



G00002

Image Display Apparatus and Its Method of Operation

This application is based on applications No.11-194551 filed in Japan on July 8, 1999, No. 11-302493 filed in Japan on Oct. 25, 1999, and No. 5 11-303134 in Japan on Oct. 25, 1999, the contents of which are incorporated hereinto by references.



BACKGROUND OF THE INVENTION

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The present invention relates to a display apparatus provided with a plurality of light emitting devices such as light emitting diodes arrayed in a matrix display panel, and to its method of operation. 10

Currently, bright red, green, and blue (RGB) light emitting diodes (LEDs) of 1000mcd or more have been developed, and fabrication of large-scale LED displays has become possible. These LED displays have 15 features such as low power consumption, lightness in weight, and the possibility for thin panel display. Further, demand for large-scale displays, which can be used out doors, has increased dramatically.

Practical large-scale LED displays are configured to fit the installation space by assembling a plurality of LED units. An LED unit is formed from a dot 20 matrix array of RGB LEDs arranged on a substrate board.

Further, an LED display is provided with a driver circuit capable of driving each individual light emitting diode. Specifically, each LED control device, which transmits display data to each LED unit, is connected to the LED display, and a plurality of LED units is connected to form one large-scale LED display. 25 The number of LED units used increases as the LED display becomes larger in scale. For example, a large-scale display can use 300 vertical x 400 horizontal, or 120,000 LED units.

The LED display uses a dynamic driver system as its driver method, and specifically, the display is connected and driven as described below.

30 For example, in an $m \times n$ dot matrix LED unit, each LED anode in each

line is connected to a common source line, and each LED cathode in each column is connected to a common current line. The m-line common source lines are sequentially turned on for display with a prescribed period. For example, m-line common source line switching is performed via decoder circuitry based
5 on the address signal.

However, when LEDs connected to a selected common source line were activated in related art apparatus, charge accumulated in non-activated LEDs connected to unselected common source lines. When these common source lines were then selected, excess current developed as a result of charge
10 built-up during their inactive period. As a result of this problem, LEDs controlled to be off emitted low levels of light and sufficient image contrast could not be obtained. These types of effects caused display quality degradation.

Thus, the object of the present invention is to reduce the effects of accumulated charge and provide a high quality image display apparatus and its
15 method of operation.

The above and further objects and features of the invention will more fully be apparent from the following detailed description with accompanying drawings.

20 SUMMARY OF THE INVENTION

The image display apparatus of the present invention is provided with a dot matrix of light emitting devices, driver circuitry, and a switching circuit section. The dot matrix is a plurality of light emitting devices arranged in a matrix of m-lines and n-columns. One terminal of each light emitting device in
25 each column is connected to a current line, and the other terminal of each light emitting device in each line is connected to a common source line. Driver circuitry controls the display drive to be in an active or inactive state depending on an input illumination signal. In the display drive active state, driver circuitry controls connection of one end of each common source line and each current
30 line according to input display data. The switching circuit section floats the other

end of each common source line in the active state and connects the other end of all common source lines to ground in the inactive state.

In this image display apparatus, charge accumulated at light emitting devices and their periphery in the active state, is discharged via the switching
5 circuit section during the inactive state. Consequently, the effects of charge accumulated during active illumination of prescribed light emitting devices are essentially eliminated, and a high quality image display apparatus is realized.

In the image display apparatus of the present invention, driver circuitry can be configured as m-units of current source switching circuits connected to
10 respective common source lines, and a constant current control circuit section. In the active state, a current source switching circuit connects a current source to the common source line selected by an input address signal. The constant current control circuit section is provided with memory circuits, and these memory circuits store pixel level data for n-pixels of sequentially input display
15 data. In the active state, the constant current control circuit section drives a current line for the pixel level width corresponding to pixel level data stored in the memory circuit.

Further, the present invention is a method of operation of an image display apparatus provided with a plurality of light emitting devices arranged in a
20 dot matrix of m-lines and n-columns, wherein one terminal of each light emitting device in each column is connected to a current line, and the other terminal of each light emitting device in each line is connected to a common source line. This method of operation is characterized by inclusion of a step to control active and inactive states according to an illumination control signal which controls the
25 state of illumination, a step to control conduction through one end of each common source line and one end of each current line in the active state based on input display data, and a step to float the other end of each common source line in the active state and ground the other end of each common source line in the inactive state.

