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(54) **Light emitting display apparatus and method of driving the same**

(57) A light emitting display apparatus and method for driving same is provided. In one embodiment, the light emitting display apparatus includes a plurality of pixel circuits, wherein each of the pixel circuits includes a light emitting device, a driving transistor having a first electrode coupled to the light emitting device and a second electrode coupled to a first power supply voltage supply line, a compensation capacitor having a first terminal coupled to a gate electrode of the driving transistor, a first switching device configured to provide a voltage from the

second power supply voltage supply line to a second terminal of the compensation capacitor in response to an initialization control signal, and a second switching device configured to provide a data signal to the second terminal of the compensation capacitor in response to a scan signal, wherein the first power supply voltage supply line and the second power supply voltage supply line are electrically coupled.

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**Description**

**[0001]** The present invention relates to a light emitting display apparatus, and more particularly, to an organic light emitting display apparatus and a method of driving the same.

**[0002]** Organic light emitting display apparatuses are display apparatuses that display an image by applying a current or a voltage to organic light emitting diodes (OLED) to emit light by electrically exciting phosphorous organic compound materials.

**[0003]** An OLED includes an anode layer, an organic thin layer, and a cathode layer. The organic thin layer of the OLED has a multi-layer structure including an emitting material layer (EML), an electron transport layer (ETL), and a hole transport layer (HTL) in order to improve balance between electrons and holes to increase light emitting efficiency, and may further include an electron injecting layer (EIL) and a hole injecting layer (HIL). The organic thin layer emits light when holes are combined with electrons in the emitting material layer (EML).

**[0004]** In general, organic light emitting display apparatuses include a plurality of pixels arranged in an N x M matrix, where N and M are natural numbers, and a plurality of driving circuits for driving each of the pixels. The pixels are driven using a passive matrix driving method or an active matrix driving method. In a passive matrix driving method, anode lines and cathode lines are arranged to cross each other perpendicularly and the lines are selected to be driven. In an active matrix driving method, a data signal is applied to each pixel using a switching device, and a capacitor is used to store the data signal, thereby maintaining a previously applied data signal during a period in which data signals are not applied. In order to realize a switching device, a thin film transistor (TFT) may be used. An active matrix driving method is classified as a voltage programming method and/or a current programming method, according to whether a voltage or a current is applied to a capacitor in order to maintain a voltage of the capacitor.

**[0005]** A driving transistor may be used to apply a current corresponding to a data signal to an OLED of each of the pixels. The driving transistor supplies a current according to a data signal input to a gate terminal and supplies the current to the OLED. The amplitude of the current is determined according to a difference in a gate voltage determined by the data signal and a source voltage determined by a driving voltage.

**[0006]** Holes and electrons are excited in the OLED by the current provided by the driving transistor, and light is emitted as the electrons and the holes are combined.

**[0007]** The present invention provides a light emitting display apparatus and a method of driving the same, whereby problems related to variations in the power supply voltage applied to each pixel, according to the position of the pixels, which is due to a parasitic resistance component of a wiring or a voltage drop due to a current applied to each pixel circuit according to an increased size of a panel, are addressed.

**[0008]** The present invention also provides a light emitting display apparatus and a method of driving the same, whereby variations of a power supply voltage that is applied to compensate for a threshold voltage of a driving circuit of each pixel circuit can be removed.

**[0009]** One embodiment of the present invention relates to a light emitting display apparatus including a plurality of pixel circuits, wherein each of the pixel circuits includes a light emitting device, a driving transistor having a first electrode coupled to the light emitting device and a second electrode coupled to a first power supply voltage supply line, a compensation capacitor having a first terminal coupled to a gate electrode of the driving transistor, a first switching device configured to provide a voltage from the second power supply voltage supply line to a second terminal of the compensation capacitor in response to an initialization control signal, and a second switching device configured to provide a data signal to the second terminal of the compensation capacitor in response to a scan signal, wherein the first power supply voltage supply line and the second power supply voltage supply line are electrically coupled.

**[0010]** Another embodiment of the present invention relates to a light emitting display apparatus including a first power supply voltage supply line configured to provide a first power supply voltage, a second power supply voltage supply line configured to provide a second power supply voltage, and a plurality of pixel circuits, each including a light emitting device, a driving transistor configured to receive the first power supply voltage and to generate a light emitting input signal for the light emitting device in response to a data signal, and a compensation capacitor having a first terminal coupled to a gate electrode of the driving transistor, the compensation capacitor configured to receive the second power supply voltage and to compensate for a threshold voltage of the driving transistor, wherein the first power supply voltage supply line and the second power supply voltage supply line are electrically coupled.

**[0011]** Another embodiment of the present invention relates to a light emitting display apparatus including a plurality of pixel circuits, a first power supply voltage supply line configured to provide a first power supply voltage to each of the plurality of the pixel circuits, a second power supply voltage supply line configured to provide a second power supply voltage to each of the plurality of the pixel circuits, and a power supply voltage compensating unit configured to compensate for a voltage drop of the first power supply voltage supply line and the second power supply voltage supply line, wherein each of the plurality of pixel circuits comprises a data input unit configured to receive a data signal, and to provide the data signal in response to a scan signal, a threshold voltage compensating unit configured to receive the data signal and the second power supply voltage, a driving unit configured to receive the data signal from the threshold

voltage compensating unit and to generate a light emitting input signal based on the data signal and the first power supply voltage, and a light emitting unit configured to emit light in response to the light emitting input signal, wherein the threshold voltage compensating unit is configured to compensate for a threshold voltage of the driving unit.

**[0012]** Another embodiment of the present invention relates to a method of driving a light emitting display apparatus including a plurality of pixel circuits, each pixel circuit including a light emitting device, a driving transistor configured to provide a light emitting input signal to the light emitting device based on a magnitude of a data signal, the driving transistor configured to be driven by a first power supply voltage, and a compensation capacitor having a first terminal coupled to a second power supply voltage via a switching device and a second terminal coupled to a gate terminal of the driving transistor, wherein the compensation capacitor is configured to compensate for a threshold voltage of the driving transistor, the method including charging the compensation capacitor to a level of the threshold voltage of the driving transistor by applying the second power supply voltage to the compensation capacitor via the switching device, compensating for the threshold voltage of the driving transistor, wherein the data signal is provided to a gate electrode of the driving transistor via the compensation capacitor, and providing the light emitting input signal, from the driving transistor, to the light emitting device, wherein a first power supply voltage supply line, for supplying the first power supply voltage, and a second power supply voltage supply line, for supplying the second power supply voltage, are electrically coupled.

**[0013]** The above and other features and aspects of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. 1 illustrates a conventional pixel circuit of a light emitting display apparatus;

FIG. 2 is a schematic view for explaining a phenomenon that occurs in a large-sized panel;

FIG. 3 is a schematic view illustrating a light emitting display apparatus according to an embodiment of the present invention;

FIG. 4 illustrates a pixel circuit for a light emitting display apparatus according to an embodiment of the present invention;

FIG. 5 illustrates a light emitting display apparatus that can be used with the pixel circuit of FIG. 4;

FIG. 6 illustrates a pixel circuit for a light emitting display apparatus, according to another embodiment of the present invention;

FIG. 7 illustrates a light emitting display apparatus that can be used with the pixel circuit of FIG. 6; and

FIG. 8 is a flowchart illustrating a method of driving a light emitting display apparatus according to an embodiment of the present invention.

