US007952543B2

(12) **United States Patent**
Chang et al.

(10) **Patent No.: US 7,952,543 B2**
(45) **Date of Patent: May 31, 2011**

(54) **DRIVE CIRCUIT, DISPLAY APPARATUS, AND METHOD FOR ADJUSTING SCREEN REFRESH RATE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 848 days.

(21) Appl. No.: **11/926,507**

(22) Filed: **Oct. 29, 2007**

(65) **Prior Publication Data**

US 2008/0225062 A1 Sep. 18, 2008

(30) **Foreign Application Priority Data**

Mar. 12, 2007 (TW) ..... 96108372 A

(51) **Int. Cl.**
G09G 3/30 (2006.01)

(52) **U.S. Cl.** **345/76**

(58) **Field of Classification Search** 345/691
See application file for complete search history.

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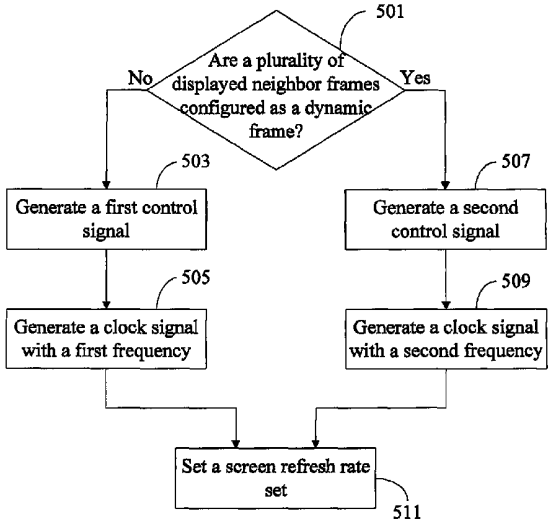
(57) **ABSTRACT**

A display apparatus and a drive circuit for adjusting a screen refresh rate of the display apparatus and a method thereof are disclosed. The display apparatus comprises an OLED diode display array and a drive circuit. The drive circuit comprises a detection unit, a clock generating unit, and a timing control unit. The detection unit determines whether a plurality of frames displayed by the OLED diode display array are configured as a dynamic frame. The detection unit generates a first control signal when the displayed frames are not configured as a dynamic frame, and the detection unit generates a second control signal when the displayed frames are configured as a dynamic frame. The clock generating unit generates a clock signal, the frequency of which is a first frequency in response to the first signal, or a second frequency in response to the second signal. The first frequency is greater than the second frequency. The timing control unit sets the screen refresh rate of the display apparatus in response to the frequency of the clock signal.

25 Claims, 5 Drawing Sheets



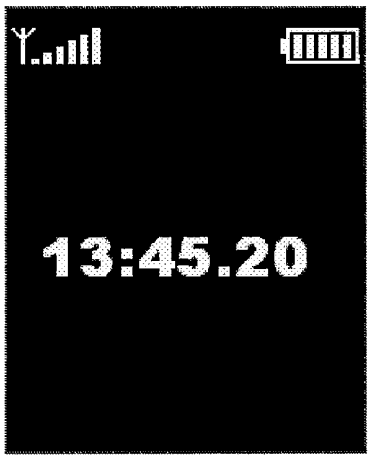


FIG. 1 (Prior Art)

FIG. 2 (Prior Art)