30 In the image display apparatus and method of operation of the present

invention, charge accumulated at light emitting devices and their periphery in the active state can be discharged via the switching circuit section during the inactive state. Consequently, the effects of charge accumulated during active illumination of prescribed light emitting devices can essentially be eliminated, and a high quality image display apparatus and method of operation can be offered.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a conceptual drawing showing the structural format of the image display apparatus of an embodiment of the present invention.

Fig. 2 is a block diagram showing a specific example of the image display apparatus shown in Fig. 1.

Fig. 3 is a block diagram showing another specific example of the image display apparatus.

Fig. 4 is a timing diagram showing common source driver and switching circuitry control for the image display apparatus shown in Fig. 3

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Fig. 1 is a conceptual drawing illustrating an image display apparatus provided with a switching circuit section to discharge accumulated charge in the dot matrix. The display apparatus of Fig. 1 is provided with an LED dot matrix 10, a current source switching circuit 1, a constant current control circuit section 3, and a switching circuit section 2. The display apparatus of Fig. 1 uses LEDs as light emitting devices, but devices other than LEDs may also be used as the light emitting devices.

(1) The LED dot matrix 10 is a plurality of LEDs 4 arranged in an m-line, n-column matrix. The cathode of each LED 4 in each column is connected to a current line 6. The anode of each LED 4 in each line is connected to a common source line 5.

(2) The current source switching circuit 1 is provided with m-switching circuits which correspond to, and are connected to, each respective common source line 5. The current source switching circuit 1 connects a current source to the common source line 5 selected by the address signal for the illumination period specified by the input illumination control signal. This supplies current to the LEDs 4 connected to the selected common source line 5.

(3) The constant current control circuit section 3 is provided with memory circuits to store n-sets of sequentially input pixel level data. The constant current control circuit section 3 drives the current lines with a pixel level width, corresponding to the pixel level data stored in each memory circuit, over the time interval specified by the input illumination control signal.

(4) The switching circuit section 2 floats the opposite end of each common source line over the illumination time interval of the input illumination control signal, and grounds the opposite end of each common source line during the off interval (non-illumination interval) of the input illumination control signal.

In a display apparatus with the above configuration, on-off switching of the current source switching circuit 1, the constant current control circuit section 3, and the switching circuit section 2 are all performed according to the illumination control signal. During the illumination interval of the illumination control signal, the current source switching circuit 1 and the constant current control circuit section 3 are activated, while the switching circuit section 2 is deactivated (each switch connected to the opposite end of a common source line is off). When activated, the current source switching circuit 1 connects a common source line selected by the input address signal to the current source. At this time, the constant current control circuit section 3 drives the current lines with a pixel level width corresponding to pixel level data stored in each memory circuit. In this manner, LEDs 4 connected to the common source line selected by the address signal are illuminated with the pixel level width corresponding to the associated pixel level data. Further, in the deactivated state, both the current source switching circuit 1 and the constant current control circuit section

3 are deactivated, while the switching circuit section 2 is activated. Consequently, during off intervals indicated by the illumination control signal, charge accumulated by each LED or its associated connections is discharged to ground via each closed switch in the switching circuit section 2. Therefore, each
5 LED and its associated connections do not accumulate charge under these conditions.

Subsequently, illumination intervals and off intervals are sequentially repeated. LEDs disposed in each line are sequentially illuminated during each illumination interval, and the desired image is displayed on the LED dot matrix.
10 With this system, charge accumulated by LEDs (or their associated connections) which are not illuminated during an illumination interval, is discharged during the next off interval. Consequently, during the illumination interval, LED illumination can be controlled with each LED and its associated connections always in a discharged state with no unwanted charge build-up.

15 Accordingly, the display apparatus of Fig. 1 can obtain sufficient image contrast, and high quality display is possible. This is because illumination control can be accomplished without the effects of charge accumulation.

Turning to Fig. 2, the following describes a specific configuration of the display apparatus of the present invention. In Fig. 2, items which are the same
20 as those in Fig. 1 are labeled with the same part number.