**[0014]** In the following detailed description, with reference to the accompanying drawings, only certain exemplary embodiments of the present invention are shown and described by way of illustration. As those skilled in the art would recognize, the invention may be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. Accordingly, the scope of the invention is to be defined by the appended claims. The terms used herein should be understood with meanings and concepts in conformity with the technical aspects of the present invention, describing the present invention in ways that enable those of ordinary skill in the art to make and use the invention.

**[0015]** FIG. 1 is a schematic view illustrating a conventional pixel circuit of a light emitting display apparatus.

**[0016]** The pixel circuit of the light emitting display apparatus includes a light emitting device (e.g., an organic light emitting diode OLED), a driving transistor M1, a scanning transistor M2, and a storage capacitor Cst. The driving transistor M1 supplies a current in response to a data signal Dm that is input through the scanning transistor M2 to the light emitting device OLED. The data signal Dm is applied to the driving transistor M1 only for a predetermined period in response to a scan signal Sn. Also, while the data signal Dm is being applied during a scanning period, the data signal Dm is stored in the storage transistor Cst, and a voltage corresponding to the data signal Dm is applied to the driving transistor M1 even after the scanning period. When the current generated by the driving transistor M1 is applied to the light emitting device OLED, the light emitting device OLED emits light having luminance corresponding to the amplitude of the current applied to the light emitting device OLED.

**[0017]** The amplitude of the current applied from the driving transistor M1 to the light emitting device is as in Equation 1 below:

## Equation 1

$$I_{OLED} = \frac{\beta}{2}(V_{gs} - V_{th})^2 = \frac{\beta}{2}(VDD - V_{data} - |V_{th}|)^2$$

where IOLED is a current applied to the light emitting device OLED, Vgs is a voltage between a gate electrode and a source electrode of the driving transistor M1, Vth is a threshold voltage of the driving transistor M1, Vdata is the voltage of the data signal Dm applied to the gate electrode of the driving transistor M1 via the scanning transistor M2, and  $\beta$  is a constant. As expressed in Equation 1, the current supplied to the light emitting device OLED is a function of the voltage Vdata of the data signal Dm, a power supply voltage VDD, and the threshold voltage Vth. However, as the size of a panel is increased, the power supply voltage VDD, hereinafter referred to as a first power supply voltage VDD, and the threshold voltage Vth increasingly vary according to the position of pixels.

[0018] FIG. 2 is a schematic view for explaining a phenomenon that occurs in a large-sized panel.

[0019] In general, a panel includes a plurality of pixel circuits arranged in an N x M matrix, and a data signal Dm, a scan signal Sn, and a first power supply voltage VDD are applied to each of the pixel circuits. The first power supply voltage VDD may be commonly supplied to all of the pixel circuits.

[0020] However, as illustrated in FIG. 2, as the first power supply voltage VDD is supplied to each of the pixel circuits, a voltage drop may occur. A parasitic resistance component is usually present in a wiring for supplying a power supply voltage, and when the first power supply voltage VDD is supplied through the wiring, a voltage drop occurs due to the parasitic resistance component. Accordingly, due to this voltage drop, the longer the wiring between the pixel circuits and the voltage source of the first power supply voltage VDD, the greater the voltage drop of the first power supply voltage VDD supplied to each of the pixel circuits due to the parasitic resistance of the wiring.

[0021] Also, when the first power supply voltage VDD is applied as a driving voltage of the driving transistor M1 of each pixel circuit, a current is supplied from a first power supply voltage supply line to the driving transistor M1. Due to the current being applied to each of the pixel circuits, the voltage level of the first power supply voltage VDD supplied to the pixel circuits drops as the position of the pixel circuit is farther away from a supply point of the first power supply voltage VDD as shown with B of FIG. 2. Thus, long range non-uniformity (LR), wherein the first power supply voltage VDD of Equation 1 varies according to the position of pixels, occurs.

[0022] Also, as described above, short range non-uniformity (SR), which refers to variation in the amount of current supplied to the light emitting device OLED due to variation in the threshold voltage Vth of a TFT caused by irregularities in the manufacturing process, may occur. The degree of the problem increases as the size of the panel increases. Referring now to FIG. 4, for example, in order to compensate for the irregularities (e.g., non-uniformities) in the threshold voltage Vth of the pixel circuits, each of the pixel circuits, according to one embodiment, further includes a compensation capacitor Cvth connected to a gate terminal of the driving transistor M1. By applying a predetermined power supply voltage to the compensation capacitor Cvth, embodiments of the pixel circuits compensate for irregularities in the threshold voltage Vth. The predetermined power supply voltage in one embodiment may be an additional second power supply voltage Vsus. The second power supply voltage Vsus may also vary due to a voltage drop shown by A in FIG. 2 due to a parasitic resistance component of a second power supply voltage supply line and/or the voltage drop shown by B in FIG. 2 due to a current applied to each of the pixel circuits.

[0023] In general, the supply line of the second power supply voltage Vsus has smaller supply capacity than the supply line of the first power supply voltage VDD. In this case, the second power supply voltage Vsus is more sensitive to the size of the panel, and thus varies more as the size of the panel is increased.

[0024] In order to solve this problem, in several embodiments, as shown in FIG. 4, for example, the first power supply voltage VDD and the second power supply voltage Vsus are electrically connected to each other to compensate for the variations in the second power supply voltage Vsus.

[0025] FIG. 3 illustrates a light emitting display apparatus 300 according to an embodiment of the present invention.

[0026] The light emitting display apparatus 300 includes a plurality of pixel circuits Pnm, a first power supply voltage supply line 310, a second power supply voltage supply line 320, and a power supply voltage compensating unit 330.

[0027] The plurality of pixel circuits Pnm may be arranged in an N x M matrix as illustrated in FIG. 5, for example.

[0028] The first power supply voltage supply line 310 and the second power supply voltage supply line 320 are connected to each of the pixel circuits Pnm and apply a first power supply voltage VDD and a second power supply voltage Vsus, respectively, thereto. To this end, the first power supply voltage supply line 310 may be electrically connected to a first power supply voltage source (not shown) that supplies the first power supply voltage VDD, and the second power supply voltage supply line 320 may be electrically connected to a second power supply voltage source

(not shown) that supplies the second power supply voltage  $V_{sus}$ .

**[0029]** Also, in a number of embodiments, the first power supply voltage VDD and the second power supply voltage  $V_{sus}$  may have the same voltage level. In one embodiment, for example, the first power supply voltage supply line 310 and the second power supply voltage supply line 320 may be connected to a single source to provide the same voltage level.

**[0030]** The power supply voltage compensating unit 330 compensates for variations between the voltage levels of the first power supply voltage supply line 310 and the voltage levels of the second power supply voltage supply line 320. According to one embodiment of the invention, the power supply voltage compensating unit 330 may be realized by electrically connecting the first power supply voltage supply line 310 and the second power supply voltage supply line 320 to each other. Also, the electrical connection between the first power supply voltage supply line 310 and the second power supply voltage supply line 320 may be realized using additional wiring therebetween. Alternatively, the electrical connection may be realized using a switching device that electrically connects the first power supply voltage supply line 310 and the second power supply voltage supply line 320 in response to a control signal (e.g., a predetermined control signal). However, the present invention is not limited thereto, and, in one embodiment, the power supply voltage compensating unit 330 may be realized using circuitry that can compensate for voltage drops of the first power supply voltage supply line 310 and the second power supply voltage supply line 320.

**[0031]** The plurality of the pixel circuits  $P_{nm}$  may include a light emitting unit 340, a data input unit 350, a driving unit 360, and a threshold voltage compensating unit 370.

