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(54) DISPLAY DEVICE AND ELECTRONIC DEVICE HAVING THE SAME

(71) Applicant: **Samsung Display Co., Ltd.**, Yongin-si (KR)

(72) Inventors: **Byoung Dae YE**, Yongin-si (KR); **Junwoo YOU**, Seongnam-si (KR); **Taeho LEE**, Hwaseong-si (KR)

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(57) **ABSTRACT**

A display device includes a display panel including a plurality of pixels that each include an organic light emitting diode and a driving element, the display panel being configured to display an image data on the pixels; a data driver configured to generate a data voltage corresponding to the image data; a compensation circuit configured to sense a driving current flowing through the pixels and to generate a compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the driving current; a scan driver configured to generate a first scan signal and a second scan signal provided to the pixels; and a timing controller configured to generate control signals that control the data driver and the scan driver.

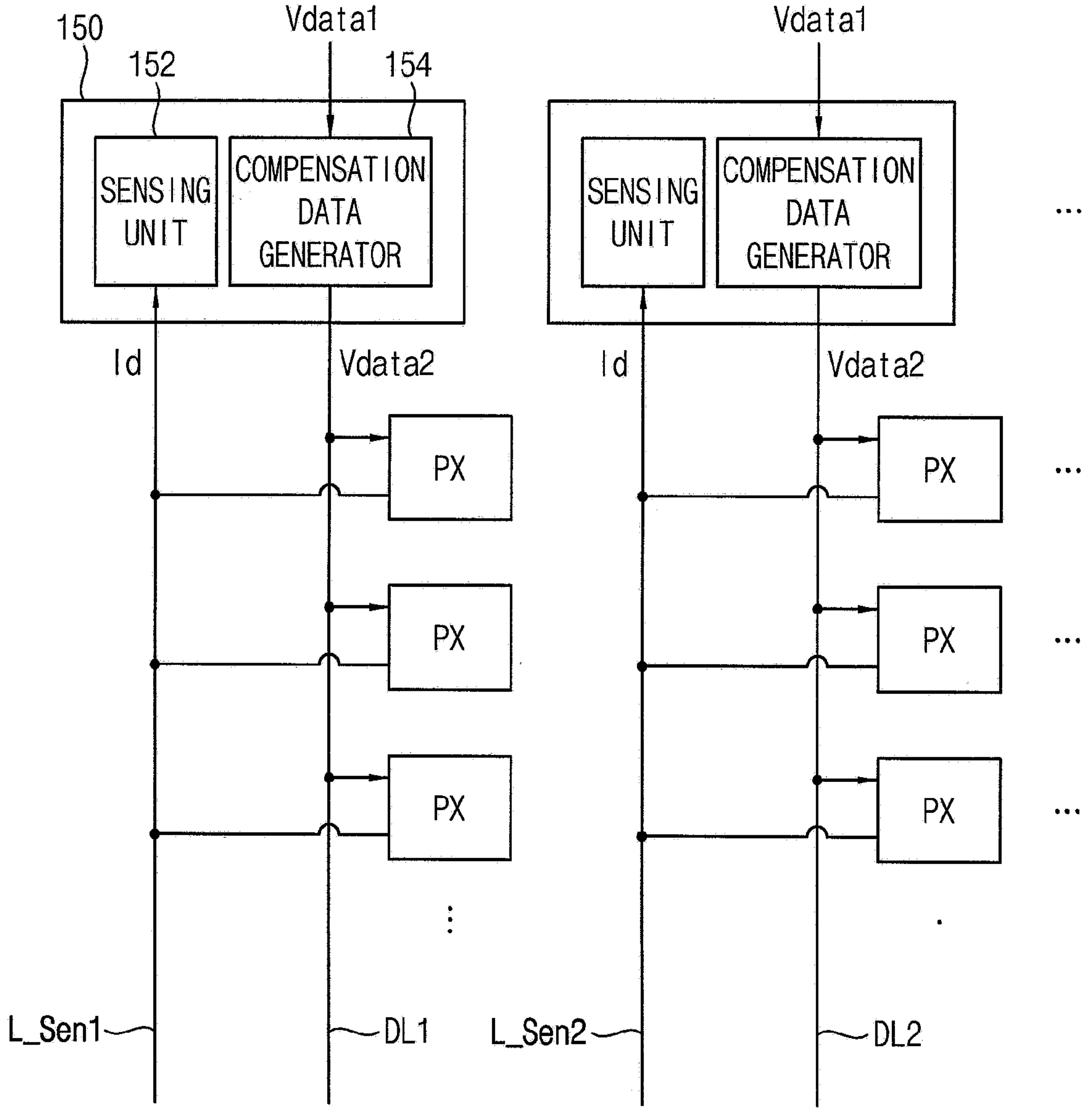


FIG. 1

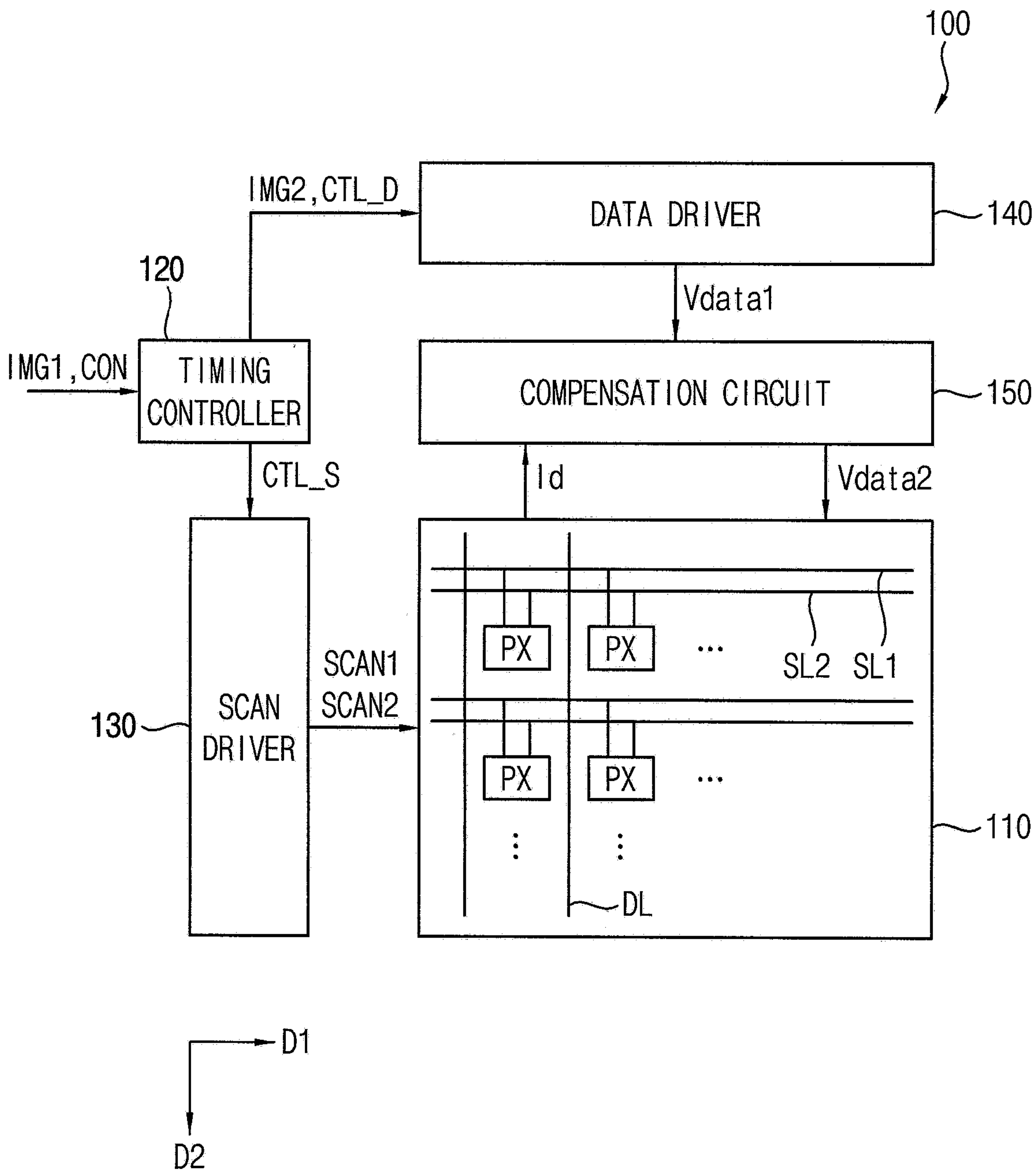

100
DATA DRIVER
140
IMG2,CTL_D
120
Vdata1
IMG1,CON
TIMING CONTROLLER
COMPENSATION CIRCUIT
150
CTL_S
Id
Vdata2
PX
PX
SL2
SL1
SCAN1
SCAN2
130
SCAN DRIVER
PX
PX
110
DL
D1
D2