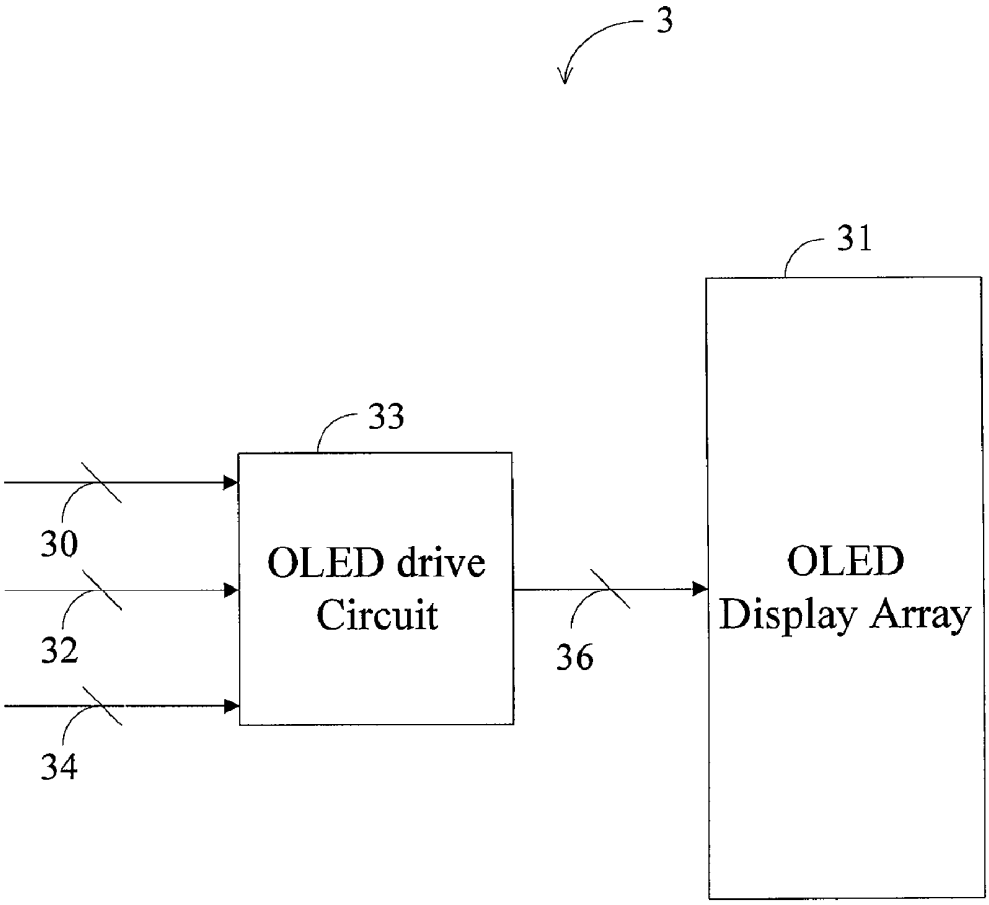


FIG. 3

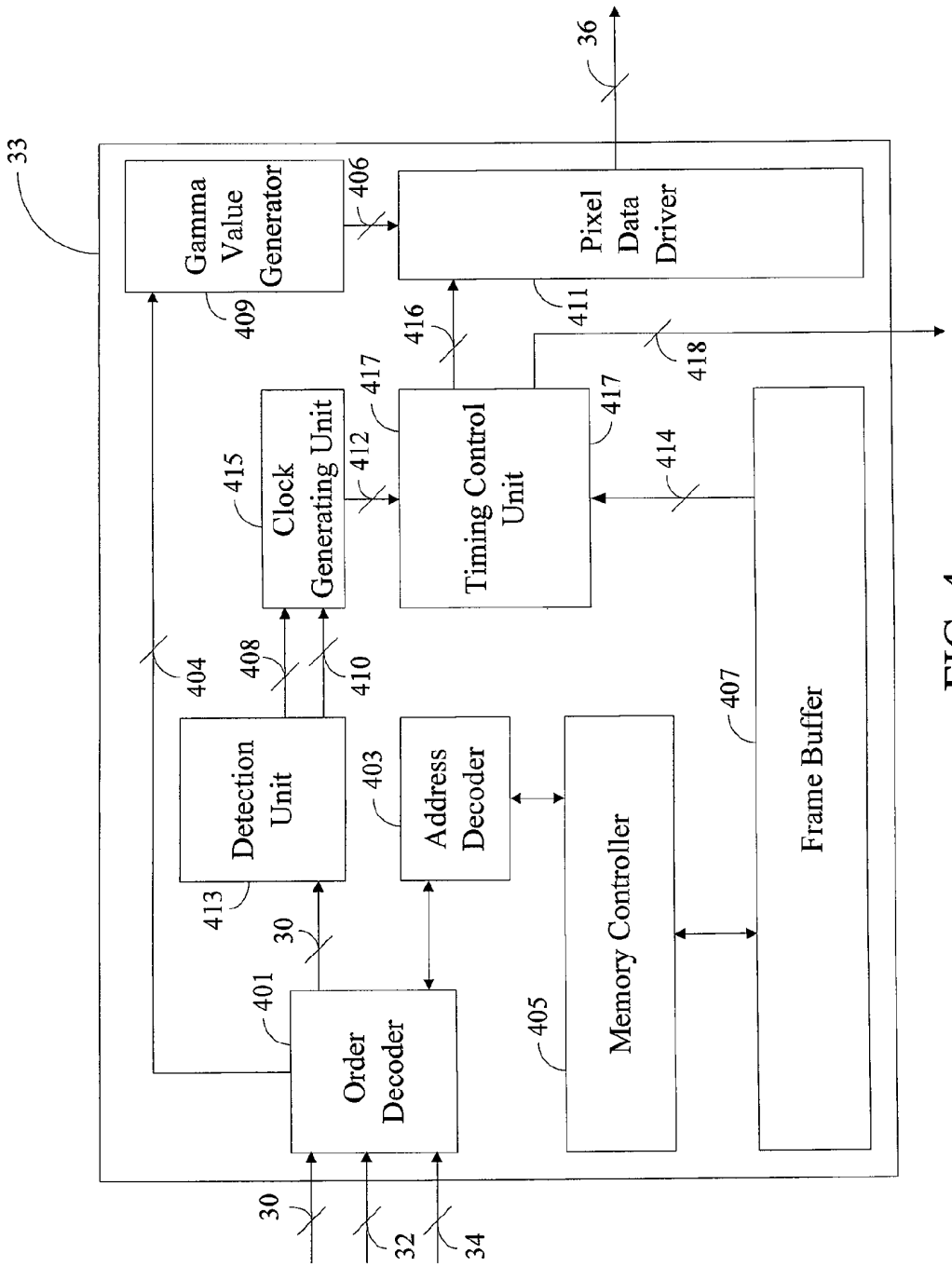

33
36
Gamma Value Generator
406
Pixel Data Driver
409
411
416
418
417
Clock Generating Unit
412
Timing Control Unit
417
415
414
404
408
410
407
Frame Buffer
Detection Unit
403
Address Decoder
Memory Controller
413
30
401
Order Decoder
405
30
32
34