**[0032]** The light emitting unit 340 receives a light emitting input signal and emits light having luminance according to the amplitude of the received light emitting input signal. The light emitting unit 340 may be any light emitting device that emits light in response to an electrical input signal. In one embodiment, the light emitting unit may be an OLED. Also, the light emitting input signal may be a current input.

**[0033]** Furthermore, the light emitting unit 340 may be configured to receive the light emitting input signal at periods (e.g., predetermined periods) in response to a light emitting control signal  $E_n$ . Then the light emitting input signal may be provided to the light emitting unit via a switching device that is switched in response to the light emitting control signal  $E_n$ .

**[0034]** In several embodiments, the data input unit 350 receives a data signal  $D_m$  in response to a scan signal  $S_n$ , and stores the received data signal  $D_m$  for a predetermined period, for example, until the data signal  $D_m$  of the next frame is provided to the data input unit 350. To this end, the data input unit 350 may include a switching device that is switched in response to the scan signal  $S_n$ . Also, the data input unit 350 may further include a storage capacitor for storing the received data signal  $D_m$ .

**[0035]** In one embodiment, before the data signal  $D_m$  is provided to the data input unit 350, the threshold voltage compensating unit 370 stores a voltage corresponding to a threshold voltage of the driving unit 360 in order to compensate for the threshold voltage of the driving unit 360, and then compensates for the voltage drop corresponding to the threshold voltage as the data signal  $D_m$  is provided to the driving unit 360. To this end, the threshold voltage compensating unit 370 may include a compensation capacitor for storing a voltage corresponding to the threshold voltage of the driving unit 360. Also, the threshold voltage compensating unit 370 may further include a switching device that applies the second power supply voltage  $V_{sus}$  to the compensation capacitor in response to an initialization control signal  $S_{n-1}$  that is generated during a predetermined period before the data signal  $D_m$  is provided to the data input unit 350. Moreover, the threshold voltage compensating unit 370 may further include a switching device to diode-connect a driving transistor of the driving unit 360 in response to the initialization control signal  $S_{n-1}$ .

**[0036]** In one embodiment, the driving unit 360 receives the data signal  $D_m$  via the threshold voltage compensating unit 370, generates a light emitting input signal corresponding to the amplitude of the data signal  $D_m$ , and outputs the light emitting input signal to the light emitting unit 340. To this end, the driving unit 360 may include a driving transistor. The driving transistor may receive the data signal  $D_m$  from a gate electrode to generate the light emitting input signal. The first power supply voltage VDD may be applied to a source electrode of the driving transistor as a driving voltage of the driving transistor via the first power supply voltage supply line 310.

**[0037]** FIG. 4 illustrates a pixel circuit for a light emitting display apparatus, according to an embodiment of the present invention.

**[0038]** The pixel circuit includes an organic light emitting device OLED, a driving transistor M1, a first switching device M3, a compensation capacitor  $C_{vth}$ , a second switching device M2, and a storage capacitor  $C_{st}$ . The first power supply voltage supply line 310 is connected to the driving transistor M1 to supply a driving voltage, and the second power supply voltage supply line 320 is connected to an end of the first switching device M3.

**[0039]** In the embodiment illustrated in FIG. 4, the first power supply voltage supply line 310 and the second power supply voltage supply line 320 are electrically connected to each other to compensate for voltage drops of the first power supply voltage supply line 310 and the second power supply voltage supply line 320. To this end, a wire (e.g., power supply voltage compensation wiring) or another electrical conductor 400 is located between the first power supply voltage supply line 310 and the second power supply voltage supply line 320.

**[0040]** Before the data signal  $D_m$  is provided to the pixel circuit in response to the scan signal  $S_n$ , a voltage for

compensating a threshold voltage of the driving transistor M1 is stored in the compensation capacitor Cvth. To this end, an initialization control signal Sn-1 is applied during a predetermined period before a scan signal Sn is applied, and a second power supply voltage Vsus is applied to the compensation capacitor Cvth via the first switching device M3 in response to the generated initialization control signal Sn-1. A voltage is stored in the compensation capacitor Cvth up to a voltage level corresponding to the threshold voltage of the driving transistor M1 by the second power supply voltage Vsus.

**[0041]** In one embodiment, after the predetermined period in which the initialization control signal Sn-1 is applied, the scan signal Sn is applied, and the data signal Dm is provided through the second switching device M2. The data signal Dm is applied to the storage capacitor Cst during the period in which the scan signal Sn is applied, and the storage capacitor Cst stores the data signal Dm. The data signal Dm may be stored using a voltage programming method or a current programming method.

**[0042]** The data signal Dm stored in the storage capacitor Cst is provided to a gate electrode of the driving transistor M1 through the compensation capacitor Cvth. Here, the threshold voltage of the driving transistor M1 is compensated for by the compensation capacitor Cvth, and thus a light emitting input signal generated in the driving transistor M1 is independent from the threshold voltage of the driving transistor M1.

**[0043]** The light emitting input signal is provided to the light emitting device OLED, and the light emitting device OLED emits light having luminance corresponding to the amplitude of the light emitting input signal. The light emitting input signal may be a current input.

**[0044]** In the embodiment illustrated in FIG. 4, the first switching device M3 and the second switching device M2 may be p-type metal oxide semiconductor field-effect transistors (MOSFETs), but are not limited thereto and may be replaced with any devices that function as switches in response to predetermined control signals.

**[0045]** In one embodiment, the second switching device M2 and the storage capacitor Cst may correspond to the data input unit 350 of FIG. 3, and the first switching device M3 and the compensation capacitor Cvth may correspond to the threshold voltage compensating unit 370 of FIG. 3. Similarly, the driving transistor M1 may correspond to the driving unit 360 of FIG. 3, and the light emitting device OLED may correspond to the light emitting unit 340 of FIG. 3. Also, the power supply voltage compensation wiring 400 may correspond to the power supply voltage compensating unit 330 of FIG. 3.

**[0046]** FIG. 5 illustrates a light emitting display apparatus that can be used with the pixel circuit of FIG. 4.

**[0047]** A plurality of pixel circuits Pnm may be arranged in an N x M matrix. The first power supply voltage supply line 310 and the second power supply voltage supply line 320 are connected to each of the pixel circuits Pnm. The first power supply voltage supply line 310 and the second power supply voltage supply line 320 may be electrically connected to each other via the power supply voltage compensation wiring 400. Also, the light emitting display apparatus, according to the embodiment illustrated in FIG. 5, may further include a scanning driver 510 supplying a scan signal Sn to the plurality of the pixel circuits Pnm, and a data driver 520 supplying a data signal Dm to the plurality of the pixel circuits Pnm. According to the embodiment illustrated in FIG. 5, the scan signal Sn is commonly supplied to all of the pixel circuits Pnm on the same low.

**[0048]** According to the embodiment illustrated in FIG. 5, a plurality of the power supply voltage compensation wirings 400 may be located at multiple positions. Also, according to another embodiment, the power supply voltage compensation wiring 400 may be located between the first power supply voltage supply line 310 and the second power supply voltage supply line 320 near a predetermined pixel circuit Pnm that is located farther from a first power supply voltage supply source (not shown) than other pixel circuits. In such case, the distance between a node along the first power source voltage line 310 corresponding to the predetermined pixel circuit Pnm and the first power supply voltage supply source (not shown) is longer than the distances between other nodes along the first power source voltage line 310 corresponding to other pixel circuits and the first power supply voltage supply source. Similarly, in other embodiments, the power supply voltage compensation wiring 400 may be located between the first power supply voltage supply line 310 and the second power supply voltage supply line 320 near a predetermined pixel circuit Pnm that is located farther from a second power supply voltage supply source (not shown) than other pixel circuits. In such case, the distance between a node along the second power source voltage line 320 corresponding to the predetermined pixel circuit Pnm and the second power supply voltage supply source (not shown) is longer than the distances between other nodes along the second power source voltage line 320 corresponding to other pixel circuits and the second power supply voltage supply source.