FIG. 2

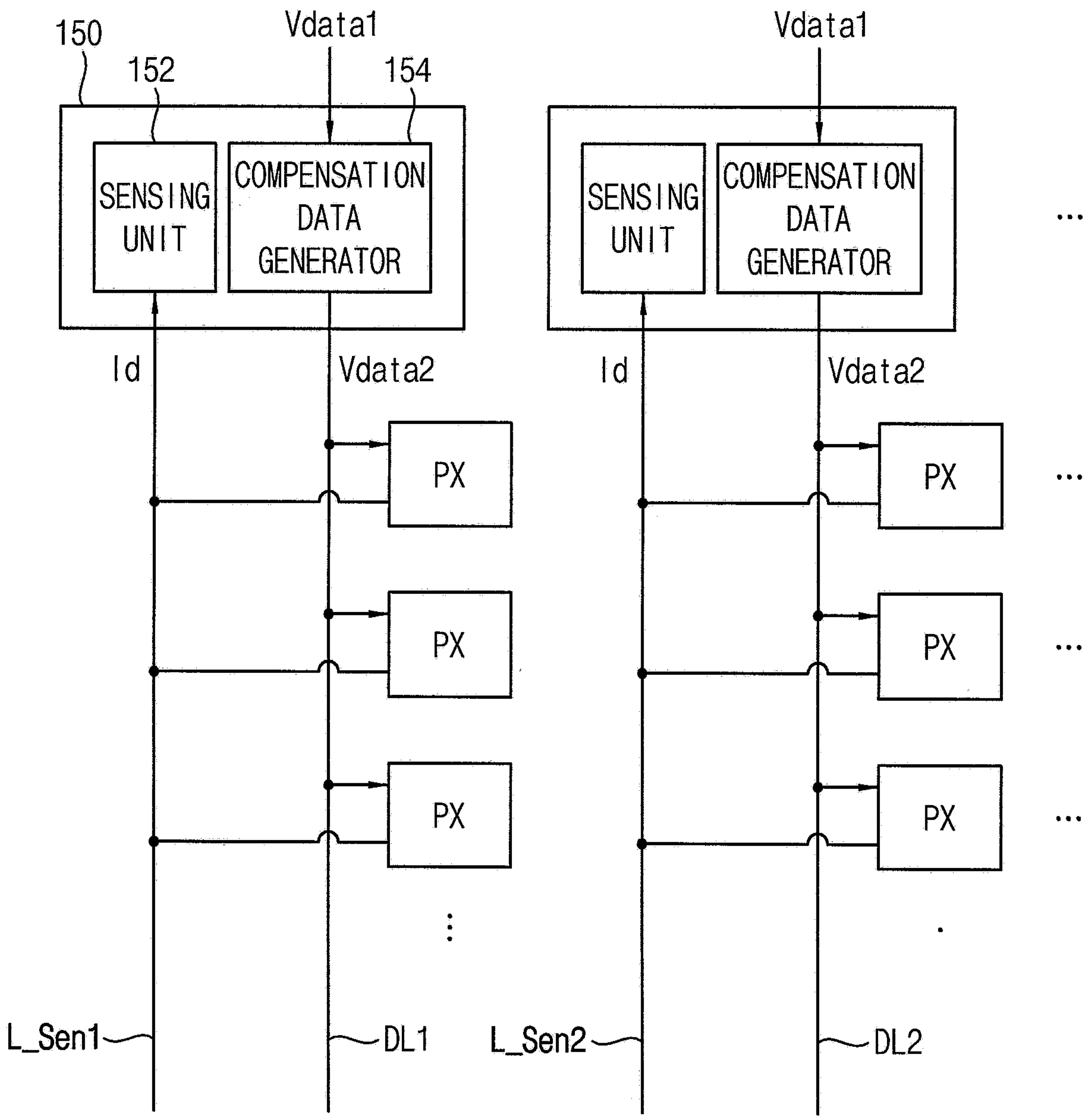

150
152
Vdata1
154
SENSING UNIT
COMPENSATION DATA GENERATOR
Id
Vdata2
PX
PX
PX
L_Sen1
DL1
Vdata1
SENSING UNIT
COMPENSATION DATA GENERATOR
Id
Vdata2
PX
PX
PX
L_Sen2
DL2

FIG. 3

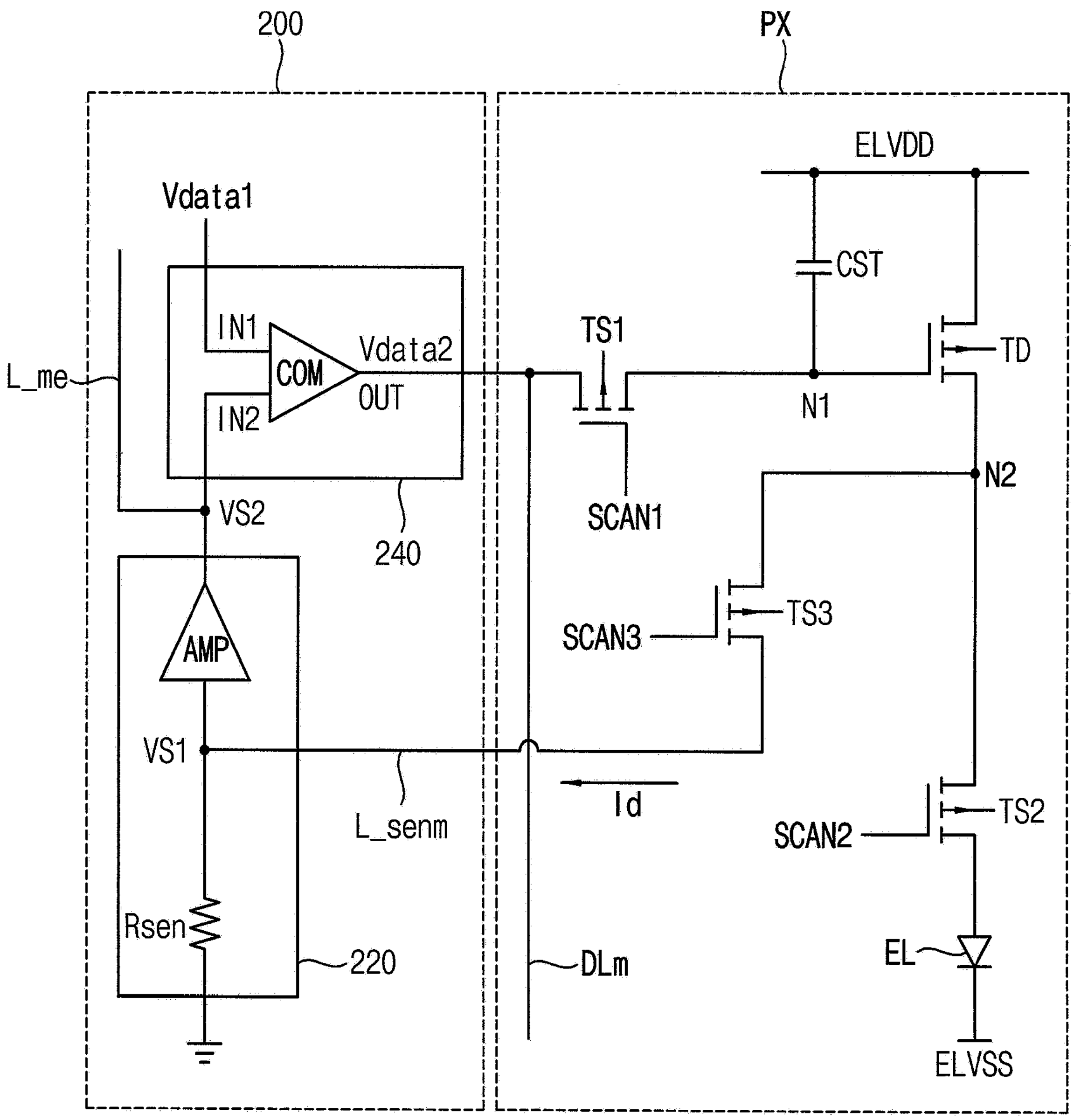

200
PX
ELVDD
Vdata1
CST
IN1
TS1
TD
Vdata2
L_me
COM
OUT
N1
IN2
N2
VS2
SCAN1
240
SCAN3
TS3
AMP
VS1
Id
L_senm
SCAN2
TS2
Rsen
220
DLm
EL
ELVSS