FIG. 4

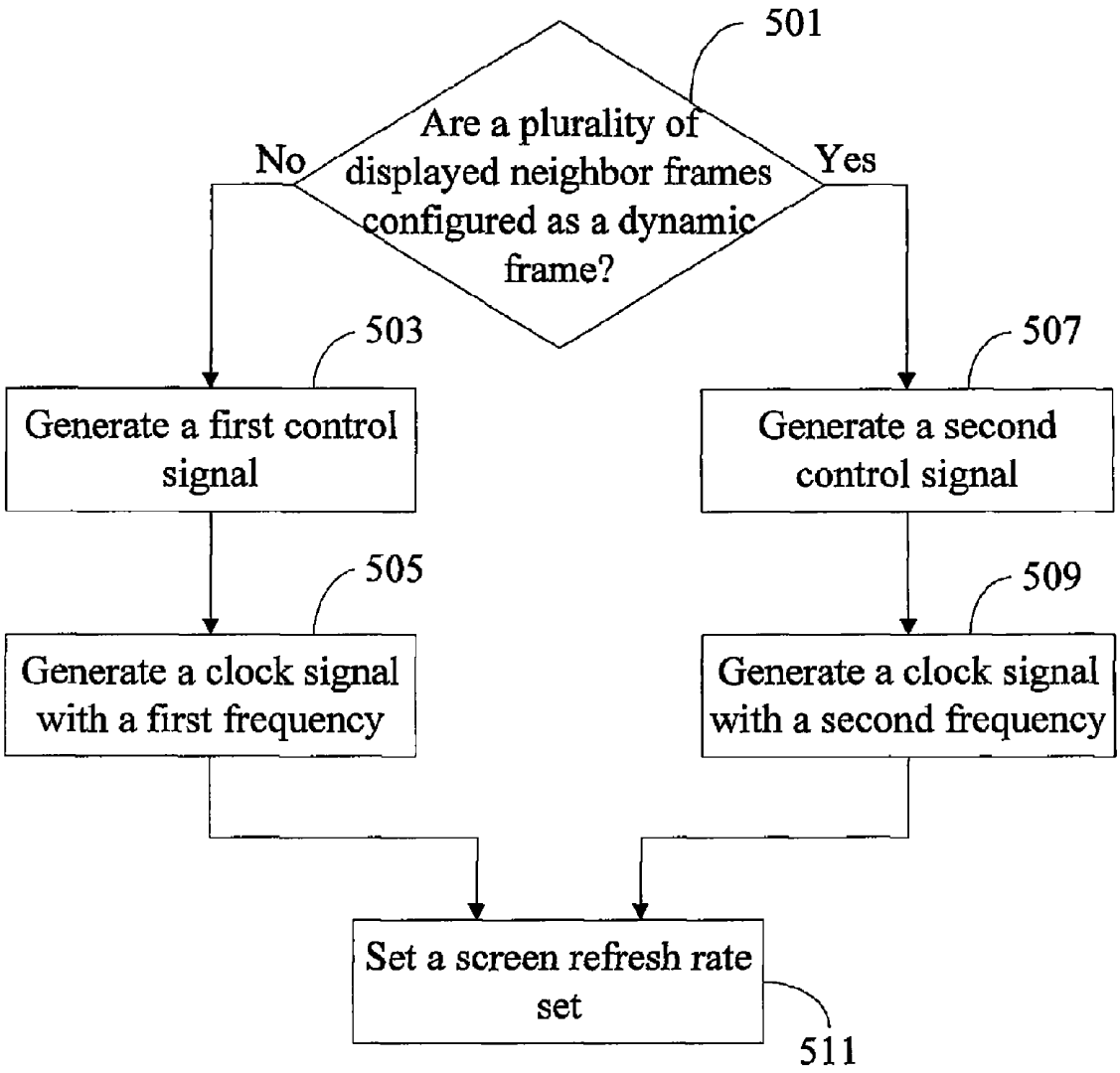

501
Are a plurality of displayed neighbor frames configured as a dynamic frame?
No
Yes
503
Generate a first control signal
505
Generate a clock signal with a first frequency
507
Generate a second control signal
509
Generate a clock signal with a second frequency
Set a screen refresh rate set
511