**[0049]** FIG. 6 is a pixel circuit for a light emitting display apparatus, according to another embodiment of the present invention.

**[0050]** The light emitting display apparatus according to the embodiment shown in FIG. 6 includes a light emitting device OLED, a fourth switching device M5, a driving transistor M1, a first switching device M3, a third switching device M4, a compensation capacitor Cvth, a second switching device M2, and a storage capacitor Cst. A first power supply voltage supply line 310 is connected to the driving transistor M1 to supply a driving voltage, and a second power supply voltage supply line 320 is connected to an end of the first switching device M3.

**[0051]** In one embodiment, when an initialization control signal Sn-1 is applied, the first switching device M3 and the

third switching device M4 are turned on.

[0052] In one embodiment, as the third switching device M4 is turned on, the driving transistor M1 is diode-connected, and a voltage  $V_{gs}$  between a gate electrode and a source electrode of the driving transistor M1 increases up to a threshold voltage  $V_{th}$  of the driving transistor M1. A source voltage of the driving transistor M1 is provided by the first power supply voltage  $V_{DD}$ , and thus the voltage applied to the gate terminal of the driving transistor M1, that is, to one terminal of the compensation capacitor  $C_{vth}$ , is the sum of the first power supply voltage  $V_{DD}$  and the threshold voltage  $V_{th}$ .

[0053] Also, as the first switching device M3 is turned on, a second power supply voltage  $V_{sus}$  is applied to the other terminal of the compensation capacitor  $C_{vth}$ .

[0054] Accordingly, a voltage  $V_{Cvth}$  applied between the terminals of the compensation capacitor  $C_{vth}$  can be expressed as recited in Equation 2 below:

### Equation 2

$$V_{Cvth} = V_{Cvth1} - V_{Cvth2} = (V_{DD} + V_{th}) - V_{sus}$$

where  $V_{Cvth1}$  is a potential applied to one terminal of the compensation capacitor  $C_{vth}$  and  $V_{Cvth2}$  is a potential applied to the other terminal of the compensation capacitor  $C_{vth}$ .

[0055] In one embodiment, the initialization control signal  $S_{n-1}$  is no longer applied, and a scan signal  $S_n$  is applied. In such case, the operations of the second switching device M2 and the storage capacitor  $C_{st}$  according to the scan signal  $S_n$  can be the same as described with reference to the embodiments of FIG. 4.

[0056] The voltage  $V_{gs}$  between the gate electrode and the source electrode of the driving transistor M1 after the data signal  $D_m$  is stored in the storage capacitor  $C_{st}$  can be expressed as recited in Equation 3 below:

### Equation 3

$$V_{gs} = (V_{data} + (V_{DD} + V_{th} - V_{sus})) - V_{DD} = V_{data} + V_{th} - V_{sus}$$

[0057] A current  $I_{OLED}$  flowing to the light emitting device (e.g., OLED) can be expressed as recited in Equation 4 below:

### Equation 4

$$I_{OLED} = \frac{\beta}{2}(V_{gs} - V_{th})^2 = \frac{\beta}{2}((V_{data} + V_{th} - V_{sus}) - V_{th})^2 = \frac{\beta}{2}(V_{data} - V_{sus})^2$$

[0058] In other words, a light emitting input signal as expressed in Equation 4 is provided to the light emitting device OLED, and light having luminance corresponding to the amplitude of the current  $I_{OLED}$ , which is the light emitting input signal, is emitted from the light emitting device OLED. The amplitude of the light emitting input signal is dependent on the amplitudes of the data signal  $V_{data}$  and the second power supply voltage  $V_{sus}$  as expressed in Equation 4. Accordingly, if the second power supply voltage  $V_{sus}$  is applied to the pixel circuits unevenly due to a voltage drop (A) or (B) (see FIG. 2) according to the position of each pixel circuit along the second power supply voltage supply line 320, distortions may occur in a displayed image.

[0059] In order to address this problem, a structure for compensating for the voltage drop of the second power supply voltage supply line 320 can be formed in the light emitting display apparatus according to an embodiment of the present invention. In some embodiments, the structure may be, for example, the power supply voltage compensation wiring 400 formed between the first power supply voltage supply line 310 and the second power supply voltage supply line 320. In the past, the first power supply voltage supply line 310 and the second power supply voltage supply line 320 have been arranged in a complementary relationship such that if one of the two lines is thickened, the other is reduced. In such

case, a voltage drop along one of the two lines can develop, and thus, cross-talk may be generated. In several embodiments of the present invention, the first power supply voltage supply line 310 and the second power supply voltage supply line 320 are electrically connected to each other so as to compensate for the voltage drops of the first power supply voltage supply line 310 and the voltage of the second power supply voltage supply line 320, thereby preventing cross-talk.

**[0060]** FIG. 7 illustrates a light emitting display apparatus that can be used with the pixel circuit of FIG. 6.

**[0061]** In the embodiment illustrated in FIG. 7, a plurality of pixel circuits Pnm may be arranged in an N x M matrix. The first power supply voltage supply line 310 and the second power supply voltage supply line 320 are connected to each of the pixel circuits Pnm. The first power supply voltage supply line 310 and the second power supply voltage supply line 320 may be electrically connected to each other via the power supply voltage compensation wiring 400. Also, the light emitting display apparatus, according to the embodiment illustrated in FIG. 7, may further include a scanning driver 510 supplying a scan signal Sn and a light emitting control signal En to the plurality of the pixel circuits Pnm, and a data driver 520 supplying a data signal Dm to the plurality of the pixel circuits Pnm. According to the embodiment illustrated in FIG. 7, the scan signal Sn may be commonly supplied to all of the pixel circuits Pnm of the same row. Also, according to the embodiment illustrated in FIG. 7, an initialization control signal Sn-1 is a scan signal of a previous row, which is applied before the scan signal Sn for a predetermined pixel circuit Pnm is applied.

**[0062]** FIG. 8 is a flowchart illustrating a method of driving a light emitting display apparatus according to an embodiment of the present invention.

**[0063]** In one embodiment of the light emitting display apparatus, a data signal Dm is provided to each of the pixel circuits during a frame, and, more specifically, the data signal Dm may be provided sequentially to the pixel circuits Pnm arranged in the same columns while a scan signal Sn is generated during one frame. Also, the initialization control signal Sn-1 and the light emitting control signal En may be commonly supplied to the pixel circuits Pnm of the same rows or may be generated sequentially with respect to each row.

**[0064]** In one embodiment, when the initialization control signal Sn-1 is provided, a driving transistor M1 is diode-connected, and a second power supply voltage Vsus is applied to a compensation capacitor Cvth via a first switching device M3 in operation S802. The compensation capacitor Cvth is charged up to the level of a threshold voltage Vth of the driving transistor M1 while the initialization control signal Sn-1 is provided.

**[0065]** In one embodiment, after the initialization control signal Sn-1 is no longer applied, the scan signal Sn is applied. While the scan signal Sn is being applied, the data signal Dm is received and stored in the storage capacitor Cst in operation S804. The data signal Dm stored in a storage capacitor Cst is then provided to the gate terminal of the driving transistor M1 via the compensation capacitor Cvth, and the driving transistor M1 generates a light emitting display signal in response to the input data signal Dm. The driving transistor M1 is driven by a first power supply voltage VDD.

