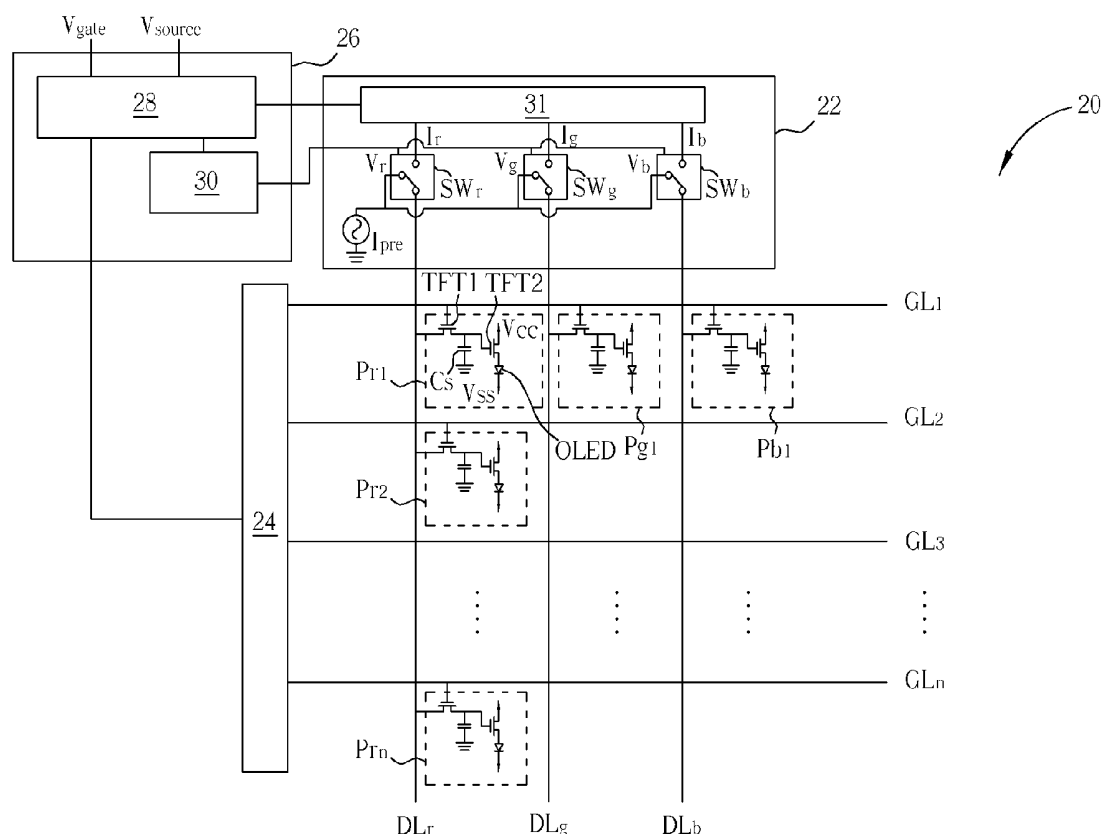
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MERRIFIELD, VA 22116 (US)**(57) **ABSTRACT**

A display includes a plurality of data lines, a plurality of scan lines, a plurality of pixel circuits, a source driver, a gate driver, a timing controller and a gray scale circuit. The source driver includes a data line driving circuit for generating driving current corresponding to an image to be displayed by a pixel circuit, a current source for pre-charging the pixel circuit and a switch for electrically connecting the current source to the pixel circuit or electrically isolating the current source from the pixel circuit. The timing controller controls the source driver and the gate driver. The gray scale circuit controls the switch of the source driver based on gray scales of images to be displayed by the pixel circuits of a scan line.