FIG. 4

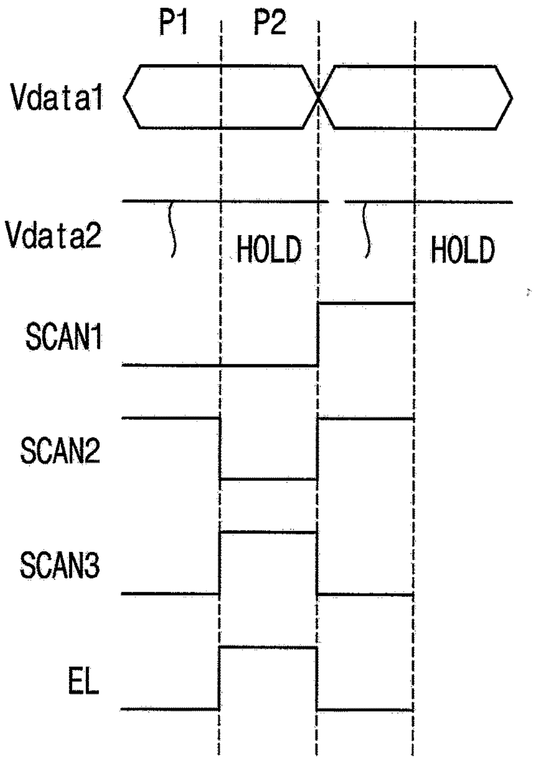

P1
P2
Vdata1
Vdata2
HOLD
HOLD
SCAN1
SCAN2
SCAN3
EL

FIG. 5

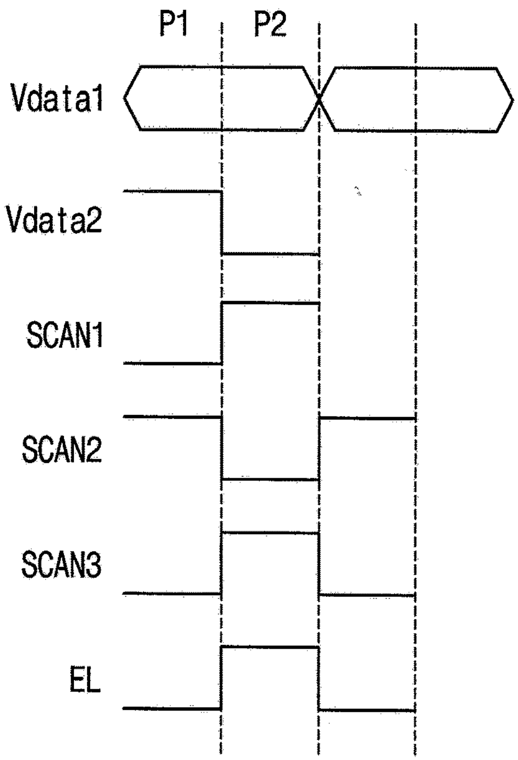

P1
P2
Vdata1
Vdata2
SCAN1
SCAN2
SCAN3
EL

FIG. 6

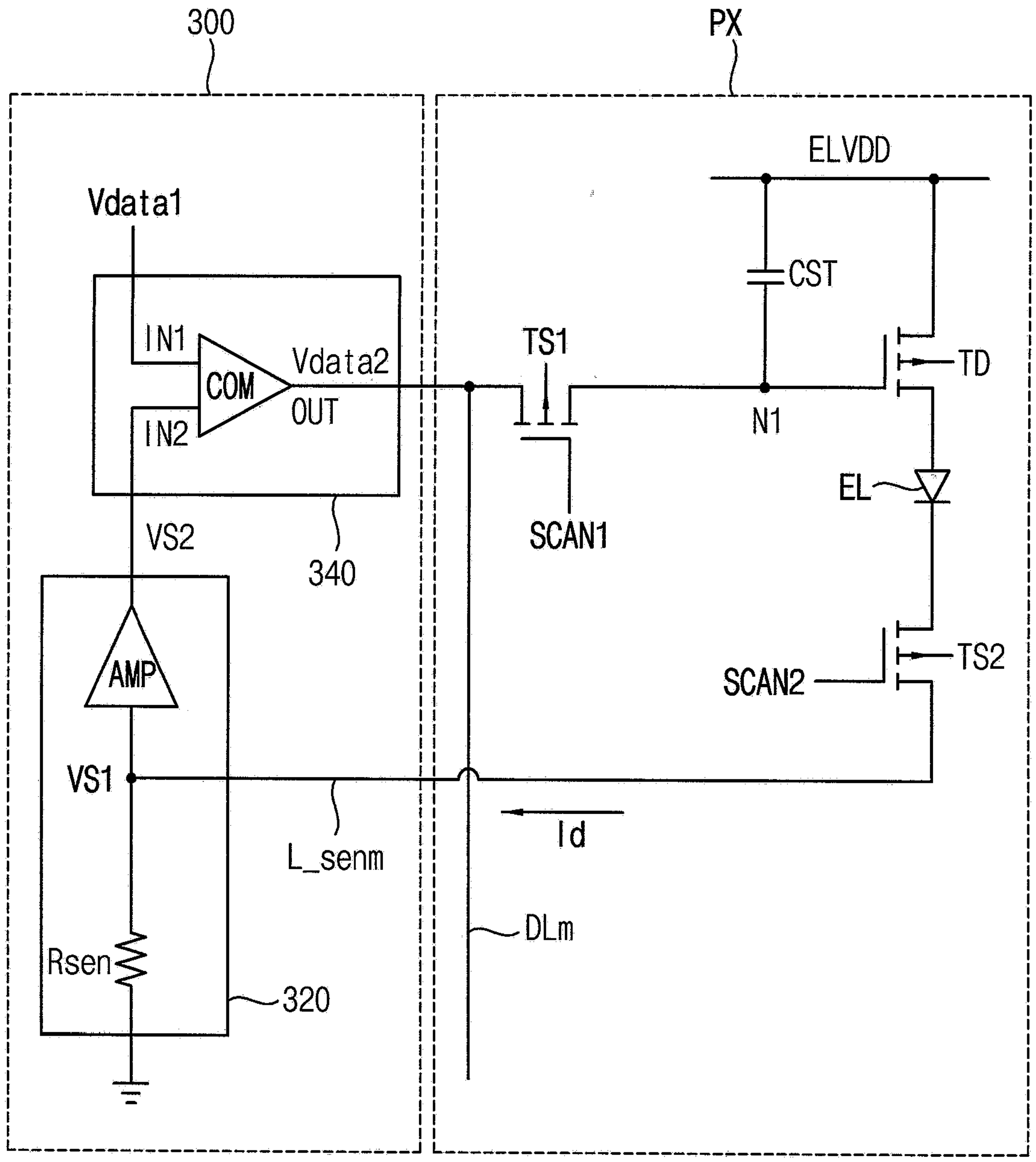

300
PX
ELVDD
Vdata1
CST
IN1
Vdata2
TS1
TD
COM
OUT
N1
IN2
EL
VS2
SCAN1
340
AMP
SCAN2
TS2
VS1
Id
L_senm
DLm
Rsen
320

FIG. 7

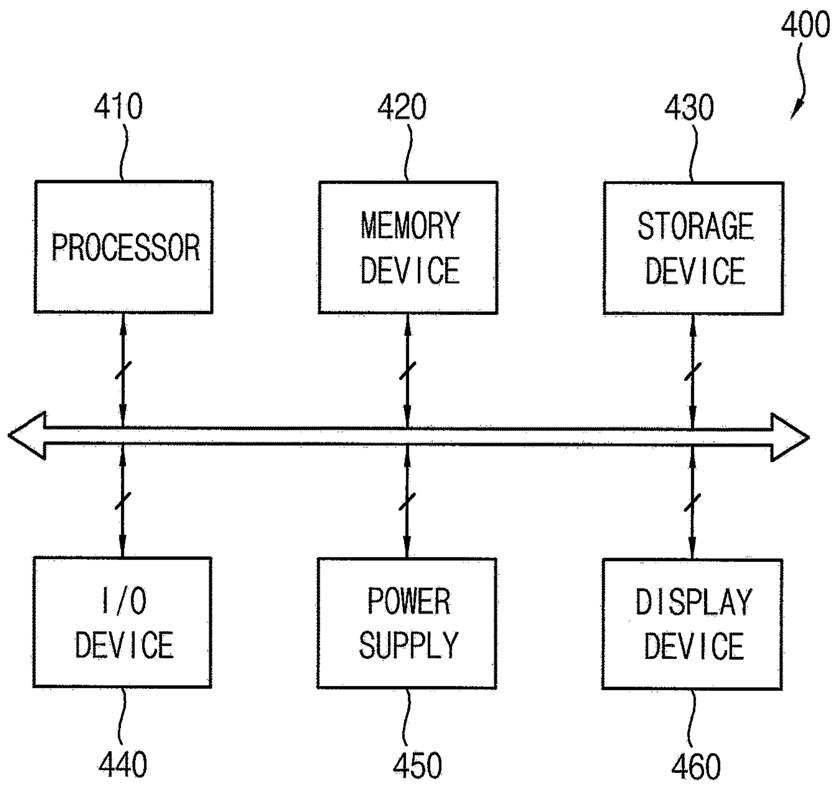
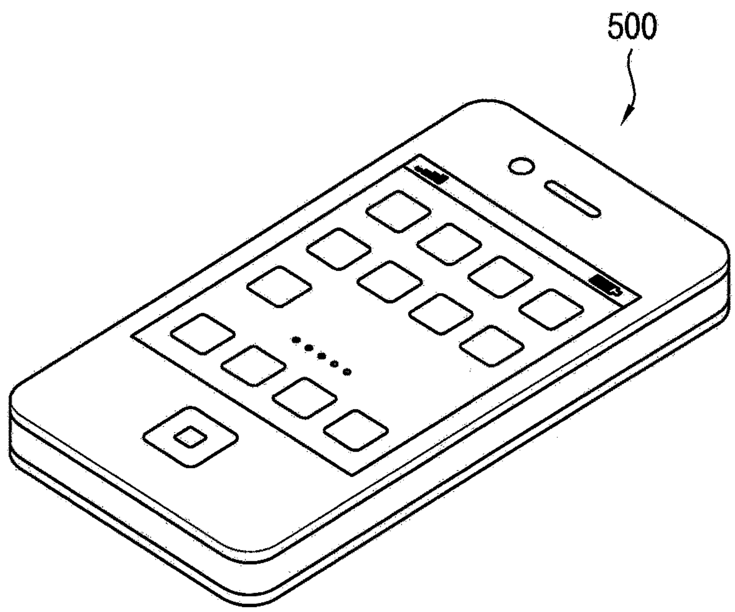

400
410
420
430
PROCESSOR
MEMORY DEVICE
STORAGE DEVICE
I/O DEVICE
POWER SUPPLY
DISPLAY DEVICE
440
450
460

FIG. 8


500

DISPLAY DEVICE AND ELECTRONIC DEVICE HAVING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority to and the benefit of Korean Patent Application No. 10-2018-0137446, filed on Nov. 9, 2018 in the Korean Intellectual Property Office (KIPO), the content of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

[0002] Aspects of some example embodiments relate generally to a display device and an electronic device having the same.