**[0066]** Next, the light emitting control signal En is applied, and while the light emitting control signal En is being applied, the light emitting display signal generated by the driving transistor M1 is provided to an organic light emitting device OLED in operation S806. The organic light emitting device OLED emits light having luminance according to the light emitting display signal. According to one embodiment of the present invention, a first power supply voltage supply line supplying the first power supply voltage and a second power supply voltage supply line supplying the second power supply voltage are electrically connected to each other.

**[0067]** In one embodiment, the light emitting display apparatus and the method of driving the same apparatus can compensate for the voltage drop of the power supply voltage applied to each pixel, which is due, at least in part, to the increased panel size.

**[0068]** In one embodiment, by compensating for the voltage drop of the power supply voltage, distortions in the output image of the light emitting display apparatus, which are also due, at least in part, to the increased panel size, can be reduced.

**[0069]** Furthermore, crosstalk between the plurality of power supply voltage supply lines can be removed.

**[0070]** While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, the terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the invention, which is defined by the claims. Thus, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the scope of the present invention, as defined by the claims.

## Claims

1. A light emitting display apparatus comprising:

a plurality of pixel circuits, wherein each of the plurality of pixel circuits comprises:



a light emitting device;

a driving transistor (M1) having a first electrode coupled to the light emitting device and a second electrode coupled to a first power supply voltage supply line;

a compensation capacitor (Cvth) having a first terminal coupled to a gate electrode of the driving transistor;  
 5 a first switching device (M3) configured to provide a voltage from a second power supply voltage supply line to a second terminal of the compensation capacitor in response to an initialization control signal (Sn-1); and

a second switching device (M2) configured to provide a data signal (Dm) to the second terminal of the compensation capacitor in response to a scan signal (Sn),

10 wherein the first power supply voltage supply line and the second power supply voltage supply line are electrically coupled.

2. The light emitting display apparatus of claim 1, further comprising at least one wire that electrically connects the first power supply voltage supply line to the second power supply voltage supply line.

3. The light emitting display apparatus of claim 2, wherein the at least one wire is located proximate to a pixel circuit located farther from a second power supply voltage source, for supplying voltage to the second power supply voltage supply line, than pixel circuits nearer to the second power supply voltage supply source.

4. The light emitting display apparatus of any one of the preceding claims, wherein each of the plurality of pixel circuits further comprises a storage capacitor (Cst) having a first terminal coupled to the second terminal of the compensation capacitor and a second terminal coupled to the first power supply voltage supply line.

5. The light emitting display apparatus of any one of the preceding claims, wherein each of the plurality of pixel circuits further comprises a third switching device (M4) configured to electrically couple the gate electrode to the first electrode of the driving transistor in response to the initialization control signal.

6. The light emitting display apparatus of claim 5, wherein the initialization control signal for a pixel circuit during a current scanning period is a previous scan signal (Sn-1) generated during a previous scanning period.

7. The light emitting display apparatus of claim 5 or 6, wherein each of the plurality of pixel circuits further comprises a fourth switching device (M5) coupled between the first electrode of the driving transistor and the light emitting device, wherein the fourth switching device is configured to switch in response to a light emitting control signal (En).

8. The light emitting display apparatus of any one of the preceding claims, wherein the light emitting device is an organic light emitting diode (OLED).

9. The light emitting display apparatus of any one of the preceding claims, further comprising:

40 a scanning driver configured to provide the scan signal and the initialization control signal; and  
 a data driver configured to provide the data signal.

10. The light emitting display apparatus of any one of the preceding claims, further comprising a power supply voltage compensating unit configured to compensate for a voltage drop of the first power supply voltage supply line and the second power supply voltage supply line.

11. A light emitting display apparatus comprising:

a plurality of pixel circuits;

50 a first power supply voltage supply line configured to provide a first power supply voltage to each of the plurality of the pixel circuits;

a second power supply voltage supply line configured to provide a second power supply voltage to each of the plurality of the pixel circuits; and

a power supply voltage compensating unit configured to compensate for a voltage drop of the first power supply voltage supply line and the second power supply voltage supply line,  
 55 wherein each of the plurality of pixel circuits comprises:

a data input unit configured to receive a data signal, and to provide the data signal in response to a scan signal;

a threshold voltage compensating unit configured to receive the data signal and the second power supply voltage;  
a driving unit configured to receive the data signal from the threshold voltage compensating unit and to generate a light emitting input signal based on the data signal and the first power supply voltage; and  
a light emitting unit configured to emit light in response to the light emitting input signal;  
wherein the threshold voltage compensating unit is configured to compensate for a threshold voltage of the driving unit.

**12.** The light emitting display apparatus of claim 11, wherein the power supply voltage compensating unit is arranged to electrically connect the first power supply voltage supply line and the second power supply voltage supply line.

**13.** The light emitting display apparatus of claim 11 or 12, wherein the threshold voltage compensating unit is configured to:

store the second power supply voltage in a compensation capacitor in response to an initialization control signal generated before a activation period of the scan signal;  
charge the compensation capacitor up to the threshold voltage of the data driver; and  
provide the data signal to the data driver via the compensation capacitor; and wherein the scanning driver is configured to provide the initialization control signal.

**14.** A method of driving a light emitting display apparatus comprising a plurality of pixel circuits, each pixel circuit comprising a light emitting device, a driving transistor configured to provide a light emitting input signal to the light emitting device based on a magnitude of a data signal, the driving transistor configured to be driven by a first power supply voltage, and a compensation capacitor having a first terminal coupled to a second power supply voltage via a switching device and a second terminal coupled to a gate terminal of the driving transistor, wherein the compensation capacitor is configured to compensate for a threshold voltage of the driving transistor, the method comprising:

charging the compensation capacitor to a level of the threshold voltage of the driving transistor by applying the second power supply voltage to the compensation capacitor via the switching device;  
compensating for the threshold voltage of the driving transistor, wherein the data signal is provided to a gate electrode of the driving transistor via the compensation capacitor; and  
providing the light emitting input signal, from the driving transistor, to the light emitting device,  
wherein a first power supply voltage supply line, for supplying the first power supply voltage, and a second power supply voltage supply line, for supplying the second power supply voltage, are electrically coupled.

**15.** The method of claim 14, wherein further comprising diode-connecting the driving transistor while charging the compensation capacitor.