As shown in Fig. 2, the current source switching circuit 1 of this specific embodiment comprises a decoder circuit 11 and common source drivers 12. When the illumination control signal is in a digital signal low state (LOW), the decoder circuit 11 controls the common source drivers 12 on or off for current
25 source connection to the common source line 5 selected by the address signal. When the illumination control signal is in a digital signal high state (HIGH), the current source switching circuit 1 controls the common source drivers 12 via the decoder circuit 11 to disconnect all common source lines from the current source.

30 When the illumination control signal is LOW, this type of current source

switching circuit 1 connects only the common source line 5 of the LED dot matrix 10 selected by the address signal to the current source.

The constant current control circuit section 3 is provided with a shift register 31, memory circuits 32, a counter 33, data comparators 34, and a
5 constant current driver section 35. In this type of constant current control circuit section 3, pixel level data are shifted n-times by the shift register in synchronization with a shift clock. Pixel level data corresponding to each of the n-current lines are clocked into, and stored in, respective memory circuits 32 in response to a latch clock signal. When the illumination control signal is LOW,
10 the output signal from data comparators 34 is input to the constant current driver section 35. The data comparators compare pixel level data with the value output from a counter 33 clocked by a pixel level reference clock used as the counter clock. The constant current driver section 35 controls the flow of constant current in each current line for a driver pulse width interval
15 corresponding to the pixel level data value.

As described above, the current source switching circuit 1 and the constant current control circuit section 3 perform LED display pixel level control when the illumination control signal is LOW. When the illumination control signal is HIGH, the LED dot matrix is not connected to the current source switching
20 circuit 1 or the constant current control circuit section 3.

When the illumination control signal is HIGH, the switching circuit section 2 turns on switches to ground all common source lines 5. When the illumination control signal is LOW, switches are turned off to disconnect (float) all common source lines 5.

25 The display apparatus of Fig. 2 configured as described above drives the LED dot matrix 10 with constant current to illuminate prescribed LEDs when the illumination control signal is LOW. When the illumination control signal is HIGH, constant drive of the LED dot matrix 10 is suspended. In this state, accumulated residual charge in each LED of the LED dot matrix 10 and its
30 associated connections is discharged via the switching circuit section 2.

The embodiment of Fig. 2 described above is organized to drive the LED dot matrix 10 with constant current when the illumination control signal is LOW, and to turn the switching circuit section 2 on when the illumination control signal is HIGH. However, the present invention is not restricted to this system, and control may also be performed with the LOW level and HIGH level reversed.

Turning to Fig. 3, another embodiment of the image display apparatus of the present invention is shown. Elements of Fig. 3 which are the same as those of Figs. 1 and 2 are labeled with the same part number. The image display apparatus shown in Fig. 3 is provided with a switching decoder circuit 13, which separately controls each switch SW1-6 of the switching circuit section 2. The switching decoder circuit 13 controls each switch SW1-6 of the switching circuit section 2 ON and OFF based on input signals such as the address signal and the illumination control signal. When the illumination control signal is logic HIGH, the switching decoder circuit 13 controls only the switch selected by the address signal ON to ground only the common source line connected to that switch. At this time, all remaining switches not selected by the address signal are OFF, and all remaining common source lines connected to those switches are left floating.

The timing diagram of Fig. 4 shows display apparatus control for the current source switching circuit 1 common source drivers 12 and for each switch SW1-6 of the switching circuit section. The common lines 1-6 shown in Fig. 4 are the common source lines connected to the corresponding switches SW1-6 of the switching circuit section 2.

As shown in Fig. 4, when the illumination control signal is logic LOW, the current source switching circuit 1 controls the common source drivers 12 to connect only the common source line 5 selected by the address signal to the current source. Further, when the illumination control signal is logic HIGH, the switching decoder circuit 13 turns only the switch selected by the address signal ON to ground that common source line. For example, when the address signal

is 0 and the illumination control signal is LOW, common line 1 is controlled ON, and the current source is connected only to that common source line. At this time, all the switches SW1-6 are controlled OFF. Next, when the address signal is 0 and the illumination control signal goes HIGH, common line 1 is controlled
5 OFF, in addition only SW1 connected to the other end of common line 1 is controlled ON, and only that common source line is grounded. When an illuminated LED goes to the inactive state (not illuminated), the switching decoder circuit 13 immediately controls the switching circuit section 2 to ground the common source line connected to that LED. This is done to effectively
10 prevent accumulation of charge when an illuminated LED is turned OFF.

