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(54) **METHOD AND APPARATUS FOR DRIVING LIQUID CRYSTAL DISPLAY**

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(73) Assignee: **LG Display Co., Ltd.**, Seoul (KR)

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G09G 3/36 (2006.01)

(52) **U.S. Cl.** **345/102**; 345/690; 348/672

(58) **Field of Classification Search** 345/87–89, 345/98, 102, 690; 348/672
See application file for complete search history.

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(57) **ABSTRACT**

A driving method and apparatus for a liquid crystal display are disclosed that stabilizes the variation of the brightness of a back light in correspondence with data to be displayed. In the method, the data is converted into brightness components. The brightness components are divided into a plurality of brightness areas. The brightness components are arranged into a histogram for each frame and thereafter a control value of a most-frequent value or average value of the histogram is extracted. The extracted control value is stored along with other control values including the extracted control value of a frame prior to the control value of the current frame by at least two frames. The brightness of the back light is controlled using the extracted control value of the current frame and one or more of the other stored control values.

19 Claims, 10 Drawing Sheets

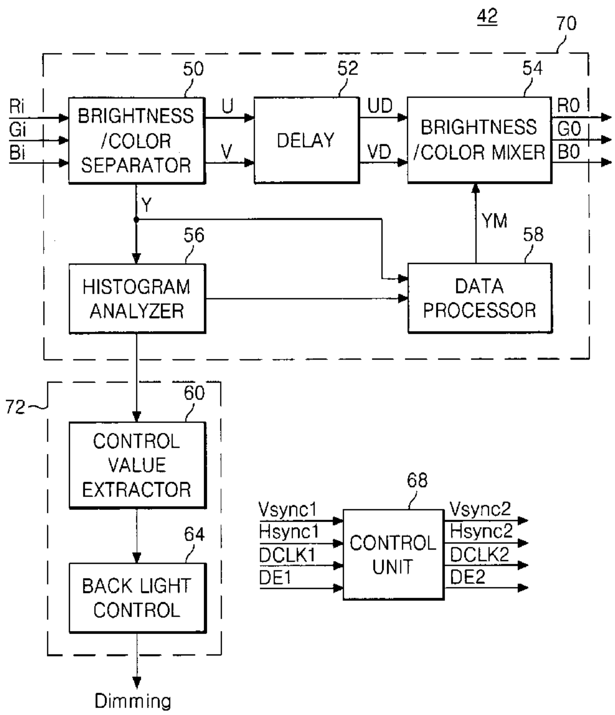


FIG. 1
RELATED ART

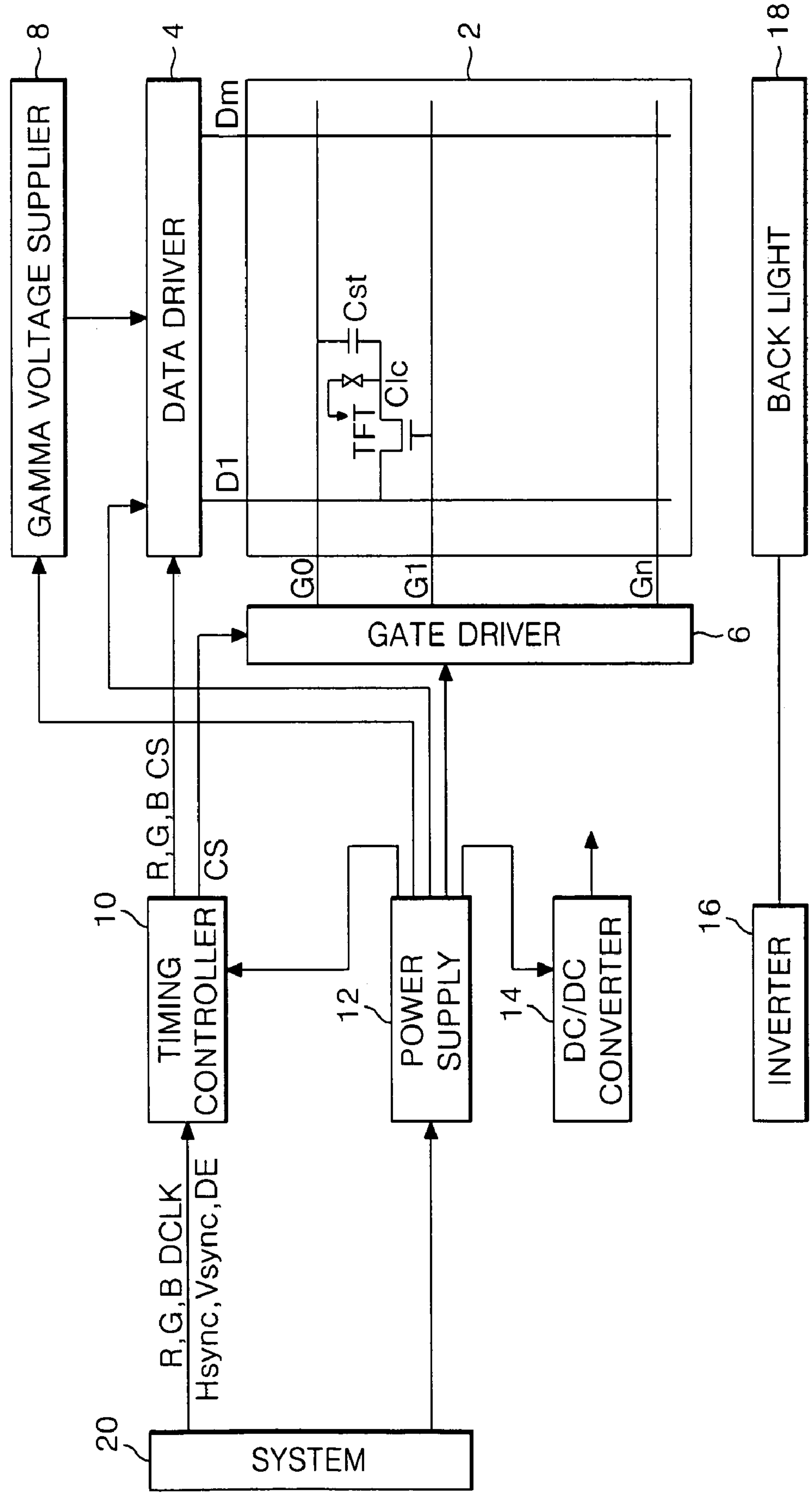


FIG. 2

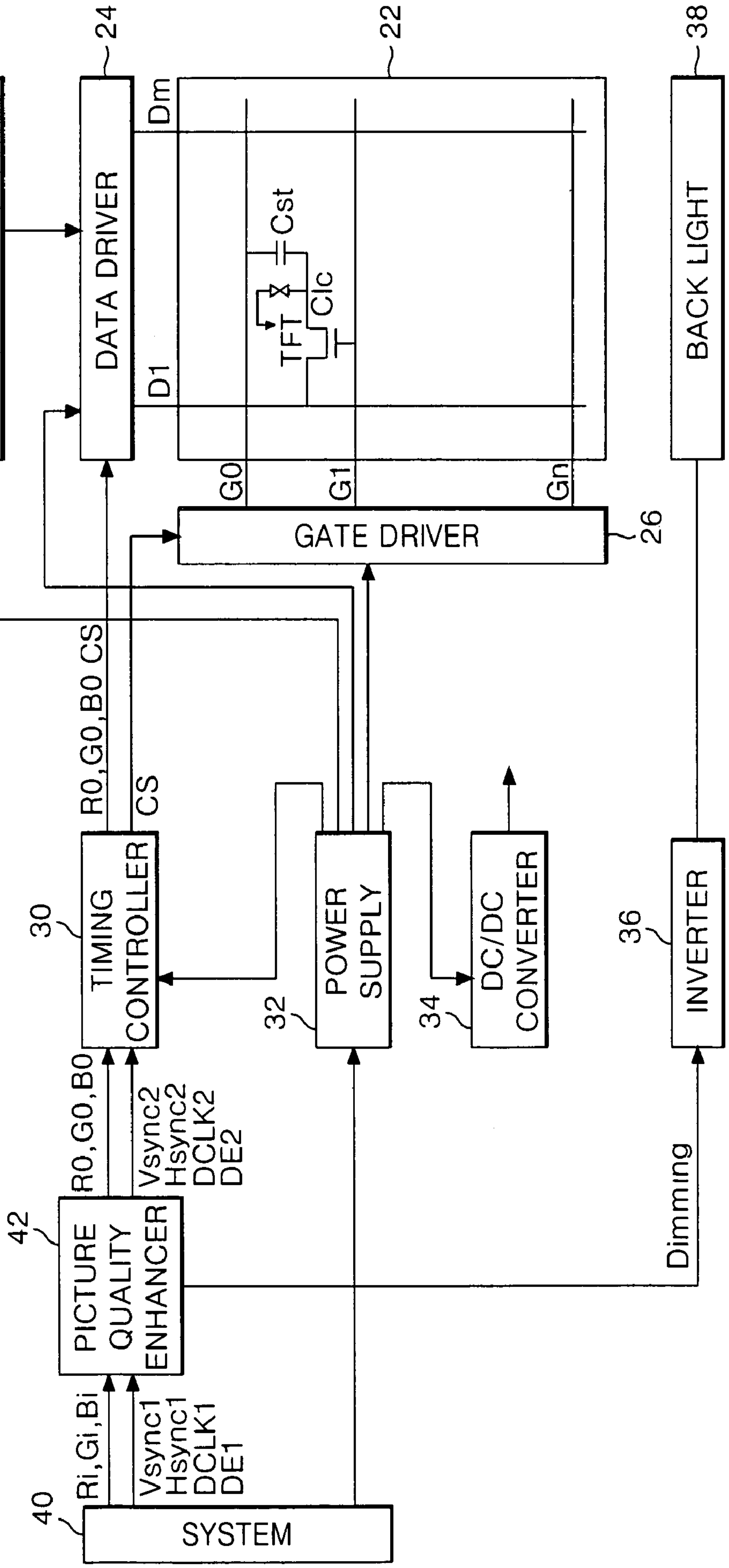

28
GAMMA VOLTAGE SUPPLIER
24
DATA DRIVER
22
Dm
D1
Cst
Clc
TFT
38
BACK LIGHT
G0
G1
Gn
GATE DRIVER
26
R0,G0,B0 CS
R0,G0,B0
CS
30
TIMING CONTROLLER
32
POWER SUPPLY
34
DC/DC CONVERTER
36
INVERTER
42
PICTURE QUALITY ENHANCER
Vsync2
Hsync2
DCLK2
DE2
Dimming
40
SYSTEM
Ri,Gi,Bi
Vsync1
Hsync1
DCLK1
DE1

FIG.3

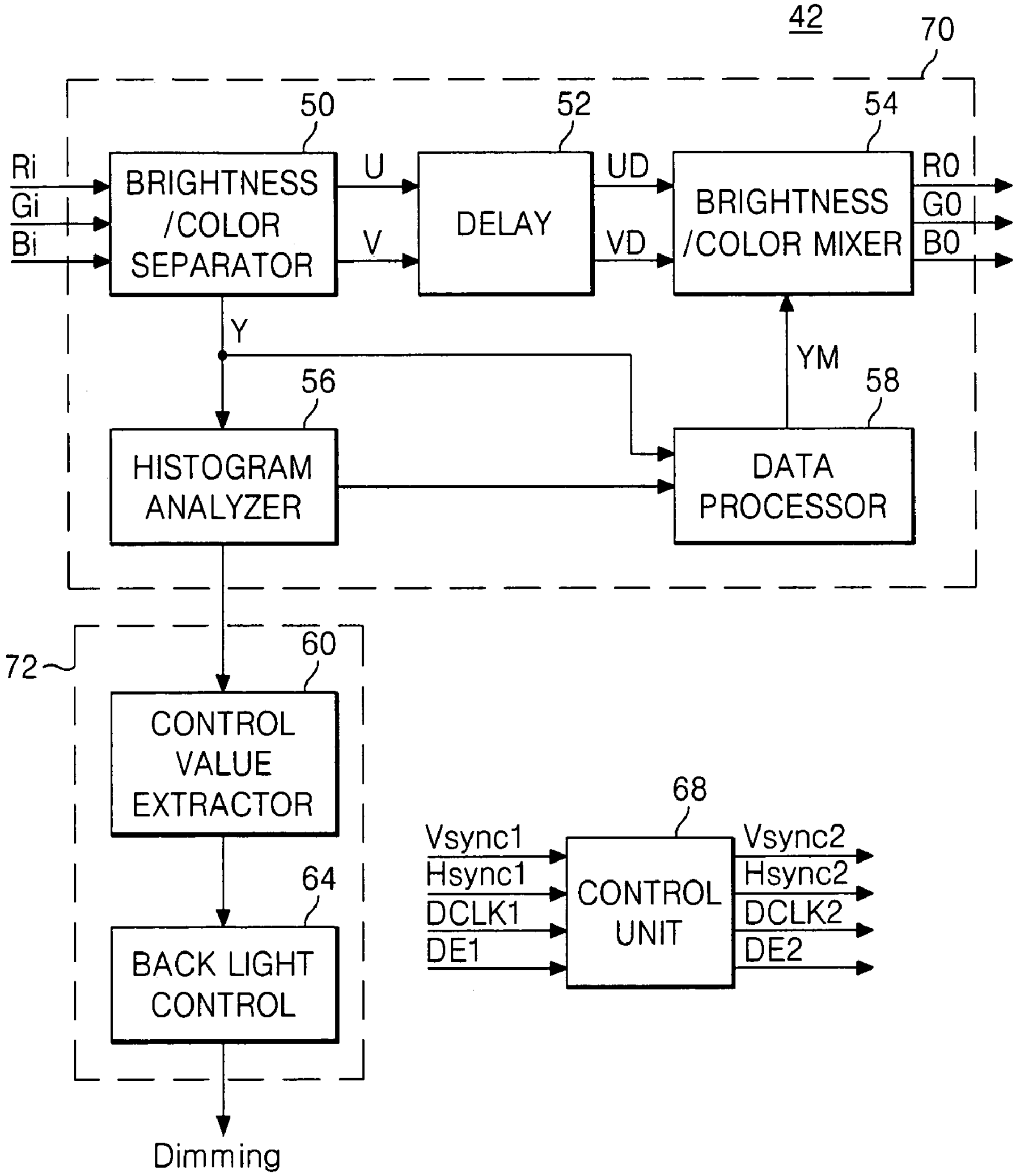

42
70
50
52
54
Ri
Gi
Bi
BRIGHTNESS /COLOR SEPARATOR
U
V
DELAY
UD
VD
BRIGHTNESS /COLOR MIXER
R0
G0
B0
Y
YM
56
58
HISTOGRAM ANALYZER
DATA PROCESSOR
72
60
CONTROL VALUE EXTRACTOR
64
BACK LIGHT CONTROL
Dimming
68
Vsync1
Hsync1
DCLK1
DE1
CONTROL UNIT
Vsync2
Hsync2
DCLK2
DE2