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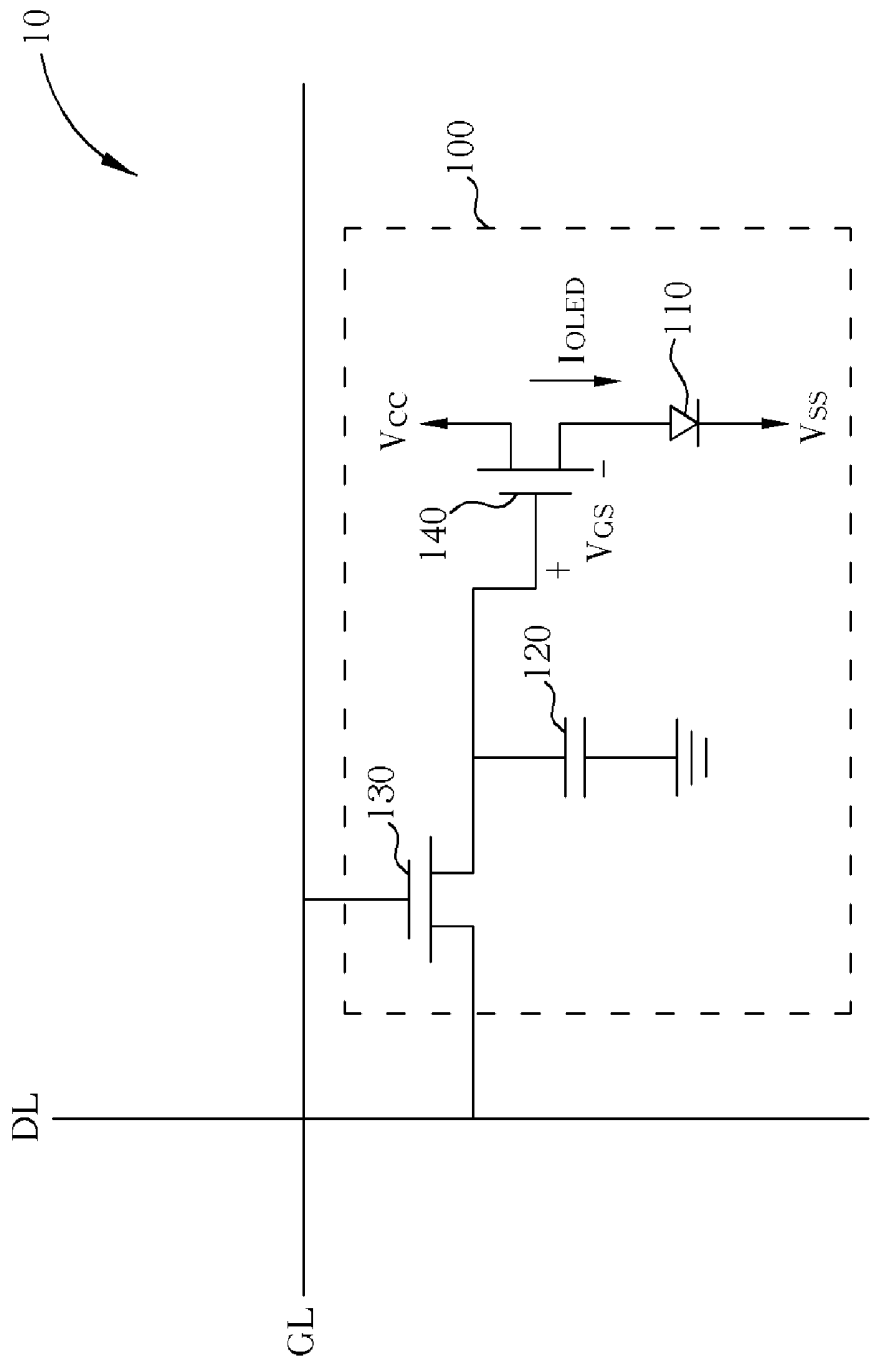
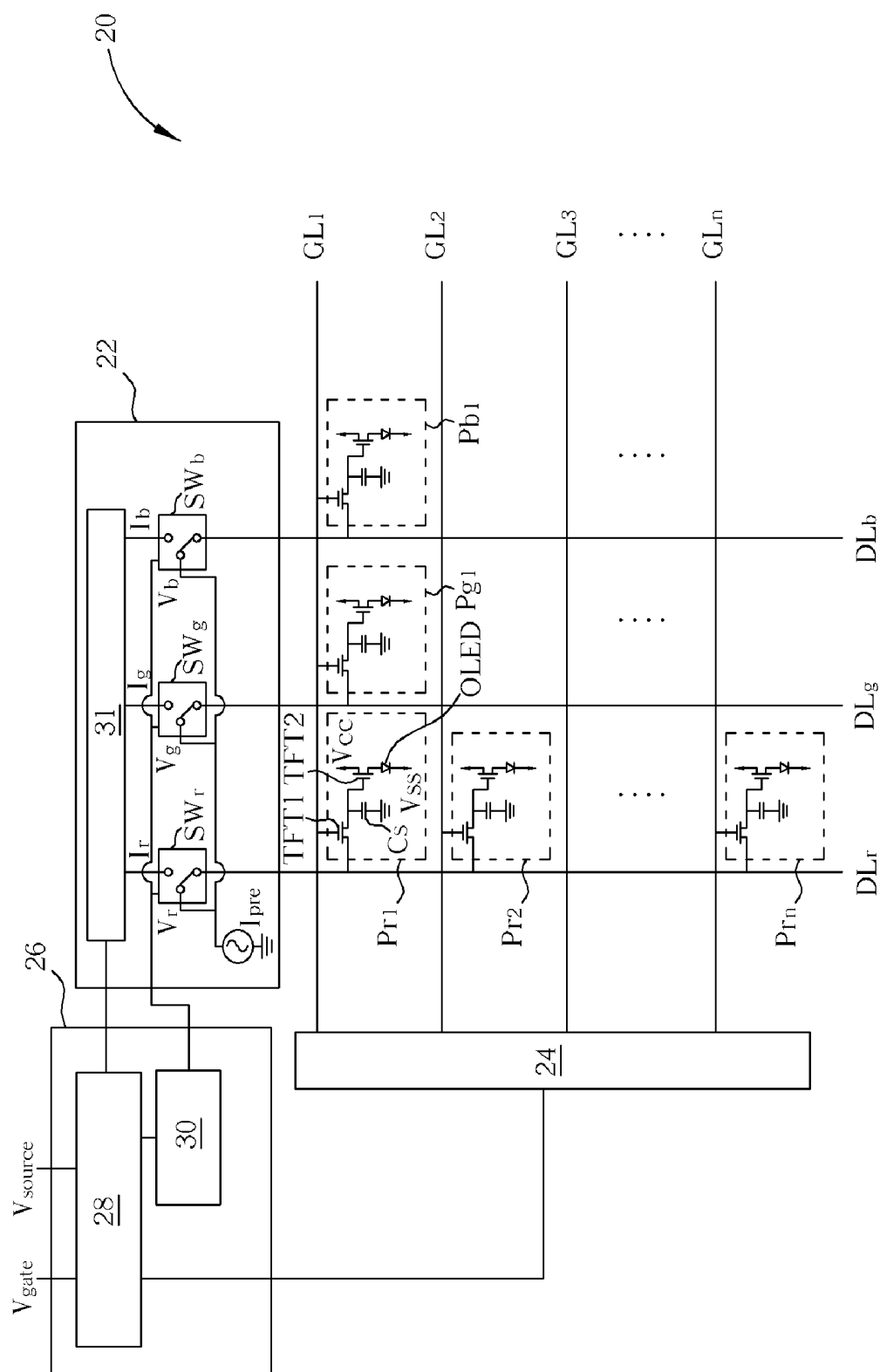


