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(54) **PIXEL DRIVING CIRCUIT OF AN ORGANIC LIGHT EMITTING DIODE**

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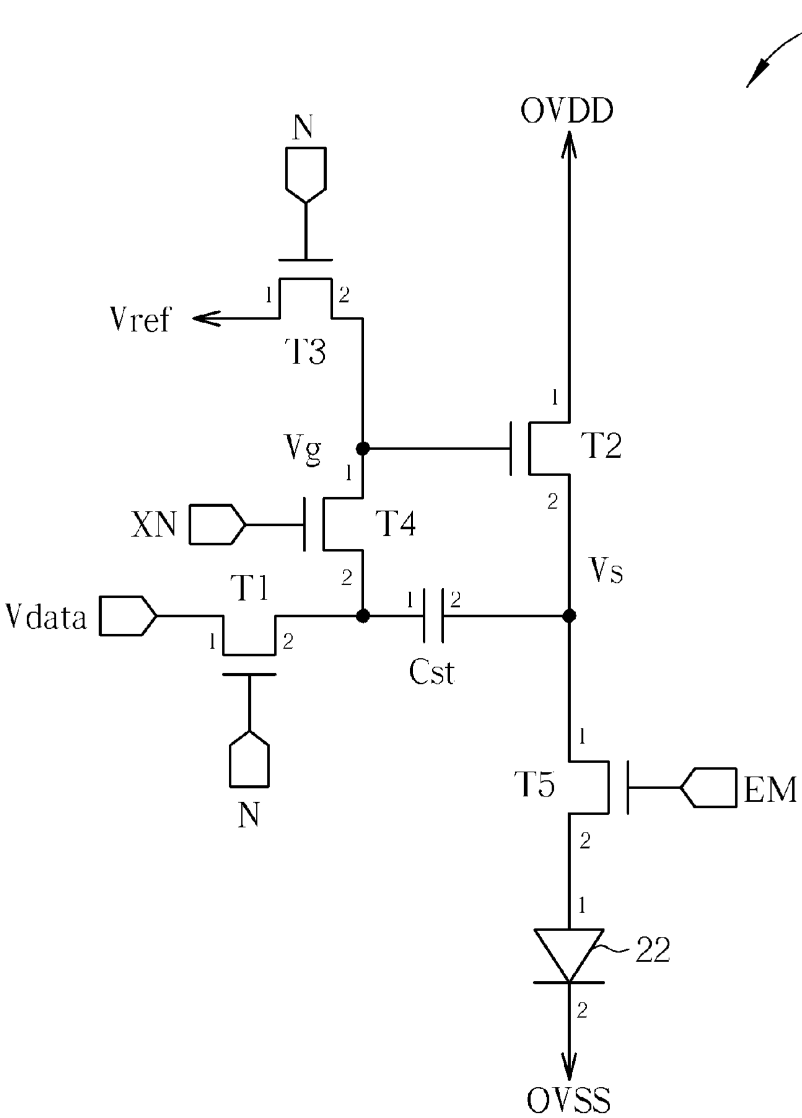
(57) **ABSTRACT**

A pixel driving circuit of an organic light emitting diode (OLED) includes a first transistor, a second transistor, a third transistor, a fourth transistor, a fifth transistor, a capacitor, and an OLED. The operation of the pixel driving circuit includes three stages including discharging, data writing, and emitting. The pixel driving circuit compensates the threshold voltage of the transistor in the stage of data writing, so the driving current of the OLED can be irrelevant to the variations of threshold voltages.