FIG.4

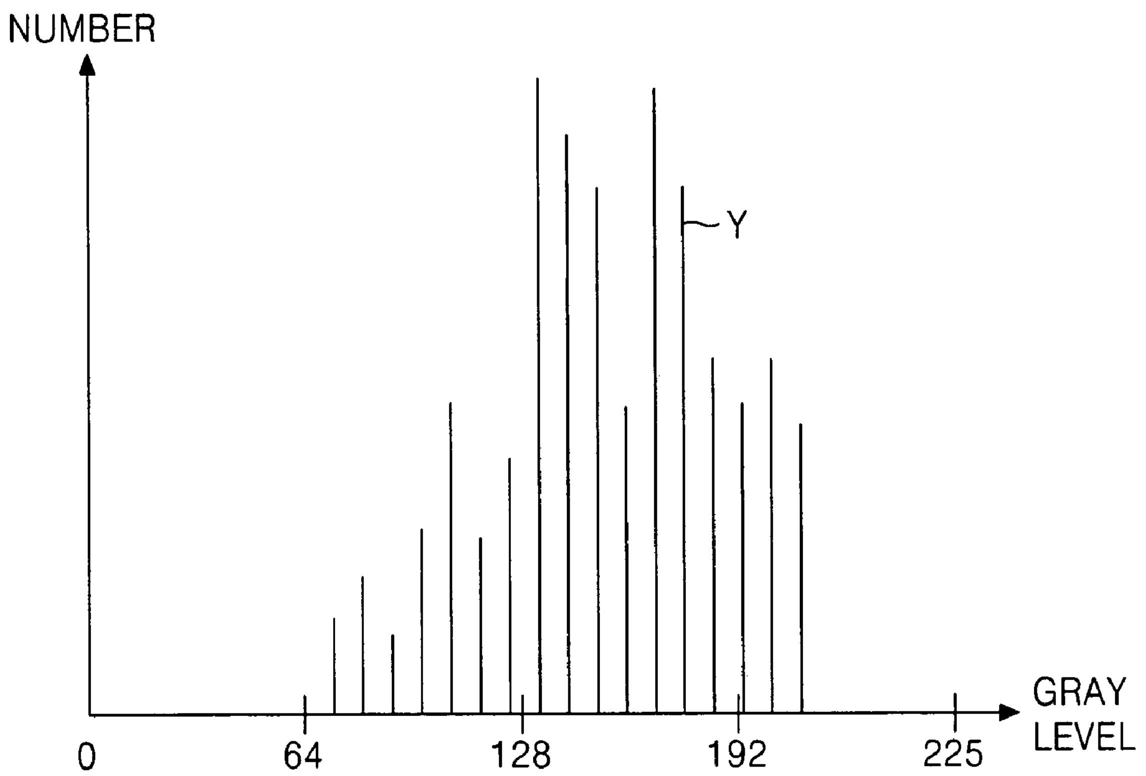


FIG. 5

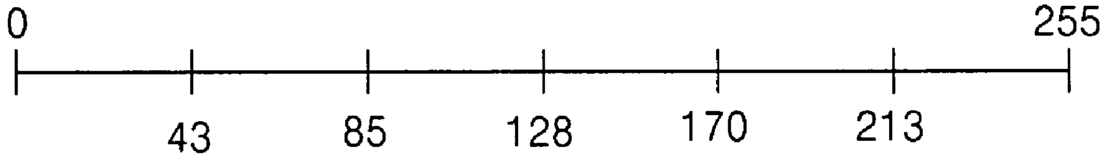


FIG.6

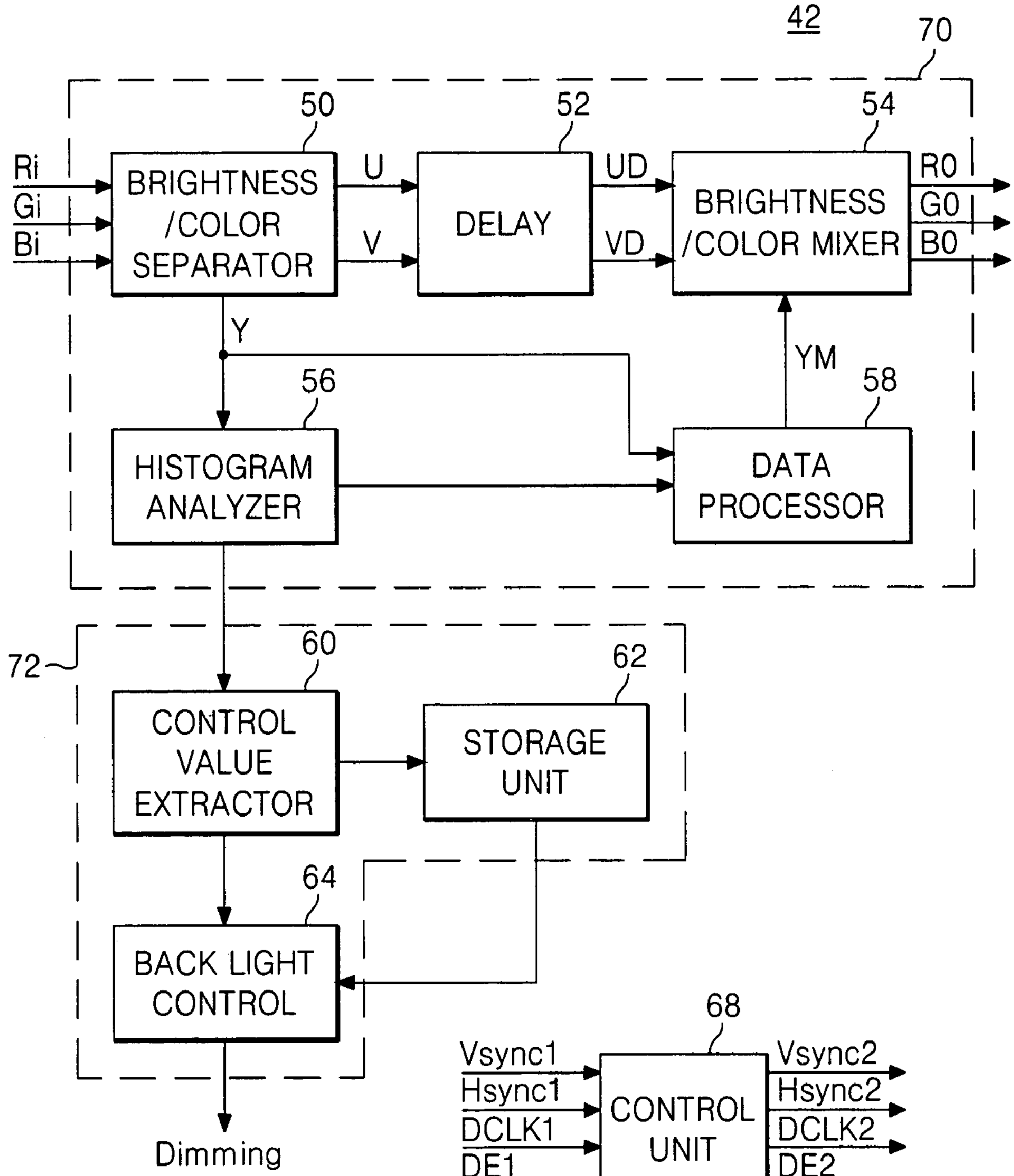

42
70
50
52
54
Ri
Gi
Bi
BRIGHTNESS /COLOR SEPARATOR
U
V
DELAY
UD
VD
BRIGHTNESS /COLOR MIXER
R0
G0
B0
Y
YM
56
58
HISTOGRAM ANALYZER
DATA PROCESSOR
72
60
62
CONTROL VALUE EXTRACTOR
STORAGE UNIT
64
BACK LIGHT CONTROL
Dimming
68
Vsync1
Hsync1
DCLK1
DE1
CONTROL UNIT
Vsync2
Hsync2
DCLK2
DE2