Fig. 1 Prior Art



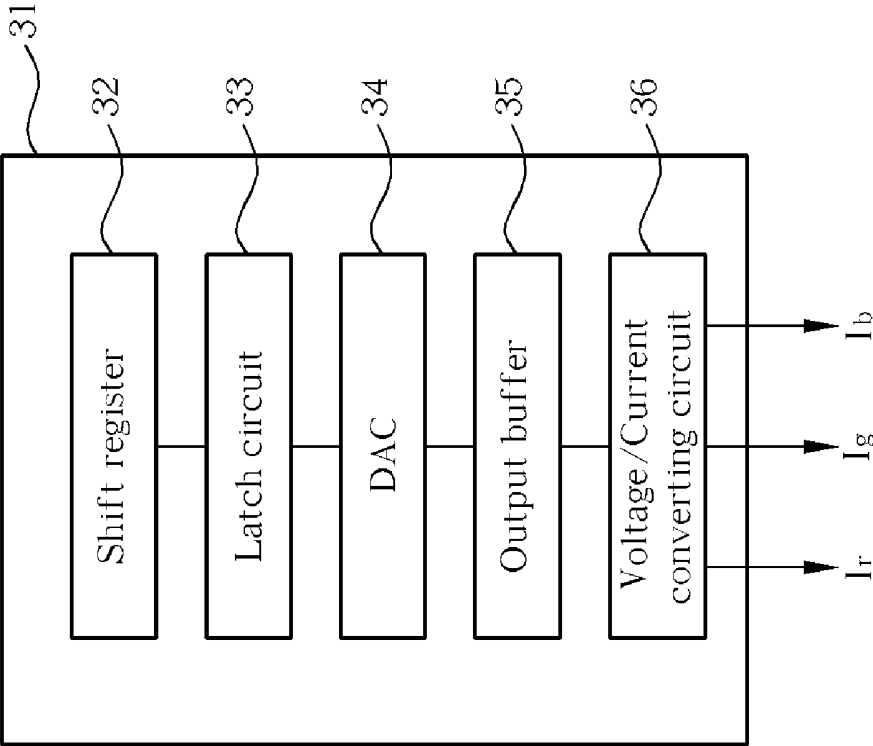


Fig. 3

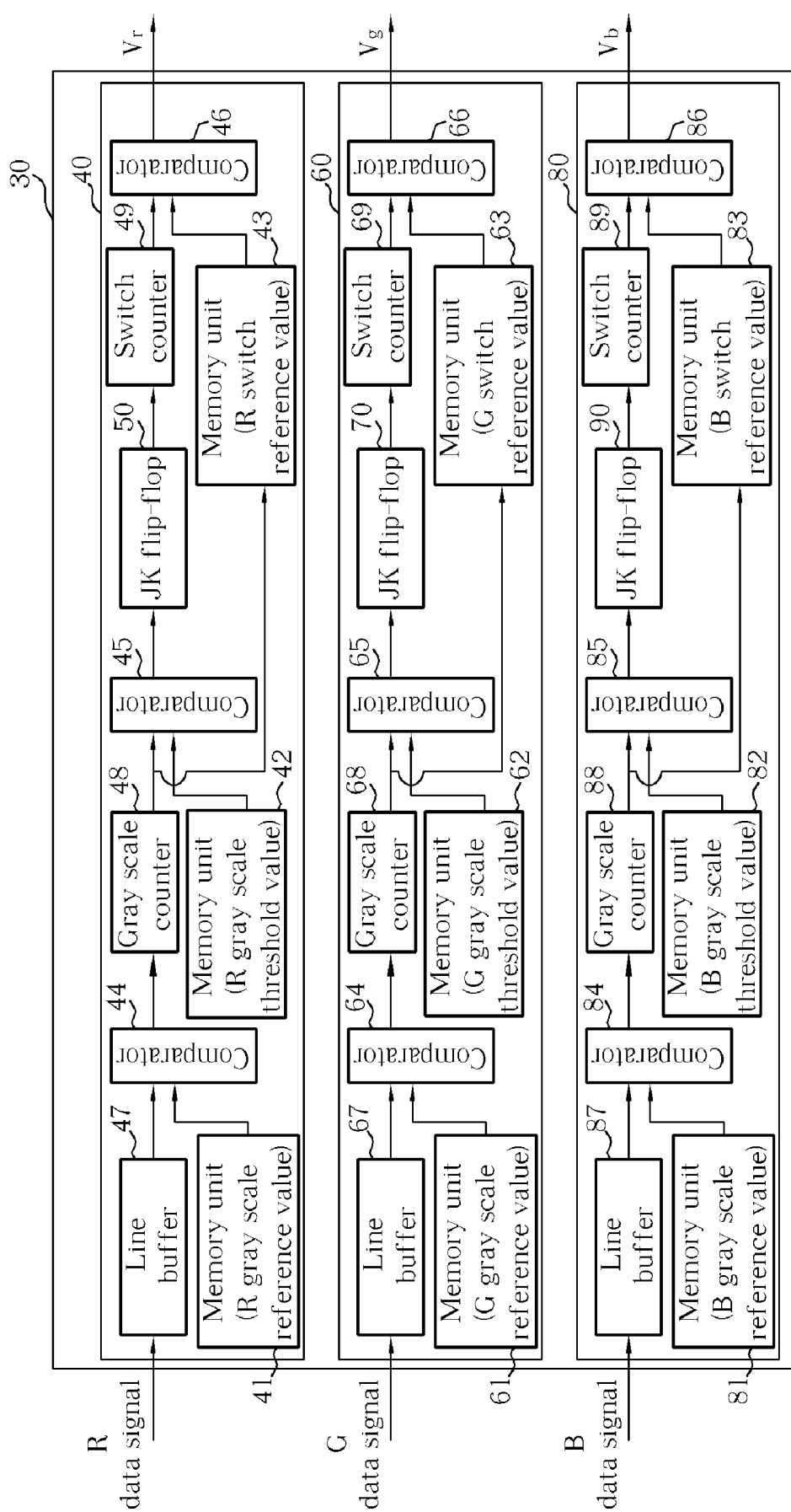


Fig. 4

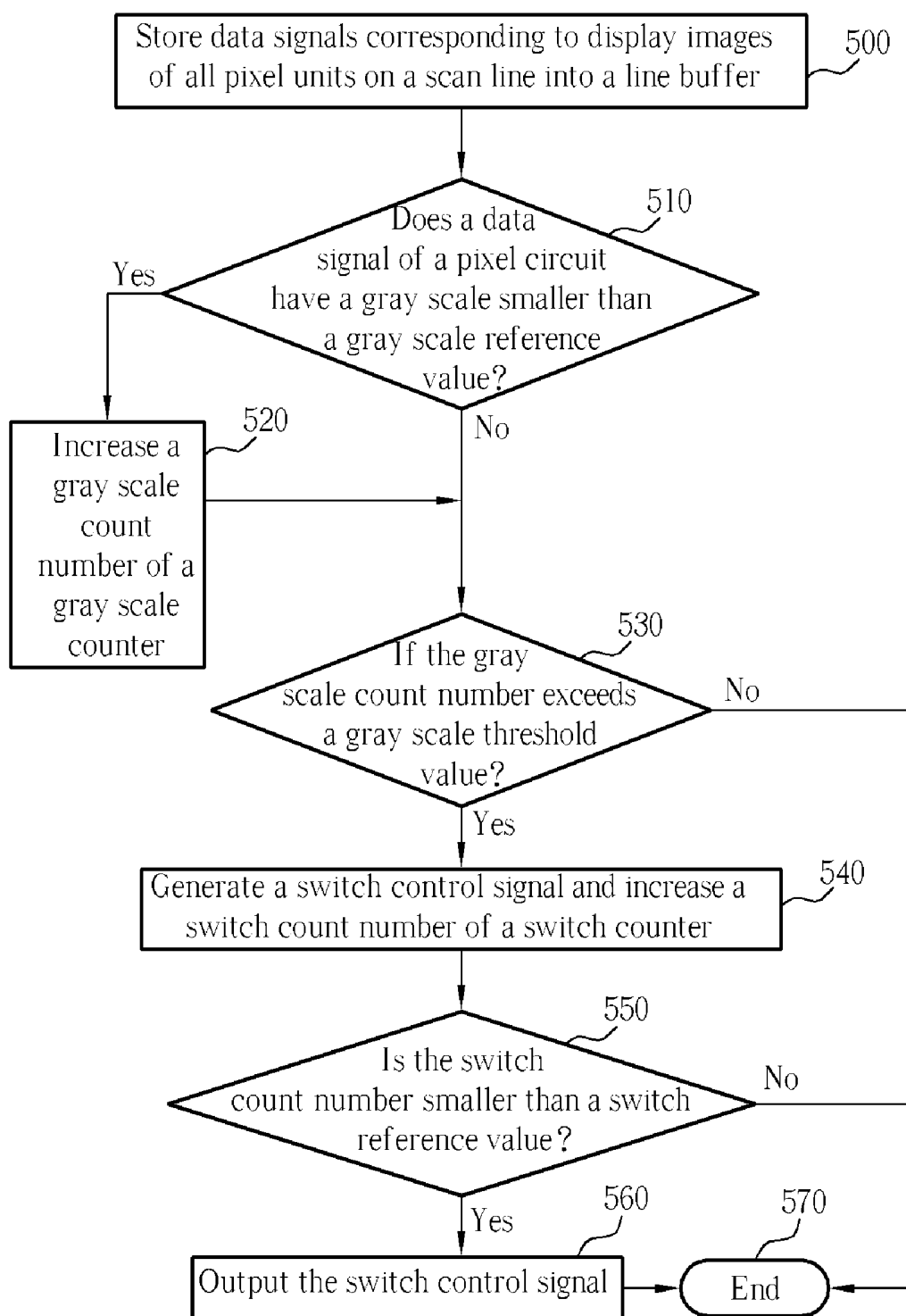


Fig. 5

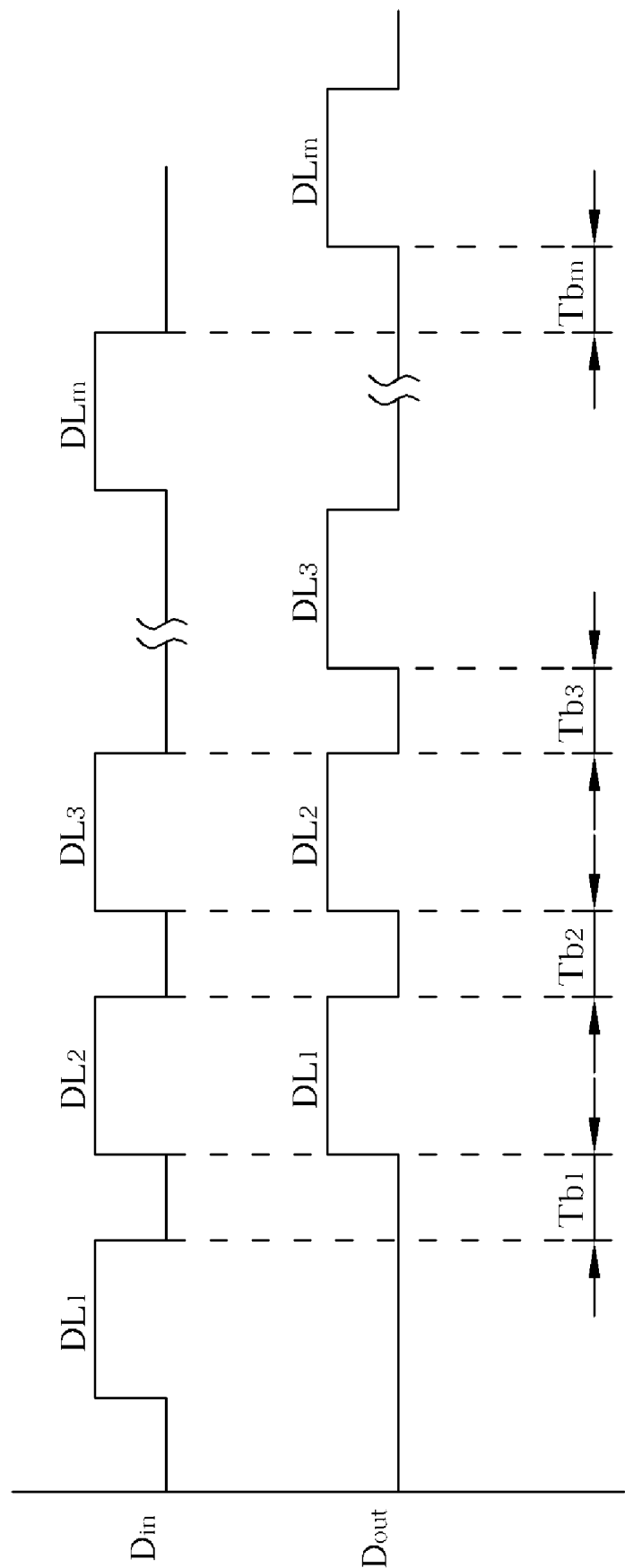


Fig. 6

ACTIVE MATRIX ORGANIC LIGHT EMITTING DIODE DISPLAY AND DRIVING METHOD THEREOF

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an active matrix organic light emitting display and driving method thereof, and more particularly, to an active matrix organic light emitting display having a pre-charge current source and driving method thereof.

[0003] 2. Description of the Prior Art

[0004] Flat panel displays have advantages such as low power consumption, no radiation and thin appearance, and have therefore gradually replaced traditional cathode ray tube (CRT) displays. Various kinds of flat panel displays have been developed to offer consumers better products. Among them, organic light emitting diode (OLED) displays have gained more and more attention due to their characteristics such as self-emitting light source, high brightness, high contrast, high emission rate, fast reaction, wide viewing angle, and low power consumption.

[0005] An OLED is a current-driven device whose luminance is determined by the driving current passing through the OLED. By controlling the value of the driving current, images having different brightness (or different gray scales) can be displayed. OLED displays can be categorized into passive matrix organic light emitting diode (PMOLED) displays and active matrix organic light emitting diode (AMOLED) displays according to the driving methods. In a PMOLED display, pixels on different rows/columns (scan lines/data lines) are driven sequentially. The luminance of each pixel is thus limited by the scan frequency and the number of the scan lines. Therefore, the PMOLED displays are mainly used in small-sized and low-resolution displays. In an AMOLED display, each pixel has a separate pixel circuit comprising a storage capacitor, an OLED and two thin-film transistors (TFTs). The pixel circuits can control the amount of current supplied to corresponding OLEDs. Therefore, the AMOLED displays can achieve uniform display characteristics by supplying a stable driving current to each pixel, and are particularly suitable for applications in large-sized and high-resolution displays.