FIG. 5

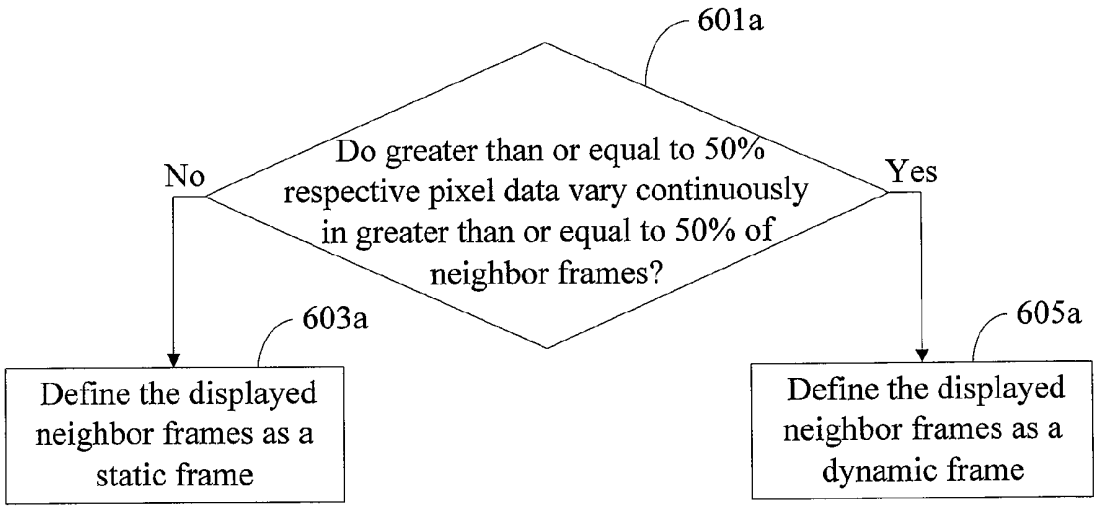

601a
Do greater than or equal to 50% respective pixel data vary continuously in greater than or equal to 50% of neighbor frames?
No
Yes
603a
Define the displayed neighbor frames as a static frame
605a
Define the displayed neighbor frames as a dynamic frame

FIG. 6A

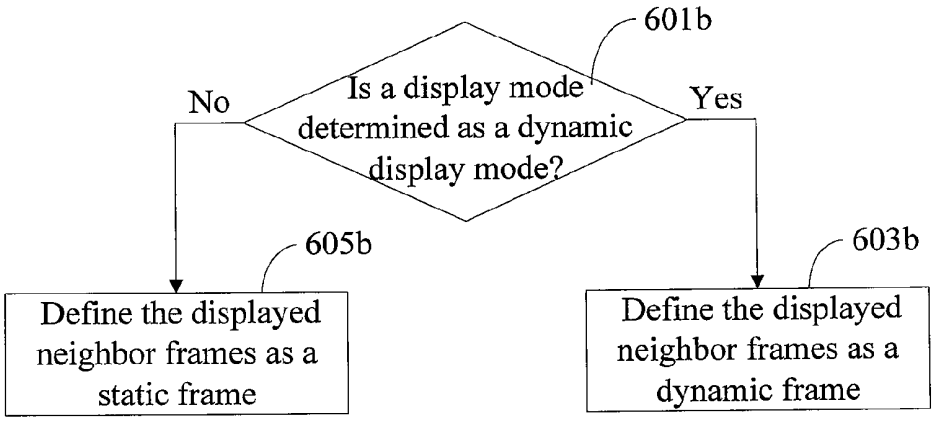

601b
Is a display mode determined as a dynamic display mode?
No
Yes
605b
Define the displayed neighbor frames as a static frame
603b
Define the displayed neighbor frames as a dynamic frame

FIG. 6B

DRIVE CIRCUIT, DISPLAY APPARATUS, AND METHOD FOR ADJUSTING SCREEN REFRESH RATE

This application claims the benefit of priority based on Taiwan Patent Application No. 096108372 filed on Mar. 12, 2007, the disclosures of which are incorporated herein by reference in their entirety.

CROSS-REFERENCES TO RELATED APPLICATIONS

Not applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a display apparatus, a drive circuit and a method for adjusting a screen refresh rate of the display apparatus.

2. Descriptions of the Related Art

In recent years, developments for flat panel displays have grown rapidly, gradually replacing traditional cathode radiation tube (CRT) displays. Nowadays, major flat panel displays include: Organic Light-Emitting Diodes Displays (OLEDs), Plasma Display Panel (PDP), Liquid Crystal Displays (LCDs), and Field Emission Displays (FEDs).

Although active type OLED displays exhibit a faster response speed than LCDs during a frame transition process, image ghosting still occurs in OLEDs just as in LCDs. As shown in FIG. **1** and FIG. **2**, FIG. **1** illustrates a screenshot of the display frame in the standby state of a mobile phone utilizing an active type OLED display, and FIG. **2** illustrates a screenshot of the frame of the mobile phone during the transition from the standby state to the dialing state. During the frame transition (i.e., from the frame shown in FIG. **1** to that shown in FIG. **2**), the frame of the standby state may remain in the frame of the dialing state shown in FIG. **2**, thus causing the phenomenon of image ghosting to occur (e.g., 13:45:20 shown in FIG. **2**). This is especially significant in case of static frames.

