(19) **United States**

(12) **Patent Application Publication** (10) Pub. No.: **US 2017/0186366 A1**
    Parikh et al.   (43) **Pub. Date:**   **Jun. 29, 2017**

(54) **DISPLAY CONTROL BASED ON A DIGITAL SIGNAL**

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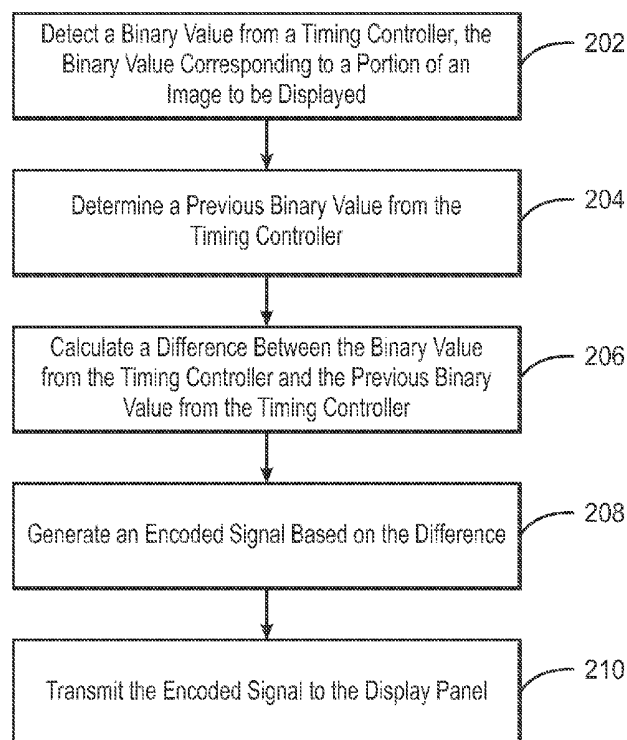
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Publication Classification

(57)   **ABSTRACT**

In one example, a method for controlling a display with a digital signal includes detecting a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed. The method can also include determining a previous binary value from the timing controller and calculating a difference between the binary value from the timing controller and the previous binary value from the timing controller. Furthermore, the method can include generating an encoded signal based on the difference and transmitting the encoded signal to a display panel.
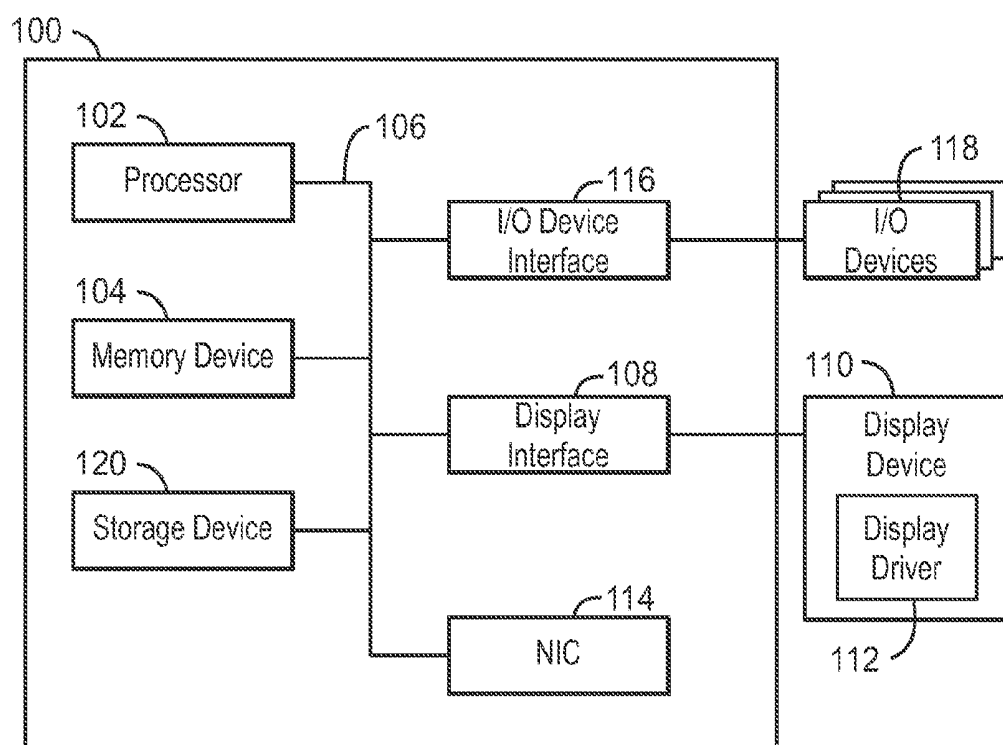
Detect a Binary Value from a Timing Controller, the Binary Value Corresponding to a Portion of an Image to be Displayed — 202

