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(54) **POWER MANAGEMENT DEVICE, POWER MANAGEMENT METHOD, AND PIXEL CIRCUIT**

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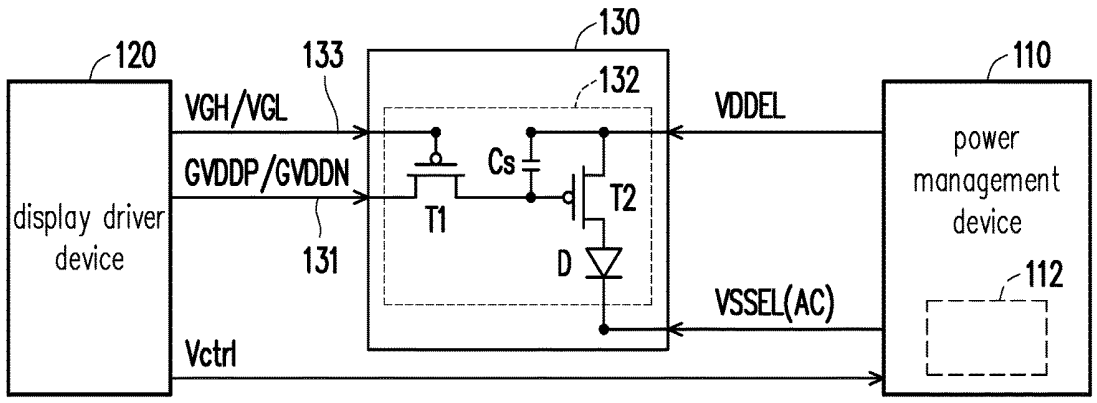
(57) **ABSTRACT**

A power management device including a power management circuit is provided. The power management circuit is configured to output a first power signal and a second power signal to a pixel circuit of a display panel. The pixel circuit includes an organic light-emitting diode. The organic light-emitting diode includes an anode terminal and a cathode terminal. The anode terminal is coupled to the first power signal. The cathode terminal is coupled to the second power signal. The second power signal is an alternating-current voltage. In addition, a pixel circuit of a display panel, and a power management method for the pixel circuit of the display panel are also provided.