To solve the image ghosting problem during a frame transition, the display apparatus of Taiwan Patent No. I226949 alternatively displays a black frame and various data frames via a doubled display rate in an attempt to eliminate the image ghosting. However, this method to increase the screen refresh rate requires a corresponding increase of the clock rate generated by a drive circuit in the display apparatus, which in turn increases the power consumption, resulting in a low power efficiency and reduced service life of the display apparatus. As a result, the need to conserve energy and prolong the service life of the display apparatus while mitigating the problem of image ghosting still exists in the display manufacturing field.

SUMMARY OF THE INVENTION

An objective of this invention is to provide a drive circuit that adjusts the screen refresh rate of a display device. The drive circuit comprises a detection unit, a clock generating unit, and a timing control unit. The detection unit determines whether a plurality of displayed frames is configured as a dynamic frame. The detection unit generates a first control signal when the displayed frames are not configured as a dynamic frame. Otherwise, the detection unit generates a second control signal. The clock generating unit generates a clock signal, the frequency of which is a first frequency in response to the first signal, or a second frequency in response to the second signal. And, the first frequency is greater than the second frequency. The timing control unit sets the screen refresh rate in response to the frequency of the clock signal.

Another objective of this invention is to provide a display apparatus, which comprises an OLED display array and a drive circuit. The OLED display array displays a plurality of frames according to the screen refresh rate. The drive circuit determines whether the displayed frames are configured as a dynamic frame. The frequency of the clock signal is set to a first frequency when the displayed frames are not configured as a dynamic frame. Otherwise, the frequency of the clock signal is set to a second frequency. And, the first frequency is greater than the second frequency. The drive circuit sets the screen refresh rate in response to the resulting frequency of the clock signal.

Yet a further objective of this invention is to provide a method for adjusting the screen refresh rate. The method comprises the steps of: determining whether a plurality of displayed frames are configured as a dynamic frame; generating a first control signal when the displayed frames are not configured as a dynamic frame; generating a second control signal when the displayed frames are configured as a dynamic frame; generating a clock signal, wherein the frequency of the clock signal is a first frequency in response to the first signal, or a second frequency in response to the second signal; and setting the screen refresh rate in response to the resulting frequency of the clock signal. The first frequency is greater than the second frequency.

This invention utilizes an ordinary screen refresh rate, such as 60 Hz for dynamic frames, and a higher screen refresh rate, such as 120 Hz for non-dynamic frames. Therefore, a display apparatus can utilize these various screen refresh rates to mitigate the problem of frame ghosting, while achieving reduced power consumption and prolonged service life.

The detailed technology and preferred embodiments implemented for the subject invention are described in the following paragraphs accompanying the appended drawings for people skilled in this field to well appreciate the features of the claimed invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a screenshot of the display frame illustrating the standby state of a mobile phone utilizing an active type OLED display apparatus;

FIG. **2** is a screenshot of the display frame of the mobile phone utilizing an active type OLED display apparatus during a transition to a dialing frame;

FIG. **3** is a diagram illustrating a first embodiment of this invention;

FIG. **4** is a block diagram illustrating a drive circuit of the first embodiment of this invention;

FIG. **5** is a flow chart illustrating a second embodiment of this invention;

FIG. **6**A is another flow chart of the second embodiment of this invention; and

FIG. **6**B is yet another flow chart of the second embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. **3**, a first embodiment of the present invention is an OLED display apparatus **3**. The OLED display apparatus **3** comprises an OLED display array **31** and an OLED drive circuit **33**. The OLED drive circuit **33** is config-

ured to receive frame data **30**, a mode signal **32**, and a pixel setting signal **34**. The frame data **30** comprises a plurality of neighbor frames, and the OLED drive circuit **33** determines whether the neighbor frames are configured as a dynamic frame. A dynamic frame means that greater than or equal to 50 percent of respective pixel data vary continuously in greater than or equal to 50 percent of neighbor frames. For example, presuming that the frame data **30** comprises ten neighbor frames, and more than half of respective pixel data vary in at least five of the previous ten neighbor frames, then the ten neighbor frames are defined as a dynamic frame. Otherwise, they are defined as a static frame. Additionally, whether a frame is dynamic or static can also be determined by the mode signal **32**. More specifically, when the display mode is in a dynamic display mode, that is, when greater than or equal to a first predetermined percentage (e.g. 50 percent) of respective pixel data vary continuously in greater than or equal to a second predetermined percentage (e.g. 50 percent) of neighbor frames, the frame data **30** is defined as a dynamic frame. On the contrary, if the display mode is not a dynamic display mode, then the frame data **30** is defined as a static frame. The first and the second predetermined percentage can be set by those of ordinary skill in this field, according to actual operations and requirements. The display mode determined by the mode signal **32** can be changed in response to an order inputted by a user. For example, when the user inputs an order to play an animation, the mode signal **32** will direct the apparatus into a dynamic display mode. The pixel setting signal **34** is used to set a pixel. It should be noted that the definition of a dynamic frame depends on the actual operations. For example, the percentages described above can be adjusted to be higher or lower than 50%, and the present invention is not limited to this value.