Determine a Previous Binary Value from the Timing Controller — 204

Calculate a Difference Between the Binary Value from the Timing Controller and the Previous Binary Value from the Timing Controller — 206

Generate an Encoded Signal Based on the Difference — 208

Transmit the Encoded Signal to the Display Panel — 210

200

FIG. 1

Detect a Binary Value from a Timing Controller, the Binary Value Corresponding to a Portion of an Image to be Displayed — 202

Determine a Previous Binary Value from the Timing Controller — 204

Calculate a Difference Between the Binary Value from the Timing Controller and the Previous Binary Value from the Timing Controller — 206

Generate an Encoded Signal Based on the Difference — 208

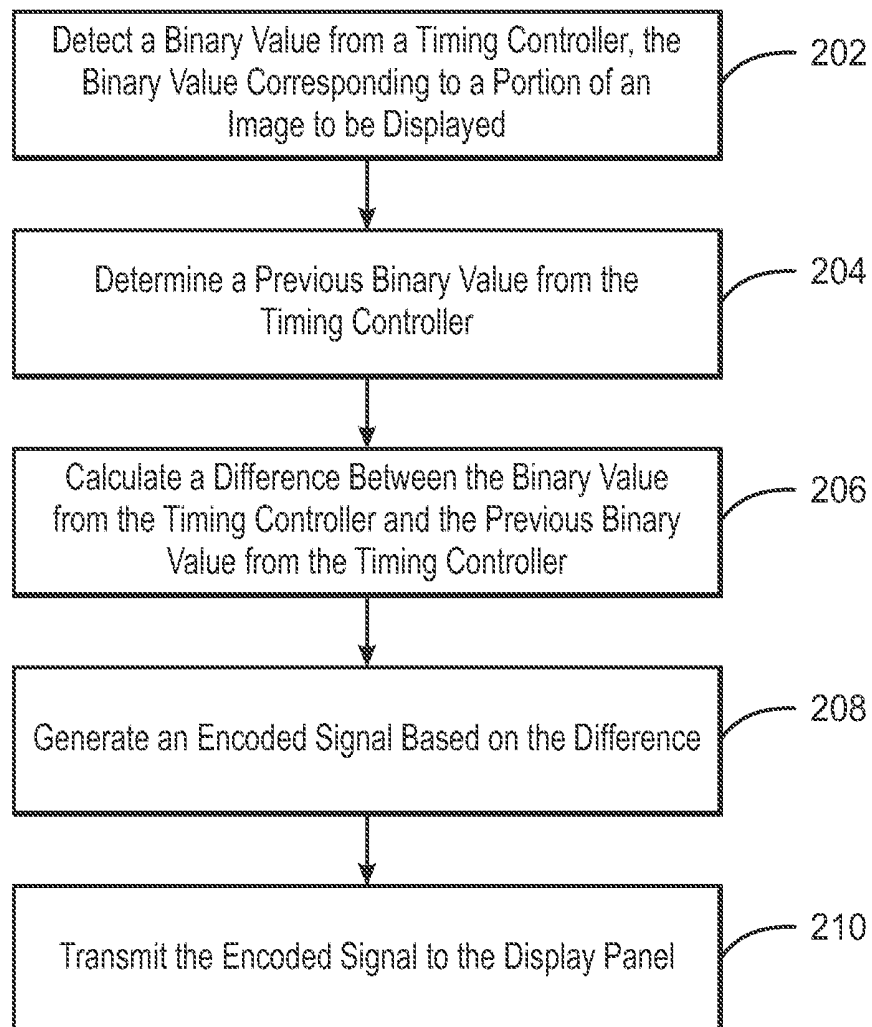Transmit the Encoded Signal to the Display Panel — 210