[0006] FIG. 1 shows a diagram of a prior art AMOLED panel 10. The AMOLED panel 10 includes a data line DL, a scan line GL, and a pixel circuit 100. The pixel circuit 100 includes an OLED 110, a storage capacitor 120, TFTs 130 and 140, and voltage sources Vcc and Vss. The TFT 130 includes a gate coupled to the scan line GL and a drain coupled to the data line DL. The TFT 140 includes a gate coupled to a source of the TFT 130 and a drain coupled to the voltage source Vcc. The storage capacitor 120 is coupled between the source of the TFT 130 and ground, and the OLED 110 is coupled between the source of the TFT 140 and the voltage source Vss. When displaying an image, a scan signal is sent to the TFT 130 via the scan line GL for turning on the TFT 130, thereby coupling the storage capacitor 120 to the data line via the TFT 130. Also, current from the data line charges the storage capacitor 120 and a gate voltage required for turning on the TFT 140 is stored in the storage capacitor 120. Once the TFT 140 is turned on, a

current I_{OLED} flows through the OLED 110, whose luminance is determined by the value of the current I_{OLED} . The current I_{OLED} can be represented by the following formula:

$$I_{OLED} = \frac{1}{2} \mu \cdot C_{OX} \cdot W/L \cdot (V_{GS} - V_{TH})^2; \text{ where}$$

[0007] μ is the electron mobility;

[0008] C_{OX} is the gate oxide capacitance per unit area of the TFT 140;

[0009] W is the channel width of the TFT 140;

[0010] L is the channel length of the TFT 140;

[0011] V_{TH} is the threshold voltage of the TFT 140; and

[0012] V_{GS} is the voltage difference between the gate and the source of the TFT 140.

[0013] The gray scales of images displayed by the pixel circuit 110 is determined by the value of I_{OLED} , which is controlled by the voltage V_{GS} based on charges stored in the storage capacitor 120. When displaying an image of a low gray scale, the pixel circuit 100 requires a small current I_{OLED} . To generate a corresponding