FIG. 1 (PRIOR ART)

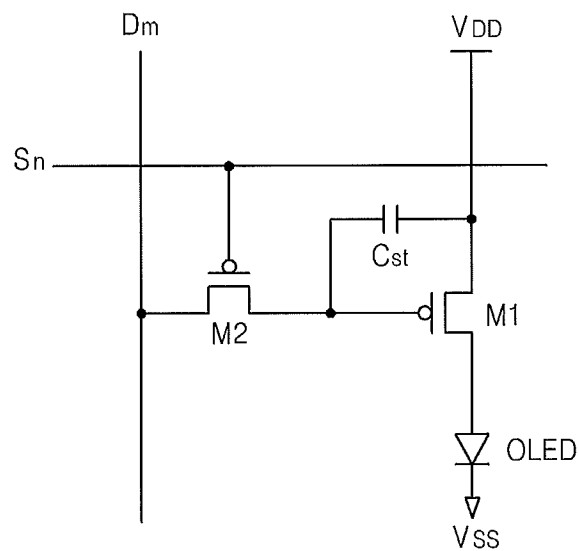


FIG. 2 (PRIOR ART)

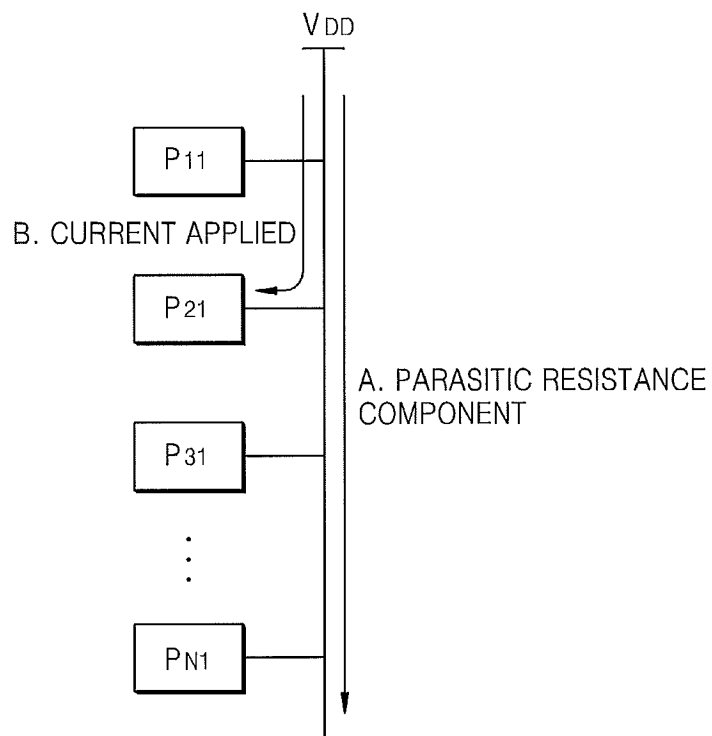


FIG. 3

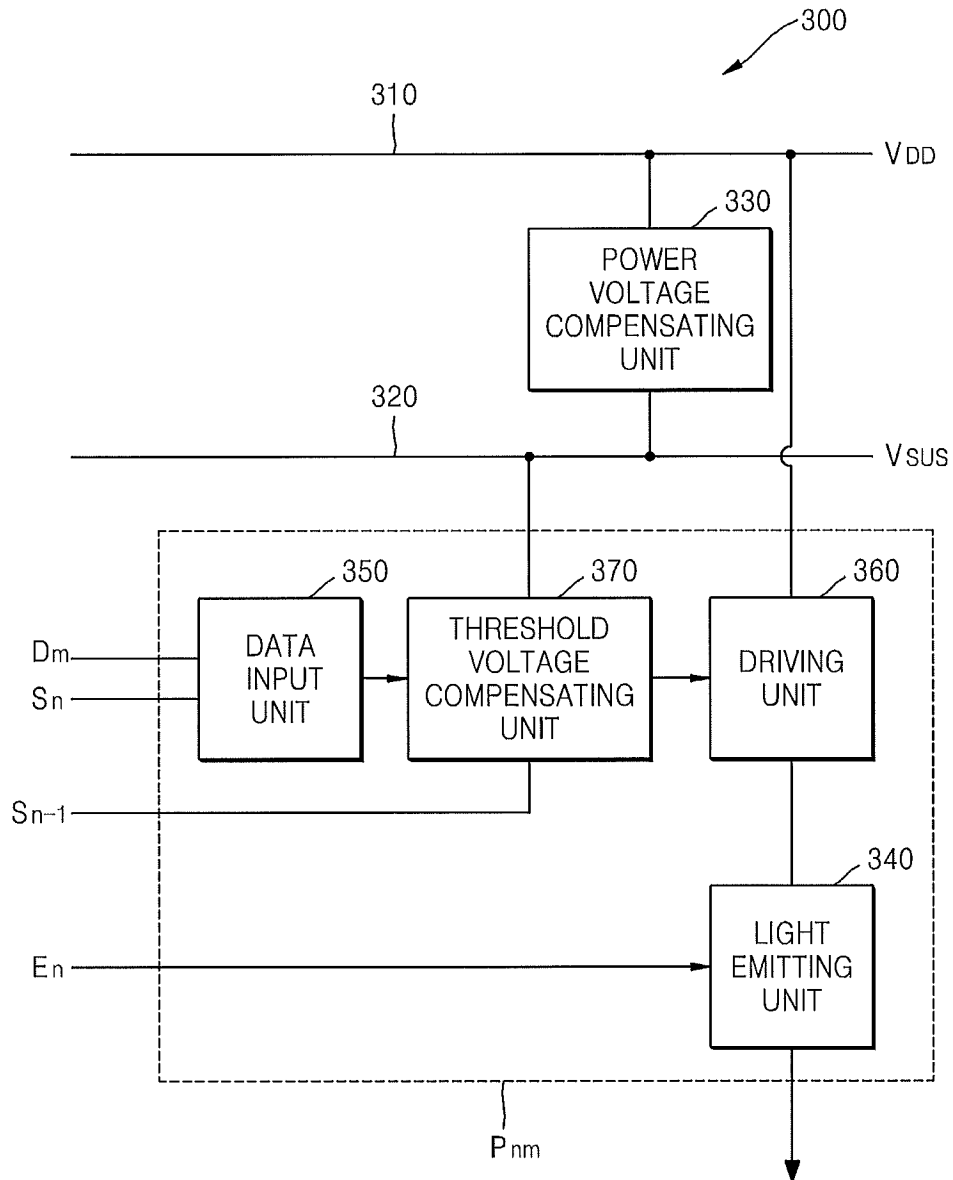


FIG. 4

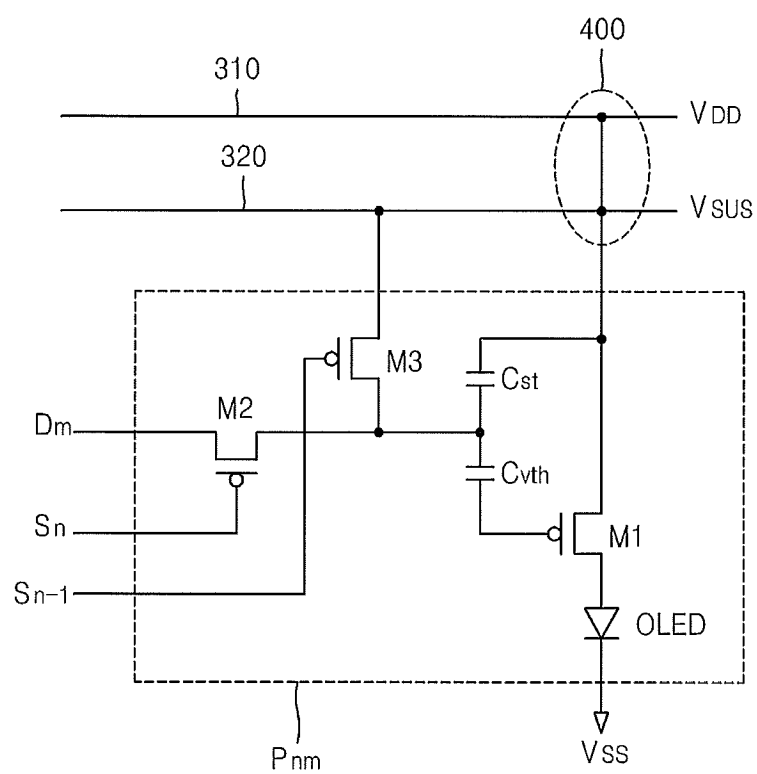


FIG. 5

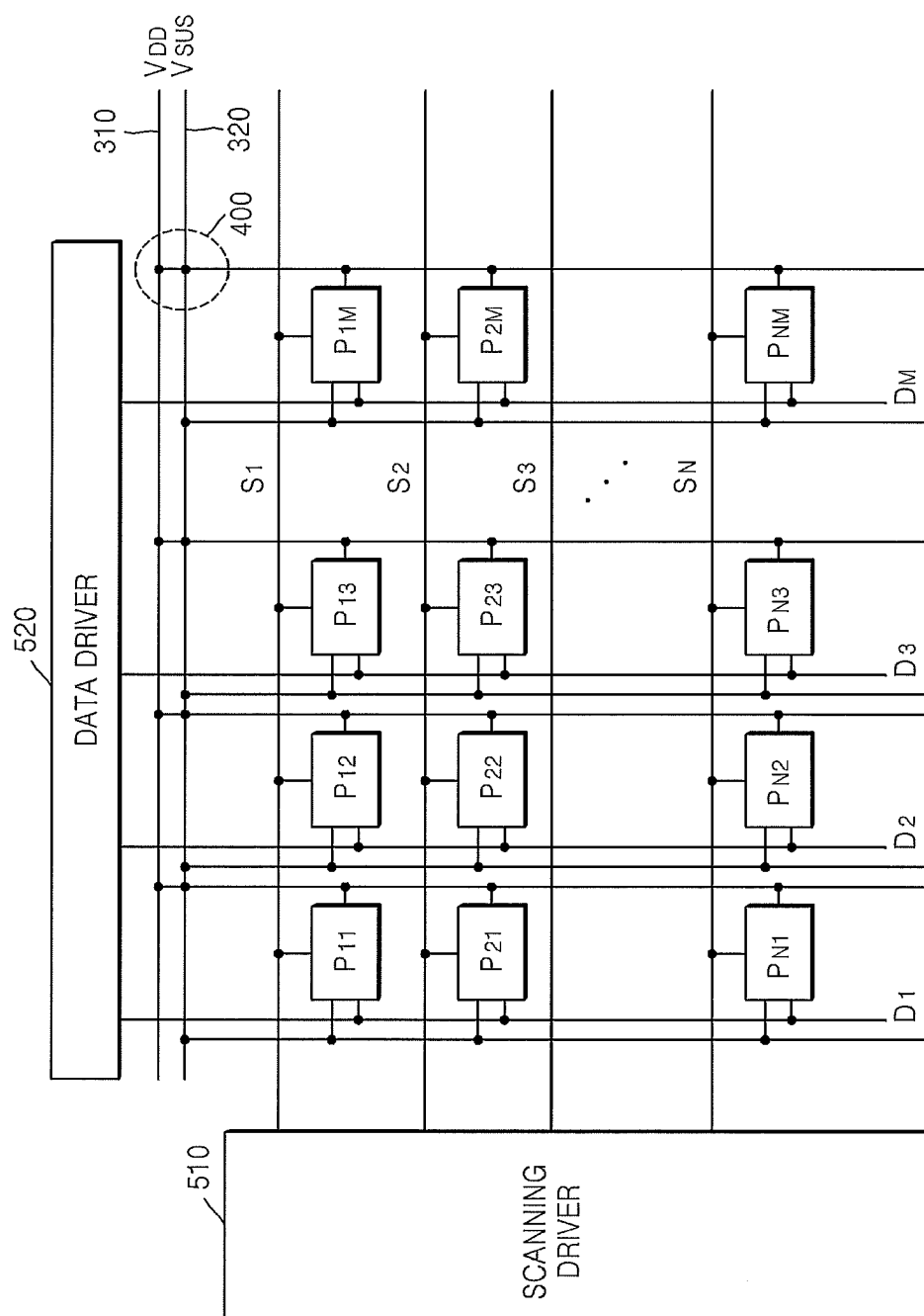


FIG. 6

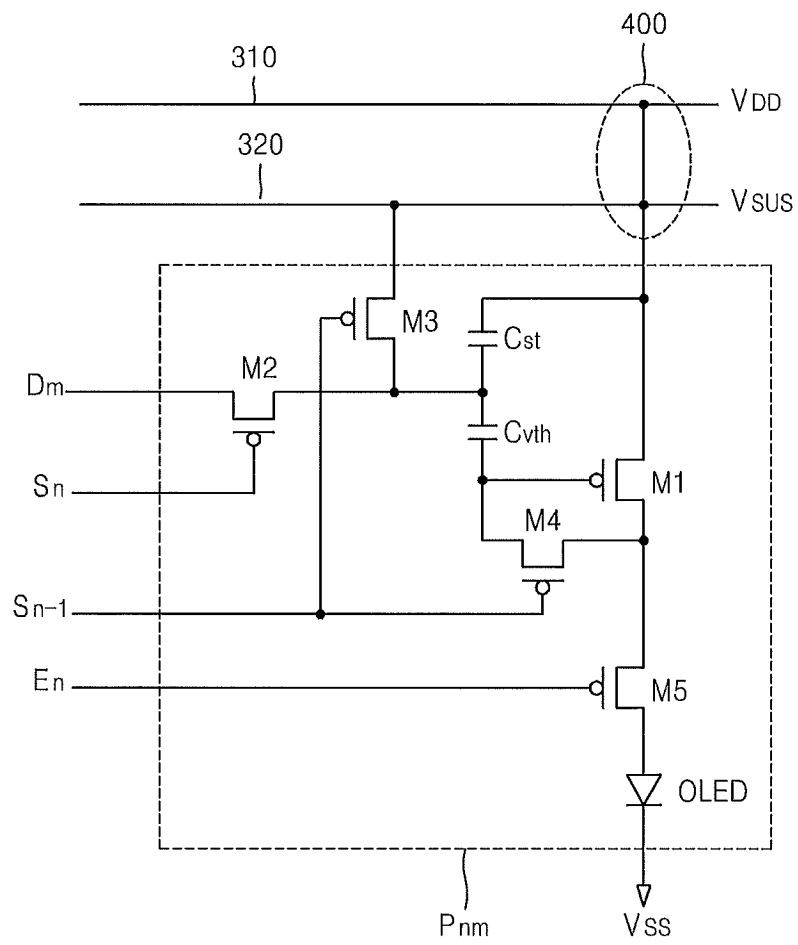


FIG. 7

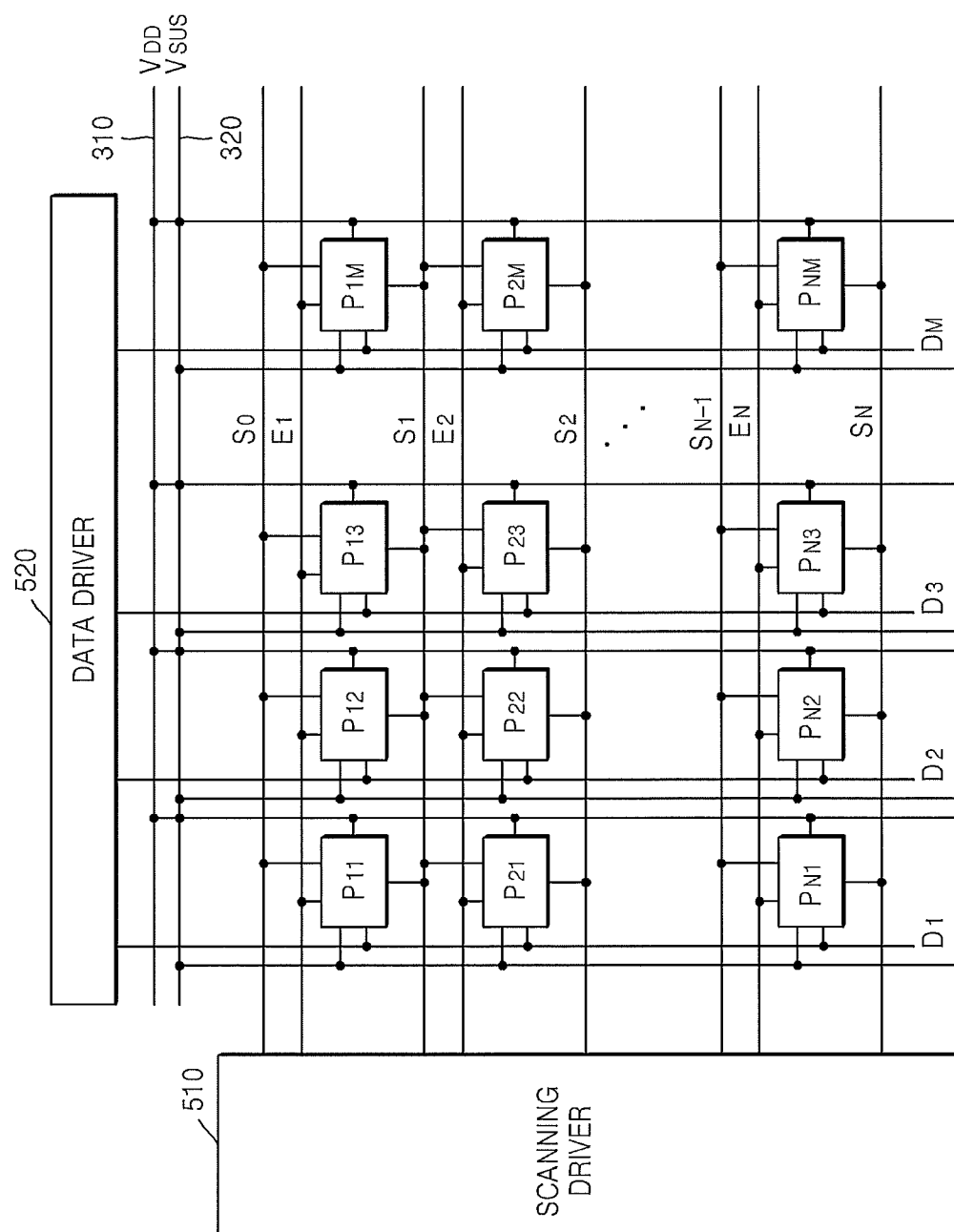
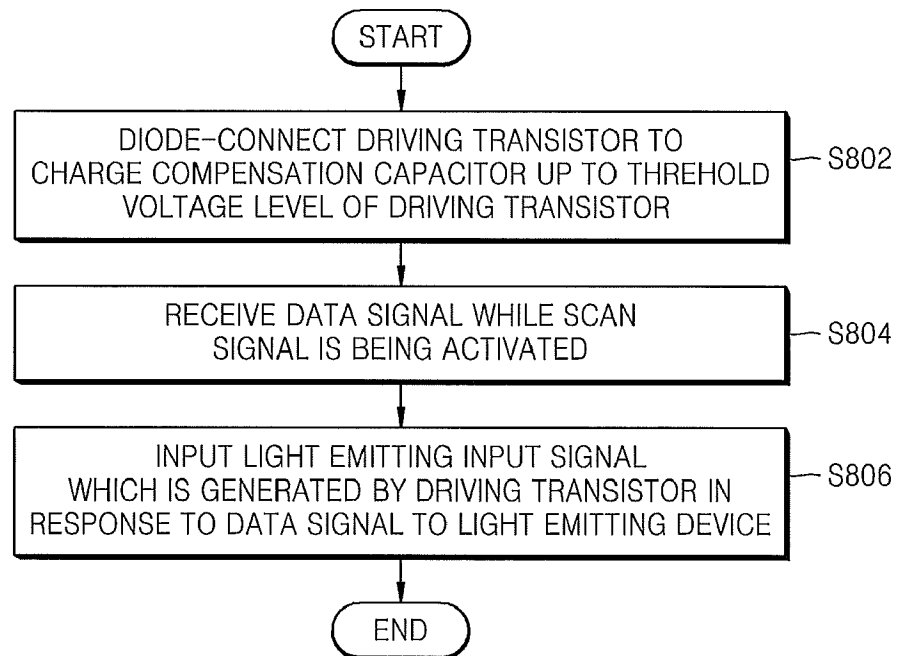




FIG. 8





## EUROPEAN SEARCH REPORT

Application Number  
EP 10 15 2605

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2005/285825 A1 (EOM KI-MYEONG [KR] ET AL) 29 December 2005 (2005-12-29) * figures 3-7 * * paragraph [0050] - paragraph [0064] * * paragraph [0065] - paragraph [0074] *	1-15	INV. G09G3/32