200

FIG. 2

FIG. 3

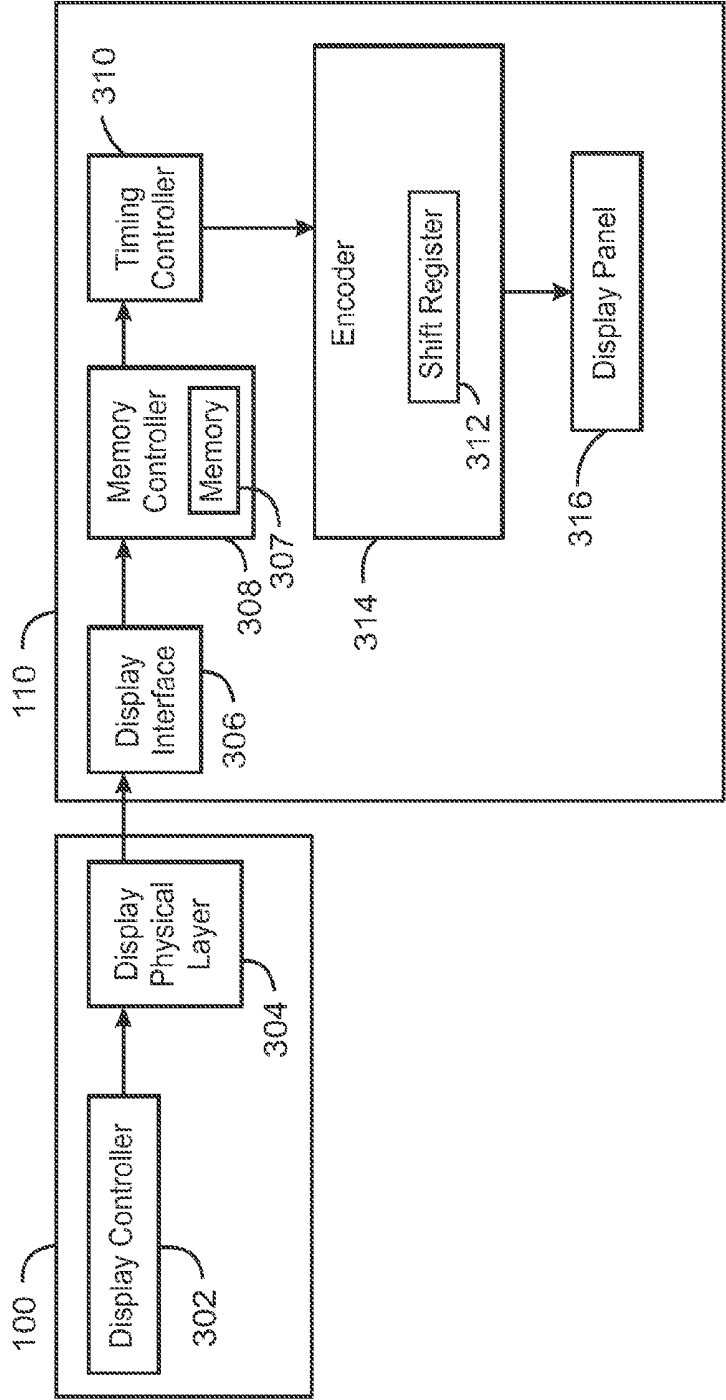## DISPLAY CONTROL BASED ON A DIGITAL SIGNAL

TECHNICAL FIELD

[0001] This disclosure relates generally to controlling a display and specifically, but not exclusively, to controlling a display based on a digital signal.

BACKGROUND

[0002] Display devices commonly include light-emitted diodes (LEDs), which provide a two-lead semiconductor light source. When a suitable voltage is applied to the light-emitted diodes, light is emitted. In some examples, display devices can include micro-LEDs that include arrays of microscopic LEDs that form individual pixel elements. The micro-LEDs can receive an analog signal to display images.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The following detailed description may be better understood by referencing the accompanying drawings, which contain specific examples of numerous features of the disclosed subject matter.
[0004] FIG. 1 illustrates a block diagram of a computing device that can transmit a generated encoded sequence to a display device;
[0005] FIG. 2 illustrates a process flow diagram for generating an encoded sequence; and
[0006] FIG. 3 illustrates a block diagram of an example driver that can generate an encoded sequence.
[0007] In some cases, the same numbers are used throughout the disclosure and the figures to reference like components and features. Numbers in the 100 series refer to features originally found in FIG. 1; numbers in the 200 series refer to features originally found in FIG. 2; and so on.