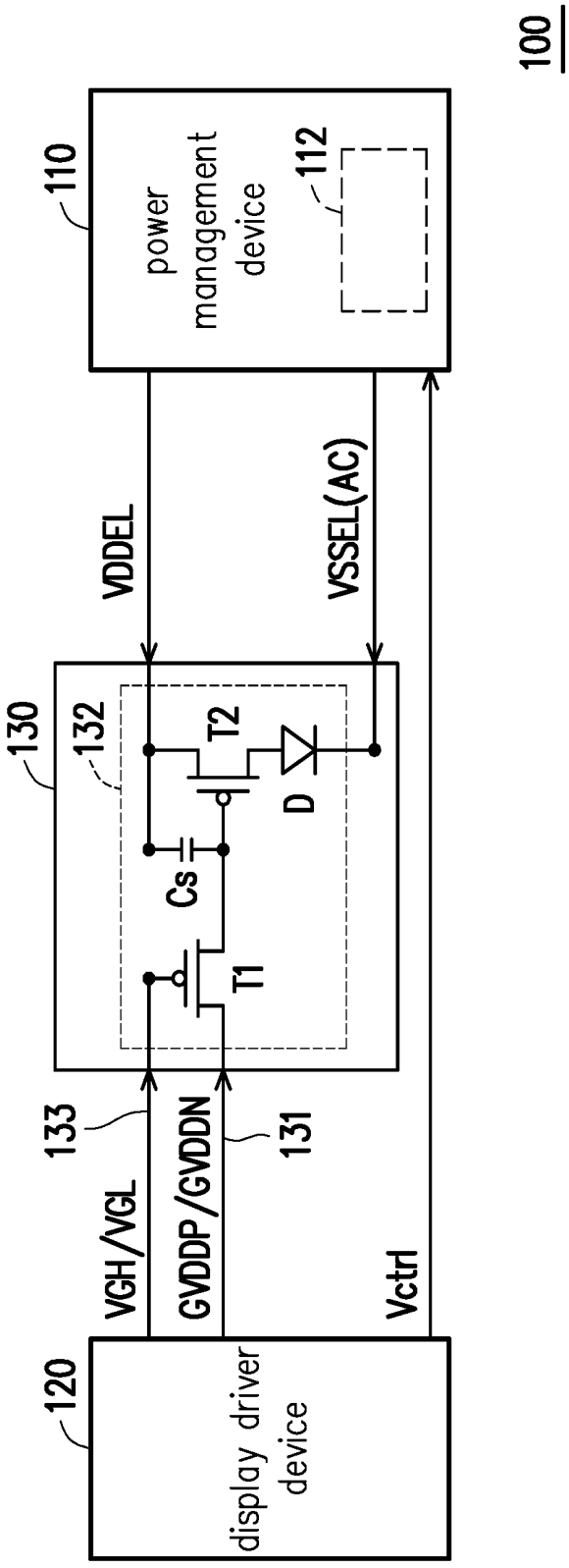

100
110
power management device
112
VDDEL
VSSEL(AC)
130
132
T2
D
Cs
T1
133
131
VGH/VGL
GVDDP/GVDDN
VctrI
120
display driver device