2. Description of the Related Art

[0003] Recently, flat panel display (FPD) devices have been widely used as display devices for electronic devices because FPD devices are relatively lightweight and thin compared to cathode-ray tube (CRT) display devices. Examples of FPD devices are liquid crystal display (LCD) devices, field emission display (FED) devices, plasma display panel (PDP) devices, and organic light emitting display (OLED) devices. OLED devices have been spotlighted as next-generation display devices because they have various characteristics such as a relatively wide viewing angle, a relatively rapid response speed, relatively low thickness, relatively low power consumption, etc.

[0004] Each pixels of an OLED device may include an organic light emitting diode and a pixel circuit that drives the organic light emitting diode. The pixel circuit may include a driving element that generates a driving current provided to the organic light emitting diode. As use time of the organic light emitting display device increases, the driving element may be degraded and a threshold voltage of the driving element may be changed. As the threshold voltage of the driving element is changed, the luminance of the pixel may decrease, which may reduce the perceived display quality of the OLED device.

[0005] The above information disclosed in this Background section is only for enhancement of understanding of the background and therefore it may contain information that does not constitute prior art.

SUMMARY

[0006] Aspects of some example embodiments may include a display device capable of improving display quality.

[0007] Aspects of some example embodiments may include an electronic device having a display device capable of improving display quality.

[0008] According to some example embodiments according to the present disclosure, a display device includes: a display panel including a plurality of pixel that includes an organic light emitting diode and a driving element, the display panel configured to display an image data on the pixels, a data driver configured to generate a data voltage corresponding to the image data, a compensation circuit configured to sense a driving current flowing through the pixels and generate a compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the driving current, a scan driver configured to generate a first scan signal and a second scan signal provided to the pixels, and a timing controller configured to generate control signals that control the data driver and the scan driver.

[0009] According to some example embodiments, the compensation circuit may include a sensing unit configured to sense the driving current and generate a sensing voltage corresponding to the driving current and a compensation data voltage generator configured to generate the compensation data voltage that compensates for the threshold voltage of the driving element based on the data voltage and the sensing voltage.

[0010] According to some example embodiments, the sensing unit may include a sensing resistor configured to sense the driving current and generate a first sensing voltage corresponding to the driving current and an amplifier configured to output a second sensing voltage by amplifying the first sensing voltage.

[0011] According to some example embodiments, the compensation voltage generator may include a comparator that compares the data voltage to the second sensing voltage and converts the data voltage to the compensation data voltage.

[0012] According to some example embodiments, the comparator may include a first input terminal configured to receive the data voltage, a second input terminal configured to receive the second sensing voltage, and an output terminal configured to output the compensation data voltage by comparing the data voltage and the second sensing voltage.

[0013] According to some example embodiments, the organic light emitting diode may include an anode electrode and a cathode electrode and the driving element may include a gate electrode coupled to a first node, a first electrode that receives a first power voltage, and a second electrode coupled to a second node.

[0014] According to some example embodiments, the scan driver may further generate a third scan signal provided to the pixels.

[0015] According to some example embodiments, each of the pixels further may include a first switching element including a gate electrode that receives the first scan signal, a first electrode coupled to the compensation data voltage generator, and a second electrode coupled to the first node, a second switching element including a gate electrode that receives the second scan signal, a first electrode coupled to the second node, and a second electrode coupled to the anode electrode of the organic light emitting diode, a third switching element including a gate electrode that receives the third scan signal, a first electrode coupled to the second node, and a second electrode coupled to the sensing unit, and a storage capacitor including a first electrode that receives the first power voltage and a second electrode coupled to the first node.

[0016] According to some example embodiments, the first switching element and the third switching element may turn on and the second switching element may turn off in a compensation period of the pixel.

[0017] According to some example embodiments, the first switching element and the second switching element may turn on, the third switching element may turn off, and the compensation data voltage is maintained in an emission period of the pixel.

[0018] According to some example embodiments, the second switching element may turn on, and the first switching element and the third switching element may turn off in an emission period of the pixel.

[0019] According to some example embodiments, each of the pixels may further include a first switching element including a gate electrode that receives the first scan signal, a first electrode coupled to the compensation data voltage generator, and a second electrode coupled to the first node, a second switching element including a gate electrode that receives the second scan signal, a first electrode coupled to the cathode electrode of the organic light emitting diode, and a second electrode coupled to the sensing unit, and a storage capacitor including a first electrode that receives the first power voltage and a second electrode coupled to the first node.

[0020] According to some example embodiments, the second switching element may turn on and the driving current may be sensed in an emission period of the pixel.

[0021] According to some example embodiments, the compensation circuit may be located in the data driver or coupled to the data driver.

[0022] According to some example embodiments of the present disclosure, an electronic device includes: a display device and a processor that controls the display device. The display device may include a display panel including a plurality of pixels that includes an organic light emitting diode and a driving element, the display panel configured to display an image data on the pixels, a data driver configured to generate a data voltage corresponding to the image data, a compensation circuit configured to sense a driving current flowing through the pixels and generate a compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the driving current, a scan driver configured to generate a first scan signal and a second scan signal provided to the pixels, and a timing controller configured to generate control signals that control the data driver and the scan driver.

[0023] According to some example embodiments, the compensation circuit may include a sensing unit configured to sense the driving current and generate a sensing voltage corresponding to the driving current and a compensation data voltage generator configured to generate a compensation data voltage that compensates for the threshold voltage of the driving element based on the data voltage and the sensing voltage.

[0024] According to some example embodiments, the sensing unit may include a sensing resistor configured to sense the driving current and generate a first sensing voltage corresponding to the driving current and an amplifier configured to output a second sensing voltage by amplifying the first sensing voltage. The compensation voltage generator may include a comparator that compares the data voltage to the second sensing voltage and converts the data voltage to the compensation data voltage.

[0025] According to some example embodiments, the organic light emitting diode may include an anode electrode and a cathode electrode and the driving element may include a gate electrode coupled to a first node, a first electrode that receives a first power voltage and a second electrode coupled to a second node.

[0026] According to some example embodiments, each of the pixels may further include a first switching element including a gate electrode that receives the first scan signal, a first electrode coupled to the compensation data voltage generator, and a second electrode coupled to the first node, a second switching element including a gate electrode that receives the second scan signal, a first electrode coupled to the second node, and a second electrode coupled to the anode electrode of the organic light emitting diode, a third switching element including a gate electrode that receives a third scan signal, a first electrode coupled to the second node, and a second electrode coupled to the sensing unit, and a storage capacitor including a first electrode that receives the first power voltage and a second electrode coupled to the first node.

[0027] According to some example embodiments, each of the pixels may further include a first switching element including a gate electrode that receives the first scan signal, a first electrode coupled to the compensation data voltage generator, and a second electrode coupled to the first node, a second switching element including a gate electrode that receives the second scan signal, a first electrode coupled to the cathode electrode of the organic light emitting diode, and a second electrode coupled to the sensing unit, and a storage capacitor including a first electrode that receives the first power voltage and a second electrode coupled to the first node.

[0028] Therefore, a display device according to some example embodiments may prevent or reduce instances of the luminance of the pixels of a display device being lowered due to a change in the threshold voltage of the driving element by including the compensation circuit coupled to the pixels having 4T1C structure or 3T1C structure to sense the driving current flowing through the pixels and generate the compensation data voltage that compensates for a threshold voltage of the driving element included in each of the pixels by comparing the data voltage and the driving current. Thus, the display quality of the display device may improve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Illustrative, non-limiting example embodiments will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings.

[0030] FIG. **1** is a block diagram illustrating a display device according to some example embodiments.

[0031] FIG. **2** is a diagram illustrating a compensation circuit and a pixel included in the display device of FIG. **1**.

[0032] FIG. **3** is a circuit diagram illustrating an example of the compensation circuit and the pixel of FIG. **2**.

[0033] FIG. **4** is a timing diagram illustrating an example of an operation of the pixel of FIG. **3**.

[0034] FIG. **5** is a timing diagram illustrating an example of an operation of the pixel of FIG. **3**.

[0035] FIG. **6** is a circuit diagram illustrating an example of the compensation circuit and the pixel of FIG. **2**.