DESCRIPTION OF THE EMBODIMENTS

[0008] A growing number of flat panel display technologies are incorporating micro-LEDs, which use arrays of microscopic LEDs to form individual pixel elements. The micro-LED technology uses less energy than other comparable display devices that rely on organic LEDs, and the like. Furthermore, micro-LED display devices can be easily read in direct sunlight. However, some embodiments display images with micro-LEDs by providing currents to the micro-LEDs. The current values must be precise or there can be an exponential decrease in quantum efficiency of the micro-LEDs.
[0009] The techniques described herein include displaying images with micro-LEDs by providing digital signals to the micro-LEDs. In some embodiments, the digital signals transmitted to micro-LEDs in a display device can be based on a maximum voltage for the display device. The techniques described herein can include detecting a binary value from a timing controller, wherein the binary value corresponds to a portion of an image to be displayed. The techniques can also include calculating a difference between the binary value from the timing controller and a previous binary value from the timing controller. The techniques can then include generating an encoded signal based on the difference and transmitting the encoded signal to the display panel. Accordingly, the encoded signal, which is a digital signal based on a binary value, can be transmitted directly to

a display panel in order to display an image. Therefore, the techniques enable a display device to display an image without a digital to analog converter or a driver amplifier.
[0010] Reference in the specification to "one embodiment" or "an embodiment" of the disclosed subject matter means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosed subject matter. Thus, the phrase "in one embodiment" may appear in various places throughout the specification, but the phrase may not necessarily refer to the same embodiment.
[0011] FIG. 1 is a block diagram of an example of a host computing device that can transmit a generated encoded sequence to a display device. The host computing device 100 may be, for example, a mobile phone, laptop computer, desktop computer, or tablet computer, among others. The host computing device 100 may include a processor 102 that is adapted to execute stored instructions, as well as a memory device 104 that stores instructions that are executable by the processor 102. The processor 102 can be a single core processor, a multi-core processor, a computing cluster, or any number of other configurations. The memory device 104 can include random access memory, read only memory, flash memory, or any other suitable memory systems. The instructions that are executed by the processor 102 may be used to implement a method that can transmit a generated encoded sequence to a display device.
[0012] The processor 102 may also be linked through the system interconnect 106 (e.g., PCI®, PCI-Express®, NuBus, etc.) to a display interface 108 adapted to connect the host computing device 100 to a display device 110. The display device 110 may include a display screen that is a built-in component of the host computing device 100. The display device 110 may also include a computer monitor, television, or projector, among others, that is externally connected to the host computing device 100. The display device 110 can include light emitting diodes (LEDs), and micro-LEDs, among others. In some embodiments, the display interface 108 can include a display driver 112 that can generate an encoded signal and transmit the encoded signal to the display device 110. For example, the display driver 112 can detect a binary value from a timing controller and determine a previous binary value from the timing controller. The display driver 112 can also calculate a difference between the binary value from the timing controller and the previous binary value from the timing controller and generate an encoded signal based on the difference. Furthermore, the display driver 112 can transmit the encoded signal to the display panel.
[0013] In addition, a network interface controller (also referred to herein as a NIC) 114 may be adapted to connect the host computing device 100 through the system interconnect 106 to a network (not depicted). The network (not depicted) may be a cellular network, a radio network, a wide area network (WAN), a local area network (LAN), or the Internet, among others.
[0014] The processor 102 may be connected through a system interconnect 106 to an input/output (I/O) device interface 116 adapted to connect the computing host device 100 to one or more I/O devices 118. The I/O devices 118 may include, for example, a keyboard and a pointing device, wherein the pointing device may include a touchpad or a touchscreen, among others. The I/O devices 118 may be

built-in components of the host computing device **100**, or may be devices that are externally connected to the host computing device **100**.

[0015] In some embodiments, the processor **102** may also be linked through the system interconnect **106** to a storage device **120** that can include a hard drive, an optical drive, a USB flash drive, an array of drives, or any combinations thereof. In some embodiments, the storage device **120** can include any suitable applications.