FIG. 1

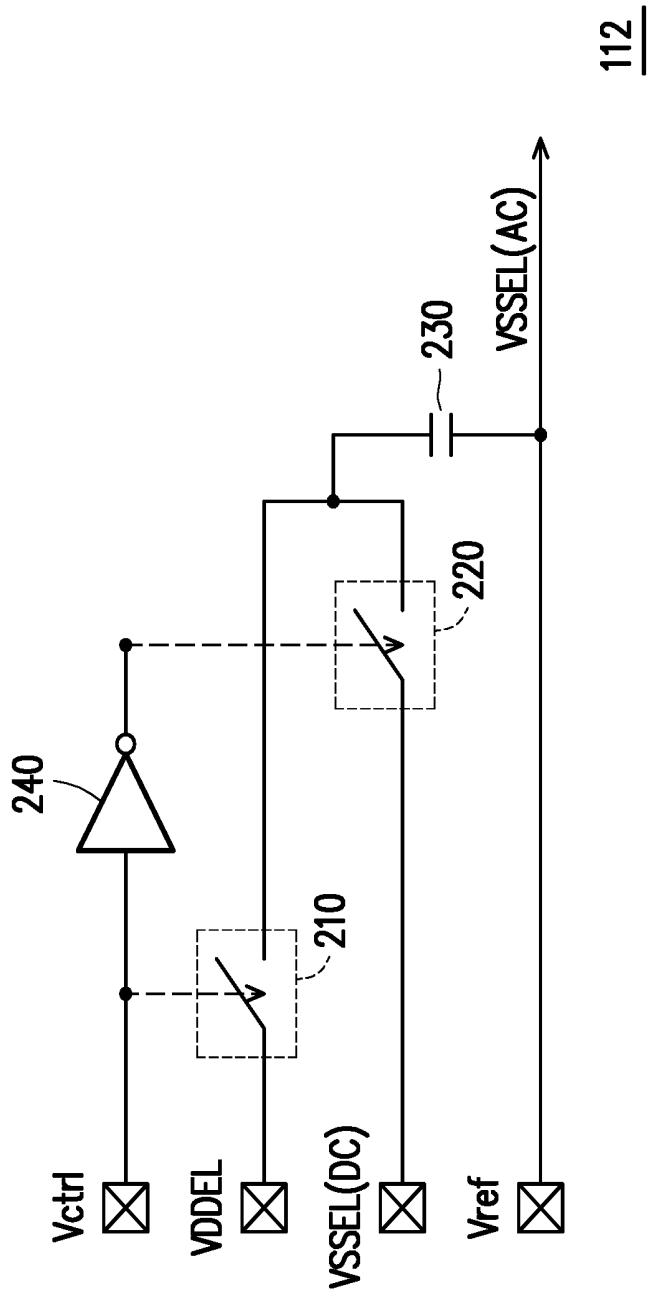


FIG. 2

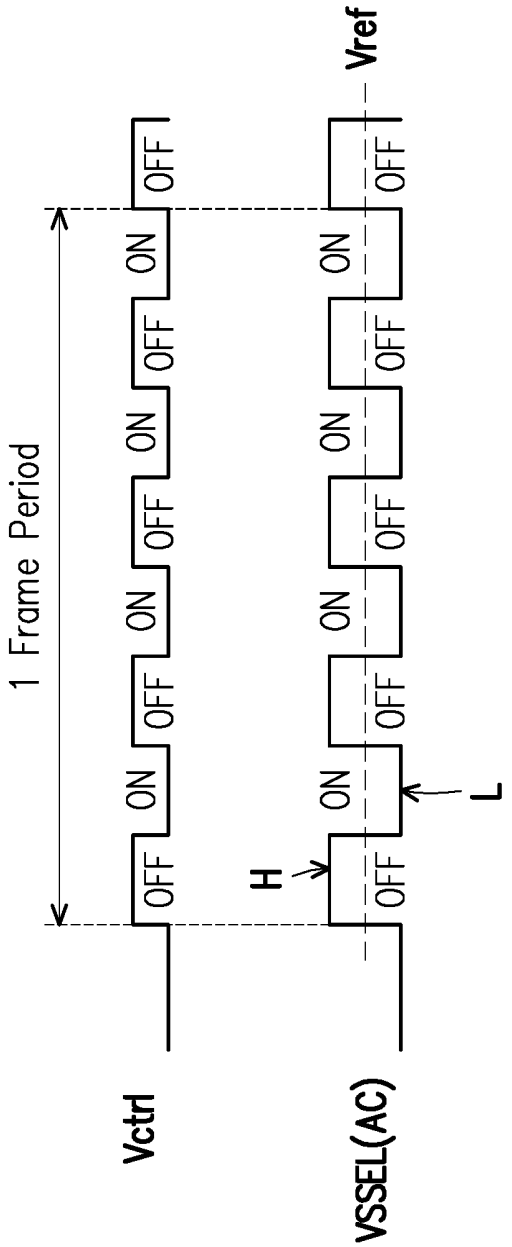

Vref
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
ON
OFF
1 Frame Period
H
L
Vctrl
VSSEL(AC)

FIG. 3

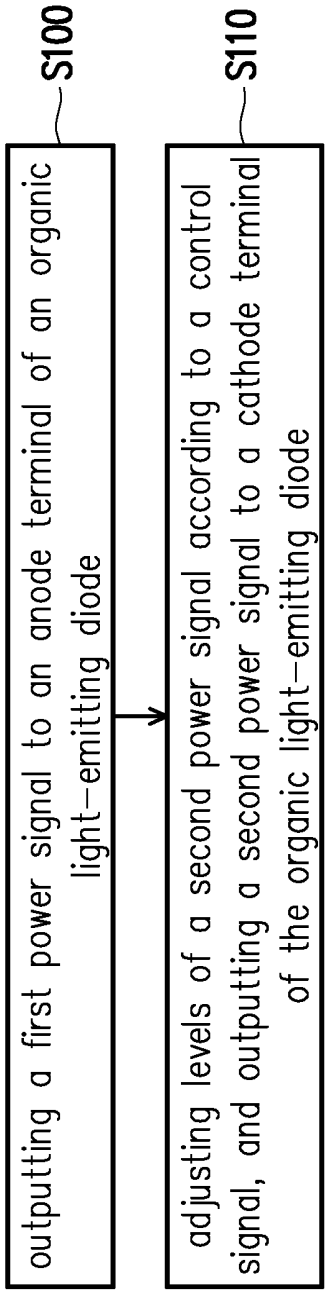

S100
outputting a first power signal to an anode terminal of an organic light-emitting diode
S110
adjusting levels of a second power signal according to a control signal, and outputting a second power signal to a cathode terminal of the organic light-emitting diode

FIG. 4

POWER MANAGEMENT DEVICE, POWER MANAGEMENT METHOD, AND PIXEL CIRCUIT

BACKGROUND

Technical Field

[0001] The invention generally relates to an electrical circuit, a pixel circuit of a display panel, and a management method for the pixel circuit of the display panel. More particularly, the invention relates to a power management circuit, a pixel circuit of a display panel, and a power management method for the pixel circuit of the display panel.

Description of Related Art

[0002] Display panels, and especially organic light-emitting diode (OLED) displays, are applied widely in the real-life applications and electronic devices. OLED displays have advantages on energy efficiency, thinness, high contrast ratio and overall display quality. Typically, an OLED display includes a plurality of OLEDs that are integrated with thin-film transistors (TFT) to form an OLED pixel arrays. However, OLED displays have disadvantages such as the burn-in issue. Burn-in is a form of image retention that lasts much longer on the display panel. Burn-in is usually visible even when the display panel plays other image content. It's usually caused by leaving a static image the display panel for a long period of time. In addition, as the resolution increases, the power consumption of the OLED displays also increases, especially when the OLED displays display images of high brightness.