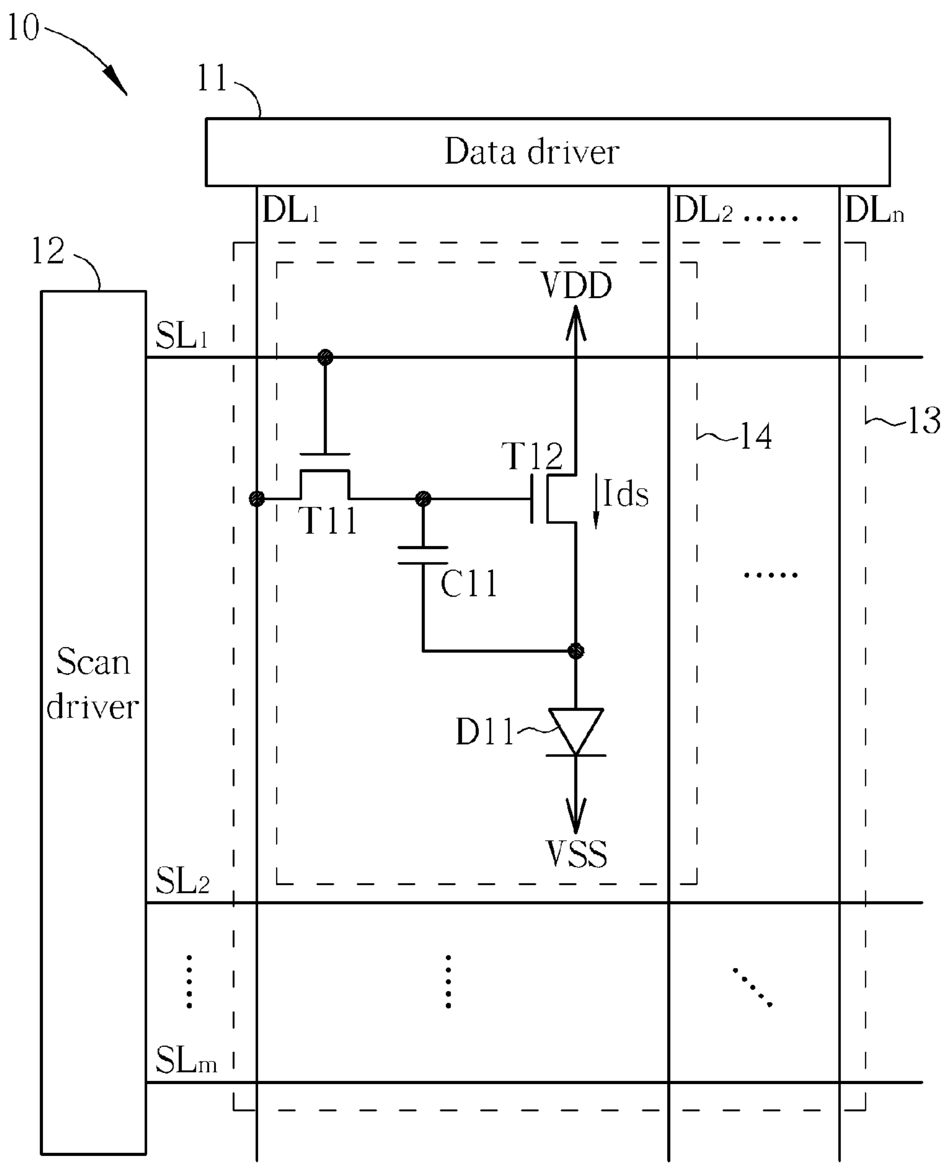
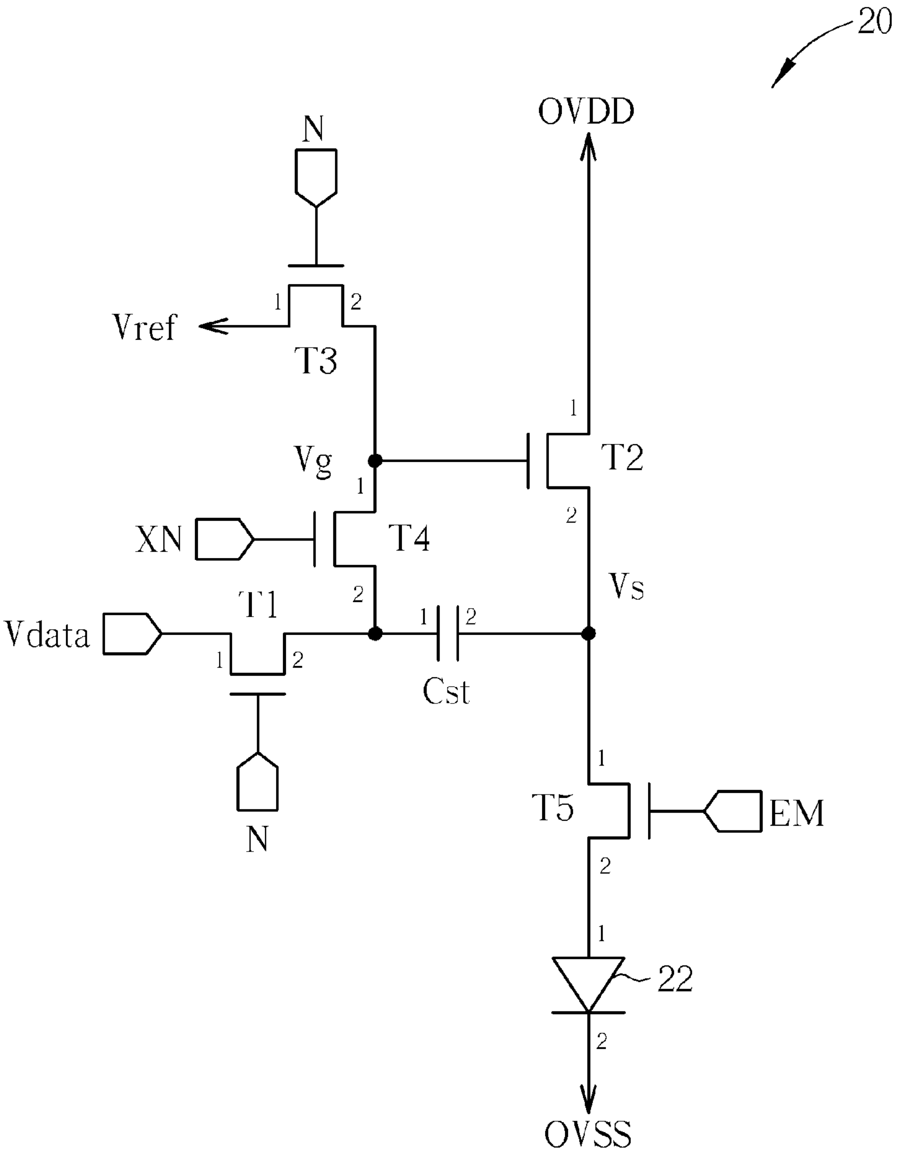