[0036] FIG. **7** is a block diagram illustrating an electronic device according to some example embodiments.

[0037] FIG. **8** is a diagram illustrating an example embodiment in which the electronic device of FIG. **7** is implemented as a smart phone.

DETAILED DESCRIPTION

[0038] Hereinafter, aspects of some example embodiments of the present inventive concept will be explained in more detail with reference to the accompanying drawings.

[0039] FIG. **1** is a block diagram illustrating a display device according to some example embodiments. FIG. **2** is a diagram illustrating a compensation circuit and a pixel included in the display device of FIG. **1**.

[0040] Referring to FIG. **1**, a display device **100** may include a display panel **110**, a timing controller **120**, a scan driver **130**, a data driver **140**, and a compensation circuit **150**.

[0041] The display panel **110** may include a plurality of pixels PX that includes an organic light emitting diode and a driving element. The display panel **110** may include a plurality of scan lines SL**1**, SL**2**, and a plurality of data lines DL. Each of the pixels PX may be electrically coupled to each of the scan lines SL**1**, SL**2**, and the data lines DL. The scan lines SL**1**, SL**2** may extend in a first direction D**1** and be arranged in a second direction D**2** perpendicular to the first direction D**1**. For example, a first scan line SL**1** and a second scan line SL**2** may be formed in the display panel **110**.

[0042] Although the first scan line SL**1** and the second scan line SL**2** formed in the display panel **110** are described in FIG. **1**, the number of the scan lines is not limited thereto. For example, a third scan line may be additionally formed in the display panel **110**. The data lines DL may extend in the second direction D**2** and be arranged in the first direction. The first direction D**1** may be parallel with a long side of the display panel **110**, and the second direction D**2** may be parallel with a short side of the display panel **110**. Each of the pixels PX may be formed in intersection regions of the data lines DL and the scan lines. Each of the pixels PX may include an organic light emitting diode, a driving element, switching elements, and a storage capacitor. For example, the switching element may be a thin film transistor (TFT). The pixels PX of the display panel **110** may display an image data.

[0043] The timing controller **120** may convert a first image data IMG**1** provided from an external device to a second image data IMG**2** and generate a data control signal CTL_D and a scan control signal CTL_S that control the second image data IMG**2**. The timing controller **120** may convert the first image data IMG**1** to the second image data IMG **2** by applying an algorithm (e.g., dynamic capacitance compensation (DCC)) that compensates display quality to the first image data IMG **1**. When the timing controller **120** does not include the algorithm that compensates for the display quality, the timing controller **120** may output the first image data IMG **1** as the second image data IMG **2**. The timing controller **120** may receive the control signal CON from the external device and generate the data control signal CTL_D provided to the data driver **140** and the scan control signal CTL_S provided to the scan driver **130**. For example, the data control signal CTL_D may include a horizontal start signal and at least one clock signals. For example, the scan control signal CTL_S may include a vertical start signal and at least one clock signals.

[0044] The scan driver **130** may provide scan signals SCAN**1**, SCAN**2** to the pixels PX through the scan lines SL**1**, SL**2**. The scan driver **130** may generate the scan signals SCAN**1**, SCAN**2** based on the scan control signal CTL_S provided from the timing controller **120**. For example, the scan driver **130** may generate a first scan signal SCAN**1** provided to the pixel PX through the first scan line SL**1** and a second scan signal SCAN**2** provided to the pixel PX through the second scan line SL**2**. The scan driver **130** may further generate a third scan signal SCAN**3** provided to the pixel through the third scan line SL**3**.

[0045] The data driver **140** may generate a data voltage Vdata**1** based on the second image data IMG**2** and the data control signal CTL_D. The data driver **140** may generate a grayscale voltage corresponding to the second image data IMG**2** as the data voltage Vdata**1**. The data driver **140** may provide the data voltage Vdata**1** to the compensation circuit **150**.

[0046] The compensation circuit **150** may sense a driving current Id flowing through the pixels PX and generate a compensation data voltage Vdata**2** that compensates for a threshold voltage of the driving element based on the data voltage Vdata**1** and the driving current Id.

[0047] Referring to FIG. **2**, the compensation circuit **150** may be respectively coupled to the data lines DL and sensing lines L_sen of the display panel **110**. In some example embodiments, each of a plurality of compensation circuits **150** may correspond to each of the data lines DL of the display panel **110**. Each compensation circuit **150** may include a sensing unit **152** and a compensation data voltage generator (or compensation data generator or compensation voltage generator) **154**. The sensing unit **152** may sense the driving current Id of the pixel PX through the sensing line L_sen and generate a sensing voltage corresponding to the driving current Id. The sensing unit **152** may be coupled to each of the pixels PX. The sensing unit **152** may sequentially sense the driving current Id of the pixels PX. For example, the sensing unit **152** may include a sensing resistor and an amplifier. The sensing unit **152** may provide sensing voltage corresponding to the driving current Id to the compensation data voltage generator **154**. The compensation data voltage generator **154** may generate the compensation data voltage Vdata**2** that compensates for the threshold voltage of the driving element based on the data voltage Vdata**1** and the sensing voltage. For example, the compensation data voltage generator **154** may include a comparator. The compensation data voltage generator **154** may provide the compensation data voltage Vdata**2** to the pixels PX through the data line DL.

[0048] Although the compensation circuit **150** coupled to the data driver **140** is described in FIG. **1**, the compensation circuit **150** is not limited thereto. For example, the compensation circuit **150** may be located in the data driver **140**.

[0049] As described above, the display device **100** of FIG. **1** may prevent the driving current Id from changing due to the threshold voltage of the driving element by sensing the driving current Id flowing through the pixels PX, generating the compensation data voltage Vdata**2** that compensates for the threshold voltage of the driving element based on the data voltage Vdata**1** and the driving current Id, and providing the compensation data voltage Vdata**2** to the pixels PX. Thus, the display quality of the display device **100** may improve.

[0050] FIG. **3** is a circuit diagram illustrating an example of the compensation circuit and the pixel of FIG. **2** according to some example embodiments. FIG. **4** is a timing diagram illustrating an example of an operation of the pixel of FIG. **3**. FIG. **5** is a timing diagram illustrating an example of an operation of the pixel of FIG. **3**.

[0051] Referring to FIG. **3**, a compensation circuit **200** may be coupled to the pixel PX. The compensation circuit **200** of FIG. **3** may correspond to the compensation circuit **150** of FIGS. **1** and **2**. The compensation circuit **200** described in FIG. **3** may be coupled to an Mth data line DLm and the Mth sensing line L_senm. The pixel PX described in FIG. **3** may be one of the pixels coupled to the Mth data line DLm and the Mth sensing line L_senm.

[0052] Referring to FIG. **3**, the pixel PX may include a driving element TD, a first switching element TS**1**, a second switching element TS**2**, a third switching element TS**3**, a storage capacitor CST, and an organic light emitting diode EL. For example, the driving element TD, the first switching element TS**1**, the second switching element TS**2**, and the third switching element TS**3** may be P-channel metal oxide semiconductor (PMOS) transistors.

[0053] The driving element TD may include a gate electrode, a first electrode, and a second electrode. The driving element TD may include the gate electrode coupled to a first node N**1**, the first electrode that receives a first power voltage ELVDD, and the second electrode coupled to a second node N**2**. For example, the first power voltage ELVDD may be a high power voltage. The driving element TD may generate the driving current Id corresponding to the voltage applied to the first node N**1**.

[0054] The first switching element TS**1** may include a gate electrode that receives the first scan signal SCAN**1**, a first electrode coupled to the data line DLm, and a second electrode coupled to the first node N**1**. When the first switching element TS**1** is the PMOS transistor, the first switching element TS**1** may turn on in response to the first scan signal SCAN**1** having low level. When the first switching element TS**1** turns on, the compensation data voltage Vdata**2** provided through the data line DLm may be provided to the first node N**1**.

[0055] The second switching element TS**2** may include a gate electrode that receives the second scan signal SCAN**2**, a first electrode coupled to the second node N**2**, and a second electrode coupled to an anode electrode of the organic light emitting diode EL. When the second switching element TS**2** is the PMOS transistor, the second switching element TS**2** may turn on in response to the second scan signal SCAN**2** having the low level. When the second switching element TS**2** turns on, the driving current Id generated in the driving element TD may be provided to the organic light emitting diode EL and the organic light emitting diode EL may emit light.

[0056] The third switching element TS**3** may include a gate electrode that receives the third scan signal SCAN**3**, a first electrode coupled to the second node N**2**, and a second electrode coupled to the compensation circuit **200**. When the third switching element TS**3** is the PMOS transistor, the third switching element TS**3** may turn on in response to the third scan signal SCAN**3** having the low level. When the third switching element TS**3** turns on, the driving current Id may be provided to the compensation circuit **200** through the third switching element TS**3** and the sensing line L_senm.

[0057] The storage capacitor CST may include a first electrode that receives the first power voltage ELVDD and a second electrode coupled to the first node N**1**. The storage capacitor CST may store a voltage applied to the first node N**1**.