When the frames are determined as a static frame, the OLED drive circuit **33** sets a frequency of a clock signal to a first frequency; otherwise, when the frames are determined as dynamic, the frequency of the clock signal is set to a second frequency. This clock signal dictates a screen refresh rate, that is, the frequency for displaying these frames. Once the frequency of the clock signal is set based on the frame state by the OLED drive circuit **33**, these frames are displayed by the OLED display array **31** according to the pixel data **36**.

The second frequency is an original display frequency of these neighbor frames. When the OLED drive circuit **33** sets the screen refresh rate in response to the first frequency, these neighbor frames are displayed alternately with black frames. As a result, the first frequency is greater than or equal to twice the second frequency. However, this invention is not limited to such an amount that the first frequency exceeds the second frequency. For example, if the second frequency is set to 60 Hz, the first frequency can be set to 120 Hz.

A detailed structure of the OLED drive circuit **33** is shown in FIG. **4**. The OLED drive circuit **33** comprises an order decoder **401**, an address decoder **403**, a memory controller **405**, a frame buffer **407**, a gamma value generator **409**, a pixel data driver **411**, a detection unit **413**, a clock generating unit **415**, and a timing control unit **417**. The order decoder **401** is configured to receive the frame data **30**, the mode signal **32**, and the pixel setting signal **34**, thereby to control the display mode and set the timing. The frame data **30** is processed by the address decoder **403** and the memory controller **405**, and is then stored in the frame buffer **407** for access by the timing control unit **417**. The gamma value generator **409** is configured to receive a signal **404** from the order decoder **401** to generate a gamma signal **406**. The detection unit **413** is configured to receive the frame data **30** and the mode signal **32** via the order decoder **401**, and determine whether the frames to be displayed in the OLED display **3** (FIG. **3**) are configured as a dynamic or a static frame (or a dynamic or a static display mode) according to the frame data **30** and/or the mode signal **32** respectively. In other words, the detection unit **413** detects whether the neighbor frames in the frame data **30** are configured as a dynamic or a static frame, or finds out the display mode through the mode signal **32**, thereby to define the frame data **30** as a dynamic frame (dynamic display mode) or a static frame (static display mode). In the case of a static frame (static display mode), the detection unit **413** generates a first control signal **408**. Otherwise, in case of a dynamic frame (dynamic display mode), the detection unit **413** generates a second control signal **410**. The clock generating unit **415** is configured to generate a clock signal **412** with an associated first frequency when the clock generating unit **415** receives the first control signal **408** and a second frequency when the clock generating unit **415** receives the second control signal **410**. The timing control unit **417** receives buffered frame data **414**, and sets the screen refresh rate for the buffered frame data **414** in response to the frequency of the clock signal **412** to generate a frame signal **416** and a switching signal **418** for controlling the switching of horizontal scan lines in the display array **31** (FIG. **3**). The pixel data driver **411** receives the gamma signal **406** and the frame signal **416**, and combines them into pixel data **36** for outputting to the OLED display array **31**. The pixel data **36** additionally comprises the frames and the information about display clocks.

It should be noted that, although two signal lines shown in FIG. **4** transmit the first control signal **408** and the second control signal **410** separately, this invention is not limited to transmission of these two signals via separate lines. More particularly, the detection unit **413** can be designed to indicate a dynamic frame (dynamic display mode) and a static frame (static display mode) respectively with a "high level" and a "low level" of a signal. In other words, the first control signal **408** can be represented by the high level of the signal, while the second control signal **410** be represented by the low level of the same signal, thus to indicate the dynamic frame (dynamic display mode) and the static frame (static display mode) via a single signal line.

A second embodiment of this invention is a method for adjusting a screen refresh rate in the OLED display apparatus **3** of the first embodiment. As shown in FIG. **5**, the method comprises the following steps. In step **501**, it is determined whether a plurality of displayed neighbor frames are configured as a dynamic frame. If not, the method proceeds to step **503** to generate a first control signal, and in response to this, a clock signal with a first frequency is generated in step **505**. Otherwise, if the displayed neighbor frames are configured as a dynamic frame, then the method proceeds to step **507** to generate a second control signal, and in response to this, a clock signal of a second frequency is generated in step **509**. Subsequent to step **505** or **509**, the screen refresh rate is set in step **511** in response to the frequency of the clock signal, and the displayed neighbor frames will be displayed with this screen refresh rate.