[0003] Therefore, it would be desirable to remedy the influences of the burn-in to a display apparatus, thereby improving quality of the display apparatus and improving user experience in using the display apparatus.

SUMMARY

[0004] A power management circuit, a pixel circuit of a display panel, and a power management method for the pixel circuit of the display panel are introduced to remedy the burn-in issue in the display panel. In addition, a display apparatus including the power management circuit has low power consumption.

[0005] The invention provides a power management device including a power management circuit. The power management circuit is configured to output a first power signal and a second power signal to a pixel circuit of a display panel. The pixel circuit includes an organic light-emitting diode. The organic light-emitting diode includes an anode terminal and a cathode terminal. The anode terminal is coupled to the first power signal. The cathode terminal is coupled to the second power signal. The second power signal is an alternating-current voltage.

[0006] In an embodiment of the invention, levels of the second power signal are adjusted according to a control signal.

[0007] In an embodiment of the invention, the levels of the second power signal includes a first level and a second level. The first level and the second level are respectively determined according to a reference voltage, a first voltage and a second voltage. The first level is higher than the second level.

[0008] In an embodiment of the invention, the power management circuit includes a first switch, a second switch and a capacitor. The first switch includes a first end, a second end and a control end. The first end of the first switch is coupled to the first voltage. The control end of the first switch is coupled to the control signal. The second switch includes a first end, a second end and a control end. The first end of the second switch is coupled to the second voltage. The control end of the second switch is coupled to a reverse signal of the control signal. The capacitor includes a first end and a second end. The first end of the capacitor is coupled to the second end of the first switch and the second end of the second switch. The second end of the capacitor is coupled to the reference voltage. The power management circuit outputs the second power signal via the second end of the capacitor.

[0009] In an embodiment of the invention, the power management circuit further includes an inverter. The inverter includes an input end and an output end. The input end of the inverter receives the control signal. The output end of the inverter outputs the reverse signal of the control signal.

[0010] In an embodiment of the invention, the control signal is a digital signal. When the first switch is conducted, the second switch is not conducted. When the second switch is conducted, the first switch is not conducted.

[0011] In an embodiment of the invention, the power management circuit receives the control signal from a display driver device. The display driver device outputs a scan signal and a data signal to the pixel circuit and outputs the control signal to the power management circuit.

[0012] In an embodiment of the invention, the first power signal is a direct-current voltage.

[0013] The invention provides a pixel circuit of a display panel. The pixel circuit includes: a first transistor, a second transistor, an organic light-emitting diode and a capacitor. The first transistor includes a first end, a second end and a control end. The first end of the first transistor is coupled to a data line. The control end of the first transistor is coupled to a scan line. The second transistor includes a first end, a second end and a control end. The first end of the second transistor is coupled to a first power signal. The control end of the second transistor is coupled to the second end of the first transistor. The organic light-emitting diode includes an anode terminal and a cathode terminal. The anode terminal is coupled to the second end of the second transistor. The cathode terminal is coupled to the second power signal. The capacitor includes a first end and a second end. The first end of the capacitor is coupled to the first end of the second transistor. The second end of the capacitor is coupled to the control end of the second transistor. The second power signal is an alternating-current voltage.

[0014] In an embodiment of the invention, levels of the second power signal are adjusted according to a control signal.

[0015] In an embodiment of the invention, the levels of the second power signal includes a first level and a second level. The first level and the second level are respectively determined according to a reference voltage, a first voltage and a second voltage. The first level is higher than the second level.

[0016] In an embodiment of the invention, the first power signal is a direct-current voltage.

[0017] The invention provides a power management method for a pixel circuit of a display panel. The pixel circuit includes an organic light-emitting diode. The organic light-emitting diode includes an anode terminal and a cathode terminal. The power management method includes: outputting a first power signal to the anode terminal of the organic light-emitting diode; and adjusting levels of a second power signal according to a control signal, and outputting the second power signal to the cathode terminal of the organic light-emitting diode. The second power signal is an alternating-current voltage.

[0018] In an embodiment of the invention, the power management method further includes: receiving the control signal from a display driver device. The display driver device outputs a scan signal and a data signal to the pixel circuit.