In the manner described above, common source lines 1-6 and switches SW1-6 are selected according to the address signal, and the selected common source lines and switches are controlled ON or OFF by LOW and HIGH logic levels of the illumination control signal. By successive repetition of LED
15 illumination and common source line grounding, this image display apparatus displays a prescribed image on the LED dot matrix. In this display apparatus, only the switch connected to the selected common source line is turned ON. Therefore, low level current flow through unselected line LEDs is reliably prevented, and low level illumination of these unselected LEDs can be
20 prevented.

As this invention may be embodied in several forms without departing from the spirit of essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appending claims rather than by the description preceding them,
25 and all changes that fall within the meets and bounds of the claims, or equivalence of such meets and bounds thereof are therefore intended to be embraced by the claims.

What is claimed is:

1. An image display apparatus comprising:

5 a dot matrix of a plurality of light emitting devices arranged in a matrix with m-lines and n-columns, one terminal of each of the light emitting devices disposed in each column is connected to a respective current line, and the other terminal of each of the light emitting devices disposed in each line is connected to a respective common source line;

10 driver circuitry operable to control an activation state to be either active or inactive depending on an input illumination control signal and, in the active state, control conduction through one end of each common source line and each current line based on input display data; and

15 a switching circuit section operable to float the other end of each common source line in the active state, and to ground the other end of each common source line in the inactive state;

20 wherein said driver circuitry is provided with a current source switching circuit with m-switching circuits corresponding to each common source line and, in the active state, said current source switching circuit is operable to connect the common source line selected by an input address signal to the current source; and

25 wherein said driver circuitry is provided with a constant current control circuit section having memory circuits operable to store n-sets of pixel level data of the sequentially input display data and, in the active state, said constant current control circuit section is operable to put the related current line in the conducting state for a pixel level width corresponding to the pixel level data stored in each of said memory circuits.

2. An image display apparatus comprising:

30 a dot matrix of a plurality of light emitting diodes (LEDs) arranged in a matrix with m-lines and n-columns, a cathode of each of the LEDs disposed in

each column is connected to a respective current line, and an anode of each of the LEDs disposed in each line is connected to a respective common source line;

driver circuitry operable to control an activation state to be either active
5 or inactive depending on an input illumination control signal and, in the active state, control conduction through one end of each common source line and each current line based on input display data; and

a switching circuit section operable to float the other end of each common source line in the active state, and to ground the other end of each
10 common source line in the inactive state;

wherein said driver circuitry is provided with a current source switching circuit with m-switching circuits corresponding to each common source line and, in the active state, said current source switching circuit is operable to connect the common source line selected by an input address signal to the current
15 source; and

wherein said driver circuitry is provided with a constant current control circuit section having memory circuits operable to store n-sets of pixel level data of the sequentially input display data and, in the active state, said constant current control circuit section is operable to put the related current line in the
20 conducting state for a pixel level width corresponding to the pixel level data stored in each of said memory circuits.

3. An image display apparatus as recited in claim 1, wherein said switching circuit section is a plurality of switches connected between each common
25 source line and ground.

4. An image display apparatus as recited in claim 1, wherein said switching circuit section is controlled by the illumination control signal which controls a state of light emitting device illumination to be on or off, wherein in the
30 illumination on state of the illumination control signal, said switching circuit

section is operable to disconnect the common source line from ground, and wherein in the illumination off state, said switching circuits is operable to connect the common source line to ground.

5 5. An image display apparatus as recited in claim 3 wherein said switching circuit section is controlled by the illumination control signal which controls a state of light emitting device illumination to be on or off, wherein in the illumination on state, said switches of said switching circuit section are turned off to disconnect the common source line from ground, and wherein in the
10 illumination off state, said switches of the switching circuit section are turned on to connect the common source line to ground.

6. An image display apparatus as recited in claim 1, wherein said switching circuit section is operable to disconnect the common source line from ground for
15 a logic LOW illumination control signal for light emitting device activation, and connect the common source line to ground for a logic HIGH illumination control signal for light emitting device deactivation.

7. An image display apparatus as recited in claim 2, wherein said switching
20 circuit section is a plurality of switches connected between each common source line and ground.