[0016] It is to be understood that the block diagram of FIG. 1 is not intended to indicate that the host computing device **100** is to include all of the components shown in FIG. 1. Rather, the host computing device **100** can include fewer or additional components not illustrated in FIG. 1 (e.g., additional memory components, embedded controllers, additional modules, additional network interfaces, etc.). Furthermore, any of the functionalities of the display driver **112** may be partially, or entirely, implemented in hardware and/or in the processor **102**. For example, the functionality may be implemented with an application specific integrated circuit, logic implemented in an embedded controller, or in logic implemented in the processor **102**, among others. In some embodiments, the functionalities of the display driver **112** can be implemented with logic, wherein the logic, as referred to herein, can include any suitable hardware (e.g., a processor, among others), software (e.g., an application, among others), firmware, or any suitable combination of hardware, software, and firmware.

[0017] FIG. 2 illustrates a process flow diagram for generating an encoded sequence. The method **200** illustrated in FIG. 2 can be implemented with any suitable computing component or device, such as display device **110** of FIG. 1.

[0018] At block **202**, the display driver **112** can detect a binary value from a timing controller. The binary value can include any suitable data received by the display device that is to be displayed. For example, the binary value can correspond to a portion of an image transmitted from a computing device to a display device. In some embodiments, the timing controller can receive the binary value from a memory device in the display device. The timing controller s explained in greater detail below in relation to FIG. 3.

[0019] At block **204**, the display driver **112** can determine a previous binary value from the timing controller. For example, the display driver **112** can store any suitable number of binary values retrieved from the timing controller. In some embodiments, the display driver **112** may store the current or most recent binary value retrieved from the timing controller and the binary value retrieved from the timing controller preceding the current binary value.

[0020] At block **206**, the display driver **112** can calculate a difference between the binary value from the timing controller and the previous binary value from the timing controller. For example, the display driver **112** can use any suitable shifting operation, mathematical operation, or any other techniques for calculating the difference between two subsequent binary values retrieved from the timing controller.

[0021] At block **208**, the display driver **112** can generate an encoded signal based on the difference. For example, the display driver **112** can generate an encoded signal corresponding to a gray value that is to be displayed. In some embodiments, the display driver **112** can generate a set of encoded signals, wherein each of the encoded signals cor-

responds to a separate gray value based on a separate difference value between current binary values and previous binary values received from the timing controller. In some examples, each of the encoded signals comprises at least one period of time for providing a maximum voltage. For example, each encoded signal can include any suitable period of times during which a maximum voltage is applied to a display panel and any suitable period of times during which power is not applied to a display panel. Accordingly, a color value can be displayed at a display panel by applying a maximum voltage in a particular sequence based on the encoded signal. For example, each of the encoded signals can include a different density of encoded pulses based on each different gray value. In some embodiments, each gray value represents a number of pulses to be included in each encoded signal.

[0022] At block **210**, the display driver **112** can transmit the encoded signal to the display panel. In some embodiments, the display driver **112** can transmit the encoded signal directly to the display panel without amplification. Thus, a driver amplifier circuit may not be included in the display device. Similarly, a digital to analog converter may not be included in the display device since the encoded signal transmitted to the display panel is a digital signal. In some examples, the display driver **112** can repeatedly send the encoded signal to the display at a predetermined frame rate. In some embodiments, the display panel can be a micro-LED display panel, LED display panel, or any other suitable display panel. A micro-LED display panel, as referred to herein, can include any suitable number of microscopic LEDs forming individual pixel elements in a display panel.

[0023] The process flow diagram of FIG. 2 is not intended to indicate that the operations of the method **200** are to be executed in any particular order, or that all of the operations of the method **200** are to be included in every case. Additionally, the method **200** can include any suitable number of additional operations.

[0024] FIG. 3 illustrates a block diagram of an example driver that can generate an encoded sequence. In some embodiments, the driver illustrated in FIG. 3 can correspond to functionalities implemented by the display driver **112** of FIG. 1.

[0025] In some embodiments, a display controller **302** can display data by sending the data through a display physical layer **304** of a computing device **100** to a display interface **306** in a display device **110**. The display interface **306** can send the data to memory registers **307** via a memory controller **308**. A timing controller (TCON) **310**, can transmit the data to a shift register **312** included in an encoder **314**. In some embodiments, the timing controller **310** transmits the data from the memory **307** to the encoder **314** based on a predetermined timing sequence.