In the second embodiment, step **501** can be performed through two ways, the first of which is shown in FIG. **6**A and comprises the following steps. First in step **601***a*, it is determined whether greater than or equal to a first predetermined percentage (e.g. 50 percent) of respective pixel data vary continuously in greater than or equal to a second predetermined percentage (e.g. 50 percent) of neighbor frames. If not, then the displayed neighbor frames are defined as a static frame in step **603***a*. Otherwise, the displayed neighbor frames are defined as a dynamic frame in step **605***a*. It should be notes that the definition of a dynamic frame depends on the actual

operations; for example, the percentages described above can be adjusted to be higher or lower than 50%, and this invention is not limited to this value. The first and the second predetermined percentage can be set by those with moderate skill in this field according to actual operations and requirements.

The second way to perform step **501** is shown in FIG. **6**B and comprises the following steps. First in step **601***b*, it is determined whether the display mode is a dynamic display mode. If so, then the displayed neighbor frame is defined as a dynamic frame in step **603***b*. Otherwise, the displayed neighbor frame is defined as a static frame in step **605***b*.

In addition to the steps depicted in FIGS. **5**, **6**A and **6**B, the second embodiment can also execute all the operations of the first embodiment. Those skilled in the art can understand the corresponding steps and operations of the second embodiment by following the descriptions of the first embodiment, and thus no unnecessary detail is given.

Accordingly, the present invention utilizes the original screen refresh rate for dynamic frames, and a higher screen refresh rate for non-dynamic frames. Therefore, a display apparatus can utilize these various screen refresh rates to mitigate the problem of frame ghosting, while achieving reduced power consumption and prolonged service life.

The above disclosure is related to the detailed technical contents and inventive features thereof. People skilled in this field may proceed with a variety of modifications and replacements based on the disclosures and suggestions of the invention as described without departing from the characteristics thereof. Nevertheless, although such modifications and replacements are not fully disclosed in the above descriptions, they have substantially been covered in the following claims as appended.

What is claimed is:

1. A drive circuit for adjusting a screen refresh rate, comprising:

a detection unit for determining whether a plurality of displayed frames of an organic light emitting diode display apparatus are configured as a dynamic frame, in which the detection unit generates a first control signal when the displayed frames are not configured as a dynamic frame, and the detection unit generates a second control signal when the displayed frames are configured as a dynamic frame;

a clock generating unit for generating a clock signal, wherein a frequency of the clock signal is a first frequency in response to the first control signal, and the frequency of the clock signal is a second frequency in response to the second control signal, the first frequency is greater than the second frequency; and

a timing control unit for setting the screen refresh rate in response to the frequency of the clock signal.

2. The drive circuit as claimed in claim **1**, wherein the detection unit determines whether pixel data being greater than or equal to a second predetermined percentage in a plurality of neighbor frames being greater than or equal to a first predetermined percentage vary continuously, in which the neighbor frames are defined as a static frame and the detection unit generates the first control signal when the pixel data in the neighbor frames do not vary continuously, and the neighbor frames are defined as the dynamic frame when the pixel data in the neighbor frames vary continuously.

3. The drive circuit as claimed in claim **2**, wherein the first predetermined percentage is 50%.

4. The drive circuit as claimed in claim **2**, wherein the second predetermined percentage is 50%.

5. The drive circuit as claimed in claim **2**, wherein the neighbor frames and a black frame are displayed alternately when the frequency of the clock signal is the first frequency.

6. The drive circuit as claimed in claim **2**, wherein the second frequency is an original display frequency of the neighbor frames.

7. The drive circuit as claimed in claim **1**, wherein the detection unit detects a display mode of the drive circuit, the detection unit generates the second control signal when the display mode is a dynamic display mode, and the detection unit generates the first control signal when the display mode is not the dynamic display mode, the dynamic display mode means that pixel data being greater than or equal to a second predetermined percentage in a plurality of neighbor frames being greater than or equal to a first predetermined percentage vary continuously.

8. The drive circuit as claimed in claim **7**, wherein the detection unit determines the display mode in response to an order inputted by a user.

9. The drive circuit as claimed in claim **1**, wherein the first frequency is greater than or equal to twice the second frequency.

10. An organic light emitting diode (OLED) display apparatus, comprising:

an organic light-emitting diode display array for displaying a plurality of frames according to a screen refresh rate; and

a drive circuit for determining whether the displayed frames of the OLED display apparatus are configured as a dynamic frame, in which the drive circuit sets a frequency of a clock signal into a first frequency when the displayed frames are not configured as a dynamic frame, and the drive circuit sets the frequency of the clock signal into a second frequency when the displayed frames are configured as a dynamic frame, wherein the first frequency is greater than the second frequency;

wherein the drive circuit sets the screen refresh rate in response to the frequency of the clock signal.

11. The OLED display apparatus as claimed in claim **10**, the drive circuit further comprising:

a detection unit for determining whether the displayed frames are configured as a dynamic frame, in which the detection unit generates a first control signal when the displayed frames are not configured as a dynamic frame, and the detection unit generates a second control signal when the displayed frames are configured as a dynamic frame;

a clock generating unit for generating the clock signal, wherein the frequency of the clock signal is the first frequency in response to the first control signal, and the frequency of the clock signal is the second frequency in response to the second control signal; and

a timing control unit for setting the screen refresh rate in response to the frequency of the clock signal.