FIG. 1 PRIOR ART



20
OVDD
N
1
2
Vref
T3
1
T2
Vg
2
1
XN
T4
2
Vs
T1
1
2
Vdata
1
2
Cst
1
T5
EM
N
2
1
22
2
OVSS

FIG. 2

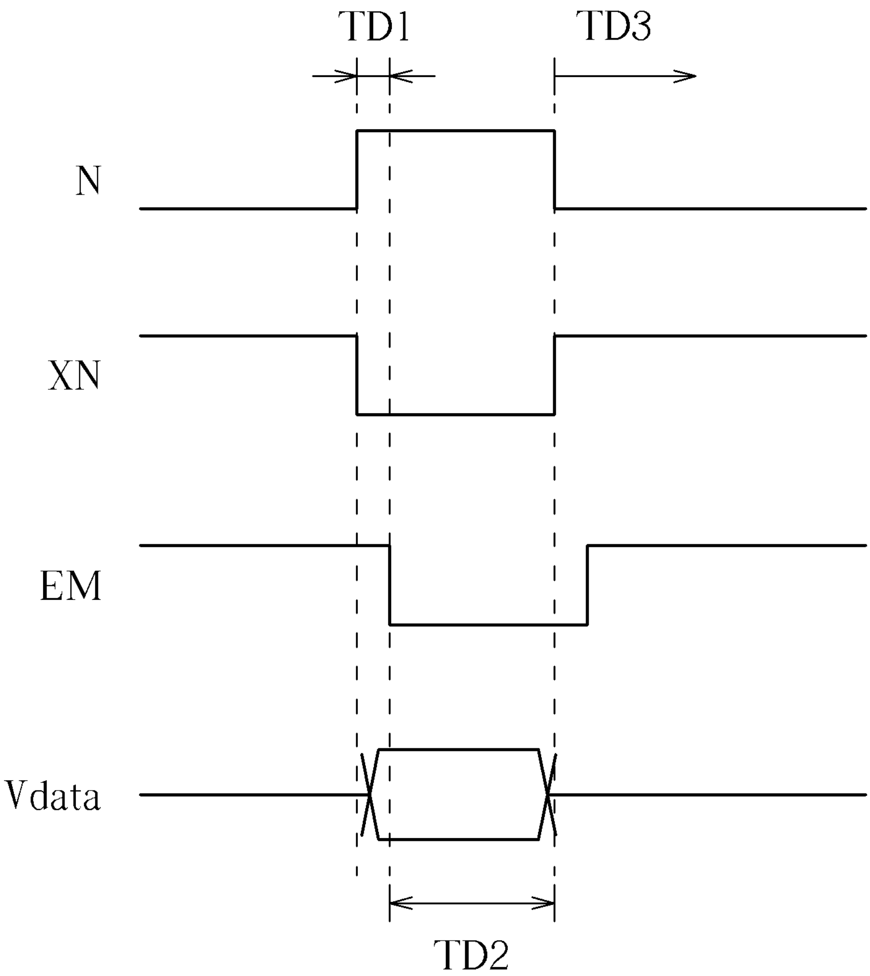


FIG. 3

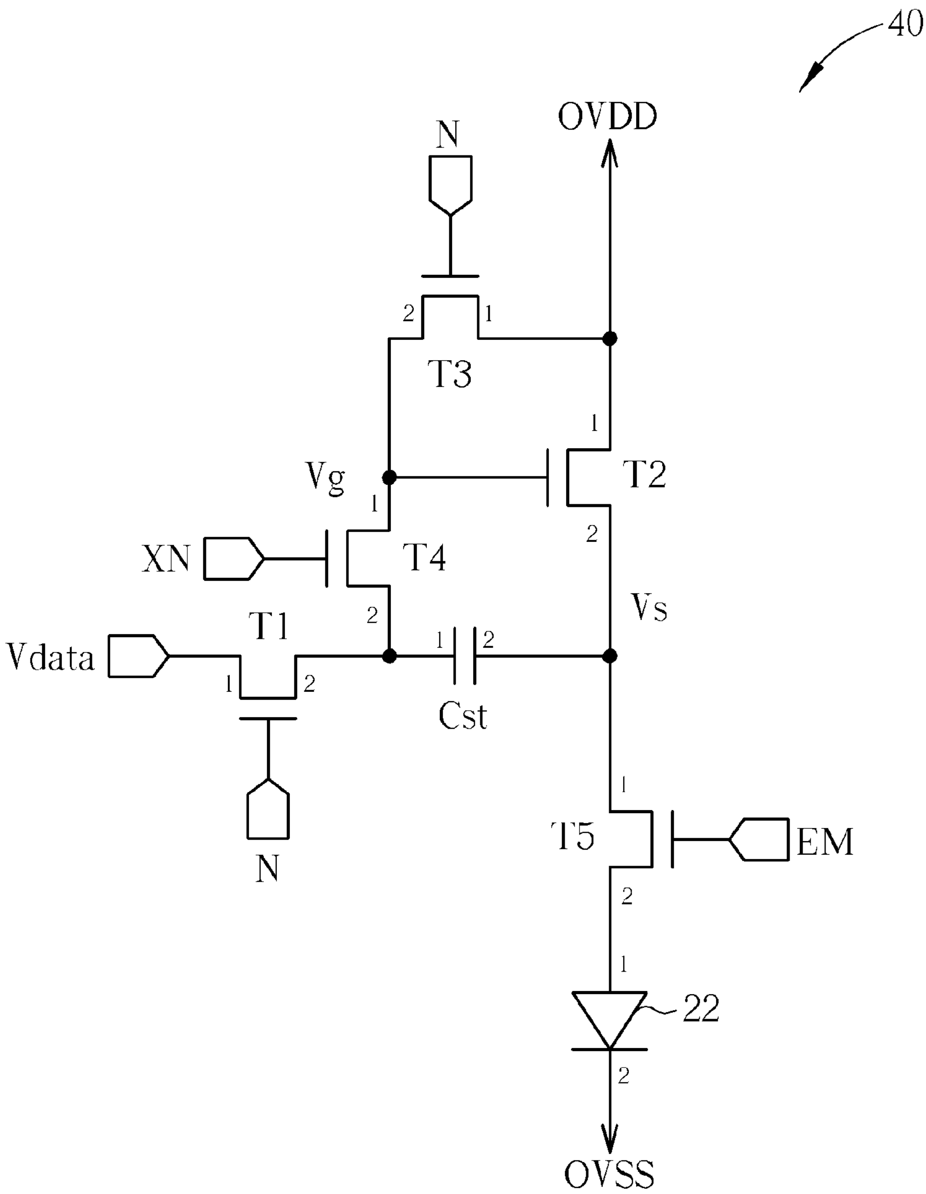

40
OVDD
N
2
1
T3
1
T2
Vg
1
XN
T4
2
2
Vs
Vdata
T1
1
2
1
2
Cst
N
1
T5
EM
2
1
22
2
OVSS

FIG. 4

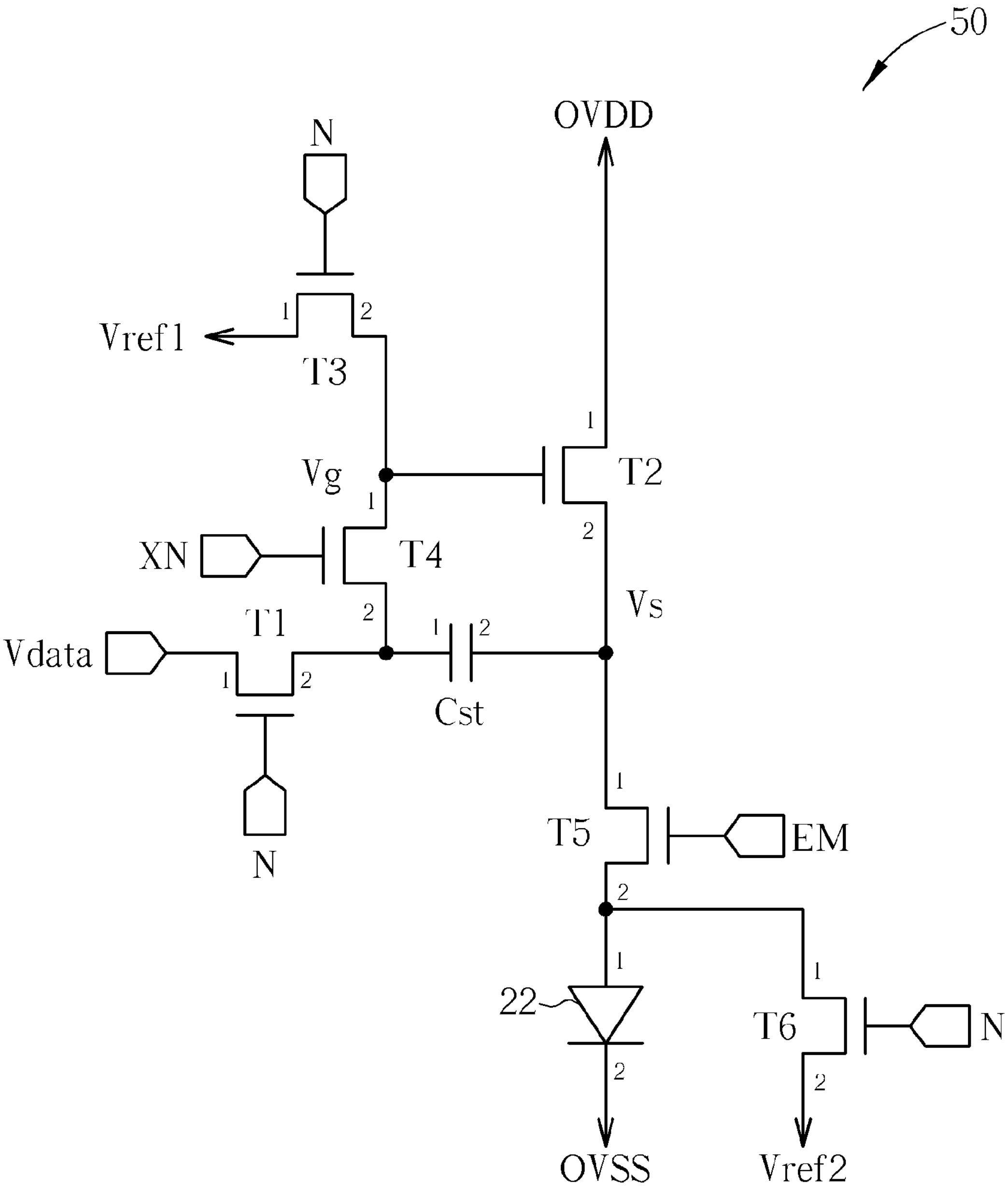

50
OVDD
N
Vref1
T3
Vg
T2
XN
T4
Vs
Vdata
T1
Cst
N
T5
EM
22
T6
N
OVSS
Vref2

FIG. 5

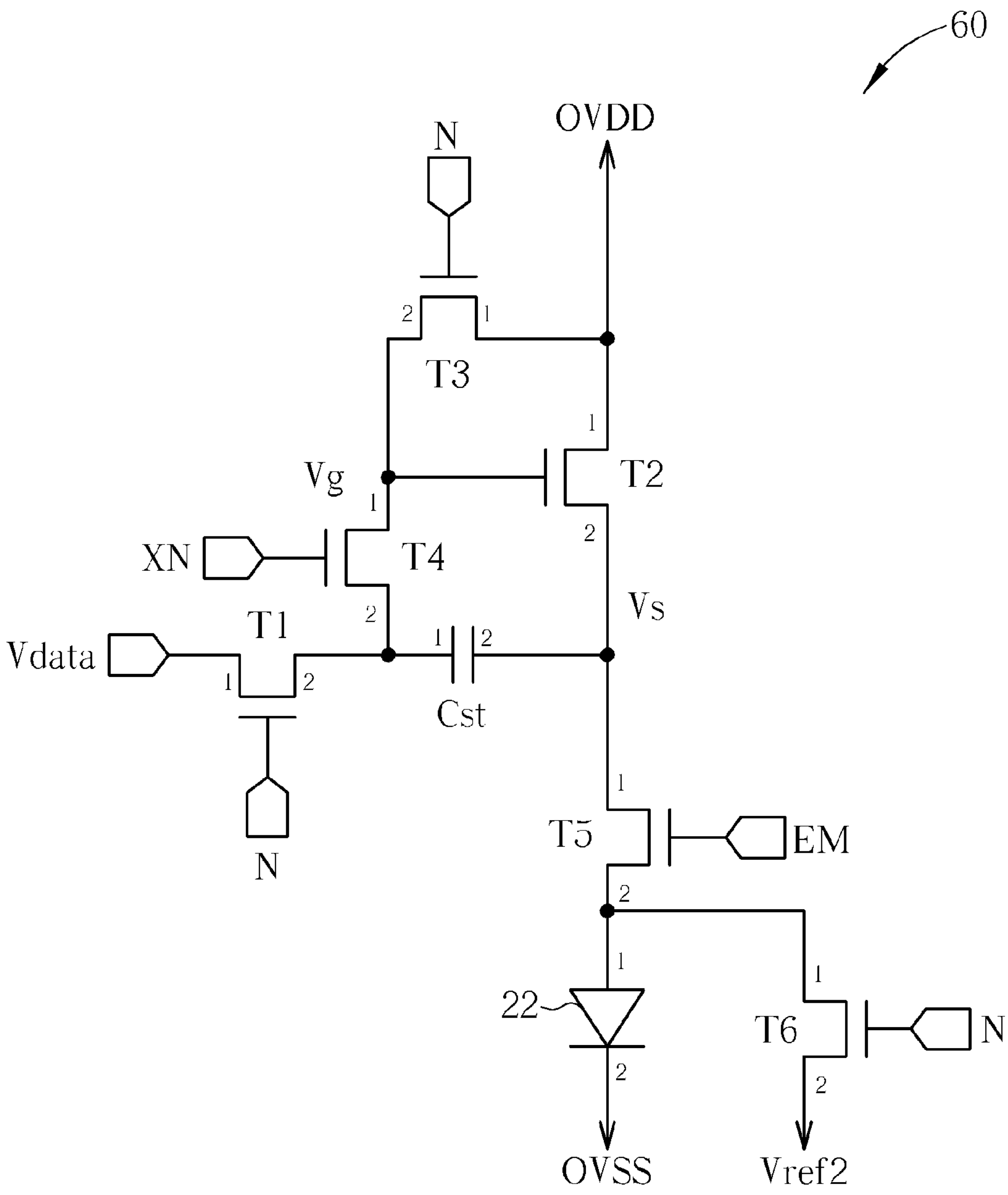


FIG. 6

PIXEL DRIVING CIRCUIT OF AN ORGANIC LIGHT EMITTING DIODE

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field

[0002] The disclosure is related to a pixel driving circuit of an organic light emitting diode, and more particularly, to a pixel driving circuit of an organic light emitting diode that is capable of compensating a threshold voltage of a transistor.

[0003] 2. Related Art

[0004] FIG. **1** is a diagram of a conventional organic light emitting diode (OLED) display panel . The display panel **10** includes a data driver **11**, a scan driver **12** and a display array **13** . The data driver **11** controls data lines DL_1-DL_n, and the scan driver **12** controls scan lines SL_1-SL_m. The display array **13** includes a plurality of pixel units, each disposed at corresponding intersections of the data lines DL_1-DL_n and the scan lines SL_1-SL_m. For example, the display unit **14** is disposed at the intersection of the data line DL_1 and the scan line SL_1. As illustrated in FIG. **1**, the equivalent circuit of the display unit **14** (and also those of other display units) includes a switch transistor T**11**, a storage capacitor C**11**, a driving transistor T**12** and an OLED D**11**, where the switch transistor T**11** and the driving transistor T**12** are N-type transistors.