[0026] In some examples, the encoder **312** can store any suitable number of binary values retrieved from the timing controller **310**. For example, the encoder **312** may store a current binary value from the timing controller and a previous binary value from the timing controller. The encoder **312** can calculate the difference between the current binary value from the timing controller **310** and the preceding binary value retrieved from the timing controller **310**. The encoder **312** can also generate an encoded signal corresponding to the difference, wherein the encoded signal indicates a gray value to be displayed by a display panel **316**. The encoder **312** can send the encoded signal to the display

panel **316**, which can include micro-LEDs, LEDs, and the like. Thus, in some embodiments, the encoder **314** can perform the functions of the shift register **312**, a digital to analog converter, and a driver amplifier, among others. Accordingly, the encoder **312** can enable a display device to display an image without a digital to analog circuit or a signal amplifier.

EXAMPLE 1

[0027] In some examples, a system for controlling a display panel with a digital signal can include logic to detect a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed. The logic can also determine a previous binary value from the timing controller and calculate a difference between the binary value from the timing controller and the previous binary value from the timing controller. Furthermore, the logic can generate an encoded signal based on the difference and transmit the encoded signal to the display panel.

[0028] Alternatively, or in addition, the logic can generate a set of encoded signals, wherein each of the encoded signals corresponds to a separate gray value based on a separate difference value between current binary values and previous binary values. Alternatively, or in addition, each of the encoded signals comprises at least one period of time for providing a maximum voltage. Alternatively, or in addition, the logic can transmit the encoded signal directly to the display panel without amplification. Alternatively, or in addition, each of the encoded signals can include a different density of encoded pulses based on each different gray value. Alternatively, or in addition, the logic can repeatedly send the encoded signal to the display at a predetermined frame rate. Alternatively, or in addition, the display panel can be a micro-LED display panel. Alternatively, or in addition, each gray value can represent a number of pulses to be included in each encoded signal.

EXAMPLE 2

[0029] In some embodiments, a method for controlling a display with a digital signal can include detecting a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed and determining a previous binary value from the timing controller. The method can also include calculating a difference between the binary value from the timing controller and the previous binary value from the timing controller and generating an encoded signal based on the difference. Furthermore, the method can include transmitting the encoded signal to a display panel.

[0030] Alternatively, or in addition, the method can include generating a set of encoded signals, wherein each of the encoded signals corresponds to a separate gray value based on a separate difference value between current binary values and previous binary values. Alternatively, or in addition, each of the encoded signals comprises at least one period of time for providing a maximum voltage. Alternatively, or in addition, the method can include transmitting the encoded signal directly to the display panel without amplification. Alternatively, or in addition, each of the encoded signals can include a different density of encoded pulses based on each different gray value. Alternatively, or in addition, the method can include repeatedly sending the encoded signal to the display at a predetermined frame rate.

Alternatively, or in addition, the display panel can be a micro-LED display panel. Alternatively, or in addition, each gray value can represent a number of pulses to be included in each encoded signal.

EXAMPLE 3

[0031] In some examples, a system for controlling display panels with digital signals can include a display panel to display an image and logic to detect a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed. The logic can also determine a previous binary value from the timing controller and calculate a difference between the binary value from the timing controller and the previous binary value from the timing controller. Additionally, the logic can generate an encoded signal based on the difference and transmit the encoded signal to a display panel, the encoded signal to cause a timing sequence of a maximum voltage to be applied to the display panel.

[0032] Alternatively, or in addition, the logic can generate a set of encoded signals, wherein each of the encoded signals corresponds to a separate gray value based on a separate difference value between current binary values and previous binary values. Alternatively, or in addition, each of the encoded signals comprises at least one period of time for providing a maximum voltage. Alternatively, or in addition, the logic can transmit the encoded signal directly to the display panel without amplification. Alternatively, or in addition, each of the encoded signals can include a different density of encoded pulses based on each different gray value. Alternatively, or in addition, the logic can repeatedly send the encoded signal to the display at a predetermined frame rate. Alternatively, or in addition, the display panel can be a micro-LED display panel. Alternatively, or in addition, each gray value can represent a number of pulses to be included in each encoded signal. Alternatively, or in addition, the maximum voltage can correspond to a maximum voltage that a micro-LED of the display panel is enabled to receive without damage to the micro-LED.