FIG.7A

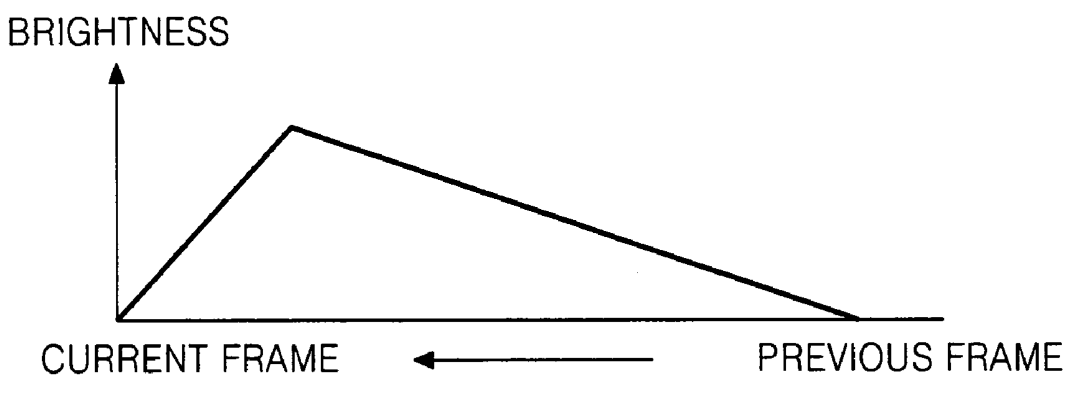


FIG. 7B

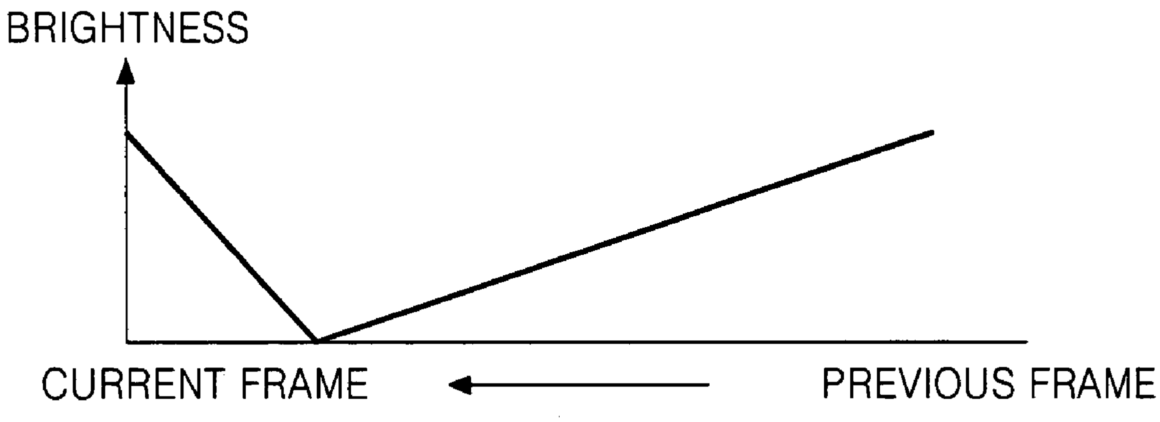


FIG.8A

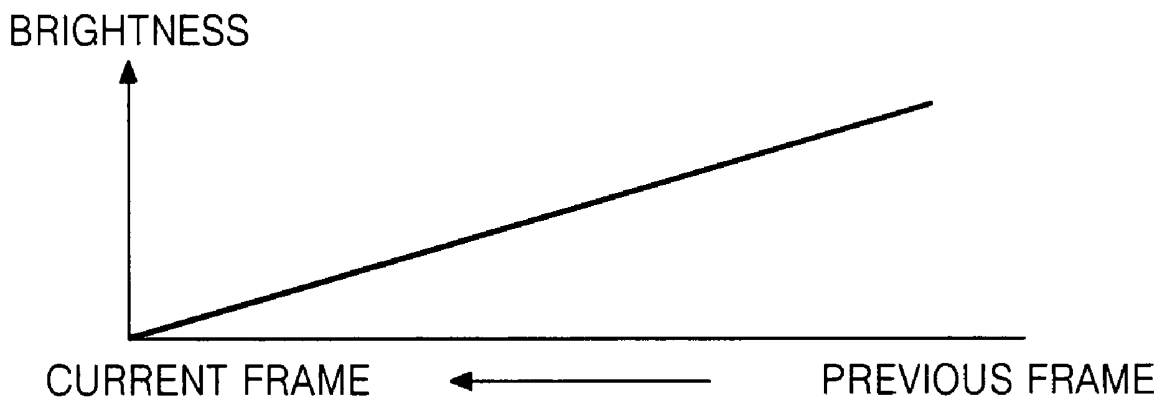
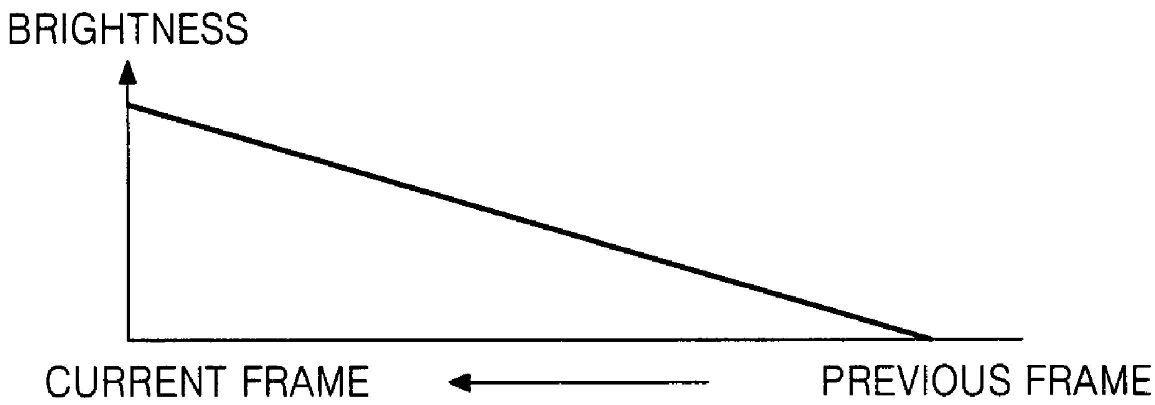


FIG.8B



METHOD AND APPARATUS FOR DRIVING LIQUID CRYSTAL DISPLAY

This application claims the benefit of Korean Patent Application No. P2003-81175 filed in Korea on Nov. 17, 2003, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a liquid crystal display, and more particularly to a driving method and apparatus for a liquid crystal display that is adaptive for making stabilizing brightness of a back light in correspondence with data to be displayed.

2. Description of the Related Art

Generally, a liquid crystal display (LCD) controls light transmittance of liquid crystal cells in accordance with video signals to thereby display a picture. Such an LCD has been implemented by an active matrix type having a switching device for each cell, and applied to a display device such as a monitor for a computer, office equipments, a cellular phone and the like. The switching device for the active matrix LCD mainly employs a thin film transistor (TFT).

FIG. **1** schematically shows a conventional LCD driving apparatus.

Referring to FIG. **1**, the conventional LCD driving apparatus includes a liquid crystal display panel **2** having m×n liquid crystal cells Clc arranged in a matrix type, m data lines D**1** to Dm and n gate lines G**1** to Gn intersecting each other and thin film transistors TFT provided at the intersections, a data driver **4** for applying data signals to the data lines D**1** to Dm of the liquid crystal display panel **2**, a gate driver **6** for applying scanning signals to the gate lines G**1** to Gn, a gamma voltage supplier **8** for supplying the data driver **4** with gamma voltages, a timing controller **10** for controlling the data driver **4** and the gate driver **6** using synchronizing signals from a system **20**, a direct current to direct current converter **14**, hereinafter referred to as "DC/DC converter", for generating voltages supplied to the liquid crystal display panel **2** using a voltage from a power supply **12**, and an inverter **16** for driving a back light **18**.

The system **20** applies vertical/horizontal signals Vsync and Hsync, clock signals DCLK, a data enable signal DE and data R, G and B to the timing controller **10**.

The liquid crystal display panel **2** includes a plurality of liquid crystal cells Clc arranged, in a matrix type, at the intersections between the data lines D**1** to Dm and the gate lines G**1** to Gn. The thin film transistor TFT provided at each liquid crystal cell Clc applies a data signal from each data line D**1** to Dm to the liquid crystal cell Clc in response to a scanning signal from the gate line G. Further, each liquid crystal cell Clc is provided with a storage capacitor Cst. The storage capacitor Cst is provided between a pixel electrode of the liquid crystal cell Clc and a pre-stage gate line or between the pixel electrode of the liquid crystal cell Clc and a common electrode line, to thereby constantly keep a voltage of the liquid crystal cell Clc.