small voltage V_{GS} , the current sent from the data line for charging the storage capacitor 120 is also small. Under this circumstance, the small current cannot efficiently charge the storage capacitor 120 for providing a sufficient voltage V_{GS} , and the pixel circuit 110 might not be able to completely display the image having the required low gray scale. Therefore, the prior art AMOLED displays have poor display quality when displaying images of low gray scales.

SUMMARY OF THE INVENTION

[0014] The present invention provides a method for driving an active matrix organic light emitting diode display comprising determining whether a gray scale of an image to be displayed by a pixel circuit on a scan line is smaller than a gray scale reference value, transmitting a pre-charging current to the pixel circuit if the gray scale of the image to be displayed by the pixel circuit is smaller than the gray scale reference value, and transmitting signals corresponding to the image to the pixel circuit after transmitting the pre-charging current to the pixel circuit.

[0015] The present invention also provides an active matrix organic light emitting diode display comprising a plurality of data lines for transmitting data signals, a plurality of scan lines for transmitting scan signals, a plurality of pixel circuits coupled to corresponding data lines and scan lines, a source driver comprising a data line driving circuit for generating a driving current corresponding to an image to be displayed by a pixel circuit, a current source for pre-charging a data line before sending the driving current to the data line, and a switch coupled between the current source and the data line for electrically connecting the current source to the data line, or for electrically isolating the current source from the data line, a gate driver coupled to the plurality of scan line for generating control signals, a timing controller for controlling the source driver and the gate driver based on video and timing data, and a gray scale circuit for controlling the switch of the source driver based on a gray scale of an image to be displayed by a pixel circuit of a scan line.