EXAMPLE 4

[0033] In some embodiments, a system for controlling a display panel with a digital signal can include a means for detecting a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed. The system can also include means for determining a previous binary value from the timing controller and calculating a difference between the binary value from the timing controller and the previous binary value from the timing controller. Furthermore, the system can include means for generating an encoded signal based on the difference and transmitting the encoded signal to the display panel.

[0034] Although an example embodiment of the disclosed subject matter is described with reference to block and flow diagrams in FIGS. **1-3**, persons of ordinary skill in the art will readily appreciate that many other methods of implementing the disclosed subject matter may alternatively be used. For example, the order of execution of the blocks in flow diagrams may be changed, and/or some of the blocks in block/flow diagrams described may be changed, eliminated, or combined.

[0035] In the preceding description, various aspects of the disclosed subject matter have been described. For purposes of explanation, specific numbers, systems and configurations were set forth in order to provide a thorough understanding of the subject matter. However, it is apparent to one skilled in the art having the benefit of this disclosure that the subject matter may be practiced without the specific details. In other instances, well-known features, components, or modules were omitted, simplified, combined, or split in order not to obscure the disclosed subject matter.

[0036] Various embodiments of the disclosed subject matter may be implemented in hardware, firmware, software, or combination thereof, and may be described by reference to or in conjunction with program code, such as instructions, functions, procedures, data structures, logic, application programs, design representations or formats for simulation, emulation, and fabrication of a design, which when accessed by a machine results in the machine performing tasks, defining abstract data types or low-level hardware contexts, or producing a result.

[0037] Program code may represent hardware using a hardware description language or another functional description language which essentially provides a model of how designed hardware is expected to perform. Program code may be assembly or machine language or hardware-definition languages, or data that may be compiled and/or interpreted. Furthermore, it is common in the art to speak of software, in one form or another as taking an action or causing a result. Such expressions are merely a shorthand way of stating execution of program code by a processing system which causes a processor to perform an action or produce a result.

[0038] Program code may be stored in, for example, volatile and/or non-volatile memory, such as storage devices and/or an associated machine readable or machine accessible medium including solid-state memory, hard-drives, floppy-disks, optical storage, tapes, flash memory, memory sticks, digital video disks, digital versatile discs (DVDs), etc., as well as more exotic mediums such as machine-accessible biological state preserving storage. A machine readable medium may include any tangible mechanism for storing, transmitting, or receiving information in a form readable by a machine, such as antennas, optical fibers, communication interfaces, etc. Program code may be transmitted in the form of packets, serial data, parallel data, etc., and may be used in a compressed or encrypted format.

[0039] Program code may be implemented in programs executing on programmable machines such as mobile or stationary computers, personal digital assistants, set top boxes, cellular telephones and pagers, and other electronic devices, each including a processor, volatile and/or non-volatile memory readable by the processor, at least one input device and/or one or more output devices. Program code may be applied to the data entered using the input device to perform the described embodiments and to generate output information. The output information may be applied to one or more output devices. One of ordinary skill in the art may appreciate that embodiments of the disclosed subject matter can be practiced with various computer system configurations, including multiprocessor or multiple-core processor systems, minicomputers, mainframe computers, as well as pervasive or miniature computers or processors that may be embedded into virtually any device. Embodiments of the disclosed subject matter can also be practiced in distributed computing environments where tasks may be performed by remote processing devices that are linked through a communications network.

[0040] Although operations may be described as a sequential process, some of the operations may in fact be performed in parallel, concurrently, and/or in a distributed environment, and with program code stored locally and/or remotely for access by single or multi-processor machines. In addition, in some embodiments the order of operations may be rearranged without departing from the spirit of the disclosed subject matter. Program code may be used by or in conjunction with embedded controllers.

[0041] While the disclosed subject matter has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the subject matter, which are apparent to persons skilled in the art to which the disclosed subject matter pertains are deemed to lie within the scope of the disclosed subject matter.

What is claimed is:

1. A system for controlling a display panel with a digital signal comprising:

logic to:

detect a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed;

determine a previous binary value from the timing controller;

calculate a difference between the binary value from the timing controller and the previous binary value from the timing controller;

generate an encoded signal based on the difference; and

transmit the encoded signal to the display panel.