12. The OLED display apparatus as claimed in claim **11**, wherein the detection unit determines whether pixel data being greater than or equal to a second predetermined percentage in a plurality of neighbor frames being greater than or equal to a first predetermined percentage vary continuously, in which the neighbor frames are defined as a static frame and the detection unit generates the first control signal when the pixel data in the neighbor frames do not vary continuously, and the neighbor frames are defined as the dynamic frame when the pixel data in the neighbor frames vary continuously.

13. The OLED display apparatus as claimed in claim **12**, wherein the first predetermined percentage is 50%.

14. The OLED display apparatus as claimed in claim 12, wherein the second predetermined percentage is 50%.

15. The OLED display apparatus as claimed in claim 12, wherein the neighbor frames and a black frame are displayed alternately when the drive circuit sets the screen refresh rate in response to the first frequency.

16. The OLED display apparatus as claimed in claim 12, wherein the second frequency is an original display frequency of the neighbor frames.

17. The OLED display apparatus as claimed in claim 11, wherein the detection unit detects a display mode of the OLED display array, the detection unit generates the second control signal when the display mode is a dynamic display mode, and the detection unit generates the first control signal when the display mode is not the dynamic display mode, the dynamic display mode means that pixel data being greater than or equal to a second predetermined percentage in a plurality of neighbor frames being greater than or equal to a first predetermined percentage vary continuously.

18. The OLED display apparatus as claimed in claim 17, wherein the detection unit determines the display mode in response to an order inputted by a user.

19. The OLED display apparatus as claimed in claim 10, wherein the first frequency is greater than or equal to twice the second frequency.

20. A method for adjusting a screen rate of, comprising the steps of:

determining whether a plurality of displayed frames of an organic light emitting diode display apparatus are configured as a dynamic frame;

generating a first control signal when the displayed frames are not configured as a dynamic frame;

generating a second control signal when the displayed frames are configured as a dynamic frame;

generating a clock signal, wherein a frequency of the clock signal is a first frequency in response to the first control signal, the frequency of the clock signal is a second frequency in response to the second control signal, and the first frequency is greater than the second frequency; and

setting the screen rate in response to the frequency of the clock signal.

21. The method as claimed in claim 20, the determining step further comprising the step of:

determining whether pixel data being greater than or equal to a second predetermined percentage in a plurality of neighbor frames being greater than or equal to a first predetermined percentage vary continuously;

defining the plurality of neighbor frames as a static frame when the pixel data in the neighbor frames do not vary continuously; and

defining the plurality of neighbor frames as the dynamic frame when the pixel data in the neighbor frames vary continuously.

22. The method as claimed in claim 21, further comprising the step of displaying the neighbor frames and a black frame alternately when the frequency of the clock signal is the first frequency.

23. The method as claimed in claim 21, wherein the second frequency is an original display frequency of the neighbor frames.

24. The method as claimed in claim 20, the determining step further comprising the step of:

detecting a display mode;

generating the second control signal when the display mode is a dynamic display mode; and

generating the first control signal when the display mode is not the dynamic display mode;

wherein the dynamic display mode means that pixel data being greater than or equal to a second predetermined percentage in a plurality of neighbor frames being greater than or equal to a first predetermined percentage vary continuously.

25. The method as claimed in claim 20, wherein the first frequency is greater than or equal to twice the second frequency.

* * * * *

专利名称(译)	驱动电路，显示装置和用于调整屏幕刷新率的方法		
公开(公告)号	US7952543	公开(公告)日	2011-05-31
申请号	US11/926507	申请日	2007-10-29
[标]申请(专利权)人(译)	友达光电股份有限公司		
申请(专利权)人(译)	友达光电.		
当前申请(专利权)人(译)	友达光电.		
[标]发明人	CHANG MENG HSIANG CHEN CHI WEN		
发明人	CHANG, MENG-HSIANG CHEN, CHI-WEN		
IPC分类号	G09G3/30		
CPC分类号	G09G3/3208 G09G2320/0257 G09G2360/16 G09G2340/16 G09G2340/0435		
助理审查员(译)	HARRIS，多萝西		
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外部链接	Espacenet USPTO		

摘要(译)

公开了一种用于调整显示装置的屏幕刷新率的显示装置和驱动电路及其方法。显示装置包括OLED二极管显示阵列和驱动电路。驱动电路包括检测单元，时钟生成单元和定时控制单元。检测单元确定由OLED二极管显示阵列显示的多个帧是否被配置为动态帧。当所显示的帧未被配置为动态帧时，检测单元产生第一控制信号，并且当所显示的帧被配置为动态帧时，检测单元产生第二控制信号。时钟生成单元生成时钟信号，其频率是响应于第一信号的第一频率，或响应于第二信号的第二频率。第一频率大于第二频率。定时控制单元响应于时钟信号的频率设置显示装置的屏幕刷新率。