[0016] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in

the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a pixel circuit diagram of a prior art AMOLED panel.

[0018] FIG. 2 is a diagram of an AMOLED panel according to the present invention.

[0019] FIG. 3 shows an enlarged diagram of a data line driving circuit of the AMOLED panel in FIG. 2.

[0020] FIG. 4 is a diagram of a gray scale circuit of the AMOLED panel in FIG. 2.

[0021] FIG. 5 is a flowchart illustrating the operations of the gray scale circuit in FIG. 4.

[0022] FIG. 6 is a timing diagram illustrating the operations of the AMOLED panel in FIG. 2.

DETAILED DESCRIPTION

[0023] FIG. 2 shows a diagram of an AMOLED panel 20 according to the present invention. The AMOLED panel 20 includes data lines DL_r , DL_g , DL_b , scan lines GL_1 - GL_N , pixel circuits Pr_1 - Pr_n , Pg_1 - Pg_n , Pb_1 - Pb_n , a source driver 22, a gate driver 24, and a control circuit 26. Each pixel circuit includes an organic light emitting diode (OLED), a storage capacitor Cs, thin film transistors TFT1 and TFT2, and voltage sources Vcc and Vss. The thin film transistor TFT1 of each pixel circuit includes a gate coupled to a corresponding scan line and a drain coupled to a corresponding data line DL. The thin film transistor TFT2 of each pixel circuit includes a gate coupled to a source of a corresponding thin film transistor TFT1 and a drain coupled to the voltage source Vcc. The storage capacitor Cs of each pixel circuit is coupled between the source of a corresponding thin film transistor TFT1 and ground, and the organic light emitting diode OLED is coupled between the source of a corresponding thin film transistor TFT2 and the voltage source Vss.

[0024] The control circuit 26, coupled to the source driver 22 and the gate driver 24, includes a timing control circuit 28 and a gray scale circuit 30. Based on the timing signals V_{gate} and the data signal V_{source} of images to be displayed by the AMOLED panel 20 in a frame period, the timing control circuit 28 generates corresponding control signals to the source driver 22 and the gate driver 24. Based on the gray scales of images to be displayed by the AMOLED panel 20 in a frame period, the gray scale circuit 30 generates corresponding switch control signals V_r , V_g , and V_b . The operations of the timing control circuit 28 and the gray scale circuit 30 will be described in more detail.

[0025] The source driver 22 includes a data line driving circuit 31, a pre-charge current source I_{pre} , and switches SW_r , SW_g , and SW_b . FIG. 3 shows an enlarged diagram of the data line driving circuit 31 according to the present invention. The data line driving circuit 31 includes a shift register 32, a latch circuit 33, a digital-to-analog converter (DAC) 34, an output buffer 35, and a voltage/current converting circuit 36. The shift register 32 temporally stores digital image data received from the timing control circuit 28 and performs data shifting on the stored data. After receiving digital image data of an entire scan line, the shift

register 32 sends the digital image data to the latch circuit 33. The DAC 34 then receives digital voltage signals generated by the latch circuit 33 and converts the digital voltage signals into analog voltage signals. The output buffer 35 stabilizes the analog voltage signals and sends the stabilized analog voltage signals to the voltage/current converting circuit 36 for generating corresponding driving currents I_r , I_g , and I_b .

[0026] When the AMOLED panel 20 is operated normally, the thin film transistors TFT1 in the pixel circuits are turned on by the gate driver 24 via the scan lines GL_1 - GL_N based on the timing signals V_{gate} generated by the control circuit 26. Then the driving currents I_r , I_g , I_b corresponding to the data signal V_{source} of images are sent to the storage capacitors Cs of the corresponding pixel circuits. With the voltage differences generated by charging the storage capacitors Cs, the thin film transistors TFT2 in the pixel circuits can be turned on for controlling the amount of current passing through the organic light emitting diodes OLED. Therefore, the pixel circuits can display images of different gray scales.

[0027] However, when displaying an image of a low gray scale smaller than a gray scale reference value, the driving current required for charging the storage capacitor Cs to create a desired voltage difference is also small, making it difficult to efficiently charge the storage capacitor Cs to the required voltage level. Under this circumstance, the pre-charge current source I_{pre} is used for pre-charging the pixel circuits when displaying images of low gray scales in the AMOLED panel 20 of the present invention. If the AMOLED panel 20 determines that the pixel circuit Pr_1 needs to be pre-charged (how to determine whether a pixel circuit needs to be pre-charged will be described in more detail), the thin film transistor TFT1 of the pixel circuit Pr_1 is first turned on by the gate driver 24 and the switch SW_r is turned on by the switch control signal V_r generated by the gray scale circuit 30. Consequently, the pixel circuit Pr_1 is electrically connected to the pre-charge current source I_{pre} for pre-charging the storage capacitor Cs of the pixel circuit Pr_1 . Finally, the data line driving circuit 31 of the source driver 22 generates the driving current I_r corresponding to the image to be displayed by the pixel circuit Pr_1 , and then sends the driving current I_r to the storage capacitor Cs of the pixel circuit Pr_1 . Since the storage capacitor Cs of the pixel circuit Pr_1 has been pre-charged to a certain voltage level, it can easily be charged to the required voltage level in a frame period even with a small driving current I_r . Therefore, the AMOLED panel 20 of the present invention can improve display quality when displaying images of low gray scales.