2. The system of claim 1, wherein the logic is to generate a set of encoded signals, wherein each of the encoded signals corresponds to a separate gray value based on a separate difference value between current binary values and previous binary values.

3. The system of claim 1, wherein each of the encoded signals comprises at least one period of time for providing a maximum voltage.

4. The system of claim 1, wherein the logic is to transmit the encoded signal directly to the display panel without amplification.

5. The system of claim 2, wherein each of the encoded signals comprises a different density of encoded pulses based on each different gray value.

6. The system of claim 1, wherein the logic is to repeatedly send the encoded signal to the display at a predetermined frame rate.

7. The system of claim 1, wherein the display panel is a micro-LED display panel.

8. The system of claim 1, wherein each gray value represents a number of pulses to be included in each encoded signal.

9. A method for controlling a display with a digital signal comprising:

detecting a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed;

determining a previous binary value from the timing controller;

calculating a difference between the binary value from the timing controller and the previous binary value from the timing controller;

generating an encoded signal based on the difference; and

transmitting the encoded signal to a display panel.

10. The method of claim 9, comprising generating a set of encoded signals, wherein each of the encoded signals cor-

responds to a separate gray value based on a separate difference value between current binary values and previous binary values.

11. The method of claim **9**, wherein each of the encoded signals comprises at least one period of time for providing a maximum voltage.

12. The method of claim **9**, comprising transmitting the encoded signal directly to the display pan& without amplification.

13. The method of claim **10**, wherein each of the encoded signals comprises a different density of encoded pulses based on each different gray value.

14. The method of claim **9**, comprising repeatedly sending the encoded signal to the display panel at a predetermined frame rate.

15. The method of claim **9**, wherein the display panel is a micro-LED display panel.

16. A system for controlling display panels with digital signals comprising;
    a display panel to display an image; and
    logic to:
        detect a binary value from a timing controller, the binary value corresponding to a portion of an image to be displayed;
        determine a previous binary value from the timing controller;
        calculate a difference between the binary value from the timing controller and the previous binary value from the timing controller;
        generate an encoded signal based on the difference; and
        transmit the encoded signal to a display panel, the encoded signal to cause a timing sequence of a maximum voltage to be applied to the display panel.

17. The system of claim **16**, wherein the maximum voltage corresponds to maximum voltage that a micro-LED of the display panel is enabled to receive without damage to the micro-LED.

18. The system of claim **16**, wherein the logic is to generate a set of encoded signals, wherein each of the encoded signals corresponds to a separate gray value based on a separate difference value between current binary values and previous binary values.

19. The system of claim **16**, wherein the logic is to transmit the encoded signal directly to the display panel without amplification.

20. The system of claim **16**, wherein the logic is to repeatedly send the encoded signal to the display at a predetermined frame rate.

* * * * *

专利名称(译)	基于数字信号的显示控制		
公开(公告)号	US20170186366A1	公开(公告)日	2017-06-29
申请号	US14/757637	申请日	2015-12-23
[标]申请(专利权)人(译)	英特尔公司		
申请(专利权)人(译)	英特尔公司		
当前申请(专利权)人(译)	英特尔公司		
[标]发明人	PARIKH KUNJAL AHMED KHALED RADHAKRISHNAN PRAKASH K CHANG PETER L RANGANATHAN RAVI		
发明人	PARIKH, KUNJAL AHMED, KHALED RADHAKRISHNAN, PRAKASH K. CHANG, PETER L. RANGANATHAN, RAVI		
IPC分类号	G09G3/32 G09G3/20		
CPC分类号	G09G3/32 G09G3/2003 G09G2320/0242 G09G2310/08 G09G2300/0404 G09G3/2018		
其他公开文献	US9922592		
外部链接	Espacenet USPTO		

摘要(译)

在一个示例中，用于利用数字信号控制显示器的方法包括从定时控制器检测二进制值，该二进制值对应于要显示的图像的一部分。该方法还可以包括从定时控制器确定先前的二进制值，并计算来自定时控制器的二进制值与来自定时控制器的先前二进制值之间的差。此外，该方法可以包括基于该差异生成编码信号并将编码信号发送到显示面板。