[0058] Although aspects of the pixel PX including the driving element TD, the first switching element TS**1**, the second switching element TS**2**, and the third switching element TS**3** implemented as the PMOS transistors are described in FIG. **3**, the driving element TD, the first switching element TS**1**, the second switching element TS**2**, and the third switching element TS**3** are not limited thereto. For example, the driving element TD, the first switching element TS**1**, the second switching element TS**2**, and the third switching element TS**3** may be implemented as N-channel metal oxide semiconductor (NMOS) transistors.

[0059] The compensation circuit **200** may include a sensing unit **220** and the compensation data voltage generator **240**. The sensing unit **220** and the compensation data voltage generator **240** of FIG. **3** may be correspond to the sensing unit **152** and the compensation data voltage generator **154** of FIG. **2**. The sensing unit **220** may include a sensing resistor Rsen and an amplifier AMP. The sensing resistor Rsen may generate a first sensing voltage VS**1** corresponding to the driving current Id provided through the sensing line L_senm. The amplifier AMP may output a second sensing voltage VS**2** by amplifying the first sensing voltage VS**1** generated by the sensing resistor Rsen and removing noise. The second sensing voltage VS**2** may be provided to the compensation data voltage generator **240**. The compensation data voltage generator **240** may include a comparator COM. The comparator COM may compare the data voltage Vdata**1** to the second sensing voltage VS**2** and convert the data voltage Vdata**1** to the compensation data voltage Vdata**2**. The comparator COM may include a first input terminal IN**1** that receives the data voltage Vdata**1**, a second input terminal IN**2** that receives the second sensing voltage VS**2**, and an output terminal OUT that outputs the compensation data voltage Vdata**2** by comparing the data voltage Vdata**1** and the second sensing voltage VS**2**.

[0060] The second sensing voltage VS**2** may be a voltage corresponding to the reduced driving current Id generated by the driving element TD of which threshold voltage is changed by the degradation. The comparator COM may output the compensation data voltage Vdata**2** that compensates for a difference between the data voltage Vdata**1** provided from the data driver and the second sensing voltage VS**2** provided from the sensing unit **220**. That is, the compensation data voltage Vdata**2** may have a voltage level that compensates for the reduced driving current Id due to the change in the threshold voltage of the driving element TD. The output terminal OUT of the comparator COM may be coupled to the data line DLm and provide the compensation data voltage Vdata**2** to the first electrode of the first switching element TS**1** included in the pixel PX. Although the compensation data voltage generator **240** that includes the comparator COM is described in FIG. **3**, the compensation data voltage generator **240** may not be limited thereto. For example, the compensation data voltage generator **240** may further include a calculator that calculates the difference of the data voltage Vdata**1** and the second sensing voltage VS**2**.

[0061] In some example embodiments, the compensation circuit **200** may further include a memory sensing line L_me. The memory sensing line L_me may be coupled to an output terminal of the amplifier AMP and sense the second sensing voltage VS**2**. For example, the memory sensing line L_me may be coupled to a memory device of the data driver and store the second sensing voltage VS**2** corresponding to the driving current Id. In this case, the data driver may generate the data voltage Vdata**1** that compensates for the threshold voltage of the driving element TD based on the second sensing voltage VS2 stored in the memory device. In this case, the compensation data voltage generator **240** may be omitted.

[0062] Referring to FIG. **4**, the compensation circuit **200** may sense the driving current Id of the pixel PX during a compensation period P**1**. The first scan signal SCAN**1** and the third scan signal SCAN**3** having the low level, and the second scan signal SCAN**2** having a high level may be provided to the pixel during the compensation period P**1**. The first switching element TS**1** may turn on in response to the first scan signal SCAN**1**, the third switching element TS**3** may turn on in response to the third scan signal SCAN**3**, and the second switching element TS**2** may turn off in response to the second scan signal SCAN**2**. The data voltage Vdata**1** provided through the data line DLm may be provided to the first node N**1** because the first switching element TS**1** turns on. The driving element TD may generate the driving current Id corresponding to the voltage of the first node N**1**. Here, the driving current Id may be reduced by the change in the threshold voltage of the driving element TD due to the degradation.

[0063] The compensation circuit **200** may sense the driving current Id through the sensing line L_senm because the third switching element TS**3** turns on. The compensation circuit **200** may generate the driving current Id to the first sensing voltage VS**2** using the sensing resistor Rsen. The compensation circuit **200** may output the first sensing voltage VS**1** as the second sensing voltage VS**2** using the amplifier AMP. The amplifier AMP may output the second sensing voltage VS**2** by amplifying the first sensing voltage VS**1** and removing the noise. The compensation circuit **200** may compare the data voltage Vdata**1** to the second sensing voltage VS**2** and output the compensation data voltage Vdata**2** that compensates for the threshold voltage of the driving element TD.

[0064] The compensation circuit **200** may continuously provide the compensation data voltage Vdata**2** during an emission period P**2**. The first scan signal SCAN**1** and the second scan signal SCAN**2** having the low level, and the third scan signal SCAN**3** having the high level may be provided to the pixel PX during the emission period P**2**. The first switching element TS**1** may turn on in response to the first scan signal SCAN**1**, the second switching element TS**2** may turn on in response to the second scan signal SCAN**2**, and the third switching element TS**3** may turn off in response to the third scan signal SCAN**3**.

[0065] The compensation data voltage Vdata**2** may be provided to the first node N**1** through the data line DLm coupled to the output terminal OUT of the comparator COM because the first switching element TS**1** turns on. The driving element TD may generate the driving current Id corresponding to the voltage of the first node N**1**. The organic light emitting diode EL may emit light based on the driving current Id because the second switching element TS**2** turns on.

[0066] Although the timing diagram in which the compensation period P**1** and the emission period P**2** are sequentially ordered is described in FIG. **4**, the timing diagram of the pixel PX is not limited thereto. For example, the timing diagram further includes an initialization period during which the driving element TD and the organic light emitting diode EL are initialized, a data writing period during which the data voltage Vdata**1** is written in the storage capacitor CST, etc., arranged between the compensation period P**1** and the emission period P**2**. Further, the compensation period P**1** may be repeated at a cycle (e.g., a predetermined cycle).

[0067] Referring to FIG. **5**, the compensation circuit **200** may sense the driving current Id of the pixel PX during the compensation period P**1**. The first scan signal SCAN**1** and the third scan signal SCAN**3** having the low level, and the second scan signal SCAN**2** having a high level may be provided to the pixel during the compensation period P**1**. The first switching element TS**1** may turn on in response to the first scan signal SCAN**1**, the third switching element TS**3** may turn on in response to the third scan signal SCAN**3**, and the second switching element TS**2** may turn off in response to the second scan signal SCAN**2**.

[0068] The data voltage Vdata**1** provided through the data line DLm may be provided to the first node N**1** because the first switching element TS**1** turns on. The driving element TD may generate the driving current Id corresponding to the voltage of the first node N**1**. Here, the driving current Id may be reduced by the change in the threshold voltage of the driving element TD due to the degradation. The compensation circuit **200** may sense the driving current Id through the sensing line L_senm because the third switching element TS**3** turns on. The compensation circuit **200** may generate the driving current Id to the first sensing voltage VS**2** using the sensing resistor Rsen. The compensation circuit **200** may output the first sensing voltage VS**1** as the second sensing voltage VS**2** using the amplifier AMP. The compensation circuit **200** may compare the data voltage Vdata**1** to the second sensing voltage VS**2** and output the compensation data voltage Vdata**2** that compensates for the threshold voltage of the driving element TD. The compensation data voltage Vdata**2** may be provided to the pixel PX through the data line DLm. The compensation data voltage Vdata**2** may be provided to the first node N**1** and stored in the storage capacitor CST because the first switching element TS**1** turns on during the compensation period P**1**.

[0069] The second scan signal SCAN**2** having the low level, the first scan signal SCAN**1** and the third scan signal SCAN**3** having the high level may be provided to the pixel PX during the emission period P**2**. The second switching element TS**2** may turn on in response to the second scan signal SCAN**2**, the first switching element TS**1** may turn off in response to the first scan signal SCAN**1**, and the third switching element TS**3** may turn off in response to the third scan signal SCAN**3**. The driving element TD may generate the driving current Id corresponding to the voltage stored in the storage capacitor CST. The organic light emitting diode EL may emit light based on the driving current Id because the second switching element TS**2** turns on.

[0070] Although the timing diagram in which the compensation period P**1** and the emission period P**2** are sequentially ordered is described in FIG. **5**, the timing diagram of the pixel PX is not limited thereto. For example, the timing diagram further includes an initialization period during which the driving element TD and the organic light emitting diode EL are initialized, a data writing period during which the data voltage Vdata**1** is written in the storage capacitor CST, etc., arranged between the compensation period P**1** and the emission period P**2**. Further, the compensation period P**1** may be repeated at a cycle (e.g., a predetermined cycle).

[0071] FIG. **6** is a circuit diagram illustrating an example of the compensation circuit and the pixel of FIG. **2**.

[0072] Referring to FIG. **6**, a compensation circuit **300** may be coupled to the pixel PX. The compensation circuit **300** of FIG. **6** may correspond to the compensation circuit **150** of FIGS. **1** and **2**. The compensation circuit **300** described in FIG. **6** may be coupled to an Mth data line DLm and the Mth sensing line L_senm. The pixel PX described in FIG. **6** may be one of the pixels coupled to the Mth data line DLm and the Mth sensing line L_senm.