[0028] FIG. 4 is a diagram of the gray scale circuit 30 of the present invention. FIG. 4 further illustrates how the AMOLED panel 20 performs steps of pre-charging. The gray scale circuit 30 includes judging circuits 40, 60 and 80 which determine whether the steps of pre-charging should be performed based on the data signal V_{source} , thereby generating the corresponding switch control signals V_r , V_g , and V_b . The judging circuit 40 includes memory units 41-43, comparators 44-46, a line buffer 47, a gray scale counter 48, a switch counter 49 and a JK flip-flop 50. The judging circuit 60 includes memory units 61-63, comparators 64-66, a line buffer 67, a gray scale counter 68, a switch counter 69 and a JK flip-flop 70. The judging circuit 80 includes memory units 81-83, comparators 84-86, a line buffer 87, a gray scale counter 88, a switch counter 89 and a JK flip-flop 90. An R

gray scale reference value, a G gray scale reference value, and a B gray scale reference value are stored in the memory units **41**, **61** and **81**, respectively. An R gray scale threshold value, a G gray scale threshold value, and a B gray scale threshold value are stored in the memory units **42**, **62** and **82**, respectively. An R switch reference value, a G switch reference value, and a B switch reference value are stored in the memory units **43**, **63** and **83**, respectively. The gray scale reference values and the gray scale threshold values can vary according to different driving methods. If the gray scale of an image to be displayed by a pixel circuit is smaller than the gray scale reference value, the image is referred to as a low gray scale image. If the number of the pixel circuits of a scan line which display low gray scale images exceeds the gray scale threshold value, the scan line needs to be pre-charged. The switch reference values correspond to the pre-charge time of the pixel circuits of the scan line.

[0029] FIG. 5 is a flowchart illustrating the operations of the gray scale circuit **30**. FIG. 5 includes the following steps:

[0030] Step **500**: store data signals corresponding to display images of all pixel units on a scan line into a line buffer;

[0031] Step **510**: determine if a data signal of a pixel circuit has a gray scale smaller than a gray scale reference value; if the pixel circuit has a gray scale smaller than the gray scale reference value, execute step **520**; if the pixel circuit has a gray scale not smaller than the gray scale reference value, execute step **530**;

[0032] Step **520**: increase a gray scale count number of a gray scale counter;

[0033] Step **530**: determine if the gray scale count number exceeds a gray scale threshold value; if the gray scale count number exceeds the gray scale threshold value, execute step **540**; if the gray scale count number does not exceed the gray scale threshold value, execute step **570**;

[0034] Step **540**: generate a switch control signal and increase a switch count number of a switch counter;

[0035] Step **550**: determine if the switch count number is smaller than a switch reference value; if the switch count number is smaller than the switch reference value, execute step **560**; if the switch count number is not smaller than the switch reference value, execute step **570**;

[0036] Step **560**: output the switch control signal; and

[0037] Step **570**: End.

[0038] The scan line GL_1 is used as an example for illustrating the present invention. In step **500**, based on the data signals of the images to be displayed by the scan line GL_1 , the control circuit **26** of the AMOLED panel **20** stores R data signals corresponding to red images into the line buffer **47**, stores G data signals corresponding to green images into the line buffer **67**, and stores B data signals corresponding to blue images into the line buffer **87**. In step **510**, the gray scale circuit **30** of the AMOLED panel **20** determines the relationship between the R data signals stored in the line buffer **47** and the R gray scale reference value stored in the memory unit **41**, between the G data signals stored in the line buffer **67** and the G gray scale

reference value stored in the memory unit **61**, and between the B data signals stored in the line buffer **87** and the B gray scale reference value stored in the memory unit **81**. For example, if the gray scale of an R data signal of the scan line GL_1 is smaller than the R gray scale reference value stored in the memory unit **41**, the judging circuit **40** of the gray scale circuit **30** increase a gray scale count number of the gray scale counter **48** in step **520** before executing step **530**; if the gray scale of an R data signal of the scan line GL_1 is not smaller than the R gray scale reference value stored in the memory unit **41**, the judging circuit **40** of the gray scale circuit **30** executes step **530** directly. In step **530**, the judging circuit **40** determines if the gray scale count number of the gray scale counter **48** exceeds the R gray scale threshold value stored in the memory unit **42**. If the gray scale count number exceeds the R gray scale threshold value, which means the scan line GL_1 includes a sufficient amount of pixel circuits displaying low gray scale red images, the judging circuit **40** generates the switch control signal V_r and increases the switch count number of the switch counter **49** in step **540**. If the gray scale count number does not exceed the R gray scale threshold value, the judging circuit **40** executes step **570** directly. In step **550**, if the switch count number of the switch counter **49** is smaller than the R switch reference value stored in the memory unit **43**, the judging circuit **40** outputs the switch control signal V_r for turning on the switch SW_r of the source driver **22**. The pre-charge current source I_{pre} can then be electrically connected to the data line DL_r , thereby providing current for pre-charging the data line DL_r .

[0039] Similarly, the judging circuits **60** and **80** of the gray scale circuit **30** also perform the steps in FIG. 5 to the G data signals and the B data signals of the scan line GL_1 , respectively. If the G data signals of the scan line GL_1 is smaller than the G gray scale reference value stored in the memory unit **61**, if the gray scale count number of the gray scale counter **68** exceeds the G gray scale threshold value stored in the memory unit **62**, and if the switch count number of the switch counter **69** is smaller than the G switch reference value stored in the memory unit **63**, the judging circuit **60** outputs the switch control signal V_g for turning on the switch SW_g of the source driver **22** in step **560**. The pre-charge current source I_{pre} can then be electrically connected to the data line DL_g , thereby providing current for pre-charging the data line DL_g . If the B data signals of the scan line GL_1 is smaller than the B gray scale reference value stored in the memory unit **81**, if the gray scale count number of the gray scale counter **88** exceeds the B gray scale threshold value stored in the memory unit **82**, and if a switch count number of the switch counter **89** is smaller than the B switch reference value stored in the memory unit **83**, the judging circuit **80** outputs the switch control signal V_b for turning on the switch SW_b of the source driver **22** in step **560**. The pre-charge current source I_{pre} can then be electrically connected to the data line DL_b , thereby providing current for pre-charging the data line DL_b .

[0040] Therefore, the present invention can improve the display quality when displaying images of low gray scales.