The gamma voltage supplier **8** applies a plurality of gamma voltages to the data driver **4**.

The data driver **4** converts digital video data R, G and B into analog gamma voltages (i.e., data signals) corresponding to gray level values in response to a control signal CS from the timing controller **10**, and applies the analog gamma voltages to the data lines D**1** to Dm.

The gate driver **6** sequentially applies a scanning pulse to the gate lines G**1** to Gn in response to a control signal CS from the timing controller **10** to thereby select horizontal lines of the liquid crystal display panel **2** supplied with the data signals.

The timing controller **10** generates the control signals CS for controlling the gate driver **6** and the data driver **4** using the vertical/horizontal synchronizing signals Vsync and Hsync and the clock signal DCLK inputted from the system **20**. Herein, the control signal CS for controlling the gate driver **6** is comprised of a gate start pulse GSP, a gate shift clock GSC and a gate output enable signal GOE, etc. Further, the control signal CS for controlling the data driver **4** is comprised of a source start pulse SSP, a source shift clock SSC, a source output enable signal SOE and a polarity signal POL, etc. The timing controller **10** re-aligns the data R, G and B from the system **20** to apply them to the data driver **4**.

The DC/DC converter **14** boosts or drops a voltage of 3.3V inputted from the power supply **12** to generate a voltage supplied to the liquid crystal display panel **2**. Such a DC/DC converter **14** generates a gamma reference voltage, a gate high voltage VGH, a gate low voltage VGL and a common voltage Vcom, etc.

The inverter **16** applies a driving voltage (or driving current) for driving the back light **18** to the back light **18**. The back light **18** generates light corresponding to the driving voltage (or driving current) from the inverter **16** to apply it to the liquid crystal display panel **2**.

In order to display a vivid image on the liquid crystal display panel **2** driven in this manner, a distinct contrast between brightness and darkness must be made in correspondence with the image data that is input to the display. However, since the conventional back light **18** produces a constant brightness irrespective of the data, it is difficult to display a dynamic and fresh image.

SUMMARY OF THE INVENTION

A driving method and apparatus for a liquid crystal display are provided in which variations in the brightness of a back light are stabilized in correspondence with the data to be displayed.

A method of driving a liquid crystal display according to one aspect of the present invention includes (A) converting data into brightness components; (B) dividing the brightness components into a plurality of brightness areas; (C) arranging the brightness components into a histogram for each frame and thereafter extracting a control value; (D) storing the extracted control value; and (E) controlling brightness of a back light using a current control value of a current frame extracted at (C) and a prior control value prior to the current control value by at least two frames having been stored at (D).

In the method, the control value is the most-frequent value that is occupied by the largest number of brightness components in the histogram and the average value of the brightness components in the histogram.

Controlling the brightness includes keeping the brightness of the back light equal to the brightness of the previous frame when the current control value is equal to the prior control value.

Controlling the brightness includes changing the brightness of the back light in correspondence with the current control value when the current control value is different from the prior control value.

Controlling the brightness includes dividing the histogram into a plurality of brightness areas and changing the brightness of the back light in correspondence with a brightness area to which the current control value belongs.

The method further includes keeping the brightness of the back light equal to the brightness of the previous frame immediately preceding the current frame irrespective of the current control value of the frame if certain predetermined conditions are met.

The predetermined conditions include the brightness of the back light continuously changing in one direction before the current frame and then changing the other way at the current frame.

Alternatively, the predetermined conditions include the brightness of the back light continuously changing from a frame earlier than the prior frame through the current frame.

A method of driving a liquid crystal display according to another aspect of the present invention includes (A) setting conditions in which brightness of a previous frame is kept at a back light irrespective of a control value of a current frame; (B) converting data to be displayed into brightness components; (C) dividing the brightness components into a plurality of brightness areas; (D) arranging the brightness components into a histogram for each frame and thereafter extracting a control value; and (E) controlling the brightness of the back light in correspondence with the extracted control value when the extracted control value is not included in the conditions in which the brightness of the previous frame is kept.

As above, the control value is the most-frequent value or the average value of the histogram.

The brightness of the back light is set differently for each brightness area to which the control value belongs.

The condition in which the brightness of the previous frame is kept includes the brightness of the back light changes continuously in the two frames preceding the current frame and then changes in the opposite manner at the current frame or when the brightness of the back light changes continuously in the two frames preceding the current frame and continues to change in the same manner at the current frame.

The method further includes keeping the brightness of the back light equal to brightness of the previous frame when the current control value is equal to the prior control value.

A driving apparatus for a liquid crystal display according to still another aspect of the present invention includes a brightness/color separator for converting data to be displayed into brightness components; a histogram analyzer for arranging the brightness components into a histogram for each frame; a back light; and a back light control for extracting a control value to determine brightness of the back light from the histogram and for controlling the brightness of the back light using the extracted control value of a current frame and control values of at least two frames earlier than the current frame.

In the driving apparatus, the control value is the most-frequent value or the average value.

The back light control includes a control value extractor for extracting the control value from the histogram; a storage for storing the extracted control value from the control value extractor; and a back light controller for controlling the brightness of the back light using the current control value from the control value extractor and the prior control values from the storage.

The back light controller controls the brightness of the back light to keep the brightness of the previous frame when the current control value is equal to the prior control value.

The back light controller controls the brightness of the back light to generate brightness corresponding to the current control value when the current control value is different from the prior control value.

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the invention will be apparent from the following detailed description of the embodiments of the present invention with reference to the accompanying drawings, in which:

FIG. **1** is a schematic block diagram showing a configuration of a conventional driving apparatus for a liquid crystal display;

FIG. **2** is a schematic block diagram showing a configuration of a driving apparatus for a liquid crystal display according to an embodiment of the present invention;

FIG. **3** is a block diagram of a first embodiment of the picture quality enhancer shown in FIG. **2**;

FIG. **4** is a graph showing an example of a histogram analyzed by the histogram analyzer shown in FIG. **3**;

FIG. **5** depicts a brightness area for controlling brightness at the back light controller shown in FIG. **3**;

FIG. **6** is a block diagram of a second embodiment of the picture quality enhancer shown in FIG. **2**; and

FIGS. **7**A, **7**B, **8**A and **8**B are graphs showing a condition under which the brightness of the previous frame in the back light controller shown in FIG. **6** is maintained.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 2 schematically shows a driving apparatus for a liquid crystal display (LCD) according to an embodiment of the present invention.

Referring to FIG. **2**, the LCD driving apparatus according to the embodiment of the present invention includes a liquid crystal display panel **22** having m×n liquid crystal cells Clc arranged in a matrix type, m data lines D**1** to Dm and n gate lines G**1** to Gn intersecting each other and thin film transistors TFT provided at the intersections, a data driver **24** for applying data signals to the data lines D**1** to Dm of the liquid crystal display panel **22**, a gate driver **26** for applying scanning signals to the gate lines G**1** to Gn, a gamma voltage supplier **28** for supplying the data driver **24** with gamma voltages, a timing controller **30** for controlling the data driver **24** and the gate driver **26** using a second synchronizing signal from a picture quality enhancer **42**, a DC/DC converter **34** for generating voltages supplied to the liquid crystal display panel **22** using a voltage from a power supply **32**, an inverter **36** for driving a back light unit **38**, and a picture quality enhancer **42** for selectively emphasizing a contrast of the input data and for applying a brightness control signal Dimming corresponding to the input data to the inverter **36**.

The system **40** applies first vertical/horizontal signals Vsync**1** and Hsync**1**, a first clock signal DCLK**1**, a first data enable signal DE**1** and first data Ri, Gi and Bi to the picture quality enhancer **42**.

The liquid crystal display panel **22** includes a plurality of liquid crystal cells Clc arranged, in a matrix type, at the intersections between the data lines D**1** to Dm and the gate lines G**1** to Gn. The thin film transistor TFT provided at each liquid crystal cell Clc applies a data signal from each data line D**1** to Dm to the liquid crystal cell Clc in response to a scanning signal from the gate line G. Further, each liquid crystal cell Clc is provided with a storage capacitor Cst. The storage capacitor Cst is provided between a pixel electrode of the liquid crystal cell Clc and a pre-stage gate line or between the pixel electrode of the liquid crystal cell Clc and a common electrode line, to thereby constantly keep a voltage of the liquid crystal cell Clc.