8. An image display apparatus as recited in claim 2, wherein said switching circuit section is controlled by the illumination control signal which controls a
25 state of LED illumination to be on or off, wherein in the illumination on state of the illumination control signal, said switching circuit section is operable to disconnect the common source line from ground, and wherein in the illumination off state, said switching circuits is operable to connect the common source line to ground.

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9. An image display apparatus as recited in claim 7 wherein said switching circuit section is controlled by the illumination control signal which controls a state of LED illumination to be on or off, wherein in the illumination on state, said switches of said switching circuit section are turned off to disconnect the common source line from ground, and wherein in the illumination off state, said switches of the switching circuit section are turned on to connect the common source line to ground.
10. An image display apparatus as recited in claim 2, wherein said switching circuit section is operable to disconnect the common source line from ground for a logic LOW illumination control signal for LED activation, and connect the common source line to ground for a logic HIGH illumination control signal for LED deactivation.
11. An image display method comprising:
- providing a dot matrix of a plurality of light emitting devices to be arranged in a matrix with m-lines and n-columns such that one terminal of each of the light emitting devices disposed in each column is connected to a respective current line, and the other terminal of each of the light emitting devices disposed in each line is connected to a respective common source line;
 - controlling an activation state to be either active or inactive depending on an input illumination control signal and, in the active state, controlling conduction through one end of each common source line and each current line based on input display data; and
 - floating the other end of each common source line in the active state, and grounding the other end of each common source line in the inactive state;
 - connecting, in the active state, the common source line selected by an input address signal to the current source; and
 - storing n-sets of pixel level data of the sequentially input display data and, in the active state, putting the related current line in the conducting state

for a pixel level width corresponding to the stored pixel level data.

12. An image display method as recited in claim 11, wherein said floating is achieved by providing a plurality of switches to be connected between each
5 common source line and ground.

13. An image display method as recited in claim 11, wherein the illumination control signal controls a state of the light emitting device illumination to be on or off, wherein in the illumination on state of the illumination control signal, the
10 common source line is disconnected from ground, and wherein in the illumination off state, the common source line is connected to ground.

14. An image display method as recited in claim 12, wherein the illumination control signal controls a state of the light emitting device illumination to be on or
15 off, wherein in the illumination on state, the switches are tuned off to disconnect the common source line from ground, and wherein in the illumination off state, the switches are turned on to connect the common source line to ground.

15. An image display method as recited in claim 11, wherein the common
20 source line is disconnected from ground for a logic LOW illumination control signal for light emitting device activation, and the common source line is connected to ground for a logic HIGH illumination control signal for light emitting device deactivation.

25 16. An image display method comprising:

providing a dot matrix of a plurality of light emitting diodes (LEDs) to be arranged in a matrix with m-lines and n-columns such that a cathode of each of the LEDs disposed in each column is connected to a respective current line, and an anode of each of the LEDs disposed in each line is connected to a
30 respective common source line;

controlling an activation state to be either active or inactive depending on an input illumination control signal and, in the active state, controlling conduction through one end of each common source line and each current line based on input display data; and

5 floating the other end of each common source line in the active state, and grounding the other end of each common source line in the inactive state;

connecting, in the active state, the common source line selected by an input address signal to the current source; and

storing n-sets of pixel level data of the sequentially input display data
10 and, in the active state, putting the related current line in the conducting state for a pixel level width corresponding to the stored pixel level data.

17. An image display method as recited in claim 16, wherein said floating is achieved by providing a plurality of switches to be connected between each
15 common source line and ground.

18. An image display method as recited in claim 16, wherein the illumination control signal controls a state of LED illumination to be on or off, wherein in the illumination on state of the illumination control signal, the common source line is
20 disconnected from ground, and wherein in the illumination off state, the common source line is connected to ground.

19. An image display method as recited in claim 17, wherein the illumination control signal controls a state of LED illumination to be on or off, wherein in the illumination on state, the switches are timed off to disconnect the common
25 source line from ground, and wherein in the illumination off state, the switches are tuned on to connect the common source line to ground.

20. An image display method as recited in claim 16, wherein the common
30 source line is disconnected from ground for a logic LOW illumination control

signal for LED activation, and the common source line is connected to ground for a logic HIGH illumination control signal for LED deactivation.