X	CHOI S-M ET AL: "AN IMPROVED VOLTAGE PROGRAMMED PIXEL STRUCTURE FOR LARGE SIZE AND HIGH RESOLUTION AM-OLED DISPLAYS" 2004 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS. SEATTLE, WA, MAY 25 - 27, 2004; [SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS], SAN JOSE, CA : SID, US, vol. 35, no. 1, 25 May 2004 (2004-05-25), pages 260-263, XP001222795 * figure 3a *	1-15	
A	EP 1 887 552 A1 (SAMSUNG SDI CO LTD [KR]) 13 February 2008 (2008-02-13) * figure 3 * * paragraph [0032] - paragraph [0041] *	1-15	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			G09G
Place of search		Date of completion of the search	Examiner
The Hague		9 June 2010	Husselin, Stephane
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

1  
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 10 15 2605

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-06-2010

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		JP 2008040444 A	21-02-2008
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专利名称(译)	发光显示装置及其驱动方法		
公开(公告)号	<a href="#">EP2216770A1</a>	公开(公告)日	2010-08-11
申请号	EP2010152605	申请日	2010-02-04
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星移动显示器有限公司.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	KIM SE HO KWAK WON KYU		
发明人	KIM, SE-HO KWAK, WON-KYU		
IPC分类号	G09G3/32 G09G3/3233		
CPC分类号	G09G3/3233 G09G2300/0819 G09G2300/0852 G09G2300/0861 G09G2320/0223 G09G2320/0233 G09G2330/02		
优先权	1020090009860 2009-02-06 KR		
外部链接	<a href="#">Espacenet</a>		

#### 摘要(译)

提供一种发光显示装置及其驱动方法。在一个实施例中，发光显示装置包括多个像素电路，其中每个像素电路包括发光器件，驱动晶体管，其具有耦合到发光器件的第一电极和耦合到第一电源的第二电极电源电压供应线，具有耦合到驱动晶体管的栅电极的第一端子的补偿电容器，第一开关装置，被配置为响应于响应于第二电源电压供应线的第二端子而提供来自第二电源电压供应线的电压。初始化控制信号，以及第二开关装置，被配置为响应于扫描信号向补偿电容器的第二端子提供数据信号，其中第一电源电压供应线和第二电源电压供应线电耦合。

Equation 1

$$I_{OLED} = \frac{\beta}{2} (V_{gs} - V_{th})^2 = \frac{\beta}{2} (V_{DD} - V_{data} - |V_{th}|)^2$$