[0073] Referring to FIG. **6**, the pixel PX may include a driving element TD, a first switching element TS**1**, a second switching element TS**2**, a storage capacitor CST, and an organic light emitting diode EL. For example, the driving element TD, the first switching element TS**1**, and the second switching element TS**2** may be the PMOS transistors.

[0074] The driving element TD may include a gate electrode, a first electrode, and a second electrode. The driving element TD may include the gate electrode coupled to a first node N**1**, the first electrode that receives a first power voltage ELVDD, and the second electrode coupled to a second node N**2**. For example, the first power voltage ELVDD may be a high power voltage. The driving element TD may generate the driving current Id corresponding to the voltage applied to the first node N**1**.

[0075] The first switching element TS**1** may include a gate electrode that receives the first scan signal SCAN**1**, a first electrode coupled to the data line DLm, and a second electrode coupled to the first node N**1**. When the first switching element TS**1** is the PMOS transistor, the first switching element TS**1** may turn on in response to the first scan signal SCAN**1** having low level. When the first switching element TS**1** turns on, the compensation data voltage Vdata**2** provided through the data line DLm may be provided to the first node N**1**.

[0076] The second switching element TS**2** may include a gate electrode that receives the second scan signal SCAN**2**, a first electrode coupled to a cathode electrode of the organic light emitting diode EL, and a second electrode coupled to the compensation circuit **300**. When the second switching element TS**2** is the PMOS transistor, the second switching element TS**2** may turn on in response to the second scan signal SCAN**2** having the low level. When the second switching element TS**2** turns on, the driving current Id flowing through the organic light emitting diode EL may be provided to the compensation circuit **300** through the second switching element TS**2** and the sensing line L_senm.

[0077] Although the pixel PX including the driving element TD, the first switching element TS**1**, and the second switching element TS**2** implemented as the PMOS transistors is described in FIG. **6**, the driving element TD, the first switching element TS**1**, and the second switching element TS**2** are not limited thereto. For example, the driving element TD, the first switching element TS**1**, and the second switching element TS**2** may be implemented as the N-channel metal oxide semiconductor (NMOS) transistors.

[0078] The compensation circuit **300** may include a sensing unit **320** and the compensation data voltage generator **340**. The sensing unit **320** and the compensation data voltage generator **340** of FIG. **6** may correspond to the sensing unit **152** and the compensation data voltage generator **154** of FIG. **2**. The sensing unit **320** may include a sensing resistor Rsen and an amplifier AMP. The sensing resistor Rsen may generate a first sensing voltage VS**1** corresponding to the driving current Id provided through the sensing line L_senm. The amplifier AMP may output a second sensing voltage VS**2** by amplifying the first sensing voltage VS**1** generated by the sensing resistor Rsen.

[0079] The second sensing voltage VS**2** may be provided to the compensation data voltage generator **340**. The compensation data voltage generator **340** may include a comparator COM. The comparator COM may compare the data voltage Vdata**1** to the second sensing voltage VS**2** and convert the data voltage Vdata**1** to the compensation data voltage Vdata**2**. The comparator COM may include a first input terminal IN**1** that receives the data voltage Vdata**1**, a second input terminal IN**2** that receives the second sensing voltage VS**2**, and an output terminal OUT that outputs the compensation data voltage Vdata**2** by comparing the data voltage Vdata**1** and the second sensing voltage VS**2**.

[0080] The second sensing voltage VS**2** may be a voltage corresponding to the reduced driving current Id generated by the driving element TD of which threshold voltage is changed by the degradation. The comparator COM may output the compensation data voltage Vdata**2** that compensates for a difference between the data voltage Vdata**1** provided from the data driver and the second sensing voltage VS**2** provided from the sensing unit **320**. That is, the compensation data voltage Vdata**2** may have a voltage level that compensates for the reduced driving current Id due to the change in the threshold voltage of the driving element TD. The output terminal OUT of the comparator COM may be coupled to the data line DLm and provide the compensation data voltage Vdata**2** to the first electrode of the first switching element TS**1** included in the pixel PX. Although the compensation data voltage generator **340** that includes the comparator COM is described in FIG. **6**, the compensation data voltage generator **340** may not be limited thereto. For example, the compensation data voltage generator **340** may further include a calculator that calculates the difference of the data voltage Vdata**1** and the second sensing voltage VS**2**.

[0081] FIG. **7** is a block diagram illustrating an electronic device according to some example embodiments. FIG. **8** is a diagram illustrating an example embodiment in which the electronic device of FIG. **7** is implemented as a smart phone.

[0082] Referring to FIGS. **7** and **8**, an electronic device **400** may include a processor **410**, a memory device **420**, a storage device **430**, an input/output (I/O) device **440**, a power device **450**, and a display device **460**. Here, the display device **460** may correspond to the display device **100** of FIG. **1**. In addition, the electronic device **400** may further include a plurality of ports for communicating a video card, a sound card, a memory card, a universal serial bus (USB) device, other electronic device, etc. Although it is illustrated in FIG. **8** that the electronic device **400** is implemented as a smart phone **500**, a kind of the electronic device **400** is not limited thereto.

[0083] The processor **410** may perform various computing functions. The processor **410** may be a microprocessor, a central processing unit (CPU), etc. The processor **410** may be coupled to other components via an address bus, a control bus, a data bus, etc. Further, the processor **410** may be coupled to an extended bus such as surrounded component interconnect (PCI) bus. The memory device **420** may store data for operations of the electronic device **400**. For example, the memory device **420** may include at least one non-volatile memory device such as an erasable programmable read-only memory (EPROM) device, an electrically erasable programmable read-only memory (EEPROM) device, a flash memory device, a phase change random access memory (PRAM) device, a resistance random access memory (RRAM) device, a nano floating gate memory (NFGM) device, a polymer random access memory (PoRAM) device, a magnetic random access memory (MRAM) device, a ferroelectric random access memory (FRAM) device, etc., and/or at least one volatile memory device such as a dynamic random access memory (DRAM) device, a static random access memory (SRAM) device, a mobile DRAM device, etc. The storage device **430** may be a solid stage drive (SSD) device, a hard disk drive (HDD) device, a CD-ROM device, etc.

[0084] The I/O device **440** may be an input device such as a keyboard, a keypad, a touchpad, a touch-screen, a mouse, etc., and an output device such as a printer, a speaker, etc. In some example embodiments, the display device **460** may be included in the I/O device **440**. The power device **450** may provide a power for operations of the electronic device **400**. The display device **460** may communicate with other components via the buses or other communication links. As described above, the display device **460** may include may include a display panel, a timing controller, a scan driver, a data driver, and a compensation circuit.

[0085] The display panel may include a plurality of pixels that includes an organic light emitting diode and a driving element. The display panel may include a plurality of scan lines and a plurality of data lines. Each of the pixels may be electrically coupled to the scan lines and the data lines. In some example embodiments, a first scan line and a second scan line may be formed in the display panel. In other example embodiments, the first scan line, the second scan line, and a third scan line may be formed in the display panel. The timing controller may convert a first image data provided from an external device to a second image data.

[0086] The timing controller may generate a data control signal and a scan control signal that controls a driving of the second image data based on a control signal provided from the external device. The scan driver may provide a scan signal to the pixels through the scan lines. For example, the scan driver may generate a first scan signal provided to the pixel through the first scan line and a second scan signal provided to the pixel through the second scan line. The scan driver may further generate a third scan signal provided to the pixel through the third scan line. The data driver may generate a data voltage based on the second image data and the data control signal. The compensation circuit may sense a driving current flowing through the pixels and generate a compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the driving current. The compensation circuit may be respectively coupled to the data lines and sensing lines.

[0087] In some example embodiments, the pixel may include a driving element, a first switching element, a second switching element, a third switching element, a storage capacitor, and an organic light emitting diode. Each compensation circuit may include a sensing unit and a compensation data voltage generator. The sensing unit may sense the driving current of the pixel through the sensing line and generate a sensing voltage corresponding to the driving current. For example, the sensing unit may include a sensing resistor and an amplifier. The sensing resistor may generate a first sensing voltage corresponding to the driving current provided through the third switching element and the sensing line of the pixel. The amplifier may generate a second sensing voltage by amplifying the first sensing voltage generated by the sensing resistor. The second sensing voltage may be provided to the compensation data generator. The compensation data voltage generator may generate the compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the sensing voltage. For example, the compensation data voltage generator may include a comparator. The comparator may compare the data voltage to the second sensing voltage and convert the data voltage to the compensation data voltage.

[0088] In other example embodiments, the pixel may include a driving element, a first switching element, a second switching element, a storage capacitor, and an organic light emitting diode. Each of the compensation circuit may include a sensing unit and a compensation data voltage generator. The sensing unit may sense the driving current of the pixel through the sensing line and generate a sensing voltage corresponding to the driving current. For example, the sensing unit may include a sensing resistor and an amplifier.