The gamma voltage supplier **28** applies a plurality of gamma voltages to the data driver **24**.

The data driver **24** converts digital video data Ro, Go and Bo into analog gamma voltages (i.e., data signals corresponding to gray level values in response to a control signal CS from the timing controller **30**, and applies the analog gamma voltages to the data lines D**1** to Dm.

The gate driver **26** sequentially applies a scanning pulse to the gate lines G**1** to Gn in response to a control signal CS from the timing controller **30** to thereby select horizontal lines of the liquid crystal display panel **22** supplied with the data signals.

The timing controller **30** generates the control signals CS for controlling the gate driver **26** and the data driver **24** using second vertical/horizontal synchronizing signals Vsync**2** and Hsync**2** and a second-clock signal DCLK**2** inputted from the picture quality enhancer **42**. The control signal CS for controlling the gate driver **26** is comprised of a gate start pulse GSP, a gate shift clock GSC and a gate output enable signal GOE, etc. Further, the control signal CS for controlling the data driver **24** is comprised of a source start pulse SSP, a source shift clock SSC, a source output enable signal SOE and a polarity signal POL, etc. The timing controller **30** re-aligns second data Ro, Go and Bo from the picture quality enhancer **42** to apply them to the data driver **24**.

The DC/DC converter **34** boosts or drops a voltage of 3.3V inputted from the power supply **32** to generate a voltage supplied to the liquid crystal display panel **22**. Such a DC/DC converter **14** generates a gamma reference voltage, a gate high voltage VGH, a gate low voltage VGL and a common voltage Vcom.

The inverter **36** applies a driving voltage (or driving current) corresponding to the brightness control signal Dimming from the picture quality enhancer **42** to the back light **38**. In other words, a driving voltage (or driving current) applied from the inverter **36** to the back light **38** is determined by the brightness control signal Dimming from the picture quality enhancer **42**. The back light **38** applies light corresponding to the driving voltage (or driving current) from the inverter **36** to the liquid crystal display panel **22**.

The picture quality enhancer **42** extracts brightness components using the first data Ri, Gi and Bi from the system **40**, and generates second data Ro, Go and Bo obtained by a change in gray level values of the first data Ri, Gi and Bi in correspondence with the extracted brightness components. In this case, the picture quality enhancer **42** generates the second data Ro, Go and Bo such that the contrast is selectively expanded with respect to the input data Ri, Gi and Bi.

Further, the picture quality enhancer **42** generates a brightness control signal Dimming corresponding to the brightness components to apply the brightness control signal to the inverter **36**. The picture quality enhancer **42** extracts a control value capable of controlling the back light, for example, a most-frequent value (i.e., the gray level value occupied by the maximum number of the brightness components in the frame) and/or an average value (i.e., the average value of the brightness components in the frame), and generates the brightness control signal Dimming using the extracted control value. The picture quality enhancer **42** divides the brightness of the back light corresponding to the gray levels of the brightness components into at least two regions, and generates the brightness control signal Dimming such that regions of the brightness are selected in correspondence with the control value.

Moreover, the picture quality enhancer **42** generates second vertical/horizontal synchronizing signals Vsync**2** and Hsync**2**, a second clock signal DCLK**2** and a second data enable signal DE**2** synchronized with the second data Ro, Go and Bo with the aid of the first vertical/horizontal synchronizing signals Vsync**1** and Hsync**1**, the first clock signal DCLK**1** and the first data enable signal DE**1** inputted from the system **40**.

To this end, as shown in FIG. **3**, the picture quality enhancer **42** includes an image signal modulator **70** for generating the second data Ro, Go and Bo using the first data Ri, Gi and Bi, a back light controller **72** for generating the brightness control signal Dimming under control of the image signal modulator **70**, and a control unit **68** for generating the second vertical/horizontal synchronizing signals Vsync**2** and Hsync**2**, the second clock signal DCLK**2** and the second enable signal DE**2**.

The image signal modulator **70** extracts brightness components Y from the first data Ri, Gi and Bi, and generates second data Ro, Go and Bo in which a contrast is partially emphasized with the aid of the extracted brightness components Y. To this end, the image signal modulator **70** includes a brightness/color separator **50**, a delay **52**, a brightness/color mixer **54**, a histogram analyzer **56** and a data processor **58**.

The brightness/color separator **50** separates the first data Ri, Gi and Bi into brightness components Y and chrominance components U and V. The brightness components Y and the chrominance components U and V are obtained by the following equations:

$$Y=0.229\times Ri+0.587\times Gi+0.114\times Bi \quad (1)$$

$$U=0.493\times(Bi-Y) \quad (2)$$

$$V=0.887\times(Ri-Y) \quad (3)$$

The histogram analyzer **56** divides the brightness components Y into gray levels in each frame. In other words, the histogram analyzer **56** arranges the brightness components Y of each frame to correspond to the gray levels, thereby obtaining a histogram as shown in FIG. **4**. The shape of the histogram depends on the brightness components of the first data Ri, Gi and Bi.

The data processor **58** generates modulated brightness components YM having a selectively emphasized contrast using the analyzed histogram from the histogram analyzer **56**. The data processor **58** generates modulated brightness components YM by various methods, such as those disclosed in Korean Patent Applications Nos. 2003-036289, 2003-040127 and 2003-041127, previously filed by the present applicants and herein incorporated by reference.

The delay **52** delays chrominance components U and V until the brightness components YM modulated by the data processor **58** are produced. Further, the delay **52** applies the delayed chrominance components VD and UD to the brightness/color mixer **54** to be synchronized with the modulated brightness components YM.

The brightness/color mixer **54** generates second data Ro, Go and Bo with the aid of the modulated brightness components YM and the delayed chrominance components UD and VD. The second data Ro, Go and Bo is obtained by the following equations:

$$Ro=YM+0.000\times UD+1.140\times VD \quad (4)$$

$$Go=YM-0.396\times UD-0.581\times VD \quad (5)$$

$$Bo=YM+2.029\times UD+0.000\times VD \quad (6)$$

Since the second data Ro, Go and Bo obtained by the brightness/color mixer **54** has been produced from the modulated brightness components YM having an expanded contrast, they have more expanded contrast than the first data Ri, Gi and Bi. The second data Ro, Go and Bo produced such that the contrast can be expanded, as mentioned above, is applied to the timing controller **30**.

The control unit **68** receives the first vertical/horizontal synchronizing signals Vsync**1** and Hsync**1**, the first clock signal DCLK**1** and the first data enable signal DE**1** from the system **40**. Further, the controller **68** generates the second vertical/horizontal synchronizing signals Vsync**2** and Hsync**2**, the second clock signal DCLK**2** and the second data enable signal DE**2** to be synchronized with the second data Ro, Go and Bo, and applies them to the timing controller **30**.

The back light controller **72** extracts a control value from the histogram analyzer **56**, and generates a brightness control signal Dimming using the extracted control value. The control value controls the brightness of the back light **38**. For instance, the most-frequent value and/or average value may be used as the control value. The back light controller **72** includes a control value extractor **60** and a back light control **64**.

As shown in FIG. **5**, the back light control **64** divides the gray levels of the brightness components Y into a plurality of areas, and controls the back light **38** such that a different brightness can be supplied for each area. In other words, the back light control **64** determines the gray level of the control value and generates a brightness control signal Dimming to correspond to the area to which the control value belongs.

The control value extractor **60** extracts a control value from the histogram analyzer **56** to apply it to the back light control **64**.

An operation procedure of the back light controller **72** will be described in detail below.