[0019] In an embodiment of the invention, the levels of the second power signal includes a first level and a second level. The first level is higher than the second level. The power management method further includes: respectively determining the first level and the second level according to a reference voltage, a first voltage and a second voltage.

[0020] In an embodiment of the invention, the first power signal is a direct-current voltage.

[0021] To make the aforementioned more comprehensible, several embodiments accompanied with drawings are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure.

[0023] FIG. **1** illustrates a schematic diagram of a display apparatus according to an embodiment of the invention.

[0024] FIG. **2** illustrates a schematic diagram of the power management circuit depicted in FIG. **1**.

[0025] FIG. **3** illustrates a waveform diagram of the control signal and the second power signal depicted in FIG. **1**.

[0026] FIG. **4** is a flowchart illustrating steps in a power management method for a pixel circuit of a display panel according to an embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

[0027] FIG. **1** illustrates a schematic diagram of a display apparatus according to an embodiment of the invention. Referring to FIG. **1**, the display apparatus **100** of the present embodiment includes a power management device **110**, a display driver device **120** and a display panel **130**. The power management device **110** includes power management circuit. The display panel **130** includes a pixel circuit **132**. For the sake of brief explanation, only one pixel circuit is shown in the display panel **130**, but the number of the pixel circuit **132** does not intend to limit the invention.

[0028] In the present embodiment, the pixel circuit **132** includes a first transistor T**1**, a second transistor T**2**, an organic light-emitting diode D and a capacitor Cs. The first transistor T**1** includes a first end, a second end and a control end. The first end of the first transistor T**1** is coupled to a data line **131**. The second end of the first transistor T**1** is coupled to a control end of the second transistor T**2**. The control end of the first transistor T**1** is coupled to a scan line **333**. The display driver device **120** outputs scan signals VGH/VGL to the control end of the first transistor T**1** via the scan line **133**, so as to control the conduction state of the first transistor T**1**. The display driver device **120** outputs data signals GVDDP/GVDDN to the first end of the first transistor T**1** via the data line **131**, so as to write display data to the pixel circuit **132**.

[0029] In the present embodiment, the pixel circuit may be implemented by using structures of any pixel circuits in the related art, which are not particularly limited by the invention. Enough teaching, suggestion, and implementation illustration for aforesaid pixel circuit and embodiments thereof may be obtained with reference to common knowledge in the related art, which is not repeated hereinafter.

[0030] The second transistor T**2** includes a first end, a second end and a control end. The first end of the second transistor T**2** is coupled to a first power signal VDDEL. The second end of the second transistor T**2** is coupled to an anode terminal of the organic light-emitting diode. The control end of the second transistor T**2** is coupled to the second end of the first transistor T**1**. The organic light-emitting diode D includes an anode terminal and a cathode terminal. The anode terminal is coupled to the second end of the second transistor T**2**. The cathode terminal is coupled to the second power signal VSSEL(AC). The capacitor Cs includes a first end and a second end. The first end of the capacitor Cs is coupled to the first end of the second transistor T**2**. The second end of the capacitor Cs is coupled to the control end of the second transistor T**2**.

[0031] In the present embodiment, the power management circuit **112** outputs the first power signal VDDEL and the second power signal VSSEL(AC) to the pixel circuit **132**. The first power signal VDDEL is a direct-current (DC) positive voltage. The second power signal VSSEL(AC) is an alternating-current (AC) voltage. In the present embodiment, the display driver device **120** outputs a control signal Vctrl to the power management circuit **112**, and levels of the second power signal VSSEL(AC) are adjusted according to the control signal Vctrl.

[0032] To be specific, FIG. **2** illustrates a schematic diagram of the power management circuit depicted in FIG. **1**. FIG. **3** illustrates a waveform diagram of the control signal and the second power signal depicted in FIG. **1**. Referring to FIG. **2** and FIG. **3**, the power management circuit **112** of the present embodiment includes a first switch **210**, a second switch **220**, a capacitor and an inverter **240**.