[0041] FIG. 6 is a timing diagram illustrating the operations of the AMOLED panel **20**. In FIG. 6, a waveform D_{in} represents the input image signals inputted into a scan line, and D_{out} represents the output image signals outputted by the scan line. When the waveform D_{in} has a high voltage

potential, image data is being inputted into the data lines DL_1 - DL_m . When the waveform D_{out} has a high voltage potential, image data is being outputted from the data lines DL_1 - DL_m . In between inputting and outputting image data are blanking periods designated as Tb_1 - Tb_m in FIG. 6. The steps illustrated in FIG. 5 are performed in these blanking periods. Therefore, the present invention can improve display quality without influencing data input and output.

[0042] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A method for driving an active matrix organic light emitting diode display comprising the following steps:

- (a) determining whether a gray scale of an image to be displayed by a pixel circuit on a scan line is smaller than a gray scale reference value;
- (b) transmitting a pre-charging current to the pixel circuit if the gray scale of the image to be displayed by the pixel circuit is smaller than the gray scale reference value; and
- (c) transmitting signals corresponding to the image to the pixel circuit after transmitting the pre-charging current to the pixel circuit.

2. The method of claim 1 further comprising:

counting the number of low gray scale pixel circuits wherein each of the gray scales of an image to be displayed by the low gray scale pixel circuits on the scan line is smaller than the gray scale reference value.

3. The method of claim 2 further comprising:

determining whether the number of the low-gray-scale pixel circuits is larger than a threshold value.

4. The method of claim 3 wherein step (b) comprises transmitting a pre-charging current to the pixel circuit if the gray scale of the image to be displayed by the pixel circuit is smaller than the gray scale reference value and the number of the low-gray-scale pixel circuits is larger than the threshold value.

5. The method of claim 1 further comprising:

counting the number of times the scan line needs to be pre-charged.

6. The method of claim 1 wherein transmitting a pre-charging current to the pixel circuit is performed by coupling the pixel circuit to a current source of a source driver for transmitting the pre-charging current to the pixel circuit.

7. An active matrix organic light emitting diode display comprising:

- a plurality of data lines for transmitting data signals;
- a plurality of scan lines for transmitting scan signals;
- a plurality of pixel circuits coupled to corresponding data lines and scan lines;
- a source driver comprising:
 - a data line driving circuit for generating a driving current corresponding to an image to be displayed by a pixel circuit;

- a current source for pre-charging a data line before sending the driving current to the data line; and

- a switch coupled between the current source and the data line for electrically connecting the current source to the data line, or for electrically isolating the current source from the data line;

- a gate driver coupled to the plurality of scan line for generating control signals;

- a timing controller for controlling the source driver and the gate driver based on video and timing data; and

- a gray scale circuit for controlling the switch of the source driver based on a gray scale of an image to be displayed by a pixel circuit of a scan line.

8. The display of claim 7 wherein the data line driving circuit comprises:

- a shift register for generating digital voltage signals based on an image to be displayed by a pixel circuit;

- a latch circuit for storing the digital voltage signals generated by the shift register;

- a digital-to-analog converter (DAC) for receiving the digital voltage signals outputted from the latch circuit and for converting the digital voltage signals to analog voltage signals;

- a buffer driver for enlarging the analog voltage signals and for outputting the enlarged analog voltage signals; and

- a voltage/current converting circuit for converting the received analog voltage signals into analog current signals.

9. The display of claim 7 wherein the gray scale circuit comprises:

- a line buffer for storing an image data to be outputted to a pixel circuit of the scan line;

- a memory unit for storing a gray scale reference value; and

- a comparator for comparing a gray scale of the image data with the gray scale reference value.

10. The display of claim 7 wherein the gray scale circuit comprises:

- a gray scale counter for counting the number of low-gray-scale pixel circuits, wherein in a display frame images to be displayed by the low-gray-scale pixel circuits have gray scales smaller than a gray scale reference value;

- a memory unit for storing a threshold value; and

- a comparator for comparing the number of low-gray-scale pixel circuits with the threshold value.

11. The display of claim 7 wherein the gray scale circuit comprises:

- a switch counter for counting the number of times the switch of the source driver needs to be turned on;

- a memory unit for storing a switch reference value; and

- a comparator for comparing the number of times the switch of the source driver needs to be turned on with the switch reference value.

12. The display of claim 7 wherein each of the plurality of pixel circuits comprises:

a first switch having a first end coupled to a corresponding scan line and a second end coupled to a corresponding data line;

a second switch having a first end coupled to a first power source and a second end coupled to a third end of the first switch;

a storage capacitor having a first end coupled to the third end of the first switch and a second end coupled to ground; and

a light-emitting unit coupled between a third end of the second switch and a second power source for displaying images according to received current.

13. The display of claim 12 wherein the first and second switches include thin film transistors (TFTs).

14. The display of claim 12 wherein the light-emitting unit includes an organic light emitting diode (OLED).

15. The display of claim 12 wherein the first power source is a positive voltage source, and the second power source is a negative voltage source.

* * * * *

专利名称(译)	有源矩阵有机发光二极管显示器及其驱动方法		
公开(公告)号	US20070164935A1	公开(公告)日	2007-07-19
申请号	US11/428577	申请日	2006-07-05
[标]申请(专利权)人(译)	李舒我		
申请(专利权)人(译)	LEE I-SHU		
当前申请(专利权)人(译)	LEE I-SHU		
[标]发明人	LEE I SHU		
发明人	LEE, I-SHU		
IPC分类号	G09G3/30		
CPC分类号	G09G3/3258 G09G3/3283 G09G2310/061 G09G2310/0251 G09G2310/027 G09G2300/0842		
优先权	095102113 2006-01-19 TW		
其他公开文献	US7683862		
外部链接	Espacenet USPTO		

摘要(译)

显示器包括多条数据线，多条扫描线，多个像素电路，源极驱动器，栅极驱动器，时序控制器和灰度级电路。源极驱动器包括：数据线驱动电路，用于产生与要由像素电路显示的图像对应的驱动电流；电流源，用于对像素电路进行预充电；以及开关，用于将电流源电连接到像素电路或电气将电流源与像素电路隔离。时序控制器控制源极驱动器和栅极驱动器。灰度级电路基于要由扫描线的像素电路显示的图像的灰度级来控制源极驱动器的开关。