[0005] The scan driver **12** sequentially outputs scan signals to the scan lines SL_1-SL_m so that the switch transistors in the display units coupled to a certain row are turned on at the same time, while switch transistors in the display units coupled to all other rows remain turned off. According to image data to be displayed, the data driver **11** outputs corresponding video signals (gray levels) to display units of one row via the data lines DL_1-DL_n. For example, when the scan driver **12** outputs scan signals to the scan line SL_1, the switch transistor T**11** of the display unit **14** is turned on. The data driver **11** outputs the corresponding pixel data to the display unit **14** via the data line DL_1, thereby storing the pixel data voltage in the storage capacitor C**11**. The driving transistor T**12** then provides driving current Ids to drive the OLED D**11** according to the voltage stored in the storage capacitor C**11**.

[0006] Being a current driven component, the luminescence of the OLED D**11** is determined by the value of the driving current Ids. The driving current Ids is the current flowing through the driving transistor T**12**, which may be represented by formula (1):

$$Ids=\frac{1}{2}k(Vgs-Vth)^2 \quad (1)$$

where k represents the conduction parameter of the driving transistor T**12**, Vgs represents the voltage difference between the source and the gate of the driving transistor T**12**, and Vth represents the threshold voltage of the driving transistor T**12**.

[0007] However, due to process factors of a thin-film transistor, transistors in different regions of the display array **13** possess varying electrical characteristics, meaning the transistors possess different threshold voltages. Hence, when transistors in different regions receive pixel data of the same voltage, the threshold voltage variation of the transistors causes the driving currents provided to the OLEDs to be inconsistent, consequently causing the OLEDs to generate different luminescence when receiving pixel data of the same voltage, and inconsistent luminance results throughout the image displayed by the display panel **10**.

SUMMARY

[0008] The present invention discloses a pixel driving circuit of an organic light emitting diode. The pixel driving circuit comprises a first transistor, a capacitor, a second transistor, a third transistor, a fourth transistor, a fifth transistor, and an organic light emitting diode. The first transistor comprises a first end for receiving a data voltage, a second end, and a control end for receiving a first scan signal. The capacitor comprises a first end electrically connected to the second end of the first transistor, and a second end. The second transistor comprises a first end electrically connected to a first voltage source, a control end, and a second end electrically connected to the second end of the capacitor. The third transistor comprises a first end for receiving a first reference voltage, a second end electrically connected to the control end of the second transistor, and a control end for receiving the first scan signal. The fourth transistor comprises a first end electrically connected to the control end of the second transistor, a second end electrically connected to the second end of the first transistor, and a control end for receiving a second scan signal. The fifth transistor comprises a first end electrically connected to the second end of the capacitor, a second end, and a control end for receiving a driving enable signal. The organic light emitting diode comprises a first end electrically connected the second end of the fifth transistor, and a second end electrically connected to a second voltage source.

[0009] 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

[0010] FIG. **1** is a diagram of a conventional organic light emitting diode (OLED) display panel.

[0011] FIG. **2** is a diagram illustrating a pixel driving circuit of an organic light emitting diode according to a first embodiment of the present invention.

[0012] FIG. **3** is a waveform diagram illustrating operation of the pixel driving circuit of the organic light emitting diode in FIG. **2**.

[0013] FIG. **4** is a diagram illustrating a pixel driving circuit of an organic light emitting diode according to a second embodiment of the present invention.

[0014] FIG. **5** is a diagram illustrating a pixel driving circuit of an organic light emitting diode according to a third embodiment of the present invention.

[0015] FIG. **6** is a diagram illustrating a pixel driving circuit of the organic light emitting diode according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION

[0016] Please refer to FIG. **2**. FIG. **2** is a diagram illustrating a pixel driving circuit of an organic light emitting diode according to a first embodiment of the present invention. The pixel driving circuit **20** comprises a first transistor T**1**, a second transistor T**2**, a third transistor T**3**, a fourth transistor T**4**, a fifth transistor T**5**, a capacitor Cst and an organic light emitting diode **22**. A first end of the first transistor T**1** receives data voltage Vdata, a control end of the first transistor T**1** receives a first scan signal N, and a second end of the first transistor T**1** is electrically connected to a first end of the capacitor Cst. A first end of the second transistor T**2** is electrically connected to a first voltage source OVDD and a second end of the second transistor T**2** is coupled to a second end of the capacitor Cst. A first end of the third transistor T**3**

receives a reference voltage Vref, a second end of the third transistor T3 is electrically connected to a control end of the second transistor T2 and a control end of the third transistor T3 receives the first scan signal N. A first end of the fourth transistor T4 is electrically connected to the control end of the second transistor T2, a second end of the fourth transistor T4 is electrically connected to the second end of the first transistor T1 and a control end of the fourth transistor T4 receives a second scan signal XN. A first end of the fifth transistor T5 is electrically connected to the second end of the capacitor Cst, and a control end of the fifth transistor T5 receives a driving signal EM. A first end of the organic light emitting diode 22 is electrically connected to the second end of the fifth transistor T5 and a second end of the organic light emitting diode 22 is electrically connected to a second voltage source OVSS.