[0033] The first switch **210** includes a first end, a second end and a control end. The first end of the first switch **210** is coupled to the first power signal VDDEL (a first voltage). The second end of the first switch **210** is coupled to the first end of the capacitor **230**. The control end of the first switch **210** is coupled to the control signal Vctrl. The second switch **220** includes a first end, a second end and a control end. The first end of the second switch **220** is coupled to a second voltage VSSEL(DC). The second end of the second switch **220** is coupled to the first end of the capacitor **230**. The control end of the second switch **220** is coupled to a reverse signal of the control signal Vctrl. The inverter **240** includes an input end and an output end. The input end of the inverter **240** receives the control signal Vctrl from the display driver device **120**. The output end of the inverter **240** outputs the reverse signal of the control signal Vctrl to the control end of the second switch **220**. In the present embodiment, the control signal Vctrl is a digital signal as shown in FIG. **3**.

The control signal Vctrl controls the conduction state of the first switch **210** and the second switch **220**. When the first switch **210** is conducted, the second switch **220** is not conducted, and when the second switch **220** is conducted, the first switch **210** is not conducted.

[0034] The capacitor **230** includes a first end and a second end. The first end of the capacitor **230** is coupled to the second end of the first switch **210** and the second end of the second switch **220**. The second end of the capacitor **230** is coupled to a reference voltage Vref. The power management circuit **112** outputs the second power signal VSSEL(AC) to the pixel circuit **132** via the second end of the capacitor **230**.

[0035] Referring to FIG. **3**, the levels of the second power signal VSSEL(AC) includes a first level H and a second level L in the present embodiment. The first level H and the second level L are respectively determined according to the reference voltage DC, the first power signal VDDEL and the second voltage VSSEL(DC). The first level H is higher than the second level L. In the present embodiment, the first level H may be obtained based on the formula H=DC level+[(VDDEL−VSSEL)/2], and the second level L may be obtained based on the formula L=DC level−[(VDDEL−VSSEL)/2], where DC level is the level value of the reference voltage Vref, VDDEL is the level value of the first power signal VDDEL, and VSSEL is the level value of the second voltage VSSEL(DC). In FIG. **3**, the mark "OFF" indicates the OLED pixel **132** stays in an OFF period, and the mark "ON" indicates the OLED pixel **132** stays in an ON period.

[0036] In the present embodiment, the display driver device **120** controls the power management device **110** by using the control signal Vctrl, and the power management device **110** outputs the second power signal VSSEL(AC) of the AC format to the OLED pixel **132**. By adjusting the duty cycle of the control signal Vctrl, the ON and OFF periods of the OLED pixel **132** are adjusted. For example, adjusting the duty cycle of the control signal Vctrl to 50% can reduce a half of power consumption of the OLED pixel **132**. In addition, the power management device **110** can perform a reverse voltage operation on the OLED pixel **132** and adjust the level of the second power signal VSSEL(AC) by adjusting the level of the reference voltage Vref. By adjusting the level of the reference voltage Vref, a reverse voltage is provided during OFF period so as to initialize the OLED pixel **132** to an initial state.

[0037] FIG. **4** is a flowchart illustrating steps in a power management method for a pixel circuit of a display panel according to an embodiment of the invention. Referring to FIG. **1** and FIG. **4**, the power management method of the embodiment is at least adapted to the display apparatus **100** of FIG. **1**, but the invention is not limited thereto. Taking the display apparatus **100** of FIG. **1** for example, in step S**100**, the power management device **110** outputs the first power signal VDDEL to the anode terminal of the organic light-emitting diode D. In step S**110**, the power management device **110** adjusts levels of a second power signal VSSEL (AC) according to a control signal Vctrl, and outputs the second power signal VSSEL(AC) to the cathode terminal of the organic light-emitting diode D, where the second power signal VSSEL(AC) is an alternating-current voltage. In addition, sufficient teaching, suggestion, and implementation illustration regarding the power management method of the embodiments of the disclosure may be obtained from the foregoing embodiments of FIG. **1** to FIG. **3**, and thus related description thereof is not repeated hereinafter.

[0038] In summary, in exemplary embodiments of the invention, the power management device is control to output an AC voltage to control the OFF and ON periods of the OLED pixel, such that the power consumption of the OLED pixel, is reduced. In addition, the power management device provides a reverse voltage to initialize the OLED pixel to an initial state during the OFF period.

[0039] It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the disclosure covers modifications and variations provided that they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A power management device, comprising:

a power management circuit configured to output a first power signal and a second power signal to a pixel circuit of a display panel, wherein the pixel circuit comprises an organic light-emitting diode, the organic light-emitting diode comprises an anode terminal and a cathode terminal, the anode terminal is coupled to the first power signal, and the cathode terminal is coupled to the second power signal,

wherein the second power signal is an alternating-current voltage.