[0089] The sensing resistor may generate a first sensing voltage corresponding to the driving current provided through the second switching element and the sensing line of the pixel. The amplifier may generate a second sensing voltage by amplifying the first sensing voltage generated by the sensing resistor. The second sensing voltage may be provided to the compensation data generator. The compensation data voltage generator may generate the compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the sensing voltage. For example, the compensation data voltage generator may include a comparator. The comparator may compare the data voltage to the second sensing voltage and convert the data voltage to the compensation data voltage.

[0090] As described above, the electronic device **400** according to some example embodiments may include the display device **460** that senses the driving current of the pixel and generates the compensation data voltage that compensates for a change of the driving current due to a threshold voltage of the driving element based on the driving current. Thus, display quality of the display device **460** may improve.

[0091] The present inventive concept may be applied to a display device and an electronic device having the display device. For example, the present inventive concept may be applied to a computer monitor, a laptop, a digital camera, a cellular phone, a smart phone, a smart pad, a television, a personal digital assistant (PDA), a portable multimedia player (PMP), a MP3 player, a navigation system, a game console, a video phone, etc.

[0092] The foregoing is illustrative of aspects of some example embodiments and is not to be construed as limiting thereof. Although a few example embodiments have been described, those skilled in the art will readily appreciate that many modifications are possible in the example embodiments without materially departing from the novel teachings and advantages of the present inventive concept. Accordingly, all such modifications are intended to be included within the scope of the present inventive concept as defined in the claims, and their equivalents. Therefore, it is to be understood that the foregoing is illustrative of various example embodiments and is not to be construed as limited to the specific example embodiments disclosed, and that modifications to the disclosed example embodiments, as well as other example embodiments, are intended to be included within the scope of the appended claims, and their equivalents.

What is claimed is:

1. A display device comprising:

a display panel including a plurality of pixels that each include an organic light emitting diode and a driving element, the display panel being configured to display an image data on the pixels;

a data driver configured to generate a data voltage corresponding to the image data;

a compensation circuit configured to sense a driving current flowing through the pixels and to generate a compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the driving current;

a scan driver configured to generate a first scan signal and a second scan signal provided to the pixels; and

a timing controller configured to generate control signals that control the data driver and the scan driver.

2. The display device of claim **1**, wherein the compensation circuit includes:

a sensing unit configured to sense the driving current and to generate a sensing voltage corresponding to the driving current; and

a compensation voltage generator configured to generate the compensation data voltage that compensates for the threshold voltage of the driving element based on the data voltage and the sensing voltage.

3. The display device of claim **2**, wherein the sensing unit includes:

a sensing resistor configured to sense the driving current and to generate a first sensing voltage corresponding to the driving current; and

an amplifier configured to output a second sensing voltage by amplifying the first sensing voltage.

4. The display device of claim **3**, wherein the compensation voltage generator includes a comparator that compares the data voltage to the second sensing voltage and converts the data voltage to the compensation data voltage.

5. The display device of claim **4**, wherein the comparator includes:

a first input terminal configured to receive the data voltage;

a second input terminal configured to receive the second sensing voltage; and

an output terminal configured to output the compensation data voltage by comparing the data voltage and the second sensing voltage.

6. The display device of claim **2**, wherein the organic light emitting diode includes an anode electrode and a cathode electrode, and

wherein the driving element includes a gate electrode coupled to a first node, a first electrode that receives a first power voltage, and a second electrode coupled to a second node.

7. The display device of claim **6**, wherein the scan driver is further configured to generate a third scan signal provided to the pixels.

8. The display device of claim **7**, wherein each of the pixels further includes:

a first switching element including a gate electrode configured to receive the first scan signal, a first electrode coupled to the compensation voltage generator, and a second electrode coupled to the first node;

a second switching element including a gate electrode configured to receive the second scan signal, a first electrode coupled to the second node, and a second electrode coupled to the anode electrode of the organic light emitting diode;

a third switching element including a gate electrode configured to receive the third scan signal, a first electrode coupled to the second node, and a second electrode coupled to the sensing unit; and

a storage capacitor including a first electrode configured to receive the first power voltage and a second electrode coupled to the first node.

9. The display device of claim **8**, wherein the first switching element and the third switching element are configured to turn on and the second switching element is configured to turn off in a compensation period of a pixel.

10. The display device of claim **8**, wherein the first switching element and the second switching element are configured to turn on, the third switching element is configured to turn off, and the compensation data voltage is maintained in an emission period of a pixel.

11. The display device of claim **8**, wherein the second switching element is configured to turn on, and the first switching element and the third switching element are configured to turn off in an emission period of a pixel.

12. The display device of claim **6**, wherein each of the pixels further includes:

a first switching element including a gate electrode configured to receive the first scan signal, a first electrode coupled to the compensation voltage generator, and a second electrode coupled to the first node;

a second switching element including a gate electrode configured to receive the second scan signal, a first electrode coupled to the cathode electrode of the organic light emitting diode, and a second electrode coupled to the sensing unit; and

a storage capacitor including a first electrode configured to receive the first power voltage and a second electrode coupled to the first node.

13. The display device of claim **12**, wherein the second switching element is configured to turn on and the driving current is sensed in an emission period of a pixel.

14. The display device of claim **1**, wherein the compensation circuit is located in the data driver or coupled to the data driver.

15. An electronic device including a display device and a processor that controls the display device, the display device comprising:

a display panel including a plurality of pixels that each include an organic light emitting diode and a driving element, the display panel being configured to display an image data on the pixels;

a data driver configured to generate a data voltage corresponding to the image data;

a compensation circuit configured to sense a driving current flowing through the pixels and to generate a compensation data voltage that compensates for a threshold voltage of the driving element based on the data voltage and the driving current;

a scan driver configured to generate a first scan signal and a second scan signal provided to the pixels; and a timing controller configured to generate control signals that control the data driver and the scan driver.

16. The electronic device of claim **15**, wherein the compensation circuit includes:

a sensing unit configured to sense the driving current and to generate a sensing voltage corresponding to the driving current; and

a compensation voltage generator configured to generate a compensation data voltage that compensates for the threshold voltage of the driving element based on the data voltage and the sensing voltage.

17. The electronic device of claim **16**, wherein the sensing unit includes:

a sensing resistor configured to sense the driving current and to generate a first sensing voltage corresponding to the driving current; and

an amplifier configured to output a second sensing voltage by amplifying the first sensing voltage, and

wherein the compensation voltage generator includes a comparator configured to compare the data voltage to the second sensing voltage and to convert the data voltage to the compensation data voltage.

18. The electronic device of claim **16**, wherein the organic light emitting diode includes an anode electrode and a cathode electrode,

wherein the driving element includes a gate electrode coupled to a first node, a first electrode configured to receive a first power voltage and a second electrode coupled to a second node.

19. The electronic device of claim **18**, wherein each of the pixels further includes:

a first switching element including a gate electrode configured to receive the first scan signal, a first electrode coupled to the compensation voltage generator, and a second electrode coupled to the first node;

a second switching element including a gate electrode configured to receive the second scan signal, a first electrode coupled to the second node, and a second electrode coupled to the anode electrode of the organic light emitting diode;

a third switching element including a gate electrode configured to receive a third scan signal, a first electrode coupled to the second node, and a second electrode coupled to the sensing unit; and

a storage capacitor including a first electrode configured to receive the first power voltage and a second electrode coupled to the first node.

20. The electronic device of claim **18**, wherein each of the pixels further includes:

a first switching element including a gate electrode configured to receive the first scan signal, a first electrode coupled to the compensation voltage generator, and a second electrode coupled to the first node;

a second switching element including a gate electrode configured to receive the second scan signal, a first electrode coupled to the cathode electrode of the organic light emitting diode, and a second electrode coupled to the sensing unit; and

a storage capacitor including a first electrode configured to receive the first power voltage and a second electrode coupled to the first node.

* * * * *

专利名称(译)	显示装置和具有该显示装置的电子设备		
公开(公告)号	US20200152125A1	公开(公告)日	2020-05-14
申请号	US16/579657	申请日	2019-09-23
[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DISPLAY CO.，LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	YE BYOUNG DAE YOU JUNWOO LEE TAEHO		
发明人	YE, BYOUNG DAE YOU, JUNWOO LEE, TAEHO		
IPC分类号	G09G3/3258 G09G3/3291 G09G3/3266		
CPC分类号	G09G2320/0233 G09G3/3266 G09G2310/08 G09G2310/0243 G09G3/3258 G09G3/3291 G09G2330/028 G09G3/3233 G09G2300/0819 G09G2300/0842 G09G2300/0861 G09G2320/0295 G09G2320/043		
优先权	1020180137446 2018-11-09 KR		
外部链接	Espacenet USPTO		

摘要(译)

显示装置包括：显示面板，其包括多个像素，每个像素包括有机发光二极管和驱动元件；显示面板被配置为在像素上显示图像数据；以及显示面板。 数据驱动器，被配置为产生与图像数据相对应的数据电压； 补偿电路，被配置为感测流过像素的驱动电流并基于数据电压和驱动电流生成补偿数据电压，该补偿数据电压补偿驱动元件的阈值电压； 扫描驱动器，被配置为生成提供给像素的第一扫描信号和第二扫描信号； 时序控制器，其被配置为产生控制数据驱动器和扫描驱动器的控制信号。