[0017] In the present embodiment, the first transistor T1 to the fifth transistor T5 are N-type transistors, but are not limited to this, such that the pixel driving circuit can also be realized by utilizing P-type transistors. The first scan signal N and the second scan signal XN are complementary signals to each other, meaning when the first scan signal N is logic high, the second scan signal XN is logic low, and when the first scan signal N is logic low, the second scan signal XN is logic high. Voltage Vs represents voltage of the second end of the second transistor T2, and voltage Vg represents voltage of the control end of the second transistor T2.

[0018] Please refer to FIG. 3. FIG. 3 is a waveform diagram illustrating operation of the pixel driving circuit of the organic light emitting diode in FIG. 2. The operation of the pixel driving circuit 20 comprises three stages: discharging, data writing, and emitting. The pixel driving circuit 20 performs discharging in duration TD1 for resetting the voltage Vs. In the duration TD1, the first scan signal N is logic high, and the second scan signal XN is logic low, so the first transistor T1 and the third transistor T3 are turned on and the fourth transistor T4 is turned off. Therefore, the voltage of the control end of the second transistor T2 is equivalent to the reference voltage (Vg=Vref). In the duration TD1, the driving signal EM is logic high, so the fifth transistor T5 is turned on. Hence, the capacitor Cst discharges through the fifth transistor T5, and the voltage Vs can be represented by formula (2):

$$Vs=OVSS+V_{OLED} \quad (2)$$

where the voltage V_{OLED} represents a voltage difference between the first and second ends of the organic light emitting diode 22, thus voltage difference Vcst between the first and second ends of the capacitor Cst can be represented by formula (3):

$$Vcst=Vdata-Vs \quad (3)$$

[0019] The pixel driving circuit 20 performs data writing in duration TD2. In the duration TD2, logic values of the first scan signal N and the second scan signal XN remain unchanged, but the driving signal EM is transformed from logic high to logic low, so the fifth transistor T5 is turned off. In the data writing stage, a voltage difference between the control end and the second end of the second transistor T2 is equivalent to the threshold voltage Vth of the second transistor T2, for the voltage Vs to increase to (Vref−Vth). Hence the voltage difference Vcst between the first and second ends of the capacitor Cst can be represented by formula (4):

$$Vcst=Vdata-Vref+Vth \quad (4)$$

[0020] The pixel driving circuit 20 drives the organic light emitting diode 22 to perform emitting in duration TD3. In the duration TD3, the first scan signal N is transformed from logic high to logic low, and the second scan signal XN is transformed from logic low to logic high, so the first transistor T1 and the third transistor T3 are turned off and the fourth transistor T4 is turned on. In addition, the driving signal EM is transformed from logic low to logic high, and the fifth transistor T5 is turned on. A current I_{OLED} for driving the organic light emitting diode 22 is determined by the second transistor T2, as represented by formula (5):

$$I_{OLED}=\tfrac{1}{2}k(Vgs-Vth)^2 \quad (5)$$

where the voltage Vgs represents a voltage difference between the control end and the second end of the second transistor T2. Since the fourth transistor T4 is turned on, Vgs=Vcst=Vdata−Vref+Vth and hence the current I_{OLED} can be modified according to formula (6):

$$I_{OLED}=\tfrac{1}{2}k(Vdata-Vref)^2 \quad (6)$$

[0021] According to formula (6), the driving current I_{OLED} of the organic light emitting diode 22 is only related to the data voltage Vdata and the reference voltage Vref, which is mainly due to the pixel driving circuit 20 having compensated the threshold voltage of the transistor in the stage of data writing.

[0022] Please refer to FIG. 4. FIG. 4 is a diagram illustrating a pixel driving circuit of an organic light emitting diode according to a second embodiment of the present invention. In the second embodiment, the pixel driving circuit 40 comprises similar components to the first embodiment and the difference is the coupling relationship of the third transistor T3. Under the condition that a voltage level of the reference voltage Vref equals that of a voltage provided by the first voltage source OVDD, the first end of the third transistor T3 can be electrically connected to the first voltage source OVDD directly, while other coupling relationships remain unchanged. The second end of the third transistor T3 is electrically connected to the control end of the second transistor T2, and the control end of the third transistor T3 receives the first scan signal N. The second embodiment can save one reference voltage source.

[0023] Please refer to FIG. 5. FIG. 5 is a diagram illustrating a pixel driving circuit of an organic light emitting diode according to a third embodiment of the present invention. In the third embodiment, the pixel driving circuit 50 comprises similar components to the first embodiment, but further comprises a sixth transistor T6, and utilizes a first reference voltage Vref1 and a second reference voltage Vref2. The first end of the third transistor T3 receives the first reference voltage Vref1, the second end of the third transistor T3 is electrically connected to the control end of the second transistor T2, and the control end of the third transistor T3 receives the first scan signal N. A first end of the sixth transistor T6 is electrically connected to the second end of the fifth transistor T5, a second end of the sixth transistor T6 receives the second reference voltage Vref2, and a control end of the sixth transistor T6 receives the first scan signal N. Similar to the first transistor T1 and the third transistor T3, the sixth transistor T6 is controlled by the first scan signal N, so the sixth transistor T6 is turned on when the pixel driving circuit 50 performs discharging and data writing, so as to prevent current from passing through the organic light emitting diode 22 in stages other than the emitting stage.