2. The power management device of claim **1**, wherein levels of the second power signal are adjusted according to a control signal.

3. The power management device of claim **2**, wherein the levels of the second power signal comprises a first level and a second level, the first level and the second level are respectively determined according to a reference voltage, a first voltage and a second voltage, and the first level is higher than the second level.

4. The power management device of claim **3**, wherein the power management circuit comprises:

a first switch comprising a first end, a second end and a control end, wherein the first end of the first switch is coupled to the first voltage, and the control end of the first switch is coupled to the control signal;

a second switch comprising a first end, a second end and a control end, wherein the first end of the second switch is coupled to the second voltage, and the control end of the second switch is coupled to a reverse signal of the control signal; and

a capacitor comprising a first end and a second end, wherein the first end of the capacitor is coupled to the second end of the first switch and the second end of the second switch, and the second end of the capacitor is coupled to the reference voltage,

wherein the power management circuit outputs the second power signal via the second end of the capacitor.

5. The power management device of claim **4**, wherein the power management circuit further comprises:

an inverter comprising an input end and an output end, wherein the input end of the inverter receives the control signal and the output end of the inverter outputs the reverse signal of the control signal.

6. The power management device of claim **4**, wherein the control signal is a digital signal, when the first switch is

conducted, the second switch is not conducted, and when the second switch is conducted, the first switch is not conducted.

7. The power management device of claim **2**, wherein the power management circuit receives the control signal from a display driver device, and the display driver device outputs a scan signal and a data signal to the pixel circuit and outputs the control signal to the power management circuit.

8. The power management device of claim **1**, wherein the first power signal is a direct-current voltage.

9. A pixel circuit of a display panel, comprising:

a first transistor comprising a first end, a second end and a control end, wherein the first end of the first transistor is coupled to a data line, and the control end of the first transistor is coupled to a scan line;

a second transistor comprising a first end, a second end and a control end, wherein the first end of the second transistor is coupled to a first power signal, and the control end of the second transistor is coupled to the second end of the first transistor;

an organic light-emitting diode comprising an anode terminal and a cathode terminal, wherein the anode terminal is coupled to the second end of the second transistor, and the cathode terminal is coupled to the second power signal; and

a capacitor comprising a first end and a second end, wherein the first end of the capacitor is coupled to the first end of the second transistor, and the second end of the capacitor is coupled to the control end of the second transistor,

wherein the second power signal is an alternating-current voltage.

10. The pixel circuit of claim **9**, wherein levels of the second power signal are adjusted according to a control signal.

11. The pixel circuit of claim **10**, wherein the levels of the second power signal comprises a first level and a second level, the first level and the second level are respectively determined according to a reference voltage, a first voltage and a second voltage, and the first level is higher than the second level.

12. The pixel circuit of claim **10**, wherein the first power signal is a direct-current voltage.

13. A power management method for a pixel circuit of a display panel, wherein the pixel circuit comprises an organic light-emitting diode, and the organic light-emitting diode comprises an anode terminal and a cathode terminal, the power management method comprising:

outputting a first power signal to the anode terminal of the organic light-emitting diode; and

adjusting levels of a second power signal according to a control signal, and outputting the second power signal to the cathode terminal of the organic light-emitting diode,

wherein the second power signal is an alternating-current voltage.

14. The power management method of claim **13**, further comprising:

receiving the control signal from a display driver device, wherein the display driver device outputs a scan signal and a data signal to the pixel circuit.

15. The power management method of claim **13**, wherein the levels of the second power signal comprises a first level and a second level, and the first level is higher than the second level, the power management method further comprising:

respectively determining the first level and the second level according to a reference voltage, a first voltage and a second voltage.

16. The power management method of claim **13**, wherein the first power signal is a direct-current voltage.

* * * * *

专利名称(译)	电源管理装置，电源管理方法和像素电路		
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摘要(译)

提供了一种包括电源管理电路的电源管理装置。 功率管理电路被配置为向显示面板的像素电路输出第一功率信号和第二功率信号。 像素电路包括有机发光二极管。 有机发光二极管包括阳极端子和阴极端子。 阳极端子耦合到第一功率信号。 阴极端子耦合到第二功率信号。 第二功率信号是交流电压。 另外，还提供了显示面板的像素电路以及用于显示面板的像素电路的电源管理方法。