First, the control value extractor **60** extracts the histogram analyzed by the histogram analyzer **56** to apply the extracted control value to the back light control **64**. The back light control **64** having received the control value checks the area (i.e., gray level value) to which a control value applied thereto belongs. In other words, the back light control **64** checks the area to which the control value belongs of a plurality of divided gray level values as shown in FIG. **5**, and generates the brightness control signal Dimming corresponding thereto. The back light controller **64** then generates the brightness control signal Dimming such that light of increasing brightness is produced as the area to which the control value belongs increases.

The brightness control signal Dimming from the back light control **64** is applied to the inverter **36**. The inverter **36** controls the back light **38** in response to the brightness control signal Dimming, thereby applying light corresponding to the brightness control signal Dimming to the liquid crystal display panel **22**. In other words, the back light controller **72** divides the gray levels into a plurality of areas and applies the brightness control signal Dimming such that light of a different brightness for each area can be generated in correspondence with the control value, thereby displaying a vivid image. That is to say, the brightness is controlled in accordance with an area to which the control belongs, thereby displaying a picture having a distinct contrast on the liquid crystal display panel **22**.

However, in such an embodiment, the brightness of the back light **38** is sensitive to the control value, which may cause sparkling to occur. For instance, if the control value is disposed close enough to the border between two areas such that the area to which the control value belongs alternates between successive frames, then the brightness of the back light **38** is changed substantially in the successive frames even though the brightness of the image changes relatively little. For example, sparkling will occur when switching between a gray level of 165 and a gray level of 175 when the areas of the gray levels are divided as shown in FIG. **5**. In this case, the back light controller **64** controls the inverter **36** such that a first brightness is supplied when the control value represents the gray level of 165, whereas it controls the inverter **36** such that light of a second brightness which is higher than the first brightness is supplied when the control value represents the gray level of 175. Changing the control value back and forth between two adjacent areas in successive frames multiple times may cause sparkling in the liquid crystal display panel **22**.

The picture quality enhancer according another embodiment of the present invention shown in FIG. **6** may mitigate this problem. Since configurations and functions of an image signal modulator **70** and a control unit **68** except for a back light controller **72** in the embodiment shown in FIG. **6** are identical to those of the embodiment shown in FIG. **3**, a detailed explanation as to these elements will be omitted.

Referring to FIG. **6**, the back light controller **72** according to another embodiment of the present invention extracts a control value from the histogram analyzer **56**, and generates a brightness control signal Dimming using the extracted control value. The back light controller **72** divides the gray levels into a plurality of areas, and controls the brightness of the back light **38** in correspondence with the area to which the control value belongs. Each area from which the control value is extracted causes the back light **38** to be controlled to have a different brightness. Moreover, the back light controller **72** compares the control value of the current frame with the control values of at least one of the frames preceding the current frame to prevent the brightness of the back light **38** from being overly sensitive to the control value of the current frame.

To this end, the back light controller **72** includes a control value extractor **60**, a storage unit **62** and a back light control **64**. As before, the control value can be the most-frequent value and/or the average value.

The control value extractor **60** extracts the control value from the histogram analyzer **56** to apply it to the storage unit **62** and the back light control **64**.

The storage unit **62** stores at least the control values that were extracted from the two frames prior to the current frame. In other words, the control value of the previous frame (the frame immediately before the current frame, hereinafter referred to as the previous control value) and the control value of the frame immediately preceding the previous frame (the frame two frames before the current frame, hereinafter referred to as the prior control value) are stored in the storage unit **62**. The prior control value may also be any frame that precedes the previous frame, rather than merely the frame immediately preceding the previous frame.

The back light controller **64** divides the gray levels of the brightness components Y into a plurality of areas as shown in FIG. **5**, and controls the back light **38** such that a different brightness is supplied for each area. In other words, the back light controller **64** determines the gray level of the control value, and generates a brightness control signal Dimming to correspond to the area to which the control value belongs. The back light controller-**64** generates the brightness control signal Dimming such that the brightness of the previous frame is kept when the prior control value supplied from the storage unit **62** is identical to the current control value supplied from the control value extractor **60**.

An operation procedure of the back light controller **72** will be described in detail below.

Firstly, the control value extractor **60** extracts a control value from a histogram analyzed by the histogram analyzer **56** to apply it to the storage unit **62** and the back light control **64**.

The storage unit **62** having received the control value stores the current control value and, at the same time, applies the prior control value stored therein to the back light control **64**.

The back light control **64** receives the current control value from the control value extractor **60** and receives the prior control value from the storage unit **62**. The back light control **64** having received the current control value and the prior control value checks whether or not the current control value is equal to the prior control value. If the current control value is equal to the prior control value, then the back light control **64** generates a brightness control signal Dimming such that the brightness of the previous frame (i.e. the previous brightness) is maintained irrespective of the current control value. On the other hand, if the current control value is not equal to the prior control value, the back light control **64** generates a brightness control signal Dimming to correspond to the area to which the current control value belongs.

The brightness control signal Dimming generated from the back light control **64** is applied to the inverter **36**. The inverter **36** controls the back light **38** in response to the brightness control signal Dimming, thereby applying light corresponding to the brightness control signal Dimming to the liquid crystal display panel **22**. In other words, the present back light controller **72** divides the gray levels into a plurality of areas, and supplies the brightness control signal Dimming such that a different brightness can be produced for each area in correspondence with the control value, thereby displaying a vivid image. That is to say, the back light controller **72** controls the brightness of the light in accordance with the area to which the control value belongs, thereby displaying a picture having a distinct contrast on the liquid crystal display panel **22**.

Furthermore, the back light control **64** compares the prior control value with the current control value, and, if it is determined that the prior control value is equal to the current control value, maintains the brightness of the previous frame. Accordingly, the brightness is changed in correspondence with one of the control values, so that it becomes possible to prevent sparkling from occurring.

For example, if the control value alternates between a gray level of 165 and a gray level of 175 when the gray level areas are divided as shown in FIG. **5**, then the back light **38** maintains the brightness of the previous frame irrespective of the current control value. It is assumed that the prior control value has been stored in the storage unit **62**. In other words, since the current control value is equal to the prior control value, the liquid crystal display panel **22** maintains the brightness of the previous frame. That is to say, brightness is not changed between the frames, even if the control value shifts areas between the frames.

Moreover, the back light control **64** keeps the same brightness with respect to the previous frame under a specific condition in which sparkling may appear. Control values corresponding to the specific condition are stored in the storage unit **62**.

A process of keeping the same brightness with respect to the previous frame at the back light control **64** in correspondence with the specific condition will be described in detail below.

Firstly, FIG. **7**A represents an image that continuously brightens and then becomes dark at the current frame. In this case, then the back light control **64** controls the brightness of the back light **38** using the previous control value. In other words, in the above case, the back light control **64** controls the back light **38** such that the brightness of the previous frame is kept irrespective of the current control value, thereby preventing sparkling from being generated. The back light control **64** determines that the brightness of the image is increasing and then becomes dark at the current frame when the control values have the following condition:

$$CSN^1<CSN^2,\ CSN^2\geqq CSN^3,\ CSN^3\geqq CSN^4,\ CSN^4\geqq CSN^5, \quad (7)$$

In the above equation, 'CSN' represents the control value, and "X" represents the position of the frame. A larger value of "X" means a control value farther from the current frame while a smaller value of "X" means a control value closer to the current frame.

It can be seen from the above equation (7) that the control value becomes larger with decreasing distance from the farthest frame (the frame farthest in time from the current frame) to the frame immediately preceding the current frame (previous frame). Thus, the brightness of the back light **38** determined by the control value also becomes gradually larger. The current control value CSN^1 has a smaller gray level value than that of the previous control value CSN^2. If the current control value CSN^1 has a smaller gray level value than that of the previous control value CSN^2, then decreasing the brightness of the back light **38** should be performed. However, since, if brightness of the back light **38** is gradually increasing and then suddenly decreases, sparkling may appear at the liquid crystal display panel **22**, the present embodiment keeps the brightness of the current frame equal to the brightness of the previous frame when the control value meets the condition indicated in the above equation (7).