[0024] Please refer to FIG. 6. FIG. 6 is a diagram illustrating a pixel driving circuit of the organic light emitting diode 22 according to a fourth embodiment of the present invention.

The fourth embodiment combines the second embodiment and the third embodiment. Differences between the pixel driving circuit **60** of the fourth embodiment and that of the first embodiment are the third transistor T**3** and the sixth transistor T**6**. The first end of the third transistor T**3** is electrically connected to the first voltage source OVDD, the second end of the third transistor T**3** is electrically connected to the control end of the second transistor T**2**, and the control end of the third transistor T**3** receives the first scan signal N. The first end of the sixth transistor T**6** is electrically connected the second end of the fifth transistor T**5**, the second end of the sixth transistor T**6** receives the second reference voltage Vref**2**, and the control end of the sixth transistor T**6** receives the first scan signal N.

[0025] In summary, the pixel driving circuit of the organic light emitting diode of the present invention comprises a first transistor, a second transistor, a third transistor, a fourth transistor, a fifth transistor, a capacitor, and an organic light emitting diode. The operation of the pixel driving circuit comprises three stages of discharging, data writing, and emitting. The pixel driving circuit compensates the threshold voltage of the transistor in the stage of data writing, so the driving current of the organic light emitting diode is only relevant to the data voltage and the reference voltage. Therefore, the pixel driving circuit of the organic light emitting diode of the present invention is able to compensate inconsistent driving current caused by differences between threshold voltages of the transistors for improving differences in luminescence generated by the organic light emitting diodes and preventing the display panel from displaying an image with inconsistent luminance.

[0026] 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 pixel driving circuit of an organic light emitting diode, comprising:

a first transistor, comprising a first end for receiving a data voltage, a second end, and a control end for receiving a first scan signal;

a capacitor, comprising a first end electrically connected to the second end of the first transistor, and a second end;

a second transistor, comprising a first end electrically connected to a first voltage source, a control end, and a second end electrically connected to the second end of the capacitor;

a third transistor, comprising a first end for receiving a first reference voltage, a second end electrically connected to the control end of the second transistor, and a control end for receiving the first scan signal;

a fourth transistor, comprising a first end electrically connected to the control end of the second transistor, a second end electrically connected to the second end of the first transistor, and a control end for receiving a second scan signal;

a fifth transistor, comprising a first end electrically connected to the second end of the capacitor, a second end, and a control end for receiving a driving signal; and

an organic light emitting diode, comprising a first end electrically connected the second end of the fifth transistor, and a second end electrically connected to a second voltage source.

2. The pixel driving circuit of claim **1**, wherein the first scan signal is complementary to the second scan signal.

3. The pixel driving circuit of claim **1**, wherein a voltage level of the first reference voltage equals a voltage level of a voltage provided by the first voltage source.

4. The pixel driving circuit of claim **1**, wherein the first reference voltage is an independent voltage source.

5. The pixel driving circuit of claim **1**, further comprising:

a sixth transistor, comprising a first end electrically connected to the second end of the fifth transistor, a second end for receiving a second reference voltage, and a control end for receiving the first scan signal.

6. The pixel driving circuit of claim **1**, wherein the first transistor, the second transistor, the third transistor, the fourth transistor and the fifth transistor are N-type transistors.

7. The pixel driving circuit of claim **1**, wherein when the first transistor, the third transistor and the fifth transistor are turned on and the fourth transistor is turned off, the capacitor discharges via the fifth transistor for resetting a voltage of the second end of the second transistor.

8. The pixel driving circuit of claim **1**, wherein when the first transistor and the third transistor are turned on and the fourth transistor and the fifth transistor are turned off, a voltage of the second end of the second transistor is generated according to the first reference voltage and a threshold voltage of the second transistor.

9. The pixel driving circuit of claim **1**, wherein when the fourth transistor and the fifth transistor are turned on and the first transistor and the third transistor are turned off, the organic light emitting diode is driven to emit light according to a current generated by the data voltage and the first reference voltage.

* * * * *

专利名称(译)	有机发光二极管的像素驱动电路		
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申请号	US13/241230	申请日	2011-09-23
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申请(专利权)人(译)	蔡轩明 刘春YEN		
当前申请(专利权)人(译)	蔡轩明 刘春YEN		
[标]发明人	TSAI HSUAN MING LIU CHUN YEN		
发明人	TSAI, HSUAN-MING LIU, CHUN-YEN		
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优先权	099138807 2010-11-11 TW		
其他公开文献	US8878831		
外部链接	Espacenet USPTO		

摘要(译)

有机发光二极管（OLED）的像素驱动电路包括第一晶体管，第二晶体管，第三晶体管，第四晶体管，第五晶体管，电容器和OLED。像素驱动电路的操作包括三个阶段，包括放电，数据写入和发光。像素驱动电路在数据写入阶段补偿晶体管的阈值电压，因此OLED的驱动电流可能与阈值电压的变化无关。