Next, FIG. **7**B represents an image that darkens continuously and then becomes bright at the current frame. In this case, then the back light control **64** controls the brightness of the back light **38** using the previous control value. In other words, in the above case, then the back light control **64** controls the back light **38** such that the brightness of the previous frame is kept irrespective of the current control value, thereby preventing sparkling from occurring. Meanwhile, the back light control **64** determines that the image is darkening and then becomes brighter at the current frame when control values meet the following condition:

$$CSN^1>CSN^2,\ CSN^2\leqq CSN^3,\ CSN^3\leqq CSN^4,\ CSN^4\leqq CSN^5, \quad (8)$$

It can be seen from the above equation (8) that the control value becomes smaller as it proceeds from the farthest frame to the previous frame. Thus, the brightness of the back light **38** determined by the control value also decreases gradually. Meanwhile, the current control value CSN^1 has a larger gray level value than that of the previous CSN^2. If the current control value CSN^1 has a larger gray level value than that of the previous control value CSN^2, then increasing the brightness of the back light **38** should be performed. However, since, if brightness of the back light **38** is gradually increased and then is suddenly increased, sparkling may appear at the liquid crystal display panel **22**, the present embodiment keeps the brightness of the current frame equal to the brightness of the previous frame when the control value meets the condition indicated in the above equation (8).

In other words, the embodiment of FIG. **7**B keeps the brightness of the previous frame when the image continuously brightens and then becomes dark at the current frame and when the image is continuously darkens and then becomes bright at the current frame, thereby preventing sparkling from occurring in the liquid crystal display panel **22**.

Additionally, the present back light control **64** controls the brightness of the back light **38** to keep the brightness of the previous frame at the current frame both when the brightness of the back light **38** decreases as indicated in FIG. **8**A and the following equation (9) and when the brightness of the back light **38** increases as indicated in FIG. **8**B and the following equation (10). Since the brightness of the liquid crystal display panel **22** is continuously changed when the brightness of the back light **38** continuously increases or decreases, sparkling appears at the liquid crystal display panel **22**.

$$CSN^1 \leqq CSN^2,\ CSN^2 \leqq CSN^3,\ CSN^3 \leqq CSN^4,\ CSN^4 \leqq CSN^5, \quad (9)$$

$$CSN^1 \geqq CSN^2,\ CSN^2 \geqq CSN^3,\ CSN^3 \geqq CSN^4,\ CSN^4 \geqq CSN^5, \quad (10)$$

In the above embodiments, control values of the earlier frames CSN^2, CSN^3, . . . are compared with the current control value so as to determine the conditions indicated in FIGS. **7**A, **7**B, **8**A, and **8**B. More specifically, the storage unit **62** stores the control values of a plurality of the earlier frames, not just those of the two frames preceding the current frame. Thus, while some embodiments may only be required to store three control values (the current control value, the previous control value, and the prior control value), in other embodiments, control values of earlier frames may be stored in addition.

As described above, according to the present invention, data is changed into brightness components, arranged into a histogram for each frame, and the brightness of the back light is controlled by a control value extracted from the histogram, thereby displaying a vivid image. Furthermore, a control value of the previous frame is kept when a control value of frames prior to the current frame is equal to the current control value, so that it becomes possible to prevent the brightness of the back light from being sensitively changed in correspondence with the control value and thus prevent sparkling from being generated in the liquid crystal display panel. Moreover, the back light is controlled to keep brightness of the previous frame in a specific condition in which sparkling is generated from the liquid crystal display panel, thereby preventing sparkling from being generated in the liquid crystal display panel.

Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.

What is claimed is:

1. A method of driving a display, comprising:

(A) converting data to be displayed in a current frame into brightness components;

(B) arranging the brightness components into a histogram of gray levels and thereafter extracting a current control value from the histogram;

(C) storing the current control value; and

(D) controlling brightness of a back light using the current control value and a prior control value of a prior frame preceding a previous frame that is immediately before the current frame,

wherein (D) comprises maintaining the brightness of the back light from the brightness of the previous frame when the current control value is equal to the prior control value.

2. The method of claim **1**, wherein the control value is a most-frequent value occupied by the maximum number of brightness components in the histogram or an average value of the brightness components in the histogram.

3. The method of claim **1**, wherein (D) comprises changing the brightness of the back light in correspondence with the current control value when the current control value is different from the prior control value.

4. The method of claim **1**, wherein (D) comprises changing the brightness of the back light in correspondence with the brightness area to which the control value belongs.

5. The method of claim **1**, further comprising maintaining the brightness of the back light from that of the previous frame irrespective of the current control value in correspondence with predetermined conditions.

6. The method of claim **5**, wherein the predetermined conditions comprises the brightness of the back light continuously changing in one direction from a frame preceding the prior frame to the current frame and then changing in the opposite direction at the current frame.

7. The method of claim **5**, wherein the predetermined conditions comprises the brightness of the back light continuously changing in one direction from a frame preceding the prior frame through the current frame.

8. A driving apparatus for a display, comprising:

a brightness/color separator for converting data of a current frame into brightness components;

a histogram analyzer for arranging the brightness components into a histogram;

a back light that provides light for the display; and

a back light control that extracts a current control value from the histogram to determine brightness of the back light and controls the brightness of the back light using the current control value, a previous control value of a previous frame immediately preceding the current frame and a prior control value of a prior frame immediately preceding the previous frame,

wherein the back light control controls the brightness of the back light to keep the brightness of the previous frame when the current control value is equal to the prior control value.

9. The driving apparatus of claim **8**, wherein the control value is a most-frequent value occupied by the maximum number of brightness components in the histogram and an average value of the brightness components in the histogram.

10. The driving apparatus of claim **8**, wherein the back light control comprises:

a control value extractor for extracting the current control value from the histogram;

a storage for storing the current control value from the control value extractor; and

a back light controller for controlling the brightness of the back light using the current control value from the control value extractor and the previous and prior control values from the storage means.

11. The driving apparatus of claim **10**, wherein the back light controller controls the brightness of the back light to generate a brightness corresponding to the current control value when the current control value is different from the prior control value.

12. A method of driving a current frame of a display, the method comprising:

storing control values extracted from brightness components in the current frame as well as a plurality of frames before the current frame; and

comparing a current control value of the current frame to an earlier control value of an earlier frame at least two frames before the current frame; and controlling the brightness of the back light using the current control value when the current control value and the earlier control value lie outside a predetermined range of values from each other.

13. The method of claim **12**, further comprising extracting each control value from at least one statistic of the brightness components in the particular frame.

14. The method of claim **12**, further comprising controlling the brightness of the back light using a previous control value of a frame between the current frame and the earlier frame when the current control value and the earlier control value lie within a predetermined range of values from each other.

15. The method of claim **14**, further comprising selecting the control value of the frame immediately preceding the current frame as the previous control value.

16. The method of claim **12**, further comprising controlling the brightness of the back light using a previous control value of a frame between the current frame and the earlier frame when the brightness of the backlight changes monotonically with time from a frame before the current frame to a frame immediately preceding the current frame and the brightness of the backlight to be used in the current frame does not continue changing in the same manner.

17. The method of claim **16**, further comprising controlling the brightness of the back light using the previous control value only when the brightness of the back light in at least the three frames immediately preceding the current frame has changed monotonically.

18. The method of claim **12**, further comprising controlling the brightness of the back light using a previous control value of a frame between the current frame and the earlier frame when the brightness of the backlight changes monotonically with time from a frame before the current frame through the current frame.

19. The method of claim **18**, further comprising controlling the brightness of the back light using the previous control value only when the brightness of the back light in at least the three frames immediately preceding the current frame as well as the current frame has changed monotonically.

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摘要(译)

公开了一种用于液晶显示器的驱动方法和装置，其稳定与要显示的数据相对应的背光亮度的变化。在该方法中，数据被转换为亮度分量。亮度分量被分成多个亮度区域。将亮度分量排列成每帧的直方图，然后提取直方图的最频率值或平均值的控制值。提取的控制值与其他控制值一起存储，包括在当前帧的控制值之前提取的帧的控制值至少两帧。使用提取的当前帧的控制值和一个或多个其他存储的控制值来控制背光的亮度。